Fidelity Assessment of Boeing 737-800 Simulator Via Manual Flying Touch and Go

Mohd Harridon[1,2,3], Mohd Khir Harun[1], Mohd Ismawee Abdul Malik[1], Mohamed Idrus Abd Moin[1], Baha Rudin Abdul Latif[1], Muhamed Roihan Yusoff[1], Azizihadi Yaakop[1], Mohd Jalal Amran[1]

[1]Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
[2]Malaysia Civil Defence Force
[3]Sky Orbital Centre for Human Advancement

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Abstract- The acquirement of the Simulator Boeing 737-800 by Universiti Kuala Lumpur Malaysian Institute of Aviation Technology (UniKL MIAT) posed a technical challenge to the Assessment Team which was required to evaluate the fidelity of the simulator. This paper outlined the assessment of the fidelity of the simulator via a series of manual flying where numerous touch and go flights were actuated to examine the integrity of the simulator. Results indicated that several tinkering ought to be actuated to increase the fidelity of the simulator.

Index Terms- Flight Test, Fidelity, Boeing 737-800, Flight Sorties

I. INTRODUCTION

Boeing is a multinational company which had produced various aircrafts of high stature. Many variants were available, starting from 707 till 787 and continuously Boeing is churning out several more variants. Boeing philosophy is to transverse passengers from one destination to another in terms of massive number of passengers. Hence, the introduction of airplanes that could fit more than 100 passengers at one time. The Jumbo is one good example of an airplane that could fit more than 400 passengers at one time.

According to Raheem and et al, for a passenger airplane that transport high number of passengers, the lift coefficient of its airfoil is high and this is in evidence as shown by the Boeing 747 [1]. Thus, before any flights are to be actuated, it's imperative for the crew be to accustomed to the handlings of the airplane since each variant has different handling qualities. This is also to ensure the crew are properly prepared to handle any dynamic anomalies that exist during any physical maneuvers.

This is where the simulator comes in. In order to gain high realism, the simulator has to be in pristine condition and be able to simulate real life characteristics of real-life airplanes. The team that accepts the simulator has to ensure the above conditions are met. Harridon pointed out that there should be a defined structure to test the simulator before it is officially accepted [2]. Harridon went on further to state that the steps taken should be discreet and in depth where each component of the simulator has to be retested frequently in order to gauge its consistency in terms of performance [2].

Our fidelity assessment of the Boeing 737-800 Simulator is within the realm of Manual Flying Touch and Go where during the initial flight test of the simulator we had encountered frequent anomalies and system crashes whenever touch and go flights (manual flights) were actuated. We thus proceeded to make a structured account of these anomalies or system crashes which were presented here in this paper. Goblet and et al had indicated that the flight Touch and Go is a process which combined phases of landing and takeoff where this is considered a hazardous event that is of concern in terms of safety [3]. Thus, the actuation of Touch and Go (Manual Flying) should be done by a pilot which is skillful in maneuvering the aircraft. Our team consists of Harridon which flew the aircraft at several different touchdown speeds (within the Touch and Go Sorties) in order to gauge the resiliency of the system of the simulator.

We were made aware by the manufacturer that frequent high loads would create certain anomalies in the simulator. For example, it was recommended (by the manufacturer) to reset the simulator after 4 hours of continuous utilization of the simulator in order to refresh the memory of the simulator and to prevent existence of anomalies. The Touch and Go Sorties (Manual Flight) that we actuated created high loads and anomalies began to populate the simulator and we had recorded these anomalies in structural form.

Our situation was not remote as other simulators of other organizations faced similar predicaments. White and his team reported that certain simulators were inaccurate in terms of their dynamic maneuvers and do not accurately represent real flight movements [4]. This itself is an anomaly and White and his team further revealed that flights at low speed during complex maneuvering would tend to introduce anomalies [4]. We concurred with this assertion as certain flights of ours were at low speed during touchdown and anomalies were apparent at these junctures.

To solve the predicament of the simulator, it's imperative to pinpoint the problem and relate that with the uttermost parameter that is relevant for flight operation. This is a well-defined approach

and Harridon stated that an efficient framework is one that addresses the difficulties and relatable to operations [5]. With this approach, we had identified high loads as the predicament that foster the anomalies. The Touch and Go Sorties were responsible for these high loads and coincidently, as mentioned before, these sorties are relevant to flight safety. Hence our fidelity assessment through Touch and Go Sorties is validated.

II. Literature Review

Boeing is essentially the front runner in the aircraft industry with huge number of aircraft sales. Most of the sales are within the commercial sector which supplement the transportation needs of the public. According to Irwin and Pavcnik, Boeing manufactured narrow and wide bodies airplanes to cater for several destinations which are short haul and long haul [6]. Irwin and Pavcnik also stated that Boeing is not alone in this industry but has Airbus as its primary rival [6]. This rivalry is healthy as both compete to produce state of the art airplanes for consumers.

The Touch and Go Manual Flights that were actuated were complex as they required high attention. According to Skybrary, the Touch and Go maneuvers are demanding and challenging and several aspects come into play such as the landing process and the taking off process [7]. The combination of these and the short time frame that was utilized for the processes had introduced high amount of loads into the system of the simulator and thus we highly suspected this to be the source of the anomalies.

The statement by Skybrary was concurred by Harridon where Harridon stipulated that various flight incidents were due to insufficient or inferior handling qualities of the aircraft [8]. Harridon further iterated that aircraft dynamics require the individuals to understand and comprehend fully the mechanism of flight of each flying vehicle [8].

Gizzi and et al mentioned that flight simulators have ingrained anomalies and they had detected these anomalies using Contextual Information [9]. Gizzi and et al even mentioned that the most common anomalies in flight simulators are the internal update counter of the simulator and fuel weight of the aircraft [9]. We were concerned with this as this correspond to our predicaments where anomalies do exist at certain time frame and scenarios of our simulator.

As stated earlier we utilized the approach of identifying the problem in order to comprehend fully the characteristics of the simulator. This is a norm as numerous researchers utilized this approach. Chen and et al indicated that several methods exist to identify problems and had mentioned root cause analysis and event correlation techniques as methods to pin point predicaments [10]. Chen and et al also stated that current techniques to identify problems have drawbacks and these drawbacks would make the identification inaccurate [10].

The identification of problems is useful as we could derive appropriate solutions to increase the fidelity of the simulator as the simulator is a vital tool to increase the proficiency of engineers and pilots. According to Harridon there were various cases where flight incidents or accidents occurred mainly because the pilots were not proficient enough [11]. This is alarming and it is a safety concern and hence it's beneficial for pilots to go through training using adequate and sufficient tools such as high-fidelity simulator.

In order to reap the full benefit of the simulator, it's necessary to retain and achieve a desired integrity of the simulator. Harridon mentioned that carrying out the User Acceptance Test upon the simulator would ensure the manufacturer gain feedbacks upon the anomalies of the simulator and subsequently the manufacturer would provide solutions to eradicate the anomalies [12]. This is critical since there are ingrained anomalies upon any physical products. Pavel and et al had studied tolerances in flight simulators and they stated that anomalies do exist in simulators and there are certain tolerances that could be accepted but with caveats [13]. Pavel and et al noted that certifications of simulators took into account these tolerances [13]. Thus our fidelity assessment is important in terms of structurally documenting the anomalies that exist where future solutions could be developed based upon our recorded documents.

III. Methodology

Our approach to gauge the fidelity of the Boeing 737-800 Simulator is shown in Figure 1. The approach takes into account numerous anomalies where a structured reporting was actuated.

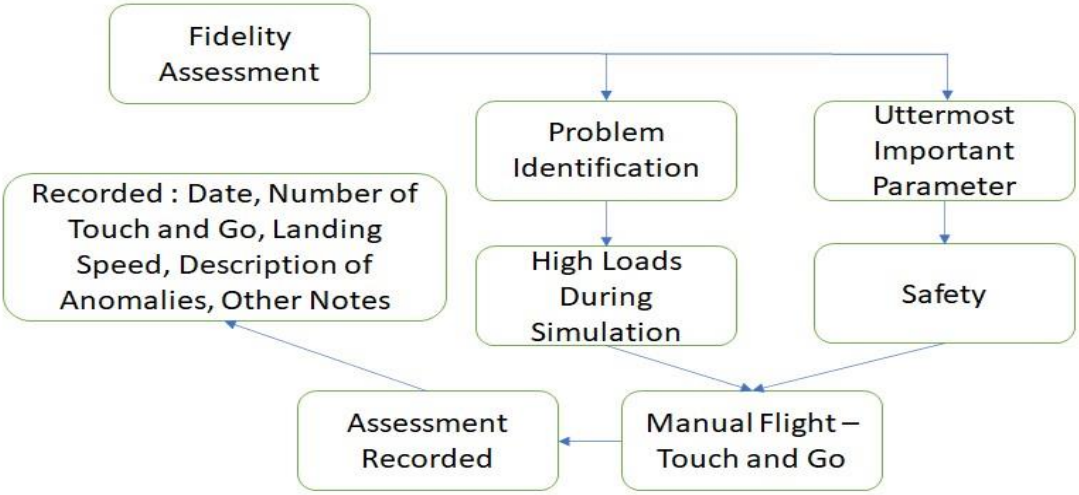

Figure 1. The Methodology for Fidelity Assessment of Boeing 737-800 Simulator

We started off by identifying the predicament or the problem of the simulator. Based upon the information from the manufacturer and also based upon previous runs of the simulator, high loads had been the prominent problem. We then proceeded to identify the most vital aspect of flight operation. This is a no brainer as safety is always the most important aspect in aviation. With the two identified, the best or suitable activity to gauge the fidelity of the simulator would be the Manual Flight Touch and Go. We proceeded with the sorties and several parameters were recorded. Those parameters were Date, Airport and Runway, Touch and Go Attempt, Landing Speed, Description of Anomalies, and other pertinent notes. The number of Touch and Go actuated was based upon arbitrary decision and usually it was ended when anomaly or anomalies were in existence. We then discussed the results and made conclusions and we also offered solutions to eradicate the recorded anomalies.

IV. Results

The results of our fidelity assessment are shown in Table 1. We included notes with regards to the switching OFF and ON of the simulator. This is vital as the switching OFF of the simulator had released high loads from the memory of the simulator and the simulator would start "fresh".

Table 1. Results of the Fidelity Assessment of Boeing 737-800 Simulator

Date	Airport / Runway	Touch and Go Attempt	Landing Speed	Description of Anomalies
26th January 2022	Kuala Lumpur International Airport / Runway 14R	5th Touch and Go Attempt	130 KIAS	Master Caution Annunciated just as the airplane touched the ground
27th January 2022	Kuala Lumpur International Airport / Runway 14R	1st Touch and Go Attempt	140 KIAS	No Anomalies
		2nd Touch and Go Attempt	142 KIAS	No Anomalies
		3rd Touch and Go Attempt	139 KIAS	After Touch Down we took off again and the MCP was not functioning as described below : - Could not set Altitude - Could not set Heading - Could not set Speed
		4th Touch and Go Attempt	140 KIAS	No Additional Anomalies
		5th Touch and Go Attempt	137 KIAS	No Additional Anomalies
Notes : The simulator was OFF and loaded back (Switch ON). Several failures existed after the simulator was fully loaded. Those failures were : Engine Number 2 malfunctioned during starting of engine, Engine Number 1 malfunctioned during starting of engine The simulator was OFF again and loaded back (Switch ON). Several failures existed after the simulator was fully loaded. Those failures were : In the Dark and Cold Situation, all the lights in the overhead panel and other panels had lighted up The simulator was OFF again and loaded back (Switch ON). Everything was back to normal with no anomalies.				
28th January 2022	Langkawi International Airport / Runway 03	1st Touch and Go Attempt	139 KIAS	No Anomalies
		2nd Touch and Go Attempt	128 KIAS	No Anomalies
		3rd Touch and Go Attempt	130 KIAS	No Anomalies

		4th Touch and Go Attempt	128 KIAS	No Anomalies
		5th Touch and Go Attempt	128 KIAS	After Touch and Go, a system check was done and it seems that the glidescope indicator (the magenta diamond) was not present even though the glidescope had been captured by the aircraft
Notes : We left the simulator ON for more than 4.5 hours				
28th January 2022	Hong Kong International Airport / Runway 07R	1st Touch and Go Attempt	138 KIAS	- Le Flaps Ext Sign Annunciated - The simulator did not recognize that the Landing Gear was down
Notes : The simulator was OFF and loaded back (Switch ON). There is one prominent failure which is the CDU where a huge X was displayed on the CDU. The simulator was then OFF again and loaded back (Switch ON).				
28th January 2022	Hong Kong International Airport / Runway 07R	1st Touch and Go Attempt	140 KIAS	- Le Flaps Ext Sign Annunciated - The simulator did not recognize that the Landing Gear was down
Notes : The simulator was OFF again. This time the Uninterruptible Power Supply (UPS) was OFF and then ON again. The simulator was then loaded back (Switch ON).				
28th January 2022	Hong Kong International Airport / Runway 07R	1st Touch and Go Attempt	140 KIAS	No Anomalies
		2nd Touch and Go Attempt	130 KIAS	- Le Flaps Ext Sign Annunciated - The simulator did not recognize that the Landing Gear was down
Notes : The simulator was OFF again. The Uninterruptible Power Supply (UPS) was also OFF again and then ON again. The simulator was then loaded back (Switch ON).				
28th January 2022	Changi International Airport / Runway 02C	1st Touch and Go Attempt	140 KIAS	- The simulator stalled

				- The simulator did not recognize that the Landing Gear was down

V. Discussion

On 26th January 2022 several Touch and Go were actuated and during the 5th Touch and Go, as the wheel touched the runway during landing, an anomaly existed which was the annunciation of the Master Caution. While on the 27th January 2022, during the 3rd Touch and Go attempt, several anomalies existed after the airplane had touched down and took off. We opinioned that high loads were in existence after several Touch and Go were actuated and this had led to the malfunctions.

It is interesting to note that after the simulator was OFF and restarted, there existed several anomalies such as malfunctioned of engines 2 and 1 during the starting phase of the engines. This compounded us to OFF and ON the simulator again but the overhead panel and other panels lighted up which is odd as the aircraft was in a state of Dark and Cold. The simulator was restarted again and all systems were back to normal.

On 28th January 2022 several Touch and Go were actuated at Langkawi International Airport. There were no anomalies from 1st till 4th Touch and Go. At the 5th Touch and Go, after taking off after touch down, an anomaly was detected when a system check was actuated. The glidescope indicator was not displayed even though the aircraft had captured the glidescope. The simulator was then left to be ON for more than 4.5 hours without any activities (the airplane was stationary parked at the airport).

The Touch and Go Flights were continued at Hong Kong International Airport Runway 07R. At the 1st Touch and Go, anomalies existed when the airplane touched the ground during landing. The Le Flaps Ext Sign had annunciated and also the system did not recognize that the landing gear was down. We proceeded to OFF the simulator and the simulator was restarted again. At this juncture, the Control Display Unit (CDU) of the airplane showed a big X which filled the screen of the CDU. The simulator was OFF again and loaded again. The system was back to normal and the Touch and Go Sorties were actuated. At the 1st Touch and Go, similar predicaments occurred where the Le Flaps Ext Sign had annunciated and the system did not recognize the landing gear was down.

We proceeded to OFF the simulator but this time the Uninterruptible Power Supply (UPS) was OFF. The simulator was then restarted and the Touch and Go Sorties were actuated. No anomalies were observed at the 1st Touch and Go but there were numerous anomalies during the 2nd Touch and Go. The Le Flaps Ext Sign had annunciated and the system did not recognize the landing gear was down. The simulator and UPS were OFF again and we proceeded to switch them ON. The Touch and Go Sorties were then actuated again but this time at Changi International Airport Runway 02C. At the 1st Touch and Go attempt, the simulator stalled during landing and the simulator did not recognize that the landing gear was down. We proceeded to OFF the simulator and discontinued the Touch and Go Sorties.

It can be seen that in order for us to actuate the fidelity assessment, we had done a mere categorization or classification as shown in Table 1. Harridon indicated that classification is a good approach to effectively identify entities of different realms [14]. Sun and Du concurred with this and they stated classification aids in the extraction of relevant information [15].

VI. Conclusions

The Boeing 737-800 Simulator were tested to gauge its fidelity. Several manual flights were actuated where Touch and Go Sorties were flown manually and during those sorties numerous anomalies existed. These anomalies were structurally recorded and from there onwards solutions can be derived to eradicate the anomalies. The best solution would be to enhance the capacity of the simulator in order for it to handle heavy loads during flight operations. Enhancement could be done by increasing the memory of the system or by other means.

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AUTHORS

First Author – Mohd Harridon, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology, Malaysia Civil Defence Force, Sky Orbital Centre for Human Advancement, mdharridon@unikl.edu.my
Second Author – Mohd Khir Harun, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Third Author – Mohd Ismawee Abdul Malik, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Fourth Author – Mohamed Idrus Abd Moin, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Fifth Author – Baha Rudin Abdul Latif, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Sixth Author – Muhamed Roihan Yusoff, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Seventh Author – Azizihadi Yaakop, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology
Eight Author – Mohd Jalal Amran, Universiti Kuala Lumpur Malaysian Institute of Aviation Technology