2016 North American Automotive Structural Manufacturing Technology Innovation Award
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Background and Company Performance

Industry Challenges

According to the 2014 International Energy Agency report, the total number of vehicles in the world is projected to double by 2050. The market will be driven by different types of vehicles, including various fuel-powered and all-electric vehicles. Advancements in electronics such as autonomous vehicles will lead to corresponding advances in the mechanics of automotive engineering, safety and design. Against this backdrop, the industry is augmenting engine platforms globally, with an emphasis on reducing carbon dioxide and other emissions from vehicles.

The rapidly increasing number of vehicles is a major contributor to pollutant emissions. Automobile exhaust is a prominent source of greenhouse gas emissions. While consumers are led to focus on tailpipe emissions when considering environmental impact, vehicle operation is far from the only source of pollution. Fuel and vehicle manufacturing processes themselves contribute significantly to greenhouse gas emissions. Governments from different countries are working toward imposing new regulations to reduce greenhouse gas emissions. The automotive industry is working toward developing cost-effective and reliable methods to address this problem.

The automotive industry is on the verge of a profound transformation: Manufacturing processes and technologies are shifting and expanding, including the advent of cooperative robots, increased sensorization, and additive manufacturing technologies. Although these technologies are innovative and potentially disruptive, they do have certain challenges and limitations in the automotive space.

Most automotive chassis manufacturers employ plasma cutting, stamping, tooling, and welding technologies that are not sustainable or energy efficient. These processes and methods are expensive and used extensively in manufacturing high volume cars to reach the breakeven point and gain profitable return on investment. In addition, conventional manufacturing processes lead to material and energy waste, require long cycle time, and are not cost effective due to equipment maintenance and massive fixed capital costs.

At present, an efficient and refined structural manufacturing technology in the automotive sector is needed. The technology must be seamlessly integrated into the existing manufacturing process flow with a high quality, lightweight, efficient, eco-friendly, and cost-effective chassis system.

Against the backdrop of these challenges, California-based Divergent 3D has developed a novel method to manufacture chassis systems for all types of vehicles. The end product is a dematerialized, high quality, and light weight chassis system which radically decreases vehicle pollutant emissions, withstands extreme forces, and delivers high performance with increased fuel efficiency, providing users with an excellent return on their investment.
Technology Attributes and Future Business Value

Industry Impact

Different vehicle specifications, as well as diverse techniques and tools used by vehicle manufacturing companies, lead to greater pressure on the chassis because of the weight of the metal or alloy used in manufacturing. The end products are heavy vehicles which contribute toward higher emissions. In addition, depending on the vehicle, high, medium or low end chassis developed by automakers are tuned to specific conditions such as size and strength. Therefore, heavy vehicles diminish engine performance and reduce fuel efficiency, raising concerns with regard to pollutant emissions. To address these challenges, original equipment manufacturers (OEMs) in the automotive domain are working towards developing a lightweight, low cost and high quality chassis system suitable for use in all markets globally. However the manufacturing process should be taken into consideration before integrating such a platform in any vehicle.

Divergent 3D, a California based company, has developed a proprietary patent-pending 3D metal printing process enabled by direct metal laser sintering (DMLS) that marks a profound advancement for chassis manufacturing. 3D printed Nodes – complex connectors joining a mixed topology of carbon fiber and other standardized structural materials - are the underlying technology for the Divergent 3D chassis system. Their technology significantly decreases the process/cycle time and reduces the material, equipment, and labor needed to manufacture an eco-conscious, cost-effective, lightweight, and efficient vehicle chassis.

This unique method gives manufacturers more freedom in component design and production by using less energy and fewer raw materials. The lightweight Node architecture increases vehicles’ performance, safety, and fuel efficiency. It is also cost effective when compared with the technologies currently available in the market, such as hard metal tooling and stamping. Key features of this technology are high efficiency and low operating cost. In effect, Divergent 3D’s chassis design results in dramatically lower emissions in both manufacturing and operation.

Best practices Example:

Divergent 3D chassis is a mixed topology system that can be applied to any vehicle type, from sports cars to pickup trucks. It can cut the total life-cycle emissions of a passenger vehicle in half and reduce the capital cost of designing and manufacturing vehicles by 10x. Therefore, the 3D Node technology has broad appeal and is expected to be used by automakers in Europe, Asia, and the United States in the next two to five years, and has the potential to set a benchmark through its installation in vehicles of all types.

Product Impact

Divergent 3D has developed a flexible technology platform by combining the data derived from its software and hardware platforms to profile the customized design of chassis
accurately and efficiently. Divergent 3D uses software to change the design according to specific preferences, removing the need for expensive fixed hard metal tooling and capital intensive stamping equipment. The 3D printed Node technology uses less energy and raw materials than traditional methods, and allows manufacturers to quickly print and build complex structures without the need for metal tooling and stamping equipment. Divergent 3D is the only company developing this novel Node technology, and has filed numerous patents. Currently, certain prototyping and engineering companies are trying to incorporate and infringe this technology for development of different automobile manufacturing processes. The engineering and research team from Divergent 3D has efficiently optimized the process and decreased the cycle time for printing and building the chassis by two magnitudes after considerable research on materials suitability, shear strength, torsion strength and the stiffness properties of individual components used to build the chassis. In addition to chassis systems, Divergent 3D’s product portfolio includes 3D printed suspension and powertrain components. Divergent 3D continues to develop the technology to reduce production cycle time and scale for volume production.

Divergent 3D has developed an engineering prototype supercar called Blade, which marks the dawn of a new era in vehicle performance and manufacturing efficiency. Based on the company’s 3D printed Node architecture, Blade accelerates from 0 to 60 mph in just over 2.5 seconds thanks to 700 horsepower, 500 lb-ft of torque, and a dry weight of only 1,388 lbs. The vehicle is currently under the process of obtaining safety certification.

Best practices Example:

Developing technologies that have the capability of catering to present and future needs of the global market in various industrial segments is a key strategy for growth. Over time, the market for 3D Node technology and complex structure manufacturing with the help of aluminum alloy and standard lightweight structural materials is expected to increase significantly.

Visionary Innovation

The vision behind Divergent 3D’s chassis system and Blade supercar is based on developing a data driven approach where manufacturing material and energy efficiency are key metrics. Divergent 3D has adopted a dematerialization strategy to decrease vehicle weight and improve the power-to-weight ratio, thereby dramatically reducing operating emissions.

Divergent 3D’s partnerships with companies that share its vision will enable it to create affordable, fully functional pilot vehicle programs to concretely demonstrate the technology’s revolutionary potential. Its team of global experts collaborated on developing the core technology and ensuring a constructive feedback loop, which underscores Divergent 3D’s adherence to industry best practices.
The Divergent 3D Blade supercar has a better power-to-weight ratio than a Formula 1 car, yet maintains high fuel efficiency. Furthermore, the vehicle’s light weight results in less wear and tear on roads and infrastructure.

**Customer Acquisition**

The automotive industry is Divergent 3D’s primary focus, though applications may expand to other industries in the long term. Although competitors are emerging in the automotive domain, Divergent 3D has an advantage because its technology enables faster, lower-cost production of greener, lighter, and safer vehicles.

Divergent 3D will support their customers in building specialized, lightweight chassis systems based on individual preferences. The company plans to build a library of 3D printed components so that customized chassis production is more readily available. It will deliver 3D printed node technology to customers by the end of 2016.

The company expects to primarily generate revenue from automotive manufacturers in Asia, Europe and the United States over the next 5 years, but hopes to expand its customer base to construction, oil and gas, and other industries within 10 years.

**Best Practices Example:**

Divergent 3D’s energy-efficient design of the chassis platform reduces vehicle chassis weight by up to 90% compared to traditional technologies. In addition, Divergent 3D technology is agnostic when it comes to drive train and fuel type, whereas mainstream companies are still working toward achieving this flexibility. It’s data-driven approach is based on a life-cycle environmental analysis using the National Academy of Sciences GREET and AP2 model, letting Divergent 3D optimize drive train and fuel source for a vehicle’s use case and manufacturing location. These factors help Divergent 3D provide excellent value to the customer and clients.

With their 3D printed Node technology, Divergent 3D has opportunities to acquire new customers in the automotive, transportation and logistics domains. In addition, it will also be used in other industries such as oil and gas.

**Technology Licensing**

Licensing is a key revenue and commercialization strategy for Divergent 3D. The company will license its proprietary technology process to all global automotive OEMs and original design manufacturers to expand their research and development portfolios. Licensing of Divergent 3D’s production system is the preferred business model and revenue from long-term agreements would fund further technological developments.

The company’s solution can be applied in the aerospace, construction, and oil and gas industries, as well as in other automotive and transportation applications. The technology is suited for any vehicle type including sedans, trucks, buses, vans, minivans, station
wagons, RVs, trailers, tractors, go-carts, trains, motorcycles, boats, spacecraft, or airplanes. Moreover, different types of structures where this technology can be employed include towers, buildings, lightweight cycles, bridges, lighting structures, furniture, stages, trusses, or walls.

**Brand Equity**

Governments around the world impose environmental regulations to restrict hazardous emissions and increasingly support additive manufacturing as a means of reducing costs and improving product life-cycles. These initiatives will let Divergent 3D take advantage of the situation and increase its brand equity with the rising population of environmentally conscious customers.

Divergent 3D position themselves as pioneers in 3D printed vehicles. This has earned them a wonderfully strong and positive response from the press. Print media, broadcast media, and social networking websites have touted Blade as among the fastest cars in the world, with a beautiful form factor and very low environmental impact. Divergent 3D stokes a fire in producers and consumers to rework manufacturing systems to attain the above-mentioned advantages. Divergent 3D’s technological superiority and customized approach will drive its brand to greater heights in the years ahead.

**Conclusion**

Divergent 3D’s advanced chassis architecture can easily be deployed in automotive and other applications to optimize performance, increase energy efficiency, and reduce life-cycle emissions. Frost & Sullivan's independent analysis clearly shows that the technology will provide excellent customer value and increase their return on investment by reducing manufacturing and assembly costs.

Its technological achievements have earned Divergent 3D Frost & Sullivan’s 2016 North America Technology Innovation Award for Structural Manufacturing in the Automotive Industry.
Significance of Technology Innovation

Ultimately, growth in any organization depends upon finding new ways to excite the market, and upon maintaining a long-term commitment to innovation. At its core, technology innovation or any other type of innovation can only be sustained with leadership in three key areas: understanding demand, nurturing the brand, and differentiating from the competition.

Understanding Technology Innovation

Technology innovation begins with a spark of creativity that is systematically pursued, developed, and commercialized. That spark can result from a successful partnership, a productive in-house innovation group, or the mind of a singular individual. Regardless of the source, the success of any new technology is ultimately determined by its innovativeness and its impact on the business as a whole.
Key Benchmarking Criteria

For the Technology Innovation Award, Frost & Sullivan analysts independently evaluated two key factors—Technology Attributes and Future Business Value—according to the criteria identified below.

Technology Attributes
- Criterion 1: Industry Impact
- Criterion 2: Product Impact
- Criterion 3: Scalability
- Criterion 4: Visionary Innovation
- Criterion 5: Application Diversity

Future Business Value
- Criterion 1: Financial Performance
- Criterion 2: Customer Acquisition
- Criterion 3: Technology Licensing
- Criterion 4: Brand Loyalty
- Criterion 5: Human Capital

Best Practice Award Analysis for Divergent 3D

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows our research and consulting teams to objectively analyze performance, according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are illustrated below.

RATINGS GUIDELINES

The Decision Support Scorecard is organized by Technology Attributes and Future Business Value (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criteria are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.
The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, Frost & Sullivan chooses to refer to the other key players as Competitor 2 and Competitor 3.

DECISION SUPPORT SCORECARD: TECHNOLOGY INNOVATION AWARD

<table>
<thead>
<tr>
<th>Technology Innovation</th>
<th>Technology Attributes</th>
<th>Future Business Value</th>
<th>Average Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent 3D</td>
<td>9</td>
<td>9.5</td>
<td>9.25</td>
</tr>
<tr>
<td>Competitor 2</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Competitor 3</td>
<td>8</td>
<td>7.5</td>
<td>7.75</td>
</tr>
</tbody>
</table>

**Technology Attributes**

**Criterion 1: Industry Impact**
Requirement: Technology enables the pursuit of groundbreaking new ideas, contributing to the betterment of the entire industry

**Criterion 2: Product Impact**
Requirement: Specific technology helps enhance features and functionality of the entire product line for the company

**Criterion 3: Scalability**
Requirement: Technology is scalable, enabling new generations of products over time, with increasing levels of quality and functionality

**Criterion 4: Visionary Innovation**
Requirement: Specific new technology represents true innovation based on a deep understanding of future needs and applications

**Criterion 5: Application Diversity**
Requirement: New technology serves multiple products, multiple applications, and multiple user environments

**Future Business Value**

**Criterion 1: Financial Performance**
Requirement: High potential for strong financial performance in terms of revenues, operating margins and other relevant financial metrics

**Criterion 2: Customer Acquisition**
Requirement: Specific technology enables acquisition of new customers, even as it enhances value to current customers

**Criterion 3: Technology Licensing**
Requirement: New technology displays great potential to be licensed across many sectors and applications, thereby driving incremental revenue streams
Criterion 4: Brand Loyalty
Requirement: New technology enhances the company’s brand, creating and/or nurturing brand loyalty

Criterion 5: Human Capital
Requirement: Customer impact is enhanced through the leverage of specific technology, translating into positive impact on employee morale and retention

Decision Support Matrix
Once all companies have been evaluated according to the Decision Support Scorecard, analysts can then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.

DECISION SUPPORT MATRIX: TECHNOLOGY INNOVATION AWARD
The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology
Frost & Sullivan’s 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree-view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often, companies make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry players and for identifying those performing at best-in-class levels.

About Frost & Sullivan
Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best in class positions in growth, innovation and leadership. The company’s Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages over 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 40 offices on six continents. To join our Growth Partnership, please visit http://www.frost.com.