# The SAFELAND project

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RPAS and AI in aviation
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Rome, Italy

# Agenda

- ❖ SAFELAND Overview

- ❖ Final Concept

- ❖ Real-time Simulations

- ❖ SAFELAND Results

- ❖ Discussion and Q&A

# SAFELAND Overview

**The Topic** (Exploratory Research)

- Single pilot operations

**The SAFELAND Project contribution**

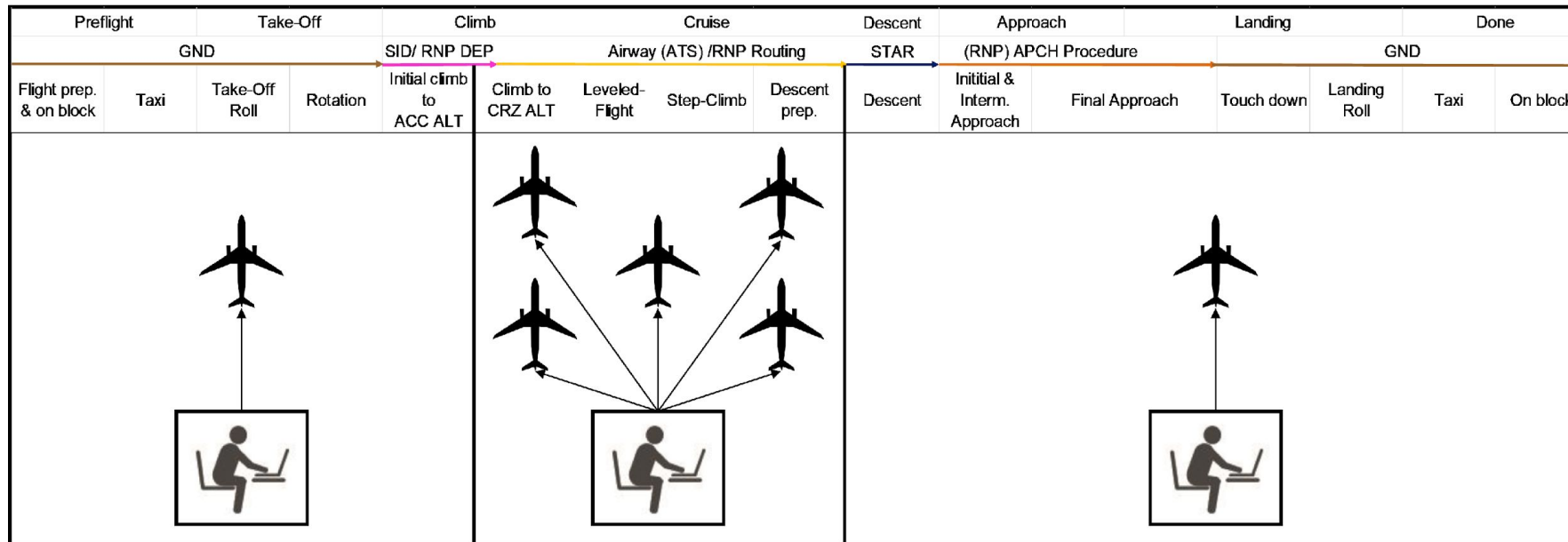- Enhancing safety in case of single pilot incapacitation, until landing

# Nominal Operational Concept

The presence of three different kinds of ground stations (GS) is assumed for SPO:

▪ Departure GS – the GSO supports one single pilot

▪ Cruise GS – the GSO supports multiple single-piloted aircraft simultaneously

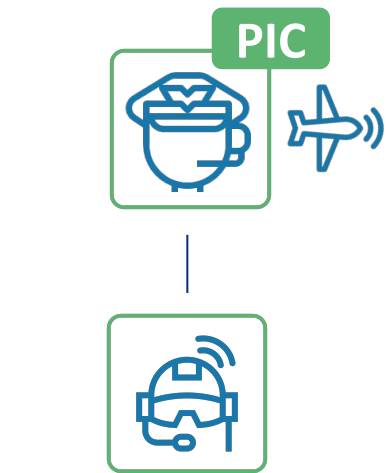▪ Approach GS – the GSO supports one single pilot

# The SAFELAND Concept

## *Onboard Single Pilot Incapacitation*

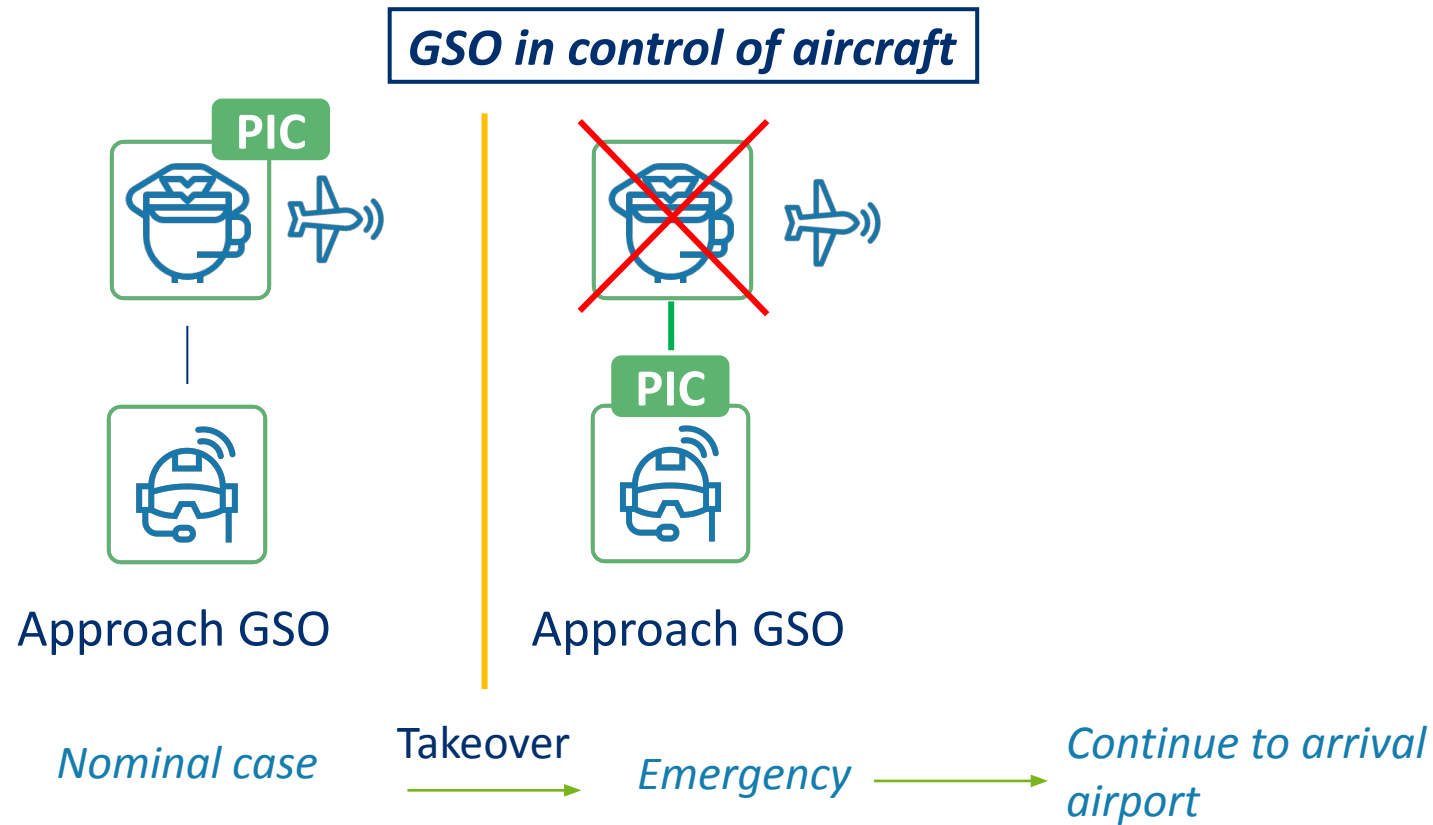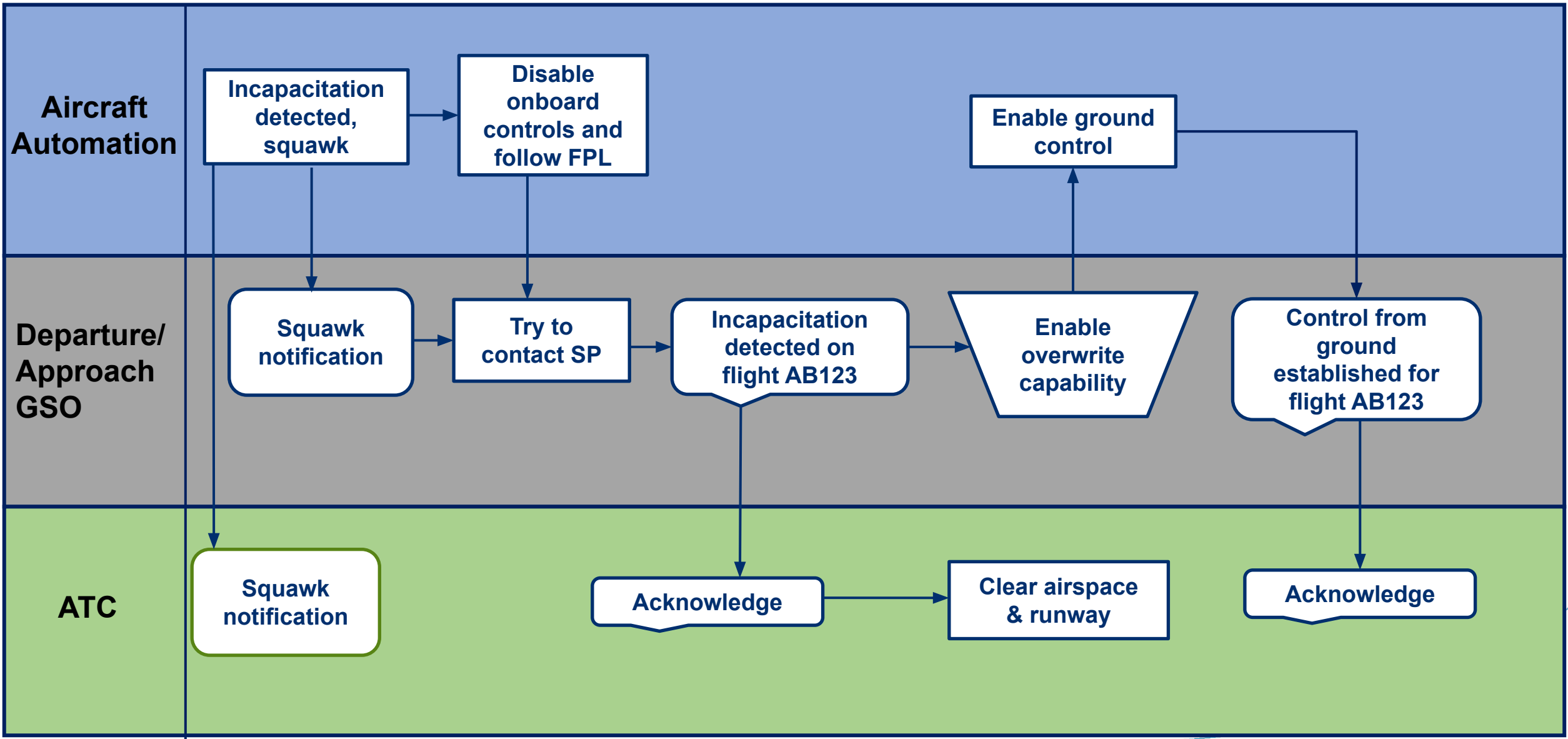# Non-nominal Operational Concept

**Pilot Incapacitation in TMA**



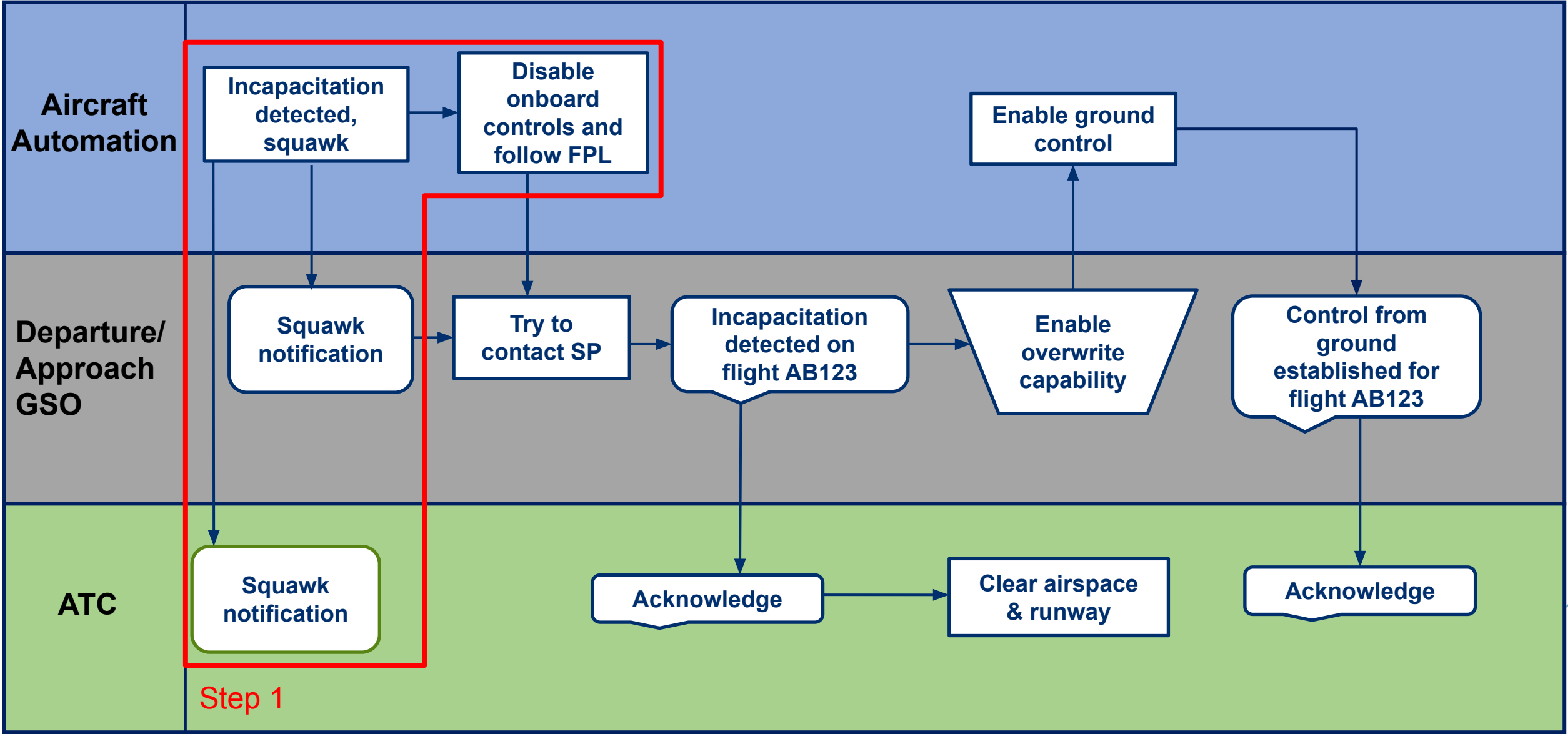PIC

Approach GSO

*Nominal case*

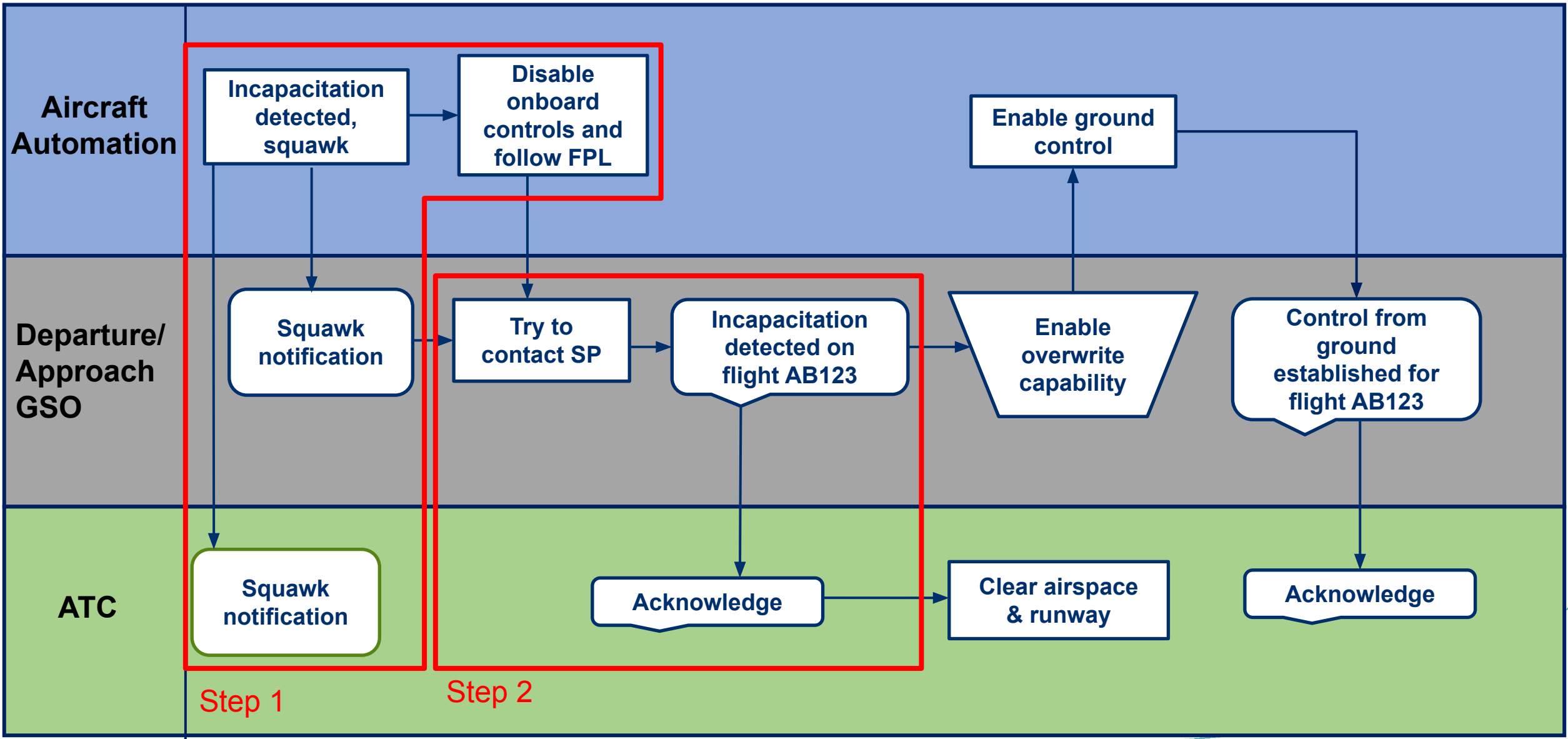# Non-nominal Operational Concept

**Pilot Incapacitation in TMA**

GSO in control of aircraft

PIC

PIC

Approach GSO          Approach GSO

*Nominal case*   Takeover   *Emergency*   *Continue to arrival airport*

# Takeover Procedure (TMA)



**Aircraft Automation**

- Incapacitation detected, squawk → Disable onboard controls and follow FPL
- Enable ground control

**Departure/ Approach GSO**

- Squawk notification → Try to contact SP → Incapacitation detected on flight AB123 → Enable overwrite capability
- Control from ground established for flight AB123

**ATC**

- Squawk notification
- Acknowledge → Clear airspace & runway
- Acknowledge

# Takeover Procedure (TMA)



**Aircraft Automation**

- Incapacitation detected, squawk
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**Departure/ Approach GSO**

- Squawk notification
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- Incapacitation detected on flight AB123
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**ATC**

- Squawk notification
- Acknowledge
- Clear airspace & runway
- Acknowledge

Step 1

# Takeover Procedure (TMA)

# Takeover Procedure (TMA)
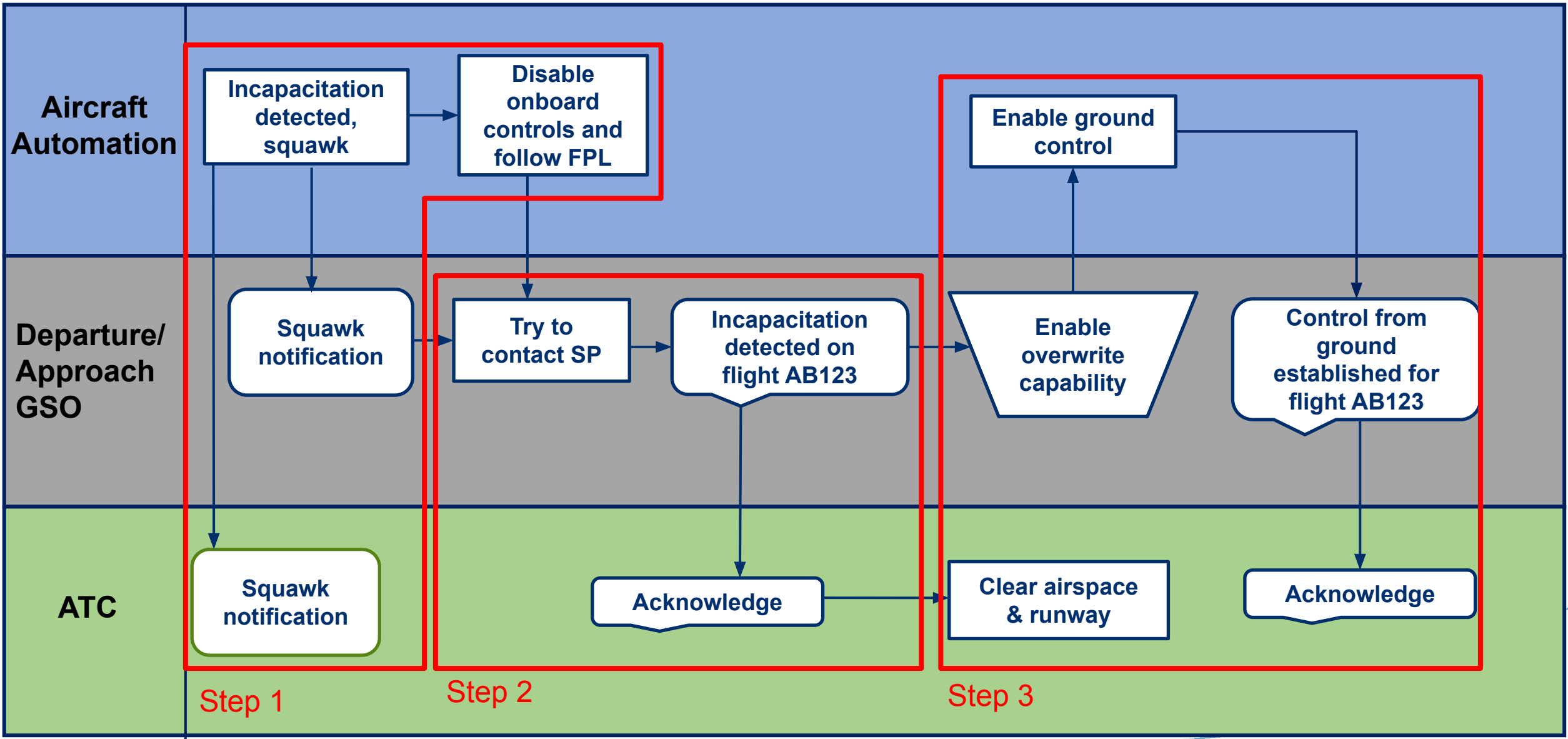
# Non-nominal Operational Concept
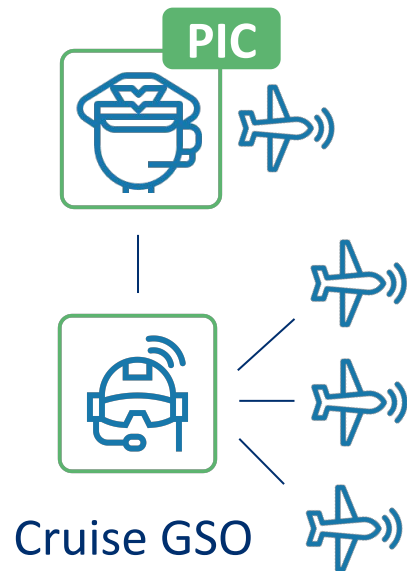
**Pilot incapacitation en-route**



PIC

Cruise GSO
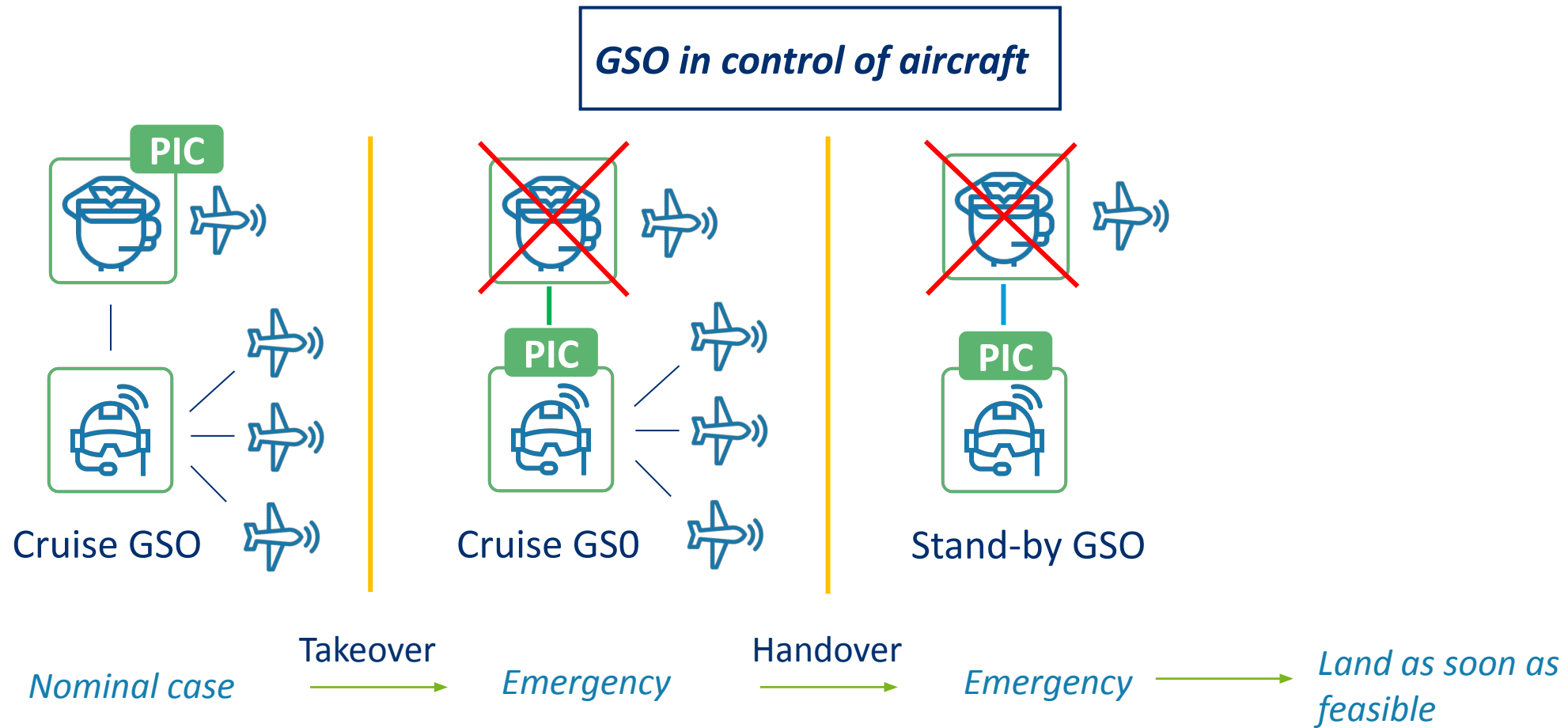
*Nominal case*

# Non-nominal Operational Concept

**Pilot incapacitation en-route**

GSO in control of aircraft

PIC

Cruise GSO

PIC

Cruise GS0

*Nominal case*    Takeover    *Emergency*

# Non-nominal Operational Concept

**Pilot incapacitation en-route**

GSO in control of aircraft

PIC

Cruise GSO

PIC

Cruise GS0

PIC

Stand-by GSO

*Nominal case* → Takeover → *Emergency* → Handover → *Emergency* → Land as soon as feasible
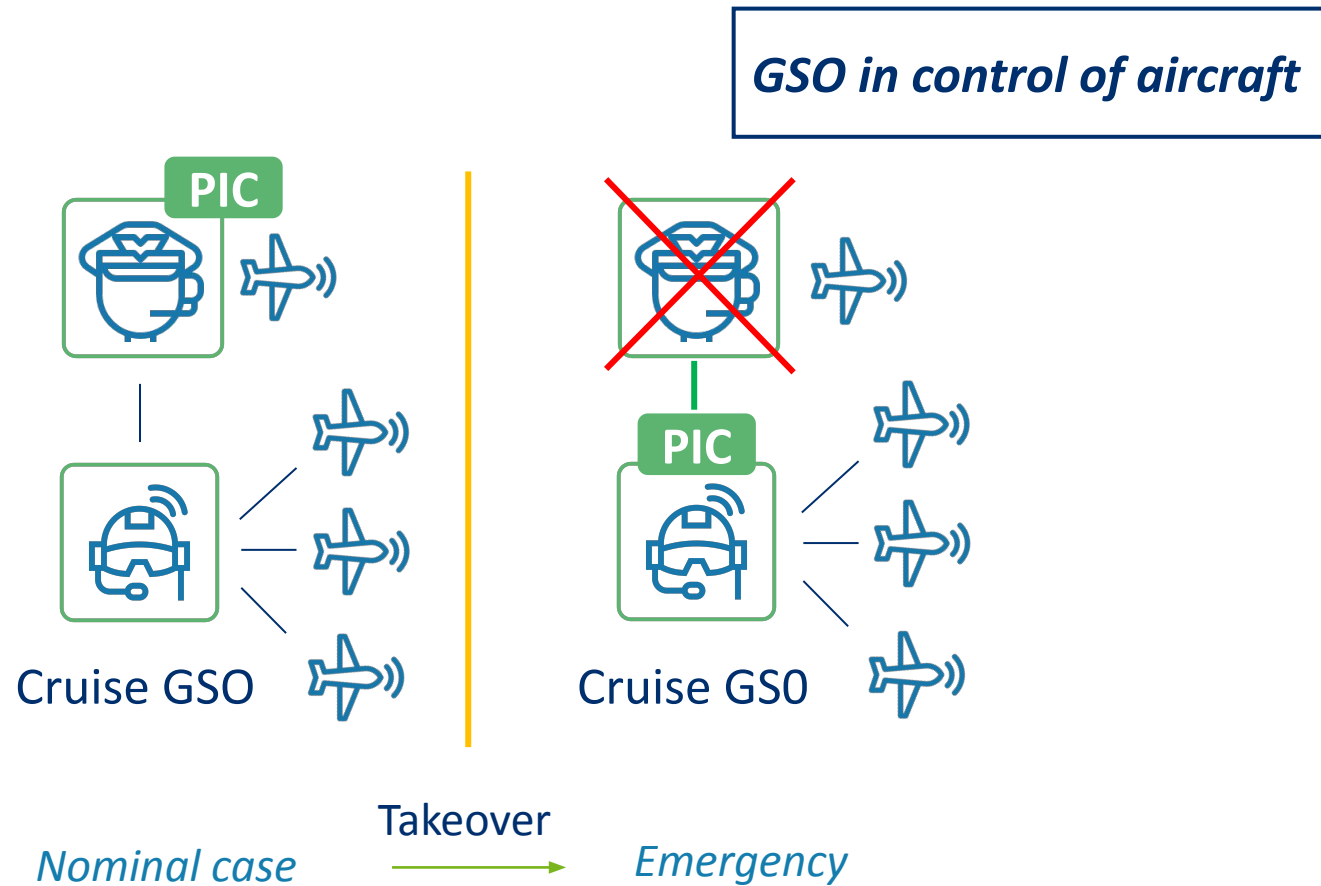
# SAFELAND Concept

## Key Attributes

- SAFELAND concept proposes **three different GSO** roles (i.e., departure, cruise, approach)

- Concept relies on **more sophisticated** onboard **automation** to support the SP throughout the flight

- Handover procedures are **closely aligned** with current requirement for handovers of remotely piloted aircraft

- **No significant changes** on the tasks and responsibilities of **ATC**

- Remote pilot able to **control multiple** highly automated **aircraft**

- GSO is **not expected** to manually fly the aircraft

# SAFELAND Evaluation

# *Real-time Simulations*

EUROPEAN PARTNERSHIP

Co-funded by the European Union

# RTS objectives

The **focus** of the RTS was on:

- **Emergency Operating Procedure** for pilot incapacitation (normal operations are out of scope)
- **Roles** and **responsibilities** of the different participants
- **Task allocation** (including between human and automation)
- **Communication** and **Coordination** between participants

# RTS participants

1. Pilots from SWISS      **-> GSO**

2. ATCOs from LFV      **-> ATCOs**

       **1 pilot + 1 ATCO each day** (5 days)

## Other roles

- Single Pilot
- Cruise GSO
- Other ATS units
- NOC

      **–> SAFELAND Consortium**

# Simulation scenarios

## Scenario 1: TMA

- **Aircraft type:** A321

- **Departure – Arrival:**
  Zurich (LSZH ) – Düsseldorf (EDDL)

- **Flight Phase:**
  About to enter TMA (FL120)

- **Surrounding traffic:**
  - Air traffic constructed based on recorded traffic at EDDL from 2019
  - 35 arrivals per hour

## Scenario 2: En-route

- **Aircraft type:** A321

- **Departure – Arrival:**
  Zurich (LSZH) – Kiev (UKKB)

- **Flight Phase:**
  About to enter a new sector in Hungarian airspace (FL330)

- **Surrounding traffic:**
  - Air traffic extracted from EUROCONTROL´s DDR2 traffic data
  - Air traffic day recorded on 29.06.2019

# Roles in RTS – TMA (Run 1)

**APP ATCO**
(CWP)

*Skynet SW*

**Controller Working Position**

- APP ATCO

- Other ATS units

**GSO**
(U-FLY)
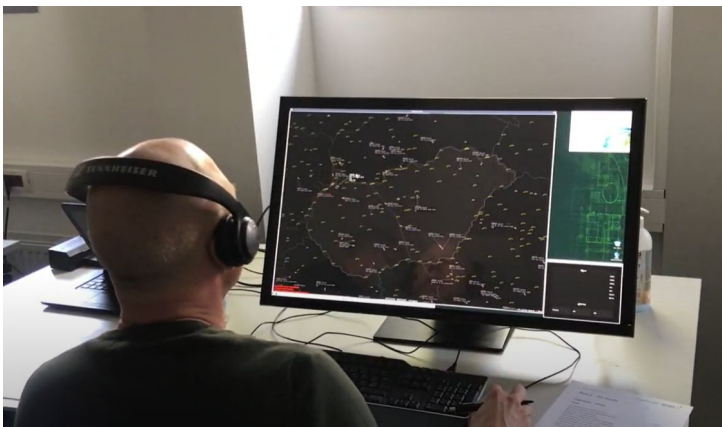
*U-FLY SW*

**Ground Station Position**

- Approach GSO

**SP**
(iSIM)

*X-plane*

**Cockpit simulator**

- On-board Single Pilot

# Roles in RTS – En-route (Run 2)

**ACC ATCO (CWP)**

*Skynet SW*

**Controller Working Position**

- ACC ATCO
- Other ATS units
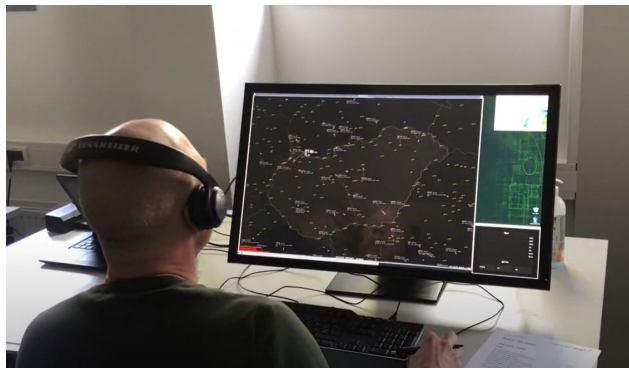
**GSO (U-FLY)**

*U-FLY SW*

**Ground Station Position**

- Cruise GSO
- Stand-by GSO

**SP (iSIM)**

*X-plane*

**Cockpit simulator**

- On-board Single Pilot

**NOC (None)**

**Operator Room**

- Network Operator

# Supporting material

- **Training session** for GSO and ATCO

- Simplified **Checklist** for all participants

- **Instruction** for all participants

- **Script** for roles simulated by SAFELAND participants



Fig. Checklist GSO



Fig. Instructions ATCO S02



Fig. Script Run 2

# Assumptions

- **All systems operating as expected**

- **No delay** (in C2 link or communication)

- Onboard **pilot health monitoring system** capable of detecting incapacitation and automatically alerting the GSO and ATCO

- Surrounding **traffic** is **datalink-equipped** (no pseudo-pilots or read backs)

- ATC provides **clearances via voice** only to **EMERG A/C**

- After incapacitation, **autopilot engaged** automatically (i.e. a/c flies according to last FMS entry)

- **Manual control** from ground not foreseen (i.e. only high-level commands from ground to a/c, such as HDG, SPEED, ALT)

- **Advanced Landing System** is engaged during arrival (TMA run)
  - If not given any further inputs, a/c lands according to the last FMS entry
  - Secondary flight controls and the landing gear are operated automatically

# Roles & Responsibilities

## Onboard Single Pilot

**Responsibilities:** Pilot in Command (PIC), responsible for flight safety and thus main decision-maker.

## ATCO

**Responsibilities:** Ensures air traffic operation and management. Responsibilities are not expected to change compared to current operations.

## Approach GSO – Run 1

**Responsibilities:** Support the PIC, contributing to a safe and efficient flight. Act as PIC after SP becomes incapacitated.

## Cruise GSO – Run 2

**Responsibilities:** Support several single pilots, contributing to a safe and efficient flight. Act as PIC after SP becomes incapacitated until a/c is transferred to stand-by GSO.

## Stand-by GSO – Run 2

**Responsibilities:** Become PIC after pilot incapacitation, responsible for flight safety and thus decision maker.

# GSO Tasks during Approach/Departure

## Tasks before incapacitation

- Departure/Approach Briefings with SP
- Monitor aircraft systems and flight (e.g., trajectory conformance)
- Monitor pilot's health (with support from pilot health monitoring system)
- Check (and inform the pilot) of potential hazardous weather in the airport vicinity
- Support the PIC upon request
- Cross-check and monitor SP actions
- Listen to communications between SP and ATC

# GSO Tasks during Approach/Departure

| Tasks **before** incapacitation | Tasks **after** incapacitation |
|---|---|
| • Departure/Approach Briefings with SP<br>• Monitor aircraft systems and flight (e.g., trajectory conformance)<br>• Monitor pilot's health (with support from pilot health monitoring system)<br>• Check (and inform the pilot) of potential hazardous weather in the airport vicinity<br>• Support the PIC upon request<br>• Cross-check and monitor SP actions<br>• Listen to communications between SP and ATC | • Contact a/c and confirm pilot incapacitation<br>• Take over control of the aircraft, check a/c state<br>• Declare MAYDAY<br>• Communicate control from ground<br>• Manage flight via high-level commands (HEAD, ALT, SPEED) or FPL changes<br>• Coordinate with ATC for emergency landing |

# Impressions
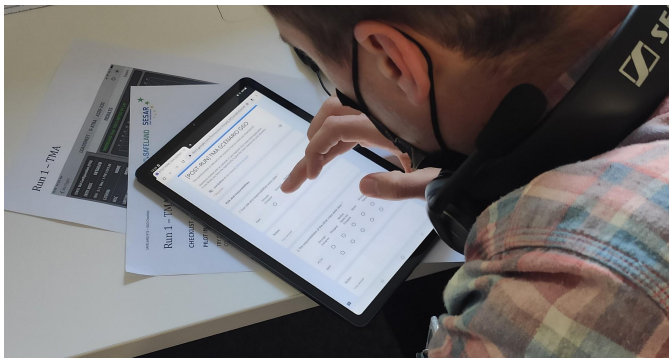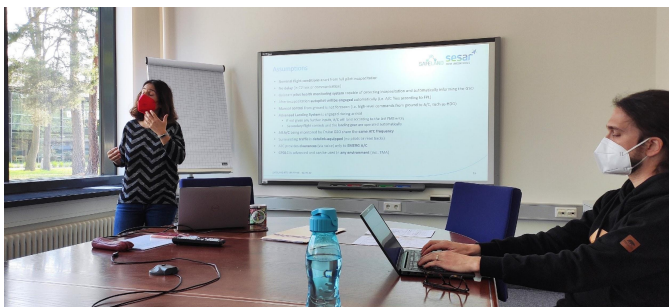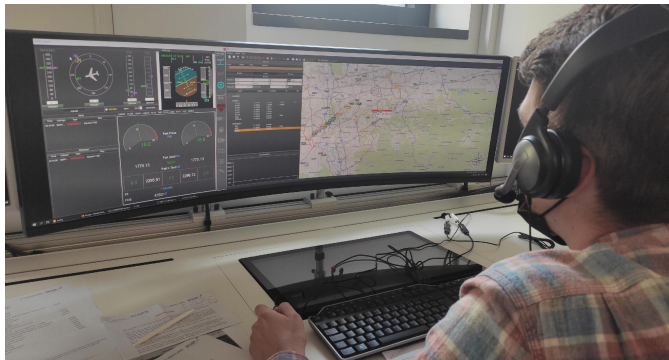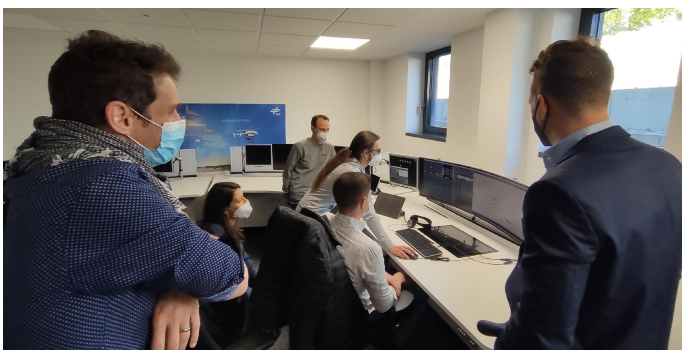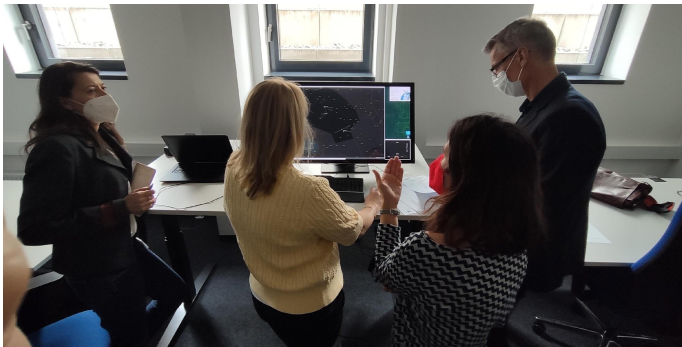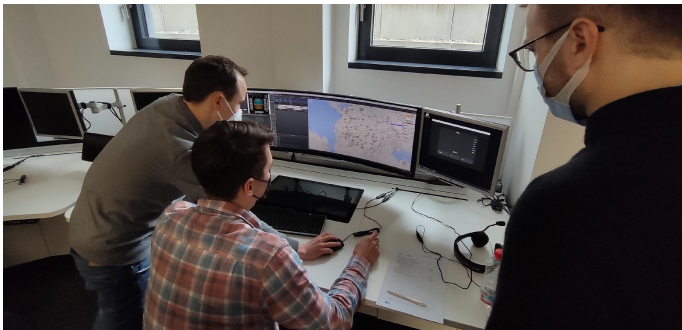
# SAFELAND Results

# *Simulation Findings*

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# SAFELAND RTS data gathering
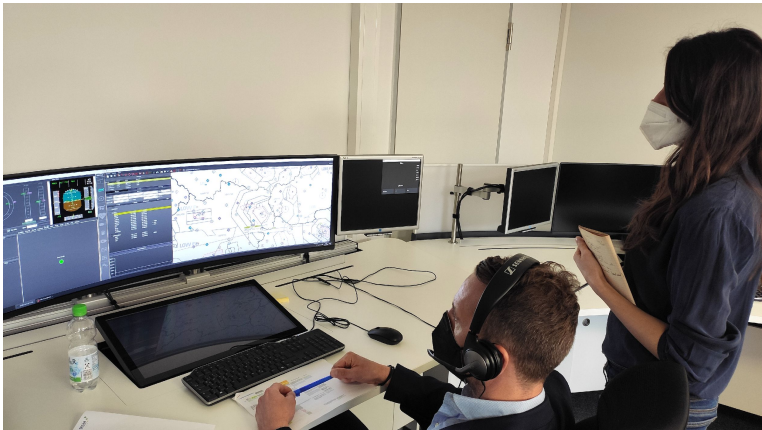


Observations



Questionnaires



Final Debriefing

# SAFELAND RTS data

Roles and responsibilities

Procedures

Coordination and communication

Technical Support Systems and HMI

Human Performance and Safety

ATCO    GSO

## Acceptability, operating methods, safety and trust - ATCO



ATCO. Roles, responsibilities, operating methods, safety and trust.
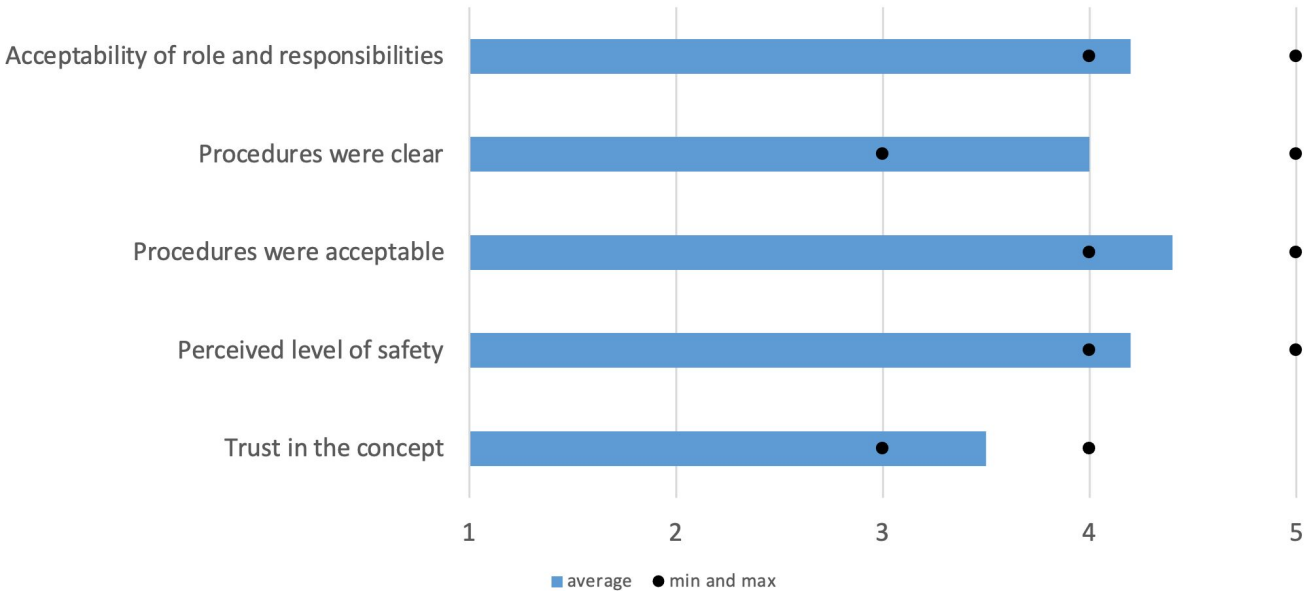
ATCO. You were able to perform your tasks as in current operations
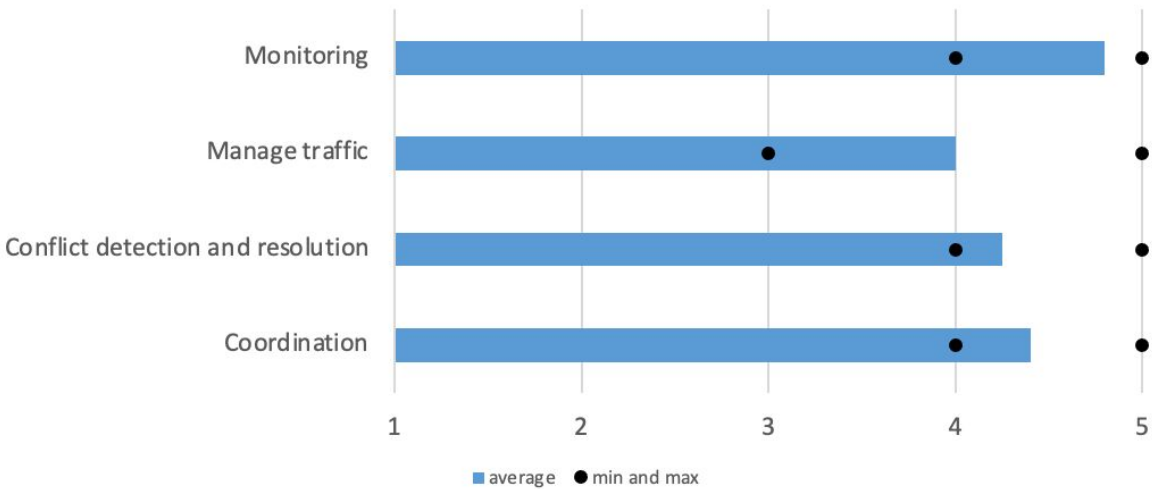
# SAFELAND changes and challenges: ATCOs

NO big changes in ATCOs' tasks, procedures and responsibilities compared to current emergency operations.

After incapacitation, the ATCO:
- clears the airspace
- coordinates with any other ATC services/concerned units as needed
- supports the GSO as needed

## Communication, workload, and situational awareness - ATCOs



ATCO. The communication was effective, clear, sufficient and on-time, between:

TMA average   EN-ROUTE average   ● min and max
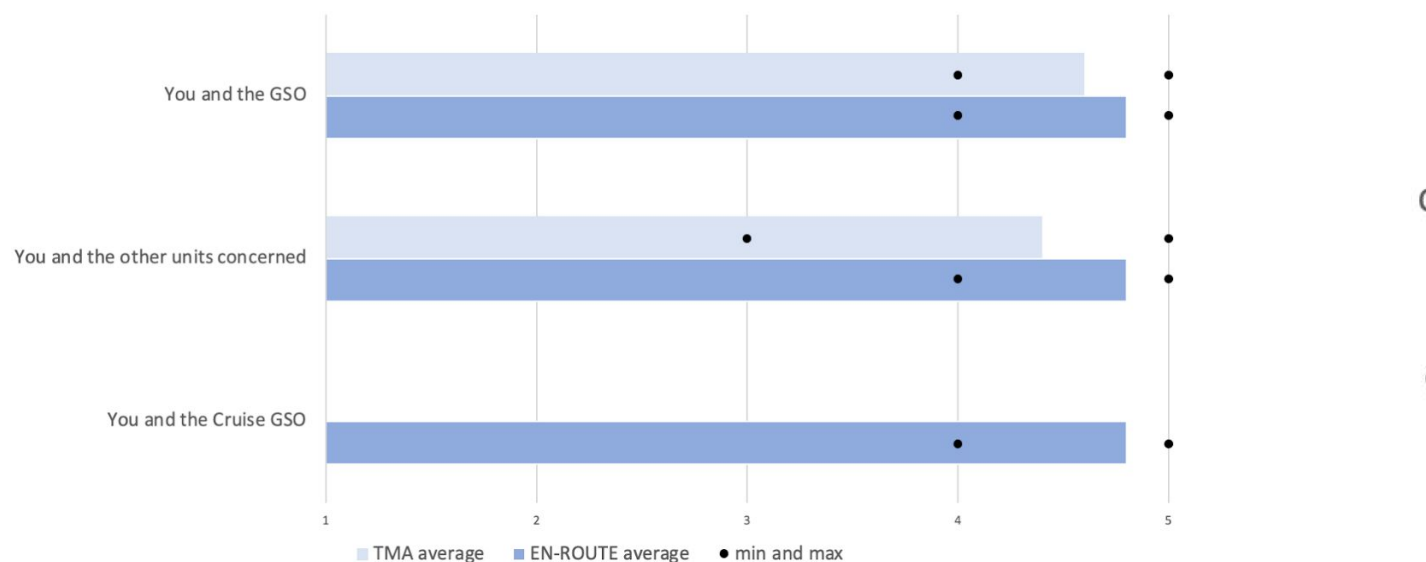


ATCO. You had all the information you needed to perform your tasks. Information provided by:

■ average   ● min and max
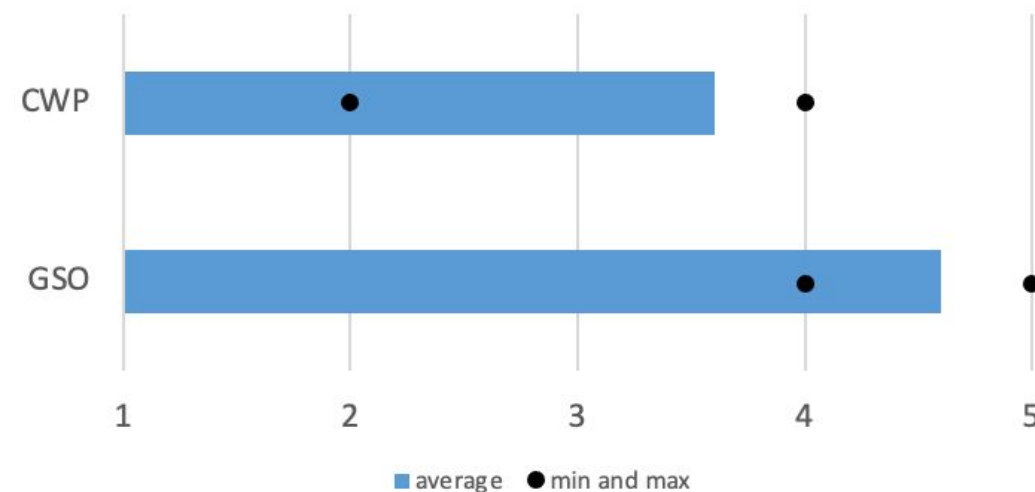


ATCO. Overall workload level

■ average   ● min and max
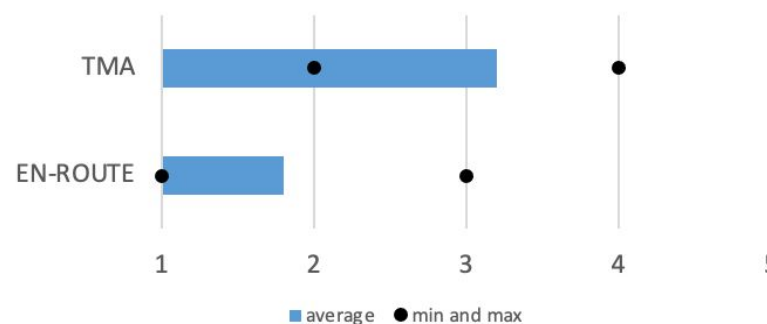
# SAFELAND RTS Results

## Additional Tools /improvements - CWP

- Different labels for SP aircraft
- Specific squawk indicating single pilot incapacitation
- System capable of automatically sending operational information (e.g., remaining fuel, number of people on-board) from the aircraft to the CWP.

# SAFELAND changes and challenges: pilots



1. New role
   On-board pilot ⟶ remote pilot (GSO)
   Two-pilot crew ⟶ single remote pilot

2. New environment
   Cockpit ⟶ Ground Station

3. New procedures

4. Assumptions (e.g., technology, no delay…)

# SAFELAND RTS Results

## Acceptability, operating methods, safety and trust - GSOs



GSO. Roles, responsibilities, operating methods, safety and trust.
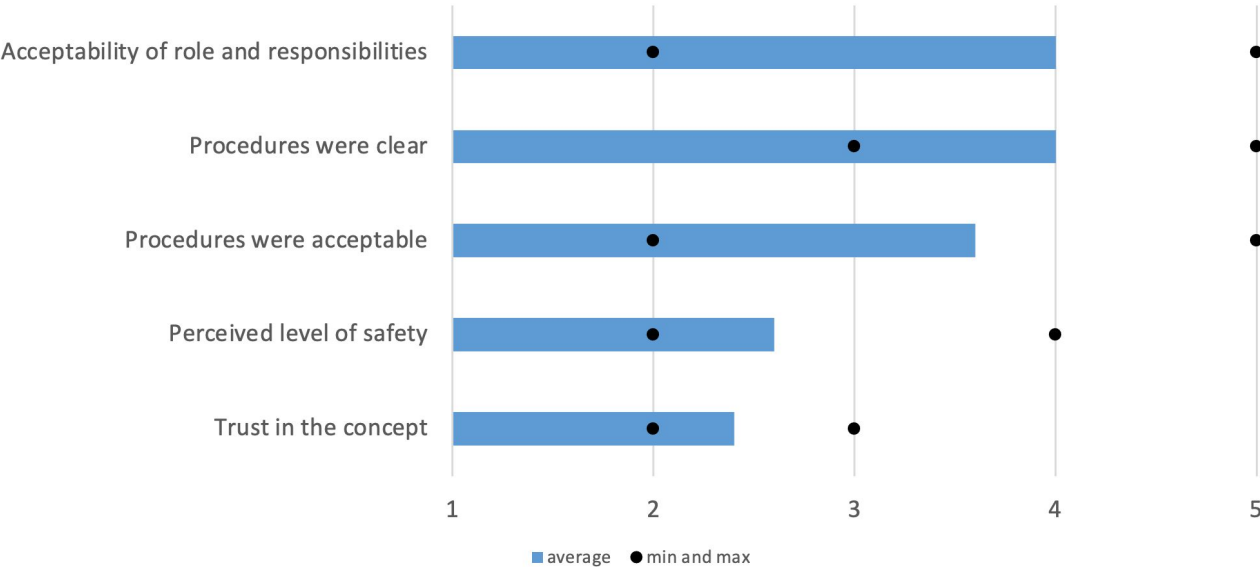
GSO. You were able to perform your tasks as in current operations
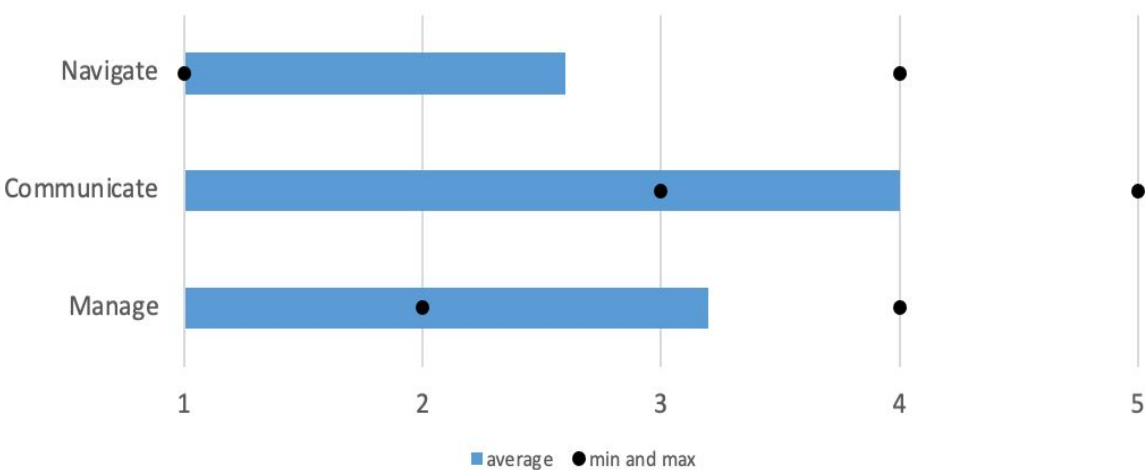
## Communication, workload, and situational awareness - GSOs
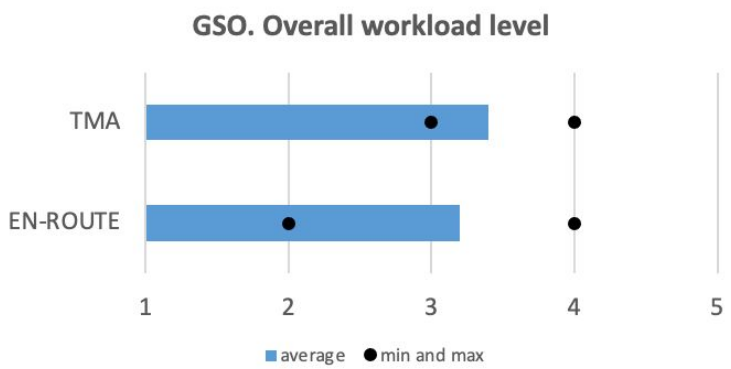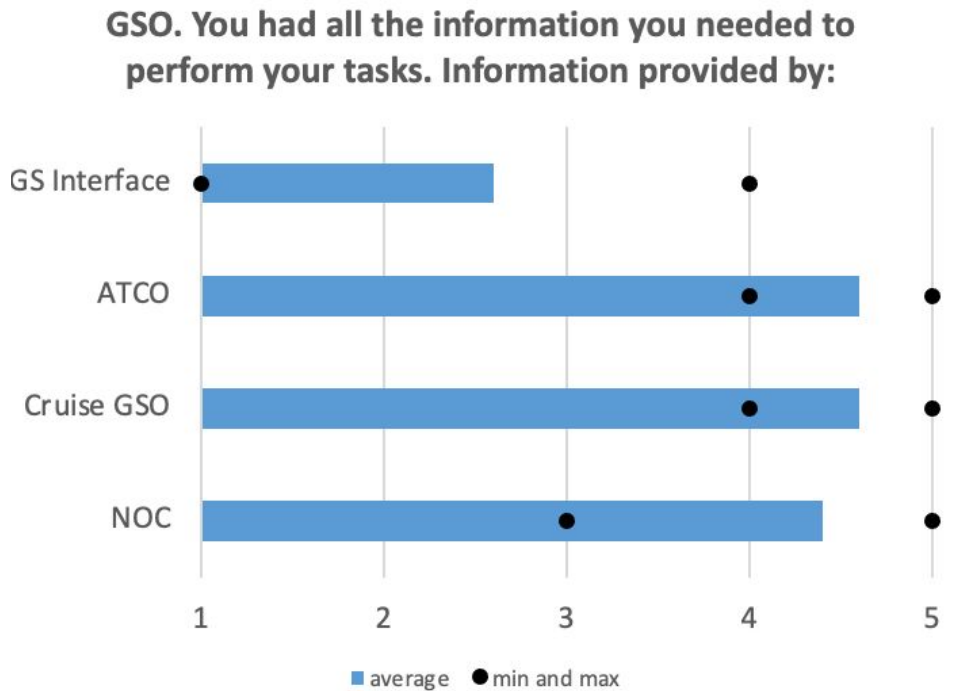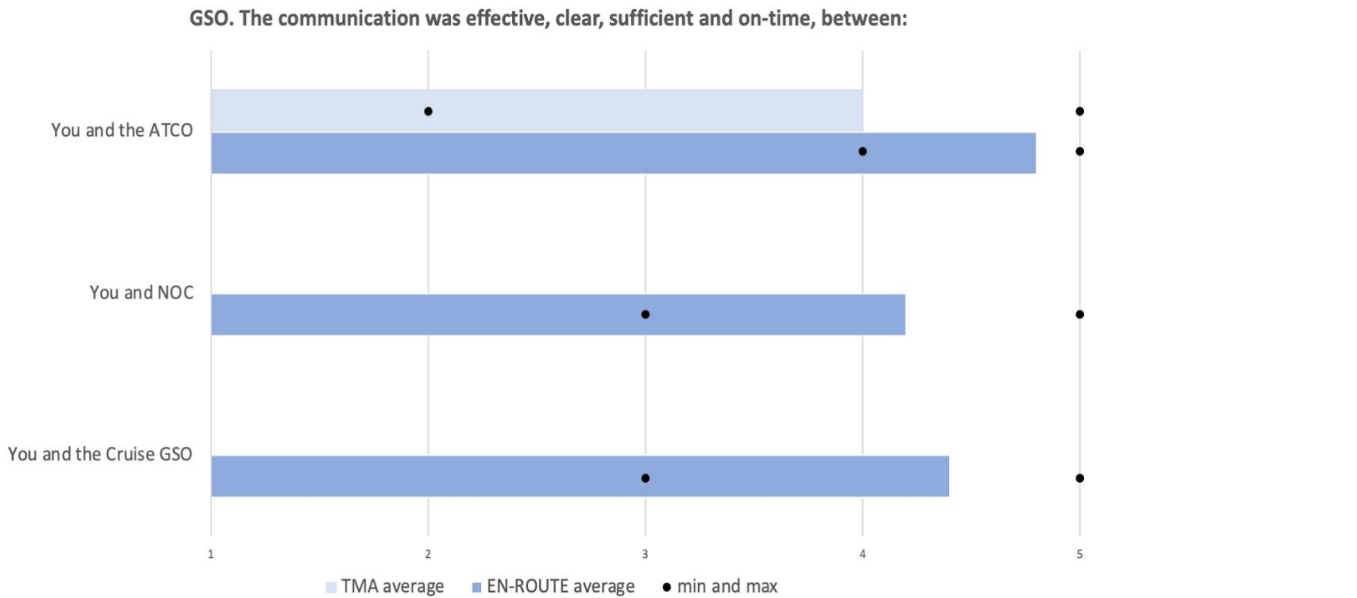


GSO. The communication was effective, clear, sufficient and on-time, between:

GSO. You had all the information you needed to perform your tasks. Information provided by:

GSO. Overall workload level

# SAFELAND RTS Results

**Main challenges - GSOs**

GS environment
Limitations imposed by design (no manual control)
Information displayed on the GS
Usability of the HMI

GSO role
Alone in handling the emergency

Safety and security issues (e.g., other possible
failures, cyber-intrusion)

Performance
Technical system and HMI
Situational awareness
Task allocation

# SAFELAND RTS Results

## Main challenges - GSOs

GS environment
Limitations imposed by design (no manual control)
Information displayed on the GS
Usability of the HMI

**GSO role**
Alone in handling the emergency

Safety and security issues (e.g., other possible
failures, cyber-intrusion)

→ Acceptability
→ Workload
→ Perceived safety

# SAFELAND RTS Results

## Main challenges - GSOs

GS environment
Limitations imposed by design (no manual control)
Information displayed on the GS
Usability of the HMI

GSO role
Alone in handling the emergency

Safety and security issues (e.g., other possible
failures, cyber-intrusion)

Perceived safety
Trust

# SAFELAND Key results

**ATCO** role, responsibilities and procedures did not change much

➤ very positive evaluation

**Pilots** faced many changes (in their role, environment, procedures) and challenges (SPO and related technologies not implemented yet).

➤ positive evaluation of operating procedures, dynamic of interactions between team members, coordination and communication flow

➤ however, feasibility acceptability and trust would depend on future technological implementations, and on reliability and redundancy of the systems in place.

# SAFELAND Next steps

Next research steps to build a framework around the SAFELAND concept, and make the concept itself more robust

- the development of a definitive **SPO CONOPS**;
- the key **technological enablers** (airborne, ground side and communication) needed to support SPO preserving the same safety levels of current operations;
- **integration** and validation of the different architectural and functional components in following maturity phases to uncover procedural gaps/ emerging system properties/ safety issues/ potential barriers.

# Open points of discussion:

## What should be the competences of a GSO?



Both pilot and ATCO participants agreed that, to ensure a **high level of safety**, the GSO knowledge, **skills and operational experience should be similar to those required for a pilot** + specific training to operate remotely from the GS + well trained monitoring skills.

# Open points of discussion:

## Pilot Health Monitoring system
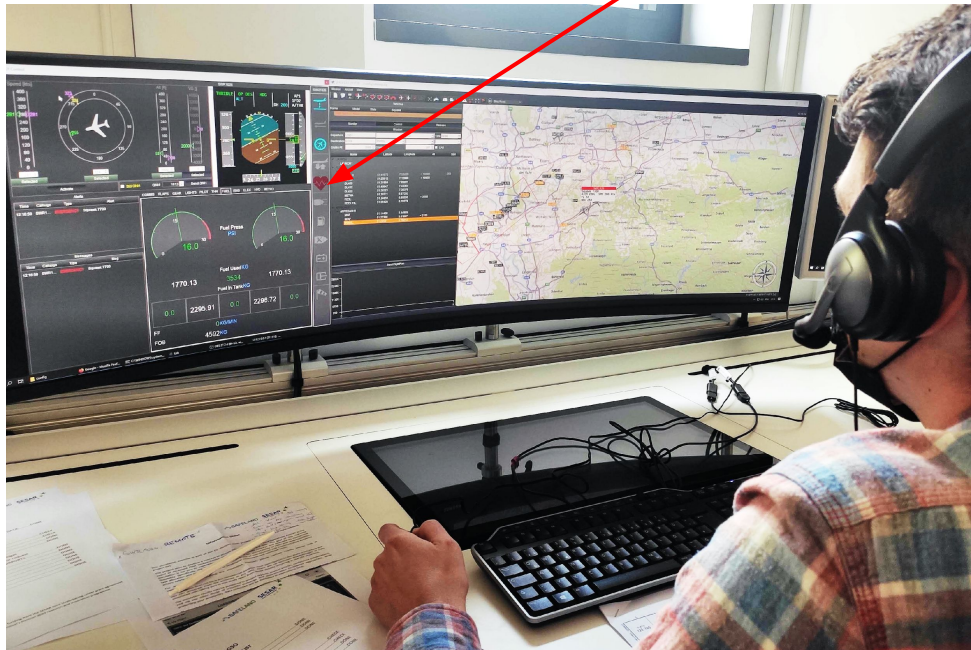


**Requirement**:
More information on on-board pilot health status

**Possible issues:**
System failure (Late/or no detection/false positives)
Subtle incapacitation

**Possible mitigations:**
Camera inside the cockpit
Shared audio environment
Precursors of incapacitation (WL, stress, fatigue) &
physio/neuro-physio measurements
Combination with rule-based behaviors and interaction
with cabin crew

# THANK YOU FOR YOUR ATTENTION

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# Open points of discussion:

**Ethical and legal (privacy) issues of the PHM system**
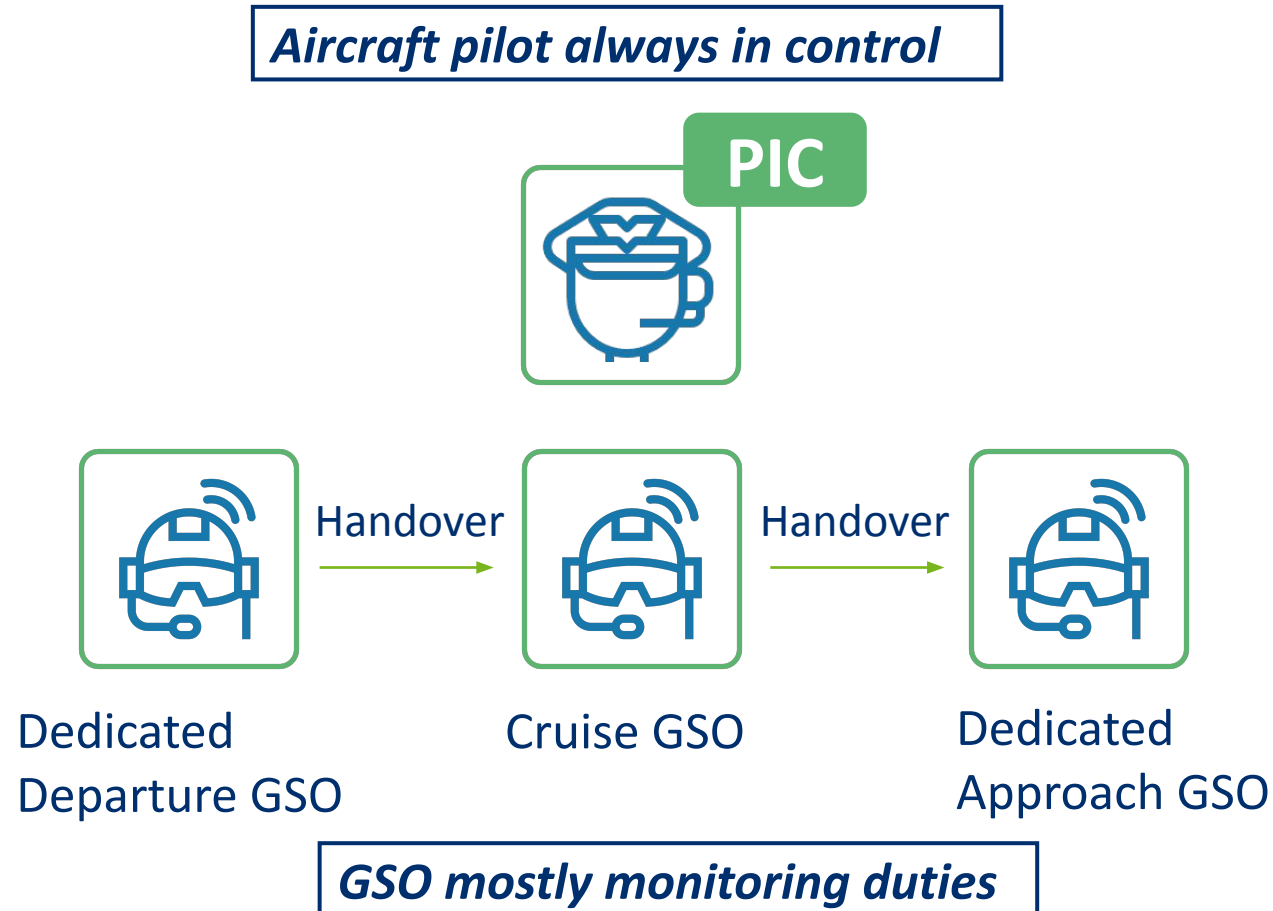


Would a system collecting and transferring pilots health data and performance be acceptable?

Would a camera inside the cockpit be acceptable?

# Nominal Operational Concept

**Simplified operational concept for SPO**



Aircraft pilot always in control

PIC

Dedicated Departure GSO — Handover → Cruise GSO — Handover → Dedicated Approach GSO

GSO mostly monitoring duties

# SAFELAND Next steps

Other open points are:

- Incapacitation detection (failure, false positive, partial incapacitation)
- Transition period from nominal SPO case (on-board pilot in control) and incapacitation confirmation
- Additional use cases (other system failures, latency communications)
- Role of the cabin crew
- Ground station (physical architecture, technical challenges, manpower & personnel, training needed, GS HMI)
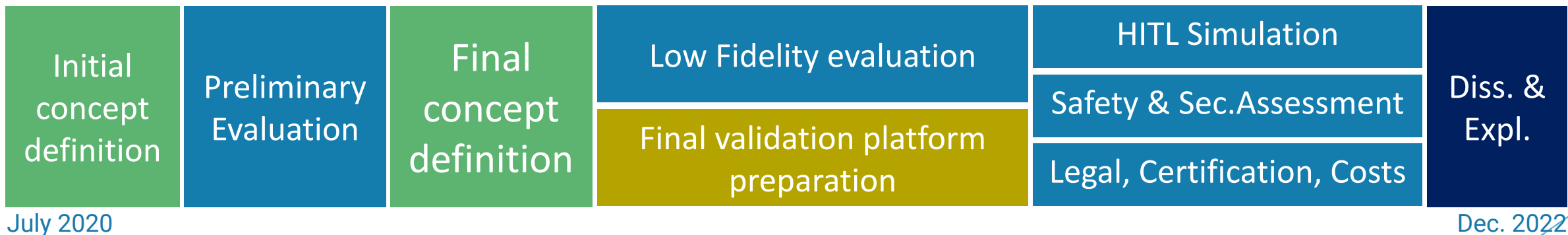- Social and ethical aspects (trust and confidence, acceptability)

# SAFELAND Overview

**The Topic** (Exploratory Research)

- Single pilot operations

**The SAFELAND Project contribution**

- Enhancing safety in case of single pilot incapacitation, until landing



| Initial concept definition | Preliminary Evaluation | Final concept definition | Low Fidelity evaluation | HITL Simulation | Diss. & Expl. |
| --- | --- | --- | --- | --- | --- |
| | | | | Safety & Sec.Assessment | |
| | | | Final validation platform preparation | Legal, Certification, Costs | |

July 2020                                                                                                      Dec. 2022

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