This project has received funding from the European Union's Horizon Europe Programme

EMCO SIPO EASA.2022.C17

D-1.2 REPORT ON BASELINE RISK FRAMEWORK FOR EMCOS

# eMCO-SiPO – Extended Minimum Crew Operations-Single Pilot Operations

An Agency of the European Union

**Disclaimer**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Union Aviation Safety Agency (EASA). Neither the European Union nor EASA can be held responsible for them.



| | |
|---|---|
| **DELIVERABLE NUMBER AND TITLE:** | D-1.2 Baseline Risk Assessment Framework |
| **CONTRACT NUMBER:** | EASA.2022.C17 |
| **CONTRACTOR / AUTHOR:** | NLR / A.L.C. Roelen |
| **IPR OWNER:** | European Union Aviation Safety Agency |
| **DISTRIBUTION:** | Restricted |

| APPROVED BY: | AUTHOR | REVIEWER | MANAGING DEPARTMENT |
|---|---|---|---|
| | A.L.C. Roelen | A.J.C. de reus | AOSH |

**DATE: 08.06.2023**

# SUMMARY

This document describes the framework for the generic risk assessment of the main changes induced by the eMCO operations while considering a series of changes to aircraft cockpit configuration identified for large CAT aircraft and including new flight management applications. This risk assessment framework will be used for the analysis of safety hazards linked to the application of the eMCO concept and the organisation of simulation exercises involving CAT pilots.

The overall strategy for the development of the risk assessment frame work is a comparative approach to align with EASA's position that the eMCO concept should have an equivalent level of safety as today's concept with two pilots operating the aircraft. This means that the analysis of safety hazards linked to the application of the eMCO concept is based on a comparison of the eMCO concept with today's two-pilot operations.

The risk assessment framework is scenario based. Scenarios are categorised according to four main flightcrew functions:

- Manage flight coordination
- Manage aircraft movement
- Manage flight path
- Manage contingencies

By assigning (conditional) probabilities to the initiating and pivotal events, the probability of each end state can be calculated. The probability in combination with the level of severity defines the level of risk of each end state. The (conditional) probabilities in the scenarios will be based on information from scientific literature and subsequently results from tasks 2 to 7. The final risk assessment will be published as a separate report.

# CONTENTS

# ABBREVIATIONS

| ACRONYM | DESCRIPTION |
|---|---|
| ACAS | Airborne Collision Avoidance System |
| ATC | Air Traffic control |
| CAT | Commercial Air Transport |
| CONOPS | Concept of Operations |
| EASA | European Union Aviation Safety Agency |
| eMCO | Extended Minimum Crew Operations |
| ESD | Event Sequence Diagram |
| NASA | National Aeronautics and Space Administration |
| NCO | Normal Crew Operations |
| NLR | Royal Netherlands Aerospace Centre |
| PF | Pilot Flying |
| PM | Pilot Monitoring |
| PR | Pilot Resting |
| SA | Situational Awareness |

# 1. Context

## 1.1 Background

Due to the ongoing developments in technology, automation and autonomous unmanned aircraft, there is an interest and desire to explore whether it is feasible to operate commercial air transport (CAT) with reduced flight crews in large aeroplanes. This feasibility is considered from both the safety as well as efficiency perspectives.

EASA was approached by aircraft manufacturers regarding the regulatory and safety aspects of such new concept of operations (CONOPs). Two specific CONOPs were identified:

- Extended Minimum-Crew Operations (eMCOs) are defined as operations where the flight time is extended by means of rest in flight with the minimum flight crew. It is achieved by allowing operations with one pilot at the controls, during the cruise flight phase; however, offering an equivalent overall level of safety through compensation means (e.g. ground assistance, advanced cockpit design with workload alleviation means, pilot incapacitation detection, etc.). It is, in particular, relevant to large aeroplanes operated in CAT operations, for which no fewer than two flight crew members are currently required as per the Air Operations Regulation.
- Single-Pilot Operations (SiPOs) are defined as end-to-end single-pilot operations. Annex III (PART-ORO) 'Organisation requirements for air operations' to the Air Operations Regulation already foresees conditions and limitations under which these types of operations are allowed. In the future, it is expected that these conditions and limitations will need to evolve in order to extend single-pilot operations to large aeroplanes, provided that compensation means (e.g. ground assistance, advanced cockpit design with workload alleviation means, capability to cope with pilot incapacitation, etc.) are in place in order to provide for an overall level of safety equivalent to today's two-pilot operations..

## 1.2 Scope of the document

The scope of the document encompasses the framework for the generic risk assessment of the main changes induced by the eMCO operations while considering a series of changes to aircraft cockpit configuration identified for large CAT aircraft and including new flight management applications.

## 1.3 eMCO concept of operation

The eMCO concept of operation has been developed on the following basic principles:

- eMCO is operated only on aircraft certified as capable for eMCO i.e. offering specific design features to simplify the pilot tasks and reduce workload, mitigate the risk of error, enhance the aircraft resilience in abnormal events, assist the pilot with more automation to manage aircraft failure and detect incapacipation.
- One pilot (called "Pilot Flying") manages all or parts of the cruise phase alone in the cockpit.
- Recovery to conventional 2-crew operations is possible at any time (except in case of pilot incapacitation).
- Execution of the eMCO flight is supported by a specific route study, flight preparation, crew scheduling and flight dispatch focusing on specific eMCO means and needs.
- eMCO can be integrated in the current ATM environment and procedures.
- The same pool of pilots can operate conventional MCO and eMCO flights on a given aircraft.
- eMCO is compatible with the same pool of pilots operating on more than one aircraft type and/or variant.

Flight crew will be required to perform a dedicated briefing at each EMCO transition. Transition to eMCO is only allowed if the automatic flight control system is engaged and there are no failures that would require abort of the eMCO segment.

It is anticipated that for particular flight segments, such as flight over high mountains, eMCO will not be allowed.

# 2. Objective

The objective is to develop the baseline risk-assessment framework. This risk assessment framework will be used for:

- the analysis of safety hazards linked to the application of the eMCO concept
- the organisation of simulation exercises involving CAT pilots.

# 3. Approach

The overall strategy for the development of the risk assessment frame work is a comparative approach. This means that the analysis of safety hazards linked to the application of the eMCO concept is based on a comparison of the eMCO concept with today's two-pilot operations.

The risk assessment framework is scenario based. The scenarios describe event sequences, starting with an initiating event and ending with an end state. Initiating events are perturbations that require some kind of response from operators or pilots or one or more systems. Pivotal events between the initiating event and the end state are identified as either occurring or not occurring and determine the course of the scenario. Criteria for choosing the initiating events are:

- They require active involvement (decisions and actions) of the flight crew.
- After that point the demand on a number of known designed barriers or recovery measures (like trained responses) can be described, leading to different event pathways and different outcomes.

Pivotal events are those events that could change the outcome. A flight is regarded as operating within a safe envelope, where pivotal events either push the operation outward towards the boundaries or back inside that safe envelope. All pivotal events following the initiating event in the scenario are conditional to the initial event. The end state of the scenarios capture 'failures', i.e. situations in which the situation has not returned to normal, as well as 'successes', i.e. cases where the situation has returned to normal.

The scenarios are depicted as event sequence diagrams (ESDs).

By assigning (conditional) probabilities to the initiating and pivotal events, the probability of each end state can be calculated. The probability in combination with the level of severity defines the level of risk of each end state. The (conditional) probabilities in the scenarios will be based on information from scientific literature and subsequently results from tasks 2 to 7.

End states will be classified according to the severity of their effects as follows (similar to the severity classification of the acceptable means of compliance for CS.25.1309):

- No Safety Effect: End states that would have no effect on safety; for example, end states conditions that would not affect the operational capability of the aeroplane or increase crew workload.
- Minor: End states which would not significantly reduce aeroplane safety, and which involve crew actions that are well within their capabilities. This may include, for example, a slight reduction in safety margins or functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some physical discomfort to passengers or cabin crew.
- Major: End states which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew workload or in conditions impairing crew efficiency, or discomfort to the flight crew, or physical distress to passengers or cabin crew, possibly including injuries.
- Hazardous: End states, which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating, conditions to the extent that there would be:
    - A large reduction in safety margins or functional capabilities;
    - Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or
    - Serious or fatal injury to a relatively small number of the occupants other than the flight crew.
- Catastrophic: End states, which would result in multiple fatalities, usually with the loss of the aeroplane.

The final risk assessment will be published as a separate report.

# 4. Scenario development

The scenarios are restricted to the cruise segment of a flight since eMCO will be restricted to cruise flight. Scenarios are categorised according to main flightcrew functions. Four primary flight crew function categories were derived from a functional decomposition of the commercial flight domain that was conducted by NASA [McGuire et al, 1991]:

- Manage flight coordination
- Manage aircraft movement
- Manage flight path
- Manage contingencies

Manage flight coordination concerns the exchange of information and coordination of the activities of the flightcrew between themselves, between the flightcrew and the cabin crew and between the flightcrew and external parties.

Manage aircraft movement concerns control of the aircraft's flight parameters in case of momentary deviations or upsets.

Manage flight path concerns strategic enduring deviations from planned airspeed, altitude or heading, including deviations that are required to avoid areas with unfavourable flight conditions.

Manage contingencies concerns the acute management of abnormal and emergency conditions that may occur.

Each primary flight crew function category includes several distinctive scenarios that are based on the combination of scientific literature, aircraft operating manuals and information from commercial pilots. The scenarios are listed in table 1.

*Table 1: List of scenarios*

| |
|---|
| **Manage flight coordination** |
| Planned transition from NCO to eMCO |
| Planned transition from eMCO to NCO |
| Unplanned transition from eMCO to NCO |
| Event or circumstance requiring communication with ATC |
| Event or circumstance requiring communication with maintenance / dispatch |
| Event or circumstance requiring communication with cabin |
| |
| **Manage aircraft movement** |
| Deviation from target airspeed |
| Deviation from target heading |
| Deviation from target altitude |
| Deviation from target attitude |
| |
| **Manage flight path** |
| Strategic deviation from airspeed/altitude/heading |
| Hazardous weather on flightpath |
| Restricted airspace on flight path |
| Other aircraft on flight path |
| |
| **Manage contingencies** |
| Fire / smoke in cabin |
| Cabin crew medical emergency |
| Passenger medical emergency |
| Pilot incapacitation |
| System malfunction |
| Cabin depressurization |
| Fuel leak |
| Turbulence encounter |
| Encounter with adverse flight conditions |
| Engine failure |
| Security threat |
| Unreliable air data |

Graphical representations of all scenarios are presented in Appendix A.

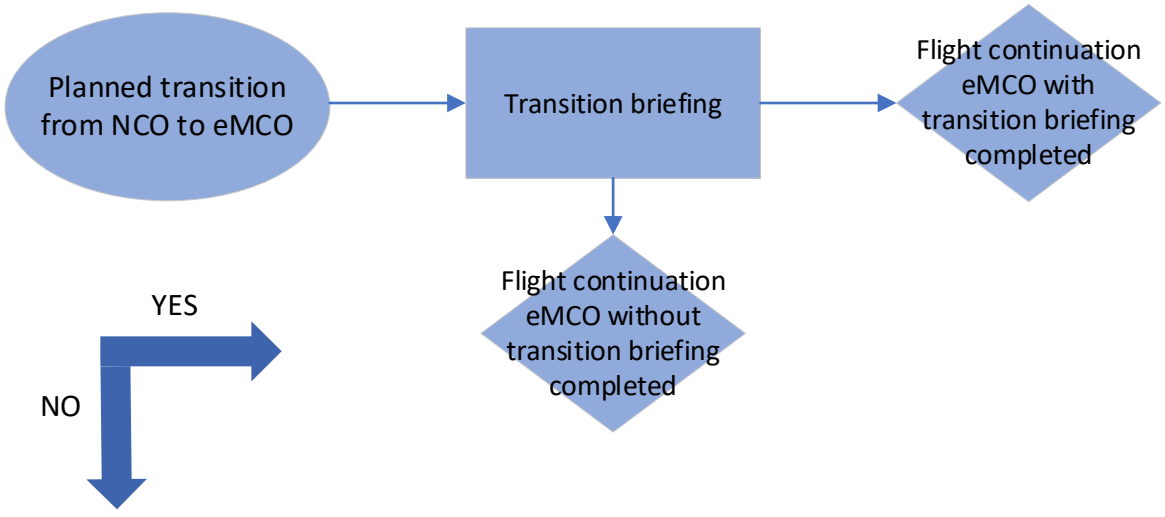
# 5. Scenarios for eMCO risk assessment framework

Tasks for each member of the flight crew are described for each pivotal event of each scenarios. The task descriptions are given for the eMCO concept of operations as well as for normal crew operations (NCO). NCO flight crew tasks include tasks for the pilot flying (PF) and pilot monitoring (PM). eMCO flight crew tasks include tasks for the pilot flying and the pilot resting (PR). Additional to the flight crew tasks, the functions that the aircraft must provide in support of the flight crew tasks are also described.

## 5.1 Manage flight coordination

### 5.1.1 Planned transition from NCO to eMCO

A planned transition from normal cruise operations to eMCO can only take place if the prerequisites for eMCO are met. This means that the automatic flight control system is engaged and there are no failures that would require abort of the eMCO segment (see section 1.3). The transition from NCO to eMCO is achieved by a dedicated briefing that includes a review of the aircraft status, a review of the projected flight during eMCO, a review of abnormal procedures during eMCO and a review of the expected aircraft and flight status at the end of the eMCO segment.



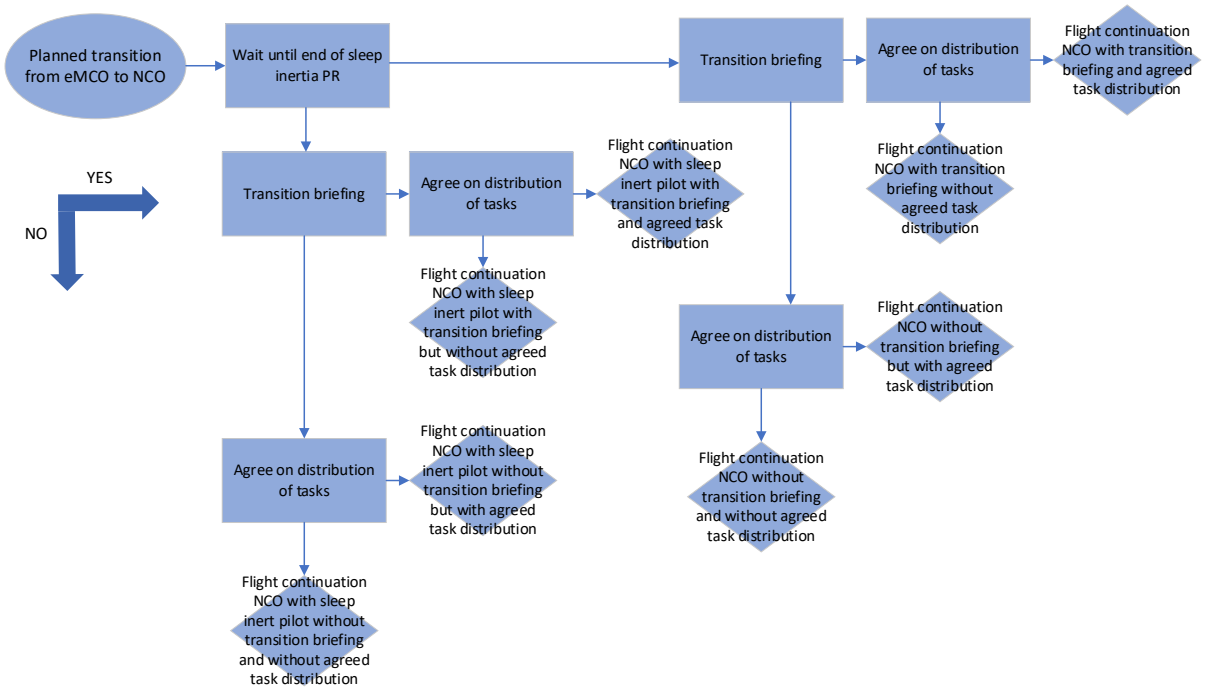

Transition briefing

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Review of current aircraft and flight status with PR | Review of current aircraft and flight status with PF | Support review of current status |
| | | | Review of projected flight during eMCO phase with PR | Review of projected flight during eMCO phase with PF | Support review of project flight during eMCO phase |

| | | | | | |
|---|---|---|---|---|---|
| | | | Review of abnormal procedures during eMCO phase with PR | Review of abnormal procedures during eMCO phase with PF | Support review of abnormal procedures during eMCO phase |
| | | | Review of expected aircraft and flight status at end of eMCO phase with PR | Review of expected aircfraft and flight status at end of eMCO phase with PF | Support review of expected status at end of eMCO phase |

### 5.1.2 Planned transition from eMCO to NCO

A planned transition from eMCO to NCO requires a transition briefing to allow resynchronisation of the pilot resuming flight related activities with the mission and flight status. It is assumed that the transition briefing can only take place if the sleep inertia of the pilot resuming flight activities has ended. The briefing includes a review of the aircraft and flight status and an report of activities and action that occurred during the eMCO segment. After the briefing the pilots make agreements on task sharing during the next segment (which may also be an eMCO segment).




Wait until end of sleep inertia PR

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Perform flight duties | Wait until end of sleep inertia. | |

Transition briefing

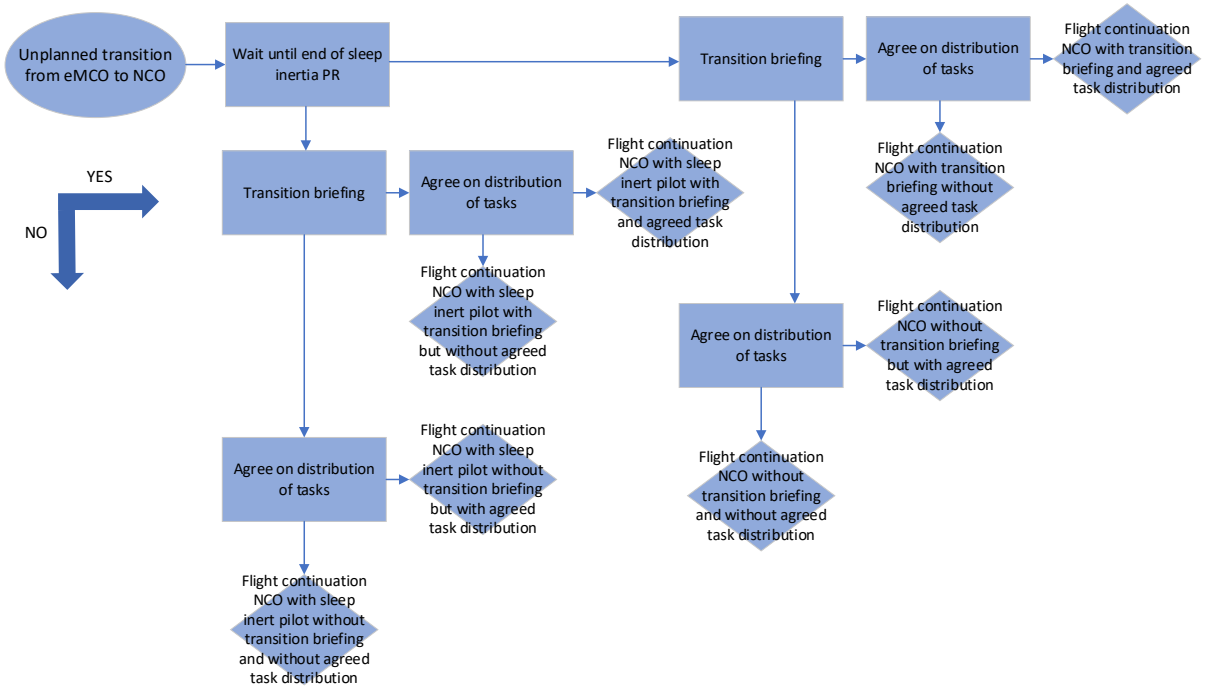
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |

Agree on distribution of task

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

### 5.1.3 Unplanned transition from eMCO to NCO

In case the essential conditions for eMCO are violated, an unplanned transition from eMCO to NCO is required. The steps to be performed are similar to the steps of a planned transition from eMCO to NCO, but depending on the level of urgency of the situation, some steps may be cut short or surpassed. Emergencies that require immediate activity of the pilot at rest (fire in the cockpit and pilot incapacitation) are described as separate scenario (see section manage contingencies).




Alert PR and wait until end of sleep inertia PR

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | | | Alert PR | | Support PR alert |
| Not applicable | Not applicable | Not applicable | Perform flight duties | Wait until end of sleep inertia | |

Transition briefing

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal | | Support briefing of location dependent |

| | | | | | |
|---|---|---|---|---|---|
| | | | procedures to PR | | abnormal procedures |

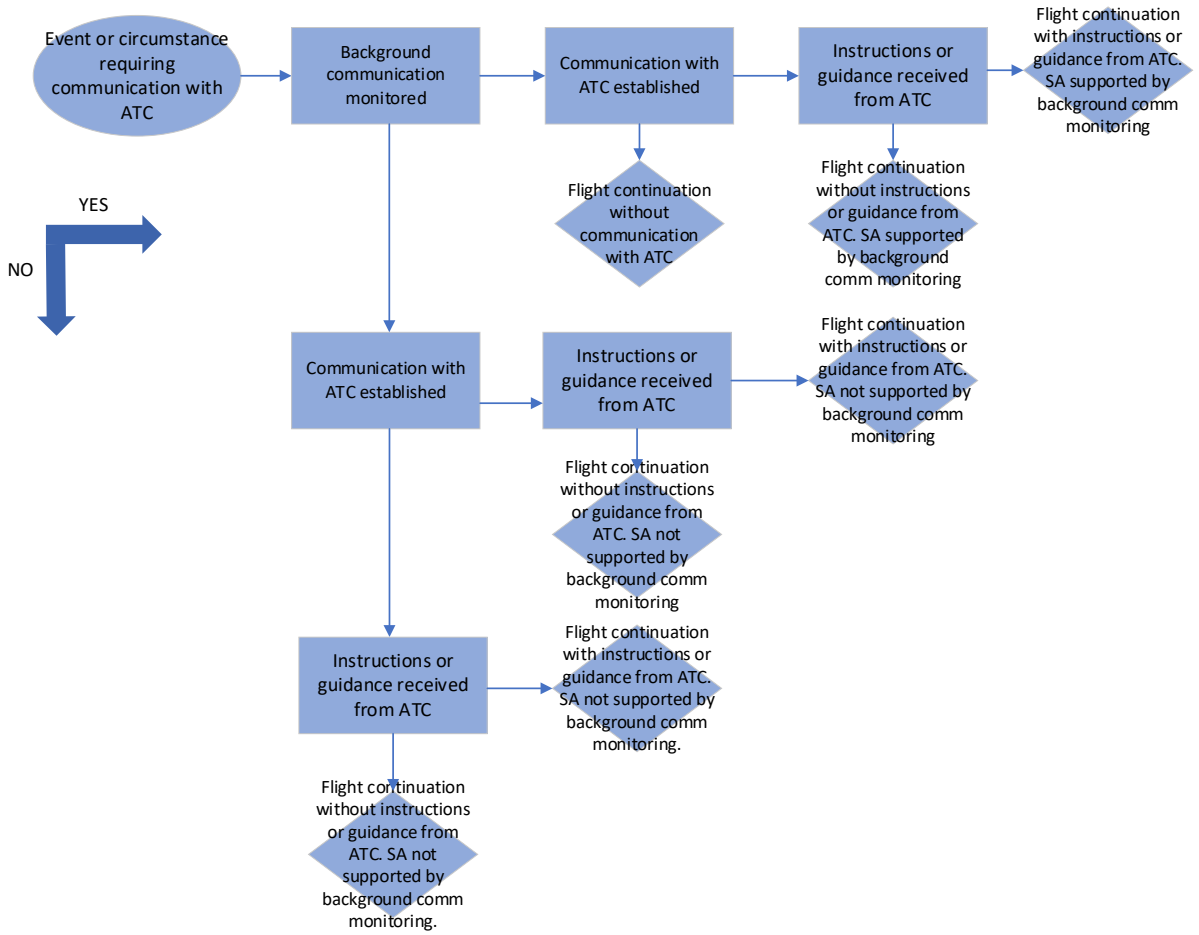
Agree on distribution of task

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

### 5.1.4 Event or circumstance requiring communication with ATC

During the eMCO segment there may be numerous communications between the flight and Air Traffic Control. It is envisioned that these communications are done by radio and datalink (CPDLC). It is also expected that the pilot flying will monitor 'background' communication on various radio frequencies (ATC, interpilot and emergency) in order to maintain situational awareness.

The communication with ATC might include instructions or guidance from ATC to the flight. If these manageable by one pilot (as determined by predefined conditions) the eMCO segment can continue, otherwise abortion of the eMCO segment is required.




Background communication monitored (ATC frequency, interpilot and emergency frequency)

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Monitor background communication (ATC frequency, interpilot and emergency frequency) | Monitor background communication (ATC frequency, interpilot and emergency frequency) | | Monitor background communication (ATC frequency, interpilot and emergency frequency) | | |

Communication with ATC established

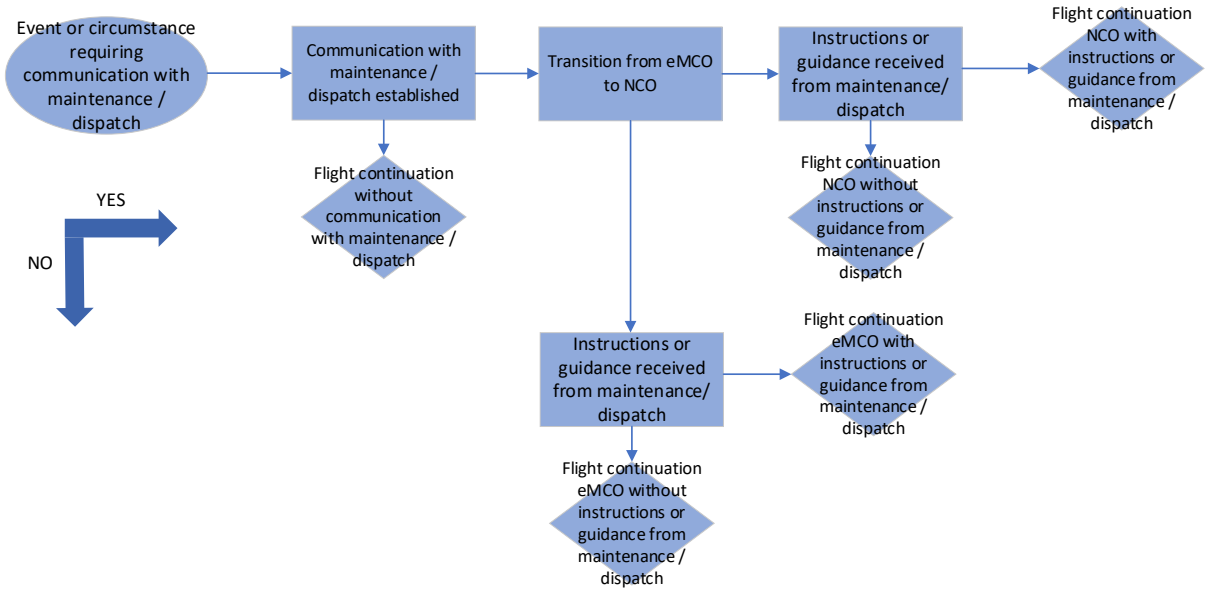
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Cross check establishment of communicating with ATC | Establish communication with ATC | Support establishment of communication with ATC | Establish communication with ATC | | Support establishment of communication with ATC |

Instructions or guidance received from ATC

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Cross check noting of instructions or guidance received from ATC | Note restrictions or guidance received from ATC | Support noting of instructions or guidance received from ATC | Note instructions or guidance received from ATC | | Support noting of instructions or guidance received from ATC |

### 5.1.5 Event or circumstance requiring communication with maintenance / dispatch

During the eMCO segment there may be a need for the flight to contact maintenance or dispatch, for instance for flight planning purposes or for issues related to flight handling at the destination airport. It is envisioned that these communications are done by radio and datalink (e.g. ACARS). The communication with maintenance or dispatch might include instructions or guidance to the flight. If these are manageable by one pilot (as determined by predefined conditions) the eMCO segment can continue, otherwise abortion of the eMCO segment is required.




Communication with maintenance / dispatch established

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Cross check establishment of communicating with maintenance / dispatch | Establish communication with maintenance / dispatch | Support establishment of communication with maintenance / dispatch | Establish communication with maintenance / dispatch | | Support establishment of communication with maintenance / dispatch |

Transition from eMCO to NCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |

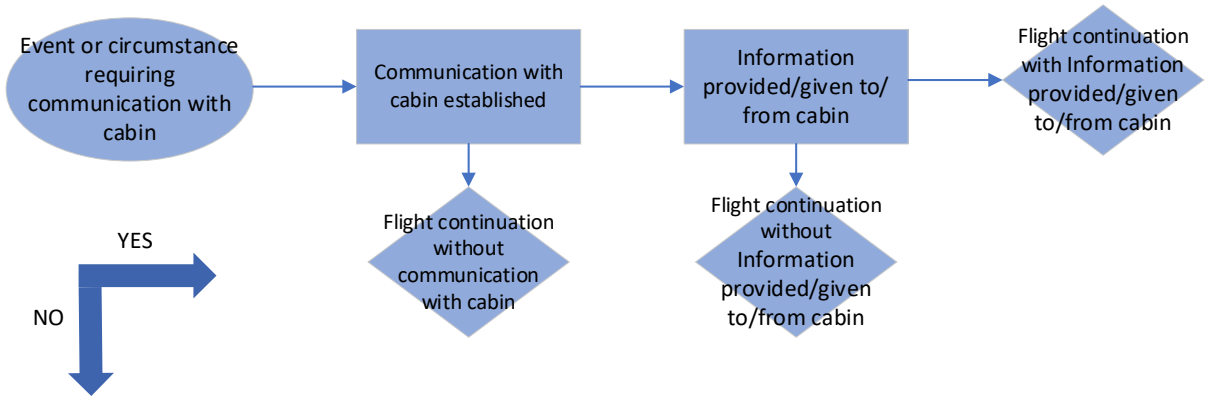
| | | | | | |
|---|---|---|---|---|---|
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

Instructions or guidance received from maintenance / dispatch

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Fly the aircraft | Communication with maintenance / dispatch | | Fly the aircaft | | |
| | | | Communication with maintenance / dispatch | | |
| | Note instructions or guidance received from maintenance / dispatch | Support noting of instructions or guidance received from maintenance / dispatch | Note instructions or guidance received from maintenance / dispatch | | Support noting of instructions or guidance received from maintenance / dispatch |

### 5.1.6 Event or circumstance requiring communication with cabin

During the eMCO segment there may be a need for the pilot flying to contact the cabin crew or vice versa. These communications can be done by interphone, but it is also possible that a member of the cabin crew enters the cockpit.




Communication with cabin established

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Fly the aircraft | Establish communication with cabin | Support establishment of communication with cabin | Fly the aircraft. Establish communication with cabin | | Support establishment of communication with cabin |

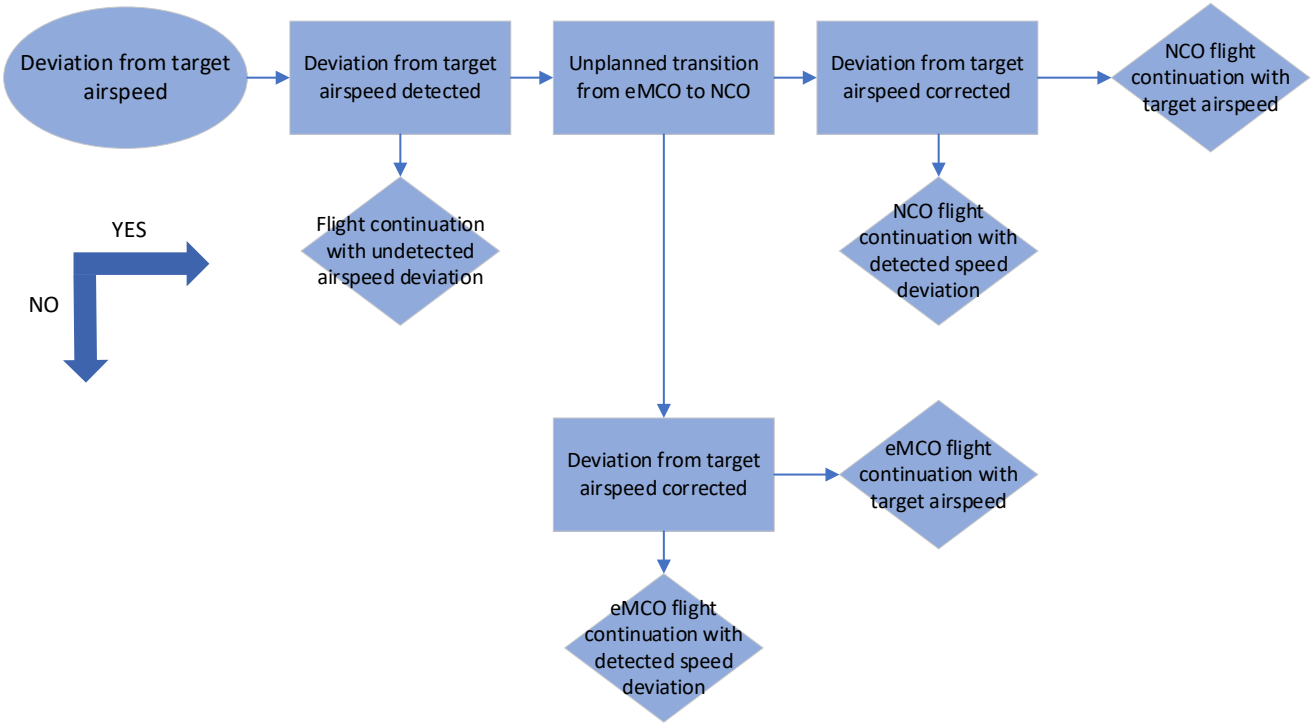
Information provided / given to/from cabin

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Cross check noting of information provided / given to/from cabin | Note information provided / given to/from cabin | Support noting of information provided / given to/from cabin | Note information provided / given to/from cabin | | Support noting of information provided / given to/from cabin |

## 5.2 Manage aircraft movement

It is assumed that the automatic flight control system (auto pilot and auto throttle) must be engaged during eMCO. Auto pilot / auto throttle disconnect will result in abort of the eMCO segment. It is expected that the eMCO segment is aborted and the pilot resting will be automatically alerted in case of aircraft speed out of the usual cruise range, abnormal aircraft attitude and altitude lower than the pre-set eMCO floor flight level.

### 5.2.1 Deviation from target airspeed




Deviation from target airspeed detected

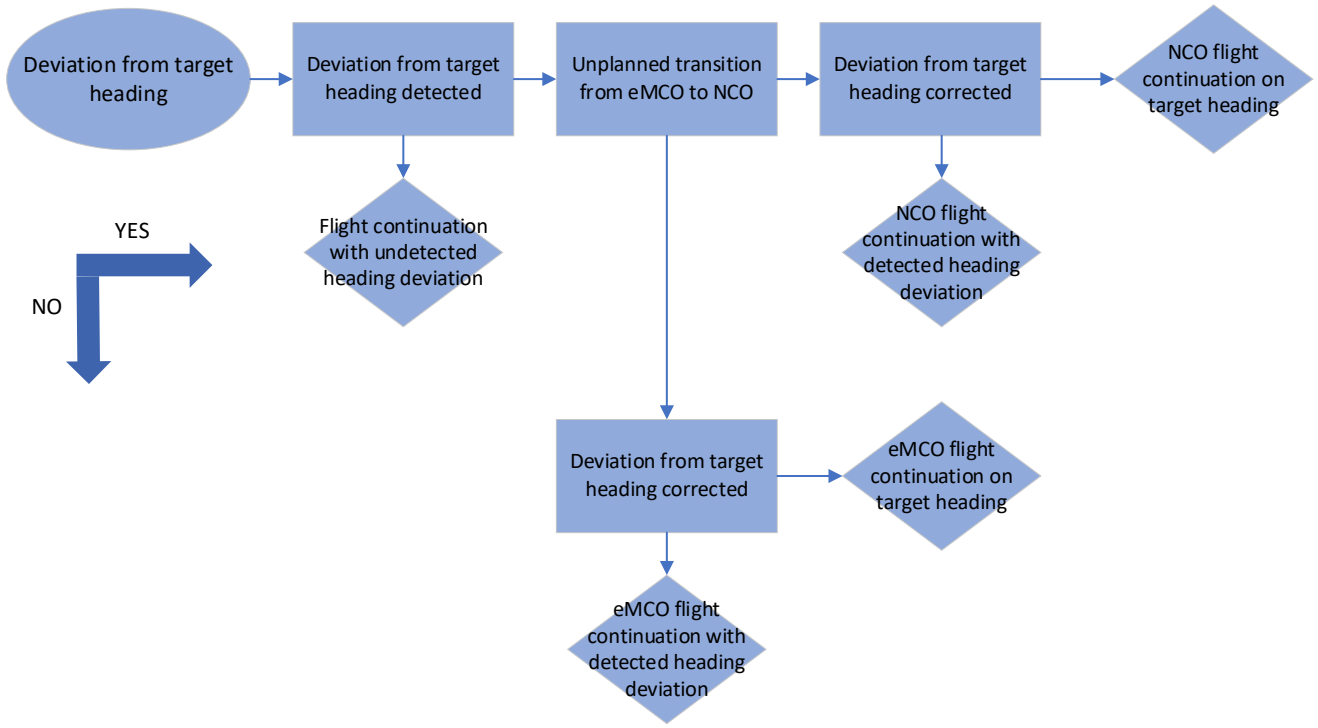
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect deviation from target airspeed | Detect deviation from target airspeed | Support detection from target airspeed | Detect deviation from target airspeed | | Support detection from target airspeed |

Unplanned transition from eMCO to NCO
See section 5.1.3

Deviation from target airspeed currected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Adjust airspeed | Cross check airspeed adjustment | Support flight crew in airspeed adjustment | Adjust airspeed | | Support flight crew in airspeed adjustment |

### 5.2.2 Deviation from target heading




Deviation from target heading detected

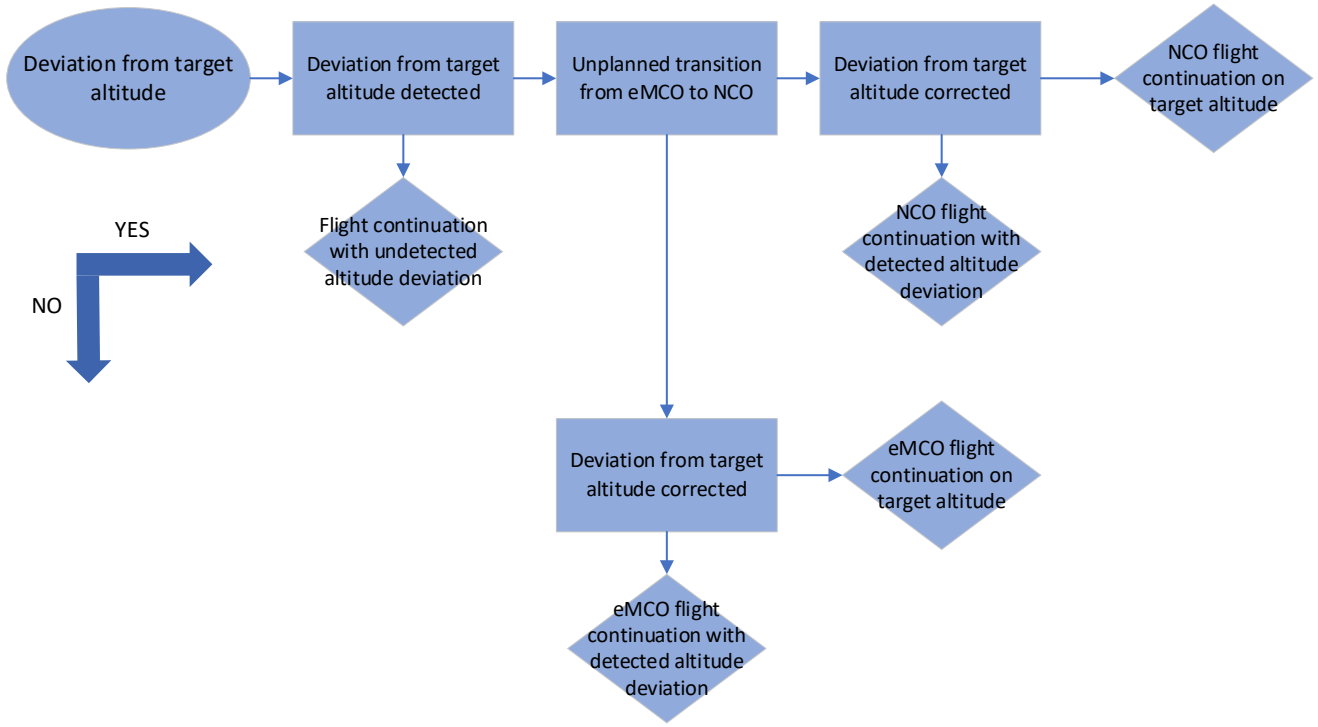
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect deviation from target heading | Detect deviation from target heading | Support detection from target heading | Detect deviation from target heading | | Support detection from target heading |

Unplanned transition from eMCO to NCO
See section 5.1.3

Deviation from target heading corrected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Adjust heading | Cross check heading adjustment | Support flight crew in heading adjustment | Adjust heading | | Support flight crew in heading adjustment |

### 5.2.3 Deviation from target altitude




Deviation from target altitude detected

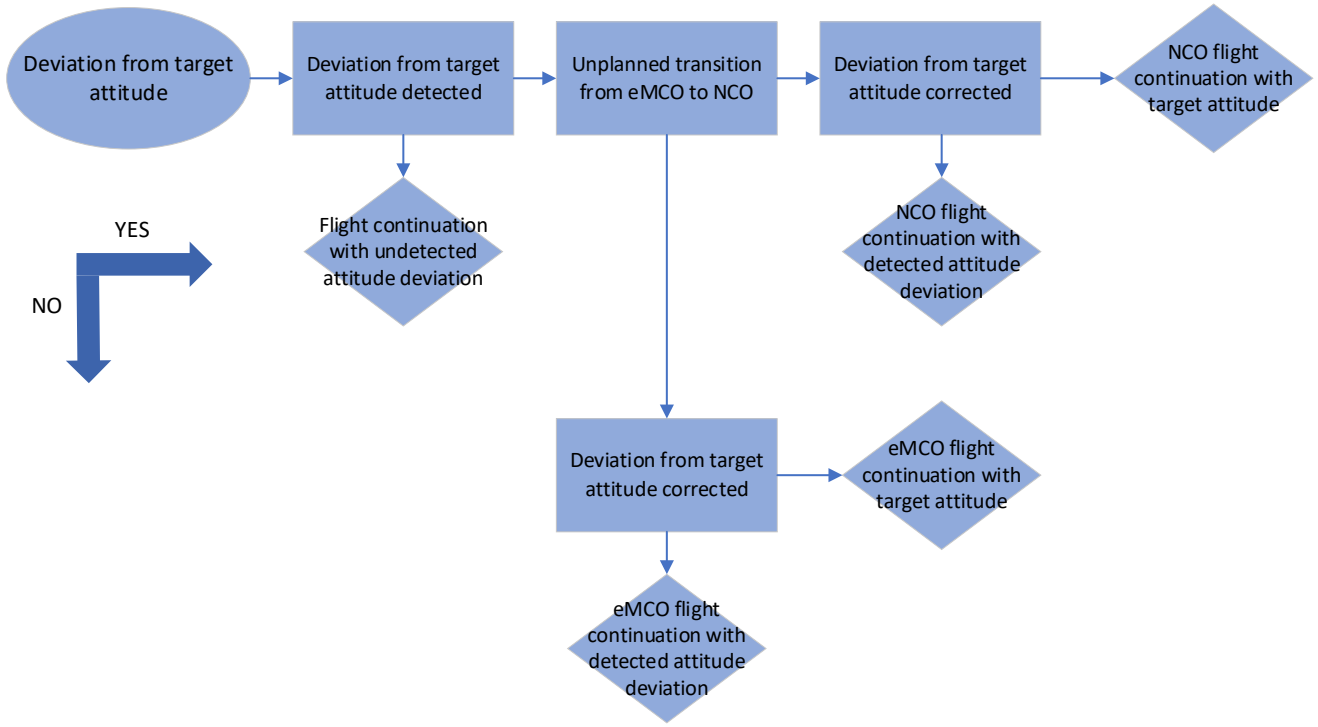
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect deviation from target altitude | Detect deviation from target altitude | Support detection from target altitude | Detect deviation from target altitude | | Support detection from target altitude |

Unplanned transition from eMCO to NCO
See section 5.1.3

Deviation from target altitude corrected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Adjust altitude | Cross check altitude adjustment | Support flight crew in altitude adjustment | Adjust altitude | | Support flight crew in altitude adjustment |

### 5.2.4 Deviation from target attitude




Deviation from target attitude detected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect deviation from target attitude | Detect deviation from target attitude | Support detection from target attitude | Detect deviation from target attitude | | Support detection from target attitude |

Unplanned transition from eMCO to NCO
See section 5.1.3

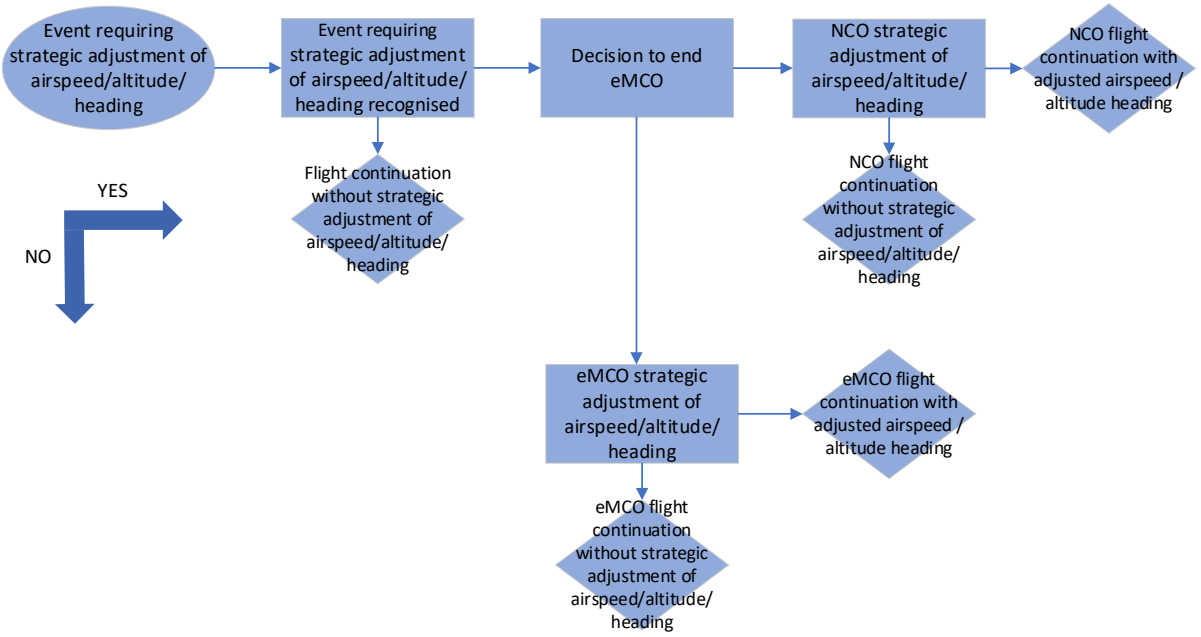
Deviation from target attitude adjusted

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Adjust attitude | Cross check attitude adjustment | Support flight crew in attitude adjustment | Adjust attitude | | Support flight crew in attitude adjustment |

## 5.3 Manage flight path

### 5.3.1 Strategic deviation from airspeed/altitude/heading

It is assumed that the automatic flight control system (auto pilot and auto throttle) must be engaged during eMCO. Auto pilot / auto throttle disconnect will result in abort of the eMCO segment. Strategic adjustments of airspeed, altitude and flight level may be required during cruise flight. Many of these adjustments are considered routine. Others might have been anticipated before the start of the eMCO segment resulting in a commonly agreed decision than only needs to be executed by the pilot flying. More complex or unanticipated situations might require substantial decision making and could require abort of the eMCO segment.




Event requiring strategic adjustment of airspeed/altitude/heading

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Recognise need to adjust airspeed, altitude or heading | Recognise need to adjust airspeed, altitude or heading | Support recognition of need to adjust airspeed, altitude or heading | Recognise need to adjust airspeed, altitude or heading | | Support recognition of need to adjust airspeed, altitude or heading |

Decision to end eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | | | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

NCO strategic adjustment of airspeed/altitude/heading

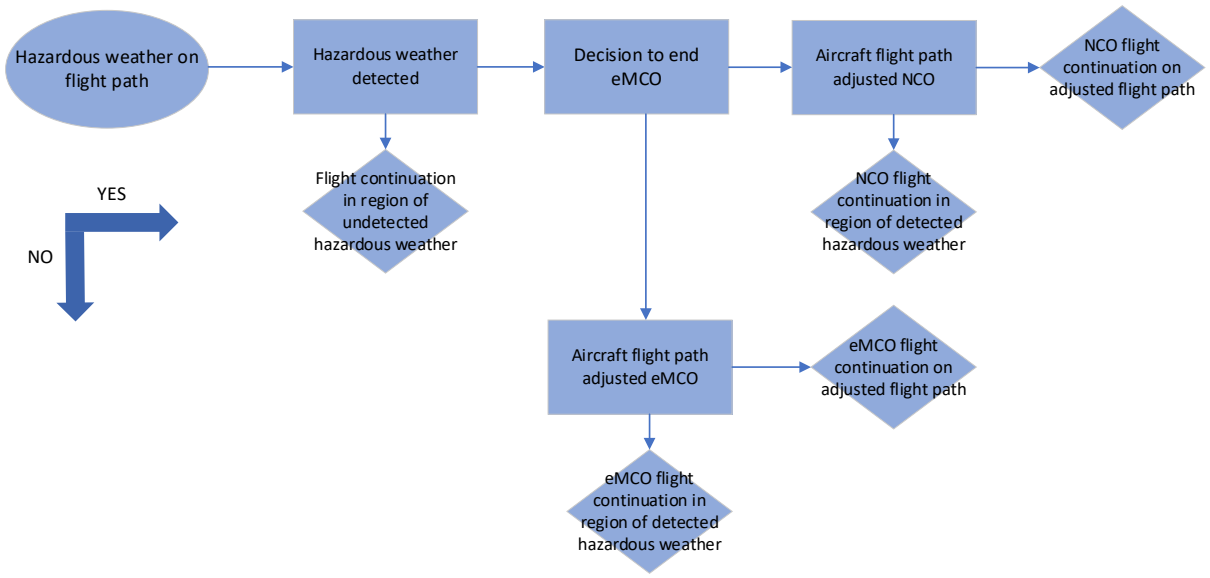
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Adjust airspeed, altitude or heading | Cross check adjustment of airspeed, altitude or heading | Support adjustment of airspeed, altitude or heading | Not applicable | Not applicable | Not applicable |

eMCO strategic adjustment of airspeed/altitude/heading

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Adjust airspeed, altitude or heading | | Support adjustment of airspeed, altitude or heading |

### 5.3.2 Hazardous weather on flightpath

Hazardous weather (e.g. thunderstorms) might require avoidance action by adjustment of the flightpath. Information on hazardous weather may be obtained from on-board systems (weather radar) but may also be given by ATC or weather information service providers. If the adjustment is considered routine or has been anticipated before the start of the eMCO segment resulting in a commonly agreed decision that only needs to be executed by the pilot flying, the adjustment can be performed under eMCO. More complex or unanticipated situations might require substantial decision making and could require abort of the eMCO segment.




Hazardous weather detected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect hazardous weather and alert PM | Detect hazardous weather and alert PF | Detect hazardous weather and alert flight crew | Detect hazardous weather malfunction | | Detect hazardous weather and alert flight crew |

Decision to end eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent | | Support briefing of location |

| | | | | | |
|---|---|---|---|---|---|
| | | | abnormal procedures to PR | | dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

Aircraft flightpath adjusted NCO

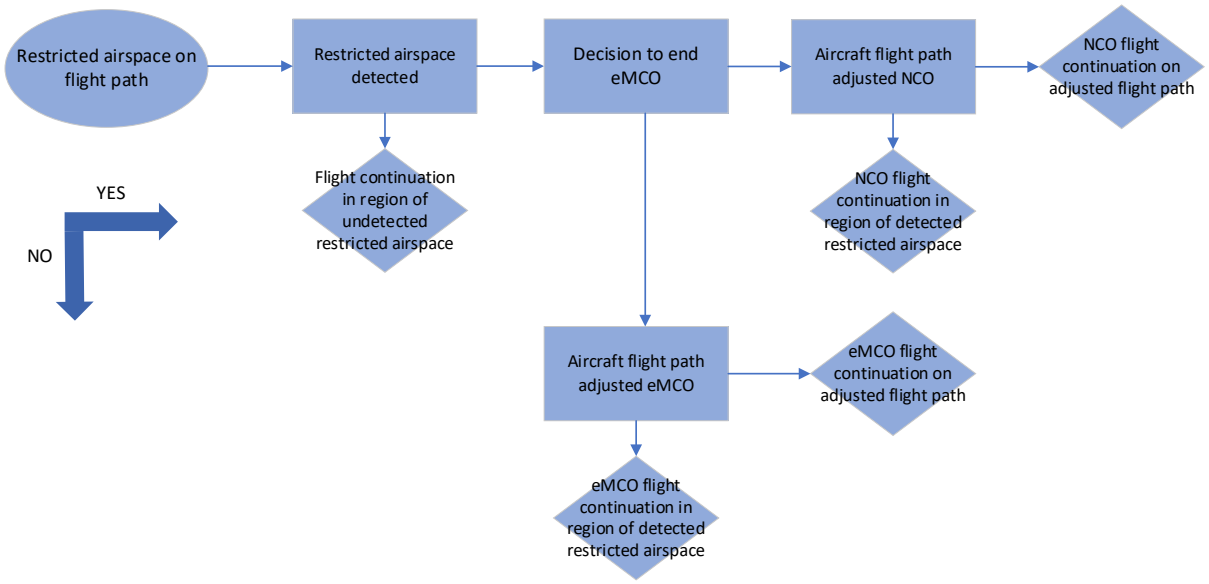
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | Confer flight path adjustment with ATC | | Not applicable | Not applicable | Not applicable |
| Select adjusted flight path | Cross check adjusted flight path selection | Support flight crew in adjusted flight path selection | | | |
| Execute flight path adjustment | Monitor flight path adjustment | Support flight crew in flight path adustment | | | |
| | Inform cabin crew | | | | |

Aircraft flightpath adjusted eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Confer flight path adjustment with ATC | | |
| | | | Select adjusted flight path | | Support flight crew in adjusted flight path selection |
| | | | Execute flight path adjustment | | Support flight crew in flight path adustment |
| | | | Inform cabin crew | | |

### 5.3.3 Restricted airspace on flight path

Although most restricted airspaces will have been anticipated and accounted for during flight planning, there is a possibility that a particular circumstance results in acute and unanticipated closure of a certain part of airspace. This may need adjustment of the flight path and, because it is an unanticipated event, will involve some decision making that may require abort of the EMCO segment.




Restricted airspace detected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect restricted airspace and alert PM | Detect restricted airspace and alert PF | Detect restricted airspace and alert flight crew | Detect restricted airspace malfunction | | Detect restricted airspace and alert flight crew |

Decision to end eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal | | Support briefing of location dependent |

| | | | | | |
|---|---|---|---|---|---|
| | | | procedures to PR | | abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

Aircraft flightpath adjusted NCO

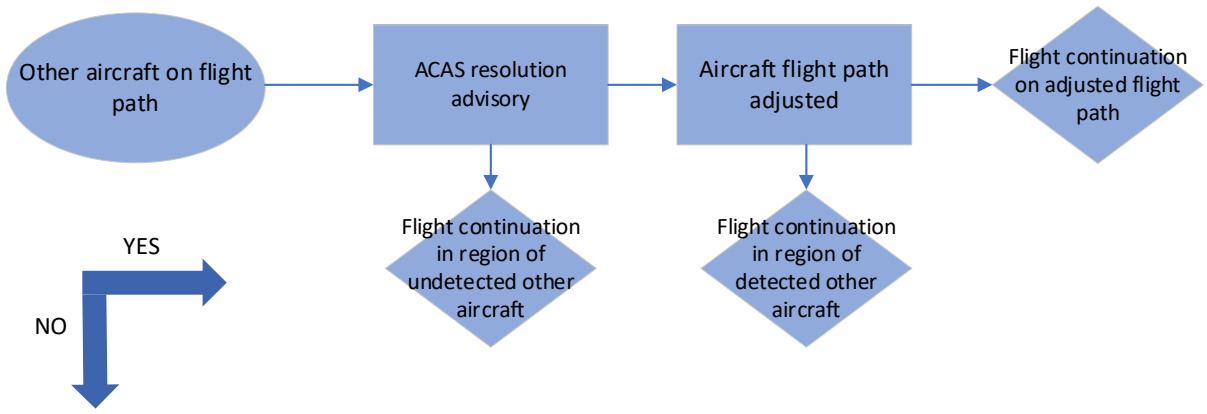
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Select adjusted flight path | Cross check adjusted flight path selection | Support flight crew in adjusted flight path selection | Not applicable | Not applicable | Not applicable |
| Execute flight path adjustment | Monitor flight path adjustment | Support flight crew in flight path adustment | | | |

Aircraft flightpath adjusted eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Select adjusted flight path | | Support flight crew in adjusted flight path selection |
| | | | Execute flight path adjustment | | Support flight crew in flight path adjustment |

### 5.3.4 Other aircraft on flight path

Although ATC is supposed to separate traffic, there is a possibility that another aircraft appears on the flight path at a distance smaller than the separation minimum. This situation will require immediate response. Aircraft are equipped with airborne collision avoidance systems (ACAS) that alert the flight crew of impending conflicts and provide instructions for collision avoidance. It is assumed that aircraft that are approved for eMCO are equipped with auto ACAS which allows the aircraft to automatically fly the resolution advisories (RA) if the autopilot is engaged. The pilot's task then is limited to monitoring of the RA response.




ACAS resolution advisory

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect ACAS RA and alert PM | Detect ACAS RA and alert PF | Detect other aircraft and alert flight crew | Detect ACAS RA | | Detect other aircraft and alert PF |

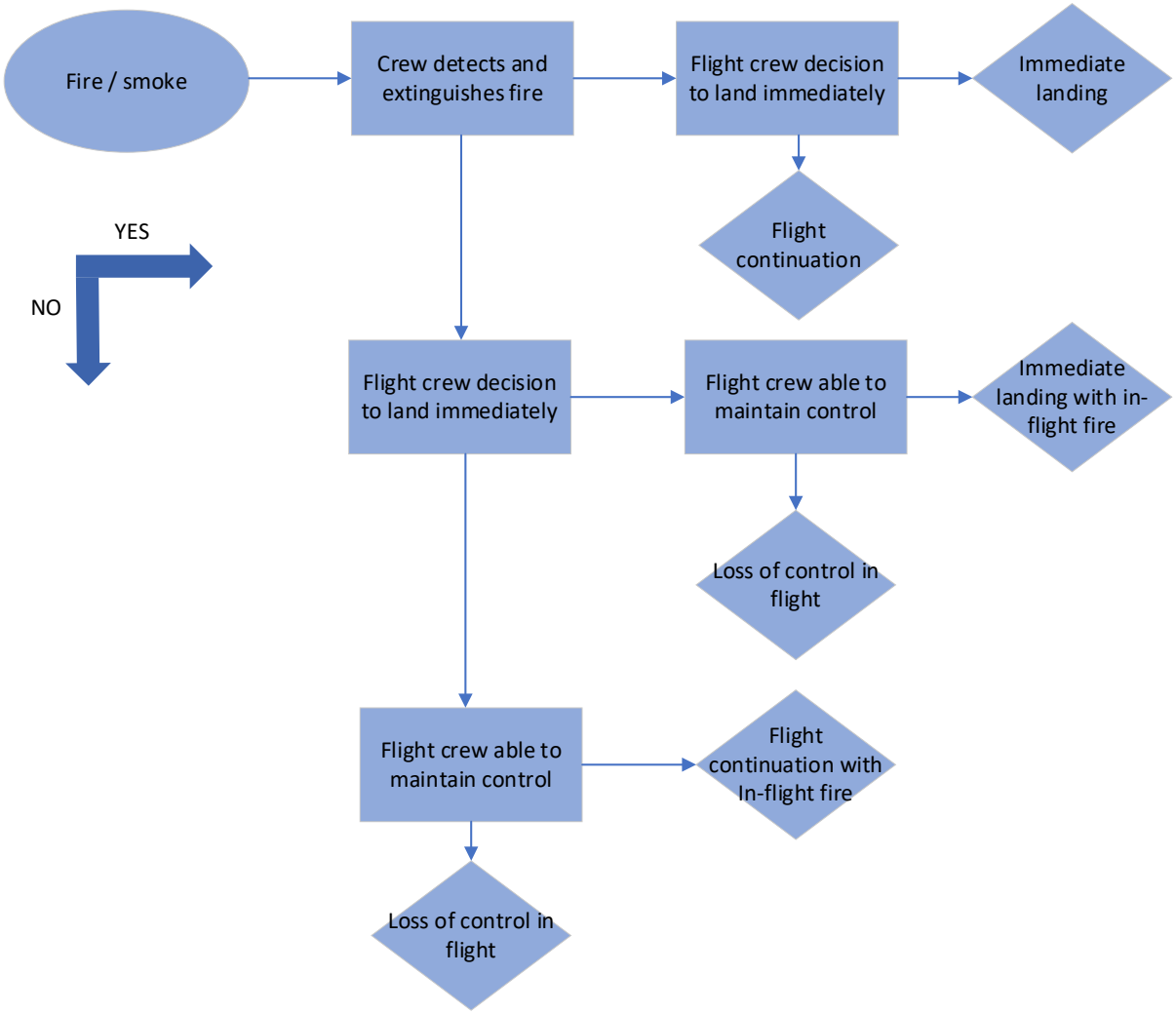
Aircraft flightpath adjusted

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Select adjusted flight path | Cross check adjusted flight path selection | Support flight crew in adjusted flight path selection | Select adjusted flight path | | Support flight crew in adjusted flight path selection |
| Execute flight path adjustment | Monitor flight path adjustment | Support flight crew in flight path adustment | Execute flight path adjustment | | Support flight crew in flight path adustment |

## 5.4 Manage contingencies

### 5.4.1 Fire / smoke

Fire / smoke with a clear origin that is restricted to cabin and can be handled by cabin crew is not described because it does not require active involvement of the flight crew. Fire or smoke in the cockpit or in a location other than the cabin will require immediate pilot action. If the fire is located in the cockpit the pilots are expected to use portable fire extinguishers to attack the fire. It is assumed that in case of a fire the pilot resting is immediately alerted and may be instructed by the pilot flying to perform firefighting tasks, even if the resuming pilot is still suffering from sleep inertia. On-board fire may require immediate landing of the aircraft.




Crew detects and extinguishes fire

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |

| | | | | | |
|---|---|---|---|---|---|
| Detect fire/smoke | Detect fire/smoke | Detect and annunciate fire/smoke | Detect fire | | Detect and annunciate fire/smoke |
| | | | Alert PR | | Alert PR |
| Don oxygen mask if required | Don oxygen mask if required | | Don oxygen mask if required | Don oxygen mask if required | |
| | | | | (Enter cockpit) | |
| | | | | SA self recovery | Support SA self recovery |
| Manage flight trajectory | | | Manage flight trajectory | | |
| Cross check smoke removal procedure | Execute smoke removal procedure | Support execution of smoke removal procedures | Execute smoke removal procedure | If sleep inertia has ended, execute smoke removal procedure | Support execution of smoke removal procedure. |
| | Investige fire and use extinguishers | | | Investigate fire and use extinguishers | |

Flight crew decision to land immediately

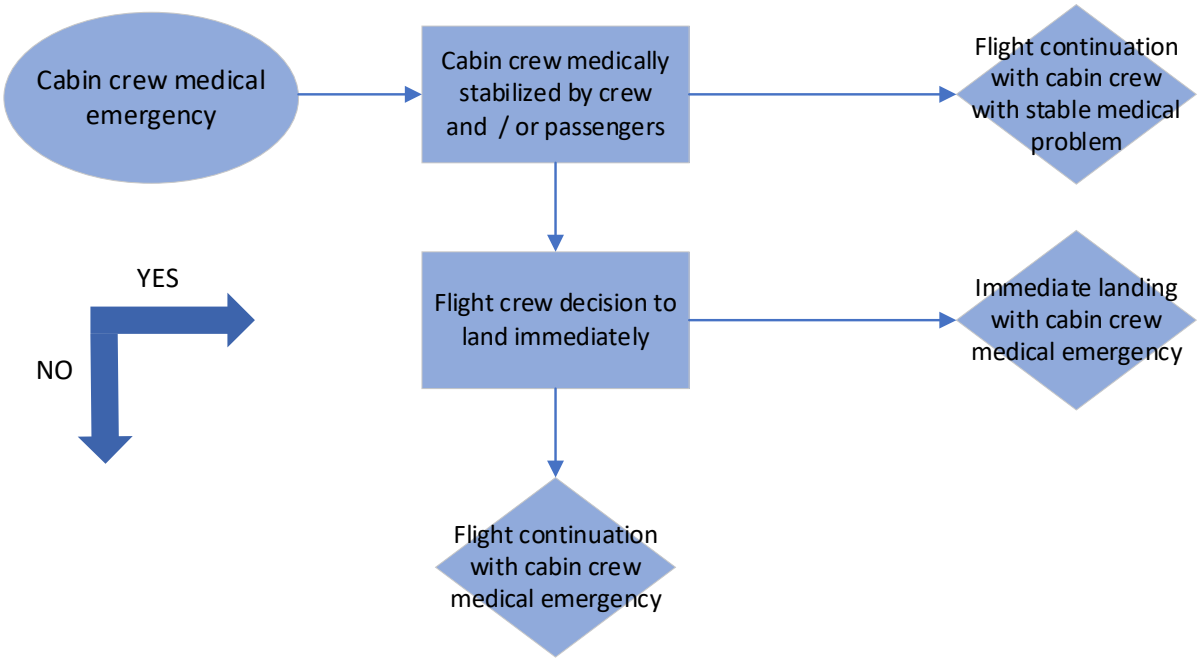
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | | | SA briefing | SA briefing | Support SA briefing |
| Initiate immediate landing decision | Cross check immediate landing decision | Support immediate landing decision | Initiate immediate landing decision | If sleep inertia has ended, cross check immediate landing decision | Support immediate landing decision |
| Cross check immediate landing preparation | Prepare aircraft for immediate landing | Support immediate landing preparation | Prepare aircraft for immediate landing | If sleep inertia has ended, cross check immediate landing preparation | Support immediate landing preparation |

Flight crew able to maintain control

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Monitor flight trajectory management | Support flight trajectory management | Manage flight trajectory | If sleep inertia has ended, monitor flight trajectory management | Support flight trajectory management |

### 5.4.2 Cabin crew medical emergency

If during an eMCO segment a member of the cabin crew has a medical emergency, the first responders will be other cabin crew (if on-board) and passengers (if onboard and willing and capable of providing medical assistance). If the condition of the affected cabin crew member does not improve and appears to be critical, the pilot flying needs to be informed. The pilot will have to decide if the eMCO segment needs to be aborted and if immediate landing is required.




Cabin crew medically stabilized by crew and / or passengers

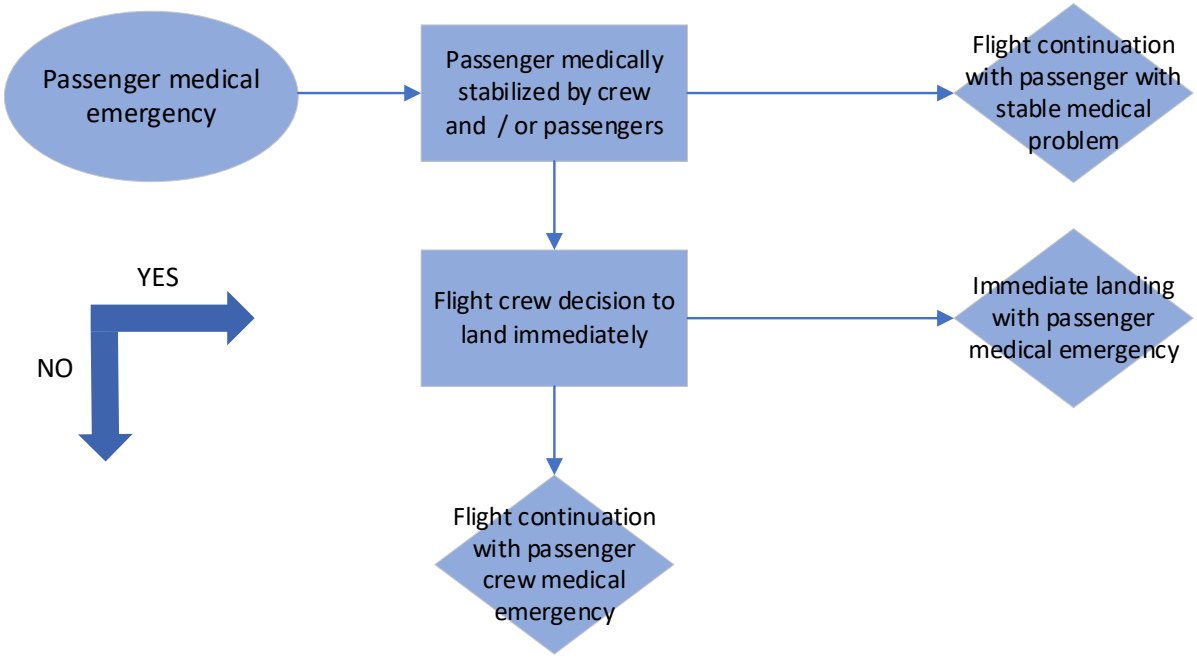
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Communicate with cabin | Support flight trajectory management | Manage flight trajectory | | Support flight trajectory management |
| | Perform / organise first aid to cabin crew | | Communicate with cabin | | |
| | Communicate with dispatch | | Communicate with dispatch | | |
| | | | Alert PR | | |
| | | | | (Enter cockpit) | |
| | | | | SA self recovery | Support SA self recovery |
| | | | | Perform / organise first aid to cabin crew | |

Flight crew decision to land immediately

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Initiate immediate landing decision | Cross check immediate landing decision | Support immediate landing decision | Initiate immediate landing decision | If sleep inertia has ended, cross check immediate landing decision | Support immediate landing decision |
| Cross check immediate landing preparation | Prepare aircraft for immediate landing | Support immediate landing preparation | Prepare aircraft for immediate landing | If sleep inertia has ended, cross check immediate landing preparation | Support immediate landing preparation |

### 5.4.3 Passenger medical emergency

If during an eMCO segment a passenger has a medical emergency, the first responders will be cabin crew and passengers (if willing and capable of providing medical assistance). If the condition of the affected passenger does not improve and appears to be critical, the pilot flying needs to be informed. The pilot will have to decide if the eMCO segment needs to be aborted and if immediate landing is required.




Passenger medically stabilized by crew and / or passengers

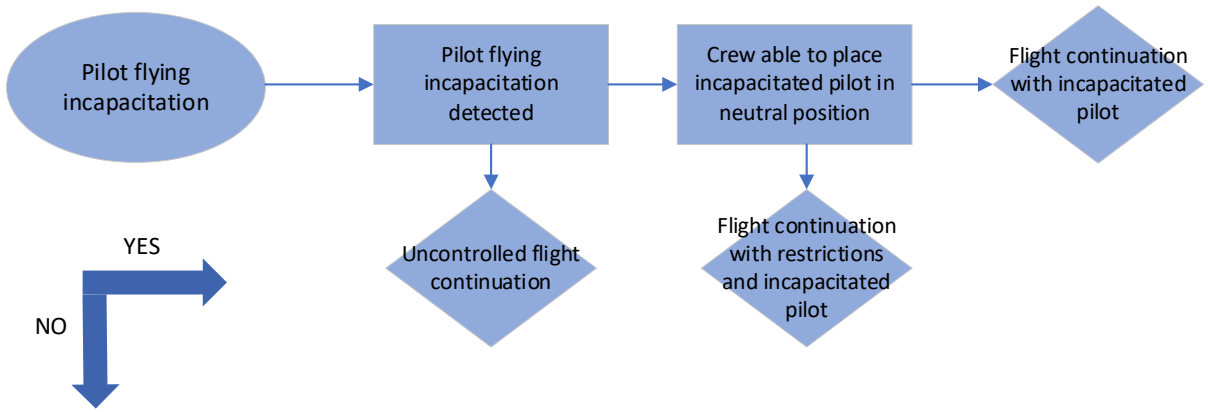
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Communicate with cabin | Support flight trajectory management | Manage flight trajectory | | Support flight trajectory management |
| | Perform / organise first aid to passenger crew | | Communicate with cabin | | |
| | Communicate with dispatch | | | | |
| | | | Alert PR | | |
| | | | | (Enter cockpit) | |
| | | | | SA self recovery | Support SA self recovery |
| | | | | Perform / organise first aid to passenger | |

Flight crew decision to land immediately

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Initiate immediate landing decision | Cross check immediate landing decision | Support immediate landing decision | Initiate immediate landing decision | If sleep inertia has ended, cross check immediate landing decision | Support immediate landing decision |
| Cross check immediate landing preparation | Prepare aircraft for immediate landing | Support immediate landing preparation | Prepare aircraft for immediate landing | If sleep inertia has ended, cross check immediate landing preparation | Support immediate landing preparation |

### 5.4.4 Pilot flying incapacitation

Incapacitation of the pilot flying during the eMCO segment results in a situation where the aircraft is momentarily not controlled by a human pilot. It is possible that the pilot flying is able to self-detect a (gradual) incapacitation and alert the PR. In any case, an on-board pilot monitoring system is expected to detect incapacitation of the pilot flying, alert the pilot resting and maintain the aircraft in a stable state until the pilot resting is able to take control of the aircraft. The incapacitated pilot must be placed in a neutral position to avoid inadvertent interference with flight controls and aircraft systems. The pilot resuming flight will need to divert the flight according to the procedures briefed at the start of the eMCO segment and inform ATC of the emergency situation.




Pilot flying incapacitation detected

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Notify PM in case of self detection | Detect incapacitation | | Notify PR in case of self detection | | Detect incapacitation |
| | Manage flight trajectory | | | | Manage flight trajectory |
| | Alert cabin crew (if available) | | | | Alert PR |
| | Coordinate with cabin crew (if available) | | | (Enter cockpit) | |
| | | | | SA self recovery | Support SA self recovery |
| | | | | Coordinate with cabin crew (if available) | Alert cabin crew (if available) |

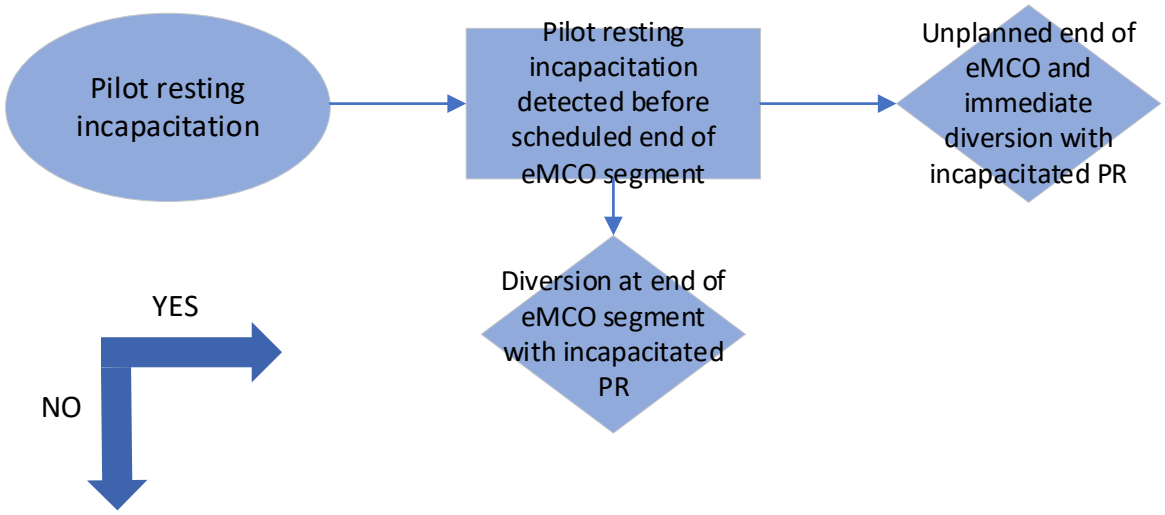
Crew able to place incapacitated pilot in neutral position

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | Place incapacitated pilot in neutral | Provide autoflight function | | Place incapacitated pilot in neutral | Manage flight trajectory |

| | | | | | |
|---|---|---|---|---|---|
| | position. If available, this may be done with help of cabin crew. | | | position. If available, this may be done with help of cabin crew. | |
| | Manage flight trajectory | | | If sleep inertia has ended, manage flight trajectory | |

### 5.4.5 Pilot resting incapacitation

Incapacitation of the pilot resting during the eMCO segment is expected to be more difficult to detect than incapacitation of the pilot flying. If incapacitation is detected before the scheduled end of the eMCO segment, it is expected that the pilot flying and the cabin crew will be alerted. the first responders will be cabin crew and passengers (if willing and capable of providing medical assistance). The pilot flying will need to divert the flight according to the procedures briefed at the start of the eMCO segment and inform ATC of the emergency situation.

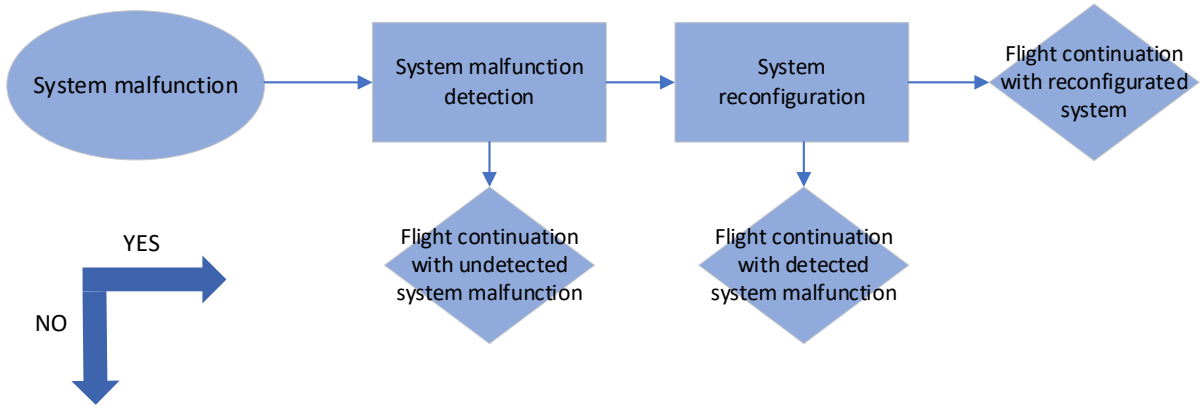



Pilot resting incapacitation detected before scheduled end of eMCO segment

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| | | | | Notify PF in case of self detection | Detect PR incapacitation and notify PF |
| | | | Initiate diversion | | Support initiation of diversion |
| | | | | | |

### 5.4.6 System malfunction

The scenario for an aircraft system malfunction is generic for all systems (hydraulic, electric, etc.) with the exception of a fuel leak, aircraft depressurisation, unreliable air data and engine failure which are described as separate scenarios. A system malfunction will be detected by the pilot flying when prompted by the aircraft's alerting system or due to secondary cues such as loss of system performance or unexpected system parameter values. The pilot flying will reconfigure the system as per the appropriate procedure (and prompted by the aircraft's system display). Complex failures requiring substantial decision making or failures that result in significant loss of system performance may require abort of the eMCO segment.




System malfunction detection

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect system malfunction and alert PM | Detect system malfunction and alert PF | Detect system malfunction and alert flight crew | Detect system malfunction | | Detect system malfunction and alert flight crew |

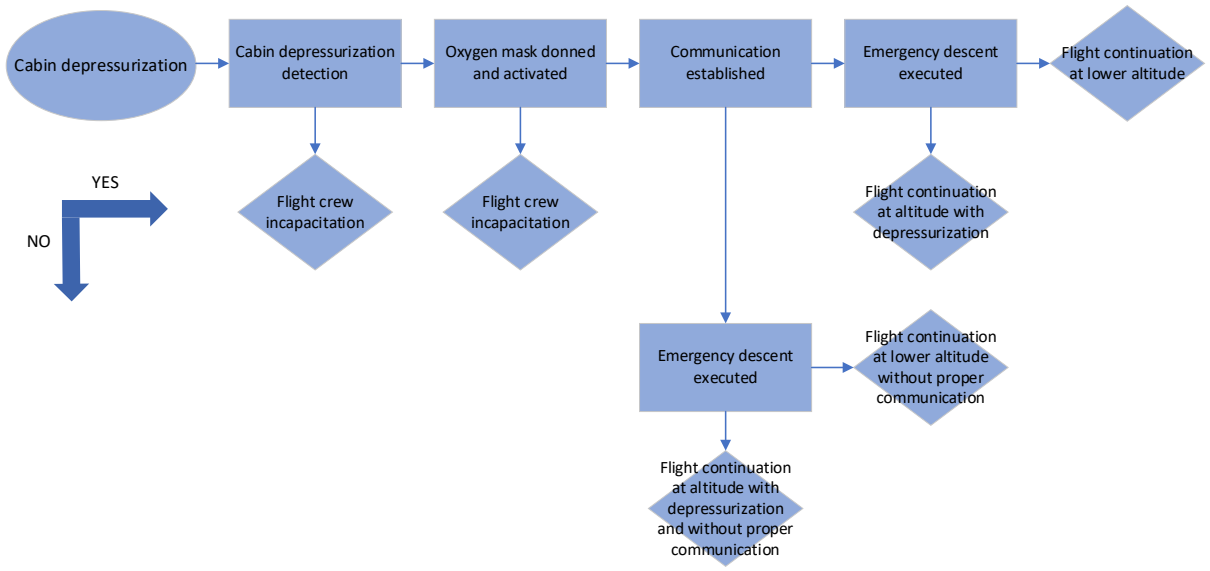
System reconfiguration

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Stabilise the aircraft | | | Stabilise the aircraft | | |
| Manage flight trajectory | Reconfigure system[1] | Support system reconfiguration | Manage flight trajectory | | |
| Cross check system reconfiguration | | | Reconfigure system[1] | | Support system reconfiguration |
| | | | If necessary, end eMCO | | |

[1] System reconfiguration may include several procedural steps such as those summarized as FOR-DEC (Facts, opinions, risks – decision, execute, check)

### 5.4.7 Cabin depressurization

An aircraft depressurization will be detected by the pilot flying when prompted by the aircraft's alerting system or due to secondary cues such as pressure on the ear or symptoms of hypoxia (e.g. blueness of the lips or fingertips, increased rate and depth of breathing). The immediate response of the pilot flying should be donning of the oxygen mask to prevent incapacitation due to hypoxia. It is assumed that descent will be initiated automatically in case of depressurization detected by the system. The PF will have to establish communication with the PR , monitor that the emergency descent is correctly executed by the aircraft systems and initiate the emergency descent if it has not yet been started by the aircraft systems.




Cabin depressurization detection

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect cabin depressurization and alert PM | Detect cabin depressurization and alert PF | Detect cabin depressurization and alert flight crew | Detect cabin depressurization<br><br>Alert PR | | Detect cabin depressurization and alert PF and PR |

Oxygen mask donned and activated

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Oxygen mask on | Oxygen mask on | Provide autoflight function | Oxygen mask on | Oxygen mask on | Manage flight trajectory |

Communication established

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |

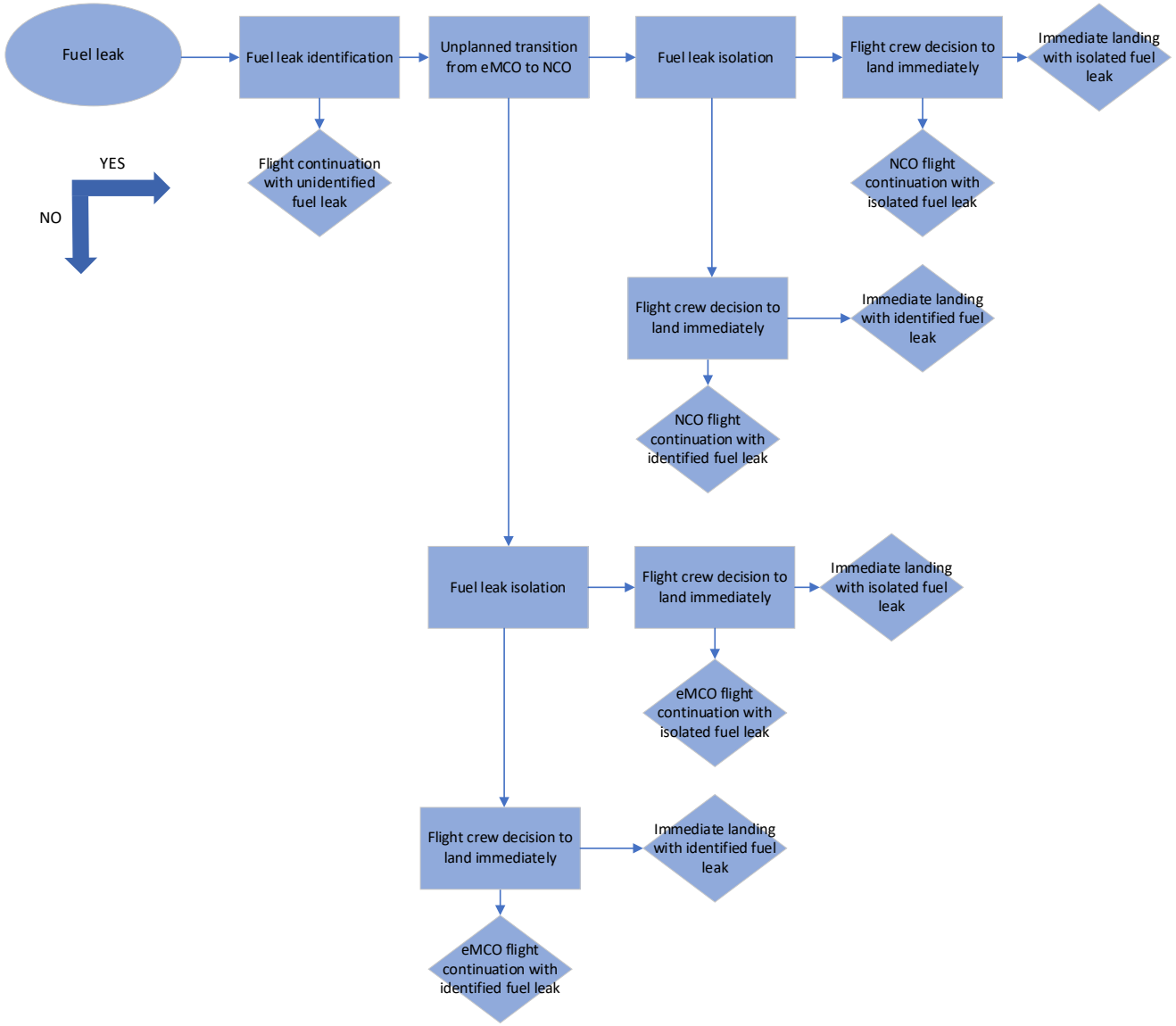
| | | | | | |
|---|---|---|---|---|---|
| Establish communication with PM | Establish communication with PF | | Establish communication with PR | Establish communication with PF | |
| | Establish communication with ATC | | Establish communication with ATC | (Enter cockpit) | |

Emergency descent executed

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Configure aircraft for emergency descent | Cross check aircraft configuration for emergency descent | Support aircraft configuration | Configure aircraft for emergency descent | SA self-recovery | Support aircraft configuration |
| Manage flight trajectory | Monitor flight trajectory | Provide autopilot function | Manage flight trajectory | If sleep inertia has ended, monitor flight trajectory | Support flight trajectory management |

### 5.4.8 Fuel leak

A fuel leak will be detected by the pilot flying when prompted by the aircraft's alerting system, from monitoring fuel quantity values over time, or by a fuel imbalance. When the fuel leak has been detected, the location of the fuel leak may not immediately be clear. If the fuel leak is confirmed, the fuel leak procedure must be executed to mitigate the consequences of the fuel leak. A typical fuel leak procedure requires landing as soon as possible in case of a confirmed fuel leak.




Fuel leak identification

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| PF | PM | Aircraft system | PF | PR | Aircraft system |

| | | | | | |
|---|---|---|---|---|---|
| Detect fuel leak and alert PM | Detect fuel leak and alert PF | Detect fuel leak and alert flight crew | Detect fuel leak | | Detect fuel leak and alert PF |

Unplanned transition from eMCO to NCO
See section 5.1.3

Fuel leak isolation

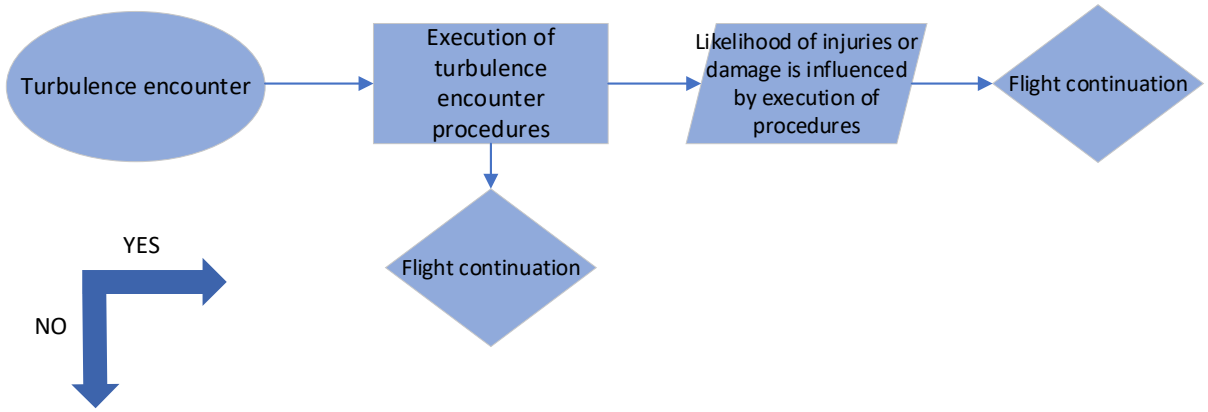
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Cross check fuel leak isolation procedure execution | Execute fuel leak isolation procedure | Support execution of fuel leak isolation procedure | Execute fuel leak isolation procedure | | Support execution of fuel leak isolation procedure |

Flight crew decision to land immediately

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Initiate immediate landing decision | Cross check immediate landing decision | Support immediate landing decision | Initiate immediate landing decision | If sleep inertia has ended, cross check immediate landing decision | Support immediate landing decision |
| Cross check immediate landing preparation | Prepare aircraft for immediate landing | Support immediate landing preparation | Prepare aircraft for immediate landing | If sleep inertia has ended, cross check immediate landing preparation | Support immediate landing preparation |

### 5.4.9 Turbulence encounter

The turbulence encounter procedures includes encounter with  a wake vortex. Turbulence encounter may be expected if it is known, e.g. from pilot reports, that there are areas of (clear air) turbulence on the flightpath, but an encounter with turbulence of a wake vortex can also be unexpected. When entering an unexpected area of turbulence, the pilot must switch the seatbelt sign ON and make an announcement to the cabin requesting passengers and crew to fasten seatbelts immediately. The pilot must inform the cabin crew when the aircraft is clear of the severe turbulence so that cabin crew can check for passenger injuries or any cabin damage. The cabin should then provide a cabin status to the pilot detailing the number of injuries and any cabin damage. Procedures may require disconnecting the autothrottle in case of excessive autothrottle variations. The eMCO segment must be aborted in case of an autothrottle disconnect.

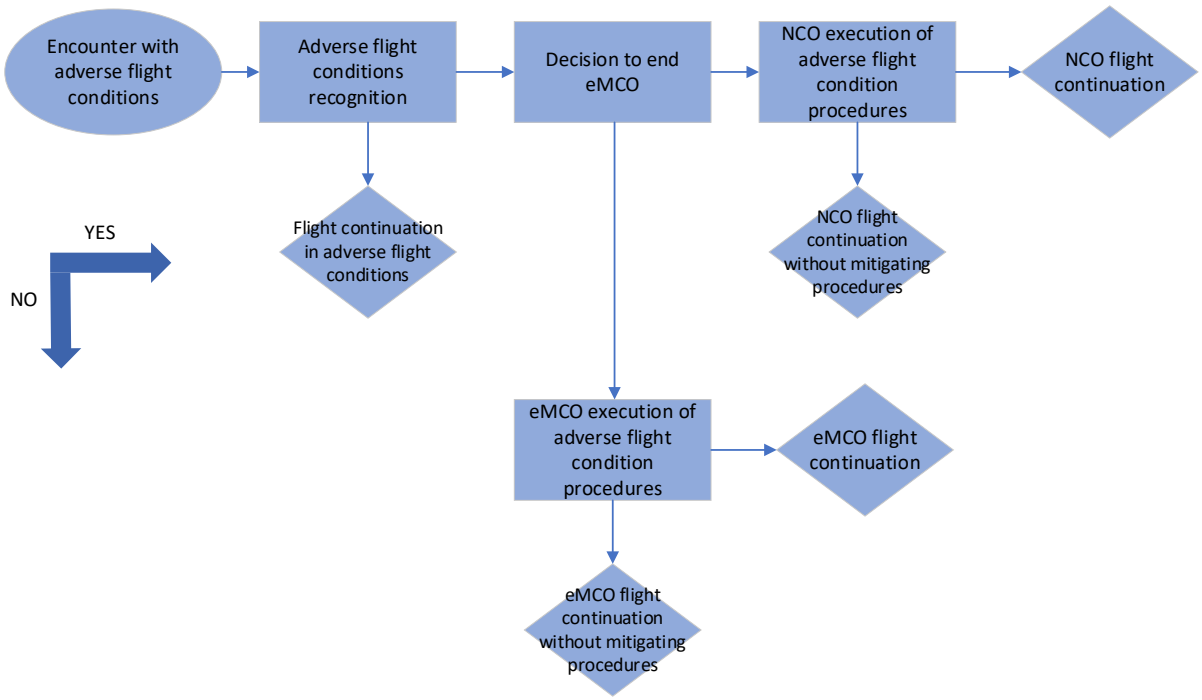



Execution of turbulence encounter procedures

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Execute turbulence encounter procedures | Cross check execution of turbulence encounter procedures | Support execution of turbulence encounter procedure | Execute turbulence encounter procedures | | Support execution of turbulence encounter procedures |

### 5.4.10 Encounter with adverse flight conditions

Adverse flight conditions may include weather, icing, volcanic ash. In many cases, regions with adverse weather conditions may have been identified during flight planning or during the flight, resulting in adjustment of the flight path (see scenario hazardous weather). Nevertheless, weather can be dynamic and it is still possible that a flight unexpectedly encounters hazardous weather conditions. Some adverse weather conditions may be difficult to detect, and once detected, the severity of the conditions may not be easy to assess. On-board aircraft systems are expected to support the pilot in the detection of adverse weather conditions. When a significant or non-obvious decision is required, it is expected that the eMCO segment will be aborted.




Adverse flight conditions recognition

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Recognise adverse flight conditions | Recognise adverse flight conditions | Support recognition of adverse flight conditions | Recognise adverse flight conditions | | Support recognition of adverse flight conditions |

Decision to end eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

NCO execution of adverse flight condition procedures

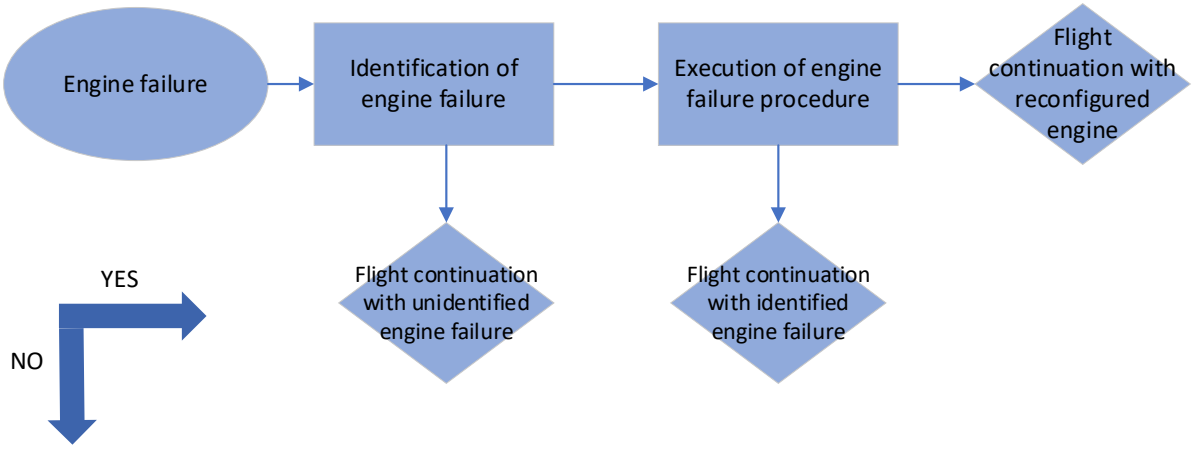
| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Stabilise the aircraft | | | Not applicable | Not applicable | Not applicable |
| Manage flight trajectory | Execute adverse flight condition procedures | Support execution of adverse flight condition procedures | | | |
| Cross check adverse flight condition procedures | | | | | |

eMCO execution of adverse flight condition procedures

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Stabilise the aircraft | | |
| | | | Manage flight trajectory | | |
| | | | Execute adverse flight condition procedures | | Support execution of adverse flight condition procedures |

### 5.4.11 Engine failure

An engine failure may be associated with a variety of primary cues (engine alerts, engine parameter values) and secondary symptoms (noise, vibration, fire or smoke). The pilot must identify that an engine has failed, and then needs to identify which of the engines has failed. The aircraft systems are assumed to support the pilot decision making process by proper indications. After identification of the failed engine, the appropriate procedure, depending on the type of failure, must be executed. It is expected that the aircraft systems support the execution of the procedure by prompting the steps and providing hand guidance. In any case an engine failure will result in abortion of the eMCO segment and will almost always require the flight to descend to a lower flight level.




Identification of engine failure

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect engine failure and alert PM | Detect engine failure and alert PF | Detect engine failure and alert flight crew | Detect engine failure | | Detect engine failure and alert flight crew |

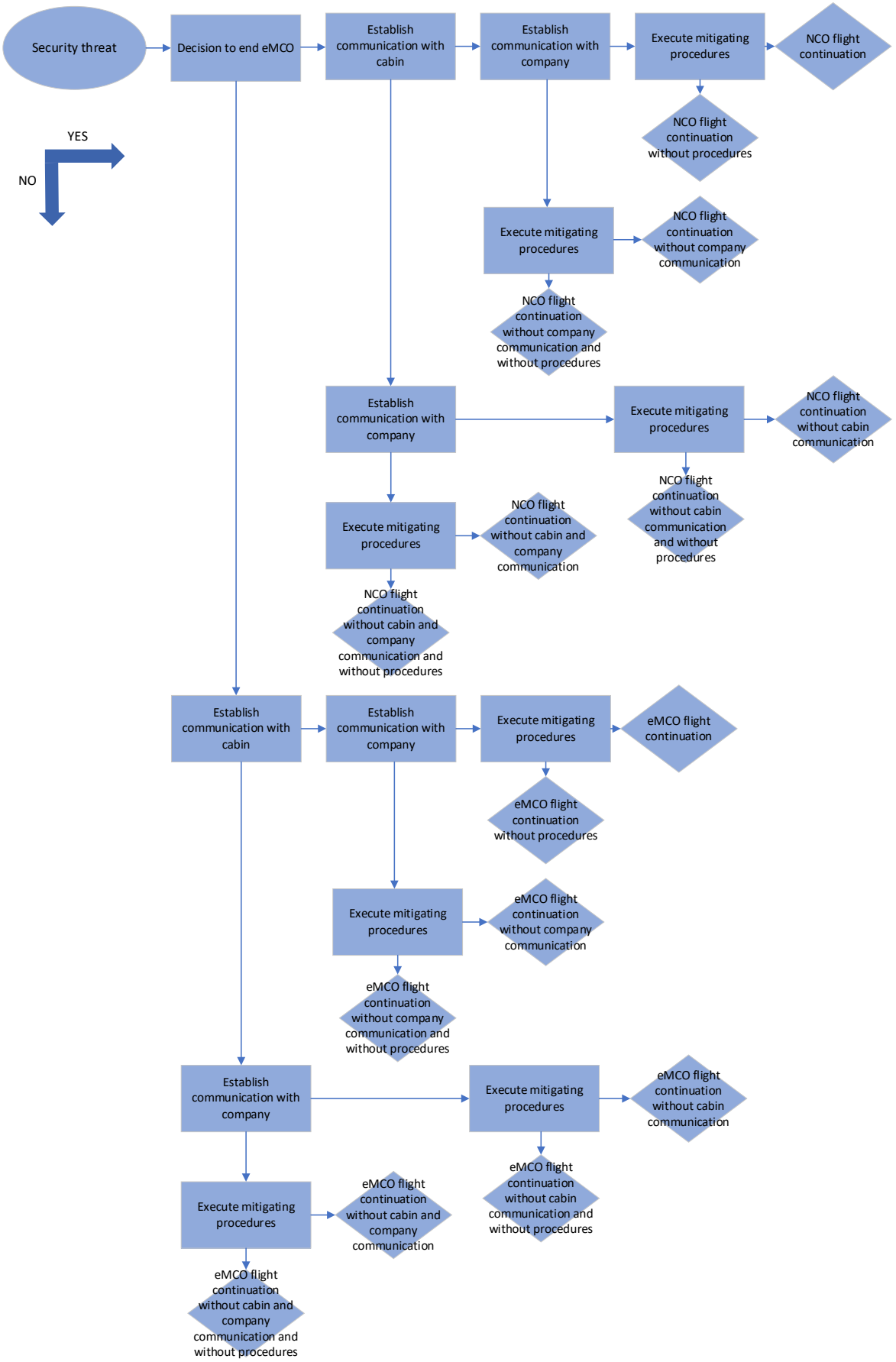
Execution of engine failure procedure

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Cross check flight trajectory | | Manage flight trajectory | | Support flight trajectory management |
| Cross check execution of engine failure procedure | Execute engine failure procedures | Support execution of engine failure procedure | Execute engine failure procedure | | Support execution of engine failure procedure |
| Descent to lower altitude | Cross check descent to lower altitude | Support descent to lower altitude | Descent to lower altitude | | Support descent to lower altitude |
| | | | Alert PR | | Support PR alert |

| | | | | | |
|---|---|---|---|---|---|
| | | | Perform flight duties | Wait until end of sleep inertia | |
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

### 5.4.12 Security threat (bomb on board, hijack, unruly passenger)

A flight may encounter security threats such as (message of) a bomb on-board, hijack and unruly passengers. These situations are very unpredictable, and therefore flight crew procedures are limited. The most frequent security threat is an unruly passenger. It is expected that unruly passengers are handled by the cabin crew and flight crew only be informed. Nevertheless, a situation with an unruly passenger may deteriorate to such an extent that the flight crew must be involved. In any case, as security threat that involved the flight crew requires abortion of the eMCO segment.


Security threat
Decision to end eMCO
Establish communication with cabin
Establish communication with company
Execute mitigating procedures
NCO flight continuation
NCO flight continuation without procedures
YES
NO
Execute mitigating procedures
NCO flight continuation without company communication
NCO flight continuation without company communication and without procedures
Establish communication with company
Execute mitigating procedures
NCO flight continuation without cabin communication
NCO flight continuation without cabin communication and without procedures
Execute mitigating procedures
NCO flight continuation without cabin and company communication
NCO flight continuation without cabin and company communication and without procedures
Establish communication with cabin
Establish communication with company
Execute mitigating procedures
eMCO flight continuation
eMCO flight continuation without procedures
Execute mitigating procedures
eMCO flight continuation without company communication
eMCO flight continuation without company communication and without procedures
Establish communication with company
Execute mitigating procedures
eMCO flight continuation without cabin communication
eMCO flight continuation without cabin communication and without procedures
Execute mitigating procedures
eMCO flight continuation without cabin and company communication
eMCO flight continuation without cabin and company communication and without procedures

Decision to end eMCO

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Not applicable | Not applicable | Not applicable | Alert PR | | Support PR alert |
| | | | Perform flight duties | Wait until end of sleep inertia | |
| | | | Brief current aircraft and flight status to PR | Become aware of current aircraft and flight status | Support status briefing |
| | | | Brief location dependent abnormal procedures to PR | | Support briefing of location dependent abnormal procedures |
| | | | Agree with PR on distribution of tasks | Agree with PF on distribution of tasks | |

Establish communication with cabin

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Fly the aircraft | Establish communication with cabin | Support establishment of communication with cabin | Fly the aircraft. Establish communication with cabin | | Support establishment of communication with cabin |
| Cross check noting of information provided / given to/from cabin | Note information provided / given to/from cabin | Support noting of information provided / given to/from cabin | Note information provided / given to/from cabin | | Support noting of information provided / given to/from cabin |

Establish communication with company

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |

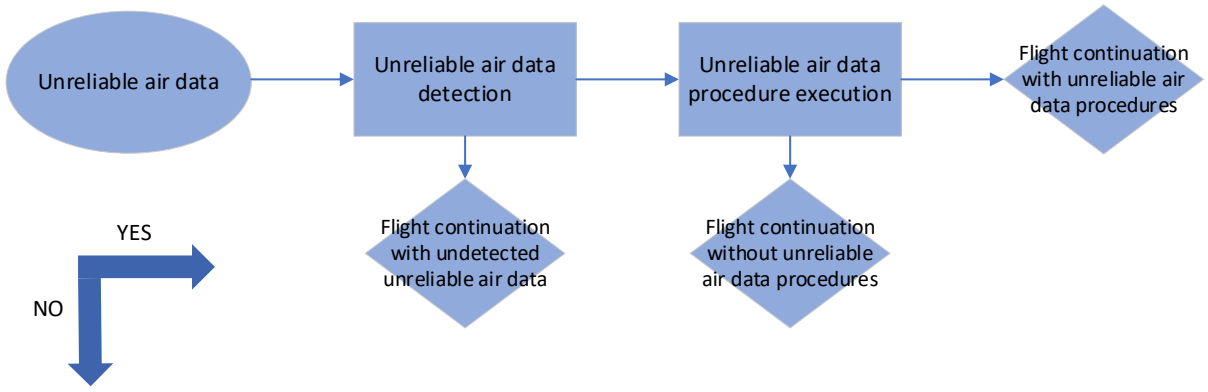
| | | | | | |
|---|---|---|---|---|---|
| Cross check establishment of communicating with company | Establish communication with company | Support establishment of communication with company | Establish communication with company | | Support establishment of communication with company |
| Fly the aircraft | Communication with company | | Fly the aircaft | | |
| | Note instructions or guidance received from company | Support noting of instructions or guidance received from company | Note instructions or guidance received from company | | Support noting of instructions or guidance received from company |

Execute mitigating procedures

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Execute mitigating procedures | Support procedure execution | Manage flight trajectory | | |
| Cross check execution of mitigating procedures | | | Execute mitigating procedures | | Support procedure execution |

### 5.4.13 Unreliable air data

Air probe failure or obstruction can result in erroneous speed or altitude indications. If the aircraft is equipped with other independent sources to measure speed and altitude (e.g. inertial data), unreliable air data can be detected by the aircraft systems. Unreliable air data can be detected by the flight crew as abnormal (fluctuations of) airspeed and altitude or abnormal combination of basis flight parameters (in particular speed, pitch attitude, thrust and climb rate). In case the aircraft does not provide automatic reconfiguration, the pilot must stabilise the flight path by maintaining the correct attitude and thrust setting.




Unreliable air data detection

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Detect unreliable air data and inform PM | Detect unreliable air data and inform PF | Support detection of unreliable air data | Detect unreliable air data | | Support detection of unreliable air data |

Unreliable air data procedure execution

| NCO | | | eMCO | | |
|---|---|---|---|---|---|
| **PF** | **PM** | **Aircraft system** | **PF** | **PR** | **Aircraft system** |
| Manage flight trajectory | Execute mitigating procedures | Support procedure execution | Manage flight trajectory | | |
| Cross check execution of mitigating procedures | | | Execute mitigating procedures | | Support procedure execution |

# Bibliography

McGuire, J.C., Zich, J.A., Goins, R.T., Erickson, J.B., Dwyer, J.P., Cody, W.J., Rouse, W.B. 1991. An Exploration of Function Analysis and Function Allocation in the Commercial Flight Domain. NASA CR 4374, National Aeronautics and Space Administration, Langley Research Center, Hampton, VA


European Union Aviation Safety Agency

Konrad-Adenauer-Ufer 3
50668 Cologne
Germany

Mail EASA.research@easa.europa.eu
Web www.easa.europa.eu

**An Agency of the European Union**