Garmin GTN 650 Workshop

VFR & IFR Operations

Presentation Outline

- Basic 650 Operations
  - GTN 650 Overview
    - Start-Up Screens
    - Interface Basics
  - Terrain Awareness
  - Traffic & Weather
  - Useful Features
    - "Nearest"
    - Computing Winds Aloft
    - Vertical Navigation
    - Miscellaneous
  - Flight Plans
    - Database Currency
- VFR Demonstrations
- GPS Do's and Don'ts
- Break
- IFR Operations
  - More Flight Plans
    - Loading Approaches
    - Multiple Destinations
    - SIDs and STARs
  - GPS Approach Modes
  - GPS Substitutions
  - Suspend Mode
- IFR Demonstrations
  - KDXR -> KGON (GON ILS Rwy 5)
  - OXC RNAV (GPS) Rwy 18
  - MMK GPS Rwy 36
- IFR Do's and Don'ts

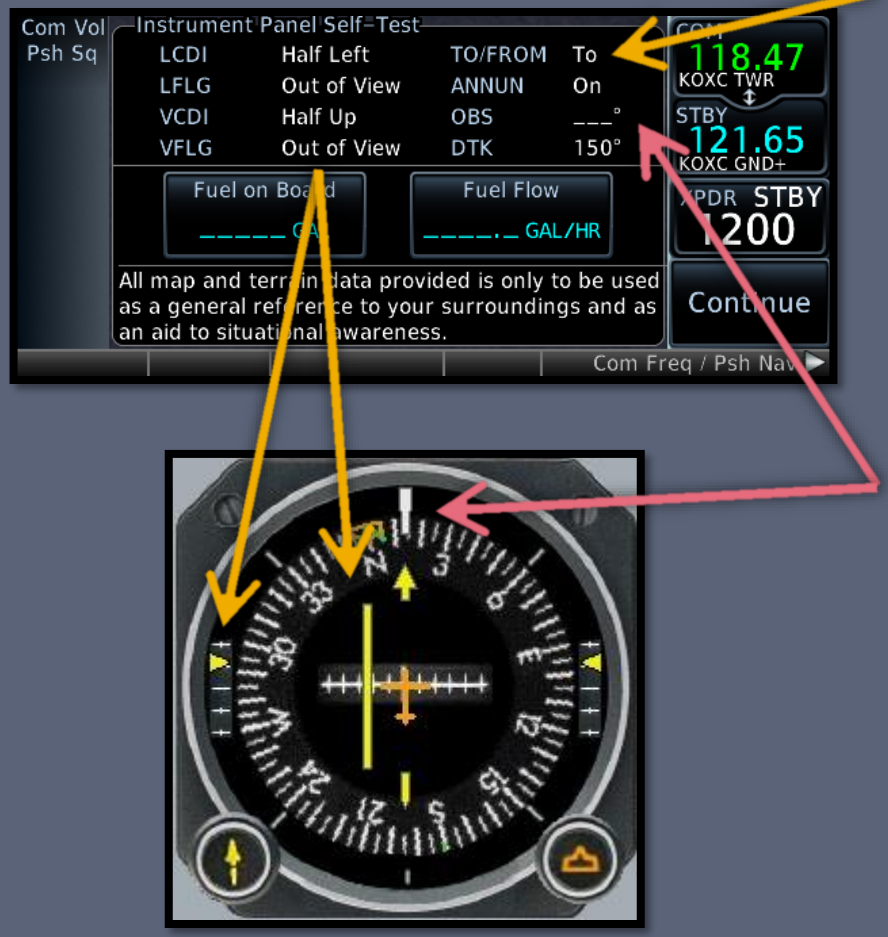
GTN 650 Overview

Database Verification

- Displays GTN software versions
- Displays installed databases and their expiration dates
  - Expired databases will be shown in yellow
  - "Navigation" database required to be current for IFR flight*
  - All other databases are optional for VFR and IFR flight

* Some exceptions apply – addressed in a later slide

Instrument Panel Self-Test



- Verify CDI / GS displacement is correct
  - CDI (LCDI) half left
  - G/S (VCDI) half up
  - To/From is TO
  - No flags
- Verify OBS course
  - Garmin "OBS" value and selected OBS course should match
    - Should be within 2 degrees
- Technically, IFR flight is prohibited if any of the self-tests fail

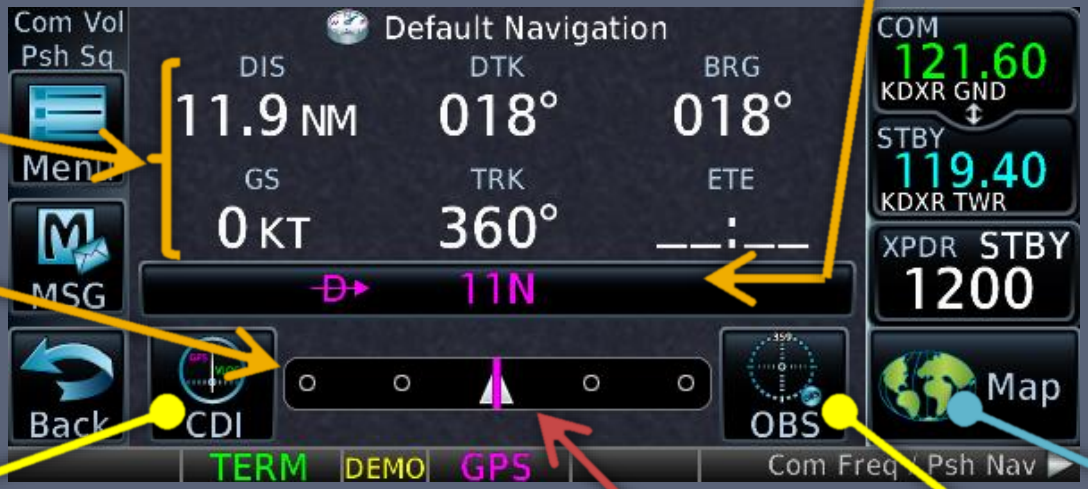
Default Nav Page

- Press and hold HOME to load from any page
  - Can also access it from the Home page
- Provides a shortcut button to enter the moving map page
- It's where the CDI and OBS functions are controlled from

User-selectable data fields

Active leg of flight plan

Course deviation indicator (CDI)



CDI Source Selector

TO/FROM flag*

OBS Selector

Moving Map Shortcut Button

* Always TO when in GPS mode

GTN 650 Home Page

- The home page replaces the "chapter" and "page" knobs of the 430

Replaces the 430 "Nav Group"

Replaces the 430 FPL button

Replaces the 430 "Wpt Group"

Replaces the 430 PROC button

Replaces the 430 "Nrst Group"

Replaces the 430 "Aux Group"

GTN 650 Navigation

- NAV group
  - How do I get to my destination?
  - Are there any hazards on the way (traffic, terrain, weather)?
- WPT group
  - Where am I going, and what is available there?
  - The "AFD" section of the Garmin
- AUX group
  - Flight planning and E6B-like utilities
  - System setup
- NRST group
  - What is nearest to my current location?

GTN 650 Key Functions

KNOB: Volume
PUSH: Squelch / Nav Identification

Volume Knob Function Hints

User-Configurable Data Fields

Nav/Com Frequencies

Frequency Swap

HOME Key

MSG annunciation and key

Photocell

Direct-To Navigation

Large and Small Rotary Knobs: Selection

Gripping point (for finger stabilization)

PUSH: Toggle

Zoom In/Out

Mode Annunciations

Map

Rotary Knob Function Hints

GTN 650 Data Fields (Subset)

- ACTV WPT – Active Waypoint
- BRG – Bearing To Waypoint
- **DIS** – Distance To Waypoint
- DFLT NAV – Default nav page (lower-right only)
- **DTK** – Desired Track
- ESA – En-route Safe Altitude
- ETA – Estimated Time of Arrival
- ETA at Dest
- ETE – Estimated Time En-route
- **GS** – Groundspeed
- OBS/Susp/Unsusp button (lower-right only)
- **TRK** – Track
- Wind – Wind Speed and Direction
- Time to TOD – Time to Top of Descent
- XTK – Cross-Track Error

BOLD = Default; Underlined = Recommended

Map Declutter

- There are 4 user-selectable map detail levels
  1. All data shown
  2. Removes all land data except rivers & lakes.
  3. Removes all airspace except Prohibited & Restricted. Also removes NDBs, Intersections, and User waypoints.
  4. Removes all data except the Active Flight Plan, Airways, rivers, lakes, traffic, and lightning data.

The OBS/SUSP/UNSUP Button

- Enroute
  - Disables waypoint sequencing past the current waypoint
  - Turns the current waypoint into a virtual VOR
    - You can select any radial off the waypoint
- Approaches & Holds
  - Changes to SUSP/UNSUSP
  - Suspends or unsuspends waypoint sequencing

Visual Approaches & Runway Centerlines

- Visual Approach
  - Available within a pre-configured distance from the destination airport (default is 10nm)
  - Provides advisory lateral (and at some airports, vertical) guidance to any runway
    - A 3nm final approach marker is also provided
- Runway Centerlines
  - Displayed for all runways at the destination airport

Terrain Awareness

Terrain Awareness

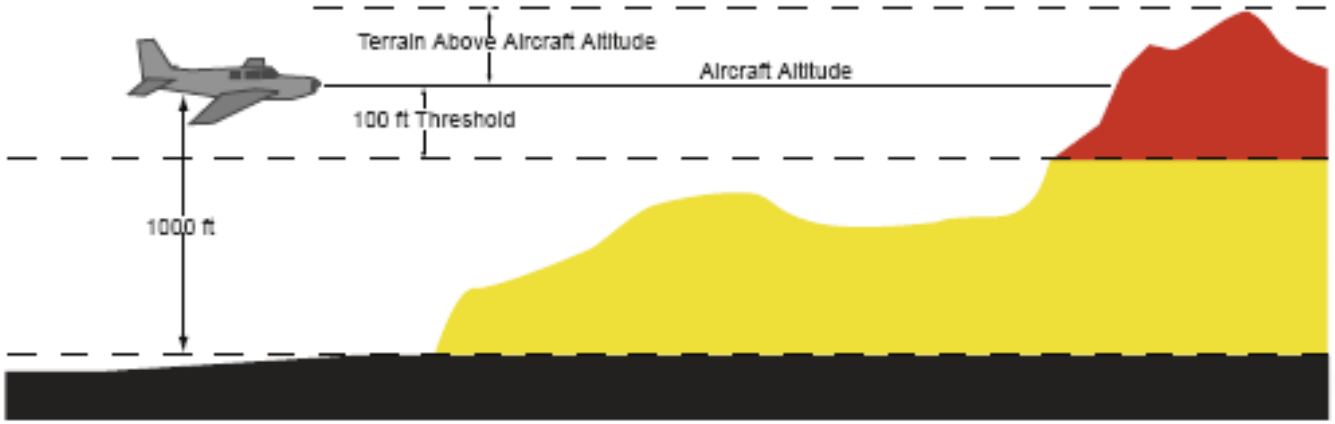
- Portrays a 2D picture of the surrounding terrain and obstacles relative to the position & altitude of the aircraft
  - Based off of GPS altitude, converted to MSL
- Non-TSO-C151b terrain awareness system
  - *Advisory-only* - but very useful when flying in hilly areas, especially at night
- Separate terrain database updates
  - Obstacle and terrain databases are updated at different intervals from the nav data

On-Screen Caution

Terrain Awareness Criteria

Obstacle Symbol	Unlighted Obstacle		Lighted Obstacle		Color	TERRAIN/Obstacle Location
	< 1000' AGL	> 1000' AGL	< 1000' AGL	> 1000' AGL		
					Red	Terrain/Obstacle above or within 100 ft below current aircraft altitude
					Yellow	Terrain/Obstacle between 100 ft and 1000 ft below the aircraft altitude
					Black	TERRAIN/Obstacle is more than 1000 ft below the aircraft altitude

Terrain Color Symbology



TERRAIN Altitude/Color Correlation

TAWS Alerts

Alert Type	Alert Annunciation	Aural Message
Excessive Descent Rate Warning (EDR-W)	PULL UP	"Pull Up"
FLTA Terrain Warning (RTC-W, ITI-W)	PULL UP	"Terrain Ahead, Pull Up; Terrain Ahead, Pull Up"* or "Terrain, Terrain; Pull Up, Pull Up"
FLTA Obstacle Warning (ROC-W, IOI-W)	PULL UP	"Obstacle Ahead, Pull Up; Obstacle Ahead, Pull Up"* or "Obstacle, Obstacle; Pull Up, Pull Up"
FLTA Wire Warning (ILI-W, RLC-W)	PULL UP	"Wire Ahead Pull Up, Wire Ahead Pull Up"
FLTA Terrain Caution (RTC-C, ITI-C)	TERRAIN	"Terrain Ahead; Terrain Ahead"* or "Caution, Terrain; Caution, Terrain"
FLTA Obstacle Caution (ROC-C, IOI-C)	OBSTCL	"Obstacle Ahead; Obstacle Ahead"* or "Caution, Obstacle; Caution, Obstacle"
FLTA Wire Caution (ILI-C, RLC-C)	WIRE	"Wire Ahead"
Premature Descent Alert Caution (PDA)	TERRAIN	"Too Low, Terrain"
Excessive Descent Rate Caution (EDR-C)	TERRAIN	"Sink Rate"
Negative Climb Rate Caution (NCR-C)	TERRAIN	"Don't Sink"* or "Too Low, Terrain"
Voice Call Out (VCO-500)	None	"Five-Hundred"

Hard Warning – Take evasive action immediately

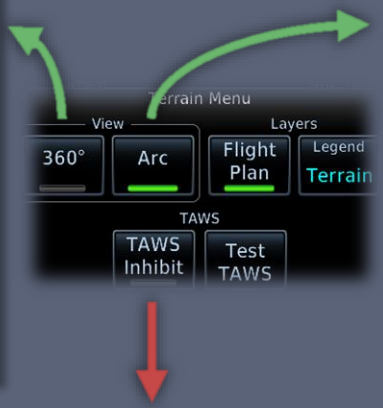
1. Apply full power
2. Retract speed brakes (if applicable)
3. Pitch for Vx
4. Leave flaps & gear alone until clear

Soft Alert – Check your situational awareness and take action if necessary to avoid a collision

<u>Informational</u> – Verify cleared to land, runway is clear & approach is stabilized. Otherwise, go around.

Terrain Modes

360-view



Arc-view

Terrain Inhibit Notification

Traffic & Weather Pages

Traffic Page

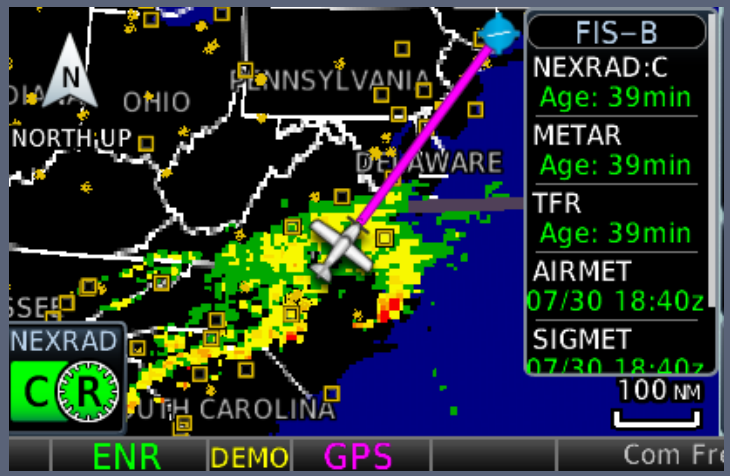
- Displays the 8 nearest targets within a specified filter range
  - Two modes:
    - Relative vector (motion relative to you)
    - Absolute vector (target's ground track)

- Traffic data can also optionally be shown on the moving map page

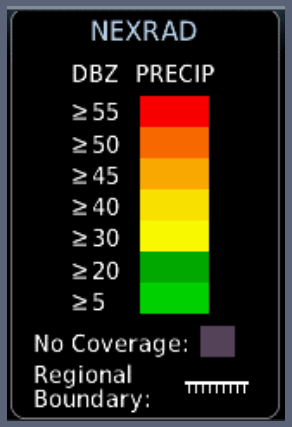
- Traffic Advisory (TA) – Traffic may pose a collision threat.
- Proximity Advisory (PA) – Traffic Is within 5nm and +/- 1,200'
- Other detected traffic

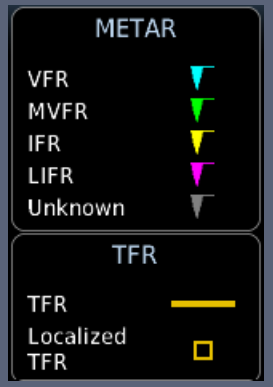
Weather Page

- From the "Home" screen, select "Weather" and then "FIS-B Weather"

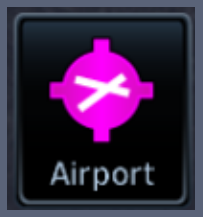


- Displays NEXRAD radar, graphical METARs, TFRs, AIRMETs/SIGMETs, and PIREPs
- Weather data (radar, stormscope, and METARs) can also optionally be shown on the moving map page

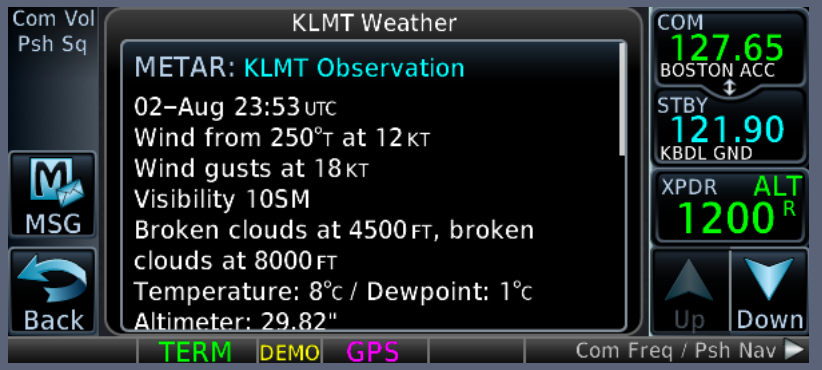




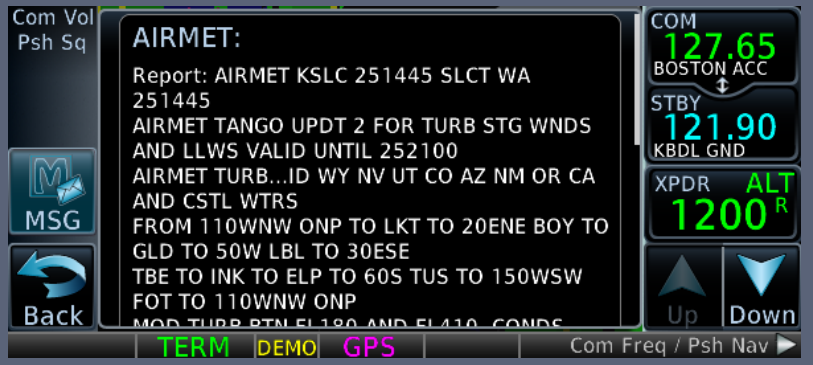
Textual Weather Pages



- From the "Map" or "Weather" page, touch the location you want more information on.

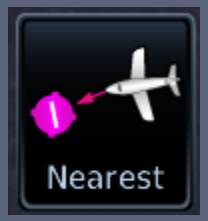


- You can also select "WX Data" from the airport information screen.



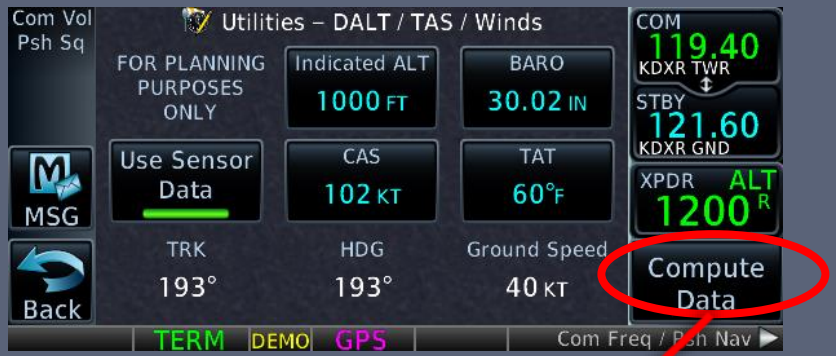
Useful Features & Tips

“Nearest” Pages



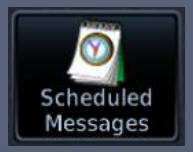
- Provides
  - Airports
  - Waypoints
    - Intersections
    - NDBs
    - VORs
    - User Waypoints
  - Airspace & Services
    - ARTCC
    - FSS
    - Airspace
- Can load information about each waypoint/airspace

Computing Winds Aloft



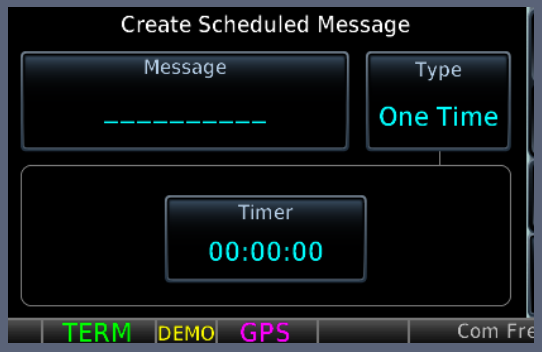
- Great tool to use when submitting a PIREP
- "Ind Alt" will initially show your GPS altitude
  - Will likely need fine tuning, but not by much
- "CAS" will initially show your GPS ground speed
- "BARO" will show the last entered value
- "HDG" will show your GPS ground track heading
  - This should be set to your magnetic heading

Scheduler & Flight Timers



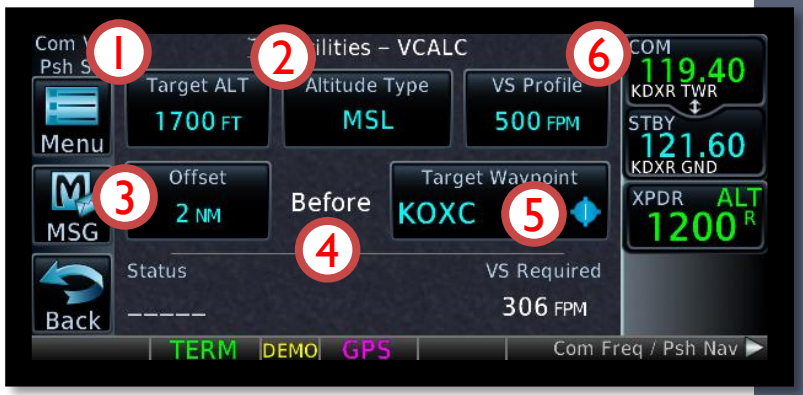
Scheduler

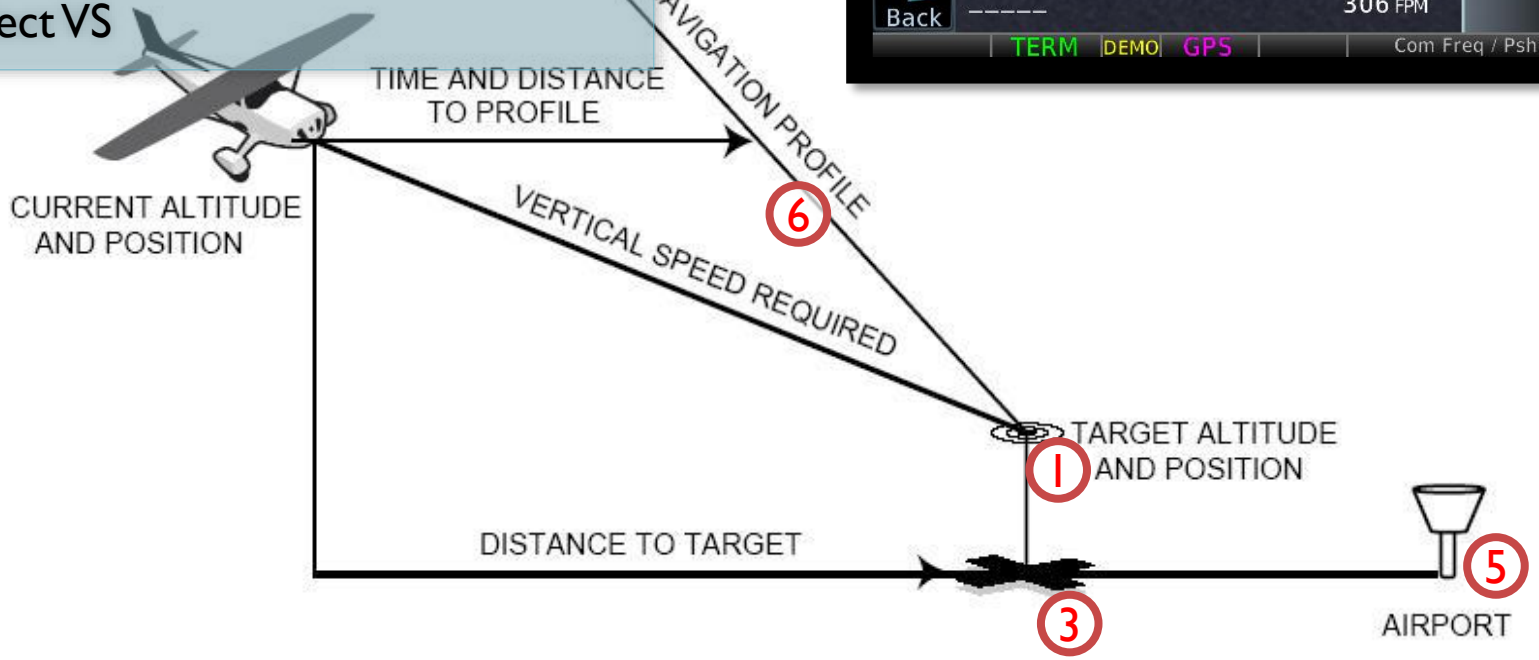
Flight Timer



Vertical Navigation

1) Select target altitude
2) Select altitude reference
3) Select distance relative to waypoint
4) Select before or after waypoint
5) Select waypoint
6) Select VS

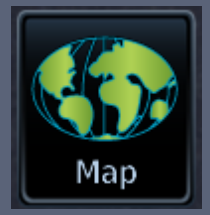




Map Orientation

- Three modes of map orientation
  - **North up**
    - Orientation of paper charts
  - **Track up**
    - Current heading is straight up
  - Heading up
    - Similar to track up, but less smooth
- From the "Map" screen, touch "Menu", select "Map Setup", then "Orientation"

Map Panning & Selection



- Can be used to move the map beyond its current limits without adjusting the zoom level
- Can also be used to select a point on the map to get bearing and distance information, as well as the name of the selected point
  - Press Direct-To to navigate direct to a highlighted point
  - Touch "Waypoint Info" to load more information on the point
  - Touch "Create Waypoint" to add a point in space as a user-defined waypoint

User-Defined Waypoints

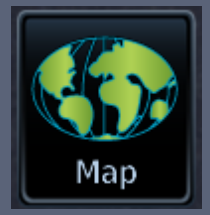
- Up to 1000 user-defined waypoints can be stored

When created from the Direct-To or FPL page, waypoint will use the aircraft's current position

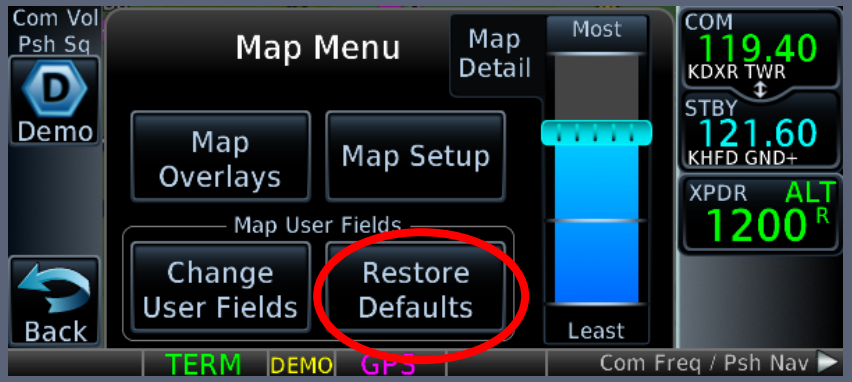
- Can be created from the User Waypoint page, from the Map page, or from the Direct-To & FPL pages.

- User waypoints are referenced by name only
- User waypoints are best used for ground references (houses, etc) or common reporting points (e.g. "the prison" at KDXR)

Miscellaneous



- Resetting the four user-selectable data fields
  - Touch the "Menu" button, then touch "Restore Defaults"



- Emergency Frequency
  - Press and hold the volume button for approximately 2 seconds

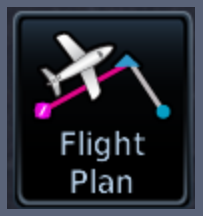
Flight Plans

VFR & IFR

When Your Database is Not Current

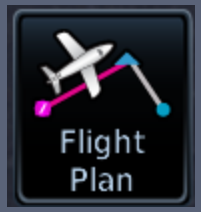
- VFR
  - No legal requirements to have a current database
- IFR
  - Legal for en-route and terminal navigation
    - Each waypoint must be verified with an alternate source of *current* data (e.g. paper chart, electronic chart)
  - Per the Garmin 650 STC, "GPS", "or GPS", and "RNAV (GPS)" approaches are *not* allowed
    - Example: Danbury's "GPS RWY 08" approach is not allowed, but something like a "VOR or GPS-A" approach is allowed *if flown using VOR guidance*.
    - Danbury's "LOC RWY 08" is also allowed

Flight Plans



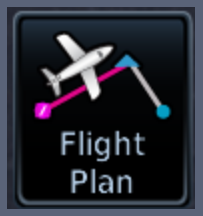
- Up to 99 stored flight plans
  - Up to 100 waypoints per flight plan
  - Custom names of up to 18 alpha/numeric characters
- Supports victor airways

Activating a Leg



1. Go to the flight plan page
2. Select the waypoint where the leg ENDS
3. Select ACTIVATE LEG

Holds



1. Go to the flight plan page & select the holding waypoint
2. Select Hold at WPT
3. Configure & preview the hold
4. Load the hold

1

2

3

4

Garmin Aviation Trainer

- PC Trainer
  - Windows 7 or later
  - macOS not supported
- iPad Trainer
  - iPad 2 or newer

VFR GPS Demonstrations

1. Start-up screen: Database currency
2. Home page
3. Interface navigation basics
4. Changing data fields on the map page
5. Map setup
6. Terrain awareness
7. Looking up waypoint/airport information
    - Entering data
8. "Nearest" demonstration
9. Scheduler and flight timers
10. Computing winds aloft
11. Vertical navigation

GPS Do's and Don'ts

DO

- Develop skills in stages
- Practice with PC/iPad simulators
- Program *on the ground*
- Delegate GPS operations to copilot
- Fly the airplane first!

DON'T

- Exceed VFR or personal minimums
- Focus inside the cockpit
- Rely solely on GPS map display for navigation
- Fiddle with it while close to an airport or in a high workload situation
- Try new features for the first time in the air

GPS is Not a Substitute for Sound ADM!!
"Proper Prior Planning Prevents Poor Performance!"

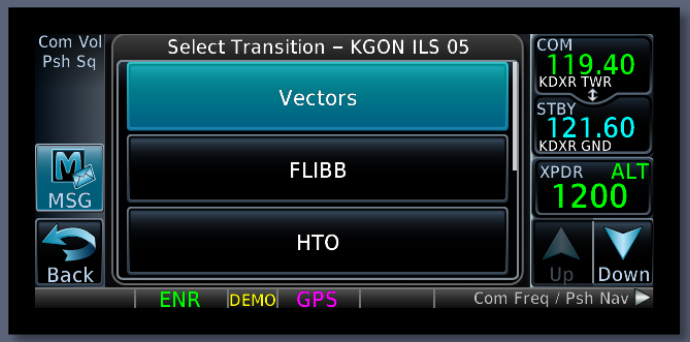
Wake Up – It's Quiz Time!

What is the difference between HDG and TRK?	*HDG is the magnetic heading the aircraft is pointed, while TRK is the aircraft's ground track.*
What is the CDI mode used for?	*To toggle between navigation sources (GPS or VLOC) output to an external HSI or CDI.*
What is the OBS mode used for?	*It allows the pilot to select a desired course to/from a waypoint (entering the traffic pattern, or holds).*
How do you cancel a Direct-To course?	*Direct-To, "Remove".*
How do you display the default nav page from any screen?	*Press and hold the "HOME" button.*
How do you swap frequencies?	*Press and hold the right knob, or tap the active frequency.*

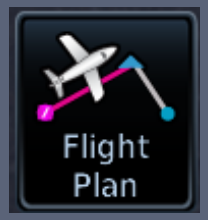
IFR Operations

Loading an Approach

1. Press the "HOME" button
2. Tap "PROC"
3. Tap "Approach"
4. Select the desired approach
5. Select the desired transition
    1. "Vectors" draws a reference line to the FAF
6. "Load" vs "Activate"
    - "Load" adds the approach waypoints to the flight plan, but doesn't activate it.
    - "Activate" also loads the waypoints, but then provides Direct-To course guidance to the initial fix



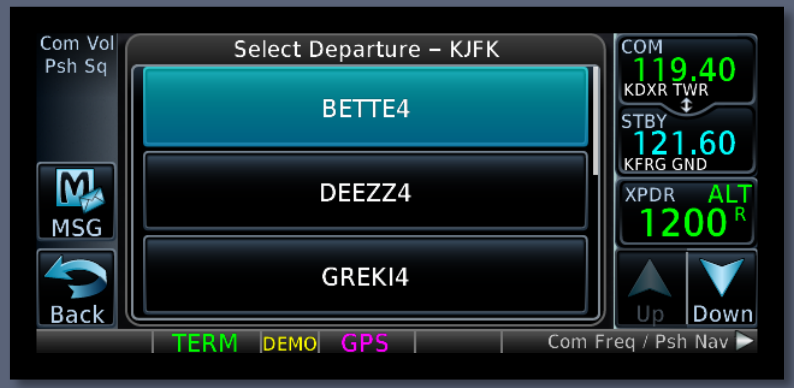
Multiple Destinations



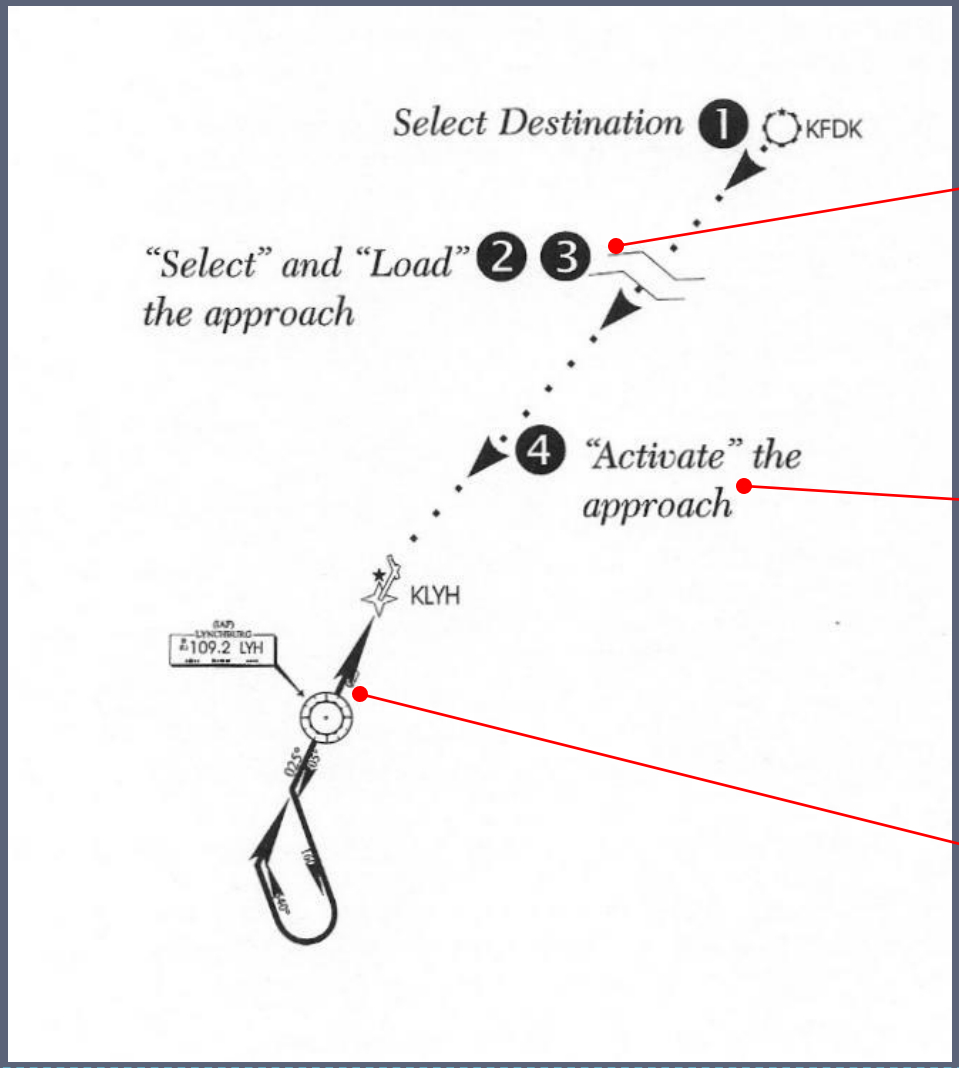
- Switching approaches
  1. Press "HOME", select "PROC" and then "Approach"
  2. Tap "Airport"
  3. Tap "Find", tap "Flight Plan", and select the approach from the list
- Reasons
  - Easily load an approach for the departure or alternate airport
  - Simplify IFR training / proficiency

Loading SIDs and STARs

- Similar method to loading an approach
  1. Press the "HOME" button
  2. Tap "PROC"
  3. Tap "Departure" or "Arrival"
  4. Select the desired departure / approach
  5. Select the desired transition
  6. Tap "Load Arrival"/"Load Departure"



GPS Approach Modes

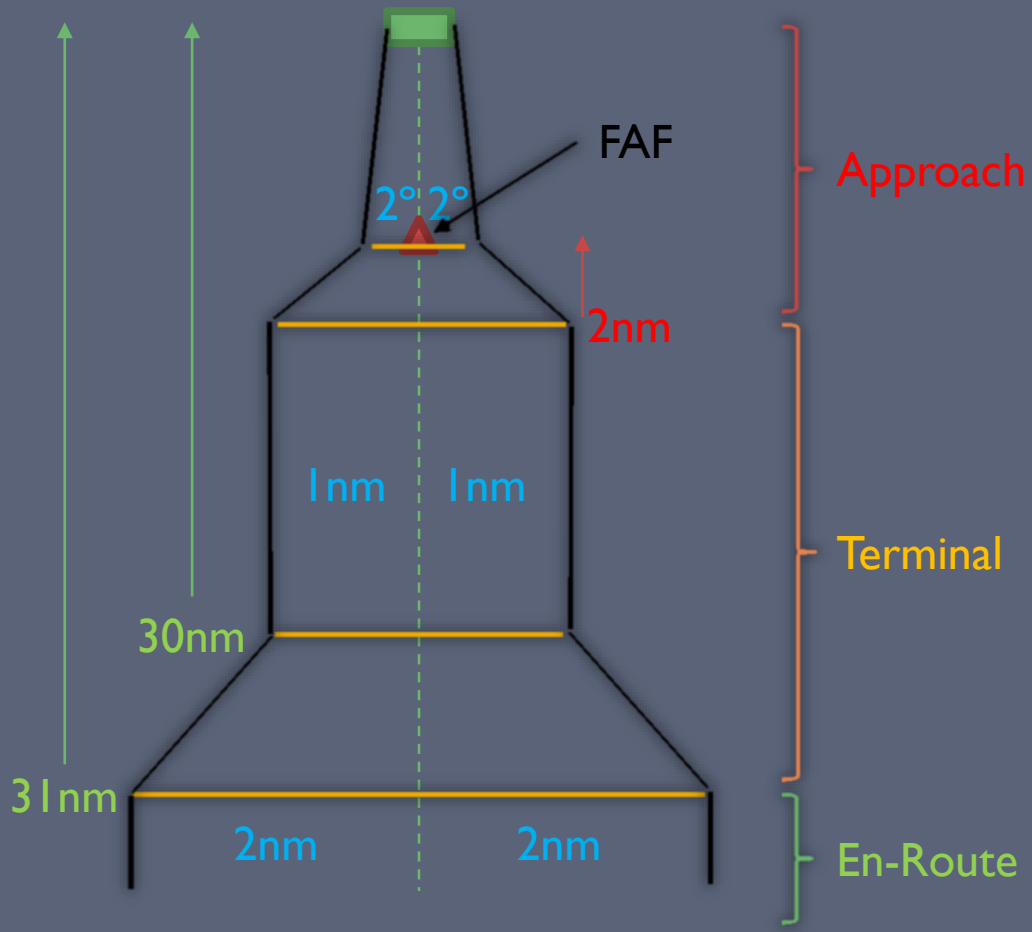


ENROUTE

TERMINAL

APPROACH

CDI Scale Transitions



During the transition phases, the CDI may give the impression that you are off course, even though you may be on a perfectly good intercept angle.

650 GPS Approach Mode Summary

Annunciation	Approach	Description
LPV	LPV	Localizer Performance with Vertical guidance
LP+V	LP	Non-precision Localizer Performance with *advisory* vertical guidance
LP	LP	Non-precision Localizer Performance – allows for lower minimums than LNAV
LNAV+V	LNAV	Non-precision Lateral Navigation with *advisory* vertical guidance
LNAV	LNAV	Non-precision Lateral Navigation

Additional 650 GPS Modes

Annunciation	Description
MAPR	Missed Approach CDI full scale deflection = 0.3 NM
ENR	En-route navigation CDI full scale deflection = 2.0 NM
TERM	Terminal area navigation CDI full scale deflection = 1.0 NM
LOW ALT	For LNAV+V and LPV approaches Indicates the aircraft's estimated height is lower than the FAF height by approximately 50 meters (164 feet). Not active when TAWS is operational.

GPS Substitutions

- AC90-108 – Operational & Airworthiness Guidance
  - Suitable RNAV system as an alternate means of navigation

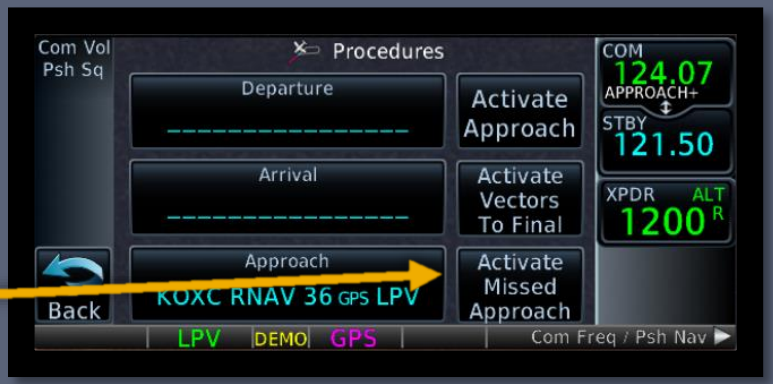
- Allowed substitutions
  - *Determine aircraft position* relative to/distance from a VOR, TACAN, NDB, compass locator, DME fix, fix defined by a VOR radial/TACAN course/NDB bearing/compass locator bearing intersecting a VOR or LOC course
  - *Navigate to/from* a VOR, TACAN, NDB, or compass locator
  - *Hold* over a VOR, TACAN, NDB, compass locator, or DME fix
  - *Fly an arc* based upon DME
  - All of the above is allowed even when a facility is identified as required on a procedure (e.g. "ADF required")
- **Non-allowed substitutions**
  - When a procedure is NOTAMed as "not authorized" ("NA")
    - Example: A procedure is based upon a recently decommissioned NAVAID
  - Substitution on a Final Approach Segment
  - Lateral Navigation on LOC-Based Courses

Vectors to Final

- Provides an extended course direct to the final approach point
- When flying outbound (opposite direction), the GTN will automatically go into SUSP mode
  - Once you start the turn inbound to the FAF, the GTN will automatically unsuspend

Missed Approach

- Upon reaching the MAP, the "Missed Approach Waypoint Reached" screen will pop up
  - "Remain Suspended" to complete the approach
  - "Activate Missed Approach" to begin guidance for the missed approach
- You can also manually activate the missed approach for any GPS approach once inside the FAF
  - HOME, PROC, "Activate Missed Approach"



Suspend Mode

- GTN suspends automatic leg sequencing when the start of the next leg cannot be determined
  - SUSP = Pilot intervention required

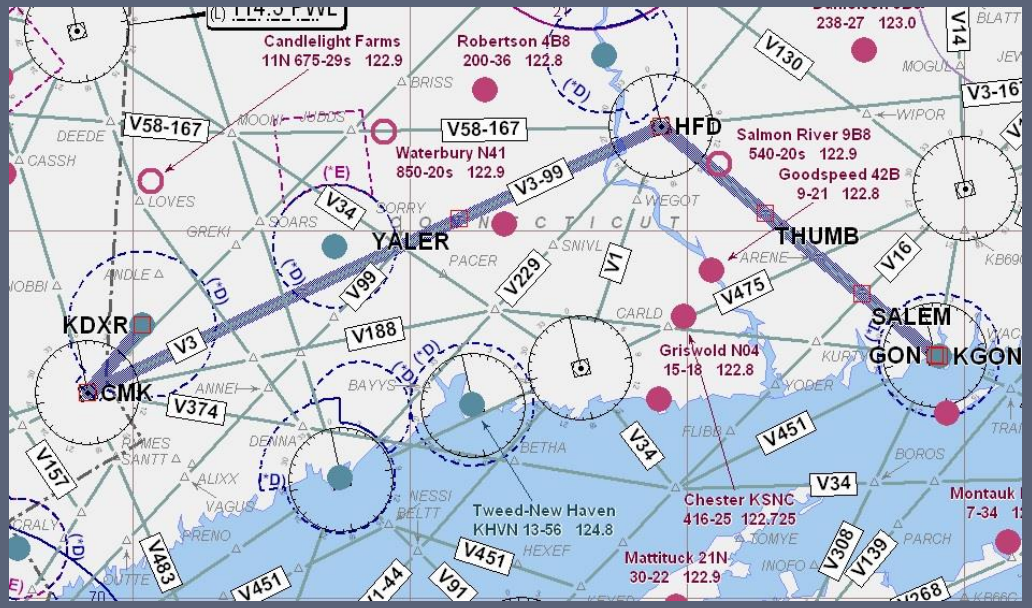
- Two main types of waypoint sequencing suspension
  - Pilot-induced
    - Pilot intentionally suspends waypoint sequencing
  - Navigator-induced
    - Navigator cannot determine when to begin the next leg

Suspend Mode

- Reasons for automatic waypoint suspension
  - The MAP has been reached
    - Does the pilot intend to land, or follow the missed approach?
  - Holding pattern requires pilot action to exit
    - Ex) A hold at the end of a missed approach procedure
  - Leg requires a course/heading to be flown indefinitely
    - Ex) "fly heading 360, expect radar vectors"
  - Leg ends at a specific altitude and baro-corrected input not provided
    - Ex) "climb to 2500, then…"
  - Aircraft flying opposite direction to a vectors-to-final course
    - Temporary – navigator will resume sequencing when flying inbound

IFR GPS Demonstrations

1. Flight plans
    1. Creation
    2. Saving
    3. Loading
2. Activating a leg
3. Loading and activating an approach
4. Loading a SID and STAR
    - KJFK.JFK1.RW04L, VCN8.BRIGS.KPHL



KDXR CMK V3 HFD V58 GON KGON

IFR Do's and Don'ts

DO

- Practice in VFR with a safety pilot before using in actual IFR conditions
- Set higher personal minimums until comfortable with its use
- **Check GPS/VLOC CDI indicator often**
- Check and ID the active VLOC frequency for ILS/LOC
- **Always set OBS (and heading bug) to DTK**
- Pay attention to suspended waypoint sequencing and active waypoint

DON'T

- Rely solely on one nav source
  - DO "shadow" GPS with other systems if available
- Program during high workload situations
- Forget to check for sequencing to appropriate approach mode prior to FAF

Wake Up – It's Quiz Time!

Is a non-GPS approach required for an alternate when using the GTN 650?

No longer required with TSO 146a certified GPS/WAAS (sole source navigation)

The alternate has an LPV approach – what alternate minimums apply?

Non-precision approach minimums (800-2) apply unless otherwise stated

What are some common Mistakes when setting up for an ILS?

Failure to Set CDI VLOC Mode, Switch and IDENT VLOC Freq

True or False: INTEG indication in flight = OK to proceed to destination via IFR

True – Monitor VOR Enroute. Destination Must Have Non-GPS Approach

What is the difference between charted and GPS distance?

Charted distance is DME slant-range distance, GPS is great-circle ground distance

More Information

- Garmin Website – http://www.garmin.com
  - GTN 650 manual
  - Garmin Aviation Trainer
  - Training Syllabus
  - Tutorial Videos
- Avweb – http://www.avweb.com
- AOPA Air Safety Foundation – http://www.aopa.org/asf
  - ASF Safety Advisor – GPS Technology

Open Sky Aviation, LLC.
http://openskyaviation.biz
gbaluha@openskyaviation.biz

Additional Information

More information for the curious

GPS/WAAS Overview

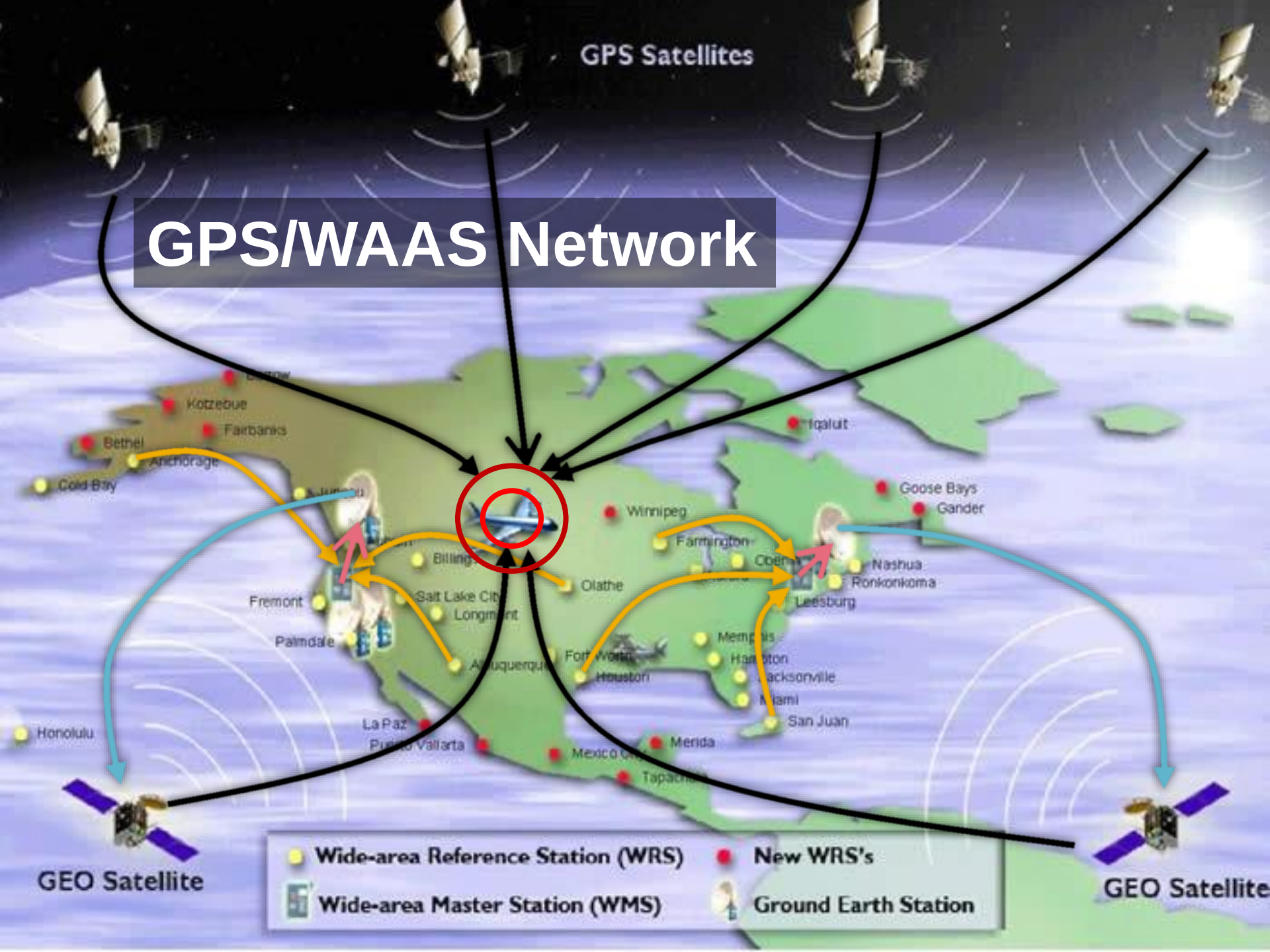
A Brief Review

GPS and WAAS Overview

- Global Positioning System (GPS)
  - Satellite-based navigation
    - 24 satellites orbiting 12,000 miles above the earth's surface
    - Satellites orbit twice a day in a precisely-known orbit
  - Full constellation became operational in 1994
  - Receivers use time-based triangulation to calculate the user's location
    - Accurate within 15 meters (~50 feet)
- Wide Area Augmentation System (WAAS)
  - Corrects for GPS signal errors
    - Consists of a network of ground reference stations at precisely-surveyed locations
    - A master station generates a correction signal and transmits it to one of two geostationary satellites
  - Available in the entire Continental US and parts of Canada and Mexico
  - Improved position accuracies
    - 1 meter (~3 feet) horizontal
    - 2 meters (~6 feet) vertical

GPS Timeline

- 1995: GPS Selective Availability (SA)
  - 330 – 990 feet
- 2000: SA Turned Off
  - 100 – 330 feet
- 2003: Wide Area Augmentation System (WAAS) Enabled
  - < 23 feet
  - Provides Vertical Guidance
  - WAAS Approaches Slightly Higher Minimums than Cat I ILS

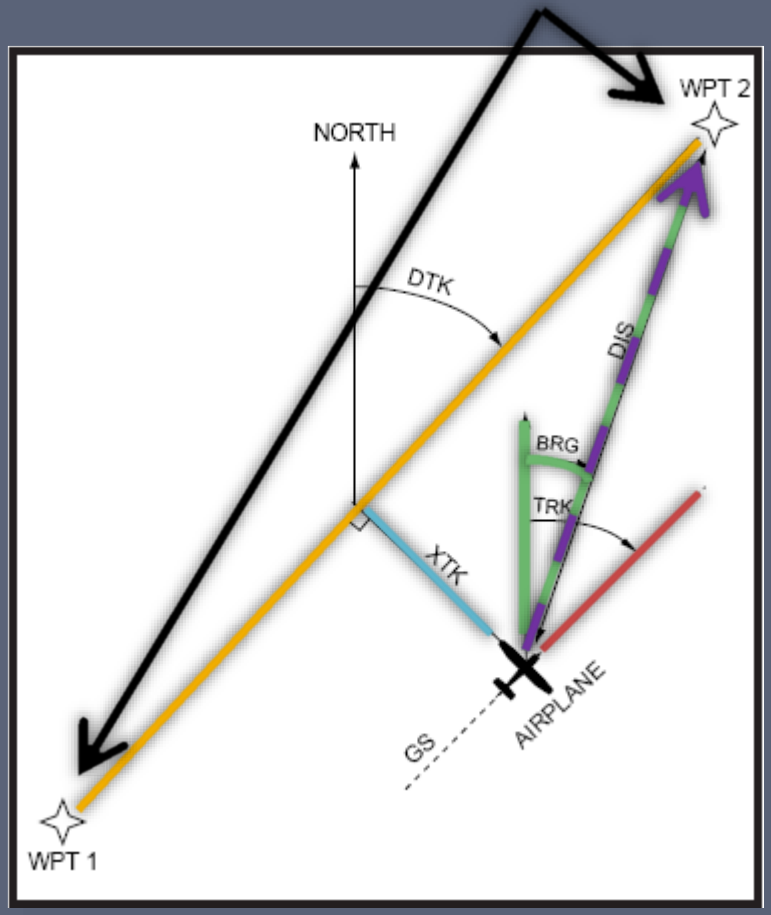

GPS Satellites
GPS/WAAS Network
Kotzebue
Fairbanks
Bethel
Anchorage
Cold Bay
Iqaluit
Goose Bays
Gander
Winnipeg
Farmington
Billings
Nashua
Ronkonkoma
Olathe
Fremont
Salt Lake City
Longmont
Leesburg
Palmdale
Memphis
Houston
Jacksonville
Miami
San Juan
Honolulu
La Paz
Puerto Vallarta
Merida
Tapachula
GEO Satellite
GEO Satellite
Wide-area Reference Station (WRS)
New WRS's
Wide-area Master Station (WMS)
Ground Earth Station

GPS Navigation Concepts

GPS Navigation Concepts

A course is always defined by two waypoints!

DTK	Desired Track
TRK	Ground Track
BRG	Bearing
CTS	Course To Steer
XTK	Cross-Track
DIS	Distance (nm)
GS	Groundspeed (kts)



What is RAIM?

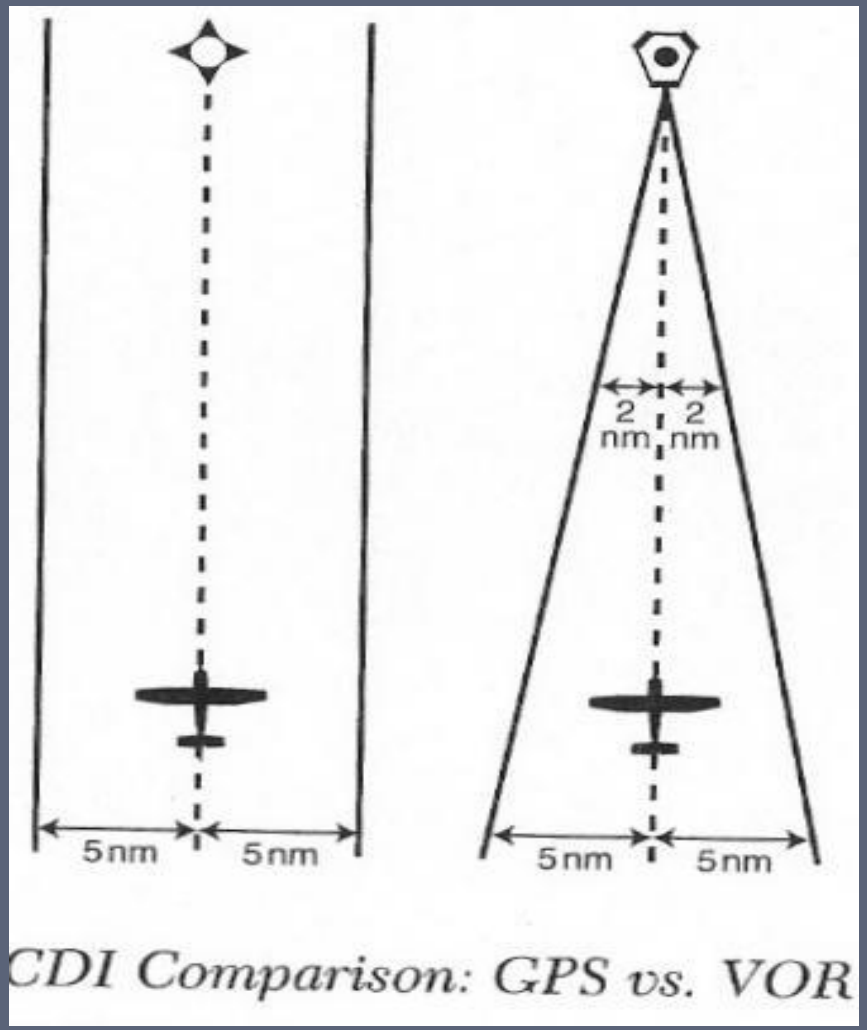
- Receiver Autonomous Integrity Monitoring
  - The "Off" flag – Primary means of ensuring receiver integrity
  - Needs a minimum of **5** satellites in view
    - 6 for FDE (WAAS)
  - *Required for IFR operations*
    - Handheld GPSes do not normally have RAIM
  - Must be available at the FAF to fly a GPS approach
- "RAIM Prediction" alerts you to RAIM error at destination *before* you fly

RAIM Prediction is required for any IFR flight that uses RNAV procedures

- RAIM not available in flight
  - Enroute/Terminal – Revert to VOR, or cross-check every 15 minutes
  - Prior to FAF – Fly to MAP and execute the Missed Approach procedure
  - After FAF – Expect 5 minutes of GPS guidance

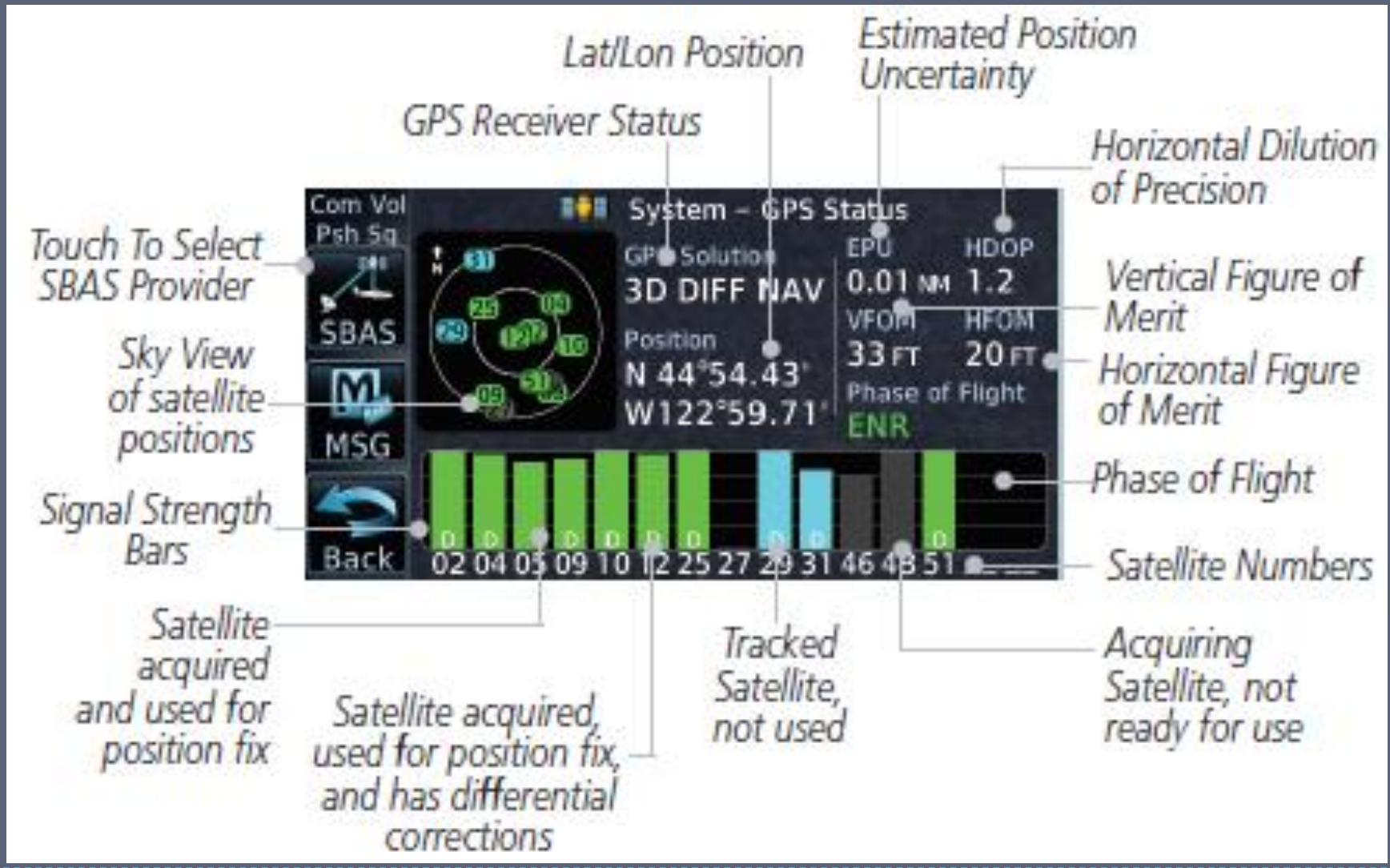
GPS Accuracy vs. VOR

- CDI Comparison
  - GPS: Fixed-width accuracy*
  - VOR: Accuracy varies with distance
    - Becomes more sensitive as you get closer
    - "Cone of confusion"
- "Resolver-Type" Design
  - Resolver course indicator coupled to CDI
  - OBS course selector must be set to desired course



CDI Comparison: GPS vs. VOR

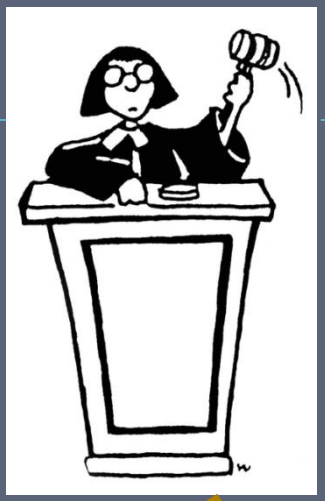
Satellite Status Page



IFR Concepts

Are You IFR Legal?

- IFR-Certified GPS Unit
  - Garmin 650
    - GPS/SBAS TSO C-146c Certified for *sole source of navigation*
- IFR-Certified Installation
  - Installation must also be certified! (AC20-138A)
  - Cockpit Reference Guide *must* be within reach of the pilot
  - Navigation database current (Updated every 28 days)?*
- IFR Usage
  - May be used in lieu of ADF and DME*
  - Review GPS/WAAS NOTAMs and "All available information" – FAR 91.103



- ~~Alternate means of navigation required – FAR 91.205~~
- ~~A non-GPS approach must be available at alternate airport (or VFR)~~
- No longer required with WAAS (TSO C-146a/c)

- IFR RNAV-Capable Aircraft
  - ICAO: B2 (RNAV 5 GNSS), C2 (RNAV 2 GNSS), D2 (RNAV 1 GNSS)

* = More details provided on a later slide

Types of GPS Approaches

- 1st Generation – Non-precision VOR/NDB overlay approaches (RNAV)
  - Many are being replaced by 2nd Gen approaches
- 2nd Generation – Stand-alone non-precision GPS approaches (RNAV)
- 3rd Generation – WAAS approach with vertical guidance