AO-1
Aircraft Operations
Analytical Approach

APPENDIX AO-1 AIRCRAFT OPERATIONS

Training activities involving aircraft operations by F-15Cs and F-22s form a focus of this Draft Environmental Impact Statement (EIS). These activities occur in airspace, a finite resource controlled and administered by the Federal Aviation Administration (FAA). For this proposed action and four alternatives, the extent and nature of the airspace and its use defines the location of the affected environment. Within the airspace, aircraft performing training activities generate noise and emit exhaust, so they can affect the noise environment and air quality. These activities must also be performed safely and with regard for all other users of the airspace. Because these training activities have the potential to affect air safety and airspace management and use, the Air Force has analyzed them in this Draft EIS.

Aircraft Sorties and Sortie-Operations

Throughout this Draft EIS, two terms are used to describe aircraft activities: sortie and sortie-operation. Each has a distinct meaning and commonly applies to a specific set of activities in particular airspace units. A sortie consists of a flight of a single military aircraft from takeoff through landing. The term sortie is commonly used to summarize an amount of aircraft activity at a base. A sortie-operation is defined as the use of one airspace unit (such as a Military Operations Area, or MOA) by one aircraft. Sortie-operations apply to flight activities outside the base airfield environment. Each time a single aircraft conducting a sortie flies in a different airspace unit, one sortie-operation is counted. During a single sortie, an aircraft may perform more than one sortie-operation.

Defining baseline and projected sorties at Langley Air Force Base (AFB) and the four alternative bases involved examination of training requirements, current airfield activities by all aircraft, and patterns of deployments. This process focused on the operational F-15Cs at the bases (except Tyndall AFB that supports F-15Cs for advanced fighter pilot training) for baseline and on the F-22s for projected sorties. Other aircraft operating at the base (either based or transient [visiting]) were also addressed, but would not change from baseline to projected. For the other aircraft, data derived from operations summaries for the airfields at each base provided the number of sorties by both based and transient aircraft during a representative busy day. These daily counts, when multiplied by flying days per year (i.e., 260 for Langley, Eglin, Mountain Home, and Tyndall AFBs and 240 for Elmendorf AFB) yielded the total annual sorties by other aircraft at each base.

To define a reasonable and representative count of baseline operational F-15C sorties at each base, several factors were considered:

- Number of Primary Aircraft Inventory (PAI) F-15Cs at a base.
- Average utilization rate for an F-15C (18 sorties per month).
- Amount of time and number of F-15Cs deployed or at off-base pre- or post-deployment training.

Table AO-1-1 presents the calculations for both on base and deployed or other off-base baseline sorties for operational (PAI) F-15Cs.

Table AO-1-1. Baseline Sortie Calculations								
Base	***(A)Total PAI F-15Cs***	***(B)Average Utilization Rate[1]***	***(C)Months***	***(D)Total Annual F-15C Sorties***	***(E)Average Number of Aircraft at Base***	***(F)Total Annual Sorties at Base***	***(G)Average Number of Aircraft Deployed***	***(H)Total Annual Sorties Deployed***
Langley	66	18	12	14,256	46	9,936	20	4,320
Eglin	48	18	12	10,368	32	6,912	16	3,456
Elmendorf	42	18	12	9,072	28	6,048	14	3,024
Mountain Home	18	18	12	3,888	12	2,592	6	1,296
Tyndall[2]	NA	NA	NA	NA	NA	NA	NA	NA

A = Based on baseline aircraft inventory for operational squadrons
B = Standard for F-15Cs
C = Months per year
D = (A x B) x C
E and G = Based on deployment patterns for Aerospace Expeditionary Force (Langley, Eglin, Elmendorf) and Aerospace Expeditionary Wing (Mountain Home)
F = (E x B) x C
H = (G x B) x C
Notes: 1. Sorties per aircraft per month.
2. No operational F-15Cs; only advanced fighter pilot training F-15Cs and F-22s.

At Tyndall AFB, baseline sorties reflect flight activities by F-15Cs and F-22s supporting advanced fighter pilot training plus those by other aircraft (as described above). Tyndall AFB supports advanced fighter pilot training for one squadron of 24 PAI F-15Cs (6,299 annual sorties) and two squadrons of F-22s (54 PAI aircraft). The aircraft delivery schedule for these F-22s begins with the first training squadron being fielded from February 2003 through September 2008, with 23 of the aircraft in place by July 2004. The second squadron will arrive between June 2007 and March 2008. Because the Air Force has already made the decision (Air Force 2000 - Tyndall EIS) to base the training F-22s at Tyndall AFB, the analysis of aircraft sorties assumes these training aircraft (11,326 annual sorties) are part of baseline conditions. These training F-22s would be conducting sorties by the time the full complement of operational F-22s would arrive at the base. As such, baseline sorties for the training F-15Cs and F-22s at Tyndall AFB reflect the level of activities analyzed in the EIS for this conversion action (Air Force 2000).

Defining the total number of baseline sorties at a base involved adding the F-15C sorties to the other aircraft sorties (Table AO-1-2). This also provided information on the percentage of total sorties performed by the F-15Cs.

Table AO-1-2. Calculation of Baseline Total Sorties				
Alternative	***(A)Baseline Sorties F-15C***	***(B)Percentage F-15C Sorties of Total Sorties***	***(C)Baseline Sorties Other Aircraft***	***(D)Baseline Total Annual Sorties***
Langley AFB	9,936	57%	7,595	17,531
Eglin AFB	6,912	26%	20,174	27,086
Elmendorf AFB	6,048	30%	13,977	20,025
Mountain Home AFB	2,592	18%	12,166	14,758
Tyndall AFB[1]	6,299	24%	19,949	26,248

A = Derived as per Table AO-1-1
B = A/D
C = Derived from Base Operations Summaries
D = A+C
Note: 1. Tyndall AFB supports F-15Cs for advanced fighter pilot training only.

To determine the projected number of sorties by the Initial F-22 Operational Wing, factors similar to those used for F-15C baseline sorties were used:

- Proposed number of PAI F-22s (72) at a base.
- Average anticipated utilization rate for an F-22 (20 sorties per month).
- Amount of time and number of F-22 deployed, at off-base pre- or post-deployment training, or at exercises at remote facilities.

Table AO-1-3 presents on- and off-base projected sorties for the F-22s. Table AO-1-4 shows the calculations used to derive total projected sorties at Langley AFB and the four alternative locations. With the exception of Tyndall AFB, these calculations involved eliminating (subtracting) the based F-15C sorties from baseline totals since the F-15Cs would be replaced by the F-22s. At Tyndall AFB, the baseline F-15Cs are used for advanced fighter pilot training and would remain even if the Initial F-22 Operational Wing would beddown at Tyndall AFB.

Table AO-1-3. Projected F-22 Sortie Calculations									
Base	***(A)Total PAI F-22s***	***(B)Average Utilization Rate[1]***	***(C)Months***	***(D)Total Annual F-22 Sorties***	***(E)Average Number of Aircraft Deployed***	***(F) Total Annual Sorties Deployed***	***(G)Average Additional Off-Base Sorties***	***(H) Total Off-Base Sorties***	***(I) Total Annual Sorties at Base***
Langley	72	20	12	17,280	24	5,760	333	6,093	11,187
Eglin	72	20	12	17,280	24	5,760	333	6,093	11,187
Elmendorf	72	20	12	17,280	24	5,760	333	6,093	11,187
Mountain Home	72	20	12	17,280	24	5,760	333	6,093	11,187
Tyndall	72	20	12	17,280	24	5,760	333	6,093	11,187

A = Based on baseline aircraft inventory for Initial F-22 Operational Wing
B = Projected standard for F-22s
C = Months per year
D = (A x B) x C
E = Based on deployment patterns for Aerospace Expeditionary Force with an average of one squadron (24 aircraft) deployed year-round
F = (E x B) x C
G = Projected annual sorties for training at other locations (1 week/year per squadron)
H = F+G
I = D-H
Note: 1. Sorties per aircraft per month.

Table AO-1-4. Projected Total Sorties					
Alternative	***(A) Projected Sorties F-22***	***(B)Percentage F-22 Sorties of Total Sorties***	***(C)Baseline F-15C Sorties Eliminated***	***(D)Projected Sorties Other Aircraft***	***(E)Projected Total Annual Sorties***
Langley AFB	11,187	60%	9,936	7,595	18,782
Eglin AFB	11,187	36%	6,912	20,174	31,361
Elmendorf AFB	11,187	44%	6,048	13,977	25,164
Mountain Home AFB	11,187	48%	2,592	12,166	23,353
Tyndall AFB[1]	11,187	30%	6,299	19,949	37,435

A = Derived as per Table AO-1-3
B = A/E
C = Derived as per Table AO-1-1; same as baseline
D = Derived from Base Operations Summaries; same as baseline
E = A+D
Note: 1. Tyndall AFB supports only F-15Cs for advanced fighter pilot training; no F-15C sorties would be eliminated and the F-22 sorties would be additive to the total.

Data on baseline sortie-operations was derived from information compiled by Headquarters (HQ) Air Combat Command/DOR, airspace managers responsible for the individual MOAs and Warning Areas used by the F-15Cs from the bases, and previous relevant environmental documentation. The level of detail on sortie-operations varied among the different airspace units. However, all data were reviewed for consistency and realism by Air Force airspace managers.

To calculate projected sortie-operations, operational F-15Cs were replaced with F-22s at the same proportion in the individual airspace units. Sortie-operations were then increased in proportion to the increase in aircraft and utilization rate by the F-22s.

Airspace Management

Under Title 49, United States Code (USC) and Public Law 103-272, the United States government has exclusive sovereignty over the nation's airspace. This sovereignty extends from the surface to above 60,000 feet mean sea level (MSL). The FAA has the responsibility to plan, manage, and control the structure and use of all airspace over the United States, including that associated with this proposal. Like the highway system and traffic laws, FAA rules govern the national airspace system, and regulations establish how and where aircraft may fly. Collectively, the FAA uses these rules and regulations to make airspace use as safe, effective, and compatible as possible for all types of aircraft, from private propeller-driven planes to large, high-speed commercial and military jets.

Civil, commercial, and military air traffic all use the airspace within the affected environment for the proposed action and four alternatives. At Langley AFB and associated training airspace, military, civil, and commercial air traffic use is high. This is also the case at Eglin and Tyndall AFBs. At Elmendorf AFB, the airfield is only a few miles from three Anchorage airports and the training airspace overlies areas used by civilian, light aircraft. Mountain Home AFB and associated training airspace overlie a region used by civil, commercial, and military aircraft in a consistent manner. FAA rules, airspace management, and procedures provide for safe operations by all types of aviation users in these airspace environs.

Two types of flight rules (visual flight rules [VFR] and instrument flight rules [IFR]) apply to airspace, providing a general means of managing its use. Both military and civil aviation abide by these rules to ensure safe operations. For example, private pilots in Alaska fly between airfields to transport hunters to lodges/resorts usually operating under VFR. VFR pilots fly using visual cues along their desired route of flight, as long as appropriate visibility conditions exist, day or night. IFR pilots undergo much more training and operate under greater procedural requirements, but they may fly during periods of reduced visibility. Only those pilots qualified for IFR may use them in flying; commercial pilots generally have IFR ratings.

FAA rules and regulations serve to separate VFR and IFR flights from each other and from other aircraft using the same rules. These rules always recommend that VFR pilots carefully examine aeronautical charts and communicate with the nearest FAA facility to obtain information on what other aircraft are flying in the area. The rules also separate VFR air traffic by designating altitudes for flying based on the direction of flight. IFR air traffic is under more stringent flight controls and requires consistent communication with the FAA.

Aircraft use different kinds of airspace according to the specific rules and procedures defined by the FAA for each type of airspace. For the Initial F-22 Operational Wing, airspace used by the military consists of MOAs/Air Traffic Control Assigned Airspace (ATCAAs), and Warning Areas. The FAA has designated MOAs and Warning Areas as special use airspace.

MOAs provide military aircrews the opportunity to perform many different training activities within a large horizontal and vertical expanse of airspace. The ceiling of all MOAs can extend to no more than 18,000 feet MSL, while the floor can be established at any altitude. Any military or civilian pilot flying VFR can enter and fly through a MOA using see and avoid techniques. When flying IFR, nonparticipating (those not using the MOA for training) military or civilian aircraft must obtain an air traffic control clearance to enter a MOA, if it is active.

An ATCAA commonly overlies a MOA and extends above 18,000 feet MSL. Once established, an ATCAA is activated for the time it is required in accordance with the controlling letter of agreement between the FAA and the Air Force.

Warning Areas are established outside the off-shore 3-mile limit, in international airspace, to conduct military flight maneuvers or other activities that may be dangerous to other aircraft. Because hazardous activities may be conducted in these areas, authorization from the controlling agency is required for entry. Warning Areas cannot be legally designated as restricted areas by international agreement.

To avoid conflicts, MOAs (since they are over land) are designed to avoid busy airports entirely or establish specific avoidance procedures around small private and municipal airfields. Such avoidance procedures are maintained for each MOA, and military aircrews build them into daily flight plans.

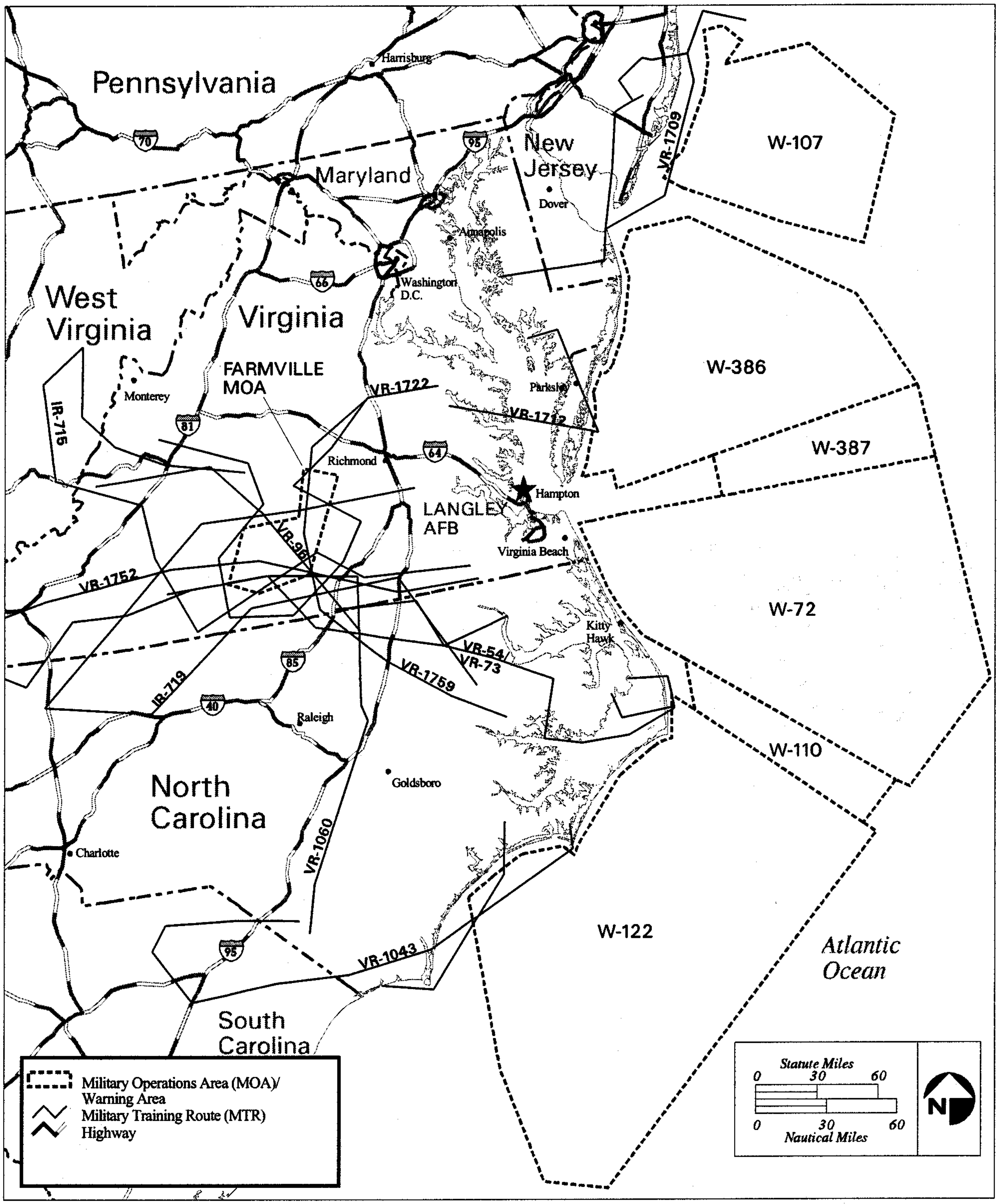
In addition to the lower limits of charted airspace, all aircrews adhere to FAA avoidance rules. Aircraft must avoid congested areas of a city, town, settlement, or any open-air assembly of persons by 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft. Outside of congested areas, aircraft must avoid any person, vessel, vehicle, or structure by 500 feet. Bases may establish additional avoidance restrictions under MOAs and Warning Areas.

The Department of Defense (DoD) has established several different Military Training Routes (MTRs) within or near to the airspace units that may be used by the Initial F-22 Operational Wing. An MTR consists of airspace corridors created for military flight training at airspeeds in excess of 250 knots per hour and below 10,000 feet MSL. Designed to support low-altitude training requirements, while minimizing disturbances to people and property, MTRs commonly avoid airports, towns, wildlife refuges, and other noise-sensitive locales. Two types of MTRs exist: instrument routes (IRs) and visual routes (VRs).

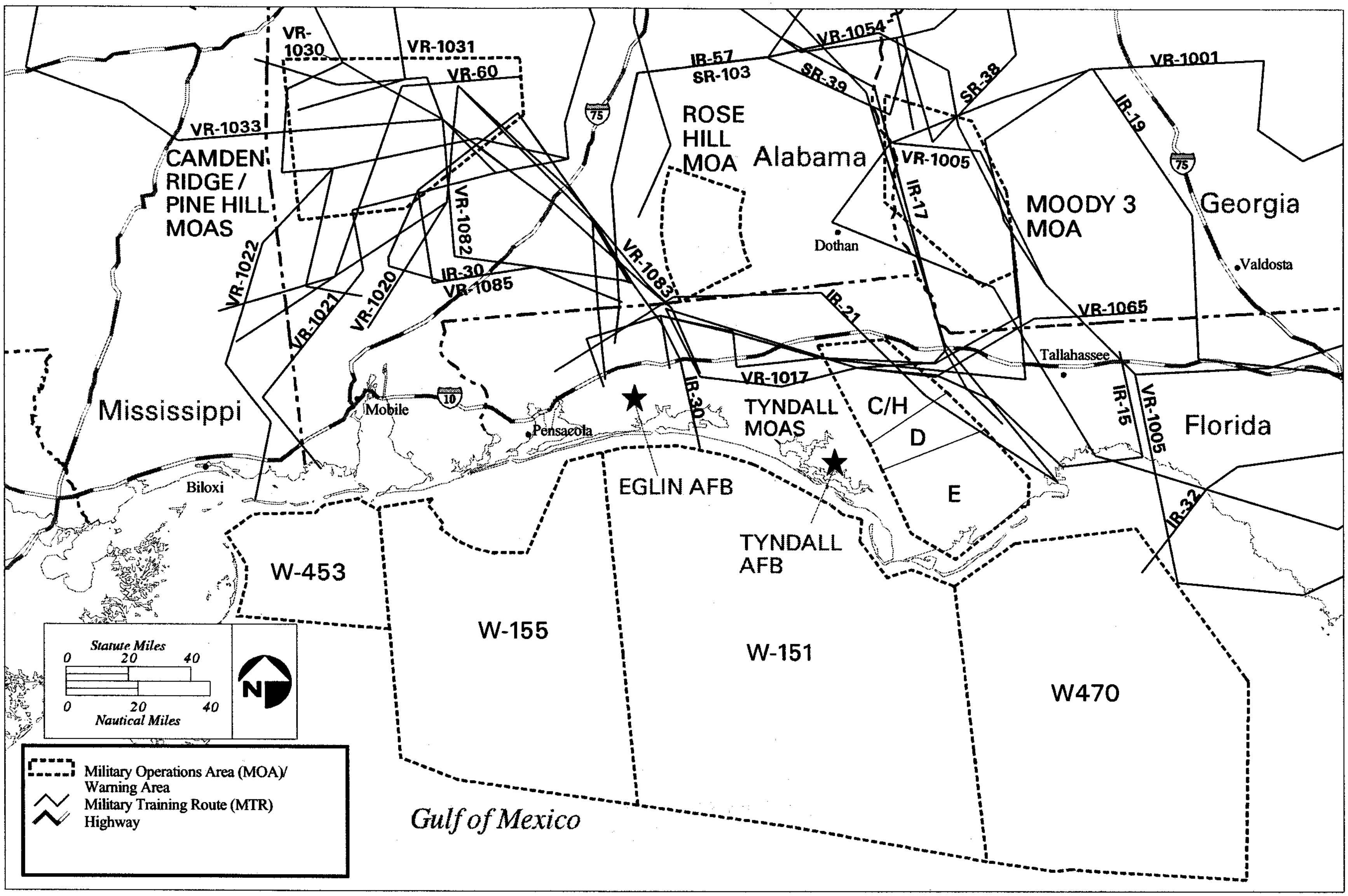
Although portions of MTRs occur within or near airspace in which the F-22s would fly, the F-22s would not use the MTRs. Use of the MTRs by other aircraft constitutes an existing and continuing activity. Figures AO-1-1 through AO-1-5 present the relationship between the MTRs and airspace units for the proposed action and four alternatives.

Aircraft Operations and the Noise Environment

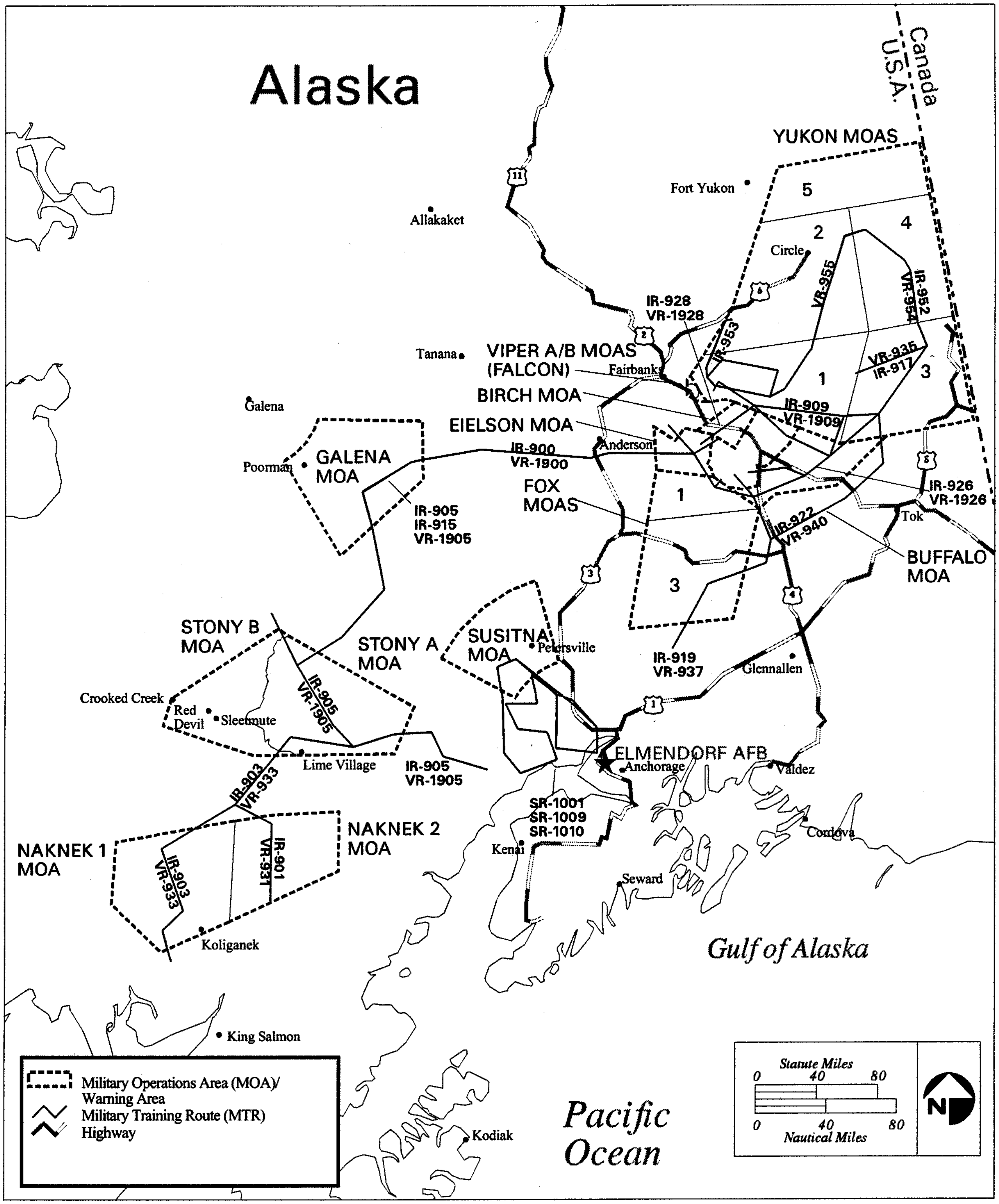
Noise represents the most identifiable concern associated with aircraft operations. Although communities and even isolated areas receive more consistent noise from other sources (e.g., cars, trains, construction equipment, stereos, and wind), the noise generated by aircraft overflights often receives the greatest attention. General patterns concerning the perception and effect of aircraft noise have been identified, but attitudes of individual people toward noise is subjective and depends on their situation when exposed to noise. Annoyance is the primary consequence of aircraft noise. The subjective impression of noise and the disturbance of activities are believed to contribute significantly to the general annoyance response. A number of nonnoise-related factors have been identified that may influence the annoyance response of an individual. These factors include both physical and emotional variables.



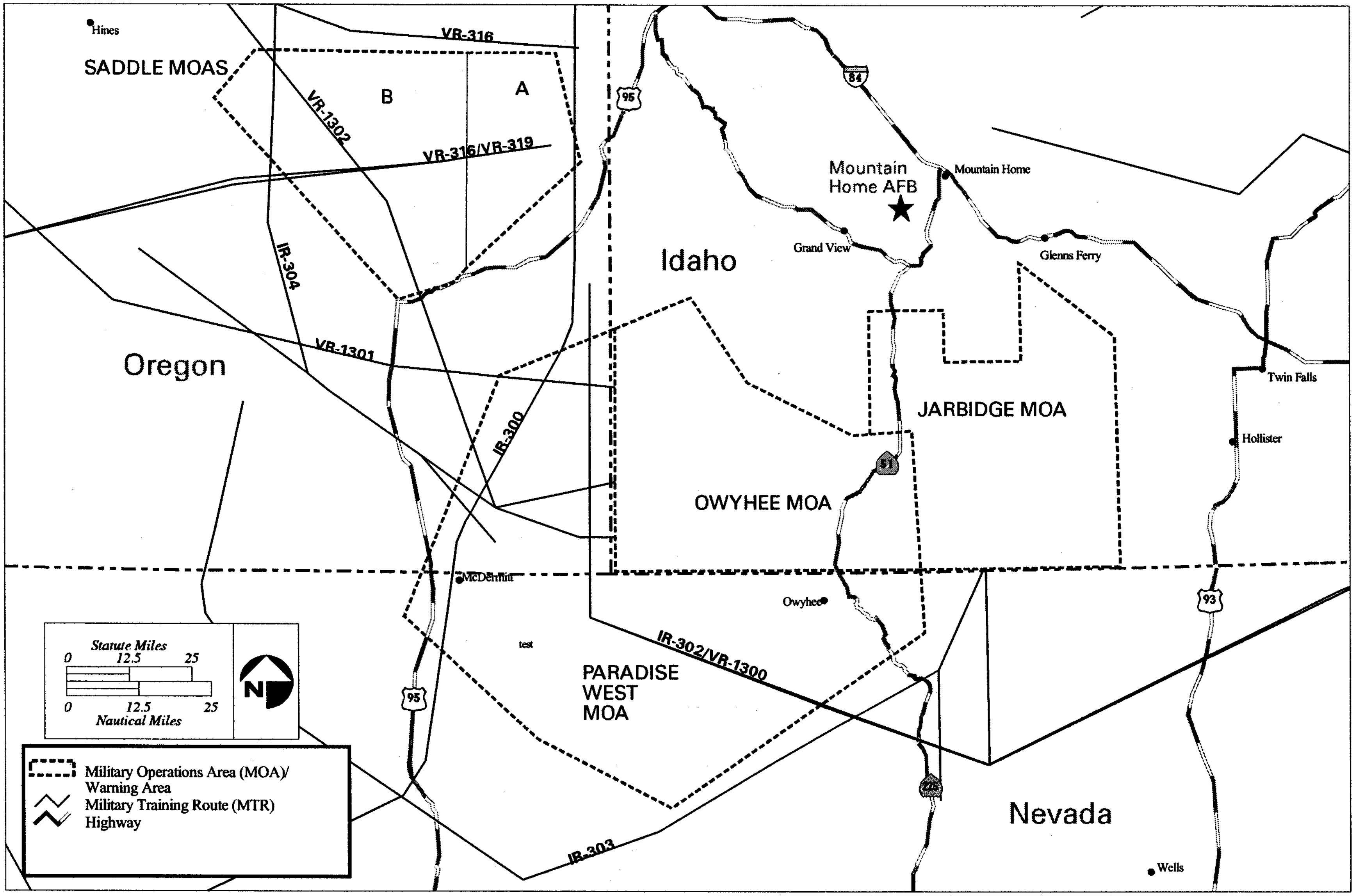
AO-1-1 Langley AFB Affected Airspace



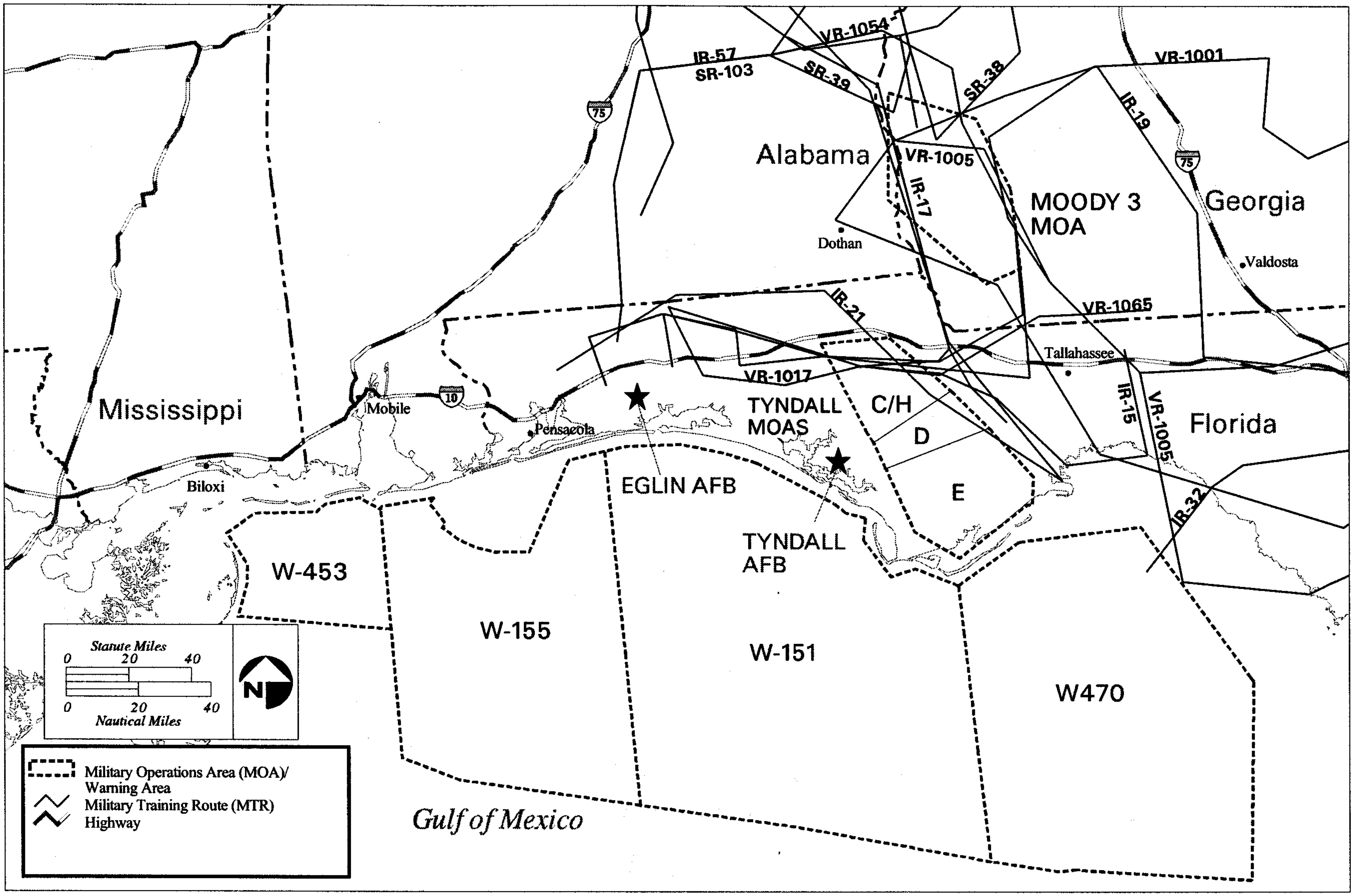
AO-1-2 Eglin AFB Affected Airspace



AO-1-3 Elmendorf AFB Affected Airspace



AO-1-4 Mountain Home AFB Affected Airspace



AO-1-5 Tyndall AFB Affected Airspace

Factors Influencing Annoyance

Physical Variables

- Type of neighborhood (i.e., rural, industrial)
- Time of day
- Season
- Predictability of noise
- Control over the noise source
- Length of time an individual is exposed to a noise

Personal opinions on noise vary widely. For example, one person might consider loud rock music as pleasing but opera music as offensive. A second person may perceive just the opposite. Likewise, opinions on noise associated with military overflights vary from positive to negative.

Aircraft Noise Assessment Methods. An assessment of aircraft noise requires a general understanding of how sound is measured and how it affects people and the natural environment. Appendix AO-2 provides a detailed discussion of noise and its effects on people and the environment. The primary information needed to understand the noise analysis is summarized below.

To quantify sound levels, the Air Force uses three noise-measuring techniques, or metrics: first, a measure of the highest sound level occurring during an individual aircraft flyover (single event); a second to combine the maximum level of that single event with its duration; and a third to describe the noise environment based on the cumulative flight activity. This Draft EIS describes single noise events with Maximum Sound Levels (L_{max}) and Sound Exposure Level (SEL) which are described below. The cumulative energy noise metric used is either the Day-Night Average Sound Level (DNL) for subsonic noise or the C-weighted Day-Night Sound Level (CDNL) for supersonic noise measurement. Each metric uses A-weighted or C-weighted sound levels (in decibels [dBA]), that approximate how humans perceive sounds by de-emphasizing the high and low frequency portions of the noise.

L_{max} comprises the highest sound level measured during a single aircraft overflight. L_{max} indicates the instantaneous sound level, occurring for a fraction of a second. For an observer, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. Table AO-1-5 lists the L_{max} sound levels for fighter aircraft. Maximum sound level is important in judging the interference caused by an aircraft noise event with conversation, sleep, or other common activities.

The SEL metric is a single-number representation of a noise energy dose. This measure takes into account the effect of both the duration and intensity of a noise event. It is a better measure of exposure than just the L_{max}, since it accounts for both the maximum level and duration. During an aircraft flyover, it would include both the maximum noise level and the 10 decibel (dB) lower levels produced during onset and recess periods of the flyover (this is also known as 10 dB down). Because an individual overflight takes seconds and the maximum sound level (L_{max}) occurs instantaneously, SEL forms the best metric to compare noise levels from overflights. SELs decrease as altitude increases and vary according to the type of aircraft, its altitude or distance from the observer, and its speed. As evidenced by the L_{max} and SEL data, L_{max} noise level during an overflight is typically 0 to 15 dB lower than the SEL with flights above an altitude of 500 feet above ground level (AGL).

Table AO-1-5. Representative A-Weighted Instantaneous Maximum (L_{max}) in Decibels Under the Flight Track for the Aircraft at Various Altitudes in the Primary Airspace[1]

			ALTITUDE IN FEET ABOVE GROUND LEVEL						
Aircraft Type	***Airspeed***	***Power Setting[2]***	***300***	***500***	***1,000***	***2,000***	***5,000***	***10,000***	***20,000***
F-15C	520	81% NC	119	114	107	99	86	74	57
F-22[3]	520	70% ETR	120	116	108	99	85	71	54
F-16A	450	87% NC	112	108	101	93	80	67	50
F-18A	500	92% NC	120	116	108	99	85	71	54
F-14A	530	100% NC	115	111	103	94	80	67	51
B-1B	550	101% RPM	117	112	106	98	86	75	61

Note: 1. Level flight, steady high-speed conditions.
2. Engine power setting while in a MOA. The type of engine and aircraft determines the power setting: RPM = rotations per minute, NC = percent core RPM, and ETR = engine throttle ratio.
3. Projected based on F-22 composite aircraft.

SEL values differ numerically from those expressed for the cumulative noise metric, DNL. The only reason this difference occurs is that the noise metric for SEL is expressed with respect to a one-second period and DNL uses a 24-hour period. Many different combinations of SEL values created by the noise of individual overflights can result in the same DNL value. For example, a single direct daytime overflight of an F-15 at 500 feet AGL would generate an SEL of 112 dB and a DNL of about 62 dB. An F-16 at the same altitude would generate an SEL value of 103 dB and a DNL of about 54 dB. The process of normalizing to a 24-hour period with DNL neither adds to nor diminishes the aircraft noise energy. It is accounted for by the DNL modeling method. Nothing is concealed or underestimated by the process of using the DNL scale.

The cumulative noise metric, DNL (also known as L_{dn} or by extension, L_{dnmr}), is a 24-hour average A-weighted sound level measure. DNL sums the individual noise events and averages the resulting level over 24 hours. It is a composite metric accounting for the maximum noise levels, the duration of the events (sortie-operations), and the number of events. DNL is also adjusted to include penalties for nighttime operations; all operations occurring after 10:00 pm and before 7:00 am are assessed a 10-dB penalty for the added intrusiveness and potential annoyance associated with nighttime flights. DNL is further adjusted up to 11 dB to account for the startle or “surprise” effect of the sudden onset of aircraft noise. This metric accounts for all of the factors shown to influence people’s reaction to noise, such as how loud the sounds are, how long each sound lasts, how often they occur, and when in the day they occur. In total, DNL cumulatively incorporates all noise generated by all the different types of aircraft using the airspace, reflects both the number and duration of the flights, and recognizes the difference between noise occurring during the day and at night. An example of calculating a hypothetical DNL is presented in Figure AO-1-6.

DNL has emerged as the most widely accepted metric for aircraft noise (USEPA 1972, FICON 1992). It correlates well with community response and is consistent with controlled laboratory studies of people’s perception of noise. It was the primary metric used in the United States Environmental Protection Agency’s (USEPA) “levels document” (USEPA 1972) and was further endorsed by the Federal Interagency Committee on Noise (FICON) (FICON 1992). DNL has been proven applicable to infrequent events (Fields and Powell 1985) and to rural populations exposed to sporadic military aircraft noise (Stusnick *et al*. 1992, 1993).

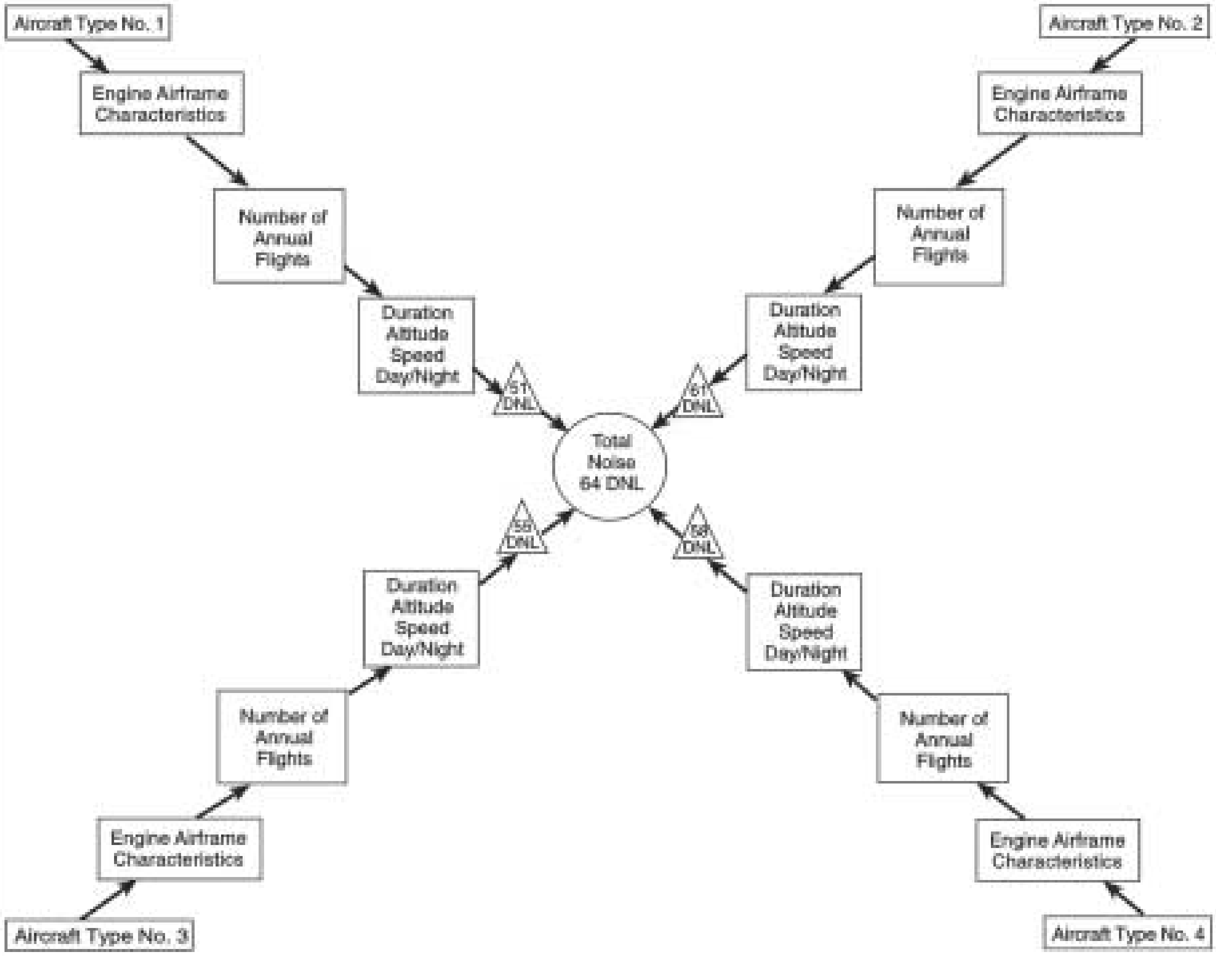
To describe airfield noise at a base, a computer-aided modeling approach was used. This model, known as NOISEMAP (Version 6.5), is approved by the Air Force and assesses all operations by based and transient aircraft.

Predicting noise levels (in DNL) for this Draft EIS involved the use of the Air Force's MR_NMAP (Lucas and Calamia 1996) noise model for activities in MOAs and Warning Areas. MR_NMAP calculates the noise levels based on aircraft operations data obtained from aircrews and airspace managers, as well as on patterns measured from radar data for the full inventory of aircraft flown by the United States military. These data include airspeed, duration of flight, altitudes of flight, distribution of aircraft in the airspace, and frequency of flight activities. Verification of these data comes from training requirements and from thousands of hours of radar data tracking aircraft operations at Nellis Air Force Range, Nevada; China Lake Naval Air Warfare Center, California; and White Sands Missile Range, New Mexico.

Noise generated by a particular aircraft type used in these models represents actual noise measurements regularly updated by the DoD for all aircraft. These measurements are made by flying aircraft under controlled conditions over a microphone array. The measurements are then incorporated into the noise model as the noise file database. Using this data set, the formulas driving the noise models account for spherical spreading, atmospheric absorption, and lateral attenuation. Spherical spreading is, in essence, the reduction in noise due to the spreading of sound energy away from its source. Sound energy decreases by approximately 6 dB every time the distance between the source and receiver is doubled. Daily and hourly variations in atmospheric conditions (e.g., humidity, clouds) can alter the amount of sound energy at a given location. The noise models use annual average temperature and humidity conditions to account for the influence of atmospheric conditions. Lateral attenuation, or the loss of sound energy due to reflection of sound by the ground, depends upon the altitude of the aircraft and the distance to the receiver.

Impulsive sounds, such as sonic booms, are perceived by more than just the ear. When experienced indoors, there can be secondary noise from rattling of the building. Vibrations may also be felt. C-weighting (ANSI 1988) is applied to such sounds. This is a frequency weighting that is flat over the range of human hearing (about 20 hertz [Hz] to 20,000 Hz) and rolls off above and below that range. In this Draft EIS, C-weighted sound levels are used for the assessment of sonic booms and other impulsive sounds. As with A-weighting, the unit is dB, but dBC or dB(C) are sometimes used. In this study, sound levels are reported in dB, and C-weighting is specified as necessary. Long-term average noise from sonic booms is denoted by CDNL.

Composite Noise Levels for the F-22. The Air Force maintains the "NOISEFILE" database for military aircraft under various operating conditions, including those occurring in airbase operations and those occurring at high speeds in the airspace. Analysis of noise in airspace requires noise levels under airspace conditions. Noise levels for the F-22 have been measured for airfield conditions, but not yet for airspace conditions. It was, therefore, necessary to select composite data for use in airspace analysis.



DNL accounts for the cumulative noise exposure of all aircraft over a 24-hour period. Each aircraft's contribution to the noise exposure is included. DNL emphasizes louder noise events and adds penalties for certain types of operations. A 10 dB penalty is included in the nighttime events to account for the added intrusiveness and a penalty of up to 11 dB is added to account for the startle effect from the rapid onset of some military aircraft. All events are then summed according to logarithm rules. In the above example, the DNL is 64, as opposed to the arithmetic average of 56.

Figure AO-1-6. How Cumulative Noise is Modeled

The Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA) recognize that such a situation may occur. For this F-22 analysis, the Air Force proceeded in accordance with 40 Code of Federal Regulations (CFR) § 1502.22, *Incomplete or Unavailable Information*, by clearly stating that such information is lacking.

The Air Force agency responsible for gathering aircraft noise data for incorporation into noise modeling programs is the Air Force Research Laboratory (AFRL) located at Wright-Patterson AFB, Ohio. The acoustic data developed by AFRL is recognized by the international scientific community, and those data developed for United States military aircraft are used by the DoD, FAA, and by other countries worldwide in noise modeling programs. As indicated, AFRL has collected some noise data for F-22s with pre-production engines. These engines are essentially the same as the actual production engine. Those data collected to date have been correlated with acoustic signatures associated with other comparable fighter aircraft for which complete data exist. In general, the F-22's Pratt and Whitney F119-PW-110 engines are comparable to both the Pratt and Whitney F100-PW-220 or 229 and General Electric F-404-GE-402 engines used in other current fighter aircraft. Thus, the data collected to date on F-22 noise levels and confirmed data on comparable fighter aircraft served as a composite for the F-22 noise analysis in this Draft EIS.

At takeoff power, noise from the F-22 is about 7 dB higher (or 60 percent louder) than an F-15C at takeoff power. Because of the F-22's greater performance, it is able to reduce power after becoming airborne from 100 percent engine throttle ratio (ETR) to 70 percent ETR. The F-22 at 70 percent ETR is about half as loud as it is at 100 percent ETR.

During approach, noise from the F-22 is about 13 dB higher than noise from an F-15C. This corresponds to the F-22 being about 2.5 times as loud as the F-15C. However, noise at approach power is always less than that for takeoff, typically (depending on particular power and speed) one third to one half as loud.

Table AO-1-6 shows SELs derived from composite data for the F-22 (airfield conditions) and from NOISEFILE for three other aircraft (airfield and airspace conditions for the F-15 and F-18 and airfield conditions only for F-18E/F). Noise levels are SEL at a distance of 1,000 feet. The speed for each test condition is shown.

Table AO-1-6. Sound Exposure Level (SEL, dB) for F-22 and Other Fighter Aircraft

	F-22			F-15C			F-18A/B/C/D			F-18E/F		
Condition	***Power***	***Speed***	***SEL***	***Power***	***Speed***	***SEL***	***Power***	***Speed***	***SEL***	***Power***	***Speed***	***SEL***
Takeoff/Mil	100% ETR	300	119	93% NC	300	112	97% NC	250	117	96% N2	325	116
Cruise	30% ETR	350	99	74% NC	280	89	88% NC	400	100	83% N2	360	104
Approach	27% ETR	160	101	75% NC	170	89	89% NC	150	110	84% N2	140	112
Airspace	—	—	NA	81% NC	520	107	92% NC	500	108	—	—	NA

Sonic Booms from the F-22. The F-22 will generate sonic booms during air combat training. Qualitatively, training will be similar to that performed by the F-15C and other current aircraft. Aircraft will set up at distances up to 100 nautical miles apart, then proceed toward each other for an engagement. Supersonic events can occur as the aircraft accelerate toward each other, during dives in the engagement itself, and during disengagement.

A major difference between current-generation aircraft and the higher performance F-22 is that the F-22 accelerates faster and achieves supersonic speeds more easily. The F-15C requires afterburner to become supersonic and, thus, needs deliberate action on the part of the pilot. The F-22 can become supersonic without afterburner, so there is no special action required by the pilot, and aircrews will be able to more routinely use this supersonic capability. Analysis of training scenarios by the Air Force indicates that during the engagement phase of air combat training, the F-22 will routinely attain a maximum Mach number of around 1.3, as compared to 1.1 for the F-15C.

One combat training mission scenario analyzed by the Air Force is a high-altitude missile intercept. The F-22 will set up about 80 miles from its opponent, then accelerate toward the intercept (becoming supersonic) and launch its missile. Following the launch, it will decelerate, break, and then return to the setup point. During the accelerate-launch-decelerate phase, the F-22 will be supersonic for about 2 to 2.5 minutes, versus about 30 to 50 seconds for the F-15C. There is another supersonic period of 1 to 2 minutes for the F-22 during break, while the F-15 would be supersonic for 30 to 60 seconds. For a 14-minute engagement (from start through return to setup), the F-22 would be supersonic for 25 percent (can range from 21 to 32 percent) of the time, while the F-15 would be supersonic 7.5 percent (can range from 7 to 12 percent) of the time.

Supersonic events during other types of air combat training missions will also be correspondingly longer, with the result that (averaged over all combat mission types) the F-22 will be supersonic slightly more than three times as long as the F-15C, 25 percent of the time versus 7.5 percent. Because sonic booms do not propagate to the ground until a Mach number somewhat higher than 1.0 is achieved, the percentage of boom-generating time of the F-22 will be more than three times that of the F-15. This factor, together with aircraft size effects and altitude ranges, has been accounted for in predicting sonic booms for the F-22.

Assessing Aircraft Noise Effects. Aircraft noise effects can be described according to two categories: annoyance and human health considerations. Annoyance, which is based on a perception, represents the primary effect associated with aircraft noise. Far less potential exists for effects on human health. Studies of community annoyance to numerous types of environmental noise show that DNL correlates well with effects; see Appendix AO-2 for further discussion.

In general, there is a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL. The correlation is lower for the annoyance of individuals. This is not surprising considering the varying personal factors that influence the manner in which individuals react to noise. The inherent variability between individuals makes it impossible to predict accurately how any individual will react to a given noise event. Nevertheless, findings substantiate that community annoyance to aircraft noise is represented quite reliably using DNL (USEPA 1972; FICON 1992).

In addition to annoyance, the effect of noise on human health was raised during the public involvement process for this Draft EIS. Other factors that can be used to evaluate a noise environment are noise-induced hearing loss, speech interference, and sleep disturbance. Effects on speech and sleep also contribute to annoyance.

A considerable amount of data on hearing loss has been collected and analyzed. It has been well established that continuous exposure to high noise levels (such as that occurring in a factory) will damage human hearing (USEPA 1972). Hearing loss is generally interpreted as the shifting to a higher sound level of the ear's sensitivity to perceive or hear sound (sound must be louder to be heard). This change can be either temporary or permanent. Federal workplace standards for protection from hearing loss allow an A-weighted time-average level of 90 dB over an 8-hour work period, or 85 dB averaged over a 16-hour period. As shown later in this section, noise levels associated with the F-22 beddown proposal would be more than 20 dB below these standards and for much shorter durations.

Studies on community hearing loss from exposure to aircraft flyovers near airports showed that there is no danger, under normal circumstances, of hearing loss due to aircraft noise (Newman and Beattie 1985). Airport traffic is commonly much more continuous and frequent than at military airfields. Air traffic at commercial/civilian airports is also substantially more frequent and generally lower in altitude than in MOAs or Warning Areas. In MOAs and Warning Areas, military aircraft fly at varied altitudes, rarely fly over the same point on the ground repeatedly during a short period, and occur sporadically over a day. These factors make it unlikely that an increase in hearing loss would occur (Thompson 1997). The conclusion of no risk to hearing loss as a result of even low-altitude flight noise is also supported by a recent laboratory study that measured changes in human hearing from noise representative of low-flying aircraft on MTRs (Nixon *et al*. 1993). In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. One-half of the subjects showed no change in hearing levels, one-fourth had a temporary 5-dB *increase* in sensitivity (the people could hear a 5-dB wider range of sound than before exposure), and one-fourth had a temporary 5-dB *decrease* in sensitivity (the people could hear a 5-dB narrower range of sound than before exposure). In the next phase, participants were subjected to a single overflight at a maximum level of 130 dB for eight successive exposures, separated by 90 seconds or until a temporary shift in hearing was observed. The temporary hearing threshold shifts resulted in the participants hearing a wider range of sound, but within 10 dB of their original range. For the F-22 beddown, the majority of flight time (80 percent) would be spent above 10,000 feet; therefore, overflights would not generate noise levels of 130 dB.

Another nonauditory effect of noise is disruption of conversations. Speech interference associated with aircraft noise is a primary cause of annoyance to individuals on the ground. Aircraft noise can also disrupt routine activities, such as radio listening or television watching and telephone use. Due to the sporadic nature of flights in MOAs and over-water Warning Areas, the disruption generally lasts only a few seconds, and almost always less than 10 seconds. It is difficult to predict speech intelligibility during an individual event, such as a flyover, because people automatically raise their voices as background noise increases. A study (Pearsons *et al*. 1977) suggests that people can communicate acceptably in background A-weighted noise levels of 80 dB. The study further indicates that people begin to raise their voices when noise levels exceed 45 dB and some speech interference occurs when background noise levels exceed 65 dB. Typical home insulation reduces the noise levels experienced by 20 dB or more, which decreases speech interference. However, it is recognized that some aircraft flyovers can interrupt speech communication shortly.

Noise-related awakenings form another issue associated with aircraft noise. Sleep is not a continuous, uniform condition but a complex series of states through which the brain progresses in a cyclical pattern. Arousal from sleep is a function of a number of factors including age, gender, sleep stage, noise level, frequency of noise occurrences, noise quality, and presleep activity. Quality sleep is recognized as a factor in good health. Although considerable progress has been made in understanding and quantifying noise-induced annoyance in communities, quantitative understanding of noise-induced sleep disturbance is less advanced. A recent study of the effects of nighttime noise exposure on the in-home sleep of residents near one military airbase, near one civil airport, and in several households with negligible nighttime aircraft noise exposure, revealed SEL as the best noise metric predicting noise-related awakenings. It also determined that out of 930 subject nights, the average spontaneous (not noise-related) awakenings per night was 2.07 compared to the average number of noise-related awakenings per night of 0.24 (Fidell *et al*. 1994). Additionally, a 1995 analysis of sleep disturbance studies conducted both in the laboratory environment and in the field (in the sleeping quarters of homes) showed that when measuring awakening to noise, a 10 dB increase in SEL was associated with only an 8 percent increase in the probability of awakening in the laboratory studies, but only a 1 percent increase in the field (Pearsons *et al*. 1995). Pearsons *et al.* (1995) reports that even SEL values as high as 85 dB produced no awakenings or arousals in at least one study. This observation suggests a strong influence of habituation on susceptibility to noise-induced sleep disturbance. A 1984 study (Kryter 1984) indicates that an indoor SEL of 65 dB or lower should awaken less than 5 percent of exposed individuals.

To date, no exact quantitative dose-response relationship exists for noise-related sleep interference; yet, based on studies conducted to date and the USEPA guideline of a 45 DNL to protect sleep interference, useful ways to assess sleep interference have emerged. If homes are conservatively estimated to have a 20-dB noise insulation, an average of 65 DNL would produce an indoor level of 45 DNL and would form a reasonable guideline for evaluating sleep interference. This also corresponds well to the general guideline for assessing speech interference. Annoyance that may result from sleep disturbance is accounted for in the calculation of DNL, which includes a 10-dB penalty for each sortie occurring after 10:00 pm or before 7:00 am.

The potential for noise to affect physiological health, such as the cardiovascular system, has been speculated; however, no unequivocal evidence exists to support such claims (Harris 1997). Conclusions drawn from a review of health effect studies involving military low-altitude flight noise with its unusually high maximum levels and rapid rise in sound level have shown no increase in cardiovascular disease (Schwartze and Thompson 1993). Since the F-22 would fly predominantly at high altitudes, even less concern exists for such health effects. Additional claims that are unsupported include flyover noise producing increased mortality rates and increases in cardiovascular death, adverse effects on the learning ability of middle- and low-aptitude students, aggravation of post-traumatic stress syndrome, increased stress, increase in admissions to mental hospitals, and adverse affects on pregnant women and the unborn fetus (Harris 1997).

The effect of aircraft noise on children is a controversial area. The reactions and behaviors of children described in the comments have not been documented in any research on the effects of aircraft noise on children or supported by anecdotal evidence. Also, no evidence has been reported about these kinds of reactions to military overflights that have occurred over the last 30 years. It has been proposed that children are potentially more sensitive to noise sources as compared to adults; however, studies completed to date have produced no unequivocal evidence of auditory or non-auditory impact due to aircraft operations. Further, many studies (which have occurred primarily around European airports) have been plagued with serious design problems including failure to incorporate control variables and account for exposure to other loud noise or small sample sizes. Numerous studies have also concluded that there is no likelihood of permanent hearing loss or psychological or physiological health effects on children or young people.

Air Quality–Construction and Aircraft, Vehicle, and Ground Equipment Emissions

The air quality analysis examined impacts from air emissions associated with the F-22 beddown at Langley AFB (proposed action) and the four basing alternatives (Eglin, Elmendorf, Mountain Home, and Tyndall AFBs). As part of the analysis, emissions generated from construction, aircraft operations (both around the base and in the training airspace), aerospace ground equipment (AGE), motor vehicles, and other area (nonmobile) sources were examined for carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter equal to or less than 10 microns in diameter (PM_{10}).

Construction Emissions: Construction activities generate both combustive emissions from heavy equipment use and fugitive dust from ground-disturbing activities. Fugitive dust would be generated during construction activities associated with building construction and modification. These emissions would be greatest during site clearing and grading activities. While construction would take place over a 3-year period, calculations assumed all activities would take place in one year to obtain a conservative estimate of the total emissions.

Combustive emissions from equipment exhaust were estimated by developing a profile of typical daily construction equipment for the months of construction activities. The equipment included a mix of heavy trucks, light trucks, graders, loaders, and tractors. Analysis of the construction vehicles was performed using AP-42 emission factors for heavy duty construction equipment (USEPA 1985).

Aircraft Operations Emissions. Military aircraft commonly contribute little to the total emissions in a region because they are mobile and cover very long distances over many different areas. This is especially true since they fly at altitudes where emissions would tend to disperse and would not result in effects on human health or visibility. Despite these factors, federal actions such as the proposed beddown of the operational F-22s must be assessed for their potential effects on air quality. Analysis of air emissions from baseline and projected aircraft operations at the bases (sorties) and in associated training airspace (sortie-operations) used the same operational data and parameters as those used for noise modeling (Air Force 1999).

Vehicle Emissions. Vehicle emissions were obtained through the use of vehicle daily trip generation for the F-22 beddown and the use of Mobile 5a. Mobile 5a is a USEPA-approved, regulatory on-road mobile-source emissions model. The model calculates vehicle emissions factors using input data such as fuel usage and distance of travel for a mix of general vehicle types (e.g., light trucks, cars). The round-trip commute of personnel living off base (for any of the five bases) was assumed according to the base analyzed (i.e., miles each way). Vehicle emissions were based on the final complement of personnel associated with the beddown in the year 2007.

Aerospace Ground Equipment. AGE is maintenance equipment associated with the particular aircraft. It includes heaters, compressors, coolers, lifts, and other miscellaneous equipment. Emissions in tons from AGE per year were calculated using the Emissions Dispersion Modeling System (EDMS) (USDOT 1997).

Other Area Sources. Other area (nonmobile) sources included facility space heating, residential space heating, and refueling emissions (including fuel evaporation and refueling truck emissions). AP-42 (USEPA 1995) provided the emission factors for these sources.

Under the Clean Air Act (CAA), the USEPA established nationwide air quality standards, known as the National Ambient Air Quality Standards (NAAQS). Table AO-1-7 outlines the standards for "criteria" pollutants, as defined by the USEPA. These standards represent the maximum levels of background pollution that are considered safe, with an adequate margin of safety, to protect human health and welfare. These standards are presented in terms of concentration (e.g., parts per million) averaged over periods of time ranging from 1 hour to annually according to the degree of potential health effects. States, as well as local agencies, may set their own standards as long as they are at least as stringent as the NAAQS. Pollutants considered in this Draft EIS analysis include VOCs, which are indicators of ozone (O_3); NO_x, which are precursors to O_3 and include nitrogen dioxide and other compounds; CO; and PM_{10}. Airborne emissions of lead and sulfides of hydrogen are not addressed because the affected areas contain no significant sources of emissions of these criteria pollutants, and F-22 activities would not materially contribute to increased levels in the region.

Military aircraft exhaust consists of the criteria pollutants listed in the NAAQS and water vapor. The water vapor mixes with other water vapor in the atmosphere. With the exception of some heavier PM_{10}, none of these criteria pollutants enter soil or water. The PM_{10} would not be hazardous or toxic.

Individual states are required to establish a State Implementation Plan (SIP) designed to eliminate or reduce emissions exceeding the NAAQS and to ensure state air quality conditions consistently comply with the NAAQS. The CAA prohibits federal agencies from supporting any activities that do not conform to a SIP approved by the USEPA. Regulations under the CAA, known as the General Conformity Rule, state that activities must not (a) cause or contribute to any new violation of any standard; (b) increase the frequency or severity of an existing violation; or (c) delay timely attainment of any standards, interim emission reductions, or milestones as stated in the SIP. This General Conformity Rule applies to those areas in maintenance, as well as in nonattainment with NAAQS.

The CAA also establishes a national goal of preventing degradation or impairment in federally designated Class I attainment areas. As part of the Prevention of Significant Deterioration (PSD) program, mandatory Class I status was assigned by Congress to all national parks, national wilderness areas (except wilderness study areas or wild and scenic rivers), and memorial (e.g., battlefield) parks larger than 5,000 acres. In Class I areas, visibility impairment is defined as a reduction in regional visual range and atmospheric discoloration (such as from an industrial smokestack). This program also sets standards for a project's effect on PSD Class I areas (Table AO-1-8). Stationary sources, such as industrial facilities, are typically the issue with impairment of visibility in PSD I areas. Mobile sources, including aircraft, are generally exempt from review under this regulation.

Table AO-1-7. National and State Ambient Air Quality Standards

Air Pollutant	Averaging Time	FEDERAL NAAQS		VIRGINIA AAQS		FLORIDA AAQS		ALASKA AAQS		IDAHO AAQS	
		Primary	***Secondary***	***Primary***	***Secondary***	***Primary***	***Secondary***	***Primary***	***Secondary***	***Primary***	***Secondary***
Carbon Monoxide (CO)	8-hour	9 ppm	--	9 ppm	--	9 ppm	--	9 ppm	--	9 ppm	--
	1-hour	35 ppm	--	35 ppm	--	35 ppm	--	35 ppm	--	35 ppm	--
Nitrogen Dioxide (NO_x)	Annual	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm
	24-hour	--	--	--	--	--	--	--	--	--	--
Sulfur Dioxide (SO_2)	Annual	0.03 ppm	--	0.03 ppm	--	0.02 ppm	--	0.03 ppm	--	0.03 ppm	--
	24-hour	0.14 ppm	--	0.14 ppm	--	0.10 ppm	--	0.14 ppm	--	0.14 ppm	--
	3-hour	--	0.5 ppm	--	0.5 ppm	--	0.5 ppm	--	0.5 ppm	--	0.5 ppm
Particulate Matter (PM_{10})	Annual	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³	50 µg/m³
	24-hour	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³	150 µg/m³
Total Suspended Particulates (TSP)	Annual (geometric mean)	--	--	75 µg/m³	60 µg/m³	--	--	--	--	75 µg/m³	60 µg/m³
	30-day	--	--	--		--	--	--	--	--	--
	7-day	--	--	--		--	--	--	--	--	--
	24-hour	--	--	260 µg/m³	150 µg/m³	--	--	--	--	260 µg/m³	150 µg/m³
Ozone (O_3)	1-hour	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm
	8-hour*	0.08 ppm	0.08 ppm	*		*		*		*	
Lead (Pb)	Calendar Quarter	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³
Particulate Matter** ($PM_{2.5}$)	Annual	15 µg/m³	15 µg/m³	**		**		**		**	
	24-hour	65 µg/m³	65 µg/m³	**		**		**		**	

Notes: * 8-hour USEPA standard is currently in the Supreme Court, consideration is anticipated sometime in 2001. Hampton Roads area, surrounding Langley AFB, anticipates it will be in nonconformity; Alaska and Florida anticipate conformity; Idaho is requesting to maintain nonclassification status for ozone.

** $PM_{2.5}$ is currently in the Supreme Court for consideration.

Table AO-1-8. Maximum Allowable Incremental Increases Under PSD Regulations		
Pollutant	***Averaging Time***	***PSD Increments (µg/m3) Class I***
Nitrogen Dioxide (NO_2)	Annual	2.5
Particulate Matter (PM_{10})	Annual 24-hour	4 8
Sulfur Dioxide (SO_2)	Annual 24-hour 3-hour	2 5 25

Note: All particulates reported as PM_{10}

Determining the effects of existing and proposed aircraft operations on air quality and visibility involved two basic steps. First, aircraft emissions were calculated for the affected MOAs and Warning Areas in each alternative (in tons per year) to determine increases or decreases relative to the baseline conditions and to qualitatively assess the potential for exceedences of the NAAQS. Sortie-operations by all aircraft using or proposing to use the affected airspace were included. Second, more detailed analyses then assessed the potential change in ambient pollutant concentrations resulting from the alternatives. Appendix AO-3 provides tables with the data used to calculate air emissions around the bases and in the training airspace. By evaluating these conditions, projections of the emissions were made relative to the NAAQS and PSD Class I standards.

Aircraft Safety

Flight safety is of paramount concern to the Air Force. Safe flying procedures, adherence to flight rules, and knowledge of emergency procedures form consistent and repeated aspects of training for all aircrews. Since the inception of the Air Force in 1947, aircraft accidents have steadily declined each year.

Starting in the early 1980s, the Air Force has averaged fewer than two major accidents (Class A mishaps) per 100,000 flying hours for all aircraft worldwide. The Air Force defines a Class A mishap as an accident that results in loss of life, permanent total disability, total cost of more than $1 million, or destruction of the aircraft beyond repair. Class A mishaps include those accidents where aircraft crash, as well as on-the-ground incidents.

Class A mishap rates are calculated by aircraft type. For this Draft EIS, F-15C rates were examined and found to be quite low. This mishap rate was used to compute a projection of the estimated years between Class A mishaps in both the base environment and training airspace. These data are only statistically predictive and actual mishaps result from many factors, not merely the amount of flight time by an aircraft.

Flight safety considerations also include bird-aircraft strikes. Bird-aircraft strikes can represent a hazard to aircraft and, in extreme cases, can result in accidents. Over 95 percent of bird-aircraft strikes occur below 3,000 feet AGL, although in extremely rare circumstances aircraft may encounter birds at 30,000 feet MSL or higher. Approximately 50 percent of bird strikes happen at airfields, with 25 percent occurring during low-altitude flight. Migration corridors and other areas where birds congregate (e.g., water bodies) represent the locations with the greatest hazard when birds are present.

Because of these potential effects, the Air Force devotes considerable attention to avoiding the possibility of bird-aircraft strikes. It has conducted a worldwide program for decades to study bird migrations, bird flight patterns, and past strikes to develop predictions of where and when bird-aircraft strikes might occur. This program, which regularly updates the data, also defines avoidance procedures through a Bird Avoidance Model. Each time an aircrew plans a training sortie, they use the Bird Avoidance Model to identify altitudes and locations to avoid. Use of this model has minimized bird-aircraft strikes. Each base or flying unit also develops and maintains a bird-aircraft strike avoidance plan that dictates the location and timing of avoidance measures within the airspace used by the base or unit.

Historical bird strikes reported within a MOA also provide an indicator as to the potential for flying bird-aircraft strikes. The Air Force maintains an extensive database on all bird-aircraft strikes, where they occurred, and the aircraft involved. For the F-22 beddown proposal, 80 percent of the flying time would be spent above 10,000 feet MSL. Therefore, there is little likelihood of an increase in bird-aircraft strikes for the proposed action at Langley AFB or at any of the four alternative bases.

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