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(U) Acoustic Signals and Physiological Effects on U.S. Diplomats in Cuba

DECLASSIFIED

Contact: (b)(6); (b)(7)(C) @mitre.org

(b)(7)(E)

November 2018

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Contents

1 (U) EXECUTIVE SUMMARY

(U//~~FOUO~~) This study concerns a series of events affecting U.S. personnel stationed in Cuba. Some personnel have reported medical symptoms that are correlated with, and have been by many personnel attributed to, specific sensory phenomena experienced at their residences in Havana.

(U) JASON was asked for a rapid-response assessment of this matter, and specifically, to:

- (U//~~FOUO~~) Evaluate possible sources for the generation of the acoustic and other sensations reported by personnel (and their families).
- (U//~~FOUO~~) [redacted] (b)(7)(E)
- (U//~~FOUO~~) Suggest ways to protect personnel in their residences to avoid medical consequences from any similar future events.

(U//~~FOUO~~) In responding to this request, JASON reviewed several types of data: audio and video recordings of high-frequency sounds taken by U.S. personnel; several recent case reports, [redacted] (b)(7)(E) personal descriptions of sensory phenomena and medical symptoms; results of published medical evaluations; and unpublished medical data. We also interviewed one embassy employee who had personally experienced and video recorded one of these events in Havana. Additional basic information about the events was [redacted] (b)(7)(E) to us during two in-person meetings in June and July of 2018. We did not consider potential events arising in countries other than Cuba.

(U//~~FOUO~~) Many of the affected individuals describe hearing unusual sounds, and there are a number of recordings of these sounds. However, in only one instance that we know of (May, 2018 event), does the recorded sound occur simultaneously with reported onset of symptoms. Other instances of the sound were recorded at a different time and/or in a different place, from the reported incident. In addition, some affected individuals did not report any sound.

(U) We present below the findings and recommendations from this rapid-response study, with supporting evidence and arguments when appropriate.

1.1 (U) Findings

~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ JASON emphasizes that the available data at present are insufficient to precisely determine the nature of these incidents. [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) [redacted]

In response to the charge, JASON lists the following key findings:

1. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ **No plausible single source of energy (neither radio/microwaves nor sonic) can produce *both* the recorded audio/video signals, *and* the reported medical effects.** [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

   - ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ The sound pressure intensity levels of the recorded and audible sounds are not, by themselves, the cause of reported long-term harm. While sounds can be annoying and can adequately explain short-term symptoms including headache and nausea, airborne sounds at the observed levels for the durations reported have not to our knowledge been shown to have long-term medical implications. Sound pressure levels in excess of 100 dB (or 0.01 W/m^2 = 0.001 mW/cm^2) are considered potentially harmful, but people who have heard such sounds don't describe them in ways consistent with them being this loud. Pain levels would have caused them to cover their ears, and they didn't. The available recordings are also inconsistent with such high amplitudes.

2. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ There is objective medical evidence that the suffering experienced by the affected individuals is real, as is the necessity for therapeutic interventions. [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) In the evaluation of exposed people, there is a lack of baseline data on the individuals involved, and a lack of a control group from a comparable population[1]. This finding is supported by:

   - ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

[1] **(U//~~FOUO~~)** "Baseline data" refers to the fact that medical issues could have been pre-existing, and there would be no way to know about such pre-existing conditions without suitable testing before personnel arrive on post in Cuba. "Control group" refers to the possibility that the medical abnormalities identified may be at levels consistent with expectations for people with career and work histories such as those involved (e.g., military veterans who have had exposure to guns, bombs, combat stress, etc.), even if they are not consistent with levels in the U.S. population at large. A study with a proper control group would perform medical evaluations on two groups of people with similar past experiences, but only one of which had experienced these events in Cuba.

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[redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

3. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ Many of the affected individuals describe hearing unusual sounds, and there are a number of recordings of these sounds. [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) In addition, some affected individuals did not report any sound.

4. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ **We believe the recorded sounds are mechanical or biological in origin, rather than electronic. The most likely source is the Indies short-tailed cricket, *Anurogryllis celerinictus*.** The call of this animal matches, in nuanced detail, the spectral properties of the recordings from Cuba once room echoes are taken into account. Other hypotheses are also plausible, such as generation by mechanical devices (e.g., a worn pump motor), or structure-borne vibrations.

5. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ **The recorded audio signal is, with high confidence, not produced by the nonlinear detection of high power radio-frequency or ultrasound pulses.** [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ **We judge as highly unlikely the notion that pulsed RF mimics acoustic signals in both the brain (via the Frey effect) and in electronics (though RF interference/pickup).**

(U) Findings 4 and 5 are supported by:

- ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)
- ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

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(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

- ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)
- ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)
- ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ It cannot be ruled out that the perceived sounds, while not harmful, are introduced by an adversary as deception so as to mask an entirely unrelated mode of causing illness in diplomatic personnel. In that case, the medical data must be most carefully assessed.

1.2 (U) Recommendations

(U) JASON places the highest priority on the following two objectives:

1. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

   a. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

   b. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

   c. ~~(S//REL FVEY//LAW ENFORCEMENT SENSITIVE)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

d. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

e. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

f. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

2. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(U) JASON further recommends:

3. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

4. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

5. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6. (S//REL FVEY//LAW ENFORCEMENT SENSITIVE) [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(U) JASON was pleased to conduct this study, which allowed us to assess the possible sources and relevance of the sounds associated with incidents in Cuba, and their possible effects on diplomatic personnel.

2 (U) INTRODUCTION

(U//FOUO) JASON was asked to consider a series of incidents affecting U.S. personnel stationed in Cuba, including both observed physical phenomena (recorded sound and perceived sensation), and also reported medical symptoms and signs. These incidents took place at people's residences, or at several different hotels, in Cuba (Stone, 2017).

2.1 (U) Briefings

(S//REL FVEY//LAW ENFORCEMENT SENSITIVE) JASON received two days of briefings [redacted] (b)(6); (b)(7)(C); (b)(7)(E) DOS provided an overview of the current state of affairs [redacted] (b)(6); (b)(7)(C); (b)(7)(E)

2.2 (U) Embassy Employee Interview

(FOUO/LAW ENFORCEMENT SENSITIVE) [redacted] (b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE) [redacted] (b)(6); (b)(7)(C); (b)(7)(E) (b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(FOUO/LAW ENFORCEMENT SENSITIVE)

(b)(6); (b)(7)(C); (b)(7)(E)

(U//FOUO) JASON noticed that the sounds in the employee's home was not truly localized like a beam of light. Rather, the sound emanated from a single location (the back kitchen door) and the intensity matched that of an acoustic source with gradual drop off in intensity. This stands in contrast to previous reports of highly localized sound.

~~(FOUO/LAW ENFORCEMENT SENSITIVE)~~ (b)(6); (b)(7)(C); (b)(7)(E)

~~(S//REL TO USA, FVEY)~~ (b)(6); (b)(7)(C); (b)(7)(E)

2.3 (U) Audio Recordings of Sounds

(U//~~FOUO~~) From the published medical assessments of people who have experienced these events, Swanson et al. (2018) note: "Affected individuals described the sounds as directional, intensely loud, and with pure and sustained tonality. Of the patients, high-pitched sound was reported by 16 (76%), although 2 (10%) noted a low-pitched sound. Words used to describe the sound include "buzzing," "grinding metal," "piercing squeals," and "humming.""

(U//~~FOUO~~) On at least eight occasions, these sounds were captured on recording devices by the people experiencing them. We were given access to these recordings, as summarized in Table 2-1. JASON was asked to consider possible sources for the generation of these sounds, and the type of sensors that could be deployed to monitor for these sounds (or the energy giving rise to them) in remote locations.

Table 2-1 (U//~~FOUO~~) Summary of recordings given to JASON for analysis

Sample (name used in this study)	Apparent date of recording*	Notes
X	(b)(7)(E)	
A		
B		
C		
D		
E		
F		
G		

* Date is derived from metadata or file name, although it is not known whether this is the same as the date that the recording was originally made. ** The year was unknown, but presumed to be 2017.

2.4 (U) Descriptions of Perceived Sensations

(U//FOUO) JASON also had information about the sensory experiences of some of the people involved. Most of these observations were already described in an open medical publication (Swanson et al., 2018), and JASON was also given access to a few subsequent case reports. These data are of course subject to personal interpretation, and also to auditory and other biological differences between different people. Nonetheless, there may be important clues here.

(U//FOUO) From the published medical assessments of people who have experienced these events (Swanson et al., 2018), the authors note: "The sounds were often associated with pressure-like (n = 9, 43%) or vibratory (n = 3, 14%) sensory stimuli, which were also experienced by 2 of the 3 patients who did not hear a sound. The sensory stimuli were likened to air "baffling" inside a moving car with the windows partially rolled down."

(S//REL FVEY) [redacted] (b)(1); 1.4 (b); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) [redacted] (b)(1); 1.4 (b); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL to USA, FVEY) [redacted] (b)(1); 1.4 (b); 1.4 (d); 1.4 (e); (b)(7)(E)

2.5 (U) Medical Evaluations

(S//REL TO USA, FVEY) U.S. personnel in Havana who reported experiencing distressing audible or other sensory phenomena, or who believe they may have been exposed to such phenomena, were evaluated by an interdisciplinary medical team at the University of Pennsylvania's Center for Brain Injury and Repair (Swanson et al., 2018). This study examined 21 such personnel, all of whom were stationed in Havana, Cuba, between late 2016 and August 2017. The most commonly reported symptoms were persistent sleep disturbance (n = 18, 86%), visual symptoms (n = 18, 86%), cognitive difficulty (n = 17, 81%), headache (n = 16, 76%), balance problems (n = 15, 71%), and auditory symptoms (n = 15, 71%). Twenty people (95%) reported symptoms lasting longer than 3 months. In all, cognitive impairment was suspected in 16 individuals (76%).

3 (U//[redacted]) ANALYSIS OF THE AUDIO RECORDINGS

(U//[redacted]) Two MP4 cell phone video files, recorded by an embassy employee, furnish a starting point for analysis of the signal (denoted sample "X" in Table 2-1). The first,

(b)(7)(E)

The second recording has periods during which the signal of interest is heard strongly, and also periods during which it is not heard, seemingly when the operator closes the back door that connects the kitchen to the back yard. JASON notes that after the conclusion of the summer study, we received additional videos from the embassy employee that have not been analyzed, but at cursory glance appear to be consistent with our findings.

(U//[redacted]) We concentrate here on the two recordings designated X, since they are directly linked to a subsequent clinical evaluation that was triggered by concerns over the loud noises. The two X samples have both audio and video components, some with voice-over by the individual who made the recordings. We note the following:

- (U//[redacted]) The individual reports that the recorded sounds match what he/she recalls hearing.
- (U//[redacted]) The sound intensity did not cause the occupant to cover his/her ears in response to painful sound levels, and the threshold of pain is below that of physical damage, for audible frequencies.
- (U//[redacted]) The sound was audible over a wide spatial area in the apartment, from the living room to the kitchen.
- (U//[redacted]) Opening and closing the back door, where the kitchen connects to the back yard, had a correlation to the sound's on/off state. This was confirmed by the person who made the recordings.
- (U//[redacted]) The sound level of the buzzing as recorded on the smartphone is comparable (within tens of dB) to the recorded voice level, and was reported as annoying but not painfully loud to the occupant. The most straightforward interpretation of this is that both the smartphone and the person were hearing actual sound energy in the room, rather than individually responding to inaudible signals from down-converted RF, since it seems superficially unlikely that the phone and the person would "hear" comparable levels of artificial sound.
- (U//[redacted]) The individual reported making a Facetime call during the time the sound was active, prior to making the recordings, and that lights and other electronics in the house (Netflix TV over WiFi, for example) seemed to be working normally.

(U//~~FOUO~~) Any proposal for the source of the sounds must be consistent with these observations. Independently, any proposal for connecting the sounds to physiological damage must be consistent with these observations.

(U//~~FOUO~~)

(b)(7)(E)

(U//~~FOUO~~)

(b)(7)(E)

3.1 (U//~~FOUO~~) Evidence that the Signal is Periodic

(U//~~FOUO~~)

(b)(7)(E)

(b)(7)(E) [redacted]

Figure 3-1. (U//~~FOUO~~) Power spectrum of recording with signal of interest present (red) and absent (blue).

(U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E)

Figure 3-2. (U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//~~FOUO~~) [redacted] (b)(7)(E)

[redacted] (b)(7)(E)

Figure 3-3. (U//~~FOUO~~) [redacted] (b)(7)(E)

(U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 3-4. (U//~~FOUO~~) Synthesized waveform. Pulse (repeated twice) with approximately the same spectral characteristics as the signal of interest. A pulse like this might plausibly be produced electronically.

(U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E)

Figure 3-5. (U//FOUO)

(b)(7)(E)

(b)(7)(E)

Figure 3-6. (U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//~~FOUO~~) While not definitive, the comparison of Figure 3-5 and Figure 3-7 suggests that the perceived and recorded signal is actually produced acoustically, and is not indirectly by the demodulation of a pulsed RF signal by nonlinearities. [redacted] (b)(7)(E)

(U//~~FOUO~~) There is even more direct evidence that the perceived and recorded signal is acoustic buried in
Figure 3-1. We will return to this below in Section 3.2.

(b)(7)(E) [redacted]

Figure 3-7. (U//~~FOUO~~) Acoustic spectrum of a model where RF is modulated by the envelope shown in Figure 3-6, [redacted] (b)(7)(E)

3.2 (U//~~FOUO~~) Recordings Provided Show Similar Characteristics, but Different PRFs

(U//~~FOUO~~) We were provided with several other recorded samples of the signal of interest, made by different people, on different dates, in different locations (**Table 1**). We denote these A, B, C, D (with related recordings D1 and D2), E, F, and G (not all of which contain analyzable data); the video sample already shown in Figure 3-1 – Figure 3-3 is denoted X. All of X, B, D, and G sound approximately the same: a piercing and slightly "fuzzy" high-pitched tone. Figure 3-8 shows that they have similar spectral characteristics, but with some notable differences. All show the comb of frequencies that suggest a periodic signal. All show an envelope with substantial power around (b)(7)(E) Most, but not all, show evidence of a second harmonic envelope at (b)(7)(E) The differences among the spectra at (b)(7)(E) and below are due to different ambient room noise, and are likely not associated with the signal of interest. Sample A's broad spectral peaks at (b)(7)(E) and (b)(7)(E) not seen in the other samples, are bird sounds in the recording.

(U//~~FOUO~~) The most notable difference among the different recordings is that the harmonic spacings—PRFs for a periodic signal—are not the same as Signal X's (b)(7)(E) but are at seemingly random values in the range (b)(7)(E)

(b)(7)(E)

Figure 3-8. (U/FOUO) (b)(7)(E)

(b)(7)(E) [redacted]

Figure 3-9. (U//~~FOUO~~) [redacted] (b)(7)(E)

(U//~~FOUO~~) Figure 3-9 [redacted] (b)(7)(E)

(U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E)

Figure 3-10. (U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(b)(7)(E)

3.3 (U//~~FOUO~~) The Signal's PRF Varies Irregularly on a Timescale of Seconds

(U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) Figure 3-11 (b)(7)(E)

(U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) (b)(7)(E)

(b)(7)(E)

Figure 3-11. (b)(7)(E)

3.4 (U//FOUO) Summary of Findings from Analysis of Recordings

(U//FOUO) With high confidence, we find that the signal of interest is not produced by the nonlinear detection of high power radiofrequency pulses whose pulse shape generates the perceived audio signal. (b)(7)(E)

(U//FOUO) With high confidence, we find that the recorded sounds are entirely consistent with bioacoustics noise (Section 4.3). We have identified a candidate species of insect whose call is an excellent match to the acoustic power spectra. This does not preclude the audio sounds being a source of harassment. Also, we find that the power levels in the audio part of the spectrum are too low to produce physiological damage.

(U//~~FOUO~~) With medium confidence we find that the pulses are not electronically, timed. [redacted]

(b)(7)(E)

(U//~~FOUO~~) With medium-to-low confidence we find that the acoustic signal of interest may be produced by the bearing noise in some kind of rotating machinery, with a concrete vibrator being one possibility.

4 (U//FOUO) MECHANICAL AND BIOLOGICAL SOUNDS CONSISTENT WITH RECORDINGS

4.1 (U//FOUO) Portable Gasoline Generators (b)(7)(E)

(U//FOUO) Interestingly, there exist commodity portable gasoline generators that produce power at a nominal frequency (b)(7)(E) see Figure 4-1.

(b)(7)(E)

Figure 4-1. (U//FOUO) Portable gasoline generator that produces (b)(7)(E) and is used to power high-cycle (b)(7)(E) concrete vibrators.

(U//FOUO) Equally interesting is that a principal use of such (b)(7)(E) generators is to power so-called high-cycle concrete vibrators. Concrete vibrators are used in construction to facilitate the settling of poured concrete in forms, in particular to collapse air bubbles in the pour. (b)(7)(E) Concrete vibrators are made in versions intended for momentary immersion in the pour, and also in versions intended to be bolted to the outside of the form and run continuously.

4.2 (U//FOUO) Bearing Noise

(U//FOUO) Bearing noise is produced by ball- or roller-bearings, especially worn bearings. It has been studied in a number of academic papers, principally as an indicator of imminent bearing failure. A typical spectral signature consists of harmonics of the fundamental train frequency

(FTF), the frequency at which rolling elements come into contact with a defect. The inner and outer traces have different FTFs. Typically the harmonics are enhanced near resonances of the bearing cage, which are said to be difficult to compute from first principles, but easy to observe (Dolenc et al., 2016; McFadden & Smith, 1984).

(U//FOUO) We downloaded from the web two recorded samples of bearing noise that seemed relevant, first, short segments of the sound of a concrete vibrator (most likely not high-cycle), and second, a recording of a swimming pool pump made specifically to illustrate what worn bearings sound like. Both recordings are, to the ear, reminiscent of the signal of interest. [redacted]

(b)(7)(E)

[redacted]

(b)(7)(E)

Figure 4-2. (U//FOUO) Comparison of bearing noise to the signal of interest. [redacted]

(b)(7)(E)

(U//~~FOUO~~)

(b)(7)(E)

(U//~~FOUO~~) Concrete workers are not known to suffer neurological damage from prolonged and frequent exposure to the sound of cement vibrators. The hypothesis that these machines explain the observed sounds does not explain the damage reported by our diplomats. It is possible that, even if we have correctly identified the sound sources, they were employed differently than in their routine use in the concrete industry.

4.3 (U//~~FOUO~~) Insects

(U//~~FOUO~~) Cuba is a highly bio-diverse region, with many species of indigenous insects. Researchers from Cuba have produced draft manuscripts that analyze the background noise of crickets in Havana (Barcelo-Perez & Gonzales Sanchez, 2018). The data do not exist (to our knowledge) to allow a comprehensive comparison of the sounds of all Cuban insects with the recordings. We instead used readily available online digital recordings of various species to perform spectral comparisons, with selections guided by the PRF and audio-frequency range power spectrum.

(U//~~FOUO~~) We found an online recording of the sound from one particular species, the Indies short-tailed cricket, that is an excellent match (at the detailed level) to the sounds heard in the recordings. This species is known to inhabit the island of Cuba.

(U//~~FOUO~~) Another insect, the robust conehead, has a signal that is similar but not as good a match. A detailed comparison of audio power spectra for these two insects is provided in the next two subsections.

(U//~~FOUO~~) We are not claiming to have unambiguously identified the exact species responsible for the sounds on the recordings. We do conclude, however, that an insect matches well the present data at hand, except for the medical assertions of causal, long-term neurological harm.

4.3.1 (U//~~FOUO~~) Katydids including *Neoconocephalus robustus*

(U//~~FOUO~~) The recorded sounds from most insect species we compared were a poor match to the data, in either PRF or power spectrum. But when comparing the sounds made by certain Katydids (related to crickets and grasshoppers, with ~6400 known species) we found that the PRF and underlying power spectrum are a good match to the recordings[2]. The PRF as a function of time is significantly more stable in the Cuba recordings than the Katydid sound samples we could find online.

[2] (U//~~FOUO~~) We are grateful to Alexander Stubbs, a biologist at UC Berkeley, for pointing out the *N. robustus* similarities, and for providing many of the references used in this section.

(U//FOUO) The species *Neoconocephalus robustus* is commonly known as the "robust conehead" katydid, and has a pulsed sound structure that seems to match that of the recordings. We obtained a digital sample of this animal's sound from http://entnemdept.ufl.edu/Walker/buzz/195a.htm.

Figure 4-3 shows a comparison of the pulse structure in the time domain from one of the high signal-to-noise recordings from Cuba (sample M) and that of *N. robustus*. The PRF for this animal is determined by how often it scrapes across a toothed skeletal structure, and the 'carrier' spectral content depends on the detailed toothed spatial structure and on the speed of scraping.

(U//FOUO) This creature can generate continuous calling sounds for extended periods of time (up to 20 minutes), at remarkably loud sound levels: "But the Robust Conehead! That degree of intensity is only tolerable from a considerable distance. Approaching him without some kind of hearing protection is absolutely excruciating!" (http://listeninginnature.blogspot.com/2017/08/too-much-of-good-thing.html)

(U//FOUO) The spectral peaks and PRF for the robust conehead recording we were able to find online and analyze is not an exact match to the spectral peaks and PRF seen in recording X. But the spectral peak locations and their relative sizes vary across the different recordings we received from Cuba, as do their PRFs. Insects specialize and evolve their call spectra in order to distinguish themselves from other creatures in the region (Walker, 1974) and the PRF is known to depend on temperature (and size of the adult insect) so these facts might account for the differences.

(U//FOUO) [redacted] (b)(7)(E)

(U//FOUO) We extracted a 4.5 second clip from the second recording from Residence X from time 7.7 to 12.2 seconds, after the door was opened for the second time but before it was closed again. During this interval the high-pitched squeal was clearest. [redacted] (b)(7)(E)

(b)(7)(E)

[redacted]

Figure 4-3. (U//F~~OUO~~) Comparison of recorded pulses from Cuba sample M and downloaded recording of katydid species *N. robustus* from https://player.vimeo.com/video/77525664. [redacted] (b)(7)(E)

(U//FOUO) An audio clip of *Neoconocephalus robustus* katydid was obtained from the web at https://player.vimeo.com/video/77525664. [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 4-3. (U//FOUO) [redacted] (b)(7)(E)

SECRET//REL TO USA, FVEY//LAW ENFORCEMENT SENSITIVE

DECLASSIFIED

(b)(7)(E)

[redacted]

Figure 4-4. (U//FOUO) [redacted]

(b)(7)(E)

(U//FOUO)

Figure 4-4 [redacted]

(b)(7)(E)

(U//FOUO) [redacted]

(b)(7)(E)

DECLASSIFIED

SECRET//REL TO USA, FVEY//LAW ENFORCEMENT SENSITIVE

Figure 4-5, [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 4-5. (U//~~FOUO~~) [redacted] (b)(7)(E)

(U//~~FOUO~~) [redacted] (b)(7)(E)

(U//~~FOUO~~) [redacted] (b)(7)(E)

(U//~~FOUO~~) Figure 4-6 [redacted] (b)(7)(E)

(b)(7)(E)

Figure 4-6. (U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) (b)(7)(E)

(b)(7)(E)

Figure 4-7. (b)(7)(E)

(U//FOUO) Figure 4-9

(b)(7)(E)

(U//FOUO)

(b)(7)(E)

(U//FOUO)

(b)(7)(E)

(U//FOUO)

(b)(7)(E)

(b)(7)(E)

Figure 4-8. (U//FOUO)

(b)(7)(E)

(b)(7)(E) [redacted]

Figure 4-9. (U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

(U//~~FOUO~~) There are two factors that argue against *N. robustus* being the source of these sounds:

1) (U//~~FOUO~~) [redacted] (b)(7)(E)

2) (U//~~FOUO~~) we don't know that this species (or perhaps a close relative) inhabits Cuba

4.3.2 (U//~~FOUO~~) Crickets including *Anurogryllis celerinictus*

(U//~~FOUO~~) The *N. robustus* spectral analysis above shows that katydid calls have an acoustical structure similar to that seen in the Cuba recordings [redacted] (b)(7)(E)

In the Dominican Republic when the warm and humid evening arrives, scattered chirping and tinkling notes issue from the shrubs and trees here and there. Some of these are clear, incisive little points of high-pitched sound; others are powerful, penetrating, buzzing, almost ringing noises, continuous and even very disconcerting to many people because of the incessant din.

In the capital city, Ciudad Trujillo, the large brown cricket *Anurogryllus muticus* (DeGeer) is very common and noisy throughout the winter. As soon as night came on and lights appeared, these ubiquitous crickets began their activities out-of-doors in the yard and even within the wide-open houses, for there are no screened windows or doors in the typical Spanish houses.

The song of the males of this cricket, here, is a continuous ringing z-z-z-z-z-z of tremendous volume and penetration which practically fills a room with veritable din. The song is quite like that of our common cone-head, *Neoconocephalus robustus crepitans* (Scudder) of the eastern United States. After being accustomed to hear the trilling notes, definitely musical in tonality, of our American individuals of this species, I was somewhat nonplussed to hear this tropical cricket singing continuously, with all the characteristics of a cone-headed katydid, and with no tonality in its stridulation. I

(U//FOUO) This passage led us to the papers by Walker (1973,1974), and to consider the Indies short-tailed cricket, *Anurogryllis celerinictus* (Walker, 1973) as a candidate insect responsible for the recorded sounds. The name *celerinictus* (*celeri*=fast, *nictus*=calling) is a clue that this creature has one of the highest PRFs seen in calling insects (Walker, 1975). The recording of *A. celerinictus* (

Figure 4-10) that we downloaded from the University of Florida archive (https://entnemdept.ifas.ufl.edu/walker/buzz/492a.htm) shows (b)(7)(E) and audio carrier peak that are all consistent with the Cuba recordings. The comparison of *A. celerinictus* and sample X is shown in

Figure 4-11 and Figure 4-12.

(b)(7)(E)

Figure 4-10: (U//FOUO) Pulse structure of *A. celerinictus* sample from University of Florida.

(U//FOUO) (b)(7)(E)

(U//FOUO) An audio clip of *Anurogryllus celerinictus* (Indies short-tailed cricket, found throughout the West Indies) was obtained from the web[1]. This recording is from a male from Big Pine Key, Monroe County, FL when the temperature was 27.0 °C. (b)(7)(E)

(b)(7)(E) [redacted]

(U//~~FOUO~~)

Figure 4-11 [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 4-11: (U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 4-12: (U//FOUO) [redacted] (b)(7)(E)

(U//FOUO) Figure 4-12 [redacted] (b)(7)(E)

(U//FOUO) [redacted] (b)(7)(E)

(b)(7)(E)

Figure 4-13: (U//~~FOUO~~) (b)(7)(E)

(U//~~FOUO~~) The single recording of *A. celerinicus* that we were able to find online matches (b)(7)(E)

(U//~~FOUO~~) One element where the single sample of *A. celerinictus* does not conform to the Cuba recordings is (b)(7)(E)

(U//~~FOUO~~) The mechanics of cricket sound generation has been studied extensively; see for example, Bennet-Clark (1999) and Bennet-Clark & Bailey (2002). There is a correlation between the age of an insect and the power spectrum that it emits. The sound-making anatomical parts degrade with age, and higher harmonics of the carrier fundamental increase over time (Hartley & Steven 1989).

(U//~~FOUO~~) We judge it as likely that the recording obtained from Univ of Florida is of a young cricket of the species *A. celerinictus*, while the buzzing sounds in the Cuba recordings are from older insects of *A. celerinictus*, or a closely related species.

(U//~~FOUO~~) We believe this likely accounts for the variation in the (b)(7)(E) content between the various recordings obtained in Cuba, and the online recording.

4.3.3 (U//~~FOUO~~) Future Directions for Exploring the Insect Hypothesis

(U//~~FOUO~~) The hypothesis that bioacoustics is responsible for the buzzing noise that was both heard and recorded in (b)(7)(E) has a number of implications that lead to the following recommendations:

- (U//~~FOUO~~) Obtain additional recordings of similar-sounding insects in Havana. (b)(7)(E)
- (U//~~FOUO~~) If insects are making these noises, we can try to locate them. Many insects are attracted to UV light- set up a sheet and UV illuminator to attract these insects, and see what develops.
- (U//~~FOUO~~) Katydids and crickets are primarily acoustically active at night. A time history of when these alleged events occurred, taking into account occupancy statistics over weekdays and weekends, might be informative.
- (U//~~FOUO~~) Many insects have evolved a response to avoid predation by bats, and they can detect the ultrasound chirps of bats. It would be interesting to play a bat ultrasound recording and see if the sounds cease.
- (U//~~FOUO~~) Based on the experience in (b)(7)(E) from Havana, it would be very informative to open and close doors and make other noises, and see if the buzzing sounds stop.
- (U//~~FOUO~~) The *A. celerinictus* males have burrows. Search for insect burrows at locations that have reported these noises. These borrows are covered over in the daytime, so this search should be conducted after dark.
- (U//~~FOUO~~) Callback experiments with katydids (where a recording is played to stimulate a response) can generate both a change in call structure (Tauber, 2001) or else phonotaxis (where the animal moves towards the source of sound). Brush et al (1985) state that "Approximately 50% of all direct responses ended with a jump onto the loudspeaker". We suggest that both interior and exterior experiments be conducted at sites that have "events", to see if insects are attracted to speakers that play back the offending sounds.
- (U//~~FOUO~~) If the sounds are originating from insects with no nefarious intent behind it, we would expect locals (neighbors, especially) to have had similar experiences. Interviews of experienced locals therefore seems worthy of consideration, with due attention being paid to the potential political/cultural complications.
- (U//~~FOUO~~) (b)(7)(E)

- (U//~~FOUO~~) Recordings from the Guantanamo region could shed light on this. We also note that Grand Cayman has a significant faunal overlap with insect species from Cuba. Collecting any insects that have (b)(7)(E) would be worthwhile, for conducting laboratory acoustic experiments.

(b)(7)(E)

Figure 4-14. (U//~~FOUO~~) (b)(7)(E)

5 (U//~~FOUO~~) OTHER EXPERIMENTAL RESULTS

(U//~~FOUO~~) We performed a set of laboratory tests to help elucidate some of the issues raised in the previous discussion.

(b)(7)(E)

(U//~~FOUO~~)

(b)(7)(E)

5.1 (U//~~FOUO~~) Acoustic Measurements with Single Tone and with Composite Waveform

(U//~~FOUO~~) Figure 5-1 shows our measurement setup for the acoustic measurements.

(b)(7)(E)

(U//~~FOUO~~)

(b)(7)(E)

(b)(7)(E)

[redacted]

Figure 5-1. (U//FOUO) Measurement setup for the acoustic measurements. (b)(7)(E) [redacted]

(b)(7)(E)

[redacted]

Figure 5-2. (U//FOUO) (b)(7)(E) [redacted]

(b)(7)(E) [redacted]

Figure 5-3. (U//FOUO) (b)(7)(E) [redacted]

(b)(7)(E) [redacted]

Figure 5-4. (U//FOUO) (b)(7)(E) [redacted]

(b)(7)(E)

Figure 5-5. (U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(b)(7)(E)

Figure 5-6. (U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(b)(7)(E)

[redacted]

Figure 5-7. (U//FOUO) [redacted]

(b)(7)(E)

5.2 (U//~~FOUO~~) Smartphone Audio Fidelity

(U//~~FOUO~~) To assess whether a smartphone video recording's audio can preserve adequate fidelity for the tasks we require, we did the following experiment: we used our (b)(7)(E) (Android) smartphone to make a recording of the composite audio, (b)(7)(E)

(b)(7)(E)

Figure 5-8. (U//~~FOUO~~) Smartphone audio waveforms of acoustic wave, as recorded in several compressed formats. Compare with (b)(7)(E) of Figure 5-3.

(b)(7)(E) [redacted]

Figure 5-9. (U//~~FOUO~~) Smartphone audio waveform in uncompressed wav format at the phone's default sampling rate.

5.3 (U//~~FOUO~~) Radiofrequency Measurements

(U//~~FOUO~~) [redacted] (b)(7)(E)

(b)(7)(E) [redacted]

Figure 5-10. (U//~~FOUO~~) A modulated microwave source drives a small antenna, to test the possibility of nonlinear audio conversion in a nearby smartphone.

(b)(7)(E)

Figure 5-11. (U//FOUO) Photograph of (b)(7)(E) used for the RF experiment.

5.4 (U//FOUO) Proposed Experiments

5.4.1 (U//FOUO) Find Distant Beaming Acoustic or RF Beaming Antennas by Reciprocity

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

(U//FOUO) (b)(7)(E)

6 (S//REL FVEY) EXPLANATORY SCENARIOUS WITH PROS AND CONS

6.1 (U) General Considerations

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

- (S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)
- (S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E) (See Figure 6-1)
- (S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

Figure 2 (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

Figure 6-1. (S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); (b)(5); 1.4 (d); 1.4 (e); (b)(7)(E)

6.2 (U) Discussion of Acoustical Scenarios

6.2.1 ~~(S//REL FVEY)~~ Calculation of sound penetration of a window

~~(S//REL FVEY)~~ External sound in the air impinging on a window is mostly reflected. At normal incidence the reflection coefficient is

$$R = \left(\frac{Z_g - Z_a}{Z_g + Z_a}\right)^2.$$

~~(S//REL FVEY)~~ Here the impedance of the window pane (not the impedance of an infinite volume of glass) $Z_g = \rho_g t_g$, where ρ_g is the glass density and t_g its thickness. The impedance of air for sound waves of frequency v is $Z_a = \rho_a c_a / (2\pi v)$, where ρ_a is the density of air and c_a its sound speed.

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) This is consistent with our experience that a closed window greatly reduces the noise from outdoor sources, but that loud noises (such as sirens) are still loud enough to be heard, and even to interrupt conversations. The window transmits low frequency sound much better than high frequency sound.

~~(S//REL FVEY)~~ Thicker glass reduces the transmission, but not by large factors. Double glazing is much more effective at attenuating sound because each pane introduces an impedance mismatch, but their contributions are not simply additive because the air space between the panes is much narrower than the wavelength.

~~(S//REL FVEY)~~ At the high frequencies discussed in this report, windows are effective barriers to sound. Acoustic coupling from outside sources is likely to be by coupling to the structure rather than through the air.

~~(S//REL TO USA, FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.2.2 ~~(S//REL FVEY)~~ Scenario: Acoustical Harassment gone awry

~~(S//REL FVEY)~~ The sounds and sensations that people are reporting might be simple acoustical harassment gone awry. There are many ways that the acoustical sound could be delivered, including structure-borne which is discussed further in section 6.4.1. However, all of these scenarios leave unexplained (by physiology, not by physics) how such a sound can have caused not merely annoyance but actual injury.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.2.3 ~~(S//REL FVEY)~~ Scenario: Infrasound

~~(S//REL FVEY)~~ The range of audible frequencies is typically quoted as 20-20000 Hz. Frequencies below 20 Hz are termed infrasound. The degree to which infrasound can produce damage to the central nervous system needs more investigation, but symptoms such as nausea, malaise, and sleep disturbances have been linked to infrasound exposure (Persinger, 2014).

~~(S//REL TO USA, FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) From the published medical assessments (Swanson et al., 2018), it is stated: "The sounds were often associated with pressurelike ($n = 9$, 43%) or vibratory ($n = 3$, 14%) sensory stimuli, which were also experienced by 2 of the 3 patients who did not hear a sound.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ The problem with this scenario is that it does not connect easily to any of the physical details that are objectively observed.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.2.4 ~~(S//REL FVEY)~~ Scenario: Ultrasonic

~~(S//REL FVEY)~~ Acoustic frequencies greater than 20 kHz are termed ultrasound. Safe limits for ultrasound are a function of both frequency and sound pressure level (Figure 6-2). As frequency increases, higher and higher sound pressures are required in order to be damaging to humans. It was noted by Muth and Lewis (2018) that ultrasound (>20,000 Hz)—specifically high-intensity focused ultrasound—is known to induce heating and coagulative necrosis of brain tissue. This characteristic has recently been exploited to stereotactically and noninvasively produce focal lesions in the treatment of movement disorders (Fishman and Frenkel, 2017). However, such lesions require direct contact with ultrasonic transducers.

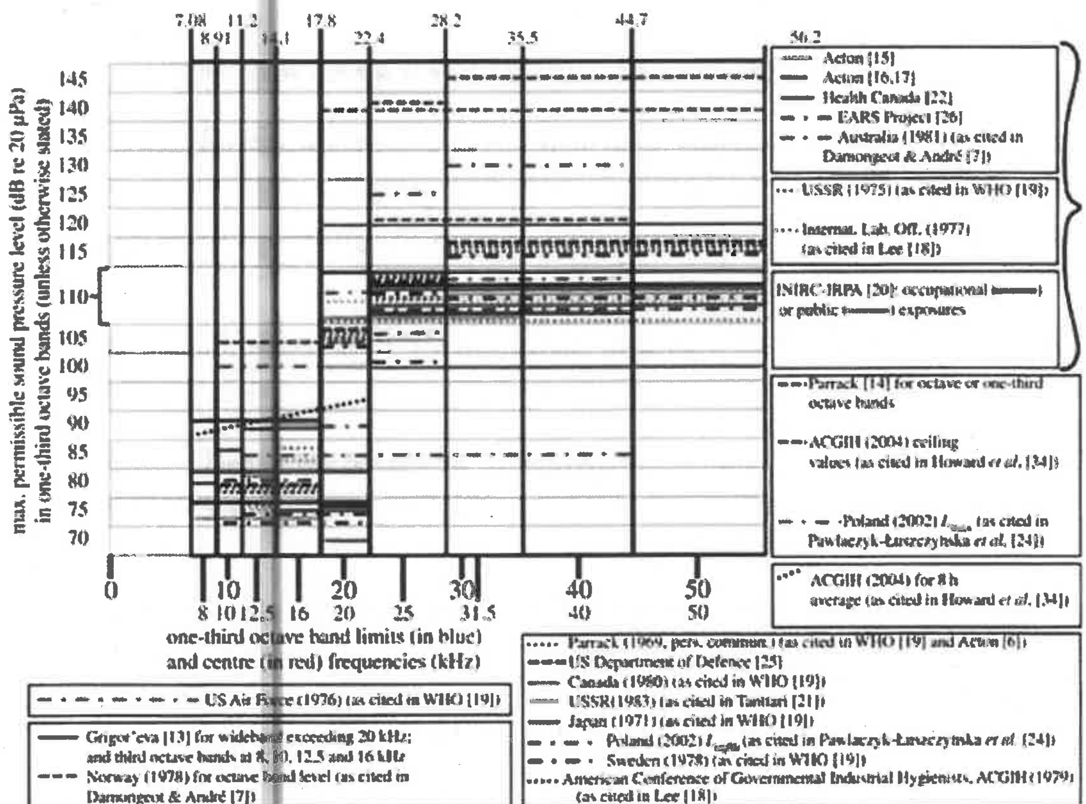

Figure 6-2. (U) Maximum permissible sound pressure levels for very high frequency (VHF) sound and ultrasound in air, as laid out by a range of individuals, groups and organizations; see Leighton (2016) for references to the other papers referred to in this figure. The use of boxes indicates 'families' of similar guidelines. Unless otherwise stated, the guidelines refer to the one-third octave level. Figure and legend modified from Leighton (2016).

~~(S//REL FVEY)~~ That being said, it is unclear how such an energy source would be converted into audible sound that would be heard by U.S. personnel (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.2.5 ~~(S//REL FVEY)~~ Scenario: Ultrasonic device run amok

~~(S//REL FVEY)~~ Inaudible ultrasonic transmissions can cause both intentional and unintentional down conversion to audible acoustic sound waves. In a non-linear medium such as air or an electronic circuit, new signals containing multiple frequency components can give rise to additional frequency components as a result of intermodulation distortion (IMD). For the case of a signal containing frequencies f_1 and f_2, where $f_2 > f_1$, the second order IMD produces signal components at the frequency f_2-f_1. Thus, an *inaudible ultrasonic* signal at high frequency can produce a lower frequency *audible acoustic* signal. One hypothesis (Chen, 2018) is that an eavesdropping device intended to transmit to a nearby receiver, and produced covert inaudible ultrasonic signals from *within* the residence, and malfunctioned.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.3 ~~(S//REL FVEY)~~ Discussion of Electromagnetic Scenarios

6.3.1 ~~(S//REL FVEY)~~ Scenario: (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.3.2 ~~(S//REL FVEY)~~ Scenario: RF source

~~(S//REL FVEY)~~ For RF energy the FCC establishes the exposure limits shown in Figure 6-3. The frequencies of interest for an RF weapon are (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) In this frequency range, the FCC limit is set, basically, by bodily heating effects: Bright sunlight is ~100 mW/cm2, so the limit is set conservatively at 1% of this (because some body parts, notably corneas, are especially sensitive to heating). [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

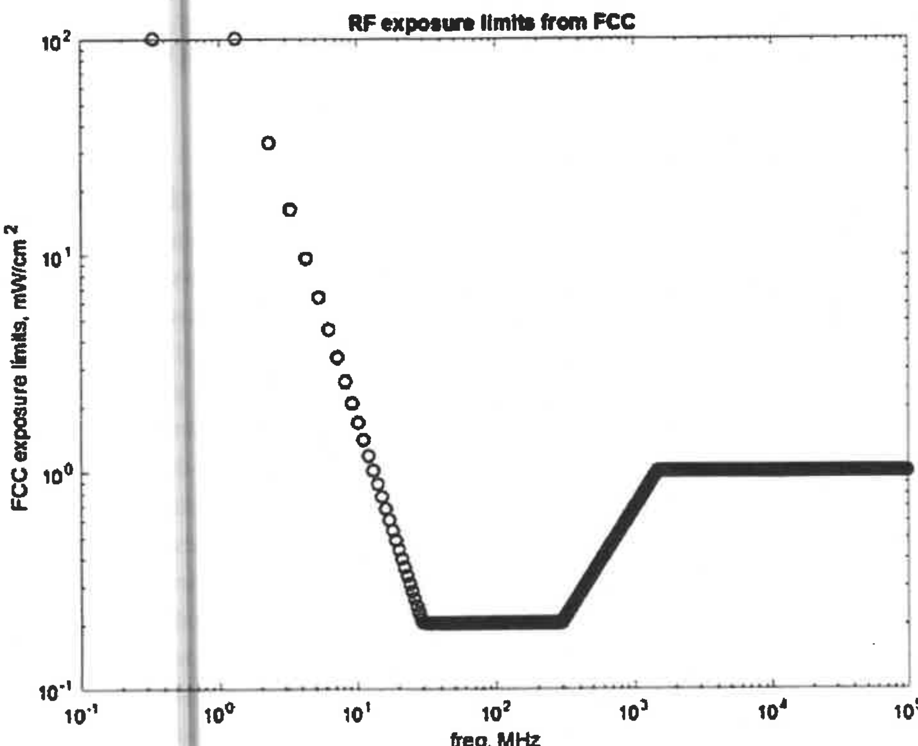

Figure 6-3. (S//REL FVEY) This graph shows the FCC's RF power exposure limits, for a half-hour average, as a function of frequency. [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) The safety limit at the door of a microwave oven is 10 mW/cm^2 = 10^2 W/m^2 = 10% of sunlight. If the space were flooded with this one would likely feel the warmth. If an entire room (3 m by 5 m) were illuminated, the required power would be [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) We think that beamed RF, as the primary energy flux, is also largely ruled out by the consistency of the acoustic observations. We discussed above how we can be fairly certain that the signal perceived by humans and cell phone is actually acoustic. [redacted] (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.3.3 ~~(S//REL FVEY)~~ Scenario: Electro-thermo-acoustic

~~(S//REL FVEY)~~ Here we investigate the possibility that electromagnetic pulses may produce perceived sound by heating the brain. This is not an original idea; such a phenomenon is known as the Frey effect, and has been the subject of an extensive literature (Elder 2013). Electromagnetic pulses have been suggested as the origin of the reported and measured phenomena, so all coupling mechanisms should be evaluated.

~~(S//REL FVEY)~~ In addition, there have been anecdotal reports of perceived sound whose direction could not be estimated, as is usually possible for environmental sound as a result of phase and intensity differences between the ears, and whose intensity did not appear to be reduced by placing a pillow over the ears. These anecdotes suggest that the possibility that acoustic pressure is produced within the head, perhaps as a result of absorption of impulsive electromagnetic energy.

~~(S//REL FVEY)~~ We emphasize that these reports are anecdotal, and that the proposed mechanism does not account for sound recorded by electronic devices. We are not proposing to explain the reported events, but only estimating one possibly relevant physical process.

~~(S//REL FVEY)~~ A detailed calculation,

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(~~S//REL FVEY~~)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.4 (U) Other Scenarios

6.4.1 ~~(S//REL FVEY)~~ Structure-borne vibration

~~(S//REL FVEY)~~ In the two recordings by the embassy employee ("X" in Table 2-1), there is video as well as audio. In one of these recordings, (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ For instance, a (b)(7)(E) concrete vibrator, powered by a portable generator, might at intervals be attached to an exterior or adjoining wall of the intended target's living spaces and run. The intent would have been to deliver, via structure-borne acoustics, a loud and very unpleasant sound into the living spaces. This scenario leaves to be explained (by physiology, not by physics) how such a sound could have caused not merely annoyance but actual injury. The principal problem with this is that it does not explain the associated medical complaints.

6.4.2 ~~(S//REL FVEY)~~ Scenario: Spatial and temporal masking / *Maskirovka*

~~(S//REL FVEY)~~ We also might consider a model in which individuals were exposed to sound as a decoy only, and that the true etiology (i.e. cause) of symptoms reported by U.S. personnel is unrelated to the sounds. (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) (b)(1); 1.4 (d); 1.4 (e); (b)(7)(E) In this case, the use of a "natural" sound (e.g., collected from a construction site or machine room or insect) would be for cover or deniability, in which the use of an unusual electronically produced signal would be too revealing.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~ Supporting the idea that the sounds were "designed to be heard" is the time of day that most people report having heard them.

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

~~(S//REL FVEY)~~

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

6.4.3 ~~(S//REL FVEY)~~ Scenario: Chemical or biological attack

~~(S//REL FVEY)~~ We are mindful that chemical attacks have been in the news in recent months, with Novichok poisonings in England, and putative chemical weapon attacks in Syria. So far, there is *no evidence* to suggest that chemical toxins are involved in the symptoms reported by U.S. personnel in Cuba. The possibility of a biological attack (i.e. purposeful infection of U.S. personnel with some sort of pathogen) also seems remote, considering that there have been no reports of transmission chains (i.e. transmission between people).

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) [redacted]

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

(S//REL FVEY) [redacted]

(b)(1); 1.4 (d); 1.4 (e); (b)(7)(E)

7 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(S//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.1 (U) (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.2 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(S//REL TO USA, FVEY)

(b)(1); 1.4 (b); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.3 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

- (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)
- (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)
- (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(S//REL TO USA, FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

- (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)
- (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

- ~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.4 ~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-1. ~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.5 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-2. (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-3. (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.6 (~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.7 (~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.8 (~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-4. (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.9 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.10 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E) [redacted]

(C//REL FVEY) [redacted]

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-5. (C//REL FVEY) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

[redacted]

Figure 7-6. (C//REL FVEY) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) [redacted]

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-7. ~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.11 ~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

~~(C//REL FVEY)~~ (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-8. (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.11.1 (C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

Figure 7-9 (C//REL FVEY)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(C//REL FVEY) Figure 7-10 shows

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E) [redacted]

Figure 7-10. (~~C//REL FVEY~~) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

7.12 (~~C//REL FVEY~~) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E) [redacted]

(~~C//REL FVEY~~) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

8 (U) MITIGATIONS

(U//FOUO) It would be useful to be able to reassure people who feel themselves at risk that measures are being taken to protect them. (b)(7)(E) it is feasible to provide some degree of protection.

8.1 (U) Electromagnetics

(S//REL TO USA, FVEY) (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

- (U//FOUO) (b)(7)(E)
- (U//FOUO) (b)(7)(E)
- (U//FOUO) (b)(7)(E)

8.2 (U) Acoustics

(U//FOUO) (b)(7)(E)

(b)(7)(E) [redacted]

- (U//FOUO) [redacted] (b)(7)(E)
- (U//FOUO) [redacted] (b)(7)(E)
- (U//FOUO) [redacted] (b)(7)(E)
- (U//FOUO) [redacted] (b)(7)(E)
- (U//FOUO) [redacted] (b)(7)(E)

9 (U) MEDICAL EVALUATIONS AND CONSIDERATIONS

9.1 (U) The Importance of Objective Measures of Neurological Damage

(U//FOUO) When interpreting the medical analyses of personnel, it is important to differentiate between symptoms (reported by the patient) and signs (observed by medical personnel), and for the clinical signs to distinguish those that can or cannot be influenced by cooperation of the patient or interpretation of the examiner.

(U//FOUO) Concerns about objectivity are especially important when there is no matched control group and no baseline measurement of the individuals prior to the reported exposure. This is not to say that subjective findings, such as patients reporting fatigue, blurred vision, or difficulty concentrating, are not real. Nor does it suggest that clinical signs that can be influenced by performance and interpretation, such as impaired word recall, unstable balance, or poor eye tracking, should be dismissed. However, given the uncertain level of exposure to the reported sensory phenomena, the variability of symptoms and signs among the individuals, and the long time interval (average 203 days) between exposure and medical evaluation, greater weight should be placed on the truly objective findings.

(U//FOUO) The evaluation of 21 U.S. personnel in Havana did reveal some objective signs of neurological damage, which increases the likelihood that a harmful exposure did indeed occur. As reported by Swanson et al. (2018), the objective signs included oculomotor tests of reflex activities that are not subject to conscious or unconscious manipulation. For example, saccadic dysfunction, a test of involuntary tracking movements of the eye, was seen in 10 of 21 individuals. For 13 individuals who exhibited severe balance impairment, vestibular function was assessed by caloric reflex testing, which involves injecting either cold or warm water into the external auditory canal to provoke nystagmus (repetitive uncontrolled movement of the eyes). 7 of the 13 individuals exhibited marked left-right asymmetry in response to cold water. Those 7 then were tested with warm water, and 3 of the 7 again exhibited marked asymmetry, which is considered diagnostic of a unilateral vestibular lesion.

(U//FOUO) [redacted] (b)(7)(E) The acoustic exposure in Havana may have triggered the recurrence of symptoms as a maladaptive behavioral response to an underlying vestibular disorder. The medical term for this condition is "persistent postural-perceptual dizziness" (PPPD), which is common among individuals with prior incidence of vestibular syndromes (Popkirov et al., 2018).

(U//FOUO) It is not clear if auditory evoked potentials were obtained for any of the evaluated U.S. personnel. This is a method for recording and averaging EEG activity in a way that is time-locked to pure tone stimuli, providing a sensitive measure of auditory function along the multi-step pathway from auditory nerve to cortex. Impairment along any step in the pathway would be manifest as a delay in nerve conduction at the corresponding step. Although MRI neuroimaging was performed on all 21 individuals, only incidental, non-specific findings were obtained. This is not surprising given the resolution of MRI. CT and PET imaging were not performed, but similarly would not be expected to provide definitive findings.

9.2 (U) Information that Might be Learned from Affected Pets/Animals

(U//FOUO) The best objective evidence would be obtained from pathology studies of the cochlea and vestibular organs, which would require autopsy of a mammalian species that had been exposed to the suspect phenomena. No tests were performed on household pets of the affected embassy personnel. Dogs, cats, and other mammals could be subject to measurement of auditory evoked potentials. Definitive studies could be made by post-mortem analysis of exposed rodents or household pets, although it is unreasonable to expect that a pet would be sacrificed for this purpose. The pathological examination would focus on the auditory hair cells of the cochlea, which would be expected to show altered morphology or loss following severe acoustic trauma.

9.3 (U) The Importance of Baseline Medical Testing Pre-Deployment

(U//FOUO) Regarding the UPenn medical study of neurological damage in personnel deployed in Cuba (Swanson et al., 2018), a subsequent critique of the study noted the lack of a control group. They state: "The lack of baseline evaluations and the absence of a control group, although understandable given the nature of the case series design, complicate interpretation of the findings because many of the symptoms and signs reported occur in the general population and in individuals with other neurological illnesses (Muth, 2018)." The point is that, while some of the people in the UPenn study do, apparently, exhibit cognitive deficiencies in objective (i.e. difficult to fake) tests, what is not known is if this damage occurred in Cuba, or during a previous tour of duty, work assignment, or even non-work related activity.

(U//FOUO) An appropriate control group would be a set of U.S. personnel with similar deployment histories and experiences (very difficult or impossible to create), but who had not been deployed to Cuba. In the absence of analysis of such a control group, JASON does not yet see "smoking gun" evidence that the sounds and senses reported by U.S. personnel, and the neurological deficiencies reported, are causally linked.

(U//FOUO) Given this, pre-exposure baseline testing becomes critical. U.S. personnel deployed to Cuba should have a series of medical evaluations before they leave the US. These would consist of the same studies described in the UPenn study (Swanson et al., 2018), with emphasis on the objective medical tests available.

9.4 (U) Sound Waves and the Vestibular System

(U//FOUO) In the UPenn study, "clinical examinations raised concern for balance impairment in 17 patients (81%), prompting referral to vestibular physical therapy" (Swanson et al., 2018). Balance and dysfunctions such as vertigo are often associated with the vestibular organs of the inner ear. Here we outline possible mechanical effects on the response of the vestibular system to "high" frequency vibrations.

(U//FOUO) Acoustics waves could potentially cause fluid flow in narrow channels (acoustic streaming) or move suspended particles (acoustophoresis), such as otoconia described below, which are naturally present in the vestibular system. We consider these effects below, considering the main features known to operate in the vestibular organs for measuring linear and angular accelerations.

(U//FOUO) Acoustically driven motions are measurable in experimental systems with length scales and material properties comparable to the vestibular system at frequencies in the MHz range, though typically with much larger energy inputs than expected from the possible acoustic signals of interest here. We are not aware of research in the literature studying this question at kHz or higher frequencies associated with vestibular mechanics. However, acoustically driven flows in channels is a topic now referred to as acoustofluidics, and has a history at least back to Lord Rayleigh in the late 19th century. Of course, medical ultrasound is used in some cases for localized examination of bone, tissue, etc.

(U//FOUO) **The vestibular system.** The ear contains multiple organs for sensing (see Figure 9-1): Sound travels through the ear canal, vibrates the tympanic membrane, which excites the small bones of the auditory ossicles, and the signal then enters the cochlea, which is responsible for our ability to hear and to transduce audible frequencies into neural signals the brain can interpret. The vestibule of the inner ear is the location of three semi-circular canals that are responsible for our ability to sense angular accelerations; the orientations of the three canals allow sensing rotations about the two horizontal directions as well as ``twist" about the vertical direction. Co-located in this region are two otolith (Greek for ``ear stones") organs, the utricle and the saccule, with which linear acceleration is sensed; in particular, otoconia, bio-crystals of calcium carbonate that are more dense than the surrounding medium, are part of the utricle and saccule and responsible for sensing head tilt, via a response to gravity, or linear acceleration as a result of inertial effects from density differences. The vestibular organs are often associated with balance disorders so it is natural to investigate if and how such organs might respond to high frequency perturbations (Lundberg et al., 2015).

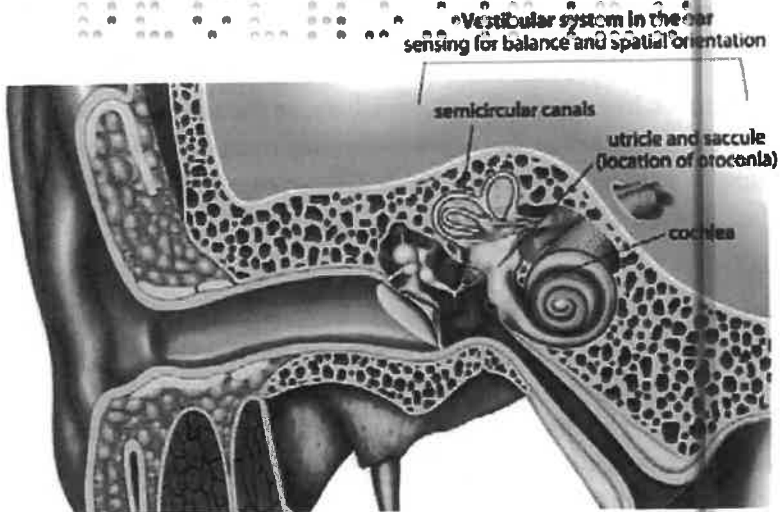

Figure 9-1. (U//FOUO) A cut-away view showing the pathway for air to enter the ear canal where it encounters the tympanic membrane, bones of the auditory ossicle, cochlea, semi-circular canals, utricle and saccule. Reference: http://www.sciencemag.org/news/2014/09/sounds-you-cant-hear-can-still-hurt-your-ears

(U//FOUO) In the case of the semi-circular canals, angular accelerations produce a fluid pressure that deforms an elastic membrane, the cupula, at one end of the semi-circular canals (the cupula is soft, with a typical elastic modulus $E \approx 10$ Pa); nerves embedded in the membrane signal the brain that the head is rotating. The neural output is input to the oculomotor system to produce eye motions and also serves as compensation for motion of the head in order to retain alignment (e.g., Squires, 2004; Squires et al., 2004). This response allows an individual to read this article even while shaking their head, which would be much more difficult if the article itself were shaken. Similarly, linear accelerations cause the dense otoconia to translate relative to the fluid or soft tissue, which triggers deformation/displacement of hair cells (embedded in the otolith organs) that communicate with the brain stem via nerve cells/action potentials.

(U//FOUO) **A mechanical dysfunction?** One relatively common source of vertigo is associated with a disorder of the vestibular system: Benign Paroxysmal Positional Vertigo. BPPV typically involves short-lived dizziness caused by rapid head movements, often associated with up-down motions and linked to the posterior semi-circular canal. This so-called "top-shelf vertigo," because the imbalance sometimes results from looking at objects on a high shelf, is believed to be caused by otoconia becoming free of the cupula and then sedimenting, causing motions and stresses on the membranes containing neurons, which thus interferes with the normal operation of the semi-circular canals (Brandt, 1991). The brain interprets the unexpected signaling as a spinning motion when in fact no rotary motion is occurring, the individual gets disoriented, and then stumbles or falls over. In fact, the medical treatment of BPPV does not involve medication but rather a patient lies down and a physician maneuver the patient's head in a designed fashion to manipulate otoconia out of the canals to positions at the base where they no longer have an effect.

(U//~~FOUO~~) **Two mechanistic hypotheses have been** advanced for explaining the physical origin of BPPV; both involve fluid motions and/or particle motions (relative to the fluid) that trigger nerve responses leading to vertigo. In addition, small displacement of the otoconia associated with the utricle and saccule, the linear acceleration organs, disturb hair cells that can trigger sensory responses.

(U//~~FOUO~~) **Mechanical responses from acoustic fields.** Acoustic signals propagate similarly in gases (air) and liquids, so the signal in the air and the liquid-filled vestibular system can be considered similarly. For example, the vestibular canals are much longer than their cross-sectional radius, and the radius of curvature of the centerline is also much larger than the cross-sectional radius. Thus, as a first approximation, we can treat the hydrodynamics similar to motions in a straight tube of circular cross section. Also, the otoconia can be treated as small spherical particles in a liquid or elastic matrix exposed to a sound wave.

(U//~~FOUO~~) We consider a one-dimensional description about the state of rest where the density is denoted ρ_0 and the pressure is denoted p_0. The perturbations in density, velocity and pressure have amplitude (ρ', v', p') and are proportional to $e^{-i\omega t}$. Also, the energy flux (energy/area/time), or intensity I, is given by the product of the pressure and velocity disturbances, $p'e^{-i\omega t}$ and $v'e^{-i\omega t}$, which in time average (<>) in independent of frequency:

$$I = \langle v'p' \rangle = \frac{(p')^2}{2\rho_0 c} \quad (1)$$

(U//~~FOUO~~) For a 60 dB acoustic field (relative to a 20 μPa reference) in air the corresponding energy flux (or sound intensity) is about $0.5\text{x}10^{-6}\text{W/m}^2=0.5\ \mu\text{W/m}^2$. An 80 dB acoustic field produces an increase of I by a factor of 100. Because of the structure of the auditory ossicles, this energy is transmitted effectively to the cochlea, and presumably some of this energy couples to the vestibular system as well.

(U//~~FOUO~~) There are several avenues to consider for how this acoustic energy can impact neurological responses by triggering the linear or angular accelerometers of the vestibular system:

- (U//~~FOUO~~) An acoustic field could trigger hair cells, stimulating the neurological response.
- (U//~~FOUO~~) An acoustic field could displace otoconia (acoustophoresis, or via acoustofluidics of the liquid in the canals), which then trigger hair cells.
- (U//~~FOUO~~) An acoustic field could deform the cupola, or other organs bearing hair cells, to stimulate a neurological response. It is not obvious how a fraction of the energy transmitted via the ear canal, e.g. 10^{-6}-10^{-4} W/m^2, can cause sufficient displacements of any of these elements to produce dysfunction of the normal response. However, if say

1/100 of the incident intensity (originally in the air) is transmitted to the region of the (soft) cupula, then the magnitude of the (oscillatory) pressure is $|p| \approx 0.1(2\rho c I)^{1/2} \approx 0.1$ Pa, which is the order of magnitude of the steady mechanical stress known to cause nerve responses in the cupula.

9.5 (U) Psychogenic Illness

(U//FOUO) A possible explanation for the reported symptoms is psychogenic illness, in part because the science is weak to declare any causal links from RF or acoustic weapons to brain injury without prior baseline measurements and a control group of a similar background.

(S//REL TO USA, FVEY) [redacted] (b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

(U//FOUO) It is also worth noting that psychogenic effects on vestibular function are common, and the symptoms can be chronic. Although the JAMA paper dismisses such a "dizziness" theory, JASON believes such psychogenic effects may serve to explain important components of the reported symptoms. In a chapter from the Handbook of Clinical Neurology on Functional (psychogenic) dizziness, the authors explain:

> (U) "Functional and psychiatric disorders that cause vestibular symptoms (i.e., vertigo, unsteadiness, and dizziness) are common. In fact, they are more common than many well-known structural vestibular disorders."

9.6 (U) Unpublished Claims of Physical Harm to Personnel

(U//FOUO) Declarations of mild traumatic brain injury have also been made, via several news outlets, by Dr. Michael Hoffer of the University of Miami (Fields, 2018; Stone, 2018). Dr. Hoffer is a former naval physician who has extensive experience with head injuries suffered by warfighters in the Iraq conflict. He has examined at least 80 individuals who have been part of the Cuba mission, and has also traveled to Cuba to conduct evaluations. JASON has several concerns regarding the claims of health effects incurred by the apparent victims of the sonic events as described in the press.

(U//FOUO) First, the news reports by the *Miami Herald* and in the journal *Science* (Stone, 2018) include comments and claims by Dr. Hoffer that have not been published in a peer-reviewed science or medical journal. Thus, we and others have not had the opportunity to judge the quality of the data or its interpretation. Second, it is not clear that there exists any independent evaluation of the patients using the same analytical tests as conducted by Dr. Hoffer. Addressing the impact of trauma on the cognitive and physical performance capabilities of humans can be highly subjective, particularly without a starting baseline of performance characteristics for comparison. Third, the diagnostic system that is under research and development by Dr. Hoffer, called the I-Portal® system, has not received 'FDA approval,' which is a standard based on both safety and efficacy. Rather, the system has only been 'FDA cleared,' which is a classification that indicates the system is no poorer than existing medical devices that have been used in an era before the FDA began to evaluate medical equipment.

(U//~~FOUO~~) Furthermore, the I-Portal® system does not appear to be used by hospitals as part of a typical suite of medical diagnostic equipment. Rather, the company that manufactures the system, NeuroKinetics, Inc., is marketing it to physical therapists, chiropractors, sports organizations, and athletes. Marketing to non-clinical customers could be due to the fact that evidence for the utility of the I-Portal® system in the diagnosis of mild traumatic brain injury is sparse. In one recent publication coauthored by Dr. Hoffer (Balaban et al., 2016), the I-Portal® system was used to evaluate two cohorts of 50 individuals who have been clinically diagnosed with mild traumatic brain injury, of which 83% were tested within 96 hours of the trauma that caused mild traumatic brain injury. Each cohort was compared to 100 control individuals who were recruited to the study without having experienced recent mild traumatic brain injury. Unfortunately, the researchers were not blinded to the classification of the individuals before testing.

(U//~~FOUO~~) Similar results and conclusions were published in a second study by the same research team (Hoffer et al., 2017). However, it is important to note that these publications are coauthored by an employee of the company that makes and markets the I-Portal® system. Given that some funding and personnel driving these two validation studies on the I-Portal® system have been supplied by NeuroKinetics, Inc., the claims made by Dr. Hoffer regarding the efficacy of the system should be interpreted with caution. Similarly, if the I-Portal® system was the primary instrument used to assess the health effects of the sonic exposure events on embassy personnel, the claims made in news stories also should require independent verification. Finally, JASON cannot assess the putative damage to 'white matter' as noted in certain news reports (Fields, 2018), given the lack of peer reviewed publication of data and claims with a control group or baseline medical assessments.

(U//~~FOUO~~) Lastly, we note that Dr. Hoffer was investigated in 2011 regarding allegations concerning traumatic brain injury research he conducted in Iraq. The findings of this investigation were published in Inspector General Report SPO-2011-005, titled "Assessment of allegations concerning traumatic brain injury research integrity in Iraq." The allegations included the treatment of affected troops with an unapproved drug in which the doctor had a financial stake, and failure to reveal this conflict of interest. This investigation concluded that 1) the management and conduct of the clinical trial were inconsistent with military standards for human subject and medical research; 2) there was possible sub-standard patient care, and 3) that there were weaknesses in the process used to review and approve medical research in Iraq. The events documented in the Inspector General Report bear a remarkable resemblance to the concerns that JASON identified with the work of Dr. Hoffer with affected Havana embassy personnel, possibly further eroding confidence in his team's findings.

10 (U) CONCLUSIONS

10.1 (S//REL FVEY) Summary Chart

(S//REL FVEY) A summary of many of the points raised in this report is the chart below. Here a plus sign (+) means "consistent" with the data, posited mission, or underlying physics; a minus sign (–) means "inconsistent"; and a plus-or-minus sign (±) means "possibly consistent".

(b)(1); 1.4 (d); 1.4 (e); 1.4 (g); (b)(7)(E)

[redacted]

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