CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF TRANSPORTATION SCIENCES
DEPARTMENT OF AIR TRANSPORT

MIKROTIK IN AVIATION

Research projects in aviation using Mikrotik and things that makes you think

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Science Projects

About Me

- Researcher and assistant at Czech Technical University, Prague, Faculty of Transportation, Department of Air Transport
  - Teaching
    - ATM/CNS,
    - Principles of Flight
    - Aircraft Engines
  - Research projects
    - Remote AFIS
    - RF propagation modeling
    - GNSS jamming and spoofing
    - Big data analysis using Machine Learning
- Programmer and IT System Engineer
  - Embedded sensor network systems
  - Communication systems with high integrity
  - Big Data analysis with Machine Learning
  - High availability online Web applications
  - Proficient in Python, Typescript, Postgres DB, and C++

About Me

- Flying
  - power and glider aerobatics
  - flight instructor
  - competitor
  - aerobatic judge
  - aviation evangelist
- Sport event organizer
  - directed over 30 international air sport events
  - online scoring system
  - many other various aviation-related activities

Remote AFIS

- Service for providing information to known traffic at uncontrolled airports

- Motivation
  - Not enough qualified personnel
  - Standardization and automation
  - Increase in service quality

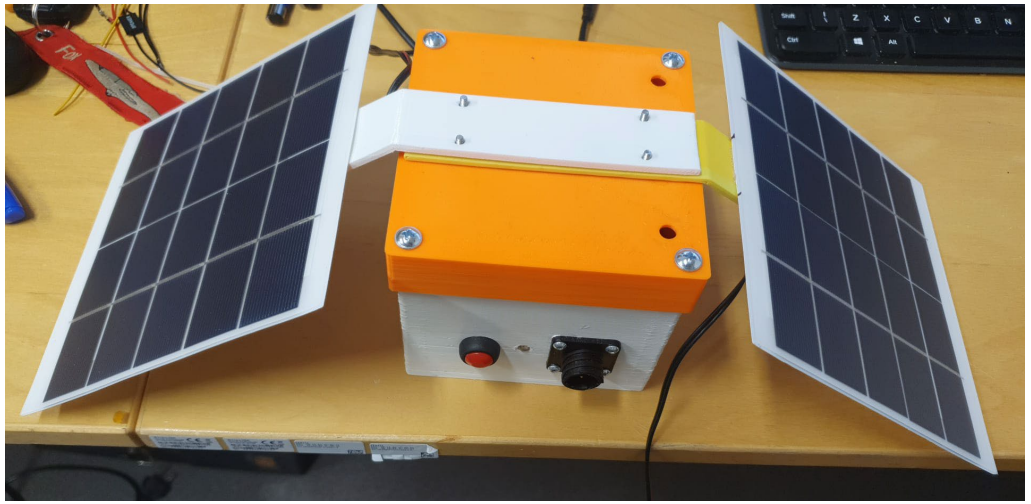
Remote AFIS

- Subsystems
  - Central Dispatcher
  - Cameras covering air traffic movement
  - RoIP gateway
  - Surveillance receiver (ADS-B, OGN, Flarm)
  - Meteo station
  - Video processing with AR feed from surveillance
- Network
  - Reliable
  - Available
  - Secure
  - Dynamically scalable
- Multipath communication
  - 3x mobile connectivity (LTE, 5G) + 1x local WiFi provider
  - Dynamic interface selection
  - Dynamically controlled Bonding

Remote AFIS – Instalation at LKBE

RSSI Detection

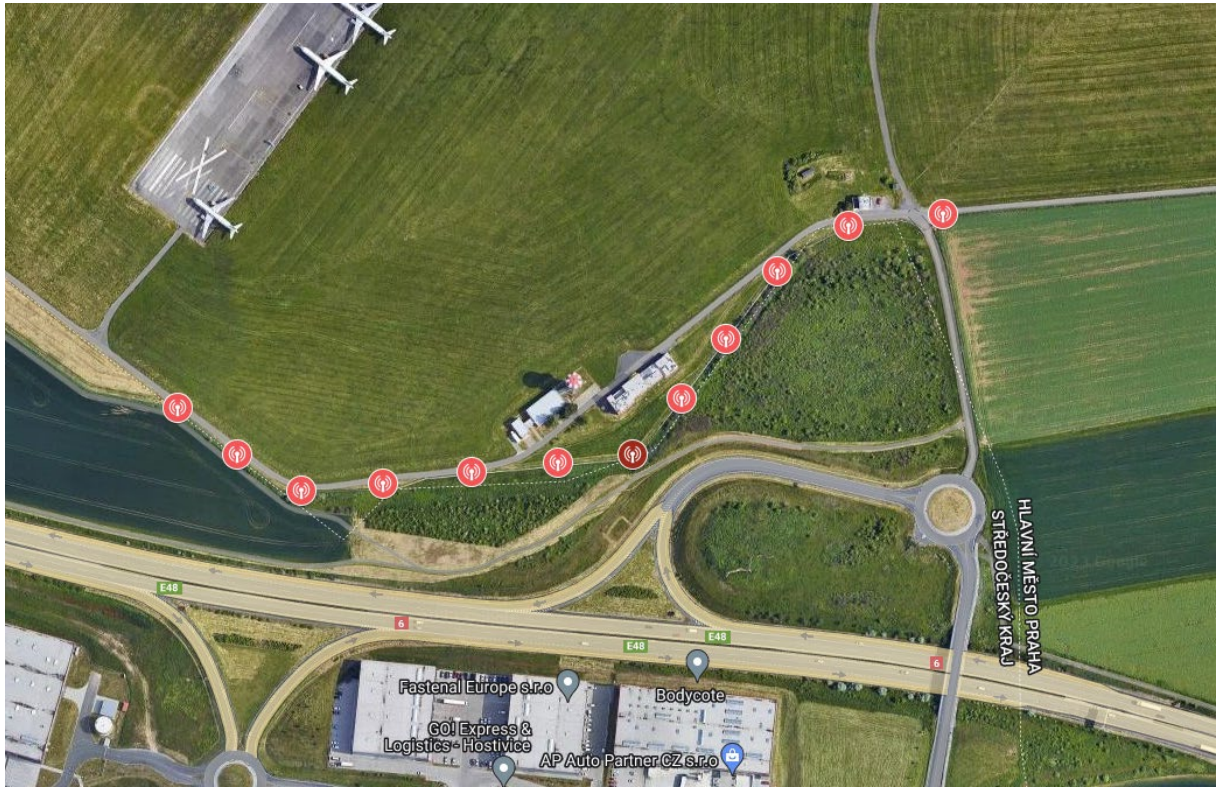
- Multi-sensor network at Prague (LKPR) Airport
- 12 embedded boxes (2x 5+1)
- Sensing of RSSI level
  - GNSS – GPS L1 interference from jammers
  - Radio Altimeter interference from 5G networks
  - Slow scanning of 0,5 – 2 GHz spectrum with SDR
- Detecting position by multilateration
- Analyzing sources by spectrum



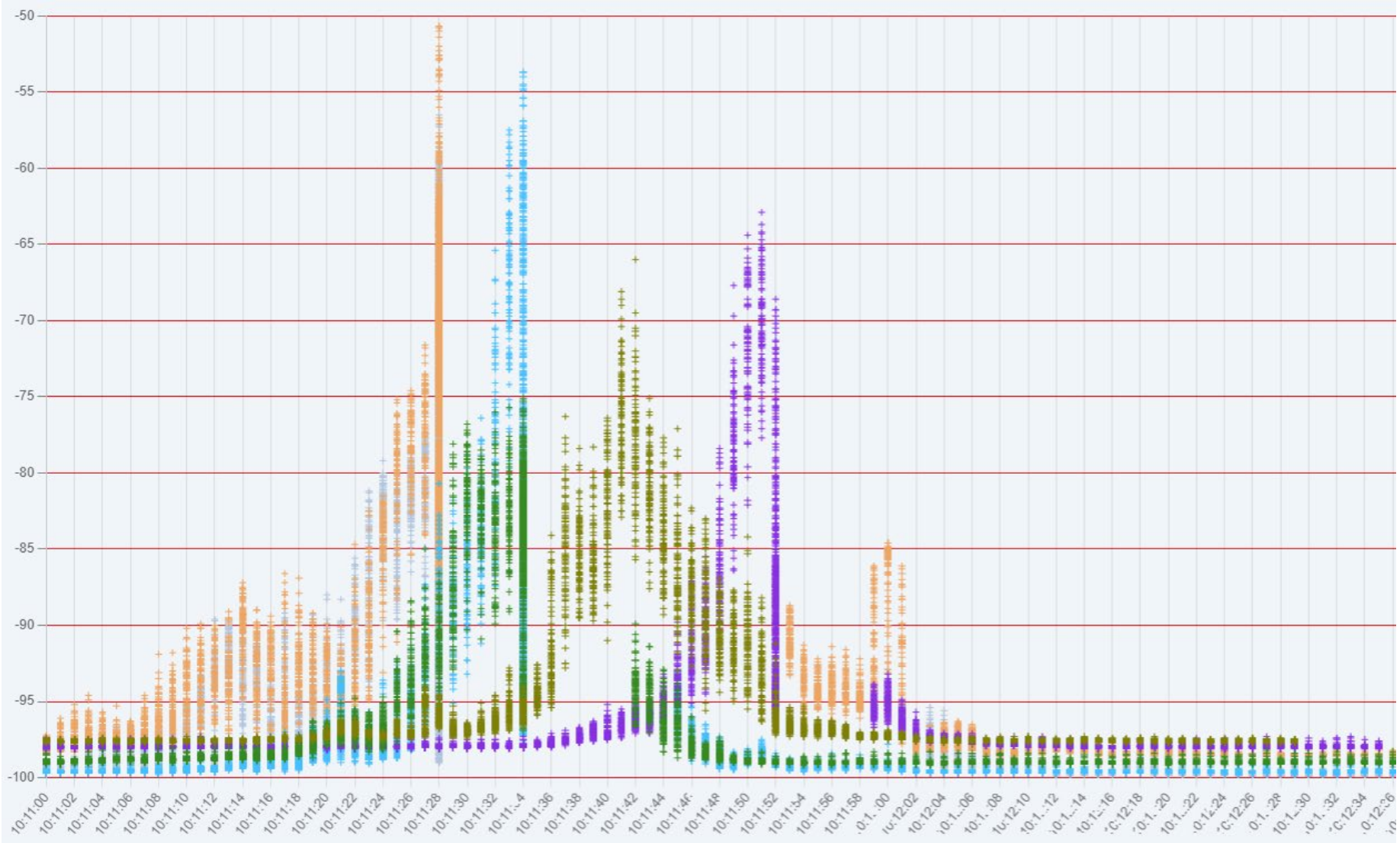
RSSI Detection

- Boxes based on Arduino MKR with WiFi
- Main box with RPi and Mikrotik RBM11G
- Solar powered
- Deployed in month cycles in 2023 and 2024
- Permanent installation in mid 2025

RSSI Detection

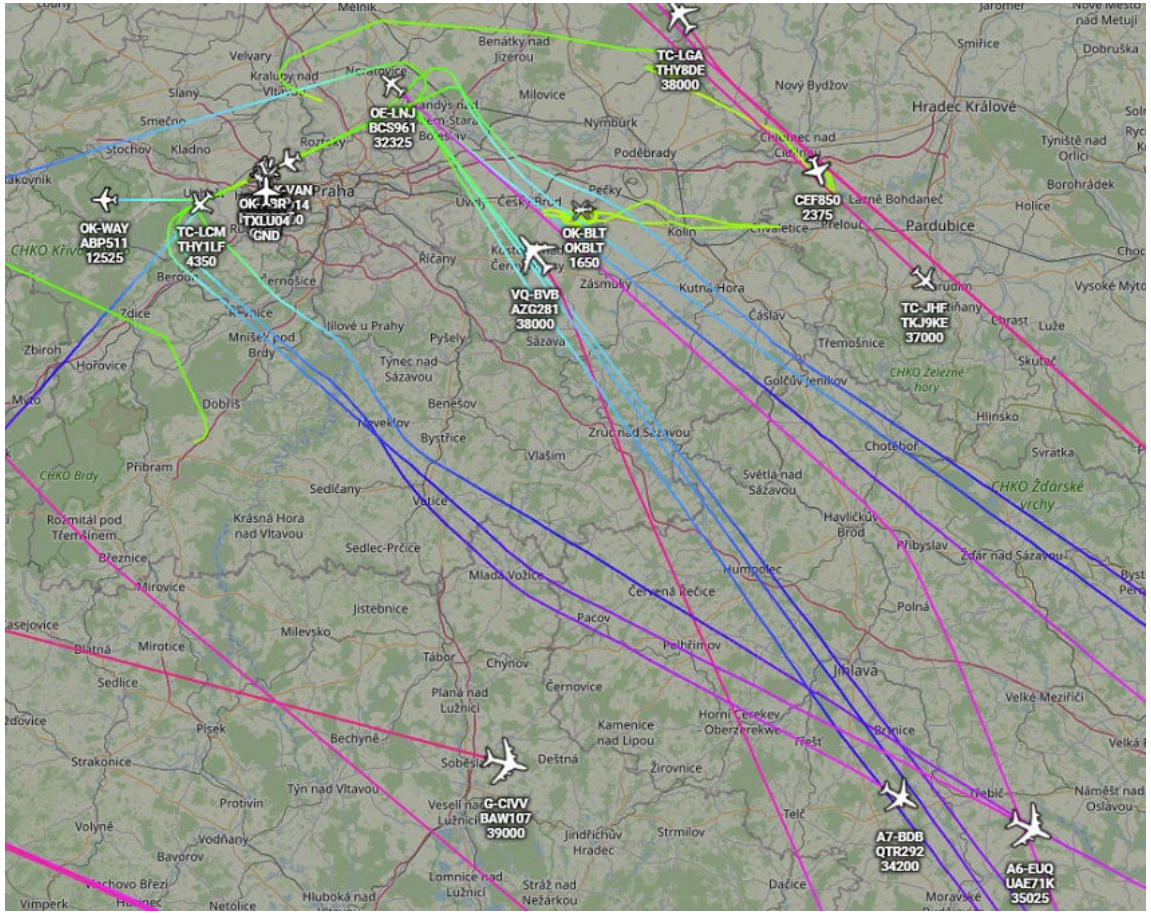


RSSI Detection



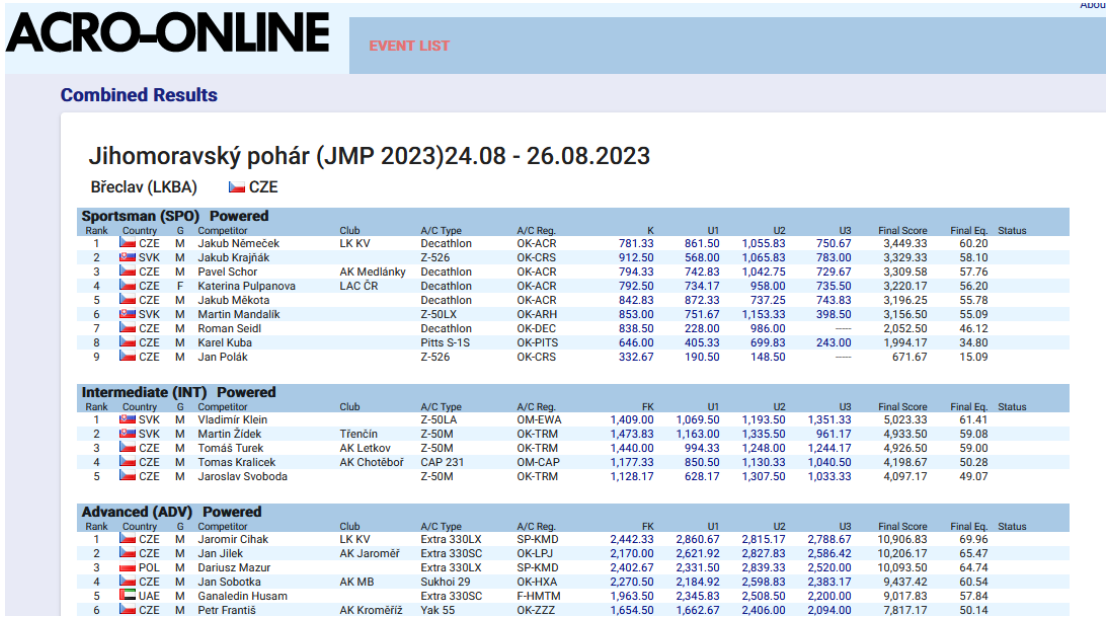
ADS-B analysis

- ADS-B receiver network
  - Airport Prague
  - Strahov dormitory
  - City Tower Prague
  - Airport Prague-Letnany
  - Airport Benesov
  - Airport Moravska Trebova
- Central storage at multi-node Cassandra DB server at FD, CVUT
- ADS-B output live streamed from sensors to central storage
- Multilateration calculations
- Meta-analysis of significant patterns



ACRO-ONLINE

- Web application for management of Aerobatic Competitions
- Scores calculation
- Output to live video stream
- Judges equipped with tablets
- Mobile router providing tablet connection to server – RBM33G
  - Battery powered
  - WiFi for tablets
  - LTE/WiFi connection to server
  - Secure and reliable



ACRO-ONLINE EVENT LIST

Combined Results

Jihomoravský pohár (JMP 2023)24.08 - 26.08.2023

Břeclav (LKBA) CZE

Sportsman (SPO) Powered

Rank	Country	G	Competitor	Club	A/C Type	A/C Reg.	K	U1	U2	U3	Final Score	Final Eq.	Status
1	CZE	M	Jakub Němeček	LK KV	Decathlon	OK-ACR	781.33	861.50	1,055.83	750.67	3,449.33	60.20	
2	SVK	M	Jakub Krajňák		Z-526	OK-CRS	912.50	568.00	1,065.83	783.00	3,329.33	58.10	
3	CZE	M	Pavel Schor	AK Medlánky	Decathlon	OK-ACR	794.33	742.83	1,042.75	729.67	3,309.58	57.76	
4	CZE	F	Katerina Pulpanova	LAC ČR	Decathlon	OK-ACR	792.50	734.17	958.00	735.50	3,220.17	56.20	
5	CZE	M	Jakub Měkota		Decathlon	OK-ACR	842.83	872.33	737.25	743.83	3,196.25	55.78	
6	SVK	M	Martin Mandalik		Z-50LX	OK-ARH	853.00	751.67	1,153.33	398.50	3,156.50	55.09	
7	CZE	M	Roman Seidl		Decathlon	OK-DEC	838.50	228.00	986.00	----	2,052.50	46.12	
8	CZE	M	Karel Kuba		Pitts S-1S	OK-PITS	646.00	405.33	699.83	243.00	1,994.17	34.80	
9	CZE	M	Jan Polák		Z-526	OK-CRS	332.67	190.50	148.50	----	671.67	15.09	

Intermediate (INT) Powered

Rank	Country	G	Competitor	Club	A/C Type	A/C Reg.	FK	U1	U2	U3	Final Score	Final Eq.	Status
1	SVK	M	Vladimír Klein		Z-50LA	OM-EWA	1,409.00	1,069.50	1,193.50	1,351.33	5,023.33	61.41	
2	SVK	M	Martin Žídek	Třenčín	Z-50M	OK-TRM	1,473.83	1,163.00	1,335.50	961.17	4,933.50	59.08	
3	CZE	M	Tomáš Turek	AK Letkov	Z-50M	OK-TRM	1,440.00	994.33	1,248.00	1,244.17	4,926.50	59.00	
4	CZE	M	Tomas Kralicek	AK Chotěboř	CAP 231	OM-CAP	1,177.33	850.50	1,130.33	1,040.50	4,198.67	50.28	
5	CZE	M	Jaroslav Svoboda		Z-50M	OK-TRM	1,128.17	628.17	1,307.50	1,033.33	4,097.17	49.07	

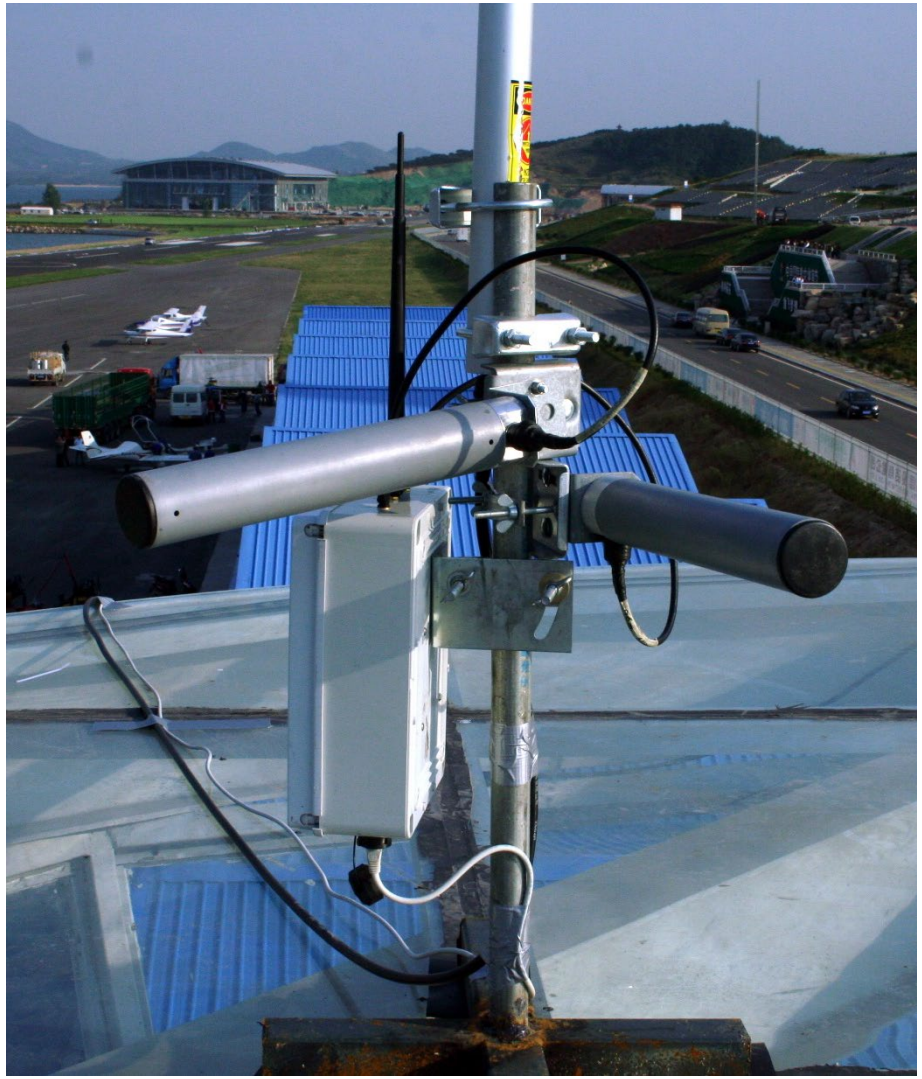
Advanced (ADV) Powered

Rank	Country	G	Competitor	Club	A/C Type	A/C Reg.	FK	U1	U2	U3	Final Score	Final Eq.	Status
1	CZE	M	Jaromir Cihak	LK KV	Extra 330LX	SP-KMD	2,442.33	2,860.67	2,815.17	2,788.67	10,906.83	69.96	
2	CZE	M	Jan Jilek	AK Jaroměř	Extra 330SC	OK-LPJ	2,170.00	2,621.92	2,827.83	2,586.42	10,206.17	65.47	
3	POL	M	Dariusz Mazur		Extra 330LX	SP-KMD	2,402.67	2,331.50	2,839.33	2,520.00	10,093.50	64.74	
4	CZE	M	Jan Sobotka	AK MB	Sukhoi 29	OK-HXA	2,270.50	2,184.92	2,598.83	2,383.17	9,437.42	60.54	
5	UAE	M	Ganaledin Husam		Extra 330SC	F-HMTM	1,963.50	2,345.83	2,508.50	2,200.00	9,017.83	57.84	
6	CZE	M	Petr Františ	AK Kroměříž	Yak 55	OK-ZZZ	1,654.50	1,662.67	2,406.00	2,094.00	7,817.17	50.14	

HD live video from aerobatic aircraft

- High-speed transmission from two 1080p HD camera
- Balanced bonding through two independent WiFi interfaces
- Antennas located on the top and bottom of the fuselage – self-made planar antennas
- Ground station automatic rotator with two directional Yagi, 90° offset polarization
- Network based on Mikrotik
  - RB433GL – ground stations
  - RB411GL – aircraft

HD live video from aerobatic aircraft



HD live video from aerobatic aircraft

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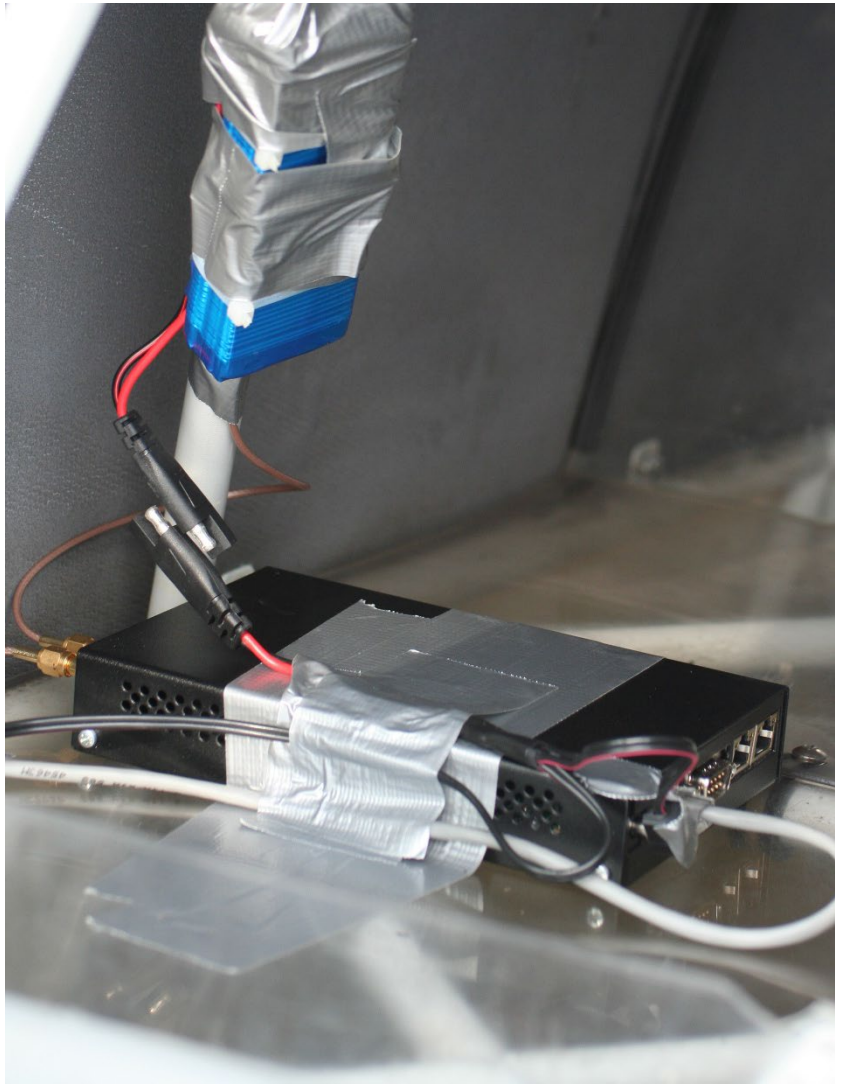

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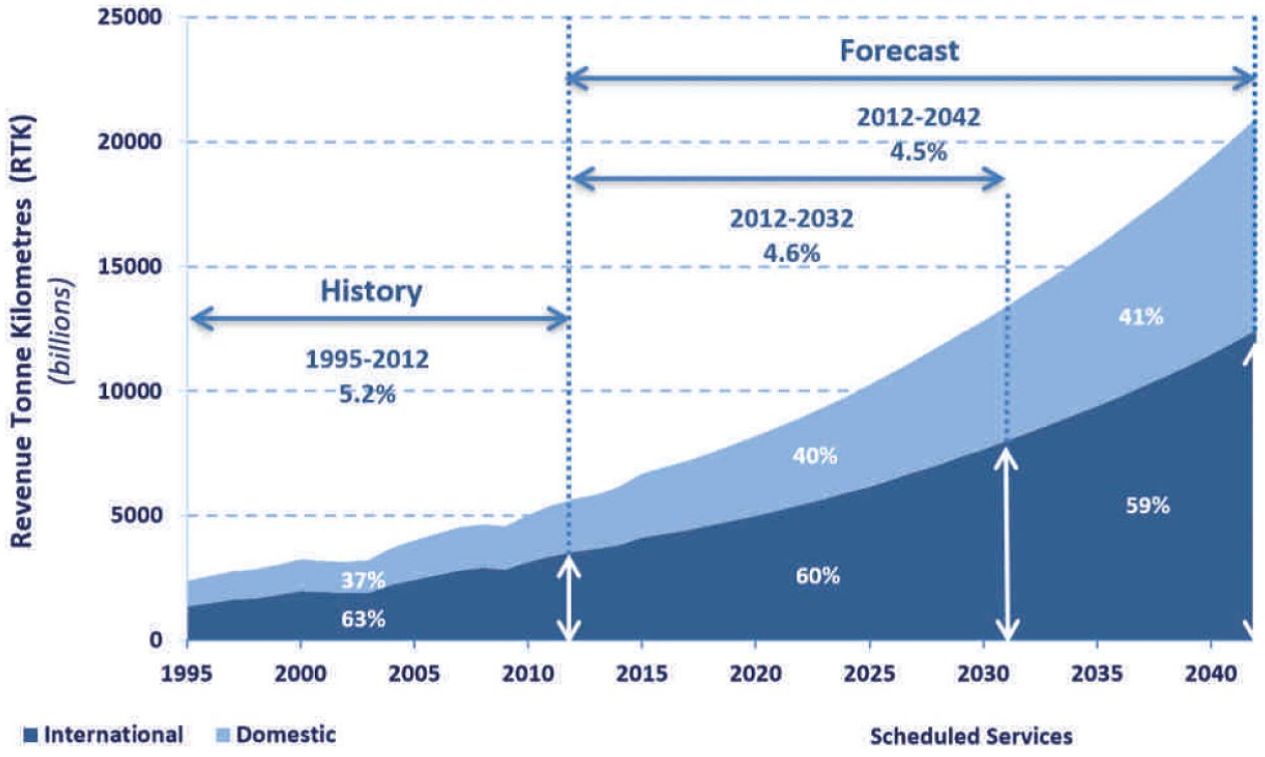
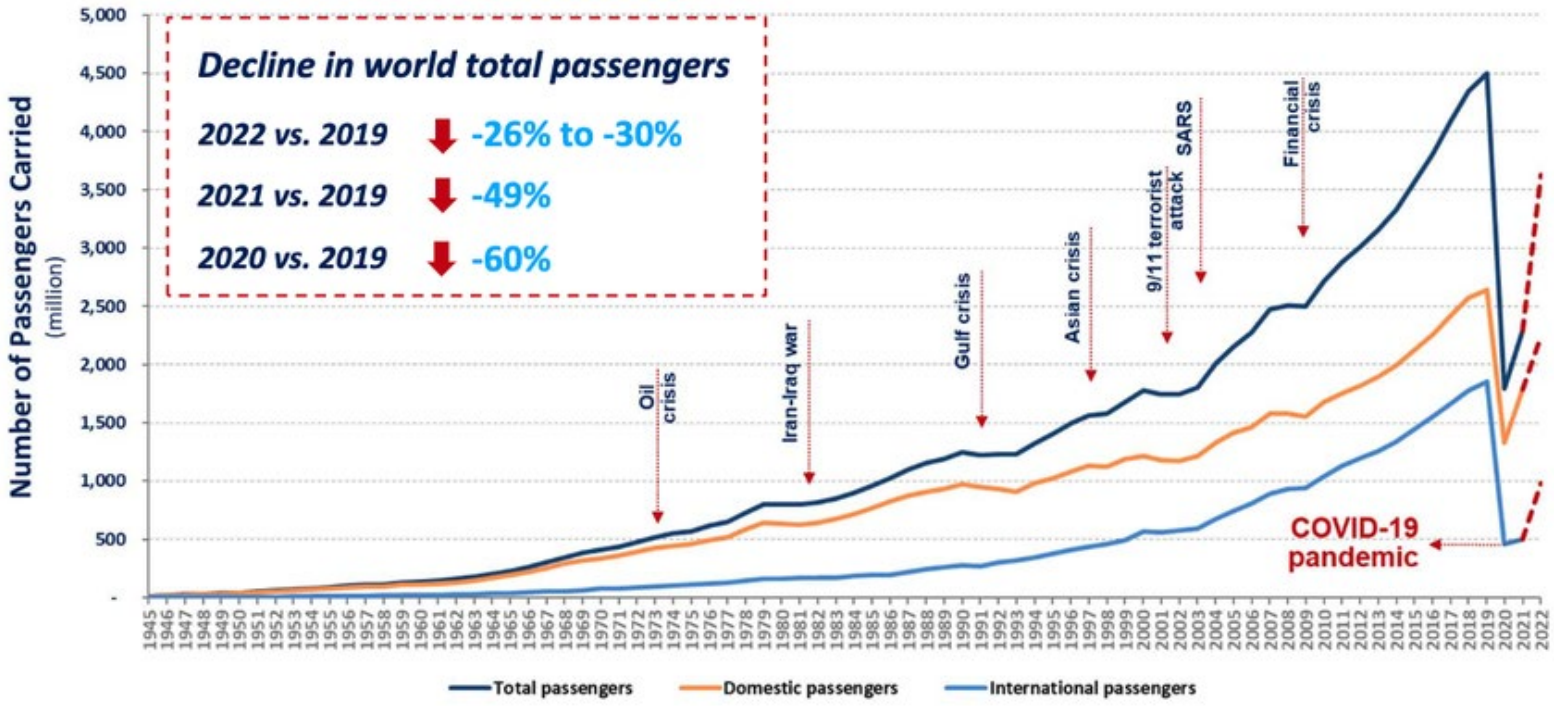
Future of CNS in Aviation
(Communication, Navigation, Surveillance)

Current state of Aviation

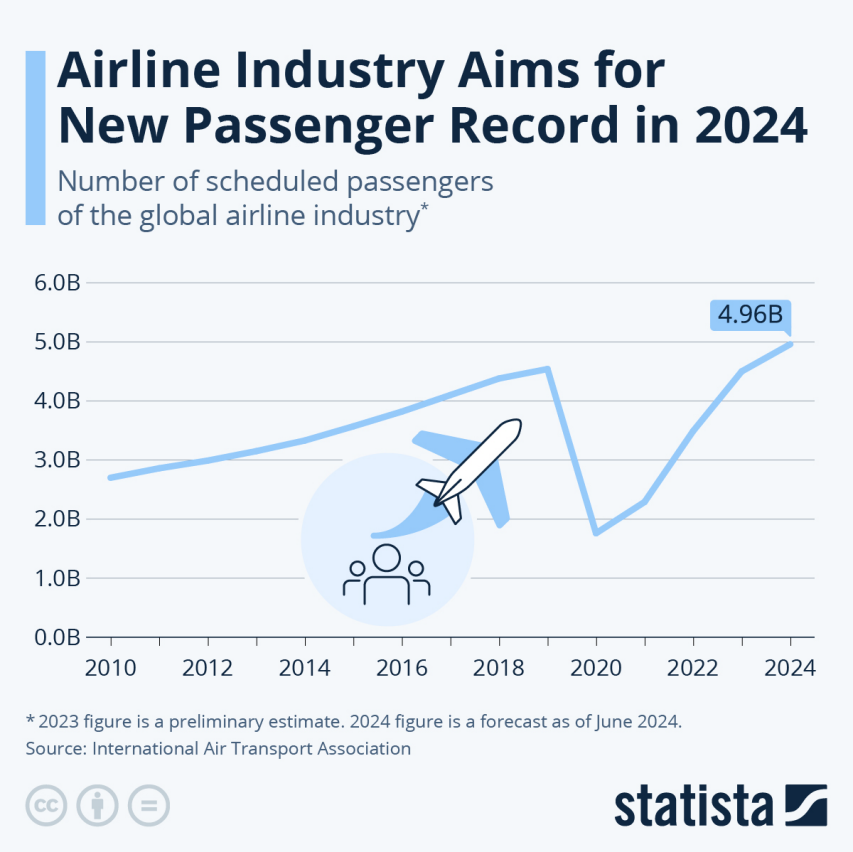
- The regulators - ICAO, FAA, EASA…
- The UN predicts that by 2050 two thirds of the world population will live in cities [ICAO].
- Demand for air transport will increase by an average of 4.3% per annum over the next 20 years.



Current state of Aviation



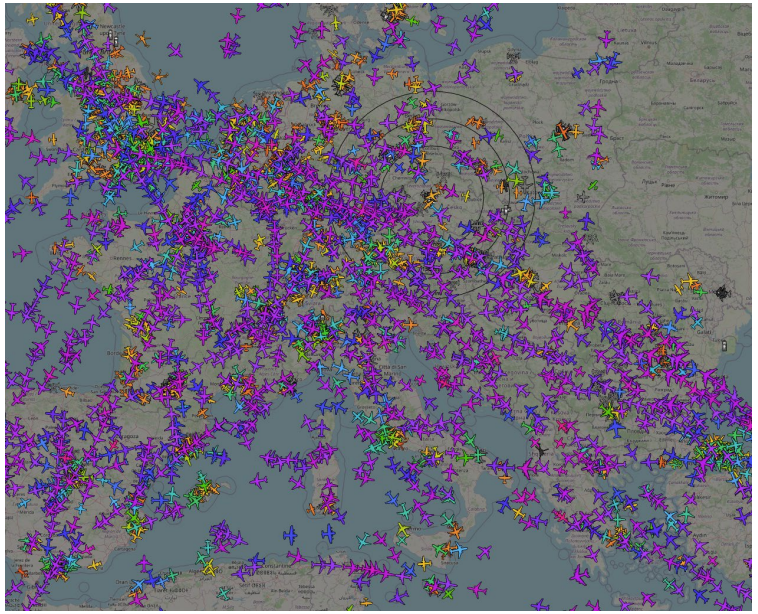
[ICAO]



Future Challenges

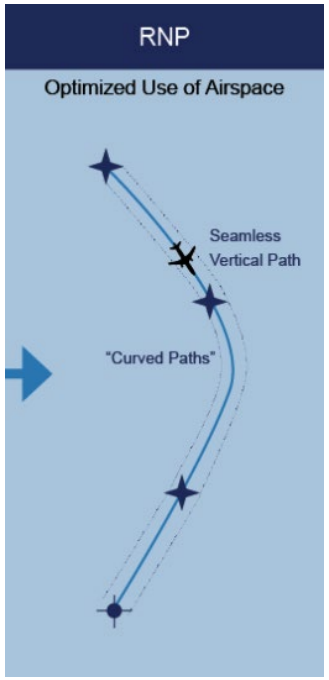
- Airspace capacity.
- Aviation safety.
- Green initiatives for more “sustainable” aviation.
- Staffing.

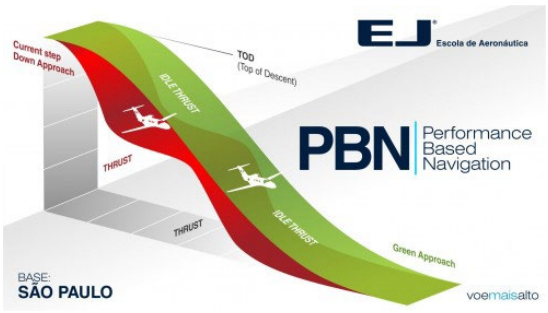
- Aviation is technologically lagging 10+ years behind consumer technologies.
- As of 2024 worldwide approx. 30% of all scheduled flights were done by LLCs (Low-Cost Carriers). 71% in India and 20% in Europe.
- (Sustainable) growth.

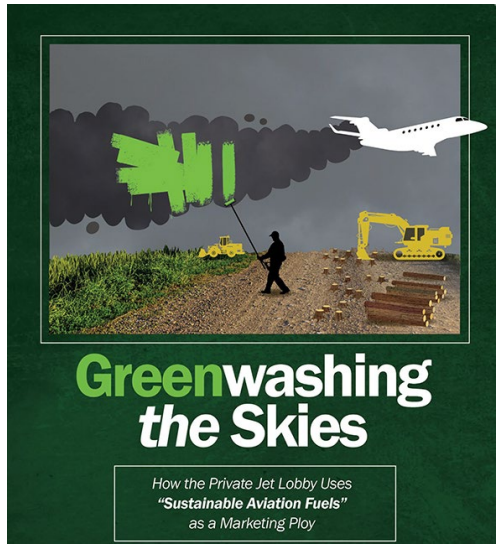


What is really happening?

- Airspace optimization
  - Free Route Airspace
  - ATM digitalization
  - pilot/ATC digital communication
- Technology advancements
  - Engines
  - Aircraft design
  - Flight path optimization
- Environment
  - Sustainable fuels
  - Study of impacts (ie. contrails)

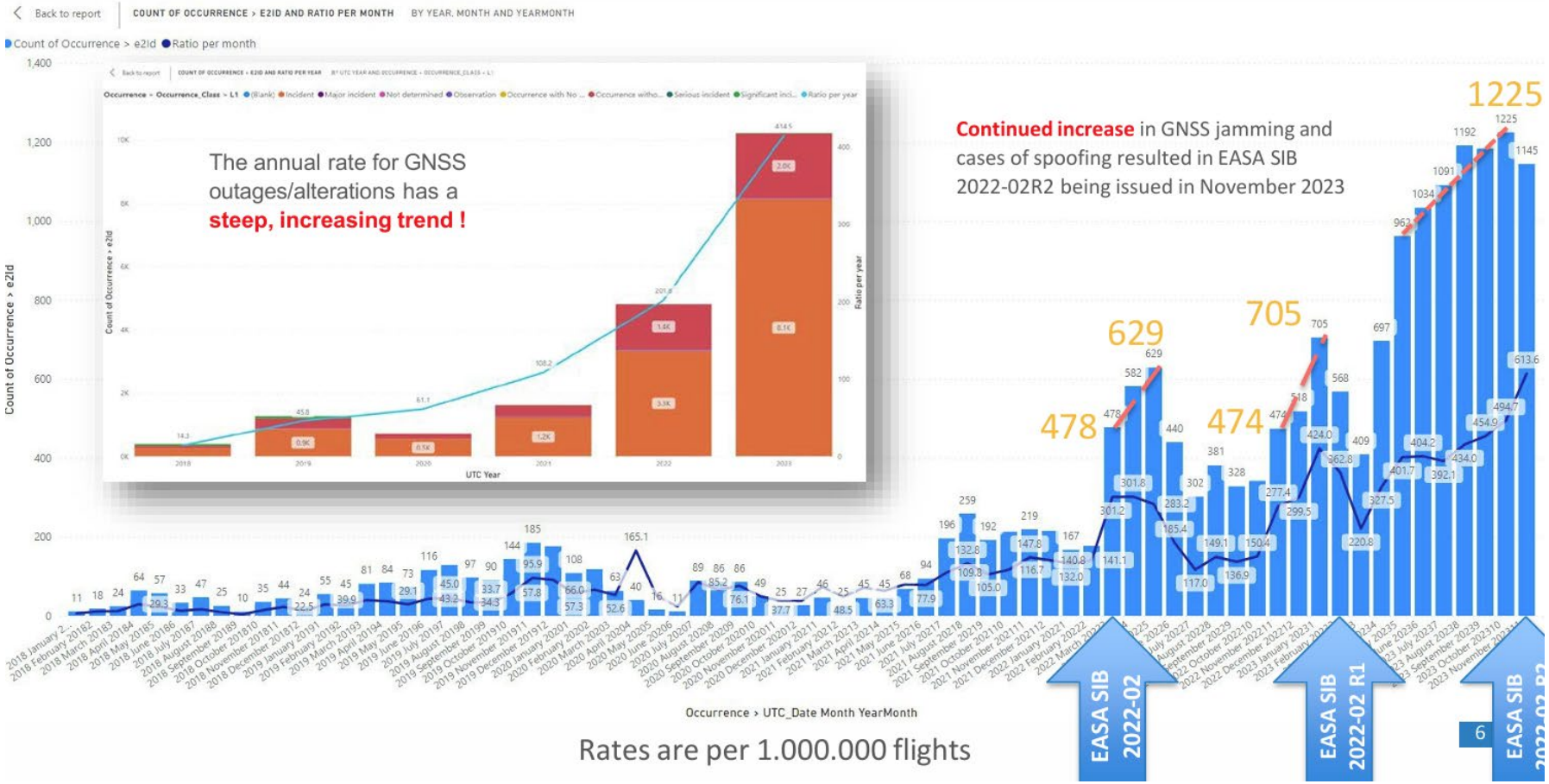






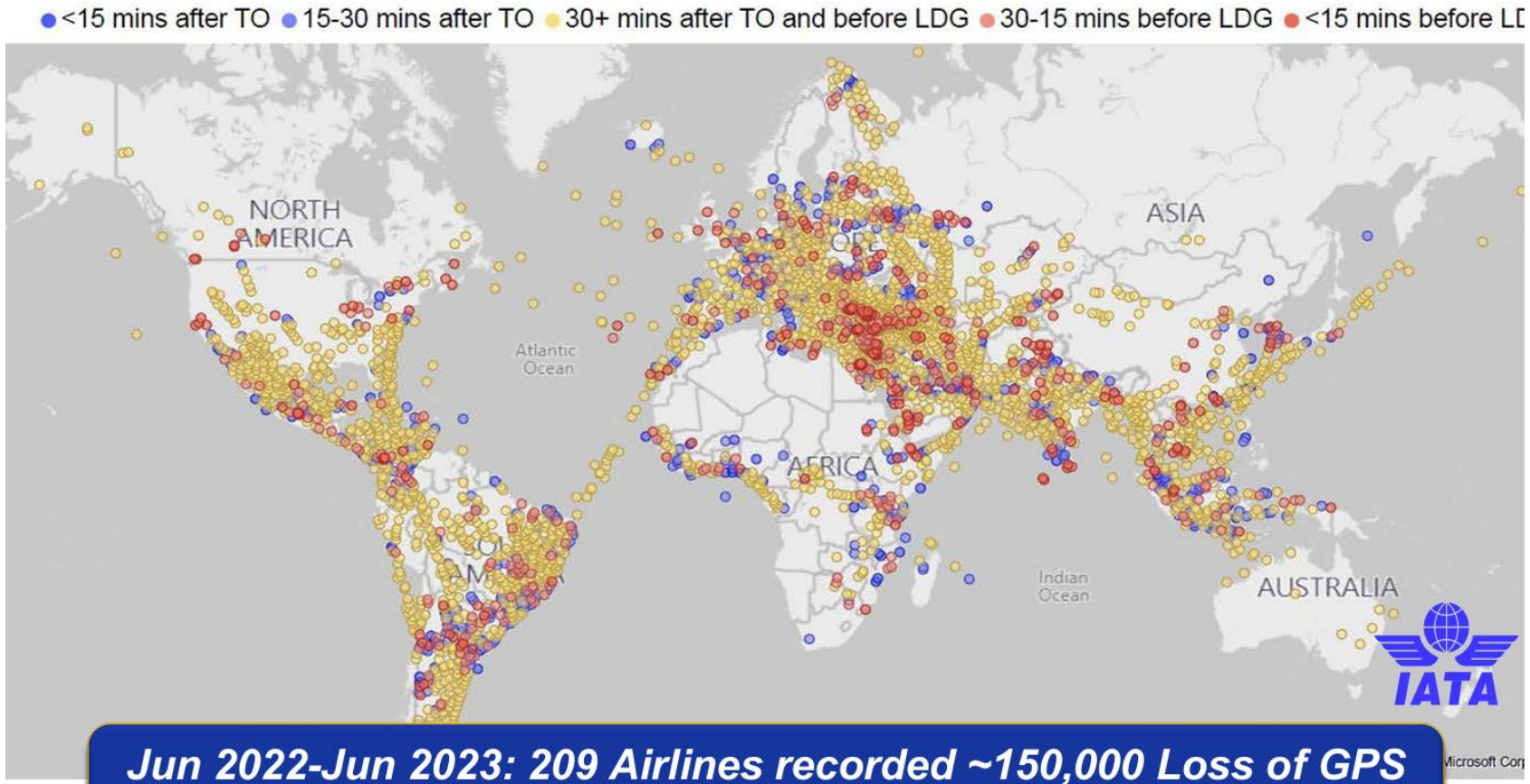
What is really happening?

GNSS outage (ECR data)



What is really happening?

GNSS Signal Loss Occurrence by Phase of Flight



Jun 2022-Jun 2023: 209 Airlines recorded ~150,000 Loss of GPS Events in ~5 million flight operations

What is really happening?

- 2022-2023: Cyber attacks in the aviation sector rose by 131%, with the majority targeting airlines and airports [Lexology].

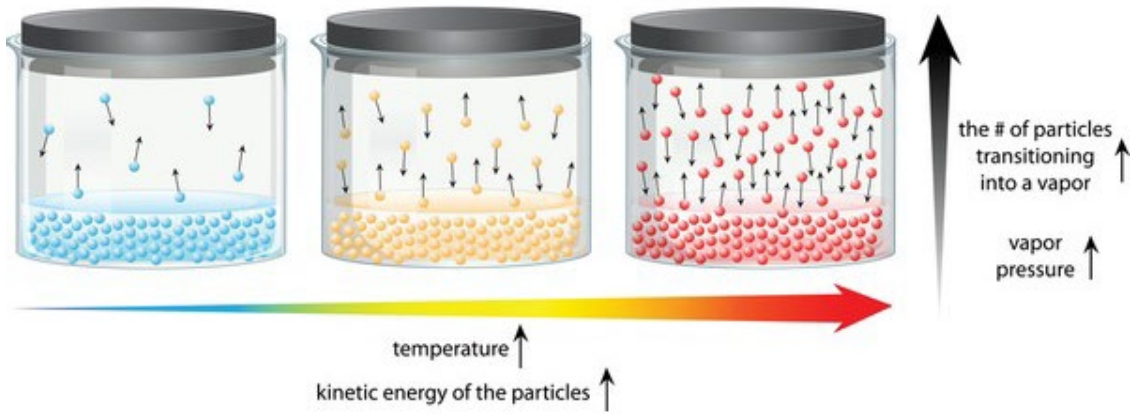
- 2023: The first half of the year saw a 24% increase in cyberattacks on the aviation industry worldwide, with ransomware attacks on supply chain entities surging by 600% compared to 2022 [acice-asean.org]

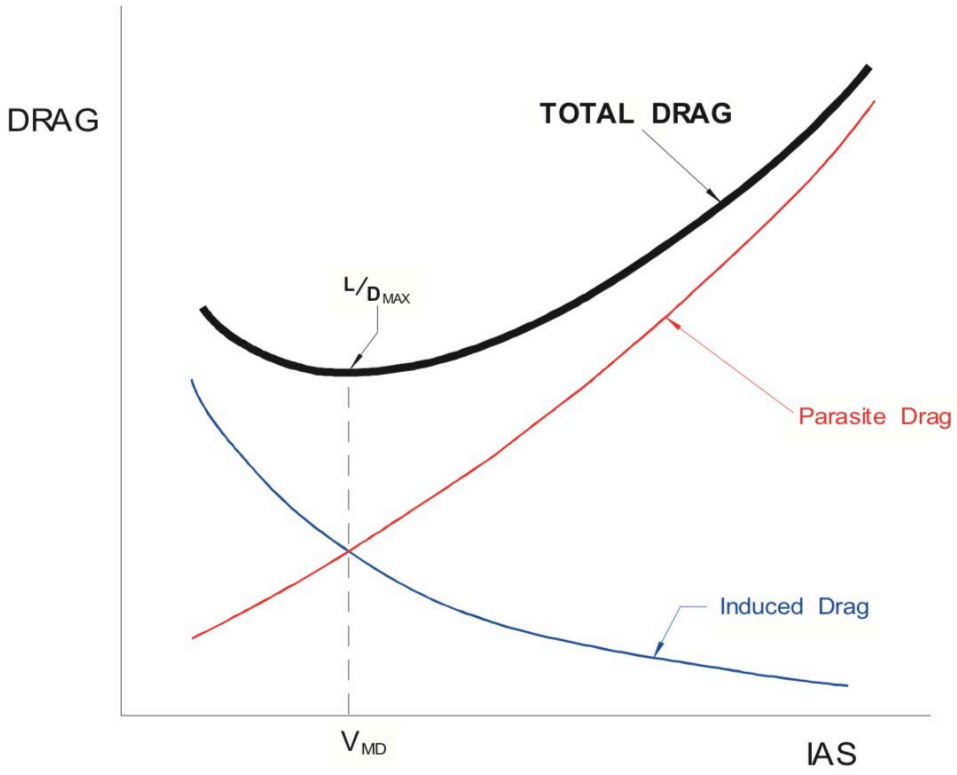
- 2023: A study analyzing cyber incidents reported 54 attacks on the aviation sector, with 65% targeting airports and 35% affecting airlines. [Springer]

Conclusion

The **laws of thermodynamics**

- **First Law (Law of Energy Conservation)**: Energy cannot be created or destroyed, only transformed from one form to another.
- **Second Law**: Entropy (disorder) of an isolated system always increases over time. Heat naturally flows from hot to cold objects, and no process is 100% efficient.
- **Third Law**: A system's entropy approaches a constant value as its temperature approaches absolute zero.



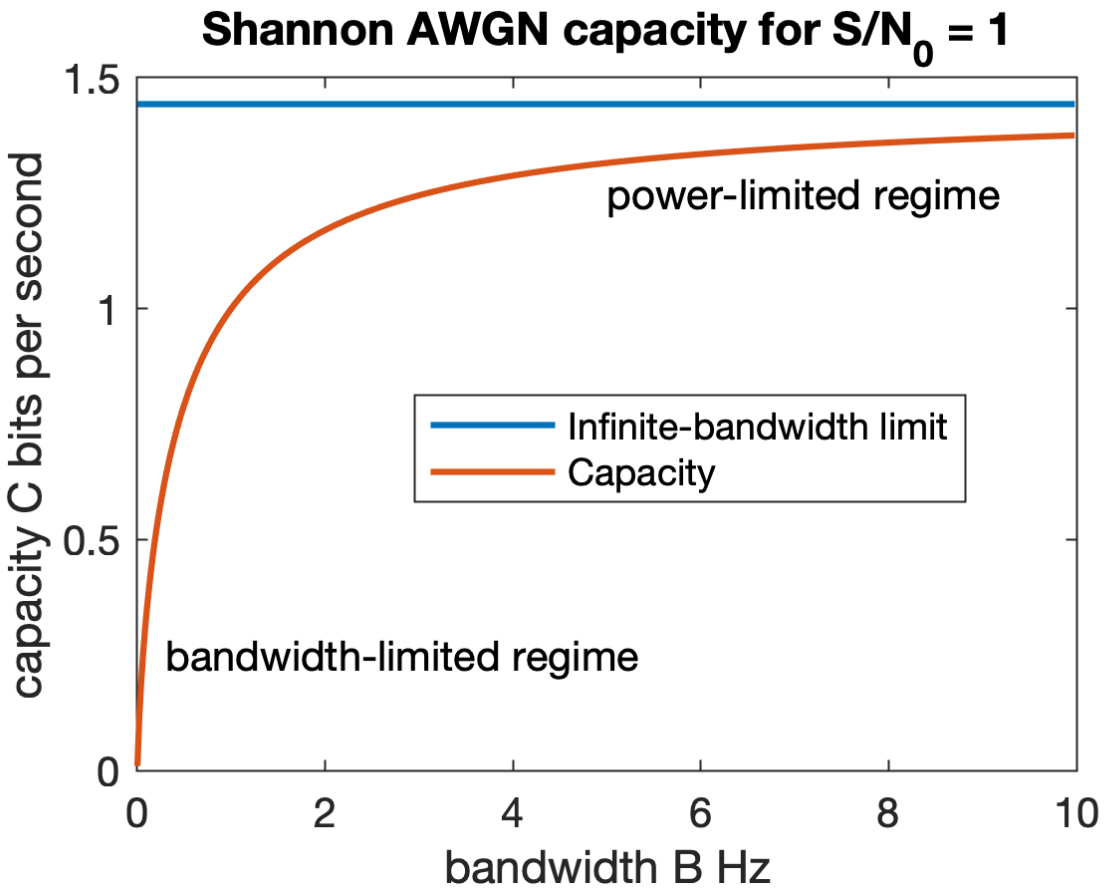


Conclusion

Implications for Systems and Projects

- Perfect Organization is Unattainable
- Diminishing Returns on Optimization
- Residual Complexity is Unavoidable

Not only sky is the limit! We can still increase badwith or change the modulation.



By Isheden at Wikipedia

Thank you for your attention.