ICE, CONFUSION, AND THE 38,000 FOOT CRASH

NICKOLAS MEANS
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CONTENT WARNING

THIS IS A TALK ABOUT A PLANE CRASH

YOUR ODDS OF DYING ON A GIVEN FLIGHT (2018-2022):

1:13,700,000

SOURCE: “AIRLINE SAFETY: STILL GETTING BETTER?”
ARNOLD BARNETT & JAN REIG TORRA
JOURNAL OF AIR TRANSPORT MANAGEMENT

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YOUR ODDS OF DYING ON A GIVEN "SAFER" FLIGHT (2018-2022):

1:~80,000,000

SOURCE: "AIRLINE SAFETY: STILL GETTING BETTER?"
ARNOLD BARNETT & JAN REIG TORRA
JOURNAL OF AIR TRANSPORT MANAGEMENT

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GERMANY 3V3 BASKETBALL WINS GOLD

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866
PARIS GOLD MEDALS
8,100,000,000
GLOBAL POPULATION
@nmeans
PHOTO: ©2024 MAXIMILIAN SPECHT, FAIR USE
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866

PARIS GOLD MEDALS

8,100,000,000

GLOBAL POPULATION

1:9,353,349

YOUR PERSONAL ODDS OF WINNING AN OLYMPIC GOLD MEDAL, JUST BY BEING ALIVE IN 2024

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8.6X

MORE LIKELY TO WIN AN OLYMPIC GOLD MEDAL THAN DIE IN A PLANE CRASH

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AIR FRANCE AIRBUS A330-203 F-GZCP

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CAPTAIN
MARC DUBOIS

FIRST OFFICER
PIERRE-CÉDRIC BONIN

FIRST OFFICER
DAVID ROBERT

PHOTOS: ORIGINAL SOURCE UNKNOWN, FAIR USE

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MARC DUBOIS

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PIERRE-CÉDRIC BONIN

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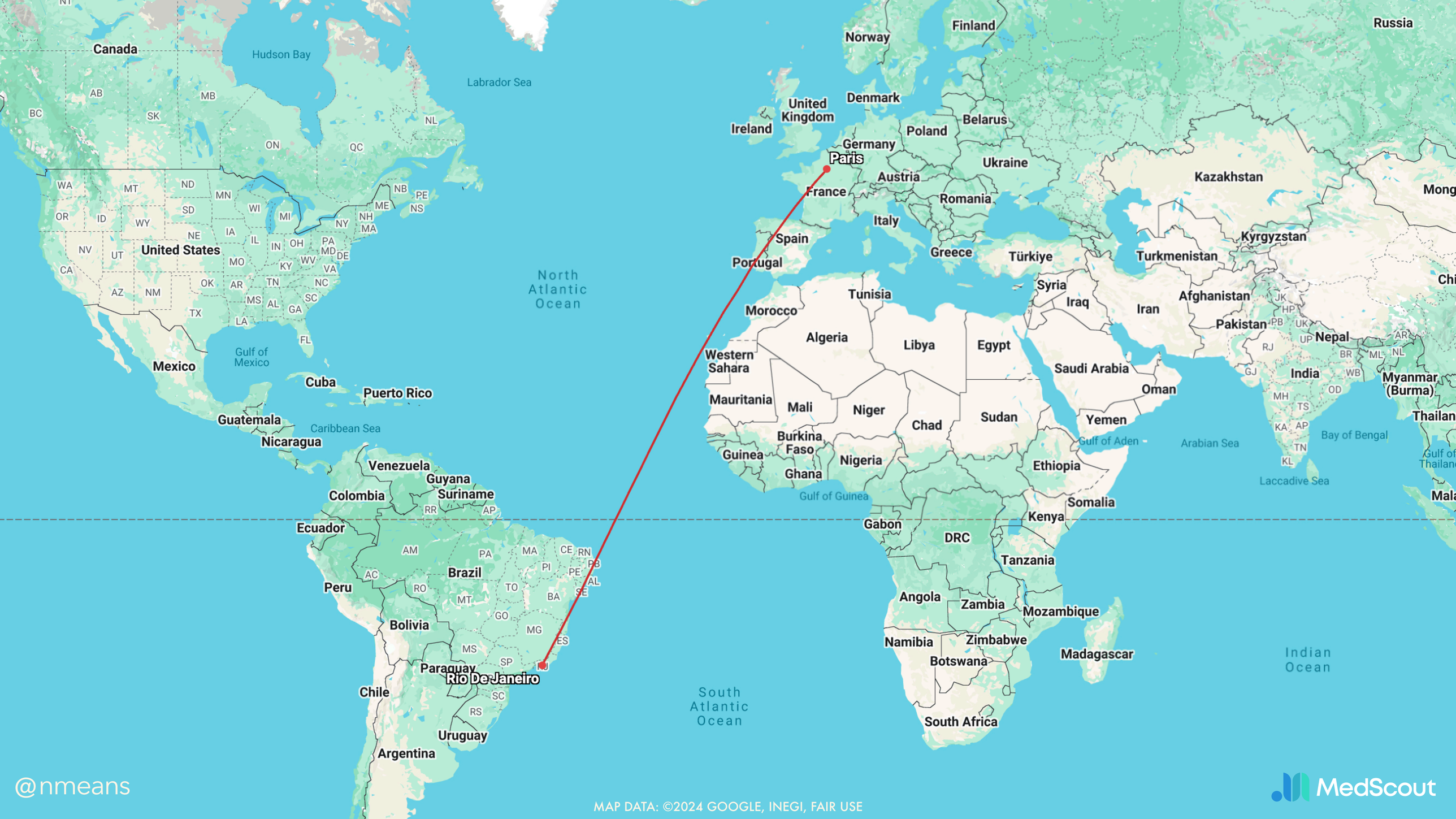
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Chile
Uruguay
Argentina
North Atlantic Ocean
South Atlantic Ocean
Norway
Finland
Russia
Ireland
United Kingdom
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Germany
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Kyrgyzstan
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Chad
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Yemen
Gulf of Aden
Arabian Sea
Bay of Bengal
Laccadive Sea
Guinea
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Ghana
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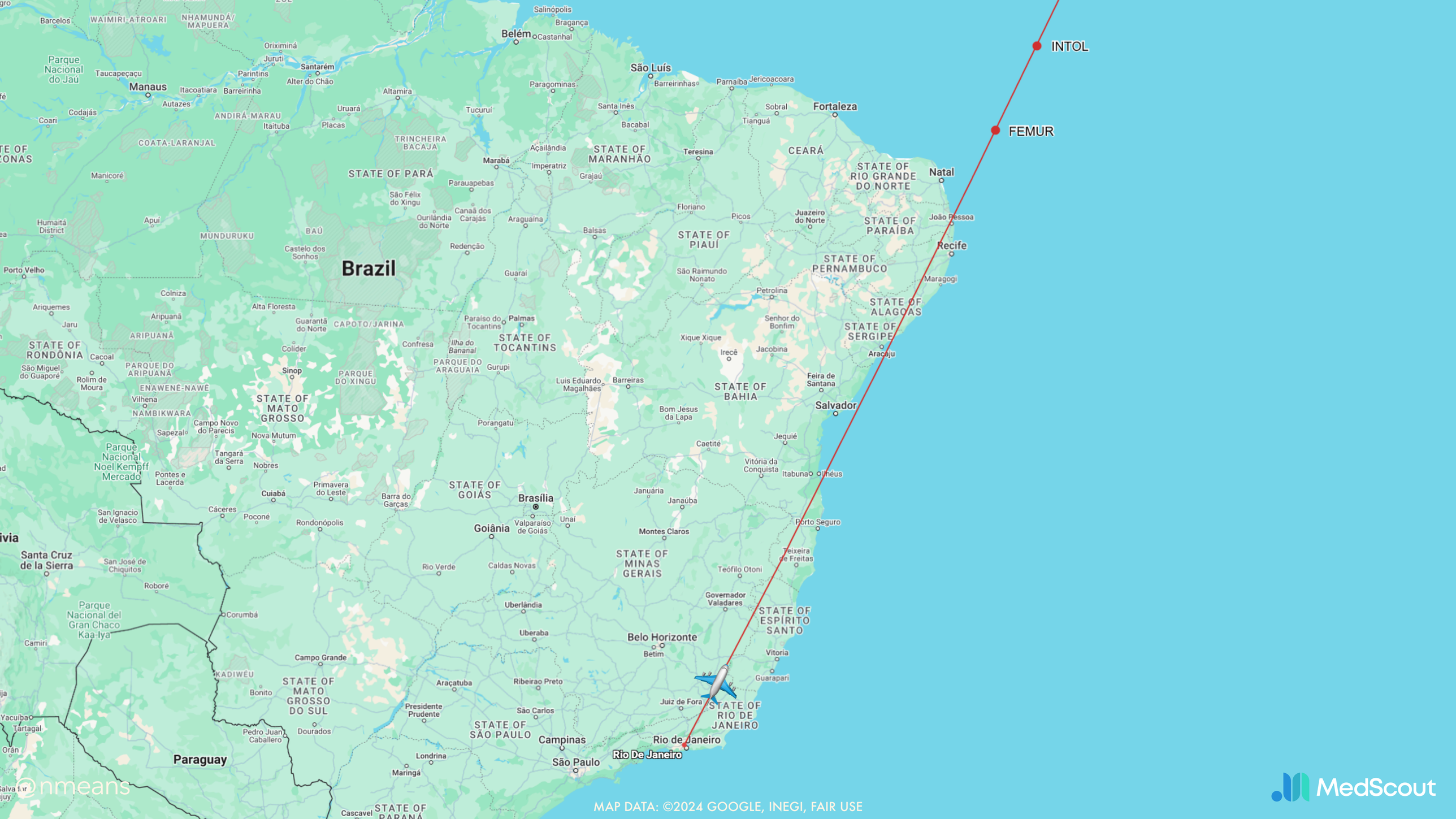
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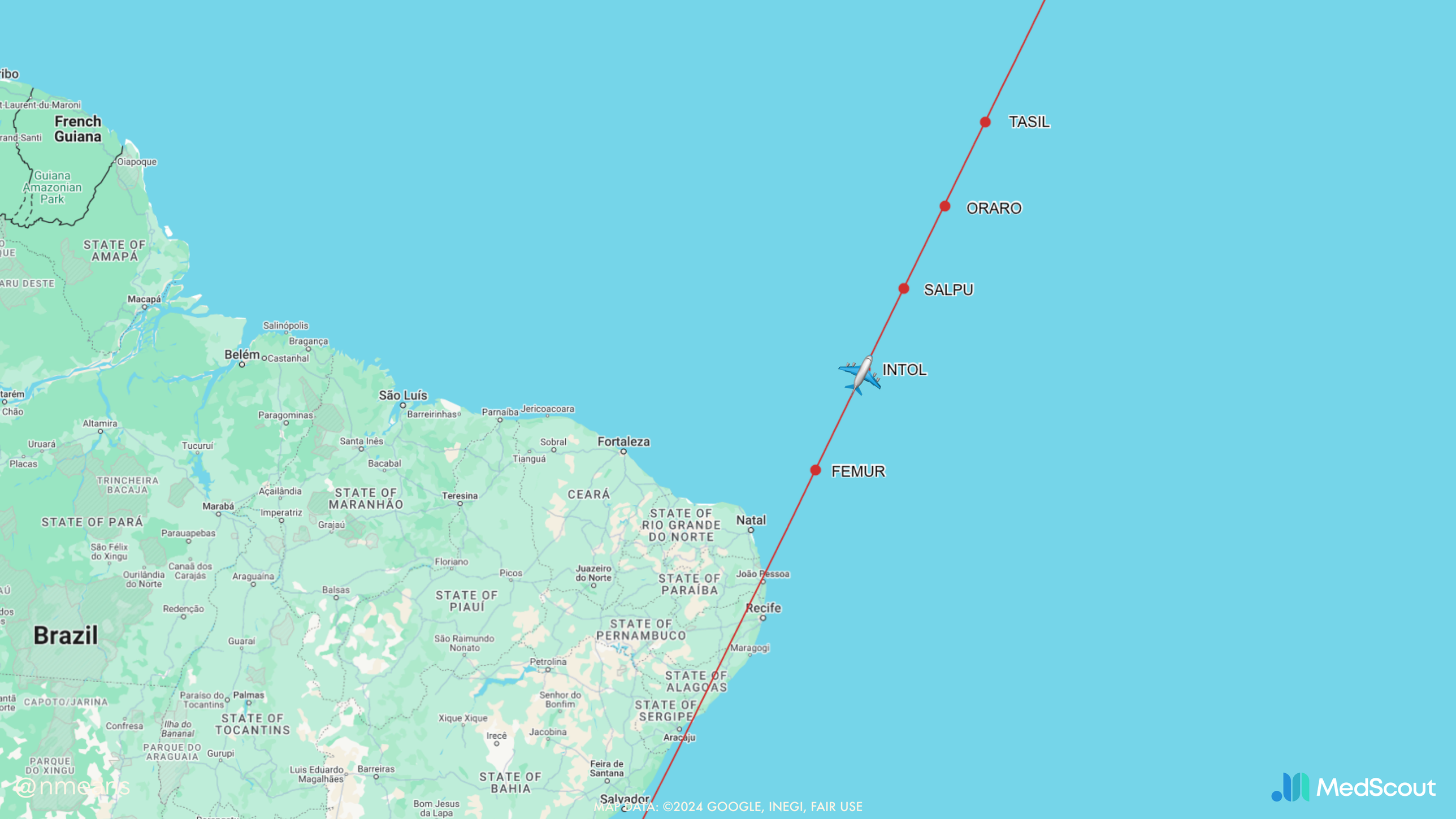
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ATC REPORTING MENU, AIRBUS A330 CDU

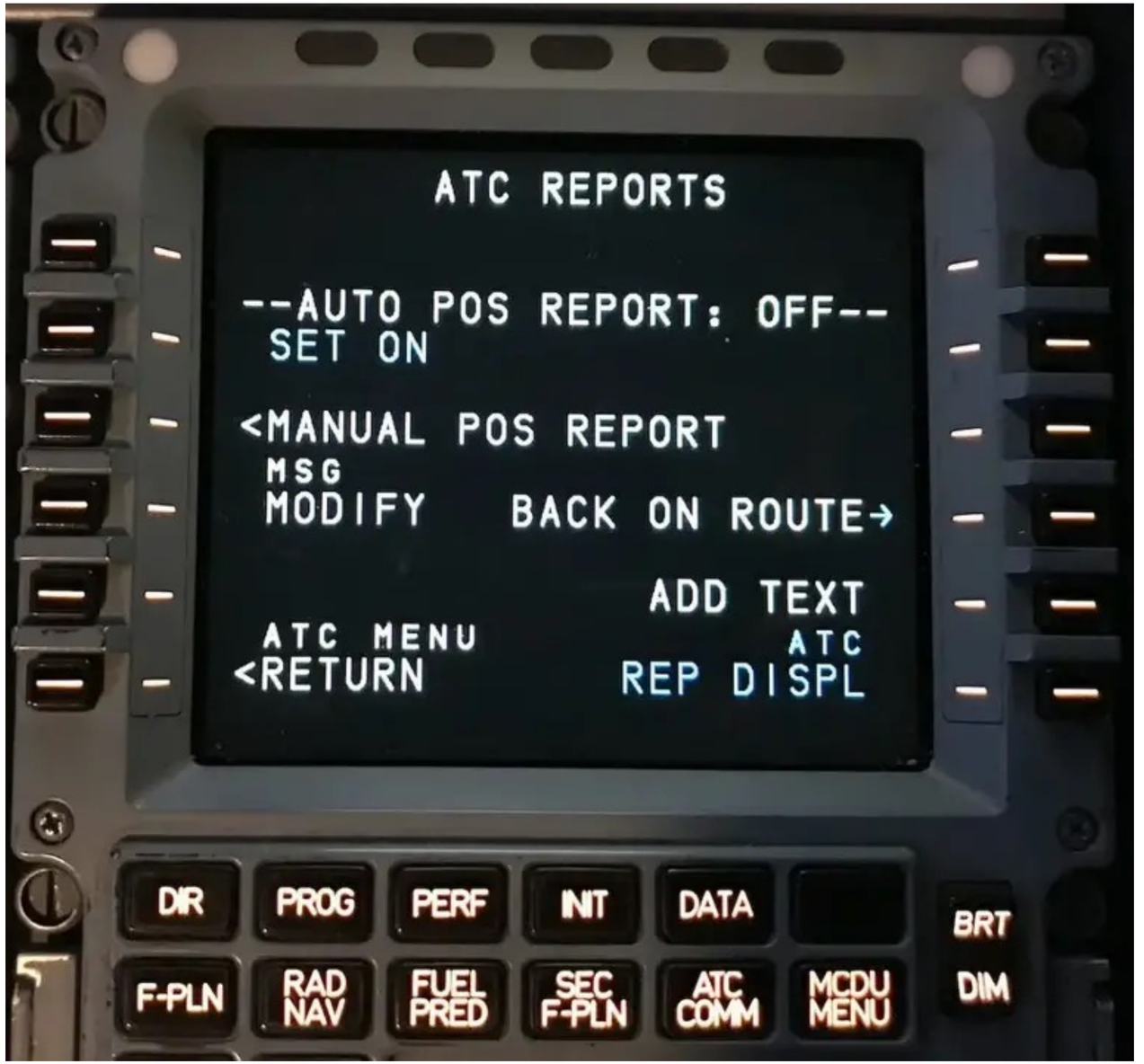

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PHOTO: © AVIATIONMATTERS.CO, FAIR USE

AFR4P AF4 B77W

Air France

flightradar24

Tracked by satellite

3,645 km, 04:09 ago 2,209 km, in 03:05

More AF4 information

AIRCRAFT TYPE (B77W)
Boeing 777-328(ER)

REGISTRATION
F-GSQU

COUNTRY OF REG.

SERIAL NUMBER (MSN)
32847

AGE (Mar 2007)
17 years

Recent F-GSQU flights

BAROMETRIC ALT.
35,000 ft

VERTICAL SPEED
0 fpm

GPS ALTITUDE
N/A

TRACK
267°

Speed & Altitude graph

GROUND SPEED
494 kts

TRUE AIRSPEED
N/A

INDICATED AIRSPEED
N/A

MACH
N/A

WIND
N/A

TEMPERATURE
N/A

FIR/UIR
N/A

Data source - Satellite

ICAO 24-BIT ADDRESS
394A14

SQUAWK
N/A

LATITUDE
49.07806

LONGITUDE
-48.27887

flightradar24 Travelers

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AFR4P

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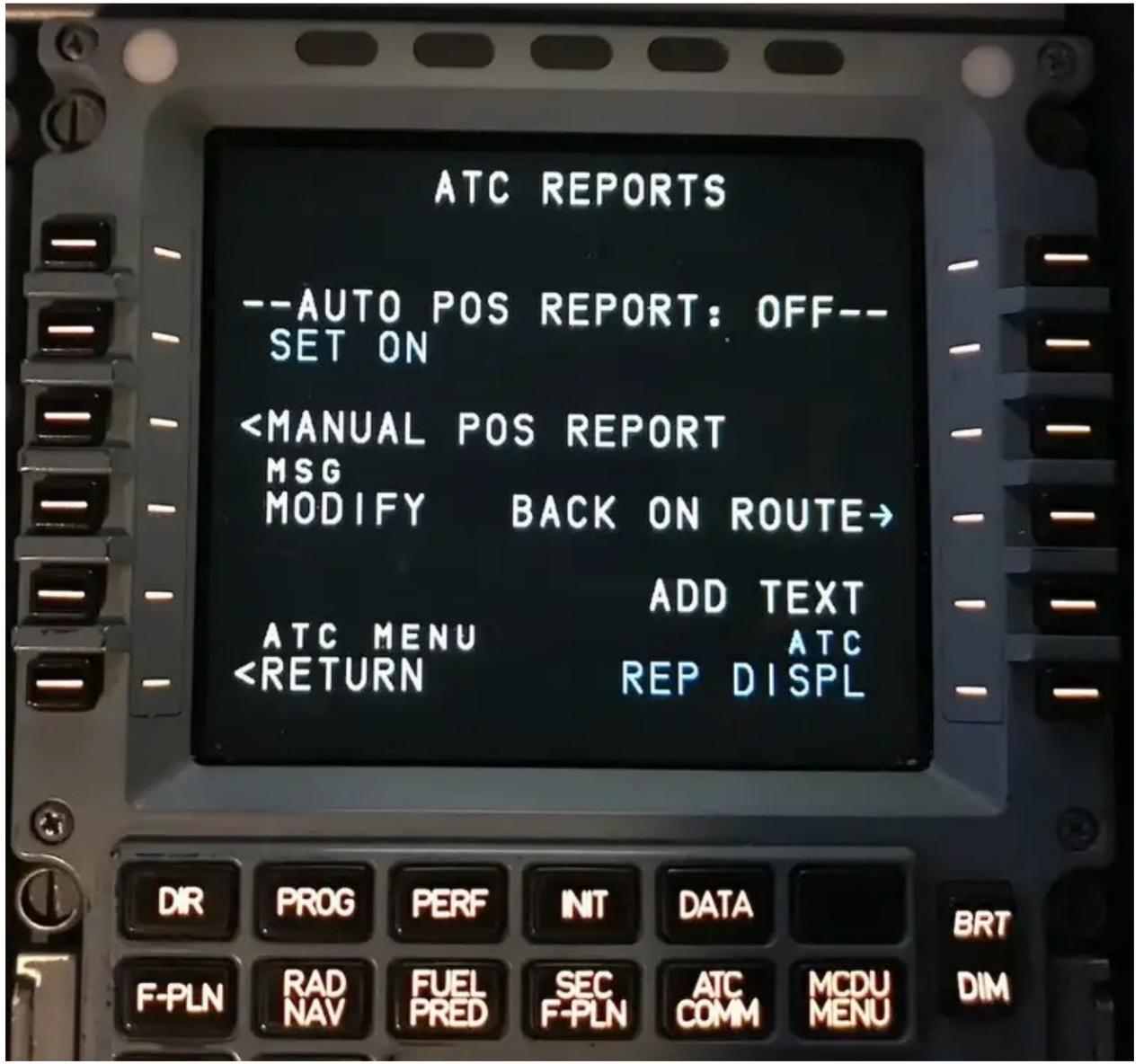
ATC REPORTING MENU, AIRBUS A330 CDU



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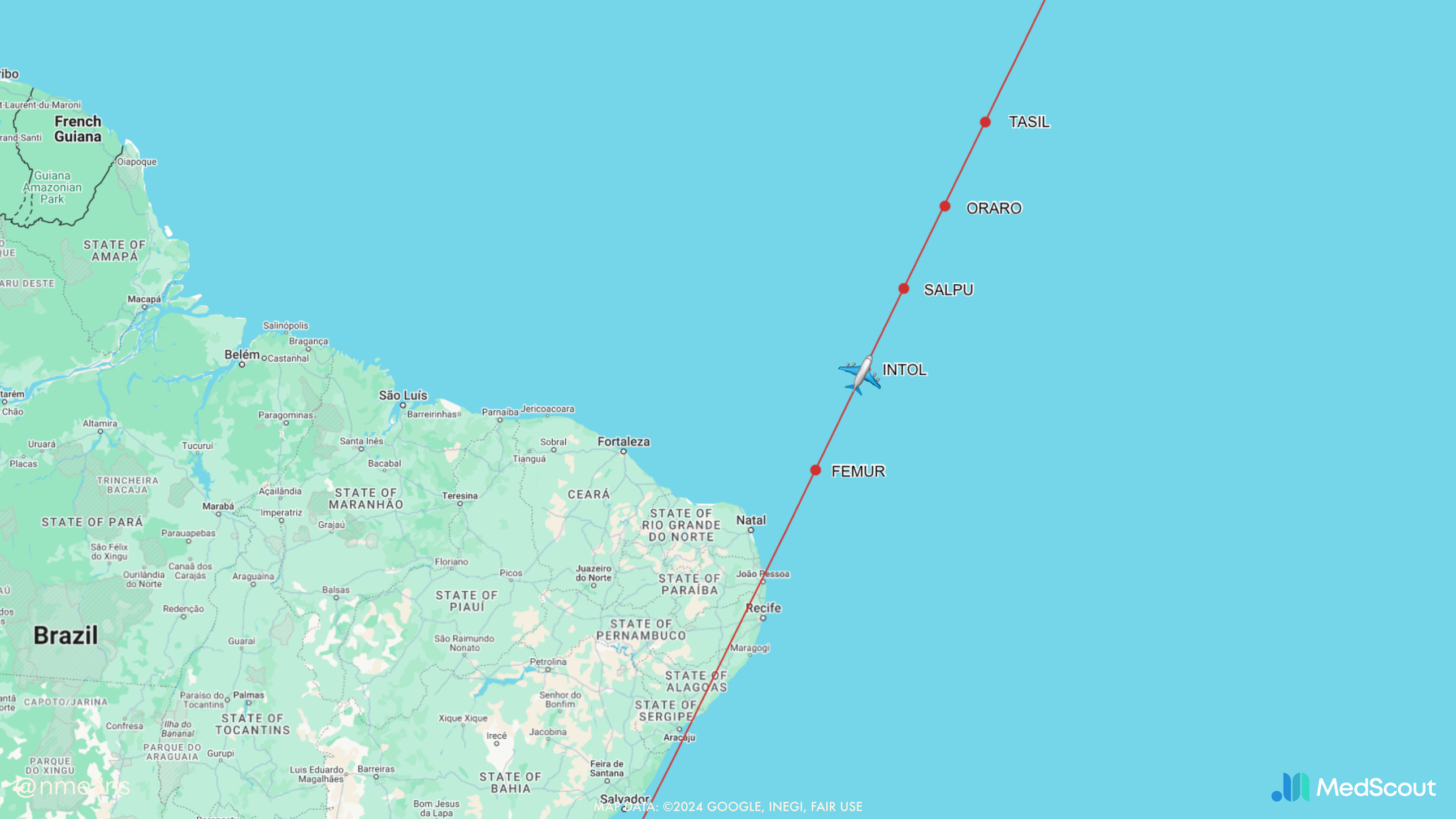
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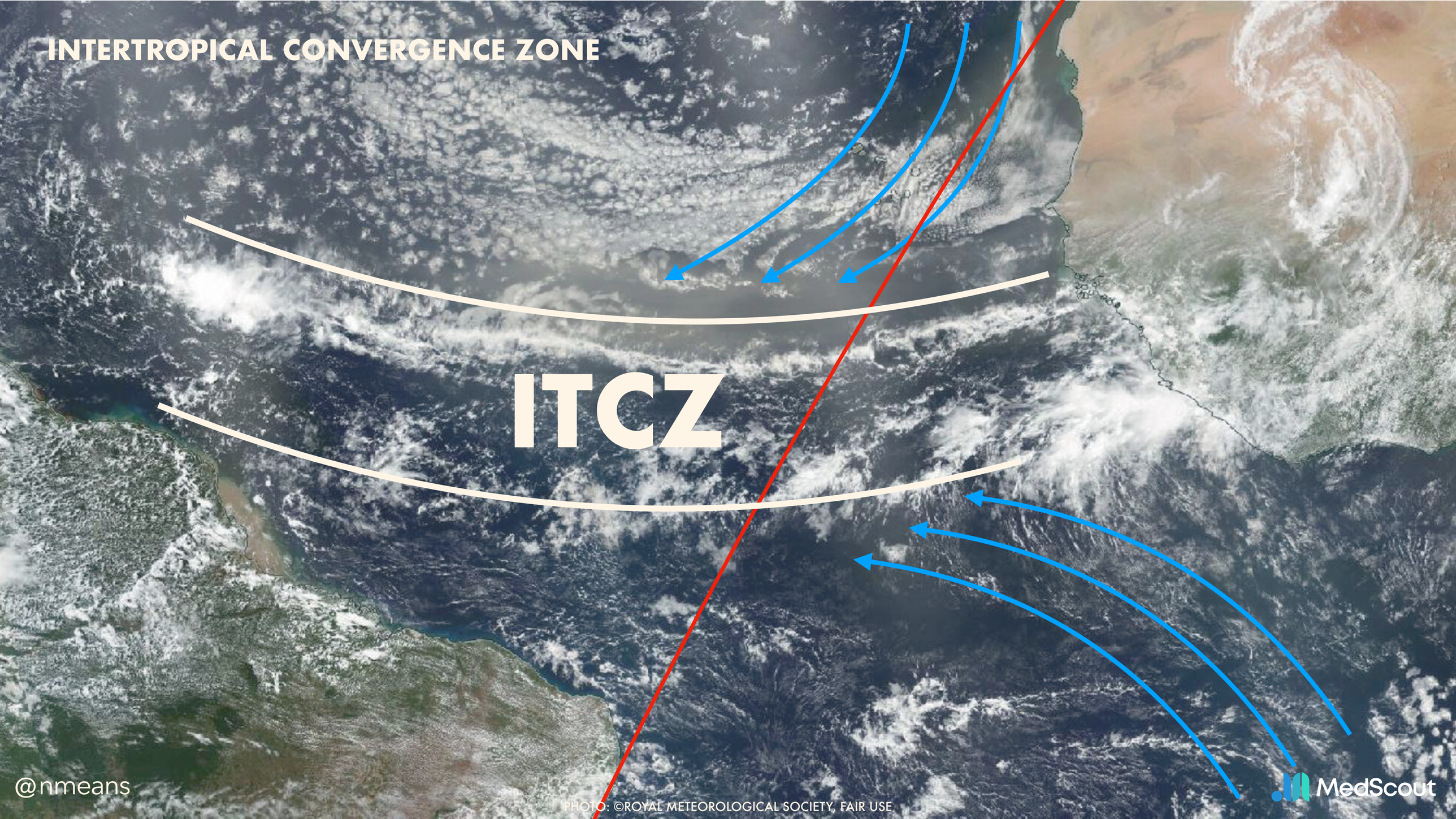

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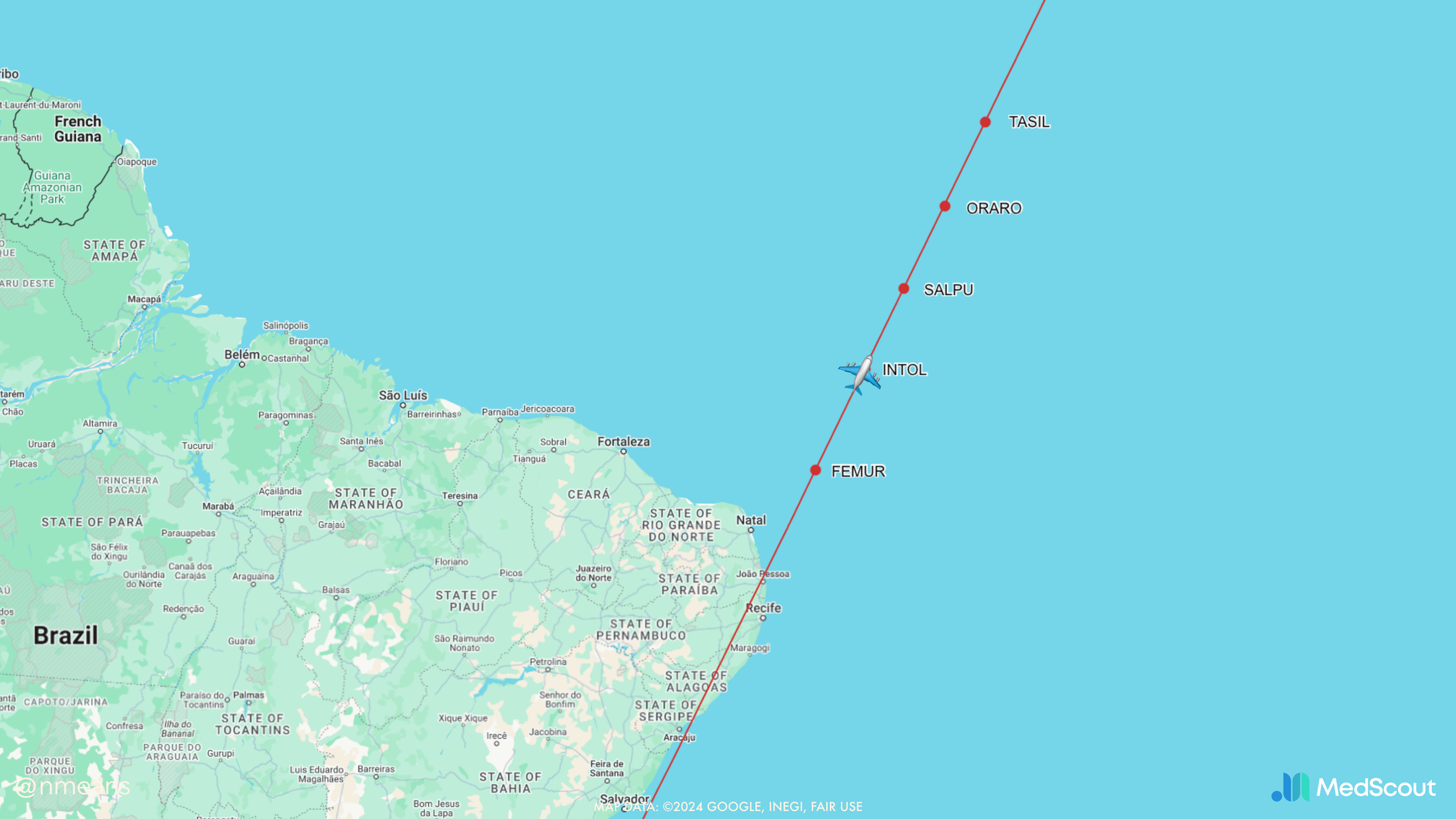
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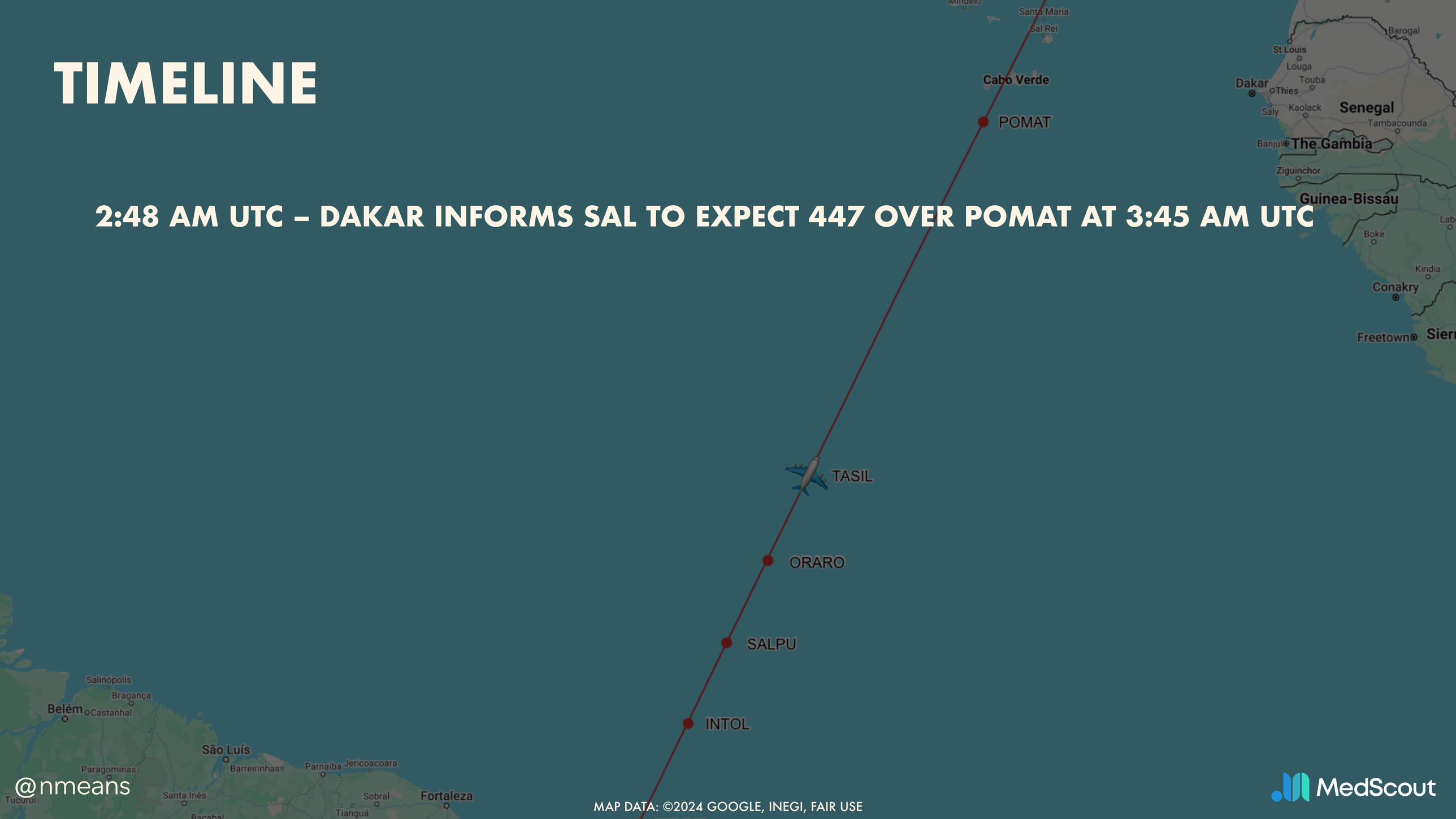
TIMELINE

2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC



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TIMELINE

2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC

3:54 AM UTC – SAL CONTACTS DAKAR TO CONFIRM ESTIMATE

@nmeans

MedScout

TIMELINE

2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC

3:54 AM UTC – SAL CONTACTS DAKAR TO CONFIRM ESTIMATE

4:08 AM UTC – SAL CONTACTS DAKAR AGAIN; STILL NO CONTACT

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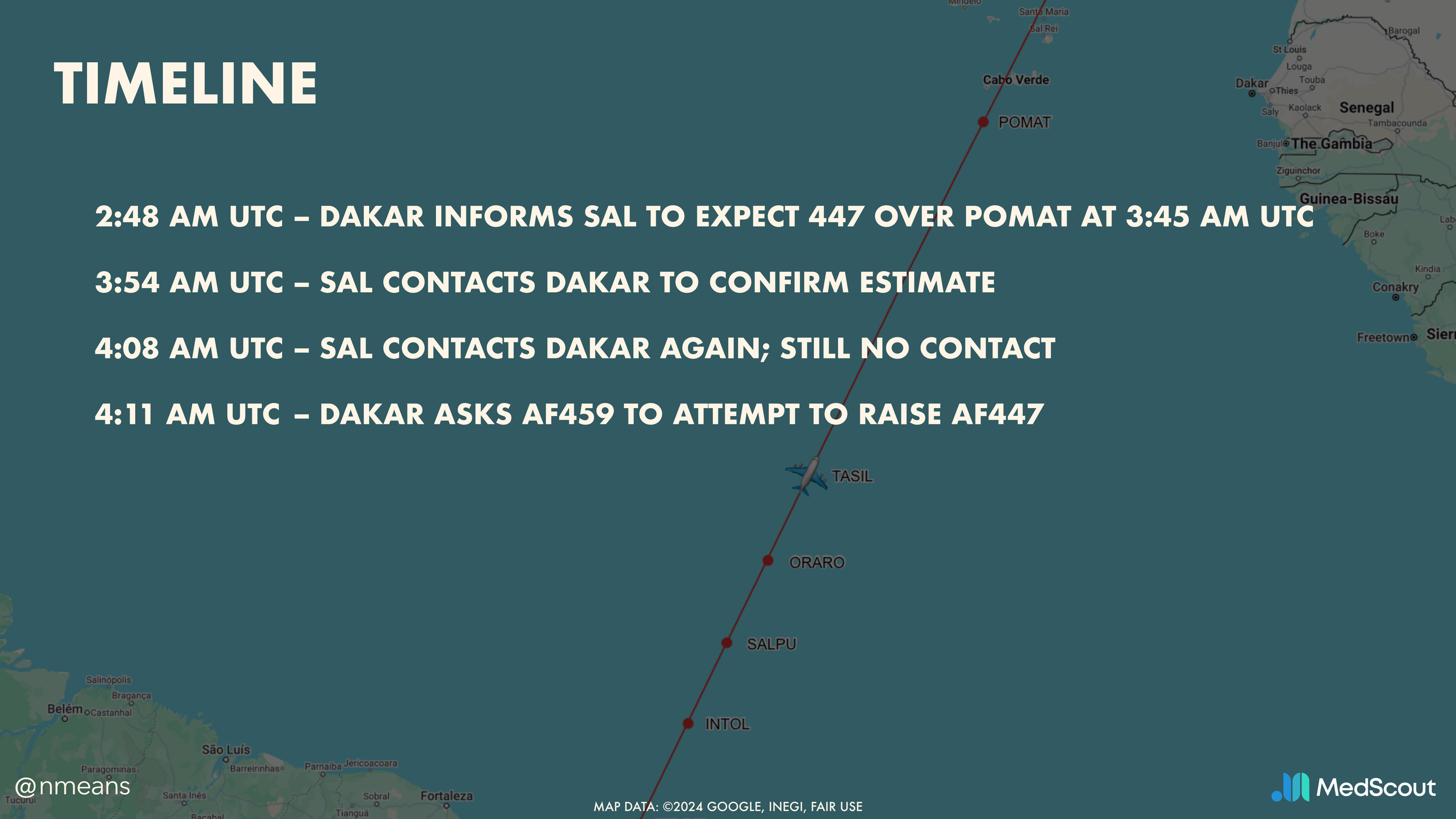
TIMELINE

2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC

3:54 AM UTC – SAL CONTACTS DAKAR TO CONFIRM ESTIMATE

4:08 AM UTC – SAL CONTACTS DAKAR AGAIN; STILL NO CONTACT

4:11 AM UTC – DAKAR ASKS AF459 TO ATTEMPT TO RAISE AF447



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TIMELINE

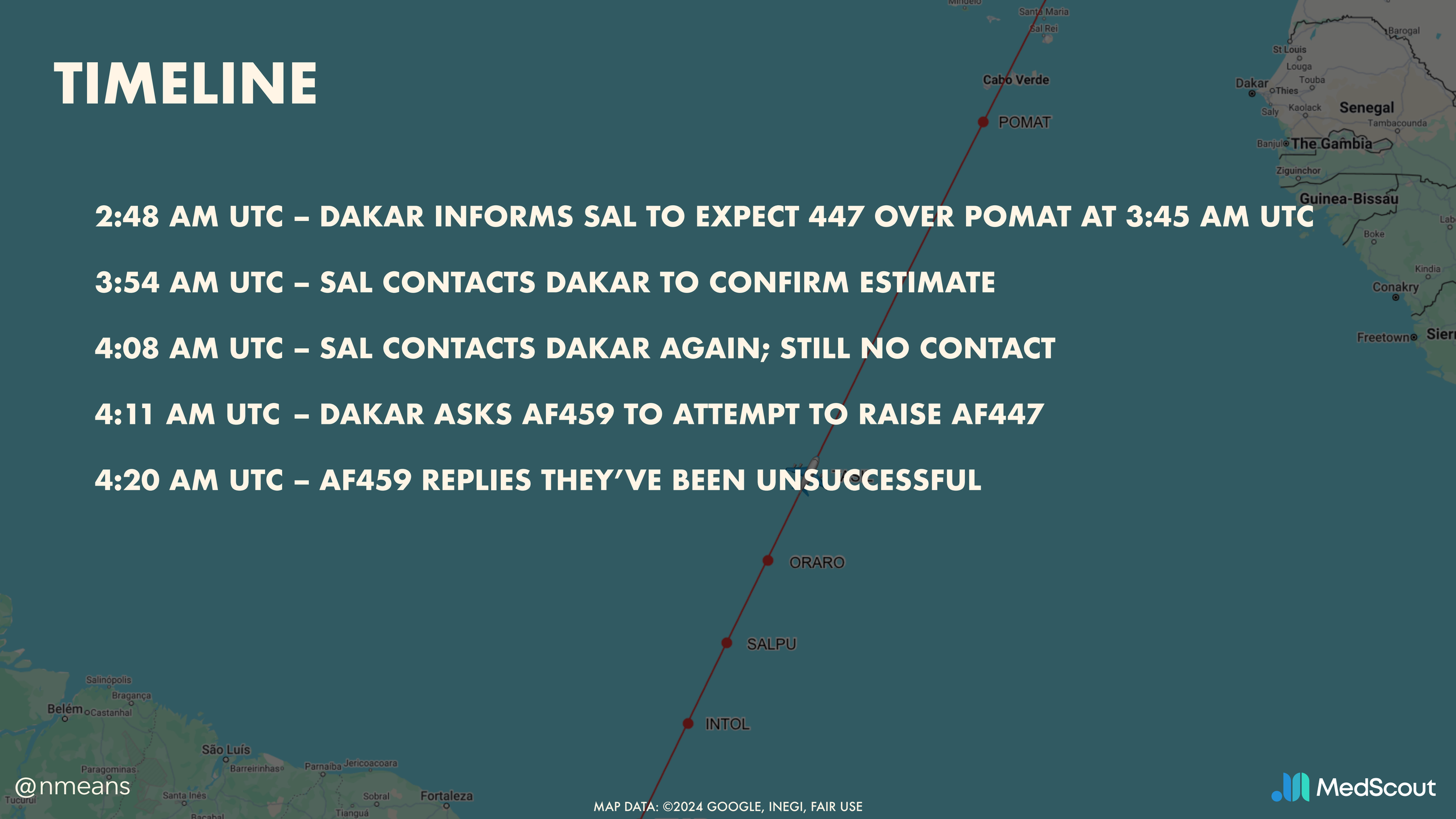
2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC

3:54 AM UTC – SAL CONTACTS DAKAR TO CONFIRM ESTIMATE

4:08 AM UTC – SAL CONTACTS DAKAR AGAIN; STILL NO CONTACT

4:11 AM UTC – DAKAR ASKS AF459 TO ATTEMPT TO RAISE AF447

4:20 AM UTC – AF459 REPLIES THEY'VE BEEN UNSUCCESSFUL



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TIMELINE

2:48 AM UTC – DAKAR INFORMS SAL TO EXPECT 447 OVER POMAT AT 3:45 AM UTC

3:54 AM UTC – SAL CONTACTS DAKAR TO CONFIRM ESTIMATE

4:08 AM UTC – SAL CONTACTS DAKAR AGAIN; STILL NO CONTACT

4:11 AM UTC – DAKAR ASKS AF459 TO ATTEMPT TO RAISE AF447

4:20 AM UTC – AF459 REPLIES THEY'VE BEEN UNSUCCESSFUL

4:37 AM UTC – DAKAR CHECKS WITH SAL AGAIN

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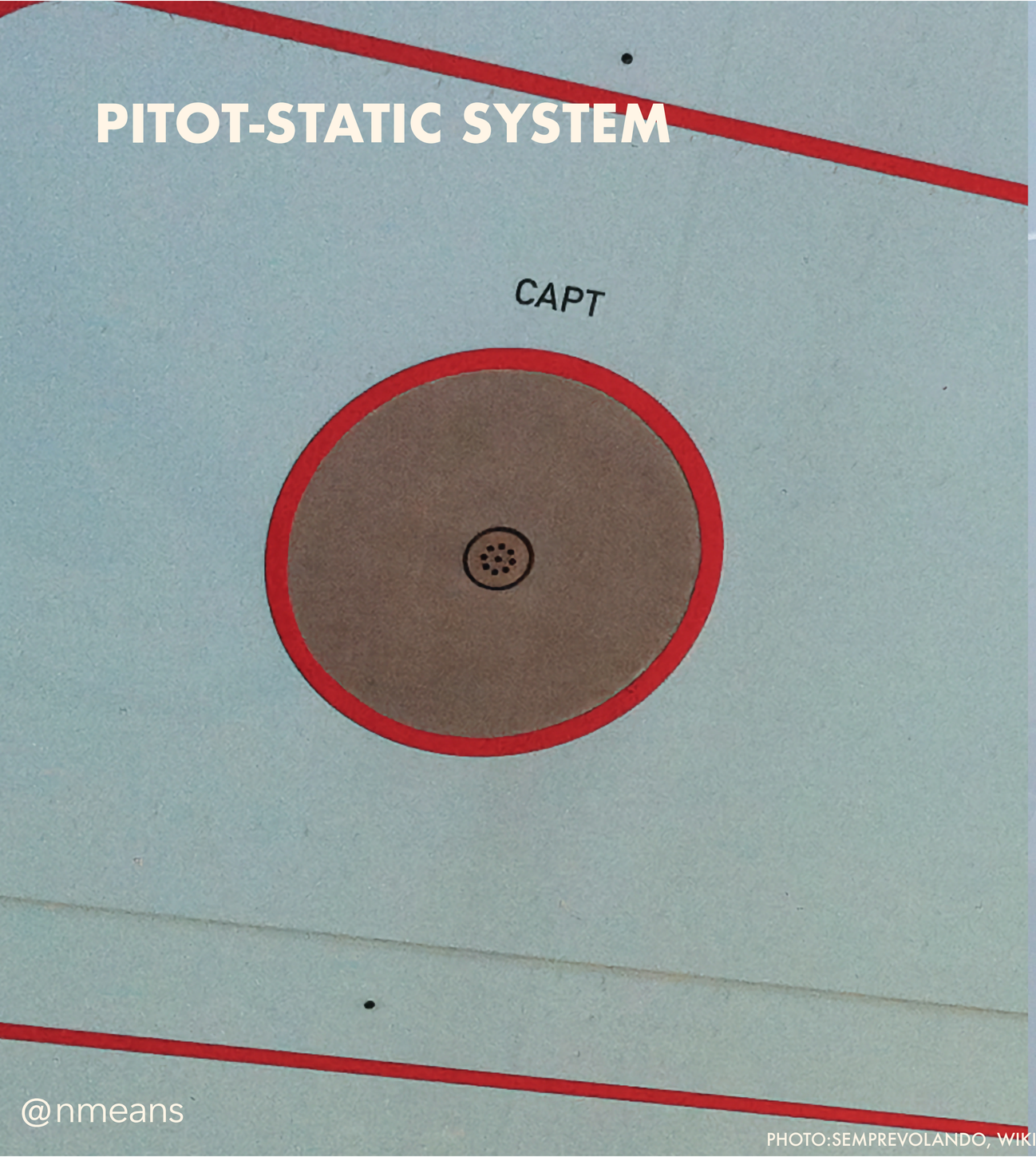
PITOT-STATIC SYSTEM



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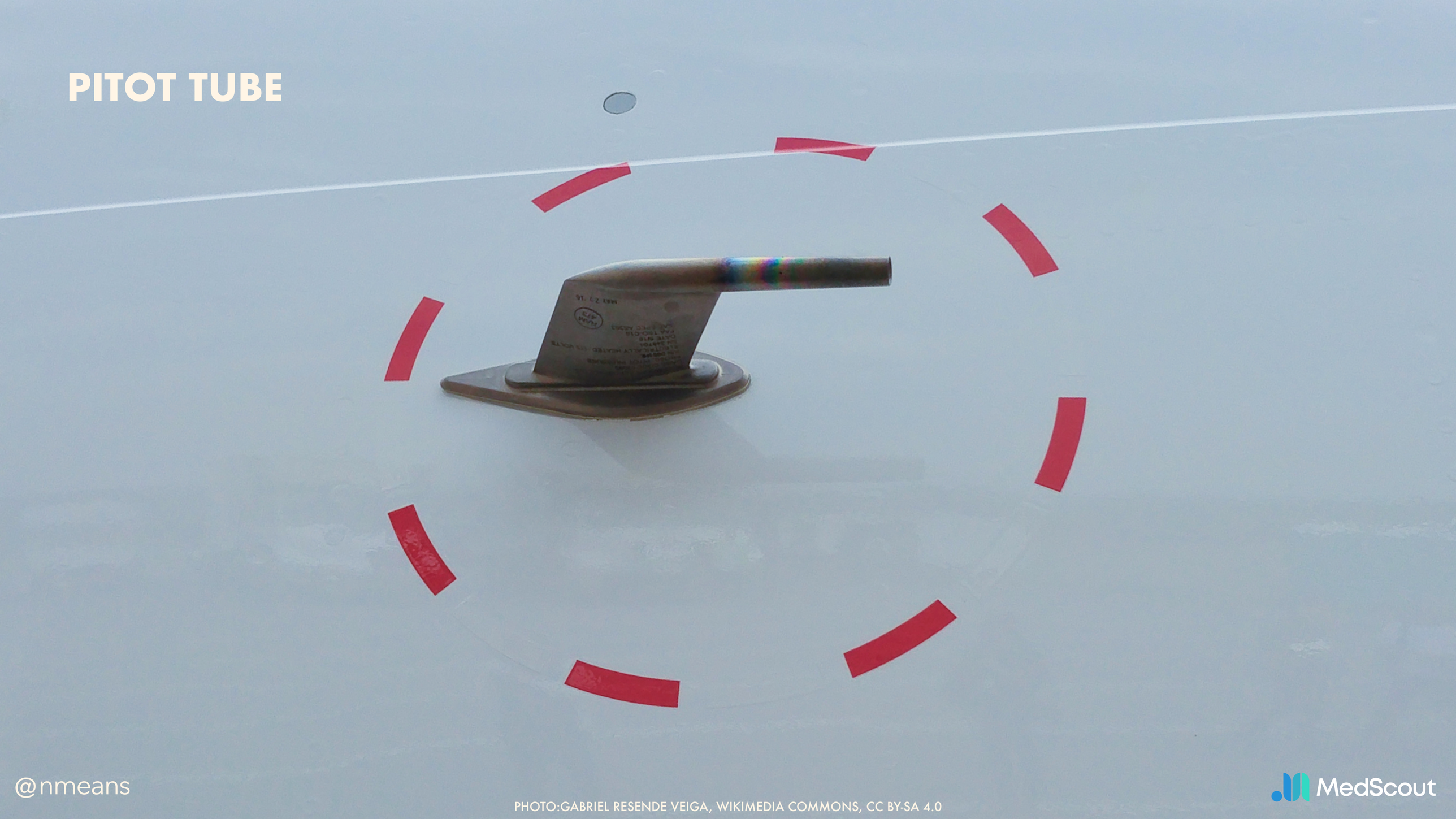
PITOT TUBE



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A330 PITOT TUBES

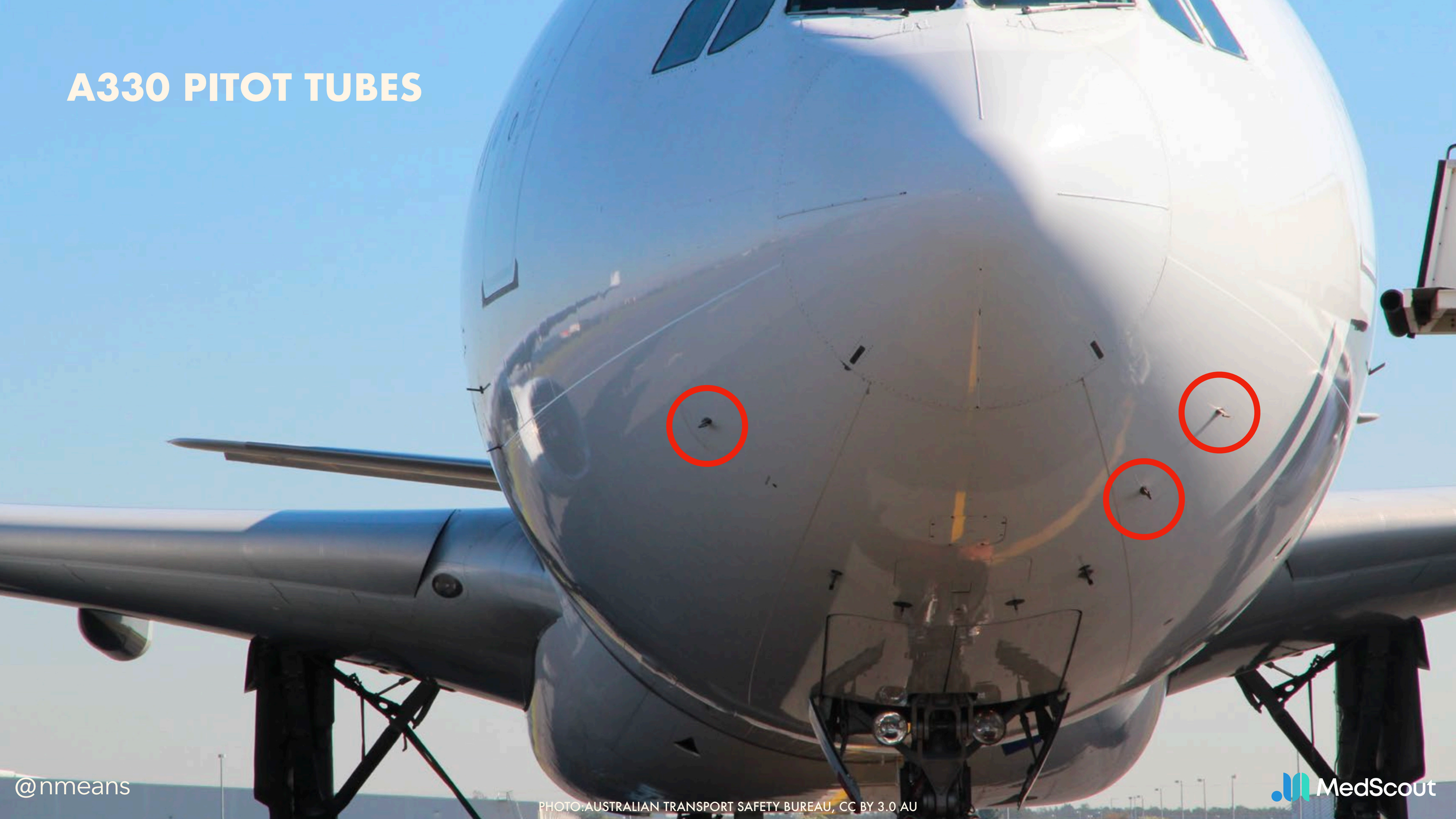

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PHOTO:AUSTRALIAN TRANSPORT SAFETY BUREAU, CC BY 3.0 AU

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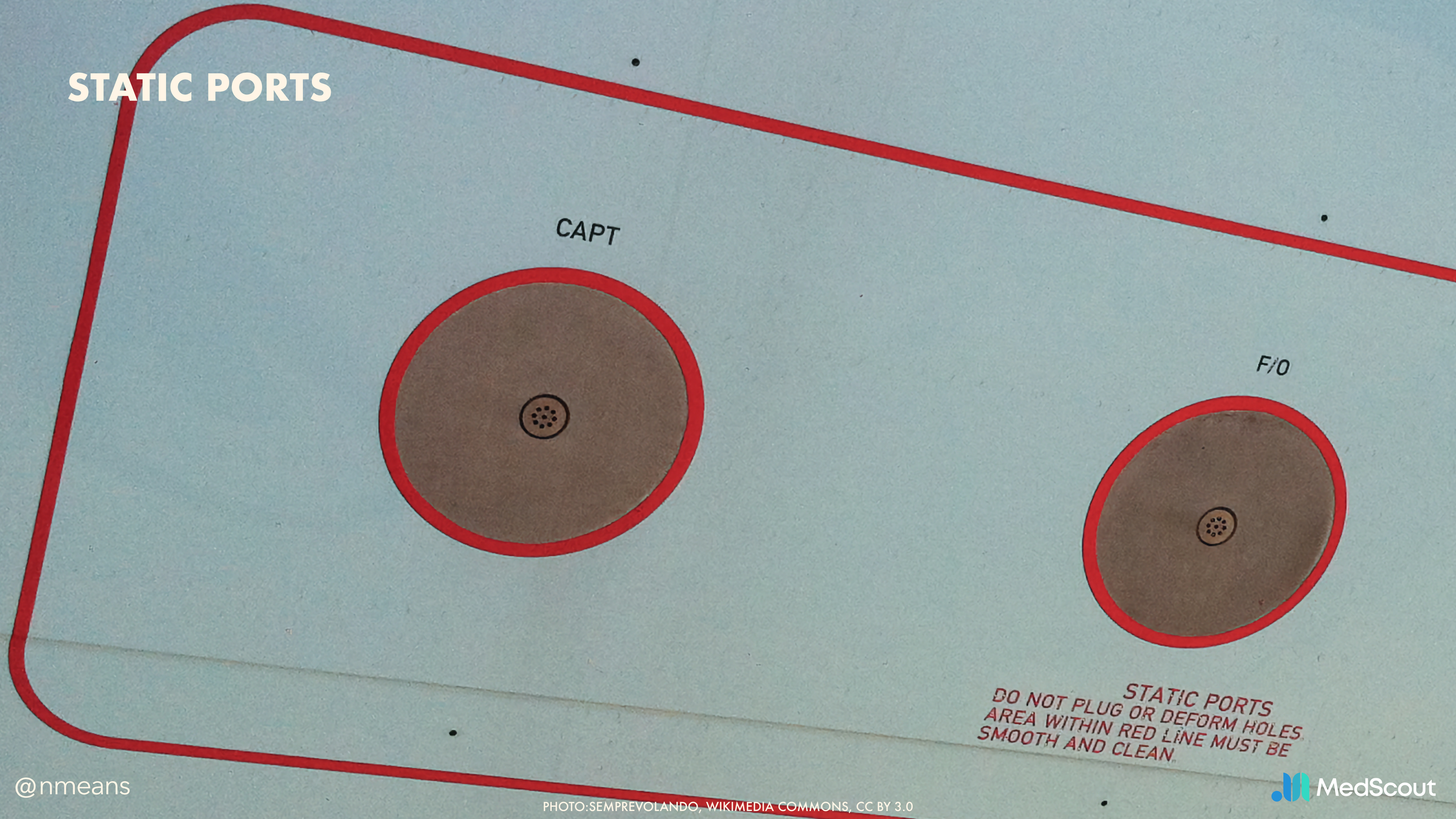
STATIC PORTS



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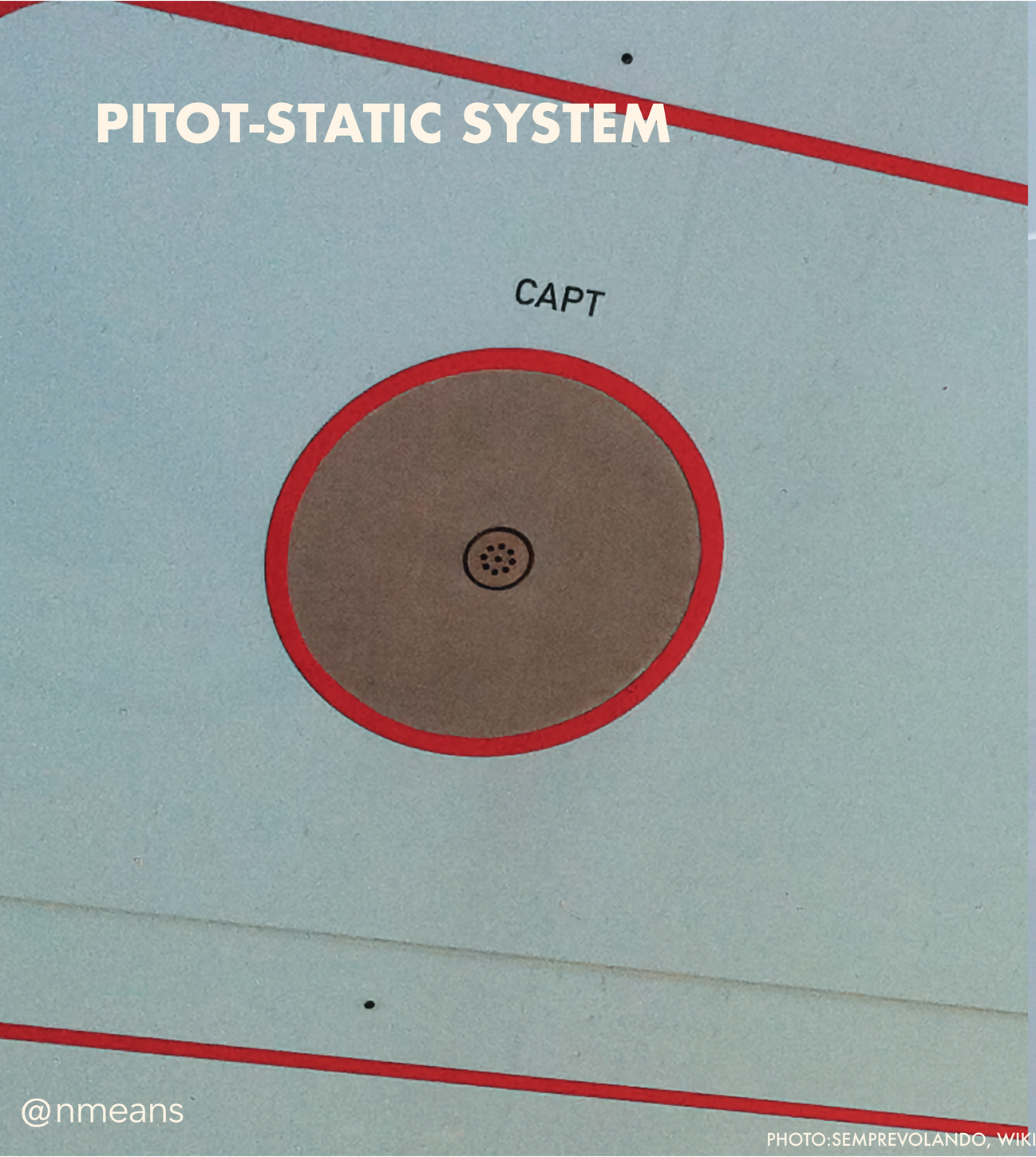

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Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

RECOVERY OF VERTICAL STABILIZER

PHOTO: ©2009 FORÇA AÉREA BRASILEIRA, FAIR USE

PITOT TUBE

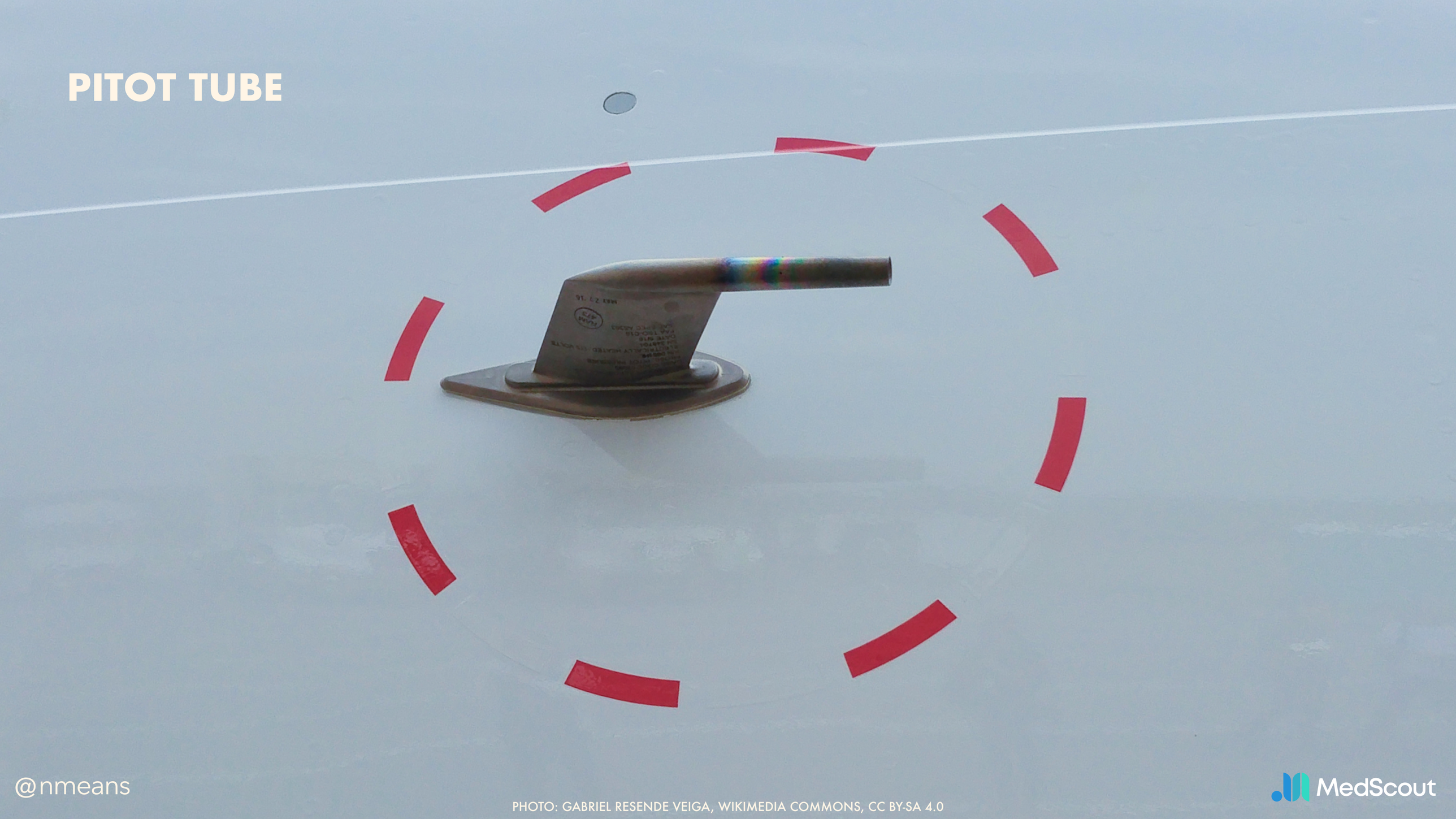

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PHOTO: GABRIEL RESENDE VEIGA, WIKIMEDIA COMMONS, CC BY-SA 4.0

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RECOVERY OF VERTICAL STABILIZER

PHOTO: ©2009 FORÇA AÉREA BRASILEIRA, FAIR USE

RECOVERY OF COCKPIT VOICE RECORDER

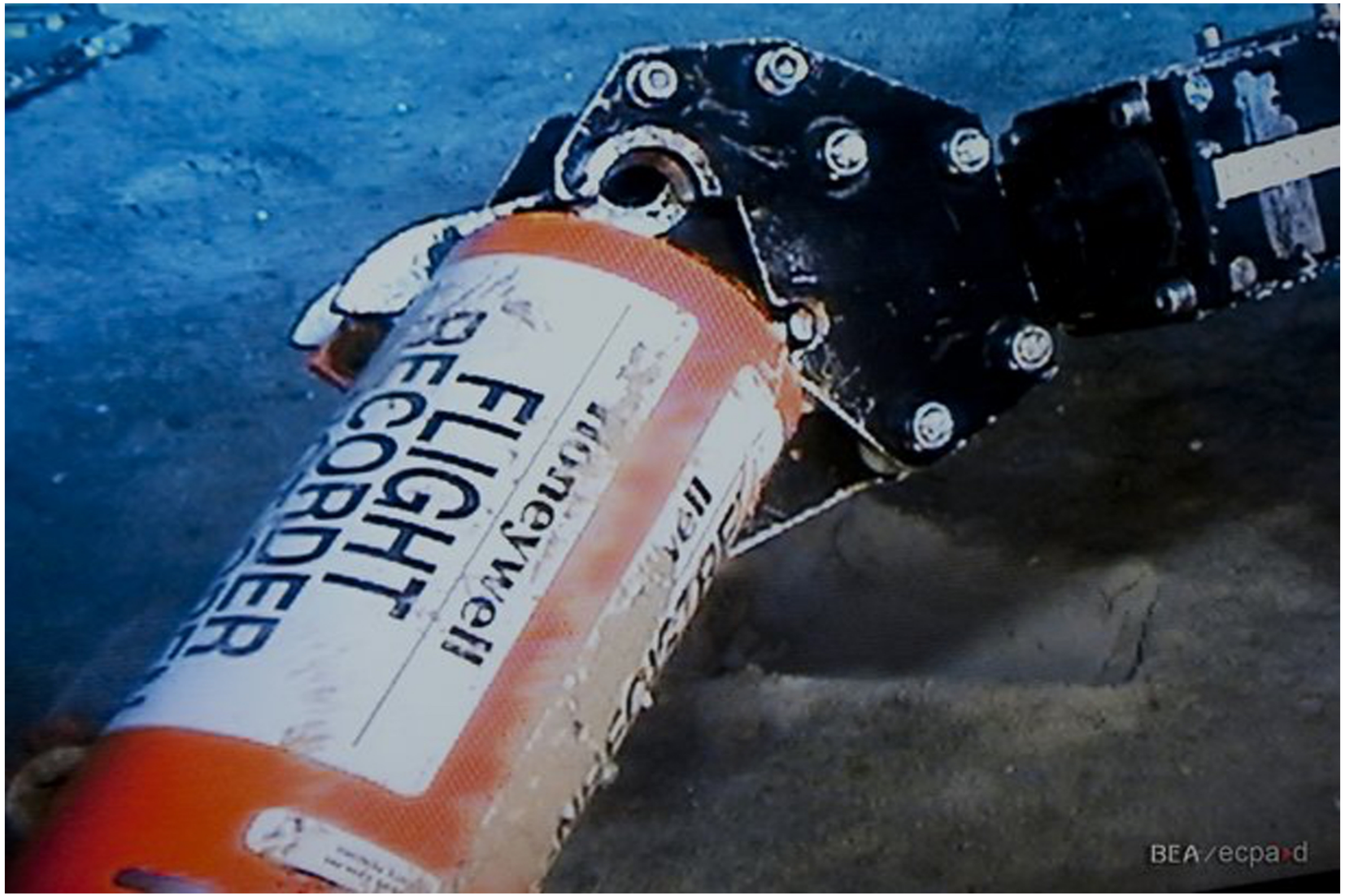

PHOTO: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

Santa Maria
Sal Rei
Cabo Verde
POMAT
Barogal
St Louis
Louga
Dakar
Thies
Touba
Saly
Kaolack
Senegal
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
TASIL
ORARO
SALPU
INTOL
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
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"[WE SHOULD TRY] TO ASK THE THREE SIX NON STANDARD BECAUSE WE'RE REALLY AT THE LIMIT"

– FIRST OFFICER BONIN 1:50:21 UTC

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MedScout

INTERTROPICAL CONVERGENCE ZONE STORM HEIGHT

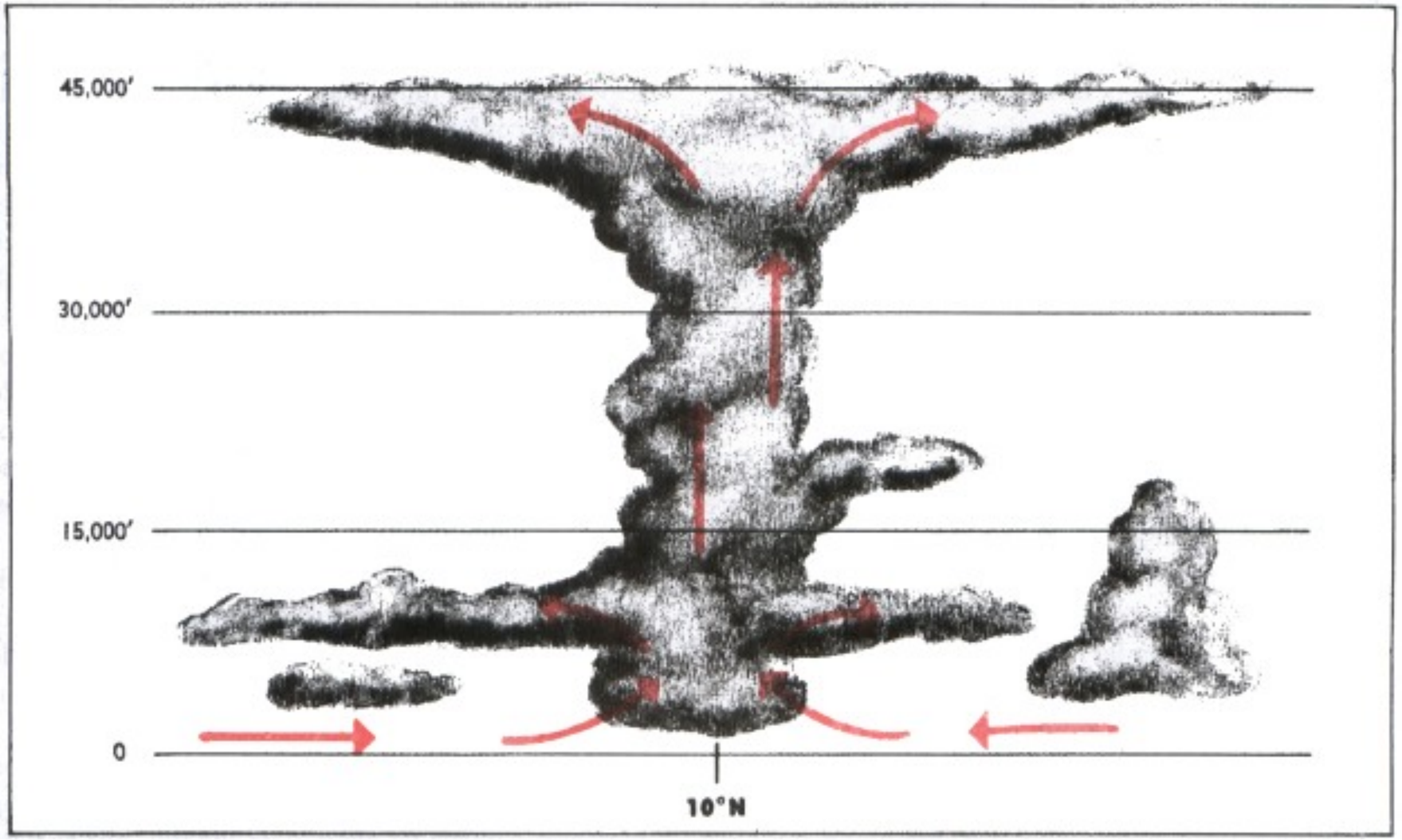

DIAGRAM: FAA AVIATION WEATHER GUIDE, US GOVERNMENT WORK, PUBLIC DOMAIN

"ALL WE NEEDED WAS MISTER SAINT-ELMO"
– CAPTAIN DUBOIS 1:51:21 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Salinópolis
Bragança
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
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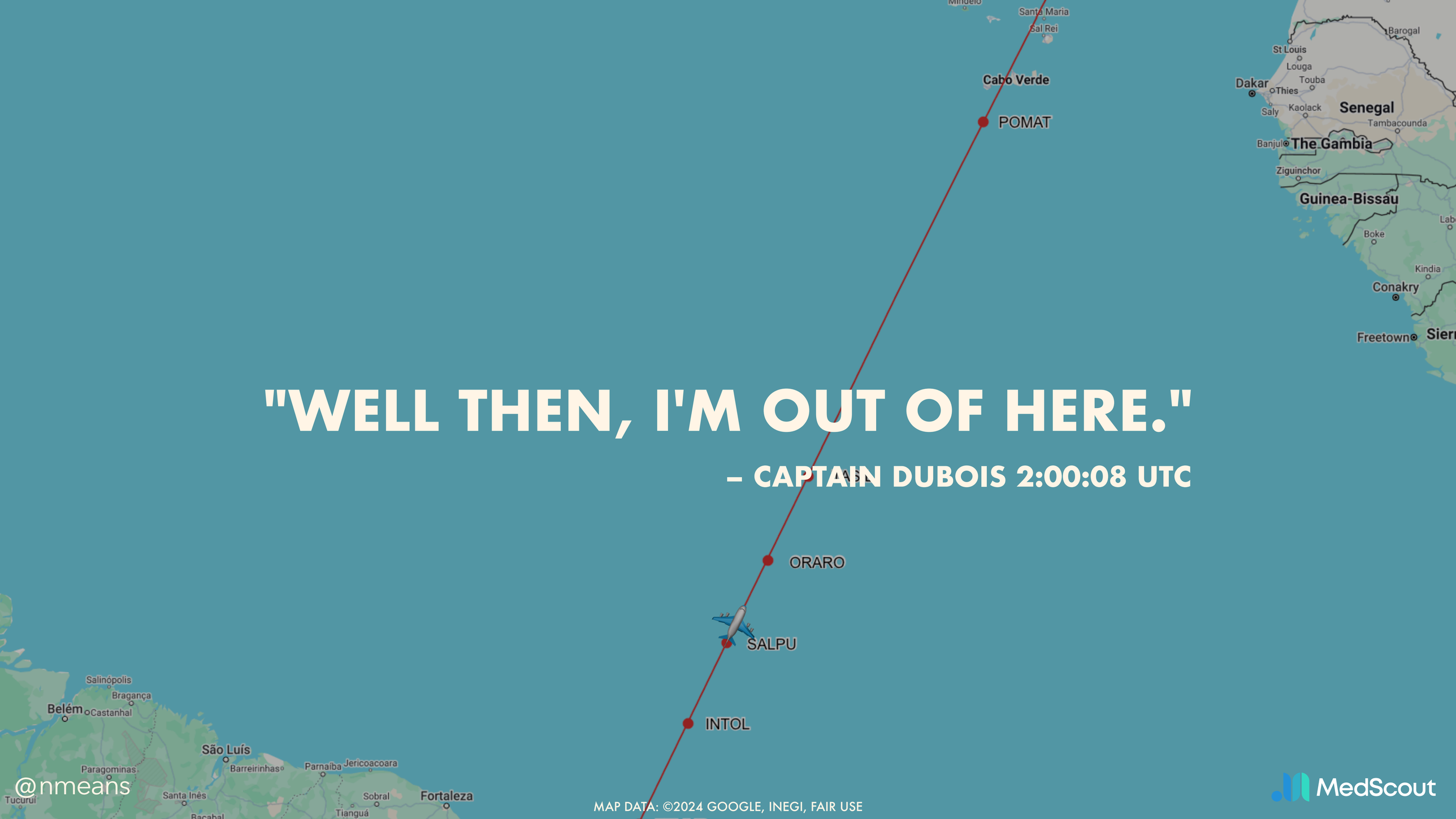
ST. ELMO'S FIRE

@nmeans

PHOTO: REDDIT USER HOOKIEBOOKIE_, FAIR USE

MedScout

"IT'S GOING TO BE TURBULENT WHEN I GO FOR MY REST"
– CAPTAIN DUBOIS 1:51:58 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout


"WELL THEN, I'M OUT OF HERE."
– CAPTAIN DUBOIS 2:00:08 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
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Santa Maria
Sal Rei
Cabo Verde
POMAT
Barogal
St Louis
Louga
Dakar
Touba
Thies
Saly
Kaolack
Senegal
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
"DON'T YOU MAYBE WANT TO GO TO THE LEFT A BIT?"
– FIRST OFFICER ROBERT 2:08:03 UTC
TASIL
ORARO
SALPU
INTOL
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
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"YOU DID SOMETHING TO THE A/C?"
– FIRST OFFICER BONIN 2:08:36 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

"WHAT'S THAT SMELL, NOW?"
– FIRST OFFICER BONIN 2:08:41 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Saly
Kaolack
Senegal
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Barogal
St Louis
Louga
Touba
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

"I HAVE THE CONTROLS"
– FIRST OFFICER BONIN 2:10:06 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Salinópolis
Bragança
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
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MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
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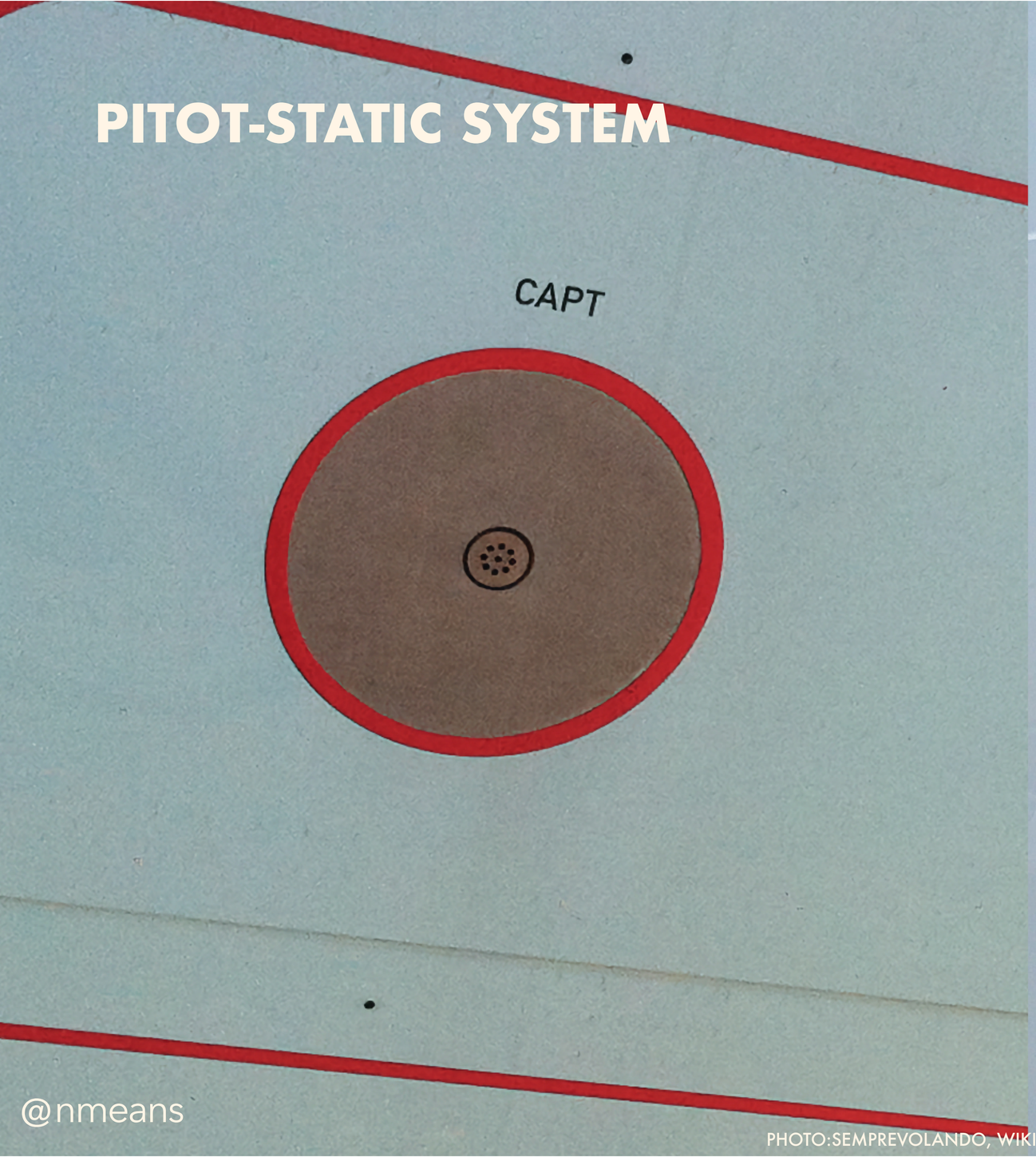
PITOT-STATIC SYSTEM



@nmeans

PHOTO:SEMPREVOLANDO, WIKIMEDIA COMMONS, CC BY 3.0

MedScout

"WHAT IS THAT?!"
– FIRST OFFICER BONIN 2:10:11 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Salinópolis
Bragança
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
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A330 FLIGHT INSTRUMENTS

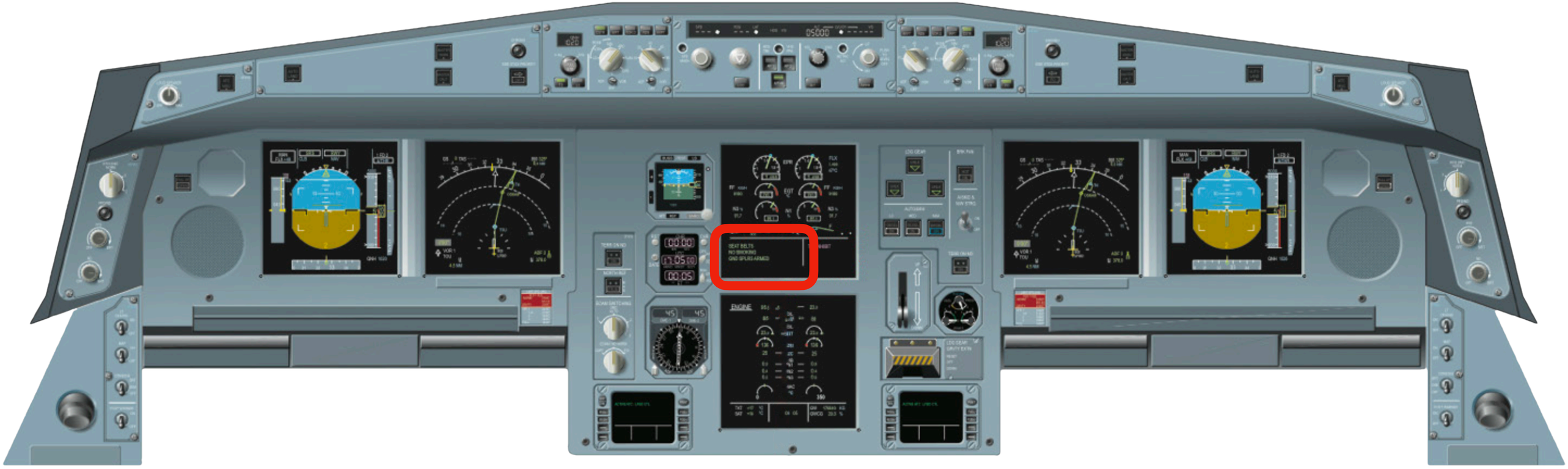

DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

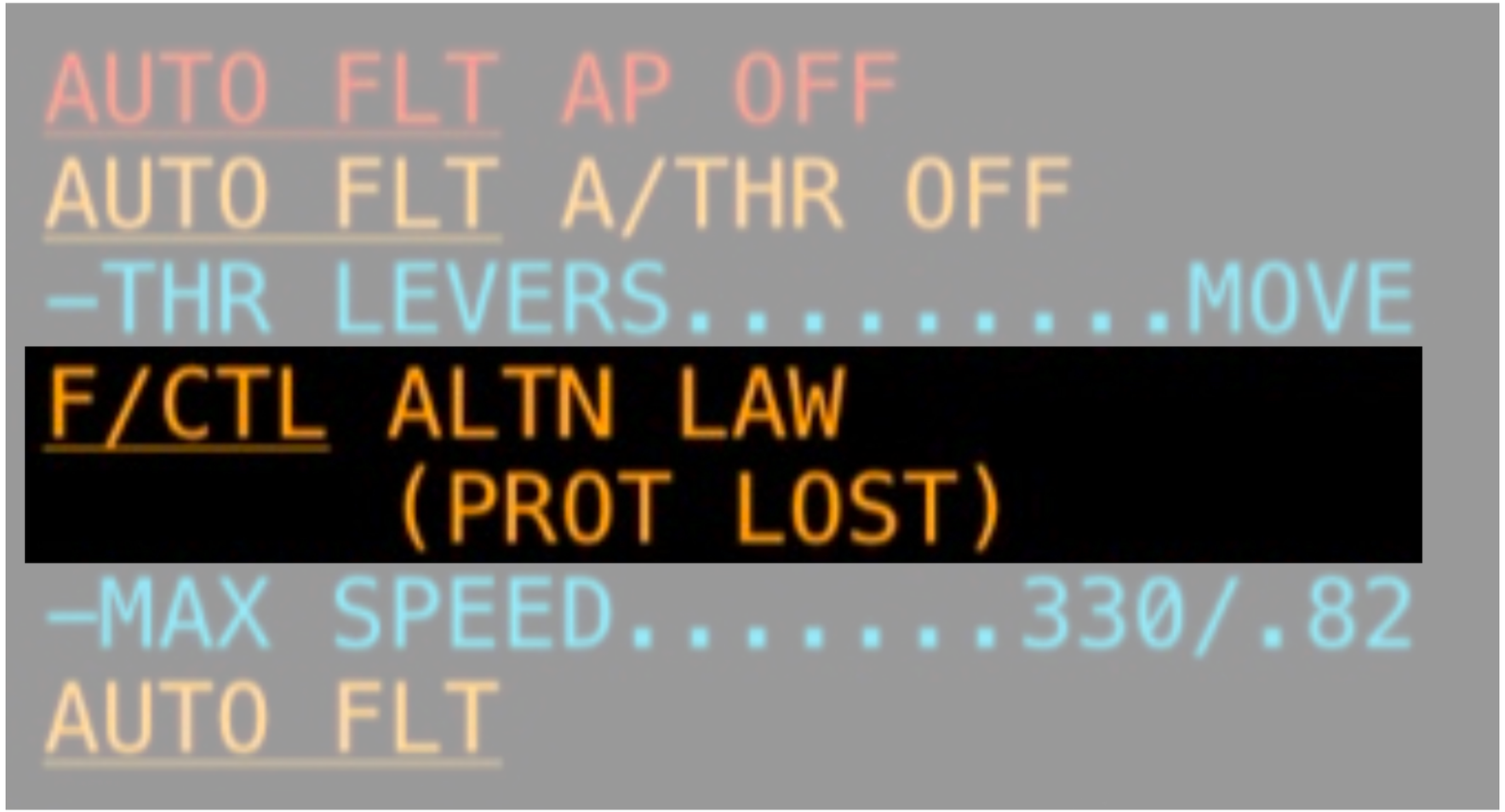

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PHOTO: ORIGINAL SOURCE UNKNOWN, FAIR USE

AIRBUS A330 COCKPIT

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AIRBUS A330 COCKPIT

@nmeans

PHOTO: EDWIN LEONG, WIKIMEDIA COMMONS, CC BY-SA 2.0

AIRBUS A330 NORMAL LAW

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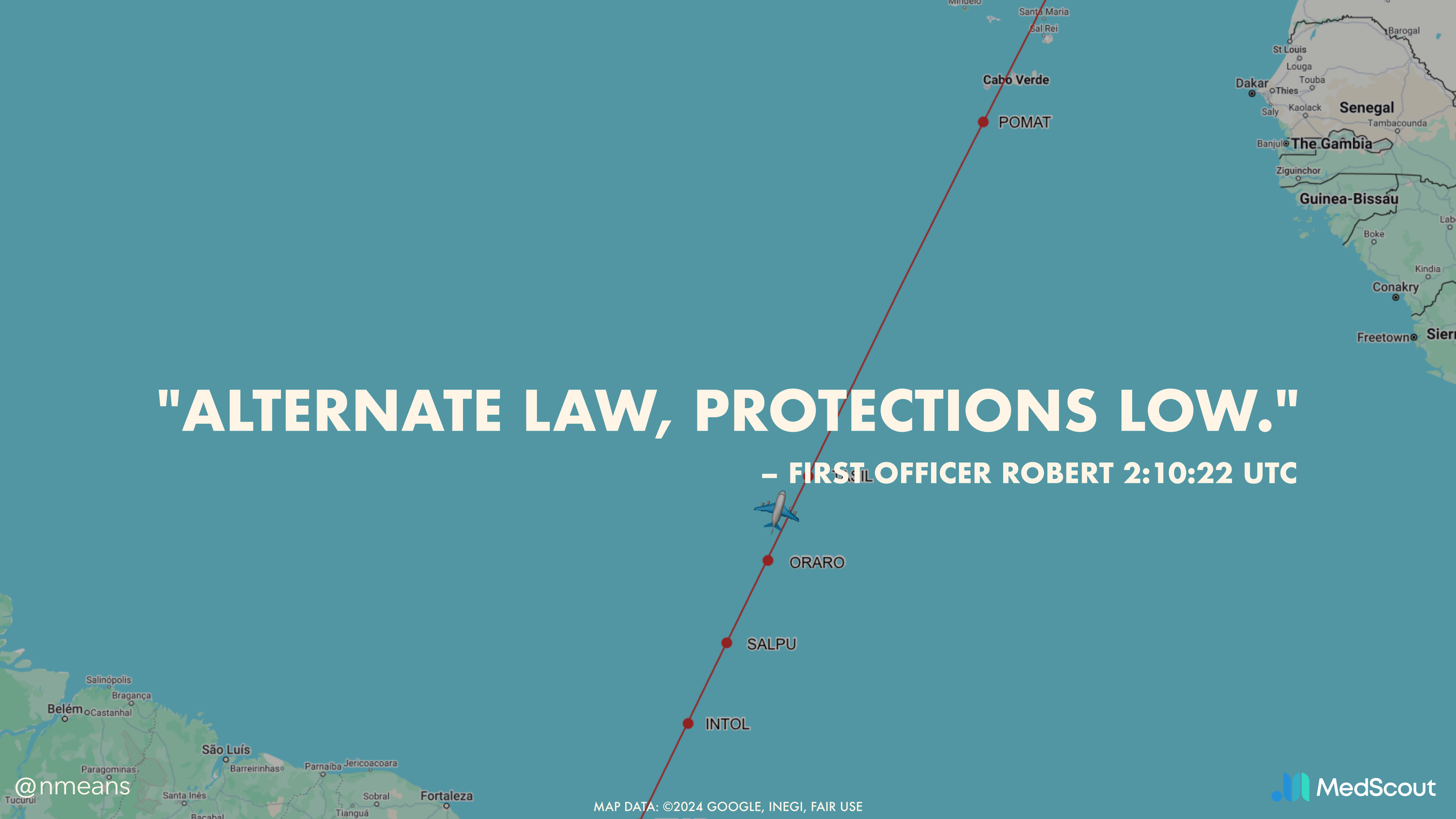
IMAGES: ©AIRBUS INDUSTRIE, FAIR USE

AIRBUS A330 ALTERNATE LAW

@nmeans

IMAGES: ©AIRBUS INDUSTRIE, FAIR USE

Santa Maria
Sal Rei
Cabo Verde
POMAT
Barogal
St Louis
Louga
Dakar
Touba
Thies
Saly
Kaolack
Senegal
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
"WE HAVEN'T GOT A GOOD DISPLAY OF SPEED"
TASIL
– FIRST OFFICER BONIN 2:10:15 UTC
ORARO
SALPU
INTOL
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout



"ALTERNATE LAW, PROTECTIONS LOW."

– FIRST OFFICER ROBERT 2:10:22 UTC

@nmeans

MedScout

"WATCH YOUR SPEED"

FO ROBERT, 2:10:28 UTC

@nmeans

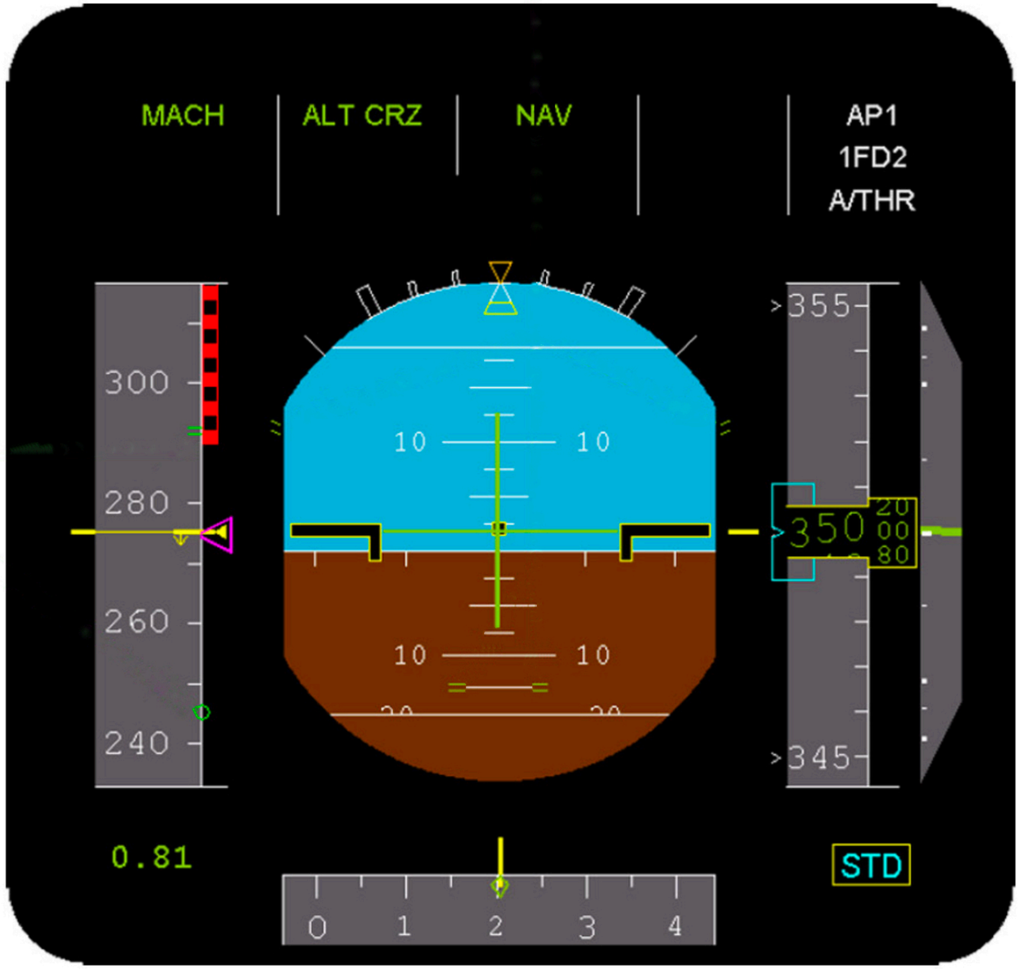
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE

MedScout

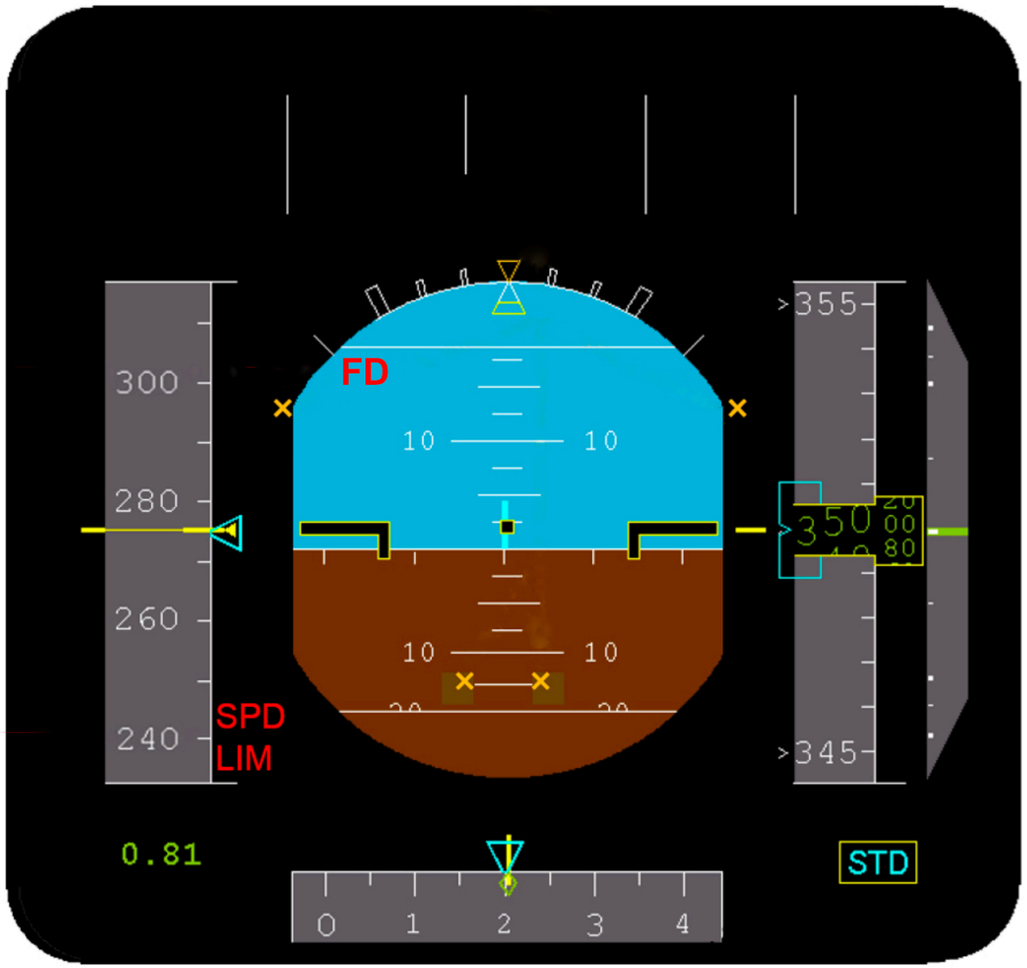
"WATCH YOUR SPEED"
FO ROBERT, 2:10:28 UTC
"OKAY, OKAY OKAY I'M GOING BACK DOWN"
FO BONIN, 2:10:28 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

"WATCH YOUR SPEED"
FO ROBERT, 2:10:28 UTC
"OKAY, OKAY OKAY I'M GOING BACK DOWN"
FO BONIN, 2:10:28 UTC
"ACCORDING TO ALL THREE YOU'RE GOING UP, SO GO BACK DOWN"
FO ROBERT, 2:10:33 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

A330 PRIMARY FLIGHT DISPLAY



NORMAL LAW

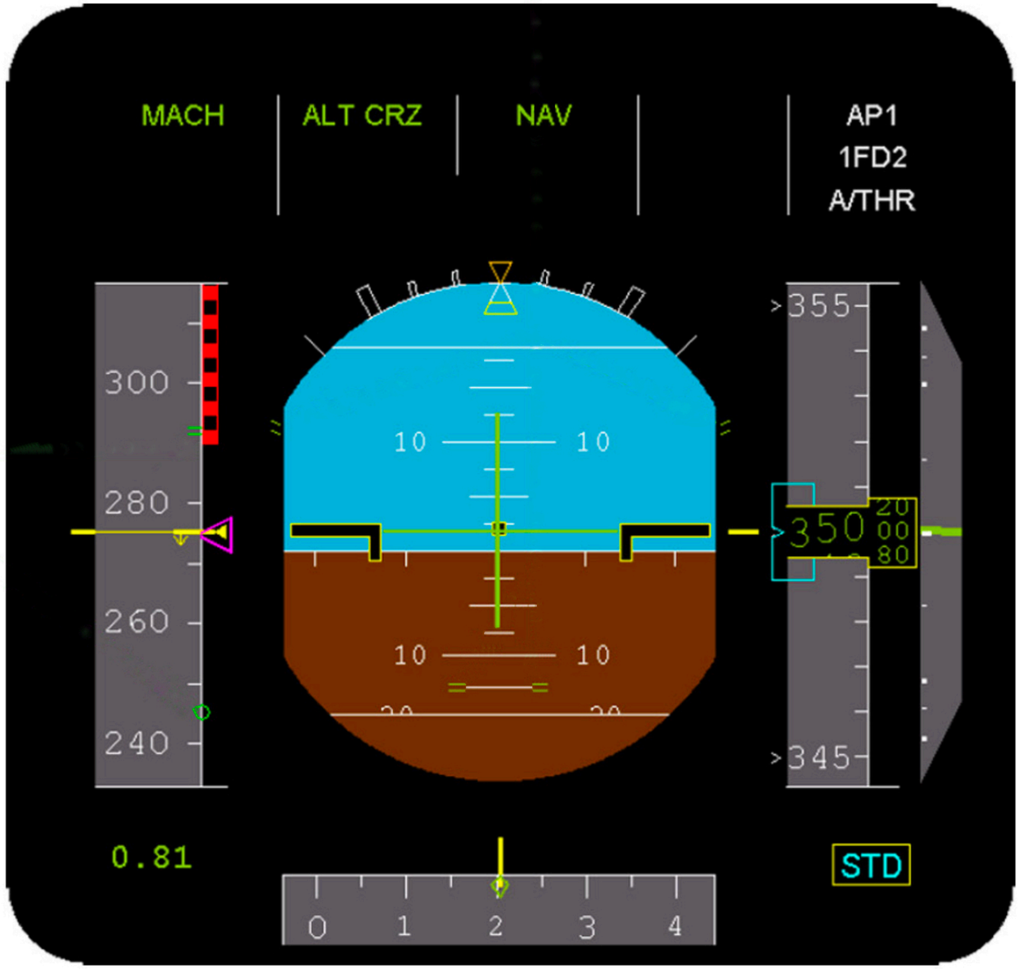


ALTERNATE LAW

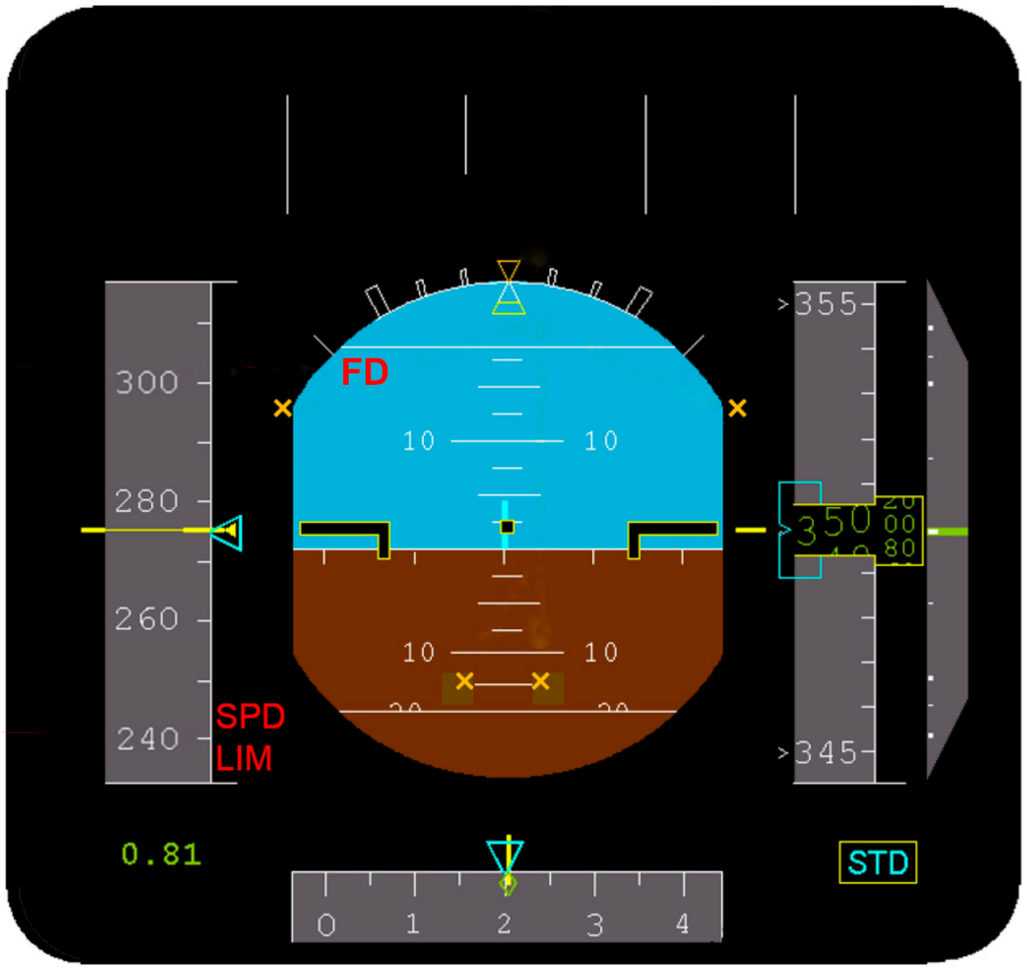
@nmeans

DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

A330 PRIMARY FLIGHT DISPLAY



NORMAL LAW

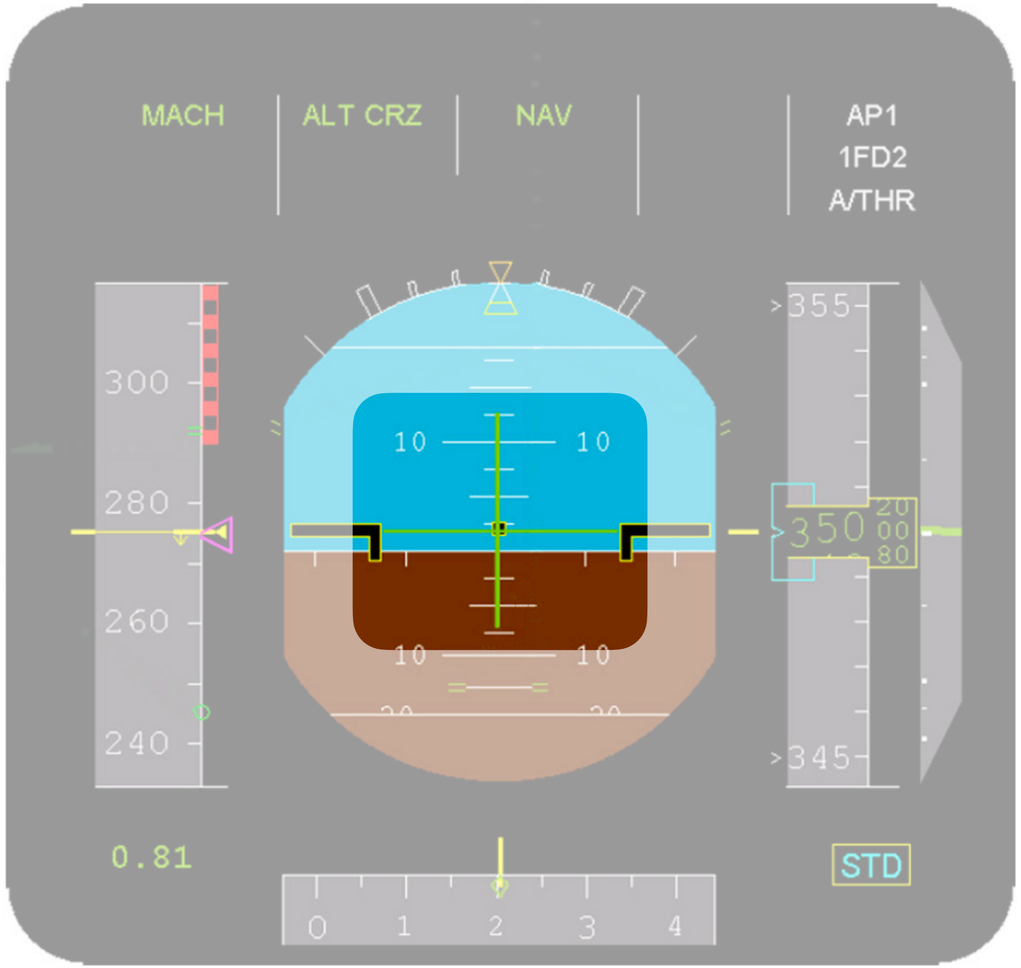


ALTERNATE LAW

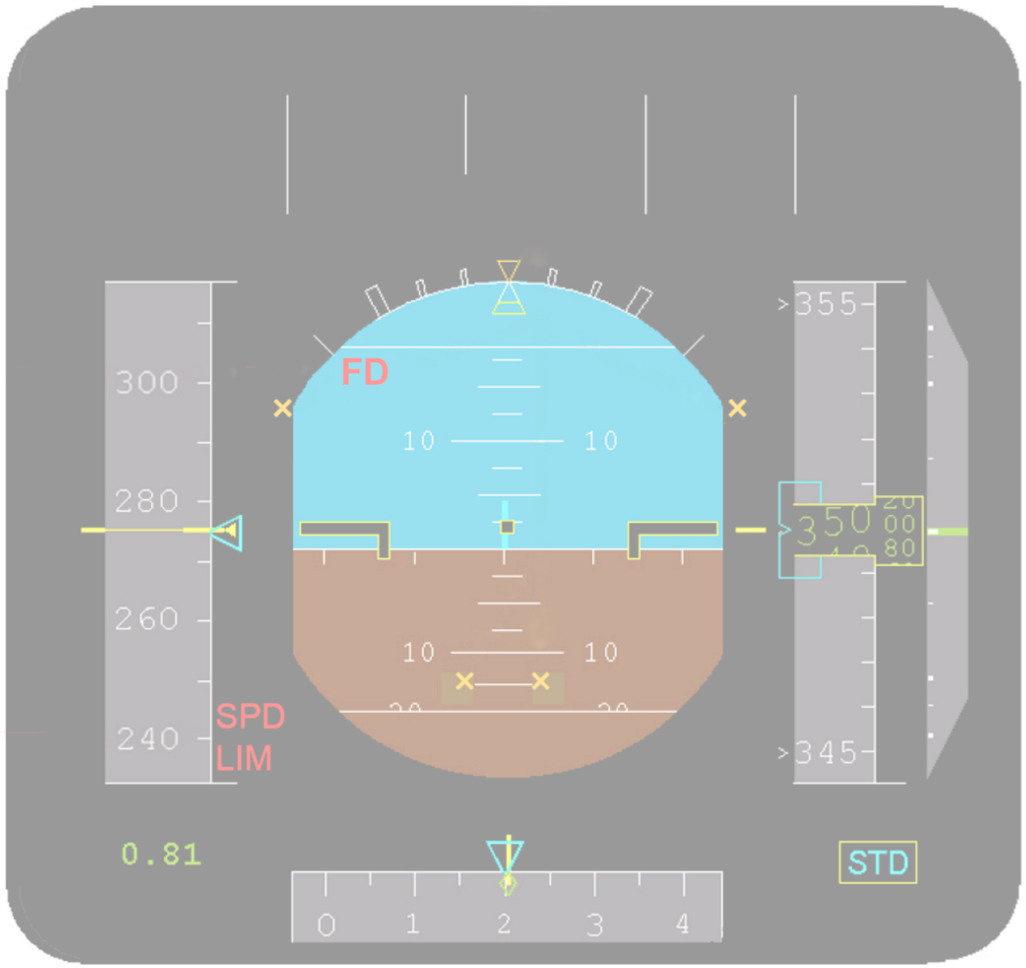
@nmeans

DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

A330 PRIMARY FLIGHT DISPLAY



NORMAL LAW

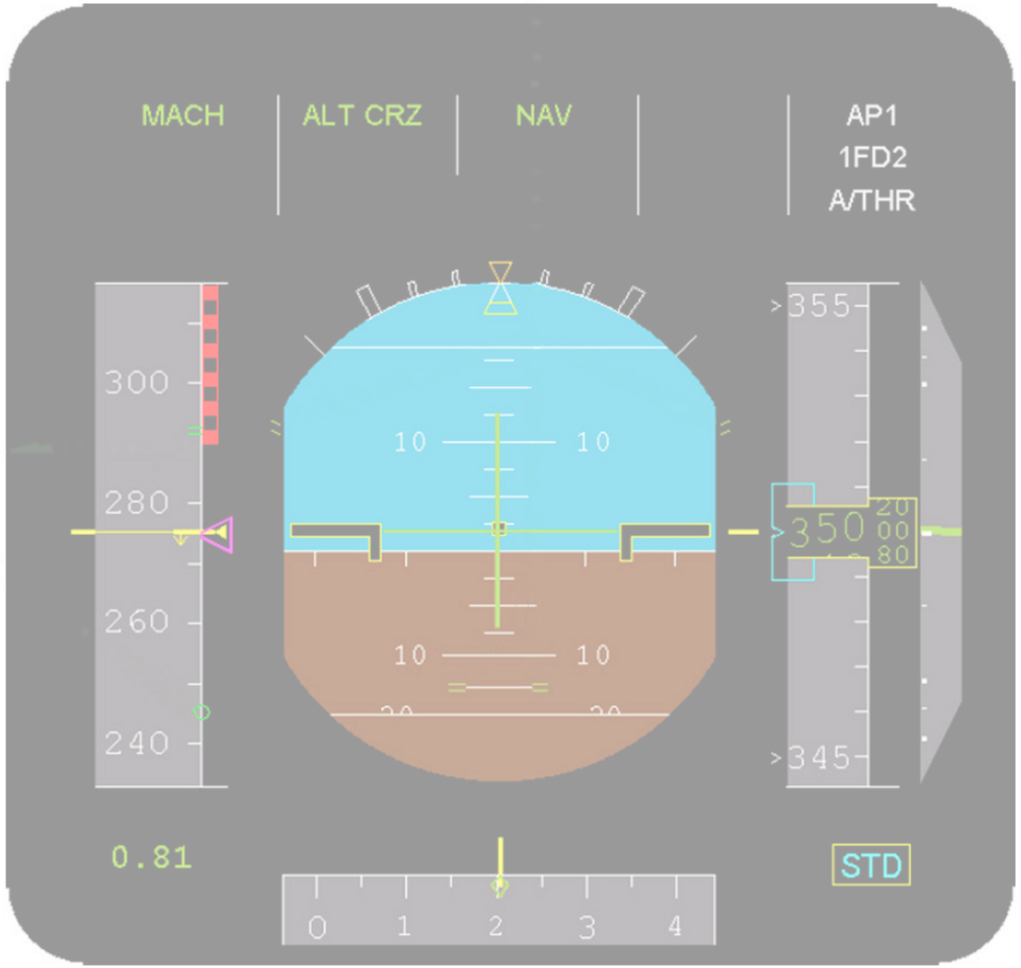


ALTERNATE LAW

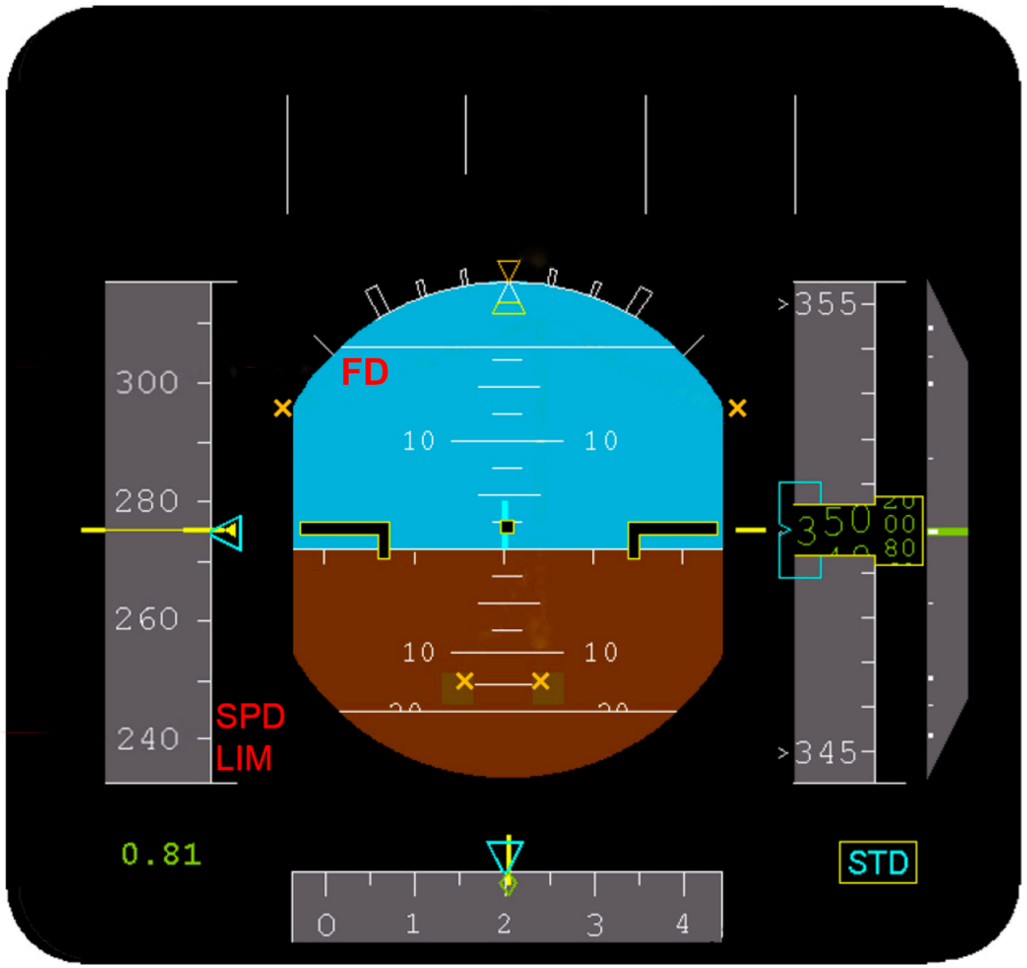
@nmeans

DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

A330 PRIMARY FLIGHT DISPLAY



NORMAL LAW



ALTERNATE LAW

@nmeans

DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

A330 PRIMARY FLIGHT DISPLAY, ALT. LAW

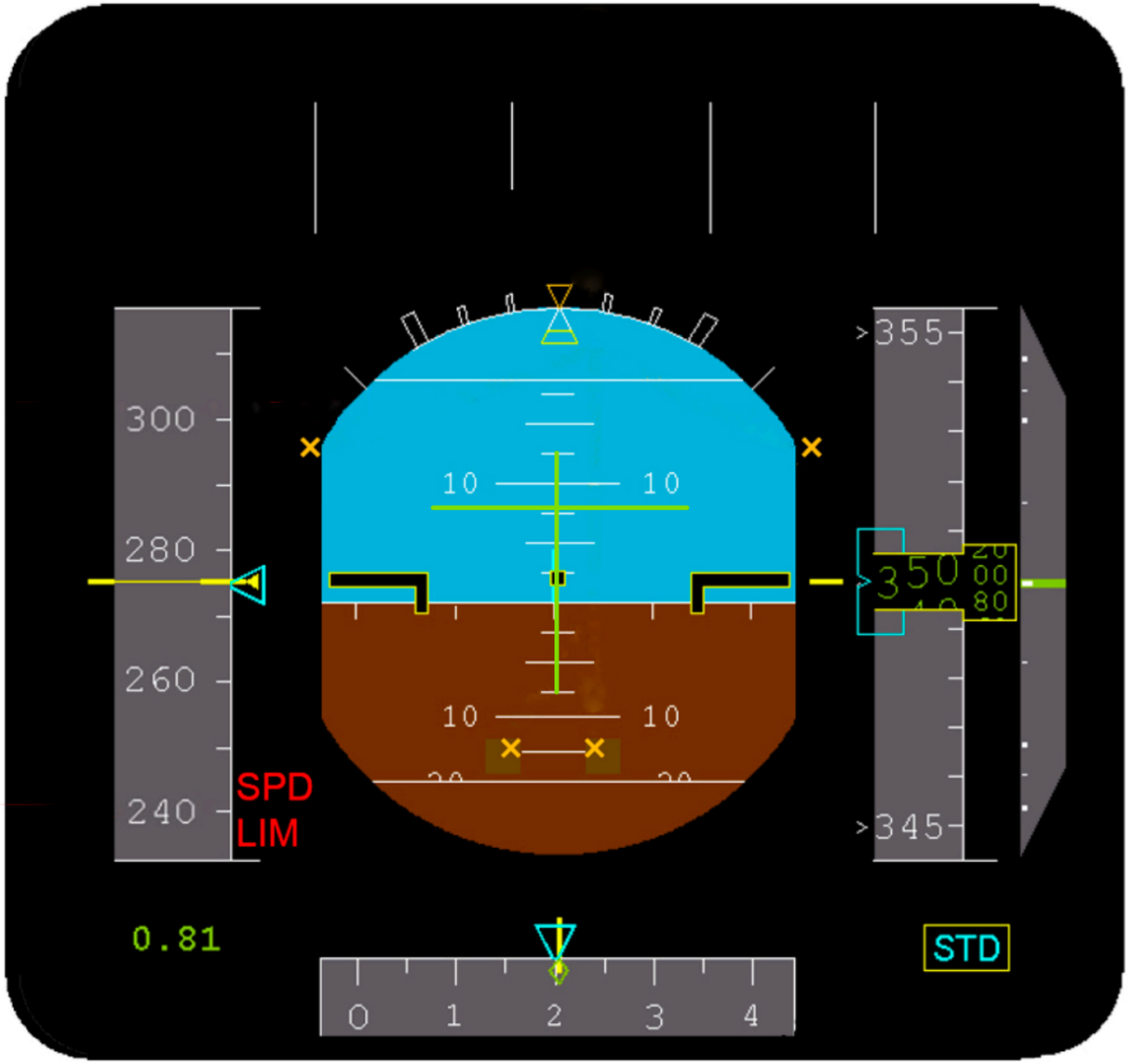
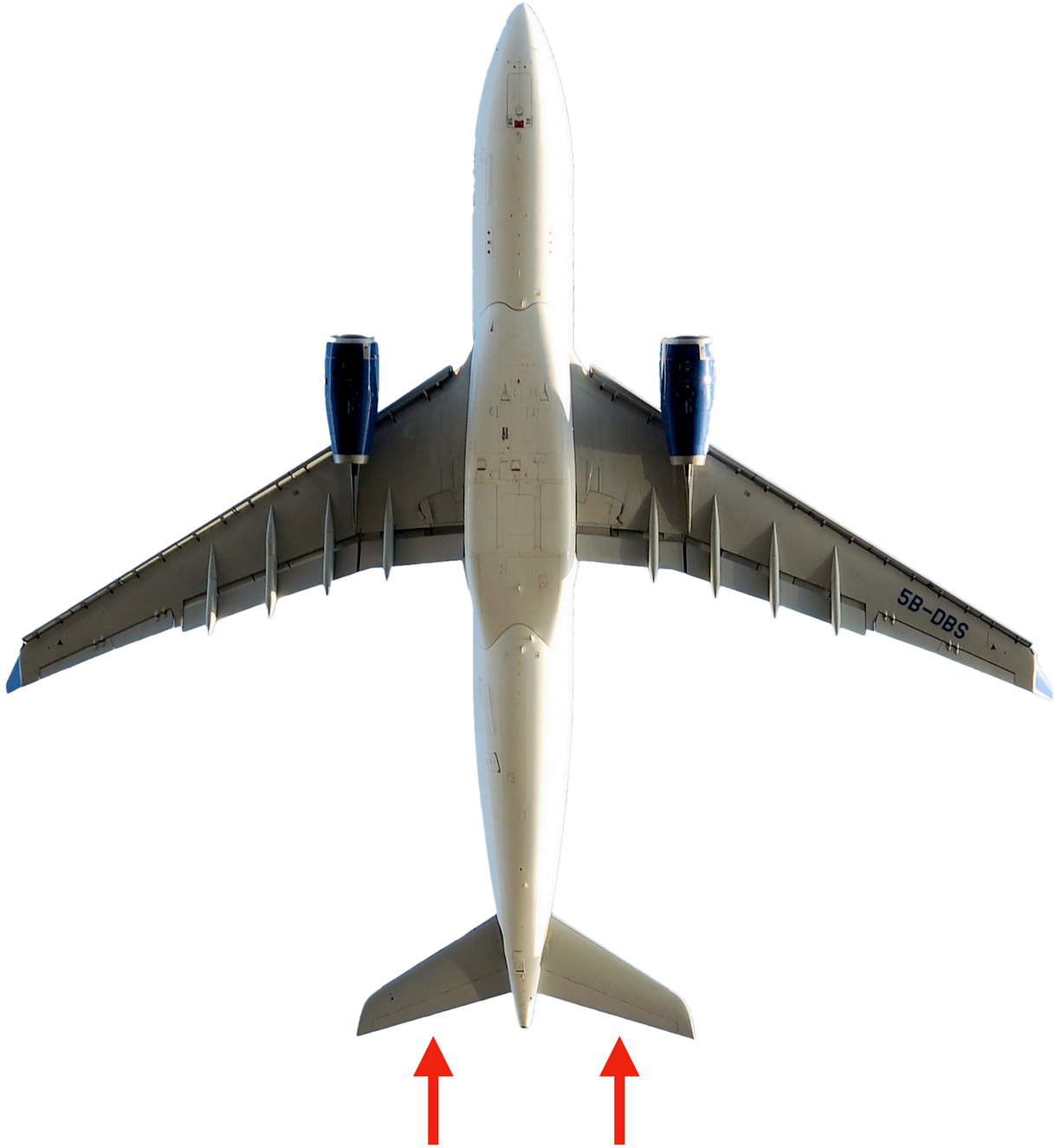


DIAGRAM: BUREAU D'ENQUÊTES ET D'ANALYSES, FAIR USE

@nmeans

AUTOTRIM



@nmeans

DIAGRAM: AIRBUS INDUSTRIE, FAIR USE

AUTOTRIM

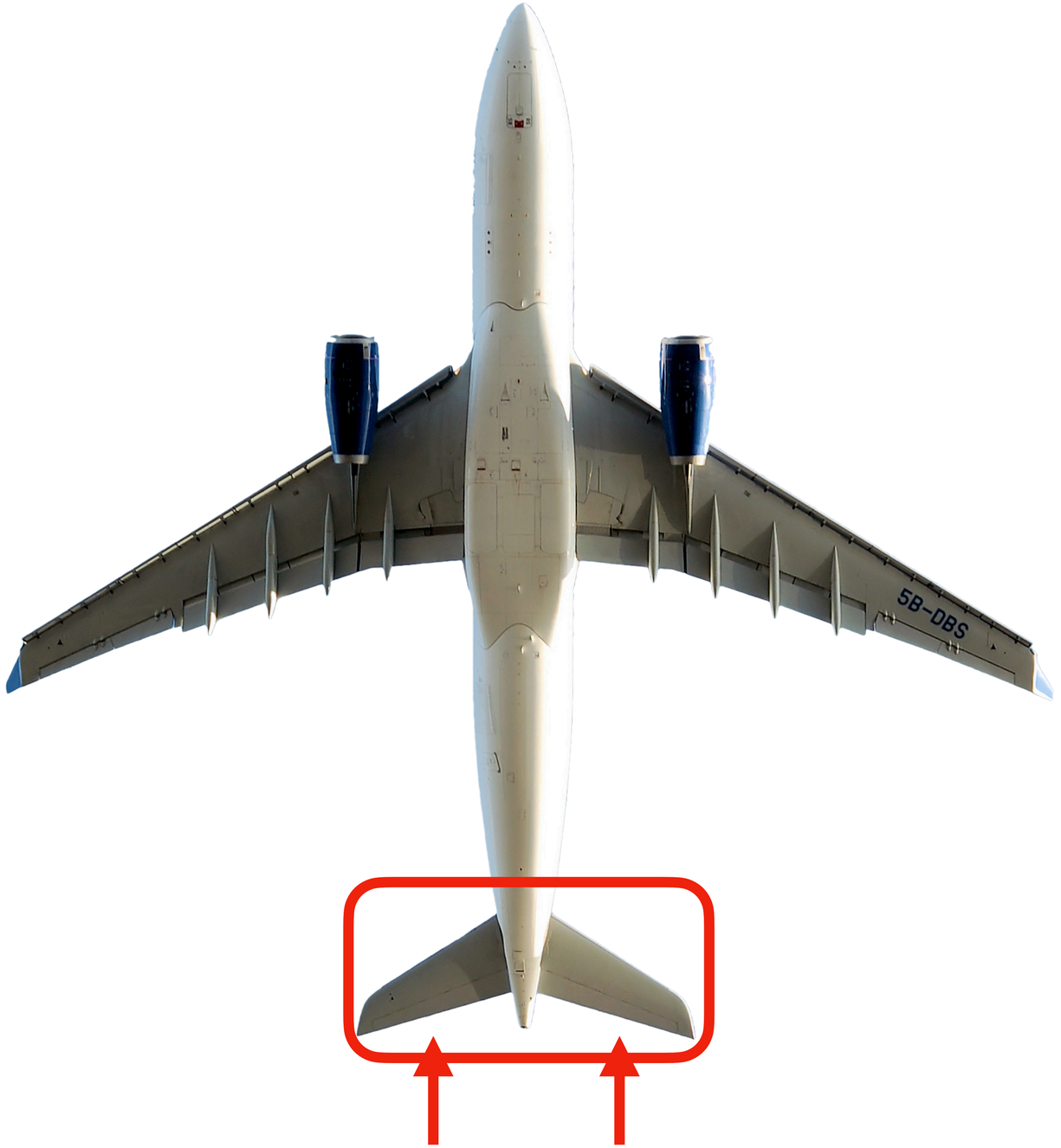


DIAGRAM: AIRBUS INDUSTRIE, FAIR USE

AIRBUS A330 COCKPIT

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MedScout

"STALL! STALL!"
– THE PLANE, 2:10:51 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
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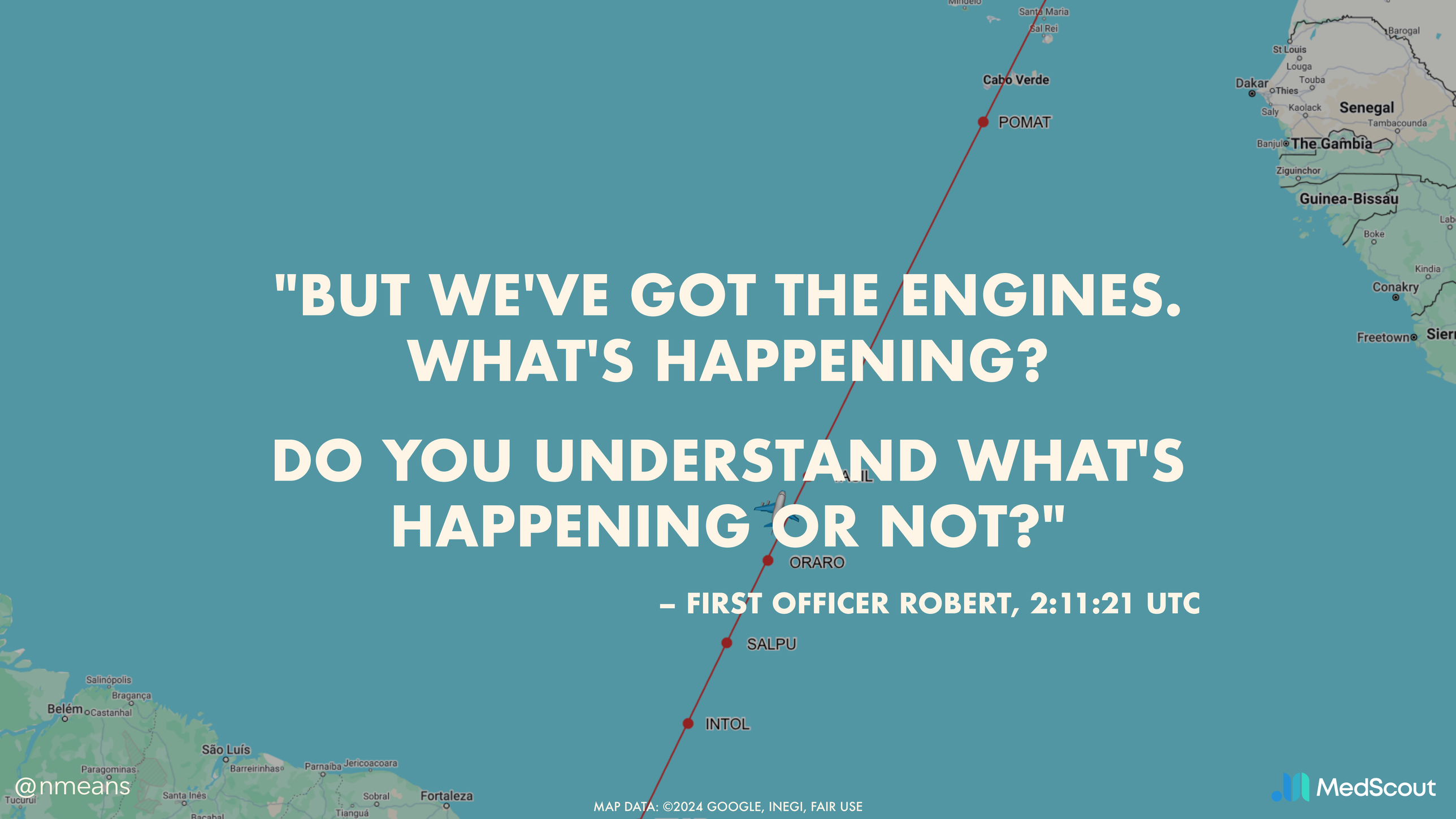
"I'M IN TOGA"
– FIRST OFFICER BONIN, 2:11:03 UTC
POMAT
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Tambacounda
Kaolack
Saly
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout

2:11:10 AM UTC
38,000 FT
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
Belém
Castanhal
Bragança
Salinópolis
São Luís
Barreirinhas
Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
@nmeans
MAP DATA: ©2024 GOOGLE, INEGI, FAIR USE
MedScout



"BUT WE'VE GOT THE ENGINES. WHAT'S HAPPENING?

DO YOU UNDERSTAND WHAT'S HAPPENING OR NOT?"

– FIRST OFFICER ROBERT, 2:11:21 UTC

@nmeans

MedScout

Cabo Verde
POMAT
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
Kaolack
Saly
Tambacounda
Banjul
The Gambia
Ziguinchor
Guinea-Bissau
Boke
Kindia
Conakry
Freetown
"I DON'T HAVE CONTROL OF THE AIRPLANE ANY MORE NOW.
I DON'T HAVE CONTROL OF THE AIRPLANE AT ALL."
– FIRST OFFICER BONIN, 2:11:34 UTC
ORARO
SALPU
INTOL
Salinópolis
Bragança
Belém
Castanhal
São Luís
Paragominas
Barreirinhas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tucuruí
Tianguá
@nmeans
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"WHAT'S GOING ON HERE?
TELL ME WHAT'S GOING ON!"
– CAPTAIN DUBOIS, 2:11:42 UTC
POMAT
TASIL
ORARO
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
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The Gambia
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Guinea-Bissau
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Conakry
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São Luís
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Paragominas
Parnaíba
Jericoacoara
Santa Inês
Sobral
Fortaleza
Tianguá
Tucuruí
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"WE LOST ALL CONTROL OF THE AIRPLANE.
WE DON'T UNDERSTAND ANYTHING.
WE'VE TRIED EVERYTHING."
FIRST OFFICER ROBERT, 2:11:46 UTC
POMAT
SALPU
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
Thies
Touba
Louga
St Louis
Barogal
Senegal
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IMAGE: AIRBUS INDUSTRIE, FAIR USE

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IMAGE: AIRBUS INDUSTRIE, FAIR USE

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IMAGE: AIRBUS INDUSTRIE, FAIR USE

"IT'S IMPOSSIBLE"
– CAPTAIN DUBOIS, 2:12:43 UTC
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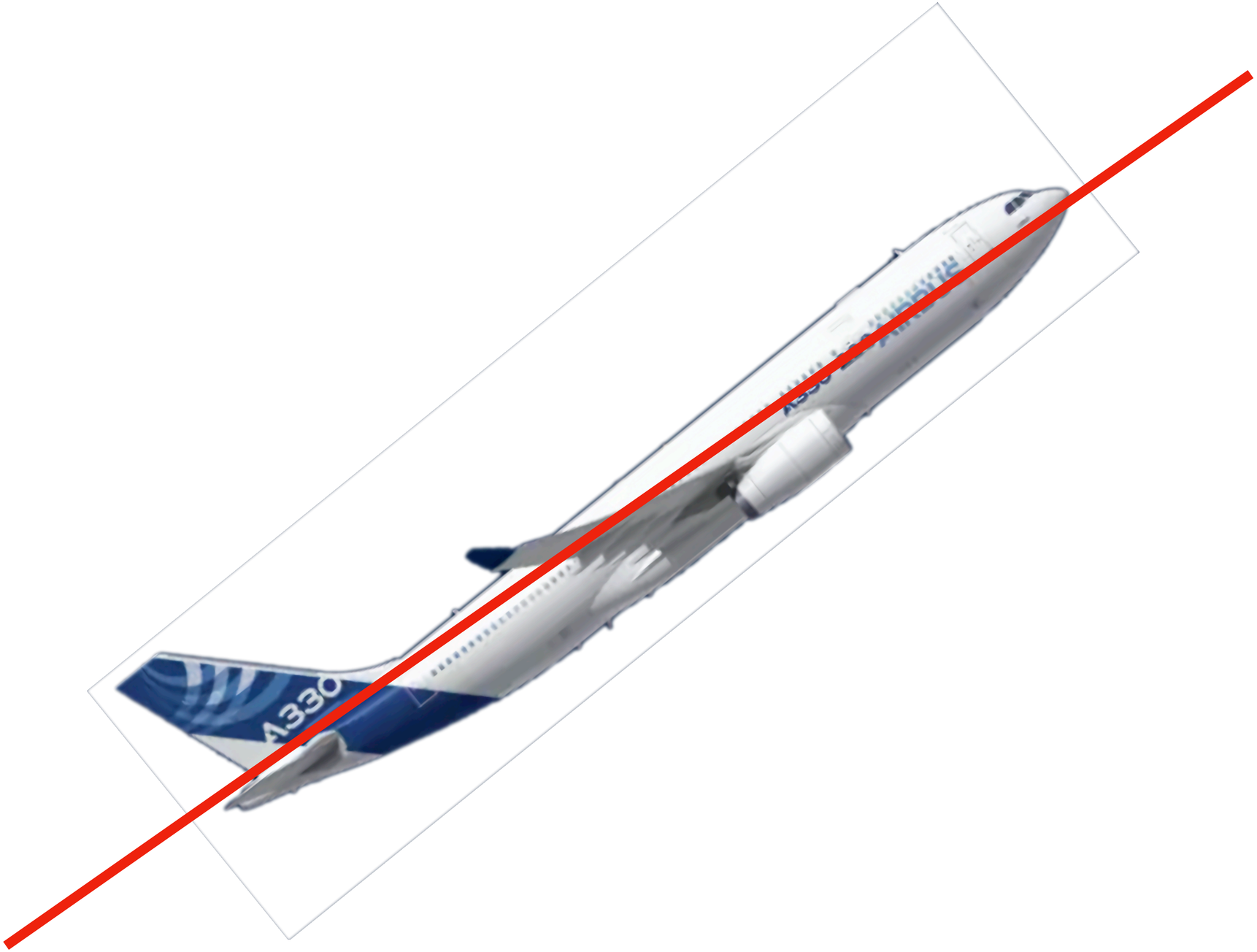

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IMAGE: AIRBUS INDUSTRIE, FAIR USE

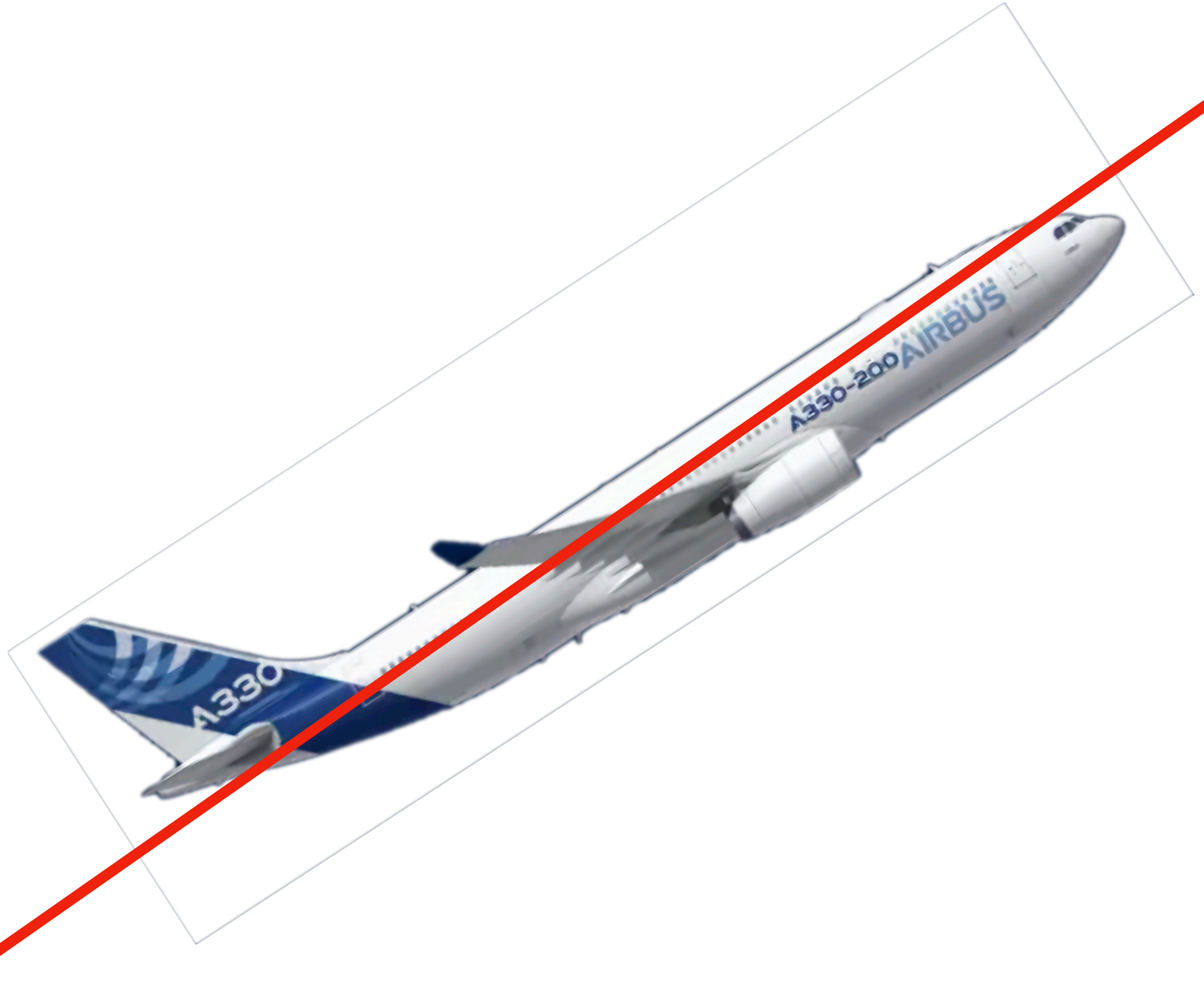

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IMAGE: AIRBUS INDUSTRIE, FAIR USE

"CLIMB CLIMB CLIMB"
FIRST OFFICER ROBERT, 2:13:39 UTC
"BUT I'VE BEEN AT MAXIMUM NOSE UP FOR A WHILE."
FIRST OFFICER BONIN, 2:13:40 UTC
"NO NO NO! DON'T CLIMB!"
CAPTAIN DUBOIS, 2:13:42 UTC
POMAT
TASIL
ORARO
INTOL
Cabo Verde
Santa Maria
Sal Rei
Dakar
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Touba
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2:14:28 AM UTC
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2:14:28 AM UTC

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CAPTAIN
MARC DUBOIS

FIRST OFFICER
PIERRE-CÉDRIC BONIN

FIRST OFFICER
DAVID ROBERT

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SOCATA TB10

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ROLLADEN-SCHNEIDER LS4 GLIDER

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Brief Paper

Ironies of Automation*

LISANNE BAINBRIDGE†

Key Words—Control engineering computer applications; man–machine systems; on-line operation; process control; system failure and recovery.

Abstract—This paper discusses the ways in which automation of industrial processes may expand rather than eliminate problems with the human operator. Some comments will be made on methods of alleviating these problems within the 'classic' approach of leaving the operator with responsibility for abnormal conditions, and on the potential for continued use of the human operator for on-line decision-making within human–computer collaboration.

Irony: combination of circumstances, the result of which is the direct opposite of what might be expected.
Paradox: seemingly absurd though perhaps really well-founded statement.

THE classic aim of automation is to replace human manual control, planning and problem solving by automatic devices and computers. However, as Bibby and colleagues (1975) point out: "even highly automated systems, such as electric power networks, need human beings for supervision, adjustment, maintenance, expansion and improvement. Therefore one can draw the paradoxical conclusion that automated systems still are man–machine systems, for which both technical and human factors are important." This paper suggests that the increased interest in human factors among engineers reflects the irony that the more advanced a control system is, so the more crucial may be the contribution of the human operator.

This paper is particularly concerned with control in process industries, although examples will be drawn from flight-deck automation. In process plants the different modes of operation may be automated to different extents, for example normal operation and shut-down may be atomatic while start-up and abnormal conditions are manual. The problems of the use of automatic or manual control are a function of the predictability of process behaviour, whatever the mode of operation. The first two sections of this paper discuss automatic on-line control where a human operator is expected to take-over in abnormal conditions, the last section introduces some aspects of human-computer collaboration in on-line control.

1. *Introduction*

The important ironies of the classic approach to automation lie in the expectations of the system designers, and in the nature of the tasks left for the human operators to carry out.

The designer's view of the human operator may be that the operator is unreliable and inefficient, so should be eliminated from the system. There are two ironies of this attitude. One is that designer errors can be a major source of operating problems. Unfortunately people who have collected data on this are reluctant to publish them, as the actual figures are difficult to interpret. (Some types of error may be reported more readily than others, and there may be disagreement about their origin.) The second irony is that the designer who tries to eliminate the operator still leaves the operator to do the tasks which the designer cannot think how to automate. It is this approach which causes the problems to be discussed here, as it means that the operator can be left with an arbitrary collection of tasks, and little thought may have been given to providing support for them.

1.1. *Tasks after automation.*

There are two general categories of task left for an operator in an automated system. He may be expected to monitor that the automatic system is operating correctly, and if it is not he may be expected to call a more experienced operator or to take-over himself. We will discuss the ironies of manual take-over first, as the points made also have implications for monitoring. To take over and stabilize the process requires manual control skills, to diagnose the fault as a basis for shut down or recovery requires cognitive skills.

1.1.1. *Manual control skills.*

Several studies (Edwards and Lees, 1974) have shown the difference between inexperienced and experienced process operators making a step change. The experienced operator makes the minimum number of actions, and the process output moves smoothly and quickly to the new level, while with an inexperienced operator it oscillates round the target value. Unfortunately, physical skills deteriorate when they are not used, particularly the refinements of gain and timing. This means that a formerly experienced operator who has been monitoring an automated process may now be an inexperienced one. If he takes over he may set the process into oscillation. He may have to wait for feedback, rather than controlling by open-loop, and it will be difficult for him to interpret whether the feedback shows that there is something wrong with the system or more simply that he has misjudged his control action. He will need to make actions to counteract his ineffective control, which will add to his work load. When manual take-over is needed there is likely to be something wrong with the process, so that unusual actions will be needed to control it, and one can argue that the operator needs to be more rather than less skilled, and less rather than more loaded, than average.

1.1.2. *Cognitive skills.*

Long-term knowledge: An operator who finds out how to control the plant for himself, without explicit training, uses a set of propositions about possible process behaviour, from which he generates strategies to try (e.g. Bainbridge, 1981). Similarly an operator will only be able to generate successful new strategies for unusual situations if he has an adequate knowledge of the process. There are two problems with this for 'machine-minding' operators. One is that efficient retrieval of knowledge from long-term memory depends on frequency of use (consider any subject which you passed an examination in at school and have not thought about since). The other is that this type of knowledge develops only through use and feedback about its effectiveness. People given this knowledge in theoretical classroom instruction without appropriate practical exercises will probably not understand much of it, as it will not be within a framework which

* Received 16 December 1982; revised 23 May 1983. The original version of this paper was presented at the IFAC/IFIP/IFORS/IEA Conference on Analysis, Design, and Evaluation of Man–Machine Systems which was held in Baden-Baden, F.R.G. during September 1982. The published proceedings of this IFAC meeting may be ordered from Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 0BW, U.K. This paper was recommended for publication in revised form by editor A. Sage.

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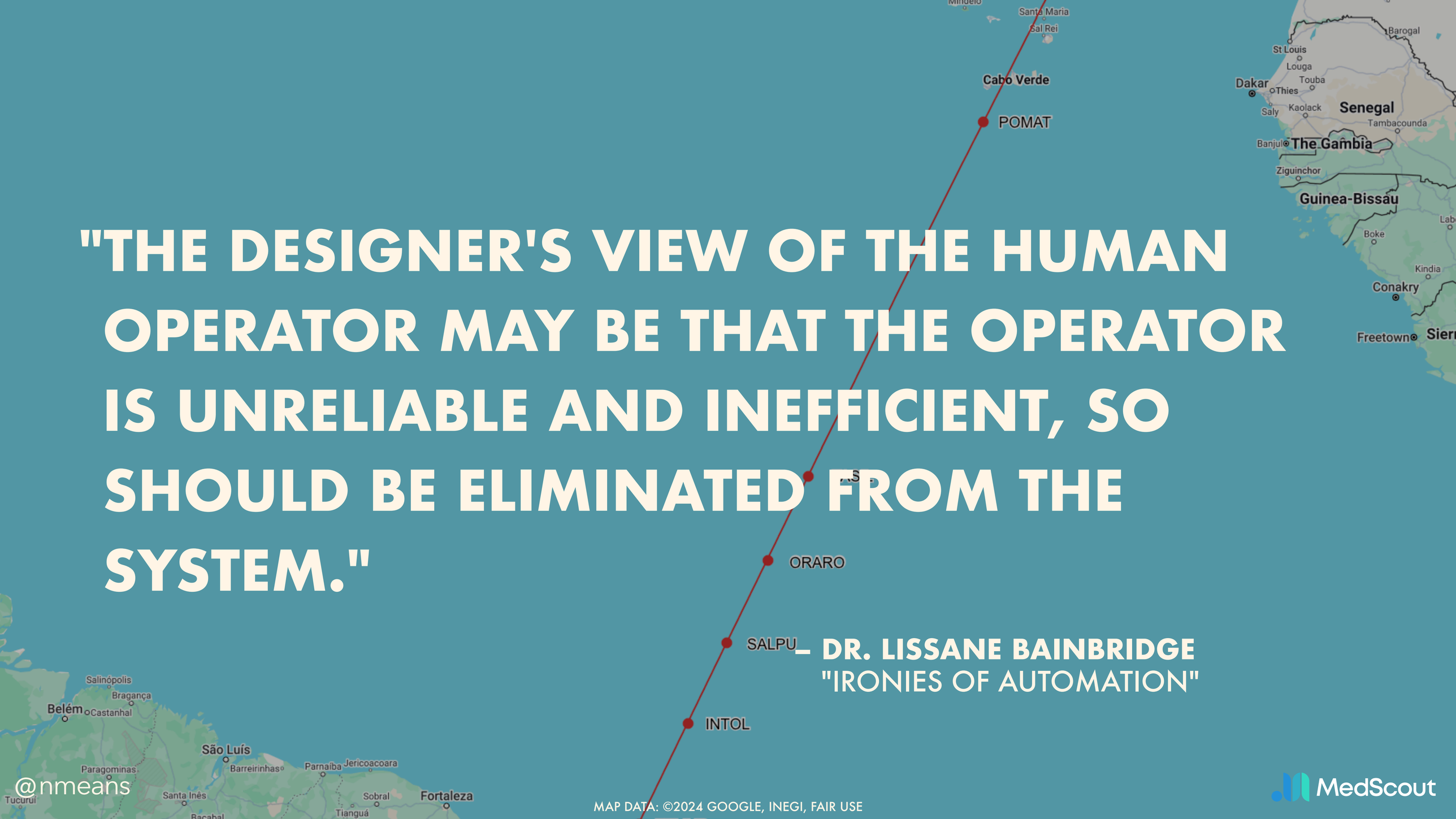

"THE DESIGNER'S VIEW OF THE HUMAN OPERATOR MAY BE THAT THE OPERATOR IS UNRELIABLE AND INEFFICIENT, SO SHOULD BE ELIMINATED FROM THE SYSTEM."

— **DR. LISSANE BAINBRIDGE**
"IRONIES OF AUTOMATION"

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"THE DESIGNER WHO TRIES TO ELIMINATE THE OPERATOR STILL LEAVES THE OPERATOR TO DO THE TASKS WHICH THE DESIGNER CANNOT THINK HOW TO AUTOMATE."
– DR. LISSANE BAINBRIDGE
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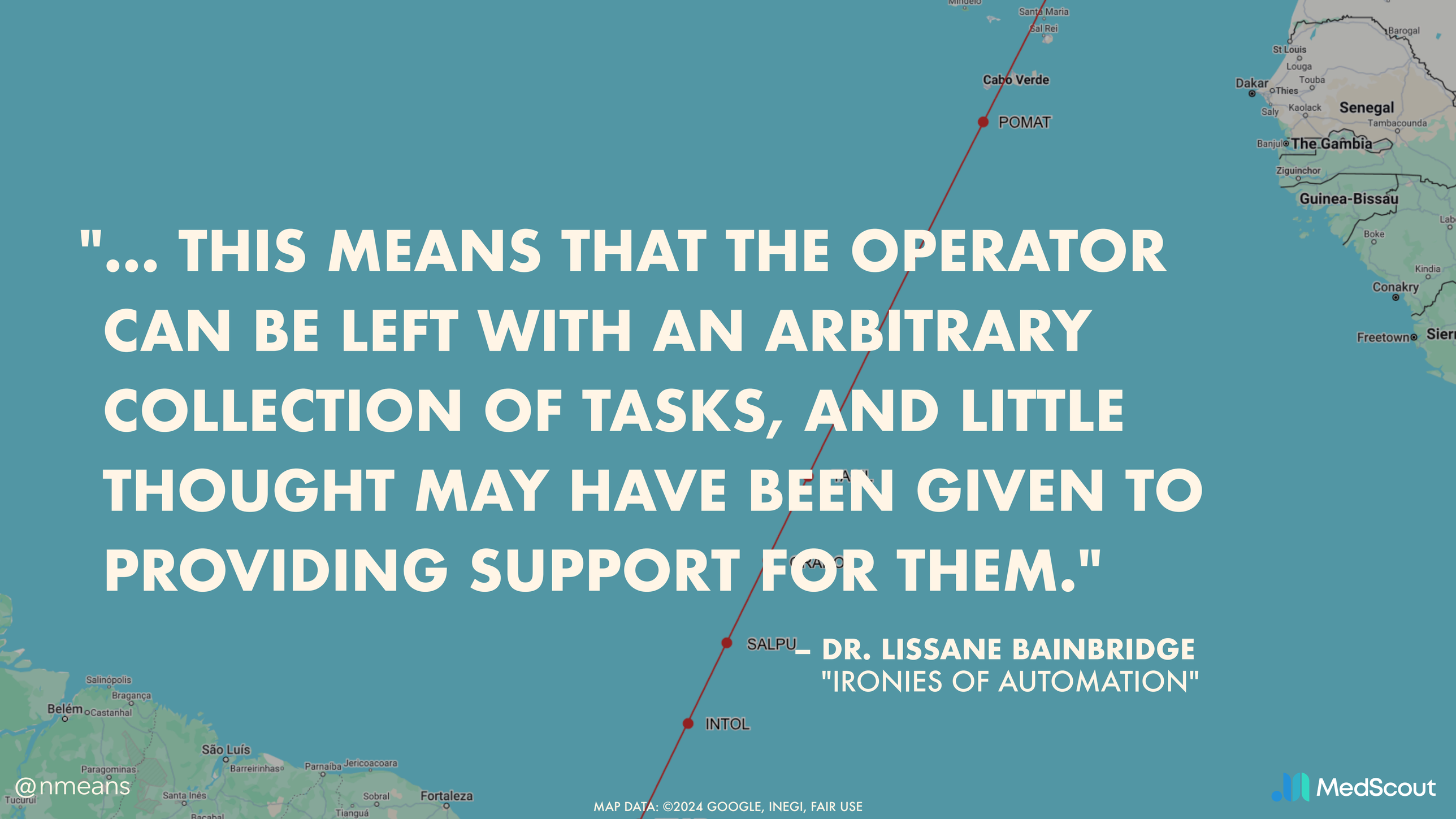
"... THIS MEANS THAT THE OPERATOR CAN BE LEFT WITH AN ARBITRARY COLLECTION OF TASKS, AND LITTLE THOUGHT MAY HAVE BEEN GIVEN TO PROVIDING SUPPORT FOR THEM."
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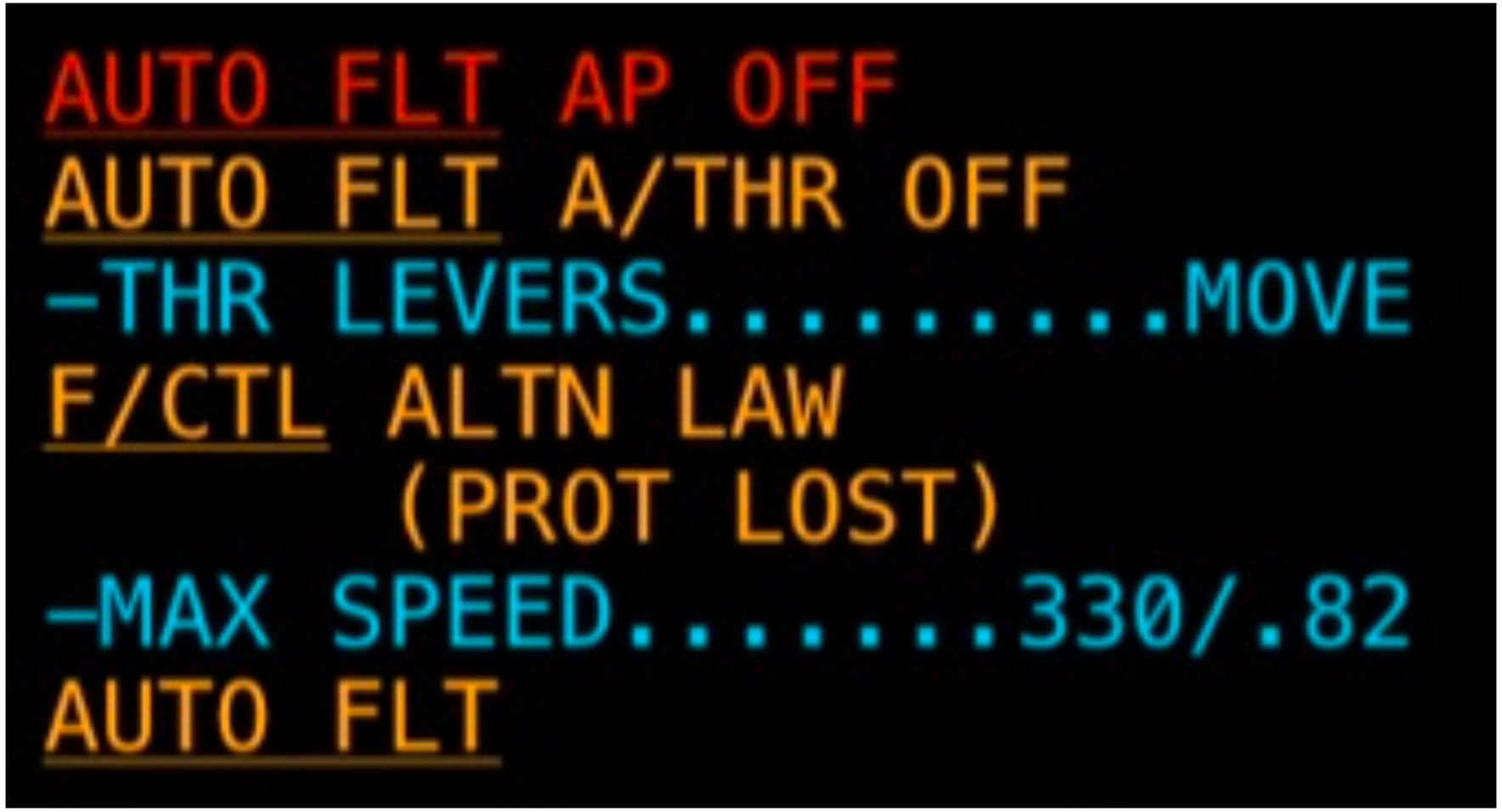

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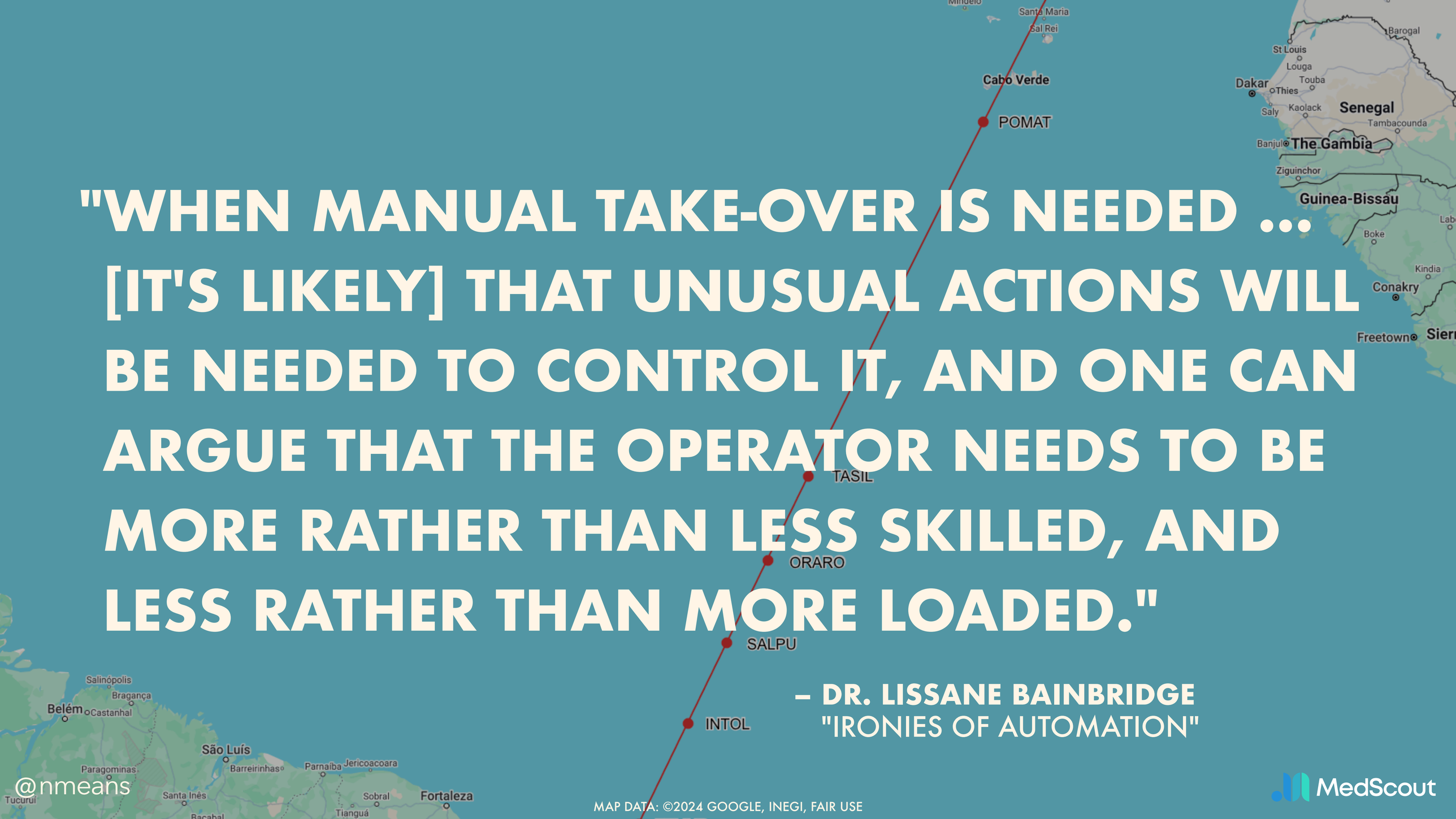
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"WHEN MANUAL TAKE-OVER IS NEEDED ... [IT'S LIKELY] THAT UNUSUAL ACTIONS WILL BE NEEDED TO CONTROL IT, AND ONE CAN ARGUE THAT THE OPERATOR NEEDS TO BE MORE RATHER THAN LESS SKILLED, AND LESS RATHER THAN MORE LOADED."
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Figure 1: Magic Quadrant for AI Code Assistants

Gartner

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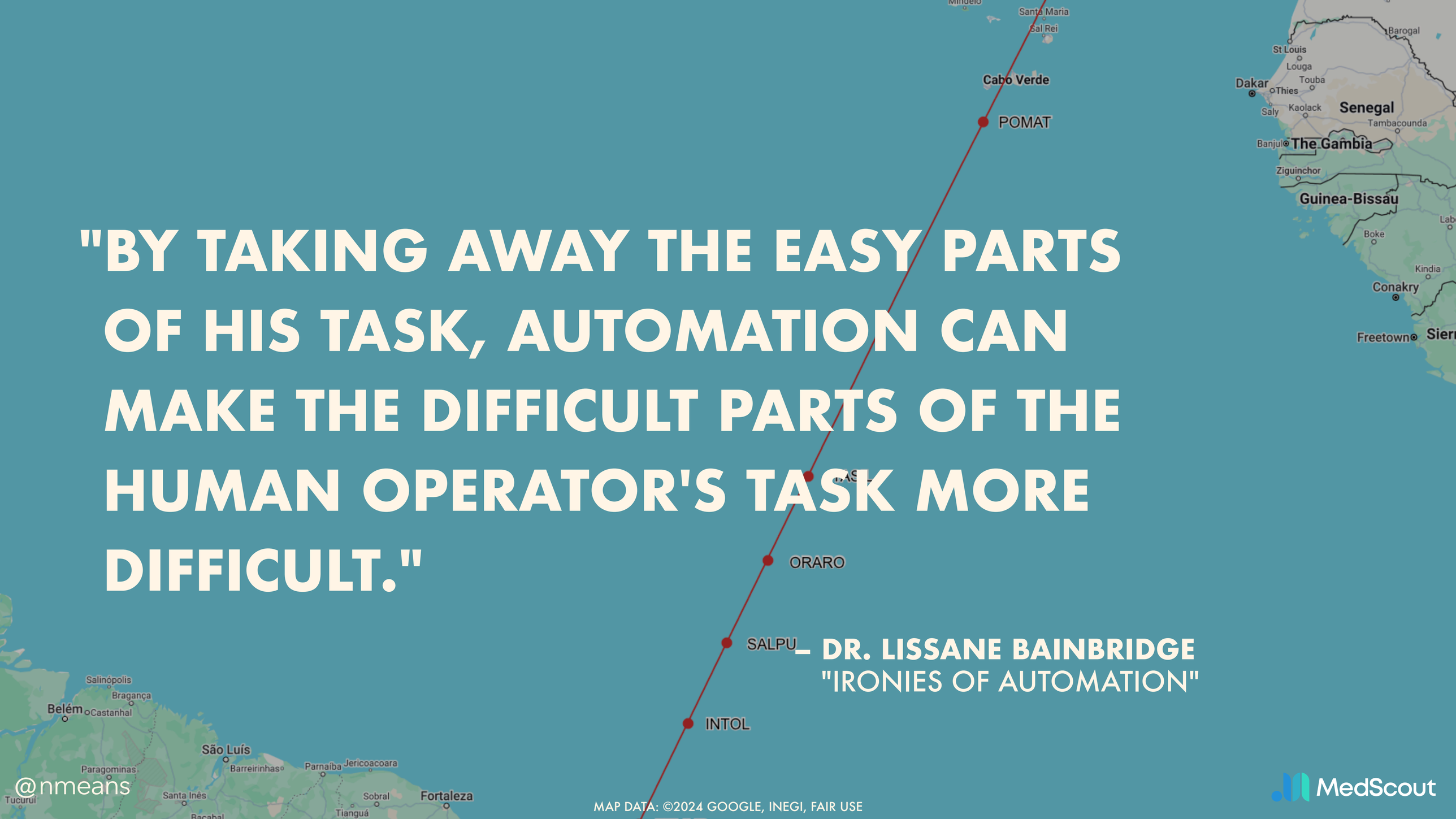
"BY TAKING AWAY THE EASY PARTS OF HIS TASK, AUTOMATION CAN MAKE THE DIFFICULT PARTS OF THE HUMAN OPERATOR'S TASK MORE DIFFICULT."
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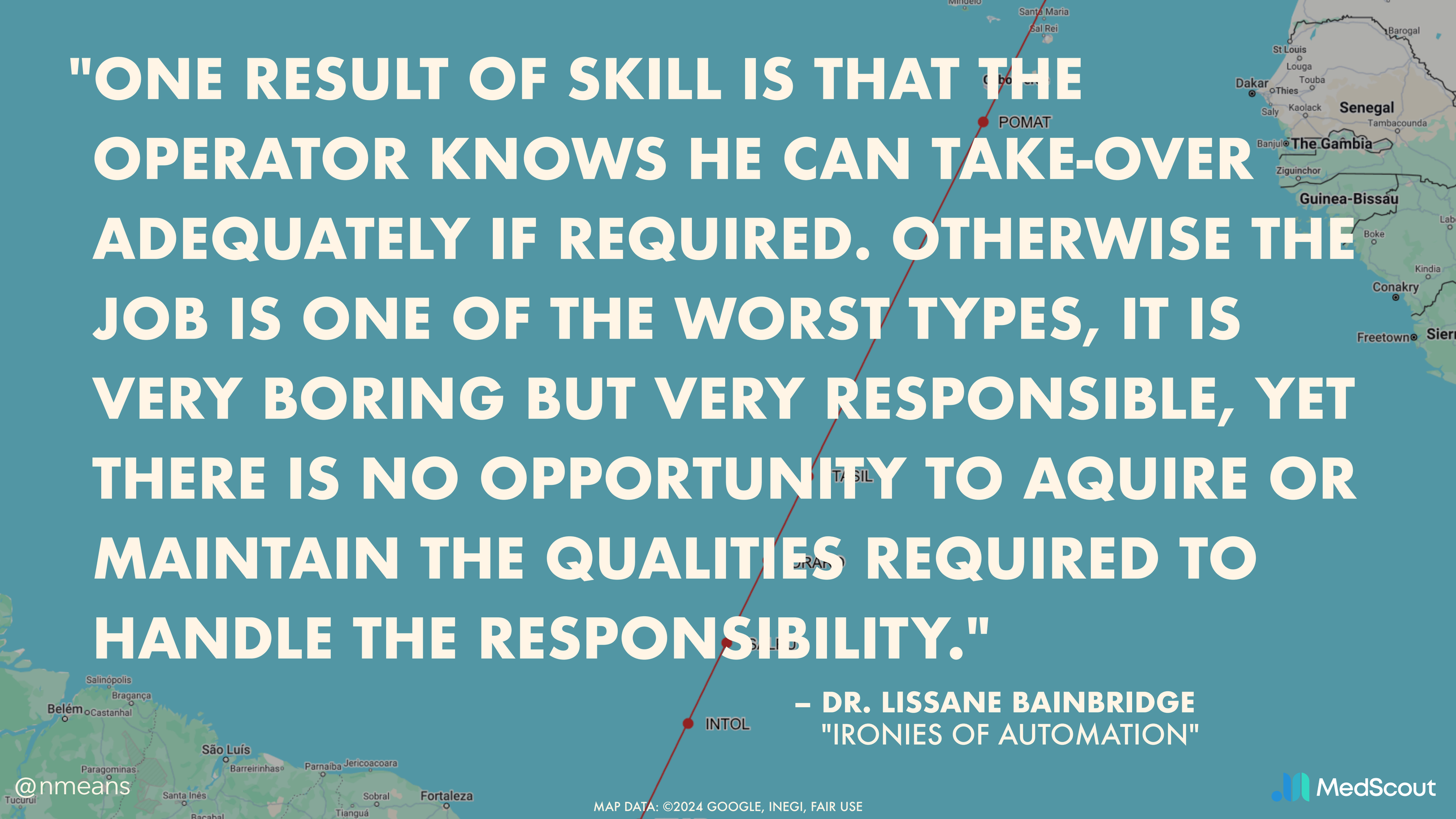
"ONE RESULT OF SKILL IS THAT THE OPERATOR KNOWS HE CAN TAKE-OVER ADEQUATELY IF REQUIRED. OTHERWISE THE JOB IS ONE OF THE WORST TYPES, IT IS VERY BORING BUT VERY RESPONSIBLE, YET THERE IS NO OPPORTUNITY TO AQUIRE OR MAINTAIN THE QUALITIES REQUIRED TO HANDLE THE RESPONSIBILITY."
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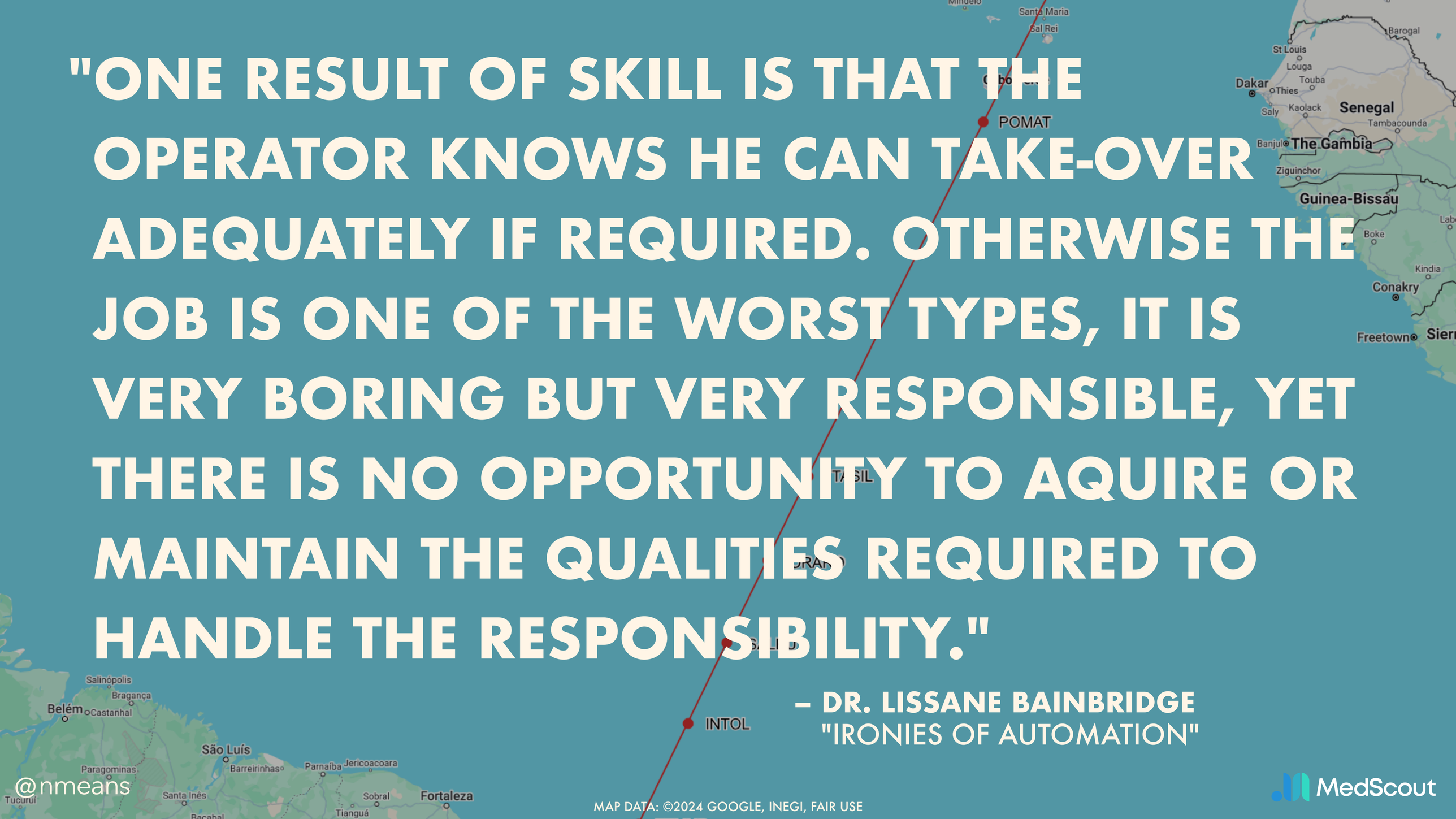
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"THE MORE ADVANCED A CONTROL SYSTEM IS, ... THE MORE CRUCIAL MAY BE THE CONTRIBUTION OF THE HUMAN OPERATOR."

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Sources

Select all sources

BEA Final Report

Brown - Automation/...

CVR Transcript

Cloudberg - The Long...

FDR Chronology.pdf

Faccini - 4m37s

Langewische - Huma...

Parameter Graphs (1)....

Wikipedia - AF447

How long was AF447 without accurate airspeed data?

Duration of Inaccurate Airspeed Data on AF447

The sources provide a timeline of the airspeed data issues on AF447, allowing us to determine how long the aircraft was without accurate airspeed data:

- **Initial Failure:** The sources pinpoint the start of the airspeed problems to **2:10:05 A.M. UTC** when the pitot tubes likely became blocked by ice crystals 1 2 3. The blockage led to a discrepancy in airspeed readings, triggering the autopilot disconnection and a reconfiguration of the flight control law to alternate 2B 3 4 5 6.
- **Erroneous Readings:** Following the initial failure, the airspeed indications displayed on the various instruments became unreliable. The sources detail how different air data reference units (ADRs) experienced varying durations of invalid airspeed data:
  - **ADR 1:** The airspeed displayed on the left primary flight display (PFD), generally derived from ADR 1, became invalid around 2:10:08 A.M. UTC and remained unreliable for 29 seconds 7 8.
  - **ADR 2:** The exact duration of ADR 2's invalid data is less certain. The report suggests that the pitot probe associated with ADR 2 started to freeze between 2:10:03.5 A.M. UTC and 2:10:05 A.M. UTC and definitively unfroze no later than 2:10:46 A.M. UTC 9. The report notes that the pitot probe on the copilot's side, linked to ADR 2, likely unfroze at least temporarily during this period 9.
  - **ADR 3:** The airspeed displayed on the Integrated Standby Instrument System (ISIS), derived from ADR 3, was also affected. The sources state that the speed on ADR 3 experienced a temporary drop between 2:10:07 A.M. UTC and 2:10:10 A.M. UTC and then fell again at 2:10:14 A.M. UTC 3. The ISIS speed remained unreliable for a total of 54 seconds 8.
- **Restoration of Valid Data:** The report doesn't specify a precise time when all three ADRs began consistently providing accurate airspeed data. However, the sources indicate that the pitot tubes eventually unfroze, allowing for the restoration of valid airspeed readings 10 11.

Analysis

- **Challenges in Determining Precise Duration:** The varying durations of inaccurate data across the different ADRs make it challenging to pinpoint the exact time when the aircraft regained full and consistent accurate airspeed information. The temporary unfreezing of some pitot tubes further complicates this determination.

What actions were taken by the pilots in response to the unreliable airspeed indications?

What were the limitations on flight time and rest periods in th

Close Chat

9 sources

Start typing...

Notebook guide

NotebookLM may still sometimes give inaccurate responses, so you may want to confirm any facts independently.

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ICE, CONFUSION, AND THE 38,000 FOOT CRASH

NICKOLAS MEANS
@nmeans

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