*Article*

# Improving Decisions to Mitigate the Risks of Organizational Accidents

**Scott Jackson** [1] and **Avi Harel** [2]

[1] Burnham Systems; jackson@burnhamsystems.net
* Correspondence: jackson@burnhamsystems.net; Tel.: +01-949-726-2003
[2] Ergolight; ergolight@gmail.com; Tel: +972-54-453-4501

**Abstract:** This paper examines cognitive biases which affect the ability of decision makers to make rational decisions in an organizational context. The motivation for this analysis begins with the observation of catastrophic accidents caused by human error but in an organizational context. This paper expands on the concept of cognitive bias to define organizational biases which are the factors that affect decisions in an organizational context. The paper distinguishes between organizational biases, which are the focus of this paper, and individual biases, which are biases experienced by individuals but may have organizational consequences. **The purpose of this paper is to identify methods to mitigate the risks of organizational accidents, accidents which involve many people operating at different levels of an organization.** The methodology is to identify those decisions that would address the specific organizational biases. The focus of this paper is the decisions for mitigating the risks associated with decisions in an organizational context. Results are shown for seven organizational biases, six specific case studies, and four decision options. This paper concludes that organizational biases are intrinsically different from individual biases and that these differences lead to different decision options from those that mitigate individual biases; however, they may exist concurrently.

**Keywords:** cognitive bias; organizational bias; decision options; risk; catastrophic, organizational accidents; human error; hierarchy; culture; policy; procedures

## 1. Introduction

This paper examines accidents that occur in an organizational context, the biases that may contribute to those accidents, and the organizational characteristics that may contribute to those biases. These biases are an extension of the individual cognitive biases identified by Kahneman [1] and Thaler [2]. This paper is also an extension of previous work by the author in [3] and [4]. Section 1 summarizes past work pertaining to the concepts of biases, rationality, and organizational accidents. Section 1 also discusses areas of disagreement regarding the concept of cognitive biases. Section 2 introduces and defines the concept of organizational biases and explains how they differ from individual biases. Section 3 presents case studies which illustrate the effects of organizational biases. Section 4 identifies options that have the potential for improving decisions in the face of organizational biases.

### 1.1 Organizational accidents

Reason [5] (p. 1) states that an organizational accident is different from an individual accident. He says that organizational accident as accidents that occur in an organizational context. He says that an individual accident is one in which a specific "individual person or group is often both the agent and

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victim of the accident." An organizational accident, on the other hand, is an accident with "multiple causes involving many people at different levels of a company." A hierarchical structure is an example characteristic of an organization that may contribute to organizational accidents. The organization's culture is another characteristic.

### 1.2 Cognitive bias and irrational decisions

Accidents can be caused by irrational decisions at both the individual and organizational level. The root cause of irrational decisions is called *cognitive bias* as defined by Chegg [6] as "a mistake in reasoning, evaluating, remembering, or other cognitive process, often occurring as a result of holding onto one's preferences and beliefs regardless of contrary information." Wikipedia [7] has compiled an extensive list of cognitive biases from various sources. Most of the cognitive biases listed in the literature qualify as individual biases since they are biases experienced by individuals. One of the more well known individual biases is the *confirmation bias* which according to Wikipedia [7] is "the tendency to search for, interpret, focus on and remember information in a way that confirms one's preconceptions." This bias, and others, may have organizational consequences, but the focus of this paper is on biases that have an organizational origin.

Some researchers have noted that in some instances biases may be beneficial. For example, Haselton *et al* [8] state that biases enable "selection may favor useful short-cuts that tend to work in most circumstances." Nevertheless, the focus of this paper is on biases that have been shown to degrade the ability of a decision-maker to make decisions in an organizational context and have been a factor in major catastrophes.

Other researchers for example Soll *et al* [9] have observed that there are two methods of reducing bias: modify the person or modify the environment. These two methods are compatible with the biases discussed in this paper. Modifying the person, for example, pertains to internal biases, that is individual biases. Modifying the environment, in this paper, has to do with modifying the organization which is the root of the organizational biases, the subject of this paper. Hence, for the purpose of this paper, the organization is the environment of interest. These categories, in particular modifying the environment, allow us to focus on the organizational biases.

In the end this paper concludes that organizational biases are intrinsically different from individual biases and that these differences lead to different decision options from those that mitigate individual biases. It also concludes that implementation of these decisions is dependent on whether the organization is overseen by an outside authority or is an independent enterprise.

### 1.3 Rationality

The definition by Webster [10] of rationality is "the quality of being based on or in accordance with reason or logic." In the context of economics and decisions, according to Kahneman [1] (pp. 411-412) "rationality is logical coherence, reasonable or not." In general a decision is often called rational if it is supported by explicit data. This paper pertains to decisions that can be irrational, that is, they are supported by data which may be ignored or biased by other factors such as stress or organizational characteristics.

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### 1.4 Decisions

Most literature on decision analysis assumes that decisions are rational and objective. The International Council on Systems Engineering (INCOSE) handbook [11] (p. 110) states that the purpose of the Decision Management process is to

> Provide a structured analytical framework for *objectively* (italics added) identifying, characterizing, and evaluating a set of alternatives for a decision at any point in the life cycle and select the most beneficial course of action

There is no discussion of decisions that are not made objectively or what the risks might be if they were not objective or why they may not be objective. Of course objective decisions are always the goal, but whether this can be achieved depends on the degree of bias either individual or organizational.

The Nobel committee awarded both Kahneman and Thaler the Nobel prize for their findings and for their studies related to cognitive bias and nudges. Thaler [2] defines a nudge as any aspect of a choice architecture that alters people's behavior in a predictable way without significantly changing their economic incentives." This paper simply uses the term decision option for nudge. Kahneman also recognizes the contributions of Amos Tversky who passed away before Kahneman's prize was awarded. Most, but not all, of the biases studied by Kahneman and Thaler are individual biases.

### 1.5 Areas of disagreement

The findings relative to cognitive bias have not been without their disagreements. These disagreements fall into three categories:

- Smart people do not suffer from cognitive bias and do not make bad decisions. According to Lewis [12] (p. 318) a critic of Kahneman and Tversky stated, "I am not interested in studying the psychology of stupid people." Kahneman and Tversky did not see their work that way. According to Lewis, "their very first experiments, dramatizing the weakness of people's statistical intuitions, had been conducted on professional statisticians." Kahneman [1] (p.430) states "Experienced researchers are also prone to the same biases when they think intuitively." Kahneman [1] (p. 49) quotes Stanovich as saying that "high intelligence does not make one immune to biases."
- People will always make good decisions if they think about them. To address this disagreement Kahneman [1] defines with two modes of thinking, fast and slow. Kahneman calls these two modes System 1 and System 2 (pp. 20-21). Fast thinking is when a person makes a decision based primarily on intuition. People, even smart people, make these decisions automatically. Slow thinking is based on thought and analysis. However, slow thinking does not always result in non-biased decisions. On the contrary, Kahneman [1] (p. 415) states that slow thinking may even reinforce the biases that were present in fast decisions. Sunstein [13] states that "System 2 can and does err, but System 1 is distinctly associated with identifiable behavioral biases."

  Three conclusions can be reached: First, decisions can be called rational if they are based on explicit data. Decisions are called proper or rational if they are supported by explicit data. Second, decisions based on intuition (System 1) are not necessarily bad decisions. It depends on

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the circumstances and the decision maker's knowledge of the issue involved. Third, decisions based on slow thinking (System 2) are not necessarily better than intuitive decisions.

- People will make good decisions if they are important enough. Thaler and Sunstein [2] (p. 76) state that "there is little evidence that performance improves when stakes go up." For example, the biases that may contribute to buying a car may also apply to the irrational decisions pertaining to a space system launch.

In summary, Kahneman according to Lewis [12] and Thaler and Sunstein [2] have refuted all three assertions with experimental proof.

In addition to the disagreements listed above, Evans [14] (p. 93) says that "Kahneman and Tversky were subject to many attacks for apparently demonstrating or claiming that human beings are irrational." One critic "believed that their experiments were unrepresentative or misleading." Nevertheless, Evans [14] (p. 3) himself states that "many mistakes are due to one or more cognitive biases." Thus, the weight of history is on the side of Kahneman, Thaler, and Tversky.

## 2. Results of organizational bias analysis

The focus of the paper is on organizational biases which this paper defines as being factors beyond the well documented individual biases that may lead to irrational decisions and possibly catastrophic consequences.

### 2.1 Definition of organizational bias

Organizational biases are those biases that are dependent on specific characteristics of an organization. Typical characteristics include a hierarchical structure, the presence of many people who may be either the genesis of the biases or the victims, and the culture of the organization. These biases will be present and exacerbate any individual biases of the decision maker.

Frequently encountered organizational biases are the *rankism* bias, the *culture* bias, the *protocol rules* bias, the *groupthink* bias, the *loss aversion* bias, the *accountability* bias, and the *responsibility* bias. Murata et al [15] discuss many of these biases including the *confirmation* bias, the *groupthink* bias and the *loss aversion* bias. These include both individual and organizational biases as currently defined. Figure 1 is a hierarchical view of how organizational biases contribute to cognitive biases. This figure shows that both individual biases and organizational biases are part of cognitive biases. The following paragraphs discuss the individual and organizational biases.

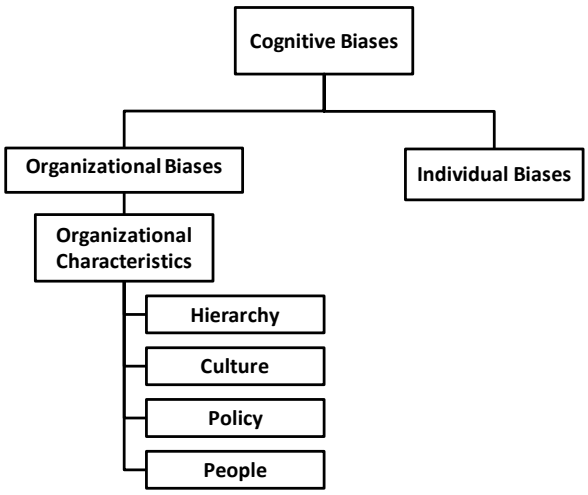


Figure 1 This figure illustrates how organizational biases and individual biases are constituent parts of cognitive biases.

### 2.2 How organizational bias differs from individual bias

It is impossible to separate organizational biases completely from individual biases

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since leaders may suffer from individual biases which may affect their decisions which may have organizational consequences.

Although organizational bias itself is anindividual bias in the sense that it is a reflection of the mental state of the decision maker, it is organizational in the sense that it is influenced by the characteristics of the organization, its structure, and its culture.

### 2.3 Aspects of organizational properties that contribute to organizational bias

The aspects of organizations that give rise to biases include the organization's structure, primarily hierarchical, the presence of many people in the organization, its culture, and the policies documented within the organization.

### 2.4 Summary of organizational biases

The organizational biases discussed below are those biases that occur in an organizational context and are stimulated by the characteristics of the organization.

#### 2.4.1 The *rankism* bias

*Rankism* is a key topic in an organizational context and is described by Fuller [16]. Rankism can be described as the mental attitude of people in positions of authority who assume that their decisions are superior to persons of lower organizational rank. The *rankism* bias is therefore influenced by the hierarchical characteristic of most organizations.

#### 2.4.2 The *culture* bias

The Columbia Accident Investigation Report [17] (p. 184) states, for example, that there was a "broken safety culture" at NASA. Regarding the Challenger disaster, Vaughn [18] (p. 190) that there was a culture of "normative risks", that is to say, that no particular attention was given to risks. There is no implication in the *culture* bias pertains to any ethnic culture but rather to the culture of the organization.

Reason [5] emphasizes the importance of a safety culture which he defines as "shared values (what is important) and beliefs (how things work) that interact with an organization's structures and control systems to produce behavioral norms (the way we do things around here)." Hence it can be inferred that the *Columbia* and *Challenger* organizations did not have these shred values and beliefs. It can also be inferred that the "broken safety culture" existed at all level of the organization in accordance with the hierarchical structure.

Jackson [19] (pp. 91-119) examines the cultural factors that may result in faulty decisions.

#### 2.4.3 The *groupthink* bias

The *groupthink* bias can be considered to be an integral part of the *culture* bias. According to Murata et al [15] *groupthink* is characterized by "overestimation of the group, closed mindedness and pressure toward conformity." The *groupthink* bias is particularly applicable to large organizations and therefore tends to exacerbate the probability of catastrophe in an organizational context.

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#### 2.4.4 The *protocol rules* bias

This bias occurs when a protocol takes precedence over a common-sense opportunity to prevent a catastrophe. The United 93 incident described in the 9/11 Commission report [20] (p. 11) is an example. Most large organizations have written protocols.

#### 2.4.5 The *responsibility* bias

According to Madigan [21] the *responsibility* bias is the tendency to exaggerate one's own contributions and minimize the contributions of others. This is, by definition an organizational bias since multiple persons are involved. Wikipedia [7] also lists the *egocentric* bias which is essentially the same as the *responsibility* bias.

#### 2.4.6 The *accountability* bias

According to Dekker [22] (pp. 91-103), this is the refusal to take responsibility for accidents. This bias qualifies as an organizational bias since the decision maker is blaming others for a lack of responsibility.

#### 2.4.7 The *loss aversion* bias

A bias described by Kahneman [1] (p. 302) is *loss aversion*. The concept is that decision makers fear losses more than the possibility of gains. If that is the case, then why do they make decisions with a high probability of failure? One possibility is that they fear disapproval of organizational superiors. Another possibility is that they do not have a sufficient appreciation of the probability of failure. Therefore, this is an organizational bias since organizational superiors are involved.

## 3 Results for Case studies

The following cases are examples of catastrophes in which organizational bias was a factor.

### 3.1 *Challenger*

The trigger physical cause of the *Challenger* accident was the failure of the O-rings. However, cultural factors were more serious and constituted the root cause of the accident. The philosophy of the "normalization of deviance" prevailed on *Challenger* as documented by Vaughn [18] (p. 190). Hence, *Challenger* stands as an example of the *culture* bias. This bias could only exist in an organizational context since, by definition culture is organizational.

### 3.2 *Columbia*

*Columbia* is a well-documented event by NASA [17] for which the causes are known and an approach recommended. The trigger physical cause was a debris strike as described by NASA [17] (p. 34). However, deeper analysis shows that the root cause was more cultural than technical. NASA [17] (pp. 99-120) shows that the same flawed practices that dogged *Challenger* were still present on *Columbia*.

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The Columbia Accident Investigation Board (CAIB) NASA [17] (p. 184) states that NASA had a "broken safety culture". So we can say that that is the organizational bias right there and one that is clearly organizationally focused. This is an example of the *culture* bias.

### 3.3 Tenerife

This accident occurred between two 747s on the island of Tenerife in the Atlantic. One aircraft was already in motion for takeoff, and the other was in the hold mode waiting to take off, but the Air Traffic Control (ATC) had not given the clearance. The second aircraft took off prematurely resulting in a collision and the loss of all occupants. This was the largest commercial aircraft accident in history from the point of view of fatalities in which 585 persons died. McCreary *et al* [23] provide a detailed account of this accident from a human factors perspective.

This was an organizational accident with the *rankism* bias from two perspectives. First, there was *rankism* between the pilot and the co-pilot. Secondly, there was *rankism* between the pilot and the company (KLM). With respect to the pilot and the co-pilot, there is evidence that the co-pilot attempted to warn the pilot not to take off prematurely. The pilot simply ignored any signals from the co-pilot due to the pilot's rank; that is to say, he was in charge of the airplane and could make whatever decisions he wanted. Secondly, with regard to the KLM policies there is evidence that the pilot was motivated to take off prematurely because of company mandated deadlines.

The airline company at the time of the Tenerife disaster had a culture in which *rankism* prevailed. In addition the company had policies that motivated pilots to hurry back to the headquarters. Hence, this is an example of a *policy* bias.

### 3.4 Honda Point

According to the web site [24] the Honda Point disaster occurred on 8 September 1923 off the coast of California. Seven US Navy ships were grounded and 23 sailors died. The commanding officer ignored navigational information and ordered the ships into a dangerous route. Other captains followed the orders even though they knew of the navigational errors. Thus, they were suffering from the *groupthink* bias.

The military concept that all ships should follow the lead ship may have contributed to this event. Thus the *protocol rules* bias may have been a factor also.

### 3.5 Bhopal

The largest industrial disaster in history occurred in Bhopal, India on 2-3 December of 1984. According to Reason [5] (p. 89), at least 2500 died and many others were injured when water was incorrectly spilled into a methyl isocyanate tank.

Causes were identified as botched decision making and poor maintenance. This disaster falls into the *culture* bias category.

### 3.6 Deepwater Horizon

The basic characteristic of this system was that it was a multi-layer system with BP at the top and Deepwater Horizon as a supplier. Friction within the company became apparent when the BP CEO blamed Deepwater Horizon for the tragedy. So did BP develop safety standards and flow them down

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to DH? This is not known; however general systems principles would assert that BP owns the entire system and was therefore responsible. The courts later found BP responsible. So this problem would also have roots in *rankism*, this case the assertion that the top level system could hold the lower level system responsible. This disaster is described by Britannica [25].

This is also a *responsibility* and an *accountability* bias, that is the reluctance to take responsibility for one's actions. The primary organizational property that contributed to the Deepwater Horizon disaster was the hierarchical nature of the BP system and the lack of communication and division of responsibility between them.

### 3.7 United 93

According to the 9/11 Commission report [20] (p. 11), the FAA failed to notify the pilots of this aircraft that there was a possibility of terrorists on board. The FAA claimed that it was not their responsibility to contact the pilots but rather the airline. The result was that valuable time was lost, the terrorists attacked, and all on board were lost. The Commission stated that the FAA did not understand their responsibility.

This is an example of the *protocol rules* bias. This bias states that when a person in either an individual situation or an organizational situation has a decision between following an existing protocol or making a wiser decision, will follow the protocol.

### 3.8 Korean Airlines Flight 801

According to the NTSB report [26] a Korean Airlines 747-300 crashed into a hill in Guam on 6 August 1997 killing 228 of the 254 persons on board. The primary cause of the crash according to the NTSB [26] was the captain's failure properly to execute the approach. However, FlightGlobal [27] cites this disaster as an example of a cockpit with personnel with a former military experience in which "a command and control culture that discourages subordinates from questioning superiors." This statement describes the *rankism* bias as described in this paper. Hence both the *culture* bias and the *rankism* bias were factors in this accident.

### 3.9 Asiana Flight 214

According to the NTSB [28] Asiana Flight 214, a Boeing 777-200ER, crashed into a seawall upon attempting a landing at San Francisco airport on 6 July 2013. Like Korean Airlines the report focuses on the lack of cockpit communication as being the primary cause of the crash. In post-accident interviews the PF (pilot flying) admitted that he was unfamiliar with the procedure for landing without glideslope guidance. He was reluctant to admit this to the PM (pilot monitoring). This is an indication of the *rankism* bias that was part of the airline culture of this aircraft.

## 4 Results for decision options in an organizational context

Either an organization leader, such as a CEO, decision options or the organizational policies will drive the decision options. Individuals may make decisions that are organizational in nature, but the decision choices themselves will depend on the organizational biases that generated the risks that need to be mitigated. In addition, the individual biases that may have existed concurrently need to be mitigated. Kahneman [1] and Thaler [2] give many examples of how this can be done.

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### 4.1 Goal of decision options

Decision options in an organizational context pertain to those biases that are influenced by the characteristics of the organization. Decision options for individual biases identified by Kahneman [1] and Thaler [2] may also be beneficial in an organizational context.

There is no assertation that organizational decisions will prevent disasters; therefore, decisions are not solutions. There is only the goal of identifying decisions that will influence the leader to make better, less risky, decisions. A better decision may result in the avoidance of the disaster completely, or it may result in reduced consequences.

### 4.2 Definition of decision architecture in an organizational context

Decision options pertain to the decisions that a leader might make in an organizational context.

### 4.3 How decisions in an organizational context differ from decisions in an individual context

Decisions in an organizational context pertain to all the organizational structural and procedural options that may influence the decisions of the organization leader, for example, a program manager or a CEO. Decisions in an individual context only pertain to the decisions made by an individual, such as the leader. These individual decisions may also influence the decisions of the leader, but the focus of this paper is on organizational decisions which may exist concurrently with individual biases.

### 4.4 Importance of *libertarian paternalism* in an organizational context

Thaler's concept of *libertarian paternalism* is important in an organizational context. This concept says that someone either the leader in our case or the individual in individual cases will make the final decision, whatever that decision may be. However, *libertarian paternalism* does not mean that decision will always be correct, that is, that it will prevent a catastrophe. It only says that the leader will be influenced to make a decision that is better than the one he would have made if the options had not been exercised. These decisions will be influenced by both individual biases and organizational biases.

### 4.5 Summary of decisions in an organizational context

The decision options below are initial judgments that might apply to the case studies in this paper. There is no claim that this list is exhaustive. Other decisions may be appropriate.

#### 4.5.1 Independent review

The only approach recommended by the CAIB in he *Columbia* case is the Independent Technical Authority (ITA) described by NASA [17] (p. 227). There is no indication that the CAIB intended that the ITA would have veto power over the program leader for decisions such as launch or delay launch. Hence it can be assumed that this approach complies with the *libertarian paternalism* policy. So the ITA merely influences the decision; it does not override it.

The organizational property that influenced this decision option is the broken safety culture which led the CAIB to mistrust the decision process on the program

#### 4.5.2 Pre-mortem

The pre-mortem is a decision option suggested by Kahneman [1] (pp. 264-265). The pre-mortem consists of organizing a group of individuals who can identify the potential negative aspects of any decision.

The pre-mortem is not mentioned by the CAIB. This decision option is not significantly different from the ITA except that the pre-mortem would be internal to the program rather than external. The post-mortem decision would also apply to the Honda Point disaster.

#### 4.5.3 Policy change

Both biases in the Tenerife case could be addressed to some extent by a change in company policies. First, in the Tenerife case there must be a policy to force the pilot to comply with warnings from the co-pilot. Secondly, the company must remove any policies that would force the pilot to take off prematurely. There may be other approaches more appropriate to the individual biases.

A second policy change would be to remove the authority of rank which the captain asserted.

In the Honda Point case the most obvious approaches to this problem are changes in official actions documented in Navy manuals.

In the Korean Airlines Flight 801 case the airline instituted improvements in their crew management system (CMS) to comply with new policies directed at improved communications.

In general, policy change decisions should focus on specific reporting responsibilities and actions and should avoid vague statements.

#### 4.5.4 Protocol change

The obvious approach to the United 93 problem described by the 9/11 Commission report [20] (p. 11) is to change the protocol with the outside influence of the 9/11 Commission. In subsequent communications the FAA has declined to state whether their protocols have been changed. In addition to a specific protocol a policy change would be necessary to require personnel the responsibility of making decisions that violate specific protocols if human safety is involved.

### 4.6 Implementation of decisions in an organizational context

For the three decision options listed below, the implementation of these decisions is largely dependent on whether the organization is overseen by a higher authority, such as the FAA or is completely an independent enterprise. In the latter case implementation will depend on the organization's leadership.

#### 4.6.1 Independent review

The independent review decision option by definition would need to be implemented external to the program in question. Independent implies organizational and financial independence. This could be done either voluntarily by the program or mandated by an external authority, such as the FAA. The Columbia Accident Investigation Board (CAIB) in NASA [17] (p. 227) suggested the independent review option in NASA

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#### 4.6.2 Pre-mortem

It would be up to the leader to organize the pre-mortem as described by Kahneman [1] (pp. 264-265)

As stated before, this approach would have to be institutionalized before it could be implemented. This raises the question of how it would be implemented. It could be implemented either by organizational policy or by an external entity such as NASA, the FAA, or a DoD branch.

A practical and current implementation of the pre-mortem approach is crew management resource (CRM) as described by FlightGlobal [27]. This source has observed that aircraft crashes can be attributed, in part, to the lack of communications among crew members. CRM calls for flight crew members to alert the captain if they have any concerns, such as the aircraft is heading into a catastrophic event. Moreover, the communication should be relayed in an assertive way so that the captain is aware of the situation. These procedures can be considered a special application of the pre-mortem approach.

#### 4.6.3 Policy change

It seems that the basic approach to this problem is to change the company policies. An external independent authority would be required to make sure this happens. For independent enterprises, policy changes would be the responsibility of the decision makers.

## 5 Discussion

Table 1 summarizes the case studies, the organizational biases that appear to have been present, and the possible decision choices that may be appropriate for future cases of these types. These biases and options are not meant to be exhaustive but rather typical for cases of these types. This table does not list individual biases which are thoroughly discussed by Kahneman [1] and Thaler [2].

**Table 1.** Potential decision options for selected case studies and associated organizational biases

| **Case Study** | **Possible organizational biases** | **Potential future decision options** |
|---|---|---|
| *Challenger* | *Rankism*<br>*Culture*<br>*Loss aversion* | Independent review<br>Pre-mortem |
| *Columbia* | *Rankism*<br>*Culture*<br>*Loss aversion* | Independent review<br>Pre-mortem |
| Bhopal | *Culture* | Policy change |
| Tenerife | *Rankism*<br>*Responsibility* | Policy change |
| Honda Point | *Groupthink* | Policy change |
| United 93 | *Protocol rules* | Protocol change<br>Policy change |
| Deepwater Horizon | *Rankism*<br>*Accountability*<br>*Responsibility* | Policy change |
| Korean Airlines Flight 801 | *Rankism*<br>*Culture* | Policy change |
| Asiana Flight 214 | *Rankism* | Policy change |

| | | |
|---|---|---|
| | *Culture* | |

Cognitive biases should be seen as a departure from previous reliance on the assumption of rational thinking. Kahneman [1] and Thaler [2] have performed a service by bringing this new perspective to light.

It is recommended that future work be focused on implementing the concepts described in this paper in enterprises particularly vulnerable to catastrophic failures. Space systems and commercial aircraft systems would be priority enterprises. Priority should given to those concepts recommended by authoritative bodies, such as the Columbia Accident Investigation Board (CAIB). It is impossible to estimate how many fatalities could he avoided by these measures; however this paper outlines one of the more scientifically validated approaches.

## 6. Materials and Methods

The cognitive biases examined were extracted from many sources including Wikipedia [7], Madigan [21], Kahneman [1], Dekker [22], Murata et al [15], and Fuller [16]. The *protocol rules* bias was inferred from the United 93 case in the 9/11 Commission report [20]. The *culture* bias was inferred from the Challenger case described by Vaughn [18] (p. 190), the Bhopal case described by [5] (p. 89), and NASA [17] (p. 184) for *Columbia*.

The *protocol rules* bias was inferred from the 9/11 Commission report [20] for the United 93 case.

The case studies were described by Vaughn [18] (p. 190) for the *Challenger* case, NASA [17] (p. 184) for the *Columbia* case, McCreary *et al* [23] for the Tenerife case, Wikipedia [24] for the Honda Point case, Reason [5] (p. 89) for the Bhopal case, Britannica [25] for Deepwater Horizon, the 9/11 Commission report [20] for the United 93 case, the NTSB reports for the Korean 801 [26] and Asiana 214 [28] cases.

Decision options were described by NASA [17] (p. 227) for the independent authority, by Kahneman [1](pp. 264-265) for the pre-mortem. Policy change was inferred from the case studies.

The division of cognitive biases into individual biases and organizational biases was performed by the author using reason based on organizational characteristics. The development in this paper of the concept of organizational bias is a departure from and an expansion of the previous work focusing on individual biases. However, as stated above the individual biases may exist simultaneously with organizational biases and may, by themselves, have organizational consequences.

## 7 Conclusions

Organizational biases are fundamentally different from individual biases and are a result of organizational characteristics. In addition, organizational biases are an extension of individual biases.

Decisions in an organizational context are unique to each organization and each bias and the situation in which the decision is necessary. Hence, organizational biases and organizational decisions should be addressed as separate phenomena from individual biases and decisions because they require an added degree of analysis to synthesize. Organizational biases and organizational decisions depend both on the mental state of the decision maker and the characteristics of the organization.

Decision options often call for cultural changes in organizations. However, these cultural changes should be implemented in specific responsibility changes and in specific required actions.

Implementation of organizational decisions is the major challenge and are primarily dependent on organization management to implement them or some outside entity to mandate them.

## 8 Author contributions

Dr. Jackson has explored the topic of cognitive bias for a number of years beginning with Jackson [19] (pp. 91-119). Other contributions in this field include Jackson and Harel [3] and Jackson [4]. The latter two papers contributed to the examination of cognitive bias as part of the decision process within systems engineering.

Dr. Jackson was responsible for conceiving the paper with a focus on organizational bias and identifying existing and new biases that supported that perspective. He also identified case studies that supported this this concept especially case studies that involved accidents of catastrophic consequences. A principal task was researching the concept of cognitive bias and especially the contributions of Kahneman, Tversky, Thaler, Murata, and others. Dr. Jackson suggested the *Challenger*, *Columbia*, Tenerife, Korean Flight 801, Bhopal, Deepwater Horizon, and United 93 case Studies as being examples of organizational accidents.

Mr. Harel has an extensive background in human factors was able to explain how human factors contributed to the concept of cognitive bias and especially to the application of cognitive bias to the organizational accidents which are the subject of this paper. He suggested the term organizational bias to differentiate it from individual bias. He was also able to elaborate on the history of cognitive bias and some of the divergent views about cognitive bias discussed in this paper. He also suggested several case studies for this paper including the Aviana Flight 214 and Hondo Point accidents.

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