Flight Test Safety Workshop

“Threat & Error Management” for Flight Test

Captain Don Gunther
Senior Director
Safety & Regulatory Compliance
History of Crew Resource Management (CRM)

- NASA workshop 1979
  - Cockpit Resource Management
  - Reduce “pilot error” through better use of resources
- Phase 1 - CLR/CCC - 1981
  - Derived from corporate management
  - Focus on management skills
  - Goal - fix the “Wrong Stuff” captains
- Phase 2 & 3 1986 - 1996
  - Change the name to Crew Resource Management
  - Focus on concepts
    - Decision Making
    - Teamwork and Leadership
History of Crew Resource Management (CRM)

- Phase 4 - Error Management - 1997
  - Returned to original concept Error avoidance strategy
  - Focus on managing human error
  - Changed from PNF to PM

- Phase 5 - Threat and Error Management - 2001
  - Identify threats that can lead to errors
  - Develop strategies to manage threats and reduce errors
Why are we still doing TEM/CRM training?
We Need to Continuously Improve Aviation Safety
1965 - 2004

Hull loss accidents per year

Airplanes in service
1960: 438
2004: 19,077
2015: 25,400

Boeing 2004 Statistical Data – May 2005

Departures 2004
17.5 Million

Accident Rate / Million Departure

Our Goal

Millions of departures

Hull loss accident rate

Continental Airlines, May 2006
Accident Rate

Western-built Jet: Hull Loss Rate 1996 - 2005

IATA Safety Report 2005
### Accidents by Primary Cause
1994 - 2003

<table>
<thead>
<tr>
<th>Primary Factor</th>
<th>Number of accidents</th>
<th>Percentage of total accidents with known causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight crew</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Airplane</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous/other</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Airport/ATC</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total with known causes</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Unknown or awaiting reports</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td></td>
</tr>
</tbody>
</table>

Excludes:
- Sabotage
- Military action

Boeing 2003 Statistical Data – May 2004
TEM Workshop Agenda

- Developing a TEM Program
  - Line Observation Safety Audit (LOSA)

- TEM Program
  - Case Studies
  - Decision-making & Leadership

- Automation Policy
Developing a TEM Program
Error

“If I commit an error I do it without bad intention.”

Stand Watie – Brigadier General Civil War
Safety Culture

Aviation Week Article on Healthy Organizations

“Investing the time and money needed to get at the root cause of a problem takes total commitment at the most senior levels of a company or organization. In most organizational settings, communicators learn early in life how bad news can impact their leaders. If the news is valued and the communicator is protected, there is a real chance information can and will routinely flow upward in time for proper action to be taken.”
The Safety Change Program

“Tailored to Continental”

- To properly target change we need current operational data, specifically for Continental, which is unique due to its...
  - History & Culture
  - Areas of operation (CMI, polar routes, etc.)
  - Training Programs
  - Philosophy
The Safety Change Program
“Tailored to Continental”

Collect Data (Measure)

- ASAP
- LOSA
- Captain Irreg
- AQP
- FOQA
- Safety Audits
- Line Checks
- Crew Contacts
By not having data to discover the precursors “specific” to your operations, this is the bottom-line...
LOSA Information for TEM
"Normal" Performance

- Distance between “Perfect” and “Normal” performance varies as a function of culture, training, etc.
- LOSA enables us to get as close to normal performance than was previously possible.
The Continental LOSA Process

- **1st year**
  - LOSA and data analysis followed by course development

- **2nd & 3rd years**
  - Training course for all crewmembers, Check Airmen training and imbedding of TEM into courseware, policy & procedures, etc.

- **4th year**
  - Preparation for next LOSA and targeting areas to be measured and new areas to be emphasized.
Line Observation Safety Audit

LOSA 1996
Error Management’s early focus was:

Managing crew error
Error Management

![Diagram showing the relationship between errors, consequences, resist, and resolve.]

- Errors
- Resist
- Resolve
- Consequence
Line Observation Safety Audit

LOSA 2000
LOSA 1996 vs. 2000

- A 70% reduction in Checklist errors
- A 60% reduction in unstable approaches (confirmed by FOQA data)
- Overall improvement in crew performance
- Still a need for improvement in Leadership skills
Threat and Error Management
Threat

- Event that occurs outside the influence of the flight crew, but which requires crew attention and management if safety margins are to be maintained

- Increases the complexity of the operation
THREATS

Influences that can lead to crew error

- Distractions
- Passenger events
- ATC
- Terrain
- Similar call sign
- Time pressures
- Flight diversion
- System malfunction

- Cabin Crew
- Weather
- Maintenance
- Ground Crew
- Heavy traffic
- Unfamiliar airport
- Automation event
- Missed approach
Threat Management

*Strategies/Countermeasures*

(Industry, Corporate and/or Personal)

- To reduce the number of errors
- To improve the error management process by increasing the awareness of potential errors
- Is managing your future
Threat and Error Management

THREATS

Strategies

ERRORS

Resist

Resolve

CONSEQUENCE
Error

- Actions or inactions by the flight crew that lead to deviations from intention or expectation

- Intentional non-compliance is not an error
Error Management

Actions taken to deal with errors committed by either

- Detecting and correcting them, or by
- Containing and reducing the severity
- Is managing your past
Error Management

ERRORS

Resist

Resolve

CONSEQUENCE
Error Management

RESIST
HARDWARE & SOFTWARE THAT EXISTS BEFORE THE HUMAN ENTERS

ERRORS

Resist

Resolve

CONSEQUENCE
RESISTANCE

HARDWARE & SOFTWARE THAT EXISTS BEFORE THE HUMAN ENTERS

• GPWS
• TCAS
• TRAINING
• MANUALS

• SOP’s
• CHECKLISTS
• AUTOMATION
• ATC
Error Management

RESIST
HARDWARE & SOFTWARE THAT EXISTS BEFORE THE HUMAN ENTERS

RESOLVE
WHAT THE HUMAN BRINGS TO THE SYSTEM

Continental Airlines, May 2006
RESOLVE

WHAT THE HUMAN BRINGS TO THE SYSTEM

• PROFICIENCY
• VIGILANCE
• ASSERTIVENESS
• MONITORING & CROSSCHECKING

• DECISION MAKING
• EXPERIENCE
• LEADERSHIP
• SIT. ASSESSMENT
• CHECKLIST DISCIPLINE
NASA Guidelines

Monitoring & Crosschecking

- Positively delegate flying and monitoring duties

- Monitoring is as important as flying

- Flying pilot does not become involved with secondary tasks

- When conflict arises-resolve with outside source

- When in doubt-must express!
Monitoring & Crosschecking

PM

Challenge

Solution

Problem

Express view

Take action
Threat and Error Management

Threats

Strategies

Errors

Resist

Resolve

Consequence

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Consequences

Undesired Aircraft State (UAS)
Threat and Error Management

THREATS

Strategies

ERRORS

Resist

Resolve

CONSEQUENCE
Case Studies

“Look in the mirror first”
Case Study
NTSB “37 Accidents”
US 121 Airlines 1978-1990

- Captain was Flying Pilot-------- **81%**
- First Day of Trip ------------------ **73%**
- First Flight------------------------ **44%**
- F/O Time in Position/Aircraft
  - Average **419** hours/seat
  - **50%** First Year
- Time Since Awake (TSA)
  - Captain    **12** plus hours
  - FO         **11** plus hours
## NTSB STUDY

Late or behind schedule 55%

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Operations</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0600 - 1400</td>
<td>44%</td>
<td>27%</td>
</tr>
<tr>
<td>1400 - 2200</td>
<td>43%</td>
<td>43%</td>
</tr>
<tr>
<td>2200 - 0600</td>
<td>13%</td>
<td>30%</td>
</tr>
</tbody>
</table>
ADDITIONAL “RED FLAGS”

Night
Weather
Late runway change
Unfamiliar Airport
Operational Pressure
Reason’s Swiss Cheese Model
THREAT AND ERROR MANAGEMENT

DIFFICULT APPROACH

LATE DESCENT

Resist

Resolve

HIGH & FAST

Stable Approach Guidelines

Approach Brief

No Fault G/A Policy

CRW and the Bottomline

One Situation Not Managed

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Threat and Error Management

Threats

Strategies

Errors

Resist

Resolve

Consequence
TEM
“the challenge”

How to improve

“Threat & Error”
identification

“Get it on the RADAR”
Distraction
Threat and Error Management

Threats → Strategies → Decision Making & Leadership → Resolve → Consequence
DECISION-MAKING

“Plan, Review, Monitor & Modify”
Decision Making

Tactical

Perceive Situation

Situation Assessment

Select a Course of Action

Monitor Results
Situation Assessment

The Nature of the Threats
Proper Threat Identification

to Enhance Situational Awareness
What have you seen?
Threat and Error Management

“Training”

THREATS

Strategies

ERRORS

Resist

Resolve

CONSEQUENCE

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TEM & Automation
To ERR is Human

To REALLY screw up you need a computer!
The Continental Airlines
Automation Policy

Verbalize
Verify
Monitor
TEM
“the challenge”

Improve “Threat & Error” identification by using

Verbalize, Verify, Monitor

To help “Get it on the RADAR”
Several airports were identified that due to ATC, environment, etc. put crews in a high-energy or potential unstabilized approach situation.

MCO selected as the “pilot” project to establish process for FMS visual approaches.

Industry and MCO TRACON worked together and established an FMS visual procedure.

- Steve Ruckman – MCO TRACON
- Jim Carmen – Delta Airlines
- John Anderson – Continental Airlines

HNL, ABQ, EWR are being developed.
Threat and Error Management

Verbalize, Verify, Monitor

AUTOMATION
THREATS

ERRORS

Resist

Resolve

Hardware & Software that exists before the human enters

What the human brings to the system

CONSEQUENCE
TEM Applied to Incident & Accident Analysis
TEM Toolkit
for
Incident & Accident (IA) Analysis
IATA Safety Advisory Committee

Incident & Accident analysis

Threat and Error Management (TEM)

ANALYTICAL TOOLKIT

Introduction

The TEM Analytical toolkit has been developed for Safety Managers to facilitate presenting and sharing events and lessons learned. The toolkit is comprised of the document, explaining the TEM concept, and the presentation template. For more information on Threats and Errors and IASA, refer to IASA 2003.

Background

Threat and Error Management (TEM) is proposed as a method to analyze incidents and occurrences. Using the model, situations leading to unsafe actions, unsafe acts, and consequences are identified. The model helps to define potential threats and highlight areas and steps that need to be addressed. It also helps to keep the focus on the relevant factors learned from the event, moving away from the why and what and towards understanding the how.

Definitions

Threats are situations external to the flight deck that must be managed by the cockpit crew during normal everyday flight. Such events increase the operational complexity of flight and pose a safety risk to the flight and one level (see attached threat sample template).

Errors are actions or omissions by the crew that lead to deviations from organizational or aetiological intentions or expectations. Error is the operational context leading to increase the number of safety and increase the probability of accidents or incidents. (See attached for examples of errors)

Undesired Aircraft States: occurs when the flightdeck places the aircraft in a state of unnecessary risk. As defined, an aircraft is an undesired state of motion which response to a non-reaction of reaction (error).

Managed by M: managed

- Managed: an action crew response to a threat, error, or undesired aircraft state is detected and mitigated to an acceptable state (e.g., normal flight).
- Unmanaged: an action crew response to a threat, error or undesired aircraft state is detected and incorrect action or reaction, additional error, undesired aircraft state, or accident. An error or undesired aircraft state becomes more difficult to control.

Comparison of Threats, Error and Accident:

An error indicates a deviation from the expected behavior. The following example is used to illustrate the difference between a threat, error, and accidents.

Aircraft B is loading in the stand and is taxiing short of the active runway. The TID short of the active runway is poorly painted and very faint. Aircraft B passes over the TID short. A runway incursion incident occurs.

In this scenario:
- The Threat is the poorly painted TID short.
- The Error is committed by the flightcrew of Aircraft B when they taxi onto the active runway.
- The outcome is a runway incursion.

Prevention Strategies

Using Threat and Error analysis and training to analyze and present events and lessons learned, the crew identifies, recognizes, and manages the threats and errors, logically evaluates prevention strategies, implements action and measures. This approach enables safety managers to go beyond the traditional approach of identifying "what went wrong" and thing it, to a more proactive approach of also examining "what went right" and encouraging behavior that contributes.

Examples of Threats and Errors

Threats
- Weather
- Mixed Approaches
- Heavy Traffic
- Distractions
- Distracted
- Flight Directions
- Similar Callouts

Errors
- Incorrect Actions
- Omissions
- Miscommunications

Continental Airlines, May 2006
THREAT AND ERROR MANAGEMENT (TEM):
ANALYTICAL TOOLKIT

Introduction
The TEM Analytical toolkit has been developed for Manager’s to facilitate presenting and sharing events and lessons learned. The toolkit is comprised of this document, explaining the TEM concept, and the presentation template.

Background
Threat and Error Management (TEM) is proposed as a useful tool to analyse incidents and occurrences. Using this model naturally leads to prevention strategies, remedial actions and countermeasures. The model helps to reinforce positive strategies and highlights areas and issues that need to be addressed. It also helps to keep the focus on the relevant lessons learned from the event, moving away from the who and what and towards understanding the WHY.
Threat and Error Management (TEM)

THREATS

Strategies

ERRORS

Resist

Resolve

CONSEQUENCE
Threats

1. List of the Threats

2. 

3. 

4. 

5. 

6. 

7. 

8.
### Threat Management

1. Identify the Threat

2. 

3. 

4. 

1. Was the threat managed or mismanaged? How?

2. 

3. 

4. 
Errors

1. List of the Errors

2.

3.

4.

5.

6.

7.

8.
## Error Management

<table>
<thead>
<tr>
<th>1. Identify the Error</th>
<th>1. Was the error managed or mismanaged? How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
<tr>
<td>4.</td>
<td>4.</td>
</tr>
</tbody>
</table>
Undesired State Management

- List how the Undesired State was managed or mismanaged.
Prevention Strategies

- List initial corrective actions at the present time and any proposed actions.
TEM as an Integral part of a Safety Management System (SMS)
Goal

- Become a better Threat Manager – actively identify threats in your operation

- “Threat Management is managing your future.”

- “Error Management is managing your past”

- Continue building a Safety Culture by encouraging open, honest communications
Threat and Error Management

- Threats
- Strategies
- Errors
- Resist
- Resolve
- Consequence

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