

GPS – Benefits for Aviation

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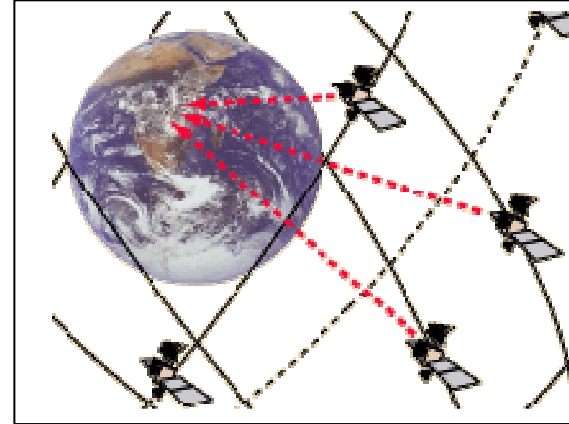
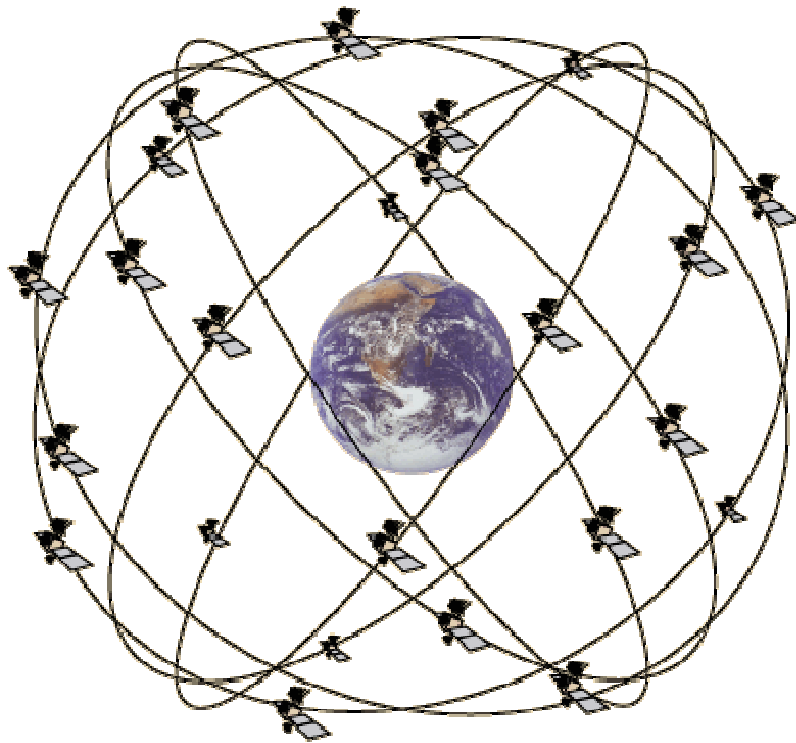
United Airlines



How does GPS benefit Aviation?:

- Precision Navigation = MORE CAPACITY, MORE ALL WEATHER OPS
- Precision Timing = BETTER FLOW MANAGEMENT, COMMON TIME PLATFORM
- Position awareness = SAFETY
- Repeatability =
 - Reduced fuel burn
 - Reduced block times

GPS Description

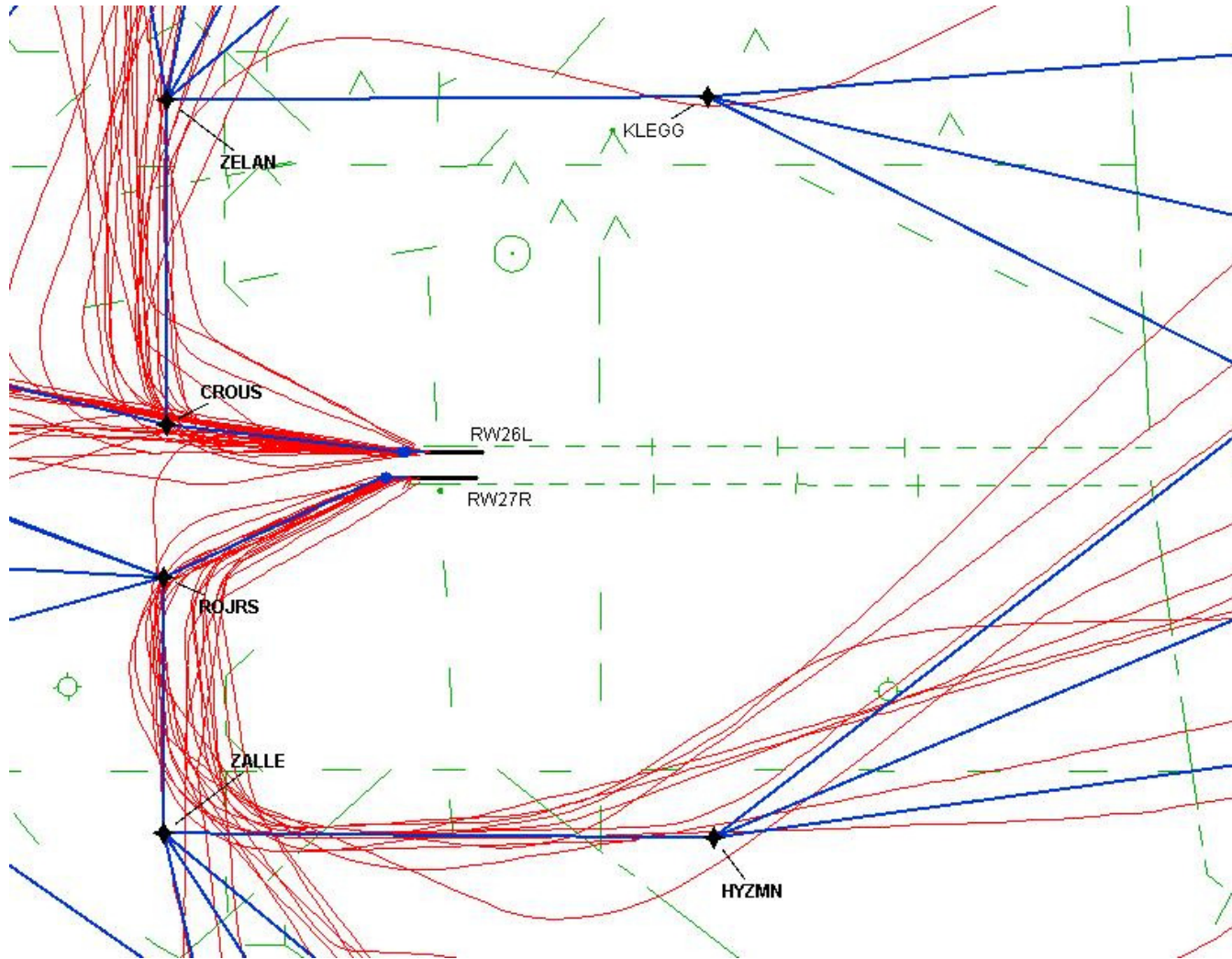


The 24 satellites of the [GPS](#) are placed in orbits at about 3.75 times the radius of the Earth (11000 nm). A [GPS receiver](#) can [triangulate](#) its position on the Earth's surface within 30 meters or less with signals from three of the satellites. The satellites are arranged in six orbital planes with four satellites in each plane. Single frequency receiver, 5 degree mask angle

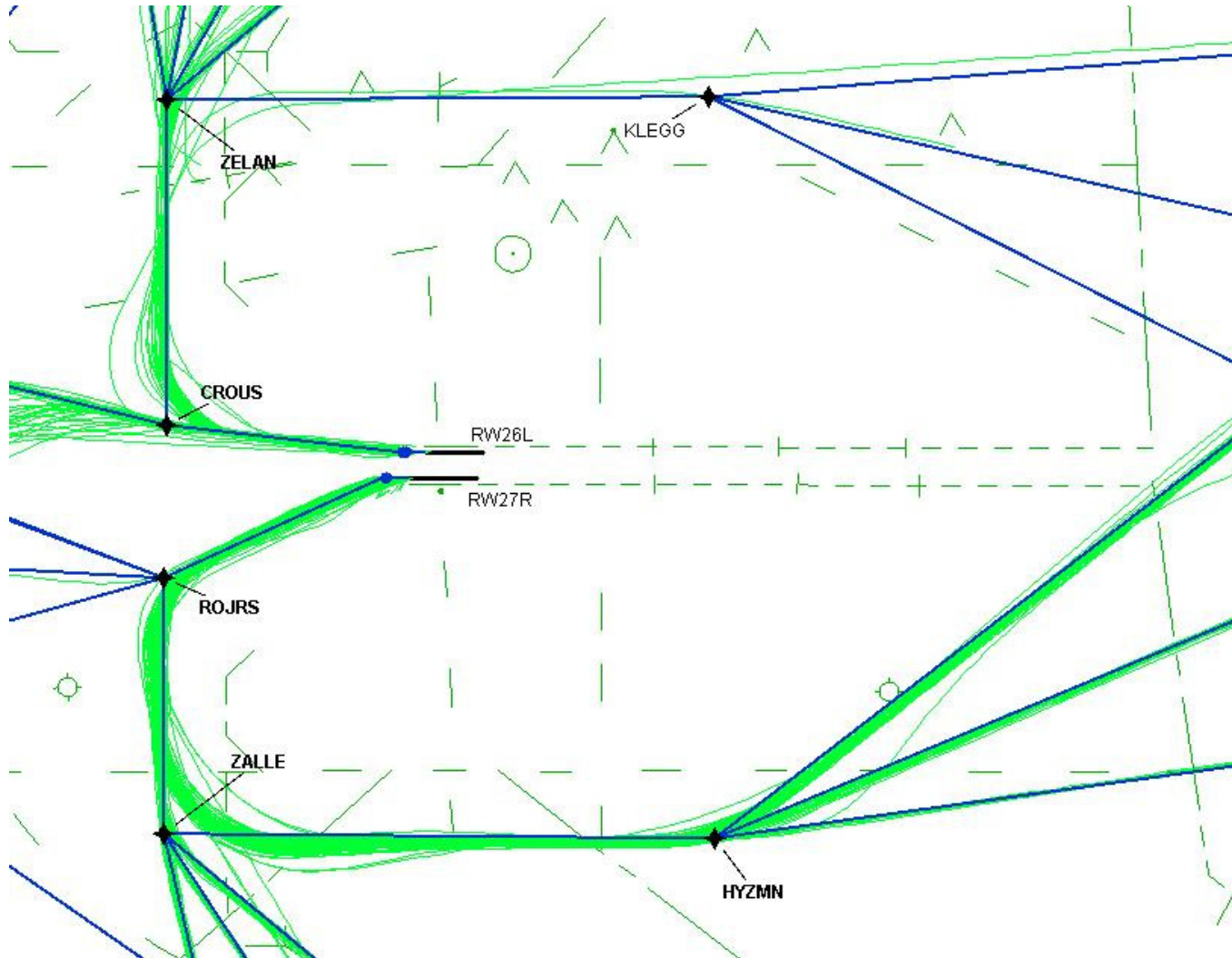
How can we use GPS today?:

- **Area Navigation (RNAV)**
- **Required Navigation Performance (RNP)**
- **Position and event reporting**
- **Common Timebase**
- **Surface Moving Map**
- **Runway Awareness and Advisory System (RAAS)**
- **Automatic Dependent Surveillance (FANS, ADS-B)**

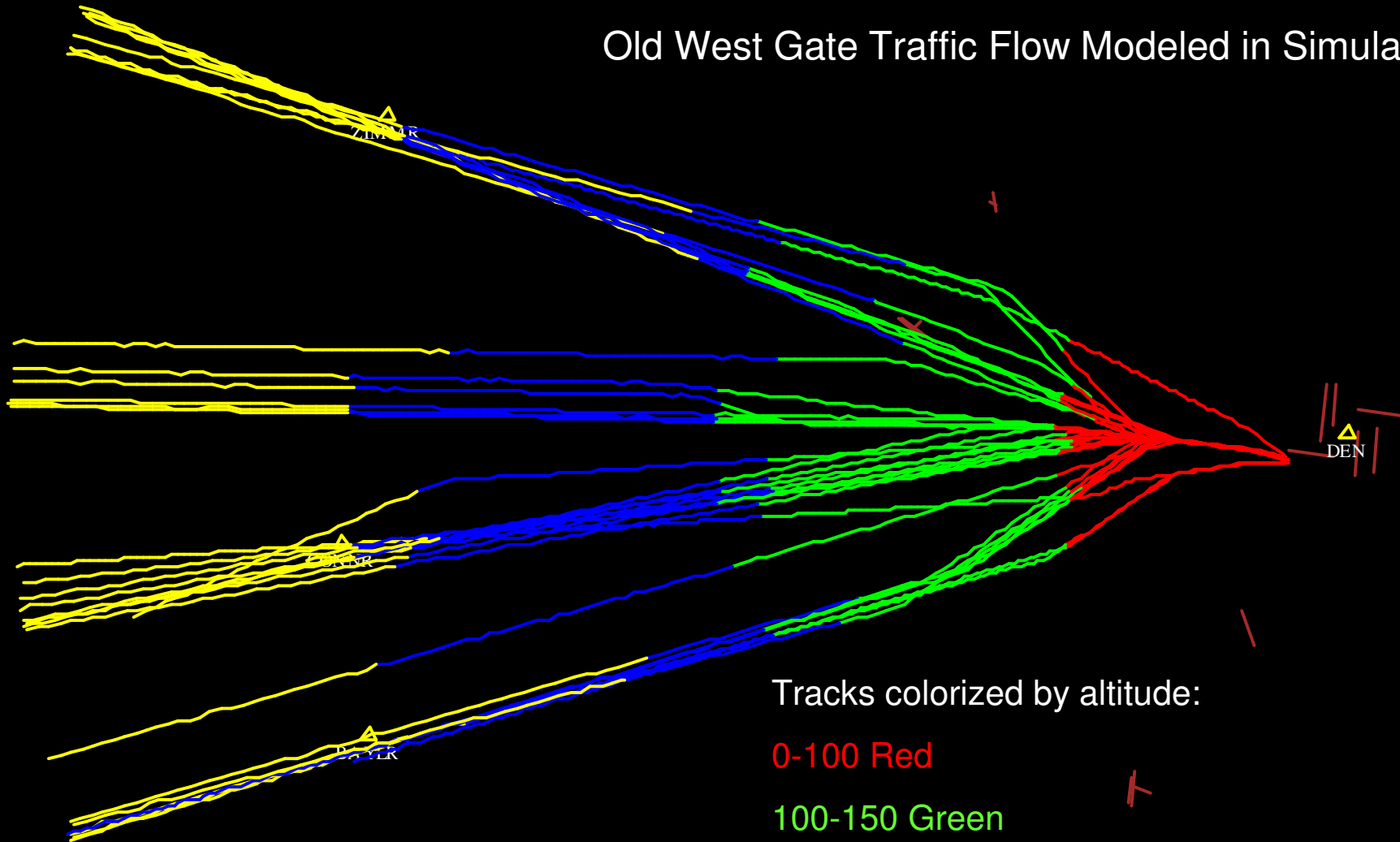
ATL Non RNAV Tracks



ATL with RNAV Tracks



Old West Gate Traffic Flow Modeled in Simulation



DR1_RWY
ETG

Tracks colorized by altitude:

0-100 Red

100-150 Green

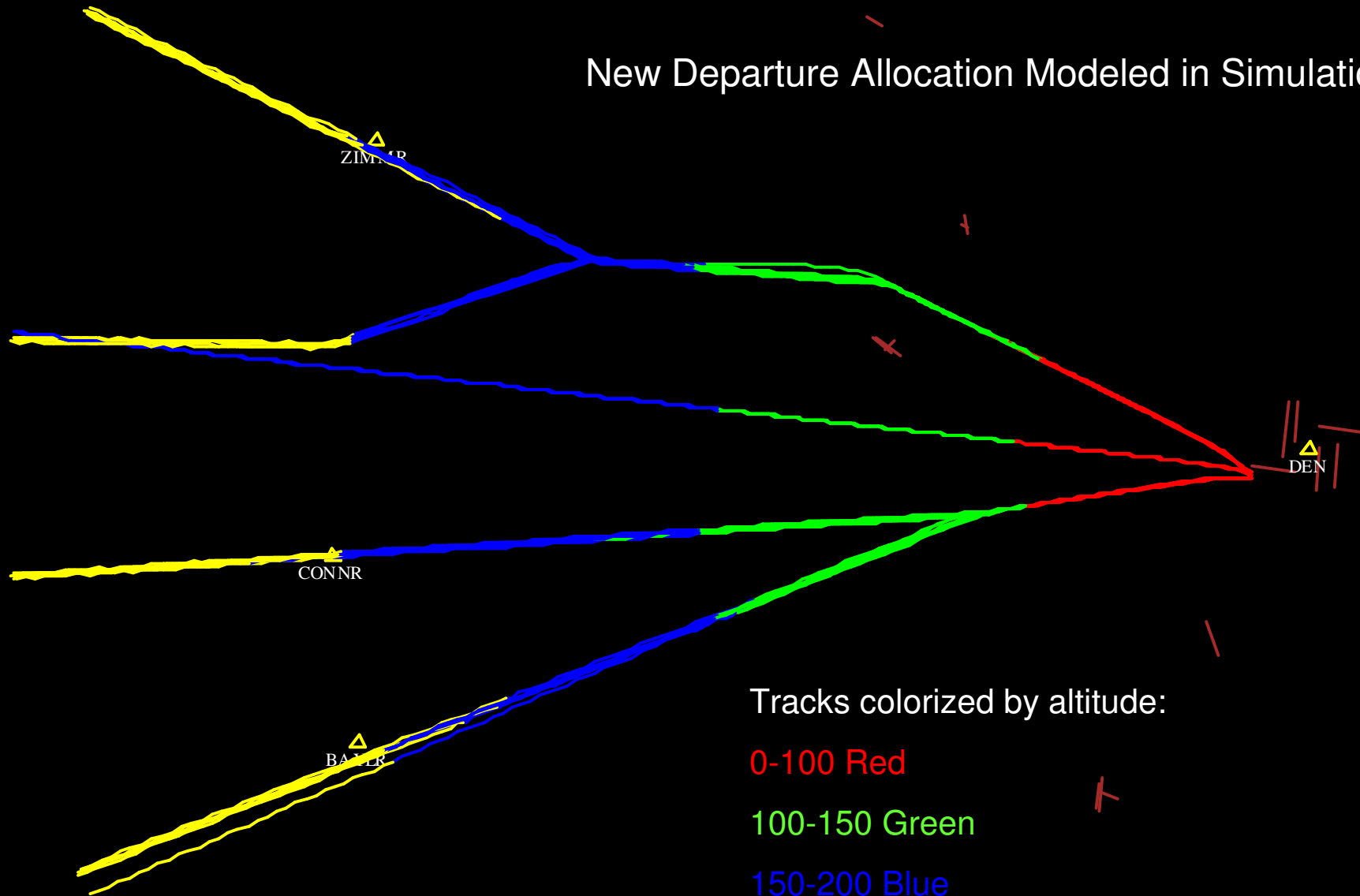
150-200 Blue

200-250 Yellow

250+ Grey



New Departure Allocation Modeled in Simulation



ZIMMER

CONNR

BAUER

DEN

DR1_RNAV
ETG

Tracks colorized by altitude:

0-100 Red

100-150 Green

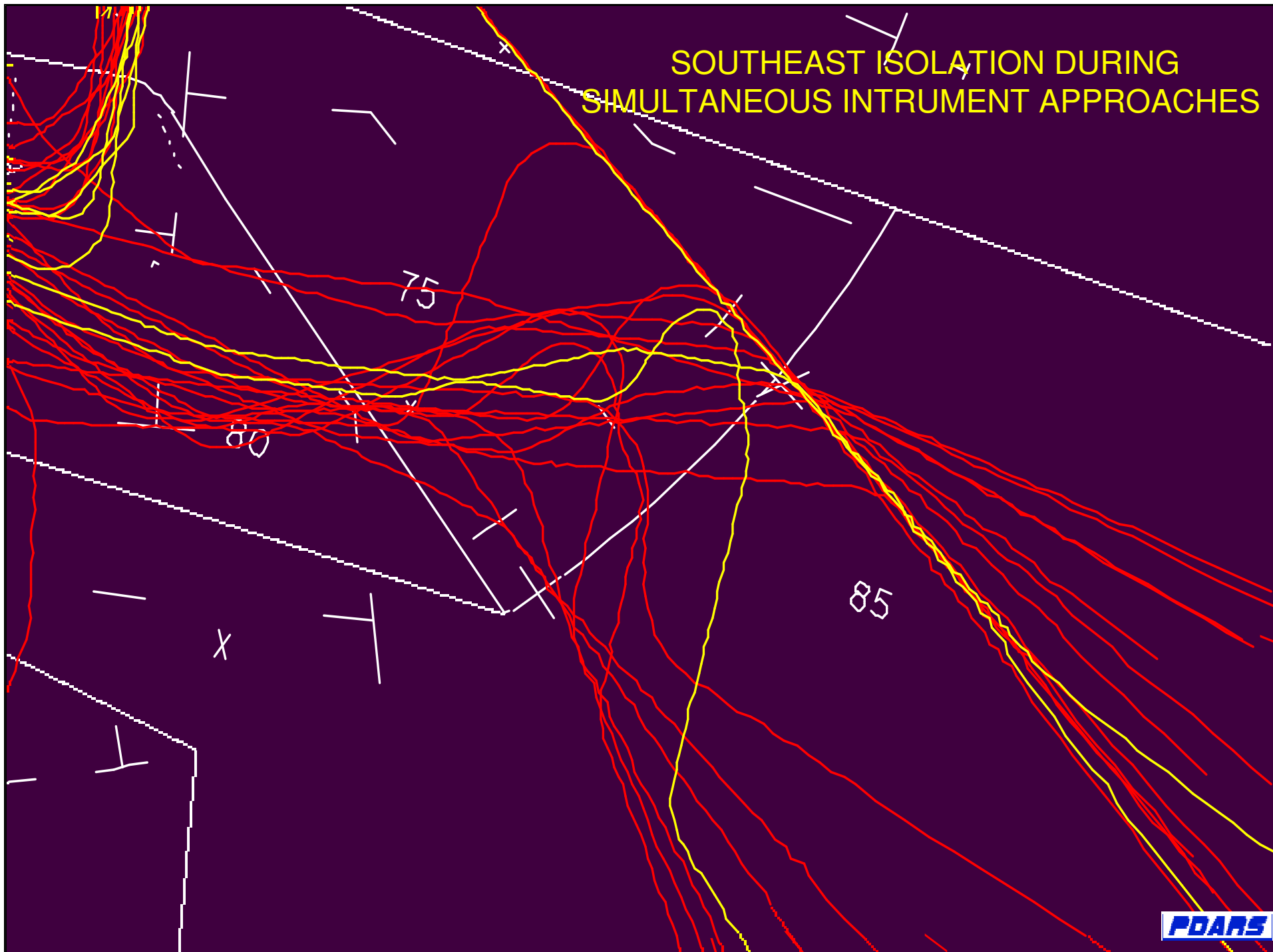
150-200 Blue

200-250 Yellow

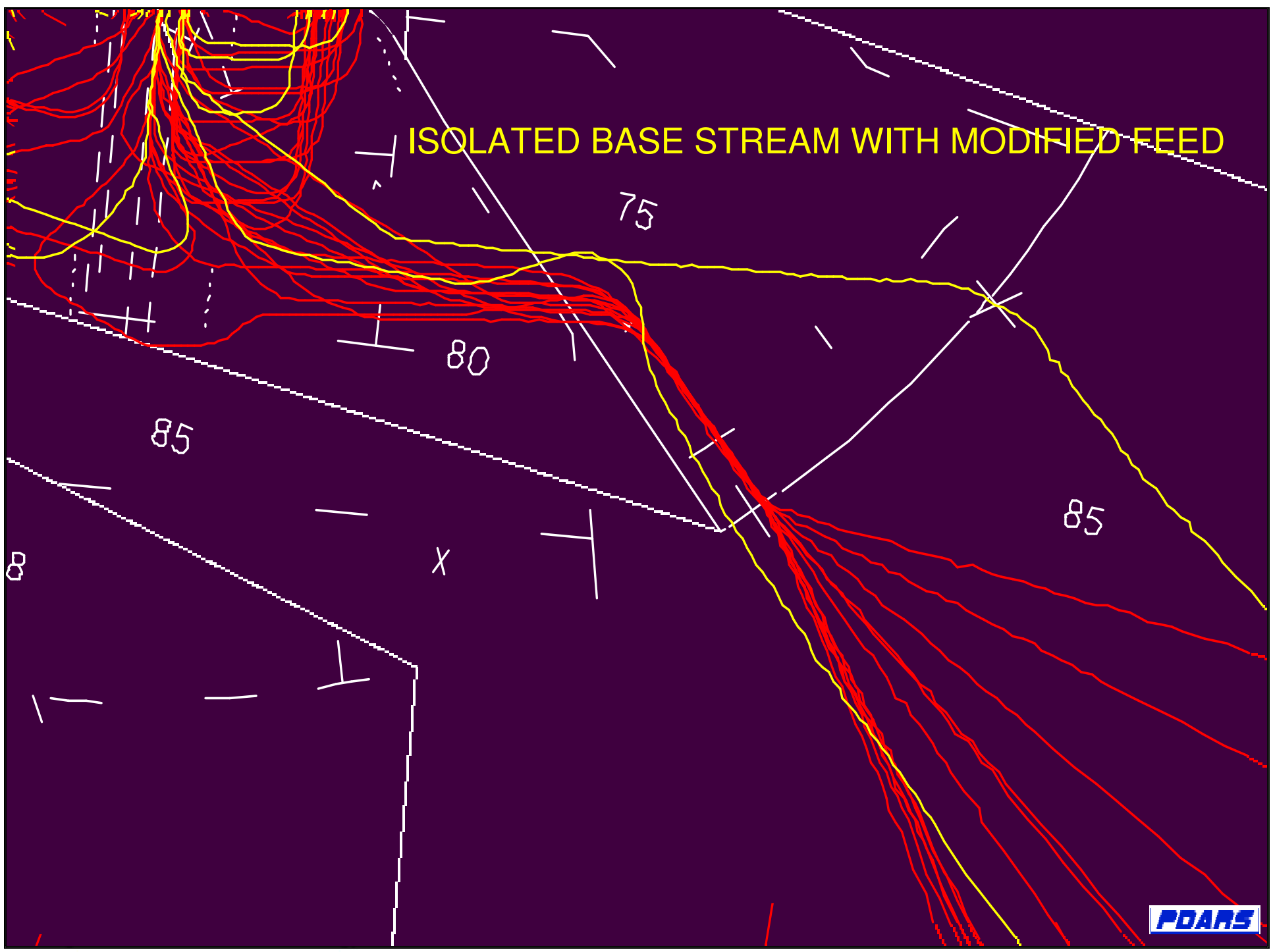
250+ Grey



SOUTHEAST ISOLATION DURING SIMULTANEOUS INSTRUMENT APPROACHES



ISOLATED BASE STREAM WITH MODIFIED FEED



Simultaneous Offset Instrument Approaches SOIA at SFO

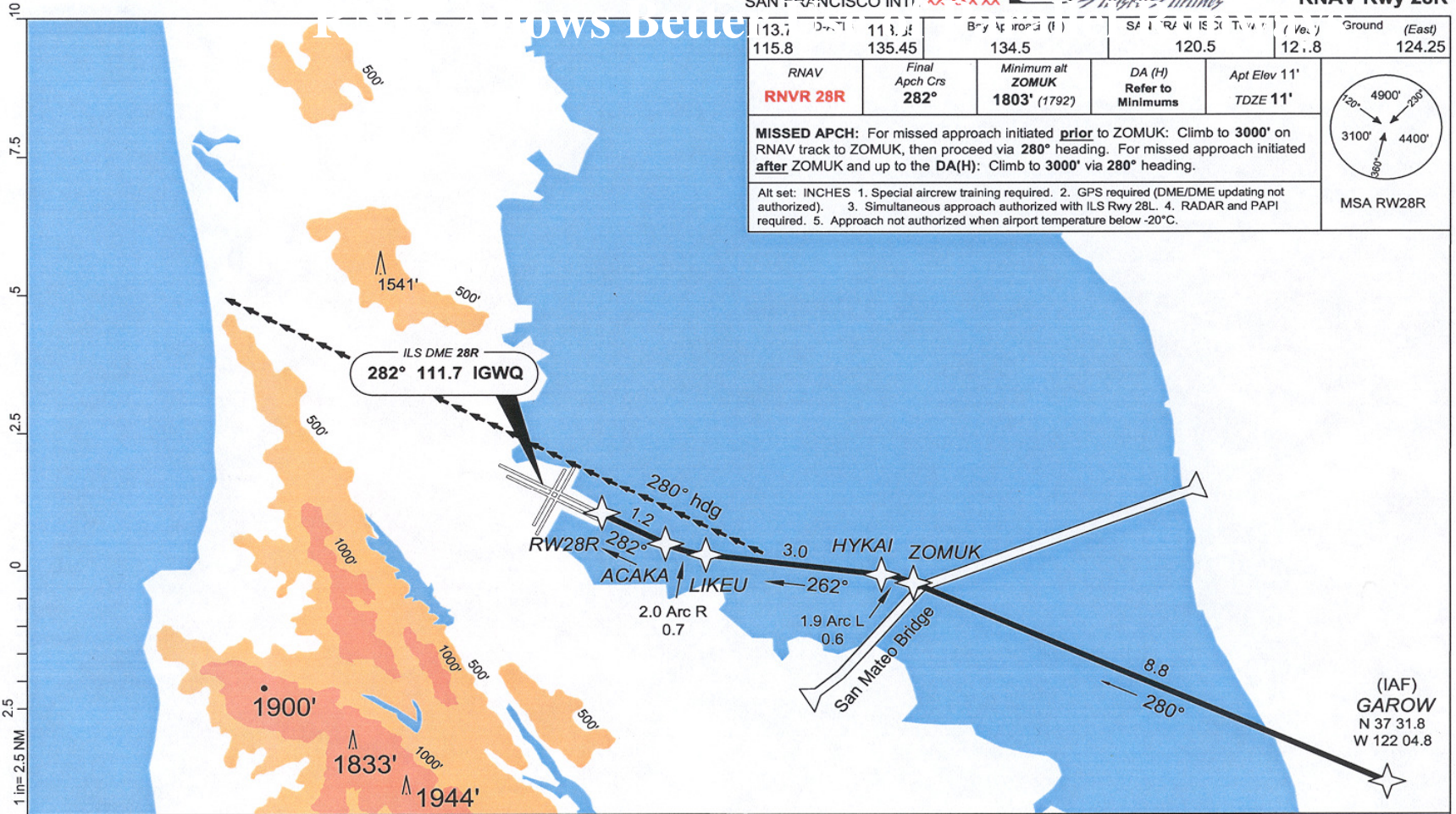


SFO 28L

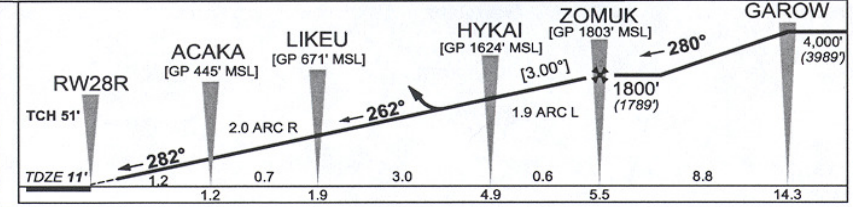
- Allows 3400' Parallels
- Visual after that
- 25% Arrival rate increase over single runway option
- Will allow dual runway operations to 2,100 foot ceilings initially, later to 1,600 feet, & visibility of 4 miles
- Began 10/26/04

KSFO SAN FRANCISCO INTL. **EFFECTIVE 19-XX** *Alaska Airlines* SAN FRANCISCO, CALIF **RNAV Rwy 28R**

113.7	113.9	113.9	134.5	120.5	12.8	Ground (East)	124.25
RNAV RNV 28R		Final Apch Crs 282°	Minimum alt ZOMUK 1803' (1792)	DA (H) Refer to Minimums	Apt Elev 11'	MSA RW28R	
<p>MISSED APCH: For missed approach initiated prior to ZOMUK: Climb to 3000' on RNAV track to ZOMUK, then proceed via 280° heading. For missed approach initiated after ZOMUK and up to the DA(H): Climb to 3000' via 280° heading.</p> <p>Alt set: INCHES 1. Special aircrew training required. 2. GPS required (DME/DME updating not authorized). 3. Simultaneous approach authorized with ILS Rwy 28L. 4. RADAR and PAPI required. 5. Approach not authorized when airport temperature below -20°C.</p>							



STRAIGHT-IN LANDING RWY 28R - LNAV / VNAV					
RNP 0.11		RNP 0.20		RNP 0.30	
DA(H) 1092' (1081')		DA(H) 1244' (1233')		DA(H) 1414' (1403')	
Ceiling: 1400'		Ceiling: 1600'		Ceiling: 1700'	
FULL	ALS out	FULL	ALS out	FULL	ALS out
4	4	4	5	5	5
ALSF-II PAPI					
3000' RT via 280° hdg					

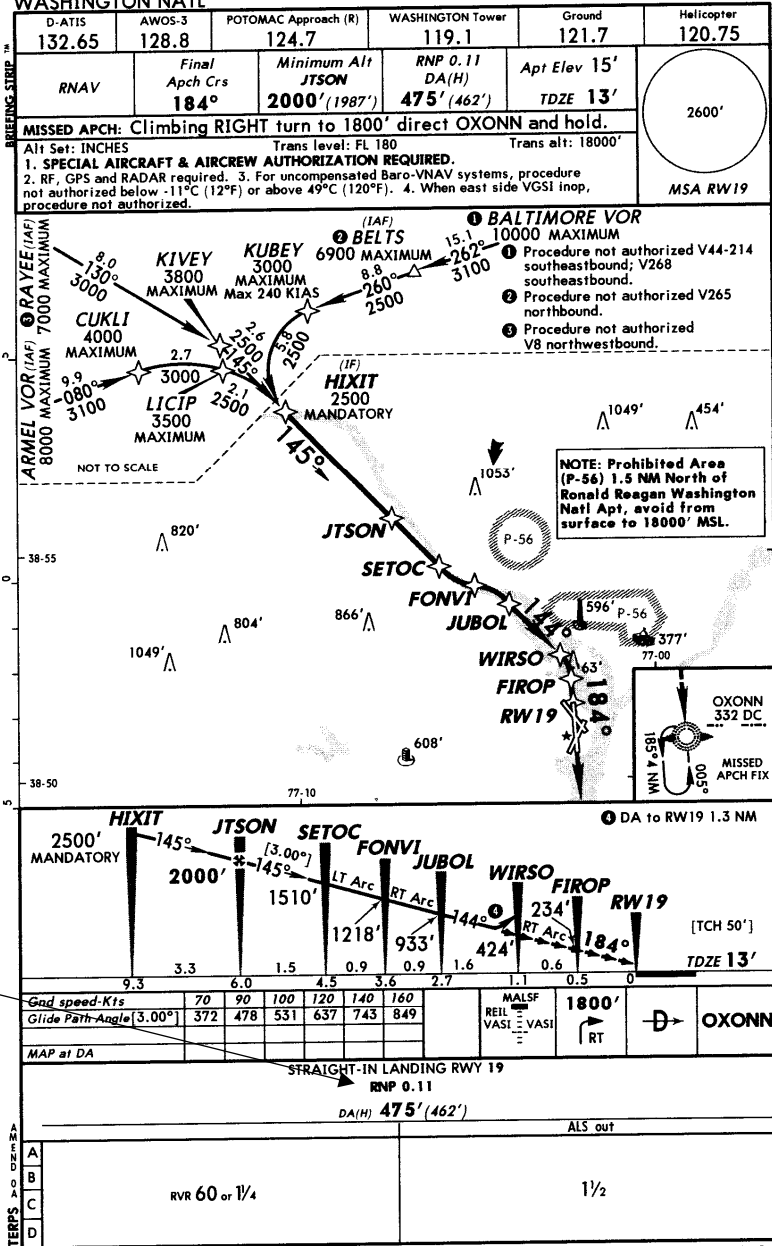


CHANGES: Edit Notes, Profile Altitudes: 8-15-02. PROOF COPY ONLY; File: SFO Plate RNVF-Final

KDCA- RNP Approach

RNP .11 required

JEPPESEN WASHINGTON, DC (VA)
21 OCT 05 (12-1) Eff 27 Oct RNAV (RNP) Rwy 19

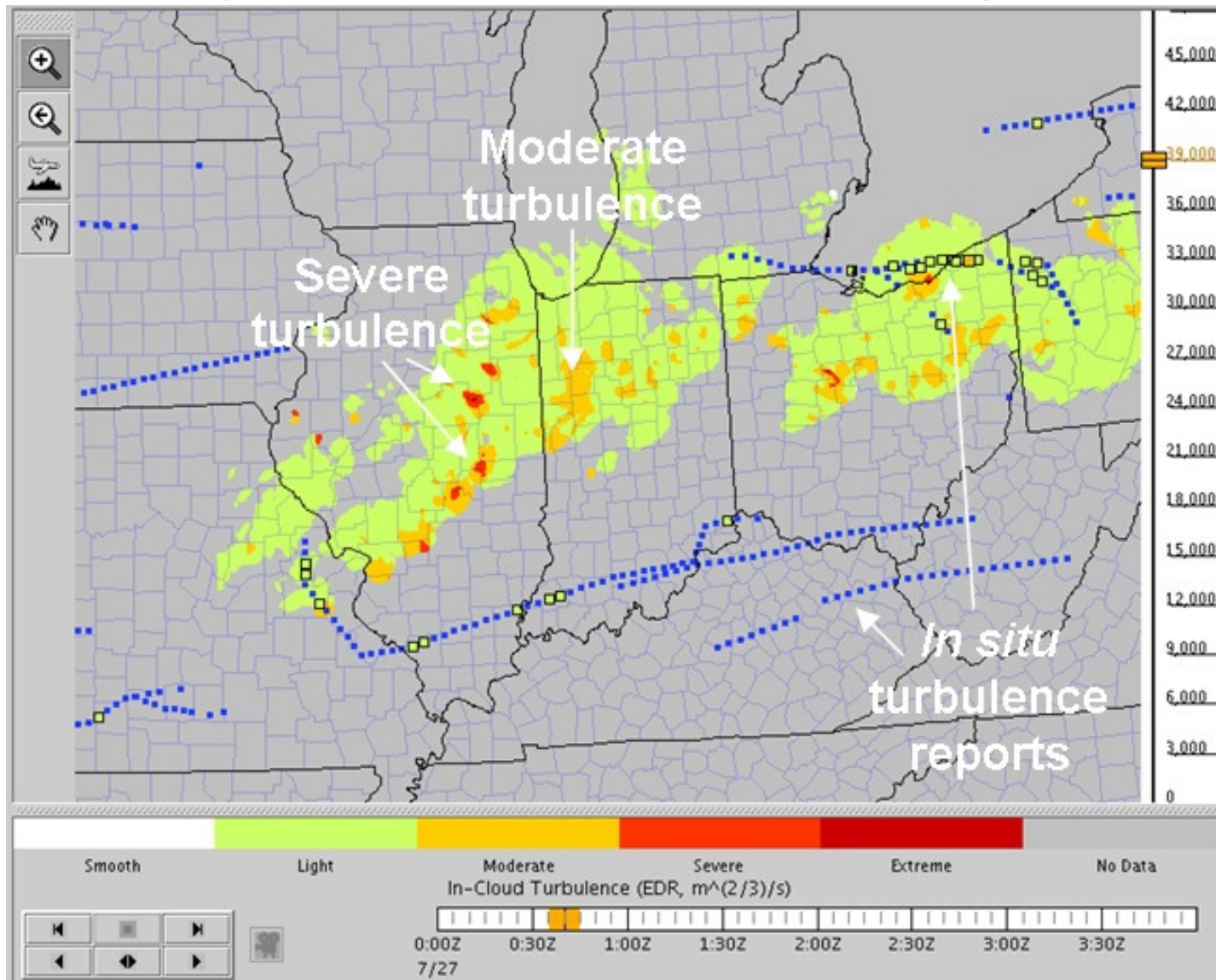


RNP in Terrain

- Using RNP in terrain environment increases safety margin and adds capacity – typical RNP 0.3



Tracking turbulence/weather with GPS position



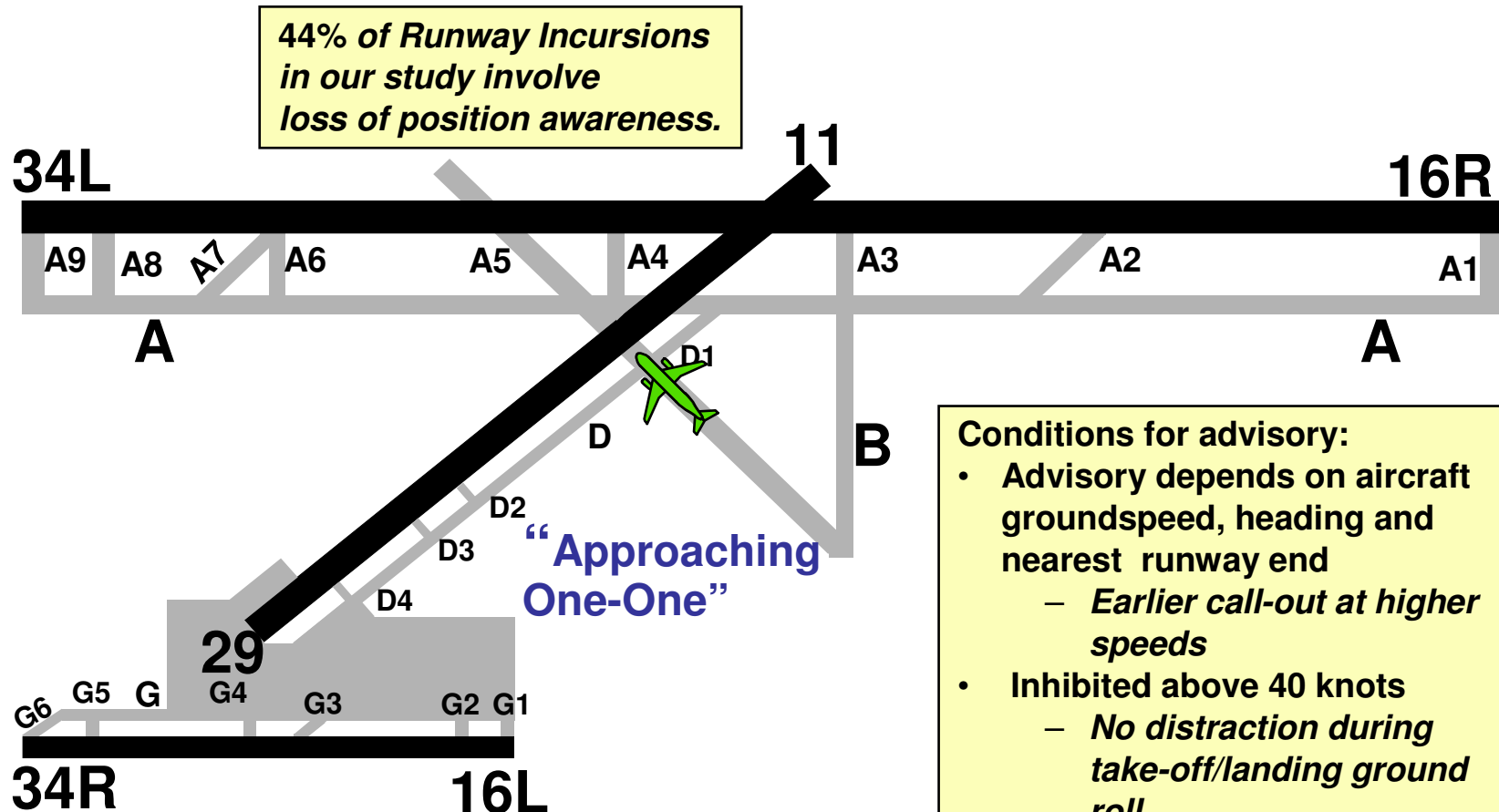
Surveillance: UAL Surface Moving Map Test





RAAS System

Approaching Runway - On Ground



RAAS in action (UAL B777 @DEN)

Runway End Advisory Call-Out

- Aircraft on the runway
- Aircraft heading +/- 20 deg of runway heading
- Aircraft enters last 100 feet of runway
- Aircraft groundspeed in < 40kts

“100 remaining”



100 remaining.AVI



flightoperations
Flight Standards and Technology

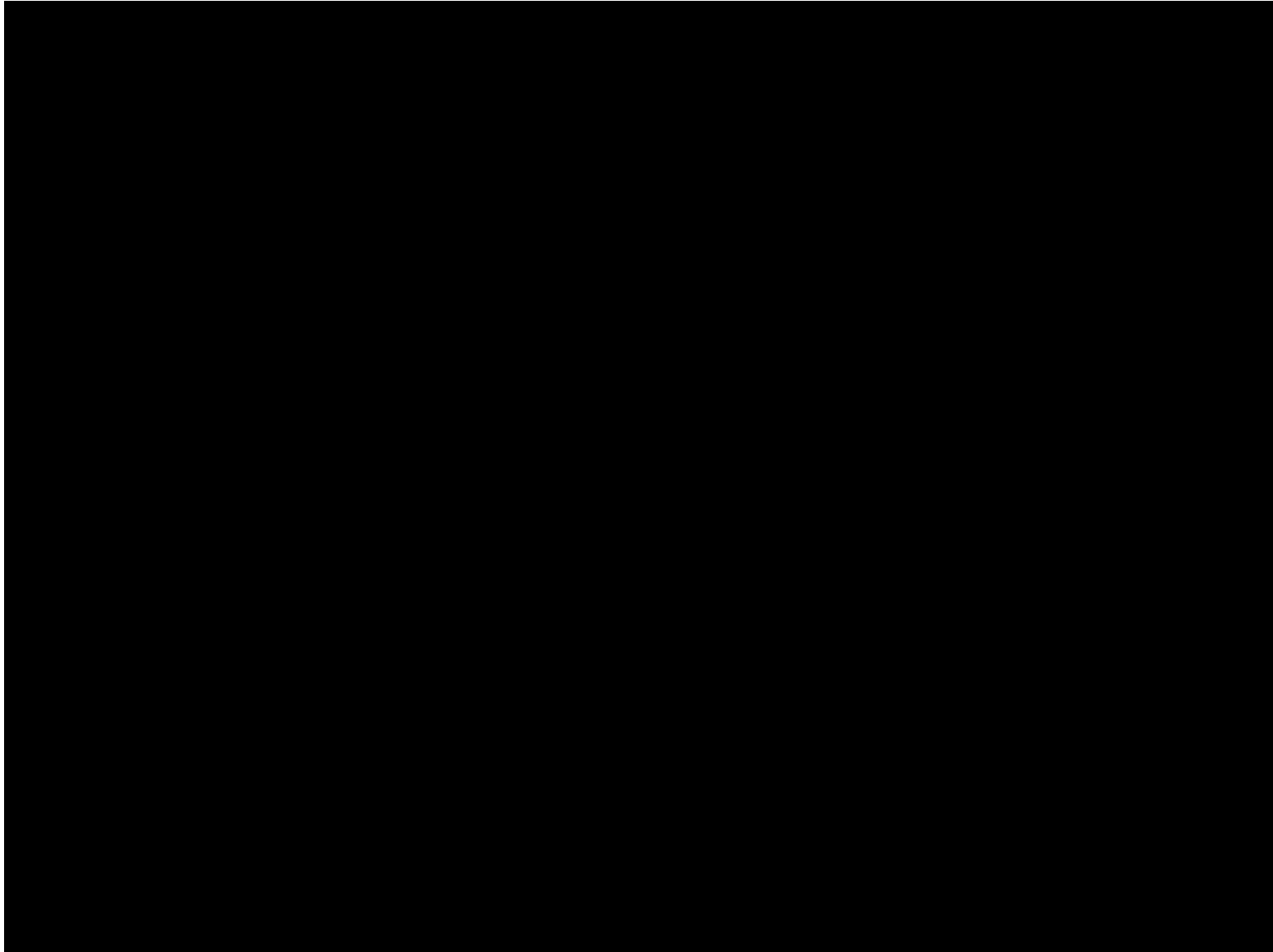
 **UNITED**
A STAR ALLIANCE MEMBER 

RAAS in action #2

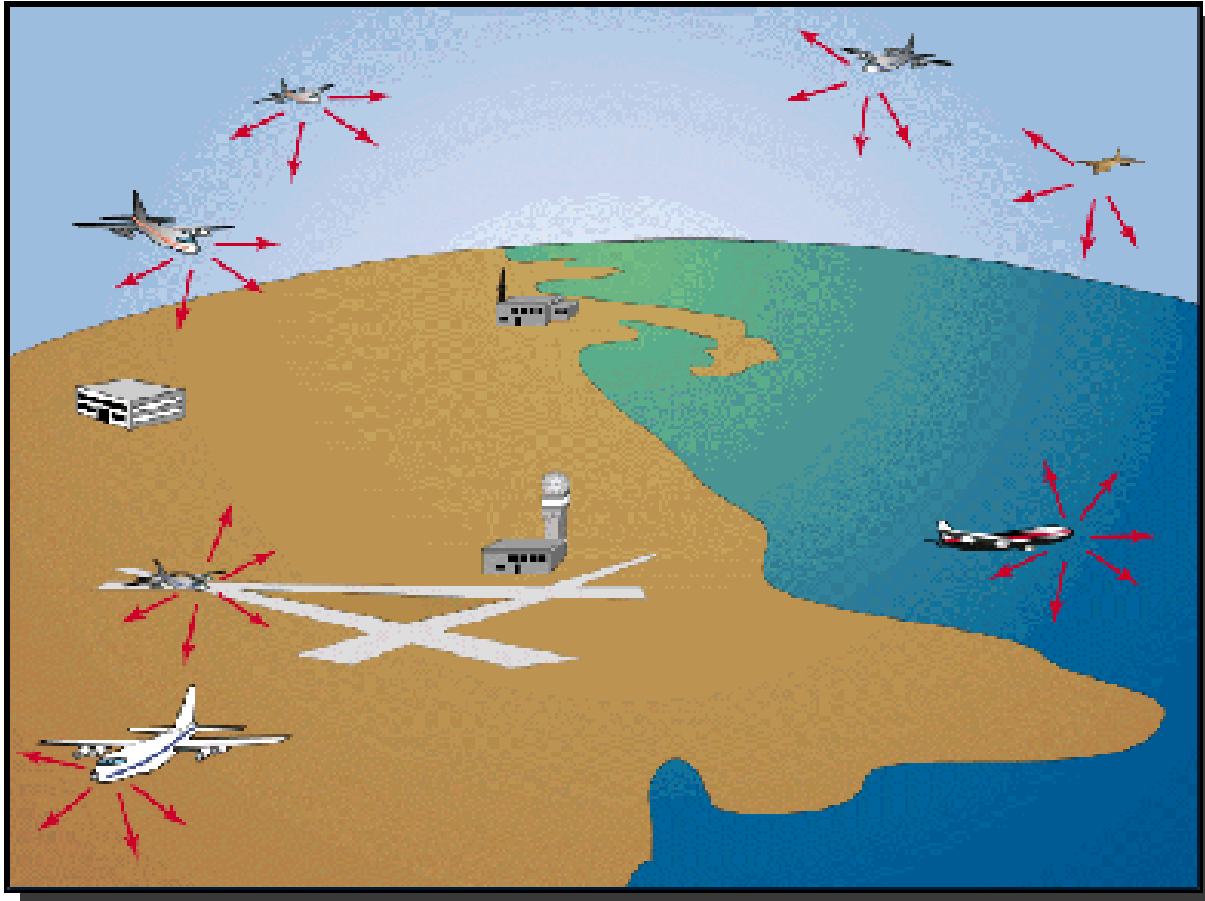
Intersection Departure – Insufficient Runway

- Aircraft must enter into runway
- Aircraft heading +/- 20 deg of runway heading
- Distance for takeoff less than nominal (user selected)

“On runway 34 Left, one thousand two hundred remaining”

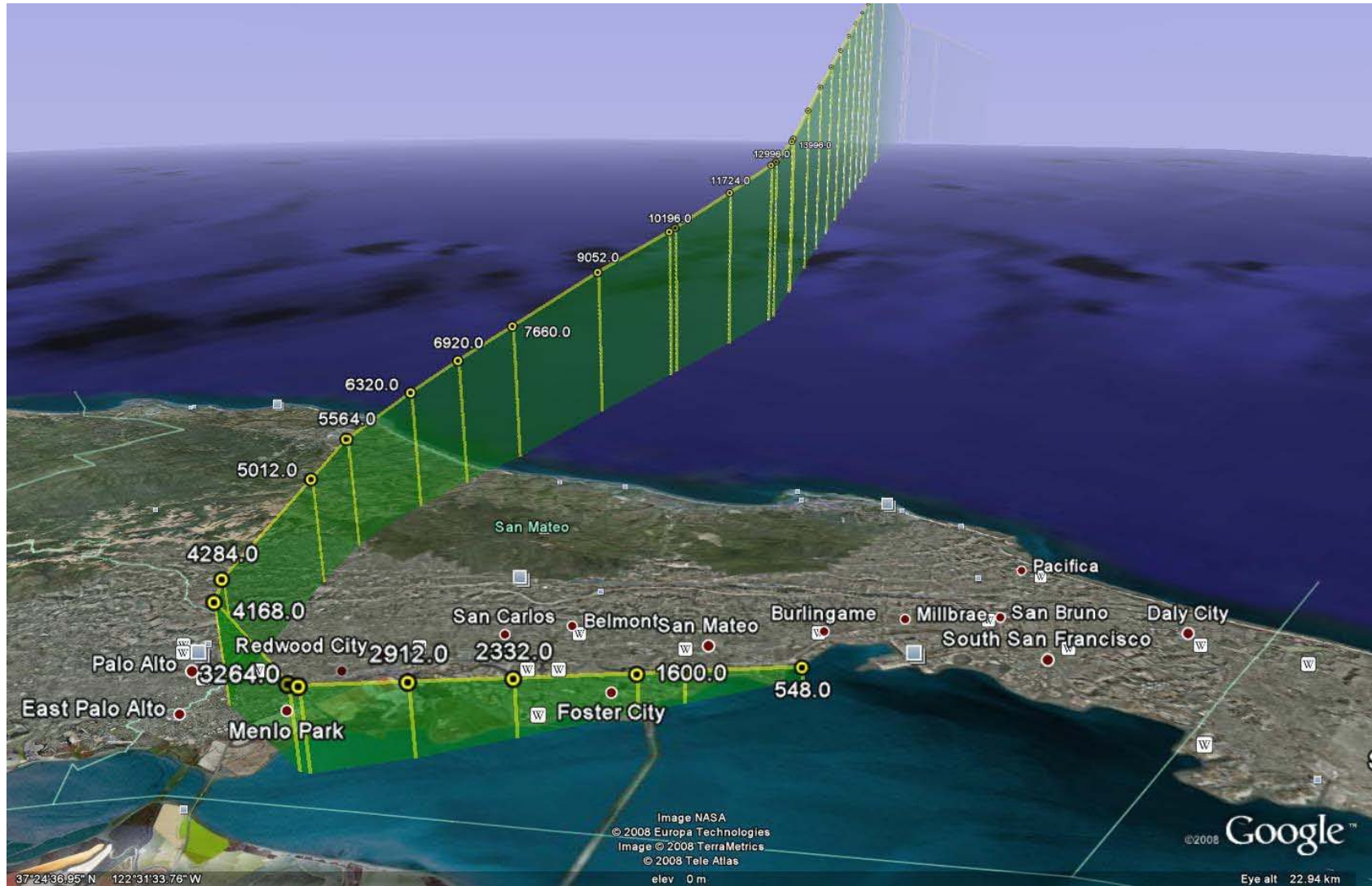


What is ADS-B?



- Automatic
- Dependent
- Surveillance
- Broadcast

Oceanic Tailored Arrivals using GPS



ADS-B Enables Safety



In the air...

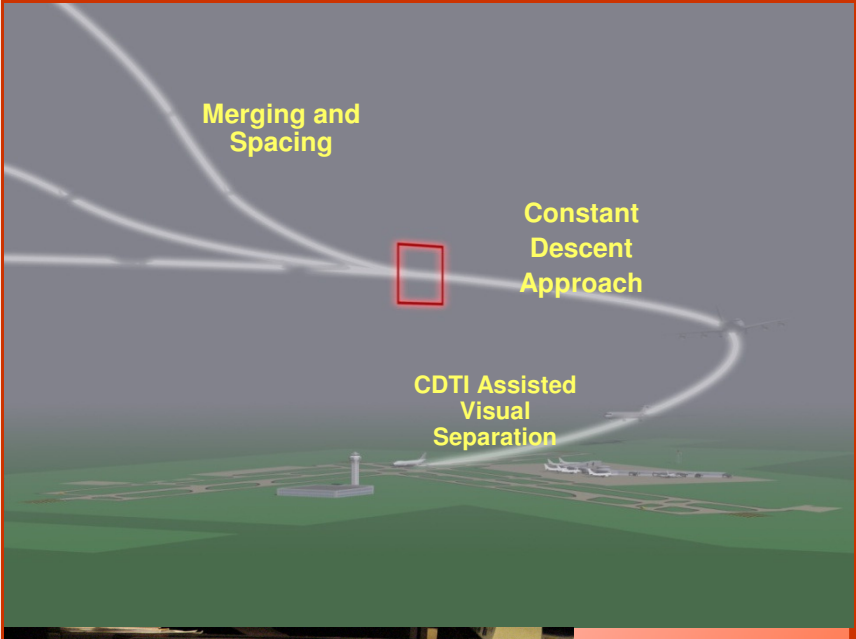
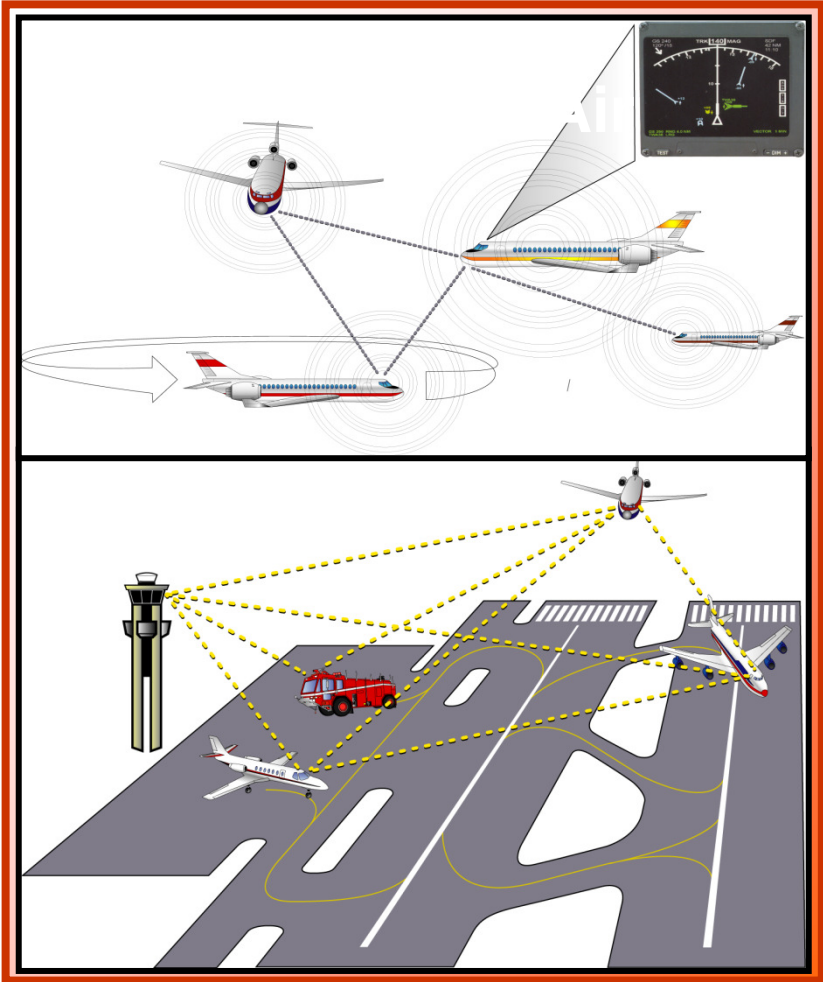
...and on the ground

Radar Equivalent Services in High-Terrain Airspace Using ADS-B Out

- Eliminates “one-in-one-out”
- Uses RNP with GPS for lower minimums
- Precision RNP missed approaches



ADS-B Improves Performance & Efficiency



Current RADAR Separation Standards

- 5nm En Route
- 3nm Terminal
- 2.5nm Terminal on approach
- 1.5nm Terminal on staggered dependent approaches
- 4,300 feet on independent parallel approaches

Separation Mins with GPS/ADS-B

Separation Standard	Satellite Constellation Av >0.9999 (with 2 deg. Mask Angle)								
	24			27			30		
	No SV Unusable	1 SV Unusable	2 SVs Unusable	No SV Unusable	1 SV Unusable	2 SVs Unusable	No SV Unusable	1 SV Unusable	2 SVs Unusable
5NM En Route	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3NM Terminal	Possible	No	No	Yes	Yes	No	Yes	Yes	Yes
2.5NM Terminal on Final Approach	Possible	No	No	Yes	Yes	No	Yes	Yes	Yes
1.5NM Terminal on Parallel Dependent Approach	Uncertain	No	No	Yes	Yes	No	Yes	Yes	Yes
4300FT Terminal on Parallel Independent Approach	No	No	No	Yes	Yes	No	Yes	Yes	Yes

Why GPS for aviation?

- "Space-based navigation" will allow more aircraft in our airspace:
 - Guarantee of 30 GPS satellites will reduce en-route and terminal spacing
- GPS will reduce fuel burn and greenhouse gas emissions:
 - More direct, time-based routings
- GPS will enable safer operations due to position awareness:
 - Reduce runway incursions
 - Provides greater situational awareness

Thank you!

