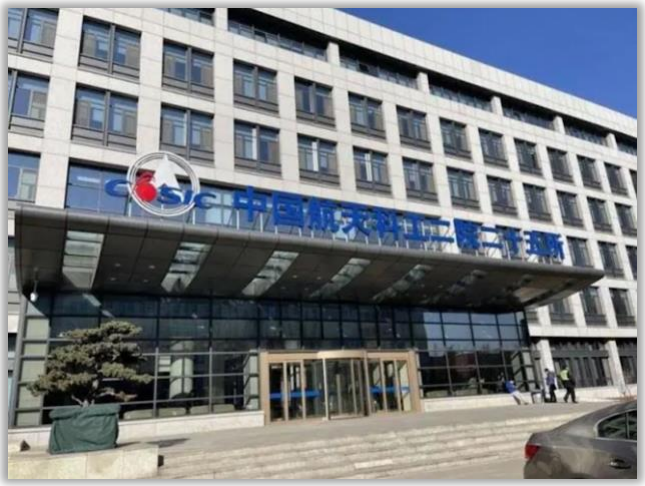
China's Space Capabilities:

The China Space 25th Institute: Design Center For Remote Sensing Systems

Summary

The Beijing Institute of Remote Sensing Equipment, also known as the **25th Institute**, is an element of the China Aerospace Science and Industry Corporation (CASIC). Chinese sources describe it as a "backbone research institute for precision guidance expertise and remote sensing technology." Research using a variety of Chinese and other online resources was conducted to develop a profile of the work currently being done by the 25th Institute. These sources indicated the following developments:

CASIC 25th Institute building in Beijing



Source: qq.com

- Product information showed a focus on radar remote sensing technologies for a variety of **missile systems and space payloads, operating in "sea, land, air, and space domains."** Specific products are identified for space docking operations and navigation satellite use.
- Solicitation of researchers showed current projects under way on **look-down target detection, machine learning for automatic target recognition, AI applications in image processing, and 3D laser imaging.**
- Published research highlighted research on algorithm design for radar signal processing. The key technologies included **background clutter reduction for sea and land targets, synthetic aperture radar image processing, and advances in missile seeker technology, with anti-aircraft missile and ballistic missile seekers mentioned specifically**.
- Patent applications further confirmed development work on **radar detection and tracking, missile-borne radar seekers, and infrared and laser imaging**. Most of the applications appear to be for signal processing techniques rather than for radar hardware.

Background

Previous China Keyhole reporting described the CASIC Second Systems Design Department, an entity involved in development of anti-missile and anti-satellite weapons.[1] This entity is subordinated to the CASIC Second Academy. In the course of research for that report, it was noted that the Second Academy had another entity known as the 25th Institute or the Beijing Institute of Remote Sensing Equipment. Research through online Chinese sources and other repositories for Chinese data was then undertaken on this entity to determine what systems it worked on and what, if any, space-based sensor systems it was developing. This report summarizes the results of this research.

As background, the following describes the two Chinese entities to which the 25th Institute is subordinated:

- **China Aerospace Science and Industry Corporation** (中国航天科工集团有限公司, known as CASIC) is a large state-owned enterprise under the direct administration of China's central government. CASIC is China's biggest missile weapon system development and manufacturing industry. It traces its history back to its formation as the Fifth Academy of the Ministry of Defense in 1956. It has had many different names through the years, including the Ministry of Aerospace Industry, China Aerospace Corporation, China Aerospace Machinery and Electronics Corporation, and then CASIC. It claims to own more than 600 companies and institutes, and it may employ more than 140,000 people. CASIC conducts research and development and manufacturing of air defense missile systems, cruising missile systems, and solid propellant rockets. Its space technology products have also supported manned space flight and lunar exploration.

- **CASIC Second Academy** (中国航天科工集团公司第二研究院) is one of several major CASIC subordinate elements that are numbered research academies. Its more formal name is the CASIC Academy of Defense Technology (中国航天科工防御技术研究院). It is also known by a corporate name, the Changfeng Electromechanical Technology Research and Design Institute (长峰机电技术研究设计院). CASIC states that its Second Academy "covers every kind of systems specialty in space equipment research and development, and holds a leading position in China in complete weapons systems, missiles, guidance and control, command control, systems simulation, and other specialties."

25th Institute Names

Like other elements of CASIC, the 25th Institute has an organizational name and a commercial name. In the organization structure, it is known as the CASIC Second Academy 25th Institute. As a commercial entity, it is called the Beijing Institute of

[1] See China Keyhole - China's Design Center For Anti-Missile and Anti-Satellite Weapons, July 6, 2021.

Remote Sensing Equipment. Multiple sources identify this entity with both names, indicating their interchangeability. For example, one posting about the products of this entity gave the names as translated below:

CASIC Second Academy Monitoring Project

Posted: September 13, 2020. By: admin

CASIC Second Academy 25th Institute (Beijing Institute of Remote Sensing Equipment),

For simplicity's sake, the name "25th Institute" will be used to refer to this entity for the remainder of this report except when specifically quoting another version of the name.

Description

Some public information is available online that gives an overview of the this entity. One typically generic profile reads as follows:

> "The Beijing Institute of Remote Sensing Equipment was founded in 26 Oct 1965. It is China's backbone research institute for precision guidance expertise and functions as a national-level key lab support unit for millimeter-wave remote sensing technology. It is a graduate degree granting institution authorized by the State Academic Degree Committee."

According to another profile, the 25th Institute currently has more than 1000 employees, with about 600 technical and management personnel and more than 300 with graduate or higher degrees.

Leadership and Organization

Very little was found online about leadership personnel at the 25th Institute. As of late 2020, the Director was Cao Zhezhi (曹哲致). The Chief Designer is Zhang Baohua (张宝华), and the Deputy Chief Engineer is Tang Chenliang (唐晨亮). Other named offices and their heads appear in the table below.

Named 25th RI entities and leadership

Element Chinese name	Element (English)	Director	Director (English)
空间载荷总体技术研究室	Space Payload Systems Design Research Office	邓晓东	Deng Xiaodong
微系统研发中心	Microsystems Research and Development Center	刘志哲	Liu Zhizhe
天馈技术研究室	Antenna Feed Technology Research Office	刘涓	Liu Juan
光电成像技术研究室	Electro-Optical Imaging Technology Research Office		Unknown
引信与数据链总体研究室	Fuse and Data Chain Systems Research Office	杨健	Yang Jian (Deputy)

Location

Multiple sources identify the 25th Institute address as No. 51 Yongding Road, Haidian District, Beijing, postal code 100854. An additional address, Being Post Office Box 142, Sub-box 205, was included in this posting. The street address corresponds to a vast compound (rather than one building) located just outside the Fourth Ring Road on Beijing's west side. Chinese online map systems identify this compound with a label that translates as "China Aerospace Science and Industry," or CASIC. Confirmation that this compound belongs to the CASIC Second Academy can be found in nearby references to the Second Academy and to Changfeng, the corporate name for that academy.

Beijing City map

Source: 2345.com

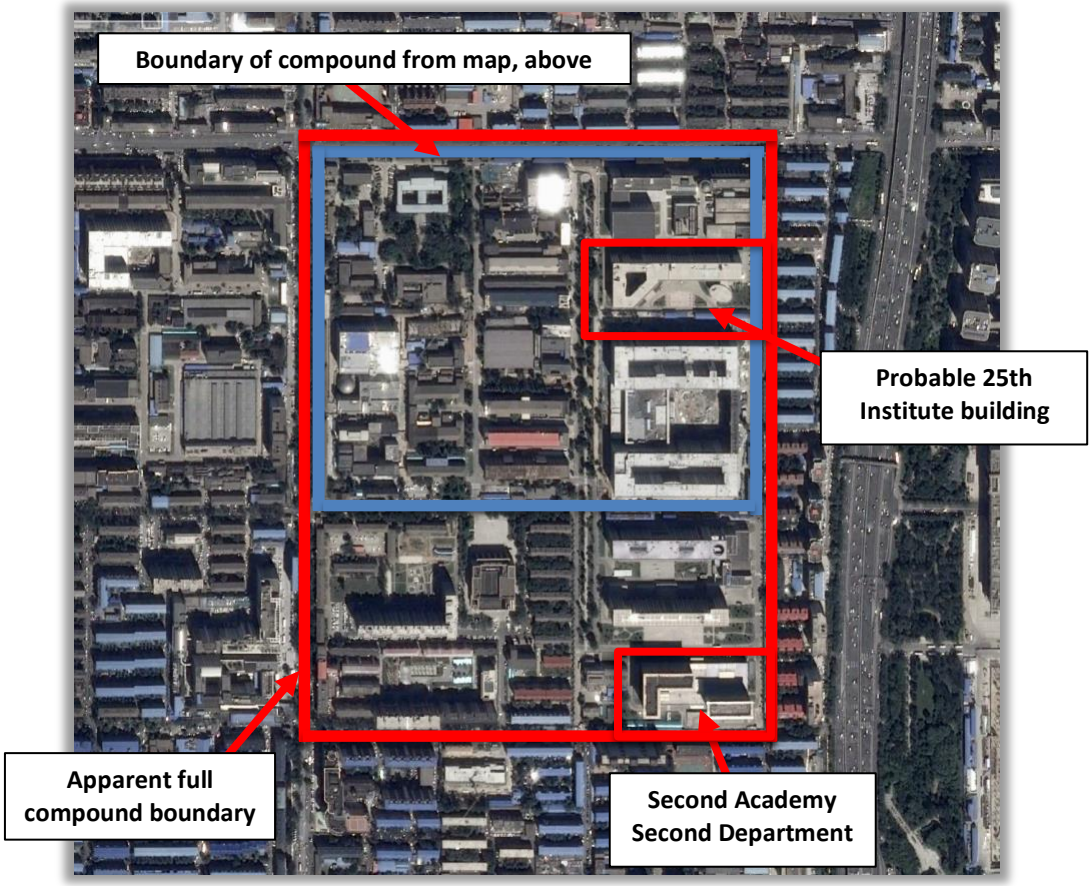
Compound (in blue) at No. 51-52 Yongding Road

Source: 2345.com

The blue boundary in the satellite image below of this location shows the buildings in the compound that is highlighted in the map above in blue. However, the grouping of buildings and the wall configuration in this area indicate that the Second Academy now operates a bigger facility that includes another group of buildings to the south as indicated by the red boundary in the image. The eastern third of of this area was largely demolished since 2006 and a suite of new buildings was constructed that runs the full length of the compound from north to south. One building in the southeast corner of this new construction area has been identified as the Second Academy Second Department.[2]

[2] See China Keyhole - China's Design Center for Anti-Missile and Anti-Satellite Weapons, July 8 2021, for details on this facility.

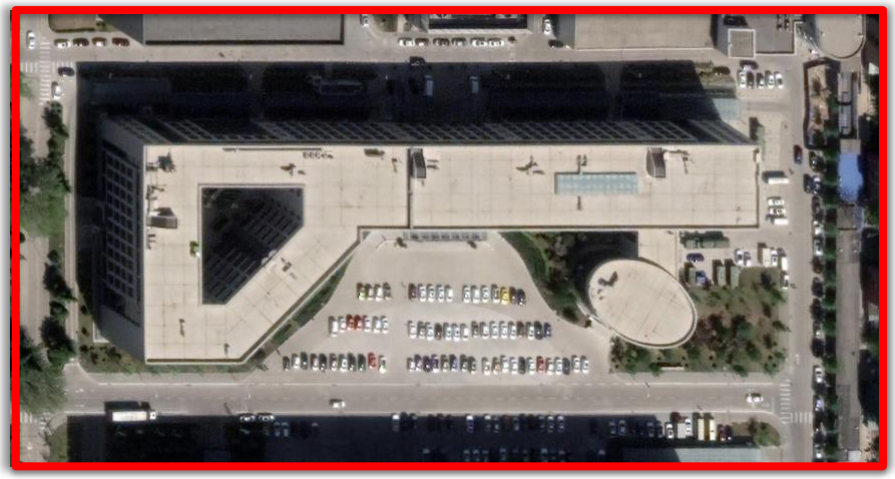
Second Academy compound with 25th Institute building



Source: map.google.com

A search of satellite imagery of this compound showed a six-story structure near the north end of the new construction complex, as indicated in the image above. A closer view of this building appears below. Historical imagery showed that this building was under construction in 2010 and was apparently complete and working by early 2013. The approximate geographic coordinates for this building are 385455N 1161555E.

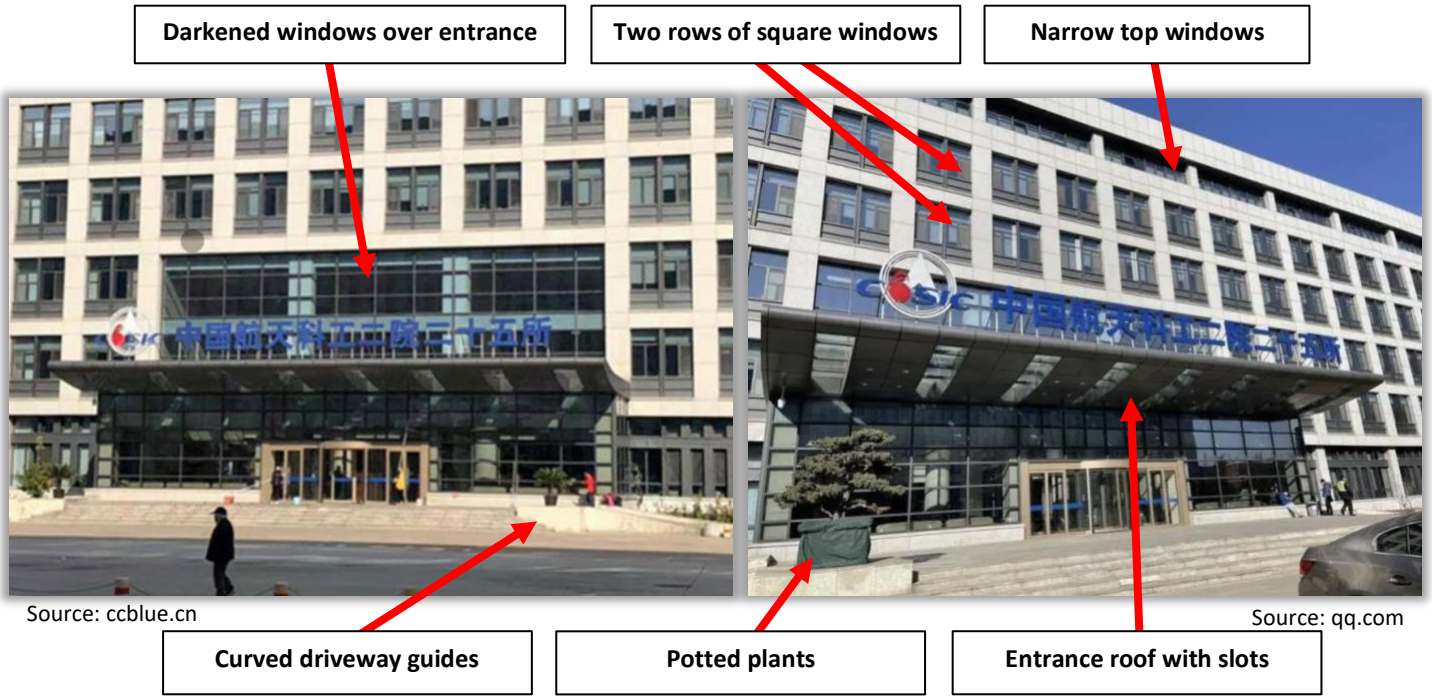
Probable 25th Institute building, Apr 2021



Source: map.google.com

The identification of this building is based on comparison of ground-level images found online of the CASIC 25th Institute to a more oblique satellite image of the building, as shown below.

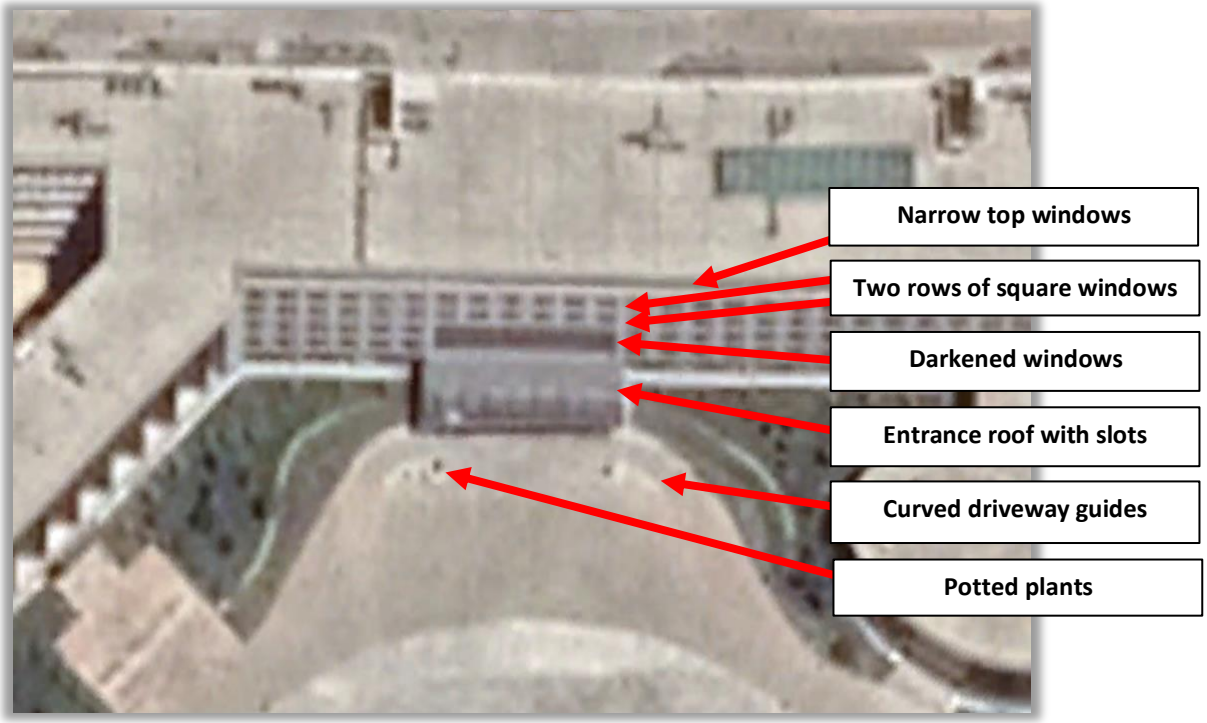
Two views of the building entrance labeled "CASIC Second Academy 25th Institute"



Source: ccblue.cn

Source: qq.com

2018 satellite image of probable 25th Institute building in CASIC compound



Source: Google Earth

The multiple features of the building in the satellite image that match the facade identified online as the 25th Institute, especially given that this building is in the CASIC compound identified by the street address, indicate that this building is in fact the location for the 25th Institute

Identifying the Nature of 25th Institute Work

While some of the work at the 25th Institute has been identified in general terms, the specific characteristics of its research on future systems are not talked about freely in Chinese media. Nevertheless, there are public aspects of 25th Institute work that, taken together, can be used to infer some important details about the systems under development. Sources include some anecdotal details found about systems already produced by the 25th Institute. There were recruiting announcements found that give details of research work the 25th Institute plans to conduct. The published results of current research projects also appear as academic journal articles in Chinese media. In addition, while some hardware and software developments may be too sensitive to announce publicly, some details of their work are reflected in patent applications for which there are public records. Data from these four sources are shown below.

Information on 25th Institute products is a primary source for characterizing this entity. Several sources identified the 25th Institute as the producer of "seekers, fuses, command guidance, and space payloads, related to sea, land, air, and space domains." They also claimed 25th Institute production expertise in a variety of technologies, including:

- Microwave and millimeter wave systems
- Infrared optical systems
- Signals and communications processing
- Automated control
- Antenna feed systems and antenna housing
- Communications engineering
- Electrical power components
- Special components and micro-assemblies

A 2020 article identified the 25th Institute Micro-Assembly Center as a production department established in 2015 with about 180 employees. This department operates a production line and a product performance testing line, and was involved in "film micro-strip composite integrated micro-assembly technology and multi-chip component technology."

The 25th Institute claims its space-related products include the millimeter-wave radar used for rendezvous and docking on China's Tianggong-1/Shenzhou-8 and Shenzhou-9 missions. They were also the reported developers of the meteorological survey radar for the Fengyun-3 weather satellite.

One report claimed that products developed by the 25th Institute "were part of four missile systems included in the [2009] 60th National Day parade." In addition, a posting at the website for Beidou, China's manufacturer of navigation satellite systems, identified that it had cooperated with the 25th Institute on production of an "Anti-Interference Highly-Dynamic Multi-System Navigation Receiver," which was capable of processing signals from the Chinese Beidou satellites, from the U.S. GPS satellites, and from the Russian GLONASS system.

Recruiting Researchers

Recent recruiting ads have stated that the 25th Institute was looking for researchers who had majored in "information and communications engineering, electronic science and technology, electromagnetic field and microwave technology, electro-optical engineering, weapons science and technology, control science and engineering, microelectronics, artificial intelligence, automation, and materials science." A 2021 announcement also stated that there were positions open for the design of "radar seeker systems, high-frequency transmission and reception technology, signal processing, antenna and antenna housings, electro-optical systems, fuses and transponders, communications, and near-sensing probes."

In addition, a 2017 recruiting announcement for graduate and doctoral research projects at the 25th Institute was found posted at the China University of Science and Technology website. It listed the following projects:

25th Institute research projects described in 2017 recruiting announcement

Research Project Title	Translated Title
智能化雷达信号处理方法研究	Intelligent Radar Signals Processing Methods
MIMO 雷达总体与信号处理技术研究	MIMO Radar Systems and Signals Processing Technology
频谱感知及综合对抗技术	Frequency Sensing and Comprehensive Countermeasures Technology
高速、高动态条件下，下视水面目标探测	Sea-Surface Look-Down Target Detection In High-Speed/Highly Dynamic Conditions
高速运动载荷协同定位同步组网技术研究	Synchronized Network Technology for High-Speed Dynamic Payload Location
基于 CMOS 的射频收发关键芯片的设计	Design of Crucial Chips Based on CMOS for Radio Frequency Transmitter/Receiver
基于机器学习技术的雷达信号处理技术及目标识别	Radar Signals Processing Technology and Target Recognition Based On Machine Learning Technology
高集成小型化天线设计	Design of Highly Integrated Miniaturized Antennas

基于可见光/红外多波段图像融合技术研究	Multiple Wave Band Image Fusion Technology Based On Visible Light/Infrared
图像处理与识别技术	Image Processing and Recognition Technology
基于 APD 阵列的激光三维成像技术研究	3D Laser Imaging Technology Based On Avalanche Photodiode
人工智能技术、图像处理技术	Artificial Intelligence Technology and Image Processing Technology
隐身/透波一体化天线罩技术研究	Invisible/Penetrating Wave Integrated Radome Technology
基于深度学习的人工智能处理器的涉及	Artificial Intelligence Processor Based On Deep Learning
新一代小型化智能组网测控与数据链技术研究	New-Generation Miniaturized Intelligent Networked Measurement and Control and Digital Chain Technology
弹载自适应波束形成技术研究	Missile-Borne Adaptive Wave Form Technology

Published Research

Several hundred articles written by 25th Institute researchers have been archived at Chinese academic data bases. In order to profile current work, abstracts for the 79 articles published from January 2019 to the present were reviewed. The majority of these dealt with some form of radar research, while others touched on infrared sensors and artificial intelligence. Rather than repeat the rather esoteric titles of these academic articles, the main themes for a selection of these articles are included below.

RADAR DETECTION AND IMAGING

- Adapting a sea-surface echo processing algorithm for application to land-surface target echos (2019)
- The use of a weighted average method to solve errors in coherent integration processing for a ship-target echo from close range (2019)
- Threshold segmentation method based on two-dimensional energy detection to counter speckles and smear in synthetic aperture radar (SAR) images (2019)
- Using Field Programmed Gate Arrays (FPGA) to compute the waveform parameters in real time for low-probability-of-intercept radars (2019)
- Design of an image generation network for military unmanned aerial vehicles to better acquire synthetic aperture radar images (2020)
- For look-down radar, finding a suitable sea-clutter backscatter coefficient model and a real-time sea-clutter echo signal power computation method (2020)
- Feature selection method using particle swarm optimization for SAR image feature extraction for images containing ship targets (2020)
- Design of ballistic-missile-borne synthetic aperture radar (SAR) capable of wide-area imaging of medium and large ship targets (2021)

MISSILE-BORNE RADAR SEEKERS

- Improving the composite seeker sensitivity for a dual-band composite-radar active seeker (2019)
- Analyzing polarization characteristics of ground-sea clutter in the design of anti-jamming algorithms for radar seekers (2019)
- Reducing pattern distortion caused by mutual coupling between the missile-borne phased array radar antenna elements (2019)
- Examining the impact of the streamlined structure of the missile seeker radome on the electromagnetic performance of the antenna array (2021)
- Proposed progressive algorithm combining weight approximation and a genetic algorithm for maximum optimization of a phased-array seeker beam (2021)
- Use of the artificial Hadamard matrix calibration method on the phased-array radar antenna of a ballistic missile seeker (2020)
- Overcoming ground/sea clutter for an anti-aircraft missile with a composite guidance system attacking a low-altitude target (2019)
- Correcting range curvature, range walking, and signal-to-noise ratio gain for radars tracking high-speed maneuvering targets (2021)

MILLIMETER WAVE RADARS

- Proposed 60 GHz wideband 4×4 antenna array based on low temperature co-fired ceramic technology (2020)
- Reducing the false alarm rate in a vehicle-mounted millimeter-wave radar target detection system (2021)

TERAHERTZ RADARS

- Proposed techniques for terahertz imaging radar signal amplitude and phase error compensation and for inherent delay correction (2019)
- An examination of basic principles and advantages of advanced imaging and detecting technologies, including terahertz radar (2019)

SPACE DOCKING RADARS

- Design of a space rendezvous and docking microwave radar system integrating ranging, velocity measurement, angle measurement and communications (2021)
- Creation of an angle measurement algorithm for a space rendezvous and docking microwave radar (2021)

MORE ON RADAR ALGORITHMS

Many of the reports on radar development were in fact on software advances—writing the best algorithm—rather than hardware. In addition to the articles listed above, they also covered the following subjects:

- Use of the short-time Fourier transform (STFT) to reduce noise interference for a frequency hopping signal (2019)
- Design of an improved artificial fish swarm algorithm to calculate the mutual coupling coefficient of missile-borne phased-array antenna elements (2019)
- Use of the second-order Keystone transform algorithm to counter the small transmitting power and low target detectability of miniaturized space target detection radars (2020)
- How the Landweber iterative algorithm can effectively reconstruct target image intensity in ghost imaging (2020)
- A chaotic sparrow search optimization algorithm (CSSA) is applied to the simple image segmentation problem (2020)
- Improved search using a multi-threshold image segmentation method based on improved sparrow search algorithm (ISSA) (2021)
- Use of a dynamic threshold calculation method based on radar ambient noise statistics to eliminate invalid radar targets (2021)

INFRARED DETECTION

- Techniques for countering decoys for infrared guided missiles (2019)
- Suppressing the background radiation of an infrared detection system used in the space environment (2020)
- Wavefront coding and decoding for an infrared optical detection system (2020)
- Infrared seeker passive ranging method based on target image area and image gray-scale (2020)
- Math equations in inertial space for the infrared seeker servo mirror (2020)
- Real-time infrared multi-class/multi-target tracking network directed against ship targets (2021)

ARTIFICIAL INTELLIGENCE

- Proposed deep learning method to address low detection precision and high false alarm rates in traditional radar ship target detection (2019)
- Special hardware accelerator to achieve applications of convolutional neural networks in edge calculation (2019)
- Proposed multi-mode control scheme for long-term in-orbit spaceflight based on reinforcement learning (2020)
- Proposed visual feedback system architecture method for image recognition based on terminal AI chips (2020)
- Proposed neural network including convolution core with fixed-point sliding for processing a large amount of heterogeneous input data in the real-time flight of aircraft (2021)

One additional 2020 article of note was a technical study of laser fuse height detection error for anti-ground missiles. Its abstract included the following summary: "In the ultra-low altitude detection mode of a circumferential laser fuse, range gate compression was used to achieve the ability to counter ground clutter. The laser echo characteristics of the ground were calculated and analyzed under different conditions of missile flight altitude, pitch attitude and ground reflection properties."

Patent Applications

Chinese patent applications are posted online both in China and abroad. A review of 41 patent applications submitted by the 25th Institute since January 2019[3] provided the following additional information on their research (patent submission numbers shown for each application):

RADAR DETECTION AND TRACKING

- **CN109828269B:** Solving the signal-to-noise ratio problem for radar angle tracking precision on a moving carrier (2019)
- **CN110007140A:** Method for testing radar Linear Frequency Modulation signal chirp rate (2019)
- **CN110068802A:** Detection method for constant false target alarm rate (2019)
- **CN112526461A:** Detection method for radar signal space-dependent clutter suppression (2020)
- **CN112731388A:** Target detection method based on effective scattering-point energy accumulation (2020)
- **CN110058226A:** Phased-array radar angle measuring system based on positive and negative chirp rate (2019)
- **CN110188628A:** Intelligent naval vessel identifying system using range-Doppler radar images (2019)
- **CN110348356A:** Deep learning dynamic network for successive frame radar image data (2019)
- **CN110188628A:** Deep learning basis for Single Shot Detection model (2019)
- **CN110031835A**: Real-time position acquisition radar processing for poor road-echo signals (2019)

OTHER RADAR

- **CN110441750A:** Missile-borne radar extracts of strong target scattering points for ground targets (2019)
- **CN110336539A:** Ku-waveband high-power burst pulse amplifier for radar fuse (2019)
- **CN110554375A:** Phased-array radar for measuring the landing on an extraterrestrial celestial body (2019)

[3] patents.google.com/?assignee=Beijing+Institute+of+Remote+Sensing+Equipment&sort=new.

- **CN109830805A:** Space-borne phased-array antenna beam control circuits (2019)
- **CN109949363A:** Object recognition and detection systems suitable for terahertz bionic compound-eyes imaging system (2019)
- **CN111416263A:** Terahertz source based on phosphorus germanium zinc crystal (2020)

INFRARED IMAGING

- **CN110148101A:** Pre-treatment for visible light and infrared image enhancement (2019)
- **CN110006530A:** Large-to-small infrared field target simulation in the laboratory (2019)
- **CN109903244A:** Real-time recovery of infrared images (2019)
- **CN109889694A:** System-on-Chip optimization of infrared image noise reduction through gamma correction (2019)

IMAGING LASERS

- **CN111431021A:** Laser output for two laser beams with the same wavelength and orthogonal linear polarization (2020)
- **CN110109132A:** Laser detection system using light feed-back of main wave signal (2019)
- **CN112630746A:** Remote target measurement using pulse Doppler laser radar (2020)

Conclusions

The types of source material reviewed above paint a picture of the 25th Institute as a hardware and software developer for systems working in all combat domains. To summarize what each source type highlighted:

- **Product information** found online shows a focus on radar remote sensing technologies for a variety of missile systems and space payloads, operating in "sea, land, air, and space domains." Specific products are identified for space docking operations and navigation satellite use.

- **Solicitation of researchers** showed that there were current projects under way on MIMO (multi-input/multi-output) radar systems, look-down target detection, machine learning for automatic target recognition, AI applications in image processing, and 3D laser imaging.

- **Published research** reporting since 2019 again showed that the predominant research focus was on radar systems development, and that much of the development centered on algorithm design for radar signal processing. The key technologies in their work included background clutter reduction for sea and land targets, synthetic aperture radar image processing, advances in missile seeker

technology (with anti-aircraft missile and ballistic missile seekers mentioned specifically), and terahertz radar imaging. There was also research done on ballistic missile laser fuses, infrared imaging, and artificial intelligence applications.

- **Patent applications** since early 2019 further confirmed development work on radar detection and tracking, missile-borne radar seekers, and infrared and laser imaging. Most of the applications appear to be for signal processing techniques rather than for radar hardware.

Much of the data refers to development of radar and infrared systems without specifics about what type of platform the sensor would be used on. Given that CASIC is known as a major China space development entity, it could be assumed that its chief remote sensing organization would be working mostly on space-based sensor systems. The data found did not indicate that that was the case. Instead, the data pointed to sensor development for multiple domains and platforms. It should be noted that the 25th Institute is an element of the CASIC Second Academy also known as the Academy of Defense Technology, and as such its focus is on defensive missiles and supporting systems. It is also the case that CASIC, while often called "China Space," is actually the China Aerospace Science and Industry Corporation, so development of systems for all combat domains fits logically within its purview.