



NASA Quesst Mission – Site Selection Process for Community Testing

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Noise and Psychological and Physiological Acoustics:

Methods for Community Noise Testing and Analysis I (2aNS6)

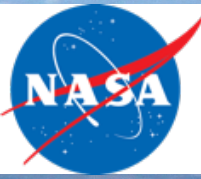
Tuesday, December 6, 2022

Outline



- **Quesst Mission Overview**
- **Key Elements**
- **Site Selection Overview, Sampling Approach and Tiered Criteria**
- **Airfields from Tiers 1 and 2**
- **Process for Identifying Best Recruitment Regions**
- **Airfield Processing and Sequencing Considerations**
- **Status and Plans**

Quesst Mission Overview and the X-59 Aircraft



Key requirements drive X-59 design

- The acoustic signal must effectively replicate that of future larger supersonic commercial aircraft.
- The X-plane must conduct community overflight tests using normal commercial aircraft flight maneuvers.



Use the X-59 Research Aircraft to gather data on community response to quiet supersonic flight

Phase 1: Research Aircraft Development (2018-24)

- Design, fabrication, ground test, and envelope expansion

Phase 2: Acoustic Validation (begins 2024)

- Detailed ground and flight measurement to prove design

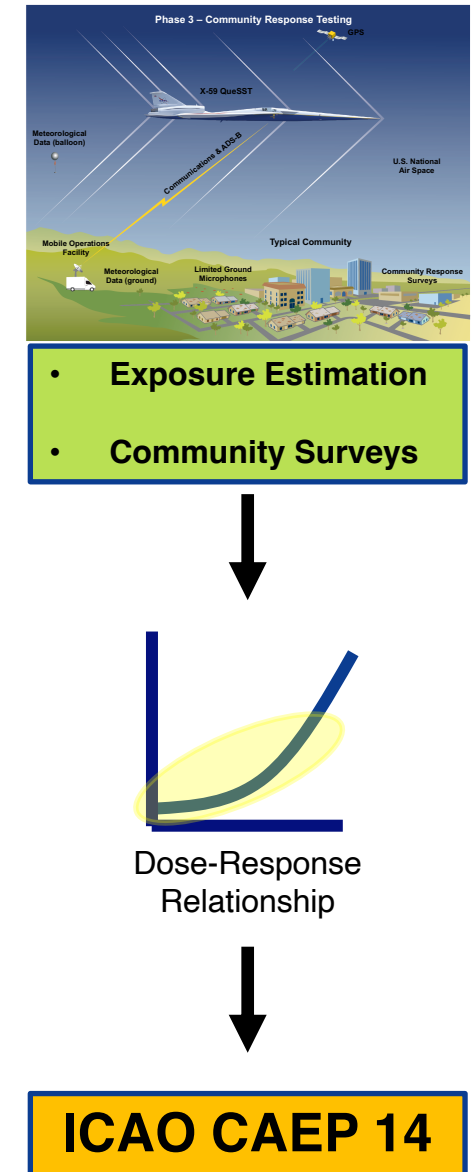
Phase 3: Community Response Testing (begins 2025)

- Overflights, sound measurement, surveys

Key Elements of Community Testing (Quesst Phase 3)



- **Test site selection**
 - **Ensure representativeness**
 - **Deployment coordination/logistics**
 - **Public engagement**
- Survey Design and Analysis
 - Participant recruitment
 - Data analysis/statistical methods
 - Tests of survey implementation, automated data processing methods
- Exposure Design and Estimation
 - Acoustic monitor placement strategies
 - Recording and extraction of signature
 - Characterization of carpet over test area (combining prediction and measurements)
- Developing Dose-Response Relationship and Delivery to ICAO
 - Matching exposure levels with participant location
 - Aggregating of multiple community test results
 - Ensuring validity/acceptance of technical approach



Airfield and Community Test Site Selection



- Quesst Mission's Phase 3 = Community Response Testing (CRT)
 - 4-6 Community Tests (CTs)
 - Each CT will consist of multiple sorties by the X-59 aircraft from a single airfield over a one-month period
 - Each CT site will have at most 1 boom carpet under which survey/acoustic/weather data will originate (~2000 sq mi)
- Nationally representative community response dataset to low-intensity sonic booms is required
- Airfield/Site selection governed by:
 - X-59 being an "X" plane (one aircraft) with operational constraints (e.g., range)
 - High-profile nature of the project, i.e., US and international scrutiny
- Requires the selection be:
 - Statistically rigorous, like the FAA's Neighborhood Environmental Survey and other projects informing policy
 - Repeatable, traceable, defensible to US and international regulators
 - Minimally subjective



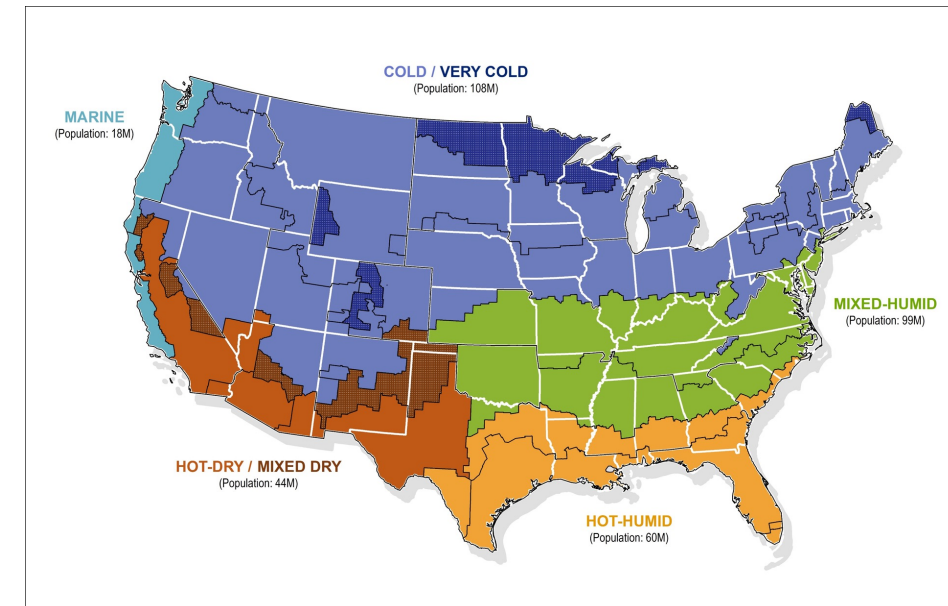
National Representativeness Goal

- True statistical representativeness (TSR):
 - Is unbiased for its target population characteristic
 - Has quantifiable level of uncertainty
 - Is achieved through explicit randomization
 - Difficult to achieve, given:
 - Single, experimental aircraft
 - Limited range and flight time
 - Quesst's Mission Phase 3 allows for only a limited number of Community Tests (CT)
- Achieve *dictionary-style* general representativeness through “purposive sampling”
 - Specifying CT site characteristics of interest (must be explicitly stated in study results)
 - Purposively selecting the sample locations to cover diversity of locations re these characteristics

Purposive Sampling Proposed Approach



- Differentiate variability within and between Community Test (CT) sites via important characteristics:
 - Planning for 4-6 CT's, assuming 5 in this approach
 - Geography -- US region
 - 1 CT site in each of the 5 US regions (e.g., NE, SE, NW, SW, Central) or 5 climate zones
 - Race/ethnicity diversity
 - 1 CT site mostly African-American residents; 1 CT site mostly Hispanic residents; 3 CT sites closer to national distribution
 - Urbanicity or population density
 - 1 CT site mostly rural; 2 CT sites mostly urban; 1 CT site w/unspecified composition (mixed)
 - Age distribution
 - Income distribution (or education level and home ownership)
- Justifying national representativeness by explicit reference to the chosen characteristics and detailed description of the studied communities



Source:

https://atlas.eia.gov/datasets/0c432b67293048b6a4704232a26ca99f_0/explore?location=38.345487%2C-101.857695%2C5.15", accessed 1/18/22.

Tiered Criteria Overview



Tier	Criteria Category			Purpose
	Operational	Technical	Miscellaneous	
1 & 2	Yes	No	No	Purely operational; used for initial down-selection of airfields
3	Yes	Yes	Yes	Mostly informs purposive sampling; GIS-style analyses
4	Yes	Yes	No	Facility-specific; highly detailed

- **Community Test (CT)-dependent**

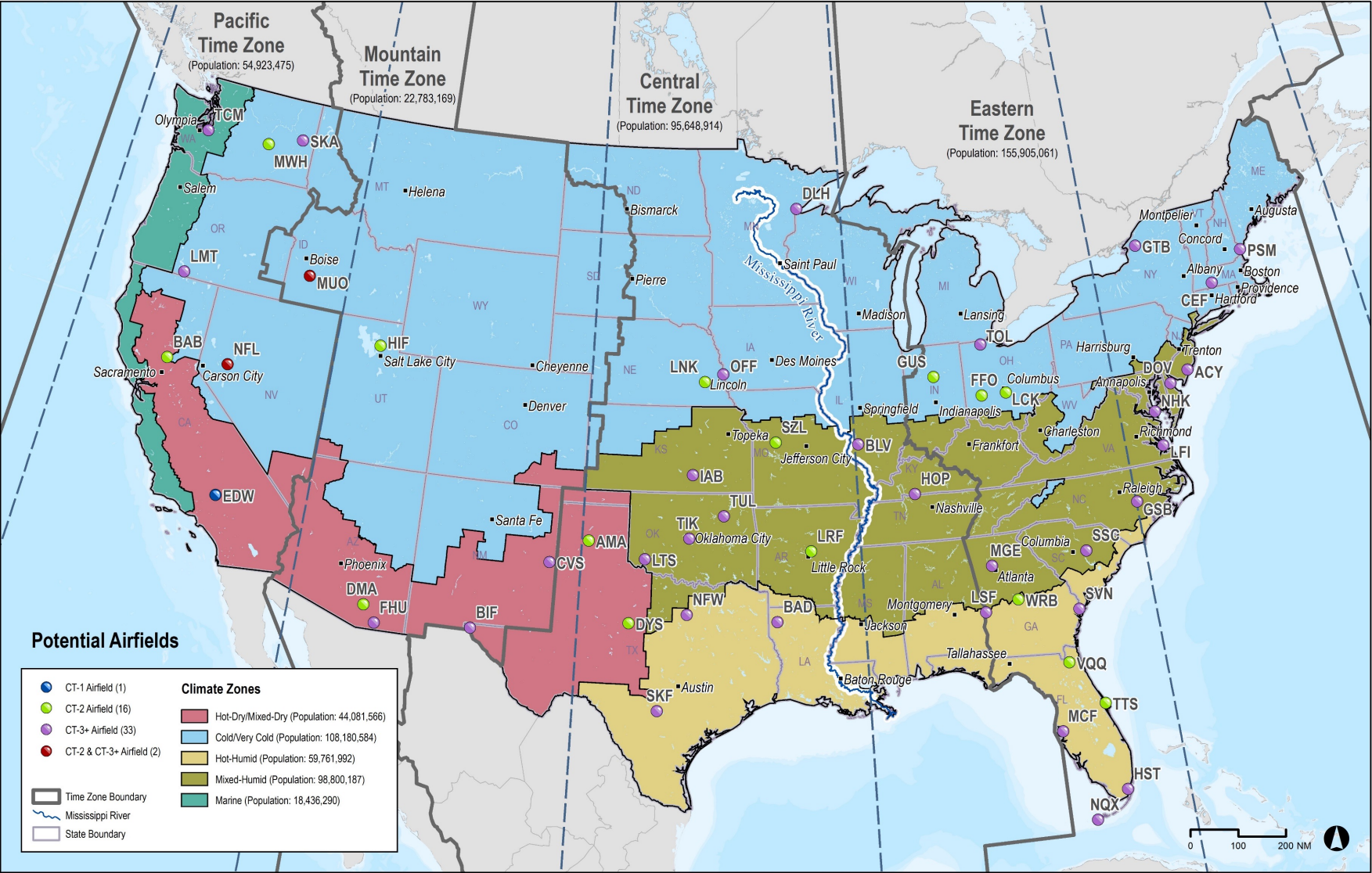
- CT1 is Edwards Air Force Base, CA
 - Satisfies Tiers 1, 2 and 4; Tier 3 was applied later
- CT2 criteria are somewhat more restrictive than criteria for CT3, CT4 and CT5



Criteria for Tiers 1 and 2 (operational category)

ID	Requirement	Tier	CT2	CT3, CT4, CT5
1.1	Operational military, NASA, or joint military/civilian airfield within contiguous US, with operating air traffic control towers, and without obvious extreme security constraints (FAA Classification: Public Ownership/Public Use, Public Ownership/Private Use)	1	Yes	
1.2	Same as 1.1 except also allow Private Ownership/Public Use; disallow Private Ownership/Private Use)	1		Yes
2.5	Available airfield runway length $\geq$ 12,000 feet	1	Yes	
2.2	Available airfield runway length $\geq$ 10,000 feet	1		Yes
3.5	Airfield runway width $\geq$ 200 feet	1	Yes	
3.2	Airfield runway width $\geq$ 150 feet	1		Yes
5	Airfield runway elevation between 1 and 5000 feet MSL	1	Yes	Yes
4	Runway surface of concrete or PEM (partially concrete, asphalt or bitumen-bound macadem) or good condition asphalt	1	Yes	Yes
18.1	Instrument Landing System (ILS) desired	1	Yes	
18.2	ILS desired; Global Positioning System (GPS) approaches may be adequate	1		Yes
8.1	At least 1 emergency landing airfields/runways (~10,000+ feet long) within 150 nm of airfield (assumes primary airfield is near and end of proposed flight track. If not, a second emergency landing airfield/runway may be required)	2	Yes	Yes
9	Avoid host airfields with more than 100,000 annual airfield operations in CY19 to facilitate potential for three X-59 flights/day	2	Yes	Yes

Database Development, Applying Tiers 1 and 2

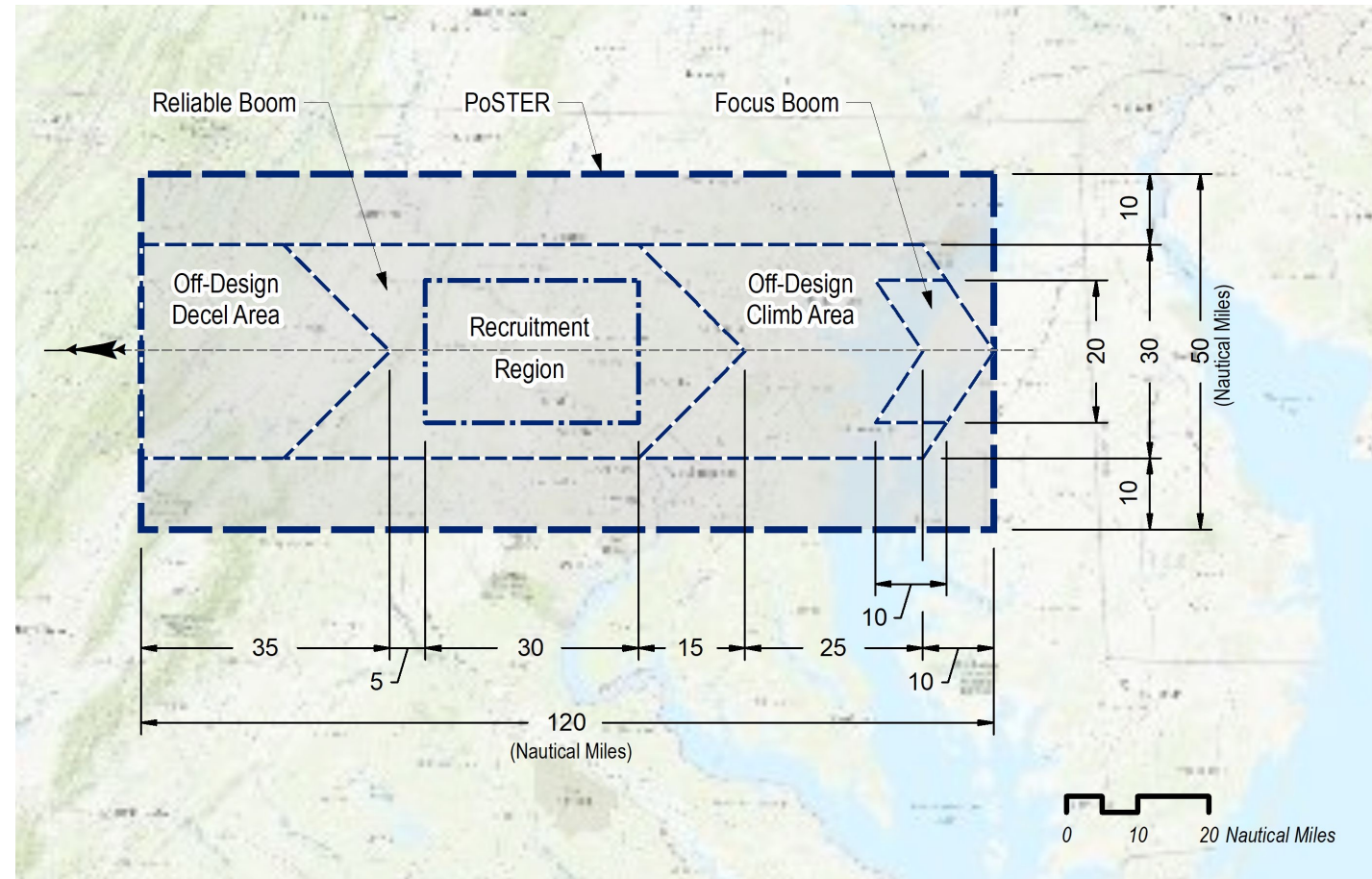


Standard PoSTER



- **Potential Supersonic Thump Exposure Region** and sub-areas

- Based on NASA's PCBoom analyses
- 120 x 50 nm rectangle
- Focus boom chevron
 - ~10 x 20 nm
 - Begins at entry point of PoSTER
- Reliable Boom Carpet (RBC) chevron
 - ~50 x 30 nm
 - Begins ~35 nm from PoSTER entry
- Recruitment Region (RR) rectangle
 - 30 x 20 nm
 - Begins ~15 nm from RBC entry
- Off-condition areas bookend the RBC
 - Climb (modified chevron)
 - Deceleration (trapezoid)

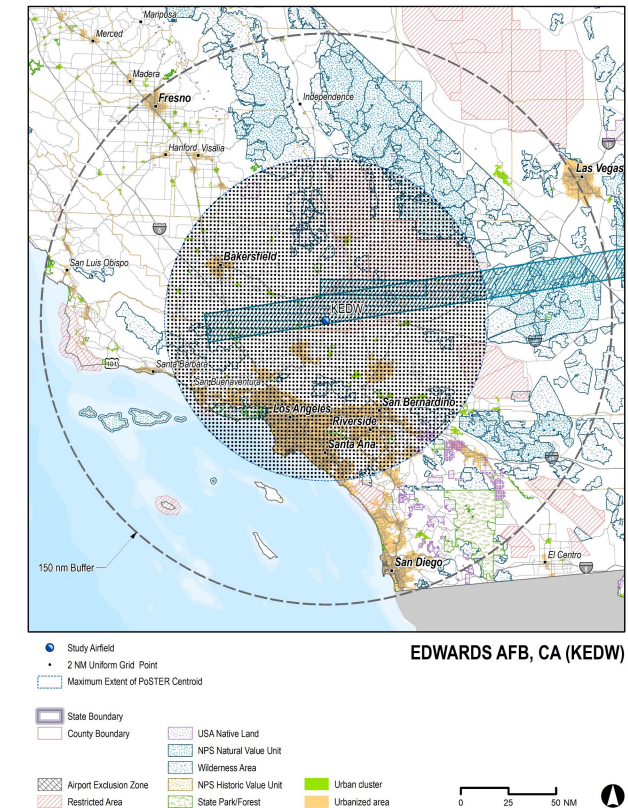


Computational Process for GIS Analyses/Tier 3 Criteria



- **March PoSTER along grid points**

- 2 nm spacing, rotate PoSTER (and sub-areas) 0-355 degrees, in 5-degree increments
- Count populations/demographics
 - 2020 US Census block-level population and urbanicity
 - Recruitment Region (RR) requires at least 40,000 dwelling units
 - Focus boom population (<5 pp per sq mi)
 - 2020 American Community Survey (ACS) block-group data for race, ethnicity, age, income and education
- Results put in an SQL database
- Filter out PoSTERs not meeting the relevant/applicable criteria
 - Focus boom chevron cannot overlap a “noise-sensitive” area (NSA)
 - No Native American (tribal) lands within any chevron
 - considered for approval streamlining, but being re-evaluated
 - No RR overlap with Restricted Areas with floors of less than 1,000 ft AGL (and established supersonic corridors for CT1)
 - Noise Bias Zone exclusions (5 nm) for the RR



Five types of noise-sensitive areas

Computational Process concluded



- **Post-processing**

- Structured Query Language (SQL) queries and calculations
- Excel workbook
- Map 10-best PoSTERs
- Plot summary statistics

- **Discuss with NASA**

- Run NASA's custom PoSTERs if ranked standard PoSTERs not operationally preferred or viable

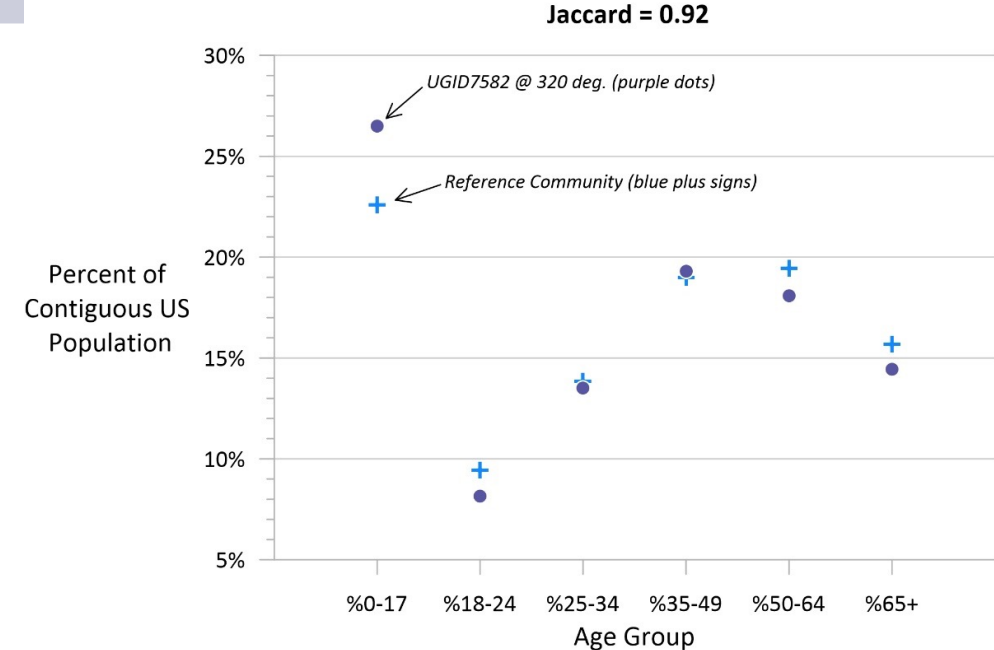
PoSTER Ranking



Ranking Characteristic	CT1	CT2+
Off-design climb/acceleration population (lowest)	Yes	Yes
Age distribution*	Yes	No
Income distribution*	Yes	No
Noise-Sensitive Area (sum of 5 types) percentage of Recruitment Region (lowest)	Yes	Yes
*best matching contiguous US		

$$Jaccard(A, B) = \frac{A \cap B}{A \cup B}$$

- **Off-design climb/acceleration population**
 - Ranks 1 to 1,000; bins initially based on the data range
 - 20% of population at or beyond rank of 1,000
- **Race, Ethnicity, Income and Age distros**
 - Race (African American) and Ethnicity (Hispanic) difference to Reference Community (contiguous US)
 - Jaccard Similarity Coefficient (JSC) used to compare RR's income and age distributions to the Reference Community's distribution





Airfield Processing and Sequencing Considerations

- **CT1 is Edwards Air Force Base, CA; primarily hot-dry/mixed-dry climate**
- **For CT2+, NASA's initial guidance was to process up to 2 airfields per climate zone per CT**
- **CT2 and CT3**
 - Cold and Hot-Humid (northwest and southeast)
 - 10 possible airfields, 4 of which are mixed use or civilian airports; 5 processed
- **CT4+, at least 500 nm from Hot-Humid (mostly Mixed Humid)**
 - Northeast, mid-Atlantic and Midwest;
 - 6 possible airfields, 3 of which were mixed use airports; 3 processed
 - Midwest
 - 6 possible airfields, 1 of which was as civilian airport; 1 processed
 - Still processing candidate solutions
- **Processed 10 airfields to date (nearly 100 PoSTERs)**
- **Sequencing is notional; will depend on time of year when testing begins**

- **Current status**

- Identified at least one boom carpet per processed airfield
- Have a mix of geography across the contiguous US (via climate zones)
- Level of success still being optimized for race, ethnicity and urbanicity across CT's, will ultimately depend upon selected airfields/PoSTERs
 - PoSTERs found African American and Hispanic RRs at 2-3 airfields, but remaining airfields' PoSTERs may not match the Reference Community well
 - Urbanicity success is TBD

- **Decision on final guidance and recommendations for airfield evaluations**

- Review and consideration of recommendations from contractor
 - Potential additional analyses/airfield processing
 - Maximize the purposive sampling
- Tier 4 criteria to be applied/researched for airfields, including site visits