

Adaptation of Remote 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 adaptations and modifications made to the Remote Cockpit simulator and its software application U-FLY that will be used in the SAFELAND simulation. The Remote Cockpit simulator will be operated by airline pilots provided by the partner organisation SWISS of the SAFELAND consortium. Their task will be to experience the developed SAFELAND concept in two different scenarios in which single pilot incapacitation will occur during flight.

This deliverable is marked as type 'Other' and consists of this document and two links. Via each link a video displaying the U-FLY operated in the two different SAFELAND scenarios can be downloaded. Each video clarifies the operational steps required to be performed by the human operator in front of the U-FLY.

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1 Introduction¹

1.1 Purpose and scope of this document

This deliverable illustrates the operability of the Remote Cockpit simulator which will be used within the SAFELAND Human-in-the-Loop real time simulation (RTS) at DLR's Institute of Flight Guidance in Braunschweig, Germany. Hereby, the Remote Cockpit simulator will be the desktop software application U-FLY developed by DLR's Institute of Flight Guidance. The U-FLY is human-machine interface (HMI) for the simultaneous supervision and guidance of multiple highly automated aircraft operated in controlled airspace. The main purpose of this deliverable is to introduce the reader to the functionalities and operability of the proposed software application U-FLY, which will be operated by external airline pilots (SWISS employees) in the SAFELAND simulation. The real-time simulation will involve airline pilots (operating a Remote Cockpit simulator *U-FLY*), Air Traffic Controllers (operating the CWP), pilots (operating a Cockpit simulator), which are planned to be conducted in April 2022.

The scope of this deliverable is to visualize the functionalities of the Remote Cockpit simulator U-FLY. As this deliverable is marked as type 'Other', it has been agreed to take advantage of screen recording applications in order to show the operability of the U-FLY in the SAFELAND context. In total, two different SAFELAND scenarios will be simulated as described in D3.1 (SAFELAND, 2021a). These videos were recorded in January 2022, where DLR employees acted as SP, ACTOS and GSOs. The envisaged structure of both scenarios, and especially the operational steps needed to be performed by the human operator operating the U-FLY 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 Remote 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, 2021a).
- Chapter 4 provides two links to download the recorded videos of the U-FLY software application.

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

- Chapter 5 lists the references used in this document.

1.3 List of acronyms

Term	Definition
A/C	Aircraft
ASV	Aircraft State Vector
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATPL	Airline Transport Pilot Licence
CWP	Controller Working Position
FCU	Flight Control Unit
FMS	Flight Management System
FPL	Flight Plan
GCS	Ground Control Station
GSO	Ground Station Operator
HMI	Human Machine Interface
PFD	Primary Flight Display
PIC	Pilot In Command
RTS	Real-Time Simulation
SJU	SESAR Joint Undertaking
SP	Single Pilot
STAR	Standard Arrival Route



TMA	Terminal Manoeuvring Area
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Table 1: Acronyms

2 Simulator and architecture

This section describes the high-level architecture of the simulation environment for the SAFELAND simulations to be conducted in April 2022. Hereby, this section details the interconnections of the Remote Cockpit simulator *U-FLY* to the traffic simulation *TrafficSim*, to the Controller Working Position (CWP), to the single cockpit simulator *iSIM* 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 Remote Cockpit simulator

In the context of the SAFELAND RTS, a ground control station application called U-FLY will be used and operated as a remote piloting station by the ground station operator (GSO). The U-FLY application is a human-machine interface (HMI) for the simultaneous supervision and guidance of multiple aircraft operated in controlled airspace. The main objective of U-FLY is to assist the onboard cockpit crew (e.g. single pilot) by enabling the GSO to monitor and control (if needed) the aircraft throughout the entire flight duration. Once onboard pilot incapacitation is detected, the aircraft will enter semi-automatic flight mode that will allow the GSO to control the aircraft through the U-FLY application. Hereby, the GSO will be able to send trajectory amendment based on high-level commands as e.g. heading, altitude or speed, as well as to file a new flight plan (SESAR Innovation Days, 2021). During the RTS, airline pilots with ATPL (SWISS employees) will operate the remote cockpit simulator. A more detailed description of the used remote piloting station can be found in D3.1 (SAFELAND, 2021a).

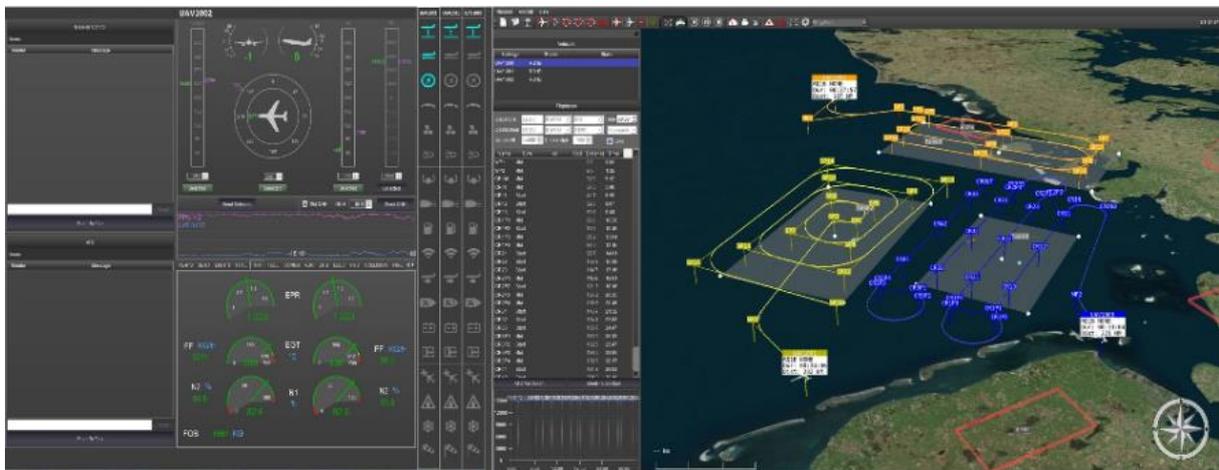


Figure 1. Remote Cockpit simulator application *U-FLY*

The main functionalities of the Remote Cockpit simulator (cf. Figure 1) for the SAFELAND RTS can be summarized as follows (for details cf. SAFELAND, 2021a):

- Monitoring and supervising of several aircraft simultaneously
- Supporting onboard single pilot upon request

- Takeover of aircraft control in case of pilot incapacitation

2.2 Interconnections between the Remote Cockpit simulator and the simulation infrastructure

Figures 2 and 3 illustrate the interconnections of the Remote Cockpit simulator to DLR's simulation infrastructure for both SAFELAND scenarios (cf. chapter 3) in nominal flight conditions and during onboard 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 the messages to the connected clients (here the different simulators). The Remote 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 Remote Cockpit simulator:

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

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

- A/C commands (in case of pilot incapacitation)

For more details on the data distribution tool *datapool* and on the transmitted message to/from the CWP, please cf. deliverable D2.4 (SAFELAND, 2022c).

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

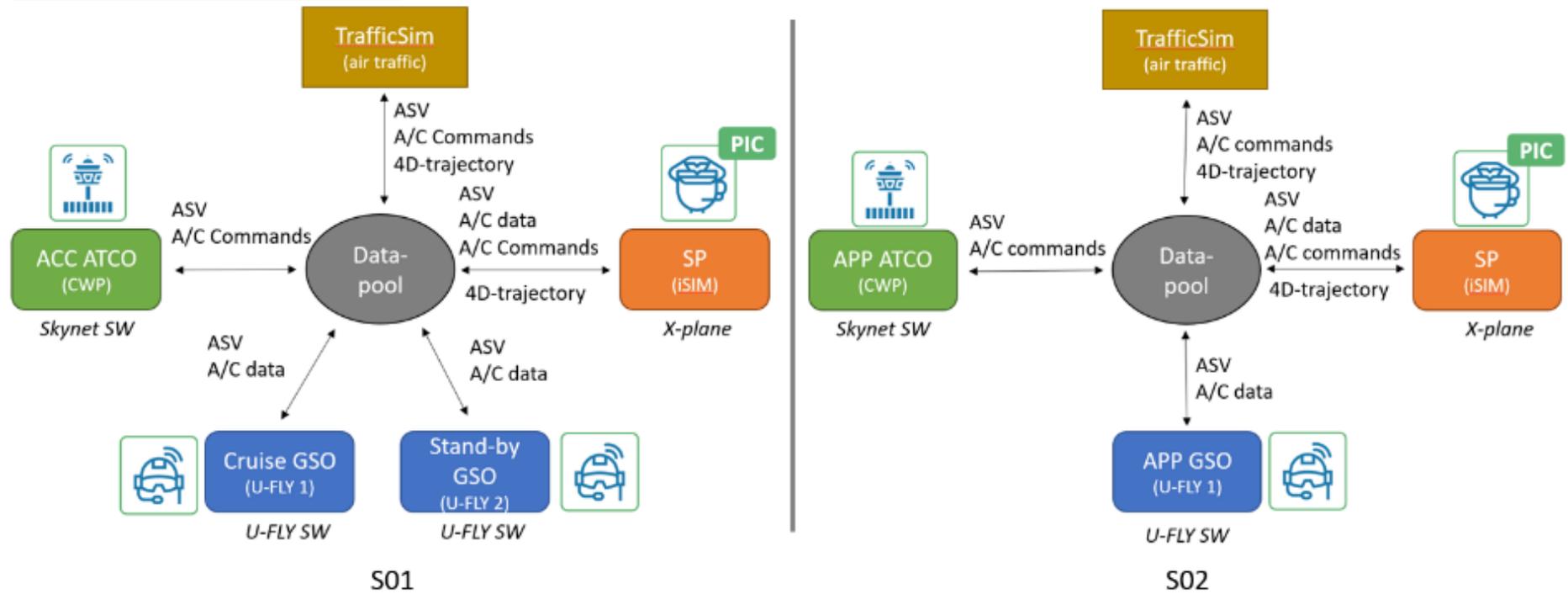


Figure 2. Interconnections between the Remote Cockpit simulator (U-FLY) in nominal flight conditions

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

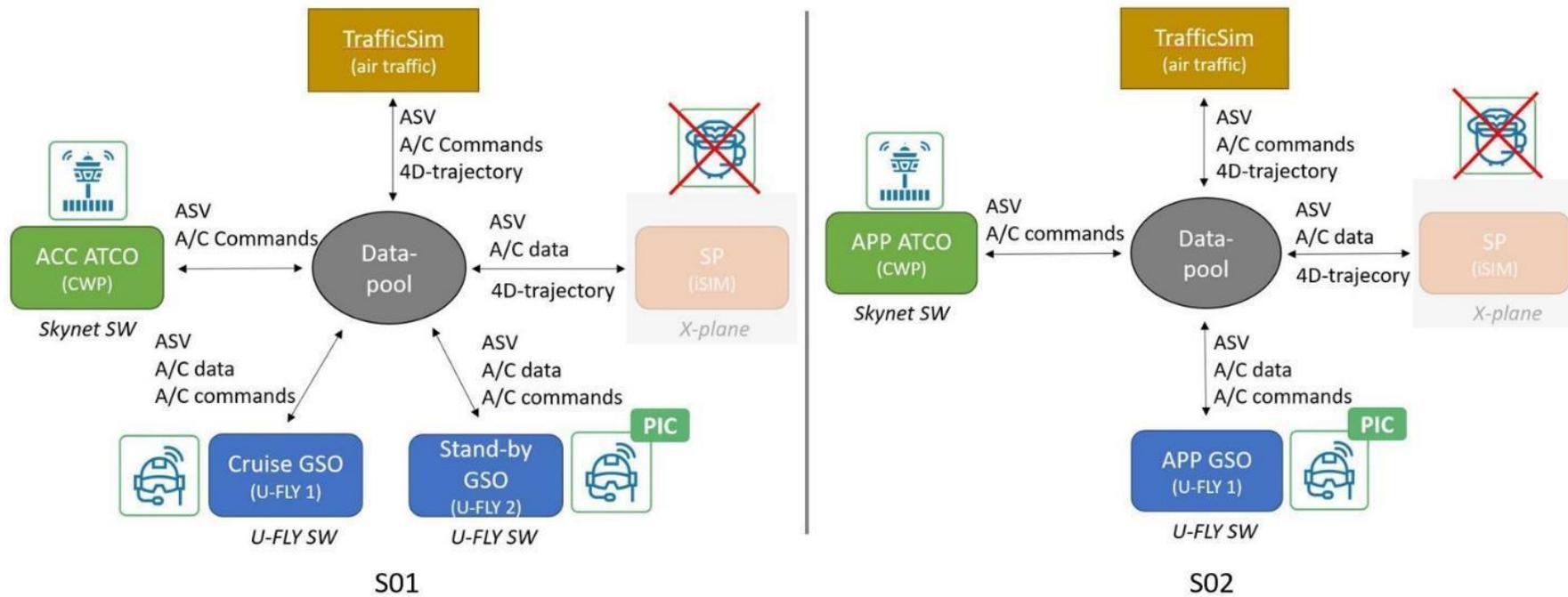


Figure 3. Interconnections between the Remote Cockpit simulator (U-FLY) in case of pilot incapacitation

3 Content of the videos

This section describes the content of the videos that have been recorded in January 2022 with DLR employees acting as SP, ATCO and GSOs. In total, two videos have been gathered via screen recording depicting the operator screens of the U-FLY ground control station (GCS). The U-Fly consists of a Map Display showing air traffic (i.e. aircraft under monitoring and surrounding air traffic) and an aircraft monitoring display entailing e.g. a Primary Flight Display (PFD) and Flight Control Unit (FCU). After the pilot incapacitation occurs, the human operator operating the U-FLY (called Ground Station Operator GSO) will become the Pilot in Command (PIC). 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 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, and whilst a cruise GSO is monitoring, amongst other aircraft, also the concerned aircraft. In scenario 2 (S02) the onboard single pilot incapacitation will occur in the Terminal Manoeuvring Area (TMA) of Düsseldorf airport (EDDL) whilst an approach GSO is monitoring the landing aircraft and the approach ATCO is monitoring the relevant sector. More details regarding the overall scenarios and the required operational steps to be performed by the GSOs will be given in the subsections below. In this document the scenario description focuses on the GSO perspective. The scenario description in deliverable D2.1 (SAFELAND, 2022a) focuses on the CWP perspective, and the scenario description in deliverable D2.2 (SAFELAND, 2022b) focuses on the onboard pilot perspective.

3.1 S01 – Pilot Incapacitation in en-route

S01 is 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, good weather conditions (i.e. dry, low wind) can be reported. The SAFELAND simulation starts in the cruise phase at flight level 330 before the aircraft enters Hungarian airspace via waypoint *PARAT* from the west. Both the autopilot and auto throttle are engaged at the start of the scenario, and the aircraft is following a predefined flight plan (FPL). 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 inputs are 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 issued through the cockpit simulator by setting the squawk code of the simulated aircraft to 7700 via the touchscreens of the simulator. In a future airline operation, the onboard pilot incapacitation would be recognized by a pilot health monitoring system which is not available for the SAFELAND simulations (and out of scope of the project). The squawk code 7700 indicates pilot incapacitation and will be transmitted to the cruise GSO and the GSO will inform the en-route ATCO. Hereafter, the cruise GSO and the other actors will follow the SAFELAND operational concept for pilot incapacitation. For a short period of time, the aircraft is

following the defined FPL before the cruise GSO takes over control of the aircraft. First, the cruise GSO confirms pilot incapacitation (i.e. contacts cockpit via voice communication), and afterwards presses the “Control” button of the GCS application (i.e. U-FLY) in order to become Pilot-in-Command (PIC) (cf. screen recording in section 4.1). At the same time, the cruise GSO announces his/her new role to the other actors (i.e. Stand-by GSO, ATCO) via voice. However, as the cruise GSO is monitoring other aircraft as well, s/he will handover the control of the aircraft to a Stand-by GSO solely responsible for landing the aircraft safely. Therefore, the cruise GSO contacts the Stand-by GSO via voice, and requests the handover of the control of the aircraft. As soon as the Stand-by GSO has gained sufficient situation awareness, the control of the aircraft will be transferred. In order to achieve the handover the stand-by GSO will press “Request handover” in his/her GCS application and cruise GSO will have to accept this request (cf. screen recording in section 4.1). Third, once the handover process is completed, the Stand-by GSO has to decide for a suitable landing airport in the vicinity of the aircraft. As a result, with the assistance of ATC, the stand-by GSO will decide where to land as well as receive the clearances to the new landing airport (if required). Fourth, within the simulation, the Stand-by GSO will create a new FPL via the U-FLY application. Therefore, the Stand-by GSO has to select the destination airport, runway, STAR and approach procedures via a drop-down menu in the GCS application. Once the new FPL is filed, it will be sent to the aircraft by pressing the “Send FPL” button in the U-FLY application. Hereafter, the aircraft is expected to be able to land automatically. Therefore, S01 ends after the new FPL has been sent to the aircraft.

3.2 S02 – 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. Further, the weather conditions are good (i.e. dry, wind speed: 10kts). The SAFELAND simulation starts after the aircraft enters the 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*. The autopilot is engaged at the start of the scenario and the aircraft is following a defined flight plan (FPL), in which the approach procedures for EDDL are stored. In the first couple of minutes of the simulation, the onboard single pilot is able to control and operate the aircraft normally via the cockpit simulator (i.e. iSIM). However, as it has been agreed in the SAFELAND project that the aircraft is able to land automatically (i.e. via automatic take-off and landing system – ATOL) (SESAR Innovation Days, 2021) no further inputs are 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 issued through the cockpit simulator by setting the squawk code of the simulated aircraft to 7700 via the touchscreens of the simulator. In a future airline operation, 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. Hereafter, the approach GSO announces pilot incapacitation on the flight, and the other actors are expected to follow the SAFELAND operational concept for pilot incapacitation. For a short period of time, the aircraft follows the defined FPL before the approach GSO takes over control of the aircraft. First, the approach GSO confirms the pilot incapacitation (i.e. contact cockpit via voice communication), and afterwards presses the “Control” button of the GCS application (i.e. U-FLY) in order to become Pilot-in-Command (PIC) (cf. screen recording in section 4.2). At the same time, the approach GSO announces his/her new

role to the other actors (i.e. ATC) via voice. Second, with the assistance of ATC, the approach will decide GSO if the aircraft should enter a holding pattern or continue the predefined FPL directly. In case the decision has been taken to enter a holding pattern, the approach GSO will have to press “Enter Holding” in the GCS application. If not, the aircraft will follow the defined FPL on its own, and land automatically.

However, as the SAFELAND operational concept relies on more sophisticated onboard automation whereby secondary flight controls (e.g. flaps, landing gear) will be operated automatically by the aircraft system - which is not available in the used cockpit simulator - the (incapacitated) pilot of the cockpit simulator (DLR employe) will have to operate these aircraft controls during landing (if required).

4 Links

This section includes the links to download the videos from a secure server that were recorded in January 2022 with DLR employees acting as SP, ACTO and GSOs. These videos depict one possible way to handle the severe event of single pilot incapacitation during both scenarios. 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 link for S01

Please find here the link to download the video for operating the CWP simulator in SAFELAND scenario 1 (S01):

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

4.2 Download link for S02

Please find here the link to download the video for operating the CWP simulator in SAFELAND scenario 2 (S02):

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

5 References

- [1] SAFELAND (2021a). *Preliminary Results*. SAFELAND D3.1.
- [2] SAFELAND (2021b). *Final Concept*. SAFELAND D1.4.
- [3] SAFELAND (2022a). *Adaptation of CWP simulator*. SAFELAND D2.1.
- [4] SAFELAND (2022b). *Adaptation of Cockpit simulator*. SAFELAND D2.2.
- [5] SAFELAND (2022c). *Integration Report*. SAFELAND D2.4.
- [6] Martins, Ana P. G.; Lieb, Joonas; Friedrich, Max; Bonelli, Stefano, Celori, Marcello and De Bortoli Vizioli, Aurora (2021) *Toward single pilot operations: A conceptual framework to manage in-flight incapacitation*. In: 11th SESAR Innovation Days: Inspiring Long-Term Research in the Field of Air Traffic Management, SIDs 2021. SESAR Innovation Days 2021, online.

