Threat & Error Management (TEM)
SafeSkies Presentation

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safe skies for all

Objectives

- Definition
- Discuss Brief history of TEM
- The Original University of Texas TEM Model
- Threats & threat management
- Errors & error management
- Uses of TEM model
- Limitations of TEM model – for GA training context
- Underlying principles of TEM model
- TEM process behaviours
- TEM training principles

References

- ICAO
- CAAP 5.59-1(0)
- Patrick Murray, Griffith University, conversation
- FAA AC 120-90 LOSA
- Australian Transport Safety Bureau Research Report 2004/0050: Error Management Training, 2004.
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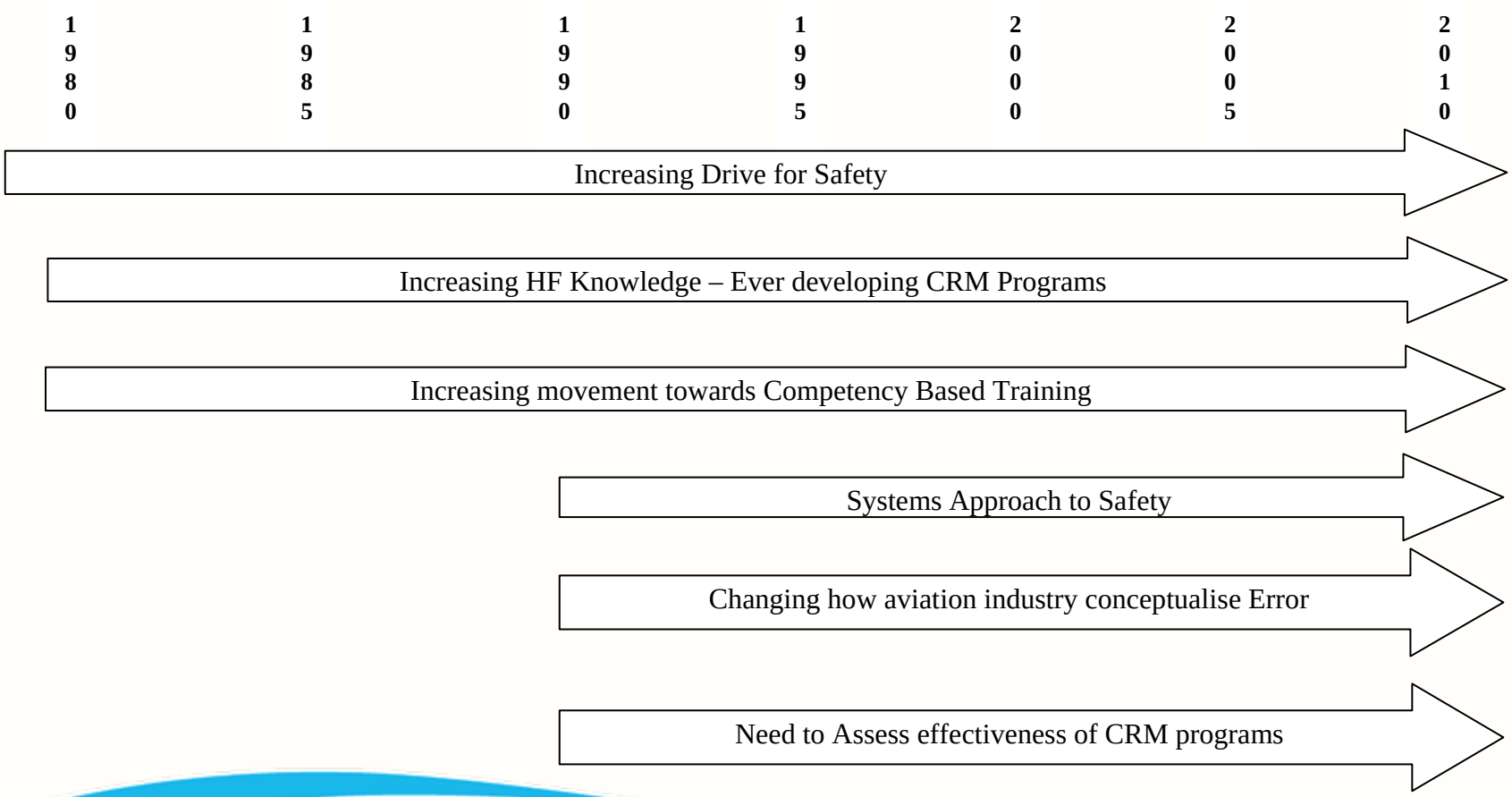
- ICAO: Threat and Error Management (TEM) in Air Traffic Control Approved by the Secretary General and published under his authority PRELIMINARY EDITION - 2005

Definition

ICAO - The Threat and Error Management (TEM) framework is a conceptual model that assists in understanding, from an operational perspective, the inter-relationship between safety and human performance in dynamic and challenging operational contexts.

CASA - ***Threat and Error Management (TEM):*** The process of detecting and responding to threats and errors to ensure that the ensuing outcome is inconsequential, i.e. the outcome is not an error, further error or undesired state.

History of TEM - Background



History of TEM – Getting Started

- Pre 1994 CRM assessed in LOFT & Line Checks
- 1994 Delta Airlines / University of Texas (UT) – Goal to assess effectiveness of CRM program systematically
- 1995 Development of LOSA
- 1996 First TEM LOSA – Continental Airlines / UT

TEM Model

Bases and principles

- Psychologists of the University of Texas designed the TEM model based on aeronautical incidents and accidents analysis in high capacity RPT airlines.
- The model assumes a sequential handling of threats and errors by the pilot – as is generally the case in airline operations.
- According to the model, part of pilot's activity consists of managing threats and errors – **the real importance isn't *that they occur* in normal operations but *how they are being managed***.
- Archival data on flight deck operations demonstrates that mismanaged threats are frequently linked to flight crew errors, which in turn are often linked to undesired states.

TEM Model

Bases and principles

- It is a fundamental premise of TEM that threats and errors are unavoidable components of complex operational contexts, and that is why TEM advocates management as opposed to avoidance or elimination.
- Some threats, errors or undesired states may not present a realistic opportunity to manage them.
- Error and threat management is performed through « CRM behaviours », which are behaviours employing non-technical skills gained from CRM courses.
- Assumes a technical competency appropriate for that role – i.e., meet qualification standard
  - Hence errors are in the main due to threats not lack of competency.
  - LOSA can detect proficiency errors (latent threat/training issue)

Outcomes From LOSA/TEM

- One common false assumption is that errors and violations are limited to incidents and accidents. Recent data from Flight Operations Monitoring (e.g. LOSA) indicate that errors and violations are quite common in flight operations.
- According to the University of Texas LOSA database:
  - In around 60% of the flights at least one error or violation was observed, the average per flight being 1.5.
  - A quarter of the errors and violations were mismanaged or had consequences (an undesired aircraft state or an additional error).
  - A third of the errors were detected and corrected by the flight crew, 4% were detected but made worse, and over 60% of errors remained undetected. This data should underline the fact that errors are normal in flight operations and that, as such, they are usually not immediately dangerous.

TEM Model

Objectives of such a model in the LOSA methodology

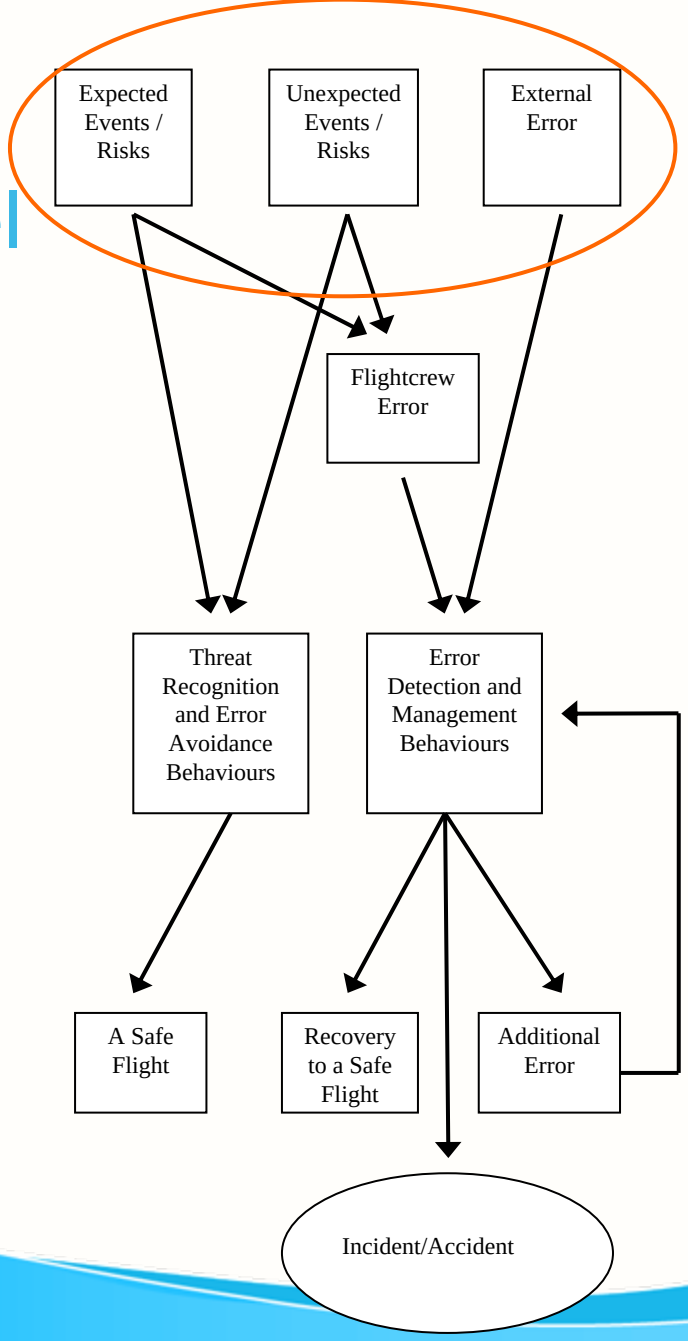
Provides a Framework to identify through observations*:

- weaknesses in training and knowledge,
- insufficient or ineffective strategies of potential error detection,
- effective strategies of error recovery or management,
- strategies of threat detection and management,
- systemic threats,
- errors types present according to the taxonomy presented in the model

* Based on observations from an impartial ‘fly on the wall’ observer and focusing on the individual, crew and organisation.

University of Texas TEM Model

- **A Threat** is defined as an event (in relation to the environment or the aircraft) or an error (from another aircraft, air traffic control or maintenance) **occurring outside the influence of the flight crew** (not caused by the flight crew). It increases the operational complexity of a flight and requires crew attention and management if safety margins are to be maintained.
- Expected vs Unexpected?



Threats

- University of Texas:
  - An event or error that occurs outside the influence of the crew
  - increase the operational complexity of the flight; and
  - Require attention and management
- Several categories and ways of categorizing them
  - Standardization important if:
    - Comparing LOSA data to other operators
    - Participating in research activity, conferences
- ***Threat*** *(CASA modified definition for single pilot operations)**:*** A situation or event that has the potential to impact negatively on the safety of a flight, or any influence that promotes opportunity for pilot error(s).

Environmental Threats (CASA – External threats)

- Adverse Weather
- Airport Conditions
- Terrain
- Other Traffic
- ATC requirements and/or Errors

Operational Threats (CASA – External threats)

- Operational Pressure
- Aircraft Malfunctions
- Maintenance Error
- Ground handling Error
- Cabin Events
- Crew Scheduling Errors

Latent Threats (CASA – External threats)

- Systematic or Organisational deficiencies
- Hardware Design
- Training deficiencies
- ATC systematic deficiencies

Other (CASA – internal threats)

- Stress
- Fatigue
- Distractions

Expected Vs Unexpected

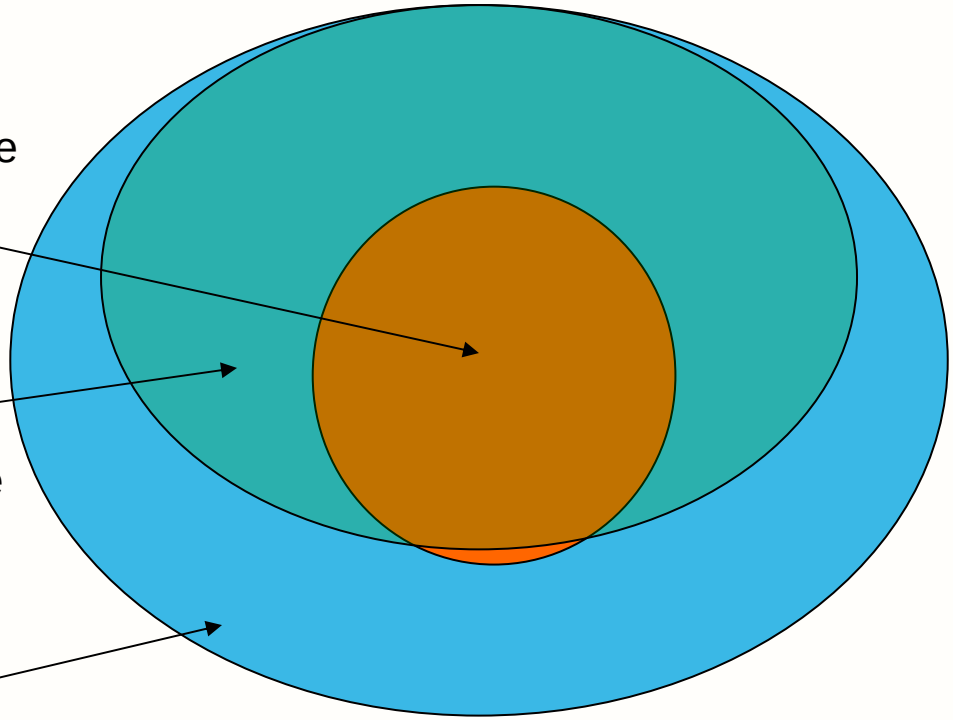
- Threats can both be expected (anticipated) or unexpected (unanticipated)
  - Dependent on pilot's knowledge and experience
  - Expected
    - Requires development of reasonable plan beforehand – self briefing
    - Consideration of differences to plan if threat materializes
  - Unexpected
    - Relies on broad skill and knowledge base - Core
    - Development of transferable skills
    - Use of General models and procedures
      - » Aviate – Navigate – Communicate – Administrate
      - » GRADE – model of decision-making
      - » Satisficing – 'near enough'
      - » Trial and Error – activate a plan and update as required

Knowledge and Experience

Perfect knowledge & total experience – “God”

Student knowledge & experience

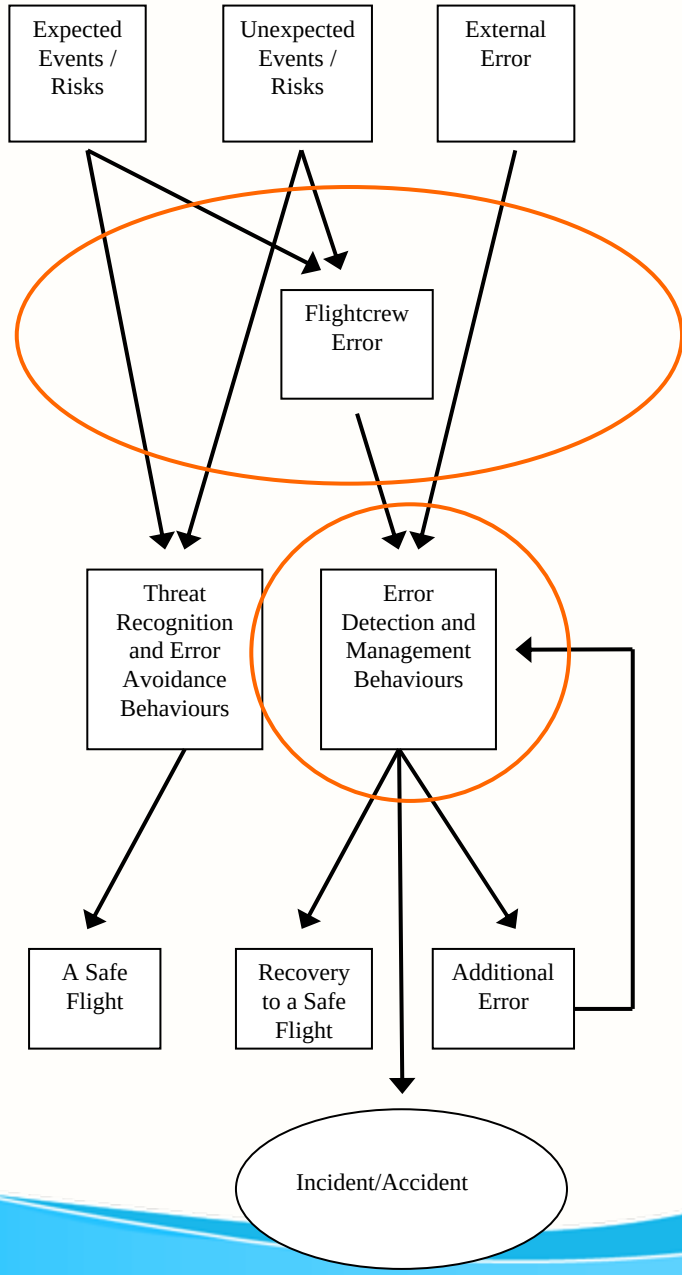
Instructor knowledge & experience



Yet to Experience and No precedent : A380 QF 32 / B767 Gimli Glider / DC10 Sioux City

TEM Model

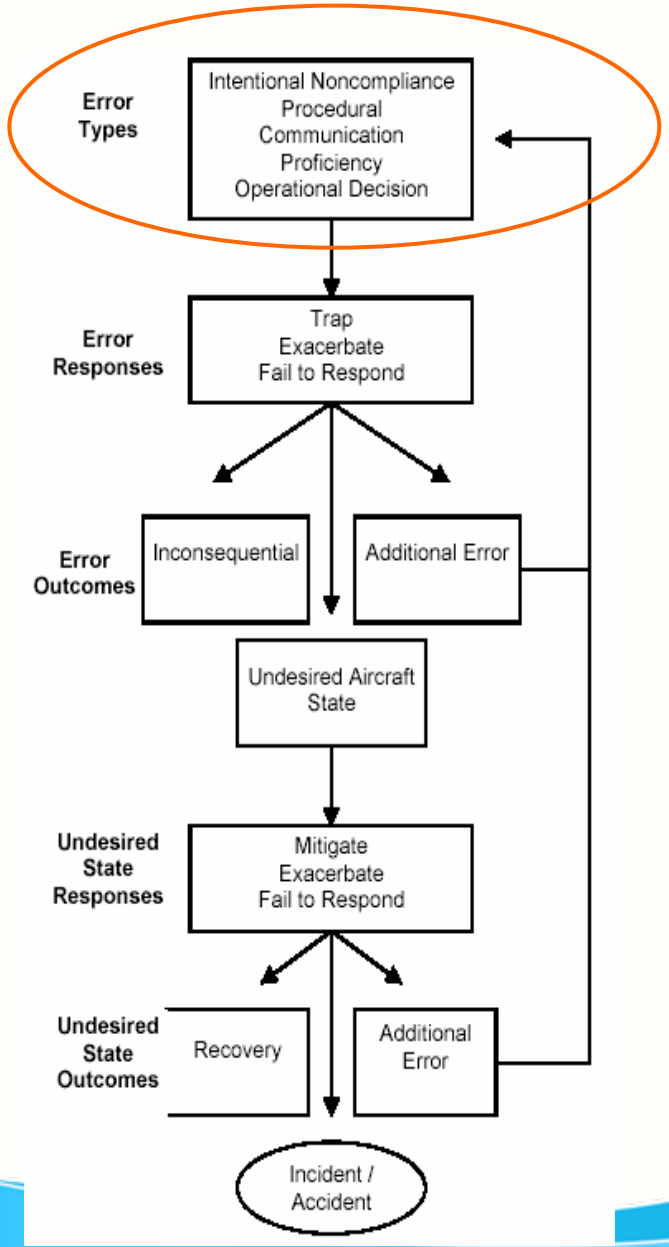
- **A Flight Crew Error** is defined as an action or inaction that leads to a deviation from crew or organisational intentions or expectations. Error in the operational context is considered as a factor reducing the margin of safety and increasing the probability of adverse events.
- Error Detection and Management Behaviours



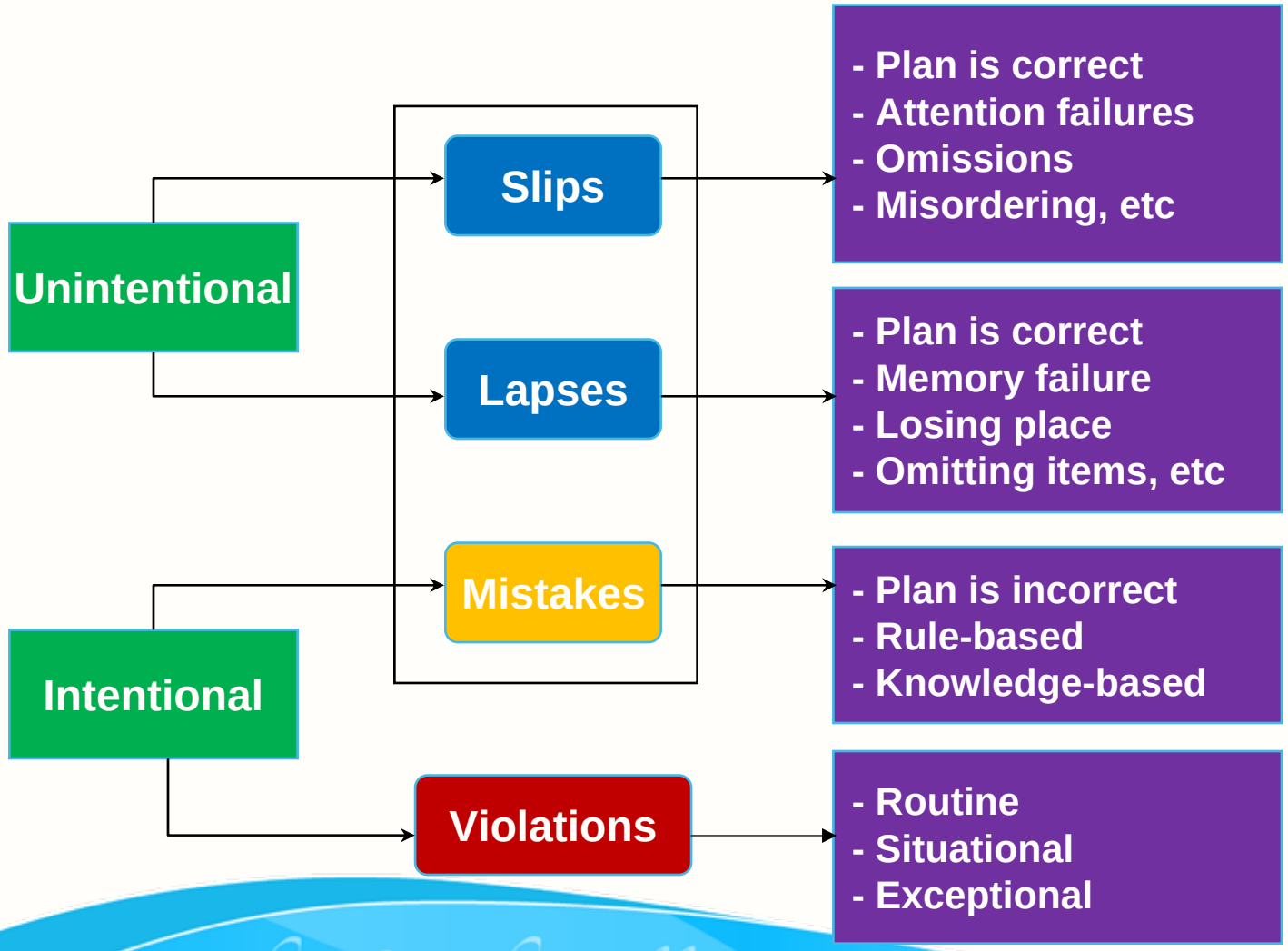
University of Texas

Error Management by the Flight Crew

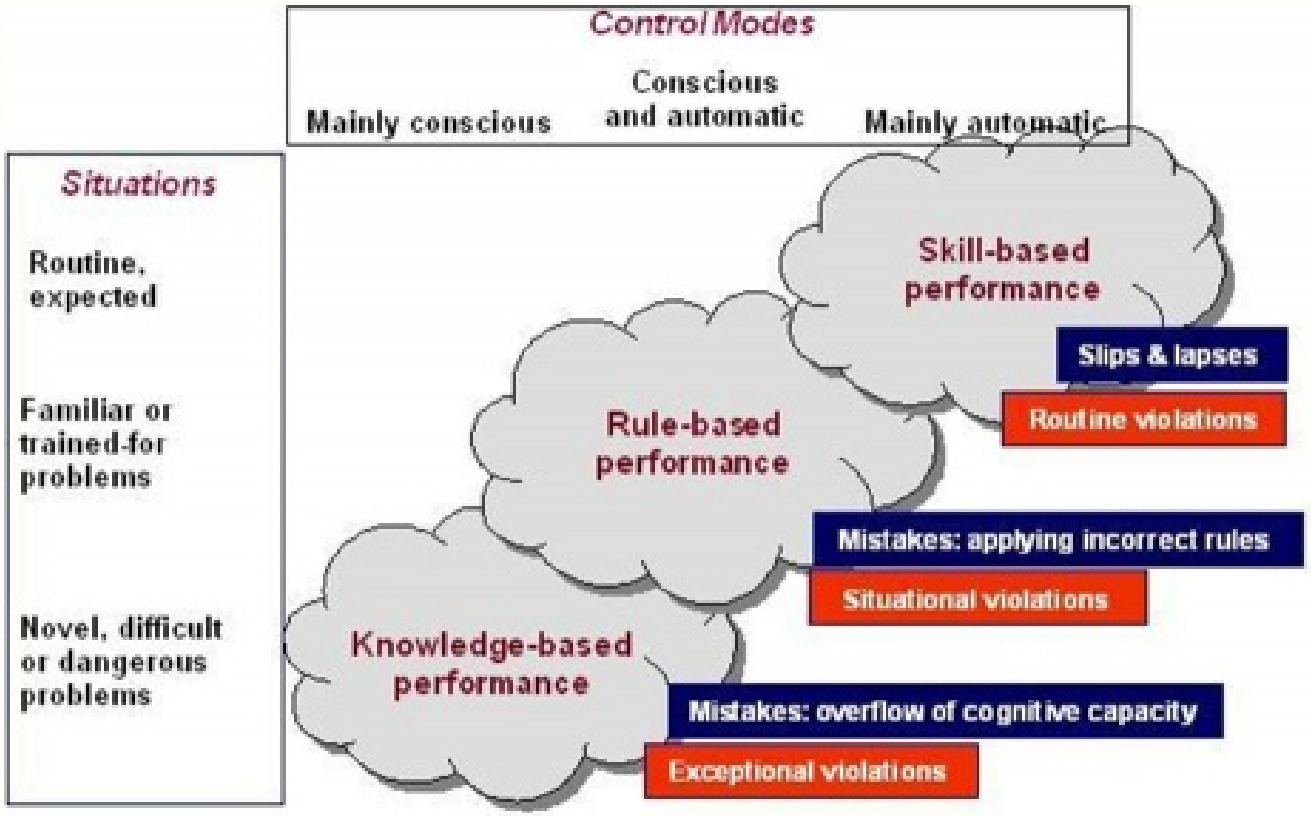
- **Error Types:**
- **Intentional non-compliance errors (violations):** intentional and conscious violations of SOPs or regulations, including shortcuts or omission of required briefings or checklists.
- **Procedural errors:** errors including slips, lapses or mistakes in the execution of regulations or procedures. The intention is correct but the execution is flawed.
- **Communication errors:** occurs when information is incorrectly transmitted or interpreted within the cockpit crew or between the cockpit crew and external sources such as air traffic control.
- **Proficiency errors (*skills errors*):** indicate a lack of knowledge or stick and rudder skill.
- **Operational decision errors:** discretionary decisions not covered by regulation and procedure that unnecessarily increases risk. Examples include extreme manoeuvres on approach, choosing to fly into adverse weather, or over-reliance on automation.



Human Error


Unintentional
Intentional
Slips
Lapses
Mistakes
Violations
- Plan is correct
- Attention failures
- Omissions
- Misordering, etc
- Plan is correct
- Memory failure
- Losing place
- Omitting items, etc
- Plan is incorrect
- Rule-based
- Knowledge-based
- Routine
- Situational
- Exceptional

Human Error



Performance Levels and Main Error and Violation Types (adapted from Rasmussen and Reason)
Airbus Flight Ops Briefing Notes, 2005

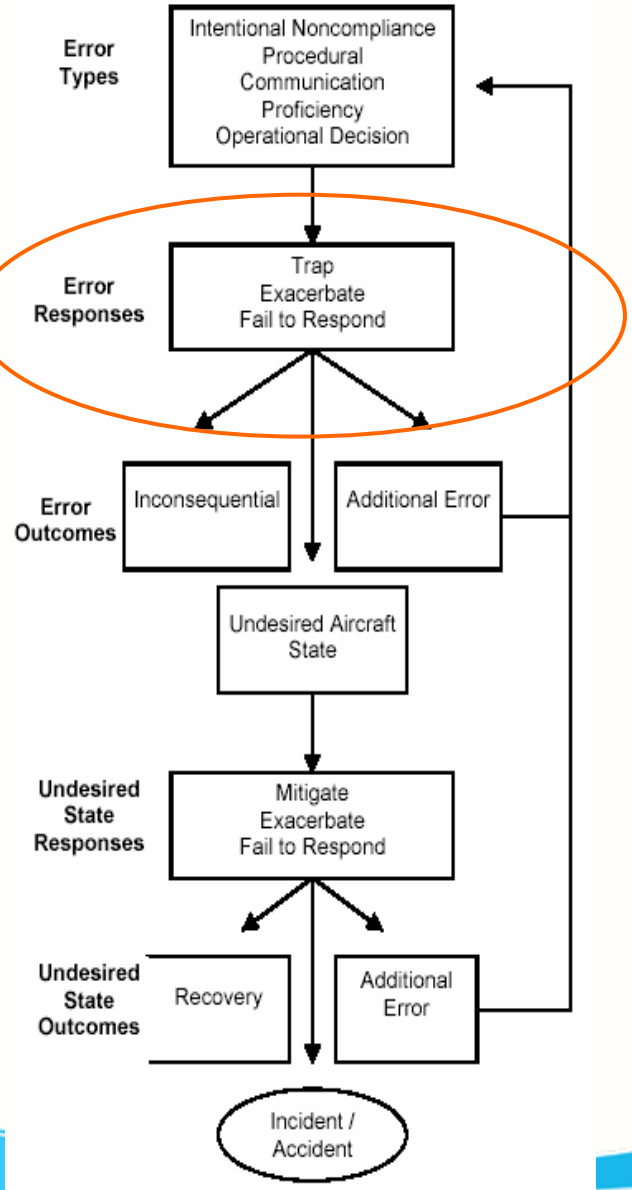
University of Texas

Error Management by the Flight Crew

Error Responses

From the **five errors types** proposed in the model, there are **three possible error responses**:

- **Trap:** the error is detected and managed before it becomes consequential,
- **Exacerbate:** the error is detected but the crew's action or inaction leads to a negative outcome,
- **Fail to respond:** the crew fails to react to the error either because it is undetected or ignored.



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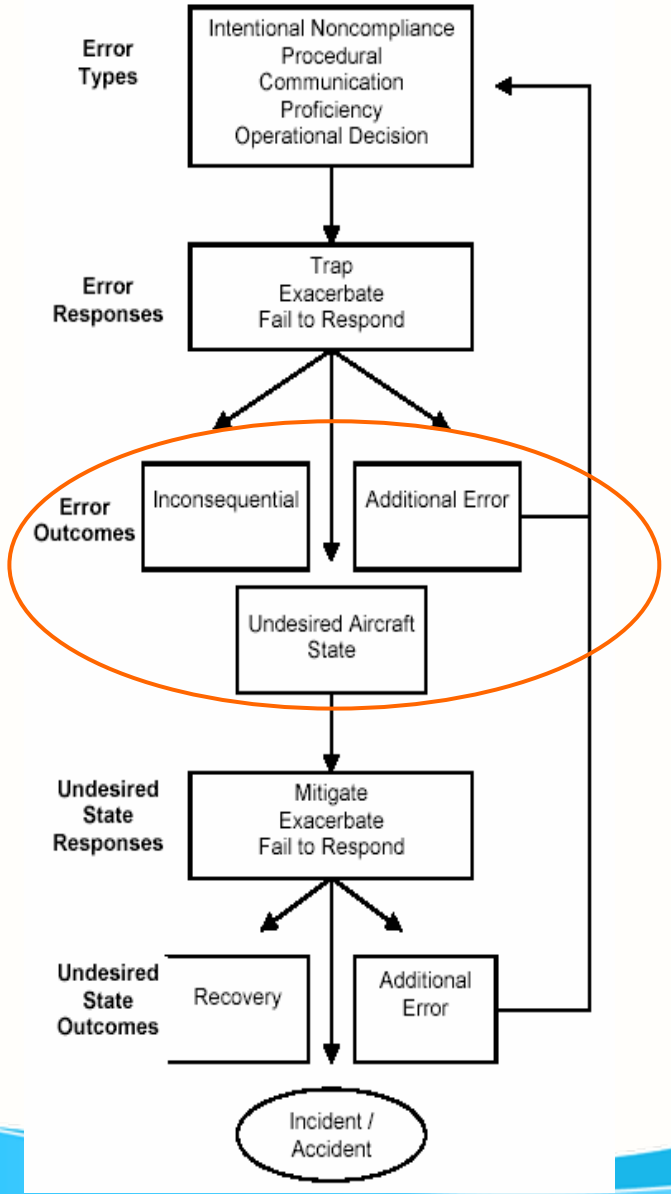
Error Management by the Flight Crew

Error Outcomes

From the **three error responses** there are three possible error outcomes:

- **Inconsequential:** the error has no effect on the safe completion of the flight, or was made irrelevant by successful cockpit crew error management. This is the most common outcome, a fact that is illustrative of the robust nature of the aviation system.
- **Undesired aircraft state:** is defined as a position, condition or attitude of an aircraft that clearly reduces safety margins and is a result of actions by the flight crew.

  The error results in the aircraft being unnecessarily placed in a condition that increases risk. This includes incorrect vertical or lateral navigation, unstable approaches, low fuel state, lining up for wrong runway and reduced separation.
- **Additional Error:** An error by the flight crew that now needs to be managed



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Error Management by the Flight Crew

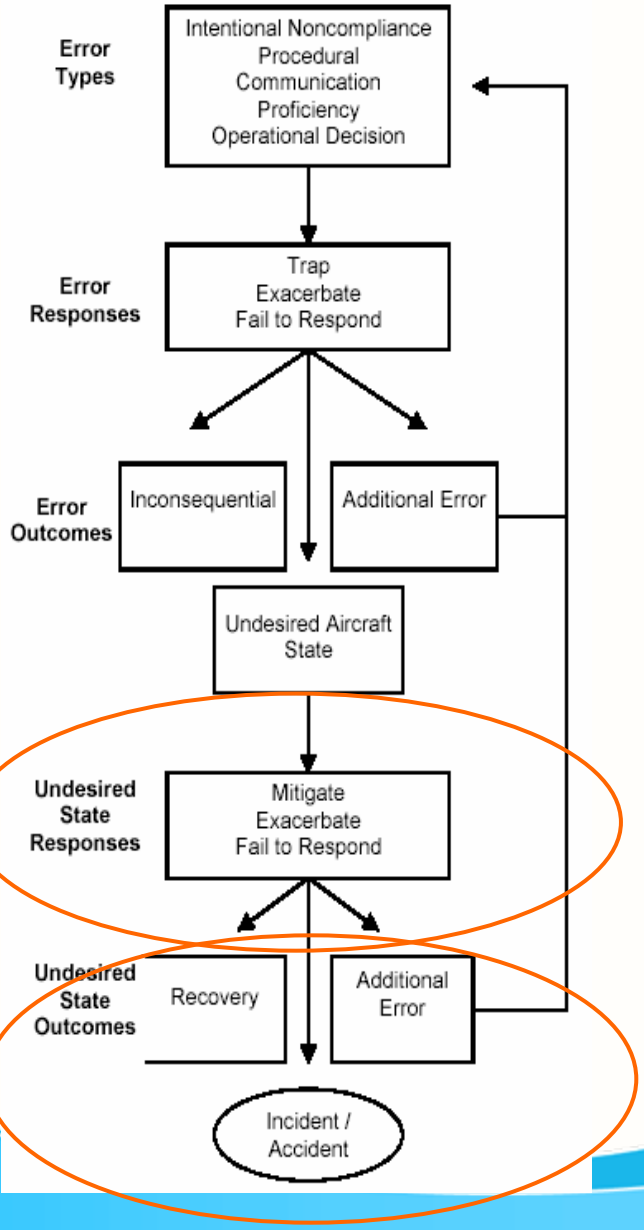
Responses to Undesired Aircraft State

The undesirable aircraft states can be:

- Mitigated
- Exacerbated
- Fail to respond: flight crew failure to respond to the situation

Outcomes to Undesired Aircraft State

- There are three possible **Outcomes** of the undesired aircraft state:
  - Recovery: is an outcome that indicates the risk has been managed
  - Additional error: the actions initiate a new cycle of error and management
  - Crew-based incident or accident



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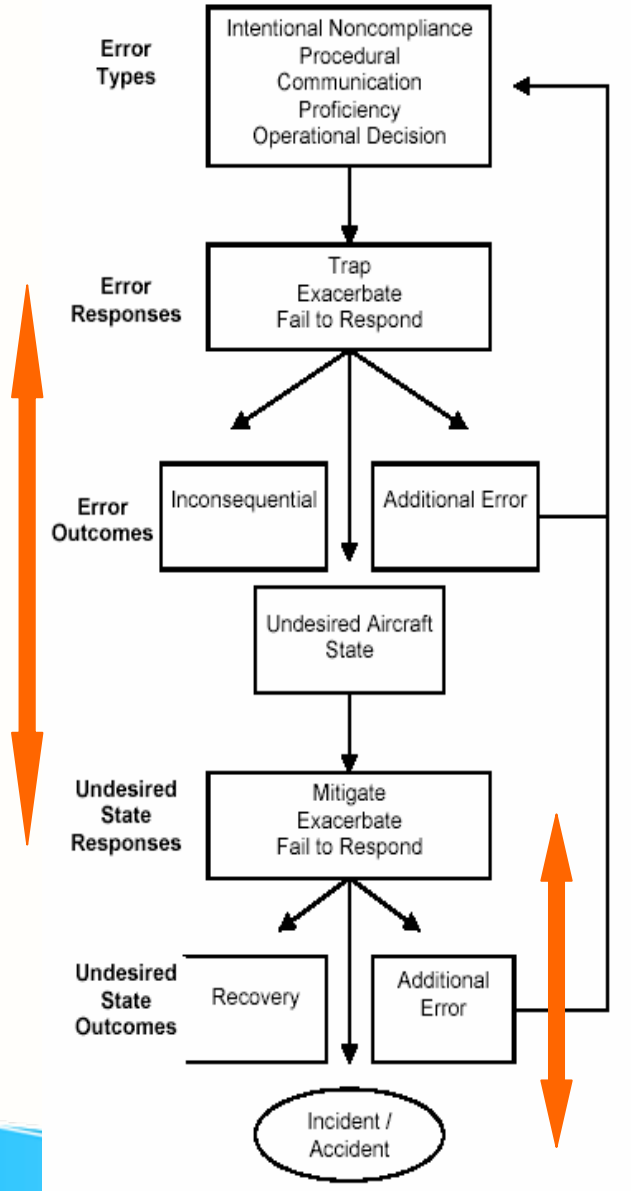
Error Management by the Flight Crew

Switching from error management to undesired state management.

- An example would be as follows: if a pilot realises that the aircraft is substantially off the intended track on arrival (undesired state), pilots must give higher priority to dealing with the potential traffic conflict (undesired state management) rather than diagnosing and correcting the error (error management).

Differentiation between undesired states and outcomes.

- Undesired states are transitional states between a normal operational state (i.e. an aircraft in climb to an assigned altitude) and an outcome. Outcomes, on the other hand, are end states, most notably, reportable occurrences (i.e. incidents and accidents).



Uses of TEM model

- Descriptive
  - Guiding HF & NTS training programs
  - For an individual it can identify
    - weaknesses in HF & NTS training and knowledge,
    - insufficient or ineffective strategies of potential error detection,
    - effective strategies of error recovery or management,
    - effective strategies of threat detection and management,
    - systemic threats present in the operating environment,
    - errors types present according to the taxonomy presented in the model
  - The TEM framework can be used to inform licensing requirements.
- Diagnostic
  - As a safety analysis tool,
    - the framework can focus on a single event, as is the case with **accident/incident analysis**; or
    - it can be used to understand systemic patterns within a large set of events, as is the case with **operational audits**.

Limitations of TEM Model

- Assumes technical competency appropriate for role.
- The threat-error-undesired states relationship is not necessarily straightforward and it may not always be possible to establish a linear relationship, or one-to-one linkage between threats, errors and undesired states.
  - For example:

  (1) threats can on occasion lead directly to undesired states without the inclusion of errors; and

  (2) operational personnel may on occasion make errors when no threats are observable.
- Essentially a ‘deficit’ model:
  - Benchmarks against a standard ‘safe’ or ‘safe enough’ i.e., other operators
  - Descriptive: It describes an outcome or end state not how to get there.
  - Little focus on minimisation of error
- Links the management of threats and errors to potential deficiencies in HF & NTS skills but not the processes supporting good TEM behaviour.
  - Same challenge as ‘Airmanship’

Principles

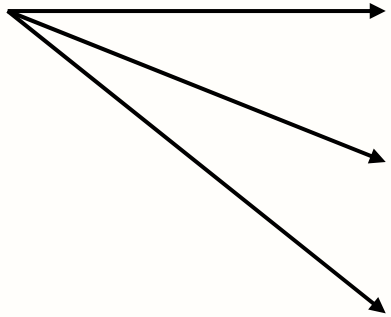
- Principles of TEM Model
  - Managing threats are a core part of a pilots work
  - Errors happen and managing errors are a core part of the pilots work
  - Threats can be expected (anticipated) or unexpected (unanticipated)
    - This will be dependent on knowledge and experience of pilot
  - A pilot should behave in manner that reflects these principles
    - Employs knowledge, experience and non-tech skills to manage threats
    - Employs non-tech skills to manage error

Behaviours

- Behaviour for effective TEM – Some Ideas
  - Self auditing
  - Professionalism – being prepared
    - Pre-briefing – Expected threats
    - Includes accessing HF & NTS training to cover deficiencies
  - Appropriate Attitude – Chooses to…
  - Chronic unease – not complacent
    - Constantly questioning / challenging assumptions
    - Defensive driving for pilots
  - Actively managing SA
    - Systematically considering implications of changing environment to conditions / assumptions / plan

Flying Training Sortie TEM

- Sortie TEM

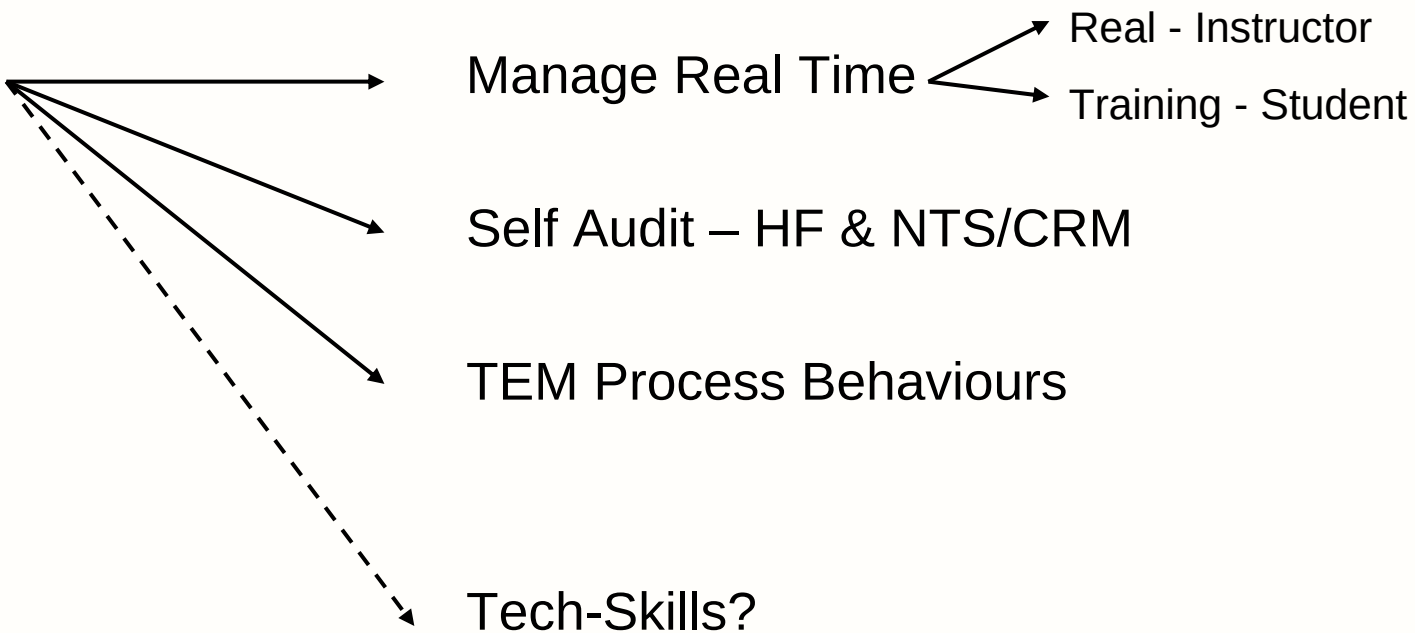


Real TEM for Sortie

- Training/Supervised TEM
- Operational Context TEM

Flying Training Sortie TEM

- Response



TEM Training

- TEM should not form a separate element of a training curriculum
  - Integrated into Ground Training, Simulator Training, and Flight Training.
  - Like the idea of 'Airmanship' – Part of every flying activity however an effort to create a more objective description of the required behaviour.
- Requires a foundation of core knowledge
    - Threat Management - Develop an appropriate knowledge base of aviation threats
    - Error Management - HF & NTS knowledge - Human Limitations, nature of error
- Critical Aspects of Classroom-based TEM Training
    - Introducing core knowledge and skills
    - Using examples from real and relevant operations
    - Providing behavioural models – simplify where possible
    - Promoting personal identification with error management strategies – professionalism etc.
- Aspects of Aircraft-based TEM training
    - Mentoring/Modeling for students
    - Transparency of analysis – Instructor's TEM as well (where appropriate)
    - Matching training expectations to current experience and knowledge level of student
    - Workload needs to be managed – Tech skills first - 'Save TEM analysis for debrief'
    - Brief & Debrief – TEM analysis

TEM Training

- TEM Skill Development
  - In Context
    - *'CRM was the development of discrete non-technical skills such as communication, leadership, decision making, conflict resolution, as well as stress and fatigue management (Helreich & Wilhelm, 1991).'*
    - *'Through an evolutionary process new generations of CRM emerged, and recently CRM has been reconceptualised explicitly as the development of threat and error countermeasures (Helmreich, Merrit,& Wilhelm, 1999).'*

TEM Training

- TEM Skill Development
  - The keystone of error management training is the development of tangible skills in:
    - Avoidance of error
    - Detection of error, and
    - Response to error
  - These skills are usually non-technical in nature
    - This means they need to be integrated into technical skills development programs
    - How is this done in GA?
    - Cannot be just a classroom activity
    - Specific experiential forms of training must be used

TEM Training

- Core TEM Skills - Countermeasures
  - Use of SOPs
    - Checklist discipline
    - Briefings
    - Altitude callouts
  - Cognitive Skills
    - Situational Awareness
      - » Development/Maintenance/Recovery – Lookout etc
    - Information Management
    - Planning and Mental Simulation
    - Vigilance, Monitoring and Evaluation
      - » Including self-regulation
  - Team and Interpersonal Skills
    - Communication
      - » Negotiation, assertiveness
    - Task Management

TEM Training

- Critical Aspects of Experiential-based Error Management Training Skill Development
  - Scenario based learning
  - Bridging the divide between Technical and Non-Technical Skills
  - Identification of ‘Gotchas’ (threats) and key error management strategies
  - Exposure to error producing conditions
  - Guided analysis of error events
  - Emphasis on Cause and Effect – context
  - Instructional prompts for effective error management

How is this done?

- Workshops later

Questions Later