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MODIFIED PERIODIC CALIBRATION OF INSTRUMENT LANDING SYSTEMS

(Presented by Netherlands)

EXECUTIVE SUMMARY

This paper presents the modification of periodic calibration programs for instrument landing systems (ILS) of all categories by utilising for particular ILS transmission properties the correlation between flight measurements and measurements on the runway or close to the runway. This correlation exists, if the transmission satisfies certain quality conditions. Moving part of the periodic flight inspections to the runway or close to the runway, may involve more ground inspections, while reducing the number of flight inspection runs. The modified periodic ILS calibration program leads to higher runway availability, less noise and emissions from the flight inspection aircraft, and less calibration cost.

1. INTRODUCTION

1.1 An instrument landing system (ILS) is a radio navigation system for a runway providing precise short-range guidance to aircraft, which allows the pilot to approach the runway under low visibility conditions. ILS uses two directional radio signals, the localizer (approximately 110 MHz frequency), which provides horizontal guidance, and the glideslope (approximately 330 MHz frequency) for vertical guidance. The relationship between the aircraft's position and these signals is displayed on an aircraft instrument, which the pilot uses to approach the runway centreline at a descent angle of approximately 3 degrees.

1.2 Because ILS is a safety critical system, it is required to calibrate the entire ILS periodically. The calibration is usually done by conventional flight measurements, sometimes combined with ground measurements using an extensible mast, sometimes combined with near-ground flight measurements using remotely piloted aircraft systems (RPAS). These calibrations supplement the standard ILS monitoring system.

1.3 Flight inspection of ILS is necessary from a safety point of view, but inconvenient from an airport's business point of view. Therefore, it often takes place at the edges of opening hours of the runway, which for busy airports is late in the evening. But if the airport is located close to a densely populated area,

the flight inspection often leads to complaints from the local community about aircraft noise. A mitigation measure is to move part of the flight inspection measurements to the ground or near the ground, if it is possible without compromising safety.

1.4 In the Netherlands, it has been shown at the request of the Luchtverkeersleiding Nederland (LVNL), that some specific measurements requiring many flight inspection runs can equally well be done on or close to the runway. Indeed, *if the ILS transmission is confirmed to be free from unacceptable disturbances*, these ground or near-ground measurements produce results which are just as useful for the calibration as the flight inspections. Only a few runs of the full flight inspection program, involving all other measurements, remain to be executed in the air. This approach, which maintains the quality of the conventional periodic flight inspection, has been designed by Royal NLR – Netherlands Aerospace Centre, and is referred to as "reduced flight inspection", or ReFI.

1.5 ReFI applicability in The Netherlands is ensured by LVNL on all civil airports, by a positive safety case, and by executing a strict ILS maintenance program including monitoring and controlling of the ILS environment. The latter involves preventing the placement of buildings or other transmission disturbing objects too close to the ILS. The few remaining flight inspection runs actually include a real-time check that the ILS signal in space is free from unacceptable disturbances. *If any unacceptable disturbance of the ILS signal in space is detected, a full periodic flight inspection should be performed.*

1.6 An advantage of using RPAS is in its ability to perform approaches near the runway for detecting transmission errors due to internal ILS deficiencies, e.g. errors in the placement of ILS antenna elements, which could remain undetected by measurements using an extensible mast at a single location on the ground. If allowed, the RPAS could even measure beyond the boundary of the ILS far field, enabling a direct comparison of the thus measured values with flight inspection measurements.

1.7 At Amsterdam Airport Schiphol, ReFI was introduced partly in 2007, fully in 2009, and subsequently at all other civil airports in the Netherlands, with ground measurements performed using a measurement bus and an extensible mast. The usual flight inspection program with about 30 runs to perform a complete periodic ILS calibration was modified to a ground inspection program complemented with only about three ILS flight inspection runs. ReFI has been in operation successfully ever since.

2. DISCUSSION

2.1 The section discusses some details of the ReFI approach.

ReFI preconditions

2.2 Applying ReFI requires careful consideration. The ILS under test needs to be under ICAO certified maintenance, and the ILS maintenance process, the environment control, and the real-time check during the remaining flight inspections need to *confirm that the transmission is indeed free from unacceptable disturbances*. Also, a sufficiently high-quality calibration capability needs to be in place, enabling to decide whether or not the measurement results fulfil the relevant ICAO requirements.

ReFI limits

2.3 Due to measurement uncertainties on or near the runway depending on individual analysis, and using the commissioning results, so-called ReFI limits on difference in depth of modulation (DDM) exist, which are more stringent than the ICAO limits, ensuring that DDM is inside ICAO limits along the entire approach path, if the ReFI preconditions are fulfilled.

ReFI activities

2.4 A typical periodic flight inspection considers dozens of ILS parameters to be measured and evaluated against the requirements in ICAO Annex 10 — *Aeronautical Telecommunications*. The aircraft flies specific trajectories (runs) during which measurements take place using the flight inspection system on board of the aircraft, and the transmission is checked for disturbances. Different measurements may take place in a single run. If any unacceptable disturbance is detected, a full periodic flight inspection should be performed.

2.5 For ReFI, the measurements of interest are all related to the transmission parameter *difference in depth of modulation*, or DDM. It is a guidance signal, used to determine if the aircraft using the ILS is approaching left or right of centreline, and above or below the required glide angle of usually approximately 3 degrees.

2.6 The main steps in the ReFI approach are the following:

2.6.1 Perform ground checks to verify that ILS transmitter 1 and transmitter 2 both produce the same signal to the same antenna array. Only proceed to step 2, if they both fulfil the ICAO requirements, and the difference between the output of both transmitters is sufficiently small.

2.6.2 Perform the remaining flight inspection runs to verify the ILS parameters, including the DDM related parameters which will be measured afterwards on or near the ground with potentially higher accuracy. Only proceed to step 3, if no unacceptable ILS disturbance is detected and all measurements fulfil the ICAO requirements. Otherwise perform a full periodic flight inspection.

2.6.3 Perform the ground measurements regarding each DDM related ILS parameter using a measurement car or extensible mast, or perform near-ground measurements using an RPAS. Declare these ground measurements successful, if the results are all within ReFI limits. Otherwise perform a flight inspection for this parameter.

ReFI advantages

2.7 The advantages of ReFI compared to a full periodic flight inspection are predominantly:

2.7.1 *Time efficiency*: the ReFI program is more flexible, and is executed faster than the corresponding full periodic flight inspection. This is advantageous in terms of runway availability at busy airports, because the ILS measurements at or near the ground are easier to manage and execute, compared to flight measurements.

2.7.2 *Environment friendliness*: ReFI contains just a few flight inspection runs, perhaps only three, therefore the flight inspection aircraft produces less noise and less emissions than a full periodic flight inspection of about 30 runs. This is particularly advantageous for airports near densely populated areas.

2.7.3 *Cost efficiency*: the ReFI program may provide significant cost savings, because ILS measurements on or close to the ground are considerably more cost efficient than flight measurements.

2.7.4 *Safety*: The impact ReFI has on safety is the same as the impact a full periodic flight inspection has on safety.

ReFI validation

2.8 Using a database of recent or historic flight measurement data and simultaneously measured data on or close to the runway, it can be verified that DDM measured near the ground correlates well to the DDM measured in the air. Every additional periodic inspection, whether a full one or a reduced one, adds data to the database.

3. CONCLUSION

3.1 ReFI is an approach for modification of periodic calibration programs for ILS. ReFI can be applied to each ILS, provided the ILS meets the abovementioned preconditions. The ReFI limits exist more stringent than the ICAO limits, such that each measured DDM value inside these ReFI limits at or near the runway, implies that the same DDM value is inside ICAO limits along the entire approach path in the air. The advantages of ReFI compared to a full periodic flight inspection are predominantly: time efficiency, environment friendliness, and cost efficiency, while maintaining safety.

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