OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE
WASHINGTON, DC

March 28, 2023

Brad Moss
(b)(6) [redacted]

Re: Litigation 22-cv-00674 | ODNI FOIA Case DF-2022-00138

Mr. Moss,

This letter is in response to your Freedom of Information Act (FOIA) request, dated 03 February 2022 and received by the Information Management Office (IMO) on 04 February 2022 (Enclosure 1), in which you requested *"... a copy of the UHI Assessment in its entirety."*

Your request was processed in accordance with the FOIA, 5 U.S.C. § 552, as amended. This response addresses the processing of the one (1) document responsive to your aforementioned request. Upon review, we have determined that this document is being released to you in part (Enclosure 2; Bates Pages: 22-cv-00674 (DF-2022-00138) 000001 – 000147), pursuant to the following FOIA exemptions:

- (b)(1), which applies to information that is currently and properly classified pursuant to Executive Order 13526, Sections 1.4(c), 1.4(d), 1.4(e), and 1.4(g);

- (b)(3), which applies to information exempt from disclosure by statute, and, in this case, specifically the National Security Act of 1947, as amended, statutes 50 U.S.C. § 3024(i) and 50 U.S.C. § 3024(m), which protect intelligence sources and methods and identifying information of ODNI personnel, respectively; and

- (b)(6), which applies to information, the release of which would clearly constitute an unwarranted invasion of personal privacy.

The Department of Energy and the Department of Homeland Security each withheld information pursuant to FOIA exemption (b)(6); the Defense Intelligence Agency and the Intelligence and Security Command each withheld information pursuant to FOIA exemptions (b)(1) and (b)(3); the Central Intelligence Agency withheld information pursuant to FOIA exemptions (b)(3) and (b)(6); the Department of Defense withheld information pursuant to FOIA exemptions (b)(1), (b)(5), and (b)(6); the Department of State whithheld information pursuant to FOIA exemptions (b)(1), and (b)(5); the National Security Council withheld information pursuant to FOIA exemption (b)(5); and the Federal Bureau of Investigation withheld information pursuant to FOIA exemptions (b)(1), (b)(3), (b)(6), (b)(7)(A), (b)(7)(C), and (b)(7)(E).

- (b)(3), which applies to information exempt from disclosure by statute, and, in this case, in addition to the aforementioned statutes, Section 6 of the Central Intelligence Agency Act of 1949, as amended, statute 50 U.S.C. § 3507;

- (b)(5), which applies to information that concerns communications within or between agencies that are protected by legal privileges;

- (b)(7)(A), which applies to information, the release of which would interfere with an ongoing investigation;

- (b)(7)(C), which applies to information compiled for law enforcement purposes which could reasonably be expected to constitute an unwarranted invasion of personal privacy; and

- (b)(7)(E), which applies to information compiled for law enforcement purposes which would disclose techniques and procedures for law enforcement investigations.

If you have any questions, your attorney may contact Attorney Sian Jones of the Department of Justice at (202) 252-2578 or via e-mail at sian.jones@usdoj.gov.

(b)(3), (b)(6)

Gregory M. Koch
Chief, Information Management Office
FOIA Public Liaison

Enclosures

ENCLOSURE

OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE
WASHINGTON, DC

July 14, 2023

Brad Moss
(b)(6) [redacted]

Re: Litigation 22-cv-00674 | ODNI FOIA Case DF-2022-00138

Mr. Moss,

This letter is a supplemental response to your Freedom of Information Act (FOIA) request, dated 03 February 2022 and received by the Information Management Office (IMO) on 04 February 2022 (Enclosure 1), in which you requested "... *a copy of the UHI Assessment in its entirety.*"

Your request was processed in accordance with the FOIA, 5 U.S.C. § 552, as amended. This response addresses the re-review of the one (1) document responsive to your aforementioned request. We are providing the entire re-reviewed document to you.

Upon further review, two additional portions, previously withheld by the Department of State, are being released. Those portions can both be found on Bates Page 22-cv-00674 (DF-2022-00138) 000112. Additionally, the Department of Homeland Security, the Department of Energy, and the Intelligence and Security Command are no longer withholding information. However, the information these agencies previously withheld must remain redacted based on the withholdings of one or more other entities.

Finally, the previously-released version inadvertently omitted the Federal Bureau of Investigation's (FBI) assertion of FOIA exemption (b)(7)(E) on existing redactions to the top and bottom headers on most pages of the document. The cover letter also included FOIA exemptions (b)(6) and (b)(7)(C) for FBI when they, in fact, are not asserting either of these exemptions. Similarly, the Department of State is not asserting FOIA exemption (b)(5). This release corrects those oversights.

If you have any questions, your attorney may contact Attorney Sian Jones of the Department of Justice at (202) 252-2578 or via e-mail at sian.jones@usdoj.gov.

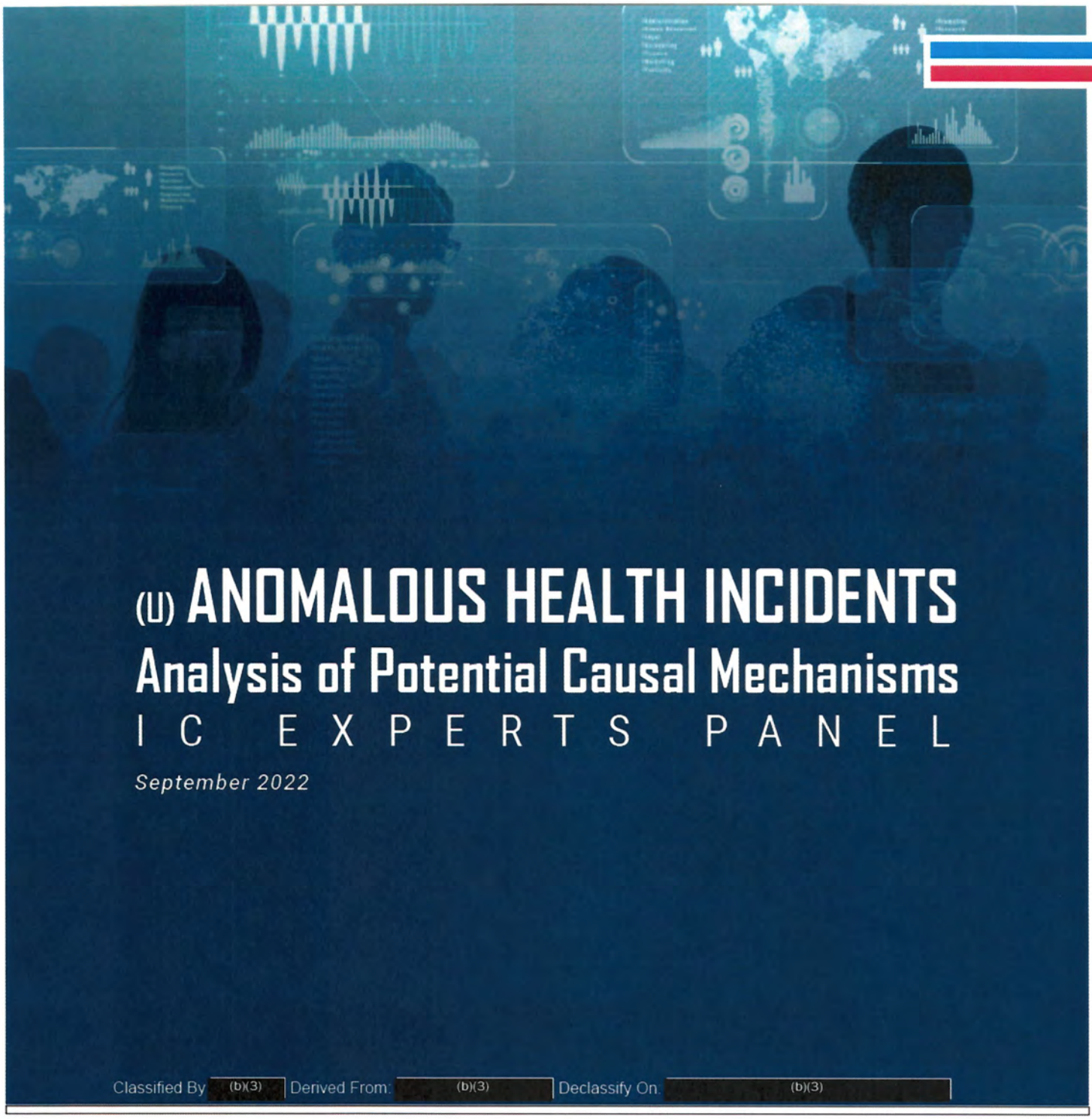
Sincerely,

(b)(3), (b)(6) [redacted]

Gregory M. Koch
Chief, Information Management Office
FOIA Public Liaison

Enclosures

ENCLOSURE



(U) ANOMALOUS HEALTH INCIDENTS

Analysis of Potential Causal Mechanisms

I C E X P E R T S P A N E L

September 2022

Classified By: (b)(3) Derived From: (b)(3) Declassify On: (b)(3)

(U) (b)(1), (b)(3), (b)(7)(e)

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(U) Anomalous Health Incidents: Analysis of Potential Causal Mechanisms

September 2022

(U) IC EXPERTS PANEL ASSESSMENT

(U/ (b)(3) (b)(3)

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(U) Table of Contents

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(U) Executive Summary

(U) **Director of National Intelligence Avril Haines and Deputy Director of the Central Intelligence Agency David Cohen established the IC Experts Panel on Anomalous Health Incidents (AHIs) to examine potential causal mechanisms of the AHIs affecting US Government personnel. The Panel comprised experts from inside and outside the US Government with expertise in relevant areas of science, medicine, and engineering. The Panel did not examine questions related to attribution of AHIs to an actor, including the question of whether a foreign actor may be involved. The Panel's findings are one of several inputs that will inform the IC's work on AHIs moving forward.**

(U) Methodology and Scope

(b)(3) **Information sources.** Access to information was central to the Panel's process. In response to a request from DNI Haines, (b)(1); (b)(3) departments and agencies provided the Panel with dozens of briefings and more than 1,000 classified documents on a variety of scientific, medical, and intelligence topics. This information included the findings (b)(1), (b)(3) sensitive intelligence reporting, AHI event descriptions and trend analyses (b)(1), (b)(3) Affected individuals also shared their personal experiences and portions of their medical records. (b)(1), (b)(3)

(U) **Potential causal mechanisms.** As a starting point, the Panel examined five potential causal mechanisms identified by the IC: acoustic signals; chemical and biological agents; ionizing radiation; psychosocial, medical, and other natural and environmental factors; and radiofrequency and other electromagnetic energy. Throughout the study, the Panel worked to identify additional possible mechanisms and to avoid bias for or against any specific hypothesis. The Panel did not examine in detail combinations of mechanisms, although it judged some combinations, particularly those involving chemical or biological agents, to be worthy of further exploration.

(U) **Core characteristics.** To narrow the problem, the Panel assessed the potential for each mechanism to account for reported aspects of those AHIs that were not readily explained through other means. The Panel's focus on these incidents should not be interpreted as diminishing the importance of other incidents. Four "core characteristics" were prominent among these AHIs: (1) the acute onset of audio-vestibular sensory phenomena, including sound and/or pressure, sometimes in only one ear or on one side of the head; (2) other nearly simultaneous signs and symptoms such as vertigo, loss of balance, and ear pain; (3) a strong sense of locality or directionality; and (4) the absence of known environmental or medical conditions that could explain the reported signs and symptoms.

(U) **Plausibility.** The Panel considered a mechanism to be plausible if all members agreed that there was at least some credible evidence that it was technically and practically feasible in each of five areas: (1) a concealable source that could generate the required stimulus; (2) the propagation and delivery of the stimulus to an individual; (3) the coupling of the stimulus to the human body; (4) the ability of the coupling to cause relevant biological effects; and (5) the ability of the biological effects to explain the reported clinical signs and symptoms. In addition, the Panel required that other evidence did not exclude the mechanism.

(U) Findings

(U) **The Panel reached six main findings. Some are limited by knowledge gaps or assessments that could be resolved or tested through implementing the Panel's recommendations.**

(U) ***The signs and symptoms of AHIs are genuine and compelling.*** **The Panel bases this assessment on incident reports, medical data from affected individuals and interviews with their physicians, and interviews with affected individuals themselves. Some incidents have affected multiple persons in the same space, and clinical samples for the small number of affected individuals who were tested within an appropriate time period have shown early, transient elevations in biomarkers suggestive of cellular injury to the nervous system. The reported signs and symptoms of AHIs are diverse and may be caused by multiple mechanisms, but no case should be discounted. Prompt medical evaluation and care are particularly important; most individuals who were treated soon after an event have improved.**

(U) ***A subset of AHIs have a unique combination of core characteristics that cannot be explained by known environmental or medical conditions and could be due to external stimuli.*** **Although some signs and symptoms of AHIs are common in known medical conditions, the combination of the four core characteristics is distinctly unusual, is unreported elsewhere in the medical literature, and so far has not been associated with a specific neurological abnormality. Several aspects of this unique neurosensory syndrome make it unlikely to be caused by a functional neurological disorder. The location dependence and sudden onset and offset, for example, argue for a stimulus that is spatially and temporally discrete. The perception of sound and pain within only one ear suggests the stimulation of mechanoreceptors, a specific cranial nerve, or nuclei in the brainstem, all of which mediate hearing and balance as well as the sensation of pressure. The lack of other symptoms also helped rule out known medical conditions as well as stimuli that are known to affect other sensory or motor systems.**

(b)(3) ***Electromagnetic energy, particularly pulsed signals in the radiofrequency range, plausibly explains the core characteristics, although information gaps exist.*** **There are several plausible pathways involving forms of electromagnetic energy, each with its own requirements, limitations, and unknowns. For all the pathways, sources exist that could generate the required stimuli, are concealable, and have moderate power requirements. Using nonstandard** (b)(1), (b)(3) **—antennas and techniques, the signals could be propagated with low loss through air for tens to hundreds of meters, and, with some loss, through most building materials.** (b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3) ***Ultrasound also plausibly explains the core characteristics, but only in close-access scenarios and with information gaps.*** The required energy can be generated by ultrasonic arrays that are (b)(1), (b)(3) portable, and produce a tight beam. Ultrasound propagates poorly through air and building materials, restricting its applicability to scenarios in which the source is near the target, (b)(1), (b)(3) It could couple to the body through the external auditory canal, interstitial spaces, or the vestibular apparatus of the inner ear. Ultrasound is used to open the blood-brain barrier in medical procedures, and ultrasonic stimulation of the aforementioned anatomical areas could produce symptoms consistent with AHIs. Studies of "ultrasound sickness" and related audio-vestibular symptoms have reached mixed conclusions, but the Panel was presented with independent accounts in which individuals were exposed to high-power ultrasound beams and subsequently experienced the core characteristics.

(U) ***Psychosocial factors alone cannot account for the core characteristics, although they may explain some other reported incidents or contribute to long-term signs and symptoms.*** No known psychosocial factors explain the core characteristics, and incidents exhibiting these characteristics do not fit the majority of criteria used to discern mass sociogenic illness. However, psychosocial factors may compound some of the incidents with core characteristics. Incidents that do not possess all or some of the core characteristics could be due to hypervigilance and normal human reactions to stress and ambiguity, particularly within a workforce that is attuned to its surroundings and trained to think about security. Some of these reactions could lead to functional neurological disorders or worsen the effects of existing conditions.

(U) ***Ionizing radiation, chemical and biological agents, infrasound, audible sound, ultrasound propagated over large distances, and bulk heating from electromagnetic energy are all implausible explanations for the core characteristics in the absence of other synergistic stimuli.*** These mechanisms are unlikely, on their own, to account for the required effects or are technically or practically infeasible. Ionizing radiation, for example, produces known biological effects that are easily measured and inconsistent with the core characteristics, and chemical or biological agents alone would not explain the reported location-dependence or directionality.

(U) Recommendations

(U) The Panel offers eight main recommendations to help the US Government better understand, prevent, and manage AHIs. Implementing these recommendations will require a coordinated approach because the challenges and solutions transcend organizational boundaries. Panelists emphasize the importance of appropriate classification, privacy, and security controls on research and information that may result. Four recommendations are near-term priorities:

- (b)(1), (b)(3) (b)(1), (b)(3) (b)(1), (b)(3) (b)(1), (b)(3)
- (U) **Biomarkers.** Identify and validate new biomarkers that are more specific and sensitive for diagnosis and triage of AHIs to reduce the reliance on traumatic brain injury biomarkers, which were validated for a specific and possibly different clinical condition. Test for the presence of these biomarkers as soon as possible after an event, ideally within hours.

- (b)(3) **Detectors.** (b)(1), (b)(3)
- (U) **Communication. Develop a coordinated communications strategy to inform and educate the US Government workforce. Prompt and forthright communication can lessen the effects of psychosocial factors and functional neurological disorders, regardless of cause. It can also build trust, strengthen resilience, and promulgate any strategies for protection or mitigation.**

(U) **Four recommendations are longer-term priorities:**

- (U) **Clinical measurements. Develop better methods for taking objective clinical measurements of vestibular, inner ear, and cognitive function and make them practical for use in the field. Collect patient histories and measurements within hours of an event, when possible.**
- (b)(1); (b)(3)
- (b)(1); (b)(3)

  (b)(1), (b)(3)
- (b)(1), (b)(3)

(U) Closing Note

(U) **Throughout the study, the Panel had the privilege of observing the IC's overall efforts related to AHIs. Although these broad and impressive activities extend beyond the Panel's remit of causal mechanisms, the group respectfully offers three thoughts for the IC's consideration going forward. The Panel encourages the IC to sustain efforts against AHIs with a sense of urgency, to preserve analytic objectivity and quality, and to collaborate and share information across agencies.**

(U) **Finally, the Panel was moved by the experiences of individuals affected by AHIs. They deserve the best possible care, as well as appreciation for their sacrifices. Panelists were also greatly impressed with the many members of the IC and broader US Government with whom they engaged. The Panel feels fortunate to have supported their work and is grateful to the senior sponsors for the opportunity.**

(U) Scope Note and Background

(U) Scope Note

(U/ (b)(3) **Director of National Intelligence Avril Haines and Deputy Director of the Central Intelligence Agency David Cohen established the IC Experts Panel on Anomalous Health Incidents (AHIs) to explore potential causal mechanisms of the AHIs affecting US Government personnel (see Appendix A for the DNI's Memorandum). The Panel's objectives were to help CIA and the IC best explain the causal mechanism(s) of AHIs; identify scientific data that would be required to increase or decrease the confidence level for each candidate mechanism; and propose experiments and a research agenda that will provide the necessary discriminating information.**

- (U/ (b)(3) **The Panel took into account the real-world circumstances under which AHIs occurred. The Panel did not seek to identify with certainty the actual cause of any specific AHIs, which was beyond its mandate and would have required access to information from investigations and medical records.**
- (U) **As the study neared completion, its senior sponsors provided the Panel with a list of additional questions based on their evolving needs. The Panel incorporated its answers into the appropriate sections of this report and summarized them in Appendix B.**

(U) **Composition. The Panel comprised experts from inside and outside the US Government with expertise in relevant areas of science, medicine, and engineering. The panelists collaborated on all aspects of the study to take a holistic approach to the problem, and some panelists were selected for their ability to look across disciplines (see Appendix C for the panelists' biographies).**

(b)(3) **Information sources. Access to information was central to the Panel's process. In response to a request from DNI Haines,** (b)(1); (b)(3) **departments and agencies provided the Panel with dozens of briefings and more than 1,000 classified documents on a variety of scientific, medical, and intelligence topics (see Appendix D for the DNI's Request for Information Memorandum).** (b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

(U) **Terminology. A glossary of terms used in this report is found in Appendix G.**

(U/ (b)(3) **Relation to 2021 JASON study. Around the same time as the Panel's study, the JASON defense advisory group conducted a study for the US Department of State that examined the potential causal mechanisms, detection, and mitigation of AHIs.[1] Members of the two study teams met periodically to share information while taking care to maintain independent thought. Appendix H compares the findings of the two studies.**

(b)(3) **Attribution. The Panel did not examine questions related to attribution of AHIs to an actor, including the question of whether a foreign actor may be involved. The Panel did not have access to information related to attribution, nor did it discuss with the IC potential causal mechanisms of specific cases. For completeness, the IC provided the following statement on attribution for inclusion in this report:** ***"The IC assesses, with varying degrees of confidence, that US adversaries are not engaged in a global campaign to harm or collect intelligence on US personnel that is resulting in anomalous health incidents.*** (b)(1), (b)(3)

(U) **Selected appendixes are only available to those with the proper clearances and need-to-know.**

(U) Background

(b)(1), (b)(3), (b)(7)(a), (b)(7)(e)

(U/ (b)(3) **At the start of the effort, it was unclear whether the vast majority of reported incidents were due to the same cause or whether subsets of incidents could be explained by different mechanisms. The broad and heterogeneous array of reported signs, symptoms, and circumstances left open the question of multiple causal mechanisms. The Panel focused on questions and gaps such as:**

- (U/ (b)(3) **What kinds of disease or disturbance to human physiology could cause the observed signs and symptoms?**
- (U/ (b)(3) **What types of external stimuli could affect these aspects of human physiology?**
- (U/ (b)(3) **How might those external stimuli be generated and delivered in a way that is consistent with the IC's understanding of the circumstances of AHIs?**

(U) Medical Analysis of AHIs

(b)(3) The Panel first sought to understand the medical and clinical aspects of AHIs. Based on incident reports, medical data from some affected individuals and interviews with the US Government physicians who treated them, and interviews with affected individuals themselves, the Panel assessed that the signs and symptoms of AHIs are genuine and compelling. The Panel assessed that a subset of incidents have distinguishing features, and preliminary clinical data suggest the interaction of an undefined energy source with specific sensory systems during discrete AHI events. The detection of well-validated biomarkers of neural cell injury raises concern that the energy source can also cause structural disturbance at the microscopic or molecular level. Some symptoms were inconsistent with known disease and became the Panel's focus. However, the reported signs and symptoms of AHIs are diverse and may be caused by multiple mechanisms. Furthermore, because incidents with less distinct features are also important in understanding AHIs, no case should be discounted. Prompt medical evaluation and care is particularly important, and most individuals who have been treated soon after an event have improved.

(U) Diverse signs and symptoms

(b)(3) Reported AHI incidents vary in sensory phenomena and clinical signs and symptoms. Most commonly, US Government employees have reported phenomena involving a sudden sense of pressure or loud, unpleasant sound, and the signs and symptoms are most commonly pain, nausea, dizziness, and cognitive impairment. A subset of incidents also reports very distinctive events including the sensation of locality or directionality. Amongst this subset, (b)(1), (b)(3) had a combination of headache, tinnitus, and ear pain.

(U) Distinguishing features

(b)(3) One distinguishing characteristic of reported AHIs was the acute onset of audio-vestibular sensory phenomena, including sound and/or pressure, sometimes in just one ear or one side of the head. In some cases, other individuals in close proximity did not hear the sound as would be expected for a usual ambient sound wave. Another feature was the rapid onset of acute signs and symptoms, concurrent with or within seconds of the sensory phenomena. These acute signs and symptoms were often connected with the inner ear and included vertigo, loss of balance, or ear pain, as well as a sense of locality or directionality. They occurred in a wide variety of combinations and varied among reports. Subacute signs and symptoms—those that last hours to days after the acute event has ended—included headache, nausea, persistent vertigo or other symptoms of imbalance, a sense of fatigue, and difficulty with cognitive tasks. Acute or subacute signs and symptoms were followed by chronic signs and symptoms that lasted weeks, months, and even years in some individuals. These long-term signs and symptoms included persistent new headache, worsening of migraine headache, sleep disorders, imbalance, a sense of dizziness, tinnitus, and the loss of high-level cognitive abilities in the memory and executive function domain. (However, these long-term signs and symptoms have been avoided or improved with prompt medical treatment.)

(U) Four core characteristics

(U/ (b)(3) The Panel found that some of the acute sensory phenomena and acute signs and symptoms were especially difficult to explain through other means and decided to focus on incidents exhibiting these core characteristics as the best lens through which to view potential causal stimuli. AHIs, like other medically complex syndromes, contain a number of signs and symptoms and other features that are

common and thus nonspecific and difficult to ascribe to any particular cause. In contrast, those features that are unique to AHIs offer greater insight into potential causal stimuli. The Panel's focus on these characteristics, however, should not be interpreted as diminishing the importance of incidents that do not share these characteristics. The Panel proceeded to assess the potential for each mechanism to account for four "core characteristics" prominent among these AHIs:

- (U) The acute onset of audio-vestibular sensory phenomena, including sound and/or pressure, sometimes in just one ear or one side of the head.
- (U) Other nearly simultaneous signs and symptoms such as vertigo, loss of balance, and ear pain.
- (U) A strong sense of locality or directionality.
- (U) The absence of known environmental or medical conditions that could have caused the reported signs and symptoms.

(U) A unique neurosensory syndrome

(U) In medicine, a syndrome is a shared set of symptoms and signs that occur together in persons and that characterize a particular abnormality or condition. The condition may be due to one or more specific mechanisms. Ischemic brainstem syndrome, for example, has certain signs and symptoms, but the diagnosis of brainstem stroke is based on magnetic resonance imaging (MRI) findings because the same signs and symptoms can also result from a basilar migraine headache.

(b)(3) Taken together, the core characteristics may be considered a preliminary definition of an AHI neurosensory syndrome that defies naturally occurring explanations. In this subset of AHI cases displaying the core characteristics, the reported acute sensory event and acute signs and symptoms included a number of features shared by multiple individuals that make this syndrome reproducible, as well as unique. No physiologic or imaging findings have been definitively and consistently linked to this syndrome at this time.

(U) Preliminary biomarker results suggest cellular injury

(b)(1), (b)(3) Even fewer cases had blood drawn and properly preserved within three days of the initial event, even though for some forms of brain injury (e.g., sports-related concussion), some commonly used blood biomarkers are elevated only during the initial one- to three-day period.[12]

(U/ (b)(3) The finding that the elevation in these well-characterized biomarkers in some affected individuals is transient, rather than sustained, is noteworthy. Researchers have shown that these same biomarkers, called neurofilament light chain (NfL) protein and glial fibrillary acidic protein (GFAP), are released from brain cells in response to mild traumatic brain injury and concussion, which impair function of the blood-brain barrier and contribute to leakage of proteins from the brain into the blood.[13,14,15,16,17,18] Upon injury, the biomarkers are released into the surrounding interstitial fluid and subsequently into circulating blood plasma with a specific time-course.[19,20] The time-course of elevation

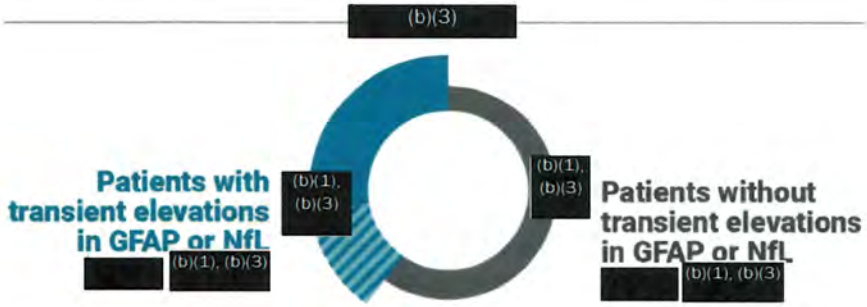
in some AHI patients, in which levels return to normal within a few weeks, matches the time-course after mild traumatic brain injury and concussion. The levels of elevation in AHI patients appear to be less than those observed in patients with mild traumatic brain injury and concussion.

(U) **FIGURE 1**

Preliminary Biomarker Data Worthy of Further Investigation

(b)(1), (b)(3)

(greater than 100 picograms per milliliter for GFAP and 10 pg/mL for NfL) according to ongoing and preliminary analysis by the National Institutes of Health. Baseline measurements before the AHI were unavailable for most of these patients. These preliminary data are insufficient to draw firm conclusions, but they highlight the importance of the Panel's recommendations for prompt collection of serial longitudinal samples; collection of baseline, predeployment samples; and research to discover new, specific biomarkers.



(U) ***Figure source note.***[21]

(U/ (b)(3) Integrating Patient Records and Intelligence Information

(b)(3) The Panel analyzed detailed medical records belonging (b)(1), (b)(3) or so affected individuals who were treated at the National Institutes of Health. (b)(1), (b)(3) The small sample size and uneven dataset prevented the Panel from drawing conclusions or ruling out hypotheses, underscoring the need for more systematic data collection and research.

(b)(3) Relevant biomarker data for most of the patients do not exist. Of the (b)(1) (b)(3) individuals, the Panel found that (b)(1) (b)(3) had their blood drawn within three days of their initial AHI, and one had their blood drawn within four to seven days. Of these (b)(1) (b)(3) patients, (b)(1) (b)(3) (b)(1) (b) (3) had a pre-event baseline measurement. (b)(1) (b)(3) of the (b)(1) (b)(3) patients had GFAP and NfL biomarker results that were particularly concerning to the Panel.

(U/ (b)(3) The diagnostic value of these blood-based biomarkers of cellular injury would pertain only to the subset of cases in which the exposure to stimulus was sufficient to cause leakage of these proteins from brain cells or injury to the blood-brain barrier. If only the ear or peripheral nerves were stimulated, current scientific knowledge would not predict that the biomarkers would be elevated. As in the case for patients with mild traumatic brain injury, the elevation of these biomarkers above a threshold value in AHI patients might suggest the presence of brain injury. The absence of such elevation, however, could not be used to rule out the occurrence of an AHI.

(U/ (b)(3) Ascribing the transient elevation of these biomarkers in AHI patients to downstream reactions such as depression or anxiety would fail to find support in the current medical literature, although there are unanswered questions related to biomarker measurements after mild traumatic brain injury.[22] NfL and GFAP have been found to be elevated in depressive disorders[23][24][25][26] and chronic insomnia disorder,[27] which are secondary conditions in some AHI patients. They are also elevated in diverse conditions unrelated to AHIs, including multiple sclerosis,[28] Alzheimer's disease,[29][30] amyotrophic lateral sclerosis (ALS),[31] Huntington's disease,[32] alcohol dependence,[33] and anorexia nervosa.[34] However, in these conditions, the biomarkers appear to exhibit a sustained elevation, often over years or decades, rather than the transient increases seen in some AHI patients and in mild traumatic brain injury, concussion, and conditions that are easily ruled out, such as COVID-19[35] and recovery from surgery and anesthesia.[36] Studies that obtain longitudinal biomarker data associated with acute anxiety and panic attacks would aid the interpretation of the current results and the design of future research. (See Appendix I for considerations for developing biomarkers.)

(U) Core characteristics unexplained by known medical conditions, including functional neurological disorder, and suggest external stimulus

(b)(3) Although some signs and symptoms of AHIs are common in known medical conditions, the combination of the four core characteristics is distinctly unusual, unreported elsewhere in the medical literature, and so far have not been associated with a specific neurological abnormality. Several aspects of this unique neurosensory syndrome make it unlikely to be caused by functional neurological disorder—a group of common neurological disorders caused by an abnormality in how the brain functions—rather than structural damage.[37][38] The location dependence and sudden onset and offset of sensations and symptoms, for example, argue for a stimulus that is spatially and temporally discrete. Although some signs and symptoms of AHIs can depend on the position of the body, such as dizziness, vertigo, and headache, there are no known medical conditions that are repeatedly experienced in only a discrete physical space (b)(3) The perception of sound and pain within only one ear suggests the stimulation of its mechanoreceptors, a specific cranial nerve, or nuclei in the brainstem, all of which mediate hearing and balance. The lack of other symptoms also helped to rule out known medical conditions as well as stimuli known to affect other motor or sensory systems.

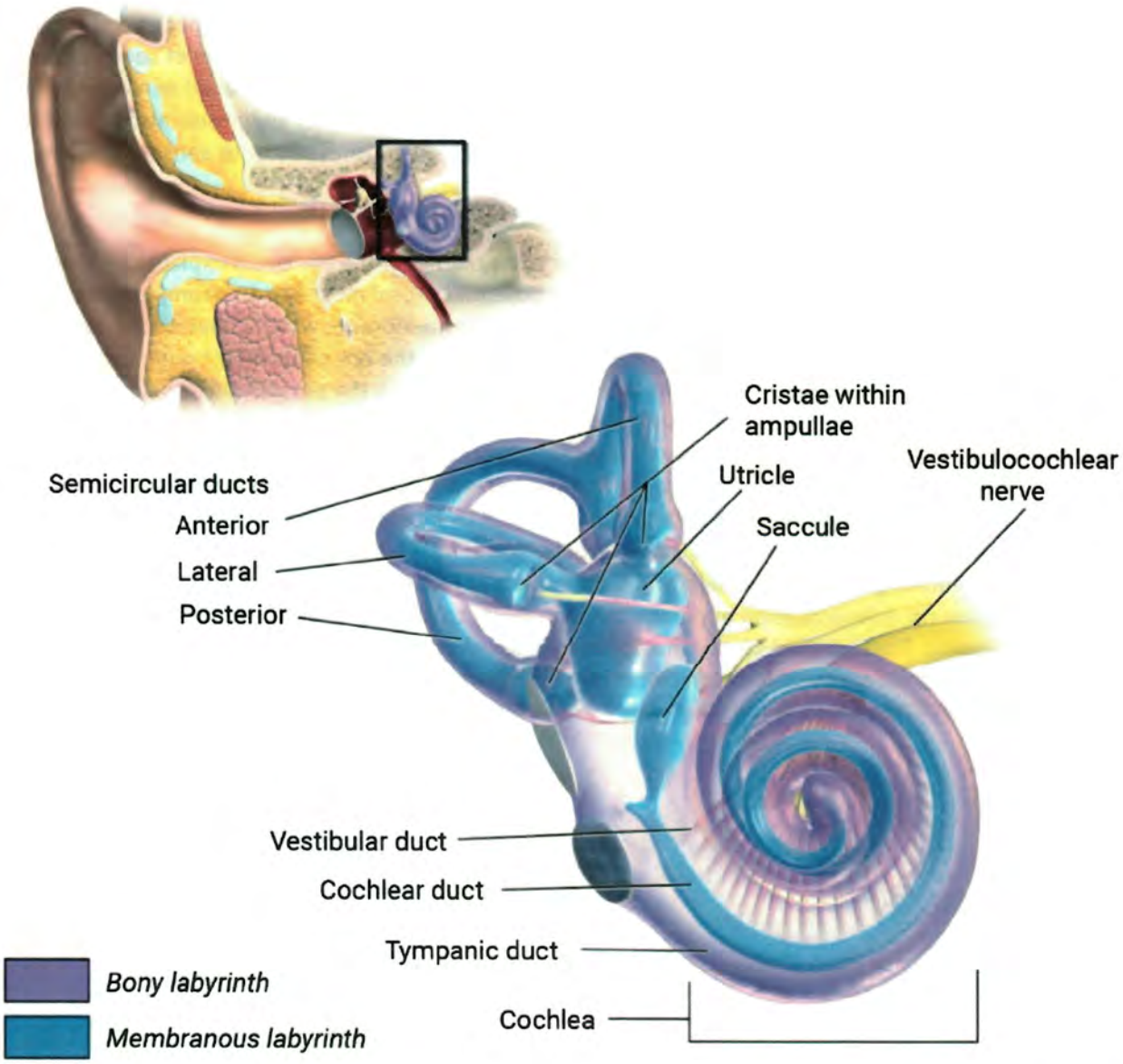
(U) Disruptions to inner ear consistent with the core characteristics

(U/ (b)(3) A disturbance of the auditory or vestibular components of the ear could explain the core characteristics and could be triggered by some of the potential causal mechanisms examined (see Figure 2). For example, the outer ear focuses sound on the tympanic membrane, which converts the sound to pressure waves. When there is a large pressure difference across the tympanic membrane, such as produced by a change in altitude, the membrane can stretch, causing the perception of pain. The pressure waves are transmitted by three small bones of the middle ear to the cochlea, a fluid-filled structure containing specialized hair cells with mechanoreceptors that detect small movements due to sound. These cells initiate the process of conveying the perception of sound through the brainstem to the brain. They are extremely delicate and can be damaged by intense acoustic energy. In addition to the cochlea, the inner ear includes the utricle, saccule, and semicircular canal, which contain hair cells that detect rotations, gravity, and acceleration. Imbalance of these organs can cause vertigo, a sense of rotation or spinning, misperception of gravity, or an inability to predict when the body is vertical, causing imbalance. These organs can be disrupted by microchanges in fluid movement or electrical potentials. An external stimulus that can cause small pressure waves[39] or changes in electric potentials[40] could create symptomatology in the inner ear, without distinct symptoms elsewhere in the brain or body.

(U) FIGURE 2
Inner Ear Has Structures Related to the Core Characteristics

(U (b)(3) The inner ear has multiple elements that detect sound, gravity, rotation, and acceleration, including the cochlea, utricle, saccule, and semicircular canal. If these elements are disturbed by an external stimulus, they could produce the AHI core characteristics.

(U)



UNCLASSIFIED (b)(3)

(b)(3)

(U) *Figure source note.*[41]

(U) Disruptions to blood-brain barrier may contribute to core characteristics

(U/ (b)(3) The blood-brain barrier helps protect most of the brain from unregulated exposure to potentially harmful compounds in the peripheral blood, and its disruption could help explain some of the nonsensory clinical characteristics. The blood-brain barrier consists of specialized cells that line the capillaries that course through the brain as well as the tight junctions between the cells. It permits only certain compounds from the blood to pass through into the brain.[42] The selectivity of this barrier varies during states of health and disease based on regulatory mechanisms that can be disrupted by chemical, biological, and physical factors. Disruptions to the blood-brain barrier have been shown to cause leakage of blood proteins, such as fibrinogen,[43] and small molecules into the brain and to elicit local inflammatory and oxidative stress responses. These responses have been linked to cognitive impairment.[4445] Local damage to the dura has also been associated with cerebrospinal fluid leaks, which can cause headaches, dizziness and vertigo, a sensation of pressure in the head, tinnitus, and cognitive impairment.[46] In addition, mild traumatic brain injury and concussion have been associated with some of the longer-term symptoms reported by AHI patients, including dizziness and balance problems, headaches, tiredness, cognitive and memory problems, anxiety, nervousness, changes in emotional state, and effects on sleep.[47]

(U) Core characteristics also unexplained by environmental factors

(U/ (b)(3) Based on literature reviews and discussions with a group of experts gathered from government and academia, including toxicologists, a microbiologist, and environmental health and safety experts temporarily cleared for classified discussions, the Panel determined that the core characteristics cannot be explained by benign natural or environmental factors. These factors include, but are not limited to, sick building syndrome, bacteria, fungi, chemical effluents, toxic substances, aerosolized particles, plumbing, or air handling equipment. Such factors would be especially unlikely to explain the rapid onset and offset of symptoms, misaligned symptomology, internally generated sounds not heard by others, and the absence of other signs and symptoms that would be expected. The Panel's assessment that environmental factors do not explain the core characteristics does not preclude these factors from playing a role in other reported AHIs, however.

(U) A Few Illustrative Cases

(U/ (b)(3) The following vignettes convey some of the circumstances, characteristics, and ambiguities of the incidents that the Panel considered. Details have been changed to protect privacy. For some cases, ongoing investigations may find medical, environmental, or other explanations that suggest an alternative causal mechanism to those discussed in the Panel's findings. Each alternative hypothesis will require a careful assessment of the data that argue for or against it.

(b)(1), (b)(3), (b)(7)(a), (b)(7)(e)

(b)(1), (b)(3)

(b)(1), (b)(3)

(U) Assessing Plausibility: From Source to Case

(U/ (b)(3) The Panel assessed the plausibility of each mechanism by decomposing a typical AHI case with core characteristics into five sequential components, starting with a potential source and ending with the clinical effects, and then asked whether the mechanism could explain each component. The Panel considered a mechanism to be plausible if all members assessed that there was at least some credible evidence that it was technically and practically feasible in each of the components: (1) a concealable source that could generate the required stimulus and be difficult to detect; (2) the propagation and delivery of the stimulus to an individual in a way that would be difficult to detect; (3) the coupling of the stimulus to the human body; (4) the ability of the coupling to cause biological effects; and (5) the ability of the biological effects to explain the core clinical signs and symptoms. In addition, the Panel required that other evidence not exclude the mechanism. Thus, a mechanism could be considered plausible if a notional line could be drawn connecting each of these five components. (See Figure 3.)

(U/ (b)(3) Some criteria depend on the type of stimulus or scenario. In considering chemical and biological agents, the Panel required that the same specific agent (rather than any agent) be plausible for all five components. The Panel defined close-access scenarios as those in which the source is near the target, (b)(1), (b)(3) (b)(1), (b)(3) Standoff scenarios involve distances of about 100 meters. Further considerations and criteria are below.

(U/ (b)(3) **Source.** A device (in the case of electromagnetic energy, acoustic energy, and ionizing radiation) or other means (for biological and chemical agents and environmental factors) that could generate the required stimulus. The source also had to be difficult to detect if the specific form of the mechanism were unknown ahead of time. Thus, the source had to be concealable (i.e., not easily seen or discovered) and for some scenarios, portable, taking into account requirements for size, weight, and power.

(b)(3) **Propagation and delivery.** The transmission of a stimulus from the source to an individual. Different scenarios imposed varied constraints and requirements for stimulus propagation, including the distance from source to individual, the presence of (b)(1), (b)(3) and other environmental variables, such as weather. Propagation of the stimulus also had to be difficult to detect, (b)(1), (b)(3) (b)(1), (b)(3)

(U/ (b)(3) **Coupling to human body.** The ability of the stimulus, if propagated to the individual, to enter the human body and reach the relevant tissues. The Panel considered the nervous system—especially the specialized organs and nerves of the inner ear, as well as the central nervous system—to encompass the most relevant tissues, given the nature of the core characteristics. There could be multiple physical paths and mechanisms for successful coupling, including penetration through bone, conduction through the external auditory canal or other openings through the skull, or penetration through the blood-brain barrier via the peripheral blood, as in the case of biological or chemical agents.

(U/ (b)(3) **Relevant biological effects.** The ability of the stimulus, once at the relevant site(s) within the human body, to elicit responses or changes in molecules, cells, or tissues that would be expected to have clinical effects. The Panel considered a number of biological effects to be possibly relevant, including disruption of, or interference with, cellular membranes and their ion channels or cellular organelles, such as mitochondria; cellular oxidative stress; elicitation or disruption of synaptic transmission; alteration of blood-brain barrier function and permeability; and local pressure wave induction with subsequent propagation in the inner ear and head.

(U/ (b)(3) **Clinical core characteristics. The feasibility that the biological effects of the stimulus would lead to the three symptom-based core characteristics: acute onset of audio-vestibular sensory phenomena, including sound and/or pressure, sometimes in only one ear or on one side of the head; other nearly simultaneous signs and symptoms such as vertigo, loss of balance, and ear pain; and a strong sense of locality or directionality. Biological effects that were considered particularly feasible in causing the core clinical characteristics would be expected to affect the inner ear or the neuronal pathways that transduce signals from the inner ear to the brainstem and elsewhere in the brain.**

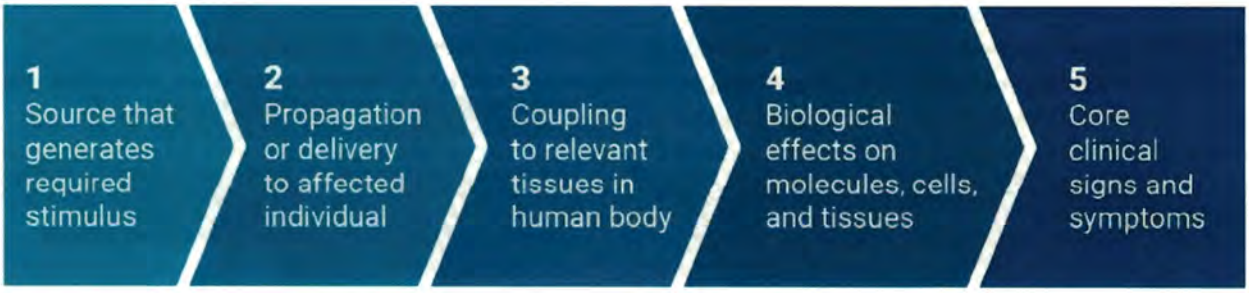
(U/ (b)(3) **Evidence for plausibility often could not be found in any one piece of information, but instead was based on a composite picture from multiple, interdisciplinary sources. These sources of information sources ranged in rigor from peer-reviewed publications of experiments on cells and tissues and well-controlled clinical studies to anecdotal reports from individuals and reports of foreign research without details. The Panel weighed each piece of information differently, depending on its source, credibility, reliability, and granularity.**

(U) **FIGURE 3**

Five Components of Plausibility

(U) The Panel assessed the technical and practical feasibility—including being difficult to detect—of each potential AHI causal mechanism in each of five sequential components. The Panel considered a mechanism to be plausible if all members assessed that there was at least some credible evidence that it was technically and practically feasible in each component.

(U)



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(U) Potential Causal Mechanisms

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(U) Electromagnetic Energy

(U/ (b)(3) Electromagnetism is a fundamental property of the universe, and it can take many forms, from the interactions between two charged particles to the composition of light itself. Electric and magnetic fields can be local or propagating, continuous or pulsed, and shaped, modulated, or combined, generating a range of possibilities. Physical constraints bound the parameter space, however. The breakdown of air limits electric field strengths at the highest powers, and traditional antennas can become very large or complicated for low frequencies. The vast majority of human safety research has focused on the potential side effects from practical applications such as cooking, communication, radar, and medical procedures, leaving the effects of many types of fields little explored.[5455] This section focuses on the lower frequency end of the electromagnetic spectrum, below 300,000,000,000 cycles per second (300 GHz). This range spans from nearly static fields, through radiofrequencies (30 kHz to 1 GHz) and microwave bands (1 to 300 GHz).

(U) Broad relevance to AHIs

(b)(3) The Panel considered electromagnetic energy as particularly relevant to AHIs because of research and development (b)(1), (b)(3) the availability of suitable sources and antennas; the ability of electromagnetic fields to enter and affect systems such as the ear and brain; and anecdotal evidence of clinical effects similar to the core characteristics.

(U) Extensive foreign research and development

(b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(3) The reporting available to the Pane (b)(1), (b)(3) the Panel cautions against dismissing it outright or prejudging it (b)(1), (b)(3) Instead, the Panel recommends further collection, experimental research, and analysis.

(U) Panel Examined Foreign Research To Assess Technology, Not To Attribute AHIs

(b)(1), (b)(3)

The Panel did not consider whether (b)(1), (b)(3) other actors have been or are involved in AHIs (see "(U) Scope Note and Background" section.)

(b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(1), (b)(3)
- (b)(1), (b)(3)

(b)(1), (b)(3)

(U) Suitable sources (b)(1), (b)(3)

(b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(1), (b)(3)

(b)(1), (b)(3)

(U) Multiple paths allow coupling to the brain

(b)(3) **An external electromagnetic or acoustic stimulus, regardless of frequency, can reach and couple with the inner ear and other parts of the brain that the Panel assess are responsible for the core characteristics (see Figure 6). The external auditory canal can act as a waveguide, directing external energy toward the inner ear and brain.[68][69][70] For parts of the head protected by the skull, electromagnetic waves with frequencies below a few GHz can penetrate tissue and bone directly to affect deeper tissues.[71][72] Additionally, the temporal bone is thinner than other parts of the skull and more vulnerable to penetration. Some studies suggest radiofrequency pulses with fast rise-times can penetrate tissue more deeply than would be expected from the base frequency alone,[73] but this phenomenon requires further study.**

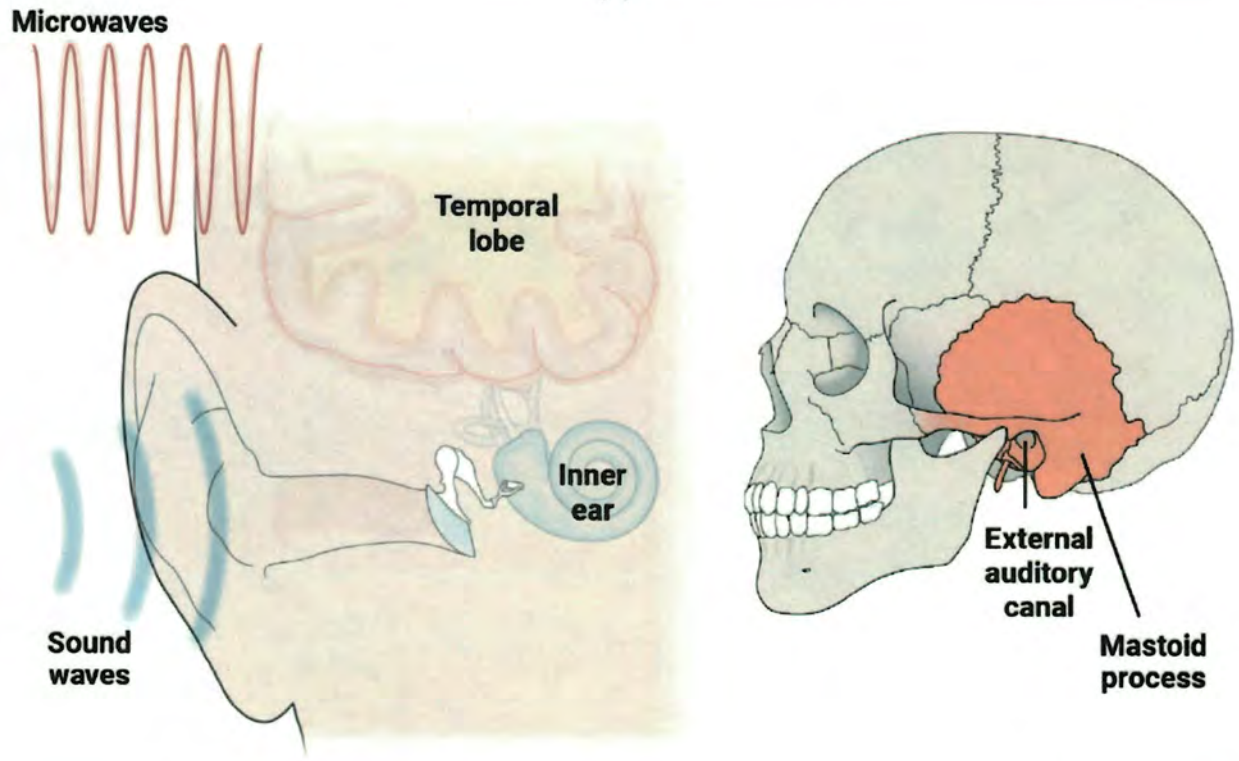
(b)(1), (b)(3)

(U) **FIGURE 6**

Some Parts of the Head Are Particularly Vulnerable to Directed Energy

(U) The external auditory canal allows electromagnetic and acoustic energy to enter the inner ear and brain. The temporal bone is thinner than other parts of the skull, making it more vulnerable to penetration by some stimuli, and the mastoid region of the skull has been found to be particularly vulnerable to ultrasound.

(U)



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(b)(3)

(U) *Figure source notes.*[747576]

(U) Medical applications demonstrate biological effects

(b)(3) The ability of external electromagnetic fields to enter the head and brain has led to a variety of uses in medicine that demonstrate the effects of such fields on human biology. Individuals scanned in high-magnetic-field MRI machines have reported vestibular disturbances,[77] and pulsed radiofrequency energy has been shown to disturb blood-brain barrier permeability for drug delivery.[7879] The US Food and Drug Administration has approved transcranial magnetic stimulation to treat depression,[80] and researchers are developing therapies that use low-frequency electromagnetic fields to improve learning and recovery after stroke.[81] Electrical stimulation of the eighth cranial nerve can produce hearing in patients who are deaf,[8283] and for decades electroconvulsive therapy has been used to treat depression.[84] Most recently, focused transcranial electromagnetic stimulation has been used to create an electric field envelope modulated to a frequency that can stimulate neural firing; this technique is used medically to stimulate the cerebellum to prevent tremor or to stimulate the brainstem to produce respiration.[8586]

(U) Accidental exposures suggest core characteristics

(b)(3) The Panel heard from several (b)(1), (b)(3) who were accidentally exposed to electromagnetic signals (b)(1), (b)(3) Although these experiences were not controlled experiments, they provide intriguing evidence that such stimuli can have relevant clinical effects. There are many examples in medicine in which accidents have advanced understanding in areas for which human experimentation would be unethical, especially regarding the brain.[8788]

- (b)(3) Uncovering information about accidental exposures is challenging. Individuals were candid during their off-the-record discussions with the Panel, but when the Panel attempted to survey organizations more broadly, its inquiries were met with carefully worded statements about members of these organizations having followed all relevant safety guidelines.
- (b)(3) Little research in the West has systematically explored configurations of electromagnetic energy that could cause nonthermal clinical effects. Although there is a large amount of research on such effects—an estimated 25,000 publications as of 2018[89]—the vast majority has understandably focused on configurations related to the safety of commercial appliances and communication systems.
- (U/ (b)(3) Interestingly, safety standards in Russia[90] and many other former Soviet states[91] place much stricter limits on human exposure to electromagnetic fields than current Western standards. Western scientists have attempted to replicate Russian claims of biological effects at nonthermal

power levels despite the absence of details about the waveforms and energy levels of greatest concern, but their efforts have failed to show similar results. Thus, the primary organizations responsible for setting Western exposure standards do not include most of the Russian studies in their considerations.[9293]

(b)(3) The data from these incidents are generally consistent with academic research, (b)(1), (b)(3) (b)(1), (b)(3) but are too limited to draw firm conclusions.[9495] They seem to suggest, however, that different individuals can experience the same type of stimulus in different ways, which may help account for some of the observed heterogeneity in cases exhibiting the core characteristics. In addition, higher power exposures appear to generate symptoms that are distinct from those with less intense exposures, suggesting that more than one variable or biological mechanism may be at play. Lastly, the effects of electromagnetic exposure may be cumulative over time (e.g., over hours) and may be capable of triggering acute symptoms without warning. The Panel emphasizes, however, that confirming or disconfirming any of these preliminary observations will require systematic research.

(b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(1), (b)(3)
- (b)(1), (b)(3)

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- (b)(1), (b)(3)
- (b)(1), (b)(3)

(U/ (b)(3) **Exposures to electromagnetic fields that were indicative of the core characteristics.** Two individuals separately described to the Panel incidents in which they experienced symptoms related to the core characteristics that varied in severity.

- (b)(1), (b)(3)
- (b)(1), (b)(3)

(U/ (b)(3) **Exposure to high-power, pulsed radar that caused bulk heating and did not result in core characteristics.** According to a scientific paper, 14 Norwegian sailors in 2012 were accidentally exposed to high-power, pulsed radiofrequency fields that caused bulk-heating effects. The signals came from the radar of a US Navy vessel at a passing distance of 70-100 meters and lasted for about seven minutes. The estimated peak power density was about 55 kW/cm^2 and the peak electric field was about 15 kV/m, with average powers and fields about 100 times less. Another group of sailors was inside the metal hull of the ship at the time and was not exposed, serving as an inadvertent control population.[112]

- (U/ (b)(3) The signs and symptoms were fairly uniform—acute onset and offset of warming of the skin and disruption of exposed electronics, followed by headaches that, for all but one individual, resolved after time, treatment, and reassurance. The exposed sailors reported none of the core characteristics, and the unexposed sailors reported no acute symptoms.[113]

(U) Electromagnetic pathways considered by the Panel

(b)(3) **A challenge of assessing electromagnetic energy as a potential cause of the core characteristics is the range of possible field configurations and ways they might affect humans. One must be careful not to take evidence that supports or disconfirms plausibility for a particular scenario and apply it to others. Thus, the Panel divided electromagnetic mechanisms into five main pathways based on their potential biological effects and separately considered the plausibility of each. The pathways are bulk heating, thermo-acoustic effects, the microwave-auditory effect, strong fields and forces, and resonant disruption (see Figure 7).**

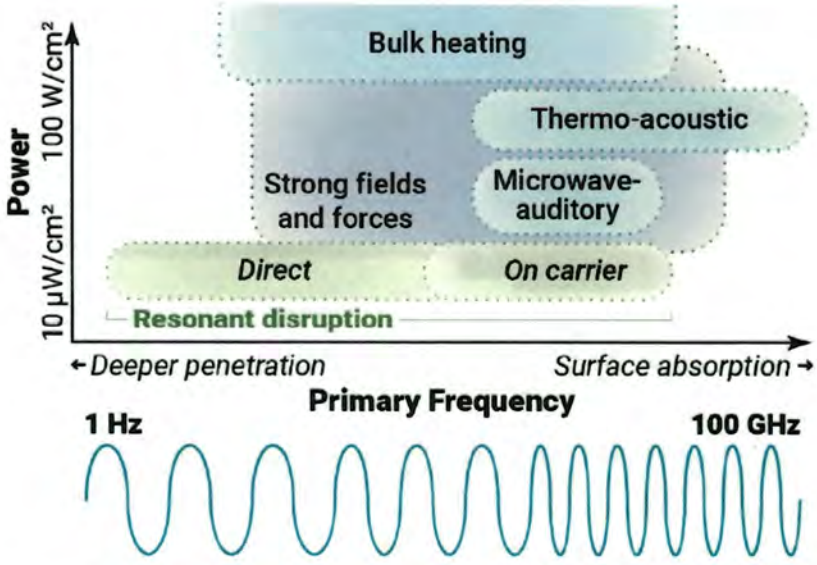
(U) **FIGURE 7**

Five Potential Pathways Involving Electromagnetic Energy

(b)(3) The Panel assessed the plausibility of five main pathways by which electromagnetic energy might cause the core characteristics. The pathways involve different energies and frequencies, although there is overlap.

(b)(3)

Note: This diagram is notional; more research will be needed to determine the parameters of each pathway.



(b)(3) (b)(3)

(U) Pulsed radiofrequency signals offer advantages over continuous ones

(b)(3) **In comparison to radiofrequency signals that are continuous, signals that are pulsed would allow for smaller, more concealable sources and antennas at a given power level, would enhance propagation and tissue penetration, and would reduce the likelihood of detection. Thus, the Panel focused its analysis on pulsed signals, although continuous signals could provide stimuli for some of the five pathways that the Panel considered. Figure 8 discusses potential biological effects for the pathways and includes signal parameters for a pulsed-radiofrequency approach to each.**

(U) (b)(3) **FIGURE 8**

Electromagnetic Pathways Involve Diverse Signal Parameters and Biological Effects

(b)(3) The five pathways involving electromagnetic energy considered by the Panel require a range of signal parameters and cause disparate effects on cells, tissues, and organs. This table shows parameters for pulsed signals, although continuous signals could also be used for some pathways.

(U) This table is (b)(3)

Pathway	Peak Power *(Field Strength)*	Primary Frequency	Duration of Single Pulse *(Pulse Repetition Frequency)*	Biological Effects
Bulk heating	> 10^3 mW/cm^2 *(> few kV/m)*	~ 200 MHz to < 6 GHz	Any duration or repetition rate, including continuous wave signals	Heat and tissue damage. Higher frequencies penetrate and heat less deeply than lower frequencies.
Thermo-acoustic	10^2 to 10^5 mW/cm^2 *(50 to 200 kV/m)*	~ 200 MHz to 3 GHz	≤ 5 µs *(~ 1 Hz to 1 kHz)*	Pressure wave and possible traumatic brain injury. May hear clicking. Lower frequencies penetrate more deeply. Higher frequencies produce sharper waveforms.
Microwave-auditory	≥ 10 mW/cm^2 *(≥ 1 kV/m)*	200 MHz to ~ 3 GHz	~ 1 ns to 1 ms *(~ 20 Hz to 20 kHz)*	Generates internal sounds through Frey effect. Can create a sense of vibrational pressure or buffeting.
Strong fields	~ 10^2 mW/cm^2 *(> few kV/m)*	Impulse rise time likely more important than frequency	≤ 1 ns *(< a few MHz)*	Can fracture membranes and capillaries, damaging myelin sheaths around neurons and the blood-brain barrier, causing leakage of cerebrospinal fluid.
Resonant disruption	~ 10s of µW/cm^2 *(~ 1 mV/m to 1 V/m)*	0 Hz to 10 kHz, possibly as much as 10 MHz Could be modulation of higher frequency carrier.	sub-ns to ms *(< 100 Hz?)*	Could interfere with neuronal function, induce currents, depolarize membranes, disrupt ion concentrations, or stimulate nerves.

(b)(3) (b)(3)

(U) ***Figure source notes.*** [114][115][116][117][118][119][120][121][122][123]

(U) Bulk heating is an implausible pathway

(b)(3) The Panel considered the effects that result from the bulk heating of tissue, particularly brain tissue, by the absorption of high-power microwave energy. This pathway is sometimes referred to less accurately as a "thermal effect" (see Appendix G), because heating is presumed to be the dominant cause of damage or symptoms when tissue is heated by more than 1 degree Celsius. This terminology can cause confusion, however, because other potential pathways may involve localized or very transient heating, sometimes without causing perceptions of heat. In fact, electromagnetic fields will cause some heating in any transfer of electromagnetic energy to cells or tissue. In most instances, however, the increase in temperature will be negligible because of the body's ability to rapidly remove excess heat from its liquid-cooled organs.[124]

(U) Inconsistent with core characteristics and AHI situational reports

(b)(1), (b)(3)

other nonmetallic barriers reduce transmission strength, and any metallic structures in the target area could create a complicated pattern of reflections and hotspots. Because of extensive research into the health and safety effects of exposure to high-power commercial sources, the potential for damage to tissue from heating is well understood.[125][126] However, the anticipated symptoms, including sensations of heat, do not match the core characteristics (see, for example, the incident involving Norwegian sailors[127] in the "(b)(3) Accidental exposures suggest core characteristics" section above). Furthermore, other expected outcomes such as reports of ambient warming, damage to electronics, (b)(1), (b)(3) are uncommon or absent in AHIs, leading the Panel to assess that bulk heating is an implausible explanation.

(U) Thermo-acoustic effects are a plausible pathway, with information gaps

(U/(b)(3) Thermo-acoustic effects occur when pulses of electromagnetic energy are absorbed and, through rapid thermal expansion of the affected tissue (but not bulk heating), are converted to an acoustic pressure wave that travels through the brain.[128][129] If a pressure wave stimulates the inner ear at audible frequencies, some individuals will hear a sound. Known as the Frey effect, or microwave hearing effect, this auditory phenomenon was discovered by researchers developing early pulsed-radar systems and has been well documented.[130][131] Although several researchers assess that the Frey effect does not cause negative clinical consequences in humans, the Panel notes that some of Frey's experimental subjects reported a sensation of pressure,[132] and other researchers have reported other signs and symptoms in human subjects who were deliberately exposed to Frey-like stimuli.[133]

(U) Sources and propagation feasible for standoff distances

(b)(1), (b)(3)

As with bulk heating, penetration of walls or other nonmetallic barriers will reduce transmission strength, and any metallic structures in the target area could create reflections and hotspots.

(U) Full scope of biological and clinical effects unknown

(b)(3) Although the mechanism by which high-power pulses produce pressure waves that can then produce the perception of sound is well studied, it is unknown if such pulses are capable of producing enough pressure to cause other AHI-like symptoms at range. Brain tissue is fragile and vulnerable to mechanical disruption on scales not easily observed by medical imaging. Researchers have suggested mechanical damage can result if the pulse has a sufficiently high-power density and is short compared to the reverberation time in the skull[136] or if the pulse shape is adjusted to optimize biological effects,[137][138] but more research is needed. If high power density or careful pulse-shaping is required to optimize the biological effects, then higher peak power for each pulse would also likely be required. (b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3) Power levels that are insufficient to cause thermo-acoustic effects may still cause a range of other biological effects. These effects fall within the three pathways discussed below and could help explain the diversity of symptoms of AHIs.

(U) Microwave-auditory effect an implausible pathway on its own

(b)(3) The microwave-auditory effect is caused by the microwave thermo-acoustic effect, but is typically observed at lower powers than those considered above for producing the core characteristics. Energy that is pulsed at audible frequencies can produce sounds that are audible to the target, but in this pathway, the pressure and shear forces are insufficient to disrupt cellular membranes or cause other biological effects.[140] The lack of biological effects is consistent with the vast majority of research on the Frey effect, which reports no detrimental signs or symptoms in participants.[141][142] The Panel considered the microwave-auditory effect as a separate pathway, however, because under certain conditions, it could appear as a side effect of any of the other four pathways, resulting in the perception of sounds in some individuals. (b)(1), (b)(3)

(U) Strong fields offer a plausible pathway, with uncertainties

(b)(3) Strong electric and magnetic fields produced by electromagnetic pulses exert considerable forces on charged particles and cellular membrane potentials within the body, potentially causing a variety of biological effects (see Figure 8).[143][144] Yet potential clinical effects in this pathway, at energies or frequencies below those required for bulk heating or the thermo-acoustic effect, are frequently dismissed as plausible explanations for AHIs in part because safety reviews have found only limited clinical effects.[145] However, these reviews have focused on the safety of commercial and military technologies, often considering only average power densities, which can be low in many scenarios relevant to AHIs. In vitro studies[146] suggest the relevant pulse shapes and repetition rates would make the fields involved in this pathway unlike those used in most modern electronic systems and therefore outside the regimes typically studied for health and safety.

(U) Sources and propagation feasible

(b)(3) In this pathway, there are more options for pulse creation and delivery, as well as a variety of possible waveforms to consider. (b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(U) Biological and clinical effects plausible but uncertain

(b)(3) Strong electromagnetic fields and the resulting forces on charged particles have been shown to disrupt ion transport, cell membranes,[153] the blood-brain barrier,[154] and other aspects of living tissues,[155][156] but there are unknowns in terms of how they might affect or be perceived by humans. Much of the work in this area has been performed in vitro or in vivo by using direct contact probes that localize the electromagnetic effects. Thus, while plausible, there is little direct evidence of whether nonlocalized cellular effects would cause the core symptoms, highlighting the need for further investigation.

(b)(3) Some research suggests strong electric or magnetic fields could cause a sensation of pressure by stimulating piezo-electric-like pressure sensors in the skin and body.[157] They also could cause a sense of moving through an energy barrier by polarizing hairs on the skin that then would react to fields above a certain threshold. Although asymmetric pulses may enhance biological effects,[158] the proposed pathway for enhancement involves asymmetry on biologically relevant timescales, and it is unclear what those timescales are or how much they vary by tissue. If the timescales are long, on the order of microseconds, then achieving high field strengths at range could be technically challenging. Finally, it is unclear if auditory stimulation would be generated unless the pulse repetition rate is at audible frequencies or overlaps with the microwave-auditory pathway, which is a weak thermo-acoustic effect.

(U) Resonant disruption is a plausible pathway, with significant research gaps

(U/ (b)(3) Like any complex electromechanical system, the human body has a variety of naturally occurring rhythmic or repetitive phenomena, ranging from neural activity[159] to cellular functions and mechanical vibrations.[160] In addition, the body has a low-frequency electromagnetic background—a.k.a., "pink noise"—from the electrical and electrochemical activity in the body and especially in the brain.[161] These background signals may affect higher function through a process known as stochastic resonance.[162] For the human body, these resonances are typically at low frequencies, below 100 Hz.

(b)(3) Human biological systems are vulnerable to disruption or influence by external fields and forces that resonate with their naturally occurring patterns, including at low powers; a variety of such effects have been demonstrated.[163][164][165] (b)(1), (b)(3)

(U) Sources and propagation feasible, especially for near-field effects

(b)(1), (b)(3)

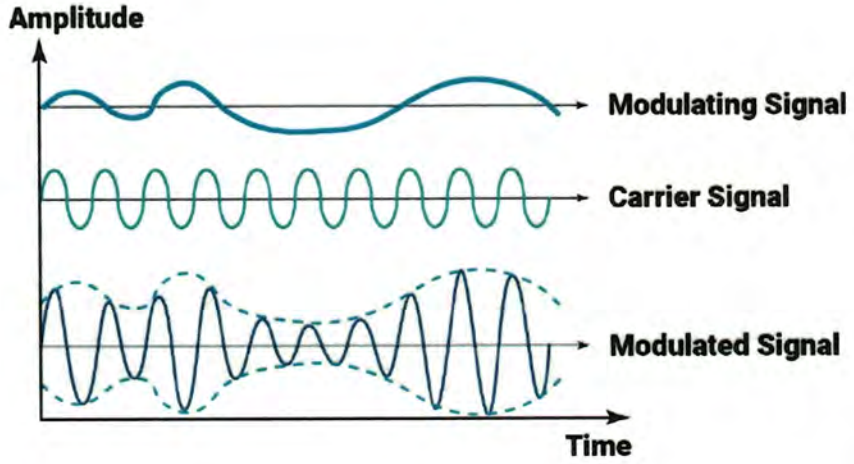
(b)(1), (b)(3)

(U) FIGURE 9

Higher Frequencies Can Be Used To Deliver a Lower-Frequency Signal

(U/ (b)(3) Combining a low-frequency modulating signal with a higher-frequency carrier signal produces a modulated signal that exhibits characteristics of both components. The resultant signal will have some of the more effective propagation characteristics of the higher-frequency component, while causing biological effects similar to those produced by the lower-frequency component.

(U)



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(b)(3)

(U) Biological and clinical effects plausible, but with significant research gaps

(b)(3) **Low-frequency fields have been shown to strongly couple with a broad range of biological processes at frequencies typically less than 100 Hz,[167][168][169] but the potential effects on humans require further study. Some work suggests that resonant coupling into biological frequencies decreases the power required and increases the biological effects,[170][171] which would be consistent with other types of resonant energy transfer such as wireless chargers of personal electronic devices, but such coupling requires further study for biological processes.**

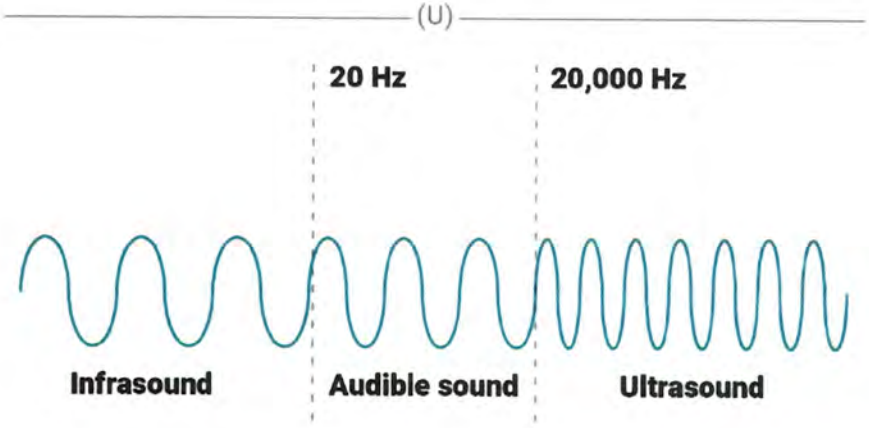
(U) Acoustic Energy

(U) **Acoustics refers to the generation and propagation of mechanical pressure waves or vibrations, including low-frequency infrasound, audible sound, and high-frequency ultrasound (see Figure 10). Acoustic waves are generated by a physical displacement of a solid, liquid, or gas, and they propagate by transferring this motion to nearby atoms. As a result, it is the mechanical—rather than electrical—properties of a material that determine how well an acoustic wave propagates through the medium and how much acoustic energy is transmitted or reflected when a new material is encountered, such as wall or window. Acoustic waves can couple strongly with a system if the transmission medium and system have similar acoustic impedances or if there is a vibrational resonance, like an opera singer shattering a wine glass, which is comparable to electromagnetic waves coupling with an electrical resonance. In other similarities to electromagnetic waves, lower acoustic frequencies are harder to focus in a particular direction and tend to radiate more broadly, and higher frequencies are easier to direct and can be modulated to carry and deliver a lower-frequency signal.**

(U) **FIGURE 10**

Three Categories of Acoustic Energy

(U) The Panel considered three categories of acoustic energy based on frequency. Infrasound corresponds to frequencies less than 20 Hz, audible sound is between 20 Hz and 20 kHz, and ultrasound is greater than 20 kHz.



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(b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(1), (b)(3)

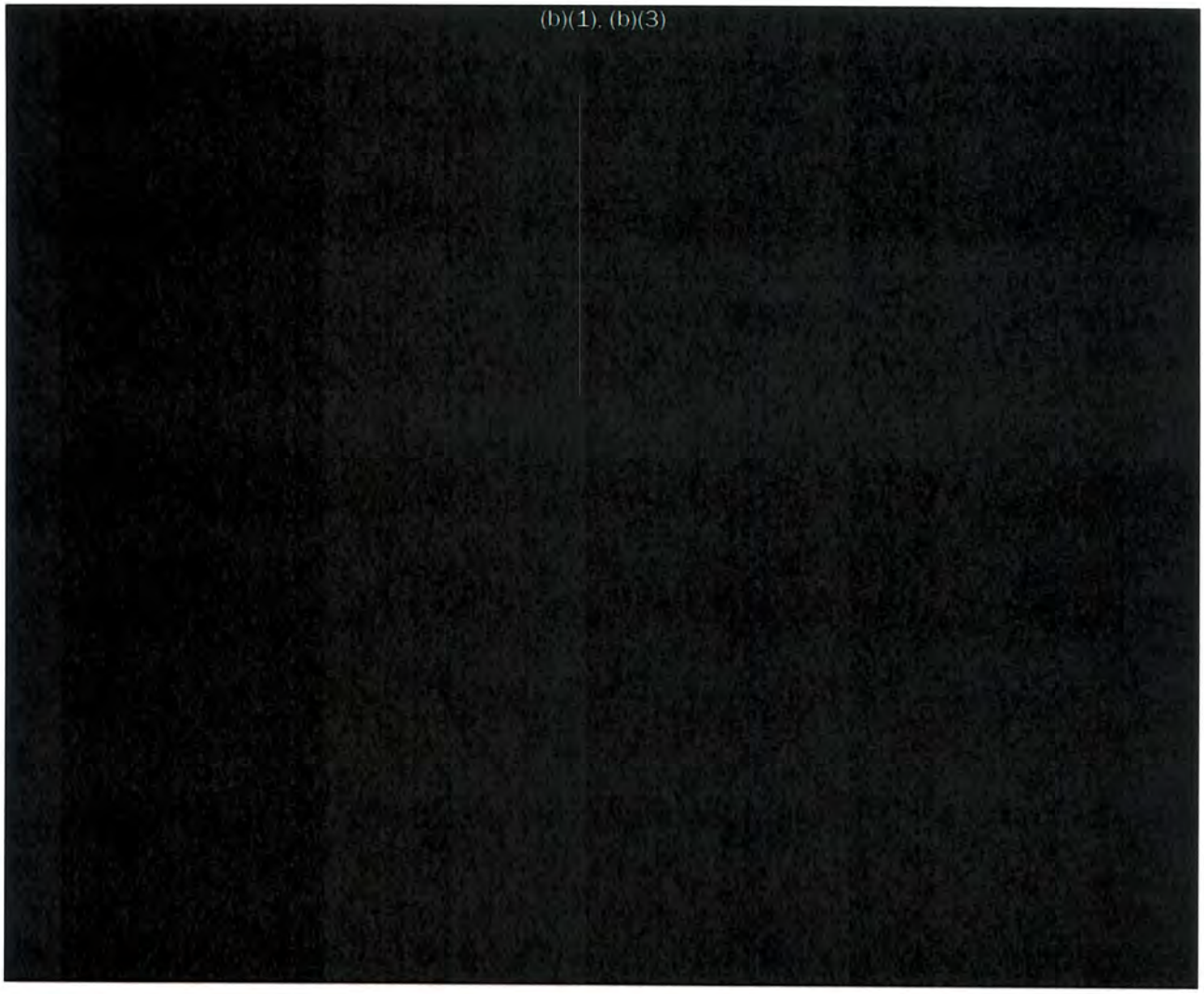
(U) Ultrasound plausible for close-access scenarios, but information gaps exist

(b)(3) The required energy for biological and clinical effects can be generated by ultrasonic arrays that are commercially available, portable, and produce a tight beam. Ultrasound propagates poorly through air and building materials, restricting its applicability to scenarios in which the source is near the target, (b)(1), (b)(3) It could couple to the body through the external auditory canal, interstitial spaces, or the vestibular apparatus of the inner ear (see Figure 2). Ultrasound is used to open the blood-brain barrier in medical procedures, and ultrasonic stimulation of the aforementioned anatomical areas could produce symptoms consistent with AHIs. Studies of "ultrasound sickness" and related audio-vestibular symptoms have reached mixed conclusions, but the Panel was presented with independent anecdotal accounts in which individuals were exposed to ultrasound beams and subsequently experienced the core characteristics. These results are suggestive rather than definitive and worthy of further research.

(U) Parametric arrays could serve as sources

(U/ (b)(3) Devices that produce ultrasound are commercially available, use mature technology, are easily portable and concealable, and can be powered by standard electricity or batteries. Ultrasound is used for diverse applications—including medical imaging[176] and medical procedures,[177] chemical mixing,[178][179] cleaning surfaces,[180] directional loudspeakers,[181] beacon technology,[182] and detection of land mines[183]—which drives innovation and availability of this technology.

(b)(3) Devices called ultrasound parametric arrays[184] may be particularly relevant to AHIs. This technology can produce a beam that is nearly free of side lobes, maximizing the strength and directionality of the main beam. (b)(1), (b)(3)



(U) Propagation inefficiencies limit plausibility to close-access scenarios

(b)(3) **Ultrasound propagates poorly through air and building materials, restricting its applicability to scenarios in which the source is near the target,** (b)(1), (b)(3) **In the most plausible situations, the source would probably be located** (b)(1), (b)(3) **from the affected individual, with no more than one barrier, such as a window or wall, between them. To the affected individual, the signal would appear to be localized, because losses related to absorption and spreading will rapidly degrade the signals with distance. In addition, reflections off interior walls will cause acoustic resonances, boosting signal strength in some parts of the room.**

(U) Coupling to brain could occur through interstitial spaces and hollow structures

(b)(3) **In AHI scenarios, the mismatch of acoustic impedances at the boundaries between air and skin and between skin and skull would prevent most ultrasonic energy from reaching the brain. Sound waves transmitted through air, regardless of frequency, are strongly impeded or reflected at these boundaries because of the dramatic differences in density and the speed of sound between the two media. However, the mammalian middle ear has evolved to improve the impedance matching for audible sound between air and the fluid-filled inner ear, which is also penetrable by ultrasound.[186] Pathways exist through the external auditory canal, interstitial spaces, and hollow structures that allow acoustic energy**

to reach the endolymphatic sac and the vestibular apparatus of the inner ear (see Figure 2.) This finding is supported by (b)(1), (b)(3) researchers.[187] Indeed, if such alternative routes to the brain did not exist, there would be no need for occupational exposure limits to airborne ultrasound.[188]

(U) Medical applications demonstrate effects on central nervous system

(U) A variety of noninvasive clinical applications show the ability of ultrasound, once it couples to the human body, to affect the central nervous system, including the alteration of the blood-brain barrier to aid in the delivery of drugs to the brain. In these procedures, ultrasound is usually applied through a gel on the scalp to circumvent the impedance mismatch between air and the skull. Damage that causes leaks of blood products through the blood-brain barrier has been associated with resultant inflammation and neural injury.[189190191192]

(U) Ultrasound is used to break down the blood-brain barrier to allow antibodies[193] and drugs[194195] to pass into the brain. It also has been used to open the blood-brain barrier to treat amyotrophic lateral sclerosis (ALS).[196] High-frequency, focused ultrasound is used in an FDA-approved procedure to create a thermal lesion in the brain for treatment of Parkinson's disease.[197] Ultrasound activates the brain via the cochlear pathway in guinea pigs,[198] and focused ultrasound at lower energies has been shown to cause nerve cells to fire[199200] and cause skull vibration that can lead to the perception of sound.[201202]

(U) Anecdotal exposures have resulted in the core characteristics, but unknowns exist

(U) Studies of "ultrasound sickness" and related audio-vestibular symptoms have reached mixed conclusions, with many studies concluding that ultrasound poses little risk within current safety limits and others suggesting unclear or adverse health effects.[203204] The challenges of experimenting on humans may contribute to these varied results. Exposures may have been insufficient in intensity, duration, or type to elicit harmful effects, or the number of subjects may have been insufficient to obtain statistically significant results, given natural variations in human responses.

(b)(3) Further experimental research is required to better characterize the clinical effects of ultrasound and associated thresholds for harm, if any. However, the Panel notes three intriguing, anecdotal incidents that suggest that ultrasound could cause the core characteristics. The first two incidents are independent, firsthand accounts (b)(1), (b)(3) Although these incidents are inconclusive in themselves, the Panel considers them to be compelling and indicative of the need for additional research.

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(U/ (b)(3) Infrasound sources unlikely to be concealable or explain localization phenomena

(b)(3) The technology needed to produce a pure infrasound signal is mature and commercially available, but conventional sources are large, bulky, and heavy. Moreover, to produce localized effects, multiple infrasound devices would have to be deployed in an array. Optimal beam-forming with infrasound requires a large footprint because of the large spacing (at least 8.5 meters) that would be required between the devices. Infrasound efficiently penetrates windows and lower-density walls, but once transmitted into a building, infrasound will generally disperse through openings and walls into other areas. Such dispersion is inconsistent with reports of localization by affected individuals.

(U) Audible sound would be detectable and inconsistent with circumstances

(b)(3) A causal mechanism involving pure audible sound would be inconsistent with the AHI events involving the core characteristics. To render the reported clinical effects, the sound pressure level of an audible tone would be insufferable and accompanied by an immediate avoidance response by the affected individual. There are few or no documented defensive mechanism reactions, such as plugging one's ears, that would be expected at the onset of discomfort at about 120 dB (equivalent to a loud rock concert.) Other persons in the vicinity would have been aware of this sound as well.

(U) Psychosocial Factors

(U) The Panel was asked to examine any potential roles of psychosocial factors in AHIs, which was one of the more challenging aspects of the study. These factors—the combined influence of psychology and the social environment on the individual—are diverse and complex from a scientific standpoint, and attempts to address them can be complicated by misconceptions. In particular, the Panel notes the unfortunate tendency to differentiate between conditions caused entirely by physical injury and those that involve psychological and social factors, with the former regarded as "real" and the latter, by implication, as "fake." This false dichotomy reflects a bias against, and stigmatization of, any condition that has a psychological component. It also ignores the fact that the symptoms themselves are genuine regardless of cause. Individuals who suspect they have experienced an AHI, especially those who pride themselves on resilience and toughness, may be understandably distressed by such improper distinctions.

(U) Psychosocial factors alone cannot account for the core characteristics

(U/ (b)(3) No known psychosocial factors explain the core characteristics, including the acute sensory experience, sudden onset of symptoms, often within seconds, and strong location dependence. In addition, the incidents exhibiting the core characteristics do not fit the majority of criteria[210] used to discern mass sociogenic illness, including symptoms that are transient and benign, the presence of extraordinary anxiety before the event, and spread from higher-status persons downward (see Figure 12).

(U) **FIGURE 12**

Cases With Core Characteristics Do Not Fit Criteria for Mass Psychogenic Illness

(b)(3) AHI cases containing the core characteristics do not fulfill the majority of criteria used by academic researchers to discern mass sociogenic illness (a defined, acute illness in small groups that, in the absence of some demonstrated medical explanation, is attributed to a type of somatoform disorder). The criteria tend toward inclusion; some incidents that meet the criteria have later been found to result from toxic fumes, insecticides, and other non-sociogenic causes. The assessed extent to which AHI cases with the core characteristics meet the criteria for mass sociogenic illness takes into account post-incident interventions such as medical treatment.

(U)

Extent of Agreement

- ● Strong agreement
- ◐ Mixed agreement
- ○ Little or no agreement
- ? Unknown agreement

(U) This table is (b)(3)

Mass Sociogenic Illness	AHI Cases With Core Characteristics	
Symptoms are transient and benign	Some affected individuals have experienced symptoms that are temporary and cause little harm, but many have had symptoms that have persisted and had serious effects.	◐
Rapid onset and recovery of symptoms	Onset is sudden, but recovery can be slow and does not appear to be linked to the recovery of close associates who were also affected.	◐
Occurrence in a segregated group	Affected individuals have served different organizations in a number of diverse locations and roles.	○
Presence of extraordinary anxiety	No evidence that affected individuals were experiencing extraordinary anxiety relative to their normal work duties.	○
Symptoms spread via sight, sound, or oral communication	Cases have spread across time and distance, and privacy has been afforded to affected individuals. However, the more recent increase in reported cases could be related to increased workforce communication related to AHIs.	○ ?
Spread begins in older or higher status population and spreads downward	(b)(1), (b)(3)	○
Preponderance of female participants	(b)(1), (b)(3)	○
No plausible organic cause	The Panel concludes that there are, in fact, plausible external causal mechanisms for AHI cases with the core characteristics.	○

(b)(3) (b)(3)

(U) Psychosocial factors may explain some incidents or contribute to long-term symptoms

(U/ (b)(3) Incidents that lack the core characteristics could be due to hypervigilance and normal human reactions to stress and uncertainty, particularly within a workforce that is attuned to its environment and trained to think about security. The subacute and longer-term effects of AHIs are consistent with the expected human responses to traumatic events, as described below. An increase in reported incidents that do not exhibit the core characteristics may be the natural result of the spread of concern through social networks (i.e., a social contagion) in a susceptible population, as well as the dissemination of information from official and unofficial sources. Because such psychosocial factors affect every individual, the absence of the core characteristics or the exacerbation of a preexisting illness in some cases should not be used to exclude the possibility of an initial injury. Prompt, standardized, and supportive care, reassurance, and forthright communication can help alleviate the effects of psychosocial factors and functional neurological disorders, regardless of cause.

(U) Reactions to AHIs are normal human behavior

(U/ (b)(3) Traumatic events—or the perception that one has been subjected to such an event—have well-known and predictable consequences. Normal human responses to traumatic events or threats of harm include the manifestation of various physical symptoms, hypervigilance leading to amplification of perceived stimuli,[211] and misattribution of co-occurring medical conditions, benign bodily sensations, or environmental experiences to the perceived threat or injury. Furthermore, the spread of symptoms in a community of individuals who believe that they may have been exposed to a harmful factor based on information received through their work, news, or social contacts,[212213] even after such an exposure is ruled out, is an expected and well-documented phenomenon.[21421521621721821922O]

(U) Exacerbating factors present

(U/ (b)(3) The effects of traumatic events are exacerbated when the threat or injury is manmade, apparently intentional, unpredictable, part of an ongoing threat environment, and uncertain in its origin, motivation, and short- and long-term health implications. These effects may be further exacerbated by an apparent lack of efficacious protective measures, as well as by organizational responses that may be perceived as inconsistent, or, at times, unsupportive. Some of these reactions could lead to functional neurological disorders or worsen the effects of existing conditions, such as posttraumatic stress disorder.

(b)(3)

(b)(1), (b)(3)

(U) Chemical or Biological Agents

(U/ (b)(3) Chemical and biological agents are a broad set of entities. The Panel considered chemicals ranging from small molecules, such as drugs, to large molecules, such as toxins and nucleic acids. (See Figure 13.) It also considered chemical technologies that could be used to aid delivery of chemical or biological agents, such as microencapsulation. The Panel considered biological infectious agents with the potential to act directly on an individual or as a delivery mechanism. The difficulty in acquiring a specific chemical or biological entity would vary significantly, from purchasing an off-the-shelf medicine to conducting a sophisticated research and development effort.

(U) Implausible explanation for acute onset of symptoms and localization phenomena

(b)(3) Despite the wide range of possible entities, the Panel found that a chemical or biological mechanism alone was an implausible explanation for the core characteristics. Such entities are inconsistent with the abrupt onset and offset of sensory phenomena and a strong location-dependence or sense of directionality. In addition, drug action is typically transient and thus inconsistent with the extended or long-term symptoms experienced by some affected individuals. Chemical or biological agents would act broadly and thus would not be selective to an individual unless they were delivered in a targeted manner, such as in an individual's water or food.[223224]

(U) Combinations involving chemical or biological agents and other stimuli warrant examination

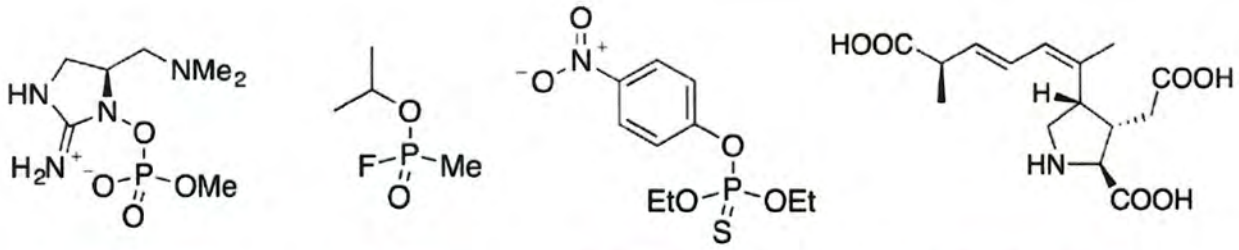
(b)(3) The Panel assessed that a chemical or biological entity in combination with another stimulus has the potential to account for the core characteristics and should be explored in detail. (b)(1); (b)(3)

This scenario would be more complex than one involving a single causal mechanism, but it might also enhance the specificity of targeting a particular individual. (b)(1), (b)(3)

(U) FIGURE 13
Examples of Chemical Compounds Considered by the Panel

(U/ (b)(3) The Panel considered chemical agents, including guanitoxin, a natural product; sarin, a synthetic neurotoxin; parathion, a synthetic pesticide; and domoic acid, a natural product. Domoic acid is a type of amino acid, and the other chemicals are organophosphorus compounds.

(U)



Guanitoxin *natural* | Sarin *synthetic* | Parathion *synthetic* | Domoic acid *natural*

(U) Ionizing Radiation

(U) Ionizing radiation consists of high-speed particles or electromagnetic waves that carry sufficient energy to remove electrons from, or ionize, atoms in exposed materials. This ionization phenomenon dominates the effects of such radiation on living tissue. As radioactive material decays to a lower energy state, it can emit ionizing radiation in forms including alpha particles, beta particles, neutrons, X-rays, and gamma rays. Devices that produce ionizing radiation electronically have extensive industrial and medical applications and include X-ray machines and neutron generators.[225226227228]

(U) Well-understood physical properties and health effects

(U) The generation, propagation, and penetration of ionizing radiation through different materials are mature fields of study, and the biological and health effects of exposure are well understood.[229230231] This knowledge derives from decades of research on the development and safety of medical, scientific, military, and industrial sources of ionizing radiation and on the effects of the intentional exposure of human tissue for medical imaging and the treatment of disease.[232233234235]

(U) Would cause clinical signs that have not been observed in AHIs

[redacted] (b)(1); (b)(3) [redacted] The resulting signs and symptoms, however, would not match the core characteristics. Crucially, the dose of ionizing radiation required to induce nausea, headaches, and cognitive issues is roughly equivalent to that of several hundred CT scans.[236237238] Such an exposure would almost certainly be accompanied by signs that were observable at lower doses, such as hair loss, skin burns, or changes in white blood cell counts, as well as by a significant mortality rate—none of which were observed in reported AHIs.[239240] [redacted] (b)(1); (b)(3) [redacted]

(U) FIGURE 14
Propagation Properties of Ionizing Radiation

(U/ (b)(3) Ionizing radiation varies in its ability to propagate in air and penetrate common materials, limiting its ability to account for many AHI scenarios.

(U) This table is Unclassified.

Type	Propagation distance in air	Shielding materials
Alpha particles	1 to 2 inches	Paper, outer layer of skin
Beta particles	12 feet per MeV[a]	Plastic, glass, aluminum
Gamma rays or X-rays	Hundreds of feet	Lead, steel, concrete
Neutrons	Hundreds of feet	Water, polyethylene, hydrogenous substances

[a](U) Typical energies for naturally occurring sources are one to a few megaelectron volts (MeV). Manmade electron beams can achieve energies greater than 100 MeV.

UNCLASSIFIED/ (b)(3) (b)(3)

(U) Figure source note.[241242243]

(U) Comparison to National Academies Study

(U/ (b)(3) In 2019 the Department of State asked the National Academies of Sciences, Engineering, and Medicine to study the health risks that AHIs posed to US Government employees posted abroad, ascertain potential causes of the illnesses, and determine best medical practices for screening, prevention, and treatment. (b)(3), (b)(6)

(U) The National Academies committee drew two main conclusions, which were broadly similar to the current Panel's findings.[244] First, the constellation of acute clinical signs and symptoms with directional and location-specific features was unlike any disorder in the medical literature, suggesting a disturbance in the labyrinth and cochlea of the inner ear or the vestibulocochlear nerve or its brainstem connections. Second, many of the reported distinctive and acute signs, symptoms, and observations were consistent with the effects of directed, pulsed radiofrequency energy.

- (U) The committee found AHI cases to be highly heterogeneous and to evolve over time, raising the possibility of multiple causal mechanisms among different patients or even for the same patient.
- (U) Psychosocial factors, in particular, could potentially reinforce or add to these effects, producing some of the nonspecific, chronic signs and symptoms, but alone these factors were unable to explain the cases with the most distinctive features, including the location-dependent accounts of acute audio-vestibular phenomena.

(U) Although both the National Academies committee and the Panel sought to characterize and understand AHI cases from a clinical perspective and identify plausible causal mechanisms and best practices for clinical management, there were some differences between their findings. The Panel found that ultrasound is a plausible mechanism for some cases, but only in close-access scenarios, while the National Academies committee did not consider acoustic energy mechanisms. The Panel found that there are plausible concealable sources of pulsed radiofrequency energy that could generate and propagate the required stimulus, while the National Academies committee did not consider the technical requirements of sources and their form factors. Finally, the Panel found that ionizing radiation, infrasound, audible sound, ultrasound propagated over large distances, and bulk heating from electromagnetic energy are all implausible explanations for the core characteristics in the absence of other stimuli, while the National Academies committee did not consider these mechanisms or aspects of these mechanisms.

(U) All of the differences in findings between the two groups resulted from differences in the charges to the groups, their expertise, and information made available to them. No differences were due to different assessments of the same information.

- (U) **Scope and timing.** The National Academies study took place in late 2019 and early 2020 and focused exclusively on cases from Havana and China. The Panel started its work in the summer of 2021 and considered cases worldwide, including the large number that occurred after the National Academies study concluded. The Panel also considered a broader set of potential mechanisms, including acoustic energy and ionizing radiation. Although the Academies focused on clinical aspects of the cases, the Panel also examined some of the physical, occupational, and other situational circumstances, as well as possible sources and delivery of stimuli to the affected individual.
- (U) **Expertise.** Both groups included experts in clinical topics and in the biological effects of directed energy. However, the membership of the National Academies committee skewed toward clinical

expertise, especially in neurological subspecialties, and toward environmental science. The Panel's expertise was broader, including biochemistry, physics, ionizing radiation, and acoustics.

- (U/ (b)(3) **Information access.** Both groups had extensive access to open-source scientific reports and presentations by outside experts. However, two-thirds of the National Academies committee did not hold security clearances, whereas all members of the Panel held TS/SCI clearances. Hence, the National Academies group neither reviewed nor relied on much classified material. In contrast, the Panel received more than 1,000 classified documents and dozens of briefings on a range of scientific, medical, and intelligence topics, including the findings of sensitive programs and intelligence reporting and AHI incident reports and trends. Although both groups had the privilege of hearing from affected individuals directly, the Panel spoke with a greater number of such individuals and received far more detail about the nature of their work and the circumstances surrounding their cases.

(U) Recommendations

(U) **The Panel offers eight main recommendations to help the US Government better understand, prevent, and manage AHIs. Many of the recommendations will help address the information gaps related to potential causal mechanisms. Implementing these recommendations will require a coordinated approach because the challenges and solutions transcend organizational boundaries. Commissioning multiple, complementary efforts will be necessary because of the scope of the challenge. Panelists emphasize the importance of appropriate classification, privacy, and security controls on research and information that may result. (For additional, more detailed recommendations, see Appendixes E and L.)**

(U) Near-Term Priorities

(U) **Four recommendations are especially pressing because of the immediacy of need and scale of impact.**

(b)(1); (b)(3)

(b)(1); (b)(3)

(b)(1); (b)(3)

- (U/ (b)(3) **Collect clinical, technical, and environmental details and** (b)(1), (b)(3) **Strengthen the capacity to undertake timely investigations, including same-day collection of blood samples.** (b)(1), (b)(3)
- (U/ (b)(3) **Review protection measures for clinical and research data, and implement immediate measures to detect and prevent unauthorized access.** (b)(1), (b)(3)
- (U/ (b)(3) **Establish a standard protocol for collecting descriptions and photos of the physical layout and environment of the locations in which AHIs are reported, to help identify and understand the potential causal mechanisms.**

(U/ (b)(3) **Biomarkers. Identify and validate new biomarkers that are more specific and sensitive for the diagnosis and triage of AHIs to reduce reliance on traumatic brain injury biomarkers, which were validated for a specific and possibly different clinical condition. Test for the presence of these biomarkers as soon as possible after an event, ideally within hours and periodically over the following days, because the relevant biomarker elevations are transient.**

- (U/ (b)(3) **Use state-of-the-art molecular technologies and rigorous, unsupervised statistical methods to aid biomarker discovery and validation. The identification of cases and controls for use in biomarker discovery studies can be challenging and will depend on the intended use of the biomarkers. (See Appendix I.)**
- (U/ (b)(3) **Biomarker research and testing should be organized and coordinated across the US Government, because of the limited number of clinical specimens from AHI cases and the sensitivity of the associated data.**

(b)(3) **Detectors.** (b)(1), (b)(3)

- (b)(1), (b)(3)
- (b)(1), (b)(3)

(U) **Communication.** Develop a coordinated communications strategy to inform and educate the US Government workforce on AHIs, new findings, and interagency efforts. Prompt, forthright, and cohesive communication can lessen the effects of psychosocial factors and functional neurological disorders, regardless of cause. It can also build trust, strengthen resilience, and promulgate any strategies for protection or mitigation.

- (U) Use communication to support individuals who have reported AHI symptoms. Acknowledging that affected persons have a range of experiences and symptoms, all of which are being taken seriously, can help mitigate anxiety.

(U) Longer-Term Priorities

(U) Four other recommendations are important, enduring priorities.

(U/ (b)(3) **Clinical measurements**. Develop better methods for taking objective clinical measurements of vestibular, inner ear, and cognitive function and make them practical for use in the field. Collect these measurements within hours of the onset of an acute sensory event and symptoms, and then sequentially over time. Early detailed reports would avoid recall bias and, if voice-recorded, would help clinicians evaluate the person's cognitive state. Onsite or remote evaluation of vestibular and cognitive function and auditory symptoms could be performed by using telemedicine, recording video of eye movements and gait, and providing a set of example sounds that affected individuals could use to describe the sensations that they experienced.

- (U/ (b)(3) To improve care, study the similarities and differences among persons who report AHIs in terms of their personality, neuropsychology, and medical, social, mental health, educational, and occupational histories. Examine any psychological and neuropsychological assessments conducted before the incidents and use them in historical and longitudinal studies.

(b)(3) **Biological effects.** (b)(1), (b)(3)

(b)(1), (b)(3)

- (b)(1), (b)(3)

- (U/ (b)(3) **Develop higher-resolution models of the human head and ear and the electrodynamic properties of living tissues; current models include only thermal-absorption effects. Judicious selection of electromagnetic energy exposures, based on computational modeling, will make this research more tractable.**

(b)(1), (b)(3)

(b)(1), (b)(3)

- (b)(1), (b)(3)

(b)(3) **Intelligence and technical analysis.** (b)(1), (b)(3) **Encourage alternative analysis to challenge thinking. Ensure AHI-related intelligence analysis and workforce messaging are conducted by separate, independent organizational units to promote tradecraft and objectivity. Use technical experts with specialized expertise,** (b)(1), (b)(3)

(b)(1), (b)(3)

- (b)(1), (b)(3)

- (b)(1), (b)(3)

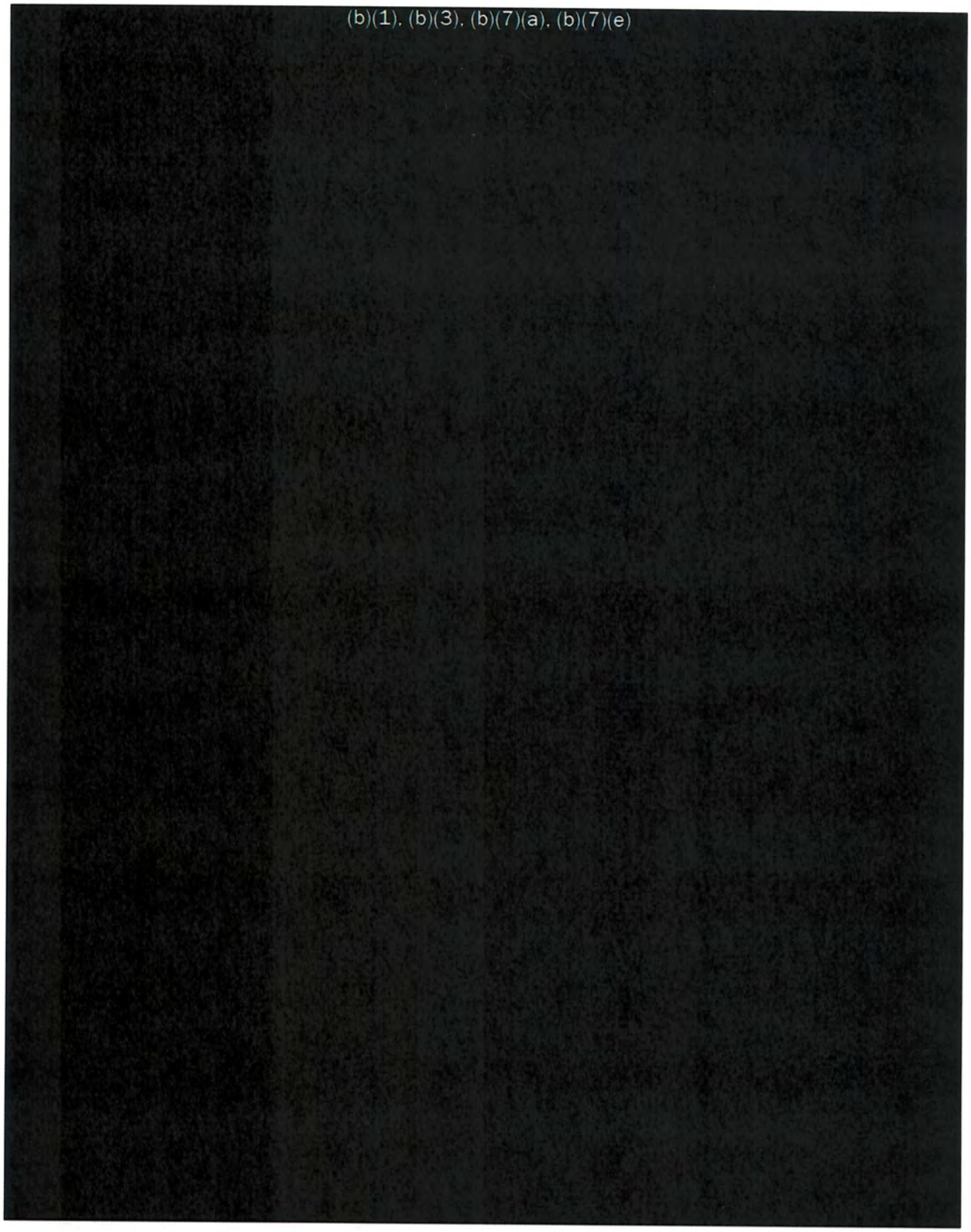
- (b)(3)

(U) Closing Note

(U) Throughout the study, the Panel had the privilege of observing the IC's overall efforts related to AHIs. Although these broad and impressive activities extend beyond the Panel's remit of causal mechanisms, the group respectfully offers three thoughts for the IC's consideration moving forward.

- (U/ (b)(3) **Sustain efforts against AHIs with a sense of urgency.** Even though the number of reported events has declined in recent months, relevant information continues to arise, and more work is needed to understand the causes, effects, and mitigations.
- (U) **Preserve analytic objectivity and quality**. Ensure the understandable desire to reduce the number of AHI cases or reach closure does not affect tradecraft, messaging, or incentives to drive the analysis forward.
- (U) **Collaborate and share.** Because AHIs are a complex and multidisciplinary issue, the necessary insights are unlikely to come from a single unit or organization, but rather from several working together. The Panel understands the need to protect information, but true collaboration cannot occur without sharing and openness.

(U) Finally, the Panel was moved by the experiences of individuals affected by AHIs. They deserve the best possible care, as well as appreciation for their sacrifices. Panelists were also impressed with the many members of the IC and broader US Government with whom they engaged. The Panel feels fortunate to have supported their efforts and is grateful to the senior sponsors for the opportunity.



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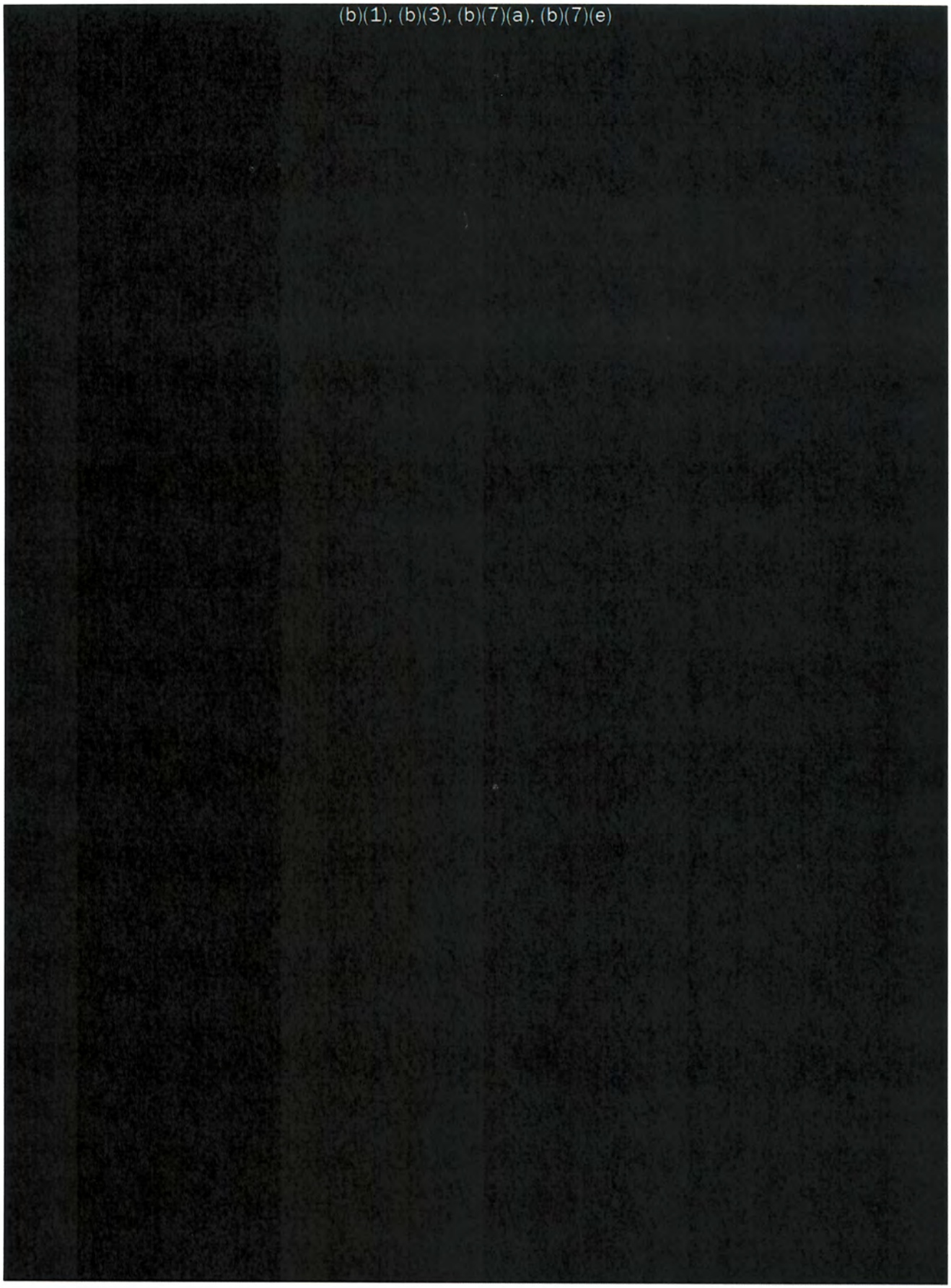
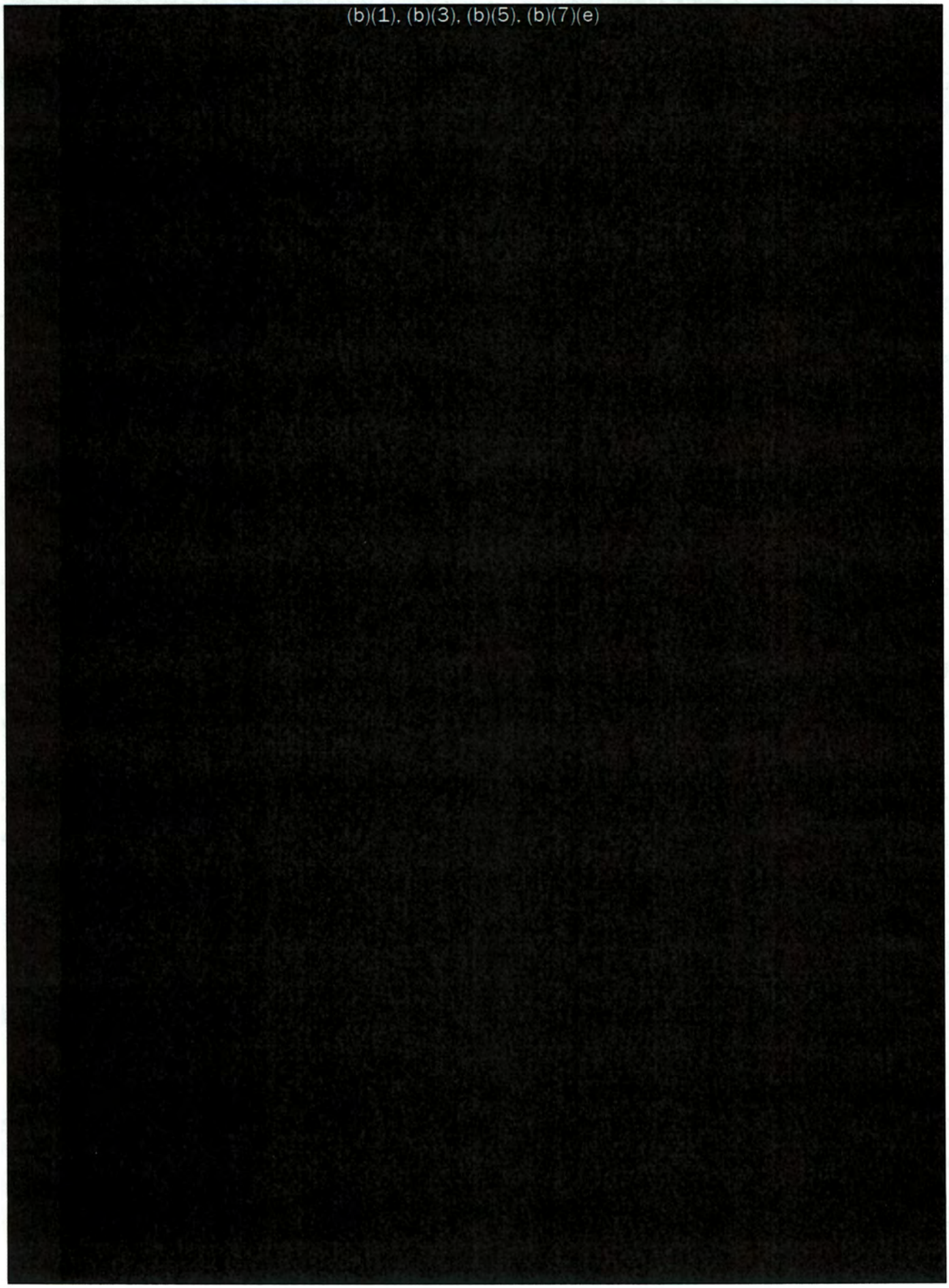


(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3), (b)(5)

(b)(1), (b)(3)



(b)(1), (b)(3)

(b)(3)

(b)(3)

(U) Appendix A: DNI Memorandum: IC Experts Panel on AHIs

DIRECTOR OF NATIONAL INTELLIGENCE
WASHINGTON, DC

MEMORANDUM FOR: Distribution

SUBJECT: (b)(3) Intelligence Community Experts Panel on Anomalous Health Incidents

(b)(3) Anomalous Health Incidents (AHI) affecting U.S. personnel around the world remain an urgent concern, and yet many fundamental questions remain unanswered as agencies and departments investigate the cause of AHI and develop protocols to protect and care for our workforce. Groups have been established to address these issues, (b)(1), (b)(3) (b)(5) that is focused on medical protocols for protecting and caring for our personnel across the U.S. Government, among other related issues. To support and enhance these efforts, it would be useful to draw on exceptional biomedical, clinical, scientific, and technical expertise within the U.S. Government and from the private sector. Consequently, we are hereby establishing an IC Experts Panel on AHI that will draw on expertise from within the IC and from outside of the IC to address a series of questions in support of (b)(3) (b)(5) work.

(b)(1), (b)(3), (b)(6) The full panel will include a broad spectrum of expertise, including wide-ranging expertise on electromagnetic radiation (EMR), the effects of EMR on humans and on biological systems in general, neurology, rehabilitation medicine, neurobiology, biophysics, chemistry, environmental sciences, and high-power electronics. The panel will consult with the Office of Science and Technology Policy, and will include participation by experts at the (b)(1), (b)(3) Defense Intelligence Agency who are currently involved in research and development work at their agencies. The panel may also collaborate with and draw expertise from other elements of the IC, the Department of Energy Laboratories, and the Department of Defense Research Laboratories, as appropriate.

(b)(3) The Experts Panel will have unfettered access to (b)(1), (b)(3) and any other IC data that is needed and can lawfully be shared with the group, consistent with privacy issues associated with health data in particular.

SUBJECT: (b)(3) Intelligence Community Experts Panel on Anomalous Health Incidents

(b)(3) The Experts Panel will in 30 days or less, after having consulted with (b)(3) and the AHI IPC, produce a work plan that identifies key questions to be addressed in support of (b)(3) (b)(5) work, a timeline for answering the questions identified that is no longer than 100 days, and any critical data the panel will need to complete its work that it does not have access to already. This plan will be shared with (b)(3) the Deputies Executive Committee, and the (b)(5) before being finalized by the Experts Panel.

(b)(3) The kinds of questions we expect the Experts Panel to address include, when it comes to questions relating to the cause of AHI, what mechanisms best explain the clinical findings; how might different mechanisms synergize to produce effects other than simply the sum of individual effects; and what does an optimal research and testing agenda for exploring causal mechanisms look like? Whereas, in relation to medical protocols, questions that might be addressed by the Experts Panel include how this clinical anomaly should be defined and identified; what clinical tests are most useful in characterizing these incidents; and what are optimal forms of clinical management that should be applied? There may also be important questions at the interface of clinical illness, electronics, and the circumstances surrounding the onset of illness, such as what types of devices and specifications might be capable of producing the kind of exposures that would result in the observed clinical phenomena. These are only intended as examples of the kinds of questions that might be addressed by the panel - the final questions should instead be ones that are agreed upon by the Experts Panel with (b)(3) (b)(5) respectively, as priority issues that must be addressed to further their work.

Avril D. Haines

Date 9 June 2021

(U) Appendix B: Answers to Additional Questions From Sponsors

(U) As the Anomalous Health Incidents (AHI) study neared completion, its senior sponsors provided the IC Experts Panel with a list of additional questions based on their evolving needs. The Panel incorporated its answers into the appropriate sections of this report and summarized them here.

(U) Questions From the (b)(5)

(b)(3) **Request panel include an annex of all the DOD research projects/programs they looked at, as well as, more generally, what they had access to, including medical data, what they did not have, and why.**

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3) Some information that may have been useful to the Panel was unavailable for reasons of security, privacy, or timing. For example, some patient-specific medical information was not available. Because the Panel did not address questions of attribution, it had limited access to situational and investigatory information about specific cases (b)(1), (b)(3) aken together, these data would have provided a more complete understanding of clinical, environmental, intelligence, and situational aspects of AHIs on a case-specific basis. (b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3)

(b)(3) **How does the panel define, in layman's terms, "thermal" and "non-thermal" effects; the forms of directed energy that could produce those effects; and under what specific set of conditions? The explanation should also address whether thermal effects are hypothetically possible without causing a person to perceive actual heat or other related sensations, and if so, under what specific set of conditions.**

(U/ (b)(3) All exposures to electromagnetic energy, no matter how small, entail some sort of fundamentally thermal interaction. The Panel's use of the term "thermal" refers to situations in which there is a perception of heat or a direct biological consequence of a temperature rise. Roughly speaking, radiofrequency or microwave effects that lead to one degree Celsius or more temperature increase are considered thermal effects, otherwise they are considered non-thermal effects.

(U/ (b)(3) Absorbing enough electromagnetic power in any material will heat it, and thermal buildup greater than a few degrees Celsius can lead to injuries. Depending on the frequency of the

electromagnetic waves, different physical interactions are responsible for heating. Above about 1 gigahertz (GHz), the rotation of water molecules dominates those interactions, and heating can definitely occur (e.g., in microwave ovens). High-power short-pulsed (< 5 microseconds [μs]) radiofrequency or microwave energy may heat a very small volume of material, creating a rapid thermal expansion. This expansion can lead to stress waves within the body, but the temperature rise might be only 0.001 degree Celsius. For longer pulses (e.g., > 100 μs), the energy in the pulse is spread over a larger volume, and heating—rather than a shock wave—can occur. A buildup in temperature occurs when the pulse width and pulse repetition rate are sufficiently high and the accumulated energy is deposited faster than thermalization can occur. Cerebral blood flow is highest in brain tissue, attenuating local heating effects and helping to maintain brain temperature close to body temperature.

(U/ (b)(3) Based on its assessment of AHI incident data and medical data, and interviews with affected personnel, how many incidents and which specific incidents has the IC Experts Panel identified as worthy of further investigation? What specific elements of each of these incidents should be explored further, and why/to what end? What would findings or a lack of findings in these elements suggest regarding the hypothetical causal mechanisms at play?

(b)(1); (b)(3) (b)(1); (b)(3) (b)(1); (b)(3)

(b)(3) To identify the causal mechanisms, the Panel identified the need to screen for: (1) stimuli that can produce a sensation of sound in an individual that is accompanied by a sense of pain or pressure, often in the ear; (2) stimuli that can produce a sensation of sound that may not necessarily be perceived by all individuals in the immediate area (i.e., it need not be an ambient audible sound wave); and (3) features of such a stimulus (i.e., dose, duration, local concentration, etc.) that can also cause unsteadiness, headache, persistent tinnitus, a sense of vibration, a sense of cognitive slowing, and elevation of markers of neural injury.

(b)(3) Reproducing the core elements of these incidents in an animal model would inform the necessary means to detect such a stimulus in the environment. A potential difficulty in this approach relates to how the anatomy of the human head, brain, and ear confer specific vulnerabilities.

(U/ (b)(3) What advice can the panel provide on additional medical protocols, including but not limited to blood draws, to consider implementing to evaluate US officials' health in the event of an AHI report or other concerning medical incident?

(U/ (b)(3) The signs and symptoms of an AHI are most prominent at the onset, similar to concussion. This time course makes it important to obtain an individual's history and perform an examination as close to the purported event as possible. For those individuals experiencing the complete or partial set of core characteristics, follow-up might include:

- (U/ (b)(3) Creating a call-in line to report the history of an event within minutes to a trained officer or instructions to record the details of an AHI to a device (such as a smartphone) as soon as possible after the event to limit recall bias.
- (U/ (b)(3) Capturing video of an affected individual within minutes of an event to assess eye movements, gait and balance, and cognitive function; using remote eye-monitoring devices may also be helpful.

- (U/ (b)(3) **Capturing an electroencephalogram (EEG) soon after an event, although doing so would be difficult but possible. These data could be captured by an EEG technician or by using a commercial device such as those used for ambulatory EEG monitoring.**
- (U/ (b)(3) **Testing neurovestibular and neurological function within a day or two of an event would be the preferred benchmark but would be difficult to achieve in most cases.**

(b)(3) **What are the range of potential causal factors for blood markers of concern identified by the National Institutes of Health and potentially elsewhere? To what extent does medical literature indicate that nontraumatic, including but not limited to psychological, factors can play a role in elevated blood markers?** (b)(1), (b)(3)

(U/ (b)(3) **Data on blood markers are concerning but preliminary and incomplete at this time. Elevations of GFAP and NfL[a] temporally associated with the report of an AHI and their subsequent return to baseline within days to weeks thereafter are strong evidence of neural cell injury. The relevance of single measures outside the normal range is less certain. The link between the time course and the event is most informative. GFAP and NfL are structural proteins inside neurons or astrocytes, and their appearance in the blood is thought to reflect neural injury, with leakage of proteins out of the cell and subsequent movement into the blood where they are metabolized. UCHL1[b] is another neural injury marker that has been FDA-approved for evaluation of mild traumatic brain injury. It rises and falls more quickly than GFAP and NfL and should be included in any diagnostic panel.**

(U/ (b)(3) **These biomarkers are not specific to any particular form of neural injury. The well-known precedent is the elevation of troponin, a cytoskeletal protein in muscle that is released into the bloodstream with a characteristic temporal pattern after myocardial infarction. The biomarkers GFAP and NfL will be elevated in a host of conditions that cause cell injury, and NfL is currently used as a marker to gauge efficacy of a number of neuroprotective therapies for a variety of neurological disorders. The rise and fall of these biomarkers after an AHI event are strongly suggestive of neural cell injury but do not provide clues as to mechanism of that injury.**

(U/ (b)(3) **Biomarker concentrations are being investigated as markers of neural cell injury in a host of other disorders. Some studies show elevations in mean levels of these biomarkers in some individuals with chronic major depression, for which there is also suspicion of neural cell injury. Those studies of major psychiatric disorders do not suggest that the biomarker elevation is caused by psychological factors. Although the entire spectrum of causal mechanisms has not been explored, at this time there is no credible alternative explanation for a rise and fall in these proteins except for neural cell injury. It should be noted that these markers may not be elevated in AHIs in which there is no injury to brain; e.g., those that cause only transient neurosensory symptoms due to stimulation of the inner ear.**

- (U/ (b)(3) **The biomarkers in current studies are those identified as useful in gauging neural cell injury in concussion/mild traumatic brain injury. The time course of these measures is most important and requires serial blood draws. Baseline values would be important to compare to levels measured as soon as six to eight hours after an event, along with measures at 24 hours, 48 hours, and weeks later.**

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[a] (U) Refers to glial fibrillary acidic protein and neurofilament light, respectively.
[b] (U) Refers to Ubiquitin carboxyl-terminal hydrolase L1.

- (U/ (b)(3) The current markers should be employed in animal experiments that are designed to reproduce some of the features of AHIs.
- (U/ (b)(3) Identifying markers that are more sensitive or specific to AHIs would require extensive discovery and validation. If a stimulus is identified as causal, then studies in animal models could be productive—for instance, if they identified blood-based markers related to effects on the inner ear or specific markers seen only with a particular stimulus.

(U/ (b)(3) The Panel is unaware of blood markers that would distinguish between external causal mechanisms and those that might be considered primarily psychosocial. Although further exploration may be warranted, any such markers are likely to be nonspecific, similar to functional MRI (fMRI) findings in individuals with functional neurological disorder to date.[2] (b)(3), (b)(6) , fMRI findings in individuals with functional neurological disorder are similar to those in individuals with a range of other medical disorders.[c]

- (U/ (b)(3) Future avenues of inquiry could include examination of any psychological and neuropsychological assessments conducted at the time that an employee was hired, to be used in both an historical examination and a longitudinal study of health, performance, and disability.
- (U/ (b)(3) It would also be worthwhile to study similarities and differences among individuals who report AHI events or symptoms, with and without core characteristics. Ideally, in addition to the examination of personality and neuropsychological assessments, that study would include a comprehensive assessment of medical, social, mental health, educational, and occupational histories.

(U/ (b)(3) Appendix I discusses considerations for developing biomarkers for AHIs.

(U) Questions From DNI Haines and D/CIA Burns

(b)(3) The following are questions that the DNI and D/CIA believe would be helpful for the IC Experts Panel to address in its report for each causal mechanism it views as a possible cause of at least some AHIs, particularly acoustic and electromagnetic energy. (b)(1), (b)(3)

(U) Physical Characteristics of Electromagnetic Scenarios

(U/ (b)(3) What are the physical parameters necessary for the mechanism to affect a living being, such as an air pathway or line of sight to the target? At what range(s) would the mechanism produce effects, and how would environmental factors—such as weather, building materials, and the surrounding radiofrequency (RF) environment—affect its ability to deliver energy to a target? What would prevent it from delivering energy to a target?

(b)(3) For radiofrequency, no direct air pathway or line of sight is required. The strongest factors affecting the power received at a given location are the power transmitted, the antenna gain, the distance between the transmitter and the location, and what kinds of materials are in between. A number of different biological effects may occur, as a function of the frequencies and power densities on target. Any one specific transmitter type may have controllable power and variable pulsing

[c] (U/ (b)(3) Panel discussions with (b)(6) .

capabilities. The system's operating time will depend on its power source, which could be a generator, wall electrical outlet, or battery.

(b)(3) A good reference example is to consider a scenario in which a 1-meter diameter reflecting dish antenna that is excited by 1 watt (W) of power (at about 8 GHz) is known to be able to focus a field at about 50 m at a power density of about 1 W/m^2 (watts per square meter). A smaller reflecting dish might result in a larger beam or target area characterized by locality and directionality for a given frequency of operation. The Frey effect (hearing microwave generated sounds) requires about 100 W/m^2.

(b)(3) A thermo-acoustic (traumatic brain injury-like) biological effect might require about 10^7 W/m^2, hence a 10 MW generator is needed for this example reference transmitter. This scenario is possible, indeed a 50 GW system consisting of three cascaded meter-long units was recently reported by Rukin and colleagues.[3] If operating the same system with pulsed emission, the average power to generate 10 pulses/s each of 1 microsecond in duration requires only a 1 W generator in principle. This power requirement makes a much smaller transmitting system, perhaps battery operated, more feasible. If the transmitter can produce even shorter pulses, e.g., with 10 picoseconds (ps) rise times, the range might extend from 50 m to 150 m. The Rukin system produces 170 ps pulses.[4]

(b)(3) When transmitted power falls off with range according to an inverse square law, delivering the same power density on target from a 10 kW source at 100 m would require the source to be 10 m from the target if a transmitter of only 100 W was available. If that beam propagates through a wall or a window, it would be attenuated by a factor of approximately 20 or 2, respectively, for each wall or window. At much closer ranges, a defined target area naturally exists in the near field of antenna because nonpropagating fields exist with field strengths that fall off rapidly in proportion to the inverse cube of the distance ($1/r^3$).

(b)(3) The tradeoffs between range and target area suggest that pulsed systems are more feasible than continuous-wave systems because of the number of controllable parameters in pulsed systems. They also have a smaller size, weight, and power for a given biological effect capability at range. However, even to deliver this capability—10^7 W/m^2, high-power pulses at high-repetition frequencies and for prolonged periods at 50 m—would demand a larger power supply.

(b)(3) Pulse power densities of 10^7 W/m^2 correspond to electric field strengths on target of kV/m (kilovolt per meter). Operating at lower powers or dealing with attenuation by walls does not make the system ineffective. Voltage differences across tissues produce currents and affect cell function. Voltages of < 10 V/m can stimulate neurons, and even lower amplitudes (tens of mV) combined with low pulse repetition frequencies that are matched to biologically relevant signals may cause interference. There is evidence for this interference,[5] but it needs to be verified.

(U/ (b)(3) Some materials, such as metals, will strongly shield the signal, although radiofrequency energy can diffract around the edges and can still expose individuals behind the shielding, albeit at a much lower level. Common building materials provide some attenuation, depending upon thickness and material properties. Materials such as concrete will reduce the signal more than materials such as glass or drywall.

(b)(3) Would the mechanism affect the surrounding environment, such as by producing any noticeable near-term or lasting effects on electronic devices? What are the physical size, power, location, or other requirements for the mechanism to be scientifically possible?

(b)(3) It is possible that radiofrequency would affect electronic devices, such as smartphones, especially if the strength of the fields was high enough at the electronic device's location. At high-field strengths,

arcing can damage electronics, causing reversible effects such as touchscreen anomalies or interference with speakers or microphones. There are some mechanisms, such as distributed apertures, that can provide focusing effects that can increase the power at the target relative to other locations that may have electronic devices.

(b)(3) The effect on electronics depends on the type of equipment. Laptops and touchscreens are likely to be more susceptible to exposure to few kV/m and about 1 kW/m^2 than military hardened equipment, which would be susceptible at around 100 kV/m and 10^8 W/m^2. It is also possible that living organisms (e.g., pets, insects, and plants) would be affected by the electromagnetic field parameters discussed above.

(b)(3) Systems generating high power but with a short time duration and customized pulse sequences can be compact. (Please see response to previous question.) The systems might be effective at ranges of relevance but with smaller diameter (foldable) reflectors, so they could be transported in a backpack. This scenario is plausible and needs to be verified. Batteries, spark-based ignitors, and other components are readily available, and it is important to determine the capabilities of a very basic system using off-the-shelf components incorporating a fast switch.

[redacted] (b)(1), (b)(3)

(U/ (b)(3) Biological Effects of Electromagnetic Scenarios

(U/ (b)(3) What are the Panel's views on the sensations and symptoms the mechanism would cause, including whether it would produce a pressure or "buffeting" sensation, thermal effects, etc.? What are the biological pathways through which it could cause each of those effects?

(b)(3) The coupling of electromagnetic energy into biological tissue is a function of the physical parameters of the signal, as discussed earlier. Depending on the frequencies and signal strengths employed, biological effects might be similar to either a shockwave, an entrainment, or something in between. Given the reported symptoms, coupling of energy into the vestibular system or key active neural pathways could trigger acute symptoms. Chronic symptoms might result from these as well, but could also result from distributed and localized damage to cell membranes, the blood-brain barrier, or cerebrospinal fluid infrastructure, any one of which might create longer term dysfunction. Mechanoreceptors—pressure sensors in the body—can be expected to respond to controlled electromagnetic wave patterns creating thermo-acoustic or microwave-auditory effects. These responses could create sensations of pressure (e.g., buffeting) and a variety of sounds if the pulse repetition frequencies lie in an individual's audible range.

(b)(3) A set of symptoms are included in the core characteristics of AHI that point to stimulation of specific sensory systems. Many symptoms can be explained by stimulation of receptors on neural cells to detect mechanical energy. The inner ear contains specialized cells called hair cells; the receptors in these cells transduce signals to detect sound, rotation, and gravitational force. Other receptors are on specialized nerve endings to detect pressure, which would include the sensation of buffeting. The inner ear is a closed space that is open to the atmosphere via the Eustachian tube. If the actual air pressure in the inner ear is unequal to atmospheric pressure, one experiences a painful sense of pressure in the ear. This sense of pressure in the ear is common in AHI reports. AHI reports occasionally include a sense of vibration in head, teeth, or torso.

(b)(1), (b)(3)

(U/ (b)(3) Would the mechanism produce effects that create a clear sensation of locality and/or directionality? Specifically, would the mechanism be able to affect only one individual without producing effects in those nearby, and would the effect dissipate upon an individual leaving the area and strengthen if they reentered the area?

(b)(3) Electromagnetic fields can be directed, can be focused, or can constructively interfere when reflected, which naturally leads to spatial regions of higher power density in which thresholds for inducing biological effects can be exceeded. A sense of directionality can be expected for such regions originating from beams but not necessarily from interference phenomena. This kind of locality could result in just one individual experiencing the symptoms. If a conducting structure is energized at some frequency but does not radiate, nonpropagating fields can extend outward but attenuate rapidly as a function of distance, giving the sensation of a localized effect.

(b)(3) Variations of anatomy as well as varied placement of an individual in the energy field might lead to heterogeneity in the effects of a stimulus. Although it is distinctly unusual in AHI reports, individuals have reported that the sound and pressure are experienced in one ear and not necessarily both. So even in the same individual, there is some localization effect.

(U/ (b)(3) Would the mechanism cause loud, piercing sounds that generate involuntary physical reactions or pain that cannot be heard by others in the area or be recorded?

(b)(3) Yes, this is possible. Also, humans' inbuilt noise-cancellation capabilities that prevent them from being distracted by the internal sounds of heartbeat, lungs breathing, and blood flow could be disrupted. Tinnitus may result.

(b)(3) Sudden loud, unpleasant sound in one ear is a distinctive feature of some AHI. A sound heard in only one ear, along with the variability of others' experience although in the same space, suggests that the stimulus need not produce an ambient sound. Either the stimulus is precisely aimed or, more likely, the sound is produced inside the ear or head of the individual, such as occurs in the Frey effect with radiofrequency energy.

(U/ (b)(3) Could the mechanism cause an individual to suddenly lose their balance or collapse?

(b)(3) A mechanism based on inducing pulsed currents of a few milliampere (mA) in skeletal muscle can cause someone to collapse (e.g., from a Taser or a stun gun). Inducing currents with these properties from a remote source might be possible. Biological effects of the kind described earlier, especially affecting the vestibular system or key neural messaging pathways that coordinate balance, might also cause a sudden loss of balance.

(b)(3) Hair cells detect sound pressure in the cochlear but also rotational forces in the semicircular canals and gravitational and acceleration forces in the otolithic organs (saccule and utricle). A disturbance in the latter causes instability and, if severe, falling to the ground. The semicircular canal disturbances cause a sense of spinning or vertigo, which is reported in some AHI cases, but more common is instability without a sense of spinning, which suggests disturbance of otolithic function.

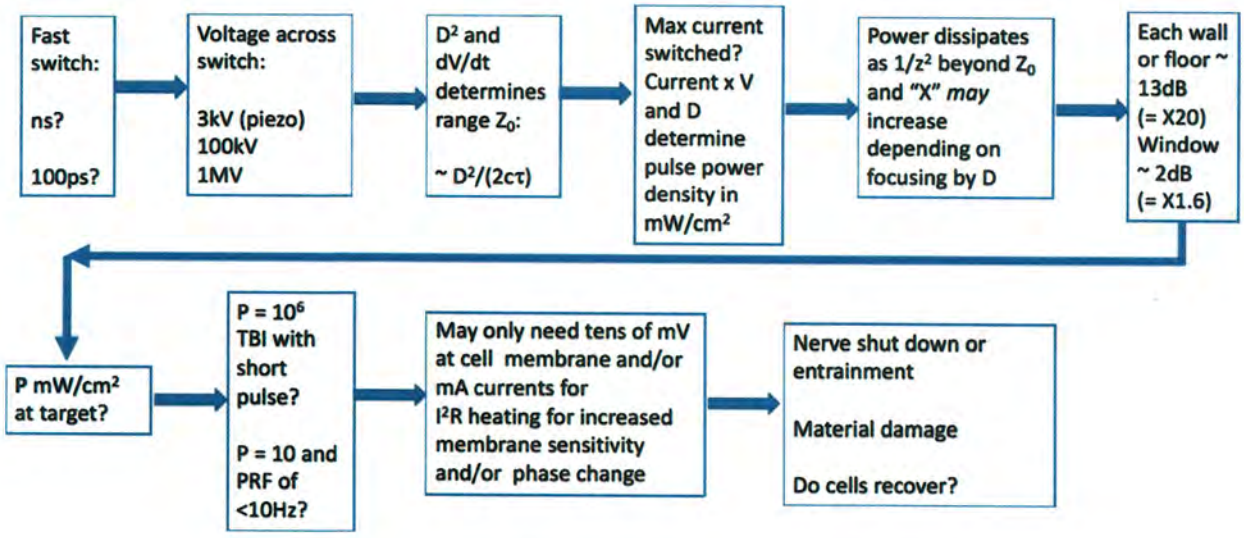
Dizziness is a nonspecific complaint that is used to describe both types of disturbances. Nausea is a reaction to abnormal vestibular function.

(b)(3) **Which, if any, commonly reported AHI symptoms (e.g., dizziness, headache, nausea) would the mechanism not produce and why?**

(b)(3) Likely none. A disturbance to the inner ear from acoustic or electromagnetic stimuli could probably account for the commonly reported AHI symptoms, including dizziness, nausea, headache, head pressure or pain, and ear pressure or pain. These symptoms are nonspecific and would occur if the stimulus produced an increased pressure in the air spaces in the inner ear or the cranial sinuses. Both dizziness and nausea, for example, are expected from disturbances of vestibular function, which would be likely to occur from a pressure or electromagnetic disturbance of the inner ear. In addition, many of the reports of AHI include persistent headache after the event that might last hours to days, and some even seem to develop or exacerbate a chronic form of headache similar to migraine. Of note, varieties of stimuli are known to trigger a prolonged headache, especially traumatic brain injury/concussion. (See Appendix B Figure 1 for a discussion of tradeoffs among electromagnetic source devices, distances, and biological effects.)

(U/(b)(3) Appendix B Figure 1:
Electromagnetic Source Characteristics and Biological Effects

(U/(b)(3) This flowchart might be useful in thinking about tradeoffs between source devices, distances, and biological effects. D is the diameter of the antenna dish; V is the applied voltage; "X" refers to the spatial localization of the power; dB are decibels; P is power; PRF is pulse-repetition frequency; I is current; R is resistance; and dV/dt stands for the derivative of voltage with time.



(U) Figure is (b)(3)

(U) Physical Characteristics of Acoustic Scenarios

(U/(b)(3) What are the physical parameters necessary for the mechanism to affect a living being, such as an air pathway or line of sight to the target?

(U/(b)(3) Low impedance pathways (i.e., direct line of sight and direct transduction through the auditory waveguide) are ideal for ultrasound, but are not necessary. To affect a human being, the sound pressure level impinging on the inner ear must exceed a threshold that is a function of several physical parameters. These parameters include propagation losses (atmospheric absorption and spreading), wall or window transmission and resonant amplification, room response and resonant amplification, and transduction through biological pathways (e.g., auditory waveguide and mechanoreceptors). Additional parameters include the sound frequency, modulation scheme, angle of incidence, and duration of exposure.

(b)(3) Because of scientists' limited knowledge of acoustic weapons effects, the combined parameter space is not well understood, especially beyond the interface with the human body. However, the basic physics of ultrasound propagation through standard media is understood, and this enables one to frame the problem with a sound pressure level budget that loosely bounds the concept-of-operations trade space. (b)(1), (b)(3)

(b)(1), (b)(3)

(b)(3) **At what range(s) would the mechanism produce effects, and how would environmental factors—such as weather, building materials, and the surrounding radiofrequency (RF) environment—affect its ability to deliver energy to a target? What would prevent it from delivering energy to a target?**

(b)(1), (b)(3)

(U/(b)(3) Would the mechanism affect the surrounding environment, such as by producing any noticeable near-term or lasting effects on electronic devices?

(b)(3) Ultrasound should not affect electronic devices; however, other organisms, including humans,[8] that are in the path of the sound pressure waves may exhibit indicators based upon their physiological response to high-frequency sounds. Ultrasonic devices are routinely used to repel animals and pests (b)(1), (b)(3) so any instance of strange animal and insect

behavior should be documented. (b)(1), (b)(3)

(U/ (b)(3) What are the physical size, power, location, or other requirements for the mechanism to be scientifically possible?

(b)(3) Plausible devices (b)(1), (b)(3) commercial off-the-shelf technology, use mature technology, are easily portable and concealable, and can be powered by standard electricity or batteries. Parametric acoustic arrays—also referred to as directional loudspeakers or acoustic lasers—are the most plausible technology, although other ultrasound technology may be at play. (b)(1), (b)(3)

(b)(3)

(b)(1), (b)(3)

(U) Biological Effects of Acoustic Scenarios

(U/ (b)(3) What are the Panel's views on the sensations and symptoms the [acoustic] mechanism would cause, including whether it would produce a pressure or "buffeting" sensation, thermal effects, etc.? What are the biological pathways through which it could cause each of those effects?

(b)(3) As with an electromagnetic stimulus, the coupling of an acoustic stimulus into biological tissue is a function of the physical parameters of the signal. Given the reported symptoms, coupling of energy into the vestibular system or key active neural pathways could trigger acute symptoms. Chronic symptoms might result from these as well, but could also result from distributed and localized damage to cells membranes, the blood-brain barrier, or cerebrospinal fluid infrastructure, any one of which might create longer term dysfunction. Mechanoreceptors—pressure sensors in the body—can be expected to respond to acoustic stimuli. These responses could create sensations of pressure (e.g., buffeting) and a variety of sounds if the pulse repetition frequencies lie in an individual's audible range. (For electromagnetic stimuli, some of the sounds could be caused by the Frey effect.)

(b)(3) A set of symptoms are included in the core characteristics of AHI that point to stimulation of specific sensory systems. Many symptoms can be explained by stimulation of receptors on neural cells to detect mechanical energy. Such receptors in specialized hair cells transduce signals to detect sound, rotation, and gravitational force. Others are on specialized nerve endings to detect pressure, which would include the sensation of buffeting. The inner ear is a closed space that is open to the atmosphere via the Eustachian tube. If the actual air pressure in the inner ear is unequal to atmospheric pressure, one experiences a painful sense of pressure in the ear. This sense of pressure in the ear is common in AHI reports. AHI reports occasional include a sense of vibration in head, teeth, or torso.

(b)(3) A variety of other neurosensory phenomena are not reported in AHI cases. These phenomena include tingling or burning sensations, pain except in the head, flashing lights, and muscle twitches. Their absence suggests that the stimulus is conveying mechanical energy as opposed to a broader effect on the nervous system. Such stimuli are transient during the AHI and suggest engagement of normal mechano-transduction in nerve and inner ear cells, but not necessarily injury. However, mechanical energy is known to cause damage to the ear (sound injury) and the brain (concussion).

(U/ (b)(3) Only low-impedance acoustic pathways to the inner ear and brain are possible because 99.9 percent of all airborne ultrasound is reflected off the body. The most probable pathway is direct transduction through the auditory waveguide and mechanoreceptors. Another potentially low-impedance pathway to the endolymphatic sac and the vestibular apparatus of the inner ear is through the mastoid region of the temporal bone.

(U/ (b)(3) Would the mechanism produce effects that create a clear sensation of locality and/or directionality? Specifically, would the mechanism be able to affect only one individual without producing effects in those nearby, and would the effect dissipate upon an individual leaving the area and strengthen if they reentered the area?

(b)(3) Yes. A nonlinear transduction technique can be used to produce a beam that is nearly free of side lobes to maximize the main-beam strength and directionality to focus in a specific area. If ultrasound penetrates into a room, the signal will be seemingly isolated due to propagation losses incurred as it spreads into adjoining rooms. As the sonic waves are reflected off interior walls, acoustic resonances will be present in certain parts of the room where the sound pressure levels will be boosted and may contribute to a sensation of locality. Open doors and other openings will allow some spreading of sound, but absorption and spreading losses will quickly degrade the signal. Scattering and absorption from furniture will also reduce the signal level.

(U/ (b)(3) Would the mechanism cause loud, piercing sounds that generate involuntary physical reactions or pain that cannot be heard by others in the area or be recorded?

(b)(3) The Panel assesses that this is possible. The microwave-auditory effect creates a wave of mechanical energy inside the head and ear that would not be heard by anyone except the affected individual and would not be recordable as an ambient sound wave. In addition, the audible range of hearing varies from person to person, but generally does not exceed 20 kHz for an otologically healthy person, hence the demarcation of ultrasound above 20 kHz. As people age, their ability to hear high-pitched frequencies wanes such that the upper threshold of hearing gradually drops to 15-17 kHz. The presence of a very-high-frequency sound at the cusp of ultrasound may be perceived by some people and not by others. It is also possible that a mechanism could emit multiple carrier waves at different inaudible ultrasonic frequencies that mix in air to produce an audible difference frequency tone that can be heard by some people. One research question is whether perceived sounds such as tinnitus may be induced from continuous insult to the auditory system from ultrasound.

(U/ (b)(3) Perennial reports of ultrasound sickness have increased in recent years due to the increasing ultrasound emissions in everyday lives, but the scientific reviews and debate for the past 80 years have not produced hard evidence that ultrasound-emitting devices can generate involuntary physical reactions or pain. (b)(3)

(b)(1), (b)(3)

(b)(1), (b)(3)

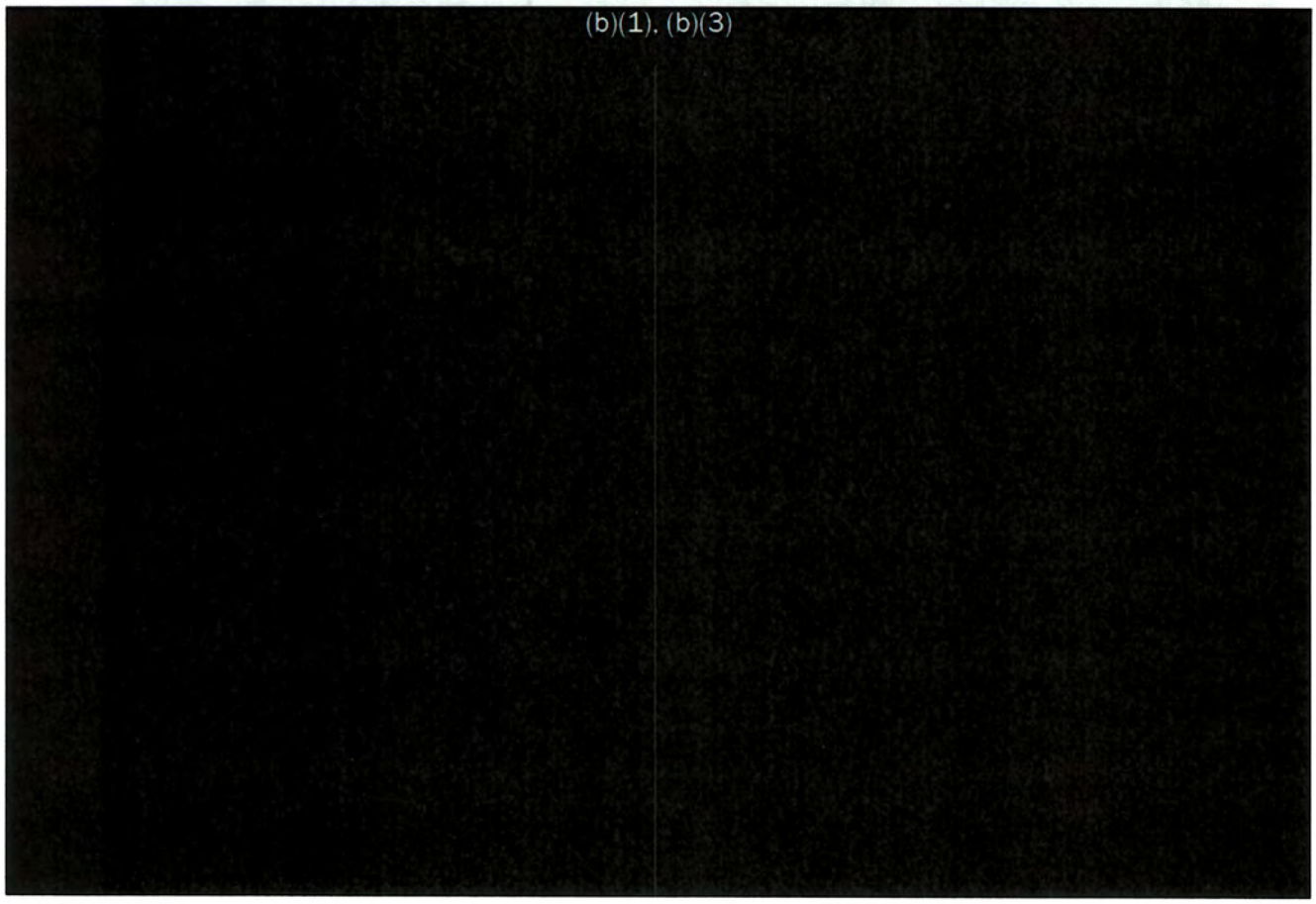
(b)(1), (b)(3)

(U/ (b)(3) Could the mechanism cause an individual to suddenly lose their balance or collapse?

(U/ (b)(3) Perhaps. Loss of balance would be expected after pressure or energy disrupts the vestibular system. The semicircular canals of the inner ear are the key mechanism by which the human body defines itself in space. Disruption of these areas will regularly produce a loss of balance. As described in the response to the previous question, however, the Panel has only anecdotal evidence of vestibular symptoms induced by exposure to ultrasound. Further research is needed to understand the cause and effect linkage of purported symptoms from exposure to high-intensity ultrasound.

(b)(3) Which, if any, commonly reported AHI symptoms (e.g. dizziness, headache, nausea) would the mechanism not produce and why?

(b)(3) Likely none. A disturbance to the inner ear from acoustic or electromagnetic stimuli could probably account for the commonly reported AHI symptoms, including dizziness, nausea, headache, head pressure or pain, and ear pressure or pain. These symptoms are nonspecific and would occur if the stimulus produced an increased pressure in the air spaces in the inner ear or the cranial sinuses. Both dizziness and nausea, for example, are expected from disturbances of vestibular function, which would be likely to occur from a pressure or electromagnetic disturbance of the inner ear. In addition, many of the reports of AHI include persistent headache after the event that might last hours to days, and some even seem to develop or exacerbate a chronic form of headache similar to migraine. Of note, varieties of stimuli are known to trigger a prolonged headache, especially traumatic brain injury/concussion.



(U) Appendix C: Panelist Biographies

(U) The affiliation of these individuals with the AHI IC Experts Panel is (b)(3)

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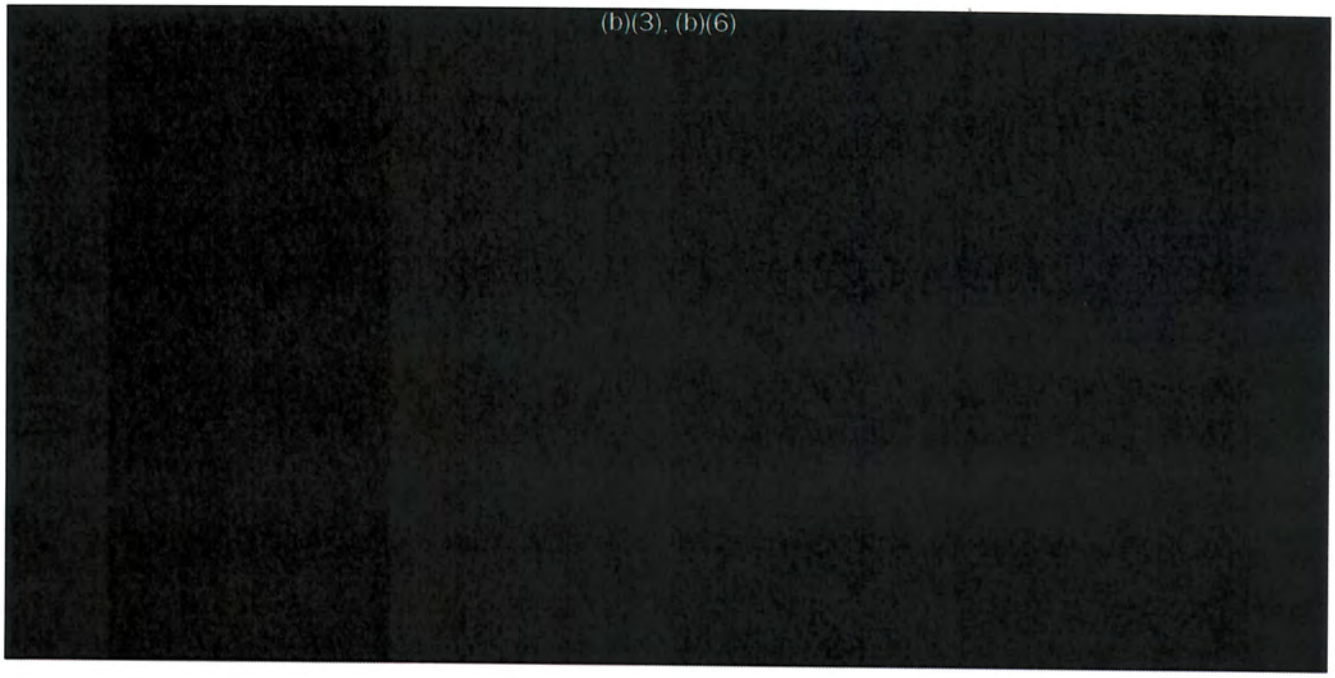

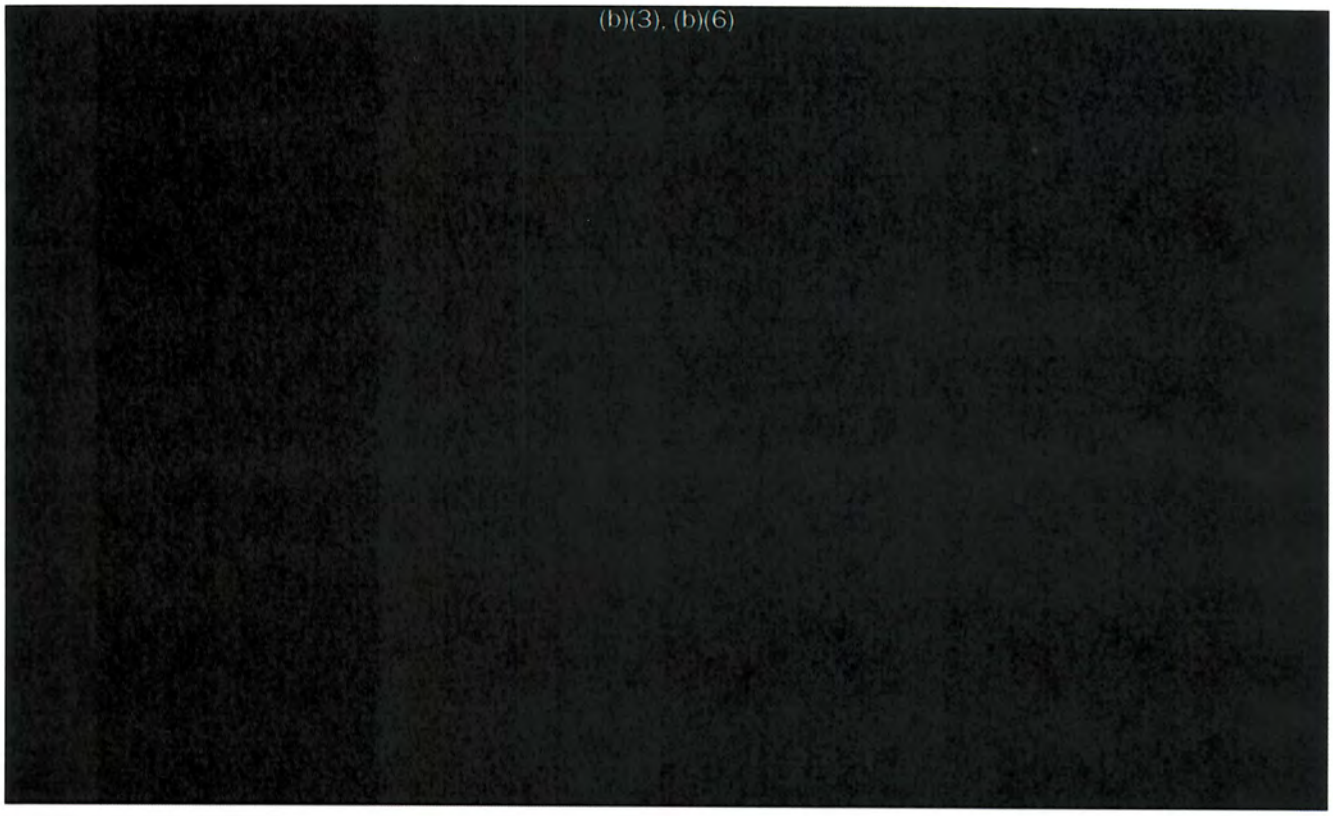

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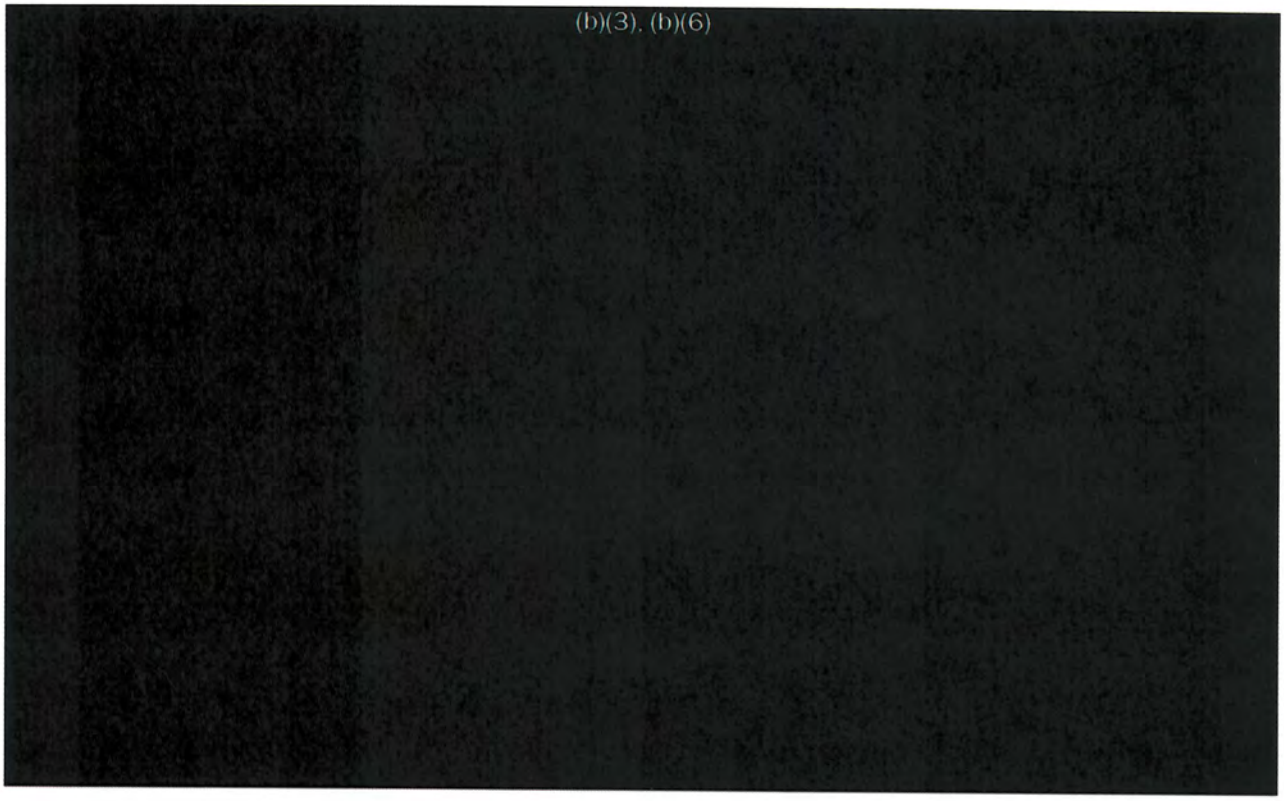

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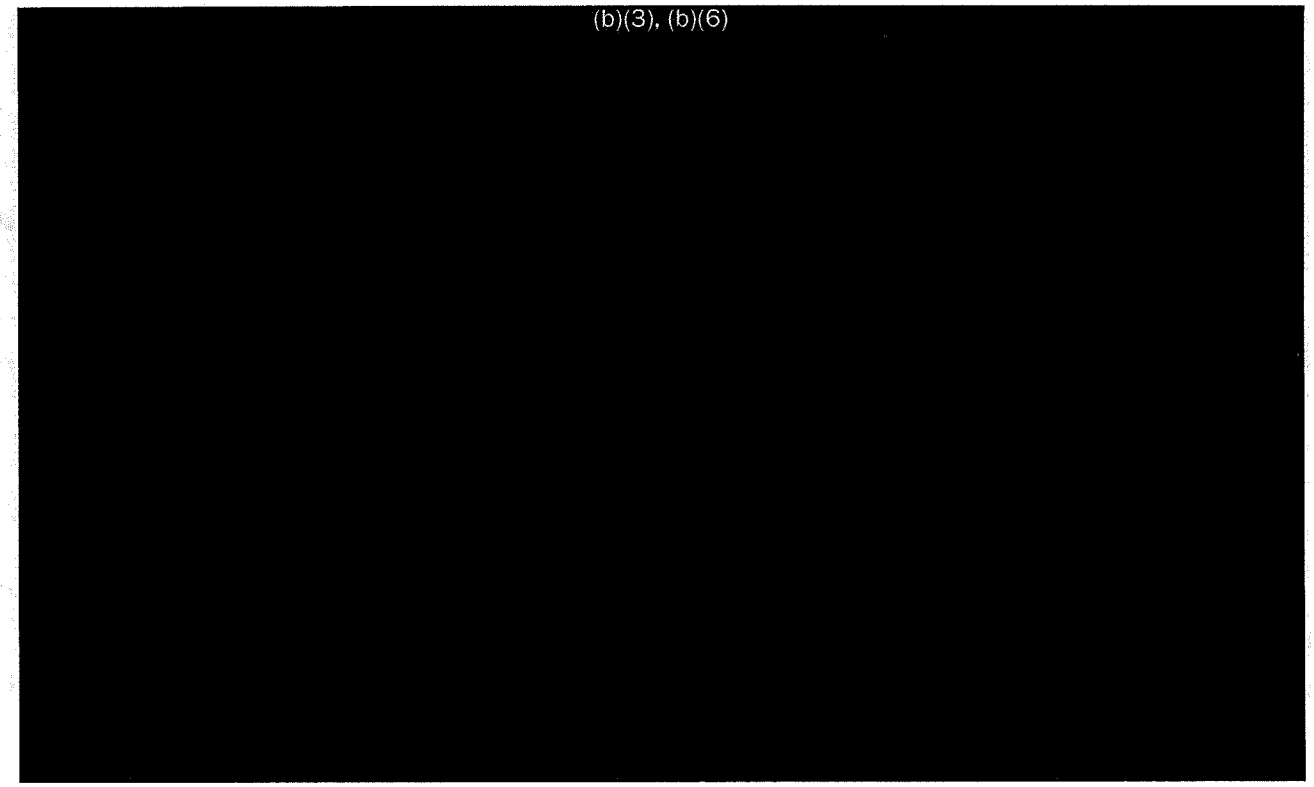

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(U) Appendix D: DNI Memorandum: Request for Information for IC Experts Panel on AHIs

DIRECTOR OF NATIONAL INTELLIGENCE
WASHINGTON, DC

ES 2021-01309

MEMORANDUM FOR: Distribution

SUBJECT: (b)(3) Request for Information for Intelligence Community Experts Panel on Anomalous Health Incidents

REFERENCE: (b)(3) ODNI Memorandum, Intelligence Community Experts Panel on Anomalous Health Incidents, 09 June 2021

(b)(3) As we continue to grow the Intelligence Community's (IC) effort to investigate the cause of anomalous health incidents (AHI) and support the work of the IC Experts Panel on AHIs, it is clear that information sharing will be critical to the panel's success. I, therefore, request IC elements provide any relevant information in their holdings that may help the panel to discover the causal mechanisms of AHIs.

(b)(3) This material is intended to supplement and is not limited to what would ordinarily be made available in (b)(1), (b)(3) and may contain medical, scientific, technical, intelligence, or other types of information or data. It may take a range of forms, including but not limited to, finished analysis, research reports, briefings, or other materials. It (b)(1), (b)(3) s , but it should not include raw intelligence reports already available in (b)(1), (b)(3) Additional details about the types of information that may be relevant to the panel is included in the attached AHI Experts Panel work plan.

(b)(3) Please provide the requested information to (b)(3) , no later than two weeks from the date of this memo with any additional relevant information to be provided through the duration of the Expert Panel's 100-day study, currently scheduled to end on 10 November 2021.

(b)(3) Please indicate in your responses if your submissions include any information that is not able to be shared and/or requires other special handling.

(b)(3)

SUBJECT: (b)(3) Request for Information for Intelligence Community Experts Panel on Anomalous Health Incidents

(U (b)(3) My point of contact for this matter is (b)(3), (b)(6), and (b)(3), (b)(6) can be reached at (b)(3)

Avril D. Haines

Sept. 15, 2021
Date

Attachment:

(b)(3) Intelligence Community Experts Panel on Anomalous Health Incidents Work Plan, 05 August 2021 (b)(3)

SUBJECT: (b)(3) Request for Information for Intelligence Community Experts Panel on Anomalous Health Incidents

Distribution:

Director, Central Intelligence Agency
Director, Defense Intelligence Agency
Director, National Geospatial-Intelligence Agency
Director, National Reconnaissance Office
Director, National Security Agency
Under Secretary for Intelligence and Security, Department of Defense
Under Secretary for Intelligence and Analysis, Department of Homeland Security
Executive Assistant Director for Intelligence, Federal Bureau of Investigation
Assistant Secretary for Intelligence and Research, Department of State
Assistant Secretary for Intelligence and Analysis, Department of the Treasury
Chief of Intelligence, Drug Enforcement Administration
Director, Office of Intelligence and Counterintelligence, Department of Energy
Deputy Chief of Staff for Intelligence, United States Army
Director of Intelligence, United States Marine Corps
Director of Naval Intelligence, United States Navy
Deputy Chief of Staff for Intelligence, Surveillance and Reconnaissance, United States Air Force
Director of Intelligence, Surveillance, and Reconnaissance, United States Space Force
Assistant Commandant for Intelligence and Criminal Investigations, United States Coast Guard
Director for Intelligence, Joint Chiefs of Staff

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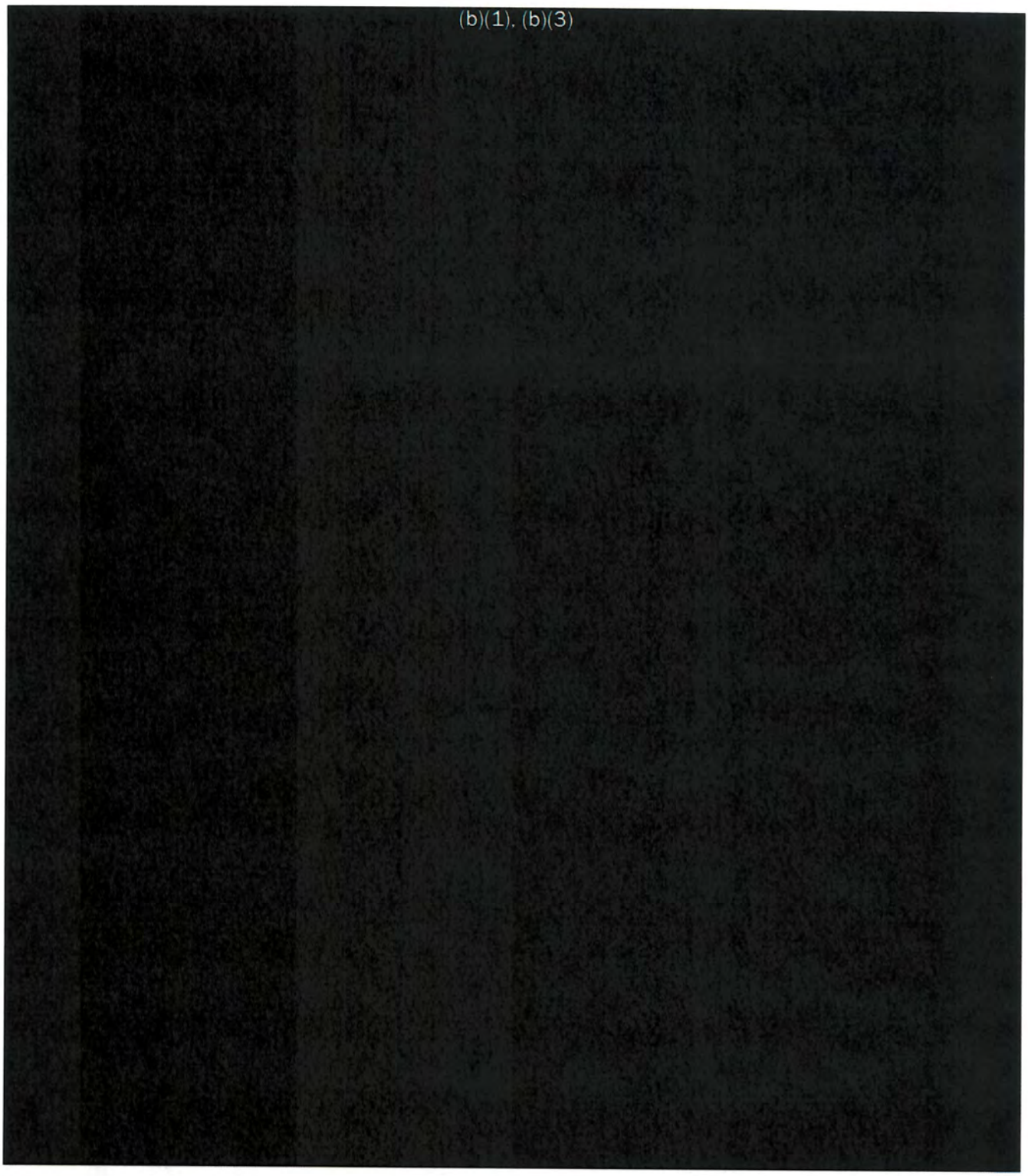

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(U) Appendix G: Glossary

(U) Asymmetric electromagnetic pulses
Any electromagnetic wave in which the incident electric or magnetic fields do not integrate to zero over a relevant timescale as defined by a biological process. When combined with the material dispersion and response time, this type of wave could have direct field effects by causing ions to drift, potentially causing depolarization of neurons and other biological effects. Extreme cases of asymmetric pulses that do not integrate to zero over any timescale can be solutions to the propagating wave equation. See **unipolar electromagnetic pulses.**

(U) Close-access scenarios
Situations in which the source is near the target, (b)(1), (b)(3) (b)(1), (b)(3) The precise distance involved will depend on the details of the source, scenario, and environment.

(U) Direct electromagnetic field effects
Effects on the body directly caused by electric or magnetic fields or propagating electromagnetic waves based on their field strengths or frequencies. (In contrast, indirect field effects include secondary effects such as heating, which are based on averaged fields.) At low frequencies (< 5 MHz), electrostimulation is a well-known direct field effect, which is included in the Institute of Electrical and Electronics Engineers (IEEE) standard. Some direct effects are used clinically, for example to treat Parkinson's disease, where electrodes or magnetic coils are placed on the head or implanted in the brain.

(U) Mechanoreceptors
"Hair cells" and specialized proteins in nerve fibers and ear that detect mechanical stimulation due to pressure and sound, rotation, acceleration, and gravity. The specialized proteins span the cell membrane and undergo conformational change in response to the mechanical stimulus. This change in protein structure opens a channel across the cell membrane through which positive ions flow into the cell, leading to neural transmission of the stimulus.

(U) Microwave-auditory effect or Frey effect
Pulsed microwaves, principally in the ultrahigh frequency range (hundreds of MHz to few GHz), at short pulsewidths can cause the perception of auditory phenomena. At low pulse repetition frequencies, these stimuli are perceived as a series of clicks. At moderate-to-high pulse repetition frequencies (tens of Hz to few kHz), the stimuli are generally perceived as a tone or buzzing, screeching, or grinding noise. At higher pulse repetition frequencies, the phenomenon either disappears or is beyond human ability to perceive it. Individuals with high-frequency hearing loss tend to have a more difficult time perceiving the Frey effect when the pulse repetition frequency is relatively high.

(U) Microwave thermo-acoustic effect
A hypothesis behind the microwave-auditory effect. The short-duration pulses cause localized, rapid heating in the brain, but only on the order of one-millionth of a degree Celsius for the microwave-auditory effect. The localized heating causes a localized pressure increase. The sudden and possibly uneven pressure change in the brain causes a propagating stress wave in the brain. This mechanical wave shakes structures in the ear, causing the perception of sound. It is hypothesized that the same effect at much higher power density levels could cause pressure waves similar to those experienced during traumatic brain injury. Microwave pulses need to be shorter than a single roundtrip time of the propagating stress wave in the head, otherwise the mechanical wave can wash out and mechanical pressures drop.

(U) Plausible
The panel considered a mechanism to be plausible if all members assessed there was at least some credible evidence that it was technically and practically feasible in each of five components: (1) a source that could generate the required stimulus and be difficult to detect; (2) propagation and delivery of the stimulus to an individual in a way that would be difficult to detect; (3) coupling of the stimulus to the human body; (4) ability of the coupling to cause biological effects; and (5) ability of the biological effects to explain the core clinical signs and symptoms. In addition, the panel required that other evidence not exclude the mechanism. Thus, a mechanism could be considered plausible if a notional line could be drawn connecting each of these five components.

(U) Standoff scenarios
Situations involving distances between the source and target of about 100 meters. The precise distance involved will depend on the details of the source, scenario, and environment.

(U) Subthermal exposure
Any exposure not expected to cause a significant temperature increase because the delivered energy levels are too low, allowing the body to regulate the temperature. The microwave thermo-acoustic effect can be a subthermal effect in this sense, unless multiple successive pulses were to incrementally increase the temperature significantly. Of course, if the power of a signal causing the microwave thermo-acoustic effect is increased beyond some threshold, then this exposure will become thermal as well.

(U) Symmetric electromagnetic pulses
Most propagating electromagnetic pulses are symmetric or biphasic. This property means that integrating the electric field over a sufficiently large time duration will yield a net electric field of zero and a similar yield for the magnetic field. For lower frequency pulses or pulse repetition frequencies, ions may move and return to an equilibrium position on timescales relevant to biological processes, resulting in biological effects that are inconsequential. If ions do not return to an equilibrium position on the relevant timescales, the biological effects may be consequential. Asymmetric pulses may result in more significant biological effects, perhaps because a net displacement of ions is possible for long enough to cause direct effects such as depolarization of cell membranes.

(U) Thermal effects
Effects that occur when microwaves absorbed by the body, or by rapidly rotating molecules in the body, are converted to thermal energy (heat). If the amount of heat deposited by the microwave source cannot be effectively removed by the body (e.g., by sweating, blood flow, etc.), the body will begin to overheat, the body's temperature receptors will prompt a sensation of heating, and tissues will be damaged, leading to the well-known health effects of hyperthermia, up to and including death. The majority of the IEEE and International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards protect against known health effects by limiting exposure to those where the amount of heating is small, e.g., less than 1°C.

(U) Thermal exposure
Any electromagnetic wave exposure expected to cause a significant temperature increase (e.g., about 1°C or higher), to a bulk volume of tissue.

(U) Unipolar electromagnetic pulses
A special case of asymmetric electromagnetic pulses for which the electric field vector never inverts. By definition, such pulses will not integrate to zero over any timescale. By Fourier analysis, the pulses are physically unrealizable in the far-field with physically realizable antennas. Such pulses can be studied by placing a target between two electrodes.

(U/ (b)(3) Appendix H: Comparison to JASON Study

(U/ (b)(3) On 11 January 2022, the AHI IC Experts Panel cochairs and selected panelists met with members of the JASON advisory panel commissioned by US Department of State in 2021 to examine similar questions about AHIs. The purpose of the meeting was to identify areas of agreement and disagreement. The four-hour session was productive and positive, as was a follow-on session a few days later with a subset of the attendees. ***This appendix is the Panel's summary of these Experts Panel-JASON sessions for DNI and CIA Sponsors and has been coordinated with the JASONs.***

(U) Large Areas of Agreement

(U) The two groups came to independent agreement on several key issues, including:

- (U (b)(3) The symptoms and signs of AHIs are genuine and compelling. They deserve special attention, and affected individuals must receive the best possible medical care.
- (U (b)(3) AHIs are heterogeneous and include diverse phenomena. No single mechanism explains all AHIs, and psychological factors play a role.
- (U (b)(3) A subset of AHIs cannot be easily explained by known medical or environmental conditions and could be due to external stimuli. The JASONs refer to this as a small subset of the incidents (on which they were provided information), while the Expert Panel focused on the incidents that were the most difficult to explain and was not in a position to evaluate the relative size of the subset.
- (b)(1); (b)(3)

(U) Main Disagreement Concerns Electromagnetic Signals as a Possible Mechanism

(b)(3) The IC Experts Panel assessed electromagnetic signals to be "plausible" as a causal mechanism, and the JASONs assessed them to be "highly unlikely but not impossible". The JASONs then went further to assess that they saw "no feasible concept of operations" for a successful, covert attack. The Panel, however, considered a mechanism to be plausible if at least some evidence indicates that the stimulus can be produced, delivered, coupled to the human body, and cause the core biological and clinical effects that are consistent with AHIs, and if it cannot be excluded by other information.

(U/ (b)(3) The difference between the Panel and the JASONs on the topic of electromagnetic signals stemmed from disagreements on two issues, as follows, both of which are covered in the Panel's report and involve several matters that the Panel's recommendations could help to further illuminate:

- (b)(3) (b)(1), (b)(3)
- (b)(3) The extent to which electromagnetic signals could cause AHI-like biological effects at very low flux levels or without causing sensations of heating.

(b)(3) Overlapping Recommendations With One Key Difference

(U) Both studies made recommendations that focused on:

- (U) Data analysis and collection.
- (U) Workforce communication.
- [redacted] (b)(1), (b)(3), (b)(5)
- (U//FOUO) Medical issues. The Panel focused on clinical testing and biomarkers, and JASON focused on Department of State medical baselining.
- (U//FOUO) Electromagnetic effects. The Panel recommended studying effects on biological systems, and JASON recommended studying effects on electronics.

(b)(3) (b)(1), (b)(3)

(U) Appendix I: Considerations for Developing Biomarkers

(U/ (b)(3) Currently, biomarker measurement in individuals who have experienced suspected AHIs is limited in individuals to two markers that are associated with traumatic brain injury: glial fibrillary acidic protein (GFAP) and neurofilament light chain (NfL) protein. (Ubiquitin carboxyl-terminal hydrolase L1 (UCHL1), an FDA-approved biomarker for evaluation of mild traumatic brain injury, was not included in assays performed to date. UCHL1 rises and falls more rapidly than GFAP or NfL and should be assessed in AHI samples.) Although these biomarkers may prove to be useful in the long term, given the gaps in knowledge about the mechanisms and medical implications of exposure to directed energy, there is a need to develop a broader understanding of possible biomarkers in this setting. There is no published work on the plausible causal mechanisms of cases with the core characteristics (e.g., pulsed radiofrequency electromagnetic energy and ultrasound) and the type of brain injury that would result from such exposure. Hence, there is no information about potential biomarkers beyond those used for traumatic brain injury, and it will be important to search for biomarkers in studies of animals exposed to different energy sources.

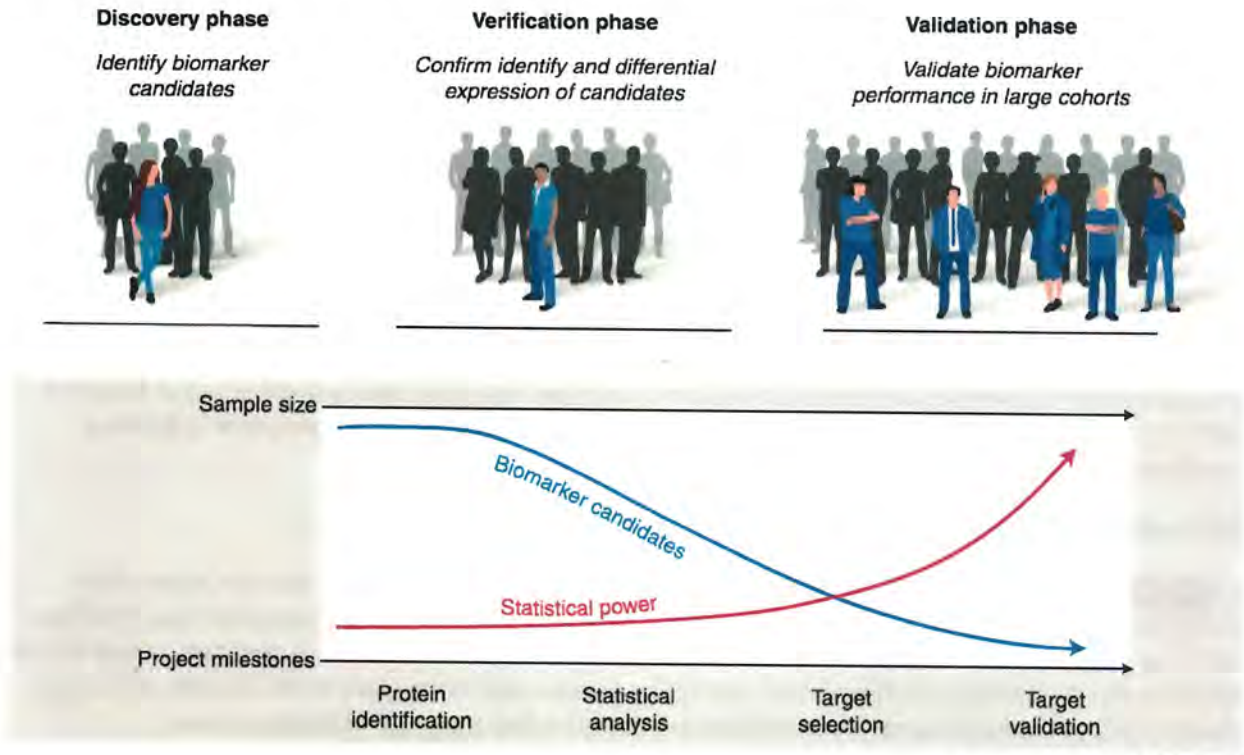
(U/ (b)(3) There are important questions that need to be addressed at the outset as they bear directly on the design of a program for biomarker discovery. Most centrally: for what purpose will the biomarkers be used? Certainly one use will be for diagnosis of an event that is severe enough to cause neural cell injury. (Of note, exposures that trigger neurosensory symptoms for short periods might not be expected to cause leaks of biomarkers indicative of injury to the central nervous system.) The intended use of the biomarkers will dictate the selection of a group of subjects and the choice of controls. Biomarkers might distinguish between different subsets of cases based on the causal mechanism or the severity of exposure. If a new AHI-specific biomarker were found to be associated with a specific type of injury, it might also point toward a more specific therapy. In addition, the timing of sample acquisition (mostly likely a blood draw) relative to the onset of the event is crucial. Sample acquisition within hours should be the goal. Another possible use of biomarkers is for predicting clinical outcome, e.g., for recovery.

(U/ (b)(3) In recent years, the technologies of mass spectrometry–based proteomics and small molecule measurement have undergone a revolution in ease of use, power, and reproducibility such that they have become commonplace in biology and medicine. The application of these technological advances can be seen in many fields beyond biomarker discovery.[1234] They may be very helpful in linking animal experimentation with the human condition.

(U/ (b)(3) Biomarker development is typically divided into three phases: discovery, verification, and validation (see Appendix I Figure 1 below). The text and procedures that follow has been adapted from (b)(3) [5]

(U/ (b)(3) APPENDIX I FIGURE 1

Phases of Biomarker Development Studies



(U) Images are U/ (b)(3)

(U/ (b)(3) Biomarker discovery is usually divided into three different phases: discovery, verification, and validation. In the discovery phase, a small number of samples are submitted for in-depth proteomics analysis where thousands of proteins are measured to identify biomarker candidates. Often, larger cohorts of samples are analyzed in the subsequent phases, increasing the statistical power. Biomarker candidates are also down-selected at each developmental phase based on their performance to accurately predict the disease or condition. In some cases, a combination of proteins, rather than an individual protein, is tested as a biomarker. In the verification phase, biomarker candidates undergo additional proteomics analysis to verify both their identities and their expression in the same or similar samples as in the discovery phase. A few of the most promising candidates are tested in the validation phase to determine their performance for clinical use.

(U) Figure source notes.[67]

(U) Discovery Phase

(U/ (b)(3) The process of biomarker identification and development begins with a discovery phase. The focus of this phase is on identifying a large number of potential biomarkers that distinguish between sample or subject categories of interest. Discovery is primarily based on in-depth, untargeted proteomic analysis to identify and quantify as many proteins as possible, leading to the identification of as many as tens to hundreds of potential candidates that will then be assessed further in the verification and validation phases. The discovery phase has a relatively low throughput and thus is typically carried out using a limited number of samples.

(U) Verification Phase

(U/ (b)(3) The verification phase takes on the task of confirming that the abundances of target peptides are significantly different between case and control groups using quantitative measurements. These quantitative measurements typically involve the use of stable-isotope-labeled synthetic peptides that are spiked into the samples of interest to facilitate confident detection and quantification of targeted peptides using mass spectrometry–based assays. This type of quantification is essential in building confidence about a new biomarker.

(U) Validation Phase

(U/ (b)(3) Analytical validation (as opposed to the clinical validation step) confirms the utility of the biomarker by analyzing samples from an expanded or independent cohort of individuals that have the same condition as was investigated in the discovery and verification phases. This comparison provides a measure of robustness of the biomarkers and of the assays used to measure them. Usually, only a few (three to 10) of the best biomarker candidates are tested in the analytical validation phase.

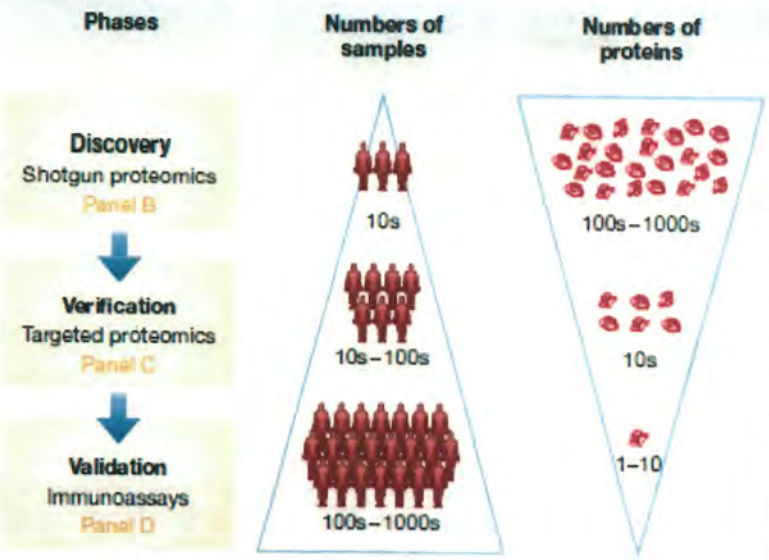
(U/ (b)(3) A recent review highlights the general approach involved in untargeted biomarker discovery and validation.[8] The authors made the important point that "the principal advantage of hypothesis-free mass spectrometry–based proteomics is that no assumptions need to be made regarding the possible nature and number of potential biomarkers, which is in contrast to single protein measurements carried out in more classical type biomarker research." Conceptually, mass spectrometry-based proteomics combines hypothesis-driven biomarker studies for each condition and defines the relation of potential biomarkers to each other. In practice, the challenges of proteomics have so far prevented in-depth and quantitative studies on large cohorts. Instead, a stepwise or "triangular" strategy for biomarker discovery has been advocated. During the strategy's three phases, the number of individuals increases from a few to many, whereas the number of proteins decreases from hundreds or thousands to just a few (see Appendix I Figure 2 for a visualization of triangulation).

(U/ (b)(3) Appendix I Figure 2

Triangulation Strategy for Biomarker Development

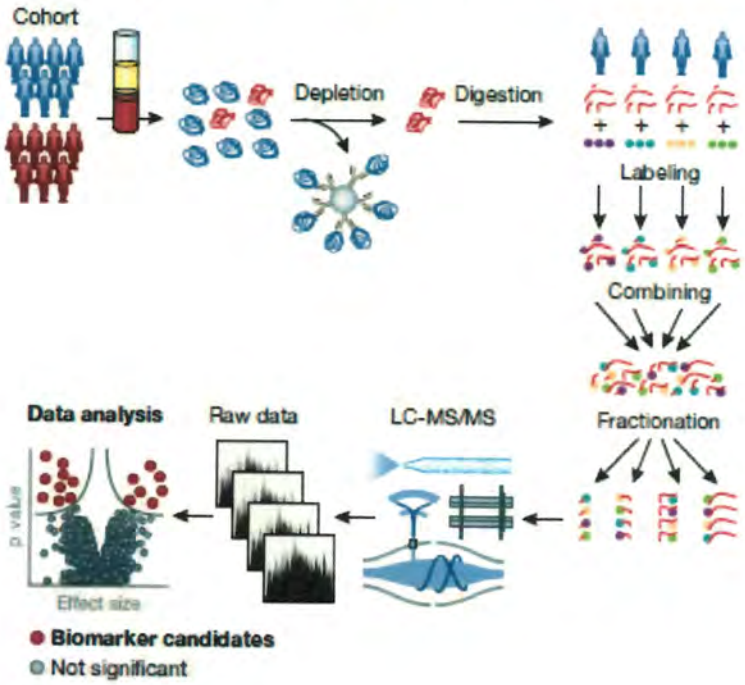
(U/ (b)(3) A triangulation strategy for biomarker discovery has three phases, during which the number of individuals increases from a few to many and the number of proteins decreases from hundreds or thousands to just a few:

(U/ (b)(3) Triangular Strategy



(U/ (b)(3) In a triangulation strategy, a relatively small number of cases and controls are analyzed by hypothesis-free discovery proteomics in great depth, ideally leading to the quantification of thousands of proteins (top layer in the triangle). This analysis may yield tens of candidates with differential expression that are screened by targeted proteomics methods in cohorts of moderate size (middle layer). Finally, for one or a few of the remaining candidates, immunoassays are developed, which are then validated in large cohorts and applied in clinical settings (bottom layer).

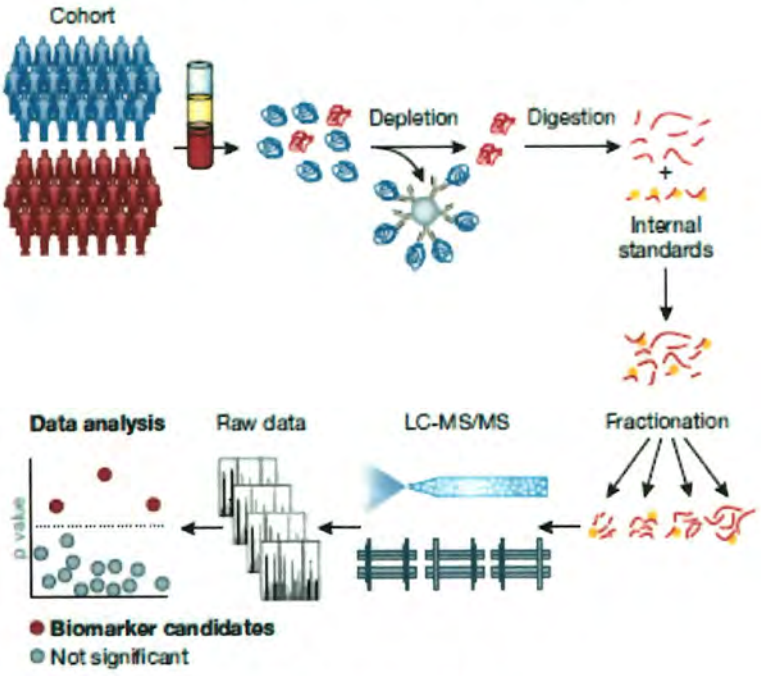
(U/ (b)(3) Discovery – Shotgun Proteomics



(U/ (b)(3) The workflow for hypothesis-free discovery (or "shotgun") proteomics.

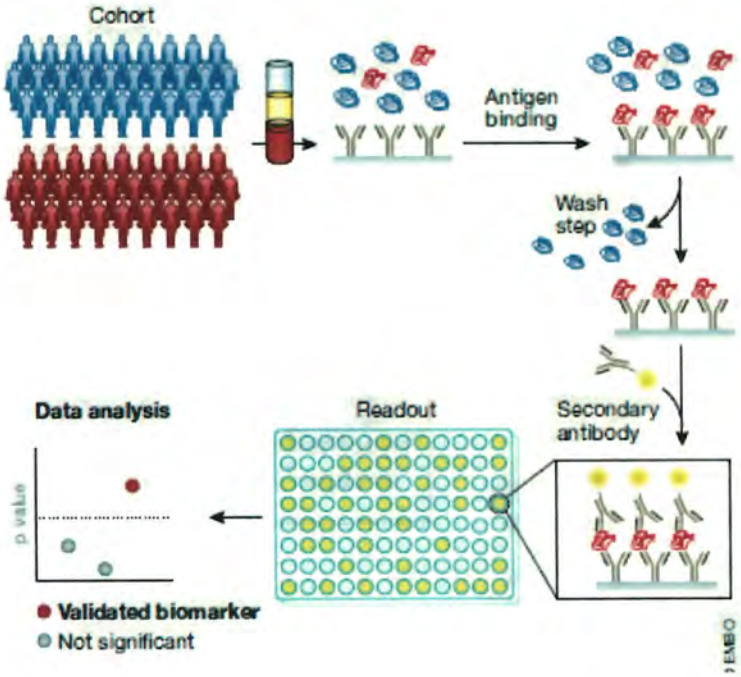
(U) Images are U/ (b)(3)

(U/ (b)(3) Verification – Targeted proteomics



(U/ (b)(3) Targeted proteomics for candidate verification.

(U/ (b)(3) Validation – Immunoassays



(U/ (b)(3) The development of immunoassays for clinical validation and application.

(U) Images are U/ (b)(3).

(U) LC-MS/MS = Liquid chromatography-mass spectroscopy or mass spectroscopy.

(U) *Figure source notes.*[910]

(U) Sample and Cohort Selection

(U/ (b)(3) The selection of samples that are representative of cases as well as the population from which the cases are drawn is critical to making appropriate inference in case prediction. This selection is a centrally important step to embarking on an AHI biomarker program. As noted, the discovery phase is focused on an in-depth analysis of a relatively small number of cases. Because cases exhibiting the core characteristics are not currently large in number and any increase is unlikely to be a large number, the in-depth analysis for a discovery program will be well-suited to the sample size.

(U/ (b)(3) Successful biomarker programs are instructive. For example, in a type-1 diabetes research project, the discovery component involved 10 pooled samples from individuals with the disease and compared them to samples from nondiseased controls.[11] Later validation steps involved larger numbers, but the initial in-depth discovery phase could be carried out on cases in which blood samples were available. In an investigation of AHI, the control samples deserve specific attention and should be drawn from individuals whose work environment, clinical and occupational histories, and job-related circumstances are similar to those with an event who have been selected for in-depth analysis. There are many other examples of successful development of biomarkers;[12][13][14] in a recent analysis of multiple kinds of cellular and molecular biomarkers, investigators identified proteins in the blood of COVID-19 patients whose abundances correlated with disease severity and distinguished COVID-19 from other, lookalike illnesses.[15]

(U) Animal Models

(U/ (b)(3) Given the knowledge gaps in AHI-associated causal mechanisms, using animal models to inform biomarker discovery should be a priority. Animal models cannot take into account the unique structure of the human skull and brain and thus may not be a good mimic of the type of injury that will take place in humans, but using such models is likely to provide valuable information and to inform studies with nonhuman primates. Discovery phase nonhuman primate studies could thus provide a focus for some expected biomarkers.

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Appendix J:

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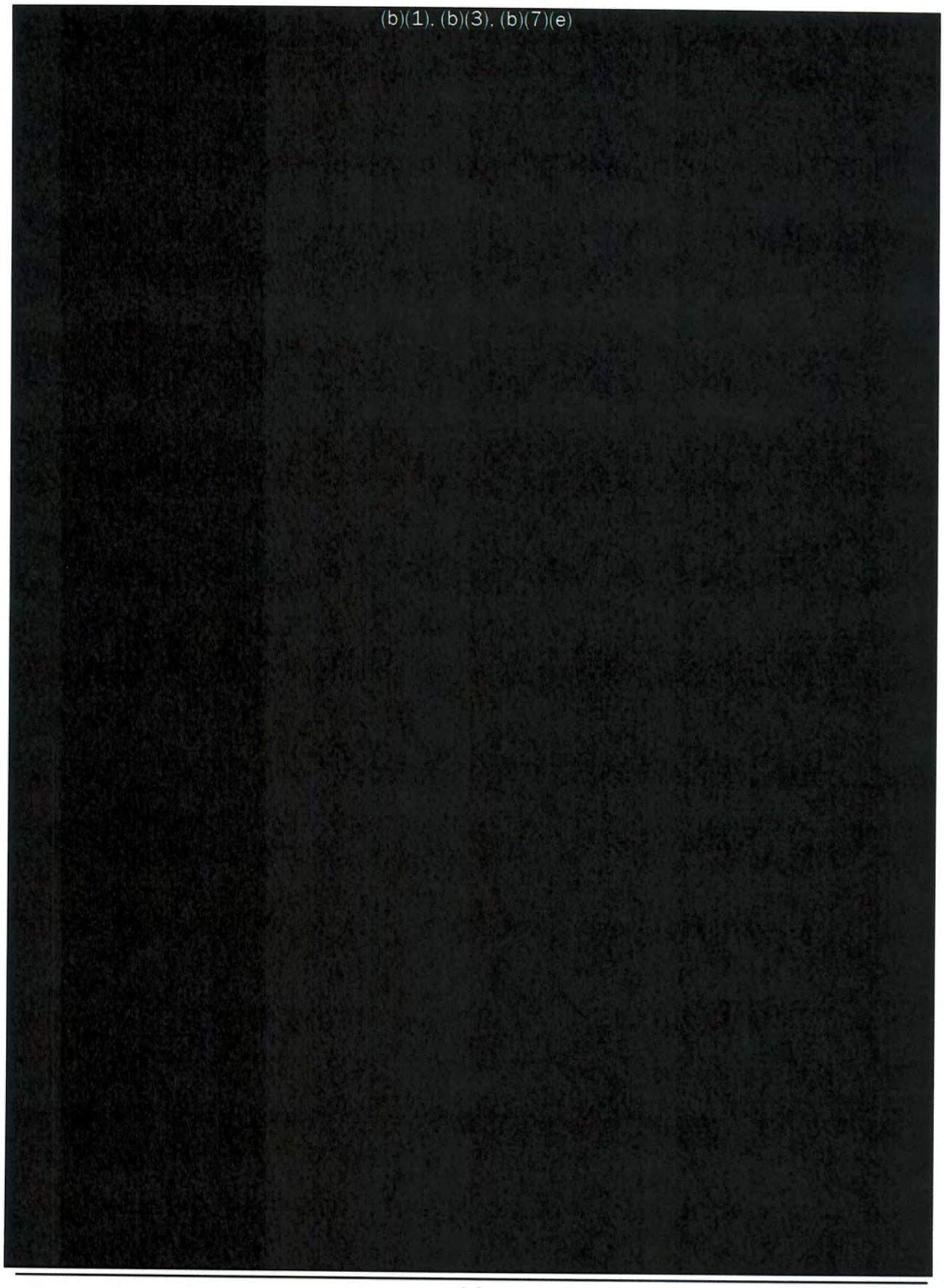

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(U) Appendix K: Red-Stripe Intelligence Reporting

(b)(3) This appendix contains examples of Red-Stripe intelligence related to foreign research into using directed electromagnetic and acoustic energy (b)(1), (b)(3) Individuals with a need to know and the appropriate clearances may learn how to request a copy by contacting the Experts Panel staff at (b)(3)

(U) Appendix L: Notes on Selected Recommendations

(U) **The IC Experts Panel's report contains eight main recommendations to help the US Government better understand, prevent, and manage AHIs. This appendix expands on some of those recommendations.** (b)(3)

(U) Data

(b)(1), (b)(3)

(U) Biomarkers

(U) **Appendix I discusses approaches to developing biomarkers for AHIs.**

(U) Detectors

(U) Types

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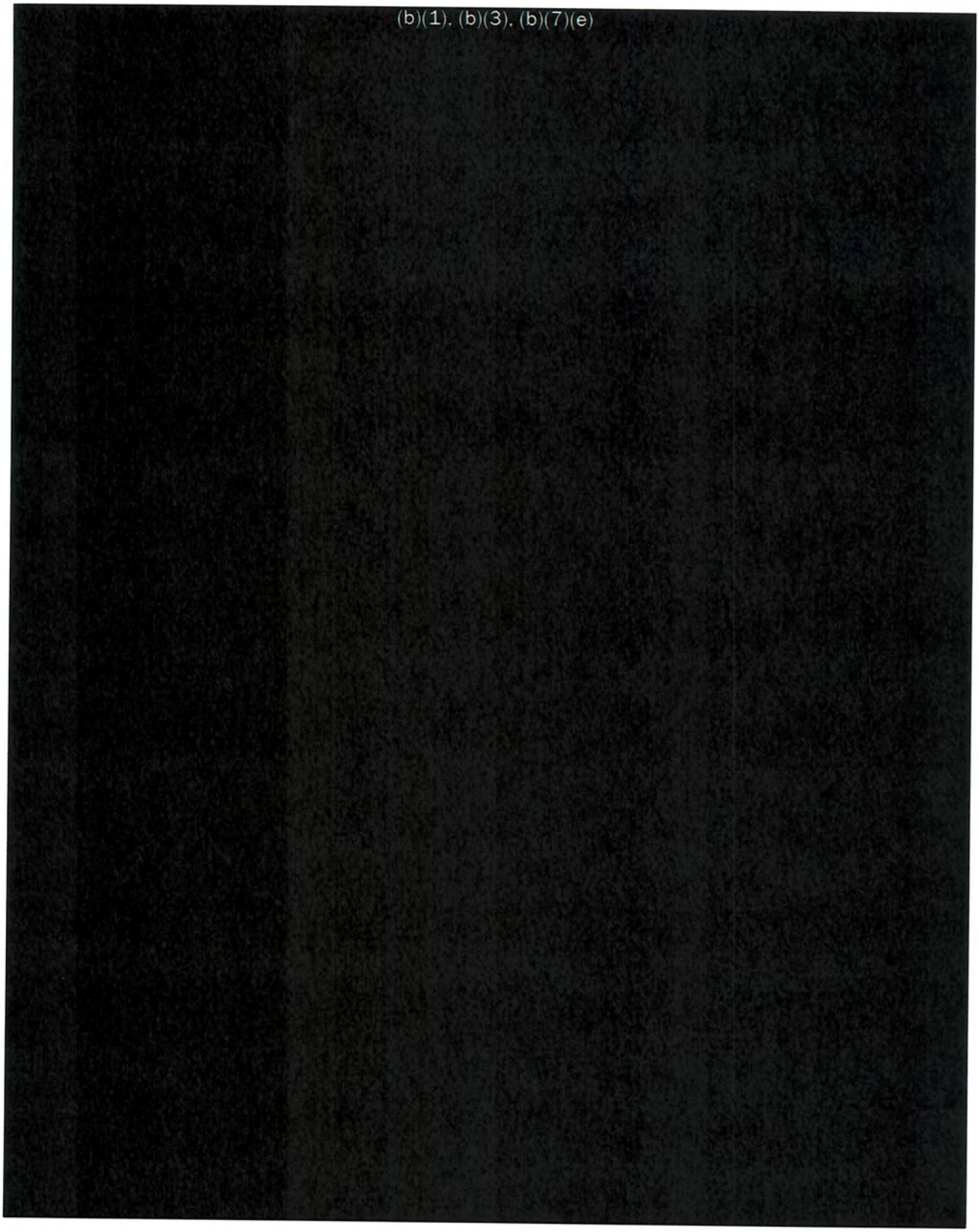

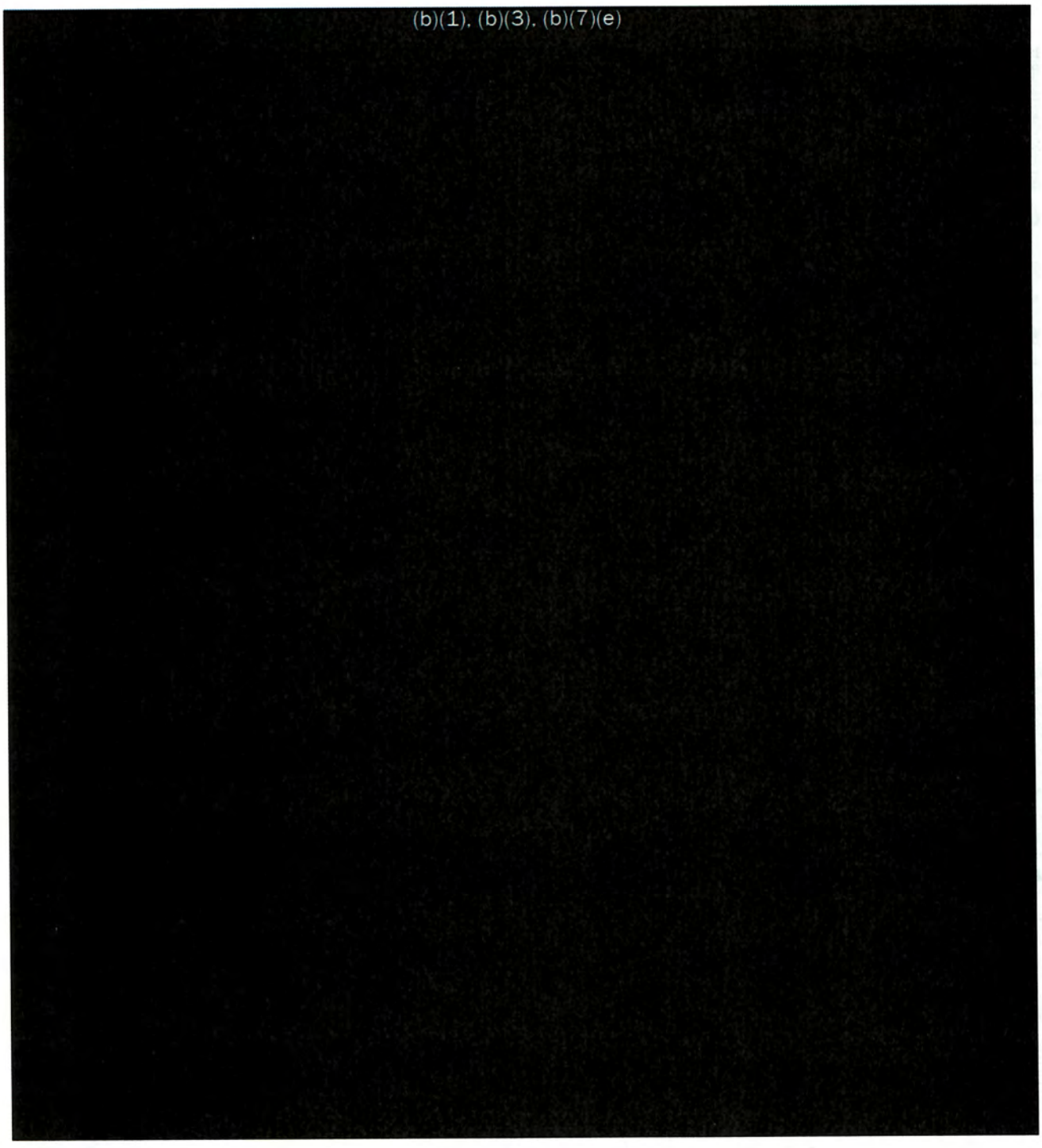

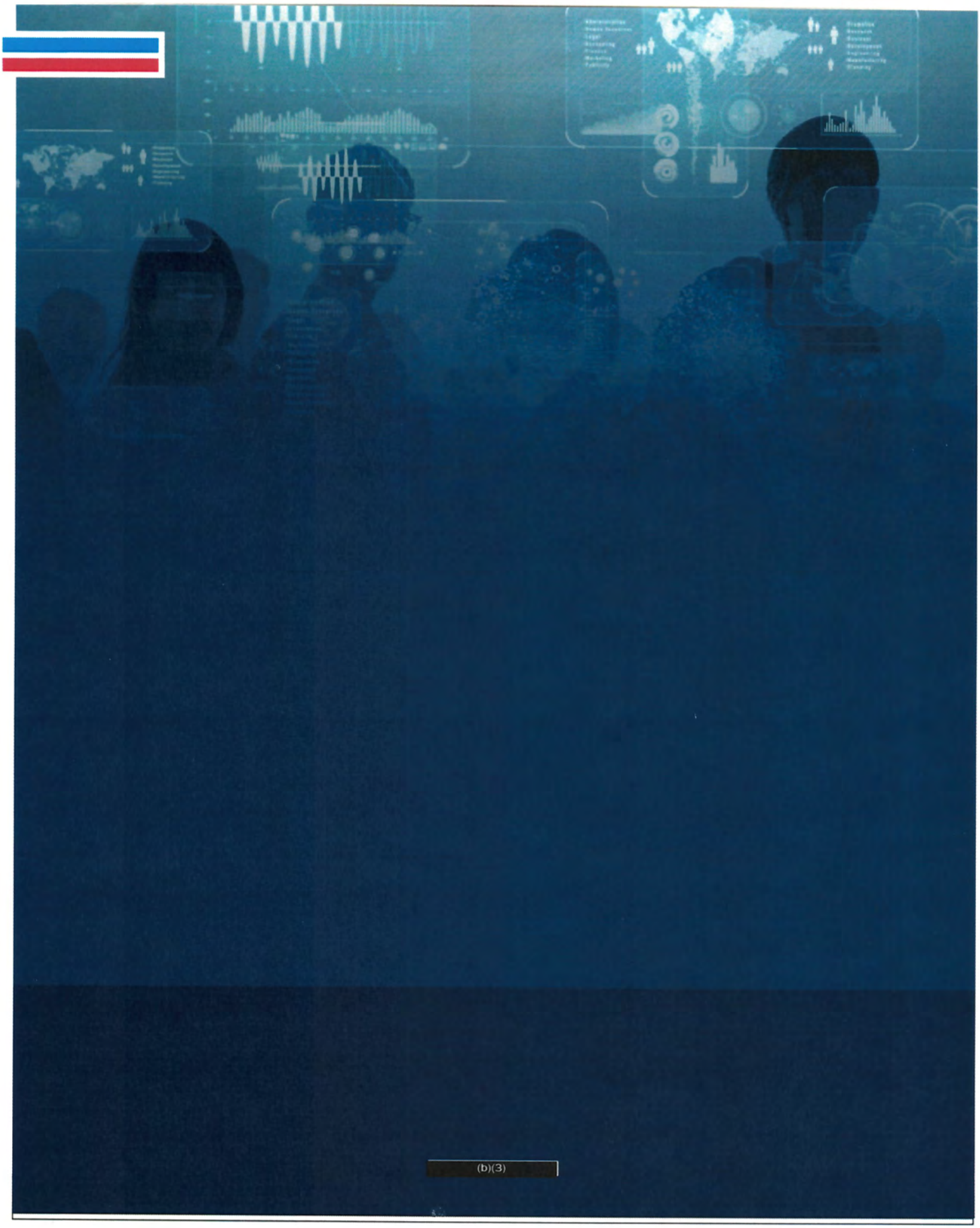
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