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IN FOCUS

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U.S.-China Competition in Emerging Technologies: LiDAR

The governments of the United States and the People's Republic of China (PRC or China) have both identified strategic and emerging technologies as a key element of economic competitiveness and national defense. Efforts to lead in such technologies are a core aspect of U.S.-China strategic competition. Some emerging technologies have both civilian and military uses. Among these technologies is Light Detection and Ranging (LiDAR), a remote sensing technology used in automotive, agriculture, manufacturing, weather, and other systems. The LiDAR market and its uses are developing quickly. U.S. firms have led in LiDAR to date, but PRC firms are advancing with the support of PRC industrial policies and access to the U.S. market and technology. Some PRC firms have used questionable practices to obtain U.S. LiDAR intellectual property (IP).

LiDAR Technology

LiDAR is a remote sensing method that uses pulsed laser light to measure the distance, speed, and/or altitude of physical objects to map the surrounding environment. LiDAR allows for precise, accurate, and rapid three-dimensional measurements of natural and manmade environments with high resolution and long-range detection. Unlike other sensing technologies (e.g., cameras), LiDAR's performance is not degraded in low-light conditions. There are different types of LiDAR. Scanning LiDAR uses mechanical rotation to spin the sensor and enables 360-degree detection. U.S. firm Velodyne (now merged with U.S. firm Ouster) developed the first scanning LiDAR. Microelectro-mechanical system (MEMS) LiDAR uses miniature mobile mirrors to scan the environment. MEMS firms include the U.S. firm Atomica. Optical phased array (OPA) LiDAR does not require sensor movement and is thus more durable than alternative LiDAR technologies. OPA firms include Quanergy. Flash LiDAR works like a camera to map environments using a single laser pulse. Flash LiDAR firms include LeddarTech (Canada), Sense Photonics (United States), and Continental (Germany).

LiDAR Development and Applications

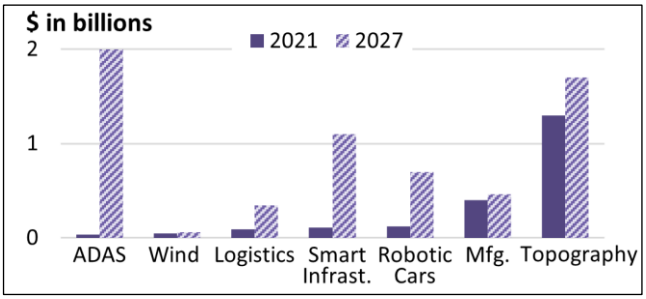
The United States first developed LiDAR as a military technology in the 1960s for defense and aerospace uses. Since then, the LiDAR market has expanded with the development of systems capable of autonomous navigation, for which LiDAR is a critical enabling technology. Its use has grown rapidly with demand for electric vehicles (EV) and related autonomous driving systems **(Figure 1)**.

Commercial: LiDAR has a range of applications in mapping, satellites, and space. In the automotive sector, LiDAR provides sensing capabilities for lane-keeping, collision avoidance, advanced driver assistance, and autonomous navigation. In precision farming, it can monitor crop conditions and soil health. In meteorology, LiDAR can improve weather forecasting. In manufacturing, firms use the technology for robotics and to monitor safety and productivity. "Smart cities" pair LiDAR with other technologies to integrate sensor networks in utilities, transportation, and infrastructure. Chattanooga, Tennessee, for example, plans to use LiDAR at 86 traffic intersections in an effort to improve traffic management and safety.

Military: U.S. and PRC forces are among the militaries using LiDAR to support autonomous navigation capabilities for uncrewed ground and aerial vehicles (UxV). LiDAR's precision and speed enable military-specific use. UxV equipped with LiDAR could be used to conduct battle damage assessment—an estimate of the physical and functional damage produced by an attack—removing the need for military personnel to be physically present and exposed on the battlefield. LiDAR-equipped UxV could be used to survey structural damage after natural disasters and to collect environmental data in remote or dangerous locations. The U.S. military has explored using LiDAR to identify and determine the depth of littoral sea mines and to conduct atmospheric monitoring to predict laser weapons' effectiveness. The U.S. Army says potential uses include "platform target identification, aim point selection, range instrumentation support, weapon defenses, and mapping."

Figure 1. LiDAR Applications: Market Forecasts

Figure is interactive in the HTML version of this In Focus.



Source: CRS, adapted from Yole Group.

Notes: ADAS is advanced driver assistance systems. Mfg. is manufacturing. 2021 is actual market. 2027 is forecasted market.

China's Industrial Policies

China's LiDAR firms benefit from PRC industrial policies and related subsidies, market protections, preferences (e.g., procurement), and other practices widely seen as unfair. PRC policies direct and finance the acquisition of foreign IP to develop China's LiDAR and related technologies (e.g., semiconductors and optical sensors). In 2020, China prioritized state support to develop sectors that use LiDAR (e.g., smart cities, smart manufacturing, autonomous driving). Since 2022, the PRC has encouraged foreign investment in its LiDAR sector on terms that develop PRC capabilities and has placed LiDAR under export controls.

PRC policies additionally emphasize technical standards setting to promote the use of China's IP and help PRC firms expand globally. PRC LiDAR firm Hesai has led China's efforts to develop national and global LiDAR standards. In the International Standards Organization, Hesai co-leads the Automotive LiDAR Working Group in developing a test method for LiDAR performance and safety. Hesai co-developed a U.S. standard for automotive LiDAR in 2020 and global optical radiation safety standards in 2022.

PRC policies incentivize aggressive tactics to obtain foreign IP, which may distort the common use of trade tools and involve questionable practices or illicit activity. In antitrust reviews of global deals, the PRC often sets terms for asset sales and technology transfer before approving deals. In 2023, the PRC effectively blocked Intel's bid for Israel Tower Semiconductor, a LiDAR chip producer. PRC firms use China's courts to set foreign IP licensing terms and launch copycat cases to challenge U.S. court rulings. In 2019, U.S. firm Velodyne charged the PRC's Hesai and RoboSense with illegally acquiring IP during talks to produce its products in China. In 2020, Veldoyne and Hesai reached a global cross-licensing patent agreement. In 2023, U.S. Ouster charged Hesai with IP infringement.

China's Use of the U.S. Market

PRC LiDAR firms are using U.S. capital markets to secure financing, enter the U.S. market, form partnerships, and acquire U.S. technology. In 2022, CITIC, a PRC state investor, undertook a $1.4 billion reverse merger with U.S. Quanergy Systems. Quanergy declared bankruptcy 10 months later and sold its assets for $3.2 million to a limited liability company (LLC) with possible Russia ties. In 2018, China's sovereign wealth fund CIC bought U.S. Boyd Corporation with Goldman Sachs. In 2015, the PRC state semiconductor fund financed PRC NavTech's acquisition of Sweden's Silex and a MEMS foundry in China that uses Silex's IP. In 2015, PRC state investors bought OmniVision, a U.S. sensor designer (**Table 1**). PRC auto firm Geely is invested in U.S. Luminar and co-developing LiDAR technologies. Hesai is partnered with Bosch, a German automotive supplier and key LiDAR patent holder. China also has ties to U.S. LiDAR research. For example, Tsinghua-UC Berkeley Shenzhen Institute's photonics lab in China works on LiDAR. The Institute's ties to University of California may allow PRC access to the Sensor & Actuator Center and Marvell Nanolab in Berkeley. LiDAR USA is a Hesai distributor; in 2024 Hesai incorporated in the U.S. market as American LiDAR. Robosense has a North American headquarters in Michigan; in 2024, it joined MCity, a University of Michigan research center.

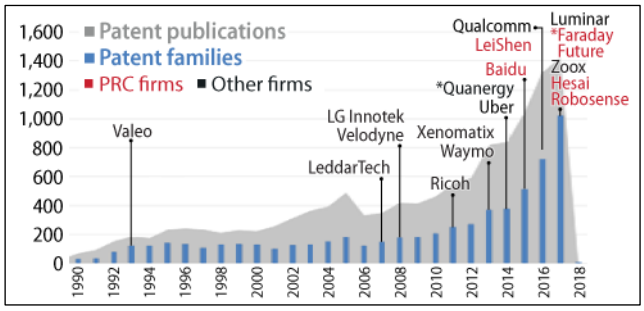
Table 1. Selected PRC Purchases of LiDAR Firms

Year	Target	Acquirer	Capability
2015	OmniVision	State investors	Sensor design
2015	Silek	NavTech, Sino IC Fund	Microscopic sensors
2018	Boyd Corp.	CIC	Optical encoders
	Faraday Future	Evergrande, CAS	LiDAR IP
2022	Quanergy	CITIC	Hardware, software

Source: Media and industry reports.

While U.S. and other non-PRC firms have led the LiDAR market with advanced research capabilities and IP, PRC firms are poised to quickly take a leadership position. PRC industrial policies, acquisitions of U.S. and foreign firms and IP, and corporate partnerships have already rapidly enhanced PRC firms' position in the LiDAR market, particularly in auto-motive LiDAR, as seen in recent patents granted to PRC firms (**Figure 2**). Supported by state monies and market preferences and protections, PRC firms are scaling up quickly in China. Hesai has a $98.4 million credit line to expand production in Shanghai and said in its 2023 filing with the SEC that it would use earnings from its U.S. initial public offering for acquisitions, research, and manufacturing. PRC firms had 58% of the global automotive LiDAR market in 2020, as measured by shipments. Many PRC firms operate at a loss and may be selling below cost to gain market share. Some analysts say the LiDAR market is ripe for consolidation, which may give China openings to acquire U.S. firms and expand.

Figure 2.Major Automotive LiDAR Patent Holdings



Source: CRS, adapted from Henry Patent Law Firm.
Note: *China acquired U.S. firms Faraday Future and Quanergy (and then sold Quanergy assets to an LLC in bankruptcy proceedings). A patent family is a patent collection covering similar technical content.

Military Ties and National Security Issues

In China, LiDAR systems are regulated as radio systems that require military approval. Additionally, PRC policies seek to develop technologies that are interoperable for civilian and military use and may allow PRC state access. PRC LiDAR firms support military programs. NavTech provides navigation technology for satellites (Beidou) and aviation defense (drones and fighter jets). Hesai makes equipment used in autonomous warfighting vehicles and is reportedly tied to the military's China Electronics Technology Group Corporation. Robosense has ties to the Harbin Institute of Technology, a military university.

There are reports that the U.S. federal government, state governments, and the U.S. military may be using or considering the use of PRC LiDAR systems. If so, it could have U.S. national security implications. China could use data compiled by PRC LiDAR systems to acquire sensitive information or exquisite mapping of U.S. infrastructure. China could use this information to conduct military or industrial espionage or gain operational advantages in a military conflict. PRC firms also could introduce malware via a software update and degrade the performance of systems using the technology.

In 2024, the Department of Defense added Hesai to its list of military companies in accordance with the William M. (Mac) Thornberry National Defense Authorization Act for FY2021, Section 1260H (P.L. 116-283). Additionally, the Department of Commerce issued proposed rules that would restrict the use of PRC connected technology in U.S. vehicles.

Issues for Congress

To help ensure fair competition and to protect U.S. national security, Congress could consider the tactics China is using to advance in LiDAR and whether to strengthen U.S. and allied procurement rules to review or restrict federal, state, and military acquisition of PRC LiDAR systems. Congress could also consider policies related to investment, export controls, fair trade, antitrust, standards, capital markets, IP licensing and infringement, bankruptcy, and research.

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