Go for Launch: ASA's Unique Positioning to Address the Growing Challenge of Rocket Noise

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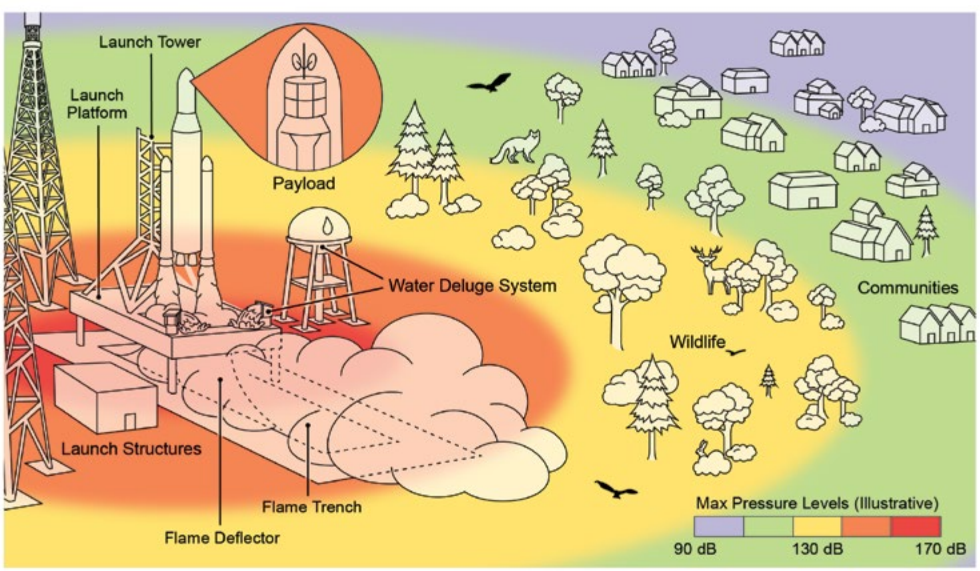
The Space Age, which started in 1957 with the launch of Sputnik 1, has evolved significantly during the past decade. This evolution is accelerating today, as new space vehicles are being developed and prepared to launch from a growing number of global spaceports. Space is being accessed for increasingly diverse purposes, including creating satellite internet networks, scientific monitoring of Earth, space tourism, and eventual crewed lunar and planetary missions. With launch industry growth comes various challenges, including those related to acoustics. In this Sound Perspectives essay, I summarize potential impacts of rocket noise and suggest that the Acoustical Society of America (ASA), with its interdisciplinary expertise in acoustics and vibration, is uniquely positioned to help address these growing challenges.

"Rockets are loud." Students and I have drily opened talks with this understatement, but the reality is that the acoustic energy produced by a rocket is so extreme that it is difficult to describe. The sound's low-frequency "rumble" is coupled with shock-like transients, or "crackle," that together form a broadband "roar" heard during launch. However, the launch creates only part of the noise footprint. Sonic booms are created by the supersonic vehicle during ascent and during reusable vehicle flyback, where they may also be accompanied by additional landing noise. And as rockets grow larger to accommodate more payload mass per launch, the resulting noise increases with thrust.

My purpose here is not to discuss rockets' history or describe their physics. Lubert (2018a; 2018b) has written

Figure 1. *During liftoff, a rocket's turbulent plume generates intense broadband noise that vibrates the launchpad, rocket, and payload and propagates to wildlife habitats and communities. Noise at the vehicle is reduced by a water deluge system and by deflecting the plume. Reproduced from Gee et al., 2024b, with the permission of the American Institute of Physics.*



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excellent histories of rockets and rocket noise mitigation. A brief rocket noise tutorial can be found in Gee et al. (2024a) and an extensive review in Lubert et al. (2022). Since that review's publication just three years ago, a great deal has been learned through additional measurements of the largest, and reusable, rockets. This essay reflects my current perspective on potential impacts of the noise associated with a rapidly expanding launch industry.

What impacts might result from launching larger rockets more frequently? As illustrated in **Figure 1**, these could range from damaging vibrations of payloads, vehicles, and launch structures (known as vibroacoustic loading, or VAL), to noise disturbances for wildlife and local communities.

Beginning at the vehicle, the primary concern is VAL. In our studies of launchpad environments, overall sound pressure levels exceed 160 dB (re 20 μPa), with peak levels around 180 dB. While sound levels inside the payload fairing (i.e., the nosecone that protects the payload) are typically lower, they can still produce significant VAL. Payloads, such as large communications satellites costing hundreds of millions of dollars, are designed to be lightweight to use smaller, more economical rockets. However, reduced satellite mass makes sensitive components more susceptible to VAL. Increasing payload mass to reduce vibration creates a new problem, as a heavier payload might require a more powerful rocket or result in a slower liftoff, both of which could exacerbate VAL. Reducing a rocket's weight using composite materials also introduces VAL challenges for vehicle designers.

Rocket VAL during liftoff and early ascent has been studied since the 1960s. Since accurate physics-based modeling for payload and vehicle VAL remains a challenging undertaking, payloads and vehicle components undergo extensive noise and vibration testing to mimic the liftoff environment and ensure sufficient ruggedness. To mitigate VAL, launchpad water deluge systems and plume deflectors are designed — often after initial test launches — to reduce the noise arriving back at the vehicle.

Beyond the launchpad, rocket noise may have environmental impacts. In Florida, Kennedy Space Center and Cape Canaveral Space Force Station are adjacent to the Merritt Island Wildlife Refuge and Canaveral National Seashore. On the west coast, the California Coastal Commission has expressed concern at the rapidly increasing launch cadence from Vandenberg Space Force Base, which is home to several threatened and endangered species. Although the long-term impacts of increased launches and landings are not well understood, short-term behavioral changes my students and I have observed include flocks of birds startling and taking flight, nearby birds' evening chorus ceasing for several minutes, and schools of fish jumping. While watching a Starship Super Heavy launch from six miles away, we saw a herd of deer galloping in the opposite direction of the launchpad in a city park by a busy roadway. To address potential concerns and update environmental assessments as needed, acousticians, ecologists, launch providers, range operators, and policymakers should collaborate to protect endangered and noise-sensitive species.

Communities near spaceports face different, but related, challenges. Launch noise and sonic booms with significant low-frequency energy can cause vibrations that rattle windows and doors, potentially damaging fragile structures. Beyond risk of structural damage within the closest communities, there are still impacts. For example, residents along portions of California's coast have reported being awakened or otherwise disturbed by sonic booms during rocket ascents. The City of Port Isabel, Texas, six miles from SpaceX's Starbase, conducted its own noise study due to residents' concerns about Starship launches.

From my perspective, shaped by working on some of these challenges with students and colleagues, additional science is needed to understand how to mitigate VAL around launchpads and to guide noise policies. We have collaborated with launch providers to measure noise environments around launchpads during liftoff and are studying the impacts of launch noise and booster flyback sonic booms on endangered species at Vandenberg Space Force Base. Downrange, we have also made coastal measurements of ascent sonic booms to study their impact on California residents and environmentally sensitive areas. We have worked with industry and government researchers to improve models for launch noise, and our recent measurements of Starship launches from Boca Chica, Texas, have broadened these connections significantly. Through these efforts, I have interacted with stakeholders that include government biologists, aerospace engineers, environmental consultants, and homeowners. Their diverse requirements and perspectives highlight the need for additional science and ongoing dialogue to find balanced solutions.

I believe the ASA can facilitate this dialogue. With 14 technical committees and a technical specialty group on acoustics education, ASA is uniquely able to address multifaceted challenges of launch acoustics and vibration. Here are examples of how members of different ASA committees can contribute:

- **Animal Bioacoustics:** Study the short- and long-term effects of rocket noise on threatened and/or endangered species.
- **Architectural Acoustics:** Examine the design and construction of buildings in response to low-frequency launch noise and sonic booms.
- **Computational Acoustics:** Improve accuracy and efficiency of numerical simulations for rocket noise and sonic boom generation and propagation.
- **Education in Acoustics:** Use rocket noise as a tool for STEM outreach and create effective resources to inform policymakers.
- **Engineering Acoustics:** Study transducer design and performance in high-amplitude, high-temperature environments.
- **Noise:** Develop appropriate metrics for launch noise and sonic booms. Organize special sessions and workshops to foster communication.
- **Physical Acoustics:** Study infrasound propagation from rockets and the nonlinearity of noise generation and propagation.
- **Physiological and Psychological Acoustics:** Assess human auditory and non-auditory responses to launch noise.
- **Signal Processing in Acoustics:** Improve phased-array measurement techniques and algorithms and characterizing broadband noise around launchpads.
- **Structural Acoustics and Vibration:** Improve and validate testing methods and models for payload and vehicle VAL.
- **Underwater Acoustics:** Study the transmission of rocket noise and sonic booms into shallow bodies of water.

Although other professional societies focus on topics such as aeroacoustics, noise, and vibration, only ASA's scope is sufficiently broad to comprehensively address all facets of launch vehicle vibroacoustics. And location matters: more than 50% of 2024's record-breaking 261 orbital space missions launched from United States spaceports.

Not only will the world benefit from ASA's engagement in rocket noise issues, but ASA itself will also gain from it. While our society typically functions with quasi-independent technical groups, solving complex, interdisciplinary challenges like determining rocket noise impacts requires broad thinking, timely action, and effective communication with diverse audiences. I believe these challenges could spark cross-cutting collaborations among ASA members and strengthen our connections with acousticians and aerospace engineers in regions where rockets are launched, such as China, Europe, Japan, and Australia (Gee et al., 2024a).

To date, how has ASA been involved with launch vehicle acoustics? Since 2010, colleagues and I have hosted over a dozen special sessions on jet and rocket noise at domestic and international ASA meetings and have invited the broader aeroacoustics community to participate. Perhaps more importantly, we have chosen to mostly publish in ASA journals rather than those more focused on aerospace sciences. These publications include the aforementioned review, as well as high media-interest articles on the Saturn V (Gee et al., 2022) and NASA's Artemis-I launch (Gee et al., 2023).

Additionally, an article about the Starship Super Heavy measurements (Gee et al., 2024c) highlights our society's ability to think creatively and act swiftly when timing is a factor. After collecting data during Starship's fifth flight, in a whirlwind of activity we submitted an article that published in *JASA Express Letters* just five days before the next launch. As a result, I was able to promote the ASA during a Flight-6 launch livestream interview discussing Starship and rocket acoustics. The host's encouragement for viewers to read the article caused so many people to try to download it that the server blocked them in response to a presumed cyberattack. The livestream (bit.ly/4g91qSV) has been watched more than 1.6 million times and the article and its sequel (Gee et al., 2025) combined have been viewed over 14,000 times.

The purpose of sharing these efforts and anecdotes is to demonstrate that rocket noise and vibration is a topic of growing global interest. As the frequency and scale of rocket launches increase, ASA has a meaningful opportunity to advance launch acoustics impact determination and mitigation for the benefit of both humanity and the environment. I conclude with three ideas for making this happen:

- To promote cross-disciplinary interactions at ASA meetings, special sessions should have organizers from all cosponsoring technical committees.
- To foster a relationship between industry, government, and academia, the Technical Council could host an ASA meeting-adjacent workshop or symposium that allows attendees to be educated on essential elements of rocket acoustics, environmental impacts, etc. and allows for flexible discussion of key issues. *Proceedings of Meetings on Acoustics* could be used to document the symposium outcome.
- This symposium could lead to a joint special issue of *The Journal of the Acoustical Society of America* and *JASA Express Letters* on the topic of rocket vibroacoustics and its impacts.

Hopefully, these activities can bring together all stakeholders — from launch providers to environmental policy experts — to promote increased, sustainable access to space. I believe ASA has a unique role to play. Are we ready to launch?

References

Gee, K. L., Mathews, L. T., Anderson, M. C., and Hart, G. W. (2022) Saturn-V sound levels: A letter to the Redditor. *The Journal of the Acoustical Society of America* 152, 1068–1073. https://doi.org/10.1121/10.0013216

Gee, K. L., Hart, G. W., Cunningham, C. F., Anderson, M. C., Bassett, M. S., Mathews, L. T., et al. (2023). Space Launch System acoustics: Far-field noise measurements of the Artemis-I launch. *JASA Express Letters* 3, 023601. https://doi.org/10.1121/10.0016878

Gee, K. L., McLaughlin, B. W., Mathews, L. T., Edgington-Mitchell, D., Hart, G. W., and Anderson, M. C. (2024a). Launch Vehicle Noise and Australian Spaceports. *Proceedings of Meetings on Acoustics* 52, 040002. https://doi.org/10.1121/2.0001856

Gee, K. L., Lubert, C. P., and James, M. M. (2024b). The roar of a rocket. *Physics Today* 77(3), 46–47. https://doi.org/10.1063/pt.izel.cyox

Gee, K. L., Pulsipher, N. L., Kellison, M. S., Mathews, L. T., Anderson, M. C., and Hart, G. W. (2024c). Starship super heavy acoustics: Far-field noise measurements during launch and the first-ever booster catch. *JASA Express Letters* 4, 113601. https://doi.org/10.1121/10.0034453

Gee, K. L., Pulsipher, N. L., Kellison, M. S. Hart, G. W., Mathews, L. T., and Anderson, M. C. (2025). Starship Super Heavy acoustics: Comparing launch noise from Flights 5 and 6. *JASA Express Letters*. 5, 023602. https://doi.org/10.1121/10.0035925

Lubert, C. P. (2018a). Sixty years of launch vehicle acoustics. *Proceedings of Meetings on Acoustics* 31, 040004. https://doi.org/10.1121/2.0000704

Lubert, C. P. (2018b). From Sputnik to SpaceX®: 60 years of rocket launch acoustics, *Acoustics Today* 14(1), 38-46.

Lubert, C. P., Gee, K. L., and Tsutsumi, S. (2022). Supersonic jet noise from launch vehicles: 50 years since NASA SP-8072, *The Journal of the Acoustical Society of America* 151, 752–791. https://doi.org/10.1121/10.0009160.

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How loud is NASA's Space Launch System?

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In this episode of Across Acoustics, Kent Gee talks about his research trip to measure the launch acoustics of NASA's Artemis-I mission, explains why understanding launch noise is so important, and shares common misconceptions about how loud rockets are.