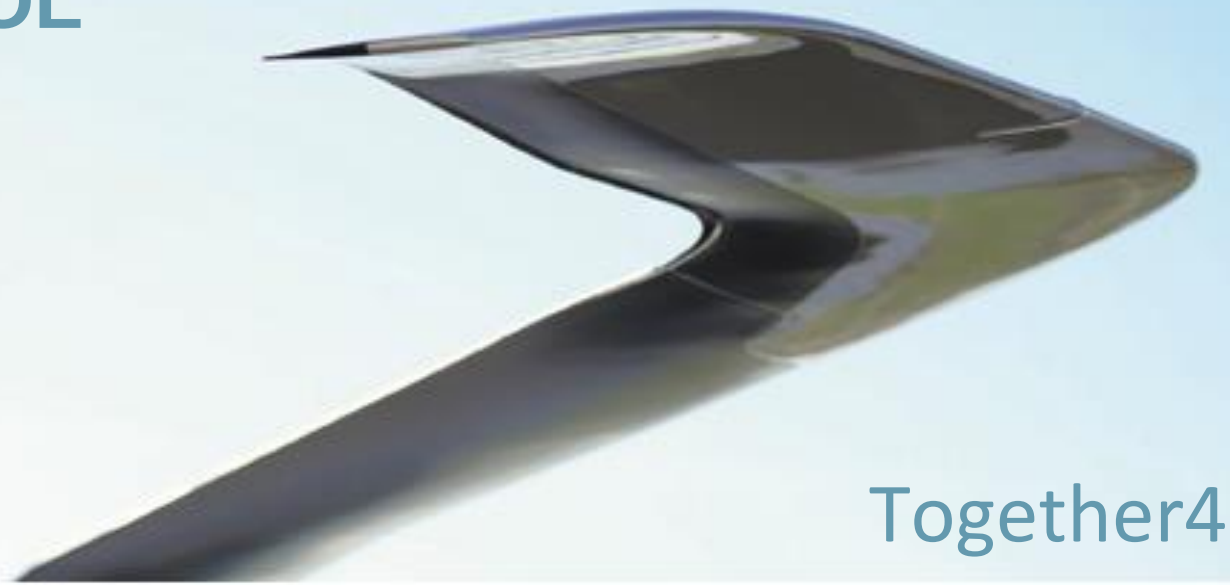
EASA Rotorcraft and VTOL Symposium
10-11 Dec 2019

Safety Workshop



Together4Safety

HELICOPTERS

What the Future Holds - Emerging Safety Technologies and How This Affects Training

European Safety Promotion Network Rotorcraft

TO SERVE THE COMMUNITY

Dr. Thomas Gogel, Airbus Helicopters Inc., Senior Expert Product Safety

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Content

- Introduction
- Connection to EASA Safety Roadmap
- Exemplary Technologies for Safety Improvement
- New Technologies – Supporting Documentation and Selected Training Means
- Conclusion

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Aviation - Overall Evolution of Accident Causes

Per 1.000 cycles

Per 100.000 cycles

Per 1.000.000 cycles

Fragile system (from 1920 to 1960ies)
- Individual risk management and intensive instruction
- Investigation of accidents
- Focus on technology causing accidents

TECHNICAL AGE

"Safe" system (from 1970 to mid 1990)
- Technology and regulations
- Investigation of accidents
- Emerging focus on technologies improving HMI and human procedures

HUMAN AGE

"Ultra safe" system (from 1995)
- SMS in organizations
- Regular collection and analysis of relational data
- Anticipation of hazards
- Focus on accident prevention technologies

ORGANIZATIONAL AGE

< than a catastrophic event per million production cycles

Example based on fixed wing evolution

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Causes of Aircraft Accidents

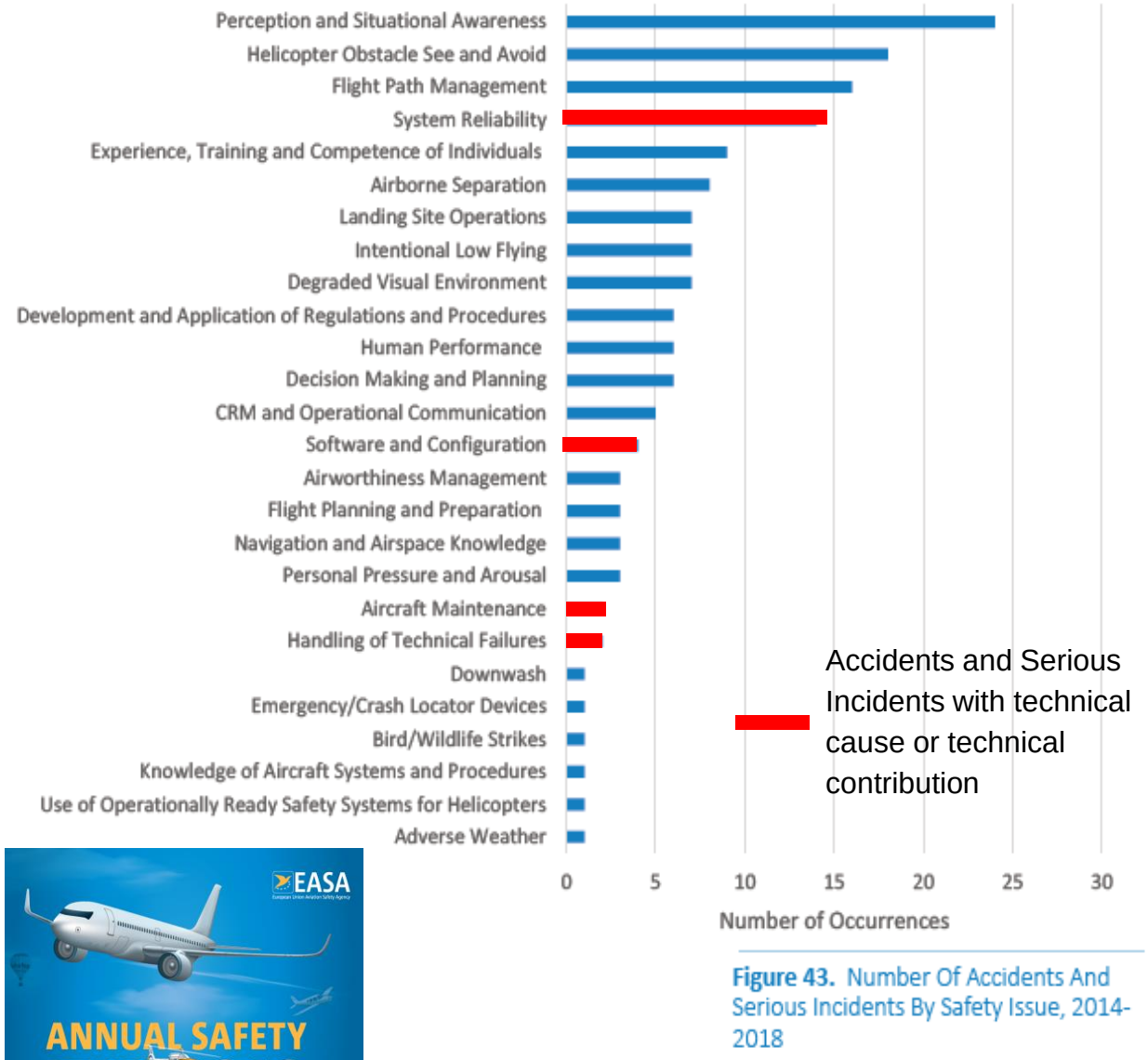

Figure 43. Number Of Accidents And Serious Incidents By Safety Issue, 2014-2018

…from Helicopter CAT other than offshore

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- **Technology to avoid operational accidents**
  - Need of technology to
    - reduce pilot's workload
    - increase situational awareness
    - support decision making
- **Further reduce technical contribution**
  - Certification standards, evolution of technical standards
  - HUMS/ early warning systems in the cockpit
- **Increase Survivability of accidents**
  - Adapted certification standards
  - Embrace new technologies

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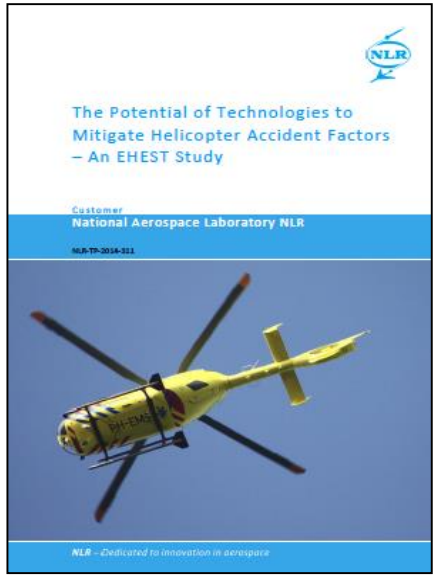
Safety Potentials of Technologies

- **Starting 2010 – analysis of more than 300 h/c accidents**
  - EHEST team investigated safety potential of technologies
  - Ranked the 15 ‘highly promising’ technologies mitigating 11 of the top accident factors
  - Recommendations provided for industry, regulatory authorities, researchers and universities



EHEST Publication 2014
NLR-TP-2014-311

- **Work resumed in 2017 under ESPNR, aligned with EPAS SPT 095**
  - Assessment of current status
  - Inclusion of new technologies
  - ‘Net Safety Benefit’ elements in the EASA Rotorcraft Safety Roadmap

NLR Publication 2019
NLR-TP-2018-470

Safety Potentials of Technologies

Highly Promising Technologies:

- Enhanced Ground Proximity Warning System / Terrain Awareness and Warning System
- Digital range image algorithms for flight guidance aids for helicopter low-level flight
- Laser radar obstacle and terrain avoidance system
- Digital Map
- Deployable Voice and Flight Data Recorder
- Passive tower-based Obstacle Collision Avoidance System
- Miniature Voice and Flight Data Recorder
- Wire Strike Protection System
- Flight data evaluation and processing for accident and incident investigation
- Cockpit Information Recorder
- Full Authority Digital Engine Control (FADEC)
- Light helicopter HOMP systems
- Efficient Numerical Approaches for On-Board Rotorcraft Flight Performance Modelling
- Radar Altimeter for altitude measurement
- Immersive Visualisation

Added Technologies since 2016:

- Collective Pull Down (CPD)
- Emergency breathing devices
- Helicopter Emergency Release Operator (HERO)
- Emergency exit training device
- High-speed data via satellite communication
- Eye for Autonomous Guidance and Landing Extension (EAGLE)

Exemplary Technologies for Safety Improvement

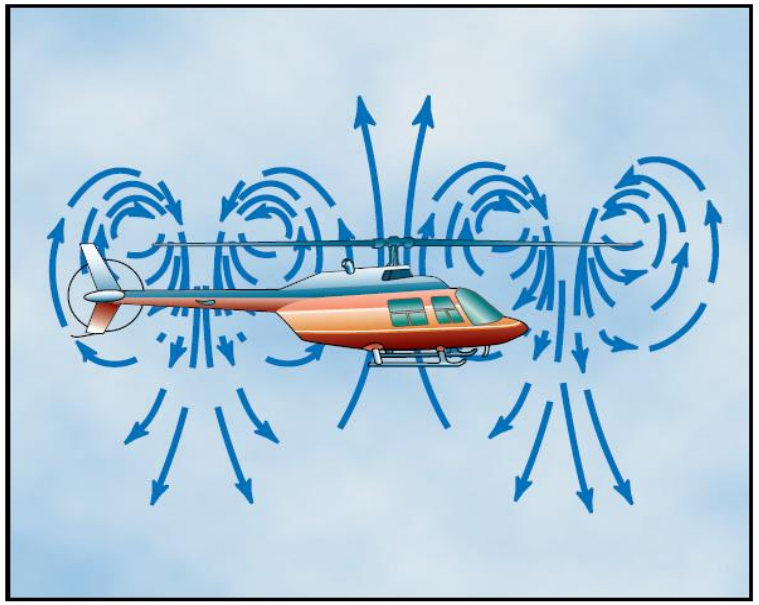
Recovery Function ‘Wing leveler’

4	AP/BKUP ON (4-way switch)	Engages / resets AFCS and upper modes as follows: – Left press: Simultaneously resets and engages AP1 and sets the back-up SAS in stand-by. When any failure was present on AP1, the system tries to recover a fully functional state by resetting transient failures. – Right press: Simultaneously resets and engages AP2 and sets the back-up SAS in stand-by. When any failure was present on AP2, the system tries to recover a fully functional state by resetting transient failures. – Single forward press: Simultaneously engages AP1 and AP2, and places SAS in standby. It also resets the operational AP. The left/right and single forward press allow the autopilot to be “reset” in case of a problem without having to release the cyclic. In many cases, this will recover full autopilot functionality. – Double forward press: Provides a quick engagement of the autopilot upper modes ALT, IAS, and HDG or TRK (whichever is set on the APCP). – If pressed in a non-level attitude, the aircraft will roll-out and level off. In a descent, it will recover to the altitude at which the ALT mode was engaged; in a climb it will level off and maintain the altitude. Operationally, the quick engagement (double click) can be used to immediately establish a level flight condition, e.g. in case of disorientation (e.g. inadvertent entry into IMC). The quick engagement is not always capable of recovering from unusual attitudes or low speeds. Therefore, recovery from unusual attitudes should be performed manually, before using the quick engagement. In hover, the aircraft will automatically accelerate to 30 kt (minimum IAS mode speed) and hold and maintain altitude and heading.

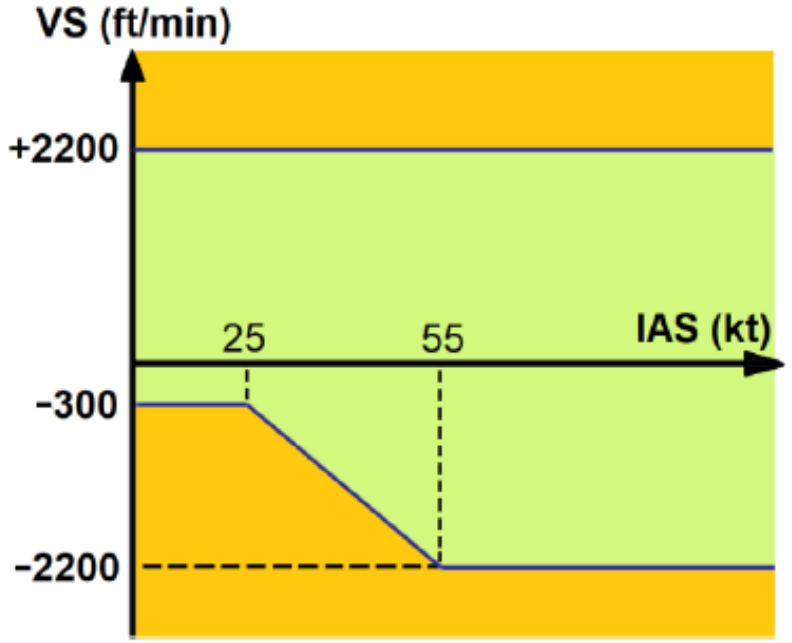
AFCS description– from FOBN H145 No 12-22

Vortex ring state - AFCS Envelope Protection

– Vortex ring state protection: with a vertical mode engaged, the maximum commanded rate of descent decreases with the indicated airspeed, to provide protection against inadvertent entry into (incipient) vortex ring state at low air speed.



Vortex ring state – picture from FAA-H-8083-21

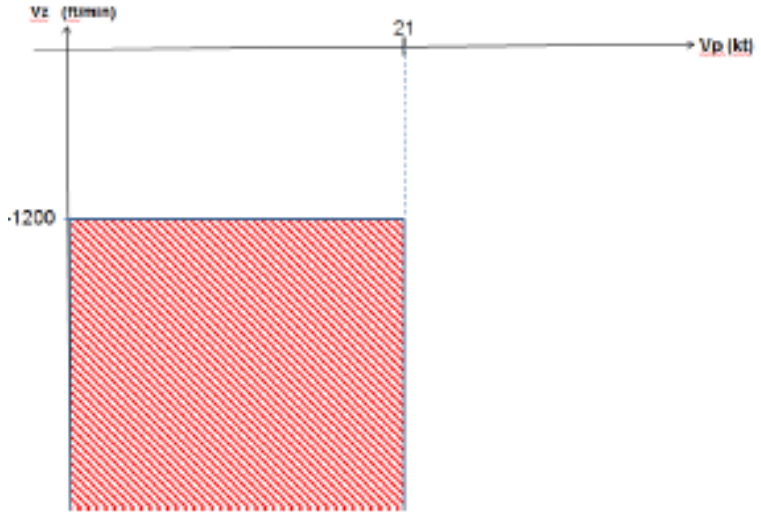


AFCS upper mode envelope protection – from FOBN H145 No 12-22

Vortex ring state – Pilot awareness

AH conducts system research trials for a cockpit warning of vortex ring state

- Intendend Function: warning of flight crew of vortex ring state to trigger evasive action:
  - 2 levels: impending ring vortex state and possible ring vortex condition
- Assures a minimum of 5 s eary warning time prior entering vortex ring state
- Defined Envelope to to trigger warning:
  - Assures a minimum of 5 s eary warning time prior entering vortex ring state



Validity: < 1200 ft/min & < 21 kts
Inhibition conditions:
- during 30s in case of engine failure
- < 70fts
- ± 20° attitude (roll and pitch)

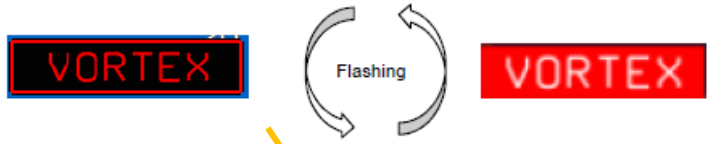
Pre-Vortex condition:

VORTEX

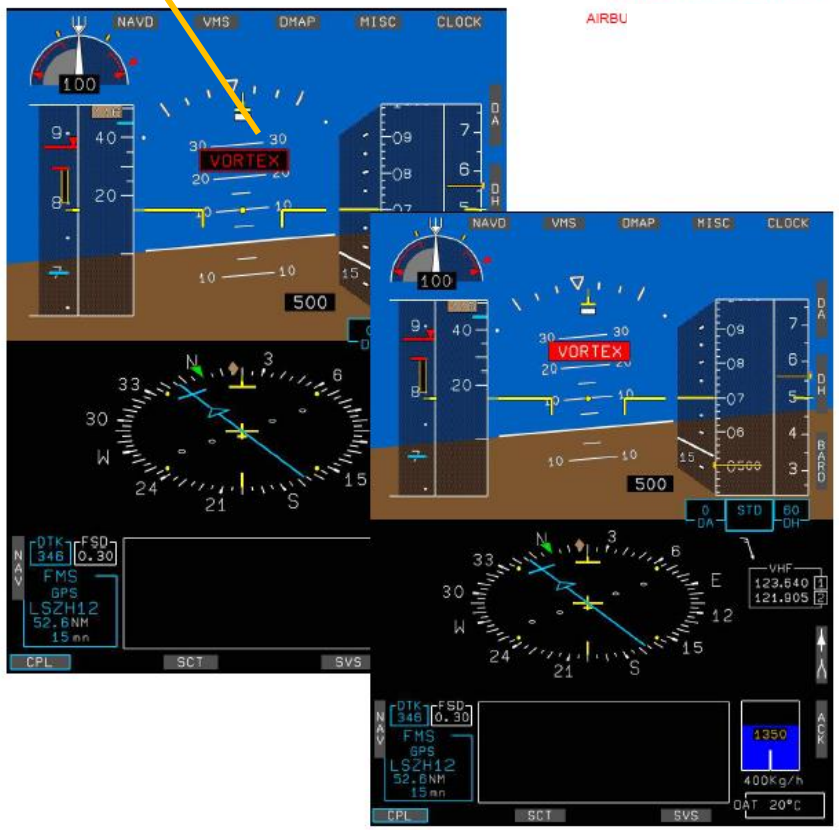
Constant amber msg

+ aural alert ‚CHECK POWER' every 3s

Vortex condition:



Flashing red msg



+ aural alert ‚VORTEX' every 3s

Vortex ring state – Pilot awareness

- For Pre – Vortex condition, training contains:
  - Reduce Rate of Decent
  - Increase IAS

- Existing AH training concept – **Recognize and Avoid**:
  -to train vortex prevention predominantley rather than exiting vortex state
  -Valid for all AH types

	As-Is	To Be
<u>Recognize and avoid:</u> to train VRS avoidance	RVS early detection by flight physical cues (buffet, vibration, attitude changes)	RVS early detection by flight physical cues (buffet, vibration, attitude changes) + **Supplement by cockpit pre-vortex indication**

Advanced Vision Systems

Advanced vision system cover multiple ‘highly promising’ technologies:

- Enhanced Ground Proximity Warning System / Terrain Awareness and Warning System
- Digital range image algorithms for flight guidance aids for helicopter low-level flight
- Laser radar obstacle and terrain avoidance system – *as a potential optical substitute*
- Digital Map
- Passive tower-based Obstacle Collision Avoidance System – *as a potential substitute with ‘active’ detection*
- *Wire Strike Protection System*

Advanced Vision Systems - today

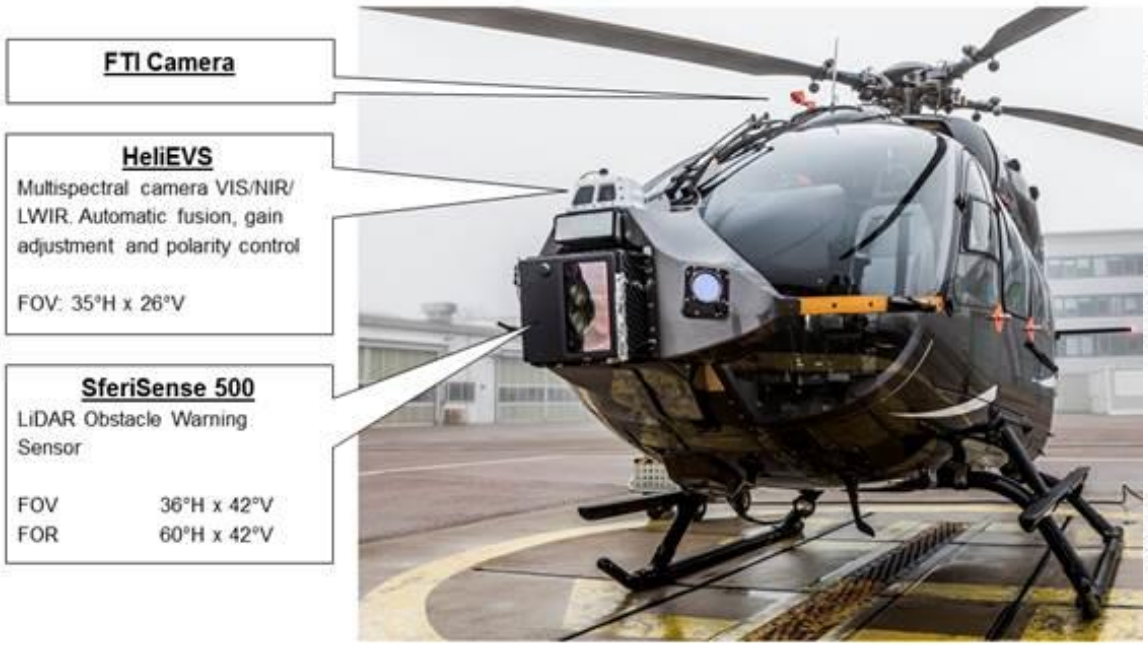
SVS – Synthetic Vision System

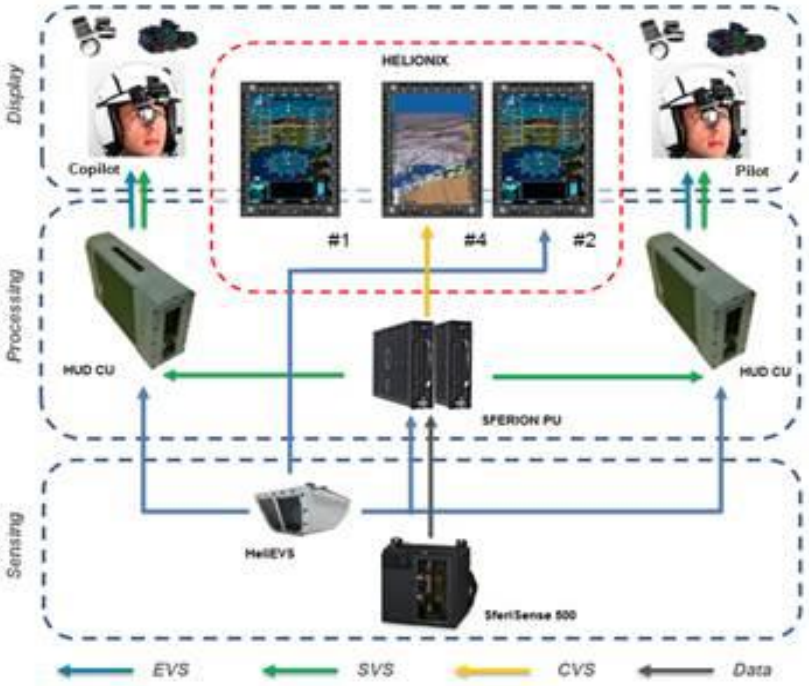
- Overlays digital terrain and obstacle data on Primary and Navigation display
- Significantly enhances situational awareness

Advanced Vision Systems – becoming

EVS – Enhanced Vision System and HMI concepts

- Active sensors (Optical –visible spectrum/IR-, LIDAR, Radar) can be used for active terrain and obstacle detection – overlay with SVS: **CVS Combined Vision System**
- Significant increase in situational awareness for ‚low level flyers' in DVE
- Possibly combination of Helmet Mounted Display and Heads Down display





Sensing
- Real-time detection using active LIDAR sensor
- Real-time imaging using multispectral camera

Processing
- Sensor fusion of LIDAR data and terrain and obstacles data-base
- Video generation and overlay of SVS and EVS for dispaly head-up and head-down

Display
- Depiction of video sources and 2D flight data symbology on MFDs and HMD

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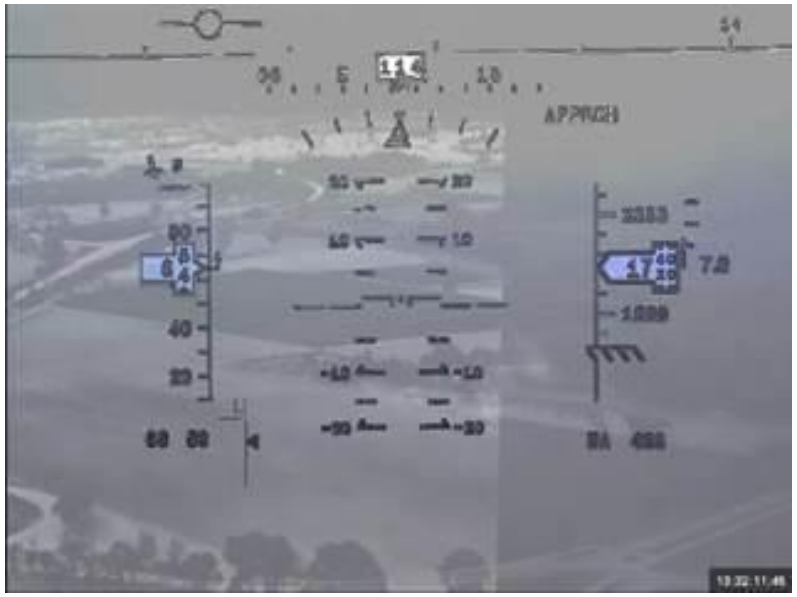
Advanced vision Systems – becoming

2D symbology with partial video signal Head up



Cockpit integration study

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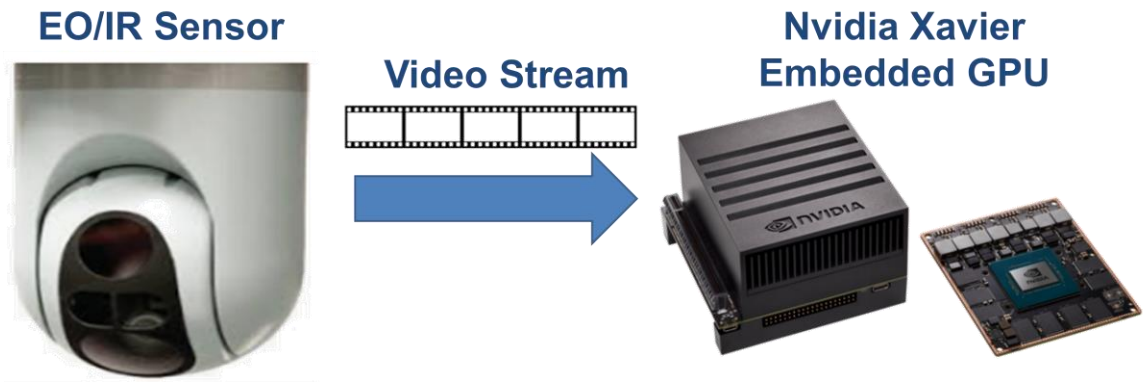
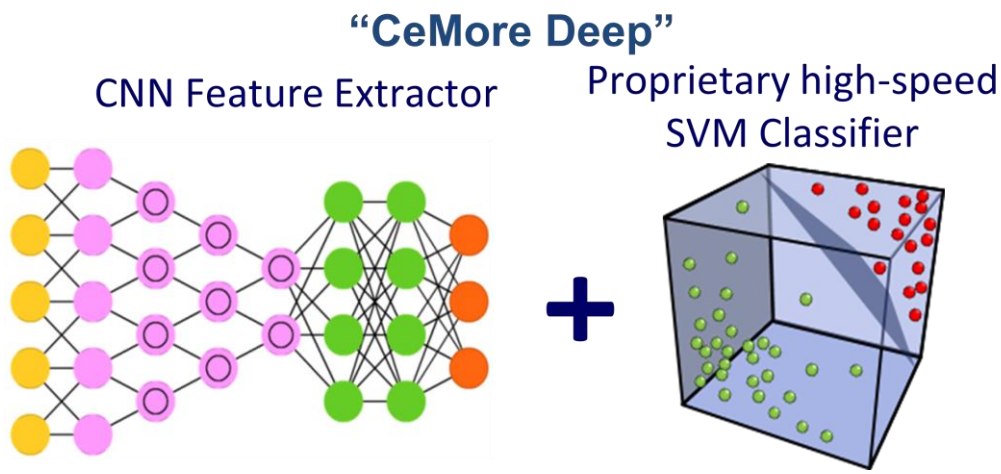
Advanced Vision Systems - outlook

Automatic Obstacle Detection

- ➔ Real-time AI technologies for enhanced pilot situational awareness
- ➔ Detect, identify, classify previously unknown obstacles
- ➔ Enhance safety and enable autonomy in future rotorcraft platforms





- ➔ High generalization ability even for small amount of training data
- ➔ „Light" resources consumption (data, time, computing power)
- ➔ Simple training (very few training parameters, fast convergence)

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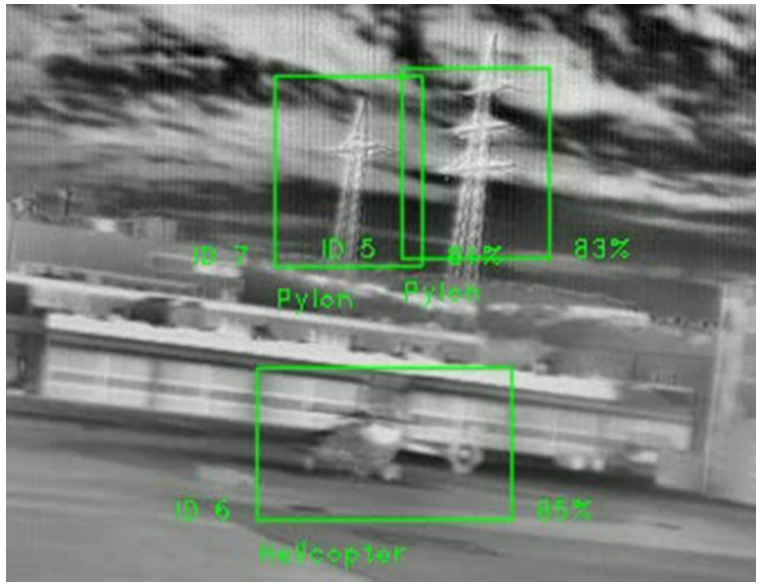
Advanced Vision Systems - outlook

Automatic Obstacle Detection - Examples



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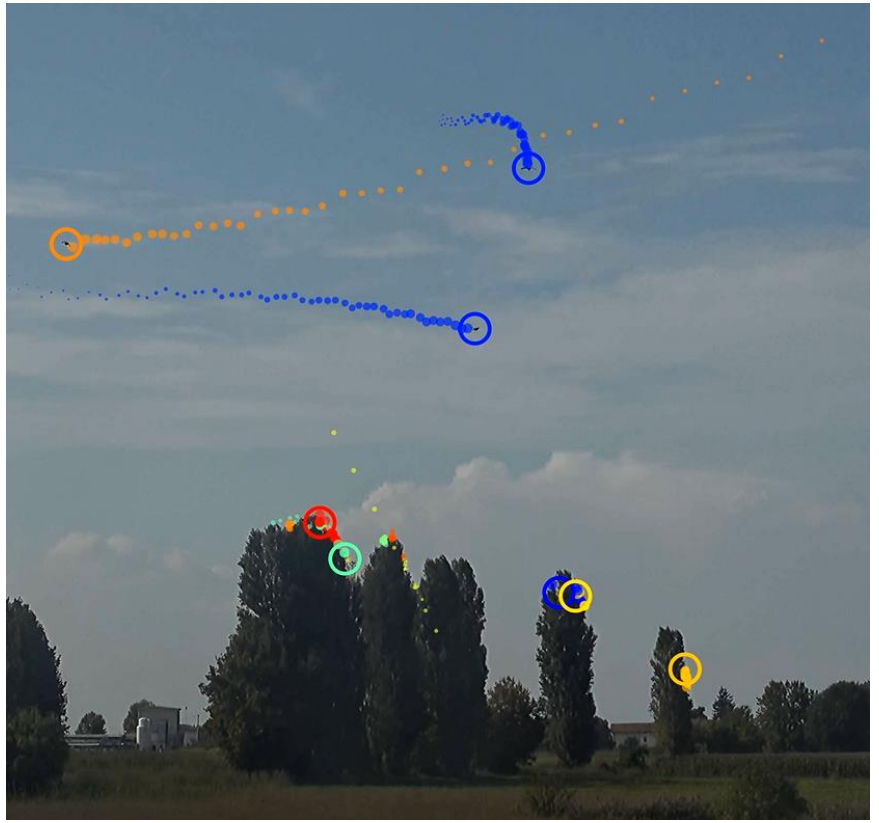
Advanced Vision Systems – further outlook

Automatic Obstacle Detection

- ➔ Real time, AI driven detection of moving obstacles (a/c, UAVs, birds)
- ➔ Classification of type of intruder (type, weight, size)

Flock of birds



Birds – in flight and in the trees

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New Technologies – Supporting Documentation and Selected Training Means

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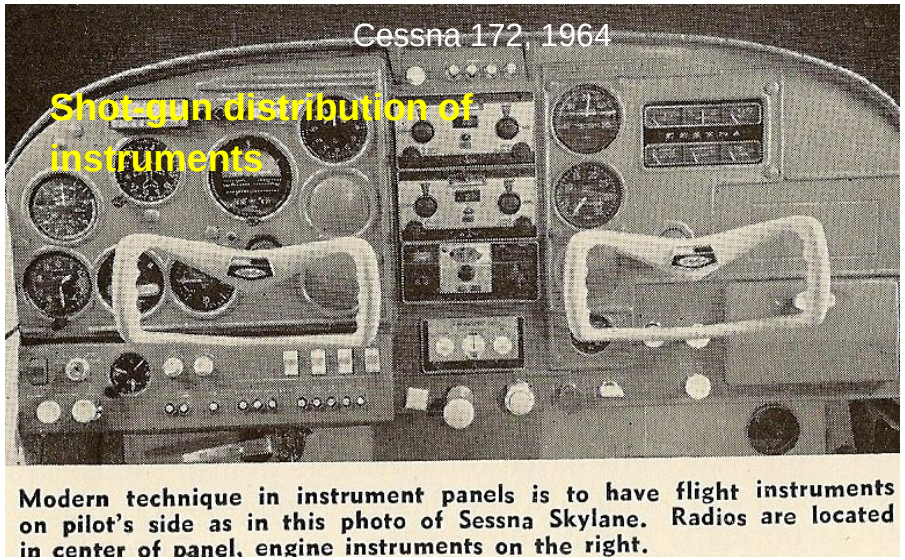
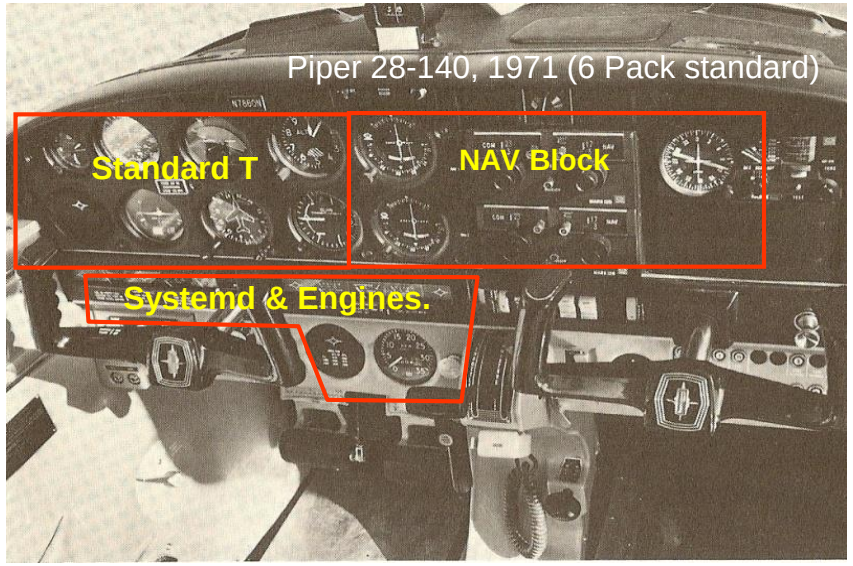
Cockpit HMI and System Complexity – Evolution of Training Needs



1964

1971



- Clear HMI strucure
- Easy information
- One-to-one link from control elements to indications
- Highly standardized accross all aircraft types

2007

Still clear HMI strucure, **but:**

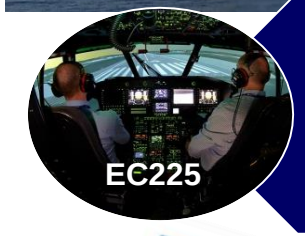
- Very high amount of informations and functions added
- Scattered via numerous menu levels
- Selecteable NAV modes and rich AFCS upper modes
- Differences accross manufacturers

➢ **Training to focus on System reccurency and recency as well**

FCOM (Flight Crew Operations Manual)

- ✓ Digital automation has improved aircraft performance and reduced crew workload
- ✓ However, there are multiple possibilities for operating the automated systems
- ✓ More joint work was necessary between OEMs and Operators to optimize the benefit of the helicopters automation
- ✓ Airbus Helicopters has launched a specific Working Group with HeliOffshore
- ✓ Resulted in the first FCOM for O&G (H225, then H175)
- ✓ **FCOM now available for many h/c types for O&G operation**

=> Improving Safety by establishing SOP for best use of automation



Automation
↓
Procedures
↓
Standards

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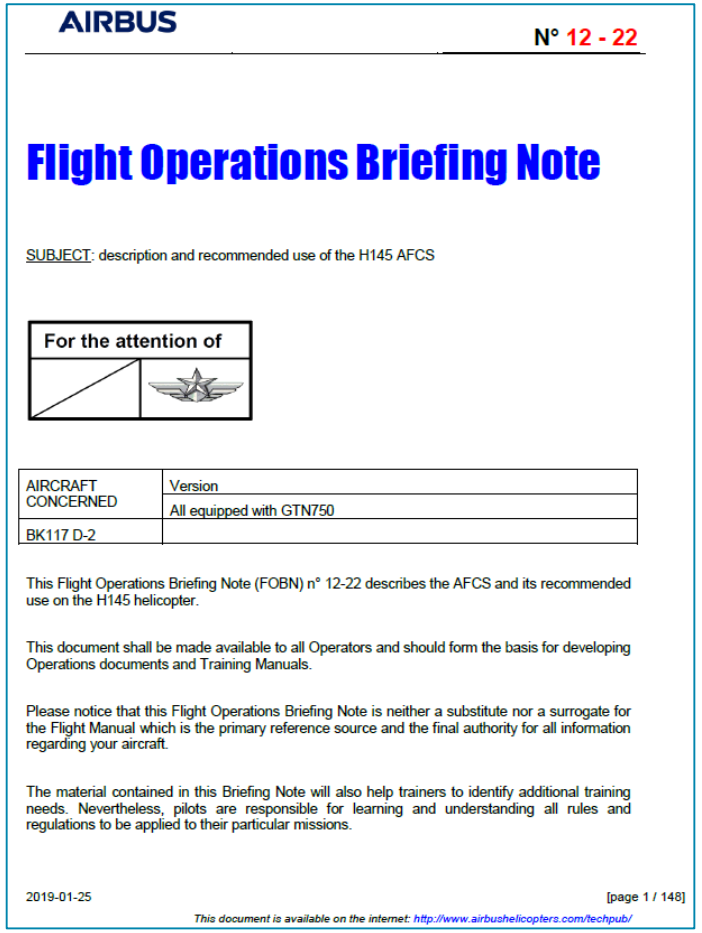
FOBN (Flight Operations Briefing Note) – FCOM 'light'

FOBN describes:

- AFCS or other systems and their recommended, procedural use
- Is made available for all operators
  - To be used for creation of Operational Documentation
  - To be used in Training or within Training Manuals
  - To be used as reading source for pilots
- Available for H225, AS332 L2, AS365 N3, EC155 B1, H215, H145
- *Does not substitute the Flight Manual*

=> Improving Safety by establishing SOP for best use of automation



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N° 12 - 22

Flight Operations Briefing Note

SUBJECT: description and recommended use of the H145 AFCS

For the attention of

AIRCRAFT CONCERNED	Version
	All equipped with GTN750
BK117 D-2	

This Flight Operations Briefing Note (FOBN) n° 12-22 describes the AFCS and its recommended use on the H145 helicopter.

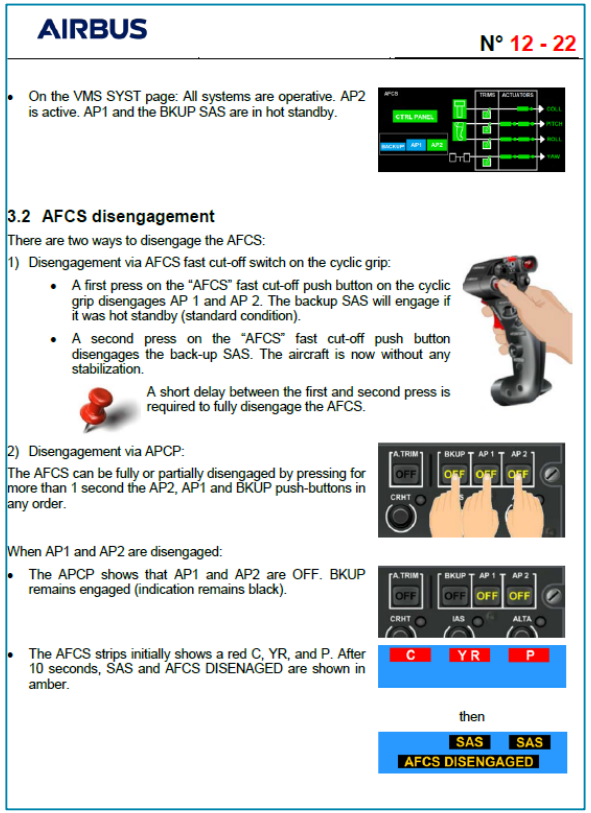
This document shall be made available to all Operators and should form the basis for developing Operations documents and Training Manuals.

Please notice that this Flight Operations Briefing Note is neither a substitute nor a surrogate for the Flight Manual which is the primary reference source and the final authority for all information regarding your aircraft.

The material contained in this Briefing Note will also help trainers to identify additional training needs. Nevertheless, pilots are responsible for learning and understanding all rules and regulations to be applied to their particular missions.

2019-01-25 [page 1 / 148]

This document is available on the internet: http://www.airbushelicopters.com/techpub/



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N° 12 - 22

- On the VMS SYST page: All systems are operative. AP2 is active. AP1 and the BKUP SAS are in hot standby.

3.2 AFCS disengagement

There are two ways to disengage the AFCS:

1) Disengagement via AFCS fast cut-off switch on the cyclic grip:
   - A first press on the "AFCS" fast cut-off push button on the cyclic grip disengages AP 1 and AP 2. The backup SAS will engage if it was hot standby (standard condition).
   - A second press on the "AFCS" fast cut-off push button disengages the back-up SAS. The aircraft is now without any stabilization.

A short delay between the first and second press is required to fully disengage the AFCS.

2) Disengagement via APCP:

The AFCS can be fully or partially disengaged by pressing for more than 1 second the AP2, AP1 and BKUP push-buttons in any order.

When AP1 and AP2 are disengaged:

- The APCP shows that AP1 and AP2 are OFF. BKUP remains engaged (indication remains black).
- The AFCS strips initially shows a red C, YR, and P. After 10 seconds, SAS and AFCS DISENAGED are shown in amber.

C YR P

then

SAS SAS
AFCS DISENGAGED

Helionix® Advanced Tool Simulator

Crew Training

Troubleshooting

Maintenance Training

Safety Management

Multi-Purpose Tool:

- HLX system and its recommended, procedural use
- Useful training tool complex Avionics Suit
- For initial systems training + recurrent training and refreshers

Together4Safety

Xplane ©
Visual with WW data base

Touch Screen

- H/C embedded SW and Flight loop
- Real Warning messages & audio
- Main H/C systems represented

One tool for H175 , H145, H135, H225 soon

Fixed Aircraft grips

- Cockpit Training
- Procedure Training
- Emergency procedures Training
- Pilot refresher and system proficiency

- Maintenance Training
- System Trouble Shooting

….VR based system in developement

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Conclusion

AH Ambition - aligned with EASA Rotorcraft Safety Roadmap:

to achieve 50% accident rate reduction until 2028:

- Strong evolution of Technologies to support safety Roadmap
- Documentation available to enhance Operations and Training
- New training means and adapted regulations available to tackle complex system training and recency for pilots

- In order to fast track new safety technologies, a close collaboration of Authorities, Operators and Manufacturers is needed

Thank you

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