



Adaptation of Cockpit simulator

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SAFELAND

SAFE LANDING THROUGH ENHANCED GROUND SUPPORT

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Abstract

SAFELAND is developing a future concept of operation for single-piloted aircraft, dealing with the problem of pilot incapacitation. The developed concept will be evaluated in a Human-in-the-Loop real time simulation involving Air Traffic Controllers and Airline Pilots in April 2022 at the premises of DLR's Institute of Flight Guidance in Braunschweig, Germany.

This deliverable elaborates the functionalities of the Cockpit simulator *iSIM* that will be used in the simulations in April 2022. During these simulations, the Cockpit simulator will be operated by DLR employees holding an Airline Transport Pilot Licence (ATPL). Their task will be to experience the developed SAFELAND concept in two different scenarios in which single pilot incapacitation occurs during flight.

This deliverable is marked as type 'Other' and consists of this document and two download links. Via each link a video displaying the functionalities of the Cockpit simulator operated in the two different SAFELAND scenarios can be downloaded. Each video clarifies the operability of the Cockpit simulator (i.e. *iSIM*) in the SAFELAND context.

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1 Introduction¹

1.1 Purpose and scope of this document

This deliverable describes the adaptations made on the Cockpit simulator which will be used within the SAFELAND Human-in-the-Loop simulations at DLR's Institute of Flight Guidance in Braunschweig, Germany. The main purpose of this deliverable is to demonstrate to the reader the functionalities and operability of the Cockpit simulator. The SAFELAND real-time simulation will involve airline pilots (operating a Ground Station), Air Traffic Controllers (operating a CWP), pilots (operating the Cockpit simulator described here), and is planned to be conducted in April 2022. Due to the global COVID-19 pandemic a reduced risk simulation with the relevant actors (i.e. ATCOs, pilots, HF experts, simulation experts, legal and regulatory experts) will be conducted by taking precautionary measures (e.g. fully vaccinated, social distancing, wearing masks at all times) into account.

The scope of this deliverable is to visualize and demonstrate the operability of the Cockpit simulator within the SAFELAND context. As this deliverable is marked as type 'Other', it has been agreed to take advantage of video recordings in order to show the operability of the simulator. In total, two different SAFELAND scenarios will be simulated as described in deliverable D3.1 (SAFELAND, 2021b). These videos were recorded in January 2022, where DLR employees acted as SP, ATCOs and GSOs. The envisaged structure of both scenarios, and especially the operational steps needed to be performed by the human operator of the Cockpit simulator are described in section 3.

1.2 Structure of the document

In total, this document consists of 5 chapters, which are further subdivided into subsections. The chapters and their main topics are the following:

- Chapter 1 describes the purpose and scope of this document. Furthermore, it details the structure of the document and provides a list of the used acronyms.
- Chapter 2 provides a preliminary overview of the simulation architecture within SAFELAND in order to illustrate the interconnections of the Cockpit simulator with the entire simulation infrastructure.
- Chapter 3 details the content of the two recorded videos referring to the pre-defined SAFELAND scenarios as described in deliverable D3.1 (SAFELAND, 2021b).
- Chapter 4 provides two links to download the recorded videos of the CWP simulator.
- Chapter 5 lists the references that were used in this document.

¹ The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein

1.3 List of acronyms

Term	Definition
A/C	Aircraft
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATPL	Airline Transport Pilot Licence
CWP	Controller Working Position
EDDL	ICAO code of Düsseldorf airport
FMS	Flight Management System
FPL	Flight Plan
GSO	Ground Station Operator
iSIM	Integrated Cockpit simulator
RTS	Real-time simulation
SJU	SESAR Joint Undertaking
SP	Single Pilot
STAR	Standard Arrival Route
TMA	Terminal Manoeuvring Area
U-FLY	DLRs Remote Cockpit simulator (GCS application)

Table 1: Acronyms

2 Simulator and architecture

This section describes the used Cockpit simulator, as well as the initial high-level architecture of the simulation environment for the SAFELAND project. Hereby, this section details the interconnections of the Cockpit simulator *iSIM* to the traffic simulation *TrafficSim*, to the remote pilot station application *U-FLY*, to the Controller Working Position (CWP) tool *Skynet* and to the data exchange software *datapool*. A more detailed description on the simulation infrastructure will be given in the deliverable D2.4 *Integration Report* (SAFELAND, 2022c).

2.1 Cockpit simulator (iSIM)

In the context of the SAFELAND RTS, the used cockpit simulator will be a fully functional A321 simulator consisting of several touchscreen displays (cf. Figure 1). This simulator is integrated into DLR's simulation infrastructure (cf. section 2.2) and is based on a X-plane 11 software simulation. A detailed description of the used cockpit simulator can be found in D3.1 (SAFELAND, 2021b).



Figure 1. Integrated Cockpit simulator (iSIM)

The main characteristics of the cockpit simulator in the context of the SAFELAND RTS are:

- Fully integrated cockpit simulator for a realistic flight experience prior to pilot incapacitation.
- Simulation of flight performance and characteristics of an Airbus A321 that can be operated via a remote cockpit position after pilot incapacitation.

Within the SAFELAND concept (SAFELAND, 2021a), the aircraft is envisaged to have sophisticated onboard automation able to land the aircraft safely based on the flight plan (FPL) stored in the Flight Management System (FMS) of the aircraft. As an example, secondary flight controls (e.g. flaps) shall be controlled by the aircraft without being commanded by the onboard pilot or ground station operator. However, as the cockpit simulator does not have these functionalities, the iSIM operator (DLR employee, also seen in the recorded videos) will be commanding these controls during the flight. Further, pilot incapacitation will be initiated via a squawk code entered by the iSIM operator, as the simulator does not have any pilot health monitoring systems.

2.2 Simulation architecture

Figures 2 and 3 illustrate the interconnections of the Cockpit simulator to DLR's simulation infrastructure for both SAFELAND scenarios (cf. chapter 3) in nominal flight conditions and during onboard single pilot incapacitation, respectively.

In general, all simulation tools are interconnected to DLR's data distribution tool *Datapool*. *Datapool* is the central communication tool and acts as a server transmitting all messages to the connected clients (here the different simulators). The Cockpit simulator receives and transfers all its messages via *datapool* to the other actors (i.e. simulators).

The following types of data will be received by the Cockpit simulator:

- A/C commands (coming from the Remote Pilot station in case of pilot incapacitation)

The following types of data will be transmitted by the Cockpit simulator:

- Aircraft State Vector (ASV)
- A/C data
- 4D trajectory

For more details on the data distribution tool *Datapool* and on the transmitted messages to/from the Cockpit simulator, please cf. deliverable D2.4 (SAFELAND, 2022c).

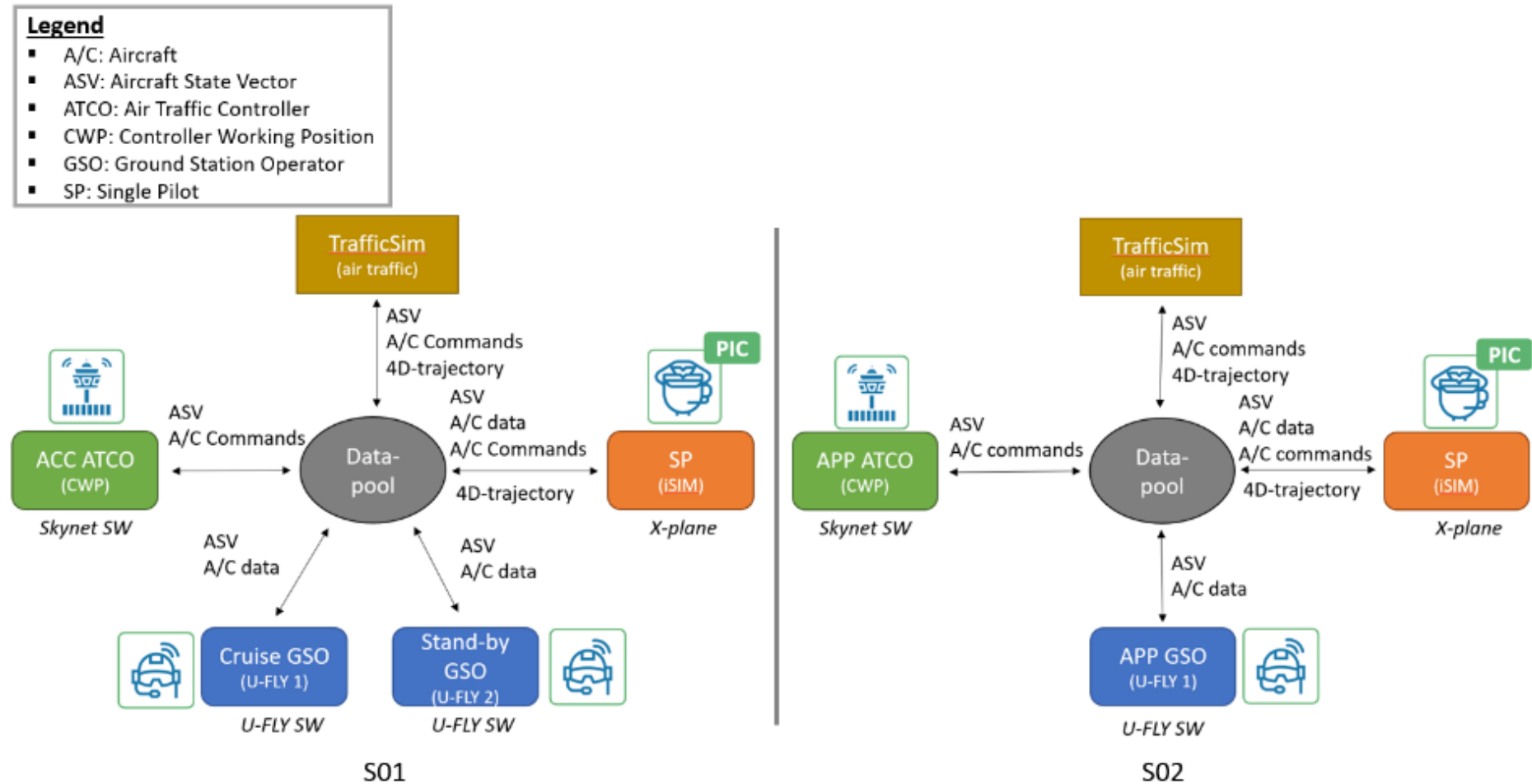


Figure 2. Interconnections of the cockpit simulator (iSIM) in nominal flight conditions

Legend

- A/C: Aircraft
- ASV: Aircraft State Vector
- ATCO: Air Traffic Controller
- CWP: Controller Working Position
- GSO: Ground Station Operator
- SP: Single Pilot

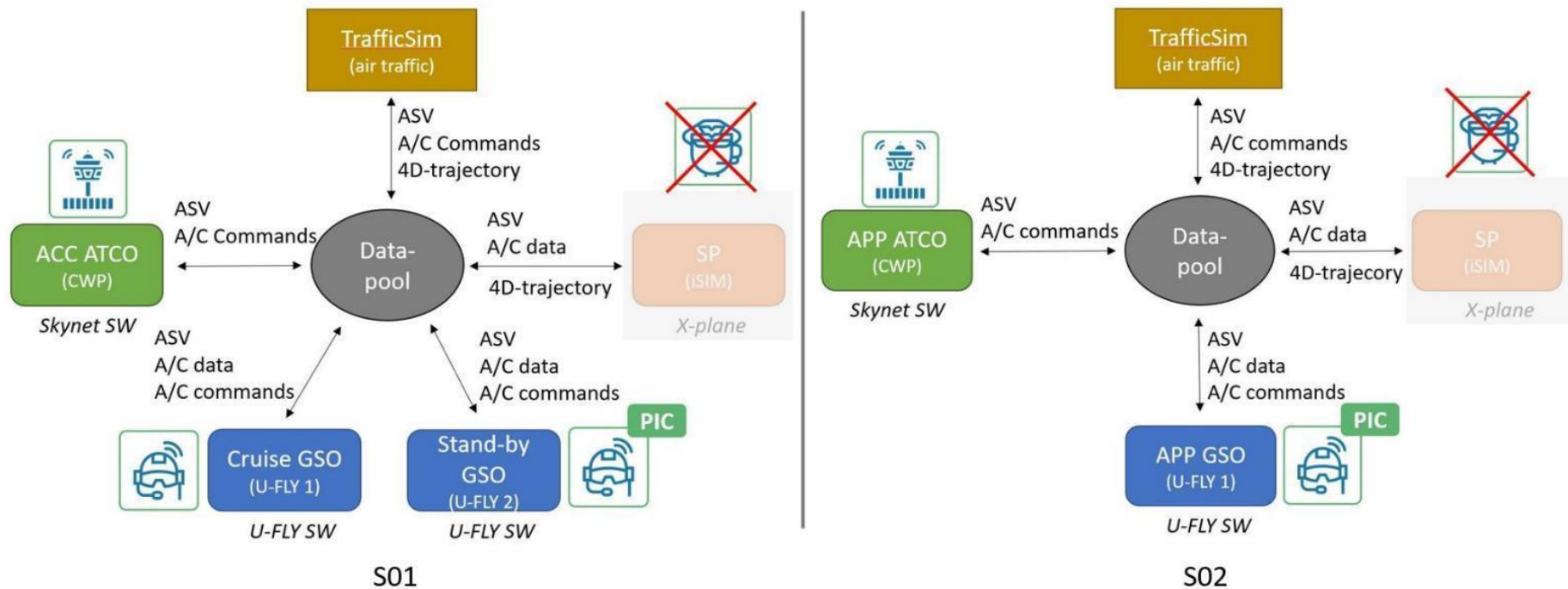


Figure 3. Interconnections of the cockpit simulator (iSIM) in case of pilot incapacitation

3 Content of the videos

This section describes the content of the recorded videos. In total, two videos were recorded depicting the cockpit simulator iSIM operated in the two different SAFELAND scenarios. These videos (cf. section 4) were recorded in January 2022 with DLR employees acting as SP, ATCO and GSOs. In the SAFELAND RTS (i.e. in April 2022), the cockpit simulator will be operated by DLR employees holding an ATPL. In order to cover the different aspects of the developed SAFELAND operational concept for single pilot incapacitation, the SAFELAND consortium identified two different scenarios that will be evaluated in the Human-in-the-Loop real-time simulations.

In scenario 1 (S01) the onboard single pilot incapacitation will occur during cruise (i.e. en-route phase) above Hungarian airspace, which is controlled by Budapest Control. In scenario 2 (S02) pilot incapacitation will occur in the Terminal Manoeuvring Area (TMA) of Düsseldorf airport (EDDL) whilst an approach GSO is monitoring the aircraft and an approach ATCO is monitoring the relevant sector. More details regarding the overall scenarios will be given in the subsections below. In this document the scenario description focuses on the onboard single pilot perspective. The scenario description in deliverable D2.1 (SAFELAND, 2022a) focuses on the ACTO perspective, and the scenario description in deliverable D2.3 (SAFELAND, 2022b) focuses on the GSO perspective.

3.1 S01 – Single Pilot Incapacitation en-route

S01 corresponds to a commercial flight of an Airbus A321 from Zurich (LSZH) to Kiev (UKBB) with passengers on board of the aircraft. The simulated traffic scenario has been adapted for the SAFELAND use-case in S01 from EUROCONTROL's DDR2 traffic data of a normal air traffic day recorded on 29th June 2019. Further, optimal weather conditions (i.e. dry, wind speed: 10kts) can be reported. The SAFELAND simulation starts in the cruise phase at flight level 330 just before the aircraft enters Hungarian airspace via waypoint *PESAT* from the west. Both the autopilot and auto throttle are engaged at the start of the scenario, and the aircraft is following the flight plan (FPL) stored in the Flight Management System (FMS) of the aircraft. In the first couple of minutes of the simulation, the onboard single pilot (DLR employee with ATPL) is able to control and operate the aircraft normally via the cockpit simulator (i.e. iSIM). However, as the aircraft is following the stored FPL, no further input is expected from the single pilot. Furthermore, a cruise GSO is monitoring multiple aircraft simultaneously, whereby one of them is the simulated aircraft operated via the cockpit simulator. In addition, an ATCO is monitoring the respective sector of the Hungarian airspace. At this point of the scenario no communication between the actors is expected.

Within the SAFELAND RTS, the onboard pilot incapacitation will be triggered by the iSIM operator setting the squawk code of the simulated aircraft to 7700 via the simulator touchscreens. In a future airline operation, the onboard single pilot incapacitation would be recognized by a pilot health monitoring system which is not available for the SAFELAND simulations (and out of scope for the project). The squawk code 7700 indicates pilot incapacitation and will be transmitted to the cruise GSO (for more details cf. D2.3) and announced by the cruise GSO to the ACTO. For a short period of time, the aircraft is following the defined FPL before the cruise GSO takes over control of the aircraft. Hereafter, the cruise GSO is in control of the aircraft and is expected to follow the SAFELAND operational concept for pilot incapacitation. In the scenario the onboard single pilot is now fully incapacitated and cannot interact with the aircraft or the other actors (i.e. GSO, ATCO).

However, as the SAFELAND operational concept relies on more sophisticated onboard automation whereby secondary flight controls (e.g. flaps, landing gear) are operated automatically by the aircraft systems, the iSIM operator (DLR employee) will have to operate these aircraft controls (if required) as the simulator is not able to operate these systems automatically.

3.2 S02 – Single Pilot Incapacitation in TMA

S02 is a commercial flight of an Airbus A321 from Zurich (LSZH) to Düsseldorf airport (EDDL) with passengers on board of the aircraft. The traffic scenario has been constructed based on recorded traffic at EDDL from 2019, with approximately 35 arrival movements per hour and adapted to the SAFELAND use-case in S02. The SAFELAND simulation starts after the aircraft enters the Terminal Manoeuvring Area (TMA) of EDDL at flight level 120. Shortly after the simulation starts, the onboard pilot (DLR employee with ATPL) will contact Düsseldorf control (i.e. Langen Radar) inbound STAR *DOMUX*. Both the autopilot and autothrottle are engaged at the start of the scenario, and the aircraft is following the FPL stored in the FMS of the aircraft, in which the approach procedures for EDDL are already included. In the first couple of minutes of the simulation, the onboard single pilot (DLR employee) is able to control and operate the aircraft normally via the cockpit simulator (i.e. iSIM). However, as the aircraft is following the FPL no further input is expected from the single pilot. Furthermore, an approach GSO and an approach ATCO are monitoring the aircraft. At this point of the scenario no communication between the actors is expected.

As in S01, the onboard pilot incapacitation will be triggered by the iSIM operator by setting the squawk code of the simulated aircraft to 7700 via the simulator touchscreens. In future airline operation, the onboard single pilot incapacitation would be recognized by a pilot health monitoring system. The squawk code 7700 indicates pilot incapacitation and will be transmitted to the approach GSO (for more details cf. D2.3) and to the approach ATCO (for more details cf. D2.1). For a short period of time, the aircraft follows the defined FPL before the approach GSO takes over control of the aircraft. Hereafter, the approach GSO is in control of the aircraft and is expected to follow the SAFELAND operational concept for pilot incapacitation. The required operational steps for the approach GSO and for the approach ATCO are described in D2.3 and D2.1. In this scenario the onboard single pilot is fully incapacitated and cannot interact with the aircraft or the other actors (i.e. GSO, ATCO).

However, as the SAFELAND operational concept relies on more sophisticated onboard automation whereby secondary flight controls (e.g. flaps, landing gear) are operated automatically by the system, (currently not possible in the cockpit simulator), the iSIM operator (DLR employee) will have to operate these aircraft controls (if required). Therefore, especially the recorded video of S02 shows that the iSIM operator (i.e. single pilot) is still in control of e.g. secondary flight controls in order to land the aircraft safely at EDDL.

4 Links

This section includes the links to download the recorded videos from a secure server that were recorded in January 2022 with DLR employees acting as SP, ATCO and GSOs. These videos depict one possible way to handle the severe event of single pilot incapacitation during flight. However, during the SAFELAND RTS in April 2022, the invited human operators (i.e. licensed ATCOs, airline pilots) might react differently to the simulated situations.

4.1 Download links for S01

Please find below the link to download the video for operating the Cockpit simulator (i.e. iSIM) in SAFELAND scenario 1 (S01):

[Download File \(dlr.de\)](#)

4.2 Download links for S02

Please find below the link to download the video for operating the Cockpit simulator (i.e. iSIM) in SAFELAND scenario 2 (S02):

[Download File \(dlr.de\)](#)

5 References

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- [3] SAFELAND (2022a). *Adaptation of CWP simulator*. SAFELAND D2.1.
- [4] SAFELAND (2022b). *Adaptation of Remote Cockpit simulator*. SAFELAND D2.3.
- [5] SAFELAND (2022c). *Integration Report*. SAFELAND D2.4.

