Example Application of Procedural Event Analysis Tool (PEAT)

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Preface

This example application has been prepared by the Boeing Company in conjunction with the Global Aviation Information Network (GAIN) Working Group B (Analytical Methods and Tools) (WGB) as one of a number of such examples of the use of analytical methods and tools described in the "*Guide to Methods & Tools for Airline Flight Safety Analysis*". The intent of these example applications is to illustrate how various tools can be applied within an airline flight safety department, and provide additional information on the use and features of the tool and the value of such analysis. GAIN WG B hopes that these example applications will help increase the awareness of available methods and tools and assist the airlines as they consider which tools to incorporate into their flight safety analysis activities.

Each example application of an analytical method or tool is posted on the GAIN website (*www.GAINweb.org*). Readers are encouraged to check the website periodically for a current list of example applications, as further examples will be added as they become available.

Procedural Event Analysis Tool

1 Introduction

The Procedural Event Analysis Tool (PEAT) is a tool for investigating flight crew operations system failures and is part of a set of reactive tools developed to augment an airline Safety Management System. In support of the industry effort to implement Safety Management Systems at airlines, Boeing has developed tools and processes to help airlines manage safety risks associated with human error.

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The objective of PEAT is to establish cause and effect in the analysis of incidents involving flight crew operations system failures which are often manifested in flight crew procedural deviations/errors. Since flight crew error has been the primary factor in most incident/accidents, an effective tool is needed to further lower the safety risk in this area. PEAT is a process for data collection and analysis with a database for storage, trend analysis, data sharing, and report generation.

PEAT relies on a cognitive approach to identify the underlying reasons for crew performance. It is well established that incidents and accidents involve flight crew errors. The underlying reasons for the flight crew errors are called contributing factors.

Contributing factors are normally defined as conditions under management control that lead to procedural non-compliance. Procedural non-compliance is broadly defined as any action that the flight crew should or should not have taken. PEAT was specifically developed to investigate serious operational events, but not accidents.

Whether or not an act of non-compliance may be intentional, it is rare a non-compliant crewmember expects a potentially negative outcome. In most cases, multiple contributing factors beyond the crewmember's control lead to erroneous actions. Obviously, cases of intended consequences or reckless disregard for possible consequences are not considered human error in the context of PEAT analysis.

The PEAT analysis Form contains 7 main categories of contributing factor types. These include Procedural, Equipment, Situational Awareness, Performance Shaping, Crew Coordination/Communication, Environmental/Facility and Technical Knowledge/Skills/Experience Factors. An open communication or "Just Culture" policy is essential to an effective PEAT investigation of those factors.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

In the event described below, a PEAT investigation was conducted to gain an in-depth understanding of factors that contributed to flight crew actions which led to a runway overrun after a landing.

2 Input Data

In addition to the collection of general event information, the essential data for the PEAT process are gathered from structured interviews with flight crews who were involved in the event. The overall objective of the investigation is to learn how similar errors can be prevented in the future.

After a preliminary review of factual incident information and interview preparation, the PEAT investigator will arrange for an interview with each of the crewmembers involved. The first step in the process is to ask the crewmember for recommendations that, in his/her opinion would prevent that type of incident in the future. This approach of soliciting crewmember recommendations further empowers the crewmember and sets the stage for determining what actions (i.e., procedural errors) led to the event and, most importantly, what the conditions (i.e. contributing factors) were that influenced flight crew decisions.

In summary, the purpose of the interview is to understand and record the errant crew member actions and the underlying reasons for their actions. Once the causal relationship is established between the crew errors and the contributing factors, it is possible for the investigator to develop a set of general recommendations aimed at reducing or eliminating the effect of the validated contributing factors initially identified from the discussion with the flight crew.

The events and procedural deviation/errors are preventable through the management of the contributing factors. See Figure 1 for the model of a PEAT event investigation. Note that all procedural deviations were necessary to make this event occur. All the depicted factors contributed to the procedural deviations.

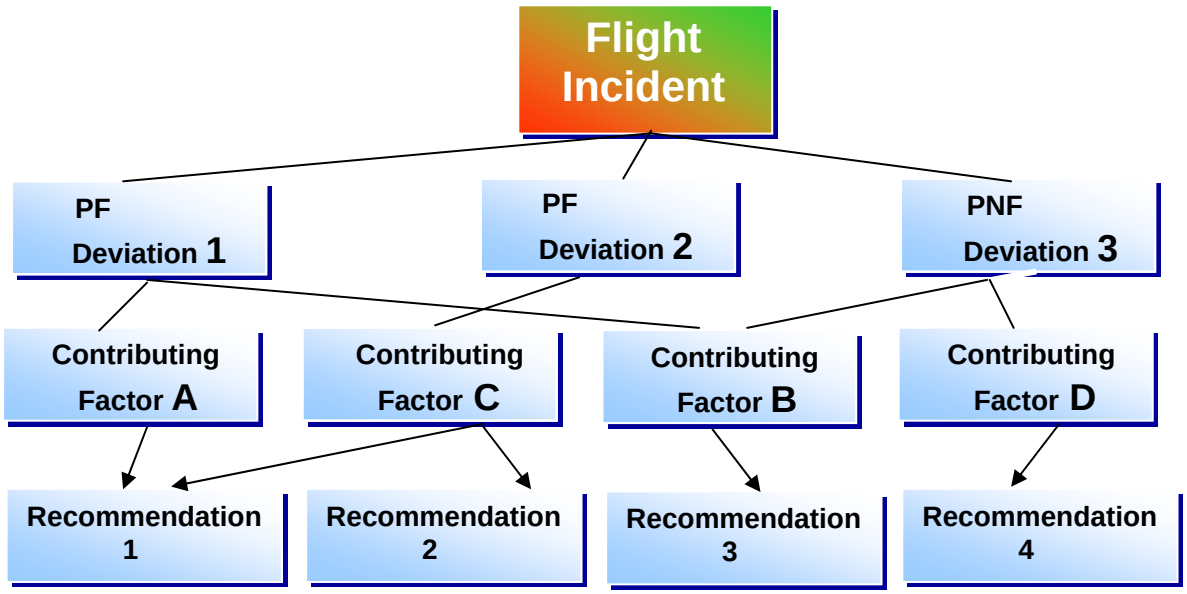

Figure 1 **Flight operation incident investigation model**

Because of the complex relationship that exists between factors and deviations in the event, PEAT analysis doesn't apply Root Cause method or a "Blame" approach.

3 Analytical Process

With the use of Cognitive Process, the task of identifying contributing factors is primarily the responsibility of the employee who actually experienced those factors and made decisions that led to the incident. The investigator is not the author of the story, just systematic organizer and describer of the story. Obviously, this process can *rarely* be applied to incidents in which the crewmember is under jeopardy.

3.1 PROCESS STEPS

After an event happens and a preliminary event summary is assessed,

1. Management determines if amnesty will be granted to each crewmember involved. The PEAT philosophy maintains this should automatically be the case with most events that are contained within the airline's jurisdiction. Management then authorizes the PEAT investigation.
2. The investigator/manager assigned to the event will prepare for the structured interview by reviewing:
    a. Preliminary event information
    b. Procedures that should have prevented the event
    c. Initial employee reports, if any

    The investigator will develop a list of potential errors that the flight crew may have committed, *but will avoid speculating about the contributing factors to those errors*. This list may be helpful to the crewmember as he recreates the event description during the interview.
3. The investigator should arrange an interview time and location that is as comfortable as possible for the crewmember.
4. As mentioned already, the investigator should start by asking the employee:
    a. What company/management should do to prevent this incident in the future?
    b. What the crewmember (as well as other employees) should do to prevent this kind of incident in the future.
5. Given those recommendations, the investigator should identify what contributing factors the crewmember's recommendations would address. Crewmember recommendations may or may not effectively remedy the effects of contributing factors. However, the process of proposing recommendations/improvements naturally leads the crewmember to think about the contributing factors to his errors.
6. Given the initial list of contributing factors identified by the crewmember, the investigator will organize those contributing factors by the crew decision errors they induced. A skilled PEAT investigator will emphasize that the focus of the investigation is not on the crewmember ability, but on how those contributing factors "worked together" to induce the errors.
7. The investigator should use the actual flight crew procedural errors to completely describe the event. The investigator may find that he and the crewmember will need to thoroughly review the sequence of procedural steps that applied to this event. The product will be a factual sequence of actions leading to the outcome called the "event summary".
8. The investigator should thank the crewmember for his help and maintain an avenue for follow-up contact with the employee.
9. Based on the event summary and list of contributing factors, the investigator will provide general recommendations aimed at reducing or eliminating the effect of contributing factors in the incident to relevant managers. While the investigator's report alone may often be sufficient, the investigator should be available to facilitate the development of specific recommendations with the applicable managers.

3.2 EXAMPLE CASE

The Chief Pilot was informed that a company aircraft had overrun a runway on landing. Airplane damage was minimal and no injuries were reported. However, there were some passenger complaints about excessive confusion prior to deplaning. The resulting damage was repaired in a few hours and the airplane was returned to service the following day. Both crewmembers had records of excellent performance prior to this event.

Summary of PEAT investigation findings upon completion of the process

This investigation discovered a number of contributing factors that could be addressed by management action. Because of the open communication resulting from the PEAT process, the strongest contributing factor to the incident was the fuel upload request procedure. In cases such as this in which pilot judgment may indicate a reasonable increase in dispatch fuel, the process for obtaining such a safety margin is cumbersome.

Because the fuel quantity prior to departure was legal for the conditions forecasted, the crew found it difficult to justify additional fuel. When the weather conditions deteriorated below forecasted levels and the destination glide slope went out, time pressure became a major factor. A late ATC clearance led to a rushed approach and delayed spoiler deployment contributed to the runway overrun. While no single error would have led to this event, a number of difficulties worked together to prevent an uneventful landing.

Subsequent discussion with Operations management resulted in changes to the fuel upload policy. While other contributing factors existed at the time of the incident, and will continue to exist to some extent, the fuel upload procedure was determined to present the most significant risk to human error. It is also the

Event information

1. Because the event was contained and the flight crewmembers passed an administrative investigation, the Chief Pilot determined that a PEAT investigation should be conducted.
2. A Flight Safety Investigator and pilot familiar with the type of aircraft were assigned to investigate the event. They compiled available event information, applicable approach/landing procedures, and copies of aircrew reports made immediately after the event. They found:
    a. Thunderstorms were in the area and the runway was wet.
    b. The thrust reversers had been deactivated by maintenance.
    c. The airplane had been dispatched with adequate fuel reserves for the forecast weather. Landing was conducted during daylight.
    d. Weight and balance figures were normal.
    e. Captain was high time in type and First Officer was low time in type.
    f. Both pilots had recently completed recurrent training.
    g. This was the third and last sector of their duty day.
    h. Runway was short, but not extremely short for this aircraft type.
    i. The ILS was out of service. A VOR approach was conducted.
    j. The aircrew reports indicated that they were number one in a three airplane-holding stack over the final approach fix waiting for a thunderstorm to pass over the airport. After the thunderstorm had passed, the approach clearance put them high on final. Ceiling was

1,000 feet; Captain was flying the airplane; touchdown was a "few hundred feet" long, braking action was poor; spoilers were deployed manually. Another weather build up was identified and expected to be over the airport in one hour.

The Flight Safety and pilot investigators developed a list of several potential crew procedural errors. They discussed a few potential scenarios (preliminary event summaries), but wisely withheld judgment until they confer with the flight crew.

3. The Flight Safety investigator contacted the pilots and familiarized them with the company policy regarding the use of PEAT. Because the program was relatively new to the company, the Chief Pilot referred to newly established non-punitive safety investigation company policy and gave personal assurances to both pilots that amnesty would be granted to them for this PEAT investigation. The First Officer agreed to an interview at the Safety office and the Captain agreed to an interview at a local lounge.
4. For brevity, this example will reflect only the Captain's interview. From the interview, the Captain (PF) made the following recommendations:
    a. Management should streamline the current fuel upload request process.
    b. Management should add at least one more enroute alternate for this sector.
    c. Management should inform the local ATC facility of the performance limits of this aircraft.
    d. The spoiler "armed" indication for this aircraft is difficult to see.
    e. This Captain plans to add one hour of holding fuel to the normal flight planned amount for this sector given similar seasonal weather conditions.
5. The Captain stated the contributing factors to the event (to be listed below).
6. The Captain disclosed his procedural non-compliance errors along with their contributing factors.
    a. (Error #1) The PF did not request sufficient holding fuel for this sector although he was within company limits.
        i. Weather forecasts for this season tend to be variable.
        ii. The procedure to request fuel from dispatch is cumbersome.
    b. (Error #2) The PF did not initiate a diversion during the hold when the fuel quantity reached the divert level.
        i. Approach clearance came at the time the divert fuel level was reached.
        ii. The weather at the Alternate airport was becoming marginal.
    c. (Error #3) The PF did not fully arm the spoilers during the before landing checklist. This resulted in late spoiler deployment upon landing.
        i. The "armed" indication for this type of aircraft is difficult to see. Note: since the thrust reversers were disarmed, spoiler arming is essential to automatic spoiler deployment.
        ii. The approach was rushed due to the fuel level, position in the holding stack, and impending reclosure of the airport due to approaching thunderstorms.
7. While the PF's list of errors and contributing factors was extensive, further discussion revealed that the Captain did not make an immediate announcement to the cabin instructing the passengers to remain seated. This resulted in many passengers getting out of their seats prematurely. The shock of

the outcome temporarily distracted the Captain from informing the passengers as well as subsequent radio communication with ATC/company to support the egress.

8. At the close of the interview, the Flight Safety investigator asked the Captain to call him if he remembered any additional information relevant to understanding this event. The investigator assured the Captain that the investigation findings would be shared with the Captain. The Captain was encouraged to explain how PEAT worked to other pilots whenever the opportunity arose.
9. General Recommendations:

   After a brief analysis, the investigative team proposed that:

   a. The company should review the pilot-requested fuel upload process since two signatures from dispatch are required to authorize any upload.

   b. The company should review the thrust reverser deactivation policy in terms of how often deactivations occur and if revenue flights should be restricted in those cases.

A sample of PEAT investigator findings using the "Actual Deviations & Contributing Factors" form is shown below. This form addresses one of the PF's procedural deviations and depicts how the interview information is captured. After completion of the analysis the General Recommendations and Specific Actions are also listed for this procedural deviation (error) on this form.

Actual Deviations & Contributing Factors Form
Event #: 737-2-3-03

After the crewmember identifies the contributing factors to (i.e. conditions inducing and underlying reasons for) procedural deviations, organize the factors under each deviation they contributed to. Provide rationale for how each factor led to the deviation.

Deviation # 1: The PF did not request additional holding fuel from dispatch prior to this departure in accordance with the company dispatch fuel policy.

Specific procedural steps/tasks that the crewmember *should* have accomplished:

1- PF recognizes the potential for holding times in excess of legal requirement for fuel.

2- PF estimates additional fuel required for this particular sector and makes request to dispatch for fuel uploads up to 30 minutes over the normally prescribed amount.

Contributing factors (include description and rationale):

1. Factor: Fuel dispatch process

Rationale:
Process for requesting additional fuel upload is cumbersome and has caused delays in the past. PF didn't want to delay the departure.

2. Factor: Unreliable weather forecasts

Form continued on next page

Rationale:

Weather forecasts and reports are unreliable for this time of year and sector. PF was concerned that the weather would be worse than predicted by the forecast. To order more fuel might raise questions by management because the forecast didn't warrant it.

Investigator General Recommendation(s):

1. Review fuel upload procedure and provide crews additional guidance for judgment calls like this.

2. Review potential for improving weather forecasts or crew interpretations of the forecasts.

Risk managers: Chief Pilot, Standardization, Dispatch Manager

Management Specific Action(s):

1. **The process for additional fuel load requests will be streamlined for this particular sector and changes to the weather forecasting process will be evaluated.**

2. **A bulletin will be sent to pilots and dispatchers announcing this change and the rationale for the change. Other sectors will be reviewed based on reports or incident cases for similar issues**

Similar documentation will be completed for the other procedural deviations in this event.

The PEAT process also uses an analysis matrix to assess risk. A table representing the relationship between the contributing factors and the deviations they affect be used to help determine the significance of the factors. A table for this example event is shown (Contributing Factors affecting Crew Deviations).

Contributing Factors affecting Flight Crew Procedural Deviations

Contributing Factors

Deviation	Fuel Dispatch Process	Fuel/Time Pressure	WX Reports	Alternate WX	Over-confidence	CRM	Control Layout	Complacency due to equipment reliability
#1. PF did not request additional fuel prior to departure.	X		X					
#2. PF did not initiate a diversion when fuel quantity reached divert level.		X		X	X			
#3. PF did not arm spoilers.		X					X	
#4. PNF did not challenge PF for request for clearance amendment.		X			X	X		
#5. PNF did not verify spoiler arming.		X					X	
#6. PF did not go-around.		X		X	X			
#7. PNF did not manually deploy the spoilers.								X

4 Tool's Output

While the procedural deviations/errors are necessary to link the contributing factors to the outcome, the key output is an organized description of the contributing factors and general recommendations for how to address those factors. The contributing factors to errors constitute threats, hazards, or system imbalances managers will want to consider in their risk management processes. Additionally, the output will include a complete event summary that presents the "whole story" of what happened.

Once the investigation has been completed the investigation information can be entered into the PEAT database via PEAT Form. The PEAT application software has several capabilities, including query, reports, graphs, trend analysis, secure communication and data sharing.

5 Application of the Analysis Results

In this particular example, management may develop a specific policy that allows 30 minutes of fuel reserves to be added without additional authorizations at dispatch. If the Captain develops a personal policy to be more conservative (adding one hour reserve to this sector) just because he was "burned," then airline efficiency might be compromised. However, it might seem reasonable to management in such cases to allow pilot-requested uploads up to 30 minutes without question.

The above example highlighted the value of using open communication with limited amnesty to obtain an in-depth understanding of the contributing factors to errors that led to an incident. By seeing the relationships between the errors and the factors, management can take more precise actions to prevent the effects of significant contributing factors in the future. The effects of contributing factors are course, procedural non-compliance errors that cover up or lead to system inefficiencies, not to mention serious incidents and accidents.

What might have happened without PEAT

It is important to note that the typical course of management action to an event such as in this example is to blame and train the involved employees. Without other investigative options, management might have been compelled to send that crew to the simulator. More training would have not addressed the fuel planning contributing factor, which was a strong contributor to the other errors. More training only for these employees would have been a waste of company resources.

Had the event been more serious, the crewmembers might have been disciplined and the problem of fuel planning processes would have remained undetected. One significant side effect of such inferential (or "unjust") administrative action could be a further drain on efficiency. Because of fear those pilots, as well as other employees, might resort to career-protecting behaviors that may not be in the interest of the airline's safety.

PEAT database storage and analyses capabilities

The information from this investigation can be stored in the PEAT database for further analysis, generating reports/graphs and for secure electronic distribution, etc.