Eastern Minds in Western Cockpits: A Cross-cultural Comparison of Aviation Mishaps by Applying Human Factors Analysis and Classification System (HFACS)

Wen-Chin Li & Don Harris

Human Factors Department, School of Engineering, Cranfield University, Bedfordshire, MK43 0AL, United Kingdom

Tel: +44 (0) 1234 750111 ext.5189 (W. Li)
+44 (0) 1234 758227 (D. Harris)
Fax: +44 (0) 1234 758209

E-mail: w.li.2002@cranfield.ac.uk (W. Li)
E-mail: d.harris@cranfield.ac.uk (D. Harris)

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ABSTRACT

Introduction: Aviation accident rates are varied in different regions; Asia and Africa have higher rates than Europe and America. There has been a great deal of discussion about the role of culture in aviation mishaps, however, culture is hardly ever mentioned as a causal factor of accidents. It is hypothesized that different cultures will show different patterns in the underlying causal factors in aircraft accidents. **Method:** This research examined statistical differences in the 18 categories of HFACS across accidents in the Republic of China (Taiwan, a feminine, collectivist, strong uncertainty avoidance, and high power-distance culture); India (a masculine, collectivist, weak uncertainty avoidance, and high power-distance culture); and the USA (a small power distance, weak uncertainty avoidance, individualist, and masculine culture). **Results**: Ten HFACS categories exhibited significant differences ($p<0.05$) between these three regions. These were related to organizational processes; organizational climate; resource management; inadequate supervision; personal readiness; physical/mental limitations; adverse physiological states; adverse mental states; skilled-based errors; and decision errors. The pattern of results was congruent with what would be expected from Hofstede's descriptions of national culture. **Conclusion:** Culture may be a soft issue in aviation operations, but it certainly can have hard consequences. Overall, the evidence from this research supports the observation that national cultures have an impact on aviation safety but adds further explanatory power with regards to why this should be so.

Keywords: Accident Investigation, Cross-culture, Human Errors, Human Factors Analysis and Classification System (HFACS)

INTRODUCTION

In accident investigations, it is often easier to identify hardware failures as a cause than human errors. It is also generally acknowledged that the aviation accident rates differ across regions. Asia and Africa have higher accident rates than either Europe or America. These regional variations suggest that there were fundamental, underlying factors causing these differences in accident rates. Furthermore, it can be suggested that the majority of the facets of the aviation system has been constructed from a Western (North American/Western European) perspective. As a result, the causal factors underlying accidents and prevention strategies that seem reasonable to Westerners might present problems for East Asian and African people. What is more, Western people might not even be aware of such a problem (9, 11).

There has been a great deal of debate about the role of culture in aviation mishaps, however, culture is rarely cited as a causal factor underlying accidents. Nevertheless, culture is at the root of action; it underlies the manner by which people communicate and develop attitudes towards life. There are many definitions of culture. Kluckhohm (12) proposed one well-known definition for culture; 'culture consists in patterned ways of thinking, feeling and reacting, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artifacts; the essential core of culture consist of traditional ideas and especially their attached values'. If the majority of people in a society have the same way of doing things, it becomes a constituent component of that culture (9). As a result it is essential to consider the cultural determinants of behavior (19). A culture is formed by its environment and evolves

in response to changes in that environment, therefore, culture and context are really inseparable (14).

Johnston (10) suggested that regional differences have a major impact on CRM implementation and crew performance. There is a marked difference in how CRM training is perceived outside the USA. In the USA, CRM is normally seen as the primary vehicle through which to address human factors issues. Other countries, notably those in Europe, see human factors and CRM as overlapping, viewing them as close but distinct relatives. Orasanu and Connolly (15) have suggested that a great deal of decision-making occurs within an organizational context, and that the organization influences decisions directly (e.g. by stipulating standard operating procedures) and indirectly through the organization's norms and culture. Culture fashions a complex framework of national, organizational and professional attitudes and values within which groups and individuals function. Cultures can be divided into different levels: families, organizations, professions, regions, and countries. The power of culture often goes unrecognized since it represents 'the way we do things here'. It is the natural and unquestioned mode of viewing the world (4). The same authors also strongly suggested that national cultural characteristics play a significant part in aviation safety.

To a certain degree, aviation human factors have been dominated by research into psychological and psycho-physiological attributes such as motor skills, visual perception, spatial abilities, communication and decision-making (3). This may crudely be classified as the 'hardware' of the human factors. However, for operating hardware, codes and instructions are required that may be referred to as the 'software of the mind'. This software of the mind may be considered to be an indication

of culture because culture provides 'a tool kit' of habits, skills, and styles from which people construct 'strategies of action' (7).

Hofstede (5, 6, 7) proposed four dimensions of national culture:

- Power distance (PDI) focuses on the degree of equality, or inequality, between people in the country's society. In countries with a large power distance, subordinates are subordinate to their superiors. A relatively small power distance between superior and subordinate results in informal relationships and a great deal of information and discussion. If necessary, the subordinate will contradict his superior.
- Uncertainty avoidance (UAI) is the extent to which the members of a society perceive a threat in uncertain or unfamiliar situations, and the extent to which they subsequently try to avoid these situations by means of regulations and bureaucratic sanctions, amongst others actions. Uncertainty avoidance concerns the situations of unclearness events, preferred more predictable and which risks are more clearly defined events.
- Individualism (IDV) focuses on the degree that society reinforces individual or collective achievement and interpersonal relationships. In a highly individualistic society rights are paramount. Individuals in these societies may tend to form a larger number of moderately distant relationships. A society with low individualism is typical of a society of a collectivist nature with close ties between individuals.
- Masculinity (MAS) exemplifies the traditional masculine work role model of male achievement, control, and power. Expressions of this are an orientation toward competition and performance

and the desire for recognition of one's performance. A highly masculine social order is one in which males dominate a significant portion of the power structure, with females being controlled by male domination. A low masculinity ranking indicates the country has a low level of differentiation and discrimination between genders. Women are treated equally to men in all aspects.

More individualist cultures show a lower probability of total loss accidents; collectivist cultures exhibit a greater chance of accidents. A high the level of uncertainty avoidance in a national culture was also found to be associated with a greater chance of accidents (19). As aircraft have become increasingly more reliable human performance has played a proportionately increasing role in the causation of accidents. This has resulted in a proliferation of human error frameworks and accident investigation schemes (e.g. 1, 8, 23). However, there has been no empirical research describing the probabilistic relationship between national cultures and the underlying patterns of causal factors in accidents and in particular comparing the contributory factors of accidents between Eastern and Western cultures. Such an analysis may provide additional explanatory power in to elucidate why national differences in accident rates occur.

The Human Factors Analysis and Classification System (23) is based on Reason’s (16) model of human error. In this model active failures associated with the performance of front-line operators in complex systems, and latent failures which lie dormant within the system, combine with other local factors to breach a system’s defenses. Active failures of operators have a direct impact on safety. However, latent failures

are spawned in the upper levels of the organization and are related to management and regulatory structures. The system was originally designed and developed as a generic human error framework for investigating and analyzing human error accidents in US military aviation operations (20). The same authors later demonstrated its applicability to the analysis of accidents in US commercial aviation (21, 22) and US general aviation (17, 18). Li and Harris (13) demonstrated that the HFACS had a high degree of inter-rater reliability and was applicable for the analysis of accidents in a different cultural context.

HFACS addresses human errors at four levels (see figure 1). Level 1 (unsafe acts of operators - active failures) is the level at which the majority of accident investigations are focused. Failures at this level can be classified into two categories; errors and violations. Level 2 (preconditions for unsafe acts - latent/active failures) addresses the latent failures within the causal sequence of events as well as the more obvious active failures. It also describes the substandard conditions of operators and the substandard practices that they perform. Level 3 (unsafe supervision - latent failures) traces the causal chain of events producing unsafe acts to the level of the front-line supervisors. Level 4 (organizational influences - latent failures) describes the contributions of the most elusive latent failures, the fallible decisions of upper levels of management which directly affect supervisory practices, as well as the conditions and actions of front-line operators. Each higher level affects the next downward level in HFACS framework.

INSERT FIGURE 1 HERE

To summarize, there is an ongoing need to understand the influence of culture on aviation safety. Detailed examination of the relative incidence of the underlying human factors components in the causation of accidents using HFACS will provide greater insight in this respect, supplementing and adding explanatory power to the observation that accident rates differ between different countries and cultures. This research examines the relative frequency of contributory factors using the HFACS framework from aircraft accidents in Taiwan (Republic of China), India and the USA, and relates these differences to aspects of national culture as described using the typology proposed by Hofstede (5, 6, 7).

METHOD

Data

The data analyzed in the present study are taken from three researches classifying aviation mishaps using the HFACS framework. These are from Taiwan, India and the USA. There were 523 accidents with 1,762 instances of human error categorized using the HFACS framework from data elicited from the Taiwan Air Force between 1978 and 2002 (13); 48 accidents with 153 categorized instances of human errors between 1990 and 1999 in the

Indian data (2); and 119 accidents with 319 of categorized instanced of human error in US data recorded between 1990 and 1996 (21).

Classification framework

This study based on the HFACS framework as described in Wiegmann & Shappell (23). The first level of HFACS categorizes events under the general heading of ‘unsafe acts of operators’ that can lead to an accident including and comprises of four sub-categories of 'decision errors'; 'skill-based errors'; 'perceptual errors' and 'violations' . The second level of HFACS concerns 'preconditions for unsafe acts' which has a further seven sub-categories of 'adverse mental states'; 'adverse physiological states'; 'physical/mental limitations'; 'crew resource management'; 'personal readiness'; 'physical environment', and 'technological environment'. The third level of HFACS is ‘unsafe supervision’ including 'inadequate supervision'; 'planned inappropriate operation'; 'failure to correct known problem', and 'supervisory violation'. The fourth and highest level of HFACS is ‘organizational influences’ and comprises of the sub-categories of 'resource management'; 'organizational climate' and 'organizational process'.

Reliability of HFACS Framework

To avoid over-representation from any single accident, each HFACS category was counted a maximum of only once per accident. These counts acted simply as an indicator of presence or absence of each of the 18 categories in any given accident. Inter-rater reliabilities of the data from Taiwan, calculated as a simple percentage rate of agreement,

obtained reliability figures for the 18 categories of HFACS of between 72.3% and 96.4% (13). The average of the inter-rater reliabilities of the data gathered from Indian accidents, calculated by percentage of agreement, was 87% (2); the US data showed an average inter-rater reliability of 76% (21).

RESULTS

According to Hofstede's categorization of national culture (5, 6, 7), Taiwan (Chinese), India and the US occupy considerably different positions on these four dimensions. This is described diagrammatically figure 2. Using Hofstede's categorization system and results from cross-cultural research, the world average score for power distance (PDI) is 55; for individualism (IDV) it is 43; for masculinity (MAS) 50 and for uncertainty avoidance (UAI) it is 64. Therefore, Taiwan can be characterized as a culture which has a high power distance (PDI = 58); is collectivist in nature (IDV =17); is feminine (MAS= 45); and exhibits high uncertainty avoidance (UAI = 69). Indian has a high power distance culture (PDI = 77); is an individualist culture (IDV = 48); is masculine (MAS = 56); and exhibits weak uncertainty avoidance (UAI = 40). The USA is a culture with low power distance (PDI = 40); high individuality (IDV = 91); is masculine (MAS = 62); and shows weak uncertainty avoidance (UAI = 46). It is hypothesized that different cultures will show different patterns in the underlying causal factors in aircraft accidents.

INSERT FIGURE 2 HERE

The presence or absence of each HFACS category at each level as a contributory factor in an accident was cross-tabulated against country of occurrence (see table 1). These data were then subject to chi-square (χ^2) analyses to measure the statistical strength of association between HFACS category and country. As there is no identifiable dependent or independent variable in a χ^2 test of association these analyses were supplemented with further analyses using Goodman and Kruskall's tau (τ) which was used to calculate the proportional reduction in error (PRE). The HFACS categories were designated as being dependent upon the country of accident (the independent variable for these purposes). The value for tau (τ) indicates the strength of the directional relationship, with country of origin being deemed to influence differences in the pattern of frequency of occurrence in the HFACS categories. Thus, these analyses go beyond what may be deemed a simple statistical test of co-variance.

Ten HFACS categories exhibited significant differences in reported frequency of aviation accidents between different countries ($p<0.05$). These were, 'organizational process', 'organizational climate' and 'resource management' (level 4); 'inadequate supervision' (level 3); 'personal readiness', 'physical/mental limitations', 'adverse physiological states' and 'adverse mental states' (level 2); 'skilled-based errors' and 'decision errors' (level 1). Furthermore 'planned inadequate operations' (level 3); 'crew resource management' (level 2) and 'perceptual errors' (level 1) were all categories verging on statistical significance ($p<0.10$).

INSERT TABLE 1 HERE

Level 4 - Organizational Influences

All three categories at level 4 showed significant differences in frequency of occurrence between the three different regions (see table 1). 'Resource management', which includes the selection, staffing and training of human resources at an organizational level, excessive cost cutting, providing unsuitable equipment, and a failure to remedy design flaws, was over-represented in both the Taiwanese and Indian sample, and was under-represented in US. 'Organizational processes' including excessive time pressures, poor mission scheduling, poor incentivization, failing to set clearly defined objectives, poor risk management programs, inadequate management checks for safety, and failing to establish safety programs, was over-represented in the Indian sample of accidents and under-represent in US and Taiwan. Issues surrounding the 'organizational climate', including inadequacies in the chain of command, poor delegation of authority, inappropriate organizational customs and beliefs, and poor accident investigation, were involved in very few accidents, so the results should be interpreted with some caution. However, this category was over-represented in India and under-represent in both Taiwan and USA (see figure 3).

INSERT FIGURE 3 HERE

Level 3 Unsafe Supervision

There was only one HFACS category which exhibited significant differences in recorded frequency of being implicated in accidents with respect to country (see table 1). This was 'inadequate supervision' which includes factors such as a failure to provide proper training, adequate rest periods, a lack of accountability, failure to track qualifications and performance, using untrained supervisors and loss of situation awareness at the supervisory level. This category was over-represented in the Taiwan sample and under-represented in India and the USA. The association between the category of 'Planned inadequate operations' and country was verging on statistical significance (p=.061). Issues in this category include topics surrounding poor crew pairings, a failure to establish if risk outweighed benefit, excessive task/workload, and a failure to provide adequate time for briefing. There was some evidence to suggest that this category was under-represented in frequency of occurrence in accidents in the USA (see figure 4).

INSERT FIGURE 4 HERE

Level 2 - Preconditions for Unsafe Acts

There were four categories with significant differences in frequency of occurrence with respect to country at level-2 (see table 1). 'Adverse mental states', which includes issues such as over-confidence, stress, loss of situational awareness, distraction, channelized attention and task saturation, was over-represented in the Taiwanese sample, and under-represented in both India and the USA. The category of 'physical/mental limitations', which includes visual limitations, information overload and a lack of experience to deal with a complex situation, was over-represented in Indian occurrences, and under-represented in both Taiwan and USA. 'Personal readiness' which encompassed issues associated with inadequate training, self-medication, poor diet, and overexertion while off duty, was over-represented in frequency of occurrence in both Taiwanese and Indian accidents, and under-represented in US accidents. 'Adverse physiological states' was over-represented in both the Indian and US sample and under-represented in accidents from Taiwan. However, as a result of low numbers in this category it is suggested that the results in this category may be somewhat unreliable. There was a result verging on statistical significance for the HFACS category of 'Crew resource management' ($p=.058$), which includes a lack of teamwork, poor communication, failures of leadership and inadequate briefing. There was some suggestion that instances of poor CRM were under represented in the Indian sample, although as a result of quite low numbers, this result must also be interpreted with some caution (see figure 5).

INSERT FIGURE 5 HERE

Level 1 - Unsafe Acts of Operators

There were two HFACS categories which showed differences in their frequency of occurrence between regions at level-1 (table 1). 'Skill-based errors' which includes actions such as inappropriate stick and rudder coordination, excessive use of flight controls, glide path not maintained, and adopting an improper airspeed or altitude, was over-represent in both Indian and US accidents but under-represented in the sample from Taiwan. 'Decision errors', which includes issues such as selecting inappropriate strategies to perform a mission, improper in-flight planning, making an inappropriate decision to abort a take-off or landing or using improper remedial actions in an emergency, was over-represented in the Taiwanese sample of accidents and under-represented in both the Indian and US sample (see figure 6).

INSERT FIGURE 6 HERE

DISCUSSION

The aviation industry strives to provide the safest possible transportation regardless of the nationality of the operating personnel or the carrier. Safety is emphasized through the selection process, training, aircraft design, and operating procedures and guidelines.

This research, using the HFACS framework (23) suggests that there are statistically significant differences in the relative frequencies of the underlying human factors causes in aviation mishap between Taiwan, India and the USA. However, such a simple analysis alone showing differences between countries has little explanatory power. It is essential to identify the potential causal roots for these differences in relative frequency of the underlying factors in these aviation mishaps.

When Western (North American/Western European) engineers and human factor specialists develop equipment, training and procedures, they incorporate their own vision of the world which is heavily influenced by the cultural norms of their country. They implicitly assume that all users around the world will share their reasoning and values. Klein (11) observed that people from different nations differ in their cognition in ways that result in dissimilar perceptions, judgments and decision-making. National culture provides a fundamental basis for a group member's behavior, social roles and cognitive processes. It also provides underlying rules about safety, effective communication, and provides the basis for verbal and nonverbal interactions. For example, a frequently used example is that Western co-pilots, from a low power distance culture are more likely to question the actions of their Captains. However, co-pilots from Eastern, high power distance countries dare not to speak out when their opinions may contradict their Captain.

Taiwan and India, countries which both have a high power distance culture have a higher frequency of events in the 'organizational influences' categories underlying accidents, compared with the USA (see table 1 and figure 3). According to Hofstede's (6) classification of

national culture, the working environments of Taiwan and India prefer tall organizational pyramids with centralized decision structures and have a large proportion of supervisory personnel. In these cultures subordinates expect to be told what to do. However, members of these cultures frequently experience role ambiguity and overload. In general, group decisions are preferred but information is constrained and controlled by the hierarchy and there is resistance to change. On the other hand, the working environment of USA exhibits low power-distance and is a culture high on individualism. Flat organizational structures are preferred with a relatively small proportion of supervisory personnel. Subordinates expect to be consulted. Self-orientation and identity is based on the individual and individual decisions are regarded as being superior (5).

These national cultural differences may explain the findings reported in table 1 (and figures 3 and 4). The USA has a much better record at the level-4 'organizational influences' and level-3 'unsafe supervision' aspects of the HFACS framework than the other two countries. In many of the constituent categories at both these HFACS levels, the USA is underrepresented in the relative frequency of occurrence factors underlying aviation accidents compared to Taiwan and India. For example, the category of 'Resource management' at level-4 of the HFACS, embraces issues surrounding the staffing and training of human resources at an organizational level; providing suitable logistics, and remedying known design deficiencies in the system. The US culture, with low power distance and high individualism promotes greater efficacy in addressing these issues through open discussion by all personnel and allows greater autonomy of action, and hence as a result may be superior at preventing accidents than the Taiwanese or Indian cultures, which are less reactive

as a result of their preferred organizational structures and discourage autonomy of action (especially at lower managerial levels). These cultures are also resistant to change.

Uncertainty avoidance reflects how the members of a society perceive a threat in uncertain situations, and the extent to which they subsequently try to avoid these situations by means of regulations and/or bureaucratic sanctions. Taiwan is a strong uncertainty avoidance culture, with a great deal of hierarchical control, a highly formalized concept of management and a great deal of top management involvement in operations. The power of superiors depends upon the control of uncertainties. On the other hand, the USA and India are both weak uncertainty avoidance cultures, with a high tolerance for ambiguity in structures and procedures. In these cultures precision and punctuality have to be learned and managed and innovations are welcomed (5). It has to be noted that the cultural dimension of weak uncertainty avoidance is coupled with high individualism in the USA (to re-iterate, both India and Taiwan are collectivist cultures). From the results in table 1 it can be seen that the USA has a relatively poor record at level-2 in the HFACS, 'preconditions for unsafe acts' (it is over-represented in the frequency of occurrence ‘crew resource management’ as a causal factor). Accidents in the US sample are also over-represented at level-1 ‘unsafe acts of operators’ (with over-representation in the ‘skilled-based errors’ category). It may be suggested that the explanation for these observations is that the USA has a culture which prefers individual decision making and responsibility for the self. In Hofstede’s terms it is an ego-oriented society. US society itself is quite loosely structured with a high tolerance for ambiguity and procedures. While low power-distance and weak uncertainty avoidance may be seen as being

positive factors in promoting good CRM (both characteristics of the USA) it can be suggested that high individualism may be a factor that mitigates against these other potentially positive CRM influences to an extent, hence the over-representation of CRM-related factors in the US sample. Taiwan is also over-represented in instances of poor CRM as an accident-related factor. In this case, however, it might be postulated that the lack of teamwork is due to a lack of assertiveness as a result of the high power-distance and collectivist nature of Taiwan's culture. The proportionate over-representation of skill-based errors in the US sample could reflect the masculine nature of US society, where weakness in performance as a result of a lack of skill or ability due to poor airmanship or over-confidence would not be readily admitted.

This study supports Soeters & Boer's (19) suggestion that individualist cultures have a lower rate of total loss accidents. However, it also adds to explanatory power to their findings by suggesting why this may be the case. The example of this type of culture included in this study (the USA) shows a lower frequency of accident causal factors at the higher levels of management, as defined by the HFACS analysis framework. It is the nature of the proactive management style with few cultural communication barriers between levels in the managerial hierarchy promoted by this type of culture that is the key to aviation safety (levels 3 and 4 in HFACS).

On the other hand, Soeters & Boer (19) observed that more collectivist cultures, such as Taiwan and India had a greater probability of accidents. Also, they proposed that the greater the degree of uncertainty avoidance within a national culture, the greater the chance there was of accidents. While this may be true, there are other aspects of the Taiwanese culture (e.g. its higher femininity) that may actually

promote safer behaviors than those found in individualist cultures. This is particularly true at the lower levels (levels 1 in HFACS).

CONCLUSIONS

The findings clearly show different patterns in the human factors causes underlying aviation accidents in three different countries. The underlying cultural causes of these differences are also postulated. It should be noted, however, that the USA, India and Taiwan are only exemplars of the cultures that they represent. It is difficult to generalize the findings reported in these papers beyond these countries. Generally the US culture seems to be superior for promoting aviation safety compared to the Taiwanese and Indian cultures. However factors such as the design of the aircraft, the management procedures and the nature of safety regulation all have a strong Western Influence. All of these factors are culturally congruent with the USA, so it is perhaps not too surprising that this country comes out best when using the HFACS to analyze the underlying causes of accidents. It could even be argued that the accident analysis system itself has an implicit cultural bias within it. Global aviation is strongly influenced by the USA and Western Europe, however, the challenge for safety is not to ignore these cross-cultural issues influencing safety but to manage the potential risks they may present.

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TABLE I.

HFACS Categories	Taiwan		India		USA		Chi-square (χ^2)and Goodman & Kruskal Tau (τ)
	Yes	No	Yes	No	Yes	No	
Organizational process	**76** ***80***	447 *443*	20 *7*	28 *41*	**10** ***18***	109 *100*	χ^2= 30.253, df= 2, p=.000; τ=.044, p=.000
Organizational climate	**4** ***7***	519 *516*	5 *0.6*	43 *47*	**0** ***2***	119 *117*	χ^2= 33.716, df= 2, p=.000; τ=.049, p=**.000**
Resource management	184 *156*	339 *366*	19 *14*	29 *34*	**3** ***36***	116 *83*	χ^2= 51.711, df= 2, p=.000; τ=.075, p=.000
Supervisory violation	8 *9*	515 *514*	2 *0.8*	46 *47*	2 *2*	117 *117*	χ^2= 1.792, df= 2, p=.408
Failed correct a known problem	12 *12*	511 *511*	2 *1*	46 *47*	2 *3*	117 *116*	χ^2= 0.939, df= 2, p=.625
Planned inadequate operations	24 *22*	499 *501*	4 *2*	44 *46*	1 *5*	118 *114*	χ^2= 5.569, df= 2, p=.061
Inadequate supervision	177 *144*	346 *379*	**7** ***13***	41 *35*	**6** ***33***	113 *86*	χ^2= 44.638, df= 2, p=.000; τ=.065, p=.000
Technology environment	44 na	479 na	na na	na na	na na	na na	na
Physical environment	74 na	449 na	na na	na na	na na	na na	na
Personal readiness	29 *25*	494 *498*	4 *2*	44 *46*	**0** ***6***	119 *113*	χ^2= 7.973, df= 2, p=.018; τ=.012, p=.019
Crew resource management	146 *142*	377 *381*	**6** ***13***	42 *35*	35 *32*	84 *87*	χ^2= 5.677, df= 2, p=.058
Physical/mental limitation	**73** ***77***	450 *446*	15 *7*	33 *41*	**13** ***17***	106 *102*	χ^2= 12.108, df= 2, p=.002; τ=.018, p=.002
Adverse physiological states	**2** ***5***	521 *518*	2 *0.4*	46 *48*	2 *1*	117 *118*	χ^2= 8.401, df= 2, p=.015; τ=.012, p=.015
Adverse mental states	184 *156*	339 *367*	**6** ***14***	42 *34*	**16** ***36***	103 *83*	χ^2= 29.291, df= 2, p=.000; τ=.042, p=.000
Violations	160 *158*	363 *365*	16 *14*	32 *34*	32 *36*	87 *83*	χ^2= 0.880, df= 2, p=.644
Perceptual errors	116 *106*	407 *417*	7 *10*	41 *38*	17 *24*	102 *95*	χ^2= 4.774, df= 2, p=.091
Skilled-based errors	**226** ***245***	297 *278*	25 *22*	23 *26*	72 56	47 *63*	χ^2= 12.218, df= 2, p=.002; τ=.018, p=.002
Decision errors	223 *202*	300 *321*	**10** ***19***	38 *29*	**34** ***46***	85 *73*	χ^2= 15.025, df= 2, p=.000; τ=.022, p=.001

TABLE I. THE FREQUENCY OF HFACS CATEGORIES BETWEEN ROC (TAIWAN), INDIAN, AND USA.

Note: 1. Numbers show as a Roman font at the top of each cell is the observed value; the numbers shown in an *Italic font* at the bottom of each cell is the expected value.

2. 'na' indicates no information was available for the categories of 'technology environment' and 'physical environment'.
3. **Bold font** indicates under-representative of the frequencies.
4. Big size font indicates over-representative of the frequencies.

FIGURE I.

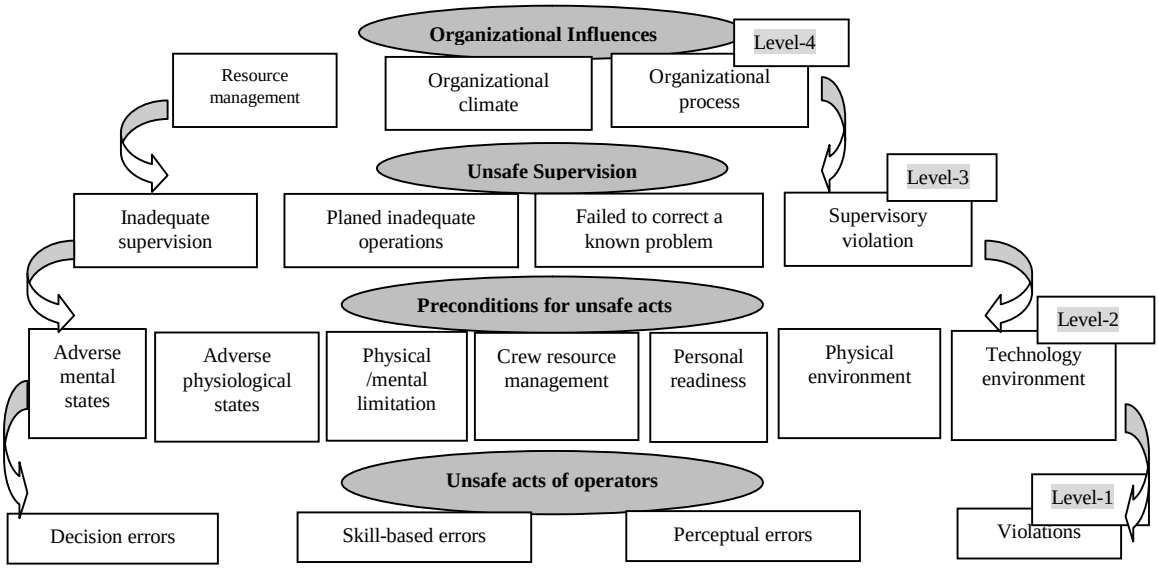

FIGURE 1 THE HFACS FRAMEWORK, EACH UPPER LEVEL WOULD AFFECT DOWNWARD LEVEL PROPOSED BY WIEGMANN & SHAPPELL (2003)

FIGURE II.

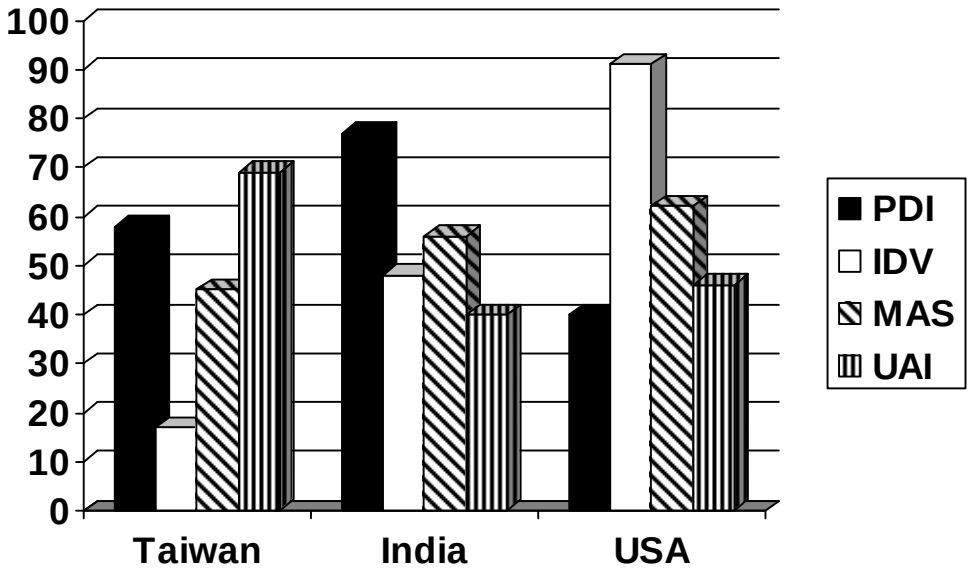

FIGURE II. INDEX OF POWER DISTANCE, UNCERTAINTY AVOIDANCE, INDIVIDUALISM, AND MASCULINE BETWEEN TAIWAN, INDIA, AND USA.

FIGURE III.

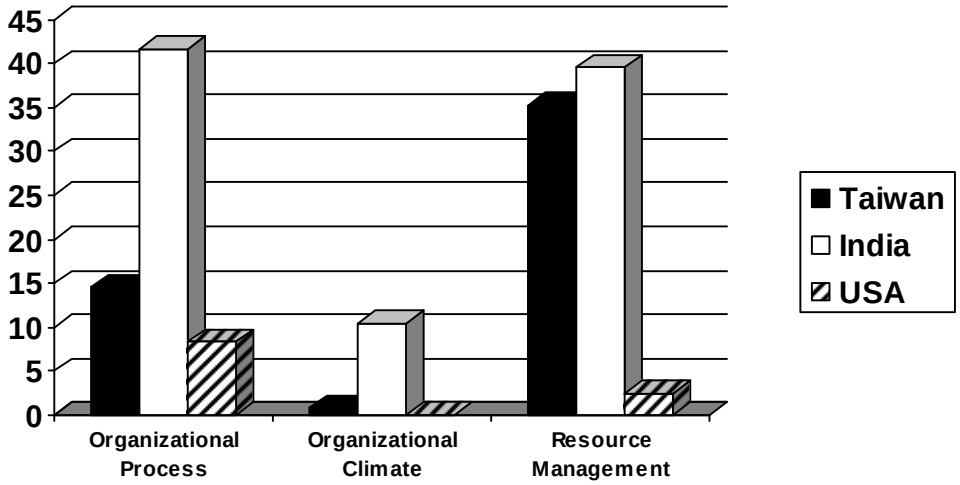

FIGURE III. THE PERCENTAGES OF 'ORGANIZATIONAL INFLUENCES' OF HFACS FRAMEWORK BETWEEN TAIWAN, INDIA, AND USA.

FIGURE IV.

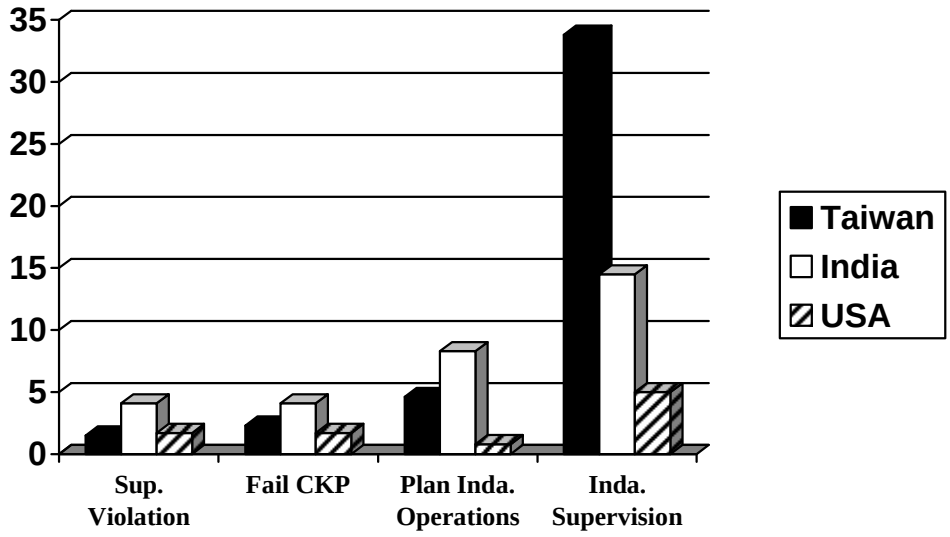

FIGURE IV. THE PERCENTAGES OF 'UNSAFE SUPERVISION' OF HFACS FRAMEWORK BETWEEN TAIWAN, INDIA, AND USA.

FIGURE V.

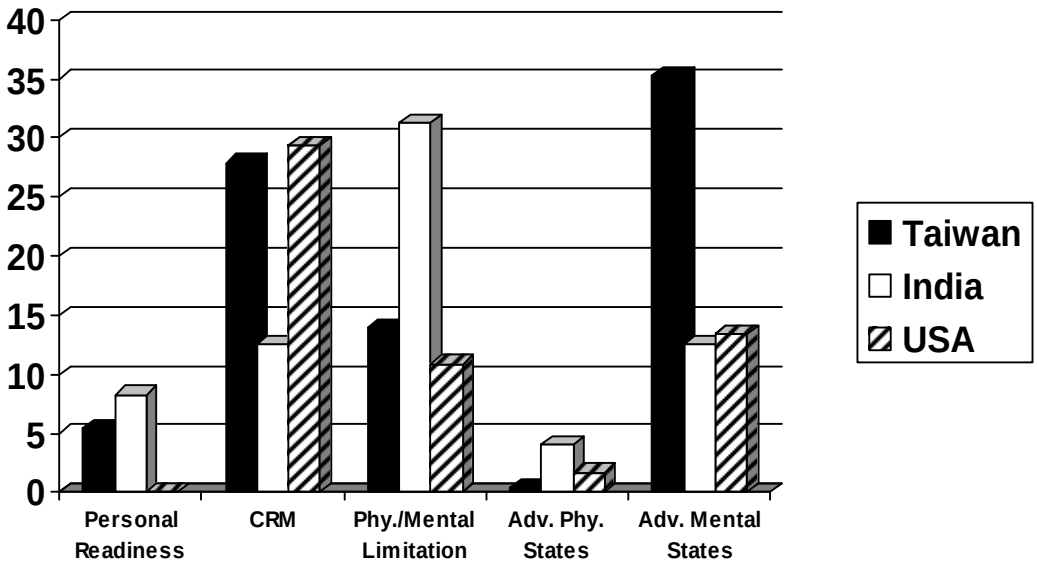

FIGURE V. THE PERCENTAGES OF 'PRECONDITION FOR UNSAFE ACTS' OF HFACS FRAMEWORK BETWEEN TAIWAN, INDIA, AND USA.

FIGURE VI.

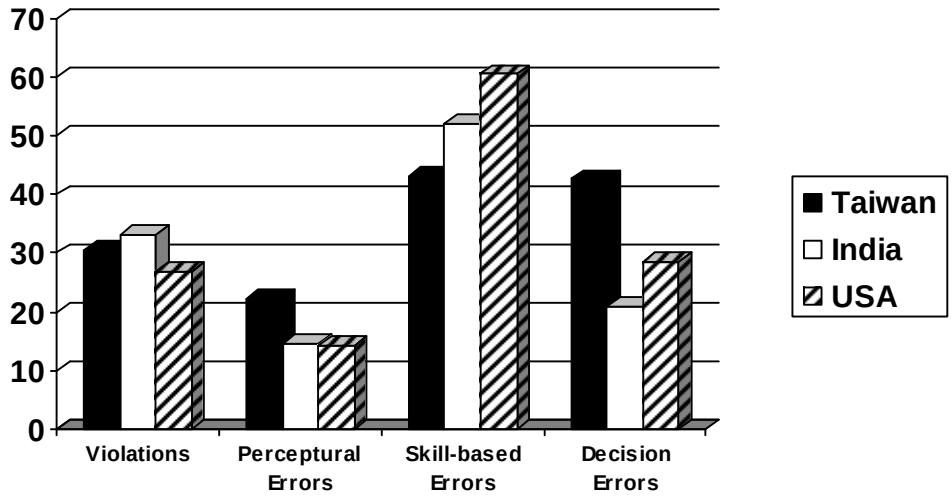

FIGURE VI. THE PERCENTAGES OF 'UNSAFE ACTS OF OPERATORS' OF HFACS FRAMEWORK BETWEEN TAIWAN, INDIA, AND USA.

Footnote 1

Wen-Chin Li was working in the Aviation Training Division, Air Force Academy, Republic of China, and is currently on sabbatical undertaking PhD research in the Human Factors Department, Cranfield University. Requests for reprints should be sent to Wen-Chin Li, Department of Human Factors, School of Engineering, Cranfield University, Cranfield, Bedfordshire, MK43 0AL, United Kingdom.

Dr. Don Harris is Reader in Human Factors Engineering, Cranfield University.