SAFETY LINE
Big Data applied to Aviation

Analyse des données aéronautiques pour la réduction de la consommation de carburant

Baptiste Gregorutti, Head of Data Science

25 septembre 2020

SAFETY LINE

- Société basée à Paris
- Fondée en 2010 par d'anciens enquêteurs du BEA

Airline Pilot

Aircraft accident investigator

→

→

Amélioration des opérations aériennes

Solutions logicielles

SAFETYCUBE
Take control of your safety

Safety & Compliance
Management Software

FLIGHT SCANNER
Safety behind your data

Flight « Big Data »
Analytics for operational
Risk Management

OPTI FLIGHT
In-flight guidance

Trajectory Optimization
through Big Data
analytics

AIRSIDE WATCH
Improve Airport Operations

RADAR data analysis
for airport management
Safety and Efficiency

OPTI FLIGHT

In-flight guidance

SAFETY LINE
Big Data applied to Aviation

OPTI FLIGHT In-flight guidance HELPS PILOTS SAVE IN ALL FLIGHT PHASES

ON GROUND

CLIMB

OPTI CLIMB
Customized Climb Speeds

CRUISE

OPTI SPEED
Time / Fuel Mach adjustment

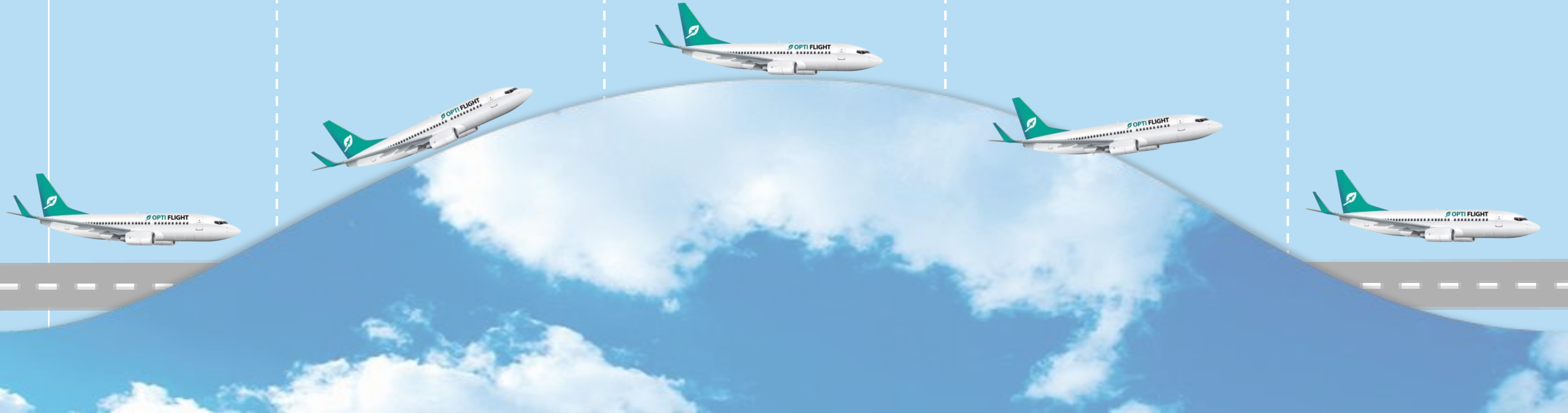
OPTI DIRECT
Shortcut Opportunities

OPTI LEVEL
Flight Level / Wind Tradeoff

DESCENT

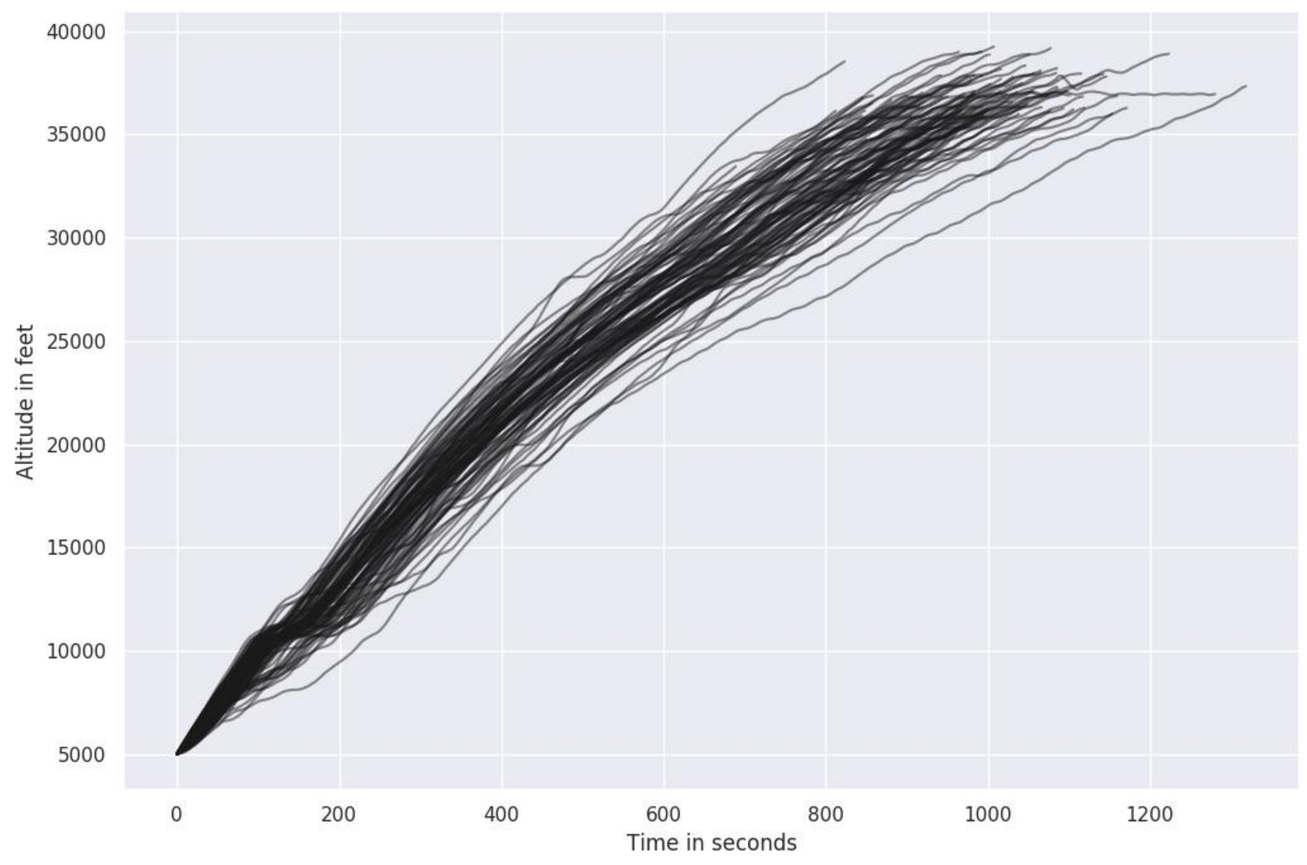
OPTI DESCENT
TOD & Descent Speeds

ON GROUND

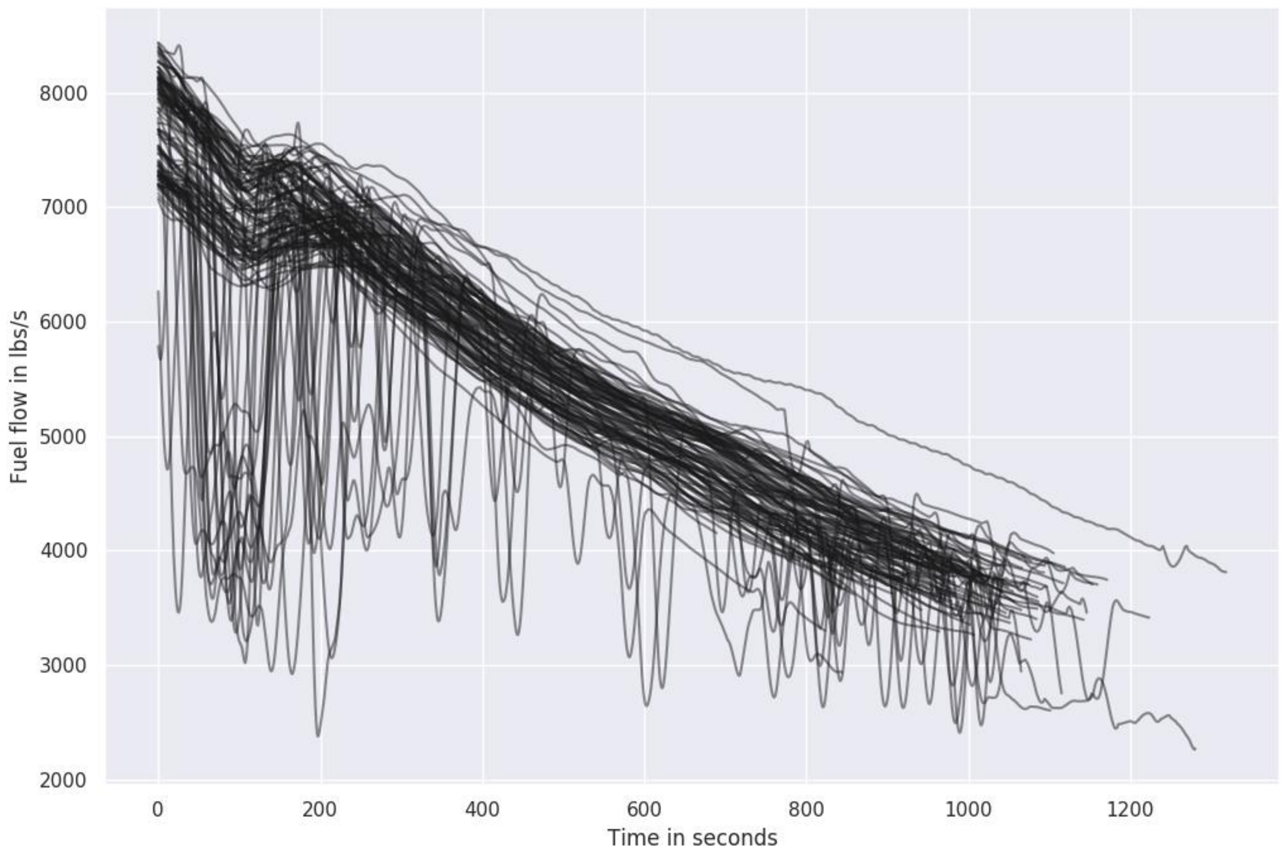


Flight data

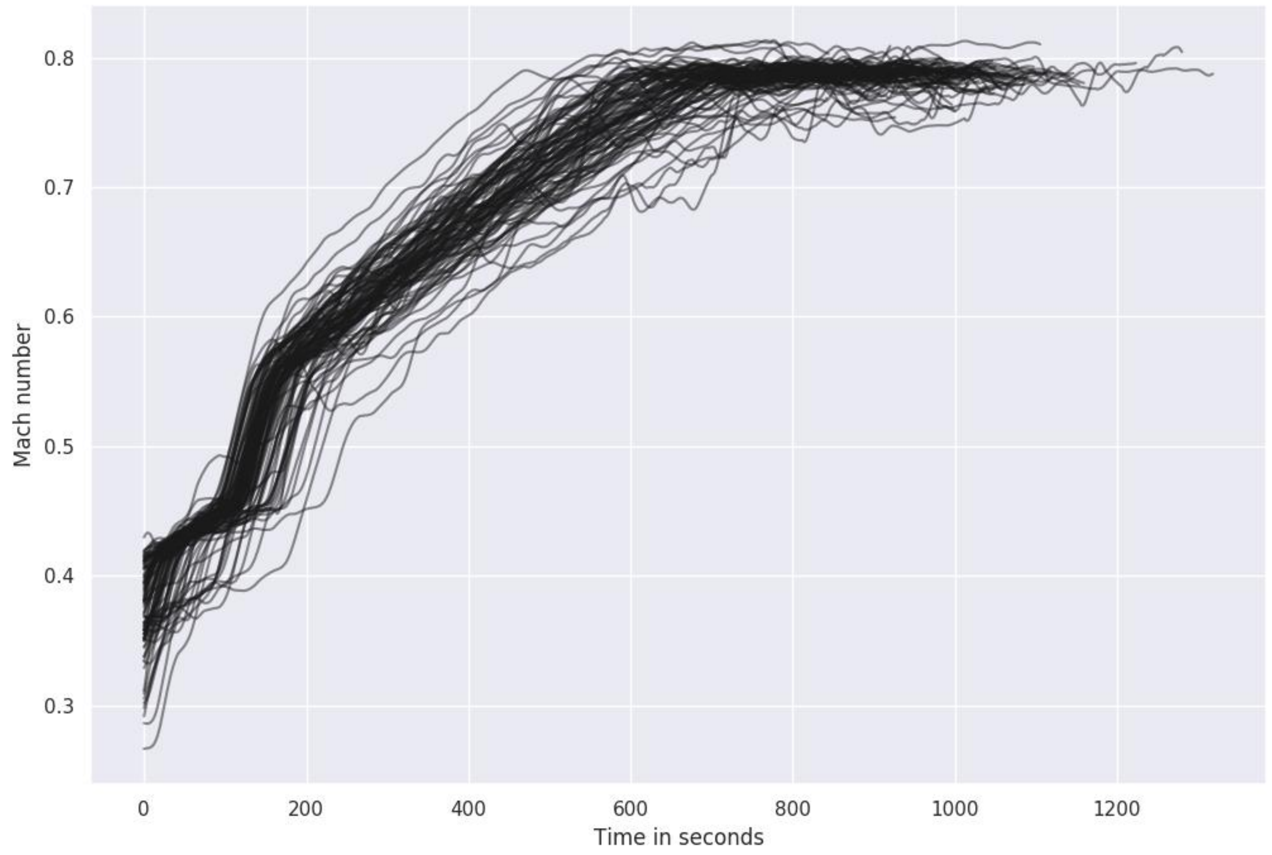
- From the Quick Access Recorders
- Up to 1000 parameters per second
- Samping from 1 Hz to 8 Hz
- For instance
    - State of the aircraft: speeds, altitudes, accelerations, fuel quantity
    - Pilot parameters: engine thrust, surface control position, brakes
    - Geolocation: latitude, longitude, heading


40000
35000
30000
25000
20000
15000
10000
5000
Altitude in feet
0
200
400
600
800
1000
1200
Time in seconds

OPTI FLIGHT
In-flight guidance



OPTI FLIGHT
In-flight guidance



OPTI FLIGHT

In-flight guidance

OPTI CLIMB - CUSTOMISED CLIMB SPEEDS

Opportunity

Climb = 30% of total fuel for medium haul flights.

Challenge

Most complex phase with many parameters changing at the same time (pitch, winds, temperatures, altitude, weight…).

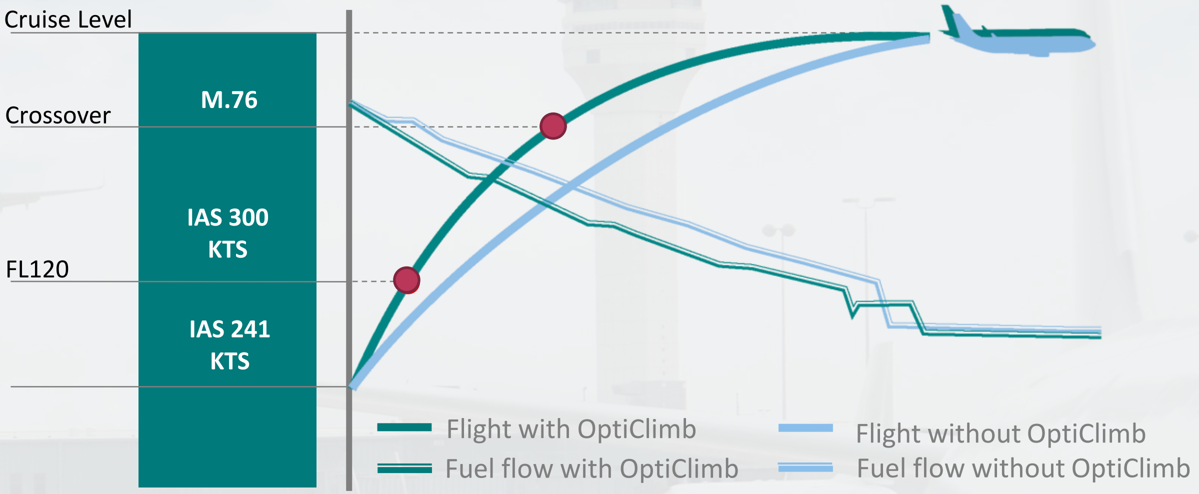
Solution

Customized speed changes at different altitudes for each climb.

OPTI CLIMB

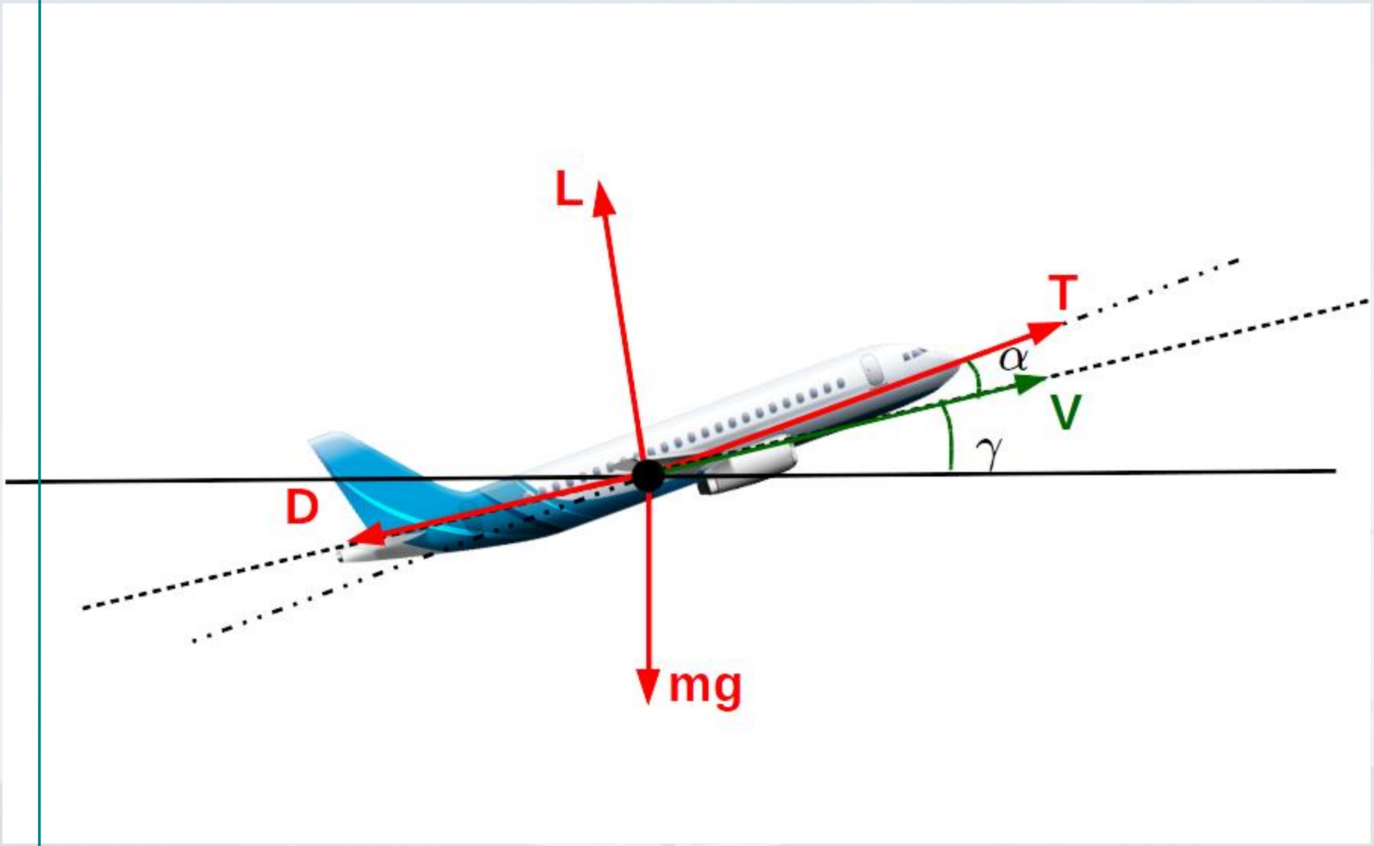
All instructions to be entered in the FMS CLB page during cockpit preparation

- ➡ Enter SPD REST **241** / FL**120**
- ➡ Enter TGT SPD**300** / 0.76

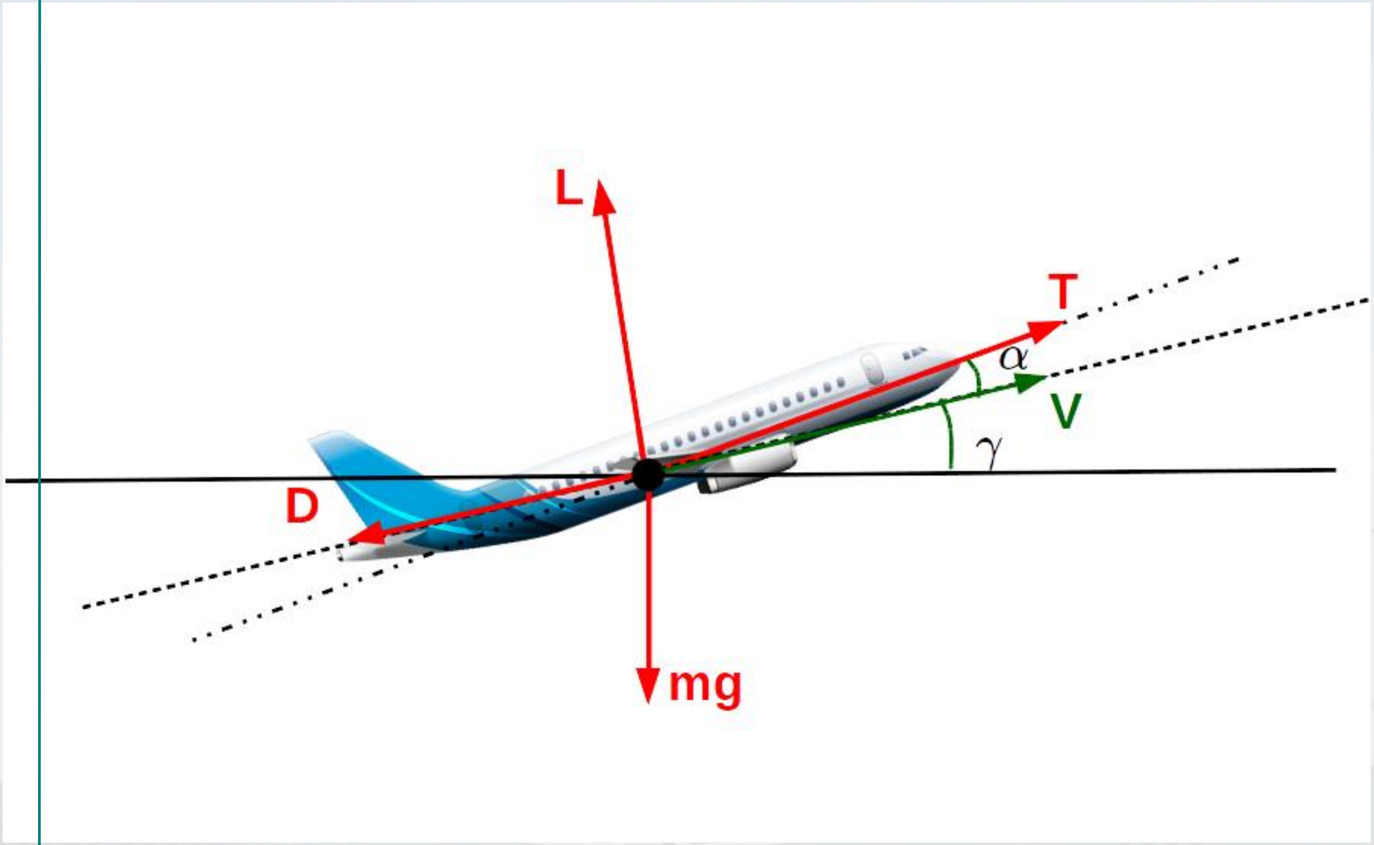


5-6% savings on climb fuel

OPTI CLIMB - CUSTOMISED CLIMB SPEEDS



OPTI CLIMB - CUSTOMISED CLIMB SPEEDS



$$
\begin{cases}
\dot{h} = V \sin\gamma \\
\dot{V} = \dfrac{T\cos\alpha - D - mg\sin\gamma}{m} \\
\dot{\gamma} = \dfrac{T\sin\alpha + L - mg\cos\gamma}{mV} \\
\dot{m} = -C_{sp}T
\end{cases}
$$

OPTI CLIMB - OPTIMAL CONTROL PROBLEM

Optimal control problem

$$\min_{(\mathbf{x},\mathbf{u})\in\mathbb{X}\times\mathbb{U}} \mathcal{C}(\mathbf{x},\mathbf{u}) \quad \text{tel que} \quad \frac{d\mathbf{x}}{dt} = g(\mathbf{x},\mathbf{u})$$

Control variable

- Angle of attack
- Mach number

State variables

- Altitude h
- Airspeed V
- Path angle γ
- Aircraft weight m

Flight dynamics

$$\frac{d\mathbf{x}}{dt} = g(\mathbf{x},\mathbf{u}) \equiv \begin{cases} \dot{h} = V\sin\gamma \\ \dot{V} = \frac{T\cos\alpha - D - mg\sin\gamma}{m} \\ \dot{\gamma} = \frac{T\sin\alpha + L - mg\cos\gamma}{mV} \\ \dot{m} = -C_{sp}T \end{cases}$$

OPTI CLIMB - ESTIMATION OF THE DYNAMICS

Problem: T, D, L are unknown!

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$$T \propto f_T(M)$$

$$D \propto f_D(M, \alpha)$$

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→ **Solution:** regression problems

i.e. the forces dépend only on the control variables

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and

$$\begin{pmatrix} T \\ D \\ L \end{pmatrix} \approx \begin{pmatrix} Y_T \\ Y_D \\ Y_L \end{pmatrix} = \varphi(\text{data})$$

i.e. the forces dépend only on the control variables

i.e. we can approximate the forces using the data

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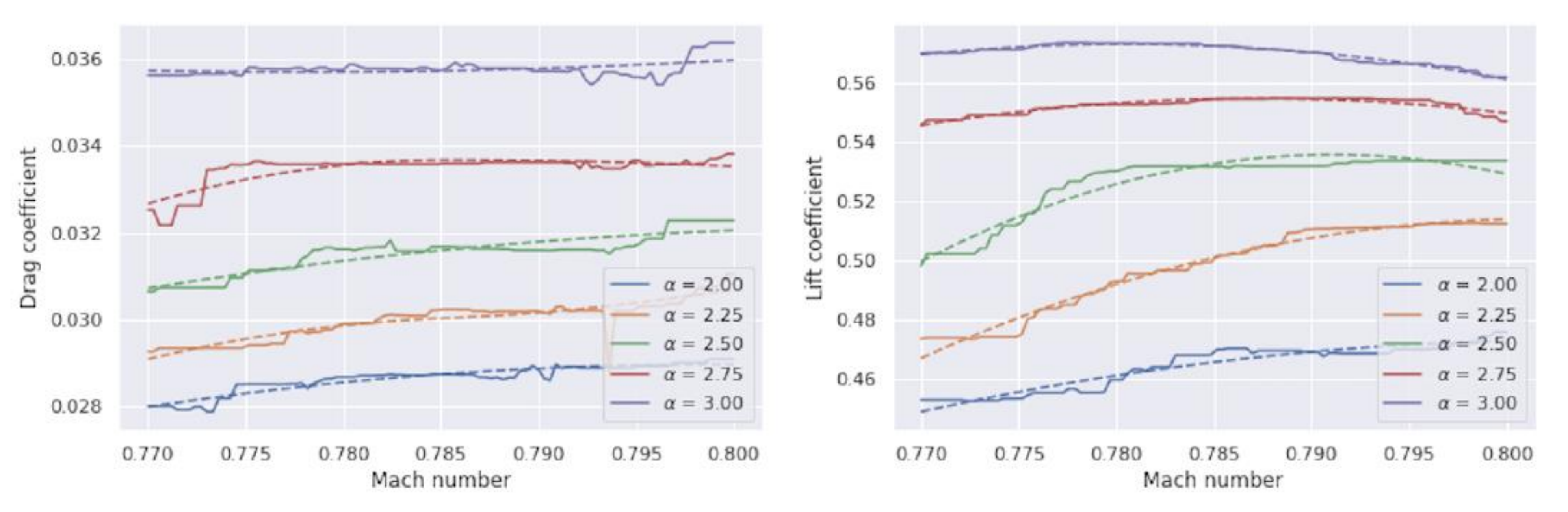
OPTI CLIMB - ESTIMATION OF THE DYNAMICS

In summary: three regression models

$$\begin{cases} Y_T &= f_T(X) + \varepsilon \\ Y_D &= f_D(X) + \varepsilon \\ Y_L &= f_L(X) + \varepsilon \end{cases}$$



Source: PERF-AI CleanSky Project, in collaboration with Florent Dewez Benjamin Guedj and Vincent Vandewalle

OPTI DIRECT - SHORTCUT OPPORTUNITIES

Opportunity

Pilots can request and obtain clearance from ATC for direct routes that will save time and/or fuel.

Challenge

- Unclear which tracks have been flown before and have chances of being granted
- Weather conditions may affect time & fuel savings

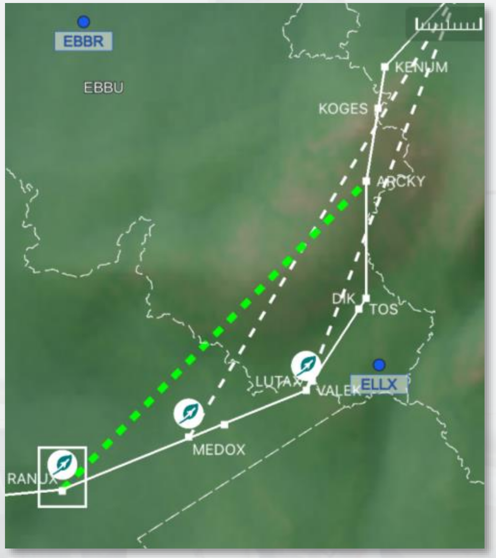
Solution

Recommend shortcuts based on historical tracks flown, with an indication of fuel & time savings.

OptiDirect

Request direct routing clearance to ATC for:

- AKUTI - GIPNO : save 126kg / 2min 30sec (flown more than 56 times)
- UKEMA - ODILO : save 59kg / 1min 30sec (flown more than 851 times)
- CVN - UTOMA : save 32kg / 1min (flown more than 22 times)



All pilots benefit from historical shortcuts

OPTI CLIMB POTENTIAL YEARLY SAVINGS

Potential annual benefit across a mixed fleet of

20 narrowbody aircraft

- $ 1,134,000 / Year

of fuel savings

- 5,100 metric tons / Year

of reduction in CO_2 emissions

- 75kg average savings per climb
- 4 flights /aircraft/ day
- 75% adherence rate
- average fuel cost of 0.70$ per kg

$56,700

$/ tail/ YEAR

255 tons

CO_2/ tail/ YEAR

AIRSIDE WATCH

Radar data at work

SAFETY LINE

Big Data applied to Aviation

Radar data

- From primary and secondary Radars
- Radius of 60 km
- Sampling from 2 Hz and 10 Hz
- Available parameters:
  - Position
  - Speed
  - Date and time
  - Altitude
  - Callsign, aircraft type, origin and destination

AIRSIDE WATCH

Radar data at work

Improvement of capacity and performances

- Search engine for the trajectories
- Visualization and KPIs
- Modules
  - Safety
  - Capacity
  - Environement

Emisions and air quality

- Realtime emision reporting
- Realtime dispersion reporting
- Speed and acceleration indicators
- **Individual** aircraft and airline analysis
- Air quality modelling

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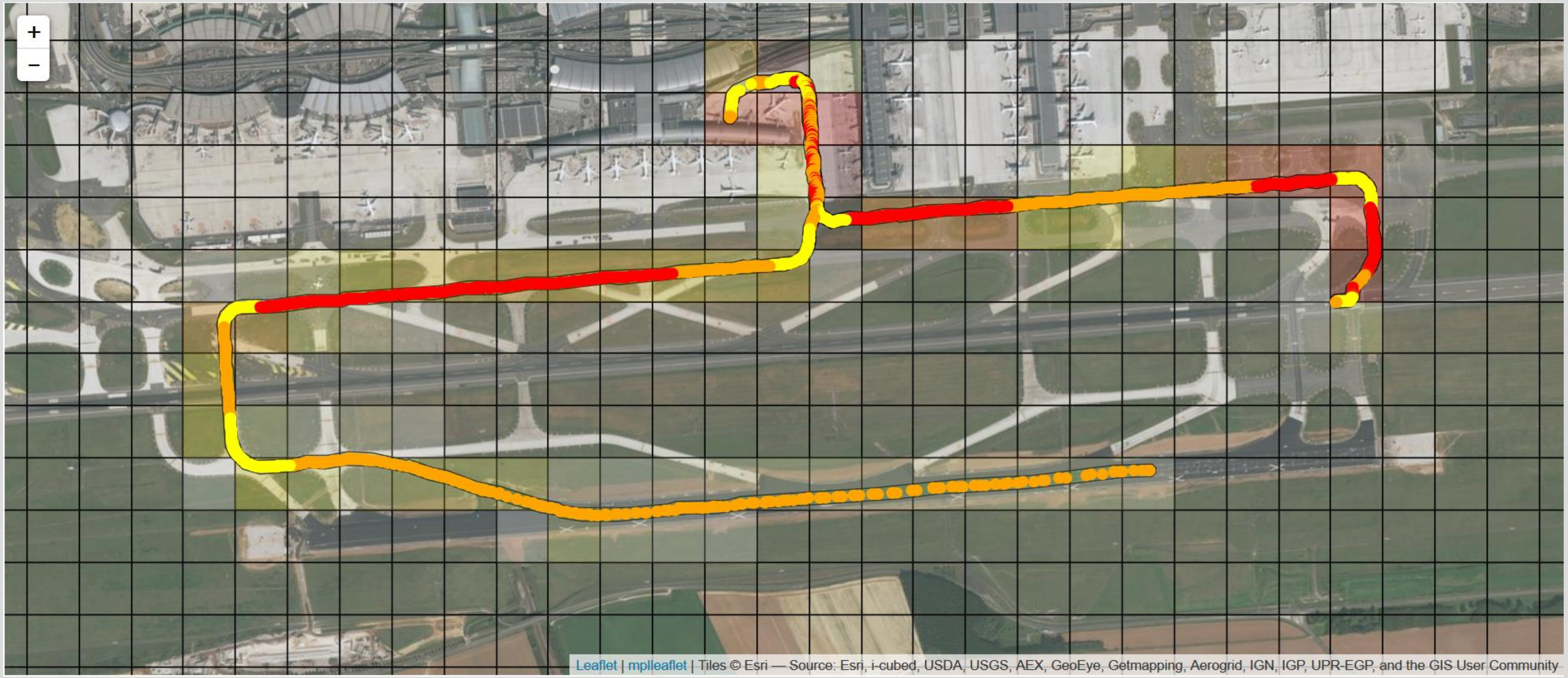
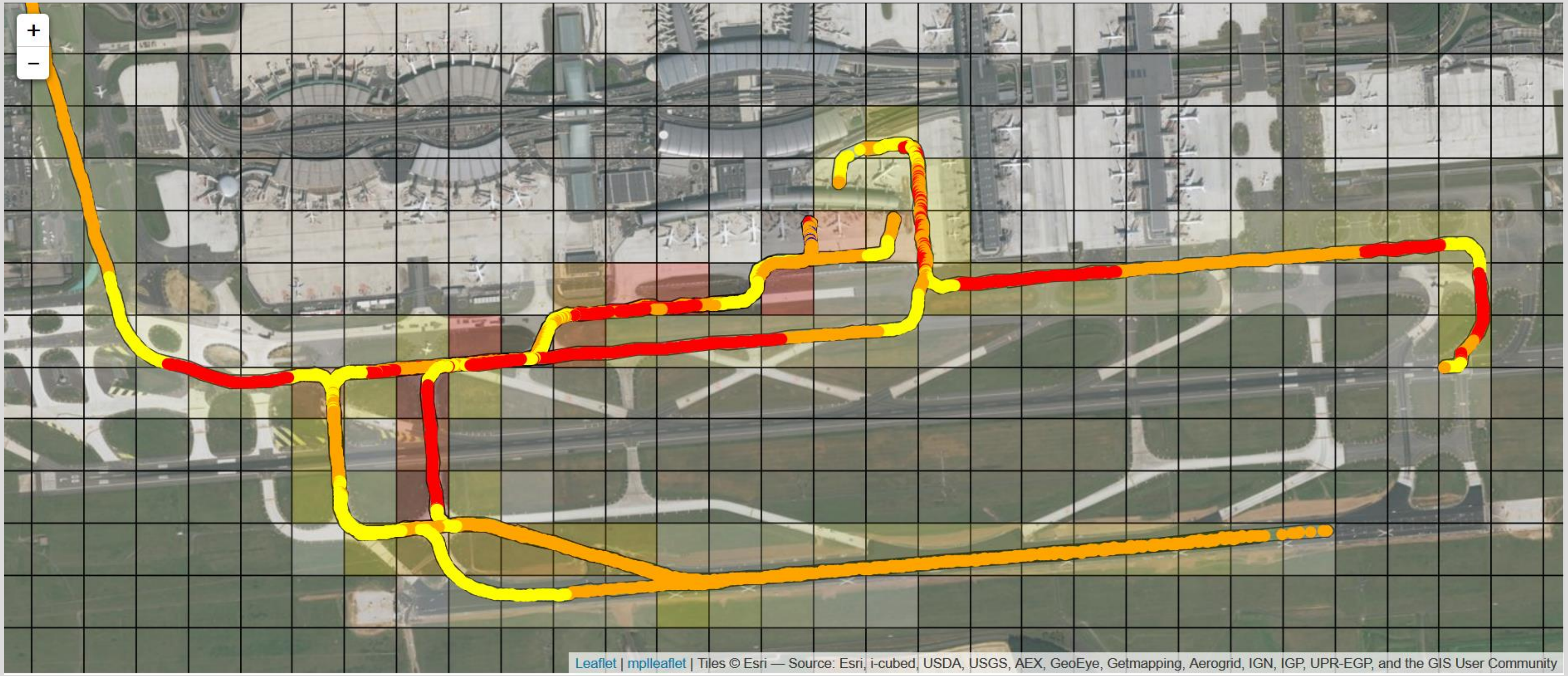
- Correlation wih **congestions**
- Modifications of the routes
- Taxiing best practices

Exemple of emissions 1 : 2 trajectories (1 take-off + 1 landing)



- Total emissions of CO_2 : 449.63 kg
- Total emissions of NO_x : 617.77 g

Exemple 2 : 5 trajectories



- Total emissions of CO2 : 1901 kg
- Total emissions of NOx : 2790 g

Exemple of dispersions (1^{st} july 2016)

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Merci pour votre attention !

contact@safety-line.fr