HUGHES AEROSPACE CORPORATION

Honeywell

Performance Based Navigation Integrated Systems Solutions

Chris Baur FRAeS

Galveston Texas
May, 2012

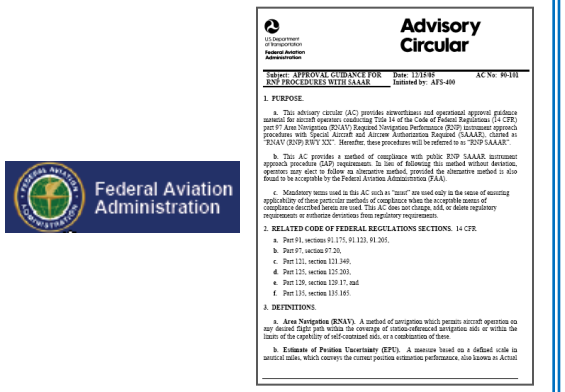
Texas Transportation Institute

Honeywell & Hughes A Broad Basis of RNP Expertise

Aircraft Equipage

- Honeywell Equipment
  - FMS software upgrades to bring low RNP capability to most Honeywell equipped aircraft
  - Inertial Reference Units
  - WAAS GPS
  - Display Systems
  - EGPWS

Operational Approval


Federal Aviation Administration

Advisory Circular

Subject: APPROVAL GUIDANCE FOR RNP PROCEDURES WITH SAAAR

Date: 12/18/95 AC No: 90-101

Initiated by: AFS-400

1. PURPOSE.

a. This advisory circular (AC) provides airworthiness and operational approval guidance material for aircraft operators conducting Title 14 of the Code of Federal Regulations (14 CFR) part 97 Area Navigation (RNAV) Required Navigation Performance (RNP) instrument approach procedures with Special Aircraft and Aircrew Authorization Required (SAAAR), charted as "RNAV (RNP) RWY XX". Hereafter, these procedures will be referred to as "RNP SAAAR."

b. This AC provides a method of compliance with public RNP SAAAR instrument approach procedure (IAP) requirements. In lieu of following this method without deviation, operators may elect to follow an alternative method, provided the alternative method is also found to be acceptable by the Federal Aviation Administration (FAA).

c. Mandatory terms used in this AC such as "must" are used only in the sense of ensuring applicability of these particular methods of compliance when the acceptable means of compliance described herein are used. This AC does not change, add, or delete regulatory requirements or authorize deviations from regulatory requirements.

2. RELATED CODE OF FEDERAL REGULATIONS SECTIONS. 14 CFR

a. Part 91, sections 91.175, 91.123, 91.205.

b. Part 97, section 97.20.

c. Part 121, section 121.349.

d. Part 125, section 125.203.

e. Part 129, section 129.17, and

f. Part 135, section 135.165.

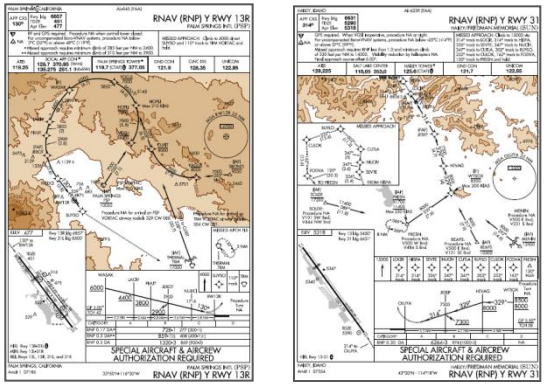
3. DEFINITIONS.

a. Area Navigation (RNAV). A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

b. Estimate of Position Uncertainty (EPU). A measure based on a defined scale in nautical miles, which conveys the current position estimation performance, also known as Actual

- Consultancy Services
  - Operational approval submittal package for AC90-101 compliance & FAA coordination
  - Timely and efficient integration of requirements into current flight operations

RNP Operations



- Procedure and Database Validation
  - Initial validation of all public RNP AR procedures & validation every 28 day cycle
- RNP Monitoring
  - Record keeping of operators RNP AR operations
- RNP Benefits
  - Reduced Operating Costs
  - Better Access
  - Increased Safety

HUGHES AEROSPACE CORPORATION

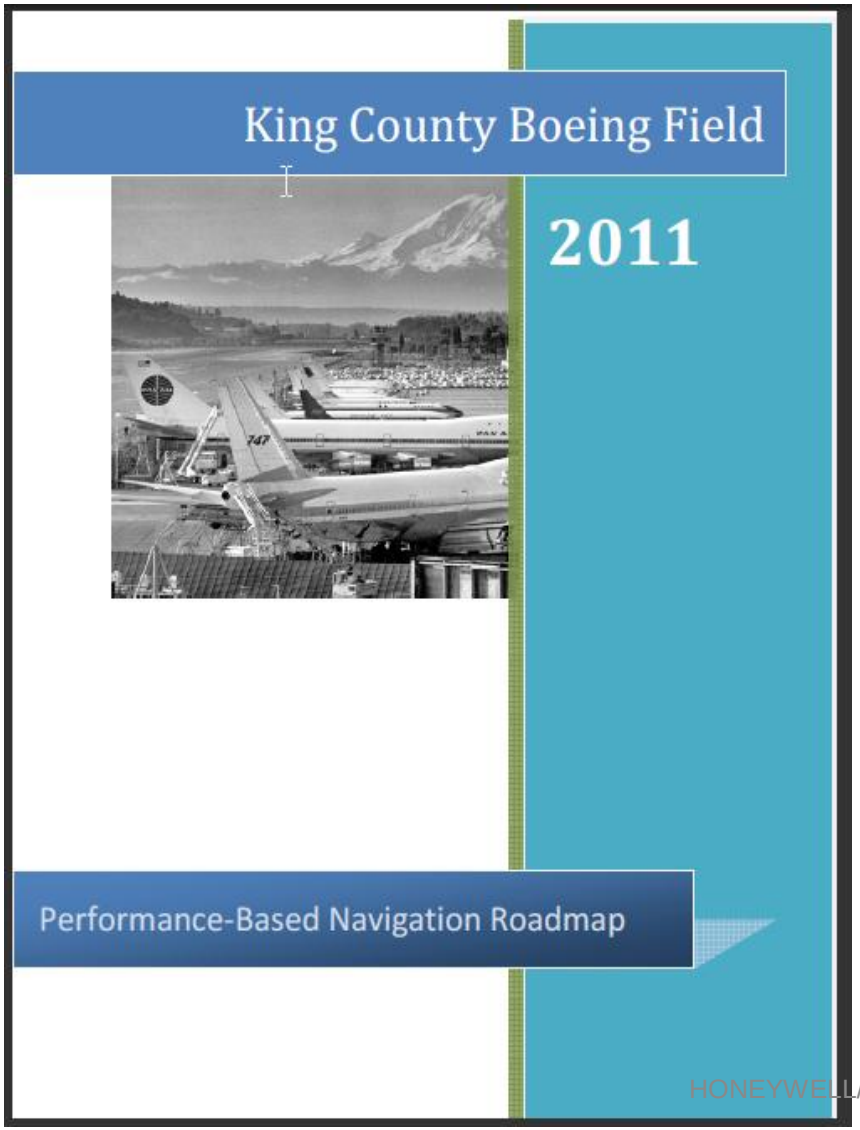
Hughes Aerospace
Global Leadership

Honeywell

Hughes & Honeywell Aerospace projects and developments cover the globe. Below are several examples of past, present and future projects around the world.

ATM & PBN – The Movement is Global and Happening Now

Why ATM & PBN?



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Hughes Aerospace Corporation
Memberships and Affiliations

Honeywell

Hughes Memberships & Affiliations

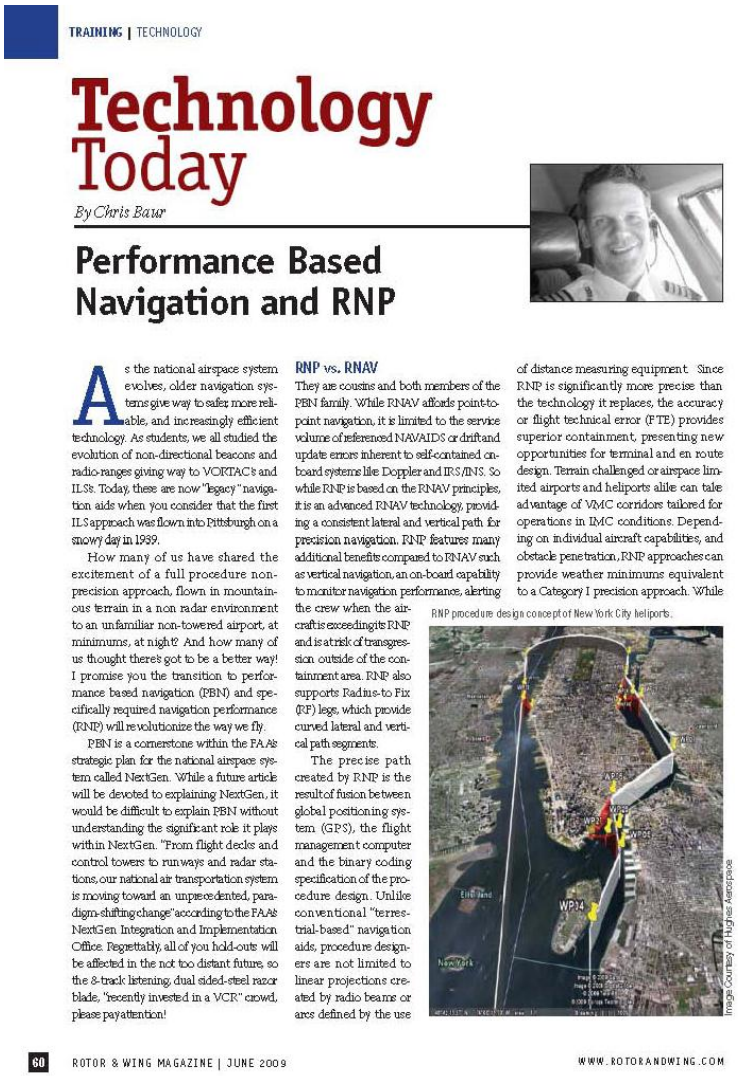
IATA – International Air Transport Association

HAI – Helicopter Association International

NBAA – National Business Aviation Association

AAAE – American Association of Airport Executives

IHST – International Helicopter Safety Team



TRAINING | TECHNOLOGY

Technology Today

By Chris Baur

Performance Based Navigation and RNP

As the national airspace system evolves, older navigation systems give way to safer, more reliable, and increasingly efficient technology. As students, we all studied the evolution of non-directional beacons and radio-ranges giving way to VORTACs and ILSs. Today, these are now "legacy" navigation aids when you consider that the first ILS approach was flown into Pittsburgh on a snowy day in 1939.

How many of us have shared the excitement of a full procedure non-precision approach, flown in mountainous terrain in a non radar environment to an unfamiliar non-towered airport, at minimums, at night? And how many of us thought there's got to be a better way! I promise you the transition to performance based navigation (PBN) and specifically required navigation performance (RNP) will revolutionize the way we fly.

PBN is a cornerstone within the FAA's strategic plan for the national airspace system called NextGen. While a future article will be devoted to explaining NextGen, it would be difficult to explain PBN without understanding the significant role it plays within NextGen. "From flight decks and control towers to runways and radar stations, our national air transportation system is moving toward an unprecedented, paradigm-shifting change" according to the FAA's NextGen Integration and Implementation Office. Regrettably, all of you hold-outs will be affected in the not too distant future, so the 8-track listening, dual sided-steel razor blade, "recently invested in a VCR" crowd, please pay attention!

RNP vs. RNAV

They are cousins and both members of the PBN family. While RNAV affords point-to-point navigation, it is limited to the service volume of referenced NAVAIDS or drift and update errors inherent to self-contained on-board systems like Doppler and IRS/INS. So while RNP is based on the RNAV principles, it is an advanced RNAV technology, providing a consistent lateral and vertical path for precision navigation. RNP features many additional benefits compared to RNAV such as vertical navigation, an on-board capability to monitor navigation performance, alerting the crew when the aircraft is exceeding its RNP and is at risk of transgression outside of the containment area. RNP also supports Radius-to Fix (RF) legs, which provide curved lateral and vertical path segments.

The precise path created by RNP is the result of fusion between global positioning system (GPS), the flight management computer and the binary coding specification of the procedure design. Unlike conventional "terrestrial-based" navigation aids, procedure designers are not limited to linear projections created by radio beams or arcs defined by the use of distance measuring equipment. Since RNP is significantly more precise than the technology it replaces, the accuracy or flight technical error (FTE) provides superior containment, presenting new opportunities for terminal and en route design. Terrain challenged or airspace limited airports and heliports alike can take advantage of VMC corridors tailored for operations in IMC conditions. Depending on individual aircraft capabilities, and obstacle penetration, RNP approaches can provide weather minimums equivalent to a Category I precision approach. While

RNP procedure design concept of New York City heliports.

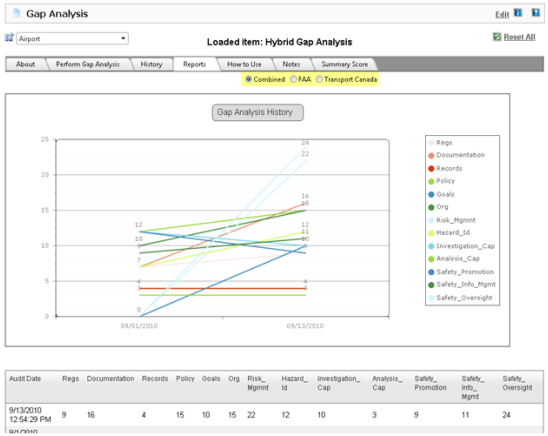
Image courtesy of Hughes Aerospace

60 ROTOR & WING MAGAZINE | JUNE 2009 WWW.ROTORANDWING.COM

Safety Management Systems
SMS Automation – SMS Pro

Hughes Safety Management Systems - SMS

Hughes Safety Management Systems Programs (SMS) are chartered to deliver operators with a framework to not only achieve regulatory compliance, but address the management of safety risk ostensibly as financial risk, and provide a mechanism to manage these threats in daily business operations. A significant return on the investment in an SMS program can be achieved when a as the outcome of company risk controls through the application of the four pillars of SMS: Safety Policy, Safety Risk Management, Safety Assurance and Safety Promotion. Hughes delivers a web based SMS solution for your company, tailored to your SMS needs as an air carrier, helicopter, corporate, or facility – airport, heliport or ATC. Please contact us for a complimentary demonstration.



Hughes develops its programs on an eight step process that is organized into four levels or phases.

Schedule of SMS Services

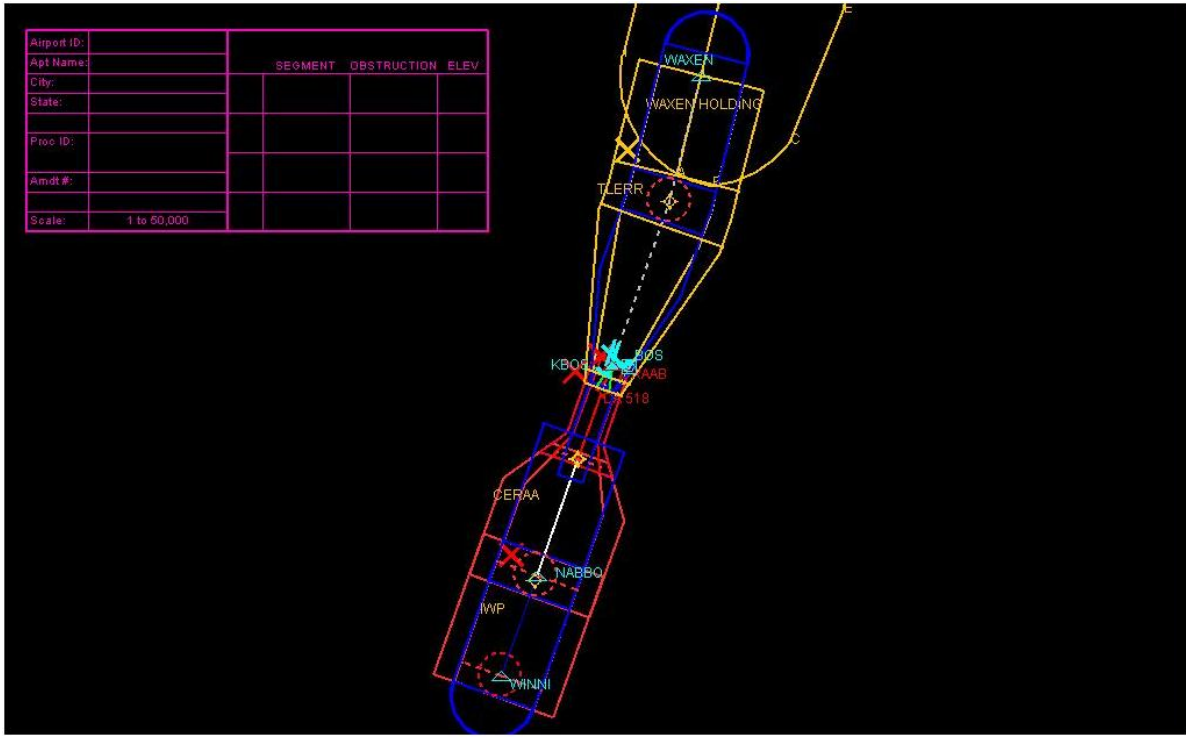
1. Aviation Safety Policy
2. Management accountability
3. Establish process to manage flight-safety risks
4. Setting up an aviation safety reporting system to record flight hazards, risks and resolution *s.*
5. Training and educating staff
6. Auditing flight operations and investigating incidents and accidents
7. Implementation of SMS Pro, automation for aviation safety management system to control documentation and data
8. Evaluating how aviation safety management system is operating

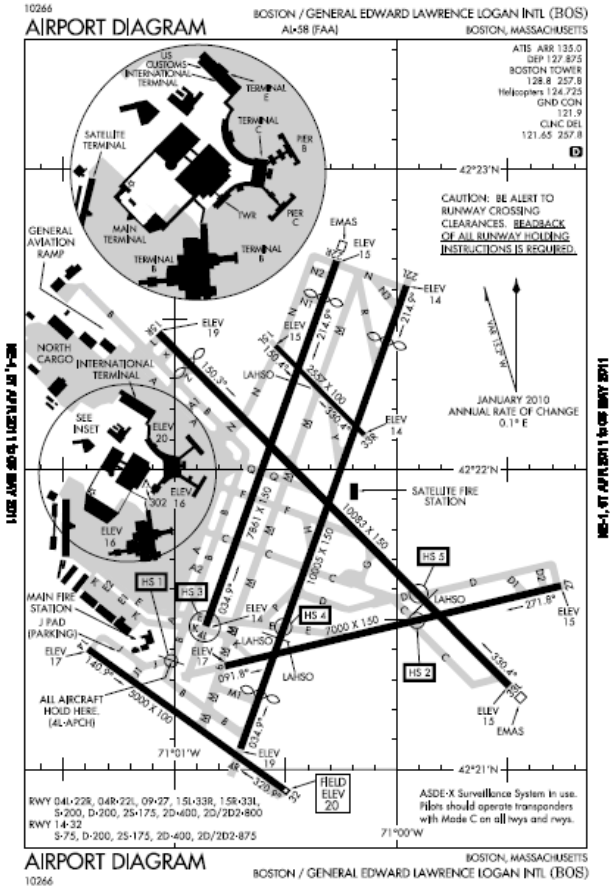
Flight & Obstacle Validation
Designated FAA Flight Examiners

Hughes Aerospace is designed by the FAA to provide both Flight and Obstacle Validation of PBN procedures, and is the only OTA designated by the FAA for both Fixed Wing and Helicopter including WAAS LPV procedure examination authority. Hughes can not only design PBN for all types of aircraft, but can also validate and maintain them. Hughes FAA certificated flight crews can provide their own aircraft for flight inspection or provide augmentation on your aircraft. Hughes Aerospace is experienced in Air Carrier, Business and Helicopter Flight Validation.

Hughes Flight Validation Team with Citation Inspection Aircraft

Boston International Airport
RNP WAAS Approach RW 04R





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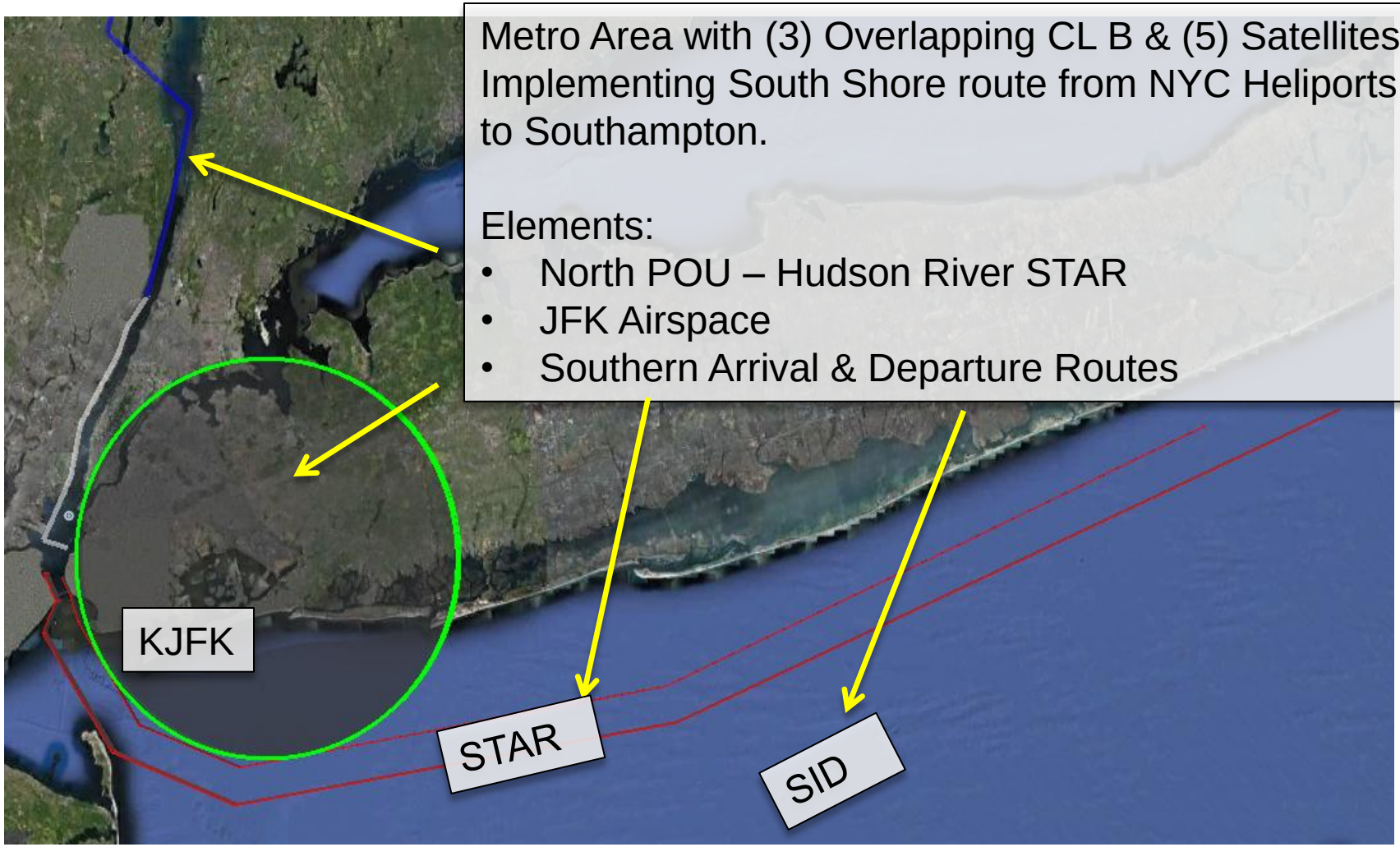
New York City Vertical Flight
WAAS LPV



Metro Area with (3) Overlapping CL B & (5) Satellites Implementing South Shore route from NYC Heliports to Southampton.

Elements:

- North POU – Hudson River STAR
- JFK Airspace
- Southern Arrival & Departure Routes

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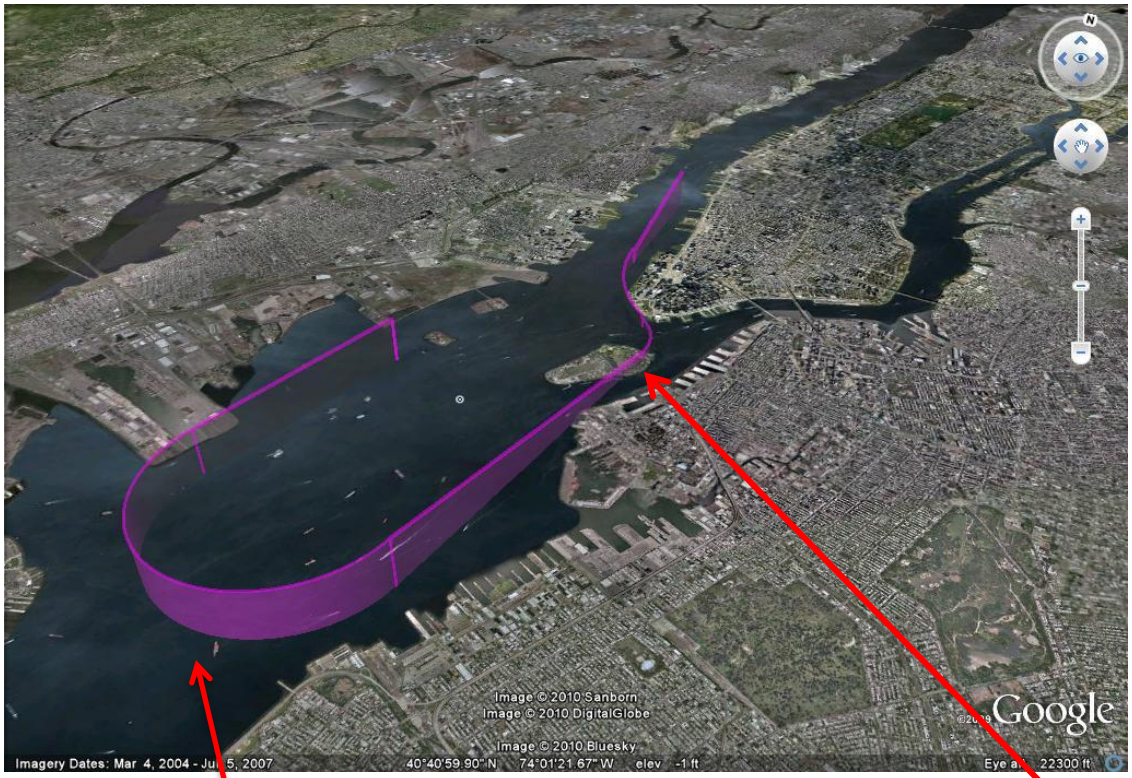
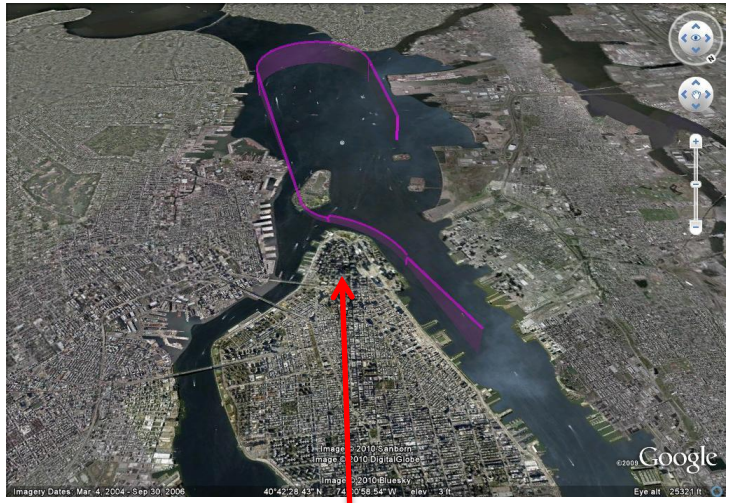
New York City Vertical Flight
WAAS LPV

Honeywell





RF Leg MAP

Vmini 5 deg

RF Leg

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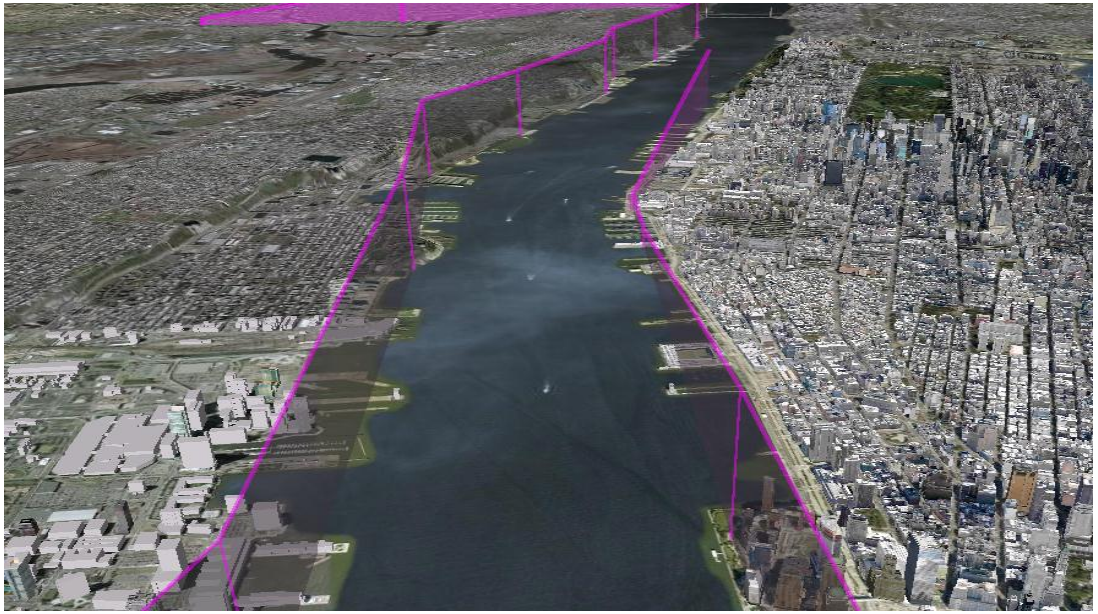
New York City Vertical Flight
WAAS LPV

Honeywell



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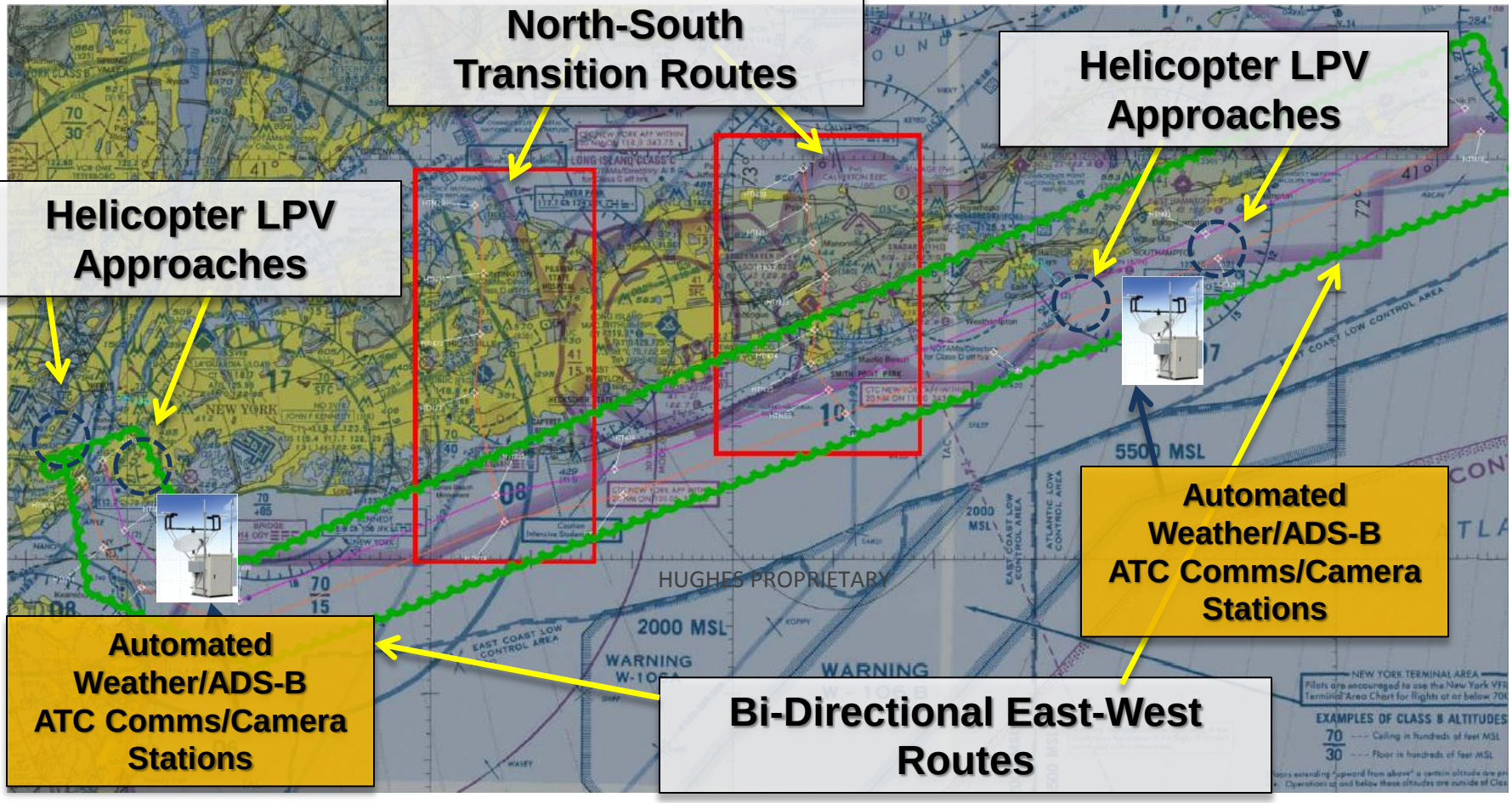
IFR Helicopter Route System

Vertical Flight PBN



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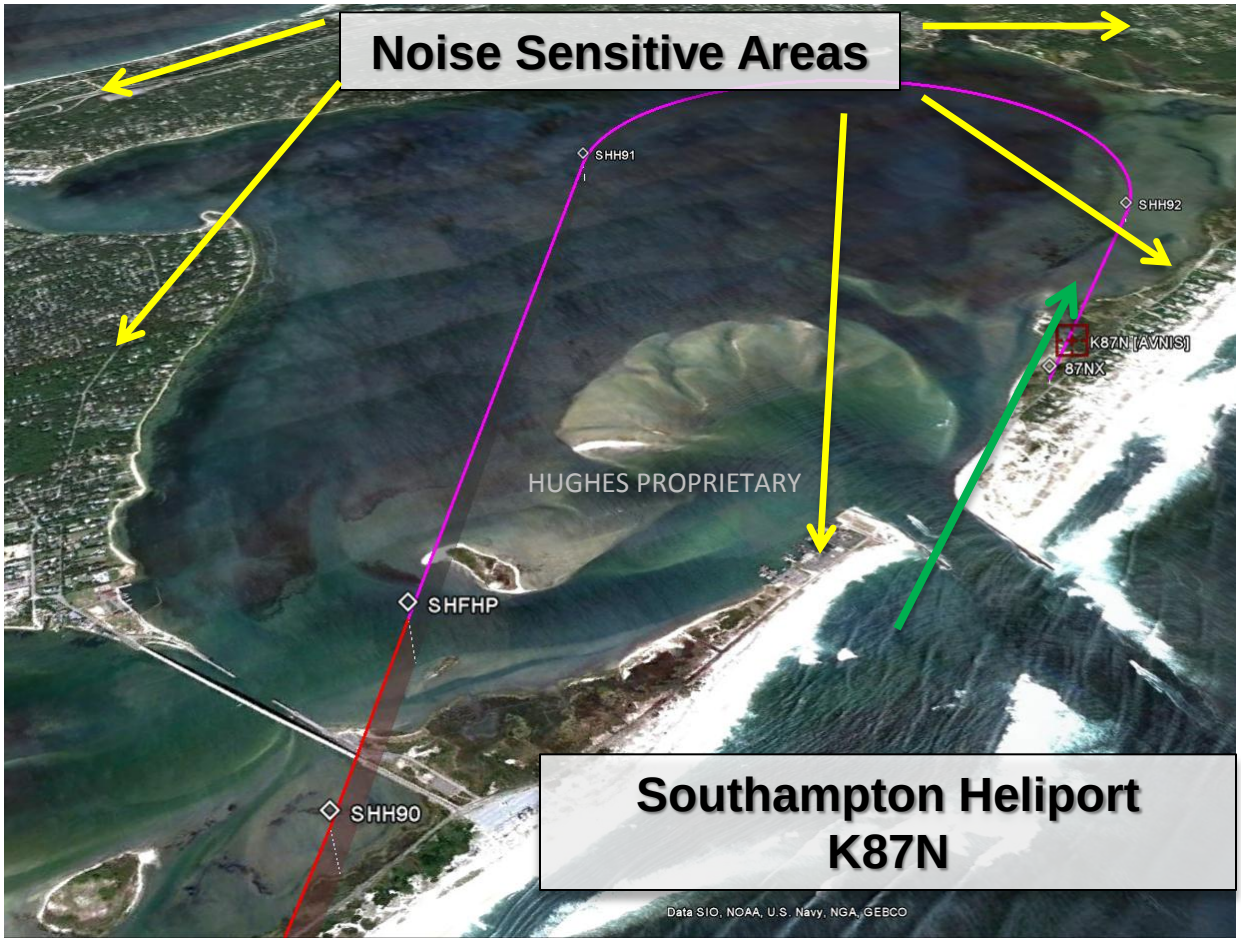
K87N Southampton Heliport
LPV PinS Approach with VAS



K87N Southampton Heliport
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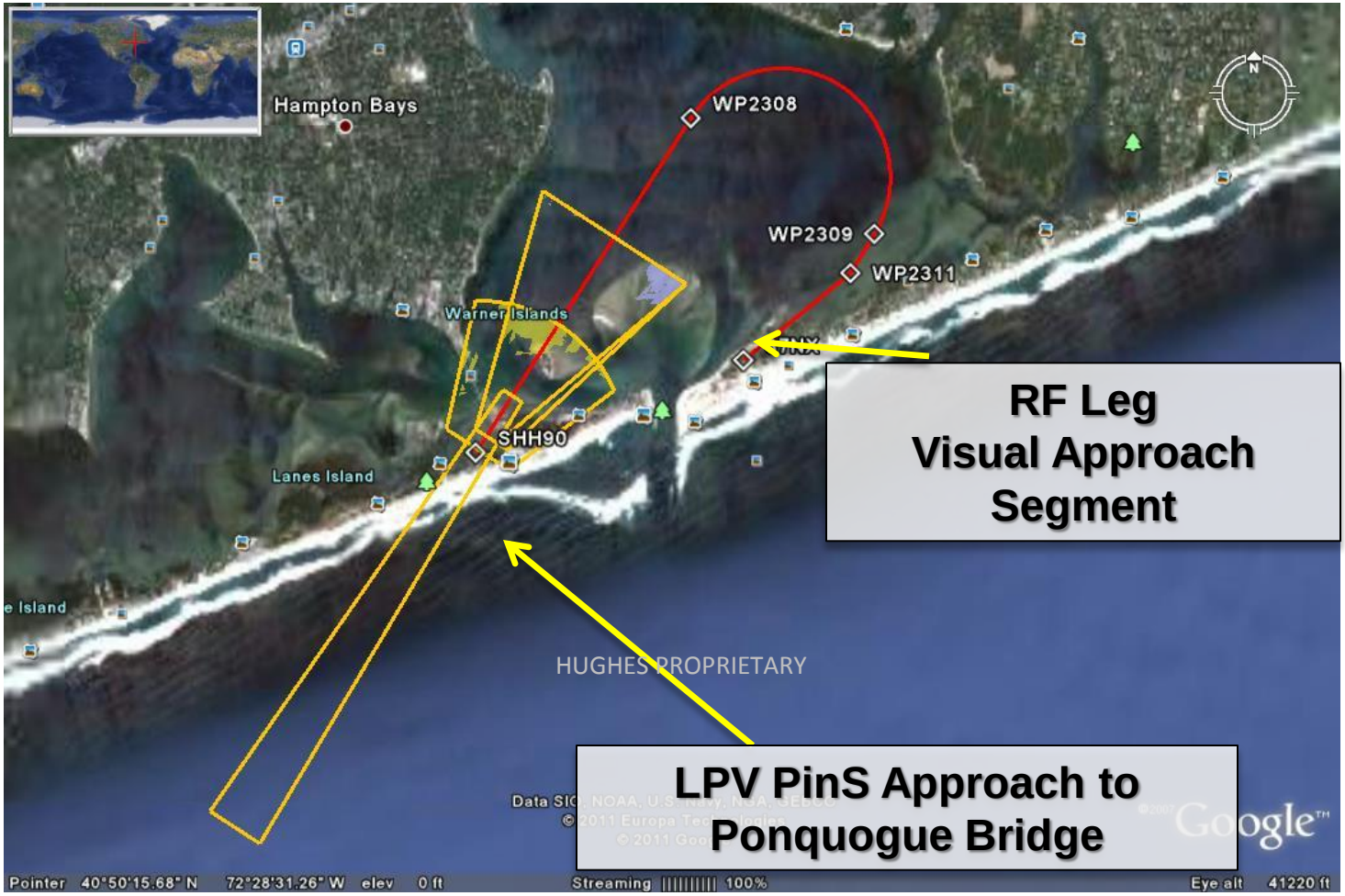


Remote Controlled Tower

Automated Weather, Communications

ADS-B Flight PBN Solutions

- AWOS III w/Dual Pressure Sensor
- RCO – ATC Communications & AWOS Broadcast
- Surveillance – ADS-B – Traffic Display on Website
- (4) Fixed Weather Cameras
- Website & iPhone App
- SWIM Wireless Data Transfer via Harris 802.11
- T1, Internet, SATCOM

- Optional Equipment
- GBAS Facility
- Surveillance Camera
  - Night Vision
  - Infrared
  - Motion Detecting

EMOCS
Emergency Management Operations & Control System

Low Altitude Air Traffic Control	ADS-B Receivers
De-conflict Low Altitude Helicopters	Command & Control Data-link
LPV Approach Surveillance	Monitoring of Mission Priorities
Night Operations for Helicopters	Pilot Access- Wx, Traffic, Obstacles
Radio Bridging with VHF/UHF & P-25	Victim Identification / Medical Needs
Multi-agency Situational Awareness	Use Existing NAS Network

EMOCS
Emergency Management Operations & Control System

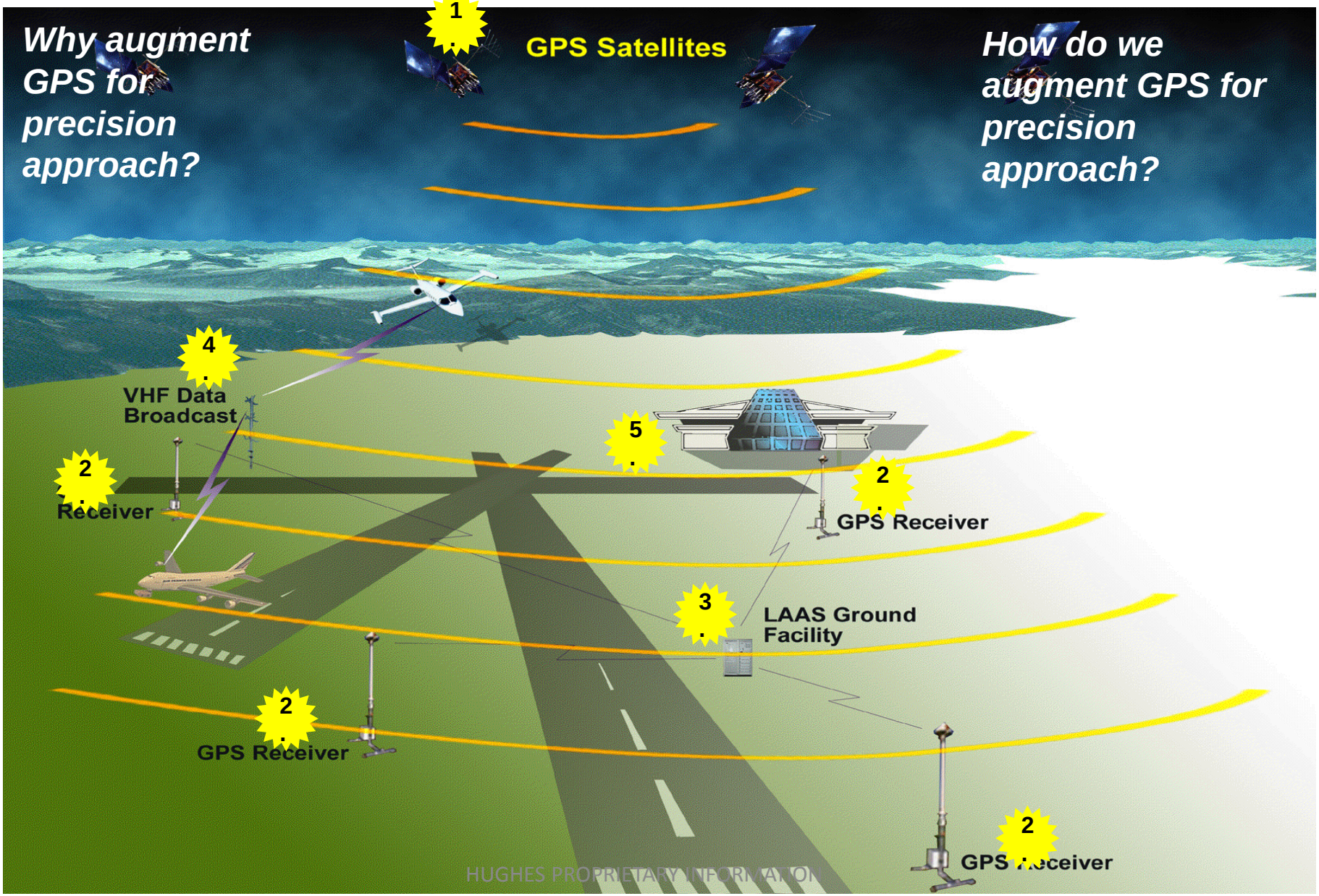
EMOCS provides

- Altitude Air Traffic Control
- De-Confliction between low altitude helicopters
- Night & All-Weather Operations of helicopters
- Radio Frequency Bridging of VHF, UHF, and P-25
- Tactical ADS-B
- Data Link Wireless Satellite Communications via VSAT and 802.11
- Command & Control – Mission Planning, Monitoring, Execution
- Multi Agency access to Weather, Air Traffic, Obstacle and Mapping Data
- WAAS LPV Approach monitoring
- Emergency Medical Facilities
- Automated Weather Observations – AWOS
- Climate controlled Sleeping and Comfort Facilities
- 35 KW Diesel Power Generation
- 51 db sound attenuation
- Internally accessible Reinforced Roof for multiple antenna and satellite dish installations
- Helicopter Transportable
- Ballistic Tolerant Shelter
- Twin 2,438m Slide Outs
- BAE 10 Ton 3 axel all-wheel drive multi-fuel chassis with central tire inflation,

EMOCS is the only self-contained Command, Control and Communications tactical solution capable of maintaining critical government infrastructure during any natural or man-made disaster. Only EMOCS is designed and equipped for multi-agency use and rapid response.

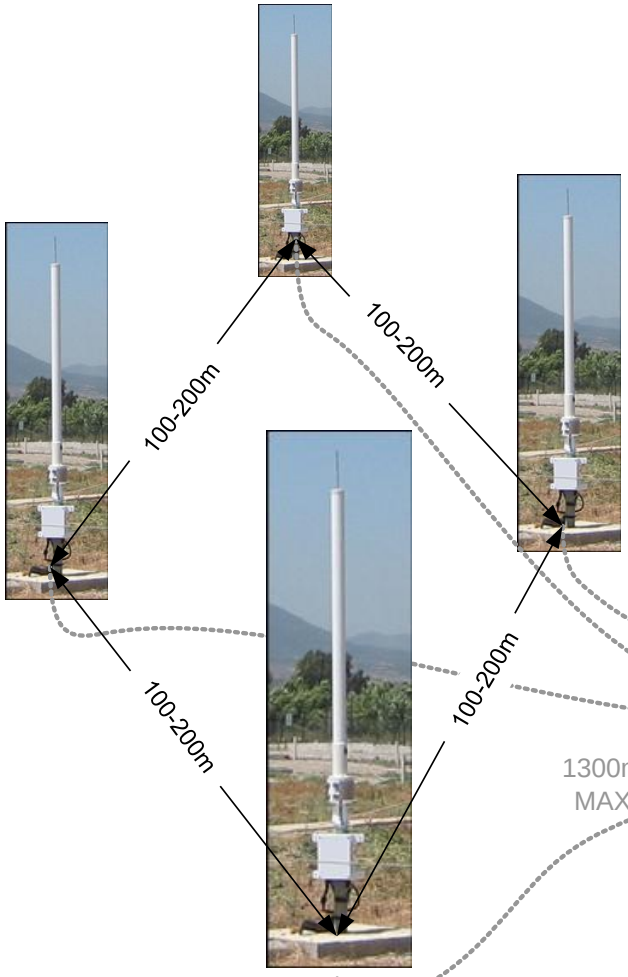
GBAS
Ground Based Augmentation System

GBAS
Ground Based Augmentation System



Ground Based Augmentation System
Honeywell SmartPath GBAS

Honeywell



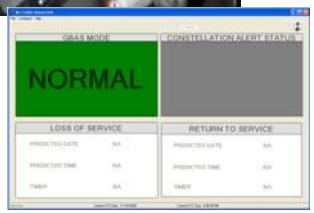
Dual Processor Channels

- Differential Corrections
- Overall System Integrity
- Approach Database
- Redundant Channel

VHF Broadcast

- Corrections, Integrity, Approaches
- Horizontally Polarized, Omni-Directional
- 108-118 MHz
- 2 TDMA Time Slots (typ.)
- 2 Hz Corrections
- Redundant Radio

200m MAX



Airport LAN

Maintenance Data Terminal

- System Status, Mode, Control
- System Alerts, Alarms
- Approach Control

Air Traffic Status Unit

- System Mode
- System Availability

Reference Receivers

- Multipath Limiting Antenna (MLA)
- Narrow Correlator GPS Receiver
- 2 Hz Measurements
- 4 Receivers (incl one Redundant Receiver)

TDMA – Time Division Multiple Access
Hz – Hertz
LAN – Local Area Network (typ. Ethernet)

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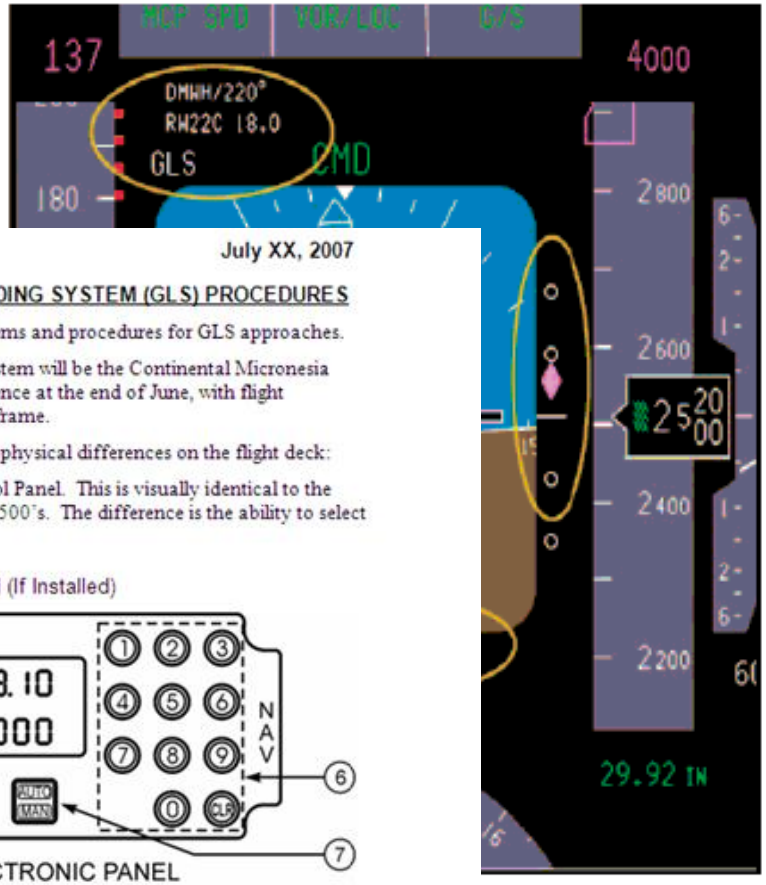
ILS Clear Zones - Eliminated

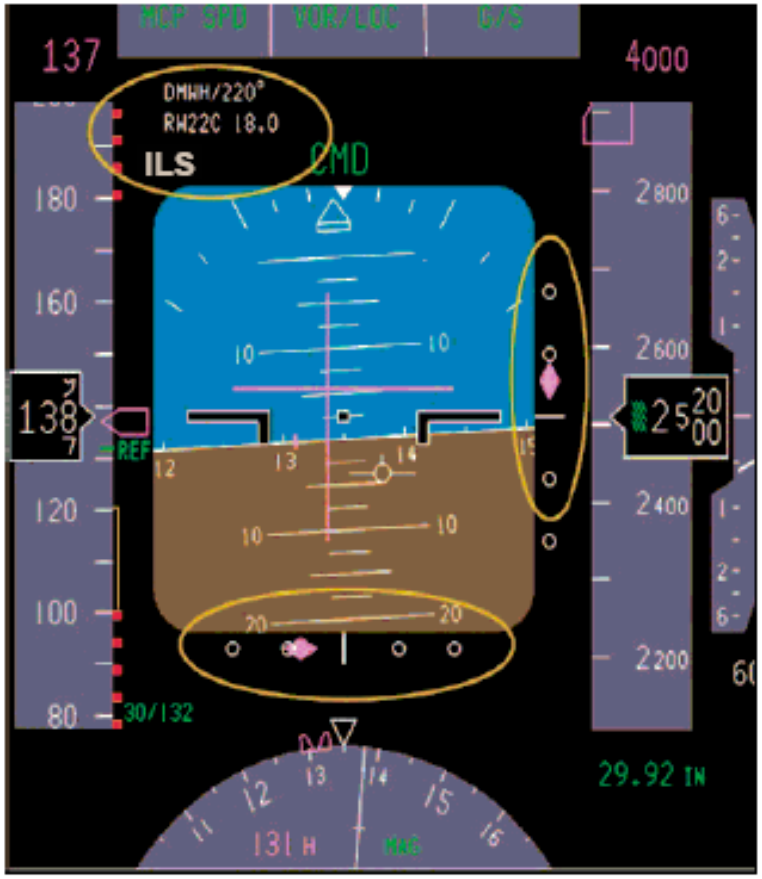
SmartPath GBAS Technology

Honeywell

Ease of Pilot Training
SmartPath GBAS Technology

Honeywell





737-07-XX July XX, 2007

GLOBAL POSITIONING LANDING SYSTEM (GLS) PROCEDURES

This bulletin describes aircraft systems and procedures for GLS approaches.

The initial aircraft to obtain this system will be the Continental Micronesia 737-800's. Installation will commence at the end of June, with flight procedures to begin in the fall timeframe.

The aircraft will have the following physical differences on the flight deck:

1. Multi-Mode Navigation Control Panel. This is visually identical to the panel currently installed in the 500's. The difference is the ability to select GLS frequencies.

Multi – Mode Navigation Control (If Installed)

AFT ELECTRONIC PANEL

7376-11005

- Active (ACT) Mode and Frequency Indicator
  Indicates the active mode and frequency.
- Transfer Switch

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Variable Geometric Paths
SmartPath GBAS Technology

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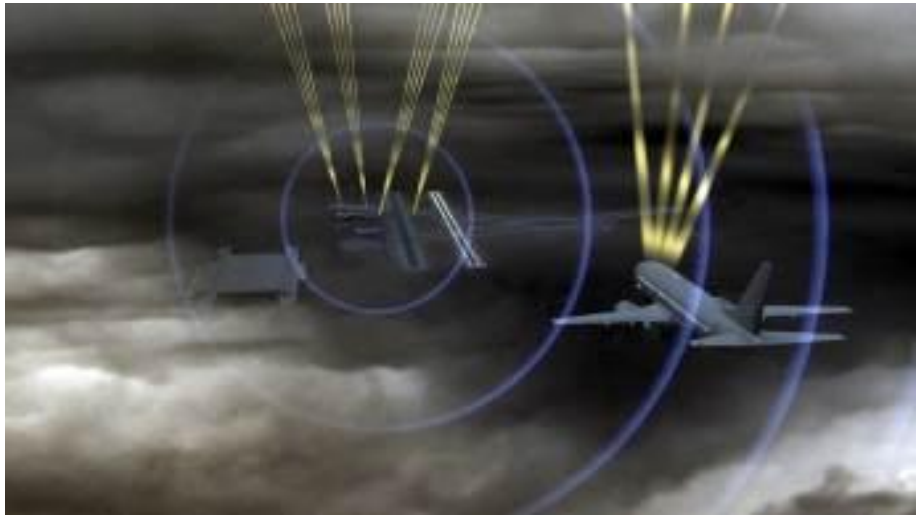
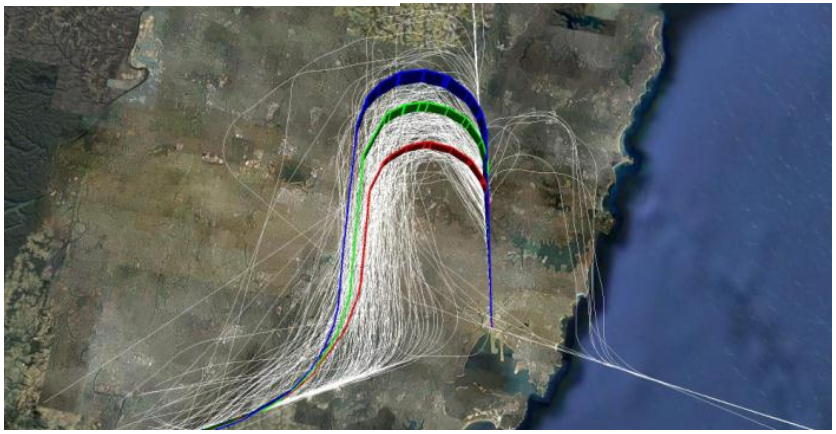
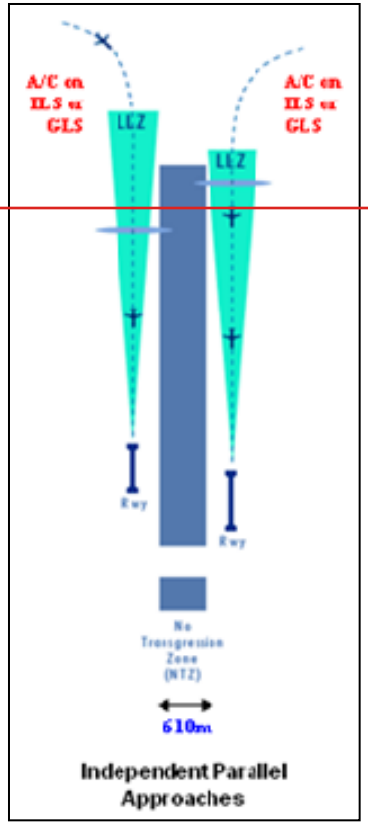


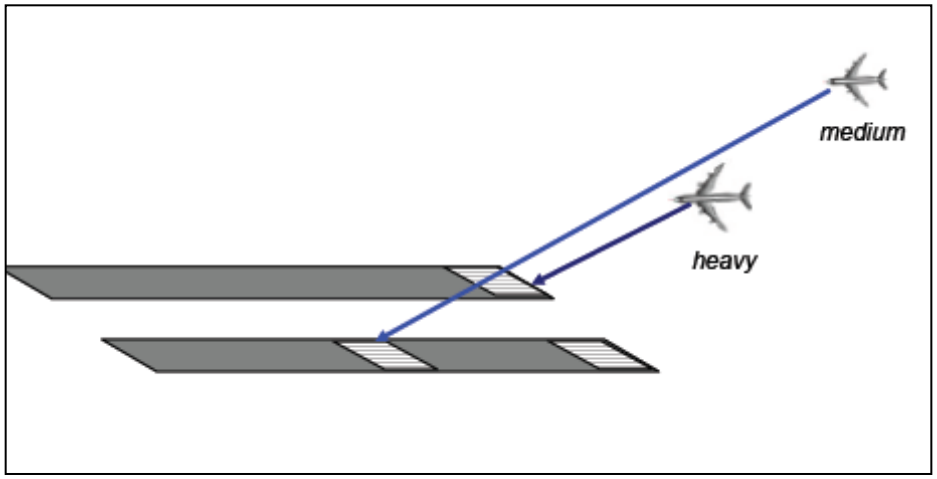
Improve traffic separation using variable geometric path technology

Sydney Australia
GBAS PHASE 3

Honeywell







Proof of concept of advanced GBAS procedures (beyond ILS overlays) & benefits validation

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The Brisbane Trial

Noise Footprint

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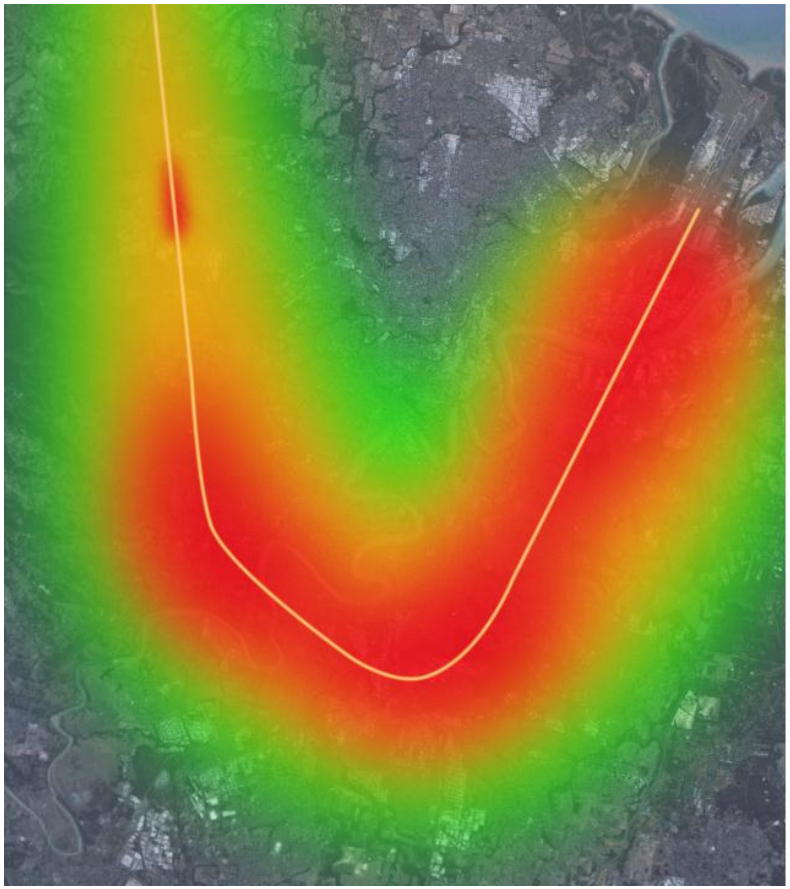
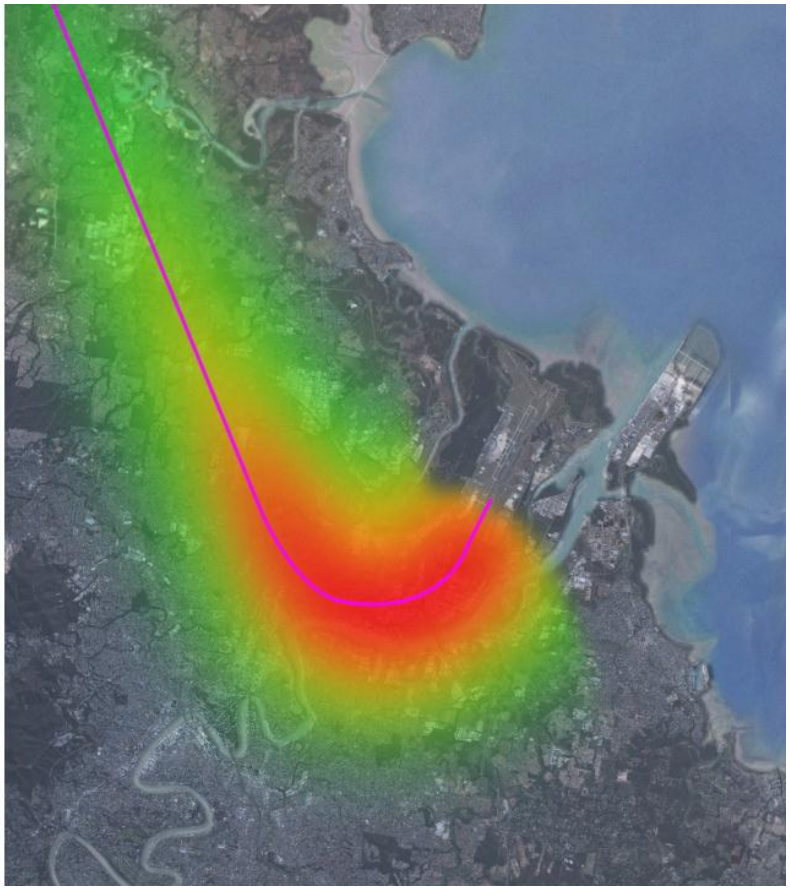


Standard ILS Approach



Multi-Mode Approach to 4 nm
GLS Precision Approach

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Honeywell GLS SmartPath System

GLS Capabilities: Definable Touchdown Point

Honeywell

An ILS system provides a single fixed vertical path. GBAS provides a variable precision path that allows an airport to perform routine maintenance on any runway without unnecessary runway closure while supporting traffic separation.

Honeywell GLS SmartPath System

GLS Capabilities: Definable Glide Path Angle

Honeywell

GBAS provides a variable geometric path that supports enhanced traffic and wake turbulence separation.

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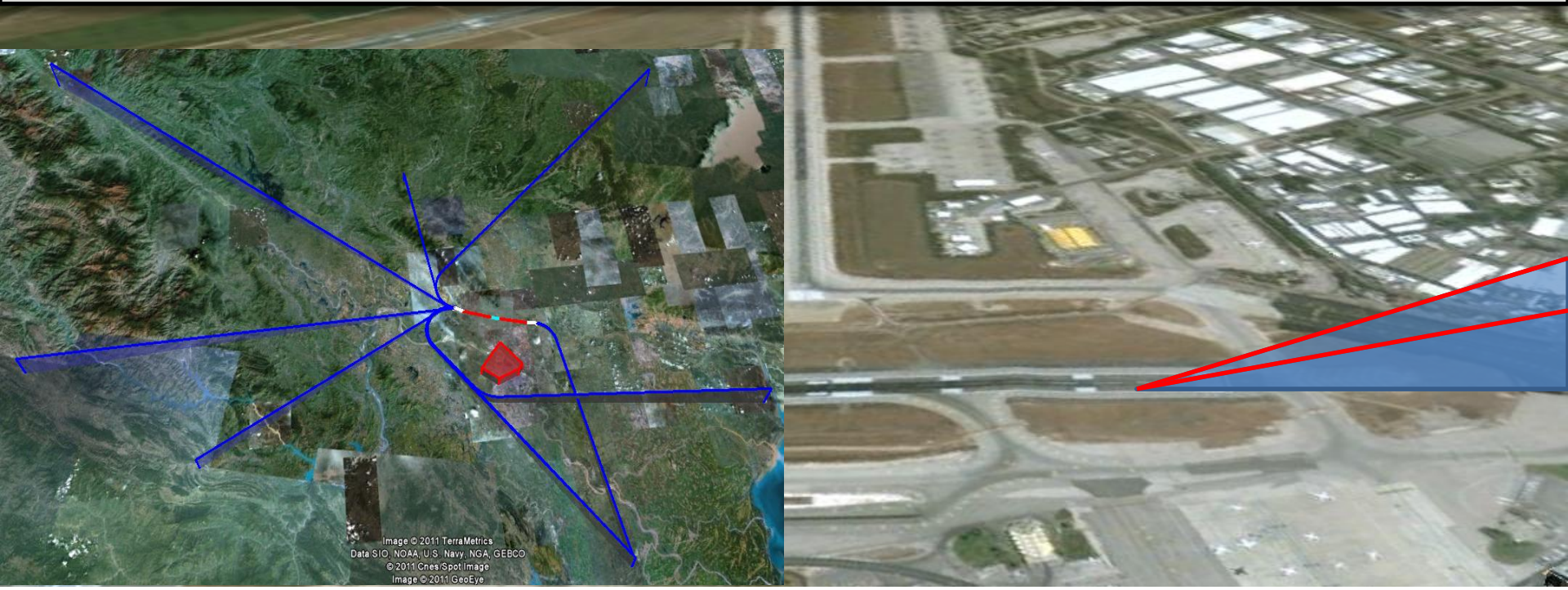
Fusion of GBAS & RNP

The Last 250’

Honeywell

RNAV (RNP) & Honeywell GLS SmartPath System Complementary Systems providing MAXIMUM Benefits to States, Airports and Operators

RNP and GLS are not an either/or system. Instead a combination of these two technologies will provide systemic benefits that are unparalleled in aviation.



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Multiple TDZ
SmartPath GBAS Technology

Honeywell

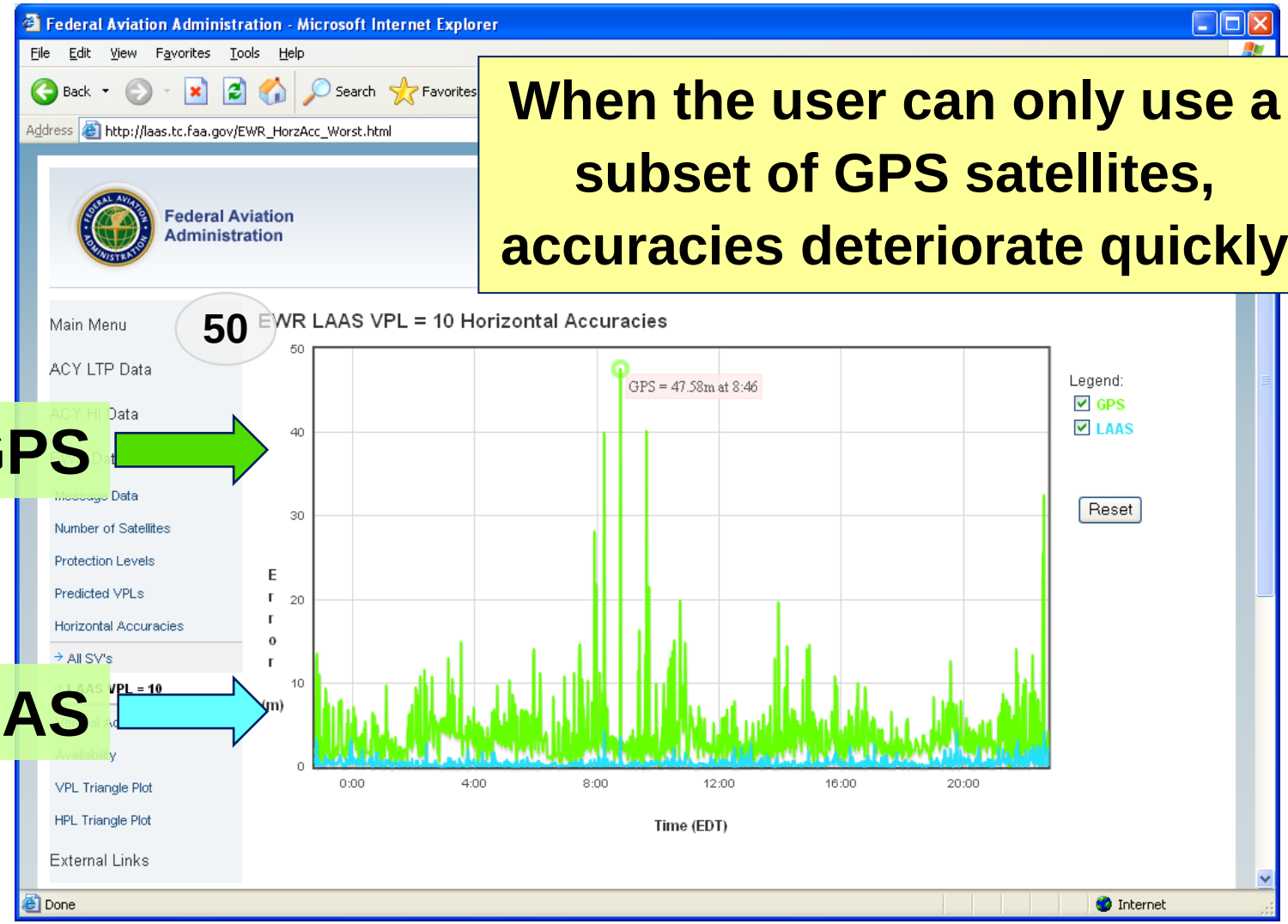
Honeywell SmartPath System

GLS Capabilities: Definable Touchdown Point

An ILS system provides a single defined vertical path that places the aircraft at the same point on the runway each landing. However, SmartPath GLS approaches can provide variable geometric paths and multiple touchdown points to the same runway.

Horizontal Accuracy
Newark Site – Subset

When the user can only use a subset of GPS satellites, accuracies deteriorate quickly

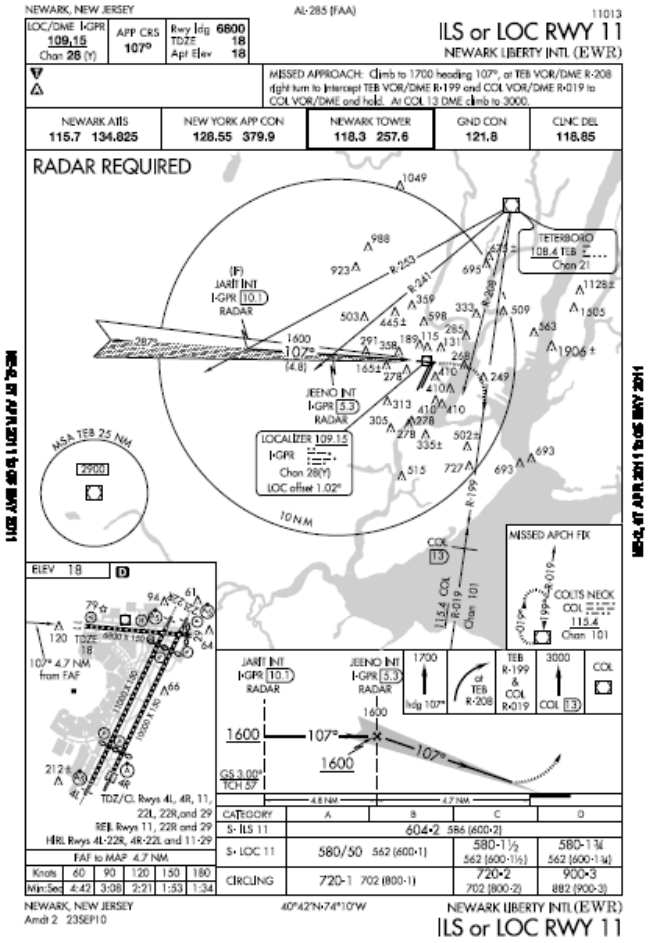


GPS

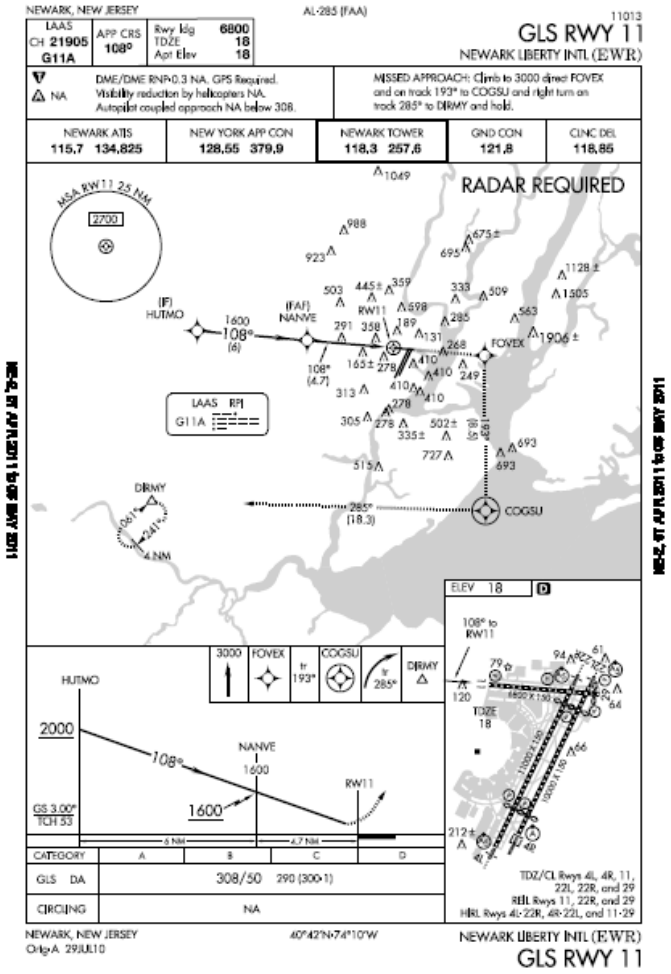
GBAS

Newark Liberty International Airport
GBAS GLS

Honeywell



Improved Access
Lower Minimums



ILS RW 11 580’/5000

GLS RW 11 308’/5000

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Current ILS
Lateral Separation

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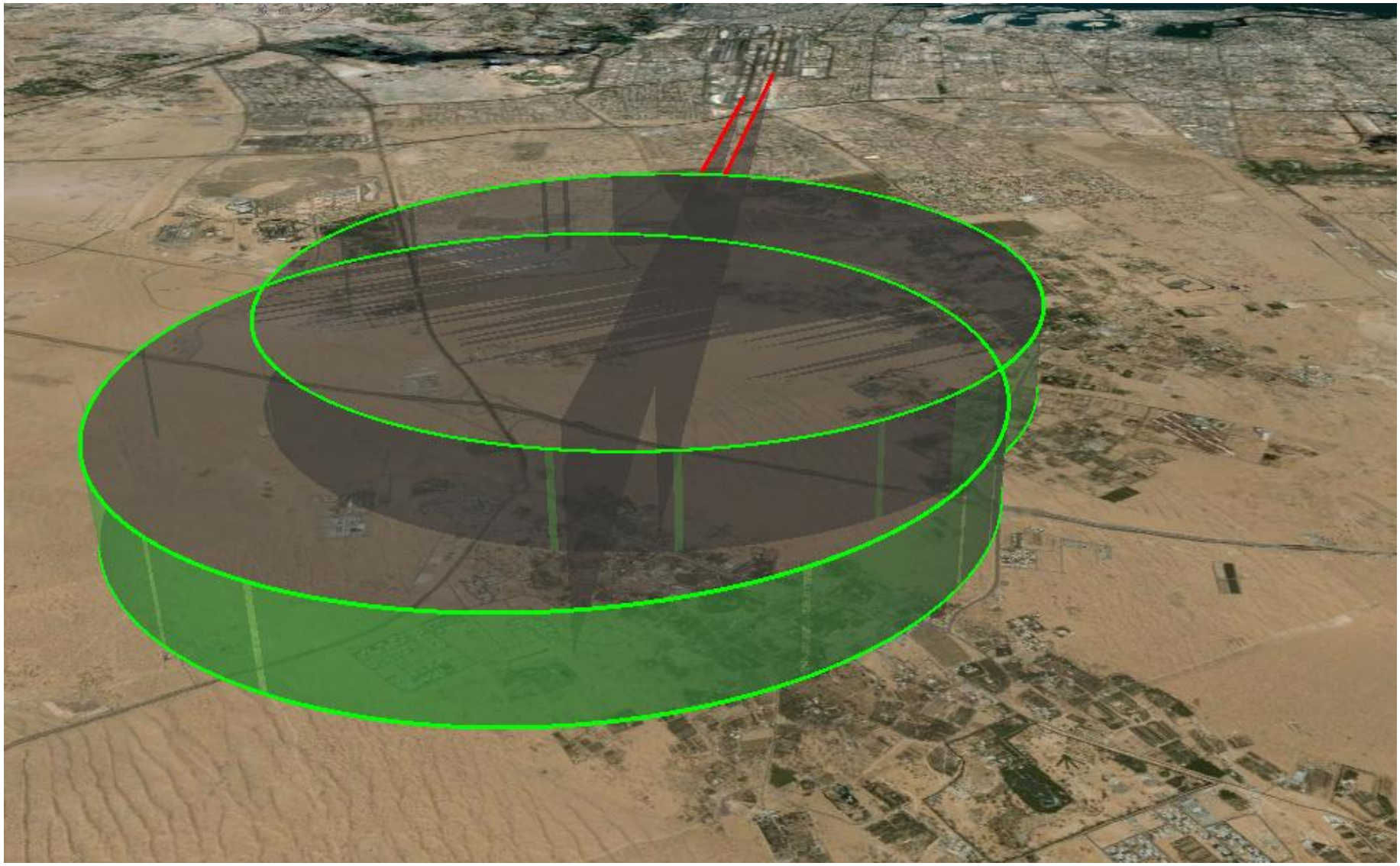

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GLS
Vertical Separation

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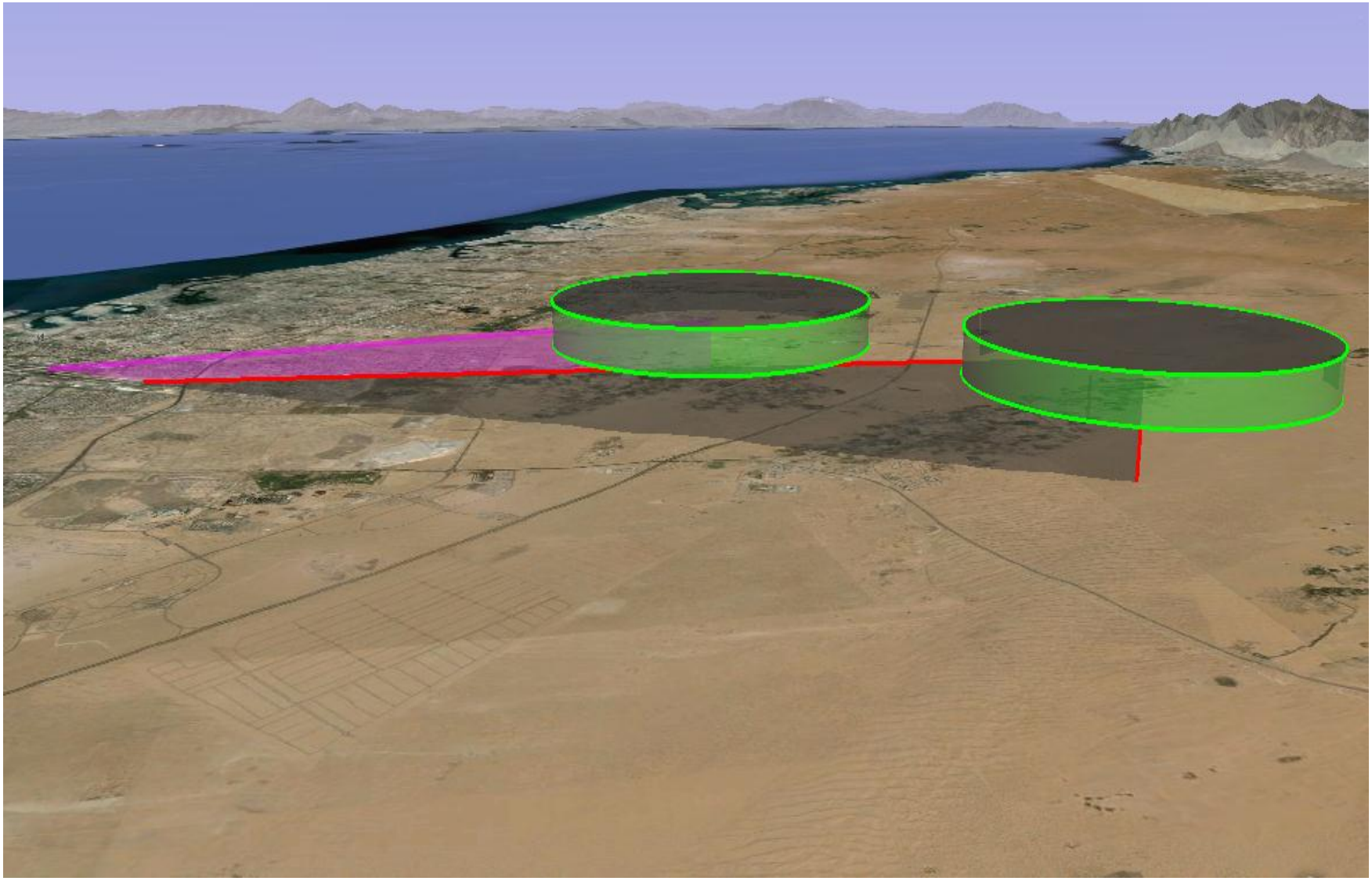

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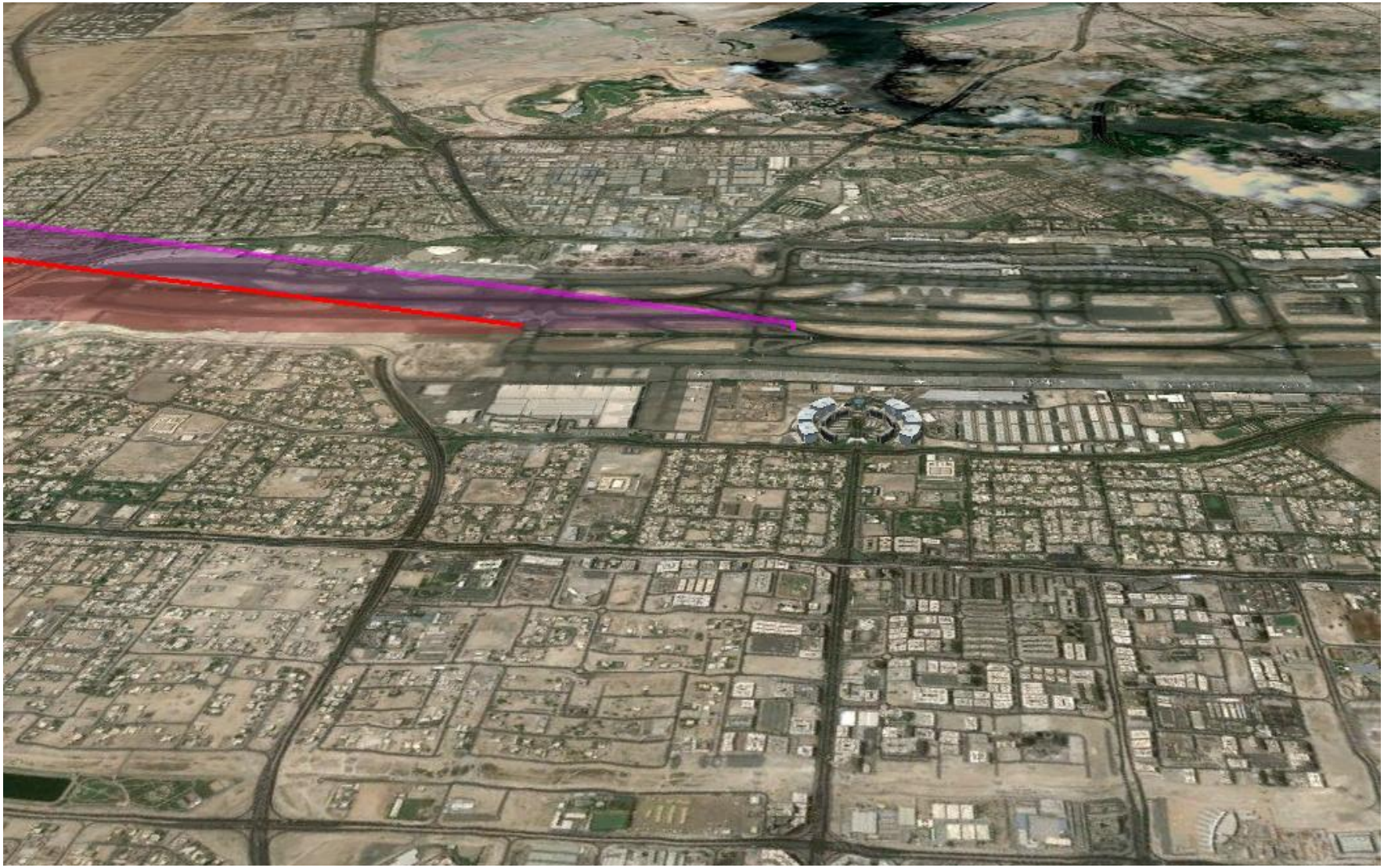
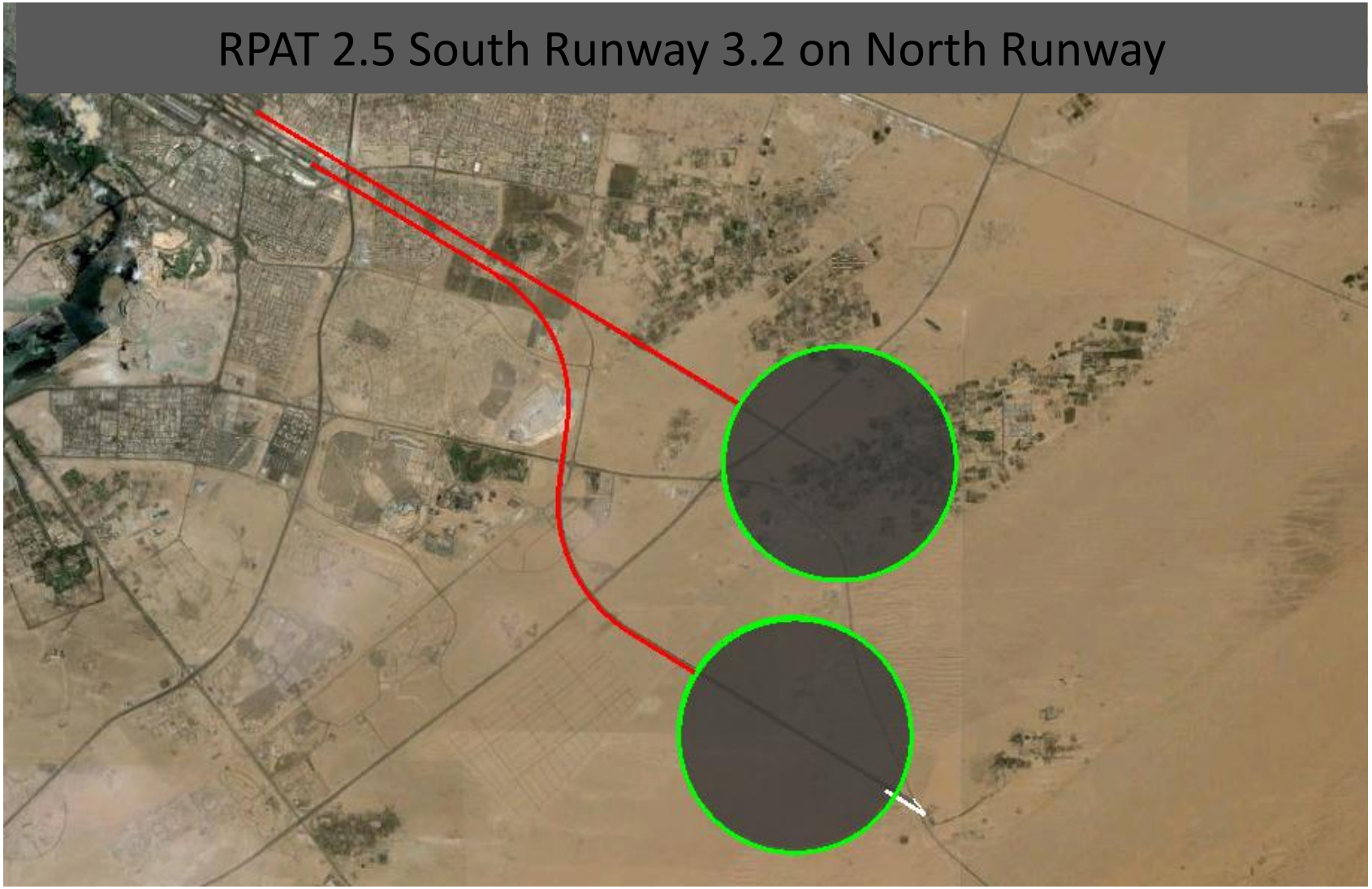
GLS
Vertical Separation

Honeywell



GLS
RPAT – Variable Azimuth Glide Slope



Questions
Discussion