ROSSI (Robotic Test System for Active Inceptors). Preliminary results.

A. Méndez, J. Iñesta, M. Gutiérrez

System's Engineering department. Airtificial A&D Engineering. Seville, Spain.

E-mail: agustin.mendez@airtificial.com

Abstract- *Rossi project deals with the technological gap of testing the capabilities of active inceptors, focusing on the haptic performance of these devices. The new active inceptors provide new functionalities and, especially, a haptic behaviour to improve both the flight experience and the crew coordination. This project is focused on the design of a fully automated test bench, able to receive and control a shipset of generic active inceptors developed by Safran Electronics & Defense, in the frame of ITD SYS. The test bench must simulate the haptic behaviour of the pilots' hands and be adaptive to the various configurations and combinations compatible with generic inceptors. This kind of bench must have a high level of versatility, both on mechanical and electronic sides, evaluating the haptic behaviour of each inceptor separately or combined in a coupling mode. This project is currently being development under the Clean Sky 2 program.*

1. Introduction

The new generation of active inceptors provides new functionalities and, especially, a haptic behaviour to improve both the flight experience and the crew coordination. Therefore, it is important to count on test means able to support these new, and high-level functionalities.

Tests whose execution rely on human tasks are subject to unnecessary and unforeseen delays, due to fatigue or distractions. On the other hand, automatic tests follow a strict schedule, resulting in a quicker execution.

In addition, results obtained from manual tests are not completely reliable, due to the inherent risk of error caused by the human intervention. On the contrary, automatic tests guarantee the execution of the whole sequence as it is programmed, excluding the possibility of short cuts, misunderstandings, or forgetfulness. Moreover, registering the test results automatically removes any possibility of intentional distortion. All this drives to a more reliable product.

The main objectives of the project are:

- Simulating the pilot´s hands. The system will allow to program countless movements simulating the behaviour of the pilot´s hand, generating different profiles (flying/auto-pilot mode, coupled/decoupled mode), regardless the platform type (A/C and H/C).
- Measuring and validating the haptic performance of the inceptor(s). The system will also be equipped with the capacity to characterize the feedback resulting from the application of the pilot action. This feedback information will be compared with the one expected, according to the applied action and the flight data, in order to evaluate the haptic performance.
- Being able to test the inceptor(s) under different environmental conditions: temperature and humidity.
- Maximizing the tests execution speed.
- Human resources optimization.
- Reliability of the measurement and repeatability of the results.

2. Automated Test Bench overview

The architecture proposed to meet all the requirements for the automated test bench includes the following main components:

- *Robotic arm (x2)*. Its main goal is to act on the inceptors by holding the grip and displacing it to the target position, following both the path and the speed required. It includes force sensor to measure the haptic characteristics of the Unit Under Test (UUT).
- *Cameras*. By processing the images, the robotic cell will be able to measure the position of the grip with a very narrow margin of error.
- *Test table* to test the inceptors at room temperature and humidity.
- *Climatic chamber* to simulate different environmental conditions.
- *Control rack* to control the operation of the test benches.

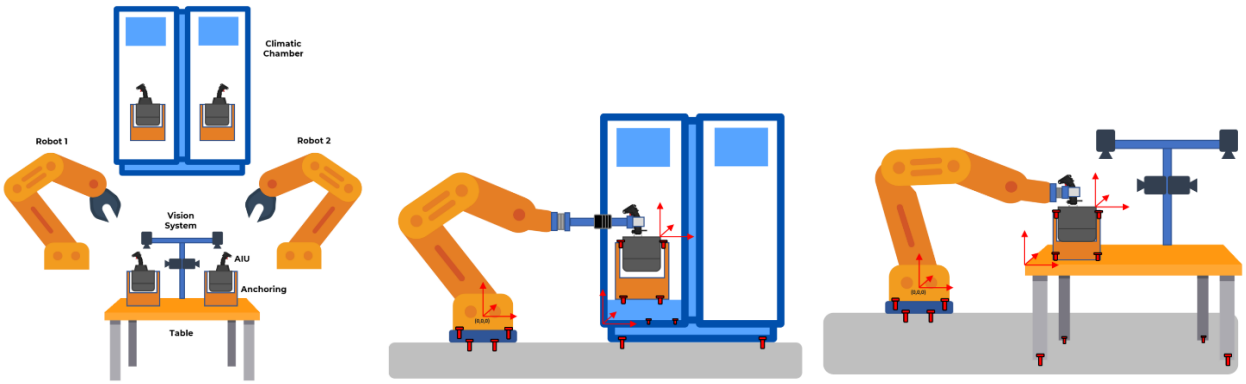

Figure 1: ROSSI Automated Test Bench main components: Left: including all the elements; Center: elements to perform test in a climatic chamber; Right: elements for testing at room temperature.

Depending on the number of inceptors under test, the operation mode of each one (passive: controlled by the operator/robot, active: controlled by external commands thanks to internal actuators) and the environmental conditions, the test bench can execute up to 8 different modes, which are depicted in the following figure

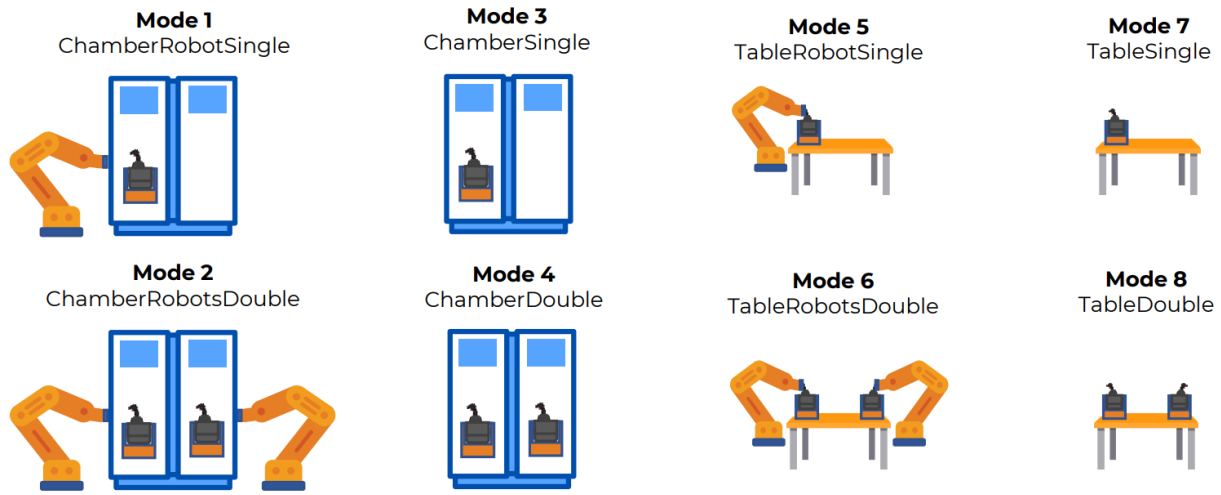

Figure 2: ROSSI automated test bench operational mode. Mode 1: single passive inceptor, custom environment. Mode 2: double inceptor, custom environmental conditions. Mode 3: single active inceptor, custom environemtal conditions. Mode 4: double active inceptors, custom environmental conditions. Mode 5: single passive inceptor, room environmental conditions. Mode 6: double inceptor, room environmental conditions. Mode 7: single active inceptor, room environemtal conditions. Mode 8: double active inceptors, room environmental conditions.

3. Methods

To validate this concept of automated test bench for active inceptors, Airtificial A&D Engineering is developing a robotic test cell including the different elements described in section 2. As of the date of this first progress report, all the components of the test bench have been manufactured and assembled and some preliminary tests have been performed in order to check the right operation of the test bench. Some of the tests performed are:

- Robot to grip mechanical interface.
- Force measurement
- Positioning the inceptor.
- Accuracy in position measurement.
- Accuracy in reaching commanded position.

Figure 3: Preliminary test bench assembly with parts of the components. The pictures show one of the two robotic arms, the control rack, cameras and different types of auxiliary fixtures and tooling.

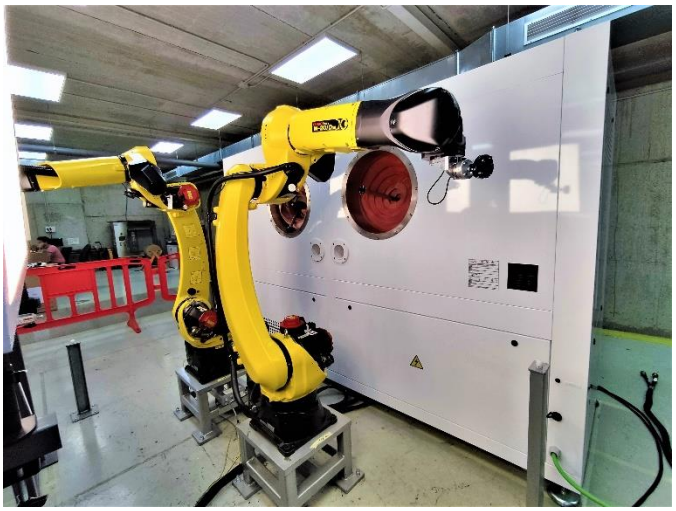

Figure 4: Fully assembled test bench. This picture includes both robotic arms and the climatic chamber.

The bench is using a real FCS (Flight Control Stick) developed by Airtificial A&D Engineering. This unit is not suitable for flight and is used only for laboratory testing purposes because it has exceeded its operational life.

4. Results

Only qualitative requirements have been tested during this stage and, therefore, the goal of the tests performed is not getting numeric measurement of parameters such as the accuracy or error, but assuring the main control computer is getting the data from the different sensors, checking that the configuration screen of the Human Machine Interface is able to set-up the different parameters, checking the communication with the UUT, etc.

Figure 5: HMI screenshots. Left: configuration window. Centre: raw data display window. The figure shows different data received from the UUT. Right: Raw data display window showing data from the load cells.

The tests have confirmed the main controller of the Automated Test Bench is able to get all the necessary information available in the test bench prototype correctly and, therefore, the next step was to start commanding and actuating over the UUT. A set of cameras, together with a backlighted LED panel, is used to get an external measurement of the position of the inceptor. This measurement will be compared with the internal measurement provided by the UUT.

Figure 6: Robotic arm actuating over the UUT. Left: overview of the assembly. Right detail with the camera, gripper, UUT and backlighted panel.

It has been also checked that the system can follow commands from the main computer and get really good performances in regards with the accuracy of the achieved position. Next picture shows a real time follow-up test.

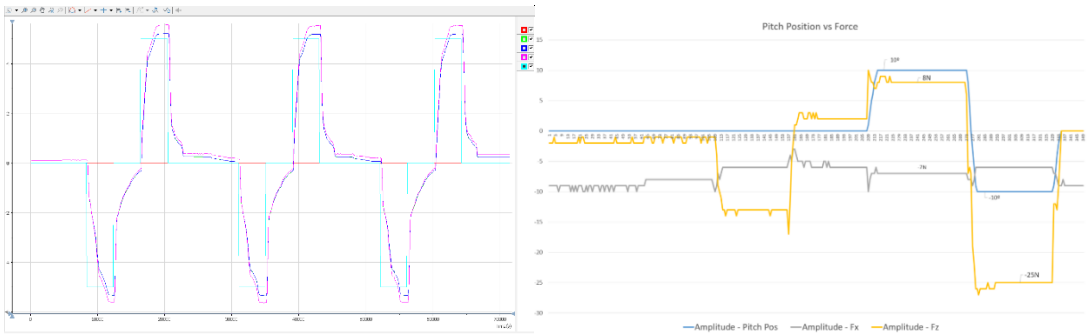

Figure 7: Preliminary tests. Left: position follow-up. The robot received a command which is squared shaped but due to the inertia of the system needs some time to reach the requested value. However; the final position marches the demand. Right position and force vs time. Blue line is the position measurement in pitch, yellow is force measurement in pitch and grey is force measurement in roll.

5. Conclusions.

ROSSI project, aimed to develop an Automated Robotic Arm, is still in an early stage to get measurable results. However, a large number of qualitative analysis has been done and the solution proposed seems to cover all the functions defined in the project description. Anyway, this statement should be validated during next stages by getting more data about the real performances of the bench. This might lead to minor/major changes in the architecture proposed. Upon the test bench is completely manufactured and assembled, the next step will be to launch the measuring of quantitative performances to validate the design. This milestone will then allow to introduce the Safran E&D active inceptor shipset and start a real evaluation of a fully functional equipment.

This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 884426. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Clean Sky 2 JU members other than the Union