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THE RELATIONSHIP BETWEEN FLIGHT OPERATIONS AND ORGANIZATIONS IN AIRCRAFT ACCIDENTS; THE APPLICATION OF THE HUMAN FACTOR ANALYSIS AND CLASSIFICATION SYSTEM

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ABSTRACT

Aviation history is replete with lessons learned from accidents. Aircraft accidents have greatly contributed to the formation of aviation laws. Analysis conducted after accidents are the first steps taken for the prevention of further accidents. Accident analyses are carried out by the countries' accident investigation board where the accident happened or the one where the airline is registered. Several models are used in the analysis of accidents. One of these models, The Human Factors Analysis and Classification System was put forward by Shappell and Wiegmann after examining more than 300 accidents. This system is based on Reason's Swiss Cheese Model. According to The Human Factors Analysis and Classification System, the cause of accidents consists of 4 levels of factors that affect each other. These are: organizational influences, unsafe management, preconditions for unsafe acts and unsafe acts. Although an accident may seem to be caused by unsafe acts, behind the accident there are many causes extend from the managers to organizations. In this study, the databases of different countries' accident investigation boards were studied and the official accident reports of "planned and commercial" passenger flights were examined. These reports were analyzed and coded according to the Human Factors Analysis and Classification System. As a result, the size and scope of the relationships between organizational influences and unsafe acts that led to the accidents were revealed.

Keywords: Aircraft accidents, Human factors, Organizational influences, Accident investigation, Unsafe acts

1. INTRODUCTION

There may be several reasons for aircraft accidents. Studies conducted in recent years have revealed that the reasons for aircraft accidents are increasing in terms of human factors rather than technical factors [1]. Classification studies of accidents caused by human factors, has led to the emergence of many models. The Human Factor Analysis and Classification System (HFACS) is one of the most commonly used and validated models in the classification of human factors. The HFACS model was presented by Shappell and Wiegman, after their examination of more than 300 aircraft accidents in the US Navy. This model is based on Reason's Swiss cheese model.

According to the Swiss cheese model, accident investigators must analyze the all aspects of the system to fully understand the causes of accidents. For example, if you go backwards from the moment of the accident, unsafe acts of cockpit crew will be the first level to be examined. What makes Reason's model different is to direct accident investigators to find hidden errors. From this point of view, Reason's model mentions additional levels of errors that could lead to an accident. These levels are as follows; level 1 - unsafe acts, level 2 - preconditions for unsafe acts, level 3 - unsafe supervision, level 4 - organizational influences [2].

Shappell and Wiegman have separated these 4 levels of error into several classes to reveal HFACS which is a more comprehensive and useful model that can be called today's version of Reason's Swiss cheese model. HFACS is a model that provides the identification and classification of causes of accidents involving human factors by making a bridge between theory and practice [3].

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In this study, HFACS analysis was conducted on official accident reports obtained from various aviation authorities according to certain criteria. As a result, relationships between the causal factors of HFACS would be present. The graphics show how the cockpit crew, which directly caused aircraft accidents, and the managers who had an indirect share of the accident, contributed to the cause of the accident.

2. HUMAN FACTOR ANALYSIS AND CLASSIFICATION SYSTEM

HFACS is a systematic framework for accident analysis. It provides more detailed analysis of accidents and incidents. In addition, HFACS framework ensures obtained data to be entered into the database in well structured form. This allows accident researchers to use an earlier data to provide an efficient analysis. HFACS consists of 4 levels of failure and 17 causal factor which are showm in Figure 1.

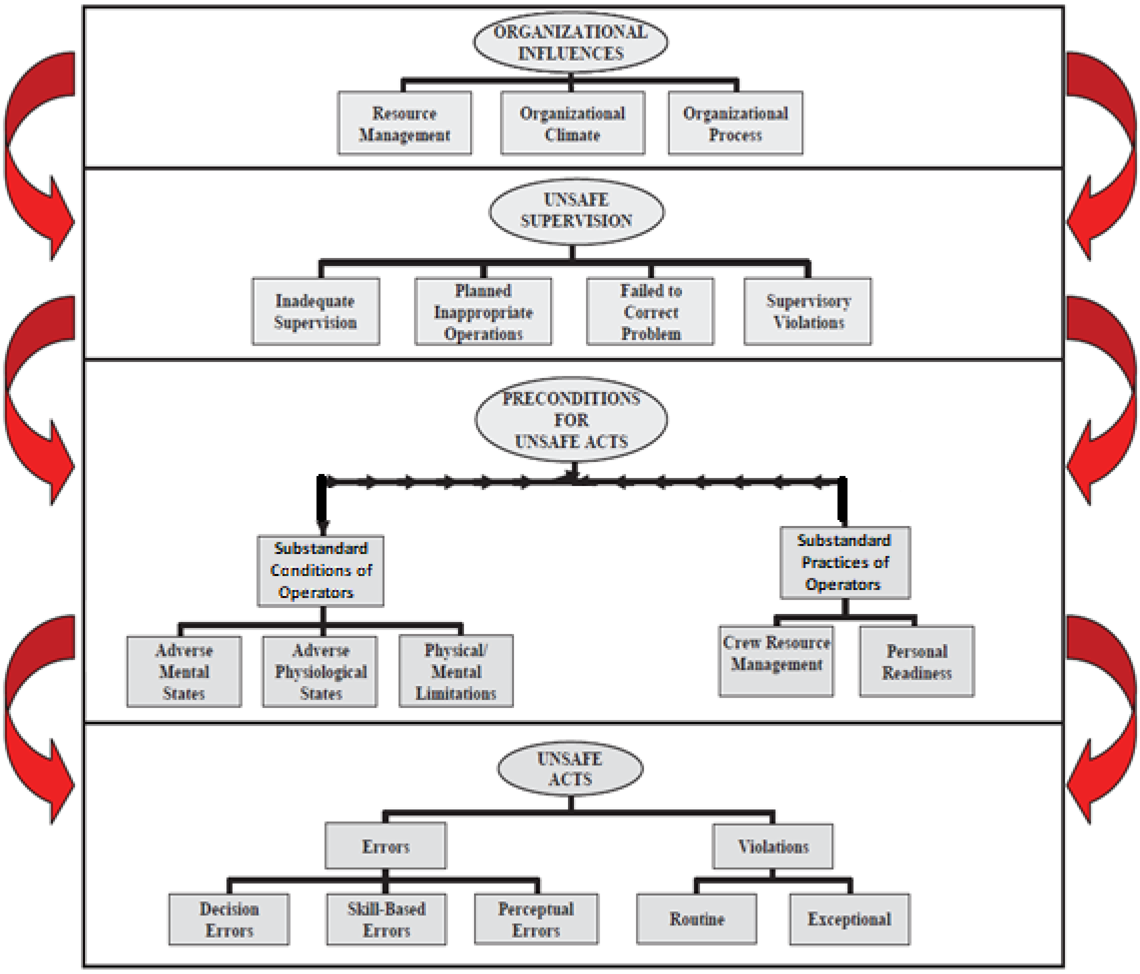

Figure 1. HFACS Framework [3]

The main headings and other factors of errors are described below. The first of these is unsafe acts which are most closely associated with accidents.

2.1. Unsafe Acts (Level-1)

Unsafe acts are divided into two groups; errors and violations. While errors involve unintentional unsafe acts, violations involve unsafe acts that the cockpit crew has performed on its own initiative [4]. In other words, errors can be described as "legal" unsafe acts that lead to involuntary bad results. The HFACS model refers to three kinds of errors. These are; decision errors, perceptual errors, skill-based errors [5]. Violations are divided into two groups; routine and exceptional violations [6].

Decision errors: These types of error are the incorrect choices that cause unsafe acts. Decision errors mean that; in an encountered situation, planned behavior is to continue as planned, but the plan is wrong at first [7].

Skill based errors: This type of error can be defined as errors that are made in situations that are constantly experienced or do not require thought. Errors such as breakdown in visual scan, omitted checklist item and inadvertent use of flight controls are examples of this error group [8].

Perceptual errors: Perceptual errors, which are less obvious than the other two error groups, are an important group of errors that result from the fact that the team lost perception or direction in the night or in bad weather conditions. Perceptual errors occur when pilots misjudge altitude, airspeed or the position of the aircraft. These also occur when the sensory inputs are reduced [9].

Violations: While errors occur within rules and laws, violations are actions that completely ignore laws and rules [4]. Violations are divided into two groups; routine and exceptional violations [3]. While routine violations are similar to driving at 65 mph on a highway with a speed limit of 55 mph, unusual violations are similar to driving at 105 mph on the same road [5]. Routine violations occur as a result of habit and can be often ignored by governments. Such violations can be described as stretching the rules. Unexpected violations are usually independent from the authority and are often the most dangerous type of violation [6]. Figure 2 shows HFACS level 1 – unsafe acts.

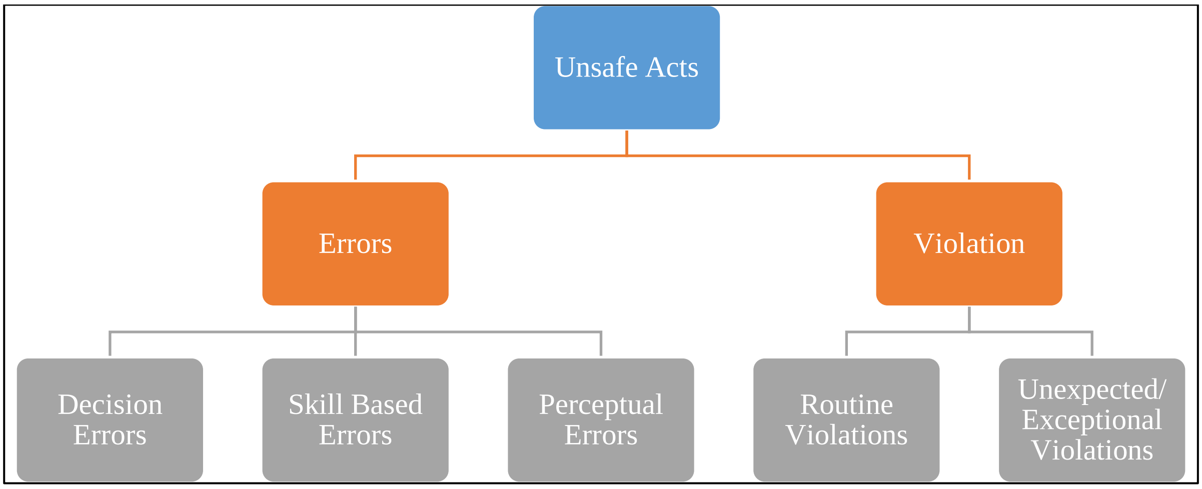

Figure 2. Unsafe acts [4]

2.2. Preconditions for Unsafe Acts (Level-2)

It is argued that unsafe acts can cause about 80% of accidents but focusing only on unsafe acts resembles focusing on the illness rather than the underlying cause. Therefore, researchers should first try to find out what caused the unsafe act [10]. The preconditions for unsafe acts are examined under two headings; the substandard practices of operators and the substandard conditions of operators. Further details of the preconditions for unsafe acts will be examined in the HFACS analysis section. Figure 3 shows HFACS level 2 – preconditions for unsafe acts.

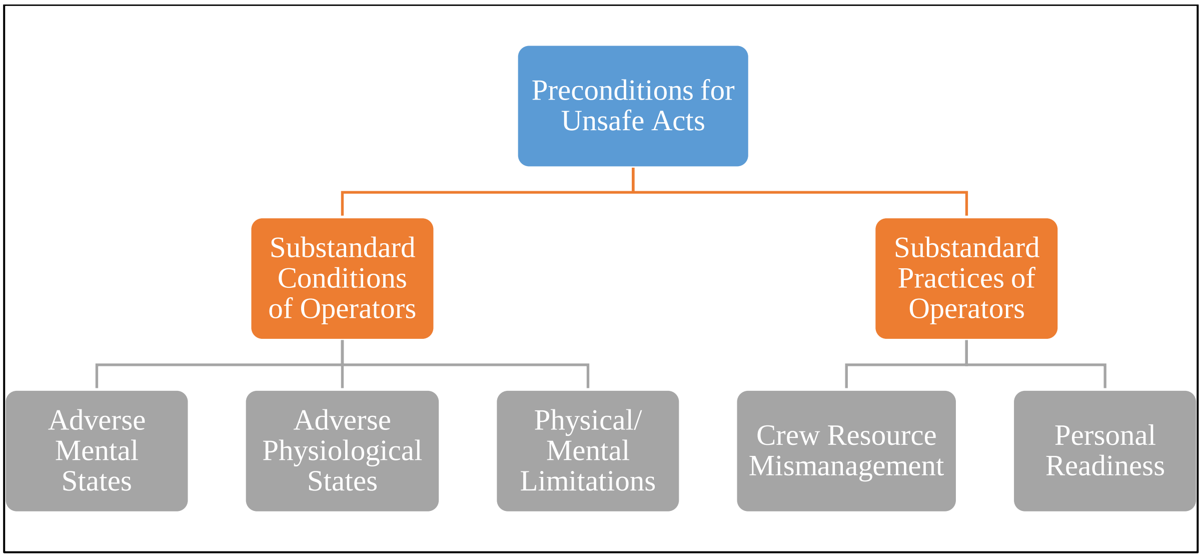

Figure 3. Preconditions for unsafe acts [4]

2.3. Unsafe Supervision (Level-3)

According to Reason's Swiss Cheese Model, this error group, which is located in the 3rd class of the HFACS framework, consists of errors and violations made by management. Unsafe supervision is examined under four main headings. These are; inadequate supervision, planned inappropriate operations, failure to correct a known problem and supervisory violations [11]. The subcategories of unsafe supervision are discussed in the HFACS analysis section. Figure 4 shows HFACS level 3 – unsafe supervision.

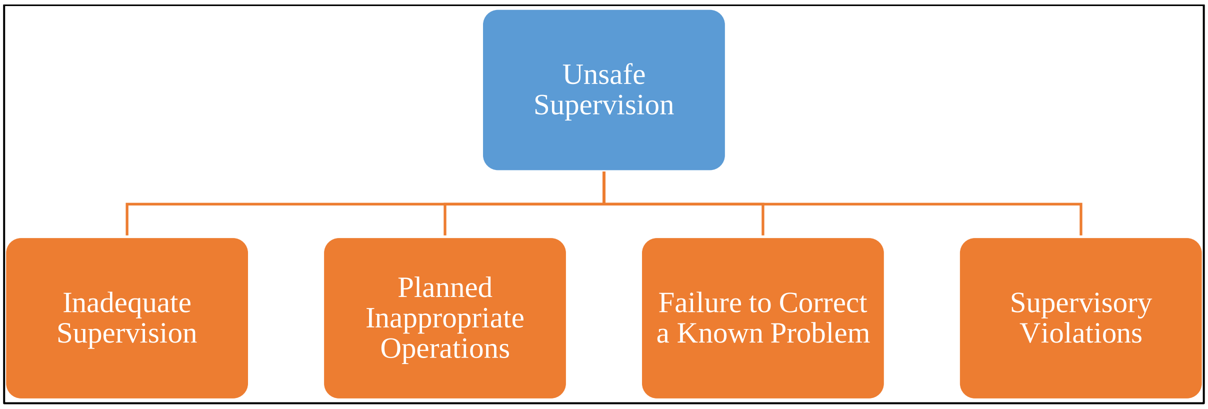

Figure 4. Unsafe supervision [4]

2.4. Organizational Influences (Level-4)

Organizational influences are the most overlooked errors in analysis. Errors in this level directly affect unsafe supervision and indirectly affect unsafe acts [12]. The HFACS model refers to three types of organizational influences; resource management, organizational climate andorganizational process [13]. Figure 5 shows HFACS level 4 – organizational Influences.

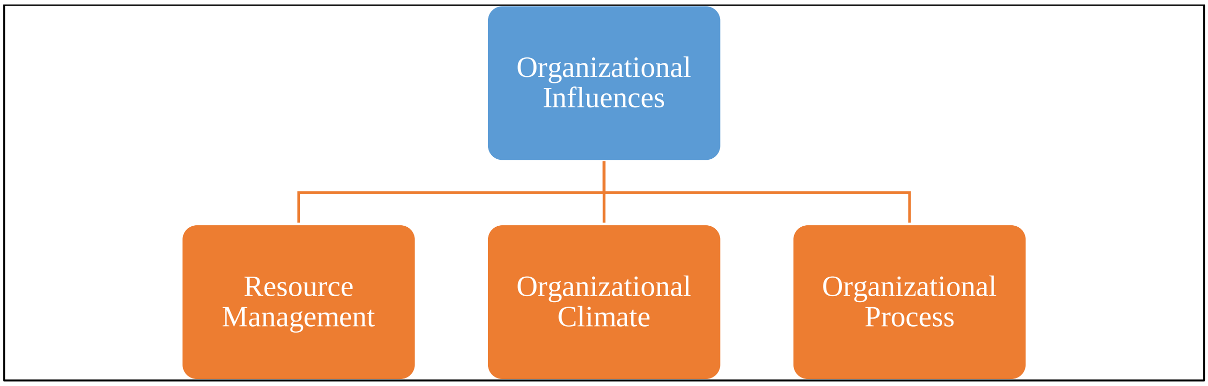

Figure 5. Organizational Influences [4]

3. LITERATURE

HFACS, maintains its validity today. Many applications in the literature have shown the theoretical bridge between the operators and the managers in the accidents. HFACS has a wide application area in the literature. Table 1 shows some application areas of HFACS.

Table 1. Application areas of HFACS in the literature

Military aviation accidents	[14, 15, 16]
Commercial passenger flights accidents	[8, 17, 5, 18, 19, 20]
General aviation and helicopter accidents	[11, 21, 22]
Accidents and incidents in the maritime field	[3, 23, 24, 25, 26]
Aircraft maintenance	[27, 28]
Air traffic control	[29]
Unmanned aerial vehicle accidents and incidents	[30]
Railway accidents and incidents	[31, 32, 33]
Mining area	[34]
Health and medical field	[35]

4. METHOD

Official reports of 50 accidents were selected from the aviation authorities of various countries according to certain criteria. The selection criteria of the accidents are as follows;

- Investigation type: Accident
- Injury severity: Fatal
- Aircraft category: Airplane
- Operation: Commercial Air Carrier
- Flight Type: Passenger
- Schedule: Planned
- Report status: Final
- Causal Factor: Human (occured from directly enviroment and technical accidents eliminated)

After elimination, these reports were coded according to HFACS factors. In this coding process, the HFACS framework published by the U.S Department of Defense is used. After the coding process, the data was analyzed by entering it into Excel and the Statistical Package for the Social Sciences (SPSS).

4.1. Process of Obtaining Data

The databases of the accident investigation boards from the 50 countries that the Flight Safety Foundation, stated that it was able to access were scanned [36]. Accidents that occurred directly from technical or enviromental causes were eliminated. From the remaining accidents, accidents resulting from human error were selected. Among these identified accidents, accidents which occurred on "planned" and "commercial passenger" flights were extracted in order to see the relationship between operators, managers and the aviation organizations managing the flights. As a result, the official reports of 50 accidents which occurred between 1950 and 2014 were obtained. These reports were obtained from the aviation authorities as listed below in Figure 6.

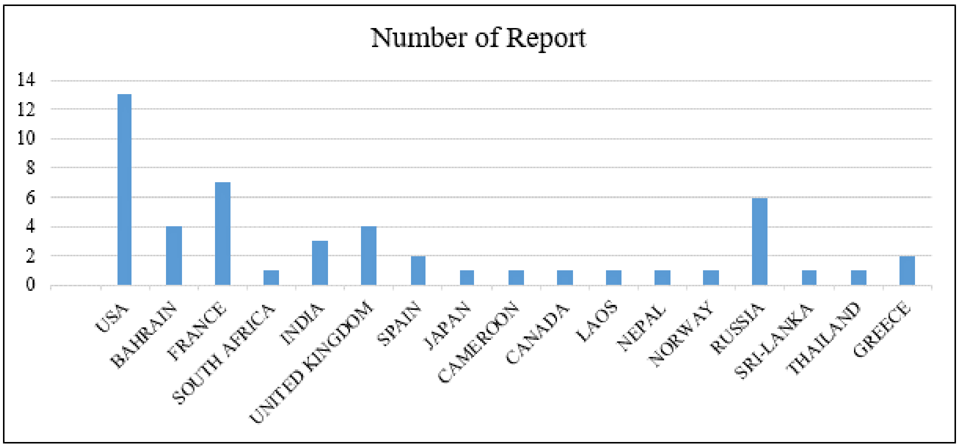

Figure 6. The accident reports by country selected from accessible acident investigation databases

As shown, the country from which the highest number of reports were obtained were the USA, France and Russia respectively. In these 50 accidents, 4,319 people lost their lives and 568 people survived. A detailed analysis of the causes of these accidents involving the human factor will be made in the HFACS analysis section. Figure 7 shows the number of fatalities in these incidents.

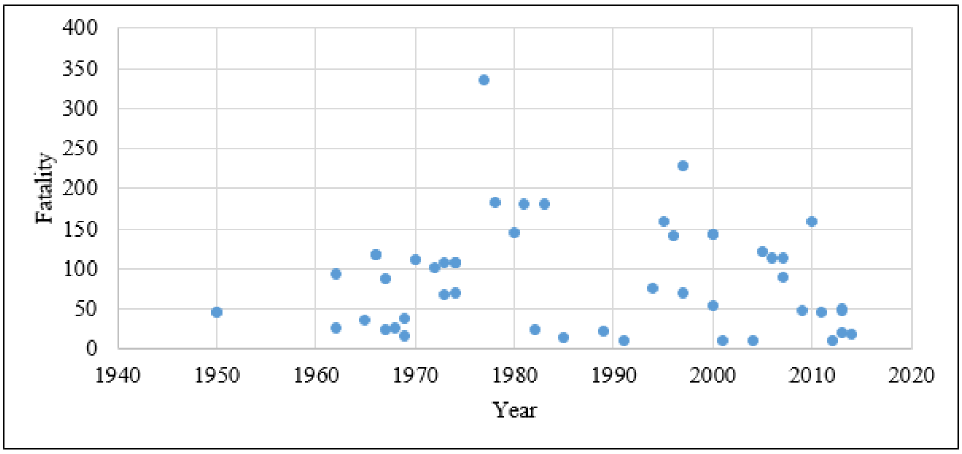

Figure 7. Fatalities by year for selected accidents

In these analyzed reports, the accident with the highest number of deaths is 335 and the accident with the lowest number of deaths is 10. Figure 8 shows the phases of the flights in which the accidents occurred.

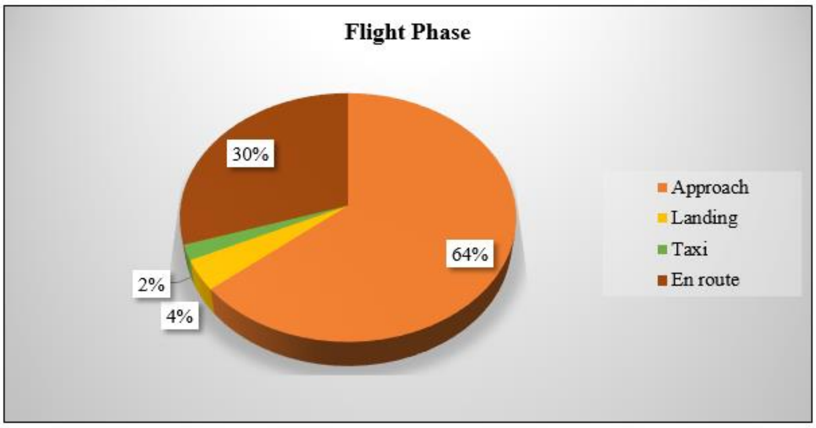

Figure 8. Flight phases

According to the Figure 8, 64% of the 50 accidents have occured during the approach phase of flight. 30% of the 50 accidents occured during en route phase of flight.

4.2. Coding Process

In coding process, benefited from The Human Factors Analysis and Classification System booklet published by the US Department of Defense [37]. As a result of coding, 386 HFACS causal factors were determined from the 50 accidents.

5. ANALYSIS

The analysis of the data consists of two parts. In the first part, the data which was obtained after coding will be explained in detail, with graphics and tables. In the second part of the analysis, the obtained data was transferred to the SPSS program and the relationship between "Causal Factors" of HFACS were examined. As a result, the relationship between operations and organizations in aircraft accidents was examined and visualized.

5.1. HFACS Analysis

The 386 HFACS causal factors identified in the coding process are listed under the four main headings as presented in Figure 9.

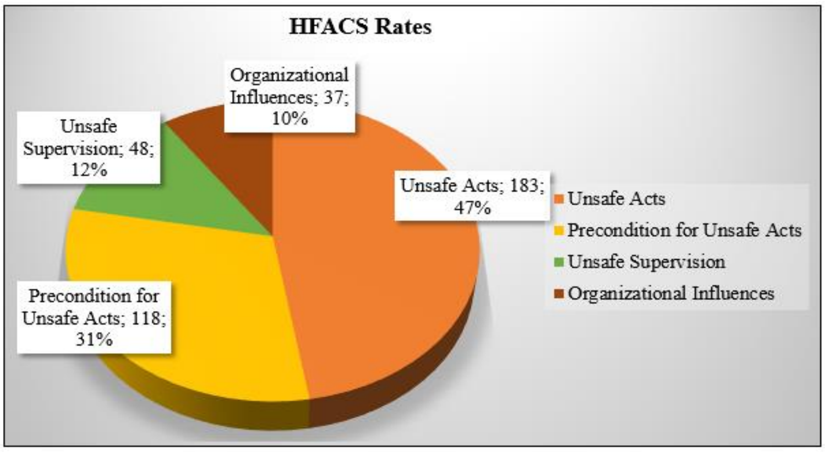

Figure 9. HFACS rates

Figure 9 was obtained by the ratio of four main factors of HFACS affecting each other. Detailed analysis of all these factors will be made below.

5.2. Unsafe Acts Analysis

Unsafe Acts: It was examined in the two categories: Errors and violations. As a result of analysis and coding the ratio of unsafe acts is given Figure 10.

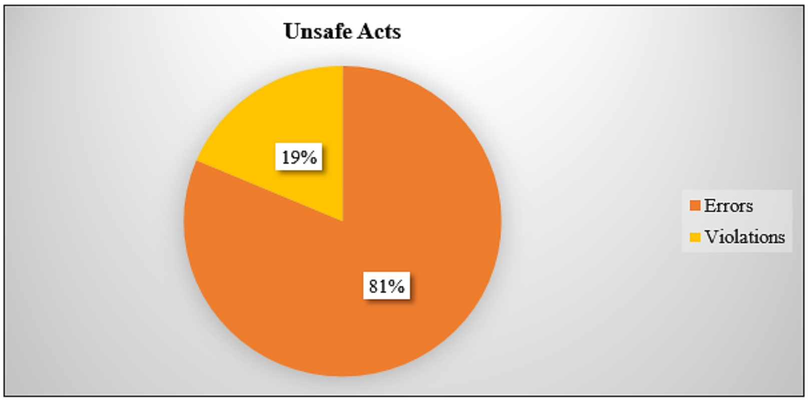

Figure 10. Percentage of unsafe acts

Figure 11 shows the breakdown of errors.

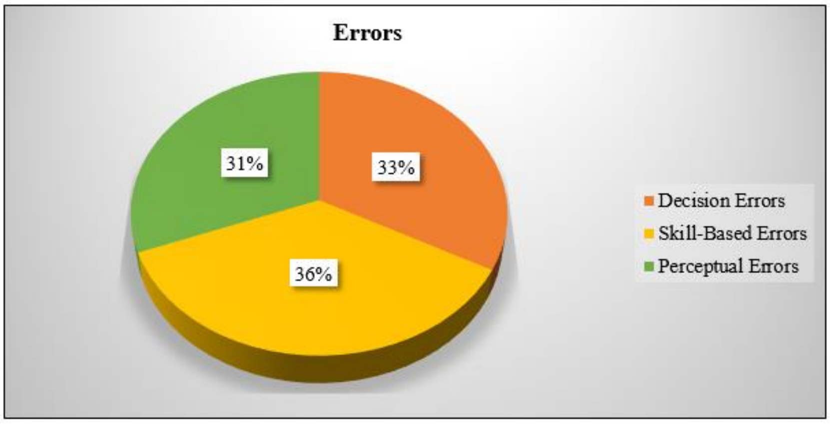

Figure 11. Percentage of errors

As shown in Figure 11, as a result of the rating of errors it is ordered as follows; 36% of skill based errors, 33% of decision errors and 31% of perceptual errors. In order to better understand how these ratios, occur and to be able to do a more detailed analysis of the errors, the following tables were created. Table 2 shows decision errors.

Table 2. Decision errors

Decision Errors	*Frequency (n)*	**Percentage %**
1- Improper procedure	23	46
2- Misdiagnosed emergency	3	6
3- Wrong response to emergency	11	22
4- Exceeded ability	1	2
5- Inappropriate maneuver	5	10
6- Poor decision	6	12

As seen in Table 2, the highest proportion of decision errors was the improper procedure factor seen in 46% of all accidents. Wrong response to emergency factor was seen in 22% of all accidents and poor decision factor in 12% of all accidents (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories). Table 3 shows skill based errors;

Table 3. Skill based errors

Skill-Based Errors	**n**	**%**
Breakdown in visual scan	12	24
Failed to prioritize attention	2	4
Inadvertent use of flight controls	26	52
Omitted step in procedure	11	22
Omitted checklist item	2	4
Poor technique	1	2
Over-controlled the aircraft	0	0

When the table of skill based errors was examined, the most common skill based error would be inadvertent use of flight controls seen in 52% of all accidents. Other factors with high rates were breakdown in visual scan at 24% and omitted step in procedure at 22%. The number of commercial aircraft accidents (n=50) associated with each HFACS causal category (Note that percentages will not add up to 100% because each accidents typically associated with multiple causal factors accross several causal categories). Table 4 shows perceptual errors;

Table 4. Perceptual errors

Perceptual Errors	**n**	**%**
Misjudged distance/altitude/airspeed	22	44
Spatial disorientation	19	38
Visual illusion	5	10

When the perceptual errors table was examined, misjudged distance/altitude/airspeed factor was seen as 44% of all accidents, the spatial disorientation factor was seen 38% of all accidents and visual illusion was seen 10% of all accidents (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories). Table 5 shows violations;

Table 5. Violations

VIOLATIONS	**n**	**%**
Routine Violations		
Failed to adhere to brief	5	10
Failed to use the radar altimeter	0	0
Flew an unauthorized approach	8	16
Violated training rules	7	14
Exceptional Violations		
Flew an overaggressive maneuver	1	2
Failed to properly prepare for the flight	6	12
Briefed unauthorized flight	2	4
Not current/qualified for the mission	0	0
Intentionally exceeded the limits of the aircraft	0	0
Continued low-altitude flight in VMC	2	4
Unauthorized low-altitude canyon running	3	6

Violations; According to the table, the most frequent types of violation in the accidents were flew an unauthorized approach 16% and violated training rules factor with 14% (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories).

5.3. Analysis of Precondition for Unsafe Acts

While unsafe acts can lead to the largest single cause of aircraft accidents, the analysis of the preconditions for unsafe acts is just as important. Figure 12 shows the breakdown of the preconditions for unsafe acts.

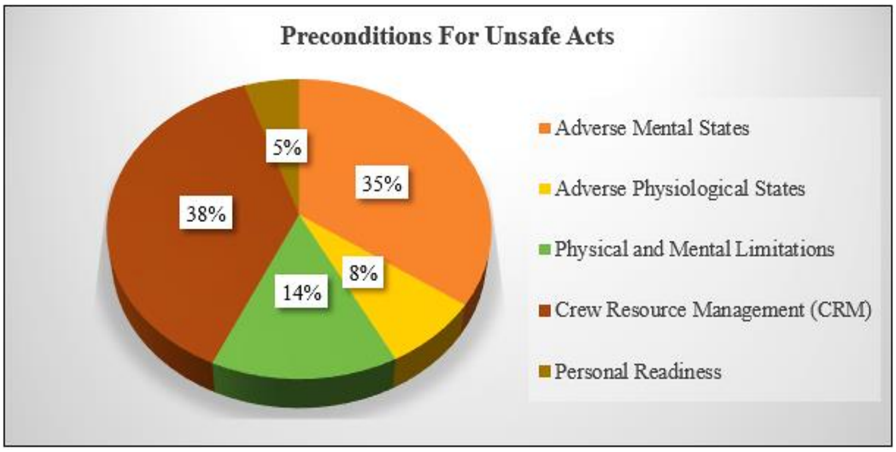

Figure 12. Percentages of preconditions for unsafe acts

As shown in Figure 12, 38% of the preconditions for unsafe acts stem from crew resource management (CRM) factor. CRM factor is followed by adverse mental states factor with 35%. A detailed form of the substandard conditions of operators is given in Table 6.

Table 6. Substandard conditions of operators

SUBSTANDARD CONDITIONS OF OPERATORS	n	%
Adverse Mental States		
Channelized attention	3	6
Complacency	0	0
Distraction	7	14
Mental fatigue	10	20
Go-home-itis	0	0
Haste	1	2
Loss of situational awareness	19	38
Misplaced motivation	1	2
Task saturation	0	0
Adverse Physiological States		
Impaired physiological state	5	10
Medical illness	2	4
Physiological imcapacitation	0	0
Physical fatigue	2	4
Physical and Mental Limitations		
Insufficient reaction time	4	8
Visual limitation	5	10
Imcompatible intelligence/aptidute	0	0
Imcompatible physical capability	8	16

The loss of situational awarenes factor, which is included in the adevrse mental states category under the heading of substandard conditions of the operators, was found in 38% of all accidents investigated. Table 7 shows substandard practice of operators.

Table 7. Substandard practices of operators

SUBSTANDARD PRACTISE OF OPERATORS	n	%
Crew Resource Management (CRM)		
Failed to back-up	4	8
Failed to communicate/coordinate	32	64
Failed to conduct adequate brief	5	10
Failed to use all available resources	1	2
Failure of leadership	3	6
Misinterpretation of traffic calls	0	0
Personal Readiness		
Excessive physical training	0	0
Self medicating	1	2
Violation of crew rest requirement	1	2
Violation of bottle-to-throttle requirement	4	8

Failed to communicate/coordinate factor, which is in the crew resource management category under the heading of substandard practises of operators, was seen in 64% of all accidents and it is the most common factor in accidents (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories).

5.4. Analysis of Unsafe Supervision

The cause of aircraft accidents can be attributed to the cockpit crew controlling the aircraft. However, there may be errors and violations made by the managers, behind the causes of aircraft accidents. The Figure 13 shows the breakdown of the unsafe supervisions.

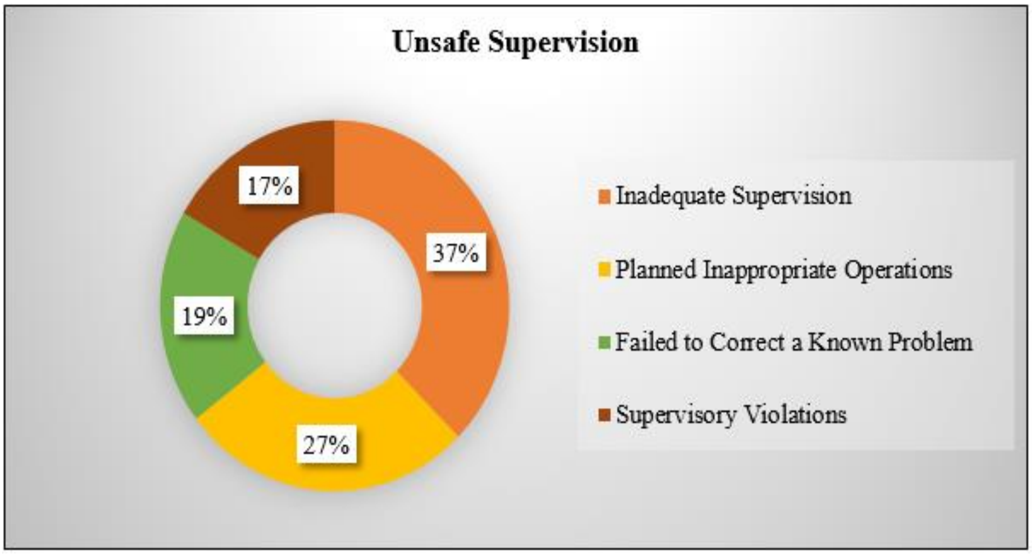

Figure 13. Percentage of unsafe supervision

As shown in Figure 13, under the “unsafe supervision” heading, the highest rate is “inadequate supervision” with 37%. This factor is repectively followed by “planned inappropriate operations” factor with 27%, “failed to correct known problem” with 19 and supervisory violations with 17%. Table 8 shows unsafe supervision factors.

Table 8. Unsafe supervision

UNSAFE SUPERVISION	n	%
Inadequate Supervision		
Failed to provide guidance	2	4
Failed to provide operational doctrine	0	0
Failed to provide oversight	3	6
Failed to provide training	9	18
Failed to track qualifications	2	4
Failed to track performance	2	4
Planned Inappropriate Operations		
Failed to provide correct data	6	12
Failed to provide adequete brief time	0	0
Improper manning	2	4
Mission not in accordance with rules	1	2
Provided inadequate opportunity for crew rest	4	8
Failed to Correct a Known Problem		
Failed to corret document in error	4	8
Failed to initiate corrective action	4	8
Failed to identify an at risk aviator	1	2
Failed to report unsafe tendencies	0	0
Supervisory Violations		
Authorized unnecesary hazard	2	4
Failed to enforce rules and regulations	6	12
Authorized unqualified crew for flight	0	0

As seen in Table 8, the most common factor under the heading of unsafe supervision is failed to provide training with 18%. It is understood from these ratios how important the training that companies provide to their employees is (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories).

5.5. Organizational Influences

Organizational influences are the last of the HFACS levels and it shows us how the top level organization or management has an impact on aircraft accidents. From the coding of 50 accident reports, Figure 14 shows the breakdown of organizational influences.

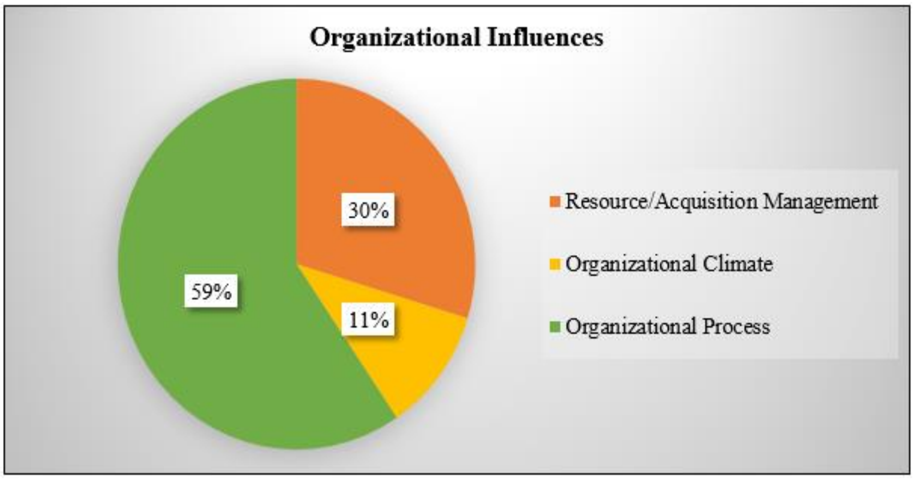

Figure 14. Percentage of organizational influences

As you can see in the Figure 14, organizational process factor constitutes majority of organizational influences with 59%. A detailed table of organizational influences was given in Table 9.

Table 9. Organizational Influences

ORGANIZATIONAL INFLUENCES	**n**	**%**
Resource/Acquisition Management		
Human resources; Selection, staffing/manning, training	7	14
Monetary budget resources; Excessive cost cutting, lack of funding	0	0
Equipment facility process; Poor design, purchasing of unsuitable equipment	4	8
Organizational Climate		
Structure; Chain of command, delegation of authority, communication, formal	0	0
Policies; Hiring and firing, promotion, drugs and alcohol	3	6
Culture; Norms and rules, values and beliefs, organizational justice	1	2
Organizational Process		
Operations; Operational tempo, time pressure, production quotas, incentives,	2	4
Procedures; Standards, documentation, clearly defined objectives, instructions	14	28
Oversight; Risk management, safety programs	6	12

Procedures; Standards, documentation, clearly defined objectives, instructions were the organizational factor that affected aircraft accidents the most. It was clear that errors made in documentation and procedures have a significant effect on aircraft accidents. The number of commercial aircraft accidents (n=50) associated with each HFACS causal category (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors accross several causal categories).

5.6. Relationship Analysis

As a result of coding the 50 official aircraft accidents reports, 386 HFACS causal factors were determined. These factors were entered into the SPSS program and Chi-square analysis was conducted. The relationship between the variables were analyzed by the chi square test of independence and phi correlation. The Chi-Square test of independence is used to determine if there is a significant relationship between two nominal (categorical) variables. The frequency of each category for one nominal variable is compared across the categories of the second nominal variable. The Phi Correlation Coefficient is designed to measure the degree of relation for two variables which are binary. It is the extension of "Chi-square" statistic. Chi-square analyzes give us the meaning of the relationship between two variables. Phi correlation gives us the strength of the relationship between the variables. Phi varies between -1 and 1. Close to 0 it shows little association between variables. Close to 1, it indicates a strong positive association. Close to -1 it shows a strong negative correlation [38]. The results obtained from the analyzes are given in Table 10.

Table 10: Chi square analyzes results

Significant association between upper level and adjacent downward level categories in the HFACS framework	*Chi - Square*		*Phi (Φ) Correlations*	
	Value	P - Value	Value	P - Value
Level 4 – Level 3				
Resource Management x Inadequate Supervision	13.581	.001**	.521	.000***
Resource Management x Planned Inappropriate Operations	7.739	.014*	.393	.005**
Resource Management x Failure to Correct a Known Problem	12.777	.003**	.506	.000***
Resource Management x Supervisory Violations	10.252	.009**	.453	.009**
Organizational Climate x Failure to Correct a Known Problem	6.640	.035*	.364	.010*
Organizational Climate x Supervisory Violations	5.980	.014*	.442	.002**
Organizational Process x Inadequate Supervision	21.387	.000***	.654	.000***
Organizational Process x Planned Inappropriate Operations	10.109	.003**	.450	.001**
Organizational Process x Failure to Correct a Known Problem	11.931	.002**	.488	.001**
Organizational Process x Supervisory Violations	18.992	.000***	.616	.000***
Level 3 – Level 2				
Inadequate Supervision x Adverse Mental States	4.635	.039*	.304	.031*
Planned Inappropriate Operations x Personal Readiness	6.805	.024*	.369	.009**
Level 2 – Level 1				
Adverse Mental States x Skill Based Errors	4.704	.043*	.307	.030*
Physical/Mental Limitations x Perceptual Errors	6.044	.021*	.348	.014*
Crew Resource Mismanagement x Violations	9.191	.002**	.429	.002**
Personal Readiness x Violations	6.818	.022*	.369	.009**

** P<.05 ** p<.01 *** p<.001*
Note: Only pairs of variables with meaningful relationships between each other are added to the table.

Analysis of the strength of association between categories at higher levels and lower levels of HFACS framework was shown in Table 10. The level-4 'organizational influences' versus level-3 'unsafe supervision' found that there were ten pairs of significant associations. Also two pairs of categories have significant association between level-3 and level-2. Analysis of the strength of association between categories at level-2 'preconditions for unsafe acts' versus level-1 'unsafe acts of operators' showed four pairs of significant associations.

In the level-2 categories 'adverse mental states' was significantly (P<.05) associated with one categories of unsafe act: 'Skill based errors'. 'Physical/mental limitations' was significantly (P<.05) associated with one categories of unsafe act: 'Perceptual errors'. 'Crew resource management' was significantly (P<.01) associated with one categories of unsafe act: 'Violations'. 'Personal readiness' was significantly (P<.05) associated with one categories of unsafe act: 'Violations'.

In the level-3 categories 'Planned inappropriate operations' was significantly (P<.05) associated with one categories of precondition of unsafe acts: 'Personal readiness'. Inadequate Supervision was significantly (P<.05) associated with one categories of preconditions for unsafe acts: 'Adverse mental states'.

In the level-4 categories 'Resource Management' was significantly (P<.01) associated with three categories of unsafe supervision: 'Inadequate supervision', 'failure to correct a known problem' and 'supervisory violations'. In the level-4 categories 'resource management' was also significantly (P<.05) associated with 'planned Inappropriate operations'. 'Organizational climate' was significantly (P<.05) associated with two categories of unsafe supervision: 'Failure to correct a known problem' and 'supervisory violations'. Organizational Process was significantly (P<.001) associated with two categories of unsafe supervision: 'Inadequate supervision' and 'supervisory violations'. Organizational process was also significantly (P<.01) associated with two categories of unsafe supervision: 'Planned inappropriate operations' and 'failure to correct a known problem'. All of these associations are shown in Figure 15 and 16.

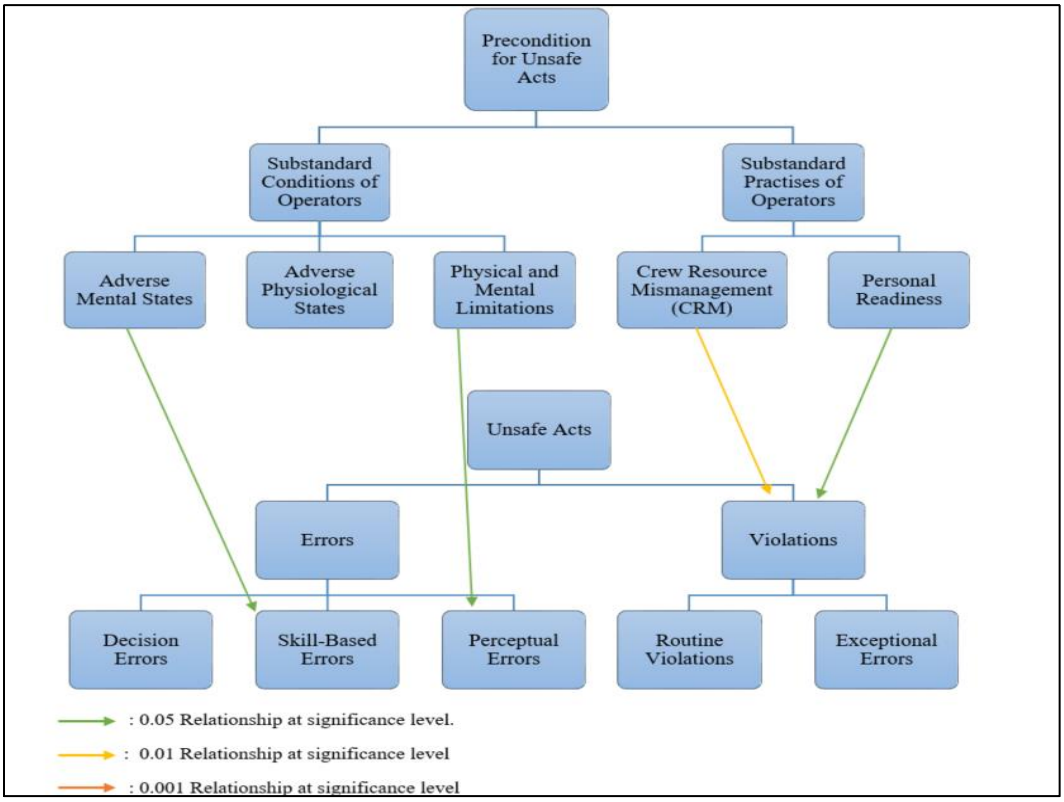

Figure 15: Relationships between level 2 and level 1

This analysis showed that at HFACS level-2 (preconditions for unsafe acts), four categories had some association with causal factors at level-1 (unsafe supervision).

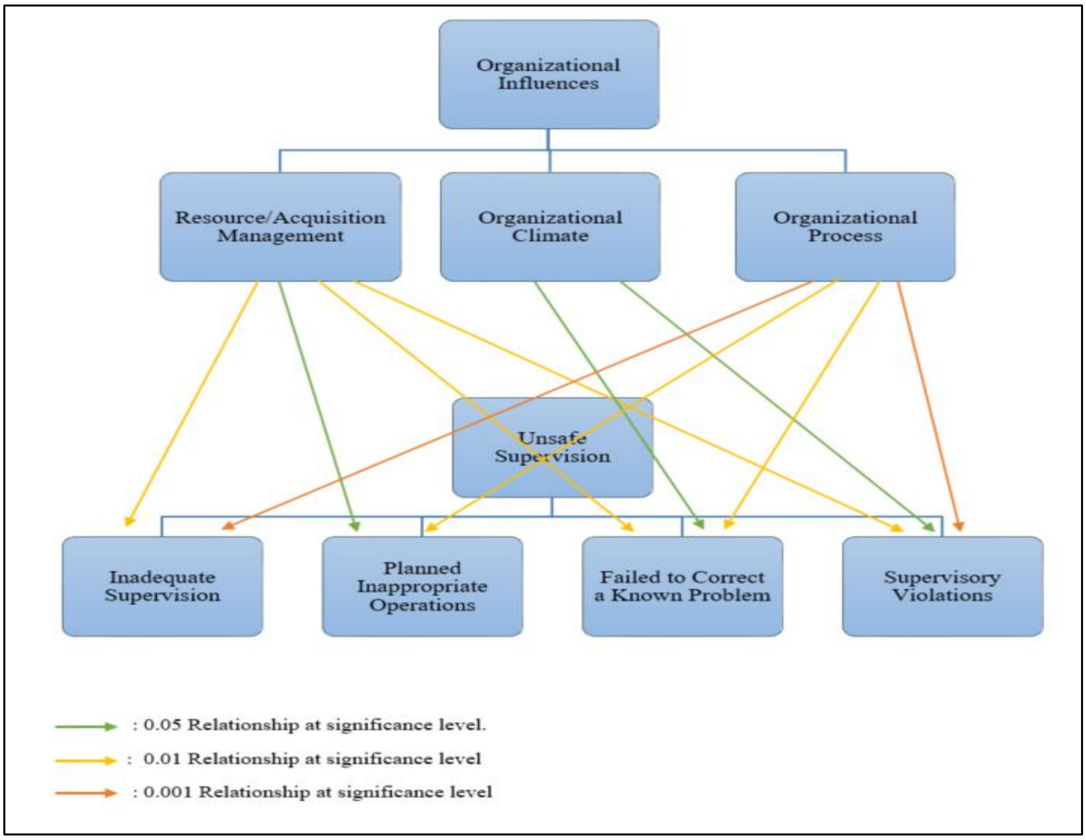

Figure 16: Relationships between level 2 and level 1

This analysis showed that at HFACS level-4 (organizational influences), all the categories had some association with causal factors at level-3 (unsafe supervision).

6. CONCLUSION AND DISCUSSION

Shappell and Wiegman examined more than 300 aircraft accidents and introduced The Human Factors Analysis and Classification System which is based on Reason's Swiss Cheese Model. The basic idea in these systems is that errors or violations made by a supervisor at the top can cause the unsafe acts of pilots. The analysis made in this study revealed the relationships between organizations, managers and cockpit crew. The analysis made in this study revealed the relationships between organizations, managers and cockpit crew. The human factors (from operation to organization) have been analyzed along with a detailed examination of the causal factors of the HFACS.

The inadvertent use of flight controls factor seen in 52% of all accidents was the most common unsafe acts - Level 1 in the accidents. This factor was followed by Improper procedure with 46%, misjudged distance/altitude/airspeed factor with 44%, and spatial disorientation with factor with 38%. The most influential factor in the accidents was observed as the failed to communicate/coordinate factor with 68% which is under the heading of Crew Resource Management (CRM), which in the preconditions for unsafe acts - level 2 category. According to these results it can be said that CRM is the key factor in aircraft accidents. Dönmez and Uslu emphasized the importance of communication in aviation accidents in their study. They emphasized the importance of standardization, training and management factors in order to prevent communication-related accidents [39]. The failed to provide education, seen in 18% of the accidents, was the factor with the highest rate under the heading of unsafe Supervision - Level 3. The most common Organizational Influences - Level 4 factor seen in %28 of the accidents was the procedures; standards, documentation, clearly defined objectives, instructions.

In addition, it has been observed that the physical environment is a factor in 40% of the accidents and the technological environment in 36%.

As a result of the relationship analysis presented here found, similar results obtained by other studies. Li, Yu and Harris (2008) examined 41 civil aviation accidents that took place in Chinese Air Space and found that the organizational process factor was associated with all categories of unsafe supervision at Level 3. In this current study, after investigating 50 civil aviation accidents, it was concluded that the organizational process is related to all the factors at level 3. Also, Li, Yu and Harris (2008) emphasized that the "crew resource management" factor was found in 68% of all accidents [19]. In this study, the Failed to communicate/coordinate factor under the crew resource management category was seen in 64% of all accidents. In addition, Shappell and Wiegmann analyzed 44 commercial passenger flight accidents in the United States, and found that crew resource management is the most common factor with 40% after skill-based errors [5].

As is presented in this work, unsafe acts are direct causes of accidents. The most common unsafe acts found from the analysis in this study are listed as follows; Skill based errors, decision errors, perceptual errors and violations. If we look at other studies, it is ranked as; skill based errors, decision errors, violations and perceptual errors [19]. Skill based errors, decision errors, violations and perceptual errors [5]. Skill based errors, decision errors, violations and perceptual errors [8]. This sequence can vary slightly according to the data used.

It is recommended that these analyzes and the results obtained, should be one step towards preventing further accidents. It should not be forgotten that the struggle to prevent an accident begins with the analysis of the previous accident.

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