

FROST & SULLIVAN

BEST PRACTICES

AWARDS

FROST & SULLIVAN

2020 BEST PRACTICES AWARD

 **DIRECTAPLUS**
PARTNERS IN NANOTECHNOLOGY

**2020 EUROPEAN
GRAPHENE FOR ENVIRONMENTAL REMEDIATION
TECHNOLOGY INNOVATION AWARD**

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Background and Company Performance

Industry Challenges

Oil spillage is a serious environmental issue that causes liquid hydrocarbon to be released in open seas or port areas. The release of large amounts of hydrocarbons in a short duration of time is quite difficult to control and causes a detrimental effect on vegetation, aquatic life, and mammals. Additionally, a minor oil spillage can lead to severe accidents in any process plant that is on the verge of pipeline failure, which could negatively affect the ground water level and soil properties.

Frost & Sullivan observes several approaches that have been taken over the past few years to mitigate the oil spillage impact. These approaches are incorporated at the cleaning phase, including chemical treatment, physical treatment, thermal treatment, and biological treatment. The physical treatment, including organic, synthetic, or inorganic sorbents, is a popular method of recovering oil traces and removing contaminants. Examples of organic materials are wool, sawdust, and bark, and synthetic materials, including polymers and inorganic materials. Material selection is dependent on various factors, such as reusability, scalability, high absorption rate, hydrophobicity, and low environment rate. Organic materials are biodegradable and have a low environmental effect, but do not have high mechanical strength and absorption rate.

Synthetic materials, such as polypropylene, are widely used in oil recovery operations because of their better mechanical strength when compared to inorganic and organic materials. Frost & Sullivan points out that synthetic materials, however, possess specific disadvantages, such as poor biodegradability and expensive land fill disposal. In addition, these materials are simply not effective enough in adsorbing oil with a lower hydrocarbon concentration or monolayer hydrocarbon layer in the aqueous phase.

Considering these issues and drawbacks, stakeholders are interested in developing natural-based oil sorbents with high biodegradability and properties like synthetic materials, in terms of adsorption and mechanical strength. Graphene, the monolayer of carbon atoms disposed in a honeycomb structure, is gaining traction due to its non-toxic, safe landfill disposal and non-flammability characteristics. Graphene-based materials show a high adsorption capacity, with high kinetics for adsorbing both unsaturated and saturated hydrocarbons in the gaseous and aqueous phases.

Water scarcity is a serious problem that must be addressed to make fresh water available for living beings. If left untreated, water contamination by hydrocarbons, pesticides, toxic dyes, and microbes can cause potential damage to the environment and human health. Water management is an important aspect of any industrial facility that produces wastewater, which needs to be treated efficiently before being recycled, reused, or discharged into the environment. If not, industrial manufacturers can incur hefty fines and face severe legal actions, thereby affecting their profitability.

Conventional technologies, such as biological or secondary treatment methods to treat industrial water, require high investment in electromechanical equipment, energy consumption, and vast land for plant setup.

Technology Attributes and Future Business Value

Industry Impact

Founded in 2005, with the production unit based in Italy Directa Plus Plc develops products based on graphene nanoplatelets (GNPs). The company has developed a robust technology for environmental application for removing hydrocarbons and treating water and wastewater, soil, and air from oil spills and organic pollutants. In November 2019 Directa Plus (together with a partner in the Oil & Gas industry) successfully completed the acquisition of SetCar S.A., a Romanian company focused on providing innovative environmental services.

Directa Plus breakthrough technology is commercialized under the brand name Grafysorber[®] and contains super expanded graphite-based, multilayer 3D graphene sheets. Grafysorber[®] production process starts from natural graphite, which is a cost-effective raw material that is readily available in the market. The graphite is thermally super-expanded in a proprietary plasma technology at high temperatures. The resulting material, Grafysorber[®], is composed of graphene-based flakes with high superficial area. Utilizing plasma technology allows to obtain high quality Grafysorber[®] and pristine graphene-based materials.

Grafysorber[®] is used as an enhanced adsorbent material and acts as a sponge to adsorb hydrocarbons from contaminated water. In addition, Grafysorber[®] is available as a loose material or contained in oil-adsorbent products, such as booms, barriers, pillows, and custom-made adsorbing sheets in various sizes and shapes. Such products can be utilized in water and wastewater treatment devices for removing different types of organic pollutants.

Furthermore, Grafysorber[®] can be produced in a mobile production unit with a specifically designed plasma expansion machine and can be deployed in dedicated water treatment plants close to the mobile decontamination unit. The technology can be applied in oil spillage sites, or in areas where an oil spill event may occur, or in remote places where logistics is difficult. To clean the contamination at the time of an environmental catastrophe, the mobile unit can produce the required amount of Grafysorber[®] on-site, making it a potential technology for site remediation and for different environmental emergencies. The Grafysorber[®] mobile unit reduces the general transportation costs and time associated with the emergency management system.

Grafysorber[®] provides high oil recovering capacity and is effective in removing both high- and low-hydrocarbon concentrations, floating oil slicks, and lubricating oils in both liquid and gaseous forms. Frost & Sullivan appreciates how the use of natural graphite, which is abundantly available in the market, and the high recovery and reusability potential of adsorbed hydrocarbons make Grafysorber[®] a more cost-effective solution than other existing technologies.

Frost & Sullivan recognizes that Directa Plus Grafysorber[®] can solve issues related to the accidental spillage of hydrocarbon by adsorbing oily pollutants weighing 100 times more than its own weight. Furthermore, in terms of oil adsorption, Grafysorber[®] is five times

more effective in removing emulsified or dispersed hydrocarbons of lower concentration than traditional absorption technologies.

Visionary Innovation and Sustainability commitment

Directa Plus Grafysorber® technology is environmentally friendly and sustainable. The company adopts a chemical-free and water-based production process and only uses natural graphite for manufacturing graphene-based products. Grafysorber® does not contain any toxic substances, such as plastics, but only pristine structures of carbon atoms, which makes it a suitable technology for water and wastewater treatment, water filtration and gas purification and separation.

A Grafysorber® boom or pillow can be easily recovered after the oil adsorption process and can be either recycled, reused, or safely disposed in landfills or incineration. Grafysorber®, due to its sponge-like nature, can be mechanically squeezed up to five times in order to recover the adsorbed oil and to mitigate the risk of waste formation, without significantly affecting the absorbing efficiency.

Directa Plus has compared Grafysorber® with widely used polypropylene adsorbents and discovered that polypropylene based products have six times lower absorption capacity and can retain 50% more water. Therefore, Grafysorber® shows higher oil adsorption and wettability properties. Other existing technologies such as dispersant are unable to meet stringent environmental requirements; they form toxic byproducts and leave traces of oil in the environment, thus damaging the ecosystem. Directa Plus technology is competitively positioned in the industry and has obtained approval from the Ministry of Environment in Romania and Italy. Grafysorber®'s absorption capacity and performance increase with volume expansion, without requiring any additives and reaction aids, which makes it a chemically and biologically inert material technology. The solution, however, is fully compatible with any additives, if required, during water clarification.

Grafysorber®'s advanced ability to contain and remediate oil spillages is certainly visionary and has positively impacted the Oil & Gas industry.

Frost & Sullivan research indicates that Directa Plus's Grafysorber® is an environmentally friendly solution that addresses issues related to contaminants and organic pollutants and provides a quality answer for onshore and offshore emergency situations. In addition, Grafysorber®'s technological features, such as reusability and recyclability of the adsorbed oil, will make it a viable and sustainable solution for mass adoption in the next years.

Application Diversity

Huge amounts of water need to be treated in the Oil & Gas industry, in upstream and downstream processes, including refining, offshore drilling, and onshore facilities. To prevent oil spillage accidents, Directa Plus's Grafysorber® can be employed in logistic operations where oil from ships is loaded and unloaded.

Directa Plus's Grafysorber® technology has been adopted in the oil and gas industry for treating water contaminated with hydrocarbons, including crude oil, kerosene, and diesel oil. For example, laboratory trials demonstrated that 1 single gram of Grafysorber® was

effective in adsorbing 81.78 grams of crude oil, 76.5 grams of diesel oil, and 50.8 grams of kerosene from contaminated water. These figures represent a high adsorption capacity for hydrocarbons without requiring reaction aids and chemical additives. In addition, several on-field trials showed high oil absorption that is typically up to 16 times its own weight, whereas synthetic material polypropylene showed adsorption between 4 and 6 times its own weight. Frost & Sullivan analysts conclude that Grafysorber®'s high capacity truly makes it a unique technology in the industry.

Grafysorber® uses multiple expanded graphene layers and shows intrinsic hydrophobic characteristics and a crystalline structure. These properties have made Grafysorber® a useful technology for water treatment in harsh environments. In addition to Oil & Gas, Directa Plus is focusing on air treatment and industrial wastewater treatment in several industries. Grafysorber® is also highly beneficial for removing organic contaminants, such as surfactants, that are difficult to treat with activated carbon.

Frost & Sullivan commends Directa Plus for developing such a lucrative technology that can be used across diverse applications, allowing Directa Plus to exploit its intangibles, such as technology licensing, positive supplier relationships, and contractual commitments, to improve its corporate growth and profitability. Moreover, the company is exploring new market opportunities, such as product launch and collaborations with Oil & Gas companies based in the Middle East.

Scalability

Directa Plus's production facility for Grafysorber® and graphene-based materials is in Italy and has a current production capacity of 30 tons per year, with expansion in production capacity expected in the next few years. With its characteristic features, such as reusability and high adsorption rate, Grafysorber® is required in relatively small amounts to achieve the desired hydrocarbon decontamination rate, allowing Directa Plus to cater to the market demand cost effectively.

With its recent partnerships with leading Oil & Gas companies and with the acquisition of SetCar S.A., Directa Plus is expected to cater to the growing market demand in Europe and to diversify its geographical footprint.

Customer Acquisition

Grafysorber® has attracted many customers in the Oil & Gas sector, including logistics, refineries, and offshore operating companies, for treating industrial water contaminated with hydrocarbon. Directa Plus offers customized options to serve each customer's varied requirements. These customization options allow Grafysorber® to be used together with conventional treatment technologies, including physical, chemical, and biological processes, and to be incorporated into the final purification process. Furthermore, such flexibility has allowed the company to attract new customers from other end-use industries – including agriculture, textiles, and automotive.

Directa Plus is open to forming collaborations with similar technology-oriented companies for new product development. Grafysorber® can be considered as an off-the-shelf product, and the company's inclination to form research and development (R&D) alliances with

research laboratories will allow it to enhance its core competency, intensify its technological knowledge, and bring new ideas to the field of graphene-based materials.

Brand Equity

Directa Plus is one of the few companies that has developed an environmentally friendly mobile technology for treating oil sludge and byproducts. The technology is efficient in removing hydrocarbons in both high and low concentrations to produce quality water, which is expected to increase Directa Plus's brand recognition among both existing and prospective customers.

The company has an extensive list of patents and has attained all necessary certifications for the Grafysorber® technology to ensure that it is environmentally friendly, non-flammable, and non-toxic in nature. Frost & Sullivan analysis shows that Directa Plus's technology provides a high yield in adsorbing both saturated and unsaturated hydrocarbons, thus creating competitive pricing in the water treatment industry. Additionally, the technology complies with safety standards in landfill management, allowing Directa Plus to meet its circular economy goals. Constant research efforts and supply agreements have provided the company with the momentum to continue attracting clients and creating brand loyalty and customer satisfaction.

Conclusion

Developed techniques, such as chemical treatment, physical treatment, synthetic absorbent materials, skimming, chemical dispersants, and filtration media are costly, time consuming, and inefficient. Additionally, these processes add toxic chemicals into the sea, requiring additional treatment. With five years of continued research and field testing in environmental technologies, Directa Plus provides customers with its cost-competitive and environmentally friendly Grafysorber® technology that uses expanded graphite, a graphene-based material that is obtained from expanded flakes, to reduce or eliminate environmental contaminants from water. With high adsorption capacity, yield, selectivity, and ease of use during accidental oil spills, this technology is in high demand for water treatment. In addition, Grafysorber® is simple to apply together with conventional technologies, without hindering its own characteristics.

Directa Plus's technology is expected to attract many potential customers in various end-use industries over the coming years based on its increasing environmental regulations for waste management in landfills. Grafysorber® is a sustainable technology that contains pure carbon and provides high adsorption oil performances, thereby enabling final safe disposal in landfill. Frost & Sullivan points out that the technology is a remarkable step toward attaining sustainable and cost-effective environmental remediation.

With its strong overall performance, Directa Plus has earned the 2020 Frost & Sullivan Technology Innovation Award.

Significance of Technology Innovation

Ultimately, growth in any organization depends on finding new ways to excite the market and 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 3 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. This spark can result from a successful partnership, a productive in-house innovation group, or a bright-minded 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 2 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

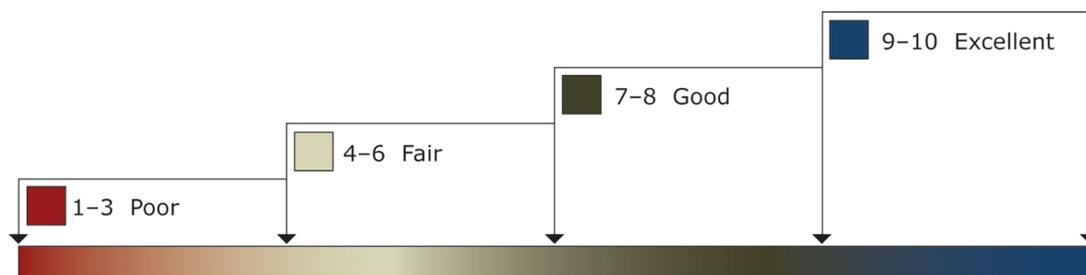
- Criterion 1: Financial Performance
- Criterion 2: Customer Acquisition
- Criterion 3: Technology Licensing
- Criterion 4: Brand Loyalty
- Criterion 5: Human Capital

Best Practices Award Analysis for Directa Plus SpA

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 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 considers Technology Attributes and Future Business Value (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criterion 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 has chosen to refer to the other key participants as Competitor 2 and Competitor 3.

<i>Measurement of 1-10 (1 = poor; 10 = excellent)</i>			
Technology Innovation	Technology Attributes	Future Business Value	Average Rating
Directa Plus SpA	9.0	9.2	9.1
Competitor 2	8.2	8.0	8.1
Competitor 3	8.0	7.7	7.9

Technology Attributes

Criterion 1: Industry Impact

Requirement: Technology enables the pursuit of groundbreaking ideas, contributing to the betterment of the entire industry.

Criterion 2: Product Impact

Requirement: Specific technology helps enhance features and functionalities 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: Potential is high for strong financial performance in terms of revenue, 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 verticals and applications, thereby driving incremental revenue streams.

Criterion 4: Brand Loyalty

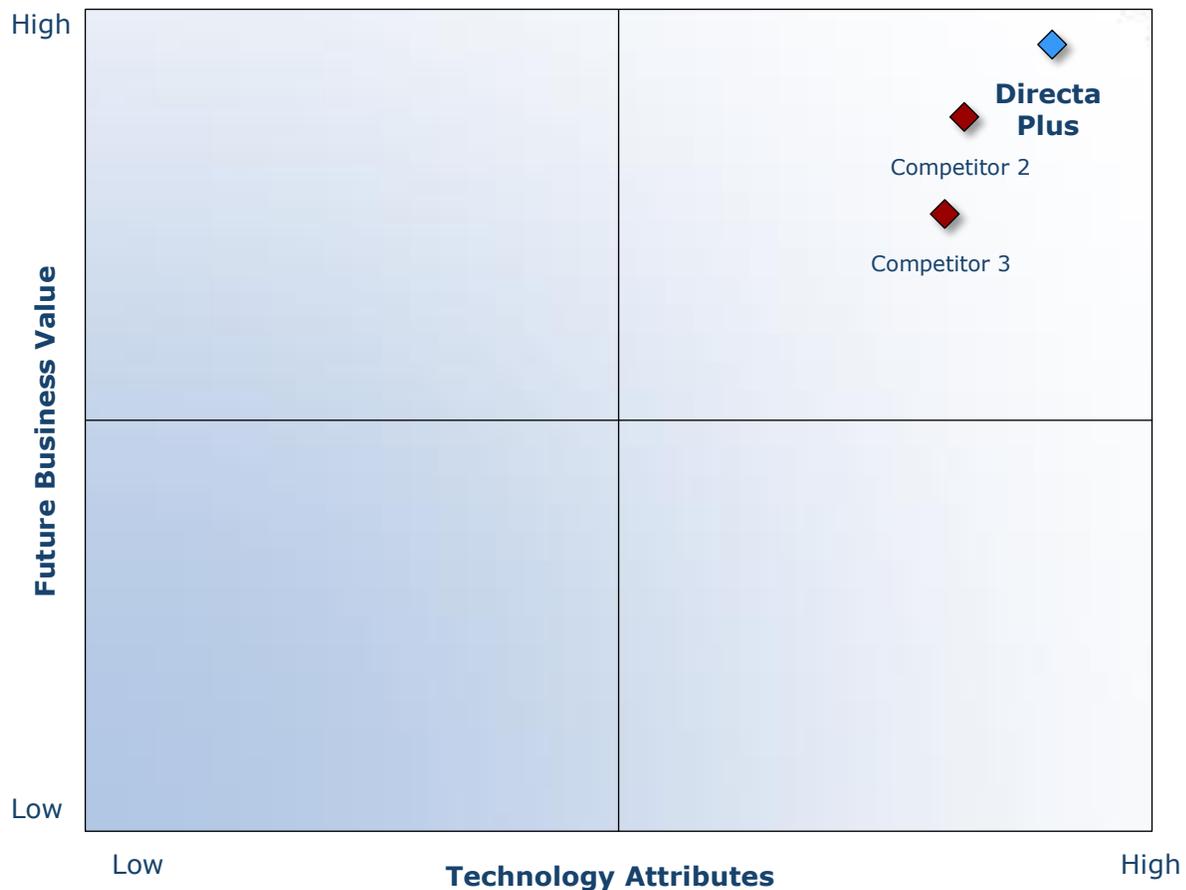
Requirement: New technology enhances the company’s brand, creating and/or nurturing brand loyalty.

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 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.



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

Frost & Sullivan analysts follow a 10-step process to evaluate Award candidates and assess their fit with select best practices 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 world	<ul style="list-style-type: none"> • Conduct in-depth industry research • Identify emerging industries • Scan multiple regions 	Pipeline of candidates that potentially meet all best practices 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 practices criteria • Rank all candidates 	Matrix positioning of 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 practices 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 practices 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 practices Award recipient	<ul style="list-style-type: none"> • Review analysis with panel • Build consensus • Select recipient 	Decision on which company performs best against all best practices criteria
9 Communicate recognition	Inform Award recipient of 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	Upon licensing, company is able to 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 strategic planning 	Widespread awareness of recipient's Award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of the 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, resulting in 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 participants and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, helps clients 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-practices models to drive the generation, evaluation, and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit <http://www.frost.com>.