

Culture

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Establishing and managing cultures, values, and behaviors is a critical aspect of systems engineering, especially in the context of deploying SE within an organization (Fasser and Brettner 2002). The Columbia Accident Investigation Report (NASA 2003, 101), defines *culture* as “*the basic values, norms, beliefs, and practices that characterize the functioning of a particular institution.*”

Stable safety and process cultures are key to effective SE, and can be damaged by an overly-rapid pace of change, a high degree of churn (see the Nimrod Crash Report, Haddon-Cave 2009), or by change that engineers perceive as arbitrarily imposed by management (see Challenger, discussed below). On the other hand, a highly competitive, adversarial or “blame” culture can impede the free flow of information and disrupt synergies in the workplace.

In the multi-national, multi-business, multi-discipline collaborative projects becoming increasingly prevalent in SE, these factors take on greater importance.

Effective handling of cultural issues is a major factor in the success or failure of SE endeavors.

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Systems Thinking and the Culture of the Learning Organization

Improving SE efficiency and effectiveness can be the goal of culture change. This kind of culture change encourages people to learn to think and act in terms of systems, organizations and their enterprises; and, to take a systems approach as described in Overview of Systems Approaches in Part 2, and by Lawson (2010). See the knowledge area Systems Thinking.

Attaining a *learning organization* culture can be another goal of cultural change. And once the learning organization exists, cultural change in general becomes easier to accomplish.

A learning organization aims to absorb, diffuse, generate, and exploit knowledge (Sprenger and Have 1996). Organizations need to manage formal information and facilitate the growth and exploitation of tacit knowledge. They should learn from experience and create a form of *corporate memory* - including process, problem domain and solution space knowledge, and information about existing products and services. Fassner and Brettner (2002, 122-124) suggest that *shared mental models* are a key aspect of corporate knowledge and culture.

A learning organization culture is enabled by disciplines such as:

- **personal mastery**, where a person continually clarifies and deepens personal vision, focuses energy upon it and develops patience in seeking it so as to view reality in an increasingly objective way;
- **mental models**, where people appreciate that mental models do indeed occupy their minds and shape their actions;
- **shared vision**, where operating values and sense of purpose are shared to establish a basic level of mutuality; and
- **team learning**, where people's thoughts align, creating a feeling that the team as a whole achieves something greater than the sum of what is achieved by its individual members.

Systems thinking supports these four disciplines, and in so doing becomes the **fifth discipline** and plays a critical role in promoting the learning organization (Senge et al. 1994).

Cultural Shortfalls and How to Change Them

Cultural shortfalls that are injurious to a system are described as negative paradigms by Jackson (2010) and others. For example, a cultural reluctance to identify true risks is the hallmark of the **Risk Denial** paradigm as seen in the Challenger and Columbia cases. When individuals believe a system is safe that is in fact unsafe, that is the **Titanic Effect** paradigm, which is of course named for the ocean liner catastrophe of 1912.

Approaches to Change

Jackson and Erlick (Jackson 2010, 91-119) have found that there is a lack of evidence that a culture can be changed from a success point of view. However, they do suggest the Community of Practice (Jackson 2010, 110-112), an approach founded on the principles of organizational psychology, and discuss the pros and cons of other approaches to culture change, including training, coaching, Socratic teaching, use of teams, independent reviews, standard processes, rewards and incentives, use of cost and schedule margins, reliance on a charismatic executive, and management selection. Shields (2006) provides a similarly comprehensive review.

The Columbia Accident (NASA 2003) and the Triangle fire (NYFIC 1912) official reports, among many others, call for cultural issues to be addressed through improved leadership, usually augmented by the more objective approach of auditing. One form of auditing is the Independent Technical Authority, which:

- is separate from the program organization;
- addresses only technical issues, not managerial ones; and
- has the right to take action to avoid failure, including by vetoing launch decisions.

An Independent Technical Authority cannot report to the program manager of the program in question, and it may be formulated within an entirely separate business or enterprise which can view that program objectively. The point of these stipulations is to ensure that the Independent Technical Authority is indeed independent.

Management and leadership experts have identified ways to lead cultural change in organizations, apart from specifically safety-related cultural change. For example, Gordon (1961) in his work on the use of analogical reasoning called synectics is one of several who emphasize creative thinking. Kotter (1995) advocates a series of steps to transform an organization.

How Culture Manifests in Individuals and Groups

As a community's physical, social, and religious environment changes over the generations, cultural beliefs, values, and customs evolve in response, albeit at a slower pace.

Helmreich and Merritt describe the effects of cultural factors in the context of aviation safety and suggest implications for safety cultures in other domains such as medicine. See (Helmreich and Merritt, 2000) and other writings by the same authors.

We can describe the cultural orientation of an individual in terms of:

- national and/or ethnic culture;
- professional culture; and
- organizational culture.

Some particulars of these aspects of culture are

sketched below.

National and/or Ethnic Culture

A product of factors such as heritage, history, religion, language, climate, population density, availability of resources, politics, and national culture is acquired in one's formative years and is difficult to change. National culture affects attitudes, behavior, and interactions with others.

National culture may help determine how a person handles or reacts to:

- rules and regulations;
- uncertainty; and
- display of emotion, including one's own.

National culture may also play a role in whether a person

- communicates in a direct and specific style, or the opposite;
- provides leadership in a hierarchical manner, or a consultative one; and
- accepts decisions handed down in superior-inferior relationships, or questions them.

Professional Culture

Professional culture acts as an overlay to ethnic or national culture, and usually manifests in a sense of community and in bonding based on a common identity (Helmreich and Merritt 2000). Well-known examples of professional cultures include those of medical doctors, airline pilots, teachers, and the military.

Elements of professional culture may include:

- a shared professional jargon
- binding norms for behavior
- common ethical values
- self-regulation
- barriers to entry such as selectivity, competition and training
- institutional and/or individual resistance to change
- prestige and status, sometimes expressed in badges

or uniforms

- stereotyped notions about members of the profession, in general and/or based on gender

Particularly important elements of professional culture (for example, those that affect safety or survivability) need to be inculcated by extensive training and reinforced at appropriate intervals.

Organizational Culture

An organization's culture builds up cumulatively, determined by factors like its leadership, products and services, relationships with competitors, and role in society.

Compared with one another, organizational cultures are not standardized because what works in one organization seldom works in another. Even so, strength in the following elements normally engenders a strong organizational culture:

- corporate identity;
- leadership;
- morale and trust;
- teamwork and cooperation;
- job security;
- professional development and training;
- empowerment of individuals; and
- confidence, for example in quality and safety practices, or in management communication and feedback.

When the culture of the people in an organization is considered as a whole, organizational culture acts as a common layer shared by all. Despite this, differing national cultures can produce differences in leadership styles, manager-subordinate relationships, and so on, especially in organizations with a high degree of multinational integration.

Because organizations have formal hierarchies of responsibility and authority, organizational culture is more amenable to carefully planned change than are either professional or national cultures. If changes are made in a manner that is sympathetic to local culture (as opposed to that of a distant group head office, for example), they can bring significant performance

benefits. This is because organizational culture channels the effects of national and professional cultures into standard working practices.

There are many definitions of culture in the literature. The Columbia Accident Investigation Board (NASA 2003) provides a useful definition for understanding culture and engineering.

Culture and Safety

Reason (1997, 191-220) describes a culture which focuses on safety as having four components:

1. A reporting culture which encourages individuals to report errors and near misses, including their own.
2. A just culture which provides *an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information.*
3. A flexible culture which abandons the traditional hierarchical reporting structure in favor of more direct team-to-team communications.
4. A learning culture which is willing to draw the right conclusions from safety-related information and to implement reforms when necessary.

Weick and Sutcliffe (2001, 3) introduce the term high reliability organizations (HROs). HROs have *fewer than their fair share of accidents* despite operating *under trying conditions* in domains subject to catastrophic events. Examples include *power grid dispatching centers, air traffic control systems, nuclear aircraft carriers, nuclear power generation plants, hospital emergency departments, and hostage negotiation teams.* There are five hallmarks of HROs (Weick and Sutcliffe 2001, 10):

1. **Preoccupation with Failure**—HROs eschew complacency, learn from near misses, and do not ignore errors, large or small.
2. **Reluctance to Simplify Interpretations**—HROs simplify less and see more. They “encourage skepticism towards received wisdom.”
3. **Sensitivity to Operations**—HROs strive to detect “latent failures,” defined by James Reason (1997) as systemic deficiencies that amount to accidents waiting to happen. They have well-developed situational awareness and make continuous

adjustments to keep errors from accumulating and enlarging.

4. **Commitment to Resilience**—HROs keep errors small and improvise “workarounds that keep the system functioning.” They have a deep understanding of technology and constantly consider worst case scenarios in order to make corrections.
5. **Deference to Expertise**—HROs “push decision making down.” Decisions are made “on the front line.” They avoid rigid hierarchies and go directly to the person with the expertise.

The US Nuclear Regulatory Agency (2011) focuses mainly on leadership and individual authority in its policy statement on safety culture.

Historical Catastrophes and Safety Culture

The cases described in the table below are some of the many in which official reports or authoritative experts cited culture as a factor in the catastrophic failure of the systems involved.

Table 1. Examples of Culture Discussion in Safety Critical Incidents. (SEBoK Original)

Example	Cultural Discussion
Apollo	According to Feynman (1988), Apollo was a successful program because of its culture of “ <i>common interest</i> .” The “ <i>loss of common interest</i> ” over the next 20 years then caused “ <i>the deterioration in cooperation, which . . . produced a calamity.</i> ”
Challenger	Vaughn (1997) states that rather than taking risks seriously, NASA simply ignored them by calling them normal—what she terms “ <i>normalization of deviance</i> ,” whose result was that “ <i>flying with acceptable risks was normative in NASA culture.</i> ”
Columbia	The Columbia Accident Investigation Report (NASA 2003, 102) echoed Feynman’s view and declared that NASA had a “ <i>broken safety culture.</i> ” The board concluded that NASA had become a culture in which bureaucratic procedures took precedence over technical excellence.

Texas City - 2005	On August 3, 2005, a process accident occurred at the BP refinery in a Texas City refinery in the USA resulting in 19 deaths and more than 170 injuries. The Independent Safety Review Panel (2007) found that a corporate safety culture existed that <i>“has not provided effective process safety leadership and has not adequately established process safety as a core value across all its five U.S. refineries.”</i> The report recommended <i>“an independent auditing function.”</i>
The Triangle Fire	On August 11, 1911, a fire at the Triangle shirtwaist factory in New York City killed 145 people, mostly women (NYFIC 1912). The New York Factory Investigating Commission castigated the property owners for their lack of understanding of the <i>“human factors”</i> in the case and called for the establishment of standards to address this deficiency.
Nimrod	On September 2, 2006, a Nimrod British military aircraft caught fire and crashed, killing its entire crew of 14. The Haddon-Cave report (Haddon-Cave 2009) found that Royal Air Force culture had come to value staying within budget over airworthiness. Referencing the conclusions of the Columbia Accident Investigation Report, the Haddon-Cave report recommends creation of a system of detailed audits.

Relationship to Ethics

A business's culture has the potential to reinforce or undermine ethical behavior. For example, a culture that encourages open and transparent decision making and behavior makes it harder for unethical behavior to go undetected. The many differences in culture around the world are reflected in different perspectives on what ethical behavior is. This is often reflected in difficulties that international companies face when doing business globally, sometimes leading to scandals because behavior that is considered ethical in one country may be considered unethical in another. See Ethical Behavior for more information about this.

Implications for Systems Engineering

As SE increasingly seeks to work across national, ethnic, and organizational boundaries, systems engineers need to be aware of cultural issues and how they affect expectations and behavior in collaborative working

environments. SEs need to present information in an order and a manner suited to the culture and personal style of the audience. This entails choices like whether to start with principles or practical examples, levels of abstraction or use cases, the big picture or the detailed view.

Sensitivity to cultural issues is a success factor in SE endeavors (Siemieniuch and Sinclair 2006).

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