



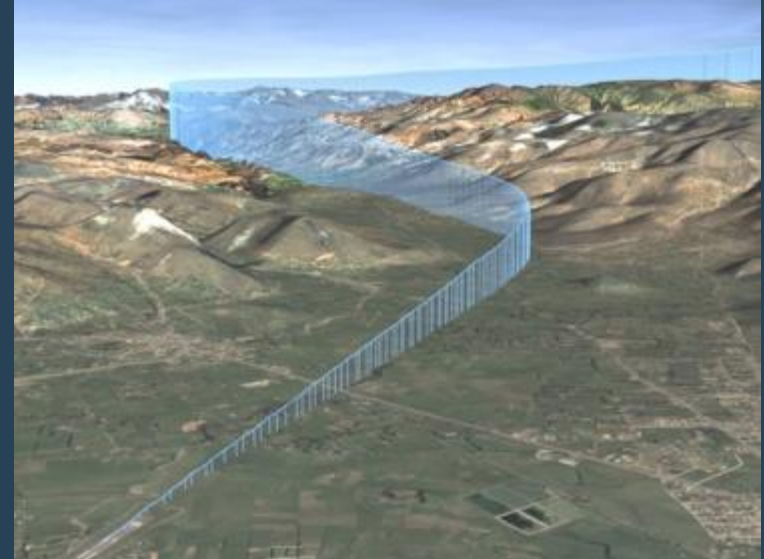
Required Navigation Performance (RNP) Approach Operational Approvals, Challenges, and Way Forward

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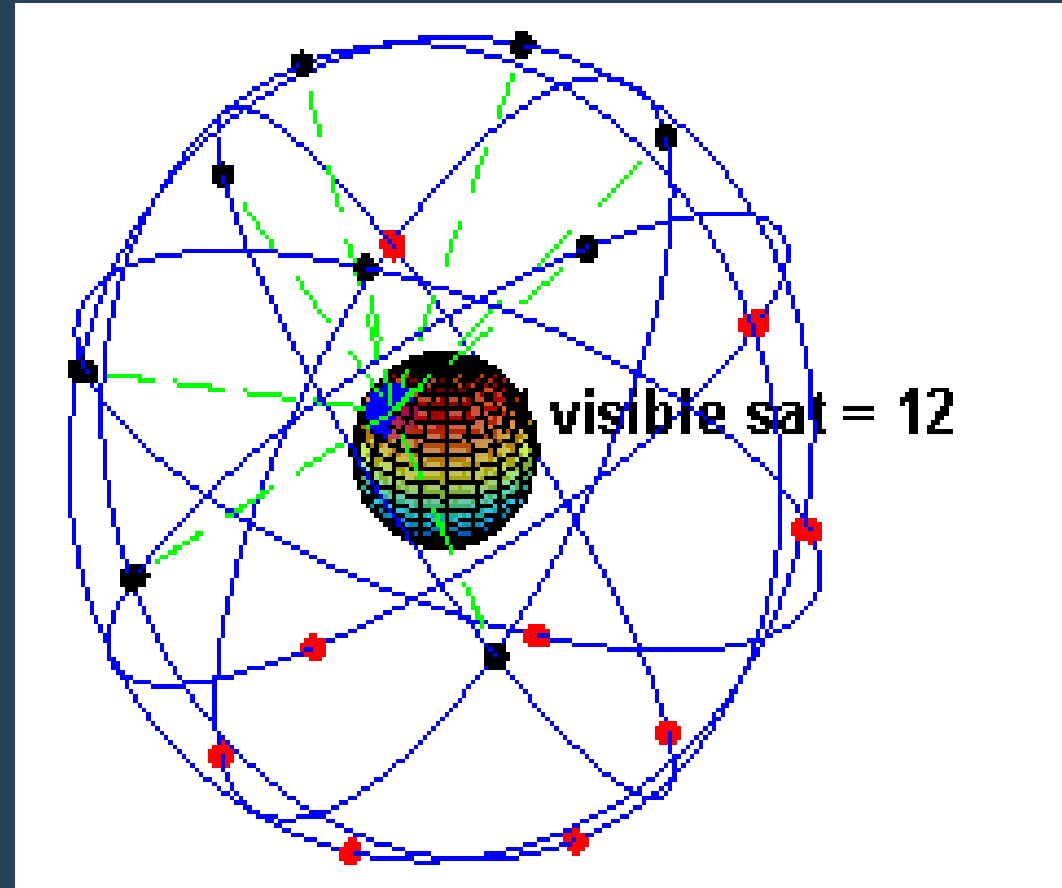
AGENDA – RNP (AR)

- What is it
- Well Known Benefits
 - Safety
 - Economic & Environmental
 - Capacity
 - Low Cost
- Challenges
- Way Forward



Performance Based Navigation (PBN)

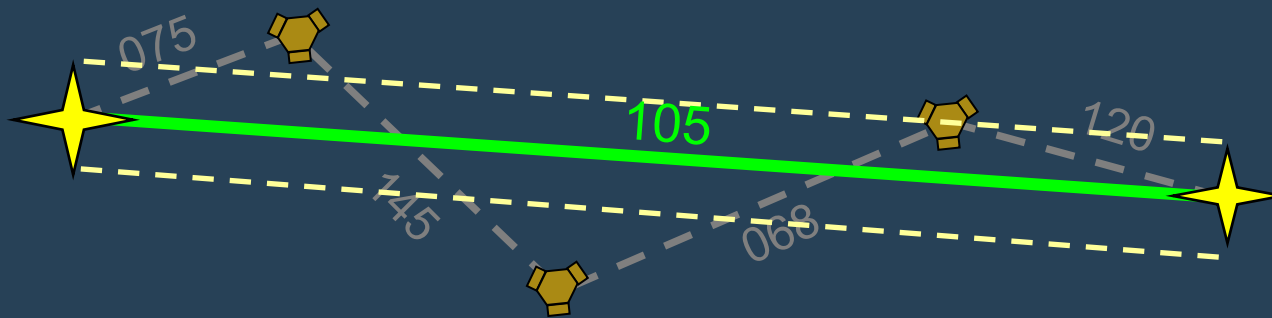
- Primarily GPS/GNSS
- Using Satellites and Navigation Data in the FMC



RNAV & Required Navigation Performance (RNP)

- Allows us to fly point to point without reference to ground equipment
- Your airplanes are already likely equipped, or can be for near trivial cost

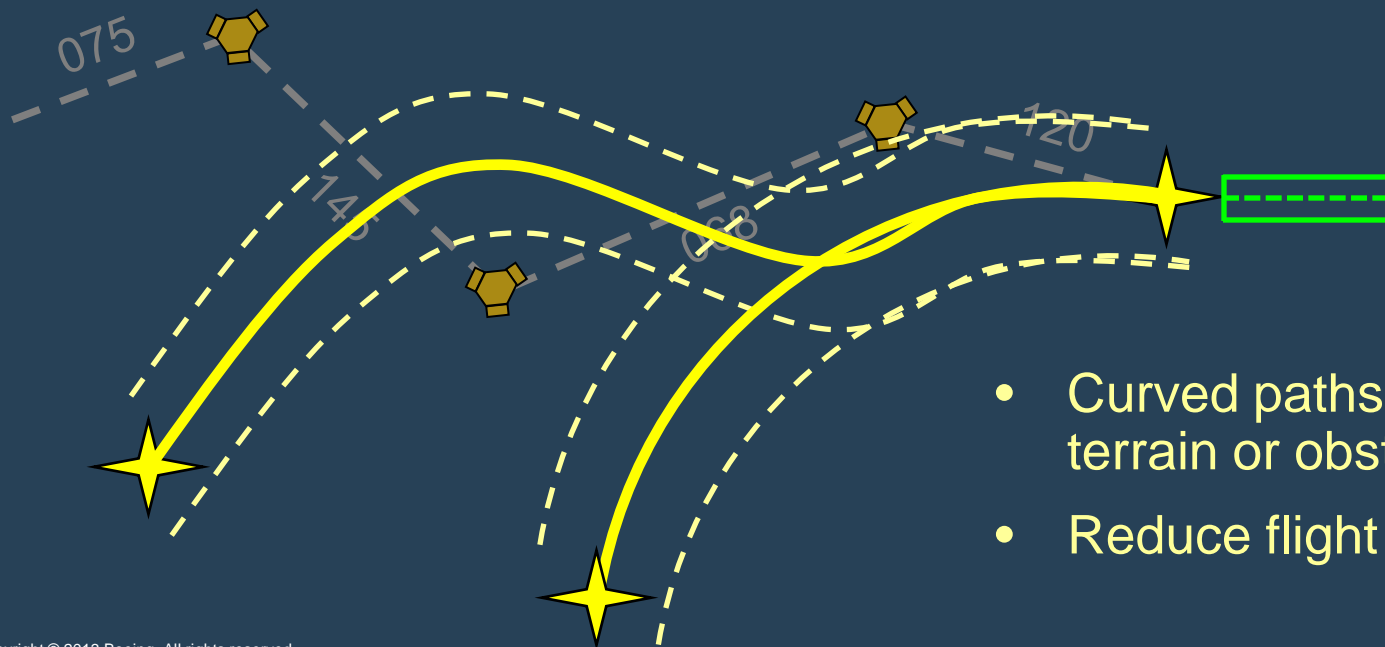
RNAV point to point



- RNP adds:
- Monitoring
 - Alerting

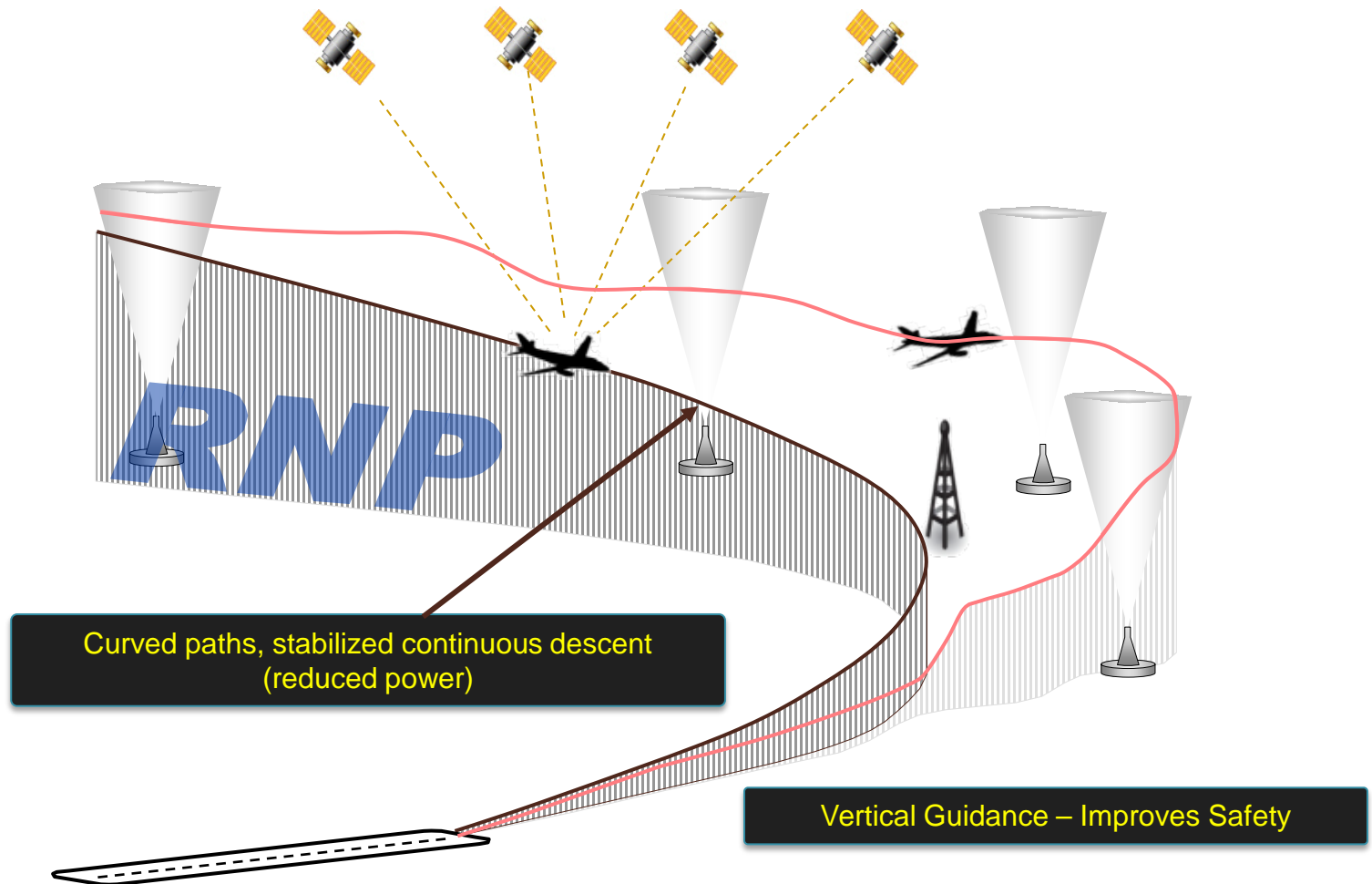
RNAV & Required Navigation Performance (RNP)

- Allows us to fly point to point without reference to ground equipment
- Your airplanes are already likely equipped, or can be for near trivial cost



- Curved paths to negotiate terrain or obstacles
- Reduce flight distance

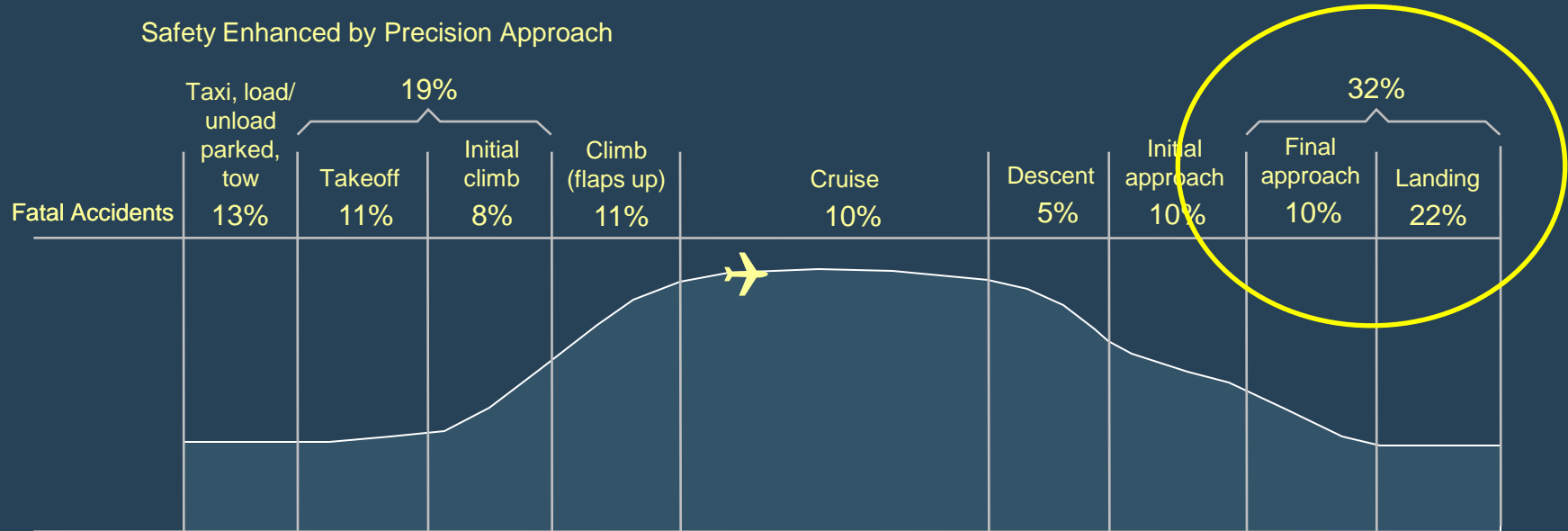
Enables Precise Lateral & Vertical Navigation



Safety

When do accidents/incidents occur?

Safety Enhanced by Precision Approach



*Percentages do not sum to 100% due to numerical rounding.

- Exceptionally rare now: < 1 fatal accident per *4.4 million flights/year world-wide
 - (*2014 IATA accident statistics)
- Approach and Landing – nearly 1/3rd of all accidents in last 10 min of flight
- Vertical guidance **REDUCES RISK** of accident or incident by **9X** in commercial ops

Reference: Commercial Aviation Safety Team (CAST) Analysis and Implementation Plan;
Worldwide 1987-2001 Hull Loss and Fatal Accidents data

Stable Flight Path = Safer Approach

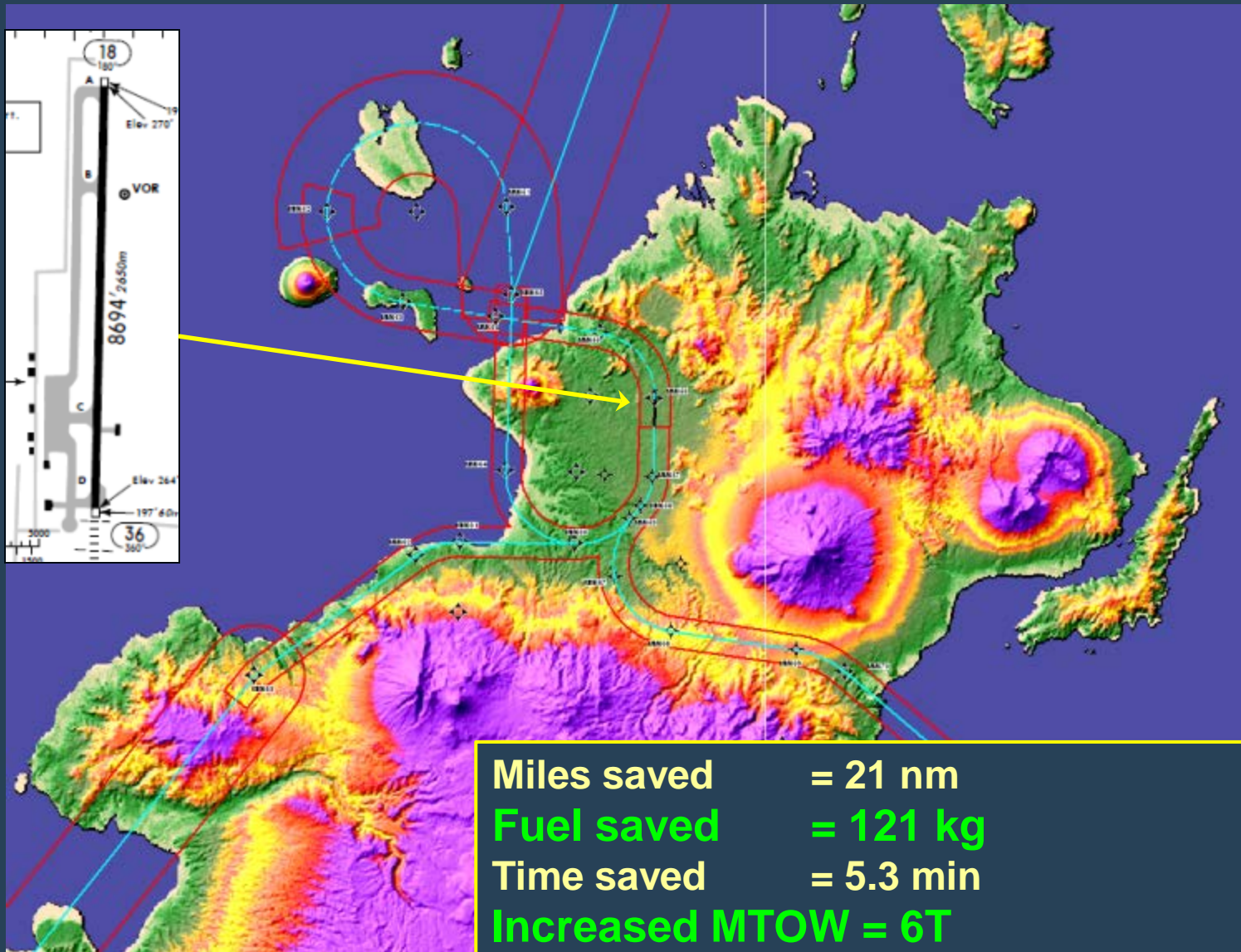
- Safety is improved by using RNP to provide path guidance during approach
- Risk is reduced by using RNP approaches to replace non-precision approaches (“dive and drive”)
- Palm Springs, Calif. Conventional
- Palm Springs, Calif. RNP
- Incident and Accident Prevention?
 - Bali (737NG), SFO (777), BHM (A300),

Reference: *Flight Safety Foundation, 2011, A Recommended Process: Safely Reducing

Redundant or Underutilized Instrument Approach Procedures

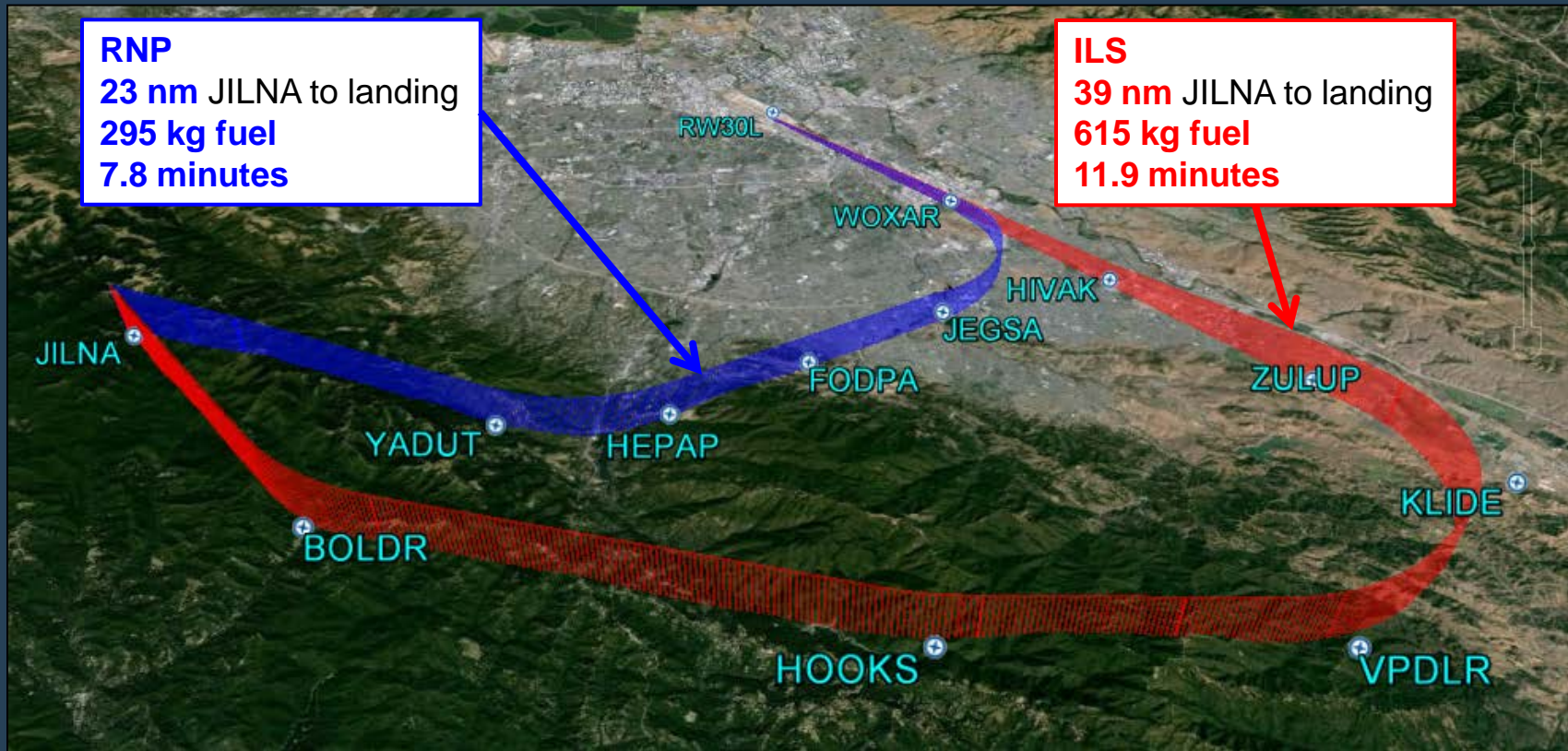
*Bregman et. al., 1997, “Safety Benefits of Precision vs. Non Precision Approaches,” The MITRE Corporation, McLean VA.

Safety (WAMM RNAV RNP RWY 36 - 737)



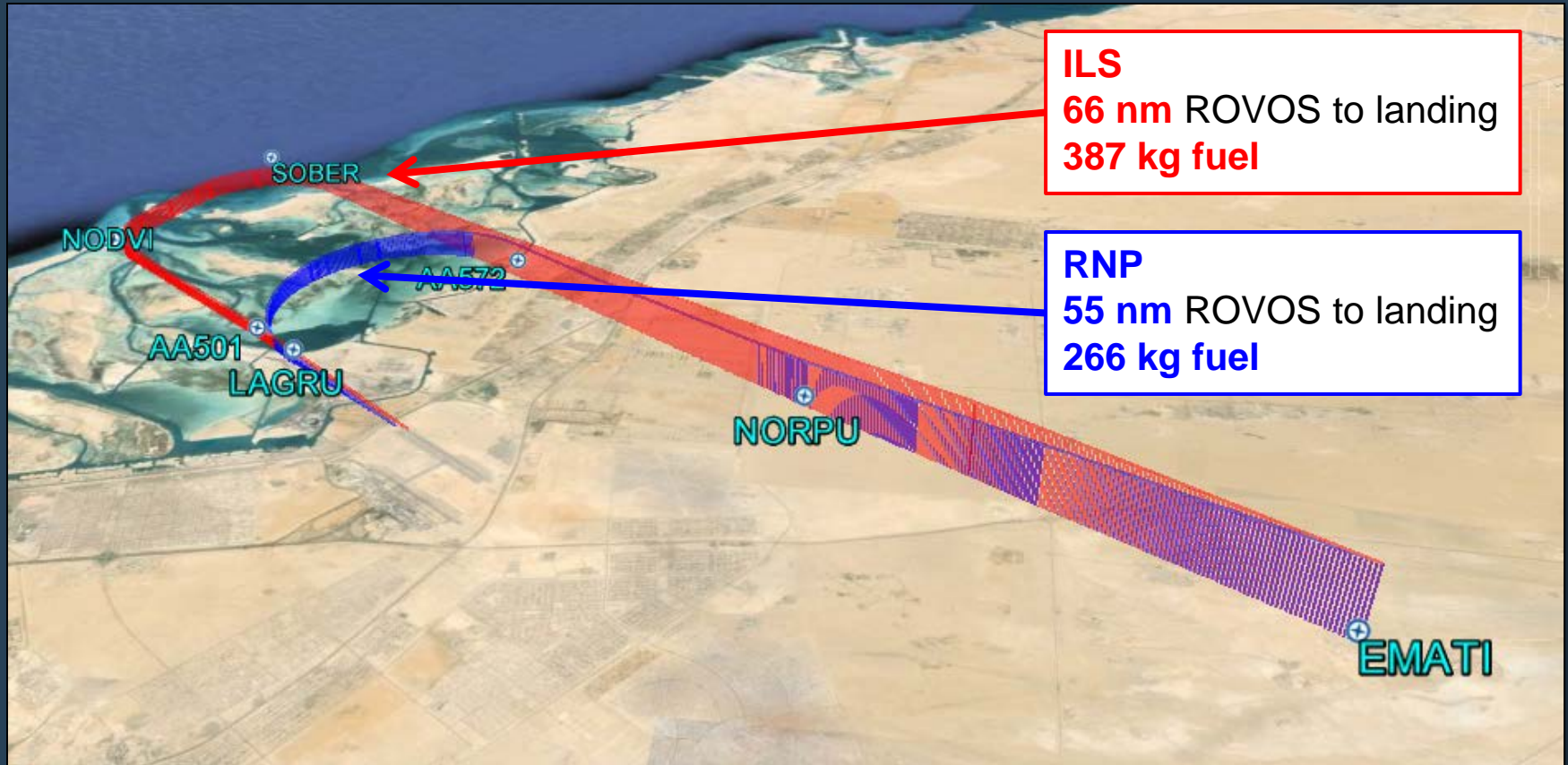
Miles saved	= 21 nm
Fuel saved	= 121 kg
Time saved	= 5.3 min
Increased MTOW	= 6T
Vertical Guidance Added	

Economic (SJC RNAV(RNP) Rwy 30L – 787)



Miles saved = 16 nm
Fuel saved = 320 kg
Time saved = 4.1 minutes

Economic (Abu Dhabi Rwy 13L – 737)



Miles saved	= 11 nm
Fuel saved	= 121 kg
Time saved	= 2.8 min

Capacity – Mumbai (RNAV (RNP) RWY 32 – 737)

Missed Approach

Climb on track 315° to BB to 3700. Thereafter expect vector.

DCT to BB803

RDH 50

THR Elev. 25

OCA(H)

Category

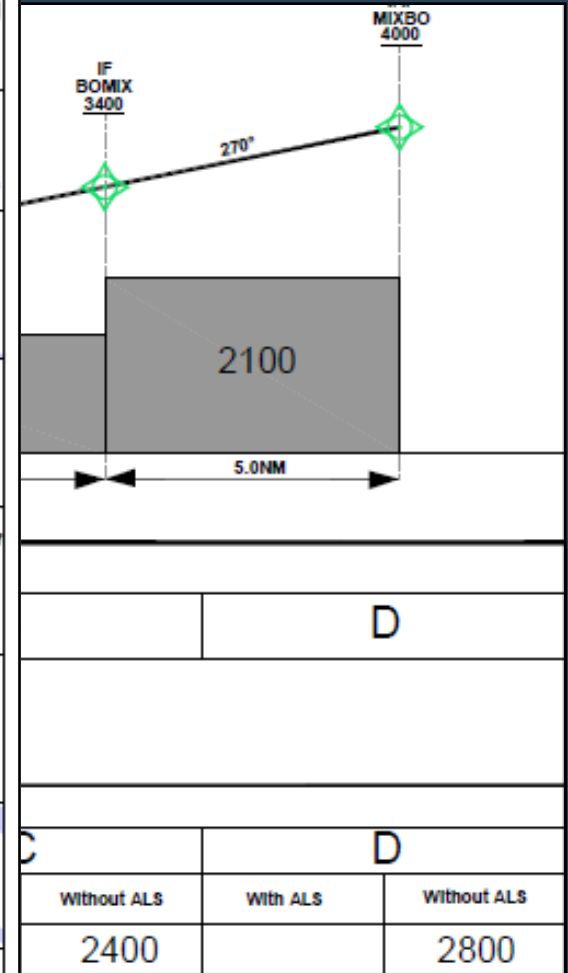
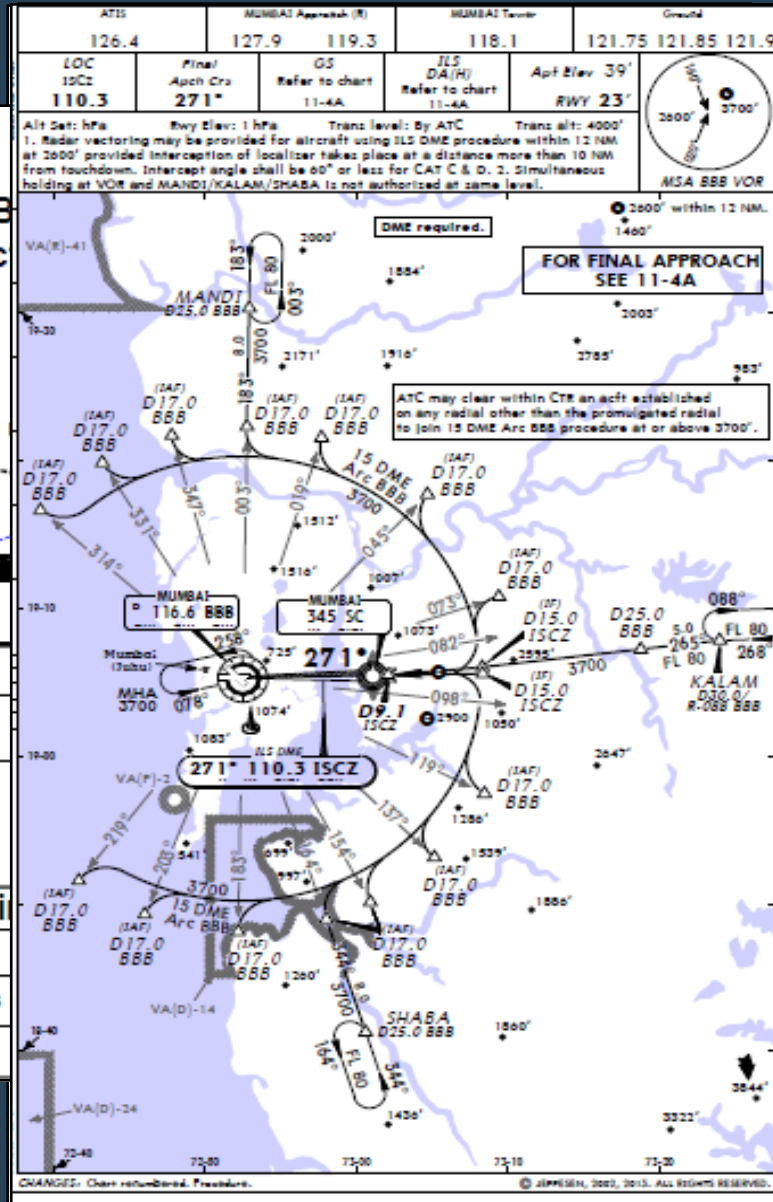
RNP 0.3

Aerodrome Operating Mini

Category

With ALS

Minima



Capacity Improvements

- **Estimated 10-30% improvements in throughput**
 - VMC, IMC low visibility

Savings for a 737 Mumbai

- **35 minute ground delay prevented by RNP Operations:**
 - 80 gal fuel saved assuming engines running half the time
 - 1,500 pounds of CO2 emissions saved
- **10 minute airborne flight extension saved by RNP Operations:**
 - 75 gal fuel saved
 - 1,760 pounds of CO2 emissions saved per flight.

Requirements, Costs

Airplane

①

New Airplane Options
Retrofits

Variable

- FMCs, MMRs
- Wiring mods
- Software Activations
 - NPS
 - TOGA/LNAV
 - EOSID
- Service Bulletins

Services

②

RNP AR
Operational Approval

\$200k-\$400k

- Full project:
 - Conventional Nav
 - RNP AR Ops
- Engineering & Compliance documentation
- Ops Procedures
- NavData Process
 - Validate/Compare
- MEL
- Training
 - Pilot
 - Dispatch
 - ATC
- RAIM Services etc.

③

Procedures
Flight Paths

\$150k - \$350k

- Feasibility Studies
- Instrument Flight Procedure Design
- Wholesale Airspace Redesign
- FAA, ICAO, etc, all design standards

④

Training

Variable

- Pilot/Dispatch Academic
- Pilot Simulator Training
- Regulatory, Education, Seminars & Workshops

Issues & Challenges

- Regulators hesitant to grant RNP AR approval despite:
 - Well known safety & efficiency benefits
 - Detailed operator applications
 - Thoroughly vetted proposed operations and training
- Risk
 - New = risky? Not doing it is risky!
 - Lack of confidence in operators
 - Potential down side – if an incident occurs?
- Regulatory framework not in place
 - Hesitant to move forward despite abundance of well established guidance available, once in place – slow...
 - ICAO 9613, EASA 20-26/7, FAA 90-101/05, CAAC 91FS05, etc
- Budget & Business Cases
- Other
 - New noise where new flight tracks might be put in?



Actions Taken

Path Forward – What we are doing now to advance approvals



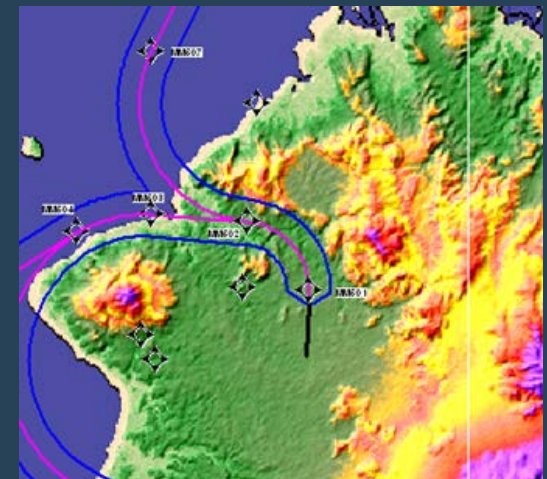
- Aircraft
 - Equipped and certified (> 15 years)
 - Onboard equipment, installed, capable, proven
- Training Available Now
 - OEMs and third party
 - Well established, available, approved by regulators
 - Available worldwide
- Operators Ready, Willing, and Able
 - Procedures, Navdata, MEL, all available
- Regulators have abundance of guidance
 - Track record is proven – Australia & China are prime
- ICAO, COSCAP Assistance
 - Available and funded



Actions Taken

Boeing's efforts – Committed to RNP AR Advancement

- Funded initial RNP AR Projects around the world
 - Full RNP AR Ops Approval plus procedure design
 - Do not charge additional for AFM certification pages
 - For Ops Approval, charge at near cost
 - Regulator education during RNP projects
- Education
 - OEMs and third party training established & regulator approved, Available worldwide
 - Regulator Staff Instruction Development
 - Seminars, forums, education on regulations, documents, resources
- Customer Benefit Analyses
- Procedure Design for maximum participation
 - Public design criteria
 - Minimum exceptions



Results

Much Progress

- ICAO simplifying operational approvals
- Reciprocal approvals (among regulators) moving forward
- Many approvals granted
- Many use on a daily basis
 - Training is mature
- Use continues to spread

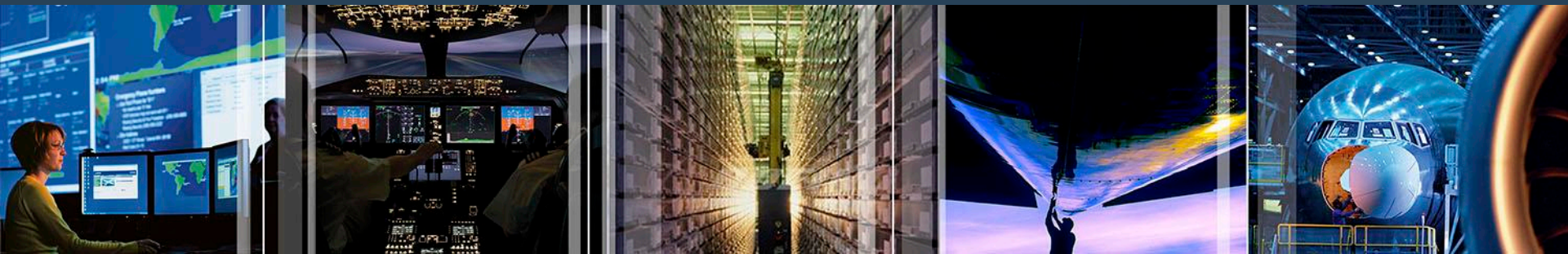
However...some approvals continue to languish

- **AND CONTINUE TO FLY NDBs** and others with no vertical guidance instead
 - NDBs, really????
 - 5 – 9 x the incident and accident rate without vertical guidance due to unstabilized approaches
- Continue to fail to benefit from fuel, emissions, track miles savings

Way Forward

SAFETY ALONE COMPELS ACTION – CALL TO ACTION

- What can we do as operators, manufacturers, regulator
- Take advantage of the resources available ICAO, COSCAP, consultants
- Education & Persistence are critical
 - Persistent emphasis on the benefits, particularly safety
 - Continued emphasis from independent sources such as COSCAP, ICAO, workshops, safety conferences & seminars...
- Business cases
- Early stakeholder buy-in
 - Operators ~ Regulators ~ ATC ~ ANSP



RNP Summary



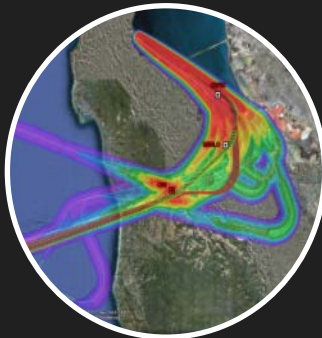
Safer

- Reduced pilot workload
- Stable flight path
- Autopilot



Quieter Smoother

- Smoother ride
- Engines idle
- Quieter cabin
- Quieter on ground



Less Fuel Burned

- Less exhaust
- Less CO2



Schedule Reliability

- Fewer delays
- Fewer Diverts



Lower Costs

- Ticket Prices
- System costs

Safer, More Reliable, Cheaper, Environmentally Responsible



Questions?