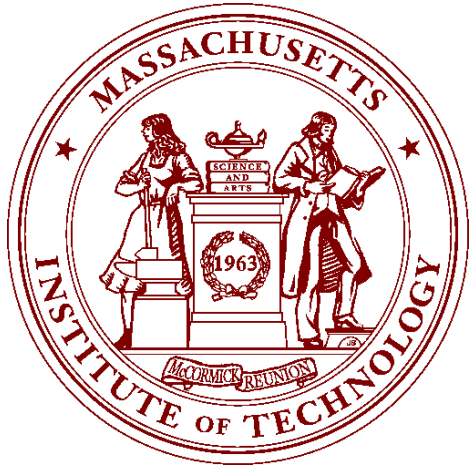
# Data analytics applications and challenges in airline operations

# Workshop ITA – MIT on Big Data Analytics for Air Transportation


August 21st, 2019


# Agenda

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Data analytics framework

The airline operations environment

Some applications...

...and challenges

# Marcelo Soares Leão

## Flight Operations Engineer

**Starting September: Coordinator, Safety Investigation**

## Professional background

| | |
|---|---|
| • Azul Brazilian Airlines | 2014 – present |
| • Instituto Tecnológico de Aeronáutica | 2010 – present |
| • EMBRAER | 2003 – 2009 |

## Education

| | |
|---|---|
| • MSc, Aeronautical and Mechanical Engineering | ITA, 2012 |
| • Specialization, Aviation Safety and Continued Airworthiness | ITA, 2009 |
| • BEng, Aeronautical Engineering | ITA, 2002 |

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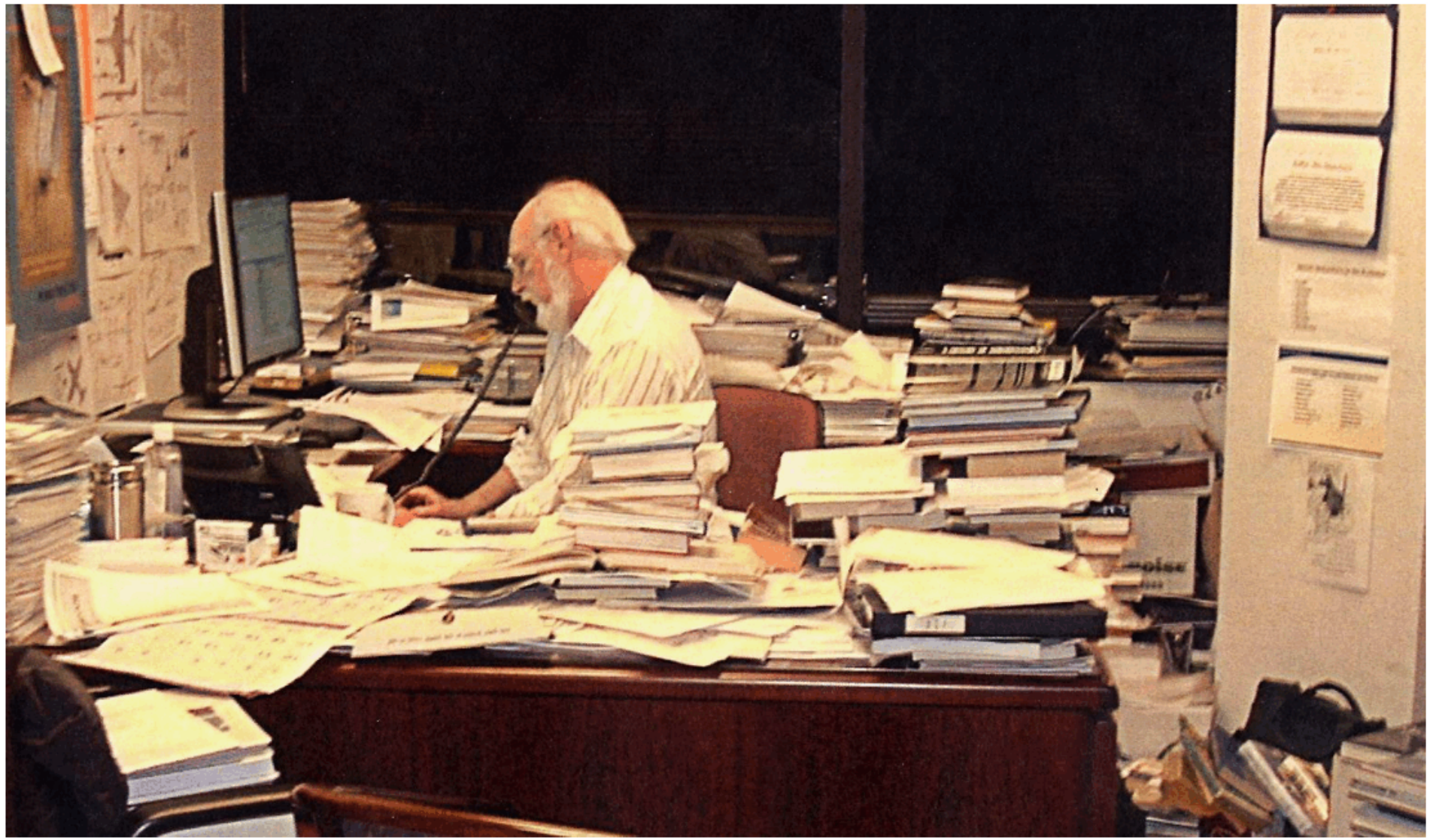
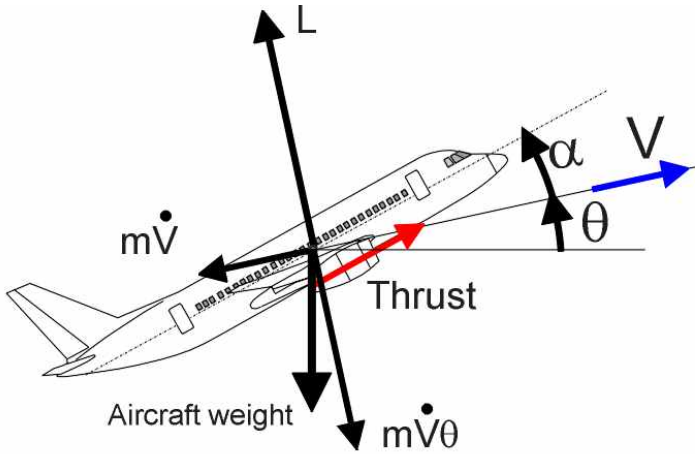
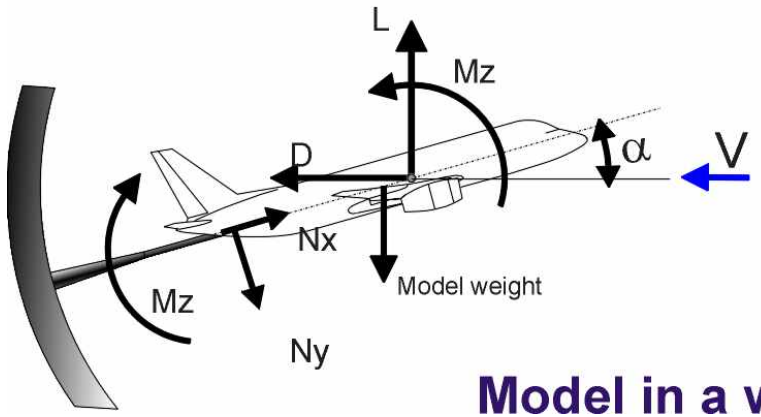
# Data analytics framework

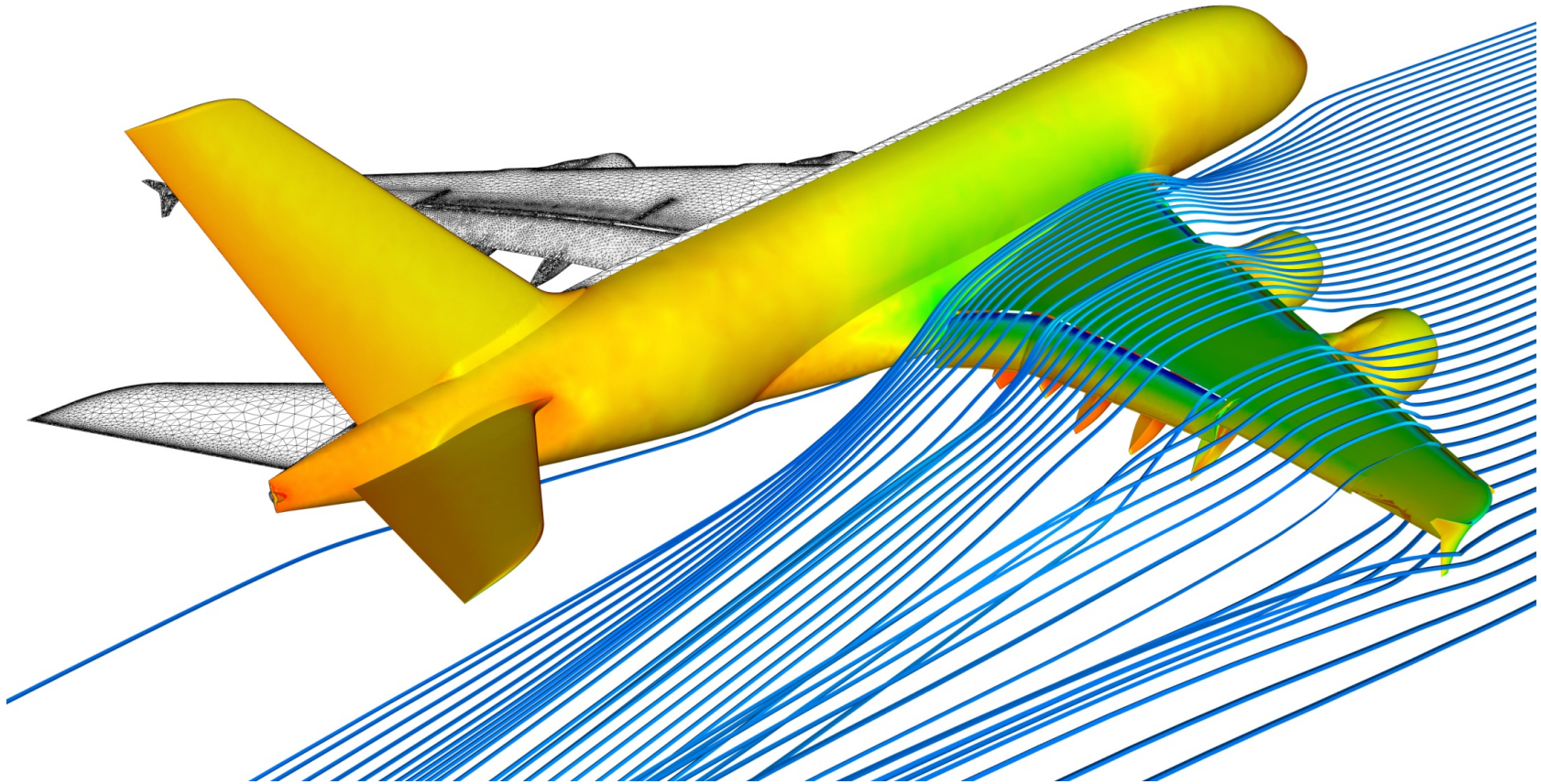


## Aircraft in flight

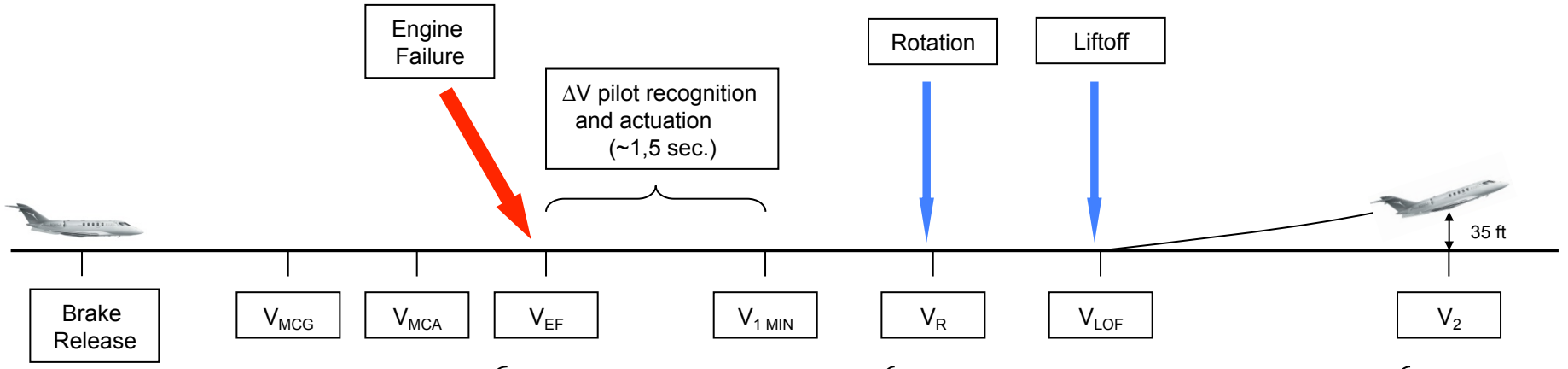



## Model in a wind tunnel





*Relation between design speeds for the aircraft takeoff performance certification under the FAA FAR Part 25 – Transport Category*




| | |
|---|---|
| $V_{MU}$ | Minimum Unstick Speed |
| $V_{MCG}$ | Minimum Control Speed - Ground |
| $V_{MCA}$ | Minimum Control Speed - Air |
| $V_{EF}$ | Engine Failure Speed |
| $V_1$ | RTO Decision Speed (“first action” to stop) |
| $V_R$ | Rotation Speed |
| $V_{LOF}$ | Liftoff Speed |
| $V_2$ | Takeoff Safety Speed (One Engine Inoperative) |

# Question: what is Data Analytics?

**Statistics?**

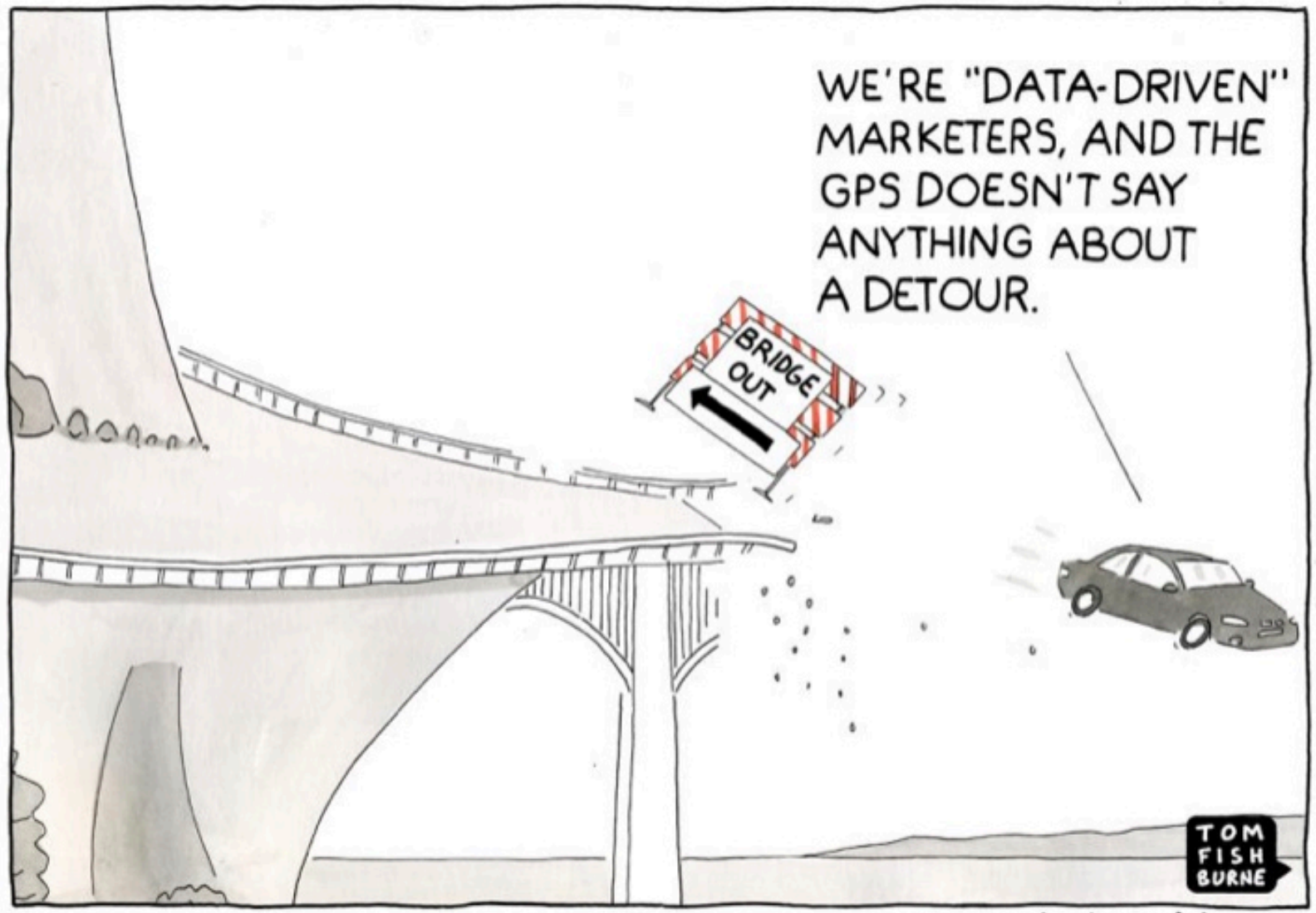
***Data Mining?***

***Big Data?***

***Machine Learning?***

***Artificial Intelligence?***

# “Data-Driven Marketing” November 2014



# Understanding: methods vs problems

Characterization, description, diagnostics

Prediction, inferences, patterns, trends

Optimization, decision making

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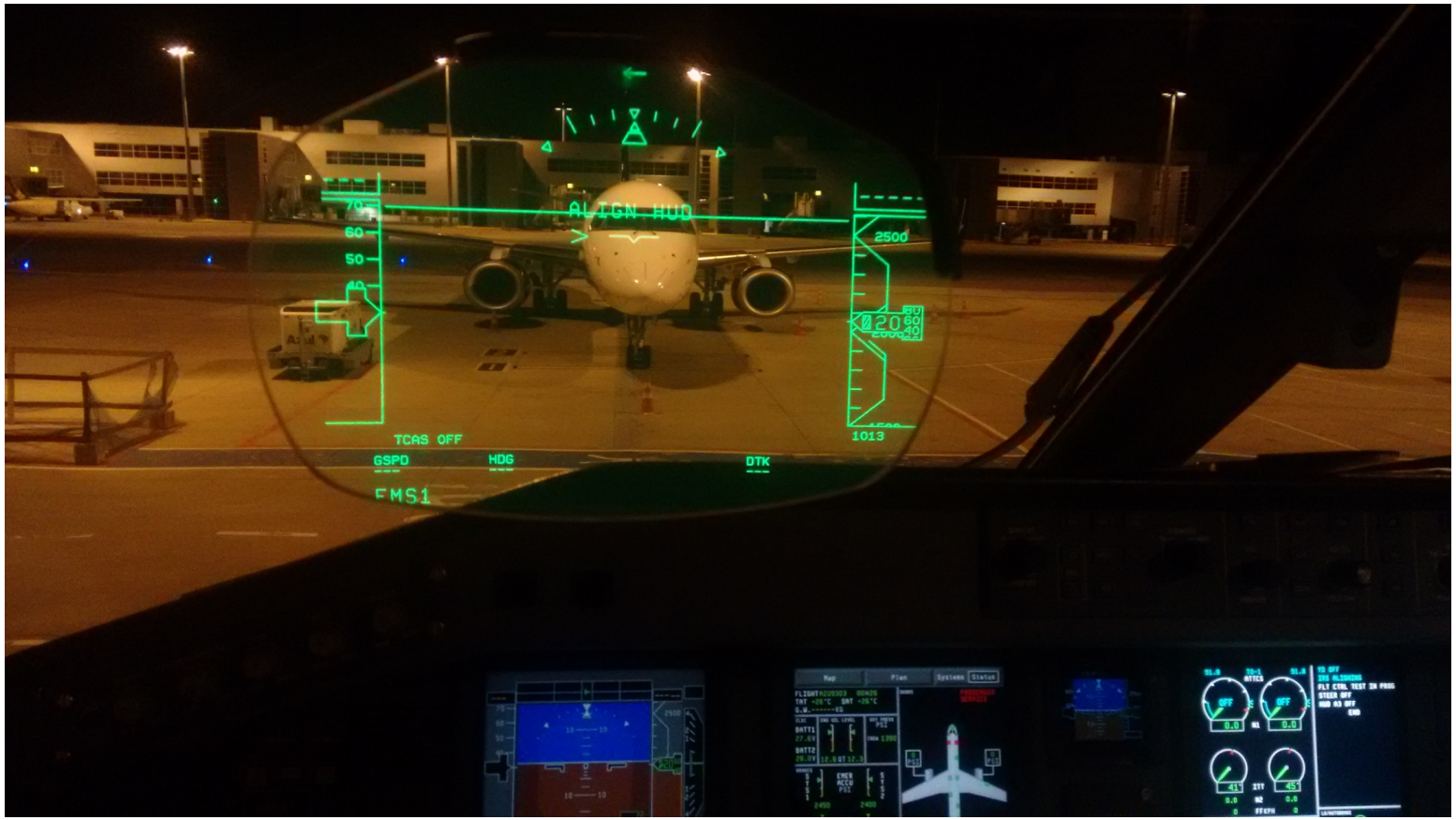
environment

# Air Transportation Industry




Highly capital-intensive

Highly technologically advanced

Long life cycle products

High integration levels of systems and processes

High complexity levels of systems and processes

Strategic transportation sector

Development strictly related to a broad international context:

- agreements
- regulation
- certification

# Azul Fleet

| | |
|---|---|
| ATR 72-600 | 33 aircraft |
| EMBRAER 190/195 | 63 aircraft |
| AIRBUS A320neo | 26 aircraft |
| AIRBUS A330ceo/neo | 9 aircraft |
| BOEING 737-400 Cargo | 2 aircraft |

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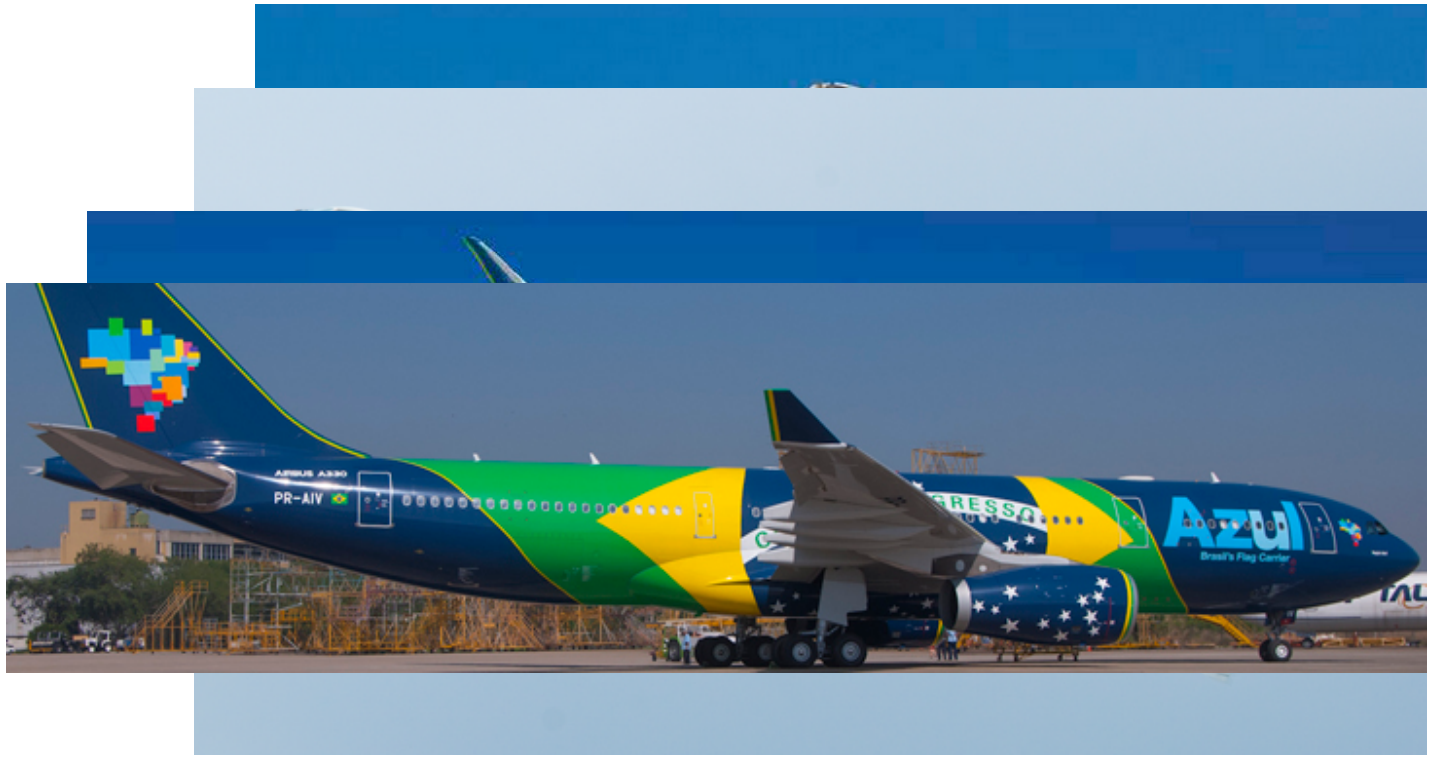

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# The future? Additional aircraft and models

EMBRAER 195 E2

AIRBUS A321neo

AIRBUS A330neo

# The future? Additional aircraft and models

EMBRAER 195 E2

AIRBUS A321neo

AIRBUS A330neo

# The future? Additional aircraft and models

EMBRAER 195 E2

AIRBUS A321neo

AIRBUS A330neo

# Azul Route Map

Different markets

Specific airplane model for each market

# Airline Operations Environment

Customers

Competitors

Civil Aviation Authorities

MROs

OEMs

Equipment

Services

Systems

Airport Admin

Air Traffic Control

Ground Service Providers

# Interrelated areas of interest

Commercial

Operations

Safety

# Interrelated areas of interest

Commercial

Operations

Safety

Network planning
Revenue management
Pricing and competitive strategies

# Interrelated areas of interest

Commercial

Operations

Safety

- Ground operations
- Flight plan & dispatch: Punctuality vs delays
- Route / performance optimization
- Fuel consumption optimization

# Interrelated areas of interest

Commercial

Operations

Safety

Safety Management System
FOQA/MOQA
Human Factors: CRM, FRMS

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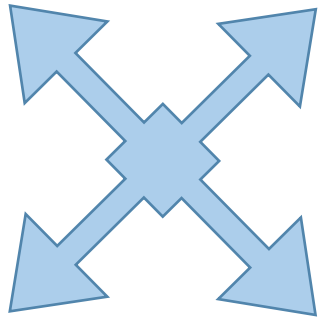
# Some applications

# Safety

## SMS - Safety Management System

*Safety Policies & Objetives*

*Safety Assurance*



*Safety Risk Management*

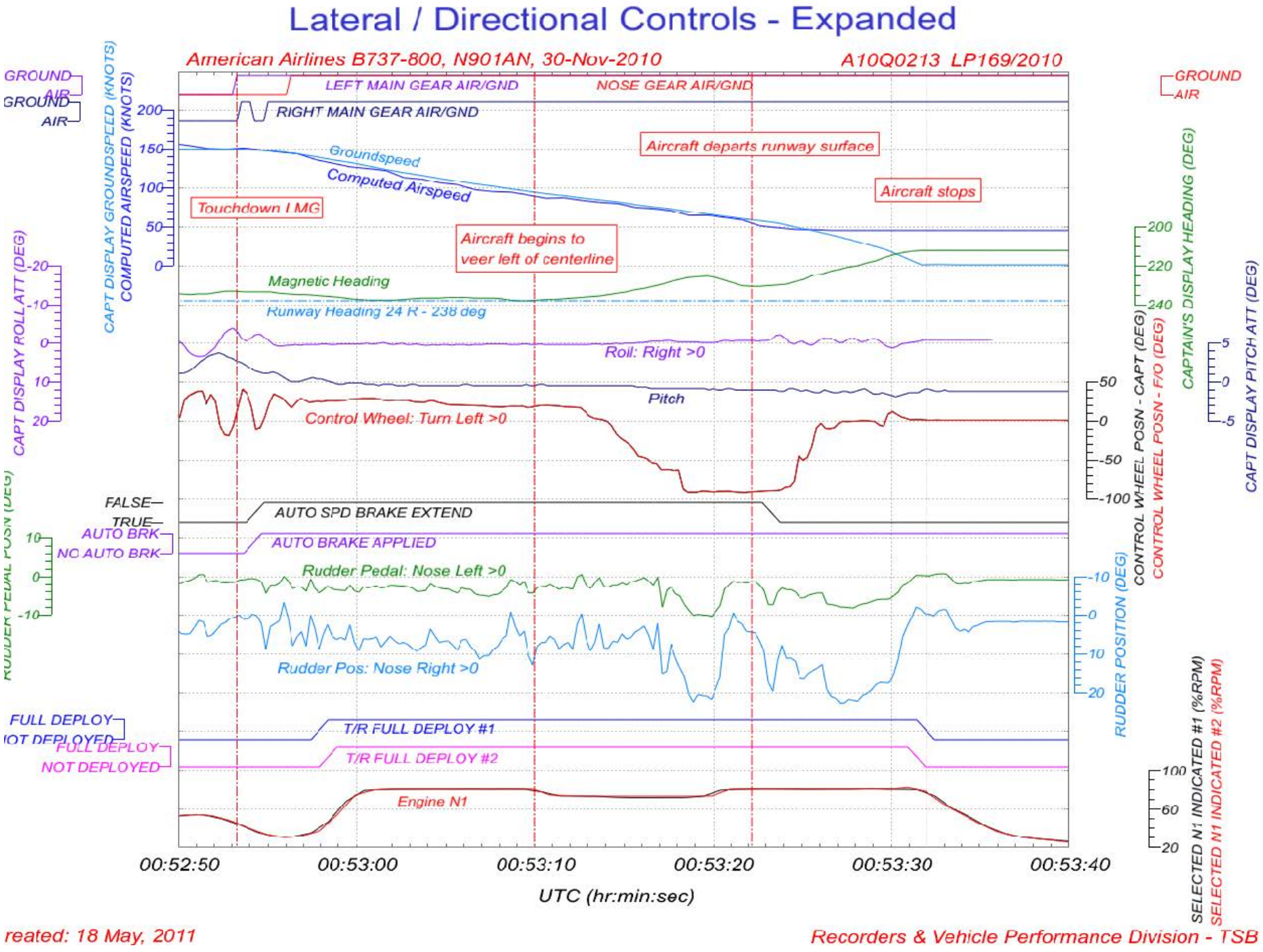
*Safety Promotion*

# Safety

## FOQA - Flight Operations Quality Assurance

## MOQA - Maintenance Operations Quality Assurance

- Definition and monitoring of operational/maintenance “events”
  - Hard landing
  - Glideslope interception from above
  - Excessive bank angle
  - Terrain alert
  - etc
- Integration with data analysis methods to investigate how closely certain parameters correlate with
- Identification of patterns




TSB of Canada Aviation Investigation Report

RWY excursion
B737-823 N901AN
Nov 30 2010

# Safety

## FRMS - Fatigue Risk Management System

## FOQA - Flight Operations Quality Assurance

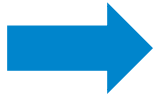
- Identification and avoidance of flight schedules more likely to fatigue risk
- SAFTE – FAST models
- Application of Machine Learning methods to prescribe fatigue rule-based crew scheduling

# Operations

## Aircraft turnaround time

# Operations

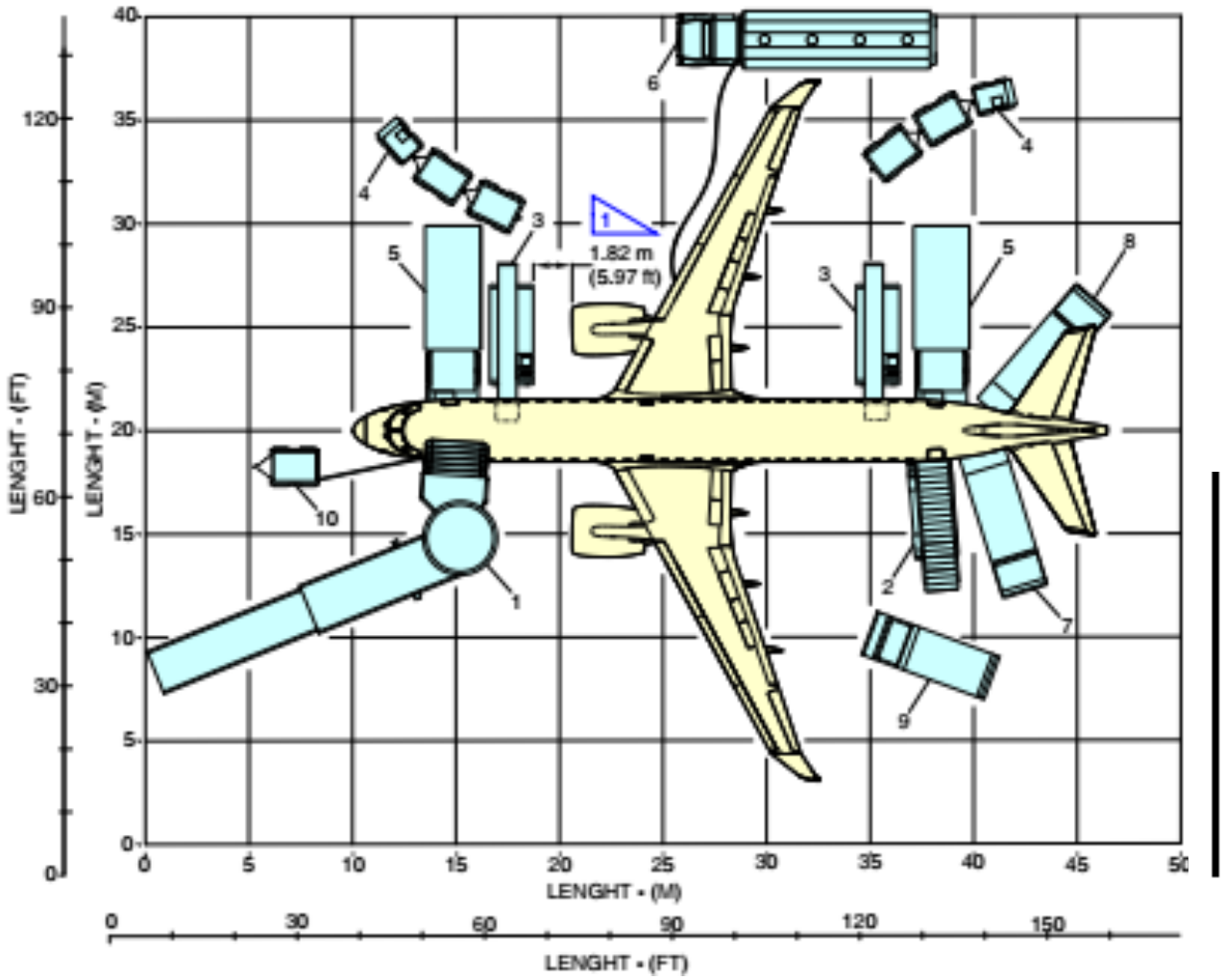
**Aircraft turnaround time**



Punctuality
Flight connections over the network

*EFFECTIVITY: EMBRAER 190-E2 ACFT*

Aircraft Servicing Arrangement With Passenger Bridge (Galley Service Adjustable Ramp)
Figure 5.2

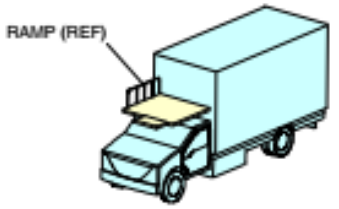



Time values affected by

airline, airport, service providers practices and operating experience

**SERVICING ARRANGEMENT**

1 - PASSENGER BRIDGE
2 - PASSENGER STAIR
3 - BAGGAGE LOADER
4 - BAGGAGE CARGO
5 - GALLEY SERVICE ADJUSTABLE RAMP
6 - FUEL SERVICE
7 - POTABLE WATER
8 - LAVATORY SERVICE
9 - CLEANING SERVICE
10 - GPU (GROUND POWER UNIT)



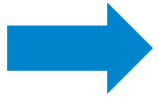

5 - GALLEY SERVICE ADJUSTABLE RAMP

1 FOR SAFE OPERATION, KEEP A MINIMUM DISTANCE OF 0.80 m (2.62 ft)

EM170E2APM050502A.DGR

# Operations

## Aircraft turnaround time



Punctuality
Flight connections over the network

- Bridge / stairs positioning
- Passengers deplane
- Galley servicing – FWD
- Galley servicing – AFT
- Airplane interior services
- Passengers boarding
- Bridge / stairs removal
- Pushback / engines start

- Maintenance task / check

- FWD baggage / cargo unload
- Rear baggage / cargo unload
- Time between unloading / loading
- FWD baggage / cargo load
- AFT baggage / cargo load

- Fuel service
- Potable water service
- Toilet service

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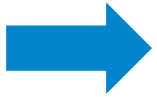
...and challenges


# And Challenges

# At the airport

## Passenger boarding strategies

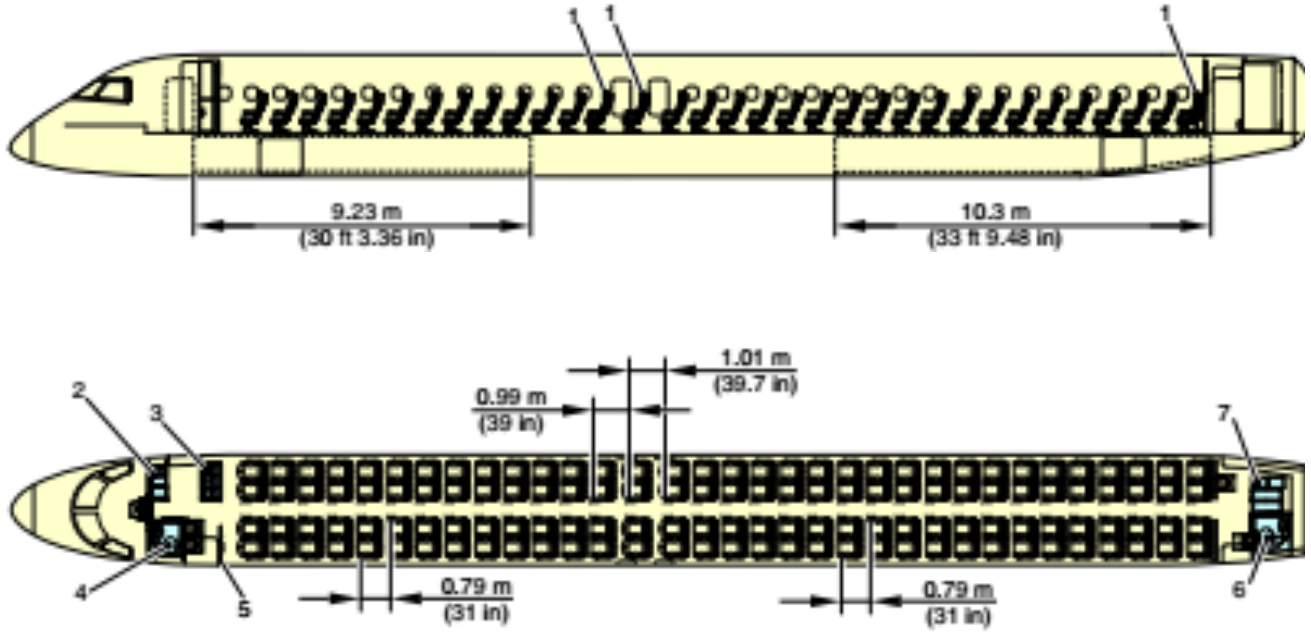
# At the airport

**Passenger boarding strategies** 

Punctuality
Flight connections over the network
Passenger comfort

*EFFECTIVITY: EMBRAER 195-E2 ACFT*

Typical Interior Arrangements - 132 Pax Single Class at 0.7874 m (31 in) pitch nominal configuration
Figure 2.8

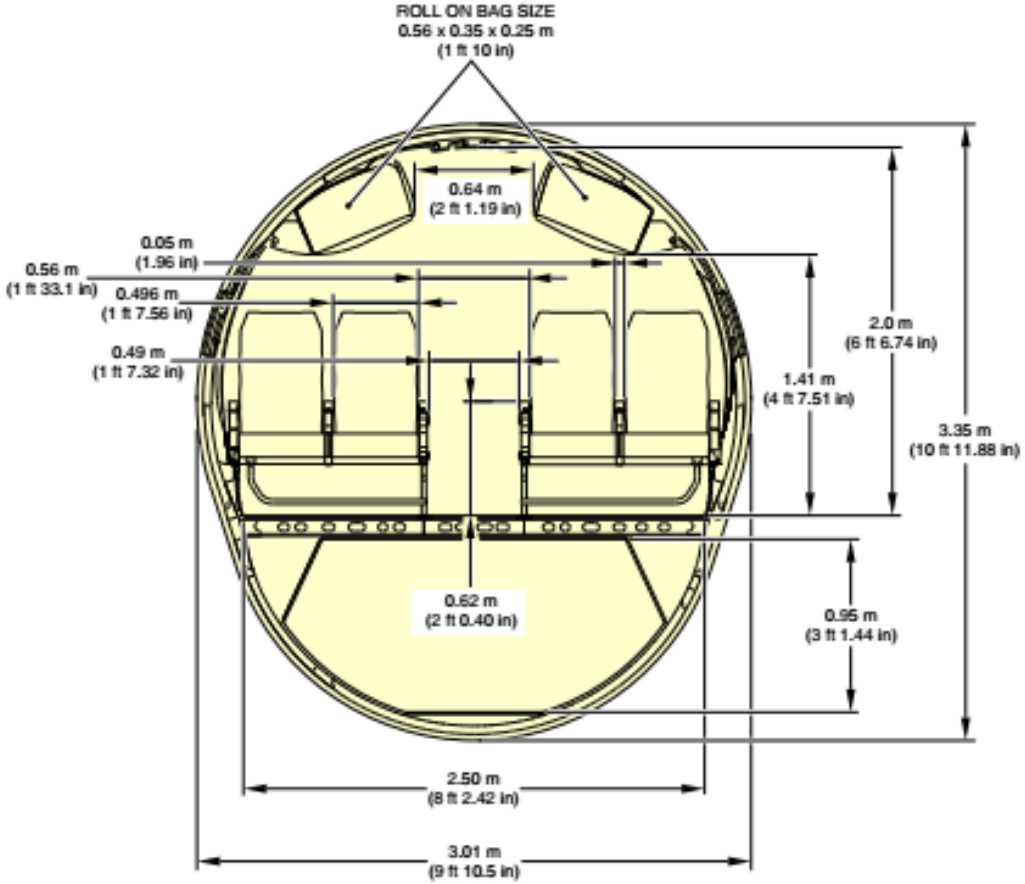



1 - NO RECLINING SEAT AT THIS ROW
2 - GALLEY G1
3 - GALLEY G2
4 - FWD TOILET
5 - HARD PARTITION
6 - AFT TOILET
7 - GALLEY G5



*EFFECTIVITY: EMBRAER 190-E2 ACFT*

Economy Class Passenger Cabin Cross-Section
Figure 2.12



# At the airport

**Passenger boarding strategies** → Punctuality
Flight connections over the network
Passenger comfort

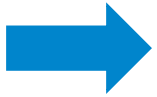
- Regulation compliance: priority boarding for certain passengers
- Aircraft seat configuration: single class, business etc
- Boarding method: bridge, stairs

- Route characteristics: tourism, business (checked baggage vs hand baggage)

- Passenger profiles: tourism, business (frequent flyer?), same applies to baggage

# Safety

## Safety Risk Assessment



Highest safety levels

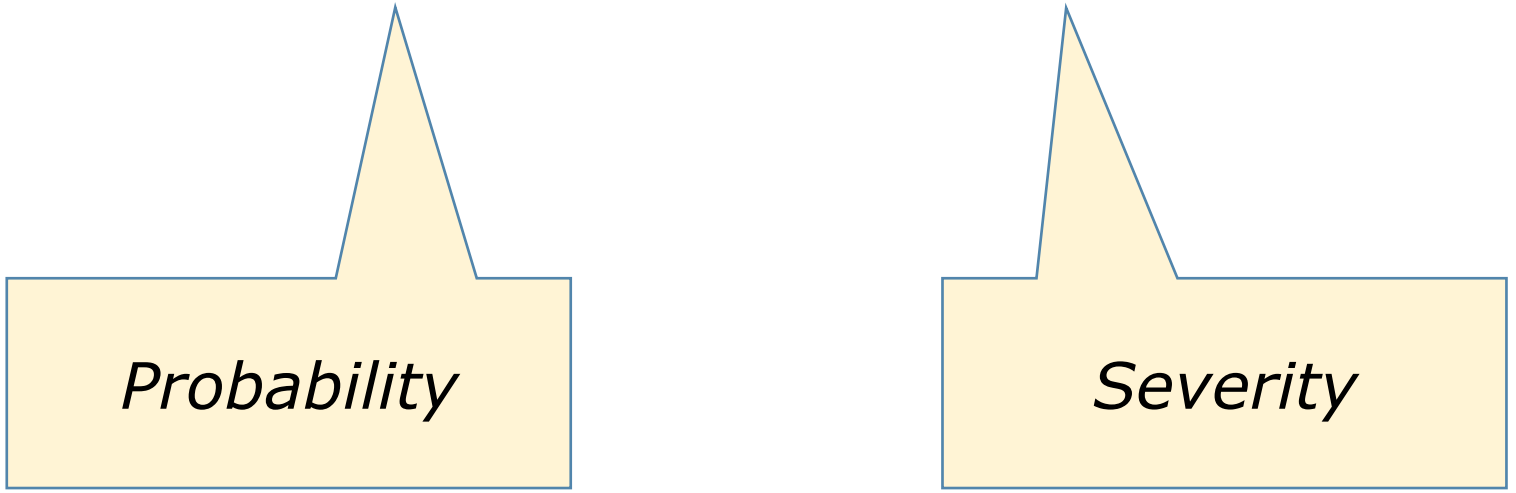
- Safety reports repository: AQD
- Integration of quantitative and qualitative approaches to risk

# Risk

Traditional concept: relates the likelihood of an adverse outcome

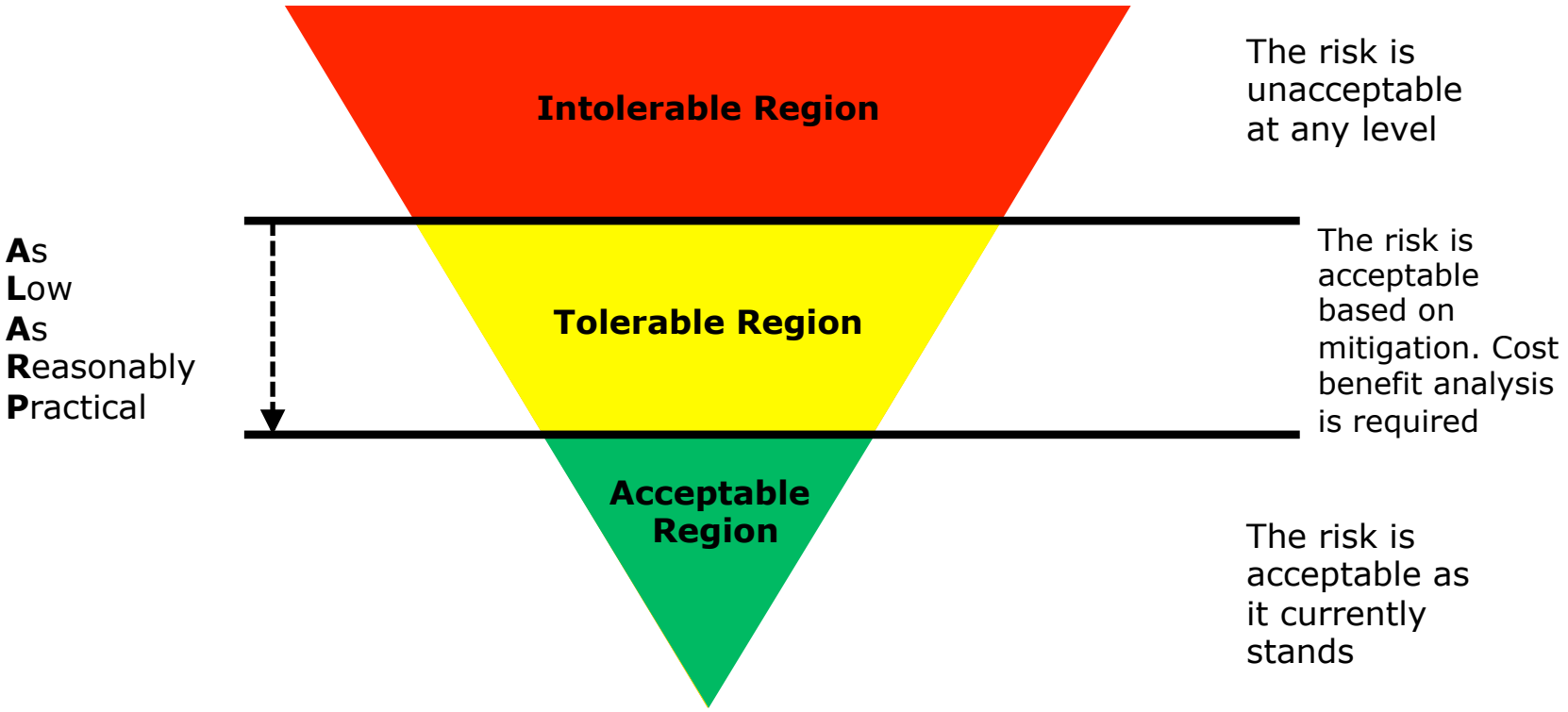
# Risk

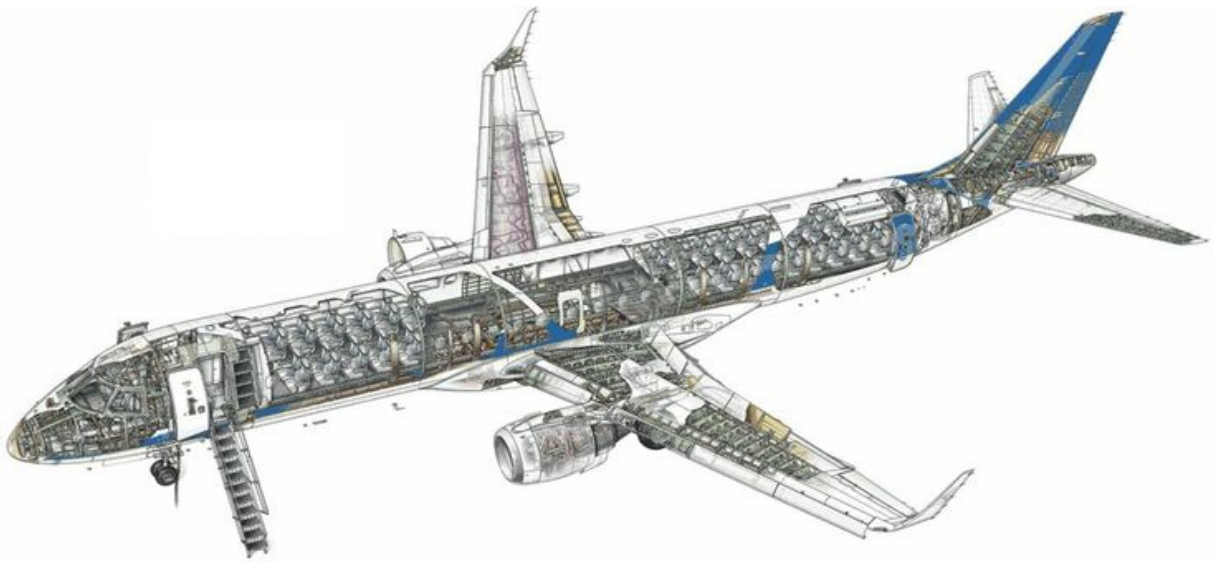
Traditional concept: relates the **likelihood** of an **adverse outcome**

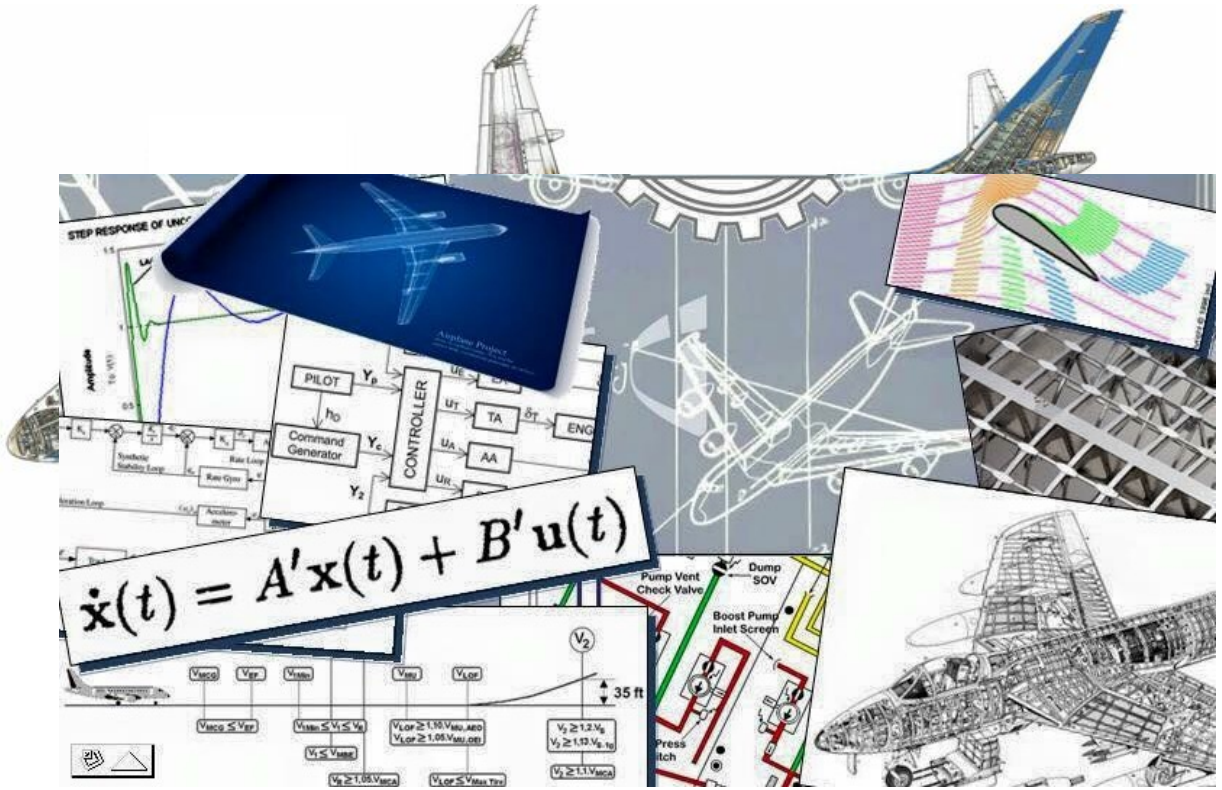


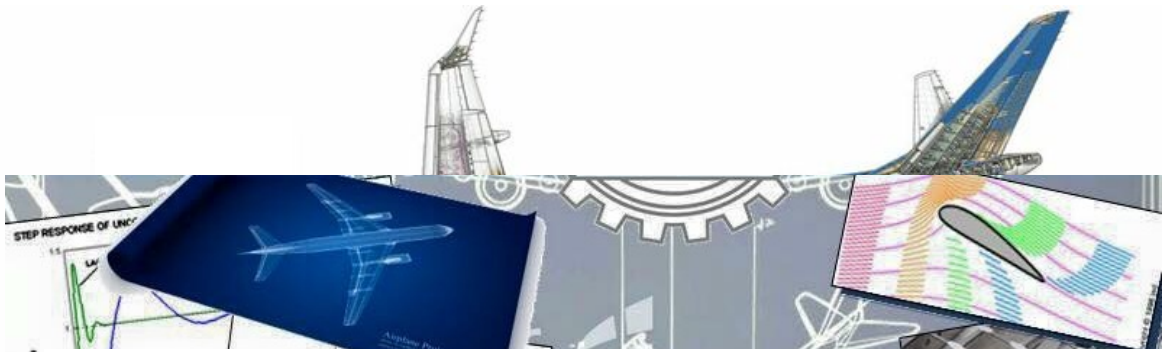
# Risk = Probability vs Severity

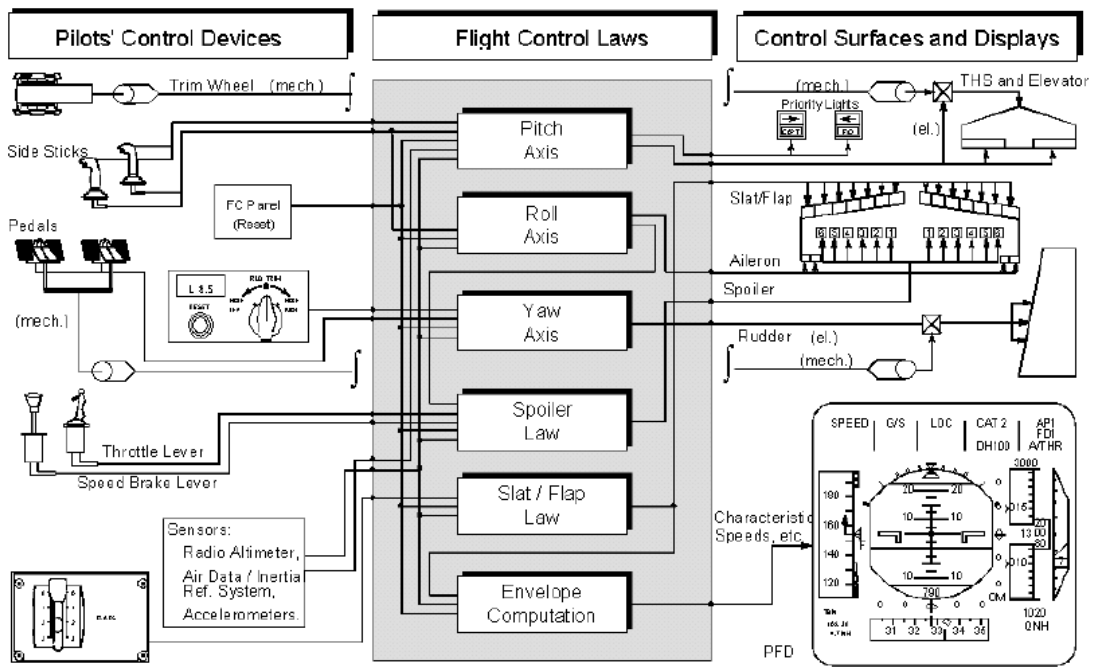
# Risk

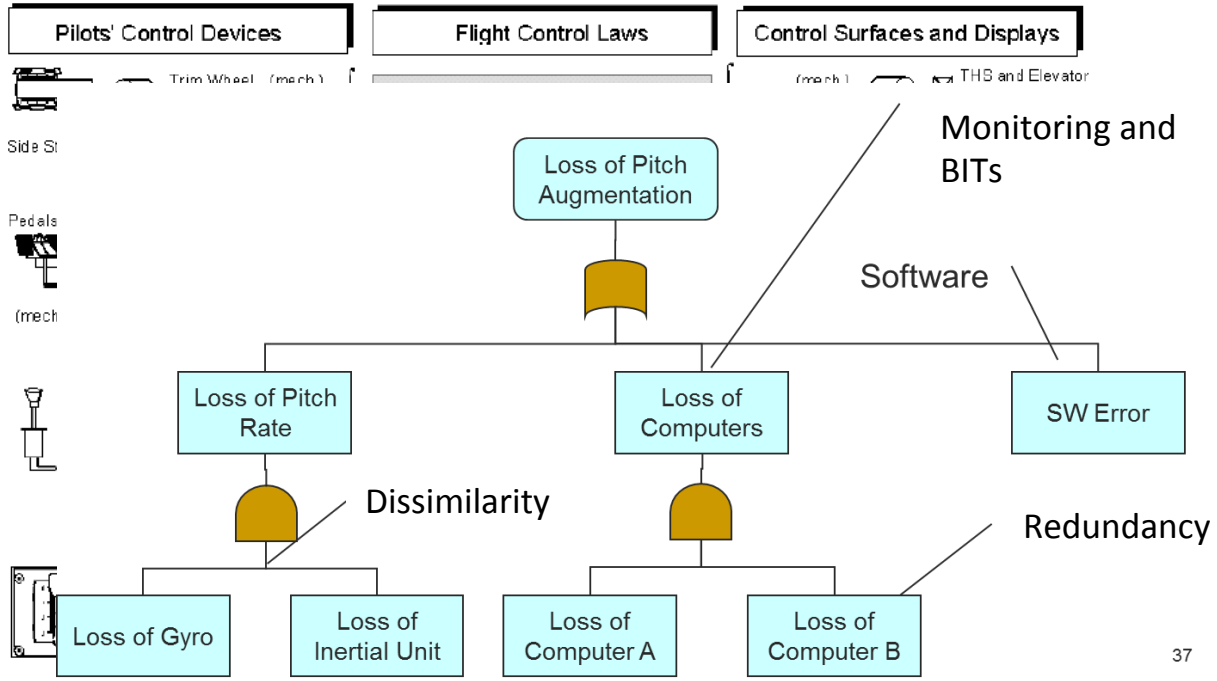

Intolerable Region
Tolerable Region
Acceptable Region
As Low As Reasonably Practical
The risk is unacceptable at any level
The risk is acceptable based on mitigation. Cost benefit analysis is required
The risk is acceptable as it currently stands

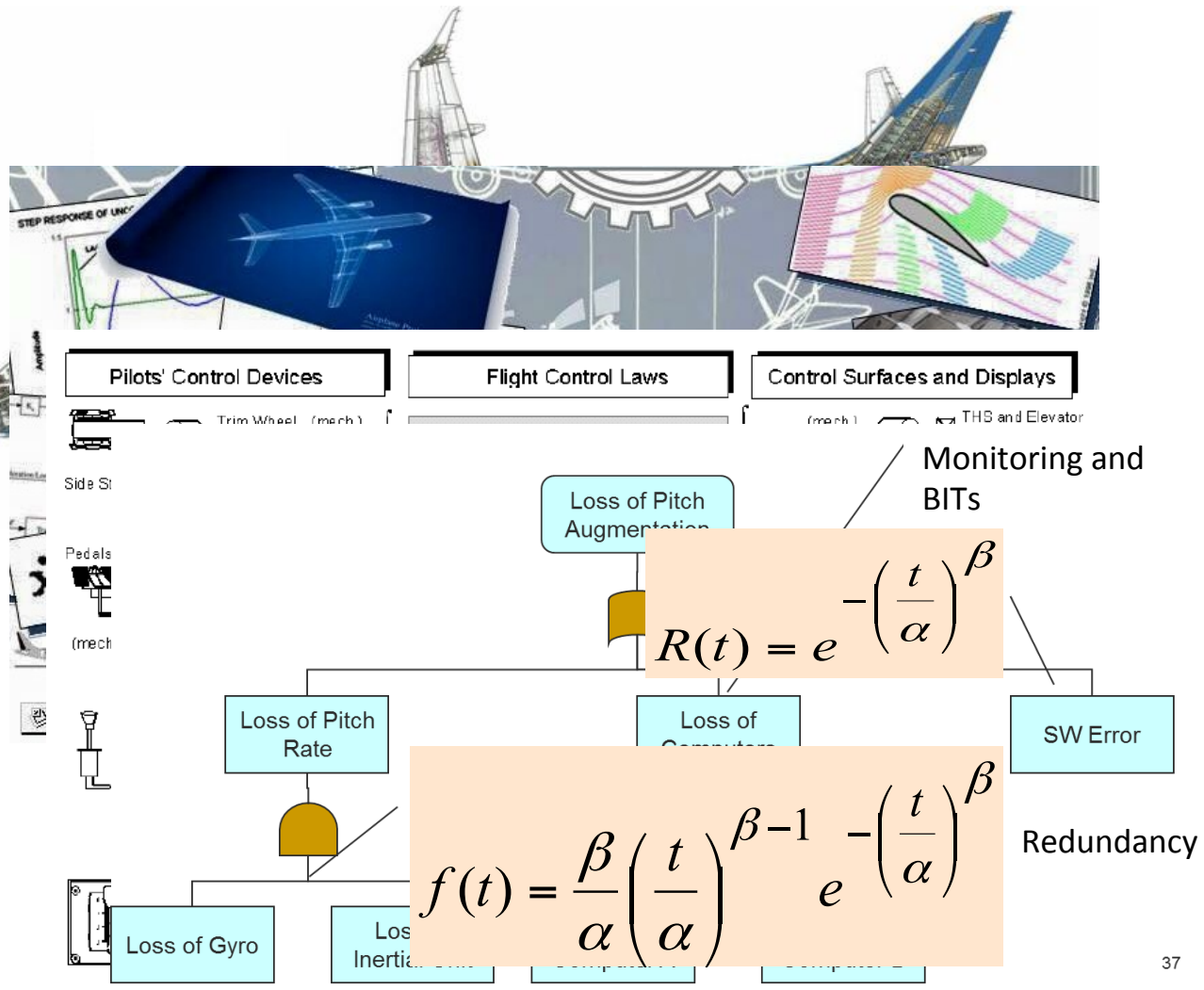



PILOT
Command Generator
CONTROLLER
TA
AA
ENG
$\dot{x}(t) = A'x(t) + B'u(t)$
Pump Vent Check Valve
Dump SOV
Boost Pump Inlet Screen
35 ft




Pilots' Control Devices
Flight Control Laws
Control Surfaces and Displays
Trim Wheel (mech.)
Side Sticks
FC Panel (Reset)
Pedals
(mech.)
Throttle Lever
Speed Brake Lever
Sensors:
Radio Altimeter,
Air Data / Inertia Ref. System,
Accelerometers.
Pitch Axis
Roll Axis
Yaw Axis
Spoiler Law
Slat / Flap Law
Envelope Computation
(mech.)
Priority Lights
THS and Elevator
(el.)
Slat/Flap
Aileron
Spoiler
Rudder (el.)
(mech.)
Characteristic Speeds, etc.
PFD
SPEED
G/S
LOC
CAT 2
DH100
API
FDI
A/THR
1020
QNH


Pilots' Control Devices
Flight Control Laws
Control Surfaces and Displays
Loss of Pitch Augmentation
Monitoring and BITs
Software
Loss of Pitch Rate
Loss of Computers
SW Error
Dissimilarity
Redundancy
Loss of Gyro
Loss of Inertial Unit
Loss of Computer A
Loss of Computer B




Risk = Probability vs Severity

Basis of systems safety assessment

Applied to technical systems

# Safety

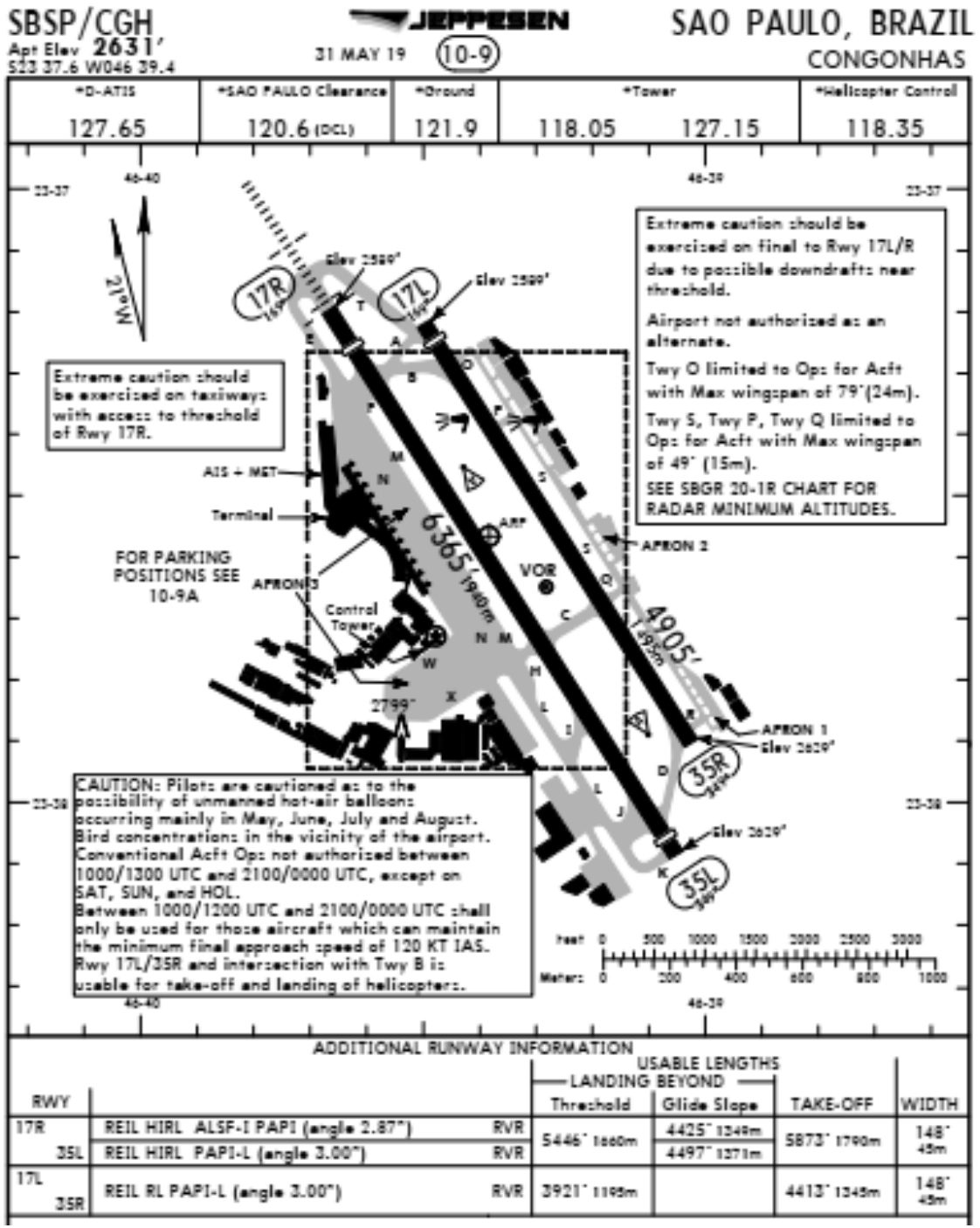
## Safety Risk Assessment in an operational context

- May be complemented by a subjective perspective: individual judgement and perception
- How to integrate both perspectives?


# Last case!

# Congonhas Airport (SBRJ)

Between 1000/1200 UTC and 2100/0000 UTC shall only be used for those aircraft which can maintain the minimum final approach speed of 120 KT IAS.




Thank you!


Questions?

**Marcelo Soares Leão**

**marcelo.leao@voeazul.com.br**