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

DCPCS: Digital cabin pressure control system

AUTO / ALTN / MAN
• 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
12000 ft (Cabin altitude 10000 ft):
- Warning horn sounded
Same for two systems: Cabin pressurisation problem and takeoff configuration error
Action of cpt: adjusted throttle as if it were a takeoff conf error.
Continued climb
18000 ft (Cabin altitude 14000 ft):
- Oxygen masks deployed
- Master Caution
Due to oxygen masks or due to equipment cooling problem.

(Visual warnings)
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!
Levelled off at FL340 (cabin altitude 24000ft).

- No response to calls from Nicosia ACC
- Entered ATH FIR without calling
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**
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
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
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
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
Misperceived the cabin pressurization warning horn as if it had been a Takeoff Configuration warning (the two failures use the same warning horn sound), despite other cues (cabin oxygen mask deployment).
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

- **ACTS**
  - Errors
  - Violations
  - Judgment and Decision Errors
    - Skill-Based Errors
    - Misperception Errors
  - DECISION ERRORS
    - Risk Assessment – During Operation
    - Task Misprioritization
    - Necessary Action – Rushed
    - Necessary Action – Delayed
    - Caution/Warning – Ignored
    - Decision-Making During Operation

Unsafe Acts
Helios: 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
DECISION ERRORS
- Risk Assessment – During Operation
- **Task Misprioritization**
- Necessary Action – Rushed
- Necessary Action – Delayed
- Caution/Warning – Ignored
- Decision-Making During Operation
Helios: **Task misprioritization**

- Crew did not use their Oxygen mask.
- Major active failure

**Task Misprioritization**

**ACTS**

- Errors
  - Judgment and Decision Errors
  - Skill-Based Errors
  - Misperception Errors
- Violations

**Unsafe Acts**
“The flight crew should don oxygen masks as a first and immediate step when the cabin altitude warning horn sounds. 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”.
Factors in the mishap that affect practices, conditions, or actions of crew that may result in an unsafe situation.
Preconditions for Unsafe Acts

Unsafe Acts

- 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

PRECONDITIONS

Environmental Factors

Physical Environment

Technological Environment

Condition of Individuals

Cognitive Factors

Psycho-Beahvioral Factors

Adverse Physiological States

Physical/Mental Limitations

Perceptual Factors

Personnel Factors

Coordination/Communication/Planning Factors

Self-Imposed Stress

Preconditions for Unsafe Acts

Unsafe Acts

PHYSICAL ENVIRONMENT

- Icing/Fog/Etc. on windows
- Meteorological Conditions
- Dust/Smoke/Etc. in Workspace
- Brownout/Whiteout
- Thermal Stress: Cold/Hot
- Maneuvering Forces In-Flight
- **Noise Interference**
Helios: Environmental Conditions

Preconditions for Unsafe Acts

Unsafe Acts

Warning horn:
- ON 5 min after take off, not cancelled, continued until aircraft crashed.
- Most probably exacerbated work-load
Helios: Environmental Conditions

PRECONDITIONS

Environmental Factors
- Physical Environment

Technological Environment
- Design of control-switches.
  - Two different system failures indicated by the same warning horn sound (takeoff configuration warning and the cabin pressure warning).
  - No visual warning for excessive cabin altitude on B737.

Personnel Factors
- Coordination/Communication/Planning Factors
- Self-Imposed Stress

Condition of Individuals
- Adverse Physiological
- Physical/Mental

Cognitive Factors
- Psycho-Behavioral Factors

Self-Imposed Stress

Preconditions for Unsafe Acts

Unsafe Acts
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!
Preconditions for Unsafe Acts

Unsafe Acts

Why did two experienced pilots make these errors?
Helios: Conditions of Individual

COGNITIVE FACTORS
- Inattention
- Channelized Attention
- Cognitive Task
- Negative Transfer
- Oversaturation
- Confusion, Distraction
- Geographic Misorientation (Lost)
- Checklist Interference

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
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.
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.
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

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

Preconditions for Unsafe Acts

Unsafe Acts

PSYCHO-BEHAVIORAL

- Physical Environment
- Technological Environment

Condition of Individuals

- Cognitive Factors
- Psycho-Behavioral Factors
- Adverse Physiological States
- Physical/Mental Limitations
- Self-Imposed Stress

Personnel Factors

Coordination/Communication/Planning Factors

Self-Imposed Stress
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.
Conditional for Unsafe Acts

Unsafe Acts

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
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.
<table>
<thead>
<tr>
<th>ALTITUDE FT</th>
<th>MINIMAL IMPAIRMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indifferent 0-10000</td>
<td>Minimal impairment, decreased visual dark adaptation</td>
</tr>
</tbody>
</table>
| 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 | 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 | Complete mental and physical incapacitation  
Loss of consciousness, convulsions, failure of respiration, death |
Preconditions for Unsafe Acts

Preconditions for Unsafe Acts

Unsafe Acts

PRECONDITIONS

Environmental Factors
- Physical Environment
- Technological Environment

Cognitive Factors

Psycho-Behavioral Factors

Adverse Physiological States

Physical/Mental Limitations

Perceptual Factors

Condition of Individuals

Coord/Comm/Plan Factors

Crew/Team Leadership
- Cross-Monitoring Performance
- Task Delegation
- Rank/Position Authority Gradient
- Communicating Critical Info
- Standard/Proper Terminology
- Mission Briefing
- Miscommunication

Personnel Factors

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

Acts

- Errors
  - Skill-Based Errors
  - Judgment and Decision-Making Errors
- Violations
  - Misperception Errors
• 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?