A Framework to Train Future Investigators

An Unexpected Finding: Predictive CAST

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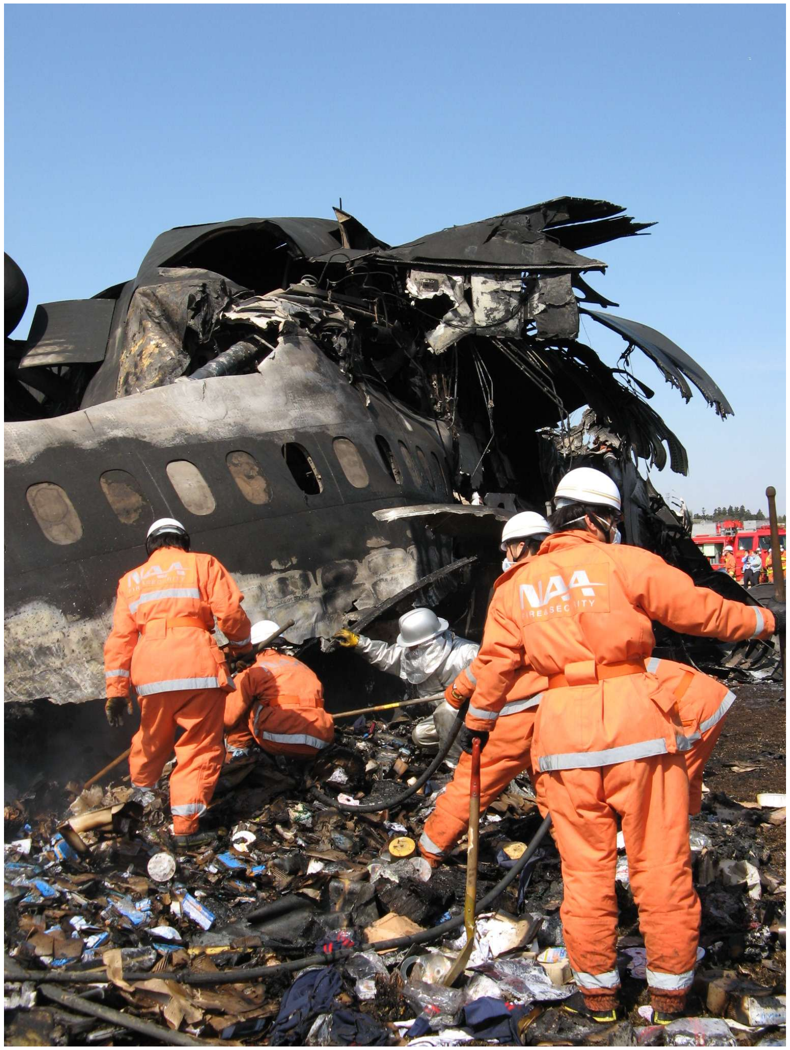
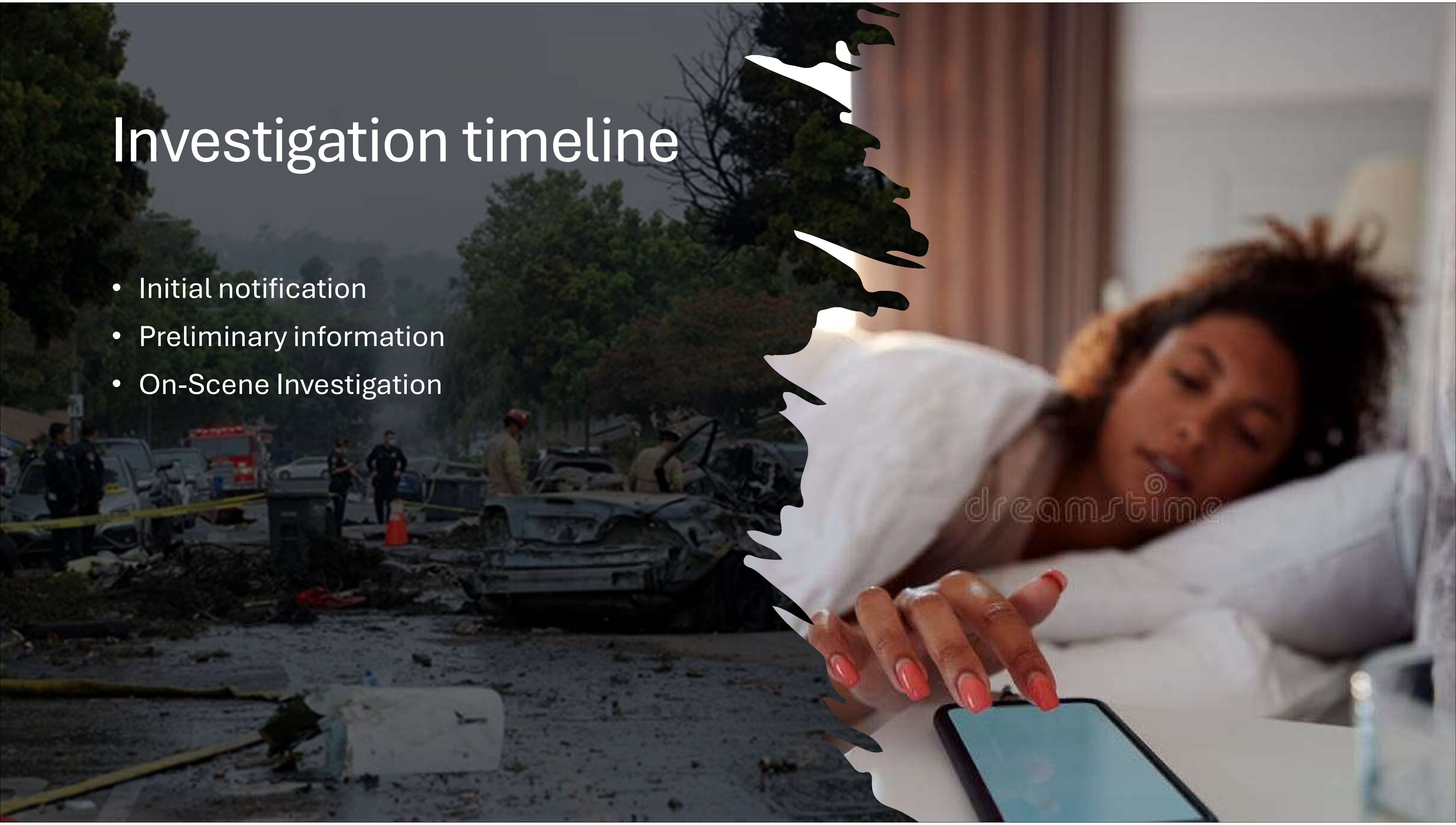


Investigation timeline

- Initial notification
- Preliminary information
- On-Scene Investigation

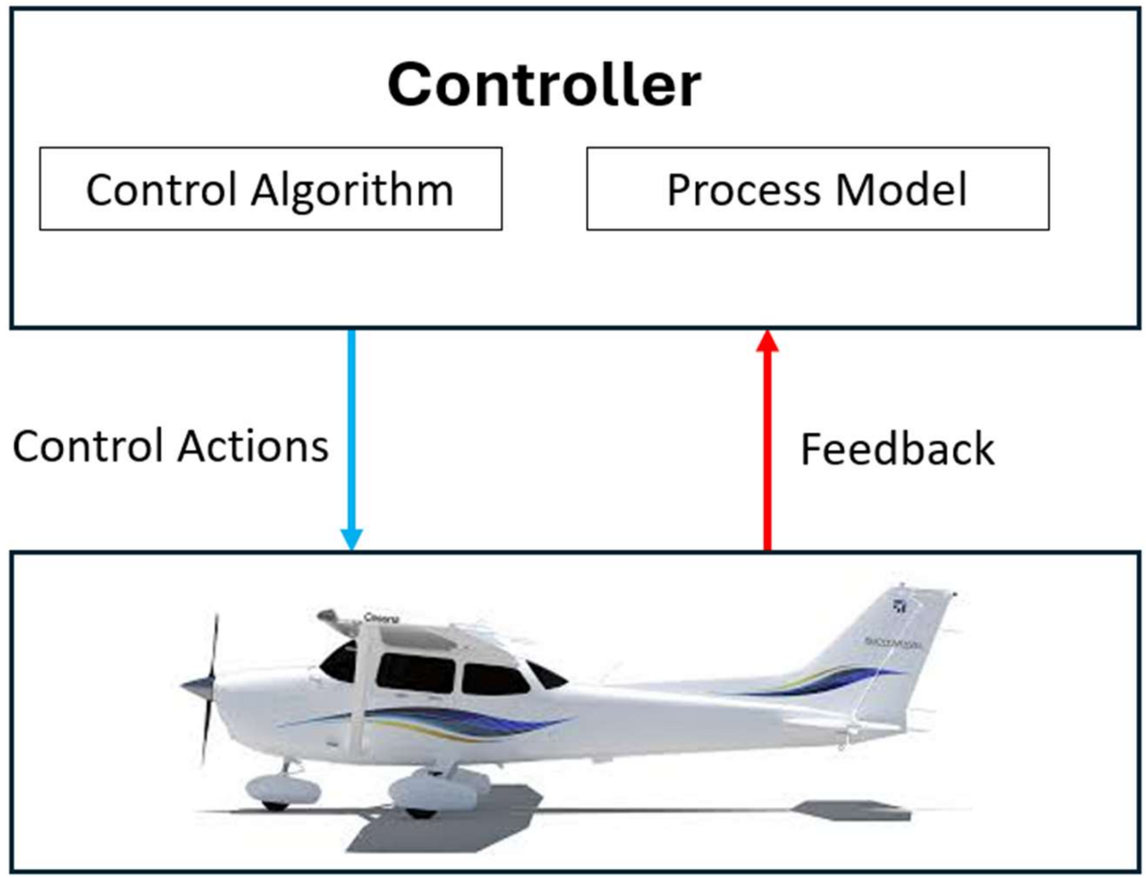


Real Time Accident Investigation

- May or may not know the losses yet
- Hazard identification tricky
- Do not have any events except the very last one
- What can we do?

We can start a control structure!

- We can guesstimate our bottom process
- We can assume what was controlling that
- We can seek information on what was controlling the next level



Evidential Information

- Proximate Events had legal connotations

“Primary, foreseeable, and direct cause that initiates a chain of events leading to injury or damage, establishing legal liability”

- **Shaped by Control Structure**
  - Triggers questions

- Show source of EI [CVR]

Seeking more

- Factual evidence can be obscured or missed
- Flawed assumptions on the part of the investigator

We know how to do that!

There is a method to identify factors before an accident

Maybe we can use that to identify potential factors that we can then eliminate

Apply the STPA UCA taxonomy to CAST

- Learning from Accidents that are a Consequence of Complex Systems (2014)
- Can we leverage this?
- Can we predict where to look?

PF Safety Constraints and Responsibilities

- PF-SCR-1: Cross check all flight instruments [SH-1]
- PF-SCR-2: Be ready for manual flight before final approach fix [SH-1]
- PF-SCR-3: Maintain stable approach [SH-1]
- PF-SCR-4: Assume manual control and provide safe inputs when needed [SH-1]
- PF-SCR-5: Follow published approach procedures [SH-1]

PF Unsafe Control Actions

- PF-UCA-1: Reduced speed while on glidepath and using FLCH SPD, causing decreased descent rate and glideslope overshoot [PF-SCR-3]
- PF-UCA-2: Selected insufficient descent rate to overcome glidepath overshoot [PF-SCR-3]
- PF-UCA-3: Selected FLCH SPD after final approach fix, causing a climb when aircraft was already above glideslope [PF-SCR-3,4,5]
- PF-UCA-4: Did not announce FLCH SPD when it was selected [PF-SCR-3,5]
- PF-UCA-5: Did not re-engage A/T after it transitioned to HOLD with thrust at idle [PF-SCR-3,5]
- PF-UCA-6: Did not confirm that both flight directors had been turned off as he requested [PF-SCR-1,3,4,5]
- PF-UCA-7: Provided pitch up commands to slow descent with A/T in HOLD, thrust at idle [PF-SCR-3,4]
- PF-UCA-8: Did not initiate a go around when approach was inadequate [PF-SCR-4,5]

Screen the Potentials

- List *every* control action that was available to each controller in the context we are investigating
- Examine each as a *potential* UCA
- Only eliminate those that clearly are not supported by the evidence

This is a sample ISEE question. Don't forget to think about which answer choices you can eliminate as you solve this problem!

~~(A)~~ Definitely wrong answer
(B) Possible answer
(C) Possible answer
~~(D)~~ Definitely wrong answer

But can we do even more?

Use control actions that were not UCAs to point to motivations.

Why did the controller choose not to do that?

Perceived Local Losses

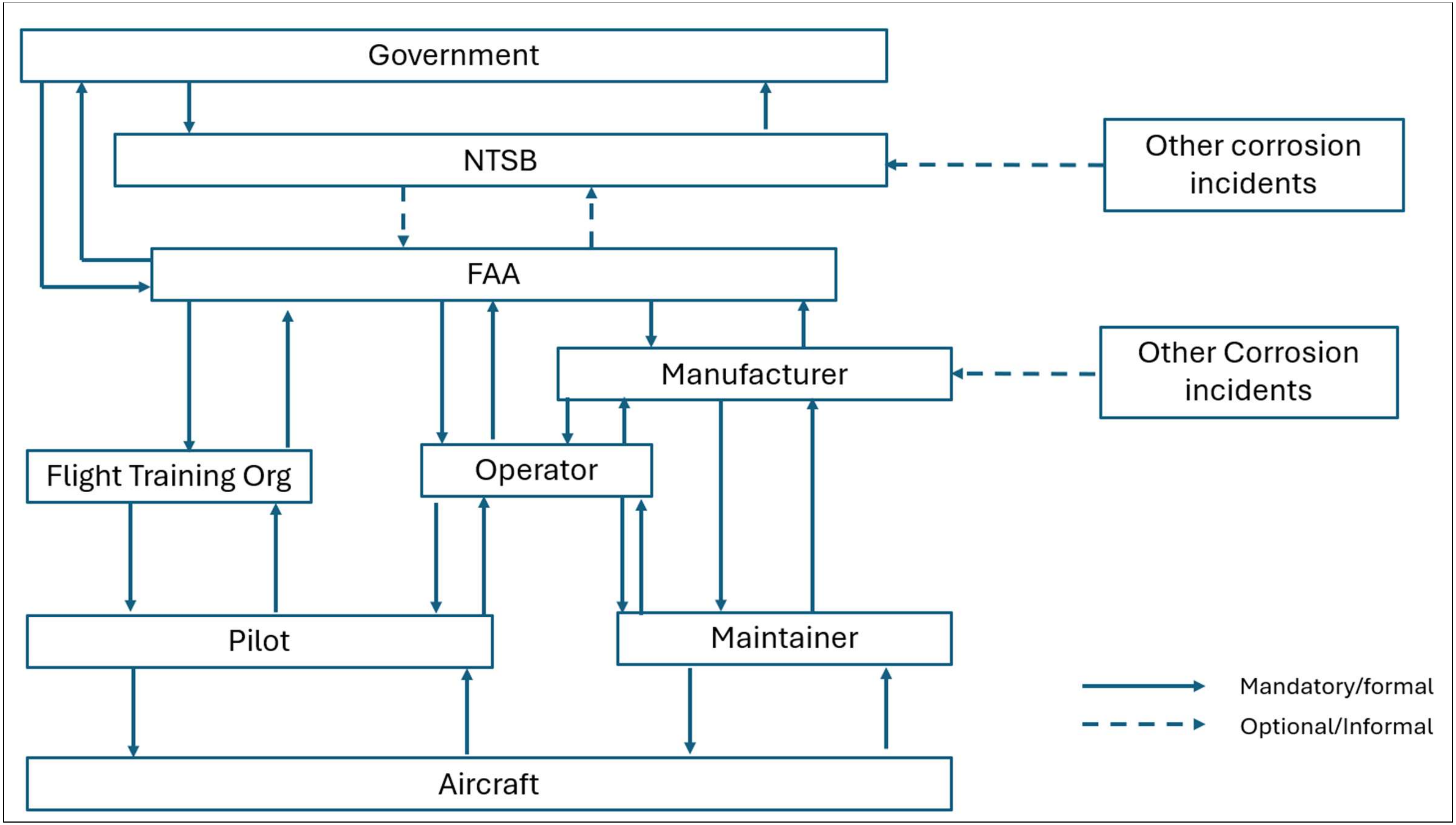
Examine why the non-UCA control action was ***not*** chosen.

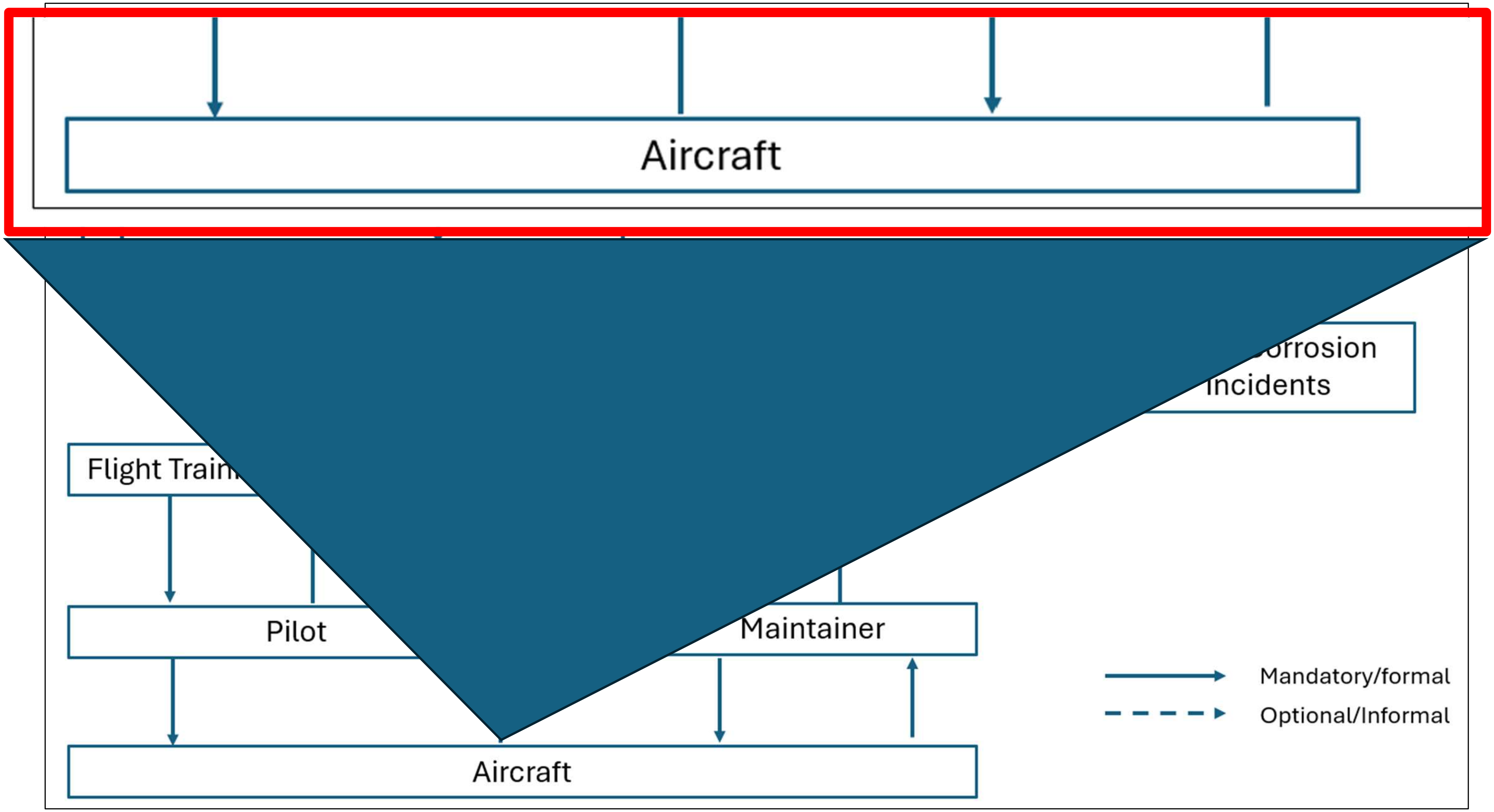
What would controller lose from *their* perspective if they did not choose UCA (include time factors)

Examine how higher-level system goals can influence decisions.

Case Study

- March 6, 2002
- Cessna 172
- Banner towing
- Dropped a banner
- Was maneuvering from base to final approach


Government
NTSB
Other corrosion incidents
FAA
Manufacturer
Other Corrosion incidents
Flight Training Org
Operator
Pilot
Maintainer
Aircraft
Mandatory/formal
Optional/Informal


Aircraft
Incidents
Pilot
Maintainer
Mandatory/formal
Optional/Informal
Aircraft

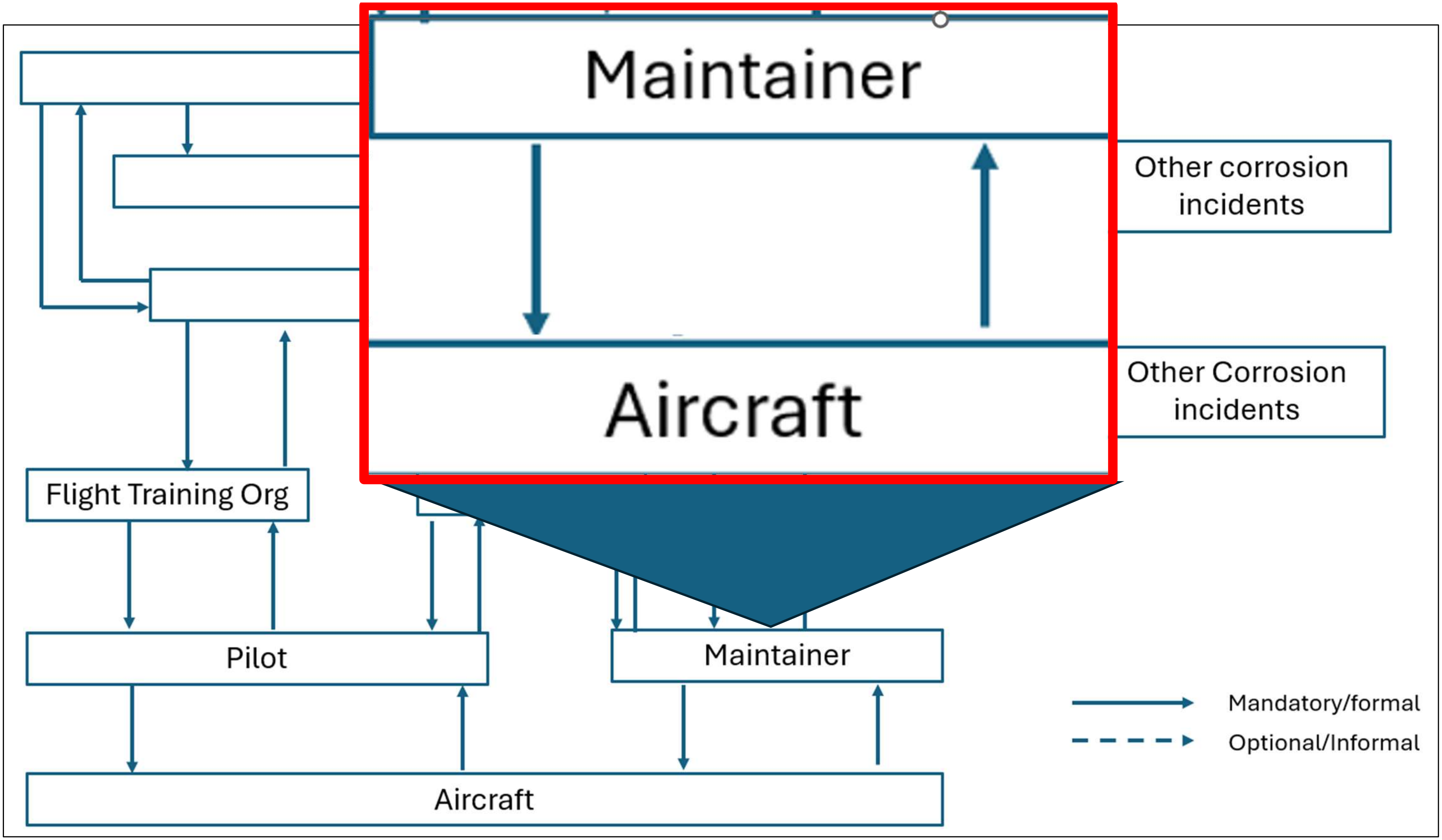
Physical Component Analysis

F&I 1**: Failures and Unsafe Interactions**

The control cable from pilot's yoke to the ailerons broke [H 1].

CF 1: Context:

- The cable had internal corrosion due to **salt exposure.**
- Operation of the aircraft in a severe corrosion area.
- Towing of banners at low altitudes over the ocean.
- Unlikely that the corrosion was limited to that component.
- **Not have been easy to detect before the failure** [F&I 1]


Maintainer
Aircraft
Other corrosion incidents
Other Corrosion incidents
Flight Training Org
Pilot
Maintainer
Aircraft
Mandatory/formal
Optional/Informal

Maintenance UCAs

Control Action	Not Provided	Provided	Provided too soon/Too late	Provided too long/too short
Inspect Aileron Cables	UCA 1: Not provided when corrosion present[H 1]	UCA 2: Provided insufficiently when corrosion present [H 1]	UCA 3: Provided too early to detect corrosion [H 1]	NA
Airworthiness Release	NA	UCA 4: Provided when corrosion is present [H 1]	NA	NA

Maintainer UCAs

We need to investigate to know which of UCAs 1-3 occurred for sure.

UCA 1: Inspection of cables not provided when corrosion present [H 1]

UCA 2: Inspection of cables provided insufficiently when corrosion present [H 1]

UCA 3: Inspection of cables provided too early to detect corrosion [H 1]

UCA 4: Airworthiness release provided when corrosion is present [H 1]

We know that UCA 4 occurred!

Maintainer Causal Factors

CF 1: **Aircraft are difficult to inspect**

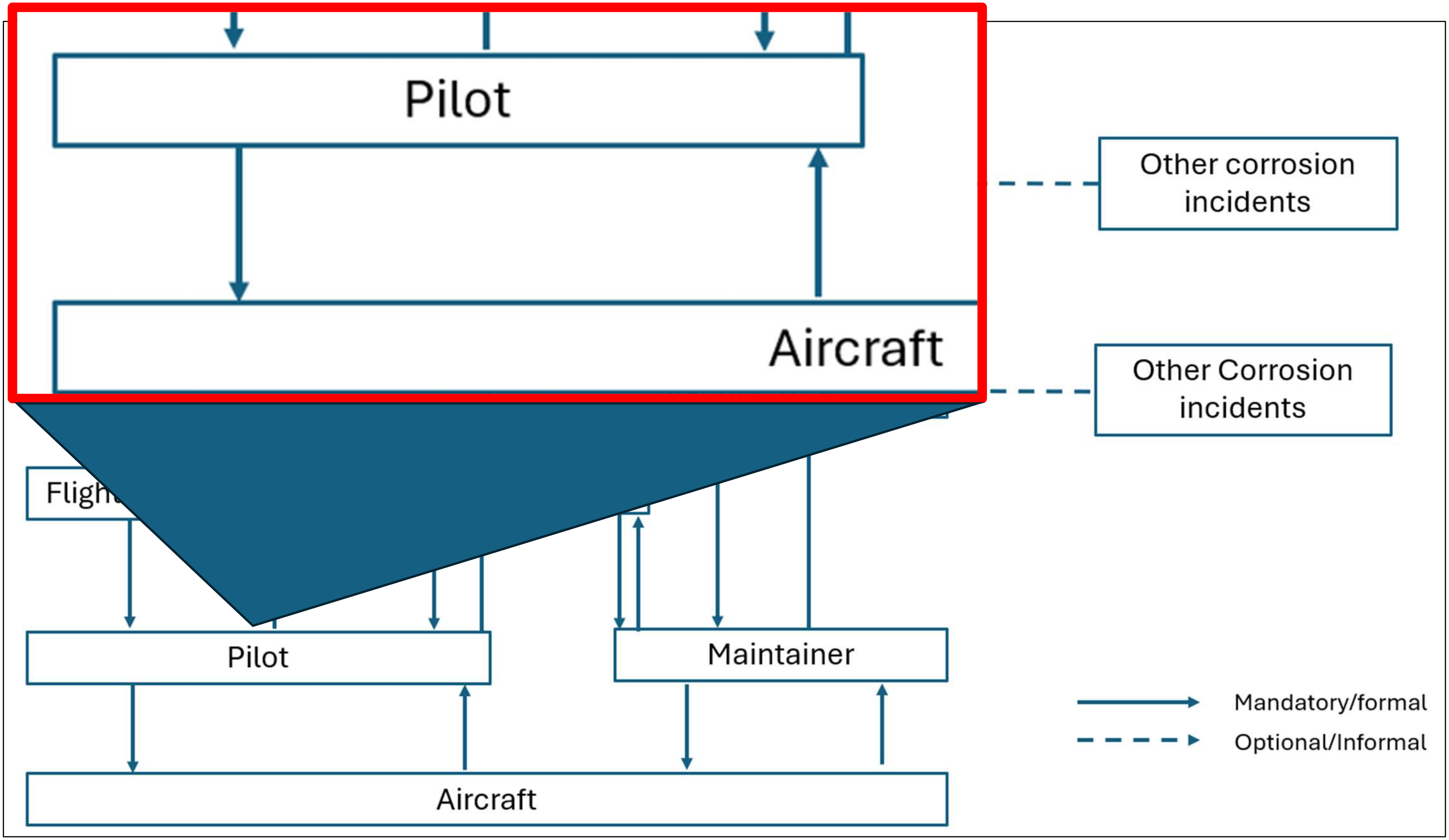
- Inspection every 15 days for severe corrosion recommended in coastal areas may be considered impractical.
- Minor corrosion commonplace – possibly ignored over time when no problems manifested [UCA1-4].

Consider *safe* control actions not chosen

Did not choose to do the inspection or refuse airworthiness release

CF 2: Charging for hours of invasive structural dismantling during peak flying season would likely anger the operator, resulting in the immediate financial loss of a major client. Not keeping the aircraft flying could jeopardize maintainer’s job [UCA 4]

CF 3: Maintainer viewed risk of losing customer as higher than the possibility that the visible corrosion would result in an accident [UCA 1-4]


Pilot
Aircraft
Other corrosion incidents
Other Corrosion incidents
Fligh
Pilot
Maintainer
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Mandatory/formal
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Pilot UCAs that flow from the Evidence

Control Action	Not Provided	Provided	Provided too soon/Too late	Provided too long/too short
Preflight Inspection	UCA 5: when corrosion present [H 1]	UCA 6: Inadequately to detect corrosion [H 1]	NA	NA

Could the pilot have detected the problem?

Possible UCAs should be investigated:

- UCA 5: Preflight inspection not provided when corrosion present[H 1]
- UCA 6: Preflight inspection provided inadequately to detect corrosion [H 1]

- *It might not have been possible for the pilot to detect these!*

Pilot Causal Factors

- CF 4: A normal pilot preflight does not include a more detailed inspection to check for corrosion other than a superficial inspection as set out by the flight control manual. [UCA 5, 6].

Consider *safe* control actions not chosen

- **Pilot did not choose to report corrosion (assuming pilot saw any)**

- **Perceived Local Losses**
- CF 5: Pilot might view the corrosion as normal and not want to call attention to it because they need the flight hours and money.
- Pilot viewed the risk of an accident as lower than the risk from losing the hours, pay and possibly risking their job [UCA 5,6]

Can we find more?

- ***What other possible control actions did the pilot have available?***

Control Action	Not Provided	Provided	Provided too soon/Too late	Provided too long/too short
Preflight Inspection	UCA 5: when corrosion present [H 1]	UCA 6: Inadequately to detect corrosion [H 1]	NA	NA
Increase Power				
Roll/Ailerons				
Yaw/Rudder				
Increase Pitch				
Decrease Pitch				

Control Actions Available to the Pilot

Control Action	Not Provided	Provided	Provided too soon/Too late	Provided too long/too short
Preflight Inspection	UCA 5: when corrosion present [H 1]	UCA 6: Inadequately to detect corrosion [H 1]	NA	NA
Increase Power	This does not appear to be a factor in this accident	NA	NA	NA
Roll/Ailerons	NA due to control failure	NA due to control failure	NA due to control failure	NA due to control failure
Yaw/Rudder	UCA 7: when needed to create sideslip for dihedral effect [H-1]	NA	NA	NA
Increase Pitch	UCA 8: when angle of attack increase needed for increased rudder effectivity [H 1]	NA	UCA 9: Too late when needed for increased rudder authority [H 1]	NA
Decrease Pitch	NA except in stall scenario	UCA 10: when increase angle of attack required to provide roll control through dihedral effect [H 1]	NA	NA

UCAs *not* apparent from the evidence

UCA 7: Rudder not provided when needed to create sideslip for dihedral effect [H 1]

UCA 8: Pitch increase not provided when angle of attack increase needed for increased rudder effectivity [H 1]

UCA 9: Pitch increase provided too late when needed for increased rudder authority [H 1]

UCA 10: Decrease pitch provided when increase angle of attack required to provide roll control through dihedral effect [H 1]

Causal Factors

CF 6: Most likely the pilot was not trained to understand or consider using dihedral effect as an alternate control strategy when ailerons are not functional [UCA 7-8].

R 4: All pilots should be trained in the use of alternate control strategies so they can maintain control of the aircraft in the event of a loss of control capability in any axis. [CF 6].

Consider *safe* control actions not chosen

Why would the pilot *not* use the rudder and increase pitch?

CF 7: Pilot may have chosen not to increase pitch and use rudders due to perception of risk of loss of control due to a spin was higher than what might have been viewed as a relatively level crash [UCA 7-8].

R 5: Pilots should receive more in depth aerodynamic training so they understand the risk factors [CF 7]

Questions

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