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"San Cai" Human Factors Analysis Model of Civil Aviation Maintenance

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Abstract. Two famous civil aviation accident Human Factors analysis models SHELL model and Reason model were introduced in this article. The advantages and disadvantages of the models were both discussed. After that, a new Human Factors analysis model of civil aviation maintenance was proposed, which is named "San Cai" model, with the purpose of designing an easy-to-use Human Factors analysis model for the Chinese maintenance personnel. The "San Cai" model is much simpler than SHELL model and Reason model. Because of its simplicity, the "San Cai" model is easy to use in Chinese maintenance personnel's daily work.

Introduction

"Human Factors is about person in their living and working situations; about their relationship with machines, with procedures and with the environment about them; and also about their relationships with other person (being work). In aviation, Human Factors involves a set of personal, medical and biological considerations for optimal aircraft and air traffic control operations", described in the International Civil Aviation Organization (ICAO)'s report [1]. With the aircraft design and manufacture technology's development, the civil aviation accidents due to the aircraft's design and manufacture faults decrease at a high rate of speed. Meanwhile, the accidents due to the Human Factors faults in aviation maintenance increase significantly [2]. The Human Factors becomes the first dangerous to the civil aviation operation safety.

The Human Factors research began in 1970s, which is still an emerging subject of science. As a multi-disciplinary approach, it is difficult to investigate the relationship between the Human Factors and the civil aviation accidents, and it is also difficult to operation the airlines excluding the Human Factors' negative impact. So, find a theoretical model to clearly and fully describe the Human Factors' impact in the airlines' operation is extremely urgent. Especially，find an easy-to-use Human Factors analysis model for the Chinese maintenance personnel's daily work is even more difficult, because the famous Human Factors models are always too complex to be understood and be used.

In the paper, the features of the famous SHELL model [3] and Reason model [4] were fully discussed. After then, a new Human Factors analysis model named "San Cai" model was designed for the easy-to-use purpose, its design concept was also deep elaborated.

The SHELL model

The SHELL model is originated from SHEL model by Edwards in 1972, and developed by Hawkins in 1975. The SHELL model mainly describes the relationship between the Human Factors and the aviation environment. Its main concept can be explained in the Fig. 1 shows. S means software, including all the non physical resources such as procedures, manuals and placards; H is

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for hardware, which contains all the physical resources such as aircraft, tools, equipments; E represents environment, which comprehends both the nature environment and the social environment, such as the noise of the workplace, the salary and the social status of the work; The central L stands for livewire, can also be simply considered as the man who charges the work., the central L is the centre of the SHELL model; The last L also stands for livewire, but it means team work, communication, leadership, and etc.

Fig. 1 The SHELL model.

The SHELL model explains almost all the factors which will influence the staff (the central L in Fig. 1). S-L, if the software is not properly designed for the worker, he may make a fault. H-L, if the equipment is too difficult to use, the worker will make a fault. E-L, if the workshop environment is very tough, the worker will make a fault, because he can't always focus on his work. L-L, if the workers can't communicate well with each other, the misunderstanding will possibly make a fault. According to the SHELL model, in order to avoid the accidents caused by Human Factors, the software, hardware, environment and livewire, all of the four modules must match the central L module. The SHELL model only enumerates various resources that will impact the worker, but there is no organization about them. The importance of the organization could be found in another famous Human Factors model: the Reason model.

The Reason Model

The Reason model was propounded by professor Reason of the University of Manchester, in 1990 [4]. The Reason model likens human systems to multiple slices of Swiss cheese, as shown in Fig. 2 [5]. In Reason model most accidents can be traced to one or more of four failure domains: organizational influences, supervision, preconditions and specific acts, just like the four slices of Swiss cheese in Fig. 2.

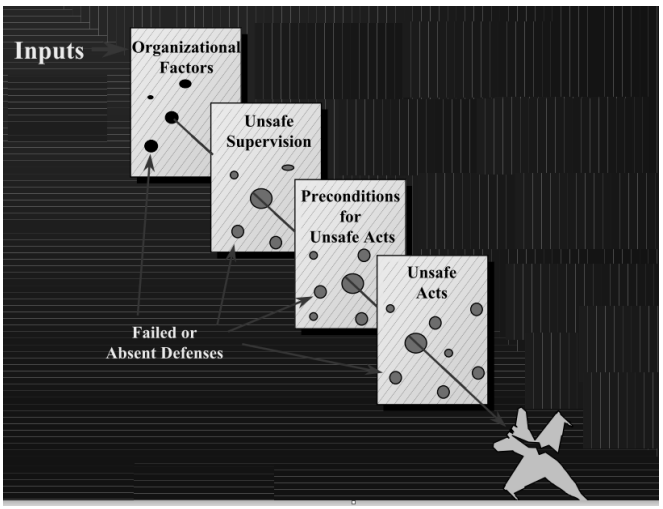

Fig. 2 The Reason model.

In the Reason model, the holes in the slices represent weaknesses in each system part. The holes size and position will always change as the system operated. When the holes in each slice could line up, the accident occurs. It is clearly that the Reason model is a typical organizational model. The Reason model shows the accident is not usually an isolated incident, it may be caused by multiple organization faults, and each fault may influence each other. The inappropriate organization will lead to both active and latent failures, so does the inappropriate supervision. The inappropriate organization and supervision provides the workers an unsafe precondition, and the accident will finally occur when the workers also do some inappropriate operation.

Compared to the SHELL model, the Reason model impresses the important of the organization (the supervision can be also considered as part of the organization). The organization factor is considered to be the mainly human factor rather than the other multiple resources.

The Limitations of the SHELL Model and Reason Model

Both the SHELL model and the Reason model are famous Human Factors analysis models. Almost all the factors that will impact the aviation safety are considered in the two famous models. They are suitable for the Human Factors theoretical research and the airlines' aviation maintenance management. But they are difficult to be understood by the maintenance workers. There are too many factors and theories in the models. Especially, for the Chinese aviation maintenance workers, the models concepts don't match the Chinese thinking habits. They are even more difficult for the Chinese workers to use in the daily work.

The "San Cai" Model

The definition of Human Factors, the SHEEL model and the Reason model all show that the nature of the aviation maintenance Human Factors research is to make the maintenance worker do the right things, at the right time, in the right environment, with the best team work. This idea is consistent with the ancient Chinese philosophy: Tianshi (in Chinese), Dili (in Chinese) and Renhe (in Chinese). In English, Tianshi means time and timeliness, Dili means the position and environment, Renhe means human and human relations. Tianshi, Dili and Renhe is called "San Cai" in eastern culture, which means three important elements for succeed. The "San Cai" philosophy is quite in line with the Human Factors research, and it's very familiar to Chinese. So, a "San Cai" model is proposed in order to make the Human Factors theory being popular with the Chinese maintenance personnel, and finally decreases the Human Factors accidents in daily work.

The main concept of the "San Cai" model is shown in Fig. 3. The model mainly contains three important elements, time, environment, and human. "Time" in this model is not only mean what time it is now, it means what should you do at this time. For an example, when the flight is going to arrival, you should remind yourself to prepare for line maintenance. You must realize what the common faults are at this time, and remind yourself not to make these mistakes. The environment contains the hardware environment and software environment. It is similar to the SHEEL model. Human is the most important part of the model. Human not only means the worker's state, but also means the relation ship between the workers who have to finish the work together. Teamwork, management, and organization are all contained in the "Human" part, a little like the Reason model. The relationship of the three elements is shown in Fig. 3. Human should to work in the right environment, at the right time. Human is the center part between Time and Environment. These three elements have to cooperate with each other, building a harmonious relationship. When they are suitable for each other, the model looks like three smooth concentric circles.

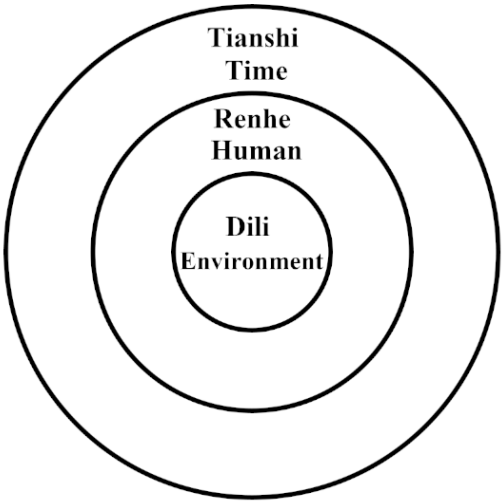

Fig. 3 The “San Cai” model.

Fig. 4 shows the system initial status, at a random time (bad situation). At the beginning, these three elements may be not suitable for each other. So, each of these parts may have an irregular boundary, with the meaning of that they are inconsistent. At this time, the maintenance worker has to find the problem, and solve it. Then make him or the team could be able to finish the work safely at the right time, in the right place. The process of using the “San Cai” model to resolve the Human Factors problems in the civil aviation maintenance could be depicted by the Fig. 4.

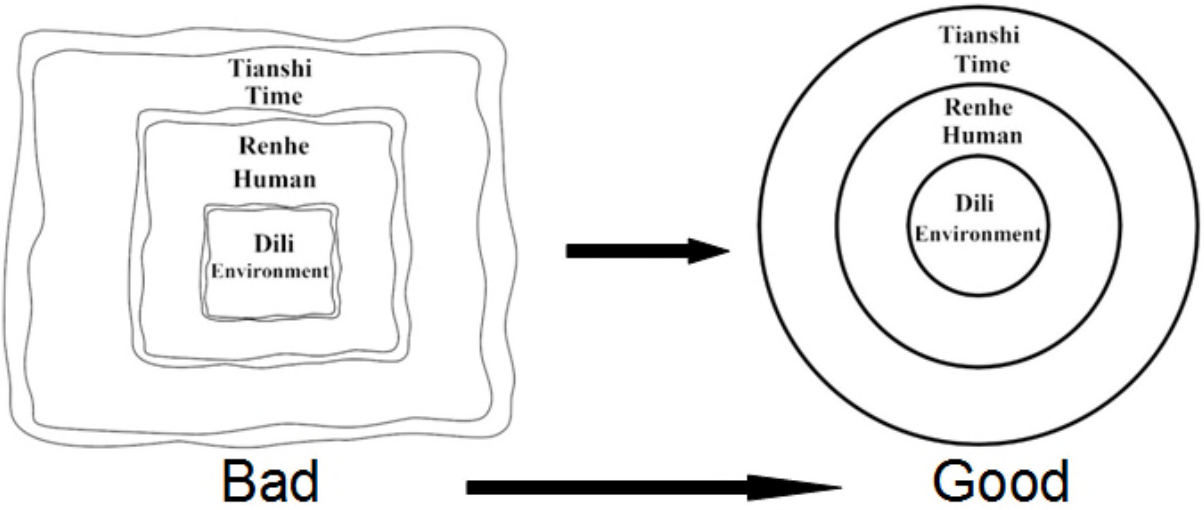

Fig. 4 The initial status and change process.

Summary

The “San Cai” Human Factors analysis model contains both the SHELL model and the Reason model’s concept, but it is much simpler than them. Additionally, the model originates form the Chinese ancient philosophy, which makes it easy to be understand by Chinese maintenance personnel. The “San Cai” model makes the common worker can also apply the Human Factors theory in their daily work, which will significantly improve the civil aviation safety level.

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