

Human performance breakdowns are rarely accidents: they are usually very poor choices with disastrous results

Robert O. Besco*

PPI, 3131 Maple Ave., Suite 12D, Dallas, TX 75201, USA

Abstract

When human error is involved in the error chain of accidents in complex systems, the causes of the errors are very seldom the result of:

1. a random slip,
2. one inadvertent oversight,
3. a single unintended action,
4. one mis-perceived event,
5. simple mal-performance of a complex action, or
6. a poor training program for the human operators.

Invariably, the cause of the break down is in a very poor conscious choice by someone from the operator back through system designer, the supervision, management and leadership through the entire organization. Usually the operator bears the burden of the blame and is either rebuked, retrained or replaced. In systems such as commercial aviation, complex manufacturing systems, power plants, process control systems, information-processing systems and communications networks, the replacement or retraining of individuals or even classes of individuals usually does not result in any long-term improvement of the safety or effectiveness of the system.

What is needed is a system that identifies the reasons why the operators made the errors. Further a system is needed that can recommend what can be done to improve the future performance within the system. The professional performance analysis system (PPAS) has been developed and applied to more than 50 major aircraft accidents in the past 30 years. The PPAS is a direct outgrowth of the human performance analysis system developed by Robert Mager over 45 years ago.

The PPAS system is applied after a complete and unbiased definition and description of the events of the accident or incident has been developed by the teams of accident investigation and accident reconstruction professionals. The PPAS then uses a systematic protocol and algorithm to determine the reasons as to why the humans committed the errors or why they performed at subnormal performance levels. This process is based on quantitative behavioral science principles and findings that have been demonstrated valid for many generations.

The PPAS looks at five attributes of human performance to identify the factors that can be changed to improve performance in the future. The result is a series of objective definitions of changes that have been demonstrated to be the attributes that influence human performance.

The PPAS provides a tool to the analyst, who lacks sophistication or experience in quantitative behavioral sciences, to arrive at recommendations that are based on validated human performance principles.

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When a very senior flight department manager, with decades of successful professional flying experience, is flying with a very experienced professional copilot, there would appear to be very little concern for them to make serious and lethal blunders that would result in a tragedy. It would appear that the several layers of defenses, which

have successfully operated for decades, would guide the crew to make choices that would not put their aircraft, their passengers and themselves in harms way.

What then, did happen on AAL Flight 1420 from DFW into Little Rock on the evening of June 1, 1999? The flight crew pressed-on into intolerable conditions resulting in an overrun accident that killed 10 passengers and the Captain. The aircraft was destroyed by impact and subsequent fire.

* Tel.: +1 214 468 0830.

E-mail address: rbesco@ppi.aero (R.O. Besco).

The National Transportation Safety Board determined that the probable causes of this accident were the flight crew's failure to discontinue the approach when severe thunderstorms and their associated hazards to flight operations had moved into the airport area and the crew's failure to ensure that the spoilers had extended after touchdown. The NTSB concluded that contributing to the accident was the flight crew's (1) impaired performance resulting from fatigue and the situational stress associated with the intent to land under the circumstances, (2) continuation of the approach to a landing when the company's maximum crosswind component was exceeded, and (3) use of reverse thrust greater than 1.3 engine pressure ratio after landing (NTSB Report Number: AAR-01-02).

This statement of probable cause is typical of the level of detail that is found in aircraft accident reports. Although factual, the statements are primarily descriptions of what happened. They shed little light on why it happened and even less on what can be done to minimize the future reoccurrence of the fatal errors. These definitions do not explain why these normally routine events that had been successfully managed dozens of times by flight crews with even less experienced aviators, on this occasion, were allowed to deteriorate into serious lethal blunders.

The members of this flight crew were well intentioned and well trained. They were operating in relatively familiar environmental and operational conditions with fully functioning components. However, a subtle combination of lowered performance margins, deteriorating weather conditions and an overly committed sense of mission fulfillment led them to make choices that in retrospect they would never have repeated. At every point in the approach and landing, it is virtually a certainty that the crew felt that they were maintaining the margins of safety and had the welfare of their passengers uppermost in their minds.

1. The normalization of deviance

When normal limits are stressed and stretched on a regular basis, the deviance from standards will often become the norm. This process has been described in detail by Refs. [14,19,20]. It is now coming to light that in the Columbia Space Shuttle disaster that the risks of the foam striking the shuttle wings had been judged to be insignificant on several previous missions. As a result the risks were discounted by leadership in the Columbia mission to not be serious. It describes a situation for which I have developed the axiom, "It won't matter", eventually will matter".

The Challenger O-Ring blow outs, the Columbia foam shedding, the overlimit cross-winds during flight 1420 [17], and the steep, fast approach of Flight 1455 [18] into Burbank (resulting in a non-lethal loss of the aircraft) all are examples of the organizational standards being overlooked on a regular basis with no serious consequences resulting. The deviations and overlimits operation eventually become the norm [20].

Eventually, it is a virtual certainty that the "normalization of deviances" will result in a negative outcome as they did in all four examples above.

Expressed in another way is the fact that a main reason that aviation can be dangerous is that it is generally so very safe. The fact that minor deviances will usually result in a non-event will almost always lead to a cultural attitude of overconfidence and complacency. The "normalization of deviance" erodes the vigilance, wariness and alertness needed to detect and counteract the subtle and stealthy risks that are often behind serious aviation accidents.

2. Complacency countermeasures

Gerard Bruggink is a retired Chief of Accident Investigation for the NTSB. He has long promoted that wariness is one of the main performance traits that will prevent accidents [13]. Bruggink was an early voice in identifying corporate culture as a major factor in complacency and risk denial.

Another axiom out of World War II radar surveillance is that "the price of eternal vigilance is indifference". Another alertness axiom that is derived from the mixing of metaphors on two ancient thoughts is "Don't cry wolf, because the sky might fall on you".

It is very easy to be alert, vigilant and wary of dangers when frightening and life-threatening events occur frequently. When potentially lethal events seldom occur, it is only human nature to become comfortable with ignoring the potential threats from rarely occurring events. This is what makes complacency so dangerous. It also makes the thorough and precise accomplishment of detection, wariness and vigilance tasks so hard to perform and so easy to ignore.

A key to accident reduction is to set up an organizational support structure that is intolerant of risk denial and supportive of risk detection [2]. In general, it will take several mistakes, errors and/or malfunctions to result in a significant mishap, mistake or accident. The corporate culture that supports wide safety margins will set goals, develop monitoring systems and follow through with recognition and rewards for all individuals, teams, and organizational entities that pay meticulous attention to and develop a persistent distaste for, all of the seemingly mundane elements of latent risk [2].

Robert Mager and Peter Pipe, in their landmark book "Analyzing Performance Problems" [14,15], point out those things that must happen to ensure that maximum safety margins result from professional performance.

1. Performance must be monitored. It must not be ignored.
2. Good performance must be recognized and positive feedback made available.
3. Poor performance must be recognized and consequential.
4. Action needs to be taken to improve performance.

These simple steps of leadership will establish a corporate culture that ensures that the widest possible safety marginal are provided in daily operations.

3. A system for monitoring and improving performance

The work of Robert Mager came to attention in the 1960s. He published his first book on Analyzing Performance Problems in 1970. Mager’s basic principles and procedures were applied to the analysis of the crew errors in the Eastern Airlines L-1011 accident in the Florida Everglades in 1972 [5–9,16].

The Mager and Pipe process was adapted to pilot error accidents in Aviation Safety Classes at USC starting in 1975. The professional performance analysis system was published in 1977 [12]. The basic system of Mager and Pipe was expanded to cover five dimensions that are causative to human performance. Fig. 1 contains the five interactive factors that are utilized in the professional performance analysis system (PPAS).

A complete description of the application of the knowledge dimension was published in Refs. [4,10]. The systems usability dimension was described in Refs. [3,11]. The skill levels and abilities dimension was published in Ref. [8]. The environmental obstacle dimension was published in Ref. [10]. The attitude dimension was first published in Refs. [7–9].

This paper focuses on the fifth dimension, productive attitudes. This is the area where corporate culture and personal professionalism come into analysis [1]. In my judgment, it is the most fruitful area for accident investigation because it has been ignored and minimized as a system-wide problem. We have focused our attention on training, selection, equipment design, and environmental obstacles such as weather, fatigue, life stressors and personality conflicts. The pilot error accident rates have remained nearly constant over the last few decades since the introduction of jet aircraft.

There are five major components that can contribute to developing positive attitudes or conversely to establishing a negative corporate culture that is limiting to human performance effectiveness.

4. Is performance ignored?

In any organization it is possible to tell the professionals that their performance is important and then not do anything about monitoring their performance. If a leader does not know the relative performance levels of the professionals in the group, the professionals will soon learn that the importance of the unmonitored functions are really not important to management’s perception of high performance. Rational performers will improve on and pay attention to their monitored performance of such parameters as record keeping, social acceptance, punctuality, shoe shines, haircuts and grooming.

It is possible to send subtle messages that the performance of a group is not important to management by such signals as low pay relative to other groups that the corporation thinks is more critical. Lack of support for the function by not maintaining cleanliness standards in the facilities such as lunch rooms, rest rooms, and tool storage rooms also sends a subtle message that the function is not important to the corporate culture.

To remove these negative influences, the organization needs to monitor performance of everyone on all critical dimensions. The high performers should be recognized and the lower performers should be provided with means of improving their performance. A method of objectively measuring performance needs to be developed that is free

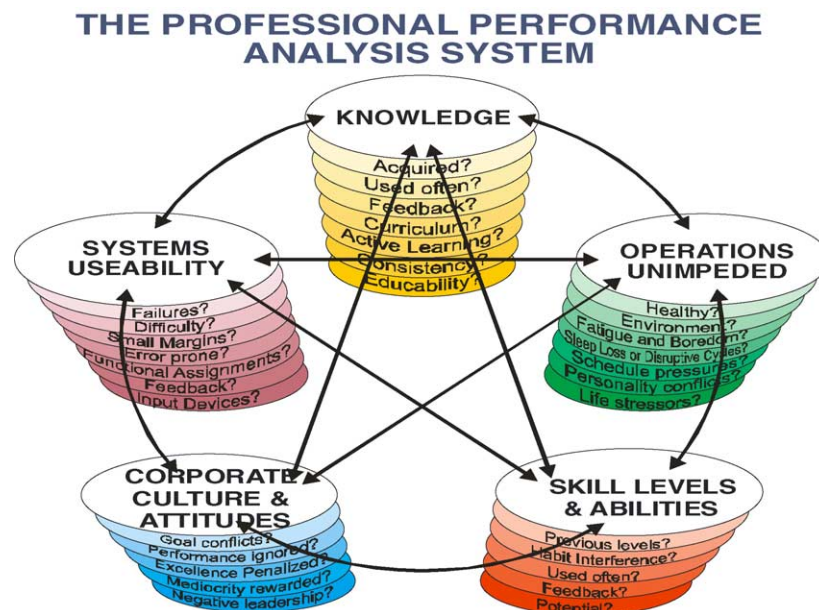


Fig. 1. A diagnostic model to analyze and understand what happened, why it happened and what to do to improve performance.

of personal bias, whimsical standards, and arbitrary application.

5. Is excellence penalized?

It is very tempting to give the toughest, dirtiest assignments to the top performers. These tough assignments are often the projects with high profiles and the opportunity for public embarrassment if failures occur. This can include night, weekend and holiday assignments. Being given the dirtiest, toughest tasks and depriving the high performers of

control of their personal lives by being put “on-call” will eventually result in professionals striving to stay within the norm. If the high performers, are given other economic, personal or professional rewards and recognition, the extra burdens can be mitigated.

Another aspect of penalizing excellence can come from the peers in the work group when a high performer is ostracized by peers for being a “rate buster”.

In the area of suggestions for changes, improvements and increasing safety margins, the suggestors can be labeled “trouble makers” for not being content with the status quo. When the first level leadership is satisfied with things as they

Table 1
Principles of leadership

The steps to leadership excellence

1. Define consistent goals
2. Find quality people
3. Make certain that the goals are universally understood
4. Provide effective training, tools, and methods
5. Clear the pathway of all obstacles and roadblocks
6. Stay out of their way
7. Actively encourage excellent performance

Leaders of high performing groups ensure that the following climate exists for everyone

1. Consideration for the value of individuals
2. Structure for the processes, tasks, functions, work groups, individuals and the organization

It is easier and much more effective to hire smart than to manage tough! (Chaney)
 If you wait to hire people until you need them bad, you will get them bad!
 Make the strengths of people productive and their weaknesses irrelevant. (Drucker)
 Get people in the same boat with you: they will not drill any holes in it (Mark Twain)
 Much of what passes for management, is doing things that make it difficult for top performing people to get their jobs done (Drucker)
 There has never been an aviation situation where having higher performing people would have made it worse!
 Leaders are appointed; leadership is earned (Cairney)
 Positive reinforcement leads to self-sustaining high performance
 Only the absolute certainty of punishment has any chance to deter or stop destructive, counterproductive performance
 When people fail, help them improve their performance
 People will rarely perform above the leader's expectations
 Expect excellence from your leaders and your people, it is the easiest way to get it
 Attract and support the best possible leaders, they will be worth it
 The only productive fear is the fear of missing the rewards of superlative performance
 People actively seek personal and professional accomplishments that are consistent with organizational goals
 Performance will always improve when feedback is available for any or all of the following

1. Personal performance
2. Group performance
3. Personal potential
4. Job standards and organizational goals

Invest in people and principles to have the best return
 People are motivated by a sense of contribution to worthwhile and reasonable organizational goals and objectives
 People will follow the behavior of leaders they admire
 A leader's authority to succeed is, in the final analysis, always delegated from below
 The single best predictor of future professional performance is past professional performance
 Focus praise on the person; focus reprimands on the performance
 The terrible/terrific: worthless/wonderful conundrums
 One “That Was Terrible” cancels ten “That Was Terrific”
 One “You Are Worthless” cancels one hundred “You Are Wonderful”
 People expect and thrive on fairness and consideration
 People, who perform well, will feel good about themselves and vice versa
 Focus on the important more than on the immediate
 Recognize and reward accomplishment, not activity
 In a labor-intensive industry, high human productivity significantly adds to increases in profitability
 In a capital-intensive industry, high human productivity multiplies the increases in profitability
 Leadership by example is far better than management by exception

are, supervisors resist change. When these suggestions for improvement or change become perceived as threats by immediate supervisors and the next higher levels of managers, the suggestions will soon disappear.

The organization needs an active program to sensitize the leadership to the negative influences of punishing high performers with short-sighted and/or inadvertently counterproductive criticisms.

6. Is poor performance encouraged?

In aviation, the flight crew that becomes committed to a squeaky clean maintenance condition of the aircraft can become criticized for causing delays and raising maintenance costs. Similar phenomena exist in almost every industry. If flight crews are encouraged to depart with an airplane that is marginal or not up to the personal standards of the crew,

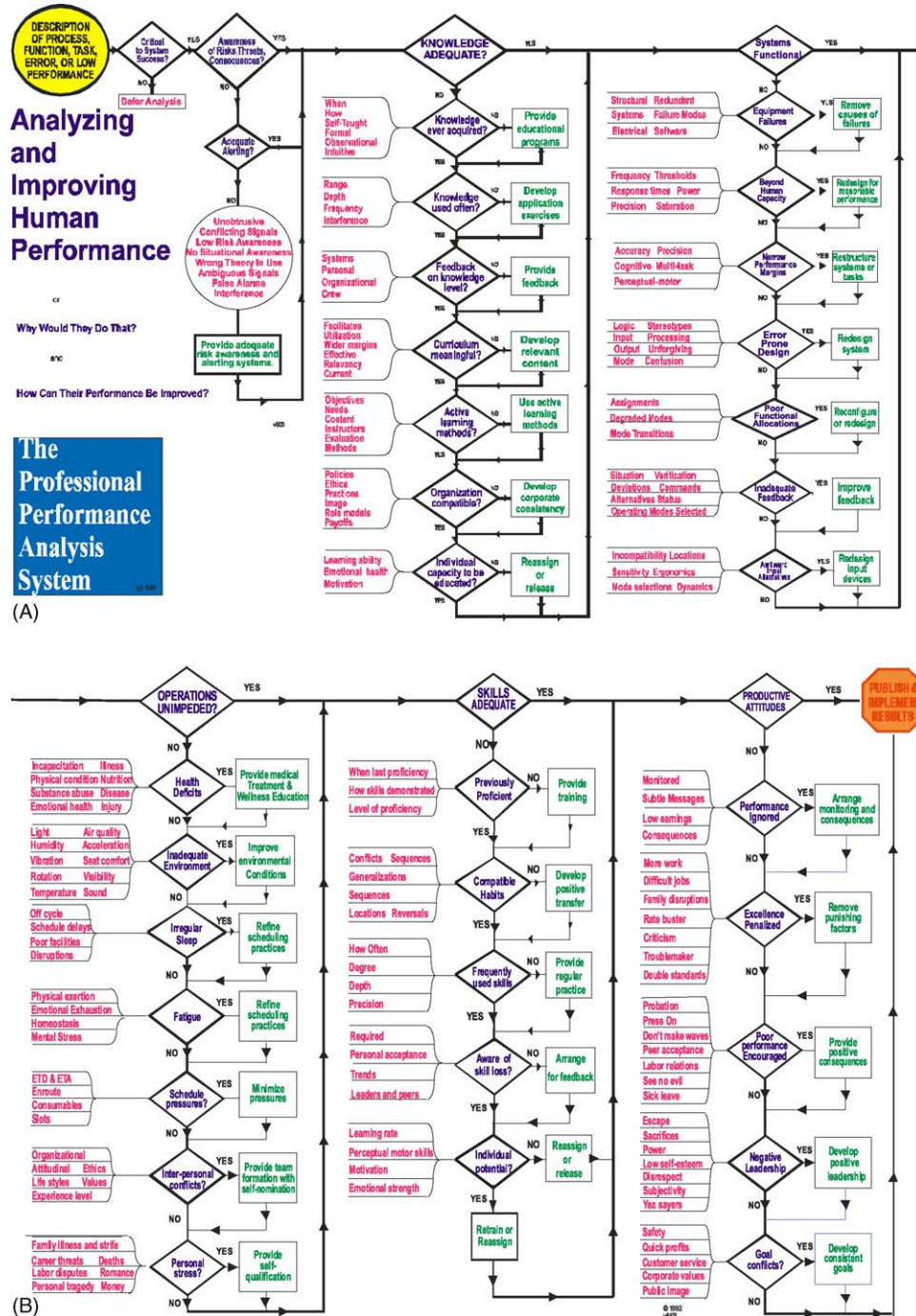


Fig. 2. (A) The professional performance analysis system. Two dimensions of a five-dimensional process flow chart to accomplish an analysis of all of the potential contributions to causing the performance failure and to define strategies for preventing a recurrence. (B) The final three dimensions of the PPAS.

the crews will come to disrespect other aspects of safety and press on into intolerable conditions. If the informal, unwritten motto of the people in an organization is to “the best way to advance in this organization is to shut up and not make waves”, the entire professional force will eventually lower their personal performance standards.

7. Are negative leadership practices tolerated?

When first level leaders are appointed on the basis of personal relationships and favoritism from middle managers, the work force will not respond to their immediate supervisors. If the first line leader has agendas other than helping the people do a good job, the organizational performance will eventually suffer. A caveat on the promotion to leadership is “leaders are appointed, leadership is earned”.

An organization would benefit greatly by selecting first line leaders who have a sincere belief and commitment to improving the performance of the professionals in their group. They should firmly believe and practice that improvement is best accomplished by:

- (1) clearly defining consistent goals,
- (2) finding the highest quality people,
- (3) making certain the goals are universally understood,
- (4) providing effective methods, tools, training and communications,
- (5) actively identifying and removing all obstacles to performance,
- (6) recognizing and encouraging the best possible performance, and
- (7) identifying and reproducing the ideas, methods and techniques of the top performers.

These seven steps can be performed by leaders with all types of personality traits. Some effective leaders may be gregarious, some may be shy, some may be studious and serious, and some may like sports, and some may like music. It is what they do and accomplish on the job that makes a great leader, not their personality type or social popularity.

Table 1 contains the principles and axioms of leadership that have been observed in my 45 years of scientific and professional study of leadership and organizational performance.

8. Goal conflicts

When goal conflicts exist within an organization’s corporate culture it is a virtual certainty that safety margins will be lowered. If the leadership of an organization says one thing to their customers and then tells their staff and employees to operate in conflict with that public image, you can predict that negative outcomes will soon emerge. The last couple of decades have revealed many corporate practices that were in direct conflict with the public image of the corporation.

The aviation organization that says that safety is their first goal and then proceeds to push schedules ahead of replacing malfunctioning equipment is ripe to have their professional level people also violate their public commitment to safety.

When the goals of an organization are inconsistent with practices many negatives outcomes will surface. Poor safety performance will be one of the many negative results of goal conflicts.

9. Conclusion

The professional performance analysis system is an easily learnable tool that has been useful for three decades to determine why human performance breaks down (see Fig. 2). The PPAAS also has been useful to determine what changes can be made to lower the probability of the breakdown reoccurring with others in similar situations. Human performance breakdowns are rarely the result of one simple mistake. They usually happen after repeated multiple failures finally intersect and result in a tragic accident.

Application of a thorough, behavioral science-based system, using a proven set of practical operational factors, can enable an experienced professional analyst who is an experienced professional organizational leader to perform a detailed analysis of human performance that has previously required a team of graduate level behavioral scientists.

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