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Human Factors Aspects of Emergency, Alarm, and Team Resource Management

Chason Coelho, Ph.D., CSP

Principal Scientist | Exponent

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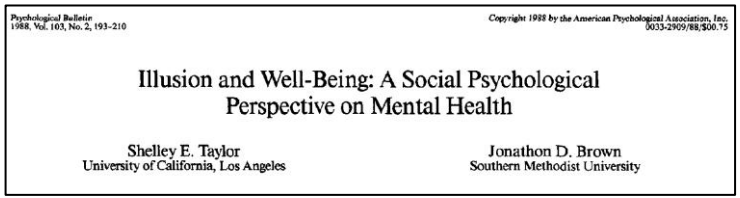
Objectives

- Our goals for this material:
  - Define alarms and emergencies
  - Lay out the general sequence of operator response
  - Learn Human Factors principles related to emergencies and alarms
  - Discover the costs of poor alarm management
  - Define Team Resource Management (TRM)
  - Understand the goals to be pursued through TRM
  - Know what Groupthink is and how it can be problematic
  - Learn strategies for avoiding Groupthink
  - Discover the six hazardous attitudes
  - Understand authority gradients
  - Apply the Span of Control concept
  - Understand how teams can develop
  - Learn basic TRM techniques that can help improve safety performance


Psychological Bulletin
1988, Vol. 103, No. 2, 193-210
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0033-2909/88/$00.75

Illusion and Well-Being: A Social Psychological Perspective on Mental Health

Shelley E. Taylor
University of California, Los Angeles

Jonathon D. Brown
Southern Methodist University

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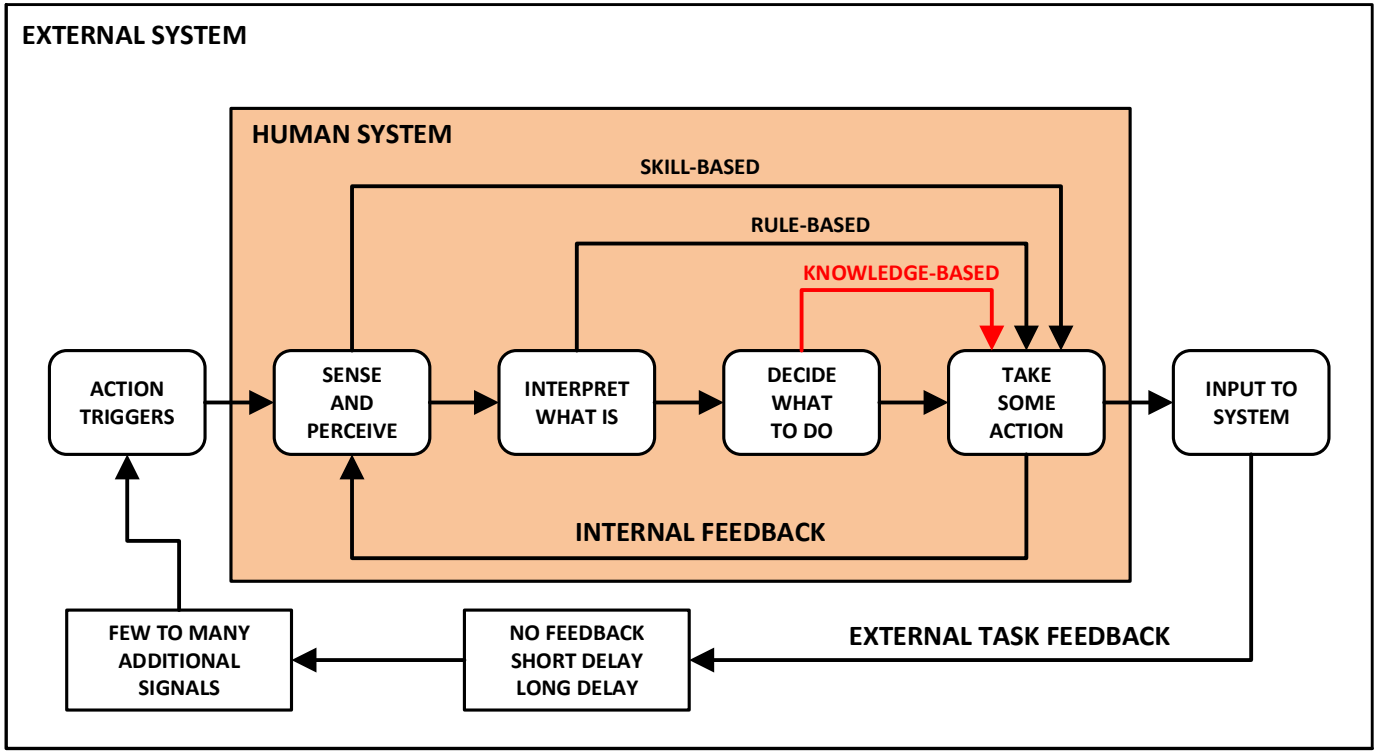
Human Factors



Rasmussen (1983)

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Emergencies and Alarms

- An emergency can be defined as:
  - a serious and unexpected state or event that presents the potential for harm to workers, assets, and/or the public
- An alarm can be defined as:
  - an audible and/or visible means of indicating to an individual that an equipment malfunction, process deviation, abnormal condition, and/or emergency requires a timely response
- Worker emergency and alarm response sequence:
  1. Detect the alarm
  2. Navigate within a control system to the relevant data
  3. Analyze the situation
  4. Determine and perform proper corrective action(s)
  5. Monitor the situation to ensure the corrective action(s) for the alarm is successful once implemented

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Principles of Emergency Management

- Emergency Management Principles
  - Generate plans that include:
    - Definitions of emergencies and abnormal conditions
    - Means of reporting emergencies
    - Evacuation procedures and emergency escape route assignments
    - Procedures and processes for employees remaining to operate critical plant operations before evacuating
    - Procedures and processes to account for all employees after an emergency evacuation has been completed
    - Procedures and processes for rescue and medical personnel
    - Names or job titles of persons who can be contacted
  - Train (e.g., initial and recurrent training on documentation)
  - Practice (e.g., fire, evacuation, shelter-in-place drills, high-fidelity sims)

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Principles of Alarm Management

- Alarm Management Principles
  - Alarms should direct attention towards relevant condition(s)
  - Alarms should alert, inform, and guide required action(s)
  - Each alarm should be useful and relevant to the responder(s)
  - Alarm levels should be set such that a responder has sufficient time to carry out defined response(s) before conditions escalate
  - System should accommodate human capabilities and limitations

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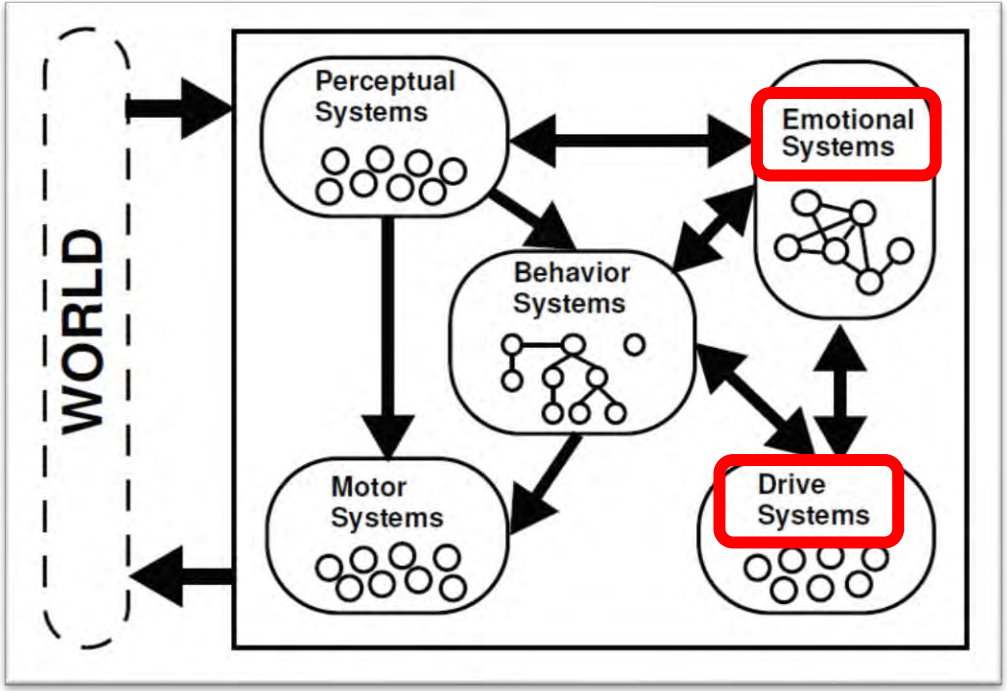
Human Factors and Emergencies



- Systems
  - Perceptual ≈ detection and understanding
  - Emotional ≈ affective states such as fear and panic
  - Drive ≈ motivations such as survival and help
  - Behavioral ≈ decisions
  - Motor ≈ combining for an action/inaction

Velasquez (1998)

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Acute Stress Response and Fear

- Acute Stress Response can manifest:
  - *Freezes*: lack of motion and hypervigilance
    - Increased but narrowed perception (“tunnel vision”)
  - *Flights*: attempts to flee
    - Gross motor control increased; fine motor control decreased
  - *Fights*: attempts to address the threat
    - Gross motor control increased; fine motor control decreased
  - *Frights*: also called *tonic immobility*
    - May facilitate escape from prey
  - *Faints*: also called *flaccid immobility* and *syncope*
    - Thought to minimize blood loss and maximize disgust aversion
- This is an example of a response hierarchy

Review Article

Freeze, Flight, Fight, Fright, Faint: Adaptationist Perspectives on the Acute Stress Response Spectrum

By H. Stefan Bracha, MD

FOCUS POINTS
- Threat-induced fainting (flaccid immobility), which often presents as blood-injection-injury type specific phobia, may have evolved as a defense response during human intragroup and intergroup warfare, rather than as a pan-mammalian defense reaction, as is currently assumed.
- Fainting can be added to the known biologically determined sequence of responses (freeze, flight, fight, fright) that humans may exhibit during acute stress.
- This reconceptualization of blood-injection-injury phobia has clinical, health services, and basic research implications.

ABSTRACT

This article reviews the existing evolutionary perspectives on the acute stress response habitual fainters and blood-injection-injury type-specific phobia (BIITS phobia). In this article, an alternative evolutionary perspective, based on recent advances in evolutionary psychology, is proposed. Specifically, that faint-induced fainters (eg, fainting following the sight of a syringe, blood, or following a visual skin injury) is a distinct Homo sapiens-specific extreme-stress survival response to an inescapable threat. The article suggests that fainters evolved in response to middle paleolithic intra-group and inter-group violence (of con-specifics) rather than as a pan-mammalian defense response, as is presently assumed. Based on recent literature, freeze, flight, fight, fright, faint provides a more complete description of the human acute stress response sequence than current descriptions. Fainters, one of three primary physiological reactions involved in BIITS phobia, is extremely rare in other phobias. Since heritability estimates are higher for fainters than for fearers or phobics, the author suggests that trait-fainters may be a useful complement to trait-anxiety as an endophenotype in research on the human fear circuitry. Some implications for the forthcoming Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition as well as for clinical, health services, and transcriptomic research are briefly discussed.

CNS Spectr. 2004;9(9):679-685

INTRODUCTION

Freeze (Hypervigilance), Flight, Fight, Fright, (Tonic Immobility)

A coherent sequence of four fear responses that escalate as a function of proximity to danger has been well established by ethologists working with non-human primates. The sequence, originally described by Gray,[1] begins with what ethologists call “the freeze response” or “freezing,” a term corresponding to what clinicians typically call hypervigilance (being on guard, watchful, alert).[1,2] This initial freeze response is the “stop, look, and listen” action tendency associated with fear. Prey that remain “frozen” during threat are more likely to avoid capture, because the visual cortex and the retina of mammalian carnivores (and, to a lesser degree, of male Homo sapiens) evolved primarily for detecting moving objects and not color.[3,4] This initial freeze response is followed by attempts to flee, and then by attempts to fight; in that order (thus “flight or fight”

Dr. Bracha is research physician at the United States Department of Veterans Affairs (VA), Pacific Islands Health Care System, Spark M. Matsunaga Medical Center, National Center for Posttraumatic Stress Disorder in Honolulu, Hawaii.

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Please direct all correspondence to: H. Stefan Bracha, MD, U.S. Department of Veterans Affairs, Pacific Islands Health Care System, Spark M. Matsunaga Medical Center, National Center for PTSD, 1132 Bishop Street, #307, Honolulu, HI 96813-2830. Tel: 808-566-1650, Fax: 808-566-1895.

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Acute Stress Response and Fear (cont'd)

- What does this mean for emergency response?
  - *Selectivity*: fear system can easily be activated by threats
    - Response to certain threats can be trained and modulated
  - *Automaticity*: Threats get access to bodily fear system quickly
    - Personnel must anticipate physiological responses
  - *Encapsulation*: Fear system difficult to deactivate once engaged
    - Influence of higher cognitive processes, such as problem solving and decision making, are impaired for some time
  - *Specific Neural Circuitry*: Fear system is an inextricable part of us
    - There is some variation across individuals, but our neural systems are wired for dealing with fear-provoking stimuli
- Humans may require significant engineering and administrative controls to respond to emergencies
- Keep it simple and train transparently with purpose and fidelity

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The neuropsychology of fear learning and fear regulation

Alfons O. Hamm*, Almut I. Weike

Department of Biological and Clinical Psychology, University of Greifswald, Franz-Mehring-Str. 47, 17487 Greifswald, Germany

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Available online 21 April 2005

Abstract

In the current review article it is suggested that fear is a central emotional state that can be activated by external threat cues. The subcortical defensive system cannot only be activated by intrinsically aversive events but shows also strong plasticity enabling previously innocuous stimuli to get access to the fear system after they were paired with painful outcomes. On the other hand, aversive conditioning does not only result in the acquisition of a defensive disposition, the organism also learns on a pure cognitive level that one stimulus predicts the occurrence of another stimulus. It is suggested here that potentiation of the acoustic startle reflex is a rather specific measure for fear acquisition, while skin conductance discrimination indexes contingency learning. It is shown that the acquisition of fear-potentiated startle does not require cortical processing of the conditioned stimulus. Moreover, data indicate that conditioned startle potentiation is abolished in patients with unilateral lesions of the amygdala. Finally, conditioned startle potentiation can be obtained without contingency awareness, which on the other hand is necessary for skin conductance conditioning to occur. It is suggested that the learning of stimulus relations is mediated by the hippocampus and that conditioned startle potentiation is also mediated by the hippocampus in trace conditioning.
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Keywords: Fear conditioning; Startle potentiation; Amygdala; Anamnesis; Cortical blindness; Temporal lobectomy

1. Fear and fear learning

Fear is an aversive emotional state elicited by external threatening cues that activate the defensive fear system of an organism. This fear system then organizes a behavioral pattern to adjust to the threat. Therefore, fear is important for survival because it prepares the organism for effective escape and motivates avoidance. Escape and avoidance, however, are often at the endpoint of a dynamic defense response cascade as elaborated in the predator imminence model (see Fanselow, 1994; Lang et al., 1997 for a fuller description of this model). According to this model activation of the fear system increases with increasing proximity of the threatening or painful stimulus. As soon as the organism detects the threat, it often freezes and engages in higher vigilance towards the threat ("Where is it?," "Where does it move?"). With increasing proximity of the threat cue, the intensity of the fear response increases as the organism mobilizes energetic resources for escape. At a certain stage of proximity (the so-called circa-strike period) the organism escapes or (if escape is not possible) starts to fight or (if attack is no option) completely immobilizes (tonic immobilization; see Marks, 1987). As soon as the threatening cue disappears, the intensity of the fear response is reduced.

It is suggested here, that this fear system serves biologically useful functions since it enables the organism to effectively detect the threat and to automatically activate defensive behavior in order to adjust to it. Thus, following theoretical considerations by Öhman and Mineka (2001) the premise here is that the fear system has been shaped by evolutionary contingencies and can be characterized by four central features: *selectivity* with regard to input, *automaticity*, *encapsulation*, and a *specialized neural circuitry* (for a more extensive discussion see Öhman and Mineka, 2001). *Selectivity* means, that the fear system can easily be activated by stimuli that have been correlated with threatening encounters in the evolutionary past. Actually, fear of

* Corresponding author. Tel.: +49 3834 863715; fax: +49 3834 863763.
E-mail address: hamm@uni-greifswald.de (A.O. Hamm).

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Cost of Poor Management

- Costs of inadequate emergency and alarm response can come from:
  - Injuries and fatalities
  - Asset damage, repair, replacement
  - Production loss
  - Schedule and delivery disruption
  - Environmental damage and remediation
  - Reputation
- International Society for Automation (ISA) notes that the total estimated cost of alarm-related issues may be as much as $20 billion per year in the United States

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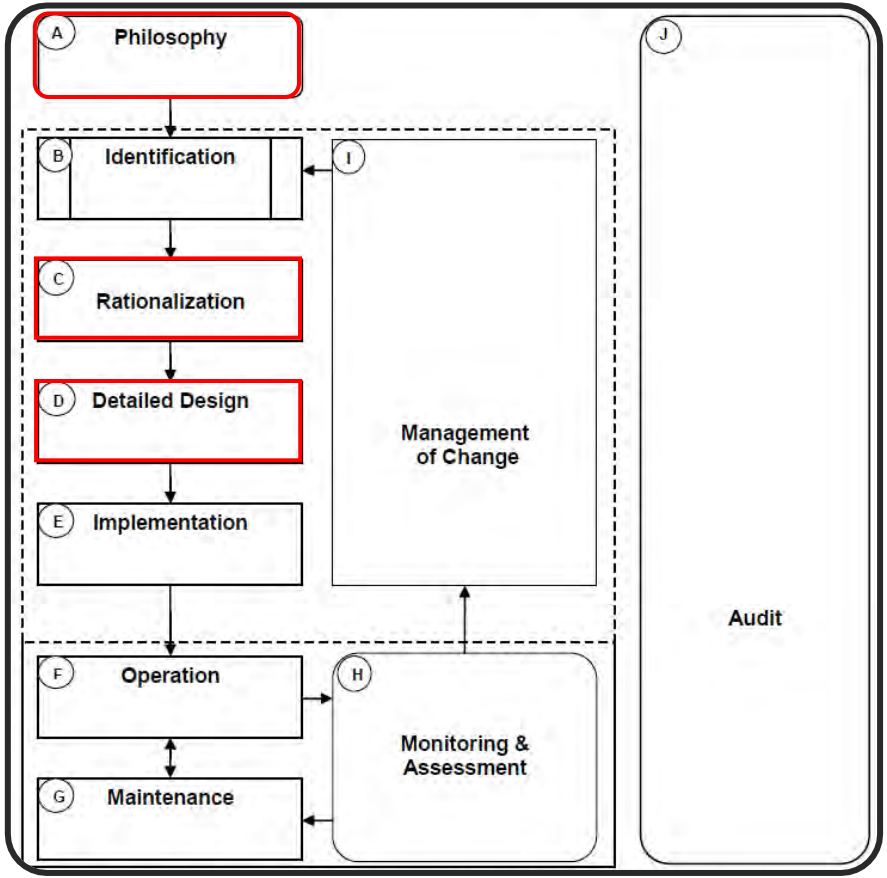
ANSI/ISA-18.2

Lifecycle

- Philosophy
  - Defines objectives for alarm system
  - Scopes processes for meeting objectives
  - Processes carry varying levels of automation and human action
- Rationalization
  - Defines relative importance of alarms and scenarios
  - Includes provisions for detection and response
- Detailed Design
  - Defines engineering and administrative controls
  - Includes provisions for positive human-machine interfaces and quality procedures



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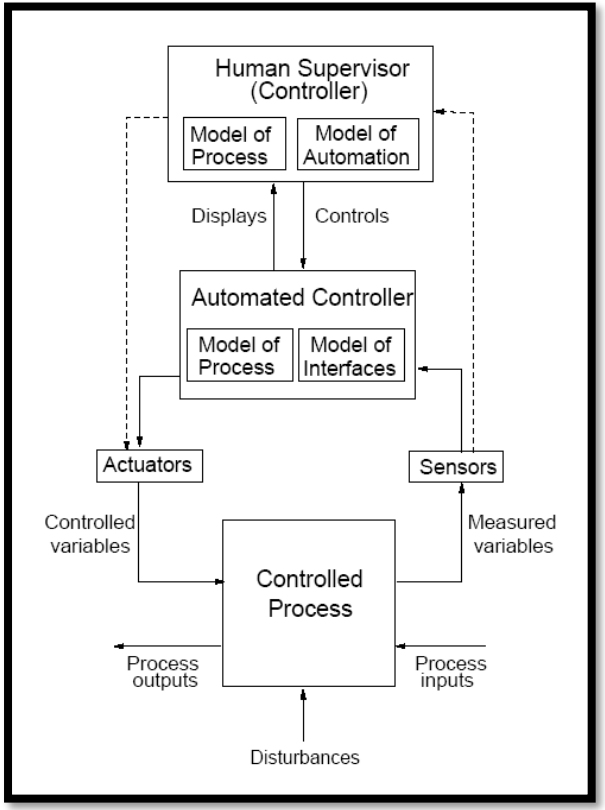
Philosophy

Leveson (2002)



FITTS LIST HUMAN-MACHINE FUNCTION ALLOCATION	
HUMANS ARE BETTER AT (HABA)	MACHINES ARE BETTER AT (MABA)
Detection of certain forms of very low energy levels	Monitoring of both the system and the human operator
Sensitive to an extremely wide range of stimuli	Performing routine, repetitive, or very precise operations
Perceiving patterns and making generalized judgments about their meaning	Responding rapidly to very discrete control signals
Storing large amounts of information for long periods and recall of relevant facts at an appropriate moment	Storing and recalling large amounts of information in short time periods.
Exercising judgment where events cannot be completely defined (bounded rationality)	Performing complex and rapid computation with high accuracy
Improvising, improving, and adopting flexible procedures	Sensitive to stimuli beyond the range of human senses
Reacting to unexpected, low-probability events	Multitasking (humans cannot truly multitask)
Applying abstract logic and originality in novel problem solving	Exerting large forces smoothly and precisely
Learning from experience and altering actions to accommodate changing conditions	Insensitivity to extraneous factors or distractions
Performing fine manipulation, especially where misalignment appears unexpectedly	Repeating operations very rapidly, continuously, and precisely
Continuing to perform when at task overload	Operating in hostile physical environments
Reasoning inductively	Reasoning deductively

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ANSI/ISA-18.2

Rationalization

- In rationalization, consider:
  - Alarm condition
  - Alarm type (e.g., visual, auditory, haptic)
  - Alarm priority (avoid alarm flooding and high workload)
  - Alarm limits
  - Extent to which alarms can be accurately detected
  - Required corrective actions
    - Time for detection, decision, and response
    - Nature of responses and supporting activities
  - Consequence for missed corrective actions
- Utilize:
  - Operational knowledge of experienced personnel
  - Knowledge of Human Factors

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Detailed Design

- Effective engineering and administrative controls
- Knowledge of Human Factors Key
  - Principles of human performance, procedure evaluation, HMI displays and controls, and communication
- Some industry-accepted thresholds for alarm management

Problems	Underlying Reasons	Effects	Solutions
• High number of false alarms • Inaudibility of alarms due to competing sounds • Difficulty in differentiating between urgency of alarms • Increasing noise with increasing number of alarms	• Alarms are often used on a "better safe than sorry" philosophy. • Alarms are designed on the "principle of thresholds," leading to inappropriate use of upper and lower alarm limits and without taking into account that many threshold changes are reversible without any clinician intervention. • There is no urgency mapping (prioritizing alarms depending on the severity of the patient or equipment condition) involved in the design of alarms.	• Increased noise levels • Increased staff and patient annoyance • Decreased faith in the alarm system • Increased alarm response time • Decreased patient safety and work performance • Increase in adverse events	• Design of auditory alarms with distinct features • Design of smart alarms • Developing alarm protocols for improving alarm performance • Application of third-party alarm integration and notification systems

Konkani Oakley Bauld (2012)

Very Likely to be Acceptable	Maximum Manageable	Peak
1 (per 10 minutes)	2 (per 10 minutes)	10 (per 10 minutes)

ANSI/ISA-18.2

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Detailed Design (cont'd)

- People are generally poor at monitoring for infrequent or unexpected visual events, and vigilance declines over time
- The traditional design solution has been to include a variety of alarms
  - However, this can lead to sensory flooding, nuisance alarms, and to operators ignoring actual alarmed conditions because of mistrust
  - Candidate solutions include:
    - Graded levels of alarms (e.g., cautions versus warnings)
    - Easy access to raw data for operator to confirm
- Another problem concerns interpretability – what do all these alarm tones mean?
  - A candidate design solution includes spoken-voice displays
    - Language, sound levels, and clarity of speech are key considerations for voice displays
- The threat of over-trusting is present when automation diagnoses and recommends
  - The operator should remain aware that automation can be incorrect
  - A candidate design solution is to require the operator to confirm the diagnosis and recommended corrective actions

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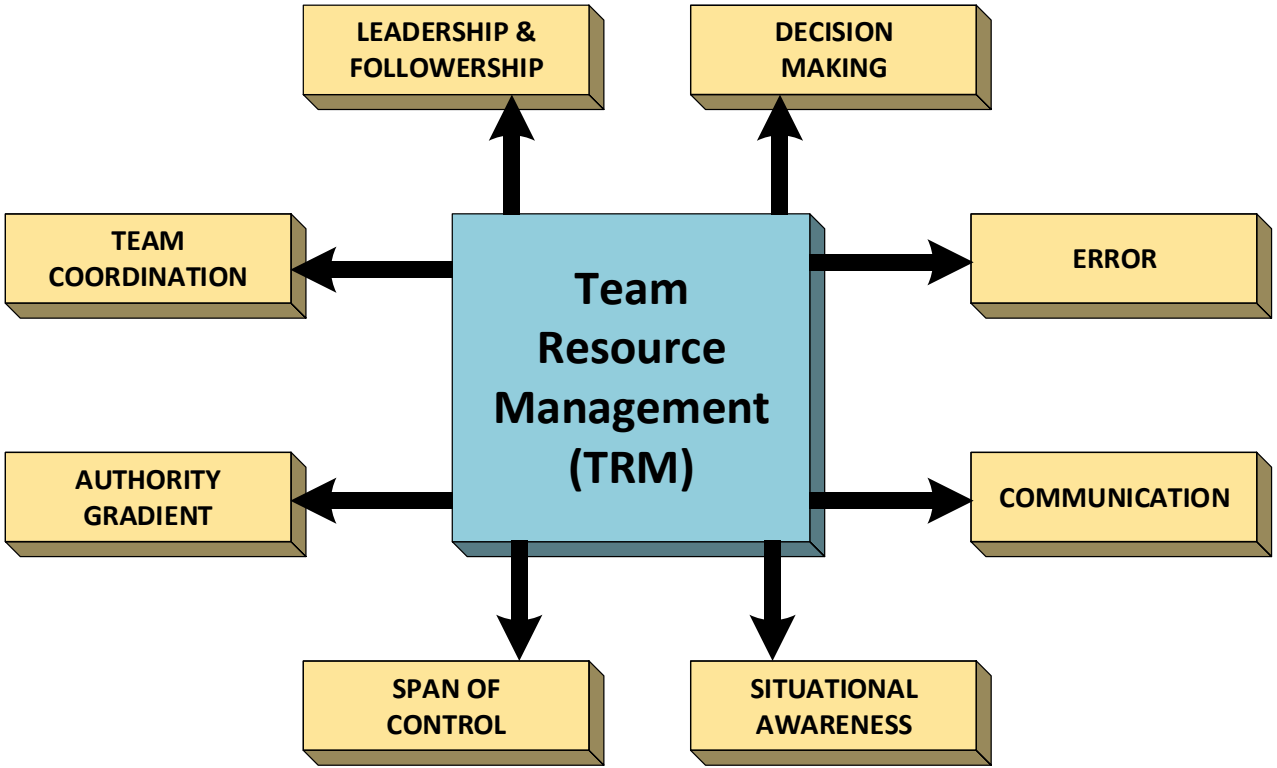
What is Team Resource Management (TRM)?



Kanki, Helmreich, & Anca (2010) and CCPS (pp.142-145)

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TRM Goals

- Goals pursued through TRM include:
  - Reduced incidents for team-involved activities
  - Enhanced task efficiency
  - Improved use of personnel
  - Enhanced continuity, stability, and performance
  - Increased job satisfaction
  - Enhanced internal cohesion
  - Increased retention
  - Cost savings

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Brehm, Kassin, & Fein (2005)

Groupthink

- A flaw of highly cohesive groups
- Occurs when group members:
  - Become more concerned with striving for unanimity than considering alternative course of action
  - Strong leaders promote their preferred solutions
  - Grow more and more isolated from expert options outside the group
  - Are stressed to the point that urgency overrules accuracy
- May result in poor decision making and outcomes
- Strive instead for:
  - Consensus, independence, healthy skepticism, criteria-driven decisions and outcomes, openness, and unbiased leadership

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AOPA (1999)

Six Hazardous Attitudes

- Machismo (poor risk assessment)
  - "Maybe that person can't do it, but I can!"
- Impulsivity (no risk assessment)
  - "Watch this!"
- Anti-authority (poor followership)
  - "The rules do not apply to me!"
- Action Imperative (something always better than nothing)
  - "Failure is not an option!"
- Invulnerability (self-exemption)
  - "It cannot happen to me!"
- Resignation (perceived ineffectiveness)
  - "What's the use?"

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Fixing Hazardous Attitudes

- Recognize the hazardous attitude
- Admit that hazardous attitudes can increase risk
- Identify situations where the attitudes tend to arise
- Double check assumptions
  - Sometimes the inconveniences of adhering to good rules are overblown
- Remember that rare events happen all the time
  - Humans can misjudge probabilities
- Hold leaders, subordinates, and peers accountable for hazardous attitudes in the workplace
  - A collaborative and open environment in which workers can speak up without fear of reprisal is an important steppingstone

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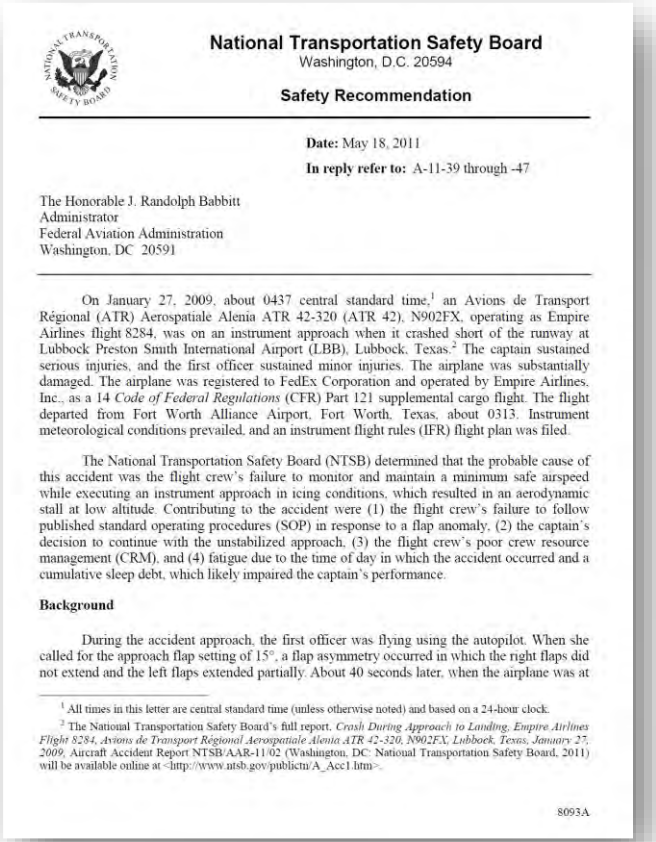
Authority Gradients

- Concept developed out of aviation and flight decks
- High status of some (e.g., captain) can lead to others (e.g., first or second officer) to defer despite correct dissent and assessment
- This status-incongruence can result in:
  - Poor outcomes
  - Dissatisfaction
- FAA recommends training for:
  - Leadership and followership
  - Balance between respect and assertiveness
  - Workload and stress management
  - Situational awareness



National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: May 18, 2011

In reply refer to: A-11-39 through -47

The Honorable J. Randolph Babbitt
Administrator
Federal Aviation Administration
Washington, DC 20591

On January 27, 2009, about 0437 central standard time,[1] an Avions de Transport Régional (ATR) Aerospatiale Alenia ATR 42-320 (ATR 42), N902FX, operating as Empire Airlines flight 8284, was on an instrument approach when it crashed short of the runway at Lubbock Preston Smith International Airport (LBB), Lubbock, Texas.[2] The captain sustained serious injuries, and the first officer sustained minor injuries. The airplane was substantially damaged. The airplane was registered to FedEx Corporation and operated by Empire Airlines, Inc., as a 14 *Code of Federal Regulations* (CFR) Part 121 supplemental cargo flight. The flight departed from Fort Worth Alliance Airport, Fort Worth, Texas, about 0313. Instrument meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed.

The National Transportation Safety Board (NTSB) determined that the probable cause of this accident was the flight crew's failure to monitor and maintain a minimum safe airspeed while executing an instrument approach in icing conditions, which resulted in an aerodynamic stall at low altitude. Contributing to the accident were (1) the flight crew's failure to follow published standard operating procedures (SOP) in response to a flap anomaly, (2) the captain's decision to continue with the unstabilized approach, (3) the flight crew's poor crew resource management (CRM), and (4) fatigue due to the time of day in which the accident occurred and a cumulative sleep debt, which likely impaired the captain's performance.

Background

During the accident approach, the first officer was flying using the autopilot. When she called for the approach flap setting of 15°, a flap asymmetry occurred in which the right flaps did not extend and the left flaps extended partially. About 40 seconds later, when the airplane was at

[1] All times in this letter are central standard time (unless otherwise noted) and based on a 24-hour clock.

[2] The National Transportation Safety Board's full report, *Crash During Approach to Landing, Empire Airlines Flight 8284, Avions de Transport Régional Aerospatiale Alenia ATR 42-320, N902FX, Lubbock, Texas, January 27, 2009*, Aircraft Accident Report NTSB/AAR-11/02 (Washington, DC: National Transportation Safety Board, 2011) will be available online at <http://www.ntsb.gov/publictn/A_Acc1.htm>.

8093A

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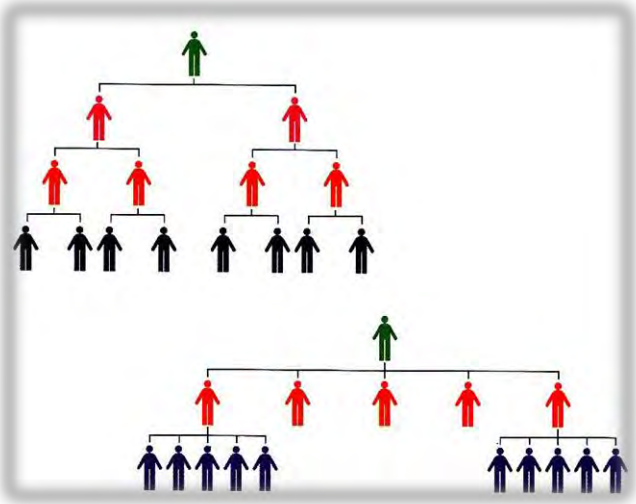
FEMA NIMS ICS (2010)

Span of Control

- Refers to the number of personnel or units that directly report to a supervisor or manager
  - Supervisors or managers should be able to adequately supervise, communicate with, manage, and control all personnel under their supervision
  - Appropriate span of control may vary between three (3) and seven (7) personnel per supervisor, with a recommended ratio of one (1) supervisor to five (5) subordinates



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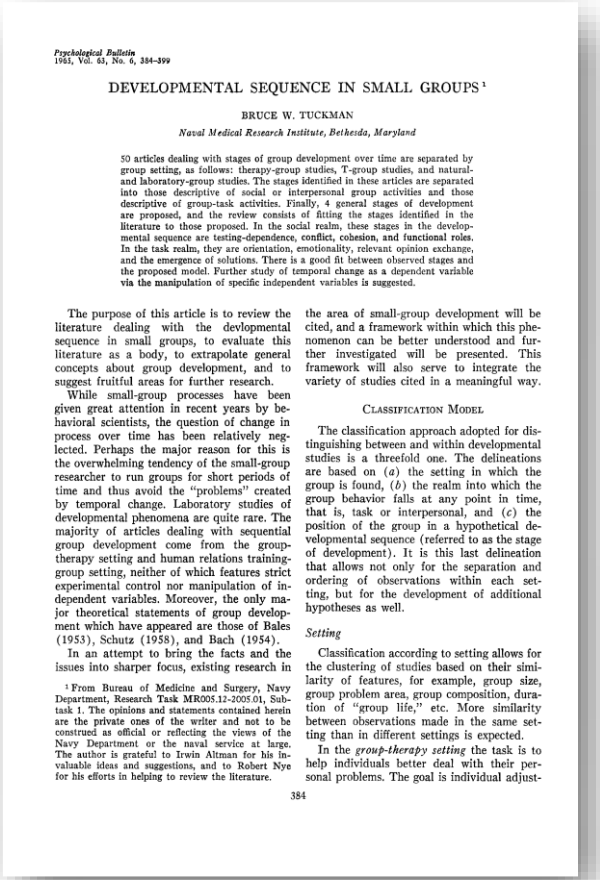
Team Development

- Tuckman suggested four main stages of team development:
  - *Forming*
    - Members depend on team leader for direction
    - Some anxiety and uncertainty occurs about how the team will work together
  - *Storming*
    - Healthy group conflict and debate arise as individual roles get sorted
    - Some teams get stuck in this stage and become unsuccessful
  - *Norming*
    - Members start to form rules for roles and communication
    - Security about individual roles develops
  - *Performing*
    - Team is task-focused and leader plays more of a coordinator role



Psychological Bulletin
1965, Vol. 63, No. 6, 384-399

DEVELOPMENTAL SEQUENCE IN SMALL GROUPS[1]

BRUCE W. TUCKMAN
Naval Medical Research Institute, Bethesda, Maryland

50 articles dealing with stages of group development over time are separated by group setting, as follows: therapy-group studies, T-group studies, and natural- and laboratory-group studies. The stages identified in these articles are separated into those descriptive of social or interpersonal group activities and those descriptive of group-task activities. Finally, 4 general stages of development are proposed, and the review consists of fitting the stages identified in the literature to those proposed. In the social realm, these stages in the developmental sequence are testing-dependence, conflict, cohesion, and functional roles. In the task realm, they are orientation, emotionality, relevant opinion exchange, and the emergence of solutions. There is a good fit between observed stages and the proposed model. Further study of temporal change as a dependent variable via the manipulation of specific independent variables is suggested.

The purpose of this article is to review the literature dealing with the devlopmental sequence in small groups, to evaluate this literature as a body, to extrapolate general concepts about group development, and to suggest fruitful areas for further research.

While small-group processes have been given great attention in recent years by behavioral scientists, the question of change in process over time has been relatively neglected. Perhaps the major reason for this is the overwhelming tendency of the small-group researcher to run groups for short periods of time and thus avoid the "problems" created by temporal change. Laboratory studies of developmental phenomena are quite rare. The majority of articles dealing with sequential group development come from the group-therapy setting and human relations training-group setting, neither of which features strict experimental control nor manipulation of independent variables. Moreover, the only major theoretical statements of group development which have appeared are those of Bales (1953), Schutz (1958), and Bach (1954).

In an attempt to bring the facts and the issues into sharper focus, existing research in the area of small-group development will be cited, and a framework within which this phenomenon can be better understood and further investigated will be presented. This framework will also serve to integrate the variety of studies cited in a meaningful way.

Classification Model

The classification approach adopted for distinguishing between and within developmental studies is a threefold one. The delineations are based on (*a*) the setting in which the group is found, (*b*) the realm into which the group behavior falls at any point in time, that is, task or interpersonal, and (*c*) the position of the group in a hypothetical developmental sequence (referred to as the stage of development). It is this last delineation that allows not only for the separation and ordering of observations within each setting, but for the development of additional hypotheses as well.

Setting

Classification according to setting allows for the clustering of studies based on their similarity of features, for example, group size, group problem area, group composition, duration of "group life," etc. More similarity between observations made in the same setting than in different settings is expected.

In the *group-therapy setting* the task is to help individuals better deal with their personal problems. The goal is individual adjust-

[1] From Bureau of Medicine and Surgery, Navy Department, Research Task MR005.12-2005.01, Subtask 1. The opinions and statements contained herein are the private ones of the writer and not to be construed as official or reflecting the views of the Navy Department or the naval service at large. The author is grateful to Irwin Altman for his invaluable ideas and suggestions, and to Robert Nye for his efforts in helping to review the literature.

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Threat and Error Management (TEM)

- A safety management approach borrowed from aviation
- TEM assumes that errors are going to happen and focuses more attention on managing the errors
- A “threat” is an event that occurs outside the influence of the team and increases the complexity of the operation
- An “error” is an action or inaction that leads to deviations from organizational intentions or expectations
- “Management,” from a TRM perspective, entails “trapping”:
  - Cross-checking, confirming, and resolving ambiguities
  - Using three-way communication
  - Two-Person Rule – two people required on all safety-critical tasks
  - 100-Percent Rule – everyone agrees with the entire plan
  - Two-Challenge Rule – everyone stops if second challenge not acknowledged

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Questions?

Chason Coelho, Ph.D., CSP
Principal Scientist
(425) 519-8712
ccoelho@exponent.com