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FMARI Application in Innovation and IT for Accidents' Investigation

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Abstract FMARI Database Application is designed to help safety auditor in investigating work accidents and as routine monitoring in regular companies reports to safety board organization in Indonesia (BPJS for Employee) with the main goal is to reach zero accident. FMARI stands for Faktor Manusia dan Analisis Resiko Industri (application: Human Factors and Industrial Risk Analysis) is following HFACS method and make a modification from HFIX in Indonesian terms. The Human Factors Analysis and Classification System (HFACS) is a system-safety model that effectively bridges the gap between human error theory and applied human error analysis. The Human Factors Intervention matriX (HFIX) is an innovative tool for mapping intervention strategies onto the specific forms of human error identified in the HFACS.

Keywords FMARI, HFACS, HFIX

1. Introduction

FMARI Database Application is designed to help the safety auditor in investigating work accidents and as routine monitoring in regular companies' reports to the safety board organization in Indonesia (BPJS for Employee and BPJS for Health Insurance) with the main goal is to reach zero accident in high risk jobs.

The number of accidents in Indonesia is among the highest in the ASEAN region. Nearly 32% of cases of occupational accidents in Indonesia occurred in the construction sector which covers all types of project work buildings, roads, bridges, tunnels, irrigation dams and others. "The construction sector is a supreme contributor to field accidents. Therefore, all construction projects must be supervised, so that number of accidents in construction can be minimized," said Minister of Manpower and Transmigration, during a working visit to the construction projects that are located in apartment of Gandaria City and Kalibata City, Jakarta, Wednesday (13/1/2010). He added that the purpose of this visit was held to disseminate guidance and supervision Occupational Health and Safety (K3) in the construction sector in supporting the implementation of the National K3 Month campaign which runs from January 12 until February 12. "From a visit to the construction project, there is a fact that the fundamentals of K3 had been conducted. However, implementation is not perfect, especially on the infrastructure of securing the construction of high rise buildings that need to be improved," said the minister. Figure of occupational accidents in construction services highest compared to the industrial sector, transport and mining. The Ministry of Manpower and Transmigration record until 2010, work accidents still dominated field of construction services (31.9%), followed by industry (31.6%), transport (9.3%), mining (2.6%), forestry (3.8%), and others (20%).

The number of construction accident cases was reported by the construction company to BPJS Employment, has been through internal verification and validation by the Technical Division BPJS within the framework of the development of surveillance applications related to insurance claims by company K3 / victim care through a designated hospital.

K3 management improvement through intervention strategies at all levels, has contributed to a decrease in the number of construction accidents and the government as the labor competency skills builder for construction etc., set the Zero Accident program that must be met by all kinds of companies.

Chairman of the Governing Body Branch (BPC) Gapensi Semarang Devri Alfiandy assess the high number of accidents in the construction sector due to the awareness of the service provider to the safety of workers is still low. It can be seen from members who had taken the certificate of Occupational Safety and Health Management System (SMK3) only around 5%. "Not all agencies require construction companies so having a certificate that they assess is not part of SMK3 priority," he said, Wednesday

(13/4). According Devri, work accidents happened mostly in the construction world, where more and more workers, the higher the risk in work accident. The regulations on workplace safety, is already provided for in article 23, paragraph 2 of Law No. 18/1999 Construction Services. Moreover article 11 Regulation No. 9/2008 mentioned MPW service providers shall involve the construction of K3 expert on every job that has a high risk.

2. Methodology

Study based on records 15.154 accident data from BPJS Employee and it is in four work-shifts between from 2007 to 2013. Data is being analyzed with descriptive statistic before it will be transferred in FMARI form of database application and be used to make investigation intervention for safety management system.

Development of taxonomy methods for investigation of human error factor in cases of accidents and incidents of aircraft known as HFACS (Shappell, 2000; Minyamer & Belay 2018) and HFACS (Human Factors Analysis and Classfication System) get a good response from various practitioners aviation, including: ICAO (International Civil Aviation Organization), GAIN (Global Aviation International Network), IATA (International Air Transport Association), FAA (Federal Aviation Administration) and other aerospace institutions. HFACS is progressing quite rapidly. At first only intended for use in the aviation world was later adopted by other fields, namely shipping (Celic, 2009), mining (Patterson, 2010), railways (Reinach, 2006), and industries such as construction and manufacturing. Human Factors Intervention Matrix (HFIX) is a development HFACS for mapping of intervention strategies that use human error identification form analysis of HFACS and HFIX allow users to systematically build a comprehensive intervention strategy to achieve the target the cause of human error that is in the system. HFIX using nanocode (codes in HFACS) and has already built a database before they can be simulated intervention strategies. HFIX give a scale of 1-5 for every aspect of risk that must be managed and supervised as follows:

1) Feasibility (feasibility - can it be done)
2) Acceptability (operators will accept it)
3) Cost / Efficiency (can we afford it)
4) Effectiveness (will it work)
5) Sustainability (sustainability)

Risk Assessment is the foundation for complishing SMS and the ability in every level of management should be continuously upgraded in the field practices, ie:

- Hazard identification;
- Continuous monitoring and regular assessment upon the level of safety;
- Identification on accidents or incidents to the make sure progress in the level of safety in the future.

Application of Human Factors and Risk Analysis Industry (trial version www.fmari.net) developed to help safety analyst and cases auditor of occupational accidents in investigating workplace accidents, especially high-risk projects. Based on HFACS and modification efforts HFIX (Human Factors Intervention matrix), then the application FMARI expected to be as analytical tool decision support applications in the company's proposed interventions and monitoring quality improvement, especially Indonesia which do not have application to human error as well as latent failure.

FMARI development in this study conducted by the limitations as follows:

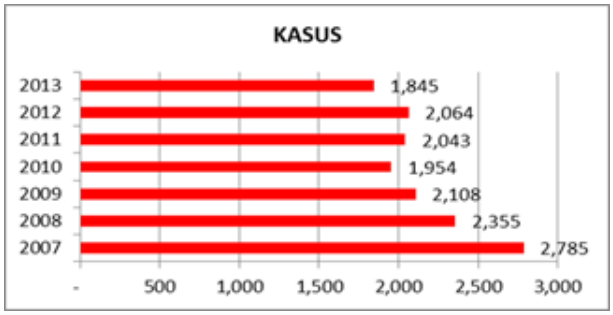
a) Database applications aimed at the context of the *safety management system* (SMS) construction industry.
b) Aspects examined only in the context of *human error* alone.
c) Focus on *latent failure* after *failure* identified *active.*

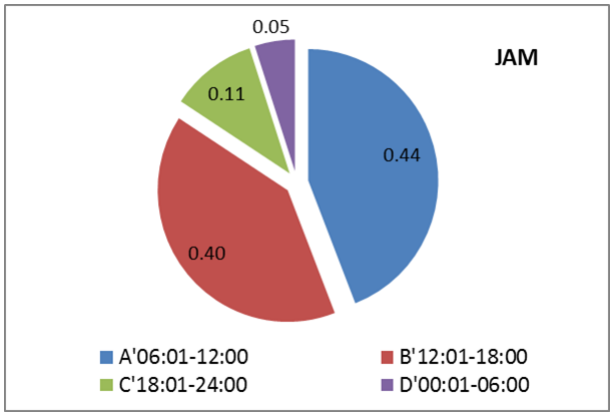
3. Results

3.1. Descriptive Analysis

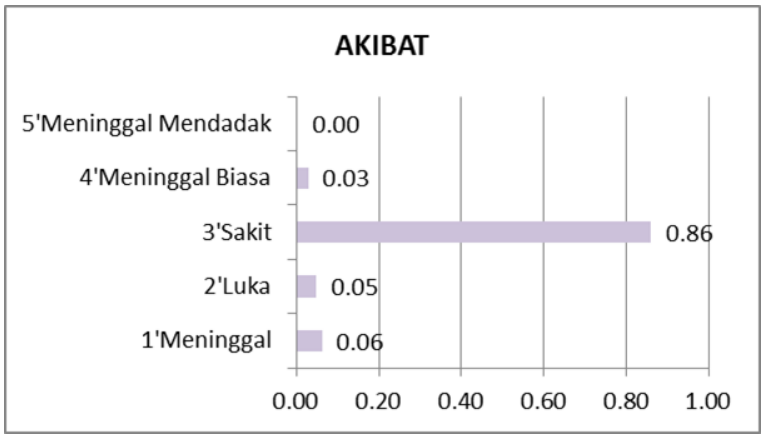
There are preliminary results from descriptive statistic, i.e:

1) High rate accident in construction jobs around 2,000 per year and it happened especially in morning shift (6 am to 12am) followed by (12am to 6pm) and then (6pm to 0am) last at (1am to 6am).

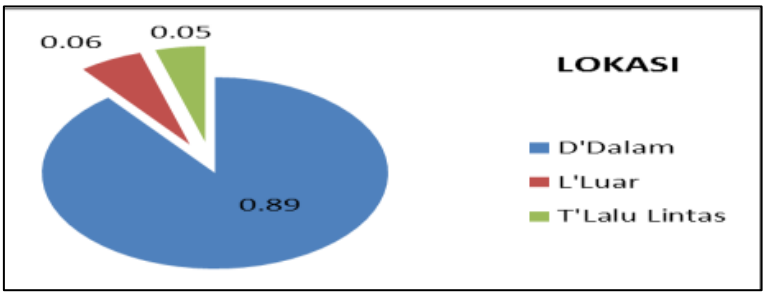




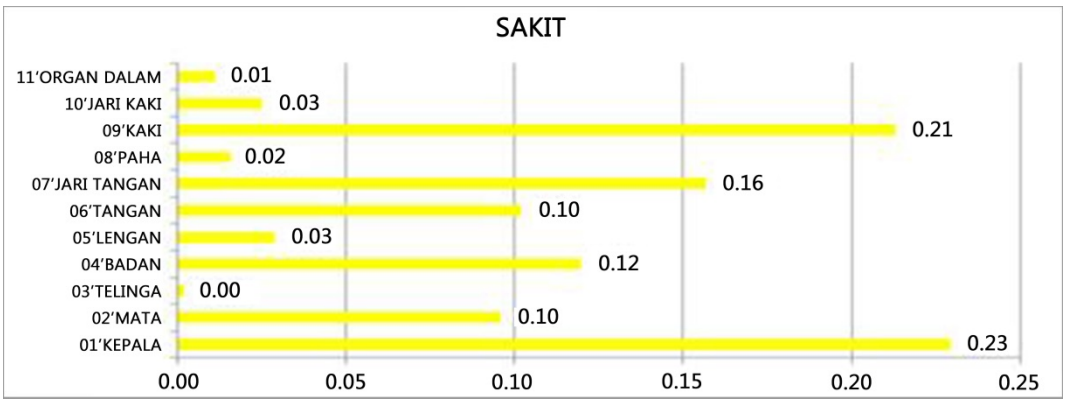
2) Prevalence in sickness 86%, death 9% and injured 5%.



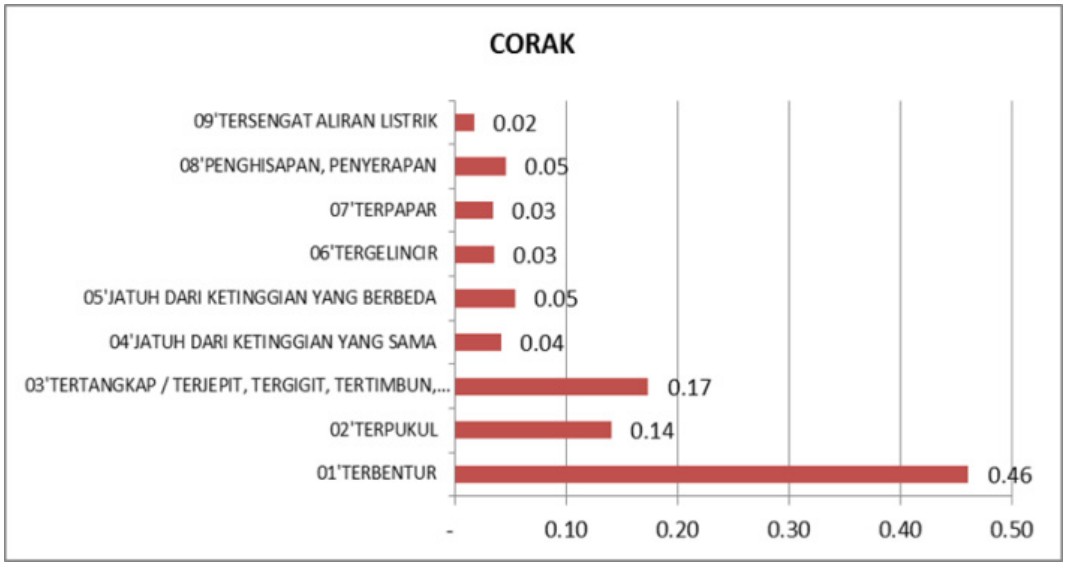
3) Location especially indoor 89%, outdoor 6% and on streets 5%.



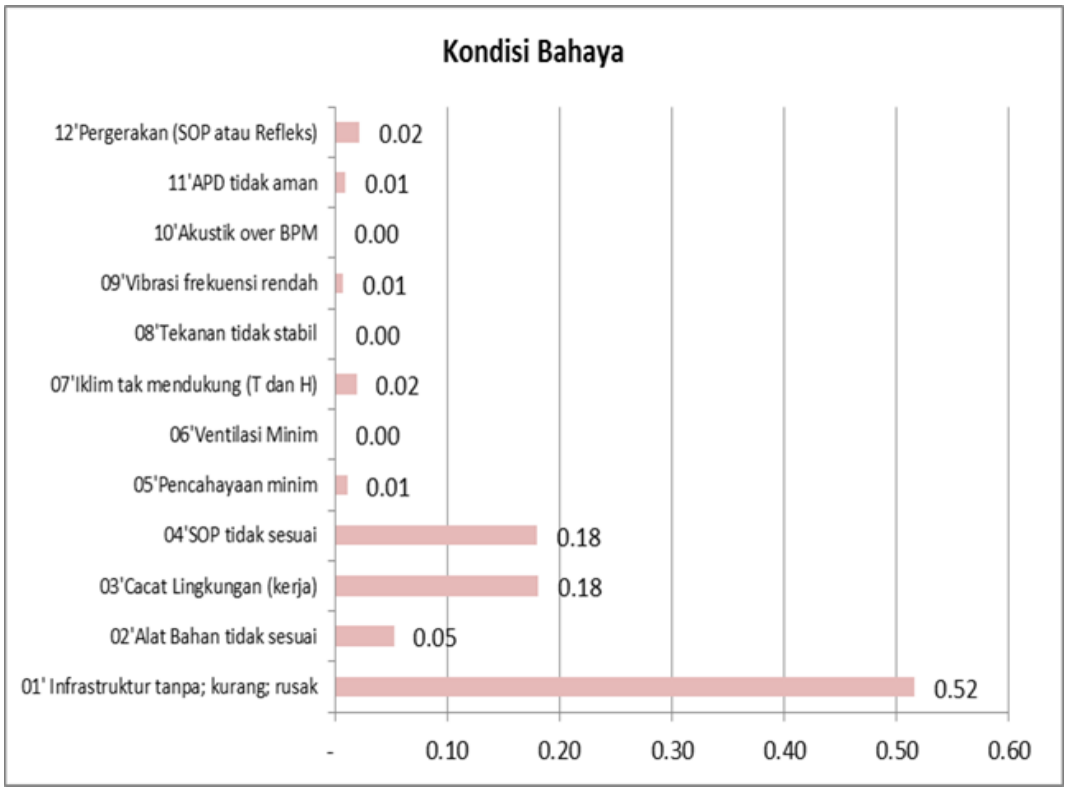
4) Parts of body in accident are head 23%, feet 21% and fingers 16%.



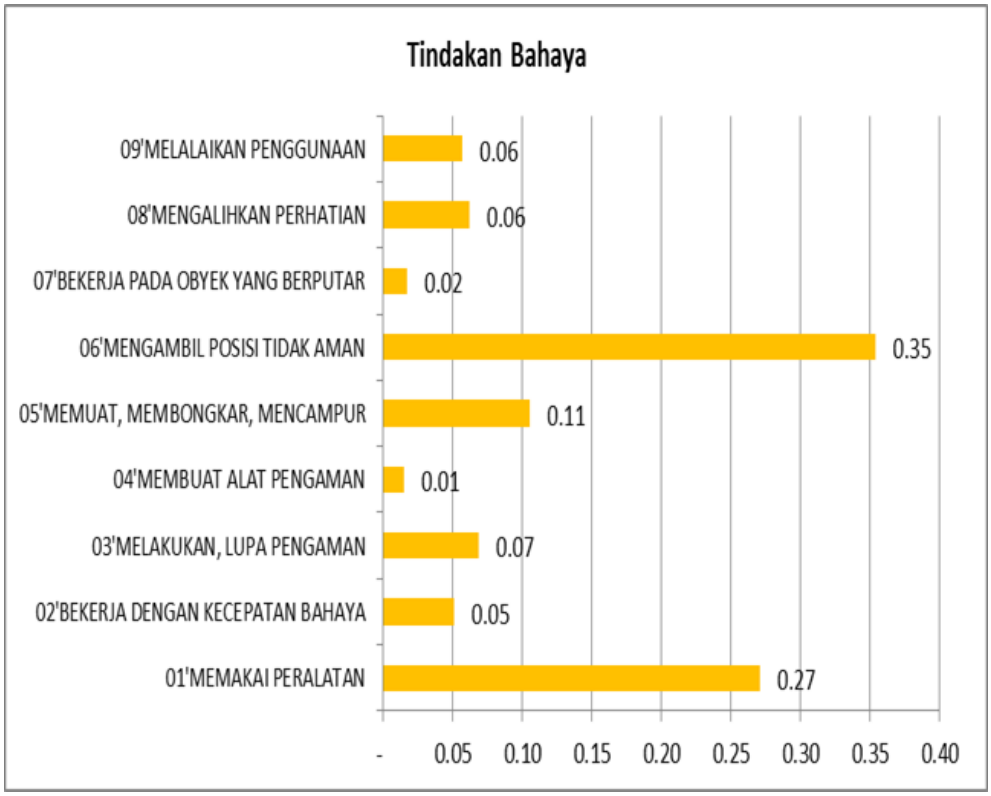
5) Mostly accident are got bumped 46%, trapped 17% and got hit 14%.



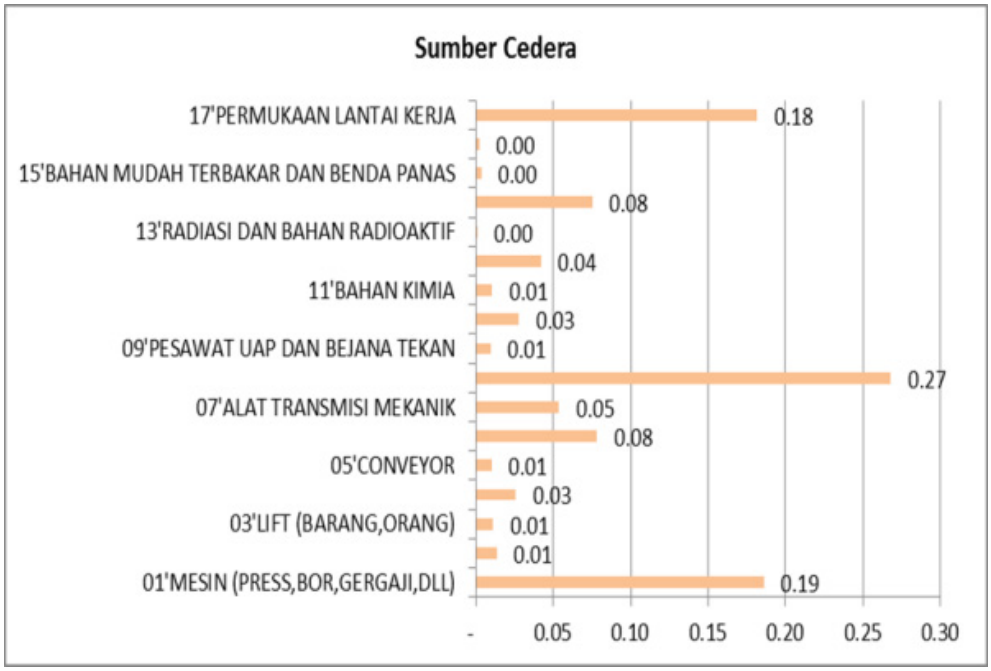
6) Danger situation caused by bad infrastructure 52%, lack of SOP 18% and disconnection 5%.



7) Danger action from not safe position 35%, lack of gear 27% and high mobilization 11%.



8) Sources of injury are hand tools 27%, machines 19% and surface of workspace 18%.



It is still being analyzed in FMARI database application with the modification of HFACS and HFIX with the use of Likert Ranking for Risk Assessment.

Table 1. Form to Fill in FMARI Database Application

Pertanyaan :

1=Rendah, 2=Cukup, 3=Medium, 4=Tinggi, 5=Sangat Bagus (penilaian untuk Feasible-Accepted-Efisien-Efektif-Sustain)

Unsafe Acts (Tindakan yang Tidak Aman) - (UA)

1 .Decision Errors (Kesalahan dalam Pengambilan Keputusan) - (UAE1xx)

Kode	Pertanyaan	Ware	Feasible Total	Accepted Total	Efisien Total	Efektif Total	Sustain Total
UAE101	Risk Assessment During Operation (Kesalahan Pengevaluasian/Penilaian Resiko Selama Proses Pengoperasian)	Human					
UAE 102	Task Misprioritization (Kesalahan Memprioritaskan Tugas)	Human					
UAE103	Necessary Action - Rushed (Kesalahan dalam Bertindak - Tergesa-gesa)	Human					
UAE104	Necessary Action - Delayed (Kesalahan dalam Bertindak - Terlambat)	Human					
UAE105	Caution/Warning - Ignored (Kesalahan dalam Mengabaikan Peringatan/Kewaspadaan)	Human					
UAE106	Decision - Making During Operation (Kesalahan Pengambilan Keputusan Selama Proses Pengoperasian)	Human					

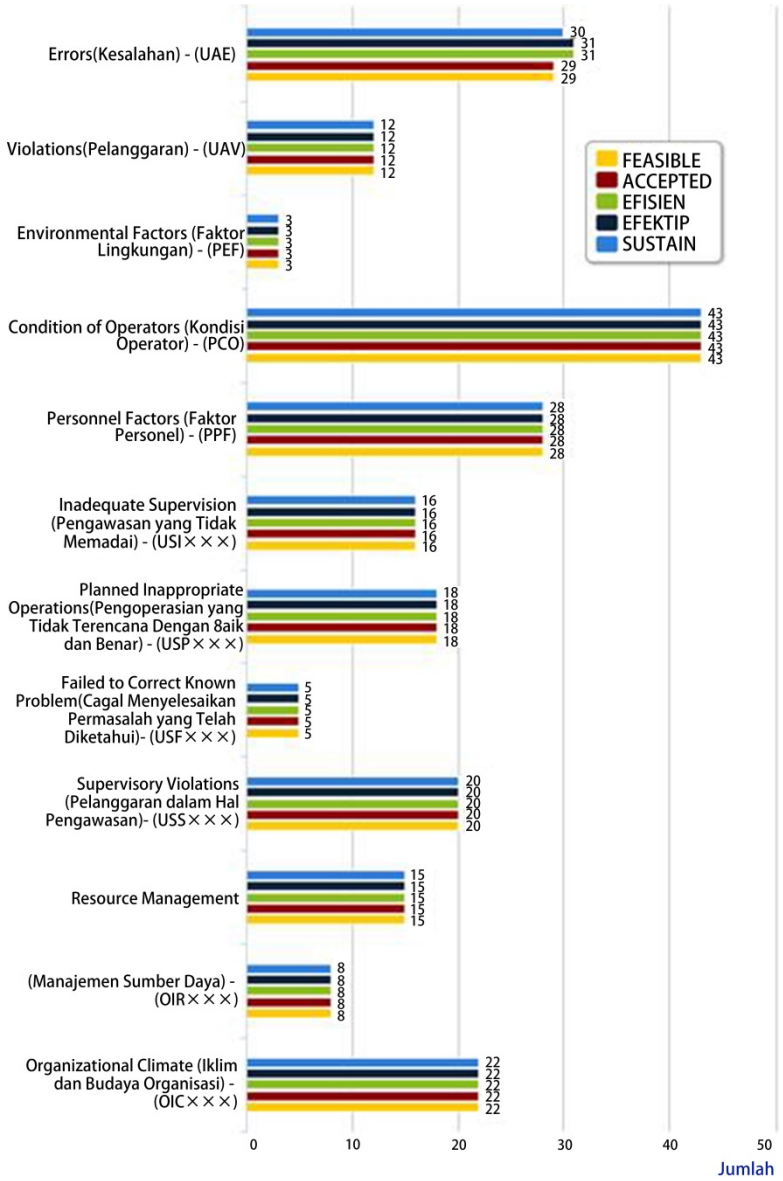


Figure 1. FMARI Analysis for Each Aspect

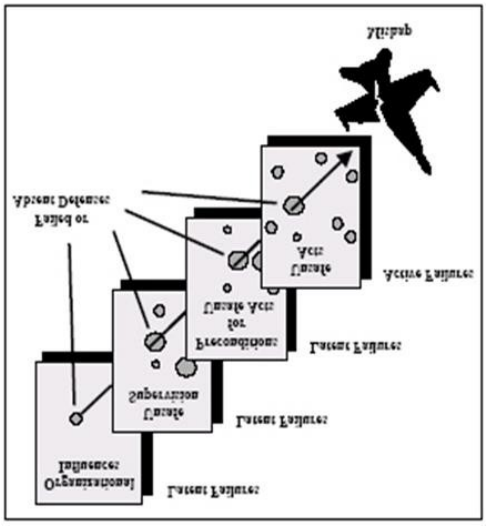
3.2. Reference for FMARI Research

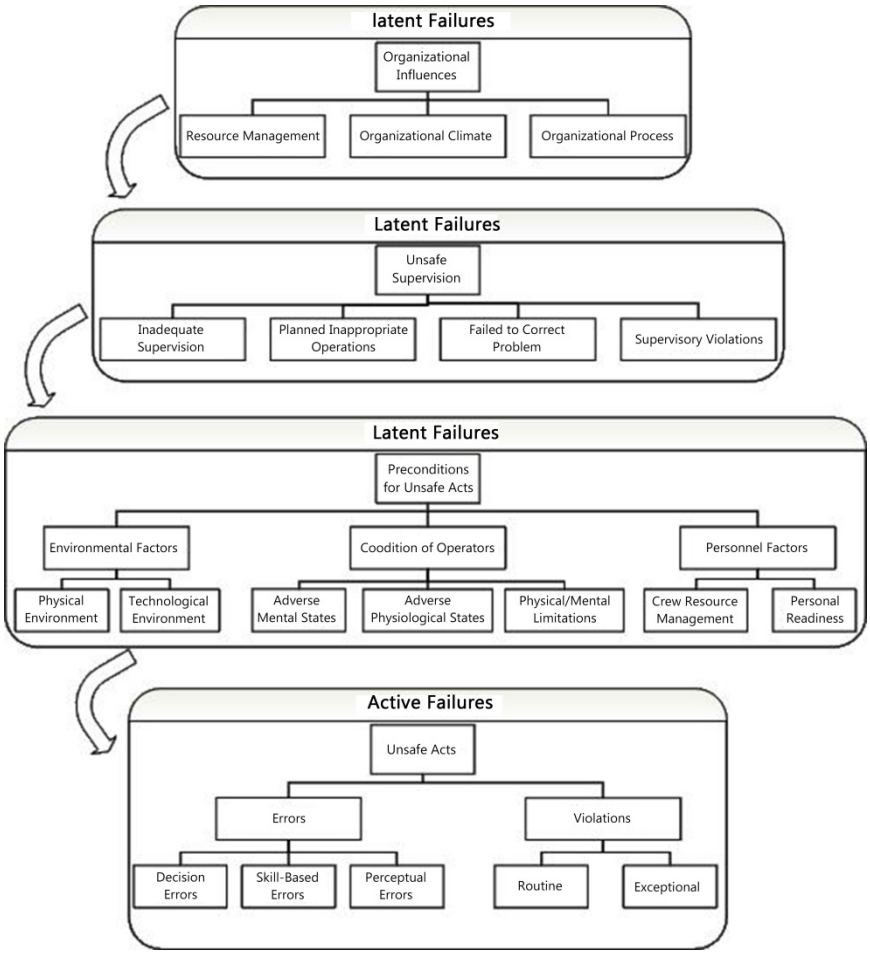
Table 2. State of the Art

Peneliti	Fokus penelitian	Metode	Partisipan	Material penelitian	Pengukuran
Culver,C.,Marshall,M.,& Connolly,C,(1993)	Analisis klaim kompensasidari pekerja konstruksi	Variasi laju jumlah kecelalaan	Data sekunder Biro Statistik	359.765kasus dari 10 area 1985-1988	Pengaruh faktor yang signifikan
Wiegmann dan Shappell (2007)	Penerapan klasifikasi kesalahan manusia pada transportasi udara	HFACS	Pegawai Federal Air Regulation (FAR)	119 laporan kecelakaan	Klasifikasi kesalahan manusia
Berlin,C.,Ortengren,R., Lamkull,D.,& Hanson.L, (2009)	Studi komparasi prosedur evaluasi	Komparasi kuantitatif, interview,statistik	2Ergonomis	Standar Nasional & Intemal Corporate	BME-AFS-98
Hamalainen,P.,Saarela, K.J.Takala,J.(2009)	Strategi Interfensi Efektif	Perhitungan Statistik	Data5 tahun	Date WHO	Trend Global
Zakaria,Z.,Hussin,Z.Hj, Noordin,N.,& Zakaria,Z. (2010)	K3di lokasikonstruksi	SPSS	100 orang	Kuesioner	Faktor kontributor kecelakaan
Village,J.& Ostry,A. (2010)	Pencegahan Cedera MSLs	Statistik	691 orang	Kuesioner Safety Climate Checklist	Model Multi Varia
M Ihsan Jambak(2011)	Perancangan petunjuk pelaksanaan penyelidikan faktor manusia pada kecelakaan pesawat udara sipil di Indonesia	HFACS	4 orang responden dengan kategoritertentu	Laporan Final kecelakaan pesawat terbang bersumberkan date dari KNKT	Klasifikasi kesalahan manusia
Eti H T (2011)	Pengaruh aspek budaya terhadap HFACS	HFACS	pilot garuda Idonesia	Quesioner HFACS budaya	deskripsiHFACS
Wu,J.,& Zhao,T.(2011)	Interaksi Manusia Mesin	C-HVACF	2 Auditor	Lap Kecelakaan Helikopter Cina	Model Kecelakaan
Amick,B.C.,Menendez, C.C.,Bazzanl,L., Robertson,M.,DeRango K.,Rooney,T.,&Moore, A.(2012)	Efek Interfensi Ergonomik	Uji Coba dan Model Statistik	78 orang	Tugas Group	Seleksi Kovariat
Yakubu,D.M.,& Bakri, I.M.(2013)	Investigasikinerjakontraktor	SHASSIC	Laporan 2002-2010	Kuesioner 3 tipe	DOSH
Yeow,P.H.P.,Yuen,Y. Y.,&Loo,W.H.(2013)	InvestigasikinerjaHSE kontraktor	SHASSIC	Lebih dari 40 pekerja di setiap lokasi 2002-2010	DOSH 2011	Ranking 3 hazard telah terdokumentasi

3.3. Other Recommendations

Wiegman and Shapell (2003) has developed a method to investigate the taxonomy of *human error* factor in the case of aircraft accidents and incidents called HFACS (Scott A. Shappel, 2000; Munoz,2018) following the Swiss Cheese Model (Reason,1990). Then adopted by other fields, namely shipping (Metin Celic, 2009), mining (Jessica M. Patterson, 2010), railways (Stephen Reinach, 2006; Munoz, 2018).





Selection method of investigation plays a crucial role, because each method has theories and concepts, each of which can produce output, focus on safety issues and different recommendations. In general, the accident investigation includes evidence collection, analysis, development of conclusions and reporting.

4. Discussion

The interaction between man and the various elements of the work are the main focus of the study of ergonomics that put forward the concept of *human-centered design.* If we examine more deeply, the human itself consists of several elements that interact to form a complex network system. Human beings have weaknesses and limits that are blending between them, raises error *(human error).*

In a simple *human error* is a specific variety of human performance which is reviewed from a clear unequivocal standards and defect performance retrospect based on a performance standard that is clearly done or omitted (Budiawan, 2010).

The definition of *"human error"* can be viewed from different angles. (Reason, 1997) gives direction *to human error* classification is based on four things:

- Intention

  The study of human error by mental process.

- Action

  The review is based on acts committed prior to human error.

- Outcome

  The review is based on the level of probability of occurrence and the consequences resulting intensity level.

- Context

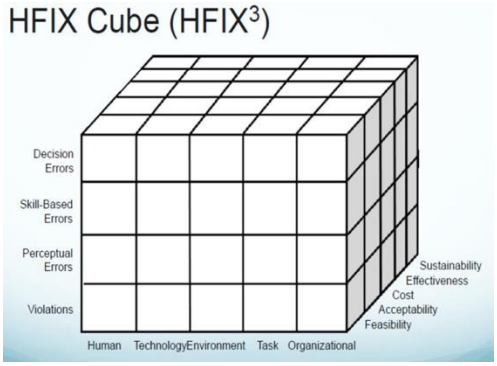
  The review is based on a contextual event where cognitive factors become one of the most influential psychological aspects (Budiawan, 2010).

Stanton stated that one way to analyze *human error* is the identification of *human error.* This process is known as *Human Error Identification (HEI)* (C. Baber, NA Stanton, *1996).* HEI is generally used as one of the aspects to be considered in designing the work system. This was done in order to minimize mismatches due to system error appears. Budiawan (2010) stated that the output of the HEI will provide knowledge to an analyst among other things;

- Potentials error that may occur.

- The intensity of the consequences if an error occurs.
- The need for recovery efforts.
- The level of probability of error that occurred.
- Posed critical level.
- Error reduction strategies.

Wiegman, Shapell & Associates (WSA) makes HFIX as intervention strategies using the mapping tool identification form human error analysis of HFACS and HFIX allow users to systematically build a comprehensive intervention strategy to achieve the target the cause of human error that is in the system.



FMARI modified HFIX applications (computerized version of HFACS) and not all nanocodes used in Indonesia.

	Unsafe Acts (Tindakan yang Tidak Aman) – (UA)		WARE
Errors (Kesalahan) – (UAE)	**Decision Errors (Kesalahan dalam Pengambilan Keputusan) – (UAE1xx)**		
	UAE101	Risk Assessment During Operation (Kesalahan Pengevaluasian/Penilaian Resiko Selama Proses Pengoperasian)	Human
	UAE102	Task Misprioritization (Kesalahan Memprioritaskan Tugas)	Human
	UAE103	Necessary Action – Rushed (Kesalahan dalam Bertindak – Tergesa-gesa)	Human
	UAE104	Necessary Action – Delayed (Kesalahan dalam Bertindak - Terlambat)	Human
	UAE105	Caution/Warning – Ignored (Kesalahan dalam Mengabaikan Peringatan/Kewaspadaan)	Human
	UAE106	Decision – Making During Operation (Kesalahan Pengambilan Keputusan Selama Proses Pengoperasian)	Human
	Skill-Based Errors (Kesalahan yang Diakibatkan oleh Kemampuan Dasar) – (UAE2xx)		
	UAE201	Inadvertent Operation (Kesalahan Akibat Ketidaksengajaan pada Proses Pengoperasian)	Human
	UAE202	Checklist Error (Kesalahan Menggunakan Daftar Periksa)	Human
	UAE203	Procedural Error (Kesalahan pada Prosedur)	Human
	UAE204	Overcontrol/Undercontrol (Kesalahan Pengendalian)	Human
	UAE205	Breakdown in Visual Scan (Kesalahan Akibat Kerusakan pada Alat Visual)	Human
	UAE206	Poor Technique (Kesalahan Akibat Teknik yang Buruk)	Human
	Perceptual Errors (Kesalahan yang Diakibatkan oleh Persepsi) – (UAE3xx)		
	UAE301	Error due to Misperception (Kesalahan Akibat Adanya Kesalahpahaman)	Human
	UAE302	Visual Illusion (Kesalahan Akibat Ilusi Penglihatan/Visual)	Human
	UAE303	Vestibular Illusion (Kesalahan Akibat Ilusi Keseimbangan)	Human
	UAE304	Misread Instrument (Kesalahan pada Pembacaan Peralatan)	Human
	UAE305	Expectancy (Kesalahan Akibat Pengharapan/Harapan)	Human
	UAE306	Auditory Cues (Kesalahan Akibat Isyarat Pendengaran)	Human
	UAE307	Temporal Distortion (Kesalahan Akibat Distorsi Sementara)	Human
	UAE308	Spatial Disorientation 1 Unrecognized (Disorientasi Spasial Tipe 1 Yang Tidak Dikenali)	Human
	UAE309	Spatial Disorientation 2 Unrecognized (Disorientasi Spasial Tipe 2 Yang Tidak Dikenali)	Human
	UAE310	Spatial Disorientation 3 Incapacitating (Disorientasi Spasial Tipe 3)	Human
	UAE311	Misperception of Operational Conditions (Kesalahan Akibat Kesalahpahaman pada Kondisi Operasional)	Human
Violations (Pelanggaran) – (UAV)	**Routine Violations (Pelanggaran Rutin) – (UAV1xx)**		
	UAV101	Routine/Widespread (Pelanggaran yang Bersifat Rutin/Menyeluruh)	Human
	UAV102	Based on Risk Assessment (Pelanggaran Berdasarkan Penilaian akan Resiko)	Human
	Exceptional Violations (Pelanggaran yang Bersifat Tidak Biasa) – (UAV2xx)		
	UAV201	Lack of Discipline (Pelanggaran Akibat Kurangnya Kedisiplinan)	Human

There is no statistical evidence on the economic level with low safety position will be more competitive, but ILO states that countries are at a high level of job security will also have the level of competition at the most good.

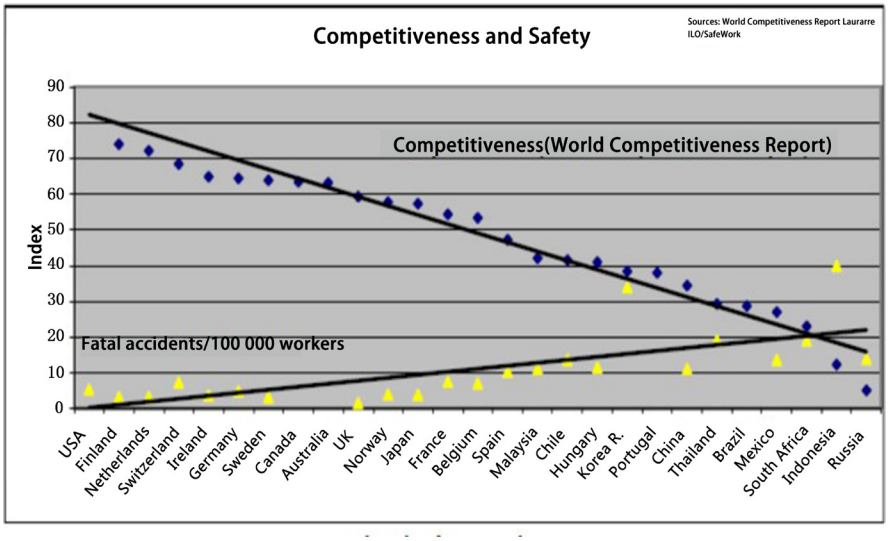


Figure 2. Competitive Safety Ranging (ILO, 2003)

In the early 1980s emerged a new view of health and safety at work, namely Behavioral Safety. Behavioral safety is the systematic application of psychological research on human behavior on the issue of safety in the workplace. Behavioral emphasize safety aspects of human behavior to the occurrence of accidents in the workplace. Suizer (1999), one practitioner Behavioral Safety suggests that practitioners have forgotten the main aspects of safety in preventing accidents that behavioral aspects of the workers. This statement is reinforced by the opinions Dominic Cooper. Cooper (1999) argues although difficult to control precisely, 80-95 percent of all workplace accidents that occur are caused by unsafe behavior. Cooper opinion is supported by the results of research of NCS on the causes of accidents. NCS research results show that 88% of causes of accidents are the unsafe behavior, 10% due to unsafe condition and 2% of unknown cause. Another study conducted by DuPont Company showed that 96% of workplace accidents are caused by unsafe behavior and 4% are caused by unsafe condition.

Unsafe behavior is the type of behavior that leads to accidents such works regardless of safety, do the job without permission, get rid of safety equipment, work operations at a breakneck pace, using non-standard equipment, abusiveness, lack of knowledge, disability or emotional state that impaired (Miner, 1994). According Suizer increase safety rules; safety training; an increase in the means of production; disciplinary and others have not been enough to prevent accidents. Changes obtained cannot last long because the workers back on old habits that unsafe behavior. Based on the reference that unsafe behavior is the biggest contributor to accidents then to reduce workplace accidents and to improve safety performance can only be achieved by focusing efforts on reducing unsafe behavior. Focus on unsafe behavior also results in better index of the safety performance in the company than focusing on the number of work accidents. It is based on two grounds, namely: occupational accident is the end result of a spate of unsafe behavior and unsafe behavior can be measured every day in a certain way. If the company is focused on the number of accidents, SMS tends reactive. Companies only pay attention to safety if the accidents increase. Instead behavioral safety approach tends to be proactive, because with this approach companies tend to try to identify any unsafe behavior that appears, so it can be directly addressed.

Accident Case Study

Based on information from various news sources, on Tuesday, February 12, 2013 around 10:00 am, some of the workers are in charge of making four holes for waste disposal at Basement Floor II. In one hole, there are four officers who do the work are two main officers (under) and mid- level officers (located above). While, making the hole is almost complete, just finishing removing the iron frame and cast the former boards to be painted.

On the fourth hole according to Standard Operating Procedures there are two workers who were on top and two workers at the bottom. But moments later, the hole heard two workers (workers 1 and 2) that were in the hole to ask for help. So that the two workers in the above (employee 3 and 4) down into the hole to help the workers who are in the hole.

Description of incident	Categories of contact that could have led to the indent	Immediate Cause	Basic cause	Activities for a successful loss control program
Poisoning gas/ defisiensi oxygen	Knotak dengan Gas poisonous	Substandard Act Failure to Secure Failure to use PPE properly Substandard Condition Hazardous Environmental Condition improperly PPE	Personal factors poor of knowledge lack of coaching Lob factor Lack of supervisory Lack of risk Identification	Gas Detector Properly and adequate blower Harness

Then two rescue workers who had come to ask for help because of difficulty breathing. A worker (workers 5) in the other hole up to cry, and then tried to help four colleagues. The worker is assisted by other workers (workers 6) and one clerk K3. Officers K3, 5 workers and assisted one another worker (worker 7) down to the bottom, while six officers kept vigil above. Then they cried again and fainted. So then a man officer of PT. Wxxx helped rescue using an oxygen mask and blower. They managed to evacuate a person. Officers of PT Wxxx that helped claimed limp. Then they replaced other officers, evacuate four other workers. Victims who had been evacuated seven people. Five people died and two people critical. Health Safety Executive, United Kingdom (2001) paparkan bahwa *The Systematic* Cause Analysis Technique (SCAT) is a method which has been developed by the International Loss Control Institute (ILCI), which can be used to determine the root causes of an incident once a description of the sequence of events has been determined. A paper describing SCAT by Bird and Germain (1985) is reproduced *in a manual by ILCI (1989).* Following the incident with the scheme SCAT method:

Scheme above is overview of the analysis of accidents that occur. Predicted the case of occupational accidents is a type of gas poisoning. Some of the symptoms showed any indication of gas poisoning that workers experiencing weakness in the body, shortness of breath and eventually unconsciousness. Besides, this suspicion is reinforced by the characteristics of the work environment in the form of Confined Space. Greatest risks in the workplace Confined Space is poisoning gas.

In the second case there is a block that contains a variety of things can lead to accidents. In the case of contact with poisonous gas is inevitable. This condition can be derived from the facts.

Among the release dangerous gases resulting difficulty breathe workers, workers are not equipped with gas detectors and the ability to use it, do not appropriate identification, and more.

In the third box is the immediate cause (direct cause) of the accident. There are two categories, namely ratings substandard conditions act and substandard. Substandard Act in this case, at least there are two main points of the points that we write SCAT diagram that failure to secure the working conditions and the workers themselves as well as the failure of workers in the use of PPE. Failure to secure in this case the victim is not protected from the risk of exposure to dangerous gases. Failure to use PPE Properly means victims do not use PPE properly. In the news, it did not mention whether workers using PPE such as respirators or not, only mentioned that the project has provided one blower for each hole.

In the fourth box, there is Basic Cause (basic cause) that contains Personal Factor and Factor Job. Personal Factor includes the Poor of Knowledge and Lack of Coaching. Poor of Knowledge means that workers and HSE officers do not yet have sufficient knowledge to perform tasks at confined space. Director General Labour Inspection Guidance No.Kep / 113 / DJPPK / IX / 2006 is set on who is allowed to work in confined spaces there is even a certain criteria that must be met to work in the confined space. Also in the news is mentioned that there was one officer who became a victim K3. This shows that the Human Resources Officer K3 especially do not know the standard first aid in an accident. Some officers K3 in the Company no competence appropriate background so that the competencies acquired during the training only General K3 or K3 specialization approximately less than a week. Victims should be able to be more and more reduced in number.

Job factors include Lack of supervisory and Lack of risk identification. It is clear that there was negligence in upholding the culture of K3 in the neighborhood. K3 officers with one of its functions is to identify the danger of omission by not detecting the presence of dangerous gases so that control measures do not exactly.

In the fifth box, it discusses what you can do to succeed Loss Control Program. Some recommendations are

equipped workers with Gas Detector, Blower right and Harness. However, the most important thing is to revitalize K3 on the project workers and equip workers with adequate knowledge about K3 so as to enhance the action of safe work. The employee or officer K3 / HSE must be qualified in the work.

In this accident evenly and systemic errors, not only the environment but the supervision and implementation of K3 were seen as insufficient.

FMARI analysis in PT Wxxx accident is:

1) For Error Type: Errors, Violations, Environmental Factors, Operator Condition Factor, Personnel, Supervision Less, SOP unplanned, Solutions fails, Management, Human Resources and Climate and Cultural Organization dominant.
2) Analysis FMARI for Mode Type: UNSAFE ACT where UAE1xx value at 15.
3) Analysis FMARI for Preconditions Error Type: PCO2xx a value of 28.
4) For FMARI Analysis Error Type UNSAFE SUPERVISION: USI1xx 16.
5) For FMARI analysis mode ORGANIZATIONAL PROCESS: Mistakes to achieve the greatest value in industry performance factor where efficiency is low because of the high cost of injury claims due to severe risk.
6) FMARI Analysis for Decision Making Errors: UAE105 reached a value of 5 for all industry performance factors.
7) Analysis FMARI for errors caused Foundational Skills: UAE203 achieve UAE202 5The value reached a value of 4, while UAE204 value 2.
8) Analysis of error caused by the perceived FMARI: UAE311 value of 5.
9) Analysis FMARI for Violations Routine: UAV101 inefficient in grades 5.
10) Characteristically FMARI for Violation Analysis Offbeat: UAV201 value of 5.
11) FMARI Analysis for Environmental Technology: PEF206 reach a value of 3.
12) Analysis FMARI Level Mental state: PCO101 and PCO111 value of 5.
13) Analysis FMARI Level Physical State: PCO206, PCO210, PCO211, PCO212, PCO215 reached a value of 5 for all industry performance factors.
14) Analysis of Physical and Mental Limitations FMARI: PCO305 value of all five.
15) FMARI Analysis of Human Resource Management: PPF1xx vary.
16) Analysis FMARI Readiness Self Implementing Task: PPF2xx grades 1-2.
17) Analysis FMARI Oversight Insufficient: USIxxx value varies.
18) Analysis FMARI Planned Operations Less: USPxxx vary.
19) Failed FMARI Analysis Solving Problems: USF101, USF102 value of 5.
20) Analysis FMARI Violations in Surveillance: USSxx value 5 (severe).
21) Analysis of Organizational Influence FMARI: OIR103 reach a value of 5.
22) FMARI Analysis of Climate and Cultural Organization: OIC grades 3, OIP value 2.

5. Conclusions

The design modifications Human Factors Intervention Matrix (HFIX) application form to Human Factors and Risk Analysis Industry (FMARI) is an effort HFACS visualization method is *user-friendly* and ease of *entry or update* data to all users in the field of occupational safety and health in Indonesia.

FMARI analysis on input of occupational accidents in the Waste Water Drainage Project Basement II was at the level: *feasibility, acceptance, efficiency, efficient,* and dominant at *sustainability* from significant nanocode. It was influenced by several factors, including:

- Errors, Violations, Environmental Factors, Operator Condition Factor, Personnel, Less Supervision, SOP unplanned, Solutions fails, Management, Human Resources and Climate and Cultural Organization shown to trigger an accident in Confined Space.
- Negligence of workers, work tools Completeness, Completeness of safety equipment, location altitude of work will also increase along with the percentage of completion of the project.
- K3 management improvement through intervention strategies at all levels, has contributed to a decrease in construction accidents and the government as the labor competency skills builder construction etc., set the Zero Accident program that must be met by all types of companies in a variety of fields.

Research that has been done is the first step for the implementation of evaluation and monitoring HFACS on SMS (SMK3) particularly construction services and other fields apart from military and transportation fields. Some of the alternative developments of FMARI include [9]:

- FMARI use as *an open-source application* and every SMK3 auditor especially in construction share findings from the field.
- The addition of such nominal input cost compensation for victims of accidents in the construction sector or the amount insurance companies imposed by BPJS.
- Database development FMARI of reports SMK3 / SMS manufacturing, oil and gas, automotive, chemical production derivatives and *high-risk projects.*
- Making FMARI applications based on Android to facilitate direct data entry shortly after the accident

occurred so that the evidence in accordance with the report.

- FMARI with local language and make improvements toward development simulation scenario programming.

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