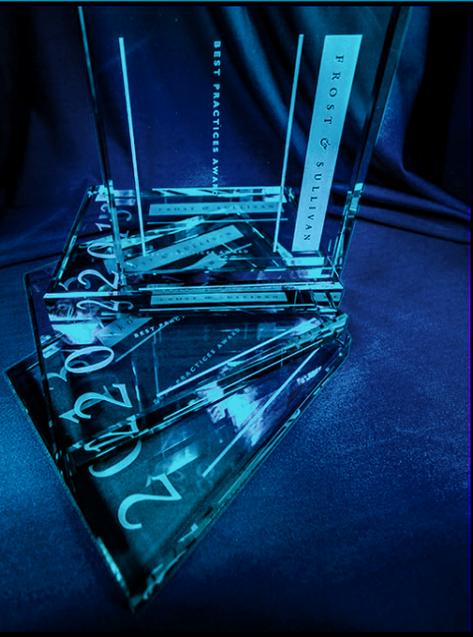




HEPTAGON™

2016 Global Near-Field Optical Sensors New Product Innovation Award



FROST & SULLIVAN

BEST
2016 PRACTICES
AWARD

GLOBAL NEAR-FIELD OPTICAL SENSORS
NEW PRODUCT INNOVATION AWARD

2016
BEST PRACTICES
AWARDS

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Background and Company Performance

Industry Challenges

Rapid technological evolution in the areas of mobile devices, electronics, augmented and virtual reality, automotive, medical equipment, home automation, and security, along with the increasing popularity of social networking and Internet of Things (IoT) products, drives consumers to use camera-enabled and sensor-assisted imaging applications. IoT innovation emphasis is now shifting away from simply connecting products to the cloud and moving towards connecting products to people. This requires miniaturization and integration of diverse technologies. Small, power-efficient sensors are integral for developing new intuitive experiences as well understanding the environment a product is operating in. Heptagon is rapidly developing a product portfolio around addressing this opportunity, i.e., the Interface of Things™. New requirements for low power and increasingly smaller size are becoming critical for the mobile, wearable electronics, augmented reality/virtual reality, and drone markets. To address this, Heptagon developed optical-electrical and packaging technology to create a new and tiny 350 um thin sensor module with highly precise and reliable detection of close proximity objects built-in, even for difficult surfaces like skin. This is a key application for AR/VR Head Mounted Displays and opens up many new applications like invisible buttons for phones and sealed products, automatic wearable activation, or reliable human contact sensors in cars. The technology platform can also be used for other applications like vital sign sensors.

These new applications show the increasing demand and growth potential across many market segments for very small, low-power and cost-effective near-field sensing solutions. The technology enabler for this next generation of ultra-small and portable products is the ability to package electronics, sensors, optics and illumination into a single complete solution while maintaining the precise measurement of available as well as reflected light in these new environments. Although optical sensors provide an array of value-added benefits such as detecting light levels by adjusting backlight intensity, providing better viewing comfort by adjusting screen brightness automatically, and reducing power consumption through activation of the power savings feature, the challenges faced by market participants remain manifold.

Such challenges include stiff competition in this market space, creating price pressures on suppliers. This situation compels companies to incorporate unique differentiating functionalities in their sensors so customers derive the best value, and consequently, the adoption rate of such solutions increases considerably. In addition, the inclusion of broad technical specifications in optical sensors translates into a significant challenge for vendors, as the operative situations tend to vary from extreme to dynamic temperature ranges. Thus developing a miniaturized optical sensor with improved communication capabilities would help address this market challenge and find seamless integration into various devices.

Companies that showcase their research and innovation capabilities by developing sensors (with enhanced and differentiating capabilities) as per changing customer preferences, therefore, find themselves best positioned to lead the market amidst relentless competition.

Match to Needs

Headquartered in Singapore and with over 20 years' experience in the industry, Heptagon is currently recognized as one of the globally leading producers and suppliers of optical and vision sensors. The company is rapidly expanding the portfolio. Recently the company introduced numerous ground-breaking optical solutions. Some examples of this are TRINITY - the industry's 1st multipoint 3D range sensor based on the Time of Flight (ToF) principle, MORA - the world's smallest all-in-one 3D adaptive stereo module, LIMA - the world's smallest and patented pattern projector for stereo systems, SWIFT - a 10Gb/s IR wireless link module, and many others in line with Heptagon's commitment to deliver the best quality and experience to its customers. The firm is focused on addressing the needs of the "Interface of Things" where small, power-efficient sensors and modules connect products to people in new and intuitive ways.

Owing to rapid technological evolution, optical sensors are being increasingly used in smartphones, tablets, and light-emitting diode (LED) TVs—gadgets that are known for increased power consumption. With their ability to optimize the display brightness, such optical sensors facilitate significant power savings, thus aptly meeting the user's need for a compact sensor that, with a reduced form factor, can be seamlessly integrated within mobile and wearable devices. The real innovation is the ability to incorporate the required technology into a system package in order to create the extremely small sensors required.

Heptagon—the 3D/imaging, illumination, and optical sensing solutions provider has uniquely positioned itself by developing and launching its 'Near-Field Optical Sensing Module' in early 2016, leveraging its proprietary, cutting-edge 'Wafer-Level Miniaturization' technology.

This Near-Field Optical Sensing Module is highly robust and is lauded for achieving the smallest module size in the global market, coupled with enriched functionalities such as low power consumption, reliable detection of skin in close proximity with the ability to work through transparent or thin "visibly opaque" cover materials for use in sealed product or invisible button applications. Heptagon's newest innovation certainly has the necessary potential to significantly penetrate varied user application areas, such as electronics, automotive, medical equipment, home automation, and security, even amidst stiff competition. Needless to say, with its customer-centric approach and strong technological skill-sets, Heptagon has established a prominent position for itself in the global optical sensors market by effectively developing products such as the aforementioned module, to meet evolving user needs.

Competitive Differentiation

Heptagon is poised for continued growth and is ready to face competition by introducing differentiated solutions to its stellar portfolio of service offerings. Having been operative in the market for many years, the company has exhibited an unmatched entrepreneurial spirit, steadily withstanding all challenges. By facilitating an internal open environment, the company has created a participative platform that encourages its customer/user partners and associates to share their innovative solutions.

Heptagon continues to differentiate itself from competitors by developing “game-changing” sensors. Heptagon has exhibited its excellence by being the first company to develop and launch the world’s smallest near-field optical sensing module. This module is possible in large part due to next generation system-in-a-package technology based on Heptagon’s wafer-level miniaturization expertise, which includes wafer-level optics, stacking, and integration. The company has demonstrated its ability to manufacture such products in high volume and on a continuous basis as shown with their recent production milestone of 2 billion units shipped. Heptagon differentiates itself from competitors in its ability to apply this cutting edge system-in-a-package technology to its entire class of optical sensors includes single and multipoint 3D range sensors, camera modules, proximity sensors and illuminators.

Furthermore, to enhance its competitiveness, Heptagon continues to invest in technology development and acquisitions like their purchase of Mesa Imaging in 2014. The acquisition brought in intellectual property and talent to design and build their own Time of Flight (ToF) pixels. ToF is one of two technologies used industrywide to add accurate distance measurements to IR-based proximity sensors. Heptagon’s release in January 2016 of the industry’s 1st multi-point 3DRanger™ TRINITY is another example of their ability to combine optical-electrical know-how and miniaturization technology into very small packages with new and differentiated features. Multi-point allows product engineers to speed up and enhance a smart phone’s autofocus by providing not only accurate distance information but also location of objects in the camera’s field of view.

To meet evolving user needs, the company has created strong system integration capabilities, all of which encompass the IoT domain. Owing to its proven expertise in these fields, Heptagon is successfully catering to customers in the entire value chain of the industrial and consumer sector.

Quality

Heptagon’s effort to introduce the best quality Near-Field Optical Sensing Module in the market has been a result of the company’s extensive effort to integrate its internal R&D outcomes with that of the customers’ unmet needs. Such collaborative efforts have helped the company develop the groundbreaking proprietary, patented wafer-level manufacturing processes in three areas, wafer-level optics used to create nanometer optical structures,

wafer-level stacking for reflowable pads, and wafer-level integration for stacked optics and filters. This achievement clearly demonstrates its top-notch quality parameters both in terms of Heptagon's developmental insight and product performance in the real-world scenarios.

Heptagon's consistent innovation, drive, and focus to ensure superior product quality (through its R&D teams based in Zurich, Silicon Valley and Singapore) have resulted in the company developing this highly reliable, small, low-cost, and extremely accurate sensor. Previously, companies struggled to eliminate the design complexities involved when attempting to simultaneously offer the other necessary technical attributes. High sensitivity and robust recognition in a 40% smaller package are the strongest evidence in support of the product's high quality.

Heptagon has effectively leveraged its patented Wafer-Level Miniaturization technology, which has successfully reduced the form factor, lowered the total system cost, and improved the aesthetics of mobile devices as well, while conforming to high-quality parameters.

Positioning

The supreme technological ability of Heptagon (backed by its wafer-level integration and process technologies) has enabled the company to develop highly accurate and miniaturized optics, sensors, and modules in large volumes, translating into economies of scale with no compromise on quality. Besides its ability to ensure price-performance parity, the use of its proprietary Wafer-Level Miniaturization technology addresses all design complexities that previously existed in conventional sensing modules. To further enhance the value proposition of its product, Heptagon maintains proximate relationships with its customers, which positions it to rightly define target specifications for light, sensing, and imaging solutions. Consequently, user inputs are incorporated effectively to form an advanced micro-optics solution. The design simulation and manufacturing of prototypes help the company optimize its technological foothold through effective tolerance and sensitivity analysis, clearly denoting its innovation acumen (writ large in its rising patent portfolio). By maximizing its competence to ensure robust value enhancement for its customers, Heptagon finds itself best positioned to pursue new market opportunities.

Design

The new Near-Field Optical Sensing Module of Heptagon is only 350 microns thick (4 times thinner than a US 1 cent coin) with a 2 mm² surface area. Within this tiny space, the module aptly incorporates a built-in illuminator, a light sensor, as well as electronics, crosstalk prevention features, and a lens system. The module's compact design truly testifies to Heptagon's technological excellence in developing next-generation systems. Unmatched in the market, this tiny new sensor module (based on Heptagon's proprietary

technology) demonstrates its expertise in wafer-level optics, stacking, and integration. Ultimately, the ultra-thin design makes the sensing module apt for integration into next-generation wearable devices, smartphones, and ultra-thin notebooks, medical devices and host of other consumer device applications.

Customer Purchase Experience

In its bid to offer customers a fulfilling purchase experience through informed decision-making, Heptagon believes in keeping its global customer base updated about its latest achievements, innovations, and product launches. Heptagon has addressed the unmet customer needs in a highly efficient manner for the past 23 years, driven by its keenness to stay abreast of evolving industry trends, and, consequently, develop innovative products. The company's skilled engineering team possesses the expertise required for the high-volume design and manufacture of miniaturized optical and image technologies. Heptagon also offers design and application services to compliment customer product development and provide cross disciplinary expertise if needed. Its recent introduction of the world's smallest proximity sensor clearly highlights that the company is open to imbibing customer responses, thus delivering them an enriched purchase experience in the process. In addition, the company announced in February 2016 that it has already crossed 2 billion unit shipments marking the wide acceptance of its product lines among customers, a clear indication that customers prefer to purchase Heptagon's products over competing solutions.

Customer Ownership Experience

Heptagon has been the undisputed global leader in 3D imaging, sensing, and illumination solutions since 1993. It remains consistent in its service delivery approach and frequently focuses on developing new products that match emerging market trends. In its attempt to maximize the ownership value for its customers, and to meet ever increasing demand for its optical products, Heptagon has completed the expansion of its production facility to achieve 1 billion units' production per year mark. And in sync with that, it has opened a semiconductor fabrication (fab) in Woodlands, Singapore, and a new factory in Ang Mo Kio, Singapore. Additionally, it has expanded its sales, marketing, and engineering expertise in Silicon Valley upon realizing the huge untapped customer interest in that area for miniaturized sensing solutions. Heptagon has established its brand excellence as a quality supplier to a number of systems integrators and device manufacturers. These long term customers include from small ventures to fortune 500 companies with diverse product portfolios.

Conclusion

A combination of world-class innovation with over 20 years' experience and effective implementation and its recent launch of numerous products around the Interface-of-Things, has enabled Heptagon to design a differentiating platform to meet the needs of the global optical sensors market. It seamlessly performs the task of both original equipment manufacturer (OEM) and systems integrator, catering to user needs from diverse industry verticals. The company's strong research partner approach coupled with its engineering expertise provides Heptagon a differentiated value proposition, while its keenness to manage every customer issue with an all-inclusive approach underlies its entrepreneurial abilities.

In the rapidly evolving IOT arena, where connecting people and products means an increasing demand for miniaturized solutions, Heptagon has utilized its unique competencies in wafer-level integration to design the world's smallest Near-Field Optical Sensing Module, launched in February 2016. Ultra-compact size and unique design features, in addition to being cost-effective as well as highly reliable, are some of the key elements enabled through a system-in-a-package approach, that give Heptagon's Near-Field Optical Sensing Module an edge over the competing solutions. Being the smallest proximity sensor globally, this highly efficient device has garnered positive acceptance from end users.

Tapping into the plethora of opportunities in the domains of electronics, automotive, security, surveillance, and medical, Heptagon has created a distinguishing mark for itself by developing the high-performance Near-Field Optical Sensing Module and groundbreaking packaging technology for next generation ultra-small sensors and modules.

With its strong overall performance, Heptagon has earned Frost & Sullivan's 2016 New Product Innovation Award.

Significance of New Product Innovation

Ultimately, growth in any organization depends upon continually introducing new products to the market, and successfully commercializing those products. For these dual goals to occur, a company must be best-in-class in three key areas: understanding demand, nurturing the brand, and differentiating from the competition.



Understanding New Product Innovation

Innovation is about finding a productive outlet for creativity—for consistently translating ideas into high quality products that have a profound impact on the customer.

Key Benchmarking Criteria

For the New Product Innovation Award, Frost & Sullivan analysts independently evaluated two key factors—New Product Attributes and Customer Impact—according to the criteria identified below.

New Product Attributes

- Criterion 1: Match to Needs
- Criterion 2: Reliability
- Criterion 3: Quality
- Criterion 4: Positioning
- Criterion 5: Design

Customer Impact

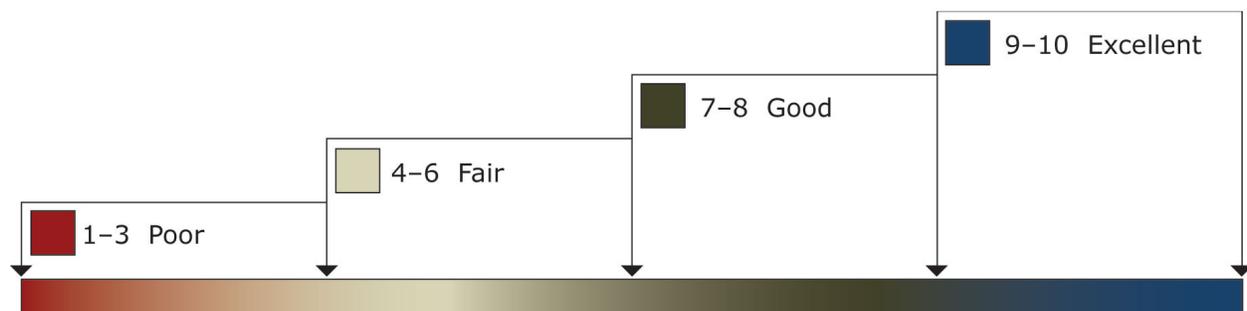
- Criterion 1: Price/Performance Value
- Criterion 2: Customer Purchase Experience
- Criterion 3: Customer Ownership Experience
- Criterion 4: Customer Service Experience
- Criterion 5: Brand Equity

Best Practice Award Analysis for Heptagon

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 New Product Attributes and Customer Impact (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, we have chosen to refer to the other key players as Competitor2 and Competitor3.

DECISION SUPPORT SCORECARD FOR NEW PRODUCT INNOVATION AWARD

<i>Measurement of 1-10 (1 = poor; 10 = excellent)</i>			
New Product Innovation	New Product Attributes	Customer Impact	Average Rating
Heptagon	9.6	9.4	9.5
Competitor2	8.0	8.2	8.1
Competitor3	7.7	7.5	7.5

New Product Attributes

Criterion 1: Match to Needs

Requirement: Customer needs directly influence and inspire the product’s design and positioning

Criterion 2: Reliability

Requirement: The product consistently meets or exceeds customer expectations for consistent performance during its entire life cycle

Criterion 3: Quality

Requirement: Product offers best-in-class quality, with a full complement of features and functionality

Criterion 4: Positioning

Requirement: The product serves a unique, unmet need that competitors cannot easily replicate

Criterion 5: Design

Requirement: The product features an innovative design, enhancing both visual appeal and ease of use

Customer Impact

Criterion 1: Price/Performance Value

Requirement: Products or services offer the best value for the price, compared to similar offerings in the market

Criterion 2: Customer Purchase Experience

Requirement: Customers feel like they are buying the most optimal solution that addresses both their unique needs and their unique constraints

Criterion 3: Customer Ownership Experience

Requirement: Customers are proud to own the company’s product or service, and have a positive experience throughout the life of the product or service

Criterion 4: Customer Service Experience

Requirement: Customer service is accessible, fast, stress-free, and of high quality

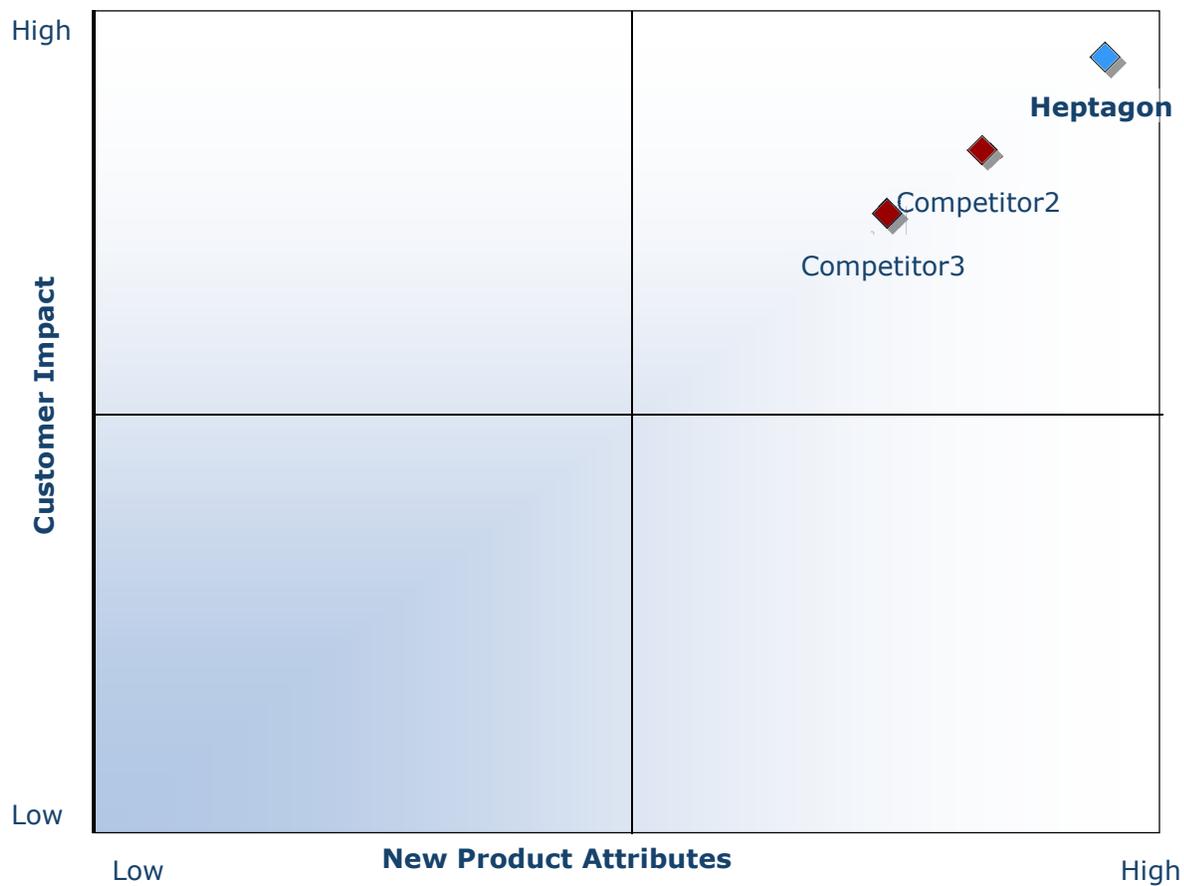
Criterion 5: Brand Equity

Requirement: Customers have a positive view of the brand and exhibit high brand loyalty

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 FOR NEW PRODUCT 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.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan Awards follow a 10-step process to evaluate award candidates and assess their fit with select best practice criteria. The reputation and integrity of the Awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 Monitor, target, and screen	Identify award recipient candidates from around the globe	<ul style="list-style-type: none"> • Conduct in-depth industry research • Identify emerging sectors • Scan multiple geographies 	Pipeline of candidates who potentially meet all best-practice criteria
2 Perform 360-degree research	Perform comprehensive, 360-degree research on all candidates in the pipeline	<ul style="list-style-type: none"> • Interview thought leaders and industry practitioners • Assess candidates' fit with best-practice criteria • Rank all candidates 	Matrix positioning all candidates' performance relative to one another
3 Invite thought leadership in best practices	Perform in-depth examination of all candidates	<ul style="list-style-type: none"> • Confirm best-practice criteria • Examine eligibility of all candidates • Identify any information gaps 	Detailed profiles of all ranked candidates
4 Initiate research director review	Conduct an unbiased evaluation of all candidate profiles	<ul style="list-style-type: none"> • Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles 	Final prioritization of all eligible candidates and companion best-practice positioning paper
5 Assemble panel of industry experts	Present findings to an expert panel of industry thought leaders	<ul style="list-style-type: none"> • Share findings • Strengthen cases for candidate eligibility • Prioritize candidates 	Refined list of prioritized award candidates
6 Conduct global industry review	Build consensus on award candidates' eligibility	<ul style="list-style-type: none"> • Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates 	Final list of eligible award candidates, representing success stories worldwide
7 Perform quality check	Develop official award consideration materials	<ul style="list-style-type: none"> • Perform final performance benchmarking activities • Write nominations • Perform quality review 	High-quality, accurate, and creative presentation of nominees' successes
8 Reconnect with panel of industry experts	Finalize the selection of the best-practice award recipient	<ul style="list-style-type: none"> • Review analysis with panel • Build consensus • Select winner 	Decision on which company performs best against all best-practice criteria
9 Communicate recognition	Inform award recipient of award recognition	<ul style="list-style-type: none"> • Present award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance 	Announcement of award and plan for how recipient can use the award to enhance the brand
10 Take strategic action	Once licensed, company may share award news with stakeholders and customers	<ul style="list-style-type: none"> • Coordinate media outreach • Design a marketing plan • Assess award's role in future strategic planning 	Widespread awareness of recipient's award status among investors, media personnel, and employees

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 almost 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 31 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.