The Multifactorial Nature of Employee Errors

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INTRODUCTION

For many years the aircraft industry attributed accidents to simple pilot error. However, the results of continuing investigations revealed that there were often causes leading to the pilot error. As a result, the aircraft industry has been building more thorough means of investigating accidents. Generically, they use system safety and human factors techniques to produce more effective analysis. One such tool is the Management Oversight and Risk Tree (MORT), a widely used system safety program. MORT stresses the multifactorial nature of accident causal factors. However, these techniques have not generally been applied to operators in industrial accidents.

The purpose of this paper is to present a MORT-based causal factor model for analyzing industrial accidents and incidents, both individually and collectively. The model is MORT-based in that it requires the identification of causes that emerge from the interfaces between personnel, hardware, and management controls. In addition, the model acknowledges the existence of multiple causes leading to an accident or incident. This type of analysis converts reactive investigation programs into proactive activities by identifying factors that “set-up” the employee error which led to the accident. Thereby eliminating, through corrective actions, conditions likely to lead to similar accidents.

CAUSAL FACTOR MODEL

The Stickman Model (**Figure 1**) is a model for analysis of employee behavior. An abbreviated description of the model follows. Note that a detailed description of the model can be found in *Basic Human Factors Considerations* (TRAC-34). The model shows the entire process of achieving desired human behavior, beginning with selection, basic training, and the certification process for a job; followed by task assignments and task related training. The individual worker is influenced by the behavioral climate (the climate in which people are motivated to comply with training, procedures, etc.), written and oral communications, command supervision and control (supplied by the supervisor and co-workers), and a man/machine interface. These worker influences are driven by management in the following ways:

1. Management directly motivates design.
2. Management communicates intent through procedures.
3. Management selects, trains, and directs employees.

Conditions and events arising from the relationships depicted in **Figure 1** can be displayed in an events and conditions chart (**Figure 2**). Events are enclosed in rectangles ☐ and conditions in ovals ○. Inherent in the charting is the assumption that conditions lead to events.[1] When the final event is an accident or incident, then the upstream conditions or events are classified as causes.

A model for causes (either events or conditions) culminating in an accident is displayed in **Figure 3**; The Multifactorial Nature of Employee Error. The model specifically depicts the cause ⇨ (to) accident/incident sequence. Management conditions influence design, procedural, and employee causal factors that, in turn, become contributory elements to the error that directly caused the accident.

Because this paper examines employee error, the figure depicts employee error as the direct cause. Note, however, that design or procedural causes can also lead directly (or indirectly) to the accident and can be analyzed the same way (rotate the dashed boxes into the relevant positions so that procedural or design become the direct cause, and employee becomes an indirect cause). It is also possible that design and procedural and employee and management causes can coexist in the same accident.

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[1] A complete description of the events and conditions charting technique can be found in *Events and Causal Factors Charting* (TRAC-14).

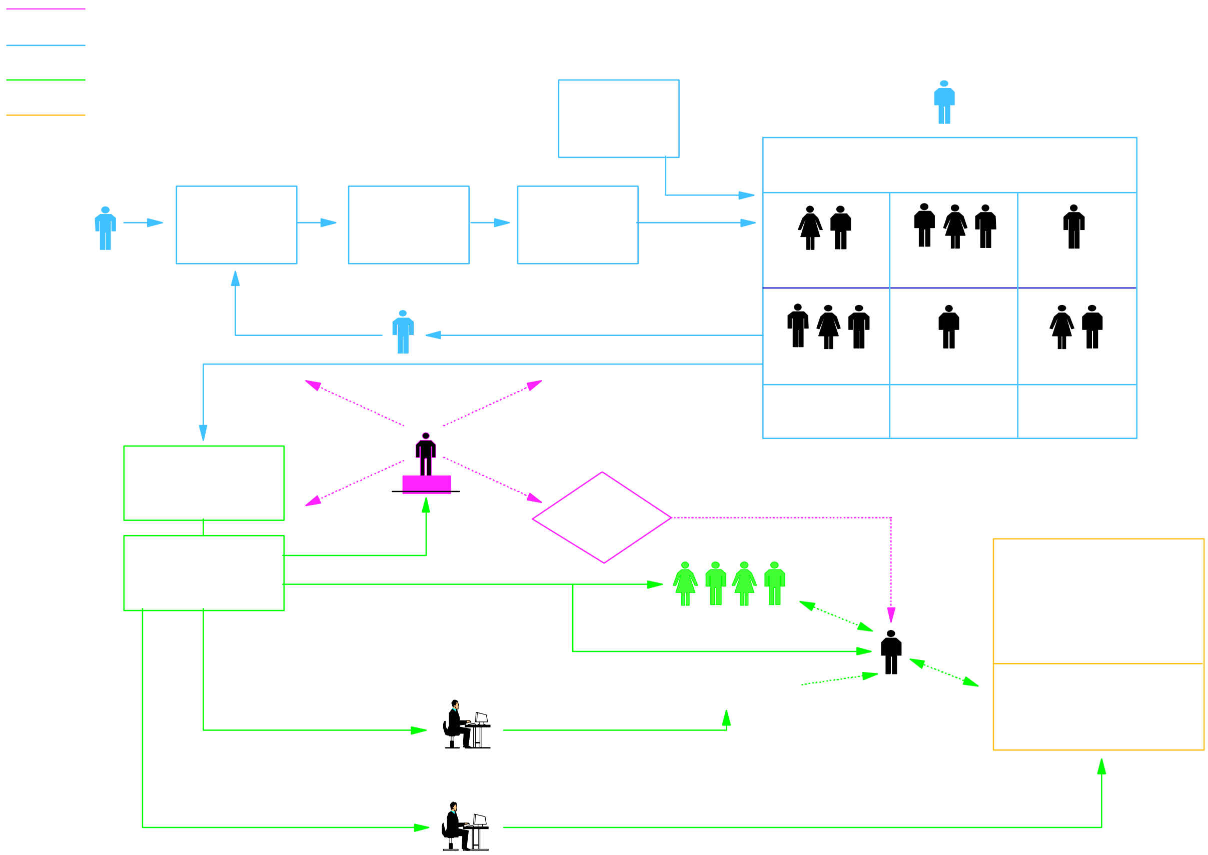

Figure 1

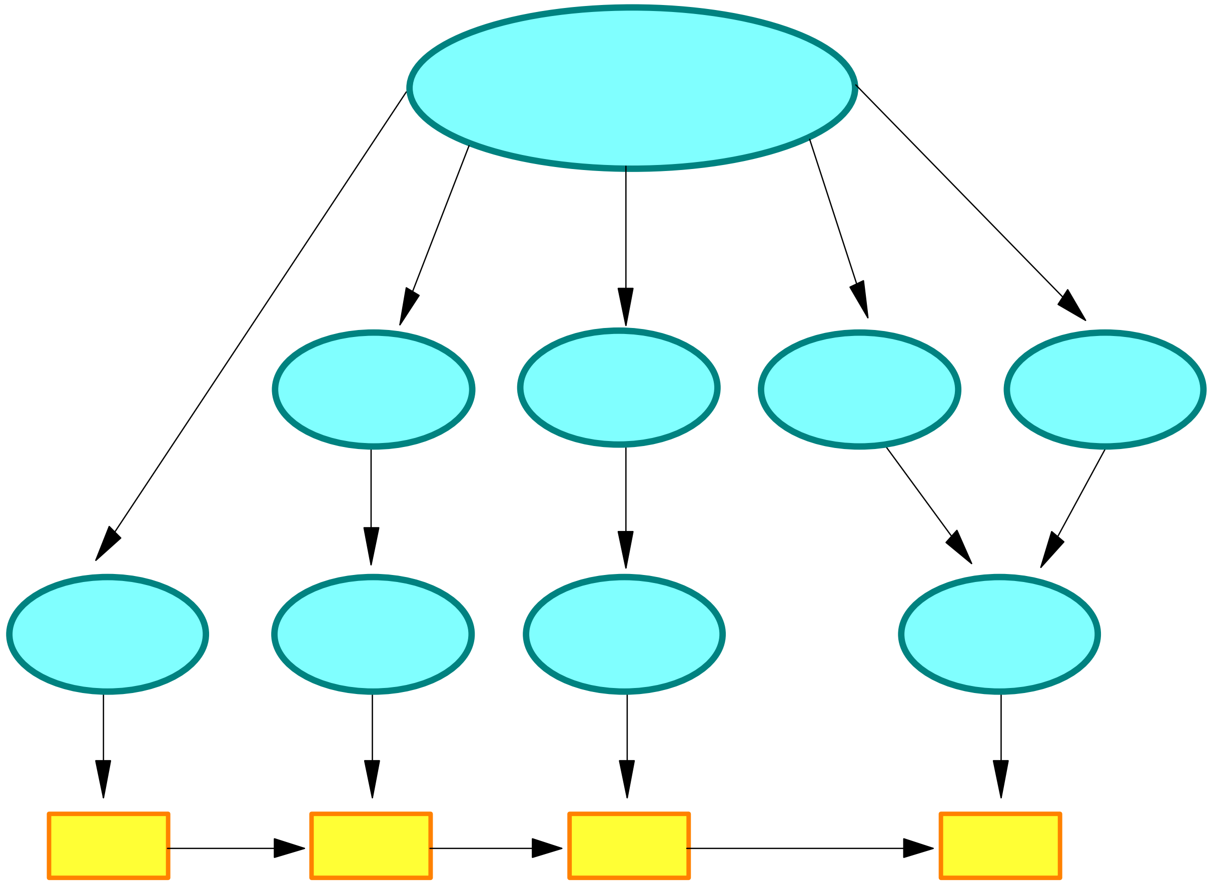

Figure 2

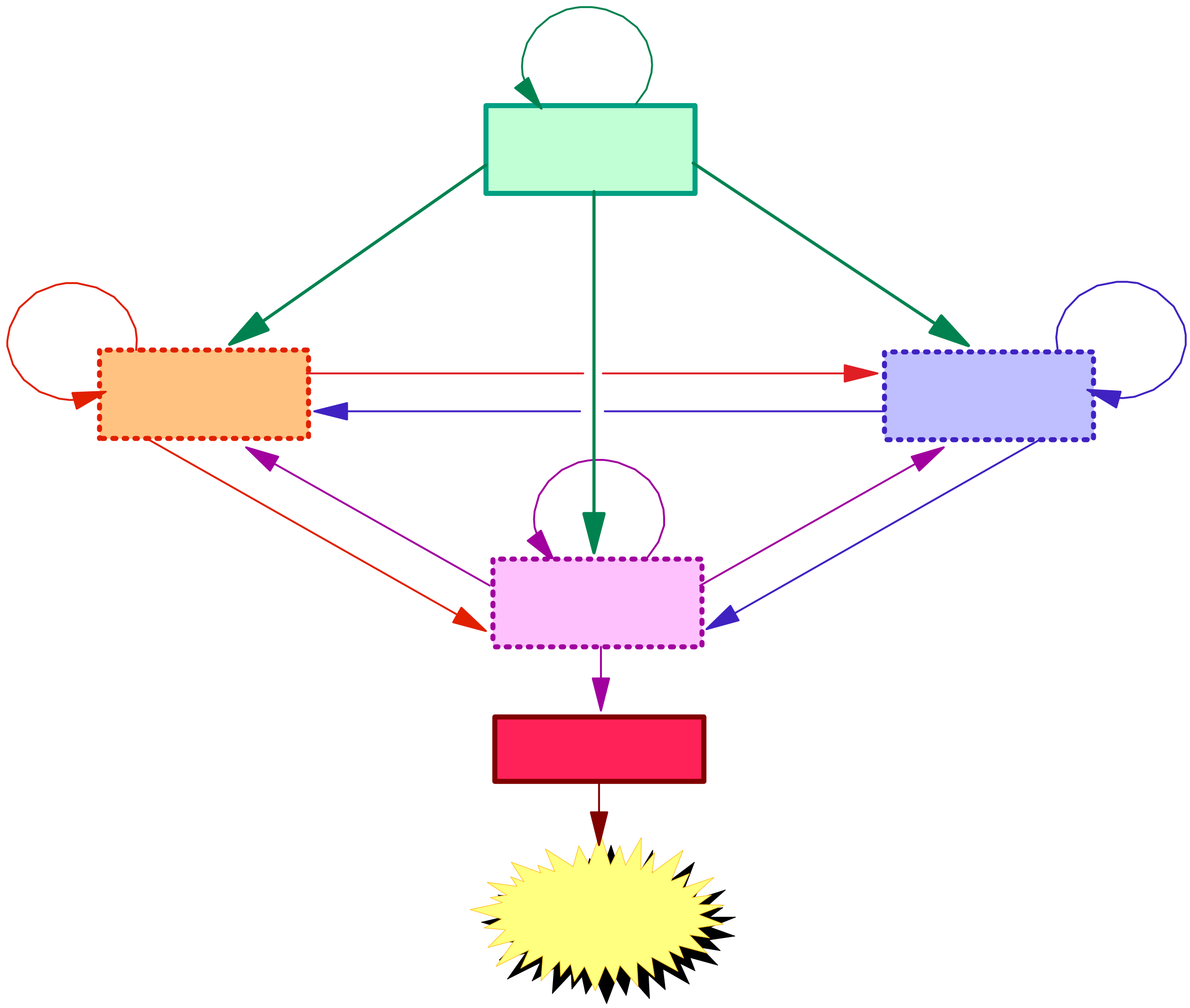

Figure 3

CAN FIELD DATA BE CLASSIFIED ACCORDING TO THE MODEL?

The Computerized Accident/Incident Reporting System (CAIRS), and the Occurrence Reporting and Processing System (ORPS) contain accident and incident data for the U. S. Department of Energy. Field personnel, ranging from trained accident investigators to administrative personnel, perform causal factor analysis for CAIRS and ORPS. In general, operational occurrences in ORPS undergo a more rigorous causal factor analysis than the C level accident investigations in CAIRS. This is due, in part, to the differences in cause classifications. ORPS supports the multi-level cause classifications specified in DOE-NE-STD-1004-92, *Root Cause Analysis Guidance Document*; whereas CAIRS supports only a two-level causal factor classification (direct and indirect). Note that CAIRS redesign requirement specifications support the multi-level cause classifications.

Although field data have not been precisely analyzed according to all model elements, there appears to be a sufficient connection between the model and actuarial data to indicate the model (**Figure 3**) can be used as an analytical tool. **Figures 4** and **5** show how the model can overlay CAIRS and ORPS causal factor classifications to demonstrate that other types of causes “set the stage” as either root causes or contributing causes for accidents attributed to operator or employee error.

The CAIRS model shows (**Figure 4**):

1. Management drives design directly.
2. Management communicates intent through procedures.
3. Management selects, trains, and directs employees.
4. Some design causes lead directly to the accident.
5. Some employee causes lead directly to the accident.
6. Some procedural causes lead directly to the accident.
7. Other design causes lead indirectly to the accident by contributing to employee error.
8. Other procedural causes lead indirectly to the accident by contributing to employee error.

It is possible that design and procedural and employee causes can coexist in the same accident.

The ORPS model shows (**Figure 5**):

1. Management determines equipment and material specifications.

2. Management drives design directly.

3. Management trains employees.

4. Management communicates intent through procedures.

5. Management selects and directs employees.

6. Some equipment/material problems lead directly to the accident.

7. Some design problems lead directly to the accident.

8. Some personnel error lead directly to the accident.

9. Some training deficiencies lead directly to the accident.

10. Some procedural problems lead directly to the accident.

11. Other equipment/material problems lead indirectly to the accident by contributing to employee error.

12. Other design problems lead indirectly to the accident by contributing to employee error.

13. Other training deficiencies lead indirectly to the accident by contributing to employee error.

14. Other procedural problems lead indirectly to the accident by contributing to employee error.

It it is possible that equipment/material problemsand design problems and training deficiencies and personnel error and procedure problems can coexist in the same accident.

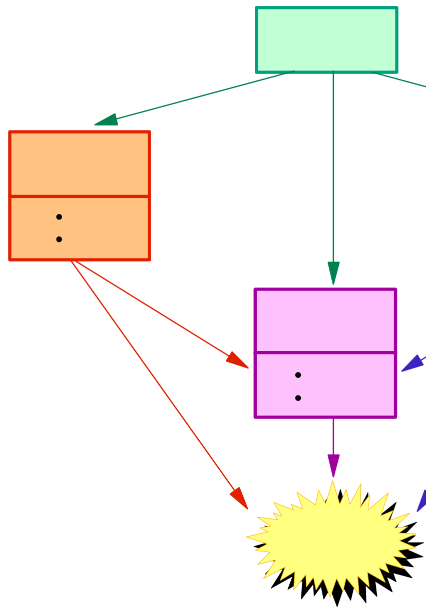

Figure 4

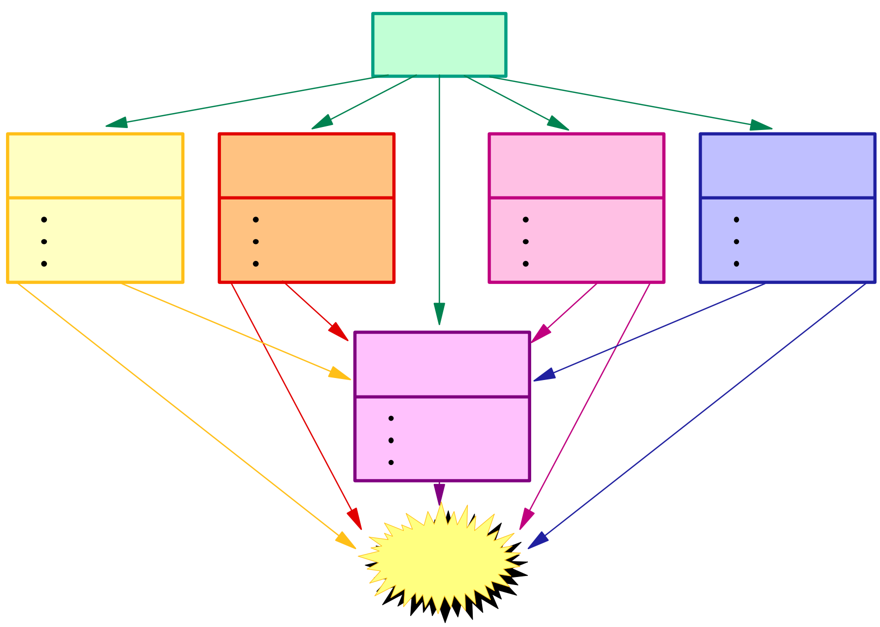

Figure 5

FIELD ANALYSIS SUPPORT FOR THE MODEL

The multifactorial nature of employee error is corroborated by actuarial data. Even the relatively simple analysis (performed for CAIRS and ORPS reports) appears to support the assumption that employee error does not stand alone in creating conditions conducive to the occurrence of an accident.

The majority of CAIRS reports and all ORPS reports cite coexisting causes for accidents or incidents directly caused by employee. Additional analysis of both CAIRS and ORPS causal factors (summarized below) reveals additional correlation between employee error and other causes.

<u>CAIRS</u>

- 26,019 accident reports cite employee error as a direct cause.
- Of the reports citing employee error as a direct cause:
  - 243 cite coexisting procedural causes
  - 4,259 cite coexisting design causes
  - 66 cite both coexisting procedural and design causes
  - 15,758 cite coexisting other causes (CAIRS does not have a classification for management causes, therefore management causes are included in this category).

<u>ORPS</u>

- 7,396 incident reports cite personnel error as a direct cause.
- Of the reports citing personnel error as a direct cause:
  - 378 cite coexisting equipment/material problems
  - 1,769 cite coexisting procedure problems
  - 850 cite coexisting design problems
  - 1,187 cite coexisting training deficiencies
  - 3,366 cite coexisting management problems.

Taken alone, coexistence of causal factors is not sufficient to show dependency between causal factors. However, analysis of the individual accident/incident cases is useful in revealing the nature of the coexisting causes. Typical of such cases are:

I.	Accident:	Power tool blade broke and piece of blade injured employee's eye.
	Employee cause:	Failed to wear safety glasses.
	Equipment cause:	Defective blade.
II.	Accident:	Property damage because wrong type of freon was charged into system.
	Employee cause:	Charged freon from wrong bottle.
	Equipment cause:	Bottles containing two types of freon were very similar in appearance.
III.	Accident:	Toxic material discharged into atmosphere.
	Employee cause:	Opened wrong valve.
	Procedure cause:	Valving procedures ambiguous and unclear.
	Design cause:	Labeling of valves less than adequate.

In the first case, the employee's failure to use proper protective equipment is clearly an independent causal factor. In the second and third cases, however, there is evidence that the employee was "set up" for the accident by primary causal factors in the design and procedural areas. Analysis of hundreds of CAIRS and ORPS cases shows that, while some coexisting causal factors are independent of each other, in general, coexisting causal factors are dependent. When such causal factor dependency exists, application of corrective actions relevant to the employee error that directly caused the accident may not eliminate the conditions or events that influenced the accident. When this is the case, the occurrence of a similar accident is relatively high.

CONCLUSION

Theoretical models indicate that multiple factors influence the worker environment. Moreover, all factors are driven by management. These factors—sometimes singly, but usually in combination—create conditions that lead to events. When an accident occurs, conditions and events that precede the accident (the final event) are classified as causes. When employee error is the direct cause of an accident, it is likely that conditions influencing employee behavior are causes that contributed to the accident.

Field analysis and interpretations of accident data corroborates the multifactorial nature of employee error. Statistical snapshots of the actuarial data shows that employee errors coexist with other causal factors, while direct analysis of the data reveals the dependency of causal factor relationships.

If accidents are analyzed using a multifactorial model, not only will direct causes be identified, but root and contributing causes will also emerge. As a result, corrective actions that apply reactively to the accident under study will apply proactively to potential incidents "set up" by the same root or contributory conditions. In so doing, accident investigation, which has traditionally been viewed as a reactive activity, becomes a proactive activity.