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A Preliminary Assessment of Airport Noise and Emission Impacts Induced by Small Aircraft Transportation System Operations

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[Abstract] This paper evaluates potential noise and emission impacts associated with an advanced Small Aircraft Transportation System (SATS). Specifically, the analysis presented in this paper quantifies possible noise and emission contributions of advanced single-engine and multi-engine piston-powered aircraft and very light jet-powered aircraft. The noise impact analysis is carried out using the standard Federal Aviation Administration (FAA) Integrated Noise Model (INM). The emission influence is modeled using the FAA Emission and Dispersion Modeling System (EDMS). The noise signature and emission parameters of a new generation Very Light Jet (VLJ) are modeled in our analysis. Major emission pollutant level is estimated at 3,415 airports. Noise contours studies are conducted at five airport noise impact spanning both metropolitan and rural General Aviation (GA) airports. Sensitivity analysis is conducted to evaluate influence of the fleet composition and advanced approach procedures in the present and future years.

Nomenclature

I. Introduction

THE Small Aircraft Transportation System (SATS) is a concept proposed by the National Aeronautics and Space Administration (NASA) to employ advanced small aircraft (propeller and jet-powered) to satisfy point-to-point, on-demand air transportation services using existing underutilized airports. The SATS program represents a joint effort by government, industry and academia to improve the intercity mobility of various communities in the country. Part of the SATS program goals is to develop aircraft technologies and four operational technical capabilities to make this a reality. From the beginning of the program, SATS proponents identified noise impacts as critical to the acceptance to the concept. To understand potential noise impacts at airports, the Virginia Tech Air Transportation Systems Lab developed a Transportation System Analysis Model (TSAM) to assess impacts of SATS in the National Airspace System (1). TSAM uses county-level socio-economic data to forecast the number of intercity trips in the United States. The model uses proven transportation engineering methods to predict the number of travelers selecting among various modes of transportation (i.e., auto, airline, and other technologies like Very Light Jets and piston-powered aircraft operating as air-taxis). The demand for on-demand air transportation services has been evaluated at 3,415 SATS technology enabled airports. The demand function at each airport is characterized in terms of daily person-trips and daily flight arrivals and departures.

This paper presents the evaluation of noise and emission impacts performed typical SATS enabled airports using the TSAM model. The noise impacts of SATS operations are assessed at five representative airports using the standard Federal Aviation Administration (FAA) Integrated Noise Model (INM) version 6.1c. The emission influences are modeled at 3,415 SATS compatible airports using the standard FAA Emission and Dispersion Modeling System (EDMS).

Three representative SATS aircraft are modeled in our study: 1) a new generation Very Light Jet (VLJ) aircraft, 2) an advanced technology Single-Engine (SE), piston-powered aircraft, and 3) an advanced technology Multi-Engine (ME), piston-powered aircraft. The VLJ aircraft is modeled as a new vehicle with advanced low-thrust, medium by-pass ratio turbofan engines in INM. VLJ aircraft have relatively slow approach and takeoff speeds (belonging to approach speed group A) and the Sound Exposure Level (SEL) curves have been adjusted to account for lower thrust produced by VLJ engines. The emission matrices of the VLJ including Carbon Monoxide (CO), Total Hydrocarbon (THC), Non-Methane Hydrocarbons (NMHC), Nitrogen Oxides (NOx) and Sulfur Oxides (Sox)

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are modeled using regression analysis. The advanced Single-Engine and Multi-Engine aircraft are substituted by aircraft with analogous features.

SATS noise impacts are evaluated at five general aviation airports: Manassas, Virginia (HEF), Blacksburg, Virginia (BCB), Danville, Virginia (DAN), Teterboro, New York (TEB) and Goodland Municipal Airport, Kansas (GLD). These airports were selected among 3,415 airports modeled in TSAM because they represent a good cross-section of airport operations, aircraft mix, runway configurations and proximity to population centers. The INM required population and street files are obtained from the U.S. Census Bureau Census 2000 (2) and TIGER 2000 (3) database. The topographical features around these airports are integrated using 3-second elevation data. Baseline scenarios without SATS activities are executed based on average daily traffic operations and using the based aircraft fleet mix reported by Airnav (4). Day and night operations of different aircraft groups are estimated using the General Aviation and Air Taxi Activity (GAATA) report (5). The GAATA categorizes general aviation aircraft into five major groups and this categorization is applied in our analysis: Single-Engine Piston-Powered, Twin-Engine Piston-Powered, Single-Engine Turbo-Propeller, Twin-Engine Turbo-Propeller and Jet. VFR and IFR flight paths are constructed using the U.S. Terminal Procedural charts (6) and pilot anecdotal information. Runway utilization estimation is gathered from various sources including wind data, tower observations, pilot anecdotal information and the FAA Aviation Systems Performance Metrics (ASPM) (7) reports. Local operation information is used wherever available.

SATS emission impacts are assessed at the full spectrum of 3,415 airports that satisfy typical operational requirements of SATS aircraft. A current small aircraft, the Cessna Citation Sovereign is modified to simulate emission rates of the VLJ. Fuel flows of the VLJ are estimated by back engineering analysis of the VLJ drag polar. Regression analysis reveals a linear relationship between thrust and NOx emission rate. Two general assumptions are made (Table 1). The total taxi and queuing time is a function of the number of operations per runway per day. The number of operations of each five major aircraft groups applies a weighted average of the number of based aircraft and operation statistics reported by the GAATA.

Table 1: General Assumptions.

<table>
<tr><th colspan="4">Assumptions for Total Taxi and Queuing Time and Local Traffic Assignment</th></tr>
<tr><td>Number of Operations per Runway per Day (N)</td><td colspan="2">Total Taxi and Queuing Time (minutes)</td><td>Percentage of Reported Local Traffic Assumed to be LTO Cycles / TGO Operations</td></tr>
<tr><td>N >200</td><td colspan="2">30</td><td>80% / 20%</td></tr>
<tr><td>200> N >100</td><td colspan="2">20</td><td>50% / 50%</td></tr>
<tr><td>N < 100</td><td colspan="2">10</td><td>20% / 80%</td></tr>
<tr><th colspan="4">GAATA Aircraft Categories and Operation Statistics (Year 2000)</th></tr>
<tr><td colspan="2">Aircraft Type</td><td colspan="2">Reported Number of Annual Landings (in millions)</td></tr>
<tr><td colspan="2">Piston – 1 Engine</td><td colspan="2">27.59</td></tr>
<tr><td colspan="2">Piston – 2 and More Engines</td><td colspan="2">2.52</td></tr>
<tr><td colspan="2">Turboprop – 1 Engine</td><td colspan="2">1.37</td></tr>
<tr><td colspan="2">Turboprop – 2 and More Engines</td><td colspan="2">2.63</td></tr>
<tr><td colspan="2">Jet Engines</td><td colspan="2">2.18</td></tr>
</table>

Future scenarios with SATS operations are executed based on the SATS demand estimated by the Virginia Tech TSAM Model. A typical SATS aircraft, the Very Light Jet (VLJ) is developed as a new aircraft and engine model in both INM 6.1c and EDMS 4.2 to represent emerging very light jet technologies such as the Eclipse Aviation 500 and the Cessna Mustang. Representative aircraft selected to model single-engine and multi-engine SATS aircraft are shown in Table 2.. All SATS operations are assumed to be itinerary.

TABLE 2: Representative Aircraft.

Baseline Scenario		
Aircraft Category	Representative Aircraft for Noise Analysis	Representative Aircraft for Emission Analysis
Single-Engine Piston-powered	1985 single-engine FP Prop	Cessna 172 Skyhawk
Multi-Engine Piston-powered	Beech Baron 58P	Aztec
Single-Engine Turboprop	Beech T34 Mentor	400A Hustler
Multi-Engine Turboprop	Cessna Citation II	Cessna 441 Conquest II
Jet	Mitsubishi Mu-300 Diamond	Mitsubishi Mu-300 Diamond
SATS Scenario		
Single-Engine small aircraft	Cessna 206H Stationair	Socata Tampico
Multi-Engine small aircraft	Cessna Conquest II	Cessna Conquest II
		Beech King Air 350
Very Light Jet	Very Light Jet	Very Light Jet

II. Literature Review

Since the late 1950s, air transportation noise has generated controversy from many communities around airports. This concern led to the passage of legislation by Congress and thus regulations by the aviation administration. In the early years, noise at airports was surveyed by continuously monitoring sound exposure levels at places of interests. An important survey revealed that when the sound levels exceed 65 decibels, people report a noticeable increase in annoyance (8). This survey assigned additional weight to sounds at night and this measurement became the standard aviation noise measurement: Day/Night Average Sound Level (DNL).

The increased number of noise studies around airports prompted the development of the Integrated Noise Model (INM) by the Federal Aviation Administration (FAA) in 1978. This model is the standard tool accepted by the federal government to conduct Federal Aviation Regulation (FAR) Part 150 noise compatibility planning and FAA Order 1050 environmental analysis (9). It is an average value model to quantify annual noise influences using the concept of an 'average annual day'. The average annual day comprises various typical long-term average conditions. These conditions serve as inputs to the INM Model as shown in Figure 1. The DNL is one of the 16 noise metrics supported by INM. The aircraft profile and noise calculation algorithms are based on three documents (10): the Society of Automotive Engineers (SAE) Aerospace Information Report (AIR) SAE-AIR-1845 (11), SAE-AIR-1751 (12) and SAE Aerospace Recommended Practice (ARP) SAE-ARP-866A (13). Noise impacts are reported by contour areas, population affected and noise level at points of interests.

In addition to the single-airport analysis tool INM, Metron Aviation developed the Noise Integrated Routing System (NIRS) under contract to the FAA to address large-scale aviation noise modeling over multi-state regions (14). The first version of NIRS was introduced in 1998 and new capacities are integrated continuously. The NIRS model allows users to specify tracks in three dimensions or follow standard tracks. Traffic elements that cause principle noise impacts can be identified. It also provides comparisons of noise impacts across alternative airspace routing designs. Noise analysis results of NIRS are presented by noise comparison maps and tables.

The INM models fixed-wing aircraft operation noise impacts and helicopter and rotorcraft are modeled by the Heliport Noise Model (HNM) and the Rotorcraft Noise Model (RNM). The HNM is based on the INM but it is able to model more complicated helicopter flight activities. The RNM, developed by NASA, is capable of developing approach and departure noise abatement procedures to promote civilian use of rotorcraft (15).

As a military counterpart of the INM, Noisemap has been used to model sound exposure in the vicinity of military air bases. Another military aircraft noise analysis model called the Military Operating Area and Range Noise Model calculates noise from subsonic military aircraft over Military Training Routes (MTRs), Military Operating Areas (MOAs) and Special Use Airspaces (such as ranges).

One common feature of all models is the evaluation of noise exposure due to multiple aircraft activities. Single aircraft flyover noise levels can be evaluated using Menu 10 or an updated version Sound Exposure Level Calculator

(SELCal). There are papers on enhancements to INM and INM error analysis in the literature. This paper will not address these issues.

Emission represents another primary environmental concern introduced by air transportation besides noise. Research on aviation emission effect is driven by increasing air transportation activities and environment protection awareness since the 1960s.

The most widely applied terminal area emission analysis model in U.S. is the Emission and Dispersion Modeling System (EDMS) developed by FAA. In 1998, FAA revised its policy on air quality modeling procedures to identify EDMS as the required model to perform air quality analyses for aviation sources instead of a preferred model. It utilizes Aircraft Engine Emission Databank provided by ICAO to estimate emissions during five phases, namely idle, takeoff, climb out, approach and touch-and-go operations. The model integrates several Environment Protection Agency's (EPA) model to estimate aircraft, Ground Support Equipment (GSE) and Auxiliary Power Unit (APU) emissions. Pollutants such as Total Hydrocarbons (THC), Non-Methane Hydrocarbons (NMHC), Volatile Organic Compounds (VOC), Oxides of Nitrogen (NOx), and PM2.5 are calculated. EPA's state-of-art dispersion model AERMOD, along with its supporting modules, is integrated for dispersion analysis. As detailed airport information is required for dispersion analysis, air quality evaluation will concentrate on emission only. The EDMS does not estimate emission beyond mixing height. Model's default mixing height is 3,000 ft and user can modify this value according to local condition.

For altitude beyond 3,000 ft, a method developed by Boeing Company called Boeing Method (BM2) has been widely applied. Different from the EDMS, BM2 emission estimation is based on power levels instead of set mode points. It is essentially a curve fitting method that plot emission indices and fuel flow on a logarithmic basis and make a series of linear fits between pair of mode points.

Similarly, EUROCONTROL developed a Toolset for Emission Analysis (TEA) including an emission module Advanced Emission Model (AEMIII), a contrail formation prediction tool CONTRAIL, and a meteorological database. The AEMIII applies the same emission estimation philosophy in the vicinity of the airport as the EDMS and extends the analysis to en-route. En-route emission analysis is based on aircraft fuel burn calculated using the Base of Aircraft Data (BADA). Emission rate and fuel flow from the ICAO databank is adapted to the atmospheric condition using the BM2. The model output agrees well with the historical data.

III. Modeling

The SATS population considered in the analysis includes proposed very light jets weighing less than 3,181 kg (7,000 lb). The new generation of VLJ aircraft is best represented by the Eclipse 500, recently achieved FAA type certification. The analysis also considers representative turboprop aircraft. Examples of existing vehicles in this category are the Raytheon B300, Pilatus PC-12, and Cessna Caravan. New generation of high-performance single engine piston-powered aircraft (Cirrus SR-22 and Lancair 400) are also considered in the analysis. In the INM and EDMS, single engine and multi-engine turboprop are modeled using similar aircraft (i.e., substitution method) because the powerplants and flight characteristics of new generation SE piston-powered aircraft are similar to modern aircraft in the same category today.

A. Noise and Emission Characteristics of the Very Light Jet

The VLJ modeled in the analysis models a pressurized aircraft with six people (including pilots), cruises at 676 km/hr (365 knots) and has a range of 2,037 km (1,100 nautical miles) with four occupants using National Business Aviation Association (NBAA) IFR reserves . The VLJ is equipped with two medium by-pass ratio turbofans producing 1100-lbf takeoff thrust at sea level static conditions.

The noise profile of the very light jets is created in the INM as they represent new generation of small jets powered by substantially lower thrust engines than their current corporate jet counterparts. The most similar corporate jet model in the INM aircraft database is the Cessna Citation II. This aircraft is selected as the baseline vehicle and then substantially modified to represent the expected acoustic and performance characteristics of the VLJ. Table 3 shows the general characteristics of the new VLJ aircraft created in the INM aircraft database. The noise profile characteristics are presented in Figure 1. Compared to first generation corporate jets, very light jets are expected to have relatively small noise footprints. Advances in engine noise reduction technology and the low thrust of the new generation turbofan engines are likely to make these aircraft very quiet. Another advantage of the VLJ is their relatively modest approach and takeoff speeds. The 3,000 kg VLJ prototype in this analysis has an approach speed of 166 km/hr (90 knots) at maximum landing weight.

TABLE 3: General Parameters of the Modeled Very Light Jet Employed to Derive Noise Signature.

Category	Parameters	Value
Weight Summary	Maximum Takeoff Weight	2,579 kg (5,640 lbs)
	Maximum Landing Weight	2,431 kg (5,360 lbs)
	Maximum Landing Distance	762 meters (2500 ft.)
Engine	Number of Engines	2
	Static Thrust	1100 lb
Maximum Climb Jet Coefficients	E	900 lb
	F	-1.99614 (lb/kt)
	Ga	6.15000e-02 (lb/ft)
	Gb	-2.40502e-6 (lb/ft^2)
	H	0
Maximum Takeoff Jet Coefficients	E	900 lb
	F	-2.21793 (lb/kt)
	Ga	6.83330e-2 (lb/ft)
	Gb	-2.67224 (lb/ft^2)
	H	0

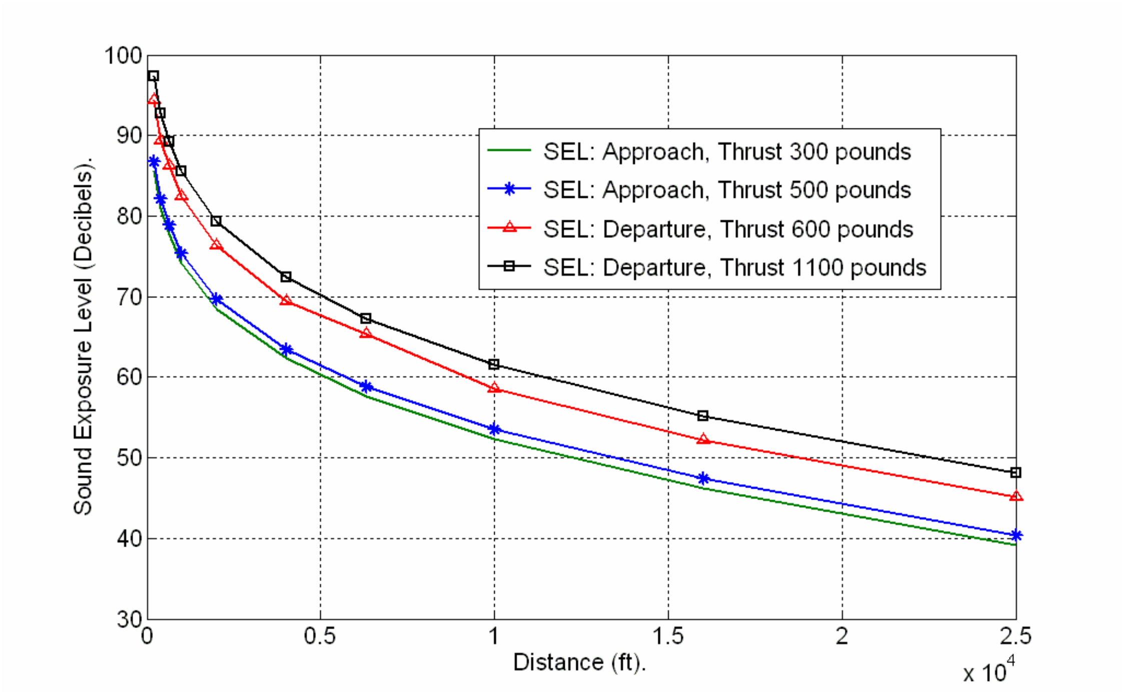

FIGURE 1: Sound Exposure Level (SEL) Curves of Very Light Jet Modeled.

To model VLJ emission characteristics, thirteen current corporate jet engine emission rate tables are extracted to establish basic statistical model between four emission indices (HC, CO, NOx, SOx). A liner relationship can be established between the NOx emission rate and the fuel flow. In the absence of published VLJ CO and HC emission rates, two assumptions are evaluated: same rate as current light jet corporate jets and a reduced (80%) rate. Cessna Citation Sovereign is used as a prototype to model VLJ. SOx emission rate is assumed to be consistent with current light corporate jets. The estimated emission parameters of the VLJ can be found in Table 4.

TABLE 4: Emission Indices of the SATS VLJ.

	Takeoff	Climb-out	Approach	Idle
Fuel flow (Kg/s)	0.140	0.120	0.030	0.012
CO Rate (g/Kg)	0.81	0.97	5.23	42.3
HC Rate (g/Kg)	0.09	0.10	0.14	5.94
NOx Rate (g/Kg)	6.77	10.93	2.20	1.60
SOx Rate (g/Kg)	0.54	0.54	0.54	0.54

B. SATS Noise and Emission Impact Analysis

Using the predicted noise footprints and emission indices of the very light jets and using aircraft substitution methods for SATS single and multi-engine, piston-powered aircraft, we derived airport noise contour maps and emission levels using the SATS demand function predicted by TSAM.

Throughout the analysis, we attempted a consistent level of detail across all five airports. Baseline operations without SATS are obtained from Airnav website, FAA records and tower records when available. SATS operations are estimated by the TSAM model and added to the baseline operations to study the potential environmental impact. The number of operations at each airport is shown in Table 3. Sensitivity analyses are conducted with different fleet composition and glide path angles for the year 2014. Two SATS fleets are tested in the analysis: 1) 100% of the SATS aircraft comprising very light jets and, 2) 30% single-engine, 30% multi-engine and 40% very light jet, comprising the SATS scenario. SATS scenarios are executed for 3, 4 and 5 degrees of Glide Path Angle (GPA) to evaluate the influences of advanced approach technology to mitigate noise and emission impacts.

Noise Case Studies

Five case studies are conducted at airports located at both metropolitan area and rural communities. The selected airports are representative of the spectrum of airports with future SATS enabled technologies. In our analysis, we identify specific operating patterns at those airports. When the local information is unavailable, assumptions are generally made based on pilot anecdotal experience. It is important to point out that general aviation traffic at non-towered airports is more difficult to characterize than commercial traffic at towered airports. Many general aviation airports lack accurate records on the number of both local and itinerant general aviation operations. At many of these small airports the Terminal Area Forecasts (TAF) data is generally unreliable.

Our analysis starts with several general assumptions made regarding the percent of day and night operations. The GAATA report states that 85% of the general aviation flights in the U.S. occur during daytime conditions. Similarly, 15% of the general aviation flights occur at night. The ratio of Visual Flight (VFR) and Instrument Flight Rules (IFR) is typically 85/15 in the NAS. Flight paths are constructed using U.S. Terminal Procedure Charts to model IFR arrivals and departures. VFR arrival and departure tracks are modeled using standard airport flight patterns. Three types of aircraft compose the SATS fleet: Single-Engine, Multi-Engine aircraft and Very Light Jet. The base scenario considers 37.5% of approach, 37.5% of departures and 25% of touch-and-go operations except for jets. Jets only operate 50% approach and 50% departures. All SATS operations are assumed to be itinerant operations with equal number of arrivals and departures. The general characteristics of the five airports studied are shown in Table 2. A brief description of each airport follows.

Teterboro Airport (TEB), Teterboro, New Jersey. Teterboro airport represents one of the busiest General Aviation (GA) airports in the country with substantial corporate jet operations. TEB is projected to attract a substantial number of SATS operations due to its proximity to the New York Metro Area. A total of 81 business jets are based at TEB today (16) demonstrating its high attractiveness to corporate aviation. To model the existing operations at TEB, an aircraft substitution scheme is developed based on the INM recommendations for various aircraft present in the INM database. Runway utilizations are obtained from the FAA Aviation System Performance Metrics (ASPM).

*Manassas Regional Airport / Harry P.Davis Field (HEF), Manassas, Virgini*a. The Manassas airport represents another busy GA airport. The airport has a fleet comprised of mostly single-engine aircraft (304) with 57 multi-engine aircraft and 10 business jets. Using the TSAM model, we forecast moderate SATS/VLJ traffic due to the proximity to the Northern Virginia and Washington DC areas. HEF was selected because its aircraft mix is different than that of TEB. Yet its location helps us understand SATS noise issues in metropolitan areas.

The GAATA landing statistics are used as the primary source to estimate operations of each aircraft group. Based on wind analysis, operations on each runway end are assigned as 80% on runway 16L/34R (1,737 meters) and 20% on 16R/34L (1,128 meters).

Danville Regional Airport (DAN), Danville, Virginia. Danville represents rural areas where SATS operations could improve the accessibility to air transportation and thus promote economic development. The airport has a fleet population very similar to the national average with 3 jet-powered, 5 multi-engine and 40 single-engine piston aircraft. The GAATA landing statistics and verbal communications with the airport control tower personnel are the main sources to estimate operations of each aircraft group. Runway utilization information is provided by observations from the airport tower personnel. A standard left-turn VFR is modeled corresponding to the flight practices at the airport.

Virginia Tech / Montgomery Executive Airport (BCB), Blacksburg, Virginia. Blacksburg represents another example of a rural airport with potential use of SATS on-demand services due to the proximity to a large State University and its Corporate Research Center. BCB is located around hilly terrain and represents a candidate to benefit from lower landing minima capability developed by the SATS Program (Highway-in-the-Sky Instrumentation, synthetic vision systems, and optimal energy steep approaches coupled with Wide Area Augmentation System navigation). Wind data, field observations and pilot anecdotal information provide detailed information about aircraft models, flight paths, number of operations on each path and runway utilization (17). Each flight path has been verified by local pilots flying at the airport. Eleven types of aircraft are modeled at the airport including a gyro-copter and a Robinson 22 helicopter. The gyro-copter and helicopter are created and added to the INM database using user-defined profiles and noise curves.

Renner Field / Goodland Municipal Airport (GLD), Goodland, Kansas. Goodland Municipal airport represents a third rural airport with potentially very low SATS demand. Based on the TSAM model airport demand estimation, the vast majority of 3,415 airports modeled are projected to have low to very low SATS demands. The GAATA landing statistics are used as the primary source of information to estimate operations at this airport. A detailed wind rose analysis using the FAA Airport Design software program AD42 is conducted for each runway end to derive runway utilization. The wind data is obtained from National Virtual Data System (NVDA) Local Data Publication (18) which provides weather information at 260 airports in the U.S.

Emission Impacts Analysis

SATS emission impacts are analyzed at 3,415 SATS enabled airports. Compared with noise analysis, the emission analysis attempts to apply national statistics instead of local information. The estimate uses FAA landing facility database to derive airport baseline operations. The same aircraft categorization is followed and one aircraft in EDMS database is chosen to represent the group. Aircraft emission indices in the EDMS are obtained from ICAO Aircraft Engine Emission Databank. Aircraft emission is the product of annual operations and emission rate. Emissions of Group Support Vehicles and Auxiliary Power Units are estimated by the integrated MOBILE 6.

IV. Results and Conclusions

In general, the analysis shows that SATS aircraft (including very light jets) could be good community neighbors. Compared to existing twin-engine jet aircraft, SATS aircraft are expected to have smaller noise and emission footprints. Table 4 and Table 5 list the INM and EDMS model results with the forecasted operations in the year 2014. Figures 2 through 6 show 65DNL contour maps at all five airports studied with a nominal three-degree GPA approach. Sensitivity analysis shows a mixed fleet generates slightly higher noise levels around airports. The changes to GPA seem to have very little impact on the noise exposure around the airports.

TABLE 4: INM Noise Analysis Impacts (65 DNL Contours, Year 2014).

Airport ID	GPA (Degrees)	Baseline Scenario		SATS Scenario VLJ Only		SATS Scenario Mixed SATS Fleet	
		Population Influenced	Area (Acres)	Population Influenced	Area (Acres)	Population Influenced	Area (Acres)
TEB	3	5,050	1,517.7	5,746	1,624.9	6,027	1,692.6
	4	5,050	1,517.7	5,627	1,617.4	6,027	1,687.1
	5	5,050	1,517.7	5,627	1,612.5	5,998	1,683.7
HEF	3	0	188.4	0	273.7	0	303.7
	4	0	188.4	0	269.4	0	300.4
	5	0	188.4	0	266.0	0	297.8
DAN	3	0	67.9	0	82.1	0	81.9
	4	0	67.9	0	81.8	0	81.8
	5	0	67.9	0	81.7	0	81.7
BCB	3	0	84.7	0	89.3	0	93.7
	4	0	84.7	0	89.2	0	93.7
	5	0	84.7	0	89.1	0	93.6
GLD	3	0	115.0	0	116.0	0	116.0
	4	0	115.0	0	116.0	0	116.0
	5	0	115.0	0	116.0	0	116.0

TABLE 5: EDMS Emission Impacts.

Compared to the Baseline (No SATS)	Takeoff	Climb-out	Approach	Idle
Maximum Increase (%)	2886.299	11151.81	230949.9	361055.5
Average Increase (%)	0.98	3.80	78.80	123.19

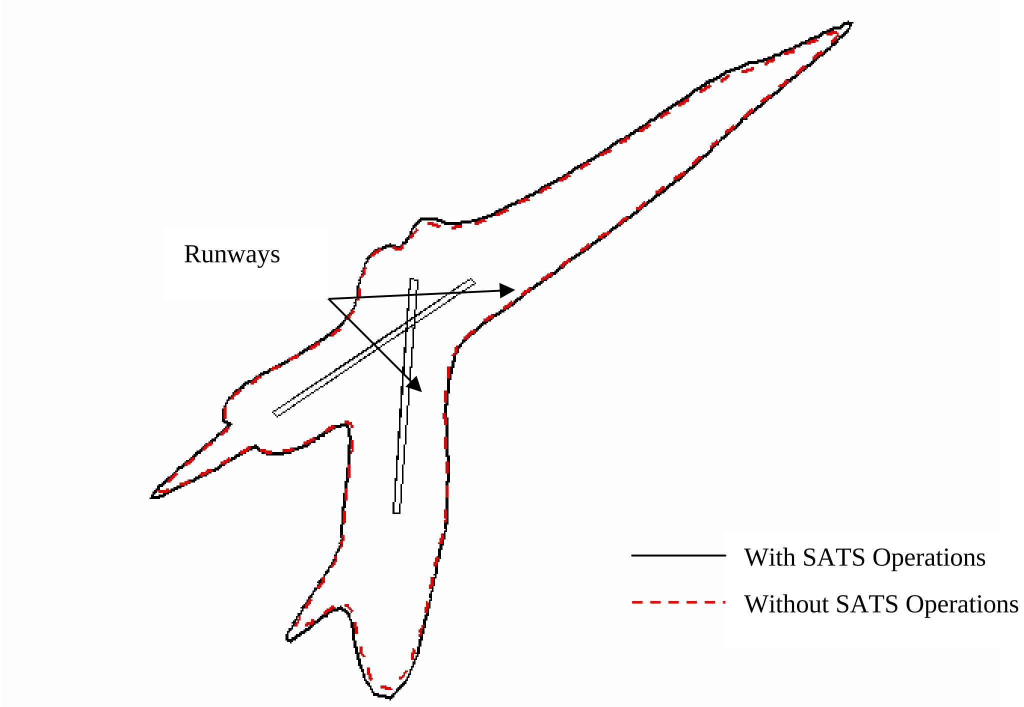

FIGURE 2: Teterboro Airport Noise Contour Maps (65DNL).

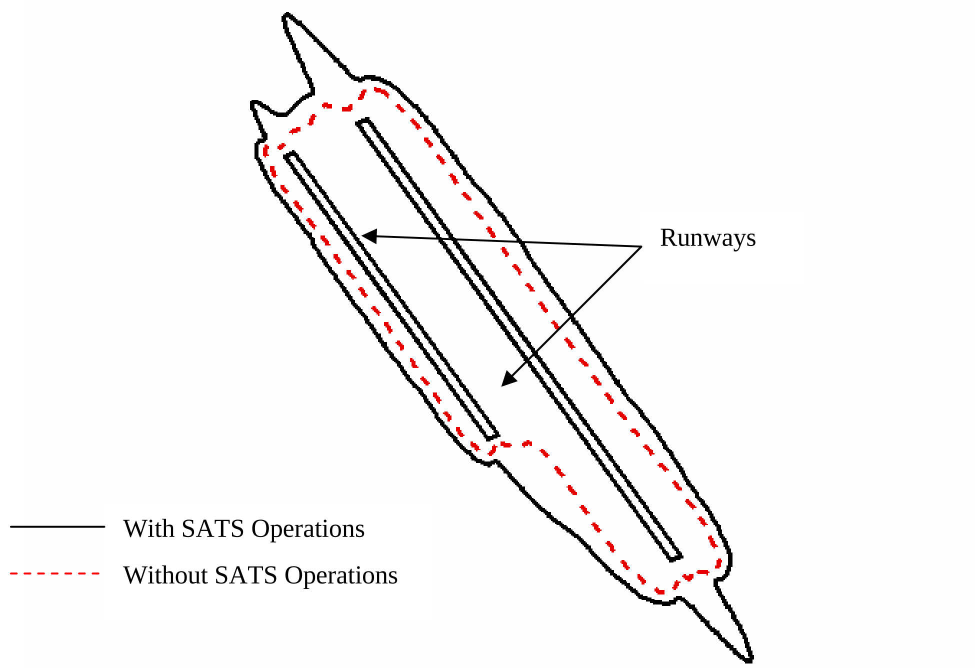

FIGURE 3: Manassas Airport Noise Contour Maps (65DNL).

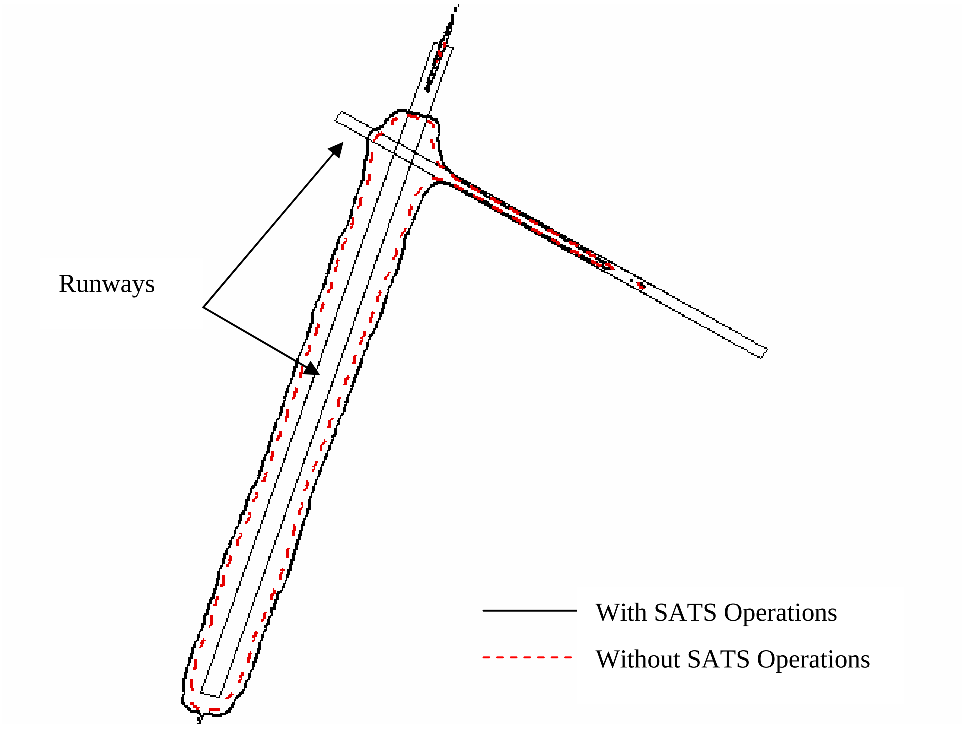

FIGURE 4: Danville Airport Noise Contour Maps (65DNL).

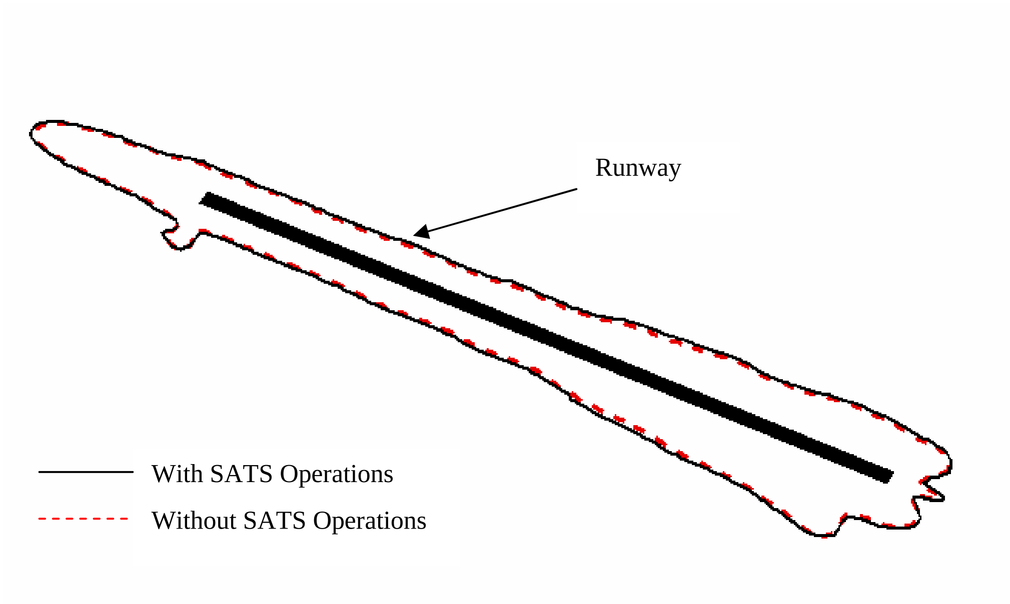

FIGURE 5: Blacksburg Airport Noise Contour Maps (65DNL).

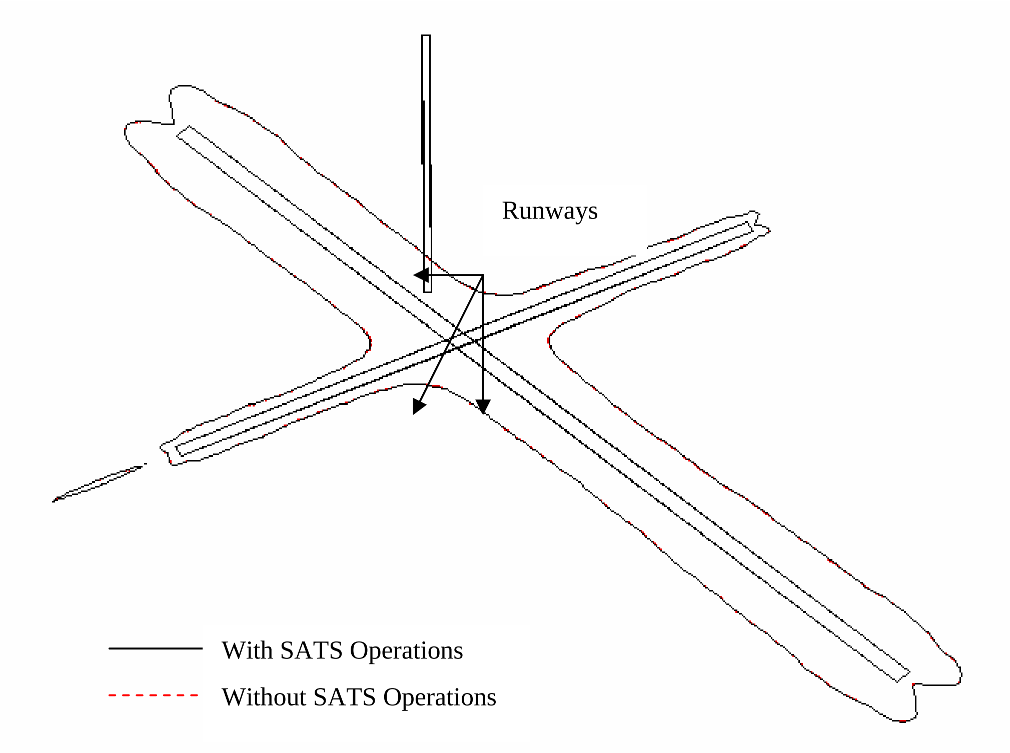

FIGURE 6: Goodland Airport Noise Contour Maps (65DNL).

In the analysis presented for the year 2014, a three percent annual growth in the GA operations has been assumed. Population density and distribution around the airports for the year 2014 are assumed to be the same as the Census 2000 survey. SATS demand is estimated using the TSAM model. The analysis shows that the additional SATS operations increase the 65DNL noise contours from 7% at TEB to less than 0.9% at a rural airport like GLD. The noise impact at a terrain-challenged airport like BCB is estimated to be 5%. At TEB an estimated five percent more populations would be affected after the introduction of SATS on-demand operations. It is important to put in context these numbers. If TEB enacts a ban to stage 2 corporate jets today, an estimated 11% reduction in the size of the 65DNL is possible. Estimate of major pollutant productions using the EDMS indicate a slight increase in CO, THC and NMHC and a significant increase in NOx and SOx. This result suggests careful environmental evaluation during deployment of the SATS system.

V. Recommendations

This paper presents a first assessment of the potential environmental impacts of SATS operations at various airports in the U.S.. The following recommendations could be pursued to improve the analysis presented in the paper.

- This study represents a "pessimistic" scenario in that all SATS operations are assumed to be additional operations above the current GA activities at each airport. This is the result of a new paradigm on-demand services possible with the introduction of VLJ and advanced SE and ME piston aircraft. SATS aircraft including the VLJs will probably have a replacement effect on existing aircraft technologies used today. Thus some of the older and noisier aircraft operating at these airports could probably be replaced by more environmentally friendly SATS aircraft. The authors are currently studying this replacement effect.

- The information on reliable local and itinerant operations at some rural airports is scarce. This is an issue that needs to be improved across NAS. The FAA Terminal Area Forecast (TAF) is unreliable and thus local information is preferred for airport impact studies. General survey and statistical data sources are preferred for nation-wide impact analyses. The analysis conducted in our study mixes local and general airport operational data as a best effort to model credible operations at each airport. Future efforts could use other data sources. For example, real-time or historical radar track data will be helpful in building flight paths and improve the estimation of runway utilization.

- The noise and emission signature of very light jets and new technologies should be continuously validated along with the flight test progress of the new SATS aircraft. At least two new generation VLJs will be certified in 2006 (the Eclipse 500 and the Cessna Mustang). Future noise impact studies will benefit from actual aircraft noise certification data.
- A more comprehensive nation-wide noise analysis is desired to address, at the national level, the impacts of SATS aircraft deployment. A method with virtual airports and virtual runways is being developed at Virginia Tech to address this concern. The method considers typical runway configurations and parametric SATS demands as two explanatory variables. Local adjustments will be made to account for specific local effects at all 3,415 airports or at other sets of airports studied.
- Commercial operation impacts should be included in future studies.

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