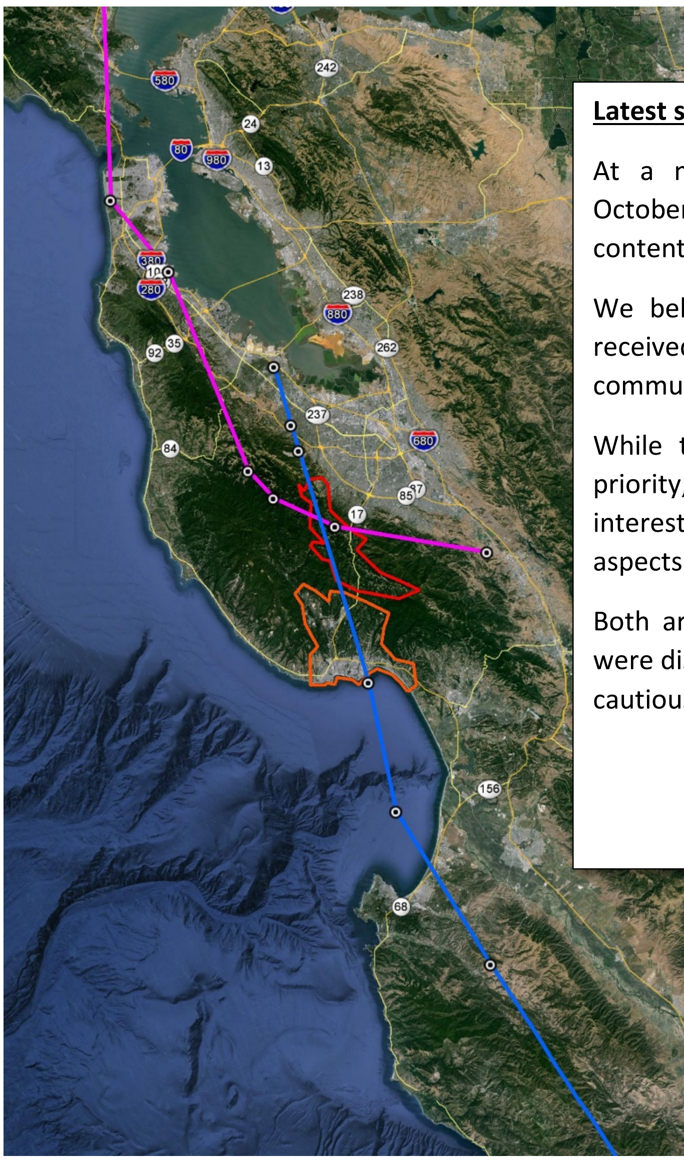
MOUNTAIN SERFR

Jet noise, fuel inefficiency, and airspace violations on NextGen routes crossing the Santa Cruz Mountains



Latest status

At a meeting with FAA officials on October 9, we were able to present the content of this and other documents.

We believe the information was well received and are expecting further communications in short order.

While the safety aspects clearly take priority, the FAA officials were very much interested in the noise mitigations aspects as well.

Both arrival and departure procedures were discussed, and we left the meeting cautiously optimistic.

Latest revision always available at: http://www.g2-engineering.com/documents/mountainSERFR.pdf

Background

This document is prepared on behalf of the residents of the communities located in the Santa Cruz mountains north of Scotts Valley and Santa Cruz, outlined in **Red** in the overview map below. Our communities lie towards the ends, and near the intersection, of the **SERFR ONE** (to SFO) and **BRIXX ONE** (to SJC) arrival routes, and represent a worst-case scenario in that the planes are already low (5000'-8000'), but ground elevation is high (~2500').

There is a significant amount of general aviation traffic over our area, and the class B violations documented below are a major risk, both for crews and passengers, and for the residents on the ground.

Our communities have a background noise level of 30 dB, which is critical when assessing the impact of jet noise that would be completely absorbed in an urban environment. The jets are by far the loudest noise in the mountains, and have a grave impact on our lives, day and night.

It is important to note that before the change to the new flight patterns, there was hardly any noise noticeable in the mountains, even though traffic volume was similar.

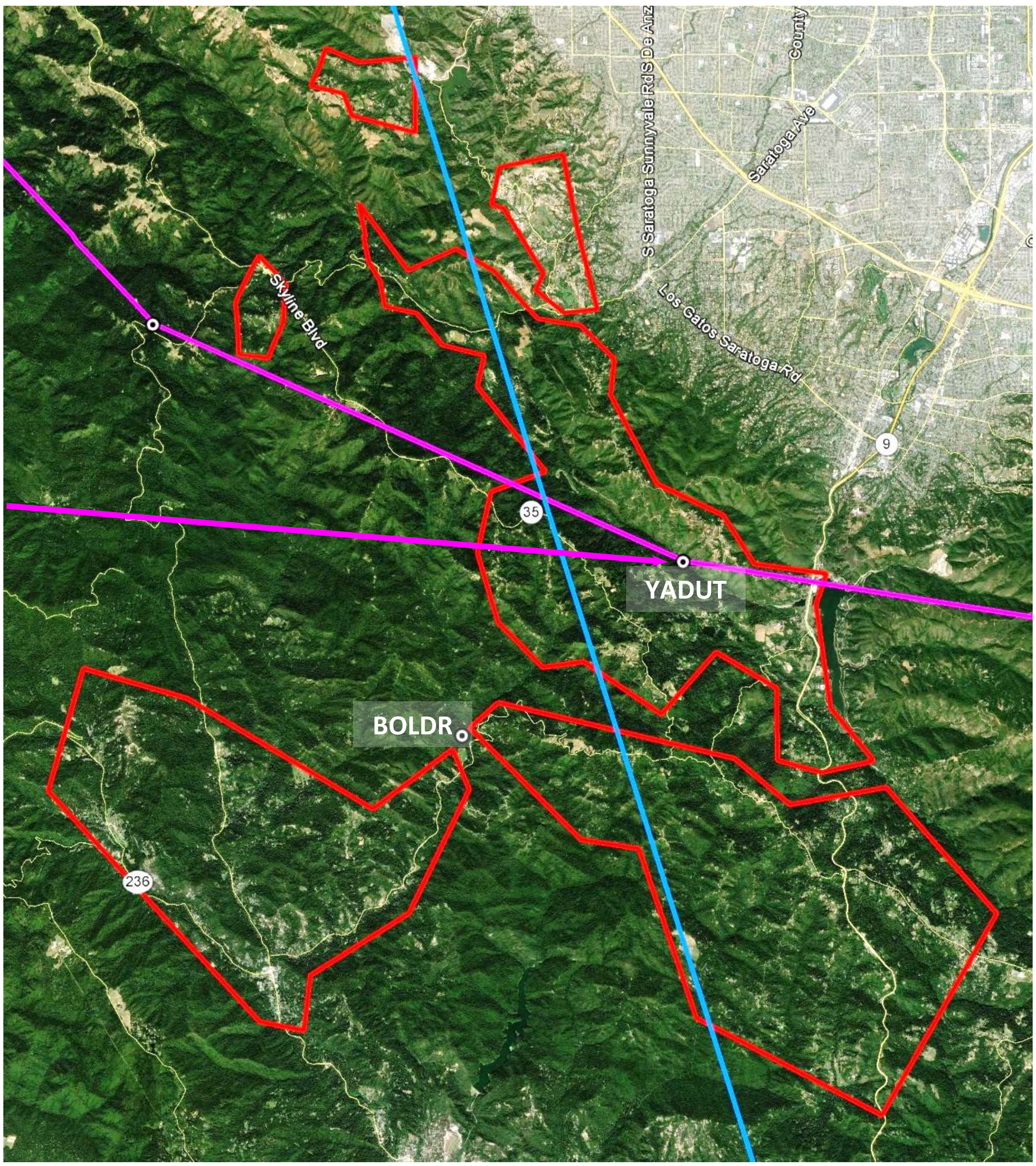


Figure 1: Existing NextGen arrivals: **SERFR ONE**, **BRIXX ONE**, and the mountain communities (in **Red**)

For this discussion we consider flights vectored over the mountains to **YADUT** to be equivalent to **BRIXX ONE** traffic.

The problem

The sharp increase in the noise impact of both **SERFR ONE** and **BRIXX ONE** stems from two issues:

- A ground track that does not avoid residential areas
- A descent profile that does not allow the planes to fly at idle power settings

As shown below, the resultant routes are problematic in terms of safety, fuel efficiency, and noise.

Ground Path

A larger-scale view is shown below, illustrating the context of the routes. Also shown are the pre-NextGen routes that fulfilled similar roles – **BIG SUR TWO** and a direct vector from **PPEGS** (Woodside) to **KLIDE.**

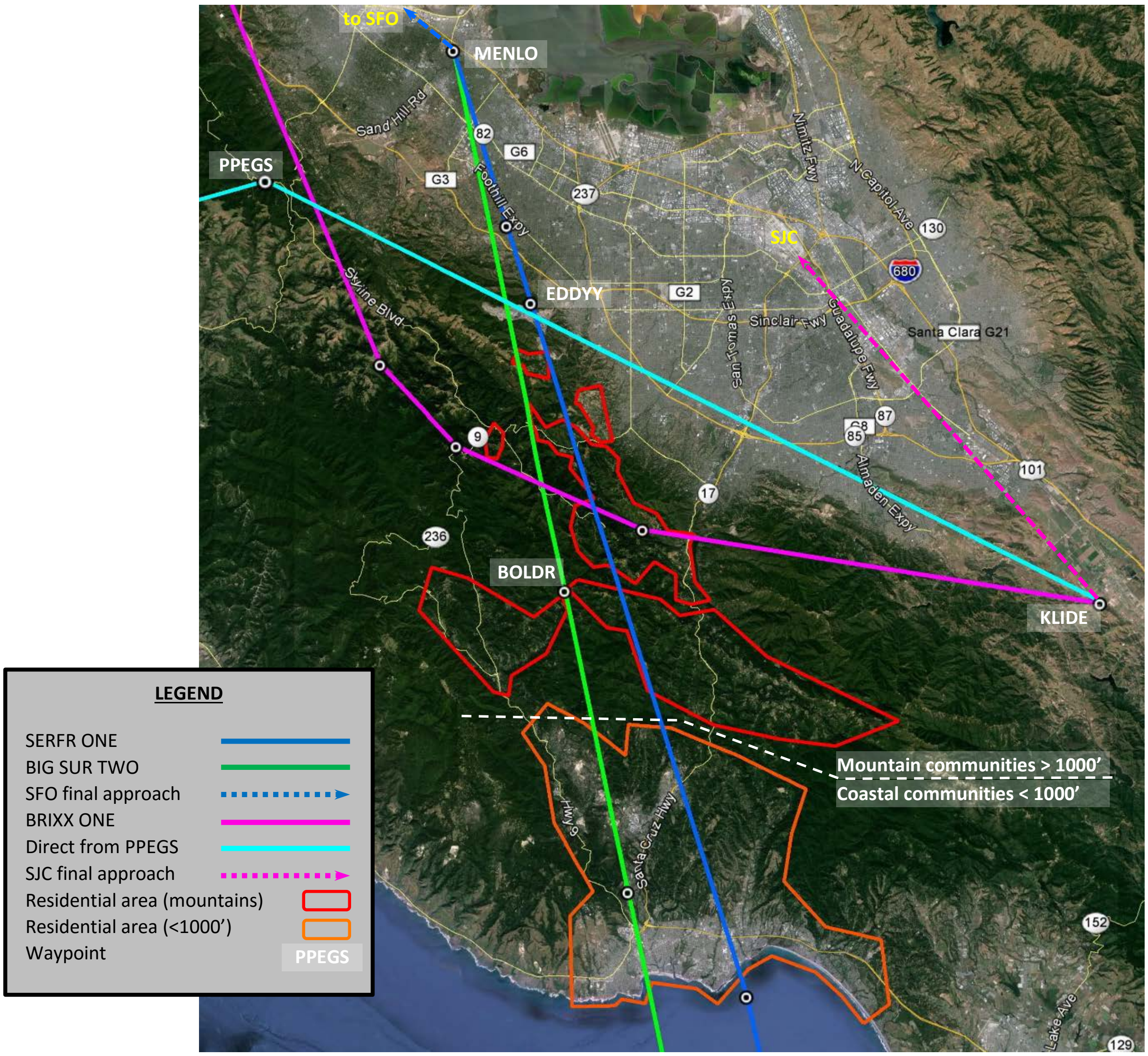


Figure 2: Mountain top communities, in context

From a plan view (ignoring the elevation profile for the moment) it is clear that the final leg of **BIG SUR TWO** was engineered to "thread the needle" and avoid as many high-altitude communities as possible. The key to this is the passage through waypoint **BOLDR**. Waypoint **BOLDR** also serves another purpose: it enforces a quiet idle-power glide slope toward waypoint **MENLO**, which is the turning point to the ILS glide path to SFO.

Additionally, **BRIXX ONE** currently passes below **SERFR ONE**, which forces its traffic to fly at about 5000' (below the stated minimum safe altitude), and only 2500' AGL at the mountain communities, making them much more sensitive to the location of the ground track. The direct **PPEGS** route flew higher, and avoided the mountain communities entirely.

Descent Profiles

Figure 3 shows a cross-section view taken along the **SERFR ONE** ground path. It shows the **SERFR ONE** route (floor, and as-flown), the SFO Class B airspace, **BIG SUR TWO** (which is located about 2 miles in back of the plane of the picture), and the **BRIXX ONE** crossing point, which occurs roughly at the edge of the Class B space.

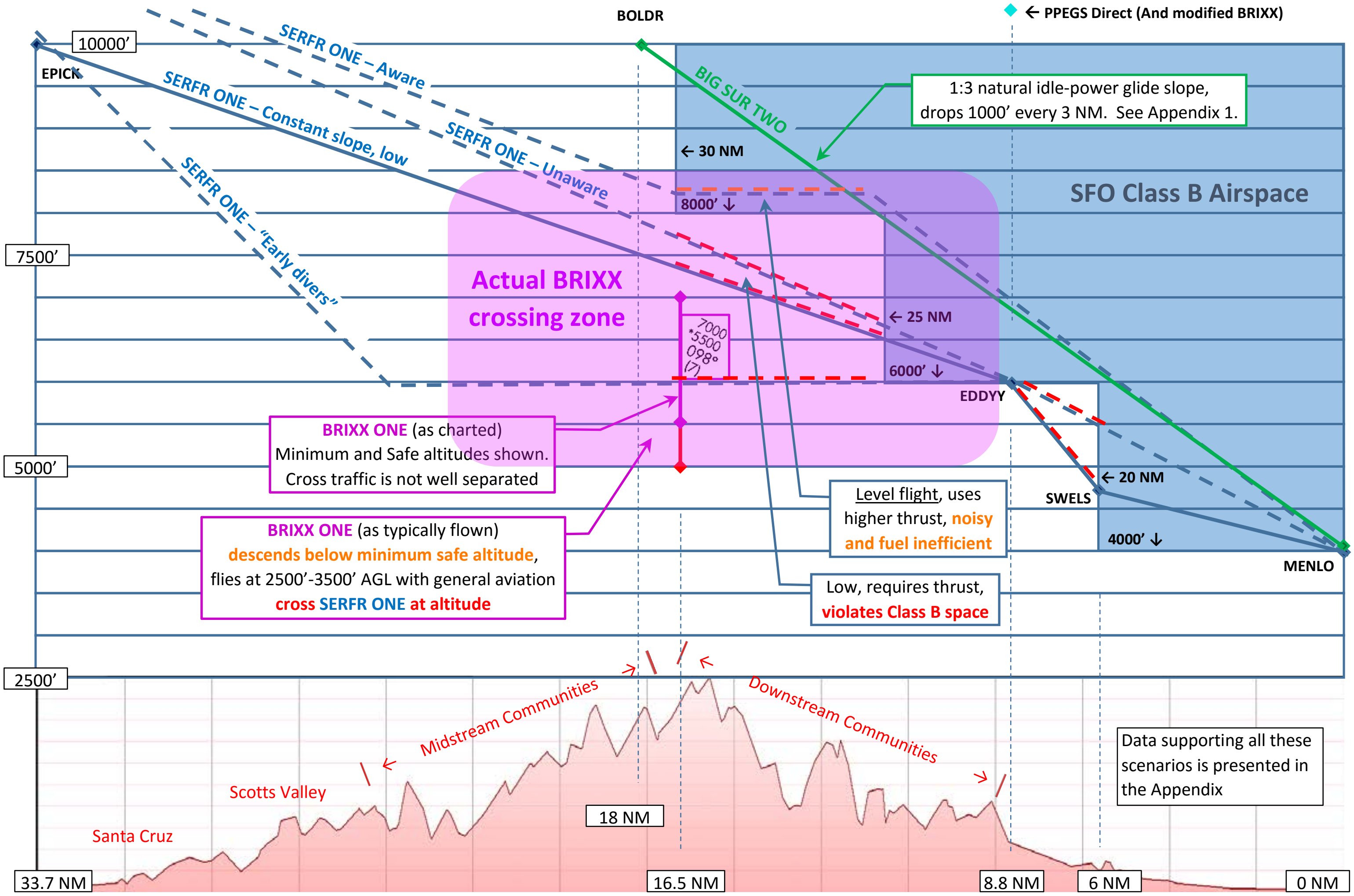


Figure 3: Cross section of the terrain and descent profile, along the **SERFR ONE** ground track

A few problems are immediately apparent. First, unlike **BIG SUR TWO** which kept the planes high for as long as possible, **SERFR ONE** brings them down much sooner, and in practice invites pilots to violate the Class B airspace rules.

Real-world traffic (which arrives at **EPICK** above 10,000'), if it is aware of the Class B geometry (upper dashed line), has to level off at 8000' and fly under power until just short of **EDDYY**, where it can idle down and glide the rest of the way to **MENLO**. Needless to say, flying level at this altitude is loud and wasteful of fuel.

In practice, a large number of airplanes are unaware (lower dashed line) and so either completely miss the outer Class B layer, or enter it briefly, drop out the bottom, and re-enter it again near **EDDYY**. This is of course a worse scenario, since the airspace between Class B and the mountains is relatively dense with general aviation aircraft. We routinely observe incursion, excursion, and speed violations of jets in this area. (SFO bound jets must fly inside the Class B airspace, and if for whatever reason they end up below it, they must slow to 200 knots, and reauthorize before coming back in – this is spelled out in FAR 91.131)

These violations are very serious. General aviation airplanes have relatively little space between the mountain side and SFO's Class B zone, and are not expecting jetliners in their space. There is a risk of a mid-air collision, or of a general aviation aircraft encountering wake turbulence, while flying at a relatively low altitude over hilly terrain.

Additionally, **SERFR ONE** leads airplanes away from the idle-power glide slope of 1:3, wasting fuel, and generating unnecessary noise. (For an explanation of idle-power glide slopes, see the Appendix)

Further, note that **BRIXX ONE** (in this segment, between waypoints **JILNA** and **YADUT**) has a minimum enroute altitude of 7000' and a minimum safe altitude of 5500'. Again, there are two scenarios: If flying above the minimum altitudes, airplanes are not well separated from **SERFR ONE** traffic. If (as occurs regularly) they are vectored by NCT (Northern Cal Tracon) to fly lower, they violate the minimum altitude limits, and often even the minimum safe altitude.

The area in question, and especially Lyndon Canyon, is often used by general aviation airplanes flying VFR. With **BRIXX ONE** jets regularly flying only 2500' AGL, this is an unsafe situation. (The worst case AGL altitude is 1600')

Finally, **BRIXX ONE** follows a descent profile that is even further from an ideal glide slope than that of **SERFR ONE**, taking 46 Nautical Miles to descend from 12,000' to 4000', or a descent ratio of almost 6:1, thus flying under power most of the way, wasting fuel and generating noise not only for the mountain communities, but also for most of the peninsula, including Redwood City, Portola Valley, and Menlo Park.

This vertical squeeze is brought about by the routing of **BRIXX ONE** over the hills, which we understand is done in order to route it under **SERFR ONE**.

If instead, **BRIXX ONE** was routed straight from near PPEGS towards **KLIDE**, it would have intersected **SERFR ONE** near **EDDYY**, passed above (instead of below) **SERFR ONE**, and could have then be flown at higher altitudes. In fact, it could have been flown level at 12,000' (from waypoint **BRIXX** over SFO), and started an optimal idle-power 1:3 descent towards **KLIDE** just before **EDDYY**, which would have had virtually no impact on the urban area below.

Vertical separation would have been guaranteed, since **SERFR ONE** airplanes over **EDDYY** would have been below 8000' (having started at 10,000' at **BOLDR**) whereas **BRIXX ONE** airplanes would be at 12,000', about to start their descent to **KLIDE**. The resultant routes would have been safer, more fuel efficient, and had lower impact on the residential areas.

This is further expanded on in the last section. The crossing point is shown as "PPEGS Direct" in the diagram above.

Risk Summary

- In a worst case scenario, a **SERFR ONE** airplane descending from 10,000' at **EPICK** to 6000' at **EDDYY** conflicts with a **BRIXX ONE** airplane that is observing the 7000' minimum altitude between **JILNA** and **YADUT**.
- **SERFR ONE** planes descending from 10,000' at **EPICK** to 6000' at **EDDYY** often fly under the Class B shelf, at 250 knots, and pose a risk to general aviation planes in the area. (Mid-air risk and wake turbulence.)
- **BRIXX ONE** planes descending towards **KLIDE** often fly at 5000' (2500' AGL) between **JILNA** and **YADUT**, posing a risk to general aviation planes. (Mid-air risk and wake turbulence.)

Fuel and Noise Summary

- **SERFR ONE** does not follow the idle glide slope of 1:3 between **EPICK** and **EDDYY**. Further, it places airplanes near the bottom of the Class B shelf, requiring them to fly level at 8000', which is both a fuel and noise issue for the mountain communities. It also overflies a large number of populated areas in the mountain, where an alternate unpopulated route is available 2 miles to the west of it.
- **BRIXX ONE** follows a very shallow descent path from **BRIXX** to **KLIDE**, which is a fuel and noise issue for a large part of the peninsula. It also overflies high altitude residential areas at a very low altitude.

Supporting Data

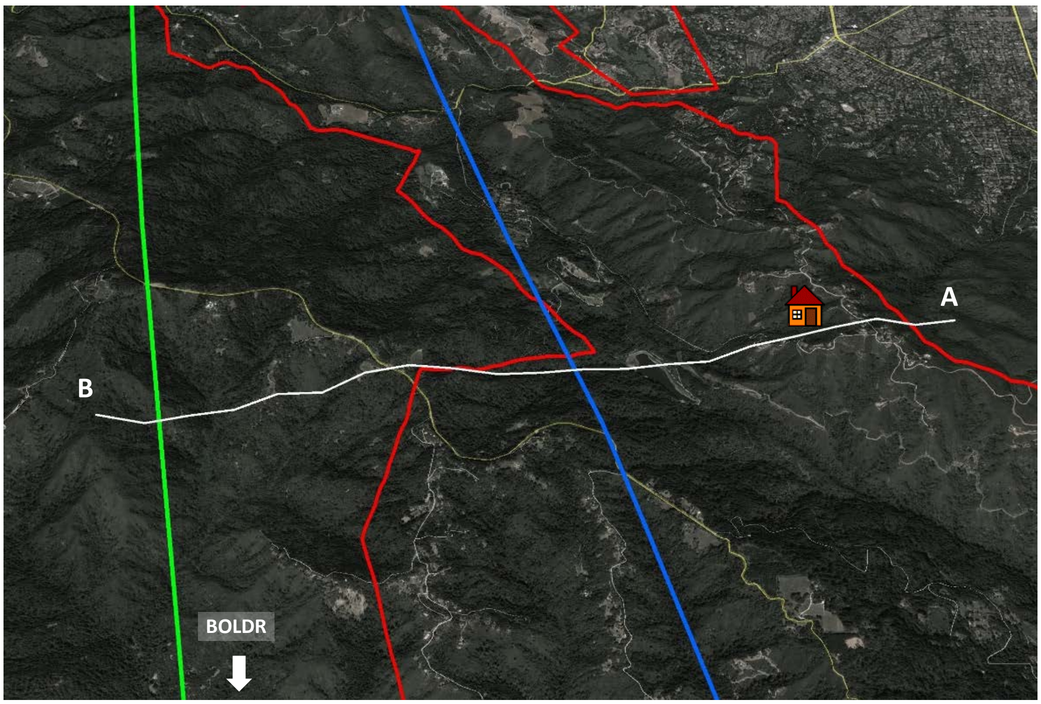
Appendix A shows sample data documenting the conditions described above. The data is ADS-B sourced, so is generated by the planes themselves and is independent of the ground equipment. We collect it using our own receivers, or via relay services. There are tens of significant class-B violations per day, tens of cases of level flight at low altitudes and BRIXX flights through the SERFR path. These scenarios are not hypothetical – they are the rule rather than the exception.

Ground path and the mountain communities

The downstream communities are located north of **BOLDR**, along two main ridges of Lynden Canyon, reaching up to 2500' ASL. They are particularly affected by **SERFR ONE** due to the combination of descent profile and ground track. It is important to note that north of **BOLDR**, there are barely any residences under the old track of **BIG SUR TWO**.

Figure 4 shows the relation between a house on Bohlman Rd. and the two flight paths, at the cross section shown by the white line. The **SERFR ONE** airplane is **more than twice as close** to the house than the **BIG SUR TWO** airplane is.

The effect is different of course for each house location, but especially considering the topography (the large valley between the communities), moving the flights back over the ridge line is clearly beneficial to all. Planes flying the **BIG SUR TWO** arrival were never an issue to our communities.



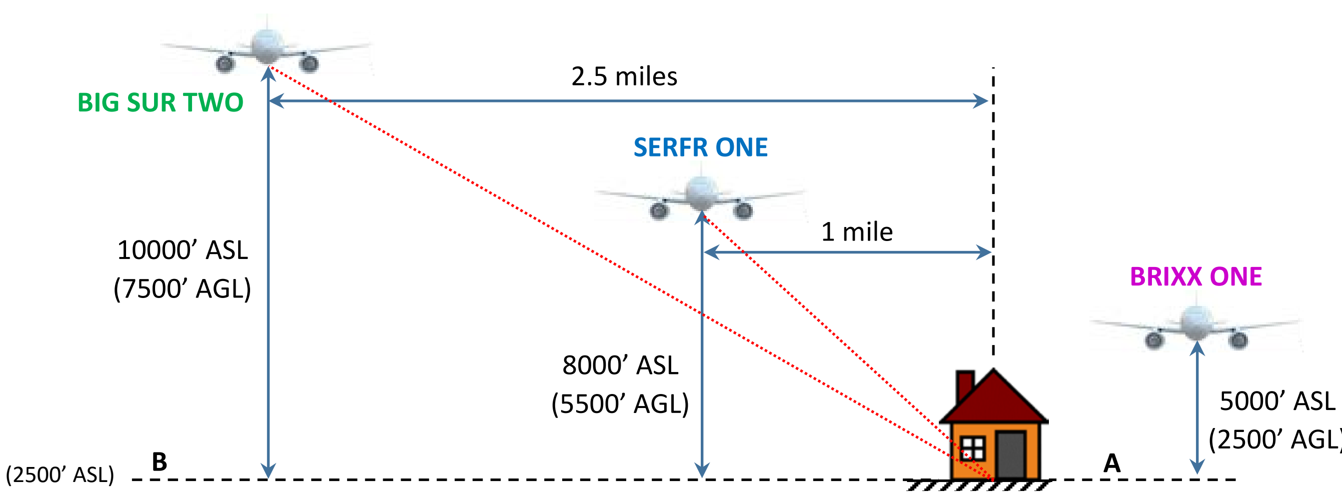


Figure 4: Simplified cross section illustrating the effect of lateral shift as seen from a house on Bohlman Rd.
Vertical and horizontal distances are to scale. Lowest common altitudes shown.
For simplicity, the terrain cross section is not shown. House and airplanes not to scale.

The situation is even more severe with **BRIXX ONE**, since airplanes on this route often overfly us at 5000'-5500', which is only 2500-3000' AGL, half that of **SERFR ONE**. (Such AGL altitudes are typically only reached on final approach). Laterally, **BRIXX ONE** planes are dispersed over several miles, since they are vectored by NTC in preparation for final approach.

Topography

The noise problem is further exacerbated because of the local topography.

Figure 5: Looking at **EDDYY**. **SERFR ONE** passes right over the lake at the bottom of the canyon. **BIG SUR TWO,** on the other hand, passed far beyond the (unpopulated) ridge on the left, and crossed over at the farthest ridgeline in this picture. Camera FoV is shown on the map below.

BRIXX ONE flies along Lyndon Canyon, whereas **SERFR ONE** crosses it, and both channel the noise all the way down to and across the Lexington reservoir and Highway 17 (Blue arrow), along the Montavina and Bear Creek communities. **BIG SUR TWO**, on the other hand, passed over land that does not interact with the canyon.

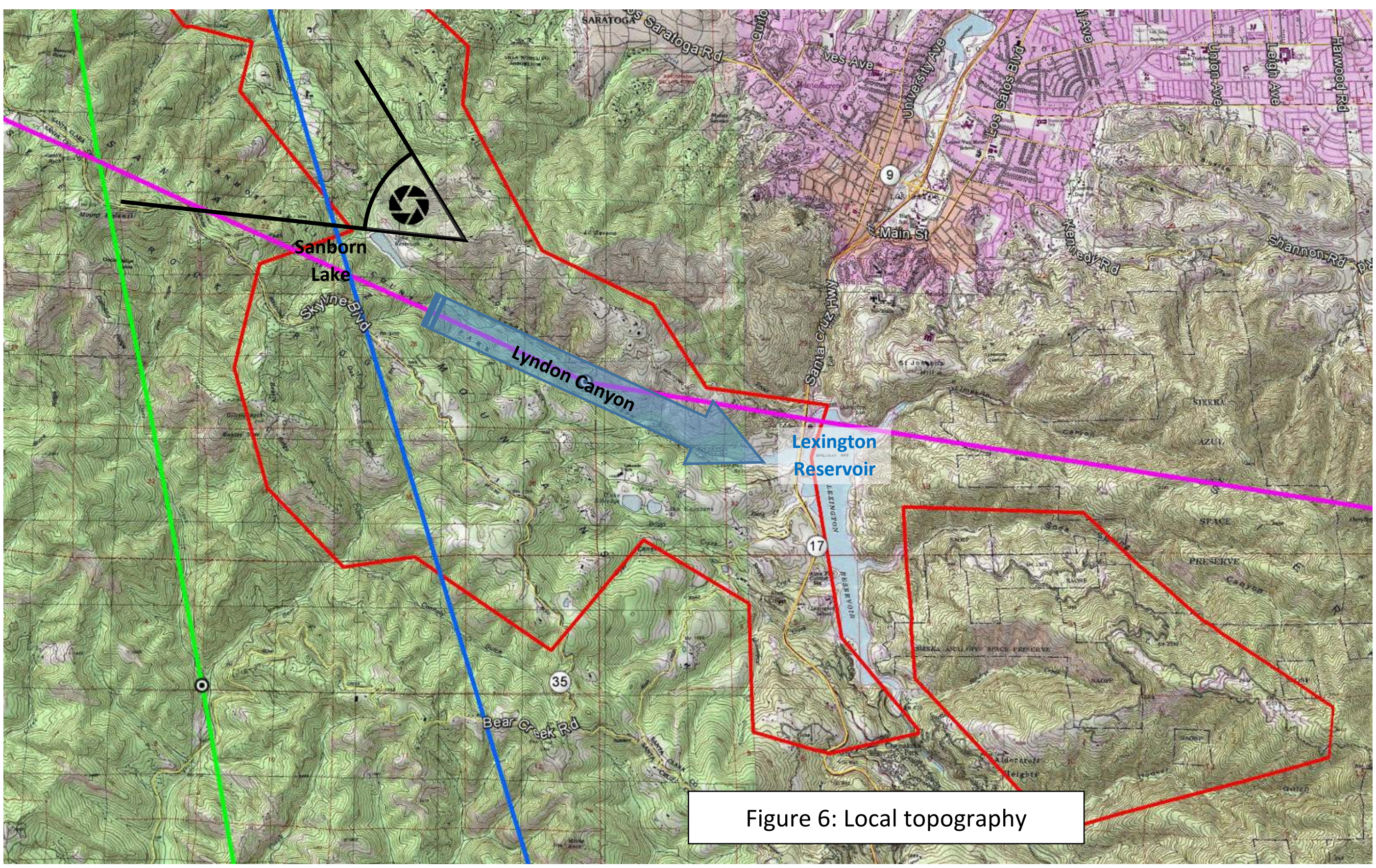


Figure 6: Local topography

Noise characterization

There are several omissions in the process used by the FAA to quantify the impact of noise.

A. **Averaging.** The FAA uses a metric that avarages the noise peaks over the course of a day. According to this metric, for example, an intermittent noise has less impact than a similar constant noise. A simple thought experiment, however, demonstrate that this is false. We've all experienced a constant source of noise, like a fan, that gets completely masked by the human ear – until it is turned off and the listener realizes it was there.

   The airplanes on SERFR ONE, on the other hand, are comparable to a loud fan in the next room that starts and stops on a one-minute cycle. It is impossible to ignore or filter out, and is in fact a lot more intrusive when compared with a fan that is always on, or something like the hum of a freeway.

B. Hours of operation. The evaluation doesn't bring into account the hours of operation. SFO traffic starts at 6 am, and last till past 1 am. This is amplified by paragraph A above – if it were just one flight at 6 am, it'd be possible to go back to sleep. But instead the 6 am flight is just the beginning of the morning traffic congestion when all the red-eye flights arrive.

C. Background sound level. In the mountain communities, the background sound level is 30 dB, and the airplanes are by far the loudest source of noise, completely masking out the small sounds of nature which are the normal there. Only 3 miles away, in Saratoga, the background level is 50 dB. The same airplanes, a mere 40 seconds later, are barely audible there.

None of these effects are captured by the FAA's metrics.

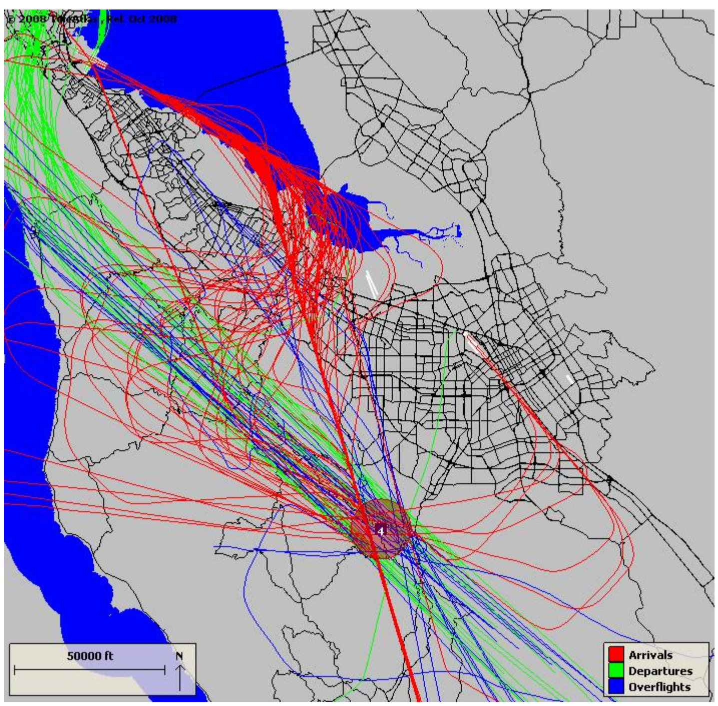


Figure 7: Flights passing within 2-miles from a house on Summit Rd on a July 13, 2015.
~200 flights are shown, though since then SERFR ONE traffic alone has increased to 175 planes/day.

Possible arrival solution concepts

While we do not have insight into all of considerations that govern the Metroplex design, we would still like to propose the following two modifications, for your consideration.

SERFR ONE:

Since the main benefits of **SERFR ONE** are derived south of **WWAVS**, and considering the benefits of **BIG SUR TWO**'s final leg, it should be possible to tweak **SERFR ONE** to benefit from both.

While keeping most of **SERFR ONE** intact, traffic can continue from **WWAVS** to **DAVYJ**, and then mimic the old flight path along its final leg.

Waypoint **BOLDR** is used for controlling the entrance into the Class B airspace, and point **EDYTO** is used to enforce the descent profile.

From a noise abatement point of view, this will make the post Santa Cruz over-land portion of the arrival equivalent to that of **BIG SUR TWO,** which operated practically complaint-free during its 30 year history.

BRIXX ONE:

It is our understanding that **BRIXX ONE** arcs into the mountains in order to fit under **SERFR ONE**, and we've demonstrated the resultant vertical congestion.

We propose routing **BRIXX ONE** over **SERFR ONE**, flying it higher, and shortening the arc over the mountains.

The resultant route allows **BRIXX ONE** to overfly the peninsula at 10,000'-12,000', and have an ideal 1:3 descent profile from **PYLOF** to **NONYZ** to **KLIDE.**

Pacific arrivals can fly directly to **NEWPT** if arriving from the West or NW, or directly to **NONYZ** (flying under **SERFR ONE**) if arriving from the South or SW.

Our request:

We realize that no flight path is perfect, and that the design of an entire airspace for an urban area like SF is incredibly complex and must provide solutions in the face of seemingly contradictory requirements.

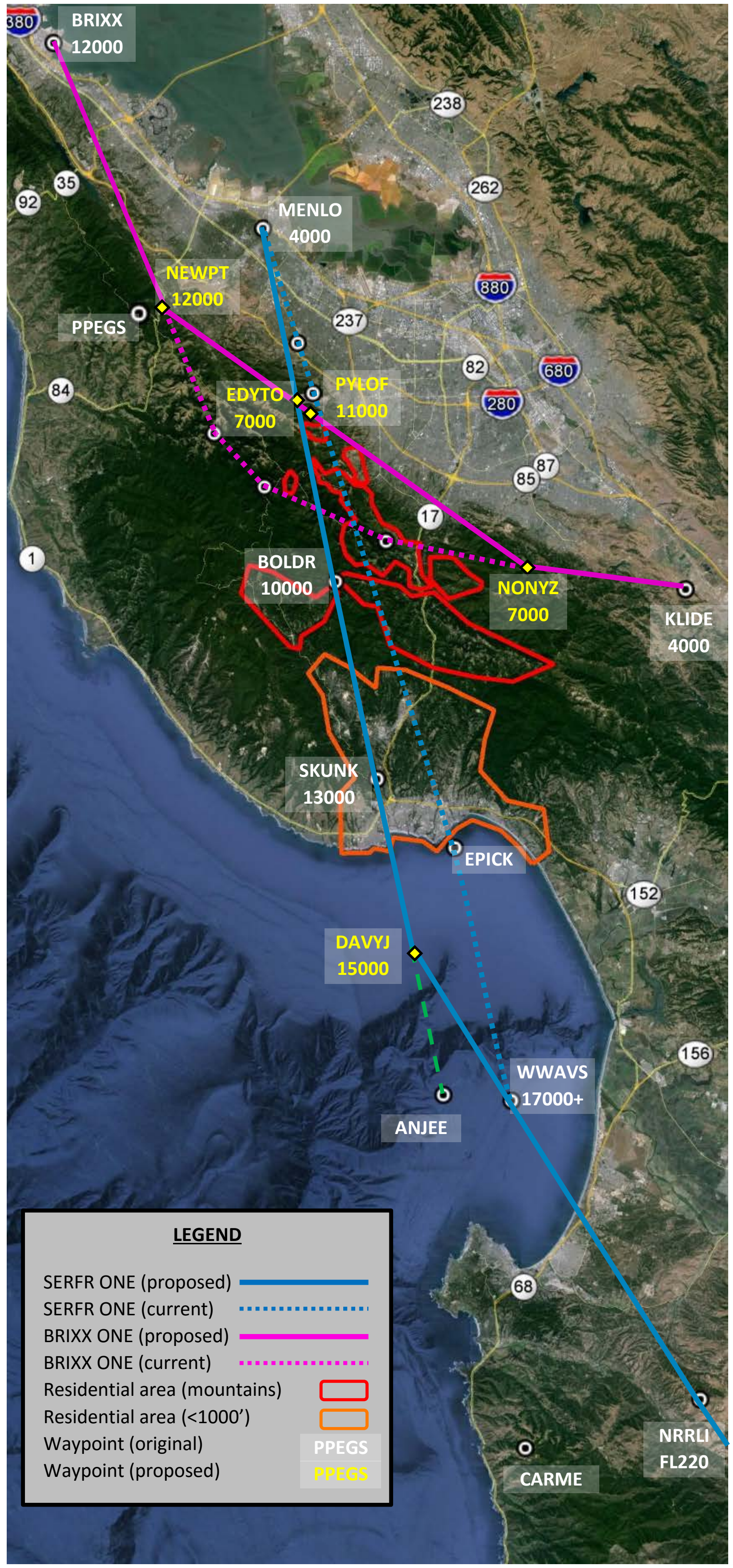


Figure 8: Proposed modifications

We still request that the FAA give these proposals consideration, since the new flight patterns have severely impacted the quality of our lives.

Aircraft spacing concept proposal

Currently, in order to properly space planes merging onto the SFO ILS path, ATC regularly adds an "S" maneuver somewhere between waypoint **BOLDR** and **MENLO**, which extends the flight time to **MENLO** by anywhere between seconds and minutes.

These maneuvers generate extra noise, since they require the airplanes to apply thrust, speed brakes, or control surfaces, and they occur at low altitude over Palo Alto and Portola Valley.

We propose, instead, to perform these maneuvers earlier on, over the Monterey Bay, at a higher altitude, as illustrated in Figure 9.

Waypoints can be added further seaward in order to introduce arbitrarily long delays. If aircraft speed is constrained at WWAVS, then the length of the delay can be highly predictable.

Monterey bay is also an ideal location for a long-duration holding loop to handle unusual congestion at SFO that requires delaying all incoming traffic until the condition causing it clears.

Once at waypoint **DAVYJ**, airplane speed should be constrained to 240 knots for a quiet descent to waypoint **MENLO**. Since this is a straight leg, arrival time at **MENLO** should be highly predictable.

Since this last leg is now on a predictable and straight descent profile, it will be as quiet as possible, certainly generating less noise than the last-minute "S" turns.

(Note that in order to facilitate these curves, waypoints **WWAVS** and **DAVYJ** are shown a bit further apart in comparison to Figure 8)

The implementation of this aircraft spacing scheme is an addition on top of what is proposed in Figure 8, and is only presented in broad of outlines.

The elimination of delayed SERFR flights over Portola Valley and Palo Alto is especially important since these towns are also under the "U-Turning" northern arrivals (e.g. BDEGA ONE). This is further explained in the next section.

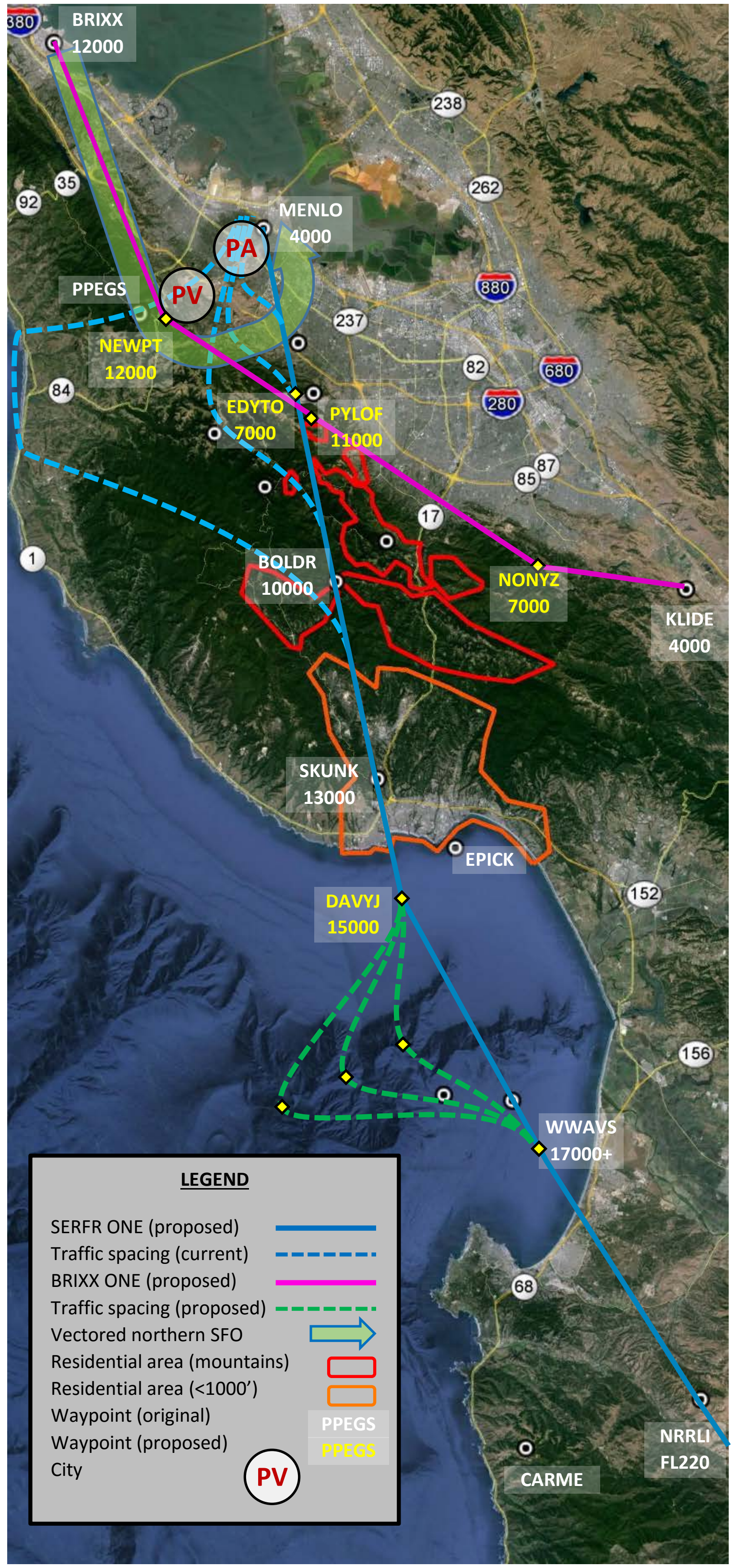


Figure 9: Traffic spacing proposal

Other peninsula communities

While this document was prepared from the point of view of the residents of the Santa Cruz mountain communities, as mentioned above, other communities in the peninsula are reporting higher noise levels as well.

For this reason, it is constructive to evaluate the proposed solutions from other points of view, specifically those of Santa Cruz, Portola Valley, and Palo Alto. These communities have airport-noise advocacy groups, but this document was prepared independently of them.

Santa Cruz and Scotts Valley:

Santa Cruz and Scotts Valley (**SC** and **SV**, below) are located upstream of the mountain communities and are affected by **SERFR ONE** but not by **BRIXX ONE**. It is worth noting that these are low-lying communities located a full **50 miles** away from SFO along the flight path, and have lived under **BIG SUR TWO**, with no reported issues, for decades.

Clearly the proposed modification of the last leg of **SERFR ONE** would benefit these residents as well since it would restore that bit of the route to its previous path.

Portola Valley:

Portola Valley (**PV**) is affected by Pacific flights that are routed from **PPEGS** to **MENLO (**shown in **light blue)** as well as by northern traffic that is routed above SFO (waypoint **BRIXX**) to the S-SE and then to **MENLO**. Portola Valley also lies under the **BRIXX ONE** arrival, which flies at about 7000' at that point, having started at 12,000' at waypoint **BRIXX**. Delayed **SERFR ONE** flights are discussed in the next page.

An extra benefit of our proposal is that if **BRIXX ONE** is indeed re-routed to fly above **SERFR ONE** at 12000', it will not only generate less noise for Portola Valley, but it will also eliminate the vertical congestion that is causing the **PPEGS-to-MENLO** and **SFO-to-MENLO** traffic to fly at 5000' above Portola Valley. These planes can now pass at 7000' (which is no longer used by **BRIXX ONE**), and can idle-slope towards **MENLO,** descending 3000' over 9 NM, following the 1:3 slope.

Palo Alto:

Palo Alto (**PA**) is affected by all local routes, since it is located under waypoint **MENLO**, next to the SFO ILS approach, and next to SJC.

The changes we propose will benefit Palo Alto in that A) **SERFR ONE** will be quieter due to the idle-compatible descent profile, and B) traffic from **PPEGS** and from **BRIXX** will be able to remain higher longer, idling to **MENLO**.

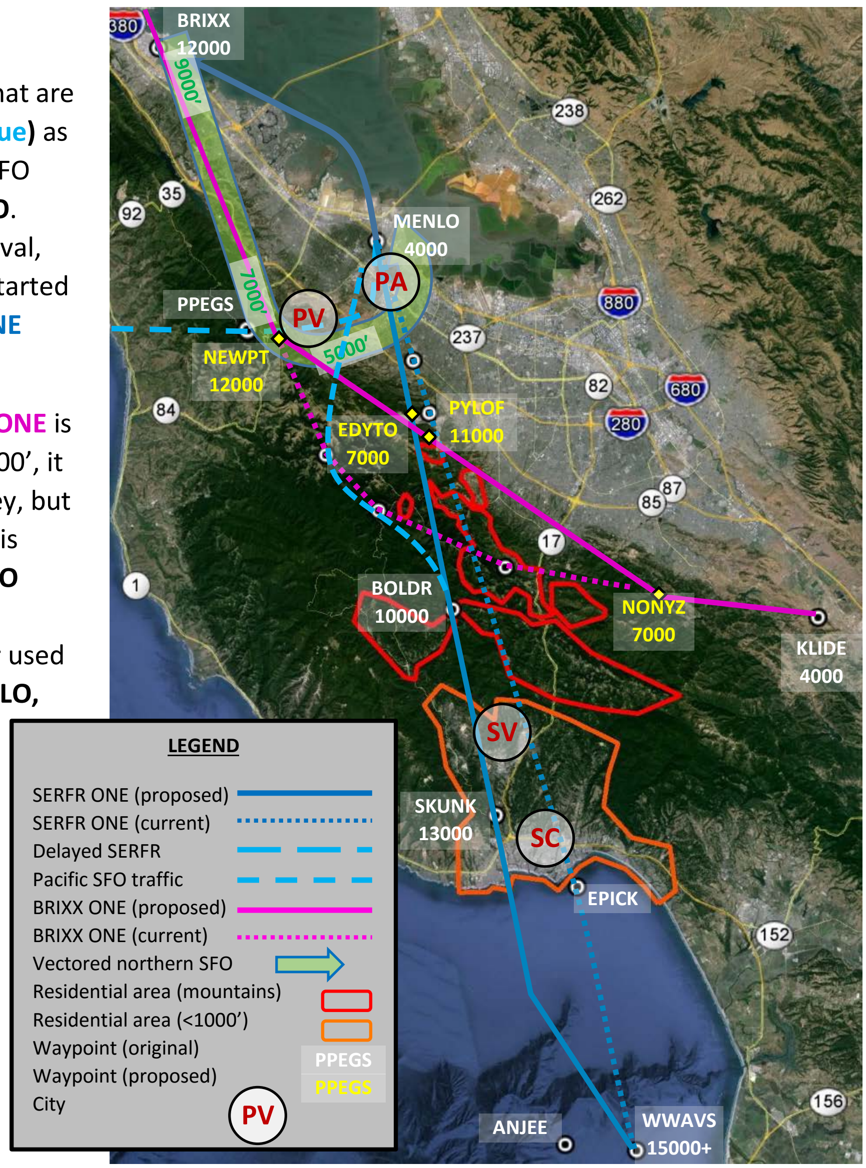


Figure 10: Other Communities

Palo Alto's position, however, is inherently complex due to its location relative to the local airports, and what is presented here may not describe the entirety of their situation.

It is interesting to look at the airspace over Palo Alto and Portola Valley in cross-section, looking roughly towards the North. (This is only a notional cross-section, with no horizontal scale). The cross section depicts the current state of affairs, before the route modifications described above.

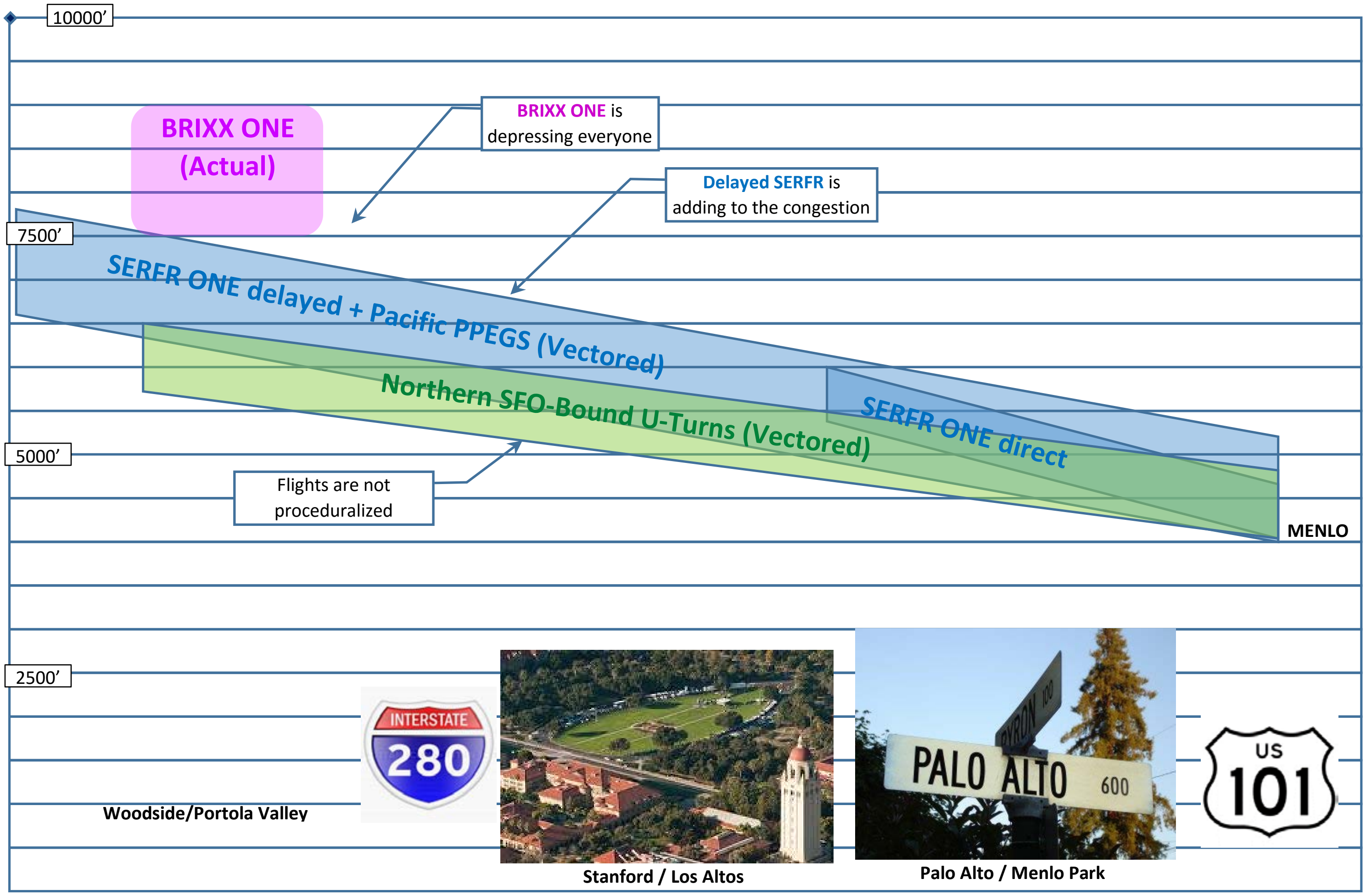


Figure 11: Palo Alto / Portola Valley cross section

Our proposal will raise **BRIXX ONE** so it is above this chart (12,000' at the location of this chart), and eliminate the delayed **SERFR** flights since those will occur over the Monterey bay and arrive with the rest of the **SERFR ONE** flights.

Additionally, a proceduralized arrival is a quiet arrival, because the entire flight route is calculated in advance by the Flight Management Software. Ideally, the arrival additionally follows an idle-power descent profile. Vectored flights are noisy since once they receive the new headings, pilots invariably have to either introduce thrust or deploy speed brakes – which create additional noise.

We believe a large component of Palo Alto's noise issue are a result of the fact that Northern arrivals can't predict when the "U-Turn" will occur. The variations occur because the MENLO waypoint is merging such a large number of streams.

After simplifying the airspace, it might be possible to add a new waypoint to the **BDEGA ONE** arrival so that the U-Turn point is well established, allowing the FMS to fly the arrival all the way through waypoint **MENLO**.

Departures

Southbound departures from SFO and OAK follow one of two routes. Coastal (dashed white), and over-land (white). Depending on the rate of climb, type of plane, and load, over-land departures can be as disturbing as arrivals. Compared to arrivals, the sound echos longer through the valleys, and the character of the noise is more abrasive.

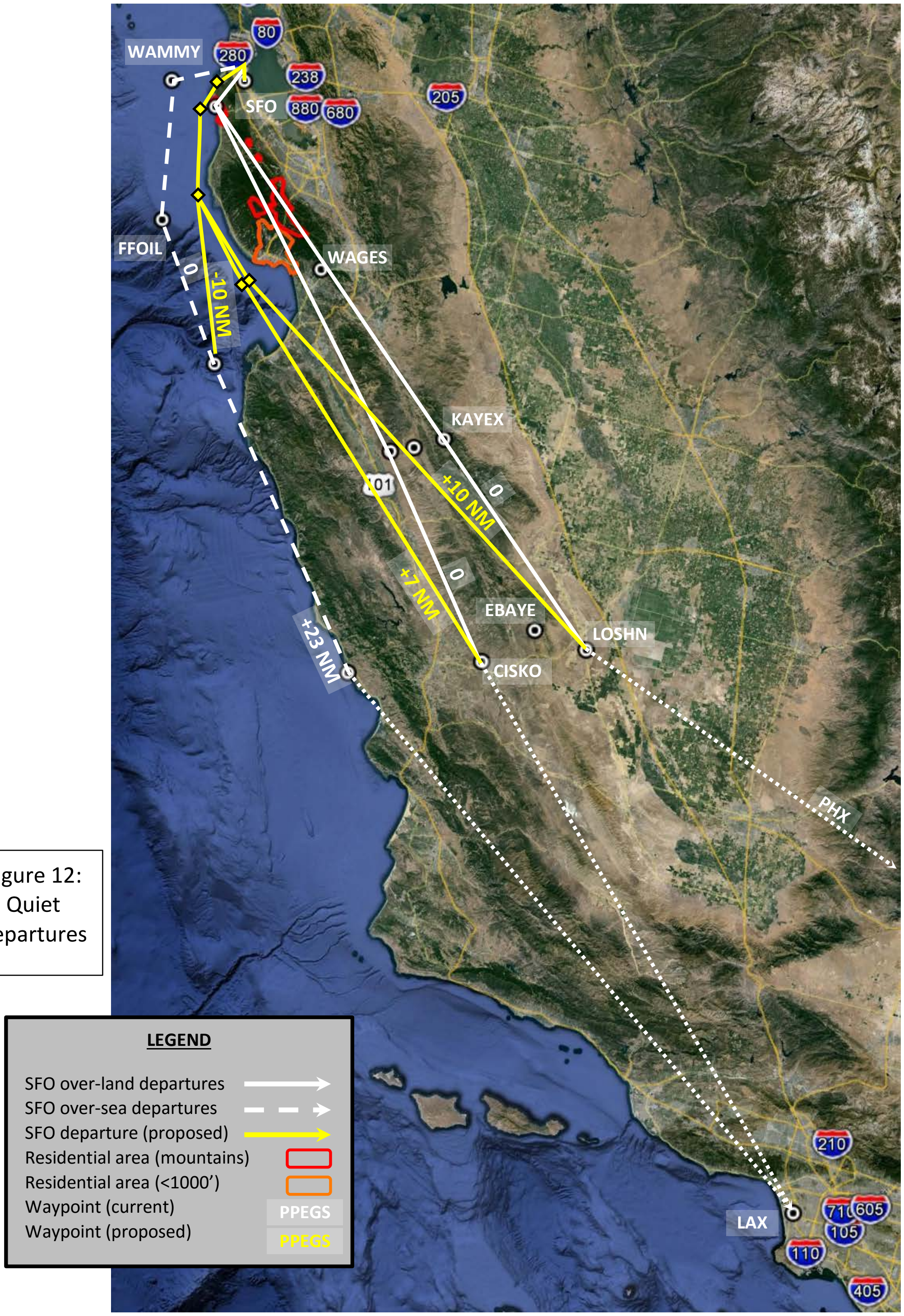


Figure 12: Quiet departures

For SFO-LAX traffic, a coastal departure can be plotted (**Yellow**) that is only 8 NM longer than the over-land route, and 16 NM shorter than the existing over-water route. For southwestern traffic, the coastal departure is only 10 NM longer, or just over 1 minute of flight time.

To calibrate these differences, because of various factors, even relatively short SFO-PHX flights routinely add 18 NM to their route by detouring through Lancaster.

For example, the current western (over water) leg of SSTIK, WESLA and CNDEL is very suboptimal, due to the northern placement of **WAMMY**. The same amount of westward separation could have been achieved by taking a more southerly tack, as shown by the dotted white line linem saving 12 NM.

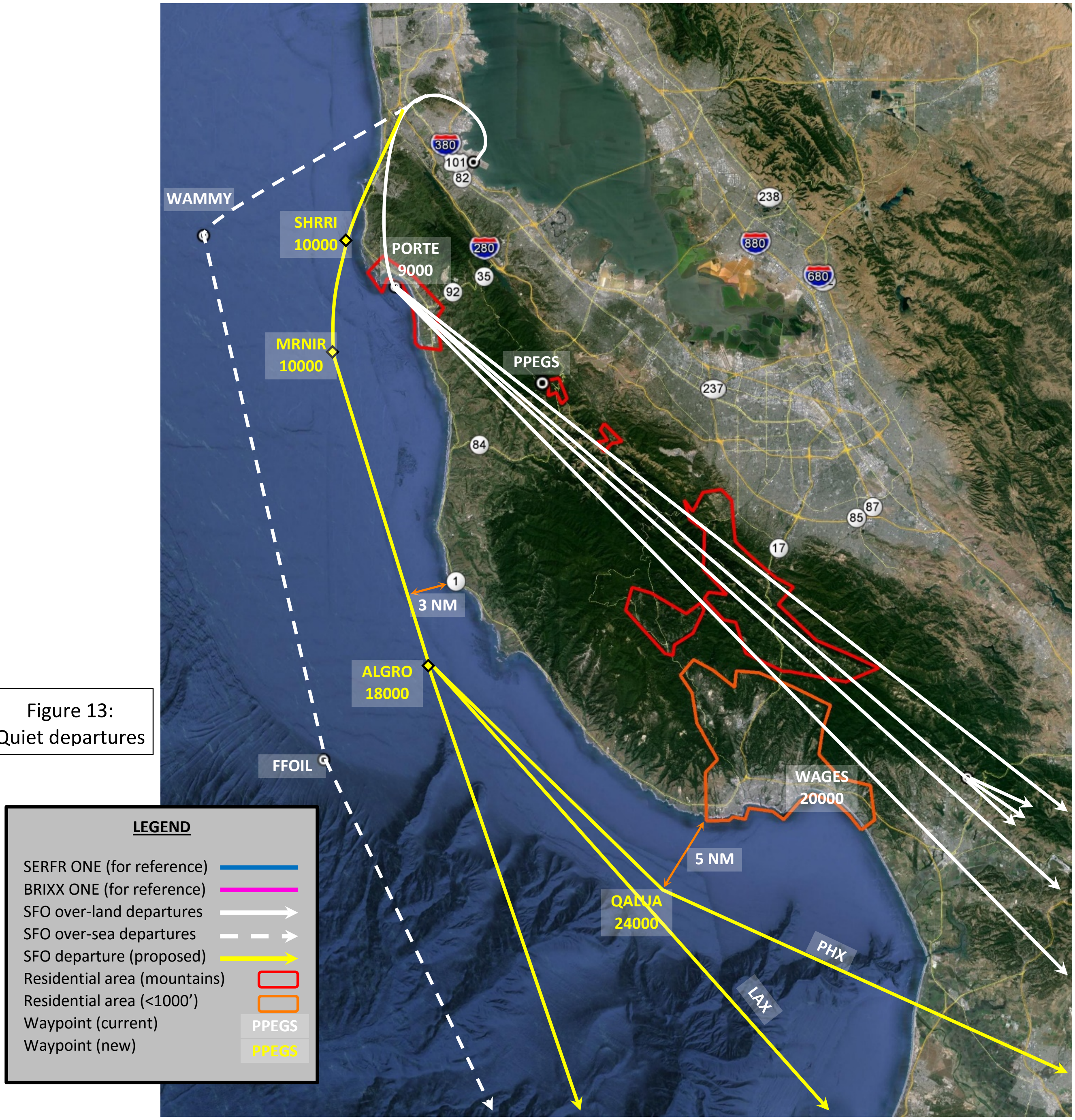


Figure 13:
Quiet departures

Unlike the SERFR and BRIXX arrival procedures which have fundamental design flaws, the departure procedures are simply a matter of balancing route length and the well-being of the local residents. The proposed departure (Yellow) flys 3 NM from the coast at closest approach and clears Santa Cruz by 5 NM – at a cost that is clearly affordable.

These departures will give relief to the communities of Half Moon Bay (under **PORTE**), La Honda, (under **PPEGS**) and the Santa Cruz mountain communities. Since departing flights also have a higher environmental signature, it will give general relief to the state parks and nature preserves on the entire Santa Cruz mountain range.

We support and enjoy air travel, but at the same time it is reasonable to expect that steps of such modest cost be taken, respecting the people over which this travel occurs.

Appendix and notes

Notes:

The maps and charts in this document are not made to navigational accuracy and are intended as demonstration aides for the concept presented.

The information is derived from public documents, ADS-B tracking sites such as FlightAware and FlightRadar24, and especially from information collected by Save Our Skies Santa Cruz.

More peninsula airplane noise information:

SOS Santa Cruz:	http://www.sossantacruz.org
Portola Valley lawsuit opening brief:	https://goo.gl/y206us
One-click noise reporting tool:	http://stop.jetnoise.net

Revision history:

Revision 1.0 – September 12, 2015	Original
Revision 1.1 – September 15, 2015	+ departures, flight frequency
Revision 1.2 – September 17, 2015	SOSSC comments
Revision 1.3 – September 19, 2015	More community comments
Revision 1.4 – September 21, 2015	+ "Other communities" section
Revision 1.5 – September 23, 2015	+ "descent profile" appendix
Revision 1.6 – October 6, 2015	+ ADS-B data appendix
Revision 1.7 – October 8, 2015	+ SERFR tweaks, BRIXX data
Revision 1.8 – October 12, 2015	+ Traffic spacing, waypoint fixes, Figure 4 update, BRIXX Scatter
Revision 1.9 – October 26, 2015	+ Departures overhaul
Revision 1.10 – November 23, 2015	+ BRIXX mod westerly adjustment
Revision 1.11 – November 24, 2015	+ Palo Alto cross section
Revision 1.12 – January 27, 2015	+ Revamped departures, odds and ends.

Latest revision at:

http://www.g2-engineering.com/documents/mountainSERFR.pdf
3D slideshow: https://goo.gl/BSGC5D

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ADS-B data collection and analysis software:	Adam Worrall	

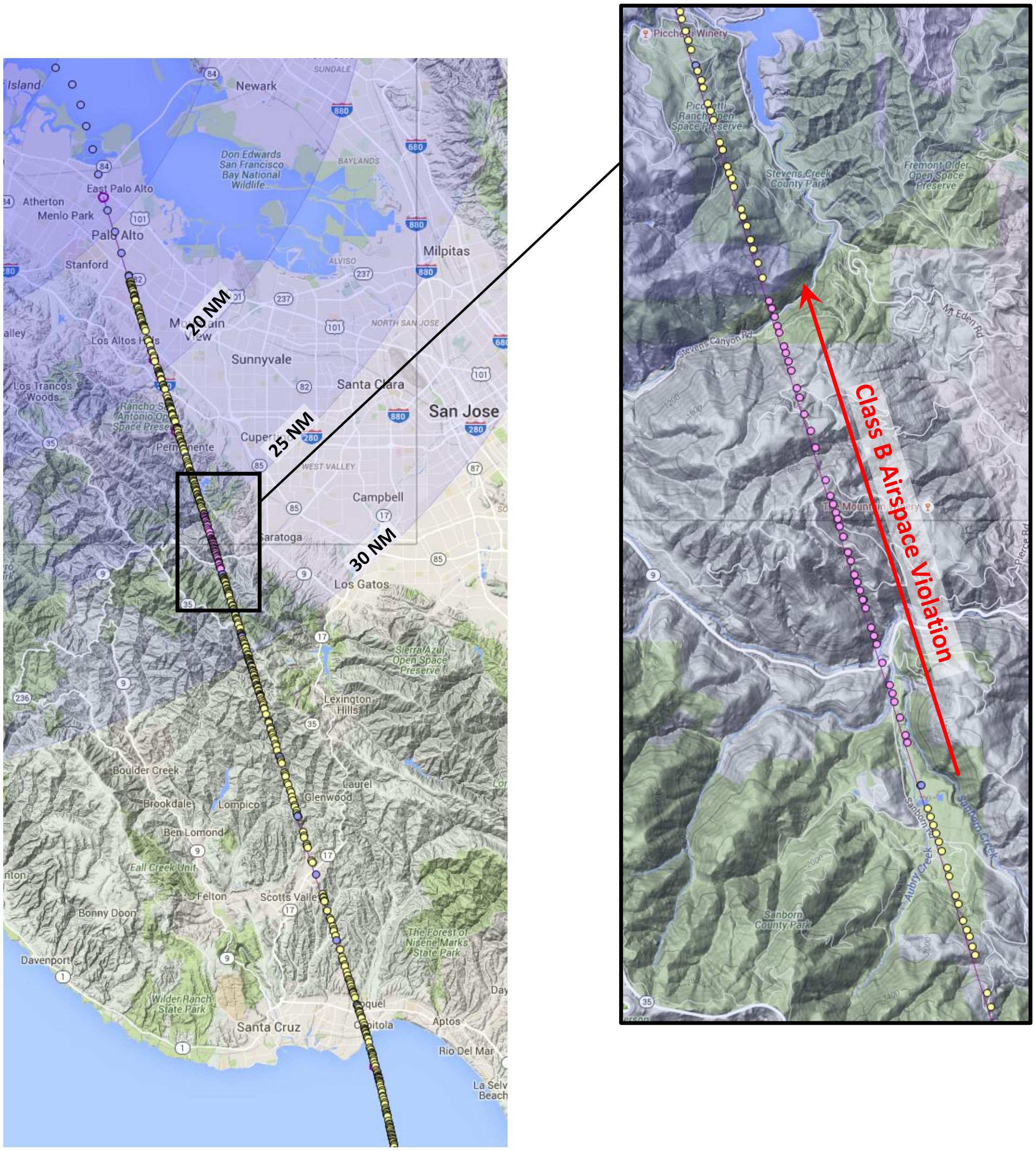
Appendices:

- A1: Sample data for Class B airspace violation on SERFR ONE
- A2: Sample data for low-altitude level flight on SERFR ONE
- A3: Sample data for below-minimum-safe-altitude level flight on BRIXX ONE
- A4: SERFR-BRIXX crossing zone scatter diagram
- A5: Data integrity
- A6: A pedestrian overview: The connection between noise levels and descent profiles
- A7: SERFR ONE STAR chart, annotated
- A8: BIG SUR TWO STAR chart
- A9: BRIXX ONE STAR chart

A1: Sample data for Class B airspace violation on SERFR ONE

The map below is a graphical representation of a single Class B violation, captured using our ADS-B receiver. As with all ADS-B data, it is generated by the airplane itself, and so is not influenced by ground equipment.

We observe tens of similar violations every day. This particular one (the pink data points) lasted more than 30 seconds, 3 NM, and was 600’ deep.



The violation starts about half way through the 100/80 space as the plane goes below 8000’, and ends at the 25NM arc as the plane enters the 100/60 space. There are two violations here, in fact. First there’s an excursion out of the Class B space, as SFO bound flight must be within the Class B space unless explicitly directed to leave it, and second there’s a speed violation, since any flight under the Class B shelf must slow down to 200 Knots IAS. A quick monitoring of the ATC audio stream confirms that these violations go unacknowledged by either ATC or the crews.

These flights correspond to the “Unaware” flights depicted in **Figure 3**.

Below is a list of violations from a single day, captured both by our local receiver and by relay sites for non-ADS-B equipped airplanes. While the non-ADS-B data is less precise, it paints an identical picture to the ADS-B data, and so should be considered reliable, at least statistically.

With such a high fraction of violations, clearly the problem is systemic.

Class B Violation report: Fri 10/02 - Fri 10/02

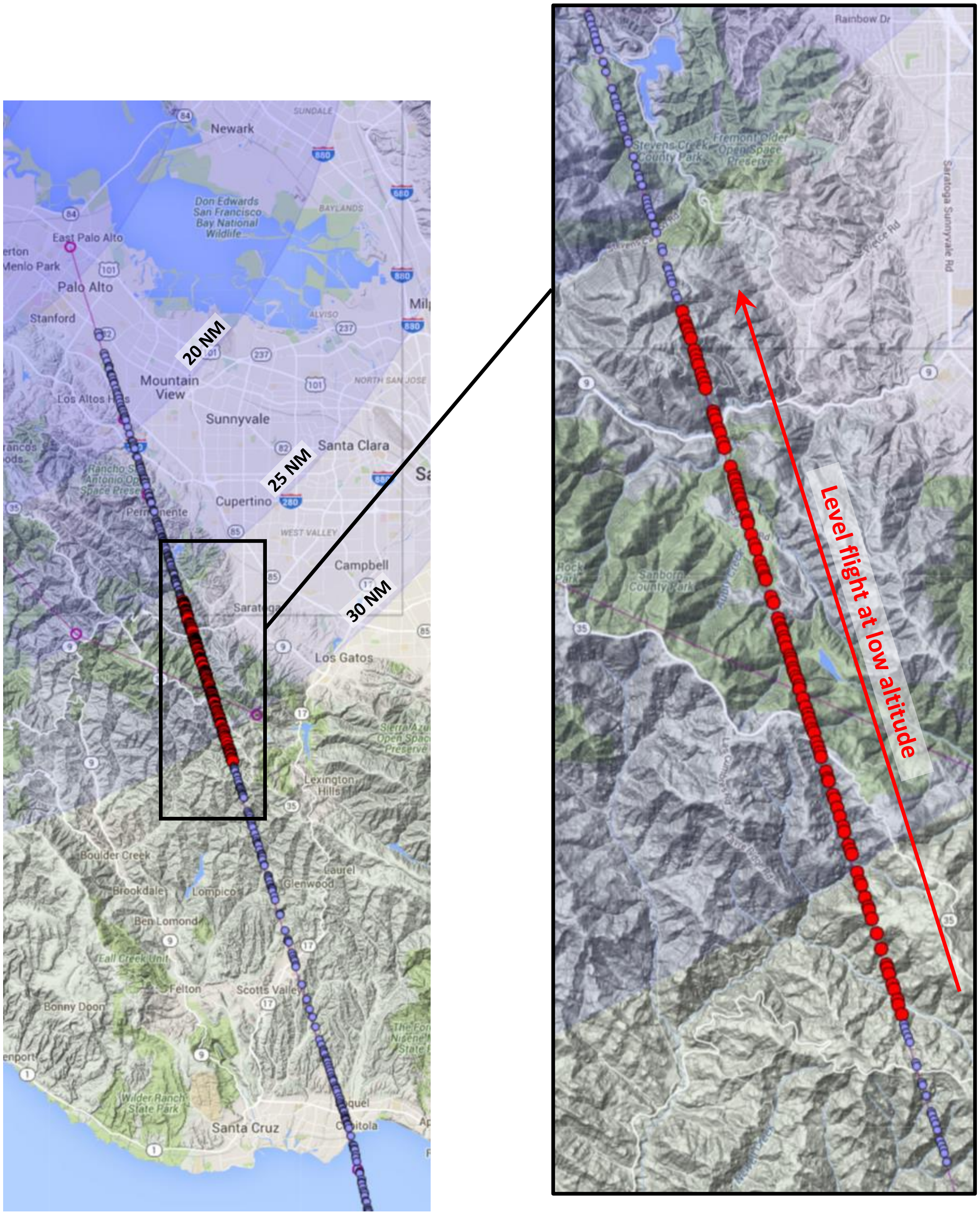
[A] Total SERFR1 Flights :	**150**
[B] Num violating flights :	**45**
[C] -- Detected via FlightAware, ADS-B (TA) :	**1**
[C] -- Detected via FlightAware, Radar (TZ) :	**20**
[C] -- Detected via Private receiver, ADS-B (ScottsValley) :	**24**
[D] Mean violation below Class B floor :	**767**
[D] Stddev :	**497**

CI5107 / B-18715 / 899101	10/01 23:54:46 PDT; 25.0 NM from SFO, at 7475 feet; **525** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
OZ286 / HL7436 / 71BC36	10/01 17:29:42 PDT; 25.0 NM from SFO, at 7400 feet; **600** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1536 / N76519 / AA56B8	10/02 02:26:41 PDT; 20.1 NM from SFO, at 4925 feet; **1075** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1106 / N76508 / AA5694	10/02 01:59:06 PDT; 25.1 NM from SFO, at 7125 feet; **875** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
VX945 / N835VA / AB6CC9	10/02 11:38:28 PDT; 25.1 NM from SFO, at 6900 feet; **1100** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA5645 / N956SW / AD4C96	10/02 18:37:00 PDT; 25.8 NM from SFO, at 6000 feet; **2000** feet below floor.	Source: FlightAware, Radar (TZ)
WN2010 / N602SW / A7D052	10/02 20:06:45 PDT; 25.1 NM from SFO, at 7500 feet; **500** feet below floor.	Source: FlightAware, Radar (TZ)
WN2719 / N497WN / A62C1A	10/02 16:10:34 PDT; 25.4 NM from SFO, at 7000 feet; **1000** feet below floor.	Source: FlightAware, Radar (TZ)
AA5946 / N203NN / A19E61	10/02 01:06:02 PDT; 25.0 NM from SFO, at 7675 feet; **325** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
AM664 / N860AM / ABCEE3	10/02 13:44:08 PDT; 25.0 NM from SFO, at 6850 feet; **1150** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1623 / N61887 / A81006	10/02 14:43:11 PDT; 25.1 NM from SFO, at 7225 feet; **775** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1681 / N61881 / A81000	10/02 14:15:51 PDT; 25.1 NM from SFO, at 7425 feet; **575** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA460 / N430UA / A524E1	10/02 16:36:45 PDT; 28.4 NM from SFO, at 7600 feet; **400** feet below floor.	Source: FlightAware, Radar (TZ)
UA6360 / N956SW / AD4C96	10/02 15:10:49 PDT; 25.2 NM from SFO, at 6400 feet; **1600** feet below floor.	Source: FlightAware, Radar (TZ)
VX929 / N625VA / A82AAC	10/02 07:31:52 PDT; 25.0 NM from SFO, at 7575 feet; **425** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1937 / N24224 / A23A28	10/02 09:17:39 PDT; 25.6 NM from SFO, at 7600 feet; **400** feet below floor.	Source: FlightAware, Radar (TZ)
UA1587 / N36444 / A41E29	10/02 14:14:13 PDT; 25.1 NM from SFO, at 7575 feet; **425** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
VX963 / N636VA / A855E2	10/02 11:34:48 PDT; 25.1 NM from SFO, at 7650 feet; **350** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
WN2042 / N241WN / A235B7	10/02 21:04:19 PDT; 25.6 NM from SFO, at 7700 feet; **300** feet below floor.	Source: FlightAware, Radar (TZ)
VX923 / N845VA / AB9448	10/02 10:26:26 PDT; 25.0 NM from SFO, at 7225 feet; **775** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1822 / N67845 / A8FC72	10/02 11:28:31 PDT; 25.1 NM from SFO, at 7600 feet; **400** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
AM662 / N859AM / ABC8D3	10/02 02:51:58 PDT; 25.1 NM from SFO, at 7650 feet; **350** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
VX933 / N527VA / A6A4CB	10/02 09:40:55 PDT; 25.1 NM from SFO, at 6925 feet; **1075** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
WN2008 / N602SW / A7D052	10/02 16:01:16 PDT; 25.1 NM from SFO, at 7600 feet; **400** feet below floor.	Source: FlightAware, Radar (TZ)
VX925 / N525VA / A69D5D	10/02 01:04:02 PDT; 25.1 NM from SFO, at 7625 feet; **375** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
(undef) / N472FX / A5C91B	10/02 08:32:19 PDT; 25.1 NM from SFO, at 7725 feet; **275** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1099 / N57864 / A76F68	10/02 23:03:04 PDT; 25.4 NM from SFO, at 7600 feet; **400** feet below floor.	Source: FlightAware, Radar (TZ)
AA1289 / N133AN / A08663	10/02 18:23:37 PDT; 25.3 NM from SFO, at 7100 feet; **900** feet below floor.	Source: FlightAware, ADS-B (TA)
UA5615 / N969SW / AD7F3A	10/02 21:22:01 PDT; 27.0 NM from SFO, at 7400 feet; **600** feet below floor.	Source: FlightAware, Radar (TZ)
UA5518 / N740SK / A9F424	10/02 16:16:56 PDT; 25.2 NM from SFO, at 6000 feet; **2000** feet below floor.	Source: FlightAware, Radar (TZ)
UA6300 / N105SY / A018EE	10/02 07:15:03 PDT; 25.1 NM from SFO, at 7775 feet; **225** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
VX1935 / N625VA / A82AAC	10/02 03:29:22 PDT; 25.1 NM from SFO, at 6725 feet; **1275** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA5512 / N118SY / A04B92	10/02 15:21:07 PDT; 25.0 NM from SFO, at 7575 feet; **425** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA5416 / N466SW / A5B18A	10/02 21:59:50 PDT; 20.1 NM from SFO, at 5300 feet; **700** feet below floor.	Source: FlightAware, Radar (TZ)
KZ109 / JA13KZ / 8466C7	10/01 23:33:55 PDT; 25.1 NM from SFO, at 6925 feet; **1075** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA1154 / N38268 / A46603	10/02 16:57:22 PDT; 27.1 NM from SFO, at 7500 feet; **500** feet below floor.	Source: FlightAware, Radar (TZ)
UA466 / N440UA / A54C60	10/02 14:45:45 PDT; 28.2 NM from SFO, at 7300 feet; **700** feet below floor.	Source: FlightAware, Radar (TZ)
UA6340 / N980SW / ADACC9	10/02 06:39:05 PDT; 20.8 NM from SFO, at 5200 feet; **800** feet below floor.	Source: FlightAware, Radar (TZ)
DL2776 / N997AT / ADECB6	10/02 20:25:59 PDT; 26.5 NM from SFO, at 7700 feet; **300** feet below floor.	Source: FlightAware, Radar (TZ)
UA736 / N849UA / ABA30B	10/02 18:02:45 PDT; 25.2 NM from SFO, at 7500 feet; **500** feet below floor.	Source: FlightAware, Radar (TZ)
UA6287 / N755SK / AA2E36	10/02 16:26:50 PDT; 28.6 NM from SFO, at 6000 feet; **2000** feet below floor.	Source: FlightAware, Radar (TZ)
UA420 / N543UA / A6E4D4	10/02 15:34:01 PDT; 25.8 NM from SFO, at 7400 feet; **600** feet below floor.	Source: FlightAware, Radar (TZ)
AA5940 / N203NN / A19E61	10/02 05:14:37 PDT; 25.0 NM from SFO, at 7700 feet; **300** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
VX969 / N853VA / ABB459	10/02 13:54:46 PDT; 25.1 NM from SFO, at 6825 feet; **1175** feet below floor.	Source: Private receiver, ADS-B (ScottsValley)
UA5260 / N932EV / ACED8F	10/02 18:13:01 PDT; 27.3 NM from SFO, at 6000 feet; **2000** feet below floor.	Source: FlightAware, Radar (TZ)

A2: Sample data for low-altitude level flight on SERFR ONE

The map below is a graphical representation of a single low-altitude level flight segment during the descent. These are "Aware" flights that were following **SERFR ONE**, but noticed they were about to leave Class B airspace and so leveled off at 8000'. Of course flying level at 8000' during a simple descent is unnecessary, and is both wasteful of fuel and noisy.

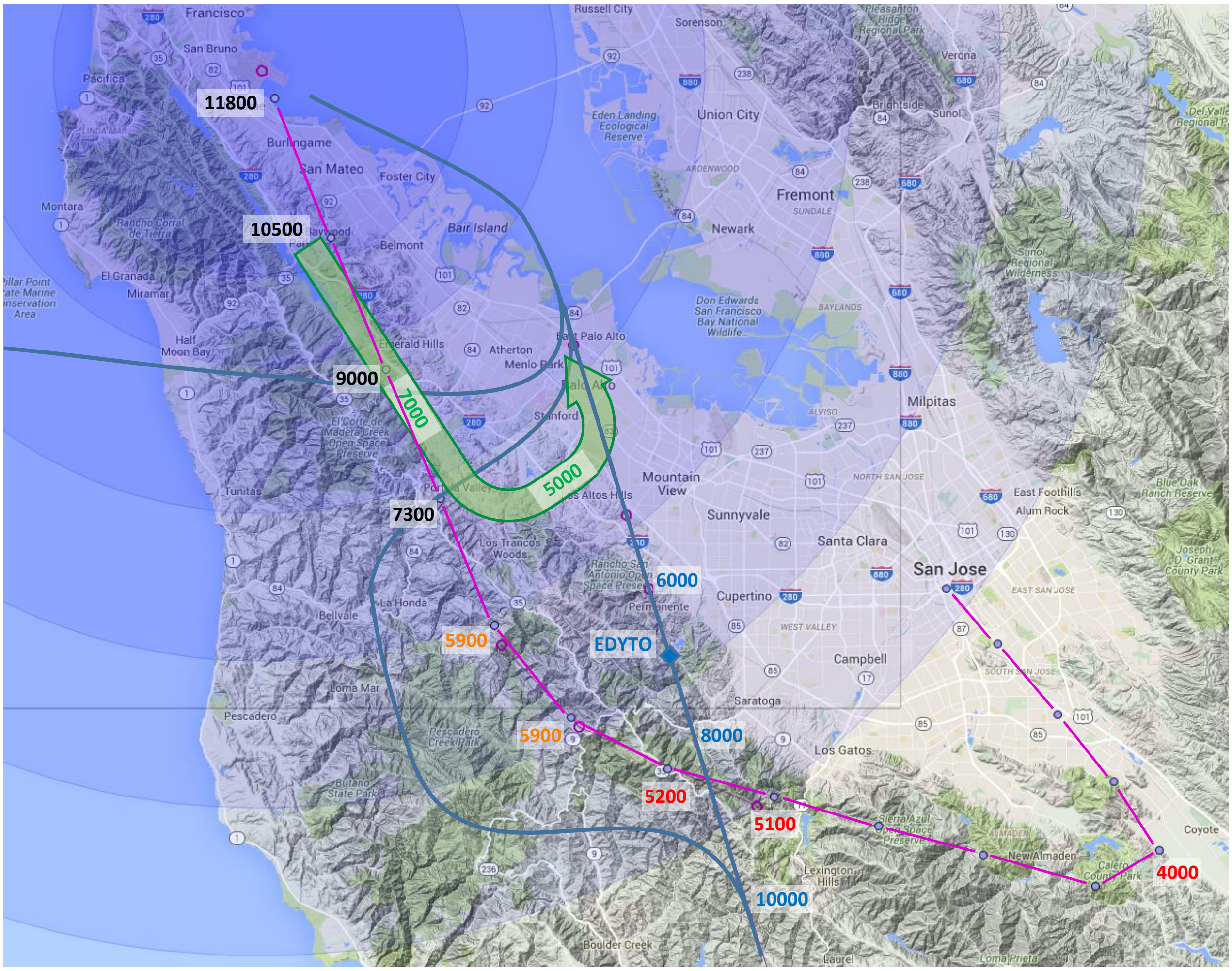
The map looks very similar to the class-B violation map, and this illustrates the problem with the descent profile: Once the planes start too low at the Santa Cruz coastline, they will either fall under the Class B shelf, or will have to fly level to remain within it. This particular level flight extends of 7 nautical miles.



As more pilots become aware of the Class B violations, they transition into this category. While flying at 8000' is not a Class B violation, you'll notice that the minimum altitude on the **BRIXX ONE** STAR chart at the crossing point is 7000', which is why **BRIXX ONE** is in practice flown much lower, resulting in additional noise over the Summit area.

A3: Sample data for below-minimum-safe-altitude level flight on BRIXX ONE

The map below is a graphical representation of a single **BRIXX ONE** arrival at SJC. The route overflies SFO at 12,000', and then begins to descend over the peninsula in order to squeeze under **SERFR ONE**. The minimum safe altitude near the crossing point is 5500', and this flight violated it (**Red**). Even before hand, the stated minimum altitude enroute is 7000', and that was violated too. (**Orange**)



However, this charts reveals much more than the altitude violation.

It also shows how in order to fit under **SERFR ONE**, the flight had to fly at 7300' over Portola Valley, and then make an arc over the Summit mountain communities at 5000' (only 2500' AGL), where **SERFR ONE** still has enough altitude.

The low flight over Portola Valley, in turn, now depresses traffic inbound to SFO from the north (shown in the fat **Green** arrow), making it descend to 7000' and then to 5000' much sooner than would have otherwise been necessary.

(In other words, "it ain't necessarily low")

If **BRIXX ONE** is made to cross over **SERFR ONE** at waypoint **EDYTO** (at 7000'), it can remain at 10,000'-12,000' all the way from SFO, cross above **SERFR ONE**, and only start descending to SJC near **PYLOF**. This will allow the **Green** SFO traffic to occupy the 9000-7000 space, giving Palo Alto and Portola Valley some relief.

A4: Data integrity

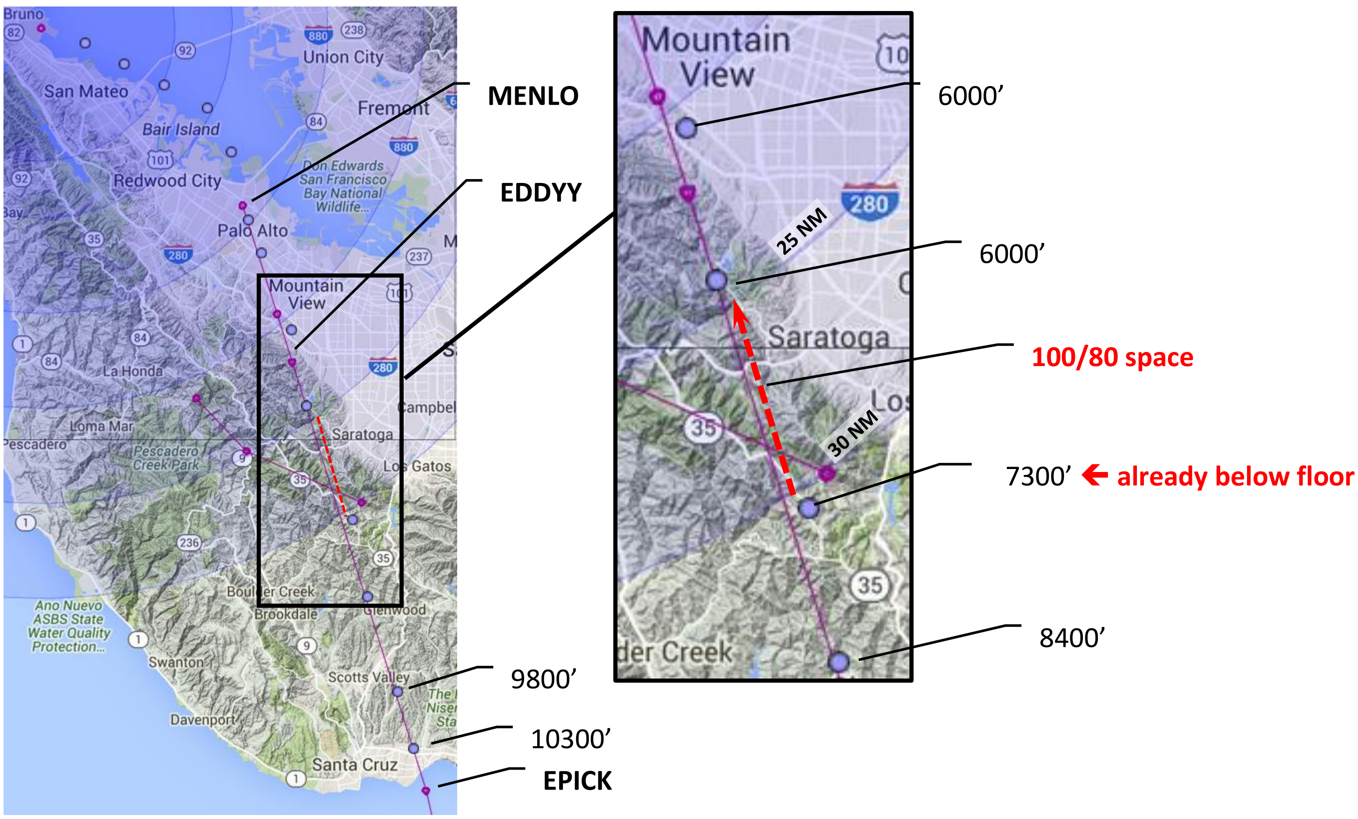
There are several methods of ascertaining the plane's position in space, and of distributing it to interested parties.

ADS-B data is generated by the plane, and transmitted out as digital data. It can be received directly by anyone with an ADS-B receiver, is made available by the FAA, and is also relayed over the web by companies that operate their own receivers. While there is always the concern that data is mishandled by intermediaries, such erroneous data will be apparent, since there is no mechanism that makes plane-sourced information "just a little bit wrong". In other words, errors will look suspicious. Only ADS-B equipped airplanes can be tracked using this method.

Non ADS-B data can be acquired by different methods, including radar and differential time-of-receipt analysis. Such information can be skewed, and this possibility must be considered. Some website operators (e.g. FlightRadar24) also interpolate between data points, to create a smoother look to their displays. Interpolated data is not erroneous, it is simply non-data. (Radar, or "Mode S" altitude data is also generated on the plane)

Operators such as FlightAware label the source of each data packet they relay, and we note this differentiation. However, while ADS-B data packets are transmitted continuously, FlightAware only relays them every 20-30 seconds.

While we take care to differentiate, non-ADS-B data can be useful <u>if taken in context</u>. Consider the flight below, which only has non-ADS-B data points, every 30-45 seconds:



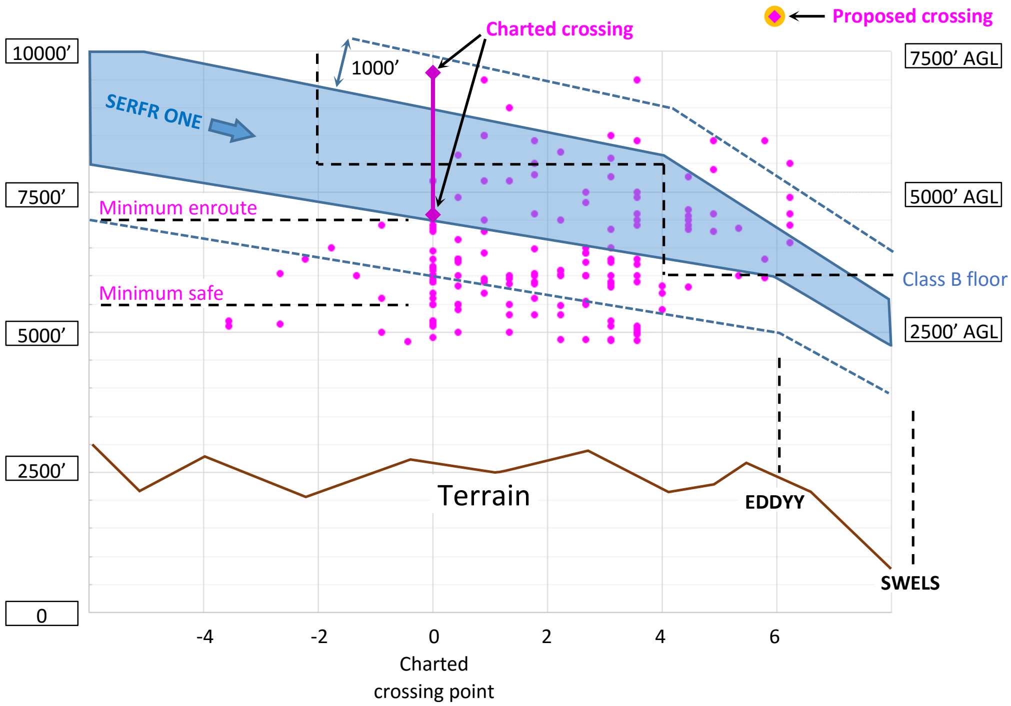
While clearly the radar data is not precise, the sum total of the data paints an unmistakable picture of a flight path that starts at **EPICK** and targets 6000' (the prescribed altitude at **EDDYY**, the next waypoint). The plane descends and reaches 6000' much too early. <u>It flies completely below the 100/80 space (hitting the 30 NM arc at 7300')</u>, and levels off at 6000' flying level for about 7NM at 6000'.

The leveling off at the exact prescribed altitude of the next waypoint, and the subsequent descent, are good evidence that the radar data is at least reliable enough to warrant further investigation.

We keep the source of all data points in our database, though of course we expect the FAA to rely on its own. All we do is report on, and analyze, publically available data.

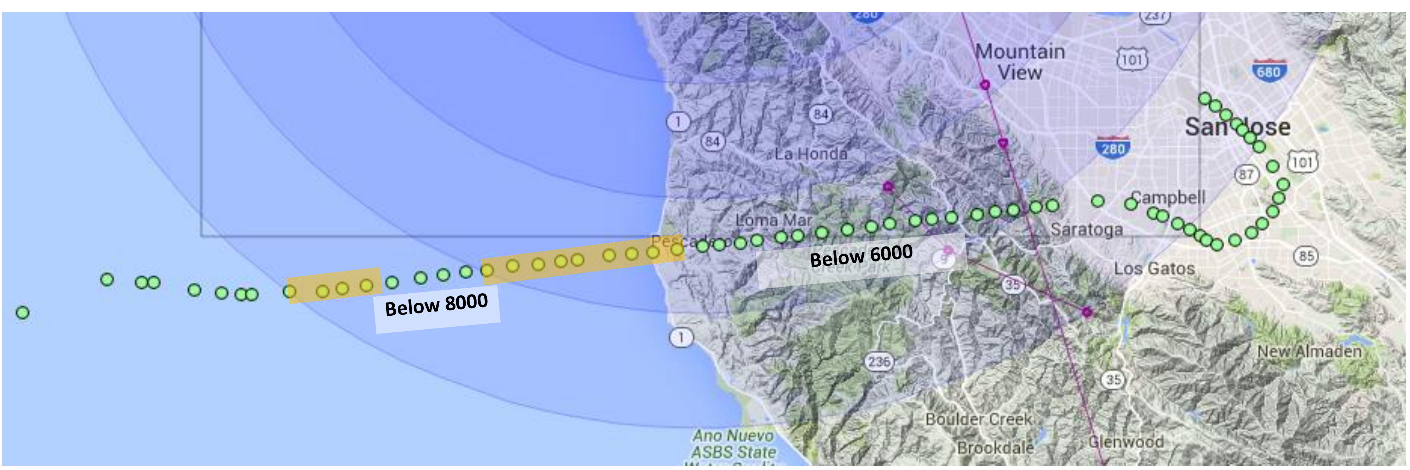
A5: BRIXX-SERFR Crossing

This scatter diagram described the altitude and position distribution of **BRIXX ONE** (and pacific-BRIXX) arrivals as they cross the **SERFR ONE** path, based on collected data. This graph corroborates the situation depicted in Figure 3. The blue zone is where most **SERFR ONE** traffic is observed. (There are occasional outliers outside it). The purple dots show actual **BRIXX ONE** flights crossing its path.



These planes belong to one of two groups – they either followed the **BRIXX ONE** route from SFO, or have joined it at its end near **YADUT**, usually from a Pacific origin.

One such Pacific arrival is shown below. Some of the Pacific arrivals briefly enter the SFO Class B space, though are generally flying so low that most of the time they are under it. (Only the highlighted points are above the Class B floor)



The only reason this flight is flying so low over the mountains is that it is trying to get under **BRIXX ONE**, which it did at 5050'. It has to be emphasized that general aviation planes that fly from the bay area to the coast occupy this same altitude range.

This specific flight deviated significantly from **YADUT**, but we include all these flights with **BRIXX ONE** arrivals because they behave similarly when crossing **SERFR ONE**.

A6: A pedestrian overview: The connection between noise levels and descent profiles

This section is written for non-pilots, explaining the connection between noise levels and descent profiles, and why of two planes flying at the same altitude and at the same speed, one is noisy and one is quiet.

Idle noise

The first thing to understand is just how much louder a plane is when applying thrust compared to when flying at idle power. A plane (to slightly oversimplify things) is a glider with 2 (or 4) giant leaf-blowers strapped under the wings. Planes move forward by blasting air backwards.

We've all had the experience of walking past a city maintenance crewman that is using a leaf-blower. The sound is deafening, until they notice us, idle it down, and allow us to pass. The difference in noise levels between a "thrusting" leaf-blower and an idle one is remarkable.

Each of the airplane's "leaf-blowers" can have over 100,000 HP worth of power, and the air comes out at some 700 MPH. It is therefore very desirable to keep them idle.

Descent profile and engine setting

In a car, the steering wheel determines which way the car turns, and the gas pedal determines how fast it goes.

Planes are a bit more complex. They can turn left and right "almost like a car", by using only their control surfaces, but in order to go up or down, the pilot also has to use the throttle (which is equivalent to the gas pedal). It is not enough to pull the stick in order to go up - the pilot must also add power. Similarly, in order to descend, the pilot has to reduce power.

Even more confusingly, when a car is going level, it uses very little power. A plane, on the other hand, is "held in the sky" due to the power of the engines, so even just in order to fly level, it has to generate significant thrust, which is noisy.

If the pilot throttles down to an "idle" setting, (a bit like putting the car in Neutral) the plane will continue to fly at constant speed, but start to lose altitude. Interestingly, the slope of the resultant glide is independent of how heavy the airplane is loaded, and is nearly identical across types of jetliners – a jetliner at idle power loses about 1000 feet of altitude for every 3 nautical miles traveled – referred to as a "**1:3**" descent profile.

Speed brakes

Speed brakes are control surfaces that protrude into the airstream and are intentionally non-aerodynamic, so they generate turbulence and noise. They are required if the pilot has to descend at a rate steeper than the aforementioned 1:3 descent profile. (Again, the pilot can't just "point the nose down", since then the plane will over-speed)

Low-noise practices

Ideally then, in order to minimize noise impact, on top of choosing the arrival path to minimize overflight of populated areas, the arrival path should also place the airplane (vertically) somewhere on the idle-power descent profile that leads to the beginning of the final ILS approach to the airport, which is waypoint **MENLO** in our case, at 4000' over Palo Alto.

The straight line distance from the Santa Cruz coastline to **MENLO** is just over 30 nautical miles, and so planes should be crossing the coastline at about 14,000'. If they cross lower, then the main source of noise is not that they overfly the mountain communities at a lower altitude, but that they have to apply and maintain thrust in order to be at 4000' at **MENLO**, and are therefore inherently much noisier than they would have been at an idle power setting.

In fact, pilots that are aware of the Class B airspace restrictions (**Figure 3**) overfly us at a 8000' while applying thrust in order to fly level, and are consistently noisier than flights that violate the Class B rules and glide right through its floor, overflying us at 7000', but with a lower (and still not idle) thrust level.

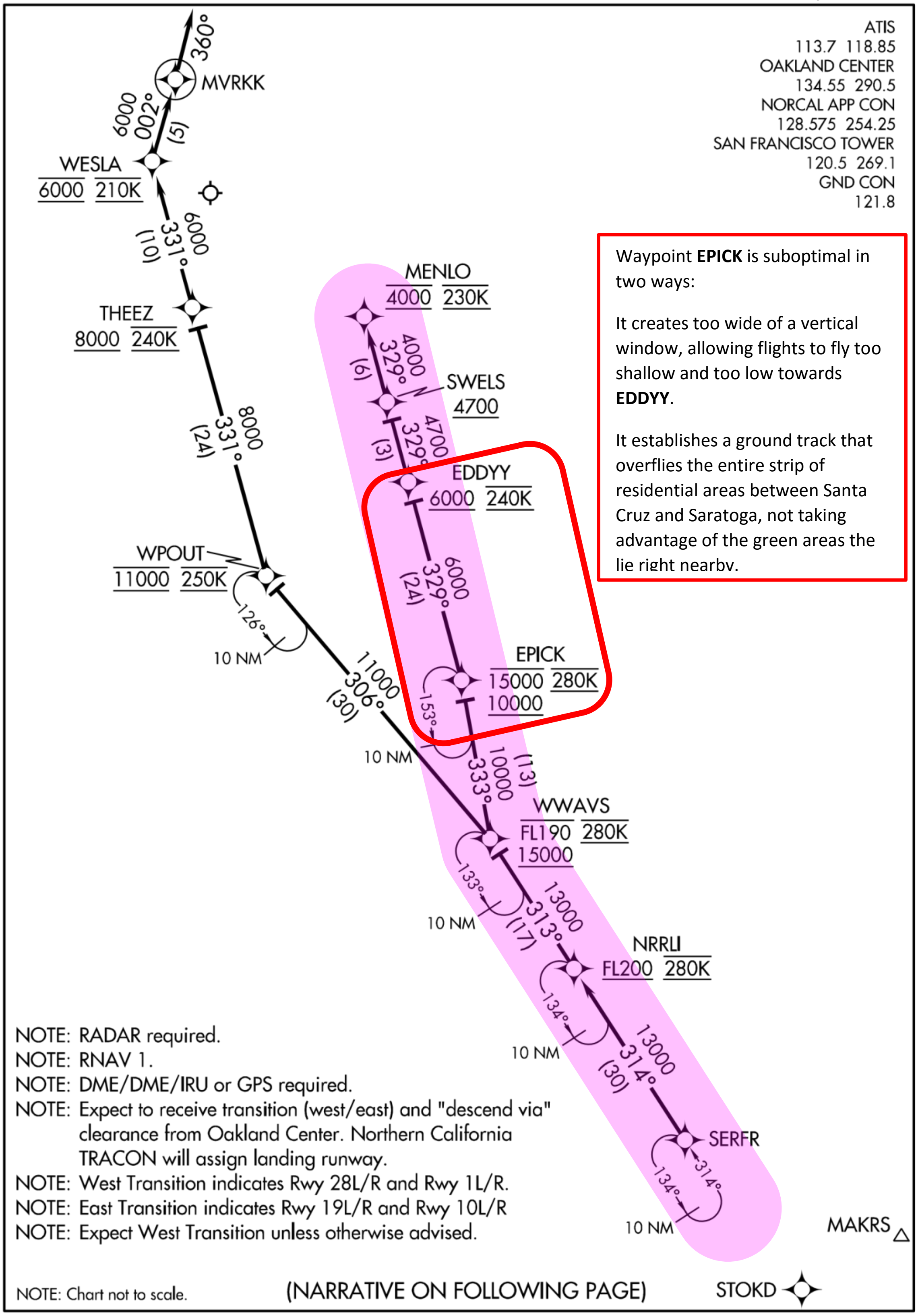
The problem therefore begins at the Santa Cruz coastline. Once the planes cross it too low, the noise downstream, from Santa Cruz to Palo Alto, is inevitable.

A7:

(SERFR.SERFR1) 15064

SERFR ONE ARRIVAL (RNAV) ST-375 (FAA)

SAN FRANCISCO INTL (SFO)
SAN FRANCISCO, CALIFORNIA



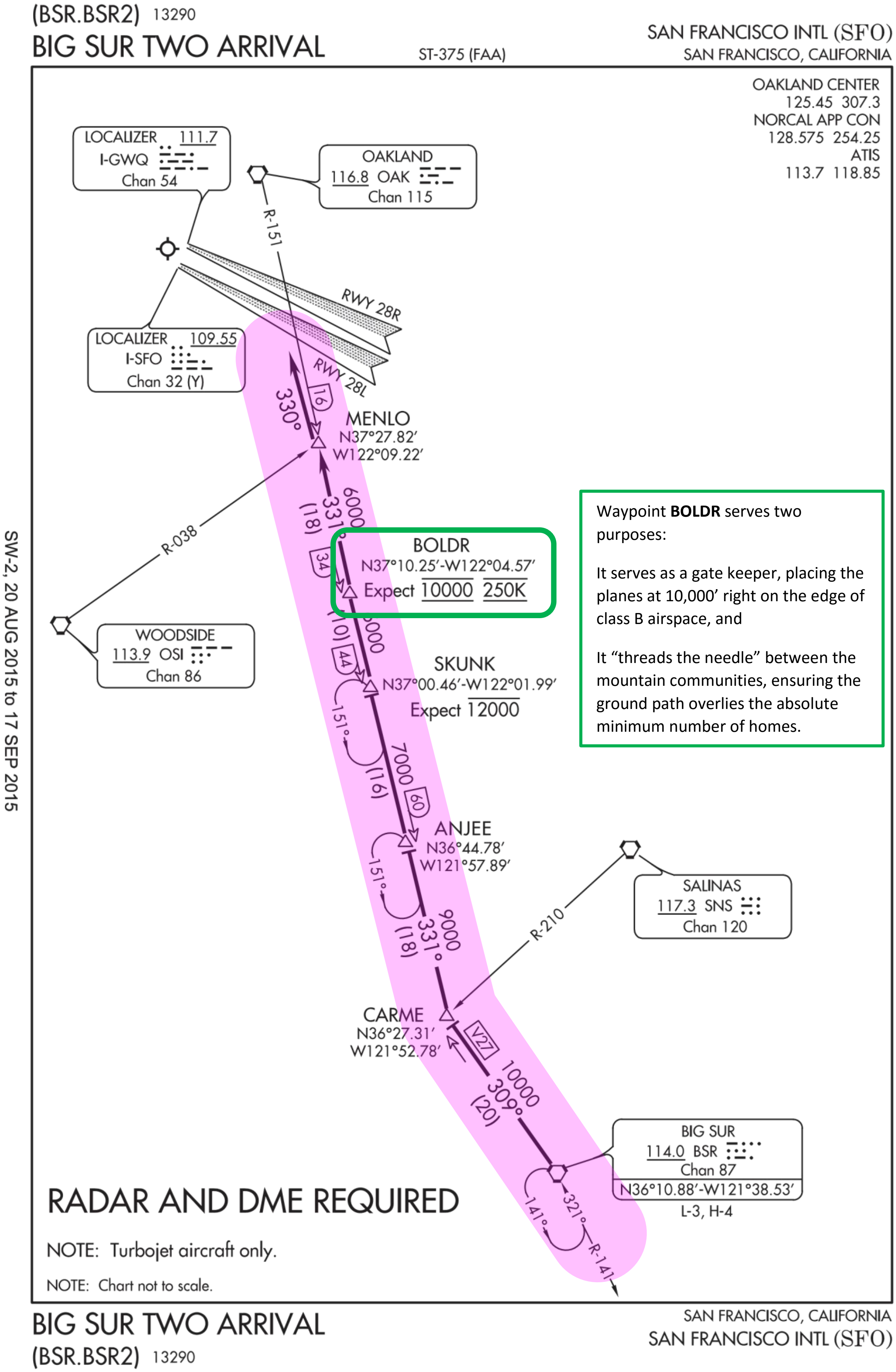
SW-2, 20 AUG 2015 to 17 SEP 2015

SW-2, 20 AUG 2015 to 17 SEP 2015

SERFR ONE ARRIVAL (RNAV)
(SERFR.SERFR1) 15064

SAN FRANCISCO, CALIFORNIA
SAN FRANCISCO INTL (SFO)

A8:



Waypoint **BOLDR** serves two purposes:

It serves as a gate keeper, placing the planes at 10,000′ right on the edge of class B airspace, and

It "threads the needle" between the mountain communities, ensuring the ground path overlies the absolute minimum number of homes.

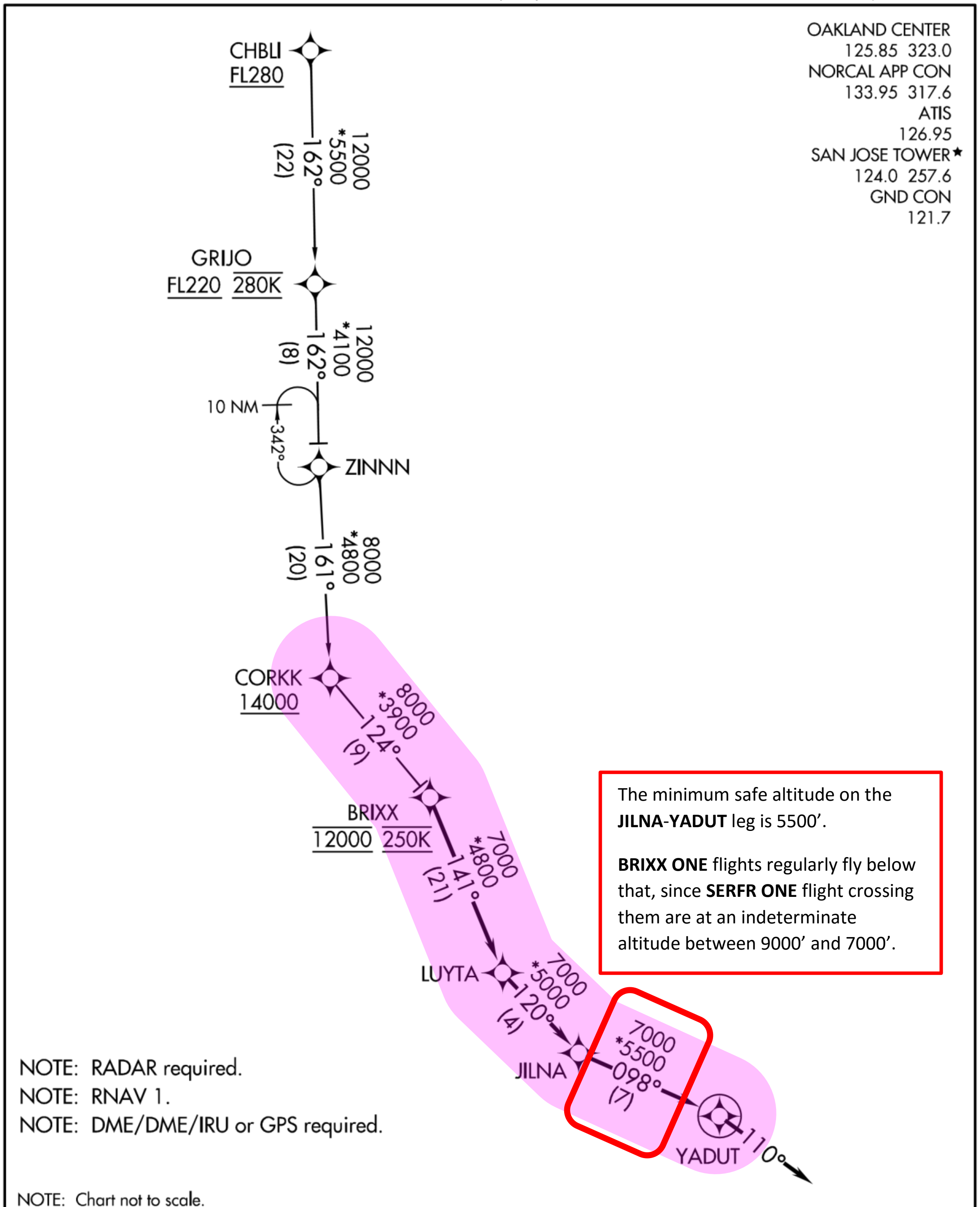
A9:

(BRIXX.BRIXX1) 15064

BRIXX ONE ARRIVAL (RNAV) ST-693 (FAA)

NORMAN Y MINETA SAN JOSE INTL (SJC)
SAN JOSE, CALIFORNIA

SW-2, 20 AUG 2015 to 17 SEP 2015



SW-2, 20 AUG 2015 to 17 SEP 2015

ARRIVAL ROUTE DESCRIPTION

CHBLI TRANSITION (CHBLI.BRIXX1)

From BRIXX on track 141° to LUYTA, then on track 120° to JILNA, then on track 098° to YADUT, then on track 110°. Expect RADAR vectors to final approach course.

BRIXX ONE ARRIVAL (RNAV)
(BRIXX.BRIXX1) 15064

SAN JOSE, CALIFORNIA
NORMAN Y MINETA SAN JOSE INTL (SJC)