Global Services

Optimization in the aviation industry

November 4th, 2019

The presenters

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Master’s in Engineering Mathematics

3 years at Boeing

Subject Matter Expert for Tail Assignment

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6 months at Boeing

Optimization Expert

Agenda

Global Services

- Introduction to Jeppesen products and the aviation business
- Modelling the planning problem
- Solving the planning problem/ Applied optimization

Boeing or Jeppesen?

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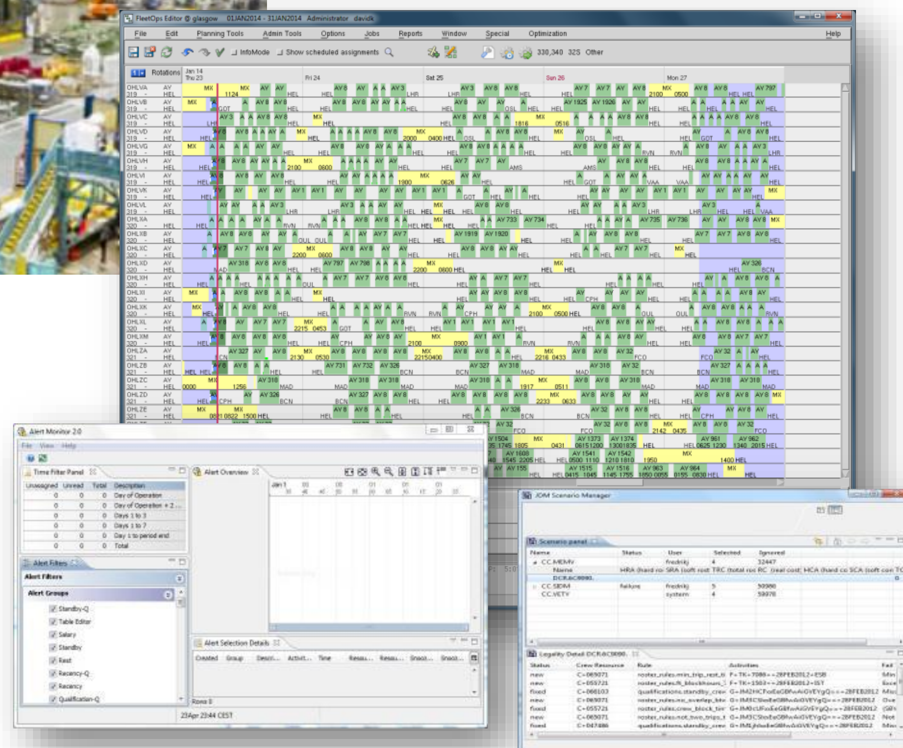


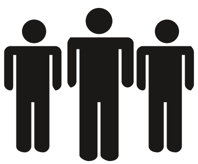
BGS Crew and Ops Customers

Global Services

AEGEAN
Aer Lingus
AirBridgeCargo
AEROMEXICO
AEROMEXICO connect
AIR CANADA
Jazz
AIR CANADA rouge
Air Europa
AIR NEW ZEALAND
AIRFRANCE
AIRLINK
airmalta
Alitalia
Avianca
Alaska
BRITISH AIRWAYS
BA CITYFLYER
CATHAY PACIFIC
Condor
airBaltic
DB
ENDEAVOR AIR
EXPRESSJET
FINNAIR
green cargo
atlasglobal
Azul
Emirates
ETIHAD AIRWAYS
Jetstar
DELTA
EVA AIR
iZair
UNI AIR 立榮航空
LOT POLISH AIRLINES
Lufthansa
GOL
IBERIA
AIR NOSTRUM LINEAS AEREAS
PEGASUS AIRLINES
HORIZON AIR
IndiGo
Philippine Airlines
PAL express
jetBlue
KLM
KLM Cityhopper
MESA AIRLINES
NORRA
norwegian
interjet
pobeda
Portugalia Airlines
LATAM
MNG AIRLINES
neos
Onurair
QANTAS
QANTASLINK
QATAR AIRWAYS القطرية
Republic Airways
SAS
السعودية SAUDIA
SkyWest AIRLINES
S7 Airlines
SILKAIR
深圳航空 Shenzhen Airlines
SWISS
edelweiss
TAP AIR PORTUGAL
royal air maroc الخطوط الملكية المغربية
TUI
TURKISH AIRLINES
UNITED
UTair
virgin atlantic
AIRLINK
vistara
volaris
vueling
widerøe
Thomas Cook Airlines
transavia

Product suite

Global Services



Manpower

Crew pairing

Crew rostering

Crew tracking

Flight scheduling

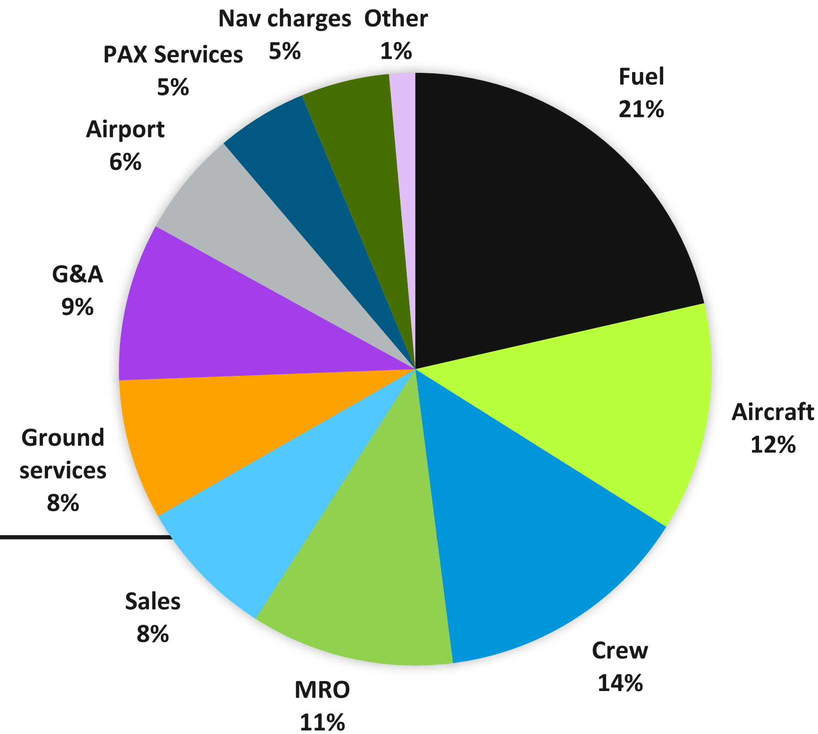
Aircraft Routing

Tail assignment

Ops control

Time

Now



Optimization

In general:

Minimize

objective function

Such that

All given restrictions are respected

Volume of a soda can

Use as little material as possible

Minimize *area*

Such that: *volume = V*

$\downarrow$

Minimize $2\pi r^2 + 2\pi rh$

Such that: $\pi r^2 h = V$

$r \geq 0,\ h \geq 0$

The planning problem

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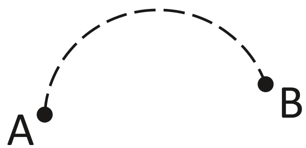
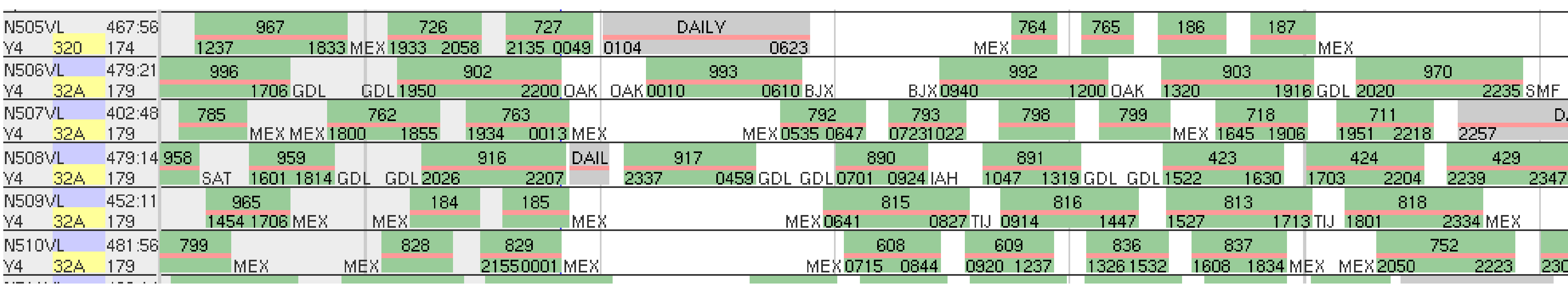
x 159

~700 billion combinations



x 30 000 /month

~250 billion stars in the milky way



Modeling the planning problem

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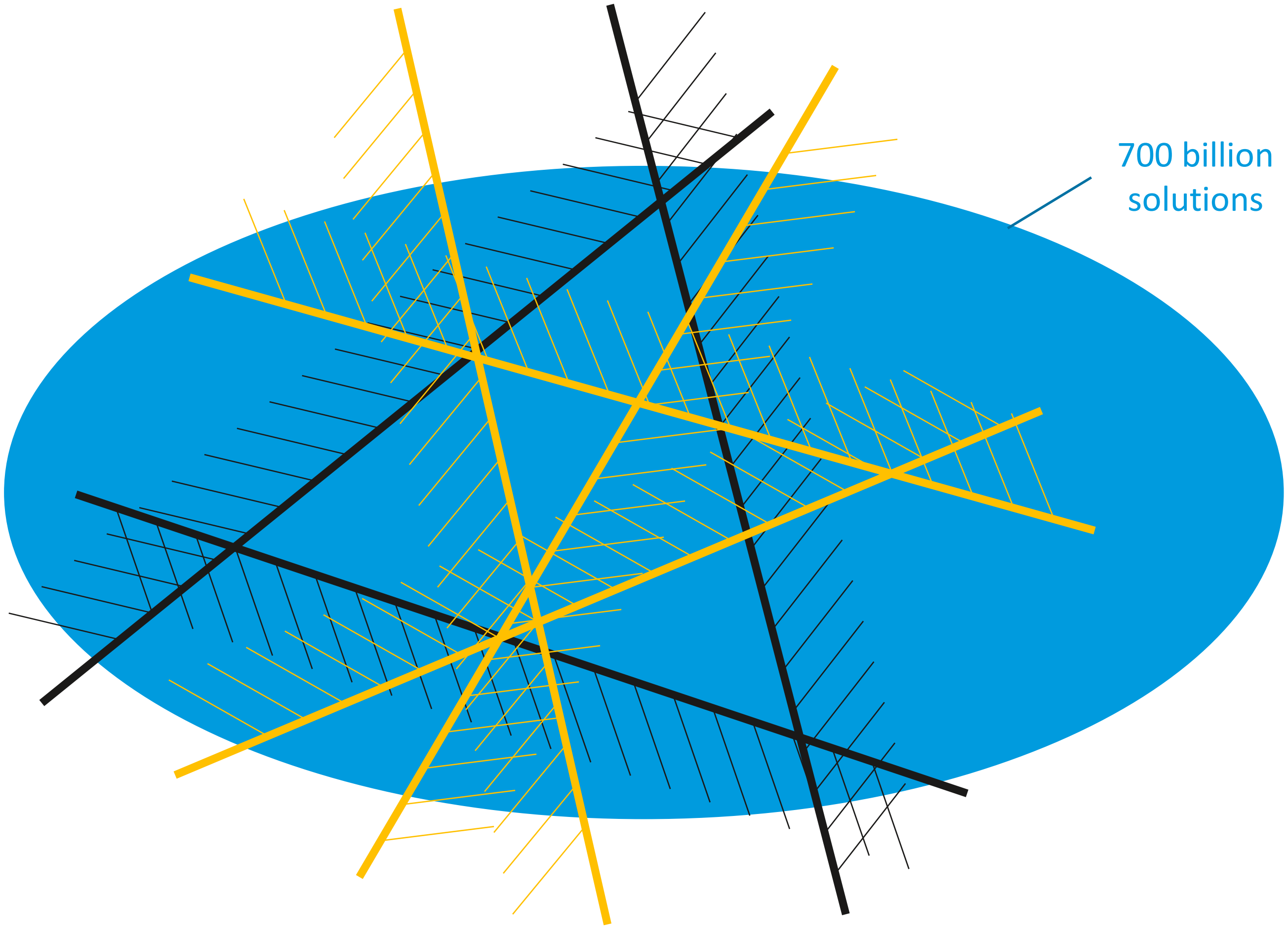
Restrictions



Modeling the planning problem

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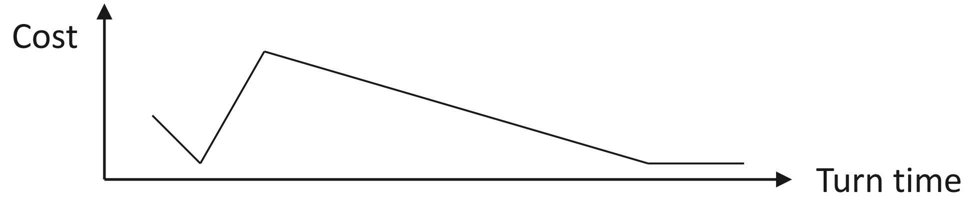
Objective function

- Rule penalties
- Robustness
- Fuel cost

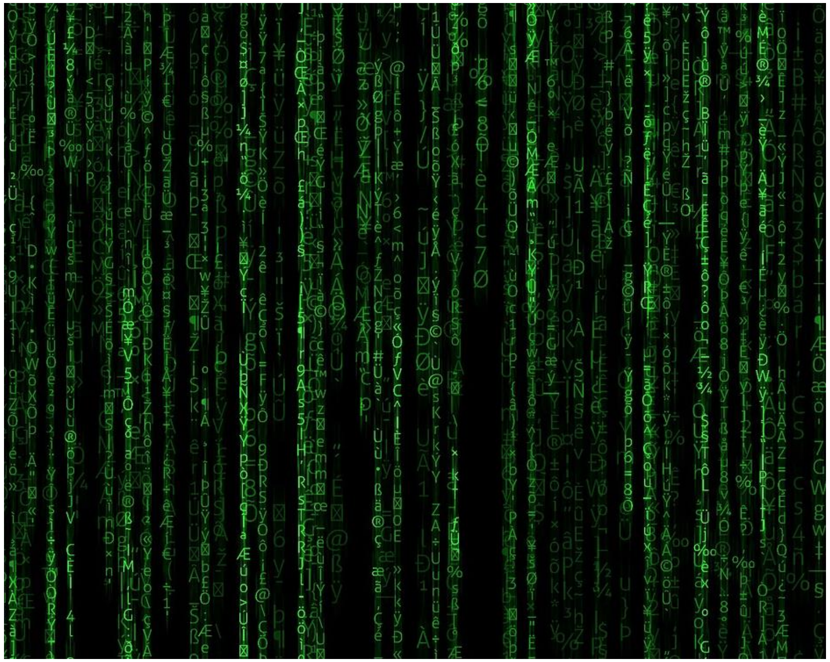



```
rule minimum_turn_time =
%turn_time% >= %minimum_turn_time%;
remark "Minimum turn time";
end

export %minimum_turn_time% =
parameter 0:35;
remark "Minimum turn time";
end

%turn_time% = next(leg(chain),
%departure%) - %arrival%;
```

Applied Optimization

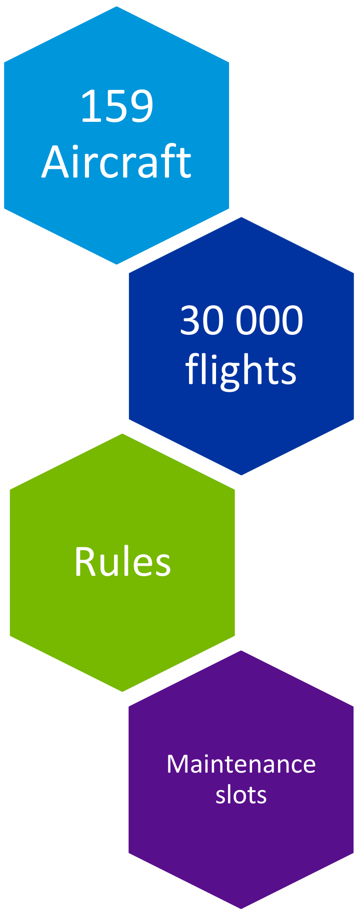
Challenges in real-world optimization

- Problem size
- Computational complexity



Tail assignment example

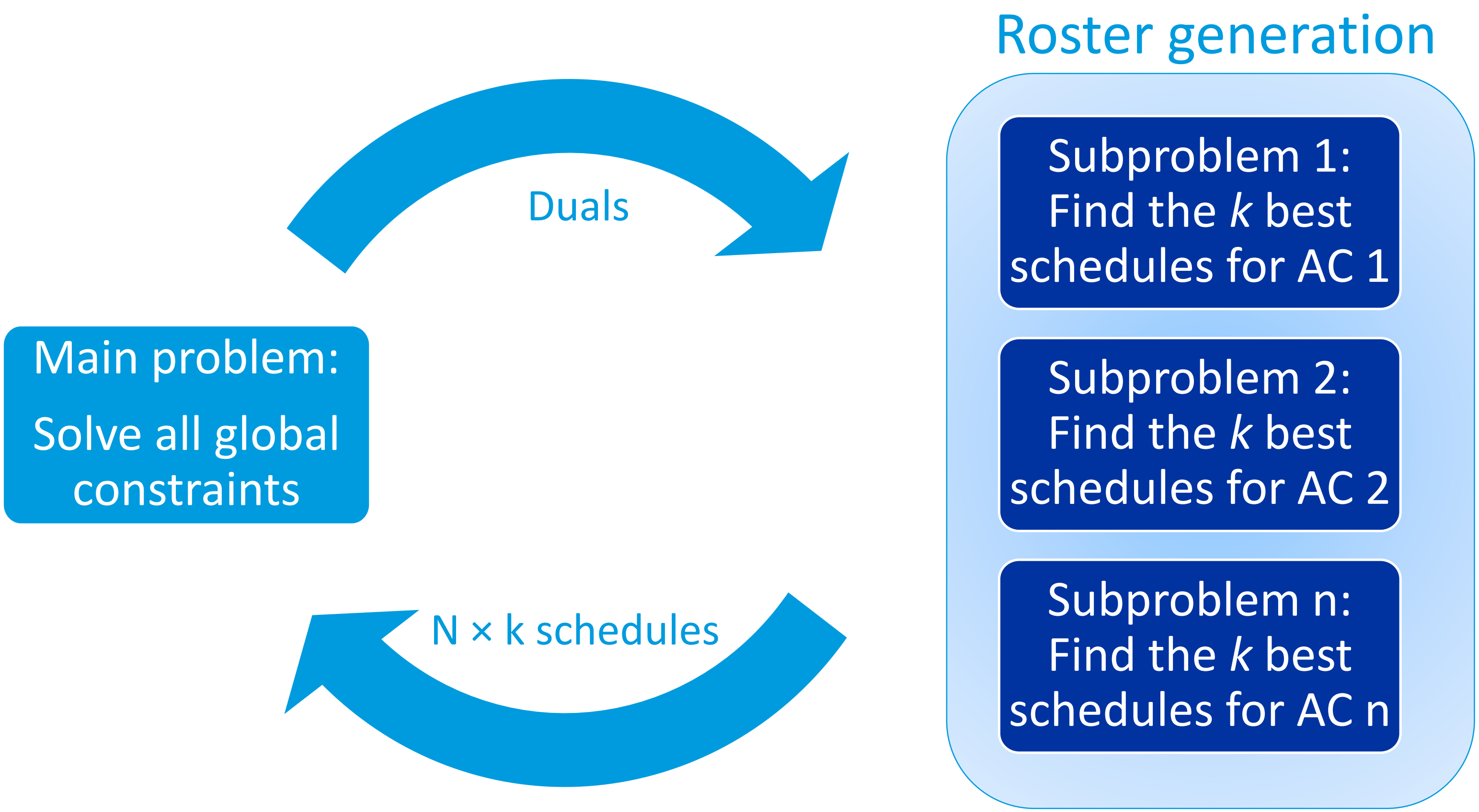
- Optimization problem



- Objective
  - $z^* := \min\{c^T x : Ax = \mathbf{1},\ x \in \{0,1\}^n\}$
  - $A_{ij} = 1$ if flight F_i is covered by schedule R_j
  - $x \in \{0,1\}^n$ is a decision variable whose jth entry is 1 if R_j is chosen
  - Set of all feasible schedules very large

- Solution method
  - Solve it iteratively through Column generation
    - Two step process
      - Many subproblems
      - One master problem

Column generation



Efficient optimization

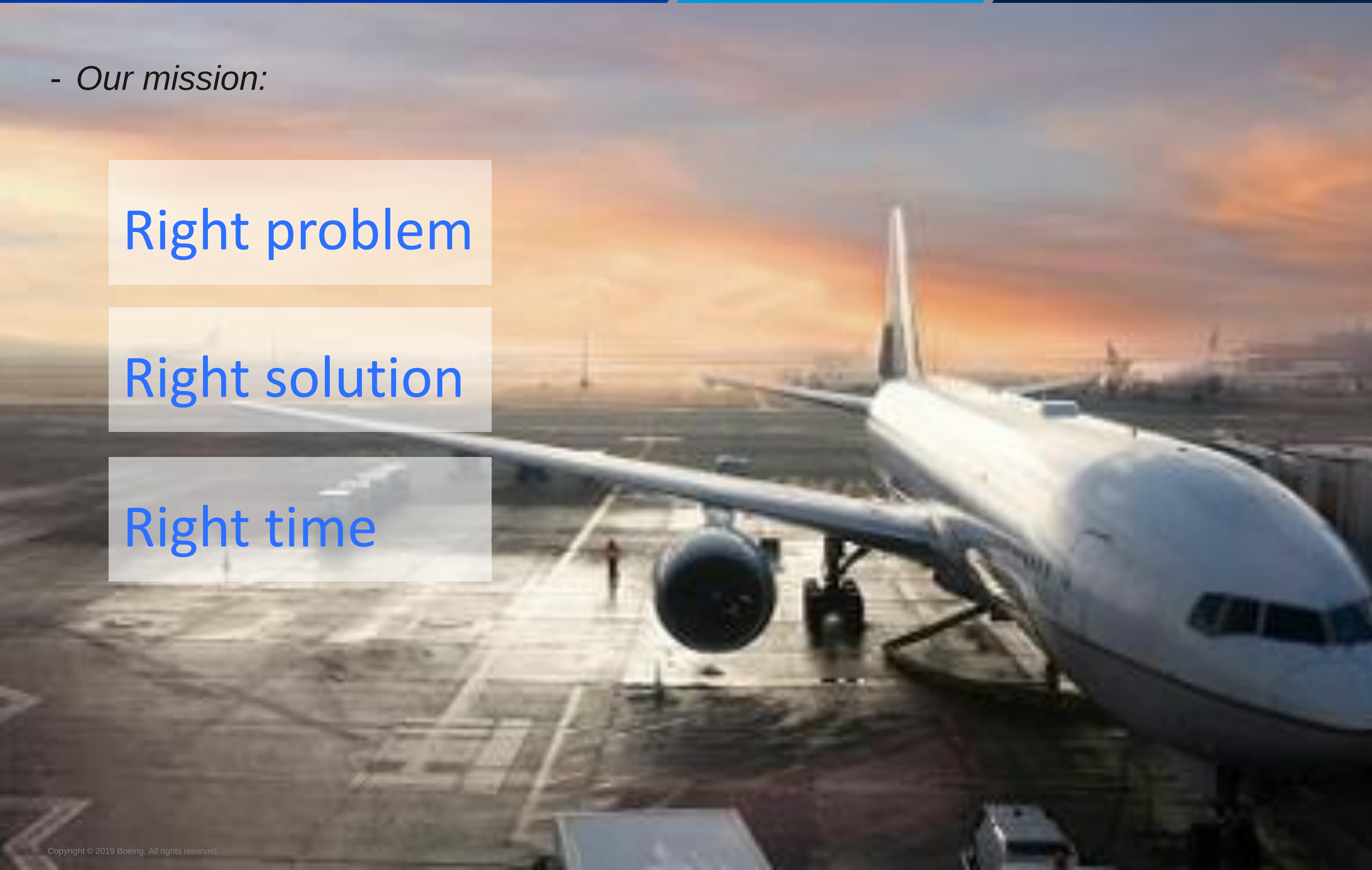
- Optimizer designed for the tail assignment problem
  - Makes use of problem-specific structures to downsize it
- Rely on heuristics to find approximative solution quickly

”We cannot solve these problems optimally within reasonable time...

But as long as we are the best in the world at it, it doesn’t matter”

Summary

- *Our mission:*



Right problem

Right solution

Right time