Steel E-Motive Q&A

1. What is Steel E-Motive?

Steel E-Motive is a virtual vehicle concept that showcases the advantages and benefits of Advanced High-Strength Steel products and technologies for the development of future vehicle programs. The program focuses to a large – but not sole – extent on battery-electric and autonomous applications, with an emphasis on total lifecycle sustainability.

2. What is the aim of the Steel E-Motive project?

Ultimately, it is to advance and enable not only the journey to Net Zero emissions, but also the quest for autonomous vehicle safety, comfort, and affordability. By providing a roadmap of structural and sustainability innovations, the Steel E-Motive concept can be immediately utilized by global manufacturers at attractive cost levels using existing supply infrastructure. In so doing, for congested urban environments where increased ride sharing/hailing is an imperative, Steel E-Motive can effectively facilitate the adoption of the greater shared vehicle occupancy critical to reducing emissions per passenger.

3. Who developed Steel E-Motive?

Steel E-Motive has been developed by WorldAutoSteel, a global consortium of 18 companies working together to enhance and communicate advanced material applications in the automotive industry. The project is led by George Coates, WorldAutoSteel's Technical Director, and Neil McGregor, Chief Engineer at Ricardo for the Steel E-Motive project. Key partners are Ricardo (UK), a premier global engineering and environmental consulting firm, and ARRK Engineering (Germany), a globally active development partner for the automotive and mobility industries.

4. Why has WorldAutoSteel developed Steel E-Motive?

The project was conceived as a means of inspiring designers and engineers to select Advanced High- Strength Steels (AHSS) as materials of choice for both driver-piloted and autonomous future programs. Steel's central role in the trajectory of the automobile dates back over 120 years. WorldAutoSteel's legacy of leadership brings with it the responsibility to continuously innovate to help meet ever-evolving societal challenges. The journey to Net Zero Emissions is one of the greatest challenges humankind has ever faced. WorldAutoSteel's research in developing Steel E-Motive has illuminated a path forward on which today's steel can enable sustainable, safe, comfortable, and affordable solutions for future mobility.

5. What kind of a vehicle is the Steel E-Motive concept?

The Steel E-Motive (SEM) program includes two vehicle concepts based on a single modular platform. SEM1 is a standard-wheelbase 4-passenger urban version for inter-city travel. It has a compact design and vehicle footprint and front-wheel electric drive. SEM2 is a longer wheelbase 6-passenger extra-urban version, with front- and rear-wheel electric drive. SEM2 maximizes use of SEM1 componentry to reduce cost and optimize manufacturing infrastructure.

6. What are the key features of Steel E-Motive?

• Conceived to support Level 5 Autonomy. Void of driver interfaces, SEM architecture affords a spacious, airy, comfortable, and safe environment for occupants.

• Planned to meet or exceed stringent high-speed frontal, side, rear, and rollover crashworthiness standards – all enabled by innovations in modern Advanced High-Strength Steels. Autonomous vehicle concepts have tended to focus on crash avoidance, via technologies such as cameras, radar, and lidar. WorldAutoSteel decided that, since it is impossible to completely eliminate the chance of collisions, world-class crashworthiness had to be a foundational dimension of Steel E-Motive's mission.

• Designed to be affordable, in terms of not only production but also lifecycle. Steel E-Motive is designed to be produced using existing manufacturing infrastructures to deliver low production costs – critical for broad adoption.

• Fully engineered to enable start-ups to advance quickly, to significantly reduce cost and time to market.

• Optimized for sustainability. Steel thicknesses are minimized for lower mass, and material utilization is maximized for reduced production needs and lower emissions. Autonomy further reduces operating emissions thanks to drive cycle smoothing. High-occupancy vehicle usage – critical to a Net Zero future – must represent enticing (for riders) and profitable (for providers) alternatives to traditional vehicles. Steel E-Motive's easy access, spaciousness, and comfort make that higher occupancy inviting.

• Envisioned as a key enabler of Mobility as a Service (MaaS). Urban mobility disruption is contingent on cost competitiveness versus such existing solutions as private ownership and traditional taxis. Steel E-Motive is designed to uniquely meet or exceed stringent global crash requirements while maintaining the low-cost advantages that modern steels provide. Steel's strength and durability contribute to longer vehicle service life and, thus, further reduce lifecycle costs, as does steel's industry-leading recyclability.

7. Will the concept's design and findings be shared with the automotive industry?

WorldAutoSteel will make the Steel E-Motive portfolio of designs, trademarkable innovations, engineering data, and CAD data available freely and transparently to the industry without restrictions. Both concepts (SEM1 and SEM2) are manufacturable using the world's existing infrastructure at costs that support profitable margins for manufacturers and mobility service providers alike. The innovations offer significant learning opportunities for the world's automotive engineering community that can influence new steel architectures for safer, more affordable, and more sustainable vehicles. Many structures, such as the side structure hex beam energy absorber and battery carrier frame, can be adopted for conventional vehicle architectures for efficiency improvements today.

8. What "firsts" does Steel E-Motive debut?

Steel E-Motive is the world's first autonomous vehicle engineered to meet the global high-speed crash requirements, with performance in keeping with an Insurance Institute for Highway Safety (IIHS) "Good" rating. SEM includes seven AHSS structural innovations (listed below). SEM1's 622 lb. (282kg) body structure represents 25% reduced mass compared to an expected reference vehicle of 825 lb. (374kg). The battery carrier frame is another industry first. SEM's steel-enabled battery integration makes its battery carrier frame 37% lighter than the average reference battery packaging, while also reducing cost by 27%.

The seven key innovations are made possible by applying Steel E-Motive's steel portfolio of 64 high-strength grades and steel technologies available globally. Many of these innovations do not have to wait for the future. They can be studied and deployed in conventional vehicle architectures for more efficient vehicles on the road to net zero.

1. B-pillarless one-box open body structure
2. Globally deployable short front crash zone
3. AHSS extended passenger protection zone
4. Small offset crash glance beam
5. (Rocker) hex beam energy absorbers
6. Scissor doors with virtual B-pillar
7. Coverless battery carrier frame

9. What aspects of Steel E-Motive's design contribute to its stellar crash safety assessment?

The design team met with representatives of the IIHS to review crash-management approaches and simulation results for Level 5 autonomous vehicles, as intrusion targets for these vehicles have not yet been established. IIHS generally agreed with the SEM approach, calling its targets "reasonable and logical."

• The use of AHSS in the roof bow, battery frame, and rocker (floor) minimizes deformation in crashes. The double-walled bottom cover for the battery pack protects batteries from road debris and jacking errors.

• The battery packaging achieves stringent global battery electric vehicle requirements, including China's GB 38031-2020, incorporating 100kN crush load.

• The use of scissor doors, which enable virtual B-pillars, contributes to crash performance. In the front safety structure, a variety of steels permit crush rails to absorb energy, glance beams to redirect energy, and rigid pieces to prevent cabin intrusion, while maintaining a very short front overhang.

• In the side structure, AHSS steel in A- and C-pillars align with front and rear occupant seating areas to provide lateral protection, while the combination of the hex beam absorber innovation, Advanced High-Strength Steel cross members, integrated B-pillars, and a robust battery carrier frame provide excellent side intrusion and battery protection.

10. What emissions reduction does Steel E-Motive promise?

Ride sharing and ride hailing autonomous vehicles increase average passenger occupancy, thus enabling optimization of CO_2 emissions per passenger-mile.

• A mass-efficient vehicle – like SEM – using improved battery technology and a renewable energy grid offers lifecycle emissions savings of 60% compared to a 2022 benchmarked conventional electric vehicle with a single occupant.

• With additional steel decarbonization, actively pursued by the steel industry, along with high passenger capacity (3+ occupants), the benefits of autonomous vehicle drive-cycle smoothing, and extended vehicle life (due to steel's durability) and battery life, vehicle emissions can reach lifecycle emissions reduction of ~86%. Net zero achievement will likely require production carbon-capture and a 100% renewable grid supply.

• In the production process, emissions are significantly reduced through the design by minimizing material thickness and maximizing material utilization.

11. What challenges in vehicle design has Steel E-Motive overcome?

Steel E-Motive demonstrates how AHSS products and technologies can solve unique architectural challenges in lightweighting and safety (see above). It also offers passengers ease of ingress and egress including disability access (e.g., through the use of AHSS to allow the B-pillar to be removed from the body and integrated into the scissor-door system). The high levels

of comfort, safety, and accessibility will meet the main user and fleet operator requirements for autonomous ride hailing vehicles, fostering user acceptance required to reach high-capacity use.

12. Why is steel considered a sustainable choice for autonomous vehicles?

• Steel's strength, durability, repairability, and recyclability offer or enable strong environmental performance from a lifecycle perspective. These characteristics are particularly important in ride hailing vehicles, which will need to have a useful life that is at least 2X longer than current passenger vehicles. These characteristics are completely aligned with the needs of these next-generation vehicles. Existing steel-making processes already have significantly lower production emissions compared to all other automotive structural materials – and our industry efforts will only strengthen that gap.

• All steelmakers are considering and implementing technologies to reduce their production emissions. Several are in the process of converting to EAF, DRI, or HBI processes to achieve this in the near-term, and the industry has developed and piloted technologies to take advantage of carbon capture, utilization, storage (CCUS), and clean hydrogen when those come online. In addition, steel is infinitely recyclable, with a strong recycling infrastructure already established throughout the world.

13. What advantages does Steel E-Motive offer vehicle manufacturers?

Steel E-Motive can be produced using existing global manufacturing and supply resources at cost levels that support profitable margins. Steel E-Motive concepts are engineered for high-volume production (>250,000) using conventional vehicle manufacturing facilities and equipment, thus reducing investment cost. The stamped and fabricated steel body structure is an inherently lower-cost solution through such cost saving measures as:

• High elongation and high-strength steel grades enable components with complex geometry to be integrated into single stampings, reducing part count and tooling costs.

• Lower cost roll forming and roll stamping methods were applied for constant section profiles.

• The integrated body and battery structure consolidates parts, and the large side doors have enabled the deletion of body side outer panels.

• The SEM vehicle and body structure cost is competitive with current production BEV vehicles.

14. How soon might Steel E-Motive become reality?

Because Steel E-Motive can utilize existing global manufacturing and supply resources, production could start as soon as 2030. Vehicles based on the Steel E-Motive concept could be autonomized and in widespread use in urban and suburban environments around the world by

2030-2035. Additionally, Steel E-Motive is a fully engineered vehicle, whose CAD data, provided freely and without restrictions, can help start-ups significantly shorten their time to market.

15. What is the difference between ride hailing and ride sharing?

Ride hailing and ride sharing are similar. Both are services for hire. Ride hailing, however, could mean one person in one hired car. Ride sharing indicates more than one person using the same vehicle to get to one or more destinations. To reach net zero emissions goals, ride sharing vehicles need to average three or more occupants per vehicle.

steel@worldautosteel.org

https://steelemotive.world/

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