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# Carousel INS

## Delco Carousel IV-A Inertial Navigation System for *Microsoft Flight Simulator*

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### Gauges User Manual

This document explains how to use supplied Flight Simulator gauges and should be read after the INS Operations Manual.

The INS system includes several gauges. Their usage depends on the configuration (single, dual or triple) used. Generally each configuration includes:

- One MSU gauge for each installed INS unit (up to 3 MSUs).
- Up to three CDU gauges for each installed INS unit (up to 9 CDUs).
- One Mode Selector Gauge.
- One Ins Updating Flags Gauge (single configuration will have only the left flag operative)
- One Battery Parallel switch gauge (Triple INS configuration only).
- Up to two Automatic Data Entry Units (ADEU)

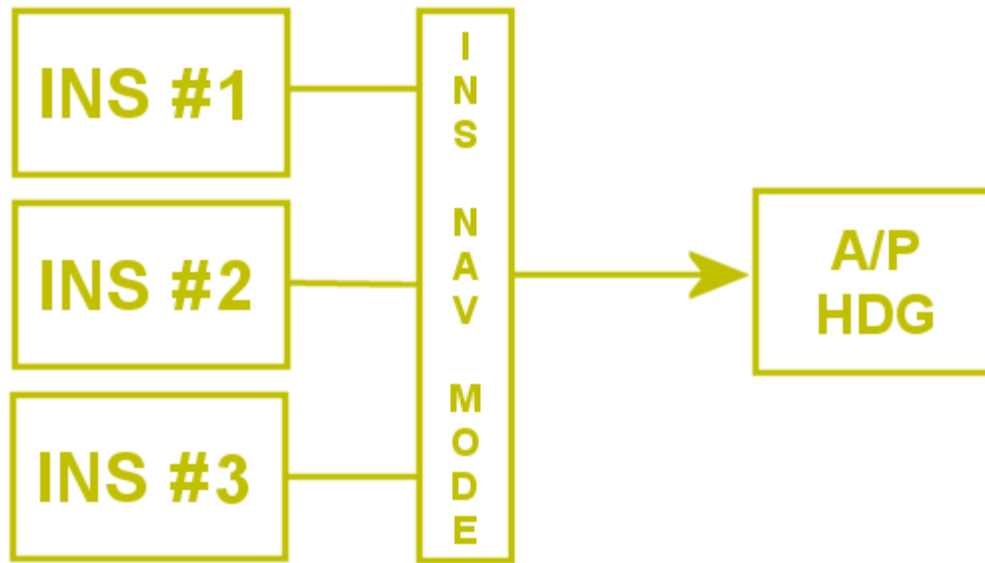
All gauges should be mainly operated by mouse clicks. The CDU gauge also offers a keyboard control mode.

### ***Autopilot Control***

In most cases, on real aircrafts equipped with multiple INS units, there are also multiple autopilot systems hard-wired to each INS unit. Normally, in a triple configuration like the 747 for example, autopilot system A is hard-wired to the INS#1, autopilot B to the INS#2 and autopilot C to the INS#3.

As Flight Simulator provides only one autopilot system, we introduced the INS NAV MODE SELECTOR gauge used to control which of the installed INS unit(s) is active over the autopilot, as picture 1 shows.

The INS systems use autopilot HDG mode to control aircraft heading. As soon as one switch is set in the ON position in the INS NAV MODE SELECTOR gauge, HDG is taken by the relative INS unit and is no longer under pilot's manual control. That is why the INS NAV MODE SELECTOR gauge is provided even for the Single INS configuration. To revert to normal autopilot HDG operations, make sure all INS NAV MODE SELECTOR switches are in the OFF position.



Picture .1: INS Autopilot Control Scheme (Triple INS configuration)

## **Simulated APU**

All initial INS setup phases (warmup, alignment, waypoints definition etc.) are normally performed at the ramp with all engines off, and they take at least 20~30 minutes to be carried out. Being the Flight Simulator battery unable to supply power for such a long time, we decided to introduce a simulated auxiliary power unit (APU). When the simulated APU is available, all installed INS units could be aligned and programmed, even if all engines (or associated generator(s)) are off. Starting from version 1.20 it is also possible to perform pushback with engines off without upsetting INS units. Basically there is nothing to control or manage. If the situation requires INS units to be powered by the simulated APU, then the aircraft must meet the requisites the simulated APU requires.

**In general, simulated APU is available if the aircraft is on the ground and ground speed is ZERO (parked) or NEGATIVE (pushback). In addition a FORWARD ground speed of 0.2 KTS is "tolerated", to overcome a commonly reported situation where the aircraft keeps moving forward even if throttles are in idle position and parking brake is set.**

As soon as the first onboard generator is operative and connected to the aircraft electrical system, all installed INS units will automatically switch to generator provided power, and the simulated APU will be shut down.

In all conditions, when the CDU BAT light is steady lit, the INS is powered by its own battery. This is an abnormal condition which has to be handled following the relevant procedure (see AbnormalProcedures.pdf).

## **Requirements and Limitations**

### **Hardware Requirements**

This gauge is quite CPU intensive due to all the calculations it continuously has to perform. In addition, being as each INS implemented as a totally independent

"process", running multiple INS units (dual and triple INS configurations) will generate 2 or 3 times the CPU load a single INS installation provides.

The only actual hardware requirement is, consequently, a sufficiently fast CPU. On slower system is may be needed to limit the number of installed INS units to only one.

### Time Compression

It is recommended not to use high "time compression" factors (8x and 16x) while the aircraft is under INS control.

### Displayed Airspeed

It is mandatory to configure Flight Simulator to display Indicated Airspeed rather than True airspeed. As the following picture illustrates, the Displayed Airspeed setting is part of the "Instruments and lights" group of the "Settings/Realism" screen.



Picture .2: Flight Simulator "Settings - Realism" screen: Make sure indicated airspeed" is checked as shown.

"Display

## ***INS Nav Mode Selector gauge***

The "INS NAV MODE Selector" gauge includes 1 or 2 or 3 switches depending on the current configuration. Each switch is connected to an INS unit (#1, #2 and #3) and, when moved to the ON position, selects which INS unit will control the autopilot HDG mode. The gauge guarantees that only one unit is linked to the autopilot, if a switch is set to ON while another one is active then the active one is automatically placed in the OFF position.



*Picture. 4: INS Nav Mode Selector (for Triple INS configuration) with all switches in the OFF position*

Note that when a switch is turned ON, the autopilot and/or the autopilot HDG mode could be off. In these cases the INS unit will not be able to control the plane, it will just set heading values in the HDG "window", no warnings will be generated as this is a supported situation where the pilot wants to hand-fly the plane using INS output as reference.

## MSU - Mode Select Unit gauge

The Mode Select (MSU) gauge has only one operable 'item', the Mode Selector knob, to be controlled using the left mouse button. In addition it provides a hidden button under the upper right panel screw.

### Mouse Areas



Picture.5: MSU gauge mouse areas

- 1 - Rotate the Mode Selector knob one position to the left
- 2 - Pull/Push the Mode Selector knob
- 3 - Rotate the Mode Selector knob one position to the right

As in the real unit, for safety reasons, the MSU knob should be pulled first and then rotated between STBY and ALIGN positions and also between NAV and ATT positions. To do that pull it (left click on the central area), then rotate it to the desired (next/previous) position (using the '+' or '-' areas)

### 4 - Multi Function (hidden) Button

The MSU Upper right screw is actually a button which can be operated with the left mouse button. It has 3 different functionalities associated, which one is triggered when pressed depends on the current INS state:

- a) If INS unit is OFF then the button is used to LOAD a saved situation (see SituationSaveAndReload.pdf)
- b) If INS unit is ON but Mode Index is still set to ZERO (NOT in NAV MODE) then the button is used to enable the Immediate Alignment mode
- c) If INS unit is ON and Mode Index is set to ONE (INS in NAV MODE) then the button is used to SAVE current situation

Note that all 3 operations will cause ALL installed INS units to Save current situation or load current situation or enter immediate alignment mode. It is not necessary to press the button on each MSU.



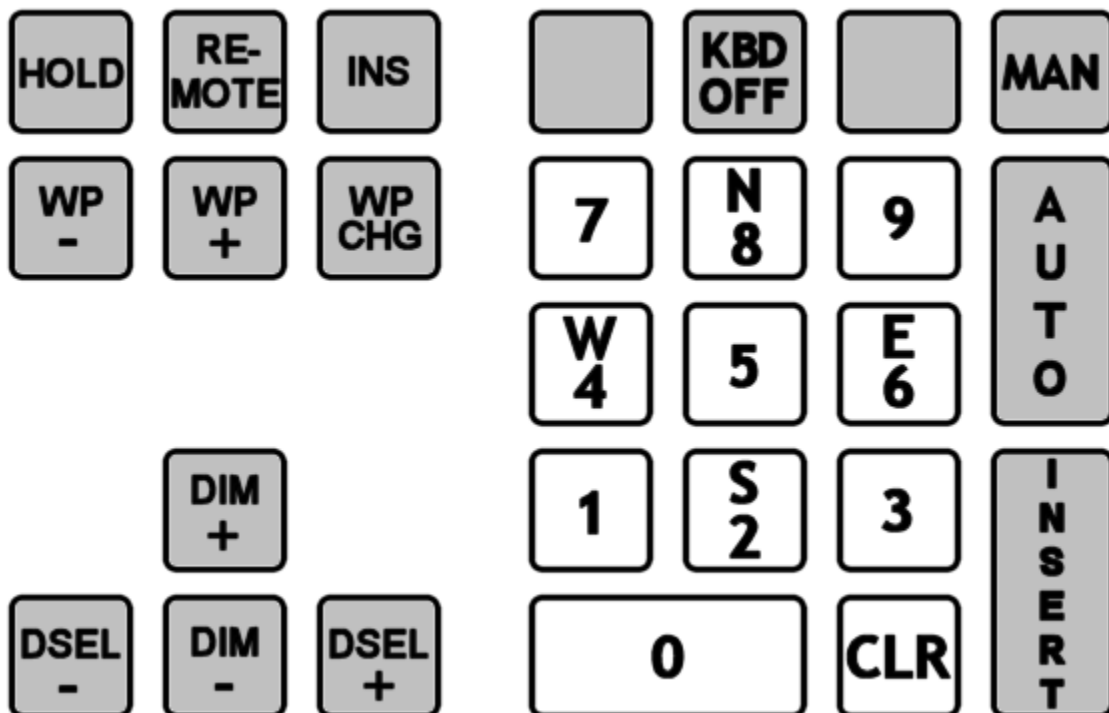
mouse click on 7 (or 9) and then a second right mouse click on 9 (or 7). Note that during this procedure pushing or rotating any other element will cause the "sequence" to be reset.

### Keyboard Capture Mode

The CDU gauge can also be operated from the PC keyboard by activating the "Keyboard Capture" mode using the hidden switch located near the upper left screw (see CDU Mouse Areas). Consider that the positions of the keys in the real CDU and in the PC keyboard numeric pad are different. It's quite not realistic but it may be more comfortable to digit positions data using a real keyboard. To maintain the North in the upper position and the South in the lower (looking at the keypad), when entering lat/long coordinates using the PC keyboard, North has been associated with the '8' key and South with the '2' key. In the real CDU it's exactly the opposite. Activation is performed using the mouse; deactivation could be performed both by the mouse and by the correct keyboard key.

**WARNING: When activated, the gauge receives all input coming from the computer keyboard. To be able to use the keyboard to control Flight Simulator the keyboard capture mode must be deactivated first.**

The following picture illustrates all supported PC keyboard keys and their associated functions:



Picture .7: CDU supported PC keyboard keys

NOTES:

- 'KBDOFF' key turns OFF the "Keyboard Capture Mode"
- There are two INSERT keys. The upper/left one is more realistic, the other (mapped over keypad enter key) is normally more familiar and faster to reach while typing waypoints.

## ***INS Updating Indicators gauge***

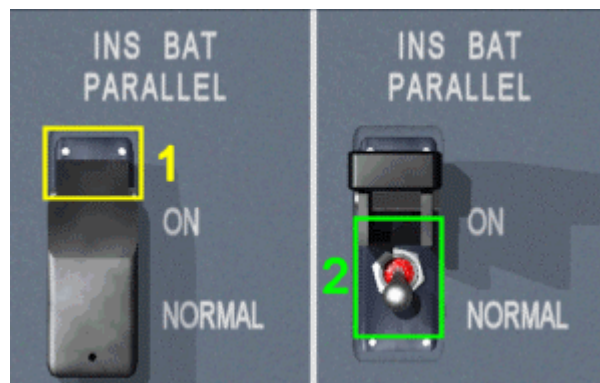
There are no items to control in this gauge. The two "flags" can switch from black to green signaling DME Updating is active/in progress on the relative (1 and/or 2) INS unit. INS 3 does not have DME Updating capabilities so there are no flags associated with it. When this gauge is used in a single INS configuration, the right flag will be inoperative.



*Picture .8: INS Updating Indicator (INS 2 DME Updating is in progress)*

## ***INS BAT PARALLEL gauge***

This gauge, available only in triple INS configuration, is used to control which INS unit is powered by the INS 3 battery. In the NORMAL position, INS 3 battery is connected to INS 3. In the ON position, the INS 3 battery is connected to INS 1 (and disconnected from INS 3) in parallel with INS 1 own one. The purpose is to extend INS 1 battery lifetime from 30 to 60 minutes in case of main power failure.



*Picture .9: INS BAT Parallel operations*

To operate the switch first click on the upper mouse area (marked as '1') to open the guard, then control the switch with the mouse as usual, clicking on the green area marked as '2'. Closing the guard will cause the switch to be moved to the NORMAL position.

Do not "play" with this gauge as moving the switch to the ON position causes INS 3 to be immediately powered OFF and alignment and programmed waypoints to be lost. If this happens during flight, INS3 will be lost, and the other two units (INS1 and INS2) will no longer be able to take advantage of the Triple Mixing position (produced only if all 3 units are available and properly programmed), so they will behave exactly as they do in a dual INS configuration, a very serious condition especially if you are in the middle of a large water area.

## INS ADEU gauge

ADEU stands for Automatic Data Entry Unit. It was used to load up to 9 waypoints or DME stations into the INS memory using special "Waypoints Cards" or "DME Stations Cards". This unit has not been widely used (and is no longer in use as far as we know) but it has been implemented as a gauge to let the user setup the INS much faster by loading all waypoints in one shot instead of typing them by hand.



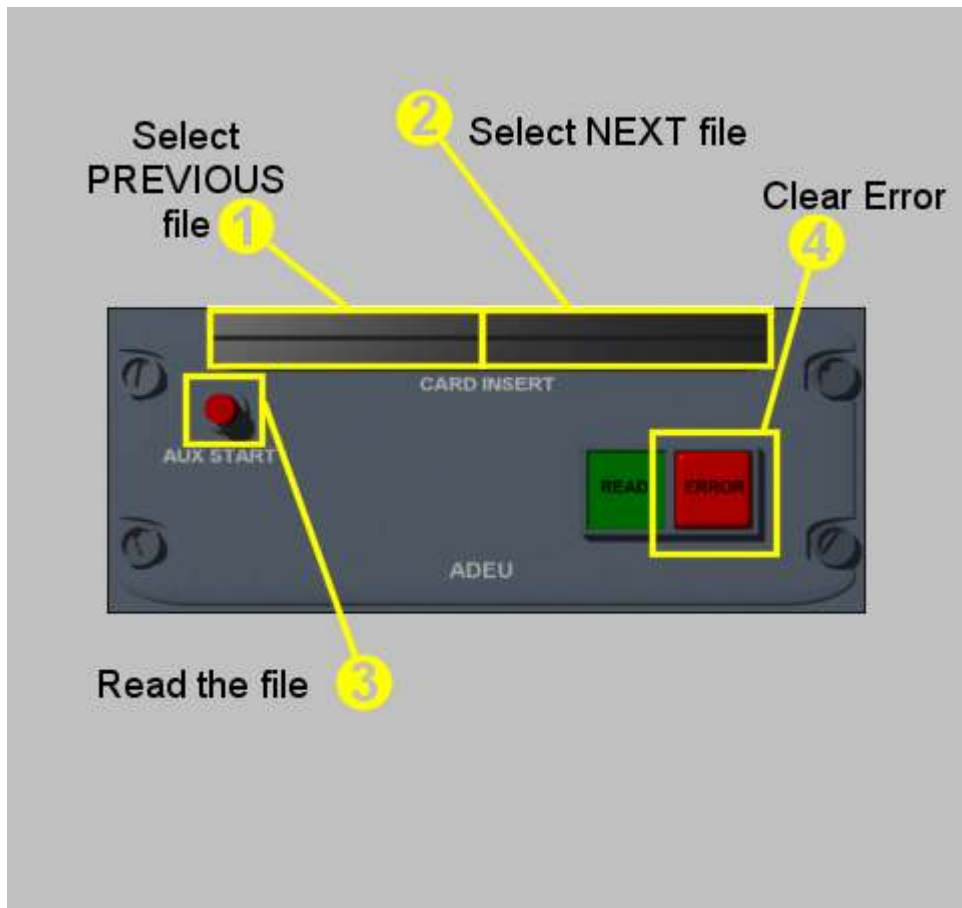
Picture .10: ADEU Control Panel

Up to two ADEUs are available. ADEU #1 is hard wired to INS #1 and ADEU #2 is hard wired to INS #2. Consequently single INS configuration may include one ADEU, while in dual and triple INS configurations both ADEUs could be installed.

Note that ADEU is sensible to the state of the REMOTE switch so, as waypoint entered by typing on the CDU keypad, ADEU entered waypoints will be broadcasted to other units according to the state of the REMOTE light/switch.

### Using the ADEU Panel

ADEU panel operations are quite simple. The procedure to load a Waypoint Data File or a DMS Stations Data File is the same. Just select the file with the correct extension (AWC for waypoints, ADC for DME Stations). The filename appears where the card should be inserted in the real instrument, so over the areas marked as (1) and (2). After 15 seconds of inactivity over any clickable area of the ADEU panel, and if the READ and ERROR lights are not illuminated, the filename is automatically hidden. Click on "Next" or "Previous" areas to make it visible.



Basic steps are:

- Select the file to be loaded by clicking with the left mouse button over the areas marked as (1), "select previous file", and (2), "select next file"
- Command the unit to process the file by clicking with the left mouse button over the area marked as (3), the "AUX Start button"
- The green "READ" light should come up for few seconds, while read operation is in progress
- The green "READ" light extinguishes
- If there were errors the red "ERROR" button/switch illuminates

If there were errors during file processing the red "ERROR" button/switch (4) will illuminate. Before starting another card read operation, the ERROR warning light must be pressed and extinguished. Error condition also causes Action Code 05 Malfunction code 55 to be activated on the connected CDU (this is actually not true, see below)

When processing is complete the green "READ" light extinguishes. It is always a good idea to manually cross check loaded data to make 100% sure it has been correctly stored into the INS memory.

#### Possible Action and Malfunction Codes

The gauge actually uses a dynamic code instead of Malfunction Code 55. So if an ADEU error occurs, an Error Code 05 will be activated, plus a 2 digits Malfunction Code to be interpreted using the following table

**05-01** Unable to read Waypoint/DME Station ID for one of the defined entries in the file. Check source file.

**05-02** Text row is too short/malformed. Check source file.

**05-03** Something is wrong with the selected input file (can't open/read). Check source file.

**05-04** Error retrieving the content of "<FS Root>/Civa/Adeu" folder. Make sure folder exists and place there all \*.AWC and \*.ADC files.

**05-[1~9]6** Specified Waypoint/DME Station ID row contains a syntax error in latitude definition.

Check source file.

**05-[1~9]7** Specified Waypoint/DME Station ID row contains a syntax error in longitude definition.

Check source file.

**05-[1~9]8** Specified DME Station ID row contains a syntax error in height definition.

Check source file.

Example:

Error code is 05-67: Syntax error in the row defining Waypoint/DmeStation number 6, error is related to longitude value.

### Creating Data Files

The ADEU gauges read waypoints and DME stations data from external files which must be placed in the "<FS Root>/Civa/ADEU" folder. Waypoints files have .AWC extension, DME stations files have .ADC extension. Format is identical except for the height field which is present only in the DME stations data file.

ADEU Data loading could be used both on ground and in flight. Special care should be taken when ADEU is used during flight because the active waypoints should not be overwritten. Waypoint data files containing only 1~8 IDs could be used, for example, by loading them while flying "8-9" leg, and by selecting WPCHG 0 9 INSERT before card processing.

Basically data files include text lines, each line defines the coordinates of a certain Waypoint ID or DME Station ID. There obviously could be up to 9 IDs defined, as the INS can hold only up to 9 Waypoints and DME stations. Not all IDs must be defined. In fact it is a good practice to avoid defining ID 1 in (first) waypoints data files, because waypoint #1 is normally used to enter the ramp position, to perform initial INS checks on ground.

If the ADEU parser encounters an error it stops reading the file. All Waypoints or DME Stations correctly parsed have been stored in memory.

The syntax of a text line is the following:

1 character	Waypoint/DME station ID
1 character	<blank>
1 character	'N' or 'S' (latitude)
1 character	<blank>
2 characters	'00' to '90' Latitude: degrees

1 character	'*'
2 characters	'00' to '59' Latitude: degrees second
1 character	'.'
1 character	'0' to '9' Latitude: tenth of degrees second
1 character	<blank>
1 character	'E' or 'W' (longitude)
1 character	<blank>
2 characters	'000' to '180' Longitude: degrees
1 character	'*'
2 characters	'00' to '59' Longitude: degrees second
1 character	'.'
1 character	'0' to '9' Longitude: tenth of degrees second

Example:

1 N 40\*51.7 E 012\*34.5

For DME stations data files only:

1 character	<blank>
2 characters	'00' to '15' DME station height, thousands of feet.

Example:

1 N 40\*51.7 E 012\*34.5 03

The ';' character identifies comments. It is possible to add comments on the same row defining a Waypoint or DME Station, like this:

1 N 40\*51.7 E 012\*34.5 03 ; DME Station xyz

Examples of complete ADEU Data Files are included in the package and can be found in the "<FS Root>/Civa/Adeu" folder.