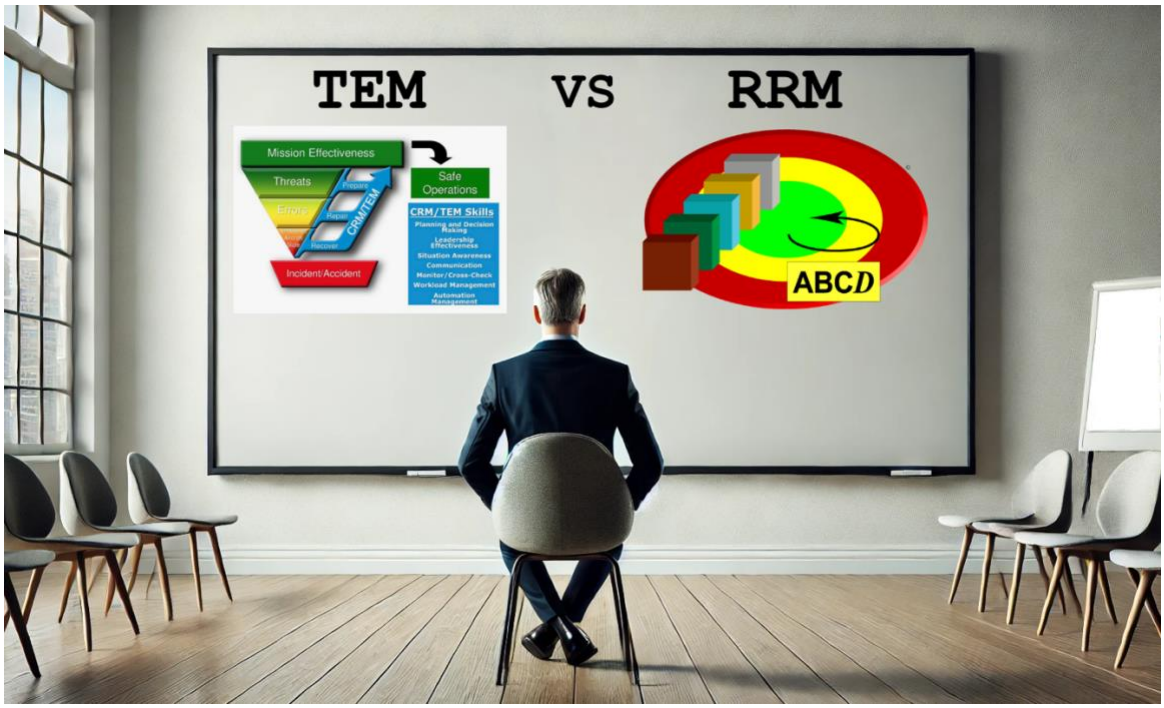
TEM vs RRM: Comparing and Contrasting Methodologies



"Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect."

Captain Alfred G. Lamplaugh (Lamps)

Risk is an inherent in aviation, but as Captain "Lamps" Lamplaugh so eloquently stated, that doesn't make it dangerous. However, it becomes dangerous when aviators are careless in their duty, lax in their training, or negligent in their preparation. Managing and mitigating the risk inherent to flying is the primary job of every professional aviator. As the complexity of aviation increases, the methodology must also improve.

What are the methods for managing risk and achieving safety? What tools are available to both the individual to communicate risk and respond with resilience to changing conditions? Are better methodologies for avoiding carelessness, incapacity, or neglect available?

Safety, being free from harm or loss, is the ultimate goal of any airline operation. However, safety is measured in the present or past tense. Safety is the goal, but not the method or the means. Carelessness, incapacity, or neglect may occur during a flight that ends safely, without harm or loss, and even though a safe outcome was achieved, the level of risk may have been unacceptable.

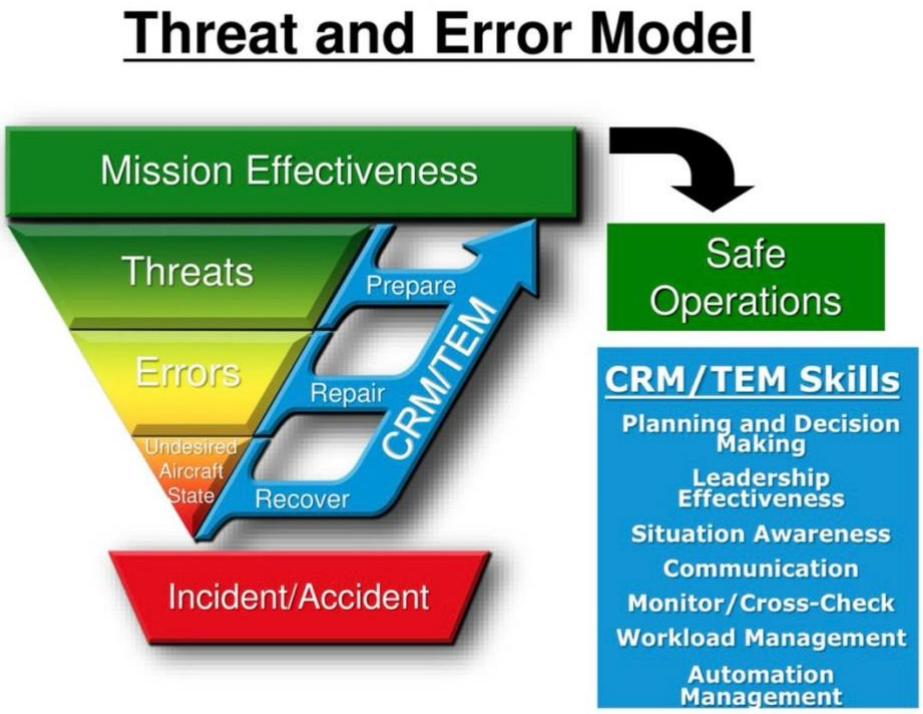
Risk management is the process of achieving our goals, including a safe outcome. It involves recognizing associated risks, mitigating and managing those risks, and achieving a safe outcome in spite of the possibility of experiencing harm or loss. It is the methodology we employ when we strive to be safe, and/or achieve a desired outcome. Taking risks is a necessary part of any worthwhile endeavor. Managing those risks is an essential part of success in any undertaking. Ultimately, safety is the product of good risk management.

British Statistician, George E. P. Box, stated, "All models are wrong, but some are useful." During the past hundred years, aviation has developed several useful models and methodologies to manage risk and achieve safety. This paper will compare two of those models—Threat and Error Management (TEM) and Risk and Resource Management (RRM).

Executive Summary

- TEM is a safety concept originally developed for the aviation industry. It emerged as a systematic approach to managing safety risks by understanding the interactions between threats, errors, and undesired aircraft states.
- RRM is built on the philosophy of combining the risk management needs of the organization, the flight crews, and the individual pilot into a single model that includes a process for managing risks, employment of resources, and basic principles for managing risks. RRM provides a systematic methodology for analyzing risk at the personal and operational levels both before and after an incident.
- Both TEM and RRM strive to enhance safety in air operations even though the two models approach the concepts of safety and risk from slightly different paradigms.
- The concepts of TEM are included in CRM training. The core behaviors of CRM are built into the RRM model.
- TEM terminology has been specifically included in regulatory language. However, RRM meets all the stated regulatory requirements and can be used to replace, or enhance, TEM.
- The taxonomies of the two models are slightly different. Both taxonomies work to support operational safety objectives and comply with Safety Management System requirements.
- TEM is supported by strong performance standards, although not directly tied to the standards. However, the RRM model can be tied directly to performance standards at a more granular level.
- The RRM taxonomy can be used during the ADDIE process of curriculum development to increase effectiveness.

Threat and Error Management



Source: https://slideplayer.com/slide/13659113/
Note: Several different visual models exist for TEM.

Threat and Error Management (TEM) is a safety concept originally developed for the aviation industry. It emerged as a systematic approach to managing safety risks by understanding the interactions between threats, errors, and undesired aircraft states. The concept was formulated to improve safety outcomes by proactively identifying and managing potential threats and errors before they can escalate into incidents or accidents.

The TEM framework was developed by the University of Texas Human Factors Research Project, led by Dr. Robert Helmreich and his colleagues and supported by funding from the FAA. The project, which began in the late 1980s, focused on understanding human performance and error in high-stakes environments like aviation. Their research identified the need for a structured approach to managing threats and errors, which led to the creation of the TEM model.

Components of TEM

Threats: External or internal events or conditions that could negatively affect operations. Threats require identification, management, and mitigation to ensure safety. Examples include adverse weather, equipment malfunction, or operational pressure.

Errors: Mistakes made by flight crew or other operational personnel that lead to deviations from safe operational practices or procedures. Errors can stem from human factors like miscommunication, fatigue, or procedural non-compliance. Errors typically fall into one of the following categories:

- Operational Errors: Mistakes made during the operation of the aircraft.
- Procedural Errors: Deviations from standard procedures.
- Communication Errors: Failures in clear and effective communication.

Undesired Aircraft States: Situations resulting from unmanaged threats or errors that significantly increase the risk of an incident or accident. These states demand immediate recognition and corrective action to return to a safe operational state.

Error Management: The process involving detection, response, and mitigation of errors. This includes the crew's ability to detect and respond appropriately to errors to prevent an escalation into an undesired state.

Threat Management: The methods and processes used by flight crews to detect and respond to threats in order to prevent them from impacting operations.

Countermeasures: Tactical responses or strategic actions taken to avoid or mitigate threats or errors. These are often predefined based on training and standard operating procedures.

Crew Resource Management (CRM): The effective use of all available resources, including human resources, hardware, and information, to ensure successful flight operations and error management.

Safety Margins: Operational buffers established through procedures and training that allow for the safe absorption of errors or management of threats without compromising the safety of flight operations.

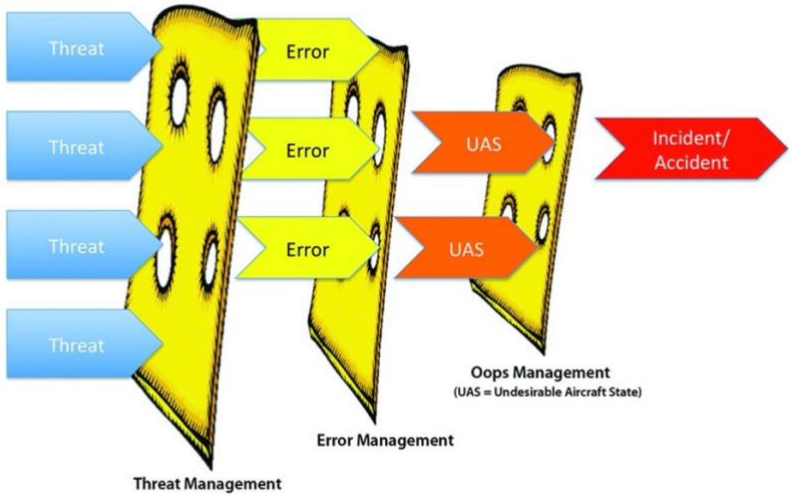
Situational Awareness: The accurate perception and understanding of all the factors and conditions within the four fundamental risk elements (flight crew, aircraft, environment, and operational) that affect safety before, during, and after the flight.

Flight Path Management: The process by which pilots ensure the aircraft follows the intended route and altitude, managing deviations due to operational demands or external factors.

These terms are foundational to the TEM framework, providing a structured approach for understanding and managing the complex interplay of safety-related challenges in aviation environments.

Application of TEM

Threat and Error Management (TEM) is utilized to systematically identify and manage potential hazards and human errors that could compromise safety. The model is integrated into various aspects of flight operations, training, and safety management systems.



Source: https://www.ifr-magazine.com/technique/loss-of-control/

Prepare: Crews are trained to anticipate and mitigate threats such as adverse weather, air traffic congestion, technical malfunctions, or complex airspace, by conducting thorough briefings, preparation, and ensuring countermeasures are in place to handle potential issues.

Repair: Emphasis is placed on error detection and recovery, training pilots to recognize errors early and correct them before they lead to adverse outcomes.

Recover: Undesired aircraft states such as deviations from the planned flight path, incorrect aircraft configuration, or proximity to other aircraft require a recovery. Continuous monitoring and timely intervention are crucial, and crews are taught to maintain situational awareness and manage undesired aircraft states effectively.

TEM principles are embedded into Crew Resource Management (CRM) training, focusing on teamwork, communication, and decision-making skills. Pre-flight briefings are conducted to identify and discuss potential threats for the upcoming flight. During the flight, crews continuously apply TEM by monitoring the environment, communicating effectively, and adapting to changing conditions. After the flight, crews review any threats encountered, errors

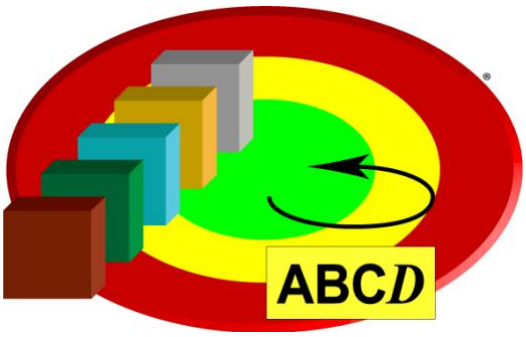
made, and how undesired states were handled, providing valuable feedback and learning opportunities for continuous improvement.

TEM can also be a fundamental component of an organization's Safety Management System (SMS), encompassing all safety-related processes and procedures. It provides a structured approach to hazard identification, risk assessment, and safety assurance.

Advanced technologies such as Flight Data Monitoring (FDM) systems and electronic flight bags (EFBs) support real-time threat and error management. These tools assist in the collection and analysis of flight data to identify trends and areas for improvement, to further enhance the effectiveness of TEM. By collecting and examining data on identified threats, errors, and undesired states, organizations can identify trends, improve safety protocols, and enhance training programs.

In conclusion, TEM in aviation is a comprehensive approach (a useful model) that integrates into every phase of flight operations, from pre-flight planning to post-flight debriefing. By fostering a proactive safety culture and equipping crews with the necessary skills and tools, TEM significantly enhances the ability to manage risks and maintain high safety standards in aviation.

Risk and Resource Management (RRM)



Source: Volant Systems

The Volant Risk and Resource Management (RRM) model was developed at US Airways after a series of accidents over a short period of time in the 1990s. A working group of pilots, instructors, and human factors experts developed the basic concepts of the model which was eventually offered in the open marketplace by KD VanDrie as the owner of Volant Systems.

The model is built on the philosophy of combining the risk management needs of the organization, the flight crews, and the individual pilot into a single model. Founded on the fundamental principles of risk management, RRM incorporates the soft skills of CRM, a layered approach of resources similar to the Swiss Cheese model, and the recognition of human error (and the need to trap those errors). Additionally, the RRM framework provides more robust process tools, or fundamental management skills, that include skills for managing the flight deck and the internal and external resources, to achieve a safe, and successful, outcome. RRM provides a systematic methodology for analyzing risk at the personal and operational levels both before and after an incident.

Components of RRM

Foundational Principles of RRM

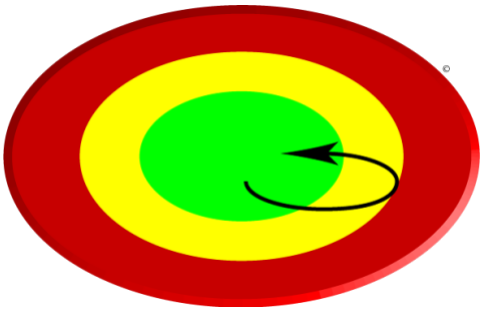
1. Accept No Unnecessary Risk: This principle emphasizes caution and conservatism, advocating for operating strictly within established policies and procedures without taking risks that are not required for successful operation.

2. Anticipate and Manage Risk by Planning: Proactive risk management is key here. It involves planning in advance to identify potential risks and devising strategies to mitigate them before they affect operations.

3. Accept Risk When Benefits Outweigh the Costs: This principle is about balancing risks against potential rewards. It supports taking calculated risks when the expected benefits justify the potential costs.

4. Make Risk Decisions at the Right Level: Ensuring that decisions are made by personnel with the appropriate level of authority and situational awareness to make informed choices.

Target Zones



Green: Indicates low risk with high likelihood of positive outcomes, characterized by good situational awareness, proactive management strategies, and resources.

Yellow: Indicates moderate risk where re-prioritization may be necessary due to increased task loading, additive conditions, or crew factors.

Red: Indicates high risk of serious error or operational failure, necessitating immediate action to recover and stabilize the situation.

The arrow represents resiliency, or the ability to recover from the Yellow or Red back to the Green.

Risk Factors

Risk factors are anything that increase risk and decrease performance. RRM breaks out these risks into one of three categories—Task Loading, Additive Conditions, and Crew Factors.

Task Loading: The amount of time needed to accomplish tasks vs the time available to accomplish tasks. High task loading increases stress and decreases performance. Low task loading can lead to inattention or complacency which also increases risk.

Additive Conditions: Any factor that adds to task loading or causes a distraction or disruption (e.g., the environment, equipment problems, operational problems, organizational influences).

Crew Factors: The physiological elements of crew members that negatively impact operational effectiveness and safety (e.g., fatigue, stress, fear, illness, experience).

Resource Blocks

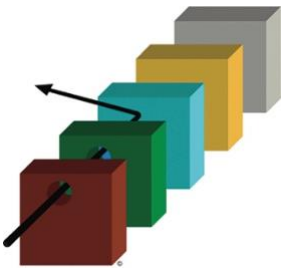
The colored Resource blocks represent Resources that can be used to improve performance, reduce risk, and manage a time-constrained situation. Each block represents one or more resources available to trap errors and mitigate risk. Using multiple blocks is effective at stopping an error chain.

Policies, Procedures, Flows, and Techniques—Policies, procedures, flows and techniques create predictability and consistency. This block reduces the mental energy involved in decision making which will improve performance, and it creates a level of predictability which improves both situation assessment and interactions with other people.

Checklists and Job Aids—Checklists and other Job Aids serve as a structured means of ensuring all critical items have been properly accomplished. They reduce the reliance on memory and/or capture errors that you might make if trying to do a task strictly from memory.

Automation/Technology—Automation and Technology are the integration of people and tools to accomplish a task. When properly managed they improve performance by making information more readily available, detecting deviances, or by automating tasks.

Briefings and External Resources—Briefings are verbal communications conducted between people working together on the same goals and in the same context. Effective briefings create a shared mental model and develop a plan based on known, or potential, risk factors. External Resources are people/groups who understand and have the same goals, but are working within a different context (e.g., Air Traffic Control, Maintenance, Dispatch, Flight Service, ARINC).



Knowledge, Skills, and Attitude—Knowledge, skills, and attitude are acquired through study, training, and experience. Knowledge is the readily recalled information that may be required or beneficial in the conduct of the flight. Skills are the mental and physical capabilities to operate the aircraft. Attitude refers to combination of past experience, training and personal value system that forms the basis for what we pay attention to and which impacts our judgement.

Used together, these resource blocks provide specific tools for trapping and eliminating errors.

Fundamental Management Skills—ABC*D*

ABC*D* is a fast and continuous process that maintains situational awareness, balances priorities, communicates intentions, promotes action, and facilitates continuous improvement.

Assess: Assess the Green-Yellow-Red status. Maintain situational awareness. Continuously evaluate what is happening now to identify, integrate, and apply the critical elements of information and determine how it affects the future outcome.

Balance: Balance the amount of time available, operational priorities, and available Resources. Make decisions to maintain redundancy and distribute workload.

Communicate: Communicate risk and intentions. Effectively communicate in the appropriate style (Green, Yellow, or Red) to gather additional information and create a shared mental model.

Do and Debrief: Do execute the plan in timely manner and Debrief the results. Perform basic and complex tasks to the best of your ability, then continuously work toward improving performance and reducing risk by improving the application of Resources and management skills.

Application of RRM

In practical terms, RRM is applied throughout aviation operations from flight planning to in-flight management and post-flight analysis. By implementing RRM principles and utilizing its components, aviation personnel can effectively manage the varied risks associated with different phases of flight and ground operations, ensuring safety and efficiency.

This framework not only helps in managing current operations but also in preparing for potential future disruptions by equipping crew members with the tools and knowledge to handle unexpected events. The emphasis on proactive planning and continuous assessment aligns well with modern safety management systems in aviation, making RRM an integral part of maintaining high safety standards in the industry.

The core behaviors of CRM are built into the RRM model in the fundamental management skills (ABC*D*), the risk target concept, and the use of resource blocks. Planning is incorporated into the Briefing and External Resources block. Risks are communicated during briefings that create a shared mental model and outline a plan or action. Situation awareness, decision making, communication, and workload management are all incorporated into the ABC*D* process. The observable CRM behaviors are integrated into the model.

Because the components of RRM are directly connected to performance standards, the RRM taxonomy can be used during the ADDIE process of curriculum development to increase effectiveness.

RRM fully supports an organization's Safety Management System (SMS) by helping establish good safety policy, assisting with safety risk management, and safety promotion at both the individual and system level. When coupled with safety data collection the RRM model serves a lens for providing context to events and data trends.

RRM provides a common risk language throughout an entire operation or business from the C-suite to frontline employees facilitating the communication of risk at all levels and the ability to create a shared mental model. It is a model that can be applied to an operational process, a safety process, and a training process with equal success.

In conclusion, RRM provides the user with principles that can be applied widely, a process that can be employed continuously, and resources that can be used individually or layered. It is both robust in design and simple in application. Effective use of the model will help mitigate risk, achieve safety, and expedite expertise.

A Comparison of Taxonomies

While both models strive to enhance safety and manage threats and risks, each model approaches the management of operational risks through slightly different lenses and terminologies. Here's a structured comparison of the two taxonomies:

Threat and Error Management	Risk and Resource Management
Safety Margin: Operational buffers that allow for the safe absorption of errors or management of threats without compromising the safety of flight operations.	Risks: The probability and magnitude of an unwanted outcome.
Threats: External or internal events or conditions that could negatively affect operations.	Factors Increasing Risk: Additive Conditions, Crew Factors, and Task Loading.
Errors: Mistakes made by flight crew or other operational personnel.	Errors: Mistakes made by flight crew or other operational personnel.
Countermeasures: Tactical responses or strategic actions taken to avoid or mitigate threats or errors.	Resources Blocks: Specific resources employed to manage the factors increasing risk.
Prepare, Repair, Recover: Process for avoiding errors, trapping errors, and recovering from untrapped errors.	ABC*D*: A fast and continuous process that maintains situational awareness, balances priorities, communicates intentions, promotes action, and facilitates continuous improvement.
Green, Yellow, Red: Color coding to describe the current safety margins.	Green, Yellow, Red Target: Graphic depiction of the risk state.

Undesired Aircraft State: Terminology used to describe the aircraft state when safety margins have not been maintained.	In the Red: High risk of serious error or operational failure, necessitating immediate action to recover and stabilize the situation. Not necessarily an aircraft state.
Crew Resource Management: Integrated into TEM training.	Crew Resource Management: Imbedded into the ABC*D* process, the factors increasing risk, and the use of the Resource Blocks.

Differences and Similarities

	Threat and Error Management	**Risk and Resource Management**
Single, clearly defined model?	No, multiple variations exist	Yes
Open source?	Yes	No, proprietary intellectual property
Meets regulatory requirements?	Yes	Yes
Includes a defined process for managing risk?	No	Yes, ABC*D*
Supported by software?	Yes, LOSA	Yes, IDCAT
Elements tied directly to performance standards?	No	Yes
Works well with SMS?	Yes	Yes

Conclusion

Although both TEM and RRM approach the task from different paradigms and taxonomies, both are useful models for managing risk and enhancing safety in aviation, and beyond. Learn more to discover which model is most useful for your organization.