

Taking the **737**



to the **MAX!**

Nickolas Means
@nmeans

SYM

Taking the **737**



to the **MAX!**

Nickolas Means
@nmeans

SYM

SYM

<https://symops.com/>



Sym APP 5:25 PM

SSO Access request by @nmeans ✓

ProdAdmin Screenshot for slide deck Expires at Mar 13 5:25:50 PM Approved by @david

Revoke

<https://symops.com/>

Content Warning

This talk contains stories of two plane crashes.

If you are a nervous flyer, this talk might not be for you.





BAe Avro RJ-85 EI-RJD





Aérospatiale/BAC Concorde G-BOAB





Boeing 737 MAX 8





Boeing 737 MAX 8





Boeing 737-900



NEWS

Home | Coronavirus | Climate | Video | World | US & Canada | UK | Business | Tech | Science | Stories

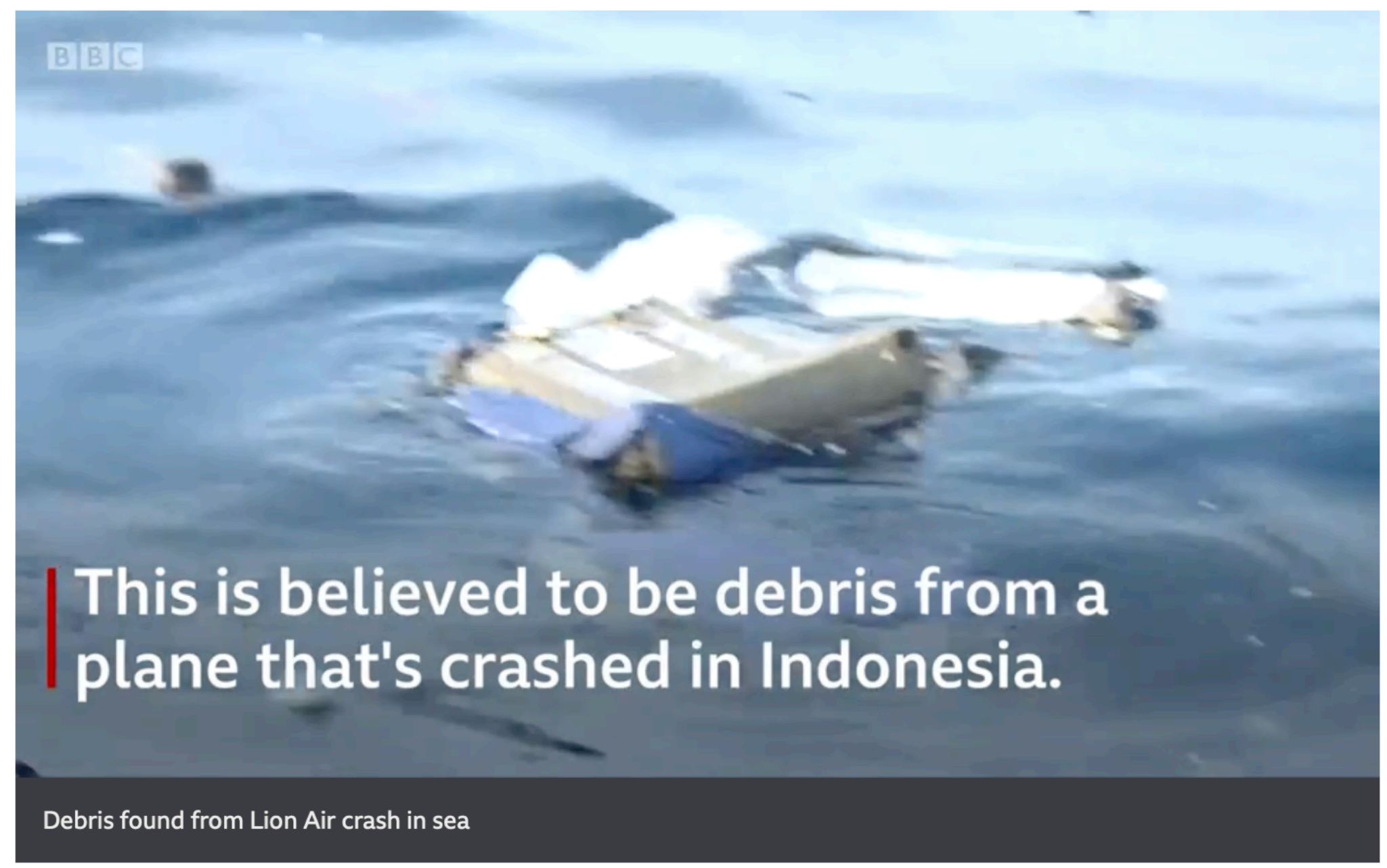
More

Asia | China | India

Lion Air crash: Boeing 737 plane crashes in sea off Jakarta

29 October 2018

Lion Air plane crash



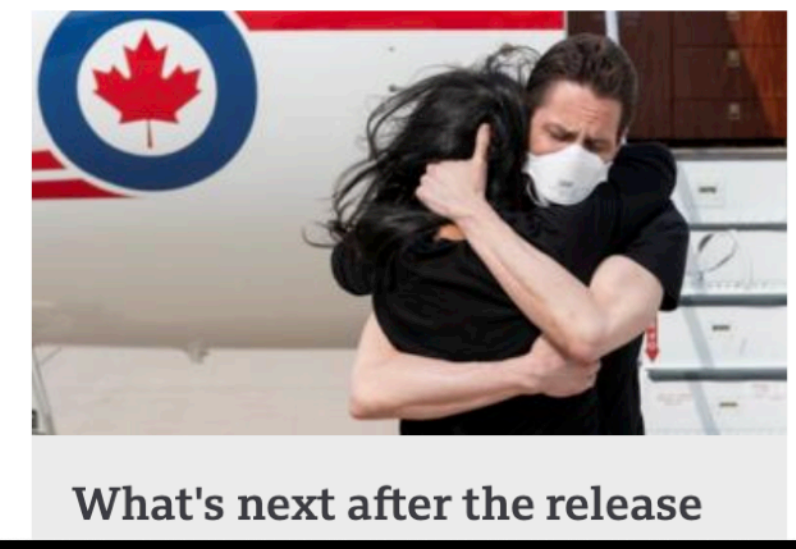
Top Stories

Colombia's most wanted drug lord captured
The US had placed a \$5m bounty on the head of Dairo Antonio Úsuga, better known as Otoniel.
1 hour ago

Injured filmmaker 'gutted' at movie set death
8 hours ago

Turkey moves to throw out US envoy and nine others
7 hours ago

Features





Boeing 737-MAX 8 PK-LQP





Captain Bhavye Suneja





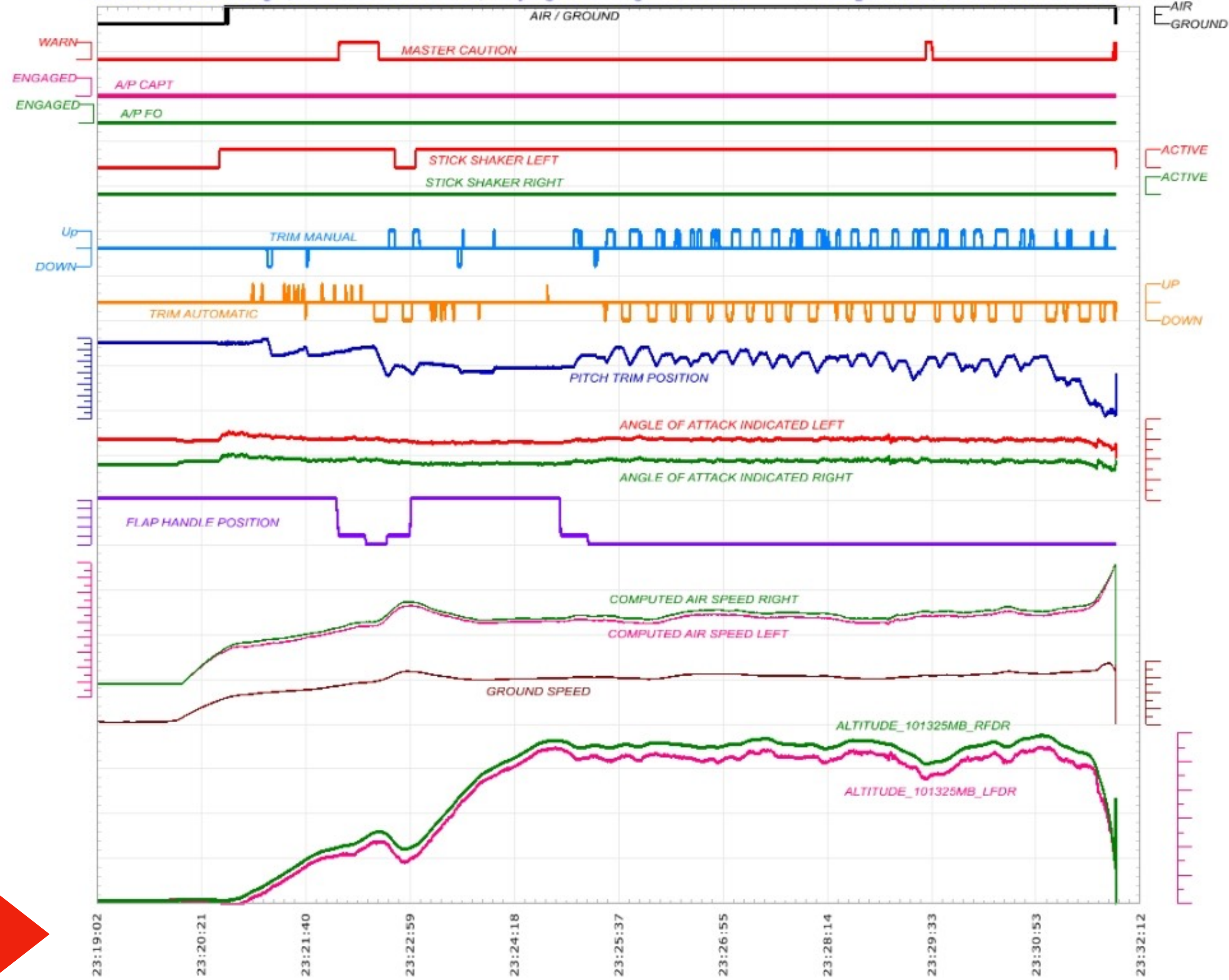
Pangkal Pinang (PGK)

Jakarta (CGK)



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

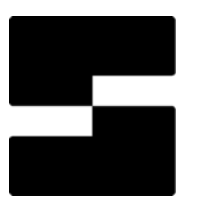


@nmeans

Komite Nasional Keselamatan Transportasi
Republic Of Indonesia

UTC Time (hh:mm:ss)

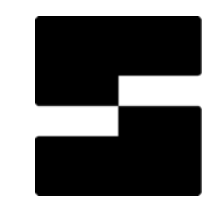
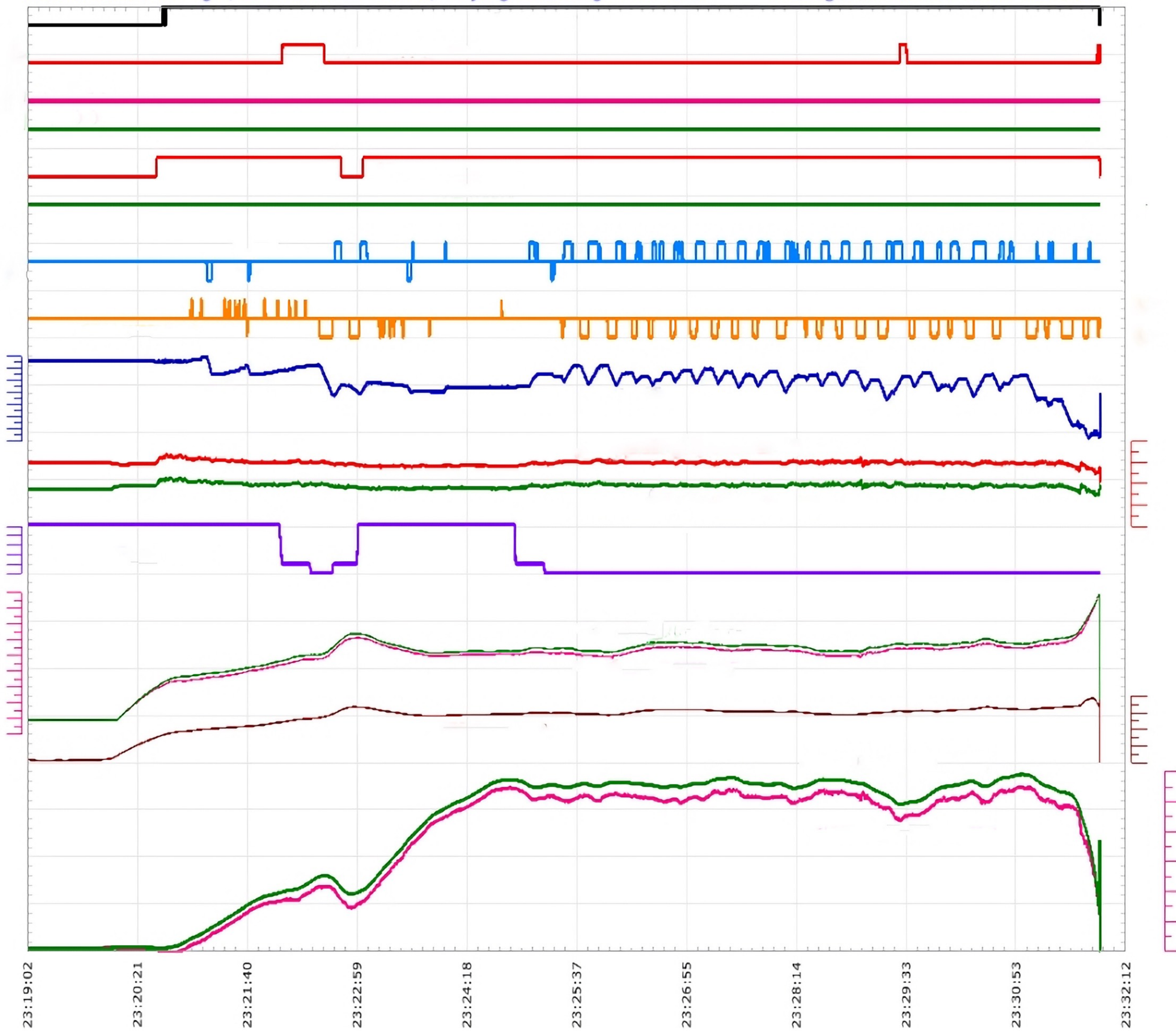
File: Accident Flight



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

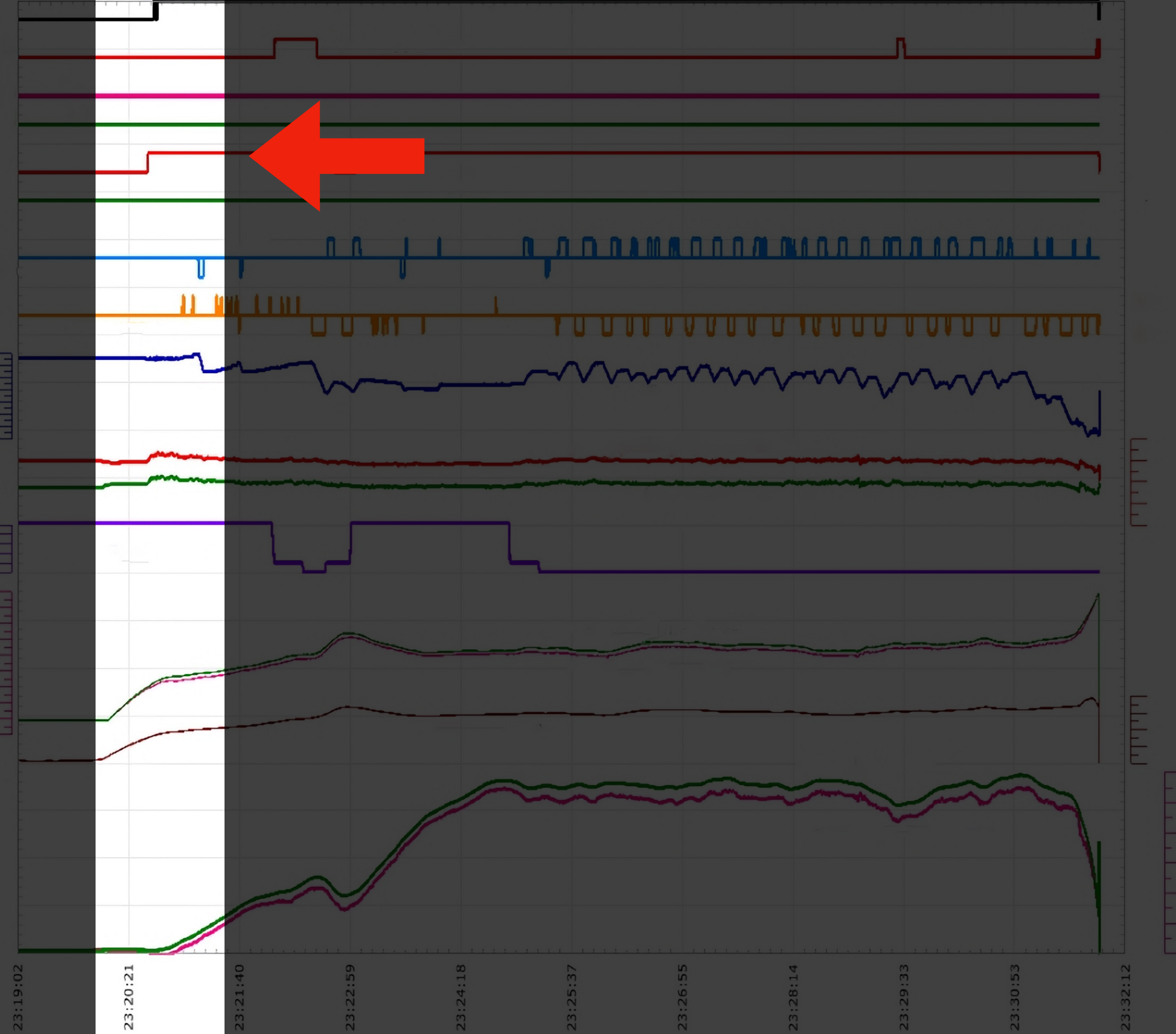
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



@nmeans





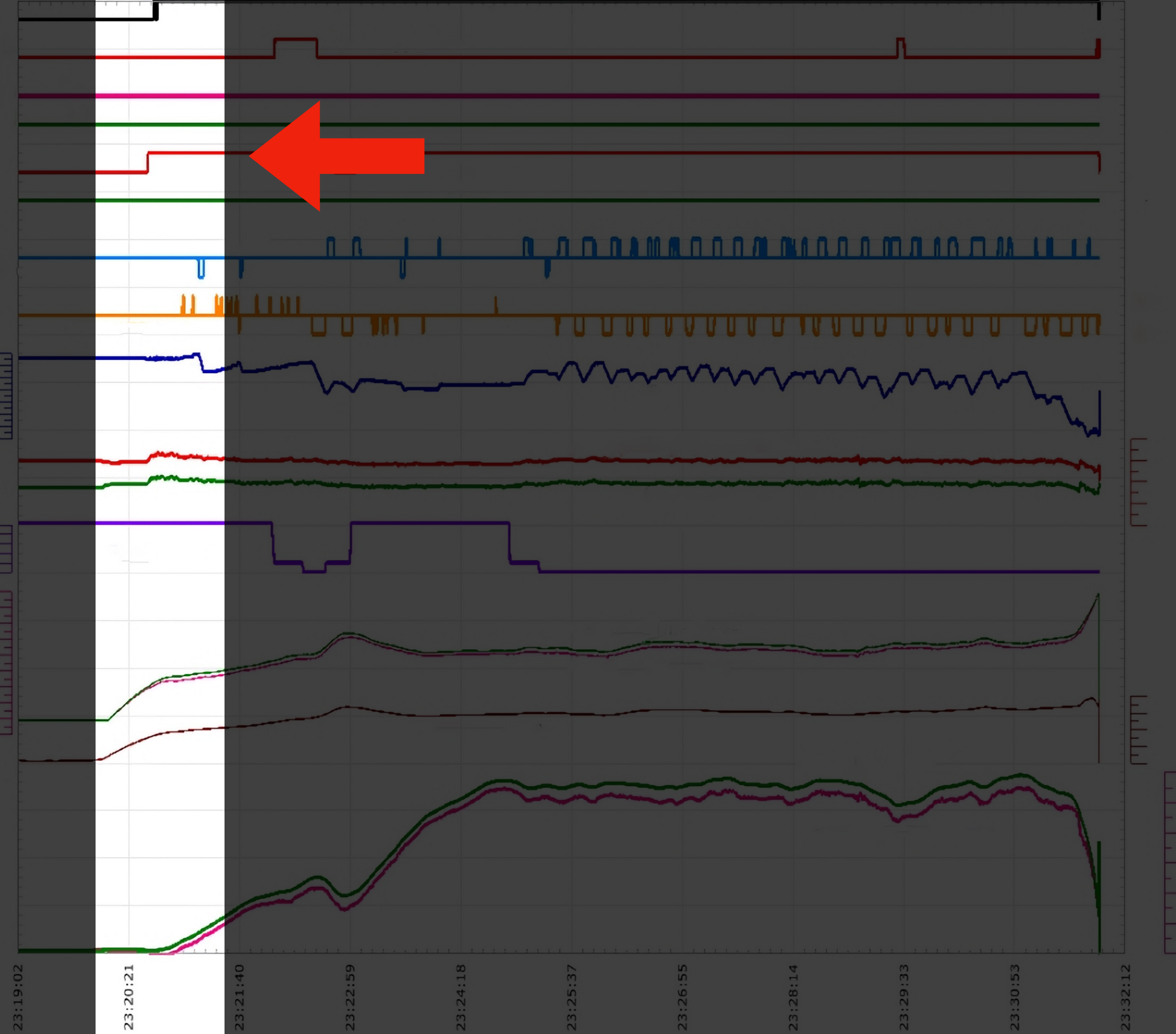
Aerodynamic Stall



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



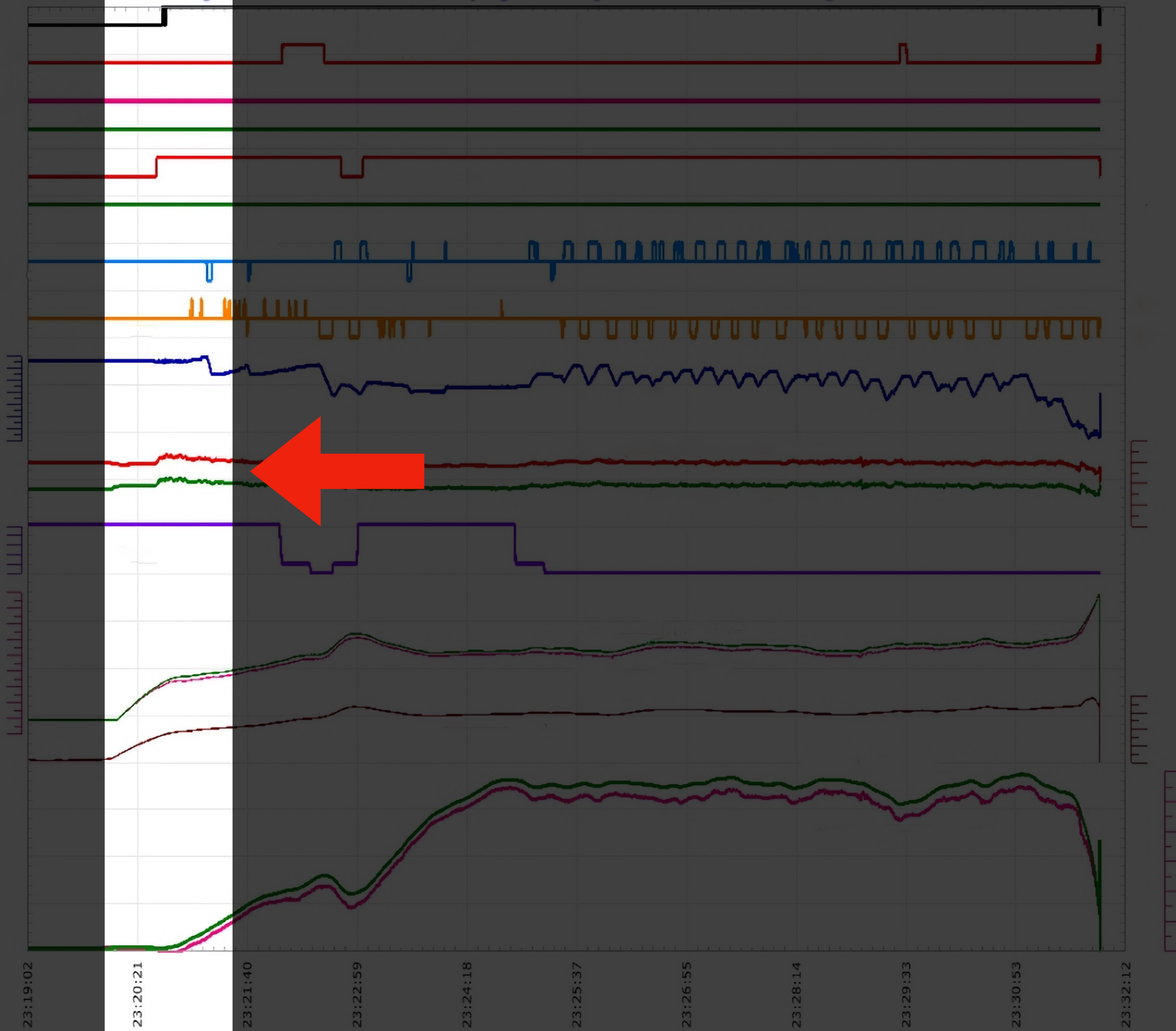
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



@nmeans



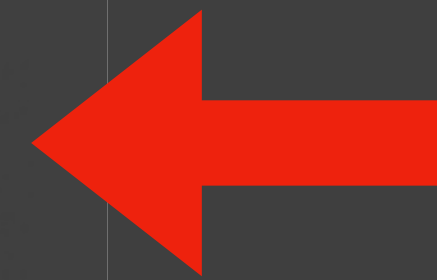
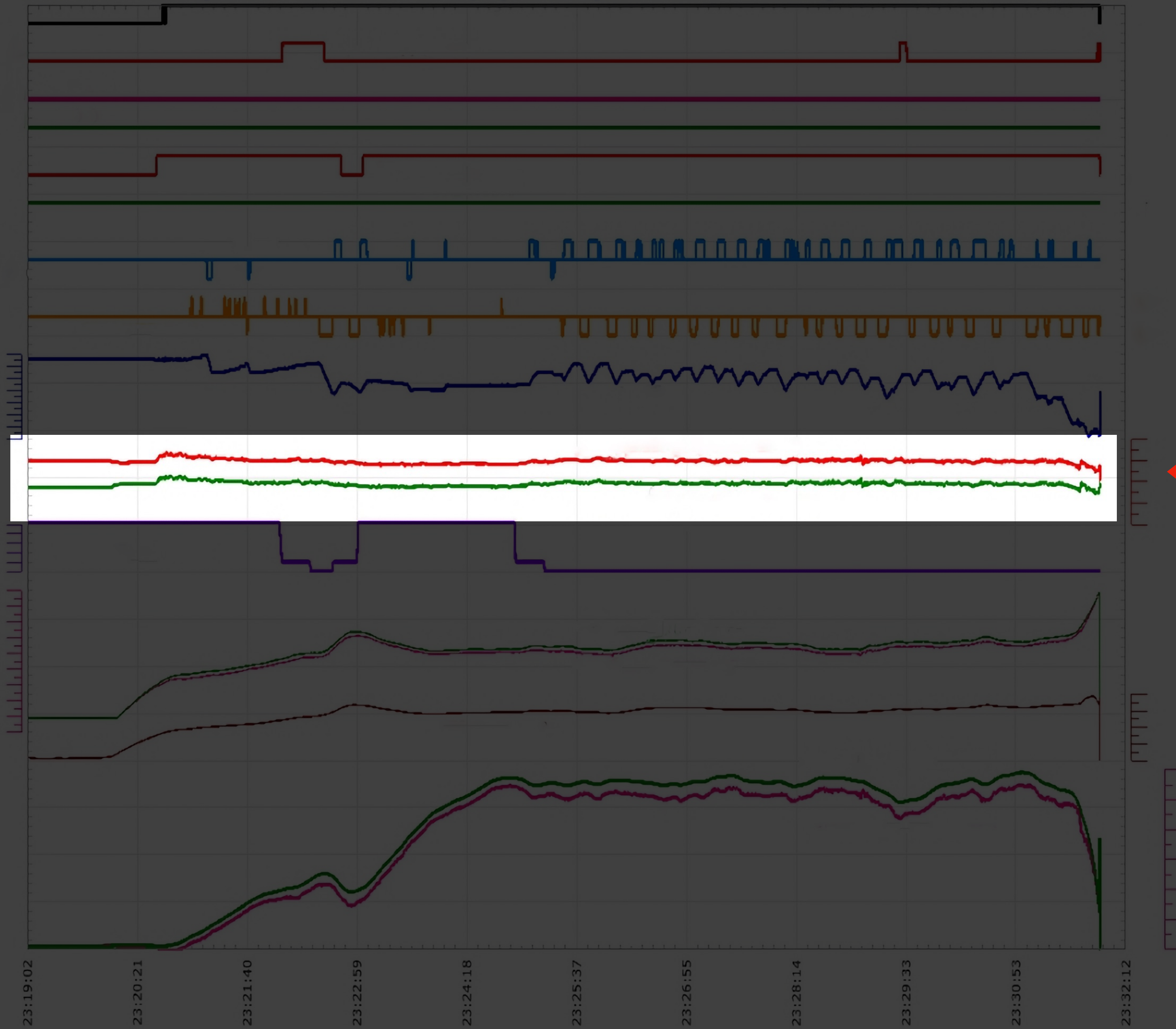
Angle of Attack Vane, Boeing 737



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

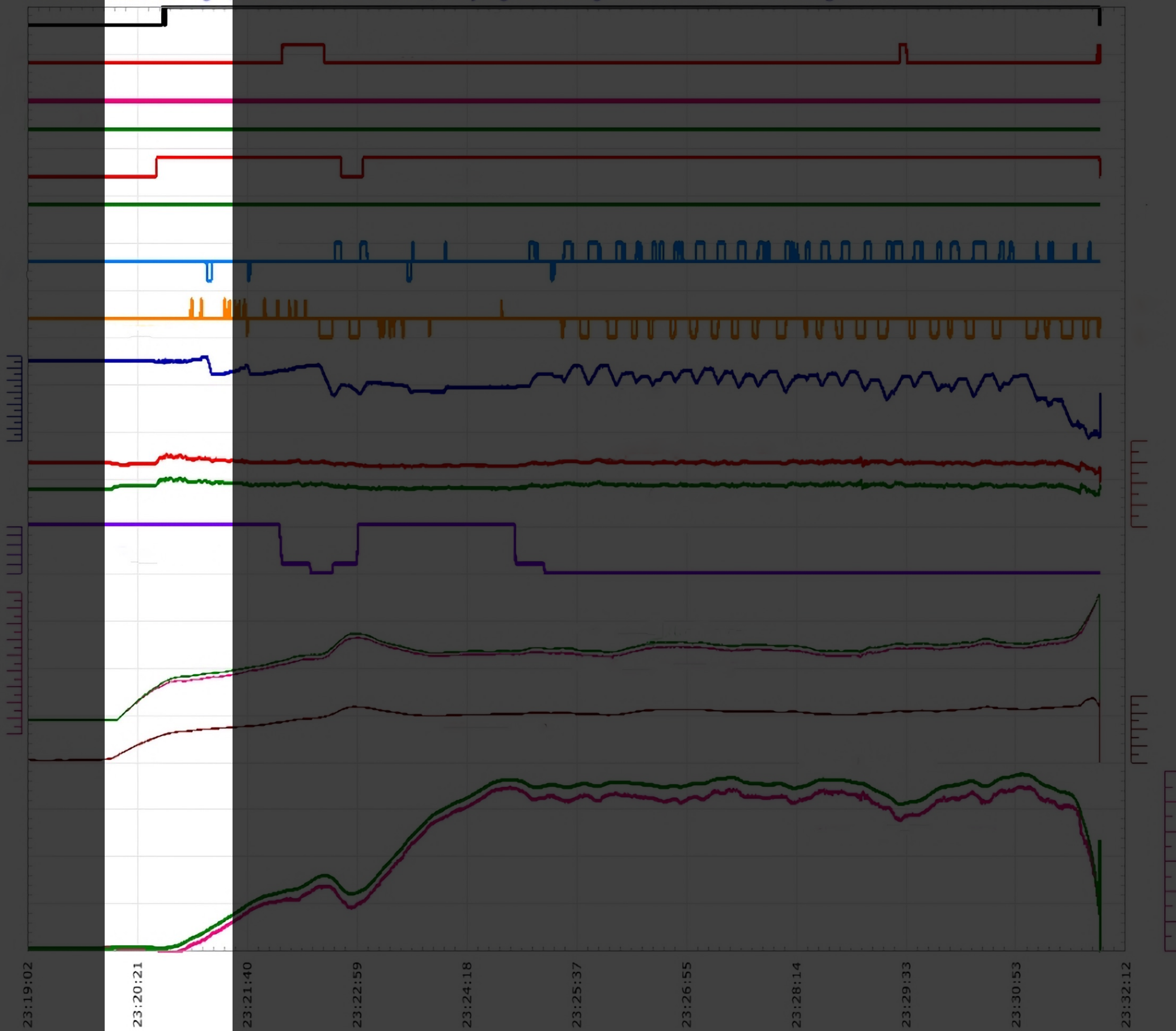
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



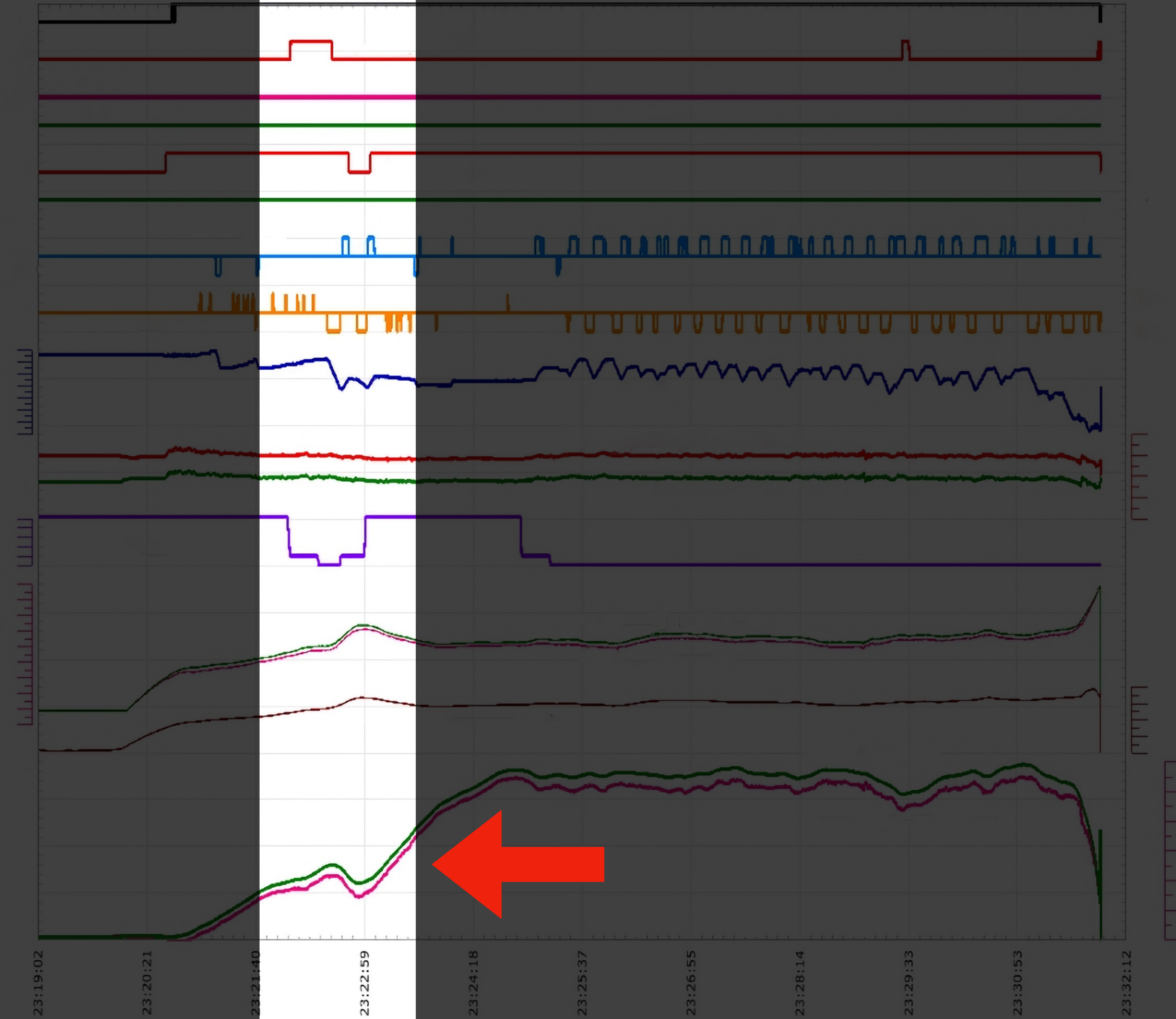
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



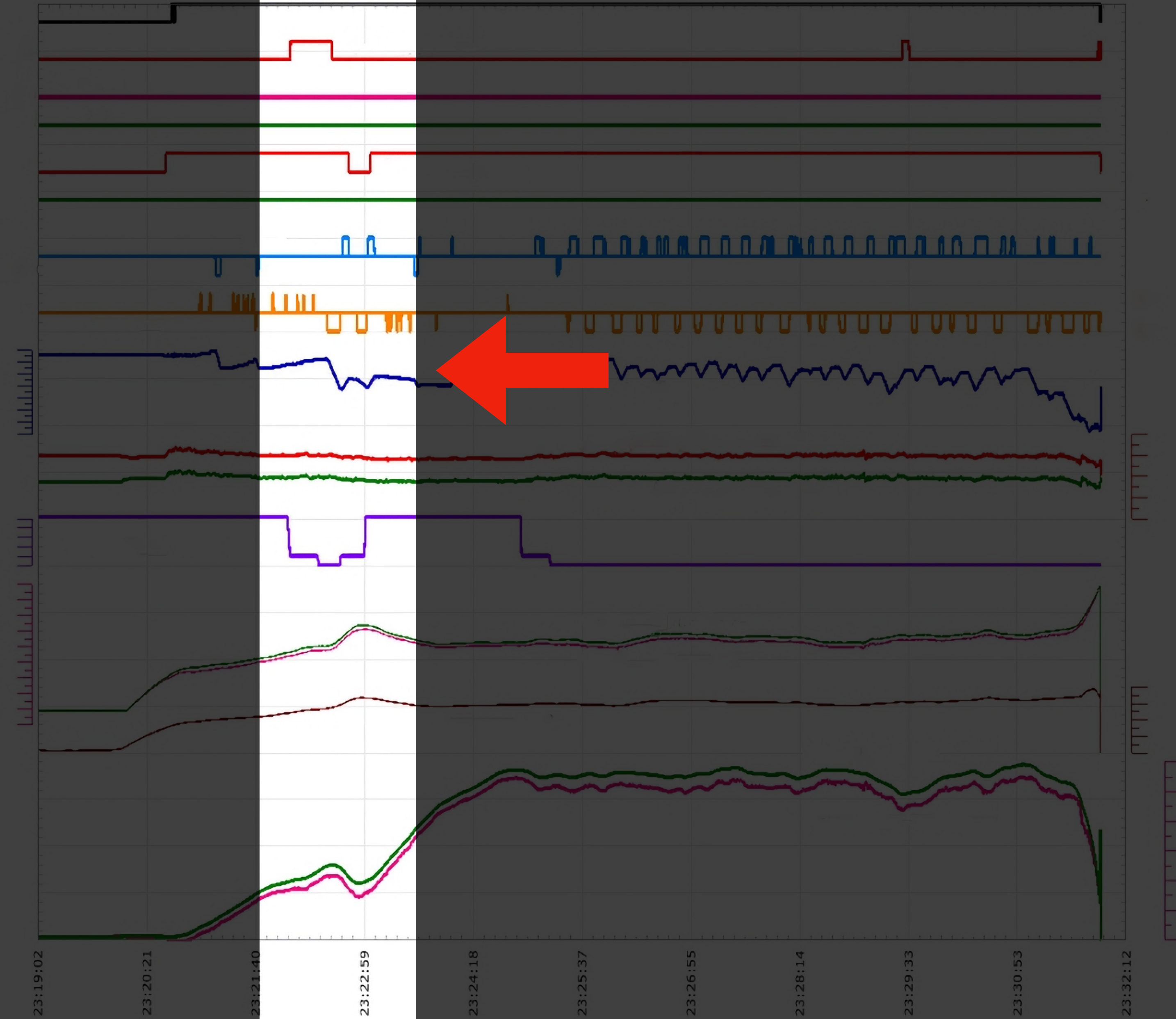
@nmeans



PK-LQP Boeing 737-MAX8

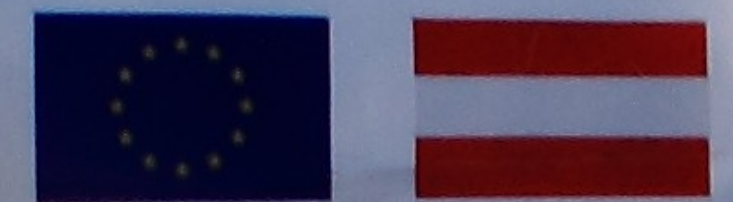
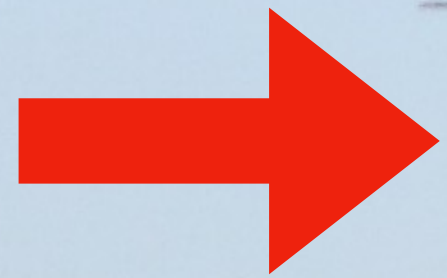
Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



TNT

sure we can



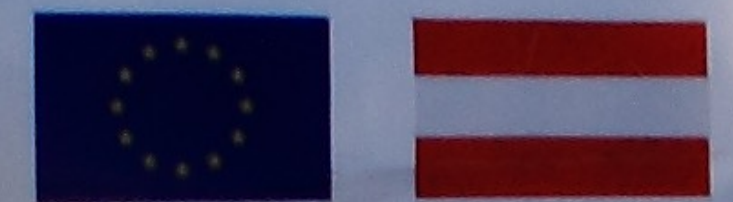
OE-IBZ

Boeing 737-700 Horizontal Stabilizer

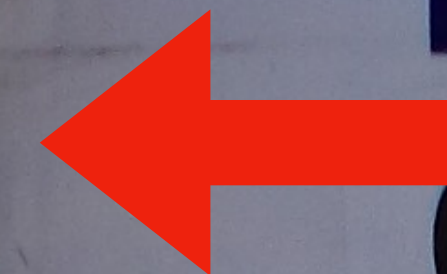


TNT

sure we can



OE-IBZ



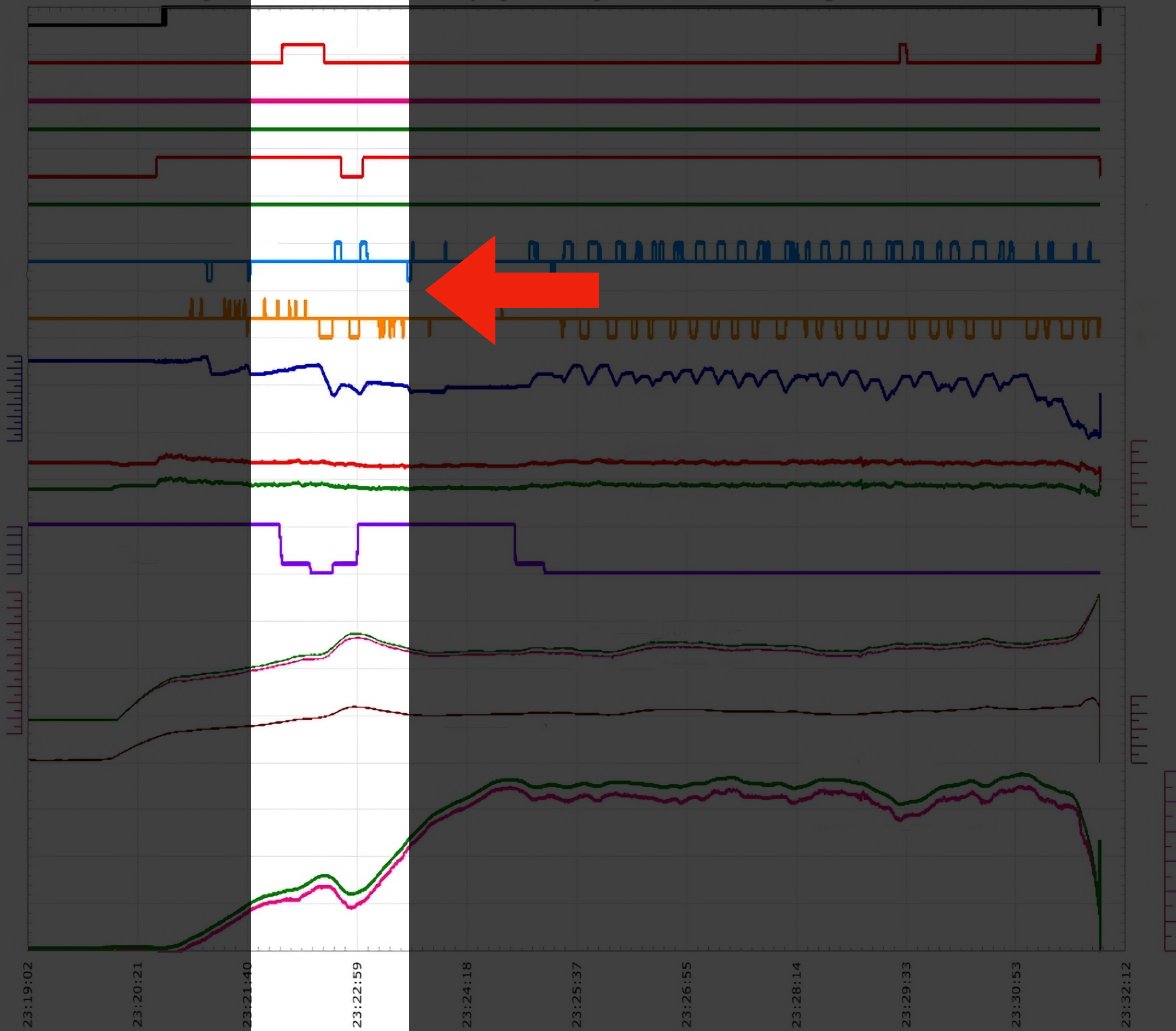
Boeing 737-700 Horizontal Stabilizer



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



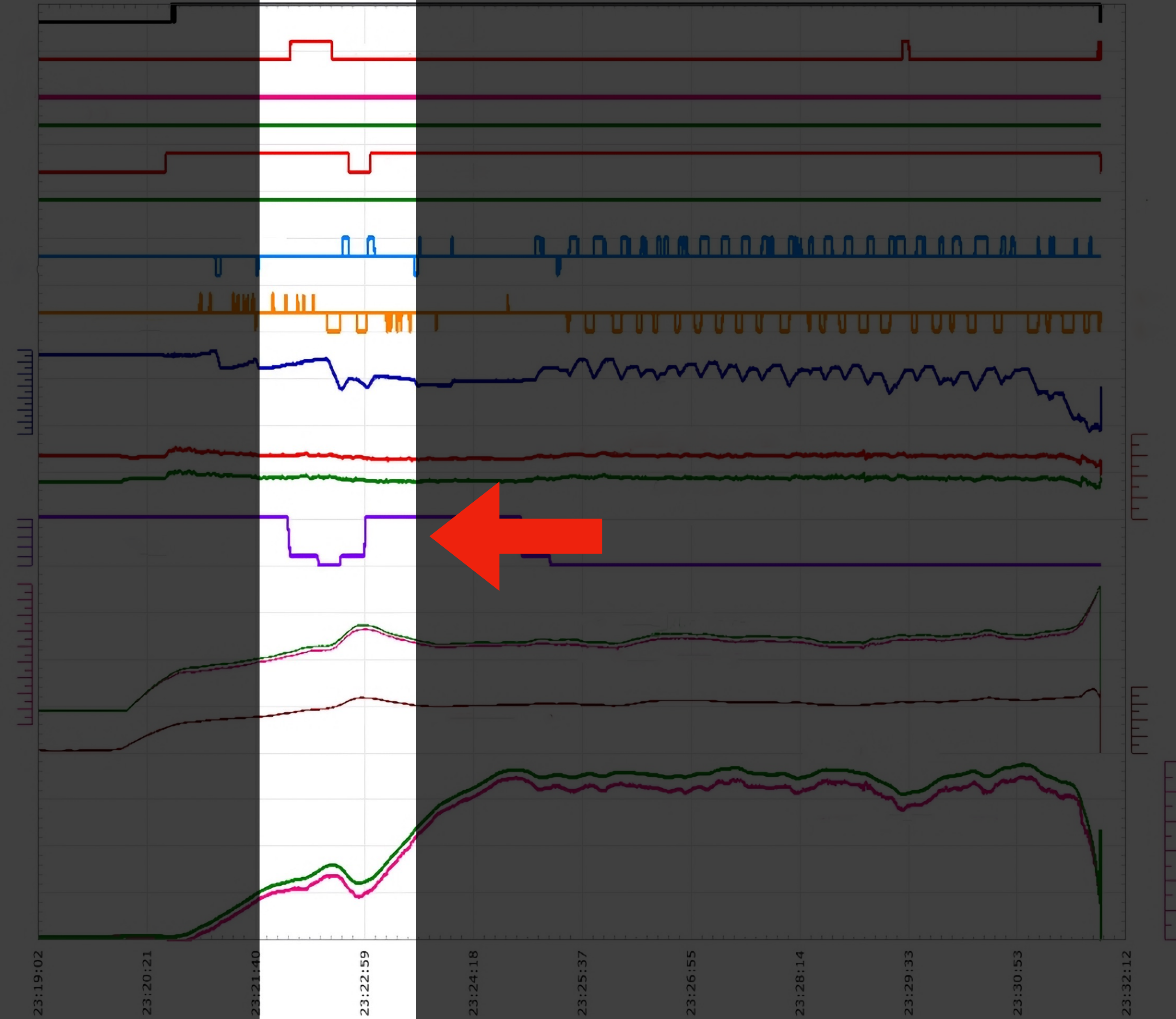
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



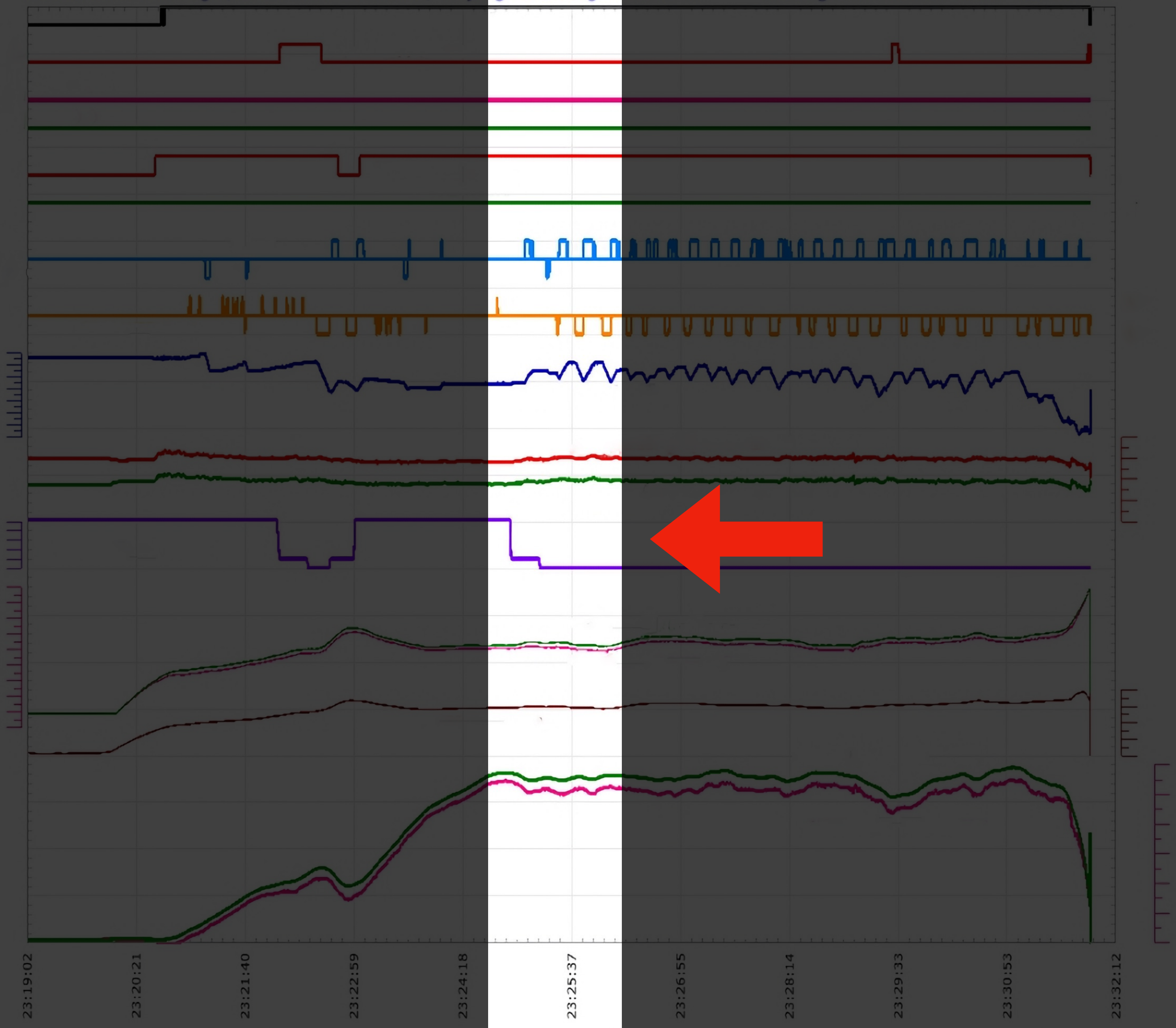
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



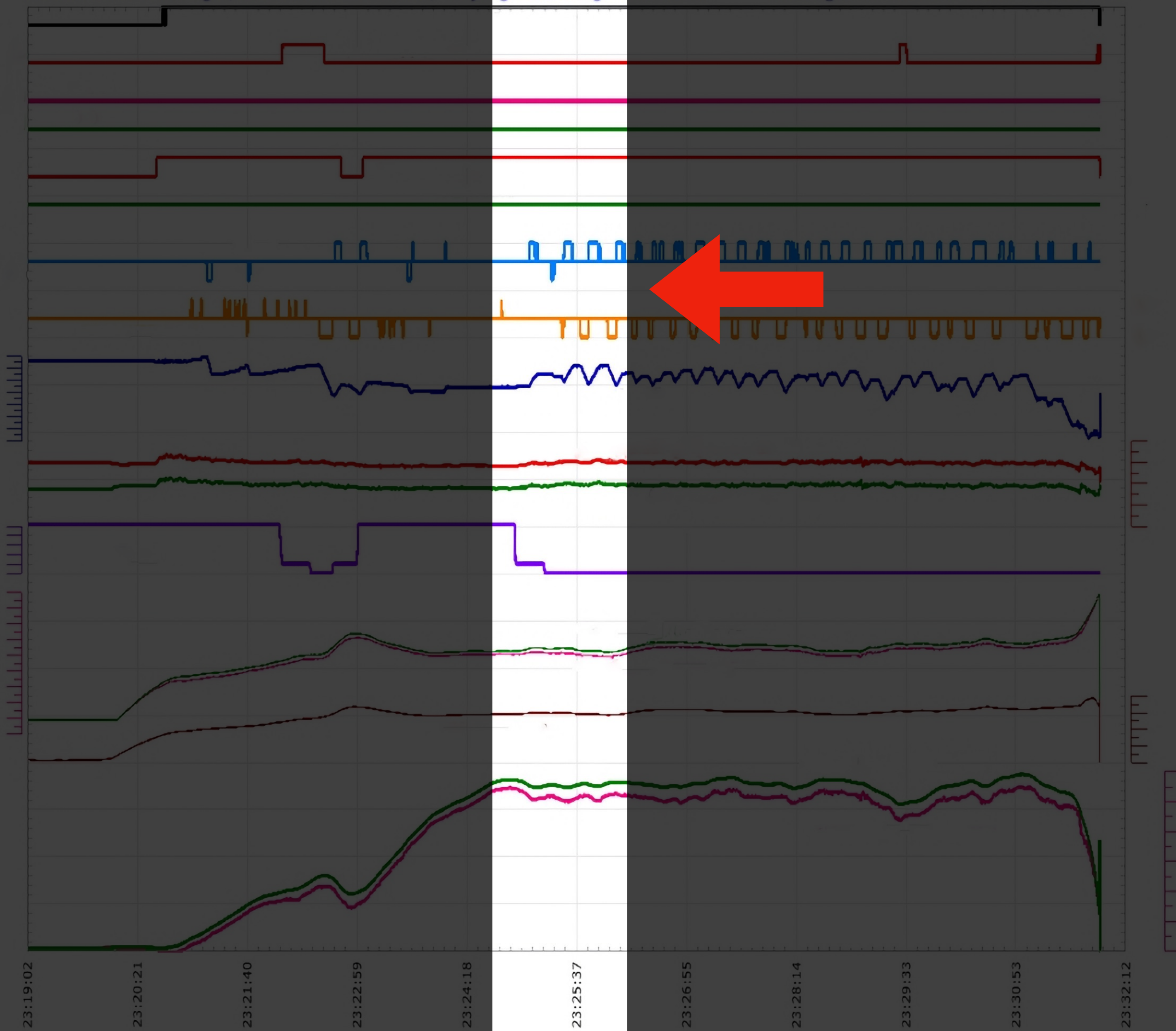
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



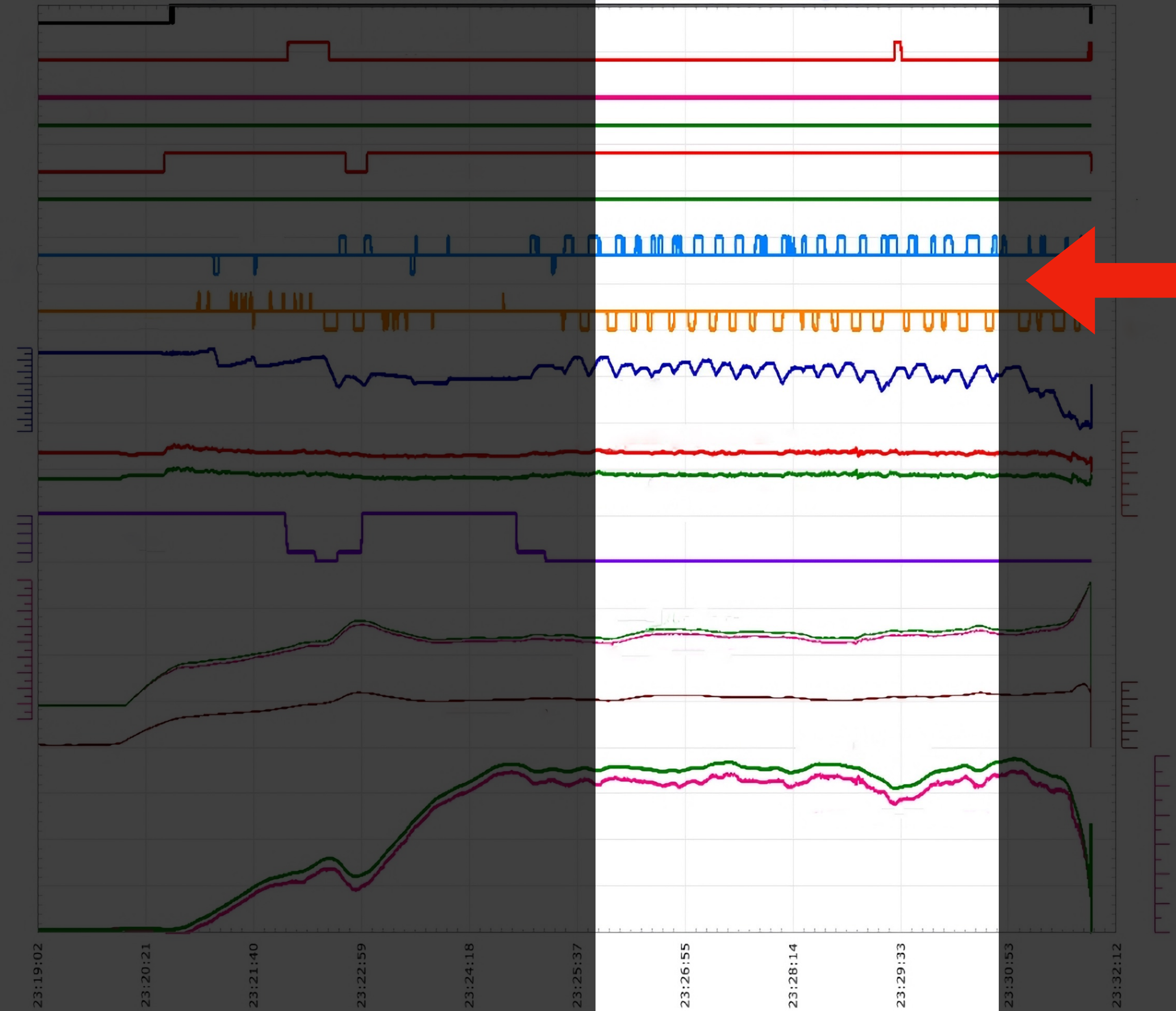
@nmeans



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

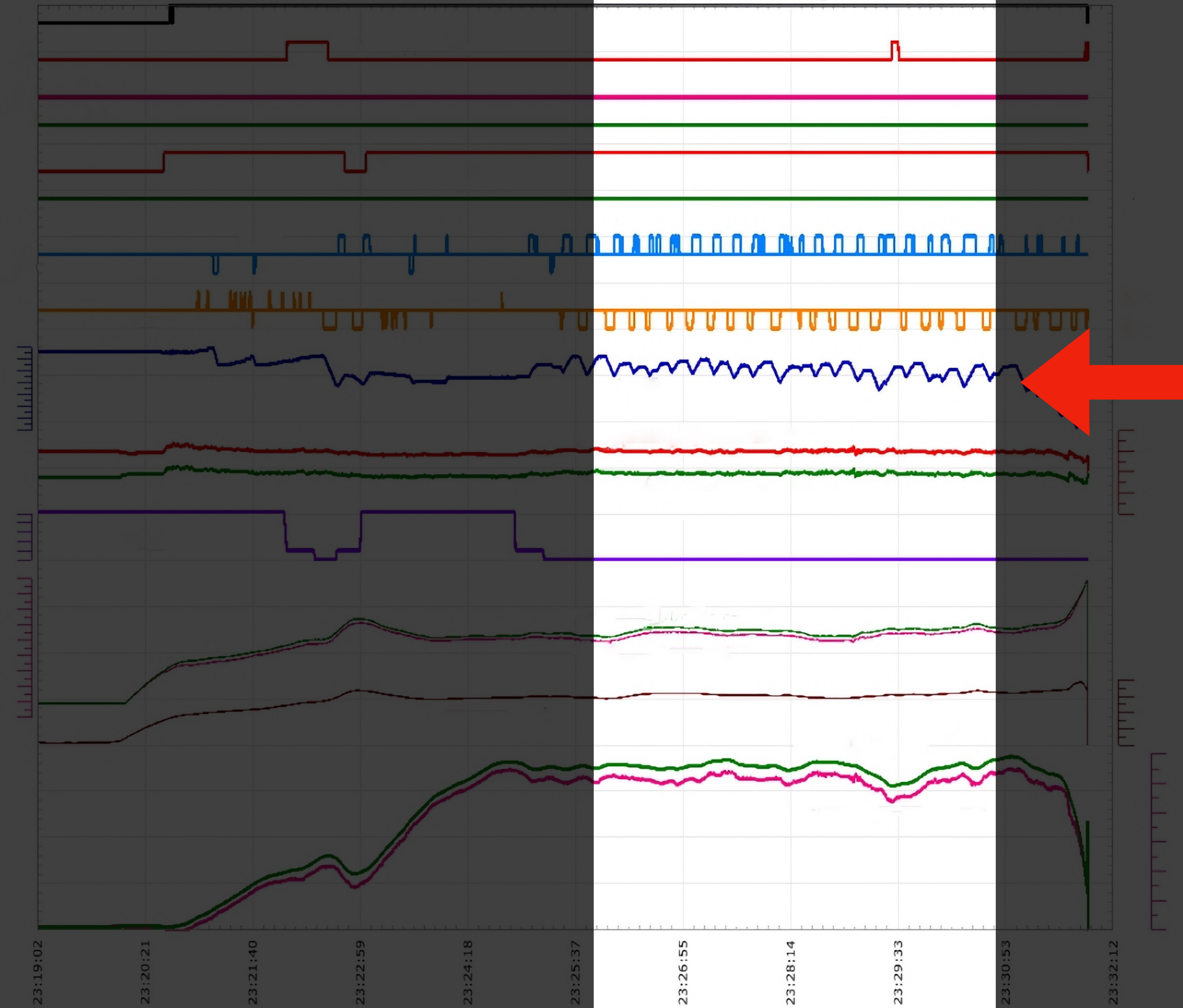
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

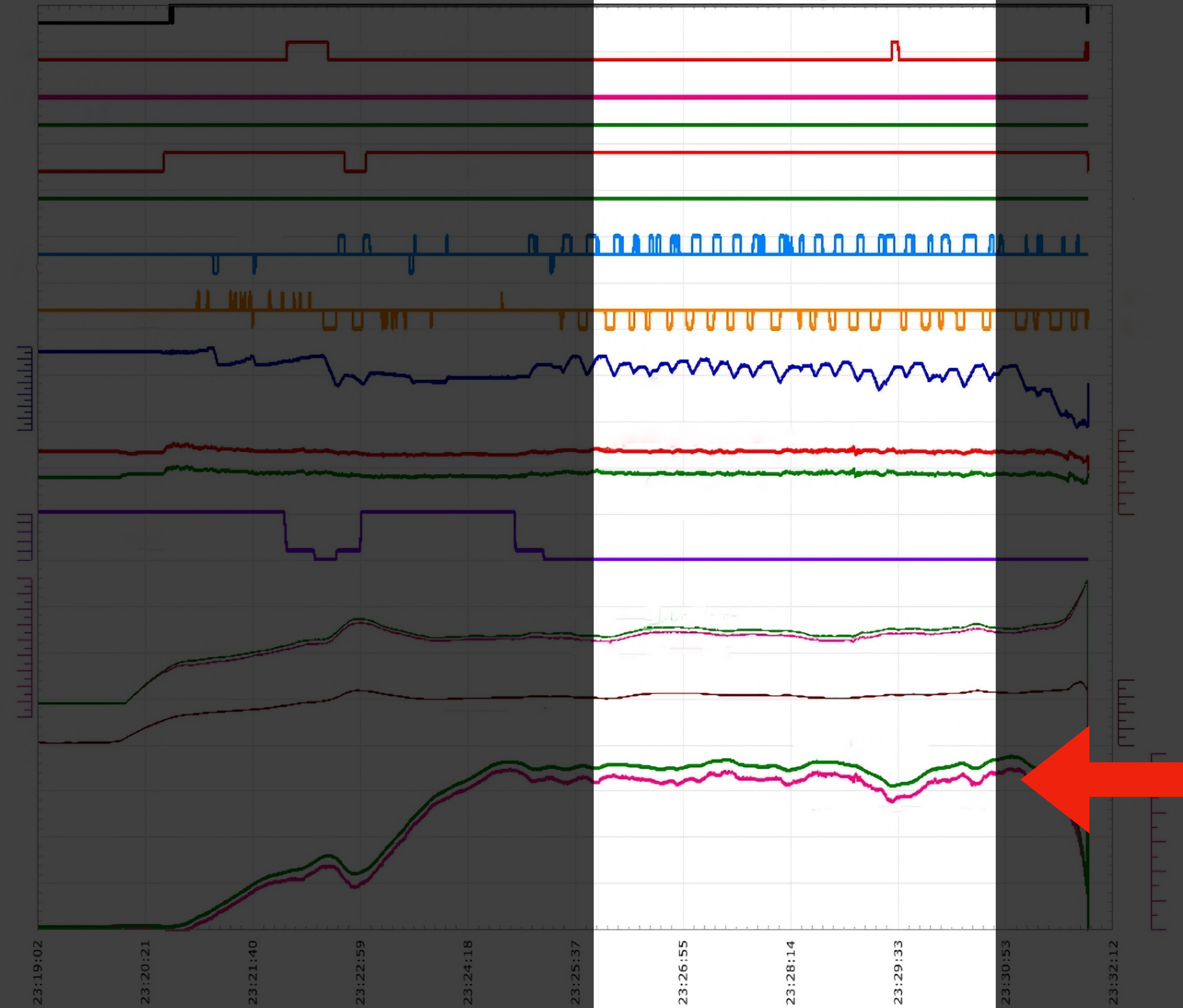
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

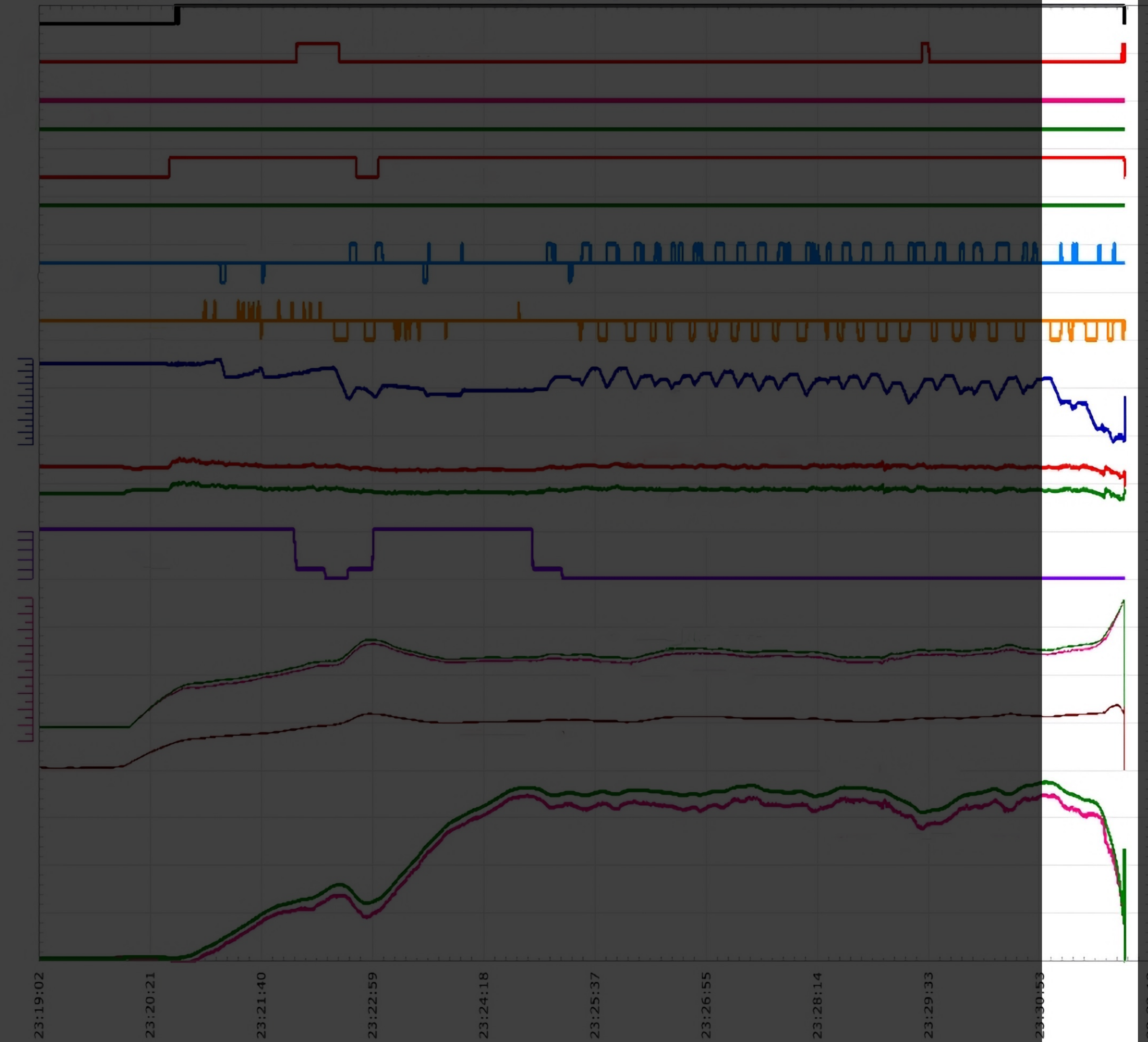
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

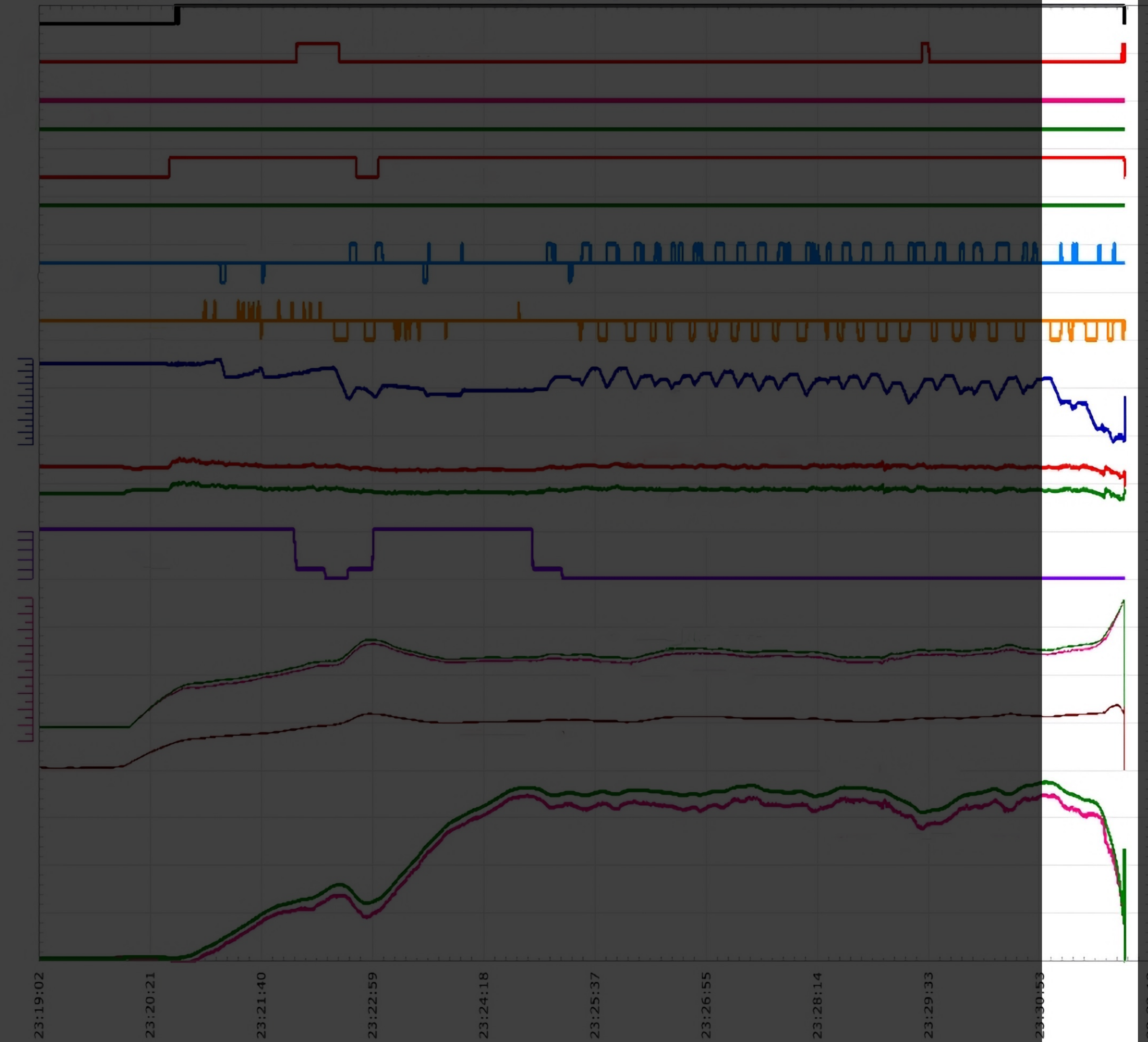
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

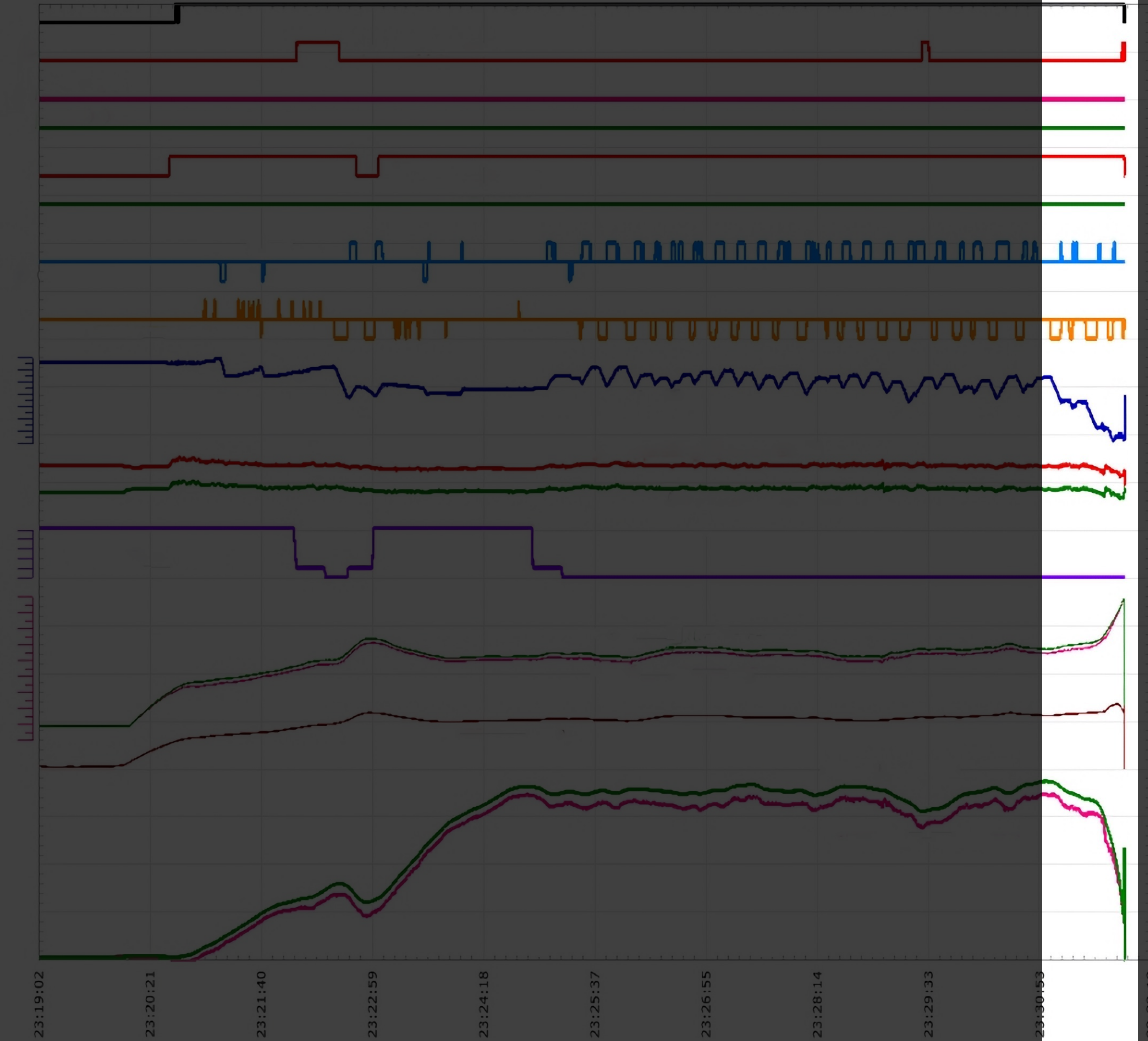
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



Komite Nasional Keselamatan Transportasi
Republic Of Indonesia

UTC Time (hh:mm:ss)

File: Accident Flight

@nmeans





Flight Crew Operations Manual Bulletin for The Boeing Company

The Boeing Company
Seattle, Washington 98124-2207



Number: TBC-19

IssueDate: November 6, 2018

Airplane Effectivity: 737-8 / -9

Subject: Uncommanded Nose Down Stabilizer Trim Due to Erroneous Angle of Attack (AOA) During Manual Flight Only

Reason: To Emphasize the Procedures Provided in the Runaway Stabilizer Non-Normal Checklist (NNC).

Information in this bulletin is recommended by The Boeing Company, but may not be FAA approved at the time of writing. In the event of conflict with the FAA approved Airplane Flight Manual (AFM), the AFM shall supersede. The Boeing Company regards the information or procedures described herein as having a direct or indirect bearing on the safe operation of this model airplane.

THE FOLLOWING PROCEDURE AND/OR INFORMATION IS EFFECTIVE UPON RECEIPT

Background Information

The Indonesian National Transportation Safety Committee has indicated that Lion Air flight 610 experienced erroneous AOA data. Boeing would like to call attention to an AOA failure condition that can occur **during manual flight only**



FROM: THE BOEING COMPANY
TO: Boeing Correspondence (MOM)
[MESSAGE NUMBER:MOM-MOM-18-0664-01B] Multi Operator Message
MESSAGE DATE: 10 Nov 2018 1810 US PACIFIC TIME / 11 Nov 2018 0210 GMT

This message is sent to all 737NG/MAX Customers, Regional Directors, Regional Managers and Boeing Field Service Bases.

CATEGORY: Maintenance, Engineering, Flight Operations, Management, Safety

SERVICE REQUEST ID: 4-4298138108
ACCOUNT: Boeing Correspondence (MOM)
DUE DATE: No Action Required
PRODUCT TYPE: Airplane
PRODUCT LINE: 737
PRODUCT: SEVERAL
ATA: 0000-57

SUBJECT: Information - Multi-Model Stall Warning and Pitch Augmentation Operation

REFERENCES:
/A/ MOM-MOM-18-0655-01B

SUMMARY:

Boeing has received many requests for the same information from 737 fleet operators in response to the reference /A/ message. This message provides technical information and operational details.

DESCRIPTION:

A pitch augmentation system function called "Maneuvering Characteristics Augmentation System" (MCAS) is implemented on the 737-8, -9 (MAX) to enhance pitch characteristics with flaps UP and at elevated angles of attack. The MCAS function commands nose down stabilizer to enhance pitch characteristics during steep turns with elevated load factors and during flaps up flight at airspeeds approaching stall. MCAS is activated without pilot input and only operates in manual, flaps up flight. The system is designed to allow the flight crew to use column trim switch or stabilizer aisle stand cutout switches to override MCAS input. The function is commanded by the Flight Control computer using input data from sensors and other airplane systems.



Boeing 737-100 Prototype





Boeing 737-300 Engine Inlet Cowling





Boeing 737-700 "NextGen"



Airbus A320neo





James McNerney
CEO, Boeing

@nmeans



Gerard Arpey
CEO, American Airlines



Trinitron

**MCDONNELL
DOUGLAS**  **BOEING**

- **\$13.3 Billion Deal**
- **Combined Sales of \$48 Billion
Projected Next Year**
- **Workforce of Nearly 200,000
in 27 States**

SONY



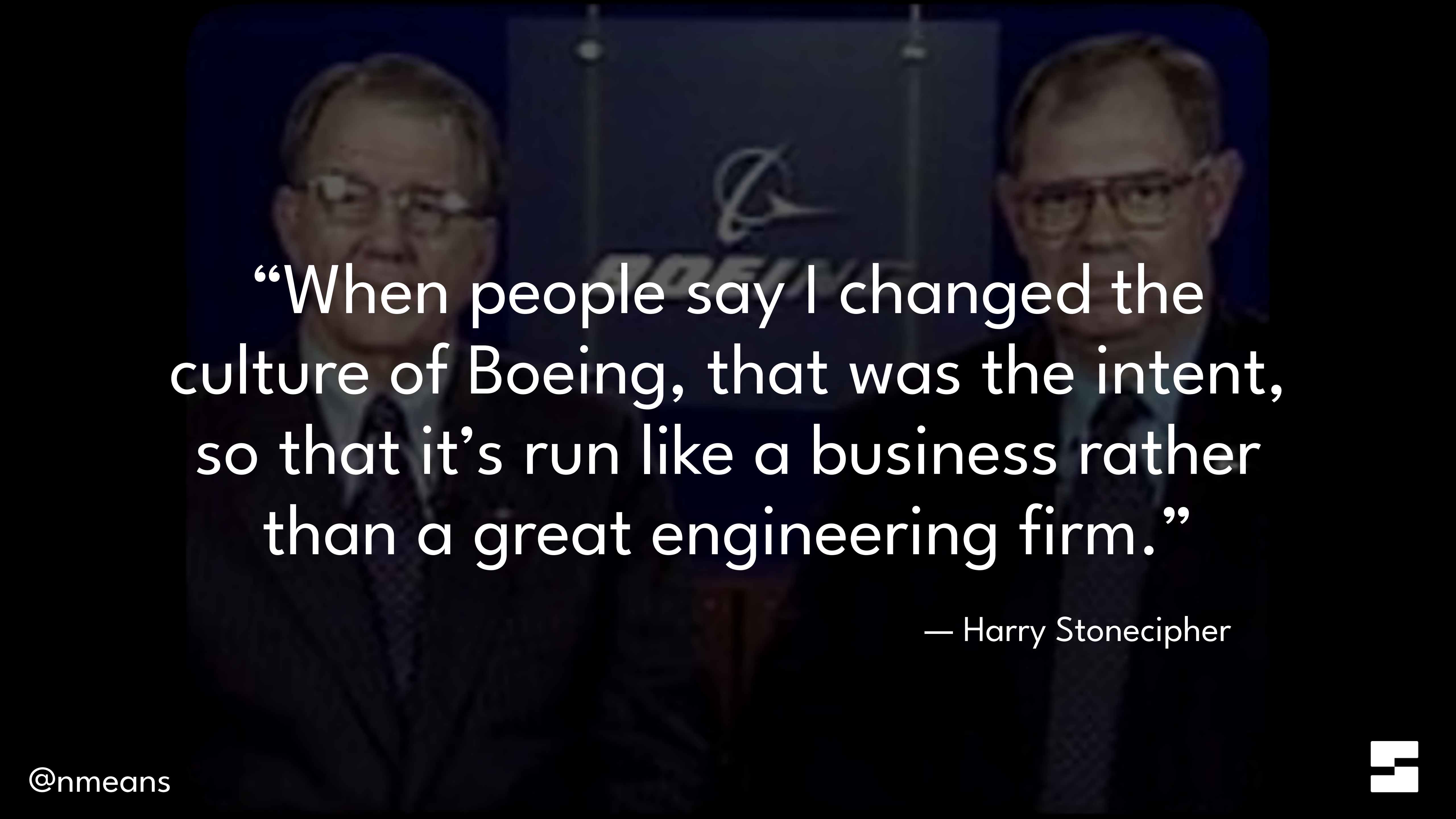


Harry Stonecipher
Boeing President & COO

Phil Condit
Boeing CEO

@nmeans





“When people say I changed the culture of Boeing, that was the intent, so that it’s run like a business rather than a great engineering firm.”

— Harry Stonecipher



James McNerney
CEO, Boeing

@nmeans



Gerard Arpey
CEO, American Airlines





Boeing 737-MAX 8



Airbus A320

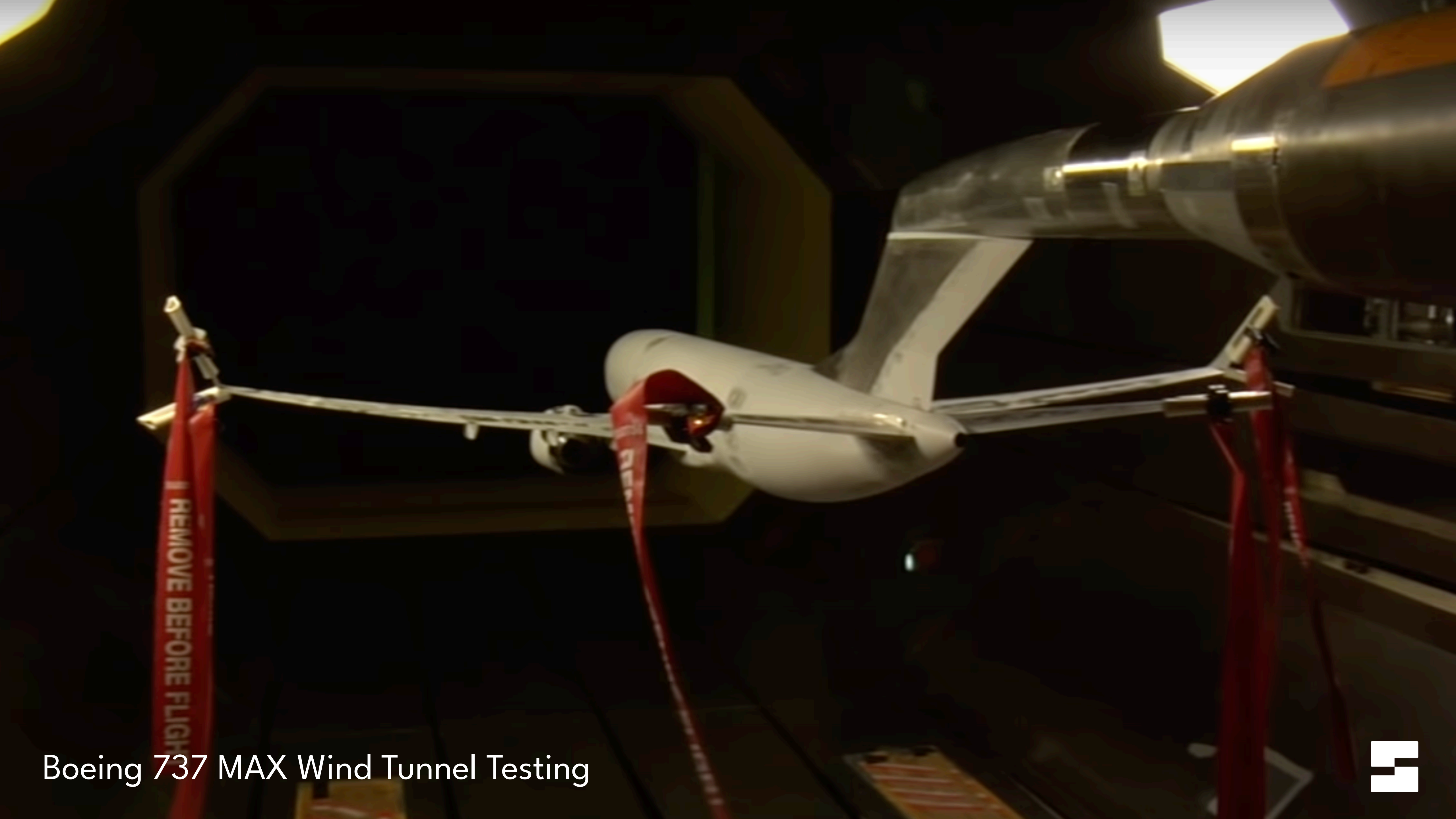
Boeing 737





Boeing 737 MAX Engine Nacelle



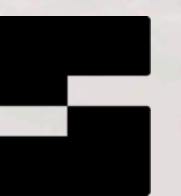


Boeing 737 MAX Wind Tunnel Testing





Boeing KC-46 Pegasus





FAA Administrator Steve Dickson





737 MAX Test Flight





737 MAX Test Flight





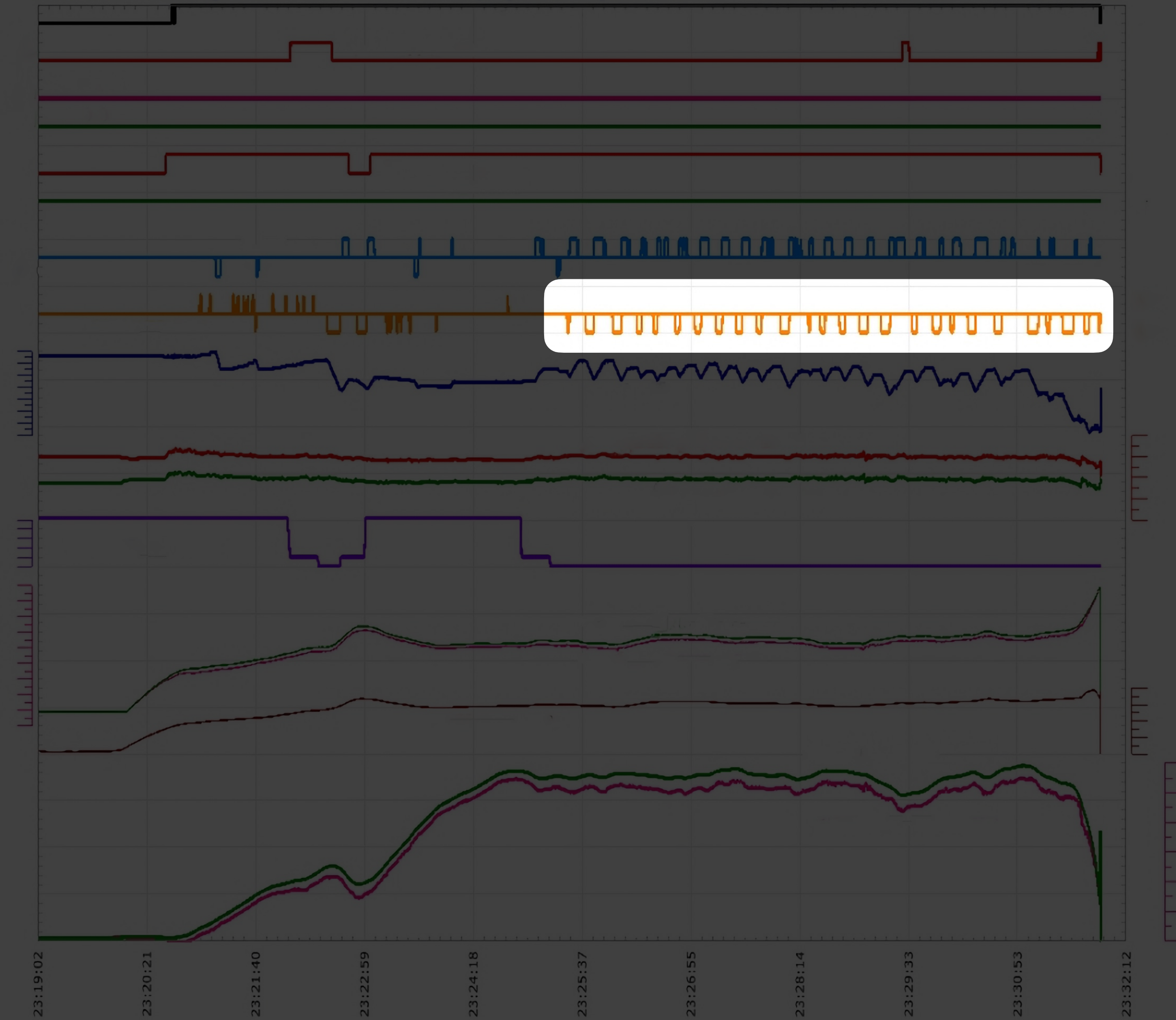
Mark Forkner, Boeing Chief Technical Pilot



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

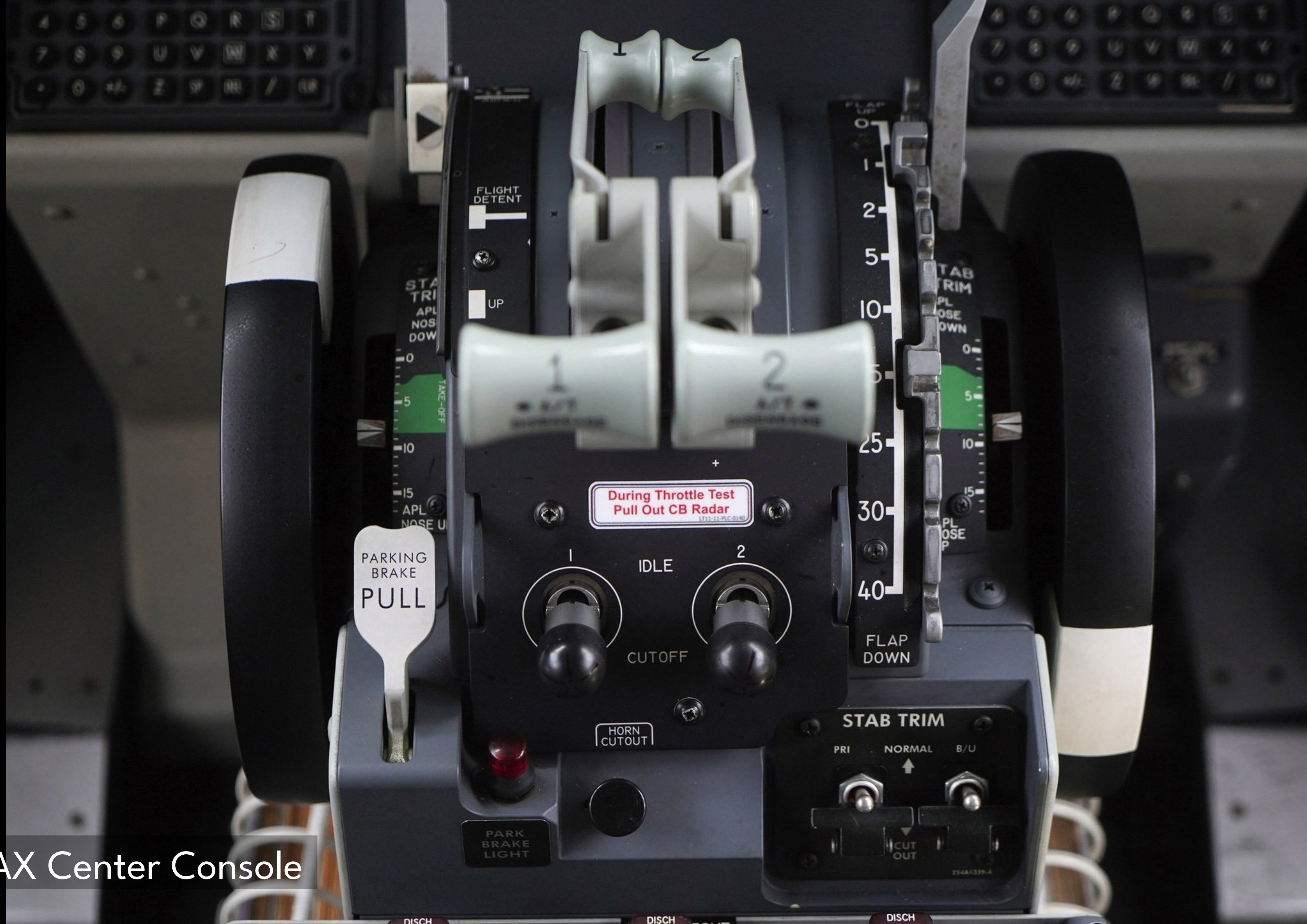
- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude



@nmeans



737 MAX Center Console





737 MAX Center Console



737 MAX Center Console





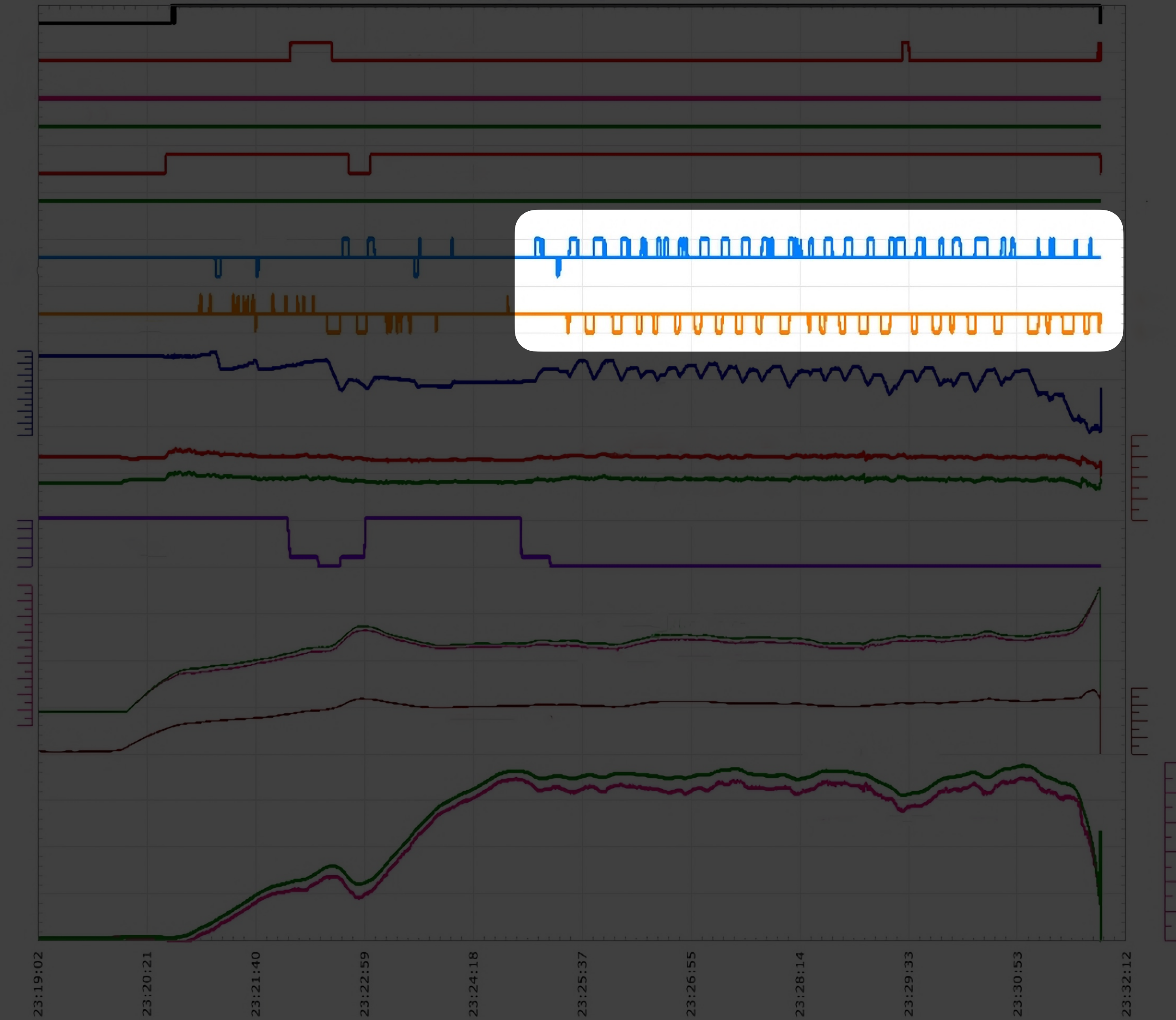
737 MAX Center Console



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude





FEATURE

What Really Brought Down the Boeing 737 Max?

Malfunctions caused two deadly crashes. But an industry that puts unprepared pilots in the cockpit is just as guilty.

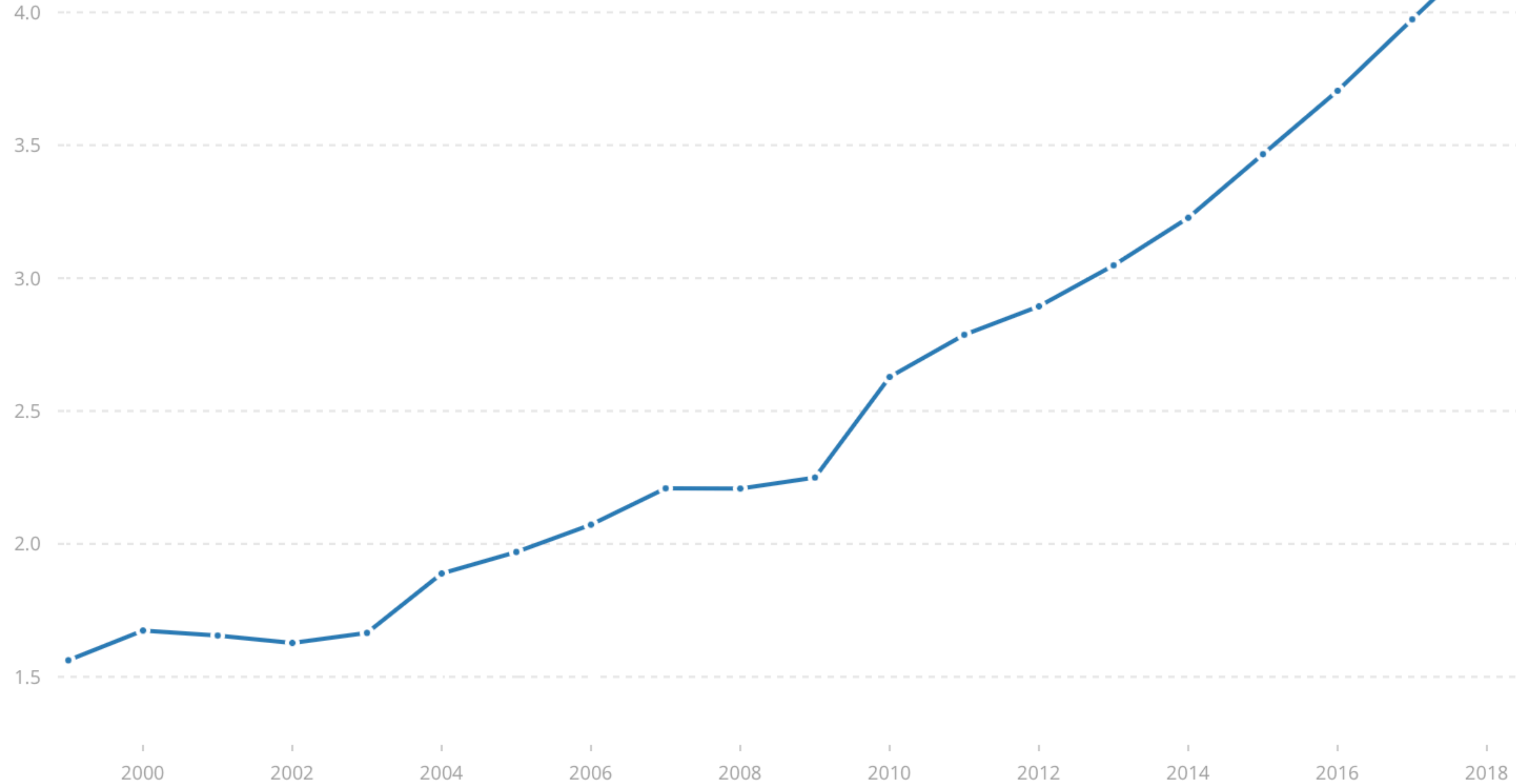
@nmeans

William Langewische



Billion

LABEL



Passengers Carried Globally per Year, 1999-2019

Source: World Bank





FEATURE

What Really Brought Down the Boeing 737 Max?

Malfunctions caused two deadly crashes. But an industry that puts unprepared pilots in the cockpit is just as guilty.

@nmeans

William Langewische





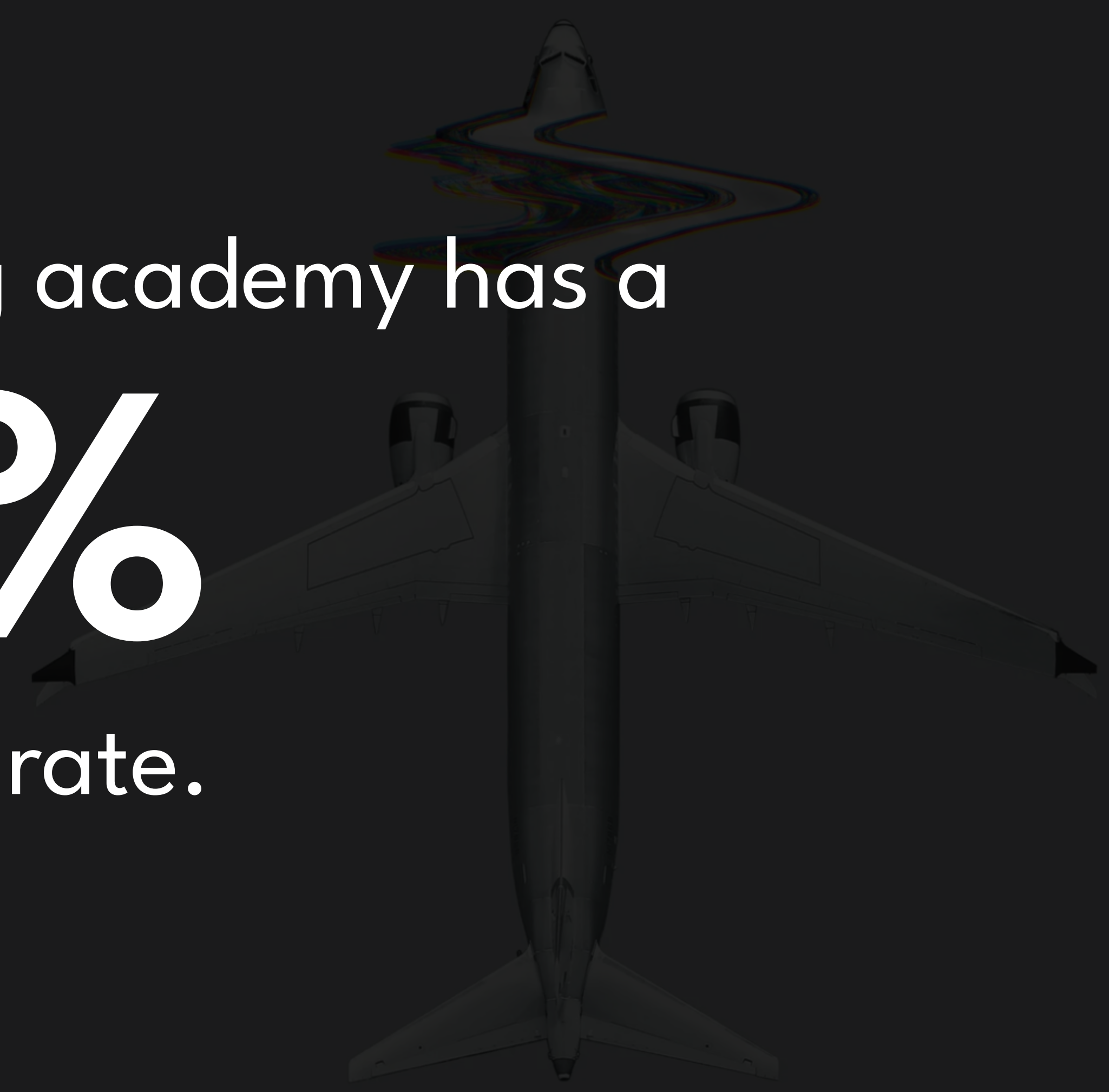
FEATURE
Lion Air's pilot training academy has a

What Really Brought Down
the Boeing 737 Max 8

95%

Malfunctions caused two deadly crashes. But an industry that puts unprepared pilots in the cockpit is just as guilty.

graduation rate.





FEATURE
Indonesia's aviation sector has a fatality rate

What Really Brought Down the Boeing 737 Max?

15x

the global average.

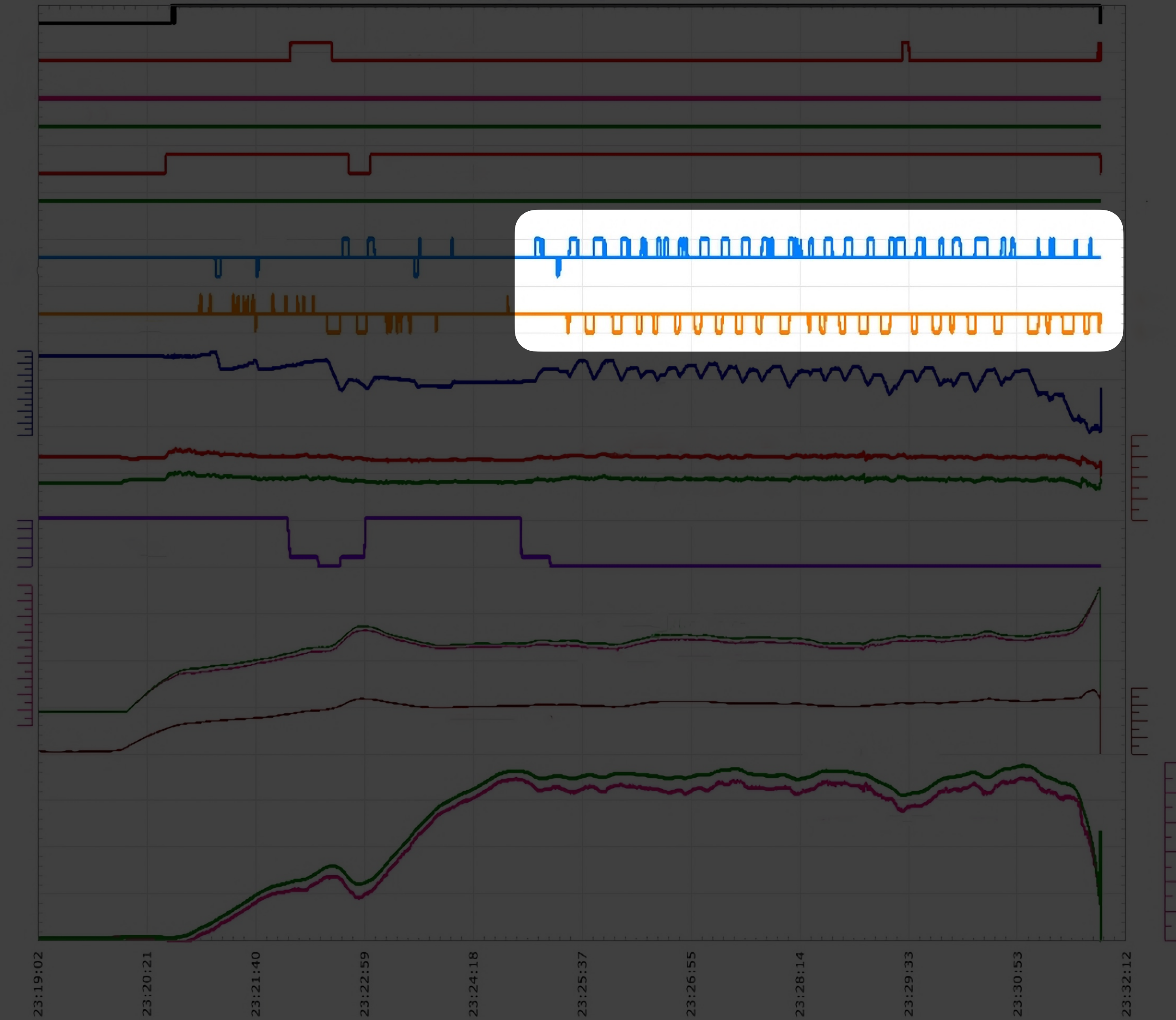
Malfunctions caused two deadly crashes. But an industry that puts unprepared pilots in the cockpit is just as guilty.



PK-LQP Boeing 737-MAX8

Loss of Control in Flight, 28 October 2018 UTC, Tanjung Karawang - Indonesia Investigation Number: KNKT 18.10.35.04

- Ground/Air
- Master Caution
- Pilot Autopilot
- Copilot Autopilot
- Pilot Stick Shaker
- Copilot Stick Shaker
- Manual Trim
- Automatic Trim
- Pitch Trim Position
- Pilot Angle of Attack
- Copilot Angle of Attack
- Flap Handle Position
- Pilot Airspeed
- Copilot Airspeed
- Ground Speed
- Pilot Altitude
- Copilot Altitude





Ethiopian Airlines 737 MAX 8





737 MAXes Parked in Renton, WA



Why did this happen?



Thinking in Systems

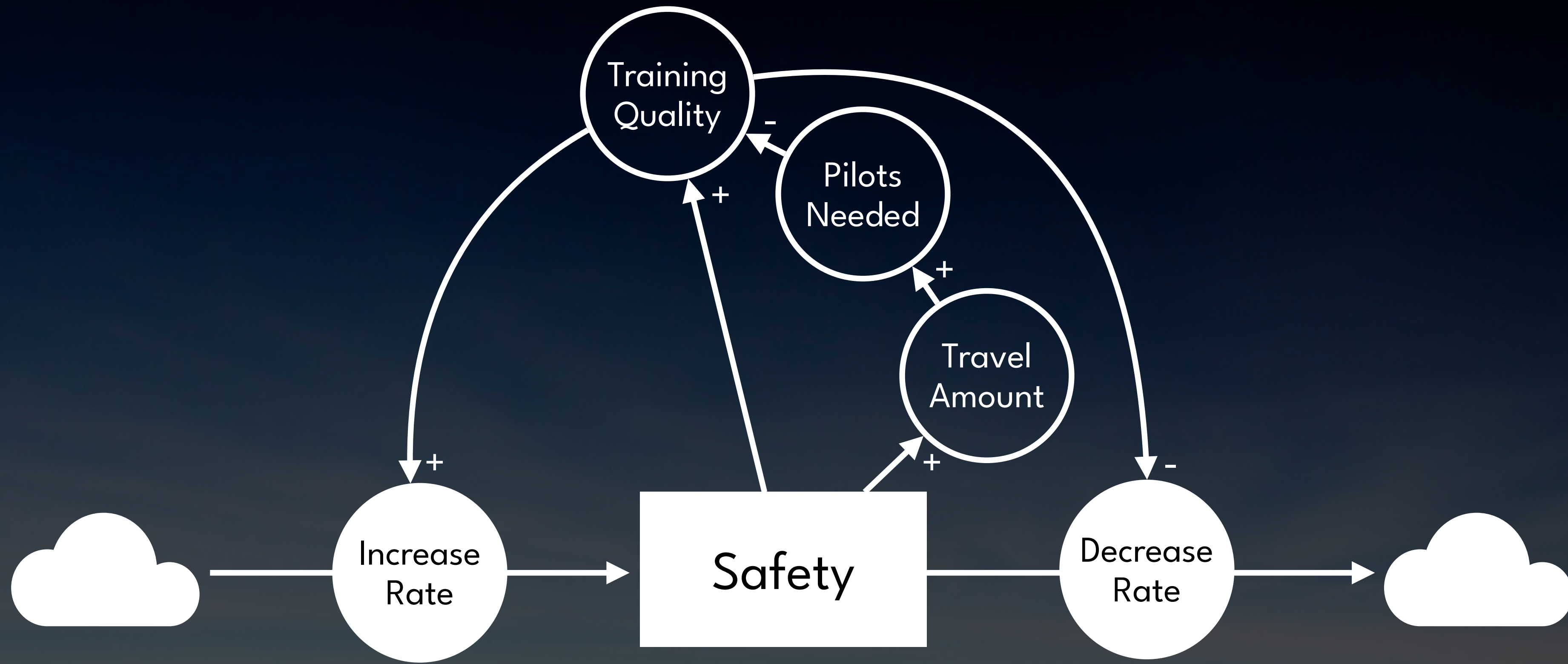
A Primer

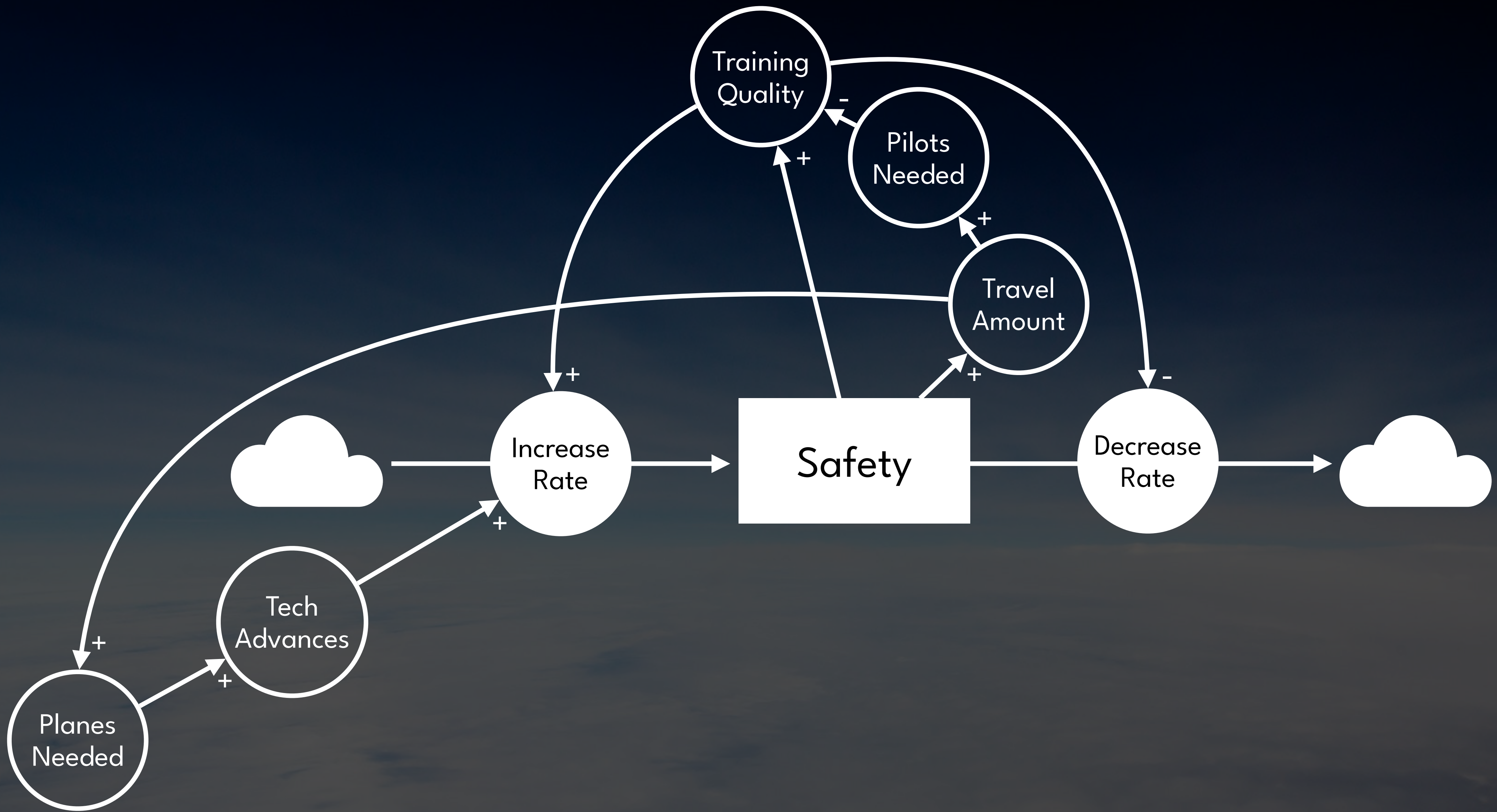
Donella H. Meadows

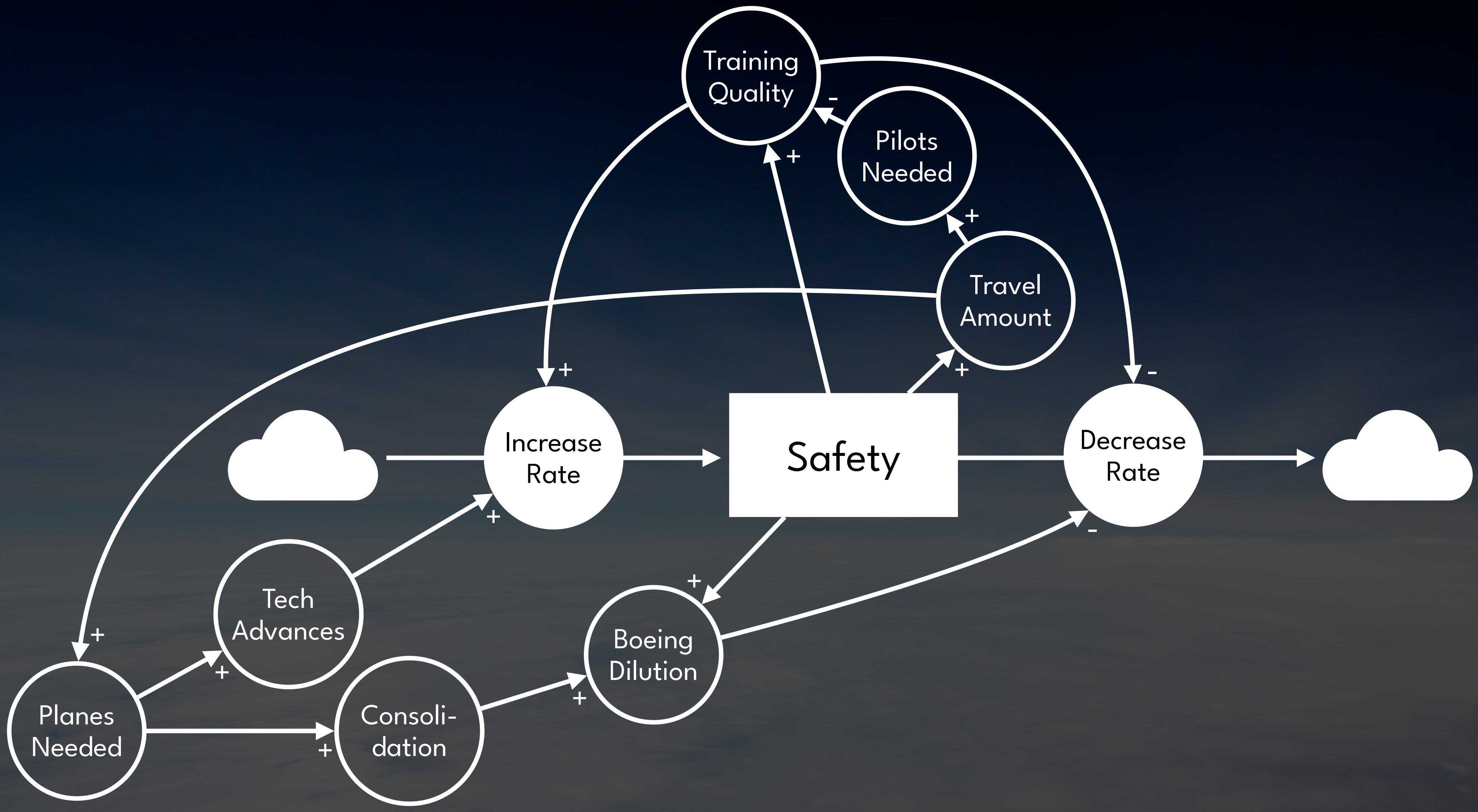
*Edited by Diana Wright,
Sustainability Institute*

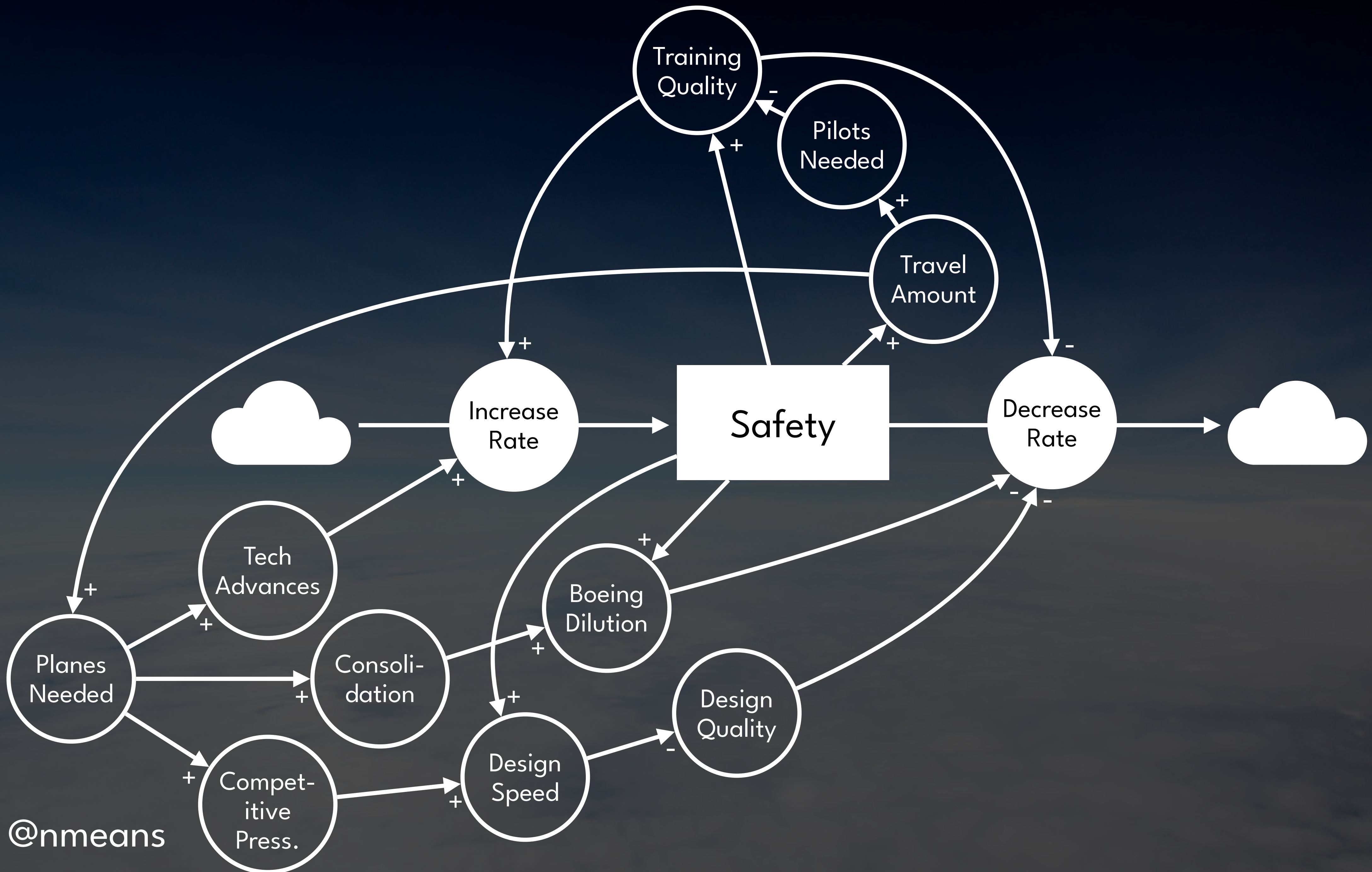
















“Everyone or everything in a system can act dutifully and rationally, yet all these well-meaning actions too often add up to a perfectly terrible result.”

— Donella H. Meadows, *Thinking in Systems*



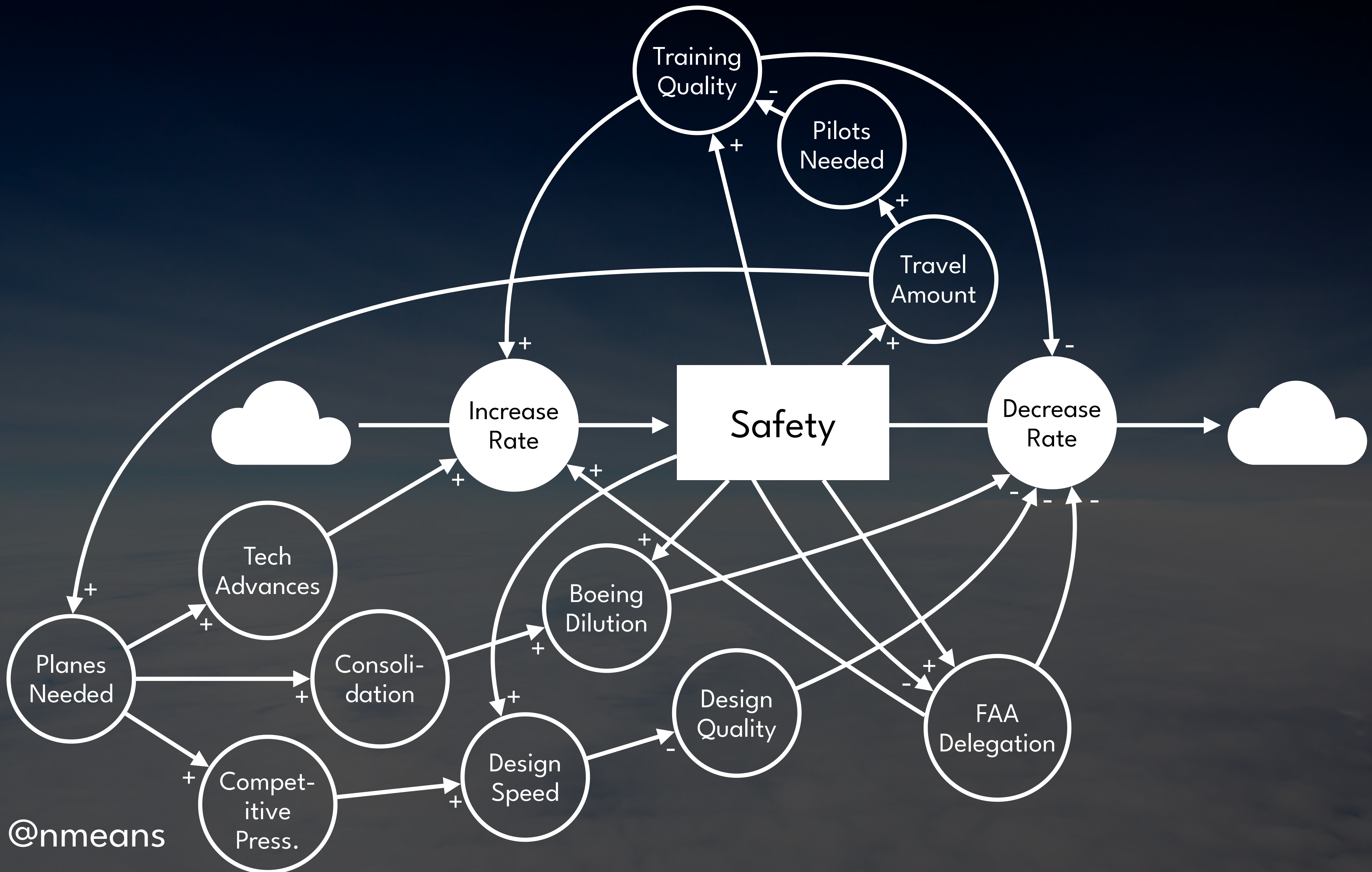
Thinking in Systems

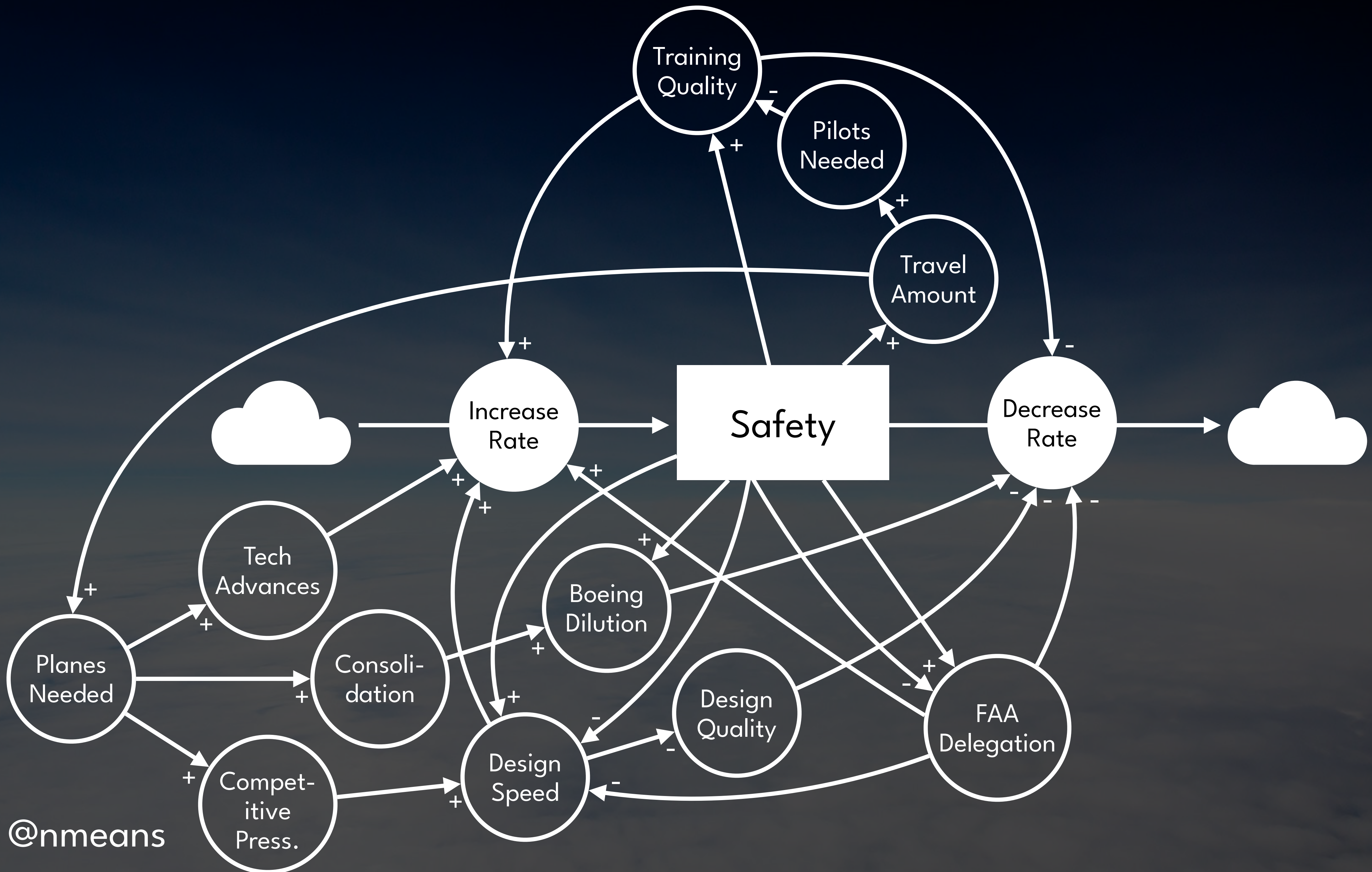
A Primer

Donella H. Meadows

*Edited by Diana Wright,
Sustainability Institute*











@nmeans





THANK YOU!

Nickolas Means
@nmeans

SYM