

CIVA for X-Plane

Delco Carousel IV-A
Inertial Navigation System Simulation

Operators Manual – revision 1.3.1



1 Credits:

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2 Inertial Navigation - An Introduction

Before the introduction of GPS in civil aviation in the 90ies and before the availability of modern flight management computers (FMCs) in the 80ies, airliners were navigated mostly by means of radio navigation (VOR, DME, NDB) and inertial navigation systems. Radio navigation can of course only be used when traveling over areas covered by the necessary ground installations. It cannot be used for crossing an ocean. Inertial navigation instead is totally independent of external sources and totally self-contained in the aircraft.

Inertial Navigation Systems (INS) are based on a principle already used by Charles Lindbergh: Dead reckoning. By starting at a known position and keeping track of speed and direction of travel, the position of the aircraft at any time can be calculated. The tricky part is knowing the precise speed and track. While Lindbergh relied on rather imprecise instruments and his intuition, the INS developed in the 60ies used mechanical gyros to measure even the tiniest acceleration. But still, inertial navigation is subject to position errors that accumulate over time, due to the nature of using acceleration sensors to track position. Therefore, it is advised to correct (update) the position calculated by the INS by means of radio navigation from time to time.

Perhaps the most famous INS installed in classic airliners like the Boeing 707 and 727, the Lockheed Tristar, the Douglas DC-10 and the Boeing 747-100 to -300 was the Delco Carousel IV-A, nicknamed "CIVA". A special variant, the Carousel IV-AC was installed in the Concorde and used to cross the North Atlantic at supersonic speeds. The name "Carousel" refers to the slowly rotating platform on which the gyroscopes were installed, to cancel out false acceleration readings due to gyro precession.

Though the unit looks primitive compared to modern flight management computers, it is not an easy device to operate. It requires manual entry of all waypoints as Lat/Lon coordinates and it has a limited memory that stores only 9 waypoints. Therefore, it is usually necessary to re-program the device in flight, perhaps several times. Procedures like DME updating to correct the calculated position are very tricky and can, if executed incorrectly, render the unit useless for the rest of the flight. Therefore, carefully read the following guide to familiarize yourself with the operation of CIVA.

3 Installation

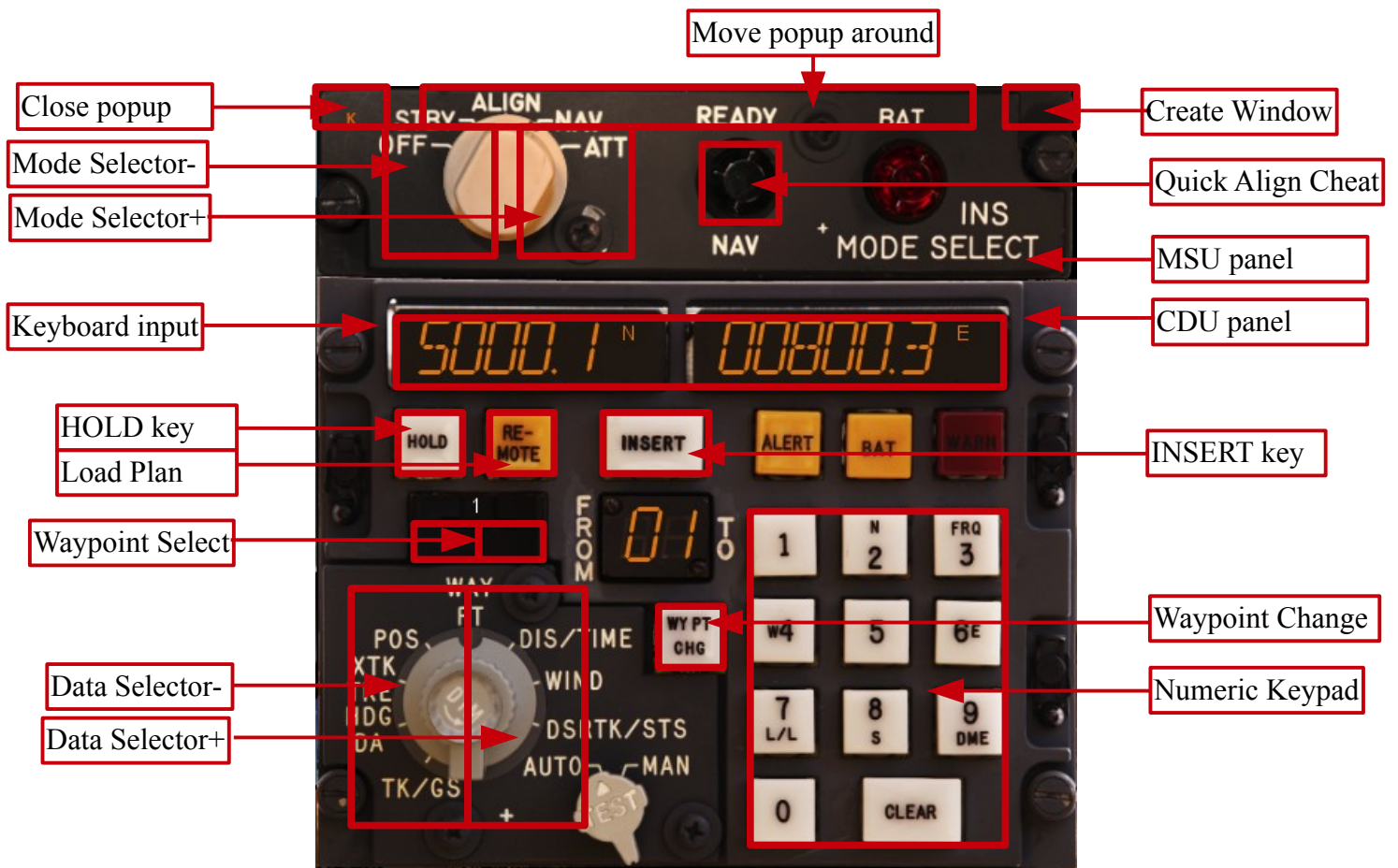
CIVA for X-Plane is a plugin that must be installed into an airplane. The 727 by FlyJSim supports the CIVA natively, but it can be used with other aircraft as well.

To install CIVA for X-Plane in the FlyJSim 727, unpack the "xciva-131.zip", where 131 is the current version number. Unpacking returns a folder called "xciva". This folder must be moved into "Aircraft/727-200Adv/plugins". "727-200Adv" is a placeholder here for any aircraft you would like to use the CIVA in. If the specific aircraft doesn't have a subfolder called "plugins", you must create it.

Linux users must make sure they have libC++ and libGLEW-1.13 or later installed. Ubuntu 16.04LTS or later or a distribution derived from Ubuntu is recommended. Other distributions might work but are not tested.

4 The CIVA Popup window

Looking at the left side of your screen when flying the FlyJSim 727 you see several icons. One of them is labeled "INS". Click it to open the popup window. When using other aircraft than the FlyJSim 727, you may use the menu item "CIVA" that appears under "Plugins" whenever you are flying a plane you equipped with CIVA.



CIVA for X-Plane consists of two panels: The upper part of the popup is the **Mode Selector Unit**, the lower part is the **Control and Display Unit**. Normally, the MSU is installed in the overhead panel of the aircraft, while the CDU is installed on the center pedestal. To simplify operation in the simulator, those two panels are combined into one window. The MSU is used during the preflight phase to get the unit running. During flight, the CDU is used for navigation and to get various information.

5 Keyboard Entry

By clicking in the numeric display area of the window, you can activate keyboard input. It is denoted by a small “K” in the upper left corner. In this mode, your numpad doubles as the numeric keyboard. Also, you can use the “N”, “E”, “S” and “W” keys to select the hemisphere of an entry. The up- and down-arrow keys move the data selector, and with the left- and right-arrow keys you turn the thumbwheel of the waypoint selector. The Backspace or Delete keys may be used for the CLEAR key, and Enter or Return on your keyboard triggers the INSERT key.

To end keyboard input, click the display area again, or simply close the popup window.

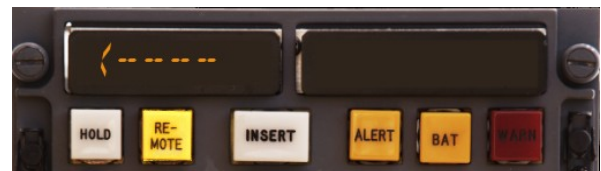
6 Basic modes of operation “Easy” and “Hard”

CIVA for X-Plane can be used in two different modes:

- When you load the aircraft **with engines running**, CIVA for X-Plane is initialized in “**Easy mode**”, which means it is already warmed up, initialized and aligned, no failure will occur and you can start flying right away
- When you load the aircraft **cold and dark**, CIVA for X-Plane is initialized in “**Hard mode**”. Which means the unit is switched off. You have to turn it on, initialize the position and complete the warmup and alignment cycle before you can use it for flying.

7 Navigation using X-Plane flightplans

The easiest way to use CIVA for X-Plane is loading up the aircraft with engines running, and then loading an X-Plane flightplan. Please note that even in Easy mode, the waypoint storage is restricted to 9 waypoints, just as in the real unit. Therefore, you can only load up to 9 waypoints from an X-Plane flightplan. To load a regular X-Plane FMS flightplan, press the REMOTE key (“R” on your keyboard if in keyboard mode). REMOTE lights up and you can use the thumbwheel (left and right arrows if in keyboard mode) to scroll through your saved flightplans.



The displays show the filename of a saved flightplan. A left arrow indicates you have reached the end of the list of saved flightplans. To load the currently displayed flightplan, press INSERT (Enter in keyboard mode). To cancel, press the REMOTE key again.

After loading a flightplan, the waypoints 1-9 are programmed according to the flightplan. You may now use the Autopilot in AUX NAV mode to fly the route.

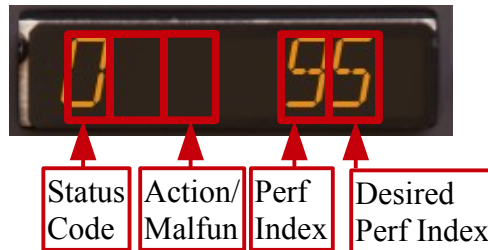
If you load a flightplan in flight while enroute to your 9th waypoint, only waypoints 1-7 will be loaded from file to not disturb your current leg to point 9.

8 Hard mode - from Cold and Dark

8.1 Warmup and Alignment

To begin using the CIVA from cold&dark, make sure to power up AC power and the avionics bus of the aircraft you are flying. The CIVA can also operate up to 30 minutes from its own internal battery, which will get you down in case of an emergency with loss of AC power.

Start by turning the Data Selector to the DSRTK/STS position and the Mode Selector to the STBY position. Observe the status code in the right CDU display.



Check that status mode is 0 (not in NAV), no malfunction is displayed, performance index is 9 (the worst), and desired performance is 5.

Next, rotate the Data Selector to POS. Now you have to initialize the position to the current ramp position of the aircraft. You get the coordinates from your airport chart, alternatively you can look them up on sites like <http://airnav.com>. You can also use X-Plane's Data In/Out feature to display the current latitude and longitude of your aircraft, and then use a calculator like <http://www.directionsmag.com/site/latlong-converter/> to convert from decimal degrees to degrees, minutes, tenths of minutes.

To enter a position into the CDU, you have to do the following:

Start with selecting the hemisphere of the latitude by pressing either 2/N for northern hemisphere or 8/S for southern hemisphere. Observe the INSERT button light up. Now enter the 5 digit sequence of latitude degrees, minutes and tenths of a minute. If you make a mistake when entering, press CLEAR. If you entered the latitude correctly, press the INSERT button. Next, select the hemisphere of the longitude by pressing either 4/W for western or 6/E for eastern longitudes. Observe the INSERT button light up. Enter the 6 digit sequence of longitude degrees, minutes and tenths of a minute. Press INSERT button to confirm the entry. Please note that longitude is always 6 digits instead of 5, because longitudes go from -180 to 180, while latitudes only go from -90 to 90.

Now make sure the parking brake is set and the plane is not moving. Set the Data Selector back to DSRTK/STS and rotate the Mode Selector to ALIGN.

Note that alignment will start after the warmup phase is completed. Warmup time is dependent on the current outside air temperature, the colder it is, the longer it will take for the unit to warm up. At 15°C outside air temperature, warmup will take a little more than 5 minutes. Note that warmup starts as soon as you select the STBY mode, so while you have been fiddling with the initial position, the unit will probably already be warm.

You can now watch the system go through its alignment. During alignment, the Performance Index will count down from the initial 9 to 0. The total time it takes

to complete this countdown depends on your latitude. The nearer you are to the equator, the faster alignment will be. At 40 degrees of latitude, alignment will take slightly less than ten minutes. During the waiting time, you may proceed with manual flightplan entry, see next section.

You may choose to cheat and skip the long waiting period by clicking the hidden spot on the READY NAV light.

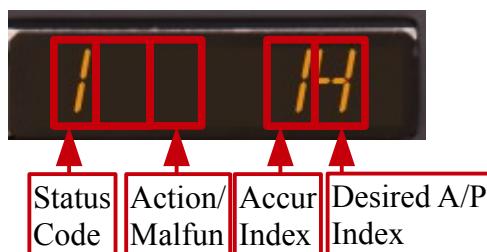
Note that at performance index 8 a test of the internal battery is commenced, which you can see by the yellow BAT light on the CDU lighting up. If also the red BAT light on the MSU lights up, the internal battery is critically low and it is unsafe to rely on it.



As soon as the Performance Index is less or equal the Desired Performance Index, the green READY NAV light on the MSU will light up. It indicates alignment is now sufficient for flight operation. You can still enhance navigation performance further by letting the aircraft sit with the parking brake set and the Mode Selector in ALIGN, while the Performance Index counts further down, until finally to 0. But at any time the READY NAV light is lit up, you can commence NAV mode by rotating the Mode Selector to NAV.



Note the READY NAV light extinguishes and the Status display now reads:



The Mode Index shows 1 for NAV MODE. The Performance Index has now been replaced by the Accuracy Index. It will slowly increase during flight indicating navigation accuracy fades due to long operation without position updating. Note that the accuracy index does not correspond to a specific navigation performance radius and is not suitable for RNP operations! The desired A/P Index will always display 4 in this simulation, as Triple-Mixing or Update Eradication are not simulated.

8.2 Manual Flightplan Entry

You may use the flightplan loading feature as described for Easy Mode. Or you may choose to enter the waypoints manually. The entry procedure is as follows: Turn the Data Selector to WAYPT. Turn the Waypoint Selector (thumbwheel) to the "1" slot.

Now you can enter the first waypoint:

Like you did for the initial position, first select the latitude hemisphere, then enter the latitude, click INSERT, then enter the longitude hemisphere, enter the longitude, click INSERT.

Verify the coordinates, then turn the Waypoint Selector to the "2" slot and repeat the entry for your second waypoint. Repeat this procedure for up to 9 waypoints that can be stored in the unit.

Note that you can enter the waypoints while in STBY, ALIGN or in NAV mode, which means you can program your flightplan while alignment is still in progress.

9 Display Modes

9.1 TK/GS:

Left display shows ground track related to true north to the nearest tenth of a degree.

Right display shows ground speed in knots.

9.2 HDG/DA:

Left display shows heading related to true north to the nearest tenth of a degree. Note that this heading will be different from the heading shown on the HSI because the HSI shows track related to magnetic north.

Right display shows drift angle due to wind, from 0 to 180° suffixed "L" for left or "R" for right.

Note that drift angle is not displayed for ground speeds lower than about 75 knots.

9.3 XTK/TKE:

Left display shows cross track error in tenths of nautical miles, suffixed with "L" for left or "R" for right.

Right display shows track angle error from 0 to 180°, suffixed with "L" for left or "R" for right.

9.4 POS:

Left display shows Latitude of current airplane position in degrees, minutes, tenths of a minute.

Right display shows Longitude of current airplane position in degrees, minutes, tenths of a minute.

9.5 WAYPT:

Shows Latitude in left and longitude in right display in degrees, minutes, tenths of a minute for the currently selected waypoint. The current waypoint is chosen and indicated with the waypoint selector (thumbwheel).

9.6 DIS/TIME:

Left display shows distance in tenths of nautical miles to the currently active TO waypoint.

Right display shows time in tenths of minutes to the currently active TO waypoint, based on current ground speed.

9.7 WIND:

Left display shows wind direction in degrees with respect to true north.

Right display shows wind speed in knots.

Note that reliable wind indication requires at least 75knots of ground speed.

9.8 DSRTK/STS:

Left display shows desired track angle to current TO waypoint in degrees.

Right display shows status codes as described in the warmup and alignment section.

9.9 HOLD mode

To enter hold mode, press the hold key and observe it is lit up.

The display modes are now the following:

TK/GS:

Left display shows sign of the along-track acceleration. No indication means positive, N indication means negative.

Right display shows along-track acceleration in milligs.

POS:

Shows position frozen at the time HOLD key was pressed/lit.

WIND:

The left display will show direction of the longitudinal wind component: N for head wind and S for tail wind.

The right display will show strength of the longitudinal wind component in knots.

To leave HOLD mode, press HOLD and observe the light is extinguished.

10 Leg change

If necessary because of ATC assignment you can skip any leg or track directly to the next assigned waypoint.

10.1 Intercept Next Leg

To intercept a leg from one waypoint to another, press WPT CHANGE, then the number of the waypoint on the "from" end of the leg, then enter the number of the waypoint on the "to" end of the leg. For example, if you are currently headed to waypoint 1, and instead want to intercept the leg from waypoint 3 to waypoint 4, press WPT CHANGE, 3, 4. Note that it is not possible to construct a leg that goes in the opposite waypoint order of your flightplan.

10.2 Direct-to next waypoint

To go directly from your present position to a waypoint in your flightplan, press WPT CHANGE, then 0, and then the number of the waypoint you want to go direct to. For example, if you are currently headed to waypoint 1, and instead want to go directly to waypoint 4, press WPT CHANGE, 0, 4.

11 DME updating

DME stations can be used to improve the accuracy of inertial navigation and get rid of the accumulated position errors. For optimum performance, you should select a DME between 15nm and 200nm off-track to either side of your flight path. Start with looking up a suitable DME on the map, note its frequency, position and station elevation. If you don't have a real enroute navigational chart, this information may be obtained from websites like

<http://worldaerodata.com>

Turn the Data Selector to WAYPT.

Before beginning DME updating, disconnect the autopilot from the INS by going into HDG or ROLL mode.

Use the waypoint selector to select a slot between 1 and 9 (0 is unavailable for DME updating).

Now press the keys 7 and 9 simultaneously. As you can't do that with the mouse, you have to activate keyboard input and do the following: Hold down the Alt-Key. Now press first 7, then 9, after that release the Alt-Key. Now you are in DME entry mode.

Note that the displays will have reverted from displaying waypoint coordinates to DME coordinates. So you are not going to overwrite a waypoint by entering the coordinates now.

Use the normal entry procedure to enter DME coordinates: Select latitude hemisphere, enter latitude, press INSERT, select longitude hemisphere, enter longitude, press INSERT.

Next, we have to enter the DME station's elevation to calculate the slant range. To do so, press 3 and 9 simultaneously, by going in keyboard mode, holding the Alt-Key, and pressing 3 and 9.

The left display will now display the DME elevation in thousands of feet. For entry, round the elevation to the nearest thousand. That is, for 2800ft station elevation, you would enter 3.

To do so, press N/2 key to put the unit in elevation entry mode.

Enter the elevation in thousands, then press INSERT. If you made a wrong entry, press CLEAR and try again.

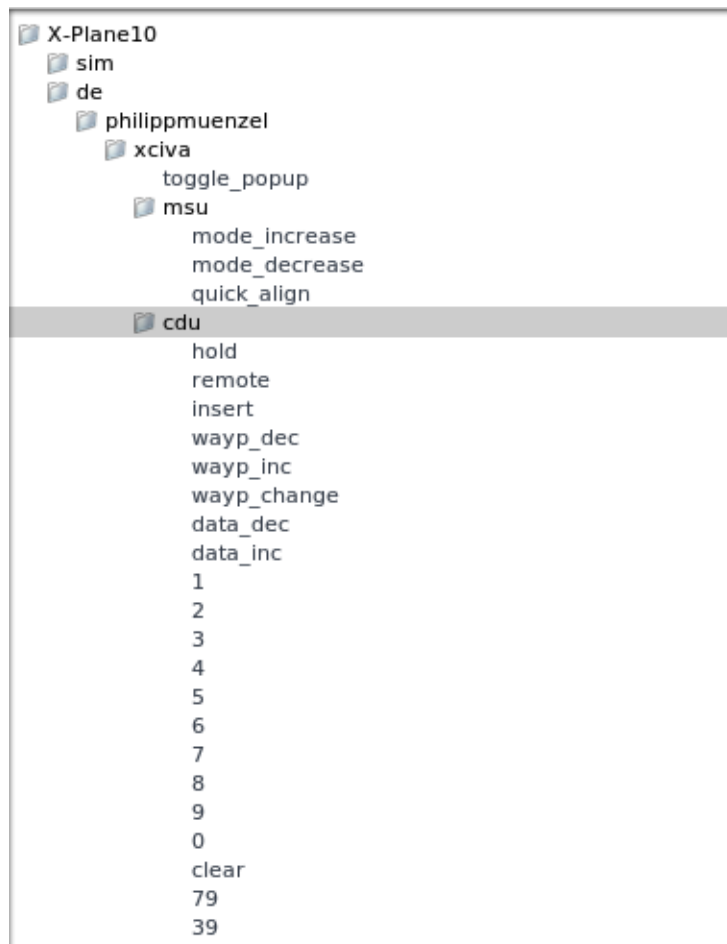
Now rotate the Data Selector to DIS/TIME. Be careful to go directly from WAYPT to DIS/TIME, not selecting any other data display, because that will cancel DME mode!

In the left display you will now see the 2-dimensional distance to the DME coordinates. Compare them to the distance the DME indicator for DME1 is reading (you should have tuned the DME frequency on the NAV1 receiver now!). Note that those distances will differ slightly, because the DME indicator shows slant range, while the CDU displays direct range. The higher you are flying, the more the values will differ. This is the last chance to detect any error: If you made an error inserting the DME coordinates, you will notice a big difference between DME indicated distance and CDU displayed distance.

If you are absolutely sure everything is alright, press WAYPT CHG, and then the number of the DME slot used. Position update will commence. Let the update run for a few minutes. To finish DME updating (or cancel the DME mode at any point in time), rotate the Data Selector to any position that is **not** WAYPT or DIS/TIME.

12 Interfacing CIVA

CIVA for X-Plane exposes all MSU and CDU function keys as X-Plane commands, which may be used to drive the unit by external means like a HID interface:



Also, the left and right displays and the waypoint FROM/TO display are available as string-datarefs, all lights and switch positions are available as int-datarefs:

```
de/philippmuenzel/xciva/cdu/alert_light=0
de/philippmuenzel/xciva/cdu/bat_light=0
de/philippmuenzel/xciva/cdu/data_selector=3
de/philippmuenzel/xciva/cdu/display_left=[0/7]:1
de/philippmuenzel/xciva/cdu/display_right=[0/8]:0
de/philippmuenzel/xciva/cdu/display_waypoint=[0/3]:0
de/philippmuenzel/xciva/cdu/hold_light=0
de/philippmuenzel/xciva/cdu/insert_light=0
de/philippmuenzel/xciva/cdu/remote_light=0
de/philippmuenzel/xciva/cdu/warn_light=0
de/philippmuenzel/xciva/cdu/waypoint_selector=0
de/philippmuenzel/xciva/msu/bat_low_light=0
de/philippmuenzel/xciva/msu/mode_selector=3
de/philippmuenzel/xciva/msu/ready_nav_light=0
de/philippmuenzel/xciva/popup=0
de/philippmuenzel/xciva/version=103
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The datarefs “de/philippmuenzel/xciva/cdu/display_left_hemisphere” and “de/philippmuenzel/xciva/cdu/display_right_hemisphere” use the following values: 0=Off (no light), 1=North/East (upper light), -1=South/West (lower light), 2=TestMode (both lights)