EHEST
Component of ESSI
European Helicopter Safety Team

Automation and Flight Path Management

FOR HELICOPTER PILOTS AND INSTRUCTORS

TRAINING LEAFLET

Example of H135 Flight Navigation Display (FND)

HE 9

TABLE OF CONTENTS

GLOSSARY

AFCS: automatic flight control system
AP: auto pilot
APCP: auto pilot control panel
ATC: air traffic control
BRG: bearing
CAS: crew alerting system
CDU: control display unit
CFIT: controlled flight into terrain
COM/NAV: communication/navigation
CRM: cockpit resource management
CRS: course
DME: distance measuring equipment
FCOM: Flight crew operating manual
FND: Flight navigation display
FL: flight level
FMA: flight mode annunciator
FMS: flight management system
GA: go around
GPWS: ground proximity warning system
G/S: glide slope
HDG: heading
IAS: indicated air speed
ILS: instrument landing system
LOC: localizer
LDP: landing point
MEA: minimum en route altitude
MORA: minimum off route altitude
MSA: minimum sector altitude
NAV: navigation
NAVD: navigation display
OM: operations manual
PF: pilot flying
PFD: primary flight display
PM: pilot monitoring
QRH: quick reference handbook
RA: radio altimeter
RMI: radio magnetic indicator
SID: standard instrument departure
SOP: standard operations procedure
TA: traffic advisory
TAWS: terrain awareness and warning system
TCAS: traffic collision avoidance system
TEM: threat and error management
VMC: visual meteorological conditions
V/S: vertical speed

INTRODUCTION

This leaflet was developed by the European Helicopter Safety Implementation Team (EHSIT), a component of the European Helicopter Safety Team (EHEST). The EHSIT is tasked to process the Implementation Recommendations (IRs) identified from the analysis of accidents performed by the European Helicopter Safety Analysis Team (EHSAT).

For many years helicopter manufacturers have used automation in the form of stability augmentation and attitude retention in assisting crews in reducing manual flying workload. The rapid advances in technology over the last 30 years, in particular the last 10, have given rise to significant capabilities from such systems.

Unfortunately the training and checking practices have not always kept pace with this continuous technological advance. The use of automation should be addressed in more depth in training and more guidance provided to operators.

The advent of JAA Operational Evaluation Board reports (OEB) and the new EASA Operational Suitability Data (OSD) has gone a long way in addressing the areas of special emphasis to be covered during specific type rating training. Some manufacturers have also published operational documents such as flight operational briefing note (FOBN) and more recently FCOM (flight crew operating manual) to address in a different way the use of the aircraft for specific mission like offshore, Search and Rescue, and HEMS operations.

Automation has contributed substantially to the sustained improvement of flight safety. Automation increases the timeliness and precision of routine procedures reducing the opportunity for errors and the associated risks to the safety of the flight.

Nevertheless, automation has its limits. Critically, in complex and highly automated aircraft, flight crews can lose mode awareness or may not understand the interaction between a mode of automation and a particular phase of flight or pilot input.

The helicopter community continues to experience incidents and accidents where accident investigators have cited that automation and complex flight displays have been significant factors. This document has been developed to identify current best practice and assist in making best use of these powerful safety enhancements. Whilst this leaflet is more oriented to multi pilot operations, a single pilot who faces the same issues in modern aircraft will find suggestions in how to decrease workload and manage the flight more effectively.

1. AUTOMATION INCIDENT CASE STUDY

1.1 Synopsis

After 28 minutes on the helideck, the commander carried out a successful takeoff and, as the helicopter accelerated, he engaged the autopilot in Go-Around (GA) mode. Almost immediately, the crew sensed that the helicopter was not transitioning to a climb as they expected, but was in fact still descending and accelerating. With the autopilot still engaged, the commander made manual control inputs in an attempt to ensure the desired climb profile was followed. Recorded flight data showed that the helicopter transitioned to a climb but that pitch attitude continued to increase steadily to 18° nose-up and the airspeed reduced to near zero. The nose-up pitch continued to increase, reaching 23.5° nose-up before recovery action was taken. In recovering from the pitch excursion, the helicopter reached a 36° nose-down pitch attitude with the subsequent high rate of descent being arrested approximately 50 ft. above the sea surface. The commander subsequently recovered the helicopter to normal flight parameters and established a climb to cruise altitude. The crew reported initial difficulties engaging autopilot modes during the climb, but normal functionality was recovered prior to a safe approach and landing.

1.2 About GA upper mode

When the commander engaged GA mode, it engaged as expected. Current airspeed (76 kt) became the autopilot speed target, with a vertical speed target of 1,000 ft/min up. As vertical speed increased towards the target and then exceeded it, collective and engine torque reduced, as would be expected. The GA mode remained engaged for 15 seconds before reverting to IAS and VS modes. However, as IAS decayed to zero, due to the aft cyclic inputs, the IAS mode disengaged automatically, being replaced with a basic attitude mode; the V/S mode remained engaged.

1.3 Lessons learned

- **Fly first:** The PF must concentrate on flying the aircraft. The PM must help the PF by monitoring flight parameters and by calling any excessive deviation or inadequate action from the PF.
- **When things don't go as expected, take over:** If the aircraft does not follow the desired flight path revert without delay from selected guidance to hand flying.
- **Use the correct level of automation for the task:** the correct level of automation often is the one the pilot feels the most comfortable with.
- **Practice task sharing and back up each other:** task sharing, effective cross-check and back up should be practiced in all phases of ground and flight operations
- **Understand your available and selected guidance at all times:** the PFD and NAVD are the prime interfaces for the aircraft to communicate with the flight crew, to confirm that the aircraft systems are correctly accepted the mode selections and targets entries.
- **Be aware of OEMs automation logic:** air crew having various OEM helicopter type ratings have to review and concentrate on each AFCS logic.
- **Communicate:** In the multi pilot operation it is crucial to articulate and confirm mode selections and aircraft responses, whether expected, or not to ensure situational awareness is maintained to the highest level

2. AUTOMATION: FRIEND OR FOE?

2.1 Statements

- Automation has greatly improved safety, comfort, and job satisfaction in many applications; however, it has also led to many problems" (Wickens)
- Automation does not simply replace human activity; automation changes human activity in planned and unplanned ways
- Many accidents are related to problems of human-automation interaction

2.2 Trust in automation

Trust is an important factor in human-automation interaction and strongly influences system performance (Sheridan, 2002).

- Automation Trust – firm faith in the integrity, ability, reliability or character of an aid (subjective)
- Automation Utilization - actual dependence upon an aid (objective)

A major factor in poor human-automation performance that is under a lot of investigation is trust in automation. As a fact, **Humans are bad at monitoring**. Crews need to trust in automation to use it properly however trust is a nonlinear process as follow:

- There is a nonlinear function of automation performance and dynamic interaction between operator and automation
- Negative experience weight more
- Initial experiences weight more
- Low reliability leads to rapidly declining trust
- Predictability of unreliability is also important: lower predictability leads to lower trust
- Recent research:when the automation gets "easy problems" wrong, less trust/reliance

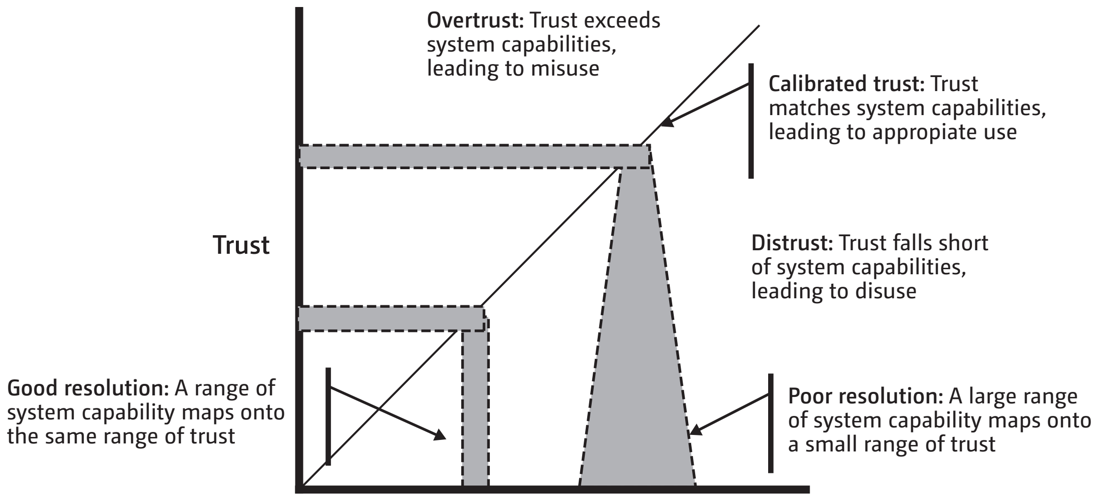


Fig 1: Automation capability

(Source: designing for Appropriate Reliance John D. Lee and Katrina A. See, University of Iowa, Iowa City, Iowa, September 4, 2003)

2.3 Basic performance model

Performance of a Man-Machine System basically depends on Design, Procedures, and Competences, which result from Education, Training, and Experience, and on the Environment (source EASA Automation Policy, Edition 2, 2013).

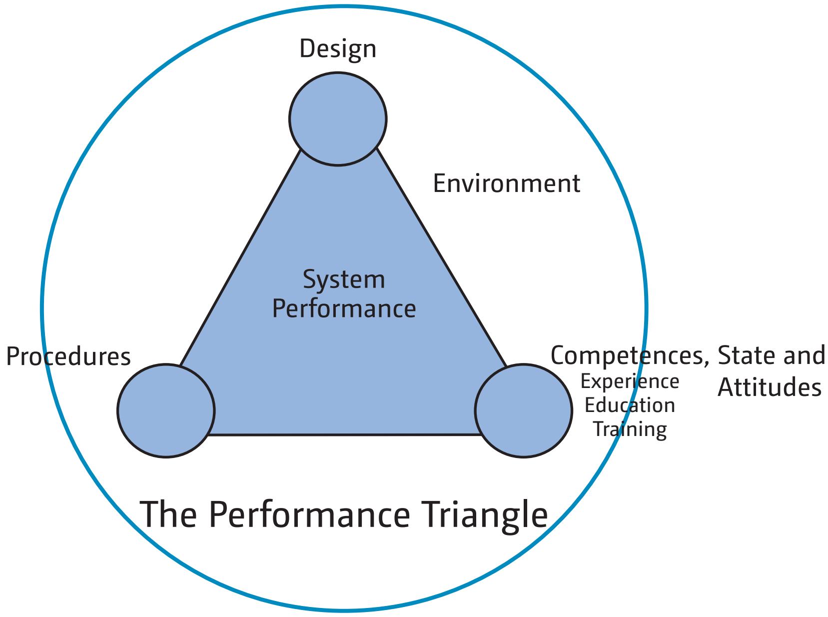


Fig 2: The performance triangle

The physiological and psychological state of the actor(s), for instance stress, fatigue, etc., attitudes, interest and involvement in the task also play a role.

The model illustrates that good (simple, intuitive, user-friendly) design requires less competences and/or procedural guidance (instructions) to be operated, and conversely that poor design requires more guidance and/or competences from the user.

The model also shows that identifying only one element of the system in case of performance breakdown is reductive and that overall system performance can by enhanced by improving any of these three basic components, individually or in combination.

2.4 *Level of automation*

Most light single engine helicopters fly without automation systems while modern medium/large helicopters are designed to be flown using the AFCS upper modes 4-axis to enhance safety and reduce pilots workload. Automation permits the benefit of AFCS protection improving error management by the crew. It's quite difficult to define the appropriate level of automation to be used, because it relies on many factors like weather conditions, environment, crew workload, crew training etc.

The level of automation used is generally the one adopted by the crew for the task or prevailing conditions.

Historically, the main automation stages from zero automation to advanced automation could be defined as follow:

2.4.1 No Automation

Most light single engine helicopters don't have automation (R22, R44, AS350, H130.) although as an option it's possible to put AFCS 2 or 3 axis in some helicopters. These types are predominately used for private flight, training or aerial work.

Without automation, a pilot needs to fly "hands on" all of the time. In this case, the direct access to flight controls (though servo assistance or not) helps the pilot 'feel' the aircraft and react accordingly especially for aerial work where precision is required (swing, hoist...). It is common practise for automated aircraft engaged in these precision hovering tasks to disengage automation to act directly on the rotors controls.

Flying "hands-on" all the time, especially under single pilot conditions, creates a significant workload which includes frequency changes, referencing to charts, calculating performance etc... This is of course acceptable given the role in a small geographic area but for en route navigation having an attitude retention system will reduce that workload.

2.4.2 Stability Augmentation System (SAS)

Stability Augmentation Systems (SAS) provide **short-term rate damping** control inputs to increase helicopter stability. Like trim systems, SAS requires "hands-on" flying.

Attitude Retention Systems (ATT) returns the helicopter to a selected attitude after a disturbance. Changes in attitude can be accomplished usually through a four- way "beep" switch or by actuating a "force trim" switch on the cyclic, which re-sets the desired attitude manually. Attitude retention may be part of a SAS system or may be the basic "hands off" autopilot function.

The simplest of these systems is a force trim system, which uses a magnetic clutch and springs to hold the cyclic control in the position where it was released. More advanced systems use electric servos that actually move the flight controls. These servos receive control commands from a computer that senses helicopter attitude.

In some modern helicopters, in case of failure of the two AP processing units, to ensure minimum helicopter stability, a back-up SAS automatically takes over the control of the series actuators. This function could be performed by a stand-alone instrument using its own referencing gyros and SAS control laws.

However, this level of piloting assistance still requires frequent pilot corrections, therefore it is no surprise the requirement for higher levels of piloting assistance emerged, as early as in the 1960s.

2.4.3 Basic stabilization mode with AFCS

The basic stabilization mode is performed by the AFCS on Pitch, Roll and Yaw axes through series and parallel actuators:

- The pitch and roll axis: holds the attitudes defined by the pilot or the current one upon engagement
- The yaw axis: either holds the heading in hover or at low speed, or provides turn coordination in cruise flight

It is the basic stabilization providing **long term attitude retention** on the pitch and roll axes to minimize workload and loads on the flight controls. It is a “hands-on” function, meaning that the pilot must have ’hands on’ the flight controls and make any necessary adjustment to maintain the desired helicopter’s flight path or speed which also depends on the actual collective setting to provide sufficient power.

Some useful tips to consider:

- When the desired cyclic stick position is selected in order to maintain the flight path, use beep trim for small adjustments and trim release for significant attitude changes
- In cruise flight, free pedals allows AFCS to counteract drift
- Roll inputs to maintain a desired bank angle should generally be achieved by applying force against the cyclic stick only. (ie do not trim into a turn). In this way the cyclic will return to the wings level in the event of an undesired aircraft state. It is recognized that some types may have significant ‘break out’ forces and trimming into the turn maybe the best practical option.
- When possible, use upper mode stabilization to reduce pilot’s work load

2.4.4 Upper mode 3-axis

For all upper modes, the use of 4 axis compared to 3 axis is a recommended practice in order to decrease the pilot’s workload. Some functions may be very helpful in critical situation and by the way increase flight safety.

In upper mode 3-axis, the upper modes command the cyclic but the collective pitch must be controlled manually (hands-on). So, no collective modes are indicated on AFCS strip.

Autopilot Systems (APs) provide for “hands off” flight for the cyclic only along specified lateral and vertical paths. The functional modes may include heading, altitude, vertical speed, navigation tracking, and approach. APs typically have a control panel for mode selection and indication of mode status. APs typically control the helicopter about the roll and pitch axes (cyclic control) but also include yaw axis (pedal control).

This means vertical and lateral modes can be engaged at the same time but the pilot needs to adjust power to maintain the speed by managing the collective lever. This point is often confusing for pilots. Monitoring the AFCS strip is the only way to be sure of the AFCS upper modes status.

However, for those systems that have 4 axis APs, sometimes it's useful to fly in 3-axis only when experiencing turbulent conditions or when performing engine power checks for example. So, the pilot can revert from 4 axes to 3 axes just for the time where upper mode 3-axis is needed.

With some modern helicopters, AFCS upper modes switch automatically from 3 axes to 4 axes to decrease pilot's workload and increase safety (for example, in case of engine flame-out or if the speed decrease below Vy without any action of the pilot on the collective lever or close to the ground).

It is imperative that when flying in pitch and roll 3-axis for a pilot must continue to fly the collective lever. The basics of helicopter flight must be mentally applied at all times, especially if changing speed or altitude, as the loss of attention to a low power setting could result rapidly in a low speed condition. It is recommended that keeping a hand on the collective lever will ensure that a pilot has the best chance of remaining in the 'loop' with the selected power setting.

2.4.5 Upper mode 4-axis

In upper mode 4-axis: the upper modes command the cyclic and collective pitches; the pilot can hence fly completely "hands off", however pilot attention is still required near the ground.

Autopilot Systems (APs) provide for "hands off" flight along specified lateral and vertical paths. The functional modes may include heading, altitude, vertical speed, navigation tracking, and approach. APs typically have a control panel for mode selection and indication of mode status. APs typically control the helicopter about the roll and pitch axes (cyclic control) but also include yaw axis (pedal control) and collective control servos.

However, those higher levels of assistance raise the question of their compatibility with pilot actions. Taking the example of the roll attitude hold, such function would attempt to counteract the pilots roll input every time he tried to enter a turn. Consequently most flight assistance functions beyond the stability augmentation detect the pilot actions so that the AFCS can automatically revert to adapted pilot follow-up functions.

Traditionally, these pilot follow-up functions were called “hands-on/feet-on” functions, “fly-through” or “transparency” or “override” modes. All these denominations conveyed the idea that the AFCS was supposed to interrupt its longer term hold function, upon pilot action detection, to momentarily replace it by some short term pilot assistance.

According to the design of some AFCS, the long term attitude is regained after a delay from “hands-on” to “hands-off”, which pilots have to take into consideration.

3. OPTIMUM USE OF AUTOMATION

3.1 Design Objective

The design objective of the AFCS is to provide assistance to the crew throughout the flight (within the normal flight envelope), by:

- Relieving the PF from routine handling tasks and thus allowing time and resources to enhance his/her situational awareness or for problem solving tasks; or
- Providing the PF with adequate attitude and flight path guidance through the FND, for hand flying

The AFCS provides guidance to capture and maintain the selected targets and the defined flight path, in accordance with the modes engaged and the targets set by the flight crew on the Auto Pilot Control Panel (APCP) or on the Flight Management System (FMS).

The APCP and the control sticks constitute the main interface between the pilot and the AFCS for short-term guidance (i.e., for immediate guidance).

The FMS constitute the main interface between the pilot and the Automatic Flight Control System (AFCS) for long-term guidance (i.e., for the current and subsequent flight phases).

3.2 Understanding Automated Systems

Understanding any automated system, but particularly the AFCS and FMS, ideally would require answering the following fundamental questions:

- How is the system designed?
- Why the system is designed this way?
- How does the system interface and communicate with the pilot?
- How do you operate the system in normal and abnormal situations?
- What are the automatic protections provided by the system and when they may be degraded?

The following aspects should be fully understood for optimum use of automation:

- Integration of AFCS modes on the FND/NAVD (i.e., pairing of modes)
- Mode transition and reversion sequences
- Pilot-system interfaces for:
  - ✓ Pilot-to-system communication (i.e., for target selections and modes engagement)
  - ✓ System-to-pilot feedback (i.e., for cross-checking the status of modes and the accuracy in guiding the helicopter to targets and active monitoring of controls)

3.3 Flight crew/system Interface

For any action on the APCP or FMS to give a command to the AFCS, the pilot has an expectation of the aircraft reaction and, therefore, must have in mind the following:

- What do I want the aircraft to fly now?
- What do I want the aircraft to fly next?

This implies answering also the following questions:

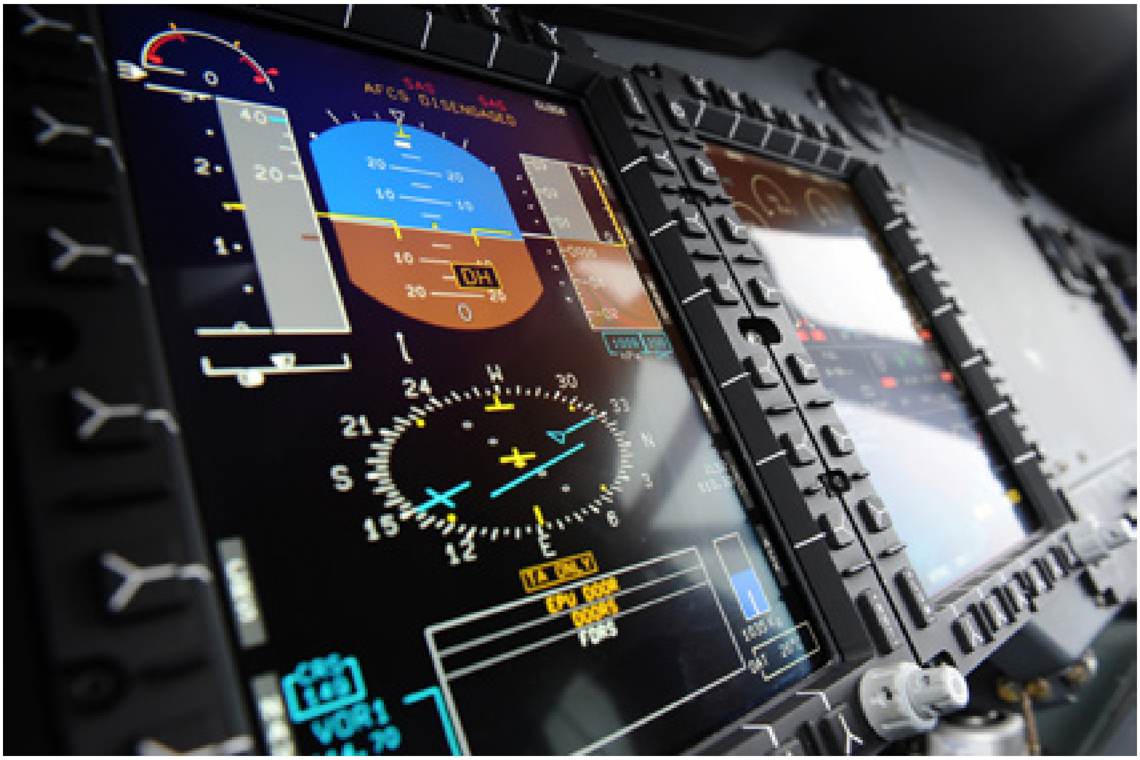
- Which mode should I engage and which target did I set for the aircraft to fly?
- Is the aircraft following the intended vertical and lateral flight path and targets?
- Which mode did I arm and which target did I preset for the aircraft to fly next?

In order to answer the above questions, the key role of the following controls and displays must be understood:

- AFCS mode selection-keys, target-setting knobs and display windows
- FMS keyboard, line-select keys, display pages and messages
- Flight modes annunciator (FMA) on PFD
- PFD and NAVD displays and scales (i.e., for cross-checking guidance targets)

The effective monitoring of these controls and displays promotes and increases the flight crew awareness of the available guidance for flight path and speed control:

- Status of the autopilot system (i.e., modes being engaged or armed)
- Active guidance targets



3.4 Operational and human factors affecting the optimum use of automation

The following operational and human factors are often observed in incidents and accidents in which the use of automation is identified as a causal factor:

- Intimidation (i.e., non-interaction with or late takeover from automation when needed)
- Overconfidence / overreliance (i.e., excessive delegation)
- Complacency (i.e., passive attitude, lack of active supervision)
- Inadvertent arming or engagement of an incorrect mode
- Failure to verify the effective arming / engagement (on the FMA) of the modes armed or engaged
- Selection of an incorrect target (altitude ALT, speed IAS, heading HDG, radial, course CRS, track, flight-path angle FPA, …) on APCP and failure to confirm the selected target by cross-checking the related target symbol on the PFD and/or NAVD
- Insertion of an erroneous waypoint on the FMS
- Arming of the lateral navigation mode with an incorrect active waypoint (i.e., an incorrect TO waypoint)
- Focusing on the FMS during a critical flight phase, with consequent loss of situational awareness
- Insufficient understanding of mode transitions and mode reversions (i.e., mode confusion, automation surprise)
- Untimely override action interfering with automation
- Inadequate task sharing and/or CRM practices preventing the PF from monitoring the flight path and airspeed (e.g., both pilots being engaged in the management of automation or in solving an unanticipated situation or abnormal condition)
- Engaging the upper modes with the aircraft in an incorrect trim attitude or in an out-of-trim condition
- Inadvertent double mode selection (non-selection of the mode) without FMA confirmation
- Failure to arm the approach mode
- Failure to set the correct final approach course

3.5 Summary of key points

For optimum use of automation, the following should be promoted:

- Understanding the integration of upper modes
- Understanding all mode transitions and reversion sequences
- Understanding pilot-system interfaces for:
  - ✓ Pilot-to-system communication (i.e., for modes engagement and target selections)
  - ✓ System-to-pilot feedback (i.e., for modes and targets cross-check)

- Awareness of available guidance (modes armed or engaged, active targets)
- Alertness to adapt the level of automation to the task and/or circumstances, or to revert to hand flying, if required
- Adherence to design philosophy and operating philosophy, SOPs and Golden Rules for Pilots

4. AUTOMATION BASIC PRINCIPLES

4.1 Introduction

In early aviation days, the Operating *Golden Rules*[1] *were* defined as the principles of basic airmanship. With the development of modern-technology aircraft and with research on man-machine-interface and crew-coordination, these *Golden Rules* have been broadened to encompass the principles of interaction with automation and CRM/TEM. In this Leaflet the "Golden Rules" are called Automation "Basic Principles"

The Basic Principles assist trainees in maintaining their basic airmanship as they progress to increasingly integrated and automated aircraft models. Although developed for trainees, the Basic Principles are equally useful for experienced pilots. Basic Principles address aspects that are considered frequent causal factors in incidents and accidents, e.g.:

- Inadequate situational / positional awareness
- Incorrect interaction with automation
- Overreliance on automation
- Ineffective crew cross-check and mutual backup

4.2 General Basic Principles

4.2.1 Automated aircraft can be flown like other aircraft

To promote this rule, each trainee should fly the simulator just using basic autopilot (yaw/roll, pitch and collective) without upper modes.

The use of upper modes and the flight management system (FMS) (normal, degraded) with the protections of the AFCS should be introduced progressively, as defined by the applicable training syllabus.

Practice of hand flying will illustrate that the pilot flying (PF) always retains the authority and capability to adopt:

- A more direct level of automation; or revert to
- Hand flying, directly control of the aircraft trajectory and power setting

4.2.2 Fly, Navigate, Communicate and Manage - in that order

Task sharing should be adapted to the prevailing situation (i.e., task sharing for hand flying or with upper modes engaged, task sharing for normal operation or for abnormal / emergency conditions, as defined in the applicable operation manual) and tasks should be accomplished in accordance with the following priorities:

[1] Automation Golden Rules were developed by Airbus

- **Fly (Aviate):**

PF must concentrate on flying the aircraft (i.e., by controlling and/or monitoring the pitch attitude, bank angle, airspeed, power, sideslip, heading,...) to capture and maintain the desired targets, vertical flight path and lateral flight path.

PM must assist the PF by monitoring flight parameters and by calling any excessive deviation.

- **Navigate:**

Select the desired modes for vertical navigation and lateral navigation (i.e., by selecting the modes on APCP and/or on FMS-managed navigation) and being aware of surrounding terrain and minimum safe altitude (MSA).

This rule can be summarized by the following three "know where..." statements of situational-awareness:
- ✓ Know where you are
- ✓ Know where you should be
- ✓ Know where the terrain and obstacles are

FMS Common errors	Possible consequences	Recommendation
Both pilots programming the FMS in low workload phase at the same time (for instance, en-route)	Loss of SA	One head up at all times
Preoccupation with FMS programming during critical phases	Loss of SA and degraded communication	Anticipate FMS programming and cross check FMS inputs Include the FMS into the sterile cockpit phases of flight.
Late FMS reconfiguration approaching IAF (e.g. following change of runway in use)	Reaching IAF with the inappropriate active FMS coupled navigation	Avoid late reconfiguration, revert to an aircrew selected guidance with the use of raw data
Entering or selecting a wrong waypoint in the FMS	Confusion and CFIT	Confirm user waypoint positions on NAVD and cross check them with fixed map locations such as airports and beacons and against raw data.

- **Communicate:**

SOP Standard calls should be developed by operators and defined for cockpit crew / cabin crew communications in both:
- Normal conditions (departure and arrival)
- Abnormal or emergency situations (e.g., on-ground emergency / evacuation, crew incapacitation, forced landing or ditching, etc.)

Effective crew communication involves communications between flight crew and controller, and between flight crew members.

Effective communication allows sharing of goals and intentions and enhancing crew's situational awareness. A thorough crew briefing should be conducted before any approach or complex event and must include the use of automation.

Use of SOP standard calls is of paramount importance for optimum use of automation (i.e., for awareness of arming or engagement of modes by calling FMA changes, target selections, FMS entries):

- The standard calls should trigger immediately the question "what do I want to fly now?", and thus clearly indicates:
  - ✓ Which target the pilot wishes to set
  - ✓ Which mode the pilot wishes to arm or engage

- When the pilot's (PF) intention is clearly transmitted to the other pilot (PM), the standard call will also:
  - ✓ Facilitate the cross-check of the FMA and PFD/NAVD, as applicable
  - ✓ Facilitate the cross-check and backup between both pilots

- **Manage:**

Managing the continuation of the flight is the next priority, this includes:

- ✓ Trajectory and flight path,
- ✓ Aircraft systems (e. g., fuel management, diversion management, etc.)
- ✓ Emergency and/or abnormal procedure(s)

The design of glass-cockpit aircraft fully supports the above four-step strategy, as summarized in the table hereafter

Basic Principles	Display Units
Fly	PFD
Navigate	NAVD
Communicate	COM/NAV systems
Manage	CAS, FMS

4.2.3 One head up at all times
System management, like with the FMS is particularly time consuming. Safe flying practices require effective monitoring of control (loss of control), navigation (CFIT), communication and visual awareness (anti-collision).

This requires a strict crew coordination application of the one head up/one head down concept.

Significant changes to the FMS flight plan should be performed by the PM and then cross-checked by PF.

4.2.4 Cross check the accuracy of the FMS with raw data
When within the Navaids coverage area, FMS navigation accuracy should be cross-checked against navaid raw-data (unless aircraft is GPS-equipped)

FMS navigation accuracy can be checked by:
- Entering a tuned VOR-DME in the bearing/distance field of the appropriate FMS page
- Comparing the resulting FMS DIST TO reading with the DME distance read on the PFD/NAVD

If the required FMS navigation accuracy criteria are not achieved, revert from the NAV mode to selected heading mode with the reference to Navaids raw-data.

4.2.5 Know your guidance at all times

The APCP, control sticks and the FMS are the prime interfaces for the flight crew to communicate with the aircraft systems (i.e., to set targets and arm/disarm or engage/disengage modes).

The PFD, particularly the Flight Mode Annunciator (FMA), and NAVD are the prime interfaces for the aircraft to communicate with the crew, to confirm that the aircraft systems have correctly accepted the flight crew's mode selections and target entries.

At all times, the PF and PM should be aware of:

- Modes armed or engaged
- Guidance targets set
- Aircraft response in terms of attitude, speed and trajectory
- Mode transitions or reversions

4.2.6 When things don't go as expected: take over

If doubt exists regarding the aircraft flight path or speed control, the flight crew should not try to reprogram the automated systems immediately and lose focus on flying the aircraft.

The flight crew should use Selected Guidance or hand flying together with the use of Navaids raw data, until time and conditions permit a reprogramming of the APCP or FMS.

If the aircraft does not follow the intended flight path, check the upper modes engagement status.

If possible disengage the upper mode causing doubt, and fly that particular mode manual or use a similar mode (e.g. initially from NAV to HDG if the helicopter seems to follow the wrong track)

If still in doubt or if the response is not relevant, disconnect the upper modes using the associated disconnect push button(s) on APCP or on the cyclic stick, to revert to hand flying (with reference to raw data).

Upper modes shall not be overridden manually.
If upper mode operation needs to be overridden (i.e., avoidance or fast speed up), immediately disconnect the affected system by pressing the associated disconnect push button. If possible, re-engage partially or fully the upper modes in respect of CRM and MCC SOPs or procedures taking in account single or multi-pilot operations.

If the aircraft does not follow the desired vertical flight path / lateral flight path or the selected targets, and time does not permit analysing and solving the observed behaviour, communicate and revert without delay from:

- FMS guidance to selected guidance
- Selected guidance to hand flying

4.2.7 Use the correct level of automation for the tasks

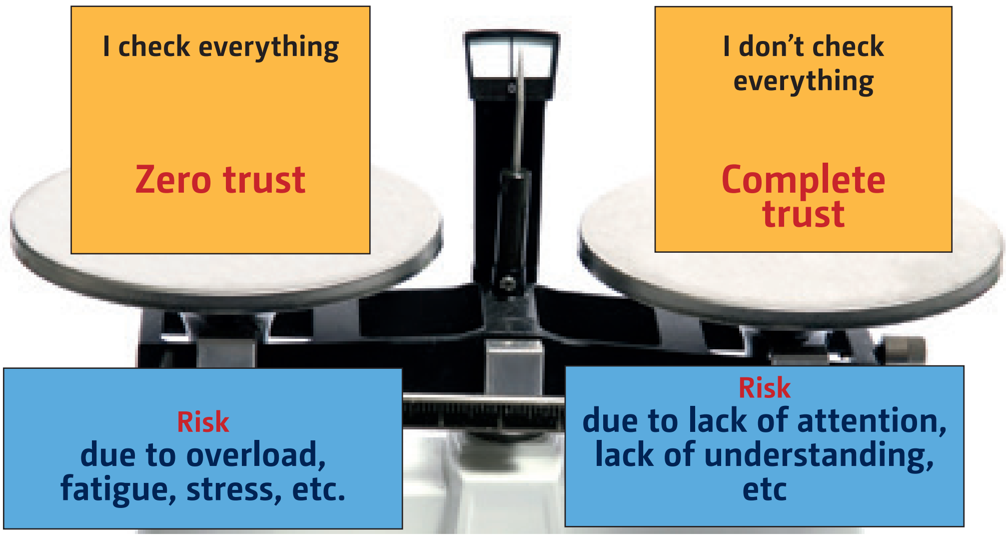
The appropriate level of automation is usually the one the pilot feels comfortable with for the task or for the prevailing conditions, depending on his/her own knowledge and experience of the aircraft and systems.

Reversion to hand flying may be the appropriate level of automation, depending on the prevailing conditions.

The PF always retains the authority and capability to select the most appropriate level of automation and guidance for the task, this includes:

- Adopting a more direct level of automation by reverting from FMS-managed guidance to selected guidance (i.e., selected modes and targets)
- Selecting a more appropriate lateral or vertical mode

Reverting to hand flying for direct control of aircraft vertical and lateral trajectories



4.2.8 Practice task sharing and back up each other

Task sharing, effective cross-check and backup should be practiced in all phases of ground and flight operations, in normal operation or in abnormal / emergency conditions.

Emergency, abnormal and normal procedures (i.e., normal checklists) should be performed as directed by the QRH.

4.3 Normal operation Basic Principles

4.3.1 Electing automation

During line operations, upper modes should be engaged throughout the flight, especially in marginal weather conditions or when operating into an unfamiliar site or with passengers on board.

When operating in good environmental conditions, flight crew can elect to fly manually to maintain flying skills.

In highly automated aircraft, it's important to ensure that the upper modes have been set up and engaged correctly. Both crew members should be involved:

- Preset the parameter using APCP
- Crosscheck the setting
- Engage or arm the AFCS mode
- Check the correct modes are engaged/armed on the FMA
- Call when the armed mode changes to engaged or disarmed
- Call when engaged mode changes to disengaged
- Monitor aircraft response is as anticipated

It is quite permissible for the PM to set up and engage the modes on the PF instruction.

4.3.2 Engaging automation

Before engaging the upper modes, ensure that modes engaged are set at the desired preselected datum's; if not, select the appropriate mode(s).

4.3.3 Interfacing with automation

When interfacing with automation, for modes arming / selection and for guidance targets entries, adhere to the following rules-of-use (rules derived from the lessons-learned from the operational and human factors analysis of operational events):

- Be aware of who is in charge: PF hands-on **or** automation with PF close to controls (PF/PM monitoring automation)
- Before any action on APCP or control sticks, check that the knob or push button is the correct one for the desired function
- After each action on APCP or control sticks, verify the result of this action on the FMA and on the PFD/NAVD
- Announce all changes in accordance with Standard Calls as defined in the SOPs
- During descent, ensure that the selected altitude is not to below the MEA or MSA
- Prepare the FMS for arrival before starting the descent; Reprogramming the FMS during a critical flight phase (e.g., on final helideck approach or EMS site) is not recommended, except to activate the secondary flight plan, if prepared, or for selecting a new approach
- In case of a routing change (e.g., DIR TO), cross-check the new TO waypoint before activating the DIR TO (i.e., making sure that the intended TO waypoint is not already behind the aircraft)
- Before engaging the NAV mode, ensure that the correct active waypoint (i.e., TO waypoint) is displayed on the FMS and NAVD

- Before arming the APPR mode, ensure that the ILS has been correctly tuned and identified, and that the aircraft:
  - ✓ Is within the ILS capture envelope (LOC and G/S deviation symbols correctly displayed)
  - ✓ Is on a LOC intercept heading
  - ✓ Has been cleared for approach

4.3.4 Supervising automation

Supervising automation is observing cockpit displays and indications to ensure that the aircraft response matches your mode selections and guidance target entries, and that the aircraft attitude, speed and trajectory match your expectations, i.e.:

- During capture phases, observe the progressive centering of deviation symbols (i.e., during localizer and glideslope capture)

Enhance your monitoring of the automation during capture phases – and crosscheck with raw data, as applicable - enables the early detection of a false capture or of the capture of an incorrect beam (e.g., ILS in maintenance mode emitting a permanent on-glideslope signal);

- Do not attempt to analyse or rectify an anomaly by reprogramming the FMS, until the desired flight path and/or airspeed are restored
- In case of upper modes un-commanded deselection,engage the second source of navigation before attempting a re-selection (e.g. ILS 2 if ILS 1 have been previously selected) to reduce PF's workload; or fly the aircraft manually until the aircraft is maintained / re-established on the correct flight path and time allows for trouble-shooting and re-programming

- At any time, if the aircraft does not follow the desired flight path and/or airspeed, do not hesitate to revert to a more direct level of automation, i.e.:
  - ✓ Revert from FMS-managed modes to selected modes
  - ✓ or, Disconnect upper modes
  - ✓ or, Hand fly the aircraft, using raw data or visually (if in VMC)

4.4 Specific Basic Principles for Abnormal and Emergency Conditions

The following additional principles may assist flight crew in their decision making when in an abnormal or emergency condition and also when faced with a condition or circumstance that is beyond the scope of published procedures.

4.4.1 Understand the prevailing condition before acting

Incorrect decisions often are the result of an incorrect recognition and identification of the actual prevailing condition.

4.4.2 Assess risks and time pressure

Take time to make time, by:

- Delaying actions, when possible (e.g., during takeoff and final approach); and/or
- Requesting entering a holding pattern or requesting delaying vectors (as appropriate)

4.4.3 Review and evaluate the available options

Consider weather conditions, crew preparation, airfield proximity and self-confidence when selecting the preferred option.

Include all flight crewmembers, ATC, as required, in this evaluation (as applicable).

Consider all implications before deciding and plan for contingencies.

4.4.4 Match the response to the situation

An emergency condition requires an immediate action (this does not mean a rushed action) whereas abnormal conditions may allow a delayed action.

4.4.5 Manage workload

Use the correct level of automation for the task and circumstances. The use of selected guidance when appropriate will significantly decrease the workload generated by the abnormal/emergency situation.

4.4.6 Apply recommended procedures and other agreed actions

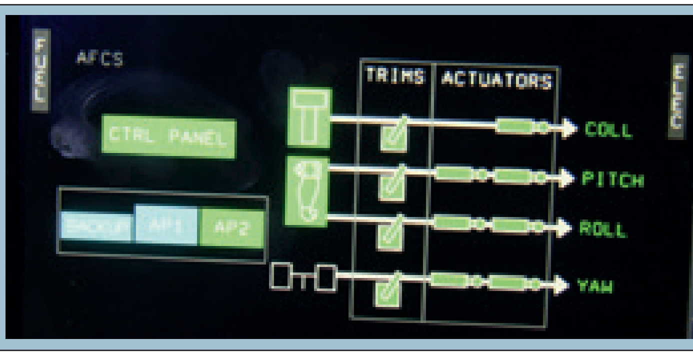
Understand the reasons and implications of any action before acting and check the result(s) of each action before proceeding with the next step.

Beware of irreversible actions (i.e., apply strict confirmation and cross-check before acting).

Pilots must refer to manufacturer automation policies, rotor flight manuals and other reference documents which will bring OEM specific information.

EHEST Component of ESSI — European Helicopter Safety Team

AUTOMATION BASIC PRINCIPLES



EHEST Component of ESSI — European Helicopter Safety Team

BASIC PRINCIPLES

1	Automated helicopters can be flown like any other helicopter
2	Fly, Navigate, Communicate- In that order
3	One head up at all times
4	Cross check the accuracy of the FMS
5	Know your FMA at all times
6	When things don‘t go as expected- Take over
7	Use the proper level of automation for the task
8	Practice task sharing and back-up each other

REFERENCES

EASA Safety Information Bulletin (SIB) No. 2010-33R1 Automation Policy - Mode Awareness and Energy State Management, issued 26 June 2015.

EASA Automation Policy Bridging - Design and Training Principles, May 2013.

Flight Operations Briefing Notes Airbus/Standard Operating Procedures/Optimum Use of Automation, July 2006.

Flight Operations Briefing Notes Airbus/Standard Operating Procedures/Operating Philosophy, September 2006.

Flight Operations Briefing Notes Airbus/Standard Operating Procedures/Operations Golden Rules, January 2004.

Flight Operations Briefing Notes Airbus/Standard Operating Procedures/Standard Calls, March 2004

ICAO circular 234-AN/142, operational implications of automation in advanced technology flight decks, 1992.

EASA Safety Information Bulletin (SIB) No. 2010-33R1 Automation Policy - Mode Awareness and Energy State Management, issued 26 June 2015.

APPENDIX 1

EASA has published different SIBs for airplanes and number of recommendations can be adapted as follows:

Air operators are encouraged to provide an Automation Policy based on the company culture, aircraft fleet and the type of operations.

The Automation Policy should be integrated in the Operations Manual, which should contain flight procedures. One of these procedures should be related to the use of autopilot and all relevant automation systems.

It is recommended that operators prepare their Automation Policy in cooperation with helicopter manufacturers. The Automation Policy should address in particular the following topics:

- Philosophy
- Levels of automation
- Situational awareness
- Communication and coordination
- Verification
- System and crew monitoring
- Workload and system use

Core philosophy is “**FLY THE AIRCRAFT**”. This principle should form the basis of the Automation Policy.

Ensure that each Automation Policy topic is regularly reinforced in the operating procedures, including flight manual emergency procedures, and in training programmes, and regularly review the Automation Policy and related operating procedures for continuous safety improvement.

APPENDIX 2

<u>Note for readers:</u> The scenario described below is based on the use of H225 automation. For more accurate information refer to H225 FCOM.

It is not possible to make a generic scenario for the use of automation because each aircraft has its own design with specific upper modes and protections associated. Therefore, it is possible to understand the general philosophy of interacting with automation according to the flight phases.

Each operator should develop their own automation SOP's. The following scenario might help to achieve this goal.

Example scenario

- Take off using CAT A profile and performance class 1 from an airfield with a ceiling at 300 ft, visibility 500m, wind 320/10 kt, in rain
- SID:climb runway heading to 3000 ft AMSL
- En route to off-shore platform
- Landing on off-shore platform using Airborne Radar Approach (ARA)
- Take off from off-shore platform
- Come back to airfield, radar vectoring to ILS

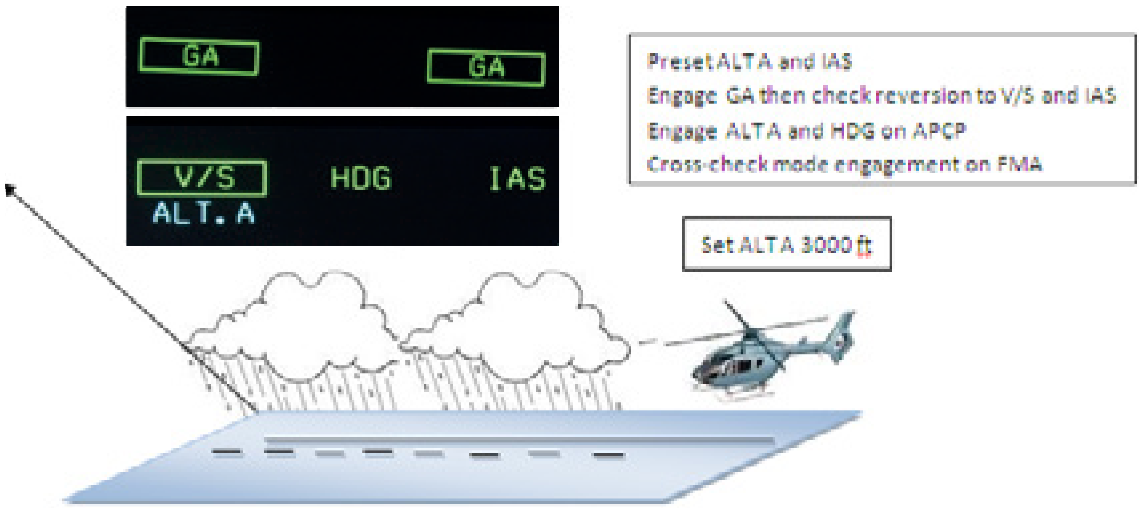
Take-off phase

The upper modes to be preset before takeoff are IAS and altitude acquire-ALT A. After take-off, before engaging ALT A, the setting shall be checked to ensure that no change has been made to the pre-selection. Make sure that the ALTA displayed on PF and PM side is consistent. PF/PM must monitor the climb/descent until the aircraft is steady at the desired altitude and perform calls before reaching the required altitude to check ALT engagement and subsequent aircraft response.

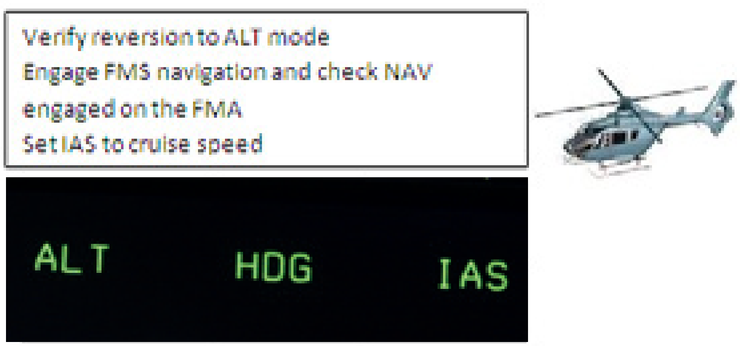
At take-off and departure, whatever the presets are, for modes engagement the priority should be given to vertical and longitudinal modes by engaging the GA mode. Then, at the appropriate time, lateral mode should be engaged.

For engaging lateral and vertical modes after take-off the recommended procedure is using the collective GA pushbutton. It permits to fly hands-on managing priority between vertical and lateral modes and avoiding mistakes at V/S and IAS presetting.

Phase of flight	PF Duties	PM duties
Before T/O	Preset ALTA and IAS	Check set values
After passing TDP	engage GA and keep hands near controls (below 200 ft), set required collective pitch to ensure MTOP is attained	Call "GA engaged" on collective and pitch Check reversion to V/S on collective and IAS on pitch
When establish in climb	confirm ALTA presetting, then press ALTA, engage lateral mode (HDG or NAV)	call "ALTA armed" call "HDG or NAV engaged"



Cruise flight



The standard cruise power setting for the H225 is Maximum Continuous Power (MCP) flying coupled in 4 axes. This allows the system to control power so as to prevent over torqueing (for example in the event of icing).

In turbulent conditions with more than a very occasional activation of the over torque gong, reduce IAS in order to avoid any power transient range incursion until the turbulence has subsided.

Otherwise, in cruise flight, disengage IAS, and apply desired power (in case of OEI, the system will revert automatically in four axis mode).

Approach to offshore platform using ARA

· Use of AFCS longitudinal modes

The entire flight shall be flown with IAS engaged and preferably managed by the PF through cyclic beep trim. Within 2nm the minimum IAS should be 60kts and maximum Ground Speed should be 70kts.

· Use of AFCS lateral modes

It is permissible to couple the aircraft to the FMS until the **O**ffset **I**nitiation **P**oint (OIP) is reached (1.5 nm) but the flight path must be monitored using weather radar and NDB (where appropriate). The NAV (FMS) mode must be reverted to HDG if the flight path deviates from the desired FAT

· Use of AFCS vertical modes

Crews shall use ALT.A whenever descending to a cleared or previously announced altitude or MDH and both pilots shall cross-check that the correct settings have been made. If necessary, in order to manage a continuous descent, V/S should be adjusted using the collective trim. (Vertical speed is not adjustable with CR.HT mode engaged)

The ALT.A shall be set to the MDH or rounded to the nearest 50 feet above (e.g. ALT.A set at 650 feet for MDA at 620 feet). If necessary, once ALT has been captured, the ALT index may be adjusted with the collective beep, preferably by the PF.

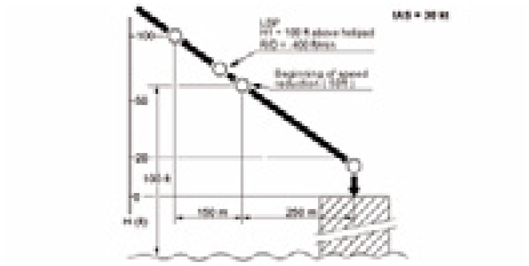
· Use of AFCS after reaching Offset Initiation Point (OIP) to MAP

Before reaching OIP, active modes are ALT, ANAV or HDG and IAS. At the latest, by OIP PM shall engage HDG. It is recommended to maintain modes engaged while maintaining visual cues allowing a transition to manual flight for a safe landing.

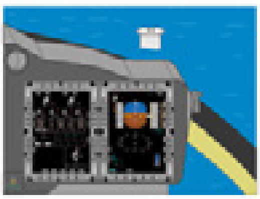
On FMS, creating a discontinuity on the leg or an alternate route could help in case of missed approach.

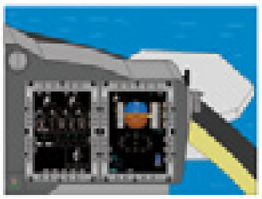
· Use of AFCS for landing

Manoeuvring from the MAP to the helideck shall be managed using 4 axes upper modes with ALT-HDG-IAS engaged. Adjust ALT, HDG & IAS through beep trims while maintaining visual cues allowing transition to manual flight for a safe landing.



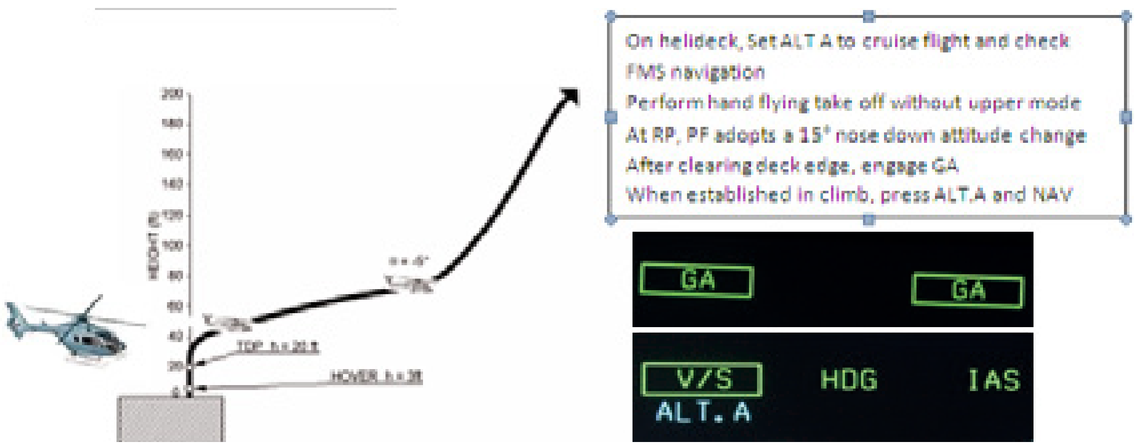
Set ALT A to MDH, Cross-check mode engagement on FMA
From OIP to MAP: Cross check ALT, HDG and IAS upper modes engaged
From MAP to helideck: when visual cues are obtained, disengage upper modes, hand flying





Phase of flight	PF Duties	PM duties
Before OIP	Preset IAS (not below 60 kt) and ALTA (MDH) arm ALTA	Check set values Call "ALTA armed" Check reversion to ALT Call "ALT engaged"
From OIP to MAP	Engage HDG	Call "HDG engaged"
From MAP to helideck	When visual cues obtained, disengage upper modes	Call "upper modes disengaged"

Taking off from offshore platform



At takeoff and departure, whatever presets are, for modes engagement the priority should be given to vertical and longitudinal modes by engaging the GA mode. Then, at the appropriate time, lateral mode should be engaged.

For engaging lateral and vertical modes after take-off the recommended procedure is using the collective GA pushbutton. It permits to fly hands-on managing priority between vertical and lateral modes and avoiding mistakes at V/S and IAS presetting.

Phase of flight	PF Duties	PM duties
Before T/O	Preset IAS and ALT.A	Check set values
In hover at 5 feet, rotor tips at the edge of the helideck	Engage GSPD	Call “GSPD engaged”
T/O (vertical climb between 400 and 500 feet per minute)	At Rotation Point (RP) adopt a 15° nose down attitude change, after clearing deck edge, press GA and keep hands near controls (below 200 feet) to ensure proper nose down attitude and MTOP are attained	Call “GA engaged” on collective and pitch Check reversion to V/S on collective and IAS on pitch
Established in climb	press ALT.A, and engage lateral mode (HDG or ANAV)	Call “ALT.A armed” Call “HDG or ANAV engaged”

ILS Approach

· Use of AFCS vertical modes

Crews shall use ALT.A whenever descending to a cleared or previously announced altitude or flight level and both pilots shall cross-check that the correct settings have been made.

Crew shall use ALT.A to manage the descent to MSA then to the altitude required to intercept ILS. If necessary, once ALT has been captured, the ALT index may be adjusted for changes less than 300' with the collective beep, preferably by the PF.

· Use of AFCS lateral modes

The arrival, holding pattern, navigation to IAF and missed approach should be flown NAV coupled to the FMS database.

· Use of AFCS longitudinal modes

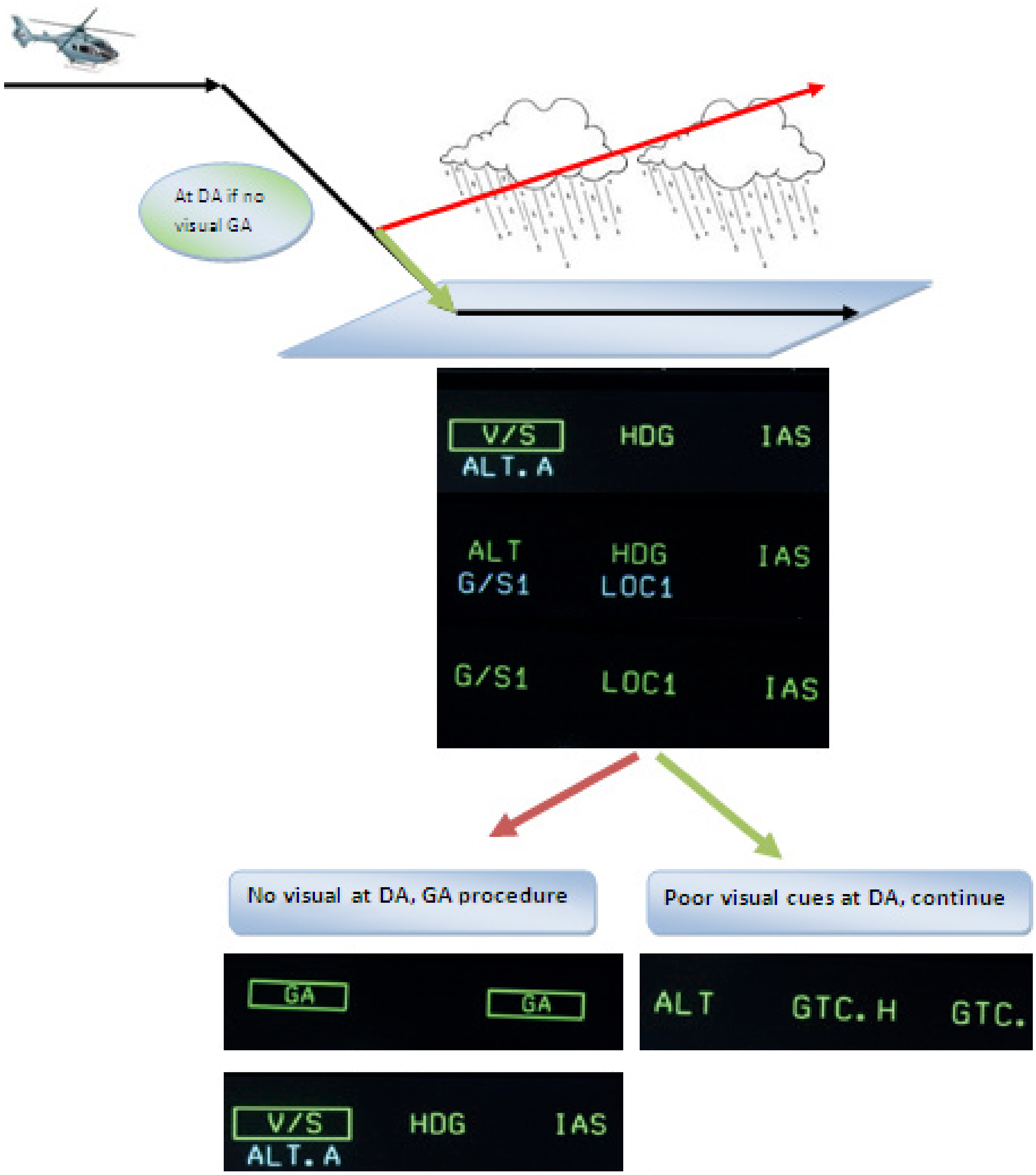
The entire approach shall be flown with IAS engaged. For final approach, without any ATC request, the recommended IAS is 100 knots on a CAT A approach and 90 knots on a CAT H approach.

· Use of AFCS after reaching DA for straight in landing

When reaching DA, active modes are GS, LOC and IAS. The aircraft is generally close to the ground and visual references are confirmed. Nevertheless, since the pertinent parameter is the RVR, a Degraded Visual Environment (DVE) is possible with associated poor situation awareness. Consequently, it is recommended to maintain modes engaged, reducing IAS to approximately 40 knots at 100 feet through cyclic beep trim while maintaining visual cues allowing a transition to manual flight for a safe landing.

In very poor visual environment (heavy rain, night, etc.), fly GS, LOC and IAS until approaching 80 feet. At a vertical speed dependent altitude above 80 feet the ALT mode engages automatically to reach level flight at 80 feet AGL. Fly ALT, LOC and IAS, ALT mode can be managed to 30 feet AGL (minimum ALT setting) using the collective beep trim. It is also possible to engage GPSD, to manage hover automatic acquisition.

Phase of flight	PF Duties	PM duties
Before IAF	Preset ALT.A to ATC clearance and engage ALT A Monitor NAV coupled to FMS	Call "ALT.A armed" and reversion to ALT Call 'ALT engaged" Monitor NAV coupled to FMS
Between IAF and DA	Coupled ILS, check LOC and G/S armed then engaged	Call "Loc and G/S armed" Call "Loc engaged" Call "G/S engaged"
After DA	If poor visual environment, check reversion to ALT mode Set ALT and IAS accordingly At the runway threshold, engage GSPD	Call "ALT engaged" Call "GSPD engaged"


At DA if no visual GA
V/S
ALT. A
HDG
IAS
ALT
G/S1
HDG
LOC1
IAS
G/S1
LOC1
IAS
No visual at DA, GA procedure
Poor visual cues at DA, continue
GA
GA
ALT
GTC. H
GTC.
V/S
ALT. A
HDG
IAS

APPENDIX 3

Example of AFCS control panel:

The FMA is displayed at the upper part of FNDs pilot and co-pilot side:

	Collective axis	Yaw/Roll axis	Pitch axis
Modes engaged or captured	XXX	XXX	XXX
Modes armed	XXX	XXX	XXX

NOTES

IMPRINT

Disclaimer:
The views expressed in this leaflet are the exclusive responsibility of EHEST. All information provided is of a general nature only and is not intended to address the specific circumstances of any particular individual or entity. Its only purpose is to provide guidance without affecting in any way the status of officially adopted legislative and regulatory provisions, including Acceptable Means of Compliance or Guidance Materials. It is not intended and should not be relied upon, as any form of warranty, representation, undertaking, contractual, or other commitment binding in law upon EHEST its participants or affiliate organisations. The adoption of such recommendations is subject to voluntary commitment and engages only the responsibility of those who endorse these actions.

Consequently, EHEST and its participants or affiliate organisations do not express or imply any warranty or assume any liability or responsibility for the accuracy, completeness or usefulness of any information or recommendation included in this leaflet. To the extent permitted by Law, EHEST and its participants or affiliate organisations shall not be liable for any kind of damages or other claims or demands arising out of or in connection with the use, copying, or display of this leaflet.

Picture Credits:

Cover picture: Airbus Helicopters.

Document pictures: Airbus Helicopters, AugustaWestland, EASA.

Contact details for enquiries:
European Helicopter Safety Team
E-mail: ehest@easa.europa.eu, www.easa.europa.eu/essi/ehest

Download the EHEST leaflets:

EHEST HE 1 Training Leaflet – Safety considerations
http://easa.europa.eu/HE1

EHEST HE 2 Training Leaflet – Helicopter airmanship
http://easa.europa.eu/HE2

EHEST HE 3 Training Leaflet – Off airfield landing site operations
http://easa.europa.eu/HE3

EHEST HE 4 Training Leaflet – Decision making
http://easa.europa.eu/HE4

EHEST HE 5 Training Leaflet – Risk Management in Training
http://easa.europa.eu/HE5

EHEST HE 6 Training Leaflet – Advantages of simulators in Helicopter Flight Training
http://easa.europa.eu/HE6

EHEST HE 7 Training Leaflet – Techniques for Helicopter Operations in Hilly and Mountainous Terrain
http://easa.europa.eu/HE7

EHEST HE 8 Training Leaflet – The Principles of Threat and Error Management (TEM) for Helicopter Pilots, Instructors and Training Organisations
https://easa.europa.eu/HE8

EHEST
Component of ESSI
European Helicopter Safety Team

September 2015

EUROPEAN HELICOPTER SAFETY TEAM (EHEST)
Component of ESSI

European Aviation Safety Agency (EASA)
Strategy & Safety Management Directorate
Ottoplatz 1, 50679 Köln, Germany

Mail ehest@easa.europa.eu
Web www.easa.europa.eu/essi/ehest