FLIGHTZOOMER
1.5

GROUNDSTATION
APP REFERENCE

1 Contents

2 Disclaimer

While FlightZoomer offers fantastic features, the following operation rules are strictly to be followed:

- The system is intended for hobby usage.
- Be familiar with the operation of RC aircraft having 1kg flying weight or more.
- Use FlightZoomer only aboard a proved combination of RC equipment, airframe, flight controller, motors, propeller, battery and ESCs.
- Operate FlightZoomer strictly within the safety boundaries of any other used components.
- Operate FlightZoomer strictly within the boundaries of any local regulatory requirement.
- Fully respect any disclaimer and safety note which is associated with any other used component.

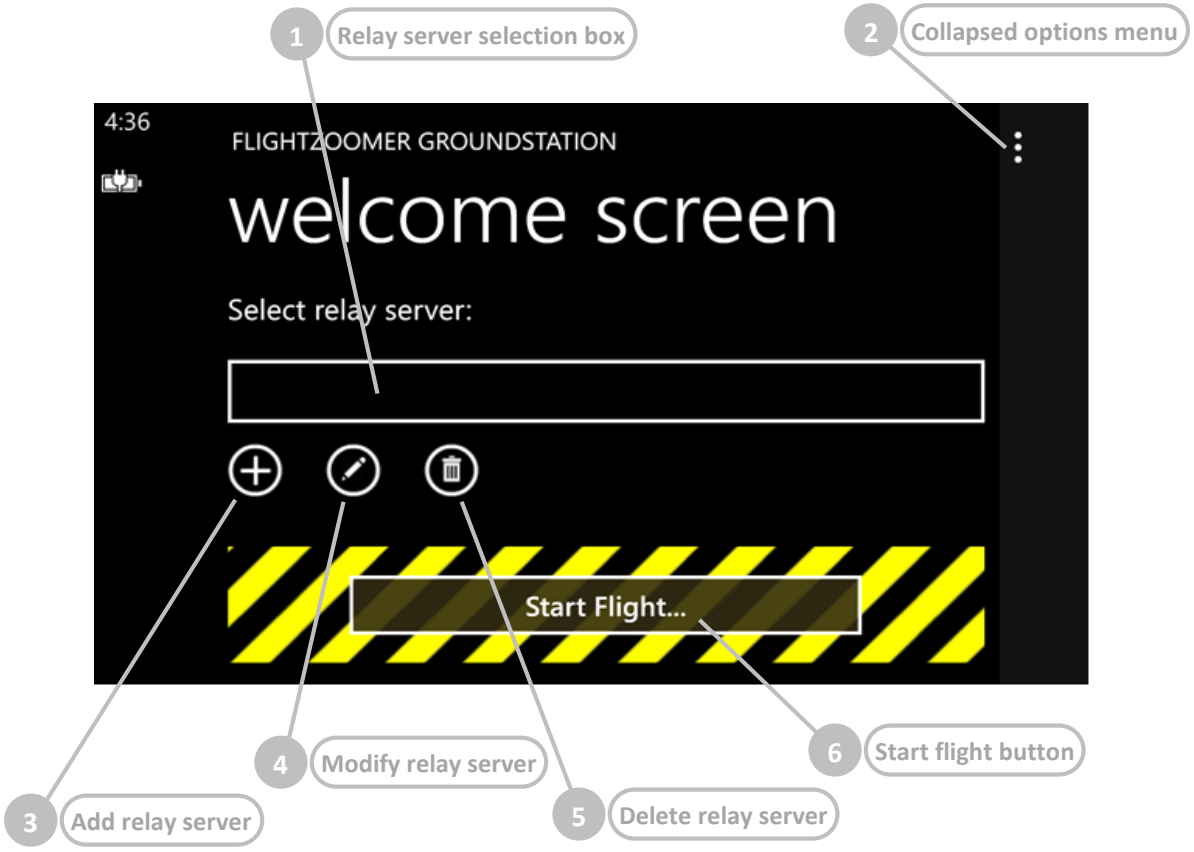
3 FlightZoomer Groundstation-app

The FlightZoomer Groundstation-app is the second app that belongs to FlightZoomer. It runs on a smartphone, which serves as cockpit to the pilot of RC aircraft. The app displays the sensor data which is received from the onboard sensor device.

The additional features are:

- Cockpit instruments with primary- and navigation-display.
- Design and features modeled after the Boeing 787 Dreamliner.
- Synthetic voice output for pilot guidance (“Barking Bob”-feature).
- Radio navigation (based on virtual radio beacons).
- Instrument Landing System.
- Flight Management System for flight planning.

3.1 Welcome screen

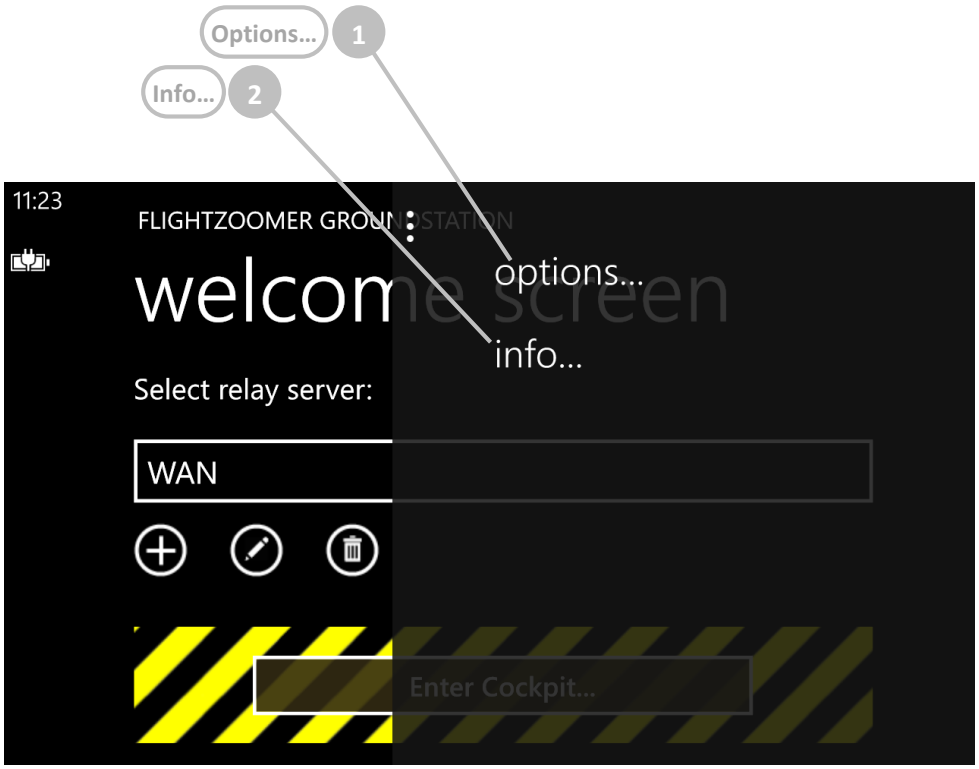


This screen is shown in order to add or modify a relay server.

	Element	Purpose
1	Relay server selection box	This selection box shows the currently selected relay server. The box is empty as long as no relay server has been defined.
2	Collapsed options menus	Pressing on the collapsed menu symbol will show the full menu (see chapter 3.2).

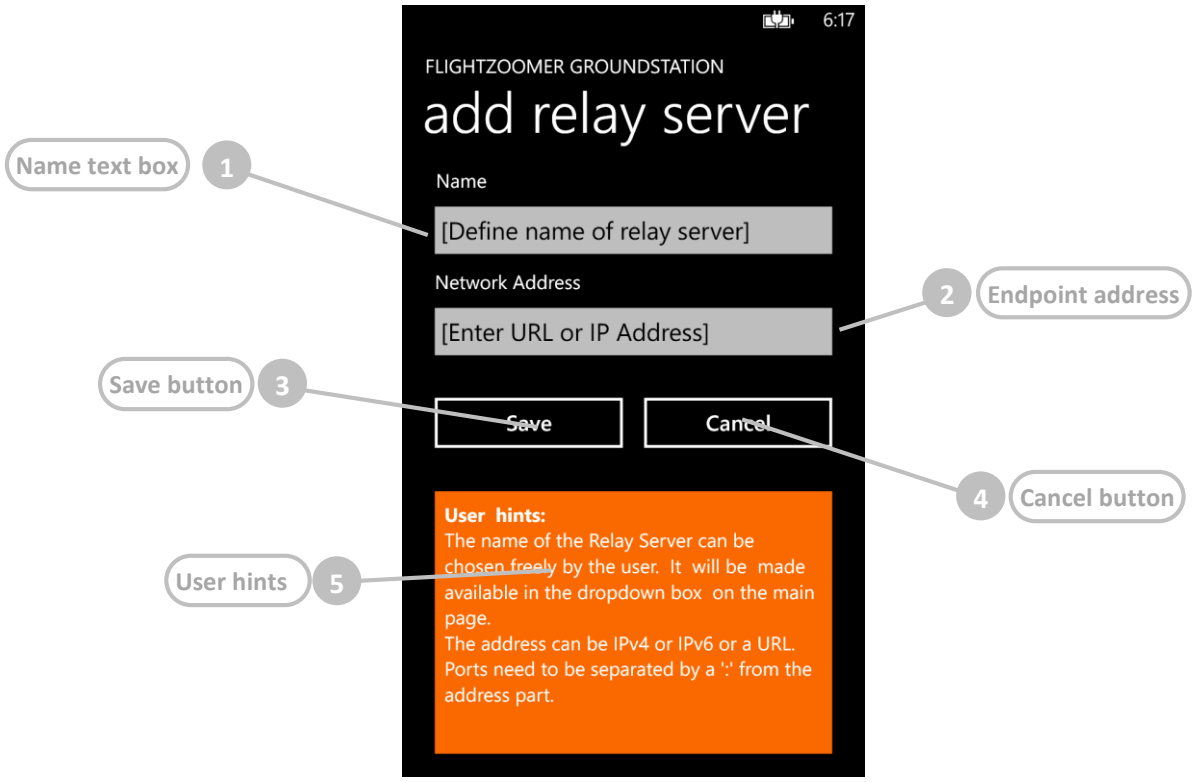
3	Add relay server	The app allows to configure and store an unlimited number of relay servers. This button opens a menu to define and add a new relay server. A relay server definition is a combination of a plain text name, an URL (or an IP address) and a port number. Pressing on the button opens the screen as described in chapter 3.3.
4	Modify relay server	This button opens a menu to modify the relay server which is displayed in the selection box. Pressing on the button opens the screen as described in chapter 3.3.
5	Delete relay server	This button deletes the relay server which is displayed in the selection box from the list of stored relay servers.

3.2 Welcome screen with options menu expanded



	Element	Purpose
1	Options…	This menu command opens the options screen. Pressing on the buttons opens the screen described in chapter 3.4.
2	Info…	This menu command opens the info screen, which shows the version, the build date and links for support purposes.

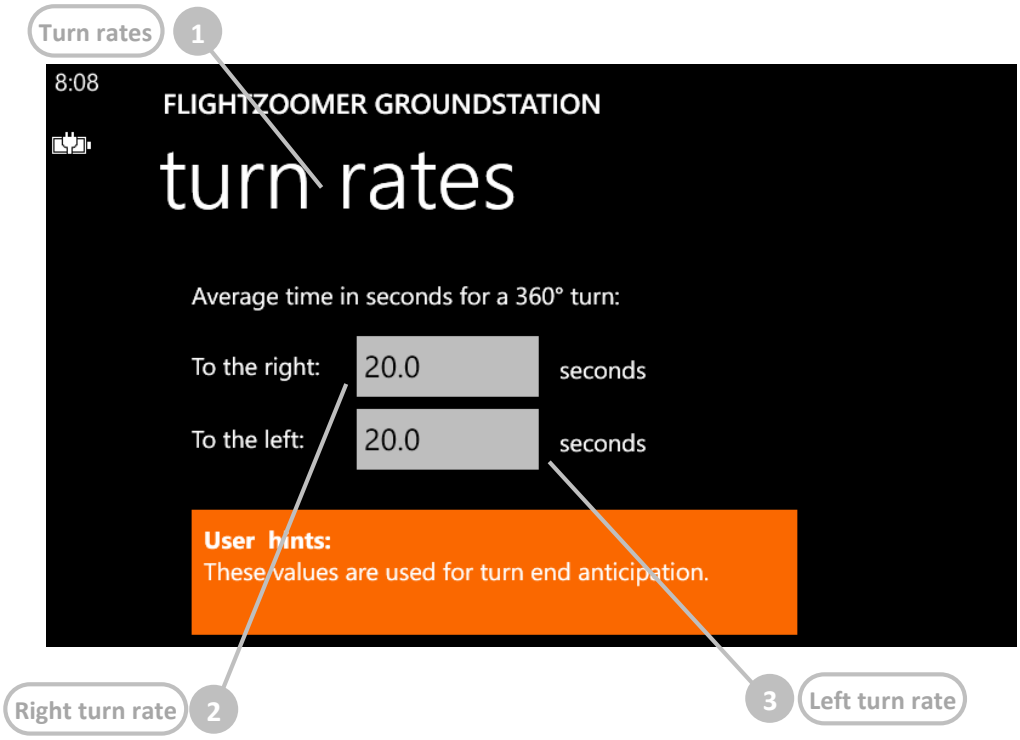
3.3 Add/modify relay server screen



	Element	Purpose
1	Name text box	This text box allows to define the name of the relay server. The name of the relay server can freely be chosen by the user. It will be available in the selection box on the welcome screen.
2	Endpoint address	This text box allows to define the IP address (IPV4 or IPV6) or an URL for the relay server. In addition the destination port can be specified (if it is missing 57778 is taken as default). If specified the port must be separated by a colon-character (:) from the IP address/URL. The FlightZoomer Sensorics App will connect to this endpoint when building up UDP connectivity with the relay server.
3	Save button	Store the definition/changes.
4	Cancel button	Leave this screen without saving the definition or modification.
5	User hints	Usage and instruction summary

3.4 Options screen

The options screen can be opened from the *options*…-menu command on the welcome screen. It allows manually setting the standard (average) turn rates. These values can also be determined automatically by the flight test feature (see chapter 3.11).

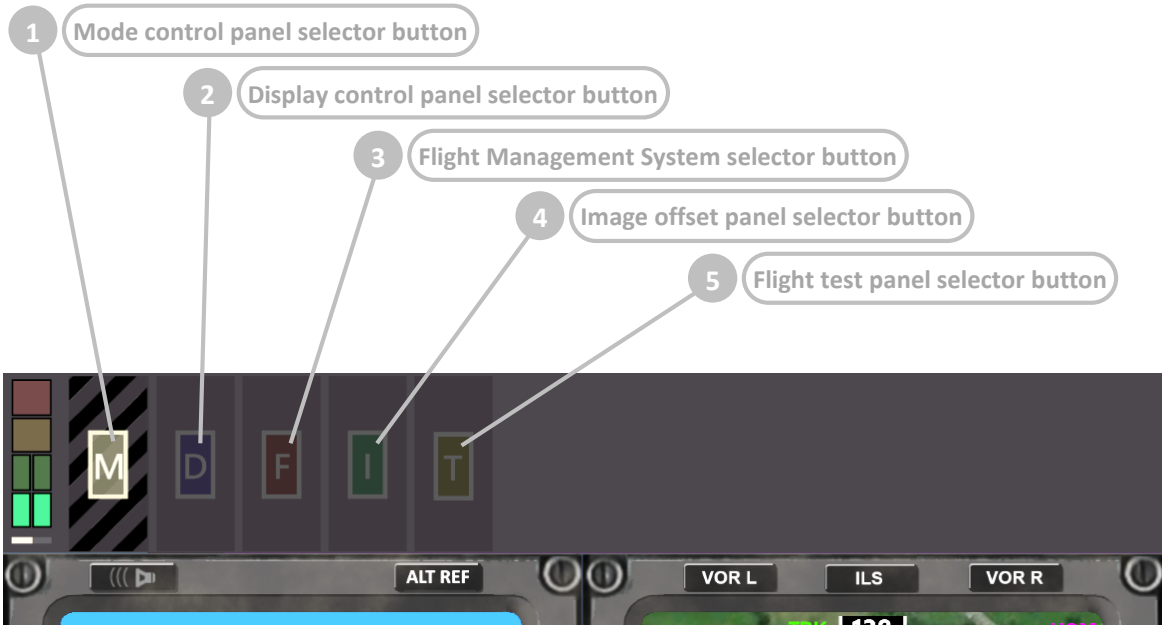


	Element	Purpose
1	Turn rates	Currently there is only the *turn rates*-options screen.
2	Right turn rate	The standard right run rate is the duration in seconds of a 360° right turn. There is a separate setting for the left turn rate (see below).
3	Left turn rate	The standard right run rate is the duration in seconds of a 360° left turn. There is a separate setting for the right turn rate (see above).

3.5 Main screen – overview

3.6 Selectable panel bar – overview

The selectable panel bar gives quick access on the various features of the app. By pressing on the capital letters the associated panels can be opened and collapsed again.



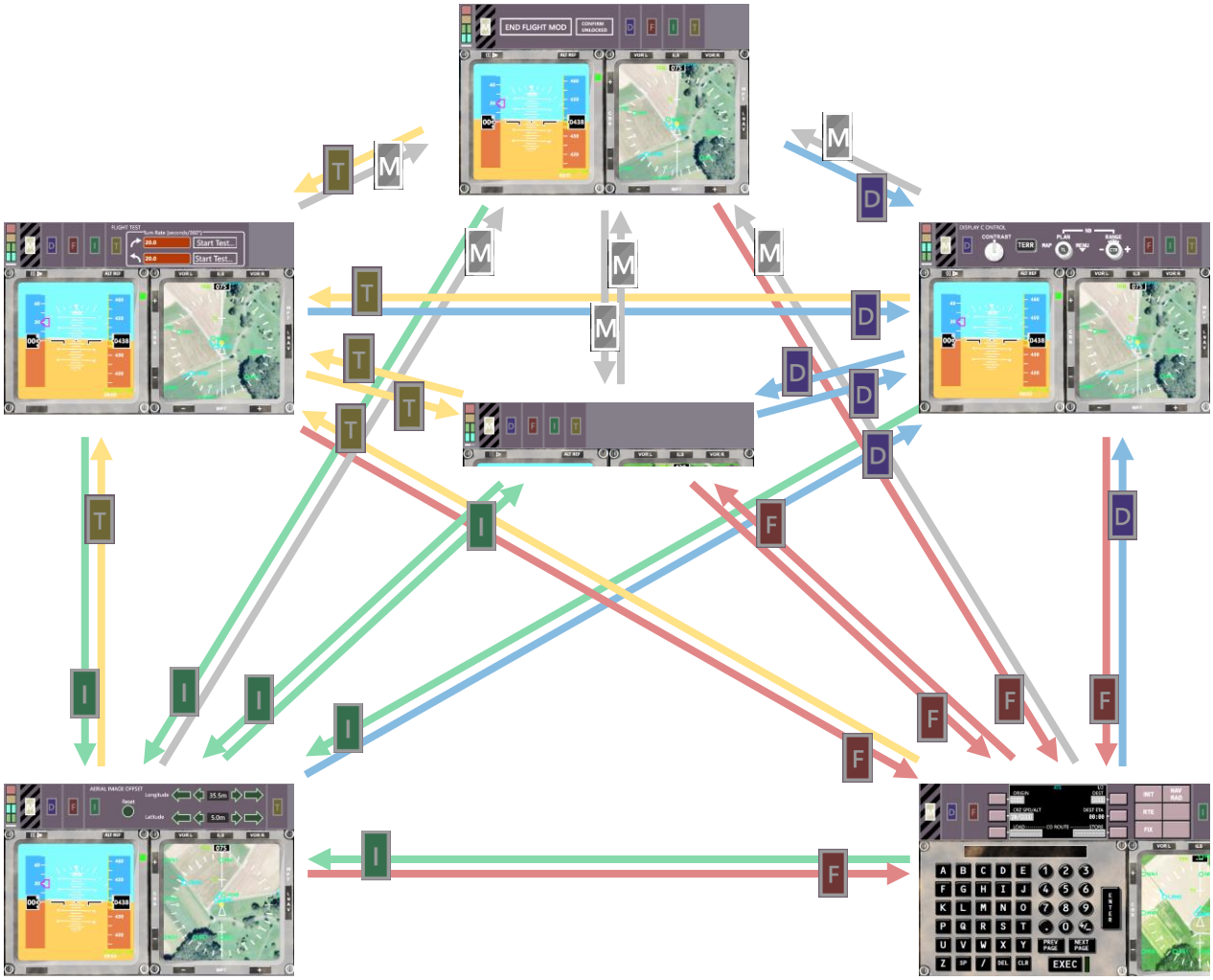
	Element	Purpose
1	Mode control panel selector	Pressing on the *M*-button opens the mode control panel.
2	Display control panel selector	Pressing on the *D*-button opens the display control panel.
3	Flight Management System selector	Pressing on the *F*-button opens the Flight Management System.
4	Image offset panel selector	Pressing on the *I*-button opens the image offset panel.
5	Flight test panel selector	Pressing on the *T*-button opens the flight test panel.

Using the selector buttons on the selectable panel bar any panel can be opened at any time regardless which panel currently is selected. At any time only one selectable panel can be open. The screenshot above shows the selectable panel bar with all panels collapsed so only the selector buttons themselves are visible.

Pressing on a selector button once opens the associated panel. Pressing on the same selector button a second time collapses the associated panel again and returns to the presentation as shown in the screenshot. Pressing on another selector button opens the associated panel and collapses the panel which was shown before.

Opening an associated panel typically means that the selected panel is shown in the selectable panel bar beside the selector button. If *F* is pressed (for FMS) also the lower area of the screen is changed in order to slide in the Flight Management System.

The following diagram shows how any panel can be reached from any other panel:



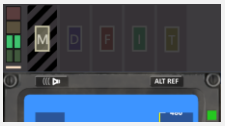
3.7 Selectable panel bar – mode control panel

The mode control panel allows switching on and off the Flight Lock mode from the groundstation (as an alternative from using the Flight Lock mode switch on the Sensorics-app). This is useful if there is no easy access to the sensor device while it is mounted on the aircraft.

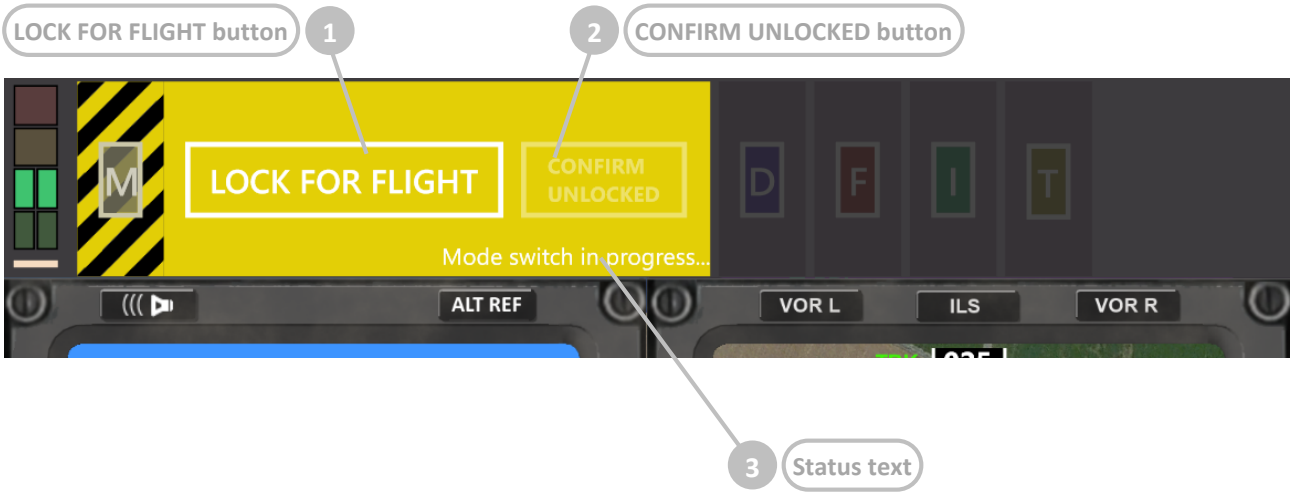
The Flight Lock mode is also coupled with the armed mode of the Ardupilot firmware via MAVLink so alternatively it can be activated also using the RC transmitter.

The FlightZoomer functionality which goes along with Flight Lock mode is locking the screen of the sensor device for user input and starting to record flight data (on the relay server).

As airworthiness is not given unless the Flight Lock mode is switched on, the mode control panel is colored with eye-catching signal colors (yellow and black) prior Flight Lock activation. This also applies to the selector button if the mode control panel is collapsed:

Mode control panel	Flight Lock not active	Flight Lock active
Collapsed		
Open		

The mode control panel in unlocked condition looks like this:



	Element	Purpose
1	LOCK FOR FLIGHT button	This button can be used to toggle the Flight Lock mode. The command is propagated to the Sensorics-app and puts the entire system into flight readiness. Once the Flight Lock mode is activated, the background of the panel becomes grey and the caption of the button changes to END FLIGHT MOD.
2	CONFIRM UNLOCKED button	This button overrides the Unlocked Flight Protection feature (see below). This can be useful if aircraft movements are simulated by the relay server.
3	Status text	This text label is only shown while a mode switch has been requested and for the time until the mode has changed.

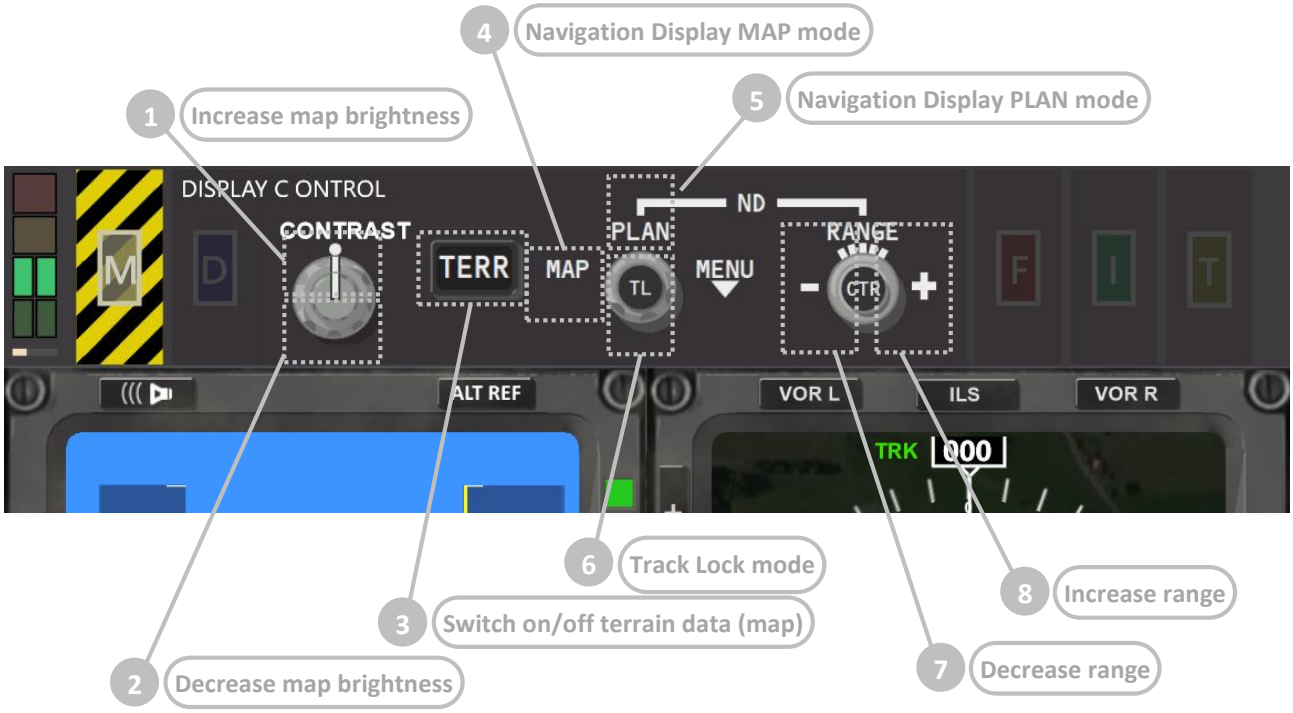
Unlocked Flight Protection

This panel can not only be opened manually by pressing on the *M*-panel selector button, but there is also the Unlocked Flight Protection-feature which prevents flying with the Flight Lock mode not activated. This protection automatically switches to the yellow mode control panel if the Flight Lock mode is not active and the sensor device starts reporting movements.

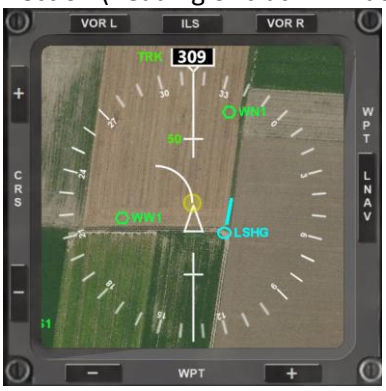
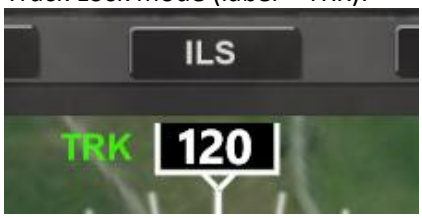
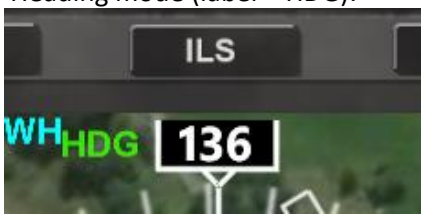
3.8 Selectable panel bar – display control panel

The display control panel is modelled after the EFIS ND Control Panel, which is located on the glareshield of the real Boeing 787:

On this panel the appearance of the Navigation Display can be controlled.

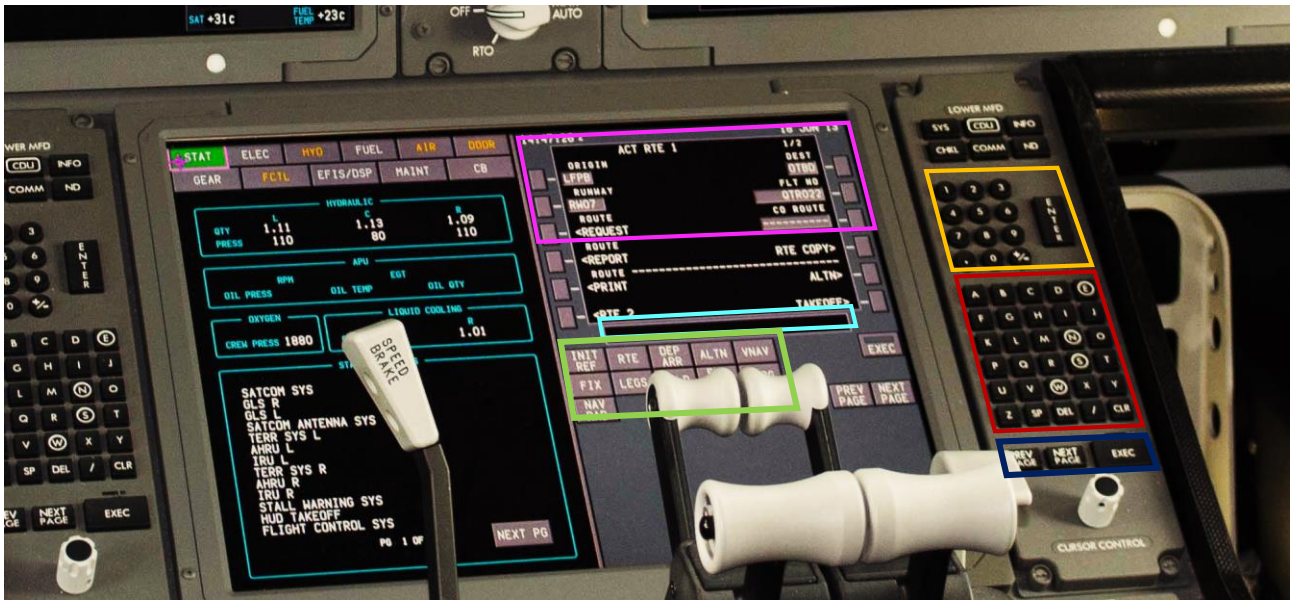


	Element	Purpose
1	Increase map brightness	By pressing repeatedly on the upper half of the CONTRAST control, the brightness of the terrain on the Navigation Display increases. At maximum brightness the Navigation Display appears like this: 
2	Decrease map brightness	By pressing repeatedly on the lower half of the CONTRAST control, the brightness of the terrain on the Navigation Display decreases. At minimum brightness the Navigation Display appears like this: 
3	Switch on/off terrain data (map)	By pressing on this button the terrain can be switched on/off. Without terrain the Navigation Display appears like this: 

4	Navigation Display MAP mode	By pressing on the MAP label the Navigation Display MAP mode is activated. In this mode the compass rose is shown, the aircraft symbol is a triangle which always points upwards while the whole map rotates to indicate the current direction (heading or track in Track Lock mode): 
5	Navigation Display PLAN mode	By pressing on the PLAN label the Navigation Display PLAN mode is activated. In this mode the compass rose is hidden, range circles are shown instead, the aircraft symbol is shaped like an aircraft which rotates according to the current direction (heading or track in Track Lock mode) while the whole map always stays fixed with north pointing upwards: 
6	Track Lock mode	By pressing on the *TL*-knob the Track Lock mode can switched on and off. The Track Lock mode determines whether the heading (compass) or the track (from GPS) is taken as source for the current direction. The green label beside the current direction indicates whether the Track Lock mode is active: Track Lock mode (label = TRK):  Heading mode (label = HDG): 
7	Decrease range	By pressing on the left half of the RANGE control, the range (zoom) of the Navigation Display decreases.
8	Increase range	By pressing on the right half of the RANGE control, the range (zoom) of the Navigation Display increases.

3.9 Selectable panel bar – Flight Management System (FMS) control panel

The Flight Management System (FMS) control panel is modelled after the FMS, which is located on the forward aisle stand in the real Boeing 787:



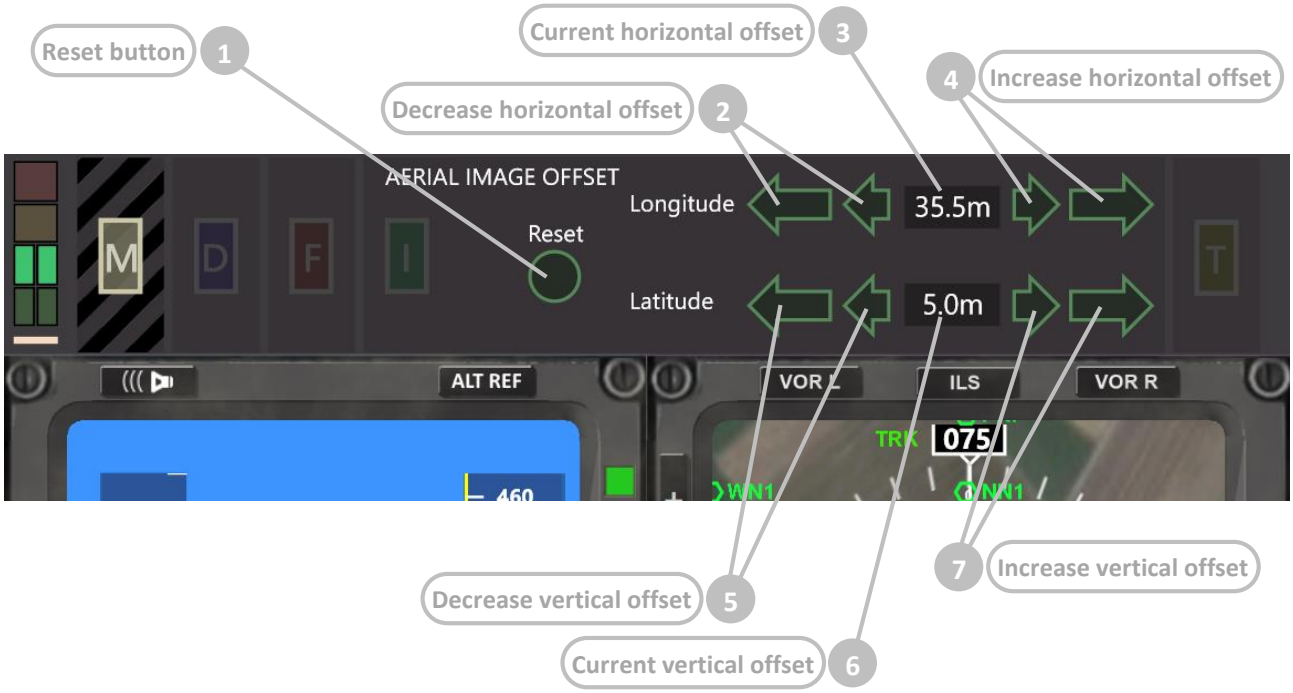
While on the Flightzoomer Groundstation-app the controls are arranged somewhat differently, the main features of the generic user interface are there:

The FMS is described in detail in the chapters 3.21 to 3.28.

3.10 Selectable panel bar – aerial image offset panel

In some case the satellite images lack accuracy. If this is the case typically there is a constant offset between the real and the displayed location. The *aerial image offset panel* allows to apply a constant offset to the terrain images to correct any given offset. As long as the aircraft stays in the same area, a constant offset is sufficient to correct any position error. This means that a particular offset setting can be kept as long as flying happens in the same area.

This panel allows to define the offset in meters of the shown location on the map. The offset only affects the positioning of the terrain. The navigation data symbols are not shifted relative to the aircraft position.



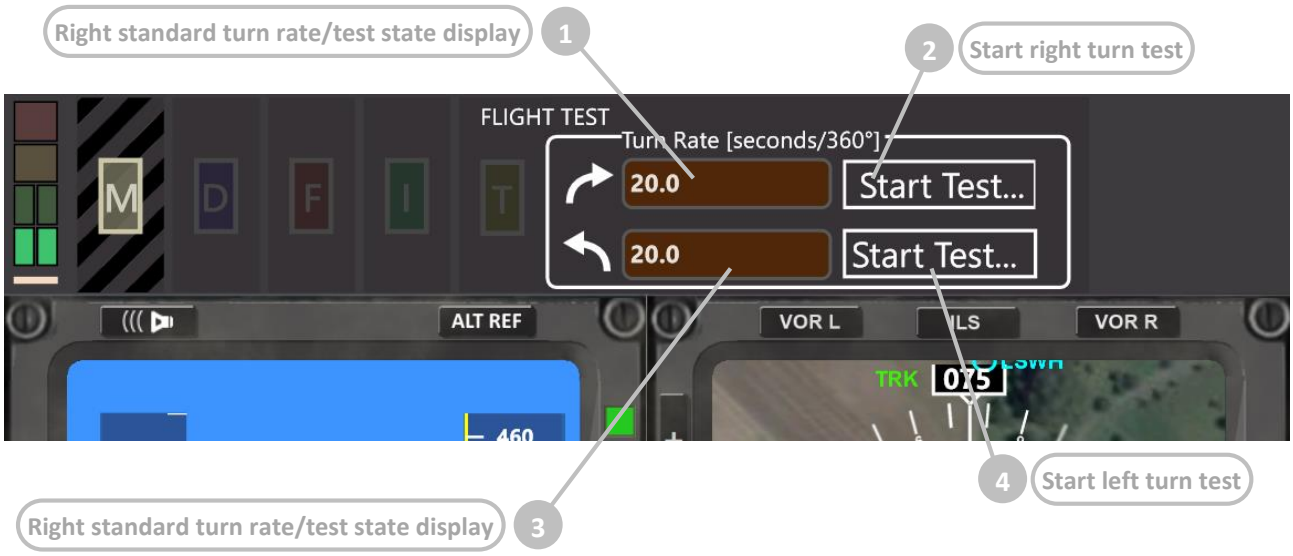
	Element	Purpose
1	Reset button	Reset the offset to 0.0m/0.0m
2	Decrease horizontal offset	Decrease the horizontal offset by 5m (larger arrow) or 0.5m (smaller arrow).
3	Current horizontal offset	This readout shows the current horizontal offset in Meter.
4	Increase horizontal offset	Increase the horizontal offset by 5m (larger arrow) or 0.5m (smaller arrow).
5	Decrease vertical offset	Decrease the vertical offset by 5m (larger arrow) or 0.5m (smaller arrow).
6	Current vertical offset	This readout shows the current vertical offset in Meter.
7	Increase vertical offset	Increase the vertical offset by 5m (larger arrow) or 0.5m (smaller arrow).

3.11 Selectable panel bar – flight test panel

As explained earlier the standard turn rates in both directions can either be set manually in the *Options…*-menu (see chapter 3.4) or be determined automatically by the flight test feature.

The flight test panel supports the execution of the flight test.

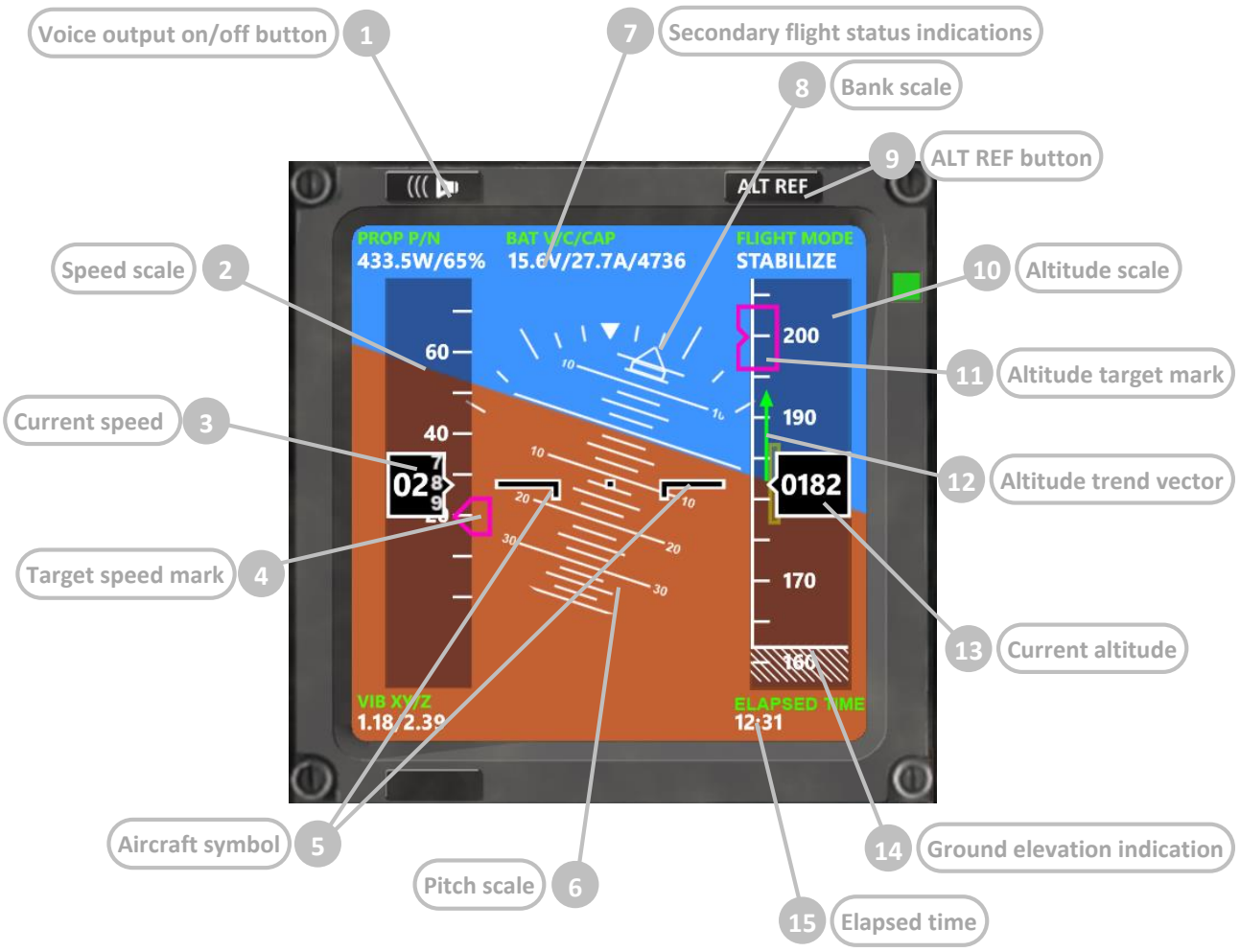
The test consists of flying a steady turn and measuring the time it takes until the initial course is reached again. Thus the turn rate is defined as the time to complete a full 360° turn. The test has to be flown in both directions separately so (somewhat) different result are supported.



	Element	Purpose
1	Right standard turn rate/test state	This read-only textbox initially and after a successfully completed test contains the currently defined right standard turn rate. During a running right turn test the display changes to “Msrg..:” concatenated by the already passed turn angle in degrees. If the test fails the text changes to “Failed…”. If the test did not complete because the turn has been interrupted the text changes to “Discontinued...”.
2	Start right turn test	This button initiates a right turn test. The test procedure looks like this: 1. Initiate a steady right turn, preferably with a reproducible and consistent yaw command. 2. Press this button to start the test. 3. Monitor the progress of the test on the display. 4. Once the 360° turn is over the test automatically ends and the result is shown in the test state display.
3	Left standard turn rate/test state	This read-only textbox initially and after a successfully completed test contains the currently defined left standard turn rate. During a running left turn test the display changes to “Msrg..:” concatenated by the already passed turn angle in degrees. If the test fails the text changes to “Failed…”. If the test did not complete because the turn has been interrupted the text changes to “Discontinued...”.
4	Start left turn test	This button initiates a left turn test. The test procedure looks like this:

1. Initiate a steady left turn, preferably with a reproducible and consistent yaw.
2. Press this button to start the test.
3. Monitor the progress of the test on the display.
4. Once the 360° turn is over the test automatically ends and the result is shown in the test state display.

3.12 Instruments – Primary Flight Display (PFD) – overview



	Element	Purpose
1	Voice output on/off button	This buttons allows switching on and off the synthetic voice output (Barking Bob feature). For more details see chapter 3.29.
2	Speed scale	The speed scale moves vertically in order to keep the current speed at the center.
3	Current speed	The current speed indication shows the momentary groundspeed in the unit chosen on the INIT page of the FMS (see chapter 3.23).
4	Target speed mark	The target speed mark indicates the target speed which was defined for the current flightplan (see chapter 3.24).
5	Aircraft symbol	The aircraft symbol consists of two wings and indicates the position of the aircraft in relation to the artificial horizon.

6	Pitch scale	The pitch scale indicates the pitch angle of the aircraft. On the screenshot above the aircraft is tilted forward by 7°.
7	Secondary flight status indications	At the top and the bottom (left) of the display a number of secondary flight parameters and status information are displayed. The following data is shown: **PROP P/N** Propulsion power [W] / propulsion power [%] **BAT V/C/CAP** Battery voltage [V] / current [A] / remaining capacity [mAh] The remaining battery is calculated from charged battery capacity as entered on the PERF page in the FMS. **FLIGHT MODE** The current flight mode from the (Ardupilot based) flight controller as received via MAVLink **VIB XY/Z (at the bottom left)** Vibration in the X or Y axis (horizontal, the larger value of the two is shown) / Vibration in the Z axis (vertical)
8	Bank scale	The pitch scale indicates the pitch angle of the aircraft. On the screenshot above the aircraft is banked left by 8°.
9	ALT REF button	The ALT REF button allows setting the current altitude as reference ground elevation. Prior taking off this button can be used to enforce that the ground elevation indication matches the actually received altitude.
10	Altitude scale	The altitude scale moves vertically in order to keep the current altitude at the center.
11	Altitude target mark	The target altitude mark indicates the target altitude which was defined for the current flightplan (see chapter 3.24).
12	Altitude trend vector	The altitude trend vector points to the altitude which will be reached in three seconds if the aircraft continues to climb or descend at the current vertical speed.
13	Current altitude	The current altitude indication shows the momentary altitude in the unit chosen on the INIT page of the FMS (see chapter 3.23).
14	Ground elevation indication	The crosshatched area represents the ground which moves along the altitude scale in order to indicate the aircraft altitude above ground. For altitudes above ground between 0 m to 15 m the indication appears in amber, above 15 m in white. Above 25 m the ground elevation indication is not visible. The reference ground elevation can be set either manually (see ALT REF button above) or is set automatically according to these rules: - If a flightplan is activated using the EXECUTE button the mean elevation of all the runways of the origin airports are taken as reference ground elevation. - If the flight mode changes to LOCKED and the ground elevation has not been set earlier, the current altitude is recorded as reference ground elevation. The reference ground elevation is always valid for a static spot. It is not updated according to the actual position of the aircraft.
15	Elapsed time	The elapsed time shows the past time after the activation of the Flight Lock mode. This time can be interpreted as the duration of the flight because activating the Flight Lock mode is intended to happen immediately prior taking off.

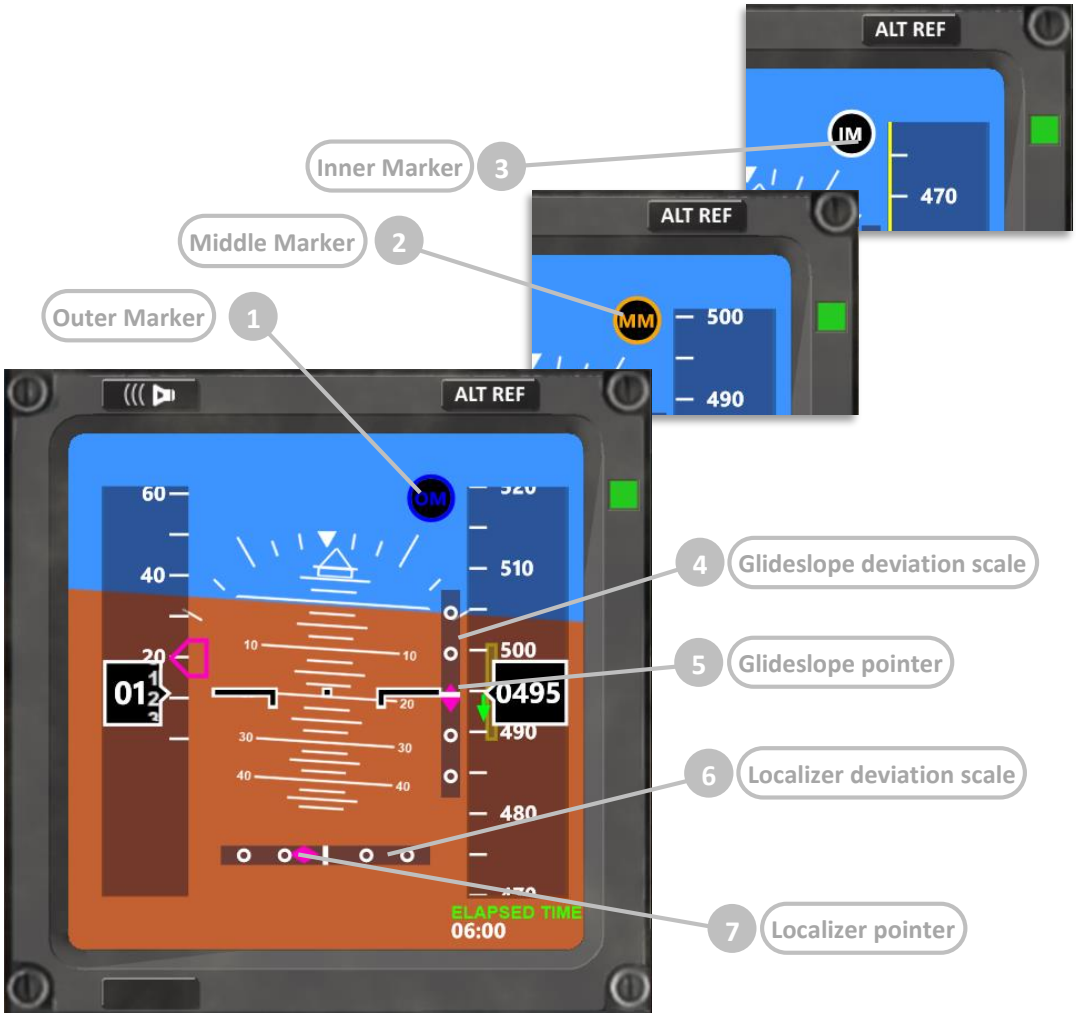
3.13 Instruments – Primary Flight Display (PFD) – ILS mode

The ILS (Instrument Landing System) allows approaching a runway on the extended runway center line. In real world aviation an ILS consists of a localizer which provides directional feedback (how is the aircraft positioned horizontally vs the runway center line) and the glideslope which provides altitude feedback (how much deviates the aircraft vertically from the glideslope).

FlightZoomer simulates this system using the following components:

- The navigation database which contains user defined runways and ILS.
- The NAV RAD page on the FMS which allows the selection of an ILS approach by tuning to the desired frequency (see chapter 3.28).
- The deviation and status indications which are shown on the Primary Flight Display during the actual approach, described in this chapter.

The following screenshots show the ILS specific indications on the Primary Flight Display. The ILS specific indications are only visible, if the navigation receiver has been tuned to the primary or reverse ILS frequency of a runway (see chapter 3.28) and the ILS mode has been activated on the Navigation Display (see chapter 3.15).



Element	Purpose

1	Outer Marker	While overflying the Outer Marker the “OM”-symbol is flashing. Additionally a 400 Hz tone is beeping. Further details see below.
2	Middle Marker	While overflying the Middle Marker the “OM”-symbol is flashing. Additionally a 1300 Hz tone is beeping. Further details see below.
3	Inner Marker	While overflying the Inner Marker the “OM”-symbol is flashing. Additionally a 3 kHz tone is beeping. Further details see below.
4	Glideslope deviation scale	The glideslope deviation scale indicates how much above or below of the glideslope the aircraft currently is.
5	Glideslope pointer	The glideslope pointer moves up and down on the glideslope deviation scale. If the pointer is above the center, the aircraft flies lower than the glideslope. If the glideslope is captured from below the pointer initially sticks to the top of the scale and then moves steadily to the center the closer to the glideslope the aircraft gets.
6	Localizer deviation scale	The localizer deviation scale indicates how much to the left or to the right of the extended runway center line the aircraft currently is.
7	Localizer pointer	The localizer pointer moves left and right on the localizer deviation scale. If the pointer is on the left side, the aircraft flies too much to the right. If the localizer is captured from the right side the pointer initially sticks at the left end of the scale and then moves steadily to the center the closer runway center line the aircraft gets.

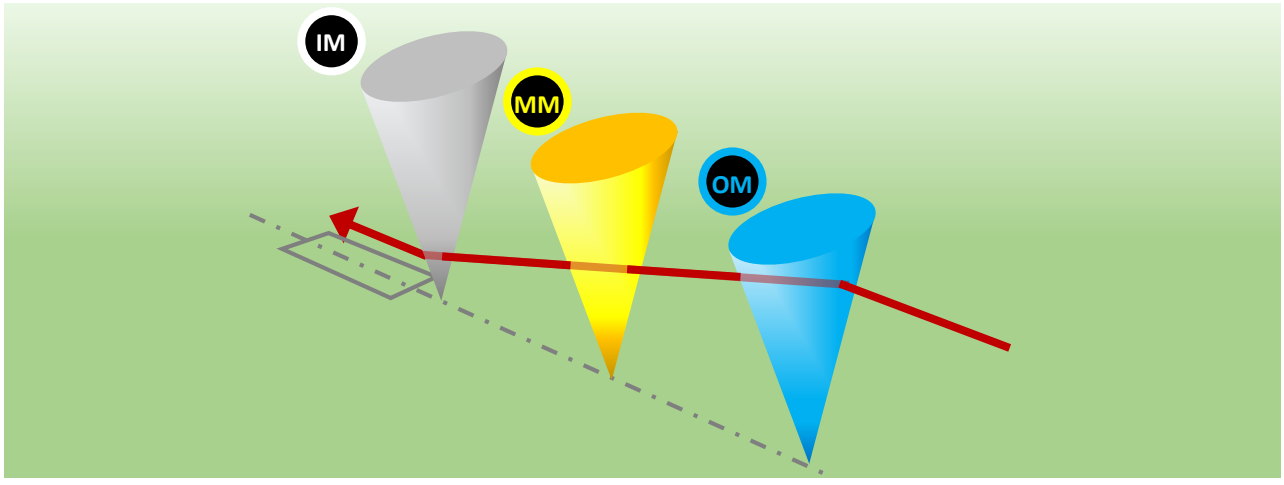
Marker beacons

In real world aviation the marker beacons are providing aural and visual feedback about the progress of an approach. There are three marker beacons, the outer being placed between 6.5 and 11 km from the runway threshold, the middle being placed at a distance of 3500 ft from the runway threshold and the inner being placed very close to the runway (at Cat II minima).

FlightZoomer marker beacons are placed at the following distances:

- Outer marker beacon: where the capturing altitude intersects the.
- Middle marker beacon: at half of the approach.
- Inner marker beacon: at about 20 ft before the threshold.

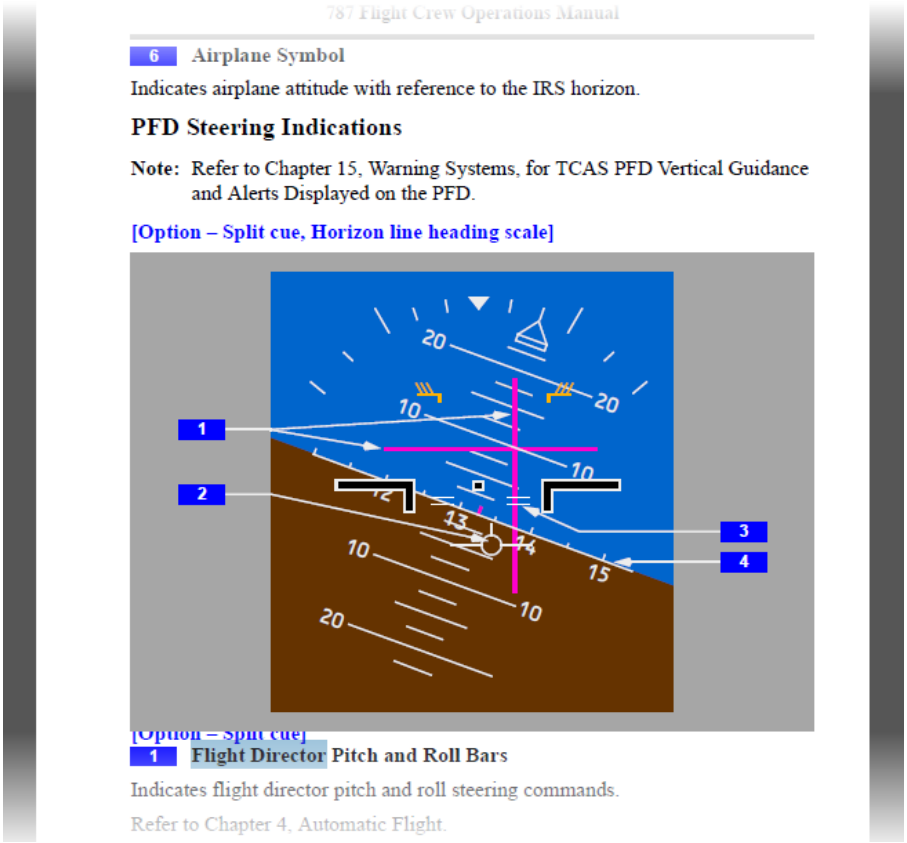
The marker beacons represent a vertical cone and while flying through that cone, the respective tone is beeping and the respective symbol on the navigation display flashes:



3.14 Instruments – Primary Flight Display (PFD) – Flight Director mode

In the cockpit of real aircraft the flight director consists of vertical and a horizontal bars which are displayed on the Primary Flight Display. These bars indicate to the pilot the exact pitch and roll steering commands which are needed e.g. to let the aircraft follow the programmed flightplan. A semi-automatic autopilot so to speak: the system tells the pilot how to manipulate the control stick.

The real 787 flight directors bars look like on the following extract from the Boeing Crew Operation Manual. In this example the pilot currently needs to apply some roll-right and pitch-up corrections:



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6 Airplane Symbol

Indicates airplane attitude with reference to the IRS horizon.

PFD Steering Indications

Note: Refer to Chapter 15, Warning Systems, for TCAS PFD Vertical Guidance and Alerts Displayed on the PFD.

[Option – Split cue, Horizon line heading scale]

[Option – Split cue]

1 Flight Director Pitch and Roll Bars

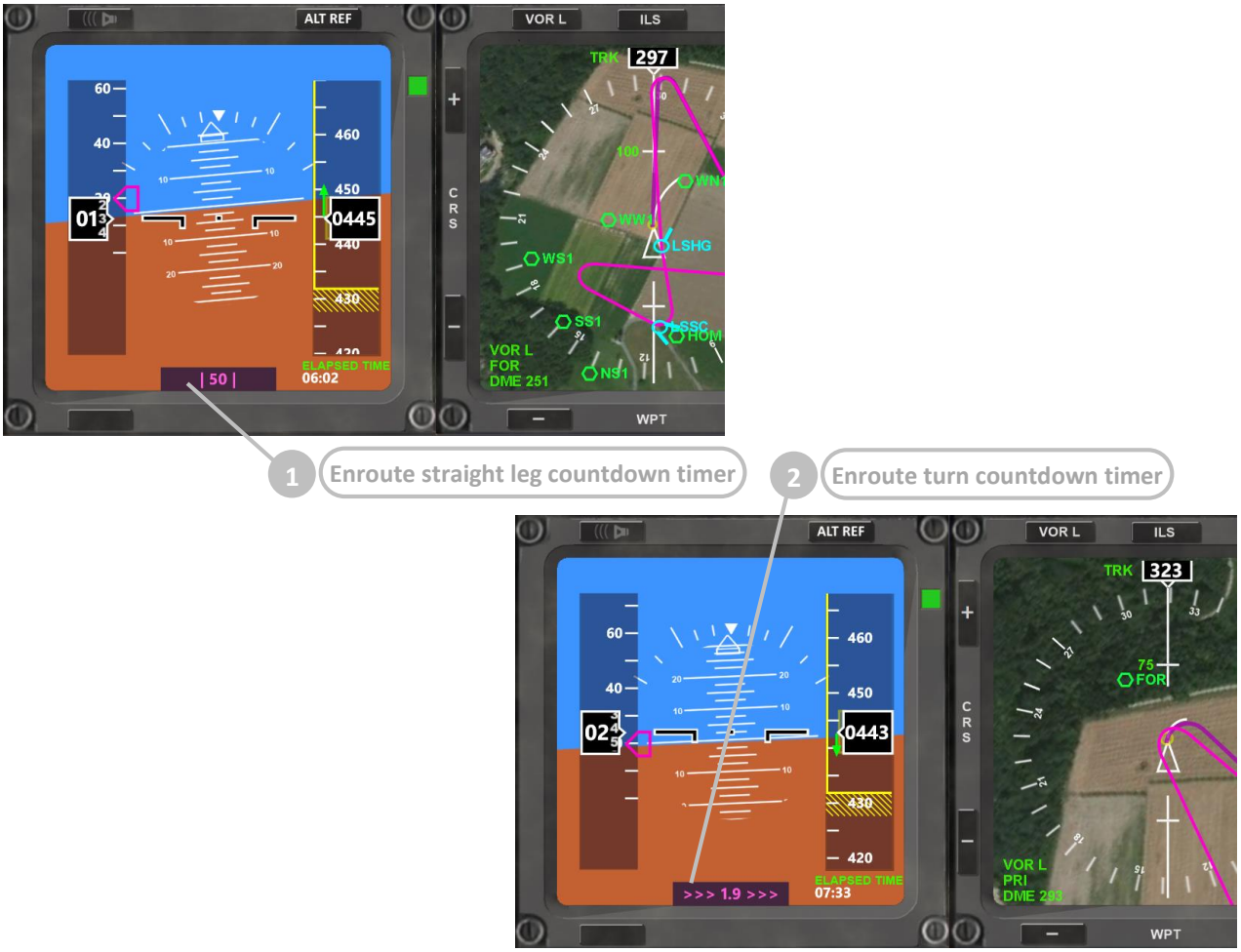
Indicates flight director pitch and roll steering commands.

Refer to Chapter 4, Automatic Flight.

This concept has also been replicated with FlightZoomer with the goal of supporting the pilot to follow the flightplan. The appearance is somewhat different but the principle is the same.

The following image shows the appearance of the FlightZoomer flight director at the bottom of the Primary Display. The flight director is only visible while LNAV is switched on (a flightplan is being followed):

The following image shows the two modes of the FlightZoomer flight director:

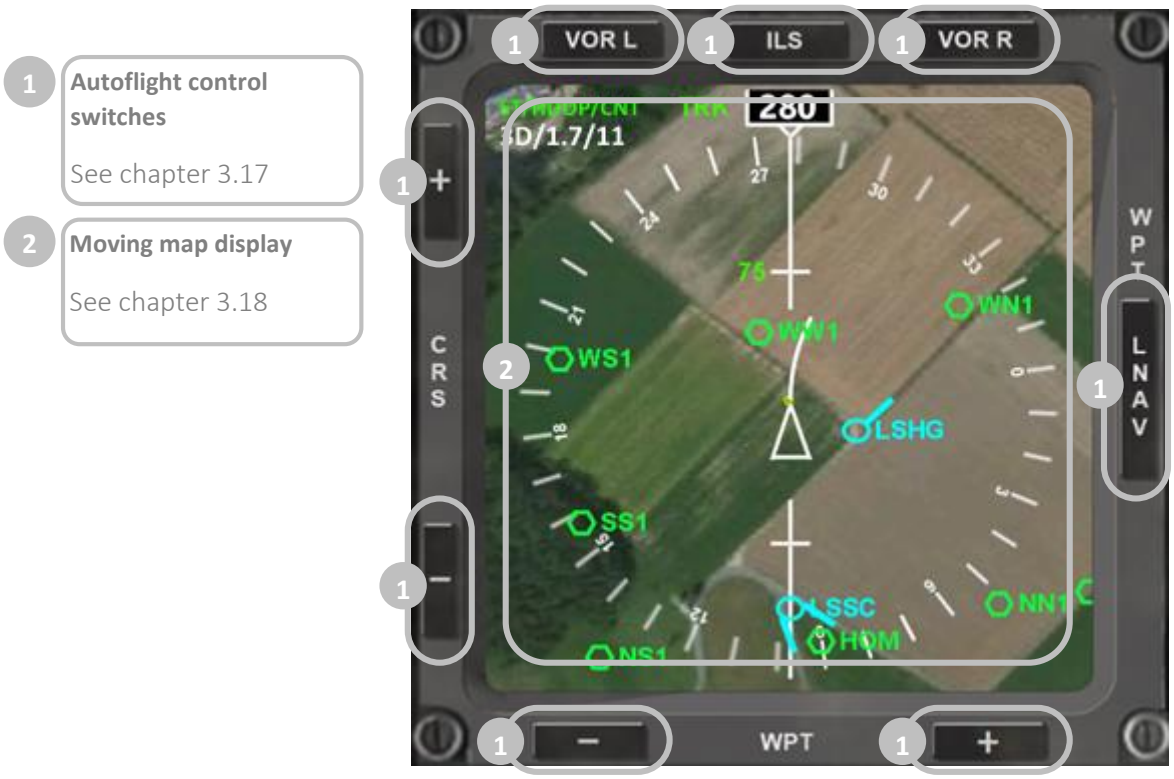


	Element	Purpose
1	Enroute straight leg countdown timer	This timer counts down the seconds of the current straight leg while approaching the next turn. Important: the system does not guide the pilot to apply the small corrections needed to follow the deviations which always occur following the straight line. The system only shows the remaining seconds until the next turn needs to be initiated (considering the exact current flight path). For the small corrections the pilot should refer to the Navigation Display. The displayed text pattern is: | [RS] | [RS] = remaining time of the current straight leg in seconds. No places after the decimal point.
2	Enroute turn countdown timer	The turn countdown timer indicates how long the current turn needs to be continued until the correct course for the next leg is established. The calculation of the remaining turn time is based on the standard turn rate. For further information about the standard turn rate refer to chapter 3.4 and 3.11. The displayed text pattern is either: >>> [RT] >>> or <<< [LT] <<< [RT] = remaining right turn time in seconds. One digit after the decimal point. [LT] = remaining left turn time in seconds. One digit after the decimal point.

3.15 Instruments – Navigation Display (ND) – overview

The Navigation Display offers situational awareness to the pilot. Additionally there are several switches which give control over the autoflight modes and settings.

The following screenshots shows the layout of the Navigation Display:



3.16 Instruments – Navigation Display (ND) – basic settings

The appearance of the Navigation Display can be controlled by the autoflight control switches (see the next chapter). Additionally the following basic settings can be controlled by the display control panel:

- Map brightness (see chapter 3.8)
- Terrain on/off (see chapter 3.8)
- Track Lock (see chapter 3.8)
- MAP mode (see chapter 3.18)
- PLAN mode (see chapter 3.18)

3.17 Instruments – Navigation Display (ND) – autoflight control switches

	Element	Purpose
1	VOR L mode button	Activates radio navigation for the left VOR receiver. The frequency to which the VOR L receiver is tuned on the NAV RAD page selects the actual target radio station (for which a radial shall be captured/followed). By activating VOR L the deviation indicator and DME indications start being displayed on the Navigation Display. Pressing this buttons switches off any other active navigation mode.
2	ILS mode button	Activates the ILS approach which is selected the ILS receiver. The frequency to which the ILS-GLS is tuned on the NAV RAD page determines the runway which is approached. By activating ILS the deviation indicator and DME indications start being displayed on the Navigation Display. Additionally the Primary Display changes into ILS mode. Pressing this buttons switches off any other active navigation mode.
3	VOR R mode button	Activates radio navigation for the right VOR receiver. The frequency to which the VOR R receiver is tuned on the NAV RAD page selects the actual target radio station (for which a radial shall be captured/followed). By activating VOR L the deviation indicator and DME indications start being displayed on the Navigation Display. Pressing this buttons switches off any other active navigation mode.
4	Increment Course	Pressing this button the course of the expected radial on which a radio beacon is approached can be incremented.

5	Decrement Course	Pressing this button the course of the expected radial on which a radio beacon is approached can be decremented.
6	LNAV mode button	Precondition for using LNAV is an activated flightplan. Pressing the LNAV button activates the mode, where the active flightplan is followed. Pressing this buttons switches off any other active navigation mode.
7	Activate the previous waypoint	Pressing this button and while following the flightplan the active waypoint can be set to the previous waypoint.
8	Activate the next waypoint	Pressing this button and while following the flightplan the active waypoint can be set to the next waypoint.

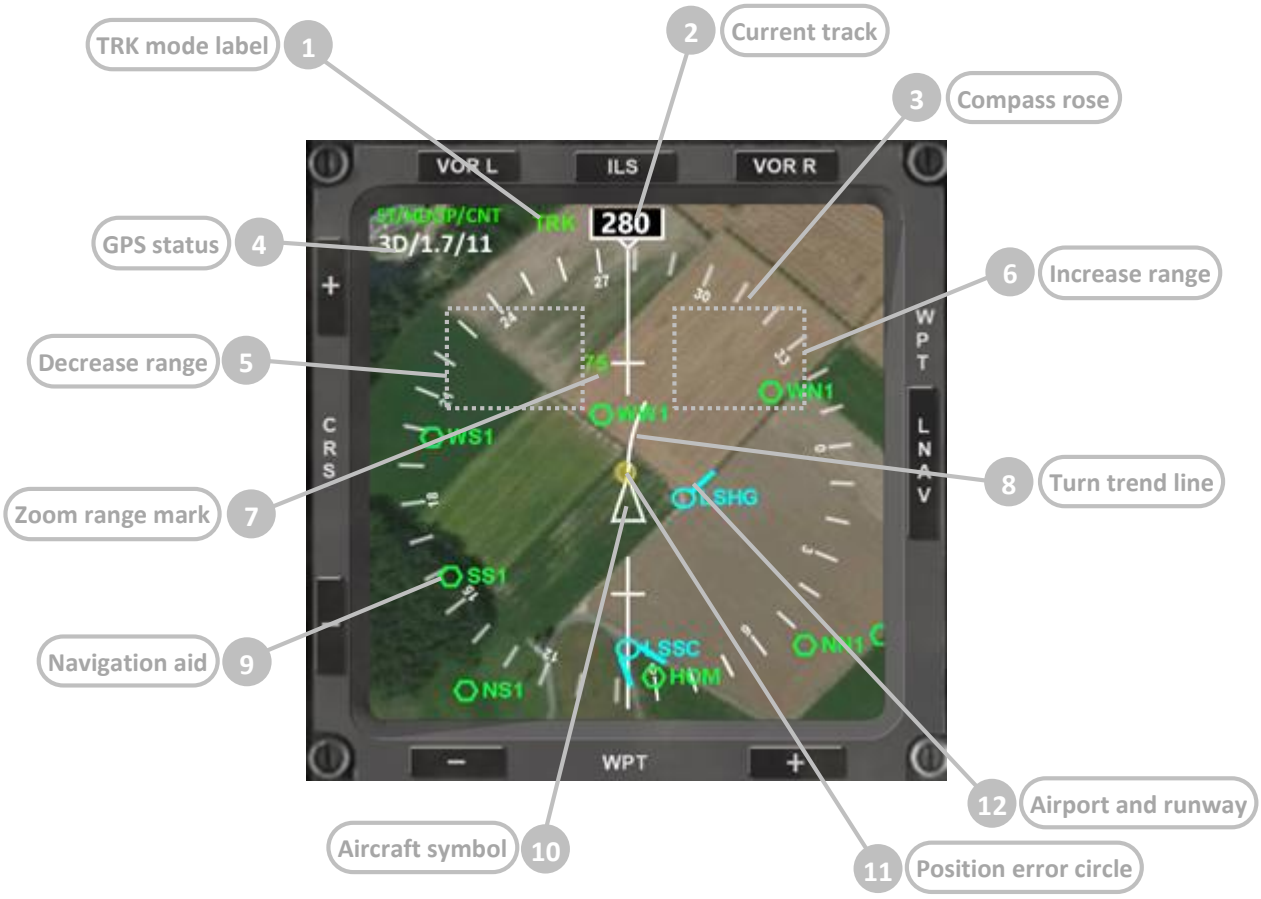
3.18 Instruments – Navigation Display (ND) – moving map display

The Navigation Display has four basic combinations regarding the presentation of the directional information. The following matrix shows vertically the two sources for directional information (track over ground and magnetic aircraft heading) and horizontally the two basic modes (MAP and PLAN):

	MAP mode	**PLAN mode**
Track over ground	In MAP mode the aircraft symbols always points exactly upwards. The map is rotated to show the flying direction over ground (derived from GPS).	In PLAN mode the map stays fixed and North is always pointing upwards. The aircraft symbol is rotated to show the flying direction over ground.
Aircraft magnetic heading	Instead of showing the track over ground the map is rotated to show the aircraft heading.	Instead of showing the track over ground the aircraft symbol is rotated to show the heading.

[Option - MAP mode, Track over ground directional source]

In MAP mode the current track over ground is shown exactly upwards and the map does rotate accordingly. The heading information is not provided.



	Element	Purpose
1	TRK mode label	This label indicates the source for the directional information either by showing TRK or HDG. TRK means that the track over ground is shown.
2	Current track	The current track over ground as 3 digit number with the range 0…360.
3	Compass rose	The compass rose rotates around the aircraft location.
4	GPS status	At the top left the current GPS status information is displayed (this only applies to the GPS information coming from MAVLink). The following information is there: **ST/HDOP/CNT** GPS Status / reported HDOP / satellite count
5	Decrease range	Pressing this overlay button zooms into the map.
6	Increase range	Pressing this overlay button zooms out of the map.
7	Zoom range mark	The zoom range mark gives an indication about the current scale of the map. The figure is the distance between center of the map and the white small horizontal mark beside the figure. The distance from the center to the compass rose is the double of this distance. The units are always metric. The following range values can be selected:

		- 6.5m; 15m; 30m; 50m; 75m; 100m; 150m; 200m; 300m; 400m; 500m; 700m; 1000m; 2000m; 3000m; 5000m; 50km; 500km; 3000km
8	Turn trend line	This line indicates the flown radius if the current turn rate is maintained.
9	Navigation aid	On the map all the navigation aids are displayed. Beside printing the ID of the navigation aid the following symbols are used: - VOR, GPS FIX
10	Aircraft symbol	The aircraft symbol is a white triangle.
11	Position error circle	A yellow circle shows the estimated position error (HDOP if the flight controller is the source).
12	Airport and runway	On the map also all the airports are displayed. Beside printing the CODE of the airport the following symbols are used: - Airport - Runway (showing length and direction)

[Option - MAP mode, Heading directional source]

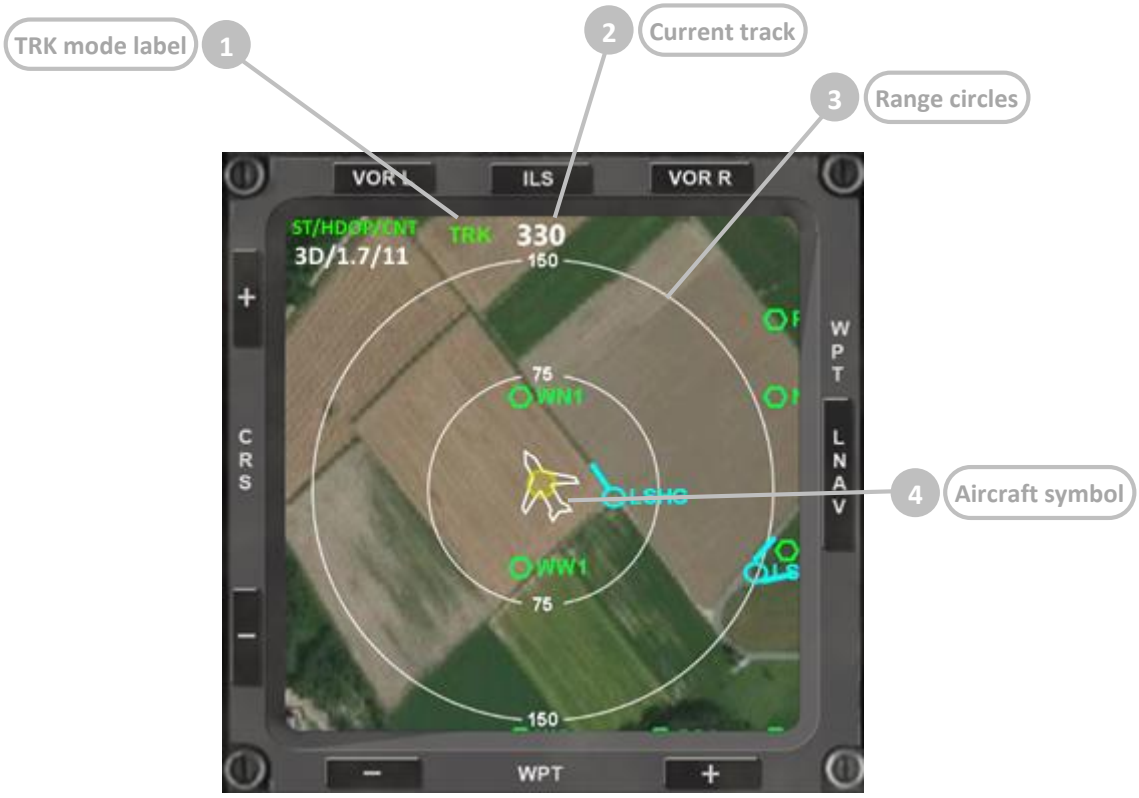
In this mode the current magnetic heading of the aircraft is shown exactly upwards and the map does rotate accordingly. The track information is provided by the track indicator.

	Element	Purpose
1	HDG mode label	This label indicates the source for the directional information either by showing TRK or HDG. HDG means that the heading is shown (where is the aircraft's nose pointing to). Due to side wind components the actual track above ground can differ from the heading.
2	Current heading	The current heading as 3 digit number with the range 0…360.
3	Track indicator	The track indicator shows the track over ground as additional information.

[Option - PLAN mode, Track over ground directional source]

In PLAN mode the aircraft symbol does rotate according to the current track over ground and the map stays fixed with north pointing upwards. The heading information is not provided.

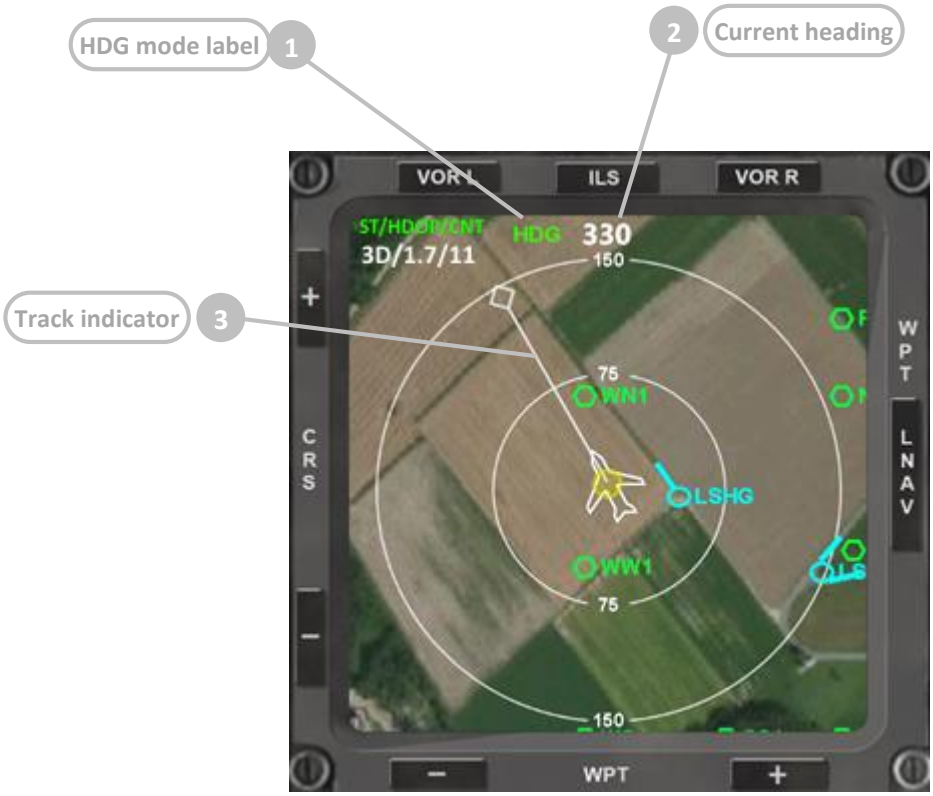
The following description only highlights the differences to the MAP mode. The range control buttons and the symbols stay the same.



	Element	Purpose
1	TRK mode label	This label indicates the source for the directional information either by showing TRK or HDG. TRK means that the track over ground is shown.
2	Current track	The current track over ground as 3 digit number with the range 0…360.
3	Range circles	The range circles are centered at the aircraft position and show zoom range and the double zoom range.
4	Aircraft symbol	In PLAN mode the aircraft symbol looks like the silhouette of an aircraft.

[Option - PLAN mode, Heading directional source]

In this mode instead of the map the aircraft symbol does rotate according to the current heading. The map is fixed with north pointing upwards. The track information is provided by the track indicator.

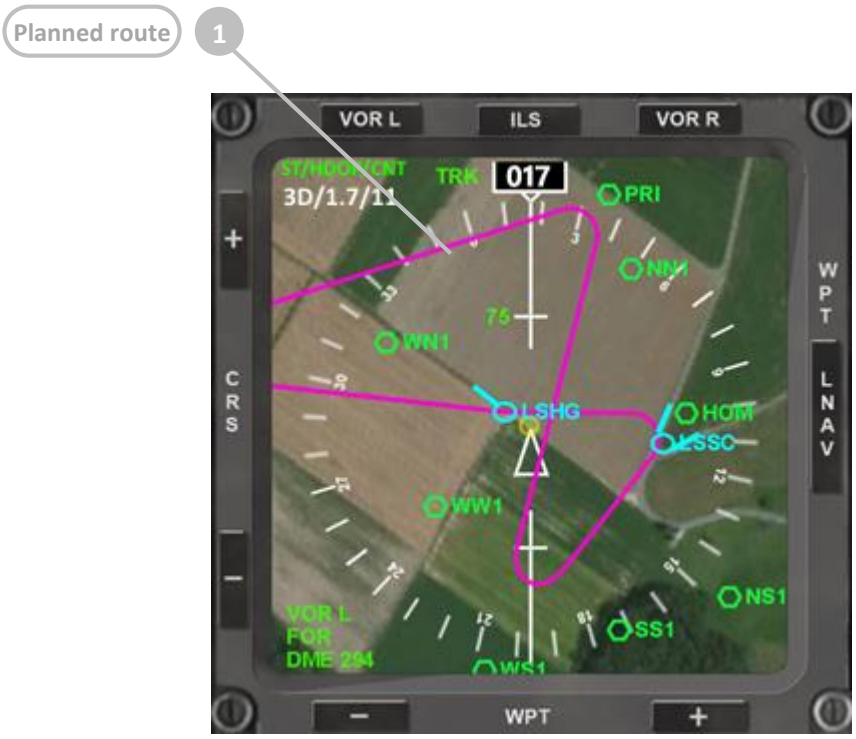


	Element	Purpose
1	HDG mode label	This label indicates the source for the directional information either by showing TRK or HDG. HDG means that the heading is shown (where is the aircraft's nose pointing to). Due to side wind components the actual track above ground can differ from the heading.
2	Current heading	The current heading as 3 digit number with the range 0…360.
3	Track indicator	The track indicator shows the track over ground as additional information.

3.19 Instruments – Navigation Display (ND) – flight plan

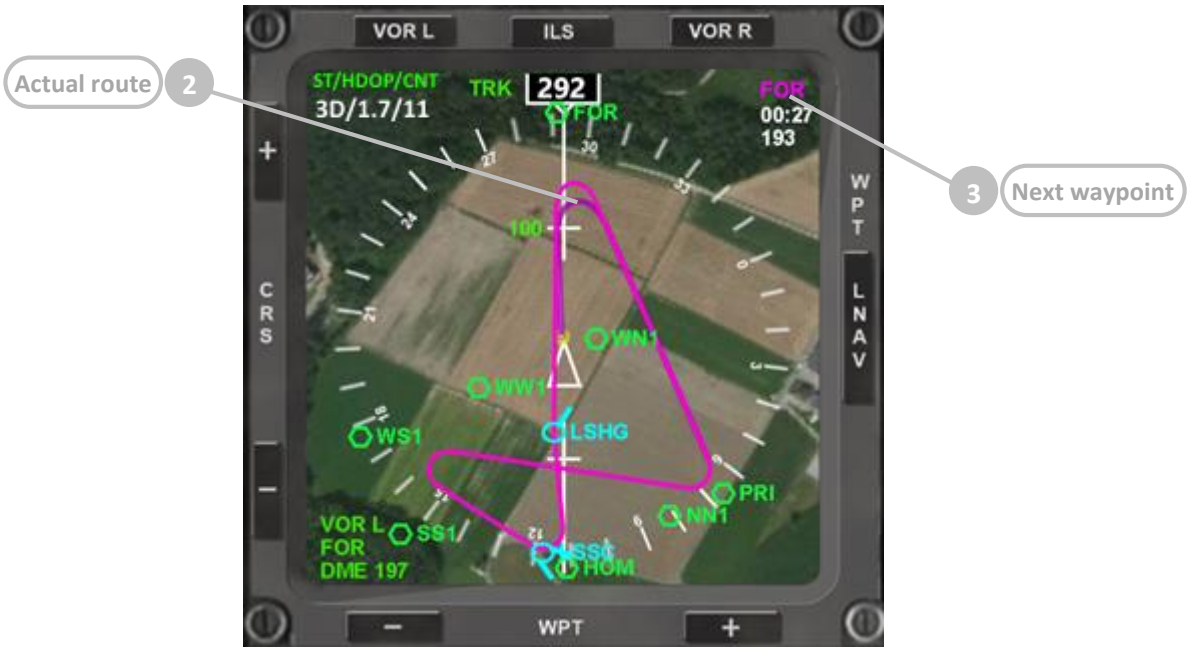
[After EXEC, prior LNAV mode activation]

Immediately after pressing *EXEC* in the FMS, the planned route is displayed on the Navigation Display:



[After EXEC, after LNAV mode activation]

After pressing on the LNAV toggle mode button on the right side of the display the actual route is shown with a darker magenta.



	Element	Purpose
1	Planned route	The planned is shown with a magenta line. The turn radius is derived from the planned cruise speed (as entered on the RTE page of the FMS) and the standard turn rate as either entered on the *Options* screen (see chapter 3.4) or determined by flight testing (see chapter 3.11).
2	Actual route	As the flown route often does not follow the planned route 100% accurately (especially if flown manually), the actual route which approximates the planned route best is shown in darker magenta in addition. Deviations from the planned route can be corrected by following the darker magenta line.
3	Next waypoint information	The most important information regarding the next waypoint is displayed at the top right corner of the Navigation Display: - The ID of the navigation aid in magenta letters - The remaining time in white letters - The remaining distance in white letters (in display unit)

3.20 Instruments – Navigation Display (ND) – radio navigation

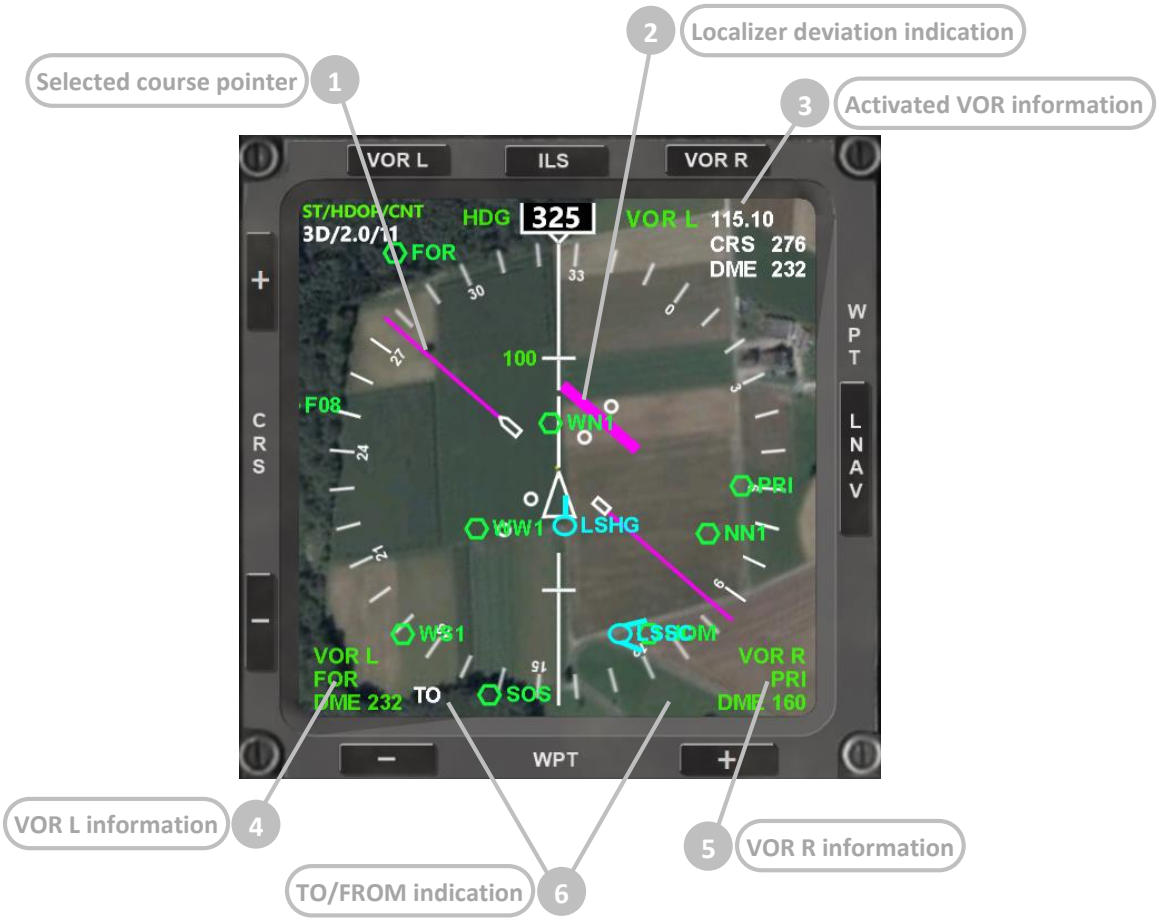
Radio navigation allows flying to or from radio beacons. The radio navigation features offered in FlightZoomer allow en-route navigation using VORs as waypoints or ILS approaches.

Activating radio navigation requires a two-step procedure:

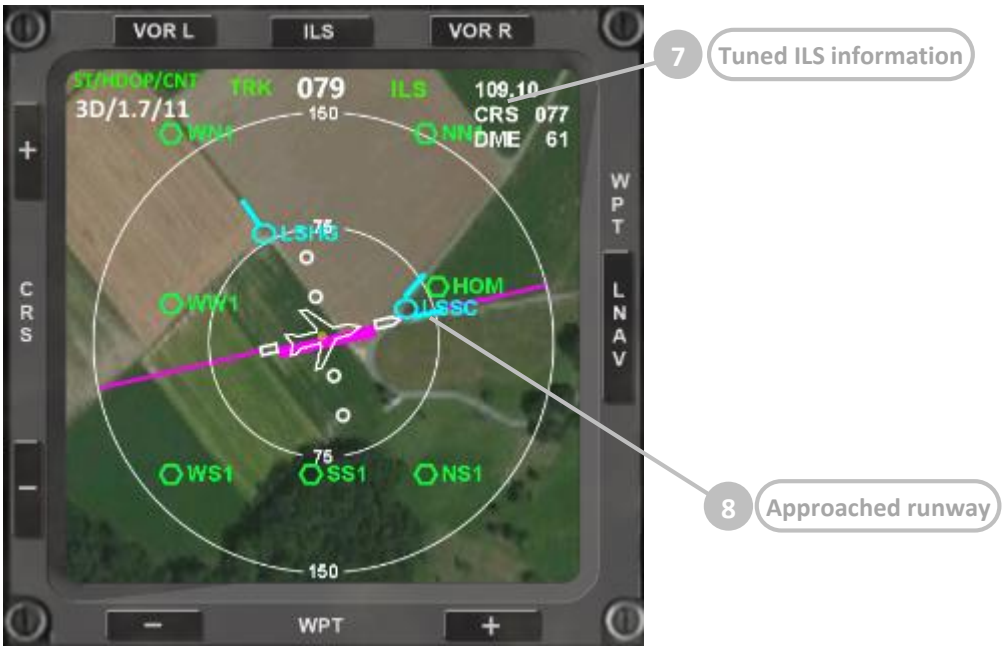
- Tuning the VOR L, VOR R or ILS receiver to particular VOR or ILS frequency and setting the desired course (on the NAV RAD page of the FMS).
- Activating one of the radio navigation buttons at the top of the Navigation display (VOR L, ILS or VOR R).

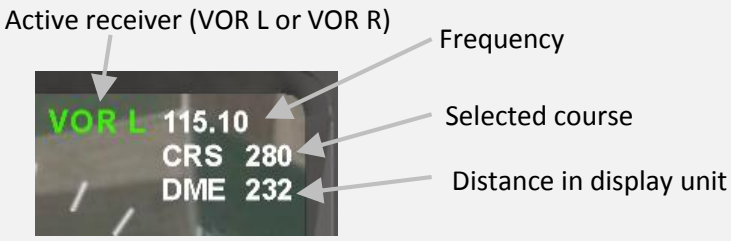
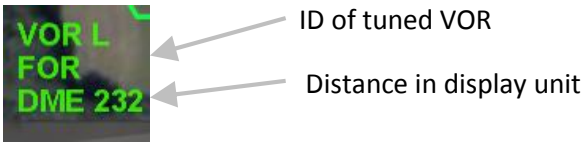
Because the activation happens in the second step using dedicated buttons for each of VOR L, ILS or VOR R, the respective receives can be tuned at the same time to a suitable radio beacon.

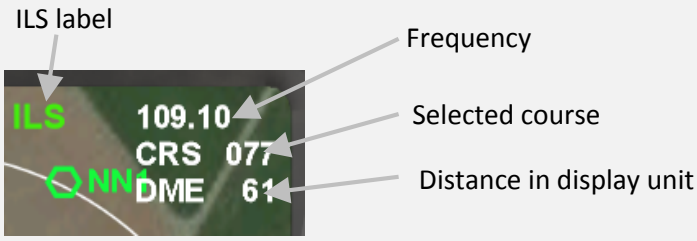
[Option – VOR L (or R) activated, MAP mode]



[Option – ILS activated, PLAN mode]



	Element	Purpose
1	Selected course pointer	The selected course pointer shows the direction of the target radial towards the localizer. It allows to flying to (or from) the radio beacon on any particular radial and not only on the direct course between the aircraft's position and the station. This means that if the direct course does not match the selected course the aircraft first needs to capture the radial. Very typically this is required flying an ILS approach to capture the extended runway centerline. The selected course must be defined on the NAV RAD page on the FMS. For ILS approaches the selected course must match the runway direction. At any time the selected course can be fine-tuned using the CRS + and CRS – buttons on the Navigation Display frame. This way also the direct course to a VOR can be identified.
2	Localizer deviation indication	The localizer deviation indicator is a magenta bar which moves sideways in parallel to the selected course pointer. The lateral deflection indicates the closeness to the selected radial towards the localizer. While the localizer is being captured the deviation indication moves into the middle until the course pointer and the deviation indicator are in-line.
3	Activated VOR information	If one of the VOR receivers is activated for navigation the detail information is presented in the top right corner of the display. This consists of the following parameters: 
4	VOR L information	Whenever the VOR L receiver is tuned to a valid frequency of a VOR, the most relevant information is shown in the bottom left corner of the Navigation display. The following parameters are shown:  This information is also present if none, the other VOR or the ILS receiver is activated for navigation.
5	VOR R information	As for the VOR L the information of the tuned VOR R receiver is shown in the right bottom corner of the display.
6	TO/FROM indication	This text label either shows TO or FROM depending on whether the selected course is leading away or to the radio beacon (from the perspective of the current position). The label appears on the left side if the active VOR is VOR L and on the right if the active VOR is VOR R.
7	Activated ILS information	While approaching a runway using activated ILS the following detail information is presented in the top right corner of the display:



8	Approached runway	Symbol for the runway for which the aircraft is on final approach.

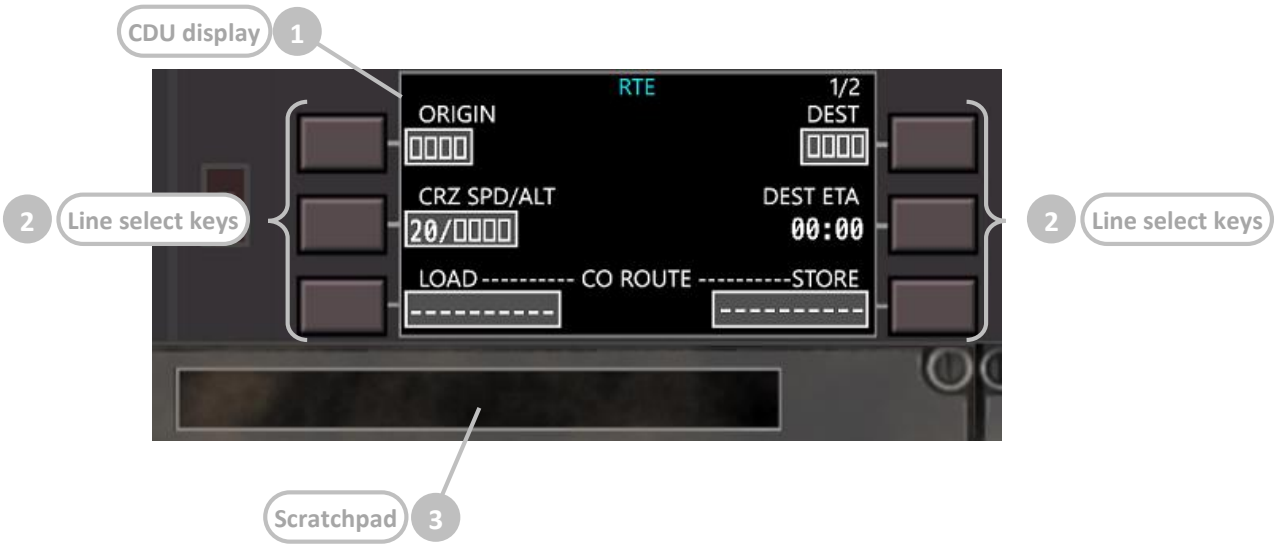
3.21 Flight Management System – overview

	Element	Purpose
1	CDU Display	
2	Scratchpad	
3	Keypad	

3.22 Flight Management System – CDU (Control Display Unit)

In this chapter the main components and mechanisms of the Control Display Unit are described. More than 70% of the descriptions are copied 1:1 from the Boeing 787 FCOM!

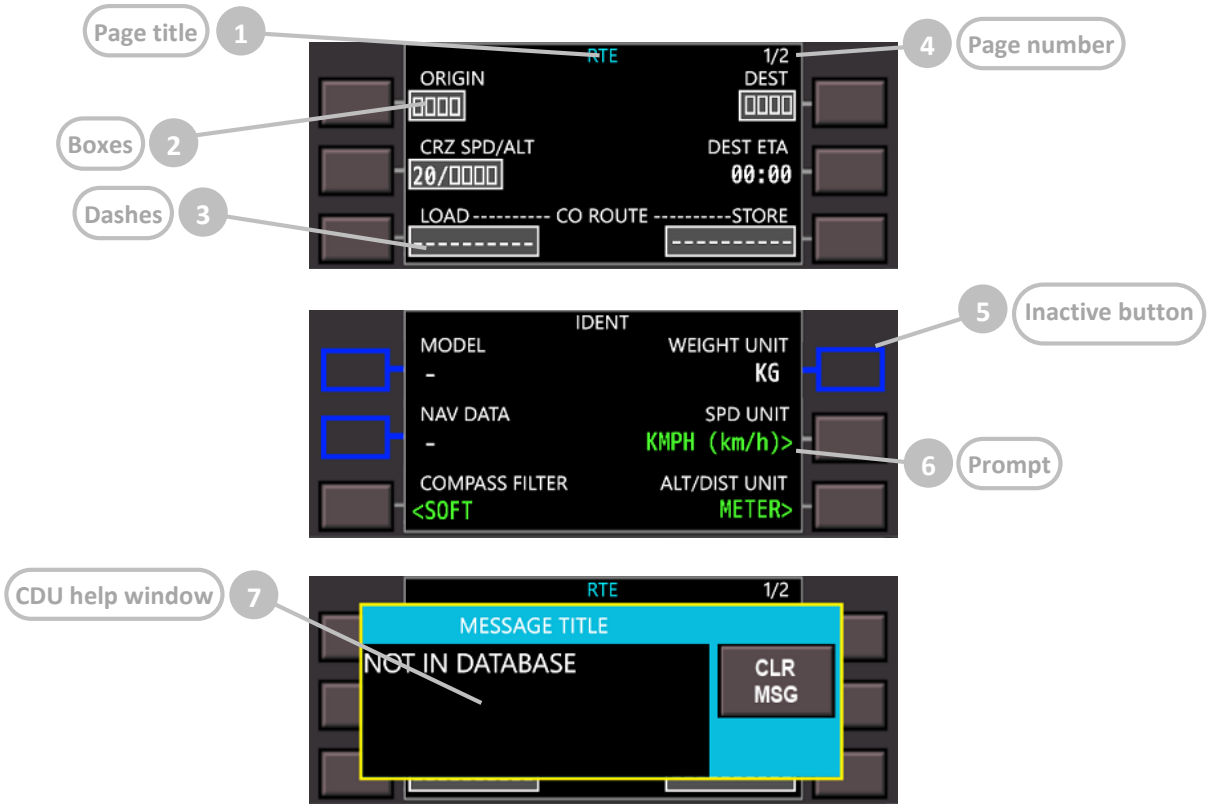
[CDU overview]



	Element	Purpose
1	CDU display	Displays FMS data pages.
2	Line select keys	Push – - moves data from scratchpad to selected line - moves data from selected line to scratchpad - selects page, procedure, or performance mode as applicable - deletes data from selected line when “DELETE” displays in scratchpad Conventions – - scratchpad must be blank for line select transfer - data cannot be transferred to a blank line - a blank scratchpad cannot be transferred to a line - not all data can be modified - message displays if inappropriate entries are attempted - The keys are designated like this: 1L 1R 2L 2R 3L 3R
3	Scratchpad	Displays crew entered data or crew line-selected data. - data may be transferred to and from the scratchpad by pushing a line select key. - data may also be transferred to the scratchpad while using the PICK WPT function on the FIX page

[CDU page components]

The following screenshots are examples that show the various generic components on the CDU display.



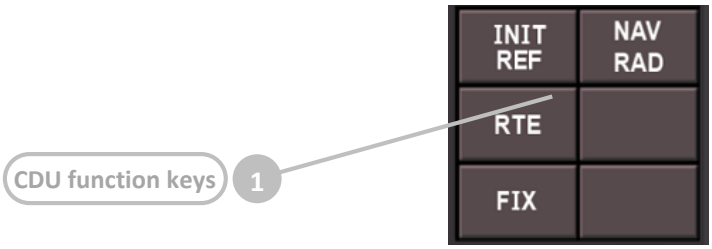
	Element	Purpose
1	Page title	Subject or name of data displayed on page.
2	Boxes	Data input is mandatory.
3	Dashes	Data input is optional.
4	Page number	Left number is page number. Right number is total number of related pages. Page number is blank when only one page exists.
5	Inactive button	No supported positions on the display have a blue button outline.
6	Prompt	Display pages, select modes, and control displays. Caret “<” or “>” is before or after prompt.
7	CDU help window	Displays error/help messages to the crew.

Color is used as follows:

- black –
  - background color of page
- cyan –
  - inactive RTE page title
  - inactive button outline
- green –
  - navigation radio data
  - active state of two–position and three–position selectors
- magenta – data used by FMC for lateral and vertical flight commands

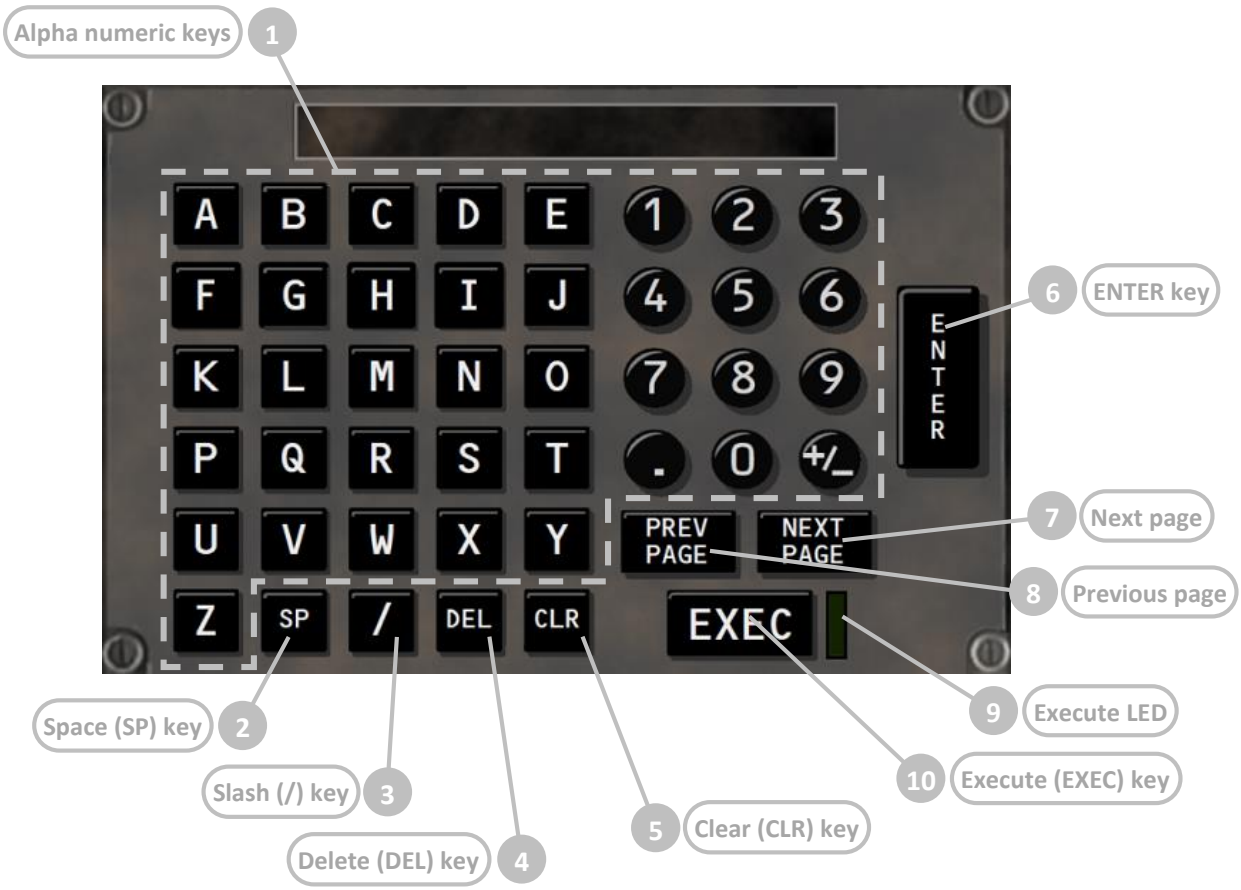
    - active waypoint
    - active airspeed
    - active altitude
    - cursor
    - highlight box
- shaded gray –
    - input field
- shaded white –
    - modifications
    - MOD precedes page titles of modified pages
- white – most data

[Function keys]



	Element	Purpose
1	CDU function keys	Press – - INIT REF – displays page for data initialization or for reference data. - RTE – displays page to input or change origin, destination and route. - FIX – displays page to browse through the navigation aid and airport database. - NAV RAD – displays page to view or control navigation radio tuning.

[Multifunctional keypad]



	Element	Purpose
1	Alpha numeric keys	Press – - puts selected character in scratchpad - Plus Minus (+/-) key – first push enters "-" in scratchpad. Subsequent pushes alternate between "+" and "-"
2	Space (SP) key	Press – enters space in scratchpad
3	Slash (/) key	Press – enters "/" in scratchpad
4	Delete (DEL) key	Press – enters "DELETE" in scratchpad. "DELETE" can then be applied to any data input line to delete the current content.
5	Clear (CLR) key	Press – clears last character of data in the scratchpad. Press and hold – clears all scratchpad data.
6	ENTER key	Not used
7	Next page	Press – displays next page of multiple page displays
8	Previous page	Press – displays previous page of multiple page displays
9	Execute LED	Illuminated (green) – active data is modified but not executed.
10	Execute (EXEC) key	Press (while EXEC light is illuminated green) – - activates data modification(s) - extinguishes execute light

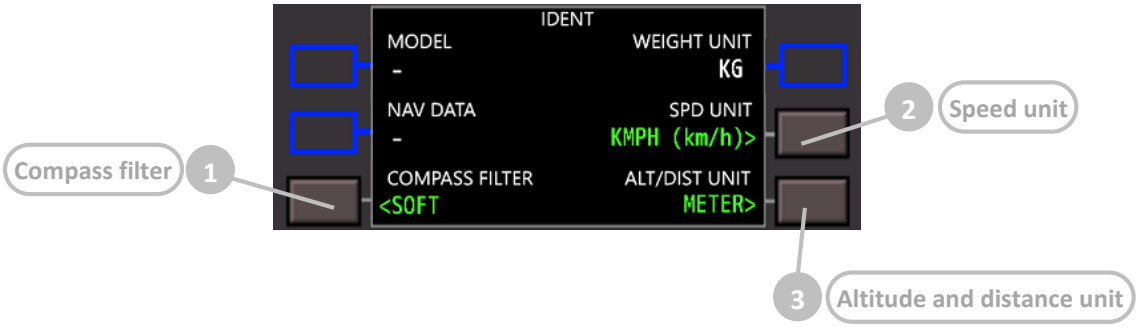
3.23 Flight Management System – INIT/REF page (initialization)

The initialization/reference index page allows manual selection of FMC pages. It gives access to pages used during preflight and not usually used in flight.

	Element	Purpose
1	Open IDENT page	The IDENT allows the identification of static system parameters. Additionally some system configurations can be done.
2	Open PERF page	The PERF page allows entering actual parameters which are relevant for performance calculations.
3	Open FIX page	The FIX page allows browsing the navigation database.
4	Open RTE page	The RTE (route) page allows to define and maintain flightplans.
5	Open NAV RAD page	The NAV RAD (radio navigation) page allows tuning the radio receivers.

3.24 Flight Management System – IDENT page (preflight checks/settings)

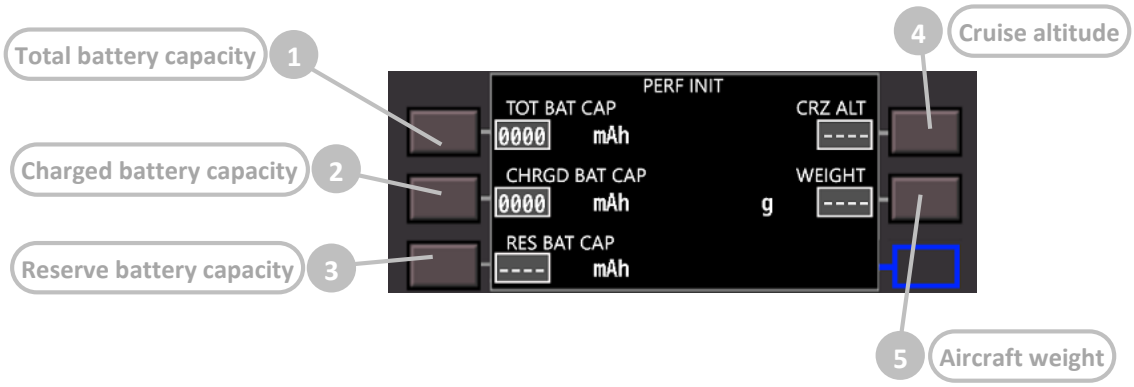
The IDENT page is used to verify basic aircraft data and define operational FlightZoomer settings. A number of parameters are constants or are not yet populated. In addition the page allows to select some system settings. This includes display units for speed and distances. While the whole transmission and processing of data is strictly based on SI units, display units can be used to change the units which are used on the presentation layer of the groundstation.



	Element	Purpose
1	Compass filter	There are four compass filter settings which can be applied to the received raw compass data: NONE, SOFT, MEDIUM, STRONG
2	Speed unit	The following speed units are available: KMPH, KTS, MPH
3	Altitude and distance unit	For distances, altitudes and also vertical speed (per second) the following units are available: METER, FT

3.25 Flight Management System – PERF page (routes & flightplans)

The PERF INIT page is used for initialization of data required for VNAV operations and performance predictions.

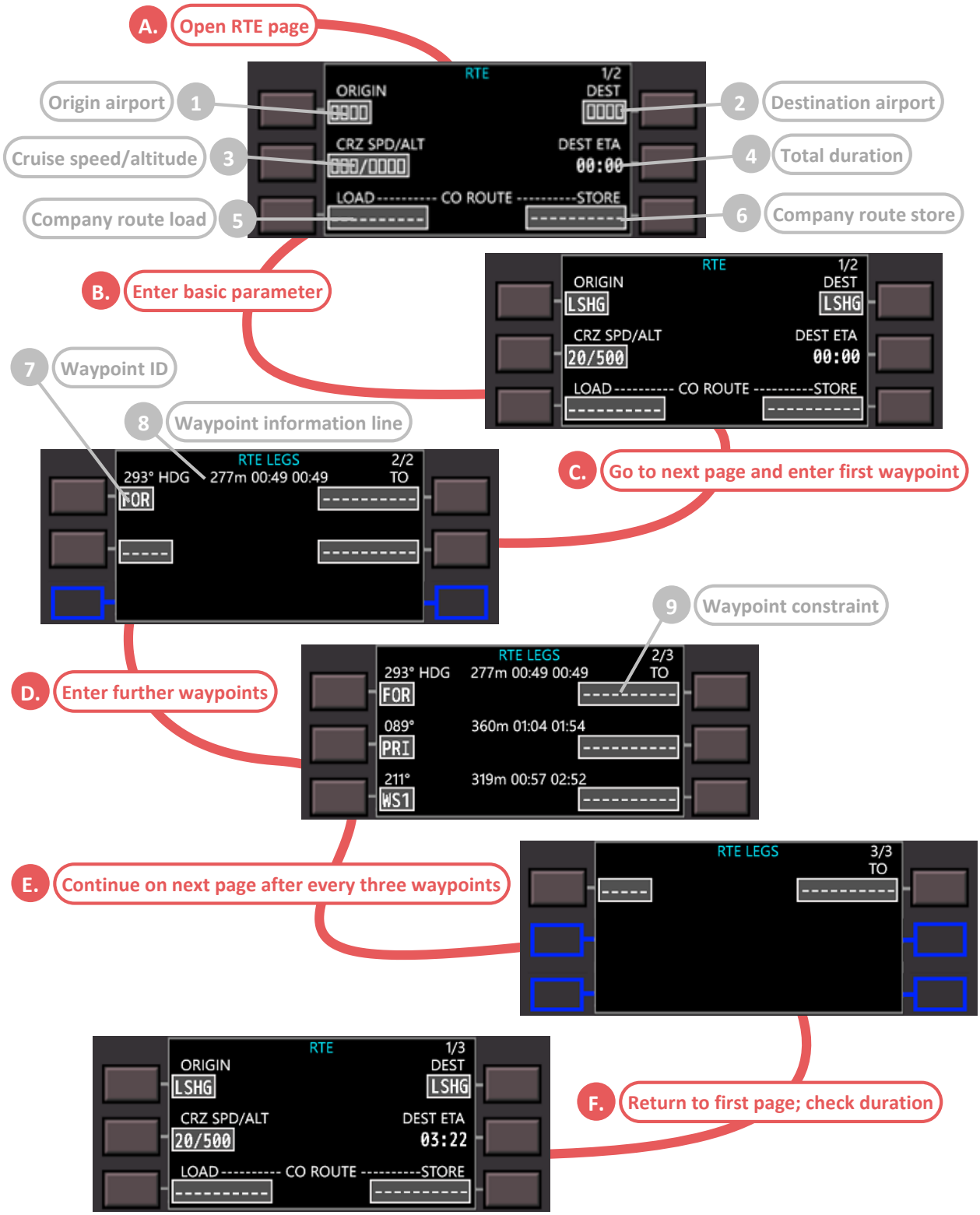


	Element	Purpose
1	Total battery capacity	The total battery capacity is stored in the app settings and stays always the same as long as the same battery is used.
2	Charged battery capacity	The charged battery capacity is the currently available battery capacity. While the battery is discharged this value is decreased. At app start the value is taken from the total battery capacity but it can also be manually be set at any time to reflect e.g. a partially charged battery.
3	Reserve battery capacity	The reserve battery capacity can be defined to calculated the overall useable capacity. Currently the system does not use this value.
4	Cruise altitude	The cruise altitude is the altitude during the cruise phase of the flight. This value is used to set the altitude target mark on the Navigation Display. This parameter can also be set on the RTE page. On the PERF page it is optional.
5	Aircraft weight	The aircraft weight is foreseen for various performance calculations. Currently the system does not use this value.

3.26 Flight Management System – RTE page (routes & flightplans)

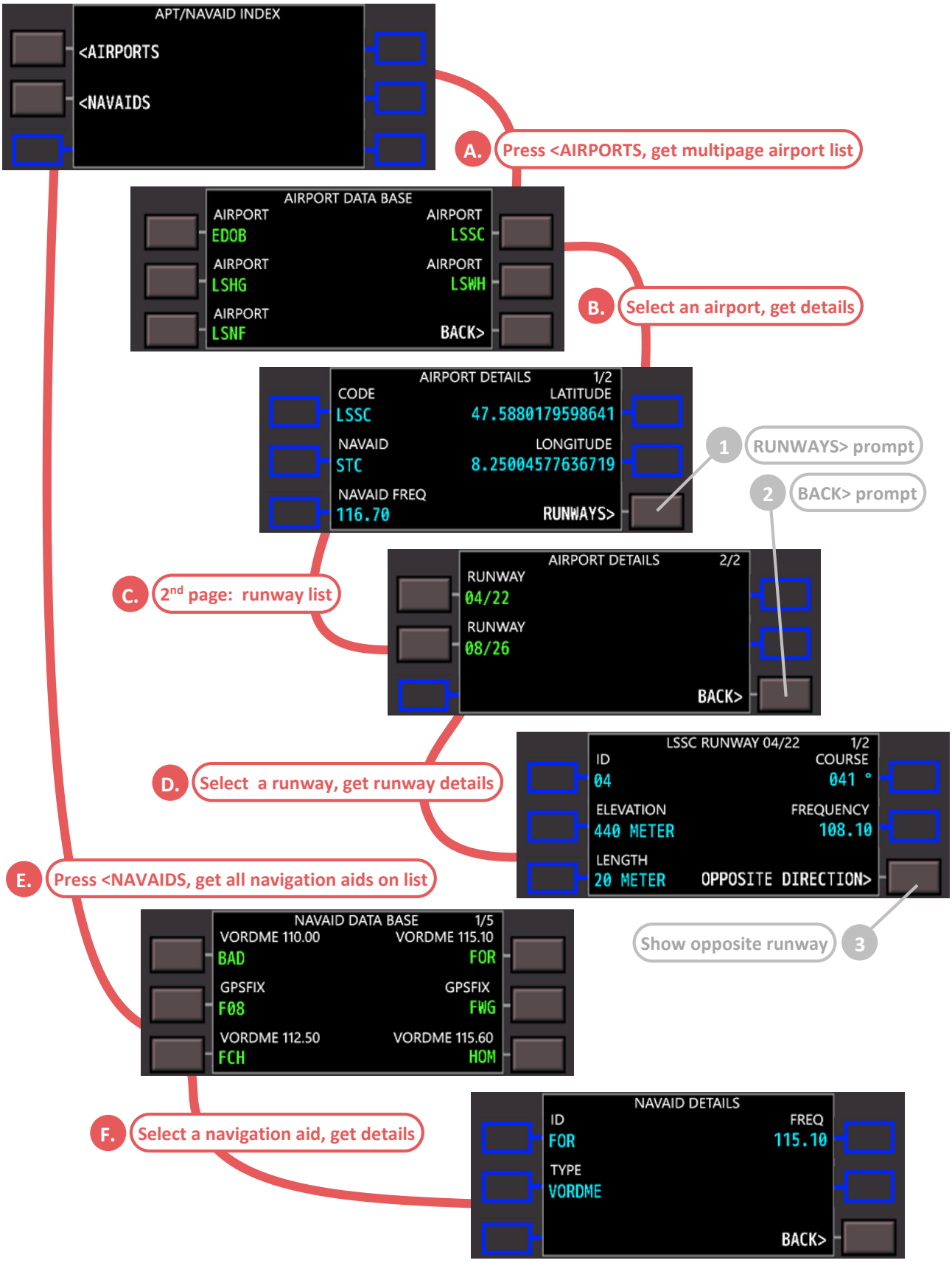
The FMS RTE page consists of several sub-pages route that allow entering flightplans during flight preparation. Flightplans can also be stored and loaded into the navigation database. The activity of creating a flightplan includes the selection of an origin and destination airport, the cruise altitude, cruise speed and any number of waypoints.

The following diagram shows the various components of the RTE page and the steps of the activity (in red):



	Element	Purpose
1	Origin airport	Origin airport of the flight. Enter an existing airport CODE as defined in the navigation database. This parameter is mandatory.
2	Destination airport	Destination airport of the flight. Enter an existing airport CODE as defined in the navigation database. This parameter is mandatory.
3	Cruise speed/altitude	Enter the planned cruise speed and cruise altitude in display unit. The two values must be separated by a dash-character (“/”). Entering a number without “/” means that only the cruise speed is changed. Entering “/” followed by a number allows changing the altitude alone while the speed is kept. This parameter is mandatory.
4	Total duration	Total duration of the flight, updated after every change. Check after the last waypoint has been entered, to see the total expected flight duration.
5	Company route load	This feature can be used to load existing company routes (see the next point how company routes can be created). Enter the name of a route in the scratchpad and press the 3L key.
6	Company route store	Any flightplan which has been created can be stored using this feature. Enter a route name in the scratchpad and press the 3R key. A status information text will inform about the progress and once the flightplan is stored completely.
7	Waypoint ID	On the following subpages of the RTE page waypoints can be added. Enter either the ID or the VOR frequency of an existing waypoint in the scratchpad and press 1L, 2L or 3L. Waypoints can either be added at the last position or replace earlier defined waypoints. If the scratchpad contains “DELETE” (DEL key) the waypoint at the selected position is removed. After three waypoints a new subpage is added which can be opened using the NEXT PAGE key. Waypoints which require 180° turns are not supported while flying.
8	Waypoint information line	After a waypoint has been set, the waypoint information line gets updated. The following information is shown from the left to the right: - Heading of the inbound leg (from the origin or the previous waypoint to this waypoint). - Distance in display unit of the inbound leg. - Duration of the inbound leg. - Total duration of all legs up to this waypoint.
9	Waypoint constraint	Not supported currently.

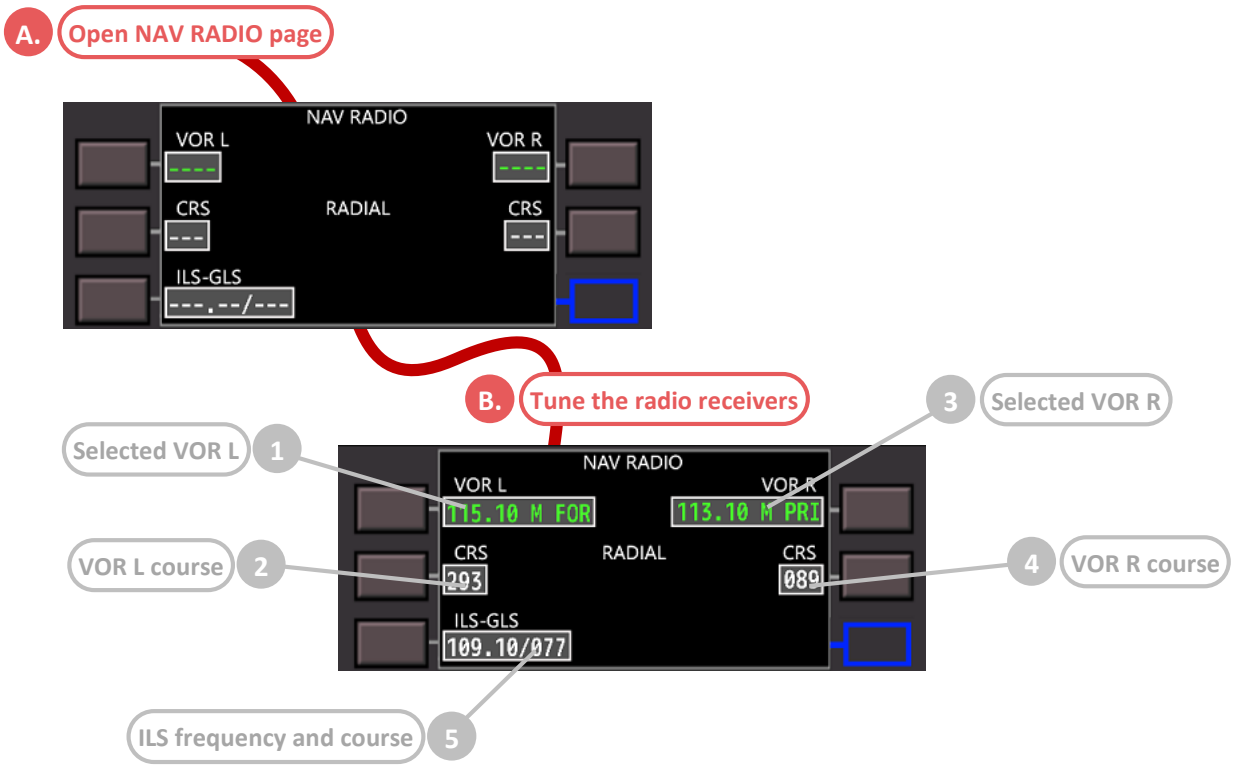
3.27 Flight Management System – FIX page (browse navigation database)



	Element	Purpose
1	RUNWAYS> prompt	Press to show the runways of an airport on the AIRPORT DETAILS page.
2	BACK> prompt	Use to return to upper levels while browsing.
3	Show opposite runway	Press to open the details of the reverse runway.

3.28 Flight Management System – NAV RAD (radio navigation)

VOR navigation radios are normally autotuned by the FMS. The NAV RADIO page displays the VOR and ILS-GLS status and allows manual control of these radios. Entering data on this page tunes the selected navigation radio. VOR courses can also be entered.



	Element	Purpose
1	Selected VOR L	The shown data is the frequency of the selected VOR L, the tuning status and the ID. Enter either the frequency or the ID in the scratchpad to tune the left receiver. The tuning status can be one of the following: - M: the receiver has been tuned manually - A: the receiver has been tuned by the LNAV feature following the flightplan
2	VOR L course	The target radial to be followed towards (or from) the VOR L.

3	Selected VOR R	The shown data is the frequency of the selected VOR R, the tuning status and the ID. Enter either the frequency or the ID in the scratchpad to tune the right receiver. The tuning status can be one of the following: - M: the receiver has been tuned manually - A: the receiver has been tuned by the LNAV feature following the flightplan
4	VOR R course	The target radial to be followed towards (or from) the VOR R.
5	ILS frequency and course	The shown data is the frequency of the selected ILS and the course. Enter the frequency the desired ILS approach in the scratchpad to tune the ILS receiver. The course is then selected automatically.

3.29 Synthetic voice generation for pilot guidance

To be completed.

4 Appendix

4.1 Glossary

Abbreviation/term	Description	Real aviation term
FMS	Flight Management System	X
ILS	Instrument Landing System	X
IM	Inner Marker	X
LNAV	Lateral Navigation Auto flight mode where the loaded flightplan is being followed.	X
MM	Middle Marker	X
ND	Navigation Display	X
OM	Outer Marker	X
PFD	Primary Flight Display	X
VOR	VHF omnidirectional range	X