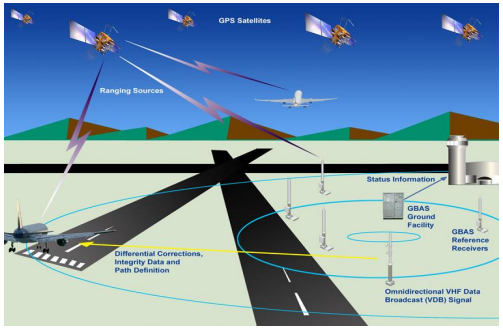
SFO San Francisco International Airport

Ground Based Augmentation System (GBAS) Information Meeting

Palo Alto, CA Workshop Meeting

October 2, 2018

Agenda



What is Ground Based Augmentation System (GBAS)?

- GLS Approach
- GLS Implementation
- Stakeholders

GBAS at SFO

- Project Goals
- What to Expect and When
- Current Progress

What's Next

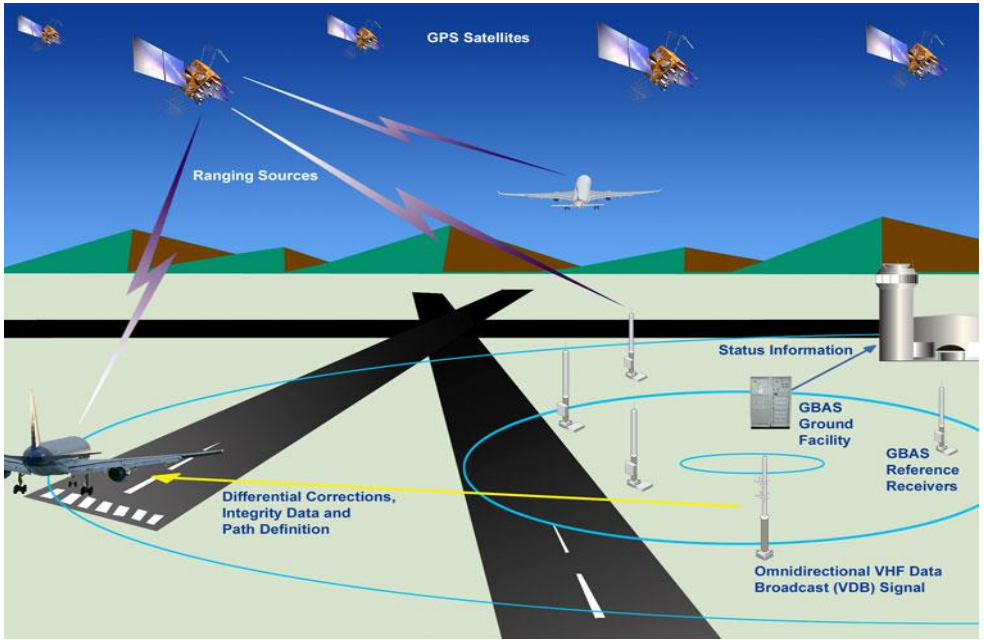
Question and Answer

Overview

Ground Based Augmentation System (GBAS)

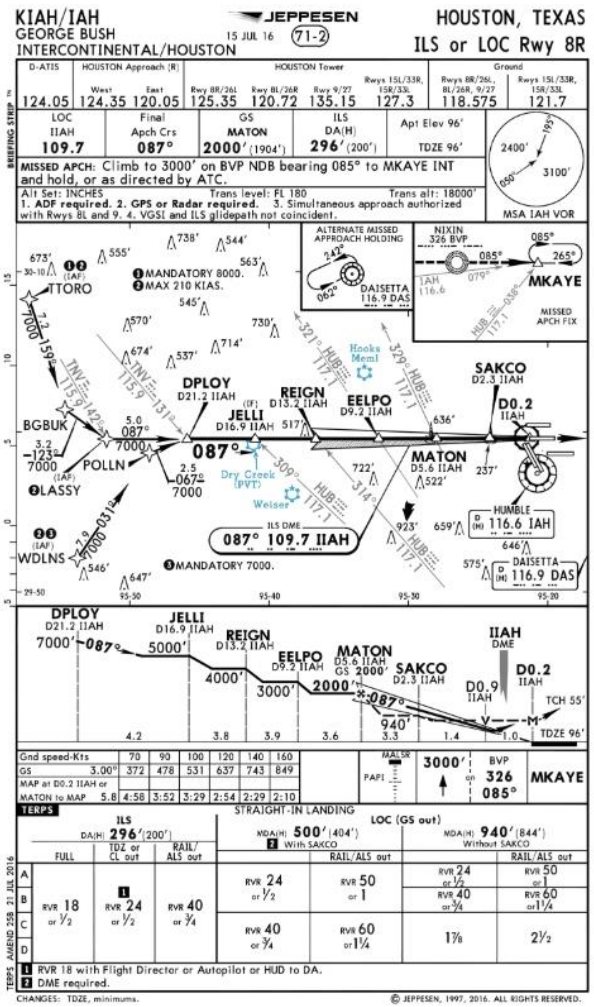
What is GBAS?

- Ground Based Augmentation System
- Produces local corrections to the GPS signal
- Corrections and flight path information broadcast via VHF to aircraft with capable receivers
- Aircraft utilize precise flight director or autopilot guidance down to the runway
- One Installation Serves All Runways

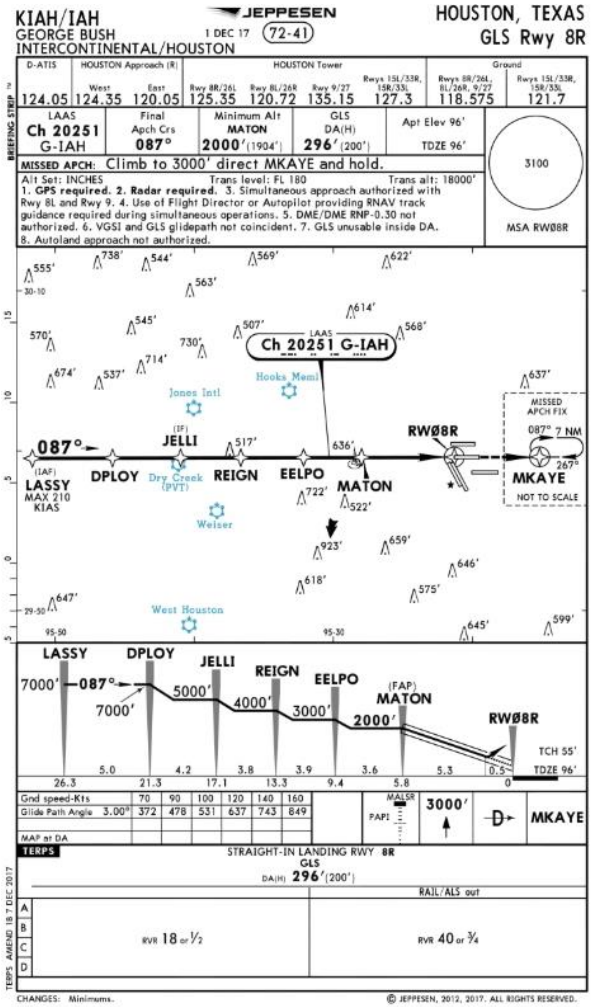


An approach that uses a GBAS is referred to as a GBAS Landing System Approach or GLS

GBAS GLS Approaches



GLS Approaches Are Currently Designed To Replicate ILS Both in Form and Function



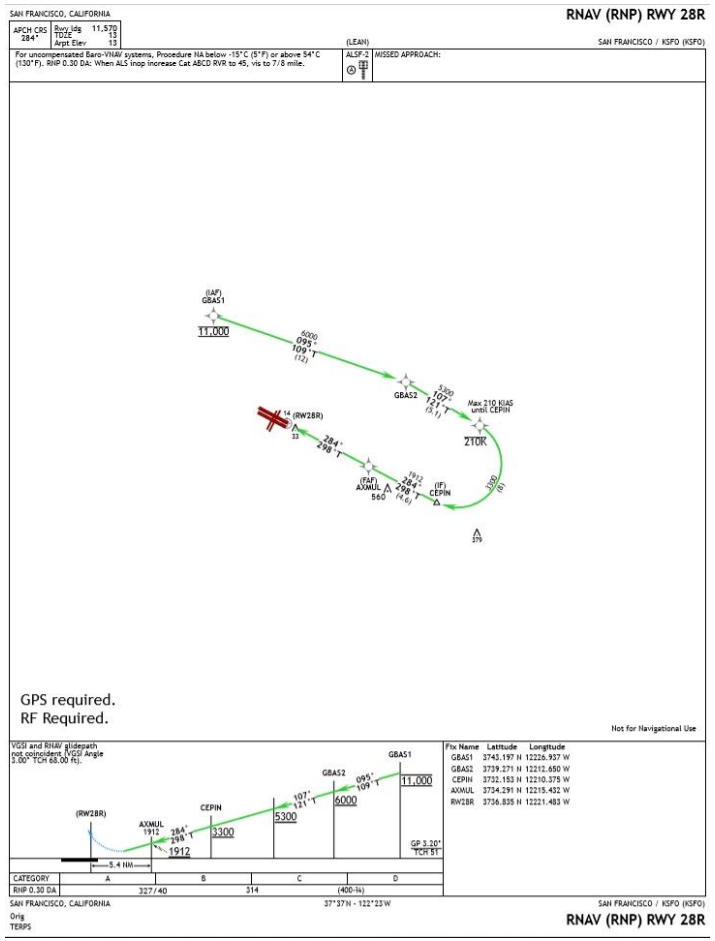
GBAS GLS and ILS Approaches

GLS Approaches are Similar to an Instrument Landing System Approach (ILS)

- Enables autopilot coupled approaches
- Provides vertical guidance in the cockpit until touchdown
- Supports CAT I Approach Minimums
- CAT I = 200ft Above the Runway and 1800ft of visibility
- Both can utilize alternative navigation methods to align with GLS/ILS precision guidance (RNP to GLS and RNAV to GLS)

In the next 2-5 years GBAS will also be capable of Supporting CAT II and CAT III Minimums

- CAT II = 100ft above the runway and 1200ft of visibility
- CAT III = 0ft above the runway and 700ft or less of visibility

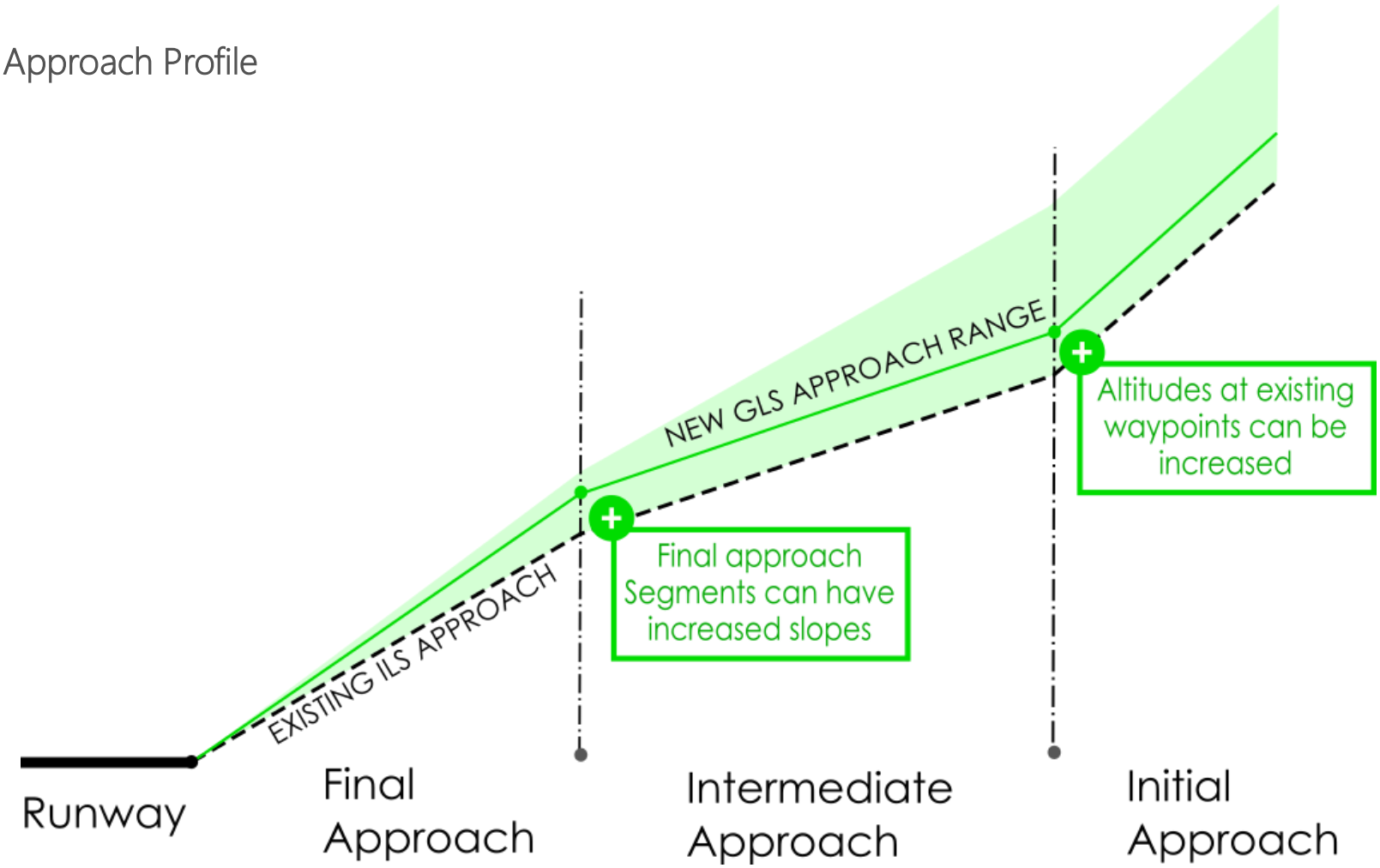


GBAS and ILS Differences

ILS	GBAS
• One Per Runway Direction • Must be aligned with/along side runway • One Glideslope Angle • One touchdown point • 2 Critical Areas which overlap taxiways • Modifications to ILS can take months	• Serves all runways • Located in vicinity of runways • Multiple Glidepath Angles • Multiple touchdown points • 1 Small Critical Area • Modifications to GBAS can take hours

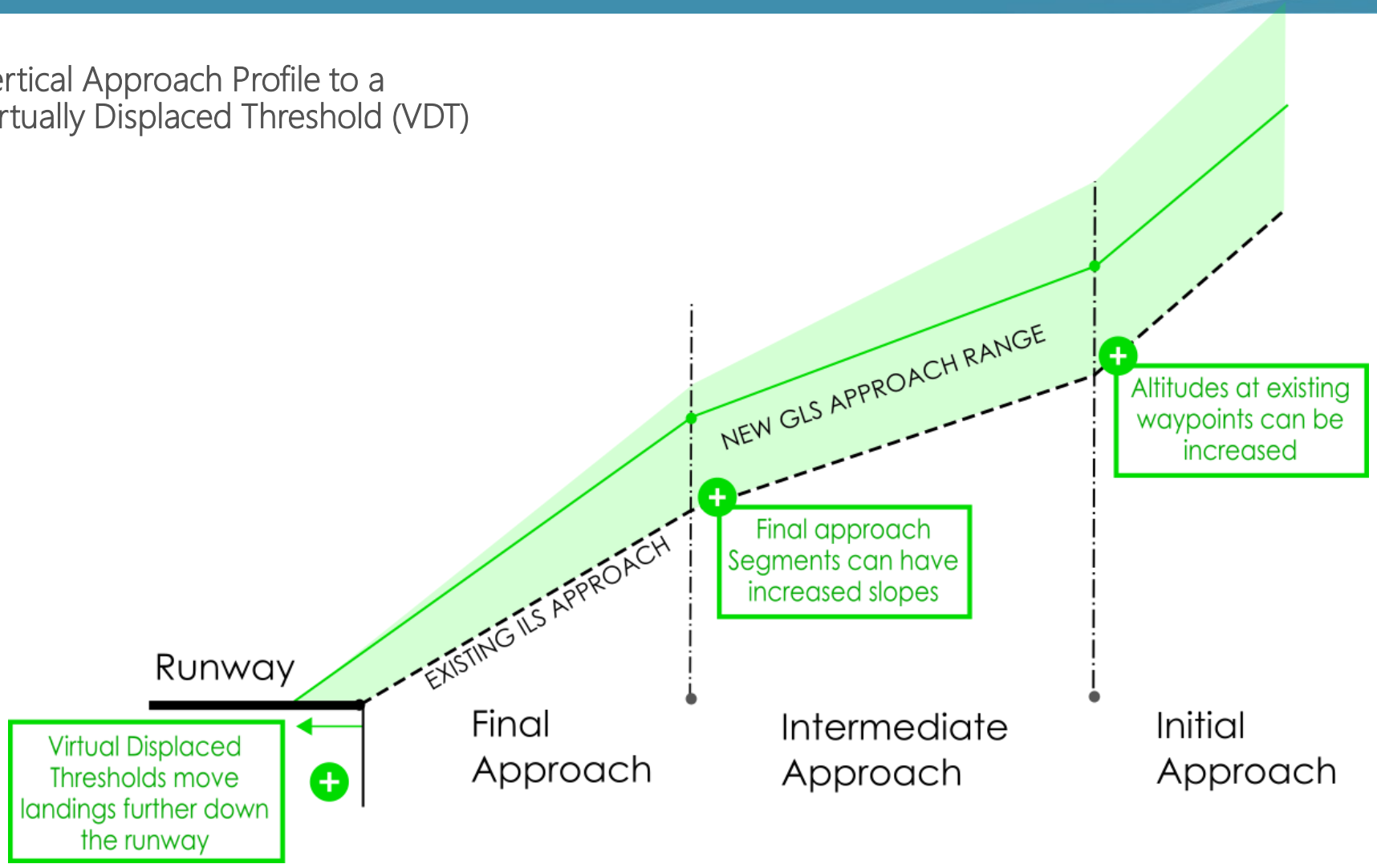
GLS Approach Options vs ILS Approach

Vertical Approach Profile



GLS Approach with VDT vs ILS Approach

Vertical Approach Profile to a
Virtually Displaced Threshold (VDT)



GBAS Service Area

GBAS/GLS US and Global Implementation

USA – Current

- Newark Liberty International (KEWR)
- Houston George Bush Intercontinental (KIAH)
- Atlantic City (KACY)
- Grant County International Airport (KMWH)
- Charleston International Airport (KCHS)

USA - Upcoming

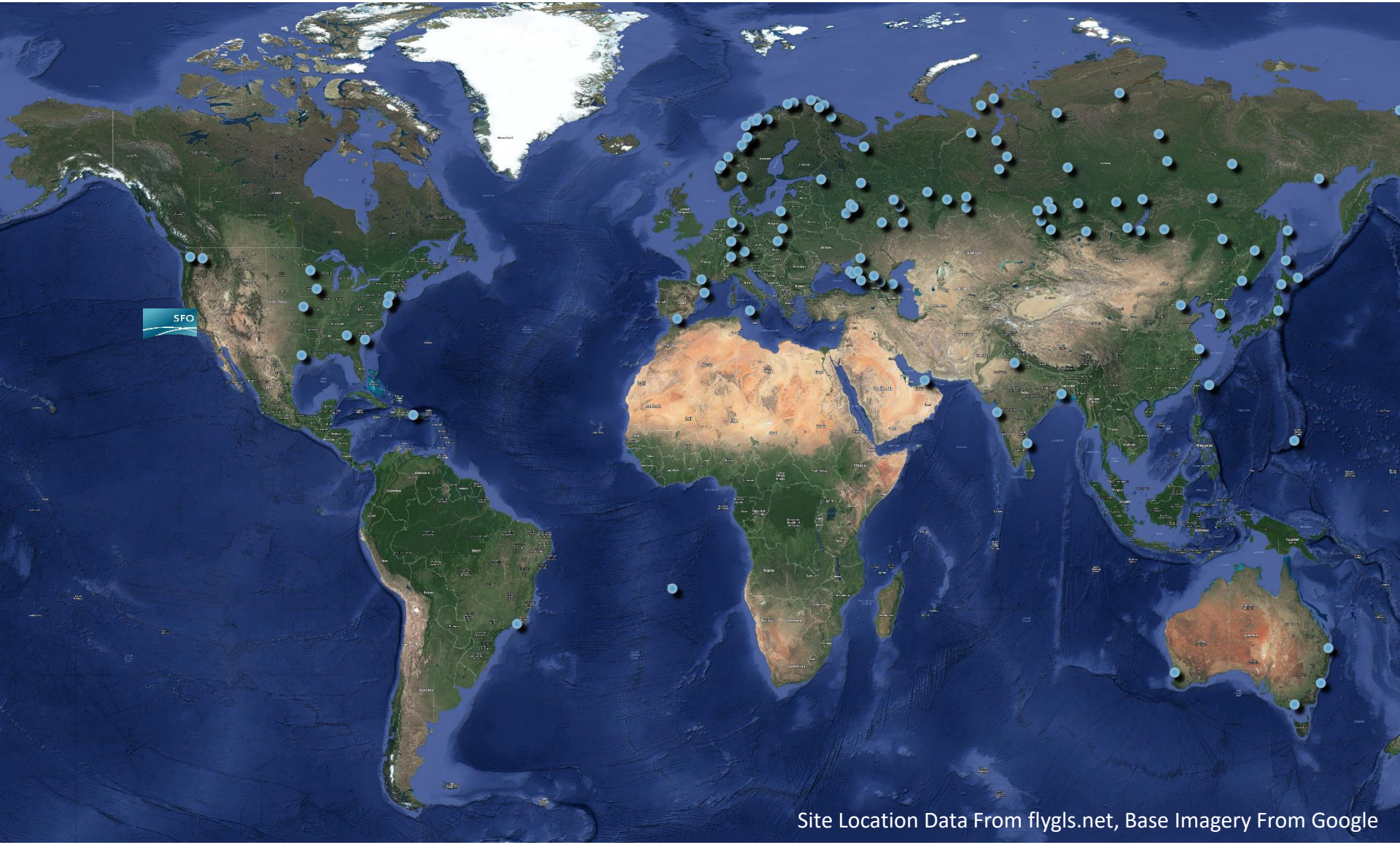
- LaGuardia Airport (KLGA)
- John F Kennedy International (KJFK)
- Seattle-Tacoma International (KSEA)
- San Francisco International (KSFO)
- Atlanta Hartsfield-Jackson International (KATL)

Over 100 GLS Approaches Currently In Use Around The World

International – Current and Upcoming

- Bremen (EDDW)
- Frankfurt/Main (EDDF)
- Zurich (LSZH)
- Malaga-Costa Del Sol (LEMG)
- Sydney Kingsford Smith International (YSSY)
- Melbourne International (YMML)
- Kuala Lumpur International – Sepang (WMKK)
- Chennai International (VOMM)
- Shanghai Pudong (ZSPD)
- Seoul Gimpo (RKSS)
- Tokyo Haneda International (RJTT)
- Rio De Janeiro Galeao Antonio Carlos Jobim International (SBGL)
- 20+ In Scandinavia
- 30+ Russian Airports
- Numerous Test and Certification Sites

GBAS/GLS US and Global Implementation



Site Location Data From flygls.net, Base Imagery From Google

GBAS/GLS Stakeholders and Benefits

Airport

- CAT I/II/III Redundancy
- Maintain Arrival Capacity During IFR
- New CAT I/II/III Approaches
- Additional Taxiway Access in IFR

Community

- Noise Reduction
- Potential Overflight Dispersion
- Missed Approach Reductions

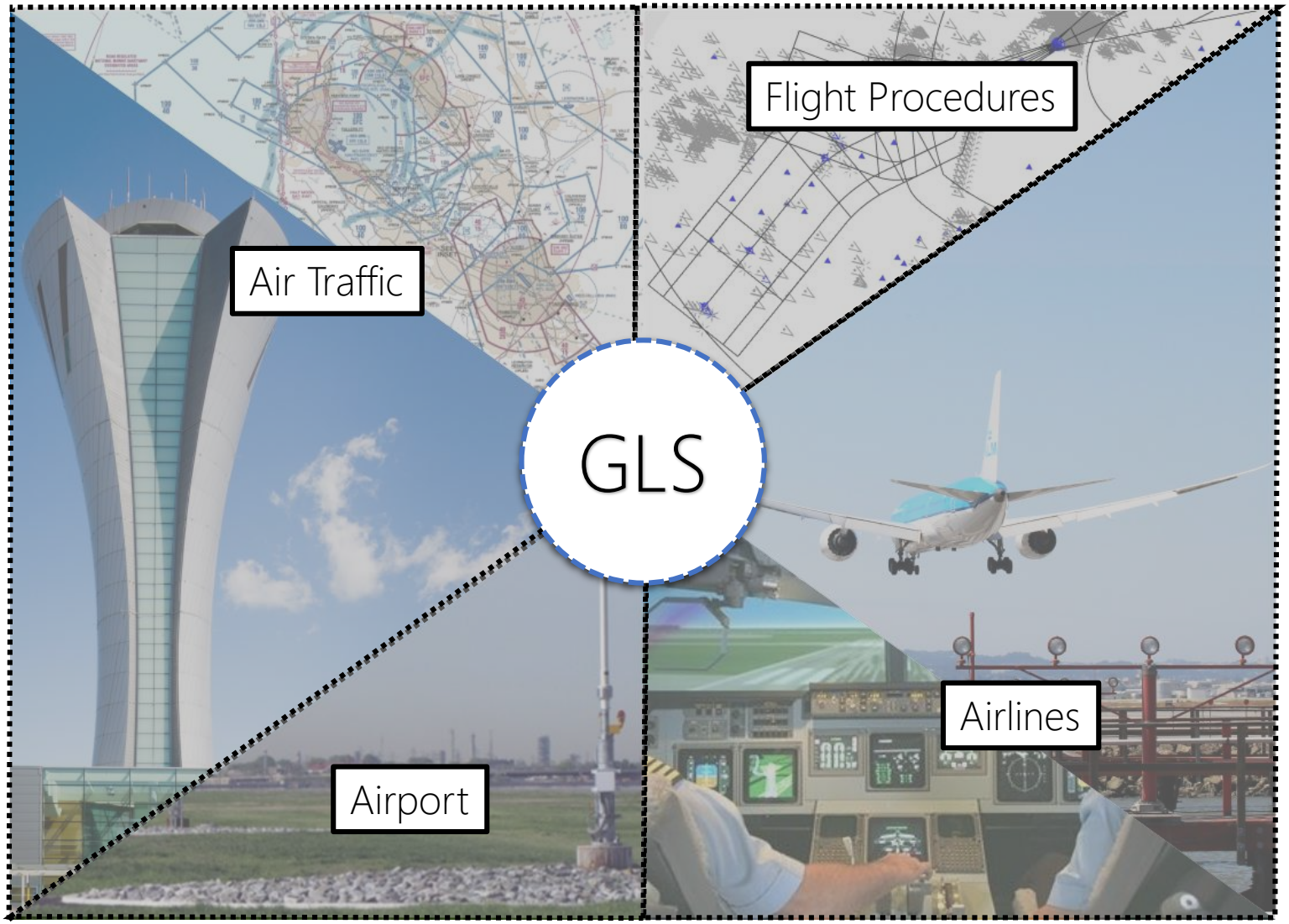
Airlines

- Reduced Distance/Time to Arrival
- Reduced Pilot Workload
- Enhanced Vertical Guidance to Touchdown
- Continuous Descent Approach Options

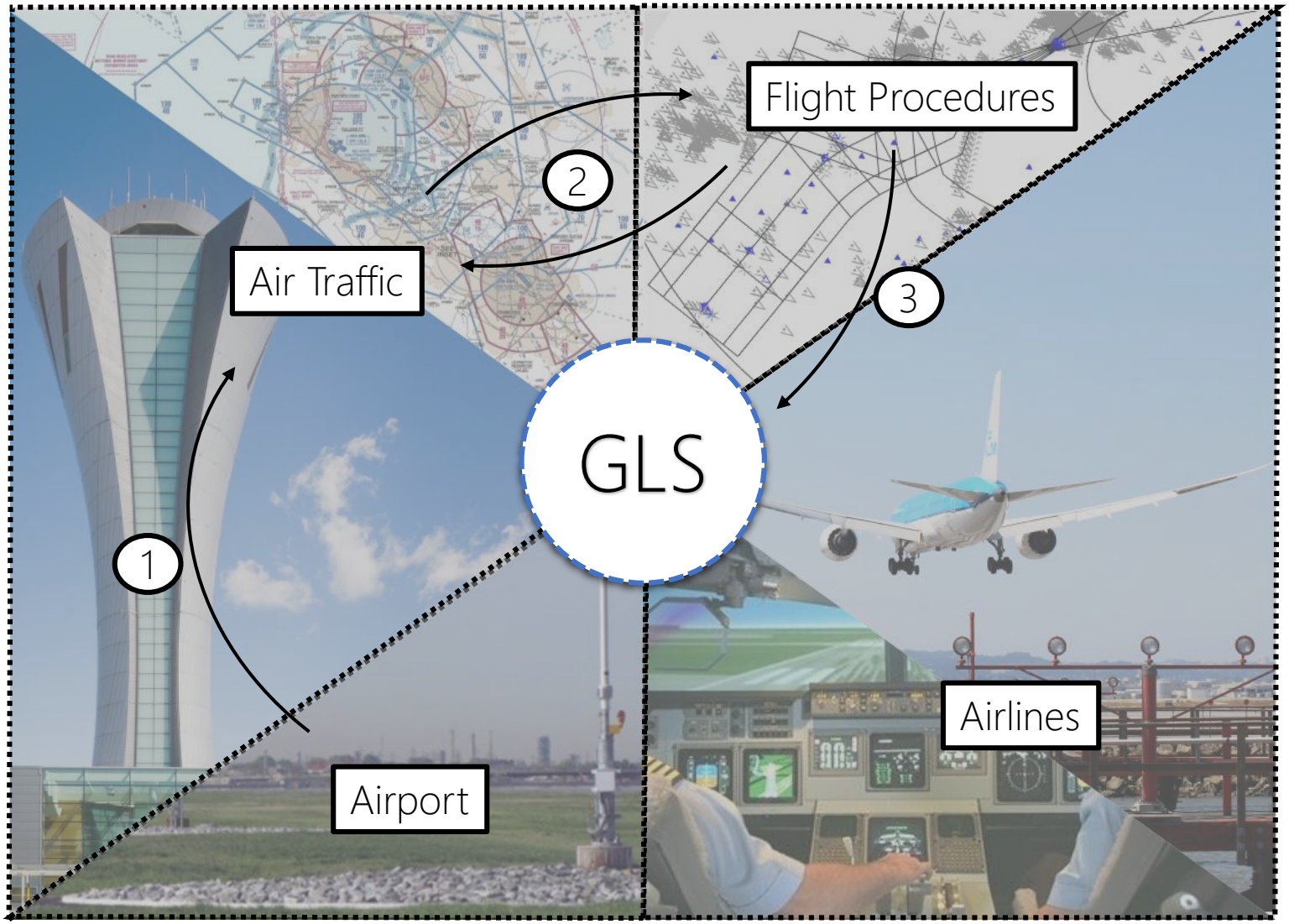
Air Traffic

- Increased IFR Options
- Reduced Controller Workload
- CSPO/SOIA
- Reduced Runway Occupancy Time

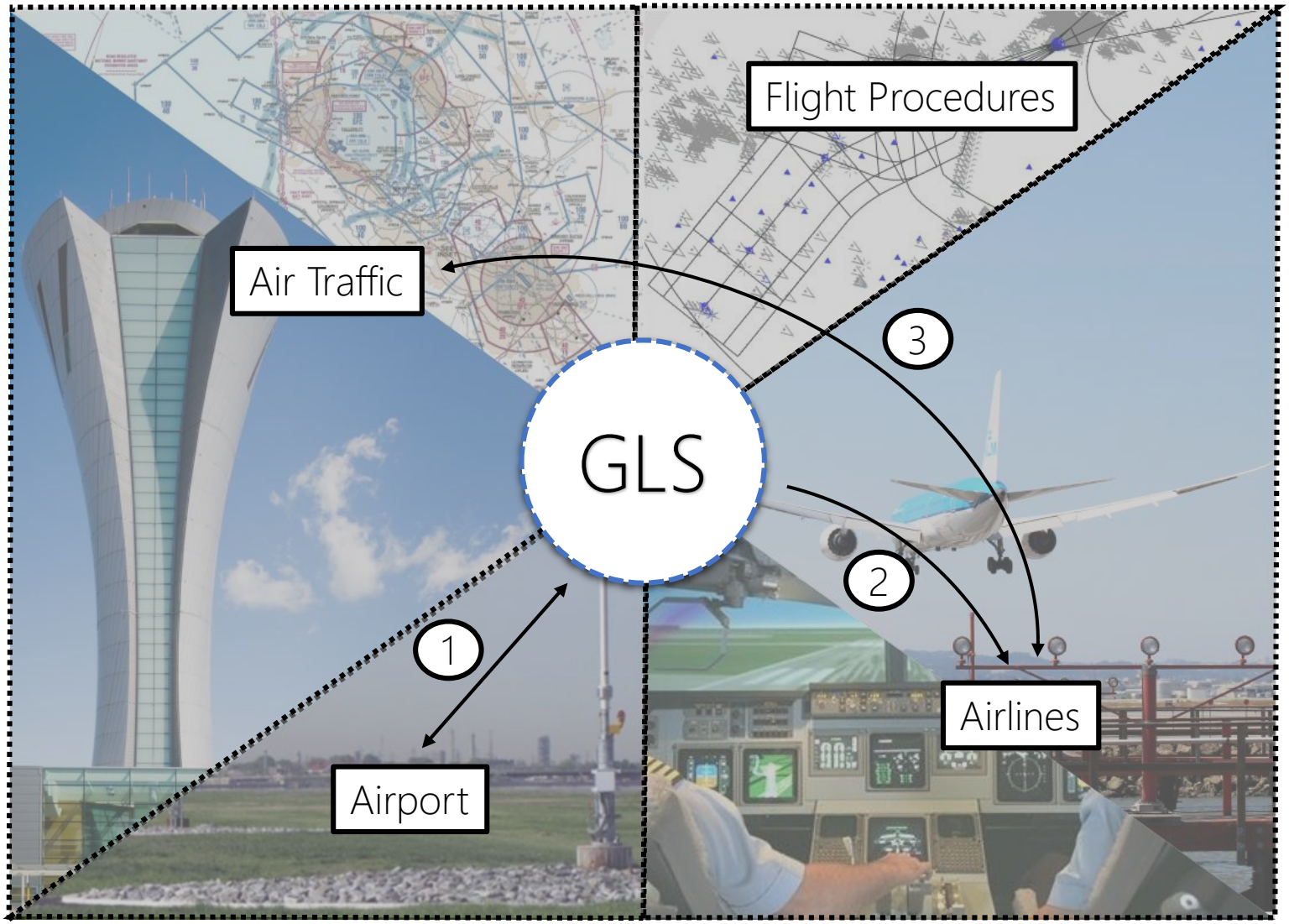
GBAS and GLS Roles and Responsibilities



GLS Procedure Development



GBAS and GLS Operations



GBAS @ SFO

Goals, Timeline and Progress

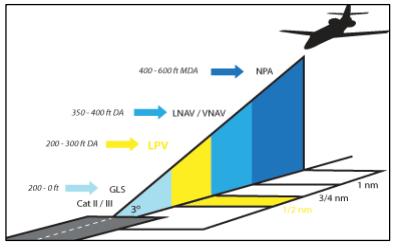
SFO GBAS Project Goals

1. Improve Noise Impact to the Community

- GLS, and RNP to GLS, allows innovative procedure design resulting in unique flight tracks and increased operational altitudes

2. Create Redundant ILS Capabilities

- Allows continued ILS like operations during runway/taxiway rehabilitation and equipment outages



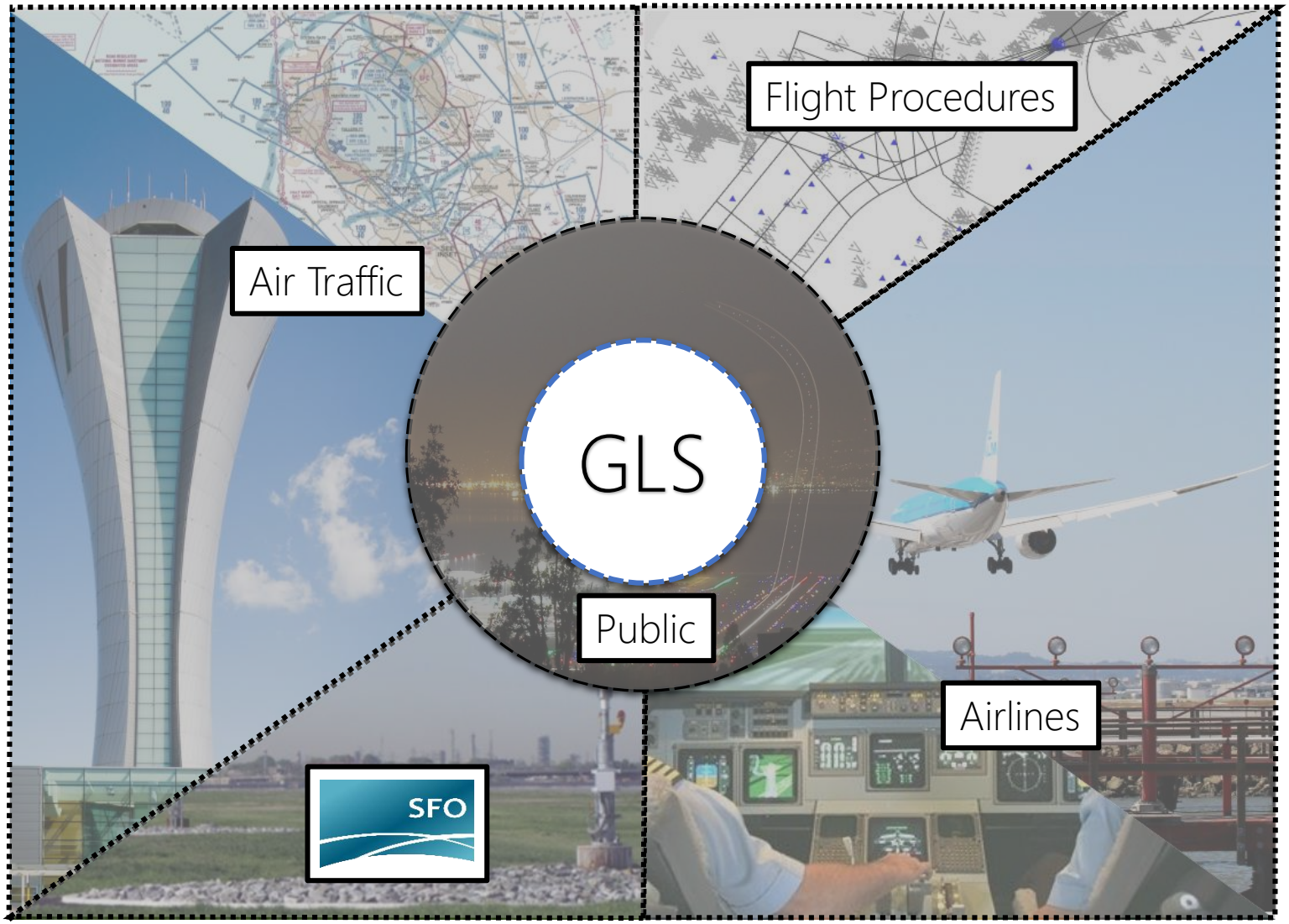
3. Enhance Efficiency

- Single GBAS can support multiple runway ends steeper approaches and reduced track miles via RNP to GLS

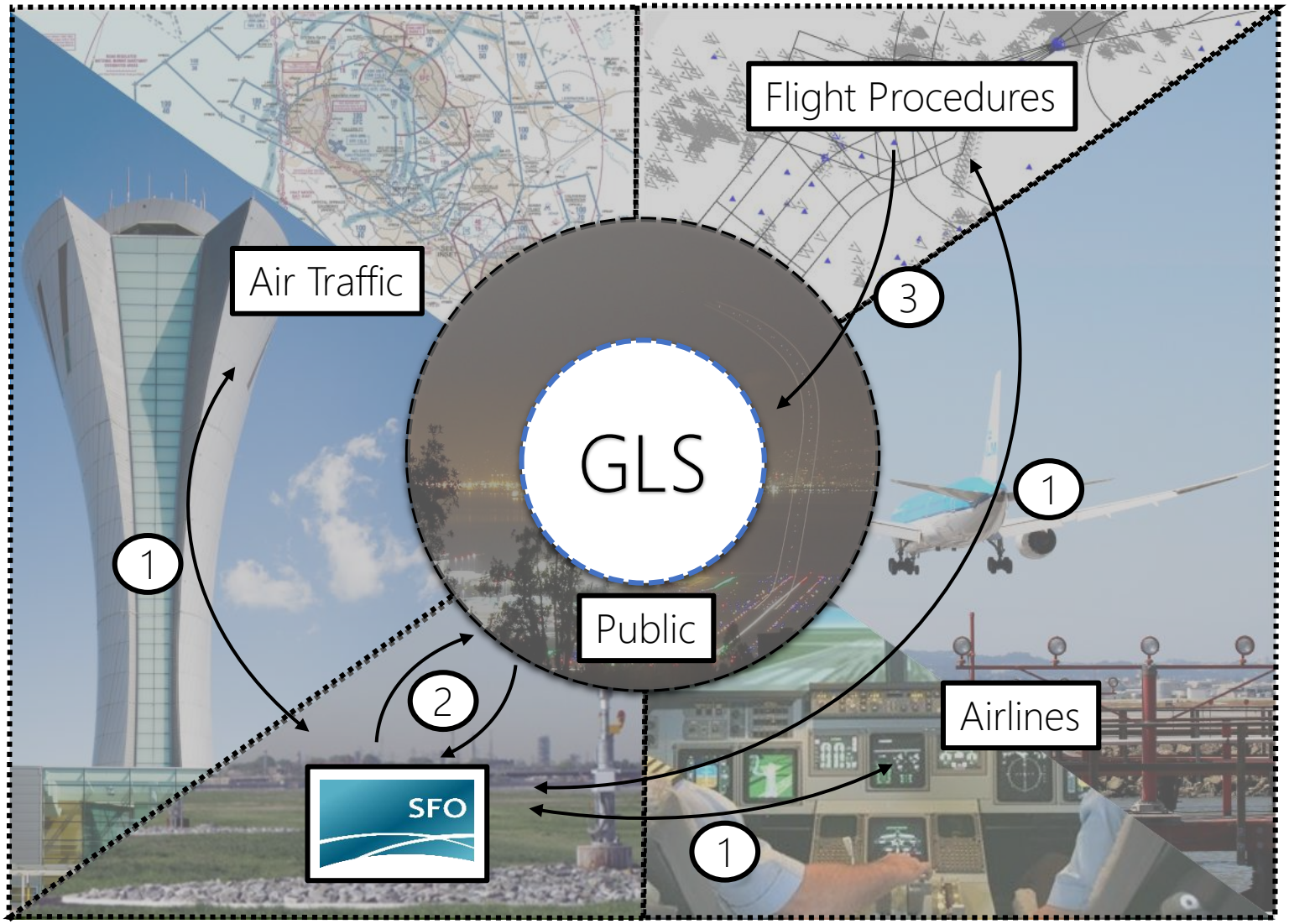
4. Reduce Delays

- Closely Spaced Parallel Runway Operations (CSPO) and CAT I/II/III Capabilities to runways that do not currently have ILS

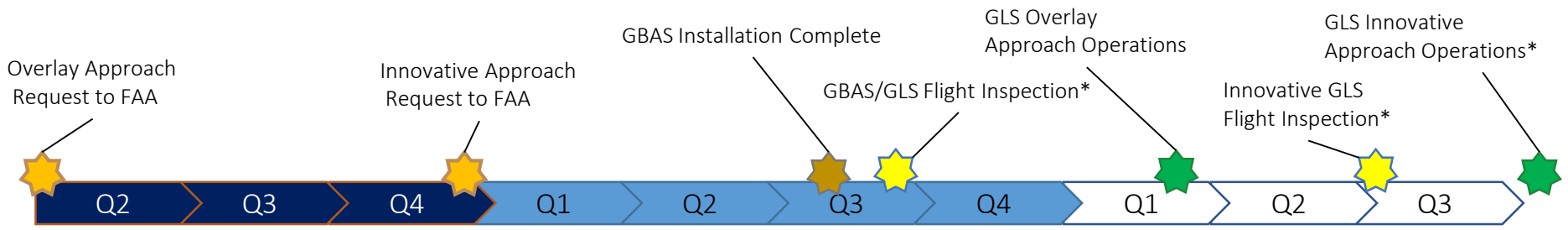
GBAS and GLS Roles and Responsibilities at SFO



SFO Process for GLS Procedure Development



GBAS/GLS Project Timeline

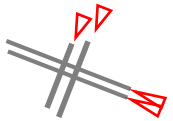


FAA GLS Overlay Approach Development

SFO Community/Noise Roundtable Technical Working Group

SFO GBAS Flight Procedure Sub-Committee

GLS Overlay Approach Operations



FAA GLS Innovative Approach Development

*Procedure dates are estimates and not reflective of RAPT decision

Flight Procedures Development/Request | GBAS Installation Complete | Flight Inspection | GLS Operations Milestone

Key Milestones

- 12/6/17 - Initial Public Outreach SFO Community Roundtable
- 02/1/18 - Established Flight Procedures Subcommittee
- 03/20/18 - FAA Began Work on GLS Overlay Approaches
- 05/30/18 - Flight Procedures Subcommittee Workshop
- 11/16/18 – Air Carrier and NCT Simulator Evaluations Complete
- 12/31/18* – Target Date for Innovative Procedure Requests to FAA

*Innovative Procedures will not be requested until community feedback has been received and Airport agree that GLS approaches will do no harm

- 03/26/20 - Official Target Publication FAA GLS Overlay Approaches

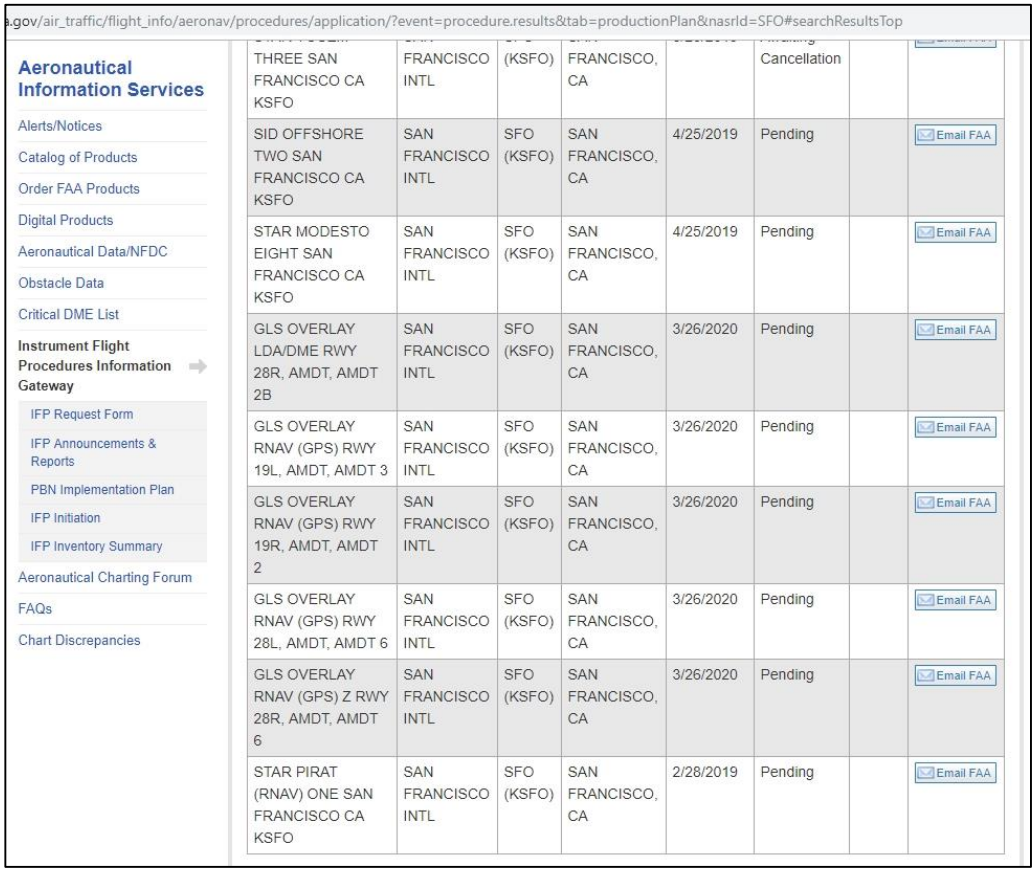
SFO GBAS Flight Procedures Subcommittee

- Representatives from SFO, SFO Tower, NCT, FAA Flight Procedures Team, FAA Flight Safety, United, Alaska, Delta, Southwest and American Airlines
- Discuss limitations from airspace, air traffic, procedure design criteria, flight crew and aircraft capabilities
- Identify GLS Overlays of existing approaches that would achieve project goals and have highest chance of initial usage in 2020
- 13 Innovative conceptual flight procedures evaluated against project goals, stakeholder considerations and implementation challenges

Current GLS Flight Procedures Under Development

Existing Flight Procedures Being Converted by the FAA

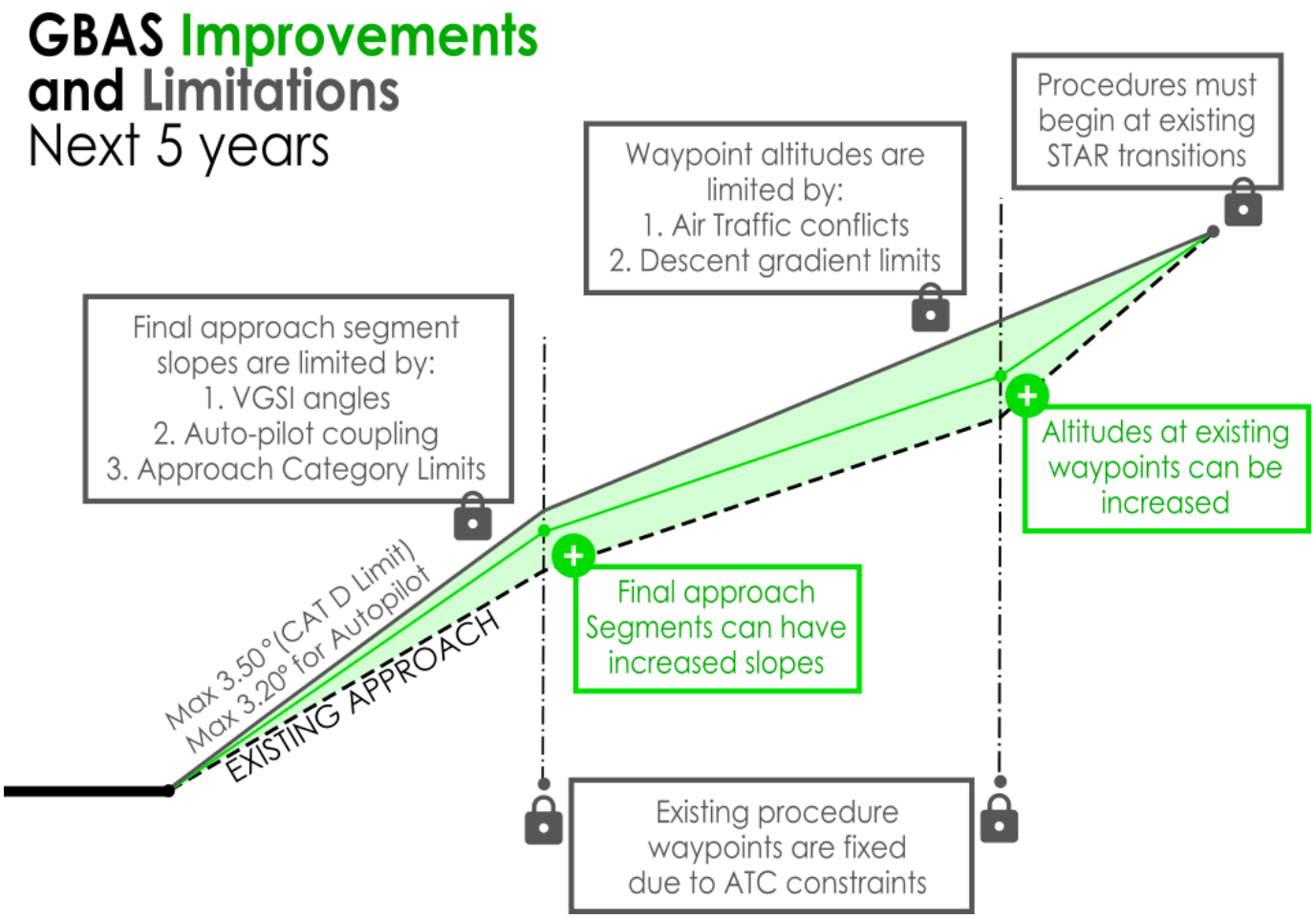
- Runway 28R
  - RNAV (GPS) Z RWY 28R
  - LDA/DME RWY 28R
- Runway 28L
  - RNAV (GPS) RWY 28L
- Runway 19R
  - RNAV (GPS) RWY 19L
- Runway 19L
  - RNAV (GPS) RWY 19R



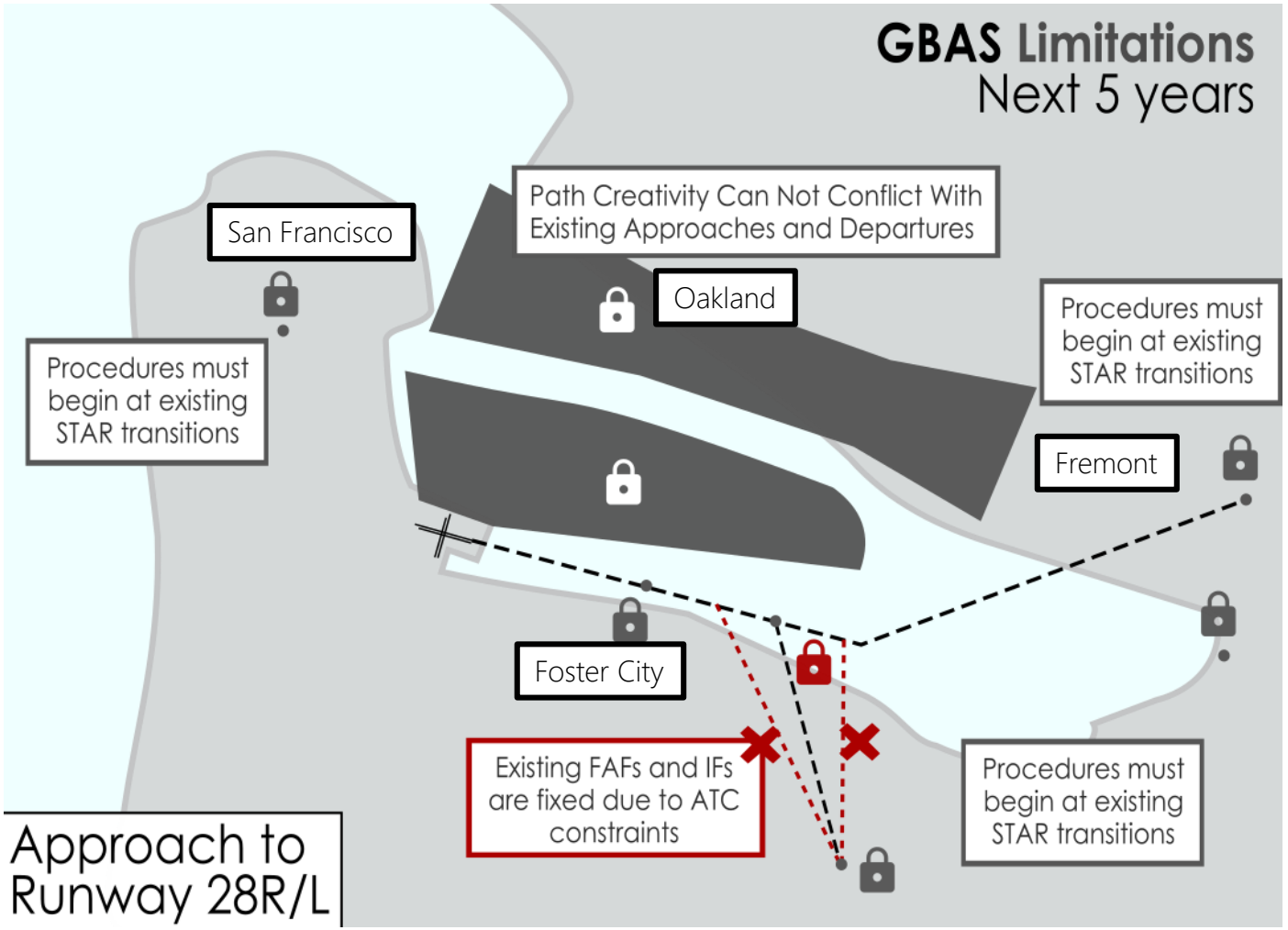
THREE SAN FRANCISCO CA KSFO	SAN FRANCISCO INTL	(KSFO)	FRANCISCO, CA		Cancellation	
SID OFFSHORE TWO SAN FRANCISCO CA KSFO	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	4/25/2019	Pending	Email FAA
STAR MODESTO EIGHT SAN FRANCISCO CA KSFO	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	4/25/2019	Pending	Email FAA
GLS OVERLAY LDA/DME RWY 28R, AMDT, AMDT 2B	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	3/26/2020	Pending	Email FAA
GLS OVERLAY RNAV (GPS) RWY 19L, AMDT, AMDT 3	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	3/26/2020	Pending	Email FAA
GLS OVERLAY RNAV (GPS) RWY 19R, AMDT, AMDT 2	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	3/26/2020	Pending	Email FAA
GLS OVERLAY RNAV (GPS) RWY 28L, AMDT, AMDT 6	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	3/26/2020	Pending	Email FAA
GLS OVERLAY RNAV (GPS) Z RWY 28R, AMDT, AMDT 6	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	3/26/2020	Pending	Email FAA
STAR PIRAT (RNAV) ONE SAN FRANCISCO CA KSFO	SAN FRANCISCO INTL	SFO (KSFO)	SAN FRANCISCO, CA	2/28/2019	Pending	Email FAA

https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/
Search "KSFO"

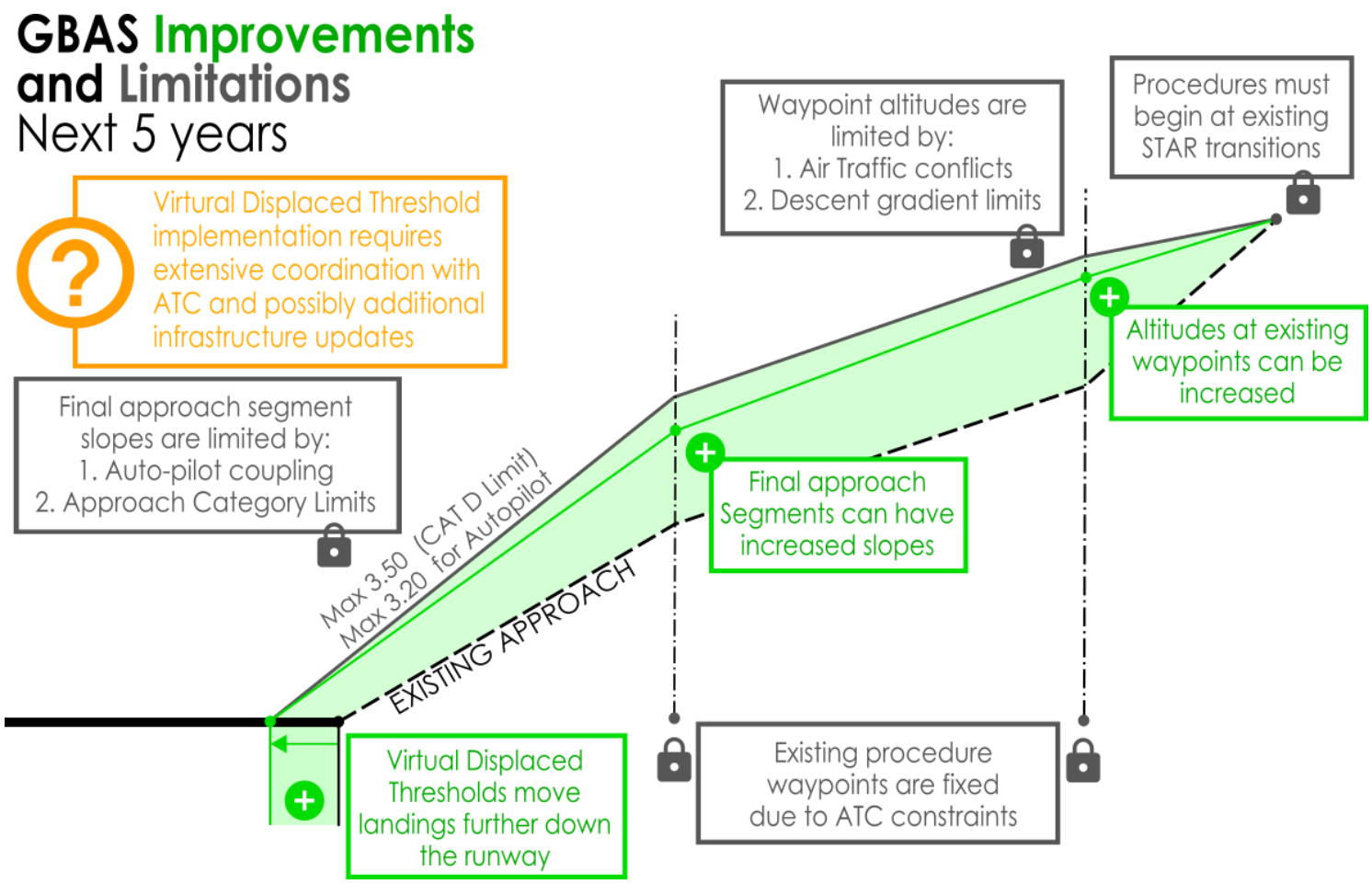
GLS Approach Short Term Limitations at SFO



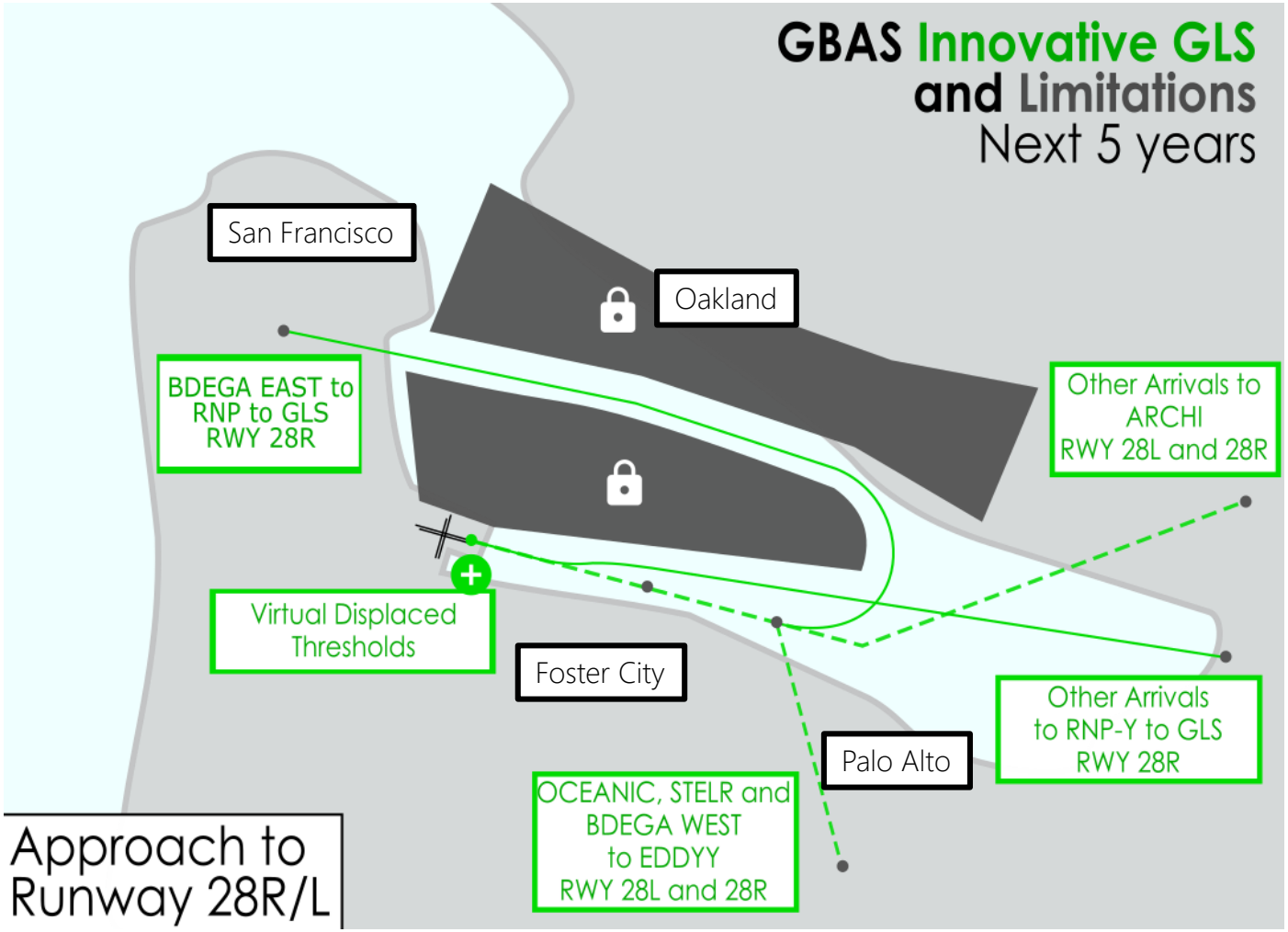
GLS Approach Short Term Limitations at SFO



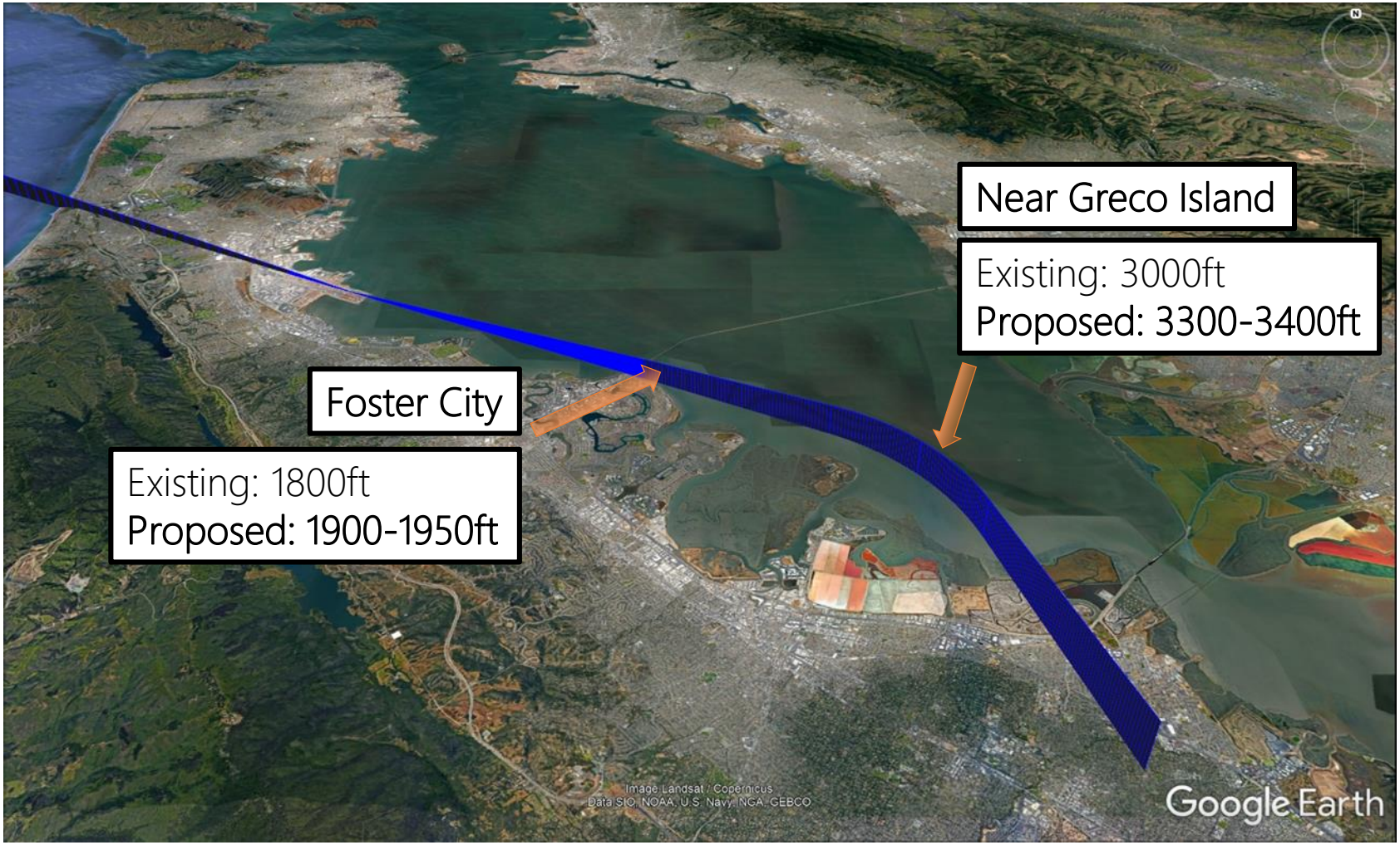
GLS Approach Short Term Limitations at SFO



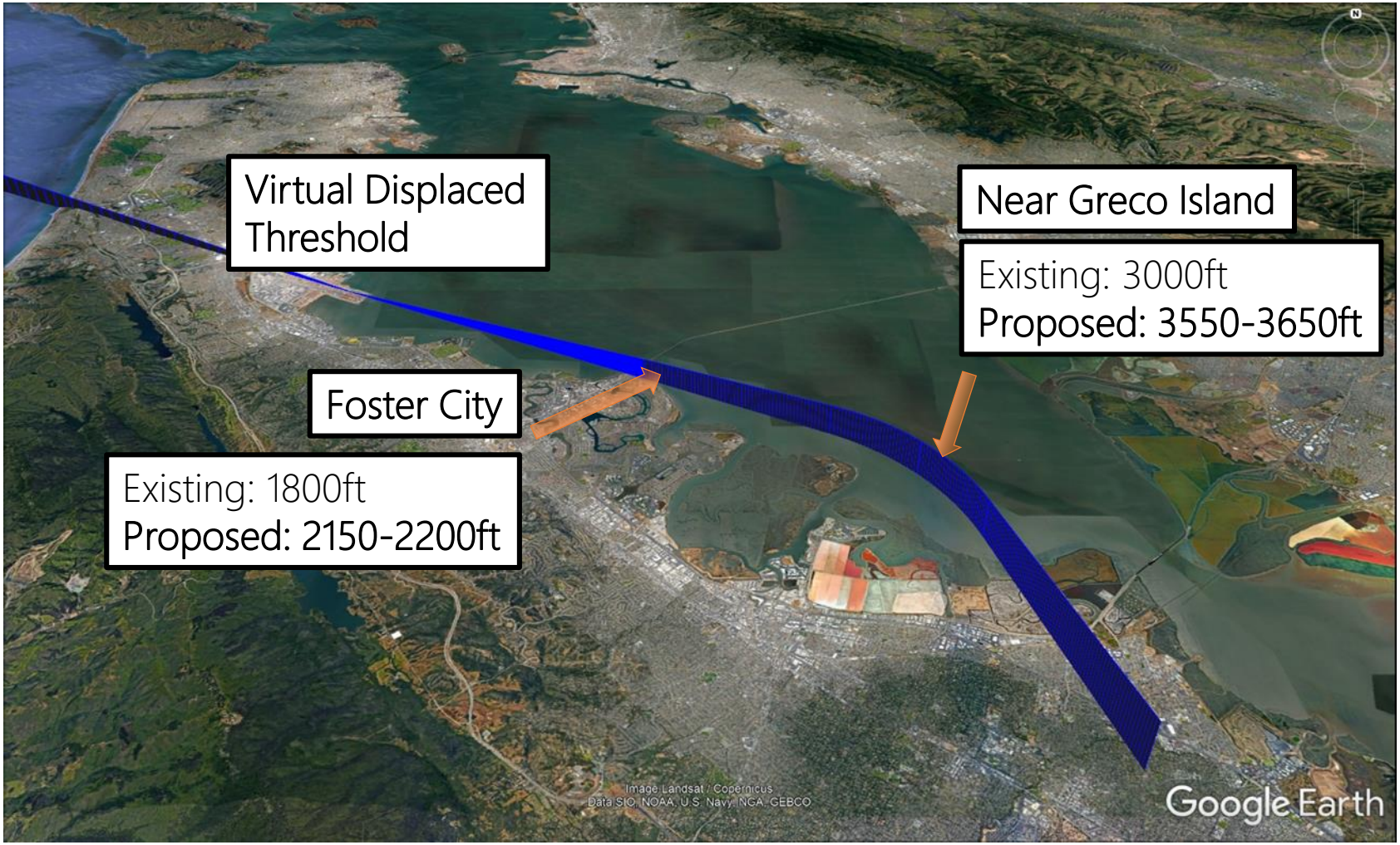
GLS Approach Short Term Limitations at SFO



OCEANIC, STLER and BDEGA WEST to 28R Straight-In

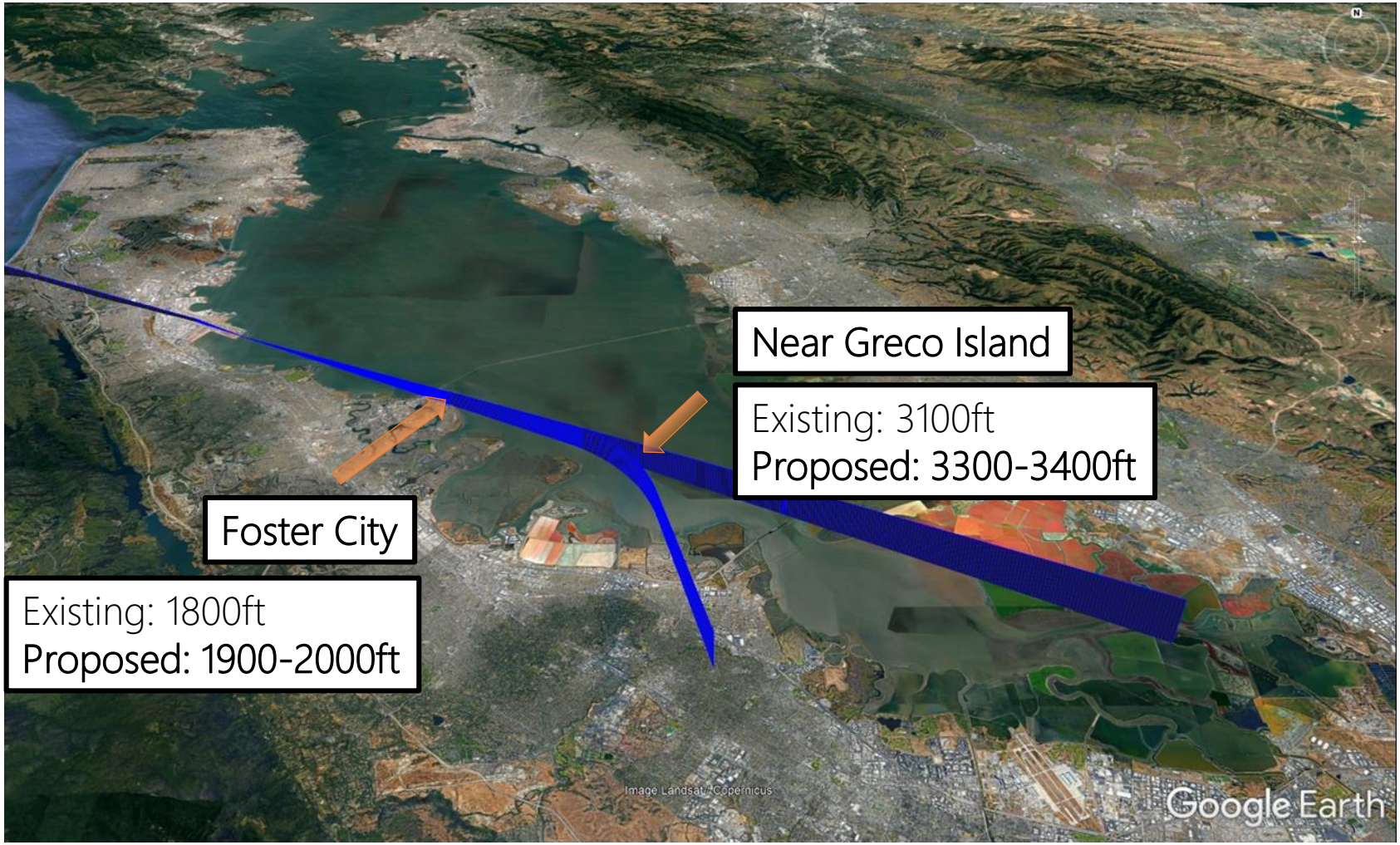


OCEANIC, STLER and BDEGA WEST to 28R Straight-In (VDT)



28R BDEGA EAST - “Down the Bay” to 28R

OCEANIC, STLER and BDEGA WEST to 28L Straight-In



What's Next?

Next Steps For GLS and Community Involvement

Next Steps: Community

Community Outreach and Feedback

Perform Initial Noise Evaluations

- Single Event Analysis for GLS Capable Aircraft (50 dBA Level)
- CNEL Analysis for Combination of GLS and Non-GLS Capable Aircraft

Create Community Flight Procedure Packages And Distribute to Roundtable and Interested Members of the Public

Review Feedback and Discontinue the Evaluation of Approaches Considered to Potentially Increase Noise

Target Date to Receive Feedback Is 45 Days After Community Flight Procedure Package Distribution

Next Steps: Flight Procedure Subcommittee Airlines and NCT

Airline Simulations

Airline Subcommittee Participants to evaluate high-GPA options in simulator

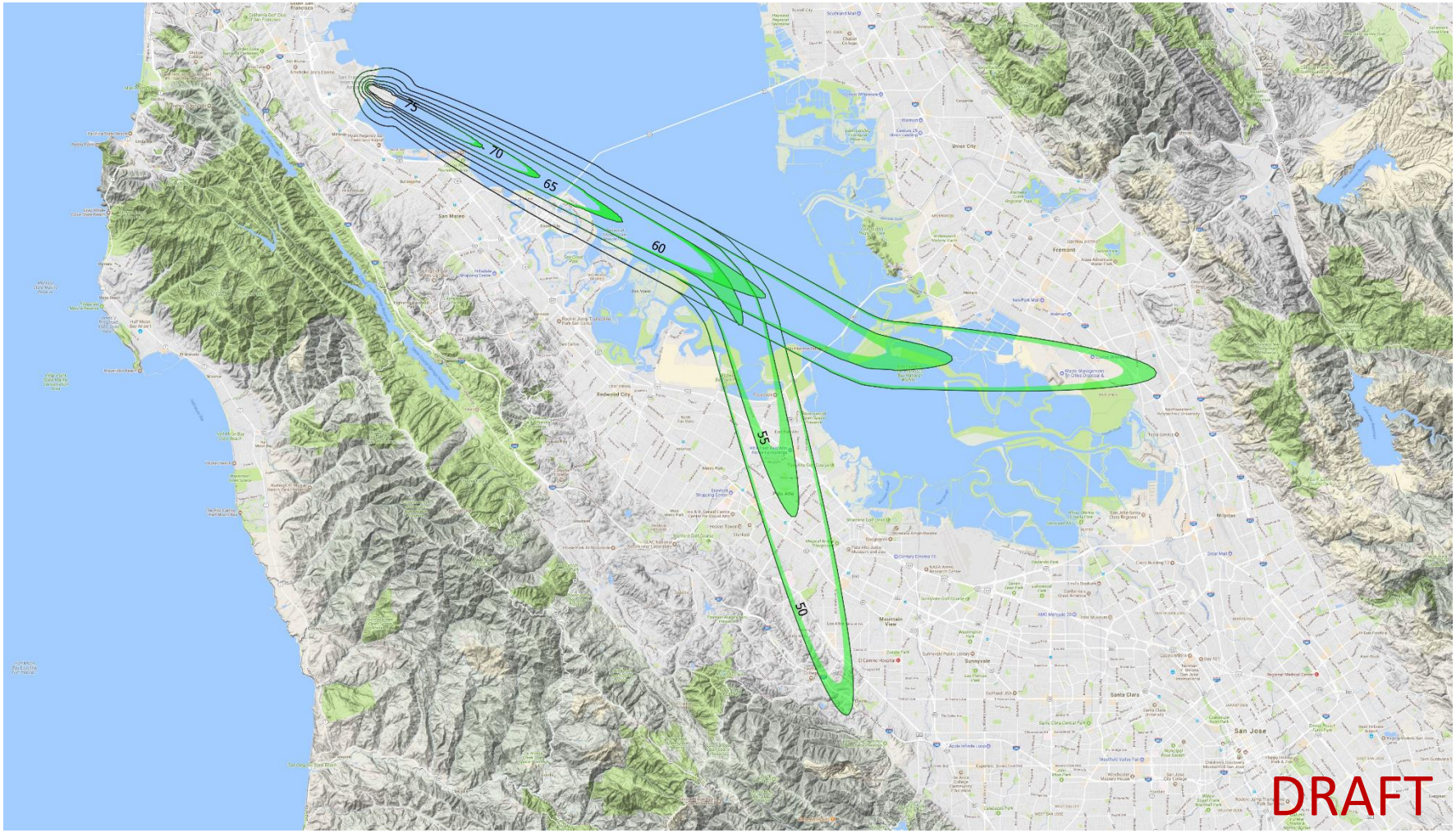
- Provide accurate flap/speed/gear schedules
- Evaluate possibility of inadvertent increased noise from speed brake/spoiler usage
- Ensure that encoding and approaches are flyable

NCT Simulations

NCT Continues to explore complex transitions from existing STARs to innovative approach IAF and IF

Potential approach options to 19R are still being considered, but are not yet under evaluation by Subcommittee

Single Event Noise Contours – A320



Single Event Noise Data – A320

28R Approach From ARCHI

		Existing ILS - A320		GLS A320	
Site	City	SENEL	LAMAX	SENEL	LAMAX
Noise Monitor 12	Foster City	78.73	64.42	78.19	63.77
Noise Monitor 28	Redwood City	69.32	51.91	69.54	52.11
Noise Monitor 29	San Mateo	42.72	19.15	43.07	19.58
SIDBY	Palo Alto	46.42	25.49	46.79	26.04

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28R Approach From EDDYY

		Existing ILS - A320		GLS A320	
Site	City	SENEL	LAMAX	SENEL	LAMAX
Noise Monitor 12	Foster City	78.73	64.42	78.18	63.77
Noise Monitor 28	Redwood City	69.32	51.91	69.54	52.11
Noise Monitor 29	San Mateo	46.73	23.47	47.12	24.05
SIDBY	Palo Alto	70.96	56.37	69.67	54.39

DRAFT

Q & A

Community Feedback

Presenter: Paul Hannah
SFO GBAS Airspace and Flight Procedures

Daniel Lee
SFO GBAS PM
Daniel.Lee@flysfo.com

Please submit question regarding GBAS by October 16, 2018