Science and Technology Trends

2010 National R&D Mega-Projects in East Asia

CHINA

Progress Toward Implementation of China's Key National Scientific and Technological Programs

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1. General Overview of China's Key National Scientific and Technological Programs

1. Overview

The key scientific and technological programs implemented in China such as those involving missiles, satellites, manned space flight, hybrid rice , etc., have played a significant role in enhancing the nation's overall strength in the past years.In this way, it is following the course pursued by the United States, Japan, South Korea and the countries of Europe, which have- previously implemented significant projects to meet national goals as important measures to enhance their own national strength.

China has defined, in The National Medium- and Long-Term Program for Science and Technology Development (2006-2020), 16 major special projects, including core electronic devices, high-end general-purpose chips and basic software, super-large-scale integrated circuit (IC) manufacturing technology and packaged units, next-generation broadband mobile communications, high-grade numerically controlled machine tools and basic manufacturing technology, large oil/gas field and coal bed methane development, large Advanced Pressurized Water Reactor (APWR) and high temperature gas-cooled reactor (HTGR) nuclear power plants, water pollution control and treatment, genetically modified varieties culturing, significant new drug development and manufacturing, prevention and treatment of major infectious diseases including HIV/AIDS and viral hepatitis, etc., jumbo passenger planes, high resolution earth observing system (EOS), manned space flight lunar exploration, etc. The major special projects cover a range of strategic industries such as information and biotechnology, and pressing issues concerning energy, resources and public health as well as dual-use technologies and national defense technologies.

These projects are being launched to attain significant strategic products, key generic technologies and important projects within a specified period through core technological breakthroughs and resource integration, which is the priority for China's scientific and technological development.

2. National Key Scientific and Technological Projects under Implementation

To fulfill the national overall strategic objective, the Chinese government has selected 16 significant strategic products, key generic technologies and important projects, including significant scientific and

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Table 1 China's 13 Promulgated Significant Scientific and Technological Programs

Significant programs	Contents and Objectives
Core electronic devices, high-end general-purpose chip and basic software	Tackle key technologies, and develop core strategic products in the fields of chip, software and electronic products. By 2020, China will establish an internationally-competitive R & D and innovation system in the high-end generic chip, basic software and core electronic element sectors.
Super-larger-scale integrate circuit manufacturing technology and package unit	Accomplish mass production of 90-nm manufacturing equipment, domestic production of core technologies, parts and components; develop the prototype of 65-nm manufacturing equipment; break through key technologies for 45-nm or less manufacturing equipment, tackle core and generic technologies of huge scale integrate circuit, and primarily establish IC manufacturing in China.
Next-generation broadband mobile communications	Research and develop new-generation broadband cellular mobile communication system with mass communication capability and low-cost broadband wireless communication access system with wide-coverage, short-distance wireless internet system and transducer network; increase China s proportion of intellectual property rights involved in on mainstream international standards technologies; and form an industry with a value of more than RMB 100 billion.
High-grade numerically control machine tools and basic manufacturing technology	Research and develop 2-3 kinds of large, high-precision, numerically controlled machine tools, develop critical, high-precision numerically controlled machines and basic equipment demanded in such industries as aviation, space flight, watercrafts, automobiles and energy equipment; acquire basic, key and generic technologies for numerically controlled machine tools, and establish a platform for researching and developing numerically controlled machines and for educating relevant talents.
Large oil/gas fields and coal-bed methane development	Research exploration and prospecting technologies for oil, gas, and coal-bed methane as well as oil/gas resources in complex conditions in western China and deep sea,;enhance independent design and manufacturing capability of packaged technologies and units; increase proven reserves rates of petroleum and natural gas by 10% and 20%, respectively, and the petroleum recovery rate by 40%~45%.
Large advanced PWRs and HTRs	Break through the key technologies for third-generation advanced pressurized water reactor (PWR); accomplish the standard design, and commence construction of the first commercial-purpose trial unit; acquire key technologies for high-temperature gas cooled reactor (HTR); and build a model 200,000 kw HTR project with independent IPR.
Water pollution control and governance	Select diverse watersheds to divide aqueous biological functions; research key technologies for water pollution control, lake eutrophication prevention & governance and biological renovation of water environment; break through technologies for protecting water sources and, intensively processing and transporting drinking water; develop integral technologies for guaranteeing safe drinking water and for optimizing water quality and allocating drinking water; and establish a system for monitoring and controlling the water environment and technologies for improving the water quality that are applicable to China s particular situations.
New gene modified biological species cultivation	Acquire a batch of genes with application values and independent IPRs; culture new disease/insect resistant, high-quality, high-yield and high-efficiency gene-modified biological species and enhance research for gene-modified biological products and the overall level of the agricultural industry
Significant new pharmaceutical innovation	Research chemical and biological pharmacological products; identify and verify new targets, research key technologies for new pharmaceutical design as well as large-scale high-efficient screening of pharmaceutics; prepare and evaluate pharmaceutical effects and safety as well as forecast final products, develop end-product traditional Chinese medicines (TCM) with reliable and stable qualities, and research and develop 30~40 new medicines with independent IPRs and market competitiveness.
Prevention and curing ofserious diseases such as AIDs and virus hepatitis	Break through the key technologies for creating new vaccines and medicines; independently develop 40 high-efficiency special diagnostic reagents and 15 vaccines and medicines; study and prepare therapeutic plans with TCM, western medicine and the two combined establish 10 internationally advanced therapeutic technologies platforms , and establish the technological system for preventing and controlling Aids and virus hepatitis.
Jumbo passenger planes[1)]	Break through the core and critical technologies centered on designing, developing and manufacturing systems integration, power system and evaluation of the jumbo passenger plane, and thus laying a foundation for researching and developing the plane.
High-resolution earth observation system	Break through satellite-, plane- and stratospheric airships-based high-resolution, advanced observing system; and establish the all-weather earth observation system and ground support and operating system such as a land data observing center.
Manned spaceflight project and lunar exploration project	Break through key technologies such as astronaut extravehicular movement and rendezvous and docking; establish a space lab that can independently orbit for long periods or be operated by humans over the short-term; based on circumlunar exploration, break through key technologies for lunar exploration; research and develop satellites for lunar exploration, thus laying the solid foundation for overall launch of the lunar exploration program.

Note: Only part of the contents and objectives of the high-resolution earth observing system program, the manned spaceflight and moon exploration projects are listed in the above table as other contents and objectives have not been promulgated yet.
Source: the Ministry of Science and Technology, August 2010

technologic programs, that are to be carried out before 2020 as defined in the Outline of Medium and Long Term Scientific and Technological Development. The aim is to enhance overall industrial competitiveness through core technological breakthroughs and resource integration, thereby augmenting national strength.

The 16 significant scientific and technological programs involve strategic industries such as information and biological projects and the attenuation of pressing problems in energy resources, environment and public health as well as dual-use technologies for civil and military purposes and national defense technologies, etc. Of the 16, 11 programs[2] are for civil purposes and the other three projects are still kept confidential.

Those significant scientific and technological programs are being conducted by scientific research institutes, higher education schools and enterprises, and financed by central and local financial funds raised by the above institutes as well as other channels. Funds for the significant programs financed and organized by the central fiscal authority are used and managed in accordance with the Interim Methods on Management over Special Funds for Significant Civil-Purpose Scientific and Technological Programs issued by the Ministry of Finance, the Ministry of Science and Technology and the National Development and Reform Commission on September 2, 2009.

In accordance with the central fiscal budgetary plan, the central government provided RMB 32.8 billion in 2009 and RMB 30 billion in 2010 to promote of implementation of the 11 significant civil-purpose programs.

2. Implementation of major specific Scientific and Technological Programs in 2009 - 2010

By the end of 2009, there were 13 scientific and technological projects organized for overall implementation, and some milestones have been reached in some projects.

1. Core Electronic Devices, High-End General-Purpose Chip and Basic Software Programs

Stage Achievements

China's first supercomputer named "Tianhe-1", developed successfully in 2009, runs on Kylin Operating System[3], and is able to do more than 1 quadrillion calculations per second (one petaflop) theoretically at its peak speed. "Tianhe-1", was ranked first in Asia and fifth on the list of the Top 500 Supercomputers released in November 2009. With the advent of "Tianhe-1", China has become the second country after the United States to develop a supercomputer with a capacity of 1 quadrillion calculations per second.

In May 2010, Xingyun (Nebulae), an even faster supercomputer than Tianhe-1, was developed in China. With a Linpack performance of 1.27 PFlop/s Xingyun holds the No.2 spot in the newest version of the Top 500 list and its theoretical peak is 2.98PFlop/s.

Figure 1 Tianhe-1 Supercomputer running with Kylin Operating System and FT CPU at one quadrillion calculations per second

1) Due to differences in the development level of the aviation industry among countries, passenger planes with over 150 seats are called the jumbo passenger plane, planes with 100-150 seats are the main plane and the plane with less than 100 seats is the branch plane.
2) Refer to non-military purpose technologies and projects;
3) The Kylin system is a closed source server OS jointly developed by China National University of Defense Technology (NUDT), China National Software & Service Co., Ltd., Lenovo Company, Inspur Group Ltd., and Beijing Minzu Hengxing Company since 2002, and passed acceptance inspection by experts at the end of 2006.

Feiteng CPU Chips, developed by China National University of Defense Technology (NUTD), are specially customized for Tianhe serial computers. Fei Teng 1500 will be installed in the Tianhe-1 in the second half of 2010, at which point the operating speed of the computer will be increased on the basis of 1.206 petaflops. In 2011, FT-1500 CPU will also be installed in Tianhe-2 supercomputer.

In addition, great progress has been made in areas such as – research & development and industrialization of embedded software platform for smart phone and network operating system oriented to the new network application mode.

Project Funds

An average RMB 4 billion has been appropriated for the projects every year, of which, about 2 billion is sourced from the central government and the remainder from local funds. More than 1 billion was allocated to basic software projects

Project Implementation

During 2010-2011, China's research and development for core electronic devices, high-end general-purpose chip and basic software project will focus on the following aspects:

High-end general-purpose chips: This project is dominated by the research and development of key technologies applicable to the computer CPU, - high-performance embedded CPUs, high-performance, low-power DRAMs oriented to the relevant computer, R & D and application of embedded access memory IP core and high-speed serial interface IP core.

Basic software products: This refers to R&D and application of new information terminal products based on domestically made CPU and operating systems, establishment of document format standards, research, development and industrialization of software products and creation of a significant application platform and integration environment, new network computing operating system, network application support tools and the next-generation search engine and browser based on the domestic basic software.

2. Major special project of Large Advanced PWR & HTR

Stage achievements

Since March 2007, when the four power-generation units applied at the Sanmen Nuclear power plant (Zhejiang Province) and Haiyang Nuclear plant (Shandong Province) were approved by the Chinese government as independent development projects[4] based on the new AP1000 technology[5], the units have been constructed and and are progressing well. According to the schedule, the first units at the two nuclear plants will be connected to the grid and commence electricity generation in August 2013 and February 2014 respectively.

In addition, the localization rate of key equipment of the four units above has reached 55 percent by introducing and assimilating foreign technologies, and breakthroughs have been made in the technologies for main pipes, pressurized containers, steam generators and main pumps.

Main Implementation Units

On February 15, 2008, the Chinese government approved the State Nuclear Power Technology Corporation Ltd.(SNPTC) as the lead implementor tasked with organizing and carrying out major special projects associated with the large-scale advanced pressurized water reactor (PWR) and high-temperature gas cooled reactor (HTR) nuclear power plants. Meanwhile, 67 institutes and enterprises were also approved to participate in the research, development

4) Refers to the projects developed with the independent IPR based on independent innovation by assimilating new internationally advanced technology.

5) AP1000 is a dual-circuit 1000MW PWR nuclear power generation unit developed by the Westinghouse Electric Company in 2002, modelled on the mature Model314 technology of the Westinghouse Company. This technology has been successfully used in the power stations Doel-4 and Tihange-3 in Belgium, and South Texas Project in the US.; The reactor cooling system is designed with dual circuits; each circuit is connected to a huge steam generator and two sets of sealed coolant pumps with pipes.The passive safety system has been adopted, and the instrument control system has been developed on the basis of Sizewell B full digital technology.

Table 2 Major Participants in Large AHWR and HTR Nuclear Power Plant Significant Programs

Projects	Participant	Overview
Research, development and design	Shanghai Nuclear Engineering Research and Design Institute (SNERDI)	One of the first design institutes in the world for the AP1000 general nuclear power project, the institute for China s AP1000 standardization design and the research, development, tasked with designing and implementing national key programs of the large nuclear CAP1400, and designing the first nuclear power station (Qinshan nuclear plant) on China s mainland and the first nuclear power unit exported.
	State Nuclear Electric Power Planning Design & Research Institute (SNPDRI)	The company designs and carries out conventional island[6], BOP and other engineering for one of the first batch AP1000 nuclear power projects in the world, and one for research, development and design of the conventional island for the national key program of the large nuclear power CAP1400.
	State Nuclear Power Technology R & D Center	The center researches, develops and verifies nuclear power technology established by SNPTC and Tsinghua University
	State Energy Nuclear-Level zirconium Material R & D Center	One of the first 16 national energy R & D center approved by the China National Energy Administration.
Equipment Manufacturing	Shandong Nuclear Power Equipment Manufacturing Co., Ltd.(SNPEMC)	Enterprise designing and manufacturing equipment such as steel shell and modules for the first AP1000 nuclear power in the world and implements China s third-generation nuclear power in a modular manner.
	State Nuclear Baoti Zirconium Industry Co., Ltd (SNZ)	China s unique base for independent research, development and manufacture of nuclear-level zirconium material
	State Nuclear Power Automation System Engineering Company	Company independently researches, develops and manufactures the digital instrument control and safety protection system for China s nuclear power station.
Project management	State Nuclear Power Engineering Company	Responsible for management of the world s first batch of AP1000 nuclear power projects
	Shandong Electric Power Engineering Consulting Institute Co., Ltd.	One of the general contractors in China s electric power industry
Operation service	State Nuclear Power Model Station Co., Ltd.	Owner of China s nationally significant nuclear power CAP1400 program
	State Nuclear Power Plant Service Company_SNPSC_	Provides technological and professional services for nuclear power station operation and service life management

Source: website of SNPTC, August 2010

and implementation of the project, including the State Nuclear Power Engineering Corp, Ltd. (SNPEC), Shanghai Electric Nuclear Power Equipment Co., Ltd. (SENPE), Institute of Nuclear and New Energy Technology of Tsinghua University, among others.

Project funds

The central government is expected to appropriate RMB 3 billion for project research and development in 2010.

Project Implementation

While importing advanced technologies, the Chinese government has decided to develop its independently designed and produced nuclear power technology – CAP1400[7], which is listed in the Mid- and Long-term Development Program of the Nuclear Power Industry (2005-2020) launched by the NDRC (National Development and Reform Commission). At present, Rongcheng Shidaowan Bay, Weihai City, Shandong

6) Conventional Island (CI for short), the generic term for a steam turbine generator unit and supporting facilities for nuclear power units and the premises where these facilities are located. The main function of the island is to convert the thermal energy of the steam flowing from the nuclear island to the conventional island into mechanical energy through the steam turbine and then convert the mechanical energy into electric energy through the power generator. CI premises include steam turbine workshop, cooling water pump room and water treatment workshop, and structures, switch stations, network-controlled building, transformer substations and power distribution substations at the transformer area.

7) Based on the AP1000 technology, China has designed the code of the independently developed large nuclear power technology with IPRs, of which, C is for China, A and P respectively for advanced and passive. CAP1400 refers to the advanced passive nuclear power station designed by China with aninstalled capacity of 1.40 MKW.

Province, has been selected as the power plant location, and the Feasibility Study Report, Site Security Analysis Report and Environmental Impact Evaluation Report and other relevant technological argumentation have been conducted. In accordance with the construction schedule of the CAP1400-based Demonstrative Power Plant Project,, the preliminary design will be completed by the end of 2011, and plant construction will commence in April 2013, and begin operation in December 2017.

In addition, SNPTC has already launched preliminary research on the CAP1700 nuclear power plant.The Institute of Nuclear and New Energy Technology of Tsinghua University has signed the first series of contracts for the high-temperature gas-cooled reactor (HTGR) research with the Power Industry Department, National Energy Administration.

3. Jumbo Passenger Aircraft Project

Stage Achievements

The Shanghai-based COMAC (Commercial Aircraft Corporation of China, Ltd) was established in May 2008 after approval in 2007, initiating the launch of China's jumbo Passenger aircraft project. The company is mainly responsible for developing and manufacturing the ARJ21[8] regional jumbo jet, codenamed C919[9].

Figure 2 The main structure of C919 jumbo passenger plane cockpit prototype was delivered officially on December 25, 2009

The main R & D work for the C919 in 2009 included

1) Technological requirements for plane design; 2) Primary overall technological scheme; 3) Tunnel test and preliminary design load test; 4) Determination for domestic suppliers and preliminary determination for foreign suppliers; 5) Selection of engine technology; 6) Preliminary digital electronic prototype; 7) Manufacturing of physical prototype; 8) Manufacturing of prototypes for exhibition and sale; 9) Development of key technologies; and 10) Technological and economic feasibility studies.

In December, the foundation was laid for the construction of the assembly and manufacture center of COMAC, and as of now, planning for three research, development, design, assembly, manufacture and service centers for the jumbo passenger plane have been completed.

The R&D work for the preliminary development of the C919 project will be completed in 2010, and the engineering development stage has commenced.

Major Implementation Units

The main participants in the project are COMAC, Shanghai Aircraft Manufacturing Factory (SAMF), AVIC 1st Aircraft Institute (Shanghai Branch), Commercial Aircraft Co., Ltd., AVIC II Group, Baosteel Group and Aluminum Corporation of China. The participants are responsible for program design, materials and equipment.

In addition, according to the plan, four training

8) ARJ21 plane is regional jet aircraft driven by turbofan engine for medium and short distances (the standard flight is 2,225 km) with 70 to 90 seats. The project was proposed and approved in April 2002, and the first flight was successfully made on November 28, 2008. For the time being, a serial of trial flights have been made, and it is expected to deliver the first plane in 2011.The plane includes four versions: standard range, extended range, freight and corporate jet.

9) It is the second jumbo passenger plane model designed independently by China (the first model is Yun-10), The passenger seats will number 156/168 (two-stage/one-stage), the maximum weight is 72500kg(STD)or 77300kg(ER), and the maximum designed flight is 2200nm(STD)or 3000nm(ER).

Table 3 Training Program for Jumbo Passenger Aircraft

Training system	Implementing unit
Training centers	China Executive Leadership Academy, Pudong (training headquarters)
	Shanghai Aircraft Design Institute (training base for design, research and development)
	Shanghai Aircraft Manufacturing Factory and Shanghai Xing Jian Polytechnic College (training base for assembly and manufacture)
	Jumbo Passenger Plane Target Customer Service Company (training base for customer service)
Production, Learning & Research bases	Shanghai Jiao Tong University (SJTU)
	Beijing University of Aeronautics and Astronautics (BUAA)
	Northwestern Polytechnical University
	Nanjing University of Aeronautics and Astronautics
Overseas training channels	Cranfield University (UK)
	Institute Sup rieur de l'A ronautique et de l'Espace_ISAE_

Source: Business Weekly, July 2010

centers, four bases for production, training and research, and two overseas training channels are being established to ensure implementation of the project.

In April 2010, COMAC preliminarily determined the suppliers for the equipment to be used in various systems, e.g., as hydraulic, oil fuel, air management, supporting power devices and lighting, etc. The Aviation Industry Corporation of China (AVIC) and Parker Hannifin Corporation received a contract for the hydraulic and fuel systems; AVIC and German Liebherr-Aerospace Toulouse SAS were chosen to supply the air management system; AVIC and Honeywell International Inc received the order to supply auxiliary power units and related equipment, and Goodrich Corporation will provide the exterior lighting system.

Project Funds

In accordance with the plan, the central government will invest RMB 50-60 billion in the major special jumbo passenger plane project.

Project Implementation

During July 20-22, 2010, COMAC assessed the scheme of the Shanghai Aircraft Design Institute on the overall structure design for the C919 jumbo passenger plane and the key technologies provided by the Shanghai Aircraft Manufacturing Co., Ltd. for assembling and manufacturing the 41 composite materials and parts in three specific areas of the C919 jumbo passenger plane.

Noteworthy is the first delivery of the ARJ21, expected in the end of 2007, was postponed to 2009 due to technological problems, and delayed yet again until the end of 2010. Delays have cast doubts on whether the C919 jumbo passenger plane can be implemented on schedule[10].

4. High-Resolution Earth Observing System Significant Program

Stage Achievements

In 2007, China began to construct an advanced atmospheric, land and marine observation system consisting of land-based, airborne and special observation platforms and significant programs have been launched. By the first half of 2009, China's earth observation satellites had been undertaken (China has launched 4 meteorological satellites, 7 resource

10) In accordance with the development plan, research, development and industrialization of China's jumbo passenger plane are divided into three stages: 2009 – 2014: accomplish construction of the assembly base and the capability for ensuring the R & D of the jumbo passenger plane; 2015-2020: accomplish mass production of the single-channel passenger plane with 150 seats; 2021-2025: accomplish mass production of the dual-channel jumbo passenger plane with 250 seats.

satellites, 2 maritime satellites, 4 Beidou satellites for navigation and positioning, 10 communication satellites, 18 returnable satellites, 18 satellites for scientific experiments, andspacecrafts SZ-1, 2, 3, 4 and 5 as well as the small satellite Beijing 1#. It is expected China's data provided by the domestic satellites will be increased by 60% - 80% by 2020.

However, China has not built a high-resolution earth observation system and high-resolution data are still being provided by foreign satellites or the Chinese Airborne Remote Sensing System.

Project Funds

Total investment in 18 significant projects/subjects involving earth observation data reached RMB 200 billion in the eleventh five-year plan period alone.

5. Manned Space Flight Project and Lunar Exploration Project

Stage Achievements

As for space flights, Zhai Zhigang, a Chinese astronaut accomplished a serial of space science experiments in September 2008, and returned to the orbital module of SZ-7 after undertaking a space walk per the pre-determined schedule, which indicates that China has obtained Extra-Vehicular Activity technology of manned space flight.

In accordance with the manned space flight development strategy, China will seek breakthroughs in manned spacecraft rendezvous and docking technology of, develop and launch the space laboratory in the next step to solve problems of the spatial application of the spatial lab in a certain scale, taken by human in short time. The current plan is to set up a spatial target craft (i.e., simple spatial lab) in 2011 or so, and then launch unmanned and manned spacecrafts for rendezvous and docking experiments.

As for the moon exploration program, China successfully launched the first lunar satellite Chang'e 1 (CE-1) on October 24, 2007 and accomplished a serial of scientific research studies including creating the country's first full map of the moon's surface. On March 1, 2009, the satellite carried out a controlled crash into the lunar surface successfully.

For the time being, China is preparing to launch the Chang'e 2 satellite, and breakthroughs have been made in the key technologies of research and development for earth-moon transfer orbit launch, X-band measurement and control, moon capture technology and skills, circumlunar flight orbit control, deep space tracking telemetering and control system and high-resolution stereoscopic camera, among others. It is expected that Chang'e 2 will be launched at the end of 2010. Its main tasks are to make high-precision images for the landing area and verify the measurement and control band as well as develop direct-access-to-orbit technologies, so as to make tests for key technologies for the soft landing of Chang'e 3 on the moon and make high-precision images for the landing area of Chang'e 3.

3. Conclusion

As far as the implementation of the 13 major special projects is concerned, the performance and quality of most projects meet the requirements as defined in the *Outline of Medium and Long Term Scientific and Technological Development,* which is laying a solid foundation for implementation of the next stage.

The only disadvantage is that China has not yet established a complete system[11] to assess the performance of the major specific projects to ensure final implementation of the project, although the central government has already defined the particular outline and objectives of each project.

The Chinese government has started work on formulating the 12th five-year plan, the draft version of which will be discussed at the Fifth Plenary Session of the 17th CPC Central Committee in October this

11) The assessment system mainly includes overall assessment of major objectives (such as achievements and processes), range (including internationally and nationally advanced), degree (such as advances in the overall project or key components) as well as quantitative and qualitative analytical feedback .

year, and it is expected the twelfth five-year plan will commence from March 2011.

Meanwhile, the compilation the of *China's National Planning for Scientific and Technological Development during the Twelfth Five-Year Plan Period* (2011-2015) is proceeding as well. The Chinese government has gradually increased investment in the research and development of new materials, information technology, biotechnology and state-of-the-art communication. From the prospect of the planning for the scientific and technologic development during the eleventh five-year plan period, major specific projects under the twelfth five-year plan period will include the aforesaid 16 projects; therefore, those significant programs are guaranteed to receive a steady flow of financial and technical resources, and market-based operation during their implementation.

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