The Experimentation of Implementing Chase View in Landing Phase

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***Abstract*— Situation awareness could be considered as one of the most important factors that directly influences the pilot operation. In order to enhance the pilots' situation awareness, this research was carried out by implementing a new display method, chase view, in flight simulator, not only to provide the front view, but also the airframe configuration. During the experiment, the training time and attempting times, area of interest of eyes and the flight performance of the landing phase were evaluated to determine the usability of chase view. And according to the results, the chase view could enhance the situation awareness during landing phase.**

Keywords-situation awareness; chase view; AOI; flight path.

I. INTRODUCTION

According to NASA's statistics, about 70%-80% of the aviation accidents could be attributed to the performance of human, and among these accidents, decision errors contribute to 35% [1]. Decision making, as known, is directly related to the situation awareness of the pilots, which means if pilots have a thorough consciousness about what happen instantly and what is going to happen about the components or the whole aircraft, the disaster like turning off the wrong faulty engine, happened on the 8th of January 1989, of the British Midland Airways Boeing 737-400 which resulted in the loss of 47 lives [2] would have been avoided.

The definition of situation awareness is formally described as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future [3]. Therefore, it includes three levels: firstly, perceiving critical factors around; secondly, understanding the means of those factors; thirdly, understanding what will happen in the near future [4].

A lot of researches have been carried out to enhance the situation awareness of the pilots. For example, the Highway-in-the-sky (HITS) display [5] gives the path of the aircraft, conveying primary flight path guidance through use of a tunnel-in-the-sky [6], and 2D coplanar display contains a top-down view of the flight environment in the top panel [7]. Synthetic vision systems have been already wildly used in the aircraft as a solution to such problems as controlled flight into terrain and low-visibility condition [8].

All the studies reviewed above were about how to present a clear front view of the aircraft to the pilots. However, none of them was dealing with the failure of the airframe if the annunciation in the cockpit was ambiguous, like whether the landing gear was correctly released, and whether the flap was in proper position. Under the condition of the chase view, the viewpoint was located above and rear the aircraft, therefore the information of the airframe and the front view was combined together to provide a more useful scene to the pilots.

In this research, the chase view was used in a flight simulator as a method to enhance the situation awareness.

When the subjects operated the landing phase, the training time and times, area of interest (AOI) of eyes [9] and the flight performance will be discussed later.

II. METHOD

A. Apparatus

The apparatus comprised two parts: the flight simulator and eye-tracking device.

The flight simulator part, as shown in Figure 1, includes four workstations to simulate the landing phase and record the behavior of the subjects and the flight performance of the landing phase, six 22-in. Liquid Crystal Display (LCD) monitors to present the display information of the aircraft and a spherical screen to display the outside view of the airplane. This flight simulator is flexible, and it could be easily changed to several types of aircrafts according to the demands. In this research, the Boeing 777 was used as prototype to carry out the experiments.

Figure 1. the Flight Simulator

The second part of apparatus is SmartEye eye-tracking system from SensoMotoric Company from Sweden. This

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eye-tracking device could give out many characteristics of the eye movement data during the experiments like Duration Time, Size of Pupil, Blink Rate, and etc. In this research, the eye-tracking device is used to record the AOI of the subjects.

B. Procedure

A scenario of landing phase was built up in the flight simulator, and Boeing 777 model was used in. The typical 'T' layout, however, was changed in following way: a chase view of the aircraft was presented in front of the subjects, and the Prime Flight Display (PFD), Navigation Display (ND) were presented in the middle display, as shown in Figure 2.

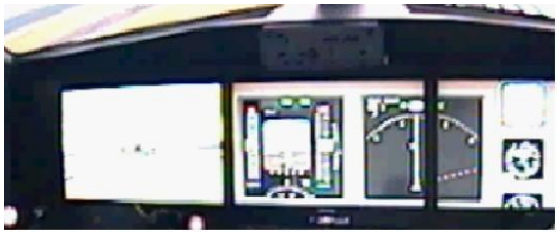

Figure 2. Layout of Chase View

Landing phase began from 2000 feet above the surface, and the distance was 6 nautical miles from the runway of San Francisco International Airport, which height is 13 feet above the sea level. The time to complete the landing was less than 2 minutes, and the whole progress was recorded by scene camera. During each landing, the subject needed to manipulate the aircraft well through control wheel and throttle. Moreover, they needed to lower the landing gear at 1000 feet, and to drop the flaps at 500 feet. This scenario was built up according to the Pilot Operation Procedure and Flight Crew Training Manual [10].

Before the real experiment, the subjects were given some training time to be familiar with the operations in the flight simulator, and the time and times to finish the first landing completely (landing on the runway) from the very beginning were recorded during the practice.

After training and the calibration of eye-tracking device, the experiment was carried out. Each subject was asked to accomplish three landing, no matter landing on the runway or crashing, the times and eyes parameters were recorded for analysis and discussion.

C. Participants

Eight master students from the School of Aeronautics and Astronautics to be the subjects, who all have aviation studying background more than 2 years, were participated in this experiment. They have the knowledge on aircraft design, and know well about the landing process, but without experience on how to manipulate an aircraft in a flight simulator. Among the eight subjects, the whole average age was 20.53 (SD=1.24).

The same eight students also manipulated the same B777 model, however, the layout of display was the normal way after a week, and they just provided comparative data in practical phrase.

D. Measurements

The collection of measurements accomplished through two phrases as following.

Firstly, during the practice, each subjects had 20 minutes of test-flight. At this process, the total time and attempting times of each subject to finish the first landing completely (landing on the runway), and the overall times of successful landing in training were recorded. These data would give some advices on training time and training strategy in some extent.

Secondly, during the experiment, the eye movement of each subject was recorded by eye-tracking system. Eye movement could reflect the attention of the subject allocated when he/ she completes a task. These data were used to determine the AOI of each subject when he/ she carried out the landing. The AOI comprised four parts: Chase View area; Primary Flight Display area; Outside area and Other area. Furthermore, the whole flight process of each subject was also recorded.

III. RESULTS

A. A ttempting Times and Time for first landing

Among the eight subjects, two of them finished the landing on runway within 5 times, three of them between 6-8 times, one in 9 times, one above 10 times, and one did not land successfully, as shown in Table 1.

Except the subject who did not complete landing, the mean times of other subjects is 6.71 (SD = 2.81), which is much smaller than the times by normal layout of B777 in the same flight simulator that is the mean times is 9.17 (SD = 3.49), and the mean times of landing in training is 3.37 (SD =1.85).

And the other data of subjects who operated under normal layout is shown in Table 2, and the comparative results of attempting times and times of landing are shown in Figure 3 and Figure 4, respectively.

Table 1. Chase View

Subject	Attempting Times of first Landing	Time (min)	Times of landing
1	9	12	3
2	6	10	4
3	8	11	3
4	6	8	5
5	?	20	0
6	4	7	4
7	3	5	6
8	11	14	2

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Table 2. Normal Layout

Subject	Attempting Times of first Landing	Time(min)	Times of landing
1	6	7	3
2	5	7	3
3	10	14	2
4	14	18	1
5	12	15	1
6	8	10	2
7	?	20	0
8	?	20	0

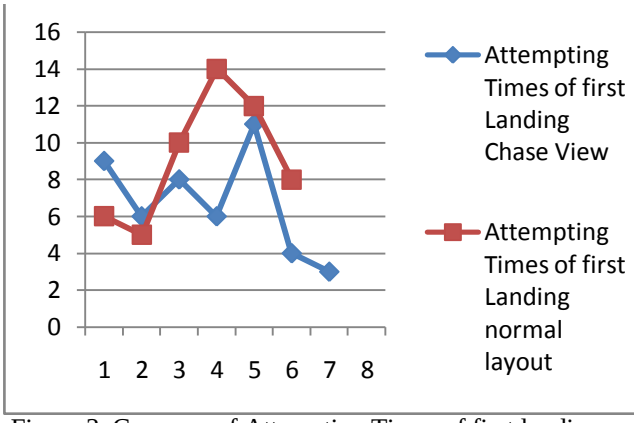

Figure 3. Compare of Attempting Times of first landing

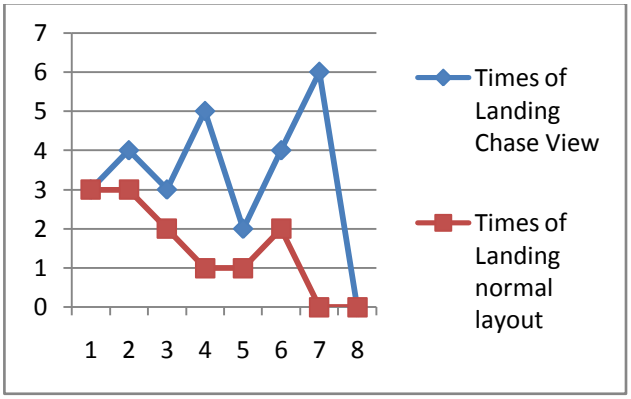

Figure 4. Compare of Times of successful Landing

From Figure 3 and Figure 4, both on times of successful landing and the attempting times, the Chase View is better than Normal Layout. Furthermore, ANOVA analysis was used to determine the significance. Comparing times of successful landing, the effect is significant ($F = 5.81$, $p<0.05$), however, the effect on attempting times is not significant enough ($F = 1.56$, $p>0.23$).

B. AOI and Flight Performance

As described above, the areas of interest included four parts: Chase View area (CVA); Primary Flight Display area (PFDA); Outside area (OUTA) and Other area (OA).

Each subject was needed to accomplish three landing, no matter landing on the runway or crashing. The flight performance determining here are by the times of successful landing in three attempts and whether the landing is overweight landing or not. Table 3 gives mean seconds that each subject paid on different areas within the three landing.

Table 3. the results of the AOI

Subject	Seconds of CVA	Seconds of PFDA	Seconds of OUTA	Seconds of OA
1	50.57	57.85	0.9	0.12
2	44.76	12.15	14.06	1.25
3	63.35	66.61	0.03	0.2
4	69.02	19.89	35.82	0.03
5	0.25	0.2	13.9	63.69
6	22.39	40.18	22.38	0.32
7	28.35	40.64	48.44	3.82
8	67.82	12.93	6.41	23.61

Figure 5 shows the distributions of the results more clearly, where the blue part is Chase View area, red part is PFD area, yellow part is Outside area, and green part is Other area.

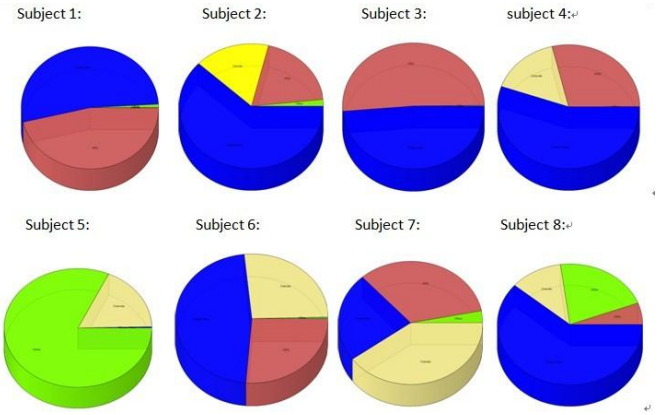

Figure 5. Distribution of the eye location of the subjects

And Table 4 presents the numbers of successful landing and the numbers of overweight landing of each subject.

Table 4. Results of the flight performance

Subject	Numbers of successful landing	Numbers of overweight landing
1	1	1
2	2	1
3	2	2
4	3	2
5	0	0
6	3	2
7	3	1
8	1	1

From the Table 4, Subject 7 did excellent in the experiments, while the pattern of distributions shows that it

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combines three main areas: CVA, PFDA and OA. Subjects 2, 4 and 6 also did good job. Comparing their patterns, they paid more attention on the Chase View area. Subject 1, 3 and 8 did common during the experiment. There were almost no focus of outside area of subjects 1 and 3, and subject 8 paid more attention on other area. The performance of subject 5 was bad. However, it was consistent with the performance in training phase. This may because that the subject 5 felt frustration during the practice, and did not cooperate well during the experiment.

Furthermore, to determine the correlation of each area with attempting time, the correlation coefficients were calculated as follow Table 5.

Table 5. the correlation coefficients of each area with attempting time

	CVA & Time	PFDA & Time	OUTA & Time	OA & Time
correlation coefficients	-0.29	-0.44	-0.60	0.86

According to the correlation coefficients, CVA, PFDA and OUTA had negative correlations with attempting time, since CVA gave out the state of the aircraft on certain moment, PFDA provided the main control information and OUTA supplied the situation awareness of what was happening in front of the aircraft. All of these are essential to safe flight and successful landing, while OA had a positive correlation with attempting time. Moreover, the abstract value of correlation coefficient of CVA versus attempting time was not as high as expect, however, the correlation coefficient of OA versus attempting time was high, which was consistent with the expectation.

IV. DISCUSSION

The main aim of this research was to examine the influence of Chase View on landing phase. The research included two phases: training phase and experimental phase.

In training phase, the comparative data between the Chase View and the normal layout show that, to novices, the different on attempting times to first landing was not obvious. The disparity, however on times of successful landing was significant. Therefore, subjects performed better under the condition of Chase View than normal layout. This could be considered that Chase View would be helpful during the early training period. It could enhance the experience of the novice about how the aircraft really operates in the real environment quickly, and arouse the interest to manipulate it.

The results during the experiments showed that the flight performance was closely related to the distribution of eyes focus of the subject, and the Chase View improved the flight performance in some extent. However, the recommended pattern was to combine the Chase View, PFD and Outside parts together. It also means that the PFD information indispensable not only to pilots, but also to the novices. Furthermore, from the recorded video of eye-tracking device, when the eyes attention located on PFD area, the subjects were almost observing the information of speed and altitude. This was reasonable, since the attitude information could be obtained from Chase View, and the speed and altitude are also essential for landing. Moreover, Outside View is also important, especially to the novices, but not necessary. This is a common sense. After effective training, the pilots must have the skill to land under the condition of minimum visibility requirements by instrument landing system. According to the analysis of correlation coefficients, the abstract value of correlation coefficient of CVA versus attempting time was not as high as expect. It is probable that the smart combination of CVA, PFDA and OUTA that contributes an excellent performance. And the correlation coefficient of OA versus attempting time was high, which was consistent with the expectation, since the more irrelevant attention paid the probability of terrible performance was higher.

V. CONCLUSION AND FUTIRE WORK

In this research, the Chase View was used in the flight simulator. According to the analysis of the training performance and the flight performance, the Chase View could be helpful during the early training period and improve the training efficiency. During the landing phase, although the Chase View cannot replace the normal layout, it could enhance the situation awareness of the operators.

Further study would be carried out in several aspects. Firstly, more subjects will be anticipated in the training phase, and the training time will be expended. Then, the performances of Chase View and normal layout could be compared to determine whether the enhancement of situation awareness is significant or not, and the appropriate pattern of combination of CVA, PFDA and OUTA which would result in a better performance will also be considered.

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