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Innovation in ATFM: the rise of Artificial Intelligence

Trevor Kistan

Today: Big Data, Machine Learning & Predictive Analytics - 1/2

Thales CeNTAI Big Data & Analytics Laboratory & acquisitions

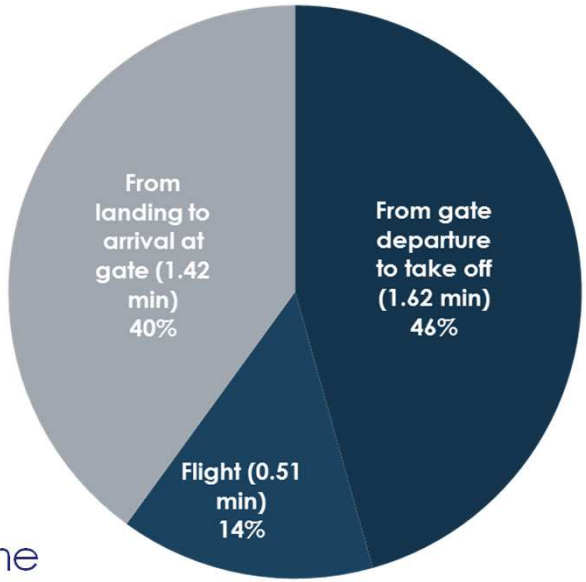
- Custom algorithms deployed in the Thales ECOsystem ATFM product
- Trial on 16 months of data: European domestic flights, surveillance, weather…

Forecast Estimated Time of Arrival

Airlines (RMSE)	Thales (RMSE)
12.99 min	3.25 min

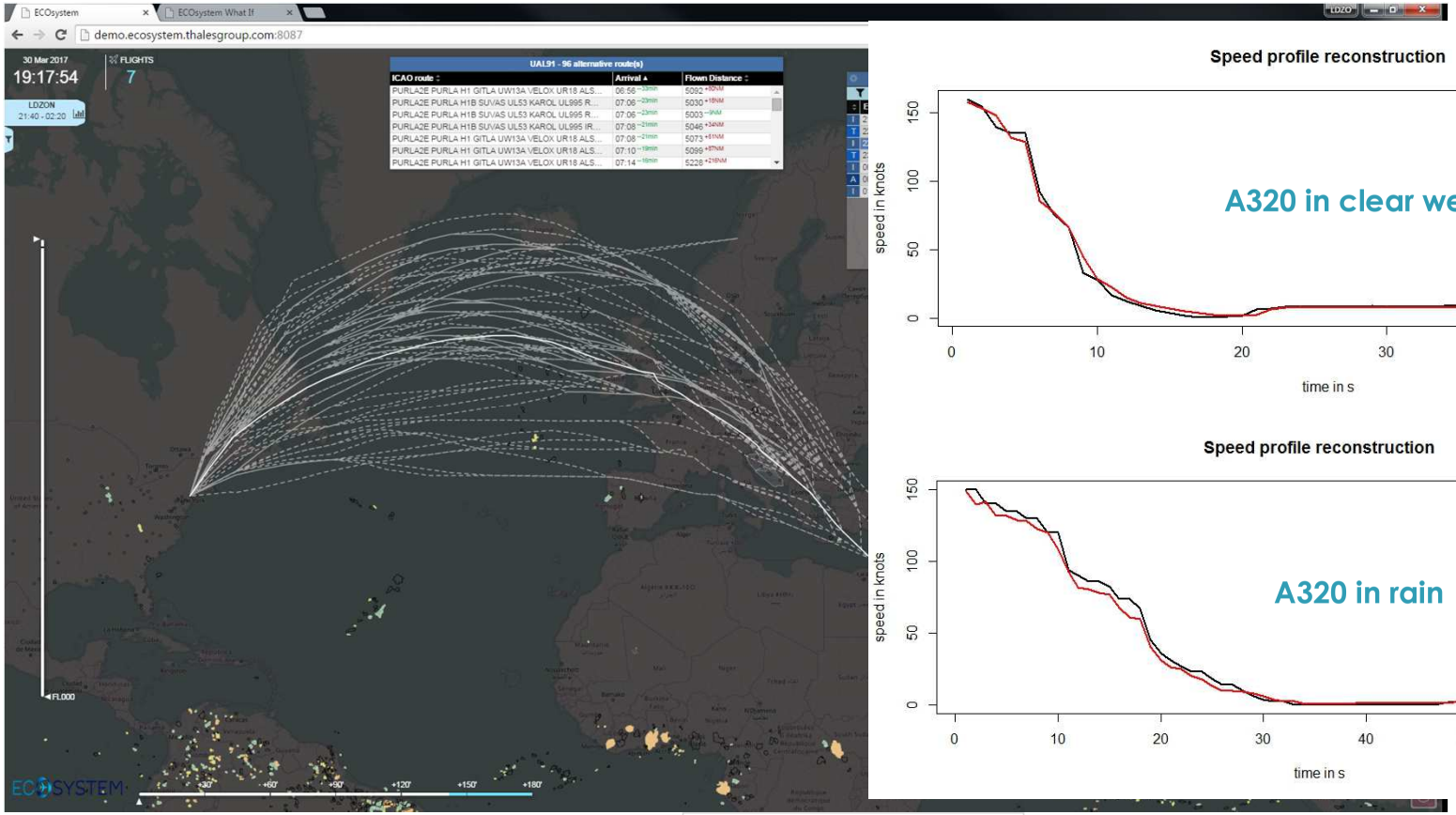
Forecast Taxi Time

Airport	Average	$\sigma_{\bar{x}}$	Thales (RMSE)
Paris-CDG	17.29 min	4.41 min	3.21 min
Lyon	7.86 min	0.74 min	0.52 min



- Identified main factors impacting ETA and Taxi Time
- Superior to controls: Kernel Regression, Random Forest & Stochastic Calculus

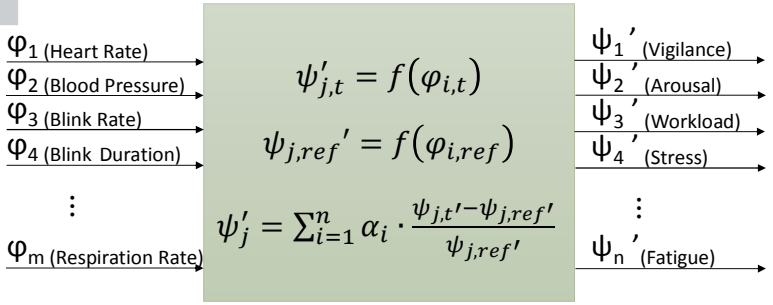
Today: Big Data, Machine Learning & Predictive Analytics – 2/2



Tomorrow: Human Machine Teaming

Human Machine Teaming

Machine Strengths	Human Strengths
Precision Information acquisition Information synthesis	Creative and flexible Strategic decision making Adapt to unexpected situations



- What are the changing roles of humans in an environment where autonomous machines operate?

Cognitive Teaming & Adaptive HMI

- Assess and adapt to the operator's **cognitive state**
  - workload, fatigue, stress, attention, arousal, intent
- Contributes towards **trusted autonomy**

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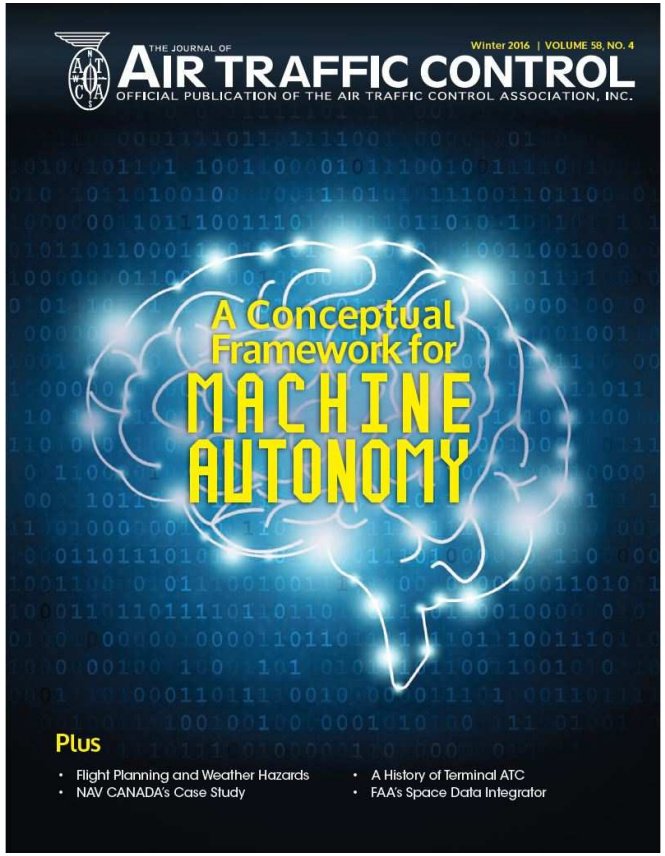
Day After Tomorrow: Autonomy

Sheridan (aviation)	
1	Human does it all.
2	Machine offers alternatives &
3	narrows selection to a few, or
4	suggets one, &
5	executes if human approves, or
6	allows human set time to veto before executes automatically, or
7	executes automatically & informs human, or
8	informs human after execution if the human asks it, or
9	informs human after execution if it decides to.
10	Machine acts autonomously.

Adapted from: Sheridan, T. B. Telerobotics, Automation, and Human Supervisory Control. The MIT Press. 1992.



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SAE J3016 (automobiles)	
0	No Automation
1	Driver Assistance
2	Partial Automation
3	Conditional Automation
4	High Automation
5	Full Automation

Reference: SAE J3016: Taxonomy & Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems.

*"The post-GDP traffic build-up is an **emergent phenomenon** arising from the interaction of traffic flow practices with airlines' business rules."*

Reference: Liviu Nedelescu, "A Conceptual Framework for Machine Autonomy", ATCA Journal of ATC, Winter 2016, Vol. 58, No. 4

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Case Study: Future of the Traffic Collision Avoidance System (TCAS)

Potential MAC

TCAS

2020

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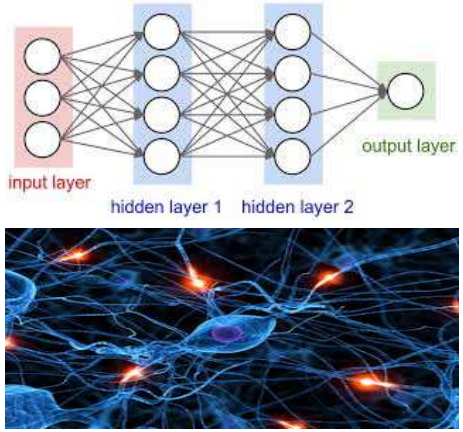

ACAS X

Airborne Collision Avoidance System (ACAS X) is a Neural Network

- No "if-then-else" rules !!!
- Trained on millions of simulated encounters & 180 000 real-life potential collisions
- **BUT** – Trust: Verification, Certification and Explanatory Power

Reference: "Smarter Collision Avoidance", Aerospace America, June 2017.

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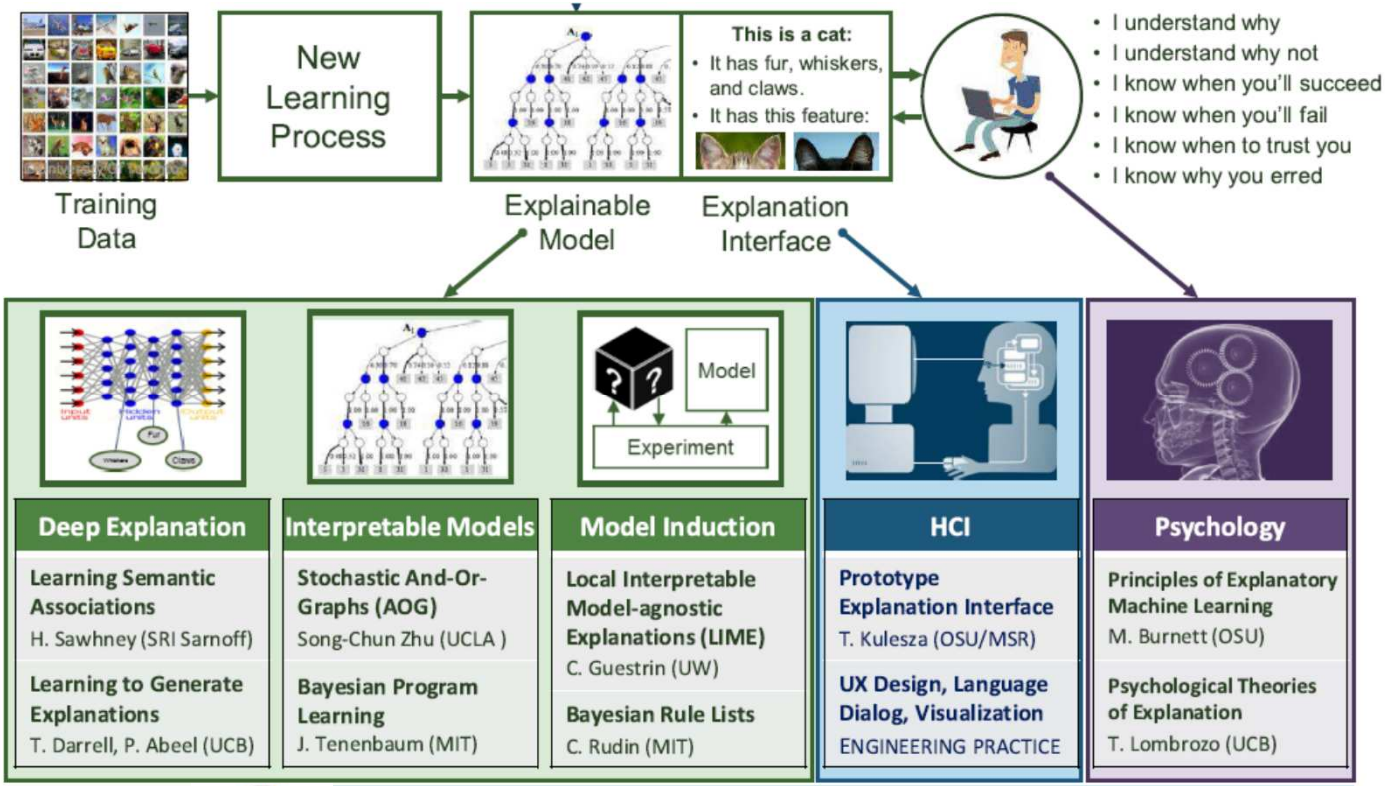
XAI: Explainable Artificial Intelligence

EU General Data Protection Regulation, Article 22

Who else?

ORACLE

amazon web services



DARPA

Reference: David Gunning, Explainable Artificial Intelligence (XAI), DARPA/I20, https://www.cc.gatech.edu/~alanwags/DLAI2016/(Gunning)%20IJCAI-16%20DLAI%20WS.pdf

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Potential applications of Automation & AI in ATFM

Automation can be applied at 4 stages:

Reference: Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. IEEE Transactions on systems, man, and cybernetics, 30(3), 286 - 297.

Data Acquisition	Data Interpretation	Decision Selection	Action Selection
Smart Sensors: Space-based ADS-B, 4-D weather cube, biometrics	**Identification & Prediction:** major traffic flows, workload, congestion, flight delays, arrival time	**Decision Support:** scheduling, multi-agent flow control, sector planning, airport configuration	**Pre-tactical Conflict Detection and AI-based Resolution:** hotspots, multiple flights or flows, weather
…	…	…	…