

## The stereo speaker company giving sight to self-driving cars

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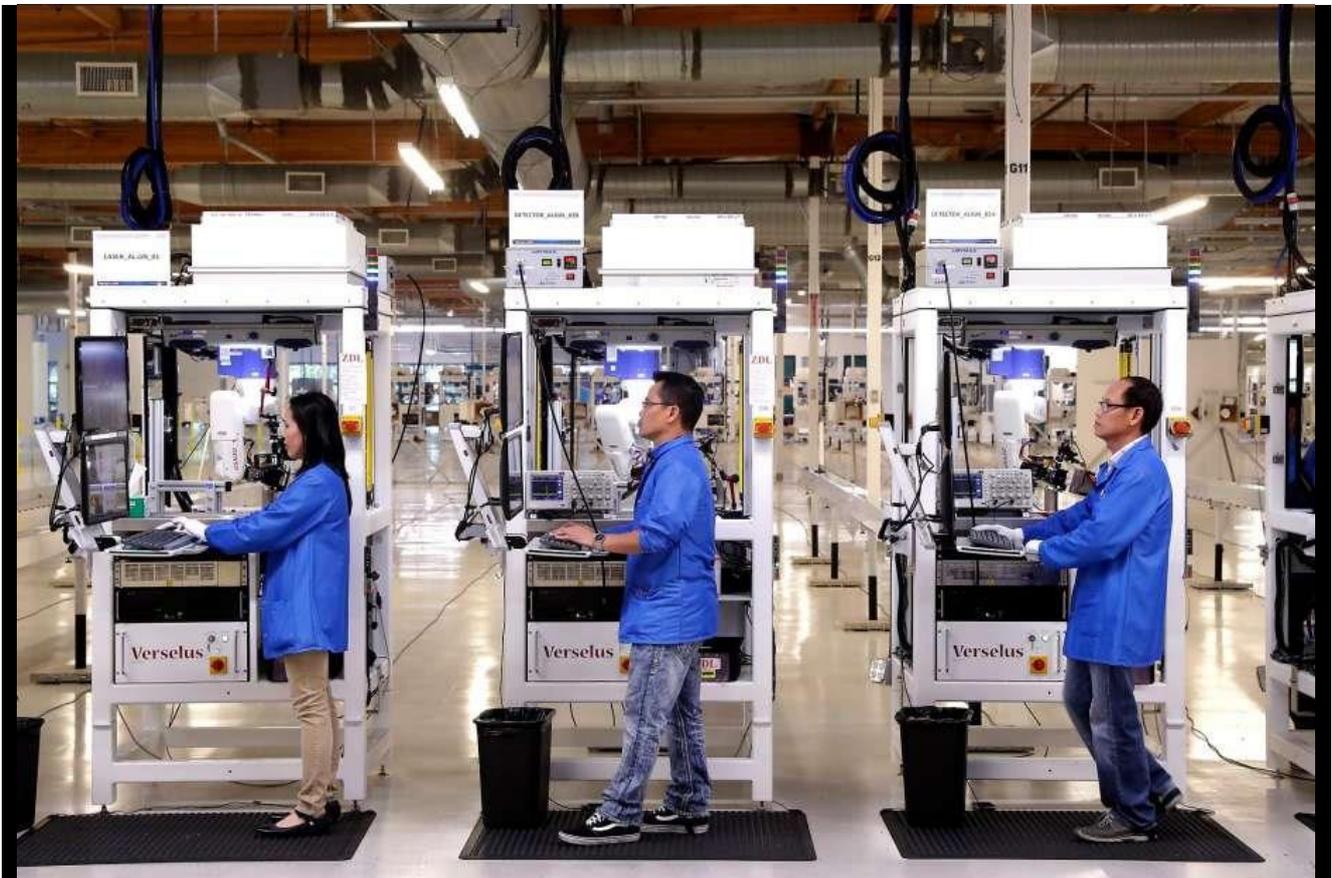


Photo: Michael Macor, The Chronicle



### IMAGE 1 OF 7

Above: Velodyne is cranking up production in its San Jose mega-factory since it became the self-driving vehicle industry's go-to lidar supplier. Below: The laser-based sensor that lets cars "see" their ... [more](#)

The whine of a power tool somewhere within Velodyne's new, half-empty San Jose factory nearly drowns out David Hall's voice. His lips tilted in a slight smile, eyes focused nowhere in particular, he doesn't seem to notice.

Hall is right in the middle of explaining how the company he founded in 1983 to make stereo speakers became a key player in the race to develop self-driving cars.

Velodyne now makes lidar, the laser-based sensors that let autonomous cars see their surroundings with stunning precision, even at freeway speed.

Although it will soon face plenty of competition, Velodyne has become the industry's go-to lidar supplier and is cranking up production to match. Last year, Ford Motor Co. and Chinese Internet giant Baidu pumped \$150 million into Velodyne, money the company used to open its "mega-factory" on San Jose's southern edge.

None of this would have happened had Hall, a soft-spoken and restless inventor with a tumbled mop of blond hair, not grown frustrated with the audio business years ago. The shift from subwoofers to lidar may be one of the oddest product pivots in Silicon Valley history, but it worked.

"That's just what I invent," said Hall, 66, who speaks in a wry, quiet voice just above a chuckle. "I look for a merging between mechanical, moving parts and electrical, computer parts and try to find something there, in that little niche that no one's really good at. So the self-driving car was perfect."

Lidar works by firing laser beams — thousands per second — at nearby objects and measuring how quickly they bounce back. With the notable exception of Tesla, most companies pursuing autonomous vehicles rely on lidar, along with radar and cameras.

"The prevailing view is that in the near term — at least a decade — you're not going to be able to execute this safely without lidar," said Mike Ramsey, research director at Gartner.

So pivotal is the technology that companies are willing to go to war over it.

The high-profile lawsuit between Waymo, the new corporate home for Google's self-driving program, and ride service Uber boils down to a fight over lidar. Waymo claims that one of its former top engineers who went to work for Uber took with him Waymo's designs for a better, cheaper lidar, accusations Uber denies.

And yet, while Waymo and Uber are developing lidar designs, both have used Velodyne.

Many companies, from legacy auto-part suppliers like Continental to startups such as Quanergy in Sunnyvale, have their own lidar offerings, with more on the way. So far, Velodyne is considered the company to beat.

"One major automaker told me they had vetted 50 lidar companies," Ramsey said. "So more than 50 companies exist, but only Velodyne is producing a lidar they can use."

Privately held Velodyne doesn't release profit figures. But the company, which is mulling an initial public offering within the next two years, expects revenue to top \$150 million this year. Hall says the company is in the black. And the automotive lidar market is just getting started.

“As far as opportunities go, this lidar thing is probably a rare beast,” Hall said. “I tell everyone working here that you’d better enjoy it, because you’re never going to see this again in your lifetime. I beat that into people on a daily basis, and it’s probably true.”

Hall has been tinkering for most of his life.

Velodyne’s website boasts that he built his first amplifier at age 4. One of his more recent projects is the Martini, a boat with a shock-absorbing system so effective that even in choppy seas, cocktails won’t spill. Hall lives with his wife Marta, Velodyne’s president of business development, on an Alameda houseboat, so the nautical experiments make a certain sense.

In its early days, Velodyne built a reputation among audiophiles for its subwoofers, speaker components that produce deep bass tones. Hall wanted to expand to a full line of speakers. But starting in the late 1990s, Chinese companies began driving all his domestic parts suppliers out of business. He started to feel like an importer, not a builder.

So Hall cast around for something else, something potentially more lucrative.



Photo: Michael Macor, The Chronicle



John Eggert, marketing manager at Velodyne, displays on a monitor what the lidar sensor is seeing as a test vehicle drives near the company in San Jose.

For a while, he toyed with robots, thinking they would be Silicon Valley’s Next Big Thing. While that vision didn’t quite pan out, it did land him and his brother Bruce a spot on the British bot-fighting show “Robot Wars” in 2001. Their robot, Drillzilla, gained notoriety for graphically incinerating a competitor topped with a clown head.

“I think we gave children some nightmares,” Hall said.

Then in 2004 the U.S. military’s deep research arm, the Defense Advanced Research Projects Agency, sponsored a contest to design vehicles that could drive themselves across the desert. Intrigued, the Hall brothers bought a Toyota Tundra truck and outfitted it with a GPS and a stereo camera system that David designed. They also threw in Drillzilla’s steering motor.

The truck didn’t finish the race — none of the contestants did. But Hall realized that self-driving technology might be the he’d been seeking for years. “I went into it thinking, ‘This is robots, this is vision — I’ll find something here,’” he said. “ ‘I don’t care what it is, I’ll find something I can make.’”

Other contestants in the race had used versions of lidar that scanned in front of their vehicles. Hall began pondering how to improve upon the system, and after letting the idea percolate in his head for months, hit upon what would become the basic design for Velodyne’s original lidar. It would spin and fire off 64 laser beams in a 360-degree sweep around the car. While human drivers tend to focus on what’s ahead, computers need to know all of the surroundings. “What a computer wants to see is a top-down map, not a forward-looking map,” Hall said. “That’s my greatest contribution. I went there and said, ‘Hey, if you just look at the problem this way, top-down instead of forward, it works.’”

The Hall brothers installed the lidar atop their Tundra and took it to the next DARPA race, in October of 2005. An executive with Texas Instruments, which sponsored the team, told *The Chronicle* at the time that David Hall was “my prime example of someone on the lunatic fringe,” adding that he meant it as a high compliment. Lunatics, he explained, tend to light on new technologies well ahead of the pack.

“Well, guess what the lunatic fringe is doing right now?” said Texas Instruments’ Gene Frantz. “Figuring out how to make cars run autonomously.”

The Tundra still didn’t finish, making it 26 miles before loose wiring knocked it out of the competition. But Hall, and Velodyne, had a new product. By the time DARPA held another robot-car race, in 2007, five of the six teams that finished the course used Velodyne lidar, with each unit costing \$75,000.

Now, the race is to cut lidar’s cost.

Velodyne’s most popular lidar, about the size of two stacked hockey pucks, sells for \$8,000. As it ramps up production, the company hopes to bring prices down to “a few hundred dollars,” Hall said. “We’re in the inventing business, so we’re going to keep working on this thing until we crack that nut.”

The stereo speakers never went away. Velodyne Acoustics still makes them, while Velodyne Lidar now operates as a separate company. But Hall has no doubt that the growth potential lies with supplying self-driving cars.

“It’s the potential for the worldwide adoption of a fairly expensive device that does a wonderful thing,” he said. “We have an opportunity to save lives. We’re up there with a cure for malaria.”

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