Grand Canyon Advisory Group Integrated Noise Model (INM) Workshop
January 19-20, 2006

The objective of the workshop was to provide an understanding of what modeling elements are most important when it comes time to develop commercial air tour-related alternatives for Grand Canyon National Park (GCNP). Attendees discussed and tested sensitivities that have a direct relationship on how noise is modeled/abated in GCNP. Note: A copy of the final presentation is attached at the end of this document.

Attendees:
Kurt Fristrup (NPS Natural Sounds)
Elling Halvorson (Papillon Helicopters)
Dick Hingson (Grand Canyon Trust & National Parks Conservation Association)
Ken McMullen (Grand Canyon National Park NPS)
Greg Price (J R Engineering)
Alan Stephens (Scenic/Grand Canyon Airlines)
Charlie Vaughn (Hualapai Tribe)

Brief overview of INM:
An introduction to acoustics was provided where: (1) various terminology were explained, including sound, sound pressure, frequency, and units of measure; (2) a comparison of hearing abilities of humans and other animals, including thresholds and frequency weightings; and (3) an audio example of animal sounds with aircraft sounds was played.

The overview of INM consisted of a brief discussion of: (1) aircraft source data (e.g., Noise-Power-Distance curves); (2) how sound is propagated through a user-defined atmosphere and over user-input terrain; (3) how flight tracks are input; (4) the use of ambient data in computing different metrics; and (5) how to interpret output contours for different metrics.

Pre-Run INM modeling sensitivities (variables important to noise in Grand Canyon):
The following INM parameters/data were used in computing the pre-run cases presented to the group (Note: Some of these parameters were selected primarily to improve run-time. Higher resolution terrain data and refinement level were used in the modeling scenarios that were presented to the Working Group on January 31, 2006):

- USGS terrain data (approximately 100 meter resolution National Elevation Dataset)
- Line-of-Sight blockage set to 'on'
- Hard ground attenuation
- Refinement of 4, tolerance of 1 dB
- Ambient data provided by Grand Canyon NPS

The purpose of the sensitivity runs performed in the workshop was to provide a relative comparison of various options for improving the noise climate (expressed in terms of audibility) in GCNP. Although the absolute % changes in area computed during the workshop may not translate directly to full GCNP runs, the relative effectiveness of the various options is expected to be consistent. The results of several pre-run cases were presented to demonstrate the affect of

changing different variables on the time aircraft are potentially audible during a 12-hour day (7 am to 7 pm) in GCNP:

- Substitute Quiet Technology (QT) aircraft for non-QT aircraft to find the impact of different aircraft types:
  - Replace all fixed-wing aircraft with DHC6QP (DeHavilland Twin Otter DHC-6 with Raisbeck modifications, i.e., Vistaliner). *This resulted in a decrease of 1.7% in the contour area.*
  - Replace all rotary-wing aircraft with EC-130 (Eurocopter EC130). *This resulted in a decrease of 5.3% in contour area. Note: The change in area affected was greater when replacing rotary-wing aircraft because a greater number were replaced as compared with fixed-wing aircraft.*
- Shift commercial air tours from some routes onto new or other existing routes:
  - Shift all Dragon Corridor (Green 2 and Black 1A) operations onto the Zuni Corridor (Green 1 and Black 1). *This resulted in a decrease of 18.5% in contour area. Note: Although the contour area decreased as all operations are now concentrated in a smaller area of the park, this would also result in aircraft sounds being audible for longer periods during the day.*
- Change some or all of the aircraft performance parameters (Note: It is understood that current regulations limit the performance parameters that can be changed.):
  - For operations in the Zuni Corridor, change the tour airspeed for Vistaliners (104 KTAS or knots true airspeed) to transport cruise airspeed (143 KTAS). *This resulted in an increase of 1.1% in contour area. Note: Although increasing the airspeed would decrease the amount of time an aircraft might be audible, the corresponding increase in power needed to increase airspeed resulting in a net increase in contour area.*
- Change the altitudes along a tour route:
  - Raise the altitude flown by rotary-wing aircraft on Dragon Corridor (Green 2) by 1000 ft. *This resulted in an increase of 1.8% in contour area. Note: Although increasing the altitude increased area aircraft might be audible; the levels of those aircraft sounds would be decreased.*
- Remove the shielding effects of terrain (Note: Changes to the terrain database do not generally affect the contours substantially; however, changing the effects of terrain on acoustic propagation can have large impacts):
  - Remove Line-of-Sight blockage from propagation calculations. *This resulted in an increase of 12.1% in the contour area.*
- Change the ambient levels, which can greatly influence the potential masking of aircraft sounds by the background ambient:
  - Change from daytime to nighttime ambient levels, but keep the level of operations the same. *This resulted in an increase of 2.8% in the contour area as nighttime ambient levels are generally lower than daytime.*
  - Increase daytime ambient levels by 3 decibels.[*] *This resulted in a decrease of 3.7% in the contour area as more aircraft sounds may be masked.*

[*] In determining ambient sound levels in national parks, because it is not feasible to measure all hours of all seasons, the FAA and NPS have agreed that they will "strive to collect data that will provide a margin of error not to exceed ± 3 dB" [ATMP Implementation Plan (September 2005)]. To examine how the audibility results might be affected taking this 3-dB uncertainty into account; the ambient data were increased by 3 decibels. During the brainstorming session discussed below, the group also asked to see how the audibility results might change if the ambient data were decreased by 3 decibels. The results were similar.

Brainstorm and discussion of sensitivities modeling overnight runs:

Using the knowledge gained from the above, the following scenarios were brainstormed to test additional sensitivities and modeled overnight for discussion the next morning:

- Change all commercial air tour aircraft to QT. *This resulted in a decrease of 7.3% in the contour area.*
- Double GC West operations. *This resulted in an increase of 1.5% in the contour area.*
- Reduce daytime ambient levels by 3 decibels.* *This resulted in an increase of 3.6% in the contour area as less aircraft sounds may be masked.*
- Reduce commercial air tour operations by 20%. *This resulted in a decrease of 0.9% in contour area. Note: Because all commercial air tour operations are now concentrated in specific areas of the park, those areas are already saturated with aircraft sounds audible during the day, the effect of small decreases/increases in number of operations to contour area is likely small.*
- Increase commercial air tour operations by 20%. *This resulted in an increase of 0.6% in contour area. Note: Because all commercial air tour operations are now concentrated in specific areas of the park, those areas are already saturated with aircraft sounds audible during the day, the effect of small decreases/increases in number of operations to contour area is likely small.*
- Change Green 2 route operations:
  - Eliminate all operations on the Green 2 route. *This resulted in a decrease of 3.1% in the contour area.*
  - Model Green 2 operations only. *This resulted in a decrease of 18.5% in the contour area. Note: Although the contour area decreased as all operations are now concentrated in a smaller area of the park, this would also result in aircraft sounds being audible for longer periods during the day.*
  - Model Green 2 operations only and lower altitude by 1000 ft. *This resulted in a decrease of 22.3% in the contour area. Note: The net change in contour area due to lowering operations on this route by 1000 ft is an additional decrease of 3.8%.*

Additional cases brainstormed by the group to be run at a later date include:

- Lower altitude for operations on Dragon Corridor (Green 2) by 1000 ft:
  - Lower altitude for rotary-wing aircraft operations only.
  - Lower altitude for all operations.
- Remove all GC West operations.
- Move Black 1A/Green 1A routes further south.

* In determining ambient sound levels in national parks, because it is not feasible to measure all hours of all seasons, the FAA and NPS have agreed that they will "strive to collect data that will provide a margin of error not to exceed ± 3 dB" [ATMP Implementation Plan (September 2005)]. To examine how the audibility results might be affected taking this 3-dB uncertainty into account; the ambient data were decreased by 3 decibels. The results were similar to the Pre-Run INM modeling sensitivities test where the ambient data were increased by 3 decibels.

Grand Canyon Advisory Group
Integrated Noise Model (INM) Workshop

Cynthia Lee and Eric Boeker
Volpe Center Acoustics Facility

Dave Senzig
Senzig Engineering

January 19-20, 2006

Attendees

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Brief Overview of INM

- Introduction to acoustics
- Source data
- Propagation and terrain
- Flight tracks
- Ambient data
- Example INM input
- Example INM output

Introduction to Acoustics

- Explain sound, sound pressure, frequency, and units of measure
- Explain hearing abilities of humans and other animals, including thresholds and frequency weightings
- Show example of animal sounds with aircraft sounds

Introduction to Acoustics: What is Sound?

Sound can be defined as a pressure variation in air or other media that is within the hearing range of a given species

Introduction to Acoustics: Amplitude

- **Amplitude is the magnitude of sound pressure, measured in Pascals (Pa).**
  - **Pascals are the metric equivalent of pounds per square inch**
- **The range of pressures that a human can detect is greater than 1,000,000:1.**
  - **Because of this very large range, the decibel scale is used.**
  - **A decibel (dB) is the logarithm of a ratio of the measured pressure to a reference pressure (the threshold of human hearing).**
  - **A-weighted decibels (dBA) have been adjusted to account for humans' frequency sensitivity**

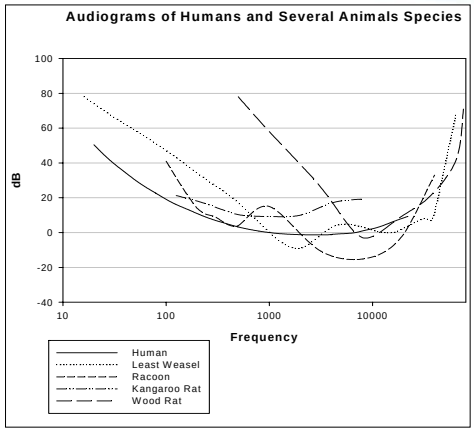
Introduction to Acoustics: Amplitude

- Some examples of sound amplitudes found in park environments are:

	Sound Pressure (Pa)	dBA
Threshold of human hearing:	0.00002	0
HALE: Volcano crater	0.000064	10
CANY: Leaves rustling	0.0002	20
ZION: Crickets (5 m)	0.002	40
WHMI: Conversational speech (5 m)	0.02	60
YELL: Snowcoach (30 m)	0.2	80
ARCH: Thunder (est. 700 m)	2	100
YUCH: Military jet (100 m AGL)	20	120

Introduction to Acoustics: Frequency

- Frequency is the rate of pressure variations per second, measured in Hertz (Hz).
- The frequency of a sound is perceived as the pitch or tone of a sound: most aircraft are low frequencies, and most bird calls are high frequencies.
- Most sounds are made up of a number of different frequencies.
- A person with normal hearing can hear sounds between 20 Hz and 20,000 Hz. Frequency is commonly displayed on a logarithmic scale.



From Skip Ambrose (NPS Natural Sounds Program)

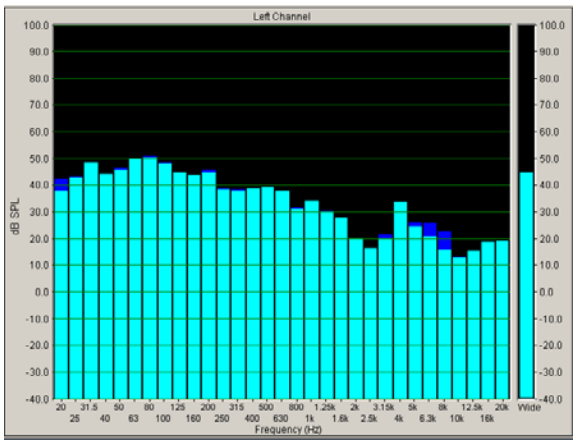
Introduction to Acoustics: Noise Propagation

- Noise propagates in all directions away from its source.
- As it propagates, the amplitude and frequency content of the noise are effected by:
  - The distance between source and receiver (spreading);
  - The atmosphere (absorption, scattering, bending); and
  - Objects along the propagation path (reflection, line-of-sight blockage, absorption)

Introduction to Acoustics: Noise at a Receiver

- The noise at a receiver is the combination of:
  - Noise propagated from sound source(s) of interest to the receiver;
    - Direct sound
    - Reflected sound
  - Noise from other known noise sources; and
  - Ambient noise (also known as Background Noise).
- All noise levels at a given receiver are added logarithmically to yield its overall noise level.

Introduction to Acoustics: Example of Amplitude and Frequency



From Skip Ambrose (NPS Natural Sounds Program)

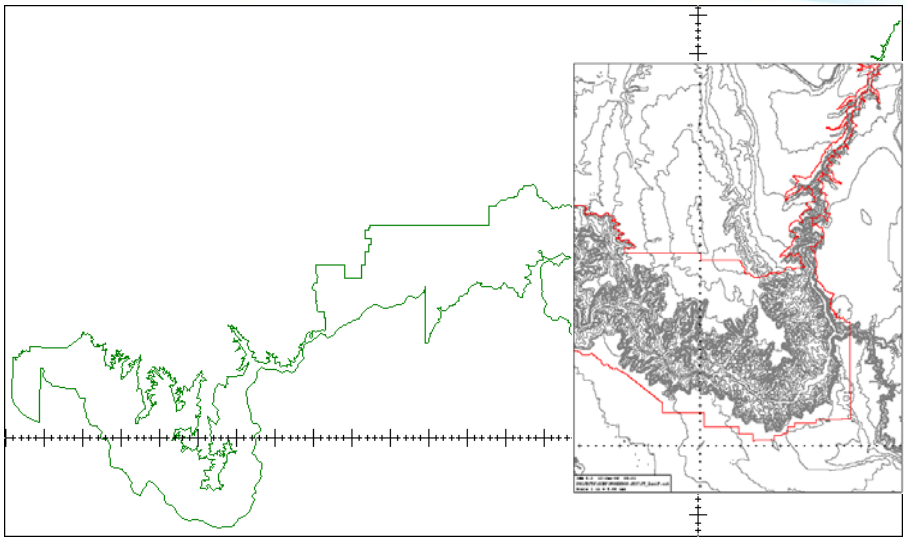
Birds, 47 dBA; Overflight, 47 dBA

Source Data

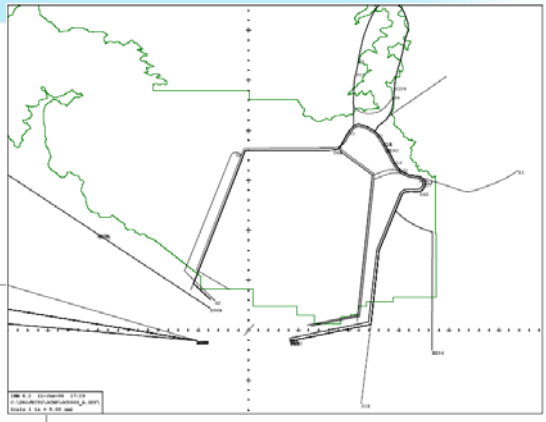
Eurocopter EC-130

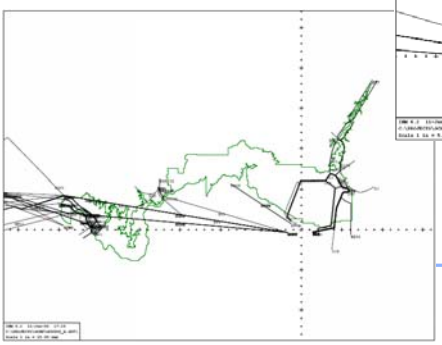
Digital Tracking System

Propagation and Terrain

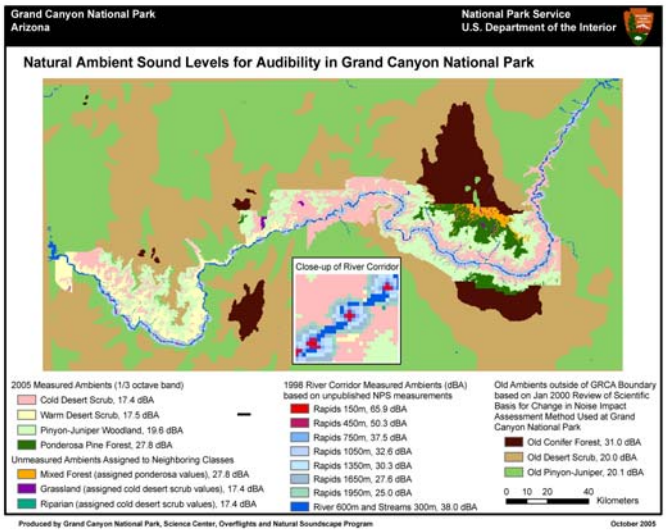


Flight Tracks

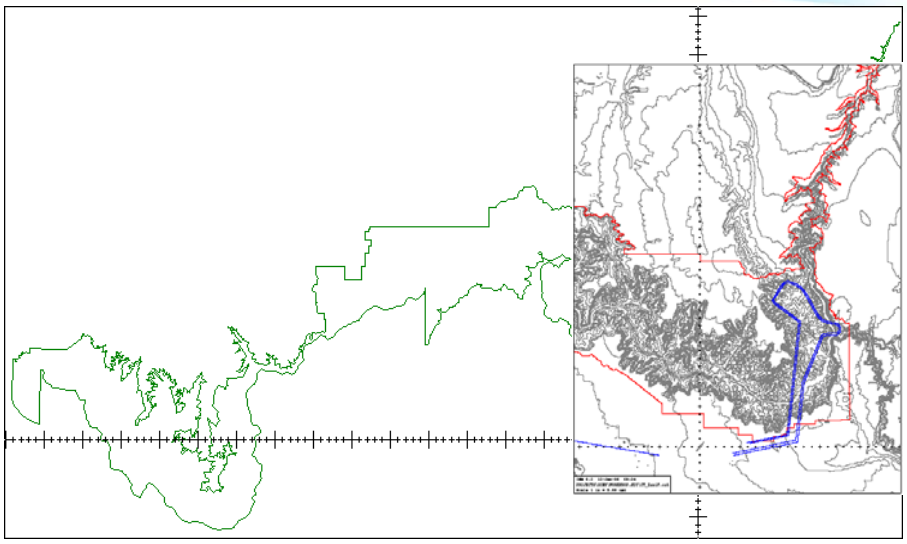




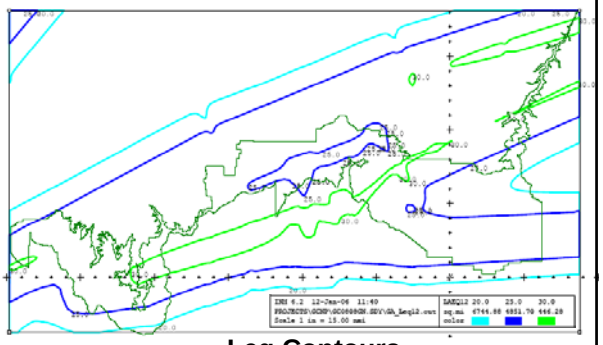
Ambient Data



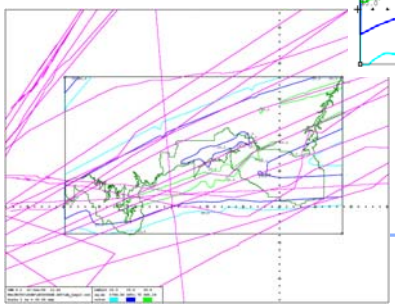
Example Input



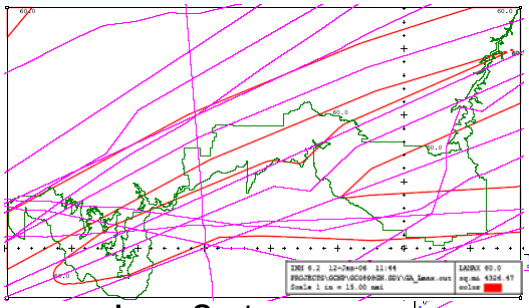
Example Output



Leq Contours

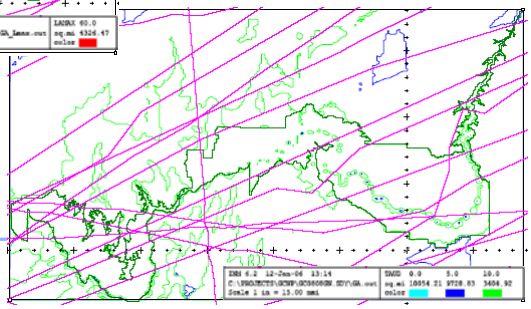


Example Output



Lmax Contours

Time Audible Contours



Pre-Run INM Modeling Sensitivities

Variables Important to Noise in Grand Canyon

- **Aircraft types**
- **Flight tracks**
- **Performance**
- **Altitude**
- **Terrain**
- **Ambient data**

Aircraft Types

Major Aircraft Substitution in GCNP modeling

- **BAE-32 (DHC-6)**
- **Cessna 402 (Beech 58P)**
- **Do-228 (DHC-6)**
- **Do-328 (DHC-8)**

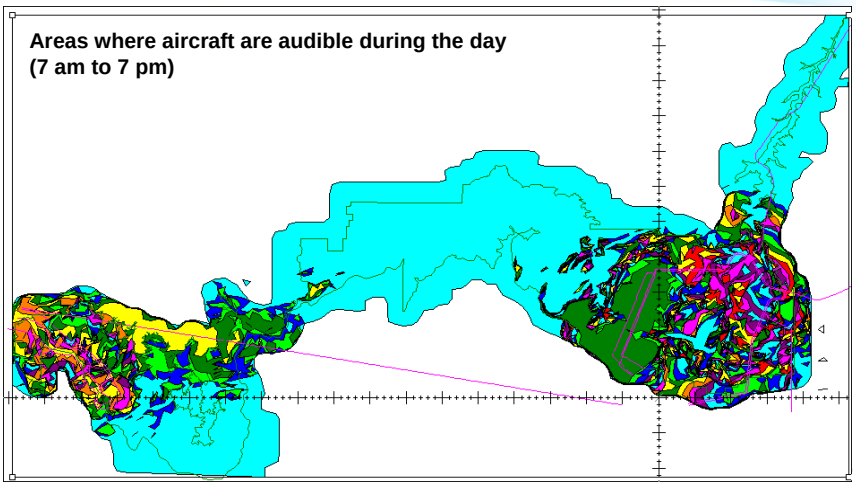
- **Bell 407 (As-350)**

Aircraft Types

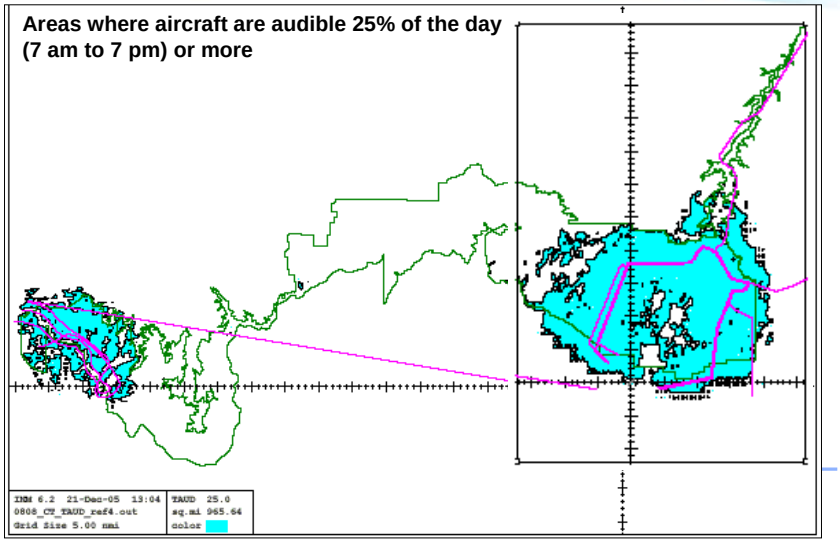
Aircraft Usage in GCNP modeling – Commercial Air Tours (Workshop Example "Base Case")

DHC6	2
DHC6QP	56
DHC8	0
BEC58P	1
CNA20T	27
CNA206	5
EC130	51
SA350D	40
B206L	132
Total	314

Overall Base Case



Overall Base Case



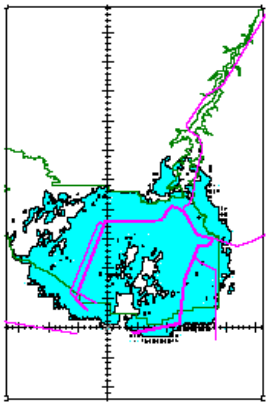
Aircraft Types

We can substitute Quiet Technology aircraft for the other in the fleet to find the impact of different aircraft types:

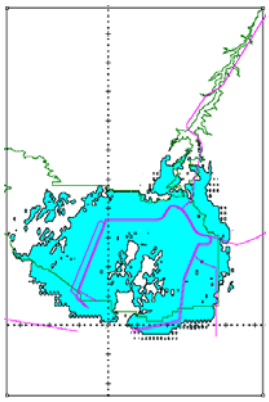
- **Replace all fixed wing aircraft with DHC6QP (DHC-6 with Raisbeck modifications – Vistaliner)**
- **Replace all rotary wing aircraft with EC-130**

Aircraft Types

Base Case



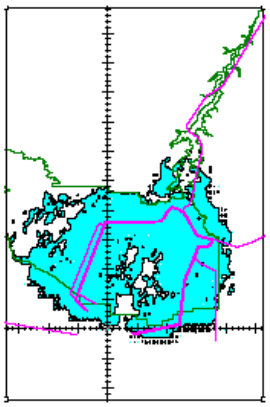
DHC6QP only



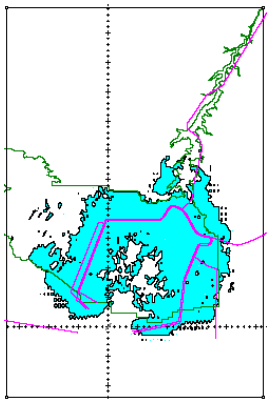
Change = -12.3 sq-mile, -1.7%

Aircraft Types

Base Case



EC-130 only



Change = -138.1 sq-mile, -5.3%

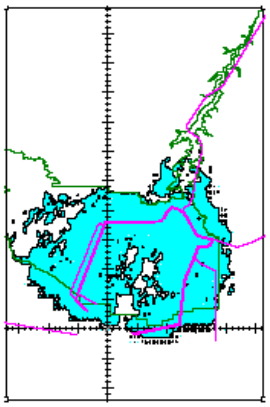
Flight Tracks

We can shift tour off existing routes onto new or other existing routes

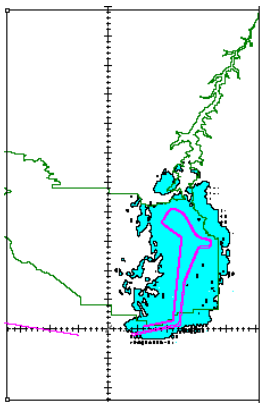
- **Shift all operations on the East End away from the Dragon Corridor (Green 2 and Black 1A) and into Zuni Corridor (Green 1 and Black 1).**

Flight Tracks

Base Case



Zuni Corridor



Change = -436.1 sq-mile, -18.5%

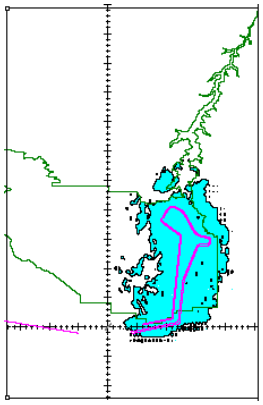
Performance

The regulations in place at GCNP limit the performance parameters we can change

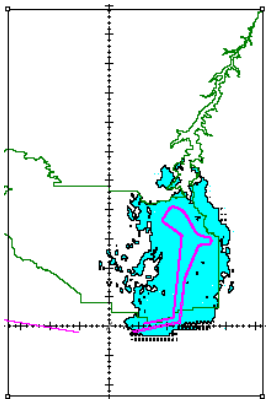
- **Change Vistaliner from tour airspeed (104 KTAS) to transport cruise airspeed (143 KTAS)**

Performance

Zuni Corridor – 104 KTAS



Zuni Corridor – 143 KTAS



Change = +23.2 sq-mile, +1.1%

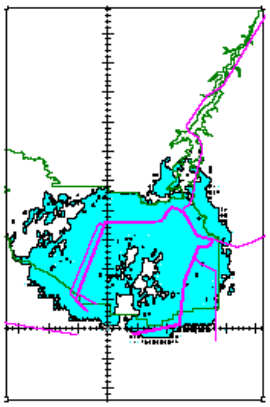
Altitude

We can change the altitudes along the tour route. This often has the counter-intuitive affect of increasing noise exposure with increasing altitude.

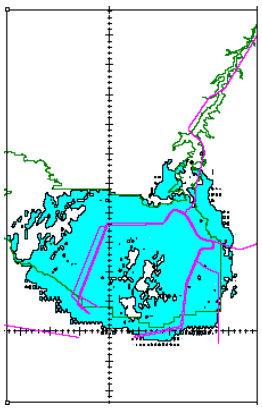
- **Raise altitude on Green 2 (Dragon Corridor helicopters) by 1000 feet**

Altitude

Base Case



1000 ft Higher Altitude



Change = +39.8 sq-mile, +1.8%

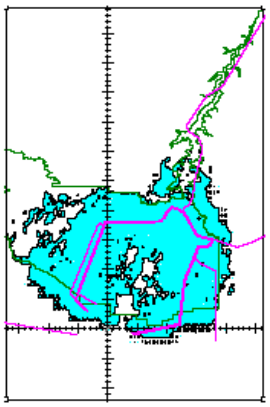
Terrain

Changes to the terrain database don't significantly affect the contours. But changing the effects of terrain on acoustic propagation can have large impacts.

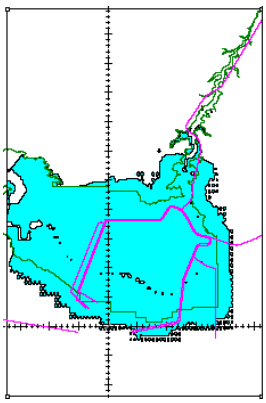
- **Remove Line-of-Sight Blockage from propagation calculations**

Terrain

Base Case



LOS Blockage Off



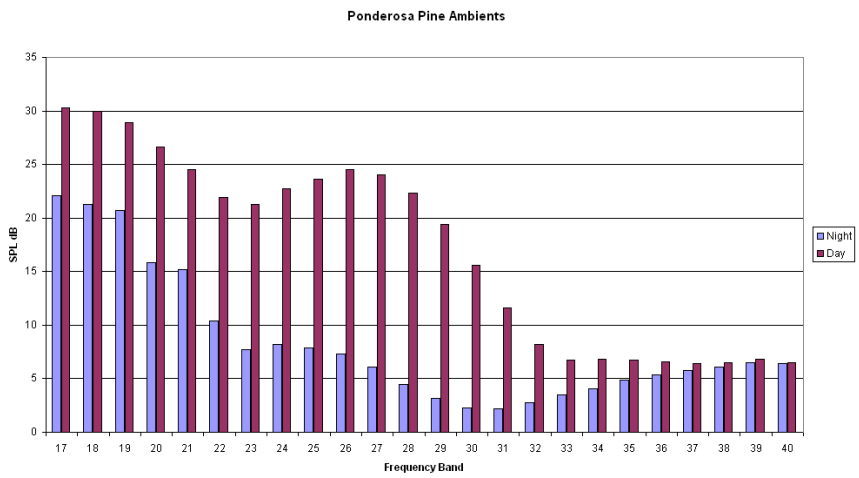
Change = +351.1 sq-mile, +12.1%

Ambient Data

Changing the ambient levels greatly influences the Time Audible metric – but has no affect on Lmax or Leq.

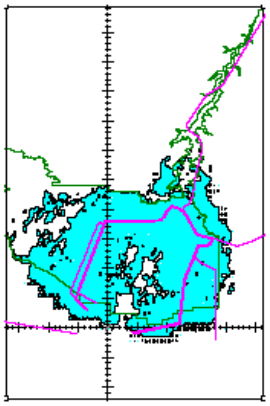
- **Change from daytime to nighttime ambient levels**
- **Increase daytime ambient levels by three dB**

Ambient Data

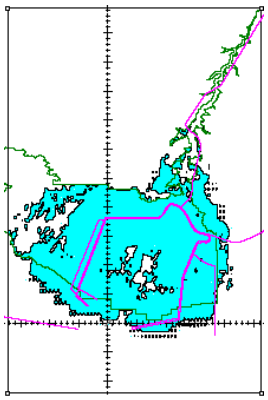


Ambient Data

Base Case



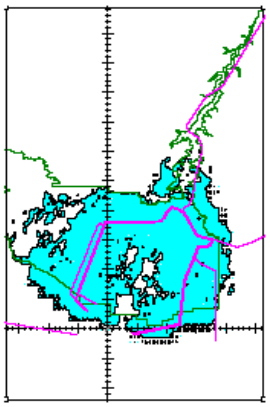
Nighttime Ambient Levels



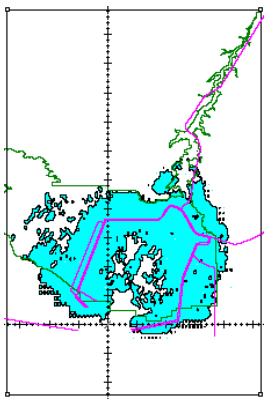
Change = +55.2 sq-mile, +2.8%

Ambient Data

Base Case



+3 dB Daytime Ambient Levels



Change = -109.0 sq-mile, -3.7%

Brainstorm Sensitivities Modeling
Overnight Runs

Day 2
Discussion of Sensitivities Modeling
Overnight Runs

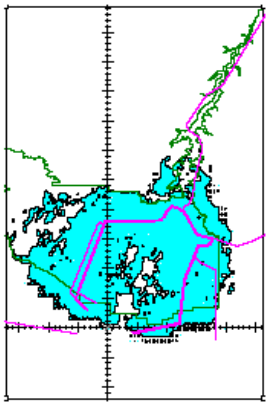
Brainstorm Sensitivities Modeling Overnight Runs

1. Lower altitude on Green 2 (Dragon Corridor helicopters) by 1000 ft
   a. Helicopter operations only
   b. All operations
2. Change commercial air tour aircraft to Quiet Technology
3. Change GC West operations
   a. Remove all GC West operations
   b. Double GC West operations
4. Reduce daytime ambient levels by three dB
5. Move Black 1A/Green 1A routes further south
6. Reduce commercial air tour operations by 20%
7. Increase commercial air tour operations by 20%
8. Change Green 2 route operations
   a. Eliminate Green 2 route operations
   b. Model Green 2 operations only
   c. Model Green 2 operations only and lower altitude by 1000 ft

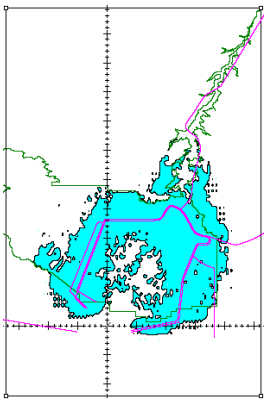
Note: Items in gray were not modeled due to time constraints.

2. Change all air tour aircraft to Quiet Technology

Base Case



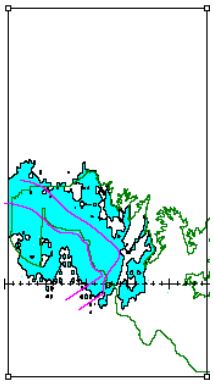
QT Only



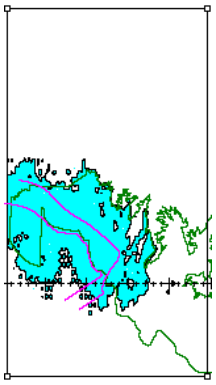
Change = -180.5 sq-mile, -7.3%

3b. Double GC West operations

Base Case



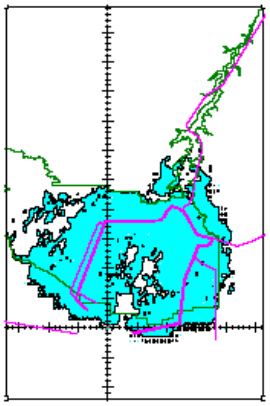
Double Operations



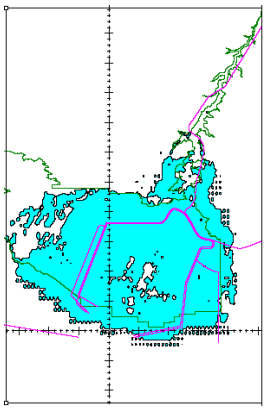
Change = +43.2 sq-mile, +1.5%

4. Reduce daytime ambient levels by 3 dB

Base Case



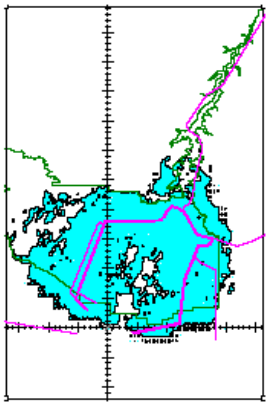
-3 dB Daytime Ambient Levels



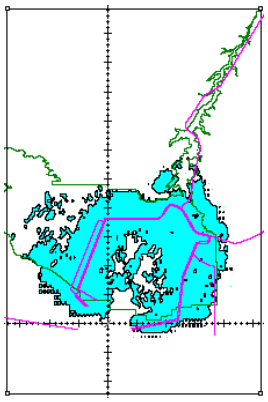
Change = +115.1 sq-mile, +3.6%

(from Day 1 – increase daytime ambient levels by 3 dB)

Base Case



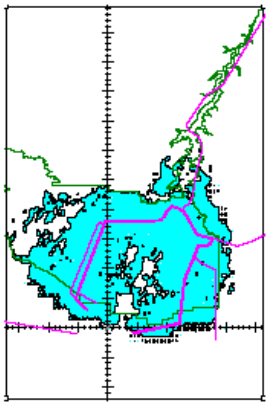
+3 dB Daytime Ambient Levels



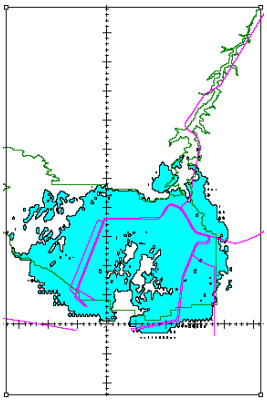
Change = -109.0 sq-mile, -3.7%

6. Reduce commercial air tour operations by 20%

Base Case



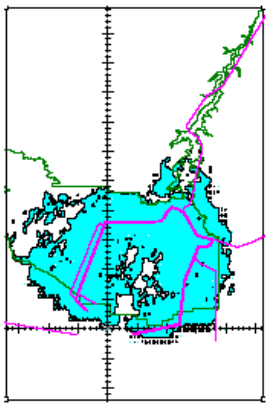
20% Fewer Ops



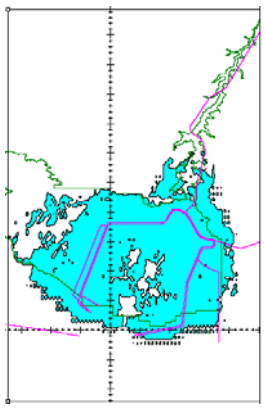
Change = -35.1 sq-mile, -0.9%

7. Increase commercial air tour operations by 20%

Base Case



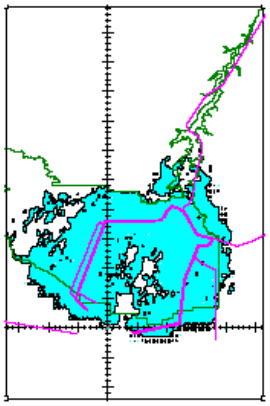
20% More Ops



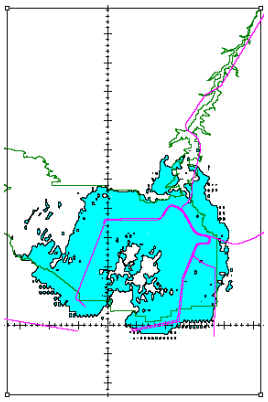
Change = +24.4 sq-mile, +0.6%

8a. Eliminate Green 2 route operations

Base Case



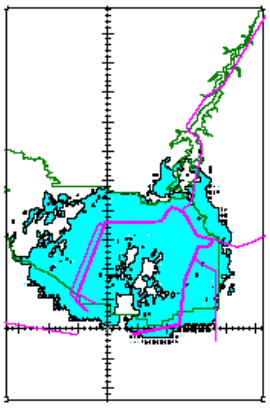
No Green 2



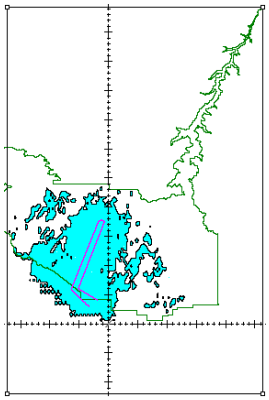
Change = -75.8 sq-mile, -3.1%

8b. Model Green 2 operations only

Base Case



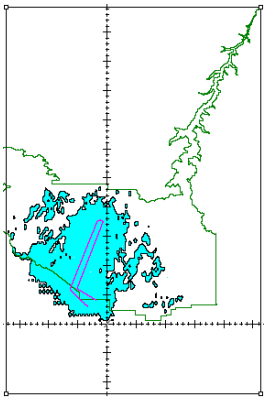
Only Green 2



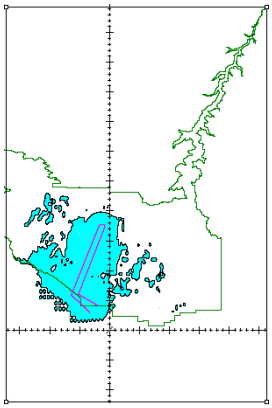
Change = -491.1 sq-mile, -18.5%

8c. Model Green 2 operations only and lower altitude by 1000 ft

Only Green 2



Only Green 2, 1000 ft Lower Altitude



Change = -84.3 sq-mile, -3.8%

Summary

	25% Time Audible Area Change
1. Lower altitude on Green 2 (Dragon Corridor helicopters) by 1000 ft	N/A
a. Helicopter operations only	
b. All operations	
2. Change commercial air tour aircraft to Quiet Technology	-7.3%
3. Change GC West operations	
a. Remove all GC West operations	N/A
b. Double GC West operations	+1.5%
4. Reduce daytime ambient levels by three dB	+3.6%
5. Move Black 1A/Green 1A routes further south	N/A
6. Reduce commercial air tour operations by 20%	-0.9%
7. Increase commercial air tour operations by 20%	+0.6%
8. Change Green 2 route operations	
a. Eliminate Green 2 route operations	-3.1%
b. Model Green 2 operations only	-18.5%
c. Model Green 2 operations only and lower altitude by 1000 ft	-22.3%

Note: Items in gray were not modeled due to time constraints.

Adjourn