Development of Competency Model for Test Pilots Selection and Training

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Abstract. Objective: To explore the competency model of test pilots, and to provide theoretical basis for psychological selection and post matching. **Methods:** On the basis of reviewing more than 200 relevant research papers, technical reports and reviews, 2130 evaluation indexes describing pilots' psychological attributes were collected. According to the job requirement of test pilots, 108 items were selected by three aviation psychologists which were used to develop the questionnaire of test pilots' psychological quality. All items were constructed as four dimensions including "knowledge", "skill", "ability" and "others". Then 30 test pilot experts were asked to complete the questionnaire, the multigrade fuzzy set (MFS) evaluation technique was used to deternmine the competency model of test pilot. **Results:** ① A total of 24 indexes were included in the competency model of test pilots. ② Dedication and flight procedure were identified as the most important indexes of test pilots (MFS value > 0.704); Eight indexes were identified as important indexes for evaluating test pilots ($0.704 >$ MFS value > 0.599) and 14 relatively important indexes (MFS < 0.599). ③ The Hierarchical competency model which conluded 4 dimensions and 3 levels was developed based on the importance and specificity of 24 indexes. **Conclusion:** This study provides theoretical basis and technical support for the establishment of competency evaluation model of test pilots which would be used in psychological selection and training of test pilots.

Keywords: Test pilot · Competency model · Delphi method · Multistgrade fuzzy set · Selection

1 Introduction

Test pilot is defined as a pilot who specializes in putting new or experimental airplanes through maneuvers designed to test them (as for strength) by producing strains in excess of normal [1]. Otto Lilienthal's famous saying [2], to design a flying machine is nothing, to build it is not much, to test it is everything, shows that test pilots play an extremely important role in flight test and aircraft development.

As a special group in pilots, there are independent requirements for the psychological quality of test pilots [3], and American test pilot schools have established enrollment requirements and Comprehensive Candidate Evaluation Program [4, 5]. The latest

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test pilot selection system and comprehensive evaluation procedures were developed to evaluate the professional skills, engagement, test flight ability and test flight environment adaptability of candidate pilots, replacing the Pilot Candidate Selection Method (PCSM) which included three components, Air Force Officer Qualifying Test, Test of Basic Aviation Skills and previous flying experience [6].

With the development of new aviation weapons and equipment, the demand for high-level test pilots is also increasing. Liu studied the the mental attributes of aged test pilots in order to maximum professional span and suggested routine aptitude test which would benefit the need for test pilot and aviation safety [7]. However, there is no clear standard for test pilot selection and relevent studies are rare in China. Therefore, it is necessary to establish competency model for test pilots base on flight test tasks so as to provide a theoretical basis for the psychological selection and posttraining of test pilots.

2 Methods

2.1 Subjects

There are 30 active flight test pilot experts (flight level: Level I or above) with rich flight test experience, aged 40 ± 6.53 yrs participated the survey and completed the questionnaire. Admission requirements were that the severic time must more than 10 years and 1500 h or Instructor Pilot in a major aircraft system.

2.2 Survey Tool and Methods

On the basis of reviewing more than 200 relevant research papers, technical reports and reviews, 2130 evaluation indexes describing pilots' psychological attributes were collected. According to the job requirement of test pilots, 108 indexes were selected by three aviation psychologists using Delphi method [8]. Each index consists of a word or phrase representing a psychological quality term and a clause to determine the defintion. The questionnaire of test pilots' psychological quality with 108 items was developed for the importance evaluation of each psychological quality using five levels scale according to the five level positive importance estimation fuzzy set model [9, 10]. The five levels were commonly, a little important, important, more important, very important. All items were constructed as four dimensions including "knowledge", "skill", "ability" and "non ability factors". In order to ensure the credibility of the results, psychologists were required to self rate the degree of familiarity with the field, with a full score of 10 and the admission criteria of ≥ 8.

Flight test experts are invited to complete the questionaire by rating the importance of psychological quality for an excellent test pilot.

2.3 Statistical Analysis

All data were expressed as Mean and statistically analyzed on SPSS statistical software package of version 20.0. An alpha-level of 0.05 was used as threshold for significance.

3 Results

Among the 30 subjects actually surveyed, 30 copies were recovered and 30 copies were effective, with an effective rate of 100%.

3.1 Sequency of Importance of Evaluation Items of Competency for Test Pilots

According to the principle of fuzzy set evaluation [10], the indexes with the value of fuzzy set (MFS) less than 0.477 are deleted. A total of 24 revelent qualities were included in the model after 84 items with the value of fuzzy set (MFS) less than 0.477 were deleted. Then 24 items were classified as three levels according to MFS value: items with MFS value > 0.704 is "very important", MFS value < 0.599 is "more important", and MFS value between 0.704 and 0.599 is "important". Dedication and flight procedure were identified as the most important indexes of test pilots (MFS value > 0.704); Eight indexes, including aircraft system, emergency coping ability, judgment and decision-making, were identified as important indexes for evaluating test pilots ($0.704 >$ MFS value > 0.599); Analytic ability, verbal understanding and expression, and sense of responsibility were 14 relatively important indexes (MFS < 0.599) Table 1.

Table 1. Sequency of importance of evaluation items of competency for test pilots (n = 30)

Qualities	MFS score	Qualities	MFS score	Qualities	MFS score
Dedication	0.815	Judgement and decision making	0.630	Operation and control	0.519
Flight program	0.778	Self-control	0.593	Independent	0.519
Aircraft system	0.704	Stress resistance	0.593	Verbal understanding and expression	0.481
Flight control system	0.704	Responsibility	0.593	Coperation	0.481
Honest	0.667	Aerodynamics	0.556	Emotion stability	0.481
Rigorous	0.630	Analytic ability	0.556	Firmness	0.481
Aircraft performance	0.630	Self-confidence	0.556		
Engine theory	0.630	Flight mechanics	0.519		
Emergency coping ability	0.630	Finding and coping disorder	0.519		

3.2 Establishment of Competency Evaluation Model for Test Pilots

The Hierarchical competency model which conluded 4 dimensions and 3 levels was developed based on the importance and specificity of 24 indexes. (Fig. 1). The four

dimensions are “knowledge”, “ability”, “skill” and “other factors”. Among them, “knowledge” includes 7 evaluation indexes, “ability” includes 3 evaluation indexes, “skill” includes 6 evaluation indexes, “other factors” includes 10 evaluation indexes. The first level just conludes two indexes, Dedication for other factors and Flight program for Knowledge. There is no first level indexe for Skill and Ability dimensions.

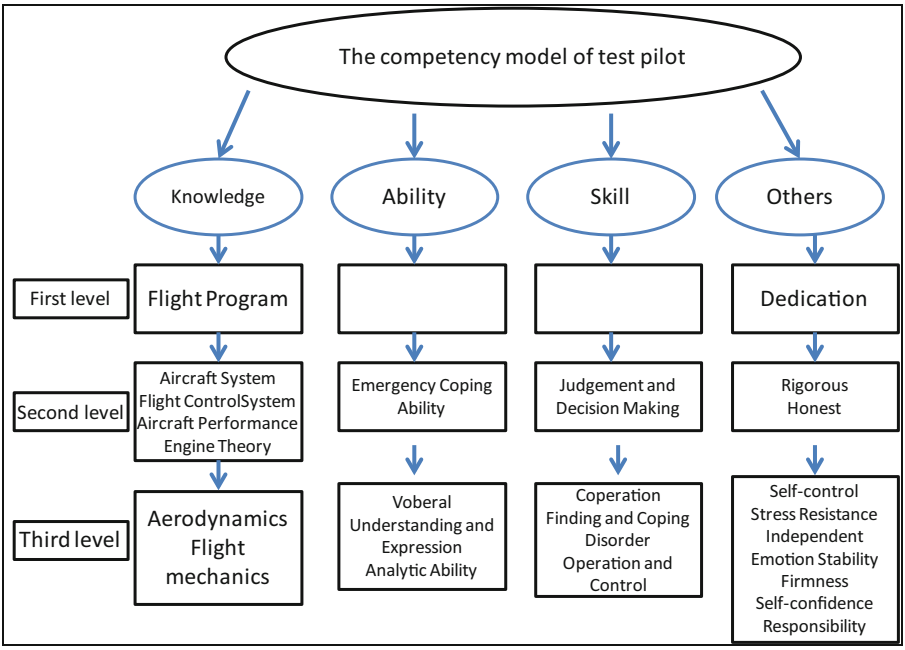

Fig. 1. The competency model of test pilots

4 Discussion

Competency refers to core traits and individual potential that distinguish the excellent person from the general ones in a job or organization [11]. A good competency model can predict their work performance [12, 13]. Competency models are widely accepted in many countries in recent decades since David Mc Clelland made his famous remark in the year 1973: Testing for Competence Rather than Intelligence. However, the competence concept was drived from many selection practices including AirForce selection.

Competency model of pilots see competence in terms of knowledge, abilities, skills, and other fators such as motivation, traits, self-concept, attitude or values [14]. Then it links two common misunderstandings of competence, one approach is to link it exclusively to task performances and another is to define competence as the generic attributes.

However test pilots are special pilots. In the past three decades, aircraft handling qualities and automation have improved rapidly which lead to great change in flight and

mission. Long missions at medium altitudes and operation of precision weapon system supplanted searching targets with eyes in low altitudes. Pilots are system operators other than pilots. As a result traditional stick-and-rudder control skills and flight envelope awareness are being less important. But test pilots still require these skills because they may fly a developmental aircraft with an unguaranteed automation or lower handling qualities [15]. At the same time, test pilots must make a diagnosis on the potential design problems of the test aircarft and put forword the the proposal for improvement of the handling qualities. In order to accomplish these tasks, they must not only know how to operate, but also understand how and why does the increasingly complex systems work [16]. In addition, they must hadle emergency conditions when the aircraft equipment goes down or the flight environment becomes worsen. To sum up, the skills necessary for an operational pilot and the skills necessary for a test pilot become increasingly different since the job requirements become different. Some countries have establish.

In the research results, "dedication" and "flight procedure" are identified as the most important indicators to evaluate test pilots, and among the 24 evaluation indicators included in the test pilot competency model, 7 indicators belong to the category of "knowledge". We should emphasize the importance of "knowledge" in both test pilots selection and training, because requirement of aviation theoretical knowledge is more relevent for test pilots than civil aviation pilots and military pilots. As mentioned above, the flight test mission determines that the test pilot should not only be able to complete various flight test subjects, but also verify whether the aircraft meets the design indicators and use needs through personal experience. Only in this way can they find the design defects in flight quality and man-machine interface, and put forward the direction of improving the design.The evaluation indexes of test pilots in the research results are compared with the results of Miao Danmin et al. [17] on the competency of young pilots. Knowledge isn't been included in the Model of young pilots competency. Test pilot competency stresses emergency handling ability more than typical pilots which mostly due to the great differences between test pilots and military pilots in completing tasks and performing duties. Especially for new aircraft test flights, emergencies occur from time to time, so test pilots must keenly monitor and judge the aircraft response in the process of flight test, find the abnormal phenomena of the aircraft or system in time, and deal with them timely and correctly. In addition, in terms of other factors, test pilots emphasize "honest". The opinions of test pilots have a significant legal and economic impact on the labor achievements of tens of millions of people, and once "dishonesty" may bring irreparable losses.

In the past century, a large number of experimental verification studies have been carried out on the predictive validity of pilot competency. Hunter and Burke (1994) [18] and martinussen (1996) [19] analyzed the predictive validity of various ability characteristics of pilot selection system through meta-analysis method. The comprehensive results show that in the predictive validity of KASO, the prediction of ability factor is better, while the prediction of personality is lower. Limited by the number of investigators, the competency evaluation model of test pilots established in this study only provides a theoretical basis for the selection, evaluation and training of test pilots, and needs to be further verified.

Compliance with Ethical Standards. The study was approved by the Logistics Department for Civilian Ethics Committee of AirForce Medical Center, FMMU, PLA.

All subjects who participated in the experiment were provided with and signed an informed consent form.

All relevant ethical safeguards have been met with regard to subject protection.

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