HFACS applied to Helios 5B-DBY Accident

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Human Factors

- The causal factor in 80% of all mishaps
- Identified as the single greatest mishap hazard.
- Mishaps are rarely attributed to a single cause or a single individual. They are the end result of many conditions, both active and latent.

Human Factors:
Active and Latent conditions

- **Active failures** are the last actions/inactions that are believed to cause the mishap (*direct causes*). Referred to as “error”.

- **Latent failures** are the conditions that *pre-exist* that may influence the sequence of events in a mishap. May remain undetected for some time before they manifest into an event.

Human factors

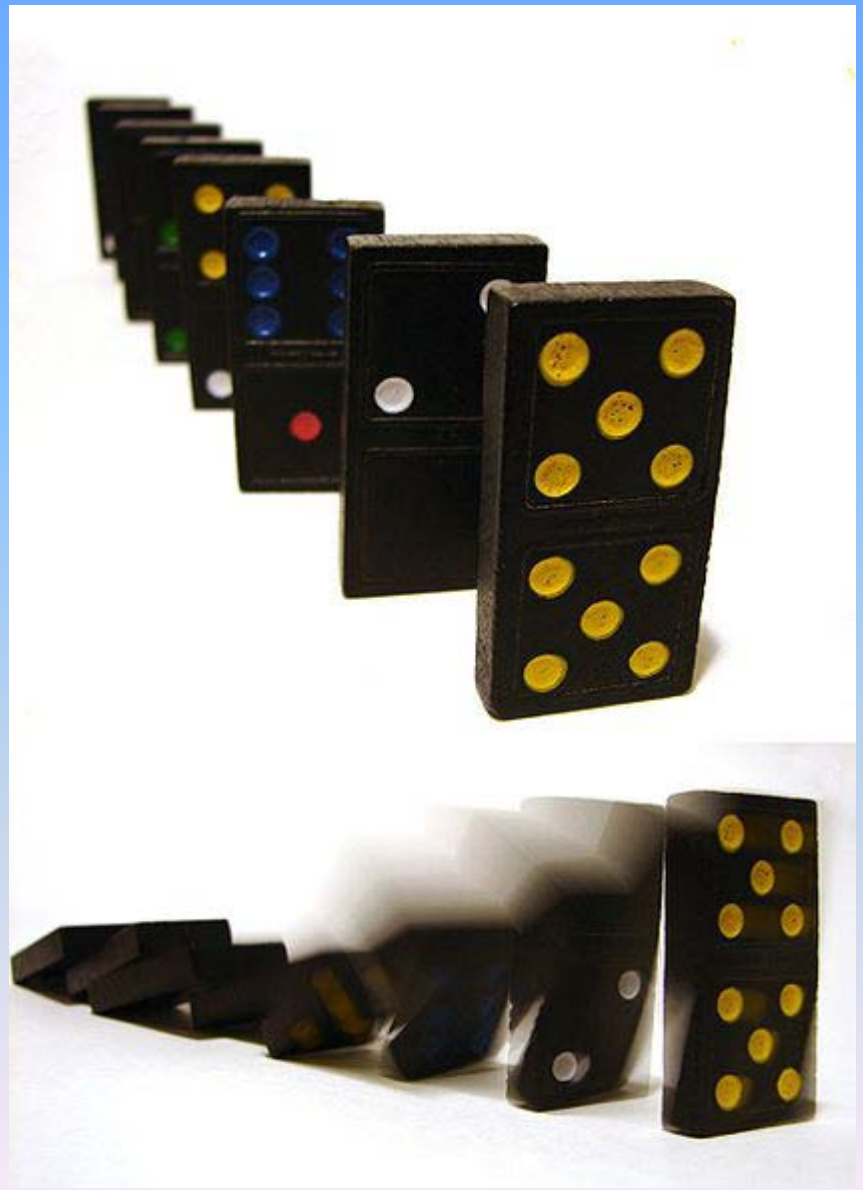
- The aim of an event investigation is

- to identify these failures,
- understand why it happened,
- prevent it from happening again.

Human Factors: *Domino Theory*

- "Domino" theory:

  mishap is the end result of a series of errors.



Human Factors: *Swiss Cheese Model*

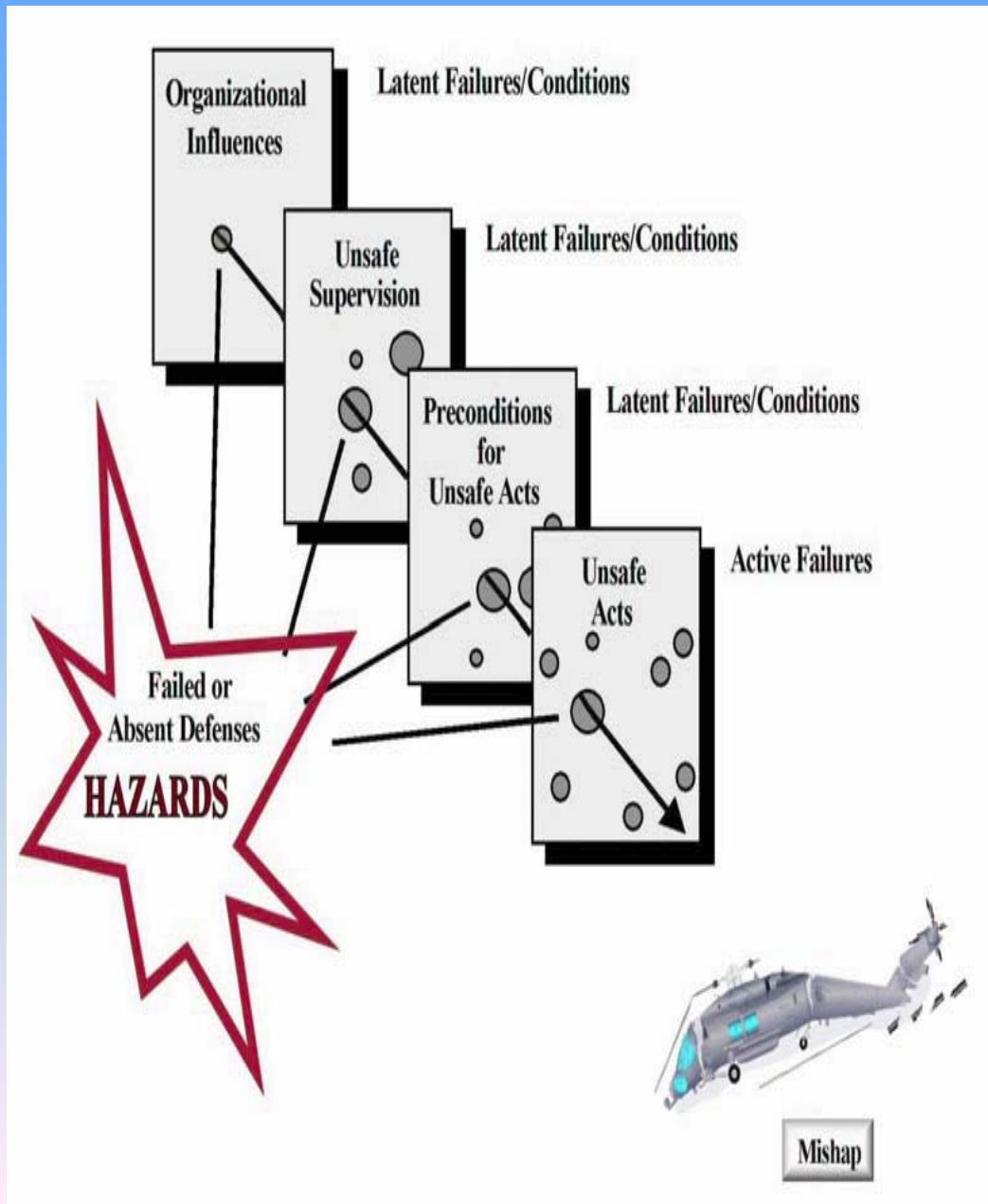
Describes different levels at which failures and conditions may occur.

First level:

- Unsafe acts of the operator (actions/inactions) leading to the event.
- Active failures / direct causes

Other levels:

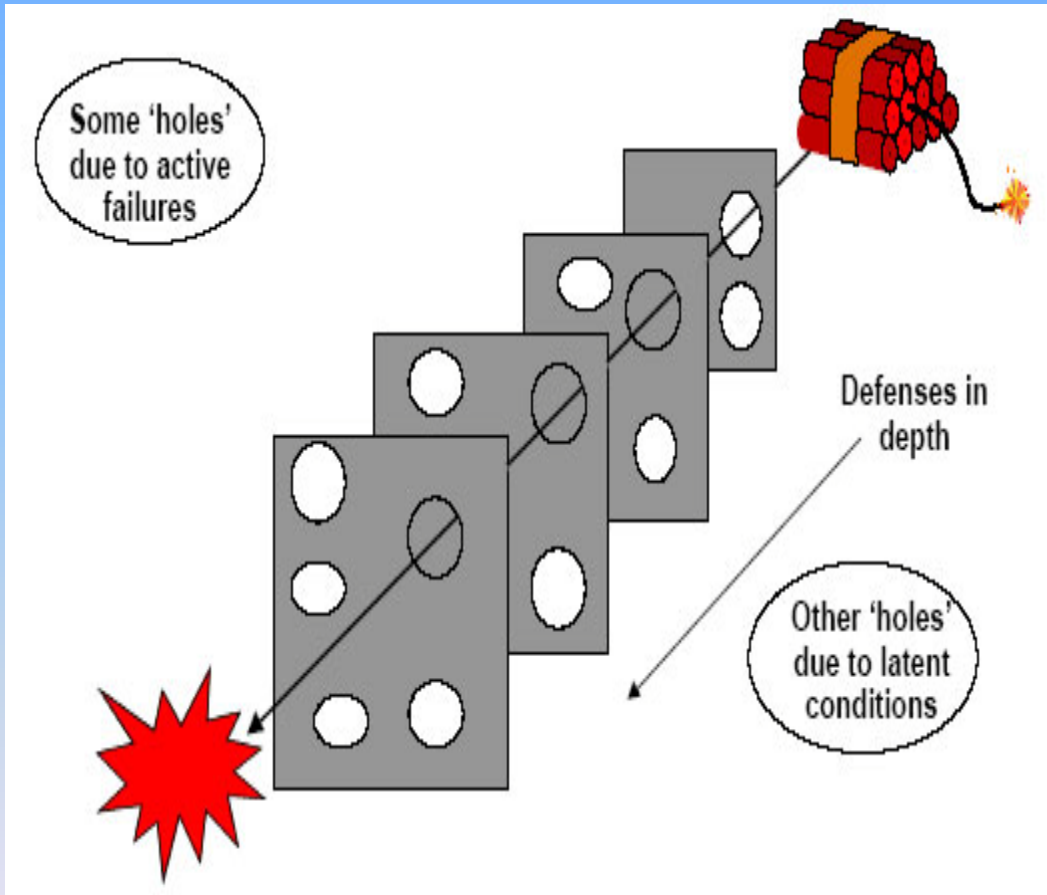
- Latent causes
- Should be examined for a more thorough investigation of the mishap.



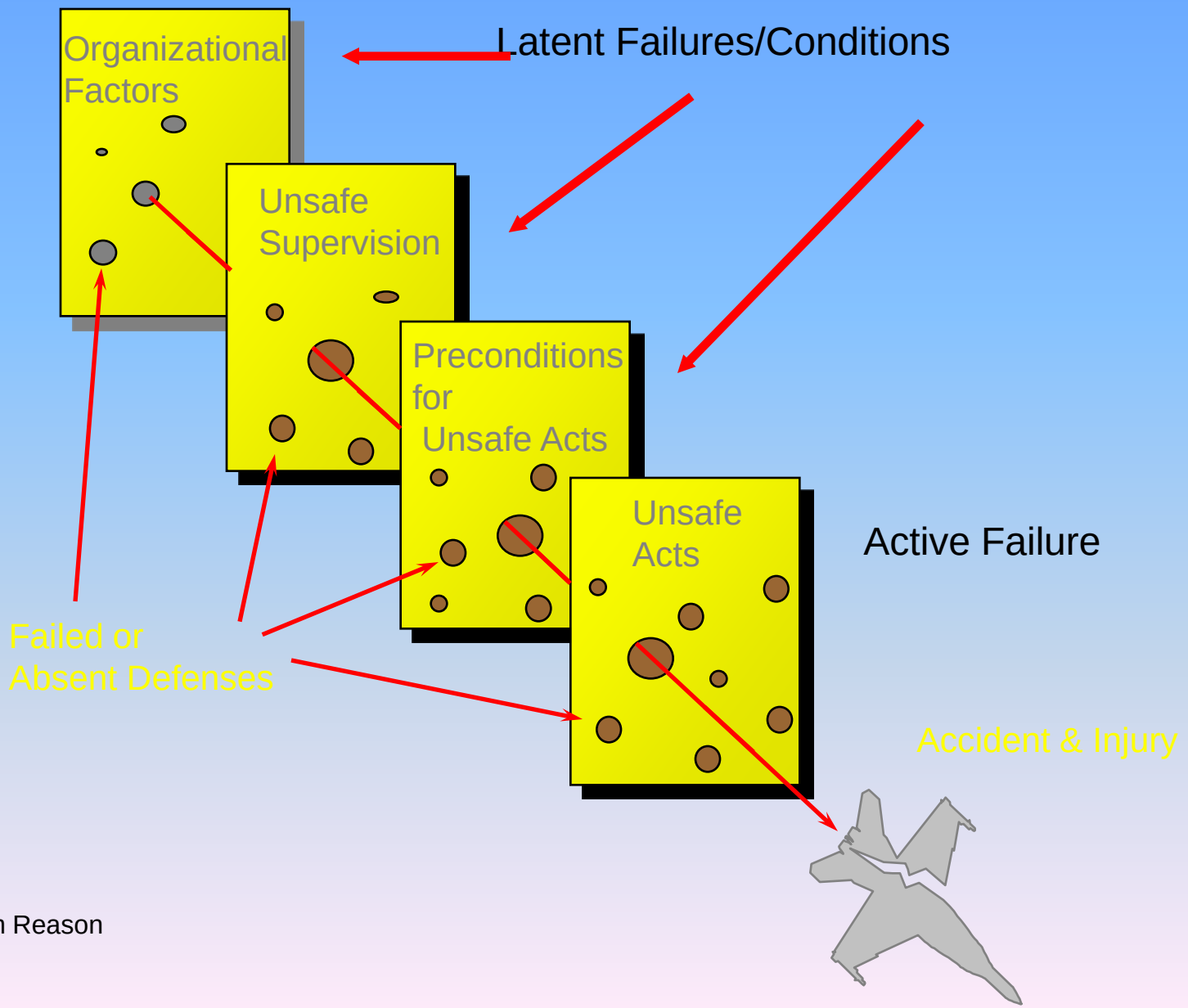
Human Factors: *Swiss Cheese Model*

Even if each mishap is unique, most mishaps have very similar causes! Same “holes” in the cheese!

When the “holes” of every “slice” line up, the system provides a trajectory for an accident to occur



Reason's "Swiss-cheese" Model of Human Error

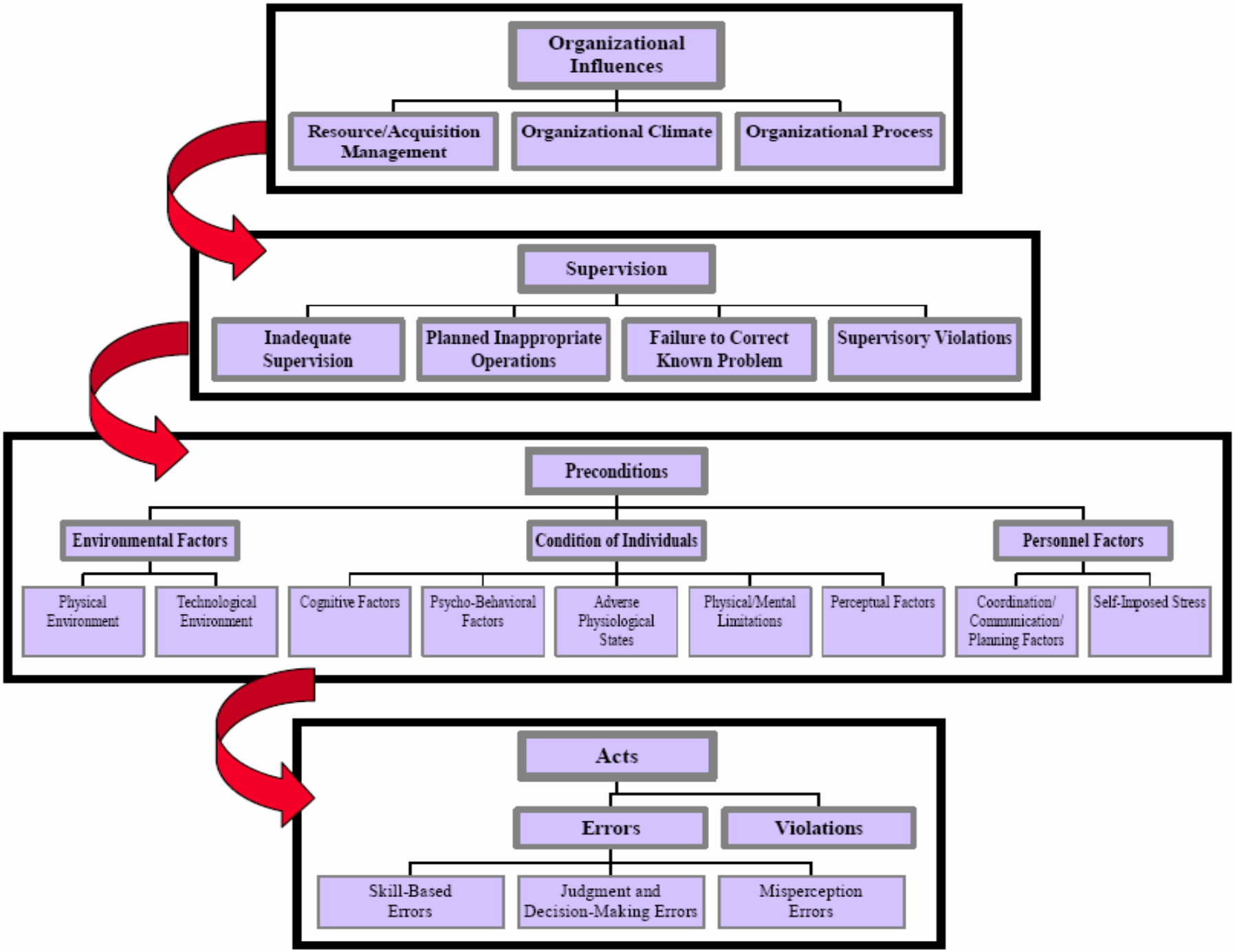


Adapted from Reason (1990)

Human Factor Analysis and Classification System (HFACS)

- A new model/taxonomy of Human factors.
- Aim to reduce the number of mishaps and accidents in organizations, incl. aviation.
- Can be used as a primary or secondary tool to investigate ***active*** and ***latent*** failures in an event/mishap.
- Brings together Human Factors, Operations, Human Systems, Engineering Issues:

  Man, Machine, Medium, Mission, Management.
- It describes four main tiers of failures/conditions:
  - Acts
  - Preconditions
  - Supervision
  - Organizational Influences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Organizational Climate
Organizational Process
Supervision
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Failure to Correct Known Problem
Supervisory Violations
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Acts
Errors
Violations
Skill-Based Errors
Judgment and Decision-Making Errors
Misperception Errors

Human Factor Analysis and Classification System (HFACS)

- Focuses on the system instead of the individual (more holistic approach)
- Not just individual failures
- Failures in systems that humans design, build, operate and maintain
- Organized in a systemic format / code system for easier identification

The Helios 5B-DBY Accident

14 Aug 2005

Sequence of events

- B737-300 arrived LCA from LHR 04:25
- After concerns of crew, inspection of aft service door and cabin pressurization check by ground engineer.

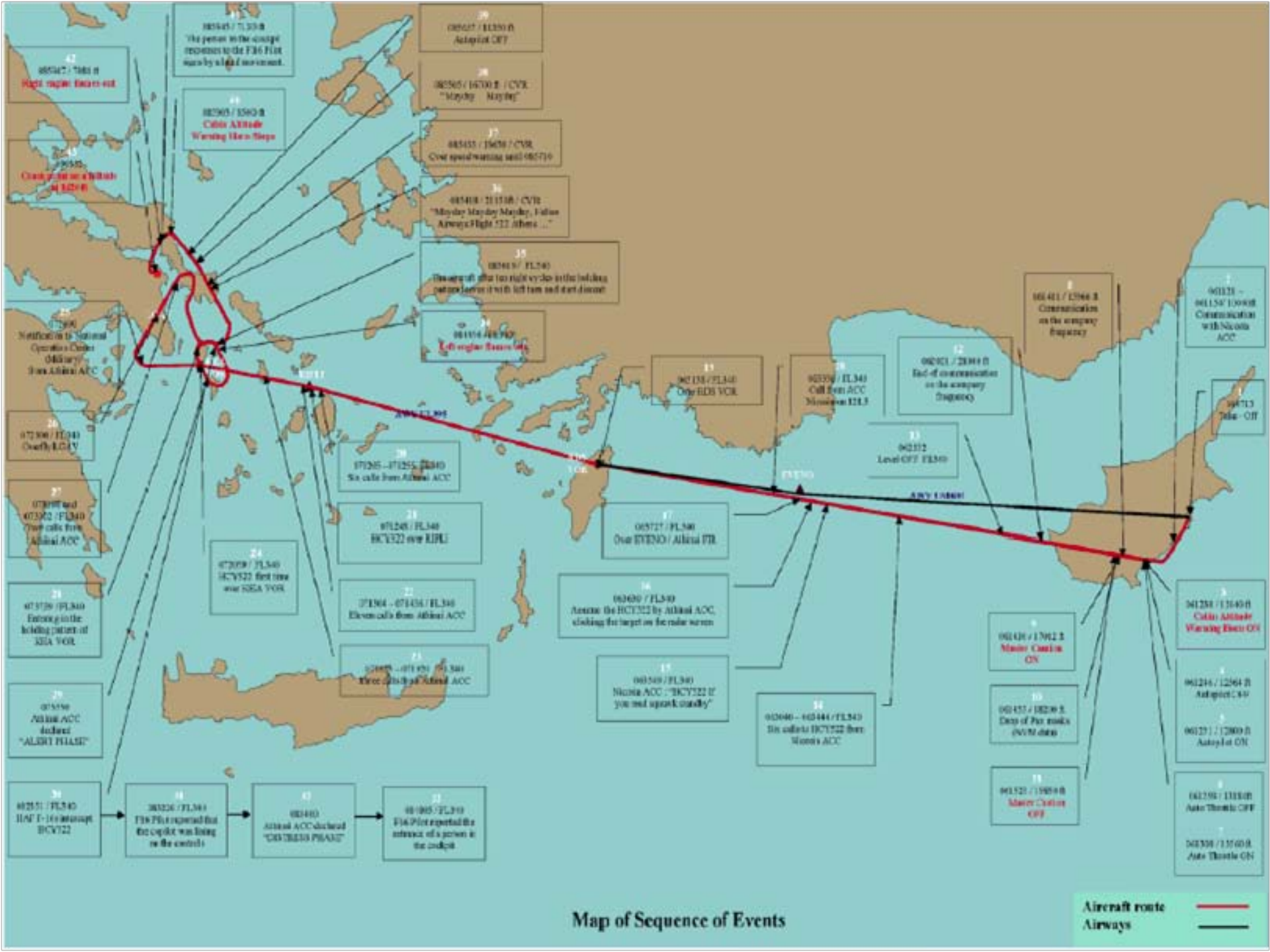
- DCPCS : Digital cabin pressure control system
- AUTO / ALTN / MAN

- Ground pressurization check requires the DCPS to be in the MAN position.
- Nil defects
- Aircraft released for next flight
- Remained in MAN position

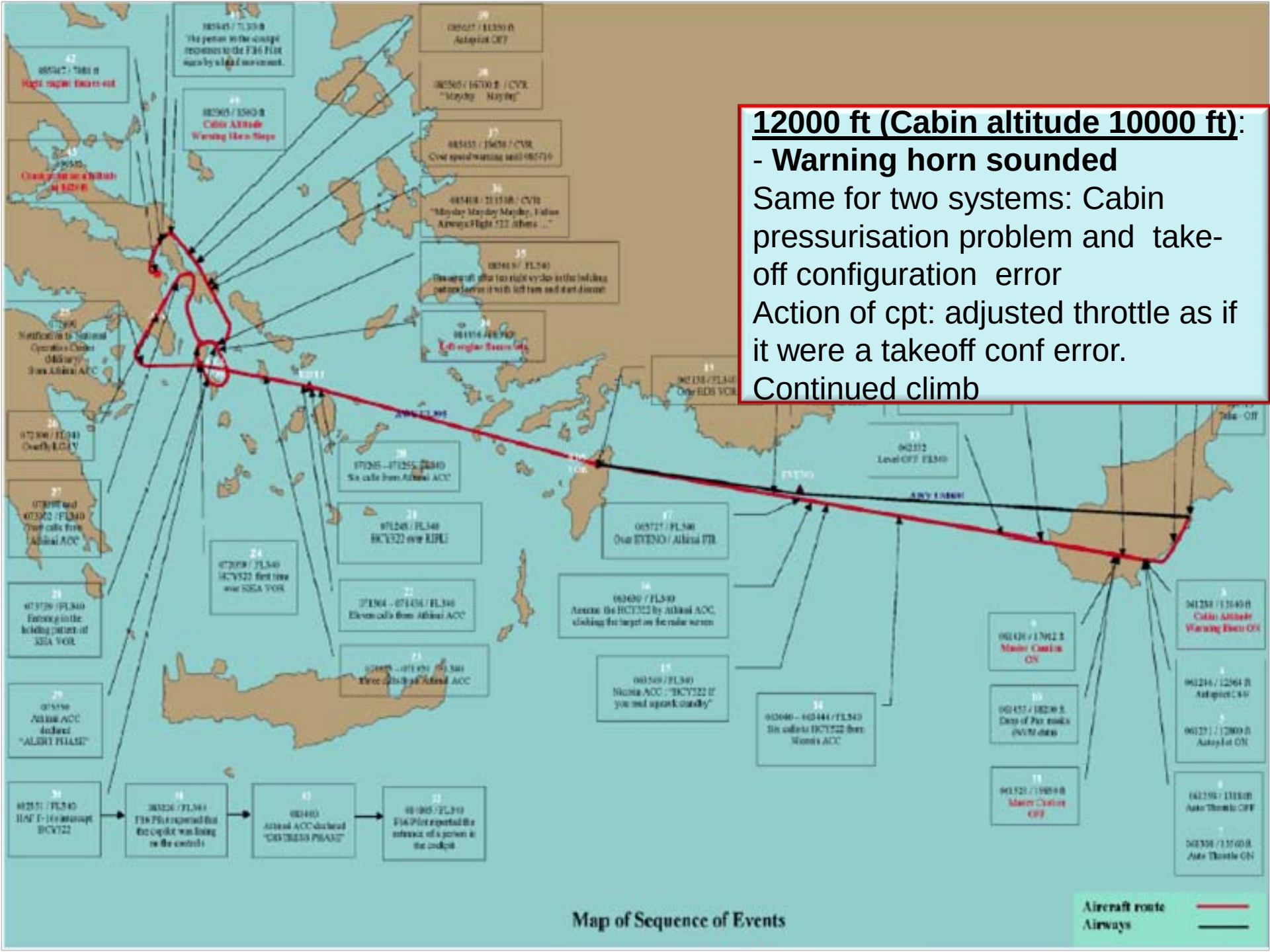
- Scheduled flight HCY522 LCA-ATH-PRG 09:00h
- German Captain, Cypriot FO, 4 cabin crew, 115 passengers

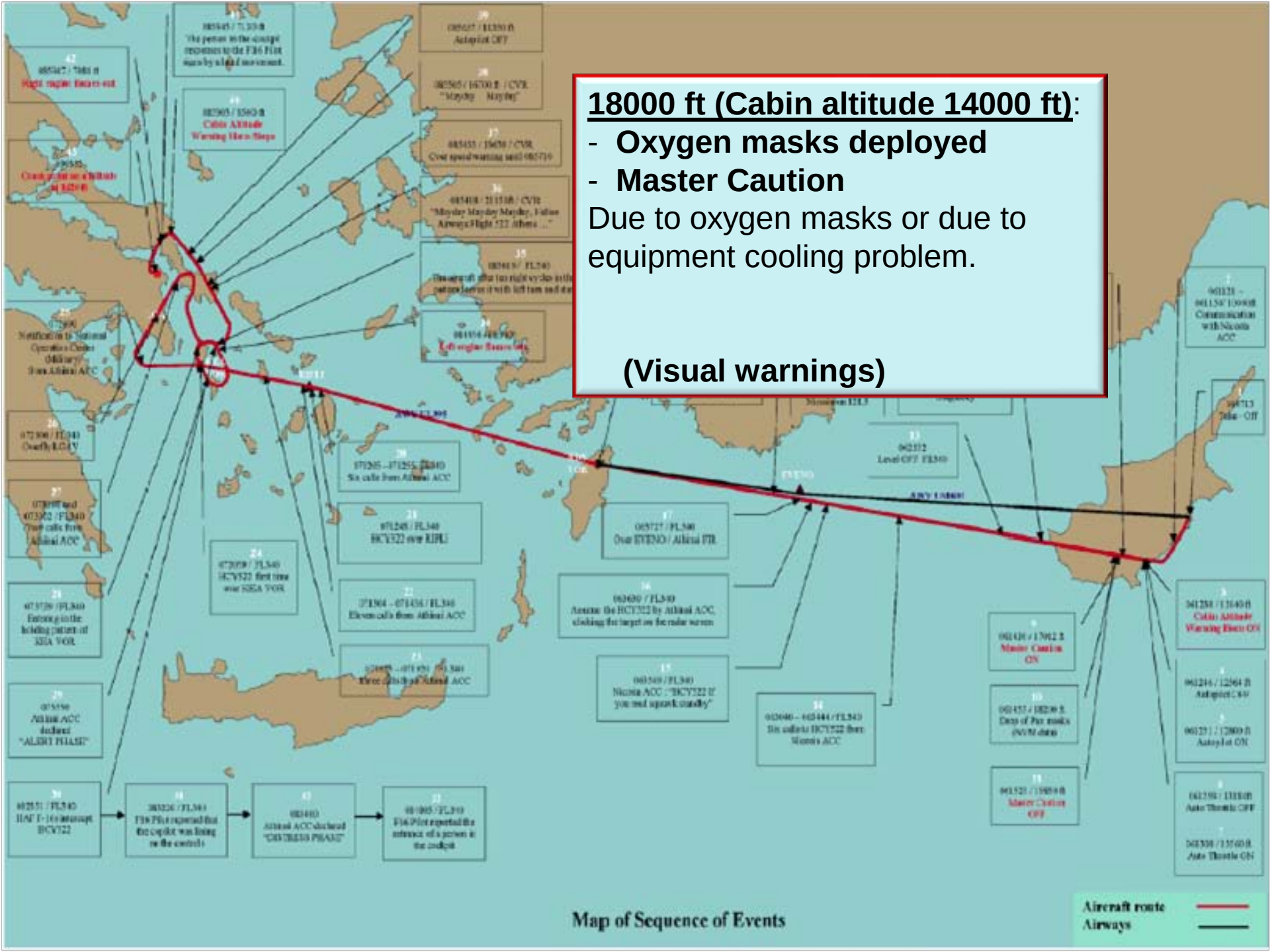
Departure from RNW 22 LCA 09:07am

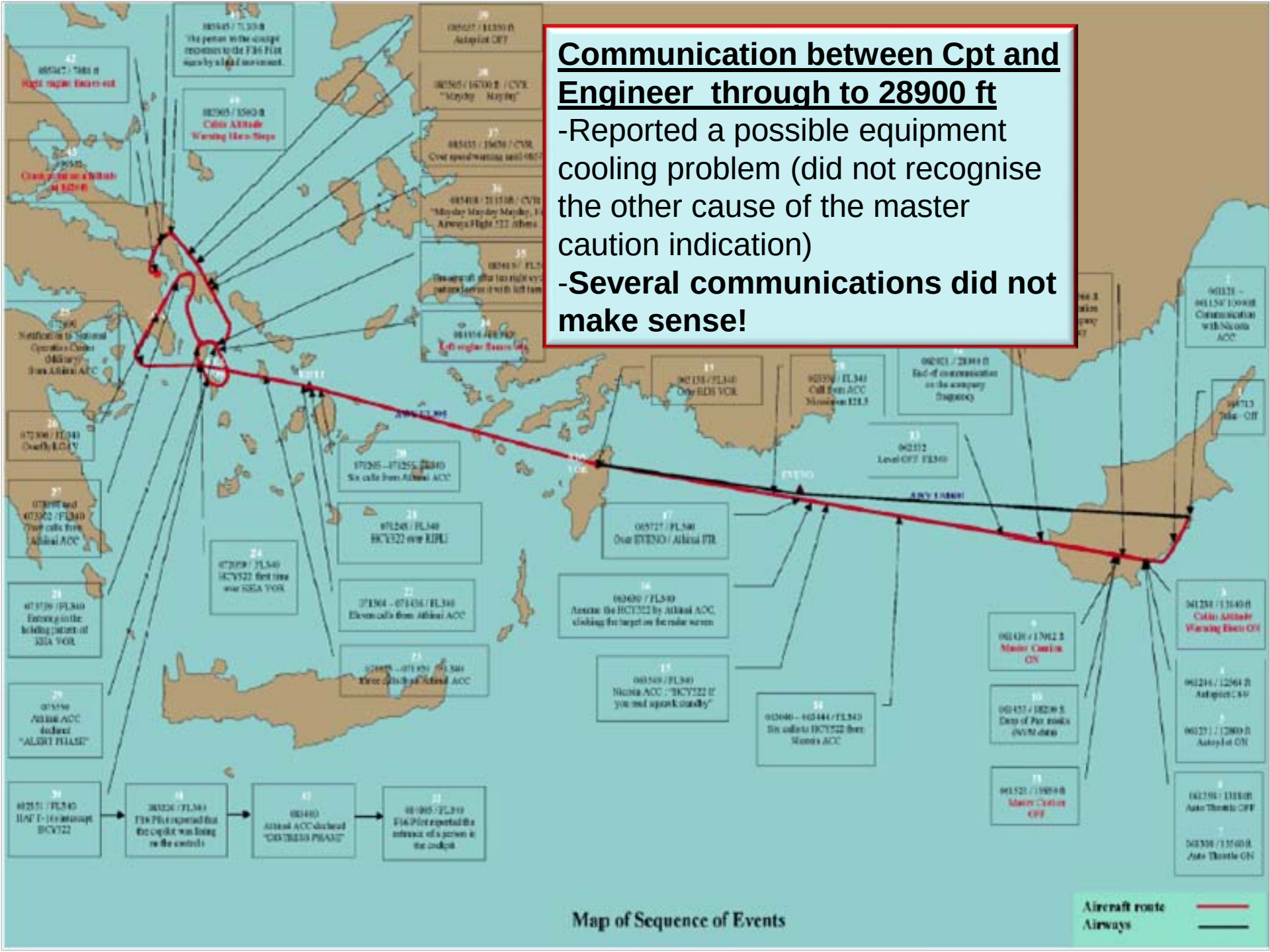
Cleared for FL340, direct to RDS VOR

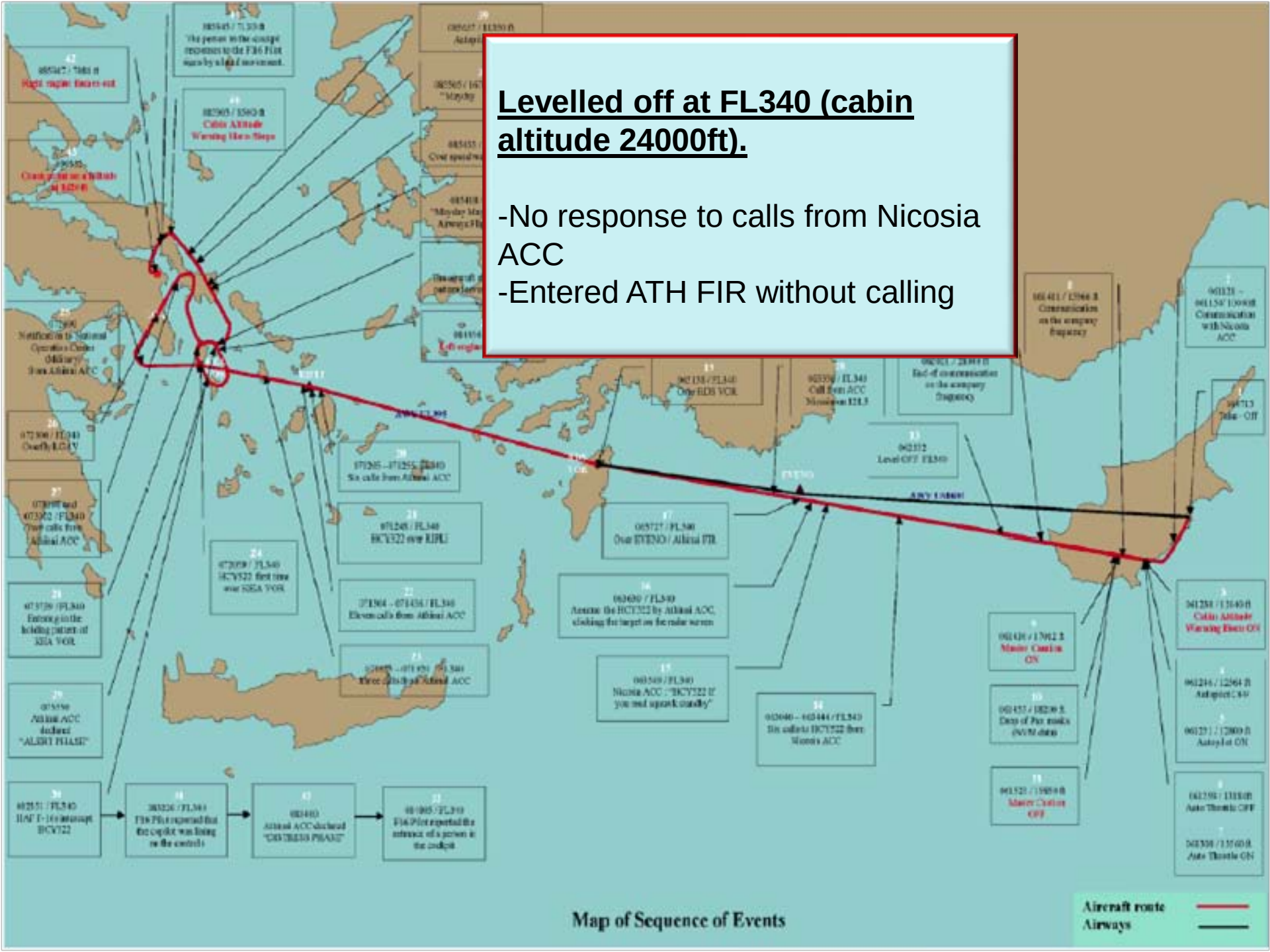


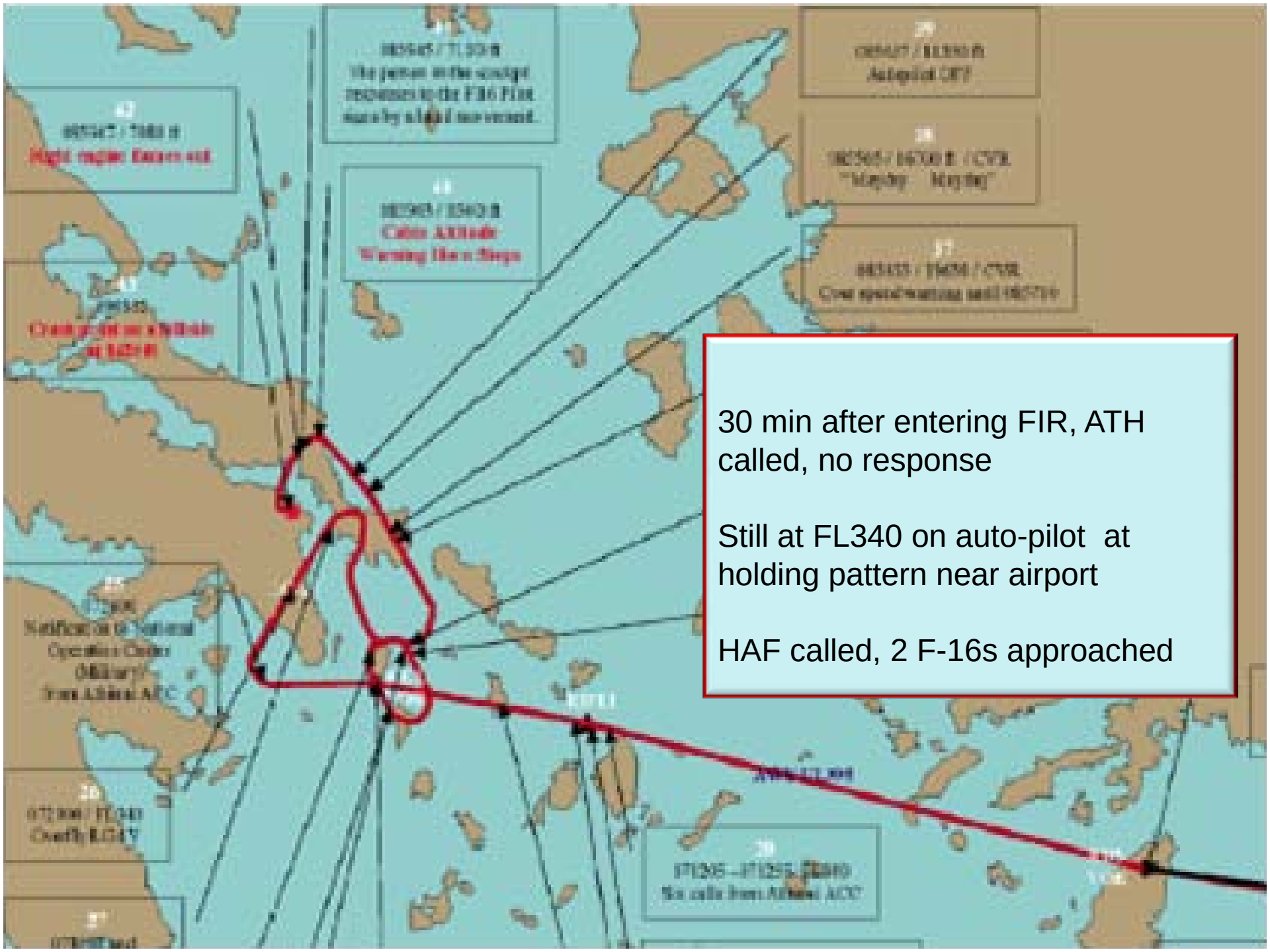
Map of Sequence of Events


12000 ft (Cabin altitude 10000 ft):
- Warning horn sounded
Same for two systems: Cabin pressurisation problem and take-off configuration error
Action of cpt: adjusted throttle as if it were a takeoff conf error.
Continued climb
Map of Sequence of Events
Aircraft route
Airways


18000 ft (Cabin altitude 14000 ft):
- Oxygen masks deployed
- Master Caution
Due to oxygen masks or due to equipment cooling problem.
(Visual warnings)
Map of Sequence of Events
Aircraft route
Airways

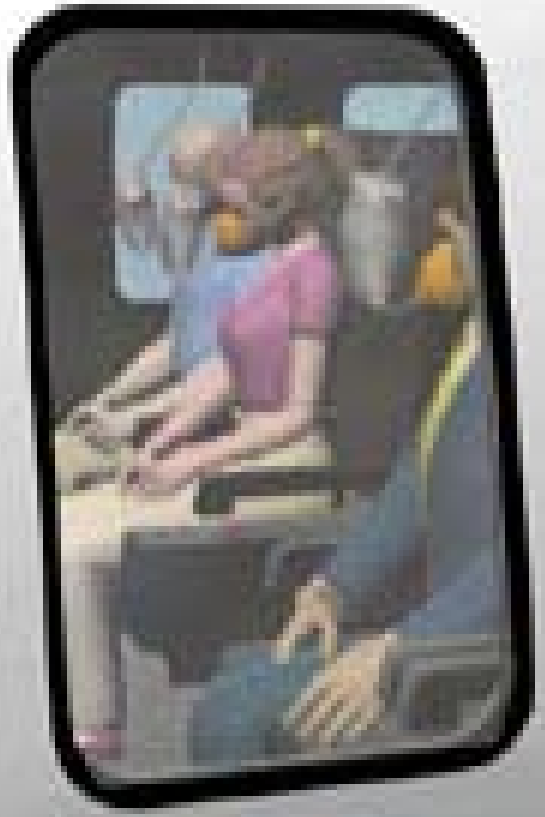

Communication between Cpt and Engineer through to 28900 ft
-Reported a possible equipment cooling problem (did not recognise the other cause of the master caution indication)
-Several communications did not make sense!
Map of Sequence of Events
Aircraft route
Airways

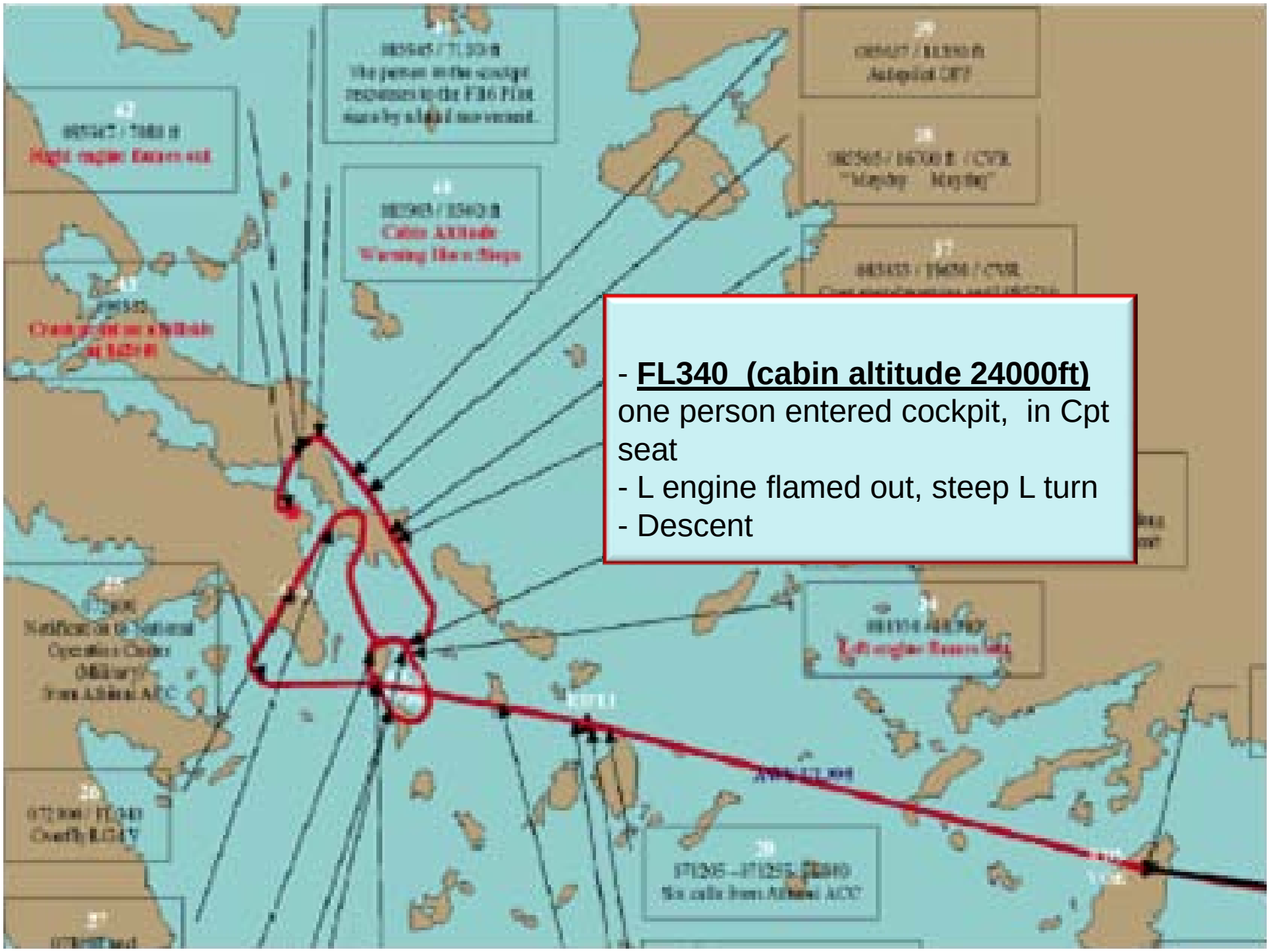

Levelled off at FL340 (cabin altitude 24000ft).
-No response to calls from Nicosia ACC
-Entered ATH FIR without calling
Map of Sequence of Events
Aircraft route
Airways


30 min after entering FIR, ATH called, no response
Still at FL340 on auto-pilot at holding pattern near airport
HAF called, 2 F-16s approached

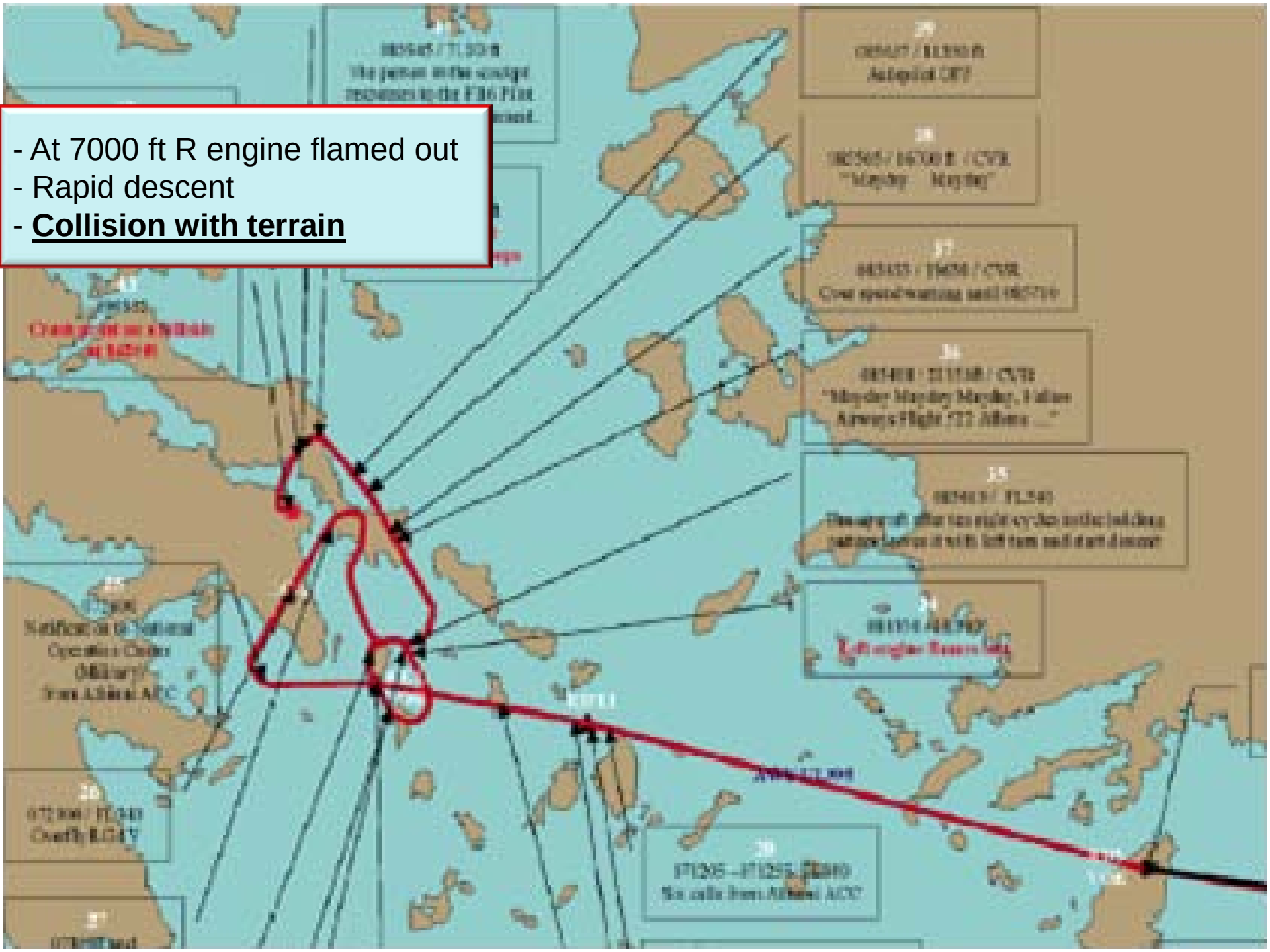


- Cpt seat empty
- FO slumped over controls without Oxygen mask
- Cabin motionless
- Passenger oxygen masks deployed
- Some passengers wearing masks

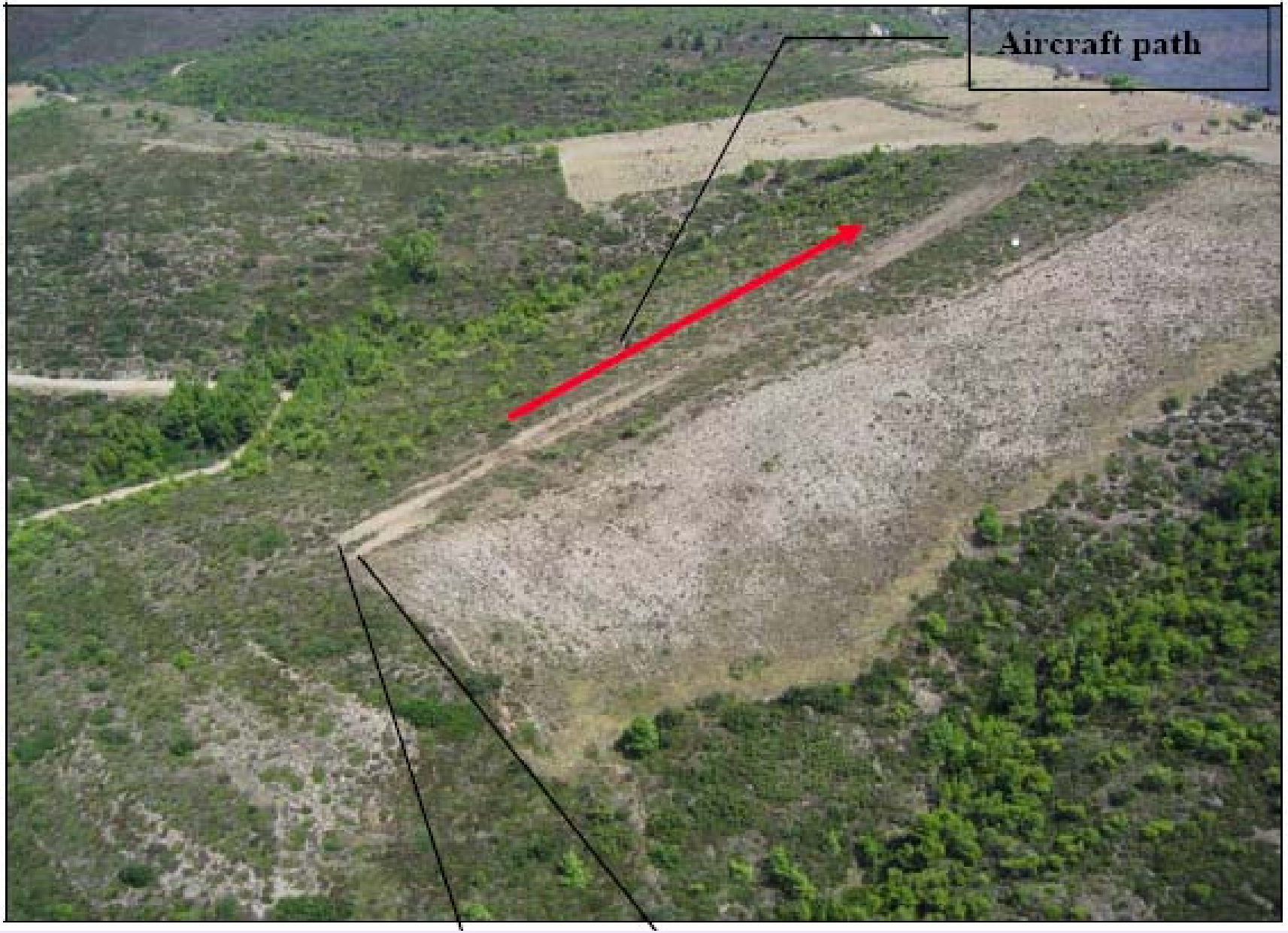



- **FL340 (cabin altitude 24000ft)**
one person entered cockpit, in Cpt seat
- L engine flamed out, steep L turn
- Descent

A very weak voice was recorded on CVR:
"MAYDAY, MAYDAY, MAYDAY, Helios Airways Flight 522 Athens…"


- At 7000 ft R engine flamed out
- Rapid descent
- **Collision with terrain**


Crash Site
Grammatiko
ATHENS

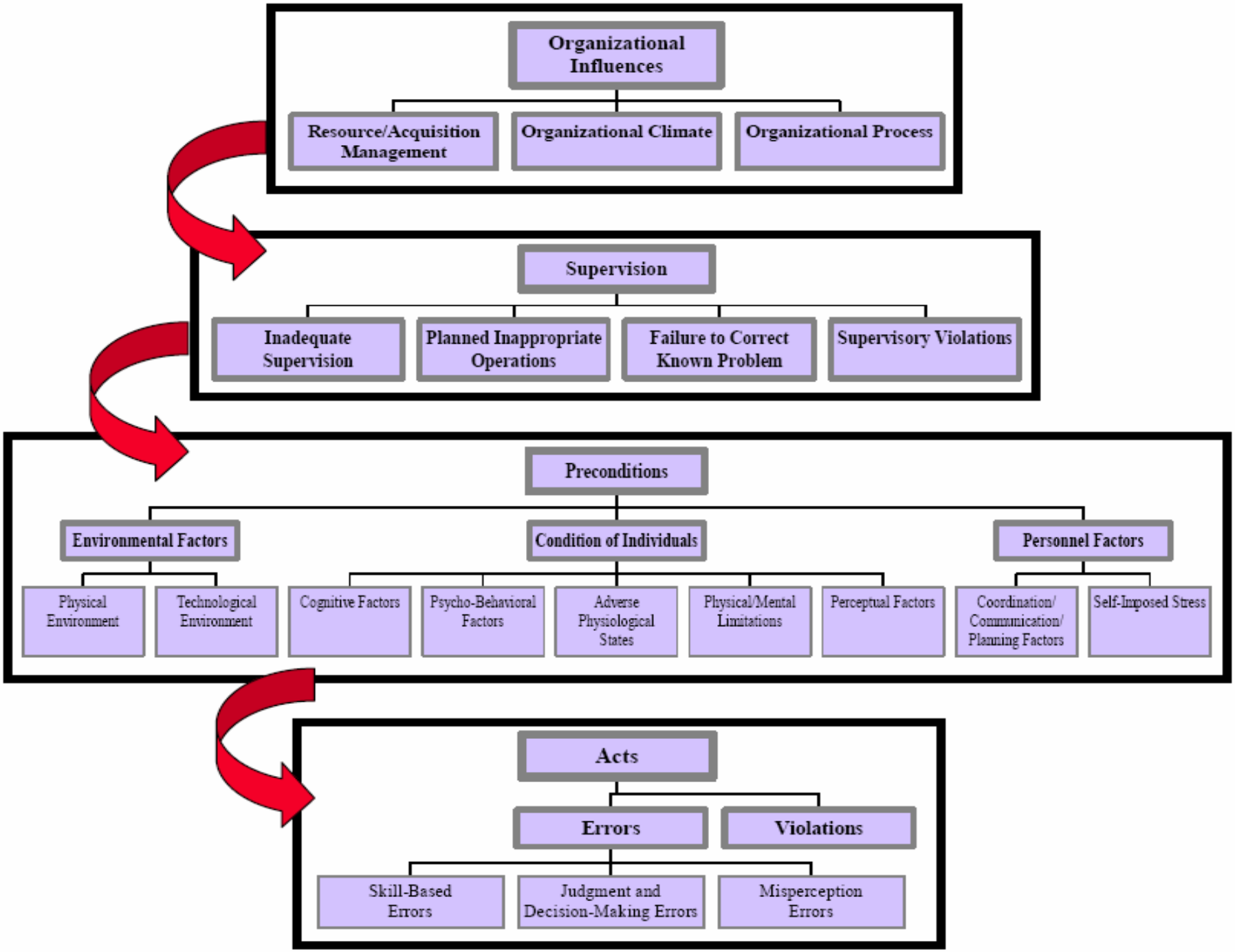

Aircraft path

HELLENIC REPUBLIC
MINISTRY OF TRANSPORT & COMMUNICATIONS

AIR ACCIDENT INVESTIGATION & AVIATION SAFETY BOARD (AAIASB)

AIRCRAFT ACCIDENT REPORT

HELIOS AIRWAYS FLIGHT HCY522
BOEING 737-31S
AT GRAMMATIKO, HELLAS
ON 14 AUGUST 2005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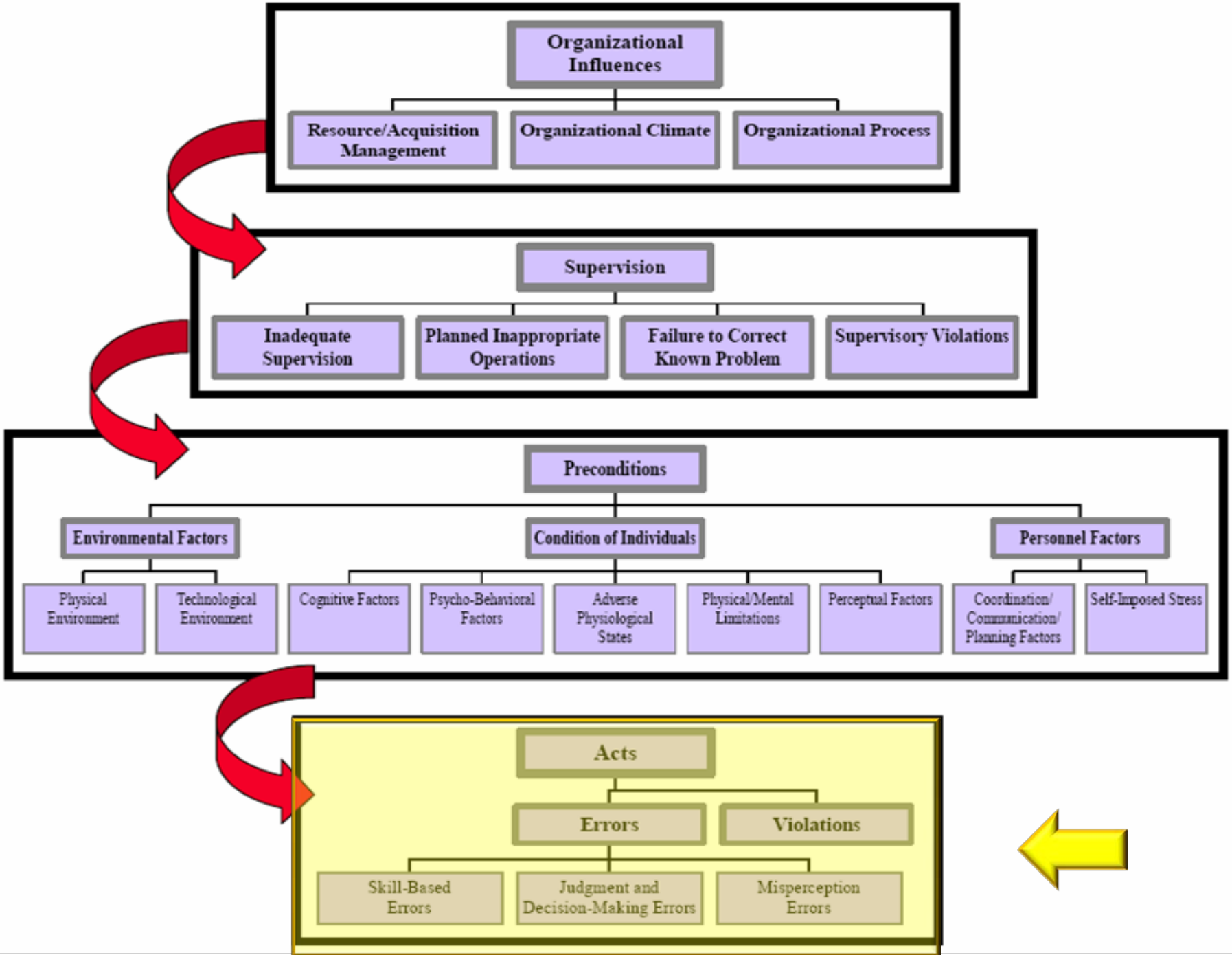
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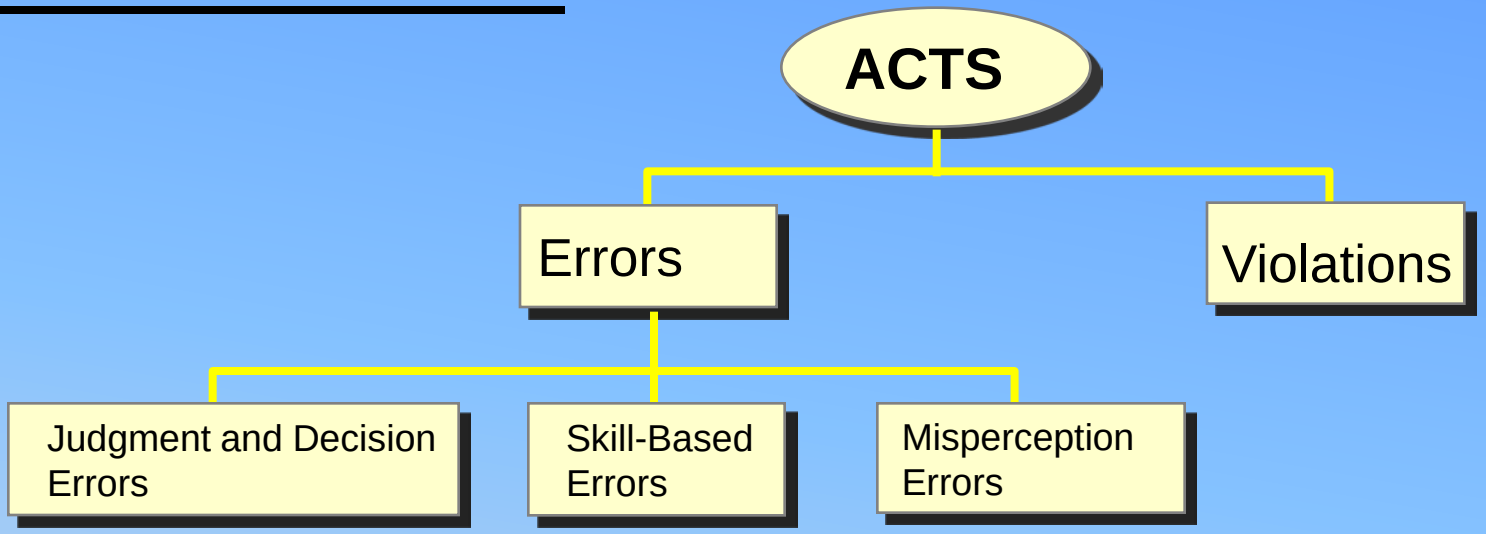
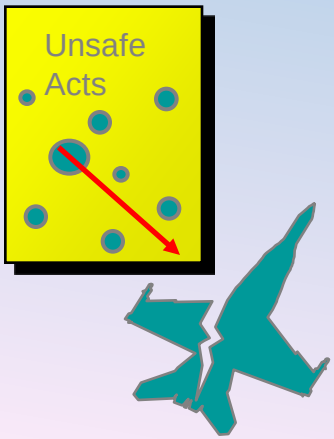
Helios: ACTS

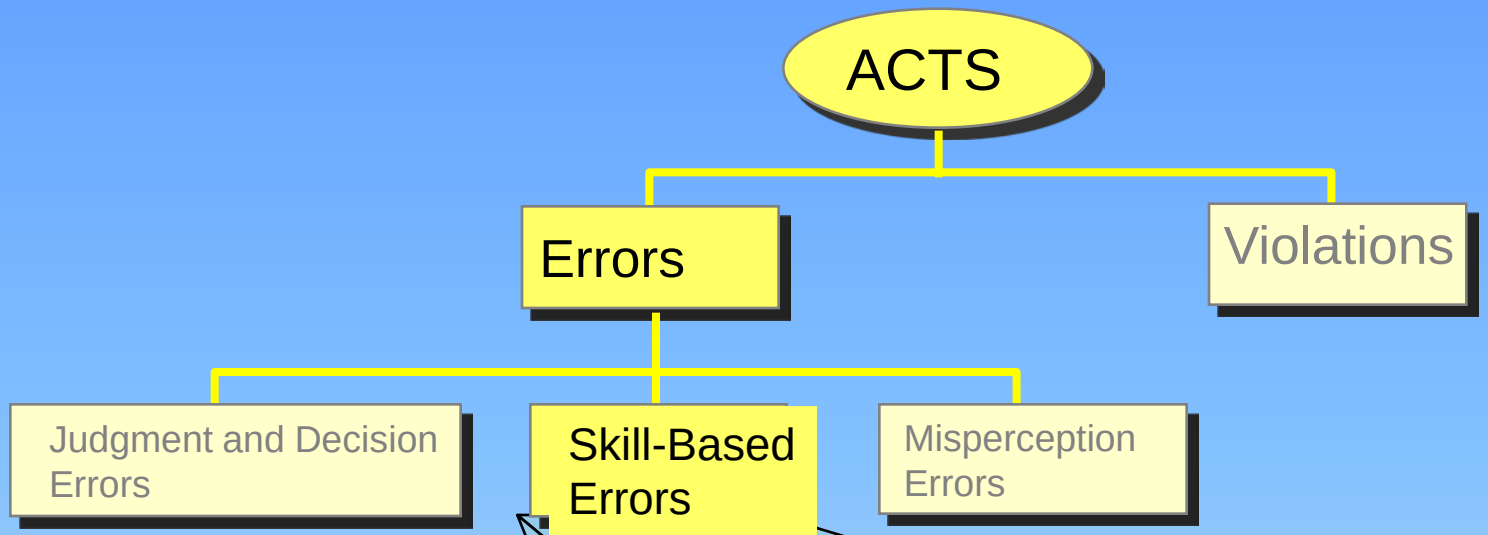


- Active failures / Direct Factors most closely tied to a mishap.

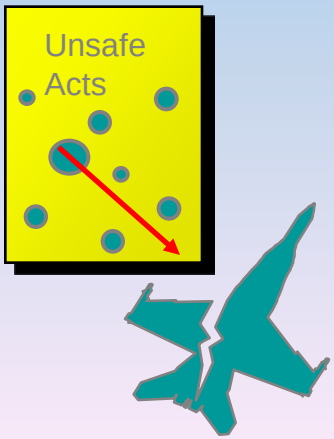


- Errors: Unintended factors as a result of skilled-based, judgment or decision making errors and misperception
- Violations: deliberate actions in a mishap that lead to unsafe situation

Helios: **Skill based Errors**



The main active failures of accident

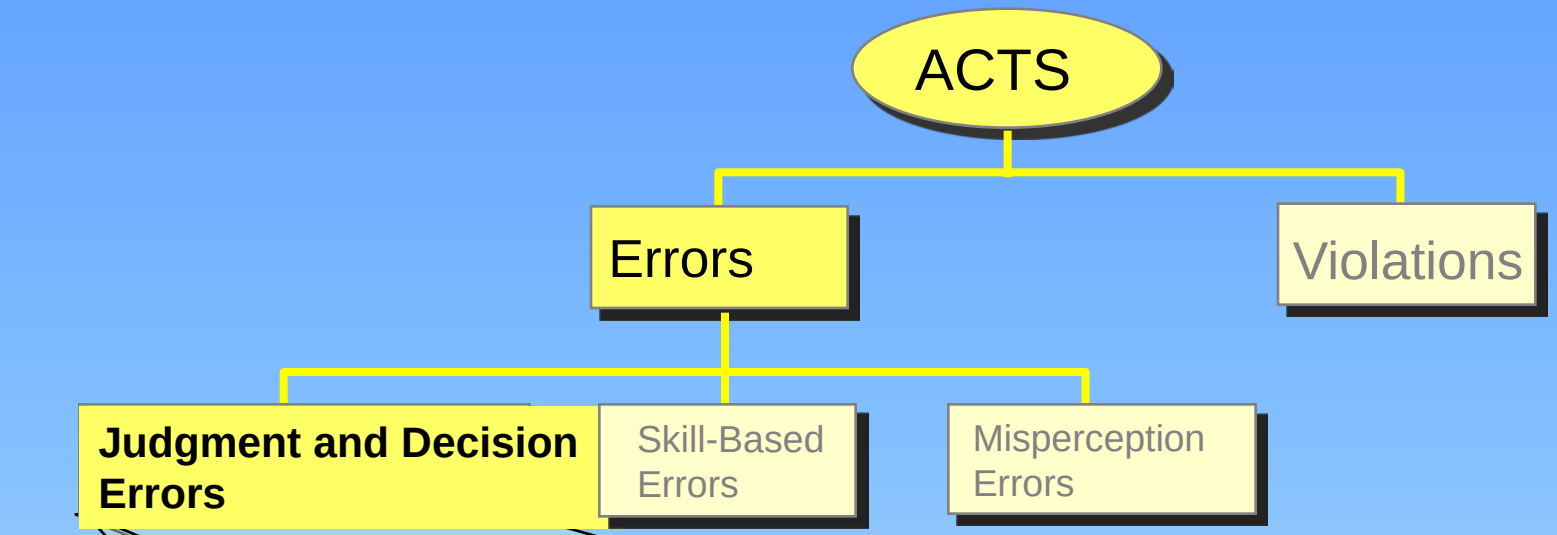


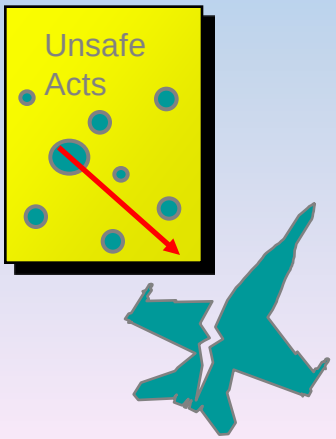
- **Failure to notice that the pressurization system was on MAN position instead of AUTO.**

- **Failure to run appropriately the checklist in at least three occasions**: Preflight, Before Start, After Take-off


AUTO
MANUAL
FLT ALT
VALVE
CLOSE
OPEN
ALTN
AUTO . MAN
LAND ALT

Helios: **Judgment and Decision-making errors**

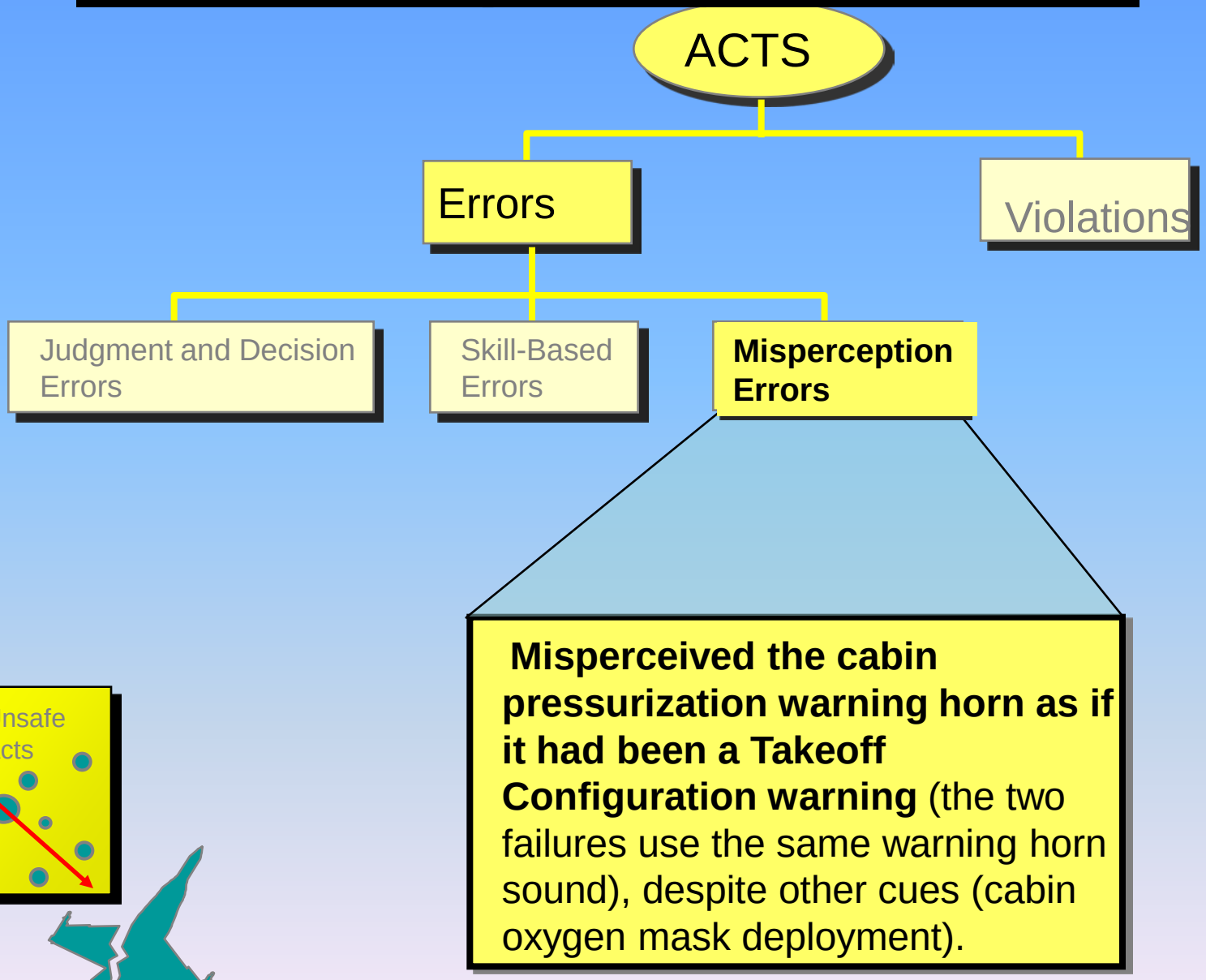




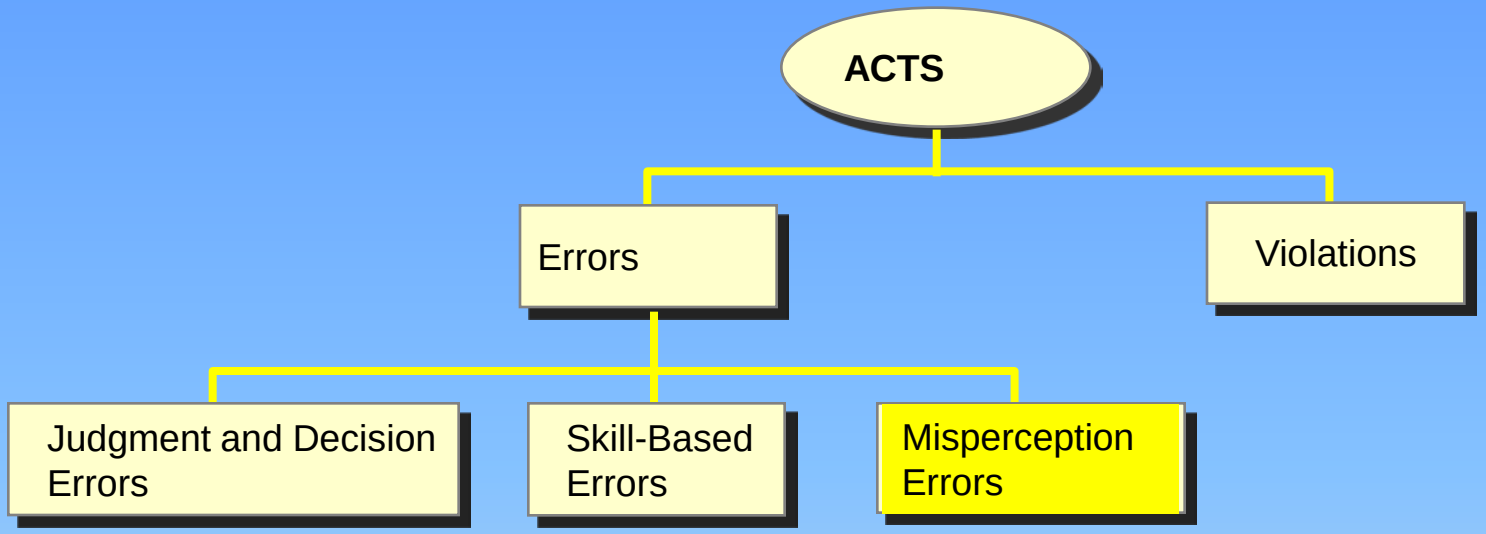
-**Failure to identify the warnings and the reasons for the activation of the warnings: Three consecutive warnings** (Cabin Altitude Warning Horn, Passenger Oxygen Masks Deployment indication, Master Caution)

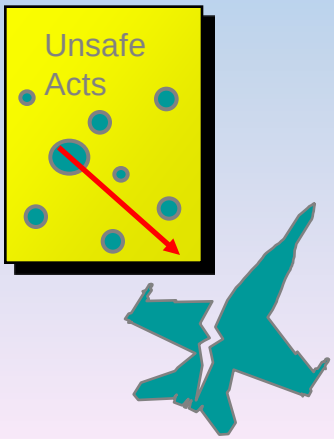
- Error in risk assessment: failure to adequately evaluate the risk even after alarms

Helios: **Misperception errors**



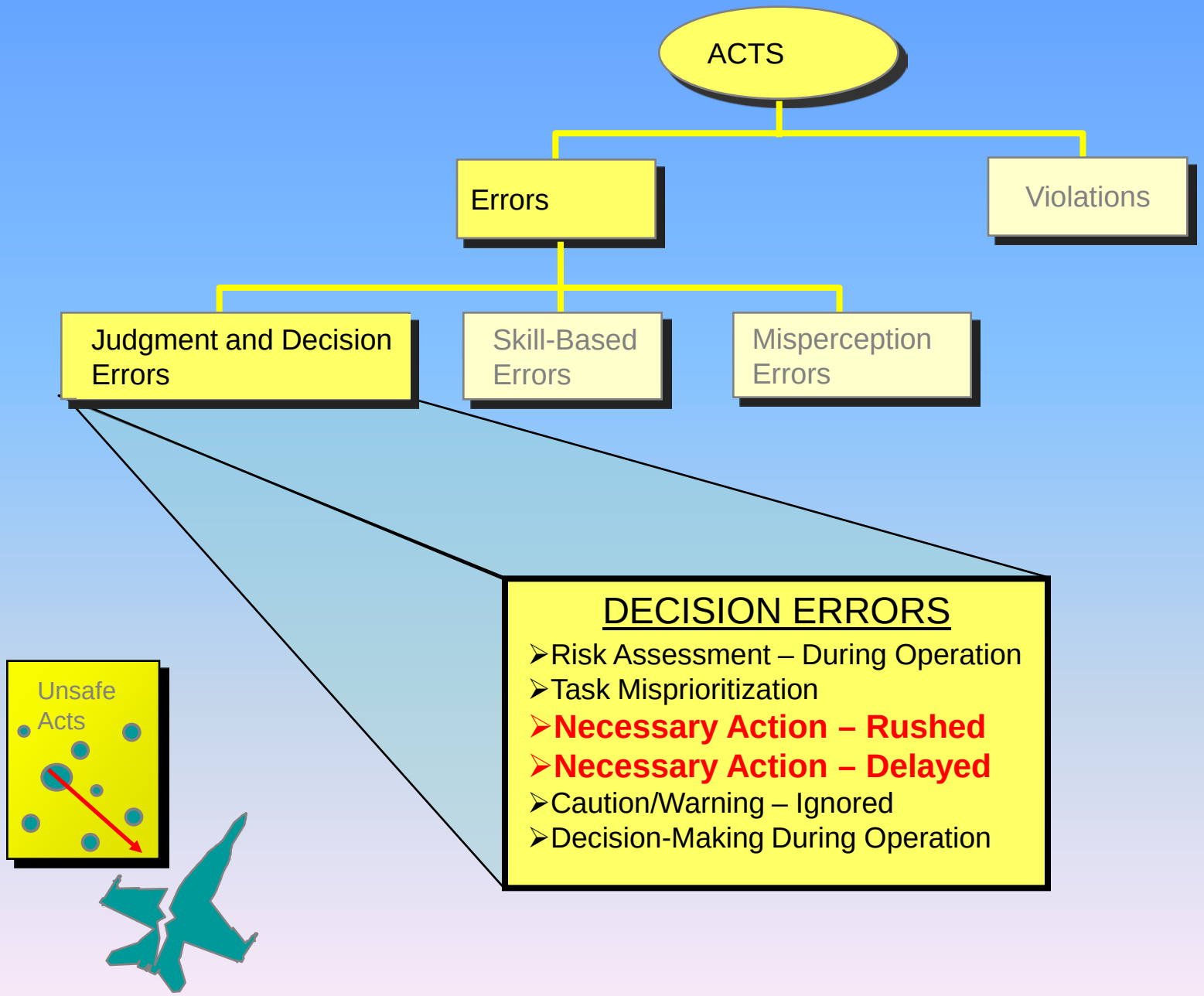
Helios: **Misperception errors**



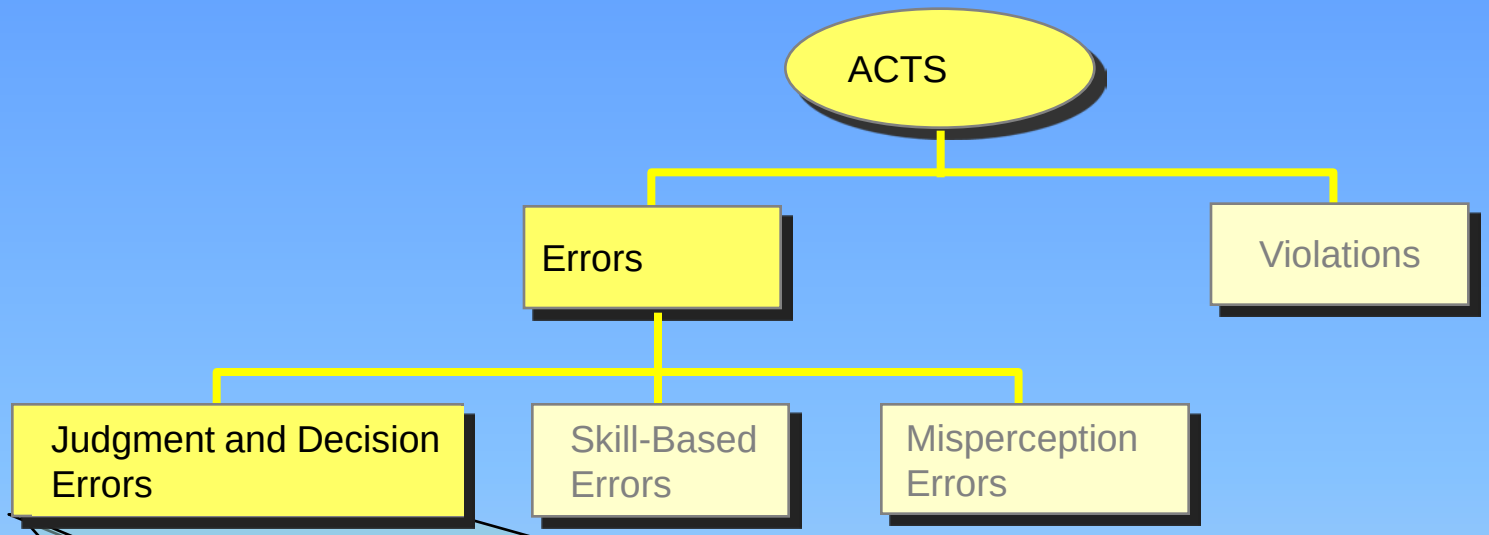


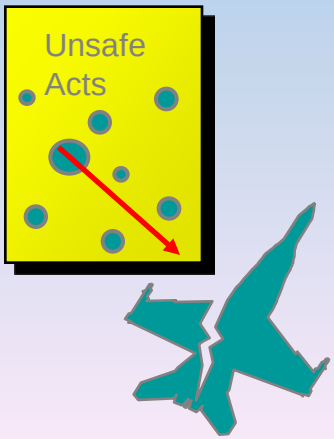
- Recommendation to FAA to differentiate the warning horn between the two systems.
- *Why two experienced pilots misperceived these cues?*

Helios: **Inappropriate action**



Helios: **Inappropriate action**



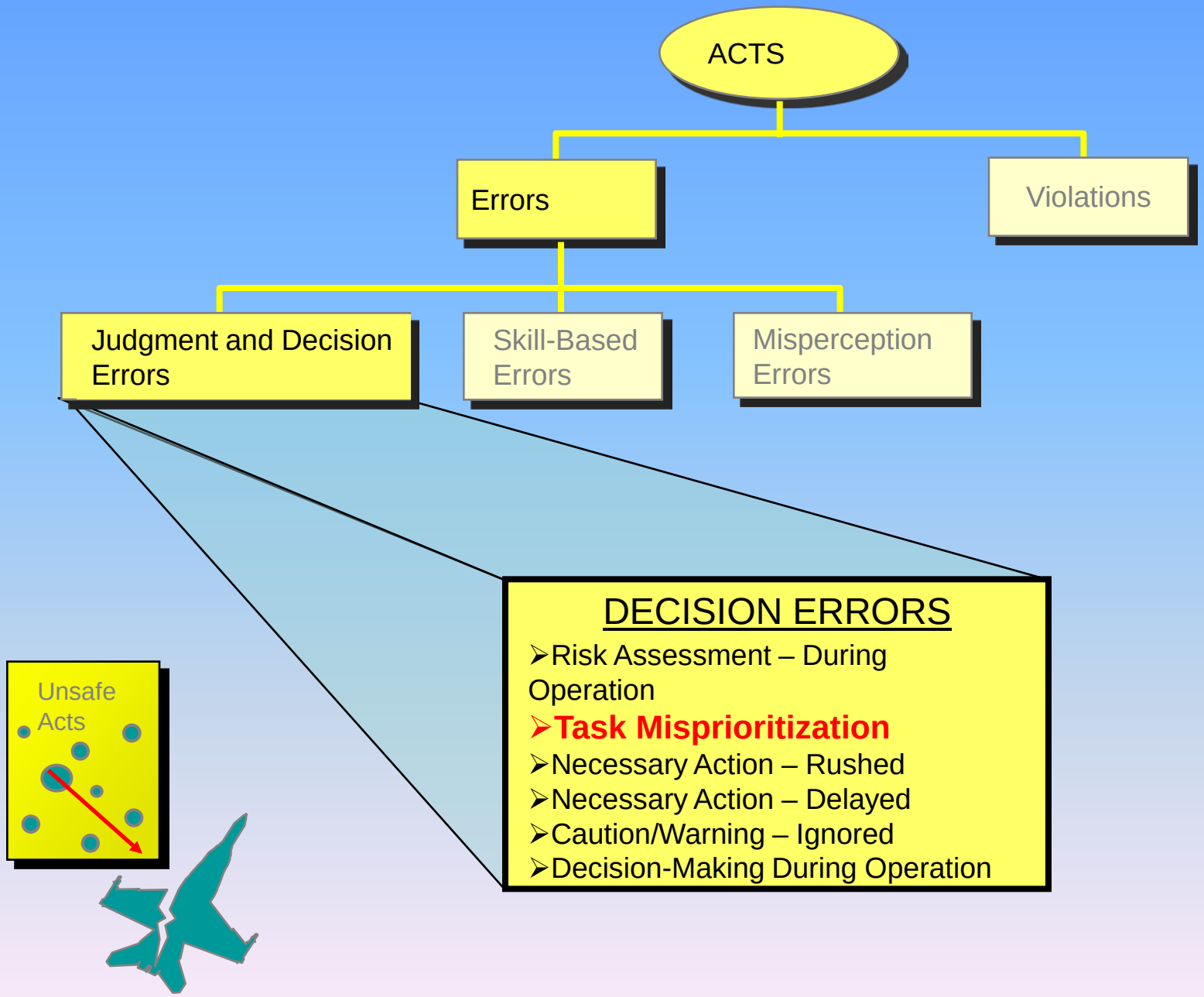


Inappropriate action:

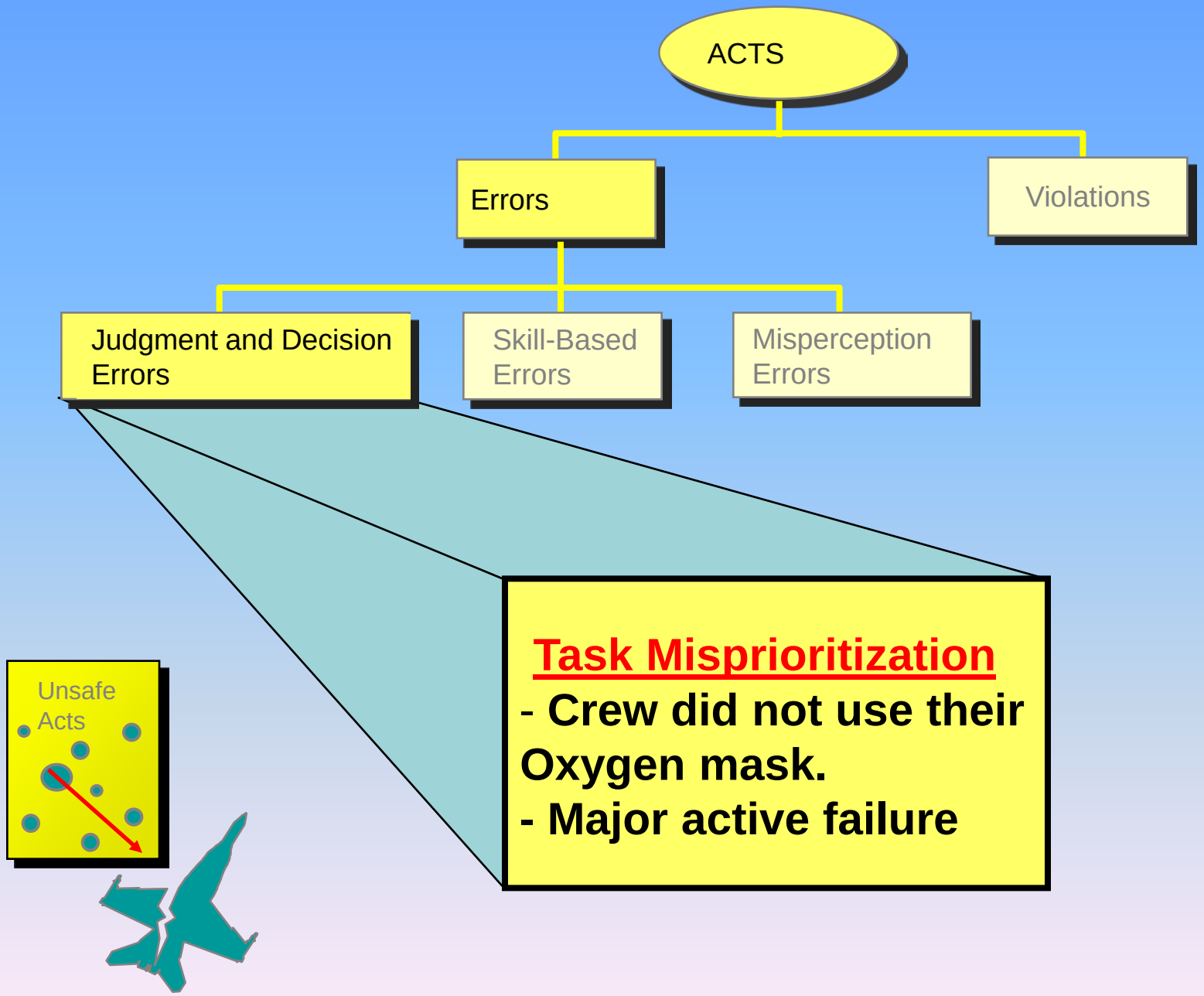
- The expected reaction to cabin altitude warning horn:
stop climb - start a descent

- Crew reacted to cabin altitude warning horn as if it had been a Takeoff Configuration Warning and **continued the climb**

Helios: **Task misprioritization**

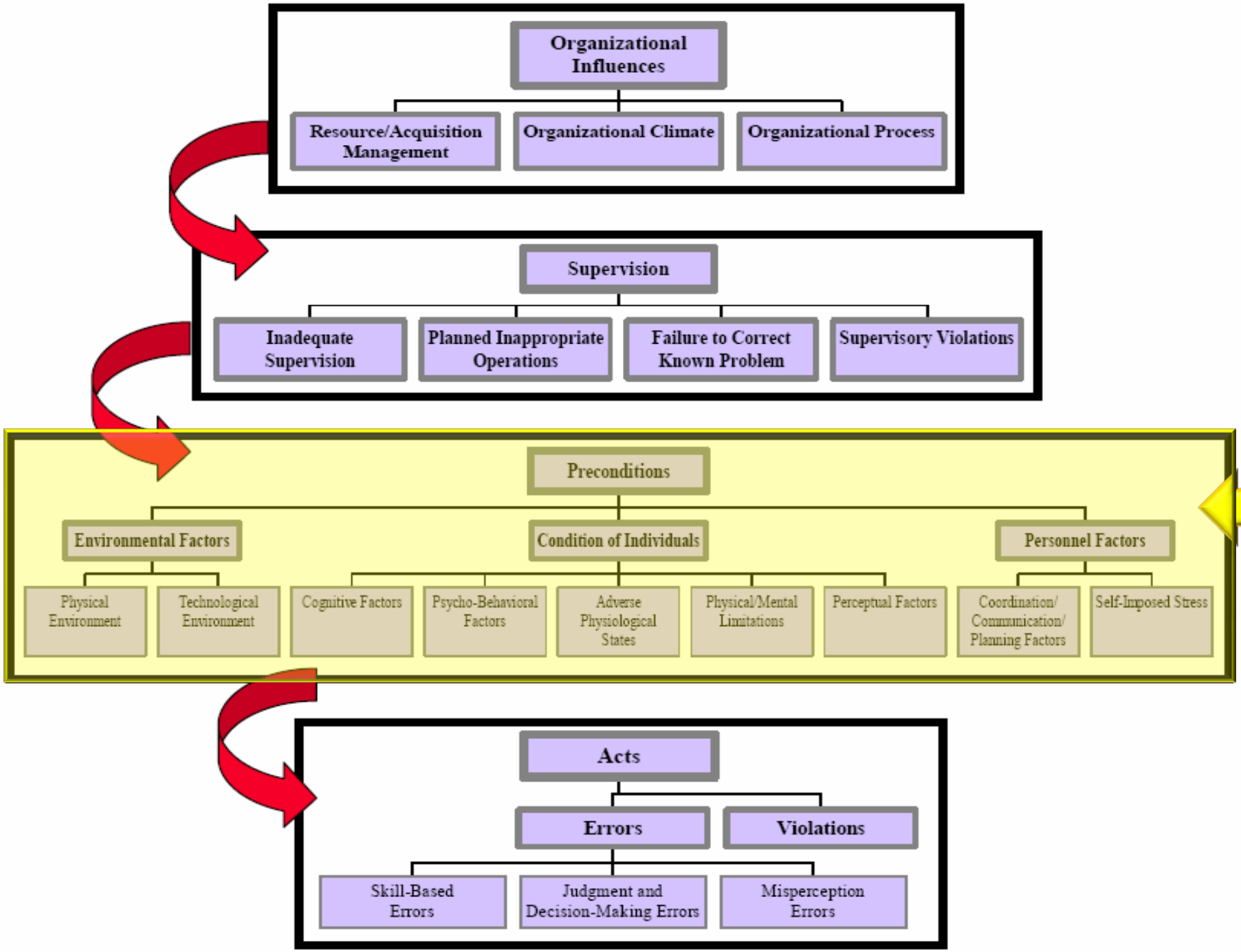


Helios: **Task misprioritization**



- Operations manual:

"The flight crew should don oxygen masks as a <u>first and immediate step</u> when the <u>cabin altitude warning horn sounds</u>. This action is necessary to prevent incapacitation of the flight crew due to lack of oxygen, which could result in loss of control of the airplane".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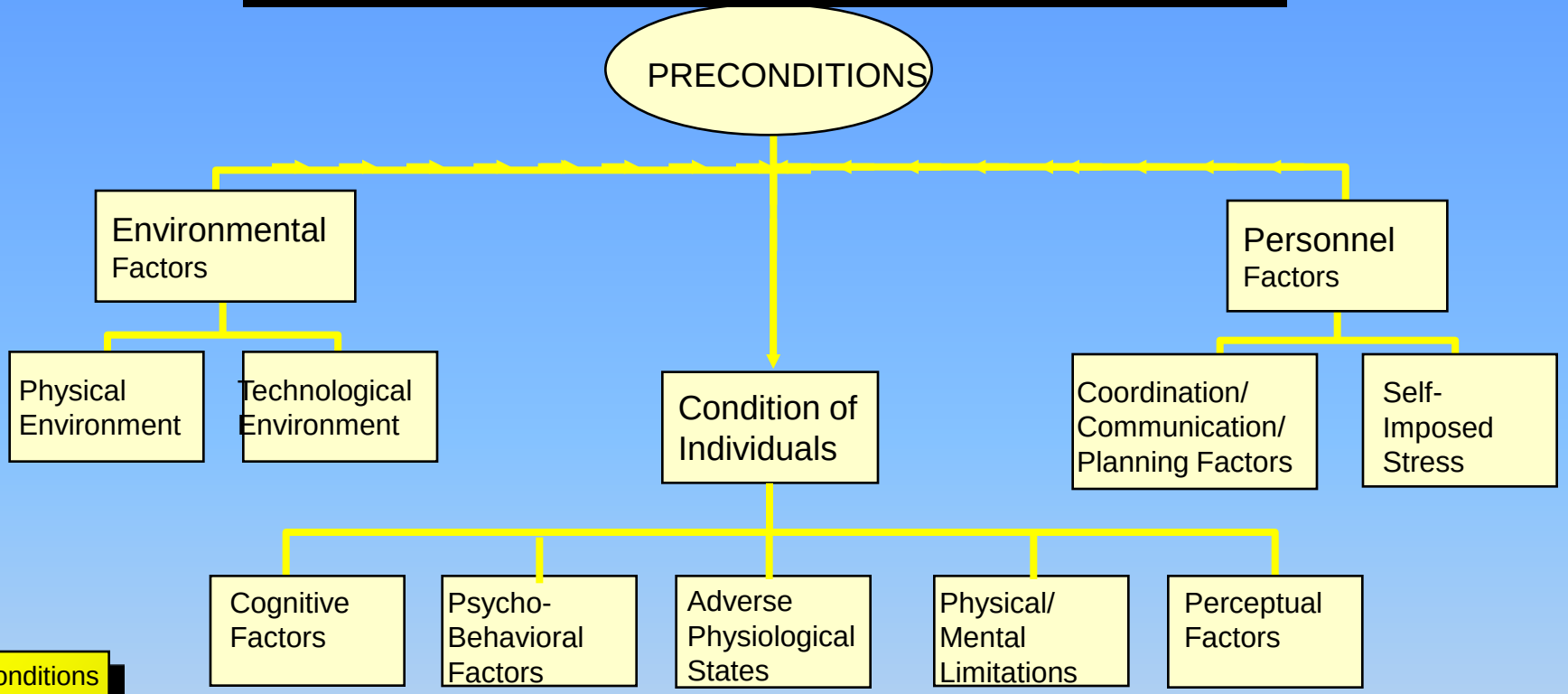
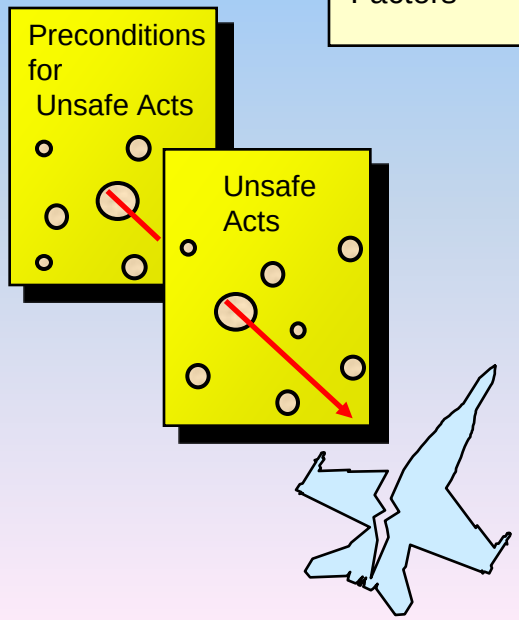
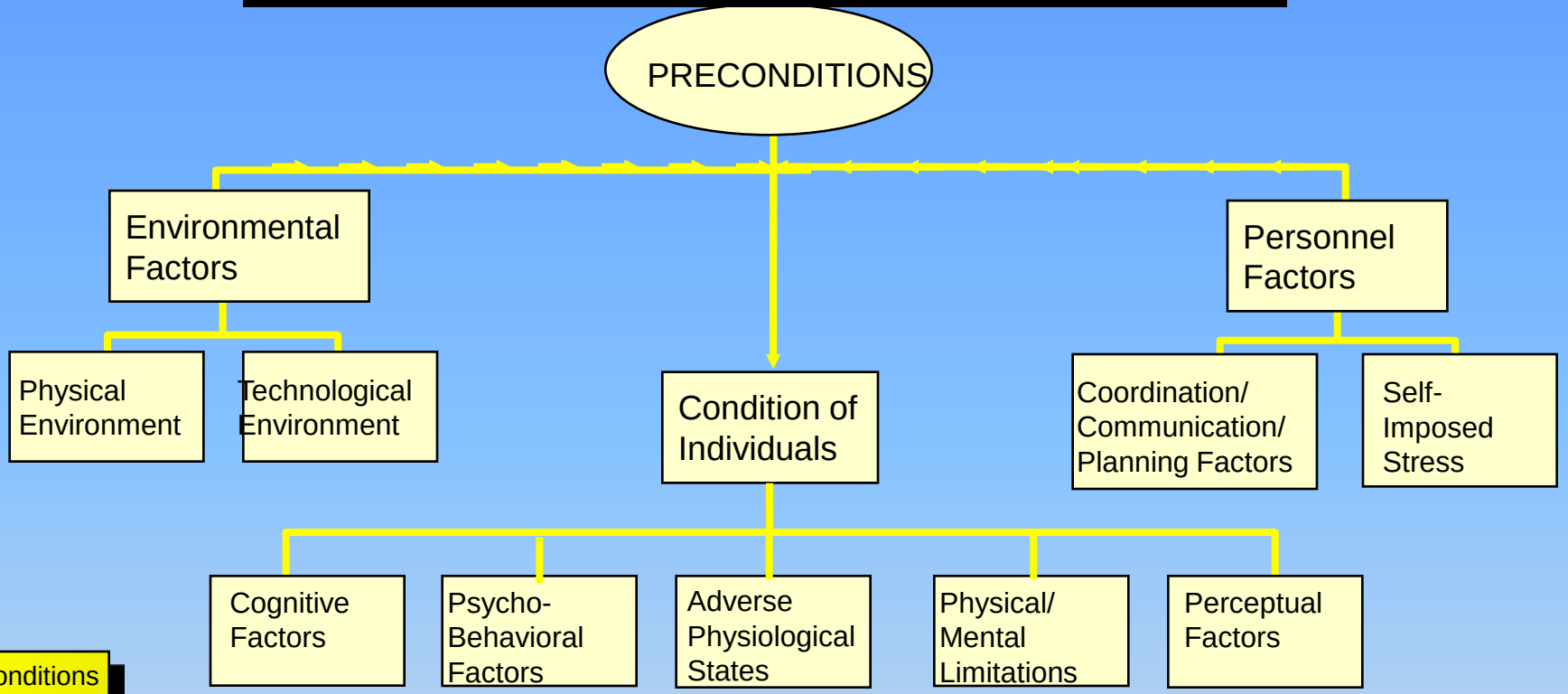
Helios: **PRECONDITIONS**

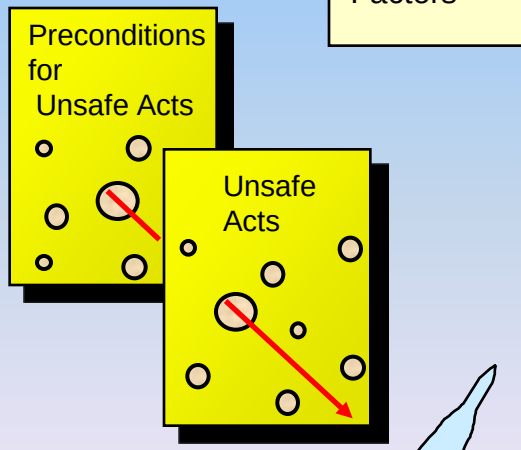




Factors in the mishap that affect practices, conditions, or actions of crew that may result in an unsafe situation.

Helios: **PRECONDITIONS**





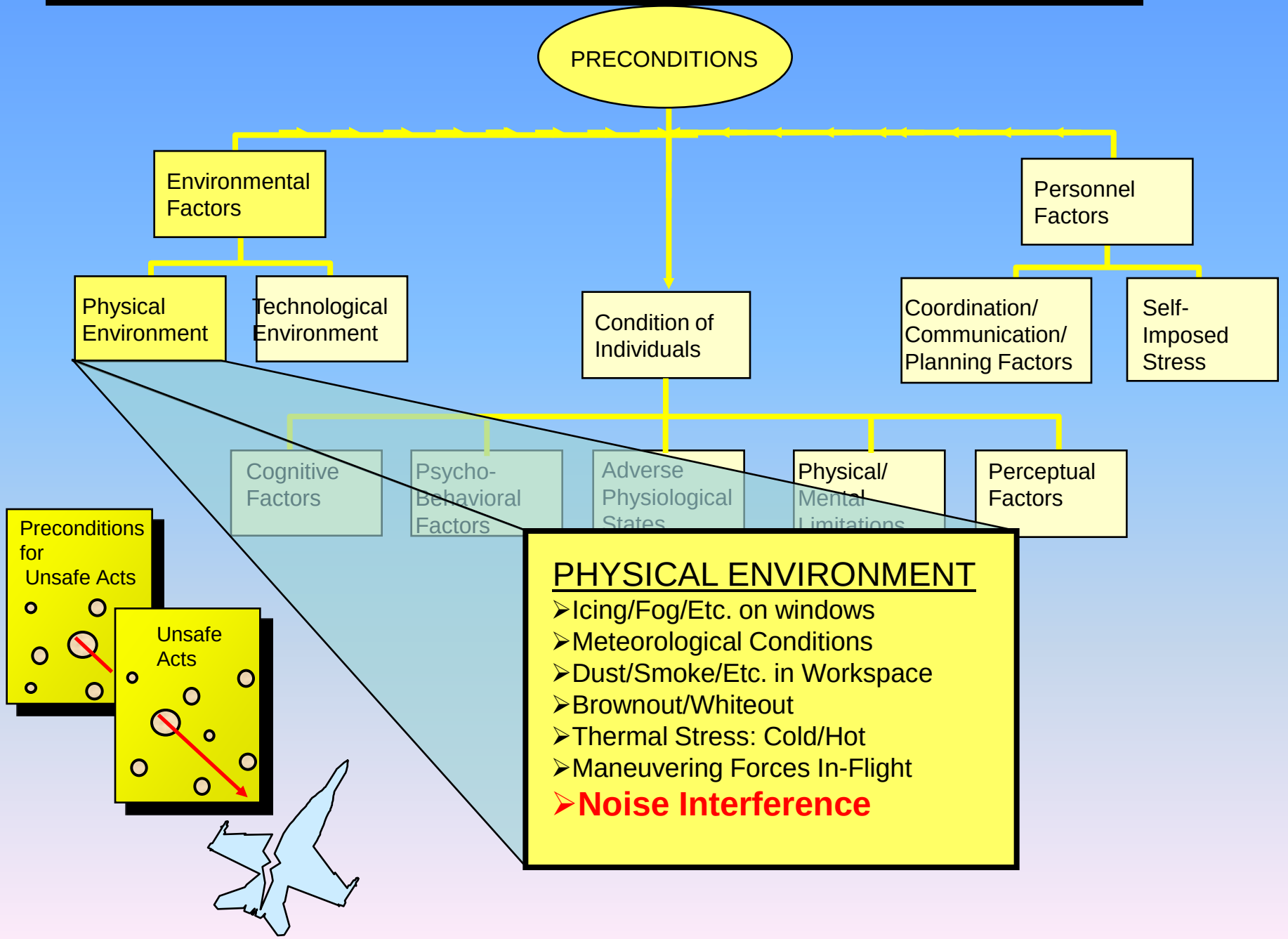
- Most complex tier

-Includes Environmental Factors, Perceptual Factors, and Conditions of the Individual.

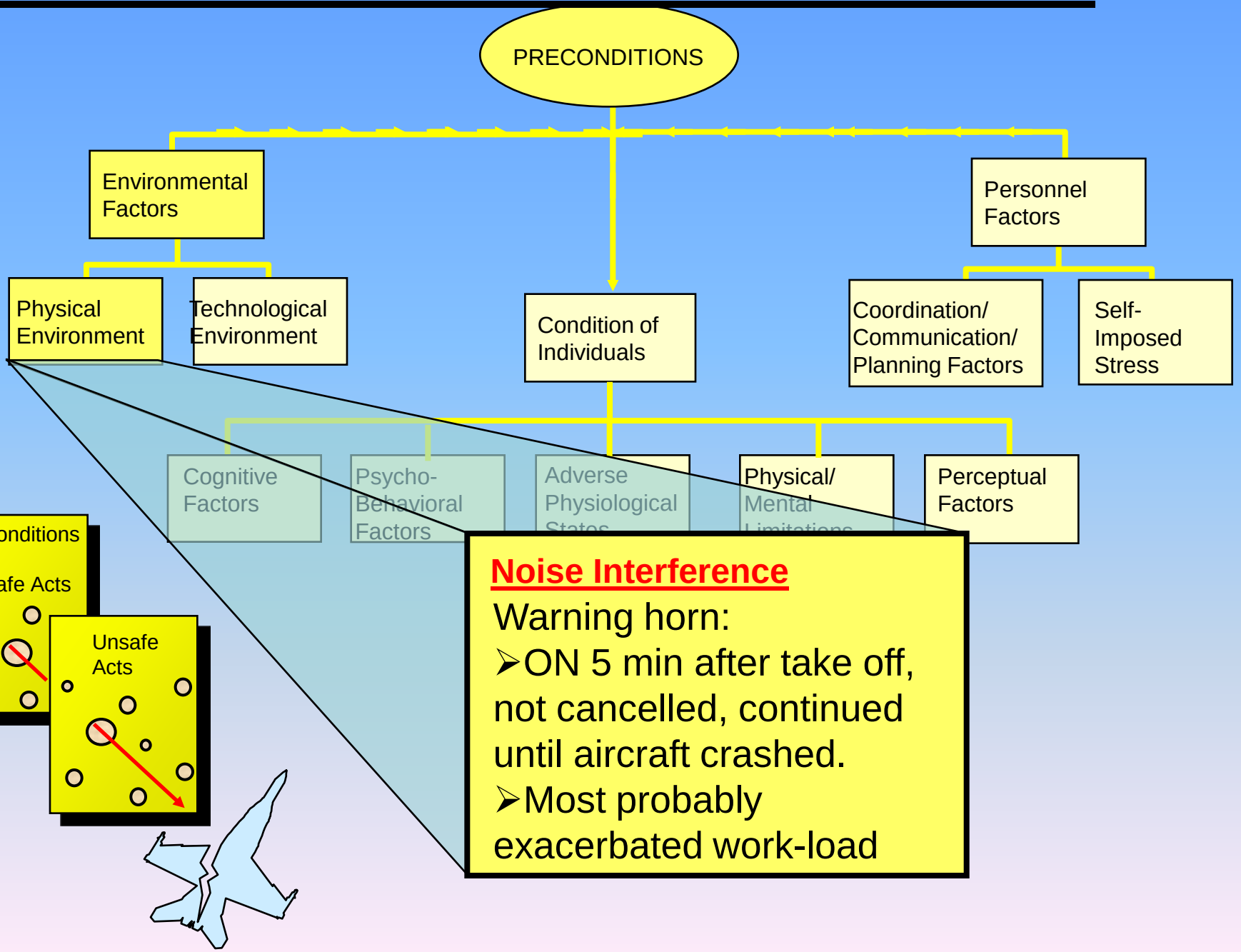
- They can be forecasted before mishap!

- Should be recognized and managed properly, otherwise they may be present in the mishap

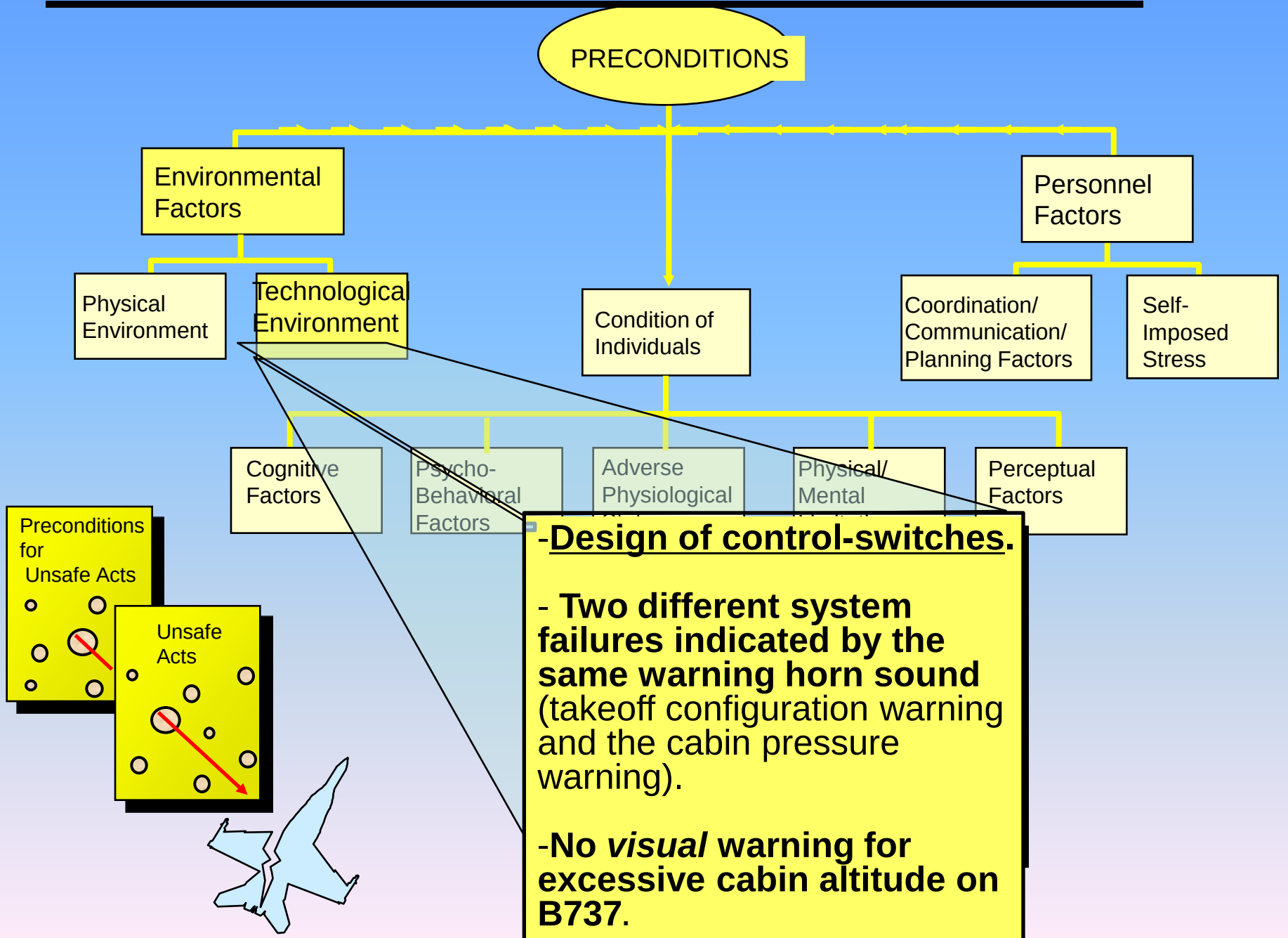
Helios: **Environmental Conditions**



Helios: **Environmental Conditions**



Helios: **Environmental Conditions**



Helios: **Environmental factors**

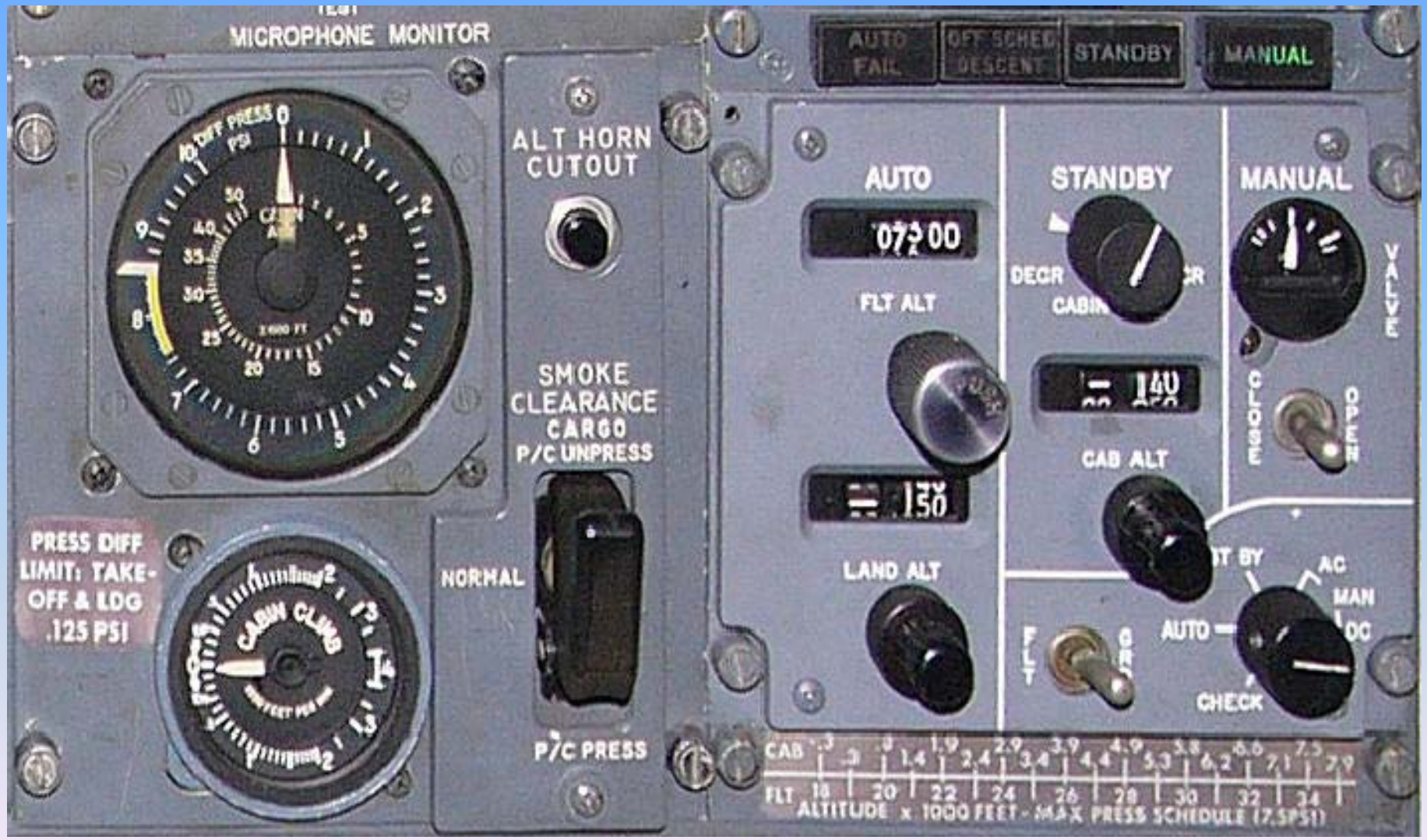
More Technological Factors B737-300 (first flight 1984):

-When Pressure system is on MAN mode, a **GREEN** light turns on.

-Green does not typically imply that something is out of the ordinary!

-**RED**? Might have attracted crew's attention?

B737-200: (first flight 1967)



Helios: Recommendations to FAA

Following the accident, new auditory and visual warnings were fitted:

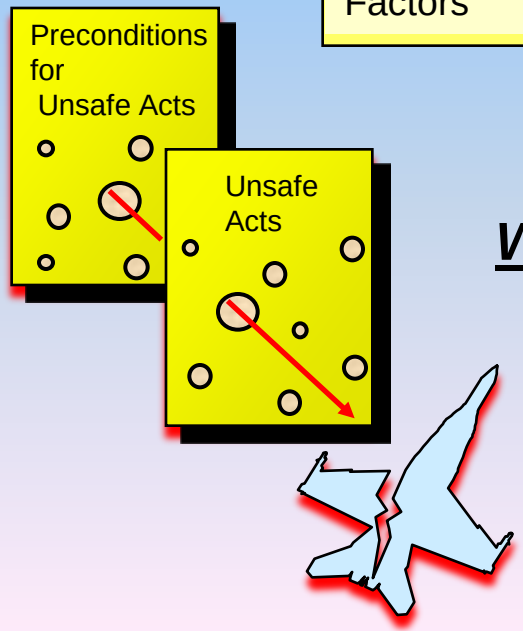
Separate Cabin altitude and Takeoff configuration warnings.

Use of RED colour!

Helios: **Conditions of Individual**

PRECONDITIONS

- Environmental Factors
  - Physical Environment
  - Technological Environment
- Condition of Individuals
  - Cognitive Factors
  - Psycho-Behavioral Factors
  - Adverse Physical State
  - Mental State
  - Perceptual Factors
- Personnel Factors
  - Coordination/ Communication/ Planning Factors
  - Self-Imposed Stress



Why did two experienced pilots make these errors?

Helios: **Conditions of Individual**

PRECONDITIONS

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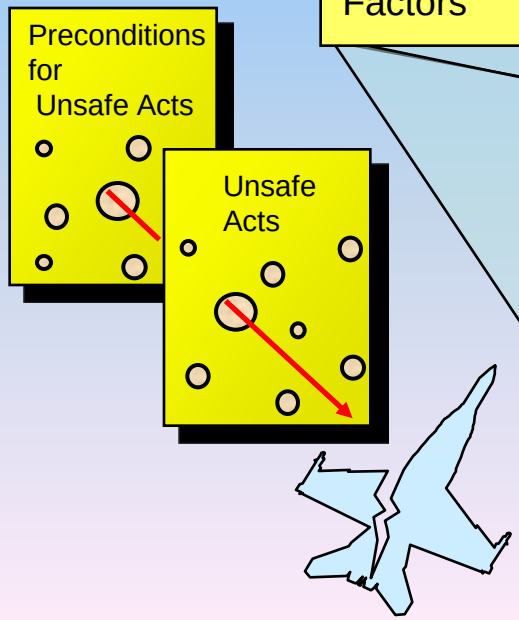


COGNITIVE FACTORS

- **Inattention**
- **Channelized Attention**
- **Cognitive Task**
- **NegativeTransfer**
- Oversaturation
- Confusion , Distraction
- Geographic Misorientation (Lost)
- Checklist Interference

Helios: **Conditions of Individual**

Why did two experienced pilots make these errors?

Inattention:

- highly repetitive tasks reduce conscious attention of the crew
- “Looking without seeing” during check list
- Automatic execution is affected by assumptions i.e. perception biased by expectation.
- This may explain why FO missed noticing that the pressure system was on the MAN instead of AUTO, because he expected it to be in the AUTO!

Helios: **Conditions of Individual**

Why did two experienced pilots make these errors?

Channelized attention:

- Occurs when all conscious attention is focused only on some cues, other cues are ignored.
- Preoccupied with one task (i.e. trouble-shooting the source of the Equipment Cooling problem), Cpt even left his seat.
- Other important visual cues excluded: Oxygen masks deployment indicator and Master Caution.

Helios: **Conditions of Individual**

Why did two experienced pilots make these errors?

Negative Transfer:

- A highly learned behavior learnt/used in previous situation, is inappropriate for the specific event.

- Automatic reaction results from experience and frequency of encounter.

- Automatic reaction may be inappropriate for a specific situation.

Helios: **Conditions of Individual**

Why did two experienced pilots make these errors?

- A pilot, during his career, is likely to only hear the warning horn when there is a takeoff configuration error, not cabin pressure problem.

- With onset of warning horn

  -> Declarative Memory (stores facts and events) and Muscle memory (skeletal muscle activity that becomes automatic with practice)

  -> automatically linked the horn to take-off configuration problem (previously encountered)

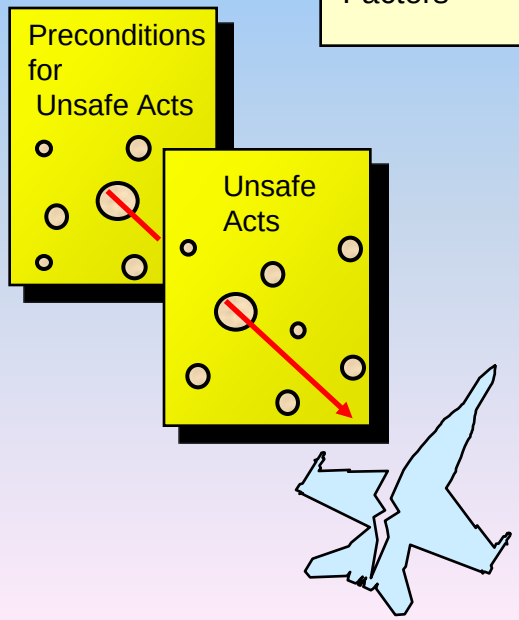
  -> automatic reaction to adjust throttles & power.....

  -> Inappropriate! .... Should have descended!

Helios: **Conditions of Individual**

PRECONDITIONS

- Environmental Factors
  - Physical Environment
  - Technological Environment
- Condition of Individuals
  - Cognitive Factors
  - Psycho-Behavioral Factors
  - Adverse Physiological States
  - Physical/ Mental Limitations
  - Perceptual Factors
- Personnel Factors
  - Coordination/ Communication/ Planning Factors
  - Self-Imposed Stress



PSYCHO-BEHAVIORAL

- Pre-Existing Personality Disorder
- Pre-Existing Psychological Disorder
- **Emotional State**
- **Personality Style**
- **Overconfidence**
- **Complacency**
- Get-Home-Itis/Get-There-Itis
- Overaggressive

Helios: **Conditions of Individual**

Psycho-behavioral factors:

- Personality style of Captain:
  Authoritarian? Typical command attitude?
  Different cultural backgrounds?
  East German Vs Cyprus

- Personality style of FO:
  Training reports showed tendency to over-react / lose confidence in difficult situations

  "*Standards achieved, but with room for lots of improvement. Some difficulties met in complex tasks. Do not rush through check lists.*"

Helios: **Conditions of Individual**

Psycho-behavioral factors:

- Emotional state of FO

Happy personal life, but unhappy with Helios, looking for a new job.

- Complacency of FO?:

Overconfidence, undermotivation, sense that “others have the situation under control”.

FO performed no action, not even to silence the warning horn, while cpt was communicating with the ground engineer just after the warning horn sounded.

Helios: **Conditions of Individual**

PRECONDITIONS

- Environmental Factors
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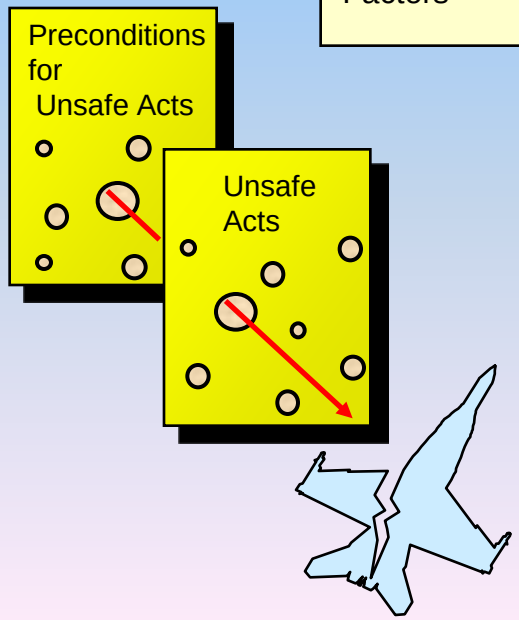


ADVERSE PHYSIOLOGICAL

- Effects of G Forces (G-LOC, etc)
- Physical Fatigue (Overexertion)
- Fatigue – Physiological/Mental
- **Hypoxia**
- Motion Sickness
- Circadian Rhythm Desynchrony
- **Pre-Existing Physical State**
- Prescribed Drugs

Helios: **Conditions of Individual**

Adverse physiological state **:**

Pre-existing physical illness:

- Post-mortem exam of FO's heart, revealed extensive atherosclerosis (90% occlusion in LAD and Cx).

- This may have attributed to the possibly earlier symptoms of Hypoxia.

Helios: **Conditions of Individual**

***Adverse physiological state* :**

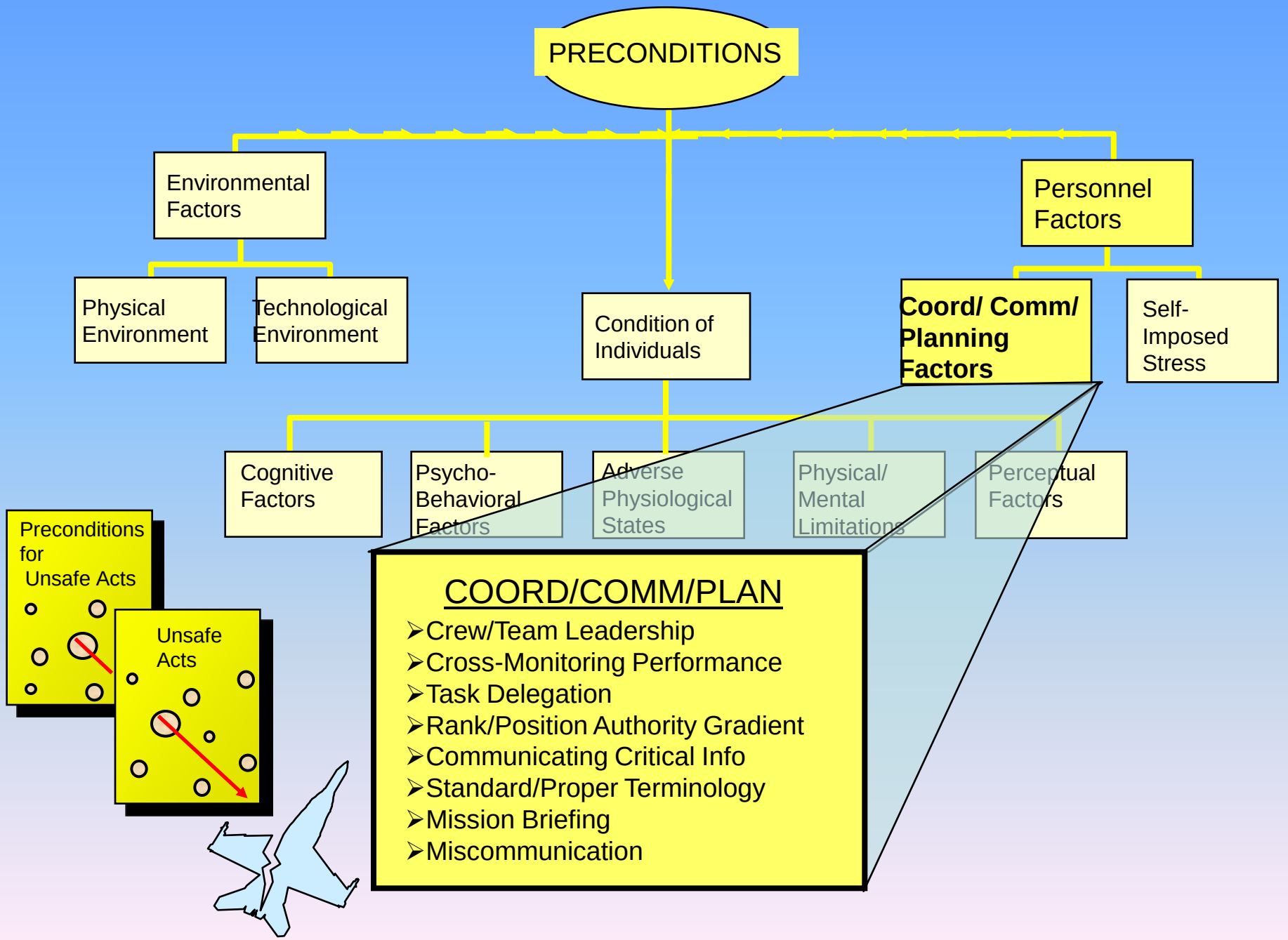
Incapacitation of crew due to Hypoxia:

One of the direct causes of the accident.

The combination of hypoxia and distractions generally increases stress levels.

Stress is known to decrease human cognitive function (memory, attention, decision-making, risk management, communication skills) particularly vulnerable to errors.

	ALTITUDE FT	
Indifferent	0-10000	Minimal impairment, decreased visual dark adaptation
Compensatory	10000-15000	Body tries to compensate for hypoxia with Increased pulse and respiratory rate: - Fatigue, irritability, headache, - Decreased judgment - Difficulty with calculations
Disturbance	15000-20000 Within the first 15 min of the flight	Body can not compensate for hypoxia: -Senses: impaired vision (acuity and accommodation), touch and pain sense is lost, hearing is lost last -Mental: slow thinking, poor judgement, can not recognise emergency situations -Euphoria, overconfidence, behaviour similar to alcohol intoxication - Physical movements impaired
Critical	20000-23000 20 min after take off for 1.5 hours	Complete mental and physical incapacitation Loss of consciousness, convulsions, failure of respiration, death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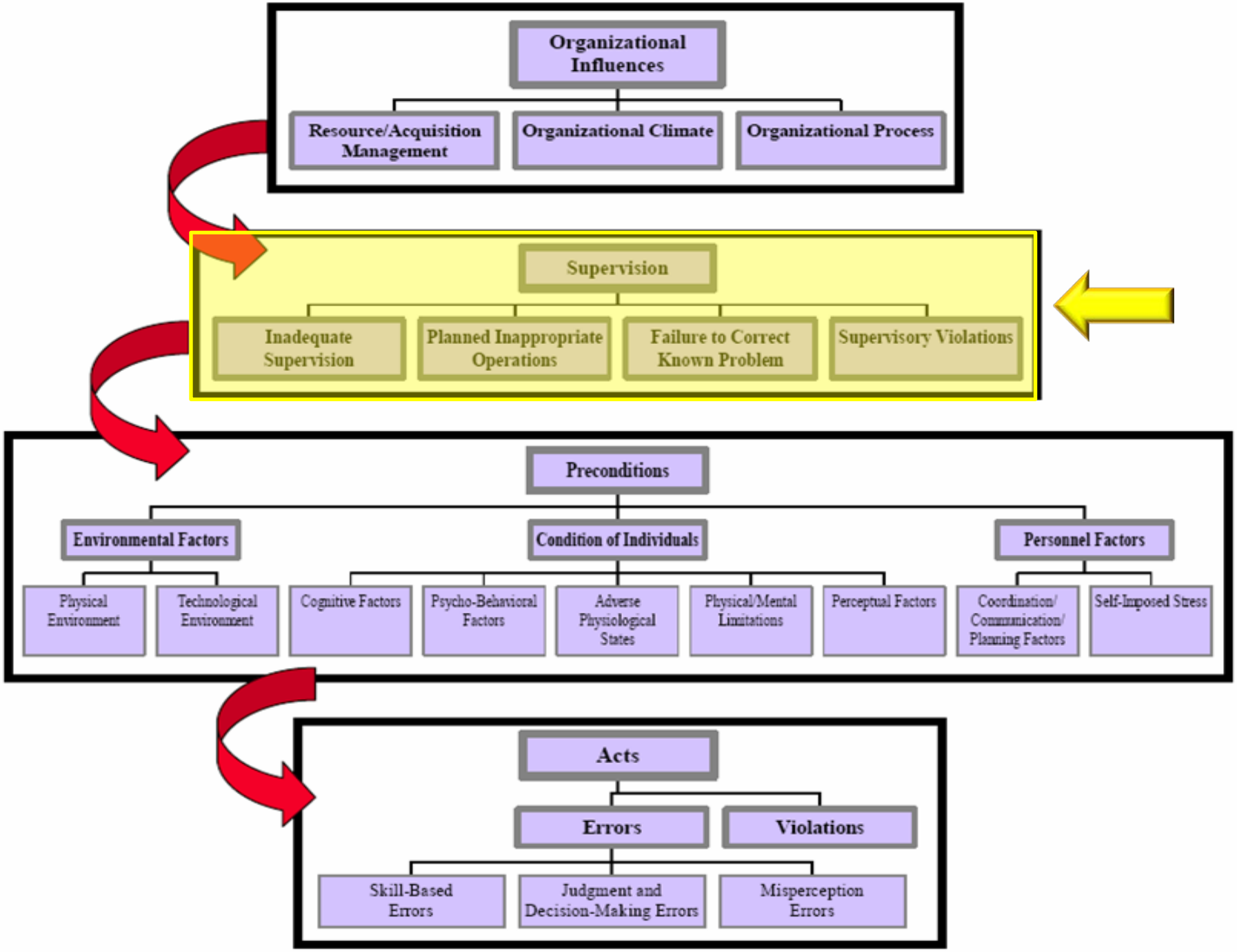
Technological Environment
Condition of Individuals
Coord/ Comm/ Planning Factors
Self-Imposed Stress
Cognitive Factors
Psycho-Behavioral Factors
Adverse Physiological States
Physical/ Mental Limitations
Perceptual Factors
Preconditions for Unsafe Acts
Unsafe Acts
COORD/COMM/PLAN
Crew/Team Leadership
Cross-Monitoring Performance
Task Delegation
Rank/Position Authority Gradient
Communicating Critical Info
Standard/Proper Terminology
Mission Briefing
Miscommunication

Helios: **Personnel Factors**

Communication between Cpt and Engineer:

- Communication difficulties?
- Helios dispatcher suggested that the FO speaks with a second engineer in Greek.
- English as a second language in stress situation, may require words that are not part of the “normal” vocabulary
- Memory suffers during stress, the search and choice of words to express one’s concern in a non-native language can be compromised.


Organizational Influences
Resource/Acquisition Management
Organizational Climate
Organizational Process
Supervision
Inadequate Supervision
Planned Inappropriate Operations
Failure to Correct Known Problem
Supervisory Violations
Preconditions
Environmental Factors
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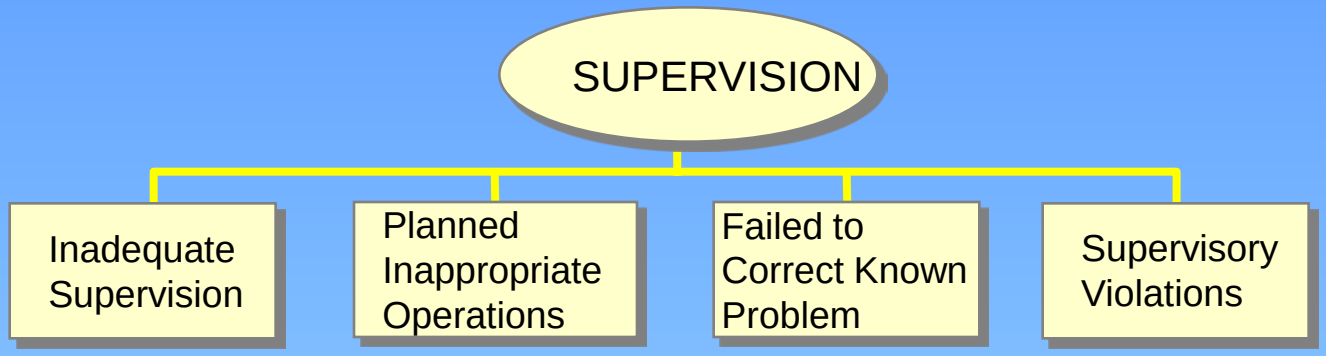
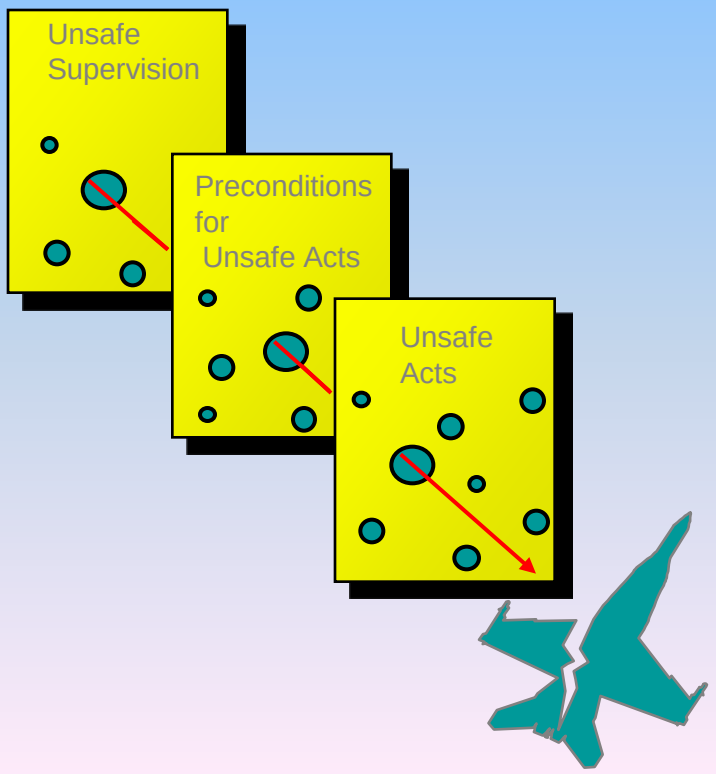
Self-Imposed Stress
Acts
Errors
Violations
Skill-Based Errors
Judgment and Decision-Making Errors
Misperception Errors

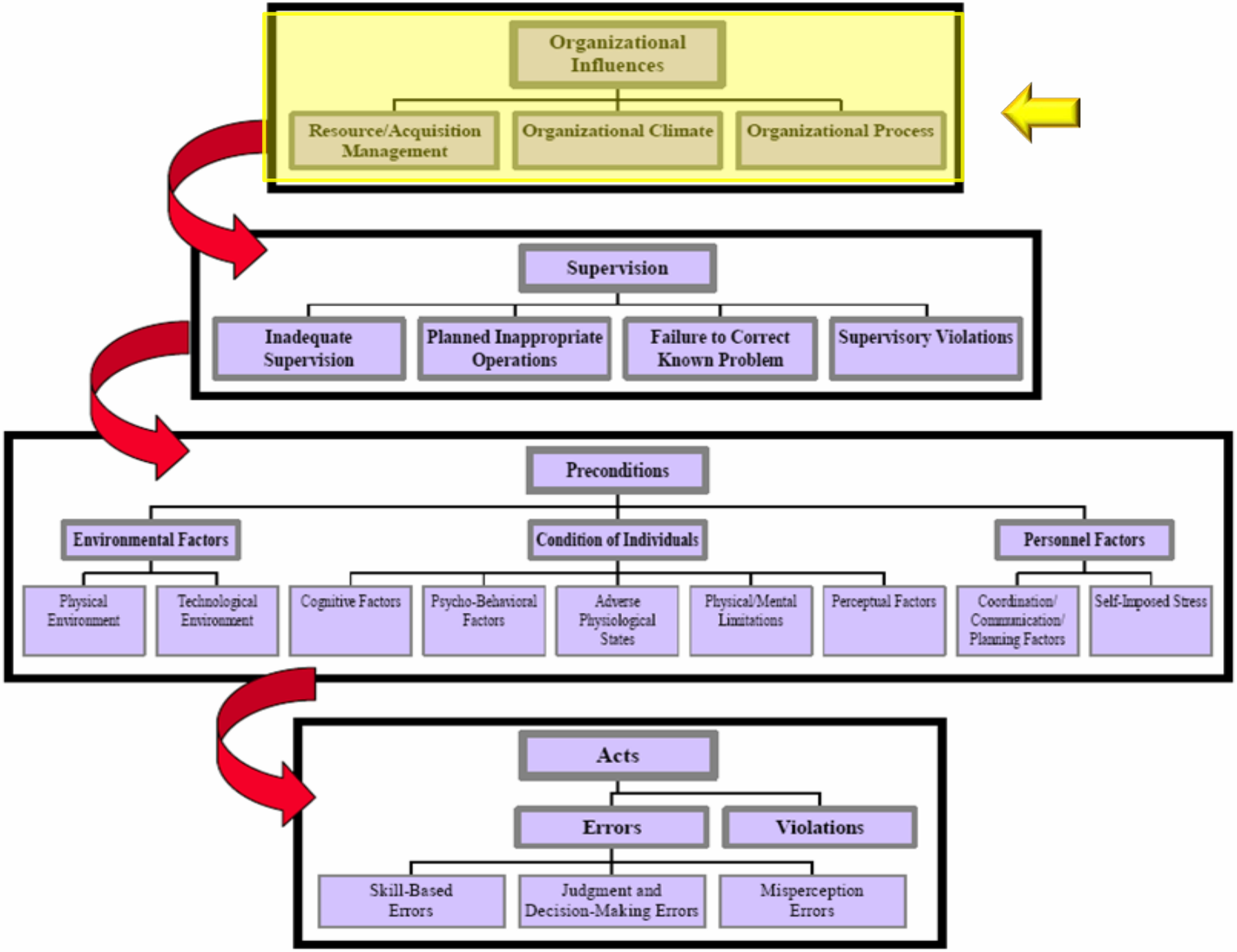




- Third tier - Latent conditions
- Include: Decisions or policies of the supervisory chain of command
- E.g. Inadequate supervision, training issues, failure to correct known problems etc

Helios: **SUPERVISION**

- Helios Crew Training approved by Cy DCA, carried out in accordance with the manual.
- Flight Crew Training included simulator training in Rapid Decompression, not in Gradual Decompression…flight crew not trained to monitor and detect this less-obvious situation
- Cabin Crew undertrained for the procedures after Oxygen Mask deployment, esp. when no descent.
- Lack of adequate training in hypoxia. Global problem!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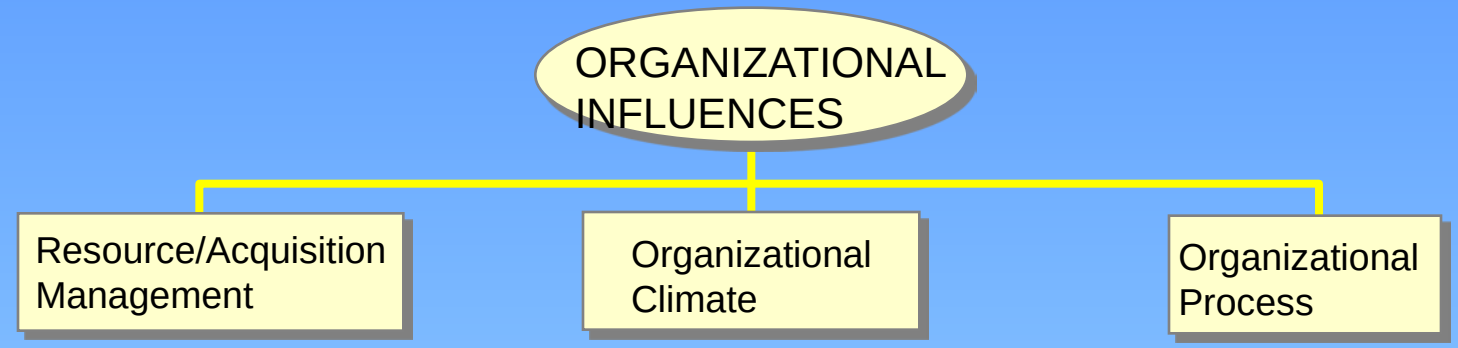
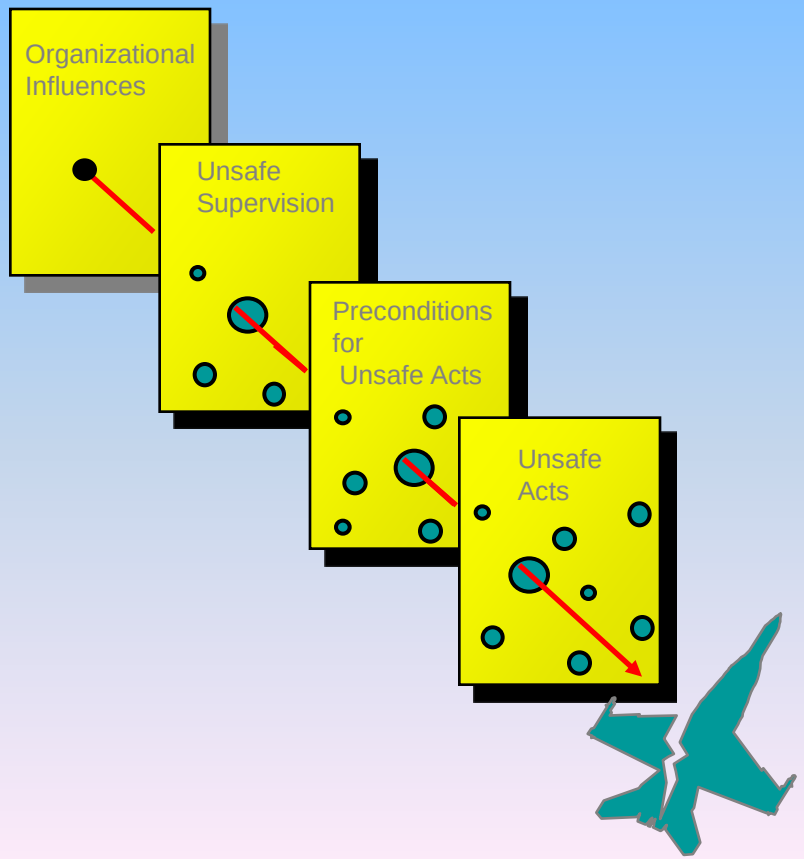




- Fourth tier - Latent conditions
- Include: Resource management, organization climate, organization failures in all levels of the chain of command.

Helios: **ORGANISATIONAL INFLUENCES**

Helios company:

- High turn-over of ground engineers 3 days – 21 months
- Understaffed Engineering Dept
- 33% seasonal/part-time employees -> reluctant to report or solve problems
- UK CAA: level 1 & 2 findings, flight safety compromised due to "***the lack of operational management control***".
- Incomplete Management structure – vacant Training Standards Manager position
- ***"Not healthy"*** organization climate
- ***"Unapproachable management, profitability being the only interest"***

Helios: **ORGANISATIONAL INFLUENCES**

Dept Civil Aviation

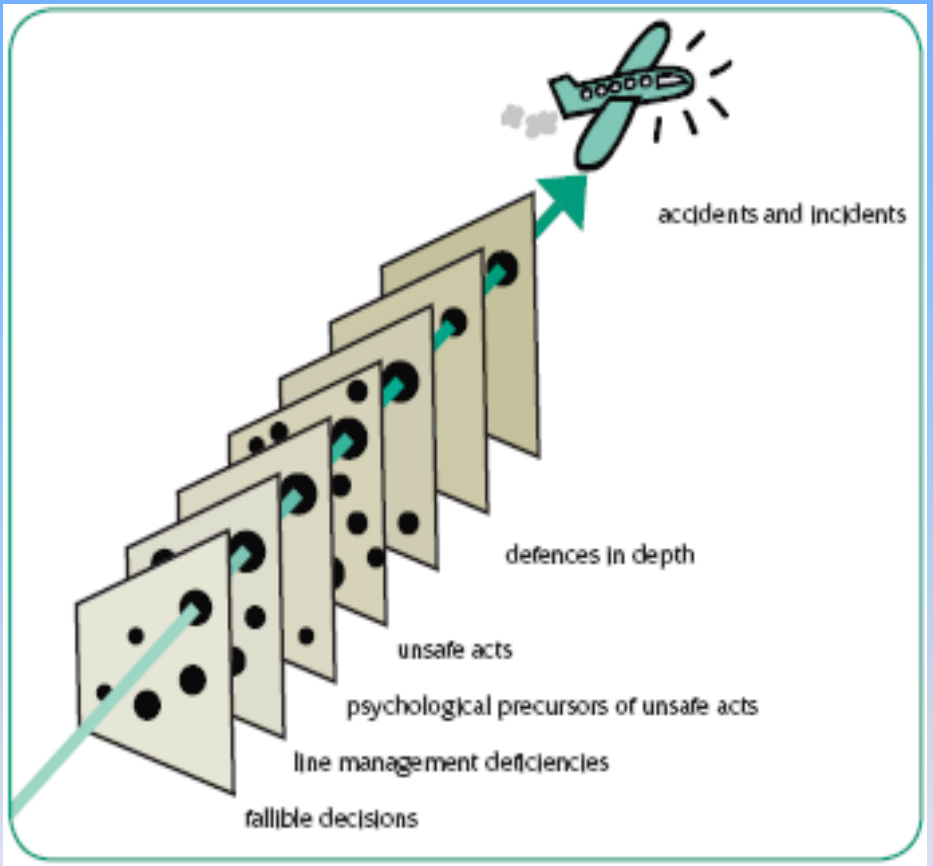
- Safety and Regulations Unit of Cy DCA diachronically not organized & understaffed.
- Operates as a functional dept of MoC and not as an independent authority.

Boeing

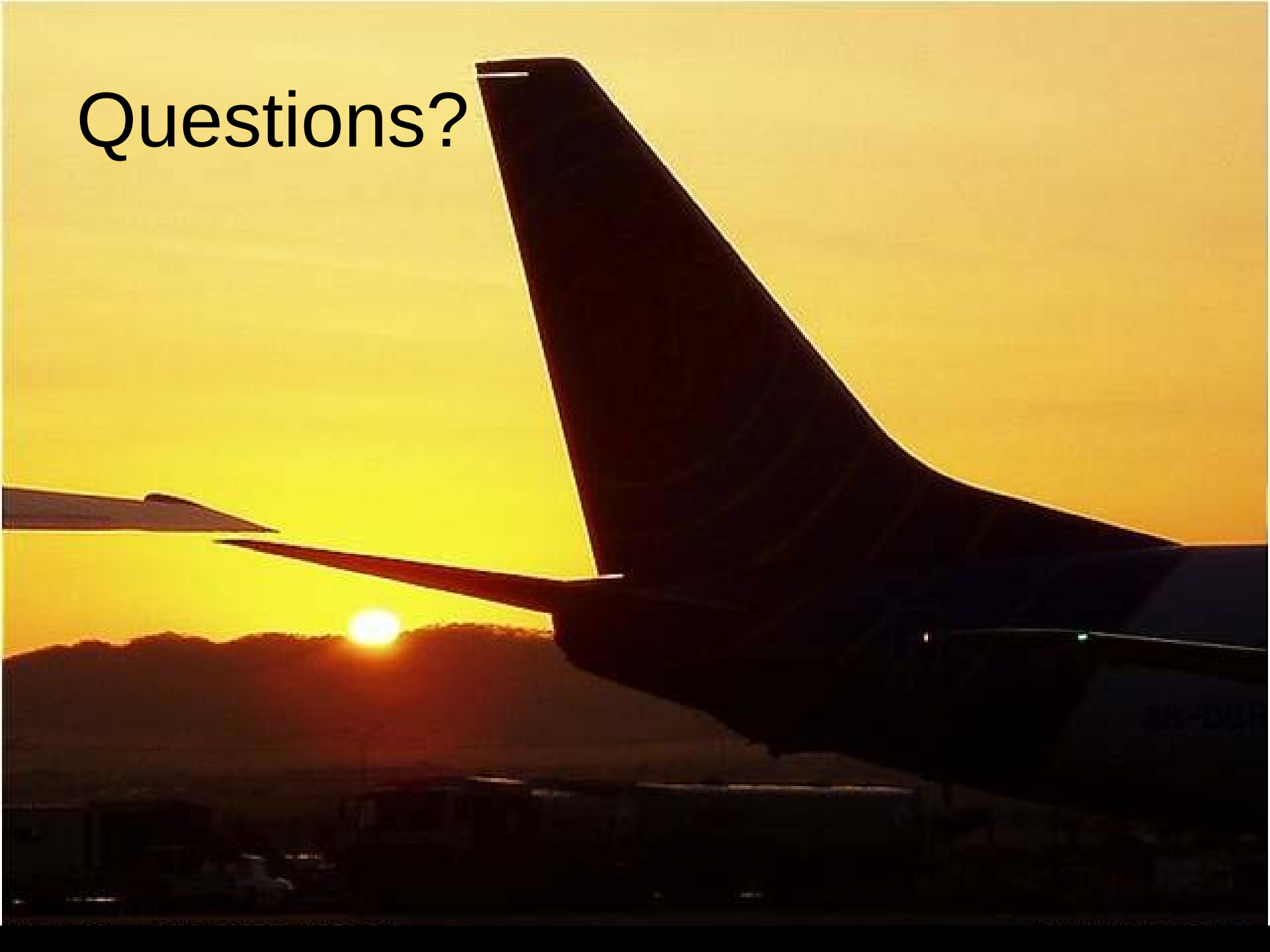
- No measures taken by Boeing on response to previous pressurization incidents on B737.

HFACS

- Good guide when investigating human factors
- Good tool to identify system failures/hazards or “holes” in system
- Develop a risk minimization strategy to identify and correct the “holes” before the mishap occurs.



Thank You for your attention


Questions?