

Research on Landing Guide Instruction of Carrier-Based Aircraft Based on LSO Model

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Abstract. To ensure the operation safety of landing signal officer (LSO) to pilot during carrier-based aircraft landing, the paper proposed a “LSO-pilot-aircraft” instruction associated with operation system. To analyse LSO guide mission, and design instruction associated with operation element. The relationship and matching of “LSO-pilot-aircraft” system are exhibited by instruction associated with the operation model, and “instruction sending-operation responding-deviation correcting” process is realized based on LSO guidance instructions (original version), aircraft real-time flight states (boundary conditions) and pilot response operation (model output). Multiple loading conditions simulation results show that corrective strategies is in line with the actual situation of carrier-based aircraft landing.

Keywords: Landing Signal Officer (LSO); Introduction Associated with Operation Model; Guide System; Carrier-Based Aircraft

1 Introduction

To ensure landing on angled-deck of carrier safely and quickly during manual landing process, the pilot of carrier-based aircraft should be control flight path and attitude precisely. Although there are great flight characters, excellent flight control system and favorite landing approach of carrier-based aircraft, landing deviations still exist owing to complicated environment, varied disturbance and flight character loss in low-velocity status. During final approach, besides accurate manipulation of pilot, the Landing Signal Officer (LSO) should guide auxiliarily and instruct pilot by flight status at present and future. It is essential to modeling LSO for guide mission of carrier-based aircraft [1-6].

The rest of this paper is structured as follows: next section we first analyse LSO guide mission. Section 3 design instruction associated with operation element. The relationship and matching of “LSO-pilot-aircraft” system are exhibited by instruction associated with the operation model in Section 4. Multiple loading conditions simulation results show that corrective strategies is in line with the actual situation of carrier-based aircraft landing in Section 5.

2 Guide Mission Description

The LSO landing guide mission include: at the head of final approach, LSO decides whether sending correct order or not, and in the rear, the wave-off decision making be considered. In conclusion, LSO not only supervises flight motion but also has main responsibility for landing safety during the final approach. Considering the important role of LSO, it adds the LSO landing guide and wave-off decision making system to original carrier-based aircraft landing model, the “LSO-pilot-aircraft” man-machine closed loop system has been established in the end, as shown in Fig.1. [7-15]

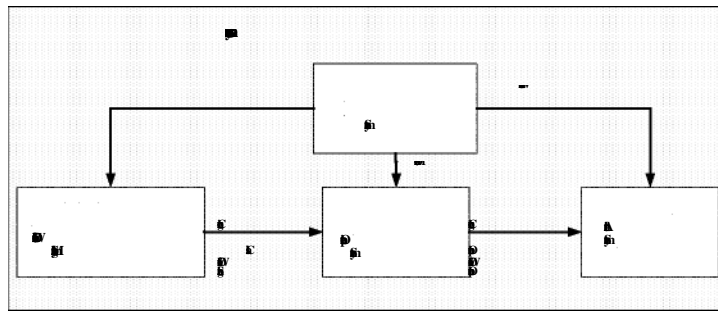


Fig. 1. LSO-pilot-aircraft guidance system

Because of the nonlinear, complexity and fuzziness, it is so difficulty to establish LSO model using the traditional control technology. According to the expression form of LSO guide correction strategy, we design the guide model of LSO: “instruction sending-operation responding-deviation correcting” process is realized based on LSO guidance instructions (original version), aircraft real-time flight states (boundary conditions) and pilot response operation (model output), and it establishes the “LSO-pilot-aircraft” instruction associated with operation model finally.

LSO Guide and

Pilot

3 Instruction Associated with Operation Element

During final approach, the practical guide process could be seen a discrete motion set including some “sending instruction(LSO)—responding-deviation operation(pilot)—flight correcting(carrier-based aircraft)” elements.

Definition 1. Instruction Associated With Operation Element(IAWOE) : In the process of landing, LSO and pilot finish one “sending instruction—responding-deviation operation—flight correcting” status correcting course.

Definition 2. Instruction Associated With Operation Set(IAWOS) : For guaranteeing landing safety, LSO and pilot finish all IAWOE during one approach.

A whole IAWOE should include three parts: LSO guide instructions, instruction-released conditions (carrier-based aircraft flight status when instruction-releasing) and pilot responding operations (pilot maneuvering operation for the instruction).

$$, \quad (1)$$

Where is the set of LSO guide instructions, is the set of instruction-released conditions, and is the set of pilot responding operations.

4 LSO Instruction Associated with Operation Model

Let be a set of instruction operations, be a set of LSO guide instructions, and be a set of responding operations of pilot, where be a set of throttle operation and be a set of stick operation. Let be a discrete set of instruction-released conditions, and where is multi-set item of carrier-based aircraft flight status. The “LSO-pilot-aircraft” instruction associated with operation model is shown as follow:

$$\begin{matrix} \square \\ \square \end{matrix} \quad (2)$$

$$\begin{matrix} \text{if} \\ \text{then} \end{matrix} \quad (3)$$

$$\begin{matrix} \text{if} \\ \text{then} \end{matrix} \quad (4)$$

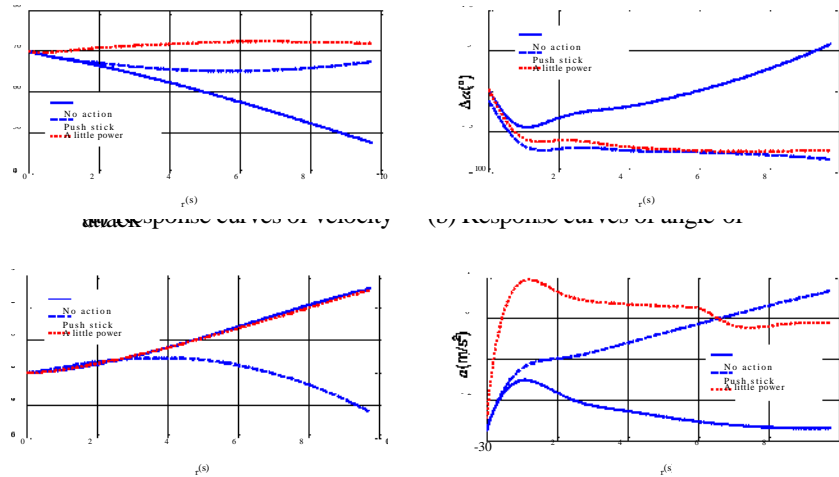
So:

$$\square \quad \square \quad \square$$

5 Model Verification and Analysis

The initial range from touchdown is 926m, flight altitude is 36.67m (glideslope deviation -20m), initial velocity is 69.96m/s and angle-of-attack is 8.1° .

Because of longitudinal deviation, the velocity will decrease with climbing motion. It move on to simulations for no-operation situation, push stick situation and a little power situation. Fig. 2 shows response curves of different velocity, angle-of-attack, height deviation and acceleration.



(c) Response curves of height deviation (d) Response curves of acceleration
Fig. 2. Response curves of different operations

1)When pilot executes no-operation, the velocity will decrease rapidly, cause a large deceleration, and angle-of-attack enlarges quickly after minishing a little. Aircraft will remain climbing situation of high AOA and low velocity which is so difficulty for pilot’s controlling.

2)When pilot executes push-stick operation, the velocity will increase after decreasing a little, and angle-of-attack will be decrease because of pushing stick. The height deviation will be magnify during damping rapidly, and the resultant velocity increase from acceleration curves. It is adverse to landing safety with high speed and large height deviation.

3)From LSO instruction associated with operation model, we know the right call is “a little power”, A command for v_{LSO} and steady angle-of-attack. The velocity remains stable after a little increasing, and acceleration will be zero which can guarantee safe landing velocity range from Fig.3 (a). During adjust process, angle-of-attack is decrease, altitude is increasing to compensate initial height deviation. Following every record, we can see the advantage of “a little power” instruction.

6 Conclusion

The difficulty of LSO guidance control is analyzed and emphasized in this paper, and LSO instruction associated with the operation model is built according to the format of LSO guidance strategy. The relationship and matching of “LSO-pilot-aircraft” system are exhibited by instruction associated with the operation model, and “instruction sending-operation responding-deviation correcting” process is realized based on LSO guidance instructions (original version), aircraft real-time flight states (boundary conditions) and pilot response operation (model output). Multiple loading

conditions simulation results show that corrective strategies is in line with the actual situation of carrier-based aircraft landing.

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