A STRATEGIC APPROACH TO MANAGING THE RISK OF HUMAN ERROR IN OPERATIONS
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This whitepaper describes the services described on the Website, http://www.muschara.com. It describes an approach essential to successfully managing operational resilience through human and organizational performance (HOP). Managing effectively involves all of the following elements:

- defining the gap between where you are and where you want to be and developing a plan to close the gap
- implementing the plan to achieve the desired outcome
- regular monitoring of progress relative to the outcome’s acceptance criteria
- adjusting the plan as needed to close the gap more effectively, efficiently, or safely

Yes, managing is important, even to something that tends to be capricious and resistant to being managed—human error. However, in relation to your organization’s mission and the safety of its people and assets, you cannot leave human performance (and human error) to chance. You MUST manage the risk posed by human error in your operations purposefully and intentionally.

However, you cannot manage what you do not understand. Individual human performance (Hu) is NOT common sense. Performance, especially failure, always involves complex relationships: relationships between people and processes, people and technology, people and machines, people and other people.¹ Therefore, to be consistent and effective managing human performance and its associated risks, it is important to understand some of the theory and fundamentals of human performance.

**Context of Human Performance: Work**

Generally, industrial operations involve the production of goods and services that are suitable for use or have economic value. Production includes the processes and methods used to transform tangible resources (raw materials, semi-finished goods, subassemblies) along with intangible ones (data, information, knowledge, expertise) into goods or services—thus adding value.² In addition to adding value, one of the essential goals of successful operations includes the avoidance of harm, especially harm triggered when we lose control—human error.

Work creates value. The work of production involves a series of human actions—making, constructing, assembling, or manufacturing an end product. People are intrinsic to the production process—they touch things to accomplish the organization’s goals. Multiple and varied human actions occur during the transformation process in handling materials, parts, machinery, assemblies/subassemblies, tools, and information from their natural, unprocessed state to a finished product state. Other human involvement includes planning, scheduling,
routing, shipping, dispatching, storage, etc. The end result of production comprises all goods
and services that are delivered or provided to a customer or end-user.

Human beings are involved in much of the production and delivery processes. All along the
way, people touch things, and with each and every touch there is the potential to either create
or extract value. Take a moment to consider some of these touchpoints.* They could involve
multiple transfers of energy, several movements of mass from one place to another, or they
may consist of the creation and/or the transmissions of information or data from one
repository to another. To accomplish work, human actions require the use of tools or systems
that present inherent hazards, most of the time, energy. We are interested in those
touchpoints that involve permanent change when people work. Therefore, to accomplish
production operations in an organized, efficient, reliable, yet safe manner—control, learning,
and adaptation are necessary. More on this later.

Defining Human and Organizational Performance

Dr. Aubrey Daniels, a well-known authority on human behavior in
the workplace, defines Human performance as (Hu), one or more
behaviors, B, directed toward accomplishing some outcome or
result, R. To perform is to act in a way that accomplishes a desired outcome. Together (+),
one’s actions and the results they produce define his/her performance.4

The commercial nuclear industry adopted the abbreviation Hu in the mid-1990’s to avoid
confusion with another field of performance called health physics (HP), a domain of
technology aimed at protecting people from the adverse health effects of radiation. Hu is
used in this paper to refer to individual human performance. However, human performance
in relation to its broader context of the organization within which people perform is managed
differently. To make this distinction from individual human performance, Hu, I use the
abbreviation HOP, human and organizational performance. The concept of HOP refers to the
collective performance of an organizational unit involving the work outputs of many workers
performing within the systemic context of the organization’s technical and social
environments. The practice of HOP involves work across the spectrum of the organization,
which can be divided into two broad categories, the sharp end and the blunt end.†

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* A touchpoint is a human interaction with an object such that the state of that object is changed or altered in some
way. This involves work, a force over a distance.
† The sharp end of an organization includes those individuals who interact directly with intrinsic hazards, performing
the physical work of creating value in the production processes, while the blunt end comprises the policy makers,
line managers, designers, and other support personnel in creating expectations, resources, and incentives, among
other various conditions for production personnel at the sharp end.
THE HUMAN ELEMENT IN OPERATIONS

Human error is a behavior that unintentionally deviates from a desired behavior. Most errors are trivial, but sometimes errors are grievous causing you, coworkers, and your organization a great deal of pain, frustration, cost, and, sometimes, heartache. Most people do not have a proper understanding of human error, and without a proper knowledge and attitude toward human error and its organizational context, your company's ability to cope with the impact of human error is at risk.

Companies face ever increasing demands for profitability, quality, reliability, and safety; striving to do more with less. Using fewer people and fewer resources at a higher pace in complex work environments is a recipe for error, and the cost of doing business this way is aggravated by "simple" human error. As a manager, you are compelled to look for ways to meet these competitive pressures while minimizing the risk that human error poses to your company's bottom line, including the safety of your employees.

Therefore, managers, supervisors, and front-line staff need practical methods to help them anticipate and manage situations that MUST absolutely go right every time. This is accomplished most effectively and efficiently by establishing positive control at CRITICAL STEPS.

Safety is traditionally described as the freedom from an unacceptable risk of harm. But, harm to what? Events and accidents are always defined in terms of harm to assets, without which there is no event, except in the case of a near-miss. Assets include people, product, property, facilities, reputation, equipment and anything important to the organization’s reason for being—its mission. Assets and their limitations define the harm that could be realized and what constitutes an event.

Harm involves an unwanted change in the state of assets or serious degradation or termination of the organization’s ability to accomplish its mission. Every organization possesses multiple assets, but some are more important than others—i.e., people and product as a minimum. Strategically, it is important to protect these assets from harm due to the residual, intrinsic hazards present in your operations.

Events have many names, such as incident, accident, deviation, nonconformance, etc. In other contexts, the term “event” can refer to every day occurrences such as a birthday party, a

‡ Near-misses are important to those who oversee the company, because they recognize that the operation was performed out of control, and under different circumstances, harm would have been realized. This is unacceptable. Therefore, near-misses have to be evaluated to regain control of the operation.
wedding, a concert, or a baseball game. But in human and organizational performance, managing human error in operations, the word event refers to unwanted outcomes that involve harm to assets such as the following:

- **People** who are killed, injured, or infected with a disease
- **Product or property** that is lost, defective, damaged, or destroyed
- **Environment** that is contaminated, spoiled, or ruined
- **Reputation** that is defamed or tarnished
- **Value** that is lost

The occurrence of an event—the onset of loss of or damage to one or more assets—strongly indicates that control over the damaging properties of hazardous processes has been lost—usually triggered by some form of human failing. But, the harm that ensues is more the result of ineffective defenses, where the barriers or safeguards are either missing, ineffective, or circumvented. Sustaining safety in operations is essentially a control problem—control of 1) human variability during high-risk activities and 2) hazardous processes used to create value. Therefore, the word event as used in this paper denotes harm to an asset due to an uncontrolled:

- Transfer of energy (such as mechanical, gravity, electrical, chemical)
- Movement of mass (solids, liquids, or gasses)
- Transmission of information or data

These three work situations involve hazards of various types that are intrinsic to industrial operations. Intrinsic physical hazards used in industrial operations have the potential for causing harm to all kinds of assets, such as people, products, environment, and property. Generally, hazards are either inherent to the material or to its conditions of use. The following list of energy forms (with examples in parentheses) is provided not as an all-inclusive list, but to show generally what is meant by an intrinsic hazard:

- Electricity (power sources (potential), electrostatic charges)
- Kinetic (rotating machinery, moving equipment, fluid flow, linear speed)
- Chemical (corrosion, fire, dust, explosive reactions)

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§ The most prevalent source of variation in operations is human beings, which is typically manifested by some form of human error. However, rare events can occur by the “normal” functioning of the organization due to combinations of actions and conditions not anticipated by the organization’s managers, the procedures’ authors, or the facility’s designers.
• Gravity (people working at heights, bulk storage at heights)
• Thermal energy (steam, fire, hot surfaces)
• Toxic or inert gases (phosgene, carbon monoxide)
• Biological (viruses, bacteria, fungi)
• Information (defective software updates, out-of-date prints, networks, missing or inaccurate procedures, corrupt data, lax security)
• People (fallible decisions and actions, imprecise movements)

Yes, people are a hazard. Because of human fallibility and the prevalence of human beings in operations, human performance poses the greatest source of variation in operations. Variations with behavior leads to variations in results, and the prevalent trigger of events is most often attributable to human error. It’s crucial for managers of operations to understand that it’s not the error that triggers an event that you should be concerned about. It’s the harm to one or more assets that results from the error. If we can, we want to avoid both losing control and suffering the harm. Each are managed differently.

The primary challenge for managers is one of risk. In the healthcare industry, the admonition is to, “first, do no harm.” In high-hazard operations that’s exactly the mindset that managers and leaders need to instill at all levels of the organization. In the following paragraphs I describe one frame of reference for managing the risk of human error in operations that focuses on “doing no harm.”

A Model of What to Manage

Thus far, I’ve addressed human performance, the notion of human error, the importance of protecting assets during operations from intrinsic hazards in the workplace, and what constitutes an event. Now we can arrange these concepts together in a workable model that will help you manage the uncertainty of human error in the workplace, avoiding events. Whenever work is performed, three things are present:

1) Assets (things important, of high value, to an organization)
2) Hazards (intrinsic sources of energy use to create value)
3) People (work they do to create value; transformation processes)

The figure below illustrates the relationships between assets, hazards, and people—what I call the human performance “risk management concept.” This mental model enriches the understanding of operational human performance among managers, supervisors, and even workers. It also is an accurate visual of the uncertainty that human fallibility introduces to an
operational setting. Because of the potential impact on the organization, this uncertainty is a strategic uncertainty. The presence of uncertainty in the interactions between assets and hazardous processes creates a strategic risk. Therefore, managing human error in operations is as important as managing production—they must occur concurrently, not separately.

This model can also be represented in an alternative, mathematical form:

\[
\text{Asset + Hazard + Human} \rightarrow \text{Risk}
\]

Interactions or combinations are illustrated by the plus signs (+) (overlapping circles). The first ‘+’ sign represents the establishment of a pathway for either the transfer of energy, movement of mass, or transmission of information between an intrinsic hazard and an asset, where only one action (or failure) is needed to initiate value creation (under control) or harm (out of control). A pathway for harm exists when a hazard is poised in such a way as to expose an asset to potential harm—a condition. For example, a firearm that has a bullet loaded in the chamber, with the safety off, and the hammer cocked is poised to be discharged. The firearm is ‘ready’ to be fired with one action—pulling the trigger. A person would be exposed to harm if standing in front of the muzzle of a firearm in such a condition, especially if the firearm is wielded by another person with their finger on the trigger.

The photo below illustrates in classic fashion the human performance risk management model. This photograph, “Lunch Atop A Skyscraper,” taken in 1932 during the construction of the RCA building in New York City, highlights the three distinct elements of Hu risk: asset, hazard, and human. Obviously, the assets are the people, the steelworkers. What makes the photograph breathtaking is the obvious hazard—the beam the workers are sitting on is more than 800 feet about the streets below. The apparent absence of barriers to prevent them from falling makes it doubly fearsome, which is accentuated by the fact that people, including
steelworkers, are fallible. They are one mistake (misstep) away from falling. In actuality out of camera range, there is a netting stretched below the men to catch them should they lose their balance on the high beams—a barrier to prevent a fall to certain death below.

“Lunch Atop a Skyscraper.” Construction workers eat their lunches atop a steel beam 800 feet above ground, at the building site of the RCA Building in Rockefeller Center in New York, Sept. 29, 1932. © Bettmann/Corbis, courtesy First Run Features.

The second ‘+’ sign represents a human touchpoint. Recall that a touchpoint is a human interaction with an object that changes the state of that object—work. Touchpoints involve a force applied over a distance. Because of human fallibility, touchpoints create uncertainty regarding the action to be performed, whether under control or out of control. The interaction of assets, hazards, and human beings create the conditions for risk. Eric Hollnagel explains events as “unusual combinations of conditions,” which emerge from the weaknesses embedded in the system, including human fallibility. In human performance, risk is managed by exerting control over these combinations—touchpoints and pathways.

Both the creation of pathways and the occurrence of touchpoints (work) is a normal part of everyday operations. Pathways establish conditions for the creation of value through the transfer of energy, a movement of mass, or a transmission of information. Value is accomplished by the actions of front-line workers such as pilots, operators, surgeons, nurses, and craftsmen. If an action is performed in error, the performer potentially loses control and harm—an event—is likely to occur. This suggests that defenses must be built into the facility
design, production processes, procedures, and expectations to protect the asset from errant operations. Otherwise, harm is likely.

Risk is born with the creation of pathways and touchpoints. The anchor point in any event occurs at a point in time when control is lost over the damaging properties of energy, mass, and information; when the destructive potential of intrinsic hazards are unleashed because of a loss of control or the absence of adequate protection. Therefore, risk is reduced through the prudent deployment of controls, barriers, and safeguards to lessen the chance of human error at important pathways and touchpoints.

**PRINCIPLES OF MANAGING HUMAN ERROR RISK**

To sustain resilience in human and organizational performance management, actions and initiatives must remain consistent with the principles listed below. Otherwise, misalignments will occur in the organization leading to efforts working at cross purposes.

- **People are fallible.** To err is human—it’s normal to err. Fallibility is a permanent, innate feature of the human condition, which creates uncertainty in the workplace, especially when people do work involving interaction of key assets with intrinsic hazards of an operation. Human fallibility is a leading source of variation in the workplace.

- **People want to do a good job.** No one comes to work to fail. Error is NEVER a conscious choice, and, by definition, it is unintentional—no one errs purposely. However, everyone wants to be effective and efficient, and sometimes people make tradeoffs or take shortcuts to do so. To create value people touch things—they do work. Work alters the state of assets, things important to the organization, as well as hazards. Some touchpoints have greater potential to trigger harm if performed out of control.

- **Errors are predictable and manageable.** Despite the certainty of human error in the long term for large populations, a specific error for an individual performing a particular task is avoidable. Error is a loss of control, and avoiding a loss of control is particularly important for key work activities intended to add value to assets. There are occasions when error cannot be tolerated—performance must be **perfect** to avoid harm to assets. We call these occasions **Critical Steps.**

- **Risk is an inherent, emergent property of the way an organization operates.** Nothing is always as it seems. Risk lurks everywhere and persists as a result of the ways an organization is designed, constructed, operated, maintained, and managed. The workplace contains (1) assets important to the survival of the organization, (2) hazards (sometimes hidden) poised to trigger harm to those assets, (3) situations that foster the likelihood of error (error traps), and (4) faulty or missing defenses. Hazards to assets are inherent in all operations needed to create value during work. The built-in risks associated with these hazards is a function of the system’s organization and technologies within
which the work is accomplished. The organization and its system must continually adjust and adapt in response to change, stress, misfortune—and human error—and yet remain within critical boundaries that define the limits of safety (loss or damage) of each asset.

- **Organizations are perfectly tuned to get the results they are getting.** There is no such thing as a perfect process, or perfect maintenance, perfect training, or perfect procedures. Managers go to great lengths to design their management systems to control work effectively and efficiently. They try to be faster, better, cheaper, and, of course, safer. Management systems are not perfect. As with military battle plans, once those systems go into operation, they prove to be imperfect. Budgets are approximations. Resources are constrained. Process designers are unable to anticipate all conditions. Schedules are best guesses. Tools and equipment wear out. Procedures are often underspecified. Training is not always adequate for the job demands. And, there are usually not enough competent supervisors to be everywhere.

- **The causes of tomorrow’s events exist today.** *Land mines* are conditions in the workplace that pose a hidden hazard to assets. Additionally, *error traps* exist in the workplace that provoke mistakes. Unless found and corrected, both tend to accumulate unabated everywhere. These workplace conditions are formed by other obscure weaknesses hidden with the organization and its various systems. Serious events are fundamentally organizational failures. Because managers cannot plan perfect systems, they must perfect their systems by persistent and relentless learning.

**THREE KEY WAYS MUSCHARA CAN HELP**

**Mission:** To help managers and leaders of high hazard operations protect people, product, and property from the human element by providing them with risk-based error management principles and applications, developed from leading-edge research and hands-on experience, while honoring God and others through Wisdom, Integrity, and Love. With this mission in mind, Muschara helps you in three key ways:

**First,** by anticipating **Critical Steps**, operations on the shop floor stand a greater chance of being accomplished without incident—without harm to assets. As the number of **Critical Steps** performed without error increase, so the frequency of events decrease.

* **A Critical Step** is a human action that will trigger immediate, irreversible, and intolerable harm to an asset, if that action or a preceding action is performed improperly.*

I can help you identify **Critical Steps** through a systematic mapping process, which is followed up with the development of the means of controlling human interactions with assets and hazards at these points in your operations.
Second, and I think more important than controlling performance at critical steps, creating and sustaining a tenacious approach to System Learning tends to reduce the severity of events. By establishing a relentless pursuit of the true condition of their management systems, its culture, and its work management processes, managers will improve the resilience and robustness of its defenses (controls, barriers, and safeguards) that protect key assets from inevitable human error. System Learning is characterized by:

- Identifying and learning from important and persistent differences between work as done and work as imagined or planned; recognizing important drift from expectations
- Minimizing the accumulation of hidden system weaknesses that undermine safety of assets, the reliability of operations, and the integrity and robustness of defenses
- Observing and coaching performance in the workplace
- Integrating risk-based thinking and chronic unease into important business processes

Together, an effective human and organizational performance strategy that combines control of variation at Critical Steps and system learning tends minimize both the frequency and severity of events.

Finally, and I think most importantly, I help managers understand how to integrate Risk-based Thinking into all facets of operation at all levels of the organization.

Risk-based Thinking is a habit of thought in the conduct of work that systematically creates a clear understanding of risk to assets during work, characterized by anticipating, monitoring, responding, and learning.

Whenever people engage in work involving transformations of assets—using various forms of energy, movements of mass, or transmissions of information—caution and care are definitely necessary. People want to create value, not harm. On most occasions procedures, checklists, skill, or policies guide work. But, in some unforeseen cases, threats and challenges arise that have no precedent—no guidance how to respond to them. Therefore, front-line personnel must “think on their feet,” being able to adjust to novel work situations to keep the asset within its safety boundaries. People must be able to adapt for safety sake.

Research in resilience engineering has identified four cornerstone processes of successful organizations that enhance mindfulness of operational risks. These cornerstones of logic include the following practices:

- Anticipate – know what to expect
- Monitor – know what to pay attention to
- Respond – know what to do, when
• **Learn** – *know:*
  - what has happened
  - what is happening
  - what to change

As you can see, risk-based thinking encourages people to proactively and intentionally make things go right instead of mindlessly letting things happen to them—to *know*. Inherent in risk-based thinking is a **chronic unease** among employees who possess an ongoing mindfulness of transfers of energy, movements of mass, or transmissions of information during work—planned and unplanned—related to key assets. People are aware of the key assets they work with and their intrinsic hazards—they think before acting to prove to themselves the safety of assets before doing work.

**WHAT MUSCHARA CAN DO FOR YOU**

**Human Performance Consulting.** I help line managers resolve current operational human performance issues relative to safety, quality, production, delivery, efficiency, and services. As a Certified Performance Technologist (CPT), my approach to consulting is guided by the following key traits espoused by the International Society for Performance Improvement (ISPI):

- **Results-focused** – with respect to business outcomes that are threatened or not obtained (used to judge performance improvement and effectiveness of corrective actions)
- **Systemic aspects emphasized** – identification of local factors influencing performance linked to relevant organizational components; identification of organizational and related local factors influencing performance
- **Value-added recommendations** – clear understanding of the risks and benefits of corrective actions to the organization’s mission
- **Partnership with client** – consulting engagement conducted with the participation of representatives of key organizational stakeholders

**Independent Assessments.** My purpose is to identify opportunities for improving the management of the risk of human error during operations for discrete organizational units (business units). I identify gaps in the management of the risk of human error compared to state-of-the-art practices, processes, and conditions; providing practical recommendations to close the more important gaps.

**Critical Step Mapping.** CRITICAL STEP MAPPING is a systematic tabletop analysis of key operations to identify critical steps, related risk-important actions, and countermeasures that create positive control interventions. A table-top analysis is conducted in collaboration with process experts and experienced operator representatives using a systematic mapping process.
Together, we identify critical step(s) and related risk-important actions for at least one manufacturing process. This service consists of the following elements:

- One-day classroom instructor-led course on critical steps and the critical step mapping process attended by process engineers, procedure writers, and production operators.
- Two-to-three days of table-top analysis of one or more production processes until I’m convinced the participants are proficient with the mapping process.
- Integrate outputs of critical step mapping into related pre-job briefings for specific work tasks.

**Human Performance Training.** Instructor-led classroom training courses are offered for executives/senior managers, line managers and supervisors, front-line production staff, event analysts, and human performance practitioners. The overall strategic intent of acquiring the knowledge and skills is to ultimately minimize the frequency and severity of human performance events. Also offered is advanced training for human performance specialists (train-the-trainer) to improve their support of the organization’s management of human performance, such as observation and coaching, human performance technology (HPT), and strategic risk management.

- Training for executives (half day), and line managers and supervisors (two days) is oriented toward an understanding of a risk-based approach to managing human error risks to key assets.
- Training for workplace production staff (one-to-two days) promotes an understanding of basic human performance fundamentals and the skills to manage, promote, and sustain safe and reliable human performance work practices (Hu Tools) during work execution, identifying and controlling critical steps in high-hazard operations.
- A separate course, offered to Human Performance Practitioners (specialists), involves a complete technology transfer. This five-day course provides the depth of knowledge necessary to train and mentor others in managing human error in an operational environment (technology transfer). These courses require agreeing to a non-exclusive license agreement.

**Human Performance Tools** (Non-technical Skills). I assist you in developing behavior-based, Hu Tools (aimed at integrating anticipating, monitoring, responding, and learning into operations) and conducting related training, generic or tailored to the work at hand.

**Mentoring, Observation, and Coaching.** I work with line managers and supervisors in a facilitative, advisory role to improve their oversight of human performance strategically, operationally, and in the field (observation and coaching).

- One-day classroom training session followed by One-on-One in-field mentoring
• 4-hr. mentoring sessions
• 4-hour segments with as many observation sessions as can be accomplished within the allotted time
• Each session involves an observation and a follow up coaching session.
• Maximum of 2 leaders per day; maximum of 8 per week
• Operator Aid: Provide each leader with a generic set of sentence starters to aid them in debriefing positive practices, at-risk practices, reckless or unethical behavior, and problematic organizational factors.

Local Rationality Event Analysis. People do things that make sense to them at the time. Otherwise, they would not do them. This is the essence of local rationality, which assumes people want to do a good job, not wanting to fail. Given this assumption, the analyst is trained to explore relevant working conditions that contributed to the choices people made as well as identifying the related organizational factors (causes). The local rationality methodology is supported by two other analysis methods to validate what happened. These methods include human performance technology and culpability assessments. The overall analysis approach adopts a non-judgmental, non-accusing approach, unless there is clear evidence of malicious intent to the contrary.

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