National Transportation Safety Board

# Human Factors in the Accident Involving Gulfstream Aerospace Corporation G-IV, N121JM Bedford, Massachusetts May 31, 2014

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NTSB Office of Aviation Safety

Photograph used by permission of Mr. Jerry Search. Obtained via Airliners.net

# Accident Overview

- Operator – Arizin Ventures, LLC
- Part 91 flight departing BED
- 2 pilots, 1 flight attendant, 4 passengers
- Overrun during a rejected takeoff
- All occupants were fatally injured

# Itinerary


- Trip began at 1325
- ILG → ACY
- Passengers boarded
- ACY → BED
- 1545 – Passengers left to attend a function while the crew stayed with the airplane
- 2128 – Passengers re-boarded
- 2139 – Takeoff roll began


Paved
Overrun
Main
Wreckage

# Gust Lock Handle


**Figure 4a.** Photograph of an exemplar gust lock handle in the ON position.


**Figure 4b.** Photograph of an exemplar gust lock handle in the OFF position.




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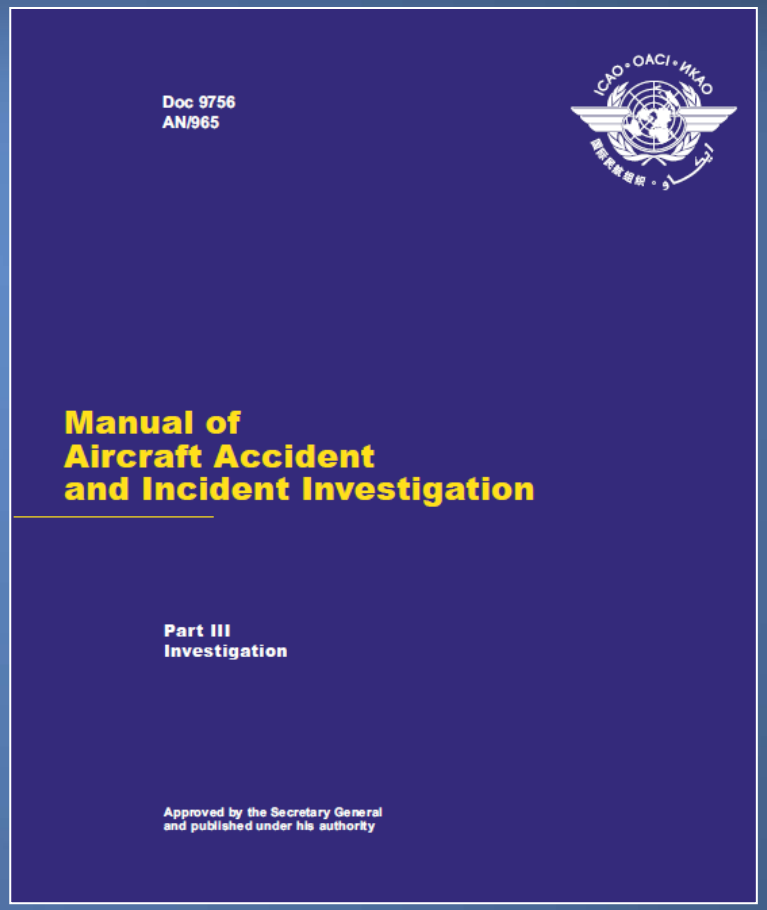
# Investigating Human Factors

"…from unsafe acts and inadequate or removed defenses, through the accident trajectory, all the way back to upper-management levels."

- ICAO



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# Probable Cause

"…the flight crewmembers' failure to perform the flight control check before takeoff, their attempt to take off with the gust lock system engaged, and their delayed execution of a rejected takeoff after they became aware that the controls were locked."

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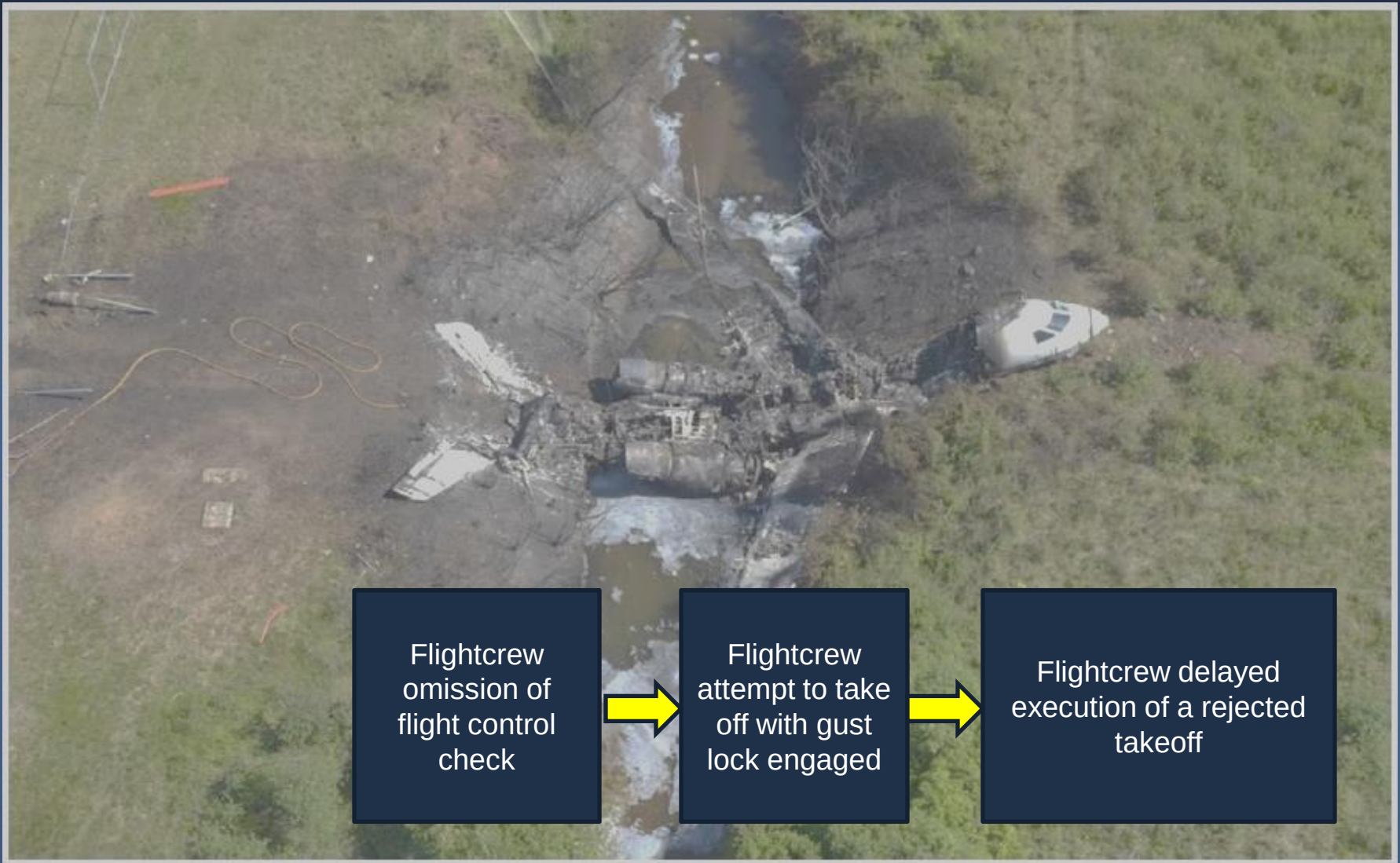
1

2

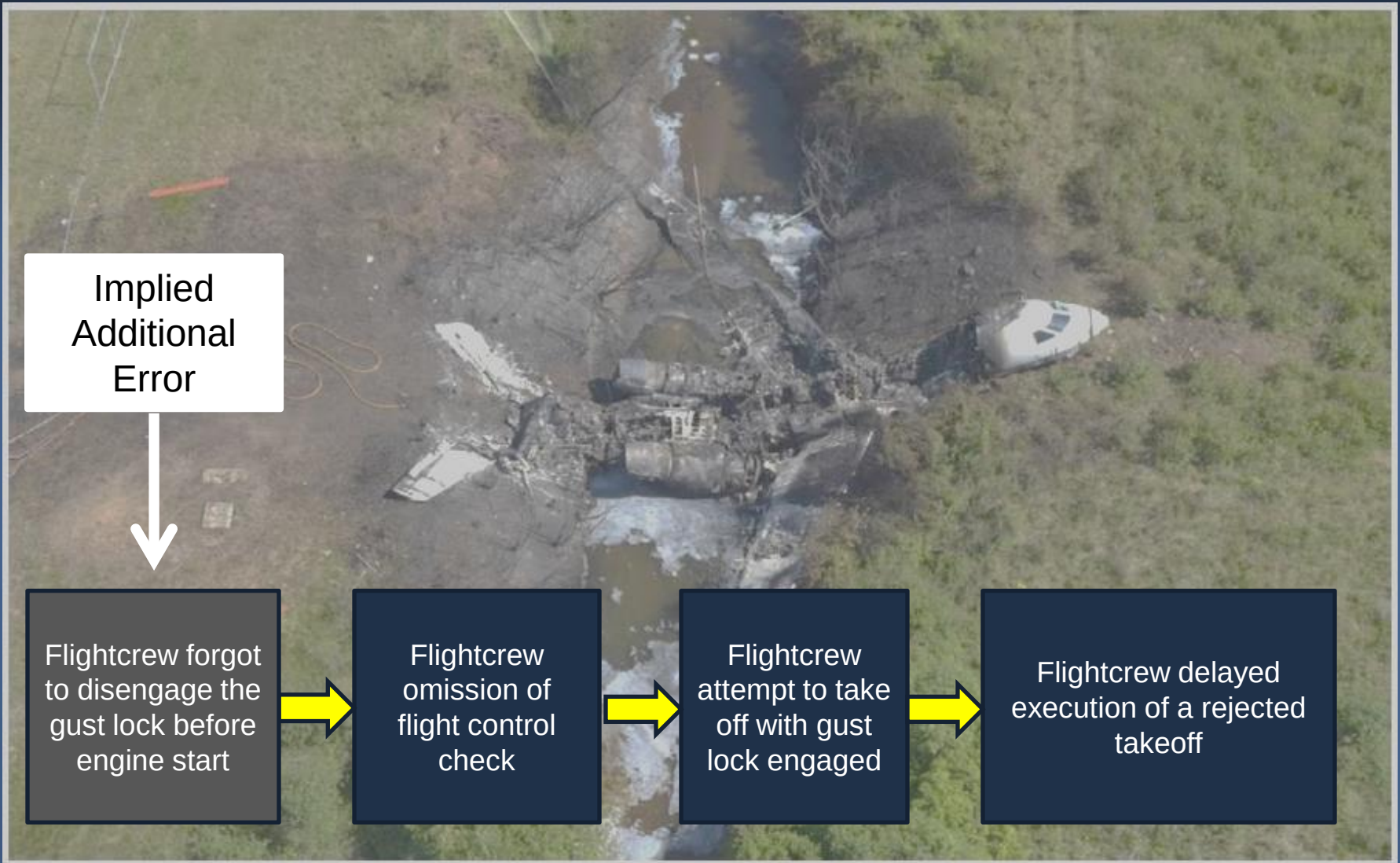
3

# Flightcrew Errors




Source: Massachusetts State Police.

# Flightcrew Errors

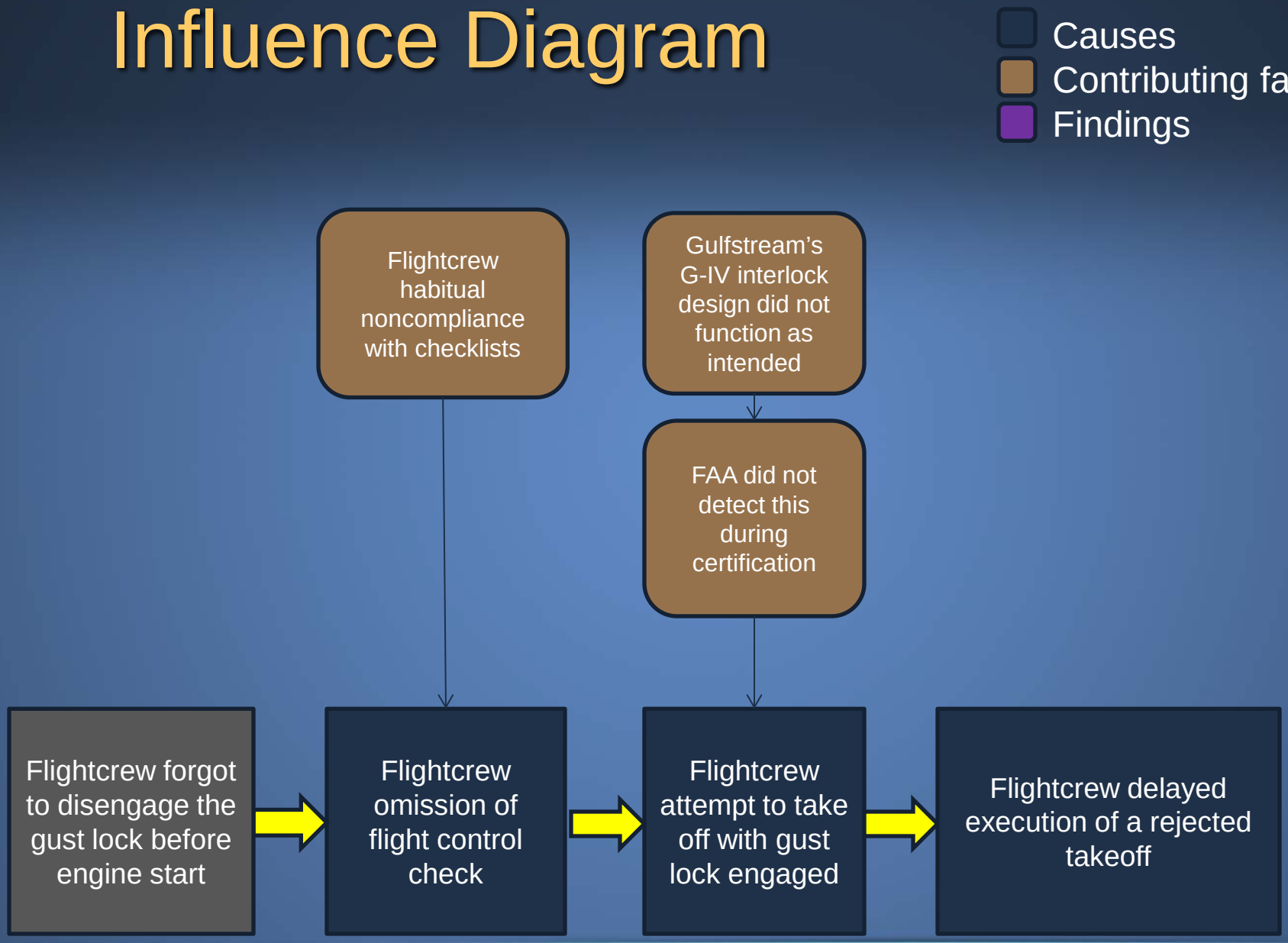



Source: Massachusetts State Police.

# Contributing Factors

"Contributing to the accident were the flight crew's habitual noncompliance with checklists, Gulfstream Aerospace Corporation's failure to ensure that the G-IV gust lock/throttle lever interlock system would prevent an attempted takeoff with the gust lock engaged, and the Federal Aviation Administration's failure to detect this inadequacy during the G-IV's certification."

# Influence Diagram



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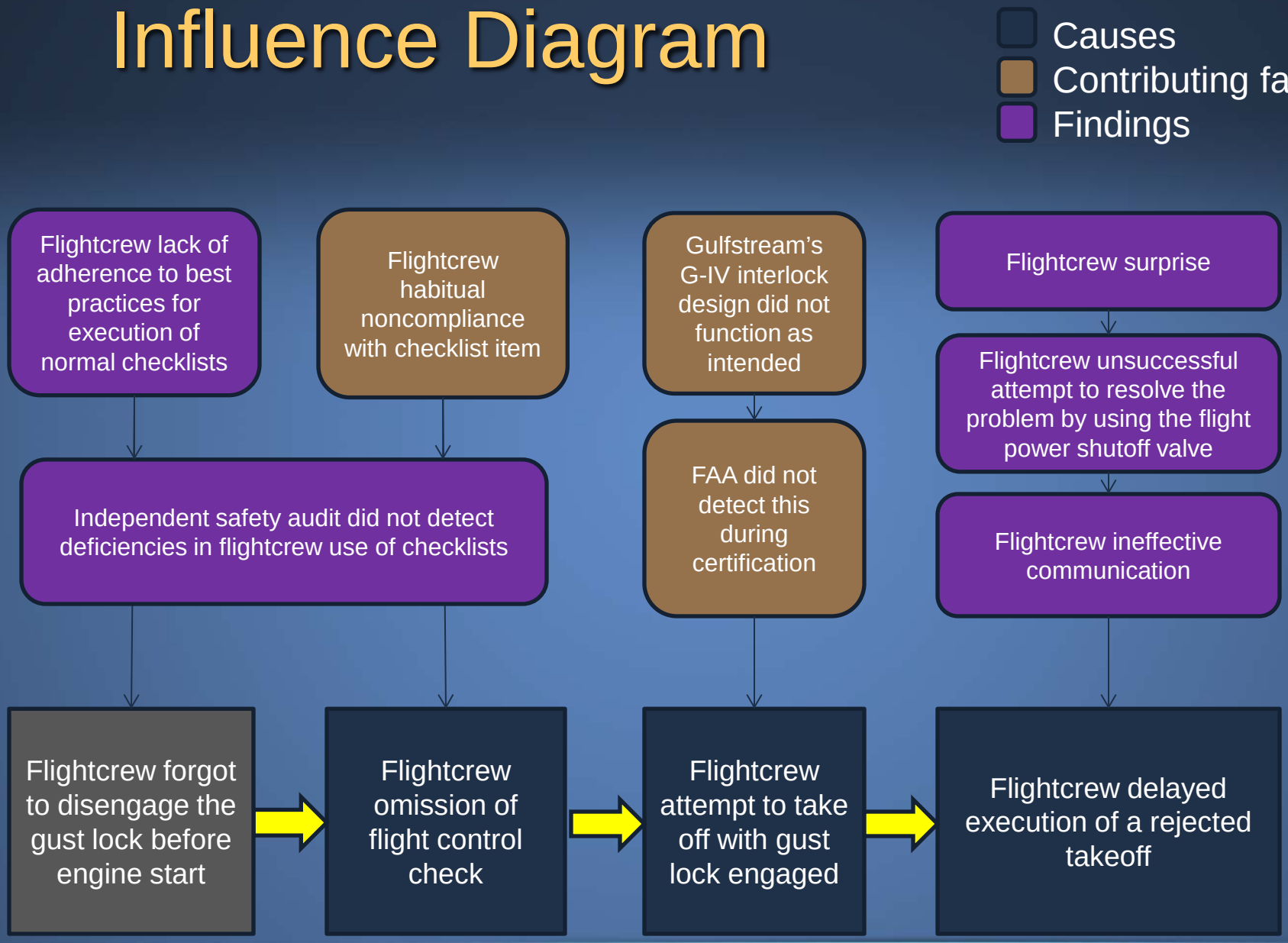




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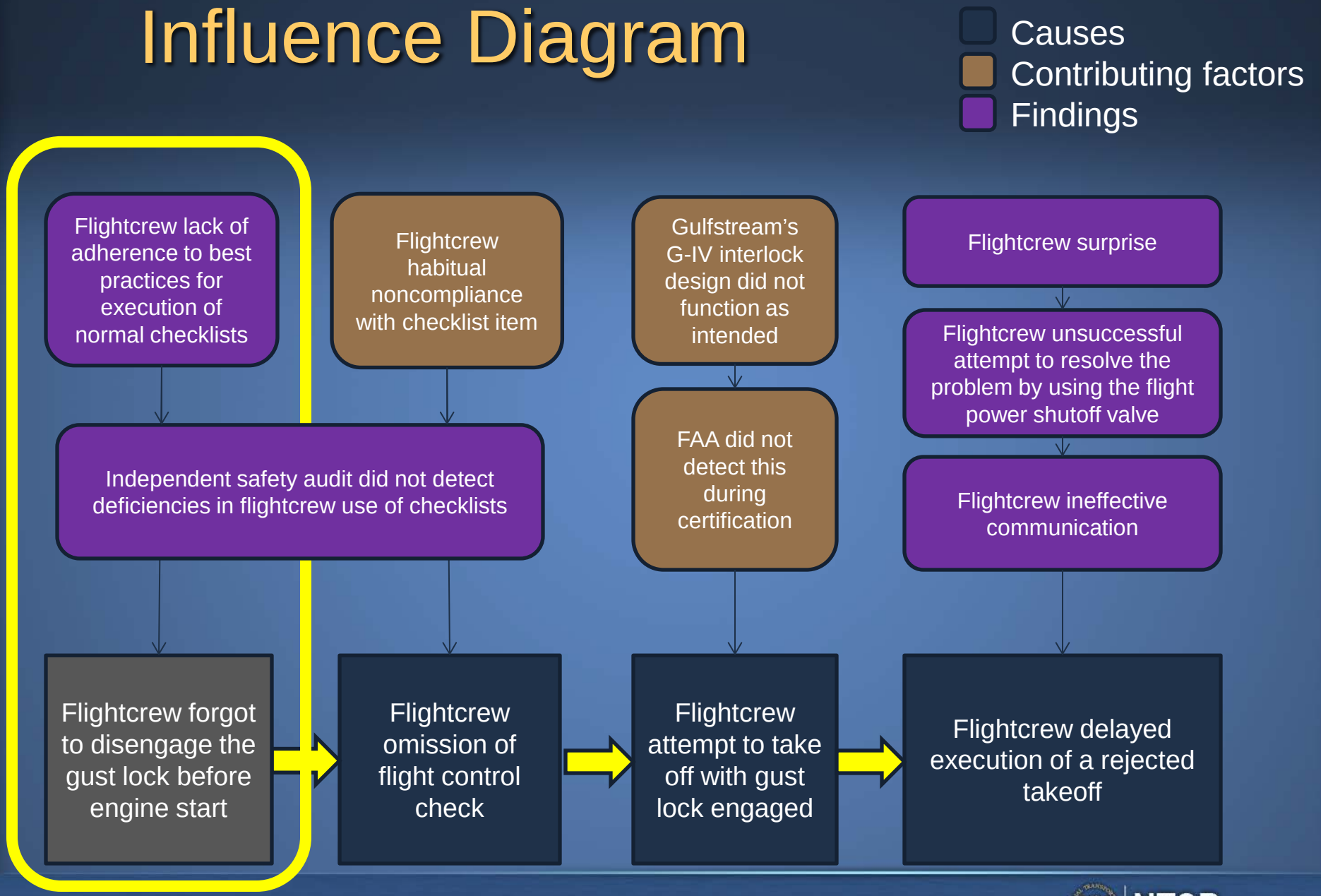
# Influence Diagram



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# Starting Engines Checklist

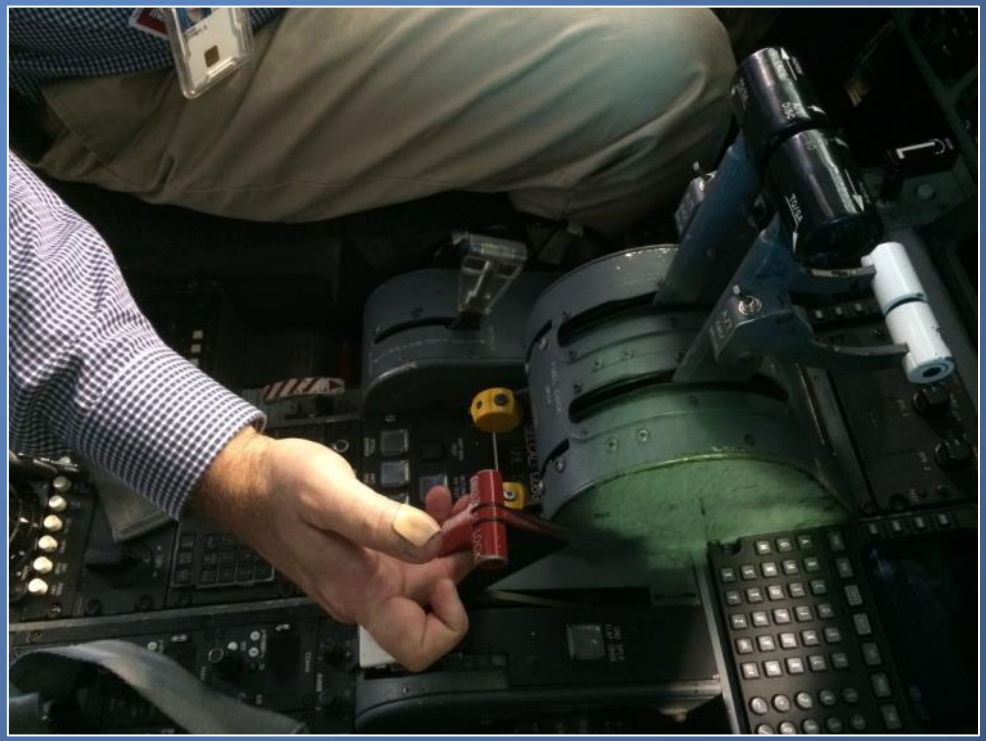
GUST LOCK……OFF

**GULFSTREAM IV** *Pilot's Checklist*

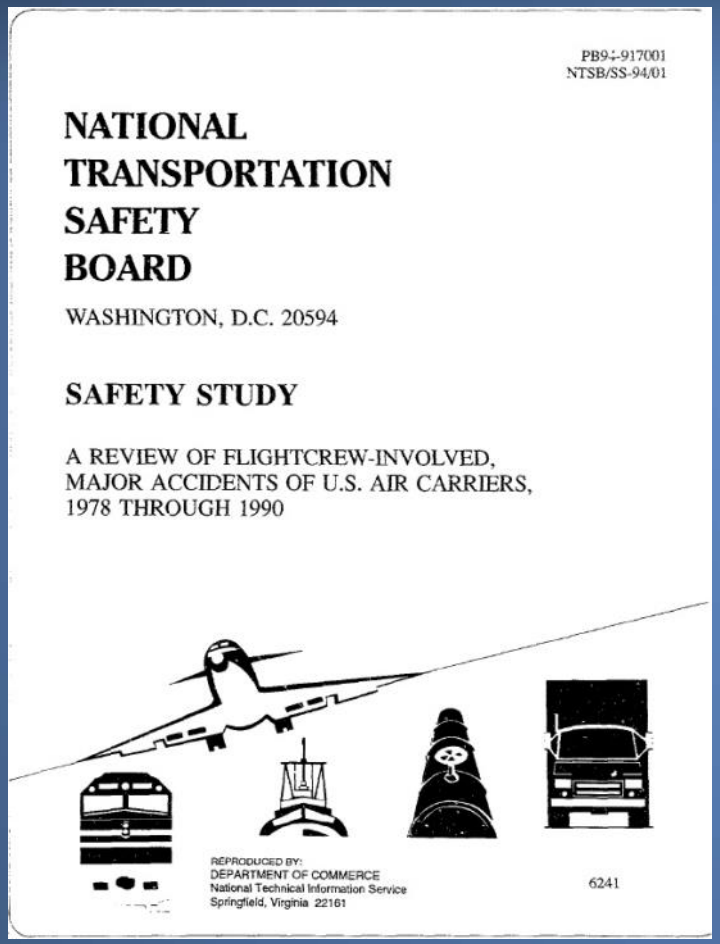
**Starting Engines** AFM 2-08-20

1. Start Page ..... SELECT
2. HP Fuel Cocks ..... SHUT
3. Power Levers ..... IDLE
4. GUST LOCK ..... OFF
5. Beacon Switch ..... ON
6. APU Air / External Air ..... ON / PRESSURE 25 PSI MINIMUM
7. Fuel Boost Pumps (One Each Side) ..... ON / MESSAGE OUT
8. Electrical Power ..... CHECK (35% MAX)
9. Engine Start Master ..... ON
10. Engine Start Switch ..... PRESS
11. Start Valve and Ignition ..... ON
12. Positive LP RPM ..... CHECK
13. HP Fuel Cock ..... OPEN (15% HP MINIMUM)
14. Start Valve and Ignition ..... OFF
15. TGT ..... MONITOR (700° C MAX)
16. Engine RPM ..... CHECK (46.6% HP MINIMUM)
17. Oil Pressure and Temperature ..... CHECK
18. EVM ..... CHECK
19. SNGL RUDDER LIMIT Message (right engine only running) ..... ON
20. Hydraulic Pressure ..... CHECKED (0 / 3000 / 3000 / 0)
21. Flight Data Recorder Fail Message ..... CHECK OUT
22. Second Engine Start ..... REPEAT STEPS 10 THRU 18
23. SNGL RUDDER LIMIT Message (both engines running) ..... OUT
24. Hydraulic Pressure ..... CHECKED (3000 / 3000 / 0 / 0)

**END**



# Errors of Omission



PB94-917001
NTSB/SS-94/01

**NATIONAL TRANSPORTATION SAFETY BOARD**

WASHINGTON, D.C. 20594

**SAFETY STUDY**

A REVIEW OF FLIGHTCREW-INVOLVED, MAJOR ACCIDENTS OF U.S. AIR CARRIERS, 1978 THROUGH 1990

REPRODUCED BY:
DEPARTMENT OF COMMERCE
National Technical Information Service
Springfield, Virginia 22161

6241

- 20% of flightcrew-involved major accidents
- Linked to distractions, interruptions, failures of prospective memory
- Checklists are an important counter-measure



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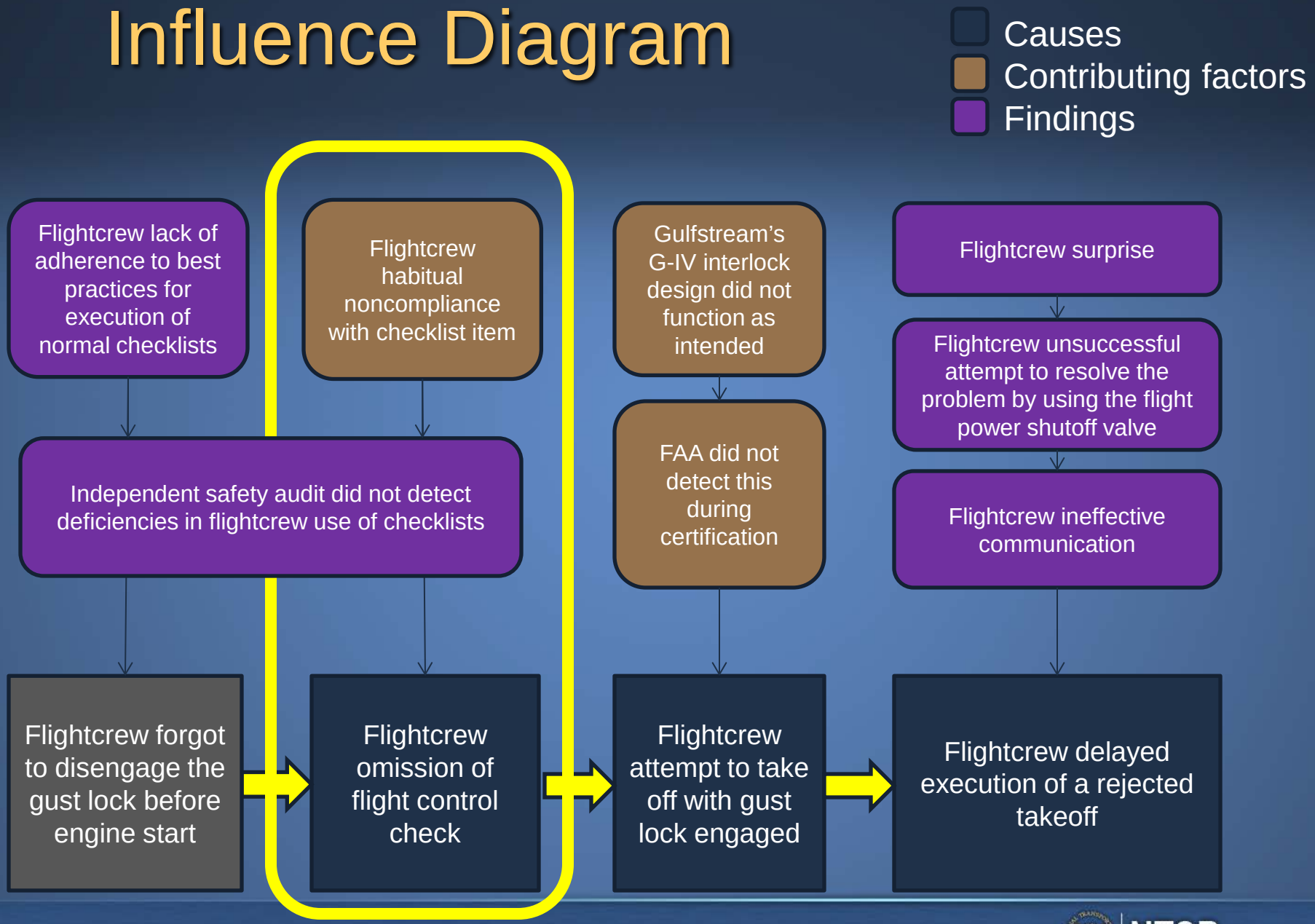
# Flightcrew Use of Checklists

- No checklist verbalization
- The PIC had “memorized” the checklists
- The PIC did not ask for the normal checklists or read them aloud

# Challenge-Verification-Response Method Benefits

- Recall steps for configuring the airplane
- Ensure a logical sequence and distribution of workload
- Enhance mutual supervision (crosschecking)
- Facilitate shared awareness

# Influence Diagram



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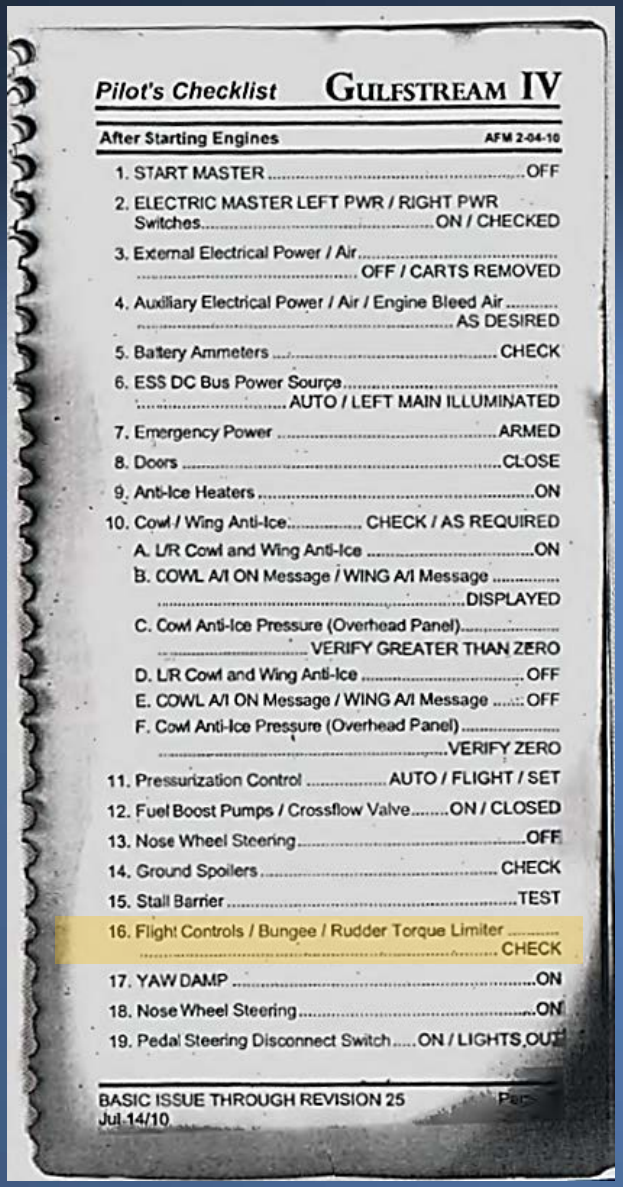
# After Starting Engines Checklist

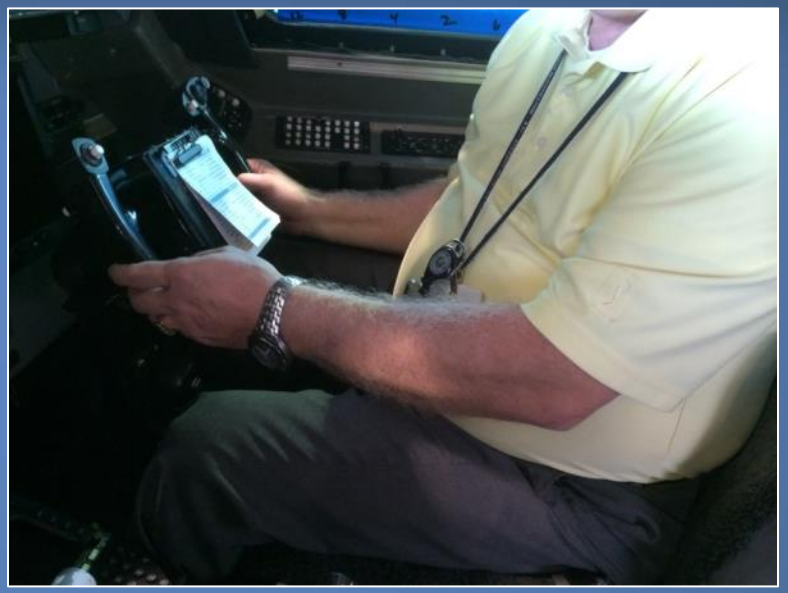


*Pilot's Checklist* **GULFSTREAM IV**

**After Starting Engines** AFM 2-04-10

1. START MASTER ..... OFF
2. ELECTRIC MASTER LEFT PWR / RIGHT PWR Switches ..... ON / CHECKED
3. External Electrical Power / Air ..... OFF / CARTS REMOVED
4. Auxiliary Electrical Power / Air / Engine Bleed Air ..... AS DESIRED
5. Battery Ammeters ..... CHECK
6. ESS DC Bus Power Source ..... AUTO / LEFT MAIN ILLUMINATED
7. Emergency Power ..... ARMED
8. Doors ..... CLOSE
9. Anti-Ice Heaters ..... ON
10. Cowl / Wing Anti-Ice ..... CHECK / AS REQUIRED
    - A. L/R Cowl and Wing Anti-Ice ..... ON
    - B. COWL A/I ON Message / WING A/I Message ..... DISPLAYED
    - C. Cowl Anti-Ice Pressure (Overhead Panel) ..... VERIFY GREATER THAN ZERO
    - D. L/R Cowl and Wing Anti-Ice ..... OFF
    - E. COWL A/I ON Message / WING A/I Message ..... OFF
    - F. Cowl Anti-Ice Pressure (Overhead Panel) ..... VERIFY ZERO
11. Pressurization Control ..... AUTO / FLIGHT / SET
12. Fuel Boost Pumps / Crossflow Valve ..... ON / CLOSED
13. Nose Wheel Steering ..... OFF
14. Ground Spoilers ..... CHECK
15. Stall Barrier ..... TEST
16. Flight Controls / Bungee / Rudder Torque Limiter ..... CHECK
17. YAW DAMP ..... ON
18. Nose Wheel Steering ..... ON
19. Pedal Steering Disconnect Switch ..... ON / LIGHTS OUT

BASIC ISSUE THROUGH REVISION 25 Jul 14/10



Flight Controls……CHECK

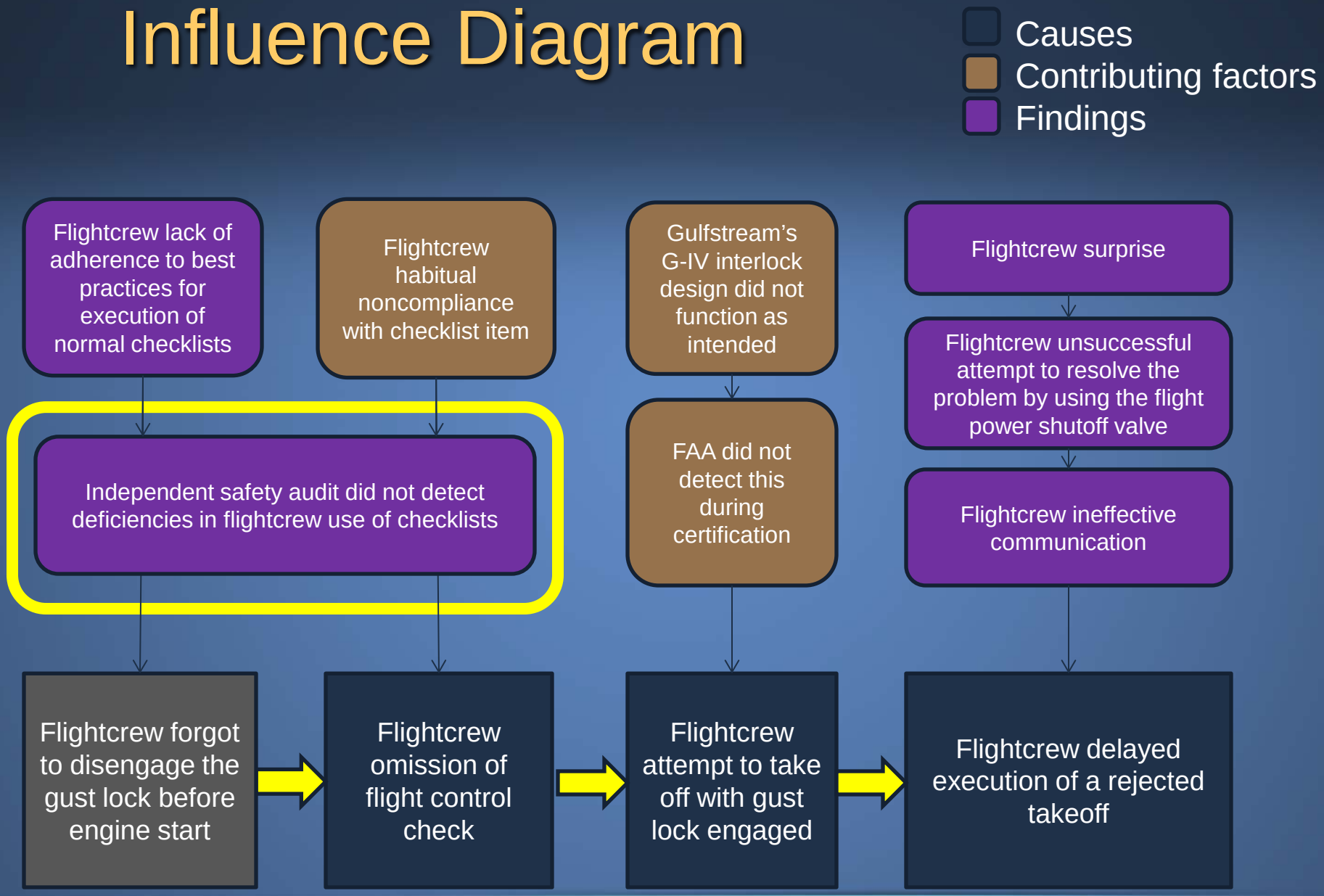
# Procedural Noncompliance

- 90% of previous 175 takeoffs lacked a preflight check of any control surface
- 98% lacked a full control check
- Procedural drift
- Normalization of deviance

# Risk Factors for Procedural Noncompliance in this Operation

- Long-term pairing of two pilots
- Lack of larger airline characteristics encouraging by-the-book standardization
- Little monitoring of the flightcrew's operational practices

# Influence Diagram



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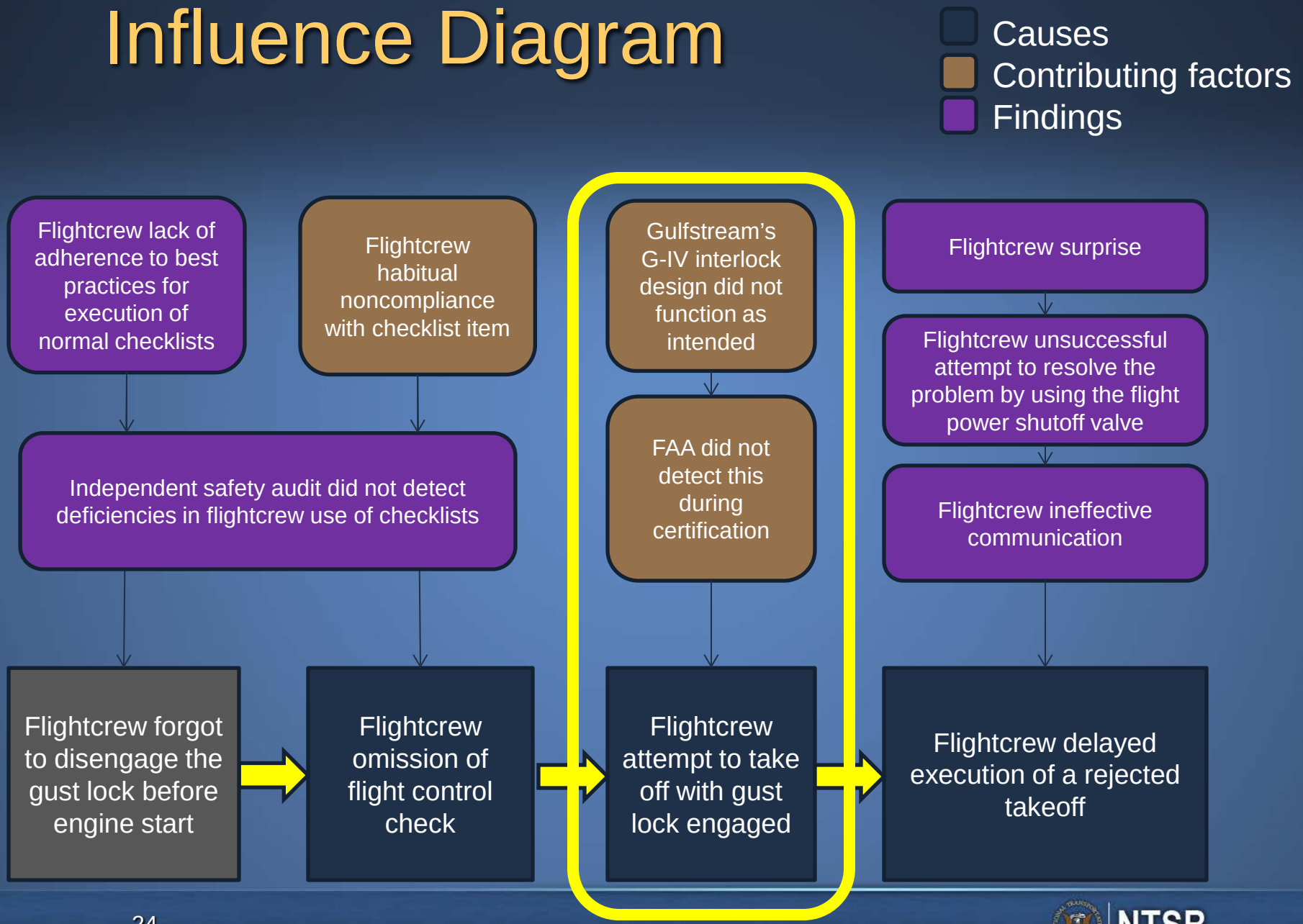




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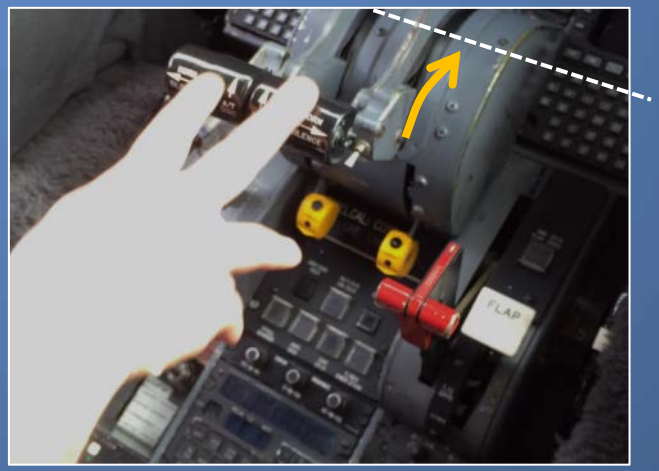
# Attempt to Take Off with the Gust Lock Engaged

- Crew set flaps for takeoff
- Crew taxied to the runway
- Crew did not notice the position of the gust lock

# Attempt to Take Off with the Gust Lock Engaged

- "RUDDER LIMIT" advisory message appeared on the EICAS, brief discussion
- PIC advanced the throttle levers and encountered a restriction
- PIC engaged the autothrottle and expressed puzzlement about restriction

EICAS Message Display




Throttle Lever Restriction

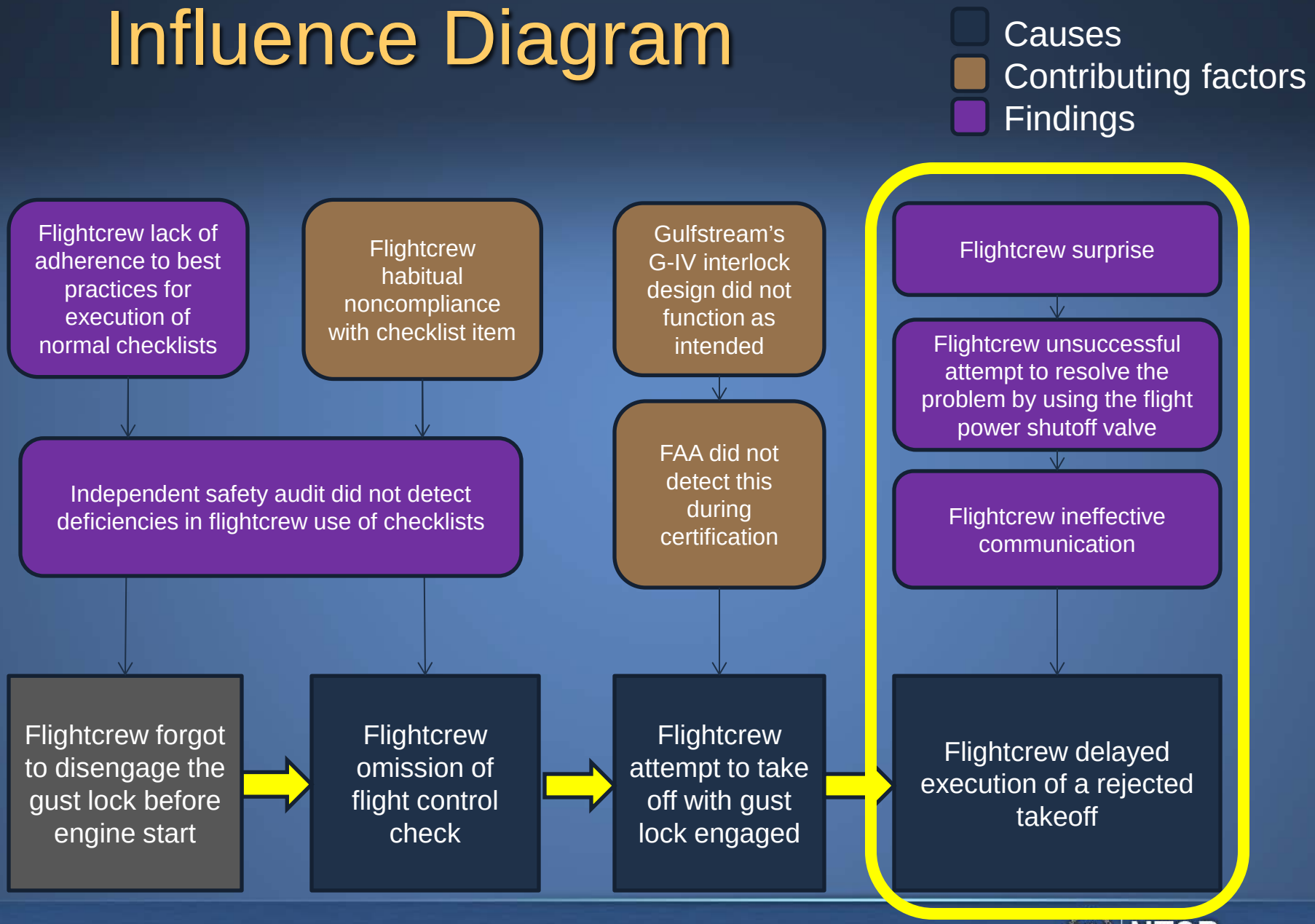
# Throttle Interlock

- Certification required “unmistakable warning at the start of takeoff” if gust lock was engaged
- Interlock mechanism was intended to limit throttle lever angle to 6°, but it actually permitted 22° of movement
- The levers reached 27° after autothrottle servos broke the gust lock pin

# Throttle Interlock

- NTSB examined several other G-IV airplanes and found the same issue
- The throttle interlock was not performing its intended function
- FAA certification records indicated that the design was reviewed using engineering drawings with no functional test

# Influence Diagram



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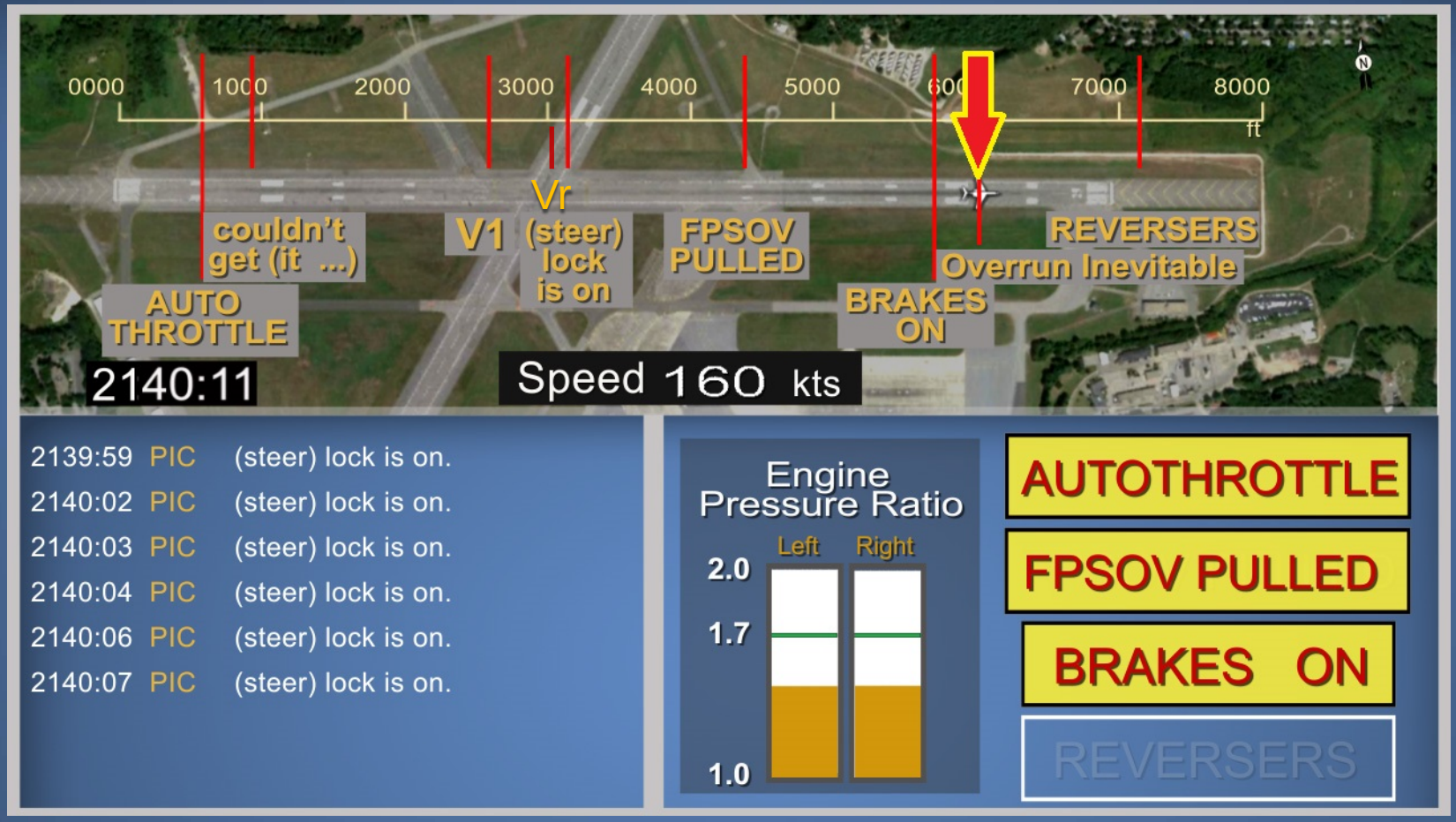
# Delay in Rejected Takeoff



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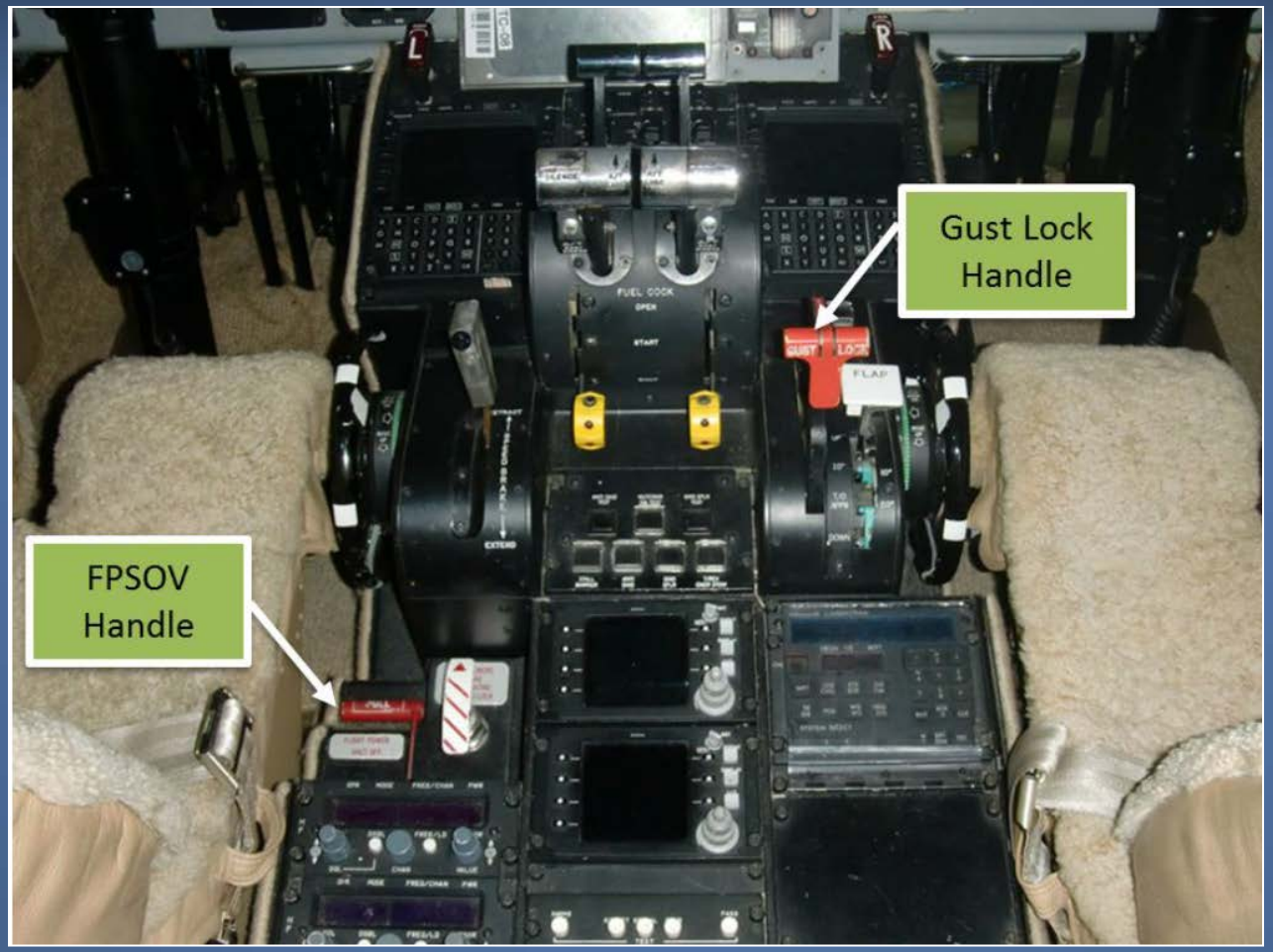




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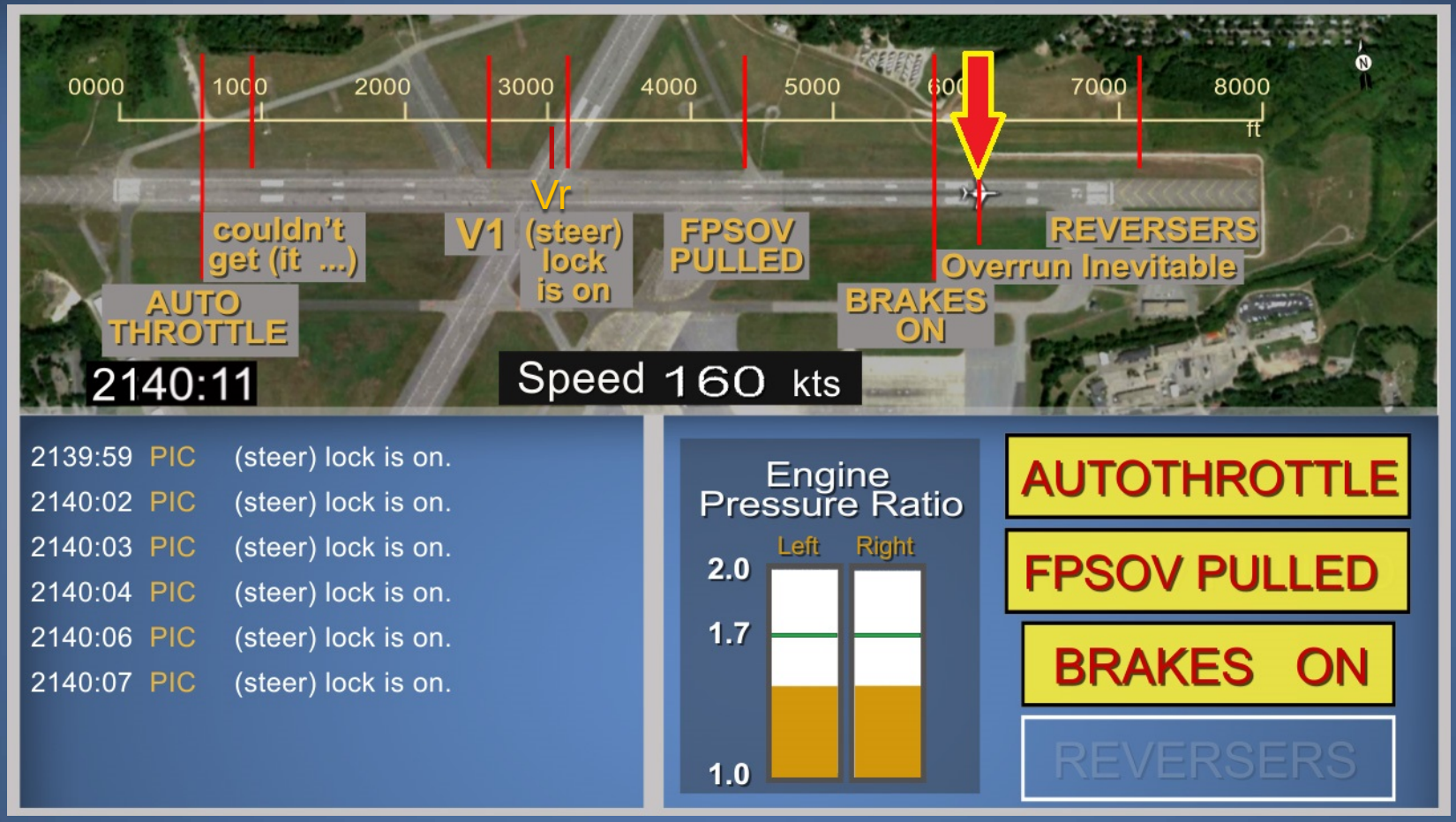




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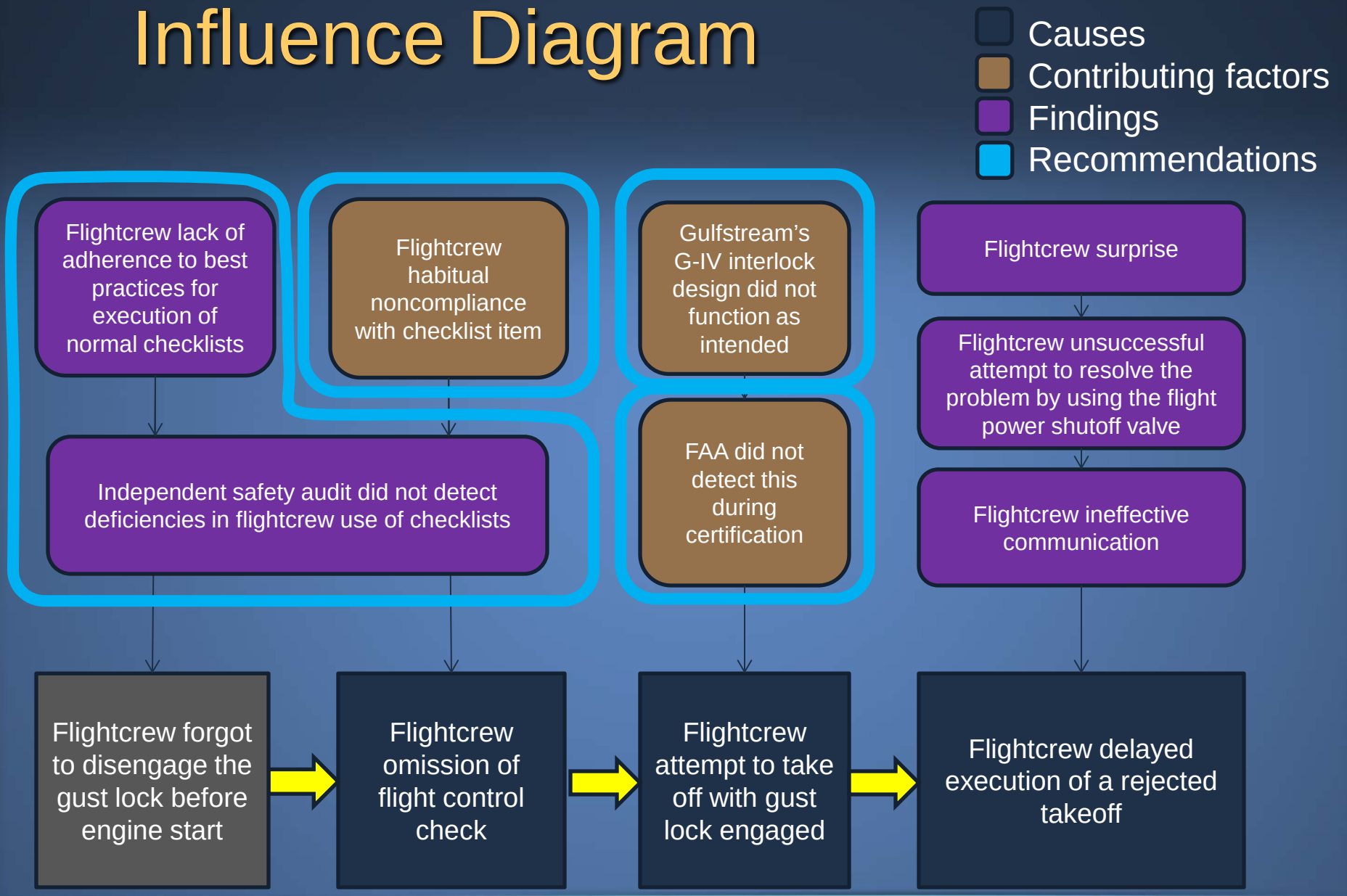




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# Safety Recommendations

To the IBAC:

- Amend audit standards to include verifying that operators require pilots to follow best practices for use of checklists

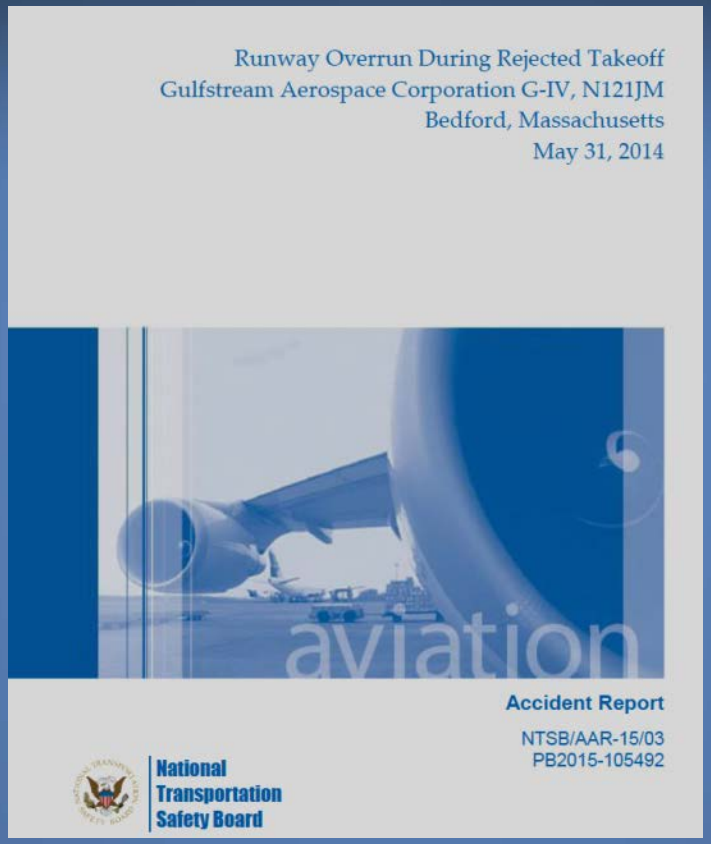
To NBAA:

- Work with business aviation flight operational quality assurance groups to assess the rate of noncompliance with required flight control checks

To the FAA:

- Require the gust lock system to be retrofitted on all G-IV airplanes
- Develop guidance on the appropriate use of engineering drawings during aircraft certification

# Looking for More Information?

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