
NASA Safety

Cultural Improvements

J. D. Wetherbee

Outline

- **Culture**
- **Organizational Accident Models**
 - High Reliability
- **Psychology of Decisions**
- **Preventing The Next Accident**
 - Managing Risk
 - Past, Present, Future
- **Bibliography**

Challenge

- **Highly advanced technology**
 - Tremendous energy required to accelerate 100 tons to orbital velocity
 - Must intellectually manage this advanced technology
 - System is large, complex, unpredictable, cannot test everything, cannot foresee all possible environments

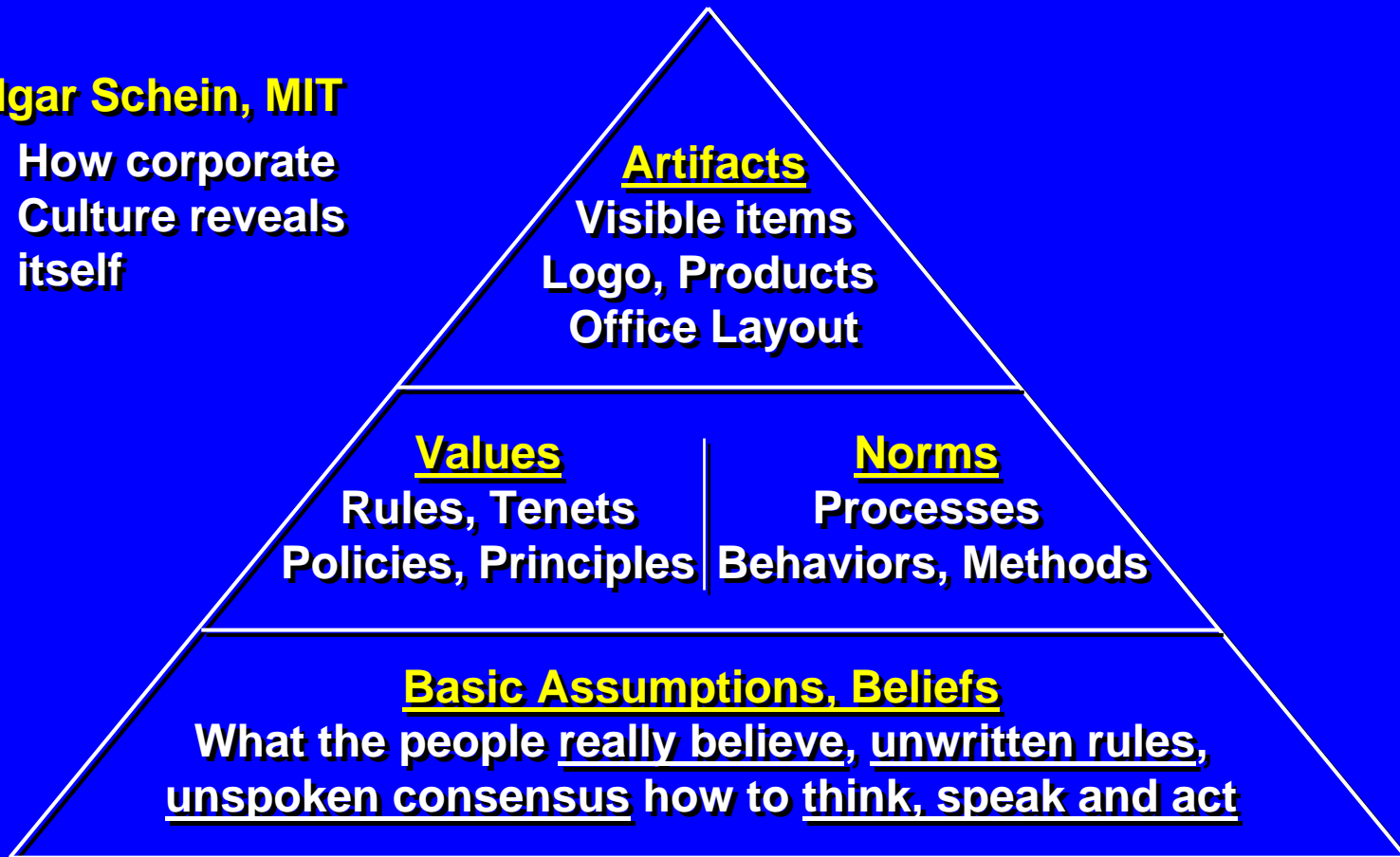
Culture

- **Psychologist's Definition**
 - Culture is the shared values, beliefs and norms for behavior in the organization.
 - Defined by mostly unspoken and sometimes unconscious consensus about how people should think, speak and act.
- **Changing the culture is very simple; but it's not very easy.**

Corporate Culture

Edgar Schein, MIT

How corporate
Culture reveals
itself



Culture

- **Safety Culture is measured by the alignment of Values, Beliefs, and Behaviors. ★**
 - **Values** are basic principles or tenets preserved by the policies, rules and methods specified by leaders to guide the organization.
 - **Beliefs** are what the members of the organization really think.
 - **Behaviors** are what the workers really do in practice. They are how people talk in meetings, the quality of questions asked, how people elevate or resolve issues, and the relationships that different organizations and individual people have when working with each other.

Cultural Change

- **Management**

- Acknowledgement

- Leaders must Create Conditions for Transformation

- Goals, Incentives, Encouragement, Reinforcement

- Lead, then Trust

- **Workforce**

- If Leaders Create Conditions, Organizational Norms will evolve

- (More Rules, Policies, Procedures won't work to change behaviors)

High Reliability Orgs.

Karl Weick and Kathleen Suttcliffe, U. of Mich.
High Reliability Org's display 4 Characteristics in
"Managing the Unexpected":

- **1. Leadership Commitment** – Safety Priority, top to bottom, in the face of other goals!
- **2. Organizational Redundancy** – allow errors and malfunctions to be trapped
- **3. Decentralized Capability** – defer to experts; quick, flexible, absorb mistakes, contain damage, prevent accidents
- **4. Problem Reporting** – Horizontal and vertical, accurate, timely

High Reliability Orgs.

HRO's use 5 Processes to manage:

Anticipation of Failure

- 1. Preoccupation with Failure
- 2. Reluctance to Simplify Interpretations
- 3. Sensitivity to Operations

Containment of Failure

- 4. Commitment to Resilience
- 5. Deference to Expertise

High Reliability Orgs.

- **Discovering Unknowns**
 - **Combine processes:**
 - 1. Preoccupation with Failure
 - 2. Reluctance to Simplify Interpretations

“In the brief interval between surprise and successful normalizing lies one of your few opportunities to discover what you don’t know.” (Weick and Suttcliffe)

High Reliability Orgs.

- **Safety is Elusive because it is a “Dynamic Non-Event”**
 - What produces a safe, stable outcome is constant change
 - **Continuous mutual adjustment:** Respectful Interaction, Communication, Trust, Firsthand Knowledge of the Technology, Attentiveness, Familiarity with each other’s roles, experience.

Psychology of Decisions

Cognition
Intuition
Inadequacies
Decisions

Human Brain Systems

- Comparison between Neocortex's **Left** and **Right Hemisphere** structure and functions:

Left	Right
Axons: Shorter	Axons: Longer
Similar Neurons	Disparate Neurons
Intensive, detailed	Integrating concepts
Logic	Creativity

Human Brain Systems

- Comparison between **Vertical** structure and functions of the brain:
 - **Neocortex**
 - Four surface lobes, Data, Cognition, Rationalization
 - **Limbic System**
 - Amygdala, Memory, Emotions, Intuition, Values
 - **Brain Stem**
 - Mission-critical Functions, Breathing, Heart Beat, Blood Pressure

Strengths

- **Cognition**

- Deliberate Thinking, Conscious, Neocortex, Prefrontal Lobes, Single Channel Processing, Decision-making, Problem solving techniques

- **Intuition**

- Automatic, Subconscious, Inspiration, Feelings, Creative, “Came to me in a flash”, “Sleep on it”, “Something told me”, “I just knew”

Relative Advantages

Computer or Mechanical System:

Fast, Accurate, can solve complex problems

Can perform mundane tasks,

Not susceptible to boredom,

Endurance,

Multi-tasking,

Physical power,

Short and long term memory capability.

Human Brain:

Superior judgement,

Can make inferences,

Can solve problems given incomplete data,

Flexible,

Self-programming ability,

Pattern interpretation,

Risk-taking capability,

Ultimately resilient,

reliable and safe,

Use of intuition.

Intuition

- **Significance of Intuition**

- Intuition is a powerful internal resource and a gift that humans have
 - (Retention of knowledge is a skill)
- Intuition is always a response to something
 - Everything it communicates to you is meaningful (although it may occasionally send out a signal that is less than urgent)
- Intuition is a cornerstone of personal safety

Intuition

- **Applying Expertise**

- The process of editing out of unimportant details in favor of those known to be relevant
- Many experts lose the creativity and imagination of the less informed
 - Experts are so intimately familiar with known patterns that they may fail to recognize or respect the importance of the new wrinkle

- **Treasured experts**

- Combine informed opinions with strong respect for their own intuition and curiosity
- To become experts – Learn
- To become **treasured experts** – **Unlearn**

Human Inadequacies

- **Psychological Reasons for Inadequacies in Human Thought Processes:**
 - 1. **Slow, Single Channel Processing (Present)**
 - 2. **Desire to Exhibit Competence (Present)**
 - 3. **Insufficient Memory (Past)**
 - 4. **Omission of Predictive Thought Processes (Future)**

Rules

- **Safety Rules are Unique**
 - Temptation to Violate
 - **Violation**
 - Routine before an accident
 - Does not usually result in catastrophe
 - Positive consequences
 - Work made easier
 - Reinforces tendency to violate
 - Likelihood of disaster increases

Decisions

- To ensure **effective decisions**, leaders should enable the **collective wisdom**, by encouraging:
 - **1. Diversity (Individuals and possible solutions)**
 - Different data, broader perspective, relevant experience, unique perspective
 - **2. Independence**
 - Never compromise integrity
 - Don't change opinions to conform
 - **3. Decentralization (Organization)**
 - Allows organization to benefit from the local knowledge of different sub-groups.
 - **4. Aggregation (Collection of inputs)**
 - After group members have clearly stated their opinions,
 - “Dissent” can be terminated, and
 - Can be satisfied that they helped the organization make a better, more informed decision

Decisions

- **Dissenting Opinions**

- Valuable, will protect Organization
 - Result in better decisions
- Great Leaders want Dissenting Opinions
 - Discourage **conformity**, encourage **dissent**
- Dissenting Opinions must be solicited
 - People are usually reluctant to voice dissent
- “Mind Guard”
- If absent, group polarization, missing info

Decisions

- **Open Communication**
 - **Two Advantages**
 - **1. Involve the group’s “collective IQ” to achieve better decisions**
 - **2. Quicker acceptance, if dissenters involved in development of rationale and solutions**

Cognitive Complexity

- **Robert Kegan, Harvard Education Professor, 1994**
 - **Five Stages of Cognitive Complexity**
 - **Level 2:** “I want my way.”
 - **Level 3:** Struggling to find a solution.
 - **Level 4:** Other factors are brought in. Principle values that are larger than we (marriage, love) to help make decision.
 - **Level 5:** She thinks, “I want him to hold his decision, to preserve the tension until a transcendent (beyond limits of experience) solution is realized.” It’s not about who is right.

Effective Decision Making

SUPERVISOR, WORKER

- **Responsibility**

- Develop Opinion

- State Opinion

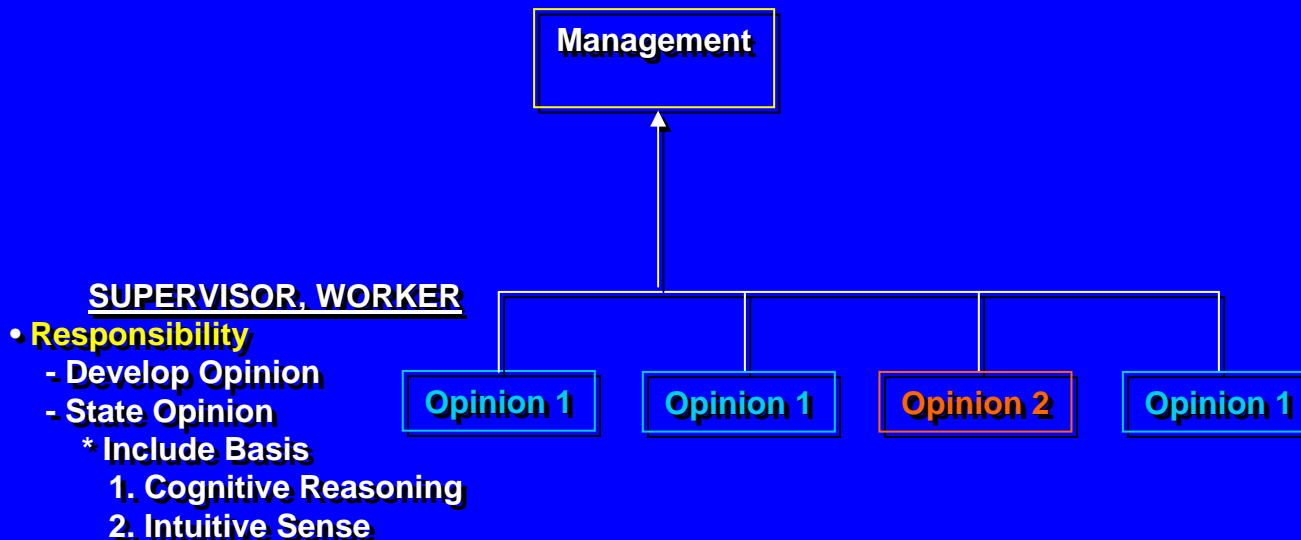
- * Include Basis

1. Cognitive Reasoning

2. Intuitive Sense



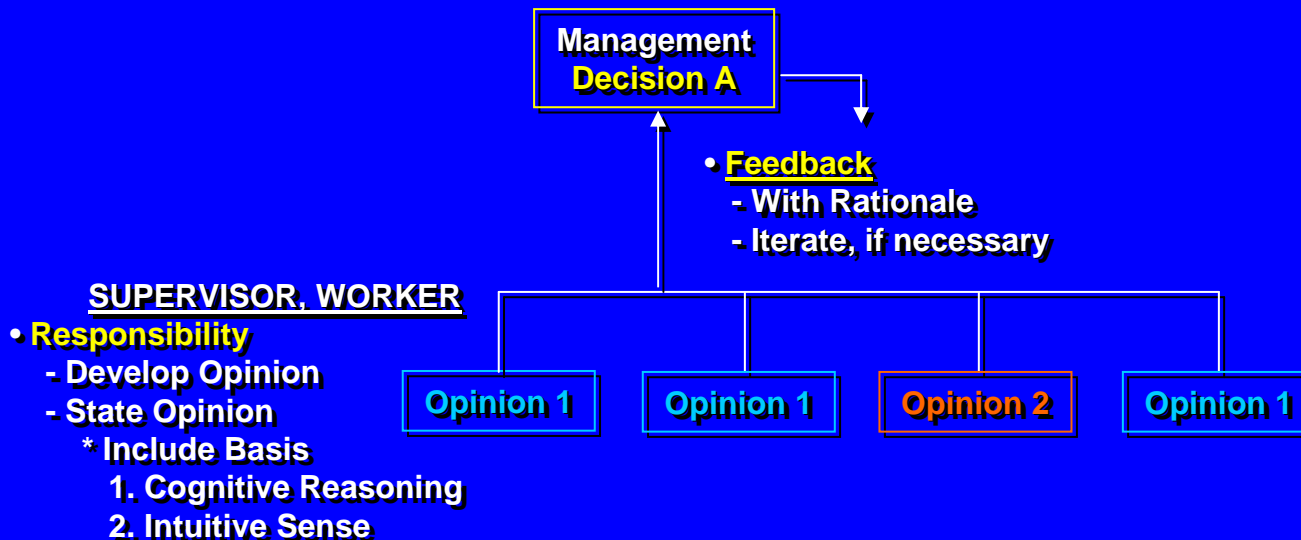
Effective Decision Making



MANAGEMENT DISCUSSION

- **Information Phase**
 - Open, Honest, Share Data
 - Informed, Cognizant
 - Encourage Opinions
 - Inclusive, Stakeholders
- **Deliberation Phase**
 - Robust Debate, Influence
 - Diversity, Independence
 - Decentralized
 - Ldr listen more than talk
 - Ensure proper logic
 - Don't terminate early

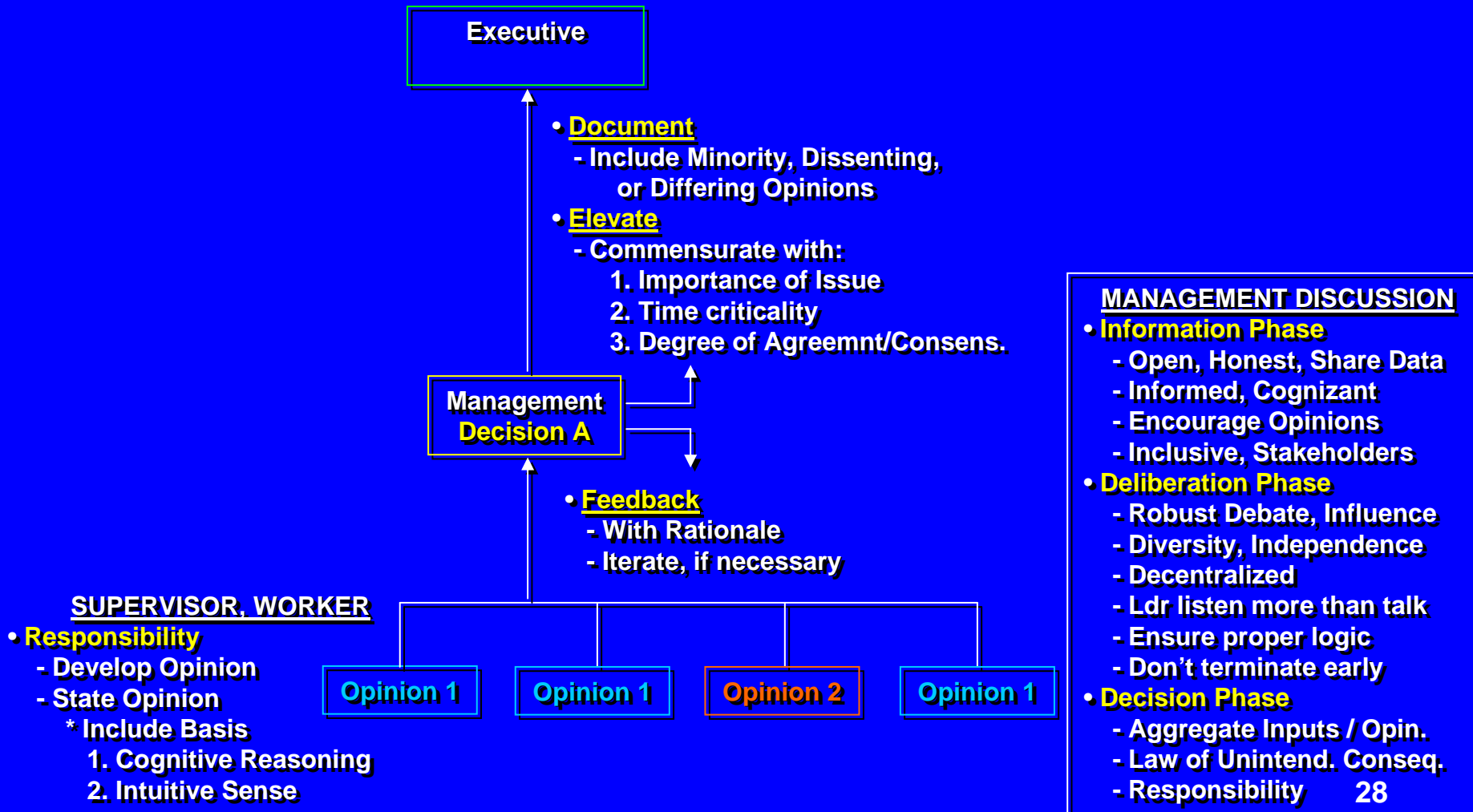
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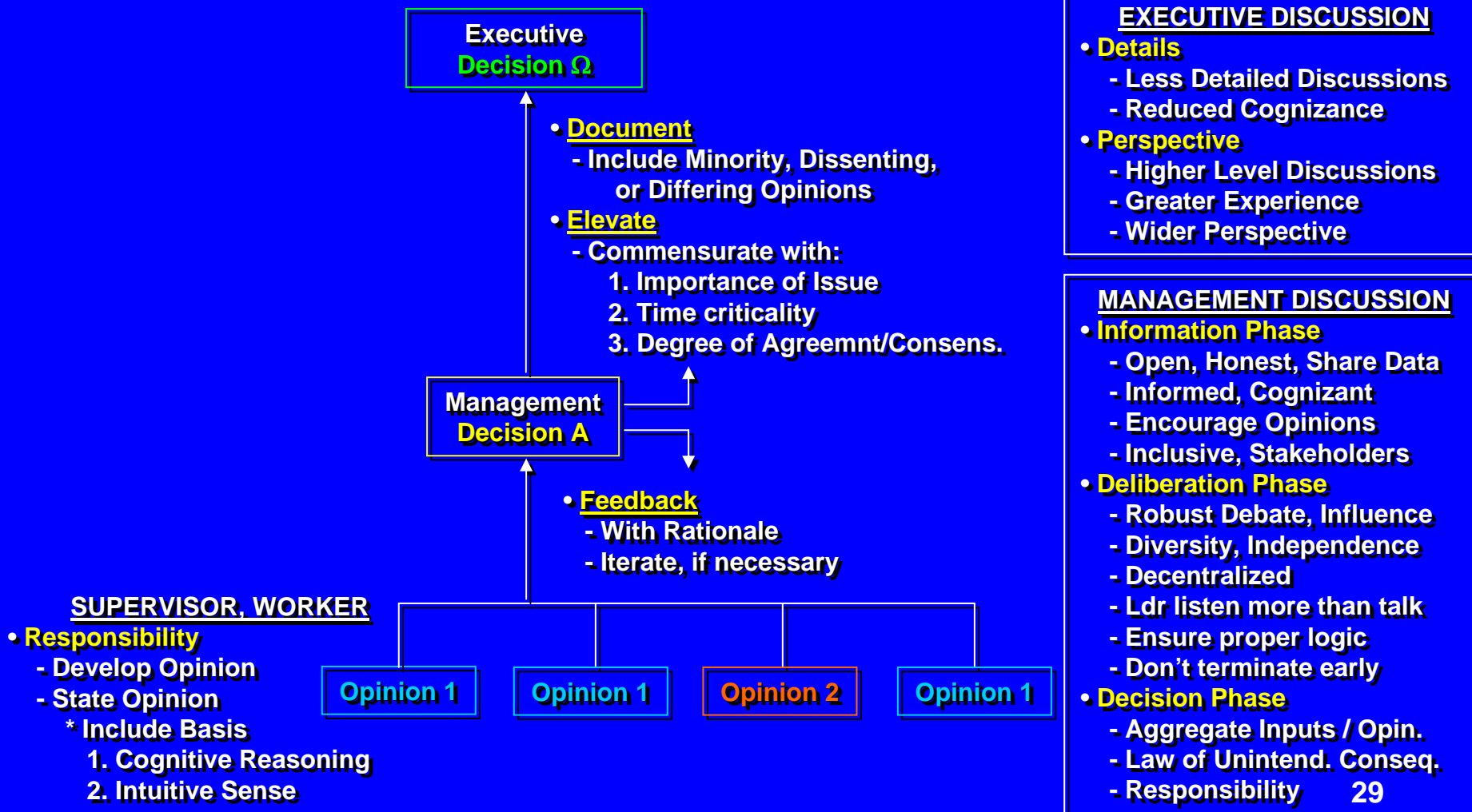
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 - Don't terminate early
- **Decision Phase**
 - Aggregate Inputs / Opin.
 - Law of Unintend. Conseq.
 - Responsibility 27

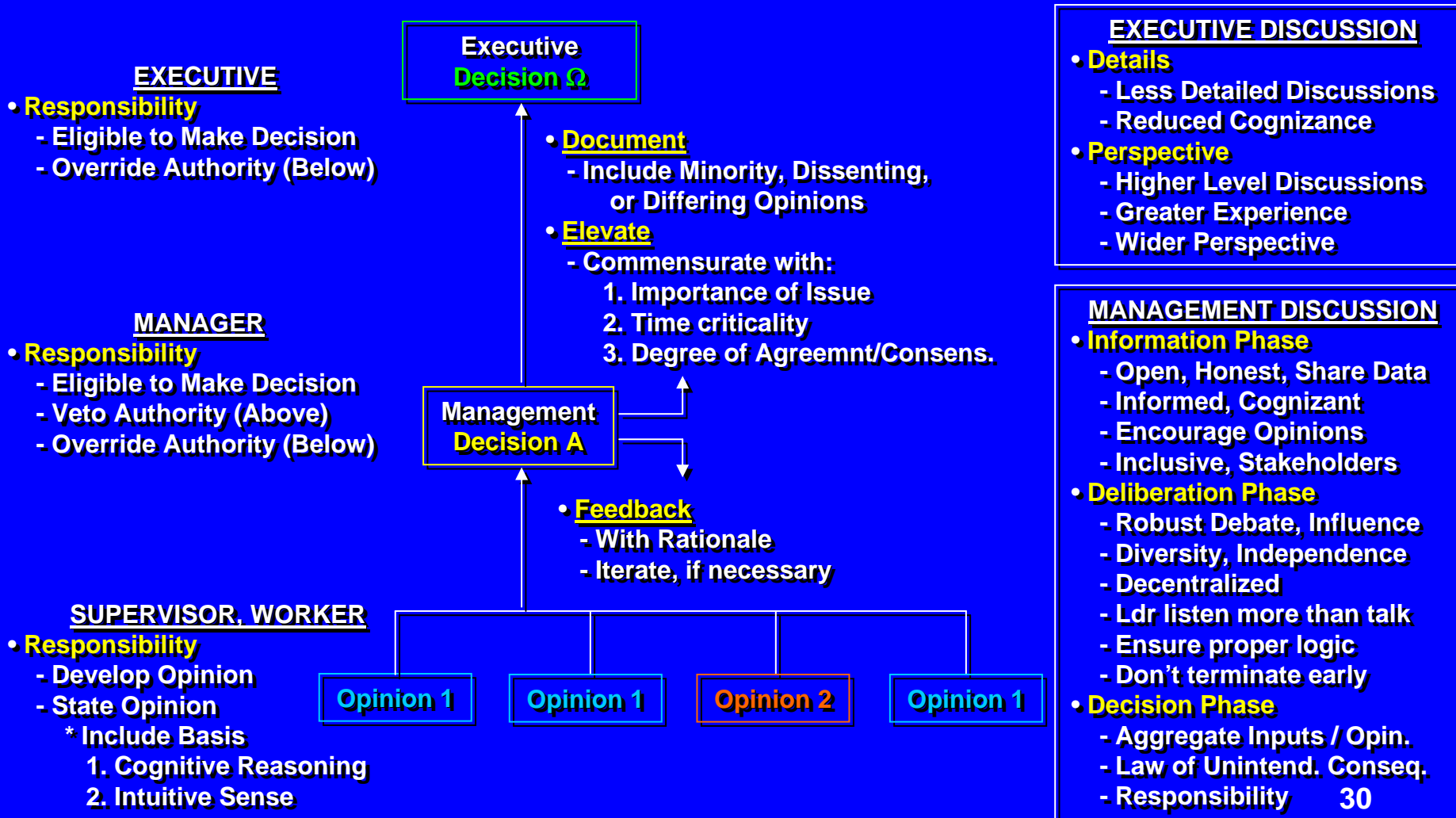
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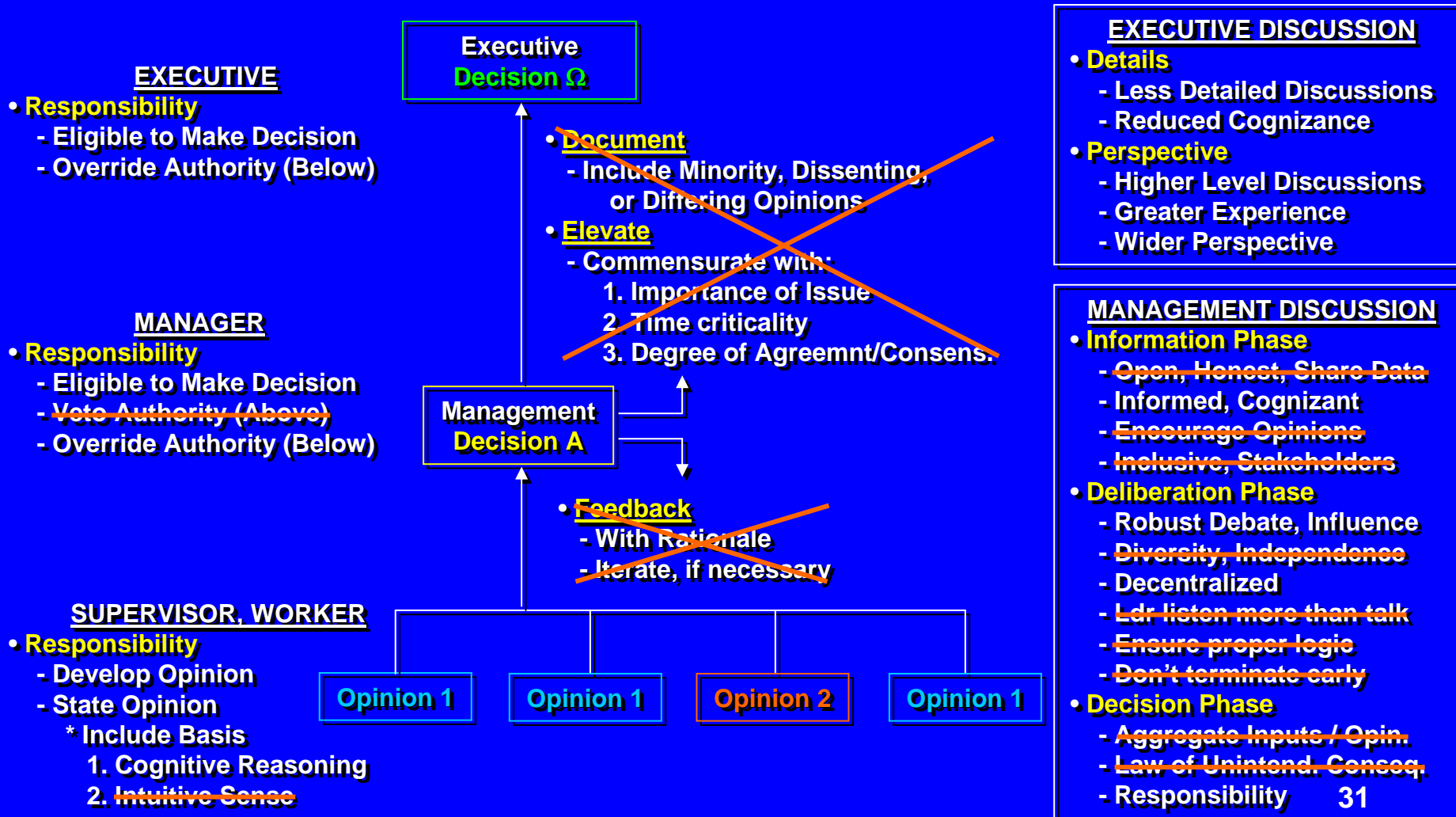
Effective Decision Making



Effective Decision Making



Ineffective Decision Making



The Next Accident

Challenge

- **How do we stop the next accident?**
 - “Create foresight – anticipate the changing shape of risk.” Deb Grubbe
 - Identify new vulnerabilities and paths to failure
 - Measure, report, evaluate, new hazards and re-analyze the existing hazards
 - Ask insightful questions
 - Develop senses
 - Improve our Safety Culture and Decisions
 - Create an Environment that allows reporting w/o fear
 - Preserve Values, then Accept Risks
 - Eliminate Error-Prone Conditions
 - Develop and maintain Situational Awareness

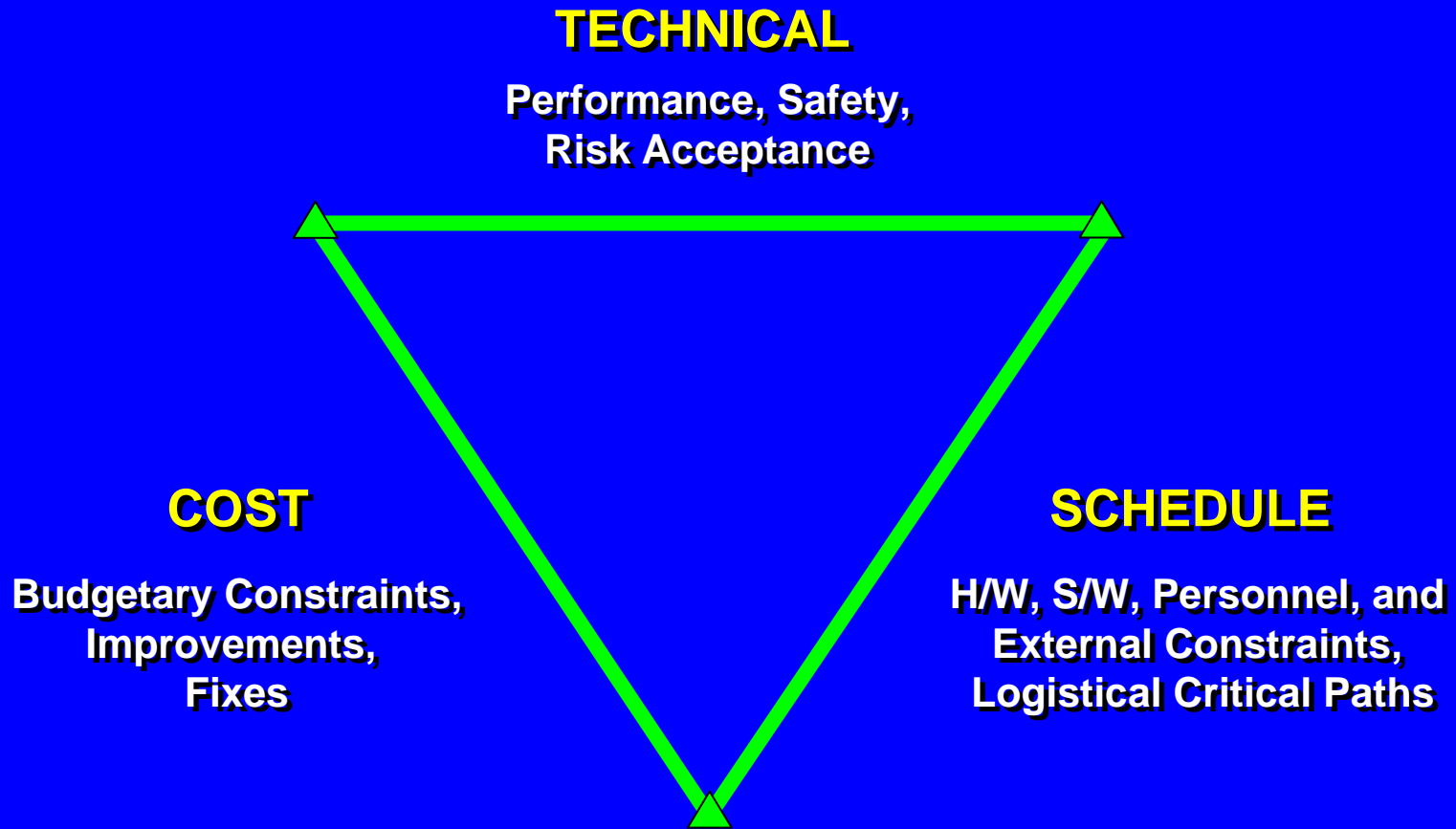




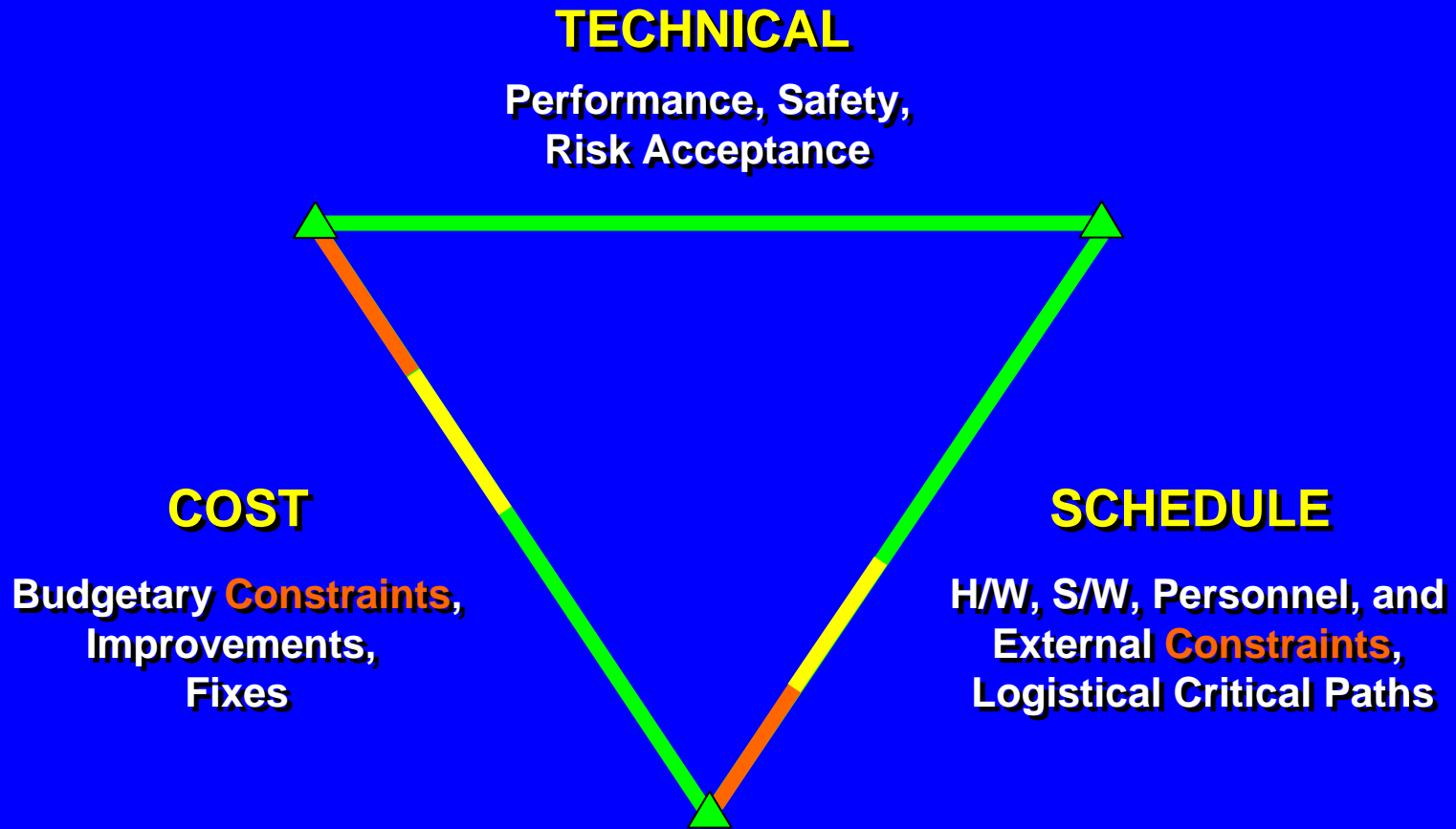
Guidance

- “Ultimately, we must balance cost, schedule and technical risk.”

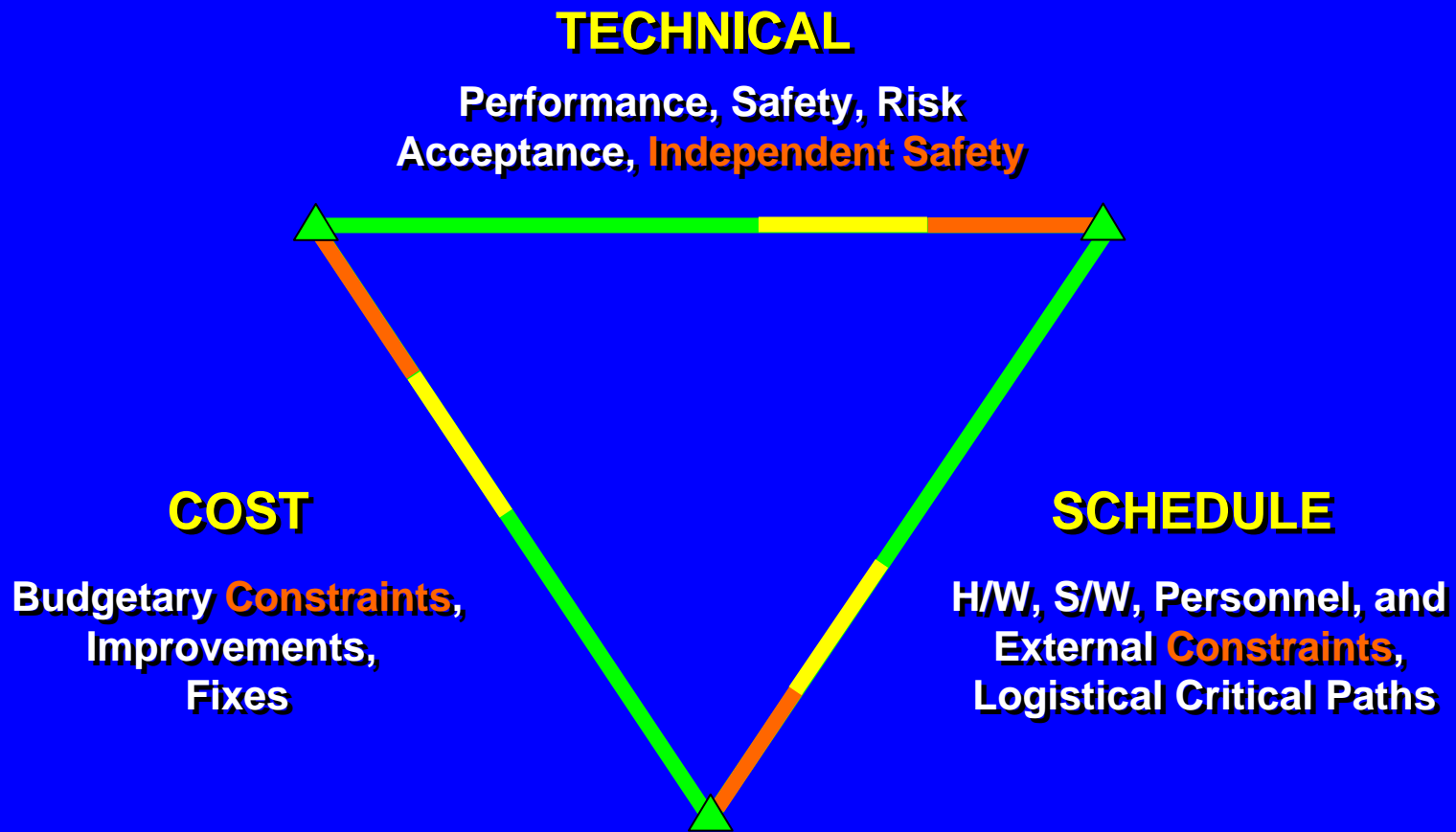
Program Decisions



Program Decisions



Program Decisions



Cultural Deficiencies

- **Schedule Pressure**

- Defer Improvements or Fixes (**Accept Risks**)
- Won't Search for Vulnerabilities (**Ignore Risks**)
- Cognitive Bias Occurs (**Underestimate Risks**)
- Human Errors Increase (**Add Risks**)
- Unsafe Behavior Encouraged (**Hide Risks**)

- **Technical Inaccuracy**

- Incomplete Information or
- Inaccurate Data or
- Invalid Logic
 - Incorrect Conclusion (**Unknown Risks**)

Environment

- **Error-Prone Conditions**
 - People
 - Parts
 - Paper
 - Planning
 - Processes

Guidance ★

- “Ultimately, we must balance cost, schedule and technical risk. When it is time to make this trade, we must have a full and in-depth understanding of the risk.”

– B. Randy Stone, Sept. 2003

Risks

- **Risk Assessment**
 - Quantitative Accuracy: Difficult or Impossible
 - Incomplete data, Complex interaction, Management Risk uncertainties
 - Qualitative Estimate: Is Possible
 - Must use expertise, judgment, intuition

Guidance ★

- “Ultimately, we must balance cost, schedule and technical risk. When it is time to make this trade, we must have a full and in-depth understanding of the risk. Only then can we apply the best possible human judgment, using proper logic, good rationale, vast experience, high values, and expect the decision to be correct.”

Accident signals

- **Every accident gives signals before it becomes an accident**
 - Anomalies
 - Words, data, or charts in meetings
 - Weak signals
 - Ephemeral signals
- **Develop senses to detect signals**

Mars Climate Orbiter

- **Spacecraft entered orbit too steeply, crashed on Mars (1999)**
 - Loss attributed to use of “Metric vs. English Units”
 - Problem was observed enroute
 - Residual navigation errors were increasing
 - More Angular Momentum Desaturation events
 - **Enroute Navigation group and Entry Guidance group failed to transfer information effectively**

Decisions

- **Information in meetings is often lost or not presented due to:**
 - “Slidesmanship” (John Schmidt)
 - Selling ideas; Biased
 - Power Point, Executive Summary
 - Required Systematic Censorship, Patterned Reduction, Simplification
 - Lack of Specialization
 - Lack of Data
- **Managers must have all the information necessary to make an informed decision**

Review of Test Data Indicates Conservatism for Tile Penetration

- The existing SOFI on tile test data used to create Crater was reviewed along with STS-87 Southwest Research data
 - Crater overpredicted penetration of tile coating significantly
 - Initial penetration to described by normal velocity
 - Varies with volume/mass of projectile (e.g., 200ft/sec for 3cu. In)
 - Significant energy is required for the softer SOFI particle to penetrate the relatively hard tile coating
 - Test results do show that it is possible at sufficient mass and velocity
 - Conversely, once tile is penetrated SOFI can cause significant damage
 - Minor variations in total energy (above penetration level) can cause significant tile damage
 - Flight condition is significantly outside of test database
 - Volume of ramp is 1920cu in vs 3 cu in for test

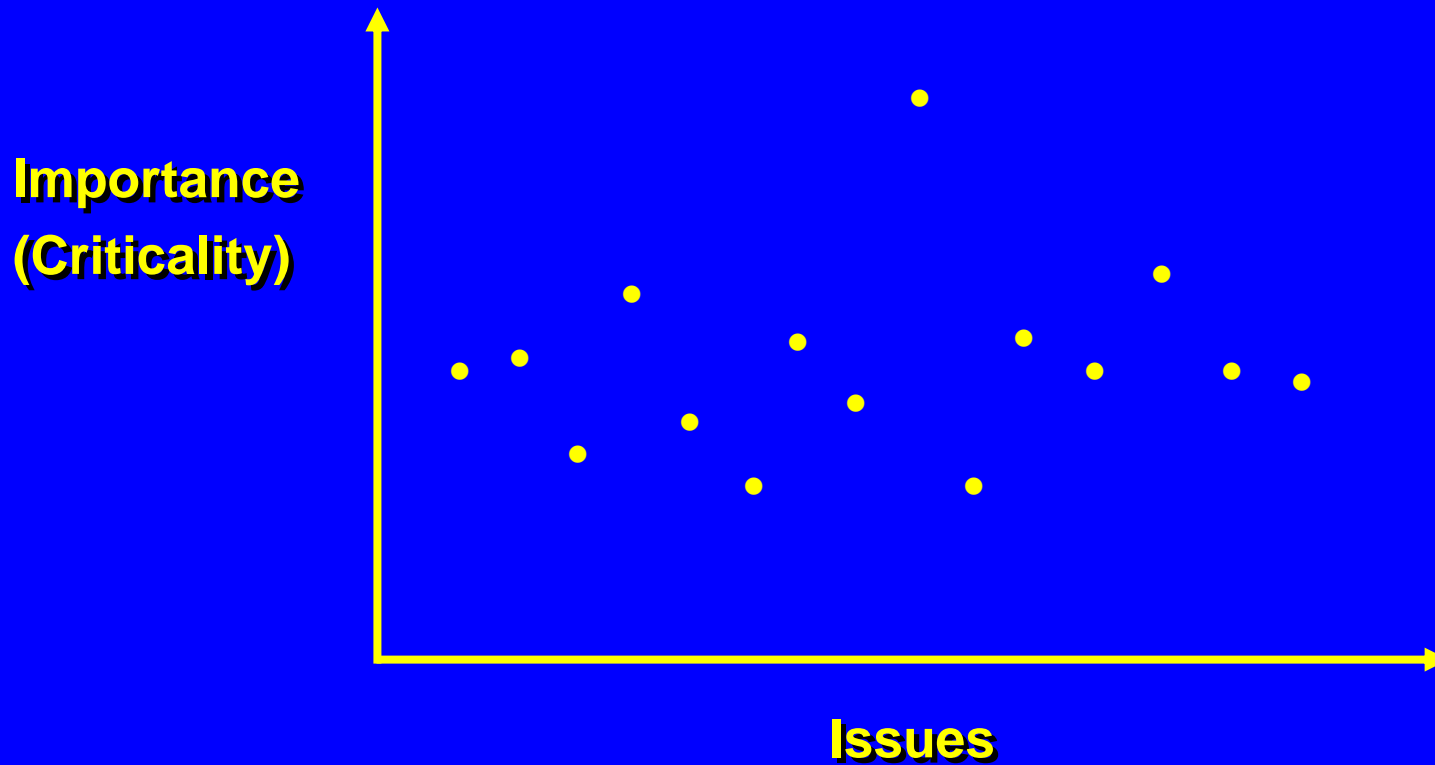
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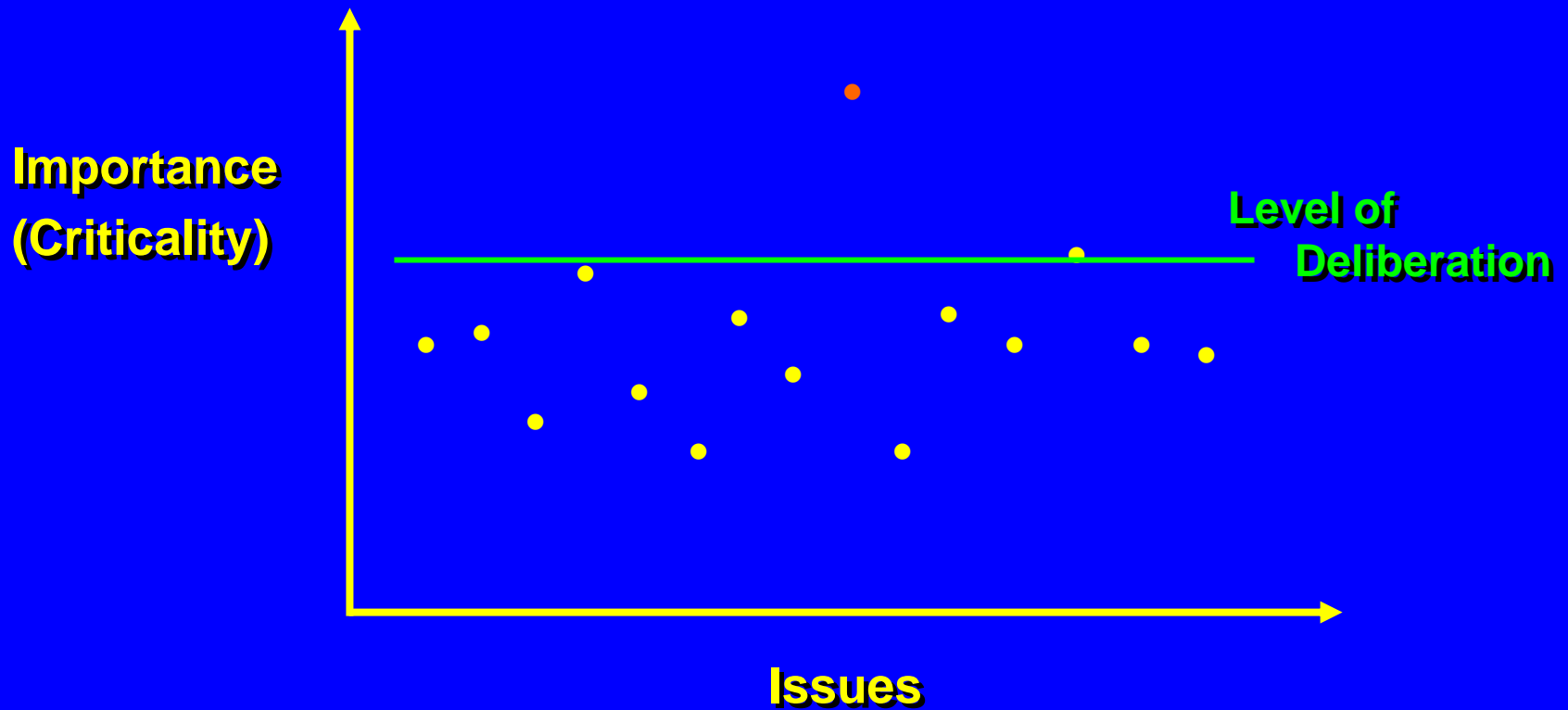
Decision-Making

- **Former Techniques (Early Space Program)**
 - **Deliberation**
 - Chalk Talk
 - No E-mail
 - Disagreements
 - **Charts**
 - 5 Chart Limit
 - Math-ades
 - No Power Point
 - **Reports**
 - Prose
 - Rationale

Management Attention



Management Attention



Booster Sep Motor FOD



- **Heat shield door impacts SRB TPS**
 - Hypalon chipped away (1.5" x 0.75")
 - Exposed BTA substrate, light sooting
 - **FOD Problem?**
 - No fracture or indentation of BTA

Guiding Principles

- **RESPECT** – Imagine how great we can become if people of this Agency are respected.
- **CANDOR** – Candor, honesty and truth can only happen if managers create an environment that encourages openness, and they encourage respect.
- **TRUST** – Listen to the experts; after inputs are provided, managers need to trust that the individuals closest to the hardware and data are competent.
- **MINDFULNESS** – Situational Awareness, Emotional Intelligence; Five Processes of High Reliability Organizations.

Cultural Enhancements

- **Situational Awareness**
 - Stay Connected to Operations, Learn, Gather Data, Communicate, Lead and Manage
- **Environment**
 - Create an Environment that allows people to elevate Concerns or Dissenting Opinions without feeling threatened
- **Effective Decisions**
 - Ensure Proper Logic, Technical Accuracy, Document Rationale, Eliminate Negative Effects of Schedule Pressure and Cognitive Bias, Preserve Values then Accept Necessary Risks

Guidance ★

- “Ultimately, we must balance cost, schedule and technical risk. When it is time to make this trade, we must have a full and in-depth understanding of the risk. Only then can we apply the best possible human judgment, using proper logic, good rationale, vast experience, high values, and expect the decision to be correct.”

Cultural Enhancements

- **Effective Decisions**

- **1. Engineering Data (Objective)**

- IQ, Education, Engineering, Numbers, Logical Analysis, Rigorous Thinking, Left-Brain

- **2. Human Values (Subjective)**

- EQ, Emotional Intelligence, Social Skills, Interpersonal Relationships, Intuition, Respect, Inner Voice, Non-Linear Thinking, Right-Brain

Cultural Enhancements

- **Effective Decisions**

- Will yield:

- Lowest cost,
 - Fastest possible,
 - With no accidents

**(The most correct balance between Cost,
Schedule and Technical)**

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