ASTI

WHERE SYNERGISM IS A REALITY

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SAFETY OF HIGH SPEED GUIDED GROUND TRANSPORTATION SYSTEMS: STUDY OF THE STARTLE EFFECT

DRAFT FINAL REPORT

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PREFACE

The ever increasing probability that high-speed rail systems may become an operating reality in future years has provided the framework for a number of conferences and an equal number of studies involving a myriad of safety concerns and issues. One safety issue, albeit of lesser concern until now, revolves around what is referred to as the "human startle reflex," and the consequences if it is precipitated in nearby highway drivers by the sudden passage of high-speed guided ground transportation (HSGGT) vehicles, contributing to the likelihood that it might cause an increased prevalence of motor traffic accidents on highways sharing or adjacent to the HSGGT right-of-way (ROWs).

The plenitudinous, detailed studies on human factors done over the years in rail, highway, and other contexts have provided ample evidence of the role that the various human factor elements contribute to serious highway automobile accidents and play just as great a part in accidents at railroad-highway grade crossings as in other accidents. It has always been considered possible that the startle reflex could be one of those contributing human factors.

This study was commissioned to research the question of whether the human startle reflex could be a problem if an unsuspecting motorist were to experience a surprising encounter with either the sight, sound, or other manifestation of the nearby passage of high-speed guided ground transportation vehicles, thereby precipitating an accident. Moreover, if indeed that were the case, then this study would recommend appropriate startle mitigation strategies to enhance highway safety in the vicinity of American HSGGT systems. Conducted primarily through interviews to solicit information and opinions, the methodology also included an exhaustive review of the appropriate scientific literature. The findings of the study were negative, but with the caution that it is impossible to prove with certainty that a hypothetical problem is non-existent, and it cannot be stated that sheer startle due to the close and rapid passage of a HSGGT vehicle or train could never be the direct or indirect cause of a nervous or impaired motorist becoming involved in a highway accident.

This study was prepared for the United States Department of Transportation (U.S. DOT), Federal Railroad Administration's (FRA) Office of Research and Development. The authors wish to thank Mr. Arne J. Bang of the FRA Office of Research and Development, for his direction, helpful guidance and input during the preparation of this document.

The authors especially wish to thank Dr. Judith Burki-Cohen of the Volpe National Transportation Systems Center, and Dr. Tom Raslear of the FRA Office of Research and Development for contributing reference material, important input, and critical review.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meters (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft,ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)

TEMPERATURE (EXACT)

$[(x-32)(5/9)]^\circ F = y^\circ C$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

$[(9/5)y + 32]^\circ C = x^\circ F$

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES 0 1 2 3 4 5 6 7 8 9 10

CENTIMETERS 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
25.40

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

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EXECUTIVE SUMMARY

This report was undertaken to address the question of whether or not the rapid passage of high-speed guided ground transportation (HSGGT) vehicles is likely to startle motorists sufficiently to increase the prevalence of traffic accidents on public highways sharing or adjacent to the right-of-way (ROW); and if so, determine which startle mitigation devices or procedures might be used cost-effectively to minimize the risk.

The impetus for this report came about largely as a result of a very real and growing concern on the part of high-speed rail conceptualizers, planners, and developers that there is a significant risk of HSGGT trains startling motorists and causing highway accidents.

In our approach to the highway startle question, ASTI reviewed selected bodies of published scientific literature addressing the effects upon human task performance of acoustic, visual, and other triggers of the normal startle reflex. The principal effort, however, was directed toward interviewing and soliciting information and opinions, both by telephone and through correspondence on the startle question from a broad range of agencies and individual experts in the United States as well as in foreign countries already experienced in HSGGT operations (Appendix C).

No evidence, including anecdotal, that the physiological startle response per se, evoked by the rapid or close passage of other vehicles, for example, trains, speeding trucks, or low-flying aircraft, or startling natural events such as nearby lightning strikes or running into a hailstorm, had ever been recorded as the probable or proximate cause of a highway accident. ASTI extended its inquiries to the fields of military operations and industrial safety, in case more remote precedents could be established, with similarly inconclusive findings. A similar search of the scientific literature was also essentially inconclusive, regarding relevant and applicable data.

Numerous interviews were conducted over the phone and through correspondence with a number of experts outside the United States in several foreign countries already having much experience in the operation of intercity HSGGT systems, including some steel-wheel trains and prototype maglev's with service speeds on the order of 200 mph, paralleling or crossing public highways. The consensus among those experts is that a startle effect on motorists is not a problem. There have apparently been no accidents attributed to such a cause. In fact, the problem reportedly was not even considered worthy of investigation during the development and subsequent demonstration and revenue operation of contemporary British, Canadian, European, or Japanese HSGGT systems, most of which are currently being upgraded and networks are being extended to achieve higher service and consensus among these experts speeds.

Moreover, the present study yielded no instance in which the deployment of startle mitigation technology was deemed necessary, by any system, in any country.

In a concurrent search for existing startle mitigation devices used in highway planning, engineering, or safety administration in the United States (and/or any underlying rationale for startle mitigation) the study found these to be few and simple; mainly exemplified by advisory roadside notices such as, "Beware of low-flying aircraft" or "Dim headlights," put up by military or local authorities (see Section 5.1). It appears that in some military flying areas, these notices were erected on local command initiative in an attempt to protect the aviator, not the motorist, from bright headlights shining up from highways at night when the pilot is on approach.

Additionally, the present study yielded no evidence (with the possible exception of stationary signage) that the range of startle mitigation devices which have been proposed in anticipation of a highway accident problem due to startle from HSGGT operations would be cost-effective or prevent an accident. Indeed, some expert opinion received in the course of this study suggested that some of the startle mitigation technology that has been proposed during current HSGGT conceptual development, such as system-activated warning signals or active informational displays deployed along the highway, could be counter-productive by increasing the risk of accidents due to anticipatory rubber-necking or other disorganization of normal driver behavior in traffic.

It is, of course, impossible to prove with certainty that a hypothetical problem is non-existent; and it cannot be stated that sheer startle due to the close and rapid passage of an HSGGT vehicle or train could never be the direct or indirect cause of a nervous or impaired motorist becoming involved in a highway accident.

Prudently, therefore, the study recommends the following follow-on effort:

- The initiation of an effective, nationwide campaign to make the driving population in the United States, aware of and educated about the appearance and basic safety of HSGGT systems and vehicles to be deployed around the country. This might include both general public service programs in the media, including actual and simulated images of HSGGT trains in motion as seen from the highway, to familiarize the public with them: as well as the inclusion of additional material in drivers' education programs addressing the same topic, in a way perhaps analogous and supplementary to instruction about railroads and grade-crossing safety.

1.0 INTRODUCTION

1.1 Purpose of study

This report is intended to address the question of whether the human startle reflex, if evoked in nearby highway drivers by the sudden passage of high-speed guided ground transportation (HSGGT) vehicles, is likely to cause an increased prevalence of motor traffic accidents on highways sharing or adjacent to the HSGGT right-of-way (ROW); and, if so, what startle mitigation devices or procedures might be used cost-effectively to minimize that risk.

Future American HSGGT systems are expected to operate in a service speed range of 95 to 300 mph (150 to 500 km/h). The tracks or guideways, although mostly grade-separated, will in many areas run at or above grade level along existing public ROWs. Hadden, Kerr, Lewalski, & Ball, in a 1992 report described the typical alignment in most areas as one in which the ROW will be shared with interstate and other major highways [1], so that the HSGGT vehicles or trains will overtake or approach highway traffic at very high relative speeds. Depending on the topography and the different radius of curvature requirements of the HSGGT line and the highway, there will be many points at which the guideways will diverge from and reapproach the highway or pass over it. In some areas, the HSGGT vehicles will emerge abruptly from the mouths of tunnels in the vicinity of the highway.

1.2 Rationale

In recent years it has been suggested by participants in several conceptual development conferences and workshops addressing human factors and safety aspects of HSGGT, and particularly of very high-speed maglev (magnetic levitation) systems with optimal service speeds of the order of 250 mph, that the risk of a startle-induced accident might be significant. This concept was postulated categorically by Hadden, Lewalski, & Ball (1992) [1], although the presumption that the physiological startle response causes accidents appeared to be unsupported by any empirical evidence, epidemiological data, or other substantiating research. These same authors drew attention to the lack of any existing data relating traffic accidents to startle; but nevertheless suggested a probable need for startle mitigation devices, such as visual screening of the guideway.

"Startle effect," as a concept quite properly received mention as a potential safety threat in a 1990 Federal Railroad Administration (FRA), broad agency announcement of human factors and other research requirements for the assessment of magnetic levitation transportation system technology [2]. This study addresses that concern.

Other detailed studies of existing or prospective high-speed rail and maglev HSGGT system safety, while they did address a range of human factors including shared right-of-way (ROW) aspects [1, 3, 4, 5], have not evaluated, and in some instances never addressed at all, the question of HSGGT startle effect as a potential hazard to nearby highway traffic. However, the premise, although hypothetical, that the involuntary human startle response of highway drivers to the sight, sound, or other manifestation of the rapid passage of an HSGGT vehicle could pose a serious threat meriting preventive (startle mitigation) measures remains a reasonable and compelling one in the view of some officials in the Federal Railroad Administration (FRA), the United States National Maglev Initiative (NMI), and other agencies.

This study was accordingly funded to determine whether there are in fact any significant empirical or research data to support the premise; and hence to determine the need to develop startle mitigation technology to enhance highway safety in the vicinity of American HSGGT systems. The study also included a concurrent search for information on any existing startle mitigation technology already in use in the United States or elsewhere for the protection of highway traffic from the real or presumed threat.

Existing precedents for potentially adverse HSGGT rapid passage effects include, for example: (1) the running of fast (95 to 200 mph) steel-wheel trains beside and across highways at grade level or over bridges, a long-familiar sight in many European countries and in Japan; (2) the sudden appearance of low-flying aircraft above the highway near airports and in military flying areas; and, (3) abnormal traffic (such as speeding heavy trucks or emergency vehicles) on the highway itself.

2.0 THE STARTLE REACTION

2.1 Definition and nature of "startle" vs. "surprise"

The startle reaction may be defined in the present context as an immediate and short-lived (order of 0.5 to 2 seconds) whole-body reflex of flinching, jerking, jumping, crouching, running, and blinking caused by any sudden, unexpected, and sufficiently intense visual, acoustic, and mechanical stimuli (e.g., vibration, impact, or pressure wave). The adequate stimulus for startle is usually a very steep rise-time, a very high intensity stimulation of the sensory receptors (e.g., must be greater than 90 dB SPL for sounds), with a very high signal-to-noise ratio. Startle conforms with all normal properties of reflexes. Startle is involuntary, habituates with repeated elicitation, exhibits spontaneous recovery, and can be conditioned.

Startle is a normal, unconscious, generalized physiological response to any unanticipated and sufficiently intense external stimulus; accordingly, motorists must expect to be startled on occasion during highway driving. In his 1986 textbook on noise and human efficiency, Loeb describes how "unexpected intense stimuli" (lights, sounds, etc.) elicit a complex but transient reflex response in man (as in all other vertebrates, including livestock and wildlife). The startle response includes eye blink, bodily orientation towards the stimulus (orienting response), flexion of the knees in standing subjects (ducking), and internal cardiopulmonary responses, such as changes in heart and respiration rate, blood pressure, peripheral blood flow, and the electrical resistance of the skin [6]. These reactions are characteristic of the organism being alerted automatically-before conscious perception and cognitive response- to a sudden potential threat. Regarding acoustic startle (due to high-speed aircraft fly-overs), Rosenberg (1991) has reported that the startle effect can be triggered by impulse noise with a rise time exceeding 30 dB/second [7].

The muscular and autonomic reflex response has also been described in detail by Davis, Buchwald & Frankman (1955) [8], noting the very transient nature of the reaction. It is the brevity of the startle response and the strong adaptation with repetition, prevailing expectation, swift cognitive identification of the source, and increasing familiarity with the stimulus that make it questionable whether a startle effect due to HSGGT operations will increase the prevalence of highway driving accidents. Nevertheless, the startle response is measurable when evoked by unexpected events such as those occurring as an individual drives a car. This conclusion was reached by Ziperman, Haskell, and Smith (1975) in a study that found that, although non-accident connected, unexpected deployment of airbags in automobiles does evoke a startle reaction, good control of the vehicle continued in drivers 19-74 years old [9].

However, the startle reflex can demonstrably cause brief but rapidly recoverable disruptions of on-going human activity and skilled task performance. Military human factors research, for example, has studied the effect of battle noises on soldiers' rifle-aiming [10], although the relevance of such findings to possible impairment of the highway driving task by HSGGT operations may be remote.

Expectation and repetition of the provocative stimulus usually reduce substantially the magnitude and duration of the response and its effect on cognitive function and skilled performance. However, as Landis & Hunt (1939) pointed out in their classic account of the startle pattern [11], adaptation may never be complete.

2.2 Causes and effects of startle

One or more of the following effects of rapid passage of a HSGGT vehicle may be:

- Sudden noise, including sounding of audible warning devices
- Sight (sudden appearance of a fast-moving HSGGT vehicle; or of its lights at night)
- Mechanical disturbance of the highway vehicle (ground vibration, pressure wave, or air turbulence from aerodynamic vortex-shedding)

Acoustic startle - In the 1960s a considerable amount of research was done to determine whether the atmospheric propagation of loud booms cast off by supersonic military and commercial (e.g., Concorde) aircraft would adversely affect the comfort, safety, health, and hearing of the people on the ground. Kryter (1970) considered the startling effect of booms, or of sudden high-speed aircraft fly-over noise, to be significant only as a component of public annoyance due to noise from aircraft operations, with disruption of critical task performance being an improbable consequence as a practical matter [12].

This view of acoustic startle has been supported by a number of other authorities [13-16]. It may be recalled in this connection that, as a result of public complaint during the Federal Aviation Administration's (FAA) 7-day, Oklahoma City F-104 sonic boom tests during that era, the Oklahoma City council prevailed upon the government to stop the tests, which created booms with an overpressure of 1.2 psf in inhabited areas [13]. At no time during that study, however, or in other work reported by Kryter and his associates [14], or in contemporary research on sonic boom effects conducted by the Southampton University Institute of Sound and Vibration Research (ISVR) in England, was there any recorded instance of a highway or other (domestic or industrial) accident having been attributed to startle caused by a sonic boom (although, studies by ISVR have indicated that excessive on-going industrial noise may be hazardous to safety for other reasons, including stress effects on task performance, and interference with communication) [15].

Similar conclusions were drawn from studies of public reaction to artillery fire heard from military practice ranges near populated areas: the startle factor contributes to the rating of community annoyance due to noise, but startle is not apparently perceived as a threat to safety because it might cause accidents [16,17].

Visual startle - Abrupt or intense visual stimuli can be startling, particularly when first detected in the peripheral field, depending upon a number of factors determining detection. Those factors include apparent size, brightness, rapidity of onset (flash), relative speed, apparent closeness, and rapidity of approach of the source.

Perusal of the extensive published literature on human factors, vision research, perceptual and motor skills, and safety research, however, does not yield convincing evidence that a visually induced startle reflex evoked by the sudden appearance of an HSGGT train or vehicle on a nearby track or guideway has caused or is likely to cause a highway traffic accident. Boff & Lincoln (1988) noted several types of potentially startling stimuli, including acoustic and visual ones, but observed that only noise bursts have been shown to induce a startle reflex affecting certain kinds of human task performance [18]. Paradoxically, the startle effect can bring about an improvement in scores in some kinds of performance relevant to the driving task (e.g., vigilance), probably by enhancing arousal in the central nervous system.

In aviation, both commercial and military, there is a requirement to report "near-miss" incidents, in which, anecdotally, there is always an element of startle. But it is the aviator's responsibility, like the highway driver's, to be prepared for the unexpected and to maintain or regain control. For that reason, it is plausible that startle effect is not reported, or is universally under-reported, as a proximate cause of aviation incidents or accidents.

Mechanical startle - A startle response to a mechanical stimulus is innate in vertebrates, including human beings. It is exemplified by the reflex in babies (who from birth will react to a sudden noise or a knock on their crib) and by adult human reactions to a wide variety of intrusive shock or vibration stimuli such as sudden building rattle or motion caused by traffic passage, pile-driving, quarrying or other detonations in the vicinity, severe sudden wind loads, and tremblers.

The mechanical stimulus is often associated indistinguishably with an acoustical component, with temporal separation of the onset of each component being dependent upon the distance from the source. As in the case of acoustic startle, shock and vibration startling people in buildings is usually considered a component of community alarm and annoyance [19]. On highways, the motorist may be startled by sudden displacement of his vehicle caused by a cross-wind or the close passage of a large truck or bus (a factor considered in the specification of minimum lane widths in highway engineering), nevertheless, the responsibility for maintaining or immediately regaining manual control of his own vehicle is deemed to be part of the continuous driving task.

<u>Mechanical disturbance of the highway vehicle and its control as a causative or intervening factor</u> - Mechanical disturbance of the highway vehicle and its control has become widely recognized in the HSGGT conceptual development community that mechanical displacement or disturbance of highway vehicles, and particularly those light vans or RVs, for example, which are unusually sensitive to wind gusts or the wash of passing trucks, could be a problem if there is insufficient protection of the highway (by distance or barriers) from vortex-shedding and aerodynamic pressure loads created by HSGGT vehicles passing close by. Such phenomena could conceivably aggravate a mechanical startle effect upon the driver, but it may be impossible to distinguish the physiological reflex from the direct mechanical impact of the dynamic loading of the vehicle and its control system upon the driving task as a practical matter.

Essential elements of the driving task potentially sensitive to brief disruption or impairment by startle include: (1) continuous manual control (steering, speed maintenance, and lane- and station-keeping in highway traffic); (2) vigilance, i.e., monitoring of surrounding highway activity, and particularly of the vehicle ahead and/or vehicles likely to slow down, change lanes, or exit the highway; and (3) observation (e.g., of highway signage, road surface, and other conditions).

2.3 Individual susceptibility to startle

Clinically, the startle response may be exaggerated in sufferers from certain disorders of the brain and central nervous system (e.g., some forms of epilepsy and post-traumatic stress disorder (PTSD) [20]. Also the startle response may be exaggerated in some demographically distinguishable groups of drivers (e.g., the aged, persons having certain disabilities prescribed under the Americans with Disabilities Act [ADA], and the unusually fearful) [21].

Elander, West and French (1993) found that even in the normal and healthy driving population, substantial individual differences in ability to cope with unexpected events on the highway are to be expected [22]. Moreover, conscious compensation for the initial transient disruption of task-performance by startle may be delayed or otherwise impaired in circumstances where there is perceptual conflict or a dearth of reorienting cues (e.g., when a motorist suddenly encounters an approaching light at night, or another vehicle in conditions of poor visibility such as heavy rain or fog).

It may be noted incidentally that drivers impaired by fatigue, illness, stress, drugs (including some kinds of prescribed or over-the-counter) or alcohol are likely to be particularly prone to performance impairment and possibly delayed functional recovery from startle effects, even as they are impaired in coping with any perceptually challenging or unusual event or circumstance on the highway (for instance, encountering someone running a red-light, road works, another drunk, or a stalled car on the highway at night or in fog) [23]. But again, inasmuch as it is a motorist's responsibility under law not to drive when impaired, especially by alcohol, this particular aspect of human fallibility arguably cannot be adduced in support of a rationale for implementing startle mitigation technology in the HSGGT context.

3.0 POTENTIALITY FOR STARTLE BY HSGGT OPERATIONS

The various descriptions of HSGGT systems and vehicle designs proposed for development in the United States [1, 2, 4, 5] mention or suggest several features of the evolving technology and future operations that might be startling to highway motorists sharing the ROW or driving close by or under HSGGT guideways. These features include in summary:

- Acoustic startle - Sudden loud noise from:
    - Running-gear and bogie/track interaction in steel-wheel trains
    - Aerodynamic effects in both steel-wheel and maglev vehicles or trains moving at very high speeds (> 200 mph)
    - Use of audible warning devices

(Note: Acoustic startle effect could be intensified when the HSGGT vehicle is heard unexpectedly while unseen, (e.g., in darkness or in other conditions of poor visibility.)

- Visual startle
    - Sudden appearance of a HSGGT vehicle overtaking, approaching, or flashing over highway traffic
    - Moving at very high or disproportionate speed relative to the highway traffic and/or very close to the highway
    - Appearing - from a local topographical illusion - to intersect the highway ahead at grade level
    - Use of flashing lights
    - Suddenly projecting bright lights at night or in conditions of reduced visibility
    - Lacking instant recognizability as HSGGT (possibly a problem with single HSGGT vehicles)

(Note: Visual startle is likely to be the predominant form experienced when the highway driver is insulated from all but very loud outside noises such as when one is driving, as millions of Americans do, in a roaring truck or in a closed auto with the air-conditioning on, the radio playing, or noisy children. Interior noise levels exceeding 85 dBA in private automobiles are not uncommon in such circumstances.)

- "Mechanical" (ground- or vehicle-borne) startle - Abrupt, transient displacement, shaking, or disturbance of steering of the driver's vehicle from:
    - Ground-borne shock or transient vibration from dynamic loading of the guideway and its footings adjacent to the highway (most likely to be a problem near monorail HSGGT systems using low-cost, lightweight construction)
    - Airborne pressure waves and/or aerodynamic turbulence arising from rapid passage of the HSGGT vehicle
    - Airborne pressure waves arising extremely abruptly from emergence of the HSGGT vehicle or train from a tunnel, or from behind a trackside barrier gap or ending, or from another topographical feature adjacent to the highway

4.0 METHODOLOGY

4.1 Literature review

Specific searches of the academic literature were conducted through Index Medicus (1975 to April 1993), MEDLINES, and cognate databases using "startle," "startle reflex," and variations thereon as keywords; and, through index searches of selected peer-reviewed journals in pertinent fields. These included aerospace medicine, military medicine, bioacoustics, biodynamics, ergonomics/human factors, experimental psychology, industrial engineering, neurology, cognate clinical sciences, occupational safety, occupational health, perceptual skills, motor skills, railway, highway, traffic and general safety engineering, and vision research. Index searches were mostly (but not exclusively) limited to journals and report series published from 1975 through April 1993.

4.2 Survey of agency and expert individual data and opinion

The main effort in this study was devoted to the solicitation of relevant data and/or opinion from agencies and many individual experts in the United States and in several other countries already experienced in the development and operation of revenue, demonstration, or prototype HSGGT steel-wheel rail or maglev systems. More than 250 agency scientific or technical directors, other agency representatives, and individual experts in cognate scientific, technical or administrative fields were interviewed by letter and/or telephone or in person. The majority of those contacted are listed with brief annotations in Appendix C.

Depending on agency responsibilities or individual fields of expertise, some or all of the following questions were asked (Questions 1 through 3 routinely), with variations in wording following a brief exposition of FRA's concern regarding the potential HSGGT shared or adjacent ROW startle effect problem:

1. Are you aware of any data (statistical, research, case, or anecdotal) or reports showing that a highway traffic accident(s) had resulted essentially from a motorist being startled by:
    - Rapid passage of a train near or across the highway?
    - Low-flying aircraft near an airport or military base?
    - Unusual traffic (e.g., emergency vehicle) on the highway?
2. Are you aware of any published research or empirical data indicating that the startle reflex could cause a traffic accident?

3. Do you know of any highway startle mitigation measures, devices, procedures, or programs in place or being instituted; and, if so, what type; and for what reason and by whom were they deployed?

4. Do you know of any past or present research programs addressing startle by trains or aircraft as a cause of highway accidents?

5. Are you aware of any pertinent standards, rules, or codes of practice in transportation or industry?

6. Do you know of any published research or empirical data indicating that startle could cause an industrial accident? (Addressed only to experts in industrial engineering; ergonomics and safety research or practice; or in occupational safety and health)

7. Can you identify any special groups of people with ailments or disabilities that might render them unusually susceptible to startle while driving? (Addressed only to physicians and allied medical professionals)

5.0 FINDINGS

5.1 Startle as a problem

Despite extensive inquiries made of rail and intermodal transportation authorities, operators, users, planners, and safety professionals in the United States, as well as in several foreign countries already operating HSGGT systems (see Appendix C), the present study discovered no evidence or accident data that indicated a real startle effect problem existed for highway drivers using shared or adjacent ROWs.

Railroad operators and law enforcement authorities were also contacted and were aware of no case in which a highway accident attributed to startle arising from their operations had ever been reported. The study discovered no instances where the alleged attribution of a traffic accident to startle by an event off the highway (such as sudden train passage or aircraft flyover) had led to the pursuit of a legal or insurance claim or figured as the putative cause of a traffic accident in state or local police reports. HSGGT system in North America or abroad had startle mitigation been considered a necessary policy or even worthy of expenditure on research and development.

Highway planners, traffic planners, and engineers interviewed likewise reported no known historical or current requirement for startle mitigation to protect highway users, with one possible exception: that is the fairly common deployment in the United States of stationary roadside notices advising motorists to be on the lookout for low-flying aircraft. The deployment of roadside notices was supported by Lang, Bradley, and Cuthbert because in a 1990 report they concluded the emotional state and level of arousal do affect startle, which implies that warnings and notices may not be entirely useless in the mitigation of startle [24].

These advisory notices, with such wording as "Beware of low-flying aircraft" or "Dim headlights," are deployed in military flying areas (where the highway drivers may not have a prevailing expectation of suddenly seeing an aircraft zooming low over their ROW) and on state or local highways approaching airports, put up by military or local authorities. It appears that in some military flying areas, these notices have long been erected on local command initiatives in an attempt to protect the aviator, and not the motorist, from bright headlights shining up from highways at night when the pilot is on approach.

More than one interviewee (including civil court judges and other experienced attorneys, and an airport director in the United States) opined that the startle question as raised in relation to the anticipated novel technology of HSGGT was reminiscent historically of the dire expectations that prevailed a century ago with the introduction of the automobile. Many then feared and predicted that the sudden appearance and noise of a motor car would so startle and frighten people and animals that there would be frequent accidents to bicycle riders and horse traffic. In some countries, notably Great Britain, draconian and needless legislation (later repealed) was enacted to severely restrict automobile operation in mitigation of that fear, which soon proved to be groundless.

As a follow up to the search for state and local police reports, ASTI expanded its search into case law to determine the extent to which the word "startle," or variations of it may have been used in any legal context, perhaps as a defense against liability for negligence, or in a criminal context, as a defense against culpability or blame - for example, as in a traffic accident. In a suit alleging negligence, for example, the law does recognize that there could be circumstances when liability for negligence may be excused, counterbalanced or cancelled by other factors in the situation. The case law search methodology consisted of a search in WESTLAW [25], a computer-assisted legal research service of West Publishing Company, along with an exploration of Words and Phrases [26], another West Publishing Company publication that lists all judicial constructions and definition of word and phrases by the state and federal courts from the earliest times.

Both sources revealed nothing germane to this inquiry. A "startling event" has been recognized in several civil cases as sufficient to qualify as an utterance exception to the hearsay rule. In other words, a statement made by a person as a result of a startling event rather than reflection may not be incriminating in such a context.

Further, the present study yielded no evidence that the range of startle mitigation devices which have been proposed in anticipation of a highway accident problem due to startle from HSGGT operations would be cost-effective or prevent an accident. Indeed, some expert opinion received during this study suggested that some of the startle mitigation technology that has been proposed during current HSGGT conceptual development, such as system-activated warning signals or active informational displays deployed along the highway, could be counter-productive by increasing the risk of accidents due to anticipatory rubber-necking or other disorganization of normal driver behavior in traffic (Irving, UK Transport Research Laboratory, personal communication, 1993).

5.2 Startle as a problem in other contexts

Upon discovering no evidence, including anecdotal, that the startle response alone, if triggered by the close or rapid passage of a high-speed train or low-flying aircraft (an obvious precedent familiar to the American motorist), or a startling natural event (e.g., nearby lightning strikes or suddenly encountering heavy rain or hail), had ever been the probable or proximate cause of a highway accident, inquiries were extended to the fields of military operations and industrial safety (in case more remote precedents could be established), with similarly unproductive findings. Moreover, inquiry into the question whether special motoring populations (e.g., the disabled, and those with ailments associated clinically with heightened susceptibility to startle) might be prone to startle-related traffic accidents, yielded no pertinent data.

Based on these inquiries and the broad range of other likely sources of case-history or statistical data examined, a database applicable to the highway driver startle question was found to be essentially non-existent in the United States, as well as in the several foreign countries (noted in Appendix C) investigated in which high-speed trains are already in public service. Hence this study found no published material or expert opinion upon which to base retrospective epidemiological or case-analytical studies of startle effect; or to establish a present need for the development of startle mitigation technology.

6.0 FINDINGS REGARDING STARTLE MITIGATION

6.1 Startle mitigation: conceptual taxonomy and technology

A contingent premise of this study was that a range of startle mitigation devices, either proposed by FRA or highway agencies, or discovered to be already in use in the United States or elsewhere, would be evaluated for their efficiency, reliability, and cost-effectiveness in preventing highway accidents possibly attributable to HSGGT- generated startle effects. The candidate mitigation devices or procedures would be discovered from four main sources:

- Devices or procedures already in use
- Devices or procedures mandated or recommended by laws, regulations, standards, or codes of practice
- Devices or procedures proposed as the result of contemporary research and development
- Devices or procedures suggested or proposed theoretically in current HSGGT conceptual development reports and literature

The following working taxonomy of startle mitigation devices and procedures has been developed[1] during the review of the literature and the interview of the cognate agencies and individual experts listed in Appendix C. Its applicability and usefulness becomes moot, however, if the need for and cost-effectiveness of startle mitigation cannot be established or evaluated because there is no evidence of significant HSGGT/highway startle effect to mitigate.

Taxonomy of startle mitigation devices and procedures:

- Planning and engineering
    - Distance: adequate separation of guideway and highway
    - Visibility: adequate marking and lighting of guideway
- Devices

---

[1] *Enquiries of various US Department of Transportation agencies (including FAA, FRA, NHTSA, and NTSB), state highway authorities, and counterpart agencies in foreign countries already providing HSGGT yielded no existing taxonomy of startle mitigation methods.*

- Active:
    - Audible warnings of approach
        - On the HSGGT vehicle
        - On the guideway or trackside (system-activated)
        - System-activated transponders in highway vehicles
    - Visual warnings of approach (system-activated)
        - Sequential lights or flashers
        - Adaptive informational displays
- Passive:
    - Visual screens or barriers
        - Built structures
        - Plantations of trees or shrubbery
    - Turbulence/pressure-wave attenuators (for locations where highway and HSGGT separation is narrow)
- Signage: stationary roadside warning notices and railroad signs
- Highway markings and/or texturing, e.g.,:
    - Assured clear distance enhancement devices (chevrons and other highway markings)
    - Rumble strips
- Distinctive night lighting of HSGGT vehicles and guideways

- Administrative
    - Laws and regulation of highway traffic in HSGGT vicinity
    - Establishment and enforcement of highway speed limits in HSGGT territory

  - Road vehicle construction and stability requirements for unrestricted use of highways in HSGGT territory

- Information and education

  - Public service information and announcements to familiarize the motoring public with HSGGT manifestations and enhance safety consciousness

  - Drivers' education: inclusion of instruction about driving near HSGGT ROWs (analogous to education about grade-crossing safety)

- Protection of special populations, e.g., the disabled or people with ailments rendering them unusually prone to startle (if shown to be at special risk from HSGGT startle or rapid-passage effects)

- Operational

  - Speed restrictions on HSGGT systems in particular areas where (due to unusual topography or other factors) an unusual risk of rapid passage effects on nearby highway traffic has been identified

6.2 Existing startle mitigation practices

In a search for existing startle mitigation devices (apart from standard railroad grade-crossing and related warnings), startle mitigation practices were found to be very few and primitive (mainly exemplified by advisory notices of the kind already mentioned (e.g., "Beware of low-flying aircraft").

In the United Kingdom, Japan, and European countries already advanced in HSGGT technology, startle mitigation (and, accordingly, the expenditure of public funding on startle mitigation devices) is reportedly considered to be a nonexistent problem. In the United States, Hadden, Kerr, Lewalski, & Ball, [27], described occluding vertical metal strips used on narrow medians of certain highways as startle effect "barriers," although it was unclear whether the devices mentioned were actually intended for that purpose or to prevent glare from opposing highway vehicle headlights at night. Those authors cited specifically such an array on State Route 315 in Ohio; but the Ohio state department of transportation confirmed during the present study that the array described is to prevent continuous headlight glare and dazzle, not startle (Thomas, G., Ohio Department of Transportation, personal communication, 1993) [28].

Wayside fences and barriers, notwithstanding their added burden to HSGGT system installation and maintenance costs, are currently being advocated or considered for grade-separated systems proposed for the United States. Startle mitigation, however, is apparently not yet part of the rationale for erecting them. Their proposed functions include the prevention of trespassing and vandalism [29], although in some locations they could conceivably be engineered to serve also as acoustic and visual screens.

Except for traditional stationary roadside signage of the kind already mentioned as installed where low-flying aircraft may interact with highway traffic, there appear as yet to be no existing startle mitigation technology or an established need for it, even in areas where HSGGT systems have been in safe revenue service close to and openly visible from busy highways for many years.

The French TGV (Train à Grande Vitesse: high-speed train), for example, has flashed alongside and over French highways during more than ten years of operation with service speeds exceeding 185 mph; and without any screening or other startle mitigation devices deemed necessary to protect adjacent motorists. The TGV's safety record remains exceptional [30]. The same is reportedly true of the Japanese Shinkansen ("Bullet Train") after 25 years of commercial operation at service speeds that are somewhat lower than the TGV but still higher (> 125 mph) than have yet been a familiar experience in the United States.

7.0 CONCLUSIONS

7.1 Potentiality of startle effect from HSGGT systems

It is natural to be startled by sudden and unexpected events during highway driving or any other human activity; but it does not follow that the physiological startle response can cause irrecoverable loss of control leading to accidents on the highway [31]. The present study discovered no evidence that startle alone, due to the sudden appearance or rapid passage of a high-speed train, a low-altitude aircraft, or any other dramatic occurrence close to highway traffic, had ever caused or could cause an accident. An important proviso is of course that the motorist is trained to expect and cope with the unexpected; and must exercise, unimpaired, normal competence and responsibility in the driving task (maintaining or swiftly regaining control of his vehicle) as required by law.

With but a few cautionary provisos regarding the possibility of perceptual conflict supervening after a startle response in unusual circumstances (e.g., the sudden appearance of a high-speed train's lights from a tunnel, over a hill, from around a bend at night, or in other conditions of poor visibility and reduced cues to spatial location and orientation), more than 99% of the agency and individual experts surveyed opined that startle was unlikely to be a significant, if real, cause of an increased prevalence of traffic accidents due to HSGGT operations affecting highway drivers in shared or adjacent ROWs.

7.2 Likelihood of need for HSGGT startle mitigation

Hence the results of this study were essentially negative and do not justify recommendation of a startle mitigation program other than perhaps the deployment of simple signage to alert highway drivers of the proximity of HSGGT operations; and public information, education, and familiarization regarding HSGGT technology, safety, and the extent of future operations in the United States.

By the same token, the expenditure of substantial public funds on developing and implementing elaborate startle mitigation technology (such as system-wide wayside screening or system-activated live signage) for American HSGGT systems was generally considered difficult to justify because it would be unlikely to play any significant or demonstrable role in highway accident prevention. Indeed, some of the devices (e.g., system-activated train approach warnings or active descriptive signage) could in some instances conceivably be counterproductive with regard to highway safety by triggering rubber-necking, dithering, or racing on the highway.

8.0 RECOMMENDATION

It is of course impossible to prove with certainty that a hypothetical problem is non-existent; and it cannot be said that sheer startle due to HSGGT operations could never cause a highway accident. Before highway driver startle due to HSGGT operations be dismissed as a risk, it is recommended that:

> Consideration should be given to the development and implementation of an effective, popular, nationwide public information and education campaign to make the American motoring population aware of and knowledgeable about the appearance, safety, and national worth of future HSGGT systems and vehicles to be deployed around the country under federal government and regional initiatives. This effort should include both general public service programs in the media, including actual and simulated images of HSGGT trains in motion as seen from the highway, to familiarize the public with them; and the inclusion of additional material in driver's education and safety programs addressing the same topic.
>
> Such informational and educational efforts directed through the press and popular media are likely to be invaluable and very cost-effective in allaying public nervousness or uncertainty about HSGGT, specifically those aspects concerning its potential startle effect and general system safety. In some cases, antipathy towards HSGGT or fear of the new technology; and other adverse psychological attitudes or reactions to it could conceivably engender a predisposition toward altered driving behavior or performance when encountering HSGGT vehicles.

APPENDIX A

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APPENDIX B

GLOSSARY, ABBREVIATIONS, AND ACRONYMS

ADA.	Americans with Disabilities Act [acronym].
dB.	decibel [abbreviation].
dBA.	
e.g.	for example [abbreviation].
etc.	et cetera [abbreviation].
FAA.	Federal Aviation Administration [acronym].
FRA.	Federal Railroad Administration [acronym].
HSGGT.	high speed guided ground transportation [acronym].
i.e.	that is [abbreviation].
ISVR.	Institute of Sound and Vibration Research [acronym].
km/h.	kilometer per hour [acronym].
maglev.	**adj.** Magnetically levitated [abbreviation]. **n.** A maglev vehicle or transportation system.
mph.	miles per hour [acronym].
NHTSA.	National Highway Traffic Safety Administration [acronym].
NTSB.	National Traffic Safety Board [acronym].
NMI.	National Maglev Initiative [acronym].
orienting response.	A (generally mild) facet of the startle pattern in which the startled person or animal instinctively turns briefly to face the source of the triggering stimulus.
psf.	pound per square foot [acronym].

PTSD.	post-traumatic stress disorder [acronym].
ROW.	right-of-way [acronym].
RV.	recreational vehicle [acronym].
SPL.	
startle.	**n.** Involuntary (reflex) flinching, temporary orientation of attention towards the stimulus, and transient physiological changes triggered by any abrupt and unexpected stimulus. [Synonyms (terminologically redundant): startle reaction, startle reflex, startle response.]
	v. To cause the effect.
startle effect.	A (usually adverse) transient disruption or interruption of human task performance or activity in man or animals caused by any abrupt or unexpected physical stimulus or event.
startle mitigation.	The theory and practice of preventing or reducing adverse startle effects by engineering, procedural, or other devices.
TGV.	Train à Grand Vitesse [acronym].
UK.	United Kingdom [acronym].
U.S. DOT	United States Department of Transportation [acronym].

APPENDIX C

AGENCIES AND INDIVIDUAL EXPERTS SURVEYED

I. AGENCIES CONCERNED WITH TRANSPORTATION SYSTEM SAFETY OR COGNATE HUMAN FACTORS

Agency[2]	Key[3]
Aeromedical Training Institute	
Aerospace Medical Association (AsMA)	MTG
AsMA Aerospace Human Factors Committee	
Alabama Highway Dept., Public Transportation Div.	NOT
American National Standards Institution	NOS
ANSI/HFES 100 Cttee (U.S. Member, ISO Technical Committee 159, Ergonomics)	NOS
American Society of Safety Engineers	NOS
Amtrak	SEV
Argonne National Laboratory	
[USAF] Armstrong Aerospace Medical Research Laboratory	
Army Aeromedical Research Laboratory	
Army Corps of Engineers	SEV
Association of American Railroads, Safety Research Div.	
Aviation/Airport directorates:	
Charlotte	HSC
New Orleans International Airport	
NOIA Noise Mitigation Project Office	
New Orleans Lakefront Airport	
Richmond	
San Diego	DNR
Bay Area Rapid Transit (San Francisco)	
Brotherhood of Locomotive Engineers	DNR
California Dept. of Transportation, Rail Div.	
California-Nevada Super Speed Ground Transportation	
Canada:	

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[2] *All agencies and individuals contacted were in the United States unless indicated otherwise.*

[3] *A key to remarks or special comments follows this listing. Where no entry is made, the respondents knew of no history, perceived problem, cognate research, standards, or mitigation technology, policy or programs pertaining to startle effects as a probable cause of highway or industrial accidents.*

Agency	Key
Canadian Institute of Guided Ground Transport	
Canadian Pacific Railway System	
National Research Council, Div. of Physics	NOS
Ontario Ministry of Transport	
Quebec Ministry of Transport	
Transportation Safety Board of Canada	
Transport Canada (Railway Safety Office)	
Carnegie-Mellon U High Speed Ground Transportation Center	DNR
Center for Ergonomics, University of Michigan	
Civil Aeromedical Institute	
Crew System Ergonomics Information Analysis Center	
CSX Transportation	
Czech Republic National Institute of Public Health	NOS
Eurotunnel (UK and France)	TUN
Federal Aviation Administration, Office of Aviation Medicine	NOS
FAA National Plan for Aviation Human Factors	
FAA Technical Center	
Federal Highway Administration	NOT, NOS
Fiat Ferroviaria (Italy)	SCR
Florida Department of Transportation, Office of High Speed Transportation	
France:	
SNCF (French National Railway) TGV	
Trans-Manche Super Train	TUN
Germany:	
Deutsche Bundesbahn (German Federal Railways)	
InterCity Express (ICE)	
Transrapid International	DNR
Verband der Deutsche Bahnindustrie EV (VDB)	
High Speed Rail/Maglev Association	SEV
Highway Safety Research Center, U.N. Carolina	
[J.B.] Hunt Transportation, Inc. (Safety & Claims)	DNR
Institute for Transportation Systems	DNR
International Foundation for Industrial Ergonomics & Safety Research	SEV
International Loss Control Institute/Norske Veritas	INS
International Organization for Standardization -	

Agency	Key
National delegations:	SEV, NOS
British Standards Institution (BSI)	
Dansk Standard (Denmark) (DS)	
French National Standards Association (AFNOR)	
German National Standards Institute (DIN)	
Italian Institute for Standardization (UNI)	DNR
Norwegian Standards [Institute] (NS)	
Swedish Standards Institute (SIS)	
Insurance Institute for Highway Safety	DNR
Japan:	
HSST Corporation	
Railway Technical Research Institute	
Shinkansen	
Liberty Mutual [Insurance] Research Center	INS
Long Island Railroad MTA (Safety Improvements Office)	
Louisiana:	
Chamber/ New Orleans & the River Region, Transportation and Rail Committees	SEV
Dept. of Safety & Corrections	POL
Dept. of Transportation & Development	SEV
Highway Users Federation	DNR
Jefferson Parish Department of Planning	
Jefferson Parish Sheriff's Department	POL
Louisiana State University Medical Center	
New Orleans City Planning Commission	
New Orleans Public Belt Railroad	
Regional Planning Commission (New Orleans & region)	
Southern University at New Orleans, Intermodal Transportation Program	
Statewide Intermodal Transportation Plan	MTG
Transportation Research Center	
University of New Orleans, College of Engineering	SEV
University of New Orleans, Dept. of Psychology	
Mercedes-Benz AG, Germany	
National Academy of Sciences/NRC Committee on Hearing & Bioacoustics (CHABA)	
National Aeronautics & Space Administration (NASA)	SEV
NASA Johnson Space Center, Man Systems Div.	NOS
NASA Langley Research Center	

Agency	Key
National Highway Traffic Safety Administration	NOT
National Safety Council (NSC)	SEV, NOT
NSC Highway Traffic Safety Division	
NSC Railroad Section	
NSC Traffic Records Committee	
National Transportation Safety Board	NOT
Naval Aerospace Medical Research Institute	
Naval Aerospace Medical Research Laboratory	
Naval Biodynamics Laboratory	
Naval Safety Center	
New York State Energy Research & Development Authority	
Ohio High Speed Rail Authority	NOT
Operation Lifesaver	
Oregon Dept. of Transportation	NOT
OSHA	
Portugal:	
Center for Human Performance	SEV
Portuguese State Railways	NOI
Professional Aeromedical Transport Association	
Railway Technical Research Inst (Japan)	DNR
Seattle Metro Transit (Transit Safety)	DNR
Science Applications International Corporation	
Shock & Vibration Information Analysis Center	NOS
SNCF (French National Railways)	
Society of Automotive Engineers, Human Behavioral Technology/G-10 Committee	NOS
Southern Rapid Rail Commission	MTG
Spanish National Railways/RENFE (AVE train)	
Techlex Technology Law Group (Reed Smith Shaw & McClay)	
Texas High-Speed Rail Authority	SEV
Texas High Speed Rail [TGV] Corporation	DNR
Transportation Research Board (NRC)	SEV, NOT
Transportation Technology	DNR
Tulane U. (New Orleans) Dept. of Psychology	SEV,VEC
Union Internationale des Chemins de Fer (UIC)	NOS
United Airlines (Mgr., Corporate Ground Safety)	
United Kingdom (UK):	

Agency	Key
British Airways (medical directorate)	
British Rail Research	TUN
Health & Safety Executive	NOS
Institute of Highways and Transportation	
Medical Commission on Accident Prevention	DNR
Medical Research Council, Applied Psychology Unit	
Motor Industry Research Association	
Royal Air Force Institute of Aviation Medicine	
Royal Air Force Institute of Health & Medical Training	CIV, NOS
Institute of Naval Medicine	
Royal Society for the Prevention of Accidents	
Transport Research Laboratory	NOS, NOT
University of Southampton, Human Factors Research Unit	
University of Technology, Loughborough, Dept. of Human Sciences (Vehicle Safety)	DNR
University of Westminster, Human Factors Research Group	

II. AGENCIES CONCERNED WITH OCCUPATIONAL SAFETY AND HEALTH AND/OR INDUSTRIAL ENGINEERING

American Conference of Gov't Industrial Hygienists	NOI, NOS
American Industrial Hygiene Association	NOI, NOS
[German] Federal Institute for Occupational Health	
Industrial Engineering Dept., Louisiana State U.	
Industrial Engineering Dept., Texas Tech.	
National Institute for Occupational Safety & Health	
National Ports & Waterways Institute, LSU	
Occupational Safety & Health Administration	NOS
Port of New Orleans	
Swedish National Institute of Occupational Health	SEV, NOS
USDOT Maritime Administration	

III. INDIVIDUAL EXPERTS AND CONSULTANTS

Name	Key
Aghazadeh, F.	ERG
Akers, T.	ENV
Ashley, C. (UK)	
Ayoub, M.	ERG,NOS
Bachman, J.A.	CAU
Bell, L.	
Berry, M.A.	OAP
Bento Cuelho, J.L. (Portugal)	NOI
Berlin, C.	
Billings, C.E.	OAP
Bilodeau, I.	
Bittner, A.C.	PCC
Borgman, T.	OAP
Call, D.W.	OAP
Carmichael, G.	
Casey, R.J.	EDS
Castelo Branco, N.N.A. (Portugal)	OAP
Chaffin	ERG
Chaikin, G.	NOS
Cohen, H.H.	
Conner, W.	
Danby, G.	
Eastham, A.R. (Canada)	
Evans, L.	AUT
Ewing, C.L.	OAP
Fedoroff G.P.	HSC
Fitzmorris, J.	
Griffin, M.J. (UK)	NOS
Gierke, H.E. von	AUT, NOS
Handcock, J.E. (UK)	HSC
Hansen, O.K.	
Hanson, C.	NOS, NOI
Helander, M.E.G	NOS
Hoffman, D.A.	
Irving, A.	CTP
Irwin, A.	AUT, DNR
Krilov, S.	INS
Jex, H.R.	PCC
Johnson, D.L.	NOI
Jones, D.R.	EDA
Kennedy, R.S.	PCC

Name	Key
Leventhall, G. (UK)	EDL
Lidström, I-M (Sweden)	
Manninen, O. (Finland)	EDC
Mawson, A.J.	
Martinez, M.	INS
May, J.	
Maxwell, V.B. (UK)	OAP
Nammack, J.	
Paterson, W.	INS
Perry, I.C. (UK)	OAP
Peters, G.A.	AUT
Proise, M.	
Ritchie, M.L.	PCC
Sandover, J. (UK)	
Seidemann, M.	
Spang, K. (Sweden)	NOS
Stayner, R.M. (UK)	
Stramler, J.	AUT
Suter, A.	AUT, NOS
Swift, D.	OAP
Szymanski, K. (Poland)	NOS
Taylor, H.L.	
Thomas, D.J.	OAP
Tustin, W.	
Unterharnscheidt, F.J.	OAP
Vranich, J.	AUT
Waters, D.P.	EDM
Williams, M.	CAU
Yonekawa, Y. (Japan)	NOS

KEY TO REMARKS AND COMMENTS

AUT	Author of a notable and pertinent publication cited (see Appendices A and D)
CAU	Urged caution in reaching final conclusion that startle effects a non-problem
DNR	Had not responded by closure date of survey or had no comment
EDA	Editor, "Aviation, Space, & Environmental Medicine"
EDM	Editor, "Maglev News"
EDN	Editor, "Journal of Low Frequency Noise & Vibration"
EDS	Editor, "Speedlines," newsletter of the High Speed Rail/Maglev Association
ENV	Environmental & public health
ERG	Ergonomics research/standards
HSC	Remarked that the startle effect question was reminiscent of 1890s fears that the new-fangled automobile ("horseless carriage") would cause highway mayhem by startling horses and bicyclists: a fear not realized as a practical matter
INS	No record of startle as a basis for a highway accident insurance claim
MTG	Several individuals interviewed at meetings
NOI	Startle not currently considered in HSGGT noise programs
NOS	No applicable standards developed or in preparation
NOT	No established taxonomy of startle mitigation technology known to have been developed by USDOT or elsewhere
OAP	Physician, occupational, military, or aerospace medicine
PCC	Startle response could be prelude to perceptual conflict problem in unusual circumstances (e.g., sudden appearance of lights from fast-moving train at night), but not causal

POL	No record of citation of startle as a cause of a highway accident in police reports, statistics, or accident investigations
SCR	Has developed noise screens for use in certain limited areas where high-speed train passes urban areas or over-passes highways: unclear whether this is for startle mitigation or simple noise reduction
SEV	Agency contacted directly; and interviews with individuals at meetings
TUN	Emergence of fast trains from tunnels near highways not considered a problem meriting research or mitigation
VEC	Vection could conceivably be a problem, distracting to the motorist passed by a very high-speed train, although this is not part of startle

APPENDIX D

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