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Responsible Nuclear Energy Program (RNEP) and Nuclear Safety, Security and Safeguards (3S) Culture

Roles of System Analysis Approach, Critical Thinking and Scientific Method

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Note for SNL R&A Process

Development of this presentation is a part of the work funded by the US Department of State's Partnership for Nuclear Security (PNS). PNS has scheduled three events in which this work will be presented as follows:

1. Workshop on Development of Human Resources for a Safe and Secure Nuclear Power , Amman, Jordan, January 15 – 17, 2012 (Tentative dates).
2. Gulf Nuclear Energy Infrastructure Institute (GNEII) at Khalifa University, Abu Dhabi, UAE, February 19 – February 23, 2012.
3. Workshop on Development of Human Resources for a Safe and Secure Nuclear Power , Rabat, Morocco, February 28 – March 1, 2012 (Tentative dates).

Objectives and Goals

Objective:

- Connection Between the Attributes of a Responsible Nuclear Energy Program (RNEP) and a Strong 3S Framework Based on Systems Analysis Approach and Critical Thinking

Take away:

- A Responsible Nuclear Energy Program **(RNEP)** Based on a Strong Safety, Security, and Safeguard **(3S) Framework** Can Be Developed and Maintained **Through Utilization of Systems Analysis Approach and Critical Thinking**

An RNEP Based on a Strong 3S Framework Through Utilization of Critical Thinking and Systems Analysis Approach

RNEP and 3S Culture

Main Topics

1. Characteristics of a RNEP
2. Characteristics of a Strong 3S Culture
3. Responsibilities of the Individual (workforce) in an RNEP?
4. Requirements for education and training of a RNEP workforce
5. Need for education and training on Critical Thinking and System Analysis Approach

Overview

- Characteristics and/ or traits of a Responsible Nuclear Energy/Power Production Program (RNEP)
- Characteristics and/ or traits of a Strong Integrated Nuclear Safety, Security, and Safeguards (3S) Approach
- Role of a strong 3S Culture in an integrated 3S Approach
- Characteristics of a strong 3S Culture
- 3S enabling tools
- Balance between the 3S Culture and the 3S enabling tools can be established and maintained
- Responsibilities of the Individual (workforce) in an RNEP
- Human resource development program ensure that the workforce meets its responsibilities
- Requirements for education and training of a responsible NPP workforce
- Education and training on critical thinking and System Analysis Approach promote a strong 3S culture

Characteristics and/ or Attributes of an RNEP Program

- A responsible nuclear enterprise (RNEP)
  - improves the standard of living in the society/country by
  - contributing to public life and prosperity while
  - minimizing risk to the public, environment and infrastructure

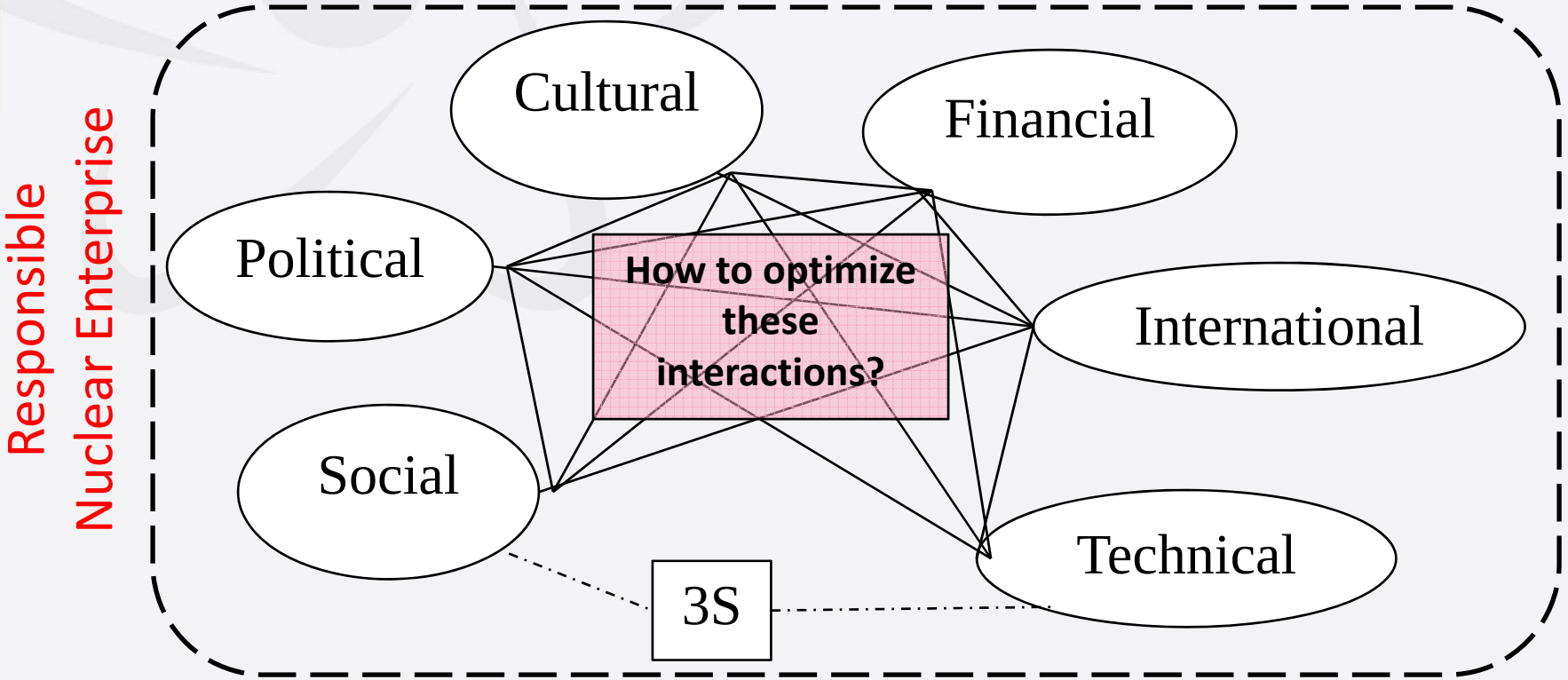
- All associated elements should support the above objectives:
  - Political
  - Financial
  - Cultural
  - International
  - Social
  - Technical

3S?

RNEP is a "SYSTEM" with many elements (components), attributes (requirements), and relationships (feedbacks).

Understanding Responsible Nuclear Energy

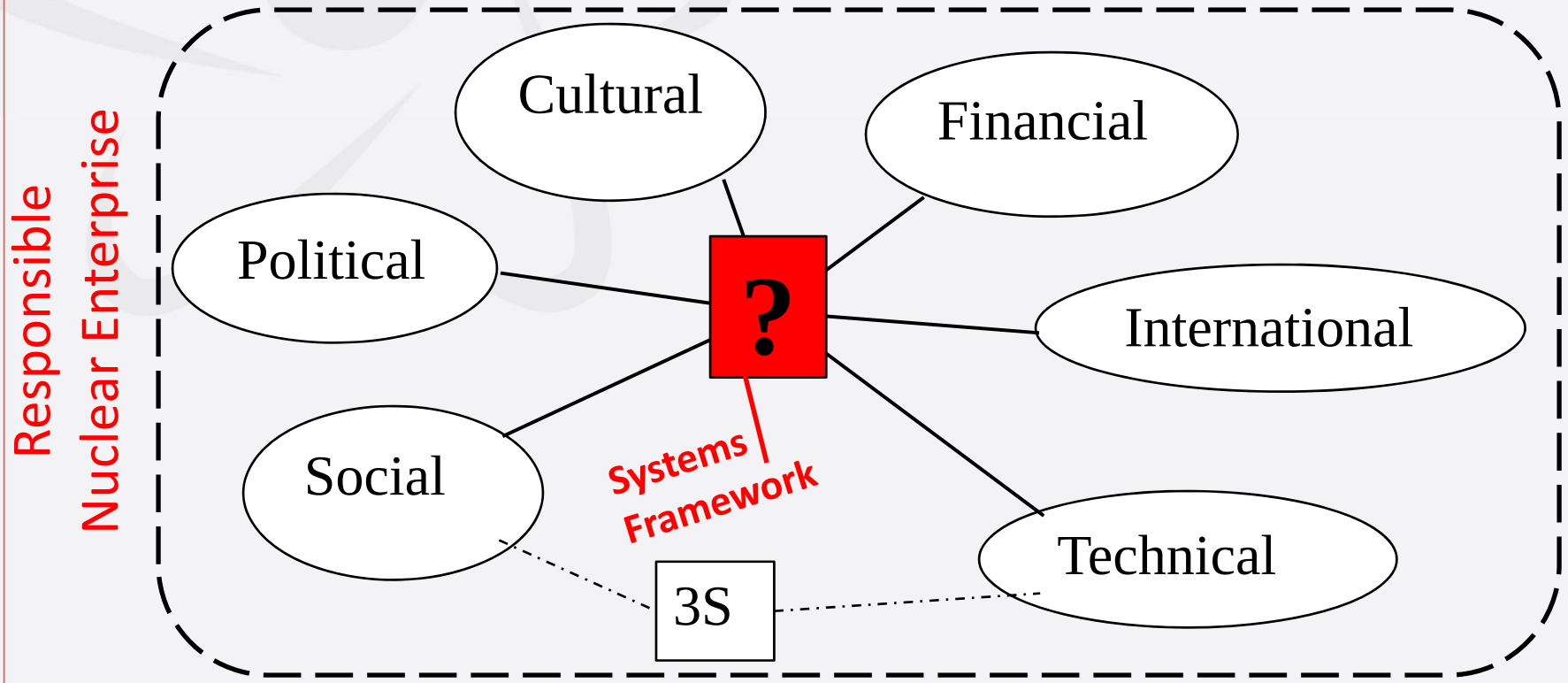
- What elements or factors affect or influence decisions related to an RNEP?



Understanding Responsible Nuclear Energy

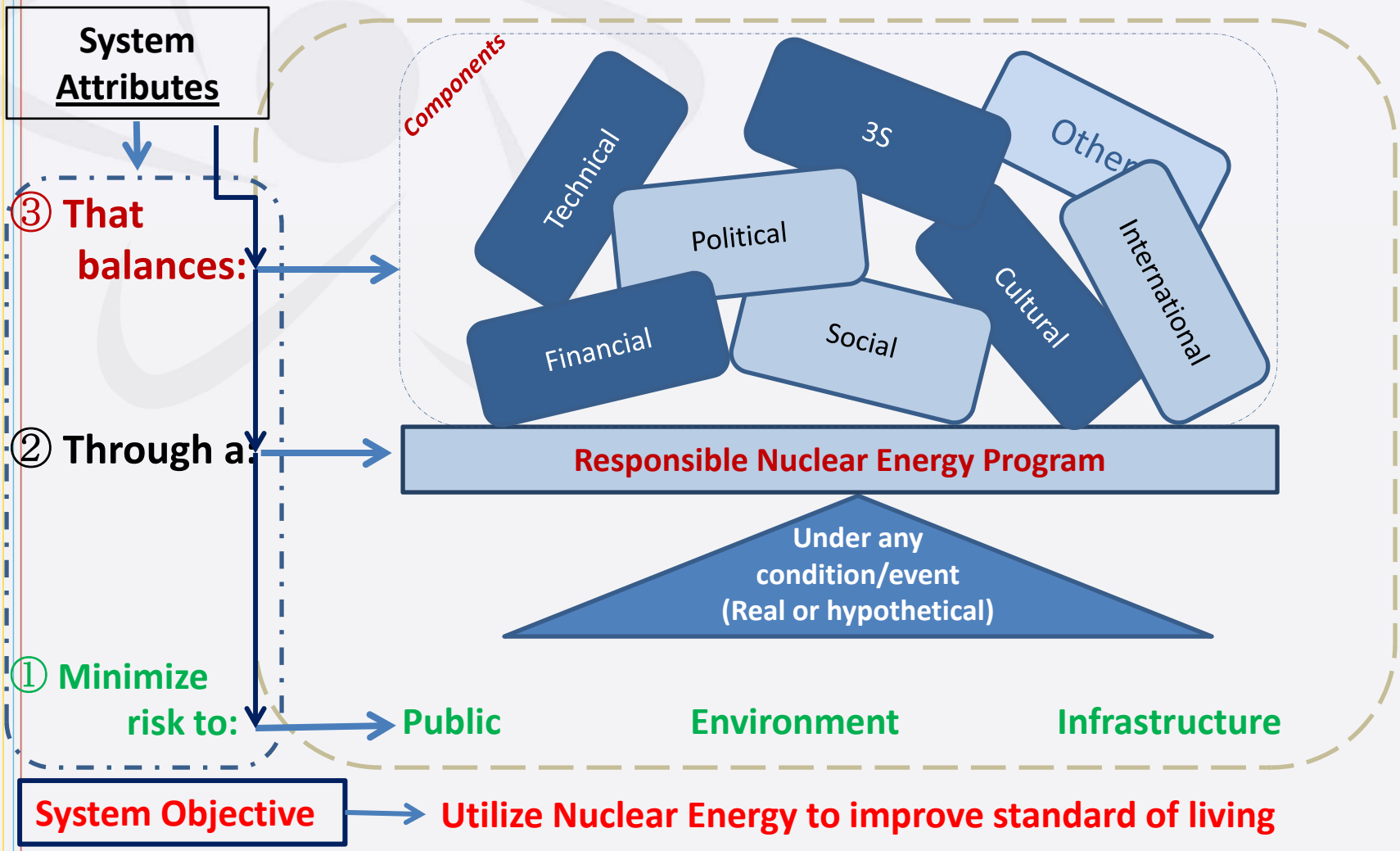
- All of these elements are related, is there is a clear method for understanding these complex, adaptive relationships?

Our Answer (Hypothesis) is: Systems Framework



Our Systems Framework - Model

SYSTEM: Responsible Nuclear Energy Program



How to achieve that balance?

- How can this balance be achieved?
  - Complex Problems (competing interests, prioritization issue)
  - Dynamic Problems (economic cycles, political cycles)
  - Many moving parts (each part represents a system itself!)
- How can elements be influenced?
  - **Political** – intrinsic right of sovereign nations
  - **Cultural** – longstanding traditional, historical and religious considerations
  - **Financial** – significant monetary commitment
  - **International** – strong global norms related to nuclear energy programs

3S

  - **Social** – the powerful "will of the people"
  - **Technical** – the substantial infrastructure (equipment) and human (know-how) resources

What is the 3S Role?

Connection of 3S to RNEP

- Technical solutions & human (social) behaviors combine to operate an RNEP, which should:
  - Pose minimum additional risk to the **safety** of the public or environment
  - Reduce additional risk to the **security** of the public or infrastructure
  - Meet its **safeguards** obligations under its international agreements

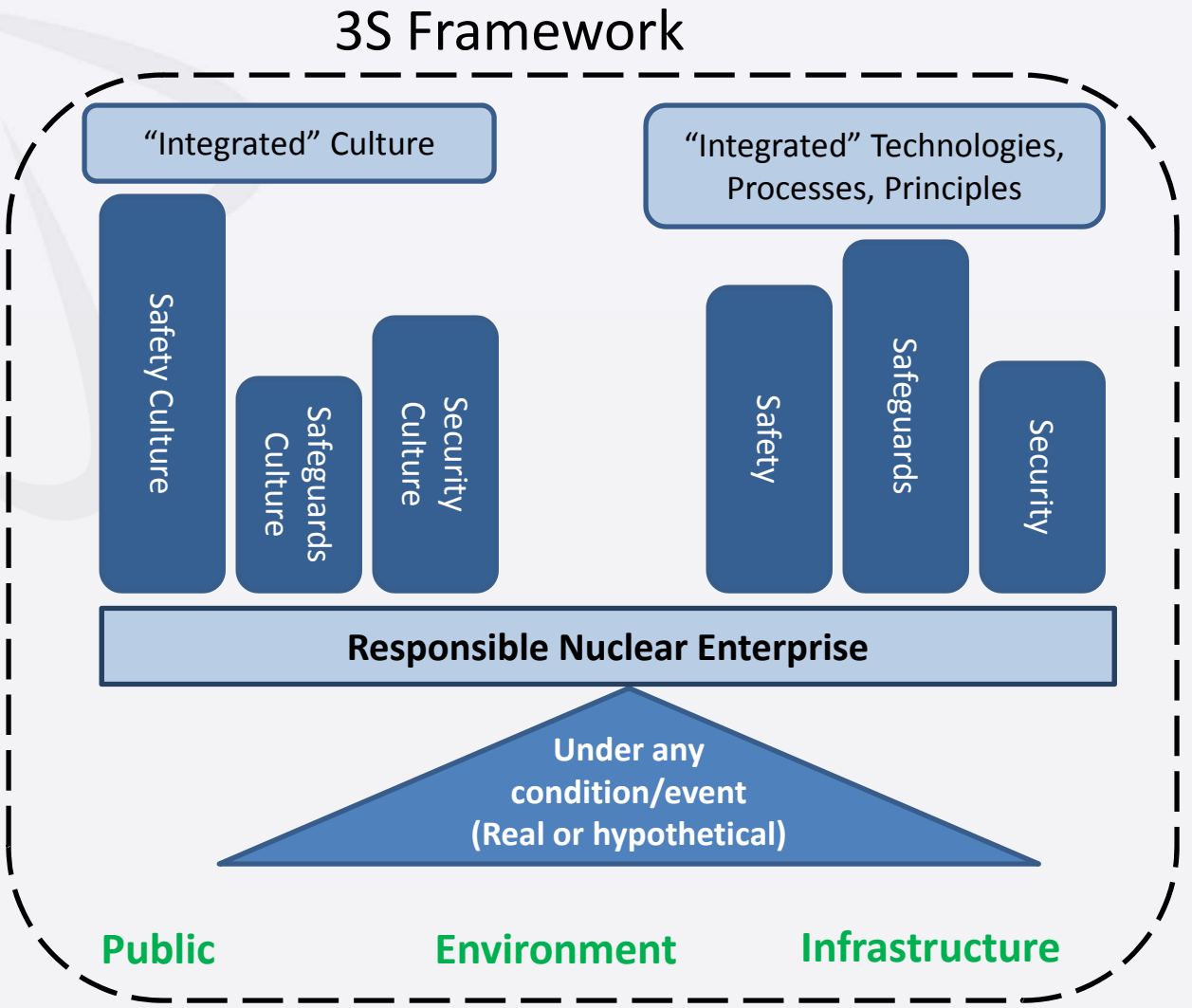
What is the 3S Role?

Connection of 3S to RNEP

- What role do safety, security and safeguards (3S) play in a responsible nuclear energy program (RNEP) minimize the risk to the public, environment and infrastructure?
  - In isolation?
  - As an integrated framework?
- An RNEP can best meet its goal of **minimizing risk** to the public, environment and infrastructure through **a balanced integrated nuclear safety, security, and safeguards, (3S) framework**

Current (Traditional) Integrated 3S Framework

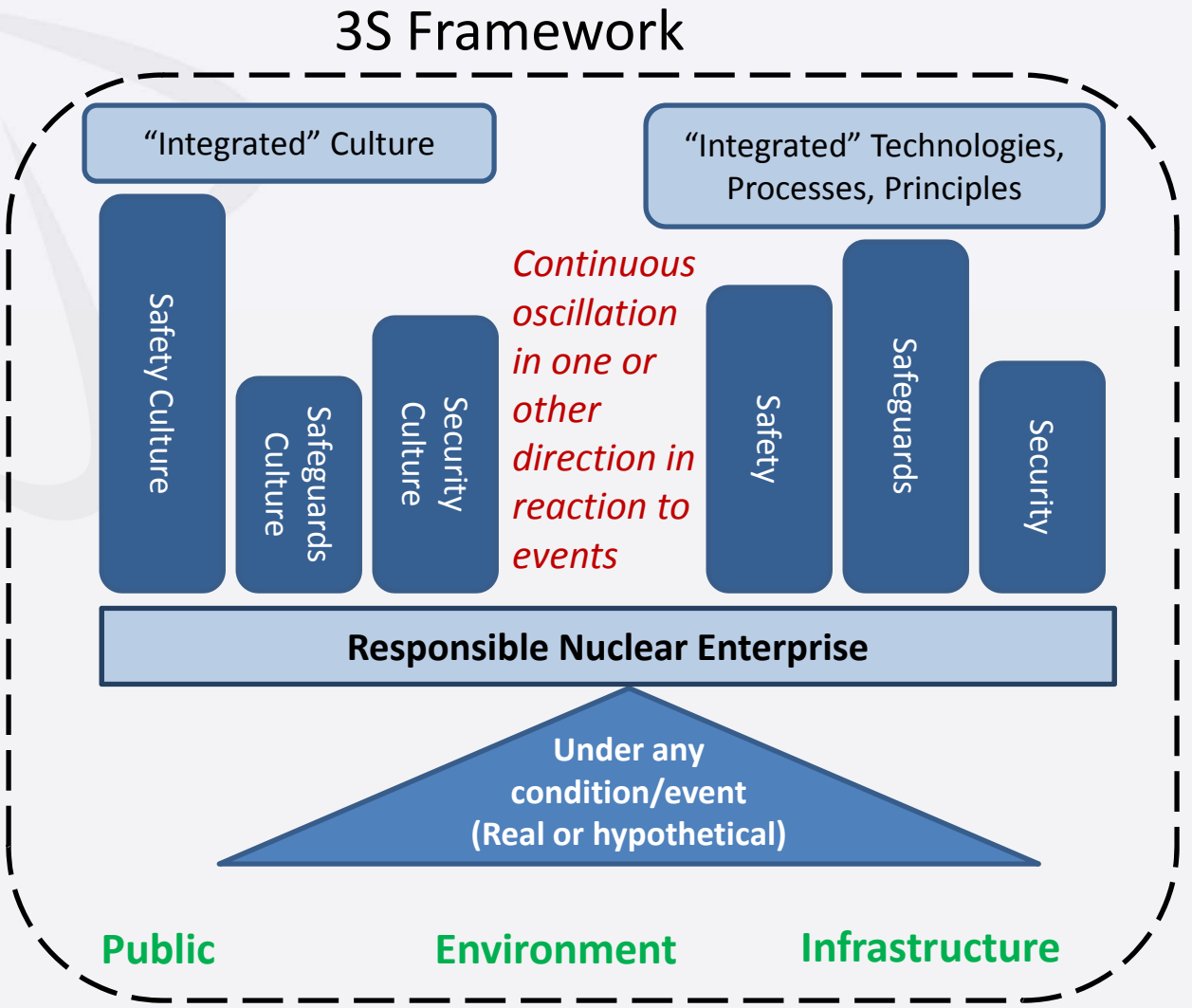
- Prescriptive
  - Based individually established policies
- Descriptive
  - Focuses on interface between existent culture and tools
- Reactionary
- Stove-piped areas of expertise



Current (Traditional) Integrated 3S Framework

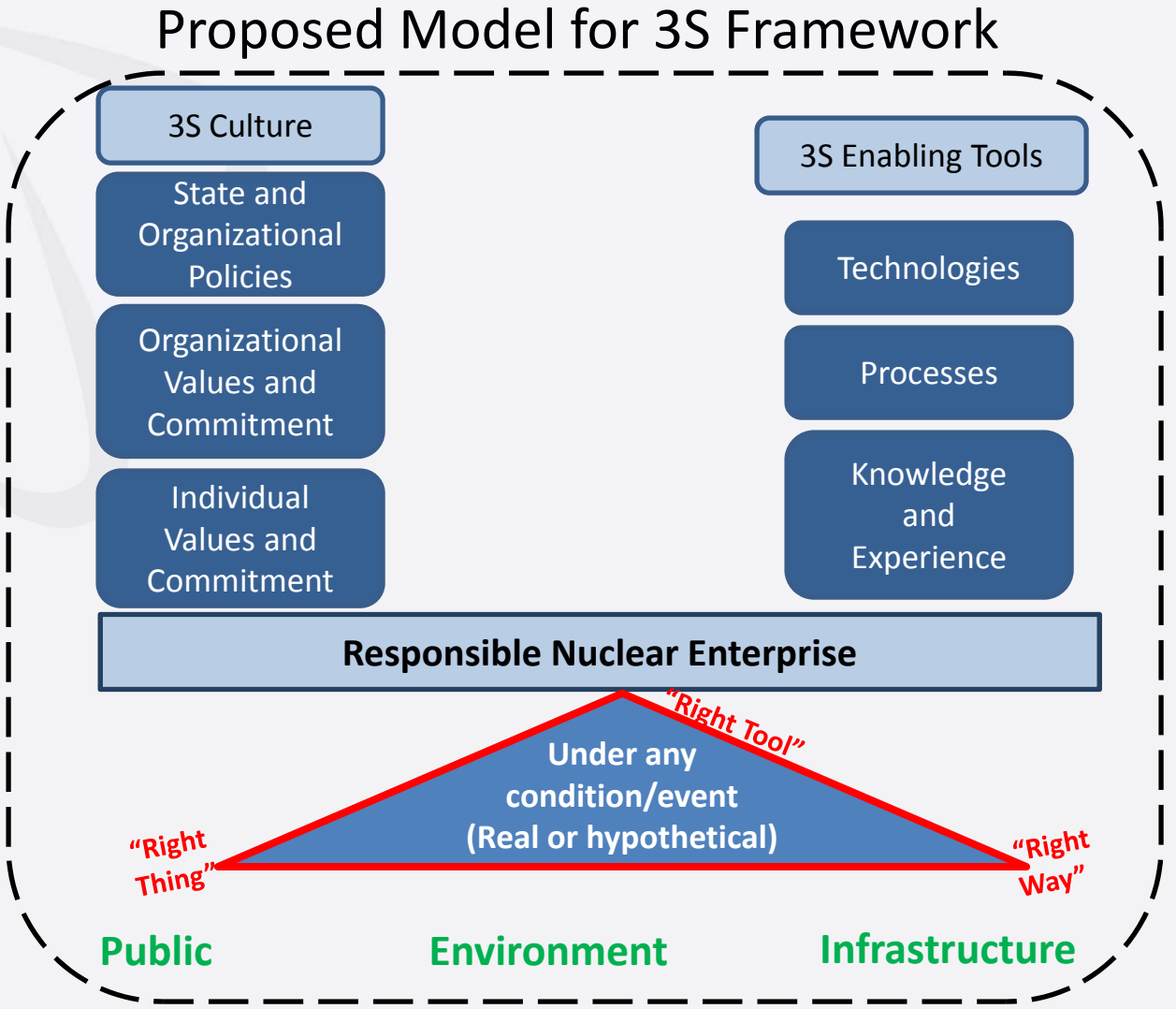
Examples:

- A first constructed NPP in a new nuclear country experiences a radioactive leak due to an operator error
- An IAEA inspection indicates missing nuclear material
- Recent attacks on a critical infrastructure prompt a national requirement for 10 foot reinforced concrete barriers around all such facilities



Our Proposed Model for Integrated 3S Framework

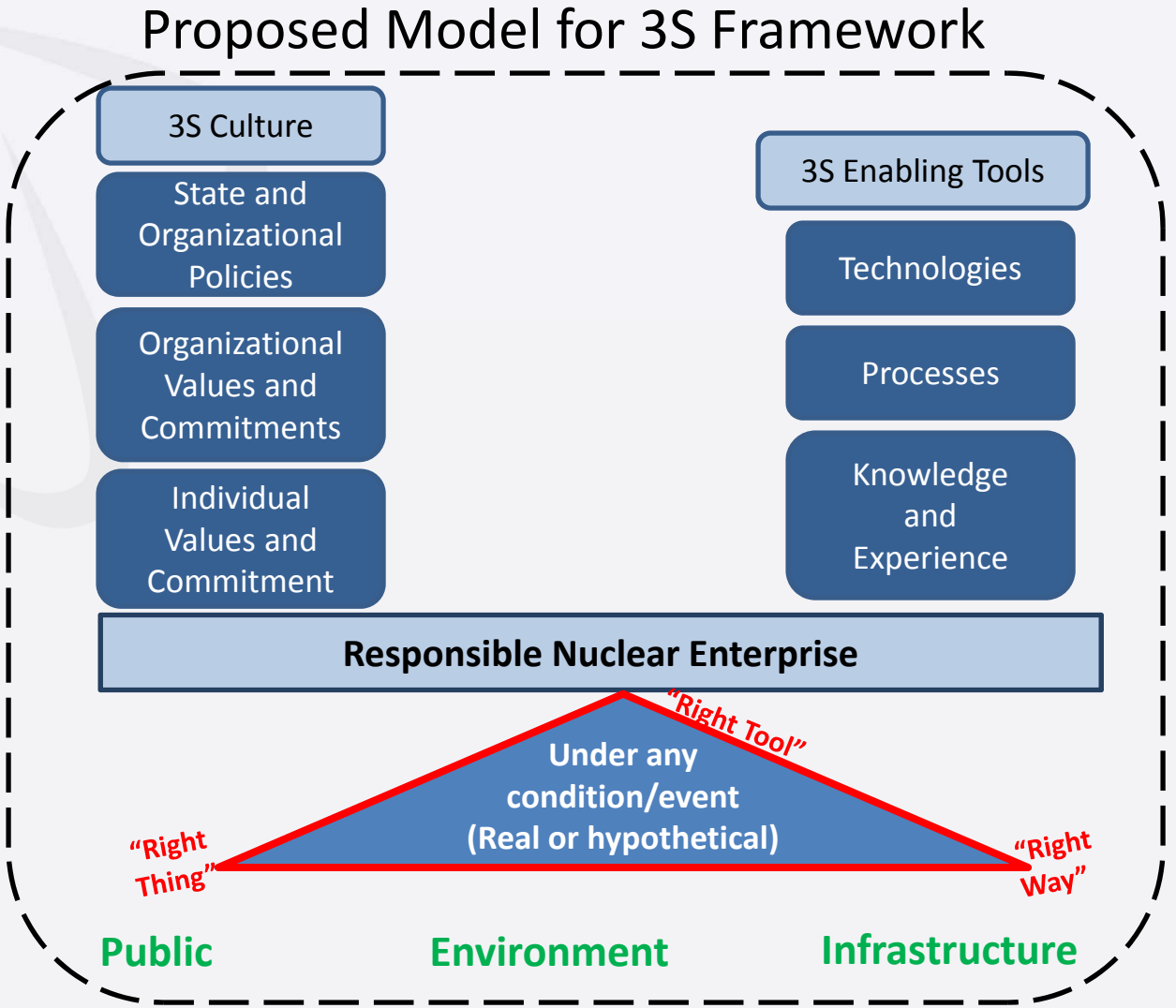
- Dynamic
  - Based on combining right thing, way and tool in timely manner
- Adaptive
  - Able to easily (and dynamically) find the balance; focuses on integrating necessary components of culture/tools
  - Feedback capable
- Proactive
- Comprehensive understanding across areas of expertise



Our Proposed Model for Integrated 3S Framework

Examples:

- A first constructed NPP in a new nuclear country experiences a radioactive leak via operator error
- An IAEA inspection indicates missing nuclear material
- Recent attacks on a pieces of a country's critical infrastructure prompt a national requirement for 10 foot reinforced concrete barriers around all such facilities



Our Proposed Model Integrated 3S Framework

Examples:

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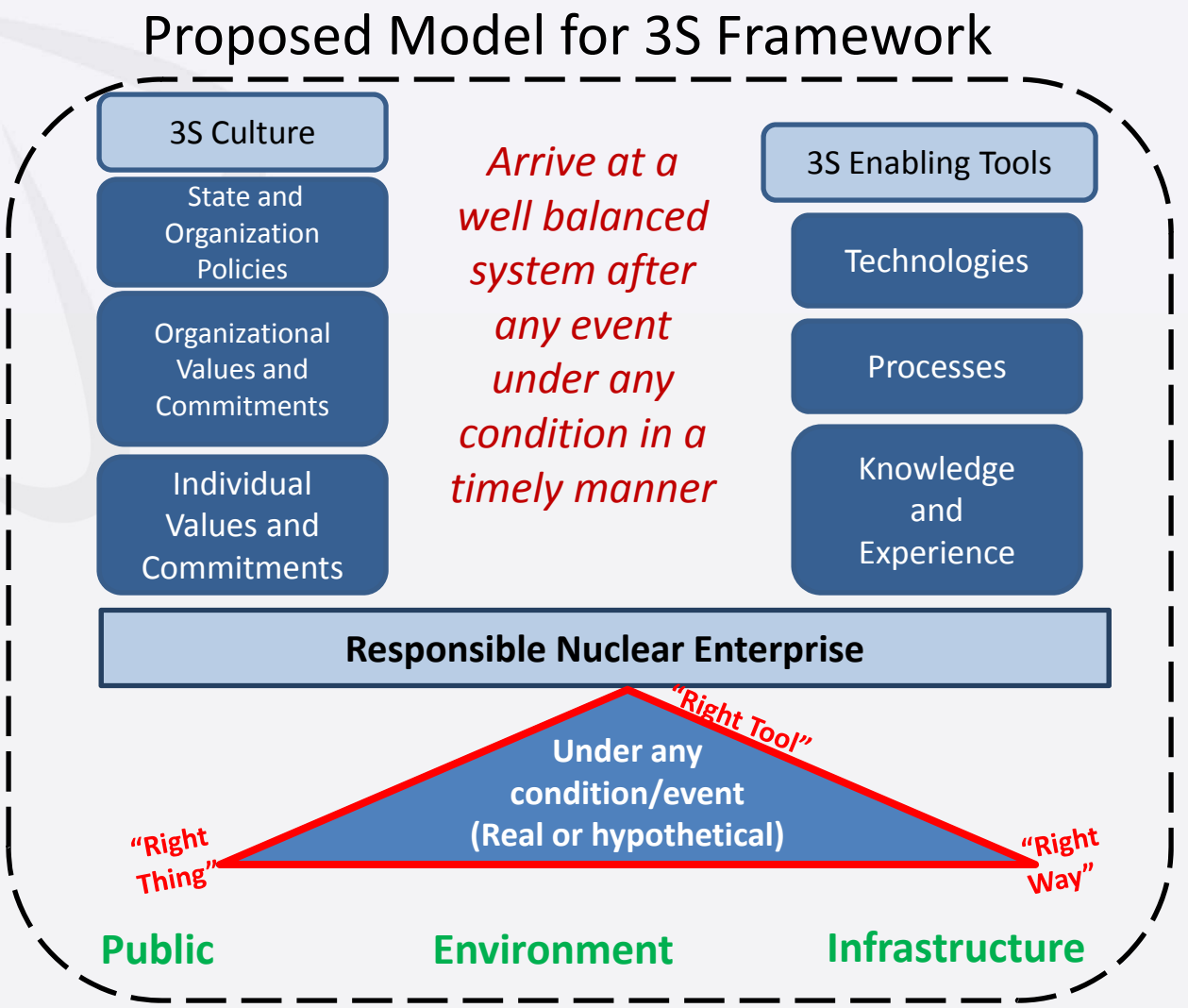
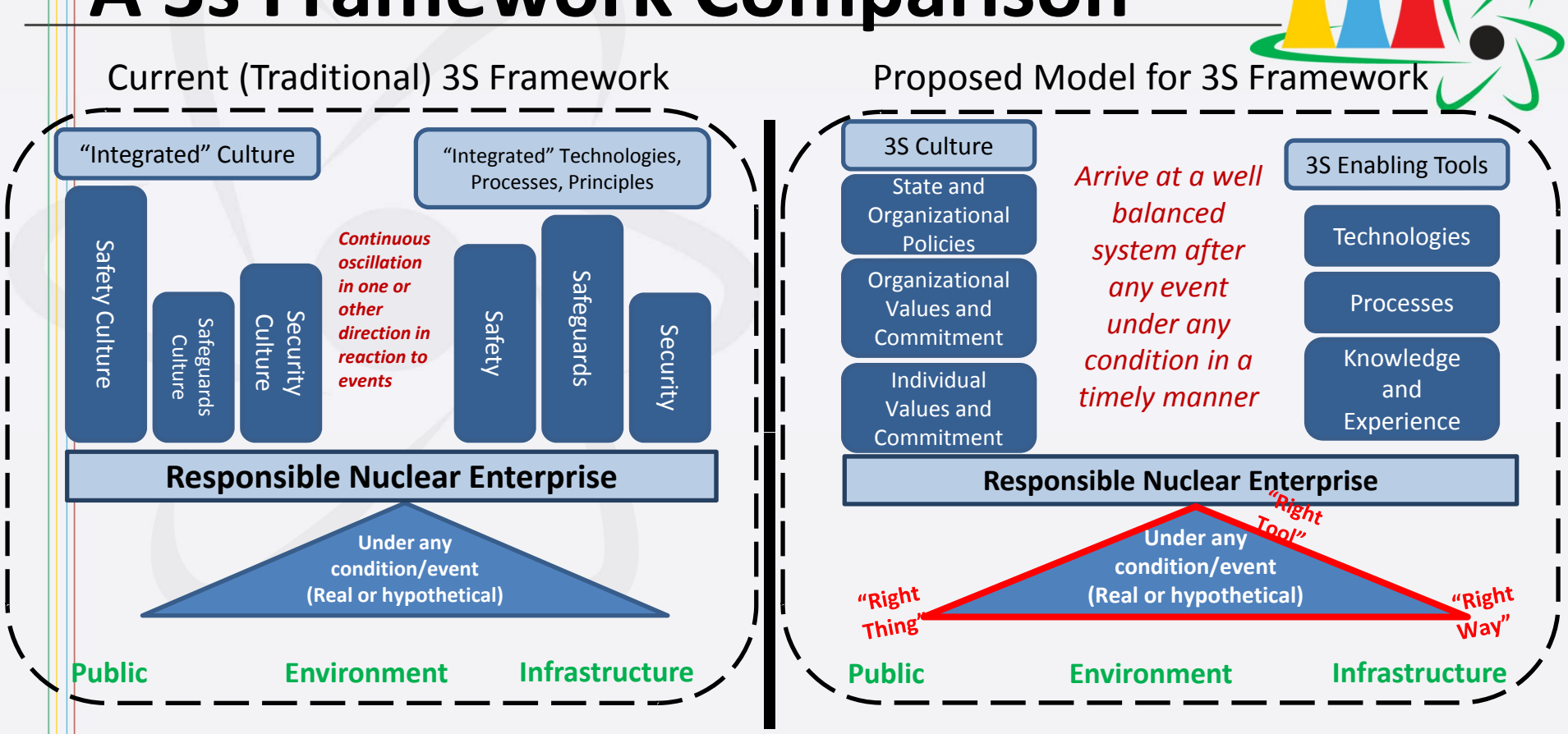


A 3s Framework Comparison



How can we develop, implement, and maintain such a framework?

1. Utilize System Analysis Approach in Analyzing the culture components and enabling tools across the 3Ss;
2. Use Critical Thinking in all aspects of our analysis

A New Look at an Integrated 3S Framework

- A Strong 3S Framework should allow:
  - Identify "right thing"
  - Identify "right way"
  - Identify "right tool"

  All in the "right time"
- A critical thinking and systems analysis approach considers both the:

—3S Culture
- Individual (All) Values and Commitment
- Organizational Values and Commitment
- Sate and Organizational Policies

AND

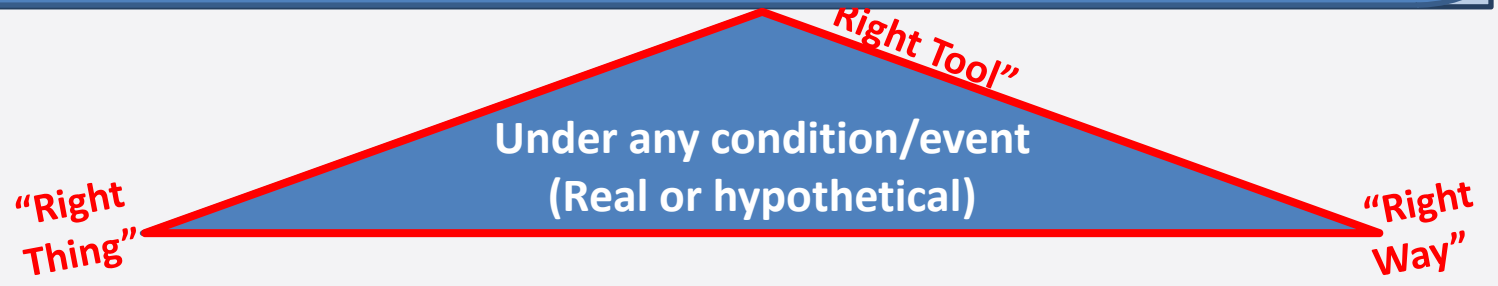
—3S Enabling Tools
- Technologies
- Processes
- Knowledge and Experience

Foundation of Our 3S Framework - 3S Culture Component

- "Right Thing" = Requirements
- "Right Way" = Functions
- "Right Tools" = Solutions

"Right Time" = timely manner to mitigate the greatest risk

- These form our "Value System," so we analyze it as a system.
- How can we objectively evaluate our commitment to these values?
- How can we assess that our actions are consistent with these values?



Answer: Through Critical Thinking and System Analysis Approach

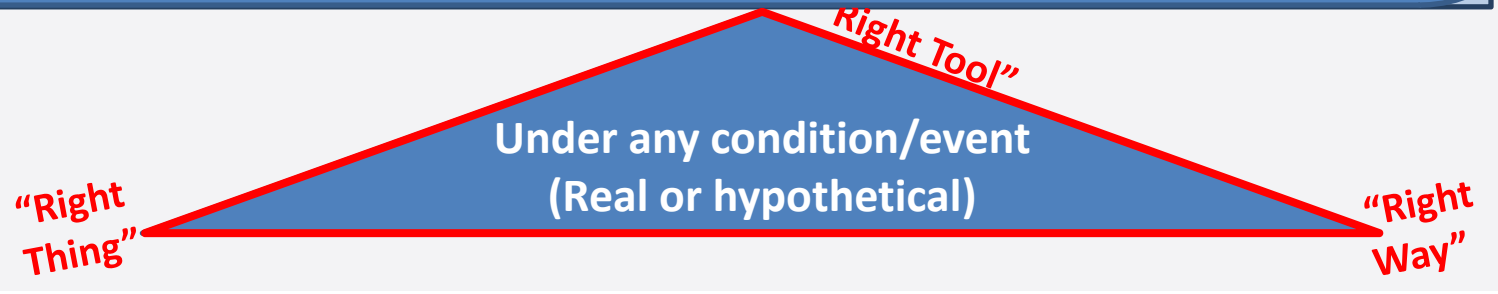
Why Critical Thinking and System Analysis Approach?

Critical Thinking: a process for consistent evaluation of thought processes and examinations of assumptions, values and behaviors

- Elements of thought
- Intellectual standards
- Intellectual traits

Systems Analysis Approach: developing and using complex mental models to analyze the mutual interaction of components of a system , or systems:

- Components
- Attributes
- Relationships



How to Impact the 3S Culture?

- Need to know what the “right thing” and the “right action” are:
  - Make the right decision and choose the right option(s) (right thing) - Involves “the human factor” which cannot be always regulated
  - **Based on the individuals’ sets of values, beliefs, commitments, and attitudes; and the organizational policies, processes,.. which indeed shape (form) the personal and organizational cultures**
  - Requires an objective and consistent examination of decisions, and actions

How to Impact the 3S Culture?

- **Must impact at the Basic Assumption level (deepest level);**
- **Make a positive impact on individual's "values, beliefs and assumptions"**
- Utilize Fair-minded Critical Thinking to provide a process for consistent evaluation of thought process and examination of values, beliefs, and assumptions
- *Use Systems thinking / Approach* to develop the complex mental models required to analyze the mutual interaction of elements and components.
- So, how do we become a Fair-minded Critical Thinker?

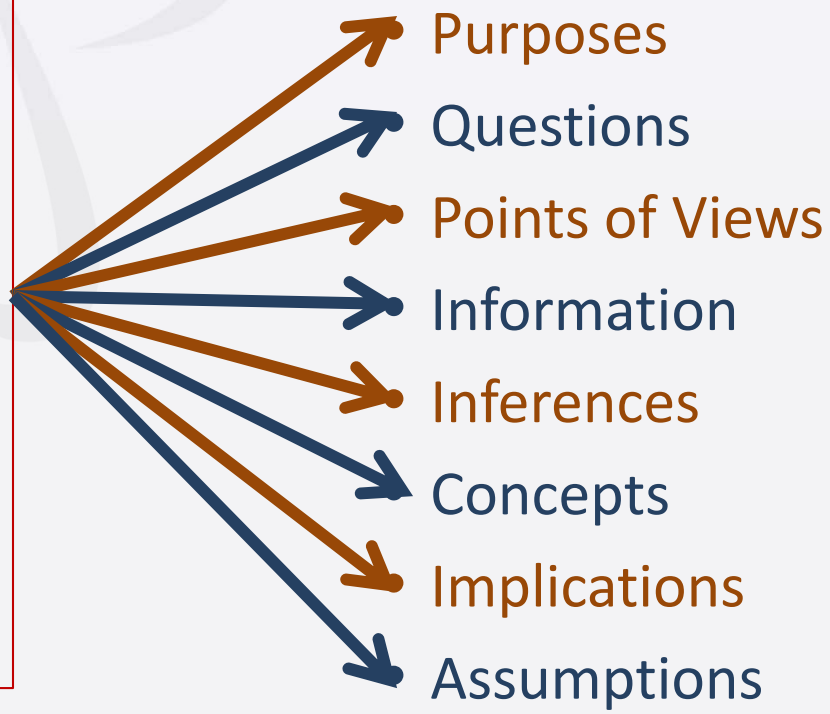
Fair-Minded Critical Thinking

Apply the Intellectual Standards to Each Element of Thought

Intellectual Standards

- Clarity
- Accuracy
- Precision
- Relevance
- Depth
- Breadth
- Logicalness
- Significance
- Reasonableness
  Completeness

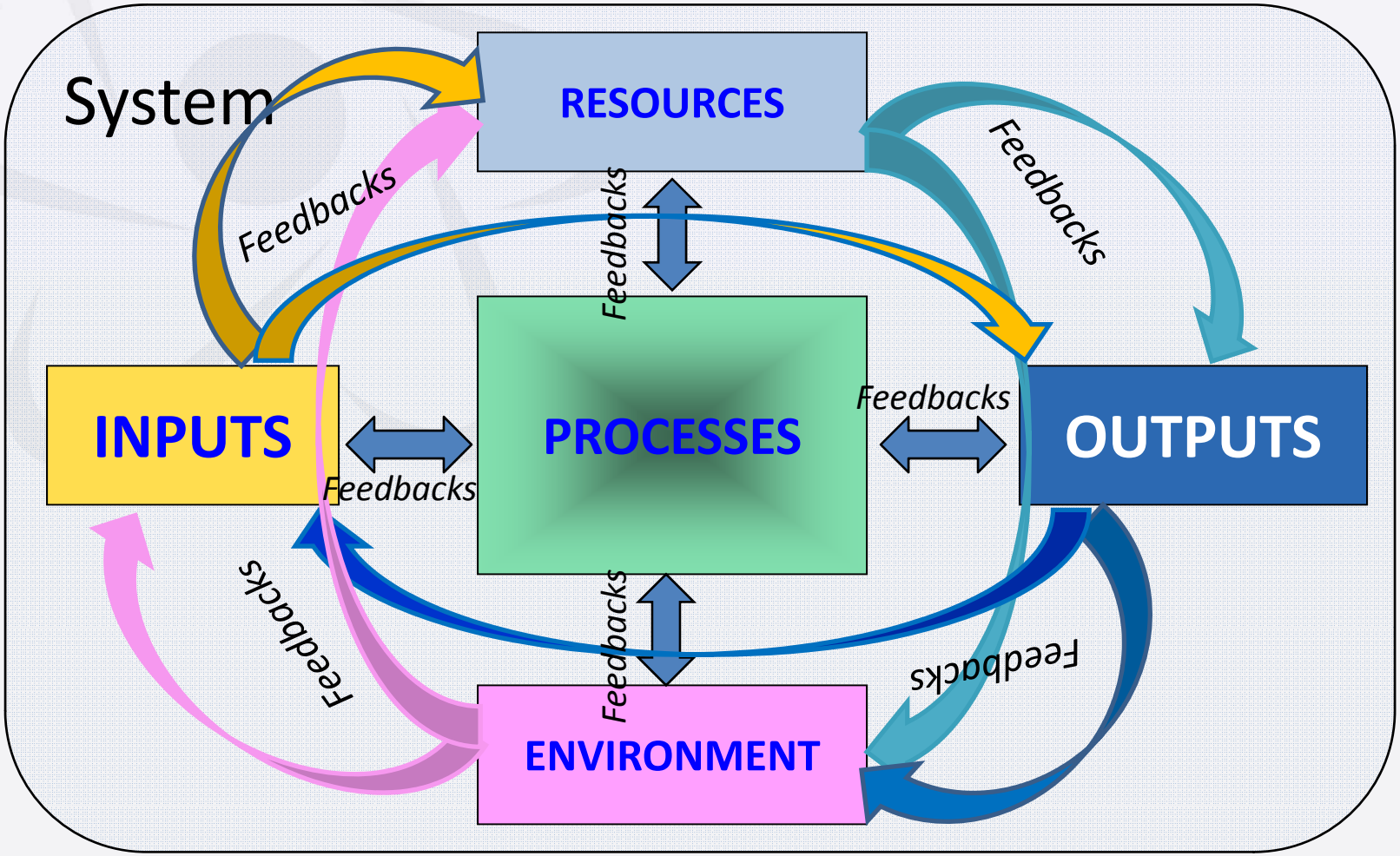
Elements of Thought



We will cover the details of this process in the lectures of day 2 of Week 1

Why System Analysis Approach in 3S?

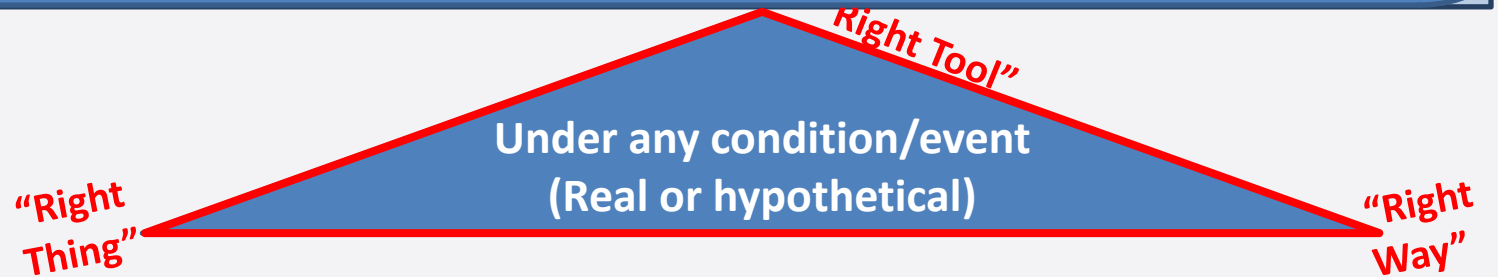
3S is a complex "system-of-subsystems" where each subsystem has many components with their own interactions and interplays (feedbacks) – a conceptual model shown below.



System Analysis Approach

Systems Analysis Approach:

- Elements
  - **Components:** are the operating parts of a system consisting of input, process, and output. Each system component may assume a variety of values to describe a system state as set by some control action and one or more restrictions.
  - **Attributes:** are the properties or discernible manifestations of the components of a system. These attributes characterize the system.
  - **Relationships:** are the links between components and attributes.
- Steps
  - Think Critically Throughout
  - Define the System Goals / Objectives
  - Gather Information and Data
  - Analyze Desired System
  - Include System Dynamics - Feedback
  - Develop Several Possible Solutions
  - Evaluate the Risk and Consider the Unintended Consequence
  - Develop Mitigation Plans for Risks
  - Rank Solutions
  - Make Recommendation / Decision



We will Cover the System Thinking and System Analysis Approach on Day 3 of Week 1

CONCLUSIONS for Part One

During the GNEII Curriculum We Present a Model for Making the:

- Connection Between the Attributes of a Responsible Nuclear Energy Program (RNEP) and a Strong 3S Framework Based on Systems Analysis Approach and Critical Thinking

PART Two: Critical Thinking

Recall: Our Integrated 3S Framework

- A Strong 3S Framework should allow:
  - Identify "right thing"
  - Identify "right way"
  - Identify "right tool"

  All in the "right time"
- A critical thinking and systems analysis approach considers both the:

—3S Culture
- Individual (All) Values and Commitment
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AND

—3S Enabling Tools
- Technologies
- Processes
- Knowledge and Experience

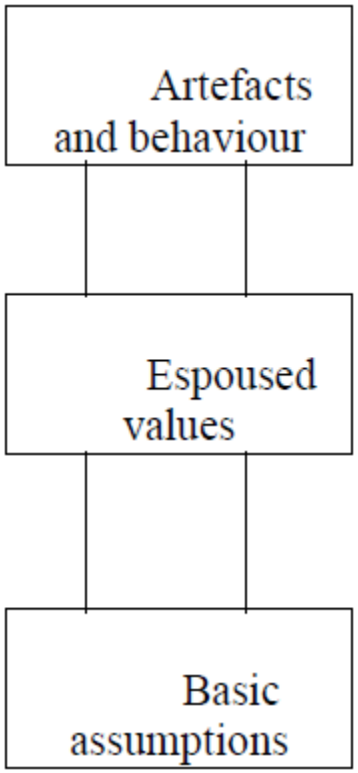
Major Responsibilities of Individual in a RNEP

- Do the Right Thing,
- Do it the Right Way,
- Do it at the Right Time,
- Do it using the Right Tools.

A Strong Integrated 3S Approach Ensures That Each Individual is Enabled, Empowered, and Required to Deliver on His or Her Responsibility

What is culture?

Three Levels of Culture



Architecture, greeting rituals, dress, forms of address – visible

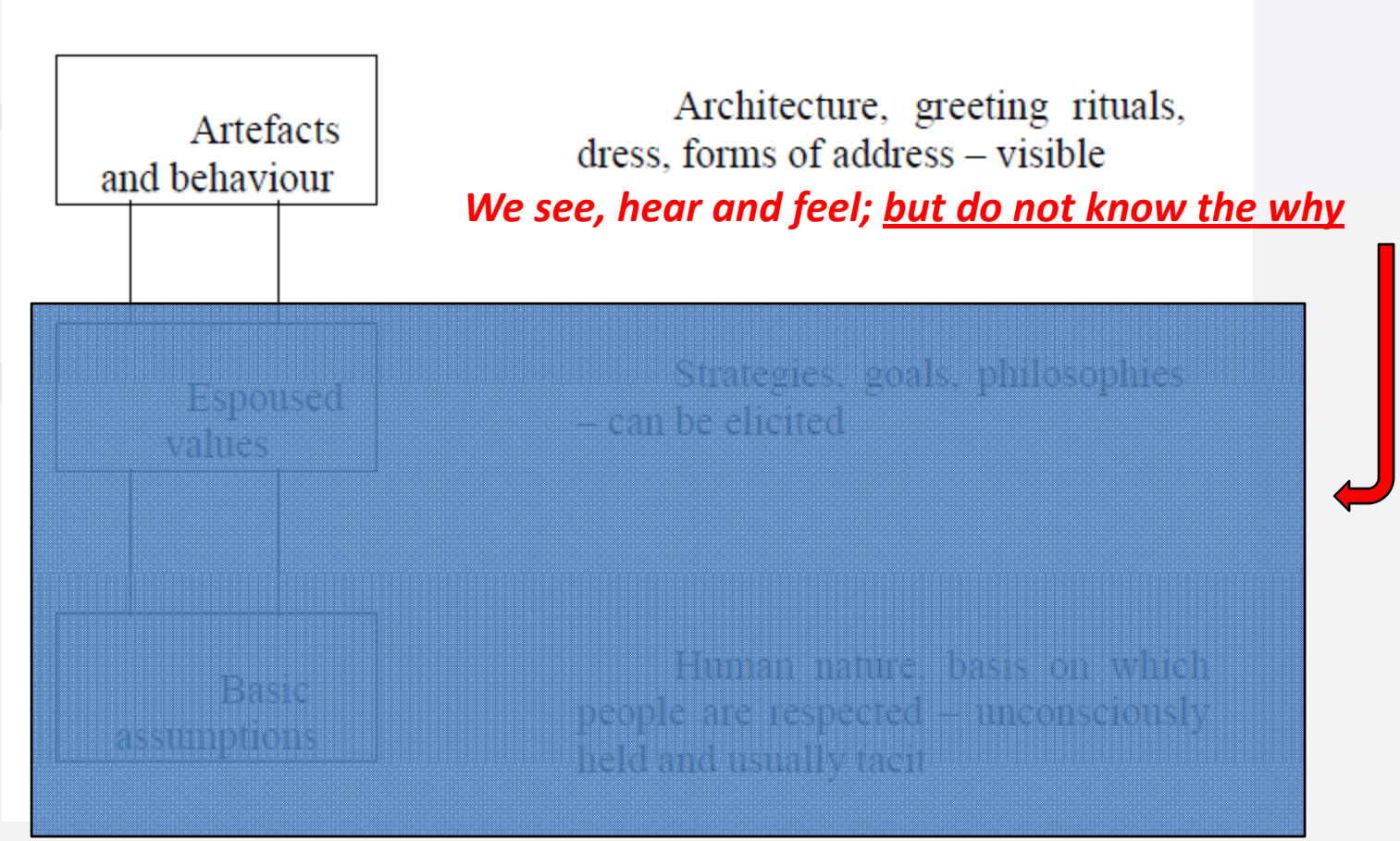
Strategies, goals, philosophies – can be elicited

Human nature, basis on which people are respected – unconsciously held and usually tacit

IAEA-TECDOC-1329, "Safety culture in nuclear installations, Guidance for use in the enhancement of safety culture," December 2002

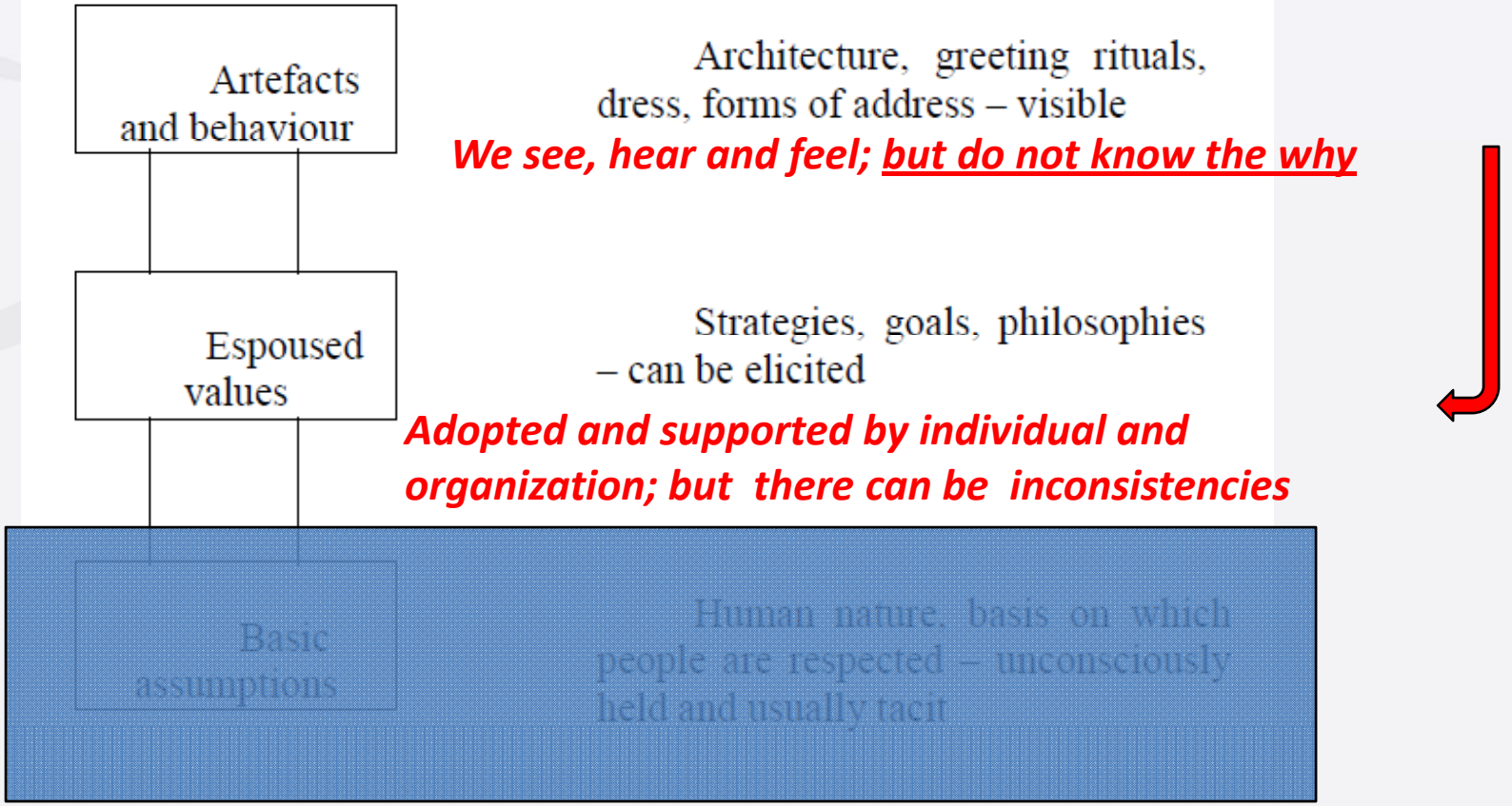
Level 1 of Culture: Artifacts and Behavior

If we make a, presumably positive, change at this level, have we really made a positive change in the culture?

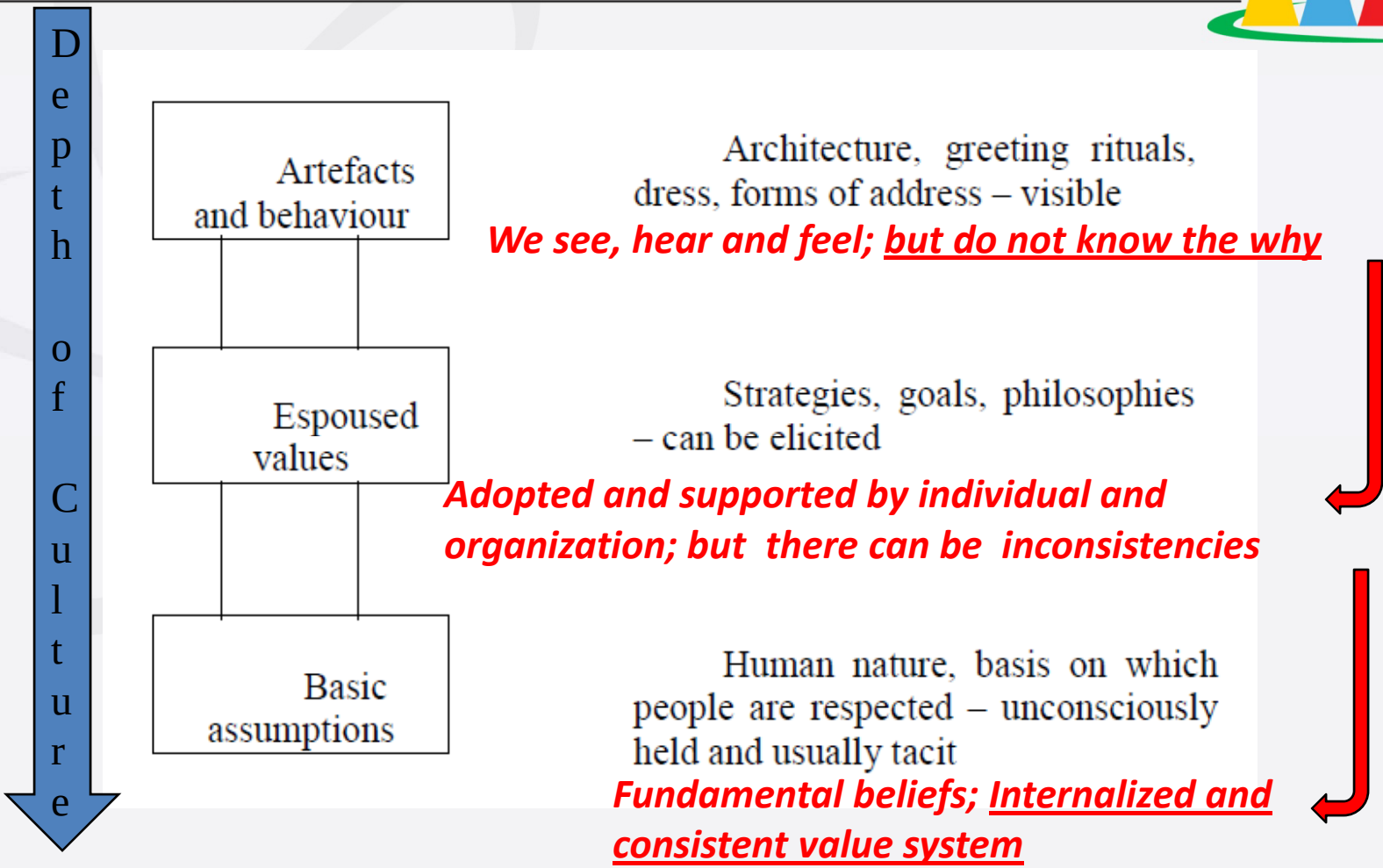


Level 2 of Culture: Espoused Values

If we make a, presumably positive, change at these levels, have we really made a positive change in the culture?



Level 3 of Culture: Basic Assumptions



- **Making a positive change or impact at the individual's "values, beliefs and assumptions" positively impact the Culture – at ALL levels**
- **We can make the positive impact on our "values, beliefs and assumptions" through critical thinking**

Important Note about Culture

1. We must emphasize that there no absolute "right" or "wrong" "Social cultures"
   - "Social Culture" is a complex system that interacts with the history, geography, economy, religion, ethical, and many other aspects of the society

2. In GNEII, we are discussing the "3S" Culture, that;
   - Must harmoniously interact with the "Social Culture"
   - Must be compatible with the 3S best practices, norms, and guidelines

Objective examination of "3S Culture" is one of the attributes of a Responsible Nuclear Energy Program (RNEP)

How to Impact the 3S Culture?

- Must impact at the Basic Assumption level (deepest level);
- Make a positive impact on individual's "values, beliefs and assumptions"
- Utilize Fair-minded Critical Thinking to provide a process for consistent evaluation of thought process and examination of values, beliefs, and assumptions
- *Use Systems thinking / Approach* to develop the complex mental models required to analyze the mutual interaction of elements and components.
- So, how do we become a Fair-minded Critical Thinker?

Introduction

- **Three types of Thinkers**
  - Naïve Thinker
  - Selfish Critical Thinker
  - Fair-minded Critical thinker
- Balanced 3S Culture requires Fair-minded Critical Thinking

Types of Thinkers

Naïve Thinker

- Believes he/she does not need to think
- Believes most of what he/she hears
- Does not question the message
- Does not need/want to figure things out – just ask others
- Figuring things out is a lot of work / takes too much time for him/her
- Believes thinking gets one into trouble

Types of Thinkers

Selfish Critical Thinkers

- Use thinking to get what they want
  - No consideration for how their actions might affect others
- Are good at thinking, but are selfish
- Think a lot!!
- Question only opposing views / ideas / beliefs
- Manipulate others
- Tell people what they want to hear – even if it is not true

Types of Thinkers

Fair-minded Critical thinkers

- Work to improve their thinking whenever they can
- They are generous
  - Willing to give up things to help other – when it makes sense to do so
- They think a lot!
- Want to understand what other people think
- Do not always believe what others say
  - Try to question and understand other people's motives

How to Impact the 3S Culture?

- Must impact at the Basic Assumption level (deepest level);
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- **Utilize Fair-minded Critical Thinking to provide a process for consistent evaluation of thought process and examination of values, beliefs, and assumptions**
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To Become a Fair-Minded Critical Thinker

We must:

1. Understand the Elements of Thought
2. Apply Intellectual Standards to the Elements of Thought
3. Acquire the Intellectual Traits

To Become a Fair-Minded Critical Thinker

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- **Understand the Elements of Thought**
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A Fair-Minded Critical Thinker

Understands the Elements of Thought

- Know the elements and learn their attributes –
  - Purposes
  - Questions
  - Points of Views
  - Information
  - Inferences
  - Concepts
  - Implications
  - Assumptions

To Become a Fair-Minded Critical Thinker

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Fair-Minded Critical Thinking

Apply the Intellectual Standards to Each Element of Thought

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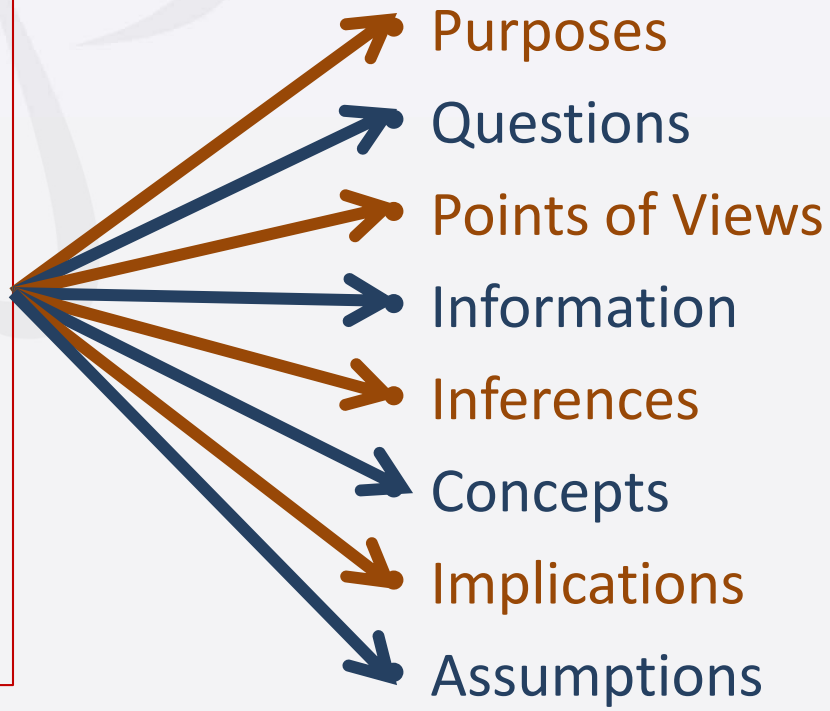


Next, we will cover the details of this process

To Become a Fair-Minded Critical Thinker

We must:

- Understand the Elements of Thought
- Apply Intellectual Standards to the Elements of Thought
- **Acquire the Intellectual Traits**

Fair-Minded Critical Thinking

Develop Intellectual Character

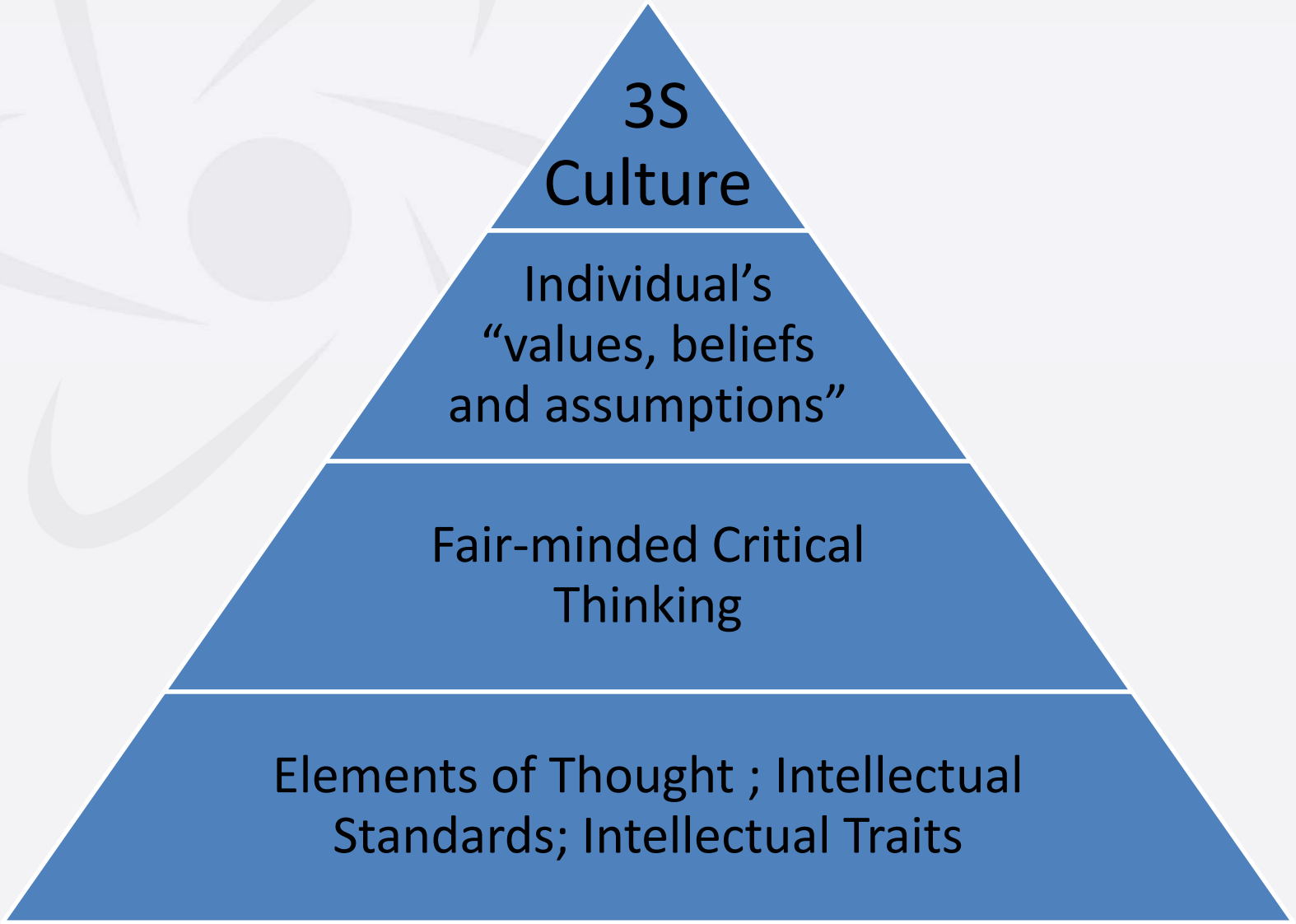
These traits define how Fair-minded Critical Thinkers live their lives

- **how they learn,**
- **how they communicate**
- **how they see the world**

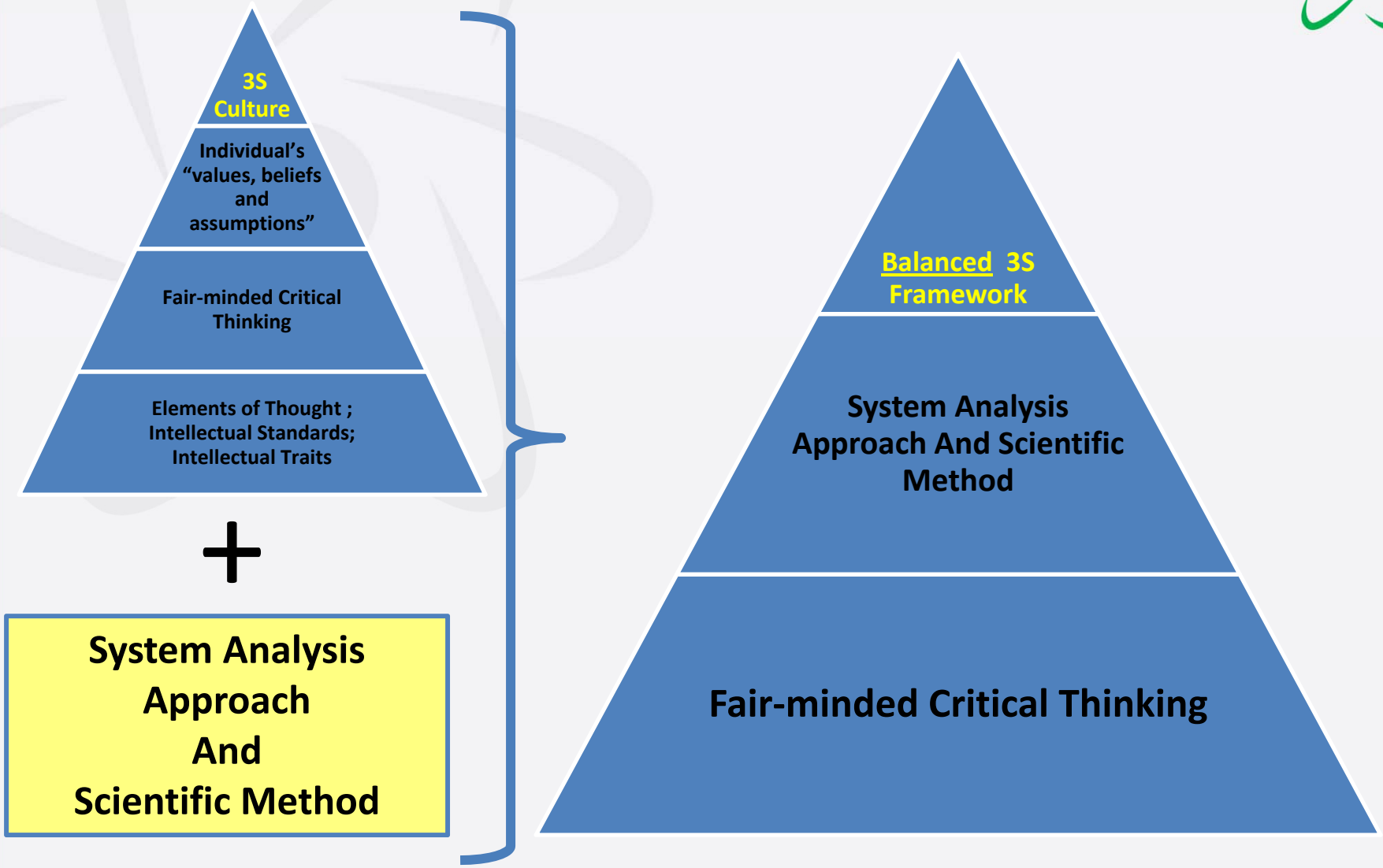
Fair-minded Critical Thinkers Want to Develop An Intellectual Character

These traits are clearly visible in the behavior of Fair-minded Critical-Thinkers

How to Impact the 3S Culture?



Create a Balanced 3S Framework



PART Three: System Analysis Approach

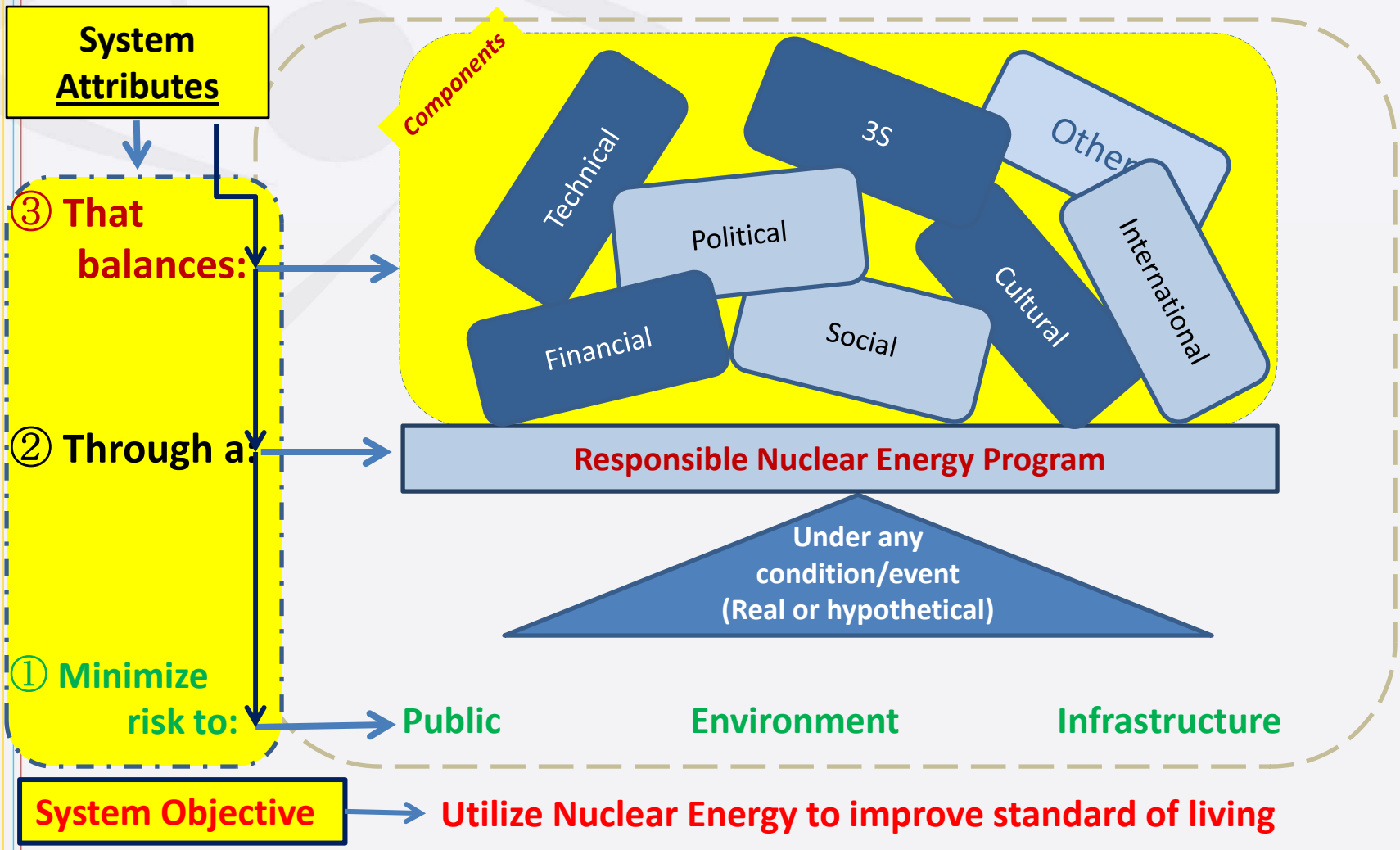
When to Use System Analysis Approach?

- Multiple interdependent parameters exist;
- Need for balancing or reinforcing feedback;
- There are multiple perspectives on just what the situation is, and how to deal with it;
- No Balanced Approach – endless oscillation;
- Previously applied fixes have created problems elsewhere
- A tendency to allow an established standard to slip
- Partners for growth become adversaries
- Growth leads to decline elsewhere

Why System Analysis Approach?

Recall our Model for RNEP? It is a "System".

SYSTEM: Responsible Nuclear Energy Program



Define a Typical System

- According to the Webster's New Dictionary:
  1. A regularly interacting or interdependent group of items forming a unified whole;
  2. An organized set of doctrines, ideas, or principles usually intended to explain the arrangement or working of a systematic whole
- Many other definitions

Define a Typical System

- What is NOT a System?
- However; Not every set of items, facts, methods, or procedures is a system; For example:
  - *A random group of items in a room would constitute a set with definite relationships between the items, but it would not qualify as a system because of the absence of unity, functional relationship, and useful purpose.*

Definition of System for GNEII's Curriculum

- A regularly interacting or interdependent group of items each with its own attributes forming a unified whole to serve an stated purpose
  - Components = group of items
  - Attributes: items' attributes
  - Relationships: interaction or interdependence of items

Definition of System for GNEII's Curriculum

An assemblage of interacting or interdependent components, each with its own attributes, and relationships forming a unified whole(system) to serve an stated purpose

- ***Components:*** are the operating parts of a system consisting of input, process, and output. Each system component may assume a variety of values to describe a system state as set by some control action and one or more restrictions.
- ***Attributes:*** are the properties or discernible manifestations of the components of a system. These attributes characterize the system.
- ***Relationships:*** are the links between components and attributes of components.

Properties of System Components

As they work together toward some common objective or purpose (System Objectives), a set of interrelated components has the following properties:

- **The properties and behavior of each component of the set has an effect on the properties and behavior of the set as a whole [feedbacks].**
- **The properties and behavior of each component of the set depends on the properties and behavior of at least one other component in the set [Interplay, Relationships].**
- **Each possible subset of components has the two properties listed previously; the components cannot be divided into independent subsets [Interdependent].**

System Objective and Effectiveness

- The **objective or purpose** of a system must be **explicitly defined and understood** so that system components may be selected to provide the desired output for each given set of inputs.
- Once defined, the objective or purpose makes it possible to establish a given measure of effectiveness indicating how well the system performs.

Connection to Critical Thinking: **Understand the objective or purpose clearly**

Open System

Open systems interact with their environment, examples being plants, ecological systems, and business organizations:

- They exhibit the characteristics of *steady state*, wherein a dynamic interaction of system components adjusts to changes in the environment. Because of this steady state, open systems are self-regulatory and often self-adaptive.

.....exhibit the characteristics of *steady state*, ... dynamic interaction of system components adjusts to changes in the environment...

Don't these attributes remind of us of our Balanced and Integrated 3S Framework?

System-Approach Analysis

- The System Analysis Approach looks at a system from the top down rather than from the bottom up
- By focusing on systems, subsystems, and components in a hierarchy, one is forced to consider all pertinent functional relationships.

Analytic and Synthetic Thinking / Analysis Approach

- ***Analytic thinking*,** an explanation of the whole is derived from explanations of its parts.
- ***Synthetic* thinking,** something to be explained is viewed as part of a larger system and is explained in terms of its role in that larger system.
- **Analytic thinking is outside-in thinking; synthetic thinking is inside-out thinking.**
- ***Neither negates the value of the other, but by synthetic thinking one can gain understanding that cannot be obtained through analysis, particularly of collective phenomena.***

Synthetic Thinking / Analysis

- **The synthetic mode of thought, when applied to systems problems is called the *systems (analysis) approach.***
- **This way of thinking is based on the observation that, when each part of a system performs as well as possible, the system as a whole *may not* perform as well as possible.**

[Q: Why is that? What is missing here?]

  - **This follows from the fact that the sum of the functioning of the parts is seldom equal to the functioning of the whole.**
  - **Accordingly, the synthetic mode seeks to *overcome the often observed predisposition to perfect details and ignore system outcomes.***

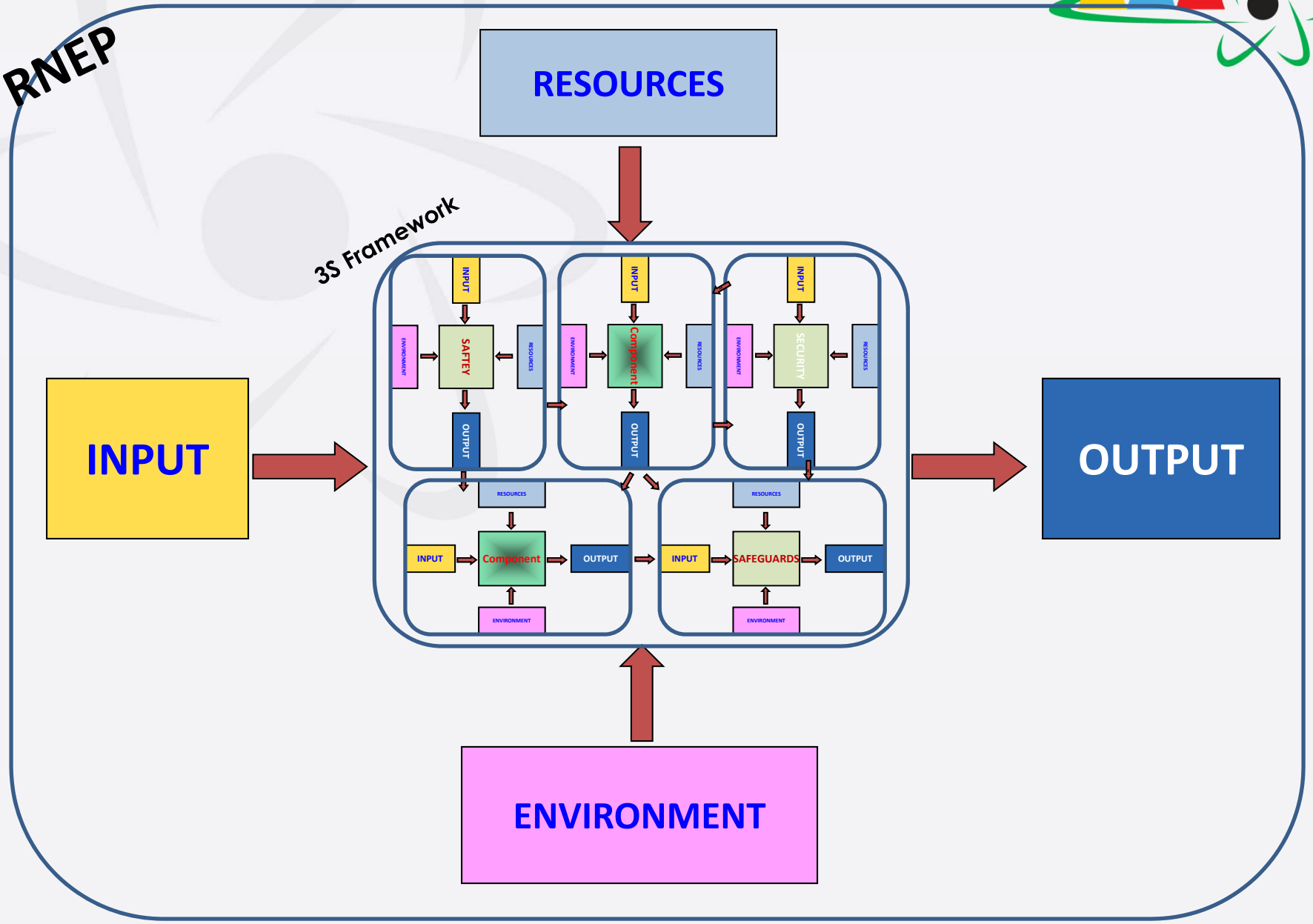
For an Open and Dynamic RNEP (System) we need to "clearly understand the synergy between its components."

Our Approach to 3S

Our Approach to Analyze this Complex System

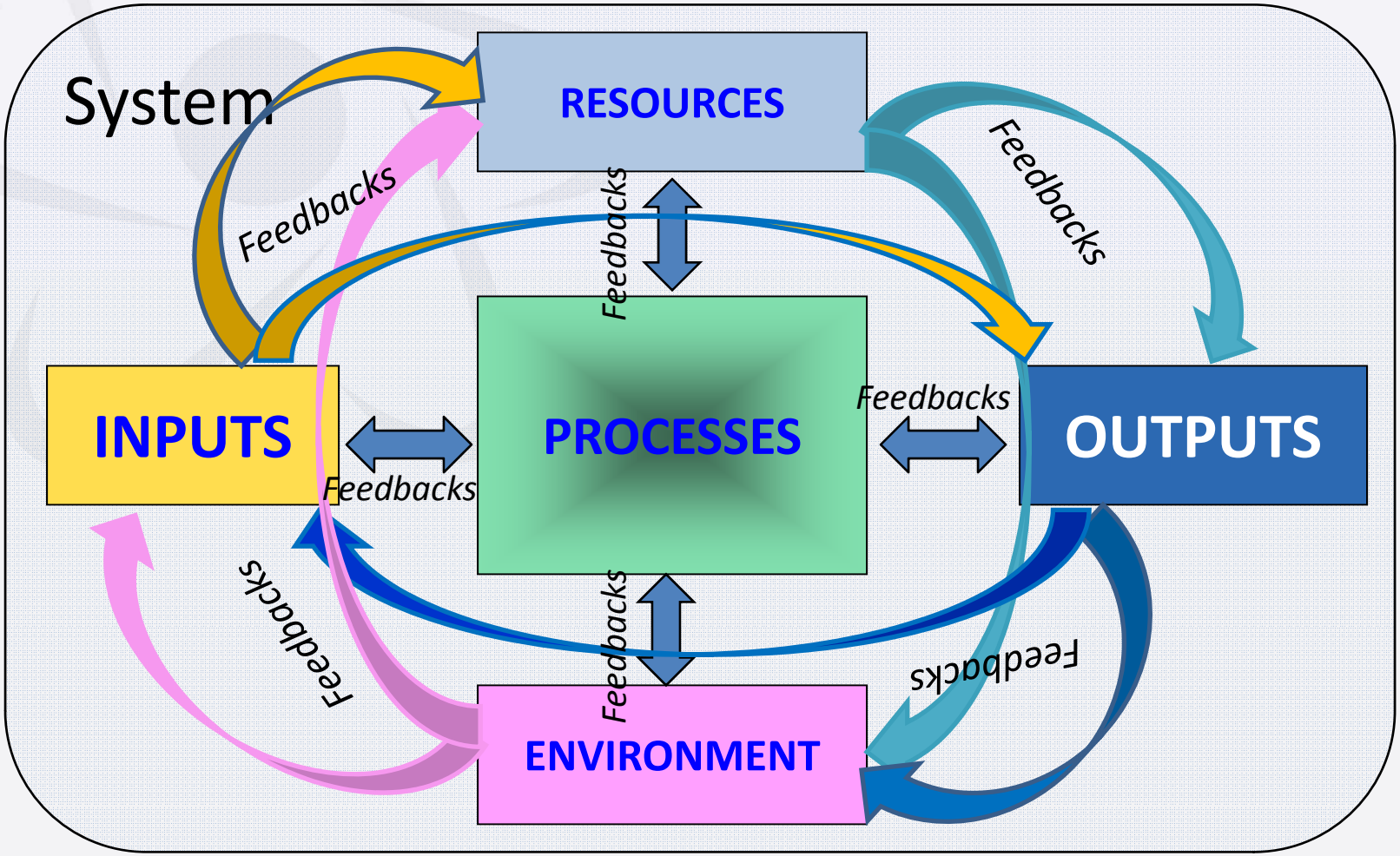
- System Analysis/Solution approach
- Goal of GNEII Curriculum is to:
  - Identify the major components of the 3S system
  - Provide suggestions to analyze, and understand the system and components attributes
  - Guide students in recognizing the interactions between the system and its components (Safety, Security, Safeguards)

The System of Systems – 3S Framework



The System and Feedbacks –

Interactions/Interplays



System Analysis and System Solution

- Up to now we have provided the foundations on which we will build the system solution approach
- First we need to analyze the problem – as a system
- Next we will discuss the major steps in developing *a* solution – as a system
- Notice the role of critical thinking in these processes

System Analysis Approach

- Determine if problem / issue constitutes a system:
  - Components
  - Attributes
  - Relationships
- Additional indicators include:
  - multiple perspectives on just what the situation is, and how to deal with it
  - previously applied fixes seem to overshoot the goal, or created problems elsewhere
  - tendency to allow an established standard to slip
  - progress slows over time
  - more than one limit to growth
  - Fixing on problem results in a problem elsewhere
  - .....

System Analysis Approach

- Determine the system:
  - Type
  - Objective(s) / Goals / Scope
  - Environment
  - Component attributes
  - Relationship between components
  - Role of each component
  - Component Feedbacks
- Use Scientific Method to Examine / Test Hypothesis / Solution
  - We discuss the Scientific Method (process) next

Scientific Method

A tool for implementation of Critical Thinking and System Analysis Approach

Scientific Method

Connection to Critical Thing and System Analysis Approach

1. **Ask a question or state a problem. (one of elements of Thought)**

2. **Propose an "Educated " answer /opinion/ view for /on the question /issue/topic/ or solve the problem (Hypothesis). (requires collection of data/information and check assumptions before developing a view or opinion – an element of critical thinking)**

3. **Provide supporting arguments / evidence for your answer /opinion/ view AND those against ;**
   - **Provide arguments against other views – why you disagree? Why they will not work? What are their risks / un-intended consequences? (similar to elements of Thought and Critical Thinking).**

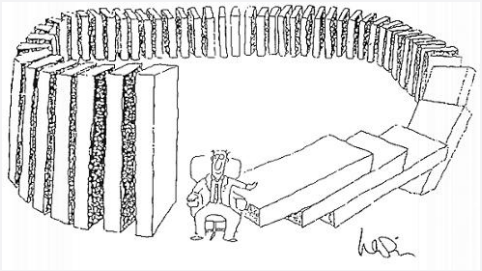
4. **Summarize your analyses/ results; and provide potential challenges with implementation/adoption of your answer /opinion/ view (similar to elements of Thought and Critical Thinking).**

5. **Draw (make) Conclusions *(How does the conclusion compare to the hypothesis?) What the unintended consequences.* (similar to elements of Thought and Critical Thinking).**

System Solution Approach Requirements

"It's so much easier to suggest solutions when you don't know too much about the problem."
--Malcolm Forbes

- Think Critically Throughout
- Define the System Goals / Objectives
- Gather Information and Data
- Analyze Desired System
- Include System Dynamics - Feedback
- Develop Several Possible Solutions
- Evaluate the Risk and Consider the Unintended Consequence
- Develop Mitigation Plans for Risks
- Rank Solutions
- Make Recommendation / Decision

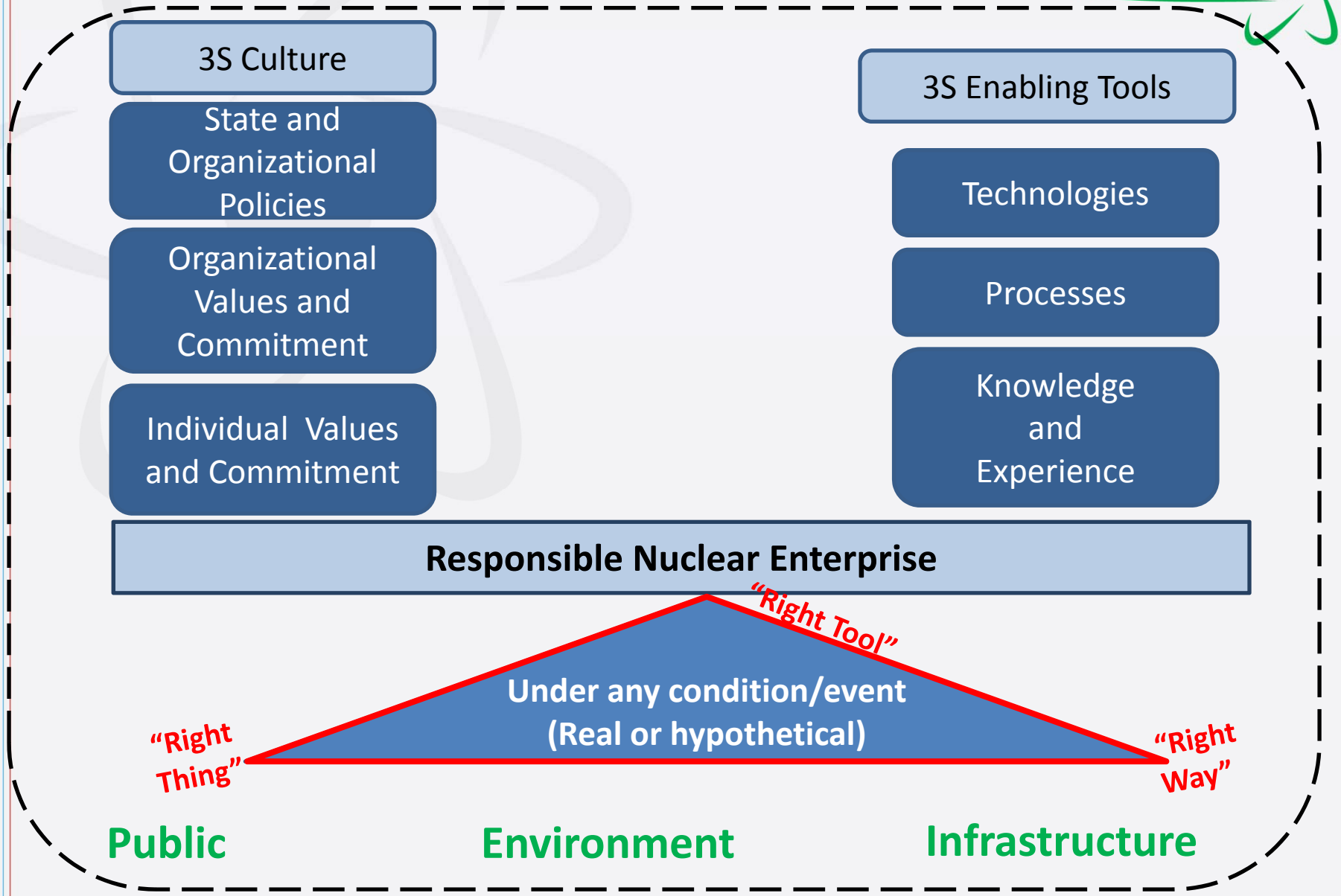


Concluding Remarks

- **System thinking is one of the most important reasoning capabilities available to us;**
- **Systems Analysis (Solution) provides a holistic approach to deciding *what we want;* and *getting it with resource constraints;***
- **Decision analysis and risk analysis are very useful in that context (don't forget dependencies!)**
- **When facing sequential decisions, consider the future effects of your actions: think forward, then back to initial decision**

KEEP IN MIND THE BIG PICTURE

Concluding Remarks: Review of 3S Framework



Concluding Remarks: Review of 3S Framework

Public: generic term consisting of
- Personnel staffing the nuclear facility
- People living/working in the immediate vicinity of the nuclear facility
- The population at large

Environment: generic term composed of the topographic, vegetation, water, and air resources
- Inside the nuclear facility
- Immediately surrounding the nuclear facility
- Along intra- and international borders

Infrastructure: generic term representing
- The revenue generating nuclear facility
- Surrounding national pieces of infrastructure (roads, bridges, etc)
- Personal property

Public **Environment** **Infrastructure**

Concluding Remarks: Review of 3S Framework

- **Must serve a Responsible Nuclear Energy Program**
  - **All of these can be built based on Fair-minded Critical Thinking, System Analysis Approach, and Scientific Method**
    - **“Right Thing”**
    - **“Right Way”**
    - **“Right Time”**
    - **“Right Tools”**

Responsible Nuclear Enterprise

Concluding Remarks: Review of 3S Framework

3S Culture

3S Enabling Tools

- **Has two main components**
  - **3S Culture**
  - **3S Enabling Tools**

- **3S Culture – itself has three components**
  - **Safety Culture**
  - **Security Culture**
  - **Safeguards Culture**

Concluding Remarks: Review of 3S Framework

- **"3S Culture"**
  - Individual Values and Commitment
  - Organizational Values and Commitment
  - State and Organizational Policies
- **All of these can be built based on Fair-minded Critical Thinking**
  - **"Right Thing"**
  - **"Right Way"**
  - **"Right Time"**

Concluding Remarks: Review of 3S Framework

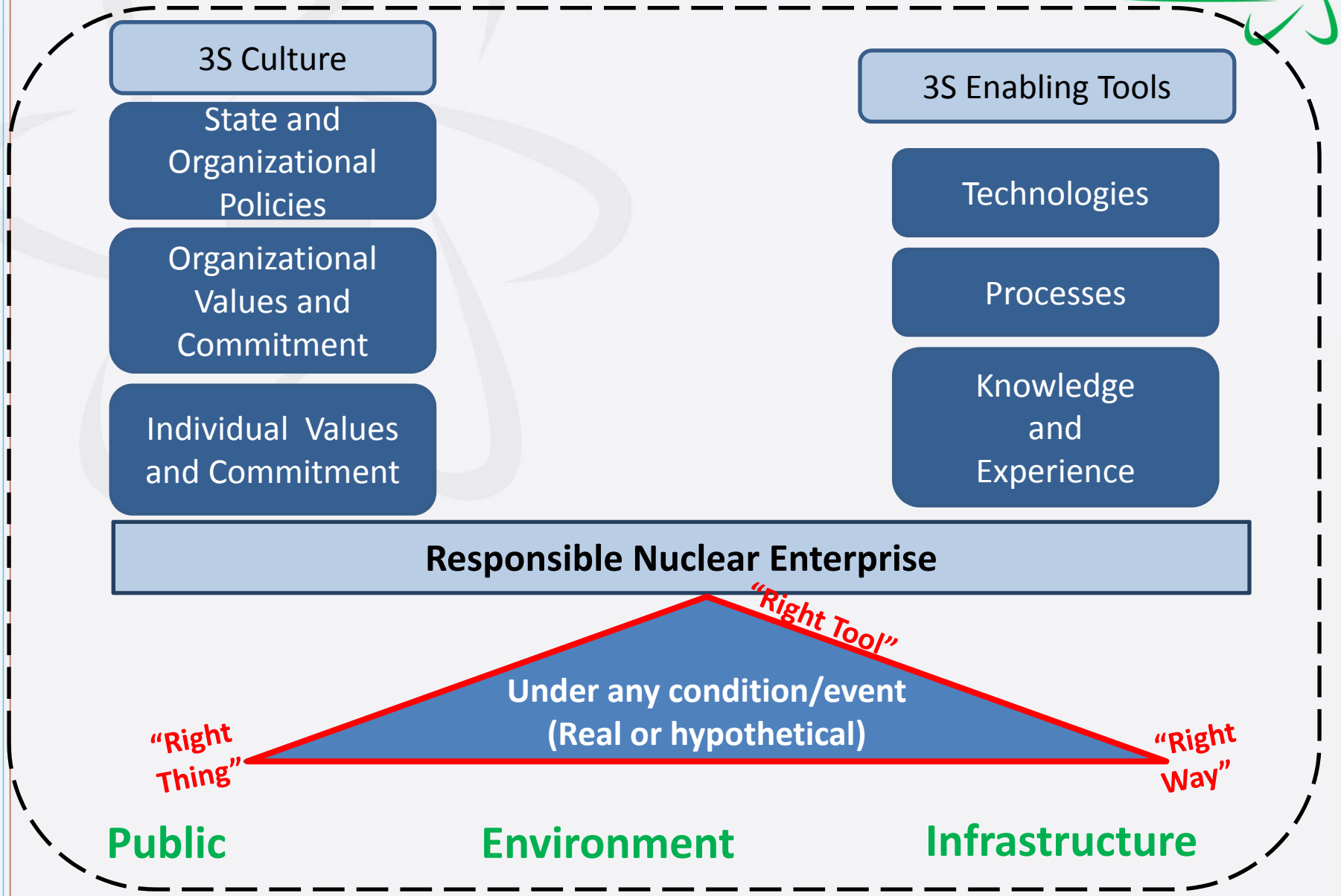
3S Enabling Tools

- **3S Enabling Tools**
  - **Safety Enabling Tools**
  - **Security Enabling Tools**
  - **Safeguards Enabling Tools**

Concluding Remarks: Review of 3S Framework

- **Enabling Tools**
  - **Technologies**
  - **Processes**
  - **Knowledge and Experience**
- **All of these will utilized based on Fair-minded Critical Thinking, System Analysis Approach, and Scientific Method**

Concluding Remarks: Review of 3S Framework



References

1. B. S. Blanchard and W. J. Fabrycky; “System Engineering and Analysis,” Third Edition, 1998; chapter 1.
2. http://www.systems-thinking.org/index.htm
3. http://www.systems-thinking.org/stada/stada.htm#anchor909268
4. Systems Thinking, Systems Practice; by Peter Checkland, John Wiley & Sons, Reprinted November 2000

List of Required Texts

1. The Aspiring Thinker's Guide to Critical Thinking by Dr. Linda Elder and Dr. Richard Paul; The Foundation for Critical Thinking
2. The Thinker's Guide to Engineering Reasoning by Dr. Linda Elder, Dr. Robert Niewoehner, and Dr. Richard Paul, and ; The Foundation for Critical Thinking
3. The Miniature Guide to Critical Thinking, Concepts and Tools, by Dr. Linda Elder and Dr. Richard Paul; The Foundation for Critical Thinking