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VISION - Colour vision requirements in the new full glass cockpit environment and modern ATCO consoles

Report on task identification using colour-coded details

An Agency of the European Union

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SUMMARY

Problem area

The current colour vision requirements were established based on evidence available over 30 years ago. Since then, there have been significant advancements in aviation technology, including full glass cockpit and ATM consoles, which have greatly enhanced the safety and efficiency of air travel. These advancements have also changed the working environment for pilots and air traffic controllers (ATCOs), and it is necessary to assess whether the current colour vision requirements are still suitable for these modern working environments.

To further improve safety and reduce reaction times, much of the information provided to pilots and ATCOs is now colour-coded. This colour-coding system allows pilots and ATCOs to quickly and easily identify important information, such as warnings, alerts, and critical instructions. Although for most colour-coding there are redundant systems that allow pilots and ATCOs to receive the information, this may entail more extensive cognitive processes that require additional time. Consequently, in emergency situations the proper perception of colours may have a considerable positive impact on safety by reducing reaction times.

The EASA funded VISION research project (EASA.2024.C07) aims to assess the suitability of current colour vision requirements for pilots and ATCOs in modern working environments and provide scientifically based evidence that will support decision-making regarding regulatory needs for colour vision assessment.

Description of work

The objective of this deliverable was to identify relevant colour-coded activities used by pilots and ATCOs in the regular performance of their jobs, focussing on identifying the safety critical elements that would have an impact in quality and timeliness of the response in an emergency situation.

Colour-coded activities used by pilots and ATCOs in the regular performance of their jobs were identified from applicable operating procedures. The source of the colour-coded information (e.g. primary flight display in the cockpit, approach light, ATCO display, etc.) was identified and the activities were classified according to safety criticality, where safety criticality was defined as the severity of the effect of an untimely or inappropriate task execution. Additionally, the effect of colour-coding on the timeliness and appropriateness of the task execution was determined. The influence of different lighting conditions (due to day/night, weather conditions artificial light) was described for the most safety critical tasks.

Results and Application

The results describe all relevant colour-coded activities used by pilots and ATCOs in their regular tasks. The identified and documented pilot activities encompass flight operations ranging from general aviation to commercial air transport and includes tasks for fixed wing as well as rotary wing aircraft. The identified and documented ATCO activities include tower control, approach control and en-route control. The report describes safety critical elements associated with the colour-coded activities, and the impact of these elements on the timeliness and appropriateness of the response in normal, abnormal and emergency situations. The results will be used in Task 2 of the VISION research study where measurements of colour outputs related to safety critical colour-coded activities will be performed to find common thresholds for colour vison.

CONTENTS

ABBREVIATIONS

ACRONYM	DESCRIPTION
ACAS	Airborne Collision Avoidance System
ANSP	Air Navigation Service Provider
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
DH	Decision Height
EASA	European Union Aviation Safety Agency
EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning System
FAA	Federal Aviation Administration
FMS	Flight Management System
FPS	Flight Progress Strips
GA	General Aviation
GPS	Global Positioning System
G/S	Glideslope
HMI	Human Machine Interface
HUD	Head Up Display
ILS	Instrument Landing System
LCD	Liquid Crystal Display
LOC	Localizer
LVNL	Luchtverkeersleiding Nederland
MDA	Minimum Descent Altitude
MTCA	Medium-term Conflict Alert
NASA	National Aviation and Space Administration
NAVAIDS	Navigational Aid
ND	Navigation Display
NLR	Royal Netherlands Aerospace Centre
PAPI	Precision Approach Path Indicator
PFD	Primary Flight Display
RPM	Revolution Per Minute
STCA	Short-Term Conflict Alert
TAWS	Terrain Awareness and Warning System
TOGA	Take-off/Go-Around

1. Introduction

1.1 Background

The current colour vision requirements were established based on evidence available more than 30 years ago. Since then, there have been significant advancements in aviation technology, including full glass cockpit and ATM consoles, which have greatly enhanced the safety and efficiency of air travel.

These advancements have also changed the working environment for pilots and Air Traffic Controllers (ATCOs), and it is necessary to assess whether the current colour vision requirements are still suitable for these modern working environments.

To further improve safety and reduce reaction times, a lot of the information provided to pilots and ATCOs is now colour-coded. This colour-coding system allows pilots and ATCOs to quickly and easily identify important information, such as warnings, alerts, and critical instructions. Although for most colour-coding there are redundant systems that allow pilots and ATCOs to receive the information, this may entail more extensive cognitive processes that require additional time. Consequently, in emergency situations the proper perception of colours may have a considerable positive impact on safety by reducing reaction times.

The EASA funded VISION research project (EASA.2024.C07) aims assess the suitability of current colour vision requirements for pilots and ATCOs in modern working environments and provide scientifically based evidence that will support decision-making regarding regulatory needs for colour vision assessment.

1.2 Scope of this report

This report represents deliverable “D.1” of the VISION research project. The objective of this deliverable is to identify relevant colour-coded activities used by pilots and ATCOs in the regular performance of their jobs. It focuses on identifying the safety critical elements that would have an impact in quality and timeliness of the response in an emergency situation.
The following sub-tasks are covered:

1. List of tasks performed by pilots and ATCOs;
2. Assessment of safety criticality;
3. Assessment of the impact on timeliness and appropriateness of the response;
4. Assessment of the effect of colour-coding; and
5. Assessment of the influence of lighting conditions

This report will be the basis for Task 2 of the project, in which colour output will be measured in cockpit displays and in ATCO working positions.

1.3 Structure of this report

This report starts with an explanation of the method used in carrying out the above-mentioned task, in Chapter 2. The arrangement of the working positions for pilot and air traffic controllers are detailed in Chapter 3 and Chapter 4 respectively. These chapters also include how warnings and cautions are annunciated. A summary of the task listings is given in Chapter 5. Chapter 6 describes the influence of different lighting conditions, and conclusions and recommendations are given in Chapter 7.

2. Method

2.1 Generating task lists

Colour-coded activities used by pilots and ATCOs in the regular performance of their jobs were identified from applicable operating procedures. For flight crew activities four classes of aircraft will be considered, representing a wide range of flight operations:

- Large commercial aircraft
- Business aircraft
- Helicopters
- General aviation aircraft

For the identification and documentation of ATC activities three types of ACTO positions will be considered:

- Tower control
- Approach control
- En-route control

The arrangement of information and displays was first described, as to provide the context.

Flight crew activities were identified from the Flight Crew Operating Manuals (FCOM) of aircraft that are representative of the four classes of aircraft that will be considered. ATCO activities were identified generically using tasks analysis documents from the EPISODE 3 project[1] and EUROCONTROL/DeepBlue[2] for tower and en-route control. The original lists were adapted in the sense that tasks concerning different systems and displays are listed as information sources used instead of separate tasks. The task list for approach control was generated by the project team with a similar level of detail. The results are listed in Annex A and Annex B for flight crew and ATCOs respectively.

2.2 Assessment of safety criticality

2.2.1 Flight crew

A safety critical task is defined as a task for which substandard task performance would adversely affect safety. Essentially all flight crew tasks are safety critical. The severity of the effect of an untimely or inappropriate task execution can be classified as follows, based on EASA CS25.1309:

No Safety Effect
Substandard task performance that would have no effect on safety; for example, substandard performance that would not affect the operational capability of the aircraft or increase crew workload.

[1] Episode 3 Consortium. (2007). *Today's Operations Task Analysis – Human Factor Assessment* (Deliverable 2.4.4-05 of the EPISODE 3 project funded by the European Commission.
[2] Tavanti, M. (2006). *Control Tower Operations: A Literature Review of Task Analysis Studies.* (As part of the MMF project in collaboration with EUROCONTROL).

Minor
Substandard task performance which would not significantly reduce aircraft safety, and which involve crew actions that are well within their capabilities. Minor effects 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
Substandard task performance which would reduce the capability of the aircraft 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
Substandard task performance, which would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating, conditions to the extent that there would be:
(i) A large reduction in safety margins or functional capabilities;
(ii) Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or
(iii) Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

Catastrophic
Substandard task performance, which would result in multiple fatalities, usually with the loss of the aircraft.

2.2.2 Air traffic control

For consistency in describing the safety criticality of tasks, a similar classification will be used to describe the safety criticality of ATCO tasks.

No Safety Effect
Substandard task performance that would have no effect on safety; for example, an ATC action or decision that does not affect aircraft separation, navigation, or communication, and does not introduce any risk to flight operations. This might involve routine administrative or procedural tasks that do not influence aircraft safety or increase workload for controllers or pilots.

Minor
Substandard task performance which would not significantly reduce air traffic safety, and involves actions that are within the ATC personnel's capabilities. Minor effects may include, for example, a slight increase in controller workload or communication delay that does not jeopardize aircraft separation or navigation or a slight inconvenience to flight crews, such as delays in flight clearances or minor changes in flight routing.

Major
Substandard task performance that could reduce the effectiveness of air traffic control to the point where there is a significant risk to aircraft safety or flight crew ability to operate safely under normal conditions. Examples of major effects could include, for example, significant increases in workload or fatigue for air traffic controllers, impacting their ability to maintain effective oversight of air traffic or a significant reduction in safety margins potentially leading to near-miss situations.

Hazardous
Substandard task performance that reduces the capability of air traffic control to ensure safe separation and coordination of aircraft to the extent that it could result in significant safety risks, such as a large reduction in safety margins or operational capabilities, leading to a possible near-miss, conflict, or loss of separation between aircraft and excessive workload, distraction, or cognitive overload for air traffic controllers, impairing their ability to make accurate decisions and respond to critical situations in a timely manner.

Catastrophic
Substandard task performance that would result in a catastrophic event, such as multiple fatalities or the loss of an aircraft, due to the failure of air traffic control to maintain the required safety standards. This could include: A large-scale failure in air traffic control systems or procedures that results in the inability to maintain safe separation between aircraft, leading to a collision or similar event, serious errors or omissions by air traffic controllers in responding to critical or emergency situations that could result in multiple fatalities, usually with the loss of (multiple) aircraft.

2.3 Effect of colour-coding on the timeliness and appropriateness of task execution

For the most safety critical tasks, the effect of colour-coding on the timeliness and appropriateness of the task execution is determined. The follow effect classes are used:

- No effect - colour-coding does not influence task execution
- Supportive effect - colour-coding supports correct and timely execution of tasks
- Essential effect - colour-coding is essential for correct and timely execution of tasks

Wickens' model of information processing and decision making[3] (Figure 2-1) shows how the response to a particular situation depends on the ability of the senses to detect stimuli and the subsequent perception of this information and decision making. The level of attention influences perception. This means that in situations where attention is low (this can be due to boredom and fatigue, but also due to high workload when attention must be distributed among many items) sensory information must be 'stronger' to be perceived. For visual information, conspicuity is influenced by characteristics such as size, movement and colour. Also, knowledge stored in the memory plays a role in the perception and interpretation of signals.

In cases where information is only based on colour, such as the information provided by a PAPI (Precision Approach Path Indicator) on the vertical position of the aircraft relative to the correct glidepath, the effect of colour-coding is essential. Most of the colour-coded information provided in cockpits and ATC working positions has a form of redundancy. The specific information provided by the colour (for instance 'normal', 'requiring awareness', and 'requiring immediate action') is usually also provided in an alternative way such as displayed text, symbols, numerical value, a frame around an information item, pulsing of the colour-coded information or an aural signal. In cases where the coding is also represented in additional cues, the colour-coding effect often can be regarded as a supportive effect. However, even with additional coding the colour-coding might still be essential. This is the case when:

- Immediate action is required to prevent a catastrophic effect;
- Attention to the signal is low (either due to boredom/fatigue or due to high workload which required distribution of attention);
- The alternative information requires interpretation.

[3] Wickens, C. D., & Flach, J. M. (1988). Information processing. In E. L. Wiener & D. C. Nagel (Eds.), Human factors in aviation (pp. 111–155). Academic Press.

To give an example of the latter, excessive engine temperature can be represented by a numerical value displayed in red, but the numerical value is only meaningful as an indication of excessive engine temperature if the observer has knowledge of applicable temperature limitations.

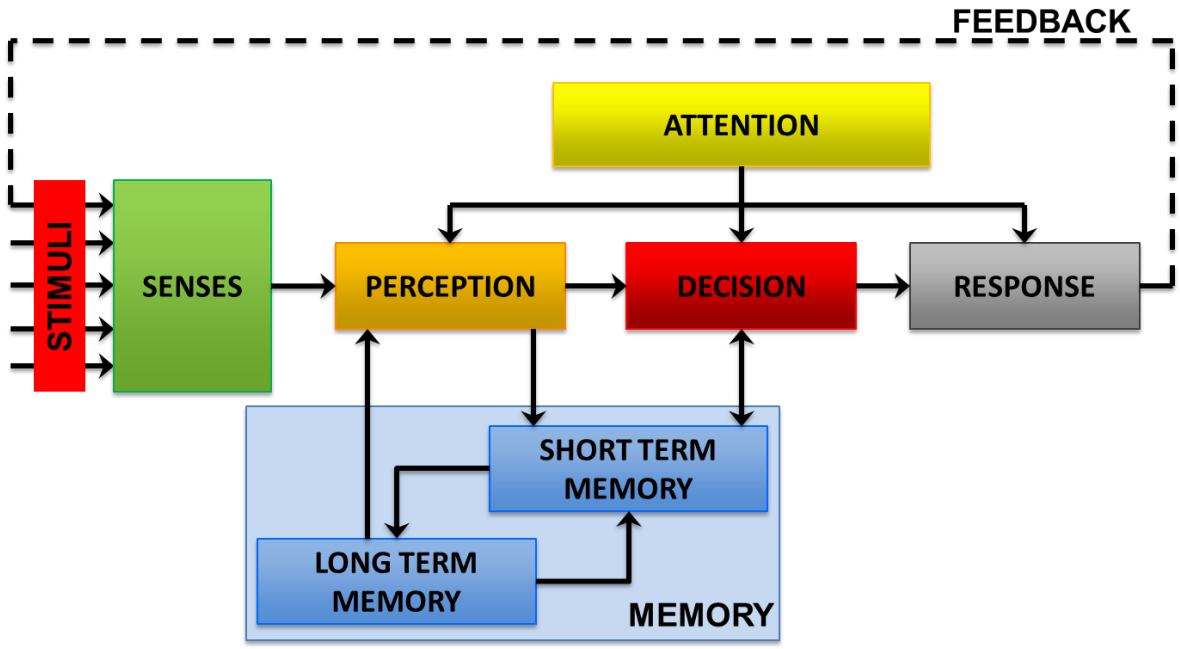

Figure 2-1: Wickens' model of information processing and decision making.

Finally, the influence of different lighting conditions (due to day/night, weather conditions artificial light) needs to be addressed in the project. The effect of different lighting conditions is described relative to a baseline situation of "ideal" lighting. In this document, the different critical circumstances are identified for quantification later on in the project, either through measurement or theoretical analysis.

3. Arrangement of the flight deck

3.1 Transport category aircraft

Typically, the flight deck of a large transport category aircraft includes the following panels (see Figure 3-1 and Figure 3-2):

- Overhead panel
- Glareshield
- Main instrument panel
- Pedestal

The overhead panel includes the system control panels. The glareshield includes the tactical control for the autoflight system and the attention getters (master caution and master warning lights). The main instrument panel includes multifunction displays that are normally configured as the Primary Flight Display, the Navigation Display (ND), Engine Display and Systems Display. Figure 3-3 shows a typical configuration of the multifunction displays of a large transport category aircraft. In some aircraft one of the multifunction displays is normally configured as Electronic Flight Bag (EFB) for assessing operational documentation, company communication and applications. In some aircraft the PFD and ND are displayed on a single display, with the PFD on the top half and the ND on the bottom half of the display. The pedestal includes controls for engines, controls for aircraft configuration (landing gear, flaps) and controls for navigation (including the Flight Management System (FMS)) and communication. Head-up displays (HUD) are available as an option for several aircraft types. The HUD provides flight data in the flight crew's field of view.

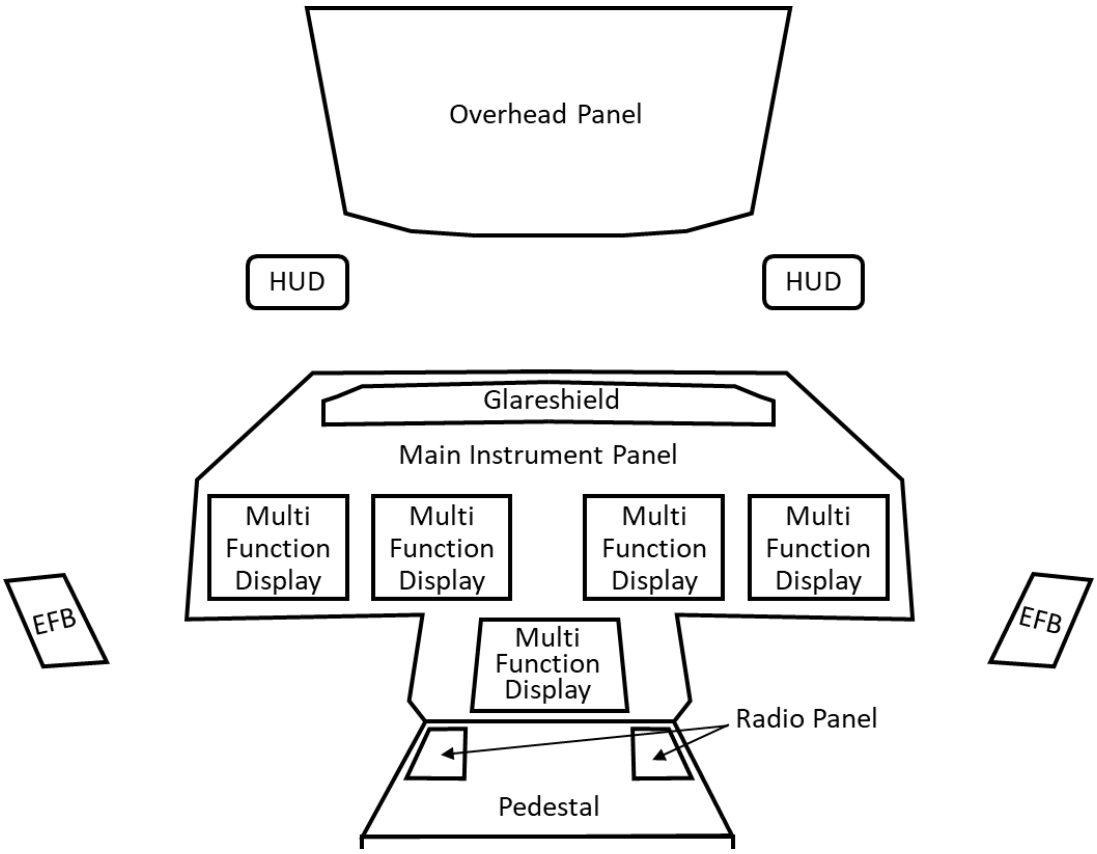

Figure 3-1: General arrangement of the Boeing 787 flight deck.

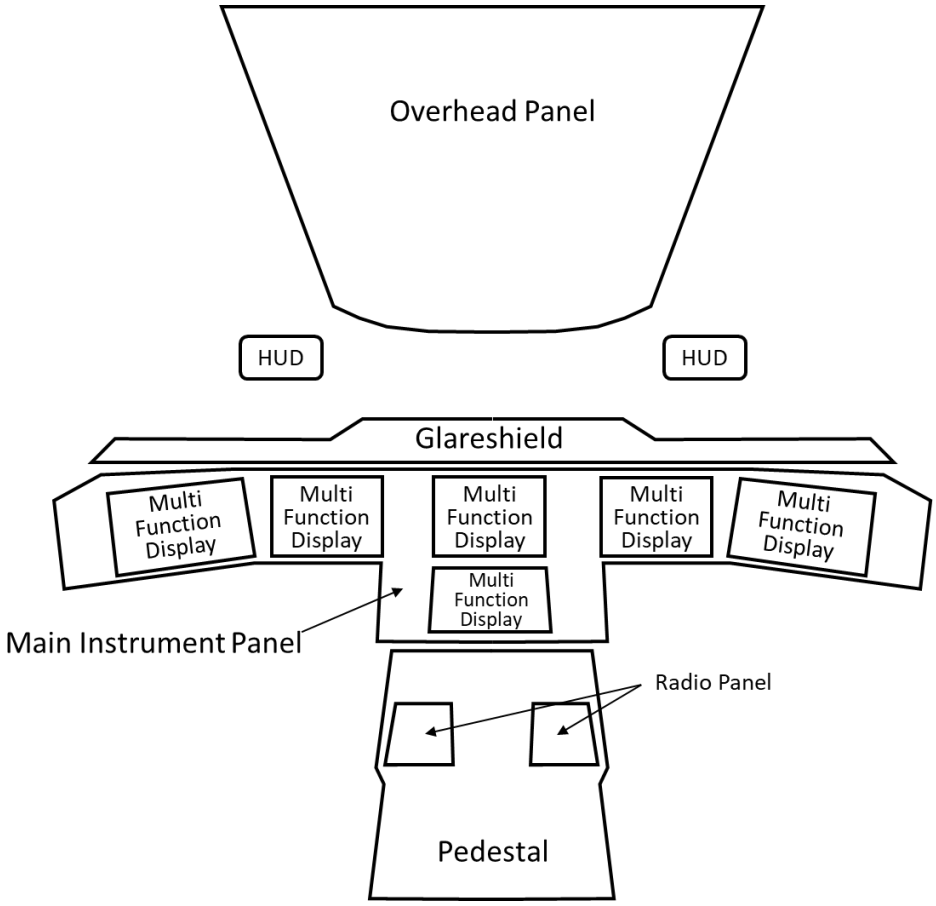

Figure 3-2: General arrangement of the Airbus A350 flight deck.

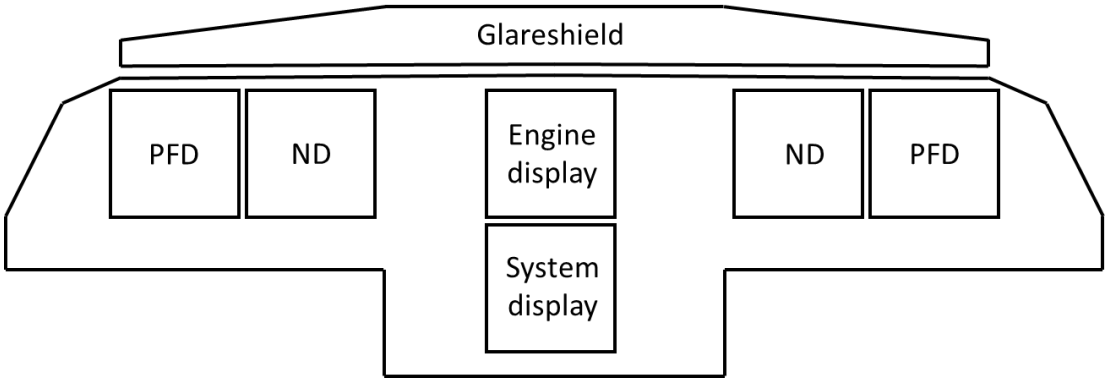

Figure 3-3: Typical configuration of a main instrument panel.

The PFD presents information on the flight parameters speed, altitude, attitude and autoflight/autothrottle modes (Flight Mode Annunciations). Figure 3-4 shows a typical PFD arrangement.

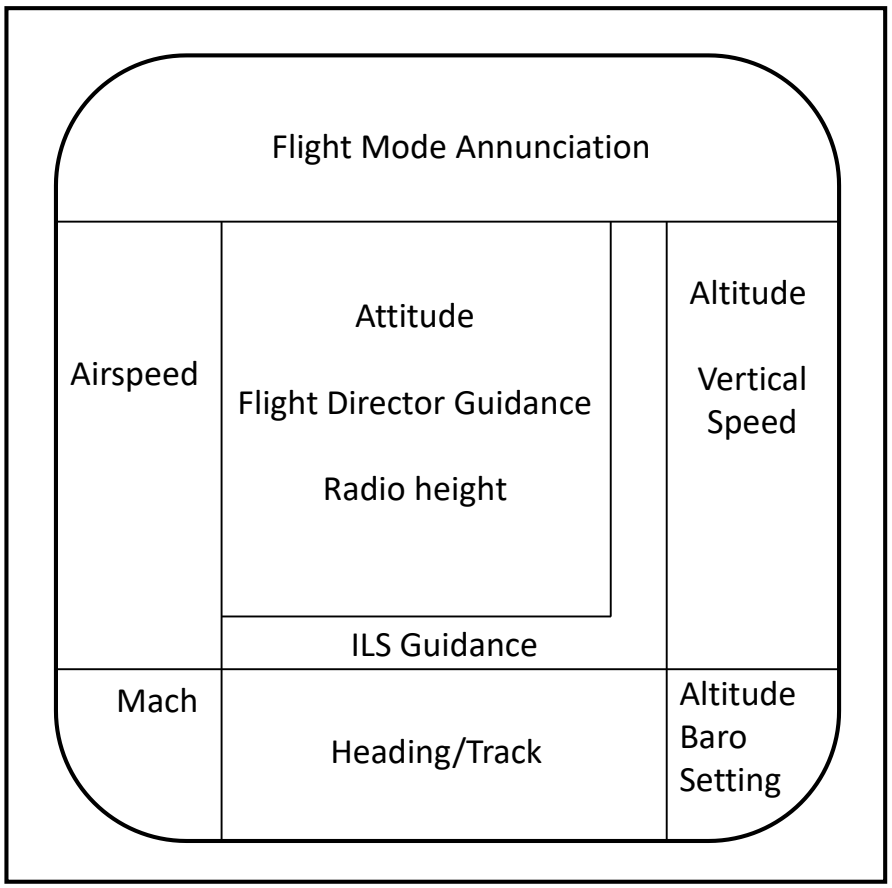

Figure 3-4: Typical arrangement of a Primary Flight Display.

3.2 General aviation aircraft

There is a wide variety in arrangement of the flight decks of general aviation (GA) aircraft, reflecting the diversity in size, complexity and performance of GA aircraft. Complex high performance GA aircraft such as the Embraer Phenom 300 have a flight deck that is very similar to that of large transport aircraft. Non-complex GA aircraft usually have a much simpler flight deck, with separate instruments for speed, altitude, attitude, engine parameters and a navigation display. Figure 3-5 shows a typical arrangement of the flight deck of a non-complex GA aircraft. Non-complex GA aircraft typically do not have an advanced autopilot system nor an autothrottle system.

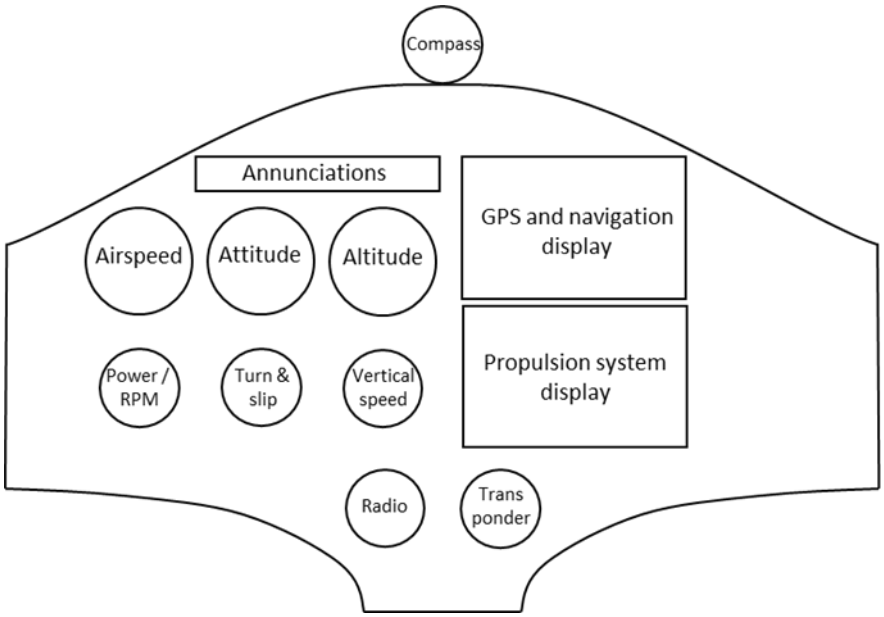

Figure 3-5: Typical arrangement of the instrument panel of a non-complex GA aircraft, in this case a Pipistrel Velis Electro.

3.3 Helicopter

The typical main instrument panel of medium and large helicopters is similar to that of large transport aircraft and complex GA aircraft. The main instrument panel includes multifunction displays that are normally configured as the Primary Flight Display, the Navigation Display, Engine Display and Systems Display. Figure 3-7 shows a typical configuration of the main instrument panel of a helicopter. A main difference between helicopters and fixed wing aircraft is the presentation of the rotor speed (expressed as revolutions per minute, RPM) which is a safety critical parameter for rotorcraft. The rotor speed can be presented on a separate display or integrated with engine information and presented on the engine display.

Another difference between multi-engine helicopters and multi-engine fixed wing aircraft is that multi-engine helicopters have engines that are linked via the main gearbox. In the case of a failure of one engine, the remaining engine is still able to provide power to the rotor. In multi-engine helicopters, the engine parameters are sometimes displayed on a single dial with two needles, one for each engine, see Figure 3-6.

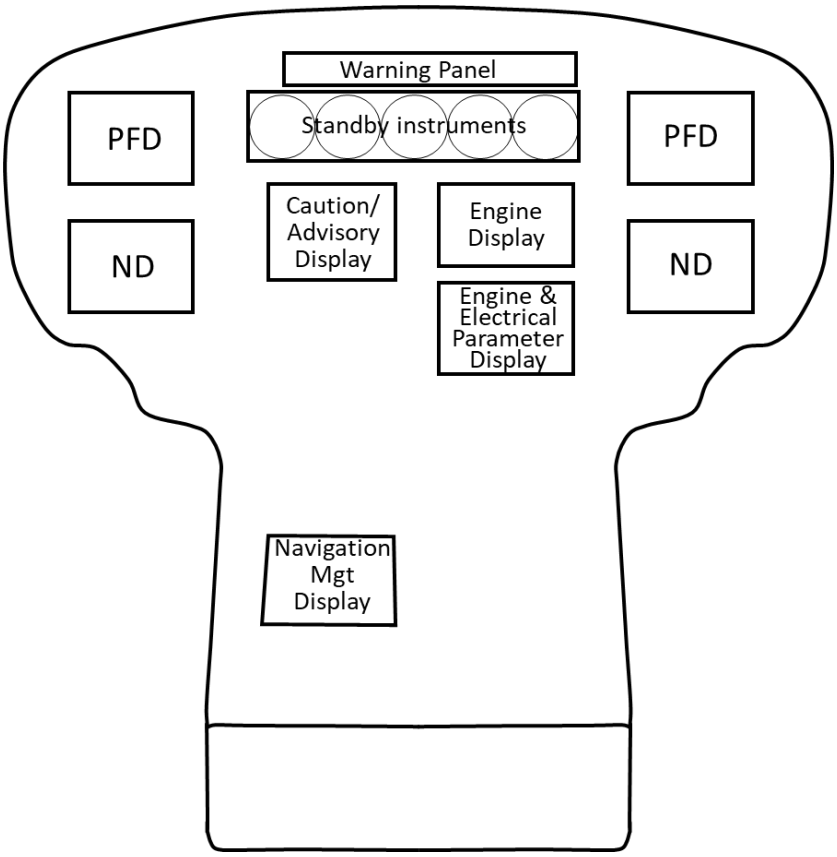

Figure 3-6: Typical arrangement of the main instrument panel and pedestal of a helicopter, in this case a Eurocopter EC-135.

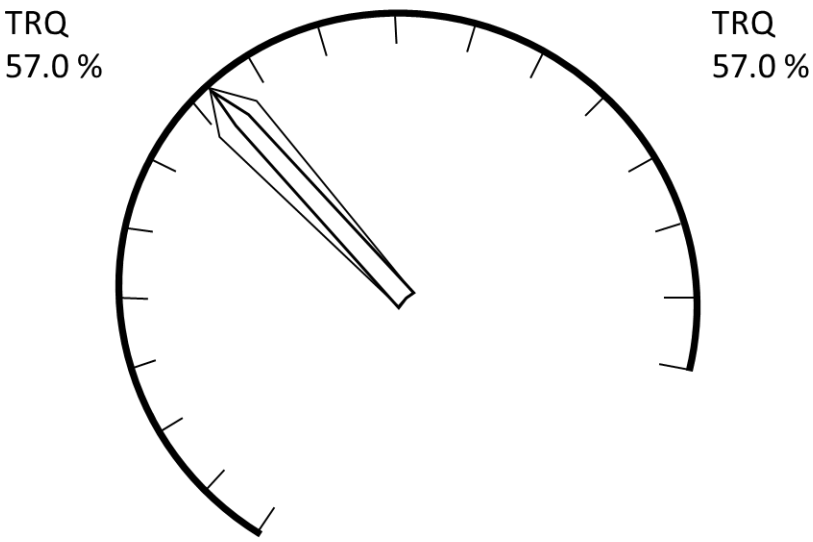

Figure 3-7: Typical display of helicopter engine parameters in a single dial with separate needles for each engine. In this case both needles overlap because the left and right engine produce identical torque. Engine parameter values for each engine are also numerically displayed, in this case 57% torque for each engine.

3.4 Annunciation of abnormal and emergency conditions

In most modern large transport aircraft, emergency situations that require immediate flight crew action (the aircraft is in a dangerous configuration or in a limiting flight condition, or a system failure impacts the safety of the flight) are annunciated by:

- Illumination of a red master warning light;
- Aural signal (repetitive chime or specific sound); and
- A red warning message on a warning display

Abnormal conditions that require awareness but no immediate flight crew action are annunciated by:

- Illumination of an amber master caution light;
- Aural signal (single chime); and
- An amber caution message on a warning display

Abnormal conditions that require the crew to be informed are annunciated by:

- An amber caution message on a warning display.

EASA AMC 25-11 Electronic Flight Deck Displays recommends the following colours for electronic display systems in the cockpit, as shown in Table 3-1.

Table 3-1: Recommended colour-coding according to EASA AMC 25-11.

Feature	Colour
Warnings	Red
Flight envelope and system limits, exceedances	Red or Yellow/Amber as appropriate
Cautions, non-normal sources	Yellow/Amber
Scales, dials, tapes, and associated information elements	White
Earth	Tan/Brown
Sky	Blue/Cyan
Engaged Modes/Normal Conditions	Green
Instrument landing system deviation pointer	Magenta
Divisor lines, units and labels for inactive soft buttons	Light Gray

4. Arrangement of ATC work stations

As Air Navigation Service Providers (ANSPs) have developed their own ATC system in the previous century, each ANSP tends to have their own Human Machine Interface (HMI). Also in the past, the ATCO working position consisted of several subsystems from different suppliers, each coming with their own HMI. Even now that it is becoming more common to use ATC systems from one of the main suppliers in the world, with subsystems integrated into one system, several ANSPs still want to customise the HMI to their own preferences and principles. As a consequence, little standardisation exists in ATC working position and HMI design. Of course, commonalities do exist. ATCO tasks are dependent of a certain set of information sources, which allows sketching generic ATCO working positions.

Main information sources of most ATCO working positions are: planning data, current station and geographical position of traffic (radar), weather data, and an administration tool that allows the ATCO to keep track of the instructions given to flight crews. The latter if often in the form of Flight Progress Strips (FPS), digital or paper, or more integrated in the working position.

ATC consists of various types of positions, each with their own work station arrangement. This section provides a general overview of the workstations for tower, approach and en-route control. Other ATC positions also exist (e.g. apron control), but are less safety critical and are thus deemed out of scope.

The graphics below only show the displays used by the controllers and do not include any buttons, computer mouses, phones etc. As mentioned before, there is not one configuration for work stations per ATC position. Different ANSPs have different configurations for each controller position. They could also have different tasks and responsibilities for each position and could even have different positions in general (e.g. having or not having a stack controller). ANSPs are also continuously updating their systems leading to new displays, some advancing faster than others, leading to even more differences.

4.1 Tower control

Tower control is also referred to as “aerodrome control”. The number of controller working positions depends on the traffic demand and the aerodrome layout. Smaller aerodromes with one runway can have a single tower controller. When traffic increases it may be necessary to split the tasks between a runway controller serving aircraft on the runway and a ground controller serving aircraft during the start-up and taxi phases. Tower controllers heavily rely on outside visuals to do their job. For this reason, their work stations are positioned in the shape of a circle looking outside to ensure the controllers have a clear view on the area or runway(s) they are servicing. In some cases, a remote tower is used. However, this visually resembles a real tower with large displays providing information from the remote cameras. Figure 4-1 shows a general layout of a tower controller’s work station.

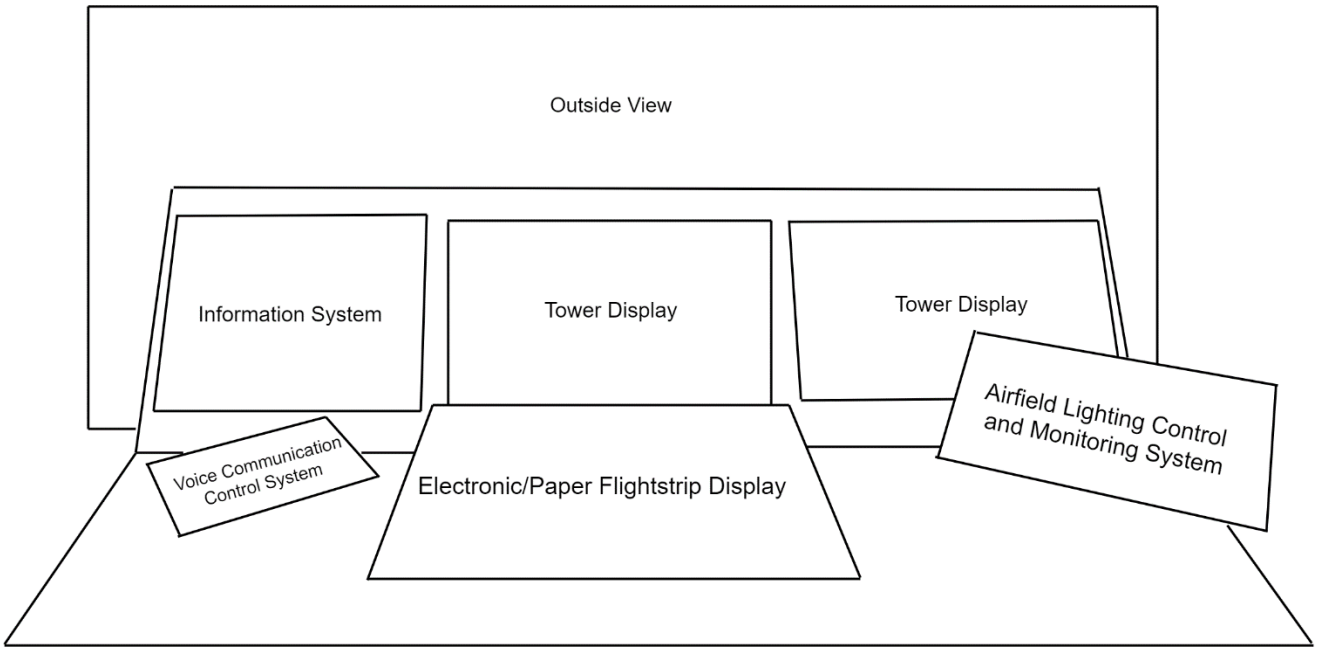

Figure 4-1: Generic configuration of the work station of a tower controller.

Flight strips can come in electronic or paper form depending on the available system. Electronic flight strips work in the same way as paper strips where notes can be written on them and they can be passed along to the next controller. Flight strips are often colour-coded to show their purpose, e.g. yellow for inbound, blue for outbound, however this is not standardised and can differ per ANSP. A generic example of a flight strip for departing traffic is shown in Figure 4-2. The Information System provides detailed maps and contains information on the occupation of the runways and the current weather. The Airfield Lighting Control and Monitoring System allows the controller to control the various airfield lighting systems including runway, approach, taxiway, stop bars, apron etc. The system can also include alarms related to airfield lighting equipment. The tower displays provide flight information (e.g. flight numbers and aircraft types), aircraft positions and trajectories, the airfield status (e.g. runway usage) and warnings. The Voice Communication Control System is a touch screen interface that commonly contains the following features: frequency management, phone shortcuts and dial options, a control panel (e.g. to select the output device) and functional buttons (e.g. to transfer calls). A generic example of the system is shown in Figure 4-3.

<table>
<tr><td>Actual time of departure</td><td>Aircraft type + wake turbulence category</td><td>Number of aircraft (formation flights)</td><td rowspan="3">Requested level or VFR

Estimated time of departure</td><td>SSR Code</td><td rowspan="3">Revised clearance</td><td rowspan="3">Other information</td></tr>
<tr><td>Aerodrome of destination</td><td colspan="2">Callsign</td><td>SID</td></tr>
<tr><td>Runway</td><td>Calculated take off time</td><td>Tail number</td><td>FL xxx</td></tr>
</table>

Figure 4-2: Generic flight progress strip for departing traffic.

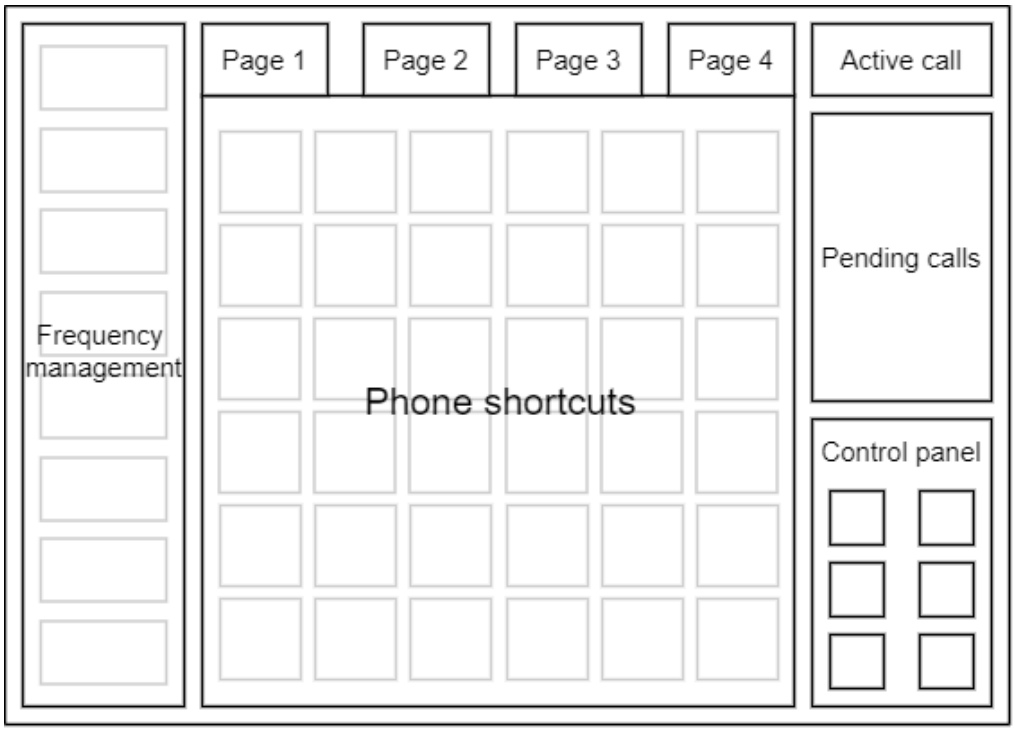

Figure 4-3: Generic example of the voice communication control system interface.

4.2 Approach control

The approach controller forms the link between the tower and en-route controllers and is hence also provided with aerodrome-related equipment such as the tower display, as can be seen in Figure 4-4. The approach controller's main source of information is the radar display showing at a minimum all aircraft in their sector along with identification and level information. Most current displays also show navigation features, active special use areas and geographic information as well as an indication on the "Distance to go", usually written next to the aircraft track. This number informs the controller what the distance from the aircraft to the touchdown of the selected runway is. One of the Information Systems is usually dedicated to show weather data from the aerodrome, a second display (if present) can be used for any other additional tools or information the ANSP wishes to provide. The Voice Communication Control System works in the same way as the one for the tower controller. Lastly, the Touch Input Display is used to control the radar display. This display is not always present, some ANSPs use a regular computer mouse instead.

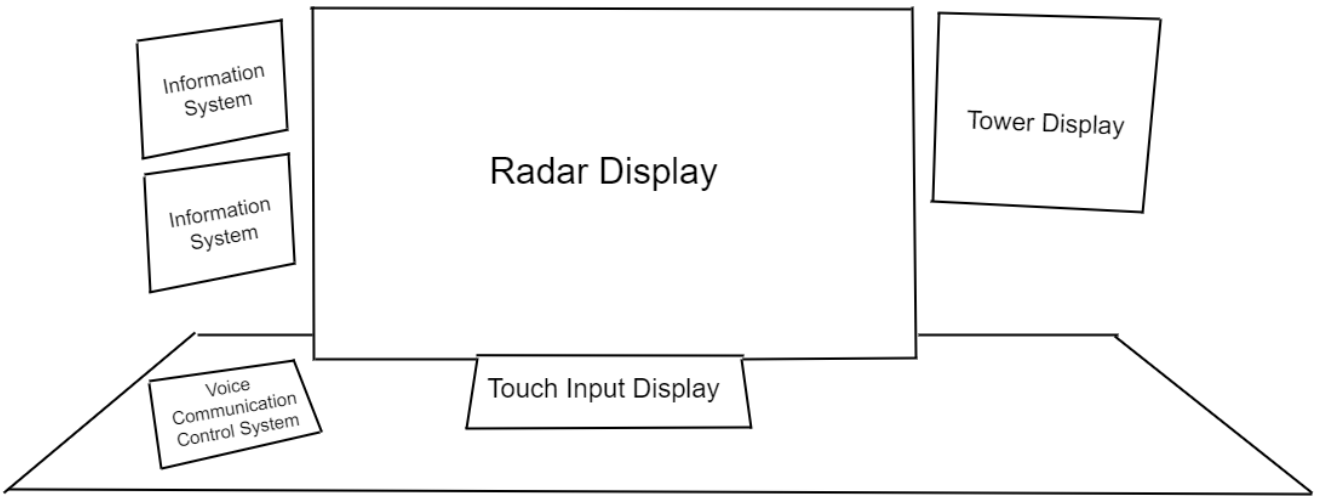

Figure 4-4: Generic configuration of the work station of an approach controller.

Figure 4-5 provides a generic overview of the radar display. The largest portion of the display is occupied by all aircraft in the sector (as illustrated by the circles with the aircraft identification label) along with additional information as mentioned previously. When the controller selects a flight, additional information on that flight is displayed at the bottom of the screen. In one of the top corners, a list of incoming aircraft is provided arranged in the order of arrival or departure as a planning tool.

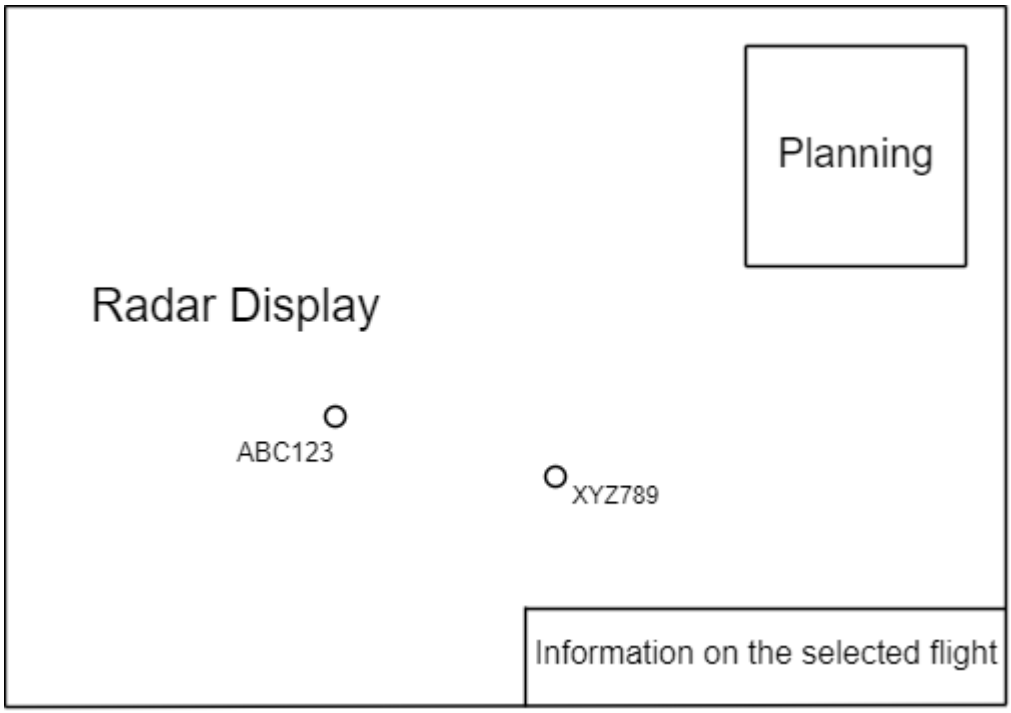

Figure 4-5: Generic presentation of a radar display.

In some ANSPs, during the busy hours roles of feeder and arrival are distinguished, where the feeders take care of the departing traffic and the arrival controllers merge the traffic towards final approach.

4.3 En-route control

En-route control is also referred to as “area control”. The en-route controller’s job is predominantly discovering and solving conflicts which they do by constantly scanning a number of sectors in the airspace on their radar display. The number of sectors depends on the expected traffic and the weather situation. Each sector is usually served by a team of two controllers: an executive and a planner. Sometimes only one person is assigned to a sector and other times, when needed, more than two people serve the sector.

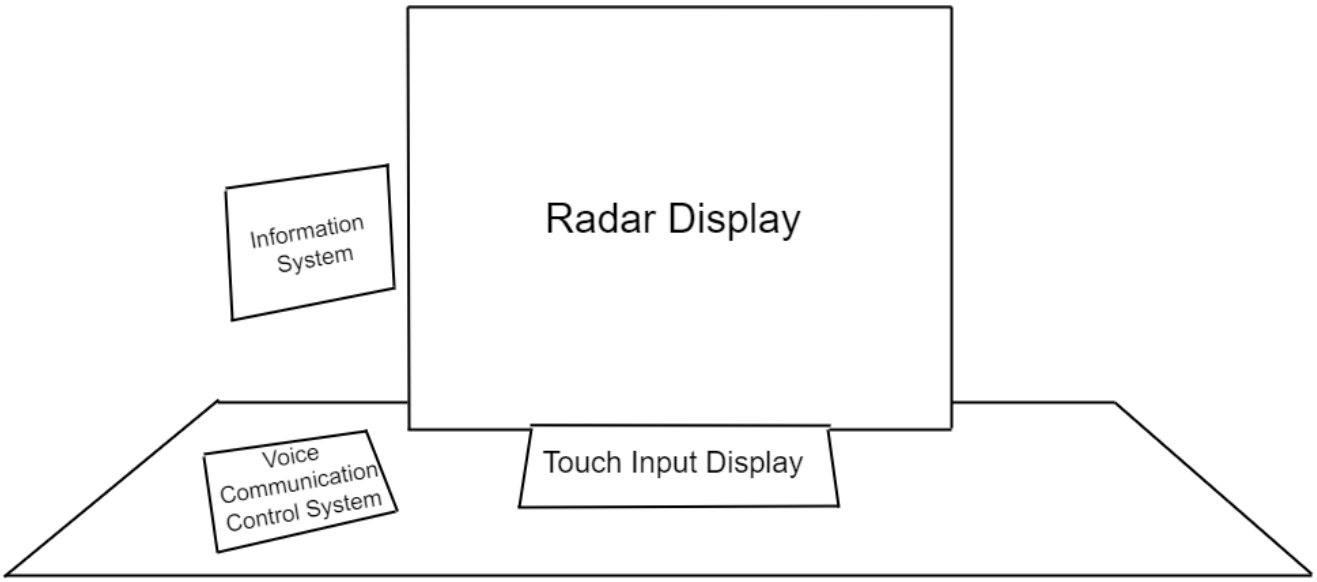

Figure 4-6: Generic configuration of the work station of an en-route controller.

Overall, the workstation of an en-route controller is very similar to the approach controller’s, as can be seen in Figure 4-6, with the exception that the en-route controller has no need for a tower display since they normally serve flights during the climb, cruise and initial descent phase. Some ANSPs’ en-route controller’s still use paper flight strips. Others (such as the ANSP in the Netherlands), display the strip information in the form of lists on the radar display. Changes to those flight strips are made with the touch input display. Figure 4-7 show the layout of a generic flight strip for an overflying traffic. The radar display is very similar to that of the approach controller.

<table>
<tr><td>Aircraft type + wake turbulence category</td><td>Number of aircraft (formation flights)</td><td>Departure</td><td rowspan="3">Requested level or VFR</td><td>ENTRY
FL xxx</td><td>MID01
FL xxx</td><td>MID02
FL xxx</td><td>EXITS
FL xxx</td><td rowspan="3">Other information</td></tr>
<tr><td colspan="2">Callsign</td><td>SSR Code</td><td colspan="4" rowspan="2">Estimated and actual times over significant points</td></tr>
<tr><td>Equipment</td><td>Tail number</td><td>Destination</td></tr>
</table>

Figure 4-7: Generic flight strip of an overflying traffic.

4.4 Annunciation of abnormal and emergency conditions in ATC

Despite there is a lack of a formal standardisation of colour coding in ATC, the colour usage for cautions, alerts and warnings often follows a generic coding similar to cockpit systems. Yellow/amber indicates caution or advisory conditions whereas red indicates warning or alert conditions.

- Short-Term Conflict Alerts (STCAs) automatically generated on the basis of the current position, speed and heading are indicated in red. The aircraft labels on the radar display of the flights that are in conflict with each other, turn red and additional cues are used e.g. a frame around the labels. A typical time frame is around 2 minutes before it becomes really critical.
- For spacing on final approach different minimum separation criteria apply, here minimum distances are in some ANSPs displayed in colour coded symbols, expectedly red.
- Medium Term Conflict Alerts (MTCAs) are presented in amber/yellow. Maastricht Upper Area Control has a medium-term conflict detection tool that is used by the planner controller. An amber/yellow indication in the label shows that a conflict may arise in a time frame of around 7 or 8 minutes.

Many ANSPs use so called “safety nets” which are automated systems that detect unsafe situations (e.g. using radar data) and warn the human operator (in ATM the air traffic controller), to solve a conflict situation before it evolves into an accident. Safety nets are designed as a last resort to detect and solve an unsafe situation, when other safety barriers have failed to avoid the event from happening. In essence, safety nets make ATM operations safer. An interesting observation is that the more safety nets an ANSP has in place, the more time-critical (colour coded) tasks can be identified. An increase in time-critical tasks may lead someone to conclude that the operation is more safety-critical, when in fact the safety nets are designed to make it safer.

Some examples of safety nets are presented in the following list. As mentioned before, the availability of the systems is not regulated and the systems are not available at all ANSPs.

- Minimum Safe Altitude Warning: A ground-based safety net that warns the controller about increased risk of controlled flight into terrain by alerting of aircraft proximity to terrain or obstacles
- Runway Incursion Alerting System: A safety system that uses surveillance technology to detect and alert controllers when an aircraft or vehicle is entering a runway without permission, helping to prevent collisions. A warning gives the ATCO the time to determine if there is a possible risk of collision in the future whereas a warning requires immediate action from the ATCO to assess the situation.
- Go-Around Detection System: Unique to LVNL, the Go-Around Detection System gives an audio prompt and a warning on the radar screen when an aircraft makes a go-around. As go-arounds are not planned for, they can lead to dangerous situations where traffic can unexpectedly cross paths.
- Intrusion alerts notify ATCOs of potential or actual unauthorized aircraft or vehicles into restricted airspace.

5. Task listing and analysis

5.1 Flight crew tasks

Annex A provides a full overview of all flights crew tasks and the visual information that is used during the execution of the tasks. The task listing is arranged chronologically for a typical flight with a large transport aircraft, starting when the flight crew reports for duty and ending when the flight crew has stopped the aircraft and deactivated the systems or configured the aircraft for handover to the next crew. Abnormal flight crew tasks related to emergencies or abnormal situations are listed separately. The task listing is based on a NASA study[4], a job task listing and analysis for transport jet airlines published by the FAA[5], and input from commercial pilots.

While the task listing represents a typical flight with a large commercial aircraft, the tasks for a flight with a general aviation aircraft or a helicopter are to a large extent similar. Non-complex GA aircraft have less sophisticated autopilot systems, no autothrottle, no lift dumpers and no autobrake systems and therefore no tasks related to operating and monitoring of these systems. For helicopters there is an additional task regarding monitoring and control of the rotor speed.

The severity classification and colour-coding effect were assessed for each of the tasks. The flight crew tasks listed in Table 5-1 are tasks with a severity class 'hazardous' or 'catastrophic' and where the colour-coding was deemed 'supportive' or 'essential'.

Table 5-1: Flight crew tasks with hazardous/catastrophic severity class and supporting/essential colour-coding effect.

Activity	Visual information	Severity class	Colour-coding effect	Flight phase
Apply pitch up control input	Attitude and target on PFD	Catastrophic	Essential effect	TAWS activation
Close thrust levers	Engine parameters on engine display	Catastrophic	Essential effect	Rejected take off
Control and monitor the aircraft trajectory	Speed and altitude on PFD, attitude on PFD, track on ND	Catastrophic	Essential effect	Powerplant and aircraft system emergency
Manage aircraft attitude	Attitude and target on PFD	Catastrophic	Essential effect	Take off, initial climb, final approach and missed approach
Rotate aircraft	Attitude and target on PFD	Catastrophic	Essential effect	Take off

[4] 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

[5] FAA. Transport Jet Airlines, AQP Pilot Job Task Listing and Analysis (JTL/JTA), (Template Document). https://www.faa.gov/sites/faa.gov/files/training_testing/training/aqp/library/Pilot_JTA_Example.pdf

Stop the flight path divergence and recover to a stabilized flight path	Speed, altitude and attitude on PFD, autopilot setting on glareshield, autopilot mode on PFD, autothrottle mode on PFD	Catastrophic	Essential effect	Unusual attitude / in flight loss of control
Manage aircraft altitude	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude, PAPI lights, G/S deviation on PFD	Catastrophic	Essential effect (PAPI), supporting effect	Final approach
Adjust collective lever as necessary to maintain rotor RPM within the normal range	Rotor RPM on engine display	Catastrophic	Supporting effect	Low or high rotor RPM (helicopters only)
Initiate diversion / descent	FMS, ND for route and NAVAIDS, glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND	Catastrophic	Supporting effect	Fire/smoke (annunciated and non-annunciated)
Manage aircraft altitude	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Catastrophic	Supporting effect	Missed approach
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Catastrophic	Supporting effect	Initial climb
Set TOGA thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Catastrophic	Supporting effect	TAWS activation
Verify automatic braking or apply manual braking	Brake status on systems display, autobrake mode on PFD	Catastrophic	Supporting effect	Rejected take off
Assess the energy, become situationally aware	Attitude and target on PFD, speed, speeds trends and speed boundaries on PFD, altitude on PFD	Hazardous	Essential effect	Unusual attitude / in flight loss of control

Check RPM indicator	Rotor RPM on engine display	Hazardous	Essential effect	Low or high rotor RPM (helicopters only)
Control the aircraft with the operative flight controls, trim and engine thrust	PFD for speed, pitch trim, altitude and attitude, engine display for engine parameters, pedestal for rudder trim, flight control page on systems panel.	Hazardous	Essential effect	Flight control system failure / jam (not annunciated)
Deploy spoilers/verify spoiler deployment	Spoiler status on system display	Hazardous	Essential effect	Landing
Descent to 10,000 ft - Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect	Depressurization (pressurised aircraft only)
Follow the Resolution Advisory instruction / monitor Autopilot – Autothrust response to RA	Attitude and target on PFD, PFD for airspeed and vertical speed, speed trend and reference speeds, glareshield for autopilot /autothrust setting, PFD for autopilot/autothrust mode, PFD for altitude	Hazardous	Essential effect	ACAS activation
Identify depressurization	Attention getter, cabin pressure indication on system display	Hazardous	Essential effect	Depressurization (pressurised aircraft only)
Identify engine failure	Attention getter, engine parameters on engine display, engine lights on overhead panel, engine lights on pedestal	Hazardous	Essential effect	Powerplant emergency
Identify possible conflict	Terrain conflict on the ND, EGPWS light on the instrument panel	Hazardous	Essential effect	TAWS activation
Identify smoke	Warning/system display	Hazardous	Essential effect	Fire/smoke (annunciated and non-annunciated)
Identify unusual attitude	Attitude and target on PFD, bank angle exceedance on PFD	Hazardous	Essential effect	Unusual attitude / in flight loss of control
Identify windshear	Windshear warning/advisory on PFD and/or ND	Hazardous	Essential effect	Windshear encounter
Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect	Climb to cruise, cruise and descent

Maintain awareness of terrain/obstacles	Terrain/obstacle indication on airport chart (EFB), terrain information on ND, obstacle lights, (radio) altimeter on PFD	Hazardous	Essential effect	Initial climb
Maintain awareness of terrain/obstacles	EGPWS on ND, obstacle indication on airport chart (EFB), obstacle lights, (radio) altimeter on PFD	Hazardous	Essential effect	Initial and intermediate approach
Maintain awareness of terrain/obstacles	Obstacle indication on approach chart, obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Essential effect	Final approach
Maintain awareness of terrain/obstacles	Obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Essential effect	Windshear encounter
Manage aircraft attitude	Attitude and target on PFD	Hazardous	Essential effect	Initial and intermediate approach and missed approach
Manage take-off thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Essential effect	Take off
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Essential effect	Initial climb
Monitor and manage airspeed	PFD for airspeed, speed trend and reference speeds, systems display for take-off monitoring alerts	Hazardous	Essential effect	Take off
Move toward correct pitch attitude	Attitude and target on PFD	Hazardous	Essential effect	Windshear encounter
Recognise the need for a go-around	Deviations from glidepath on PFD, PAPI indication, vertical speed on PFD, aircraft configuration (gear, flaps) on PFD, EGPWS annunciations on ND	Hazardous	Essential effect	Missed approach

Secure the affected engine	Fuel control switches, engine fire switches, engine parameters on engine display	Hazardous	Essential effect	Powerplant emergency
Verify spoilers/speedbrakes deployment or manually deploy spoilers/speedbrakes	Spoiler/speedbrake status on system display	Hazardous	Essential effect	Rejected take off
Accelerate to correct speed	Glareshield for autopilot setting, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect	Missed approach
Calculate landing performance based on most recent data of runway and weather conditions	EFB	Hazardous	Supporting effect	Descent
Configure aircraft for take-off	System status on system display, overhead panel for system setting	Hazardous	Supporting effect	Taxi to take-off position
Configure FMS - set and check performance data	EFB, FMS/multi-function display	Hazardous	Supporting effect	Systems initialization
Descent to 10,000 ft - Manage speed	Autopilot mode on PFD, speed on PFD	Hazardous	Supporting effect	Depressurization (pressurised aircraft only)
Descent to 10,000 ft - Manage vertical speed	Vertical speed on PFD	Hazardous	Supporting effect	Depressurization (pressurised aircraft only)
Determine V-speeds and thrust settings for take-off	EFB	Hazardous	Supporting effect	Pre-flight
Engage wheel brakes/verify autobrake response	Wheel brake status on system display	Hazardous	Supporting effect	Landing
Evaluate condition and decide if emergency evacuation is required	System status on system display, engine parameters on engine display	Hazardous	Supporting effect	Rejected take off
Evaluate consequences	System status on system display	Hazardous	Supporting effect	Aircraft system emergency
Identify possible conflict	Intruder position on ND, vertical order on PFD	Hazardous	Supporting effect	ACAS activation

Maintain awareness of other aircraft	Aircraft exterior lighting, ACAS display on ND	Hazardous	Supporting effect	Take off
Maintain awareness of other aircraft	ACAS on ND, aircraft exterior lighting	Hazardous	Supporting effect	Initial climb and initial and intermediate approach
Maintain awareness of other aircraft	ACAS on ND	Hazardous	Supporting effect	Climb to cruise, cruise and descent
Maintain awareness of other aircraft	Aircraft exterior lighting, ACAS display on ND	Hazardous	Supporting effect	Final approach and landing
Maintain awareness of terrain/obstacles	Obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Supporting effect	Landing
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Hazardous	Supporting effect	Initial and intermediate approach
Manage aircraft heading	Runway markings, runway lighting	Hazardous	Supporting effect	Take off
Manage aircraft heading	Track/heading on ND, track/heading on PFD, runway markings, runway lighting, LOC deviation on PFD	Hazardous	Supporting effect	Final approach
Manage airspeed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect	Initial climb
Manage airspeed	Glareshield for speed selection, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect	Final approach and landing
Manage taxi route	Taxiway marking, taxiway lighting, stop bars, airport map on EFB, track/heading on ND, track/heading on PFD	Hazardous	Supporting effect	Taxi to take-off position and taxi to gate and park aircraft
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect	Final approach and landing

Manage vertical speed	Glareshield for autopilot setting, PFD for autopilot mode, vertical speed on PFD	Hazardous	Supporting effect	Final approach
Monitor speed	Glareshield for speed setting, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect	Windshear encounter
Perform line-up check	Heading on PFD/ND, runway marking	Hazardous	Supporting effect	Taxi to take-off position
Set TOGA thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect	Missed approach and windshear encounter
Verify landing gear down and locked	Lights on landing gear indicator panel, gear status on system display	Hazardous	Supporting effect	Final approach
Monitor flight path	Glareshield for autopilot setting, PFD for autopilot mode, track and heading on ND	Hazardous	Supporting effects	Windshear encounter

5.2 ATCO tasks

The full list of ATC tasks is provided in Annex B. A list of tasks was retrieved from the EPISODE 3 project[6] and from a study done by DeepBlue in collaboration with EUROCONTROL[7]. Together with an air traffic controller, the lists were adapted for the purpose of the needs of the current study. When no visual information is available to support a task, clearly no colour-coded information is available, and thus the task can be excluded from the analysis. In some cases, tasks were grouped. For each ATCO control area (en-route control, approach control and tower control) the considerations are provided in the current section.

The processes of conflict resolution and quality of service improvement (e.g. providing service to airlines to fly more efficient), in the original tasks analysis consisted of the task of considering a solution, verifying a solution and choosing one. In each category, the same sub-tasks were mentioned. We considered the generation of solutions, the verification and the selection of a solution as an iterative process and grouped them into one task. The detection of conflicts and non-conformance was a task that was not explicitly mentioned and was added subsequently.

The task of workload monitoring was according to the project team (including the consulted air traffic controller) a task for the supervisor, e.g. a so-called flow control display is something that is only used by the

[6] Episode 3 Consortium. (2007). Today's Operations Task Analysis – Human Factor Assessment (Deliverable 2.4.4-05 of the EPISODE 3 project funded by the European Commission.

[7] Tavanti, M. (2006). Control Tower Operations: A Literature Review of Task Analysis Studies. (As part of the MMF project in collaboration with EUROCONTROL).

supervisor. The implicit self-monitoring of workload experienced was removed, as it is considered a secondary task and not being safety critical.

There are several tasks for which no visual information is presently available. For probing of solutions, most ANSPs do not have tools to support this at the moment and takes place as part of a cognitive process of the ATCO.

In en-route control, most often ATCOs work in teams with one planner controller and one executive controller. When it is not busy in the sector these roles are combined. In the task listing the distinction between the roles not made. Neither was the role of stack controller explicitly analysed.

The severity classification and colour-coding effect were assessed for each of the tasks. The ATCO tasks listed in Table 5-2 are the tasks with severity class 'hazardous' or 'catastrophic' and where the colour-coding was deemed 'supportive' or 'essential'.

Table 5-2: ATC tasks with hazardous/catastrophic severity class and supporting/essential colour-coding effect.

Activity	Visual information	Severity class	Colour-coding effect	ATC Position
Respond to runway incursion alert	Tower Display	Catastrophic	Essential effect	Tower, Runway control
Aircraft or vehicle incursions	Tower display	Hazardous	Essential	Tower, Ground control
STCA	Radar	Hazardous	Essential effect	Approach control
Deviating Pilot selected level	Radar	Hazardous	Essential effect	Approach control
Detect and respond to non-conformance	Radar, tools (Pilot selected level)	Hazardous	Supporting or no effect depending on HMI	Approach control
Refine conflict detail: - Linearly extrapolate aircraft positions - Search for interactions	Radar, STCA	Hazardous	Essential effect	En-route control
STCA	Radar	Hazardous	Supporting or no effect depending on HMI	En-route control
Deviating Pilot selected level	Radar	Hazardous	Supporting or no effect depending on HMI	En-route control
Do visual check for obstacles;	Outside view (e.g. people), ground radar	Hazardous	Supporting	Ground control

No obstacles: approve pushback and annotate strip (time, stand number etc) Obstacles: disapprove pushback and contact appropriate person to take action				
Issue push-back clearance	FPS, outside, ground radar	Hazardous	Supporting effect	Tower, Ground control
Check wind information and relate to pilot	Weather information on information system	Hazardous	Supporting effect	Tower, Runway control arrivals
If runway is free and wind is OK, give landing clearance. If not, instruct go-around	Outside view and tower display, Voice communication control system	Hazardous	Supporting effect	Tower, Runway control arrivals
Give clearance for vehicles to enter runway, check traffic situation	Outside view and tower display	Hazardous	Supporting effect	Tower, Runway control arrivals
Give line-up clearance when next in taxiway sequence while ensuring appropriate separations and checking positions of other relevant traffic	Tower display, outside view, FPS, Comms	Hazardous	Supporting effect	Tower, Runway control departures
Deliver take-off clearance after: Checking runway is free, Checking and give wind information, Recording any relevant info on FPS	Tower display, outside view, FPS, Information System	Hazardous	Supporting effect	Tower, Runway control
Solve conflict	Radar	Hazardous	Supporting effect	En-route control
Check wind information and relate to pilot	Weather information on information system	Hazardous	Supporting or no effect depending on HMI	Tower, Runway control
If runway is free and wind is OK, give	Outside view, FPS, tower display	Hazardous	Supporting or no effect	Tower, Runway control

landing clearance. If not, instruct go-around	Voice communication control system		depending on HMI	
Give line-up clearance when next in taxiway sequence while ensuring appropriate separations and checking positions of other relevant traffic	Tower display, outside view, FPS, Comms	Hazardous	Supporting or no effect depending on HMI	Tower, Runway control
Deliver take-off clearance after: Checking runway is free Checking and give wind information Recording any relevant info on FPS	Tower display, outside view, FPS, Information System	Hazardous	Supporting or no effect depending on HMI	Tower, Runway control

6. Influence of different lighting conditions

The lighting condition on the flightdeck may vary as a result of direct and indirect sunlight and cockpit interior lights. The brightness of the cockpit interior lights can be controlled by the flight crew. The flight crew can have some control over the influx of direct and indirect sunlight by using sun visors and sunblinds, but the influx of direct sunlight on flight deck displays cannot always be prevented. Readability of displays in a high ambient lighting can be improved by increasing the contrast ratio. A contrast ratio of 5:1 is required as a minimum for image details detection in a high ambient light environment. Displays utilising LCD technology can achieve contrast rations of more than ten to one[8].

The same applies for tower operations in ATC, where sometimes in darkness and sometimes in bright daylight the displays need to be readable. Here also sunblinds are in place and it may be assumed that the illumination of the displays is adjusted according to the outside conditions.

EASA CS25.1321 requires that if a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.

What is most critical in this context is any colour identification in the outside view. It is expected that the colour distinction of e.g. coloured lights (PAPI and other lights used on airports) is most challenging in:

1. reduced visibility conditions,
2. bright daylight, or
3. darkness.

In reduced visibility conditions, procedural adjustments are in place and increased safety margins to maintain safety levels.
In bright daylight, airport lights are less visible to the human eye. In these circumstances the light does not play a large role as it would be visible without artificial light e.g. which is the runway and which is the taxiway.

In darkness, the human eye is less sensitive to colours. In reduced light, human vision shifts from the colour-sensitive cone cells to rod cells, which are more sensitive to light but do not distinguish colours. The rod cells do not have the ability to distinguish between different wavelengths of light, necessary for colour perception. The dark adaptation process can take up to two hours for the human eye to fully adjust from bright light to darkness. During this time, colour perception gradually diminishes as the rod cells become more dominant. Something called the Purkinje effect occurs during the transition from daylight to night vision. This effect makes blue colours appear brighter in twilight conditions, while red may appears less bright. Additionally, during night-time operations, tower controllers may for operational reasons need to transition between brighter areas (closer to the terminal) and darker areas (remote runways and taxiways).
The reduced sensitivity to colour in darkness refers to coloured objects that do not emit light themselves, such as airport markings. Nevertheless, this aspect may play a role in distinguishing different colours in the airport lighting.

[8] Livade, B. (2012) Avionic Displays. *Scientific Technical Review*, Vol. 62, No. 3-4, p 70-79.

7. Conclusion and recommendations

Based on literature, lists of tasks were generated for the flight deck and for ATC working positions. For each task the visual information involved was indicated. Furthermore, the criticality and colour coding effect were identified for each task. The full results are presented in Annex A and Annex B Even though much of the information could be filled in generically (e.g. a short-term conflict alert is marked in red in most ANSPs), differences exist in presentations of cautions and warnings between different cockpits and in time critical tasks between different ANSPs.

Tasks with a severity classification 'hazardous' or 'catastrophic' and where the colour-coding is 'essential' or 'supportive' will be considered for measurement in VISION Task 2. These tasks are listed in tables 5-1 for flight crew tasks and 5-2 for ATCO tasks.

For the flight deck, colour coded tasks that are in the severity category 'hazardous' or 'catastrophic' are related to flight phases close to the ground (take-off and approach/landing) and/or failures of flight critical systems. The time-criticality of appropriate response by the flight crew is a determining factor here. Colour coding is used to support early detection of unsafe situations and prioritisation of required flight crew actions. The preferred use of colours is described in regulation, with red for warnings and amber/yellow for cautions. This convention is used in all aircraft types - commercial transport aircraft, business jets, general aviation aircraft and helicopters.

For ATC working positions, the number of tasks that are in the severity category 'hazardous' or 'catastrophic' are quite limited. Regarding the colour-coding, besides some very obvious tasks (e.g. respond to Short Term Conflict Alert are presented in red), it is quite unclear what colours are used in ATC HMIs due to lack of standardisation. Also, the safety nets used at different ANSPs seem to vary and as such the time to detect also varies.

Meanwhile, it should be considered that when safety nets are in place, the operators (ATCOs) working with the system may slowly but surely rely on them. However, this can vary depending on the culture and ATCO personal characteristics, as some operators may instead try to avoid alerts from going off at all times. It should also be noted that the introduction of safety nets may have facilitated the growth in air traffic that is under control by one controller. In summary, safety nets provide an extra safety layer to timely detect and solve critical situations. Since the warnings/alerts provided by the safety nets are often colour-coded, it is important to analyse these at the different ANSPs. The following questions need attention: which safety nets are available, what is the expected reaction time, how are alerts presented, is colour-coding used, and are additional visual cues presented?

Therefore, at every ANSP where measurements will take place, an inventory will be made prior to the colour measurements. In the Task 2 Measurement Plan, tasks and scenarios will be grouped based on the results of this inventory.

Annex A List of flight crew tasks per flight phase

Pre-departure planning & preparation

Activity	Visual information	Severity class	Colour-coding effect
Desk activity, acquire flight plan information	EFB	Minor	No effect
Check maintenance log and required procedural actions (if applicable)	-	Major	Not applicable
Set up navigation charts in EFB	EFB	Minor	Supporting effect
Determine V-speeds and thrust settings for take-off	EFB	Hazardous	Supporting effect

Systems initialization

Activity	Visual information	Severity class	Colour-coding effect
Walk around inspection If applicable)	Aircraft outward appearance	Minor	No effect
Verify aircraft systems status acceptable for flight	Overhead panel, main instrument panel, systems panel, pedestal	Minor	Supporting effect

Systems activation

Activity	Visual information	Severity class	Colour-coding effect
Internal cockpit checks/ initialise and verify aircraft systems.	Overhead panel, systems panel	Minor	Supporting effect
Start APU (if required).	Systems display	No safety effect	Supporting effect
Configure and verify aircraft systems.	Overhead panel, main instrument panel, systems display, pedestal	Minor	Supporting effect
Configure FMS - set initial data	FMS/multi-function display	Major	Supporting effect
Configure FMS - set navigation data	FMS/multi-function display	Major	Supporting effect
Configure FMS - set and check performance data	EFB, FMS/multi-function display	Hazardous	Supporting effect

Gate disengagement

Activity	Visual information	Severity class	Colour-coding effect
Manage pushback	Marking on apron	Minor	Supporting effect
Maintain awareness of other vehicles/aircraft	Vehicle lighting, aircraft exterior lighting	Minor	No effect

Start engines	Overhead panel, engine parameters on engine display	Minor	Supporting effect

Taxi to take-off position

Activity	Visual information	Severity class	Colour-coding effect
Communicate with ATC	Radio panel	Minor	No effect
Monitor aircraft system status	System display, attention getter	Minor	Supporting effect
Manage taxi speed	PFD for airspeed, taxiway marking, taxiway lighting	Minor	No effect
Manage taxi route	Taxiway marking, taxiway lighting, stop bars, airport map on EFB, track/heading on ND, track/heading on PFD	Hazardous	Supporting effect
Maintain awareness of other vehicles/aircraft	Vehicle lighting, aircraft exterior lighting	Major	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Configure aircraft for take-off	System status on system display, overhead panel for system setting	Hazardous	Supporting effect
Perform line-up check	Heading on PFD/ND, runway marking	Hazardous	Supporting effect

Take-off

Activity	Visual information	Severity class	Colour-coding effect
Communicate with ATC	Radio panel	Hazardous	No effect
Manage take-off thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Essential effect
Monitor and manage airspeed	PFD for airspeed, speed trend and reference speeds, systems display for take-off monitoring alerts	Hazardous	Essential effect
Manage aircraft heading	Runway markings, runway lighting	Hazardous	Supporting effect
Monitor aircraft systems	System display, attention getter	Major	Essential effect

Rotate aircraft	Attitude and target on PFD	Catastrophic	Essential effect
Manage aircraft attitude	Attitude and target on PFD	Catastrophic	Essential effect
Maintain awareness of other aircraft	Aircraft exterior lighting, ACAS display on ND	Hazardous	Supporting effect

Rejected take-off

Activity	Visual information	Severity class	Colour-coding effect
Close thrust levers	Engine parameters on engine display	Catastrophic	Essential effect
Verify automatic braking or apply manual braking	Brake status on systems display, autobrake mode on PFD	Catastrophic	Supporting effect
Verify spoilers/speedbrakes deployment or manually deploy spoilers/speedbrakes	Spoiler/speedbrake status on system display	Hazardous	Essential effect
Apply reverse thrust	Reverser indication and engine parameters on engine display	Major	Essential effect
Maintain aircraft heading	Track/heading on PFD/ND, runway markings, runway lighting	Hazardous	No effect
Verify brake temperature	Brake status on system display	Major	Supporting effect
Evaluate condition and decide if emergency evacuation is required	System status on system display, engine parameters on engine display	Hazardous	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Initial climb

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Essential effect

Manage aircraft heading	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND	Major	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Catastrophic	Essential effect
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Catastrophic	Supporting effect
Manage vertical speed	Glareshield for autopilot setting, PFD for autopilot mode, vertical speed on PFD	Major	Supporting effect
Maintain awareness of terrain/obstacles	Terrain/obstacle indication on airport chart (EFB), terrain information on ND, obstacle lights, (radio) altimeter on PFD	Hazardous	Essential effect
Maintain awareness of other aircraft	ACAS on ND, aircraft exterior lighting	Hazardous	Supporting effect
Select gear up	Gear status on system display	Major	Supporting effect
Retract flaps	Flap status on system display	Major	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Monitor aircraft systems	System status on system display, attention getter on glareshield	Major	Essential effect
Communicate with ATC	Radio panel	Major	No effect

Climb to cruise

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for airspeed, speed trend and reference speeds	Major	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode,	Major	Supporting effect

	engine display for engine parameters		
Manage aircraft heading/navigation	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND, waypoint on ND/FMS, map on EFB	Major	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Major	Essential effect
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Major	Supporting effect
Manage vertical speed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for vertical speed	Major	Supporting effect
Configure aircraft for climb	System status on system display, overhead panel for system setting	Minor	Supporting effect
Set altimeters upon passing transition altitude	Barometric reference on PFD	Major	Supporting effect
Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect
Maintain awareness of other aircraft	ACAS on ND	Hazardous	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Monitor aircraft systems	System status on system display, attention getter on glareshield	Major	Supporting effect
Communicate with ATC	Radio panel	Minor	No effect

Cruise

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for airspeed, speed trend and reference speeds	Major	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD	Major	Supporting effect

	for autothrust mode, engine display for engine parameters		
Manage aircraft heading/navigation	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND, waypoint on ND/FMS, map on EFB	Minor	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Major	Essential effect
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Major	Supporting effect
Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect
Maintain awareness of other aircraft	ACAS on ND	Hazardous	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Configure aircraft systems for cruise	System status on system display, overhead panel for system setting	Minor	Supporting effect
Monitor fuel	Fuel status and fuel system configuration on system display	Major	Supporting effect
Monitor aircraft systems	System status on system display, attention getter on glareshield	Major	Supporting effect
Communicate with ATC	Radio panel	Minor	No effect

Descent

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for autopilot setting, PFD for autopilot mode, PFD for airspeed, speed trend and reference speeds	Major	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Major	Supporting effect

Manage aircraft heading/navigation	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND, waypoint on ND/FMS, map on EFB	Major	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Major	Essential effect
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Major	Supporting effect
Manage vertical speed	Vertical speed on PFD, flight path angle on PFD, glareshield for vertical speed	Major	Supporting effect
Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect
Maintain awareness of other aircraft	ACAS on ND	Hazardous	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Configure altimeters for local pressure	Barometric reference on PFD	Major	Supporting effect
Monitor ATIS for pertinent information on weather, visibility, etc.	-	Minor	Not applicable
Calculate landing performance based on most recent data of runway and weather conditions	EFB	Hazardous	Supporting effect
Select arrival routing and approach	FMS, ND for route and NAVAIDS	Major	Supporting effect
Select approach speeds	FMS, PFD for reference speeds	Major	Supporting effect
Select autobrake setting	Autobrake setting on system display	Major	Supporting effect
Set anti-ice system as required	Overhead panel, system status on engine display	Major	Supporting effect
Select DH/ MDA	PFD for DH/MDA setting	Major	Supporting effect
Set altimeters for barometric pressure	Barometric reference on PFD	Major	No effect
Set nav radios as required	Radio panel	Major	Supporting effect

Communicate with ATC	Radio panel	Major	No effect

Initial and intermediate approach

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for speed selection, PFD for airspeed, speed trend and reference speeds	Major	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Major	Supporting effect
Manage aircraft heading/navigation	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND, waypoint on ND/FMS, map on EFB	Major	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Hazardous	Essential effect
Manage aircraft altitude / flight level	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Hazardous	Supporting effect
Maintain awareness of terrain/obstacles	EGPWS on ND, obstacle indication on airport chart (EFB), obstacle lights, (radio) altimeter on PFD	Hazardous	Essential effect
Maintain awareness of other aircraft	ACAS on ND, aircraft exterior lighting	Hazardous	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Monitor aircraft systems	System display, attention getter	Major	Supporting effect
Arm autoflight approach mode	Glareshield for autopilot/flight director setting, PFD for flight mode annunciation	Major	Supporting effect
Prepare for missed approach	FMS	Major	Supporting effect

Final approach

Activity	Visual information	Severity class	Colour-coding effect
Configure lift augmentation system for landing and verify	Flap/slat status on system display	Major	Supporting effect
Arm spoilers	Spoiler status on system display	Major	Supporting effect
Select gear down	Lights on landing gear indicator panel, gear status on system display	Major	Supporting effect
Verify landing gear down and locked	Lights on landing gear indicator panel, gear status on system display	Hazardous	Supporting effect
Verify autobrakes armed	Autobrake setting on system display	Major	Supporting effect
Verify spoilers armed for landing	Spoiler status on system display	Major	Essential effect
Verify flaps/slats extended for landing	Flap/slat status on system display	Major	Essential effect
Verify altimeters set for local pressure	Barometric reference on PFD	Minor	No effect
Manage airspeed	Glareshield for speed selection, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect
Manage aircraft heading	Track/heading on ND, track/heading on PFD, runway markings, runway lighting, LOC deviation on PFD	Hazardous	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Catastrophic	Essential effect
Manage aircraft altitude	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude, PAPI lights, G/S deviation on PFD	Catastrophic	Essential effect (PAPI) Supporting effect
Manage vertical speed	Glareshield for autopilot setting, PFD for	Hazardous	Supporting effect

	autopilot mode, vertical speed on PFD		
Maintain awareness of terrain/obstacles	Obstacle indication on approach chart, obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Essential effect
Maintain awareness of other aircraft	Aircraft exterior lighting, ACAS display on ND	Hazardous	Supporting effect
Maintain awareness of weather	Weather radar on ND	Major	Essential effect
Monitor aircraft systems	System status on system display, attention getter	Major	Essential effect
Receive and acknowledge landing clearance	-	Major	Not applicable

Missed approach

Activity	Visual information	Severity class	Colour-coding effect
Recognise the need for a go-around	Deviations from glidepath on PFD, PAPI indication, vertical speed on PFD, aircraft configuration (gear, flaps) on PFD, EGPWS annunciations on ND	Hazardous	Essential effect
Set TOGA thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Hazardous	Essential effect
Determine aircraft is safely established in the go-around	Speed, altitude and attitude on PFD, glareshield for autopilot setting, glareshield for autothrust setting, PFD for autopilot mode, system status on system display, engine parameters on engine display	Major	Supporting effect
Retract flaps one step	Flap/slat status on system display	Major	Supporting effect

Retract landing gear	Lights on landing gear indicator panel, gear status on system display	Major	Supporting effect
Accelerate to correct speed	Glareshield for autopilot setting, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect
Manage aircraft attitude	Attitude and target on PFD	Catastrophic	Essential effect
Manage aircraft altitude	Glareshield for autopilot setting, PFD for autopilot mode, PFD for altitude and target altitude	Catastrophic	Supporting effect
Follow missed approach route	Glareshield for autopilot setting, PFD for autopilot mode, track and heading on ND	Major	Supporting effect
Monitor aircraft systems	System status on system display, attention getter)	Major	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Landing

Activity	Visual information	Severity class	Colour-coding effect
Manage airspeed	Glareshield for speed selection, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect
Manage thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect
Manage aircraft heading	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND, approach lights, runway lights, runway markings	Hazardous	No effect
Manage aircraft attitude	Attitude and target on PFD, outside references	Catastrophic	No effect
Manage vertical speed	Approach lights, vertical speed on PFD, EGPWS sink rate on ND	Major	Supporting effect

Maintain awareness of terrain/obstacles	Obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Supporting effect
Maintain awareness of other aircraft	Aircraft exterior lighting, ACAS display on ND	Hazardous	Supporting effect
Rotate aircraft for landing flare	Runway markings, runway lights	Major	No effect
Engage wheel brakes/verify autobrake response	Wheel brake status on system display	Hazardous	Supporting effect
Deploy spoilers/verify spoiler deployment	Spoiler status on system display	Hazardous	Essential effect
Command reverse thrust	Reverser status on engine display, engine parameters on engine display	Major	Essential effect
Evaluate speed decrease	Speed on PFD, runway markings	Major	No effect

Taxi to gate and park aircraft

Activity	Visual information	Severity class	Colour-coding effect
Communicate with ATC	Radio panel	Minor	No effect
Monitor aircraft system status	System status on system display, attention getter	Minor	Supporting effect
Manage taxi speed	Speed on PFD, taxiway marking, taxiway lighting	Minor	No effect
Manage taxi route	Taxiway marking, taxiway lighting, stop bars, airport map on EFB, track/heading on ND, track/heading on PFD	Hazardous	Supporting effect
Maintain awareness of other vehicles/aircraft	Aircraft exterior lights	Major	Supporting effect
Receive and acknowledge parking instructions	-	Minor	Not applicable
Configure aircraft for parking	System status on system display	Minor	Supporting effect
Monitor indicated/commanded position	Apron markings and signs, docking system indications	Minor	Supporting effect

Modify steering commands as required	Apron markings and signs, docking system indications	Minor	Supporting effect
Decelerate to a stop	Outside references	Major	No effect
Set parking brake	Parking brake status on systems display	Minor	Supporting effect
Shutdown engines	Engine parameters on engine display	Minor	Supporting effect

Systems deactivation

Activity	Visual information	Severity class	Colour-coding effect
Deactivate systems and configure aircraft for layover	-	Minor	Not applicable

Respond to emergency and/or abnormal situations

Powerplant emergency

Activity	Visual information	Severity class	Colour-coding effect
Identify engine failure	Attention getter, engine parameters on engine display, engine lights on overhead panel, engine lights on pedestal	Hazardous	Essential effect
Secure the affected engine	Fuel control switches, engine fire switches, engine parameters on engine display	Hazardous	Essential effect
Control and monitor the aircraft trajectory	Speed and altitude on PFD, attitude on PFD, track on ND	Catastrophic	Essential effect
Monitor aircraft systems	System status on system display	Major	Supporting effect
Perform remaining checklist items	Checklist on system display	Major	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Aircraft system emergency

Activity	Visual information	Severity class	Colour-coding effect
Identify emergency	Attention getter, system status on system display, fault light on overhead panel	Major	Essential effect
Control and monitor the aircraft trajectory	Speed and altitude on PFD, attitude on PFD, track on ND	Catastrophic	Essential effect
Perform memory items	Autopilot mode on PFD, autothrust mode on ND	Major	No effect

Select checklist	Checklist on system display	Major	Supporting effect
Perform checklist items	Checklist on system display, system status on system display, system indicator lights on overhead panel	Major	Supporting effect
Evaluate consequences	System status on system display	Hazardous	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Depressurization (pressurised aircraft only)

Activity	Visual information	Severity class	Colour-coding effect
Identify depressurization	Attention getter, cabin pressure indication on system display	Hazardous	Essential effect
Put on oxygen mask and establish communication	Radio panel	Hazardous	No effect
Check and restore pressurization system	Pressurization system status on system display	Major	Supporting effect
Descent to 10,000 ft - Manage speed	Autopilot mode on PFD, speed on PFD	Hazardous	Supporting effect
Descent to 10,000 ft – Manage altitude	Altitude on PFD	Major	Supporting effect
Descent to 10,000 ft - Manage thrust	Autothrust mode on PFD, engine parameters on engine display	Major	Supporting effect
Descent to 10,000 ft - Manage vertical speed	Vertical speed on PFD	Hazardous	Supporting effect
Descent to 10,000 ft - Maintain awareness of terrain	EGPWS on ND	Hazardous	Essential effect
Perform checklist items	Checklist on system display, system status on system display, system indicator lights on overhead panel	Major	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Unusual attitude / in flight loss of control

Activity	Visual information	Severity class	Colour-coding effect
Identify unusual attitude	Attitude and target on PFD, bank angle exceedance on PFD	Hazardous	Essential effect
Assess the energy, become situationally aware	Attitude and target on PFD, speed, speeds trends and speed	Hazardous	Essential effect

	boundaries on PFD, altitude on PFD		
Stop the flight path divergence and recover to a stabilized flight path	Speed, altitude and attitude on PFD, autopilot setting on glareshield, autopilot mode on PFD, autothrottle mode on PFD	Catastrophic	Essential effect
Communicate with ATC	Radio panel	Major	No effect

Windshear encounter

Activity	Visual information	Severity class	Colour-coding effect
Identify windshear	Windshear warning/advisory on PFD and/or ND	Hazardous	Essential effect
Set TOGA thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Hazardous	Supporting effect
Move toward correct pitch attitude	Attitude and target on PFD	Hazardous	Essential effect
Monitor flight path	Glareshield for autopilot setting, PFD for autopilot mode, track and heading on ND	Hazardous	Supporting effects
Monitor speed	Glareshield for speed setting, PFD for airspeed, speed trend and reference speeds	Hazardous	Supporting effect
Maintain awareness of terrain/obstacles	Obstacle lights, (radio) altimeter on PFD, EGPWS on ND	Hazardous	Essential effect
Communicate with ATC	Radio panel	Major	No effect

ACAS activation

Activity	Visual information	Severity class	Colour-coding effect
Identify possible conflict	Intruder position on ND, vertical order on PFD	Hazardous	Supporting effect
Follow the Resolution Advisory instruction / monitor Autopilot – Autothrust response to RA	Attitude and target on PFD, PFD for airspeed and vertical speed, speed trend and reference speeds, glareshield for autopilot /autothrust setting, PFD for autopilot/autothrust mode, PFD for altitude	Hazardous	Essential effect

Inform ATC	Radio panel	Major	No effect
When clear of conflict, resume normal navigation	Glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND	Minor	Supporting effect

TAWS activation

Activity	Visual information	Severity class	Colour-coding effect
Identify possible conflict	Terrain conflict on the ND, EGPWS light on the instrument panel	Hazardous	Essential effect
Apply pitch up control input	Attitude and target on PFD	Catastrophic	Essential effect
Set TOGA thrust	Glareshield for autothrust setting, PFD for autothrust mode, engine display for engine parameters	Catastrophic	Supporting effect
When flight patch is safe, decrease pitch attitude and accelerate	Attitude and target on PFD, PFD for airspeed, speed trend and reference speeds	Major	Essential effect
Communicate with ATC	Radio panel	Major	No effect

Fire/smoke (annunciated and non-annunciated)

Activity	Visual information	Severity class	Colour-coding effect
Identify smoke	Warning/system display	Hazardous	Essential effect
Put on oxygen mask	-	Hazardous	Not applicable
Select checklist	Checklist on system display	Major	Supporting effect
Perform checklist items	Checklist on system display, system status on system display, system indicator lights on overhead panel	Major	Supporting effect
Initiate diversion / descent	FMS, ND for route and NAVAIDS, glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND	Catastrophic	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Flight control system failure / jam (not annunciated)

Activity	Visual information	Severity class	Colour-coding effect
Identify jammed flight control	-	Hazardous	Not applicable

Try to overpower jammed control	-	Major	Not applicable
Descent to lower altitude if freezing water is the suspected cause	ND for route and NAVAIDS, glareshield for autopilot setting, PFD for autopilot mode, track/heading on PFD/ND	Minor	Supporting effect
Control the aircraft with the operative flight controls, trim and engine thrust	PFD for speed, pitch trim, altitude and attitude, engine display for engine parameters, pedestal for rudder trim, flight control page on systems panel.	Hazardous	Essential effect
Communicate with ATC	Radio panel	Major	No effect

Low or high rotor RPM (helicopters only)

Activity	Visual information	Severity class	Colour-coding effect
Check RPM indicator	Rotor RPM on engine display	Hazardous	Essential effect
Adjust collective lever as necessary to maintain rotor RPM within the normal range	Rotor RPM on engine display	Catastrophic	Supporting effect
Communicate with ATC	Radio panel	Major	No effect

Annex B Task listing of ATC according to responsibility area

B.1 Ground controller

Departures

Approve pushback

Activity	Visual information	Severity class	Colour-coding effect
Update strips	FPS	Major	Supporting effect
Receive request pushback	FPS, Voice communication control system	Minor	-
Contact pilot, check whether ready	Voice communication control system	Minor	No effect
Check departure time	FPS, planning system	Minor	Supporting
Do visual check for obstacles; No obstacles: approve pushback and annotate strip (time, stand number etc) Obstacles: disapprove pushback and contact appropriate person to take action	Outside view (e.g. people), ground radar	Hazardous	Supporting
Issue push-back clearance	FPS, outside, ground radar	Hazardous	Supporting effect

Issue taxi clearance

Activity	Visual information	Severity class	Colour-coding effect
Answer request	Voice communication system	Minor	No effect
Check departure information: check slot times	FPS, planning	Minor	No effect
Select (standardised) route	Ground radar, outside	Minor	No effect
Issue clearance to taxi, and directions to take (incl. taxiways to follow and hold points)	Ground radar, outside Voice communication system	Major	Supporting effect
Monitor adherence	Ground radar, outside	Major	Supporting effect

Transfer aircraft

Activity	Visual information	Severity class	Colour-coding effect
Decide when it is an appropriate time or aircraft are at an appropriate location to transfer	Tower display	Minor	No effect
Distribute strip to RWY CR at or just before holding point	FPS, tower display	Major	Supporting effect
Instruct aircraft to contact RWY controller	Voice communication system	Minor	Supporting effect

Arrivals

Receive arrival aircraft when vacating runway

Activity	Visual information	Severity class	Colour-coding effect
Receive aircraft call	Voice communication system	Minor	No effect
Receive strip from RWY or flight data assistant and update	FPS	Major	Supporting effect

Give taxi clearance to arriving traffic exiting to stand (via standardised route)

Activity	Visual information	Severity class	Colour-coding effect
Issue clearance to taxi, and directions to take (incl. taxiways to follow and hold points)	FPS, Outside, ground radar	Major	Supporting
Update strips	FPS	Minor	Supporting effect
Monitor adherence	Outside, ground radar	Major	Supporting effect

Towed aircraft

Activity	Visual information	Severity class	Colour-coding effect
Receive call (from the apron controller identifying a) towed aircraft	Voice communication system	Minor	No effect
Monitor towed aircraft at regular intervals	Tower display, outside, FPS	Major	No effect

Ground control non-nominal or unplanned situations

Activity	Visual information	Severity class	Colour-coding effect
Aircraft or vehicle incursions	Tower display, RIAS	Hazardous	Essential

B.2 Runway control

Arrivals Controller

Activity	Visual information	Severity class	Colour-coding effect
Receive inbound traffic	Approach radar, (FPS), Verbal Planning: list of inbound flights	Minor	No effect, or supporting depending on operations
Check separation on final approach (about 4 miles out)	Approach radar	Major	No effect, or Supporting effect depending on HMI
Coordinate with approach controller as required	Voice communication control system	Minor	Supporting effect
Update strips	FPS	Minor	No effect
Check wind information and relate to pilot	Weather information on information system	Hazardous	No effect, or Supporting effect depending on HMI
If runway is free and wind is OK, give landing clearance. If not, instruct go-around	Outside view, FPS, tower display Voice communication control system	Hazardous	No effect, or Supporting effect depending on HMI
Coordinate with air departures to ensure separation is maintained	(Shoulder to shoulder) comms, outside view	Major	No effect
Record required arrival information on strips	FPS	Minor	No effect
Mark aircraft landing time on strip	FPS	Minor	No effect, (or Supporting effect depending on HMI)
Issue runway exit instructions, coordinate with ground controller as required	Voice communication control system	Minor	No effect
Check aircraft has cleared runway	Outside view and tower display	Minor	No effect
Transfer aircraft to ground control distribute flight strip to ground control	FPS Verbally	Minor	Supporting effect
Give clearance for vehicles to enter runway, check traffic situation	Outside view and tower display	Hazardous	Supporting or no effect depending on HMI
Monitor adherence	Outside view and tower display	Major	Supporting effect

Departures Controller

Activity	Visual information	Severity class	Colour-coding effect
Receive dep aircraft	FPS, information system with list of outbound flights, radar	Minor	Supporting or no effect depending on HMI
Estimate final departure sequence, taking into account the following constraints: Departure time Taxiway layout Aircraft types, speed, size and weight classification, SID, Time constraints Availability of taxiways and exits	FPS, tower display, Information System	Minor	Supporting effect
Give line-up clearance when next in taxiway sequence while ensuring appropriate separations and checking positions of other relevant traffic	Tower display, outside view, FPS, Comms	Hazardous	Supporting or no effect depending on HMI
Deliver take-off clearance after: Checking runway is free Checking and give wind information Recording any relevant info on FPS	Tower display, outside view, FPS, Information System	Hazardous	Supporting or no effect depending on HMI
Carry out departure sequence by: Checking altitude if required	Tower display, outside view and FPS	Major	No effect
Transfer aircraft to next controller: Communicate with next controller if required Update FPS		Minor	Supporting or no effect depending on HMI

Runway control non-nominal or unplanned situations

Activity	Visual information	Severity class	Colour-coding effect
Detect and respond to non-conformance	Tower Display, outside view	Major	Supporting or no effect depending on HMI
Respond to runway incursion alert	Tower Display	Catastrophic	Essential effect

B.3 Approach control

Detect and take UCO inbound flight

Activity	Visual information	Severity class	Colour-coding effect
Detect aircraft position	Radar	Minor	Supporting or no effect depending on HMI
Check planned route, runway and distance to go	Radar	Minor	No effect
Check system coordination with adjacent sectors	Tools, radar	Major	Supporting or no effect depending on HMI

Detect and take UCO outbound flight

Activity	Visual information	Severity class	Colour-coding effect
Detect aircraft position	Radar	Major	No effect
Check SID	Radar	Major	No effect
Checking squawk and call-sign correlation	Tower display, outside view and FPS	Minor	No effect

Merge arriving traffic

Activity	Visual information	Severity class	Colour-coding effect
Get aircraft's position, level and speed	Radar Lists/FPS	Minor	No effect
Get other aircraft's position's, level and speed	Radar Lists/FPS	Minor	No effect
Issue instructions to flight crew to implement sequence	Tools, conflict detection	Minor	No effect

Identify conflicts

Activity	Visual information	Severity class	Colour-coding effect
Get aircraft's position, level and time at waypoints	Radar Lists/FPS	Minor	No effect
Search for interactions	Tools conflict detection	Major	No effect

Find solutions, verify and choose solution

Activity	Visual information	Severity class	Colour-coding effect
Understand aircraft capability	Radar, lists, strips	Major	No effect
Consider a change in heading, speed, altitude	-	Minor	N.A.
Issue instructions to flight crew to maintain separation	Radar, lists, FPS	Major	

Warn of unsolved solution

Activity	Visual information	Severity class	Colour-coding effect
Verbally inform (assistant to contact) tower or en-route	Verbal	Minor	No effect
Highlight	Radar, FPS	Minor	Supporting or no effect depending on HMI

Coordinate change in entry conditions

Activity	Visual information	Severity class	Colour-coding effect
Make coordination proposal: - Propose new entry point or level	FPS, lists	Minor	Supporting effect
Receive and assess response	FPS, lists	Minor	Supporting effect
Coordination agreement: Update flight data	FPS, lists	Minor	Supporting effect
Coordination disagreement not reached: warn of the unsolved problems	FPS, lists	Minor	Supporting effect

Request and forward a radar handover

Activity	Visual information	Severity class	Colour-coding effect
Make radar handover proposal: request new exit/entry heading/level/speed	Voice comms system,	Major	No effect
Receive response: - Agree or disagree on handover conditions Update flight data	Radar/ FPS	Major	No effect

Identify quality of service improvement, verify and choose

Activity	Visual information	Severity class	Colour-coding effect
Receive request (not necessarily)	Radar	Minor	No effect
Consider a more expeditious route	Radar, FPS, lists	Minor	No effect
Consider issuing turbulence warning		Major	No effect
Consider issuing context traffic information	Radar	Minor	No effect

Transfer aircraft

Activity	Visual information	Severity class	Colour-coding effect
Determine if aircraft can be transferred: - Final conflict check - Check if exit conditions will be reached	Radar	Minor	No effect
Instruct aircraft to change frequency	Information System (Frequency)	Minor	No effect
Verify readback	-		N.A.
Update flight data	Radar, FPS	Minor	Supporting effect

Respond to received co-ordinations

Activity	Visual information	Severity class	Colour-coding effect
Receive co-ordination proposal	List, FPS, verbally	Minor	Supporting effect
Asses proposal: verify proposal is problem free	Radar, lists, FPS	Minor	No
Make counter-proposal	-	Minor	N.A.
Co-ordination agreement reached: update flight data	Radar, FPS	Minor	Supporting effect

Respond to received radar handover proposal

Activity	Visual information	Severity class	Colour-coding effect
Receive radar handover proposal	Verbally and radar	Minor	No effect
Assess proposal: verify if proposal is conflict-free	Verbally and radar	Minor	No effect
Respond to proposal: if agreed update aircraft's plan with handover conditions	Verbally and radar	Minor	Supporting effect

Respond to aircraft reports

Activity	Visual information	Severity class	Colour-coding effect
Receive report	Verbally	Minor	N.A.
Respond to requested reports: integrate report into aircraft's planning	Verbally	Minor	Supporting or no effect depending on HMI
Respond to unrequested reports	Verbally	Minor	N.A.
Turbulence reports: - Process accompanying request - Add information to quality of service planning	Coordination within unit	Major	Supporting or no effect depending on HMI

Accommodate delays

Activity	Visual information	Severity class	Colour-coding effect
Accommodate delays (e.g. to allow runway reconfiguration or accommodate Go-Around)	Radar	Major	No effect
Give instructions to flight crew (heading, speed, altitude instructions)	Verbally	Minor	No effect

Approach control non-nominal or unplanned situations

Activity	Visual information	Severity class	Colour-coding effect
Detect sector entry by unplanned aircraft	Radar	Major	Supporting or no effect depending on HMI
Requests from pilots	Verbally	Major	No effect
STCA	Radar	Hazardous	Supporting or no effect depending on HMI
Deviating Pilot selected level	Radar	Hazardous	Supporting or no effect depending on HMI
System functioning	Radar, technical monitor	Major	Essential effect
Observe weather area/intensity ceiling/base/height/ movement/ visibility/winds	Weather (radar) information, wind per runway	Major	Supporting effect
Detect and respond to non-conformance	Radar, tools (Pilot selected level)	Hazardous	Essential effect (if available)

B.4 En-route control

Detect planned flight

Activity	Visual information	Severity class	Colour-coding effect
Detect aircraft position	Radar	Minor	No effect
Understand aircraft's routing, requested flight level and destination	Radar	Minor	No effect

Identify entry/transit/exit problems

Activity	Visual information	Severity class	Colour-coding effect
Get aircraft's position, level and time at waypoints	Radar Lists/FPS	Minor	No effect
Get other aircraft's position's, level and times at shared waypoints	Radar Lists/FPS	Minor	No effect
Search for interactions	Tools conflict detection	Minor	No effect

Find entry/transit/exit solutions, verify and choose solution

Activity	Visual information	Severity class	Colour-coding effect
Understand aircraft capability	Radar, lists, strips	Major	No effect
Consider potential solutions	-		N.A.

Warn of unsolved entry/transit/exit solution

Activity	Visual information	Severity class	Colour-coding effect
Verbally inform executive controller (if present)	Verbal	Minor	No effect
Highlight	Radar, FPS	Minor	Essential effect

Coordinate change in entry conditions

Activity	Visual information	Severity class	Colour-coding effect
Make coordination proposal: - Propose new entry point or level	FPS, lists	Minor	Supporting effect
Receive and assess response	FPS, lists	Minor	Supporting effect
Coordination agreement: Update flight data	FPS, lists	Minor	Supporting effect
Coordination disagreement not reached: warn of the unsolved problems	FPS, lists	Minor	Supporting effect

Request and forward an entry/exit radar handover

Activity	Visual information	Severity class	Colour-coding effect
Make radar handover proposal: request new exit/entry heading/level/speed	Voice communication system	Minor	No effect
Receive response: - Agree or disagree on handover conditions Update flight data	Radar/ FPS	Minor	No effect

Identify quality of service improvement, verify and choose

Activity	Visual information	Severity class	Colour-coding effect
Receive request (not necessarily)	Radar	Minor	No effect
Consider a more expeditious entry point	Radar, FPS, lists	Minor	No effect
Consider a more efficient entry level	Radar, FPS, lists	Minor	No effect
Consider a more expeditious exit point	Radar, FPS, lists	Minor	No effect
Consider a more expeditious exit level	Radar, FPS, lists	Minor	No effect
Consider issuing turbulence warning	-	Minor	No effect
Consider issuing context traffic information	Radar	Minor	No effect

Identifying (potential) conflicts

Activity	Visual information	Severity class	Colour-coding effect
Identify suspected conflicts	Radar, conflict detection tools	Major	Essential effect
Search aircraft plans for conflicts: - Get aircraft's position, level and time at waypoints - Get other aircraft's positions, levels and times at shared waypoints - Extrapolate aircraft positions between waypoints - Search for interactions	FPS, lists	Major	Supporting effect

Search radar for conflicts: - Linearly extrapolate aircraft positions - Search for interactions	Radar	Major	No effect
Request information from aircraft	-		N.A.

Finding and choosing best conflict solution

Activity	Visual information	Severity class	Colour-coding effect
Understand aircraft capability: request information from aircraft	Radar, list, verbally	Major	No effect
Plan solution (route, speed, altitude)	Radar	Major	No effect
Linearly extrapolate conflict solution	Radar, speed vector	Major	Supporting effect
Get aircraft's what-if position, level and time at waypoints	-	Major	Supporting effect
Search for interactions	Radar	Major	No effect
Consider safety assurance	Conflict detection tools, as a safety net, mentally	Major	Supporting effect
Consider ATC constraints	Mentally, radar, information system	Major	Supporting effect
Update aircraft's plan with conflict solution actions	FPS, radar and lists	Minor	No effect

React to unsolved entry problems

Activity	Visual information	Severity class	Colour-coding effect
Detect entering aircraft with problem	Radar	Major	Supporting effect
Confirm and solve entry conflict	Radar	Minor	Supporting effect
Identify if entry conflict solution requires a change in entry conditions	Radar	Minor	Supporting effect
Search aircraft's plan for conflict solution	Radar	Minor	Supporting effect
Plan and perform an entry radar handover	Radar	Minor	No effect

Transfer aircraft

Activity	Visual information	Severity class	Colour-coding effect
Determine if aircraft can be transferred:	Radar	Minor	No effect

- Final conflict check - Check if exit conditions will be reached			
Instruct aircraft to change frequency	Information System (Frequency)	Minor	No effect
Verify readback	-		N.A.
Update flight data	Radar, FPS	Minor	Supporting effect

Respond to safety net alerts

Activity	Visual information	Severity class	Colour-coding effect
Refine conflict detail: - Linearly extrapolate aircraft positions - Search for interactions	Radar, STCA	Hazardous	Essential effect
Solve conflict	Radar	Hazardous	Supporting effect
Update aircraft's plan with conflict solution actions	FPS, radar	Minor	No effect

Respond to received co-ordinations

Activity	Visual information	Severity class	Colour-coding effect
Receive co-ordination proposal	List, FPS, verbally	Minor	Supporting effect
Asses proposal: verify proposal is problem free	Radar, lists, FPS	Minor	No
Make counter-proposal	-	Minor	N.A.
Co-ordination agreement reached: update flight data	Radar, FPS	Minor	Supporting effect

Respond to received radar handover proposal

Activity	Visual information	Severity class	Colour-coding effect
Receive radar handover proposal	Verbally and radar	Major	No effect
Assess proposal: verify if proposal is conflict-free	Verbally and radar	Major	No effect
Respond to proposal: if agreed update aircraft's plan with handover conditions	Verbally and radar	Minor	Supporting effect

Respond to ETO revision

Activity	Visual information	Severity class	Colour-coding effect
Receive revision	Verbally, lists	Minor	Supporting effect
Update flight data	Radar/FPS	Minor	No effect

Accommodate delays/ 'stack control'

Activity	Visual information	Severity class	Colour-coding effect

Instruct level	Verbal	Minor	No effect
Adherence monitoring	Pilot selected level	Hazardous	Essential effect

En-route control non-nominal or unplanned situations

Activity	Visual information	Severity class	Colour-coding effect
Detect sector entry by unplanned aircraft	Radar	Major	Supporting effect
Requests from pilots	Verbally	Major	No effect
STCA	Radar	Hazardous	Essential effect
Deviating Pilot selected level	Radar	Hazardous	Essential effect
System functioning	Radar, technical monitor	Major	Essential effect
Observe weather area/intensity ceiling/base/height/ movement/ visibility/winds	Weather (radar) information, wind per runway	Major	Supporting effect
Detect and respond to non-conformance	Radar, tools (Pilot selected level)	Major	Essential effect

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