GRT Avionics, Inc

HXr - Instrument Approach Option

Manual Supplement

Revision: Initial Release

20-July-2018
# Revision History

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<th>Revision</th>
<th>Date</th>
<th>Change Description</th>
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<tr>
<td>Initial</td>
<td>20-07-2018</td>
<td>Initial Release</td>
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Overview
The Instrument Approach Function provides GPS derived guidance and autopilot coupling for published GPS LPV, LNAV, and other GPS RNAV approach types, as well as VOR/ILS instrument approach procedures. Any GPS source (receiver) for this function can be used. Higher integrity GPS sources, such as those with RAIM, are recommended. The GRT Safe-Fly is an excellent GPS source for this use. A certified GPS approach navigator, such as a Garmin or Avidyne GPS, is not required. All data for these approaches is included in the GRT supplied navigation database (for US territory only) and the Jeppesen navigation database (US and worldwide).

Although this function is incomplete at this time, it does provide the necessary functions to allow for selecting and flying approaches for practice, or in case of an emergency, with the limitations described within. Additional functionality will be added in future software releases. (See the “Functions to be Implemented” below.)

This manual describes the functions implemented in HXr software release with “PROC-4" in the software version. It is also applicable to the HX, although the figures showing the various screenshots will not match the HX graphics.

We encourage our customer base to evaluate the IFR approach functions (in VFR flight only), and provide us with feedback regarding all issues, and especially any incorrect operation and issues related to the efficiency of the pilot interface.

It is our hope that the low-cost access we are providing to GPS approaches will inspire our customer based to practice with them in their routine flying and make them more likely to pursue instrument ratings and instrument proficiency.

Free Use Period
Free use of this option is provided for all users of the HX and HXr for the time specified on the download page of the website, and on the accept page at display unit startup. (This expiration date of the software is shown in yellow on the startup page.) As new functions are added to this option, the expiration date will be extended to allow sufficient time for our customer base to evaluate and provide feedback to us.

Legality
GPS Approaches
When complete, the approach option will be designed to meet the requirements of TSO-C129, TSO-146C, but is not an FAA certified navigation source. GRT Avionics makes no claim regarding the legality of using this function for intentional flight into IFR conditions for GPS approaches within the US or foreign counties. Use of this function for GPS approaches in VFR conditions, such as for flight instruction, maintaining currency, etc., is legal, as well as for use in an emergency per FAR 91.3.

VOR/ILS Approaches
VOR and ILS approaches are included in this function. VOR/ILS approaches are displayed on the map allowing the GPS to be used as a reference during the approach, reducing workload and enhancing situational awareness. Waypoint altitudes are included on the flight plan. These approaches may be
legally flown using this function, including coupling to the autopilot, provided the VOR/ILS receiver output is monitored during the approach. Current approach data, such as approach plates, are still required.

**Current Functionality**

All approaches published digitally by the FAA are included in the GRT navigation database. This includes about 99% of all US GPS approach procedures, and most ILS/VOR approaches. Functions to use this data include:

- Instrument approach procedure selection and display in the flight plan
- Display of the approach on the moving map
- Display of the GPS lateral and vertical deviations
- Lateral and vertical coupling to the autopilot (for GRT Servos and external autopilots)
- Selection of a transition or vectors to final
- Split-Screen flight planning on PFD, MAP and Split-Screen
- Calculations of GPS lateral and vertical deviations conform to certification requirements for LPV approaches

**Function to be Implemented**

The following functions will be added in the upcoming months:

- Enhancement of navigation data displays and goto waypoint annunciation
- Holds (Holds in a procedure are implemented but require manual selection to exit them at this time.)
- Standard instrument departures
- Standard instrument arrivals
- Airways
- Alerting and warnings
- Lateral Offsets

Although not required to meet the requirements of quoted TSOs above, enhancement to autopilot coupling are planned for the heading select function, capture of GPS courses after waypoint transitions, curved path coupling for procedure turns and holds, and possibly other autopilot functions.

**GPS Source Data**

The approach function will provide guidance and coupling whenever it is supplied with 3D position data, however warnings will be generated when this data lacks RAIM integrity or accuracy requirements for the selected approach immediately after an approach is loaded. In addition, an annunciation, “GPS Aprch - VFR Only” will always be generated when the approach is loaded.

**GPS Receiver Types**

**Non-RAIM GPS**: This is the most common GPS and is typical of handheld and panel mount avionics not certified for IFR, and GPS modules that do not include RAIM. Most GPS units fall into this category. They also do not provide an output indicating their accuracy. Use of this GPS source will cause the warning, “No GPS Accuracy”, and further, “No GPS Integrity”.

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Panel Mounted IFR GPS: This includes navigators such as the Garmin GNS430, GNS530, GNS650, GNS750, etc. While RAIM and accuracy data is computed within these units, this data is not made available to the EFIS, and thus will generate the same warnings as a Non-RAIM GPS.

GPS Modules with RAIM Only: Some older GPS modules, including the GRT Avionics RAIM GPS module, do provide RAIM integrity monitoring. If the GPS does not provide accuracy data, a “No GPS Accuracy Warning” will be generated.

GRT Safe-Fly GPS: This GPS provides RAIM and accuracy data required for determining if sufficient accuracy exists for a selected GPS approach. Since this GPS is not a FAA-certified GPS receiver, it will generate a warning, “Non-Certified GPS Source”. While the Safe-Fly GPS is very similar to a certified approach GPS source, various filtering parameters in this GPS are fixed, unlike an actual approach GPS in which these parameters are changed for different phases of flight, such as approach vs. enroute. While this difference is subtle, it does mean the Safe-Fly GPS does not completely comply with the requirements set out in TSO-C145a.

TSO-C145a Certified: This includes the FreeFlight systems SBAS/GNSS WAAS/GPS 1201, and the GRT IFR GPS. This GPS provides RAIM and accuracy data required for determining if sufficient accuracy exists for a selected GPS approach. Since this GPS is a FAA-certified GPS receiver, it will not cause the “Non-Certified GPS Source” warning to appear.

Configuring the EFIS for Instrument Approaches
The following is required to configure an HX or HXr for instrument approaches.

- The software in the EFIS must be updated to a version with “PROC” in the software version.
- The current navigation database must be loaded
- The setting, “Show GPS on Loc/GS” (in the Set Menu, Primary Flight Display menu) must be set to “YES”.

Entering a Flight Plan

Split screen PFD/flight plan and MAP/flight-plan pages were introduced with this option. This will be a standard part of all HXr software. A flight plan is entered or edited by clicking the “FLT PLAN” softkey on the PFD or MAP screens.

The flight plan menu provides functions to:
- Delete Waypoint, Procedures, and flight plans
- Show information (Details) about a waypoint
- Load and save a flight plan
- Create user waypoints as lat/lon, or range/bearing from an existing waypoint
- Importing flight plans created from flight planning software, and copying a flight plan, and a toggle between the direct-to and sequence flight plans. (These are selected from the “More Options” sub-menu.)

Not included in this manual is the ability to create your own database items, such as your own airport. These are created as a text file and loaded into the EFIS.

![Flight Plan Split Screen Menu](image)

**For the highlighted item:**
- **Details** - Show information about this item
- **Del WP** - Deletes Item from the flight plan
- **Sel FP** - Select a flight plan that has been previously saved.
- **Rev FP** - Reverse the flight plan
- **Save** - Save the flight plan for later use
- **User WP** - Enter a user waypoint

**SEQ**
- Switches to Direct-To flight plan mode and waypoint entry

**AUTO** - waypoints sequences automatically

**HOLD** - Waypoint sequencing is suspended

**Go Direct**
- Sets the highlighted waypoint as the current goto

**Select Wpt/Proc**
- Pressing this knob allows altering this item. In this case it will allow entering a waypoint.
Adding and Deleting Waypoints
Pressing the right knob toggles between the main flight plan menu (in the figure above), and the waypoint (or waypoint entry) menu.

Adding Waypoints
Waypoints are added to the end of the flight plan by selecting the “Add Waypoint” box and pressing the right knob. Waypoints may be inserted anywhere in the flight plan by selecting an existing waypoint, pressing the right knob, and then clicking on the “Insert Before” or “Insert After” softkeys. This is shown on the “Waypoint Entry Menu” figure below.
Deleting Waypoints

Waypoints are deleted using the main flight plan menu. Pressing the right knob toggles between waypoint menu and flight plan menu. Flight plan menu options are show in the “Entering a Flight Plan” section above.

Waypoint Functions Menu

Once a waypoint has been inserted into the flight plan, it can be highlighted it by turning the right knob. Pressing the right knob toggles between the flight plan menu and the waypoint functions menu. The
Waypoints functions menu includes the option to insert a waypoint before or after this waypoint or select an instrument approach procedure (if available) for that airport.

Waypoints that are part of an instrument approach procedure can not be deleted individually, nor can waypoints be inserted before or after them. Waypoint that are part of a procedure (approach, departure, or arrival) are shown in cyan colored boxes.

**Waypoint Functions**

*Insert Before* - Inserts a waypoint before the highlighted waypoint.

*Insert After* - Inserts a waypoint after the highlighted waypoint.

*Proc* - Shows procedures (such as instrument approaches) available for this waypoint.

**Select Wpt/Proc**

Pressing this toggle between flight plan function, and functions associated with the highlighted item.
Reading a Flight Plan

The flight plan provides a variety of information as shown in the figure below.

Selecting an IFR Approach from the Flight Plan

Selecting an IFR approach begins by entering the desired destination airport waypoint into the flight plan. The approach can be selected from the flight plan, or using the “PROC” softkey from the main PFD menu. See “Selecting an IFR Approach from PFD Menu”.

RNG - range to waypoint
BRG - bearing in degrees magnetic
CUM - cumulative distance in flight plan
ETE - estimated time enroute (hr:min)
ETA - estimated time of arrival (zulu)
Fuel Rem - Predicted fuel remaining

These labels identify the data in the waypoint boxes.

The goto waypoint is shown in magenta and will be identified as a direct-to (as shown here) or a leg, using an arrow like this.

Turning this knob moves the selector box through the list so that waypoints not shown on the screen can be displayed.
To select the approach from the flight plan, the flight plan is displayed, the right knob is then used to highlight this airport, and then clicked to show the options available for this airport. If an IFR approach is available for this airport, the “PROC” (procedures) softkey will appear.

Pressing the “PROC” softkey displays the available procedure types. Currently only approaches are available, with arrivals and departures coming in a future software update. The approach softkey shows the list of available approaches. An inset shows the approach graphically (north up). When an approach is selected, any transitions and vectors to final (VTF) will be displayed with the option to preview the approach waypoint list.

From the transitions selection page, the option to load the approach into the flight plan or activate the approach (load it and set it as the current goto) are provided.

This is illustrated in the following figure.
Selecting an Approach

Turn this knob to select the desired procedure. Press the knob or press the “Select” softkey to show the transitions available.

Load - Adds the approach to the flight plan but does not alter the current goto.

Activate - Adds the approach to the flight plan and sets it as the current goto.

Preview - Shows the waypoints and graphical inset of the approach with the selected transition. Pressing again returns to transition selection.
Selecting an IFR Approach from PFD Menu (PROC Softkey)
The “PROC” softkey on the PFD main menu provide a shortcut for selecting or changing an approach and has the added benefit that it does not cause the screen to be split. Insets are used for displaying the available procedures. Approaches and transitions can be selected in this way, and in a future software update, arrivals and departures will be selectable also.
After pressing the “PROC” softkey, the available procedures are shown.

(Approaches are the only available procedures in this case.)

The selection is made using the arrow softkeys.

**Load** - Adds the approach to the flight plan but does not alter the current goto.

**Activate** - Adds the approach to the flight plan and sets it as the current goto.

**Preview** - Shows the waypoints and graphical inset of the approach with the selected transition.

Selecting an Approach from PFD or Map Menu “PROC” Softkey
Flying the Approach
The instrument approach option allows flying GPS LPV, LNAV/VNAV, LNAV, LP, and stand-alone GPS approaches and traditional nav radio approaches with near equal ease. All approaches may be hand-flown or coupled to the autopilot.

The EFIS includes the full precision calculation of these deviations required for an IFR GPS navigator. These deviations are displayed on the PFD as familiar ILS localizer and glideslope needles or scales (user-selectable).

While traditional nav radio approaches using raw data (ILS or VOR) can be accomplished the same way it is done without the IFR approach option, using this option and select the approach adds the approach waypoints to your flight plan, showing your position relative to the approach on the moving map. The precision and anticipation provided by the moving map makes it easier to accurately fly the approach. In addition, the approach can be flown coupled to the GPS (while monitoring raw nav radio data), the flight plan includes the altitudes required for the approach, and the missed approach procedure can be selected with a single button push.

Hand flown approaches benefit from the flight director that can be used for all approach types. The flight director is the most under-appreciated function for hand-flying the airplane among general aviation pilots. (It is activated on the second autopilot menu.) It lieu of interpreting the raw data deviations to maneuver the airplane, the flight director combines this with intercept angle, attitude, speed and other data to provide a single cue roll and pitch command. This greatly reduces pilot workload, and results in higher accuracy approaches. Raw data deviations are retained and displayed in the “scales” format when the flight director is on.

Flying coupled to the autopilot is also available for all approach types. The autopilot annunciators (above the airspeed and altimeter tapes) are very useful for observing the navigation mode and autopilot targets, as well as verifying the arming of automatic capture of the approach.

Flying a GPS Approach
Flying an LPV approach is very similar to navigating any GPS flight plan until reaching the inbound course to final approach fix (FAF). When inbound to the FAF vertical deviations are provided (like an ILS glideslope). Like and ILS, vertical navigation changes from altitude control to LPV glideslope as this glideslope deviations goes to zero. The “MISSED” approach softkey will appear after passing the FAF, allowing switching lateral and vertical navigation to the missed approach. See the “Missed Approach” section for more details.

Flying a GPS approach without vertical guidance is similar, except vertical navigation remains altitude control.

Autopilot coupling is provided for the entire approach. Selected altitude is used for the vertical autopilot until capturing the glideslope (if one exists). If the autopilot “ARM” feature was activate, the autopilot will switch from altitude hold to glideslope coupling automatically as the glideslope deviation goes to zero. The arming of the autopilot will be displayed by the autopilot/nav mode annunciators. Manually selecting “GPSV” for the vertical autopilot will force coupling to the glideslope at any time. “GPSV” will be grayed out if a glideslope does not exist.
When flying vectors to final, the airplane maybe hand flown, or coupled to the heading select autopilot. Automatic capture of the inbound course to the final approach fix can be activated using the “ARM” function on the autopilot menu. Once established on the inbound course, the “ARM” function will capture the glideslope as the airplane flies into it, just as it does with an ILS approach.

**Caution:** As noted above, the EFIS is not an approved device for flying GPS approaches in IFR conditions. Although no known bugs are known from laboratory and field beta testing GRT Avionics does not recommend the use of this for an emergency backup at this time due to the maturity of the software, and the lack of alerting functions related to GPS precision. This recommendation will be revised with experience and functional enhancements.

**Flying a Nav Radio Approach (ILS/VOR)**

Loading a nav radio approach has, in addition to the benefits of pilot awareness of his position relative to the approach, the ability to fly (coupled or by hand) the approach using the GPS for lateral guidance.

**Caution:** Flying these approaches in actual IFR requires that the nav radio be tuned to the appropriate navaid, and raw data be monitored.

When using the GPS for the lateral reference on a nav radio approach, the EFIS navigation mode is set to “GPS”. Setting the EFIS navigation mode to “NAV” will use the LOC/VOR deviations for guidance and autopilot coupling, as in the past. Note: Current software does not allow the nav radio raw data to be monitored on display unit when its nav mode is “GPS” when the “PFD Set Menu” selection for “Show GPS CDI on Loc/GS” is set to “YES”.

Vertical deviation will not be generated by the EFIS and is only available from the navigation radio (glideslope). Lateral guidance and autopilot coupling is provided via the GPS for the entire approach when the navigation mode is set to GPS.

In installations where the nav radio does not provide data to the EFIS, the vertical speed function can be used to help follow the glideslope while coupled to the autopilot. Of course, the vertical speed command will need to be adjusted as necessary to follow the ILS glideslope.

The navigation radio is not auto-tuned when an approach is selected at this time. See also the sections on procedure turns for current limitations on display and guidance in these maneuvers.

**EFIS Guidance Symbology and Mode Annunciation for Approaches**

The EFIS uses the familiar Horizontal Situation Indicator (HSI), and lateral/vertical deviation indicators on the PFD for guidance on the approach. This is illustrated in the following figure.
The type of approach is displayed in the navigation mode box. The mode is dependent on GPS accuracy when used with GPS receivers that supply accuracy data and could downgrade. If the GPS does not supply accuracy data, the mode is will not downgrade, but the warning “No GPS Accuracy” will be generated when the approach is selected or if the GPS source is changed.

### Approach Guidance Symbology

<table>
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<th>Navigation Mode Annunciation</th>
<th>Description</th>
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<tr>
<td>LPV</td>
<td>Localizer performance with vertical guidance approach. (LPV). Fly to LPV minimums</td>
</tr>
<tr>
<td>LP</td>
<td>Localizer performance with no vertical guidance approach. Fly to LP minimums</td>
</tr>
<tr>
<td>L/VNAV</td>
<td>Lateral and vertical navigation approach. (LNAV/VNAV) Fly to LNAV/VNAV minimums</td>
</tr>
<tr>
<td>LNAV</td>
<td>Lateral and vertical navigation approach. (LNAV) Fly to LNAV minimums</td>
</tr>
<tr>
<td>GPS, GPSV, GPSNA, GPS(V)</td>
<td>Generic GPS approach for VFR guidance only. Not an authorized approach.</td>
</tr>
</tbody>
</table>
The moving map displays the approach when it has been loaded, as shown in the following example.

Holds will change size depending on airplane speed.

The approach and missed approach with hold is shown on the moving map. 

Approach waypoints have this shape.

Moving Map with Approach
Missed Approach

The missed approach softkey appears on the PFD and MAP main menu after sequencing the final approach fix.

Missed Approach Activation

The missed approach softkey appears on the main PFD and MAP pages after the final approach fix has been sequenced, as shown above. Clicking it immediately commands a 500 fpm climb to the MAP altitude. The MAP altitude is set automatically but can be subsequently adjusted by the pilot using the normal autopilot controls menu.

Lateral navigation will continue to the MAP waypoint before sequencing to the next waypoint in the MAP procedure.

Procedure Turns

Procedure turns are included but implementation is incomplete. The following limitations exist with the current software:

- Guidance through the turn may not represent any particular path
- No assurance for staying with the approach protection area during the course reversal is assured
- Procedure turns are not depicted on the moving map.
- Not fully tested

Holds

This software version requires that holds be manually exited by selecting the next waypoint in the flight plan as the goto. The “SEQ” (Auto/Hold) does not function with the approach currently.

GPS Approach Annunciations and Warnings

No warnings or announcements related to GPS accuracy requirements for an approach are implemented at this time. These will be added in an upcoming software update.

GPS Accuracy Display (Experimental)

An experimental provision for observing GPS accuracy relative to required accuracy for an approach has been included however. This does not generate warnings, thus requiring manual monitoring. The GPS accuracy can vary for a variety of reasons, so short-term indications of insufficient accuracy can be normal. The symbology is illustrated in the following figure:
Outer rectangle represents required GPS accuracy. Inner rectangle represents currently reported GPS accuracy.

Horizontal Accuracy

Green indicates sufficient accuracy for the current approach type.

GPS Required Accuracy vs. Actual for Approach (Experimental)

Red indicates insufficient accuracy for the current approach type and depicts inaccuracy level relative to that required for the approach.
GPS Accuracy Indicator
Integrity/accuracy suffix is shown on the GPS mode in the navigation status indicators above the airspeed tape. The suffix indicates the best alert level corresponding to the current accuracy of the GPS data. It is intended to give the pilot some insight into the reported accuracy of the GPS position data. If a RAIM GPS routinely reports low accuracy (blank or -E suffix), the GPS/installation (such as antenna wiring, antenna location) should be evaluated.

<table>
<thead>
<tr>
<th>Suffix on GPS Nav Mode</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>blank</td>
<td>GPS accuracy is unknown or (when using a RAIM GPS) is insufficient for Enroute IFR operation</td>
</tr>
<tr>
<td>-E</td>
<td>GPS accuracy is sufficient for Enroute IFR operation</td>
</tr>
<tr>
<td>-T</td>
<td>GPS accuracy is sufficient for Terminal area IFR operation</td>
</tr>
<tr>
<td>-A</td>
<td>GPS accuracy is sufficient for LNAV approach.</td>
</tr>
<tr>
<td>-APP</td>
<td>GPS accuracy is sufficient for the selected LPV approach</td>
</tr>
<tr>
<td>-INTEG</td>
<td>A RAIM GPS that should provide integrity data is failing to provide this data.</td>
</tr>
</tbody>
</table>

Summary of Known Software Limitations
As of the time of this writing, the known limitations, in addition to those listed in the “Functions to be Implemented” section, are as follows:

- The full set of alert responses for integrity and RAIM are not implemented. If an integrity condition fails the software keeps going without flagging the indications, assuming it can still compute them. If a RAIM error affects integrity it may show up as poor integrity, but it will not be indicated as a RAIM error.
- The WAAS ID/channel is not shown anywhere and can't be entered.
- There are no messages about when or how to turn at the next waypoint.
- The flight mode of the LPV GPS is not updated, so it stays in Enroute mode and does not transition to Terminal and Approach modes. (The Safe-Fly GPS does not have flight modes.) This may result is slightly less GPS accuracy/integrity for approach.
- A resume sequencing function for approach-side holding patterns has not been implemented, although these are rare in GPS approach procedures. We will probably use the AUTO/HOLD button in the CDI/OBS menu. For now, the Go Direct function can be used to go to another waypoint in the procedure.
- The split plan page doesn't jump to the active waypoint if it's in a procedure.
- Procedure selection and LPV GPS data is not shared over the display link. This means that only the display unit in which the approach is selected can navigate the approach.
- Automatic capture of the LPV approach will not occur until AFTER the final approach fix.
- Jeppesen databases currently do not include all the data needed for approaches. We are working with Jeppesen to resolve this.