

A High-Performance Imaging System That Thrives in Tough Environments

Project Overview

When no third-party solution would do, a cross country collaboration between Benchmark facilities helped resolve an array of mission-critical concerns for long-range surveillance in the field. The result: an imaging system with reliable precision optics and positioning mechanisms, ruggedized for use in all types of environments, and assembled in the United States at scalable quantities and a reasonable cost. Here's how a diverse "team of teams" brought a new high performance imaging system to life.

The Challenge: Build a Long-Range Imaging System That's Rugged and Precise

The high-performance imaging system was developed for use in Benchmark's Integrated Surveillance Solution. A mobile Integrated Surveillance Solution (ISS) is a vehicle-mounted imaging system that uses a variety of sensors integrated with cutting-edge software to provide surveillance, day or night, in any weather, over vast distances, in any type of terrain.

Precision Optics—Surveillance of expansive, remote areas poses a unique set of challenges. Imaging systems need to acquire high-quality images anywhere and at any time. This necessitates both a high-definition

Engineered to achieve:

- High-resolution images over long distance
- Tolerance of G-forces and vibration off-road
- Operation from -40C to +70C in rain, wind and dust
- Reliable medium-volume final assembly in the U.S.A.



color daytime camera, along with an infrared camera, mounted such that the two cameras are centered on the same spot at infinity.

Positioning—The ability to precisely point the imaging system mandates that the positioning system be just as robust, and stable enough that images don't "bounce." Laser systems also must be included to provide range information and to "illuminate" targets with infrared light when agents are wearing night-vision equipment.

Uniquely, any new solution also has to integrate with the pre-existing mobile surveillance system, mounted on the same retractable tower, with the same user interface. But the accuracy required of these delicate optical systems is at odds with the rugged environment in which they must operate while rigidly mounted on masts in the beds of pickup trucks. Rocky desert terrain, for instance, subjects imaging systems to extreme vibration and shock loads and the masts can only handle so much weight.

Environment—The environmental challenges that a long-range surveillance solution must also face include the ability to operate at temperature extremes (-40C to 70C) along with wind, rain (including thunderstorms),

blowing dust and sand, high and low humidity, solar loading, and salt fog found in coastal areas.

Additional requirements of a new imaging system are that it be easily repaired in the field, impervious to wildlife (rodents, snakes, insects), and consume very little power in order to operate for extended periods in remote locations using only the batteries in the vehicle.

No Third-Party Product Could Meet These Expectations

For the initial design, Benchmark considered commercial, off-the-shelf solutions. But this proved problematic, as all existing products were significantly limited.

Mass was a major issue with several third-party options; thus was a major design criterion. Additionally, the country of origin was important because the customers are U.S. government entities. Further, no system on the market was stable enough in its design that production could be scaled up to the requested rates of delivery at a reasonable cost.

That's when Benchmark engineers reached across teams and across the country to design and build an imaging system using in-house expertise in system integration, mechanical design, software engineering, and supply chain optimization.



The Solution: A Reliable, Road-Ready Imaging System

Created Through Teamwork

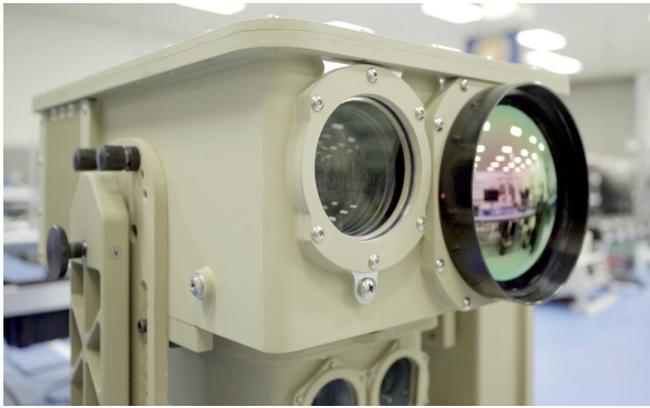
Benchmark Secure Technology based in Santa Ana, California, took the lead on the design and performed the systems engineering, camera integration, software design and supply chain optimization functions. Meanwhile, the complex mechanical design challenge was handled by the Benchmark Design Center of Innovation in Rochester, Minnesota, where the team's efforts included the enclosure design, optical windows and a means to align the optics in production.

Working virtually side-by-side, engineers and subject matter experts from facilities nearly 2,000 miles apart were able to meet or exceed all design requirements and to perform pilot production at the Santa Ana location. Production documentation for assembly and test also was created by Benchmark Secure Technology's manufacturing engineering group in preparation for full-rate production. Meanwhile, Benchmark's supply chain specialists worked closely with the engineering teams to ensure that components met all technical and environmental requirements and would be available at volume.

Crafted by Innovation

In compressed design and prototyping cycles—each lasting less than two months—the teams effectively created a housing that mounts the two cameras and laser optics in a manner such that they can be aligned with one another. Focused on maximizing the accuracy and stability of the servo mechanism used to aim the optics, the center of mass had to be placed close to the center of rotation of the system at the yaw and pitch axes.

Weight and vibration were considered at every stage of development. The solution could weigh no more than 90 pounds, but still have sufficient mechanical integrity to endure harsh terrain and environments without impacting the convergence of the optics. The different IR cameras used in the various integration models have different lengths, weights and moments, too, that had to



be accommodated by the new design. These tolerances required each component to be selected carefully for size and durability.

Because the imaging system is intended for use outside, mounted high atop a mast, it was critical that the optics not be subject to fogging caused by condensation at low temperatures. Due to limited power supplies in the field, heaters were not practical, so the entire enclosure was purged of ambient air during manufacturing and replaced with dry nitrogen.

Throughout mechanical and electrical design, both teams had to ensure that every opening in the housing (windows, covers, access ports and pins in external connectors) were gas-tight to prevent the loss of dry nitrogen or the ingress of moist air.

In the end, engineers implemented a design in which the cameras and optics were well supported in a lightweight housing which allows nulling-out all parallax. The entire design was modeled in CAD systems that revealed final weights and balances prior to cutting any metal. The CAD models provided the additional benefit of aiding in collaboration between the two facilities—as did integration with corporate configuration-management tools such as Agile and LN.

Controlled by Embedded Software

Benchmark Secure Technology was responsible for designing a Linux OS that allows all aspects to be controlled over an Ethernet connection using a RESTful

web interface. The Minnesota-based software engineers also created the drivers required to provide command-and-control of both cameras, the laser rangefinder, the positioning platform, and the tilt sensors (inclinometers). Because the computer is mounted in the camera housing, its design had to meet all of the system requirements—making collaboration essential between the two design groups.

The Benefit: An Integrated Surveillance Solution Designed and Built in the USA

Ruggedization experience and environmental testing capabilities at Benchmark, gained through years of experience and numerous projects for defense customers, were the keys to ensuring that all specifications were met in this mobile surveillance challenge.

Using a testing lab specially designed to replicate intense off-road conditions, Benchmark Secure Technology engineers evaluated every aspect of the design. Applying the results of that testing, they implemented advanced modeling techniques to continuously address any design weaknesses that may have been uncovered.

Production of the Benchmark imaging system is now underway in Santa Ana, and the solution is being installed on mobile surveillance vehicles at the Benchmark facility in Angleton, Texas, for final delivery to government customers.

Today, end users—from U.S. customs and border-protection agents to military installation security forces and other security professionals—can work with confidence, knowing their mission-critical imaging systems are American designed and assembled and ready to handle any mobile surveillance task anywhere.