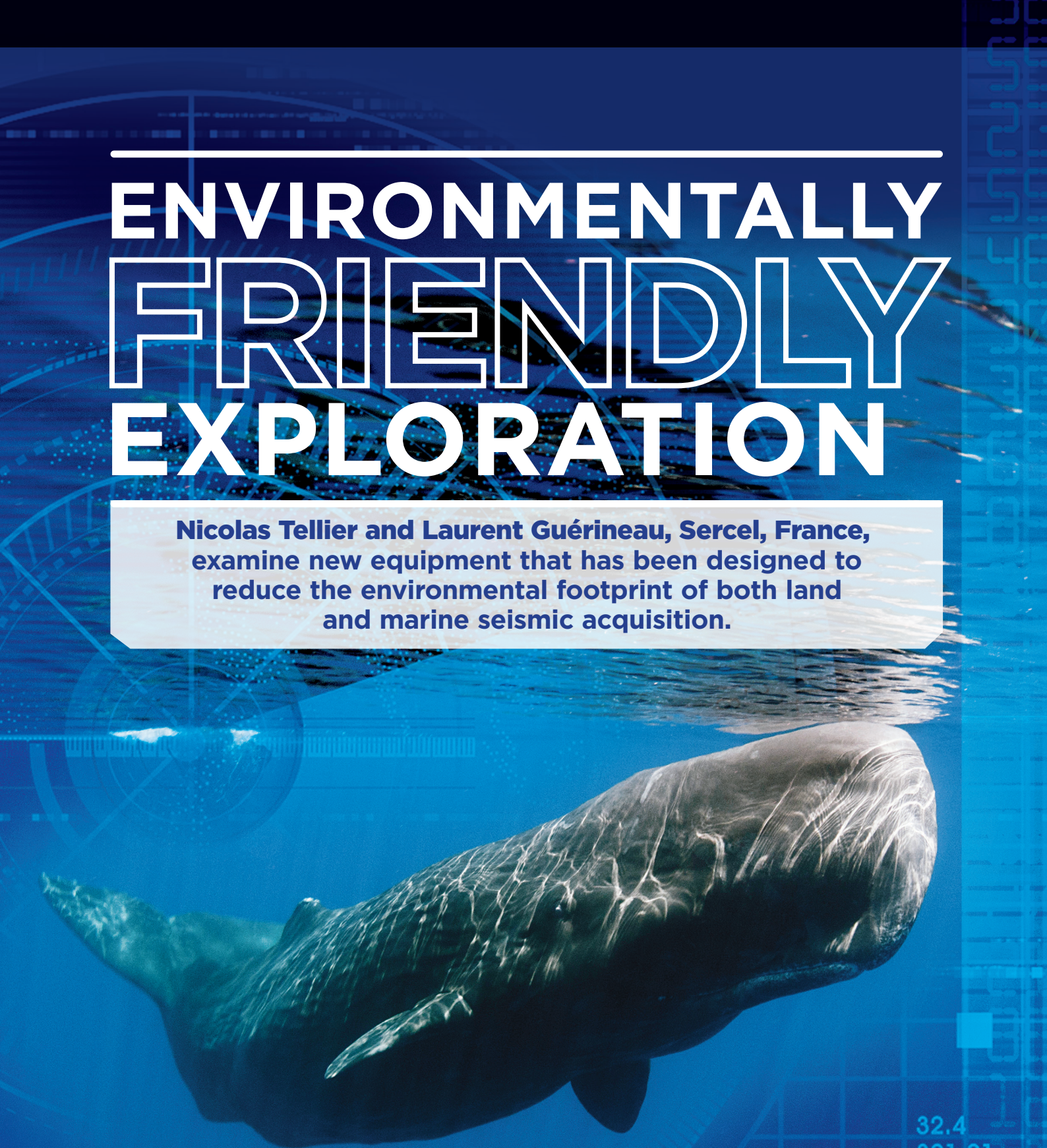
ENVIRONMENTALLY FRIENDLY EXPLORATION

Nicolas Tellier and Laurent Guérineau, Sercel, France, examine new equipment that has been designed to reduce the environmental footprint of both land and marine seismic acquisition.



For many years, the seismic industry has strived to reduce its impact on the environment.

In land acquisition, the main concern is generally vehicle traffic. Be it the source vehicle fleet roaming thousands of kilometres in sometimes fragile soil and ecosystems, or the vehicles required for the transport and supply of field staff.

In marine seismic, after more than four decades of worldwide acquisition, there is still no consensus in the scientific community on the potential impact of anthropogenic sound generated during geophysical surveys on marine mammals. This topic has lately received increased attention from the government regulators of several countries, leading to the introduction of mitigation and monitoring guidelines aimed at reducing the potential impact of marine seismic sources on marine mammals.

Figure 1. *The Nomad 15.*

Table 1. Nomad 15 specifications	
Peak force output	17 364 lbf (7724 daN)
Hold down weight	16 135 lbf (7177 daN)
Frequency range	1 - 400 Hz*
Length	6.57 m
Width	2.44 m
Height	3.11 m
Gradeability	55% (29˚)
Turning circle (curb to curb)	7.81 m
Turning circle (wall to wall)	9.86 m
Gross vehicle weight	9 T
**Full drive from 7 Hz.*	

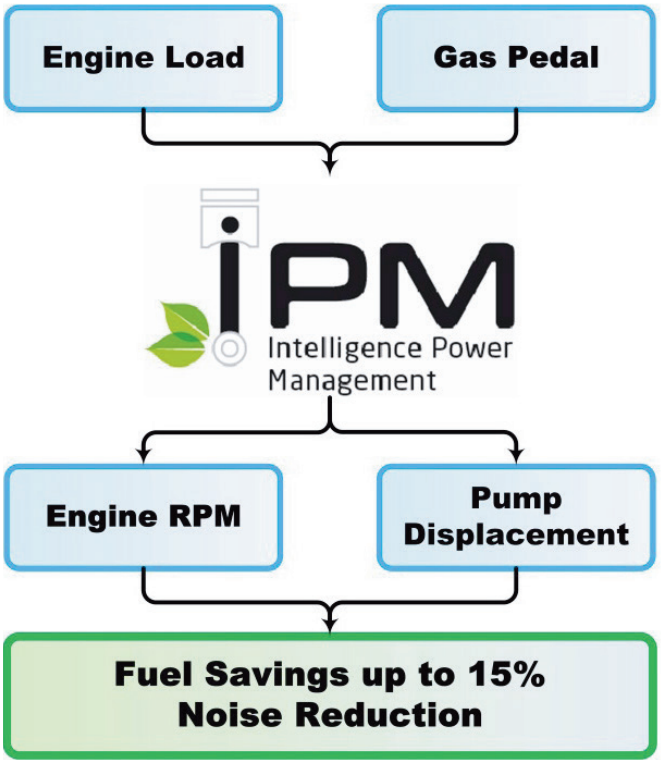


Figure 2. *The intelligent power management concept.*

Manufacturers focus their efforts to reduce the environmental impact of their equipment, and help contractors leave no more than footprints on the prospected areas. This article presents two newly released products: for land acquisition, a compact vibrator, designed to reduce the impact of energy sources; and for marine acquisition, a system to detect and localise marine mammals around the area of operation.

Reducing the vibrator footprint

The Nomad 15 is a new compact system, designed to reduce the environmental impact of the vibrator, improve accessibility and enable broadband performance. The Nomad family now offers a full range of vibrators, from light (Nomad 15 - 17 000 lbf), to heavy (Nomad 65 - 62 000 lbf) and to super-heavy (Nomad 90 - 90 000 lbf).

Emission standards compliance

The Nomad 15 engine complies with Stage 3b and Tier 4i emission standards, the EU and US regulations that define the acceptable limits of exhaust emissions – mainly nitrogen oxides (NOx) and particulate matter (PM), applicable to non-road equipment powered by diesel operating within their territories. For the Nomad 15 class of engine, NOx have been reduced by 50% and PM by 90% compared to the previous Stage 3a/Tier3 standard. Compared with the Tier1/Stage1 in force until 1999, the reduction reaches 90% for NOx and 95% for PM.

Fuel consumption reduction

In vibroseis operations, vibrator groups usually pass through production/stand-by cycles. The stand-by periods are due to various factors, such as: short weather stand-by, line testing and repair, or third-party interference. Vibrator stand by is also dependent on the topography of the survey area (flat desert requiring less stand-by than detour intensive small fields or uneven terrain), and on the methodology used (single source blended acquisition yielding less stand-by than single fleet or flip-flop). So while some Middle East or North Africa crews may dramatically reduce stand-by time, it remains significant in many other areas.

Unlike road vehicle engine operation, the engines used on vibrators are driven at a constant speed measured by the rotations per minute (rpm). Even when the vibrator is on stand-by, the engine runs at full rpm, greatly exceeding the power requirements of the vibrator at that given moment. Idling the engine requires driver intervention and is rarely carried out during short stand-by periods.

Intelligent power management (IPM) is a new feature developed for the Nomad 15, and made available for the entire Nomad family (Figure 2). IPM automatically adjusts the engine RPM to equal the power required for the vibrator's current mode of operation, without any action from the driver. This is accomplished through measurement of the engine load and the signal denoting the accelerator pedal position. This new feature can help significantly reduce fuel consumption, as well as noise and exhaust emissions.

A field test carried out by a seismic crew using five vibrators, each working for more than 2000 hours, showed fuel savings of up to 15% on the two vibrators equipped with IPM.

Noise mitigation

Another important aspect in vibroseis operation is noise emission. The power required to shake the ground necessitates the use of strong engines. The vibrators available on the market, in their standard configuration, do not come equipped with noise mitigation devices. Optional soundproof covers are available, but are rarely purchased by contractors.

Soundproof covers are mandatory for operations in some areas, such as the European Economic Area.

Noise assessment in the field is not easy, as it is highly dependent on measurement distance and location, surrounding noise, engine load, engine cooler and air conditioning operation. Manufacturers do not provide much information on vibrator noise levels. Nonetheless, without an engine soundproof cover, it is common to have noise levels above 95 dB 1 m from the engine, and 85 dB 7 m away. Such levels of noise become an important issue while operating either in populated or fragile animal habitats.

On the Nomad 15 vibrator, noise reduction is maximised by the means of an included soundproof engine housing, as well as the IPM system that reduces engine noise during stand-by periods. The maximum noise level is reduced to 77 dB just 7 m from the side of the vibrator, and less than 70 dB 7 m in front of the vibrator.

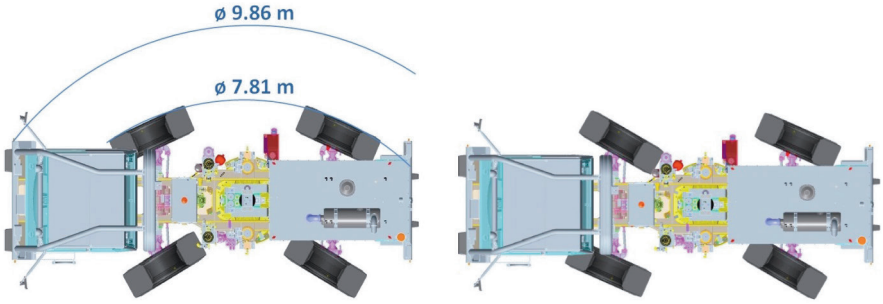


Figure 3. *Directional steering modes: in addition to the standard mode, where only the front wheels provide steering, the Nomad 15 has two special directional modes to ease access to difficult areas: co-ordinated mode (left), the wheels turn in opposition offering an enhanced turning radius, and synchronised mode (right), which allows the vibrator to move in a sideways direction, often referred to as 'crabbing'.*

Accessibility and broadband capacity

Nomad 15 was developed to offer excellent accessibility. Its compact dimensions (Table 1) and manoeuvrability, excellent turning radius (7.81 m curb-to-curb, 9.86 m wall-to-wall) combined with four directional wheels offering several steering modes (Figure 3) for ease of access to the toughest areas, usually closed to larger or heavier vibrators. The different modes offer the best solution for navigating difficult terrain and reduce the need for a winch or external assistance when operating in soft soil conditions. Its powerful hydraulic transmission makes it a capable climber of even the steepest slopes (over 55%).

To foster the development of broadband acquisition, Nomad 15 offers high performance at both low and high frequencies. The Nomad 15 can initiate a sweep at 1 Hz with reduced force; reaching full force at 7 Hz. High frequencies of up to 400 Hz are achievable, depending on ground characteristics, and are made possible by an extra stiff circular baseplate. The hydraulic peak force (17 364 lbf) is higher than the hold-down weight (16 135 lbf) to compensate for the mass-to-baseplate phase shift above the ground cutoff frequency. High frequencies are particularly beneficial when imaging shallow targets.

Monitoring marine mammals

Over the years, there has been a growing number of regulatory agencies requiring or encouraging the use of passive acoustic monitoring (PAM) for real time detection and localisation of marine mammals within the exclusion zone (EZ) in order to minimise the potential environmental impact from marine seismic sources.

The exclusion zone – usually defined as the radius around the seismic sources within which mitigation measures, such as seismic source shutdown, are implemented – is generally set at 500 m.

Current PAM systems are typically comprised of a dedicated towed array containing several hydrophones, an onboard signal conditioning and data acquisition device, all of which is connected to a dedicated computing system.

Although the potential value of PAM as a real time mitigation tool has been recognised by most regulatory agencies, the currently available PAM systems, while well suited for research and scientific use, are limited as tools for marine seismic surveys:

On the acquisition vessel, the management of a dedicated PAM towed array poses safety concerns for operators during the deployment and retrieval phases. The current PAM systems also greatly increase the risk of entanglement with lead-ins and streamers, which increases the likelihood of unnecessary downtime and equipment replacement costs for the seismic contractor.

Figure 4. *PAM towed array entanglement with lead-in.*

PAM towed arrays are usually deployed a few hundred meters from the back deck of the seismic vessel. The boat-induced noise masks the vocalisation of marine mammals and the vessel wash acts as an acoustic barrier, both of which hinder the system's ability to detect cetaceans.

Commercially available PAM systems typically rely on a single linear antenna containing a limited number of hydrophones, which leads to several restrictions in terms of system performance:

- Limited forward detection/localisation performance, which is a direction of particular interest, and the inability to solve the port/starboard localisation ambiguity.
- The limited number of hydrophones may not provide enough information for localisation in some cases, and does not offer any redundancy in case of hydrophone malfunction.
- The use of a single antenna results in operational downtime during night-time in case of entanglement. Indeed, PAM being the only mammal-monitoring tool available at night as marine mammal observers cannot operate; its unavailability leads contractors to wait until day time to resume operations.
- Towed arrays do not provide any QC status concerning their state of health, elevating the risk of operating a malfunctioning system.
- Poor low frequency response, which may exclude some whale species from being identified through acoustic monitoring.

Current PAM system software is not intuitive, making it cumbersome to configure and operate:

- Expert PAM operators are required for configuration and operation as there are no standard software settings for optimal results. System performance is inconsistent and highly dependent on the skills, ability and experience of the operator.
- Expert skills are required to analyse the data, confirm acoustic detections, reject false alarms, provide range estimates, etc. This subjective interpretation is operator-dependent and results in inconsistent, unreliable performance.

Cutting the volume

A new fully integrated passive acoustic monitoring system known as QuietSea overcomes many of the limitations of current PAM systems.

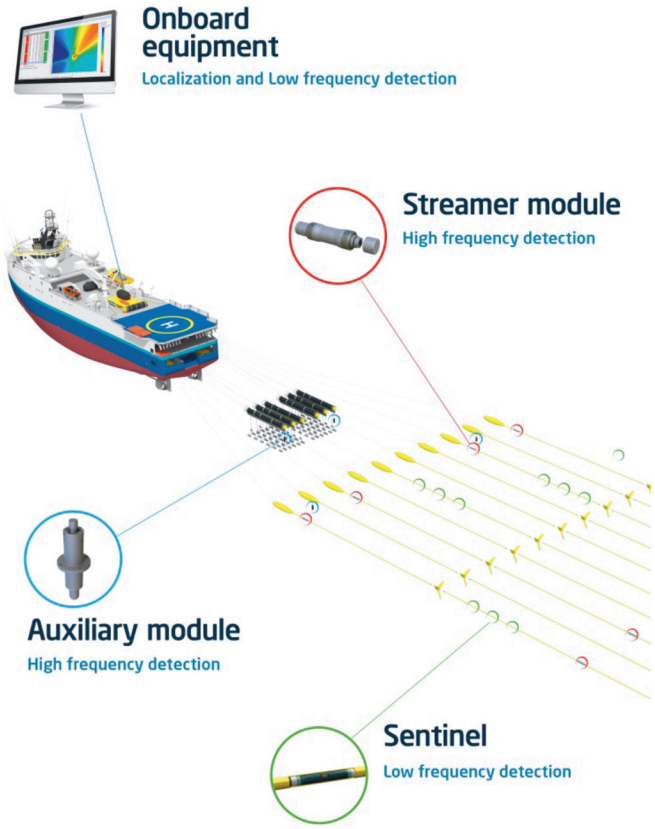


Figure 5. *QuietSea insea architecture.*

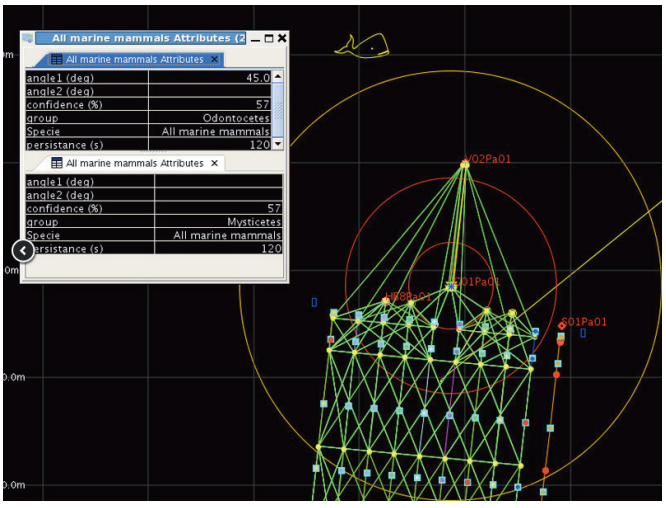


Figure 6. *SeaProNav display showing Exclusion Zones and localised cetacean.*

Designed to integrate with the Seal 428 seismic acquisition system, SeaProNav navigation system, and incorporated in the Sentinel® streamer, this system offers various benefits to seismic contractors.

By eliminating the need for deployment of separate PAM antennas at sea, the QuietSea system mitigates the possibility of accidents during deployment, retrieval and operation, thus reducing the possibility of downtime and possible equipment replacement costs.

In addition, the bidirectional communication with the navigation software, coupled with the network of broadband in-sea modules seamlessly integrated within the Sentinel® streamers, provides improved cetacean localisation accuracy and real time reporting of detected events for faster decision making.

QuietSea offers an enhanced monitoring of the exclusion zone (EZ) and beyond. Thanks to the very low noise Sentinel hydrophones, the system utilises up to 512 sensors to monitor baleen whales, such as blue whales, down to 10 Hz.

Additionally, numerous broadband hydrophones seamlessly integrated within the streamers and placed in strategic positions (on streamer heads, outside the vessel wash and close to the centre of the EZ) constitute a large, redundant 2D array that provides good detection and localisation of baleen and toothed whales, regardless of the listening direction.

QuietSea relies on advanced automated detection and localisation algorithms, which drastically decrease the false alarm rate, delivering truly objective, consistent and reliable information for decision making, regardless of the skills, ability or experience of the operator.

The QuietSea GUI is designed to be intuitive and user-friendly, with minimal settings, relying on self-adjusted software parameters to deliver stable performance across various environments.

The rugged and reliable in sea modules are based on a field-proven design, with a built-in quality control capability that allows the system to assess the health of the hydrophones as well as the detection performance of the modules.

QuietSea provides seismic contractors with a reliable PAM system optimising the control of their environmental footprint.

Conclusion

New equipment accompanies the seismic exploration industry effort to reduce its environmental impact.

In land acquisition, noise, particle emissions, as well as fuel consumption are significantly reduced thanks to compact vibrators including features such as IPM, Stage 3b/Tier 4i emission standard compliance and soundproof housings. Combined with high accessibility and broadband capacity, such vibrators are ideal seismic sources for various applications, such as limited access areas (populated areas, forests, narrow lanes, or sebkhas), mixed source shooting (where large and small vibrators operate according to terrain type for optimal productivity), imaging of shallow targets with high frequencies (for mines, gas storage or CO_2 sequestration) and complete or partial replacement of dynamite by safer and more productive sources.

In marine acquisition, PAM is recognised as a promising tool to complement current mitigation measures during geophysical surveys, but has yet to realise its full potential.

QuietSea's integrated PAM system addresses most of the limitations encountered in today's PAM systems, making it the most intuitive PAM system available for marine seismic surveys.

By carefully balancing both the expectations of the regulatory agencies and the operational constraints of the seismic contractor, systems such as QuietSea will help PAM gain the wide acceptance it deserves among the marine seismic industry while actively contributing to the reduction of the environmental footprint of marine seismic surveys.