1.4 Threat and Error Management

To conclude the section 1 of this human performance guide, this chapter will explain Threat and Error management as the foundation of CBTA in aviation. While born from the world of aviation, these chapters will develop the competency ideas across other safety critical areas, such as healthcare, maritime, air traffic control and more.

You may recall from the Introduction chapter, the evolution of CRM to TEM:

Let us first define some important key terms [i]:

	Threat: events or errors that occur beyond the influence of the flight crew, increase operational complexity, and must be managed to maintain the margins of safety. Threats may lead to errors, undesired aircraft states, incidents, or accidents
	Error: action or inaction by the flight crew, that leads to a deviation from intentions of expectations.
	Undesired Aircraft State: aircraft position or speed deviations, misapplication of flight controls, or incorrect systems configuration, associated with a reduction in margins of safety.

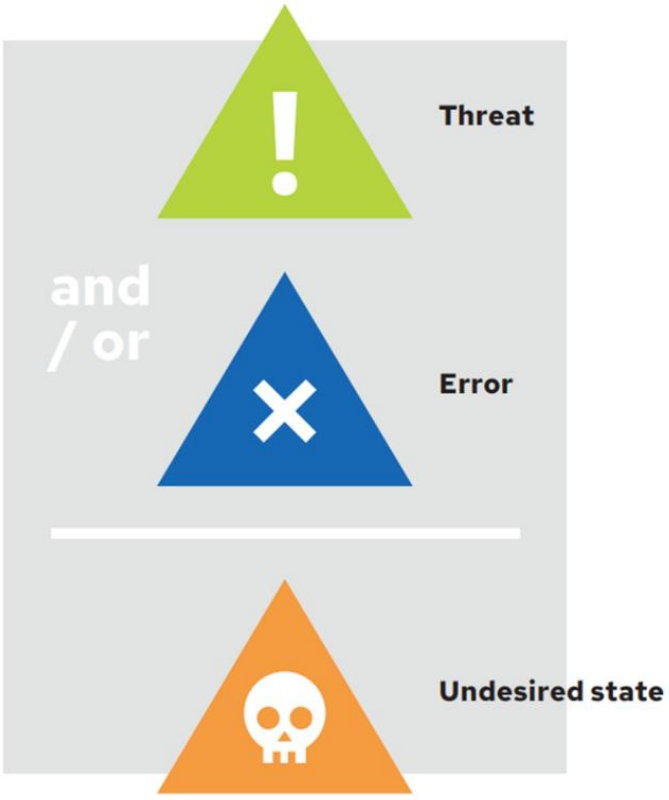
Forensic investigation and the use of hindsight provides valuable information after an accident or incident. Traditionally this was the only way to discover flaws in the system or in the humans operating it. But this was not sufficient, humans were still making mistakes and committing errors, some of which led to injuries and deaths.

	Accident: An unexpected and often unfortunate event that results in damage or injury.
	Incident: An event that can be considered a near miss, where there is the potential for damage or injury, or the outcomes were much less severe than they might have been.

To discuss the aspects of Threat and Error Management (TEM), this chapter will look at 'performance environments'. These are the location/scene/teams in which the work is being done, for example:

- A flight crew on a flight deck,
- A surgical team in an operating room,
- An engineering team in a maritime engine room.

The goal of TEM is to identify threats and errors quickly and accurately, then plan and implement appropriate responses to manage them. In simple terms, a threat and/or an error can lead to an undesired state where an accident or incident may occur.[ii]



Threats

Events or factors that are external to the performance environment are classified as threats. They are not necessarily deficiencies in the system, but events that increase the complexity of operations and therefore increase the likelihood of errors. Threats can be overt or latent.

Overt threats are well defined and observable. Little can be done to control them, so managing threats must become the focus for crews.

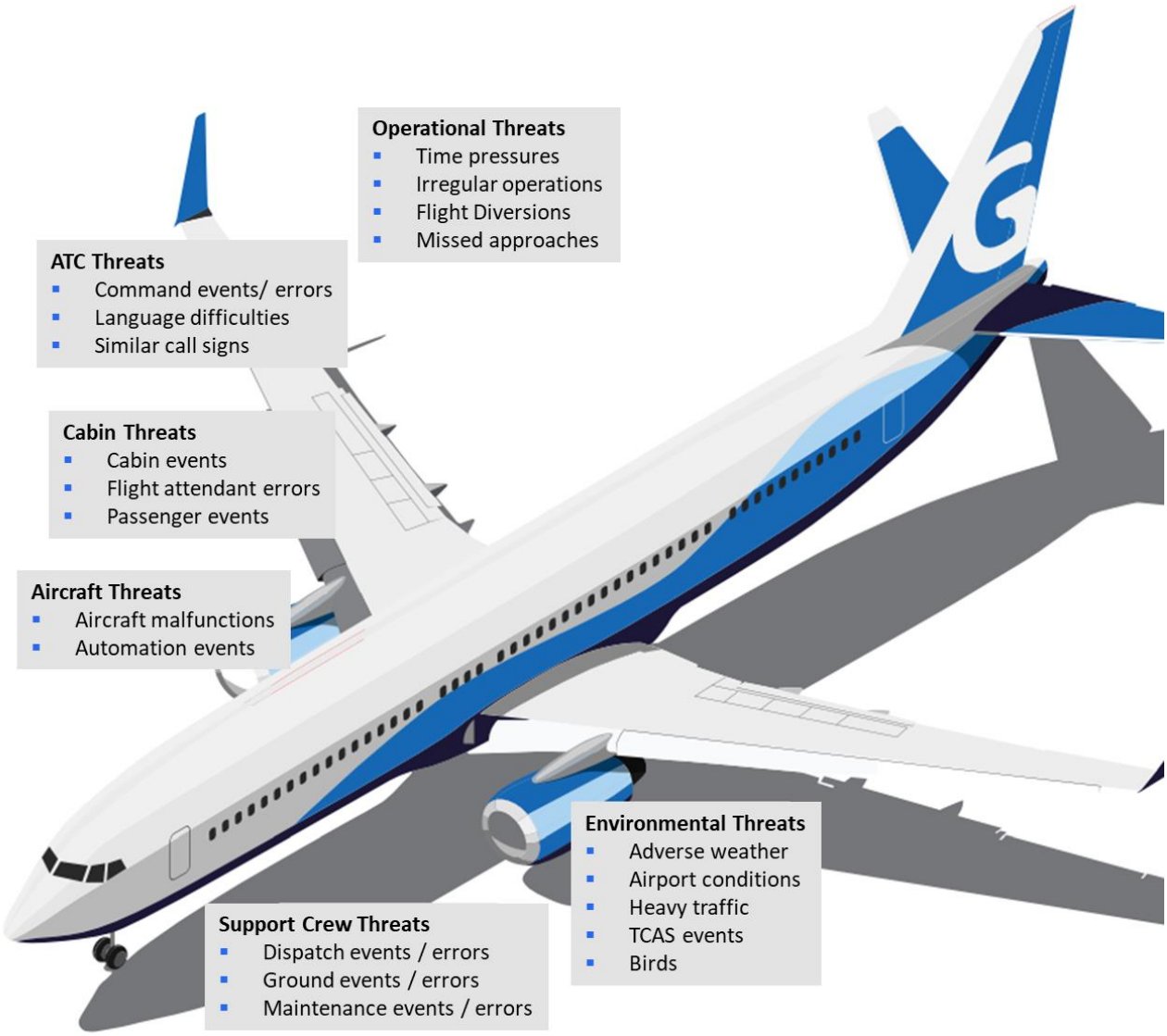
Examples include:

- poor weather (thunderstorms, adverse wind, turbulence) that could disrupt a flight schedule
- violent or abusive passengers, patients, people
- technology malfunctions, blank screens in a flight deck, on medical equipment of failed machinery

Overt threats are unavoidable in many performance environments, such as aviation, healthcare, and defense; so, managing threats must be a focus to increase safety.

Latent threats are not readily observable and may conceal themselves within the operation itself.

Some examples of latent threats can be in relation to organizational culture or discrepancies within policies and procedures. These threats can be hard to see clearly; they may be masked by overt threats, or entirely unseen, until too late. Additionally, they are often complex and difficult to classify in terms that can easily show solutions. For example, there may be two conflicting policies/procedures that are rarely used together. But in those rare cases, it then emerges that both cannot be followed correctly, and give ambiguous results.



Errors

There are four common types of error:

Slip: An incorrect action is performed, such as a substitution or insertion of an inappropriate action into a sequence that was otherwise good.

For example, a slip might be setting the wrong altitude into the mode selector panel, even when the pilot knew the correct altitude and intended to enter it.

Mistake: The human did what they intended, but the planned action was incorrect.

Mistakes can result from an incorrect diagnosis of a problem or a failure to understand the exact nature of the current situation. For example, it would be a mistake to shut down the wrong engine because of an incorrect diagnosis of a set of symptoms. The plan of action thus derived may contain inappropriate behaviors and may also fail to rectify the problem.

Lapse: Omission of one or more steps of a sequence**.**

A lapse could be missing one or more items in a checklist that has been interrupted by a radio call. Similarly, emergencies can often distract teams from their normal task, therefore creating lapses in those otherwise standard routines.

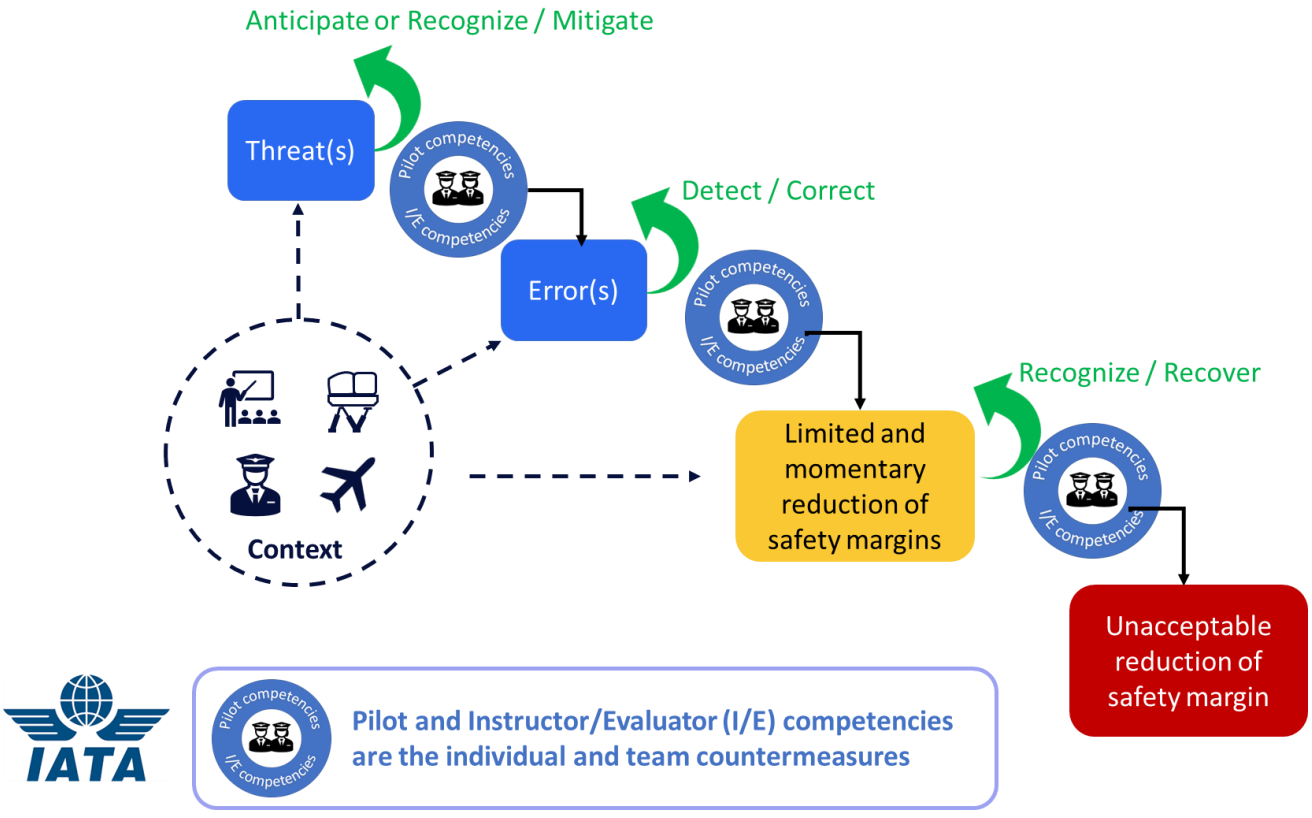
Violation: Failure to follow established procedures, or performance of actions that are generally forbidden.

Starting an approach in IMC when the broadcast weather was below your minima or continuing to attempt a landing without the required visual reference at the minima are examples of violations. Violations are generally deliberate. This does not mean they are malicious in intent, but that an action has been purposefully taken against the established procedure (although an argument can be made that some violation cases can be inadvertent). Violations are not restricted to regulation or other legal requirements, but can encompass a wide range of social, moral, and political issues too.

Threat and Error Management

Training has traditionally focused on eliminating error. This ignores the fact that errors are a by-product of human behavior. As Alexander Pope wrote, "To err is human"[iii]. Therefore, the outcome of managing errors can never be to eliminate them all. We must instead develop a range of countermeasures to give us some layers of defense against an undesirable outcome. IATA developed a diagram[iv] to demonstrate a few key points:

- TEM is applicable in various contexts – Not only in flight, but also in terms of the simulator, classroom activities as well as the organizational employees.
- Just like James Reason's Swiss cheese model, TEM countermeasures should be used, with the aim of preventing the escalation of a threat or error to any form of reduced safety margin, UAS, or accident/incident.
- The Pilot and Instructor Evaluator competencies (shown in the blue donut shapes) are the barriers we place to reduce the risk of a slide down the diagram.



Anticipate or Recognize/Mitigate

At the initial threat level, we aim to *Anticipate or Recognize/Mitigate* the threat. The outcome may lead to three possibilities:

1. A return to safe operations if the management techniques work
2. Trigger an error in the crew
3. Directly causes an Undesired Aircraft State (UAS) or an Incident/Accident

Undesired aircraft states are transitional states with a limited and momentary reduction in safety margins between a normal operational state and an unacceptable reduction is safety margin, such as in an incident/accident.

For example:

- Normal state: stabilized approach
- UAS: un-stabilized approach
- Incident/accident: runway excursion

Detect and Correct

If an error occurs (triggered or not by a threat), the crew will need to *Detect and Correct* the error in a safe and timely manner. This has three possible outcomes:

1. Return to safe operations
2. Initiate additional errors
3. Directly causes an Undesired Aircraft State (UAS) or an Incident/Accident

Recognize and Recover

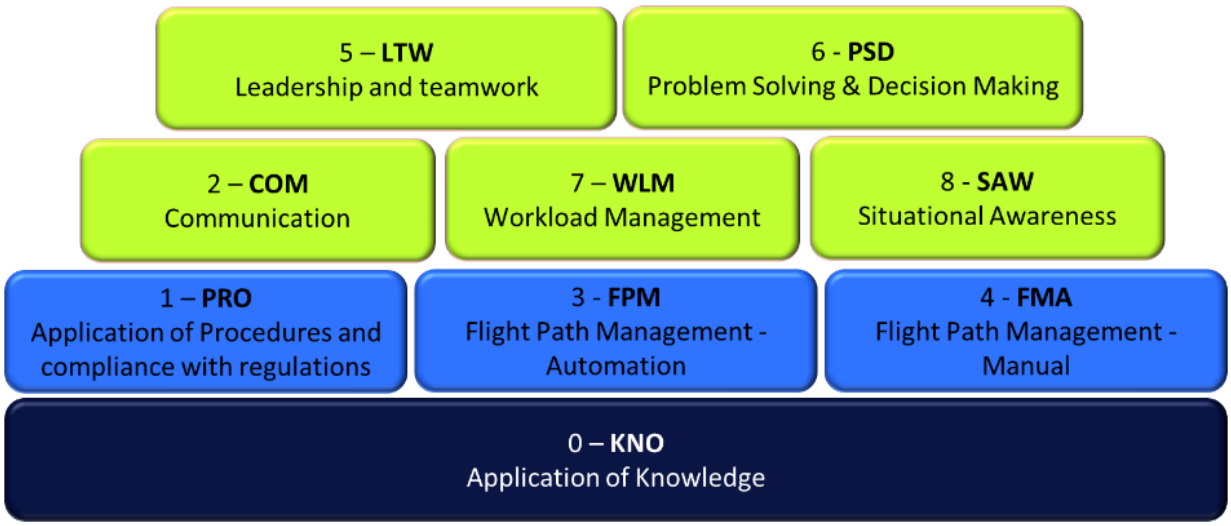
From the undesired state, the crew must prioritize actions to *Recognize and Recover* to safe flight. Again, there are three possibilities:

1. Recovery to safe operations
2. Initiate further error
3. An error induced accident or incident

The TEM Model shows that threats need to be managed as a first line of defense in limiting errors. It also shows that a threat can be as great a contributor as an error to an incident or accident.

TEM Countermeasures

The TEM countermeasures are the pilot competencies and instructor evaluator competencies introduced in the CBTA chapter. Here is an overview, and each will be discussed in much more detail in section 2 of this human performance guide.



If in doubt – always revert to:

Aviate - Navigate - Communicate

Operational Errors

Once some experience has been gained, it becomes useful to understand errors in a more operational sense, rather than the theoretical 'slip, lapse, mistake, and violation.' These are equally relevant across many performance environments, as shown by each example. Operational errors are put into 5 categories:

- Communication
- Procedural
- Proficiency
- Intentional non-compliance
- Operational decision

Communication error is a miscommunication, misinterpretation, or failure to communicate pertinent information.

In the 1990s, NASA launched the Martian Climate Orbiter[v] which included a Martian Polar Lander. Unfortunately, the orbiter and lander team had different measurement systems (metric and imperial) which were not communicated. The mix up caused the complete loss of both probes.

Procedural error is a deviation in the execution of a procedure where the intention was appropriate, but the execution was incorrect.

A procedural approach required an outbound heading from the beacon of 102M. However, the pilot inadvertently dialled 120M onto the course bar and flew the wrong outbound heading, ending up 19 degrees off course.

Proficiency error results from lack of knowledge or skills.

A surgical doctor had learned and practiced the steps required to perform a kidney transplant. However, once in the operating room, threats arose that forced a change of plan, but the doctor did not have the knowledge or skills to correctly complete the task.

Intentional non-compliance error is a willful deviation from regulations and/or procedures.

A busy port requires a local marine pilot to be onboard the tanker ship before entry into the narrow and congested waters. However, the captain was advised there would be a significant delay in getting a pilot out to them. The captain was under intense pressure to make up some lost time. Having visited the port many times before, the captain and crew felt comfortable with the procedure, and decided to enter the port under their own navigation and steering. The ship subsequently caught in an unexpected current and grounded on a sand bank.

Operational decision error is a decision-making error that is not standardized by regulations or procedures, unnecessarily comprising safety. This could be due to one (or more) of these 3 reasons:

1. the crew had more conservative options to choose from
2. the decision was not verbalized with the crew
3. the crew had time available but did not utilize it effectively to evaluate the decision

An aircraft is on a short haul turn around. The crew arrive late and are under intense time pressure. An issue that would normally necessitate further investigation was postponed due to the commercial time pressure perceived by the crew. The aircraft departed on time, but safety was compromised.

Summary

- To err is human
- Threats are beyond the influence of the crew and errors come from within.
- Threats can trigger an error, UAS and/or accident.
- The Pilot competencies and the Instructor Evaluator competencies are the TEM countermeasure to:
  - ***Anticipate or Recognize/Mitigate***
  - ***Detect/correct***
  - ***Recognize and recover***
- If ever in doubt, revert to - Fly, Navigate, Communicate. Fly the aircraft first!

Further Reading

- Helmreich, Robert L., James R. Klinect, and John A. Wilhelm. "System safety and threat and error management: The line operational safety audit (LOSA)." *Proceedings of the eleventh international symposium on aviation psychology*. 2017.
- Dekker, Sidney WA, and Johan Lundstrom. "From threat and error management (TEM) to resilience." *Human Factors and Aerospace Safety* 6.3 (2006): 261.
- Brennan, P. A., et al. "Avoid, trap, and mitigate–an overview of threat and error management." *British Journal of Oral and Maxillofacial Surgery* 58.2 (2020): 146-150.

References

i ICAO PANS Training 9868

ii The Principles of Threat and Error Management (TEM) for Helicopter Pilots, Instructors and Training Organisations. European Helicopter Safety Team. EASA.

iii Pope, Alexander. An Essay on Criticism. Czechia, Good Press, 2019.

iv IATA White Paper. Competency-Based Training and Assessment (CBTA) Expansion within the Aviation System. 2021.

v https://solarsystem.nasa.gov/missions/mars-climate-orbiter/in-depth/