# Understanding Nuclear Safety Culture through Systemic Approach

IAEA International Conference on Human and Organizational Aspects of Assuring Nuclear Safety — Exploring 30 Years of Safety Culture in Vienna from 18 to 27 Feb. 2016.

> Nasir Afghan, PhD IBA Karachi <u>nafghan@iba.edu.pk</u> <u>https://designconcepts3.com</u>

© Nasir Afghan

#### IMPORTANCE OF SYSTEMIC THINKING: LEARNINGS FROM THE FUKUSHIMA DAIICHI ACCIDENT

#### The Fukushima Daiichi Accident Report by the Director General IAEA

- First Assumption : "That Japan's nuclear power plants were so safe that an accident of this magnitude was simply unthinkable. This assumption was accepted by nuclear power plant operators and was not challenged by regulators or by the Government."
- Second Assumption: "There was an assumption that there would never be a loss of all electrical power at a nuclear power plant for more than a short period. The possibility of several reactors at the same facility suffering a crisis at the same time was not considered."
- Third Assumption: "That the design of nuclear power plants and the safety measures that had been put in place were sufficiently robust to withstand external events of low probability and high consequences."

#### IMPORTANCE OF SYSTEMIC THINKING: LEARNINGS FROM THE FUKUSHIMA DAIICHI ACCIDENT

#### • A "manmade" disaster

The TEPCO Fukushima Nuclear Power Plant accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They effectively betrayed the nation's right to be safe from nuclear accidents.

Therefore, we conclude that the accident was clearly "manmade." We believe that the root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions, rather than issues relating to the competency of any specific individual. The National Diet of Japan (page 16) 2012.

When the system is complex, there is unpredictability and unknown risks (Kauffman, 1993).

The paradox for nuclear managers is how to conceptualize and manage the technical problems vs systemic problems?

## Technical problems vs Systemic problems.

Manager's Basic Assumptions Conceptualization of the situation, based on cognitive process and Actions



Theory Of Social Cognition: Interplay of basic assumptions, cognitive process, behavior responses and consequences and external environment: Miller and Dollard 1941, Bandura, 1963, 1991, 1997, Glanz et al, 2002



## The Influence of Basic Assumptions on Behavior **Responses and Consequences.**



experiences and emotions of individuals and teams

teams

# THE RESEARCH OBJECTIVE

- What is systemic failure and how to manage it?
- What is systemic thinking?
- Safety culture as complex adaptive system.
- System attractors in nuclear safety culture.
- How basic assumptions of NPP operators towards nuclear regulator influence the safety culture? behavior and consequences.
- How leaders can influence complex adaptive systems? Lessons learned from chemical industries.

## **SYSTEMIC FAILURES**

•Systemic Safety failures are most of the time due to the failure of collective thought process or cognitive failure of leadership of the organization.

 Cognitive failure is when leadership/organization don't change old mental models.

 Also when Leadership does not challenge old assumptions and stick to the old thinking and follow the wait and see model.

# **SYSTEMIC FAILURES**

- Systemic Failure is failure at the system level that cannot simply be described from individual component failure within the system.
- Systemic failures are due to the nature of interdependences, complexities, and unpredictability within the system.
- Such complex systems are also known as <u>Complex Adaptive Systems</u>. (slides 15-17)

# **OUR COGNITIVE PROCESSES**

- Traditional Systematic / Analytical / Critical thinking
  - Divided in small units, step by step (for hindsight)
  - Study of large system by dividing it into smaller units
- Synthesis thinking
  - Synthesis mean putting different pieces together, to see the connections, relationships, and patterns of interactions to see the new whole (for insight).
  - Thinking two or more opposite ideas at the same time.
- Systemic thinking
  - Systemic thinking is understanding and seeing the interrelationships within the a complex system.
  - It is both Systemic and Analytics, think big and small at the same time.

## WHAT IS MECHANISTIC LINEAR SYSTEM?

- Forecasting models based on past knowledge for-examples, yearly projected figures for sales / costs etc.
- A budget process where capital funds are reserved for administration, building, and new projects etc.

#### Findings:

 Little room for chance, changing conditions or creativity. Not useful to understand and manage complex and unpredictable systems.

# WHAT IS SYSTEM THINKING?

- Systems thinking originated in 1956, when Professor Jay Forrester founded the Systems Dynamic Group at MIT's Sloan School of Management
- Systemic thinking is the ability to understand and make sense of your Complex Adaptive System (CAS).
- To identify different internal and external variables / attractors and their inter-relationships and behavior patterns within this CAS.
- To identify new emergence and leverage points (attractors/stakeholders) that are influencing behaviors (people or agents') at systemic level.
- To design and implement actions/strategies to influence the systemic basic assumptions, behaviors and to achieve desirable outcomes and new emergence.

## IMPORTANCE OF SYSTEMIC THINKING

- "We cannot understand complex system behavior by observing individual agent behavior alone". (Bailey, 1994).
- "To think and act strategically, we must first understand the context in which our decisions are being made. We need to see and understand the world as an interconnected whole, where our thoughts and actions influence and are influenced by many unknowns". (Sanders 1998)

## IMPORTANCE OF SYSTEMIC THINKING

 The Fukushima Daiichi Accident Report by the Director General IAEA.

The IAEA report stresses the need to "take an integrated approach that takes account of the complex interactions between people, organizations and technology in order to better identify plant vulnerabilities to natural disasters and other unexpected events".

# **COMPLEX ADAPTIVE SYSTEMS**

- Complexity theory was first presented by researchers at Santa Fe Institute (SFI), by Holland, 1990, Kauffman, 1993, Murray Gell-Mann, 1994,
- According to Gell-Mann, 1994, Stacey 1995, Senders, 1998, Chan 2001, Reiman 2014, all social systems, including business and cultures are Complex Adaptive Systems (CAS).
- Complex Adaptive System is where heterogeneous agents within a system exist independently but are interdependent, to produce a complex interaction and constantly and unpredictably evolve as wider system.

## CHARACTERISTICS OF COMPLEX ADAPTIVE SYSTEM

- Increasing number of individuals, stakeholders, suppliers, operators, regulatory organizations, national and regional governments, and international organizations constantly interacting in interdependent and unpredictable ways. Creating a big complex network of hubs and nods, without any centralized control.
- Individuals/firms/Governments are adapting to the new information and reacting to what the other people are doing. New shapes and structures emerge and disappear within the system. Much coming from little.

## CHARACTERISTICS OF COMPLEX ADAPTIVE SYSTEMS

#### Findings:

- Number of varied agents, own decision, how to behave and evolve over time. Coevolution.
- Small changes can caused big transformation. Butterfly Effect.
- Agents interact with one another and with external environment at multiple levels. Influence the environment and influenced by the environment.
- Rapid changes in the whole system, responsiveness, never stable .
- Emergence of new behavior and innovation.
- We can not understand the complex system by analyzing individual parts/subunits. Can we understand group behavior by observing individuals?
- Complex Systems are open and dynamic and self organizing.
- Examples: Fukushima Systemic Failure (The National Diet of Japan Report)

Safety Culture Complex Adaptive System: Attractors may or may not Share Safety Culture Assumptions at Systemic Level



## Possible: System Attractors in Nuclear Safety Culture

- Operators and shift managers
- National nuclear authority
- Nuclear regulator/s and régulatory oversight
- Integrated management system, SOPs and assessment and development systems
- Accidents and accidents reporting system
- Operational meetings
- Stories of seniors and past events
- Training and mentorship programs
- Learning and adaptation from safety exercise and drills, local and international NPP/IAEA reports/ IAEA Meetings / IAEA Conferences
- Human performance and reward systems
- Public and society at large
- Plant Management and
- CEO of Nuclear Power Company
- More..

Attractors could be stakeholders, events and inter-relationships within the complex system.

## Nuclear Plant Operator's Basic Assumptions for Nuclear Regulator

#### Analysis of Attractors' Assumptions and Behaviors

Following are few desirable and not so desirable assumptions of operators, plant managers and shift in-charges about nuclear regulator:

- 1. Regulator will accept what we report to them as they are part of national nuclear system
- 2. No need to report the event to regulator
- 3. Regulator has little expertise about nuclear plant operations
- 4. We always report all events and assessments results to regulator since our regulator is very knowledgeable about plant operations
- 5. Do not expect strict regulatory actions in case of serious violation
- 6. Regulator is weak and dictated by nuclear authority
- 7. Regulator is captured by the nuclear industry
- 8. Regulator lacks competence
- 9. Regulator lacks legal basis

## Nuclear Plant Operator's Basic Assumptions for Nuclear Regulator

#### Desirable Safety Culture Assumption, Behavior and Consequence

- Assumption: We always report all events and assessments results to regulator since our regulator is very knowledgeable about plant operations
- Behavior: Open and trustworthy communication between plant operators and regulators
- Consequence: Regulator is in a better position to conduct safety oversight and review action plans

#### Not-so-desirable Safety Culture Assumption, Behavior and Consequence

- Assumption: Regulator will accept what we report to them they are part of national nuclear system
- Behavior: Lack of respect for regulatory oversight among operators
- Consequence: Poor and ineffective regulatory oversight and high risk of nuclear accidents

## **KEY FINDINGS**

- Re-conceptualize safety assumptions and behaviors, old conceptualization and closed system mindset will not help.
- If you find better conceptualization for your safety culture assumptions you will be able to change your actions and behaviors.
- Even one individual can influence the whole system (one small event can change the final outcome in a big ways). Small changes in the initial conditions in a subsystem may have big impact on the whole system.

# **KEY FINDINGS**

- Systemic changes will be unexpected and unpredictable
- Prepare mindset for unthinkable. VUCA (volatility, uncertainty, complexity and ambiguity)
- Complex system /systemic thinking helps in developing resilience, robustness and response- abilities within the organization.

# LEADER'S COGNITIVE PROCESS

How and what we think directly influence the actions we take (Sherman and Schultz, 1998)

What are the sources of our thinking?

- 1. Our thought processes, our basic assumptions
- 2. Our past experiences, education, culture and family history
- 3. Our personalities, traits and dispositions
- 4. Our abilities to conceptualize and understand our environment/ situation, external challenges and simulations
- 5. Our purpose, missions, self believe and self confidence

## LEADER'S COGNITIVE PROCESS and CONCEPTUALIZATION

 Conceptualization of volatility, uncertainty, complexity and ambiguity as a situation or high risk situation".

Two Different types of Conceptualizations:

#### Closed system view:

These leaders conceptualize the environment as "risky and uncertain" for business. Thought process encourages the leader that you should wait and see before things and situation is more clear and manageable. Leaders will not take any action or just will keep things as they are. (for example, Packaging and Printing Co.). Management of known and predictable. Management by Objectives .

Their response was good old time will be back! These are cautious leaders, kept the status quo. Mostly, satisfied and content with existing outcomes/ situation.

## LEADER'S COGNITIVE PROCESS and CONCEPTUALIZATION

- B. <u>Open system view</u>: These leaders conceptualize the environment as "a business situation". They first try and understand the CAS and then they influence their CAS together with different agents and stakeholders through the collaborative network. Leader's thought process or cognition encourages him/her that he/she must do something, try and change the situation, influence it, go out and change the situation, he/she will act accordingly. Even he/she may fail initially but will rebound and make another attempt. Leader was successful in turning the situation around. (for example, Refinery). Managing unknown, nonlinear dynamics and unpredictable situation. Management by efforts and process.
- These leaders proactively influence the external environment, for them complex, unpredictable and ambiguous world is the new normal. They are quick thinker and doer type leaders and are not satisfied with the status quo. Proactively influence the agents and stakeholders towards desirable directions/actions.
  - With Open System Conceptualization has two levels of Response Strategies:
    - 1. Proactive Influence Approach
    - 2. Crisis Management Approach

## LEADERS RESPONSE STRATEGIES: case example from Chemical Industry

- How Proactive Influence Approach works in Complex System?
  - Developed social, business and political network across the CAS. Top Government level, civil administration levels, chamber industry levels, community levels, and political levels.
  - Influencing social well being and development of the local community. Setting up hospital, school, first aid box, Jeep for medical emergency, renting tractors from the person threatening business. To change basic assumptions and get desirable behaviors and outcomes.
  - Joined the local chamber of commerce and industry, and head the law and order committee. To influence the safety and security system of the industrial zone. Police Inspector.
  - How Crisis Management Approach works in Complex System. Designing and Developing organization, teams and leadership for Crisis Management Skills and Attitudes.

## LEADERSHIP RESPONSE STRATEGIES: China: Proactive Influence Approach

China "One Belt One Road Strategy". Six Economic Corridors with 62 countries in three continents.

- **1**. Education Cooperation (people to people cooperation)
- 2. Free Trade
- 3. Financial Integration
- 4. Culture and Truism (people to people cooperation)
- 5. Infrastructure Projects
- It is a Proactive approach to influence leverage points or system attractors to influence Asia, Europe, Africa/World complex adaptive system.
  - Three Trillion Dollars Investments.

## LEADERSHIP RESPONSE STRATEGIES: China: Proactive Influence Approach

The Belt and Road Initiative: Six Economic Corridors Spanning Asia, Europe and Africa



# LEADERSHIP RESPONSE STRATEGIES: USA: Crisis Management Approach

- The White House has nominated a veteran Special Operations commander to lead U.S. Central Command (The United States Central Command is a theater-level Unified Combatant Command of the U.S. Department of Defense).
- Typically the command overseeing the Middle East and Central Asia has been led by an Army or Marine general with a conventional background.
- The selection of special operations veteran, Army Gen. Joseph L. Votel who has headed U.S. Special Operations Command, to head Centcom represents a break with tradition (paradigm shift).
- Reasons:
  - Obama administration's reluctance to commit conventional ground forces to costly, unpredictable insurgencies.
  - Volatile, uncertain and complex nature of conflict i.e. Unconventional wars, ISIS, Al-Qaeda, Taliban, Terrorism, Hostages crises, politically intensive and adaptive conflicts, Guerrilla wars, Drone attacks, training of local forces etc.
  - White House officials have seen use of special operations forces as more efficient and effective.

## How to Understand and Influence Safety Culture Complex Adaptive System?

- Complex social system can be understood by its interdependencies and relationships how individuals interact and influence and get influenced by others. We need to understand and record this interplay.
- Understand and develop nuclear safety culture Complex Adaptive System for Systemic view.
- Identify all attractors, stakeholders and dynamic interdependencies and relationships.
- Map attractors and stakeholder's basic assumptions, values, behaviors, and believes for safety culture.
- Use proactive Influence approach to change not so desirable basic assumptions at systemic level

# Thank you!