Haystack Robotics

# 2025 TECHNOLOGY INNOVATION LEADER

*Enhancing Customer Impact Through Powerful Technology Integration*

*RECOGNIZED FOR BEST PRACTICES IN THE INDIAN HOSPITAL DISINFECTION ROBOTS INDUSTRY*

FROST & SULLIVAN

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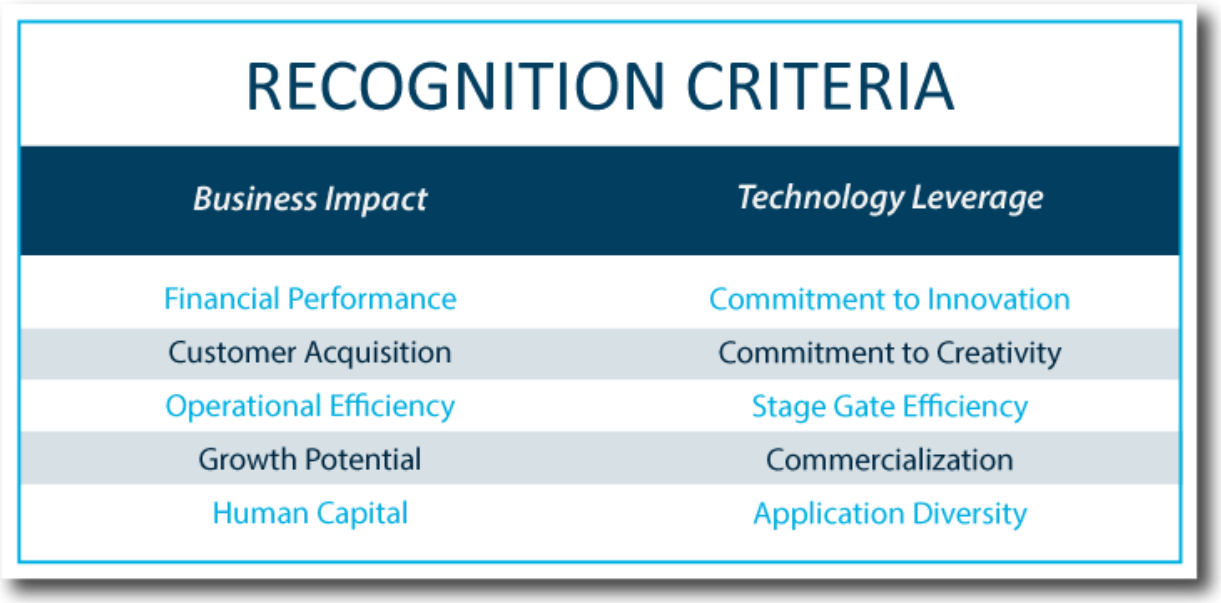
## Best Practices Criteria for World-class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each recognition category before determining the final recognition recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. Haystack Robotics excels in many of the criteria in the hospital disinfection robots space.




## The Transformation of the Hospital Disinfection Robots Industry

Healthcare-associated infections (HAIs) are a significant challenge in medical settings, leading to increased morbidity, extended hospital stays, and higher healthcare costs. It is predicted that 10% to 20% of hospitalized patients acquire HAIs, with the intensive care unit (ICU) being the primary source of infection.[1] A study in hospitals in western India indicated an incidence of 30.5% nosocomial infections from ICUs.[2] Hospitals have traditionally relied on manual cleaning and basic disinfection protocols, which, as indicated by several studies, present major health risks for healthcare workers, increasing the incidence of respiratory illnesses and allergies.[3,4] However, a technological revolution driven by robotics and artificial intelligence (AI) is transforming hospital disinfection approaches. With the increasing adoption of automation, the role of robotic disinfection systems has shifted from being experimental to essential, marking a new era in healthcare safety.

[1] Thakkar J, Shanoo A, Gupta S, Thakkar A. The Pattern and Impact of Hospital-Acquired Infections and Its Outlook in India. Cureus. 2023 Nov 9;15(11):e48583.
[2] Pranali Patil, Jignesh Shah, Amol Muthal, Asavari Raut. Economic burden analysis of nosocomial infections in tertiary care hospital in western India: A prospective evidence-based study, Clinical Epidemiology and Global Health, 2025, Volume 31,101907.
[3] Heibati, B., Jaakkola, M.S., Lajunen, T.K. et al. Do hospital workers experience a higher risk of respiratory symptoms and loss of lung function?. BMC Pulm Med 22, 303 (2022).
[4] Gao L, Chen X, Jiang Z, Zhu J, Wang Q. Respiratory Flora Intervention: A New Strategy for the Prevention and Treatment of Occupationally Related Respiratory Allergy in Healthcare Workers. Microorganisms. 2024; 12(12):2653.

## The Journey of Haystack Robotics: From a Personal Project to a Global Vision

Haystack Robotics is committed to developing advanced robotic systems that minimize human involvement during disinfection processes. The prototype for the company's robotics platform was initially developed by CEO Mahadev Ekambaram in 2020 when the COVID-19 pandemic exacerbated concerns about infections transmitted at the point of care. What began as a basic UV disinfection device designed primarily to ensure his parents' safety gradually transformed into an enterprise-oriented product as interest grew and the broader applications of the invention became apparent.

Initially a bootstrapped venture with minimal resources, the company's early development was largely driven by collaboration with other companies and contractors in exchange for equity. This allowed Haystack Robotics to pursue its core mission without compromising on quality. A notable partnership was with Mobiveil Inc., which supported the growing vision of Haystack Robotics with crucial engineering resources. This early partnership provided advanced expertise in embedded systems, the Internet of Things (IoT), and AI algorithms—capabilities rarely accessible to start-ups—enabling faster and robust development of its disinfection robot.

To combat resource limitations, the company embraced adaptive product development methodologies, lean manufacturing processes, and agile practices, enabling efficient operation while adhering to the core mission. This approach helped establish a culture of continuous improvement early on. As the company evolved, the focus shifted specifically to hospital automation and healthcare, where there was already a growing trend of integrating IoT, AI, and robotics for hygiene management.

## Expanding the Vision: Market Fit and Commercialization

> *"The Violet Gen IV robot features a comprehensive suite of 14 different sensors, which include LiDAR sensors for precise mapping and sonar sensors to detect humans and objects. The sensors work in unison with 3D cameras, enabling the robot's 3rd-degree algorithm to dynamically adjust its path and coverage based on the real-time room layouts and obstructions. These features, along with over-the-air connectivity and its smart disinfection capabilities that can identify high-touch surfaces, make the Violet Gen IV well-suited for a range of hospital environments and help it stand out among competitors."*
>
> ***- Dr. Isai Pratha Karthik, Ph.D.***
> ***Senior Research Analyst, TechVision***

Haystack Robotics' Ultraviolet-C (UV-C) disinfection robotics platform is capable of minimizing healthcare-associated infections, in alignment with the global trend of smart hospital technologies. Headquartered in Portland, Oregon, United States, with engineering and manufacturing operations in Chennai, India, the company strategically combines global innovation with local manufacturing. This approach helps leverage India's robust engineering talents and promote local manufacturing. It also strengthens the company's supply chain resilience in the country, reducing import dependency for healthcare UV robots.

Emphasizing collaborative innovation, Haystack Robotics partners with Pudu Robotics to co-brand its autonomous delivery robots in India. The solution addresses both the challenge of staff shortages in hospitals in the United States and leverages the shift towards smart automated technologies in healthcare facilities in India, enhancing operational efficiency

and safety in diverse healthcare environments. Haystack Robotics has strategically positioned its Violet Gen IV robot to be competitively priced, with an anticipated cost of below 2,000,000 INR (~$23,000) in India. The value proposition lies in the robot's efficiency in reducing HAIs, ensuring long-term cost savings to the hospitals, and reducing India's economic burden from these infections.

## The Violet Robots: Technology that Drives Impact


***Figure 1: Violet Gen IV Robot from Haystack Robotics***

Haystack Robotics' disinfection platform has undergone significant evolution, beginning with early-stage Violet prototypes and culminating in the advanced Violet Gen IV (previously branded as Purple). While Violet Gen III was briefly commercialized, the company's focus has since shifted towards Gen IV due to its superior performance and commercial readiness. Haystack Robotics' disinfection robots utilize UV-C light (200 nm to 280 nm), which has the highest germicidal effectiveness. The UV-C light disrupts the DNA and RNA of microorganisms, rendering them unable to replicate or cause infections. UV-C devices have demonstrated 35% more efficiency in reducing HAI incidence.[5] The Violet Gen IV robots have 8 UV-C bulbs in an L-shaped tower, reducing shadow zones, a redesigned base for tighter navigation, and enhanced AI capabilities. They exert their germicidal effects on diverse pathogens, including vegetative bacteria, viruses, mycobacteria, vegetative fungi, and even bacterial spores. Integrated with AI, these robots can seamlessly navigate complex hospital layouts autonomously. Notably, the Violet Gen IV robot is the only disinfection robot with a 3rd-degree AI algorithm advantage. This allows it to auto-map its path based on environments and employ comfort mapping, that is, adjust the disinfection path when it detects human presence. It can also apply a smart disinfection approach by prioritizing high-infection risk areas such as bed rails, switches, and doorknobs. These intelligent features ensure comprehensive coverage, optimizing cleaning routines and reducing the likelihood of human error. The platform's adaptability to various healthcare environments, from large tertiary hospitals to smaller facilities like dialysis units, clinics, and veterinary hospitals, demonstrates its application diversity. Moreover, with rising global demand for infection control technologies across sectors like geriatric care, pharmaceutical manufacturing, food processing, fitness centers, schools, and diagnostic laboratories, the company's UV disinfection robots hold promising growth potential beyond hospitals.

[5] Poster DL, Miller CC, Obeng Y, Postek MT, Cowan TE, Martinello RA. Innovative Approaches to Combat Healthcare-Associated Infections Using Efficacy Standards Developed Through Industry and Federal Collaboration. Proc SPIE Int Soc Opt Eng. 2018;10730:10.1117/12.2500431.

> *"Haystacks Robotics has implemented a comprehensive quality management system (QMS) to comply with ISO 13485 standards. Moreover, in line with its expansion strategy, it has recently established a manufacturing facility in a special economic zone in Chennai (India), leveraging the Make in India initiative. This move will enhance its production ability and optimize costs while maintaining high-quality standards."*
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> ***Senior Research Analyst, TechVision***

### Designed for Practicality and Simplicity: A Maintenance-friendly Approach to Automated Disinfection

A standout feature of Haystack Robotics' Violet Gen IV robot is its practical and straightforward design, purpose-built for healthcare environments. Unlike other complex robotic systems, the Violet Gen IV robot is designed with minimal moving parts, making it easier to maintain. These robots use standard golf cart batteries, known for their reliability, cost-effectiveness, and ease of replacement. Also, the robots' UV-C bulbs—essential for pathogen elimination—are designed to be quickly and easily replaced. The company plans to collaborate with strategic channel partners in the United States and India to manage field service, avoiding the need for a large in-house team. By enabling channel partners and training personnel for maintenance and support, Haystack Robotics plans to promote job creation in the Indian service ecosystem. This partner-driven model reflects Haystack Robotics' strategy to leverage human capital efficiently while ensuring smoother service operations. Haystack Robotics' commitment to practicality and simplicity ensures that hospitals are equipped with cutting-edge disinfection technology without the burden of complex maintenance.

### Smart Movement: Leveraging Advanced Sensor Technologies

Despite its simple build, the solution does not compromise on technology. The Violet Gen IV robot features a comprehensive suite of 14 different sensors, which include LiDAR sensors for precise mapping and sonar sensors to detect humans and objects. The sensors work in unison with 3D cameras, enabling the robot's 3rd-degree algorithm to dynamically adjust its path and coverage based on the real-time room layouts and obstructions. These features, along with over-the-air connectivity and its smart disinfection capabilities that can identify high-touch surfaces, make the Violet Gen IV well-suited for a range of hospital environments and help it stand out among competitors.

### Smart Connectivity: Mobile Integration and Cloud-based Management

Haystack Robotics has integrated a robust cloud-based management system with its Violet Gen IV robots, allowing healthcare professionals to maintain control and oversight from virtually anywhere. Through an Android-based mobile app, Haystack Robot Control, the users can remotely monitor disinfection schedules, compliance adherence, and real-time performance and receive maintenance alerts. The disinfection modes can be custom-adjusted or made autonomous according to the requirements to adjust the exposure and disinfection speed. By leveraging cloud infrastructure, the programs can provide intuitive control to manage a fleet of robots in larger healthcare facilities.

### Building Credibility: Quality Enhancement, Production Expansion, and Validation from Leading Clients

Haystacks Robotics has implemented a comprehensive quality management system (QMS) to comply with ISO 13485 standards. Moreover, in line with its expansion strategy, it has recently established a

manufacturing facility in a special economic zone in Chennai (India), leveraging the Make in India initiative. This move will enhance its production ability and optimize costs while maintaining high-quality standards. The company's flagship product, the Violet Gen IV robot, has been validated in India's leading healthcare institutions, including Rajagiri Hospital, MGM Hospitals, and Hinduja Hospital. Its disinfection efficacy has been demonstrated against a wide range of multidrug-resistant pathogens, such as Staphylococcus aureus, Actinobacter species, Klebsiella species, and Enterococcus species. The company is currently pursuing approvals from the Central Drugs Standard Control Organization (CDSCO) in India and FDA 510(k) clearance in the United States for Class 2 medical devices. Unlike many commercially available disinfection robots, Haystack Robotics aims to market its products as medical devices, emphasizing their safety, efficacy, and adherence to healthcare standards. This positions Haystack Robotics' product as one among the very few UV-C disinfection robots aiming to meet clinical-grade validation and regulatory approvals in the emerging healthcare robotics landscape.

## Conclusion

Haystack Robotics has distinguished itself in the healthcare disinfection robot landscape by integrating IoT sensors and AI to ensure superior disinfection according to healthcare needs. Violet Gen IV stands out as a cost-effective, clinically driven solution that helps hospitals improve infection control, reduce healthcare-associated costs, and ease the economic burden of HAIs in India. Haystack Robotics represents the future of hospital disinfection, seamlessly blending automation with healthcare sanitation. With its strong overall performance, Haystack Robotics earns Frost & Sullivan's 2025 Indian Technology Innovation Leadership Recognition in the hospital disinfection robot industry.

# What You Need to Know about the Technology Innovation Leadership Recognition

Frost & Sullivan's Technology Innovation Leadership Recognition is its top honor and recognizes the market participant that exemplifies visionary innovation, market-leading performance, and unmatched customer care.

## Best Practices Recognition Analysis

For the Technology Innovation Leadership Recognition, Frost & Sullivan analysts independently evaluated the criteria listed below.

### Technology Leverage

**Commitment to Innovation:** Continuous emerging technology adoption and creation enables new product development and enhances product performance

**Commitment to Creativity:** Company leverages technology advancements to push the limits of form and function in the pursuit of white space innovation

**Stage Gate Efficiency:** Technology adoption enhances the stage gate process for launching new products and solutions

**Commercialization:** Company displays a proven track record of taking new technologies to market with a high success rate

**Application Diversity:** Company develops and/or integrates technology that serves multiple applications and multiple environments

### Business Impact

**Financial Performance:** Strong overall business performance is achieved in terms of revenue, revenue growth, operating margin, and other key financial metrics

**Customer Acquisition:** Customer-facing processes support efficient and consistent new customer acquisition while enhancing customer retention

**Operational Efficiency:** Company staff performs assigned tasks productively, quickly, and to a high-quality standard

**Growth Potential:** Growth is fostered by a strong customer focus that strengthens the brand and reinforces customer loyalty

**Human Capital:** Leveraging innovative technology characterizes the company culture, which enhances employee morale and retention

# Best Practices Recognition Analytics Methodology

## Inspire the World to Support True Leaders

This long-term process spans 12 months, beginning with the prioritization of the sector. It involves a rigorous approach that includes comprehensive scanning and analytics to identify key best practice trends. A dedicated team of analysts, advisors, coaches, and experts collaborates closely, ensuring thorough review and input. The goal is to maximize the company's long-term value by leveraging unique perspectives to support each Best Practice Recognition and identify meaningful transformation and impact.

| | | VALUE IMPACT | |
|---|---|---|---|
| STEP | | WHAT | WHY |
| 1 | **Opportunity Universe** | Identify Sectors with the Greatest Impact on the Global Economy | Value to Economic Development |
| 2 | **Transformational Model** | Analyze Strategic Imperatives That Drive Transformation | Understand and Create a Winning Strategy |
| 3 | **Ecosystem** | Map Critical Value Chains | Comprehensive Community that Shapes the Sector |
| 4 | **Growth Generator** | Data Foundation That Provides Decision Support System | Spark Opportunities and Accelerate Decision-making |
| 5 | **Growth Opportunities** | Identify Opportunities Generated by Companies | Drive the Transformation of the Industry |
| 6 | **Frost Radar** | Benchmark Companies on Future Growth Potential | Identify Most Powerful Companies to Action |
| 7 | **Best Practices** | Identify Companies Achieving Best Practices in All Critical Perspectives | Inspire the World |
| 8 | **Companies to Action** | Tell Your Story to the World (BICEP*) | Ecosystem Community Supporting Future Success |

*Board of Directors, Investors, Customers, Employees, Partners

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## The Growth Pipeline Generator™

Frost & Sullivan's proprietary model to systematically create ongoing growth opportunities and strategies for our clients is fuelled by the Innovation Generator™.

Learn more.

***Key Impacts***:

- **Growth Pipeline:** *Continuous Flow of Growth Opportunities*
- **Growth Strategies:** *Proven Best Practices*
- **Innovation Culture:** *Optimized Customer Experience*
- **ROI & Margin:** *Implementation Excellence*
- **Transformational Growth:** *Industry Leadership*


## The Innovation Generator™

Our 6 analytical perspectives are crucial in capturing the broadest range of innovative growth opportunities, most of which occur at the points of these perspectives.

***Analytical Perspectives***:

- Megatrend (MT)
- Business Model (BM)
- Technology (TE)
- Industries (IN)
- Customer (CU)
- Geographies (GE)