



AIRBUS PRO SKY



canso
civil air navigation services organisation



ICAO/CANSO Regional PBN Workshop Ciudad de México 25 - 29 Nov, 2013

Designs with CDO / CCO



Think the solution,
experience the change

AGENDA

- CCO and CDO Documentation
 - Continuous Climb Operations
 - Continuous Descent Operations
 - CCO and CDO Design Thoughts

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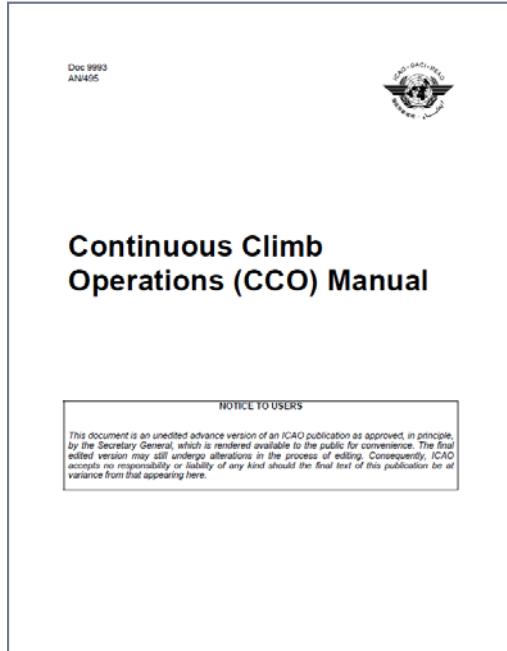




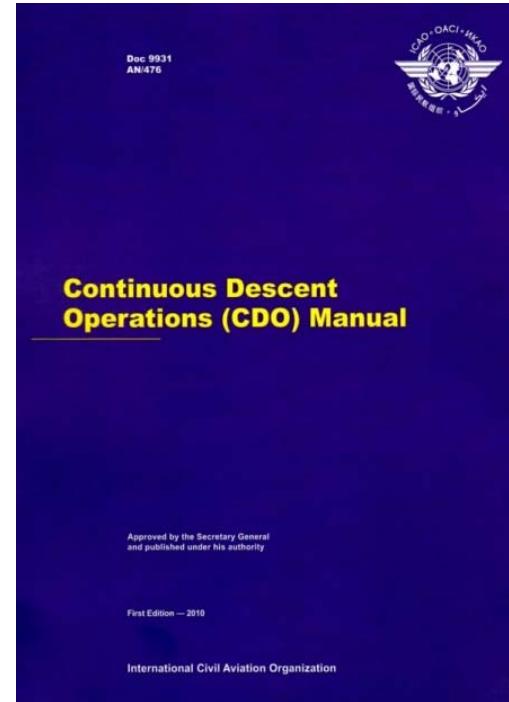
ICAO Manuals for CCO/CDO

CCO and CDO are documented in ICAO Manuals

Doc 9993 – Continuous
Climb Operations Manual



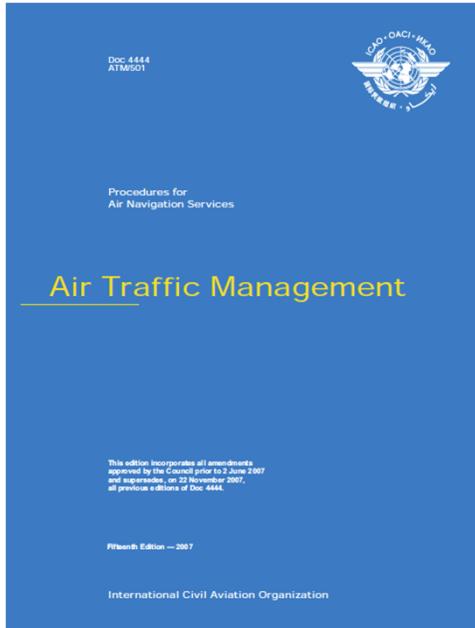
Doc 9931 - Continuous Descent
Operations Manual



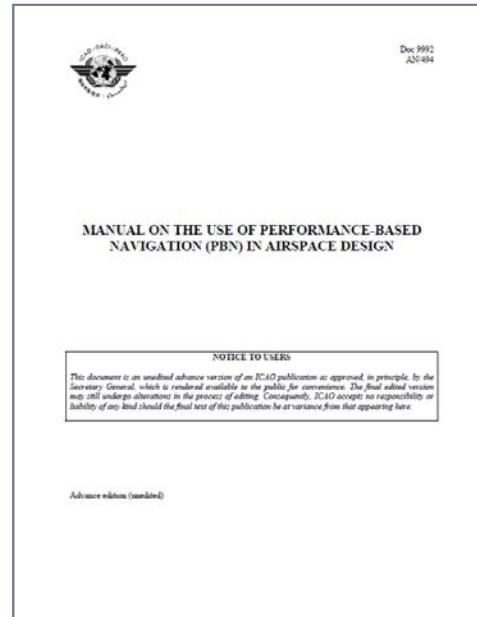


Additional ICAO Manuals for CCO/CDO

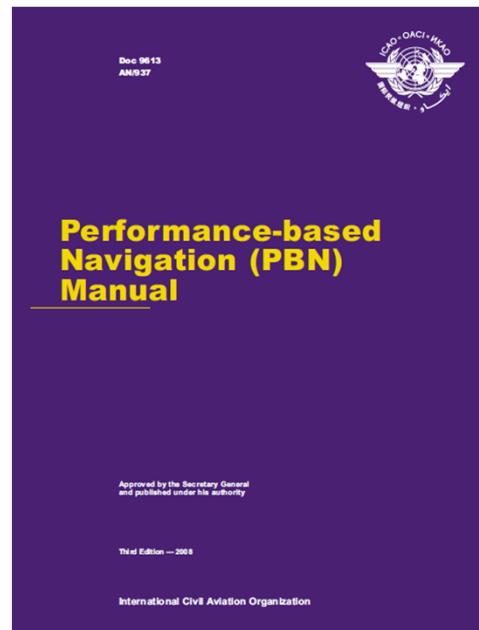
Doc 4444 Air Traffic Management



Doc 9992 Manual on The Use of Performance-Based Navigation(PBN) in Airspace Design



Doc 9613 Performance-based Navigation



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ASBU Block Upgrades



CCO and CDO implementation listed as near term (**now thru 2018**) steps in the ICAO Aviation System Block Upgrades and Global Air Navigation Capacity & Efficiency Plan

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Module	Performance Improvement Area	Module Title	Module Description
B0-05	Efficient Flight Path	Improved Flexibility and Efficiency in Descent Profiles (CDO)	To use performance-based airspace and arrival procedures allowing aircraft to fly their optimum profile using continuous descent operations (CDOs). This will optimize throughput, allow fuel efficient descent profiles and increase capacity in terminal areas.
B0-20	Efficient Flight Path	Improved Flexibility and Efficiency in Departure Profiles - Continuous Climb Operations (CCO)	To implement continuous climb operations in conjunction with performance-based navigation (PBN) to provide opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb profiles and increase capacity at congested terminal areas.



AGENDA

- CCO and CDO Documentation
- **Continuous Climb Operations**
- Continuous Descent Operations
- CCO and CDO Design Thoughts

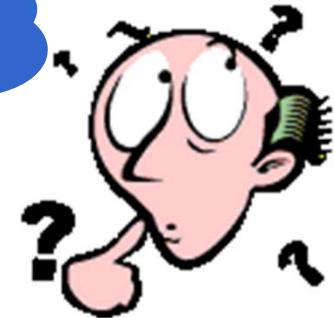
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Definition CCO

What is CCO?



Continuous Climb Operations (CCO)

Is a flight operation enabled by:

- ✓ Airspace design,
- ✓ Procedure design, and
- ✓ ATC facilitation.

CCO Continued...

In detail....



- Where a departing aircraft climbs without interruption to the greatest possible extent.
- By employing optimum climb engine thrust, ideally at optimum climb speeds.

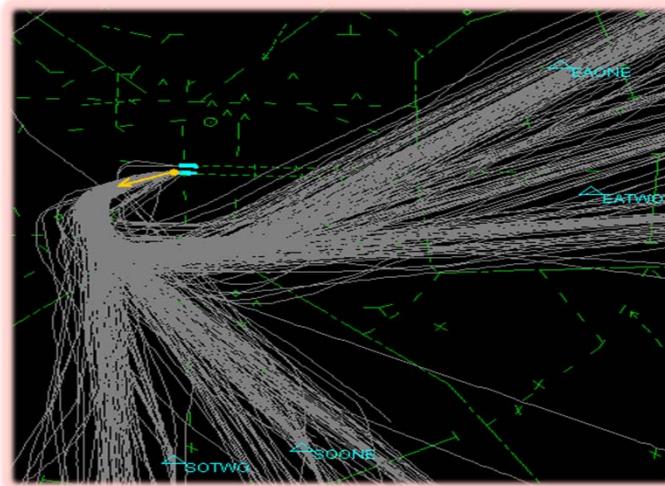
CONF1+F		CONF2	
OAT	TAILWIND	WIND	HEADWIND
-10 KT	0 KT	0 KT	0 KT
-20	60.5 4°	62.5 4°	60.2 4°
-30	100.45 44	120.51 31	120.51 31
-40	60.6 4°	62.4 4°	63.0 4°
-50	110.43 13	120.30 50	120.30 50
-60	60.4 4°	62.0 4°	62.4 4°
-70	120.42 42	130.30 29	130.30 29
-80	60.2 4°	62.9 4°	63.8 4°
-90	130.41 41	140.30 43	150.31 31
-100	60.0 4°	62.8 4°	63.6 4°
-110	140.40 40	150.30 30	160.30 20
-120	60.8 4°	63.6 4°	64.4 4°
-130	150.47 37	160.30 39	170.31 41
-140	61.6 4°	64.2 4°	65.0 4°
-150	160.47 37	170.30 39	180.31 41
-160	62.4 4°	65.0 4°	65.8 4°
-170	170.47 37	180.30 39	190.31 41
-180	63.2 4°	65.8 4°	66.6 4°
-190	180.47 37	190.30 39	200.31 41
-200	64.0 4°	66.6 4°	67.4 4°
-210	190.47 37	200.30 39	210.31 41
-220	64.8 4°	67.4 4°	68.2 4°
-230	200.47 37	210.30 39	220.31 41
-240	65.6 4°	68.2 4°	69.0 4°
-250	210.47 37	220.30 39	230.31 41
-260	66.4 4°	69.0 4°	69.8 4°
-270	220.47 37	230.30 39	240.31 41
-280	67.2 4°	69.8 4°	70.6 4°
-290	230.47 37	240.30 39	250.31 41
-300	68.0 4°	70.6 4°	71.4 4°
-310	240.47 37	250.30 39	260.31 41
-320	68.8 4°	71.4 4°	72.2 4°
-330	250.47 37	260.30 39	270.31 41
-340	69.6 4°	72.2 4°	73.0 4°
-350	260.47 37	270.30 39	280.31 41
-360	70.4 4°	73.0 4°	73.8 4°
-370	270.47 37	280.30 39	290.31 41
-380	71.2 4°	73.8 4°	74.6 4°
-390	280.47 37	290.30 39	300.31 41
-400	72.0 4°	74.6 4°	75.4 4°
-410	290.47 37	300.30 39	310.31 41
-420	72.8 4°	75.4 4°	76.2 4°
-430	300.47 37	310.30 39	320.31 41
-440	73.6 4°	76.2 4°	77.0 4°
-450	310.47 37	320.30 39	330.31 41
-460	74.4 4°	77.0 4°	77.8 4°
-470	320.47 37	330.30 39	340.31 41
-480	75.2 4°	77.8 4°	78.6 4°
-490	330.47 37	340.30 39	350.31 41
-500	76.0 4°	78.6 4°	79.4 4°
-510	340.47 37	350.30 39	360.31 41
-520	76.8 4°	79.4 4°	80.2 4°
-530	350.47 37	360.30 39	370.31 41
-540	77.6 4°	80.2 4°	81.0 4°
-550	360.47 37	370.30 39	380.31 41
-560	78.4 4°	81.0 4°	81.8 4°
-570	370.47 37	380.30 39	390.31 41
-580	79.2 4°	81.8 4°	82.6 4°
-590	380.47 37	390.30 39	400.31 41
-600	80.0 4°	82.6 4°	83.4 4°
-610	390.47 37	400.30 39	410.31 41
-620	80.8 4°	83.4 4°	84.2 4°
-630	400.47 37	410.30 39	420.31 41
-640	81.6 4°	84.2 4°	85.0 4°
-650	410.47 37	420.30 39	430.31 41
-660	82.4 4°	85.0 4°	85.8 4°
-670	420.47 37	430.30 39	440.31 41
-680	83.2 4°	85.8 4°	86.6 4°
-690	430.47 37	440.30 39	450.31 41
-700	84.0 4°	86.6 4°	87.4 4°
-710	440.47 37	450.30 39	460.31 41
-720	84.8 4°	87.4 4°	88.2 4°
-730	450.47 37	460.30 39	470.31 41
-740	85.6 4°	88.2 4°	89.0 4°
-750	460.47 37	470.30 39	480.31 41
-760	86.4 4°	89.0 4°	89.8 4°
-770	470.47 37	480.30 39	490.31 41
-780	87.2 4°	89.8 4°	90.6 4°
-790	480.47 37	490.30 39	500.31 41
-800	88.0 4°	90.6 4°	91.4 4°
-810	490.47 37	500.30 39	510.31 41
-820	88.8 4°	91.4 4°	92.2 4°
-830	500.47 37	510.30 39	520.31 41
-840	89.6 4°	92.2 4°	93.0 4°
-850	510.47 37	520.30 39	530.31 41
-860	90.4 4°	93.0 4°	93.8 4°
-870	520.47 37	530.30 39	540.31 41
-880	91.2 4°	93.8 4°	94.6 4°
-890	530.47 37	540.30 39	550.31 41
-900	92.0 4°	94.6 4°	95.4 4°
-910	540.47 37	550.30 39	560.31 41
-920	92.8 4°	95.4 4°	96.2 4°
-930	550.47 37	560.30 39	570.31 41
-940	93.6 4°	96.2 4°	97.0 4°
-950	560.47 37	570.30 39	580.31 41
-960	94.4 4°	97.0 4°	97.8 4°
-970	570.47 37	580.30 39	590.31 41
-980	95.2 4°	97.8 4°	98.6 4°
-990	580.47 37	590.30 39	600.31 41
-1000	96.0 4°	98.6 4°	99.4 4°



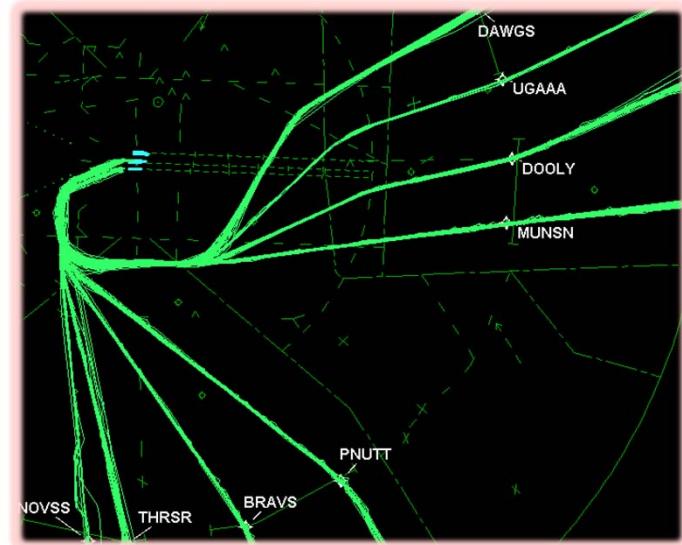
Capacity and Efficiency

PBN and CCO allow improved capacity and efficiency

Example Before PBN



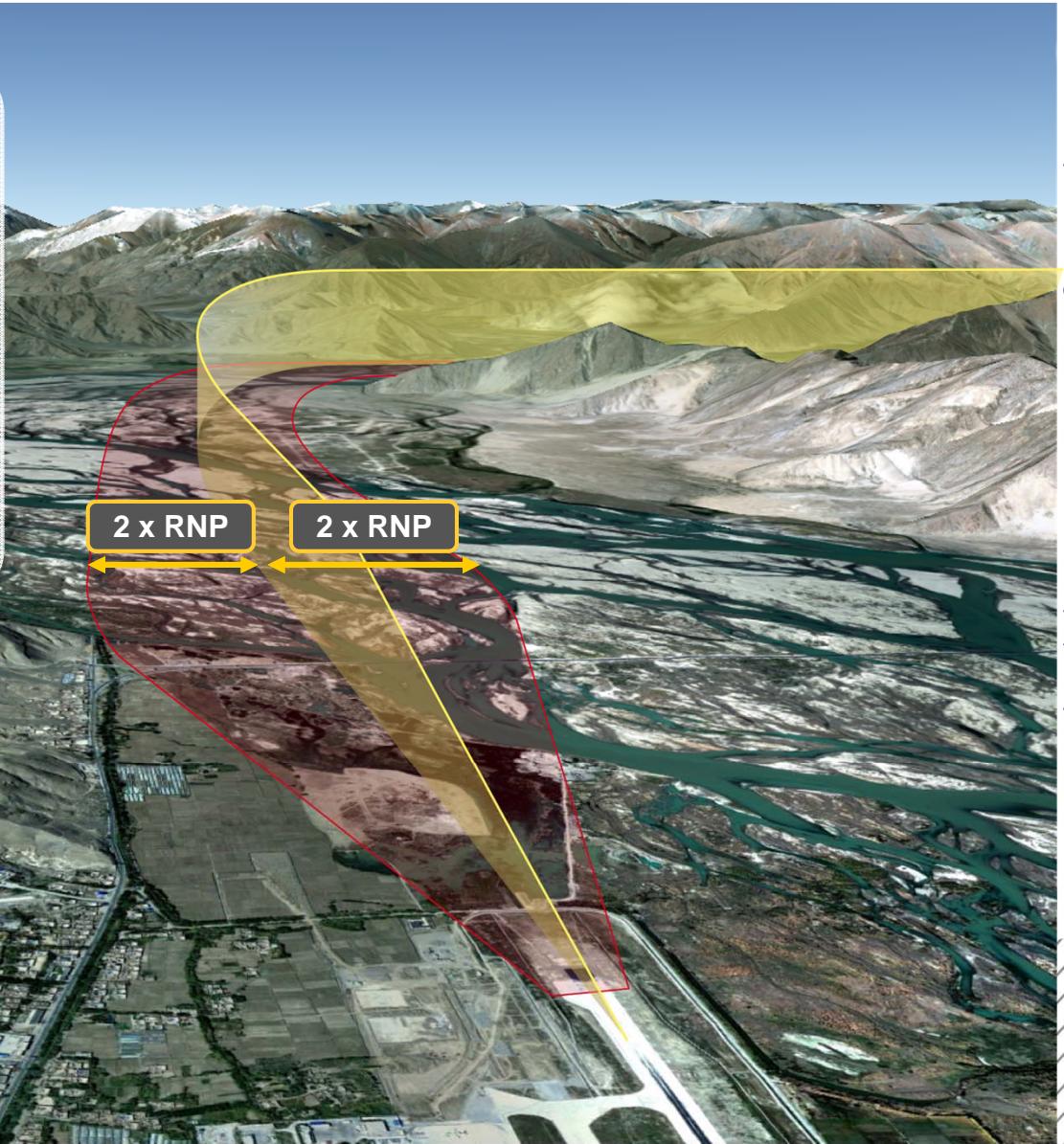
Example After PBN





CCO Continued...

Optimized RNP and RNP AR SIDs designs take into account obstacles along the clearance corridors. Aircraft performance plays an important role in CCO, and calculations may differ from conventional SIDs.



AGENDA

- CCO and CDO Documentation
- Continuous Climb Operations
- **Continuous Descent Operations**
- CCO and CDO Design Thoughts



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Definition CDO



Continuous Descent Operations (CDO)

Is a flight operation enabled by:

- ✓ Airspace design,
- ✓ Procedure design, and
- ✓ ATC facilitation.



Definition CDO

- Where an arriving aircraft descends continuously to the greatest possible extent;



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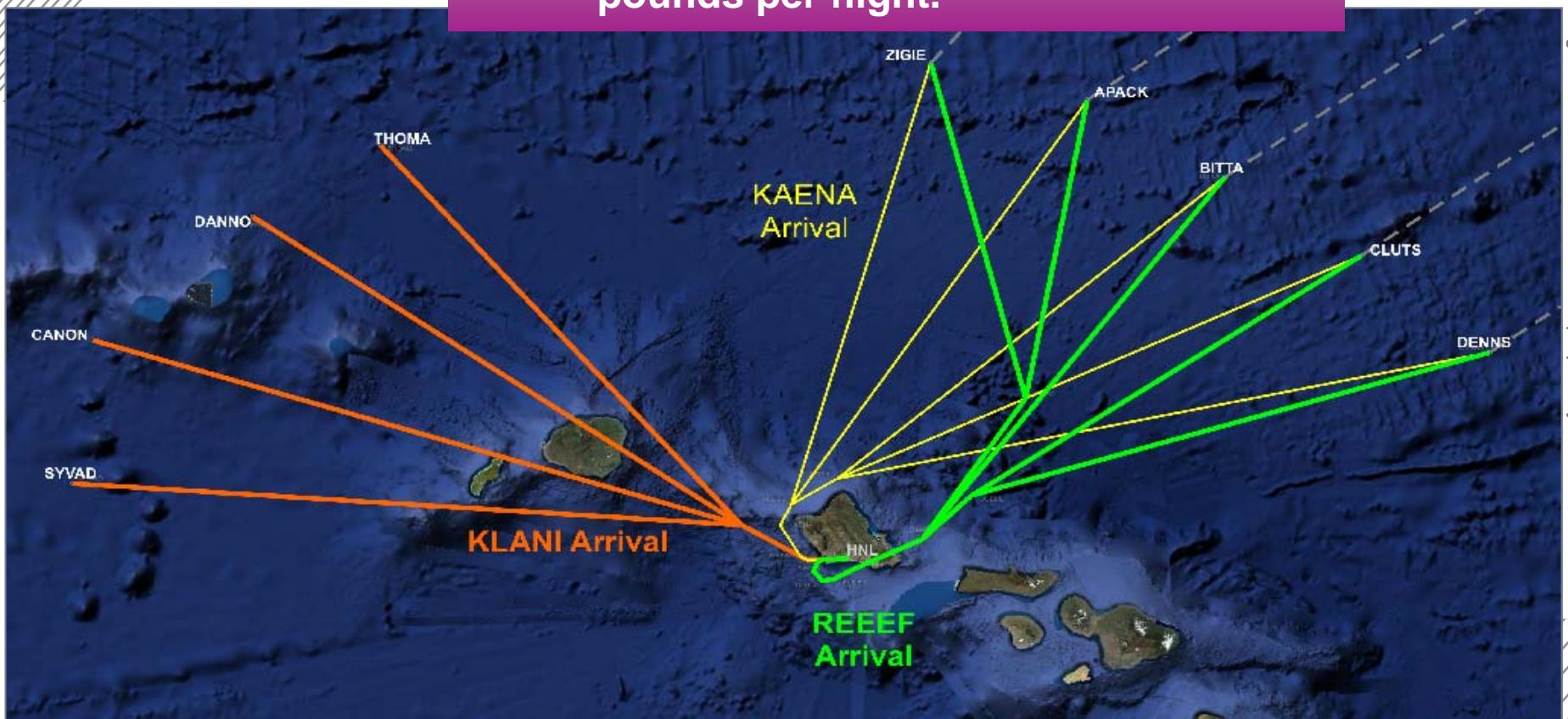
- Employing minimum engine thrust, ideally in a low drag configuration



HNL CDO Example

- **KAENA, KLANI, REEEF CDO**

- ✓ Fully integrated/linked to approach.
- ✓ Descend via from cruise flight levels.
- ✓ Initial Fuel Savings 300-1200+ pounds per flight.



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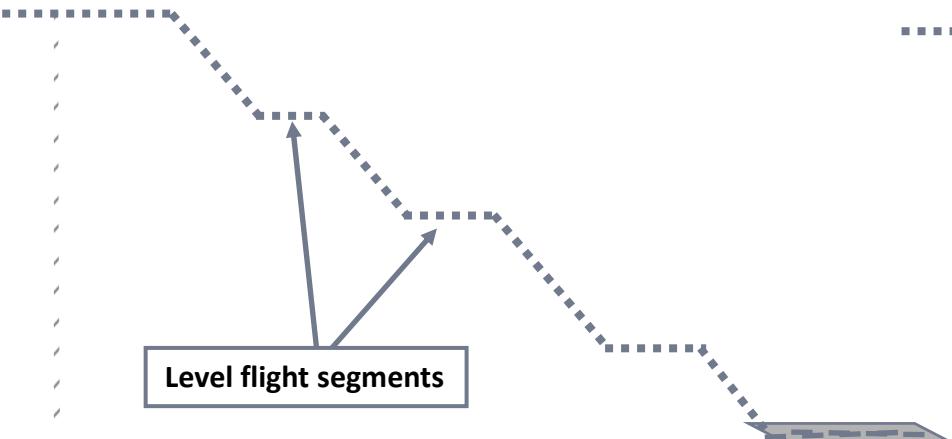


CDO Side View

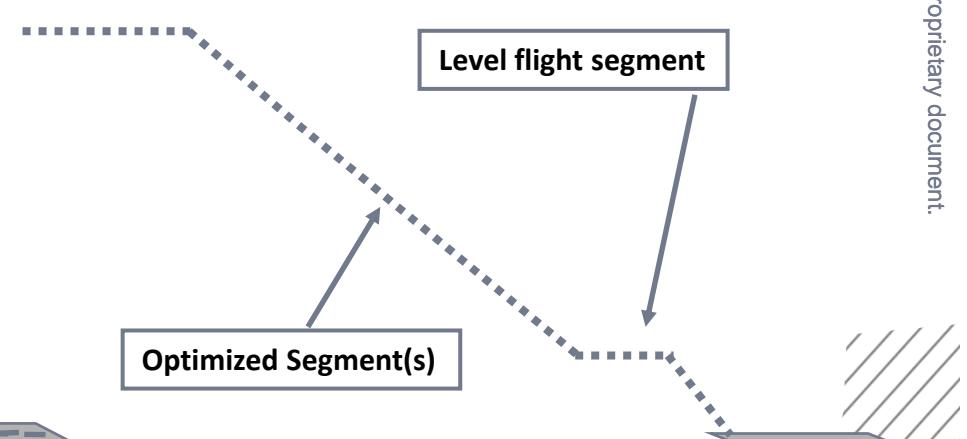
Continuous Descent Operations (CDO) Vs. Conventional Arrival

- ✓ Leverages RNAV STAR implementations
- ✓ Reduce the amount of time spent in level flight on published arrival procedures (i.e., STARs)

Conventional Arrival



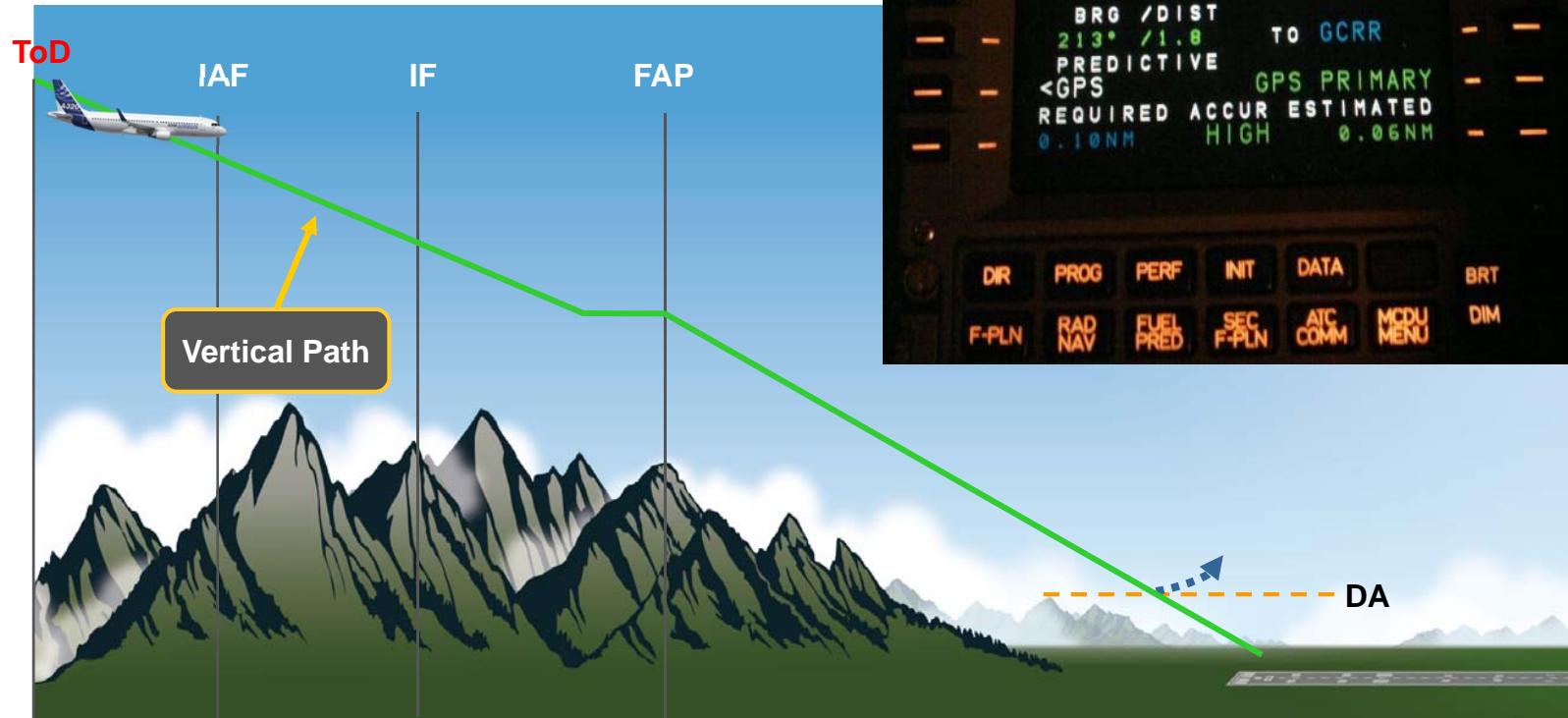
Continuous Descent Operation





CDO Vertical Trajectory

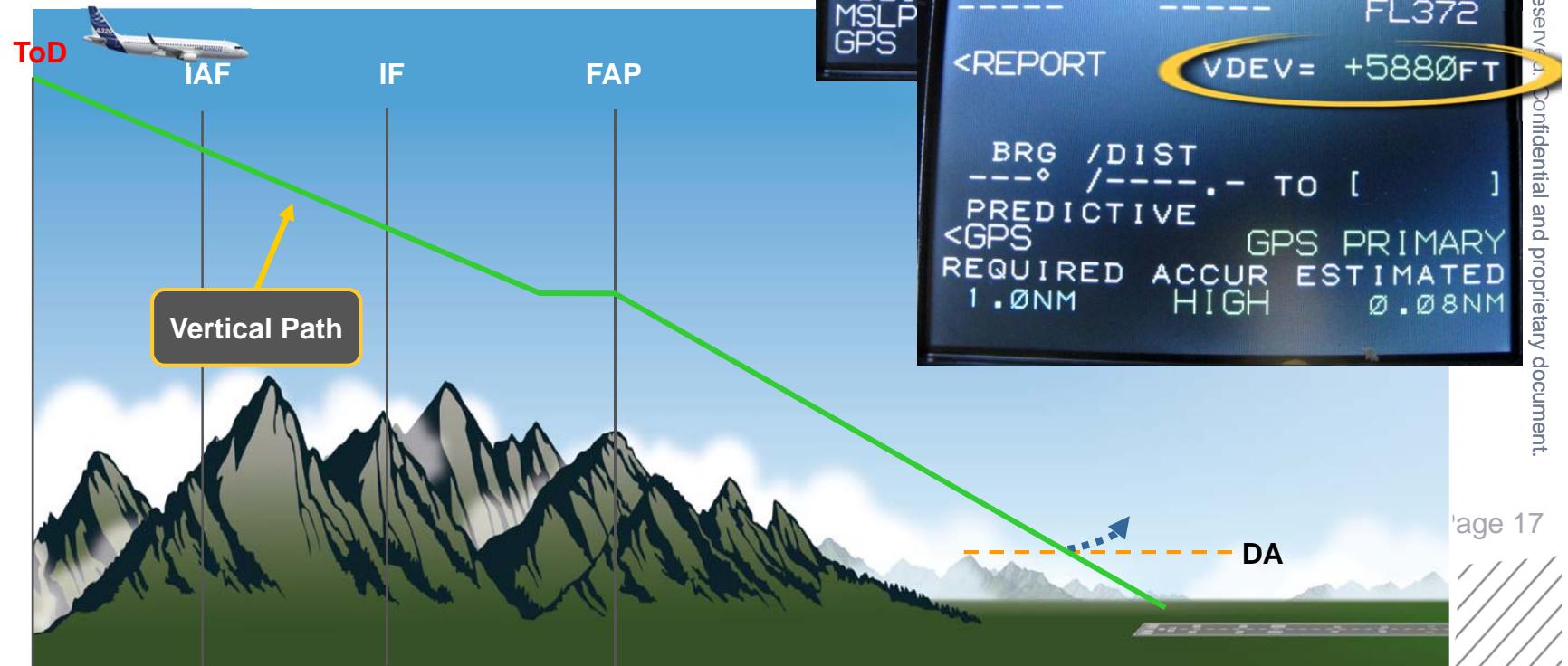
A well designed and balanced CDO allows the aircraft to calculate appropriate ToD and maintain on the vertical trajectory.





CDO Vertical Trajectory

... otherwise, an aircraft may have a challenging time descending and decelerating at the appropriate schedules.



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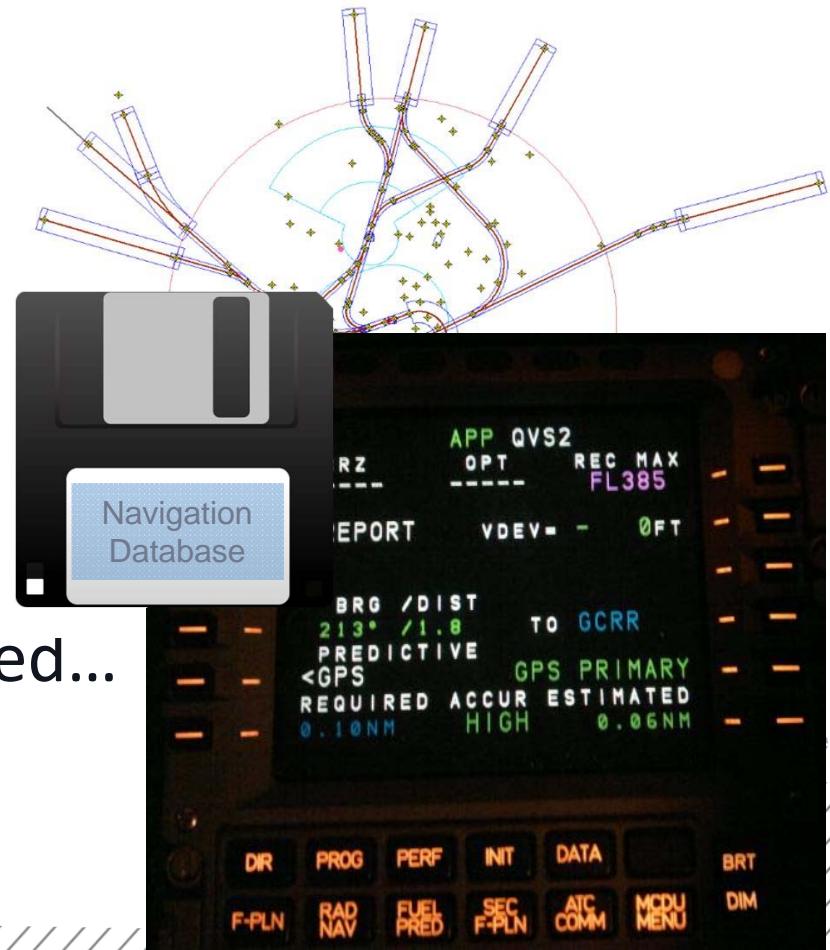
Think broad

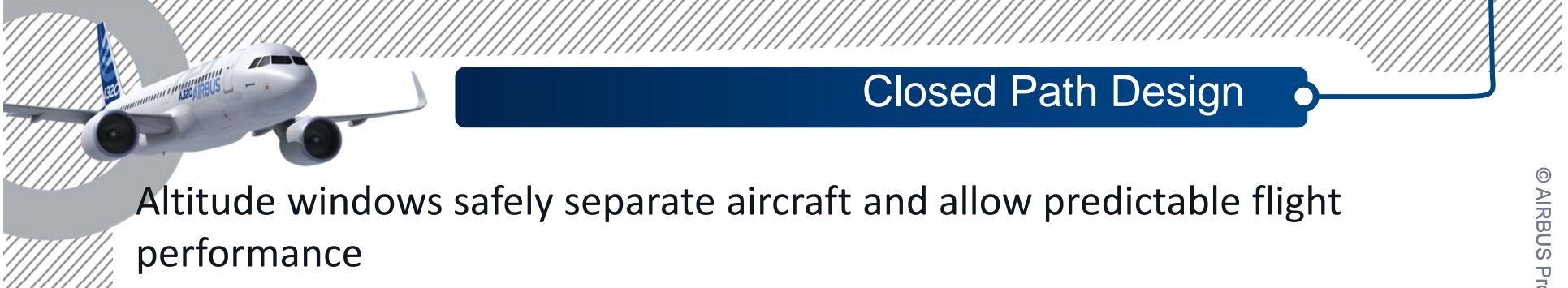
A CDO or CCO trajectory is designed

BUT

- ✓ If it can not be coded
- or
- ✓ The aircraft can not fly it,

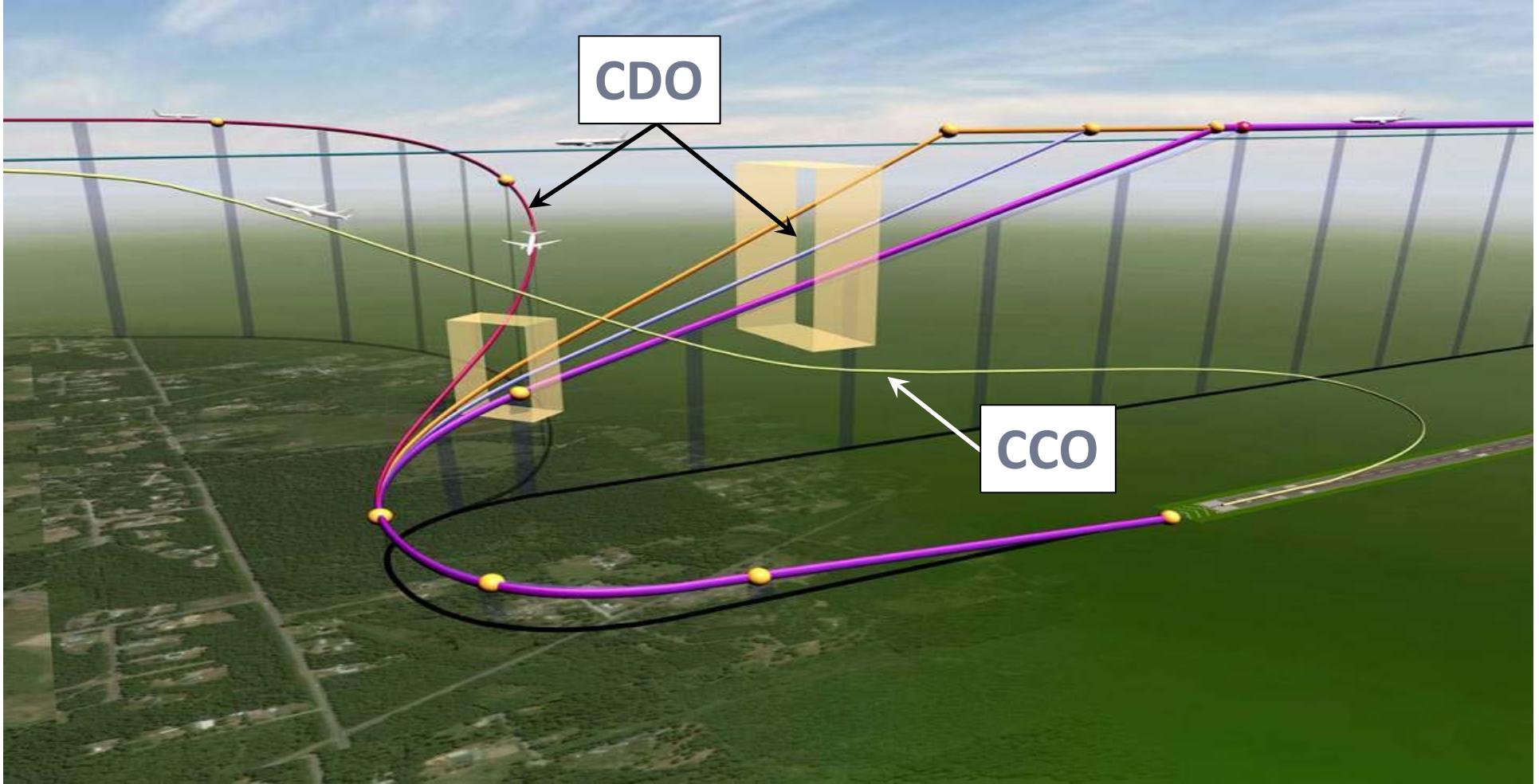
chances are it may never be used...





Altitude windows safely separate aircraft and allow predictable flight performance

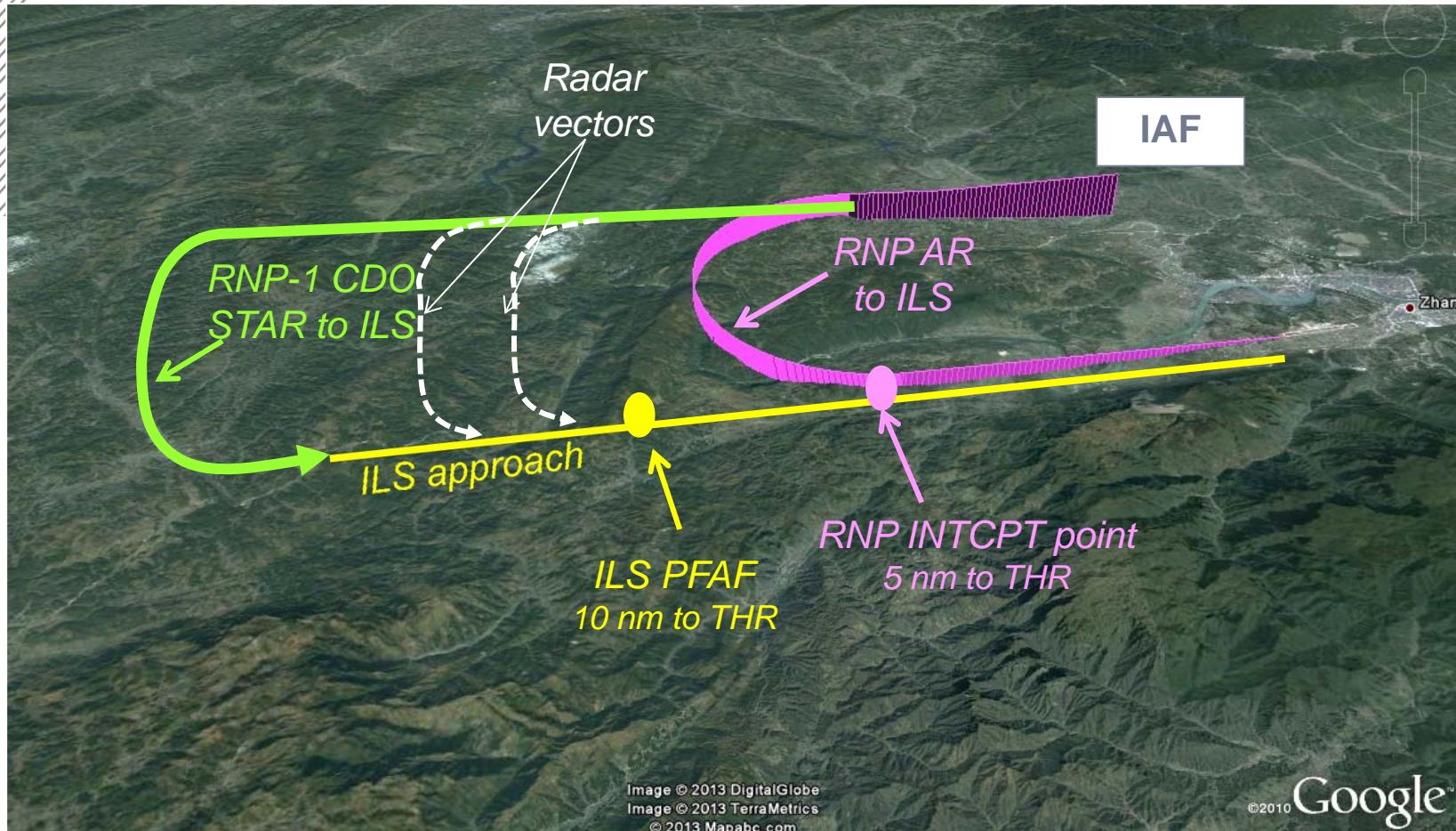
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CDO Integration Techniques

Good Design Integrates PBN, CDO, & Conventional Capabilities

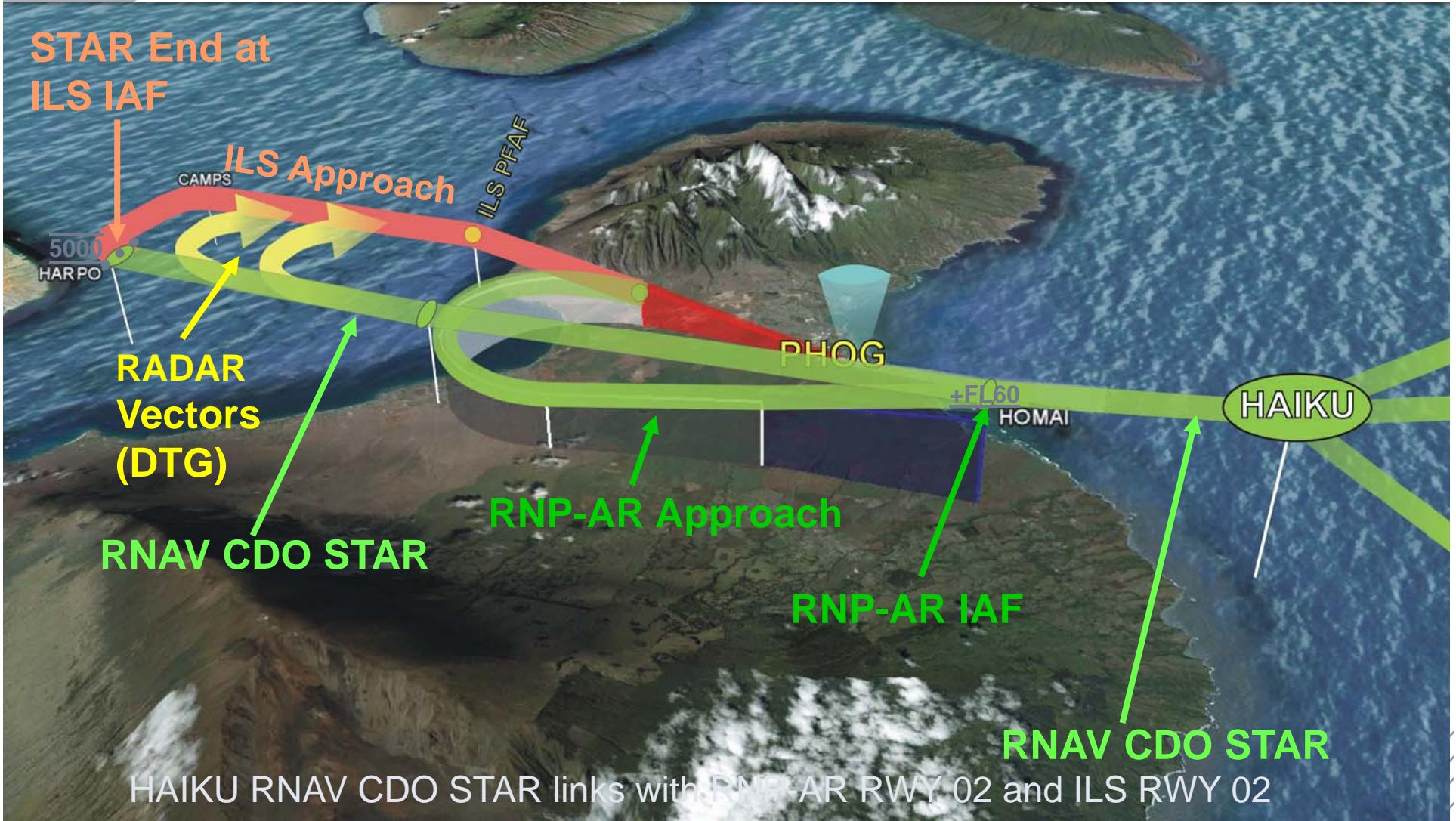


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Integrating RNAV, RNP, & Conventional Capabilities

© N

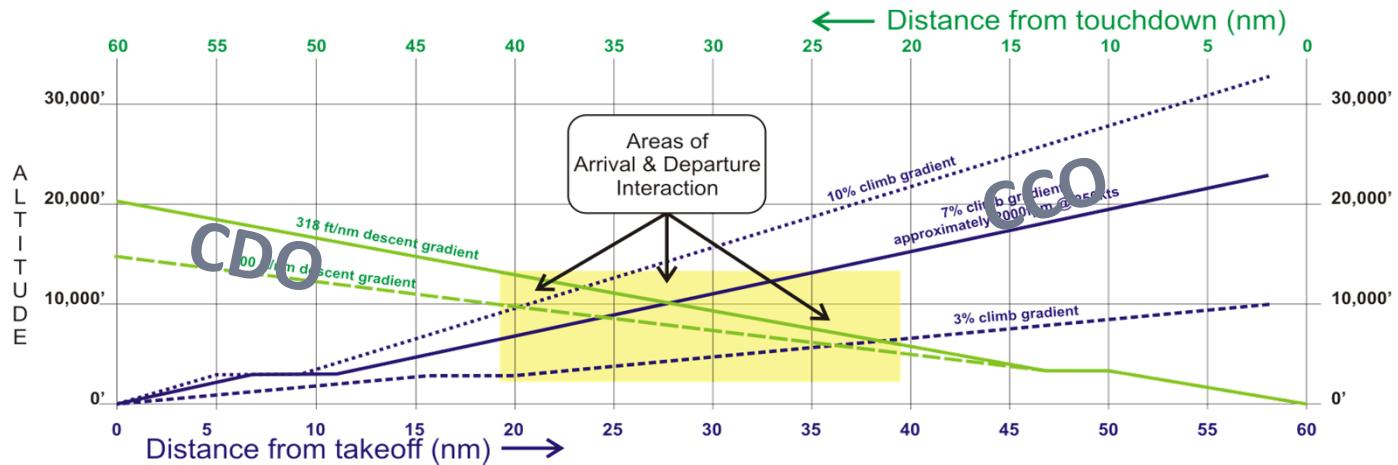




ATC Integration

ATC operating procedures to accommodate PBN.

- Design using updated techniques to minimize interaction
 - CDO
 - CCO

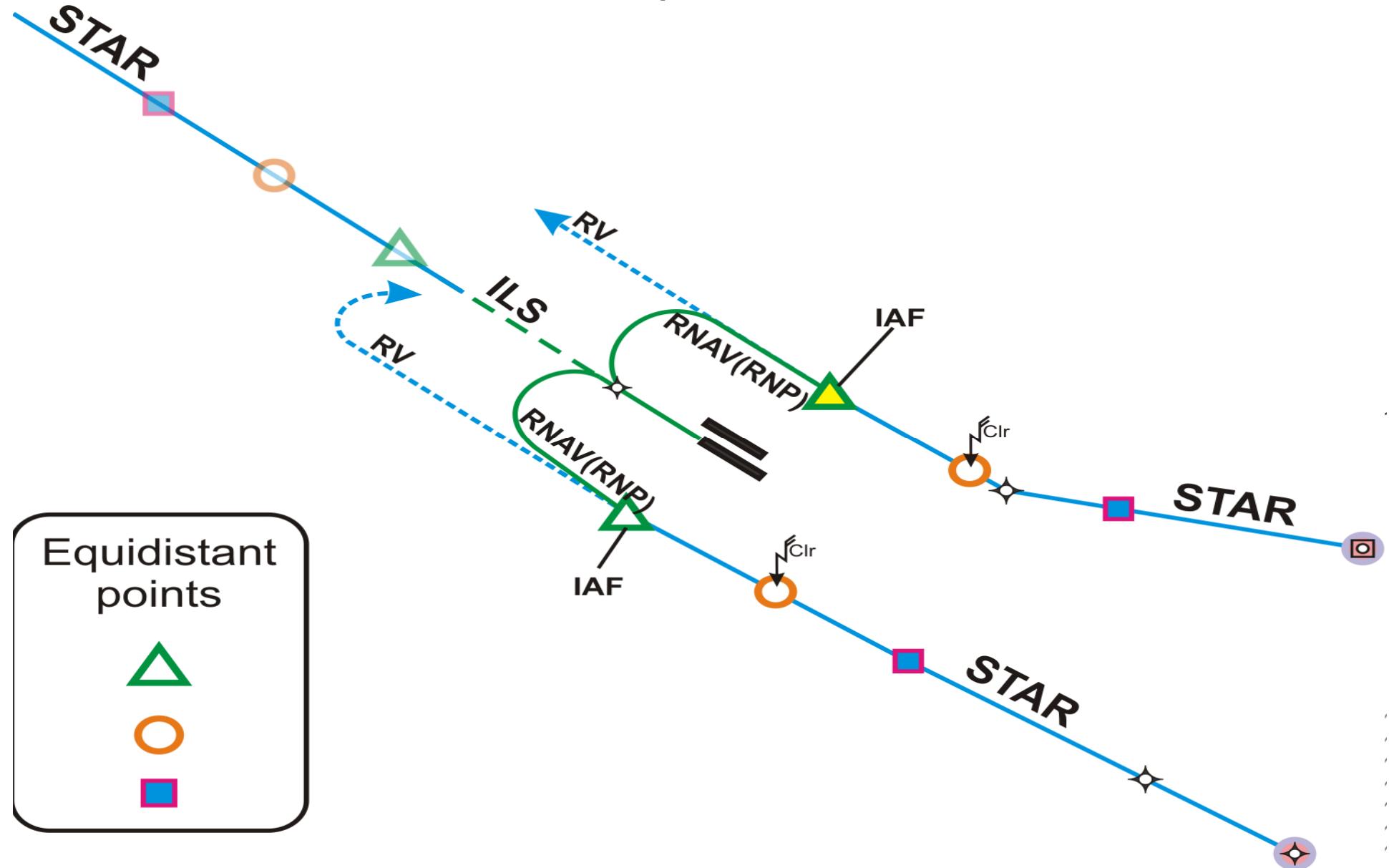


- Education is critical
 - Concept of operations
 - ATC benefits
 - Clear responsibilities defined
 - Structured Decision Points give ATC ability to judge control actions early.



PBN CCO/CDO Sequencing Methods

V



AGENDA

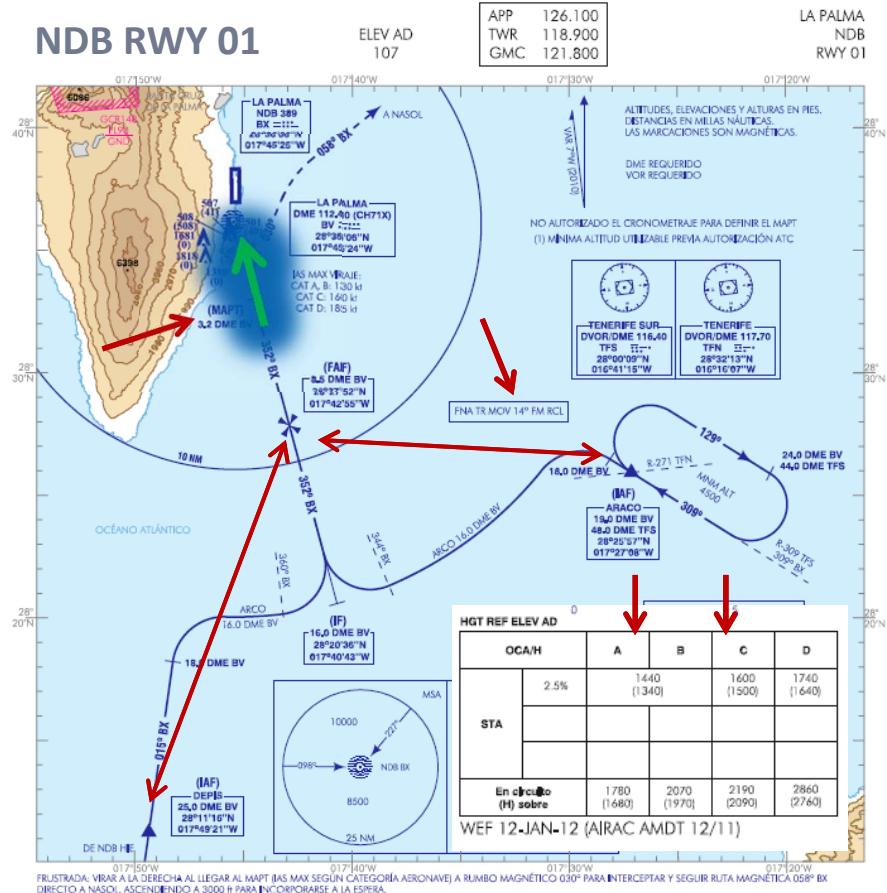
- CCO and CDO Documentation
- Continuous Climb Operations
- Continuous Descent Operations
- CCO and CDO Design Thoughts
 - Example



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GCLA Conventional Procedures

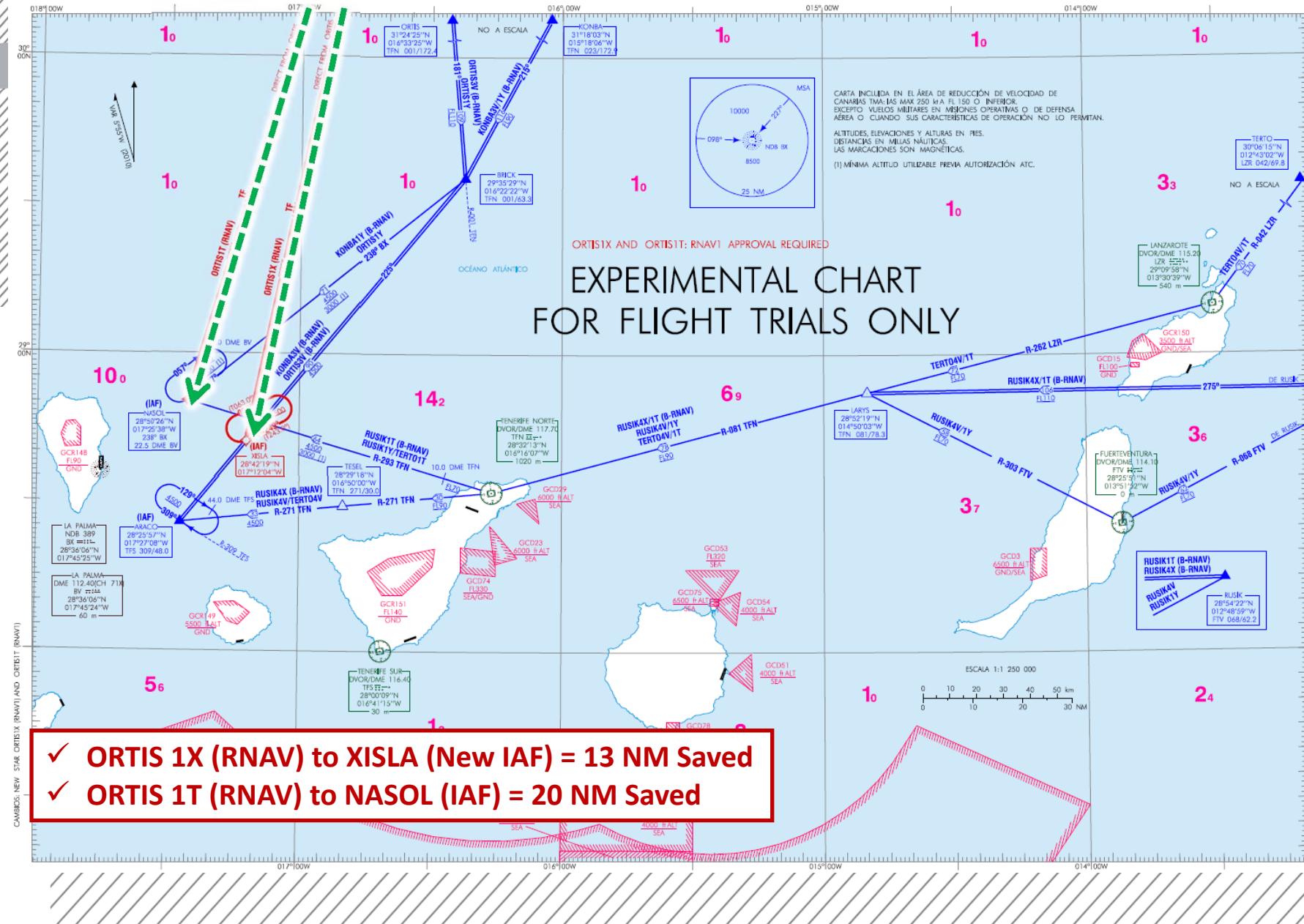


- ✓ HIGH MINIMA
 - ✓ Final Approach NOT ALIGNED with Runway Centerline
 - ✓ NO VERTICAL GUIDANCE
 - ✓ NOT OPTIMIZED



GCLA Flight Trials - STARS

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GCLA RNAV (RNP) RWY 01



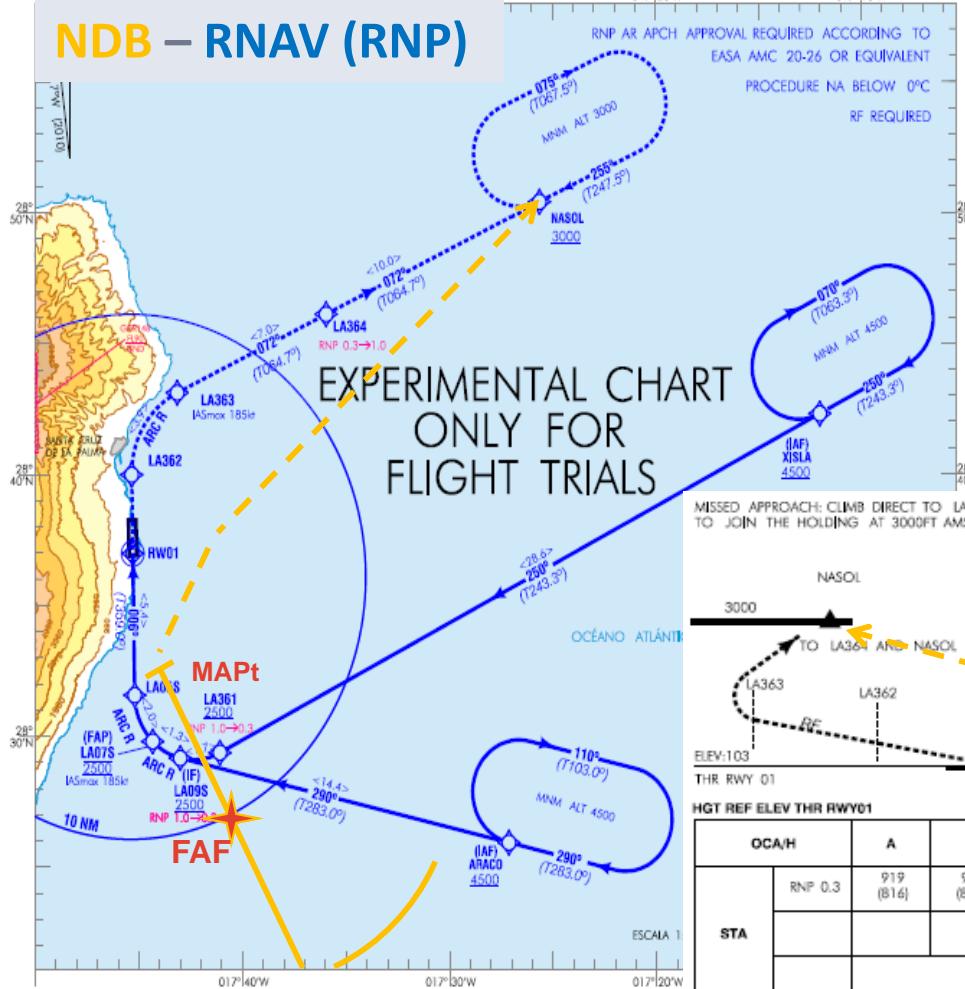
SESAR - LOT1, AIRE
CANARIAS PROJECT
PROPOSAL
INSTRUMENT APPROACH CHART - ICAO

ELEV AD
107
017°40'W

APP 126.100
TWR 118.900
GMC 121.800

LA PALMA
IATM-13-DTC-001-2.0
V2
RNAV (RNP) RWY01
017°10'W

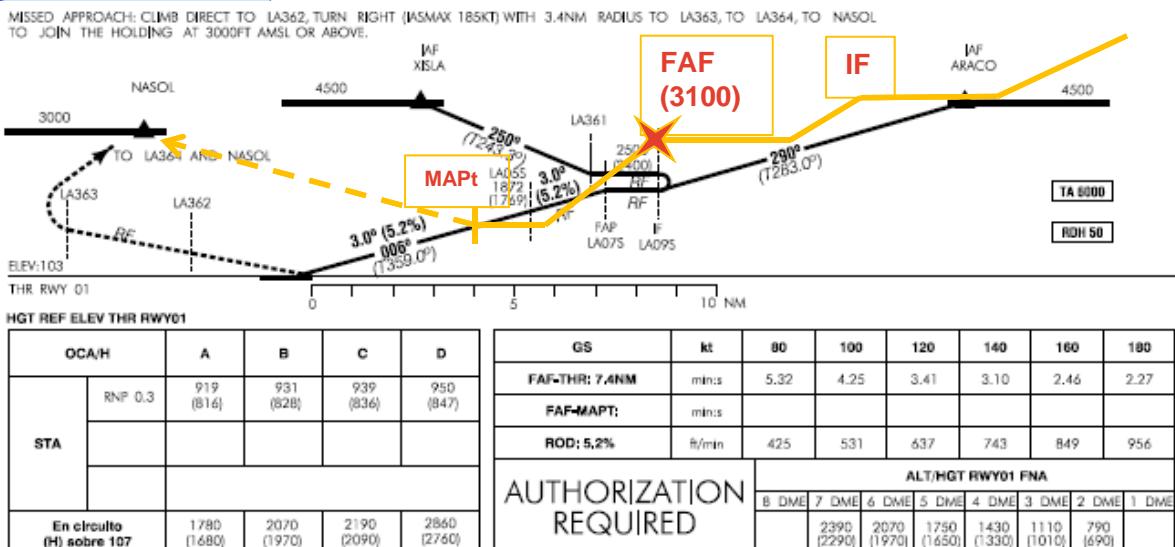
NDB – RNAV (RNP)



HGT REF ELEV THR RWY01

OCA/H	A	B	C	D
STA	RNP 0.1	509 (406)	521 (418)	529 (426)
	RNP 0.3	919 (816)	931 (828)	939 (836)
En circuito (H) sobre 107	1780 (1680)	2070 (1970)	2190 (2090)	2860 (2760)

CAT C Minima cut by 700ft





CCO / CDO Benefits

CCO/CDO benefits:

- ✓ Lower pilot/controller workload
- ✓ Shorter time in sector
- ✓ Improved safety
- ✓ Improved flight predictability and containment
- ✓ Reduced radio transmission
- ✓ Reduced chance of readback / hearback errors
- ✓ Reduced fuel consumption
- ✓ Increased throughput
- ✓ Reduced departure delays
- ✓ More departure lanes and exit points to the en route airspace

Successful CCO/CDO implementation requires joining a number of disciplines including:

- ✓ Previous CCO/CDO design experience
- ✓ Previous CCO/CDO ATC implementation experience
- ✓ ATM CCO/CDO implementation experience
- ✓ PBN Airspace design knowledge
- ✓ Pilot, Aircraft, and Airframe performance knowledge