Spring-Loaded Target Carrier for Laser Tracking

Patent #10,508,917

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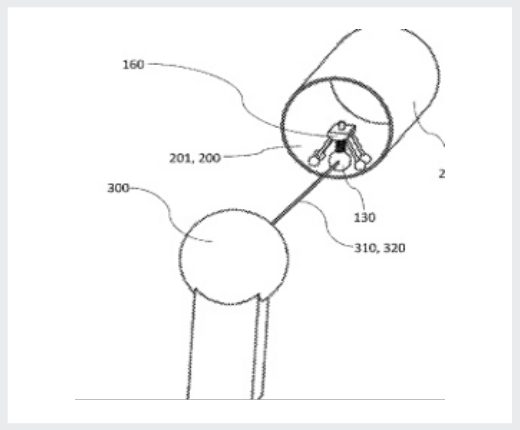
Technology Overview

Spring-Loaded Target Carrier for Laser Tracking – Patent #10,508,917

The Spring-Loaded Target Carrier for Laser Tracking provides a better methodology for taking multiple measurements using a laser tracker and a retroreflective target with respect to a cylindrical or other three-dimensional object. The first inventive mode of practice is characterized by downward force associated with a spring. A laser target assembly includes a generally rectangular member, four legs, a shaft, a coil spring, and a retroreflective target (such as a spherically mounted retroreflector). The Spring-Loaded Target Carrier for Laser Tracking imposes downward pressure so the laser tracking target at the bottom end of the shaft is maintained in a state of constant contiguity with respect to the underlying surface of the object being measured.



Capabilities

- Provides a better methodology for taking multiple measurements using a laser tracker and a retroreflective target with respect to a cylindrical or other three-dimensional object.

Benefits

- Multifarious combinations of leg lengths and leg angles are possible to suit the shape or configuration of the surface on which the Spring-Loaded Target Carrier for Laser Tracking is mobile.
- Consistent, forceful contact is maintained to achieve more accurate measurements that are easy to repeat without variance.

Benchmarks

Benchmarks are unique qualities that are used to compare against existing patents, patent filings, and commercially available products in this assessment tool.

Index Number	Title	Description
1	**Accurate Measurement**	An inventive cradle allows the spherically mounted reflector to move freely in a vertical axis to capture the surface profile accurately.
2	**Multifarious Combinations**	Multifarious combinations of leg lengths and leg angles are possible to suit the shape or configuration of the surface upon which the Spring-Loaded Target Carrier for Laser Tracking is mobile.

Market Research

Executive Summary

This section provides insights into market size, trends, and barriers to entry for commercial applications of the technology, as well as recommendations for deeper market research. Potential markets include Surveying Equipment, Measuring and Control Instruments, and Autonomous Mobile Robots. The fastest-growing market is Autonomous Mobile Robots, with a Compound Annual Growth Rate (CAGR) of 15.5%.

Potential Markets

Surveying Equipment
All tools and electronics related to surveying land, and mining and construction.

Market Insights

Market Size

- The global Land Survey Equipment market was valued at $7.3 billion in 2020 and is projected to reach $13.4 billion by 2030 (a CAGR of 6.1% from 2021 to 2030).

Market Trends

- The Land Survey Equipment market is mainly driven by urbanization and industrialization in developing countries.
- This equipment saves significant time and gives accurate outputs, a result of its data-processing software.

Barriers to Entry – High

- Many local companies offer rental and leasing services for land equipment products, which may reduce the number of end users buying their own equipment.
- Market entry is restricted, owing to a need for skilled workers and technical knowledge about operating equipment and software.
- The use of drones to capture images and videos has increased in recent years.

Key Players

- Hexagon, Hi-Target, Hudaco Industries Limited, Kolida Instrument Co., Ltd., Robert Bosch GmbH, Shanghai Huace Navigation Technology Ltd.

Market Research (cont.)

Potential Markets	Market Insights
Measuring and Control Instruments Consists of superconductors, Photoelectric sensors, automotive DC-DC converters, and control instruments	**Market Size** • The global Measuring And Control Instruments market is expected to grow from $699 billion in 2021 to $782.4 billion in 2022 (a CAGR of 11.9%). **Market Trends** • Market growth is due primarily to companies rearranging their operations and recovering from COVID-19; restrictive containment measures involving social distancing, remote working, and the closure of commercial activities resulted in operational challenges. • Governments around the world are investing in the creation of small cities. This is expected to drive demand for measuring- and control instruments for a variety of applications. **Barriers to Entry – Medium** • Differentiation of this product from products that exist already in the market landscape. **Key Players** • Thermo Fisher Scientific, Siemens AG, Apple, Jabil Circuit inc., Honeywell international inc., Schneider Electric.
Autonomous Mobile Robots Autonomous mobile robots pick, transport, and sort items within manufacturing and distribution facilities without manual intervention	**Market Size** • The global Autonomous Mobile Robots market was valued at $2.9 billion in 2022 and is expected to have a CAGR of 15.5% from 2023 to 2030. **Market Trends** • Warehousing and retailing companies collaborate with technology companies and automation solution providers to transform their material handling operations. • E-commerce companies acquire autonomous robot vendors to expand their warehouse operations. • Autonomous robots also enable warehouses and production facilities to introduce process automation without extensively changing their operating environment. **Barriers to Entry – High** • The competitiveness in the market is high. **Key Players** • ABB, Bleum, Boston Dynamics, Clearpath Robotics, Inc., GreyOrange

Market Research (cont.)

Conclusions

- The Surveying Equipment market seems to be the most viable option for this invention. The technology already lends itself to existing use cases in this field and could easily be retrofitted for near-term use.
- Measuring and Controls Instruments is a more difficult market to enter; the invention would require adaption of to make it useful for this marketplace.
- The Autonomous Mobile Robots market could be a feasible market for the invention. The highly competitive nature of this market, combined with the existing use of lasers for measuring applications would make the invention a highly innovative development and could bring value to this market.

Recommendations

Priority Key:

- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations	Priority	ROM Cost	ROM Timeline
Advance TRL and MRL Plan	2	$15,000	4 months
Market Planning and Scouting	3	$35,000	6 months
License technology	1	$15,000	2 months
ROM Total:		**$65,000**	

Level of Market Opportunity

Low----------Moderate----------High

Analyst: DVIRC

Competitor Analysis

Competitor Analysis Intent

The intent of this section is to identify potential commercially available, competing technologies and provide conclusions and recommendations based on the information provided at the time of assessment. The resulting information may be used to identify technology strengths or weaknesses in features or claims, as well as potential licensing partners.

Research Methods

Various resources to uncover information about different companies that perform similar functions

Markets	Competitors
Surveying Equipment	• **Hexagon:** Surveyors geared with Leica Geosystems' end-to-end workflow solutions allow the equipment to achieve efficient and accurate processing, report and share information. • **Hi-Target:** HiScan-C is a fully integrated mobile mapping system with Hi-Target advanced 3D laser and geo-referenced digital imagery, which provides value when a massive amount of asset data must be collected in a short period of time. • **Kolida Instrument Co:** KTS-442UT includes a series of new display chips, screen, and font. A new CPU has been used in the 442UT to allow the instrument to calculate faster with lower battery consumption.
Measuring and Control Instruments	• **Siemens AG:** SITRANS LUT420 Level Controller enables level or volume measurement of liquids, slurries, and solids, as well as basic pump control functions, and basic data logging capability. SITRANS LUT430, and SITRANS LUT440 models feature better accuracy (± 1 mm within 3 m). • **Jabil Circuit Inc:** Light Detection and Ranging (LiDAR) has become the technology of choice for 3D sensing for autonomous vehicles. It uses laser light to survey and measure the distance to surrounding objects and features. • **ThermoFisher Scientific:** Level Measurement Controller products include instruments and sensors designed to monitor and control test material levels under a wide range of conditions in laboratory and industrial applications.
Autonomous Mobile Robots	• **ABB:** Non-contact laser volume and level products provide solutions for accurate measurement including the following applications: inventory in bunkers, blending hoppers, reactor vessels, level control, volumetric measurement, and various dry bulk solids and liquids in silos. • **Prime Robotics:** Prime's MobileShelf is a goods-to-person pick solution for warehouses, e-commerce, and factory environments. Offers a pick rate of 350+ picks per hour, max payload capacity of 1,100 lbs. (500 kg), average speed of 5 mph, 2D LIDAR safety, bump bars, navigation. • **Boston Dynamics:** Stretch Warehouse Solution is an advanced vision system that detects boxes and container surroundings, with a powerful gripper that handles packages up to 50 pounds.

Competitor Analysis (cont.)

Markets	Competitors
	Substitutes
Hand Pipe Measuring Tool	• **Pipe Measure Tool – Wraparound Tape, Flex Angle Measuring and Marking Gauge** is a flexible pipe measuring tool with a marking scale from 3.88 inches to 4 feet designed for pipe diameters sized from 3 to 6 inches. • **Gauge Meter Calipers:** Dial Pipe Thickness Gauge is a 0-10mm, 0.1mm thickness meter with an iron metal handle that can be used to measure plate- and pipe thickness.
Laser Pipe Measuring Tool	• **Acuity:** AR1000 Laser Distance Sensor measures targets from 4” up to 100’ without the use of reflective targets. It can work with any opaque target, even glowing steel, at temperatures up to 1000°C (1800°F). The AR1000’s accuracy is typically ± 3 mm (0.12”). • **Milwaukee:** 330’ Laser Distance Meter is a three-position auto-detecting levers and an industry-first digital auto-level with IP54 rating and continuous real-time measurements. • **Johnson Level:** Electronic Self-Leveling Pipe Laser Level tool offers an accuracy of +/- 1/16” inches at 100’, which is valuable for contractors involved with road construction, landscaping, bridge building, pipe jacking, tunnel boring, or for the installation of sanitary storm sewer pipelines.

Conclusions

There are already several handheld and laser tools on the market mainly focused on the leveling capabilities of a laser for use in industries that construct long lines of pipe. This invention could add value for measuring the diameter of difficult pipes to get to that handheld devices would struggles with.

Technology Readiness Level – Hardware

Technology Readiness Level Intent	Current TRL
The intent of this document is to determine the level of effort required to advance the technology from its current state to a desired future state. Project tasks may be proposed to assist in technology advancement. The *Technology Readiness Level (TRL) Deskbook* version July 2009 served as the reference document for the TRL assessment. TRLs run from 1 to 9.	**5**

Research Methods

TRL determination has been conducted on applicable levels as seen below. The assessment was conducted by reviewing the following materials:

- Technology Overview
- Patents No. 10,508,917
- Q&A call with inventor

Findings

The Spring-Loaded Target Carrier for Laser Tracking provides a better methodology for taking multiple measurements using a laser tracker and a retroreflective target with respect to a cylindrical or other three-dimensional object.
The technology has been prototyped and validated in a relevant environment, categorizing it as TRL 5. In terms of manufacturing, there are no special or exotic requirements for the carrier. For the assembly of the invention, the inventors state that it would be comprised of mainly commercial off the shelf (COTS) parts with some high- tolerance/precision machining or 3D printed parts. There are no formal TDP or BOM created at this time, but a 3D model does exist. To advance the TRL, prototype validation in an operational environment is essential.

Conclusions

To advance the Spring-Loaded Target Carrier for Laser Tracking TRLs, additional validation needs to occur along with creation of a TDP and BOM for the invention. As the development progresses, the manufacturability of the device on a large scale must be considered and evaluated.

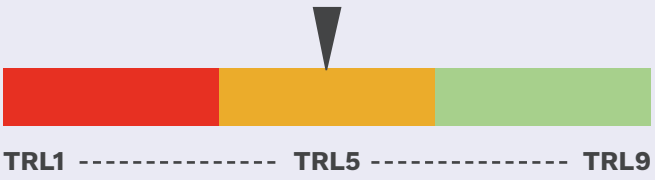
Technology Readiness Level – Hardware (cont.)

Recommendations

Priority Key:

- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations to advance TRL to 9	Priority	ROM Cost	ROM Timeline
Develop TDP	Must	$1,000	1 month
Develop Cost Model	Must	$1,000	1 month
Validate prototype in operational setting	Must	$3,500	2 months
Complete Design for Manufacturing	Must	$3,500	2 months
Control system development/testing	Should	$5,000	3 months
Study necessary compliance approvals/accreditations	Must	$4,000	3 months
Discuss potential to license technology to OEMs	Could	$2,000	2 months
Finalize Cost Model	Should	$1,000	1 month
Third party TRL revision	Could	$3,500	2 months
Finalize TDP	Should	$1,000	1 month
ROM Total		**$25,500**	**16 – 18 mos**



Analyst: DVIRC

Manufacturing Readiness Level

Manufacturing Readiness Level Intent	Current MRL
The intent of this assessment is to determine the level of effort required to advance the technology from its current state to desired future state. Project tasks may be proposed to assist in the advancement of the technology. The *Manufacturing Readiness Level (MRL) Deskbook* version 2.0 served as the reference document for the MRL assessment. MRLs run from 1 to 10.	**4**

Research Methods

Although a contractor has not been identified, an MRL determination has been conducted on applicable levels as seen below. The assessment was conducted with the following events and materials:

- Q&A interview with the inventor
- Patent No. 10,508,917

Findings

The MRL will generally track with the TRL but be slightly lower. The following is an assessment of the technology's current MRL and reasoning for the rating.

The Spring-Loaded Target Carrier for Laser Tracking has been developed and prototyped, with the prototype validated in a lab environment, categorizing the technology as MRL 4.

The Spring-Loaded Target Carrier for Laser Tracking is comprised of a laser target assembly that includes a generally rectangular member, four legs, a shaft, a coil spring, and a retroreflective target. The rod is preferably made of a strong, rigid material such as a suitable composite, steel, or other suitable material. The coil spring is preferably a helical metal spring (e.g. a suitable composite). The body and legs can be made of a variety of metals (e.g., steel or aluminum), polymers (e.g. plastic), or composites (e.g., nylon-reinforced plastic or other reinforced matrix) materials. Although the components are mainly commercial off the shelf (COTS), high tolerance and precision would be required. A 3D printer was used to create the tools, but there are no special or exotic materials or tools required. Neither are any approvals or accreditations needed, but it is expected that the Spring-Loaded Target Carrier for Laser Tracking would eventually be part of the tool kit for laser tracking. In terms of testing, alignment tests are required to confirm correct operation, as well as real-time functionality testing to validate the technology.

Conclusions

Until the TRL process (TDP, testing) is advanced, the MRL will remain low. Since most of the parts are COTS basic materials, the technology can be advanced through the remaining MRL levels without excessive expense. Further prototyping of the technology is a crucial next step to validate the invention in an operational environment.

While the prototype approaches a more developed level, it is recommended to finalize suppliers (including possible backups) to widen sourcing options for COTS parts and avoid supply chain issues. A more thorough MRL assessment should be completed when these suppliers have been identified and an evaluation can be made in a production environment.

Manufacturing Readiness Level (cont.)

Recommendations

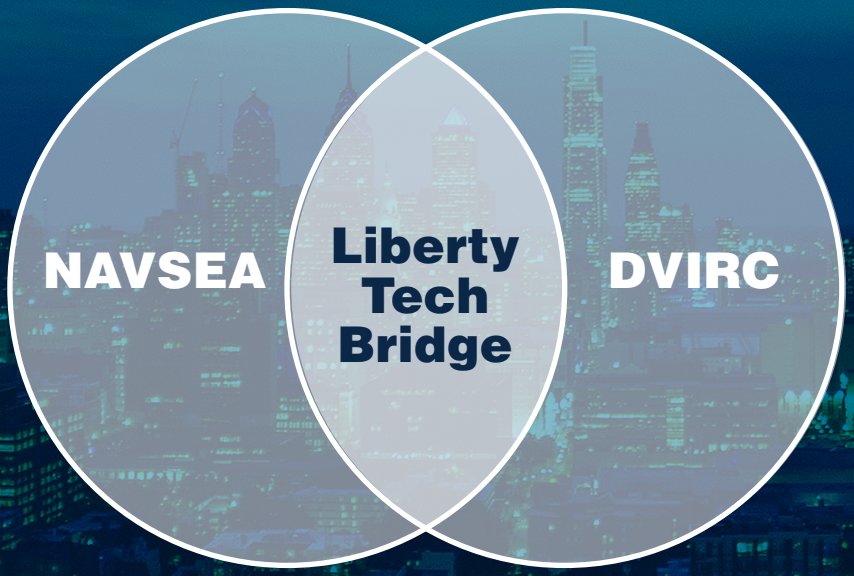
Priority Key:

- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations to advance MLR	Priority	ROM Cost	ROM Timeline
Develop BoM	Must	$1,500	2 months
Develop Cost Model	Should	$1,000	1 month
Scout assembly/COTS suppliers	Must	$1,500	2 months
Perform Critical Design Review	Must	$1,500	1 month
Complete Design for Manufacturing	Should	$2,500	2 months
Discuss potential to license technology to OEMs	Could	$2,500	2 months
Finalize Cost Model	Should	$1,000	1 month
Finalize BoM	Should	$1,000	1 month
Third party MRL revision	Should	$3,500	2 months
Finalize/Select COTS suppliers	Must	$1,000	1 month
Pilot Production Run	Must	$3,000	1 month
Evaluation and Design Modification	Must	$2,000	1 month
Full-Rate Production Run	Must	TBD	TBD
ROM Total:		**$22,000**	**16-18 mos**

Analyst: DVIRC

TECHNOLOGY VIABILITY ASSESSMENT POWERED BY MILTECH



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DVIRC

2905 Southampton Road
Philadelphia, PA 19154

215-464-8550
info@dvirc.org
www.dvirc.org

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/company/dvirc/

/user/dvirc