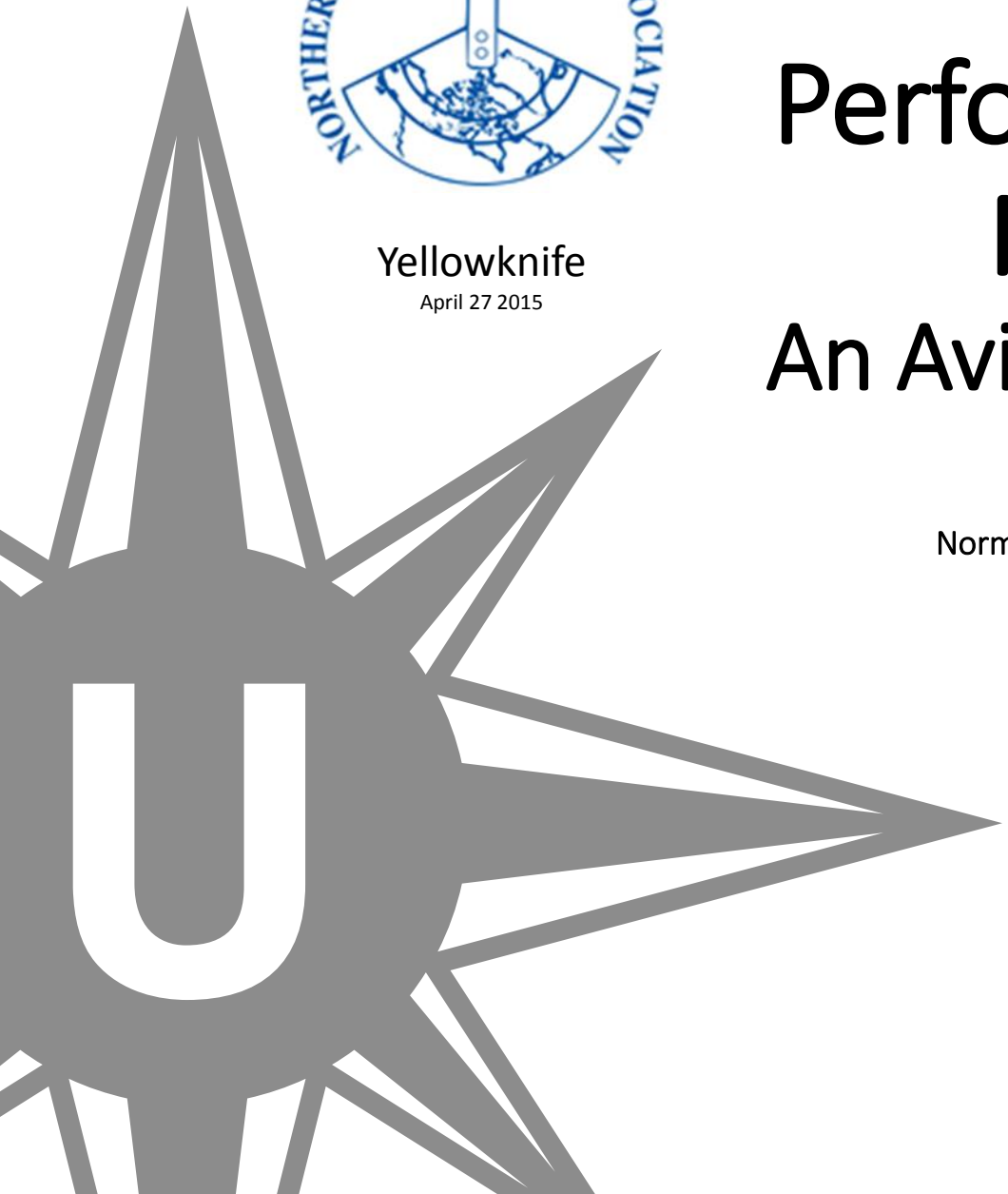

Yellowknife

April 27 2015

Performance-based Navigation

An Avionics OEM's View

Norm Matheis - Regional Manager - Canada

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Universal Avionics - Who We Are

- Privately-held Avionics OEM - Arizona Corporation
- Manufacturing, Sales/Marketing & Customer Support Headquartered In Tucson, Arizona
- R&D Groups Located In Redmond WA & Duluth GA
- Founded In 1982 By Hubert Naimer As A Navigation Company
- 430 Team Members
- Sales Channels Through Our Authorized Dealer And Integrator Network, Airlines and Government/Military

What We Build

- A Retrofittable SBAS (WAAS) Flight Management System
- Advanced Flat Panel Integrated Flight Displays
- Flight Recorders
- TAWS
- Vision-1® Synthetic Vision
- UniLink Datalink
- Application Server Unit
- Radio Control Unit & Radio Tuning Unit
- Peripherals

Where We're Heading

- Air Navigation Has Moved On From Traditional Navigation "Sensor-based Ground-based" To Performance-based Navigation (PBN)
- This Involves Transitioning To Area Navigation By Introducing Specifications Of Performance, Not Just Which Black Boxes To Carry
- Means Both Area Navigation (RNAV) and Required Navigation Performance (RNP)
- The Key Difference Between Them Is The Requirement For On-board Performance Monitoring And Alerting
- A Navigation Specification That Includes A Requirement For On-board Navigation Performance Monitoring And Alerting Is Referred To As An ***RNP*** Specification
- One Not Having Such A Requirement Is Referred To As An ***RNAV*** Specification
- This Isn't NextGen, It's NowGen

Conventional Routes

Today's airways connect ground-based navigation aids

Limited Design Flexibility

RNAV

Area Navigation (RNAV) routes follow defined "waypoints"

Increased Airspace Efficiency

RNP

Required Navigation Performance (RNP) routes within specified "containment area"

Optimize Use of Airspace

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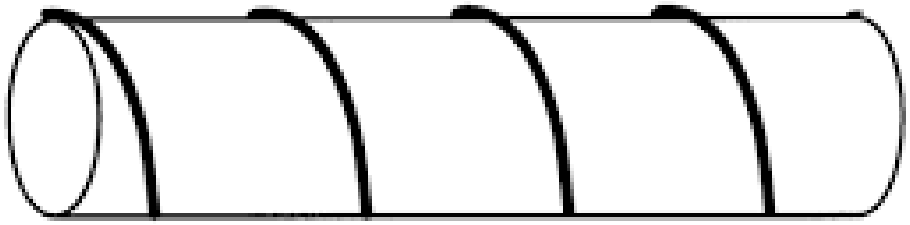
A Usual Question We Get…

What Is The RNP OF My FMS?

A string is wound symmetrically around a circular rod. The string goes exactly 4 times around the rod. The circumference of the rod is 4 cm and its length is 12 cm.



Find the length of the string. Show all your work.

RNP (Public) Operations All Specify Aircraft Equipment Requirements Of Which The FMS *Is Only One Part*

In Order To Qualify For Any RNP Operations In A Chunk of RNP AIRSPACE, The Operator Must Have A Compliance Statement In The AFMS For The FMS Establishing That The Aircraft Meets The Equipage And Performance Requirements

RNP How DO I DO IT?

- E.g. RNP 1 in Canada
- An RNP Of 1 Means That The Navigation **SYSTEM** Must Be Able To Calculate (Read Guarantee) Its Position To Within A Circle With A Radius Of 1 Nautical Mile
- **Operations Specification (Ops Spec) 618 for Required Navigation Performance 1 (RNP 1)**
- **Advisory Circular (AC) No. 700-025**
- **Universal Will Support And Has Compliance Matrix SILs**

Then There's RNP AR

- RNP AR Approaches Include Unique Capabilities That Require Special Aircraft And Aircrew ***A***uthorization ***R***equired Similar To Category (CAT) II/III ILS Operations
- All RNP AR Approaches Have Reduced Lateral Obstacle Evaluation Areas And Vertical Obstacle Clearance Surfaces
- In Addition, Selected Procedures May Require The Capability To Fly An RF Leg And/Or A Missed Approach, Which Requires RNP Less Than 1.0
- Our Regional Aircraft Operators Have Obtained RNP AR Approval Including The Bombardier Q400 Down To RNP 0.1
- Operators Or Airlines That Have Achieved This Goal Have Attained Benefits For Their Operations
- Each Potential RNP AR Applicant Should Assess The Return On The Investment Required For RNP AR Certification
- In A Universal Architecture Only A Navigation Solution With SBAS (WAAS) FMS And IRS Can Meet All The Requirements Of RNP AR
- The RNP Capability Depends On The Availability Of GPS/IRS Integrity
- Universal Avionics Will Support RNP AR Efforts For Those Operators Desiring This Capability

RNP AR – Why?

- Safety: Reduced Control Flight Into Terrain (CFIT) Risk Compared To Visual Approaches
- Stabilized Approach With Constant Descent Final Angle
- Operations Efficiency: Increased Airport Access (Curved And Contained Trajectories And Lower Minima), Resulting In Fewer Weather-related Delays And Diversions
- Efficiencies From More Reliable And Repeatable Flight Paths And Reduced Flight Time Due To Optimized Routing
- Environment: Reduced Fuel, Emissions, And Noise Resulting In A Small Environmental Footprint

Case Study – Kodiak RNP
What IT CAN Mean To Remote Operations

- Horizon Air Had To Cancel A Flight To Kodiak AK
- They Were Unable To Dispatch Because Kodiak Had Low Visibility Conditions And The ILS Was Out For Six Weeks Of Maintenance
- Hoped To Use The FMS To Prevent Future Schedule Disruptions
- Normal Procedure Is To File ILS As The Basis For Dispatch And Then Ask To Shoot The RNP 0.15 (Authorization Required) Approach (RNP AR) Using UNS FMS

- Kodiak ILS DME Z Rwy 25 Minimums Are: 330' / 1 3/8 Mile (2 Degree Glide Slope)
- Kodiak RNAV(RNP) M Rwy 36 Minimums Are: 354' / 1 Mile (3 Degree Glide Slope)
- Horizon Can Do RNP 0.15 Approaches Because They Made A Significant Investment To Obtain Authorization For Operations Down To RNP 0.1 (Required Navigation Performance = 0.1 Nautical Miles)
- To Get This, They Had To Show That Their Q400s Are Properly-Equipped (With Dual Universal WAAS FMS) And Their Crews Were Specially Trained (the AR)
- However, They Cannot Use The RNP 0.15 Approach For Dispatch Because They Are Obliged Do A GPS RAIM Prediction For RNP Operations Less Than 0.3
- We Provided Them With Universal Flight Planning Tool So They Could Assess Its Capability To Forecast GPS RAIM Availability
- Our GPS Will Probably Be Using WAAS Instead Of RAIM, But Our Receiver Automatically Selects The Mode That Is Providing The Best Protection Level, So A RAIM Prediction Will Do


25

It's An SBAS/WAAS/LPV World

- Canadian Aircraft Need To Be SBAS (WAAS) Capable
- WAAS Ground & Space Segments Correct GPS To A Level Of Accuracy, Integrity and Availability Suitable For Near-CAT I Approaches
- Legacy FMS Operators Subject to Increasing Limitations
- There Are Now Over 3500 LPVs in the US – More Than ILS
- Approaching 250 LPVs In Canada
- A Building Block For All The Acronyms – FANS, ADS-B, RNP, CPDLC, PBN…

Value Proposition – An SBAS FMS

- Provides RNAV (GNSS) **LPV** LOS Approach Capabilities
- Basis for Seeking RNP Approvals
- True North Course Procedures, ETP/PNRs, And Gravel Runways in Database
- Trade-in Legacy Universal ***AND COMPETITOR (2015)*** FMS For Credit
- Mitigate Database Limitations Of Legacy Equipment e.g. Multiple Approach Indicators
- Enhances Safety By Providing More Accurate Global Positioning Information To The Onboard TAWS/EGPWS, TCAS
- Mitigates For Snow And Ice Accumulation Around ILS Antenna Arrays
- Required Accuracy And Integrity For **U.S. ADS-B 2020**
- Allows Preferred Routings And To Alternate Airport In Adverse Weather Conditions – Think BEBS
- Pilot Entitlement Training

Base Models

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LPV Approaches?

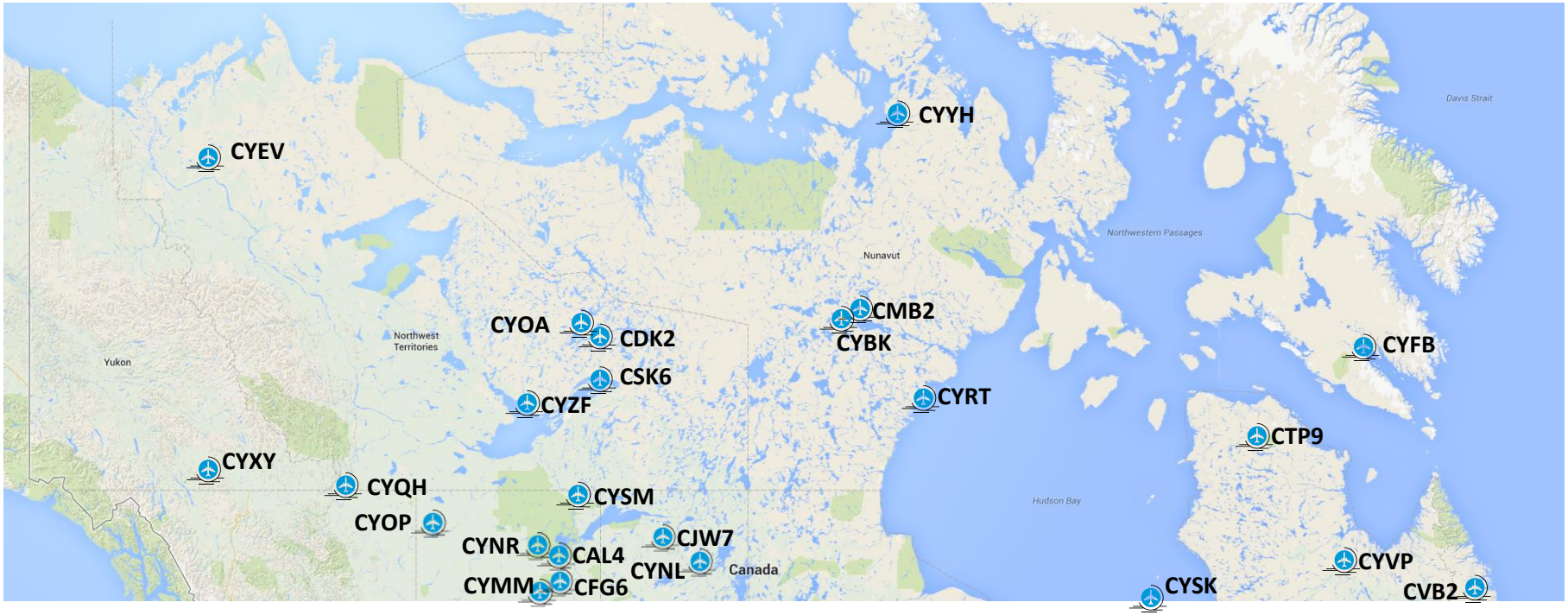
- **L**ocalizer **P**erformance with **V**ertical Guidance

- All WAAS/SBAS Approaches Are Types Of RNAV (GNSS) Non-precision Approaches

- When The Approach Is Coded In An FMS Database With Something Called A FAS Data Block, They Support Different Levels Of Service (Call This "Minimums" For The Moment) Including LNAV, LNAV/VNAV & LPV

- With "Near-CAT I" LPV, Constant Descent Angle And LOWEST 200-250 Foot Minimums Possible

Northern LPVs



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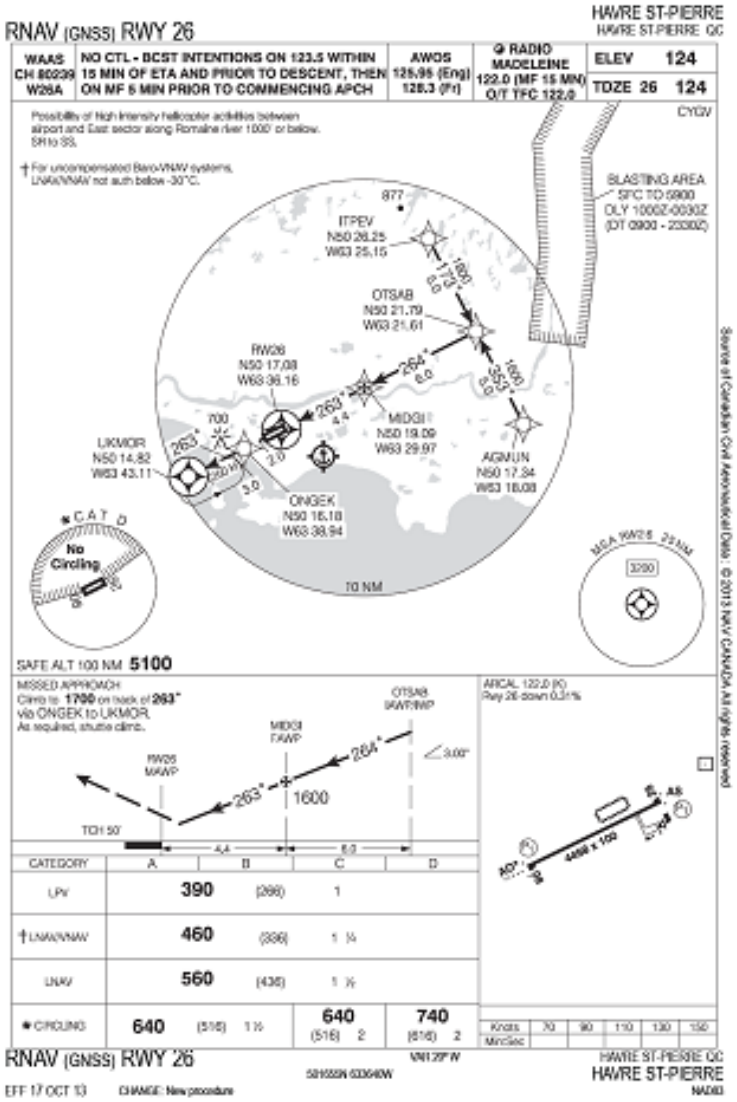
WAAS/LPV

Benefits

LPV

- **L**ocalizer **P**erformance With **V**ertical Guidance
- “ILS-like” Guidance To 200ft And ½ Mile Visibility Is Possible
- Access To All RNAV (GNSS) Approaches
- More Stable Approach Than Other Non-precision Approaches And Even Some ILS Approaches = Better Ride For The Passengers
- **Enhanced Margin Of Safety** With A Stabilized Approach
  - More Consistent Path Over Terrain – Not Affected By Baro Setting Or Temperature
  - Vertical Guidance To The Runway Surface
  - On UASC Test Aircraft, Only 12-18 Inches Deviation Off Course Is Typically Seen Within 4 Miles Of Airport



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Aircraft Changes – Legacy System

- Trade-in Legacy FMS For Credit For SBAS-FMS
- Change Antennas
- Add Wiring For Cross-channel Monitoring
- Add LOS Annunciators
- Reconfigure And Test
- AFM Supplement And STC

RNP Or LPV? It's Both

- With Support From Universal, Horizon Air Announced Ops Spec Approval For Required Navigation Performance (RNP) 0.3 November 2011
- First Such Authorization Obtained For An Operator Of A Turboprop Aircraft (Bombardier Q400) For RNP Authorization Required (AR) And The First RNP AR Based On An SBAS Platform
- Now Reduced To RNP .1!
- Bombardier's Own Q400 RNP AR 0.3/0.3 (Approach/Missed Approach) Capability (WJE) Is Based On An Aircraft Equipped With:
  - Dual UNS-1Ew WAAS FMS scn 1000.6 FMS
  - Single Inertial Reference Unit (IRU)
  - Latest EGPWS Version
- Both Horizon And Bombardier OEM Have Q400 LPV-Approved

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What's Coming?

- Curved RNP Transitions to LPV Final
- At 3 ½ Miles From The Threshold
- No TERPS Yet
- Could Mix The Best of Both Worlds
- Take Advantage of Lower Minimums Of LPV

U.S. ADS-B

- ADS-B Is An Airspace Rule Not An Aircraft Rule
- Different Than Ever Before
- Bigger Than Ever Before
- Practically Affects

Every User

Of U.S. Airspace

Effective Jan 1 2020

Including Alaska

What Is ADS-B-Out?

- Automatic Dependent Surveillance - Broadcast - OUT
- ADS-B Out - Surveillance Technology That Transmits GPS-based Position And Other Data Via “Extended Squitter” Mode S Transponder:
  - Identification
  - GPS Position
  - Altitude (Baro & Geometric)
  - Velocity
  - Quality And Integrity Data, Etc.
- ADS-B Is Nav Canada And FAA’s Satellite-based Successor To Ground-based Air Traffic Control (ATC) Radar
- It Is Not ADS-C

Why ADS-B Out?

ANSPs are Interested because:

- Allows Them To Decommission Expensive Aging SSR Radars
- Not Possible To Have New SSR In Remote Regions
- Much Faster Update Rate – Once Per Second
- Position Accuracy
- Aircraft State And Intent Information
- Ultimately Will Allow More Aircraft To Use Existing Airspace With Equivalent Or Better Safety And Efficiency

- **Estimated Savings through 2016 in Hudson Bay**
- **$158 million in fuel**
- **436,000 metric tons of CO^2 emissions**

ADS-B Recommended Equipage

Equip For The U.S. Jan 1 2020 DO-260**B** Requirement!

Do It Early To Reap The Benefits Soonest And Take Advantage Of Manufacturer's Stimulus Programs

Equipment

- TSO-C166b-Compliant Extended-Squitter Mode S Transponders
- Universal TSO-C146 SBAS/WAAS Flight Management System scn 1000.7
  - To Meet Latency And Integrity Requirements
- Update Radio Controls To Alert The Pilot Of Any Loss Of ADS-B Output Parameter

Magvar 101

In The World Of RNAV/RNP Why Are Displayed Tracks On The FMS Sometimes Not The Same As NAV CANADA Has Published On Charts?

- The Magnetic North Pole Is Moving Toward Siberia At Roughly 110 Meters/Day
- How Do Aeronautical Charts Handle This? Airports Are Resurveyed And Navaids Are Recalibrated Periodically. As A Result, Charted Course Angles, Track Angles, Headings And Even Runway Names May Change. This Occurs Even If SIDS, STARS, And Approach Procedures Themselves Are Unchanged.
- The Charted Angles Are Frozen In Time Between Surveys. Meanwhile, The Magnetic North Pole Motors On
- All IRU/FMS Complete Their Internal Calculations With Reference To TRUE North. After The Track Calculations Are Complete, Navigation Systems Reference Their Internal Magnetic Variation Table in A "World Magnetic Model" To Provide A Magnetic Track. These Tables Are Imported Into The IRU Or FMS By The Unit Manufacturer And Could Be Slightly Different

Magvar 101 continued

- When The FMS Uses A Different Source Of Magnetic Variation Than The Procedure Designer Used, Or The FMS Is Using An Outdated Magnetic Variation Table, The FMS Could Show A Discrepancy Between The Published Track On The IFR Chart And The Track Displayed On The FMS
- NOAA Updates The WMM Every Five Years
- Universal Has Made Field-loadable Kits Available To Update Legacy FMS To WMM Year 2015
- In WAAS or SBAS FMS, Support For Base WMM Year Changes Supported In NavData 28-day Updates (Full Implementation Q4 2015)
- If You Are Seeing Large Splits And Known Good Magvar Table Is Loaded, Contact The OEM's Customer Support Field Engineering

Thank You

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InSight™