Is Error-Free℠ Possible for Transmission?

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Human Performance in Transmission

(1) What is Wrong with the Big Picture?
(2) What Shall We Do or What Have We Done?

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Some System Reliability Standards by FERC/NERC

Mandatory Reliability Standards for the Bulk Power System, Order No. 693, FERC Stats and Regs, 31,242 at p.1716 (2007)

NERC Reliability Standards

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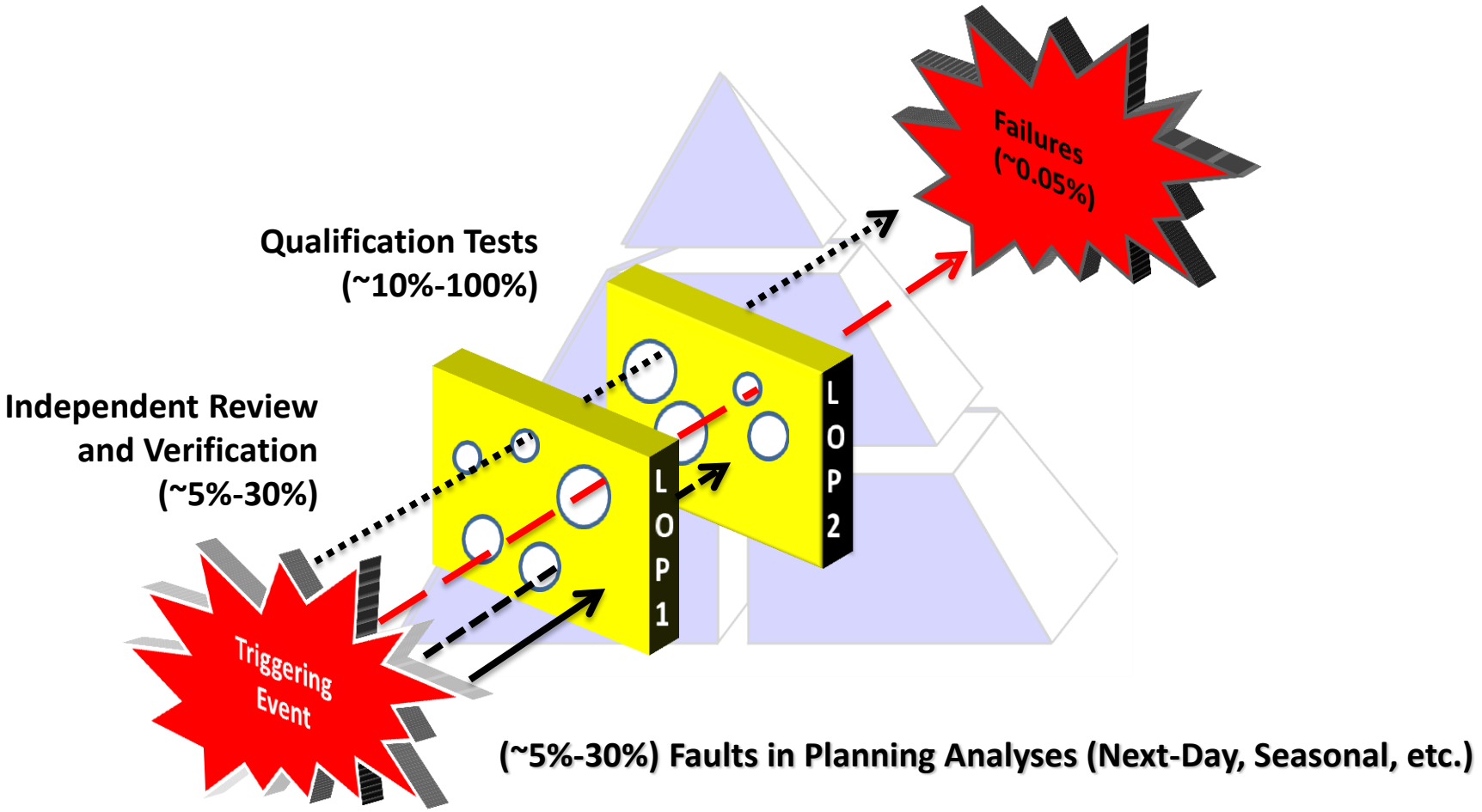
Planning Failure Model



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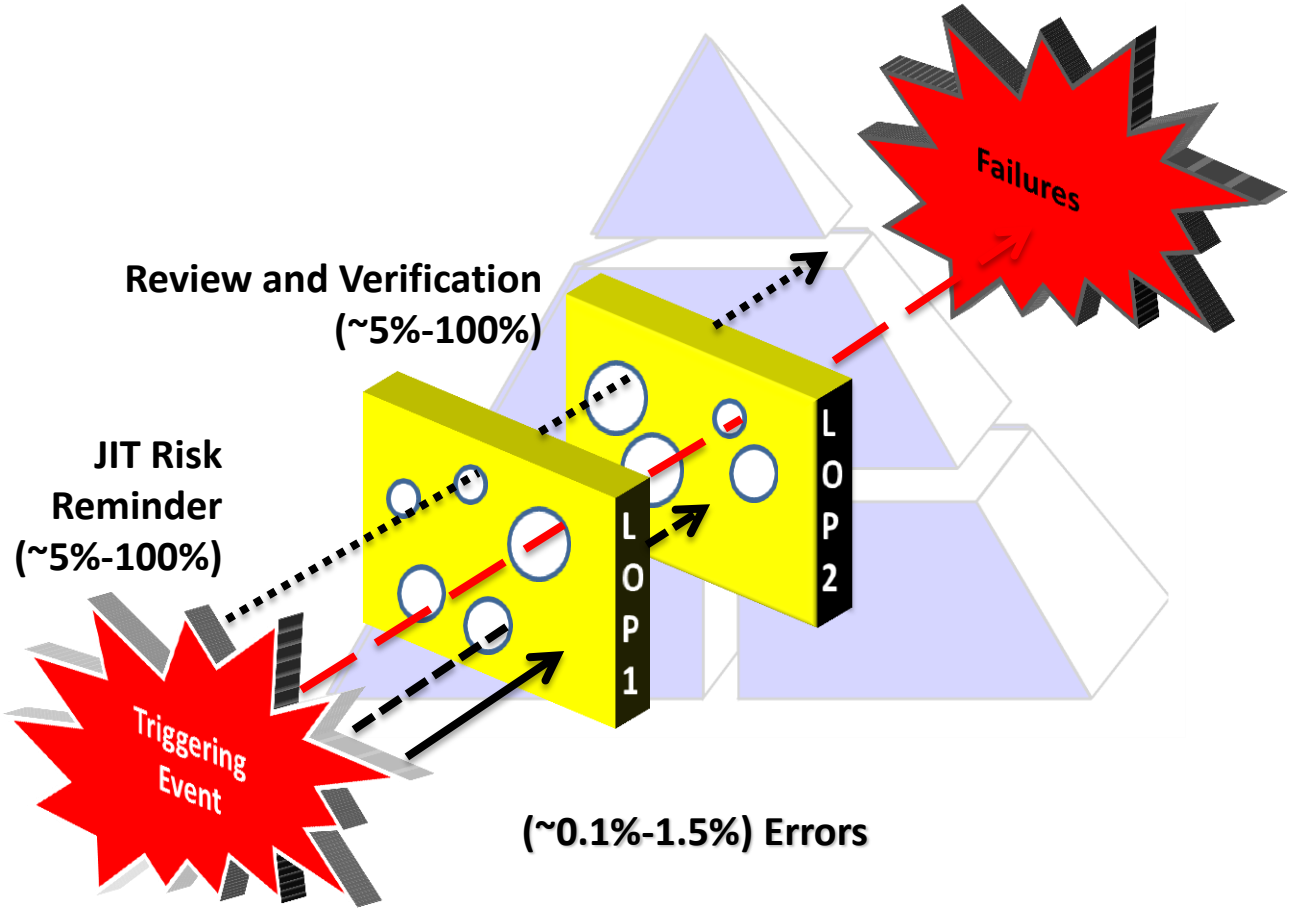
Operations Failure Model



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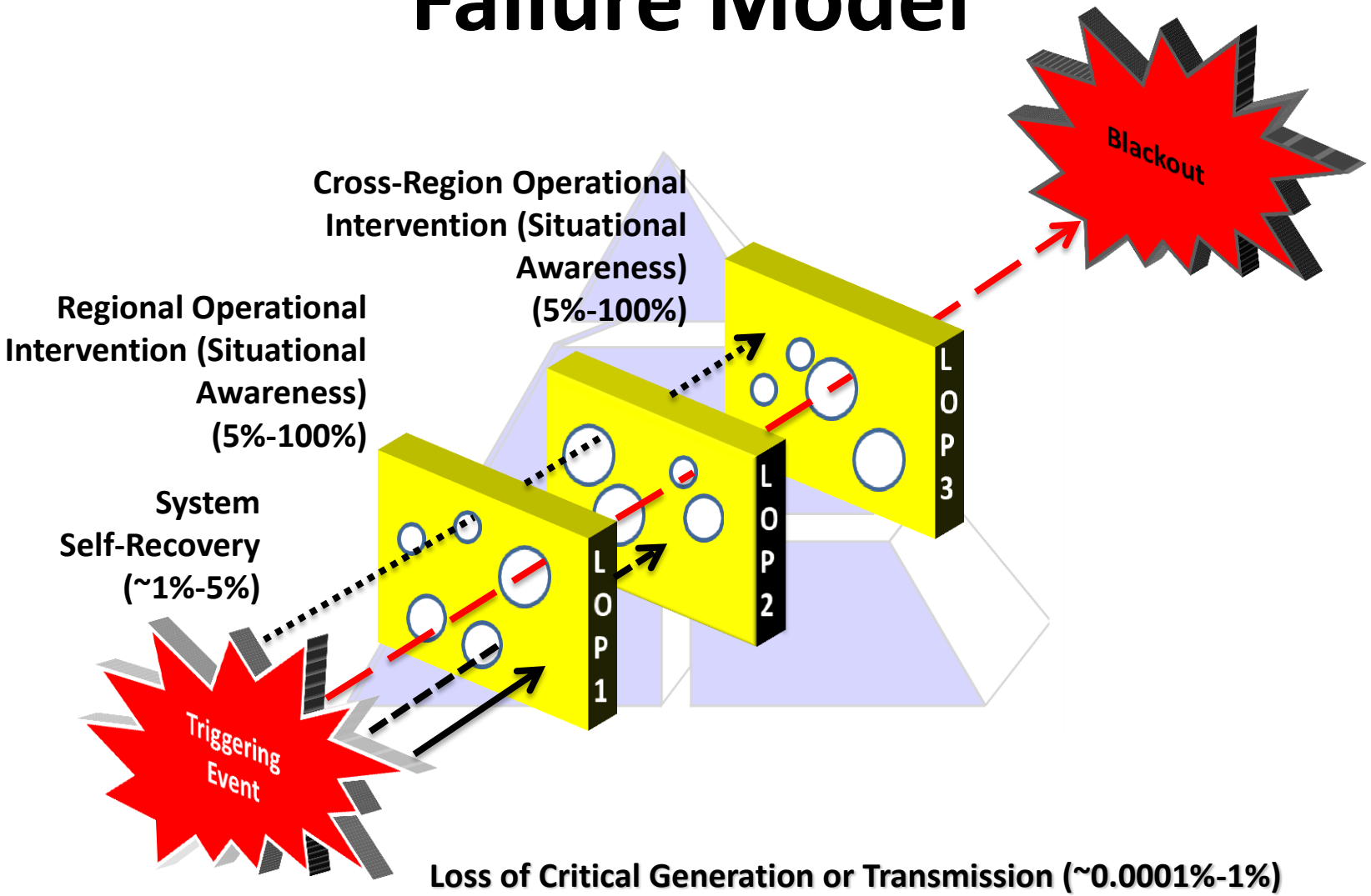
Blackout Failure Model



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Event Rate

Event (Injury) Rate = Probability of Triggering Event*

LOP1 Failure Probability*

LOP2 Failure Probability*

LOP3 Failure Probability*

Triggering Event Could be a Consequential Error, an Equipment Failure or a Special Condition

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Thought Provoking Questions

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Question 1

Are we familiar with the LOPs (barriers) established to prevent human error events, including injuries, as well as with those for critical components, such as a transformer bank?

If not, why not?

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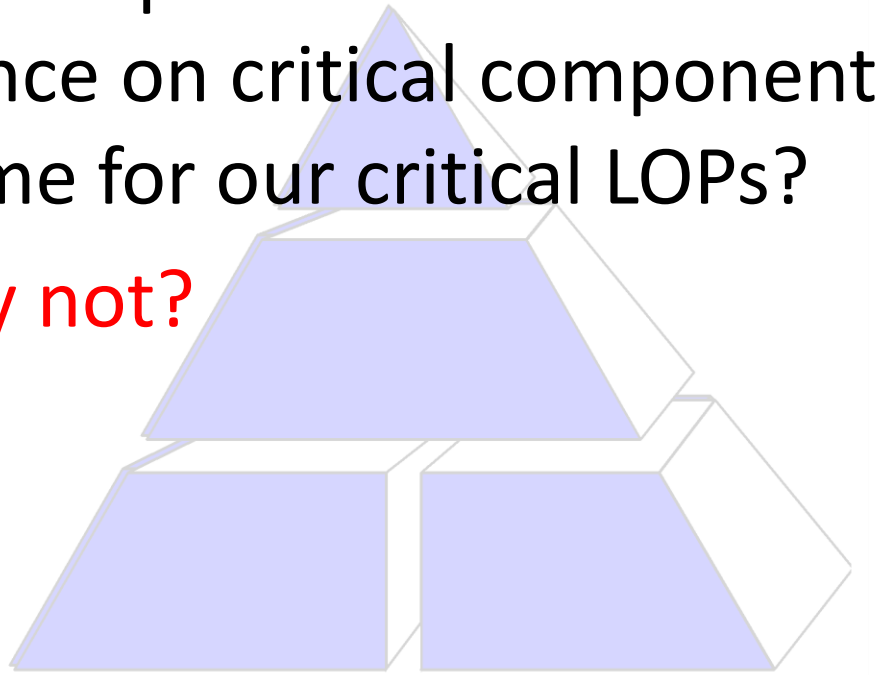
Question 2

If we monitor performance and do routine maintenance on critical components, do we do the same for our critical LOPs?

If not, why not?



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Question 3

Do we design the reliability of transmission based on quantitative analysis of LOPs? As such, would we know the important from the unimportant?

If not, why not?

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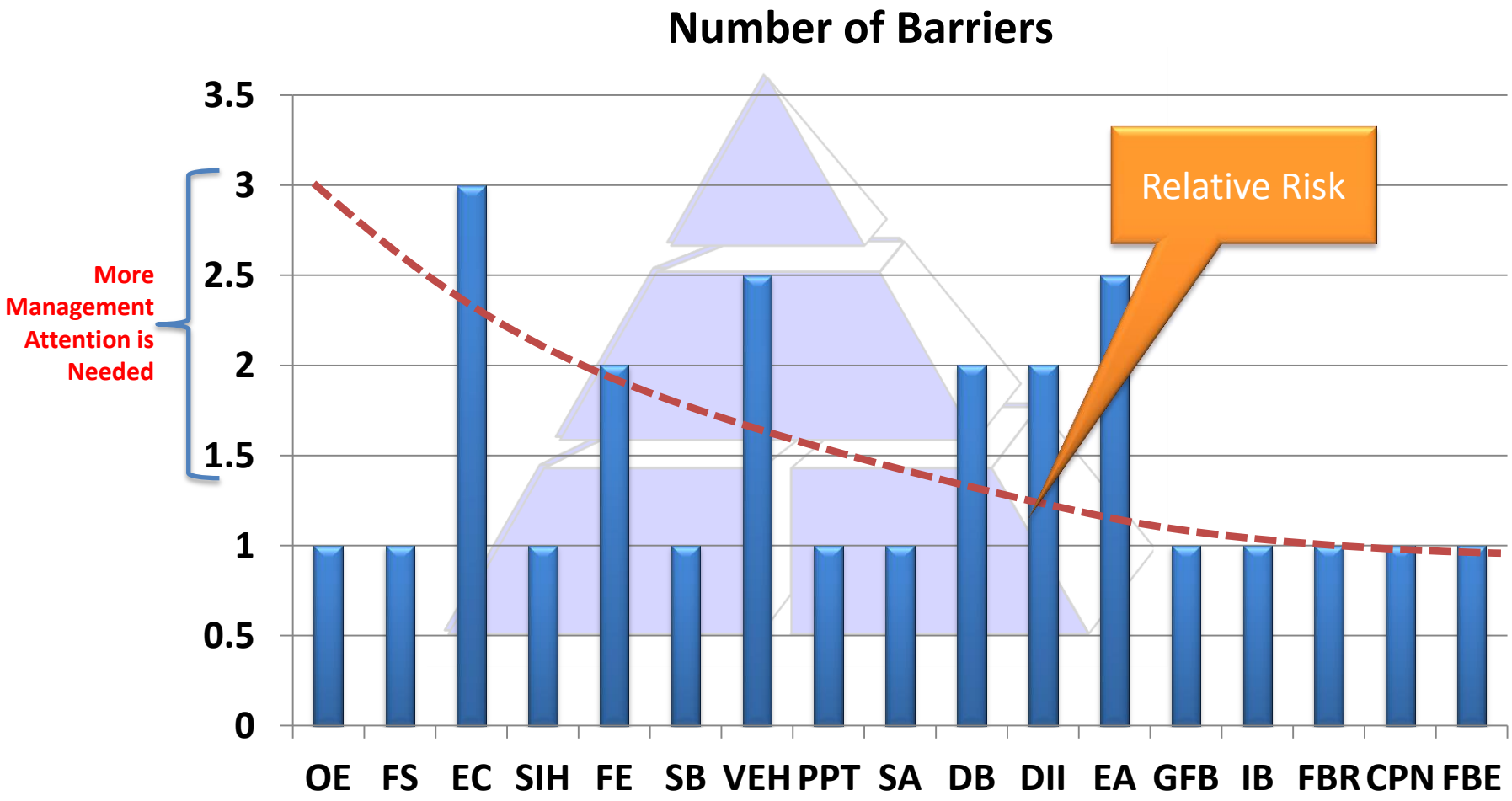
Management Attention to Various Injuries



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Question 4

We know the definition of “risk”: probability of failure times the consequence of failure.

What is the equivalent term to risk, but on the side of success? Probability of success times the benefit of success.

If we do not know that term, why not?

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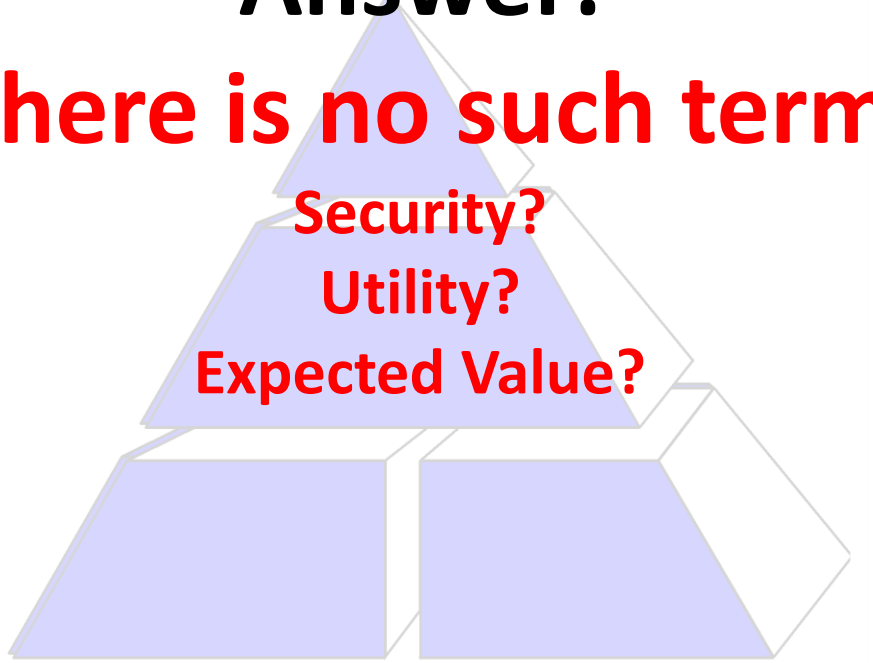
Answer:

There is no such term

Security?

Utility?

Expected Value?



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Question 5

Our workers' lives are dear to us. As we start the day, do we know where, when, and what fatality or injury will most likely to occur? If yes, have we done anything to mitigate them?

If not, why?

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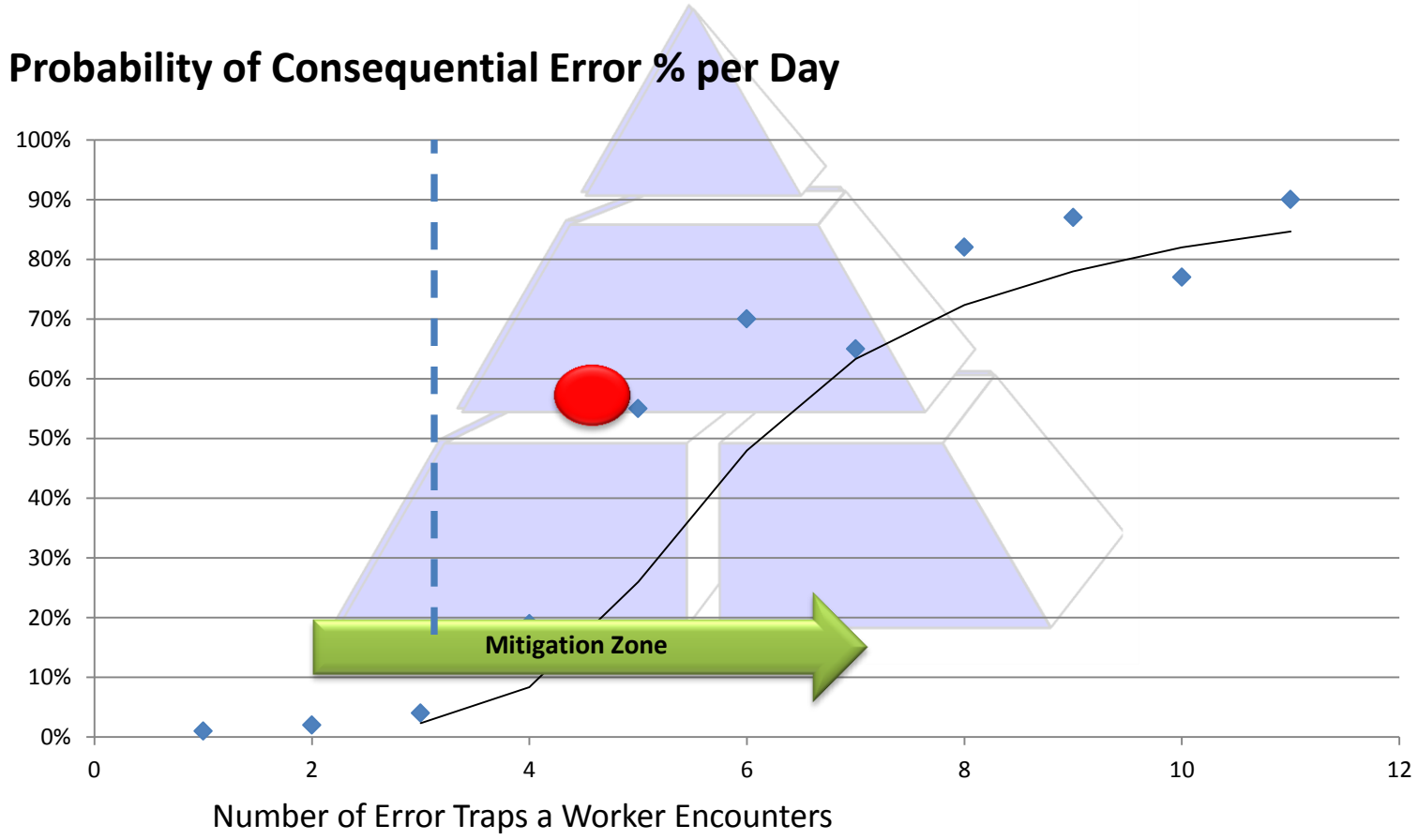
Probability of Consequential Errors

(PII Field Research, International Data, 6,555 events, 1994-2010)



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Question 6

The transmission industry's outage event rate has not dropped over the past few years, mainly due to various human errors involving the planning process, operational process and execution of tasks. Do we know how to decrease it?

If not, why not?

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Injury Statistics per Year in the USA (2005-2011)

Fatality

Vehicle – 37%
LOF- 16%
Fall -13%
Harmful Substance – 4.3%
Electrocution -3.7%
Fire and Explosion – 2.5%

~3.0 million recordable injuries, ~5,000 fatalities

(The injury rates and fatality rates essentially remain constant from 2002 and on, considering significant reduction of manufacturing industry workforce in the USA)

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Question 7

To control the flow rate of a pump, we design a control system that regulates the flow through:

- Real-time flow measurement
- Error between the actual measurement and the set-point
- Controller to change valve position and pump speed to reduce error

Human performance is as important as the pump flow in our system. Do we have a human performance control system?

If not, why not?

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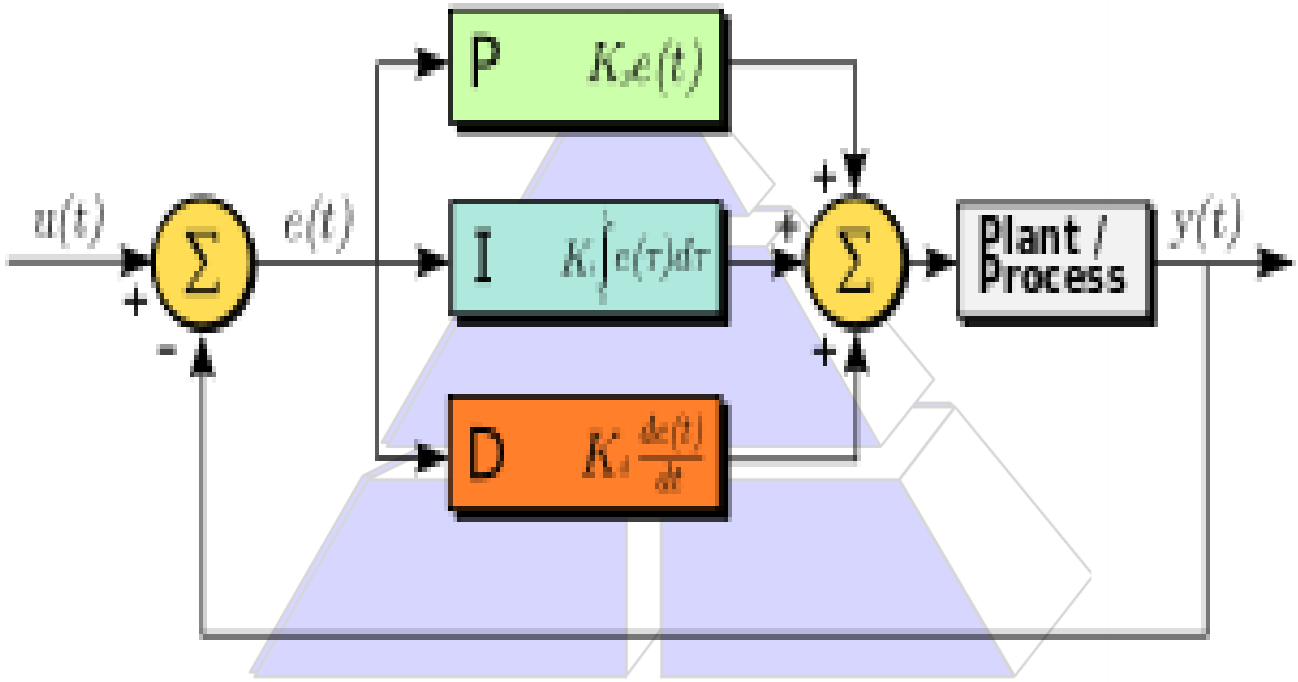
Flow Rate Control



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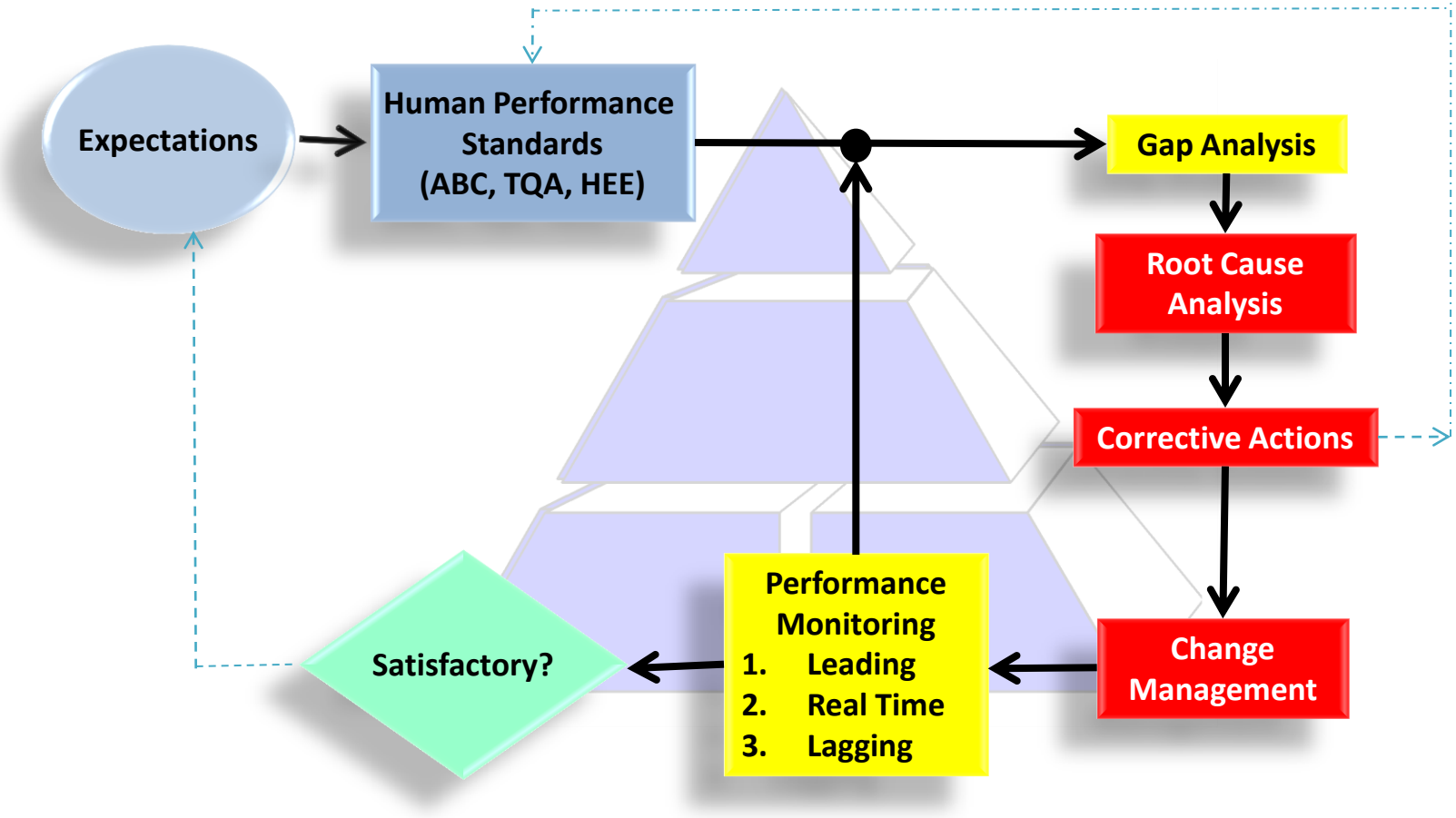
Human Performance Control Loop



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Answers to all Questions

We don't know what we don't know.

The optimism bias in the form of complacency prevents some of us from elevating to a higher level of thinking and a relentless pursuit of advanced knowledge.

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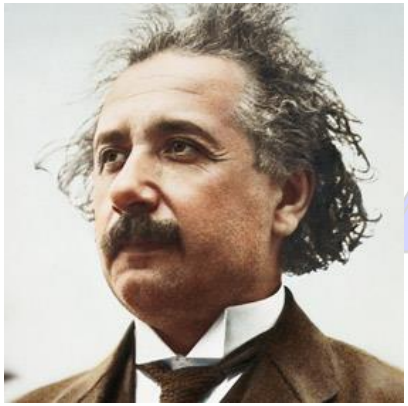
The Error-Free Zone℠

Unless we can predict it quantitatively, we really don't know how to improve the system…

Problems can't be solved by the same level of thinking that creates them…

Einstein, 1921, 1934



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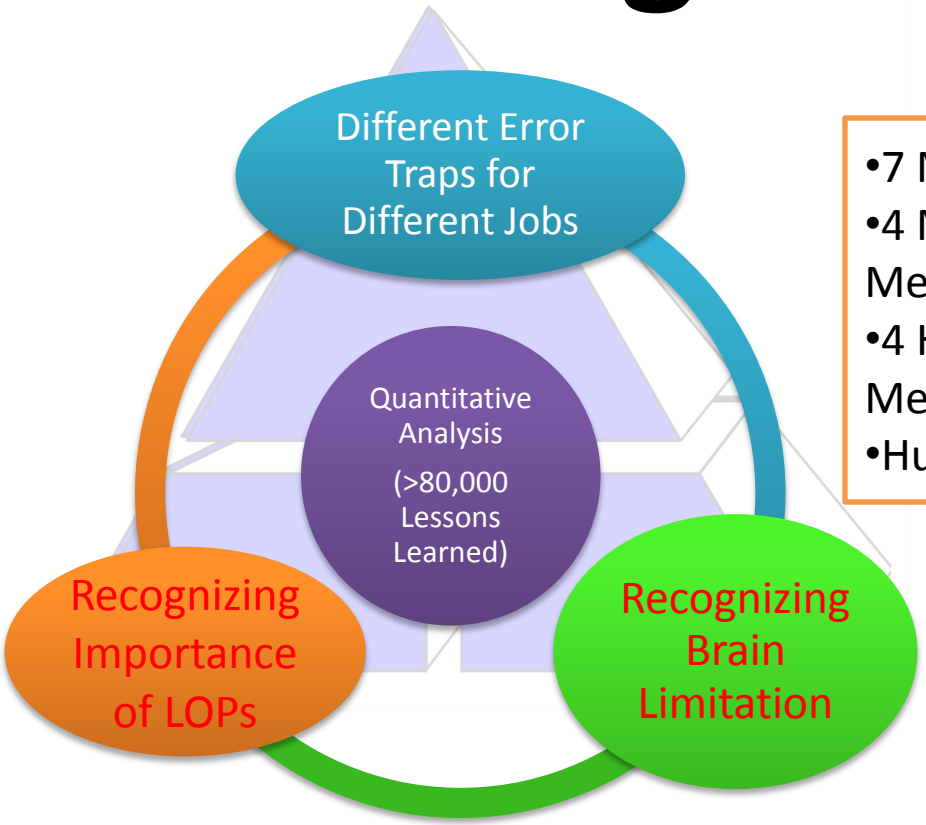
What's the New Thinking?



- 7 Marbles
- 4 Months Long-Term Memory
- 4 Hours Working Memory
- Human Error Cycles

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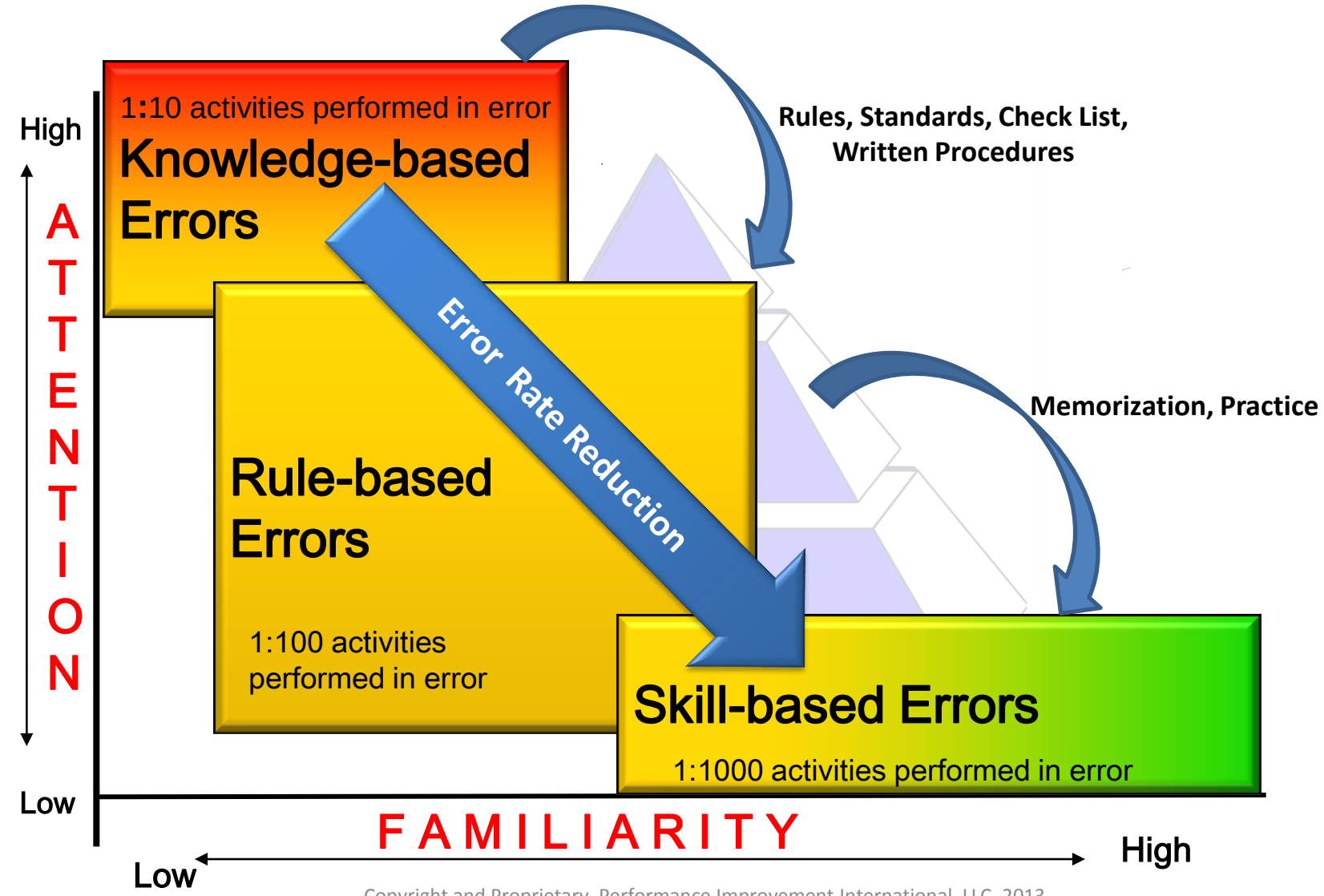
Human Error Types



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Definition of Errors

Type	Mode	Term	Definition
Skill-based	Commission	Slips	During routine and repetitive activities (e.g., driving a vehicle, reading meters, etc.), an unintentional error is made without thought, reason, or judgment. A typical example is: while driving, the driver turns the right turn signal on when making a left turn.
	Omission	Lapses	During routine and repetitive activities (e.g., driving a vehicle, reading meters, etc.), forgetting an action occurs without thought, reason, or judgment. A typical example is: while driving, the driver forgets to turn the right turn signal on when making a right turn.
Rule-Based	Intentional	Non-compliance Error	The rules, standards, procedures, or policies in question are adequate. However, workers choose to intentionally (with thought, reason, or judgment) disobey the requirements in the policies, standards, procedures or policies.
	Non-intentional	Rule Application Error	The rules, standards, procedures, or policies in question are not adequately designed, communicated to, and/or applied to the workers. In essence, they violate the principles of ABC (all-inclusive, bypass resistant, clear) and/or TQA (workers are trained, qualified, being held accountable) for adequacy of rules.
Knowledge-based	Commission	Mistakes	A decision error made to cause unexpected and negative impact to the organization.
	Omission	Indecision	No decision is made when a decision is needed in a troubled situation, a downward performance trend, an event, or a situation (e.g., routine resource re-allocation, standards change management, etc.) needing decision.

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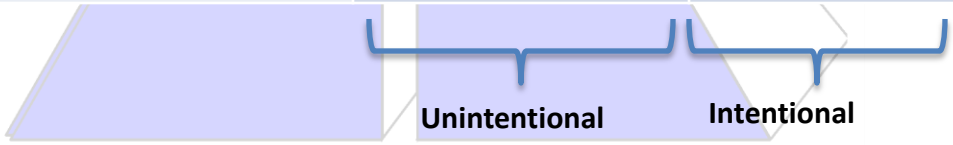
Eight Human Error Experiential Curves

	Skill-Based	Rule-Based		Knowledge-Based
Commission Error	1) Unintentional Slips Curve	3) Application Errors Curve	4) Non-compliance Curve	5) Mistakes Curve
Omission Error	2) Forgetting Curve			6) Indecision Curve



7) Engineering Error Rate Curve
8) Project Failure Rate Curve (FUSE^{SM})

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How to Calculate Human Error Probability per Activity (Error Rate)?

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Simplified Calculation

Error Rate = Nominal Error Rate*

First Order Shaping Factors

Note: For each of three error types, if it is indeterminate about omission or commission error, the average error rate shall be used in error rate calculation

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PII's Model of Human Errors (Balance of Attention Marbles)

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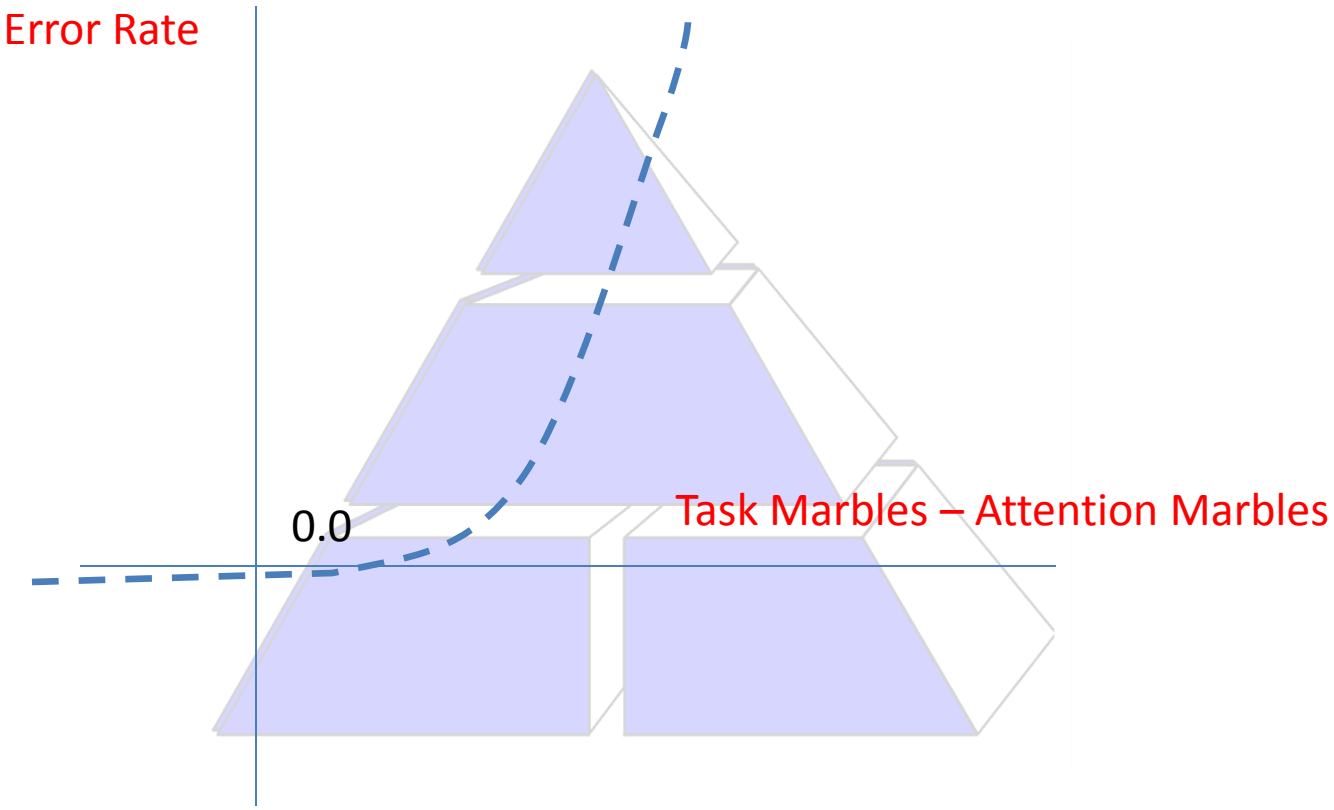
Shaping Factors = Marble Imbalance



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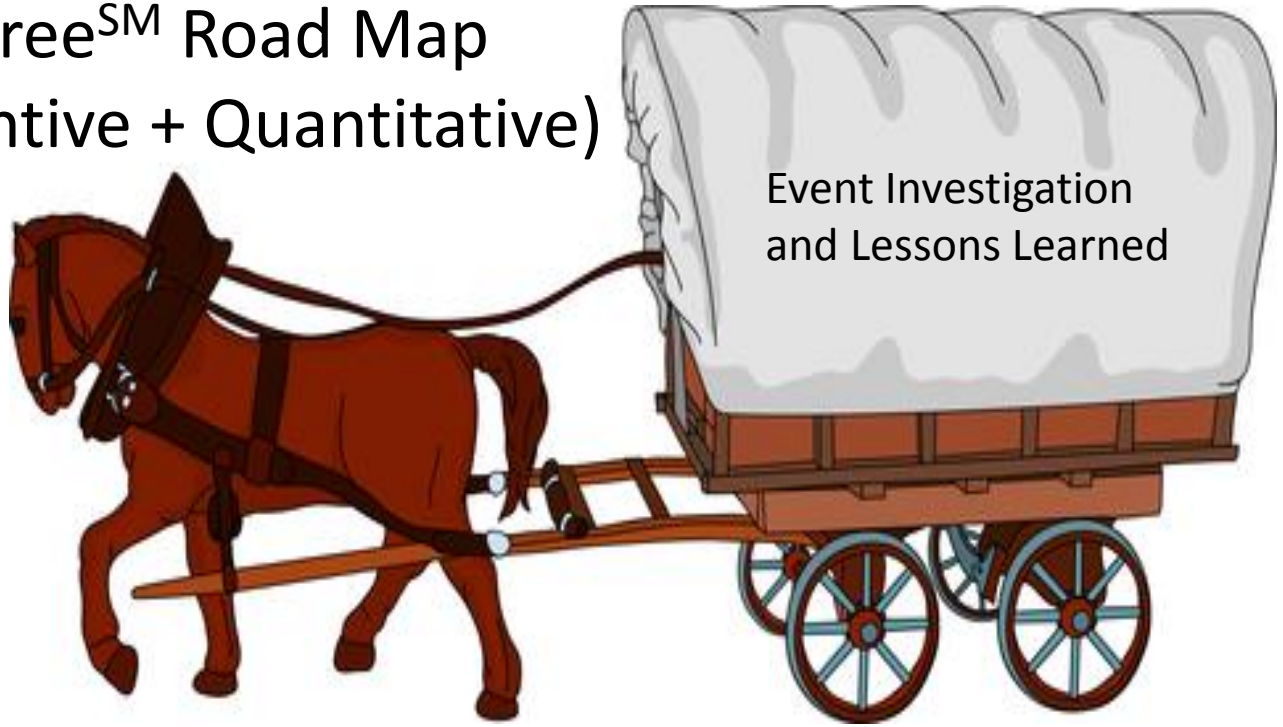
Make Sure to Place Horse-before-the-Cart

Error-Free^{SM} Road Map
(Preventive + Quantitative)



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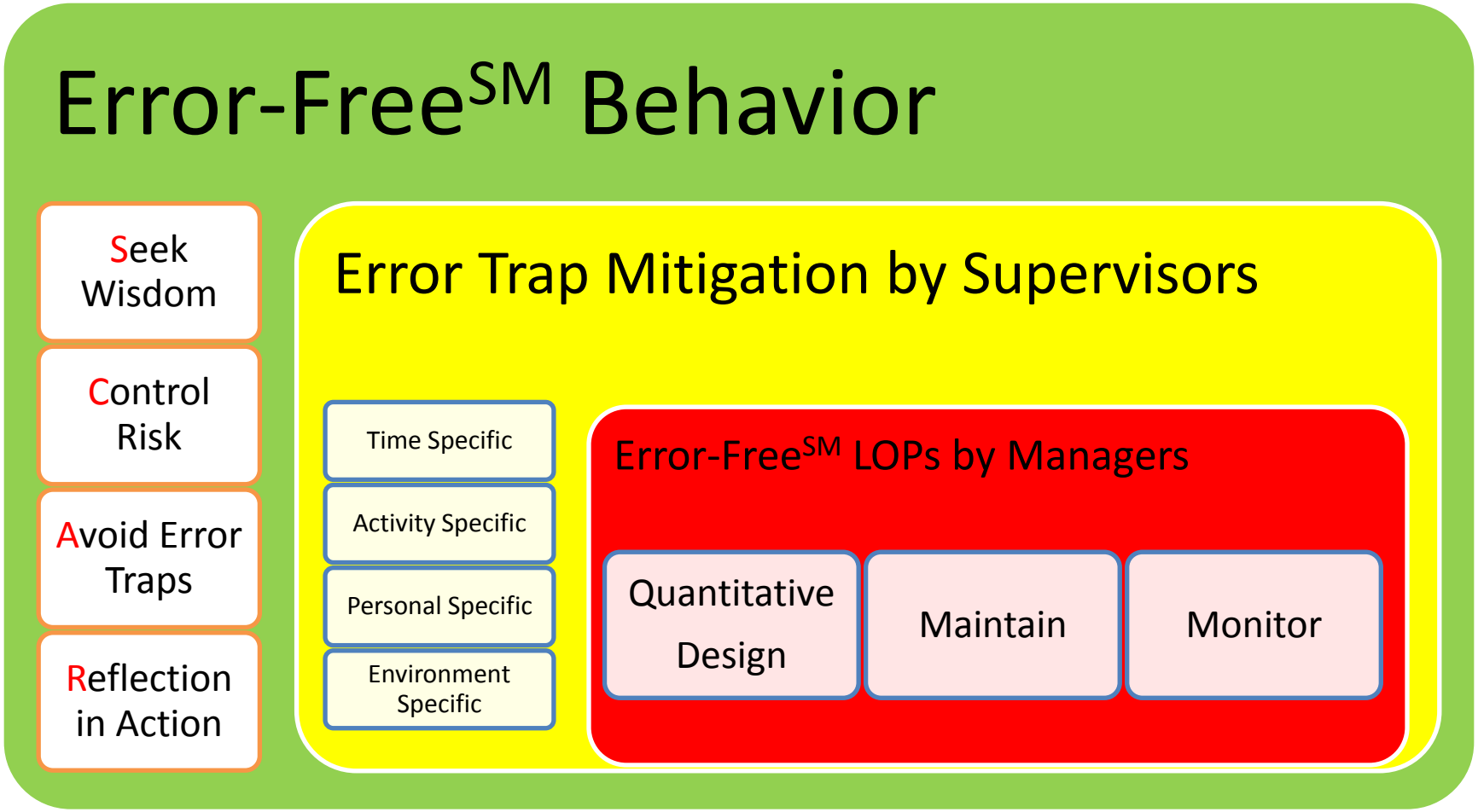
Error-Free℠ Transmission Road Map



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The Error-Free Zone℠ Lessens the Burden

Expected Event Rate Reduction

Items	Influence	Impact in Event Rate Reduction
Error-Free℠ Behavior (SCAR℠)	Reduce probability of triggering events, such as making a calculation error, use of wrong design code or data, or omission of a critical requirement by using job-specific error avoidance techniques.	**2X-5X**
Error Trap Mitigation (TAPE℠)	Reduce both the probability of triggering events and LOP failure rates through mitigating the effects of time pressure, distractions, and inexperience.	**1.5X-3X**
Effective LOPs	Reduce event rates by detecting and correcting planning errors before they cause events through improved review, qualification tests, etc.	**5X-10X**

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Let us Pause and Think about the 2003 Northeast and 2011 Southwest Blackouts…

2003 Blackout: Software Design Errors, Review Errors, Planning Errors, Decision Errors

2011 Blackout: Operating Error, Verification Errors, Planning Errors

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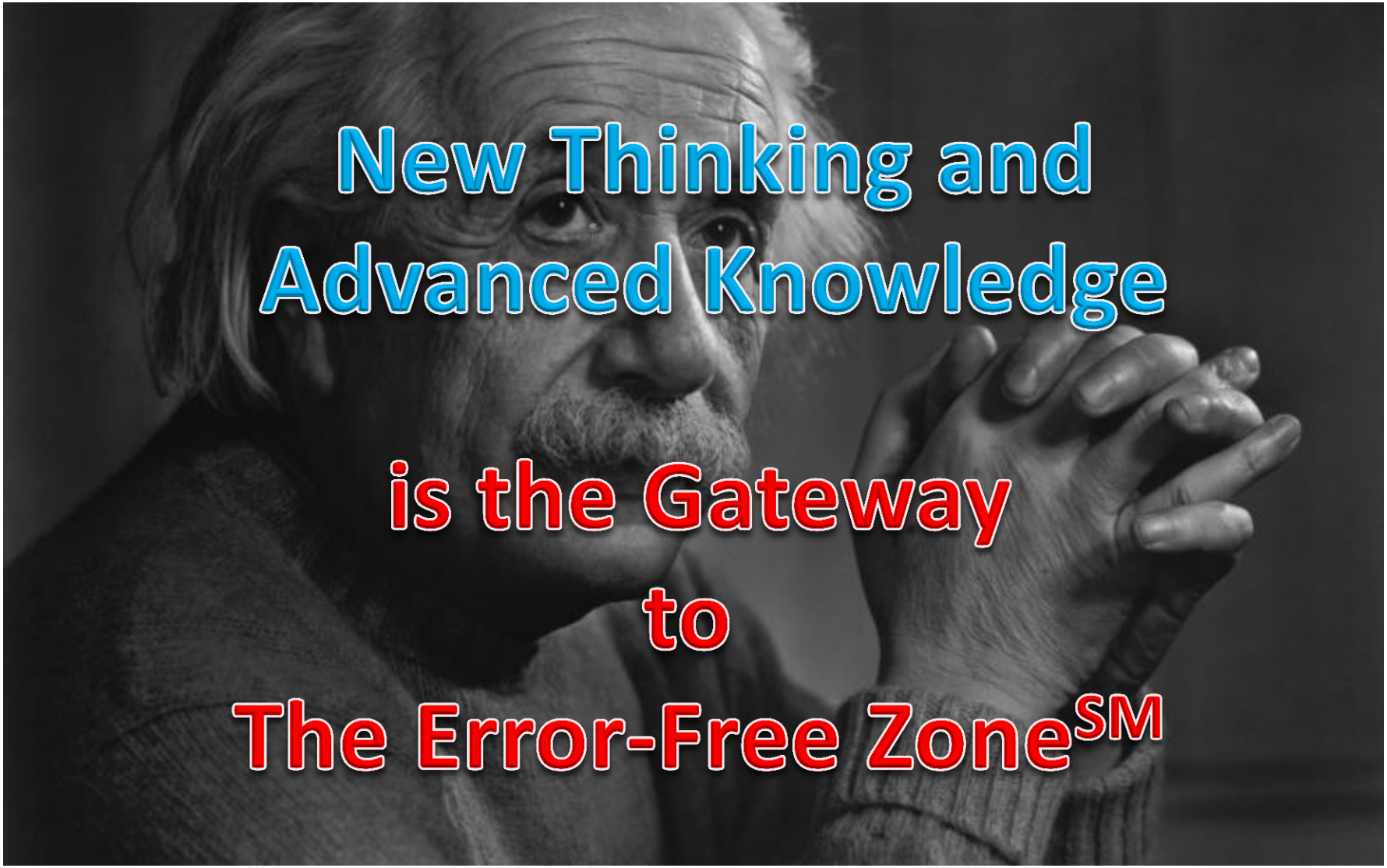

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