The Application of Human Error Template (HET) for Redesigning Standard Operational Procedures in Aviation Operations

Wen-Chin Li[1], Don Harris[2], Yueh-Ling Hsu[3], and Lon-Wen Li[4]

[1] Psychology Department, National Defense University, Taiwan, R.O.C.
w.li.2002@cranfield.ac.uk
[2] Human Factors Department, Cranfield University, United Kingdom
[3] Department of Air Transportation, Kainan University, Taiwan, R.O.C.
[4] Training Centre, National Defense University, Taiwan, R.O.C.

Abstract. Human Error Template (HET) is a checklist style approach to predict human errors in the cockpit for developing accident prevention strategies. It is applied to each bottom level task step in a hierarchical task analysis (HTA) of the task in question. This research applies the latest technique for human error prediction- Human Error Template to predict the potential design-induced human errors in the IDF during the landing phase of flight and provide a basis for improving software design and hardware equipment to enhance flight safety. In military operations emphasis is on the fulfillment of SOPs in an attempt to prevent incidents/accidents resulting from human factors. By the use of the scientific approach of HTA to evaluate current SOPs together with formal error analysis of the pilot's, interface design and procedures, the air force's combat effectiveness will be improved and a user-friendly cockpit interface can be developed.

Keywords: Aviation Safety, Hierarchical Task Analysis, Human Error Template, Standard Operation Procedure.

1 Introduction

New generation, modern technology aircraft have implemented highl automated systems and computerized cockpits. However, human factors accidents have become the most significant concern for everyone in the aviation industry. According to accident investigation reports, inappropriate system design, incompatible cockpit display layout, and unsuitable SOPs were the major factors causing accidents [9]. Li & Harris [6, 7] found that 30% of accidents relevant to 'violations' included intentionally ignoring standard operating procedures (SOPs); neglecting SOPs; applying improper SOPs; and diverting from SOPs. Dekker [1] has proposed that human errors are systematically connected to features of operators' tools and tasks, and that error has its roots in the surrounding system: the question of human or system failure alone demonstrates an oversimplified view of the roots of failure. The important issue in a human factors investigation is to understand why pilots' actions made sense to them at the time the accident happened.

D. Harris (Ed.): Engin. Psychol. and Cog. Ergonomics, HCII 2009, LNAI 5639, pp. 547–553, 2009.

Human Error Template (HET) is a checklist style approach to error prediction that comes in the form of an error pro forma containing 12 error modes. The HET methodology is applied to each bottom level task step in a hierarchical task analysis (HTA) of the task in question. The technique requires the analyst to indicate which of the HET error modes are credible for each task step, the probability of error and the criticality of error, based upon their judgment for developing effective accident prevention strategies [4]. The HET error taxonomy consists of 12 basic error modes that were selected based upon a study of actual pilot error incidents and existing error modes identified from previous research [11]. The 12 HET error modes are: (1) Failure to execute; (2) Task execution incomplete; (3) Task executed in the wrong direction; (4) Wrong task executed; (5) Task repeated; (6) Task executed on the wrong interface element; (7) Task executed too early; (8) Task executed too late; (9) Task executed too much; (10) Task executed too little; (11) Misread Information; (12) Other. For each credible error the analyst provides a description of the form that the error would take. The analyst has to determine the outcome or consequence associated with the error and estimates the likelihood of the error using three levels: low, medium or high; and the criticality of the error using three levels, low, medium or high. If the error is given a high rating for both likelihood and criticality, that aspect of the interface involved in that task step is then rated as a 'fail', meaning that it is not suitable for certification [8]. The main advantages of the HET method are that it is simple to learn and use, requiring very little training and it is also designed to be a convenient method to apply in the field. The error taxonomy used is comprehensive as it is based on existing error taxonomies from a number of HEI methods [12].

The advanced automation in new generation aircraft have without a doubt offered considerable improvements in safety over their original types, however new types of error have begun to emerge on these flight decks. This was exemplified by accidents such as the Nagoya Airbus A300-600, where the pilots could not disengage the go-around mode after its inadvertent activation, as a result of a combination of lack of understanding of the automation and poor design of the operating logic in the auto-land system. As a result of such accidents relevant to human errors, the US Federal Aviation Administration [3] commissioned an in-depth study of the pilot-aircraft interface in modern cockpits. The report identified several major flight deck design shortcomings and deficiencies in the design process. There were criticisms of the cockpit interfaces, such as pilots' auto-flight mode awareness/indication; energy awareness; confusing and unclear display symbology and nomenclature, and a lack of consistency in FMS interfaces and conventions.

HEI techniques should be capable of being used for the revision of SOPs and flight deck design to comply with the certification requirement and enhance the ability o perform Taiwan MOD's priority task. In order to enhance safety, there is also a strong economic argument for airlines for the early identification of inadequacies of interface design in the cockpit. Making revisions late in the design of interfaces and/or operational procedures is expensive. This research applies HET for evaluating the pilot interface and identifying potential instances of 'design-induced error' in components such as software system design, human-computer interaction, automation and cockpit layout, and the associated SOPSs for using these systems. The ultimate objective is to enhance pilots' situation awareness, reduce error and improve aviation safety. The results of this study will be able to improve the safety for pilots' training, revising standard operation procedures, and for modifying software and hardware design.

2 Method

Participants: Six participants took part in this research including three pilots with over 2000 flight hours (including senior IDF instructor pilots), two aviation safety domain researchers, and one aviation human factors expert with flight experience.

Purpose: There were two purposes for this research: the first purpose was to evaluate the IDF Fighter pilot interface and the second purpose was to evaluate the IDF standard operation procedures through the application of Hierarchical Task Analysis and Human Error Template analysis.

Research Design: An HTA was performed from the standard operation procedures and expert de-briefing for the final approach to parking the fighter on the ramp. This required the integration of IDF SOPs, knowledge of flight operations by senior instructors, safety management researchers, and aviation human factors researchers all of whom participated in the development of the HET analyses.

Procedures for HTA: Hierarchical task analysis is the most popular task analysis method and has become perhaps the most widely used of all HF methods available. Originally developed in response to the need for a greater understanding of cognitive tasks [2], HTA involves describing the activity under analysis in terms of a hierarchy of goals, sub-goals, operations and plans. The end result is an exhaustive description of that task. The HET template was then applied to the bottom level tasks in the HTA to identify any potential error modes.

3 Results and Discussion

Through the use of HTA, the expert team in this study analyzed the SOPs for landing the IDF and further developed the HET evaluation form for landing the IDF at CCK airport. Based on the findings of the HTA, it was found that the goal- 'Land IDF at CCK airport' was composed of 11 sub goals at level 2 (such as 1.11 Stop Aircraft at Check Zone), followed by another 28 sub sub-goals at level 3 (such as '1.11.2 Check after Landed), followed by 16 sub sub-goals at level 4 (such as '1.11.2.6 Navigation Equipment Off), and 6 sub sub-goals at level 5 (such as '1.11.2.6.1 TACAN Off). The result demonstrates the fact that the main goal of IDF Landing Safely won't be achieved unless these 61 sub sub-goals at levels 2, 3, 4 and 5 are accomplished (Figure 1).

Within the 61 sub goals in the HTA, there are contained 43 bottom level tasks as shown as the sub goals underlined in Figure 1. These bottom level tasks are also action items. Although each action item is for a specific goal, it represents an activity to be performed for a safety reason. Therefore the HET evaluation form developed for the IDF was applied to each of the 43 bottom level tasks identified from the HTA to diagnose the opportunities for the 12 basic error modes in the HET to be committed, i.e. the likelihood of the following errors " Failure to execute", "Task execution

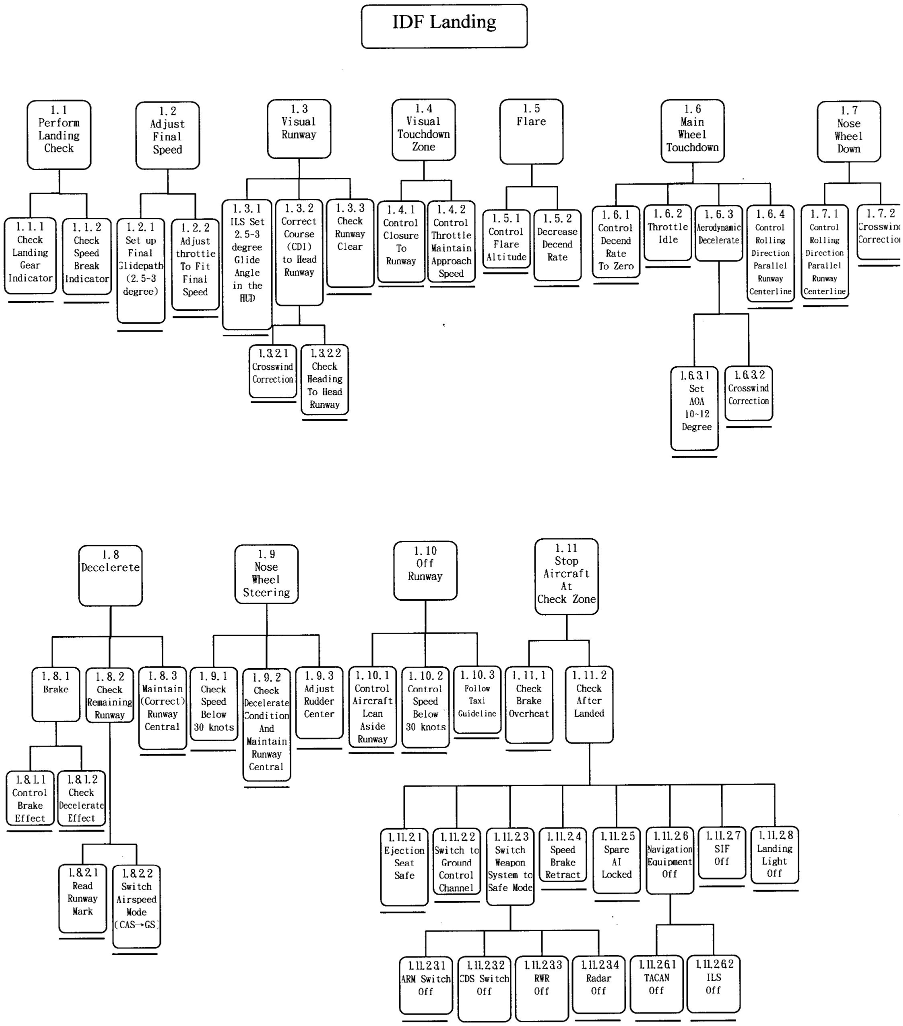

Fig. 1. The Example of SOPs for IDF Fighter Landing by HTA

incomplete", "Task executed in the wrong direction", "Wrong task executed", "Task repeated", "Task executed on the wrong interface element", "Task executed too early", "Task executed too late", "Task executed too much", "Task executed too little", and "Misread Information". Each of these actions was categorized on the basis of its error likelihood (very low, low, medium, high or very high), and the criticality of that error mode for flight safety (very low, low, medium, high or very high). For example, there are several potential error modes associated with the sub-goal of 1.1.2 Check Speed Brake Indicator, such as Forget to check, Not fully extend, Rear cockpit switch not central, Mis-switch weapon-cross switch, operate the S/B (Speed Brake)

Scenario: **IDF Landing at CCK AFB**			Task step: **1.1.2 Check Speed Break Indicator**												
Error Mode	Yes/ No	**Description**	**Outcome**	**Likelihood**					**Criticality**					**PASS**	**FAIL**
				L		M	H	H	L		M	H	H		
Fail to execute	□ Y ■ N	Forget to check	To fly with doubt, unsure right S/B allocation so that affect the speed-up power when go around												
Task execution incomplete	■ Y □ N	Not fully extend	Decelerate slowly with high speed, throttle allocation low												
Task executed in wrong direction	□ Y ■ N	Rear cockpit switch not central	Approach speed increased easily, descend rate is low												
Wrong task executed	□ Y ■ N	Mis-switch weapon-cross switch	May lead to low AOA but high speed												
Task repeated	■ Y □ N														
Task executed on wrong interface element	□ Y ■ N	Undo S/B switching but D/F	Undo S/B out												
Task executed too early	□ Y ■ N	Change flight formation in case	Undo the SOP to decrease the safety distance between two aircrafts												
Task executed too late	■ Y □ N	S/B in by accident	Abnormal operation procedure which may compress operation time and increase workload at the same time												
Task executed too much	□ Y ■ N														
Task executed too little	■ Y □ N														
Misread information	□ Y ■ N	Fake signal or misread	Lead to wrong estimation or operation												
Other	□ Y ■ N														

Fig. 1. An Example of Human Error Template Format for IDF Fighter during landing

switch instead of D/F (Dog Fight) switch, accidental S/B retraction, or misread information (see Figure 2).

These types of errors will result in operations with an unsure S/B allocation which will result in the aircraft decelerating slowly from high speed and throttle at low position, an increased approach speed with a low descent rate, AOA low with high speed. Restricted time to perform these operations increased workload at the same time, and helped to increase the chance of wrong estimates or operations. The expert team then needed to evaluate the likelihood of these errors and the criticality of the errors. If the error is given a high rating for both likelihood and criticality, this aspect of the interface involved in the task step is then rated as a ‘fail’, meaning that it is not suitable for certification. Thus, to effectively prevent the occurrence of human errors, more specific training should be implemented, the software/hardware need to be redesigned, and/or SOPs need to be updated, etc.

Diaper and Stanton [2] suggested that HTA is the best method for human-machine research, and has great potential to be used in the system design and development of aircraft. The findings from this research show a high opportunity for IDF pilots to operate the IDF’s Speed Brake by mistake because the Speed Brake is close to Dog/Fight Switch; as a result there is a potential flight safety concern. It demonstrates that HTA and HET can identify whether redesign work is needed to the controls and instruments in the cockpit. Stanton [2] suggested that HTA is good for system design and analysis, from design concept to practical application, especially for the purposes of task allocation, procedure design, training syllabus design and interface design. The reason behind HTA’s popularity is its effectiveness and flexibility. A great deal of Human Factors research is unlikely to be effective without HTA, such as usability evaluation, error identification, or performance evaluation. The step-by-step output of HTA is practical to use. Researchers are able to gain an in-depth knowledge of the activity under analysis. However, the disadvantage of the technique is the amount of data collection required and the time that it takes [5]. For example, there were 43 action items in the IDF landing process. The HET error taxonomy consists of 12 basic error modes with 3 variables to assess (severity, frequency and pass/fail). In total, each participant pilot needs to fill in up to 43*12*3 = 1,548 data cells, which is a considerable amount work for every participant. In addition, it takes time to become familiar with the technique and conduct a reliability analysis. Nevertheless, performance of a formal error analysis at the early stages of the process for designing the flight deck and its operating procedures is still a lot cheaper than re-designing the aircraft interfaces once it has entered service.

4 Conclusion

This research applies the latest technique of human error prediction- Human Error Template which is based on Hierarchical Task Analysis to evaluate current the cockpit design and standard operation procedures of IDF fighters. The research aims were to predict the potential design-induced human errors for the IDF during landing as well as improve software design and hardware equipment for flight safety. Together with data from previous incidents/ accidents and the studies of human factor engineering, HET is an appropriate technique to conduct error prediction for flight safety. This year, the military emphasis is on the fulfillment of SOPs in an attempt to prevent incidents/accidents resulting from human factors. By the use of a scientific approach using HTA to evaluate current SOPs together with error analysis, interface design and procedure certification, the air force's combat effectiveness will be enhanced and a user-friendly task environment can be achieved.

References

1. Dekker, S.: The Re-invention of Human Error. Human Factors and Aerospace Safety 1(3), 247–266 (2001)
2. Diaper, D., Stanton, N.A.: Handbook of Task Analysis in Human-Computer Interaction. Lawrence Erlbaum Associates, Mahwah (2004)
3. Federal Aviation Administration, Report on the Interfaces between Flightcrews and Modern Flight Deck Systems, Federal Aviation Administration, Washington DC (1996)
4. Harris, D., Stanton, N.A., Marshall, A., Young, M.S., Demagalski, J., Salmon, P.M.: Using SHERPA to Predict Design-Induced Error on the Flight Deck. Aerospace Science and Technology 9, 525–532 (2005)
5. Kirwan, B., Ainsworth, L.K.: A Guide to Task Analysis. Taylor and Francis, London (1992)
6. Li, W.C., Harris, D.: Pilot error and its relationship with higher organizational levels: HFACS analysis of 523 accidents. Aviation Space Environmental Medicine 77(10), 1056–1061 (2006)
7. Li, W.C., Harris, D.: Eastern Minds in Western Cockpits: Meta-analysis of human factors in mishaps from three nations. Aviation Space and Environmental Medicine 78(4), 420–425 (2007)
8. Marshall, A., Stanton, N., Young, M., Salmon, P., Harris, D., Demagalski, J., Waldmann, T., Dekker, S.: Development of the Human Error Template – a new methodology for assessing design induced errors on aircraft flight decks. Final Report of the ERRORPRED Project E!1970. Department of Trade and Industry, London (2003)
9. Stanton, N.A., Baber, C.: Error by design: methods for predicting device usability. Design Studies 23, 363–384 (2002)
10. Stanton, N.A., Harris, D., Salmon, P.M., Demagalski, J.M., Marshall, A., Young, M.S., Dekker, S.W., Waldmann, T.: Predicting Design Induced Pilot Error Using HET- A New Formal Human Error Identification Method for Flight Decks. The Aeronautical Journal 110, 107–115 (2006)
11. Stanton, N.A., Salmon, P.M., Walker, G.H., Baber, C., Jenkins, D.P.: Human Factors Methods: A Practical Guide for Engineering and Design. Ashgate, London (2005)
12. Stanton, N.A., Stevenage, S.V.: Learning to predict human error: issues of reliability, validity and acceptability. Ergonomics 41, 1737–1756 (1998)