Overview of the Chinese Academy of Sciences Strategic Priority Research Program (Type A) Postprint

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Abstract

The Chinese Academy of Sciences Strategic Priority Research Program (abbreviated as "Priority Program") is divided into two categories: A and B. Among them, Category A Priority Programs focus on breakthroughs in strategic high technologies and major public welfare-oriented key core scientific and technological issues, promoting technological transformation and the formation and development of emerging industries, and serving China's sustainable economic and social development.

Full Text

Preamble

The Strategic Priority Research Program of the Chinese Academy of Sciences (CAS) is classified into Categories A and B. Category A focuses on breakthroughs in strategic high technologies and key core scientific issues of major public welfare significance, promoting technological transformation and the development of emerging industries to support China's sustainable economic and social development.

Since January 2011, with strong support from the Ministry of Finance, Ministry of Science and Technology, and other relevant state departments, CAS has adhered to the principle of "top-level design, careful organization, launch when mature." To date, 12 Category A special projects have been initiated, with basic information summarized in Table 1 .

2. Special Project Organization and Management

To ensure the delivery of major scientific and technological achievements from Category A special projects, the Bureau of Major Scientific and Technological

Tasks (hereafter "Major Tasks Bureau") has established the 12-character requirement of "clear objectives, verifiable outcomes, practical applicability, and significant impact." For the first time in CAS' s major research project management system, concepts from defense project management have been introduced, establishing a "One Office, Two Command Lines, and Three Groups" management model. The "One Office" refers to the Special Project Management Office. The "Two Command Lines" are the administrative command line and the scientific-technical command line running in parallel. The "Three Groups" are the coordination group, the overall group, and the supervision group, which collaborate with clearly defined divisions of labor to jointly promote the orderly progress of all Category A special project work (Figure 1 [Figure 1: see original paper]).

2.2. Introducing a Supervision System for Closed-Loop Management

A special project supervision system has been introduced in Category A special project management. The Major Tasks Bureau is responsible for organizing the formulation of detailed supervision implementation rules and entrusting the CAS Defense Project Supervision Department to establish supervision groups for each special project. The supervision groups are tasked with "identifying problems and providing recommendations." Supervision experts go to the front lines to monitor and inspect task implementation, objectively and truthfully reflecting issues and providing consulting suggestions that offer important support for management decision-making. All CAS departments and special project undertaking units at various levels provide feedback and implement solutions to each issue raised in supervision reports, achieving closed-loop management (Figure 2 [Figure 2: see original paper]).

2.3. Strengthening Legal Entity Responsibility Through Implementation Agreements

In Category A special project management, CAS has continuously strengthened the target and process management of special projects, actively addressing prominent issues encountered during implementation. The program has explored institutional mechanisms suitable for special project characteristics that leverage CAS' s organizational advantages, strengthened overall coordination and effective allocation of human, financial, and material resources, and gradually established a relatively independent organization, implementation, and evaluation mechanism. This has initially formed an organizational management model conducive to achieving major innovative breakthroughs.

In May 2013, CAS headquarters launched a reform of research management. The Major Tasks Bureau assumed responsibility for managing Category A special projects. Under the leadership of CAS leaders in charge, through steps including "field investigation, thematic discussion, and in-depth advancement,"the bureau conducted systematic investigations and reviews of all Category A special projects, visiting over 30 institutes. Based on the actual management needs

of Category A special projects, the bureau has actively explored institutional development, management system construction, workflow standardization, and management model innovation.

The host units, project undertaking units, and task undertaking units are the responsible entities for ensuring the smooth implementation and successful completion of expected objectives of special projects. To strengthen the sense of responsibility of host and undertaking units, the "CAS Strategic Priority Research Program Management Measures (Revised Draft)"specifically includes provisions on legal entity responsibility: "Legal representatives and leadership teams of task undertaking units at all levels bear management responsibility for special projects···The completion status of special projects serves as an important basis for institute evaluation and leadership team assessment."

At the annual Category A special project work conference, the CAS leader in charge signs the "CAS Category A Strategic Priority Research Program Task Implementation Responsibility Agreement" with legal representatives of special project host units and project undertaking units, further strengthening the sense of responsibility among unit legal representatives.

2.4. Strengthening Process Management and Dynamic Adjustment

Category A special projects have established a dynamic adjustment mechanism combining medium- and long-term objectives with near-term tasks, and five-year budget estimates with annual budgets. Adjustments cover research content, personnel teams, technical routes, and budget allocations to ensure the ultimate realization of special project research goals. For example, the overall group of the Stem Cell and Regenerative Medicine Research special project, after careful study and demonstration, concentrated 70% of annual funding in the final two years to support 30% of the key research teams, achieving major breakthroughs in uterine wall repair and spinal cord injury repair that benefit people' s livelihoods.

The process also strengthens node assessment and process supervision, requiring each special project to "sign two documents" (task agreement and responsibility agreement), "hold two meetings" (annual plan meeting in February and mid-year promotion meeting in August), and "conduct two inspections" (supervision inspection and funding inspection), forming a sound working mechanism.

2.6. Promoting Collaborative Innovation and Driving Sci-Tech System Reform

Category A special projects are committed to using special projects as a bond to guide collaborative innovation, establishing industry-university-research innovation alliances with domestic leading enterprises and universities to explore new pathways for transforming scientific achievements into productive forces. This approach aims to enable more new technologies to bear fruit in enterprises at an early stage, serving national economic and social construction.

Through the implementation of Category A special projects, focusing on major scientific and technological issues has promoted cross-institute, cross-disciplinary, and cross-sector collaboration, optimized research organization and management models, and integrated and allocated research resources. This has initially formed a number of collaborative innovation platforms and mechanisms, accumulating experience and laying a solid foundation for CAS to promote the construction of "four types of institutions" and implement sci-tech system reform. For example, the Low-Grade Coal Clean and Efficient Cascade Utilization Key Technologies and Demonstration special project has established a "Low-Grade Coal Utilization Industry-University-Research Collaborative Innovation Alliance" with local government departments in Shanxi and Inner Mongolia, large enterprises such as Lu' an and Shenhua, and universities including Tsinghua University and Zhejiang University. The alliance conducts collaborative research on basic theories and key technologies for low-grade coal cascade utilization, promoting pilot-scale research and industrial demonstration through building information platforms, hosting summit forums, deepening cooperation and resource sharing, discussing industry status, and analyzing policy and technical needs.

3. Work Progress

Since their launch, under the correct leadership of the CAS Party Group and the guidance of President Bai Chunli and leaders in charge, Category A special projects have achieved remarkable results through the concerted efforts of undertaking units and researchers at all levels.

Stem Cell and Regenerative Medicine Research: The special project has achieved a series of major original results, including reconstructing the three-dimensional spatiotemporal transcriptome atlas of mouse whole embryos, constructing new artificial cell types, achieving same-sex reproduction using haploid stem cells, and obtaining functional sperm "in vitro." Major breakthroughs have also been realized in standardized clinical research combining stem cells with intelligent biomaterials. In clinical research on endometrial regeneration, 10 babies have been born successively, and spinal cord injury repair has launched 60 clinical cases with encouraging progress. The project has established a clinical-grade stem cell culture technology system and the nation' s first clinical-grade embryonic stem cell line, and completed relevant standard formulation and testing, greatly advancing stem cell clinical research in China.

Future Advanced Nuclear Fission Energy—Thorium-Based Molten Salt Reactor Nuclear Energy System: This special project has achieved major phased breakthroughs, comprehensively mastering core key technologies including prototype system scheme design and pilot-scale preparation of key materials. It has completed the preliminary engineering design of an experimental reactor and built the TMSR non-nuclear research facility, laying an important foundation for China to take the lead in constructing a thorium-based nuclear energy system experimental reactor. The project has been integrated into

the national energy development strategy (“Energy Technology Revolution Strategic Action Plan (2016–2030)”) and Shanghai’ s major layout for building a globally influential science and technology innovation center.

Future Advanced Nuclear Fission Energy—ADS Transmutation System: This project has proposed the original ADANES (Accelerator-Driven Advanced Nuclear Energy System) concept, developed a high-current superconducting linear accelerator prototype that has set multiple world records for proton beam intensity, built a large lead-bismuth experimental bench, and developed subcritical reactor simulation and zero-power experimental devices. The new domestically developed anti-radiation structural material—new high-temperature, anti-radiation, liquid-metal corrosion-resistant martensitic heat-resistant steel (SIMP steel)—has reached pilot scale. The project has also connected with the “Twelfth Five-Year”science and technology infrastructure project and signed strategic cooperation agreements with the State Power Investment Corporation and China General Nuclear Power Group.

Space Science: This special project has successfully launched three scientific satellites: the Dark Matter Particle Explorer satellite, the “Shijian-10”retrievable scientific experiment satellite, and the Quantum Science Experiment Satellite. The Hard X-ray Modulation Telescope (HXMT) satellite will be launched soon. The dark matter and quantum satellites are operating stably and normally, while the “Shijian-10” retrievable satellite has successfully returned. From scientific concept proposal to payload configuration and satellite development, CAS has taken the lead in all aspects. The expected scientific achievements will bring China into the world’ s advanced ranks in space science. The project has also deployed eight background model projects and three batches of 96 pre-research projects, laying a foundation for the long-term sustainable development of space science satellites.

Carbon Budget Verification and Related Issues for Climate Change Response: This special project has accurately measured carbon emission parameters and calculated China’ s energy-use carbon emissions, revealing that China’ s carbon emissions have been overestimated by 10%–15% by foreign research institutions for a long time. It has also accurately assessed the status and potential of carbon sequestration in China’ s terrestrial ecosystems at the national scale. In December 2015, the project successfully hosted the side event “Tracking Carbon Footprints—Chinese Scientists in Action” at the Paris Climate Conference, showcasing research results internationally and attracting widespread attention. A scientific database for carbon budget verification has been obtained, supporting the compilation of the national greenhouse gas emission inventory.

New-Generation Information Technology for Perception China: This special project has proposed a sea-cloud collaborative new-generation information technology system, constructing a sea computing framework centered on specialized computing that can elastically aggregate edge and terminal resources. It has innovatively proposed a data-driven sea-cloud resource collab-

orative scheduling model, broken through key technologies such as specialized computing chips and deeply programmable networks, and developed specialized chips based on algebraic computing and neural computing, as well as sea-cloud servers. This has improved efficiency by nearly an order of magnitude compared with traditional cloud computing models, achieving a 1–2 orders of magnitude improvement in global response effectiveness for local threats. Application demonstrations in sea-cloud security and industrial IoT have been carried out in key regions and important fields, achieving significant social and economic benefits.

Low-Grade Coal Clean and Efficient Cascade Utilization Key Technologies and Demonstration: This special project has broken through multiple core key technologies including pyrolysis, combustion, gasification, synthesis, and CO utilization, all of which have entered the industrial demonstration stage. Demonstration projects such as a 240-ton/day pulverized coal low-temperature pyrolysis unit, a 10,000-ton/year low-grade coal hydrogenation pyrolysis unit, and a 25,000 Nm^3/h flue gas multi-pollutant removal system have been successfully operated. Industrial demonstrations including a 350 MW supercritical circulating fluidized bed boiler and thousand-ton-scale multi-stage bed gasification technology are under construction and will be completed and operational in 2017. The special project is expected to strongly drive the transformation and upgrading of the coal chemical industry, generating hundreds of billions of yuan in social investment.

Molecular Module Design Breeding Innovation System: This special project has completed the collection, sorting, and preservation of 20,000 germplasm resources of rice, wheat, soybean, corn, and carp. It has analyzed and obtained 33 molecular modules with important application value for high yield, stable yield, quality, and efficiency, 27 molecular module systems, and developed 2 new coupling models. Thirty-six primary module new varieties have been bred, of which 3 have passed provincial variety approval. Important phased achievements and breakthroughs have been made in frontier basic major theories and core scientific issues such as rice cold tolerance mechanisms and heterosis genetic mechanisms.

Transformative Nanotechnology for Industrial Manufacturing: This special project has broken through multiple core technologies, with smooth progress in process pilot testing and industrial demonstration. Long-endurance power lithium-ion batteries based on new nanomaterial systems and next-generation high-capacity solid-state lithium-sulfur and lithium-air battery technologies have reached world-advanced levels and achieved pilot testing. The world' s first nano green printing plate/green ink production line has been built, with nano green plate-making equipment entering the South Korean market. Methane non-oxidative conversion to olefins and aromatics technology has cooperated with Saudi SABIC and PetroChina. Photocatalytic nano water treatment technology has achieved precision poverty alleviation demonstration in pastoral areas. Breakthroughs and applications have been achieved in

nanotechnology industrial manufacturing such as new metal mesh grids, 3D printing, and GaN-based lasers.

Jiangmen Underground Neutrino Observatory: This special project has successfully developed an internationally pioneering new-type photoelectric cathode and produced the world' s first 20-inch microchannel plate photomultiplier tube, establishing a production line. It has broken through core key technologies including high-performance liquid scintillator and Φ40-meter neutrino detector design and manufacturing. Tunnel excavation is more than halfway complete, laying the foundation for neutrino mass ordering measurement. International cooperation has been further strengthened, with 66 participating units from 15 countries and regions and approximately 450 collaborating personnel.

Tropical Western Pacific Ocean System Material and Energy Exchange and Its Impact: This special project has built the world's largest-scale tropical western Pacific main current system and Indonesian key strait channel subsurface buoy observation network, achieving real-time buoy data transmission. It has conducted deep-sea seafloor in-situ long-term observation and field experiments, confirming the existence of seafloor combustible ice in the South China Sea. Deep-sea near-bottom topographic detection resolution has been improved from sub-meter to centimeter level. Independently developed underwater unmanned equipment has achieved long-term autonomous observation in the Kuroshio region of the East China Sea and key areas of the western Pacific. A 30-year Indian Ocean-Pacific Ocean model product and a South China Sea environment numerical forecasting test platform have been built. Red tide prevention and control technology has been successfully applied in China' s coastal nuclear power industry.

Personalized Medicine–Inclusive New Drug R&D Based on Disease Molecular Classification: This special project has launched Phase III clinical trials for the world' s first anti-A candidate new drug 971 for Alzheimer' s disease, while simultaneously studying the impact on biomarkers for Alzheimer' s disease patient efficacy indicators, leading international Alzheimer' s drug R&D directions. The molecular targeted anti-tumor candidate new drug AL3810 is undergoing clinical research in Europe and China, showing particularly significant efficacy for malignant tumors with FGFR gene amplification and 有望成为 the first personalized anti-tumor candidate new drug from China to achieve new breakthroughs internationally.

South China Sea Environmental Change: This special project focuses on the major strategic needs of building a maritime power and the 21st Century Maritime Silk Road, taking key South China Sea sea areas as the main research zone. It conducts collaborative research on South China Sea geology, ecology, three-dimensional observation systems, and sustainable development, promoting the optimization and application demonstration of mature technologies to provide strong scientific and technological support for the sustainable development and utilization of the South China Sea. The special project has made important progress in key technology research and development accord-

ing to user needs, with some research results already being applied and forming multiple consulting reports, industry standards, and technical guidelines.

4. Conclusion

Since their launch, Category A special projects have continuously explored effective management of major projects and have produced a batch of scientific and technological innovation achievements with major domestic and international impact. In subsequent work on Category A special projects, the Major Tasks Bureau will, together with relevant CAS headquarters departments, continue to thoroughly study and comprehend the instructions from central leaders on the "Pioneer Initiative" and the strategic deployments of the CAS Party Group. The bureau will further implement the "Pioneer Initiative," continuously advance special project organization and management, highlight key work priorities, ensure the realization of special project objectives and major achievement output, strengthen connection with national science and technology plans, actively implement special project exits, standardize special project funding use, strengthen special project achievement publicity and expand influence, and further play CAS' s role as a "reliable and trustworthy national strategic scientific and technological force" to deliver satisfactory answers to the Party and the people.

Note: Figure translations are in progress. See original paper for figures.