

Polar Route Navigation by Airplane Model

747-400.

A 747-400 airplane is considered to be in the polar region if its flight management computer (FMC) position is north of 84 deg north latitude (or north of 83.5 deg north latitude after having been north of 84 deg north latitude).

When the computed position enters the region north of 84 deg north latitude or the region south of 84 deg south latitude, each FMC shifts down from the triple-mix inertial reference system (IRS) position to a single inertial reference unit (IRU) position. The SPLIT IRS OPERATION message is displayed on the control display unit (CDU) scratchpad message area. This reversion to the single IRS position is necessary because longitude and latitude singularity converge at the poles. The UNABLE RNP message is inhibited during the down mode to a single IRU position.

Each FMC selects the corresponding valid IRU position. For the left FMC, the order of selection is left, center,

and right. For the right FMC, the order is right, center, and left. Each IRU position is compared with the other two. The FMC then chooses the two IRU positions that are the closest together. The FMC navigation function gradually changes the computed FMC position from the triple-mix position to the single IRU position to prevent sudden position jumps. Ultimately, the FMC position is equal to the single IRU position.

When the computed airplane position of both FMCs is between 83.5 deg north latitude and 83.5 deg south latitude, the FMC returns to triple-mix position updating. The FMC gradually shifts from the single IRS mode to the triple-mix mode. If there is a detected IRS failure while the FMC position is greater than 89 deg north or south latitude, the FMC position immediately becomes the IRS position.

The primary roll mode for polar operations should be lateral navigation (LNAV), which may be used with the

heading reference switch in the NORM position. Manual selection of a magnetic or true heading reference is accomplished by using the HDG REF TRUE/NORM switch. When the airplane is operating in a region where the IRS does not compute magnetic heading, the reference is automatically changed to true, independent of the position of the HDG REF TRUE/NORM switch. When the option to extend magnetic variation is selected, the region comprises the area north of 82 deg north latitude (or north of 70 deg north latitude between 80 deg and 130 deg west longitudes) or south of 82 deg south latitude (or south of 60 deg south latitude between 120 deg and 160 deg east longitudes). When the option to extend magnetic variation is not selected, the region comprises the area north of 73 deg north latitude and south of 60 deg south latitude. Upon leaving this region, the heading reference again is determined by the position of the HDG

TRUE/NORM switch. When operating in the true reference mode, bearing information entered by the flight crew is assumed to be a true bearing reference.

When a North Pole (N90XXXXXX or N90WXXXXXX) or South Pole (S90XXXXXX or S90WXXXXXX) waypoint is used near the poles, a rapid heading and track reversal occurs as the airplane passes over the waypoint. If the airplane is operating in HDG SEL or HOLD mode while near either pole, the flight crew will need to rapidly update the heading selector to reflect the changing or reversed heading. Otherwise, the autopilot flight director system (AFDS) will command an unwanted turn. For autopilot operation in the polar region using a roll mode other than LNAV, the TRUE position on the heading reference switch should be selected. However, LNAV is the preferred roll mode.

When no global positioning system (GPS) updating occurs, all position and velocity corrections gradually are phased out until the FMC navigation parameters equal the selected IRU position and velocity. When GPS updating is available, it is no longer used when crossing 88.5 deg latitude flying toward a pole, and all position and velocity corrections are phased out gradually before the pole is crossed. When crossing 88 deg latitude flying away from the pole, GPS updating is enabled. When crossing 83.5 deg latitude flying away from the pole, the FMC reverts from single IRS navigation to triple IRS navigation, and the UNABLE RNP mode is operational.

The heading display on the primary flight display and navigational display (PFD/ND) and that on the radio magnetic indicator (RMI) may differ within approximately 30 nmi of the pole. This results from differences among IRU positions selected by the FMCs for the PFD/ND and the fixed IRU position on the RMI.

Loss of one or two IRUs will not significantly affect navigation accuracy. Operation on one remaining IRU should be limited to diversion to the nearest suitable airport. Navigation can be accomplished after losing both FMCs by using the alternate navigation pages on the CDU.

777.

The 777 primary and preferred roll mode for polar operations is LNAV, which may be used with the heading reference switch in the NORM position. HDG SEL/HOLD and TRK SEL/HOLD are functional but require the manual selection of TRUE for the heading reference. Deviations from the planned route may be accomplished in TRK SEL or HDG SEL mode. When operating the autopilot in the polar region in a roll mode other than LNAV, the TRUE position on the heading reference switch must be selected.

The ND track and magenta lines may exhibit ratcheting when transiting routes in close vicinity of the pole. When operating in the polar region with the ND PLAN mode displayed, the airplane position symbol disappears. This occurs when flying into the polar region.

When a North Pole (NPOLE) or South Pole (99SP, S90XXXXXX, or S90WXXXXXX) waypoint is used, a rapid heading and track reversal occurs as the airplane passes over the polar waypoint. If operating in HDG/TRK

SEL or HOLD mode while near either pole, the flight crew will need to rapidly update the heading or track selector to reflect the changing or reversed heading or track. Otherwise, the AFDS will command an unwanted turn. LNAV is the preferred roll mode.

Loss of both GPS units results in an increased actual navigation performance (ANP) and possible display of the NAV UNABLE RNP message, but this normally does not prevent polar operation.

The 777 air data inertial reference units (ADIRU) are fault tolerant. Total failure is extremely unlikely because a number of independent failures must occur before all navigation functions are





Polar navigation option.

These latitude limitations on flight operation do not apply to 747-400, 777, and 737-600/-700/-800/-900 airplanes equipped with the polar navigation option (heading reference switch and FMC Update U10.3 or later) and dispatched with the following equipment operational: CDU, left

GPS, both IRUs in navigation (NAV) mode, and both display electronic units.

Flight crews of such equipped airplanes should not use HDG SEL or ROLL CWS north of 89 deg 30 min north latitude or south of 89 deg 30 min south latitude. They also should not use the heads-up display system, if installed, when the heading reference switch is in TRUE.



757 and 767.

Operation of 757 and 767 airplanes should be limited to the region between 87 deg north and 87 deg south latitude, as stated in the airplane flight manuals.

The primary roll mode for polar operations should be LNAV, which may be used with the heading reference switch in the NORM position. The HDG SEL or HOLD mode is functional but requires the manual selection of TRUE heading reference. Deviations from the planned route may be accomplished in HDG SEL mode.

Rapid heading and track changes occur as an airplane nears either pole. If operating in HDG SEL or HOLD mode while near a pole, the flight crew will need to update the heading selector frequently to reflect the rapidly changing heading. Otherwise, the AFDS will command an unwanted turn.

When GPS updating is available, the FMC position is updated to 87 deg north latitude and 87 deg south latitude, which is the airplane certification limit. Loss of both GPS units results in an increased ANP and possible display of the UNABLE RNP message, but this normally does not prevent polar operation.

Because of the convergence of longitude and the latitude singularity at the poles, each product improvement program FMC reverts to selection of a single IRS for navigation with no updating before crossing the pole. This allows the FMC position and velocity computations to work properly. Crossing 84 deg latitude flying toward the pole, the FMC reverts from triple IRS navigation to a single IRS. All position and velocity corrections gradually are phased out until the FMC navigation

parameters equal the selected IRU position and velocity. When crossing 83.5 deg latitude flying away from the pole, the FMC reverts from single IRS navigation to triple IRS navigation.



Although the Pegasus FMC has not been certified for polar operations, it is technically operational in the polar region with the IRS or ADIRU, or both. For Pegasus FMC installations, the navigation function is computed in XYZ coordinates instead of latitude and longitude. Should both Pegasus FMCs fail, alternate navigation is available through the alternate navigation pages on the CDU to continue the flight to the destination.

For GPS-equipped airplanes, the loss of one or two IRUs does not significantly affect navigation accuracy. Operation on one IRU should be limited to diversion to the nearest suitable airport.

MD-11.

The PFD heading arc normally is referenced to magnetic heading. The ND heading scale may be referenced to either TRU or MAG, as selected on the flight control panel using the TRU/MAG switch. As the airplane flies to latitudes greater than 73 deg north or 60 deg south, the magnetic variation of the IRU is set to 0 deg. At this time, the PFD and ND heading scales automatically switch to TRU displays; magnetic selection is no longer available.

The flight management system (FMS) is considered to be in the polar region when the airplane is above 85 deg north or south latitude. The ND replaces the HDG (white) and TRU (cyan) legends on the heading scales with FMS TRK TRU (magenta). The

heading scale is then driven by FMS track information to eliminate the effect of heading splits that occur between displays when near the pole.

Position computations in the FMS evaluate the position and velocity information from each IRU. Should a "miscompare" occur, each FMS will select a different IRU using a hierarchy keyed to the FMS installed position to ensure that both FMSs do not use the same IRU source. The triple-mix mode is available until a miscompare occurs.

The primary autopilot coupled mode near the pole is NAV. The heading mode from the autoflight system is available as long as the differences in heading among IRUs are fewer than 4 deg. Heading splits appear because of position differences as the meridians converge

at the pole. Using the FMS NAV mode eliminates the effects of such splits and allows continuous coupled autoflight operation.

When the airplane is within 2 nmi of the pole, the FMS is programmed to enter a wings-level mode, which is necessary because the longitude slews rapidly during the pole transition. As the airplane crosses the pole, the map display will show the airplane symbol track backward as the longitude slews to the new value. At 10 nmi from the pole, the FMS resumes flying the flight plan track.

Note: Airlines always should consult the operations manual for the latest navigation and communication information.

