Federal Aviation Administration

Optimization of Airspace and Procedures in the Metroplex (OAPM)

Study Team Final Report

Northern California Metroplex

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1 Background

In September 2009, the Federal Aviation Administration (FAA) received the RTCA's Task Force 5 Final Report on Mid-Term NextGen Implementation containing recommendations concerning the top priorities for the implementation of NextGen initiatives. A key component of the RTCA recommendations is the formation of teams leveraging FAA and Industry Performance Based Navigation (PBN) expertise and experience to expedite implementation of optimized airspace and procedures.

Optimization of Airspace and Procedures in the Metroplex (OAPM) is a systematic, integrated, and expedited approach to implementing PBN procedures and associated airspace changes. OAPM was developed in direct response to the recommendations from RTCA's Task Force 5 on the quality, timeliness, and scope of metroplex solutions.

OAPM focuses on a geographic area, rather than a single airport. This approach considers multiple airports and the airspace surrounding a metropolitan area, including all types of operations, as well as connectivity with other metroplexes. OAPM projects will have an expedited life-cycle of approximately three years from planning to implementation.

The expedited timeline of OAPM projects centers on two types of collaborative teams:

- Study Teams will provide a comprehensive but expeditious front-end strategic look at each major metroplex
- Using the results of the Study Teams, Design and Implementation Teams will provide a systematic, effective approach to the design, evaluation and implementation of PBN-optimized airspace and procedures

2 Purpose of Northern California Team Effort

The principle objective of the Study Team was to identify operational issues and propose PBN procedures and/or airspace modifications in order to address them. This OAPM project for the Northern California Metroplex seeks to optimize and add efficiency to the operations of the area. These efficiencies include making better use of existing aircraft equipage by adding Area Navigation (RNAV) procedures, optimizing descent and climb profiles to eliminate or reduce the requirement to level-off, creating diverging departure paths that will get aircraft off the ground and heading toward their destination faster, and adding more direct high-altitude RNAV routes between two or more metroplexes, among others.

The Study Team effort is intended as a scoping function. The products of the Study Team will be used to scope future detailed design efforts and to inform FAA decision-making processes concerning commencement of such design efforts.

3 Northern California OAPM Study Team Analysis Process

3.1 Five Step Process

The Northern California OAPM Study Team (Study Team) followed a five step analysis process:

- Collaboratively identify and characterize existing issues:
  - Review current operations
  - Solicit input to obtain an understanding of the broad view of operational challenges in the metroplex
- Propose conceptual designs and airspace changes that will address the issues and optimize the operation:
  - Using an integrated airspace and PBN “toolbox”
  - Technical input from operational stakeholders, explore potential solutions to the identified issues
- Identify expected benefit, quantitatively and qualitatively, of the conceptual designs:
  - Assess the rough-order-of-magnitude impacts of conceptual designs
  - To the extent possible use objective, quantitative assessments
- Identify considerations and risks associated with proposed changes:
  - Describe, at a high-level, considerations (e.g., if additional feasibility assessments are needed) and/or risks (e.g., if waivers may be needed)
- Document the results from the above steps

Steps 1 and 2 are worked collaboratively with local facilities and operators through a series of outreach meetings. Step 3 is supported by the OAPM National Analysis Team (NAT). The analysis methodology used for the quantitative approach is described in Section 3.4. The NAT is a centralized analysis and modeling capability that is responsible for data collection, visualization, analysis, simulation, and modeling. Step 4 is conducted with the support of the OAPM Specialized Expertise Cadre (SEC). The SEC provides “on-call” expertise from multiple FAA lines of business, including environmental, safety management, airports, and specific programs (like Traffic Management Advisor [TMA]).

Assessments at this stage in the OAPM process are expected to be high-level, as detailed specific designs (procedural and/or airspace) have not yet been developed. More accurate assessments of benefits, impacts, costs and risks are expected after the Design phase has been completed.

3.2 Northern California Study Area Scope

The Northern California Metroplex consists of airspace delegated to the Northern California Terminal Radar Approach Control (TRACON) (NCT) and the Oakland Air Route Traffic Control Center (ARTCC) (ZOA). Operations at the four busiest airports within the lateral confines of NCT's airspace were examined closely due to the complexity of the interactions between these airports:

- San Francisco International Airport (SFO)
- Metropolitan Oakland International Airport (OAK)
- Norman Mineta – San Jose International Airport (SJC)
- Sacramento International Airport (SMF)

Other airports' operations and issues were also examined, as appropriate.

3.3 Assumptions and Constraints

OAPM is an optimized approach to integrated airspace and procedures projects; thus, the solution space is centered on airspace redesign or procedurally based, most notably PBN, solutions. The Study Teams are expected to document those issues that cannot or should not be addressed by airspace and procedures solutions, as these will be shared with other appropriate program offices. These issues are described at the end of this report.

The OAPM expedited timeline and focused scope bound airspace and procedures solutions to those that can be achieved without requiring an Environmental Impact Statement (EIS) (e.g., only requiring an Environmental Assessment [EA] or qualifying for a Categorical Exclusion [CATEX]) and within current infrastructure and operating criteria. The Study Team results may also identify airspace and procedures solutions that do not fit within the environmental and criteria boundaries of an OAPM project. These other recommendations then become candidates for other integrated airspace and procedures efforts.

During the course of this analysis the Study Team considered two operating configurations for the four airports mentioned in Section 3.2. The airports located along the San Francisco Bay generally operated in either a west or east (also called southeast) configuration. SMF airport will operate in either a north or south configuration. The table below shows the runway configurations for each airport as analyzed in this report.

Airport	**Main Configuration**	**Runways Used (ARR | DEP)**	**Secondary Configuration**	**Runways Used (ARR | DEP)**
SFO	West (92%)	28 | 01	Southeast (8%)	19 | 10
OAK	West (93%)	29, 27 | 29,27	East (7%)	11 | 11
SJC	West (85%)	30 | 30	East (15%)	12 | 12
SMF	North (70%)	34 | 34	South (30%)	16 | 16

3.4 Assessment Methodology

Both qualitative and quantitative assessments were made to gauge the potential benefits of proposed solutions.

The qualitative assessments are those that the Study Team could not measure but would result from the implementation of the proposed solution. These assessments included:

- Impact on ATC task complexity
- Ability to apply procedural separation (e.g., laterally or vertically segregated flows)
- Ability to enhance safety
- Improved connectivity to en route structure
- Improvements to security (avoiding restricted airspace)
- Reduction in communications (cockpit and controller)
- Reduction in need for traffic management initiatives (TMIs)
- Improved track predictability and repeatability
- Reduced reliance on ground-based navigational aids (NAVAIDS)

Task complexity, for example, can be lessened through the application of structured PBN procedures versus the use of radar vectors, but quantifying that impact is difficult. Reduced communications between pilot and controller, as well as reduced potential for operational errors, are examples of metrics associated with controller task complexity that were not quantified.

For the quantitative assessments, the Study Team relied on identifying changes in track lengths, flight times, and fuel burn. Most of these potential benefits were measured by comparing a baseline case with a proposed change using both fuel burn tables based on the European Organization for the Safety of Air Navigation (EUROCONTROL) Base of Aircraft Data (BADA) fuel burn model and a flight simulator, which was used to establish a relationship between simulator fuel burn results and BADA tables.

3.4.1 Track Data Selected for Analyses

During the study process, a standard set of radar traffic data was utilized in order to maintain a standardized operational reference point.

For determining the number, length, and location of level-offs for the baseline of operational traffic, fourteen 93rd-percentile traffic days in FY2010 were utilized. These days were selected using the Airport Specific Performance Metrics (ASPM) operational counts and weather data.

The following days were utilized by the Northern California Study Team and the NAT:

11/19/09	04/07/10	04/22/10	09/10/10	10/14/10	11/25/09	04/09/10
06/16/10	09/24/10	10/15/10	03/17/10	04/15/10	09/03/10	10/08/10

For these traffic days, historical radar track data was used to allow the Study Team to visualize the flows and identify where short-cuts were routinely applied as well as where flight planned routes were more rigorously followed. The track data was also used as a baseline for the development of several conceptual solutions including PBN routes and procedures. In many cases, the Study Team overlaid the historical radar tracks with PBN routes or procedures to minimize the risk of significant noise impact and an associated EIS.

3.4.2 Determining the Number of Operations and Modeled Fleet Mix

Due to the limited schedule associated with this study effort, there was not sufficient time to model the entire fleet mix that services the Northern California Metroplex airspace. As a result, the fleet mixes were characterized only by the primary aircraft types that service the top four airports.

The analysis determined annual operations for these four airports by examining one year (CY 2010) of FAA's Enhanced Traffic Management System (ETMS) arrivals, and assuming the same number of departures. Fleet mixes for the four airports are in the tables below.

SFO Arrivals (January 1st - December 31st, 2010)

	Yearly Counts		%'s of Jet Types
Total # Ops		205,974	
Total # Jets		171,287	
	Total # A320s	49,980	29%
	Total # B73s	28,854	17%
	Total # CRJs	31,705	19%
	Total # B75s	22,004	13%
	Total # Other Jets	38,744	23%
Total #TP's/P's		34,687	

OAK Arrivals (January 1st - December 31st, 2010)

	Yearly Counts		%'s of Jet Types
Total # Ops		89,098	
Total # Jets		65,317	
	Total # A320s	5,158	8%
	Total # B73s	39,861	61%
	Total # CRJ2s	3,546	5%
	Total # MD heavy	4,376	7%
	Total # Other Jets	12,376	19%
Total #TP's/P's		23,781	

SJC Arrivals (January 1st - December 31st, 2010)

	Yearly Counts		%'s of Jet Types
Total # Ops		66,768	
Total # Jets		57,629	
	Total # A320s	3,203	6%
	Total # B73s	29,821	52%
	Total # CRJs	8,557	15%
	Total # MD large	2,939	5%
	Total # Other Jets	13,109	23%
Total #TP's/P's		9,139	

SMF Arrivals (January 1st - December 31st, 2010)

	Yearly Counts		%'s of Jet Types
Total # Ops		57,081	
Total # Jets		47,012	
	Total # A320s	6,534	14%
	Total # B73s	28,182	60%
	Total # CRJs	5,876	12%
	Total # MD large	1,798	4%
	Total # Other Jets	4,622	10%
Total #TP's/P's		10,069	

3.4.3 Determining Percent of RNAV Capable Operations by Airport

The principal objective of the Northern California Study Team was to identify operational issues and propose PBN procedures and/or airspace modifications in order to address them. The PBN Dashboard was used to determine the percent of operations at each airport that would benefit from these new procedures. The report determines this percentage by looking at two sources: the equipment suffix of instrument flight rule (IFR) filed operations from ETMS and the percent equipped aircraft from a Part 121 avionics database maintained by The MITRE Corporation's Center for Advanced Aviation System Development (CAASD). At the four major airports studied in the Northern California Metroplex, over 98% of operations were equipped for RNAV in 2010.

3.4.4 Profile Analyses

To determine the current level-offs of arrivals in the Northern California Metroplex, the Study Team examined track data from the 14 days discussed above. Using the Integrated Terminal Research, Analysis, and Evaluation Capabilities (iTRAEC) toolset, the Northern California Study Team identified the altitudes where level-offs occurred and the average length in nautical miles (NM) that aircraft were in level flight at each altitude. The Northern California Study Team also used Terminal Area Route Generation Evaluation and Traffic Simulation (TARGETS) to calculate the length of the proposed routes compared to the current published routes and actual flown tracks. The reduction in level segments and the distance savings were then converted into fuel savings by using the European Organization for the Safety of Air Navigation (EUROCONTROL) Base of Aircraft Data (BADA) fuel flow model, taking into account the modeled aircraft fleet mixes at the metroplex airports. The fuel savings were then annualized, assuming a fuel price per gallon of $2.77.[1] These resulting benefit numbers were the basis for the minimum potential fuel benefit.

Flight simulations were also run on a current arrival procedure as well as the corresponding conceptual design during the Washington D.C. Metroplex prototype Study Team effort. The flight simulator values were obtained through a US Airways A320 flight simulator fuel burn analysis for two transitions on a proposed versus baseline arrival procedure. Derived values for fuel burn per minute in level flight, idle descent, and less-efficient descent were then used to determine and validate the relationship between the flight simulator fuel saving estimates and the BADA-based fuel burn estimates (calculated in gallons per NM). Essentially, this effort allowed for a determination of the difference between BADA's conservative aircraft performance numbers and what could be achieved with an actual pilot flying the plane. This established method was also applied to Northern California Study Team results to determine a maximum fuel savings per flight. Applying both the BADA and flight simulator and BADA methods provides for a range of potential benefits:

- Lower bound potential benefit: BADA speed/fuel burn

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[1] Based on fuel costs for February 2011 from Research and Innovative Technology Administration (RITA) Bureau of Transportation Statistics

- Upper bound potential benefit: Flight simulation speed/fuel burn

Historical radar track data from the dates mentioned above were used to allow the Northern California Study Team to visualize the flows and identify where short-cuts were routinely applied as well as where flight planned routes were more rigorously followed. The track data were also used as a baseline for the development of several conceptual solutions including PBN routes and procedures. In many cases, the Study Team overlaid the historical radar tracks with PBN routes or procedures to minimize the risk of significant noise impact and an associated EIS.

3.4.5 Cost to Carry (CTC)

For every additional pound an aircraft carries, additional fuel must be carried. This applies not just to cargo, passengers, and freight, but also to fuel. This is known as the Cost to Carry (CTC). CTC can vary widely among airlines, generally ranging from about 2% to about 15%. For this analysis, CTC was assumed to be 6%. This means that for every 100 gallons of fuel loaded, CTC is 6 gallons.

3.4.6 Analysis Tools

The following tools were employed by the Study Team and the NAT in the process of studying the Northern California Metroplex:

- **Performance Data Analysis and Reporting System (PDARS)**
  - Historical traffic flow analysis using merged datasets to analyze multi-facility operations (NCT and ZOA)
  - Customized reports to measure performance and air traffic operations (i.e., fix loading, hourly breakdowns, origin-destination counts, etc.)
  - Identification and analysis of level flight segments for NCT arrivals and departures
  - Graphical replays to understand and visualize air traffic operations
  - Verification of level segments in ZOA and NCT airspace
- **TARGETS**
  - Comparison of actual flown routes to proposed routes when developing cost/benefit estimates
  - Conceptual airspace and procedure design
- **iTRAEC Tool**
  - Identification of location, altitude and magnitude of level-off segments
- **Air Traffic Airspace Lab (ATALAB) National Offload Program (NOP) data queries**
  - Quantification of traffic demand over time for specific segments of airspace
  - Identification of runway usage over time

- **National Traffic Management Log (NTML)**
  - Identification of occurrence and magnitude of TMIs
- **ETMS**
  - Traffic counts by aircraft group categories for annualizing benefits
  - Examination of filed flight plans to determine impact of significant re-routes

3.5 Universal Considerations

The following issues were universal considerations employed by the Northern California Study Team while designing the conceptual RNAV standard terminal arrivals (STARs) and RNAV standard instrument departures (SIDs):

- Controller and pilot training
- “Descend via” procedure issues
- Environmental considerations
- Aircraft equipage
- Safety Risk Management (SRM)
- TMA issues
  - Adaptation requirements
  - Manageable feeds of traffic from multiple flows
  - Adjacent center metering (ACM) integration
- Environmental issues

4 Identified Issues and Proposed Solutions

This section presents the findings and results of the Northern California OAPM Study Team analysis. It reviews identified departure and arrival issues, proposed solutions, benefits/impacts/risks, and analysis results to the following areas:

- SFO departures and arrivals
- OAK departures and arrivals
- SJC departures and arrivals
- SMF departure and arrival
- Terminal airspace issues
- En route airspace issues
- Issues tracked and recorded

For each issue/solution area, the following topics are discussed:

- Issue characterization
- Proposed solutions
- Benefits, impacts and risks from an ATC operational/safety perspective and from an airspace user perspective
- Derived benefits

4.1 San Francisco (SFO) Departures

Only San Francisco West Plan configuration departures in this section were analyzed. This configuration is used approximately 92% of the time at SFO. Runways 01L/R and Runways 28L/R are the primary departure flows in West Plan configuration.

4.1.1 Identified Issues

The Study Team identified several operational issues related to the published SIDs at SFO.

- Currently SFO SID procedures rely on initial radar vectors to the designated exit fix. These routes can follow a lengthy common path prior to course divergence with possible delay vectoring to allow in-trail sequencing
- A majority of the SFO departure flight tracks do not follow published SIDs on the traffic days analyzed. Multiple transitions go unused due to outdated legacy procedures. For example, there are transitions over Panoche (PXN) although in the NCT/ZOA letter of agreement (LOA), PXN is an arrival fix

These identified issues can cause inaccurate fuel planning and reduced flexibility for Industry due to legacy procedures. They can also limit departure throughput.

4.1.2 Study Team Recommendations – SFO RNAV SIDs

The Study Team recommends implementing RNAV SIDs creating a predictable, repeatable path while optimizing lateral/vertical flight paths and aligning current traffic flows. Optimizing the lateral path may have the added benefit of reducing the occurrence of delay vectoring to accomplish in-trail requirements.

The Study Team collaborated with both NCT and ZOA to create 14 exit fixes. Currently, SFO departures use seven exit fixes. This could increase departure throughput and allow the user community more options in weather events.

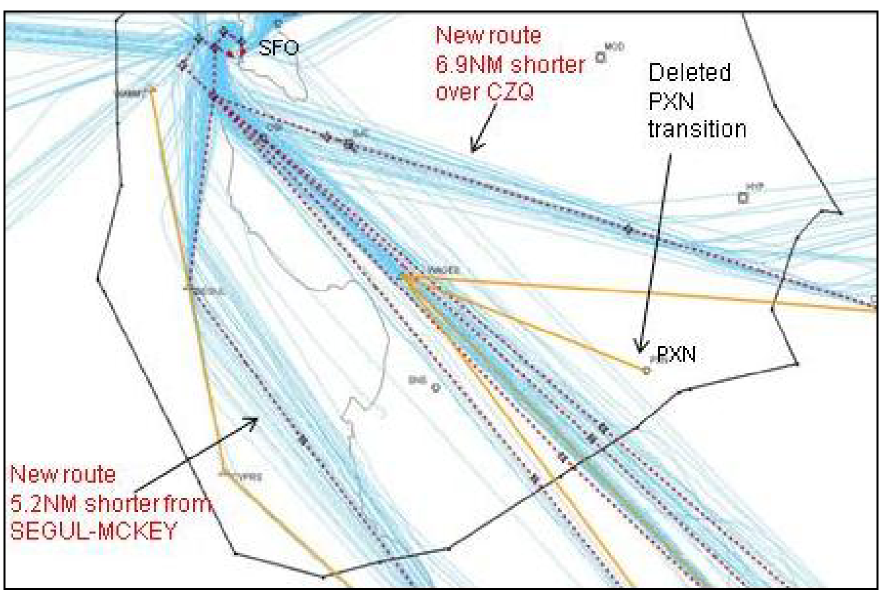
Both the users and facilities were concerned with the amount of published procedures at SFO, so the Study Team attempted to combine procedures where operationally feasible. The Design and Implementation Team will need to review this issue further to ensure that combining procedures does not result in chart clutter or multiple pages. The proposed RNAV SIDs and additional exit fixes will allow for future growth at the SFO airport.

The expected benefits associated with SFO departure procedures are described in the following sections in more detail.

4.1.2.1 South/Southeast Departures

The published PORTE/OFFSH SIDs rely upon initial radar vectors as the primary means of navigation. The actual flight tracks do not follow the published routes and have unused transitions that require excess fuel planning. Approximately 36% of SFO departures use the PORTE SID and 14% of SFO departures use the OFFSH SID.

The following figure illustrates the published procedure (solid brown) and the proposed routes (dashed red), as well as the current tracks (blue).



The proposed RNAV South/Southeast SID combines the PORTE and OFFSH SIDs and overlays actual flight tracks which incorporate the reduced mileage benefits gained in current operations. They will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from four to six. Another benefit of this SID is the use of expanded transitional separation, i.e., 3 NM increasing to 5 NM, which may allow for increased throughput. Combining the SIDs and adding exit fixes increases the potential for chart clutter, which may need to be addressed. There is a risk of flow interaction with this departure procedure as it crosses STARs inbound over Point Reyes (PYE). Adjacent center coordination will be required to accommodate new departure fixes.

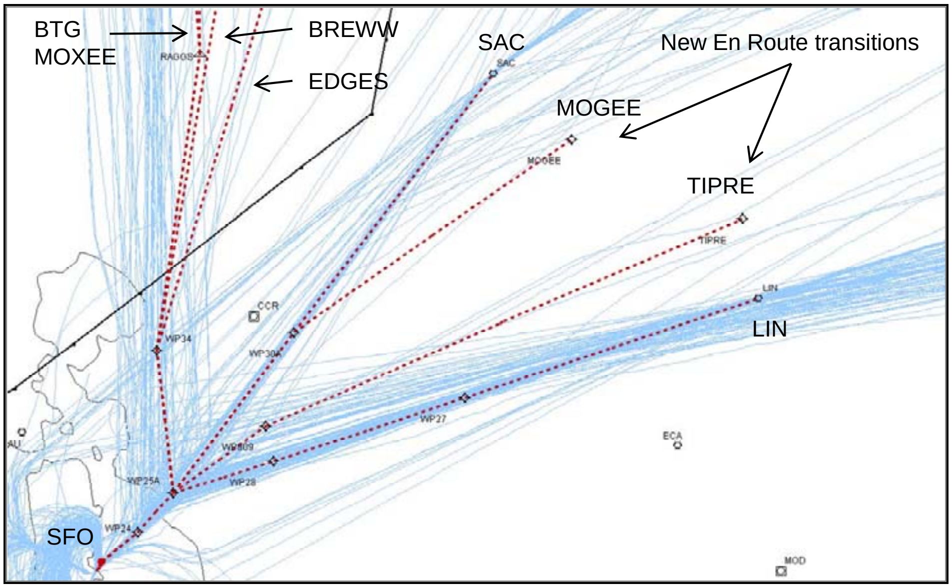
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$183,000**
	Profile	**$0**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**66,000**
	Profile	**0**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**660**
	Profile	**0**

4.1.2.2 North/Northeast Departures

The published SFO8 SID relies upon initial radar vectors as the primary means of navigation. This procedure uses radar vectors to published departure fixes between. Approximately 37% of SFO departures use the SFO8 SID.

The following figure illustrates the proposed routes (dashed red), as well as current tracks (blue).

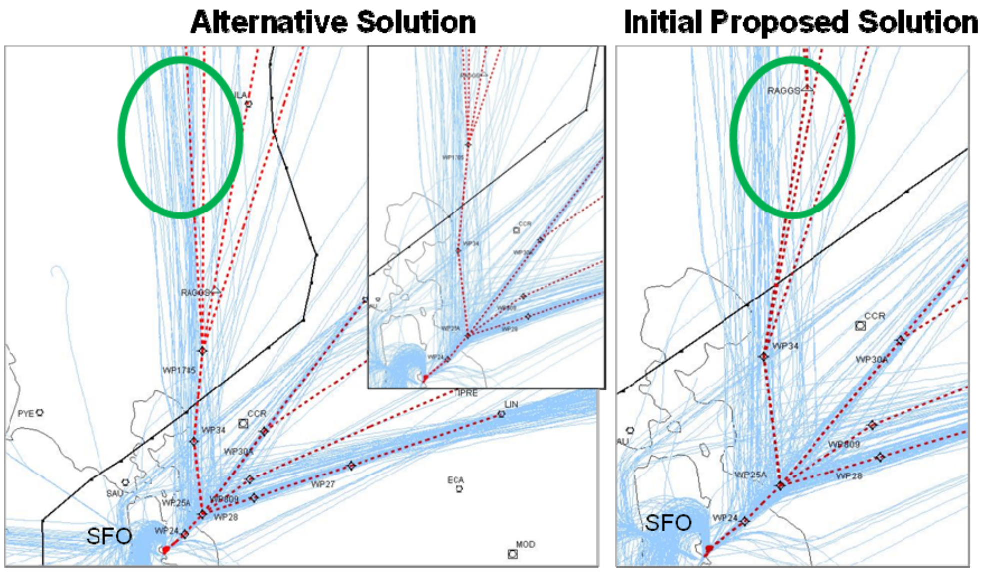


This proposed RNAV SID will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from three to eight. The northeast transitions leverage the new Q-Routes from Sacramento (SAC) VOR, Linden VOR (LIN), MOGEE and TIPRE. Preferential departure route criteria may need to be examined and developed for this route to ensure flexibility. Another benefit of this SID is the use of expanded transitional separation, 3 NM increasing to 5 NM, which may allow for increased throughput. With the increase in exit fixes, chart clutter may need to be addressed. Adjacent center coordination will be required to accommodate the new departure fixes.

No quantifiable benefits were calculated for the proposed new exit fixes. It is not known at this time how these routes will be utilized (e.g., which city pairs will use which fixes) and projected savings cannot be calculated without comparative data.

4.1.2.3 North/Northeast Departures – Alternative

The Study Team examined and supports an alternate north departure procedure that more closely aligns with current traffic flows. The ZOA proposed solution establishes the RAGGS intersection as a required fly-by waypoint before northbound traffic can proceed direct to Battleground (BTG) VOR or the MOXEE intersection.



The solution proposed by the Study Team entails the creation of a waypoint approximately 12 miles south of RAGGS to be used as an earlier transition point to BTG and MOXEE. It incorporates the ZOA requirement of a 350 degree initial heading and more closely aligns with current northbound flight tracks than the ZOA proposal. Adjacent center coordination will be required to accommodate new the departure fixes.

Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$23,000**
	Profile	**$0**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**8,000**
	Profile	**0**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**80**
	Profile	**0**

4.2 Oakland (OAK) Departures

West Plan OAK departures are analyzed in this section. The West Plan configuration is used approximately 93% of the time at OAK; Runways 27 and 29 are the primary departure runways in the West Plan configuration.

4.2.1 Identified Issues

The Study Team identified several operational issues related to the published SIDs at OAK.

- Currently OAK SID procedures rely on initial radar vectors to the designated exit fixes. These routes can follow a lengthy common path prior to course divergence with possible delay vectoring to allow in-trail sequencing
- A majority of actual flight tracks do not follow published SIDs
- Multiple transitions go unused due to outdated legacy procedures. For example, there are transitions over PXN although in the NCT/ZOA LOA, PXN is an arrival fix

These identified issues can cause inaccurate fuel planning and reduced flexibility for Industry due to legacy procedures. These issues can also limit departure throughput.

4.2.2 Study Team Recommendations – OAK RNAV SIDs

The Study Team recommends implementing RNAV SIDs creating a predictable, repeatable path while optimizing lateral/vertical flight paths and aligning with current traffic flows. Optimizing the lateral path may have the added benefit of reducing the occurrence of delay vectoring to accomplish in-trail requirements.

The Study Team collaborated with both NCT and ZOA to create 14 exit fixes. Currently, OAK departures use seven exit fixes. This will allow for an increase in departure throughput and allow the user community more options in weather events.

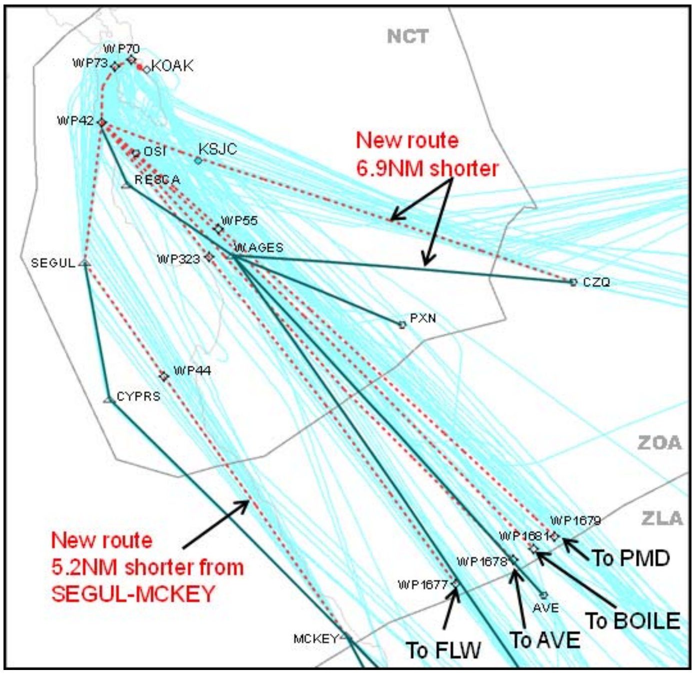
Both the users and facilities were concerned with the amount of published procedures at OAK, so the Study Team attempted to combine procedures where operationally feasible. The Design and Implementation Team will need to review this approach further to ensure that combining procedures does not result in chart clutter or multiple pages. The proposed RNAV SIDs and additional exit fixes will allow for future growth at the OAK.

The expected benefits associated with OAK departure procedures are described below in more detail.

4.2.2.1 South/Southeast Departures

The published SKYL/COAST SIDs rely upon initial radar vectors as the primary means of navigation. The actual flight tracks do not follow the current SIDs. These conventional SIDs have unused transitions that cause excess fuel loading. Approximately 44% of OAK departures use the SKYL SID and 14% of OAK departures use the COAST SID.

The following figure illustrates the published procedure (solid blue) and the proposed routes (dashed red), as well as current tracks (teal).



This proposed RNAV South/Southeast SID combines the SKYL and COAST SIDs and overlays actual tracks. Proposed RNAV SIDs will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from four to six. Another benefit of this SID is the use of expanded transitional separation (3 NM increasing to 5 NM) which may allow for increased throughput. Combining the SIDs and adding exit fixes increases the potential for chart clutter. There is a risk of flow interaction with this departure procedure as it crosses the STAR inbound from Point Reyes (PYE). Adjacent center coordination will be required to accommodate the new departure fixes.

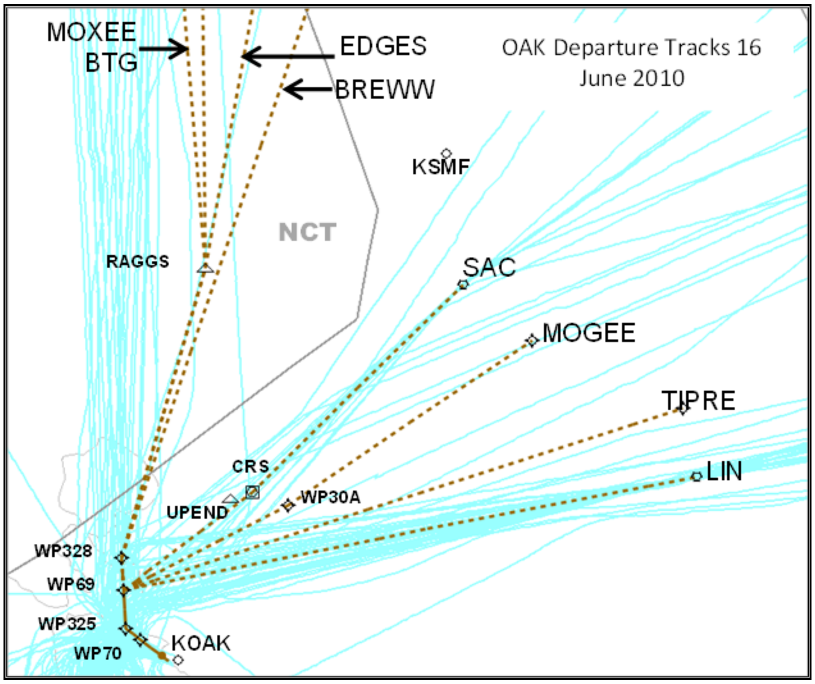
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$45,000
	Profile	$0
Estimated Annual Fuel Savings (Gallons)	Distance	16,000
	Profile	0
Estimated Annual Carbon Savings (Metric Tons)	Distance	160
	Profile	0

4.2.2.2 North/Northeast Departures

The published OAK5 SID relies upon initial radar vectors as the primary means of navigation. This procedure uses radar vectors to the negotiated departure fixes between NCT and ZOA. Approximately 37% of OAK departures use the OAK5 SID.

The following figure illustrates the proposed routes (dashed brown), as well as current tracks (teal).

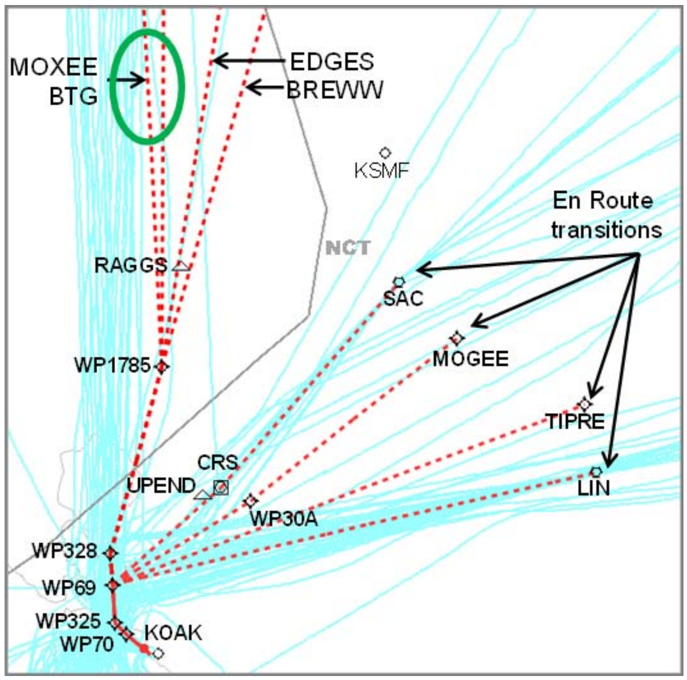


This proposed RNAV SID will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from three to eight. The northeast transitions leverage the new Q-Routes from SAC, LIN, MOGEE and TIPRE. Preferential departure route criteria may need to be examined and developed for this route to ensure flexibility. Another potential benefit for this SID is the use of expanded transitional separation, 3 NM increasing to 5 NM, which may allow for increased throughput. With the increase in exit fixes, chart clutter may need to be addressed. Adjacent center coordination will be required to accommodate the new departure fixes.

No quantifiable benefits were calculated for the proposed new exit fixes. It is not known at this time how these routes will be utilized (e.g., which city pairs will use which fixes) and projected savings cannot be calculated without comparative data.

4.2.2.3 North/Northeast Departures – Alternative

The Study Team examined and supports an alternate north departure procedure that more closely aligns with current traffic flows. The initial proposed solution establishes the RAGGS intersection as a required fly-by waypoint before northbound traffic can proceed direct to BTG VOR or the MOXEE intersection.



The recommended alternative solution entails the creation of a waypoint approximately 12 miles south of RAGGS to be used as an earlier transition point to BTG and MOXEE. The advantage of this alternative procedure is that it more closely aligns with current northbound flight tracks.

Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$9,000
	Profile	$0
Estimated Annual Fuel Savings (Gallons)	Distance	3,000
	Profile	0
Estimated Annual Carbon Savings (Metric Tons)	Distance	30
	Profile	0

4.3 San Jose (SJC) Departures

4.3.1 Identified Issues

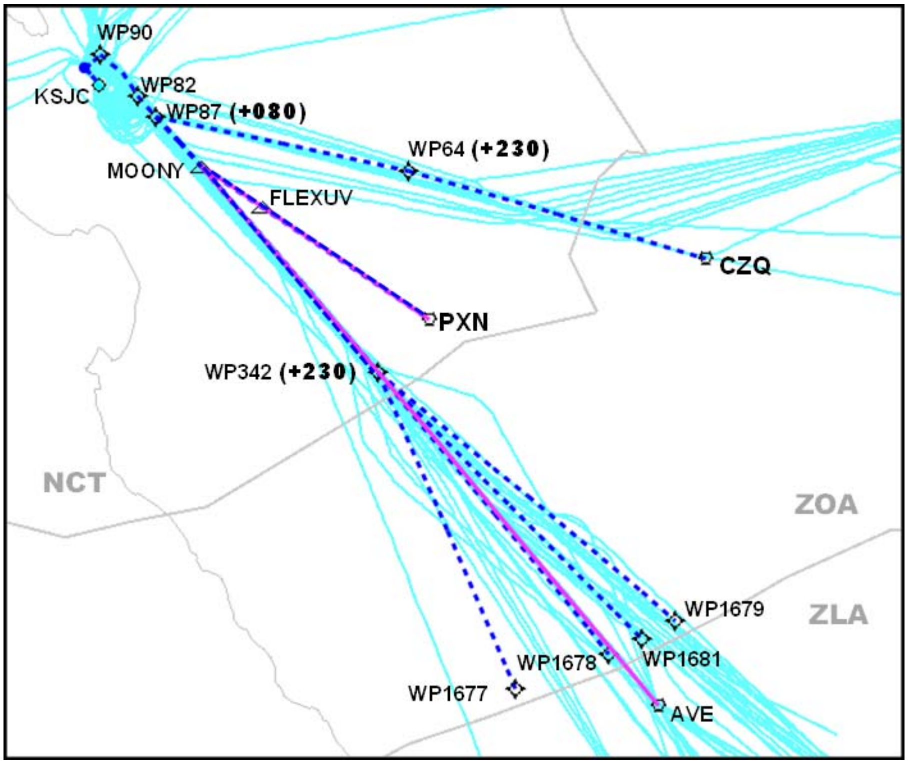
SJC departures in West Plan configuration are analyzed in this section. This configuration is used approximately 85% of the time at SJC. Runways 31 L/R are the primary departure flows in the West Plan configuration.

4.3.2 Study Team Recommendations – SJC RNAV SIDs

4.3.2.1 South/Southeast Departures

The published SJC9 SID relies upon initial radar vectors as the primary means of navigation. The actual flight tracks do not follow the current SIDs. Approximately 54% of SJC departures use the SJC9.

The following figure illustrates the published procedure (solid purple) and the proposed routes (dashed blue), as well as current tracks (teal).


WP90
KSJC
WP82
WP87 (+080)
WP64 (+230)
MOONY
FLEXUV
CZQ
PXN
WP342 (+230)
NCT
ZOA
WP1679
ZLA
WP1678
WP1681
WP1677
AVE

The proposed RNAV South/Southeast SID overlays actual tracks which incorporate the reduced mileage benefits gained in today's operations. This procedure will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from two to six. Another potential benefit for this SID is the use of expanded transitional separation, i.e., 3 NM increasing to 5 NM, which may allow for increased throughput. Preferential departure route (PDR) criteria may need to be examined and developed for this route to ensure flexibility. Adjacent center coordination will be required to accommodate new departure fixes. The Study Team recommends further evaluation of possible interactions with OAK PXN arrivals.

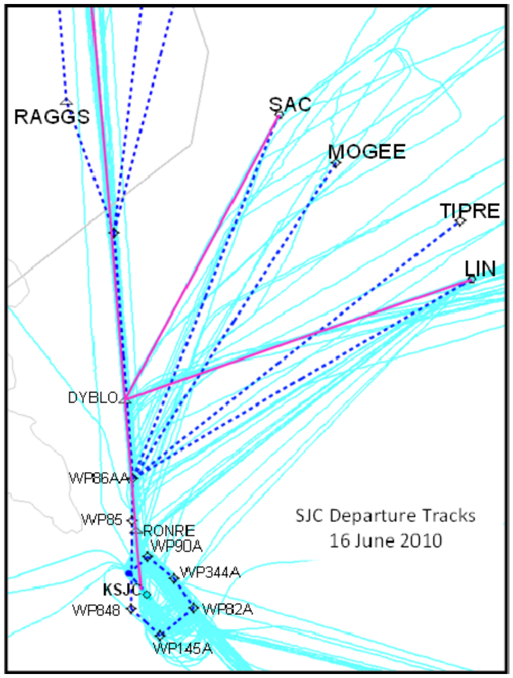
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$12,000
	Profile	$0
Estimated Annual Fuel Savings (Gallons)	Distance	4,000
	Profile	0
Estimated Annual Carbon Savings (Metric Tons)	Distance	40
	Profile	0

4.3.2.2 North/Northeast Departures

The published LOUPE SID relies upon initial radar vectors as the primary means of navigation. This procedure uses radar vectors until reaching the SJC VOR. Approximately 34% of SJC departures use the LOUPE SID.

The following figure illustrates the published procedure (solid purple) and the proposed routes (dashed blue), as well as current tracks (teal).



Several alternatives were examined to replace the current LOUPE SID geometry prior to the SJC VOR, but operational benefits could not be demonstrated. This proposed RNAV SID will facilitate accurate fuel planning by providing a more predictable, repeatable flight path. En route departure transitions are increased from three to eight. The northeast transitions leverage the new Q-Routes from SAC, LIN, MOGEE and TIPRE. A potential benefit for this SID is the use of expanded transitional separation, i.e., 3 NM increasing to 5 NM, which may allow for increased throughput. With the multiple exit fixes, chart clutter may need to be addressed. Adjacent center coordination will be required to accommodate new departure fixes.

Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$24,000
	Profile	$0
Estimated Annual Fuel Savings (Gallons)	Distance	9,000
	Profile	0
Estimated Annual Carbon Savings (Metric Tons)	Distance	90
	Profile	0

4.4 Sacramento (SMF) Departures

4.4.1 Identified Issues

The interactions between the southbound SMF FROGO SID and the westbound Madwin (MADN) and SFO Modesto (MOD) arrivals STARs were identified as an area that would benefit from the deconfliction of area procedures.

4.4.2 Study Team Recommendations

4.4.2.1 FROGO Departures

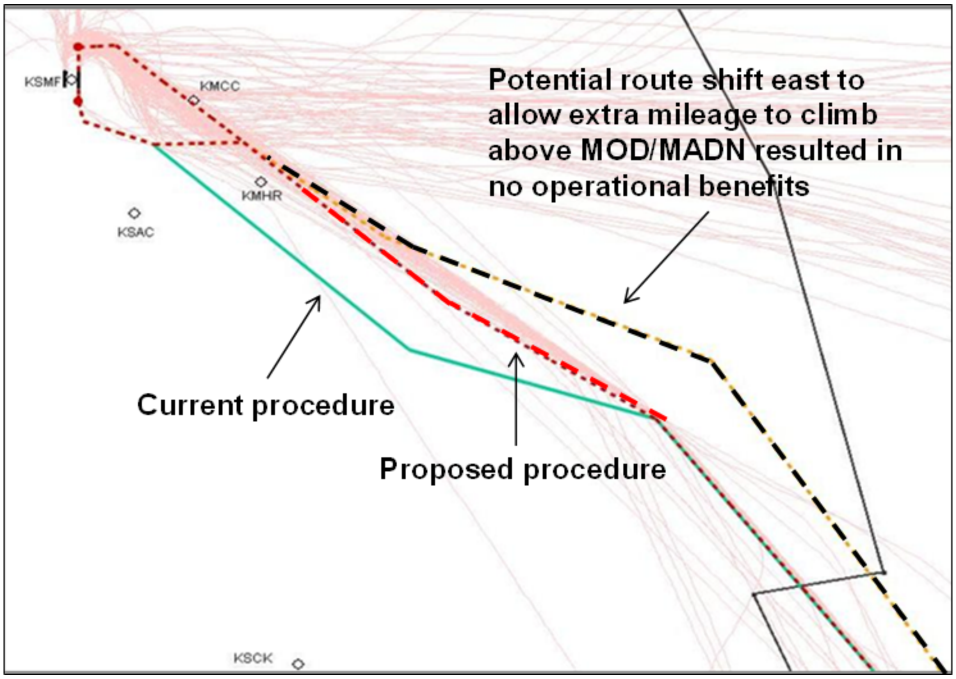
The Study Team examined several alternatives to deconflict the FROGO from the OAK MADN and SFO MOD arrivals.

Alternatives explored:

- Swapping FROGO and the WRAPS procedures at SMF
- Moving the FROGO east to evaluate higher altitudes
- Procedurally deconflicting the FROGO from the MADN and MOD STAR

As a result of these examinations, it was determined by the Study Team that no procedural gain could be derived by amending the FROGO without adversely impacting surrounding traffic.

The following figure illustrates the published procedure (solid teal) and the proposed routes (dashed red and dashed black), as well as current tracks (pink).



4.5 San Francisco (SFO) Arrivals

San Francisco arrivals were analyzed in the West Plan configuration. Ninety-two percent of SFO operations occur in this configuration. Where operationally feasible, the end waypoints of the STARs were designed with common points to join published approaches. The assumption from the Study Team is that the Development and Implementation Team will attempt to redesign approaches to merge with all proposed STARs.

4.5.1 Identified Issues

The Study Team identified several operational issues related to all published STARs at SFO.

- Published SFO STAR procedures are outdated; actual flight tracks do not overfly the published procedures
- The STARs encompass inefficient vertical profiles and level segments
- SFO STARs have unused transitions

Issues specific to individual STARs are addressed in subsequent sections.

4.5.2 Study Team Recommendations – SFO RNAV STARs

The following recommendations are intended to provide SFO RNAV STARs that:

- Have predictable repeatable paths
- Include Optimized Profile Descent (OPD) benefits
- Align with current flight paths

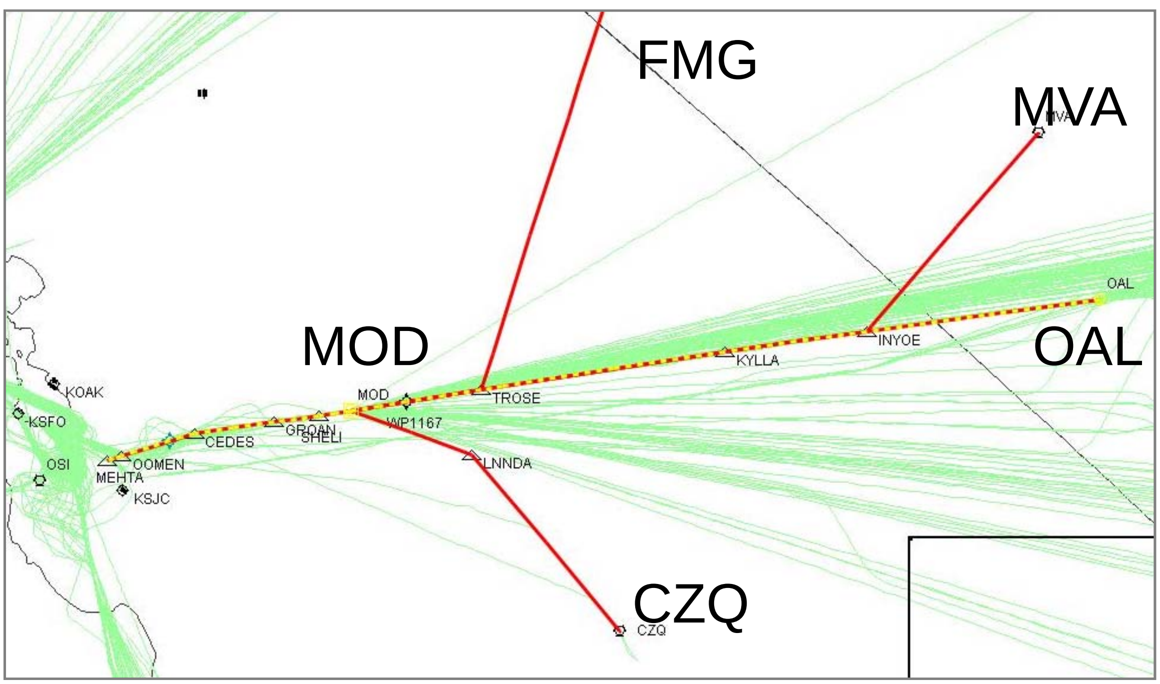
The objective of aligning proposed RNAV STARs with current flight paths is to proceduralize the shortcuts routinely taken today. This will allow more accurate fuel planning because the flights will actually fly the miles that they file.

Recommendations specific to particular procedures will be addressed in the individual descriptions of the procedures.

4.5.2.1 Modesto (MOD) STAR

The MOD STAR is the most frequently used arrival at SFO with 44% of all SFO jet arrivals entering the Bay Area from the east on this STAR. The lateral path of the proposed RNAV OPD STAR closely follows the arrival tracks that are currently flown. The current MOD STAR shares the same east entry point of Coaldale (OAL) with the OAK MADN STAR and the SJC El Nido (HYP) STAR. The Study Team has proposed the segregation of these flows. The conventional MOD STAR will remain for aircraft that are not RNAV equipped.

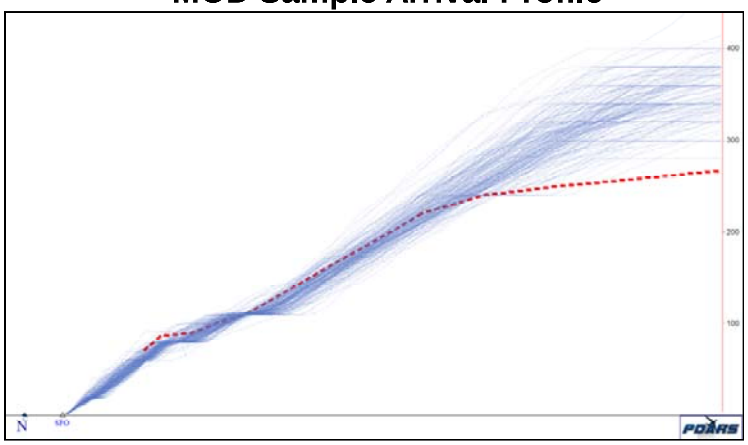
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed yellow), as well as current tracks (green).



The proposed RNAV MOD STAR overlies the lateral path of the conventional STAR from the OAL and Mina (MVA) transitions. The unused Clovis (CZQ) and Mustang (FMG) transitions are eliminated. Since the proposed STAR overlays current paths, no measurable lateral gain is achieved. However, benefits may be obtained from accurate fuel planning associated with Industry's ability to file the route their aircraft will actually fly. The Study Team also focused on development of the industry preferred descent gradient of 2.68 – 2.72 degrees as a standard for OPD development on this STAR. The Study Team identified the need for a LIDAT-MOD transition to facilitate the incorporation of the Beatty (BTY) corridor traffic on the STAR.

The figure below illustrates the elimination of the level segments seen in current tracks (blue) in the proposed procedure (dashed red).

MOD Sample Arrival Profile



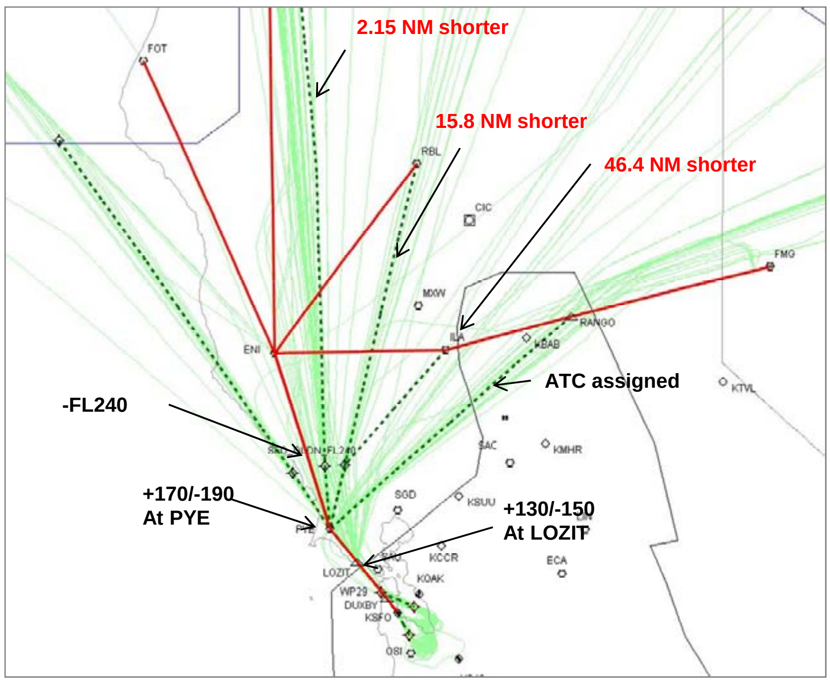
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$836,000 - $2.51M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**302,000 - 905,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**3,020 - 9,050**

4.5.2.2 Golden Gate (GOLDN) STAR

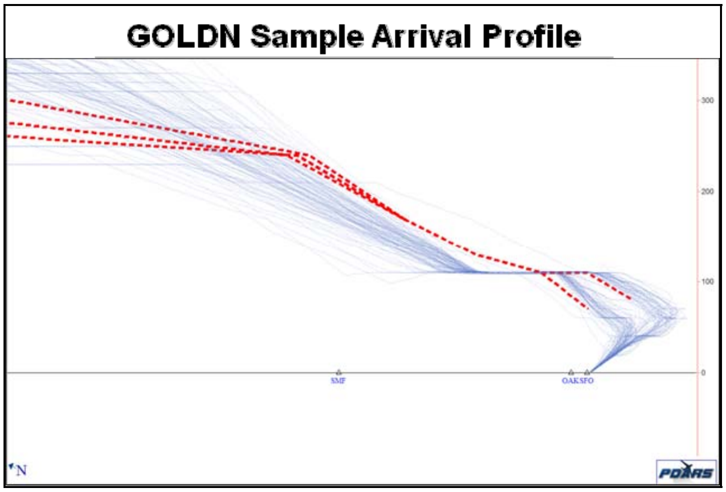
The GOLDN STAR is an arrival procedure from the north, used by 21% of SFO jet arrivals. The published STAR is outdated with multiple transitions unused. The lateral path of the published procedure is currently not flown. The current GOLDN STAR is shared by both SFO and SJC arrivals. The Study Team identified a long level-off at LOZIT.

The following figure illustrates the published procedure (solid red) and the proposed routes (dashed green), as well as current tracks (green).



The lateral path of the proposed RNAV STAR closely follows the current arrival tracks and will provide more direct routing which will define a predictable, repeatable path. The study team eliminated unused transitions in the proposed STAR, which also has OPD benefits. Arrival windows were used in the vicinity of Point Reyes (PYE) and LOZIT to reduce level-offs. The Study Team developed a separate STAR for SJC arrivals to procedurally deconflict SFO and SJC arrivals. Both procedures will have optimized lateral and vertical profiles. The proposed GOLDN STAR will include a new runway transition to SFO 28R.

The figure below illustrates the mitigation of the level segments seen in current tracks (blue) in the proposed procedure (dashed red).

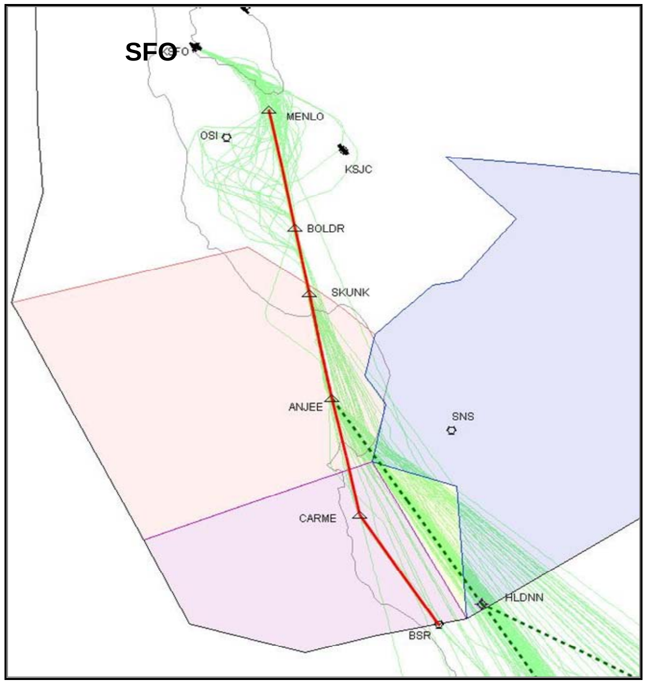


Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$65,000
	Profile	$111,000 - $332,000
Estimated Annual Fuel Savings (Gallons)	Distance	24,000
	Profile	40,000 - 120,000
Estimated Annual Carbon Savings (Metric Tons)	Distance	240
	Profile	400 - 1,200

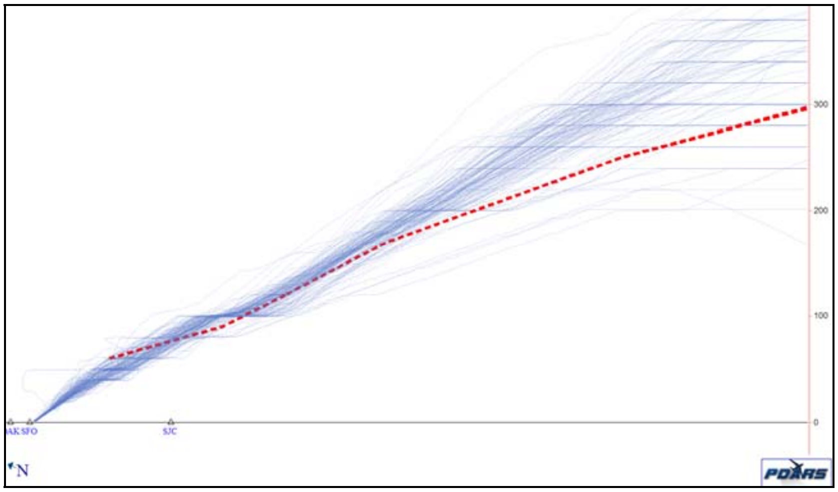
4.5.2.3 Big Sur (BSR) STAR

The BSR STAR is a procedure from the southeast for SFO, accounting for 29% of all SFO arrivals. The current transition from BSR to ANJEE is unused with aircraft vectored off of the published procedure for more direct routing. The procedure has an inefficient vertical profile with long level-offs. Extensive delay vectoring occurs to accommodate sequencing for the runway. The following figure illustrates the published procedure (solid red) and the proposed routes (dashed green), as well as current tracks (green).



The proposed procedure offers OPD benefits and will align with the current flight paths, by shifting the procedure eight miles to the east. The BSR RNAV STAR will accommodate multiple approach procedures and have optimized lateral and vertical profiles. The Study Team recommendation is to alleviate the extensive delay vectoring by creating conditional use airspace for holding at the NCT/ZOA boundary. The Design and Implementation Team will need to evaluate possible resectorization within NCT and conditional use airspace in the vicinity of ANJEE to accommodate holding.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).



Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$138,000**
	Profile	**$387,000 - $1.16M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**50,000**
	Profile	**140,000 - 419,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**500**
	Profile	**1,400 - 4,190**

4.6 Oakland (OAK) Arrivals

OAK arrivals were analyzed largely in the West Plan configuration. Ninety-three of OAK operations occur in this configuration. End waypoints of the STARs were designed with common points to join published approaches. One arrival procedure (ECA STAR) used during East Plan was evaluated for enhancements. The assumption from the Study Team is that the Development and Implementation Team will attempt to redesign approaches to merge with all proposed STARs.

4.6.1 Identified Issues

The Study Team identified several operational issues related to all published STARs at OAK.

- Published OAK STAR procedures are outdated; actual flight tracks do not overfly the published procedures
- The STARs encompass inefficient vertical profiles and level segments
- OAK STARs have unused transitions

Issues specific to individual STARs will be addressed in the descriptions of said procedures.

4.6.2 Study Team Recommendations – OAK RNAV STARs

The following recommendations are intended to provide OAK STARs that:

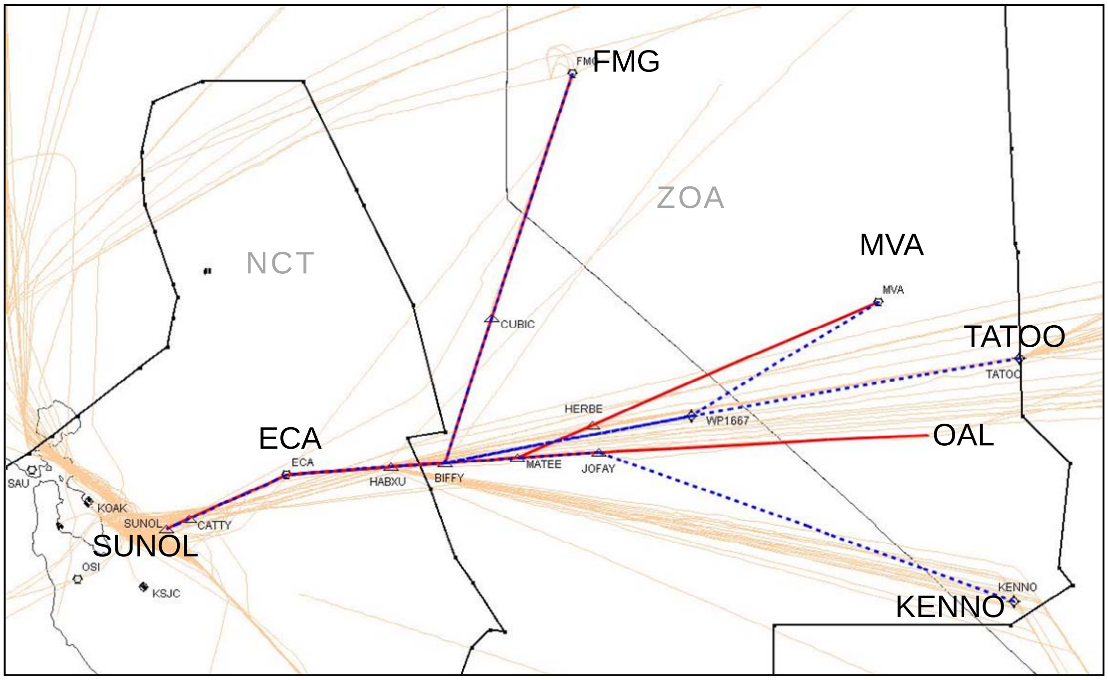
- Have predictable repeatable paths
- Include OPD benefits
- Align with current flight paths
- Accommodate multiple approach transitions into OAK

Recommendations specific to particular procedures will be addressed in the individual descriptions of the procedures.

4.6.2.1 Madwin (MADN) STAR

The MADN STAR is an arrival route from the east and accounts for nearly 29% of all OAK arrivals. The current OAK STAR shares the same east entry point of OAL with the SJC HYP STAR and the SFO MOD STAR. The Study Team has proposed segregation of these flows. The procedure as flown today has an inefficient vertical profile with costly level-offs. Current flight tracks do not overfly the published procedures, and some transitions are unused.

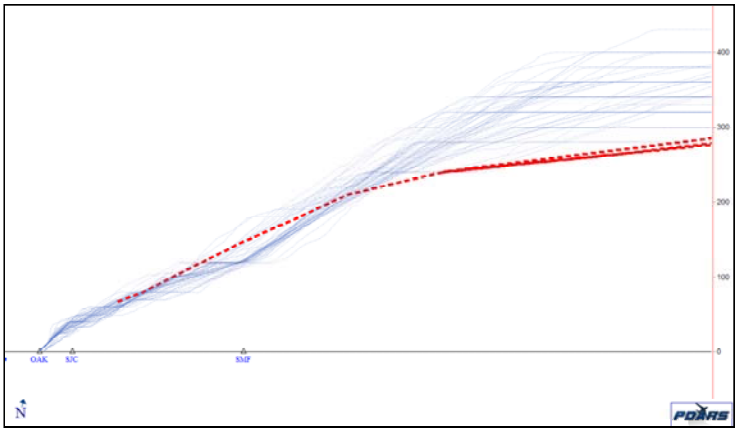
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (light orange).



The Study Team recommends an RNAV STAR that offers OPD benefits and overlies the currently flown lateral flight paths. This STAR will offer repeatable and predictable flight paths which will allow more accurate flight planning. It offers new transitions from TATOO, MVA, and KENNO and removes the unused FMG transition. These new entry points will be used to procedurally segregate this arrival from the SFO MOD STAR and the SJC HYP STAR. Further, BTY corridor traffic will have the opportunity to utilize the KENNO-JOFAY transition. Altitudes proposed on this OPD arrival are vertically deconflicted from the SMF WRAPS STAR. The STAR terminates at the SUNOL intersection which serves to accommodate multiple approach transitions into OAK.

The figure below illustrates the mitigation of the level segments seen in current tracks (blue) in the proposed procedure (dashed red).

MADN Sample Arrival Profile



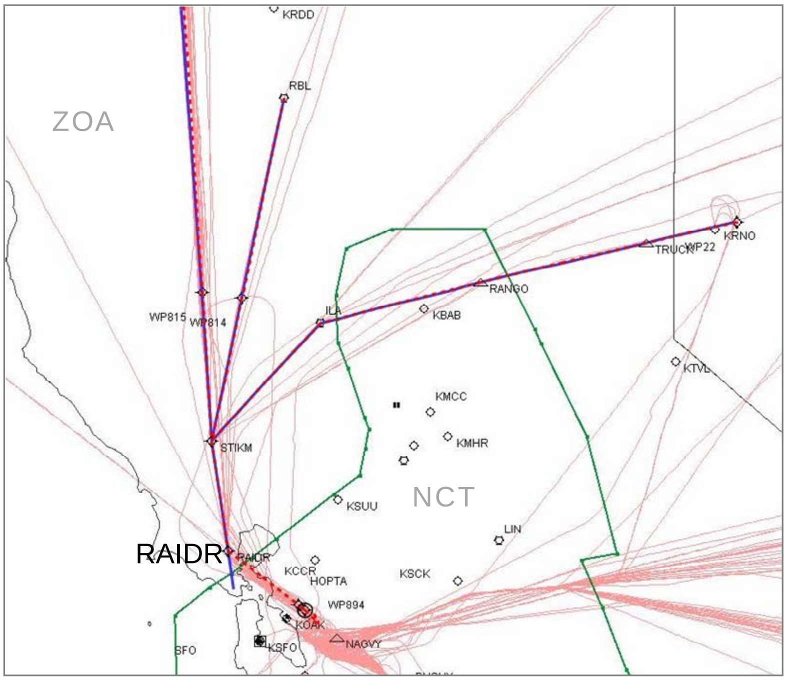
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$26,000**
	Profile	**$266,000 - $797,000**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**9,000**
	Profile	**96,000 - 288,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**90**
	Profile	**960 - 2,880**

4.6.2.2 Raider (RAIDR) STAR

The RAIDR STAR is one of only two RNAV procedures currently used in the Northern California Metroplex and the only RNAV procedure utilized at OAK. It is the only RNAV procedure in the Northern California Metroplex that can be filed by users. Approximately 21% of all OAK jet arrivals use this STAR. The published RAIDR procedure terminates over Sausalito (SAU); however, historical track data has validated that all arrivals are vectored to final prior to reaching SAU. The procedure as flown today has an inefficient vertical profile with costly level-offs.

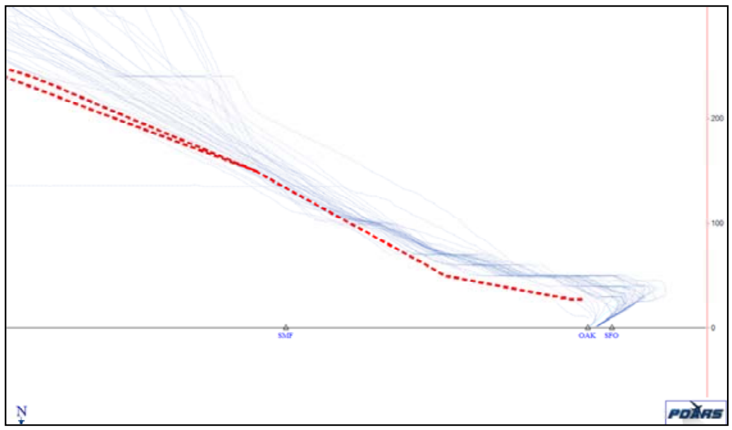
The following figure illustrates the published procedure (solid blue) and the proposed routes (dashed red), as well as current tracks (coral).



The Study Team has proposed that this procedure be modified to proceed downwind at the RAIDR waypoint. This new procedure will also continue with an extended downwind leg where the STAR then terminates with a fly-over waypoint. This design will allow for multiple Required Navigation Performance (RNP) approach transitions to be designed from the termination waypoint as well as better positioning aircraft for visual approaches.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

RAIDR Sample Arrival Profile



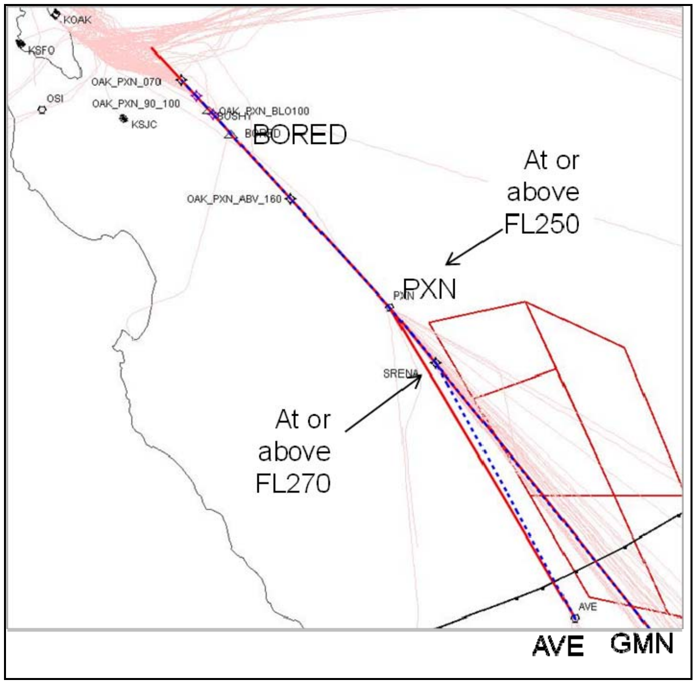
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$640,000 - $1.92M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**231,000 - 694,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**2,310 - 6,940**

4.6.2.3 Panoche (PXN) STAR

The published PXN STAR is an arrival procedure from the southeast to OAK, with 49% of all OAK arrivals using it. The lateral path of the proposed RNAV OPD STAR closely follows historical track data. The procedure as flown today has an inefficient vertical profile with costly level-offs.

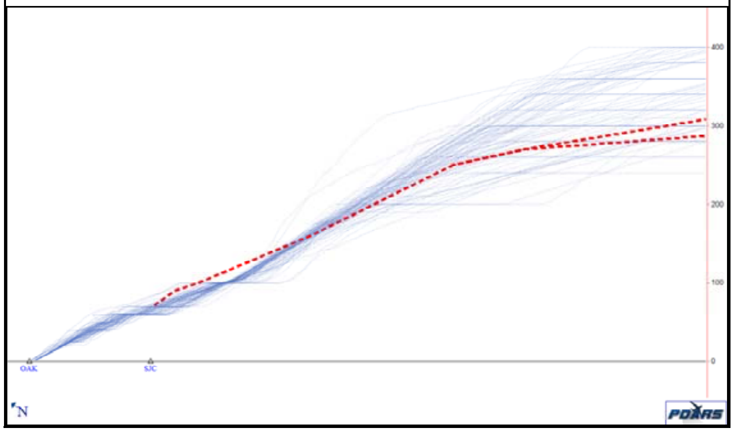
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (pink).



The proposed PXN RNAV STAR overlays the lateral path of the conventional STAR from the Gorman (GMN) VOR and alters slightly the path from Avenal (AVE). This STAR terminates at a waypoint which accommodates multiple transitions to OAK. The RNAV STAR does not impact the Lemoore SAA.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

PXN Sample Arrival Profile



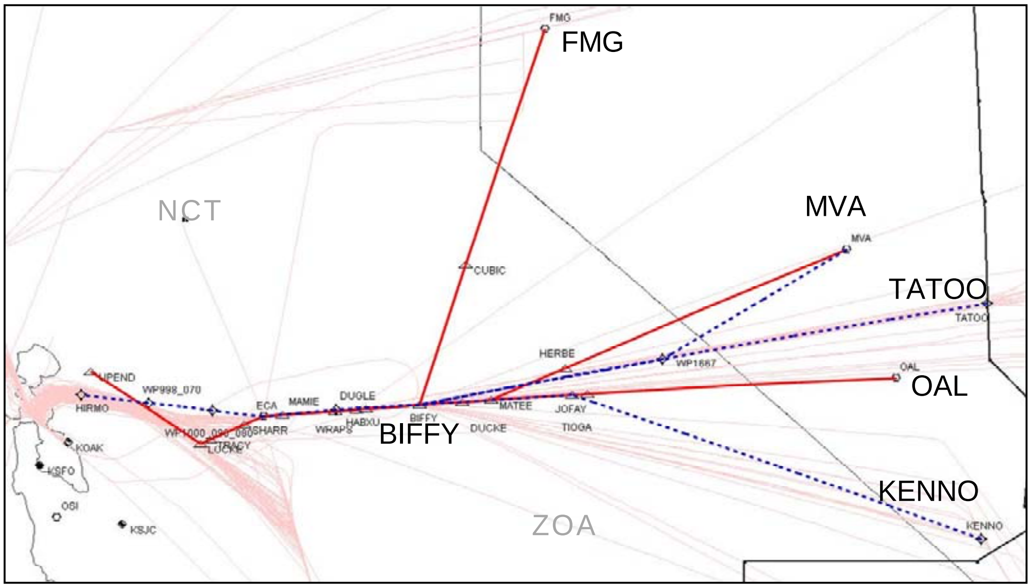
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$784,000 - $2.35M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**283,000 - 849,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**2,830 - 8,490**

4.6.2.4 Manteca (ECA) STAR

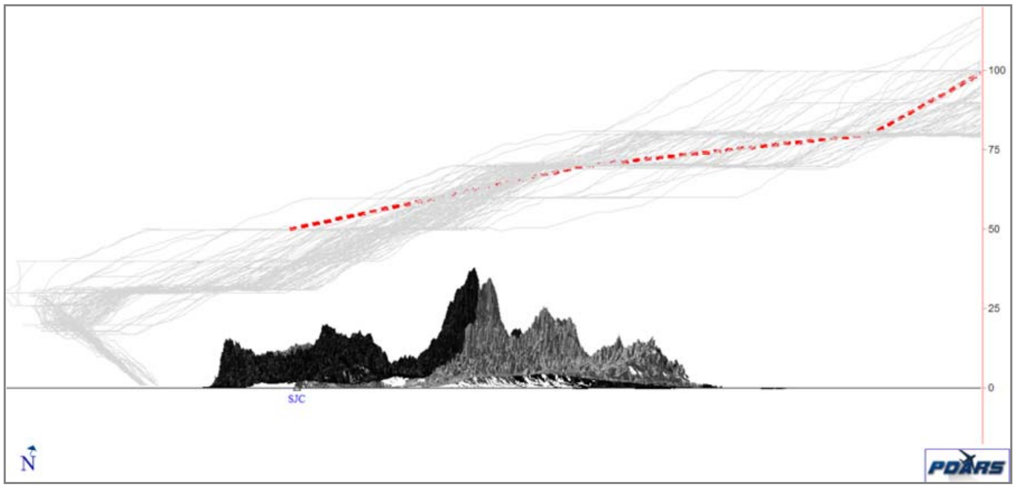
The published Manteca (ECA) STAR is used when OAK is in a Runways 11 and 09 configuration and is utilized less than 1% of the time. The procedure shares a competing flight path with the SFO LOCKE STAR and conflicts with the Sacramento (SMF) WRAPS STAR and FROGO SID. This causes the procedure to have an inefficient vertical profile and numerous level segments that increase fuel burn.

The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (coral).



The proposed ECA RNAV STAR overlies the lateral path of the proposed MADN STAR until it reaches ECA. At ECA, the STAR then proceeds west to position the arrivals on a downwind for the east complex at OAK. The procedure will terminate with a flyover waypoint that will allow multiple RNP approaches to be designed at OAK. The proposed transition from ECA will deconflict arrivals from the SFO LOCKE STAR. The lateral path does not overlay historical flight data which will be a concern when environmental issues are considered. The transition also overflies Mt. Diablo by less than 2000 ft. which may cause excessive Terrain Awareness Warning System (TAWS) alerts to the user. The Design and Implementation Team will need to evaluate possible environmental and terrain issues surrounding this proposal.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).



Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	Distance	$11,000
	Profile	$35,000 - $104,000
Estimated Annual Fuel Savings (Gallons)	Distance	4,000
	Profile	12,000 - 37,000
Estimated Annual Carbon Savings (Metric Tons)	Distance	40
	Profile	130 - 380

4.7 San Jose (SJC) Arrivals

SJC arrivals were analyzed largely in the West Plan configuration. Eighty-five percent of SJC operations occur in this configuration. End waypoints of the STARs were designed with common points to join published approaches. One arrival procedure (JAWWS STAR) used during East Plan was evaluated for enhancements. The assumption from the Study Team is that the Development and Implementation Team will attempt to redesign approaches to merge with all proposed STARs.

4.7.1 Identified Issues

The Study Team identified several operational issues related to all published STARs at SJC.

- Current SJC STAR procedures are outdated; actual flight tracks do not overfly the published procedures
- The STARs encompass inefficient vertical profiles and level segments

Issues that were identified in particular STARs will be addressed in the specific descriptions of the procedures.

4.7.2 Study Team Recommendations – SJC RNAV STARs

The Study Team has made the following recommendations based upon these assumptions that SJC STARs will:

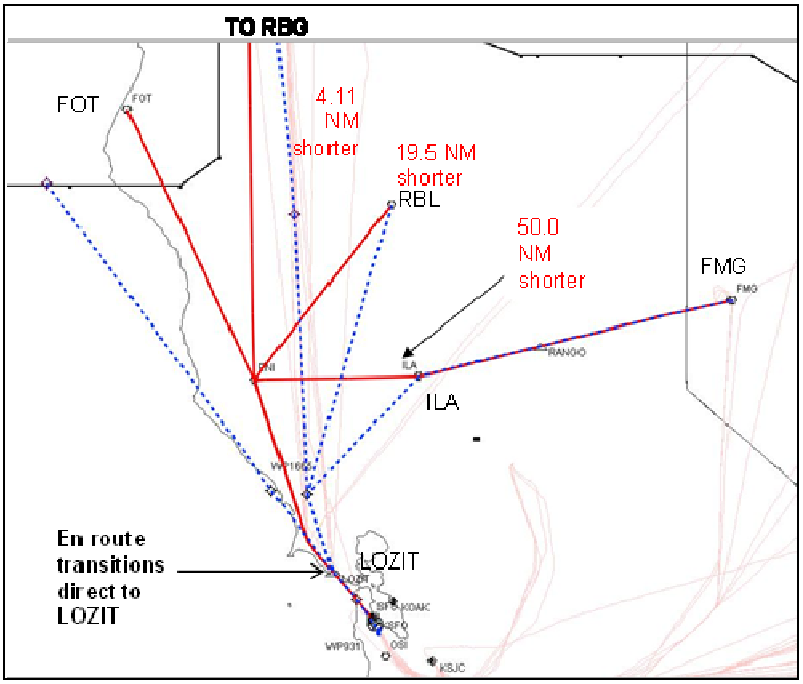
- Have a predictable repeatable path
- Include OPD benefits
- Align with current flight paths
- Accommodate multiple approach transitions into SJC

Recommendations specific to particular procedures will be addressed in the individual descriptions of the procedures.

4.7.2.1 Golden Gate (GOLDN) STAR

The GOLDN STAR is an arrival procedure from the north, used by 13% of all SJC jet arrivals. The published STAR is outdated with multiple transitions unused. The lateral path of the published procedure is not flown by current arrivals. The current GOLDN STAR is shared by both SFO and SJC arrivals. The Study Team identified a long level-off at LOZIT intersection.

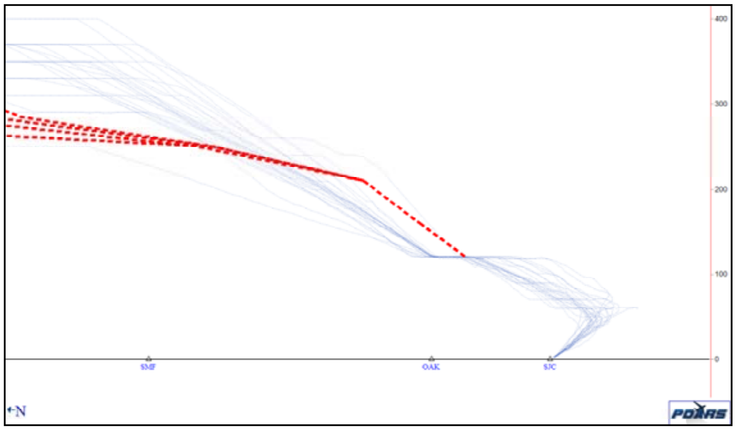
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (pink).



The lateral path of the proposed RNAV STAR closely follows the current arrival tracks and will provide more direct routing which will define a predictable, repeatable path. Unused transitions are eliminated in the proposed STAR which also has OPD benefits. Arrival windows were used in the vicinity of LOZIT to reduce level-offs. The proposed SJC STAR prior to LOZIT has been shifted east to laterally deconflict from the SFO arrival procedure. The Study Team developed a separate STAR for this arrival, thus procedurally deconflicting SFO and SJC arrivals. Both procedures will have optimized lateral and vertical profiles.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

GOLDN Sample Arrival Profile



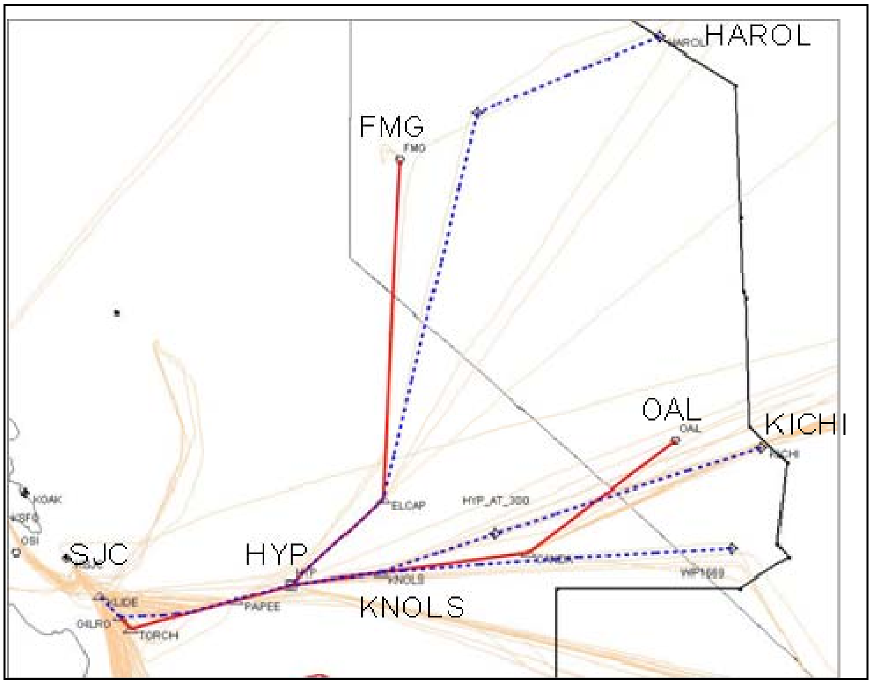
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$34,000**
	Profile	**$76,000 - $228,000**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**12,000**
	Profile	**28,000 - 83,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**130**
	Profile	**280 – 830**

4.7.2.2 El Nido (HYP) STAR

The HYP STAR is an east arrival procedure for SJC, with 35% of all SJC jet arrivals using this procedure. The current SJC HYP STAR shares the same east entry point of OAL with the OAK MADN STAR and the SFO MOD STAR.

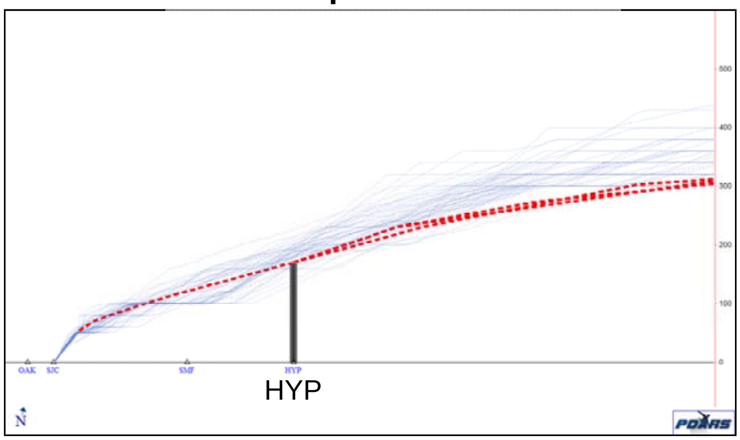
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (light orange).



This proposed SJC RNAV STAR overlies the lateral path of the current traffic flows. The unused OAL and FMG transitions are eliminated. New transitions have been added at KICHI intersection, HAROL intersection, and at a waypoint that accommodates BTY corridor traffic on this arrival. The result of these new entry points will be to procedurally segregate this arrival from the SFO MOD STAR and the OAK MADN STAR. Altitudes proposed on this OPD arrival vertically deconflict this procedure from the OAK PXN STAR. Convergence with northbound/southbound routes will be a factor at the initial entry points to this STAR. The STAR terminates at KLIDE intersection which serves to accommodate multiple approach transitions into SJC.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

HYP Sample Arrival Profile



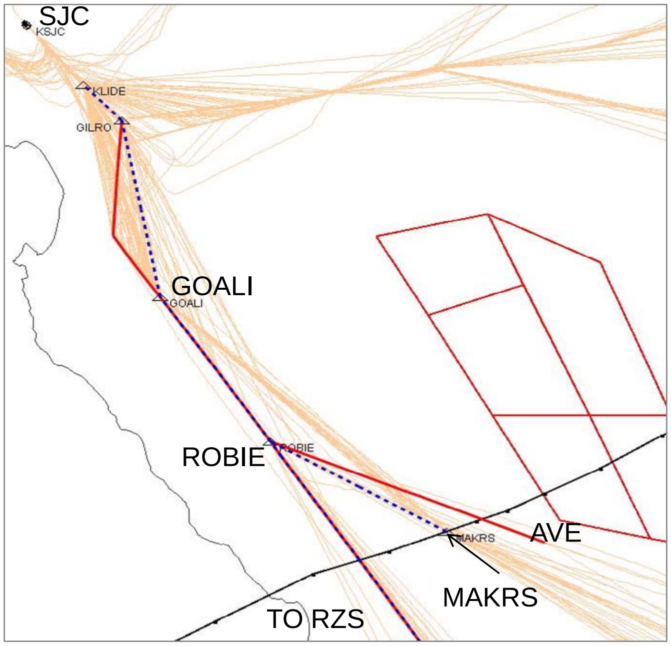
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$467,000-$1.4M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**171,000 – 508,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**1,680-5,050**

4.7.2.3 ROBIE STAR

The SJC ROBIE STAR is a southern arrival procedure used by 48% of all SJC jet arrivals. This procedure has an unused transition from AVE. The Study Team identified several level-offs in an evaluation of current traffic.

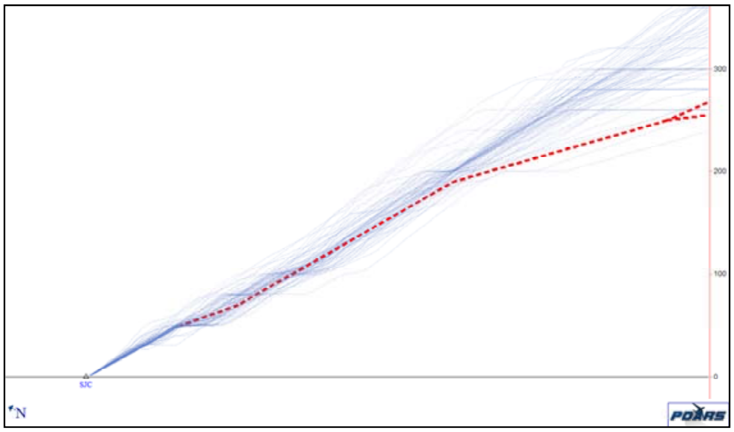
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (light orange).



This proposed SJC RNAV STAR overlies the lateral path of the current traffic flows. The unused AVE transition is eliminated. A new transition has been added at MAKRS intersection, which more closely aligns this arrival with current tracks. MAKRS transition intersects with ROBIE intersection, as requested by the facilities. This proposed STAR also employs a lateral route reduction from GOALI intersection to GILRO intersection over the published STAR. The STAR terminates at KLIDE intersection, which serves to accommodate multiple approach transitions into SJC.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

ROBIE Sample Arrival Profile



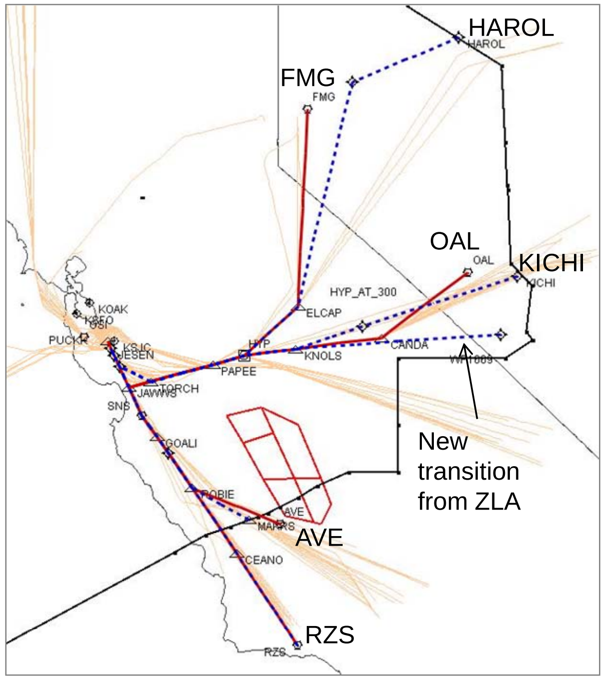
Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$602,000-$1.8M**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**217,000 – 652,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**2,170-6,520**

4.7.2.4 JAWWS STAR

The JAWWS STAR is a procedure used in east configuration plan at SJC, with 3% of all jet arrivals using this STAR. The published SJC STAR shares the same east entry point of OAL with other OAK and the SFO STARs. The Study Team identified several level-offs an unused transitions in an evaluation of current traffic.

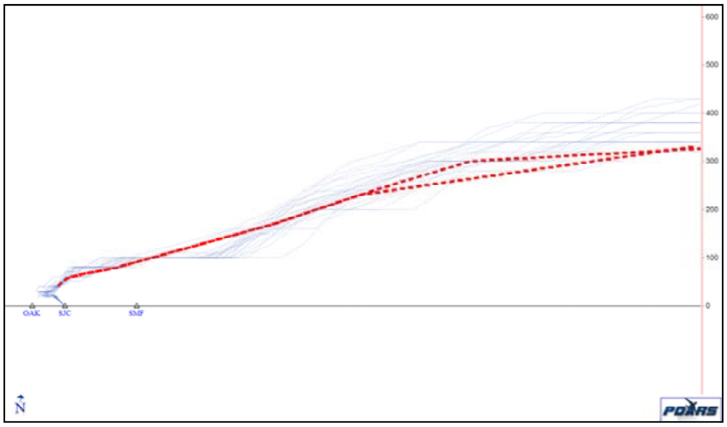
The following figure illustrates the published procedure (solid red) and the proposed routes (dashed blue), as well as current tracks (light orange).



This proposed SJC RNAV STAR overlays the lateral path of current traffic flows. The unused OAL, AVE and FMG transitions have been eliminated. New transitions have been added to this STAR at KICHI, MAKRS, HAROL intersections, and at a waypoint that accommodates BTY corridor. Altitudes proposed on this arrival vertically deconflict this procedure from other area STARs and incorporate OPD benefits. The proposed STAR terminates at JESEN intersection which serves to accommodate multiple RNP approach transitions into SJC Runway 12. JESEN will be the ending fix on the STAR for other approach options to SJC Runway12. A new transition from the south has been added at MAKRS intersection, which closely aligns this arrival with current tracks. The MAKRS transition intersects with the ROBIE intersection as requested by the facilities. This proposed STAR also employs a lateral route reduction from the TORCH intersection for traffic entering from the east.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

JAWWS Sample Arrival Profile



Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

Estimated Annual Fuel Savings	**Distance**	**$0**
	Profile	**$21,000-$62,000**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**0**
	Profile	**8,000 – 23,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**0**
	Profile	**80-230**

4.8 Sacramento (SMF) Arrival

One SMF arrival procedure was identified as a candidate for operational enhancements. The end waypoint of the STAR was designed with a common point to join published approaches. The assumption from the Study Team is that the Development and Implementation Team will attempt to redesign approaches to merge with the proposed STAR.

The Study Team identified operational issues related to the WRAPS STAR at SMF:

- Current SMF STAR procedures are outdated; actual flight tracks do not overfly the published procedures
- The STAR encompasses inefficient vertical profiles and level-offs
- SMF WRAPS STAR has competing paths with other STARs

4.8.1 Study Team Recommendations – SMF RNAV STAR

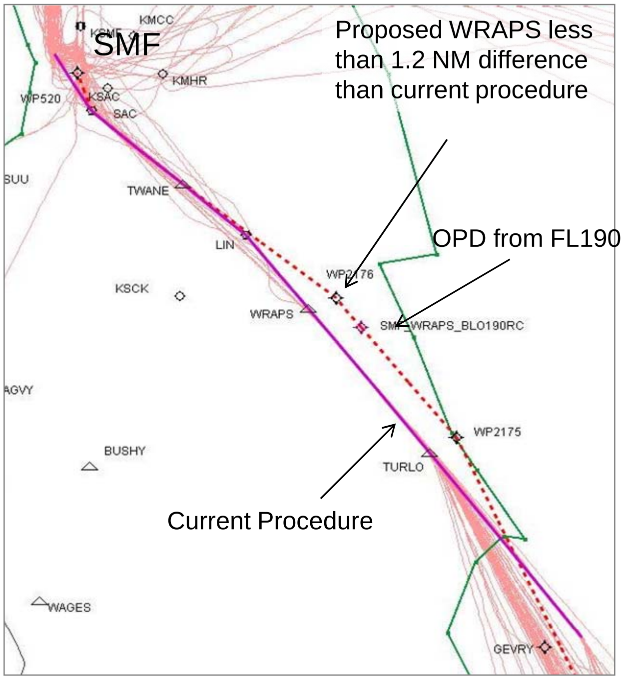
The Study Team designed the proposed SMF WRAPS STAR to:

- Have a predictable repeatable path
- Include OPD benefits
- Align with current flight paths
- Accommodate multiple approach transitions into SMF
- Procedurally deconflict from other area STARs

4.8.1.1 WRAPS STAR

The published WRAPS STAR has an inefficient vertical profile and level segments due to crossing traffic with SFO, OAK, and SJC arrivals. Actual flight tracks do not overfly the current procedure. Approximately 47% of the SMF arrivals utilize the WRAPS STAR. The WRAPS conflicts with west arrival flows to SJC, SFO and OAK airports.

The following figure illustrates the published procedure (solid purple) and the proposed routes (dashed red), as well as current tracks (pink).

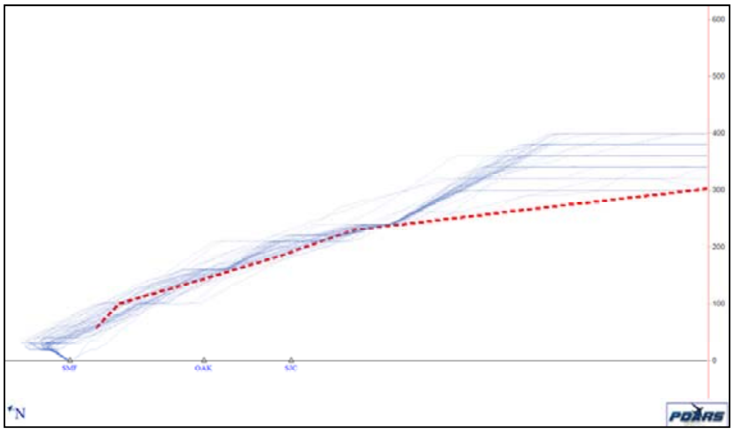


WRAPS STAR alternatives were considered, including swapping the FROGO and the WRAPS, adjusting the location east and procedurally deconflicting it from the MOD/MADN.

The Study Team concluded that the proposed STAR will be procedurally deconflicted from these other area STARs. This modified STAR will provide a more predictable, repeatable path with OPD benefits. The STAR was moved east approximately seven miles to allow optimization of these Northern California STARs.

The figure below illustrates the mitigation of the level-offs seen in current tracks (blue) in the proposed procedure (dashed red).

WRAPS Sample Arrival Profile



Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures. Profile savings are associated with fuel burn reduction due to the removal of level segments along the flight path.

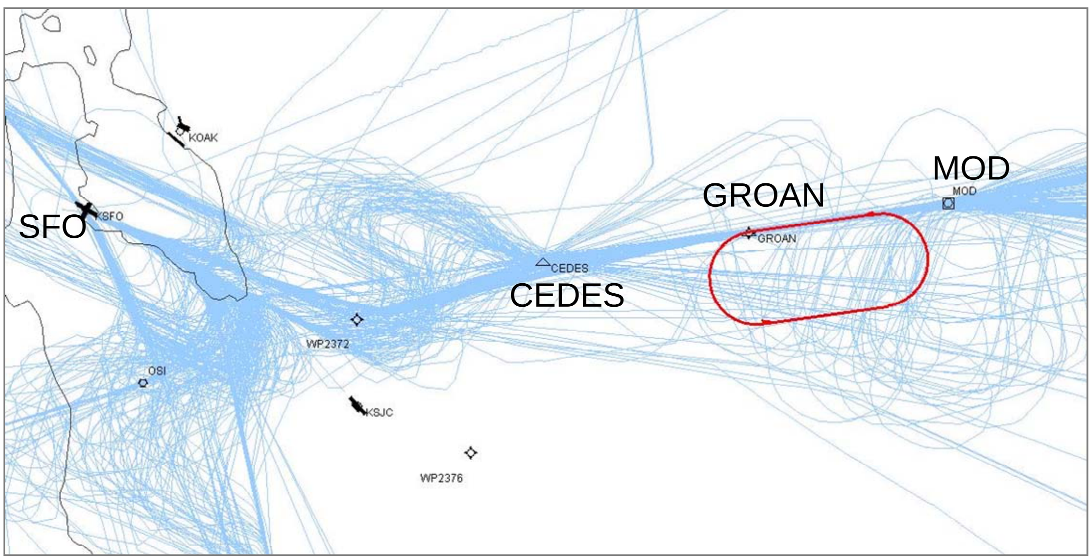
Estimated Annual Fuel Savings	**Distance**	**($79,000)**
	Profile	**$101,000-$303,000**
Estimated Annual Fuel Savings (Gallons)	**Distance**	**(29,000)**
	Profile	**36,000 - 109,000**
Estimated Annual Carbon Savings (Metric Tons)	**Distance**	**(290)**
	Profile	**360-1,090**

4.9 Initial Concepts and Recommendations – Terminal

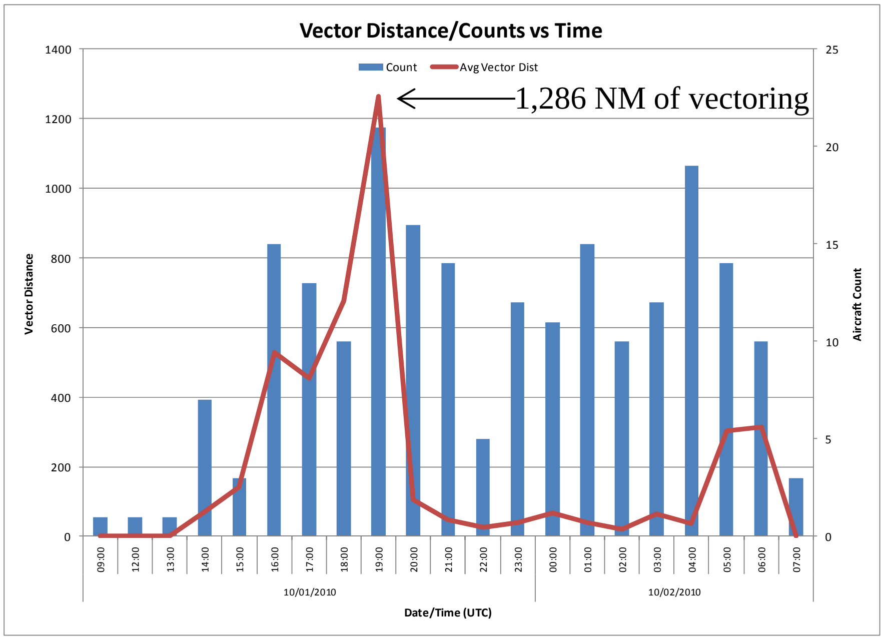
4.9.1 GROAN Holding

NCT does extensive low-altitude delay vectoring close to SFO for sequencing in Instrument Meteorological Conditions (IMC). Excessive fuel consumption is associated with low-altitude delay vectoring. Industry has indicated that it would be preferable to hold at higher altitudes than to be vectored "low and slow" into the airport.

54 NM flying distance GROAN-SFO



The graph below demonstrates increase in vector distance relative to aircraft count and time of day on the MOD arrival flow. On October 1, 2010, from 1900-1959Z, 21 aircraft were vectored 1,286 NM total (approximately 61 NM per aircraft).



The creation of holding at GROAN intersection would potentially reduce delay vectoring, provide more efficient delivery to SFO, reduce fuel costs associated with delay vectoring, and have a predictable holding pattern. The Study Team recommendation is to publish a GROAN holding pattern and establish a conditional use airspace agreement between NCT and ZOA to help alleviate the extensive delay vectoring.

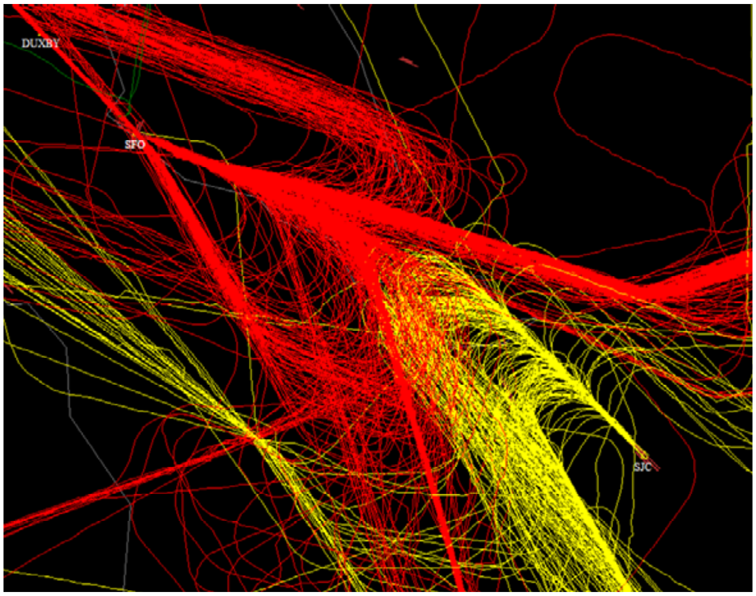
Projected annual savings are estimated in the table below. The Study Team assumed that the same amount of time in holding would occur, but would occur at higher altitudes and at a faster speed.

Estimated Annual Fuel Savings	**Total**	**$949,000 - $1.3M**
Estimated Annual Fuel Savings (Gallons)	**Total**	**343,000 - 461,000**
Estimated Annual Carbon Savings (Metric Tons)	**Total**	**3,430 - 4,610**

4.9.2 Enhance San Jose Runway 12 Operations

Aircraft flying the SJC ILS or RNP AR Runway 12 approaches are constrained by SFO's Runway 28 arrivals and Runway 10 departures. NCT asked the Study Team to investigate moving the SJC Runway 12 Final Approach Fix (FAF) closer to SJC. The Study Team requested that AeroNav Products (TERPS Division) at OKC conduct a preliminary analysis of this issue; AeroNav Products determined the SJC Runway 12 FAF could be moved 0.94 NM closer to the runway. NCT was provided this information and will determine if this enhancement is necessary.

A depiction of the traffic flows between SJC and SFO is shown below:

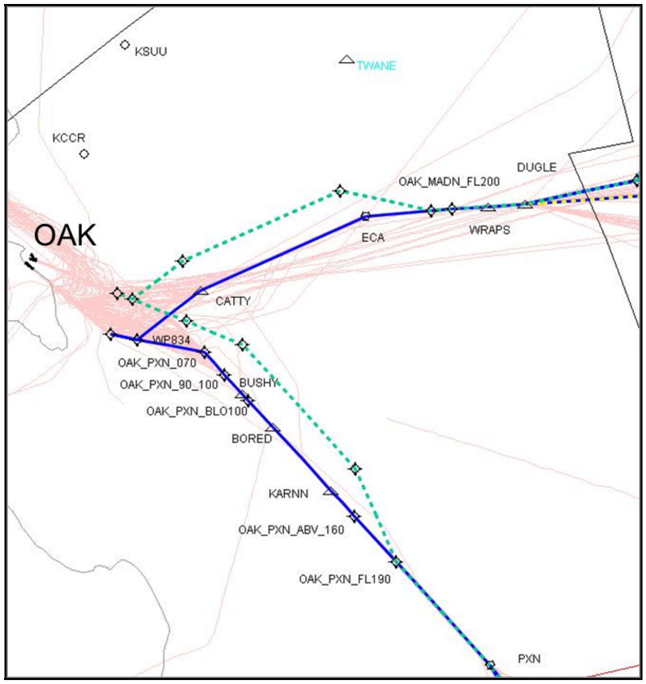


* Graphic depicts two individual days of traffic

4.9.3 Prop (T/P) RNAV STAR to OAK Runway 27

NCT vectors turbo prop aircraft off the published OAK PXN/MADN STARs to separate them from the OAK turbo jet arrivals. NCT controllers requested the Study Team design a parallel OAK RNAV STAR that would segregate turbo prop aircraft arriving Runway 27 from Runway 29 jet arrivals. The proposed OAK turbo prop STAR segregates props from jets, reducing off-route vectoring and speed restrictions, accommodating multiple approach transitions to Runway 27, and potentially increasing throughput.

The following figure illustrates the proposed turbo prop STAR (dashed teal) and the proposed turbo jet STAR (solid blue), as well as current tracks (coral).



4.9.4 San Francisco CUIT and Oakland SLNT

The SFO CUIT and OAK SLNT SIDs are noise-abatement procedures that are used for departures between 2200 and 0700 local over the San Francisco Bay. These departures join a common path between 5.5 and 7.5 NM from the departure end of the runways. These two routes are procedurally conflicted and do not support independent operations. The heaviest demand for departures is between the hours 0600 and 0700 local time, resulting in ground holds for conflicting traffic.

The Study Team investigated lateral and vertical resolutions in an attempt to deconflict these routes. Due to local noise abatement requirements, the Study Team was unable to determine a way to laterally deconflict the routes. Significant time was spent attempting to deconflict these as RNAV routes with vertical assignments *(at or above vs. at or below altitudes)*. However, due to obstacle clearance requirements, RNAV leg length/climb gradient criteria, and separation minima, the Study Team determined the limits of this design to be outside of safe tolerances.

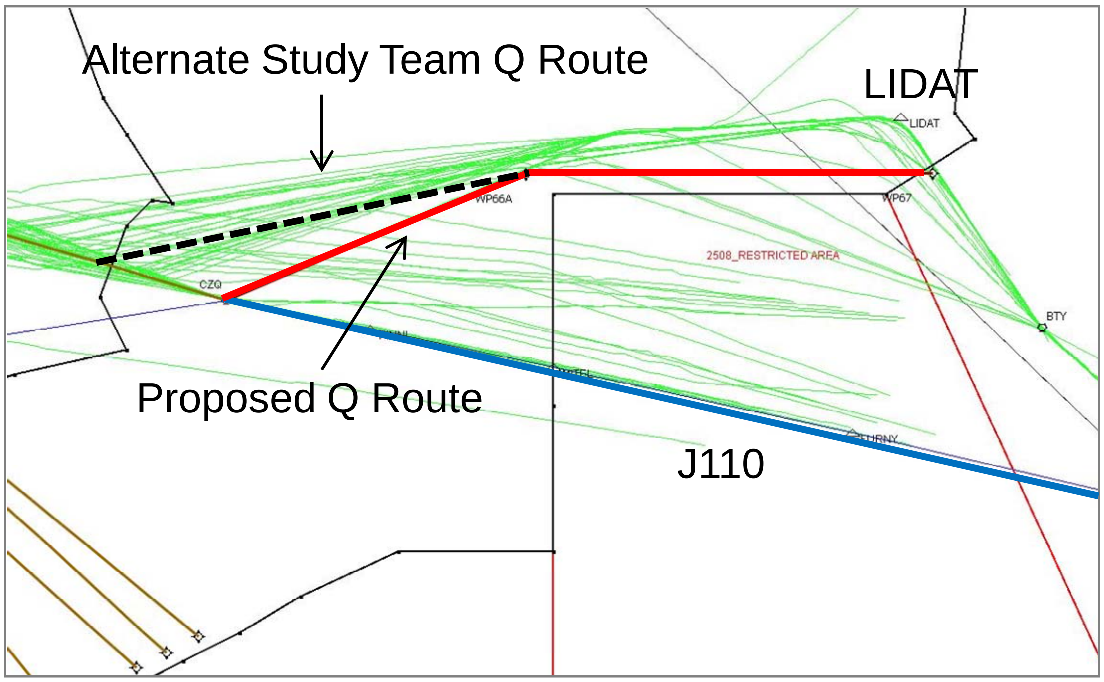
The Study Team recommends developing both of these routes as RNAV SIDs with vertical profiles. These routes will offer repeatable and predictable paths but will not be procedurally deconflicted. These RNAV SIDs will require coordination between OAK and SFO.


-2000
+2700
OAK
SFO
San Francisco

4.10 Initial Concepts and Recommendations – En Route

4.10.1 Proposed Study Team Q-Route

No published route exists on the north side of R-2508 (Edwards Range Complex). Although J110, a jet route, is defined through R-2508 from CZQ to FUZZY, this route is often unavailable due to military activity within the Special Activity Airspace (SAA). ZOA has little insight into the scheduling of military activity in R-2508. When J110 is unavailable, departure aircraft from San Francisco Bay Area airports are vectored around the north side of R-2508 via LIDAT intersection and J92 to BTY as shown in the graphic below.



The Study Team has proposed the creation of a Q-Route from west to east that proceeds around the north side of R-2508. This Q-Route would provide a predictable, repeatable flight path around R-2508 when J110 is unavailable due to military activity.

The benefits of a Q-Route around R-2508 are:

- Reduction in ATC complexity (vectoring and communications)
- Accommodation of last minute route changes if J110 becomes unavailable
- Alignment of current flight tracks to a defined routing
- Provision for a shorter route than current operations
- Facilitation of better fuel planning

Projected annual savings are estimated in the table below.

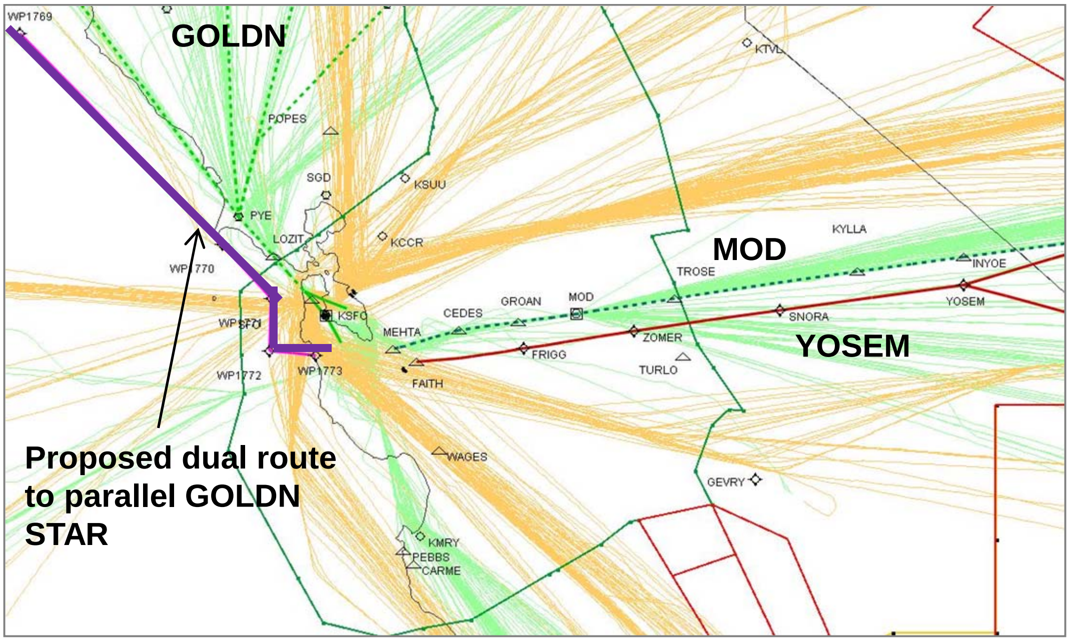
Estimated Annual Fuel Savings	**Total**	**$380,000**
Estimated Annual Fuel Savings (Gallons)	**Total**	**138,000**
Estimated Annual Carbon Savings (Metric Tons)	**Total**	**1,380**

4.10.2 Dual Arrival Routes

There is only one jet arrival route to SFO from the north. Consequently, throughput can be restricted; it is difficult to maintain arrival pressure on the airport.

From the east, the MOD STAR is the primary arrival route. The YOSEM STAR, an ATC-assigned offload route, is used sparingly to relieve pressure on the MOD STAR.

The image below depicts the Study Team-proposed GOLDN and MOD (dashed green), a hypothetical northern arrival route (solid purple), and the published YOSEM (solid red), as well as current arrival tracks (light green) and current departure tracks (light orange).

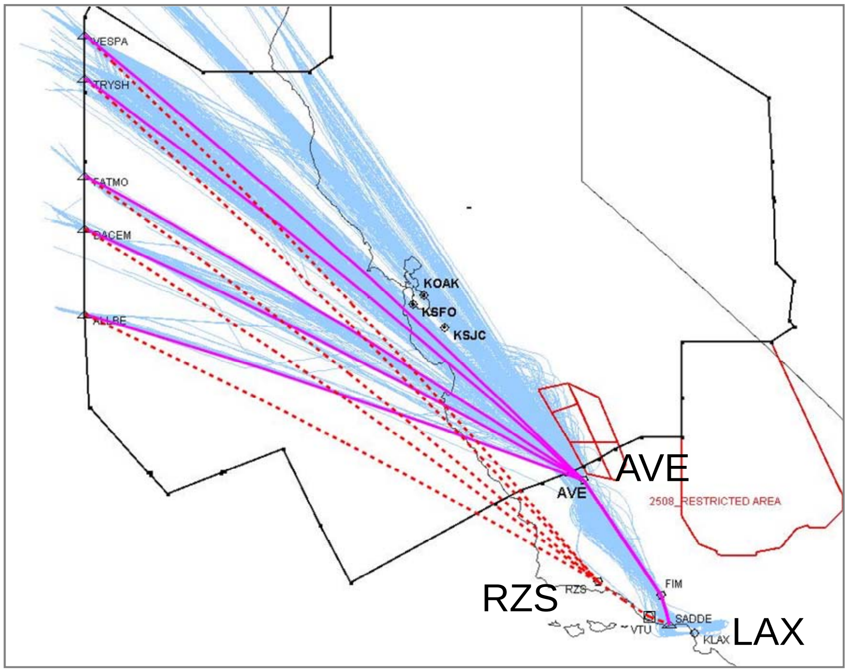


No solution was proposed for dual arrival routes to SFO from the north. Due to numerous issues such as route length and environmental concerns, the Study Team did not pursue any solution.

4.10.3 Los Angeles Arrivals from the Far East

LAX arrivals from the Far East are vectored inland over AVE VOR for sequencing with other LAX arrivals departing from within ZOA and points farther north. Mixing both the Far East and ZOA internal LAX arrivals creates sequencing complexity within some ZOA high altitude en route sectors, having a causal effect on volume and congestion over AVE.

The graphic below depicts current oceanic routes to AVE (solid purple), current oceanic tracks (light blue), and proposed routes to San Marcus (RZS) and Ventura (VTU) (dashed red).



The Study Team proposes development of an ATC assigned offshore route from the ZOA Oceanic Control Boundary (OCB) to LAX via VTU VOR and the SADDE 6 arrival. This route would join the published SADDE 6 STAR transition at RZS VOR. This offshore route may provide for aircraft arriving from the Far East to remain at higher cruise altitudes for a longer period of time and may afford OPD-like benefits prior to RZS or VTU VORs.

Potential benefits from the development of an offshore route to LAX from the Far East are:

- Efficient use of offshore airspace over Pacific Ocean
- Reduction of congestion and complexity over AVE
- Potential additional slots over AVE for LAX arrivals
- Potential reduction of vectoring/holding/ground delays for LAX arrivals
- Aircraft could receive OPD-like benefits from cruise altitude to RZS/VTU

Projected annual savings are estimated in the table below. Distance savings are associated with a reduction in excess fuel loading due to flight planning for legacy procedures.

Estimated Annual Fuel Savings	Total	$366,000
Estimated Annual Fuel Savings (Gallons)	Total	132,000
Estimated Annual Carbon Savings (Metric Tons)	Total	1,380

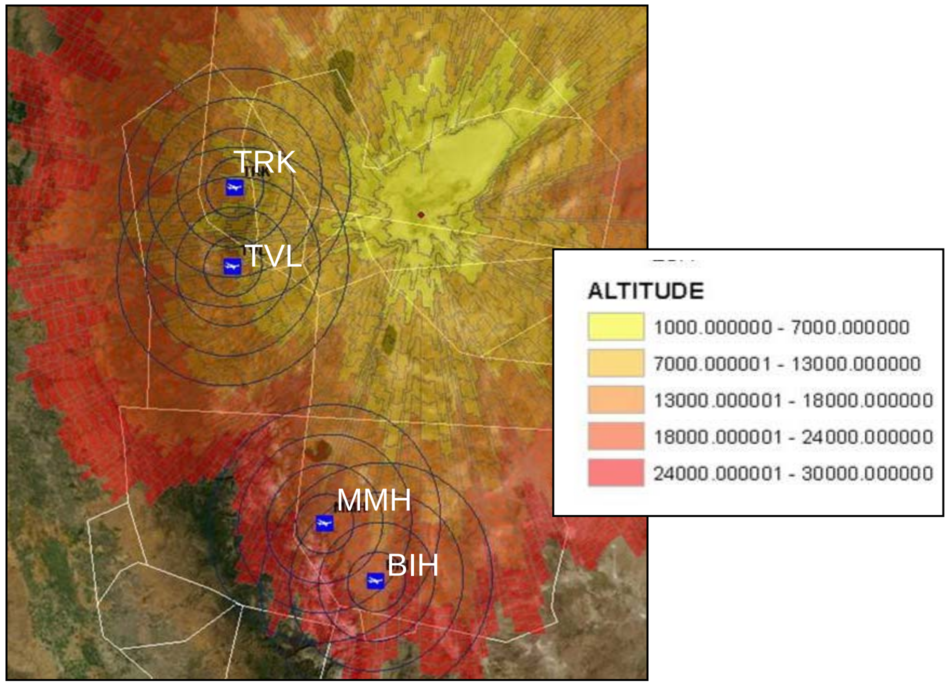
4.10.4 Traffic Management Advisor Issues

The National TMA Program Office visited Northern California in December 2010 with the dual purposes to assist ZOA and NCT with the adaptation of TMA and to identify possible enhancements to improve efficiency at SFO. ACM was identified as an enhancement that would enable first-tier En Route facilities to meter traffic more efficiently.

ZOA sectors adjust spacing between SFO arrivals using a combination of airborne holding, radar vectors, and speed control. TMA without ACM is not sufficient to effectively manage arrival volume, and ZOA must implement Miles-in-Trail (MIT) to adjacent facilities to accommodate flow control. MIT restrictions make it difficult for the ZOA Traffic Management Unit (TMU) to accurately meet the Airport Arrival Rate (AAR). TMA with ACM enables a more dynamic and accurate picture of Traffic Flow Management (TFM). The TMA Program Office has prioritized the introduction of ACM to ZOA and surrounding centers. The Study Team agrees that the introduction of ACM is necessary to increase the efficiency of SFO operations.

4.10.5 Lack of Radar Coverage at Truckee, Tahoe Valley, Mammoth, and Bishop

Radar coverage below 18,000 feet mean sea level (MSL) is limited at TRK, TVL, MMH, and BIH, which are all located within the Sierra Nevada Mountain range. An en route surveillance radar located at Fallon, NV, generally provides the most optimal surveillance for these four airports; however, the Fallon radar cannot be used to provide terminal-like radar services for arriving and departing aircraft. Procedures for aircraft arriving and departing from these four airports are limited to “one in, one out” for aircraft on instrument flight plans.



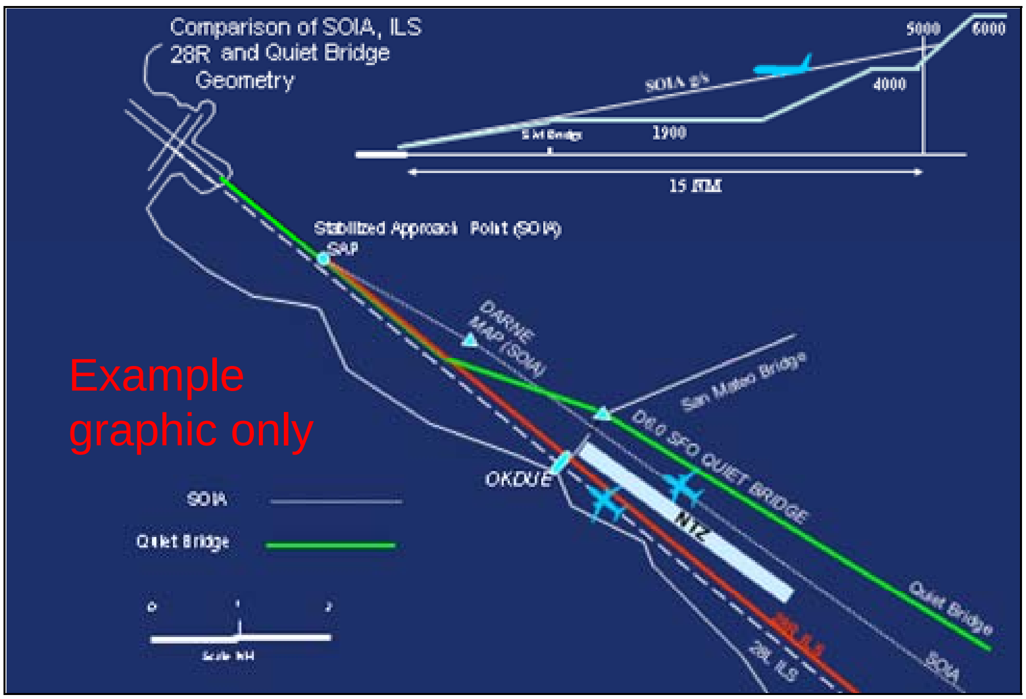
No solution was proposed for addressing the lack of surveillance at TRK, TVL, MMH, and BIH as this would entail projected costs outside the scope of OAPM for the installation of new surveillance equipment. Current technology to address the lack of surveillance would require that one of three types of surveillance would be required which costs over and above the scope of OAPM.

The Study Team recommends that when prioritization decisions are being made for Automatic Dependent Surveillance – Broadcast (ADS-B) and Wide-Area Multilateration (WAM), considerations be given to these airports for potential benefits.

4.11 Issues Tracked and Recorded

4.11.1 San Francisco SOIA

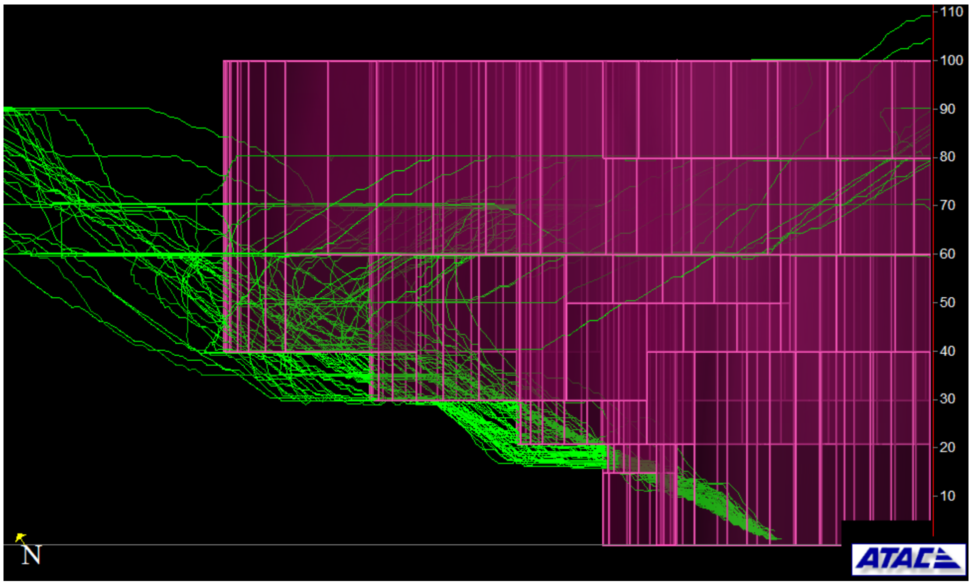
The Study Team received input regarding Simultaneous Offset Instrument Approaches (SOIA) at SFO from NCT facility personnel. Specifically, the current SFO SOIA minimums are stated as at least a ceiling of 2,100 feet and visibility of 4 NM at SFO. NCT personnel would like to see a RNP-like SOIA approach developed with lower minimums. Currently a national task force within the FAA is addressing improving capacity at SFO, including optimizing SOIA at SFO. Below is a depiction of the lateral and vertical components of the SFO SOIA procedure.



4.11.2 Class B Excursions

Twelve percent of aircraft exited and re-entered the SFO Class B Airspace in 2010. As an example, during Runway 10 operations on January 21, 2010, 30% of aircraft exited the Class B airspace. Resolving this issue would enhance operational safety and reduce controller workload.

A side depiction of the SFO Class B with Runway 10 arrivals to SFO on January 21, 2010 is shown below.



While a potential solution of re-evaluating the Class B structure could mitigate this issue, this issue is considered outside the scope of OAPM. Another solution would be amending the procedures to ensure containment within the current Class B structure. The Northern California TRACON has recently amended the current Runway 10 approach to stay inside the Class B airspace.

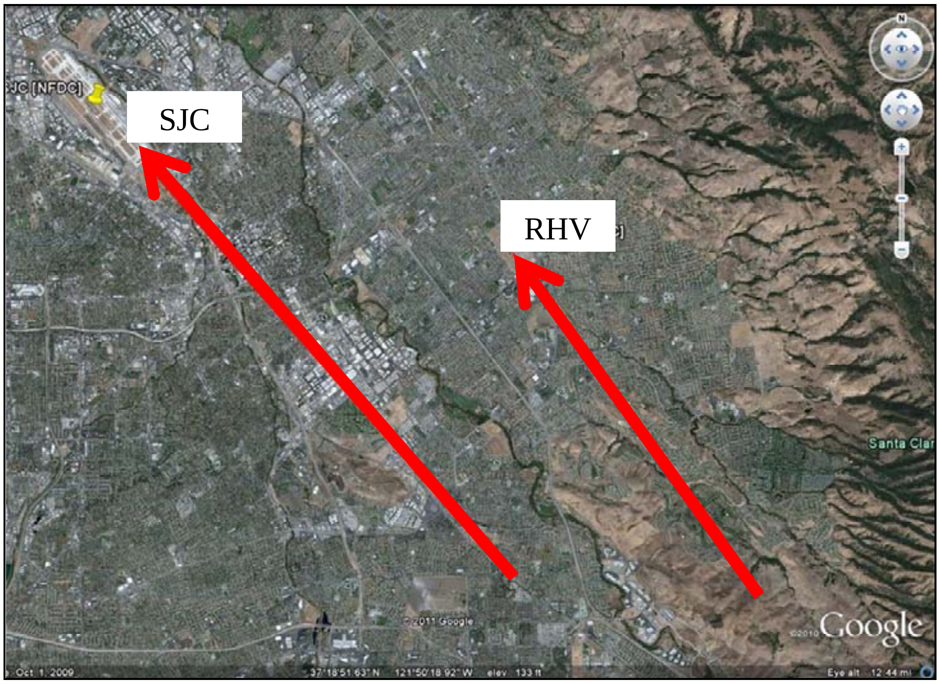
4.11.3 Mather RNAV STAR

There is a proposed RNAV STAR that had been previously developed for Mather (MHR) airport. The Study Team was asked to look into the timeline for the publication of the procedure. As of April 2011, the Study Team was advised that the publication date for this procedure is January 2012.

4.11.4 Reid-Hillview and San Jose Airport Interactions

Reid-Hillview (RHV) and San Jose (SJC) simultaneous IFR operations are interconnected due to the proximity of the airports. The airports are located less than 3 NM apart. Due to current 7110.65 regulations, these airports must be treated as a single airport in IFR operations.

The Study Team examined several alternatives to decouple the airports to allow for simultaneous IFR operations. No solutions were discovered. The Study Team has thus determined that a waiver to current regulations is required in order to accommodate simultaneous IFR operations at these airports. Obtaining this waiver was determined to be outside the scope of OAPM.



5 Benefits

5.1 Quantified Annual Benefits

Adopting the recommended changes proposed by the Northern California OAPM Study Team is estimated to result in an annual savings of between **$6.5 million and $15.5 million annual fuel savings**.

Fuel Savings from Use of OPDs and Reduced Track Distances	
SFO Departures	$183,000
OAK Departures	$45,000
SJC Departures	$36,000
SFO Arrivals	$1.5M – $4.2M
OAK Arrivals	$1.8M – $5.2M
SJC Arrivals	$1.2M – $3.5M
SMF Arrivals	$21,000 – $224,000

Other Savings from Study Team Recommendations	
Holding at GROAN versus vectoring on MOD arrivals	$949,000 – $1.3M
Q-route around R2508	$383,000
Routing oceanic arrivals to LAX over VTU versus AVE	$366,000

Other Benefits	
Carbon Savings (Metric Tons)	23,000 – 56,000
Fuel Savings (Gallons)	2.3M – 5.6M
Filed Mileage Savings (Nautical Miles)	1.5M

5.2 Qualitative Benefits

5.2.1 Near-Term Impacts

The benefits of the PBN procedures proposed by the Study Team include the following:

- Reduced phraseology

  Reduced phraseology due to PBN will reduce the number of transmissions needed to accomplish required restrictions by combining multiple clearances into a single transmission. Prior studies have demonstrated transmission reductions on the order of 18% to 34% with 85% RNAV equipage,[2] and the Study Team believes it is reasonable to expect a similar level of savings.

- Reduced frequency congestion

  Reduced transmissions will translate into less frequency congestion which could potentially reduce hearback/readback errors.

- Repeatable, predictable flight paths

  The introduction of PBN ensures lateral flight path accuracy. The predictable flight paths help assure procedurally deconflicted traffic flows and allow airlines to more accurately plan for a consistent flight path.

- Reduction in pilot workload

  The consolidation of clearances associated with an RNAV procedure reduces pilot workload, which allows for more "heads-up" time and allows the crew to focus on high-workload situations.

- OPD design characteristics

  Optimized descents reduce the number and length of level segments and therefore reduce fuel burn and carbon emissions. Altitude windows on OPDs can vertically deconflict traffic flows and allow for industry-standard glide paths.

- Accurate fuel planning

  Repeatability and predictability advantages offered by RNAV will allow users to more accurately predict the amount of fuel required for a procedure.

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2 Sprong, K., et al., June 2006, *Benefits Estimation of RNAV SIDs and STARs at Atlanta*, F083-B06-020, (briefing), The MITRE Corporation, McLean, VA.

5.2.2 Long-Term Impacts to Industry

Implementation of these proposed procedures will have long-term effects for industry.

- Flight planning

  OAPM proposed procedures will result in reduced mileage and fuel burn in the long-term, particularly as more metroplexes are optimized. In the near-term, more direct paths that are not dependent on ground-based navigational aids, plus optimized flight profiles, will lead to reduced fuel burn only within an optimized metroplex. Reduced fuel loading will also allow for a reduction in CTC.

- Timetable

  Shortened, more efficient routes will necessitate timetable adjustments, particularly as more metroplexes are optimized. This will potentially benefit crew scheduling, connecting information, time on gates, ramp scheduling, etc.

Appendix A Glossary of Terms

Navigational Aids, Waypoints, Airports, and Procedures	
AVE	Avenal VOR
BIH	Eastern Sierra Regional Airport, Bishop, CA
BSR	Big Sur VOR, Big Sur STAR
BTG	Battleground VOR
BTY	Beatty VOR
CA	California
CZQ	Clovis VOR
FLW	Fellows VOR
FMG	Mustang VOR
FOT	Fortuna VOR
GMN	Gorman VOR
HYP	El Nido VOR, El Nido STAR
LAX	Los Angeles VOR, Los Angeles International Airport
LIN	Linden VOR
MADN	Madwin STAR
MHR	Sacramento Mather Airport, Sacramento, CA
MMH	Mammoth Yosemite Airport, Mammoth, CA
MOD	Modesto VOR, MOD STAR
NV	Nevada
OAK	Oakland International Airport, Oakland VOR
OAL	Coaldale VOR
OKC	Oklahoma City, OK
PMD	Palmdale VOR
PXN	Panoche VOR, Panoche STAR
RZS	San Marcus VOR
SAC	Sacramento VOR
SFO	San Francisco International Airport, San Francisco VOR
SJC	Norman Mineta-San Jose International Airport, San Jose VOR
SMF	Sacramento International Airport, Sacramento VOR
TRK	Truckee-Tahoe Airport, Truckee, CA
TVL	Lake Tahoe Airport, South Lake Tahoe, CA
VTU	Ventura VOR

Acronyms	
AAR	Airport Arrival Rate
ACM	Adjacent Center Metering
ADS-B	Automatic Dependent Surveillance-Broadcast
ARR	Arrive
ARTCC	Air Route Traffic Control Center
ASPM	Airport Specific Performance Metrics
ATALAB	Air Traffic Airspace Lab
ATC	Air Traffic Control
BADA	Base of Aircraft Data
CAASD	Center for Advanced Aviation System Development
CATEX	Categorical Exclusion
CTC	Cost to Carry
CY	Calendar Year
DEP	Depart
EA	Environmental Assessment
EIS	Environmental Impact Study
ETMS	Enhanced Traffic Management System
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
FAF	Final Approach Fix
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
iTRAEC	Integrated Terminal Research, Analysis, and Evaluation Capabilities
L/R	Left/Right
LOA	Letter of Agreement
MIT	Miles-in-Trail
MSL	Mean Sea Level
NAT	National Analysis Team
NAVAID	Navigational Aid
NCT	Northern California TRACON
NM	Nautical Mile
NOP	National Offload Program
NTML	National Traffic Management Log
OAPM	Optimization of Airspace and Procedure in a Metroplex
OCB	Oceanic Control Boundary
OPD	Optimized Profile Descent

Acronyms	
PBN	Performance-based Navigation
PDARS	Performance Data Analysis and Reporting System
RITA	Research and Innovative Technology Administration
RNAV	Area Navigation
RNP	Required Navigation Performance
RTCA	Radio Technical Commission for Aeronautics
SAA	Special Activity Airspace
SEC	Specialized Expertise Cadre
SID	Standard Instrument Departure
SOIA	Simultaneous Offset Instrument Approach
SRM	Safety Risk Management
STAR	Standard Terminal Arrival
T/P	Turboprop/Prop
TARGETS	Terminal Area Route Generation Evaluation and Traffic Simulation
TAWS	Terrain Awareness Warning System
TERPS	Terminal Instrument Procedures
TFM	Traffic Flow Management
TMA	Traffic Management Advisor
TMI	Traffic Management Initiatives
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control
VOR	Very High Frequency (VHF) Omnidirectional Range
WAM	Wide Area Multilateration
ZLA	Los Angeles Air Route Traffic Control Center
ZOA	Oakland Air Route Traffic Control Center