



BOEING COMMERCIAL AIRPLANES



# Boeing GBAS and SBAS Overview

June 3-5, 2019 ICAO GBAS and SBAS Workshop

Bill Peterson

# Topics to be covered

**Boeing GLS/GBAS Overview**

**RNP to GLS Demonstration**

**Boeing LPV/SBAS Overview**

# Evolution of Global Navigation Satellite Systems (GNSS)

Next Generation GNSS  
Localizer Performance with  
Vertical Guidance (LPV) 2020s

Global Navigation Satellite  
Landing Systems (GLS) 2010s

Required Navigation  
Performance (RNP) 1990s

Instrument Landing  
System (ILS) 1950s

VHF omnidirectional  
range (VOR) 1930  
to

Non-Directional  
Beacon (NDB) 1940



**GLS enhances safety, economics and provides positive environmental impacts**

**Boeing is supporting GBAS CAT III (GAST D) system design approval and certification efforts**

**GLS demonstrations drive growth in airport deployment and fleet**

# Boeing GLS Program



# 737NG-700/800/900



**GLS  
CAT I**

Option



**1510**

Airplanes with GLS  
activated



**20%**

In-Service Fleet  
with GLS

# 747-8



**GLS  
CAT III**  
Standard



**140**  
Airplanes &  
Counting



**100%**  
In-Service Fleet

# 787-8/9/10



**GLS  
CAT III**

Standard



**820**

Airplanes &  
Counting



**100%**

In-Service Fleet

# 737MAX-7/8/9



**GLS  
CAT III**

Option



**250**

Airplanes &  
Counting



**90%**

In-Service Fleet

\* GLS CAT III planned 20/21

# 777X-8/9



**GLS CAT  
VIII**

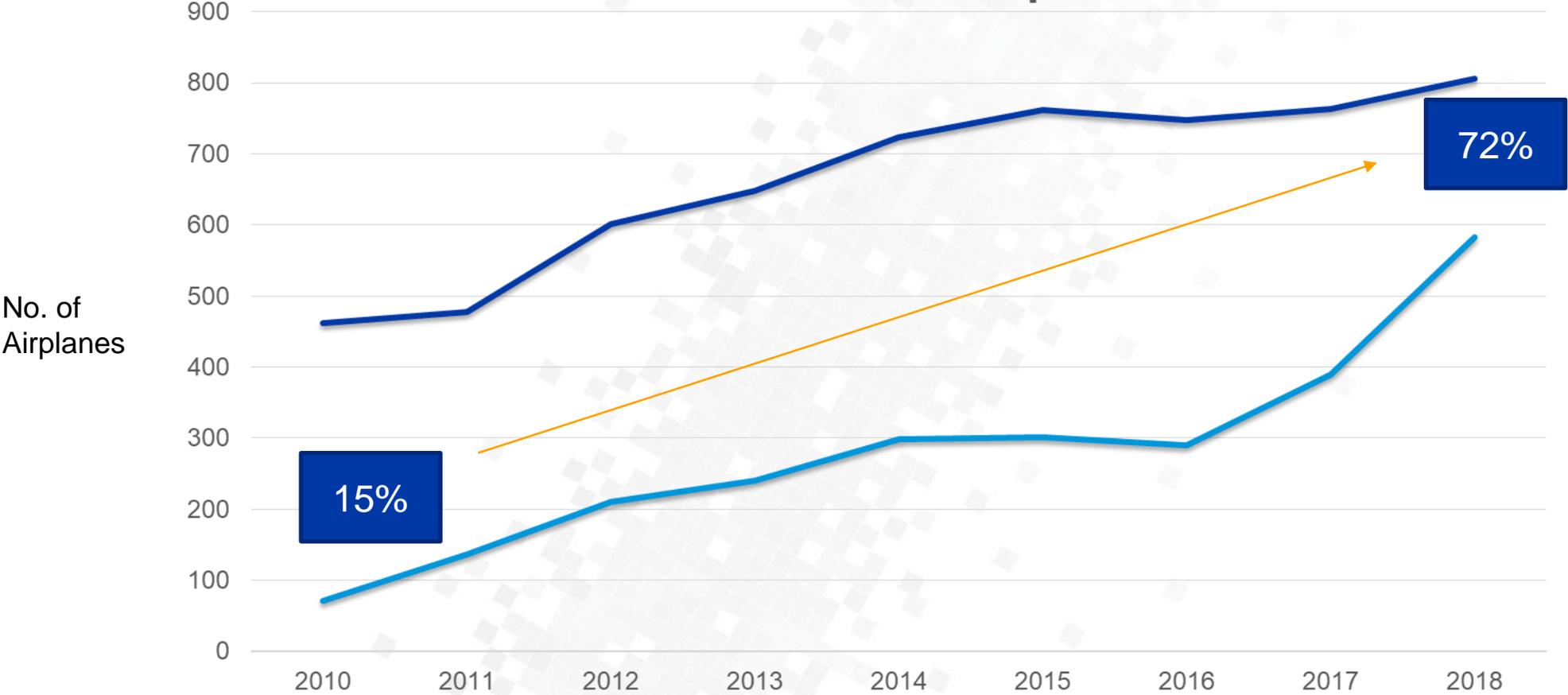
CAT I/II Standard,  
CAT III Option



**344**

Airplanes on Order

# Deliveries vs. GLS Options



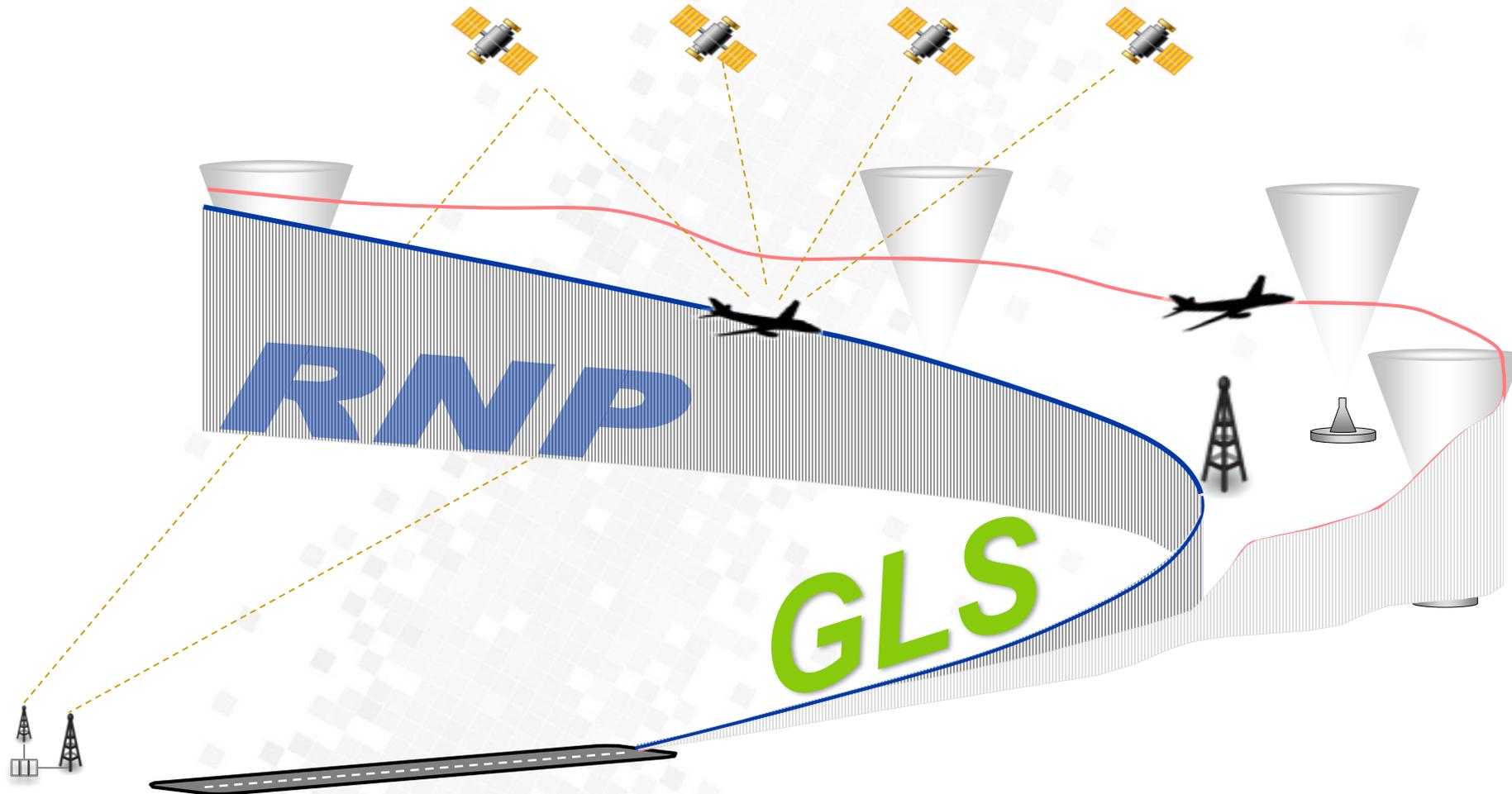
# Topics to be covered

Boeing GLS/GBAS Overview

**RNP to GLS Demonstration**

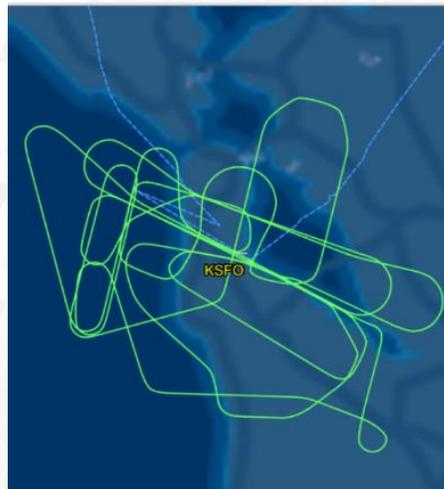
Boeing LPV/SBAS Overview

# RNP to GLS Curved Approaches

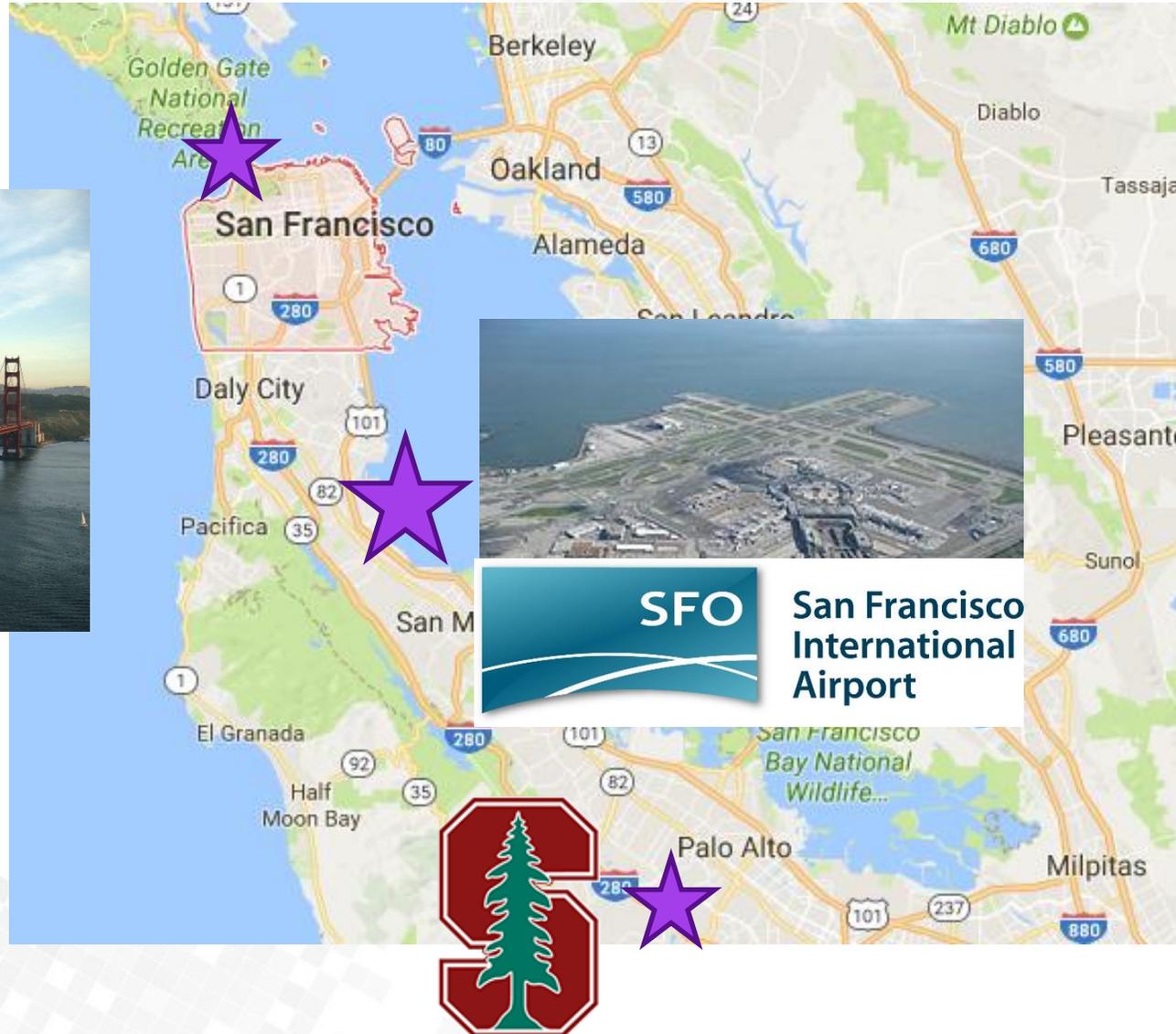


# San Francisco RNP to GLS Demonstration

Airlines, Boeing, Airport and ATC collaboratively designed procedures



# San Francisco Geography



**SFO** San Francisco International Airport



# Operational Constraints at SFO



**19R 19L**  
**NO ILS ILS**  
**Aircraft hangar**

**28R**  
**ILS**

**28L**  
**ILS**

**10L 10R**  
**NO ILS**  
**San Bruno Mountain**

**1L 1R**  
**NO ILS**

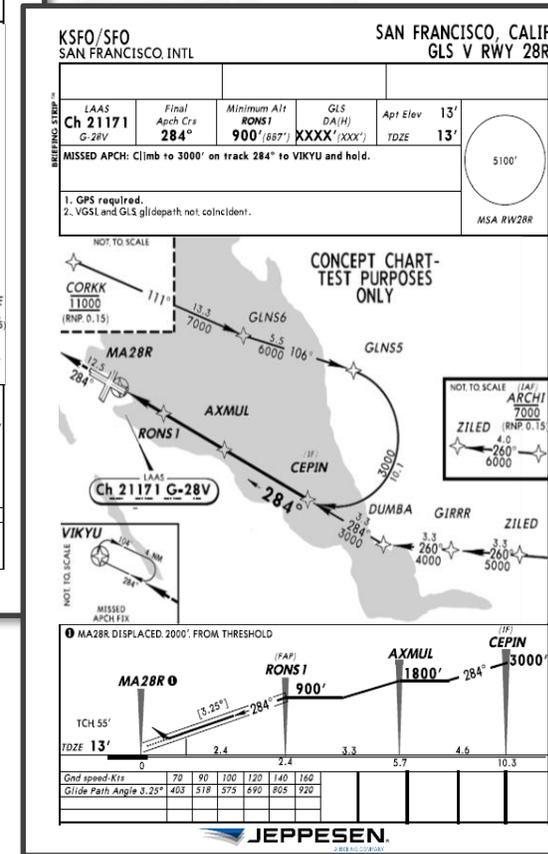
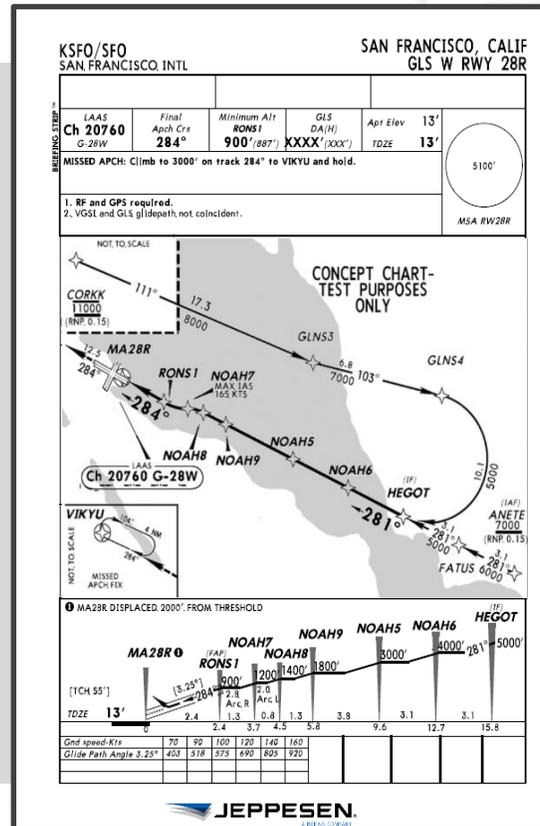
# San Francisco Geography



# New Efficient Procedures to 28L and 28R

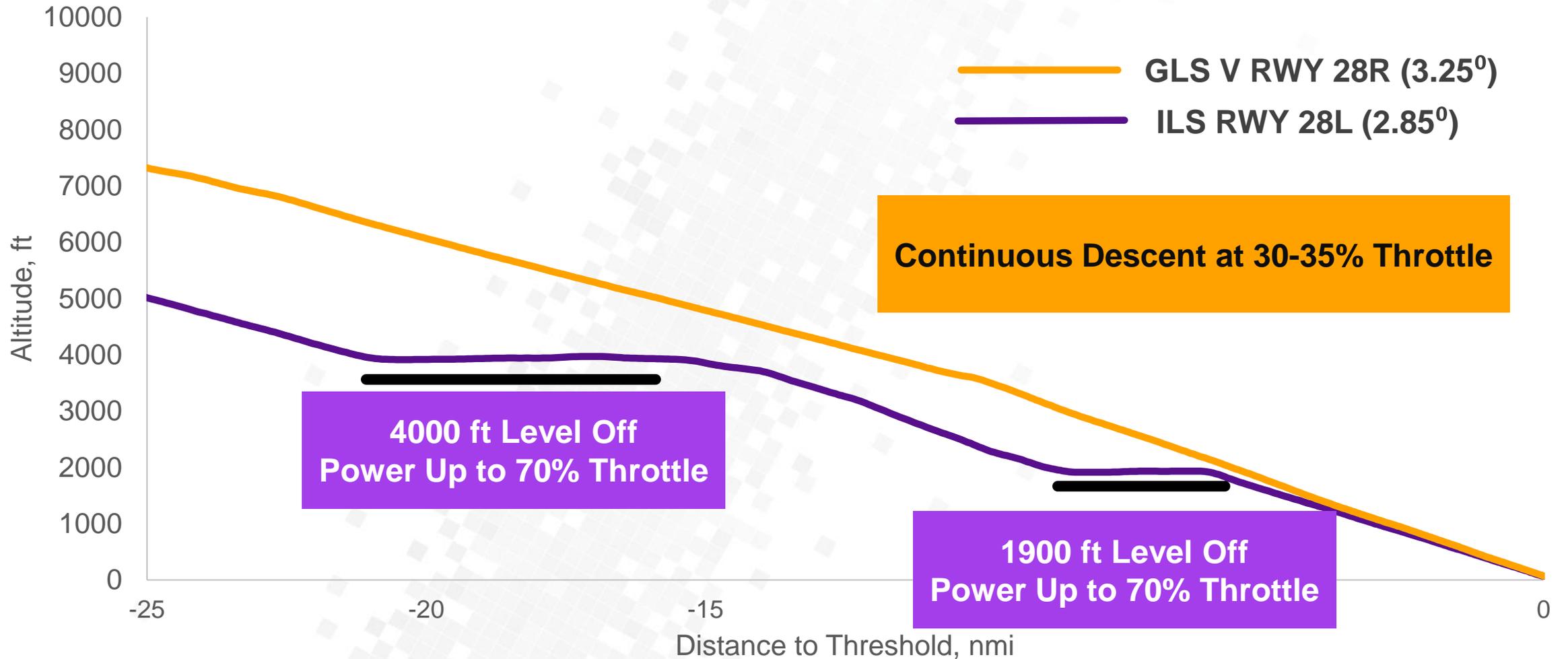
Automate 'S' turns manually flown today

Maintain continuous descent path to the runway

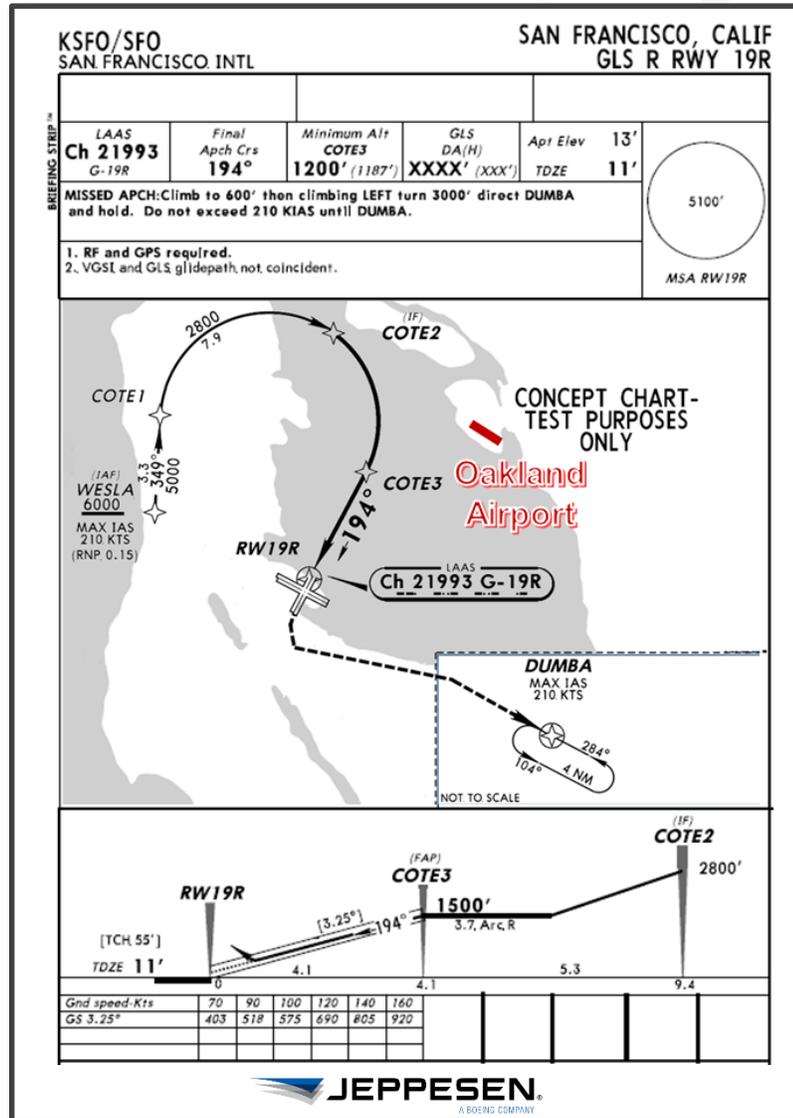


Increase vertical separation between aircraft streams using displaced threshold (2000 ft) and higher glideslope (3.25°)

# Optimized Vertical Profiles



# New Efficient Procedures to 19R



First precision approach to 19R

De-conflict approach with Oakland airspace

Continuous descent reduces noise and emissions instead of a long, straight-in final

# Benefits of New Efficient Procedures to 19R



Typical Short Vector Route  
Estimated Population: 329,600 to 55dBA



SFO GLS R RWY 19R  
Estimated Population: 47,300 to 55dBA



↓ 86 Reduction in Community Noise Exposure

FLIGHT TRACK

36.3 nm

20.5 nm

FUEL BURN

792 lb / 360 kg

424 lb / 193 kg

CARBON EMISSIONS

2499 lb / 1136 kg

1338 lb / 608 kg

↓ 60% Reduction in Fuel Burn & Emissions

# Topics to be covered

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RNP to GLS Demonstration

**Boeing LPV/SBAS Overview**

# Operational Comparison

Approach Capability	RNP + Baro-VNAV	SBAS (LPV)	GBAS (GLS)
Category I (to 250' DA)	Supported with low RNP	Supported	Supported
Category I (to 200' DA)	N/A	LPV 200	Certified with autoland
Category II (to 100' DH)	N/A	TBD	By 2019
Category III (Autoland)	N/A	N/A	By 2021

# SBAS on Air Transport Class Airplanes

## Basic SBAS

- 2-D positioning
- Improved support for RNP operations
- Supports ADS-B

## SBAS Approach

- 3-D positioning
- Supports LPV approaches
- Integrated as xLS

# Regional GNSS Mandates

Region	GNSS Receiver	Date	Aircraft Applicability
India	SBAS/GAGAN	2019	India Registered
United States	No Mandate*		
Europe	No Mandate		
Australia	SA-Aware	Dec 2016	Airspace
China	SA-Aware	Dec 2022	China Registered
Russia	GLONASS	2017	Airspace
Canada	No Mandate		

\* Exemption from US ADS-B Out pre-dispatch performance check for SBAS (WAAS) and FAA authorized ABAS

# FAA ADS-B Out Mandate

Permanent exemption for SBAS

Permanent exemption for FAA authorized Hybrid GNSS/Inertial

FAA Exemption 12555 for SA-Aware

- Exemption from 1 Jan 2020 to 1 Jan 2025
- Exemption request deadline was 1 Aug 2018

No exemptions for SA-On

# Boeing Basic SBAS Implementation

Airplane Model	Honeywell (iMMR)	Rockwell (GLU 2100)
737MAX	Available	Available
737NG	Available	2019
777	2019	Available
777X	2020	2020
747-8	Not Planned	2019
767	Not Planned	Not Planned
787	Current Study	Not Planned

# Boeing SBAS Approach Implementation

Airplane Model	SBAS Approach (LPV)
737MAX	Current Study
737NG	Current Study
777	Current Study
777X	2020
747-8	Not Planned
767	Not Planned
787	Current Study

**Over 3,000 Boeing GLS airplanes**

**72% of new airplane deliveries have GLS**

**GLS CAT III in 2020**

**Demonstrated benefits**

**SBAS receivers growing, LPV in 2020**

