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Disaster Series: The Function of Engagement for High Reliability Organizing (HRO)

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Abstract

Random, stochastic variation creates fluctuations in the environment. The organization must respond as these fluctuations become forcing functions or create an abrupt catastrophe. This variation is described by the color of noise – reddened noise frequencies or pink noise. Operations during these events uncover gaps between theory and practice, which are bridged through engagement. Engagement is behavior that has defensive functions against threats to the organization, supports thinking through motor cognition, initiates self-organization for directed responses, generates information during the flux of events, and creates a structure within a volatile environment. We describe the function of engagement in High-Reliability Organizations (HRO) as a process to use the situation to extend our understanding.

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Introduction

Theories, concepts, and models enhance organizational reliability and safety. Can a gap form between accepted theory and current practice? If so, how can we narrow or eliminate such gaps? One approach is to cross the gap between theory and practice by engagement (1-4). In real-time, engagement bridges the gaps that develop between concepts and the gaps formed between theory and practice. In this article, we describe the *function* of the act of engagement.

There is little or no gap if a theory is prescriptive for organizational reliability and safety. However, if the theory is *descriptive*, without continuous calibration, we risk losing fidelity to the operational environment – inaccurate theories or models can kill (5).

Organizations fail, and error brings harm because of tightly coupled components with complex interactions. This sequence is the premise of *Normal Accident Theory* (6). To prevent this, the organization can rely on the judgment of experienced experts and centralized, rational decision processes. This process frees subordinates from the difficulty of making decisions under uncertainty. Academic theories, concepts, and models support this approach to reducing error and achieving high levels of continuous reliability. The risk is the creation of dangerous gaps.

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Some organizations operate in hazardous conditions while achieving high levels of continuous reliability. These organizations utilize structural complexity and contingent, layered authority patterns still not fully described by theory. Todd R. LaPorte and Paula M. Consolini succinctly state, "In a sense, HROs *work in practice and not in theory"* (7). Overlapping and conflicting concepts paradoxically can fill in gaps or support crossing these gaps.

HROs "*extend* formal calculative, programmed decision analysis as widely as is warranted by the extent of knowledge. The urgency of operational needs;" are "alert to the surprises or lapses that could result in errors small or large that could *cascade into major system failures* from which there may be no recovery;" and "authority patterns shift to a basis of *functional* skill," LaPorte and Consolini (7). [Emphasis from the authors; the senior author (TAM) was captain of the USS Carl Vinson during these studies.]

"HROs "extend formal calculative, programmed decision analysis as widely as is warranted by the extent of knowledge. The urgency of operational needs;" are "alert to the surprises or lapses that could result in errors small or large that could cascade into major system failures from which there may be no recovery;" and "authority patterns shift to a basis of functional skill," LaPorte and Consolini (7)."

Theory and practice innately form gaps during routine operations (1, 4). Unexpected events can penetrate the organization through these gaps, possibly cascading into unrecoverable failure. It is not a simple matter of closing or narrowing gaps between theory and practice. Gaps form at various levels of analysis – prevention and response, planning, training, organizing, logistics, prevention, recovery, et cetera (8).

By bridging theory-practice gaps, engagement as action *extends responsiveness* which can then become prevention and can generate resilience (3, 4, 7). A well-accepted approach to action is to identify or characterize the situation, then decide on a course of action or protocol – *situation drives decisions*. For example, protocols or algorithms appropriate for the situation guide decisions, which are further calibrated by decision theory. The linear flow of situation-decision-action is *not* engagement. Engagement is more than a means to decide, then act – *engagement is a behavior.*

This is not to say we need two types of behavior – one for slow tempos and one for fast tempos. Engagement is an immediate behavior that prevents or reduces consequences at any tempo. Behavioral processes that develop within stable environments can contribute to failure in unstable environments. However, the engagement processes work efficiently in both environments, so there is no need to have two approaches.

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Organizations do not make decisions; people do. Organizations do not act; it is the individual who acts. The organization's structure influences and is influenced by the decisions and actions of individuals (9). Viewed as a dichotomy between "top-down" and "bottom-up" perspectives, we risk placing the value of one against the other. Top-down strategies can constrain bottom-up tactics that rely on local decision-making and action (2). By Viewing this as a dichotomy between the specifications of the "whole field view" immediately outside of events versus "local groupings" within the flux of events, the outside whole field view becomes privileged (10). In the flux of events, abstractions and concepts incorporated into the whole field can become fatal to local groupings (11).

As described above, the normative stance response to a given situation indicates, if not dictates, subsequent behaviors. From the pragmatic stance, the situation indicates what consequences can develop. These consequences develop nonlinearly, meaning the individual must maintain spatial and temporal views and understand that minor discrepancies or disruptions can initiate a larger cascade of events. The possible consequences drive behaviors through reciprocal feedback between the individual and the environment. Our understanding of the situation, then, determines our actions: *Do we fit the situation into our understanding, or do we use the situation to extend our understanding?*

What We Engage

For tractability in planning, education, and training, we too easily group threats into various 'typologies of convenience.' In our review of NICU responses to various disasters, we identified similar threats and similar behavioral responses regardless of the type of disaster (12-14). We can better understand engagement as a response to environmental forcing functions or to abrupt, catastrophic events.

Fluctuations – Environmental and Operational

Biological systems exist in a world of random, stochastic variation. These systems must maintain stability far from any equilibrium state (15, 16). Multiple degrees of freedom within the system allow *internal* fluctuations to create the necessary 'nonequilibrium dynamical system' (17). In the HRO, the necessary degrees of freedom emerge from cognitive, affective, and behavioral approaches that form the basis of HRO. The result is an HRO-maintained nonequilibrium dynamical balance.

"HRO describes those organizations within a stochastic environment that operate far from equilibrium. The stability of the HRO derives from the dynamic stability generated through the human interactions of self-organization (18)."

HRO describes those organizations within a stochastic environment that operate far from equilibrium. The stability of the HRO derives from the dynamic stability generated through the human interactions of self-organization (18). That is, dynamic human behavior stabilizes the organization against the destabilizing effects of external dynamic, stochastic environmental behavior. As the environment enters the organization, operators must enter the environment (19). *This recognition is engagement.*

The environment, operations, and human performance fluctuate due to random, stochastic factors. These influences correlate on different time and space scales that produce waveforms or spectral frequencies (20). The frequencies of environmental fluctuations act as environmental 'noise,' distinguished from each other by their disruptive potential within the environment. Human behaviors also have frequencies that auto-correlate from feedback onto the individual. For discussion, we can separate three color groupings based on the characteristics of their frequencies: red, pink, and white.

The Color of Noise

Forcing functions. Increasing stochastic environmental noise creates the unpredictability of events and generates the 'forcing functions' of energy. Forcing functions describe the strength of the environment to force a system or population to respond. The meaning of the types of noise lies in the unpredictability and severity of these forced events. Environmental noise can trigger events when forcing functions generate resonance of frequencies internal to the organization.

Through resonance, mundane elements within the environment or organization can develop the power to force a system or population to respond. Such 'forcing functions' act on various scales. Some occupy our attention while other low-frequency events erupt into major crises in our presence. Forcing functions introduce emergent new properties into the system.

'Red noise' (Table 1) describes environments with some frequencies having more extended periods ("red" for the longer frequencies of red light). Red noise is dominated by low-frequency (or

Table 1. Patterns and Characteristics of Noise (25)

Color	Structure	Variance	Distribution
White	No frequencies dominate Flattened spectrum Spectral density has equal amounts of all frequencies	Data *decreases* variance Forms Gaussian curve	Gaussian distribution - Elements fully independent - No autocorrelation
Red	Low frequencies dominate Long-period cycles	Data *increases* variance Forms power distribution	Power law distribution - Elements *not* independent - Mutual/ reciprocal relations
Pink	The midpoint of red noise The slope lies *exactly* midway between white noise and brown (random) noise	Data *continuously increases* variance Distinguishes pink noise from reddened spectra	Power law distribution - No well-defined long-term mean - No well-defined value at a single point

long-period) cycles that increase the probability of long runs of above or below-average conditions. Low-frequency events (reddened spectrum) have an inordinate influence on a system because prolonged decay continues dissipating energy and environmental disruption (16, 20).

'Pink noise' (also called fractal, flicker, 1/*f*, or *f -1* noise) is the power function exactly halfway between the predictability of white noise (all frequencies are equally represented and have equal strength) and the randomness of brown noise (named for the randomness of Brownian motion). We can observe 'flickers' of power (abrupt increases in magnitude) (21, 22) at 'half' the integral of white noise processes.

'White noise' has the same variance for all frequencies. There is no temporal correlation, no correlation variance, and time and space have constant variance (20, 23). The values of a random signal at two instants in time are completely independent of each other.

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Autocorrelation, when the past influences the present or from interactions with other systems, makes the system more susceptible to feedback loops. Even minor or mundane extraneous noise signals will allow the system to achieve resonance. Minor events then become amplified and consequential. White noise then shifts to red or pink noise. *All human behavior is red or pink noise*.

Because of feedback (autocorrelation), red and pink noise has zero mean, and the variance increases with more data or information. Red and pink noise do not form a Gaussian distribution without a long-term mean or defined value at an instantaneous time. Instead, they form power distributions where rare events act as powerful forcing functions. Pink noise produces sudden and catastrophic events in the environment (24).

The non-Gaussian nature of red and pink noise distributions impairs our ability to calculate descriptive statistics or probability distributions. Prevented are classical logic, rigid models, and tightly coupled concepts. Without a Gaussian distribution, we become limited in comparing our situation with a reference class or predicting an accurate trajectory. Uncertainty is a fundamental cause of psychological stress.

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This problem of more data clouding the conclusions develops when an event is influenced by what preceded the event. That is, the event is no longer independent of preceding events. Autocorrelation is when past observations or events have an impact on current ones.

Entropy

Energy transforms and dissipates, the first and second laws of thermodynamics. For HRO, we identify five relevant forms of energy: thermal, chemical, kinetic, electrical, and ionizing radiation. Elements of safety for the HRO are directed toward containment or constraint of these forms of energy and prevention of their transformation to other forms.

Information also dissipates and transforms, described mathematically by Claude Shannon in his equation for information entropy. Information dissipation and the corruption of information through communication led Shannon to identify two states of information: certain versus not certain (26). For electronic communication, this became the binary system, 1 and 0, that developed into digital

forms of electronics.

> ***"Though not entropy, we consider uncontrolled behavior as a form of red or pink noise. Human behavior interacts with the entropies of energy and information to create forcing functions. We cannot predict how someone will behave in a confusing situation or under threat,"***

Though not entropy, we consider uncontrolled behavior as a form of red or pink noise. Human behavior interacts with the entropies of energy and information to create forcing functions. We cannot predict how someone will behave in a confusing situation or under threat, whether it is our response or the response of others. Behaviors we encounter may be diagnosed as clinical disorders or subclinical, undiagnosed, or untreated psychological traits or disorders. (27).

Perhaps the true force of nature is entropic stochastic processes.

Precision and Accuracy

The color of noise differentiates the functions of precision and accuracy. Structures that must *not* deviate from specifications require precision. That is, the system cannot tolerate variance from the specified value. These systems have no autocorrelation, meaning measurements are independent and random. Data then forms a Gaussian distribution where more data decreases variance. The measure of error from the desired value guides acceptance or rejection. Error is a measure of quality to reduce error. These are *information-sensitive* systems, and gathering information may be a legitimate focus of operations.

> ***"On the other hand, structures exposed to entropic dissipating energy must remain within a specified range for continued operations. The system fluctuates in response to these environmental forcing functions, with variance increasing with the power of the forcing functions."***

On the other hand, structures exposed to entropic dissipating energy must remain within a specified range for continued operations. The system fluctuates in response to these environmental forcing functions, with variance increasing with the power of the forcing functions. Feedback within and between the forcing function and the system forms a power distribution. More data increases variance making prediction difficult. Measurements that differ from expected or desired values may indicate changing circumstances, the limits of knowledge, or the boundary of performance. Error, wrongly considered a failure signal (28), has value in the HRO. Though red and pink noise environments are *information insensitive*, they are not feedback insensitive. Engagement generates information through real-time feedback despite rapid changes in human performance or the environment.

Precision is a measure of reduced variance necessary for hardware's smooth functioning or operations in a white-noise environment. Error marks values exceeding what can be accepted. Accuracy is proximity to the desired value or state and will improve with feedback. Accuracy works well for moving targets. White noise environments with a Gaussian distribution rely more heavily on precision, while red or pink environments rely on accuracy in the absence of the Gaussian distribution—[Table 2].

Table 2: Precision versus Accuracy

Precision	Accuracy
Hardware	Human behavior
Assures our understanding	Extends our understanding
Applicable to white noise Gaussian distribution ("Six Sigma")	Applicable for red and pink noise Power distribution
Error identifies a structural defect	Error generates information An error ensures safety by identifying boundaries of knowledge and performance
Identified by feedback Short feedback only Long feedback contains too many factors	Improved by feedback Incorporates long, delayed, indirect feedback loops
	Failure as negative feedback keeps you grounded
Assures homeostasis	Supports allostasis
Uncovers structural errors	Uncovers flux in the environment Uncovers system impairments Uncovers performance decrements
Improved by moving offline	Can be improved in real-time
Supports certitude, motivated reasoning, the hedgehog, and narcissism	Creates doubt, the fox, and psychological grounding

Table developed with Ian van Stralen

Engagement as Defense

We protect ourselves within the flux of events by acting to prevent consequences. During a crisis, fixed defenses become underspecified instructions for the conditions and contexts. Preplanned routines soon constrain or impair decision-making. The resulting inability to act against consequences makes the system "brittle" and challenging to extend into new situations (29, 30).

"This is the problem of *unanticipated variability*, which frequently happens during emergencies at complex technological systems. Operators must continue operating and controlling the system in a totally new and unprecedented environment and adverse conditions. Coming up with an unprecedented plan is strongly culturally driven," Najmedin Meshkati and Yalda Khashe (31).

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Behaviors

Behavior is the most immediately adaptive method used by animals to survive an adverse or hostile environment (32). We consider our behaviors to be learned. However, some behaviors have a neurologic basis, such as relaxed selection, personality type, and emotional memory. In urgent circumstances, protective behaviors are expressed that we modulate for effective engagement.

- *Relaxed selection* occurs when an environmental demand or threat is removed, relaxing selection pressure and altering the original suites of behavior (33). This is similar to animal domestication, which introduced domesticated traits unsuitable for survival in the wild condition (34).
- *Personality types* are consistent, inter-individual behavioral differences. We are familiar with personality in psychology, linked to emotionality with neuroendocrinological characteristics. Ecologists use a broader sense definition at the population level as responsiveness to the environment. These are inheritable behavioral suites ranging from insects to primates (35, 36).
- *Evolutionary fear circuits* describe heritable fears with origins in evolution. Examples are fear of high elevations in adults (Mesozoic), snakes, confined spaces, and water immersion (Cenozoic), compulsive washing, and an obsessive fear of contamination (Upper Paleolithic) (37)
- *Emotional memory* is how we learn a survival behavior from a single, emotionally charged incident, preparing the individual for a similar circumstance. The amygdala links memory to emotions causing reflexive emotional, visceral, and behavioral responses to threats (38, 39). Emotional memory has been identified in wild animals (40).

Behaviors come in suites coordinated for various purposes (41, 42). Suites of behaviors that combine actions and non-actions will create sustained, coordinated defensive responses for survival. Relaxed selection forms some behavioral suites. Personality, consistent or repeatable inter-individual differences in behavior across time and contexts (43), form other behavioral suites.

Animal personality strategies adaptive to uncertainty fall into three groups that we also see in human responses (36):

1. gather information to reduce uncertainty (information sensitivity),
2. show strategic preferences for options that differ in their associated variances in rewards (variance-sensitivity),
3. invest in insurance to mitigate the consequences of uncertainty (associated with differences in risk-taking behaviors such as boldness).

Self-Organization

In response to a crisis, human behavior will self-organize as a defense against the threat. With the necessary degrees of freedom, individuals will use reciprocal feedback to generate information and create structure. *This is engagement.*

Through nonlinear kinetics, these defensive structures emerge by self-organization. "Individual organisms may use simple behavioral rules to generate structures and patterns at the collective level that are relatively more complex than the component and processes from which they emerge" (44). *Thus, complexity can emerge without many rules or* components and can be mistaken for the mathematical concept of *chaos* (18).

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People will spontaneously self-organize against forcing functions coming from the environment. The specifications of this process differ between the outside whole field view and internal local groupings. The understanding differs between top-down strategies and bottom-up tactics. Through engagement, however, a gap forms between the spectator's understanding and those who engage in the threat.

Bottom-up Defenses

Proactive defenses, top-down strategies, preplanned routines, and well-developed protocols contribute to the effectiveness of operations and management of risk for organizations. This top-down or "whole field view" perspective functions well for the organization during routine operations, in the presence of risk, and when faced with a crisis. (Risk is the "effect of uncertainty on objectives," ISO 31000 standards for risk management). Leaders with a full-field view can manage risk by observing operations or crises as the aggregate flow of individual events (10).

Proactive defenses, however, have their most significant effectiveness against predictable and controllable risks. Fixed constitutive defenses become effective against consistently high risks or when defensive costs are low costs (45). Top-down strategies with whole-field specifications readily support proactive and fixed constitutive defenses. For many people, reliance on fixed defenses is intuitive.

The intuitive nature of the whole field view and the order it brings to the organization gives this view a privileged perspective. Proactive defenses and top-down strategies become favored. Dimin-

ished are the processes that develop High-Reliability Organizing (HRO). Focus on a top-down approach impairs the organization's effectiveness during an unexpected event (2).

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Hazards or threats vary by location or over time, and defenses carry costs. Reactive defenses are more effective and reliable for increasingly unpredictable or uncontrollable threats that vary by location or over time. When defenses carry costs, it may be more reasonable for behaviors as inducible responses to have a role in defense. Inducible threat responses allow the selection of defensive behaviors with the variable expression: increased behaviors for elevated risks and decreased expression as the risk abates (45). While behaviors have a cost for education and training, HRO behaviors can support routine operations.

Inducible antipredator responses allow the selection of antipredator behaviors with variable expression, increased behaviors for elevated risks, and decreased expression as the risk abates [5]. We have an inducible antipredator response: terminate ongoing behaviors through the stress hypothalamic-pituitary-adrenal (HPA) axis while initiating attention-arousal behaviors through the locus coeruleus-norepinephrine (LC-NE) system. The LC-NE system utilizes broad attention networks to sustain effective cognition under stress. *This occurs at the level of engagement.*

The Covid-19 Crisis has refocused attention away from top-down normative strategies toward more bottom-up pragmatic tactics. That reorientation has grounded high reliability more firmly in operations, less preoccupied solely with error, and less entirely in the managerial language of design, human factors, leveraging, anticipation, rules, root causes, and problem-solving (2). *Bottom-up pragmatic tactics support engagement.*

The *function* of engagement is to reduce negative consequences – we act to prevent an undesired outcome. This context is the basis of pragmatism as philosophy (46), common sense decision-making (47), stress-induced symptoms, fear circuitry behaviors, amygdala-driven behaviors (37, 48), and current neuroscience research on how the brain works (49).

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Engagement is an inducible, interactive anti-threat response to the threat and the consequences of the threat. Behavioral suites from relaxed selection and learned ensembles of behaviors contribute to engagement. The engagement process, though, is directed at self-organization by reciprocal feedback. The outcomes are to generate information and create structure. *Engagement is nonlinear.*

Engagement as Thinking

In the flux of events, we must think despite threats that cause stress, fear, amygdala behaviors, shifting meaning and relevance of information, and distractions from extraneous activity. However, thinking in engagement generates information from uncertainty that can rapidly be communicated to others. Within the void of the situation, we must create structure. This structure is engagement as motor cognition.

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High-level knowledge is grounded in sensory and motor experience (50). This knowledge shapes the motor system for anticipation and provides information for the meaning of potential action (51, 52). We rely on reciprocal feedback from the environment (53). We think by acting (54).

Motor Cognition

Motor cognition describes how we adjust our actions to changing situations and learn through physical actions. The cerebellum and motor cortex influence our cognition and how we learn to understand the environment through physical action. Executive and higher-level cognitive cortical functions draw upon interactions with cerebellar motor functions (50, 55, 56).

The executive functions support motor attention, working memory, and inhibitory control:

- *Motor attention* to preparing for impending motor action – "memory of the future" (57)
- *Working (short-term) memory* for sensory stimuli mediates perception and action toward a goal in real-time (57)
- *Inhibitory control* protects goal-directed behavior from interference, distracting information, and impulsive or reflexive behaviors (57); inhibits emotional memories (38, 39), well-established habits, and more easily processed intuitions (58).

Stress-induced symptoms and fear circuitry behaviors impair ab-

stract thought, and the executive functions of memory and inhibitory control constrain abstract thought. To a degree, this is necessary to operate in unstable environments. Unmodulated, stress and fear become incapacitating (48, 59).

It is sometimes assumed that, during a crisis, people will operate with abstract thought and reason. This expectation leads to confusion. In practice, unmodulated stress and fear cause psychological regression and concrete thinking. Individuals sincerely believe they are being prudent and have not regressed to concrete thought (27). Karl Weick (personal communication, 08/04/2017) responded to this observation, "I would have assumed that capability for abstract thought is a constant, not a variable. That, by the way, is an alternative explanation for regression to first-learned behavior in the face of stress. Maybe it is NOT first learned, but the concrete that people regress to."

Actions create what we think, which continuously changes until we finish acting. During engagement, our *behavioral* interactions with the environment cause our brain to specify desirable actions as the environment changes (60). Through the motor system, continuous, bottom-up feedback for sensorimotor control detects prediction errors, updating ongoing action. This feedback enhances or cancels some sensorimotor signals. Alternative actions continue to be mentally processed (60). Our actions make us visible to ourselves our intention.

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The Reality of Motor Cognition

Operators in dangerous contexts use concrete nouns for description and emphasize action verbs for communication. Recent neuroscience findings support this behavior. Action words and motor actions noted above share common cortical representations. Action verbs, more so than concrete nouns, affect overt motor performance dependent on timing. An action verb will interfere with a reaching movement in progress within 200 msec. The exact words processed *before* movement will *assist* the movement (61). This action, fortunately, is category specific. A quick shout to move a hand causes hands to move and not random body parts. The category-specific, functional linking of language and motor action in the left hemispheric cortical systems link arm and leg actions with processing specific kinds of words. The two systems interact to produce meaningful information about language and action (52, 62, 63).

Upon encountering a novel or uncertain situation, we can fit the situation into our understanding, or we can use the situation to extend our understanding. This adaptation is less a spectrum of thinking than a strategy for uncertainty. Using the situation to extend knowledge, performance, and operations is the engine of High-Reliability Organizing.

The Ability to Think under Stress

"In potentially or actually unsafe situations, the ability to reorient attention to potential threats, mobilize energy resources, and take *rapid unpremeditated action* is critical to immediate survival" (64) (Emphasis by the authors). The effective operator searches for "alternative tasks that may provide better solutions amid a changing environment or when the *present behavior is not optimally adaptive*" (65) (Emphasis by the authors). These are High-Reliability Situations (HRS) (27). Human cognitive, affective, and behavioral responses generate engagement of the HRS, which is the crux and driver of High-Reliability Organizing (HRO) (19). *Where we stand determines how we engage*.

"It is not whether we are right or wrong but how quickly we identify whether our action is effective. One's frame of understanding and how we frame the situation are unrelated reference frames for evaluating effectiveness."

It is not whether we are right or wrong but how quickly we identify whether our action is effective. One's frame of understanding and how we frame the situation are unrelated reference frames for evaluating effectiveness. This is described by Bob Bea, Professor Emeritus, Civil Engineering, University of California, Berkeley (66), as *interactive, real-time risk assessment and management*:

> "Our [dangerous] work has termed this *interactive-real-time assessment and management of risks*. This approach was completely overlooked until the early 1990s. We were taught that there was only *proactive* (before operations) and *reactive* (after) – and that was it. And we thought we could capture all of the risks with the proactive approaches - and then provide adequate defenses if 'justified' – but we were missing some really major risks that were fundamentally unpredictable and unknowable."
>
> Bob Bea, 08/30/2005, personal communication

The strategy of fitting the situation into our understanding may give a sense of mastery and gain respect from some. In an uncertain situation, however, such certitude is more likely to lead to misdiagnosis when selecting ineffective or harmful treatments. The lack of real-time subtle and nuanced feedback indicates that a team is not using the engagement approach. The risk is to incorporate into organizational knowledge the invisible 'failure by not acting' (67) or the misrepresentation of failure as a success.

"In an uncertain situation, however, such certitude is more likely to lead to misdiagnosis when selecting ineffective or harmful treatments. The lack of real-time subtle and nuanced feedback indicates that a team is not using the engagement approach."

One of the authors (DvS) had an email exchange with Karl Weick

(03/27/2017) regarding the effect of engagement on cognitive dissonance during an emergency:

> "Knowledge in the threatening, unstructured state takes a different form than to what we are accustomed. Knowledge acts as a degree of belief that must be updated from information generated during the event. Mistaken beliefs must be identified and corrected, no matter how dearly held. A mistaken belief, compared to an updated belief, may only depend on its presence at initiation or the length of time it is held. Events happen continuously, creating the need for dynamic reasoning processes and more easily acceptance of new, disconfirming evidence. Long-held entrusted beliefs must be freely questioned, not an easy thing to do for most people, regardless of level of skilled or logic used."

Daved van Stralen

> "The clash between a mistaken old belief and an updated belief would seem to be a form of dissonance...The more you engage in dynamic reasoning [processes], the less chance there is for dissonance between the old belief and the updated, [improving] belief to develop, the fewer errors you make, but at risk of a new set of cues being neglected."

Karl Weick

Engagement, through motor cognition, continually updates and revises beliefs, no matter how firmly held.

Engagement Inside and Out

The Eulerian flow specification is measured from a fixed point of reference outside the flow of events. It gives a 'whole field view' of events. The Lagrangian specification of flow, measured from within the flow of events, also measures how small groups experience events (68) (Table 3).

Table 3: Whole Field View and Local Groupings as Eulerian and Lagrangian Specifications (69)

Whole field view	Local groupings
Eulerian, quantitative	Langrangian, qualitative
Decontextualized	Contextual
External, fixed point Select a viewing point Focus on a specific location	Within flow Select a starting point Focus on the individual moving parcel
Flow	Trajectory
Multiple fixed positions	Continuous measure with position and pressure
Rate of change of system	Individual parcels

Differentiating these specifications reveals differences in evaluating the organization's 'motion' through red or pink noise events. The different reference frames reveal different processes for the continuity of operations. Practical descriptions differ from the fixed-point whole field view that does not move despite events and the experience of local groupings that move with events. Neither is wrong, and both specifications are necessary for effective operations.

During operations, the captain of a US Navy nuclear-powered aircraft carrier is on the bridge, engaged through the whole field view. As local groupings continue operations, the captain can evaluate performance and direct support as needed (TAM). Firefighting has the phrase when a captain picks up the firehose; the captain becomes a firefighter. A captain can have the whole field view or the local groupings view, but not both. In a PICU's initial development, staff with little experience in critical care felt more secure with a critical care physician in the room for resuscitation. To increase their capacity to operate without direct attending supervision, one of the authors stood outside the room. He responded to requests to enter with, "There is a rule that you cannot run a resuscitation unless you stand at the door of the room." Upon entering the room, all participants would look to the attending for orders.

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We distinguish the engaged leader using the whole field view of operations from the spectator at too great a distance for engagement. There is order within any "difficult period" built pragmatically through engagement and self-organization. Too great a distance and observers more easily adopt a normative stance; the error is the distance from accepted norms. The nature of the order is rendered less accurately by a spectator's concepts than by the insider's detailed acquaintance.

The distance from events does not necessarily make an individual a spectator. HROs are topological structures, meaning relations are described by their strength and, though deformable, relations are never broken. A topological philosophy keeps executives, administrators, and managers involved as operators. To support the development of a PICU, John Mace, the pediatric department chair, maintained topological relations throughout the program. More interactions strengthened relations, and the interactions were much like the captain on the bridge – directing support where he could and supporting disengagement by staff when indicated.

"For others, distance from events becomes a problem as information paradoxically becomes more confident with distance (70). "A story always sounds clear enough at a distance, but the nearer you get to the scene of events, the vaguer it becomes" – George Orwell describing shooting an elephant (71). "

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story always sounds clear enough at a distance, but the nearer you get to the scene of events, the vaguer it becomes" – George Orwell describing shooting an elephant (71). Executives, administrators, and managers readily become spectators without realizing it.

As spectators far from events, they risk treating knowledge as certitude, relying on normative standards, focusing on the precision-based error in red noise environments, and micromanaging. During a discussion with HRO operators about the importance of details, Karl Weick observed that details could work against them. "The use of details without context is micromanagement," he warned.

"As spectators far from events, they risk treating knowledge as certitude, relying on normative standards, focusing on the precision-based error in red noise environments, and micromanaging."

Operators within a forcing function focus on context and what they can learn through engagement. Spectators will focus on what they already know.

Evaluating Motion and Continuity

From the outside, we choose a position in space or time that gives a "whole field view" of the evolving disaster. When viewing from the inside, as a "local grouping" of people would experience events, we select a starting place. From the starting place, we observe the local effects of the event on the local grouping. We can later aggregate local information to develop a more extensive field view.

The outside view is too easily taken as the top-down approach, while the view from inside the flow of events is assumed to be a bottom-up view. This understanding is too simple. A top-down approach develops when concepts or abstractions from a centralized authority guide action, while the bottom-up approach develops when contextual, local actions influence the centralized authority. The two views are different levels of analysis, and both support engagement.

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We can better understand these views not as directional influences but as specifications from outside or within the flux of events. The "whole field view," from outside the flux of events, observes a specific area from a fixed position, though the "fixed" position can be moved to increase the scope of the field. Whole field observers primarily use location and time static coordinates as independent variables.

A "local grouping" specification refers not only to the group's positions within the flux of events but to the group itself as an independent unit, including its actions. Within the flux of events, a local group becomes deformable; therefore, the position of the grouping is more important rather than the size of the group.

For local grouping specifications, the group's identity becomes an independent variable.

- This form emphasizes changes to the state in a frame of reference that moves with events.
- The primary measurement of change is the velocity of change rather than the physical *direction* of movement.
- Entropic changes within events cause actions of the local group.
- The velocity of events and pressure on the local group are variables within the event.

The whole field view specification formulates movement as static coordinates that can also apply to local groupings. Local grouping specifications have coordinates that move with events. The whole field view, outside the flux of events, is more amenable to reliance on concepts and is tolerant of abstractions. The contextual nature of local groupings, from within the flux of events, is not tolerant of abstractions. Rather, abstractions can be dangerous and can kill (11).

"The whole field view, outside the flux of events, is more amenable to reliance on concepts and is tolerant of abstractions. The contextual nature of local groupings, from within the flux of events, is not tolerant of abstractions. Rather, abstractions can be dangerous and can kill (11)."

Engagement Bridges Gaps

Engagement is the act of approaching and entering liminal spaces (3). In these situations, sometimes all we have are observation and action (72). Engagement describes actions taken without certainty that they will succeed (73). Engagement describes the approach and experience when the operator does not know what will work. "I don't know what is happening, but I know what to do." – said a Los Angeles Fire Department firefighter. "HRO uniquely shapes the engagement that moves through and out of a liminal period," Karl Weick (personal communication).

Spectators and those with the whole field view may too easily assume a static, closed system with parts that operate like a jigsaw puzzle – complete once assembled. This utilizes a "static process employed to analyze puzzles in matrixed depictions of the world. In that approach, all assumptions about a problem are built into the matrix at the start, thereby limiting the range of eventual deductions," Adrian Wolfberg (74). We can solve the *puzzles* sequentially and, if necessary, figure out the missing pieces within the puzzle matrix. This normative view prevents engagement.

John Boyd (75), a US Air Force officer and strategist who created the OODA (Observe, Orient, Decide, and Act) Loop, considered

these problems a dynamic *mystery* rather than a static puzzle. Wolfberg demonstrated that we use Boyd's concept of mystery for "mystery-solving." This relies on "full spectrum analysis," many lines of simultaneous engagement as events unfold across a full spectrum of possible actions. Multiple challenges can best be solved in an integrated fashion to create synergy among disparate domains. "In full-spectrum analysis, the analyst examines not only multiple, possibly interrelated intelligence problems simultaneously but also considers contextual and influential factors that could affect the interim analysis of information and its interpretation" (74).

The act of engagement does more than bridge conceptual gaps in real-time. When engagement becomes the innate strategy for the individual or organization, it penetrates and diffuses from the inciting event temporally, spatially, and socially. *Unrecognized engagement* as an emergent property of operations exists as:

- **Safety** emerges from engagement as an early process before overt, decompensated functioning occurs. Safety operates in the domain of covert, compensated operations. "What went on before" is engaged, earlier and earlier.
- **Prevention** emerges from the engagement of failing but without the presence of failure.
- **The resilience of the organization** emerges by remaining engaged with operations past the resolution of events, mental consolidation of experience – meaning-giving
- **The individual's resilience** emerges when veterans remain engaged with novices past the resolution of events through meaning-giving; veterans reframe events for healthier mental consolidation of experience (53).
- **Leadership in dangerous contexts** emerges when the leader engages subordinates AND the environment (76, 77).
- **Lessons Learned,** the integration of the experience into operations emerges when experience and comprehensive review are given meaning by outside domains of knowledge and experience (10).
- **Trust** emerges by putting others first during the engagement.

Engagement bridges the gap between abstractions and details (Karl Weick, personal communication). Engagement makes use of the nuances and subtle differences in details. Details can herald an early response to therapy or be an early herald of failure (3).

"Feedback within a system creates long-period frequencies that produce periodic forcing functions or abrupt catastrophic events. Feedback as autocorrelation prevents using data from these systems to generate a Gaussian distribution for analysis. Uncertainty becomes the environment."

Conclusion

Feedback within a system creates long-period frequencies that produce periodic forcing functions or abrupt catastrophic events. Feedback as autocorrelation prevents using data from these systems to generate a Gaussian distribution for analysis. Uncertainty becomes the environment.

Engagement bridges the gaps between certainty and uncertainty, whether abstract or concrete. These systems are *information insensitive*; more data increase the variance. Therefore, collecting more data during the event does not contribute to problem-solving.

Engagement generates changing, though accurate, information representing the situation in flux at any given time. We also act to think. That is, motor cognition through the words we use and physical activity effectively supports engagement.

Engagement as behavior changes the environment as it produces information about that environment. The environment for engagement is influenced by reddened noise-forcing functions or shaped by abrupt catastrophes. The result is an information-insensitive environment where we generate information through reciprocal feedback. Therefore, we use reciprocal feedback to achieve and maintain accuracy. Fitting the situation into our understanding limits reciprocal feedback and slows response time.

Through engagement, we advance our personal performance and how we extend the organization's operations into uncertainty

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