

Culture and Flight Deck Operations

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Abstract

Culture is widely believed to play an important role in the international aviation system. Given the many factors, including the infrastructure of aviation, that affect aviation safety, the role of culture remains uncertain. It is accepted that culture must exert some influence on the patterns of behavior enacted by flight crews on the flight deck, but different views of culture produce different hypotheses about the role of culture in the organization of behavior. We review the history of ideas about culture and describe a recently developed concept of culture that is based in contemporary cognitive science. We then use this modern theory of culture to evaluate recent attempts to understand the role of culture on the flight deck. Finally, we sketch a methodology for the study of culture on the flight deck.

Keywords: Culture, aviation safety, flight deck operations, anthropology.

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Executive Summary

Culture is widely believed to play an important role in the international aviation system. Some attempts have been made to link the widely differing accident rates in different regions of the world to differences in regional or national culture (Boeing, 1994; Soeters & Boer, 2000). However, a review of the literature reveals that at present there is no unambiguous evidence that national or regional culture has meaningful consequences for the safety of flight. Many other factors, including especially the infrastructure of aviation, differ across regions and have well understood effects on aviation safety.

It is nevertheless clear that culture must exert some influence on the patterns of behavior enacted by flight crews on the flight deck. Various views of culture produce different hypotheses about the role of culture in the organization of behavior. The history of ideas about culture shows that early models of culture are largely essentialist in nature. Essentialism is the view that culture is an essential part of every person. It asserts that culture is written indelibly into the identity of a person early in life and makes itself visible in his or her behavior. *Essentialism predicts that flight decks must be made sensitive to national culture because people cannot depart from the imprint of their original national culture, or, be made completely insensitive to known cultural differences so that any culture can perform equally successfully.* Yet, millions of people learn as adults to function well in a second culture. The extent to which non-linguistic cultural skills can be acquired later in life is one of the critical questions for this paper. At present, the dimensions of this problem and the answer to it are simply not known.

The past twenty years of research in the fields known as situated cognition, distributed cognition, and embodied cognition have shown that the organization of behavior is an emergent property of the interactions between the consequences of a lifetime of experience and one's current social and material surroundings. The focus of this work is on the organization of behavior, rather than directly on the influence of culture on behavior. This view can be called *contextualism*. Contextualism directs attention not just to **what is in the mind**, but **what the mind is in** as well (Cole, 1996). People draw on resources to construct meaningful courses of action. Activities bring together people, tasks, goals, tools, and practices. Which skills are required and which resources are recruited depends on the organization of the activity in which the practice occurs. A modern theory of culture acknowledges that societies are internally diverse. Different organizational settings within a society may call for different kinds of thinking and different styles of interaction. Thus, every person may be simultaneously a member of several cultures. A given group of individuals may enact different distributed cognitive processes depending on institutional arrangements. Observed patterns of behavior emerge from the interactions of the internal processes with structures and processes that are present in the environment for action. This means that the regularities that are often identified as being characteristic of a culture may not be entirely "inside" the individual members of the society in question and may not generalize across activity settings. From the contextual point of view, the term culture can be read as a shorthand label for an **emergent** uneven distribution of a variety of material, social, and behavioral patterns that result from a universal human process.

The question “Does culture affect the behavior of flight deck crews?” should be re-posed as “Under what circumstances is it useful for a person to use the patterns, processes, and structure of (their culture) the activity systems in which they have participated as resources for organizing their behavior?” Every person has access to resources for organizing behavior that come from a variety of activity systems.

Aviation is a cultural activity in the sense that every community of pilots develops a shared set of understandings concerning what is appropriate and what is not, what feels good, what makes one proud, and also what makes one feel uneasy or foolish or ashamed, what makes sense and what does not make sense. There is always an economy of self-esteem, a system for determining, accruing, and demonstrating one’s own worth.

Flying culture is not the native culture of any group. Pilots make use of their prior experience, including elements that are typically associated with national culture, in the process of developing or entering a culture of flying. However, the contribution of national culture to the organization of behavior on the flight deck is an unresolved empirical question. In any of its forms, culture is but one of a large number of elements that may affect the organization of behavior in the flight deck. On the flight deck, authority is marked in architecture, in attire, in procedures. Modern flight decks symbolically mark and legitimize the power and authority of the captain. Status differences can be affected by CRM training, but also by manipulating the setting and procedures.

Given this complex situation, what can be done to assess the effects of various sorts of experience on behavior in the flight deck? The most influential line of current research on culture and aviation characterizes culture as collections of traits or dimensions. The traits or dimensions may be drawn from classical ethnographic studies or derived from survey instruments. There is a temptation in such views to selectively attend to cases in which some putative property of culture contributes to an undesirable outcome. This strategy can be very misleading. Under these models, in order to assess the value of a culture to flight safety, one would have to cross all available cultural behavior patterns with all conceivable flight circumstances. In every case, one would have to measure or predict the desirability of the outcome produced by that cultural trait in that particular operational circumstance. Constructing such a matrix is clearly impossible. Instead, researchers resort to two imaginative strategies. They may start with an observed course of action and imagine a cultural trait that could account for the observed behavior. Alternatively, they may start with a trait, and imagine circumstances in which that trait could plausibly lead to desirable or undesirable outcomes. In either approach, cases that violate prior expectations are ignored. The assumption of essentialism makes it seem at least **plausible** that the national cultural traits are enduring underlying dispositions of actors and that those dispositions will shape the actor's behavior in all contexts. The results are **suggestive**, since the survey questions measure attitudes toward behaviors that have been observed anecdotally in other contexts. However, the results are also **problematic** because the aviation industry simply lacks the observational data that would be required to establish the relation of the behavior in the survey context to behavior in the flight deck. The key unanswered question is: do the factors that are measured by these instruments play a causal role in the construction of meaningful courses of action in the target context of flight deck activity? Another line of research attempts to address the process of the construction of meaningful courses of

action more directly. Two research groups have undertaken extended, explicitly ethnographic, investigations of commercial transport pilots. In the U.S, the group at UCSD has used a variety of techniques over the past 13 years to better understand the world of the airline pilot and pilots in general. Over approximately the same period of time, in France, the group “*Aeronautique et Société*” has been observing and documenting the behaviors of pilots flying all sorts of airplanes, and of designers involved in the introduction to service of the Airbus A320. The strengths of this approach are that it focuses on the process of the organization of behavior in the real world context, and does not presuppose a role for culture. The weaknesses are that it is labor intensive, requires an uncommon combination of technical and cultural knowledge, and involves a necessarily small sample size. While the two research groups are situated in different national cultures and focus on pilots from different national cultures, the most striking aspect of the comparison of their results is the similarity of the descriptions of pilots.

The unanswered questions are:

- To what extent can behavioral skills be acquired in adulthood?
- Under what circumstances do people make use of patterns, processes, and structures resulting from their prior experience (in contexts one may label as national, professional, or organizational) as resources for the organization of behavior?
- What is the contribution of experience that is typical of the life of a nation to the organization of behavior in the flight deck?

An approach that combines the comparative method with in-depth ethnographic studies of institutional context, training practices, and actual behavior in the flight deck should be able to shed some light on these questions.

Introduction

There are two major themes in the construction of culture as an important factor in the aviation system. First, it stands to reason that culture should affect the behavior of pilots and others in the system because it seems to affect so much of what people, especially *other* people, do. Second, worldwide data on accident rates show large differences between different regions of the world. These differences beg to be explained. Because culture varies by region and affects behavior, it provides a plausible element of an explanation.

In this report we review the literature on the role of culture in commercial aviation with special attention to flight deck operations. We summarize the principal arguments and critically evaluate the prior work.

The issues raised by a consideration of the role of culture in flight deck operations are very complex. If the brain is, as some have said, the most complex structure on earth, then the cultural process, which is the brain's primary occupation, can also be expected to be complex. In the literature, culture seems to come into focus momentarily and then disappear. At first glance, the effects of national culture appear pervasive and obvious, but when one seeks a theory that could link national culture to specific operational outcomes, or when one looks for direct evidence of the effects of culture on actual behavior, culture seems to vanish. Perhaps the most surprising outcome of the literature review is the absence of a "smoking gun" in the form of unambiguous evidence that national or regional culture has consequences for the safety of flight deck operations. In the existing literature, there is no clear consensus on what culture is, what effects it might have, or what, if anything, should be done about it. Culture presents a perplexing appearance for many reasons. Some of them have to do with the nature of the phenomena and some have to do with the ways in which the phenomena are represented and perceived. It is, therefore, important to examine the way that the aviation industry constructs culture as a causal factor. Attempting to sort out the relationships between culture and behavior leads to a large number of fundamental questions. Some of these questions appear to lie beyond the boundaries of our current scientific knowledge.

The Role of Infrastructure

Before addressing the role of culture in flight deck operations, it is important to address a common, yet pernicious, misconception. Some researchers have reported correlations between measures of national culture and accident rates (Boeing, 1994; Soeters & Boer, 2000). A plausible chain of reasoning goes: since both flight safety and culture vary by region, and since culture has a formative role in behavior, and patterns of behavior produce safety outcomes, then culture is a likely determinant of safety outcomes. However, many things are correlated with safety of flight, and some of them are both more plausible factors in safety of operations and much more strongly correlated with safety of flight, than is any measure of culture.

A modern airplane or fleet of airplanes is only part of the commercial aviation system. Safe operations also require a vast, and expensive, network of material and services. The infrastructure of civil aviation includes regulatory structure, facilities (airports, navigation and approach systems, etc.), weather forecasting, charts, mail services (to deliver charts), education, maintenance, and more. Accidents tend to involve

interactions among multiple elements of the system. Therefore, differences in accident rates may be driven by differences in infrastructure. For example, a recent study by Boeing's Flight Safety Foundation on worldwide infrastructure (Phillips, 2002) attributes the high accident rate in Africa to infrastructure problems. As an example, an NDB near Nairobi was out of service for months because thieves took the unit to sell the copper components in it for scrap. The government did not have the budget to replace the navigation aid. Differences in infrastructure are driven by hard economic and political considerations. Wanting a safe aviation system does not mean a nation can afford to pay for it. If a national leader has a choice between providing clean drinking water to millions or providing fancy aviation radar for a few airline passengers, a rational concern for public safety will lead to a decision to forgo the radar.

This is easy to see in the data collected for a 1994 Boeing study titled "Crew Factor Accidents: Regional Perspective." The report compares safety issues in fatal accidents for US operators in US locations with the same issues in accidents involving US operators in Non-US locations and Non US operators in US locations. For US operators in US locations, none of the top 5 safety issues directly involves infrastructure support for flight operations. (The key issues are: Windshear, Loss of control, post-crash survivability, approach and landing accident without CFIT, and out of configuration takeoff.) For US operators in non-US locations, the top three issues are all infrastructure issues: ground de-icing/anti-icing, CFIT, and ATC systems & communications. For non-US operators in US locations, the only infrastructure safety issue is ATC systems & communications. ATC communications are an issue for all pilots flying an airspace that is foreign to them, regardless of where they come from. Even when pilots and controllers understand each other's words, there are other factors at work. In the US, airline pilots have some well formed expectations about what things they can ask of a controller and what things a controller can ask of them. Pilots and controllers in each region probably have such expectations. Pérez reports it is true for Mexico. When a pilot crosses a border, these expectations no longer hold. The behavior of the pilot may change in response to the change in context. Furthermore, when US operators fly abroad the infrastructure problems they encounter seem to play a role in the accidents they are involved in there. When non-US operators enter US airspace, except for ATC communications, infrastructure seems not to play a role in the accidents they are involved in.

To test the relationship between infrastructure and safety of flight, we performed a correlational analysis across major regions of the world on a number of common measures of infrastructure quality and a measure of safety of flight (See Appendix 1). The data show that at the regional scale, safety of flight is correlated at the 0.97 level with daily caloric intake. This does not mean that well-fed pilots are safer than those who are not well fed. Pilots are a privileged group in every nation and probably get adequate nutrition everywhere. Caloric intake is an indirect indicator of an essential element of national infrastructure. If a nation does not have the wealth required to create and distribute food, it is unlikely to be able to invest in modern radar systems, ground-based navigation and approach aids, runway lighting, weather prediction services, or the myriad other institutions on which safe civil aviation operations depend.

Helmreich and Merritt (1998) point out the folly of attempting to link national culture to accident rates.

We cannot leave this chapter without clarifying a misperception. Some authors have correlated national culture with accident rates and concluded that pilots in certain countries

are safer than others. We take umbrage with the simplicity of this statement. The resources allocated to the aviation infrastructure vary widely around the globe. While pilots in Europe enjoy some of the most sophisticated Air Traffic Control support, pilots in parts of Africa and Asia are faced with little or no support; indeed, the runways may not even be lit for lack of electricity or stolen equipment. Accident rates are a function of the entire aviation environment, including government regulation and oversight, and the allocation of resources for infrastructure and support, not just pilot proficiency. (pg 104-5)

Unfortunately, this warning seems to have gone unheeded by many researchers. There is currently considerable excitement in the industry concerning the possibility that measures of culture can be correlated with measures of flight safety (See Klein, et al, 2001). The fact that the correlation between measures of infrastructure and flight safety are much stronger than the correlation between measures of national culture and flight safety should dampen this naïve enthusiasm, but it does not mean that culture plays no role in the organization of behavior in the flight deck.

No matter how it is defined, culture is but one of a large number of elements that may affect the organization of behavior in the flight deck (Maurino, 1994). Skills, flight deck architecture, tools, social interaction, experience, training, activity structure, interactions with other institutions (ATC, maintenance, media scrutiny, political systems, etc) are potential sources for the organization of flight deck behavior. There are two implications of this rich interconnectedness. First, the relative effects of culture as a determinant of outcomes are unknown and may remain so. Second, changes in behavior that are presumed to be driven by culture could be overwhelmed by the other determinants of behavior. If the cultural process works via the integration of such disparate influences, then a methodological problem follows. Observations in-situ will always leave the role of 'culture' among the confounding factors unclear, and observations made in cleaned up contexts where other factors are 'controlled' and culture is the only 'independent' variable, may be irrelevant to the phenomena of interest.

A Brief History of Ideas About Culture

The colonial expansion of Europe beginning in the 15th century brought Europeans into contact with many peoples. Culture became a topic of scientific study with the founding of the field of anthropology in the late 19th century. Over the years, culture has been given hundreds of definitions. A good general definition was provided by Tylor (1871) who said that culture is, "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society."

Essentialist Views

During the Second World War, the U.S. government commissioned a number of studies of "national character." These studies were intended to help the U.S. leadership understand the thinking and actions of our foes. The anthropological theory behind national character studies assumed that people have enduring qualities as a consequence of being a member of a culture. While individual differences were acknowledged, the task was to create portraits of culture that would support predictions concerning what a society might be likely to do. Ruth Benedict's landmark study of Japanese character, *The*

Chrysanthemum and the Sword (Benedict, 1946), is probably the best, and best known, of these studies.

The national character studies gave rise in the 1950s to a sub-field of anthropology known as culture and personality. This approach combined psychoanalytic concepts with anthropological research in an effort to understand why societies have the institutions they have. Psychoanalytic theory linked adult behavior to early life experiences. One of the most influential pioneers of this field was Abraham Kardiner, a psychotherapist turned anthropologist. (Later another psychotherapist turned anthropologist, Robert I. Levy, would be a major player.) The culture and personality movement held that subsistence patterns constrain child-rearing practices, which then create certain psychological needs, which are then embodied in cultural institutions. For example, it has been shown that cultures that have harsh toilet training practices tend also to have vengeful deities. A catch phrase of this approach is that ‘culture is personality writ large.’ An important element of this approach is the idea that various aspects of a society fit together with each other in particular ways. An economic structure can have implications for social relationships, which can affect psychological needs that are satisfied by participation in particular expressive conventions. This is one of the early models of culture as a sort of ecology in which elements of the culture constitute the environment of other elements. The work of Edward Hall (see below) grew out of this field.

By the 1960s, culture and personality had expanded into a field known as psychological anthropology, which is interested more generally in the relationships between culture and psychological function of all sorts (Spiro, 1978; Schwartz et al., 1992). A new sub-field called cognitive anthropology was founded at the end of the 1950s and entered a ‘golden age’ in the 1960s. Cognitive anthropology was interested in how people make meaning. The foundation of cognitive anthropology rests on the notion that culture is knowledge. In particular, culture is what any person would have to know in order to behave appropriately in any of the roles of a society (Goodenough, 1957). This ideational definition of culture was quite powerful and set the stage for impressive studies of the relations among language, culture and thought. For cognitive anthropology, the 1960s began in a spirit of relativism (the idea that cultures make sense of the world in equally valid and essentially arbitrary ways) and ended with a concession to biological determinism (the idea that biology may determine cognitive structure) (Berlin and Kay, 1969; Rosch, 1975). This is part of a much larger, still contended, debate concerning the relative importance of nature versus nurture in the organization of behavior (See the 1980s work on Sociobiology, Wilson (1980), but also Kitcher (1985), and the more recent interest in evolutionary psychology (Barkow, Tooby and Cosmides, 1992).

One interesting anthropological finding about color terms is that color categories have well defined centers or “best exemplars”, but poorly defined boundaries. That is, there is strong agreement, even across languages and cultures, on the prototypical or focal ‘red’. However, there is much less agreement on the boundary between the category ‘red’ and the neighboring color categories. Cultures are a bit like this as well. It seems obvious that the centers of various national cultures are different from each other. However, finding the boundaries between cultures or languages is not so easy. Cultural boundaries are flexible and practices diffuse from one culture to another. The same problem is found in other fields as well. Linguists recognize dialects as naturally forming

gradations of linguistic practice; however, it takes a political boundary to make a language. In biology the boundaries between species can be equally difficult to identify. The situation is especially pronounced in the case of civil aviation, because airplanes and the practices engaged in while flying them diffuse across cultural boundaries.

The key question for cognitive anthropology is how cultural knowledge is organized. Over the years the field has moved, in parallel with the rest of cognitive science, through a set of representational conventions (D'Andrade 1995 provides a comprehensive history of the development of cognitive anthropology). In the early years, knowledge was represented as combinations of features of meaning. Later, feature models were replaced by schema theory (D'Andrade, 1976; Hutchins, 1980; Holland and Skinner, 1987), and more recently schema theory has been re-worked in the image of connectionism (Rumelhart, et al, 1986; Strauss and Quinn, 1997)

The relations between culture and thinking were not the exclusive domain of anthropologists. In the 1960s and 70s a number of psychologists, many of them using methods and measures developed by Jean Piaget, took to the field (Bruner, Olver, and Goodnow, 1966; Jahoda, 1982; Berry & Dasen, 1974). They called their work 'cross-cultural psychology'. A typical technique was to design a test or task to measure a psychological ability, use the test to collect data in another society, and then compare results across societies. This work inspired Geert Hofstede, whose work (see below) is now central to the literature on culture and flight deck behavior. The findings of this research tradition can be interpreted as showing that there are (or are not) interesting cross-cultural differences in people's cognitive abilities. The tests often show differences in average level of performance across subjects from different societies. The lack of agreement about the meaning of the findings is largely due to the issue known as 'ecological validity.' This refers to the fact that one rarely knows how the test or task relates to the everyday activities of the subjects. It is difficult to know what the test actually measures. This question is as much a problem today as it was in the 1970s. The best treatment of the ecological validity problem appears in the work of psychologist Michael Cole and his colleagues (Cole et al., 1997). One of the authors of this report, Hutchins, participated in an expedition of this sort in the summer of 1973. A team of four researchers administered a battery of psychological tests to 450 illiterate fishermen and gardeners in the Admiralty Islands of Papua New Guinea. It was this experience, and Hutchins' sense that the tests were not measuring what people could do in culturally familiar tasks that led him to conduct his Ph.D. research as a study of cognitive performance in an indigenous (rather than an introduced) task.

By the mid-1970s, a few cognitive anthropologists and linguists (Fillmore, 1977) had noticed that the feature models of meaning were very limited. For example, American English illness terms can be defined in terms of a collection of features such as "is caused by germs," "is serious," "is best to have in childhood," "is contagious," and so on. The definitions of the terms can be specified as combinations of features. But, something important is missing. Americans have very specific and widely shared understandings of why diseases that are contagious are caused by germs. These understandings include ideas about what germs are (microorganisms) how they affect the body, and how they are communicated among persons. Such understandings are called schemas and they describe how things work in simplified, taken for granted worlds. Feature models can represent what is known, but not how people 'go about knowing what

they know' (D'Andrade, 1976). By this time, cognitive psychologists had begun a shift to using schema theory to represent knowledge (Norman & Rumelhart, 1975; Gentner and Stevens, 1983). Hutchins' Ph.D. dissertation, *Reasoning in Discourse: an analysis of Trobriand Island Land Litigation* (Hutchins 1978, published as a book titled *Culture and Inference* in 1980) provided the first example of the use of schema theory to represent knowledge and psychological processes in a non-Western society. It also played an important role in moving cognitive anthropology away from models of cultural knowledge defined by combinations of features of meaning and toward schema theoretic cultural models.

The 1980s were a second 'golden age' for cognitive anthropology. Anthropologists became interested in how people use their knowledge to do things that matter to them (Holland and Quinn, 1987). The methods required to investigate cultural models are very labor intensive. As a result, anthropologists following this approach are only able to work with a small fraction of members of a society. This is not a problem as long as culture can be assumed to be relatively homogenous. This assumption seemed justifiable for simple traditional cultures, but by the 80s, anthropologists were working in diverse modern cultures. These circumstances heightened interest in intra-cultural variability (Boster, 1985), and led to the development of cultural consensus theory (Romney, Weller, Batchelder, 1986), which gave formal representation to the distribution of knowledge and attitudes in a community.

Up to this point, theorizing in anthropology was dominated by an essentialist view of culture. Essentialism is the view that culture is an essential part of every person. It asserts that culture is written indelibly into the identity of a person early in life and makes itself seen in his or her behavior. While it is widely agreed that a healthy infant born anywhere on earth can become a member of any culture simply by being raised in that culture, the early years are taken to have special significance. There appears to be a critical period for language learning, for example, beyond which one can still learn other languages, but not in the same way they are learned in childhood. Most of the work on the relevance of culture to aviation seems to be implicitly essentialist. *Essentialism predicts that flight decks must be made sensitive to national culture because people cannot depart from the imprint of their original national culture or they must be made insensitive to culture.* Yet, millions of people learn as adults to function well in a second culture. The extent to which non-linguistic cultural skills can be acquired later in life is one of the critical questions for this paper. At present, the dimensions of this problem and the answer to it are simply not known.

By the end of the 1980s, cognitive anthropologists were in agreement that knowledge consists of idealized models of how the world works, and that the members of different societies have different systems of knowledge, different ways of making sense of the world. It was also agreed that all such systems of cultural knowledge are organized according to universal principles, and that the patterns of distribution of knowledge within any society have interesting internal structure.

Informal Ways of Making Culture Visible

As we saw above, culture can be defined in various ways. Which definition should be used in an attempt to better understand the relations of culture to flight deck

operations? Defining culture makes it into something about which one can think. It is important to briefly examine the hidden work that goes into making culture visible.

The discussion of culture often frames the issues in terms of contrasts between cultures. Because our own culture is mostly invisible to us, this is a useful tactic for making the role of culture apparent. Cultural contact situations, such as those encountered by manufacturer's field representatives assigned to foreign airlines, bring cultural boundaries into sharp relief by juxtaposing elements that are normally far apart. These situations really do create communication and interaction problems. They also create the sense of the *otherness* of the other.

While focussing on cultural differences can make the culture of the other visible, clinging too closely to this tactic can lead us to overlook our own culture. For example, an American-born crew flying an American-made airplane in American airspace is a system that must be loaded with important cultural properties. But "seeing" these properties is nearly impossible for someone who has not mastered another language and culture. English-speaking American pilots are constrained in their interactions by the fact that English provides no convenient way to distinguish second-person singular from second-person plural pronouns (you vs you). Worse yet, there is no explicit way in English to mark first-person plural pronouns (we) as including or excluding the person spoken to. Most Pacific Island languages make these distinctions obligatory. The absence of these markers is not a crippling deficit but it does affect what English speakers can do in interactions. The lack of explicit markers for these conceptually salient distinctions increases the ambiguity of communication and the load borne by context in the process of interpreting the meaning of utterances. Lacking knowledge of what other cultures do, it is difficult to notice what one's own culture does not do.

A commonsense approach sees culture as internally generated patterns of behavior. It accounts for those patterns in terms of knowledge and belief inside the persons who behave in the observed way. Common sense approaches focus on differences between cultures, describe culture as an essential property of individual persons, and expect national culture to have powerful effects. According to the essentialist view, culture is simultaneously a property of regions and of the individuals who inhabit those regions. This assumption about culture makes it seem sensible to put the causes of outcomes inside people. The propensity to do this is known in social psychology as the "fundamental attribution error." It is the belief that others behave the way they do because of their nature, while oneself behaves the way one does because of one's circumstances.

Collecting stories about cultural differences from manufacturer field representatives (Mumaw, 2001) is a good way to collect data that can be used to identify the conceptual resources used by those representatives to understand culture. That is, these reports can provide information about the cultural beliefs of the reporters. These reports are not an appropriate instrument to measure anything about the target cultures.

A triad of commonsense assumptions forms a dangerously mistaken view of the role of culture in flight deck operations. First, lacking the analysis tools and documentation of context needed to identify the relations among factors in particular events, the aviation industry is compelled to aggregate data across cases. But where one cannot identify the underlying processes in individual cases, one cannot be sure that the cases have been aggregated into categories containing only cases of a single type.

Variability among cases must be ignored or suppressed in order to justify aggregation. Thus, attention to variability is an unintended casualty of the need to aggregate. Second, the industry tends to focus on accidents. This is in part because accidents are highly visible and in part because they are the things that most obviously need to be “fixed”. Some kinds of reporting schemes can make incidents visible as well (For example, NASA’s ASRS, Airplane Manufacturer and Airline Incident reporting systems, FOQA, etc.). The industry also focuses on incidents and accidents because it is easier to specify the outcomes that are not wanted than it is to specify the processes that produce desired outcomes. Attention to how things go right and what makes aviation so incredibly robust is the unintended casualty here. Third, the concept of “performance” implicitly links process and outcome so that it is assumed that bad outcomes are produced by bad behavior (that is, poor performance) and that good outcomes are produced by good behavior (that is, good performance). This connection makes it difficult to see the virtue of Ernest Mach’s claim, as reported in Woods, et al (1994), that the same cognitive processes produce error and correct action:

“ As Rasmussen (1985) states: "It. . . [is] important to realize that the scientific basis for human reliability considerations will not be the study of human error as a separate topic, but the study of normal human behavior in real work situations and the mechanisms involved in adaptation and learning (p. 1194)." The point is that: the same factors govern the expression of expertise and of error. Jens Rasmussen frequently quotes Ernst Mach (1905, p. 84) to reinforce this point: "Knowledge and error flow from the same mental sources, only success can tell one from the other." (p. 14-15).

All of these elements together produce a compelling view of the role of culture in flight deck operations. In this view, culture varies by geographic region or by nation (intracultural variability of persons and settings is ignored), and culture is a cause of particular kinds of performance (behavior – outcome pairs) that lead to accidents or incidents. The causal relation is posed as a measurement problem of the following form, “Is cultural variable X correlated with performance variable Y? If so, can we imagine a reason for that correlation?”

This view makes the industry blind to certain kinds of relevant phenomena. For example, it focuses attention on culture as properties of persons and on performance inferred from outcomes, but diverts attention from the processes by which flight crews organize their activities. It gives culture a characterization such that we must use our imaginations to link it to behavior in the flight deck. It makes it difficult to imagine good behavior with bad outcomes or bad behavior with good outcomes. It overlooks the ways that courses of action can go right, and misses many of the sources of robustness in the current system.

The Rise of Contextualism

The past twenty years of research in the fields known as situated cognition, distributed cognition, and embodied cognition have shown that the organization of behavior is an emergent property of the interactions between the cognitive consequences of a lifetime of experience and the current social and material surroundings. The focus of this work is on the organization of behavior, rather than directly on the influence of culture on behavior. This is a good thing because it makes fewer a priori assumptions about the nature of culture.

In the 1990s, some new ideas began coalescing in cognitive science. These go under the names embodiment (Lakoff, 1987; Lakoff and Johnson, 1999; Clark, 1997; Lakoff and Núñez, 2000) situativity (Suchman, 1987; Lave, 1988; Goodwin, 1994), activity (Lave, 1988; Chaiklin & Lave, 1993; Nardi, 1996; Cole, et al., 1997; Bødker, 1991), and distributed cognition (Hutchins, 1995a, 1995b, 1996; Hollan, et al., 2000). These approaches contribute many new ideas.

One of the most important lessons of recent cognitive science is that the structures and processes internal to people are probably not direct representations of the patterns that people experience. Rather the observed patterns of behavior emerge from the interactions of the internal processes with structures and processes that are present in the environment for action. This means that the regularities that are often identified as being characteristic of a culture may not be entirely "inside" the individual members of the society in question. *When culture is attributed to an individual, culture is a shorthand term for regularities that reliably emerge out of the interactions of mental processes with material structure in socially constituted activities.* Culture is thus a shorthand label for an **emergent** pattern. When used in its common-sense form, culture refers to the observed uneven distribution of a variety of material, social, and behavioral patterns that result from a universal human process. Contextualism is grounded in contemporary theories of embodied, situated, and distributed cognition. Hutchins, 1995, Clark, 1997; Cole, 1996; Shore, 1996; Strauss and Quinn, 1997; Lave, 1988. These theories assert that many sources of the organization of behavior lie outside the contents of the mind. They direct attention not just to what is in the mind, but what the mind is in as well (Cole, 1996).

Culture is sometimes defined as a thing or as an inventory of things (D'Andrade, 1980, but see also Hutchins, 1995a). This kind of definition highlights the properties of the products of the cultural process, but draws our attention away from the process. The ideational definition of culture – that it is a collection of ideas – has now largely been abandoned by cognitive anthropology. The deeper problem is that the “activity system” framing changes the epistemological status of culture. Culture could be one of at least three things, none of which has causal force. Culture is a shorthand way of talking about

- perceived regularities in patterns of behavior,
- a very complex distributed process
- something that is brought into existence only when anthropologists write about it.

Culture cannot be an independent variable. Culture cannot be the “activity systems” themselves. Culture is something that the observer imagines is in or behind the organization of the activity systems. Geertz (1973) would say that culture is brought into existence only by the activity of anthropologists who write about it. Given this framing, one cannot ask whether “the organization of activities reflect the culture” because the perceived and represented organization of activities IS the culture. We could sensibly ask, “how does the organization of this particular (aviation) activity relate to other activity systems in this society?” For example, if we know that deference to elders is an important feature of the family activities in this society, should we expect that deference to age will also be an important feature of flight deck interactions? We don't really know, because we do not know what happens in other activity systems. When an ethnographer has discovered that deference to elders is a recurring theme across many

activity systems in a society, he or she may say, in a shorthand way, that deference to elders is part of this culture. But doing so creates something that has the appearance of a cause, when it may not be so. It is very tempting to attribute a disposition to behave in a particular way to the individual actors. Lacking a knowledge of how the observed behavior emerges from the interactions between what is in actors and what actors are in, we cannot know where to locate the causes of the observed regularity. This discussion highlights the appeal of the traditional cognitivist view (and of evolutionary psychology). By positing internal causes that are insensitive to context, one feels free to simplify the process by which behavior is generated in a way that makes it acceptable to give only superficial descriptions of context. Taking context seriously is a central feature of the distributed cognition perspective. Now, suppose we establish via observation that deference to elders appears on the flight deck as well. We would like to say, again as shorthand, that the behavior on the flight deck reflects the values of the surrounding culture. Doing this leaves us at risk because it may lead us to believe that the behavior is not sensitive to the context. The “cultural values” become reified as causes in some (usually) unspecified behavior-generating process. However, *the processes that make behavior regular enough that we can believe we see culture are exactly what we do not yet clearly understand*. The answer given by traditional cognitive anthropology and most of cognitive science is that the regularities in behavior are to be sought in internal causes. The theories of situativity, of embodied cognition, and of distributed cognition challenge this view by asserting that the patterns of behavior are emergent from the interactions between something inside the actor and the context of activity. One of the principal lessons of the past two decades of cognitive science is that cognitive scientists have in general attributed more structure to the internal workings of the person than is necessary to explain the regularities in behavior. Cognition is accomplished in interaction with material and social structure in the environment of thinking. What is the correct balance between internal and external structure in causal explanations of behavior? We do not yet know. These alternative frameworks are young. The impact of these ideas should not be simply to produce a new allocation of structure (inside and outside the organism) but to spur the development of a new theoretical understanding of the relations between what is in the mind and what the mind is in.)

Cultures generally do not have clear-cut boundaries. Rather, they blend into each other across space and time. This is consequence of the formation of the distributions of observable products of the cultural process. It is easy to “see” culture when comparisons are made across large spans of space or time. It is not so easy to see culture when comparing across small spans of space or time. It is even more difficult to see culture when there is no comparison to be made at all. But culture is always there in the sense that the cultural process is at work. Psychologists sometimes forget that “Human psychology is the psychology of acculturated human beings.” (Schwartz, n.d.)

It is more productive to think of culture as a process that is a universal property of human groups. This process involves the creation and use of structures and functional processes inside as well as outside individual persons. Signs (symbols, indices, etc) are obvious cultural structures in the social and material environment, but the material manifestations of culture are not confined to signs (Hutchins, n.d.a).

For example, theories of embodied cognition (Clark, 1997; Thelen and Smith, 1994) stress the importance of the role of the body in cognition and action. Cultural

structure may be implicitly learned and reside in unconscious bodily habits (Bourdieu, 1977). Patricia Greenfield and colleagues, looking at Maya weavers in Guatemala, noted that young Maya girls are taught to keep their bodies still while sitting. This seemingly restrictive discipline becomes a key resource for them in late adolescence when they learn how to weave with a back-strap loom (Maynard, et al, 1999). American researchers who attempted to learn Mayan weaving as adults found that they lacked the control and stillness of body required to maintain an even tension on the warp of the loom. Ways of sitting or standing are not primarily “signs” although under some circumstances they can be interpreted as indices of cultural mastery of sex-linked behavior. Rather they are conventional ways of being. For Mayan girls, these ways of being become resources later for learning the skill of weaving with a back-strap loom.

Flying a good instrument approach requires subtle control pressures rather than movements¹. Over-correcting is a common problem for student pilots (at least for American student pilots). One wonders if different cultures might provide different body control resources. Certainly, participation in different sorts of activity systems may equip pilots with different sorts of physical coordination skills.

According to the contextual perspective, people draw on resources to construct meaningful courses of action. Activities bring together people, tasks, goals, tools, and practices. Lave and Wenger (1991) discuss learning in terms of legitimate peripheral participation in culturally constituted activities. Cole shows how participation in shared cultural practices can provide children with the support needed to acquire new cognitive skills. That learning is shaped by interactions with the physical and social environment is simply common sense, but many social scientists forget that everyday and expert performances are also shaped by interaction with the physical and social environment, long after explicit training has ended.

These views draw attention to the variety of activities undertaken daily by the members of a society. Activities create a range of situations in which different sorts of thinking may be appropriate. In a series of studies among the Vai people of Liberia, Cole and Scribner (1974) and Scribner and Cole (1981) showed that literacy can be accomplished via a variety of skills. Which skills are well learned depends on the context in which literate skills are practiced. Literacy for the purpose of correspondence by letters recruits different skills than literacy for the purpose of memorizing the Koran, which uses different skills from literacy in the context of Western style schools. Which skills are required and which resources are recruited depends on the organization of the

¹ There may be an important pedagogical principle at stake here. If you try to learn to fly an approach by making small movements, you are looking for inner-loop feedback on your input in terms of the change in location of the controls. If you learn to make changes in control pressures, you are not looking for feedback in terms of change in location of the controls, rather your feedback is in the pressure you are feeling on your hands. I believe that teaching pilots to monitor control position leads to consistent problems with over-control. By the time a movement is large enough to be sensed as change in position of control (yoke or rudder), the input is already too big. Pilots talk about control pressures, and this is not sloppy thinking on their part. Given the way controls work – as far as I can tell in all sizes of airplane (but possibly not with fly-by-wire) – changes in control pressure is what you want both to produce an initial change in control surface position, and to maintain that change. Of course, control pressures are to be trimmed out once the correct settings are found. And the correctness of settings over time is monitored, by noting control pressures required to keep the airplane where it should be, not by control movements.

activity in which the practice occurs, and the organization of the activity reveals what types of literacy are valued by the culture.

Different organizational settings within a culture may call for different styles of interaction. Furthermore, the individuals who hold positions in these organizations may have positions in many other organizations. A navy captain may feel the tug of authority and responsibility acutely when he is on duty, but may be a very egalitarian member of some other organization, such as a tennis club. The parent who is authoritarian at home may reject authority at work.

Variability in American Cultural Settings

The survey-based studies of “dimensions of culture” reported below indicate that American society places moderate to low emphasis on social hierarchy. However, there are great differences in the extent to which various settings in American culture create and highlight power relations. Consider the courtroom as an example of an American activity setting in which power relations are emphasized by architecture, attire, and practices.

The judge’s bench is higher than the rest of the room, and is set off from the rest of the room by a ‘no-man’s land.’ The judge arrives in the space via a private door and as part of a small ritual performance (“All rise”) in which other participants express respect for the judge. Permission to go near the judge must be explicitly granted by a speech act, “You may approach the bench.” Those invited to approach the bench may draw near, but are expected not to touch or lean on the bench. The judge is distinguished from all others in the space by location, attire, and forms of address, i.e., “Your honor.” Certain kinds of speech cannot be directed to the judge. All of these things give legitimacy and authority to the decisions of the judge. The power of the judge is not simply marked by these features, it is created symbolically in the architecture, the attire, and the procedures of the setting.

Notice that American culture in the courtroom is not entirely in the heads of the participants. It is also in the setting. Of course, interpretations of the setting are at play in the interaction of the participants with the setting. The behavior that is characteristic of the courtroom emerges only in this setting. It cannot be produced without the props, the architecture, and the ritual context. That is, whatever the patterns of behavior observed here, they are not essential properties of the individual actors. They are properties of the cultural setting. Notice also that the participants move into this setting and then move out of it. It would be unwise to assume that judges, or lawyers, or persons accused of crimes are somehow more sensitive to power in their relations with peers than the members of some other profession are. Whether an actor in this setting behaves in similar ways in other settings will depend much more on the institutional nature of those settings than it will on anything inside the actor.

Now consider the flight deck of a commercial airliner. The left seat is the captain’s seat and is associated with more authority than the right seat is. This difference is marked in the language used by pilots. Captains are referred to as left-seaters. The difference is also marked by uniforms, the quality of instruments, and the fact that in many planes there is a steering tiller on left side only. Furthermore, the fact that jetways attach to the left side of plane is indicative of the Captain’s control over the flight because only he can see the jetway and monitor its attachment. Authority is also marked in

practices. In addition to the expected deference of the First Officer, Captains fly low-minimum approaches, and taxi the aircraft. It is interesting to note that as airplanes become more capable, the differences in instrumentation between left seat and right seat become smaller. This is a reflection of the changing role of the second member of the crew. As was the case in the courtroom, modern flight decks symbolically mark and legitimate the power and authority of the Captain in architecture, in attire, and in procedures. Among the activity settings that constitute the American way of life, the flight deck of an airliner is atypically high in markers of social power.

One of the goals of Crew Resource Management (CRM) training (as developed in the US) is to break down status barriers between Captain and FO. In the US, captains and first officers are encouraged to address each other by first name. Other steps that *could* be taken are to dispense with uniforms or at least get rid of stripes, and to have pilots alternate seats so the pilot flying is always in left seat. (One of the authors of this report, Pérez, actually observed this practice at a now-defunct Brazilian carrier. When, as a FO, he mentioned the idea at AeroMexico, he angered many captains who are acutely aware of the way the space in the flight deck is an expression of their authority.) These steps would be vastly more effective means of leveling the status hierarchy in the flight deck. The material aspects of cultural arrangements are compelling. There are many alternative uses for and interpretations of the space in which an activity is located. Once a coherent interpretation has been decided upon and implemented as a set of practices that coordinate with the organization of space, then these material elements become more powerful determinants of action than the more flexible internal representations. The behavior of not entering the area around the judge's bench arises from the interaction of the lawyer's knowledge and the actual layout of objects in space. This behavioral pattern becomes a meaningful pattern in the experience of others in the setting, even those who are not familiar with the meanings of the spaces or the rules governing their use. Of course, the reason we do not tear the stripes off the uniforms and have pilots alternate seats is that we know that there sometimes is a need for Captain's authority.

The ideational definition of culture is most often used as a variant of essentialism that implies that the determinants of behavior are mostly inside people's minds. The contextual view focuses on the processes by which persons organize meaningful courses of action. It implies that institutional contexts and activities provide additional determinants of behavior. Moving the problem of the organization of behavior from the interior of the mind to the interaction between the mind and a social and material environment for thinking makes it easier to see how people can learn culture in adulthood.

It is tempting to say that cultures create activity settings that guide behavior, and therefore, we should be looking for the effects of culture by studying how activity settings are created. That sounds right, but clearly, whatever it is that creates the activity settings is extremely complex and poorly understood. In some sense, this is THE central project of the social sciences, and it is not nearly solved at present. A colleague estimates it will take centuries to complete (Fauconnier, n.d.).

Cultural and linguistic practices require some sets of (conceptual, perceptual, and motor) skills, encourage the development of others, and are indifferent to still others. The key question then is this, *how can a person equipped with a particular set of skills engage a particular task in an appropriate social and material environment?*

- Let us summarize some of the considerations raised in the discussion so far.
- The distributions of resources used to organize behavior are not homogenous within any society. Different members of a particular society will have different knowledge and different ways of using those resources to organize behavior.
 - Cultures, conceived as emergent patterns of distributions of resources, do not have clear boundaries. This is true of the relations between national cultures and of the relations between professional and organizational cultures within national cultures.
 - Different organizational settings within a society may call for different styles of interaction.
 - Each individual may simultaneously use resources that were acquired in and normally associated with different activity systems. For example, every pilot has access to resources associated with some national society and some form of flying activity as well.
 - What appear to be ‘traits’ of individuals may in fact be properties of the relations between persons and settings. This means that ‘traits’ may not be enduring properties of individuals and may not generalize across settings.
 - Discontinuities in the distributions of resources are easiest to see when contrasts are sharp, but the process of bringing resources into coordination to organize activity is at work even in settings where there are no discontinuities of resources. (Culture operates even where there are no cultural differences).
 - The relationships of language to thought are subtle and complex. They may depend in part on how activities are organized and how problems are posed.
 - In addition to intra-society variability of access to resources, there are individual differences among members of a society in terms of cognitive abilities and personality.

These considerations suggest a new approach to the methods for determining the relationship of culture to cockpit operations and design. They also suggest that the relationship may be subtle and the effects less pronounced than previously thought.

Reflection: When Does Culture Matter?

The question “Does culture affect the behavior of flight deck crews?” has the same structure as the question “Does language affect thought?” The effects of language on thought are called linguistic determinism. The answer to this question has been debated since the time of the Greeks and hotly debated since the writings of B. L. Whorf (1956) in the 1950s. Although it is most often posed as a yes/no question, the answer turns out to be more interesting than either “yes” or “no”. The answer is that the structure of language can be expected to influence the structure of thought whenever a person uses the structure of language as a resource in the process of constructing a course of action. The importance of this answer is that it changes the question. It is no longer a yes/no question, but a distributional question. *Under what circumstances is it useful for a person to use the structure of language (whether lexical, syntactic or pragmatic) as a resource in solving a problem? When do those circumstances occur in the activity of the person? It is not difficult to show that tasks that appear very similar on the surface may encourage or discourage the use of the structure of language as a resource in performing the task (Kay and Kempton, 1984).*

For a person who is bi-lingual, a new question arises. When will the person use his first language as a problem solving resource? Under what conditions is he likely to use the second? The choice of language is sensitive to context and to the needs to maintain coordination with other people in the setting. Notice that following this line of argumentation leads us to attend to the relations between what is in the mind (language skills) and what is in the environment for thinking. Where multiple alternative mental resources are available, the recruitment of those resources will be affected by the properties of the setting (see the vast research on framing of decisions).

With this in mind, one might expect that the answer to the question “Does culture affect the behavior of flight deck crews?” has a similar sort of answer, and should be re-posed as “*Under what circumstances is it useful for a person to use the patterns, processes, and structure of their prior experience as resources for organizing their behavior?*” As was the case for a multi-lingual person deciding which language to use, the answer depends on the context. The recruitment of resources will depend on the requirements of establishing and maintaining coordination with the surrounding activity.

This, in turn, raises other questions. What are the other institutions, activities, settings, in the society from which civil aviation can borrow? What are the activities undertaken by the members of a society and what are the cognitive practices engaged in by the participants to those activities? (see Barker, 1968; Hutchins, 1995a). What other activities does flying culture borrow from? Maritime activities are the sources of the names of roles: pilot, captain (and the captain’s authority and responsibility), engineer, of the now archaic designation of airplanes as ships which still have a rudder, keel, hull (in hull-loss), cockpit, flight deck, lighting conventions and rules of the road. A conceptual blend of airplanes as ships also yields the notion of AirPORTS. In aviation we say forward and aft, but not port and starboard. Military activities are the source of the notions of officers, uniforms, procedures, training styles, chain of command, and sexism.

Flying as a Cultural Activity

Communities of pilots will make flying a cultural activity. That is, they will develop a shared set of understandings concerning what is appropriate and what is not, what feels good, what makes one proud, and also what makes one feel uneasy or foolish or ashamed, what makes sense and what does not make sense. There will be an economy of self-esteem, a system for determining, accruing, and demonstrating one’s own worth. Without doubt pilots will make use of their prior experience, including elements that are associated with national culture, in the process of developing or entering a culture of flying. And this will be true of all the “kinds” of culture. To the extent they can be made visible (apparent) we will see this in national culture, organizational culture and professional culture.

Of that much we can be sure. But now comes the interesting and difficult part. How does a flying culture arise, how is it maintained, and how does it change?

Keep in mind that flying is learned in adulthood in all cultures. It is not an activity that can be fully engaged by children anywhere. Thus, wherever a “flying culture” exists, it is not the native culture of any group. The setting for action, the cockpit or flight deck, is initially foreign to all persons who will be pilots. But, just as one can learn a new language in adulthood, one can learn new culture as well.

Flying culture was exported with the technology from the West to other parts of the world. If that is so, what is the process of the exportation of culture? Is the exportation of an activity for adults or near adults different from some other widely-exported aspects of western culture, e.g. video games, or fast-food practices?

Seeing American Culture in the Flight Deck

While in the jumpseat several years ago, one of the authors of this report was told the story of a pilot who died at home of natural causes. The dead pilot had a long-standing friendship with another pilot in his airline. They had been friends since their days at the Naval Academy, had flown together in Vietnam, and had been hired by this major airline more than 20 years earlier. This long-time friend attended the funeral, delivered the eulogy, and then picked up his recently deceased friend's next trip as a tribute to the friend. While flying the trip, he overran the runway on rollout. The storyteller attributed the overrun to a lapse of concentration on final approach caused by the pilot's grief for his friend.

This story is triply cultural. First, this kind of story telling often has a moral or a lesson. The lesson here concerns the importance of recognizing one's own limitations and declaring oneself unfit for flight on the basis of grief. Such storytelling is a common flight deck activity. It is one of the principal means of establishing and maintaining the shared values of the community. Second, there is a perception that this particular story needs to be told, because its lesson runs counter to some other meanings in the cultural system of the male American pilot. A pilot may ask himself, "Will my colleagues think I'm weak if I declare myself unfit for flight because I'm grieving for a friend?" What are the community standards for this sort of behavior? In modern American civil aviation, what are good reasons for declaring oneself unfit to fly and what are humiliating reasons for doing so? A broken leg is a good reason, illness is not so good, mental illness, depression, anxiety, etc, are bad. This concerns the construction of self-esteem. The relevance of shared combat experience in the history of the friends in the story is that it contributes to this problem. In the culture of the warrior, grief is acknowledged, but it is not a reason to be unfit for duty. As told in the flight deck, this is a cultural story meant to manipulate the culture – if only that of the storyteller. It reinterprets the emotional effects of grief in the context of flight deck operations. Like so much of storytelling in the world of aviation, it may help the pilot to reassure himself that under the same circumstances, he would not make the same mistake. It may also be a claim to the audience that he is the kind of guy who can make such decisions. Third, the story is about cultural processes of making meaning. It involves the way the accident pilot constructed the significance of the bonds of friendship and the duties of a friend. It involves the meaning of a course of action taken as a tribute to a friend. The storyteller presents the act of flying the dead friend's trip as a symbolic denial of the friend's death. The dead pilot lives on in the actions of his friend.

The pieces of the story fit together very nicely. The resources used to construct these meanings are American, but not exclusively so. We do not know how accurate the narrative is, nor do we know the actual behavioral effects of storytelling events such as this one. That is, we do not know how telling or hearing stories like this one affect the decision making process.

This story is also a reminder that the qualities of a pilot go beyond behavior on the flight deck and include decisions about fitness for duty that are made at home or in the operations office.

Change in the Culture of Flying

One way to assess the role of national culture in cockpit operations is to compare across different moments in time in a single national culture. It is clear that North American aviation has undergone significant changes over the past 40 years. The conditions of flight, quality of equipment, nature of infrastructure, organizational relations, and pilot experience base have all changed while the safety record has improved. American national culture has also changed, but probably less than these other factors. Flying was considerably less safe in North America 40 years ago, but few would claim that the improvement in safety is due to changes in national culture. In addition to improvements in equipment and infrastructure, the improvements in safety are probably linked to changes in professional and organizational culture.

How does pilot culture change? Key events leave their mark on the pilot population. The introduction of jets changed pilot behavior, pilot standards, and pilot culture. Is there a way to document the changes in pilot culture that this caused? The crashes of the Airbus A320 early in the program left traces in the worldwide pilot community. A deep-seated mistrust of automation was one result. Many pilots harbor a suspicion that engineers will never be able to anticipate every contingency (Hutchins and Holder, n.d.). Particular accidents and incidents are processed in telling and retelling to embody specific “lessons” for the pilot community. The Sioux City and the Honolulu accidents provide resources in the retelling to highlight the value of pilot decision making and CRM. Valuejet and Swiss Air accidents drive home the lesson that one must land ASAP when there is a fire in flight [Hutchins and Holder, n.d.]. These stories are not known to be causes of behavior, but they do provide justifications for courses of action. They may make some kinds of behavior more likely by providing the means to construct the legitimacy of the actions. The decision to land immediately is less likely to be blocked by considerations of production pressure when the pilot has the lessons of these stories in mind and knows that others know these lessons too. [see Hutchins and Holder n.d., Interview material]. The point is that changes in aviation technology lead to changes in pilot culture with no necessary changes in national culture.

Airline mergers bring clashes of organizational culture. This was a suspected factor in the NWA accident near Romulus, Michigan. In August of 1987, the crew of NWA 255, a departing MD-82, became distracted during a complicated taxi-out and neglected to set the flaps for takeoff. This happened just after the merger, in 1986, of NWA and Republic Airlines. Earl Wiener was called to testify on the use of checklists. This accident was one of the events that led to Wiener’s work with Asaf Degani on checklists (Degani and Wiener, 1990). Earl noted in his testimony that the two pre-merger airlines had very different checklists and different attitudes toward checklist use. Even though US Airways combined Allegheny Airlines, Piedmont, and PSA years ago, internal company relations are still understood in terms of the actions of suits (Allegheny), beachboys (PSA), and PiedMonsters. Of course, the events of September 11, 2001 have changed what it means to pilots to be a pilot. These examples show that professional and organizational cultures operate somewhat independently from national culture. The

events cited in these paragraphs are known to have had caused profound changes in pilots' attitudes and are probably linked to changes in behavior as well.

Formal Ways of Making Culture Visible

Overview of the Problem

All of the work in this area can be placed in the following sort of scheme:

Culture → Patterns of behavior → Operational outcomes (where the arrows indicate causal relations).

The properties of both connecting arrows are unknown. Furthermore, in order to be useful, the representation of the connections must be in a form that supports design activity. Since there is no way to directly access the abstraction called culture, it must be replaced by some representation of culture. Research in this field attempts to address the first connection by replacing it with another term: a representation of culture, and two more connections, thus:

Culture → Representation of culture → Patterns behavior → Operational outcomes.

The first arrow in this sequence depicts some measurement technique. What would it take to make these connections solidly enough to support design decisions? It should be obvious that in order to establish a connection between *anything* and patterns of behavior, it is necessary to have systematic measurements or observations of behavior. Research that does this is rare, in part because making informed systematic observations is a very expensive method. Training pilots are qualified to make observations, but not to interpret them. Interpretation of behavior requires a combination of an understanding of cognition and grounding in context. As explained above, correlation of representations of national culture with accident rates (e.g., Soeters and Boer, 2000) are uninformative because the relations are mediated by many uncontrolled confounding factors, infrastructure, terrain, training, maintenance, and regulatory structure, to name just a few. Although, some authors seem to imply that some sorts of cultural styles are better “pre-adapted” to the problems of flight deck operations, we know of no evidence establishing which styles or traits are best across **all imaginable circumstances** in the flight deck.

The analysis of accidents after-the-fact may identify event sequences that can be attributed to human error, which can in turn be attributed to the culture of the participants. However, we know of no case in which this argument strategy has been applied systematically. That would require that every event sequence – good or bad – be reviewed and examined for the role of culture (national, organizational, professional) in it. Selecting only the cases in which some putative property of the culture contributed to an undesirable outcome is misleading. Selectively choosing examples can make any culture seem as odd as you like. (See Horace Miner's classic “Body Ritual of the Nacirema” (Miner, 1956)). For example, Klein, Klein, and Mumaw (2001) maintain that the imposition of harsh punishments may lead to hidden unsafe practices. Because the measure “harsh punishments” has unanticipated consequences later in time, the authors

offer this as an example of an orientation to time that stresses attention to the present rather than to the future. This cultural trait is said to be characteristic of traditional (non-Western) cultures. The perception that this trait of non-Western cultures produces behavior that is different from that which occurs in our own society requires the systematic disregard of our own history. Edward Tenner's (1996) book, *Why Things Bite Back*, is a well-documented collection of examples of decisions that have produced unintended consequences in American culture. The fear of harsh consequences has produced seemingly irrational behavior in many cultural contexts including those surrounding the sinking of the Titanic, the decision to launch the space shuttle Challenger, the entry into service of the DC-10, and many other examples in the Western world. One explanation for this state of affairs is that the "present orientation" trait is shared across modern and traditional cultures. A more likely explanation is that it is not appropriate to characterize cultures by such traits. Perhaps decisions are driven by institutional settings that come to have similar organization in different cultures. The decision making that goes into managing a complex and dangerous transportation system is a process that cannot be understood as the outcome of national cultural traits that are properties of individual actors.

		Circumstance				
		1	2	3	.	.
Cultural trait	1	O ₁₁	O ₁₂	O ₁₃	O _{1...}	.
	2	O ₂₁	O ₂₂	O ₂₃	O _{2...}	.
	3	O ₃₁	O ₃₂	O ₃₃	O _{3...}	.

Table 1. Matrix of traits, circumstance, and outcomes.

To assess the value of a culture to flight safety, one would have to cross all available cultural behavior patterns or traits with all conceivable flight circumstances. In every case, one would have to measure or predict the desirability of the outcome produced by that cultural trait in that operational circumstance (See Table 1).

The outcomes predicted by traits must vary by circumstance. For example, for every case in which crew resourcefulness saved the day (e.g. Sioux City and Honolulu) one can imagine cases in which deviations from procedures led to disaster. For every case in which greater assertiveness by the first officer might have saved the day, one can imagine an instance of failure of a crew to reach agreement on the appropriate course of action. The perceived need for captain's authority versus first officer assertiveness depends on which phase of flight one is imagining. Imagine the decision by a senior KLM captain to takeoff in the fog at Tenerife. In retrospect, the need for first officer assertiveness is clear. The captain abused his authority. Now imagine the decision to

abort a takeoff at V_1 minus 5 knots². The captain's authority to make this decision alone is procedurally marked, in many airlines, by the location of the captain's right hand on the thrust levers during the first officer's takeoff roll. In some circumstances dialog between the members of the crew is desired. It should be a possibility, and ways of acting and making sense that prohibit this (such as extreme deference to authority) should be seen as obstructions to good flight deck operations. In other circumstances, there is no time for dialog. A decision must be made in a matter of seconds. This should also be a possibility, and ways of thinking or making sense that prohibit this (such as extreme egalitarianism) should be seen as obstructions to good flight deck operations. Fortunately, it is NOT the case that national cultures equip individual actors with rigid predispositions that obtain across all circumstances in all settings.

It is clearly impossible to create a complete trait-by-circumstance matrix. But suppose one had such a matrix, how would one specify the goals of design activity? Is the most desirable system one that guarantees the max-min solution – the least bad worst case. Or would it be better to find the best average performance? Clearly, it does little good to optimize the best performances, because they are already demonstrably better than is needed.

Recall the story of the pilot who flew his dead friend's trip. Decisions about fitness for flight are part of the all-possible-circumstances problem. If one could select a set of seemingly desirable traits, how would one establish that that set of traits produced a desired distribution of outcomes across all possible circumstances, including those that take place before the pilot arrives at the airplane?

It is sometimes tacitly assumed that American culture is somehow especially appropriate to flying, but a glance at the prevailing attitudes in US general aviation indicates that this is not the case. An article on general aviation in the US (Murray, 1999) cites five hazardous attitudes found among American GA pilots. In addition to possible detrimental effects of overconfidence with technical systems (a problem that persists after the transition to commercial transport pilot), the extreme individualism inculcated in primary flight training – marked by elaborate rituals surrounding the first solo flight – must be unlearned in order for a pilot to become an effective member of a flight deck crew. Experience has shown, however, that whatever resources American national culture provides, Americans can be trained to be acceptable airline pilots.

Applying Classical Ethnography

Classical ethnography provides suggestive accounts of potential differences between cultural groups. Applying these ideas to the flight deck requires a strong commitment to essentialism. It also tends to ignore difficult issues surrounding intra-cultural variability.

In a recent paper titled, "Cultural Anthropology Applications to Flight Deck Design" Victor Riley (1999) draws on the work of Edward Hall (1959, 1966, 1976,

² V_1 is the so-called 'takeoff decision speed.' As the aircraft accelerates for takeoff, this is maximum speed at which it will be possible to reject the takeoff and stop on the remaining runway. At and after reaching V_1 , the aircraft is committed to takeoff, even if an engine has failed. Because pilot reactions are not instantaneous, many airlines instruct pilots to make the "go/no go" decision at V_1 minus 5 knots.

1983), a well-known American anthropologist, to bring Hall's insights about culture to bear on the problem of flight deck design. The paper extends Hall's insights by speculating on the implications for flight deck procedures, crew composition, display design, and performance. This is a fine effort, however many of Hall's assumptions and claims are problematic. Many of Hall's claims were based on rather dated and oversimplified models of the role of cultural and linguistic knowledge in thought. It represents a strong form of relativism – the view that every culture is its own system of meanings and that cultures are fundamentally incommensurable. If these strong claims were true, we could never learn about them, since we would be incapable of understanding how the members of any other culture organize their world. Of course, cultures do seem different from each other, and there is no doubt that many cross-cultural misunderstandings do occur. In order to address these issues, one must have an understanding of just how fixed or flexible cultural constellations are.

It is important to note that Hall's books were written during a period in which mainstream anthropology took a relativist stance. Beginning in the 1930s and continuing into the late 50's and early 60's, anthropologists made their field interesting to the rest of the academic world and the public at large by emphasizing the differences among peoples of different cultures. In the early 60's the literature was full of claims about the freedom with which cultures sliced reality into categorical structures. Hall was one of the champions of this view. The beginning of the end (temporarily at least) for relativism came in 1969 with Berlin and Kay's (1969) small monograph on color categories. Their work showed that the ways cultures cut up the color spectrum was not arbitrary at all. There is, in fact, a universal sequence of basic color terms and this sequence is related to the physiology of the human color vision system. This raised the possibility that color categories were more a product of human physiology than of culture.

The difficulties presented by choosing examples specifically to make the case for cultural differences is illustrated by many of the claims made in Riley's paper. For example, consider the claim that in American culture authority and responsibility are diffused across the organization, while in Japan, managers are responsible for the actions of everyone below them. One need look no further than the American military (or to the pilot in command on the flight deck of an airliner) to find an American organization in which responsibility is not so diffused. Every society enacts a number of activity systems having different cognitive challenges and embodying different values. Many of the "cultural traits" described here are probably neither enduring and uniform properties of cultures, nor enduring properties of individual members of cultures. Rather, they appear to be properties of culturally organized settings. That is, put Japanese in a setting in which social distance is salient and you will see deferential behavior. Put an American in a similar setting and you will also see deferential behavior, although it will be differently expressed. Japanese culture probably constructs more settings in which social distance is salient, and has more ways of marking the salience of social distance. This sort of observation raises a fascinating question. Seen as a cognitive ecology, all of the activity systems of a society are potential donors of structure to all of the others. Some share features by virtue of being descendants of others. Each activity system also must interact with local constraints including the purpose of the activity and the institutional, social, and material resources that support it. Now given this complex context for the activity

system (which is itself the context for individual action), how is it that some themes and meanings are emphasized in some activities, but not in others?

The reason that the courtroom activity recruits structures that emphasize the theme of authority is not hard to see. Legal decisions must be made to stick. The recruitment of the resources that enhance various meanings is also part of the cognitive ecology, but is not a purely instrumental choice. It also has an expressive or stylistic component. In fact, the stylistic component is quite important. American institutions often emphasize themes such as individual freedom, even when they cannot enact the values they express. We use our activities to make meanings as well as to do work. The fact that we consistently invoke or express a particular value does not mean that our actions necessarily produce results that embody that value.

What is at stake here is not just the interpretation of a given state of affairs – Americans insisting on egalitarian treatment, for example. What’s at stake is how we use that interpretation to understand or predict what happens when that American person enters a particular activity system called aviation. (Note: substituting Japanese for American in this discussion does not change its meaning.) If we see culture as a monolithic independent variable, then we predict that an American person will always behave like a typical American person, and we go looking for the fixed traits that describe that way of behaving. If we see culture as a short hand for a very complex emergent process, then we predict that American pilots potentially have many ways of making their behavior meaningful in the flight deck setting. What we see there may or may not draw heavily on the seemingly ‘prototypical’ ways of behaving as an American. In some contexts, egalitarianism may be an appropriate value to express. In others, authoritarianism may be an appropriate response. Or, both of these values may be present in different aspects of the same activity. Pilots may treat each other, and perhaps even the cabin crew, as equals. But they certainly do not treat the passengers that way. Consider this excerpt of cockpit behavior:

Flight Attendant (FA) to Captain (C): “Bob, I’m having trouble keeping ‘em in their seats.”

C to FA: “OK, I’ll handle it.”

C to FO: “Dave, I’m off for a second.”

C on Public Address: “Ladies and Gentlemen, we are heading into an area of turbulence. Return to your seats immediately.”

The values of collegiality and equality are expressed in one moment, and values of elitism, social distance, and authority are expressed in the next. None of these values are more characteristically American than are others. Notice in this example as well, that the extent to which the situation becomes a context for the expression of various values is negotiated. That is, a well-behaved load of passengers does not require the captain to exhibit his authority. Every parent knows that sometimes our social roles require us to exhibit values that we would prefer not to see as parts of our identity. So the authoritarianism of the captain is not necessarily part of his cultural makeup, or even part of his personality. His ability to wield authority effectively may depend on his prior experience, but even that experience does not make ‘authoritarianism’ a trait of a person who can effectively exercise authority in institutional context.

Sometimes culture is treated as a collection of “traits” that are supposedly shared by the individuals in the culture. A problematic assumption underlying this approach is

the idea that cultural traits are more or less homogeneously distributed within social groups. Treating culture as a collection of traits may lead to narrow definitions, oversimplifications, and broad generalizations. In the past decade considerable work has been done on intra-cultural variability; that is, the variability of culture (however it is measured) within social groups. The problem is that cultural traits, if such things exist, are distributed in complex patterns across the members of social groups. Any society complex enough to participate in civil aviation will have considerable internal structure. Furthermore, there will be specialization of knowledge, and each adult will engage a variety of roles at home, at work, and at rest. Thus there is likely to be considerable individual variability in the 'cultural traits' one develops.

Another weakness of the culture trait approach is that it overlooks the possibility that cultural patterns emerge from cultural activities in ways that do not require the traits to be enduring properties of the participants. This means that what appear to be 'traits' of individuals may in fact be properties of the relations between persons and settings rather than properties of the persons themselves.

The papers by the Kleins (2001) take a radical essentialist view. They make use of an ideational variant of the essentialist position. For them culture is "a system of values, beliefs, assumptions, and cognition." They make use of a varied set of metaphors to describe culture. It is a blueprint, an ecological response, a lens. The ideational view leads them to assert that "culture is learned from birth, that it shapes behaviors and structures perception of the world." And no doubt it does those things, but the non-ideational component of culture could be even more important in shaping behavior and structuring perception. (See Goodwin, 1994).

The ideational definition of culture has recently made its way into the lay discourse and has been adopted by many researchers interested in the relations among culture and flight deck operations. Reducing culture to a set of shared understandings leads one to overlook the relationships among activity systems. Some of these relationships can be conceptualized, of course, but the more important relationships exist apart from or in addition to the conceptualizations of them. For example, a training activity context has a material relationship to the setting in which the training is to be put to use. No matter how the participants conceptualize this relationship, if the application activity disappears, the training activity will probably also disappear. Or it will produce graduates who have no place to practice their trained skills. If the training activity disappears, the application activity will change or halt. The human-made arrangements in which energy and matter and persons are manipulated are key parts of the cultural process as well.

Applying Hofstede's Approach

There is no denying that people raised in different places appear to have different ways of being, speaking, interacting, and understanding their world. It seems likely that these ways of being will affect behavior on the flight deck. An important tradition of research on this question was begun by Geert Hofstede (1980, 1991). Hofstede's approach is claimed by some to be the "gold standard" of cross-cultural studies (Helmreich and Merritt, 1998).

Summary of the Method

We will give Hofstede's work some attention because it has become established as a dominant approach in aviation and has contributed a great deal to the accepted ways of thinking about culture and workplace activities. It is of considerable sociological importance.

Data

Geert Hofstede read the works of sociologist Alex Inkeles (1959). He became especially interested in Inkeles' claim that there are a small number of problems that every social group must address. These include issues of social power, relations of individuals to the group, and sex role differentiation. With access to IBM's worldwide operations, he was in an ideal position to investigate differences in the ways different societies come to grips with these universal problems. Hofstede created a standard survey consisting of 81 Likert-scale probes. He administered his survey to a very large number of IBM employees in many countries.

Analysis

The compiled survey data consist of a huge matrix in which each respondent is associated with his responses to the 81 probes. Each respondent can be represented as a single point in an 81 dimensional space. Hofstede used a factor analysis technique to reduce the dimensionality of the high-dimensional space. In high-dimensional data, how can one find a space of reduced dimensionality that captures significant structure in the data? With 81 probes, the pilots can be placed in an 81 dimensional space. That cannot be imagined or interpreted. However, it may be possible to capture significant structure in the data in lower dimensional space. Imagine the cloud of data-points in 81 dimensional space. Now find the longest axis of the point cloud. Make that a dimension of a new space. Each data point can be given a value on that new dimension. Find the next longest axis of the cloud of data points and make that a second dimension in a new space. Each data point can be given a value on that dimension. The data can now be plotted in 2 dimensions. Of course, much of the structure of the data will probably be lost in doing that. How much is lost? That depends on the structure of the data. Each of the new dimensions accounts for some amount of the variability in the original data. Suppose the first dimension accounts for 15% of the variability of the original data and the second dimension accounts for 12%. Together, they account for 27% of the variability of the original data. If that is not sufficient, then continue the process. Find the next longest axis in the cloud of data points and make that a new dimension. If that new dimension captures 10% of the variability of the original data, then 37% of the variability of the 81 dimensional data can be captured by representing the data in three dimensions. One can continue the process out to 80 dimensions. For 81 probes all of the variability can be captured in 80 dimensions.

What do the new dimensions mean? In the original data, each of the 81 dimensions is interpreted as a representation of the responses to the particular probe. The interpretation is that pilots who are high on that dimension agree with the assertion expressed in the probe. Consider the first dimension in the new space. What does a high score on that dimension mean? It is not so easy to see. In order to interpret the meaning of that score, it is necessary to see how that dimension correlates with the dimensions that

represent the original probes. The new dimension is defined by correlations among a number of original probes. If the researcher can find a theme that seems to be common to the probes that correlate highly with the chosen dimension, then the new dimension may be given name that expresses the theme. Typically, it is easy to find plausible names for the first two or three dimensions. Beyond that it often becomes quite difficult to provide plausible interpretations for the factors representing data of high dimensionality.

Findings

Hofstede identified and named four dimensions of culture: power distance, individualism/collectivism, masculinity/femininity, and risk tolerance. A fifth dimension, 'orientation to time,' was identified later via a survey designed by a colleague working with Chinese.

The societies can be ranked on these dimensions on the basis of the average scores of members of the societies on the probes that are taken to represent the dimension. Societies cluster roughly by region. The claim is that people in these societies are, on average, more interested in or concerned with the content of the dimensions on which they achieve high scores.

Replications in Aviation

The seminal work of Hofstede has been replicated in the world of aviation. Much has been written about the success or failure to replicate Hofstede's dimensions as if the cultural dimensions tap essential qualities of the persons in the measured societies (Helmreich and Merritt, 1998 for example).

Proceed with Caution

Probes

The content of the "dimensions of culture" depend as much on the choice of probes as they do on the behavior of the respondents. The four dimensions identified by Hofstede fit the cultural universals identified by Inkeles. This was taken by Hofstede to be a surprising and heartening empirical finding. But, we know that Hofstede composed the probes to sample a particular set of concerns of social living. In fact, the content of the dimensions is as much a measure of the choice of probes as it is a measure of the nature of culture. Hofstede reports that a new dimension was added by creating a new questionnaire. Hofstede takes the fact that the new questionnaire was created by a colleague working with Chinese as evidence of culture at work. That may be correct, but it also shows that the choice of the content of the probes determines which dimensions will be discovered.

Hutchins et al., (1999) found this in a replication of Earl Wiener's classic study of attitudes towards automation. An examination of the probes constructed by Wiener make it clear that he set out to measure comfort with automation. His interviews with pilots and jumpseat observations told him that this was a major concern for pilots. It is no accident, then, that comfort comes out as the first principal component in the analysis. With the chosen set of probes, this result is impossible to avoid. No matter who the respondents

are, most of the variability will appear across the conflicting probes that will later be labeled comfort with automation.

Another problem is that Hofstede constructed the operationalized measures of the four dimensions by selectively attending to the three or four probes that had the best intercorrelation in the selected dimension. Helmreich and Merritt did the same, and their construction of a 'command' score illustrates a difficulty with this approach. Helmreich and Merritt combined "eight items addressing command roles and command interactions...to form a composite score" (Helmreich and Merritt, 1998:77). Among the eight items are "the captain should take control and fly the aircraft in emergencies" and "crew shouldn't question the captain's decisions". Helmreich and Merritt say, "Low scores on the scale reflect low power distance as conceptualized by Hofstede, that is, there is less distance between the captain and crew and communication is openly initiated in both directions" (p. 77). The problem here is that combining these items assumes something that needs to be measured. The combination of probes assumes that social distance and poor communication always go together. If there were a culture in which large social distances were accompanied by good communication, the instrument as constructed could never discover this fact. The combination of items into the composite score reflects assumptions about the social world that may seem plausible in an American context, but that may not hold in other settings. Thus they build the expected result into the measurement apparatus.

Dimensions

Unfortunately, none of the researchers report how much of the variance was accounted for by the 4 "dimensions of culture." The cumulative variability accounted for by the first four factors is critical because it provides an indication of the degree to which the selected measures model or represent the structure of the responses. It is also useful to know the variability accounted for by subsequent dimensions. We have not seen it reported.

We also need a comparison of the variability within nations with that between nations. Hofstede used combined scores for all nations. That is, he combined the scores for all individuals from each nation into a single measure of central tendency. This imposes sameness on members of a nation and removes the possibility of determining whether intra-country variability is higher or lower than inter-country variability.

Combining scores for respondents from each nation makes a strong *a priori* commitment to the reality of national culture. Another approach is to determine clusters of respondents empirically, and then compare the empirical clusters to the demographic category structure. It would be interesting to take Hofstede's or Helmreich and Merritt's data and cluster the respondents on the basis of their individual response profiles first, then see if there are good correlations between those clusters and the groupings defined by the county or region of origin variable.

Measurement

Treating culture as an independent variable and attempting to measure its effects via attitude surveys provides a sense that something is being reliably and accurately measured. Quantitative measures have high value in engineering culture. The method is

sensitive to differences in the behaviors of pilots from different countries. But what is being measured? And how is it related to behavior in the cockpit?

The attitude data collected by Hutchins, Holder, and Hayward (1999) seemed to be good indications of a prevailing set of beliefs about flying and automation, but seemed only loosely related to the actual experiences of the pilots who participated in the survey. The remarkable stability of the data over a decade of time, across two different airlines, and across huge differences in amount of automation experience, indicate that the measures are not sensitive to differences in actual experience. If the instrument were a measure of attitudes as consequences of experiences with automation, we would expect great variability where we see almost none. Furthermore, a content analysis of the transcripts of interviews with airline pilots who had little or no experience with automation highlighted the same themes. In fact, it is possible to predict from an analysis of ethnographic data which probes will generate uni-modal response profiles and which will generate bi-modal profiles. (Hutchins, n.d.b). The possibility that attitude surveys measure relatively stable cultural beliefs that are relatively independent of the actual experiences of pilots raises concerns about conclusions drawn from this sort of data. A report by the Australian Bureau of Aviation Safety Investigation sounds the alarm about the behaviors of Asian crews based on their responses to an attitude survey without any data about actual behaviors.

Another cause for concern is that response profiles for Likert scales are often bi-modal. That is, many respondents agree strongly, and many others disagree strongly with few providing neutral responses. When that is the case, averaging across respondents can confuse meanings.

Significance

Even if the dimensions of culture are an artifact of the construction of the list of probes, it is still the case that people from different cultures give systematically different responses to those probes. Does that show that pilots from the various cultures are different?

The scale values for the various cultural dimensions are constructed on the basis of the variability in the data. The only way to know if the measured differences are great enough to have behavioral consequences is to measure behavior. Statistically significant differences among average scores for different societies can be found. The question that concerns us here is not the strength of the statistical effect, but the strength of the supposed underlying factors in a causal model of the organization of behavior. That is, do the factors that are measured by this instrument play a causal role in the construction of meaningful courses of action in the target context of flight deck activity? The answer is simply not known. It is possible that the surveys are extremely sensitive to slight differences in the weighting of various interpersonal factors. If that were the case, the measured differences between societies might have no behavioral correlates in the domain of interest. Not only is there no causal evidence, even the evidence of correlation between values on the dimensions and patterns of behavior is lacking.

Are these dimensions the things that matter? If they are, do they matter enough to have measurable effects on behavior in the flight deck?

Ecological Validity

The activity contexts in which the traits are identified (if the activity contexts are even specified) are often both distant from the activities of aviation and have unknown relations to behavior in other settings and contexts. The extent to which the context of elicitation mirrors the constraints of the real-world context of interest is known as ecological validity.

One must know about not only the representativeness of the elicitation context, but know its dynamics in detail as well. This could also be stated as a sampling problem. Every elicitation context (attitude survey, interview, simulator session, e.g.) samples behavior in one activity context. How does one establish the relationships between the patterns of behavior exhibited in the elicitation context and the patterns of behavior exhibited in the target behavioral contexts? Imagining the existence of hypothetical entities called cultural “traits” that are assumed to be enduring properties of all, or virtually all, individual actors in a particular society is a way to wish this problem away. Cultural traits are assumed to be causes of patterned behavior that are effective in all contexts of activity for all members of a particular social group. That is, they are assumed to transfer across contexts. While it may be possible in principle to sample a wide variety of behavioral contexts, in practice, it is almost never done. (An exception is Barker’s (1968) work in the mid-West).

Helmreich and Merritt claim in the introduction to their book that the quantitative data are supported by observations, but no such analysis is presented (1998). The question of how the behavior of pilots in the context of attitude probes is related to the behavior of those pilots in the cockpit is answered only by folk psychological speculations. If evidence could be found linking values on the dimensions of culture and patterns of behavior in the target domain of flight deck activity, would we be able to determine the safety consequences of those patterns of behavior? This is another missing piece.

Translation

Kuroda and Suzuki (1989) warn of the dangers of translation effects in cross-cultural surveys. "All three nationals seem to respond differently to the same questions when they were asked to respond in a foreign language as opposed to their own mother tongue". (p. 151) One must wonder to what extent the results of cross-cultural surveys are measuring effects such as these or effects of the context of responding to a survey?

Wanting to See Culture

Noun phrases such as “high power-distance culture” are easily formed in English. It happens without much reflection, but it has important consequences. Many of the researchers in the tradition of Hofstede engage in this linguistic practice. Coining this phrase conceptually brings into being a new kind of thing, a culture with certain persistent qualities. Does such a thing really exist?

Summary

This research tradition relies on an undemonstrated link between behavior on surveys and actual behavior in the flight deck. The assumption of essentialism makes it

seem at least **plausible** that the surveys measure enduring underlying dispositions of actors and that those dispositions will shape the actor's behavior in other contexts. The results are **suggestive**, since the probes measure attitudes toward behaviors that have been observed anecdotally in other contexts.

The results are also **problematic** because the industry simply lacks the observational data that would be required to establish the relation of the behavior in the survey context to behavior in the flight deck. The ecological validity of the elicitation context is an open issue.

Cognitive Ethnography of Flying

It is not enough to observe in the cockpit. It is also necessary to record, to represent and to interpret what has been observed. The cognitive ethnography of flying offers an alternative approach to understanding culture in the flight deck. Two research groups have undertaken extended, explicitly ethnographic, investigations of commercial transport pilots. In the U.S, our group at the University of California, San Diego has used a variety of techniques over the past 13 years to better understand the world of the airline pilot and pilots in general. Over approximately the same period of time, in France, the group "Aeronautique et Société" led by Alain Gras has been observing and documenting the behaviors of pilots flying all sorts of airplanes, and designers involved in the introduction to service of the Airbus A320. While the two research groups are situated in different national cultures and focus on pilots from different national cultures, the most striking aspect of the comparison of their results is the similarity of the attitudes of pilots in the two cultures. For example, Scardigli reports the following statements from French pilots concerning the A320. "*C'est un bel avion, très performant, mais je m'attends un jour à ce qu'il m'envoie au tapis.*" 'It's a nice airplane, a good performer, but I'm just waiting for the day it sends me into the ground.' (Scardigli, 2001:39) "*Le constructeur nous cache des choses*" "The builder hides things from us." (Scardigli, 2001:39-40) "*Qu'est-ce que va me faire l'automate?*" "What is the automation going to do to me?" (p.45). Of course, these sentiments are echoed by American pilots flying the same airplane.

Ethnographers participate with people in their everyday lives. They learn the local language, and as much as is possible, learn to do what the people under study do. The ethnographer has several jobs. The first of these is to figure out what things mean to the natives. Any intelligent native knows what things mean. A second, very important job is to document the systematicity of meanings so that one can say not only what things mean, but why things mean what they mean. This second job is not something that can be expected of natives. It takes special training and effort. It is accomplished through the creation of representations of systems of meaning.

To illustrate how an ethnographic approach might shed light on the role of culture on the flight deck let us consider just a few seconds of routine interaction in a simulated flight³. A 727 on a simulated flight from Sacramento to Los Angeles has a filed cruise

³ The data come from videotape recorded as part of a study conducted by Gary Klein at the NASA Ames research center in 1989. The event took place as part of a pilot workload study. The event described here has no workload issues. The crew is composed of qualified pilots from a major airline.

altitude of FL330 and a current clearance to FL230. Passing FL190, the captain (pilot not flying) calls ATC and says, “Oakland Center, NASA 900, request higher.”

That is a completely routine fragment of flight deck behavior. When examined in detail, it reveals many issues that may be relevant to the role of culture on the flight deck.

First, this utterance is constructed in a conventional sequence, callee, caller, content. This is a standard convention for radio transmissions that reaches well beyond the culture of aviation. The shared understanding of this conventional form makes it easy for participants to parse aspects of the meaning that are not explicitly represented.

Second, the communication is telegraphic. It does not conform to standard English syntax. Connectives and articles are omitted. Even central content words have been omitted. Notice that all participants know that this utterance is about the altitude clearance, the word ‘altitude’ is not spoken. The telegraphic nature of the utterance is an emergent property of the technology (VHF radio – line of sight, the possibility of being “stepped on” by another transmission, etc.), the activity (ATC communications), the environment (traffic density), and culturally shared knowledge about the tasks that are undertaken in this setting and the division of labor that is appropriate for accomplishing those tasks. In this community crisp, telegraphic radio technique is considered a sign of professional competence.

Third, the utterance is grounded in the pilot’s complex situation representation and problem solving, which may include considerations related to fuel consumption, aircraft performance, the positions and velocity vectors of other airplanes, passenger comfort, and operating simplicity (to mention just a few). Fourth, the utterance is a particular sort of speech act, a request. This is important because the request structure contains a complex set of presuppositions about the relationships of the participants to the activity. Demands and notifications are rare speech acts for pilots communicating to controllers (at least in the US), because these types of speech acts violate the implicit terms of the pilot/controller relationship. Each communication act is a subtle re-negotiation of the relationship. Pilots also modulate cadence and tone of voice as parts of this negotiation.

Finally, some, but not all, American pilots are comfortable making requests to ATC. Some segments of the American general aviation community are willing to go to great lengths to avoid talking to controllers, much less making requests to them. The willingness to make a request to a controller in American culture may be affected by a number of factors. The usual practices in the community into which the pilot has been integrated will have a strong effect on willingness to make requests. In some communities, the communication practices may have inertia. The perceived relationship between pilots and controllers can be important. In the US control activity is referred to as a ‘service’ (FAR-AIM). The ‘service’ construction carries presuppositions about relationships between, and responsibilities of, service providers and service users. The choice of representations here reflects a history of development of the activity. Some pilots have visited ATC facilities and know something about the nature of the controller’s work. The official relationship between the agency operating the aircraft and the agency providing control activities may affect the willingness to make a request. Many American airline pilots believe that they are paid more and command more respect from the public than controllers do. Finally, what pilots think it means to be a pilot and what pilots think it means to be a controller may matter.

These brief paragraphs are intended to illustrate the complexity of the cultural context in which a routine communication with ATC takes place. Even in this example where the authors (and presumably most readers) are well versed in the national, organizational and professional cultures surrounding the activity, it is difficult to identify the boundaries of the different sorts of culture. The ethnography of flying provides explicit warrants for each claim concerning the elements of the activity (see the papers listed below for details).

Suppose qualified observers reliably report that pilots of a particular nationality consistently fail to request re-routing around adverse weather. What could one infer from such an observation? A modern theory of culture and cognition would direct attention first to the context of the behavior. Some of the factors described in the paragraphs above are probably features of a universal professional aviation culture. For example, we expect telegraphic speech to be a characteristic of ATC communications anywhere there is frequency congestion. Other factors are known to vary across pilot communities (even within North America). For example, considerations of passenger comfort are part of the meaning of the pilots' job and can be expected to vary. The relationships between pilots and controllers are probably also constructed in different ways in different national and organizational contexts.

Only when explanations grounded in the context of activity have been exhausted will it be reasonable to resort to the attribution of culturally determined cognitive processes. (Cf. the injunction on special cognitive explanations offered by Latour, 1987). Thinking requires both process and representation. One cannot infer the nature of process in the absence of well-documented representations (Hutchins, 1980). Representations and task demands are discovered and documented using cognitive ethnography.

The excerpt of activity described above was taken from Hutchins and Klausen, (1996). The central argument of that paper is that professional culture drives shared expectations and supports "common ground" or intersubjective understandings. Hutchins (1995b) shows how cultural processes locate and save partial solutions to frequently encountered problems. Designers often fail to foresee the solutions discovered by pilots. Cognitive processes are enacted in carefully crafted environments for action. Knowing all about what is in the pilots' heads is not enough to understand cognition on the flight deck. Hutchins and Palen (1997) shows how communication on the flight deck includes complex acts that integrate gesture, space, and speech in shared complex meaningful space. Perez (1996), Holder (1999) shows that it is not just communication that determines outcomes, it is the way communication is organized with respect to a shared meaningful world. Hutchins and Holder (2000) use interview data and jumpseat observations to show how pilots interpret the behavior of complex automation using very simple models of flight dynamics. Hutchins (n.d.c.) demonstrates how pilots draw on many resources to represent risk. Some resources can be identified as belonging to American national culture, others to professional flying culture. Scardigli, Maestrutti & Poltorak, (2000) examine the cultural beliefs of French test pilots. Scardigli (2001) is an extended reflection on the differences between the cultural expectations and goals of designers and those of pilots. Most interesting is the fact that the French pilots described here look so similar to American pilots. Gras, Moricot, Poirot-Delpech & Scardigli (1994) provides an ethnographic grounding to the introduction of the A320.

National culture does not determine the possibility of learning to act in accordance with what Boeing considers to be the “universal virtues.” It may affect the process required to socialize or enculturate people into a ‘culture of flying’ that supports and values, and gives meaning to acting in accordance with the universal virtues. In this light, CRM can be seen as a way to try to move North American pilots closer to the desired culture of flying.

Methodological Implications of a New Theory of Culture

The role of activity systems is not addressed by the current approaches to culture and flight deck operations. It is left to the reader to imagine the nature of performance in such a way that the supposed traits of culture could have an effect. In the application of classical ethnography, the traits are taken to be deeply embedded in the psyche of the people and have their effects in behavior. In applying Hofstede, the dimensions of culture are assumed to point to dispositions to act in particular ways. Readers are asked to use their everyday understandings of the situation to try to imagine when the participants might invoke the dispositions implied by the dimensions. This is the role of the anecdotes inserted into the Helmreich and Merritt book.

The position that culture is at work in all flight deck activities, be they formal activities that are instituted or spontaneous activities that are based on the immediate circumstances being encountered, requires a new approach to the study of cultural effects on behavior. We must move away from the work of Hofstede and his supporters and move towards the careful examination of the activity of flying via ethnographic research. It is crucial to preserve the character of the activity itself in the study--why ethnographic methods are required. Many of the interesting properties of complex functional systems (like the flight deck) emerge from the interactions that occur there. Once we begin to decompose the system into its working pieces (pilot, flight deck, procedures, etc.), culture and other interesting properties tend to disappear. This is why culture seems to be elusive.

Towards an Improved Method

The methodological question for this paper is, “Is it possible to replace speculation with observation?” A method that replaces imagination with observation would have to accomplish two things. First, to examine on-going behavior and identify the resources used to organize the behavior⁴, and second identify the sources of the various resources. This is difficult because courses of action are very complex making it difficult to notice what the pieces are that come together in the construction of activity.

When we attempt to understand behavior on the flight deck we face an ontological challenge. Behavior draws upon a mix of resources, some are material, some social, and some mental. Are these the correct categories of resources or should they be labeled in some other way? Perhaps using terms that define the kind of culture they are drawn from, national, organizational, and professional, is more appropriate. And finally, where are the leverage points to influence and guide behavior, in material structure and

⁴ See Hutchins, 1974, Towards an analysis of interpretations of on-going behavior for a discussion.

professional experience? In moving a method forward, we need to make some theoretically informed choices about how to study flight deck behavior.

Methodological Implications of a New Theory of Culture

Studying culture as an emergent pattern requires a shift in the theoretical application of ethnographic methods. We believe ethnographic methods are suitable methods, however the application—data collection and analysis of data—requires a new approach based on the principles of situated, embodied, distributed cognition, (or contextualism). The new theoretical focus is oriented toward the identification of patterns of interaction and emergent properties of activity systems and the resources people draw upon to construct meaningful courses of action.

Making Culture Visible Through Cognitive Ethnography

Humans are highly adaptable creatures and are capable of adapting locally to the patterns present in the activities and practices they engage in. Patterns of interaction are shaped by the local physical, social, and conceptual space as well as the larger activity systems in which they are embedded. Culture is always present in the processes that construct activity, the difficulty lies in making culture visible. The resources used in the construction of meaningful actions could be drawn from a wide range of sources and we need to know which resources are recruited and why, and how the system is constrained by the application of those resources. The aim is to understand the organization of behavior in the system, how it becomes organized, its structure, and the resources used in the process of structuring activity. Such an approach is the first step toward understanding the role of culture in the organization of pilot activities when they fly. Hutchins (1995a) demonstrates that this is possible for highly rationalized settings.

An important part of this approach is the commitment to sampling behavior in the context of interest—here it is flight deck operations. If, one observes the behavior of actors in the aviation system, it is no longer necessary to make the mapping from elicitation context to target context.

The context of the activity has important implications for the organization of behavior. The physical layout of the cockpit defines a physical context for organizing activity. The layout introduces constraints on the range of pilot behavior in relation to the display panels and to other crewmembers. For example the layout may enhance or obstruct the flow of information in the cockpit or communication patterns between pilots. It might define a context for the distribution of workload as well as social interaction between crewmembers. It might constrain certain patterns of physical movement and facilitate other patterns of physical movement. These patterns of movement have important implications for actions that are observable (and thus the ability of each pilot to monitor the other's activity) and in setting the stage for patterns of coordination of activity. It also determines the kinds and range of possible pilot-machine interactions and crew-machine interactions.

Context is not limited to the physical setting. Social context and conceptual context are also important and deserve careful analysis. The social context for each flight is set up and negotiated via crew interactions. It is embedded in the institutional setting of airline and regulatory agencies. The crew establishes a social context, explicitly or implicitly through their initial interactions and ongoing interactions, for flying,

motivating, discussing, and establishing authority. For the social context we can ask the same set of questions we pose to the system. What are the circumstances under which these contexts are established and what resources are recruited? A large piece of the social context is established through communication patterns. Communication might occur across various trajectories such as between a pilot and the cockpit interface, with another crewmember, or with external sources such as the air traffic control authority or company dispatch. Interactions with the social and physical context influence how pilots organize their behavior across various flight situations. The interaction between pilot knowledge and displays can influence how pilots perceive the flight situation, make decisions and judgments. The social-conceptual interactions between pilots might influence how pilots negotiate a course of action.

It is important to remember that none of these interactions occur in isolation. They are all integrated into a stream of on-going activity that influences the organization of behavior which influences the structure of the organization, and so on. But to conduct an analysis of a functional system requires an analysis that allows us to look carefully at the details of the activity without losing sight of the activity as a whole.

Data Collection and Analysis

The data collection method a researcher selects is critically dependent on the questions he is posing. A study investigating differences between national, organizational, and professional culture, would probably require a different set of methods and theoretical orientation than a study of the nature of flying. We feel the latter approach is more productive because it highlights the activity of piloting and everything it entails. We need to concern ourselves with the range of behaviors that pilots bring to the cockpit and how to design to support safe flight operations. The approach we present in this section is intended to identify the range of behaviors that pilots exhibit in the cockpit. Attributing the range of pilot behavior to differences in national, organizational, regional culture is simply one way to address the differences in behaviors exhibited by airline pilots. The issue that needs to be addressed isn't so much about cultural differences as it is about the range of behavior exhibited by pilots when they fly (the range of relevant individual differences). Thus the cockpit becomes the base, or foundation, or facilitator of activity, particularly interactions. For example, some pilots brief and develop shared understandings of the autoflight system and others do not. Our concern isn't so much why they behave differently but how would we design to support both kinds of behaviors so that the crew will fly safely

It is possible that patterns of national culture interact with training and institutional settings in ways that produce particular (undesirable) practices in the flight deck. We propose to begin with the behavior on the flight deck. If undesirable practices occur regularly in a population of pilots, we will first attempt to understand the cognitive ecology of the practice. This means addressing questions such as the following: How is this practice related to or supported by other practices, equipment, social relations, politics, cultural models and expectations? What needs does it satisfy? What are the observed operational consequences? We will make systematic observations of the practice in the conduct of on-going activity.

Methods

There are issues with every kind of data collection method, consequently it is important to use several different techniques to converge on the phenomena of interest. To see culture at work requires going to the context where the activity occurs. We favor methods that bring the ethnographer into direct contact with the pilots. These methods include participant observation, direct observations, and interviewing. Ideally, the following kinds of data should be collected:

- Interviews with pilots
- Video recordings of pilots flying in full-motion simulators
- Observations of pilots flying at various stages of their careers
- Participant observation in pilot training.

It may be that many of the practices, values, beliefs, that pilots use as resources on the flight deck are formed in the early stages of a pilot's flying experience. The question of how much of the pilot's early training (primary through commercial ratings) is responsible for the patterns of behavior that arise later on the flight deck, is one that warrants further study.

As we have stated elsewhere, pilots learn flying in adulthood. If childhood experience is thought to shape beliefs and practices and behavior, it seems reasonable that the place to look for the interaction of natal culture with flying behavior is in early flight training. Early flying experiences are closer in time to the early cultural experiences that essentialism holds to be critical. Furthermore, early training is less regulated, and so can be expected to draw more extensively on organizing resources from the surrounding national cultural context.

Interviews and observations of pilots at various stages of flying experience could provide a sampling of the culture of piloting and of when and how patterns of behavior become established. This would give us insights into pilot culture and what kind of activity flying is for pilots and how those ideas develop. The broad view is to understand the process of enculturation of pilots from the very early stages of their development as pilots to latter stages of airline operations.

Seeing professional culture requires exposure to the organization. To know how a pilot flying for a particular country and/or organization is trained, and the content of the training, assumptions that are made, and expectations, requires exposure to the organization's training process. Interviews and observations would need to be conducted at the professional airline pilot level to address professional and organizational cultures and their resources.

The current restrictions on access to flight deck jumpseats may limit direct observation access to flight operations, but this is a good method that should be considered when restrictions are lifted. Video of pilots flying in high fidelity full-motion flight simulators would provide the opportunity for a detailed activity analysis. Video provides the opportunity to record, represent, and interpret what has been observed. Video analysis would also provide an opportunity for a comparative analysis of piloting behavior across organizations and nationalities. Pilots from different U.S.-based airlines would fly a specifically designed scenario that would be video recorded. The next step would include pilots flying for foreign airline carriers. In the analysis the details of activity could be tracked: speech, gestures, display interactions, and flight situations. Special attention would be given to the movement of representations and the resources

pilots use when they engage in flight deck activities. The analysis would aim to identify stable patterns that emerge when pilots fly and the conditions under which those patterns emerge and change. Once patterns are identified, a comparative analysis of crew behavior in terms of the resources they use and the patterns of interaction that emerge could be pursued. It would be too limiting to only identify patterns that compromise flight safety; patterns that result in safe and efficient flight operations also need to be made explicit.

It is important to look at the details of the activity to understand the organization of behavior, but it is equally important to look at the activity as a whole to understand how pilots experience the activity of flying. A detailed analysis of the activity system would address what is happening in the cockpit and what the pilots do in the activity system. How does behavior on the flight deck become organized? What is the structure? What is the organization? What are the circumstances under which the organization changes? At the broader level the issues are about the activity of flying. What sort of activity is flying for airline pilots? How do pilots experience flying? The answers to these questions may be linked to the kinds of resources they draw upon to construct meaningful courses of action, establish responsibility, interact with crewmembers, and so on.

Summary

We expect this kind of analysis to be of great benefit to Boeing, particularly for the design of future flight decks and the design of procedures and training. The analysis would identify the kinds of organizing structure in the flight deck that might facilitate the desired structure of behavior. If we are to design cockpits that are insensitive to “culture” we must understand why pilots do what they do regardless of their cultural upbringing. The overall goal is to design flight decks, procedures, and training programs that create the best performance across the most number of crews. Boeing begins with the design assumption that the airplane is to be flown by a single pilot and gives less emphasis to the fact that there are always at least two pilots in the cockpit (pilot, copilot, autopilot). Consequently they do not design to support interaction they design to support control by a single actor. Once we identify the interaction patterns and emergent properties that facilitate safe flight operations, design guidelines and principles could be developed. For example, the cockpit is designed to support the technical organization of activity but this organization constrains social interaction because it requires that communication be clear, fast and accurate in order to be effective (Segal, 1995). But spoken language is ephemeral. There may be a way to organize the activity differently so that the demand for accurate communication is not so necessary. A cockpit design that prevents the loss of communicated information might look quite different from the cockpits of today.

Conclusion

The behavioral sciences are still struggling to understand the processes that create the regular patterns of behavior, which are identified as culture. A modern theory of culture is needed to further our knowledge and understanding of the processes that participate in the organization of behavior. Modern theories of cognition (contextualism) pose a different set of questions about the organization of behavior in the flight deck than are posed by traditional theories (essentialism). Contextualism shifts the analytic focus

from the properties of individuals to larger units of analysis in which it is easier to see the accomplishment of cognition in interaction with material and social structure in the environment of thinking. This shift in theory requires a corresponding shift in method. We propose a methodology with cognitive ethnography as its focus, supplemented by other methods for convergence. Ethnography provides a means of systematically documenting activity and the resources used to organize a course of action. What is the correct balance between internal and external structure in causal explanations of behavior? We do not yet know, but we think it will involve a new theoretical understanding of the relations between what is in the mind and what the mind is in. Only when we understand the properties of the relations between persons and settings, and the relations between activity systems can we begin to answer our central question: *Under what circumstances is it useful for a person to use the patterns, processes, and structure of (their culture[s]) activity systems in which they have participated as resources for organizing behavior?*

Moving the problem of the organization of behavior from the interior of the mind to the interaction between the mind and a social and material environment for thinking makes it easier to see how people can learn culture in adulthood. What is needed is a focus on the organization of behavior, rather than focus on the influence of culture on behavior. This change is scientifically appropriate because it makes fewer a priori assumptions than essentialism does about the nature of culture and about the nature of human actors in the aviation system.

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Appendix 1
Infrastructure and Safety:
Edwin Hutchins

Airplanes are only part of the commercial aviation system. The other parts include regulatory structure, facilities (airports, navigation and approach systems, etc.), weather forecasting, charts, mail services (to deliver charts), education, maintenance, and more. Accidents tend to involve interactions among multiple elements of the system. Therefore, differences in accident rates may be driven by differences in infrastructure.

I tried to explore the relationships between a measure of commercial aviation safety with various indirect measures of infrastructure development. The as yet untested hypothesis is that infrastructure will be a better predictor of aviation safety than any measure of ‘cultural dimensions.’ The measure, ‘Safe Depart’, is computed for each region by dividing the percentage of worldwide departures flown in that region by the percentage of worldwide fatal accidents in that region. (This result is multiplied by 100 for plotting purposes⁵.) The result can be thought of as the percentage of departures achieved in the region relative to the rate of departures that would be expected given the overall worldwide average rate of safe departures. For example, North America accounts for 42% of worldwide departures, but only 21.1% of fatal crashes. Thus, North America has about twice as many (199%) departures as would be expected if it had the worldwide average crash rate and the observed number of crashes. Africa, on the other hand, with 3% of worldwide departures, and 13.2% of worldwide fatal crashes, only has 28% as many departures as would be expected if it had average safety and the observed number of crashes.

The data are from two web sites. The accident data come from <http://aviation-safety.net/statistics/byregion.html>. These data collapse Australia and Asia into a single category. The figures provided on the site report “percentage of world (scheduled airline) aircraft departures, based on ICAO statistics” and “percentage of world fatal airliner accidents, based on Aviation Safety Network statistics of the last 10 years (1991 – 2000)”. To create an accident rate figure, I divided % crashes by % departures. (for plotting purposes, this is multiplied by 100.) As an indirect measure of aviation infrastructure, I used the percentage of countries in a region “rated category 1 (meeting ICAO standards) in FAA’s International Aviation Safety Assessment Program.” This is labeled “ICAO Cat 1” in the tables.

The development statistics come from <http://www.unep.org/geo2000/english/>, an English language version of the UN Global Environmental Outlook 2000 project. Gross domestic product is a measure of overall wealth. Energy consumption and caloric intake are indirect measures of infrastructure in essential sectors. It seems plausible that a poor nation with weak infrastructure for energy and food will probably not be able to support a

⁵ These multiplication operations do not affect the strengths of the correlations.

first-rate aviation infrastructure. GDP/cap is per capita GDP x100 in 1990 US \$. Energy is per capita annual energy use in Giga-joules x 100. Calories is per capita daily intake of kilocalories x 10 in food. I believe the region structure for this data set is comparable with the aviation safety data.

The raw data and correlation matrices now appear as follows: (see figure next page for plotted raw data).

	Safe departure rate.	Invert accident rate.	% departures/	% crashes	
	Safe depart	GDP/cap	Energy	Calories	ICAO %cat1
N. Amer	199	220	343	356	100
Europe	144	100	132	320	56
Latin Am	46	30	42	278	39
Asia	65	20	29	260	37
Africa	28	5	12	243	9

XLSTAT - Correlations analysis / Started on 04/02/2002 at 8:36:34 AM

Correlation coefficient type : Classical

Data range : Workbook = regional-comparisons.xls / Sheet = Sheet1 / Range = \$B\$152:\$G\$157

Number of additional rows : 0

Number of additional variables : 0

Number of rows removed before computations : 0

Correlation matrix :

	Safe depart	GDP/cap	Energy	Calories	ICAO %cat1
Safe depart	1	0.9647	0.9447	0.9702	0.9456
GDP/cap	0.9647	1	0.9969	0.9641	0.9637
Energy	0.9447	0.9969	1	0.9423	0.9563
Calories	0.9702	0.9641	0.9423	1	0.9617
ICAO %cat1	0.9456	0.9637	0.9563	0.9617	1

The safe departure rate is very strongly correlated with all the measures of infrastructure. It is more strongly correlated with caloric intake than with any other measure including the percentage of nations in the region meeting ICAO category 1 standards. I suspect that these correlations will be even stronger when we use national data rather than regional data and have a better measure of the quality of aviation infrastructure. In light of the data on infrastructure, only a tiny fraction of the variability in the data remains for culture (or any other factor) to explain.

The plotted data look like this:

