UNIVERSITY OF CAMBRIDGE

Cambridge Industrial Innovation Policy

International institutional reviews

ANNEX 2: FROM INNOVATION TO INDUSTRIAL COMPETITIVENESS

Cambridge Industrial Innovation Policy, Institute for Manufacturing, University of Cambridge

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Taiwan-Semiconductors

1. National overview

1.1 National Development Plans (NDPs) and prioritised sectors

Taiwan's National Development Council (NDC) is the highest authority responsible for researching, planning, evaluating, and coordinating national industrial policy and sectoral development plans. Since 1953, the Council has formulated Taiwan's National Development Plans (NDPs). The latest NDP was published in 2025 and covers the period 2025–2028.

The latest National Development Plan is built around the government's priorities in five key sectors: semiconductors, artificial intelligence (AI), military industry, security and surveillance, and next-generation communications. These are collectively referred to as the Five Trusted Industry Sectors.

Priorities combine high-value jobs, national security, technological resilience and a position as a trusted global technology partner. Output targets include an increase of NT$2.7 trillion in semiconductors, AI output above NT$1 trillion by 2026, security and surveillance above NT$130 billion, and NT$30 billion each in satellite communications and military drones.[1]

The NDC published the Five Trusted Industry Sectors Promotion Plan (2024–2028) in 2024, which connects sector targets with the capabilities needed to deliver them. For example, semiconductor policy covers the full value chain from design and research to manufacturing, packaging, materials and equipment, while the other trusted sectors combine technology development with supply-chain, security and market objectives.[2]

1.2 Key government bodies and funding institutions

Taiwan combines publicly funded research institutions with industry participation. Specifically, universities and Academia Sinica lead basic research with mainly public funding. Firms focus more on applied research, commercialisation and deployment, largely through self-funding. Publicly backed institutes support applied research and scale-up, with private participation generally increasing closer to commercial application (Figure A.1).

The Ministry of Economic Affairs (MOEA) and the National Science and Technology Council (NSTC) are the two leading government bodies responsible for managing public institutions that support industrial scale-up. Both sit directly under the Executive Yuan, Taiwan's highest administrative authority.

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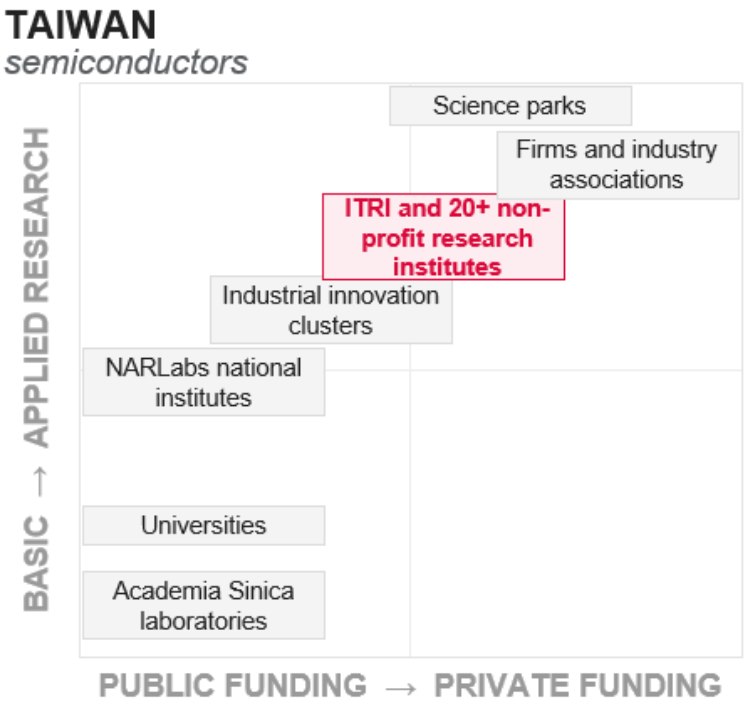
[1] National Development Council. National Development Plan (2025-2028)
[2] National Development Council. Five Trusted Industry Sectors Promotion Plan (2024-2028)

FIGURE A.1. POSITIONING MAP OF TAIWAN'S KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



- Ministry of Economic Affairs (MOEA)

The Department of Industrial Technology (DoIT), a staff unit within MOEA, promotes industrial technology aligned with sectoral priorities. Its six-unit structure covers technology policy, programme administration, innovation and start-ups, electronics and ICT, machinery and transportation, and biomedical and materials.[3]

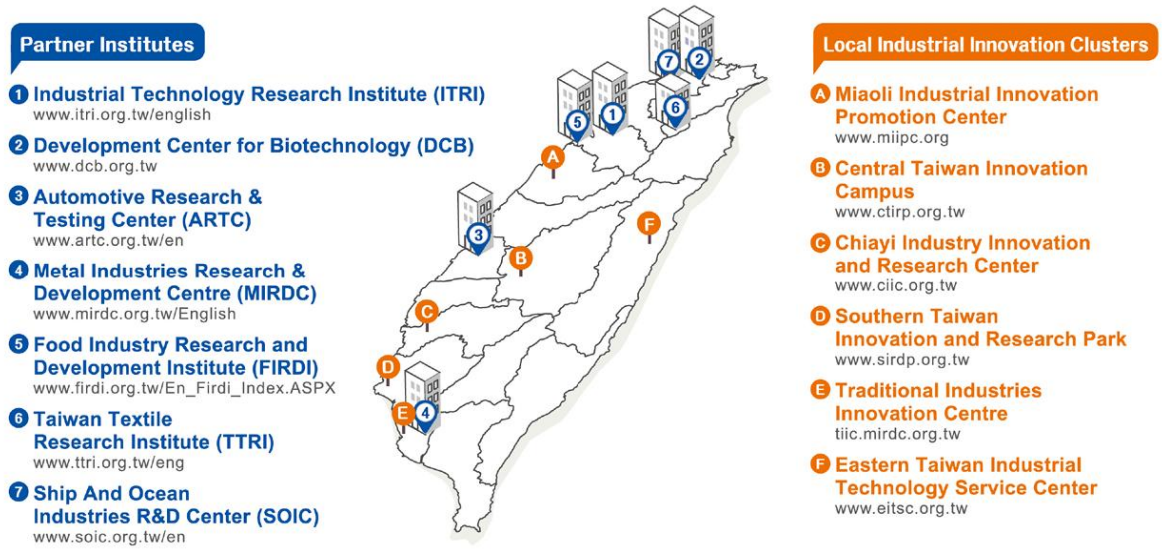
Established in 1979, Technology Development Programmes (TDPs) support forward-looking, critical and cross-cutting technologies and transfer them to enterprises.[4] Of the approximately US$857 million TDP budget in 2025, non-profit research organisations received 68%, industry 31% and academia 1%.[5] More than twenty non-profit research institutes, including seven partner institutes, receive TDP support for technologies, infrastructure, interdisciplinary collaboration and industrial application.[6]

ITRI is one of the seven partner institutes supported by TDPs. Initially wholly MOEA-funded, it now combines government funding with commissioned research for public and private clients.[7] Meanwhile, ITRI is a leading participant in MOEA-supported industrial innovation clusters. The clusters are typically organised around MOEA-funded R&D institutions, with universities, local

[3] Department of Industrial Technology. Our Organization
[4] Department of Industrial Technology. Case study for the Technology Development Programmes
[5] Department of Industrial Technology. Brochure_ DEPARTMENT OF INDUSTRIAL TECHNOLOGY 2025/2026
[6] Department of Industrial Technology. Our Mission
[7] Kang, B. (2019). Innovation process in public research institute: case studies of AIST, Fraunhofer, and ITRI

governments and industry associations participating. Resident firms in the clusters can access a series of support services, including incubation, collaborative R&D, laboratory facilities and other services covering IP, finance, human resources and business development.[8]

FIGURE A.1. DISTRIBUTION OF TDPS-FUNDED NON-PROFIT RESEARCH ORGANISATIONS



Source: Department of Industrial Technology, MOEA. Department of Industrial Technology 2025/2026

➢ National Science and Technology Council (NSTC)

Restructured from the Ministry of Science and Technology in 2022, NSTC links science and technology development to industrial application. It plans, coordinates, reviews, funds and evaluates S&T policies and programmes, including academic research, forward-looking technologies, research-based start-ups and science parks, and manages the National Science and Technology Development Fund.[9]

Its Department of Foresight and Innovation Policies handles S&T planning, foresight, major R&D and forward-looking technologies. The Department of Academia-Industry Collaboration and Science Park Affairs covers collaboration, deep-tech university spin-outs, transfer models, talent and park governance.[10,11]

NSTC supervises the National Institutes of Applied Research Laboratories (NARLabs), whose eight laboratories provide research infrastructure and frontier-technology platforms spanning environmental technology, telecommunications, biotechnology and technology policy.[12] In 2024 they employed over 1,100 staff, more than 80% of whom were researchers, engineers or

[8] Department of Industrial Technology. Industrial innovation clusters list
[9] National Science and Technology Council. Organisation
[10] National Science and Technology Council. Department of Academia-Industry Collaboration and Science Park Affairs
[11] National Science and Technology Council. Department of Foresight and Innovation Policies
[12] National Institutes of Applied Research. Mission and Vision

technicians. Revenue was approximately US$235 million: 68% public grants, 22% government-agency funding and 10% private-sector income.[13]

The northern, central and southern science park zones comprise over ten parks. Hsinchu, the earliest, helped establish Taiwan's semiconductor industry and firms including TSMC. In 2025, over 1,100 resident companies generated more than US$180 billion across integrated circuits, optoelectronics, computers, telecommunications, precision machinery and biotechnology.[14,15]

The institutional structure therefore divides responsibilities across two connected systems. MOEA and DoIT concentrate on industrial technologies, programme delivery and firm-facing application, while NSTC connects the research base, laboratories, talent and science parks. Public research institutes sit between these systems and industry, providing the applied capabilities through which national priorities can move towards commercial and industrial use.

FIGURE A.3. DISTRIBUTION OF TAIWAN'S SCIENCE PARK ZONES AND THEIR FOCUS AREAS

Hsinchu Science Parks zone
Focus area: Integrated circuits, computers and computer peripherals, telecommunications, photonics and optoelectronics, precision machinery, and biotechnology

Central Taiwan Science Parks zone
Focus area: Precision machinery industry, optoelectronics industry, integrated circuits industry, computer and peripherals industry, communications industry, and biotechnology industry

Southern Taiwan Science Parks zone
Focus area: Photonics and optoelectronics, integrated circuits, precision machinery, biotechnology, ICT, and computer peripherals

Source: InvesTaiwan. Science Parks; Taiwan Business Topics, New Directions for Taiwan's Science Parks

2. Iconic sector: semiconductors

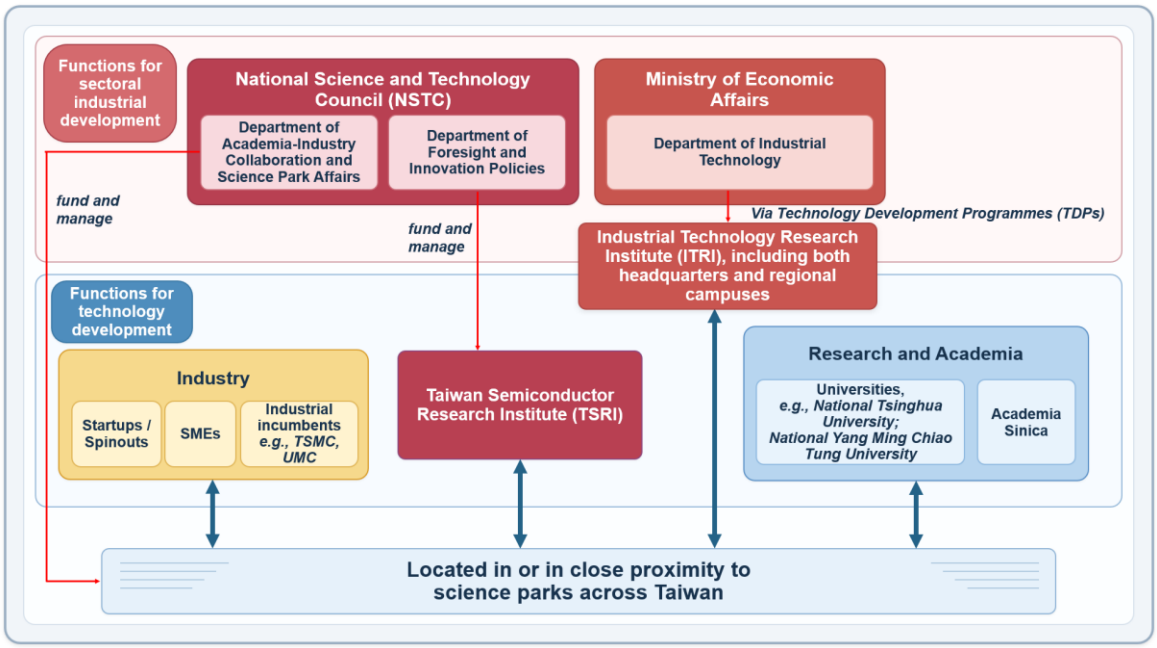
Taiwan has developed a mature semiconductor supply chain over five decades, with leading positions in manufacturing, packaging and testing. Revenue exceeded US$165 billion in 2024, equivalent to approximately 20.7% of GDP.[16] In 2023, manufacturing output was NT$2.5 trillion

[13] National Institutes of Applied Research. NARlabs Annual Report 2024
[14] National Science and Technology Council. Science Parks Distribution
[15] National Science and Technology Council. Statistics
[16] US International Trade Administration (2025). Taiwan Country Commercial Guide

and packaging/testing NT$0.6 trillion, representing 65% and 53% of global output respectively. IC design reached NT$1.1 trillion, or 19% globally, second to the US. The industry comprised 307 companies and around 317,000 employees; mass production of 3nm chips began in 2023.[17]

The ecosystem connects DoIT and NSTC, universities and Academia Sinica, firms such as TSMC, intermediary institutes including ITRI and TSRI, and geographically concentrated science parks (Figure A.4).

FIGURE A.4. KEY PLAYERS IN TAIWAN'S SEMICONDUCTOR ECOSYSTEM



Source: summarised and illustrated by the author

This review focuses on two types of innovation and industrial functions. Technology-development functions encompass R&D across readiness levels (TRLs), knowledge exchange and foresight, training, expertise and shared facilities. Sectoral-development functions address industry direction, supply-chain coordination, resources and international competitiveness (Figure A.5).

In terms of technology-development functions, universities and leading firms generate frontier technologies, while semiconductor manufacturers diffuse the technologies, train talent with universities and allocate production capacity for testing new ideas and prototypes.[18,19,20,21]

In sectoral-development functions, government bodies lead sectoral coordination: NSTC provides cross-cutting S&T planning, while DoIT takes a sector-oriented approach and publishes the annual White Paper on Industrial Technologies.[22] TDPs connect firms with advanced

[17] Taiwan's National Development Council (2025). Five Trusted Industry Sector Promotion Programs
[18] TSMC. Technology
[19] TSMC. Semiconductor courses
[20] TSMC. Open Innovation Platform
[21] TSMC. Collaboration Programs
[22] Department of Industrial Technology. White Paper on Industrial Technologies

technologies, facilities, expertise, investors and supply-chain partners. They have supported the presence of AMD, NVIDIA, Infineon, ASML and Micron, and academic commercialisation.[23] Semiconductors accounted for 31% of the 2025 TDP allocation to non-profit institutes.[24]

ITRI combines commissioned R&D, laboratories, transfer, testing and measurement with sector intelligence and roadmapping for DoIT.[25,26,27] ITRI-affiliated venture investment supports firm and technology scale-up.[28] TSRI, funded and managed by NSTC's Department of Foresight and Innovation Policies, supports international and advanced-process IC-design talent programmes such as the Chip-based Overseas Initiative.[29]

Science parks connect these actors with production infrastructure and services. Northern parks specialise in chip design and manufacturing; central parks in advanced manufacturing, memory and packaging; southern parks in advanced manufacturing, packaging and design. Park administrations support technology adoption, business development and training.[30]

Taken together, these arrangements form a continuous pathway from research to industrial scale. Universities and research institutes generate and validate knowledge; DoIT and NSTC provide direction and resources; ITRI and TSRI translate research into usable technologies and skills; and science parks provide the physical and organisational environment for production. Large firms, like TSMC, participate throughout, helping to shape roadmaps, test new processes and connect domestic capabilities to global markets.

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[23] Department of Industrial Technology. Brochure_ DEPARTMENT OF INDUSTRIAL TECHNOLOGY 2025/2026
[24] Department of Industrial Technology. Brochure_ DEPARTMENT OF INDUSTRIAL TECHNOLOGY 2025/2026
[25] ITRI. Website
[26] ITRI. Website
[27] Department of Industrial Technology. ITRI
[28] ITRI. Annual reports 2025 (Chinese version only)
[29] Taiwan's Legislative Yuan.
[30] Taiwan's National Development Council (2025). Five Trusted Industry Sector Promotion Programs

2.1 Functional mapping

FIGURE A.5. INNOVATION FUNCTIONS FRAMEWORK OF TAIWAN'S SEMICONDUCTOR INDUSTRY

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
TAIWAN · SEMICONDUCTORS (7 institutions)																		
Department of Industrial Technology (DoIT)						C	C		P	C	C	C	C	C	C	P	C	P
Industrial Technology Research Institute (ITRI)	P	C	C	P	P	P	C	C	C	C	C	C	P	C	C	C	P	P
Science Parks					P			C	C				P	C	C			
Taiwan Semiconductor Research Institute (TSRI)	P	C	C	P	P	C		C	C									P
Academia Sinica	P								P									
Universities	P	P	P		P	P		P	P									
Industry	P	C	C	C	P		P	P	C								P	C

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE A.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
DoIT	Staff unit within MOEA	Sector technology direction; TDP design, funding and coordination	TDP budget: around US$857 million (2025)
ITRI	Applied research institute and technology intermediary	Applied R&D, pilot production, technology transfer, incubation and venture investment	Revenue: approximately US$1 billion (2025); over US$700 million from public sources; over 6,700 staff
Science parks	NSTC-managed regional innovation and production hubs	Infrastructure, administrative services, clustering and talent support	Public infrastructure and resident-firm activity; turnover above US$180 billion (2025)

3.1 Department of Industrial Technology (DoIT)

Mission and position. DoIT connects industrial technology policy, programme management and sector development within MOEA. Its six-unit structure combines policy planning with technical specialisation.[31] Through TDPs, it mobilises research institutes, industry and academia to develop advanced technologies, emerging industries and industrial applications.

Services and functions. DoIT designs, funds and manages TDPs; formulates policy and related regulations; promotes international R&D; and publicises programme results. Institute support builds cross-cutting technologies and infrastructure; enterprise funding supports innovative R&D and links to multinational research; academic funding supports commercialisation and start-ups. Its Innovation and Startups Unit develops high-potential academic and institutional technologies into ventures, alongside sectoral work on semiconductors, quantum computing, displays, wireless communications, smart and unmanned vehicles, biomedicine, net-zero technologies and materials.[32]

Partners and strategic role. DoIT coordinates research institutes, firms, universities, foundations and innovation centres through funding and roadmaps. Users include SMEs, start-ups and industrial R&D teams. International partnerships support SME competitiveness and cooperation in AI, low-Earth-orbit satellites, 6G, semiconductors and telecommunications.

Funding. The 2025 TDP allocation was around US$857 million, channelled to non-profit research organisations, industry and academia.[33]

[31] Department of Industrial Technology. Our Organisation
[32] Department of Industrial Technology. Our Organisation
[33] Department of Industrial Technology. Our Organisation

DoIT's policy role is therefore closely tied to implementation. It does not deliver every technical activity itself; it sets priorities, selects and funds delivery organisations, and connects their work to industry needs. The TDPs give this arrangement a stable programme channel while allowing the mix of technologies, institutes and enterprise projects to change as sector needs evolve.

3.2 Industrial Technology Research Institute (ITRI)

Overview. The Industrial Technology Research Institute (ITRI) was founded in 1973 as Taiwan's flagship applied research institute and technology intermediary. Its core role is to transfer and diffuse technologies from domestic and overseas laboratories to Taiwanese firms in selected sectors.[34] ITRI has developed extensive international links with universities, research institutes, and companies across more than 20 countries, supported by overseas offices in the United States, Germany, the United Kingdom, Japan, and Thailand.[35]

ITRI has played a central role in Taiwan's industrial upgrading and was foundational to the development of Taiwan's semiconductor industry, with major spin-off companies including TSMC. Beyond semiconductors, ITRI now also focuses on emerging technology areas such as AI, telecommunications, smart sensing, cybersecurity, biomedical technologies, green energy, and advanced materials.

Mission. ITRI's mission is to undertake applied research that accelerates industrial development, creates economic value, and enhances social well-being. It focuses on creating new value for industrial partners by responding to emerging global challenges and opportunities, including climate change, demographic change, societal resilience, and digitalisation.

Services provided. ITRI develops advanced technologies and strengthens interdisciplinary integration. It offers comprehensive R&D collaboration and business support services, including contract research, small-scale pilot production, process improvement, calibration and measurement, technology transfer, IP value-added services, and industrial consultancy. Through its open labs and incubators, ITRI also promotes start-ups and entrepreneurship, helping accelerate technological development and nurture emerging high-tech businesses.[36]

Functions. ITRI performs both technology-development and sectoral-development functions. For technology development, it supports knowledge generation through applied research across six broad technology domains: biomedical technology and devices, green energy and environment, materials and chemicals, mechanical and systems, information and communications, and electronics and optoelectronics. It also enables knowledge deployment by helping firms access open R&D laboratories, testing and verification services, pilot production, prototyping, and contract R&D.

For sectoral industrial development, ITRI promotes technology diffusion through technology transfer, IP transactions, royalty-based licensing, incubation, industrial alliances, and international collaboration. Its role extends beyond research into firm formation and scale-up. In particular,

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[34] Cambridge Industrial Innovation Policy (2017). New industrial capabilities for new economic growth: a review of international policy approaches to strengthening value chain capabilities.
[35] ITRI. Collaboration
[36] ITRI. About Us

ITRI's venture-capital arm, the Industrial Technology Investment Corporation (ITIC), was established in 1979 and has invested more than US$400 million globally. ITIC has supported start-ups and ITRI spin-offs, especially in semiconductors and other high-tech industries.[37]

Key partners and users. ITRI works with government agencies, domestic firms, universities, research institutes, industrial alliances, and international partners. It has established collaborations with organisations across Asia, North America, Europe, and Oceania, and engages industrial partners through contract R&D, access to R&D labs, and industrial alliances. Its users include Taiwanese start-ups, SMEs, and established manufacturers across industries such as semiconductors, display panels, biomedical technology, green energy, and smart-manufacturing businesses.

Funding model and budget. In 2025, ITRI's total revenue reached NT$34 billion, equivalent to approximately US$1 billion.[38] Its strategic importance is reflected in continued industry calls for the government to increase funding for the institute.[39] More than US$700 million came from the public sector. ITRI employed more than 6,700 staff.[40]

ITRI's organisational breadth is central to its role. Applied research, pilot production, testing, licensing, incubation and investment are housed within one institution and connected to both public priorities and company demand. This allows technical work to continue beyond a laboratory result and gives firms several routes to engage, from contract research and shared facilities to technology transfer and venture support. Its overseas links also connect domestic industrial development with external knowledge and partners.

3.3 Science parks

Mission and position. NSTC-managed science parks combine R&D, production, living and working environments to attract high-tech industries and talent, balance regional development and support upgrading.[41] Their northern, central and southern locations form an island-wide technology corridor developed from the Hsinchu model.[42]

Services. Resident firms receive investment and entry assistance, company and factory registration, customs and bonded services, land, factory and dormitory leasing, construction management, labour and safety administration, environmental services, utilities, transport, training and talent subsidies.[43]

Functions and partners. Parks support collaborative R&D, emerging technology applications, key technologies, talent and start-ups through links with academia and research organisations. Production-ready infrastructure and regulatory services enable deployment; co-location

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[37] ITIC. What is ITIC
[38] ITRI. Annual reports 2025 (Chinese version only)
[39] CTI (2018). 研發預算一直減 工研院士憂; National Research Council. (2013). 21st century manufacturing: The role of the manufacturing extension partnership program. National Academies Press.
[40] ITRI. Annual reports 2025 (Chinese version only)
[41] National Science and Technology Council. Science Park distribution and introduction
[42] Hsinchu Science Park. Introduction
[43] Hsinchu Science Park. Home page

strengthens supplier connection and industrial learning. Users include resident investors, manufacturers, start-ups, research institutes and their employees.[44]

Funding and scale. Public planning and infrastructure combine with resident-firm investment, land and facility use and industrial activity. More than 95% of factory buildings were rented out; 2025 turnover exceeded US$180 billion, over 90% from integrated circuits and optoelectronics.[45,46]

The science parks should therefore be understood as industrial systems. Their value comes from combining production sites with administrative services, research links, skilled labour and supplier proximity. This combination shortens the distance between technical development and large-scale manufacturing and helps explain why the parks have become central to Taiwan's semiconductor and wider high-technology economy.

Their regional distribution also extends the original Hsinchu model across the island. The northern, central and southern park systems have developed different industrial specialisations while remaining connected through national policy, research institutions and common service arrangements. The parks therefore support both concentration and diversification: firms benefit from dense local networks, while national planning uses several locations to broaden capacity and reduce dependence on a single cluster.

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[44] Central Taiwan Science Park. Origins
[45] National Science and Technology Council. Statistics
[46] ITRI. Annual reports 2025 (Chinese version only)

Singapore-aerospace

1. National overview

1.1 Industrial strategy

Singapore has moved from labour-intensive industrialisation in the 1960s to skill-, capital-, technology- and innovation-intensive development. As a small, open economy with limited land, no natural-resource base and a small domestic market, it combines global market openness with public coordination of infrastructure, skills, investment and industrial upgrading.[47]

The five-year Research, Innovation and Enterprise (RIE) plans connect research capability with commercial and industrial outcomes. Since the 1991 National Technology Plan, policy has broadened from scientific and engineering capability to research excellence, translation and enterprise innovation; "Innovation and Enterprise" entered the plan in 2010.[48] RIE2030 introduces Flagships and Grand Challenges covering semiconductors, health and sustainability, while supporting aerospace manufacturing/MRO and cross-sector AI, additive manufacturing and robotics.[49]

Manufacturing & Economy 2030 seeks 50% growth in manufacturing value added between 2020 and 2030.[50] Industry Transformation Maps translate priorities into productivity, innovation, skills, enterprise-upgrading and internationalisation roadmaps across 23 sectors representing almost 80% of the economy.

Partnerships for Capability Transformation (PACT) connects large enterprises and multinationals with local SMEs through supplier development, co-innovation, training, internationalisation and corporate venturing.[51] Industry Digital Plans guide SME digital adoption and workforce training; National AI Strategy 2.0 treats AI as a capability for competitiveness and public value.[52,53] The Green Plan 2030 connects decarbonisation with green finance, carbon services, sustainable trade, clean energy, circularity and low-carbon industry.[54]

These policies form a cumulative model rather than a set of separate initiatives. RIE plans build the research and technology base; manufacturing and sector roadmaps translate national priorities into delivery; and enterprise, digital and green programmes help firms absorb and apply

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[47] Ministry of Trade and Industry (2024). Transforming the Singapore Economy.
[48] National Research Foundation (2026). RIE Ecosystem: Our "Research, Innovation and Enterprise" journey.
[49] National Research Foundation (2026). Research, Innovation and Enterprise 2030.
[50] Ministry of Trade and Industry (2024). Singapore's 2024 Budget for Businesses Booklet, p.3
[51] EDB (2024). Collaborations for Enhanced Partnerships for Capability Transformation (PACT).
[52] Infocomm Media Development Authority (2026). Industry Digital Plans.
[53] Government of Singapore (2026). Smart Nation Singapore: National AI Strategy.
[54] Government of Singapore (2026). Singapore Green Plan 2030.

new capabilities. The common thread is sustained public coordination of research, skills, infrastructure and investment around Singapore's position in international value chains.

1.2 Key institutions

The National Research Foundation (NRF), under the Prime Minister's Office, coordinates national research priorities and funding. The Ministry of Trade and Industry connects innovation with economic development through A*STAR, Economic Development Board (EDB), Enterprise Singapore and JTC. EDB attracts investment and anchors multinational production and R&D; Enterprise Singapore supports local firms' capabilities, standards, productivity and internationalisation; JTC provides specialised estates and facilities.

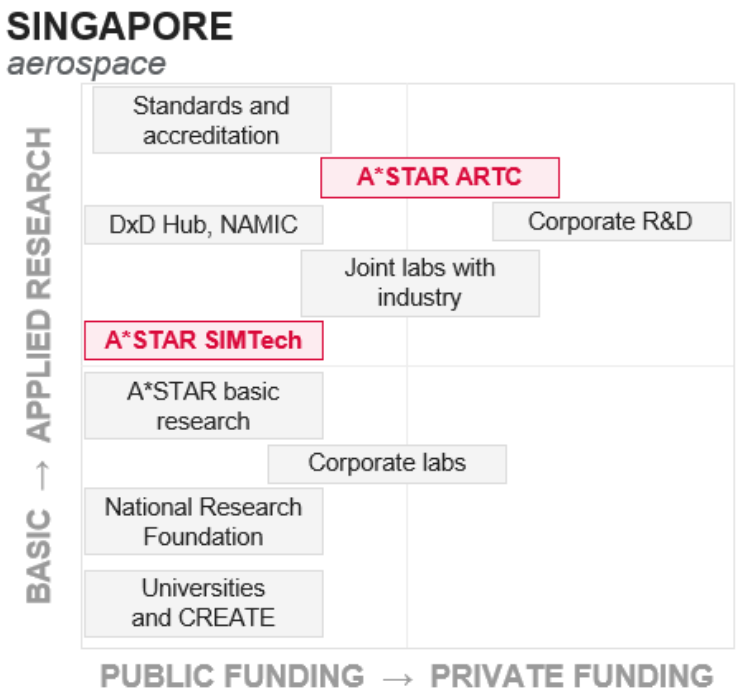
A*STAR connects mission-oriented research to industry across biomedicine, physical sciences, engineering, computing, materials, microelectronics and manufacturing. Singapore Institute for Manufacturing Technology (SIMTech) and the Advanced Remanufacturing Technology Centre (ARTC) supply applied engineering and production-relevant facilities; joint labs, consortia and collaborative projects connect research with anchor firms and suppliers. KPIs include company projects, industry R&D spending, spin-offs, licences, STEM scholarships and publications.[55] NAMIC and the Diagnostics Development Hub support additive-manufacturing and diagnostic-MedTech maturation, production readiness and ecosystem development.

NUS, NTU and SUTD provide research, graduate training and industrial collaboration. NRF's CREATE campus hosts international research centres, including ETH Zurich and MIT. Corporate Labs are long-term university–company partnerships, often publicly co-funded, addressing industry needs. Fourteen were operating by August 2026, including Rolls-Royce@NTU and Applied Materials–NUS.[56] One-North, Singapore Science Park, Jurong Innovation District and Seletar Aerospace Park connect research, firms, training and production spatially.

Responsibilities are differentiated but closely connected. NRF sets the research framework, A*STAR and the universities develop technical capability, EDB anchors investment and lead firms, Enterprise Singapore supports domestic companies, and JTC supplies specialised sites and infrastructure. Corporate laboratories and joint research platforms then bring these actors together around defined industrial problems. This institutional division of labour links national strategy to firm-level adoption.

[55] A*STAR (2026). Annual Report April 2024 - March 2025.
[56] NRF Singapore. Corporate Laboratories. Accessed on 1st August 2026.

FIGURE B.1. POSITIONING MAP OF SINGAPORE'S KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



2. Iconic sector: aerospace

Singapore hosts over 130 aerospace companies, generates S$18 billion in sector output and accounts for 10% of global maintenance, repair and overhaul (MRO) output.[57,58] Universities supply research and engineers; polytechnics and the Institute of Technical Education supply technicians and associate engineers, supporting implementation in regulated production environments.

Lead firms, including Rolls-Royce, Pratt & Whitney, GE Aerospace, Safran, Thales, Singapore Airline Engineering Company (SIAEC) and Singapore Aero Engine Services Private Limited (SAESL), provide production mandates, technology roadmaps, qualification requirements and access to global value chains. The Rolls-Royce@NTU Corporate Lab connects university research directly to these engineering needs.[59]

A*STAR supports aerospace through the Singapore Aerospace Programme and joint labs. Its Smart Manufacturing Joint Lab with Rolls-Royce and SAESL began in 2017 with S$68 million and deployed eighteen technologies. By July 2024, Rolls-Royce's fan-blade facility had improved productivity by over 20% from 2017; SAESL expected 40% output growth by 2028. The lab

[57] EDB (2026). Singapore's aerospace sector gains altitude as Asia leads global aviation growth.
[58] EDB (2026). Singapore's Aerospace Industry: Leading global MRO hub.
[59] NRF Singapore (2019). Joint News Release: Rolls-Royce and NTU extend their research partnership with new S$88 million investment.

engaged over 200 SMEs, generated more than S$4.5 million in immediate opportunities and added eight SMEs to approved vendor lists.[60,61]

EDB anchors investment, Enterprise Singapore develops supplier capability, JTC provides Seletar Aerospace Park, and skills agencies support training and reskilling. Civil Aviation Authority of Singapore (CAAS) provides aviation regulation, certification and sustainability support and established the International Centre for Aviation Innovation.

In Singapore's aerospace sector, the innovation and industrial development model is applied through a combination of global lead firms and local capability-building. Investment promotion secures production and MRO mandates, research organisations and corporate laboratories address technology and process challenges, and enterprise and skills agencies help domestic suppliers meet demanding cost, quality and certification requirements. Seletar Aerospace Park adds the shared infrastructure needed for these activities to operate as a sectoral ecosystem.

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[60] A*STAR (2026). Singapore Aerospace Programme.
[61] EDB (2025). A*STAR, Rolls-Royce, and SAESL deepen strategic partnership for aerospace manufacturing and MRO technologies.

Functional mapping

FIGURE B.2. INNOVATION FUNCTIONS FRAMEWORK: SINGAPORE'S AEROSPACE SECTOR

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
SINGAPORE · AEROSPACE · direct counterpart to UK aerospace (8 institutions)																		
Universities, institutes for higher education	C	P			P	P	P	C	P	P	P	P	P	P	P	P	P	C
University-industry Corp Labs	C	C			P	P	P	C	P	P	P	P	P	P	P	P	P	P
A*STAR & its research institutes	P	C	C	P	P	C	P	P	C	P	P	P	C	C	P	P	P	C
National translational platforms/research infrastr.	P	P	C	P	P	C	P	P	C	P	P	P	P	C	C	P	P	P
Lead firms	P	P	C	C	P	C	C	C	C	C	C	C	C	C	P	P	C	C
Industry associations			P	P	P	C	P	P	P	P	P	P	P	C	P		P	P
Regulation authorities		P	P	C	C	P	P	P	P	C	P	C	C	P			P	P
Other government agencies (EDB, ESG)				P	C	C	C	C	P	C	C	C	C	C	C	C	C	C

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE B.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
SIMTech	One of A*STAR's principal public research institutes	Applied manufacturing R&D; technology and knowledge transfer; workforce capability	Core public funding, industry projects, training and licensing; no clear annual budget figure provided
ARTC	Public–private consortium in aerospace	Co-development, validation and deployment; supplier development	Core public funding, competitive projects and consortium contributions; no clear annual budget figure provided
Rolls-Royce@NTU Corporate Lab	University–industry corporate laboratory	Aerospace research, industrial feedback and talent development	Public–private co-funding: S$75 million in Phase 1; S$88 million in Phase 2

3.1 Singapore Institute of Manufacturing Technology (SIMTech)

Overview and mission. SIMTech is one of A*STAR's principal public research institutes for manufacturing technology and industrial capability development. Established in 1993, it strengthens Singapore's manufacturing competitiveness through advanced technologies, technology transfer and workforce development.

SIMTech follows a 'T-shaped' model. Across sectors, it supports process innovation, technology adoption and training; within selected industries, it develops longer-term collaborations through joint laboratories with multinational corporations and original equipment manufacturers.

Its overall role is to transfer advanced manufacturing capabilities to local firms and suppliers, supporting their participation in higher-value global value chains.

Services and functions

- **Industry assistance:** SIMTech works with firms to identify production bottlenecks and technology gaps through collaborative, consortium-based and company-specific projects. Its Innovation Factory also supports SMEs from roadmapping and ideation to product and service design.

- **Knowledge and workforce development:** Its Knowledge Transfer Office provides industry-relevant training, while the Model Factory combines classroom learning with hands-on testing and implementation in a production-relevant environment.

- **Technology transfer:** SIMTech develops manufacturing technologies that firms can license, adapt and integrate into production processes.

- **Manpower transfer:** Through programmes such as Technology for Enterprise Capability Upgrading (T-UP), A*STAR researchers and engineers can be seconded to local firms, transferring tacit technical knowledge while strengthening internal capabilities.

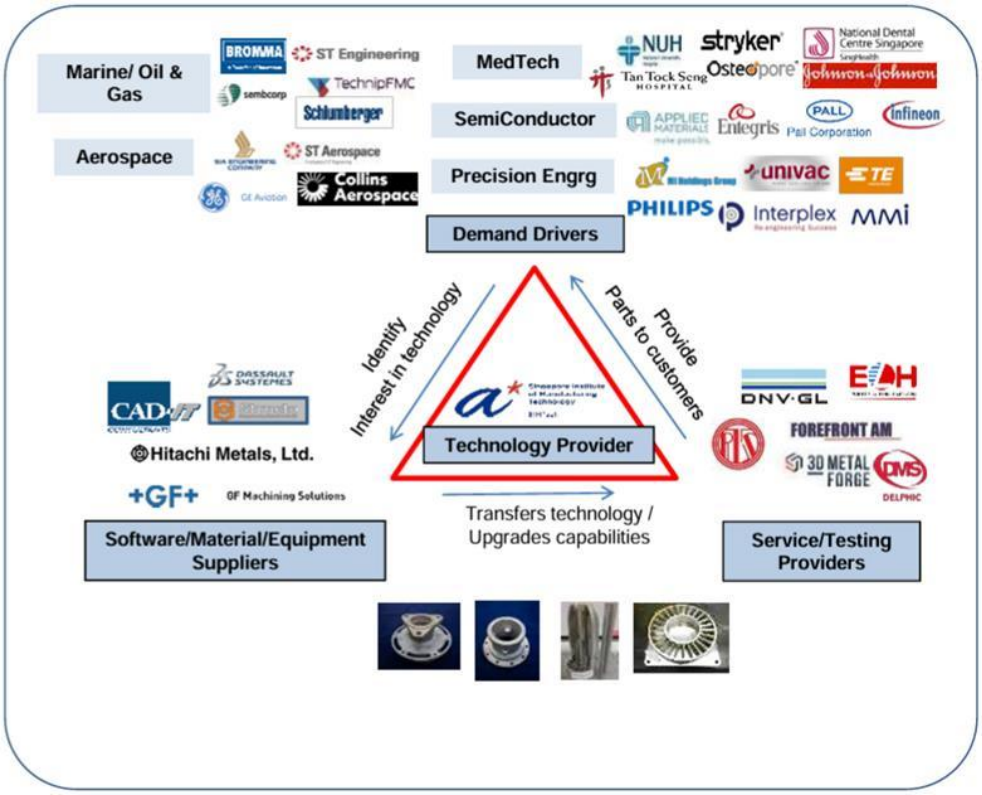
Together, these activities enable SIMTech to generate applied manufacturing knowledge, deploy it through projects and testbeds, and diffuse it through training, licensing and staff secondments.

Key partners and users

SIMTech works with NTU and NUS, local SMEs and start-ups, multinational corporations, government agencies and other A*STAR institutes. Universities support research and talent development; Enterprise Singapore and workforce agencies connect its work to enterprise and skills policies; and other A*STAR institutes provide complementary expertise in manufacturing, microelectronics, materials and computational modelling. Lead firms help define demanding industrial problems and create opportunities for local suppliers.

Strategic role and funding. SIMTech combines applied research with the practical capabilities firms need to adopt technology, including testbeds, training, collaborative projects and embedded expertise. This role is particularly important for SMEs with limited engineering capacity. Funding combines core public support, industry projects, training income and licensing or commercialisation; no clear annual budget figure is identified.

FIGURE B.3. STRATEGIC POSITIONING OF SIMTECH.



Source: A*STAR SIMTech website

3.2 Advanced Remanufacturing and Technology Centre (ARTC)

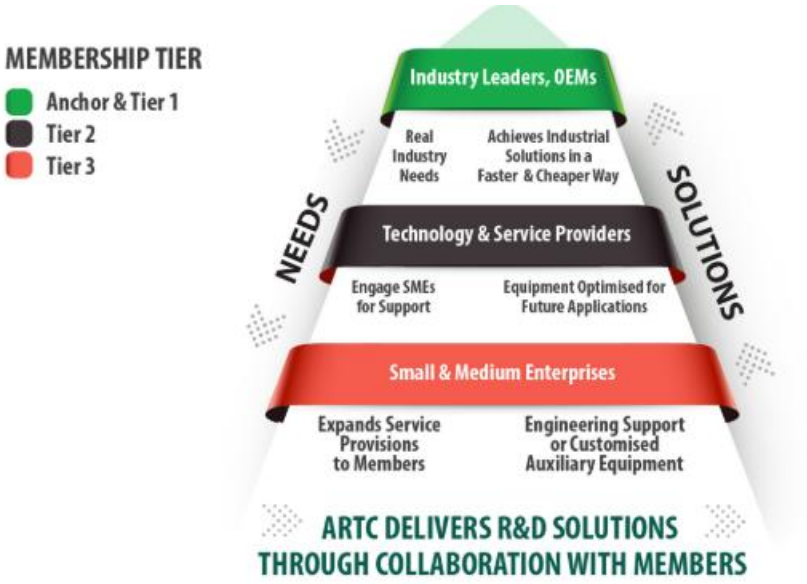
Mission and position. ARTC was established in 2013 by A*STAR, NTU and industry partners, including Rolls-Royce, to connect applied research with production-scale manufacturing, remanufacturing and repair. Its work covers automation, robotics, digital supply chains, smart factories and sustainable operations. Its tiered public–private consortium includes multinational lead firms, local enterprises, technology providers, public agencies and research organisations.

Services and functions. Consortium members jointly develop and validate solutions in the Model Factory and other production-relevant environments. This reduces adoption risks, enables firms to test technologies under realistic conditions and helps suppliers demonstrate their ability to meet lead-firm requirements.

Partners and users. Rolls-Royce and SAESL define manufacturing, repair and automation challenges; equipment and digital-system providers contribute technologies and solutions; SMEs participate as suppliers and solution providers; and NTU, SIMTech, Institute for Infocomm Research (I2R), and Institute of High Performance Computing (IHPC) provide complementary research, process and modelling capabilities. Enterprise Singapore and EDB connect this work with enterprise upgrading and investment.

Strategic role and funding. SIMTech and ARTC have overlapping research interests but different operating models. SIMTech builds broad manufacturing capability through technology transfer and training, whereas ARTC uses a more concentrated, demand-led consortium model for co-development and production validation. Funding combines core public support, competitive projects and member contributions; no clear annual budget is identified.

FIGURE B.4. RELATIONSHIP WITHIN THE ARTC MEMBERSHIP ECOSYSTEM.



Source: A*STAR ARTC website

3.3 Rolls-Royce@NTU Corporate Lab

Mission and position. Established in July 2013, Rolls-Royce@NTU was the first and largest lab under NRF's Corporate Laboratory@University Scheme. Phase 1 (2013–2018) covered electrical power and controls, manufacturing and repair, and computational engineering. Phase 2,

launched in 2019, expanded into digitalisation, Industry 4.0, power electronics, data analytics, IoT and sustainability.[62]

Services and functions. Faculty, students and Rolls-Royce engineers work on firm-defined challenges through milestones and continuous interaction, especially at early-to-mid readiness levels. Results feed into design, manufacturing and repair, including the Seletar Assembly and Test Unit, Wide Chord Fan Blade facility and SAESL. Joint work trains researchers and builds local absorptive capacity.

Partners and users. Rolls-Royce provides challenges, demand, roadmaps, mentorship and application routes; NTU provides faculty, laboratories and students; NRF co-funds and aligns the partnership with national RIE priorities. Participants include researchers, PhD and Master's students, undergraduate interns and company engineers. Direct users are Rolls-Royce engineering/business units and related MRO operations.

Strategic role. Sustained university–industry collaboration anchors multinational R&D locally, develops engineering talent and provides early signals about lead-firm technology priorities. KPIs include investment, projects, operational translation and talent participation.[63]

Funding. Public–private co-funding amounted to S$75 million in Phase 1 and S$88 million in Phase 2.

The Rolls-Royce@NTU Corporate Lab addresses a different part of the system by sustaining a long-term relationship between a university and an industrial anchor. Research themes are shaped by Rolls-Royce's technical needs, while NTU provides academic capability, facilities and a pipeline of researchers and engineers. The value of the model lies in repeated interaction over several years: knowledge, people and technical priorities move in both directions, increasing the likelihood that research is relevant to industrial operations and that firms remain engaged in Singapore's research base.

3.4 Key findings

The broader policy lesson is the value of connecting research institutions to specific routes for adoption. SIMTech provides wide access to manufacturing knowledge and workforce development; ARTC offers a production-relevant setting for consortium-based validation; and the Corporate Lab sustains firm-defined university research and talent development. Their mandates overlap where collaboration is useful, but each institution has a clear principal role in moving knowledge towards industrial application.

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[62] Nanyang Technological University Singapore. Rolls-Royce@NTU Corporate Lab. Accessed on 1 August 2026.
[63] Rolls-Royce Singapore. Why collaboration is key to fast, effective innovation. Accessed on 1 August 2026.

China- electric vehicles and power batteries

1. National overview

1.1 Industrial strategies

Since the early 2000s, China's industrial strategy has increasingly aligned science and technology policy with industrial upgrading, supply chain development and efforts to reduce external dependence. This evolution can be divided into four distinct phases.

Indigenous innovation. Following WTO accession and rapid manufacturing growth, dependence on foreign core technologies prompted the publication of the Medium- and Long-Term S&T Development Plan (2006–2020). It targeted R&D at 2.5% of GDP, S&T contributing over 60% of growth and imported-technology dependence below 30% by 2020.[64]

Strategic sector formation. Strategic Emerging Industries included environmental protection, next-generation IT, biotechnology, high-end equipment, new energy, advanced materials and new-energy vehicles (NEVs). Support combined R&D, demonstrations, standards, finance, market creation and local implementation.[65,]

Manufacturing upgrading. The 13th Five-Year Plan linked innovation-driven development with structural reform. Made in China 2025 emphasised industrial foundations, quality, smart/green manufacturing and strategic sectors. Its energy-saving-vehicle targets included an independently controllable supply chain and over 80% domestic key-component content in commercial vehicles by 2025. The accompanying Green Books of Technology Roadmaps specified technologies, pathways and performance targets.[66,67]

Self-reliance and resilience. From the 14th Five-Year Plan, policy emphasised strategic S&T capabilities and industrial-chain resilience. The Future Industries Opinions co-published by seven ministries in 2024 covered manufacturing, information, materials, energy, space and health.[68] The 15th Five-Year Plan stresses the real economy and foundational capabilities, including materials, components, industrial software, machinery, measurement, testing and equipment. The focus

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[64] The State Council (2006). Medium- and Long-Term Plan for Science and Technology Development (2006–2020).
[65] The State Council (2010). Decision on Accelerating the Fostering and Development of Strategic Emerging Industries.
[66] The State Council (2015). Made in China 2025.
[67] The State Strategic Advisory Committee for Building China into a Manufacturing Superpower (2015). Roadmap of Major Technical Domains for Made in China 2025.
[68] Implementation Opinions of Seven Ministries Including the Ministry of Industry and Information Technology on Promoting the Innovative Development of Future Industries (2024)

includes upgrading traditional industries, developing emerging sectors and incubating future sectors including quantum technology, biomanufacturing, hydrogen, fusion, brain–computer interfaces, embodied AI and 6G.

The four phases are cumulative. Later strategies place more weight on resilience, security and frontier technologies, but they continue to use sector plans, engineering platforms, standards, demonstration projects and firm investment to connect research with production. The change is therefore one of emphasis and scope: policy has moved from reducing dependence on imported technologies towards building complete innovation and industrial chains in strategically important fields.

FIGURE C.1. SECTOR COVERAGE OF CHINA'S TECHNOLOGY ROADMAP GREEN BOOKS AND FIVE-YEAR PLANS.

Sector	Green Book (2015)	Green Book (2023)
New generation IT equipment	X	X
CNC machine tools & robots	X	X
Aerospace	X	X
Marine engineering & ships	X	
Advanced rail	X	X
Energy saving & NEVs	X	X
Electric power equipment	X	X
Agricultural equipment	X	X
New materials	X	X
Biomedicine & medical devices	X	X
Food production & equipment		X
Textiles		X
Construction materials		X
Household appliances		X
Measurement devices		X
Engineering machinery		X
Environmental equipment		X

Sector	13th FYP	14th FYP	15th FYP
Robotics	X	X	X
Hydrogen energy	X	X	X
Next-generation IT	X	X	X
New energy	X	X	X
New materials	X	X	X
Connected NEVs	X	X	X
Biomedicine /biotech	X	X	X
Aerospace equipment	X	X	X
Marine equipment	X	X	X
Energy storage	X	X	X
Quantum technology	X	X	X
Integrated circuits	X	X	X
Medical devices	X	X	X
CNC machine tools	X	X	X
Shipbuilding	X	X	X
Rail equipment	X	X	
NEVs	X	X	
New batteries and storage	X	X	X
6G		X	X
Low-altitude economy			X
Intelligent driving			X
New solar cells			X
Biomanufacturing			X
Nuclear fusion energy			X
Brain-computer interfaces			X
Embodied intelligence			X

Source: Rhodium Group[69] compilation based on official documents and literature review.

[69] Rhodium Group (2026). China's Next-Generation Industrial Policy

1.2 Key institutions

The longstanding “two separate skins” problem describes weak links between science and industry. China’s response is a dense national, provincial and local institutional network.

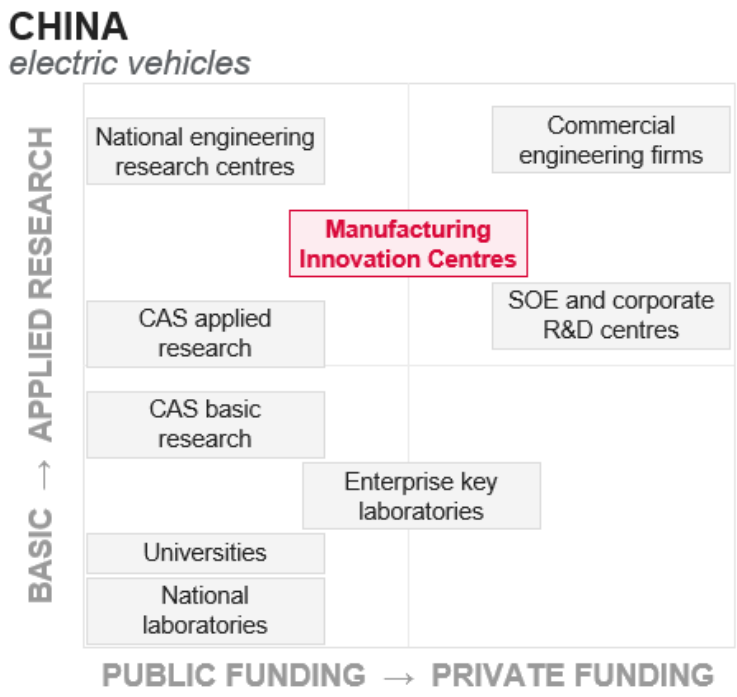
The State Council sets direction; the Ministry of Science and Technology (MOST) leads S&T programmes and system reform; the National Development and Reform Commission (NDRC) shapes industrial strategy, investment and major platforms; and the Ministry of Industry and Information Technology (MIIT) leads manufacturing upgrading, industrial chains, digital industry and sector policy. Chinese Academy of Sciences (CAS) combines frontier research, infrastructure, talent and advice. Private firms and state-owned enterprises (SOEs) increasingly lead applied R&D, engineering and scale-up.

National laboratories specialise in basic and applied-basic research, talent development and indigenous innovation. NDRC-linked National Engineering Laboratories emphasise experimental facilities and key technologies; National Engineering Research Centres focus on engineering validation, diffusion and strategic industrial capability. MOST’s National Engineering Technology Research Centres convert research into mature technologies, processes, equipment and products.

Industrial associations and alliances coordinate standards, testing, roadmaps, expert consensus and policy feedback. Newer platforms include MOST’s National Technology Innovation Centres; MIIT’s National Manufacturing Innovation Centres, often organised as “company + alliance” platforms for common technologies and pilot validation; and NDRC’s firm-led National Emerging Industrial Innovation Centres. Governance, funding, evaluation and functional boundaries of these evolving instruments are still being tested.

This layered system allows different institutions to address different stages of translation. Research organisations provide science and technical expertise; engineering centres and testing bodies reduce uncertainty around production and compliance; innovation centres organise common technologies and pilot facilities; and firms undertake product development, manufacturing and scale-up. The boundaries are not always fixed, which creates coordination challenges but also allows instruments to be adapted to sector conditions.

FIGURE C.2. POSITIONING MAP OF CHINA'S KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



2. Iconic sector: electric vehicles and power batteries

China is the largest NEV/EV market by production, sales and exports. Electric-car sales exceeded eleven million in 2024, more than global sales two years earlier.[70] Its industrial translation system links science, engineering validation, regulation and industrial coordination.

Universities and Chinese Academy of Sciences (CAS) research institutes provide upstream science and talent, including Tsinghua's State Key Laboratory of Intelligent Green Vehicle and Mobility, IOP-CAS battery-materials research and Dalian Institute of Chemical Physics.

National engineering research centres and engineering laboratories act as a bridge between academic research and industrial application. For instance, Beijing Institute of Technology's National Engineering Laboratory for Electric Vehicles, established in 2008, is described as a state-authorised institute for EV motor and controller testing. Its strongest contribution lies in applied R&D, engineering validation, access to facilities, and testing environments.

CATARC (China Automotive Technology and Research Center) is a powerful actor, supplying automotive policy, regulation, standards, testing, certification, product/catalogue management, WMI/VIN assignment, assessments and engineering/data services. Its infrastructure includes

[70] IEA (2025). Global EV Outlook 2005.

plateau and cold-weather environments, while its scope increasingly covers NEVs, intelligent connected vehicles and carbon technologies.[71,72,73]

The National New Energy Vehicle Technology Innovation Centre (NEVC) supports collaborative R&D, IP quality and operation, patent databases, technology transfer and integration. More specifically for power-battery technology, the National Power Battery Innovation Center, initiated by the China Automotive Battery Research Institute (CABRI) and the industry alliances, was created to bridge R&D, standards and first commercialisation.

Lead firms, including BYD, Geely, Changan, SAIC, GAC, NIO, Xpeng, CATL and Huawei, combine production with corporate R&D, university partnerships, workforce development and supply-chain integration. For example, BYD reports over 120,000 engineers and technicians across eleven research institutions.[74]

Industry associations and alliances, such as the China Society of Automotive Engineers (SAE), the China Association of Automobile Manufacturers (CAAM) and the China Industry Technology Innovation Strategic Alliance for Electric Vehicle (CAEV), are strongest in diffusion.

The electric-vehicle and battery sector shows how these roles interact in practice. Public research developed an upstream technical base, engineering and testing organisations supported validation and standards, and national innovation platforms addressed common production problems. Lead firms then combined these capabilities with manufacturing investment, supplier development and market expansion. The result is a translation system in which research, regulation, infrastructure and production have developed in parallel.

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[71] A World Manufacturer Identifier (WMI) is the first 3 characters of a vehicle Identification Number (VIN) which uniquely identifies the manufacturer of a motor vehicle or trailer.
[72] China New Car Assessment Program (C-NCAP) is a Chinese car safety assessment program. It is primarily modelled after safety standards established by Euro NCAP and is run by the China Automotive Technology and Research Center.
[73] China Intelligent Connected Vehicle Assessment Programme (C-ICAP) is the official evaluation standard for autonomous, smart, and connected vehicles in China.
[74] BYD (2026). About BYD.

Functional mapping

FIGURE C.3. INNOVATION FUNCTIONS FRAMEWORK: CHINA'S ELECTRIC VEHICLES AND POWER BATTERIES SECTOR

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
CHINA · ELECTRIC VEHICLES · direct counterpart to UK automotive (8 institutions)																		
Universities, higher education institutes	C	P	P			P	P	C	P	P		P			P			P
University-based key laboratories	C	C	P	P	P	P	P	C	P	P		P	P	P	P			P
Chinese Academy of Science research institutes	C	C	P	P	P	P	C	C	C	P	P	P	P	P	P	P	P	C
National engineering (tech) research centres/labs	P	P	C	C	P	P	P	P	C	P	P	P	P	P	P	P	P	C
(Central) State-Owned Enterprise (CSOE/SOE)	P	P	P	C	C	P	C	P	C	C	C	C	P	P	P	P	P	P
National Technology/Mfg. Innovation Center	P	P	C	C	P	C	P	P	C	P	P	P	C	C	P	P	P	P
Incumbent firms (e.g BYD, Geely, CATL)	P	P	C	C	P	P	C	P	P	C	C	C	C	C	P	C	C	P
Industry alliance, professional associations				P	C	C	C	P	P	C	C	C	P	C	P	P	P	P

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE C.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
IOP-CAS	Public research institute within Chinese Academy of Sciences	Battery research, pilot-line validation, technology transfer and talent development	Public budgets, research projects and institutional/commercialisation income; battery-specific funding not separately disclosed
CATARC	Central state-owned automotive technical service organisation	Testing, standards, certification, policy intelligence and regulatory coordination	SOE model; likely income from paid services and government-commissioned work
National Power Battery Manufacturing Innovation Centre	Government-guided "company + alliance" platform	Applied R&D, pilot production, testing and value-chain coordination	Shareholder investment, public projects and technical services; around RMB 930 million in registered and paid-in capital

3.1 Institute of Physics, Chinese Academy of Sciences (IOP-CAS)

Overview and mission. The Institute of Physics, Chinese Academy of Sciences (IOP-CAS), is a national public research institute with strengths in condensed matter physics, materials science and energy-related frontier research. Its battery work built domestic capability in strategic energy-storage technologies, linking basic research with early engineering validation and industrial capability formation.[75]

Translation pathway. IOP-CAS established early domestic capability in solid-state ionics and lithium-battery research. In 1998 it built an indigenous 18650 lithium-ion battery pilot line with annual capacity of 200,000 cells, using self-developed technology, equipment and domestic raw materials. Its work also covered battery materials, electrodes, electrolytes, interfaces, cell prototypes and production-related processes.[76]

Services and functions. IOP-CAS generated scientific and technical knowledge, deployed selected results through prototypes, pilot validation, process know-how and technology transfer, and diffused expertise through training, spin-outs and talent mobility. Its 'one group, two systems' model kept frontier research and industrialisation work within the same research community.

Partners and users. The institute worked with battery and materials firms, mobility and energy-storage users, CAS institutes, universities, key laboratories, local governments, investors and regional industrial platforms. Commercialisation links included Suzhou Xingheng, WeLion New

[75] Chinese Academy of Sciences (2026). China Science Daily. "I will do whatever the country needs."
[76] Chinese Academy of Sciences (20206). Chen Liquan, Founding Father of China's Battery Industry

Energy, HiNa Battery and Liyang Tianmu Pioneer Battery Materials Technology, alongside CATL-related talent links.

Strategic role. IOP-CAS occupied an upstream-to-midstream position before battery markets and supply chains were fully formed. It was not a general enterprise-support agency; its contribution was to combine protected frontier research with technically demanding validation and transfer, creating feedback between scientific questions, engineering problems and production constraints.

Position and funding. As a public research institute embedded in CAS, IOP-CAS is funded through central budget allocations, competitive research projects, institutional income and technology-transfer or commercialisation income. CAS's 2026 departmental budget reports RMB 61.1 billion in general public budget appropriations, or 29.8% of its total departmental budget; battery-specific funding is not separately disclosed.[77]

3.2 China Automotive Technology and Research Center (CATARC)

Mission and position. Founded in 1985, CATARC describes itself as an independent, impartial third-party automotive institution.[78] Its mission has expanded from domestic capability towards global competitiveness, international standards and overseas services.[79]

Services. CATARC provides policy and industry intelligence, standards and regulation, vehicle and component testing, certification, C-NCAP and C-ECAP assessments, proving grounds, quality services, engineering and data services. In 2024 it reported about thirty automotive-policy studies and recommendations.[80] Its overseas operations support testing, certification and market entry.[81] Common-technology work includes electronic controls, new-energy-vehicle software, automotive chips and advanced electric-vehicle systems.

Functions and partners. Applied evidence, datasets, test cycles and benchmarks support both regulation and product development. Ministries, regulators, automakers, suppliers, local governments, test zones and foreign standards bodies are key users; international platforms connect this work with overseas standards and markets.

Strategic role and funding. CATARC provides shared technical capabilities between regulators and manufacturers, reducing duplication for firms while giving government access to specialised automotive expertise. Its testing facilities, assessment programmes, datasets, and standards work generate evidence that supports both policy development and industrial application. This position allows CATARC to combine technical service provision with broader roles in regulation, certification, and sector coordination. Its market-facing SOE model also enables it to provide paid

[77] Chinese Academy of Sciences. Departmental budget 2026.
[78] CATARC. Center Introduction.
[79] CATARC. Center Introduction
[80] CATARC (2025). Accelerate the creation of a world-class think tank for the automotive industry.
[81] CATARC Europe Testing and Certification GmbH. Company Introduction.

services alongside commissioned policy work. While the review identifies general SOE access to public budgets and finance, it does not provide a CATARC-specific funding breakdown.[82]

3.3 National Power Battery Manufacturing Innovation Centre

Mission and position. Established in 2016 as China's first national manufacturing innovation centre, the National Power Battery Manufacturing Innovation Centre addresses common battery technologies and industrialisation gaps through a "company + alliance" structure. China Automotive Battery Research Institute (CABRI) provides a dedicated research base; the alliance mobilises firms and researchers around shared bottlenecks.

Services and functions. R&D covers high-specific-energy lithium-ion batteries, materials, separators, electrolytes, cells and systems. Flexible pilots enable small-batch production and iteration, including conventional, 100–600 mm and special-shaped pouch cells. Testing spans electrodes, cells, modules, systems and lifecycle validation. Engineering applications extend to drones, electric aircraft and other land, sea, air and aerospace uses. Alliance activities include roadmaps, industry studies, carbon-footprint methods, IP-risk monitoring, standards and technical exchange.

Partners and users. The centre is led by state-owned China GRINM Group. Shareholders include GRINM, Huading New Power Fund, vehicle manufacturers FAW, SAIC, Dongfeng, BAIC, Brilliance, Changan, GAC and Yutong; battery/materials firms CATL, BTR and Tianjin Lishen; and Neusoft Reach. Its industry alliance reportedly includes over 180 firms, universities, institutes and testing bodies.

Strategic role and limitations. The corporate entity provides practical R&D, pilot and testing capacity; the alliance connects this with demand and adoption across the value chain. Competitive incentives and conflicts of interest remain challenges; the model should not be treated as fully proven. UK relevance lies in shared pre-competitive platforms for production links, scale-up capital and common technologies.

Funding. Initial R&D relied mainly on shareholders, with registered and paid-in capital around RMB 930 million.[83] Equity combines with public R&D projects and technical-service income. The review found no record of alliance membership fees.

The battery centre brings corporate organisation and alliance-based coordination together. The core company provides laboratories, pilot production and testing, while the alliance widens participation across vehicle manufacturers, battery and materials firms, research bodies and service organisations. This structure is intended to address common technical bottlenecks that matter across the value chain. Its limitations are equally relevant: shared platforms still require clear governance, sustained finance and incentives that manage competition and conflicts of interest among participating firms.

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[82] Karen, JL et. al (2020). State-owned enterprises in China: A review of 40 years of research and practice.
[83] China Automotive Battery Research Institute. Corporate introduction. Accessed on 1st August 2026.

Germany- advanced manufacturing

1. National overview

1.1 Industrial strategy

Germany's industrial innovation policy historically emphasised open markets and framework conditions, alongside extensive federal–Länder research support and Mittelstand development. Responsibility is shared by BMWE (economic affairs and energy) and BMFTR (research, technology and space).

Hightech Strategy. Since 2006, successive editions of high-tech strategies moved from selected technologies towards missions, then back towards strategic technologies. The original strategy covered seventeen technologies across health/security, communications/mobility and cross-cutting fields, with national, technological and regional clusters.[84] The 2010 strategy became more challenge-driven; the 2014 version linked technologies to social needs, transfer, innovation-friendly conditions and participation, including digitalisation and Industry 4.0.[85,86]

The 2018 Hightech Strategy 2025 organised twelve missions around societal challenges, future capabilities and an open innovation culture. Priorities included cancer and digital health, plastics and circularity, climate-neutral industry, biodiversity, clean mobility and batteries, quality of life/work, human-centred technology and AI. It targeted R&D at 3.5% of GDP by 2025 and strengthened interministerial steering. The 2023 Future Research and Innovation Strategy further emphasised missions in industry, climate/biodiversity, health, digital sovereignty, space/oceans and resilience.[87,88]

Industrial strategy. Horizontal instruments supported universities, non-university research institutes and Mittelstand firms—a "stealth" industrial policy.[89] The 2019 National Industrial Strategy 2030 shifted towards SMEs, industrial champions and technological sovereignty, including a target for manufacturing value added to account for 25% of gross output.[90,91]

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[84] BMBF (2006) Die Hightech-Strategie für Deutschland
[85] BMBF (2010) Hightech-Strategie 2020 für Deutschland
[86] BMBF (2014): Die neue Hightech-Strategie - Innovationen für Deutschland
[87] BMBF (2018) Forschung und Innovation für die Menschen – Die Hightech Strategie 2025
[88] BMBF (2023): Zukunftsstrategie Forschung und Innovation
[89] Kattel et al. (2020): Challenge-driven economic policy: A new framework for Germany
[90] BMWi (2019) Industrial Strategy 2030: Guidelines for a German and European industrial policy
[91] Schneider (2022): Germany's Industrial strategy 2030, EU competition policy and the Crisis of New Constitutionalism. (Geo-)political economy of a contested paradigm shift

Industrial Policy in Changed Times (2023) addressed geopolitics, location weaknesses and climate neutrality, aiming to preserve existing strengths and attract future industries.[92]

Hightech Agenda Deutschland. Introduced in July 2025, the agenda prioritises AI, quantum, microelectronics, biotechnology, fusion and climate-neutral energy, with climate-neutral mobility technologies. Strategic fields include aerospace, health, security/defence, humanities/social sciences and marine/climate/sustainability. Enabling measures cover knowledge transfer, structural reforms of the bureaucracy, financing instruments, strengthening resilience in the science system, supporting skilled labour, expanding European cooperation, strengthening supply-chain resilience, investing in research infrastructure, and increasing civil-military research cooperation for dual-use technologies.[93] Around €18 billion is earmarked through 2029, with technology roadmaps published in May 2026, linking innovation to competitiveness, security and sovereignty.[94,95]

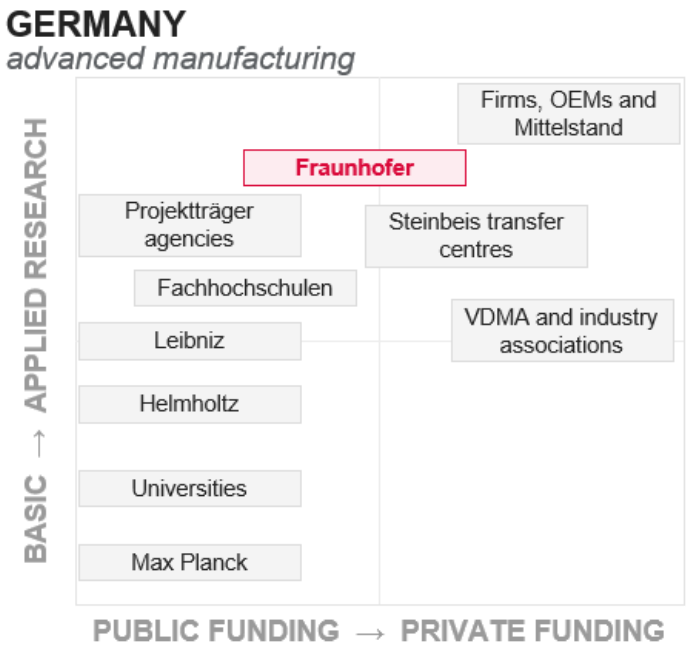
Across these strategy changes, the institutional architecture has remained comparatively stable. Federal ministries adjust priorities and instruments, while Länder, research organisations, associations, banks and firms provide decentralised delivery. This continuity allows new missions and technologies to be connected to established research, skills, finance and industrial networks rather than requiring a new delivery system for each policy cycle.

1.2 Key institutions

Federal ministries set direction while the sixteen Länder retain substantial responsibility for education, regional industry and industrial clusters. The joint Regional Economic Structure (GRW) programme mainly provides investment grants in less-developed regions. Cluster associations connect SMEs, large firms, universities, research institutes and chambers, supported through management funding, innovation projects and training. Examples include North Rhine-Westphalia's it's OWL (Intelligent Technical Systems OstWestfalenLippe) or Saxony's Silicon Saxony.

[92] BMWE (2023): Industrial Strategy in Changed Times.
[93] BMFTR (2025): Hightech Agenda Deutschland
[94] https://hightech-agenda-deutschland.de/en/roadmaps/
[95] https://www.heise.de/en/news/Hightech-Agenda-Merz-calls-for-solidarity-for-technological-sovereignty-10963783.html

FIGURE D.1. POSITIONING MAP OF GERMANY'S KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



Education system

Universities and applied-science Fachhochschulen combine with an apprenticeship system covering around 300 specialisations. In 2024 there were 1.2 million apprentices, including 690,000 in industry and trade. Berufsschulen and regionally distributed applied universities link training to local industry.[96]

The Excellence Strategy supports selected universities and clusters: annual funding increased from €533 million through 2025 to €687 million in 2026.[97,98] The Deutsche Forschungsgemeinschaft (DFG) funded around 30,100 projects with €3.8 billion in 2025, financed two-thirds federally and one-third by Länder. Its Knowledge Transfer Projects, including trilateral Fraunhofer projects, develop basic-research results with application partners.[99,100]

TU9 technical universities are important in production research. RWTH Aachen's WZL and the co-located Fraunhofer IPT illustrate joint university–institute pathways from fundamentals to industrial implementation.[101] Steinbeis links professors and applied universities to consultancy, R&D, training and industry finance; its network comprised 1,037 enterprises in 2024.[102]

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96 https://genesis.destatis.de/datenbank/online/statistic/21211/table/21211-0001
97 Bund-Länder Vereinbarung, 2005
98 Excellence Strategy, 2026
99 DFG (2026): Key Figures Portal
100 Commission of Experts for Research and Innovation (EFI) Annual Report 2026
101 German Universities of Technology (TU9): Mission Statement
102 The Steinbeis Network: Facts and Figures

Non-university research organisations (Germany's Research Cartel)

Four research organisations provide complementary capabilities: Max Planck and Leibniz mainly basic/fundamental research (TRLs 1–4/5), Fraunhofer applied/contract research (TRLs 3–7), and Helmholtz large strategic research spanning TRLs 1–9. The federal–Länder Pact for Research and Innovation, initiated in 2005, provides multi-year funding certainty in exchange for excellence and policy objectives.

Max Planck operates 84 institutes/units; its 2025 budget was €2.15 billion with 25,740 staff. Public institutional funding is split approximately equally between federal and Länder governments.[103] Leibniz comprises 96 institutions and around 21,400 staff, including 12,200 researchers; its €2.2 billion budget includes roughly €1.4 billion institutional funding, also split 50/50.[104]

Helmholtz comprises eighteen centres, over 48,000 staff and a budget around €6 billion. More than half is institutional funding, split 90% federal/10% Länder, and about a third comes from third parties. Fields cover energy, environment, health, matter, information and aerospace/transport.[105] Fraunhofer's applied research and transfer model is examined below. The Agency for Breakthrough Innovations (SPRIND), established by a 2018 government decision, supports breakthrough innovation and transfer to marketable products.

Industry Associations and Private Sector Firms

Industry associations coordinate demand and priorities. The Bundesverband der Deutschen Industrie (BDI) is the umbrella organisation of German industry and industry-related service providers and represents 184 industry associations and more than 100,000 companies that employ around eight million workers. Verein Deutscher Maschinenbau-Anstalten (VDMA) represents machinery firms and includes specialist associations such as the machine-tool organisation Verein Deutscher Werkzeugmaschinenfabriken (VDW). The Industrielle Gemeinschaftsforschung (IGF) and the Zentrale Innovationsprogramm Mittelstand (ZIM) support collaborative and SME research with federal funding and industrial participation.[106]

Roughly two-thirds of German R&D is business-funded; over 80% of private R&D investment comes from large firms, mainly manufacturing, machinery, chemicals and electronics. Production technologies combine OEMs such as Trumpf, DMG Mori, Zeiss and EMAG with Mittelstand "Hidden Champions".[107]

Development Banks and Regional Sparkassen

Municipally owned Sparkassen have a public-service mandate and lend within their owners' territories under the Regionalprinzip. Retained earnings strengthen their capital and home

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[103] Max-Planck Society: About
[104] Leibnitz Association: About
[105] Helmholtz Association: About Us
[106] VDMA: About Us
[107] Schasse et al (2018) Forschung und Entwicklung in Staat und Wirtschaft: Deutschland im internationalen Vergleich

regions. They provide local delivery of public development finance: under the Hausbankprinzip, KfW and Länder development banks reach firms through house banks, which assess borrowers and typically retain default risk while KfW refinancing addresses interest-rate risk.[108]

The network has around 520 affiliated companies, over 14,000 branches and roughly 290,000 employees. The review reports a 39.7% corporate-lending market share for Sparkassen in 2024 and nearly 40% of credit to firms/self-employed for Sparkassen and Landesbanken together, underlining their Mittelstand and regional focus.[109]

Projektträger

Project management agencies (Projektträger) are distinctive German institutions with no direct comparator in the UK. Federal and state ministries commission these project management agencies to oversee and administer projects. They can also provide technical and administrative guidance to applicants, prepare funding decisions, and handle project monitoring and performance assessment.[110] Many project management agencies are based at public research centres. Notable agencies include the Projektträger Deutsches Zentrum für Luft- und Raumfahrt (DLR – PT); Projektträger Jülich (PtJ) at the Research Centre Jülich, Projektträger Karlsruhe (PTKA) at the Karlsruhe Institute for Technology, VDI Technologiezentrum and AiF Projekte.

Germany's system is therefore organised through a dense division of labour. Universities and research organisations provide differentiated research capabilities; associations and clusters articulate sector demand; Projektträger translate ministerial objectives into programmes; and development banks and local savings banks support investment. The structure is decentralised, but recurring partnerships and long-term funding arrangements provide coordination across federal, regional and industrial levels.

2. Iconic sector: advanced manufacturing

2.1 Relevant sector strategies

Machine tools and production technologies remain economically important but have no dedicated federal sector strategy. The 2025 Hightech Agenda connects indirectly through AI/robotics, climate-neutral mobility and microelectronics equipment. Nonetheless, the sector makes an important contribution to the German economy as shown in its relative importance to overall manufacturing value added (see Figure D.2.), and Germany still holds a leading global position in the production of machinery and equipment.

Support for the sector is delivered through a horizontal, historically layered architecture of collective research, applied-research infrastructure, and regional cluster policy (a pattern consistent with the "stealth" industrial policy tradition in Germany). The current government's

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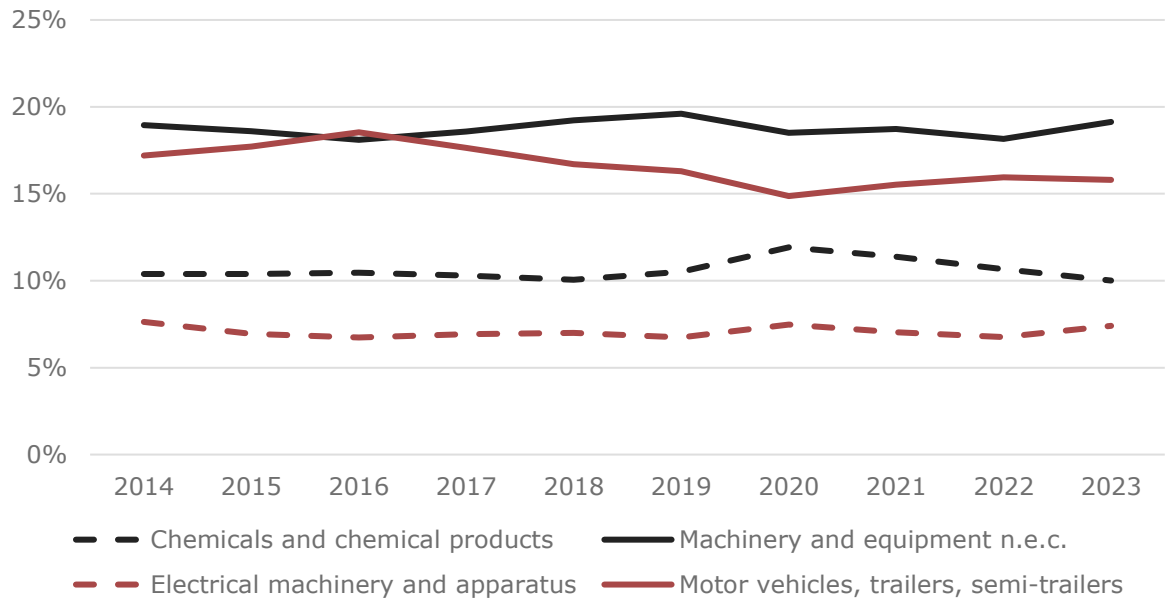
[108] Hancké and Coulter (2013): The German manufacturing sector unpacked: institutions, policies and future trajectories
[109] Finanzgruppe Deutscher Sparkassen und Giroverband (2024) Zahlen und Fakten
[110] Ziegler (2025): DELEGATION UND KOMPETENZEN: Projektträger als intermediäre Organisationen im Verhältnis zur Ministerialverwaltung

growth agenda adds cost-side measures (industrial electricity price relief, accelerated depreciation, the €500 billion special infrastructure and climate fund) that function as such horizontal industrial policy measures.

FIGURE D.2. SHARE OF TOTAL MANUFACTURING VALUE ADDED (MVA)



Source: UNIDO INDSTAT, Rev. 3

2.2 Sector initiatives

Industrie 4.0: a digitalisation-of-manufacturing platform, co-developed by BMBF/BMWi, embedded production-technology modernisation within a broader digital/cyber-physical-systems agenda rather than treating machine tools as a discrete target sector. A Steering Committee (consisting of BMWE, BMFTR, Fraunhofer Society, industry associations, and leading companies) coordinates and oversees all activities within the Plattform. It directs its technical and substantive work and consolidates the results from the topic-specific Working Groups. A Fraunhofer IAO study from 2014 estimated that Industry 4.0 could increase value added in machine engineering by 2.2% annually.

Manufacturing-X: a collaborative, government-backed industrial data initiative designed to connect supply chains securely while maintaining data sovereignty, which was introduced as a successor to Industrie 4.0. Key focus areas include Factory-X for shop-floor integration, Catena-X for automotive networks, and secure cross-company data sharing. The BMWE is supporting the Manufacturing-X initiative with a €140 million funding programme designed to back cross-sector, pre-commercial collaborative projects. This programme aims to further develop enabling technologies and implement priority use cases within the cross-sector Manufacturing-X data ecosystem. The funding programme thus supports the creation of a collaborative and decentralised data ecosystem for Industrie 4.0, along with the development of open, scalable systems that are designed for interoperability and to ensure the data sovereignty of all who use them.

Mittelstand-Digital is a digitisation network that offers guidance for small and medium-sized enterprises and the skilled crafts as they embrace the digital transformation, and informs them

about the opportunities and challenges of digitisation. The AI instructors based at the Hubs also offer special support on all issues relating to the use of artificial intelligence. The Cybersecurity for SMEs Initiative provides tailored services to support SMEs in improving their IT security.

ProDA is a BMBF research-funding programme that funds collaborative R&D. The programme rests on the premise that a strong industrial core is what makes a high-wage economy crisis-resistant, and that the resource-efficient, digital modernisation of manufacturing is the most effective way to keep value creation (Wertschöpfung) and jobs in Germany. Production research is framed as "a key to solving societal and economic challenges and an approach to implementing the priority future tasks in the further development of the High-Tech Strategy." Central to the programme are three strands: (1) Forschung für die Produktion (research for production), the "factory of the future," intelligent/networked production, Cyber-Physical Systems and the Internet of Things, green and urban manufacturing, the circular economy, know-how protection, and production technologies for electromobility and lightweight materials; (2) Forschung für Dienstleistung (research for services), including service engineering, modularisation and simulation of services, IT as the "production base" of services, and demand fields including energy, health, mobility, security, and demographics; and (3) Integrierte Produktions- und Dienstleistungsinnovationen (integrated production and service innovations) plus the cross-cutting work, learning, competence development, addressing demographic change, lifelong learning, and human-centred work design.

Functional mapping

FIGURE D.3. INNOVATION FUNCTIONS FRAMEWORK: GERMANY'S ADVANCED MANUFACTURING SECTOR

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
GERMANY · ADVANCED MANUFACTURING																		12 institutions
Federal ministries (BMFTR, BMWE)					P	P	P			P	P	C	P	P	P	P	P	P
Länder programmes						P	P	C		P	P	P	P	C	P	P	P	P
Projektträger	P	P	P			C	C			P		C		P	P			
Universities	C	C	C	P	P	P	P	C	P			P	P	P	P		P	P
Max Planck	P	P				P	P	P	P						P			
Leibniz	P	P	P			P	P	P	P						P			
Helmholtz	P	P	P	P	P	P	P	P	P	P		P		P	P		P	
Fraunhofer	P	C	C	P	P	C	P	C	C	P	P	P	P	P	P		P	P
Industry Associations (VDMA. BDI, etc.)					C	C	C	P	P	C	C	P	P	C	P		P	P
IGF	P	C	P		P	C	P	P	P	P	P	P	P	P				
Industry(OEMs & SMEs)	P	P	C	C	P	P	P	C	P	P	C	P	C	P	P	P	P	C
Sparkassen															P	C	P	

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE D.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
Fraunhofer-Gesellschaft	Applied research organisation	Application-oriented research, technology transfer and support for industry	Annual budget: €3.6 billion; contract research volume: €3.2 billion
VDMA	Industry association	Sector representation, networks, technical information and coordination	Membership fees; approximately 3,500 member companies
Industrial Collective Research (IGF)	Public funding programme for pre-competitive research	Collaborative research and transfer of results, particularly for SMEs	Federal funding; €179 million in 2025

3.1 Fraunhofer-Gesellschaft

Mission and position. Fraunhofer conducts application-focused research and transfers knowledge to industry. Its institutes are embedded in regional ecosystems and occupy the applied-research role within Germany's wider division of labour, alongside Max Planck, Helmholtz, Leibniz and universities.

Services and functions. Fraunhofer provides contract R&D, testing, certification support, demonstrations, licensing, pre-competitive research, spin-off support, skills development, technology forecasting and policy advice. Its core work spans TRLs 4–7, supported by specialist facilities, roadmapping, standards and cluster participation.

Funding model. Fraunhofer reports an annual budget of about €3.6 billion, including €3.2 billion in contract research. Roughly 30% comes from government funding and 70% from contract research, divided between public and industrial clients; institutional funding is shared by federal and Länder governments on a 90%/10% basis.

Scale and organisation. Fraunhofer operates 76 institutes and independent research units with more than 30,000 employees, covering most industrial sectors and cross-institute alliances in fields including batteries, ceramics, optics and digital technologies.[111]

Partners and workforce. Institutes maintain close university links, often through directors holding professorial chairs. The RWTH Aachen network illustrates this model through co-located institutes and joint production-research activity. A large share of Fraunhofer researchers are

[111] Gornig, Martin; Schiersch, Alexander (2012) : German manufacturing withstands the rise of emerging economies, DIW Economic Bulletin

doctoral or postdoctoral staff who later move into industry, diffusing applied research experience.[112]

Industry engagement. Fraunhofer undertakes 6,000–8,000 industry projects each year, ranging from short SME contracts to long-term partnerships. Firms also provide equipment and production problems. Large companies supply a substantial share of industrial revenue, which helps explain the complementary role of collective research programmes for SMEs.[113]

Strategic role. The model combines client-led research, public pre-competitive projects, university links, facilities and workforce mobility. Fraunhofer therefore generates application-oriented knowledge as well as transferring it, while public programmes and IGF help address its large-firm bias and widen access for SMEs.

3.2 VDMA

Mission and position. VDMA, founded in 1892, represents machinery and plant engineering. It is privately organised and membership-funded, with Germany-wide, EU and international operations, while participating in public governance through standards, platforms and training. The review describes approximately 3,500–3,600 predominantly Mittelstand members and a represented sector employing around three million people in the EU, over 1.2 million in Germany.

Services and functions. VDMA supplies consultation, regulation and standards support, training, market intelligence, research coordination, advocacy, events and trade fairs. Its order and turnover statistics serve as sector intelligence, including roughly €871 billion EU machinery turnover in 2024. It hosts DIN's mechanical-engineering standards committee, publishes specifications and supports interoperability through DIN/DKE; VDW links machine-tool standardisation nationally and through CEN/ISO.

Partners and strategic role. VDMA organises and co-finances cross-company research, supports funding applications and hosts associations that feed industry demand into IGF. Roadmaps and foresight connect technical priorities to market needs. Talent campaigns and cooperation with the Mechanical Engineering Junior Research Foundation support vocational skills. Its eleven topic areas cover workforce, digitalisation, research, business, markets, mobility, sustainability, law, tax, standards and economic/social policy.[114]

VDMA's role is less about conducting research than organising the industrial side of the system. Its specialist associations, standards work, market intelligence and research coordination help firms express common needs and convert them into roadmaps, projects and technical rules. Because its membership spans machinery and plant engineering, it can connect technology questions with workforce, regulation, trade and sustainability. This makes the association an intermediary between dispersed firms and the public research and policy organisations that support the sector.

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[112] RWTH Cluster of Excellence – Integrative Production Technology for High-Wage Countries
[113] National Academies (2013): 21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program, Appendix A2: Fraunhofer-Gesellschaft
[114] VDMA: Topics at a glance

3.3 Industrial Collective Research (IGF)

Mission and position. IGF supports SME innovation through open, pre-competitive, application-oriented research, mainly TRLs 2–5. BMWE owns the programme; DLR Projektträger became sole administrator on 1 January 2024 after procurement-related re-tendering. AiF, administrator since 1954, remains the umbrella and advocacy organisation for research associations.

Services and functions. Firms jointly define sector needs through around 102 authorised associations. Grants can cover basic/industrial research, experimental development and feasibility studies without thematic restrictions. Projects must be cross-company, offer economic benefits particularly for SMEs, and specify implementation and transfer routes. Results are published and available to all; firms adapt them to their own operations, widening access and distributing risk.

Programme variants. Leittechnologien für KMU supports broad multi-part projects across associations and institutes; PLUS connects projects from basic research to implementation, with flanking activities financed elsewhere; CORNET supports transnational projects with at least one foreign research institution and equal access to results.

Funding and users. IGF received €179 million in federal grant funding in 2025. Non-repayable grants normally use proportional financing; full funding is exceptional. Ceilings are €275,000 for one institute, €525,000 for two and €750,000 for three, subject to specified institutional limits.[115] Users include SMEs, larger firms, associations, universities and government. Its distinctive role is collective demand articulation and accessible research supporting SME adoption.

IGF complements firm-specific research by treating some innovation needs as collective problems. Associations identify topics with broad relevance, research organisations conduct open pre-competitive work, and published results remain available for firms to adapt. This lowers the cost and risk of early research for SMEs and avoids limiting results to one client. The programme's effectiveness nevertheless depends on transfer after the project: firms and associations must translate shared findings into processes, products and investment within individual businesses.

[115] Bundesanzeiger (2022): Förderrichtlinie Industrielle Gemeinschaftsforschung

Netherlands-semiconductors

1. National overview

1.1 Industrial strategy

Dutch industrial policy has moved from broad sectoral and mission-oriented collaboration towards selective technologies and growth markets, with greater emphasis on strategic autonomy and global value-chain positions.

The nine Top Sectors framework (2011) coordinated industry, academia and government; the 2018 Mission Driven Top Sectors policy linked innovation to societal challenges. Knowledge and Innovation Agendas (KIAs) structured multi-year collaboration and investment.[116,117,118] The 2024 National Technology Strategy prioritised ten enabling-technology groups, building on the existing KIAs, the Top Sectors framework, the Dutch Research Council's (NWO) research calls and the National Growth Fund system.[119,120]

The policy announced in October 2025 ended Top Sectors from January 2026 and concentrated on six Priority Growth Markets, including semiconductors, digital services/AI and machine manufacturing. Targeted initiatives such as Project Beethoven replace broader sector support; generic tax and innovation instruments remain for the wider economy.[121] Initial ambitions are industry at least 15% of GDP by 2030 and R&D at least 3%, supported by focused funding, procurement, infrastructure, finance, regulation, international positioning and talent measures.

The recent shift increases selectivity while retaining the collaborative machinery developed under earlier policies. Broad Top Sector and mission-oriented arrangements established networks among government, knowledge institutions and firms; the newer approach directs more attention and resources towards technologies and markets considered critical to future growth. Generic support remains available, but strategic programmes are increasingly expected to reinforce particular value-chain positions.

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[116] Ministry of Economic Affairs and Climate Policy [EZK] (n.d.). Encouraging innovation.
[117] EZK et al. (2023). The Knowledge and Innovation Covenant (KIC) 2024-2027.
[118] OECD (2018). Mission Driven Top-Sector and Innovation Policy.
[119] EZK (2024). National Technology Strategy.
[120] Dutch Research Council [NWO]. (n.d.). Key Enabling Technologies.
[121] EZK (2025). Those who do not choose lose: new industrial policy with a focus.

1.2 Key institutions

The Ministry of Economic Affairs and Climate (EZK) and the Ministry of Education, Culture and Science (OCW) jointly shape industrial and innovation policy. Most public research funding goes directly to universities; the Dutch Research Council (NWO) also supports research, infrastructure and national institutes. The Netherlands Enterprise Agency (RVO) supports firms through innovation/R&D credit, seed capital, SME grants and loan guarantees, proof-of-concept funding, patent information and Horizon Europe assistance. RVO has more than 6,000 employees supporting over 200,000 entrepreneurs annually; the Netherlands Innovation Network connects them with global R&D.[122,123,124]

TNO combines applied R&D with facilities, transfer and ecosystem coordination. Its six domains are high-tech industry, energy/materials, mobility/built environment, defence, health and ICT. University-embedded labs and joint platforms connect it with firms, researchers and programmes such as PhotonDelta, QuantumDeltaNL and QuTech.[125,126]

Regional systems, particularly Brainport Eindhoven, link firms, suppliers, universities, government and production infrastructure. ChipNL is emerging as a national coordinating node connecting Dutch actors with EU pilot lines and design platforms.[127] Invest-NL provides patient capital and mobilises private finance. The National Growth Fund has committed over €11 billion to fifty projects; though closed to new applications, it continues implementing its portfolio.[128,129]

The institutional model combines national direction with strong regional and sectoral organisation. Universities and NWO sustain the research base; TNO and joint facilities translate knowledge; RVO and Invest-NL address firm support and finance; and Brainport concentrates companies, suppliers, skills and infrastructure. ChipNL adds a national coordination layer for semiconductors and connects this domestic system to European facilities and programmes.

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[122] NWO (n.d.). What does the Dutch Research Council do?
[123] Netherlands Enterprise Agency [RVO] (n.d.). Netherlands Enterprise Agency.
[124] https://english.rvo.nl/business-development
[125] https://www.tno.nl/en/technology-science/technologies/digital-twin/predictive-twin-lab-built-environment/
[126] https://www.tno.nl/en/newsroom/2025/05/imec-tno-launch-photonics-lab/
[127] https://cccnl.nl/
[128] https://www.invest-nl.nl/en/themes/deep-tech
[129] https://www.nationaalgroeifonds.nl/

FIGURE E.1. POSITIONING MAP OF THE NETHERLANDS' KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION

2. Iconic sector: semiconductors

Built on more than forty years of industry–academia collaboration, the Dutch semiconductor sector comprises over 300 companies, around 60,000 jobs and approximately 9% of the global semiconductor market.[130] Its principal strengths include equipment, materials, design, high-mix production, photonics and quantum technology. Employment is concentrated in equipment, which accounts for around 85% of the sector, compared with 5% in integrated device manufacturers and 2% in photonics. ASML's global leadership in extreme ultraviolet lithography is central to this industrial position.[131,132]

In light of industrial strategies, the semiconductor sector moved from the High-Tech Systems and Materials Top Sector into the 2024 enabling-technology framework and the 2025/26 Priority Growth Markets.[133,134] Published in January 2026, the National Semiconductor Vision 2035 proposes coordinated annual R&D investment of €500 million, divided equally between public and private funding, alongside stronger participation in European programmes through ChipNL, PhotonDelta and QuantumDeltaNL.[135]

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[130] https://brainporteindhoven.com/int/blog/discover-the-thriving-semiconductor-industry-in-the-netherlands
[131] EZK (2026). National Semiconductor Vision 2035.
[132] https://www.trade.gov/country-commercial-guides/netherlands-strategic-technologies
[133] EZK (2024). National Technology Strategy.
[134] EZK (2025). Those who do not choose lose: new industrial policy with a focus.
[135] EZK (2026). National Semiconductor Vision 2035.

To address the scale-up financing gap, the Vision proposes €7 billion in public revolving-fund investment to mobilise up to €25 billion by 2035. Priorities include stronger investment vehicles, €1 billion in public funding for a national photonic integrated-circuit manufacturing facility by 2032, €800 million for shared validation and testing facilities, and a €150 million advanced-packaging pilot at CITC in Nijmegen. Proposed facilities cover silicon in Nijmegen, silicon nitride and indium phosphide in Eindhoven, and silicon nitride in Enschede. The Vision also explores the acquisition of NXP's pilot line and the establishment of a materials and metrology institute supported by €200 million in public and €250 million in private investment.

The strategy seeks to reinforce Dutch strengths in semiconductor equipment, materials, design, advanced packaging, high-mix manufacturing and integrated photonics, while developing capabilities in AI, 6G, heterogeneous integration, quantum, automotive and robotics chips. Skills measures are also central. Under the Microchip Talent Development Plan, €450 million in national funding and €310 million from regional and industry sources will support an additional 25,000 technical professionals between 2025 and 2030. For 2031–2035, the Vision envisages a further 15,000 technology students, structural government funding of €80 million annually, and additional higher-education and international-talent measures.

ChipNL provides national coordination across firms, researchers, investors and policymakers. Its support covers access to expertise and facilities, financing guidance, business development and training for validation, prototyping and scale-up. It also facilitates access to European research and pilot infrastructure, including APECS at Fraunhofer, FAMES at CEA-Leti, NanoIC at imec and PIXEurope in Spain.[136, 137]

The effectiveness of the Dutch semiconductor ecosystem depends on the complementarity of these institutions. Lead firms generate demanding technological and production requirements, while specialised suppliers provide critical equipment and components. Universities and TNO contribute research, validation and pilot capabilities. Brainport Eindhoven provides the regional density needed for repeated collaboration, while ChipNL and Invest-NL address national coordination, infrastructure access and patient finance. Together, these institutions support both technological specialisation and industrial scale-up.

[136] https://cccnl.nl/en/pilot-lines
[137] https://cccnl.nl/

Functional mapping

FIGURE E.2. INNOVATION FUNCTIONS FRAMEWORK: THE NETHERLANDS' SEMICONDUCTOR SECTOR

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
NETHERLANDS · SEMICONDUCTORS (8 institutions)																		
Ministry of Economic Affairs & Climate (EZK)					P		C	C	P	C	C	C	P	C	P	C	P	P
Dutch Research Council/Institutes (NWO & NWO-I)	C	P				C	P	P				P			P			P
Netherlands Enterprise Agency (RVO) & Netherlands Innovation Network (NIN)						C	P	P	P	C	P	P	P	C	C	C	C	
ChipNL Competence Centre						C		P	C				P	C	C			P
Invest-NL											P	P			P	C	P	
TNO	P	C	C	P	P	C	C	P	C	P	P	P	P	P	C	C		P
Brainport Eindhoven regional ecosystem	P	P	P	P	P	C		P	C				C	C	C	P	P	P
Universities (e.g. TU Eindhoven, TU Twente, TU Delft)	C	C	P	P		P	P	C	P									P

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE E.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
TNO	Applied research and technology organisation	Applied R&D, pilot facilities, technology transfer and industrial support	Mixed public funding and contract research; turnover approximately €830 million (2025)
Brainport Eindhoven	Regional innovation ecosystem	Cluster coordination, shared infrastructure, supplier networks and talent	Private investment and corporate R&D; regional, national and European public funding
Invest-NL	National impact investor and development finance institution	Patient capital, co-investment and finance for commercialisation and scale-up	Approximately €3 billion of government capital; €250 million Deep Tech Fund

3.1 TNO

Mission and position. Founded in 1932, TNO is the Netherlands' principal applied research and technology organisation.[138] It connects academia, industry and government through applied R&D, pilot facilities, technology transfer and industrial support, with particular emphasis on mid-range technology readiness, valorisation and deep-tech start-ups and scale-ups.[139]

Semiconductor role. TNO supports technology development, pilot manufacturing and scale-up in semiconductor equipment, integrated photonics, advanced packaging and quantum technologies.[140] Infrastructure includes PITC[141], the Photonic Chip Pilot Line[142], CITC[143] and the Holst Centre.

Services and functions. Capabilities cover lithography, metrology, contamination control, qualification, equipment design, prototyping and pilot production.[144] Collaborative platforms support research and de-risking[145], while licensing, spin-outs, IP transfer and SME access support commercialisation.[146][147]

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[138] https://publications.tno.nl/publication/34644952/GKa4C1wF/TNO-Strategic-2026-2029.pdf
[139] https://strategicplan.tno.nl/en/priorities/
[140] https://pitc.nl/
[141] https://www.tno.nl/en/technology-science/facilities/photonic-chip-pilot-line/
[142] https://www.tno.nl/en/about-tno/contact/locations/nijmegen-citc/
[143] https://holstcentre.com/about/photonics-lab/
[144] https://www.tno.nl/en/digital/semicon-quantum/our-role-semicon-quantum/
[145] https://www.tno.nl/en/newsroom/2025/04/eu-invests-15-million-help-companies/
[146] https://www.tno.nl/en/technology-science/patents-licenses/
[147]https://fasttrack.tno.nl/en/activities/?zoeken=true&zoeken_term=&zoeken_trefwoord=100&zoeken_trefwoord=

Indicative performance measures. TNO tracks research outputs, contract projects, licensing and investment, spin-offs and scale-ups, employment created by spin-offs and participation in parliamentary round-table discussions.[148]

Partners and strategic role. Partners include ASML and other technology firms, SMEs, TU Delft, TU Eindhoven, TU Twente, PhotonDelta, QuantumDeltaNL, QuTech, European R&D organisations and public funders. TNO links these research centres, industrial clusters and pilot facilities, while also contributing to roadmaps and technology foresight.

Funding. TNO combines structural government funding, competitive public grants and contract research for industry and public clients. Its 2025 turnover was approximately €830 million.[149]

In summary, TNO's value lies in connecting research capability with facilities and repeated industrial engagement. In semiconductors, this includes equipment and process expertise, qualification and metrology, pilot lines and collaborative platforms. These assets allow companies to test and improve technologies before committing to full production. TNO also supports commercialisation through licensing and spin-outs and contributes to roadmaps and foresight, linking individual projects to wider Dutch and European priorities. Its mixed funding model reflects this combination of public mission and market-facing work.

3.2 Brainport Eindhoven

Mission and position. Brainport Eindhoven is a regional ecosystem centred on Eindhoven–Veldhoven, connecting OEMs, specialised suppliers, research, investors, talent and government. Its semiconductor relationships extend to the Dutch "Big Five": ASML, ASM, NXP, Nexperia and Besi; the last two are strategically connected but not physically based in the region. Dutch semiconductor activity exceeds an estimated US$36 billion annually.[150]

The supplier base is essential: smaller firms account for 41% of revenue and 59% of employment, while 62% of companies generate under €10 million annually.[151] Decades of spin-offs, university collaboration and shared programmes underpin the region's open-innovation culture.[152]

Services and functions. The ecosystem supports joint R&D, supplier co-development, shared labs and pilots, incubation and finance networks, skills and international investment. Researchers and engineers move between universities and firms; industry-linked PhDs and endowed chairs

[148] https://www.tno.nl/en/about-tno/organisation/annual-report/
[149] https://www.tno.nl/en/about-tno/organisation/annual-report/
[150] https://www.trade.gov/country-commercial-guides/netherlands-strategic-technologies
[151] https://www.trade.gov/country-commercial-guides/netherlands-strategic-technologies
[152] EZK (2026). National Semiconductor Vision 2035.

strengthen knowledge exchange and progression from research through prototyping to production and global markets.[153,154,155]

Industrial anchors. ASML leads lithography and is the sole supplier of EUV systems; ASM is strong in atomic layer deposition; NXP in automotive semiconductors; Nexperia in discrete, power and analogue devices; and Besi in packaging and assembly. Their competitiveness depends on the wider supplier network.[156]

Shared assets. High Tech Campus Eindhoven hosts over 300 organisations, providing laboratories, offices, incubation, investor access and networking.[157] TNO–imec's Holst Centre develops flexible electronics, sensing, health, wireless and photonic technologies through pre-competitive collaboration and pilot lines.[158] TU Eindhoven supplies research, talent, industrial PhDs and transfer in electronics, physics, photonics, materials, systems, AI and quantum technology.[159] PhotonDelta supports the photonic-chip value chain through National Growth Fund-backed R&D, high-risk venture investment, international market development and talent initiatives.[160,161]

Funding. Brainport is not a single organisation with one budget. It combines private investment and corporate R&D with regional, national and European funding, research grants and innovation programmes.

Brainport shows how a regional ecosystem can function as an industrial institution even though it has no single organisational boundary or budget. Lead firms, specialised suppliers, universities, campuses and applied research facilities are connected through long-term commercial and technical relationships. Shared assets reduce the cost of experimentation, while labour mobility and joint training circulate knowledge. Public programmes and investment support the network, but its performance ultimately depends on the competitiveness of firms and the depth of the supplier base.

3.3 Invest-NL

Mission and position. Established in 2019, Invest-NL is the national impact investor and development-finance institution addressing gaps in capital-intensive, strategically important innovation. It links technology development to commercial scale-up and seeks to accelerate societal transitions.

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[153] https://brainporteindhoven.com/fileadmin/user_upload/Campussen/Innovation-campuses_in_Brainport_Eindhoven_brochure-2026.pdf
[154] https://brainporteindhoven.com/int/blog/discover-the-thriving-semiconductor-industry-in-the-netherlands
[155] EZK (2024). National Technology Strategy.
[156] https://brainporteindhoven.com/int/blog/discover-the-thriving-semiconductor-industry-in-the-netherlands
[157] https://www.hightechcampus.com/spaces/startup-space/
[158] https://holstcentre.com/
[159]https://issuu.com/brainporteindhoven/docs/innovation_campuses_in_brainport_eindhoven?ff&pageLayout=singlePage
[160] https://www.photondelta.com/about/
[161] https://www.photondelta.com/

Services and functions. It provides patient capital, loans/equity, co-investment, syndication and blended finance, using public investment to mobilise private capital and follow-on funding. The €250 million Deep Tech Fund targets capital-intensive companies at TRLs 3–9 in semiconductors, photonics, quantum, nanotechnology and advanced systems aligned with the National Technology Strategy.[162,163]

Partners and users. Invest-NL works with regional development agencies, venture builders, venture/growth-equity and institutional investors, corporate partners, PhotonDelta, QuantumDeltaNL and national/European financing bodies. Users include deep-tech start-ups, scale-ups and funds seeking co-investment.

Funding and terms. The Ministry of Finance, principal shareholder, provided approximately €3 billion; Invest-NL makes investment decisions independently. It generally supplies up to 50% of risk capital, usually €5–50 million, as equity, loans or both. For needs of €1–5 million, it often works with regional development agencies, particularly where larger later financing may be needed.[164,165]

Invest-NL complements the research and regional institutions by addressing the financing gap between technical progress and commercial scale. Its role is most relevant where development is capital-intensive, returns take time and private investors are unwilling to carry the full risk. Co-investment with regional, national and European partners allows public capital to support larger financing packages while keeping investment decisions connected to commercial prospects.

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[162] EZK (2026). National Semiconductor Vision 2035.
[163] https://www.invest-nl.nl/en/themes/deep-tech
[164] https://www.invest-nl.nl/en/our-approach/financing/direct-financing
[165] https://www.invest-nl.nl/en/frequently-asked-questions

United States-commercial space

1. National overview

1.1 Industrial strategies

US industrial translation operates through decentralised, overlapping institutions.[166,167,168] The Defense Advanced Research Projects Agency (DARPA) and the National Aeronautics and Space Administration (NASA), created in 1958, connected federal R&D with prototypes, demonstrations and procurement.[169,170] From the 1980s, Bayh–Dole, SBIR, MEP and Sematech broadened commercialisation and diffusion.[171,172,173] The Advanced Research Projects Agency–Energy (ARPA-E) adapted active programme management to high-risk energy technologies; Manufacturing USA, initiated in 2012, established public–private institutes providing shared manufacturing capabilities.[174,175]

The 2020 Critical and Emerging Technologies Strategy prioritised twenty fields, combining development of the national-security innovation base with protection through export controls, investment screening and research security. The 2024 list consolidated priorities into eighteen areas (Table F.1).[176,177] The CHIPS and Science Act 2022 supplied US$39 billion in manufacturing incentives and US$11 billion in semiconductor R&D, alongside an investment tax credit.[178]

The 2022 Advanced Manufacturing and 2024 National Defense Industrial strategies emphasised supply chains, workforce, production capacity and government–industry coordination. The Economic Development Administration (EDA) Tech Hubs support regional commercialisation and production. Since 2025, America's AI Action Plan and the Genesis Mission have extended

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[166] Atkinson, R. D. (2020). Understanding the U.S. National Innovation System
[167] Bonvillian, W. B. (2024). *Pioneering progress: American science, technology, and innovation policy*. MIT Press.
[168] Fasteau, M. & Fletcher, I. (2024). *Industrial Policy for the United States: Winning the Competition for Good Jobs and High-Value Industries*. Cambridge University Press.
[169] Defense Advanced Research Projects Agency. About DARPA
[170] NASA. The National Aeronautics and Space Act (1958) / NASA History
[171] US Small Business Administration. About SBIR and STTR
[172] National Institute of Standards and Technology (NIST). Manufacturing Extension Partnership (MEP)
[173] US Government Accountability Office (1992). SEMATECH's Technological Progress and Proposed R&D Program (GAO/RCED-92-223BR)
[174] US Department of Energy (2025). ARPA-E Fiscal Year 2023 Annual Report
[175] NIST (2026). Manufacturing USA 2025 Annual Report
[176] The White House (2020). National Strategy for Critical and Emerging Technologies
[177] The White House (2024). Critical and Emerging Technologies List
[178] NIST. About Chips for America

priorities to AI infrastructure/leadership and the use of AI, computing and national laboratories in scientific, energy and security challenges.[179,180,181,182,183]

The policy trajectory has broadened the purposes served by the innovation system. Mission agencies remain central, but commercialisation, manufacturing capacity, supply-chain resilience and regional development now sit alongside defence, space, health and energy missions. The resulting system uses several forms of demand and support, including research funding, active programme management, shared facilities, standards, tax incentives and public procurement.

TABLE F.1. UNITED STATES CRITICAL AND EMERGING TECHNOLOGY PRIORITIES

Critical and Emerging Technologies List Update (2024)	National Strategy for Critical and Emerging Technologies (2020)
Advanced Computing	Advanced Computing
Advanced Engineering Materials	Advanced Conventional Weapons Technologies
Advanced Gas Turbine Engine Technologies	Advanced Engineering Materials
Advanced and Networked Sensing and Signature Management	Advanced Manufacturing
Advanced Manufacturing	Advanced Sensing
Artificial Intelligence	Aero-Engine Technologies
Biotechnologies	Agricultural Technologies
Clean Energy Generation and Storage	Artificial Intelligence
Data Privacy, Data Security and Cybersecurity Technologies	Autonomous Systems
Directed Energy	Biotechnologies
Highly Automated, Autonomous and Uncrewed Systems (UxS), and Robotics	Chemical, Biological, Radiological and Nuclear (CBRN) Mitigation Technologies
Human-Machine Interfaces	Communication and Networking Technologies
Hypersonics	Data Science and Storage
Integrated Communication and Networking Technologies	Distributed Ledger Technologies
Positioning, Navigation and Timing (PNT) Technologies	Energy Technologies
Quantum Information and Enabling Technologies	Human-Machine Interfaces
Semiconductors and Microelectronics	Medical and Public Health Technologies
Space Technologies and Systems	Quantum Information Science
	Semiconductors and Microelectronics
	Space Technologies

[179] Office of Science and Technology Policy (2022). National Strategy for Advanced Manufacturing
[180] Congressional Research Service (2024). The 2024 National Defense Industrial Strategy: Issues for Congress (IN12310)
[181] US Economic Development Administration. Regional Technology and Innovation Hubs (Tech Hubs)
[182] The White House (2025). Winning the Race: America's AI Action Plan
[183] US Department of Energy (2025). Energy Department Launches 'Genesis Mission' (Executive Order 14363)

1.2 Key institutions

Congress, the White House and executive departments establish priorities, authorities and funding. The White House Office of Science and Technology Policy (OSTP) advises the President, coordinates through the National Science and Technology Council (NSTC) and works with the Office of Management and Budget on R&D budgets.[184] The National Science Foundation (NSF), National Institutes of Health (NIH) and DOE's Office of Science support research and infrastructure; universities connect research with education, licensing and ventures. National laboratories, Federally Funded Research and Development Centers (FFRDCs) and University Affiliated Research Centers (UARCs) provide long-term multidisciplinary capability through licensing, cooperative R&D agreements, sponsored research, user facilities and assistance.[185,186,187]

DARPA, NASA, ARPA-E and BARDA use active management, milestones, contracts, demonstrations and prospective-user engagement to pursue public missions. ARPA-E adds technology-to-market support; BARDA combines advanced development with manufacturing, regulatory preparation and procurement. These missions can generate wider industrial applications.

NIST supplies metrology, testing, reference materials and standards through six laboratories and facilities. Voluntary standards involve firms, standards bodies and the American National Standards Institute (ANSI); the Food and Drug Administration (FDA), Federal Aviation Administration (FAA), Environmental Protection Agency and Nuclear Regulatory Commission provide regulation and authorisation.[188] Manufacturing USA supports shared technologies, pilots and pre-competitive research; MEP assists smaller manufacturers with adoption, processes, products and supply chains.[189]

Regional organisations, including Ben Franklin Technology Partners, North Carolina Biotechnology Center and Massachusetts Technology Collaborative, connect firms, research and investment. Companies perform engineering, production, certification, supply-chain integration and market development; associations and consortia coordinate roadmaps and shared research. Venture capital, corporate, growth and project finance support different stages of scale-up. Institutional pathways vary by sector and region.

This decentralised structure does not rely on a single national intermediary. Different agencies and organisations become important according to the sector, technology and stage of development. Coordination is achieved through missions, programmes, standards, contracts and partnerships rather than through one permanent hierarchy. This creates varied institutional pathways, while allowing specialised organisations to retain technical depth and respond to distinct public and industrial needs.

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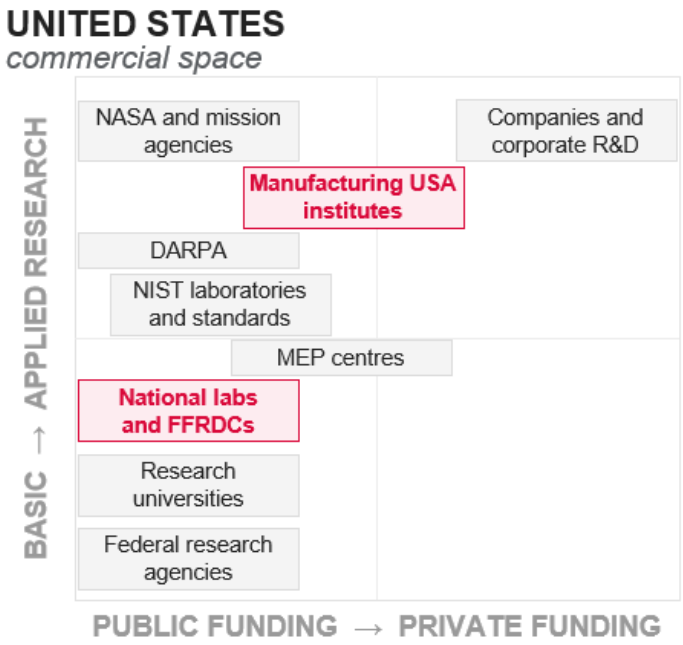
[184] White House Office of Science and Technology Policy. About OSTP
[185] Congressional Research Service (2026). FFRDCs: Background and Issues for Congress
[186] National Science Foundation. About NSF
[187] National Institutes of Health. About NIH
[188] NIST. About NIST
[189] NIST. Connect with an MEP Center

FIGURE F.1. POSITIONING MAP OF THE UNITED STATES' KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



2. Iconic sector: commercial space

US commercial space covers launch, satellites, communications, remote sensing, data, spacecraft and low-Earth-orbit services. In 2023 it generated US$240.9 billion in gross output and US$142.5 billion in GDP, around 0.5% of the economy, supporting approximately 373,000 private jobs. In 2025 US providers conducted nearly 60% of global orbital launches, while commercial providers accounted for 87% of the global total.[190,191] Its translation system combines mission demand, research, independent technical assessment, regional infrastructure, regulation, firms and finance.

Mission agencies

NASA combines research and shared facilities with technology development, demonstrations and commercial procurement. Contracts supply an initial market, revenue and operational references that can attract private investment.[192] The US Space Force creates military demand through Space Systems Command and its Commercial Space Office. SpaceWERX connects innovators through SBIR/STTR, STRATFI and TACFI; the latter two link public funding and demonstrated demand with additional government and private commitments to move beyond prototypes.[193]

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[190] US Bureau of Economic Analysis (2025). New and Revised Statistics for the U.S. Space Economy, 2012–2023
[191] BryceTech (2026). Global Orbital Space Launches 2025 Year in Review
[192] NASA Office of Inspector General. NASA's Transition of the Space Launch System to a Commercial Services Contract
[193] SpaceWERX. STRATFI/TACFI

Research intermediaries

Universities supply science, engineering and specialist skills linked to missions through programmes such as NASA Space Grant; Bayh–Dole supports invention ownership and transfer.[194,195] FFRDCs and UARCs, including Aerospace, JPL, MIT Lincoln Laboratory and Johns Hopkins Applied Physics Laboratory, provide enduring systems expertise and objective evaluation of complex capabilities, especially as government increasingly buys from commercial suppliers.

Regional institutions

Space Florida, Virginia Commercial Space Flight Authority, New Mexico Spaceport Authority and Oklahoma Space Industry Development Authority complement federal missions through sites, infrastructure, investment facilitation, spaceport operations and regional coordination. Their main contribution is enabling firms to manufacture, test, operate and expand.

Regulators

FAA authorises launches, re-entry and launch sites; Commercial Remote Sensing Regulatory Affairs licenses private remote-sensing systems. Specialist regulation is separate from technology procurement and development. Voluntary standards, including ASTM Committee F47's commercial-spaceflight standards, provide common technical practices.[196,197,198]

Private firms

Primes, specialist suppliers, SMEs and start-ups turn technologies into products and services, bearing production and market risks. Industry associations coordinate shared regulatory, skills and supply-chain concerns, while bodies such as the Commercial Space Federation engage in policy, standards and advocacy to support more predictable demand.[199] Finance combines non-dilutive research support, transition programmes, venture capital, procurement revenue and industrial financing, with investors assessing scalability and returns alongside public mission needs. Specialist investor Space Capital, for example, reports more than US$1 billion under management. [200]

Commercial space brings these elements together around mission demand: NASA and the Space Force provide customers and technical requirements; research organisations provide knowledge and assurance; regulators set market-entry rules; public authorities provide infrastructure; and private finance supports growth. Together, these functions help firms move from technology development to operational services.

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[194] NASA. Space Grant
[195] NASA (1994). Intellectual Property Rights at the NASA, Lewis Research Center
[196] Federal Aviation Administration. Licenses, Permits and Approvals
[197] National Oceanic and Atmospheric Administration (NOAA). NAO 217-109: NOAA Commercial Space Policy
[198] ASTM International. Committee F47 on Commercial Spaceflight
[199] Commercial Space Federation. Policy and Advocacy
[200] Space Capital. About

Functional mapping

FIGURE F.2. INNOVATION FUNCTIONS FRAMEWORK: THE UNITED STATES' COMMERCIAL SPACE SECTOR

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
US · COMMERCIAL SPACE (9 institutions)																		
NASA	P	P	P	P	P	C	C	P	C	C	C	C	C	P	P	P		P
US Space Force		P	P	P	P	P	P	P	P	C	P	C	P	P	P	P		P
Research Universities	C	C	P			P	P	C	P	P		P		P	P			P
FFRDC & UARCs	P	C	P	P	P	P	C	P	C	P	P	P	P	P				P
Space regulators				P	C	P				P	P	P	P					
Standard bodies					C	P	P	P		P		P	P	P				P
Industry (Primes and SMEs)	P	P	C	C	P	P	P	C	P	P	C	P	C	P	P	C	P	C
Industry associations					P	C	P	P		P	P	P	P	C	P		P	P
Finance & investors						P	P			P	C	P	P	P	C	C	C	

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Institutional deep dives

TABLE F.2. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
NASA	Federal civil space mission agency	Technology development, testing, shared infrastructure and commercial service procurement	Congressional appropriations: FY2026 enacted US$24.438 billion; FY2027 request US$18.829 billion
The Aerospace Corporation	Nonprofit operator of a government-sponsored the Federally Funded Research and Development Center (FFRDC)	Independent engineering, technology assessment, validation and mission assurance	Primarily government-sponsored FFRDC activities; reported 2024 revenue US$1.37 billion
Space Florida	State-level aerospace finance and development authority	Infrastructure, financing, firm attraction and industrial development	General Revenue Fund operating budget: US$17.5 million; infrastructure programmes and third-party finance

3.1 National Aeronautics and Space Administration (NASA)

Mission and position. NASA is the United States' civil space agency and a central institution in commercial space.[201] It increasingly works with private companies to develop and deliver capabilities, while concentrating public resources on missions and technologies beyond current commercial markets.[202]

Operating model. NASA combines technology development, engineering expertise, shared infrastructure, demonstration and procurement.[203] Companies can build, own and operate systems, while NASA purchases services for mission and research needs. This division of labour addresses both technical uncertainty and weak early demand.[204]

Development support. Space Act Agreements provide milestone-based co-investment while allowing companies to retain responsibility for their systems and intellectual property.[205] Technology programmes, testing, flight demonstrations, technical expertise and shared facilities help firms establish performance and operational readiness.[206]

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[201] NASA. NASA Identifies More Than 40 Space Technologies for Collaboration
[202] NASA. NASA Centres and Facilities
[203] NASA. Commercial Space
[204] NASA. Commercial Space
[205] NASA. Current Space Agreements
[206] NASA. Space Tech Industry Partnerships

Procurement and diffusion. Commercial service contracts make NASA an anchor customer and give suppliers an initial market and reference user.[207] Technology transfer, licensing and partnerships allow firms, universities and other organisations to build on publicly developed knowledge and capabilities.[208]

Partners and strategic role. Partners and users include commercial space companies, universities, research organisations, federal agencies and international partners. NASA shapes markets by defining mission requirements, assessing performance and purchasing services, while firms assume greater responsibility for ownership, production and wider commercial development.

Funding. NASA is federally funded through Congressional appropriations and operates ten field centres. FY2026 enacted funding was US$24.438 billion, while the FY2027 request proposed US$18.829 billion.[209] Grants, contracts, cooperative agreements and Space Act Agreements support external partners; commercial-space activity is distributed across several programmes.[210]

NASA's model combines risk-sharing with performance discipline. Milestones, testing and demonstrations require technical progress, while service procurement converts mature capabilities into operational delivery. The model depends on NASA retaining enough technical competence to define needs and assess results.

3.2 The Aerospace Corporation

Mission and position. The Aerospace Corporation is a nonprofit operating the Federally Funded Research and Development Center (FFRDC) dedicated primarily to space, sponsored by the Department of the Air Force. It provides independent, enduring technical capability between government and suppliers, without manufacturing products or competing for production work.[211] The FFRDC model addresses long-term needs that in-house or conventional contractor resources cannot meet as effectively.[212]

Services and functions. Systems engineering covers architecture, requirements, integration, verification and operations. Independent assessment examines maturity, performance, risk and mission readiness, including new entrants for government use.[213] More than eighty laboratories and test environments support validation.[214] Modelling, acquisition advice and Commercial Space Futures connect emerging commercial capabilities with public requirements and provide technical due diligence for firms and investors.[215]

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[207] NASA. Commercial Resupply Missions
[208] NASA. NASA Technology Transfer Program
[209] NASA. NASA FY 2027 President's Budget Request Summary
[210] NASA. Current Space Agreements
[211] The Aerospace Corporation. The Value of working with the Aerospace Corporation
[212] US General Services Administration. 35.017 Federally Funded Research and Development Centers.
[213] The Aerospace Corporation. Building Confidence in Commercial Launch for National Security Space
[214] The Aerospace Corporation. 2025 Annual Report
[215] The Aerospace Corporation. Commercial Space Futures

Applied research and testing generate knowledge; engineering and mission assurance apply it; standards and acquisition requirements diffuse it across programmes.[216] Its primary translation contribution is confidence, integration and informed government purchasing, rather than commercial-product development.

Partners and strategic role. Space Force and defence bodies, NASA and civil agencies, commercial firms, investors and universities use its expertise. Independent assessments reduce information asymmetry between suppliers and buyers and preserve institutional knowledge across changing programmes and administrations. Commercialisation therefore need not entail a loss of public technical competence, nor must all that competence sit inside government.

Funding. Government-sponsored FFRDC work is the principal source, with compatible commercial and partnership activities. The review's cited 2024 financial figures are US$1.37 billion in revenue and US$1.33 billion in expenses.[217]

The Aerospace Corporation addresses a problem created by commercial procurement: public buyers still require independent technical knowledge when systems are designed and supplied by private firms. Its FFRDC status supports continuity across programmes and administrations, while its laboratories and systems-engineering expertise allow it to assess complex and novel suppliers. By reducing information gaps between buyers and vendors, it helps government use commercial capabilities without giving up the ability to judge risk, integration and mission readiness.

3.3 Space Florida

Mission and position. Space Florida is a state aerospace finance and development authority, legally an independent special district and public corporation. It seeks to retain and grow aerospace activity as the sector moves from federal launch operations towards commercial markets. Its statutory remit combines business finance, spaceports, R&D, workforce and education.[218]

Services. The Spaceport Improvement Program (SIP), with Florida's transportation department, develops common infrastructure and airport–spaceport connections. By 2026, over US$531 million of state investment since 2012 had mobilised US$3.3 billion of private funding, supporting 48 major projects and over 5,000 jobs.[219] Space Florida manages Kennedy Space Center's 15,000-foot Launch and Landing Facility under a thirty-year NASA agreement signed in 2012, with investments in utilities, roads and land preparation.[220] Other sites include Exploration Park, Launch Complex 20 and the Space Life Sciences Laboratory.[221]

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[216] The Aerospace Corporation. Standards
[217] ProPublica Nonprofit Explorer. The Aerospace Corporation, IRS Form 990 filings
[218] The Florida Senate. Florida Statutes, Chapter 331: Aviation and Aerospace Facilities and Commerce (2025)
[219] Space Florida. Powering America's Busiest Spaceport State, Space Florida Announces 2026 Call for Projects
[220] NASA. NASA Signs Agreement with Space Florida to Operate Historic Landing Facility
[221] Space Florida. Facilities

Financing tools include third-party and conduit finance, municipal bonds, long-term leases and structured arrangements for facilities, equipment and tooling; eligible projects may benefit from property- and sales-tax efficiencies. Business attraction, university research partnerships, early-stage capital and training complement infrastructure services.

Functions and partners. Direct technology generation is limited. Its strongest contribution is deployment: sites, utilities, facilities and finance address barriers after technical feasibility. Coordination connects companies with state/local bodies, NASA, Space Force, investors, universities and infrastructure providers. Industry articulates needs; Space Florida evaluates and coordinates projects; state mechanisms support selected investment.

Strategic role and funding. Combining infrastructure development, asset management and finance lowers barriers to private aerospace investment and anchors activity regionally. The operating budget is US$17.5 million from Florida's General Revenue Fund.[222] SIP and third-party structures fund infrastructure, complementing federal R&D and mission organisations.

The three deep dives show complementary ways in which public institutions can shape an emerging market. NASA combines technical capability with partnership and procurement; the Aerospace Corporation preserves independent systems expertise for public buyers; and Space Florida provides regional infrastructure and finance. Together they illustrate that commercialisation depends on credible demand, informed purchasing, technical assurance and places where firms can test, operate and expand.

Space Florida adds the regional conditions that federal mission and research programmes do not supply on their own. Long-term site development, utilities, transport connections, leasing and structured finance make it easier for companies to locate and expand capital-intensive operations. Coordination with NASA, the Space Force, universities and local bodies connects these assets to national demand and skills. Its contribution therefore begins after technical feasibility, when firms need finance and physical capacity to move into sustained operations.

[222] Space Florida. Frequently Asked Questions

European Union- supranational programmes and instruments

1. EU policy and system overview

The EU combines substantial scientific capacity with persistent difficulties translating research into globally competitive firms. Its share of the world's top 10% most-cited publications fell from 24.7% in 2014 to 16.3% in 2024, while China's rose from 12.0% to 34.6%.[223] Selected WIPO patent statistics for 2023 put the EU at 45,999.9, China at 67,197.3, the US at 54,428.5 and Japan at 45,658.1.[224] In 2025 the EU had 355 unicorns, compared with China's 436 and the US's 1,770.[225] Estimated R&D intensity of 2.24% in 2024 remained below the 3% target.[226,227]

EU intervention pools resources, coordinates national efforts and shares risks beyond the capacity of individual Member States. Fragmented markets, finance and regulation nevertheless constrain scale, while complex administration can limit agility. The review considers how institutions, collaborative programmes and financial instruments connect research, technology development, industrial deployment and growth.

1.1 Recent policy debates, key strategies and initiatives

Competitiveness debates. Draghi's September 2024 report identifies fragmented priorities, regulation and investment. Although public R&I spending is comparable with the US, only about 10% is coordinated at EU level; Horizon's roughly €100 billion is spread across many fields. EIC Pathfinder's 2024 budget of €256 million contrasts with DARPA's US$4.1 billion and about US$2 billion for other US ARPAs. Programme leadership, bureaucracy and insufficient infrastructure scale are concerns.[228,229,230]

Letta's April 2024 report proposes renewing the Single Market and enabling firms to scale, using the 2028–2034 financial framework as an opportunity. A "fifth freedom" for research, innovation

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[223] OECD, Science and Bibliometric Indicators, OECD calculations based on Scopus Custom Data, Elsevier, Version 1.2026, April 2026; and Scimago Journal Rankings. https://stip.oecd.org/stats/SB-StatTrends.html?i=TOP10_X_WLD&v=6&t=2014,2024&r=4.
[224] OECD Patent data, Patents in OECD selected technologies.
[225] European Startup and Scaleup Scoreboard: Comparison with Global Competitors as per number of Unicorns (Absolute data).
[226] Eurostat, Gross domestic expenditure on R&D (all sectors).
[227] Investing in European Research - The 3% objective: brief history.
[228] European Commission tasked Mario Draghi, former European Central Bank President to prepare a report of his personal vision on the future of European competitiveness.
[229] Draghi, M., 2024, Part A The future of European competitiveness, Publications Office of the European Union.
[230] Draghi, M., 2024, Part A The future of European competitiveness, Publications Office of the European Union.

and education would connect ecosystems and infrastructure through knowledge sharing, public–private cooperation, mobility, simpler procedures and sandboxes.[231,232] Heitor's October 2024 report recommends stronger excellence-based ERC, MSCA and EIC funding, private investment, experimental fast funding, an Industrial Competitiveness and Technology Council, coordinated infrastructure and innovation procurement, alongside less prescriptive calls and review of underperforming instruments.[233,234]

Political priorities. The 2024–2029 guidelines link competitiveness with simpler regulation, a proposed "28th regime", merger rules reflecting innovation, a Clean Industrial Deal, biotechnology, joint undertakings and EIB investment. A Savings and Investments Union, European Competitiveness Fund, IPCEIs, procurement and skills portability would support finance and deployment.[235,236] The January 2025 Competitiveness Compass focuses on closing the innovation gap, decarbonisation and reduced dependencies. Measures include an Innovation Act, infrastructure/IP access, sandboxes, TechEU and a more risk-taking EIC, alongside lead markets and revised state-aid and merger approaches.[237,238,239]

Clean industry and research talent. The Clean Industrial Deal seeks to mobilise over €100 billion, including a Horizon call, faster state aid, InvestEU guarantees and Innovation Fund support. STEP coordinates eleven existing EU programmes around strategic technologies rather than creating a new fund.[240,241,242] Choose Europe, announced in May 2025, provides almost €900 million over 2025–2027 through Horizon, ERC and MSCA. Planned ERC Plus grants offer

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[231]Former Italian head of government, Enrico Letta was tasked by the European Council and the Commission to write a Report on the future of Single Market.
[232] Letta, E., 2024, Much more than a market.
[233] Drafted by a high- level group of 15 independent leading experts led by Manual Heitor, former Secretary of State for science, technology and higher education of Portugal.
[234] European Commission: Directorate-General for Research and Innovation, *Align, act, accelerate – Research, technology and innovation to boost European competitiveness*, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2777/9106236.
[235] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. (2024, July 18). *Europe's choice – President-elect Ursula von der Leyen*. European Commission. https://ec.europa.eu/newsroom/growth/newsletter-archives/54892.
[236] von der Leyen, U. (2024, July 18). *Europe's choice: Political guidelines for the next European Commission 2024–2029*. European Commission.
[237] European Commission. (2025, January 29). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: A competitiveness compass for the EU* (COM(2025) 30 final). Publications Office of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0030 and European Commission. (2026, May 29). *Competitiveness compass*.
[238] European Commission is planning to adapt European Innovation Act in 2026 which aims to establish a cross-sectoral regulatory framework aimed at removing obstacles that impede the commercialization and market uptake of innovations in all sectors: European Commission.
[239] European Commission. (2025, January 29). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: A competitiveness compass for the EU* (COM(2025) 30 final). Publications Office of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0030 and European Commission. (2026, May 29). *Competitiveness compass*.
[240] European Commission. (2025, February 26). *Clean Industrial Deal*.
[241] European Union. Strategic Technologies for Europe Platform (STEP) in a nutshell.
[242] European Union. Strategic Technologies for Europe Platform. STEP funding and programmes.

up to €7 million over seven years; relocation support increased to up to €2 million in 2025.[243,244,245]

Start-ups and commercialisation. The May 2025 strategy addresses research-to-product and scale-up financing gaps. It notes that 30% of European unicorns founded in 2008–2021 were outside the EU, while Europe accounted for only 8% of global scale-ups.[246,247,248] Large growth rounds, particularly above €100 million, remain difficult; pension investment, IP valuation and angel finance face barriers. An expanded EIC and Scaleup Europe Fund seek to address the gap.[249,250] Universities account for over 10% of EPO patent applications, but only around one-third are commercialised. The strategy proposes Unitary Patent use, Lab to Unicorn, innovation procurement, Blue Carpet talent measures, entrepreneurship incentives, a visa strategy and guidance on infrastructure access and state aid.[251,252,253]

The policy debate is therefore concerned with more than the level of research spending. It focuses on whether fragmented national and EU resources can be aligned, whether regulation and procurement allow new technologies to reach markets, and whether firms can secure finance for large-scale growth. The proposed reforms seek to connect the Single Market, research programmes, industrial policy and investment more directly around competitiveness and strategic priorities.

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[243] EURAXESS. Jobs & opportunities.
[244] European Research Council. (2025, May 5). Choose Europe for Science: ERC welcomes new budget for 'super grants'|ERC.
[245] European Commission. Choose Europe: From lab to market.
[246] European Commission. EU Startup and Scaleup Strategy. and European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[247] Testa, G., Compano, R., Correia, A. and Rückert, E., In search of EU unicorns -What do we know about them, EUR 30978 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-47058-8, doi:10.2760/843368, JRC127712. in European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[248]European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[249] EIB (2024), The scaleup gap: financial market constraints holding back innovative firms in the European Union, European Investment Bank, https://data.europa.eu/doi/10.2867/382579 in European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[250] European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[251] European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[252] European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.
[253] European Commission. (2025, May 28). The EU Startup and Scaleup Strategy: Choose Europe to start and scale (COM(2025) 270 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0270.

1.2 Key institutions, functions and programmes

Institutional architecture. EU institutions act as a system architect through regulation, priorities, investment and coordination, combining delegated supranational powers with intergovernmental decision-making.[254,255] The Parliament, European Council, Council and Commission jointly shape strategy. The Commission proposes policy and legislation, manages the budget, oversees implementation and represents EU interests internationally.[256,257] DG RTD, DG GROW, DG COMP, DG Connect and DG Regio shape programmes and frameworks; the Joint Research Centre supplies independent scientific evidence.[258]

Industrial policy. Intervention extends beyond technology funding to standards, procurement, supply chains and integrated value chains. The March 2026 Industrial Accelerator Act proposal aims to raise manufacturing's GDP share to 20% by 2035. The Net-Zero Industry Act, Chips Act and Critical Raw Materials Act address complementary industrial, semiconductor and resource challenges.[259,260,261,262]

Horizon Europe. The ninth Framework Programme runs in 2021–2027 with €93.5 billion, led by DG RTD, supporting research through deployment and the 3% R&I target.[263,264] Pillar I combines ERC frontier research, MSCA training/mobility and research infrastructure. ERC grants provide up to €1.5–2.5 million over five years; Synergy grants up to €10 million over six years; Proof of Concept €150,000 for eighteen months to explore commercial or societal potential.[265,266,267] Pillar II funds a broad TRL range through six clusters covering health; culture and inclusive society; civil security; digital, industry and space; climate, energy and mobility; and food, bioeconomy, natural

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[254] European Parliament. Fact sheets on the European Union, Supranational decision-making procedures.
[255] European Parliament. Fact sheets on the European Union, Intergovernmental decision-making procedures.
[256] European Commission. Strategy and policy.
[257] European Commission. Role of the European Commission.
[258] European Commission. Joint Research Centre.
[259] European Union, Strategic Technologies for Europe Platform (STEP). STEP in a nutshell.
[260] European Parliament. Fact Sheets on the European Union. General principles of EU industrial policy.
[261] Council of the European Union. EU industrial policy.
[262] European Commission. Net-Zero Industry Act, European Commission. European Critical Raw Materials Act and European Commission. European Chips Act.
[263] European Commission. Horizon Europe.
[264] European Commission. Horizon Europe. Research and Innovation.
[265] European Research Council. ERC at a glance., ERC Starting Grant, ERC Consolidator Grant, ERC Advanced Grant, ERC Synergy Grant.
[266] European Research Council, ERC Proof of Concept Grant.
[267] European Commission. *Marie Skłodowska-Curie Actions*.

resources, agriculture and environment.[268] Pillar III supports breakthrough innovation and ecosystems, including EIC, piloted in 2018–2020 and fully launched in 2021.[269,270]

EIC instruments. Pathfinder supports early deep-tech research at TRL 1–4 with up to €4 million, or more with justification. Transition offers up to €2.5 million to advance eligible previously funded results from TRL 3/4 towards 5/6. Both can add €50,000 booster grants.[271,272] The Advanced Innovation Challenges pilot tests phased, demand-oriented support: up to €300,000 for feasibility from TRL 4, followed by up to €2.5 million towards TRL 6/7; its 2026 challenges cover physical AI and disruptive new approach methodologies.[273]

Accelerator combines grants below €2.5 million for TRL 6–8 with €1–10 million investment for start-ups and SMEs. STEP Scale Up provides €10–30 million equity for strategic digital/deep, clean and biotechnology firms, including eligible small mid-caps; a defence programme targets critical defence technologies.[274,275] The EIC Fund provides patient capital and co-investment across Accelerator and STEP; its 2026 impact report records €3.5 mobilised per euro invested. Business Acceleration Services connect awardees with coaches, peers, investors, procurers and international partners.[276,277,278]

Partnerships. Horizon's sixty European Partnerships pool Commission, public and private resources. Joint Undertakings and EIT Knowledge and Innovation Communities connect research and industry in areas including chips, smart networks, clean aviation, energy, circular bioeconomy, pandemic preparedness and innovative SMEs.[279,280]

EIB Group and TechEU. The EIB, owned by 27 Member States, provides long-term loans, guarantees, equity and advice; the EIF specialises in SME, start-up and innovator finance.[281,282] TechEU brings financing and guidance together from R&D to scale-up and exits, including indirect venture capital, venture debt, loans, guarantees, direct co-investment and digital infrastructure finance. ETCI, launched in 2023 by the EIB Group and six Member States, committed up to €3.9 billion with an expected investment effect above €20 billion; the review reports fifteen investments supporting twelve EU unicorns. ETCI 2.0, launched in July 2026, aims

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[268] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[269] European Commission. About the European Innovation Council.
[270] Jean David Malo (2019) Introduction presentation (2 April 2019), The European Innovation Council Pathfinder and the Future and Emerging Technologies Info Day in Brussels.
[271] European Innovation Council. EIC Pathfinder.
[272] European Innovation Council. EIC Transition.
[273] European Innovation Council. Advanced Innovation Challenges - Pilot.
[274] European Innovation Council. EIC Accelerator.
[275] European Innovation Council. STEP Scale Up.
[276] European Innovation Council. About the EIC Fund.
[277] European Innovation Council. EIC Impact Report 2026 Findings.
[278] European Innovation Council. EIC Business Acceleration Services.
[279] European Commission. European Partnerships in Horizon Europe.
[280] European Partnerships Portfolio.
[281] European Investment Bank. EIB Group at a glance.
[282] European Investment Bank. European Investment Bank Group.

to mobilise up to €80 billion with governments and institutional investors, extending support to mid-sized growth funds.[283,284,285,286]

InvestEU and the Innovation Fund. InvestEU combines a Fund, Advisory Hub and investment Portal. Its €26.2 billion budget guarantee increases financial partners' risk capacity and is expected to unlock at least €427 billion of additional private investment in 2021–2027.[287,288] The Innovation Fund supports net-zero and low-carbon deployment through grants and auctions financed by EU ETS allowance revenues, with around €40 billion expected for 2020–2030. DG CLIMA leads policy, with tasks delegated to CINEA and the EIB.[289]

Cross-border and regional instruments. IPCEIs permit national state aid for high-risk strategic projects and infrastructure with significant EU benefits, involving at least four Member States.[290,291] ERDF reduces regional imbalances; its €490 million I3 instrument supports near-market projects at TRL 6–9 with grants up to €10 million, connecting smart-specialisation regions and value chains.[292,293,294] Eurostars co-funds collaborative SME R&D. Digital Europe's €8.1 billion supports adoption of supercomputing, AI, cybersecurity and semiconductors through grants, procurement and financial instruments, complementing Horizon and InvestEU.[295,296,297]

Proposed 2028–2034 framework. The Commission's almost €2 trillion MFF proposal represents 1.26% of EU GNI and targets at least 35% for climate/environment.[298,299] Proposed Horizon funding doubles to €175 billion, with four pillars: Excellent Science; Competitiveness and Society, closely linked to the European Competitiveness Fund; Innovation, including a more ARPA-like

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[283] European Investment Bank Group. TechEU - European innovators one-stop shop.
[284] European Investment Fund. European Tech Champions Initiative (ETCI) overview. and Europe launches €80 billion investment alliance to scale up tech leaders.
[285] European Investment Fund. (2026, July 9). Europe launches €80 billion investment alliance to scale up tech leaders.
[286] European Commission. (2025). Communication from the Commission: Savings and investments union, A strategy to foster citizens' wealth and economic competitiveness in the EU (COM(2025) 124 final). EUR-Lex - 52025DC0124 - EN - EUR-Lex.
[287] Increased from €372 Billion: European Commission. InvestEU map and indicators.
[288] European Commission, InvestEU Programme.
[289] European Commission. Innovation Fund-About the Programme and European Commission. What is the Innovation Fund?
[290] European Commission. Joint European Forum for IPCEI.
[291] Background Information for Important Projects of Common European Interest (IPCEI).
[292] European Commission. European Regional Development Fund.
[293] Multiannual work programme for 2021 - 2022 for the Interregional Innovation Investments instrument (Annex)
[294] European Commission. European Innovation Council and SMEs Executive Agency (EISMEA) Interregional Innovation Investments (I3) Instrument.
[295] Eureka Network. Eurostars.
[296] European Commission. Digital Europe Programme.
[297] Digital Europe work programme 2025 - 2027 amended in October 2025.
[298] European Commission. The 2028-2034 EU budget for a stronger Europe.
[299] European Commission: Directorate-General for Budget, *Europe's budget – An ambitious budget for a stronger Europe 2028-2034*, 2025, https://data.europa.eu/doi/10.2761/3758793

EIC and stronger commercialisation links; and the European Research Area, including infrastructure and regional capacity.[300,301,302,303]

Scale-up and competitiveness proposals. The Scaleup Europe Fund targets €5 billion, including €1 billion from the Commission, with investments of €100 million or more and first investments planned for autumn 2026 after legal establishment. A privately owned manager would operate on a market basis with public/private investors.[304,305] The proposed €234 billion European Competitiveness Fund consolidates several instruments, links closely to standalone Horizon and coordinates with the Innovation Fund. Windows cover clean transition; health, biotech, agriculture and bioeconomy; digital leadership; and resilience, security, defence and space. Together with the proposed €175 billion Horizon programme, the review identifies €409 billion. The ECF InvestEU instrument would provide debt and equity through the EIB Group and other financial partners.[306,307,308]

Taken together, these institutions form a layered policy architecture. Horizon supports research and collaboration; EIC instruments address maturation and early company growth; partnerships organise shared agendas; IPCEIs and the Innovation Fund support first deployment and industrial investment; and EIB, InvestEU and TechEU provide finance. Regional and digital programmes broaden access and adoption. The main policy challenge is to coordinate these instruments so that promising technologies can progress without being lost between separate programmes or levels of government.

1.3 Key programmes and instruments in economic translation

The positioning chart brings together instruments across technology maturity and public/private financing. ERC and MSCA strengthen the early knowledge and talent base; collaborative Pillar II projects and EIC instruments support development and validation. Innovation Fund, IPCEIs and

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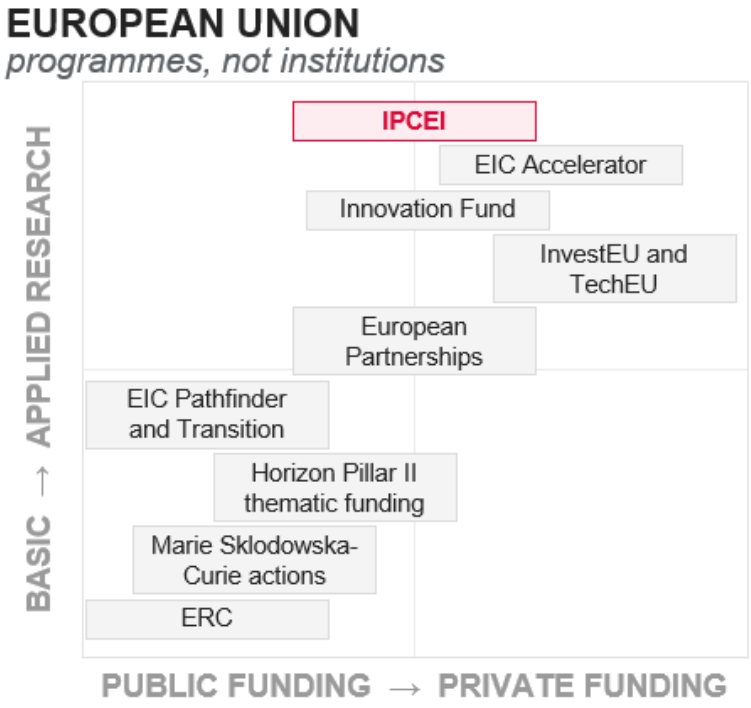
[300] European Commission. Horizon Europe 2028 - 2034: twice bigger, simpler, faster and more impactful.
[301] Horizon Europe 2028 - 2034: twice bigger, simpler, faster and more impactful - Research and innovation.
[302] European Commission. (2025, July 16). Proposal for a regulation of the European Parliament and of the Council establishing Horizon Europe, the Framework Programme for Research and Innovation, for the period 2028–2034 laying down its rules for participation and dissemination, and repealing Regulation (EU) 2021/695 (COM(2025) 543 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025PC0543.
[303] European Commission. (2025, July 16). Proposal for a regulation of the European Parliament and of the Council establishing Horizon Europe, the Framework Programme for Research and Innovation, for the period 2028–2034 laying down its rules for participation and dissemination, and repealing Regulation (EU) 2021/695 (COM(2025) 543 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025PC0543.
[304] European Innovation Council. Scaleup Europe Fund.
[305] European Innovation Council. Scaleup Europe Fund.
[306] European Commission. Internal Market, Industry, Entrepreneurship and SMEs. European Competitiveness Fund.
[307] European Commission. Internal Market, Industry, Entrepreneurship and SMEs. European Competitiveness Fund and European Commission Factsheet (April 2026). Europe's Budget - Powering Europe's competitiveness - the European Competitiveness Fund.
[308] European Commission Facsheet (April 2026). Europe's Budget - Powering Europe's competitiveness - the European Competitiveness Fund.

I3 address deployment and value chains, while InvestEU, TechEU and STEP expand growth finance. Proposed funds seek to strengthen later-stage financing and industrial uptake.

FIGURE G.1. POSITIONING MAP OF THE EUROPEAN UNION'S KEY INSTITUTIONS IN INDUSTRIAL TRANSLATION



2. EU programmes and instruments map

Pillar II combines knowledge generation, technology development and exchange across a broad TRL range. Cluster 4's 2026–2027 programme illustrates this through industrial demonstrations, pilots, AI/robotics, skills, supply-chain analysis and roadmaps. Standardisation, foresight, stakeholder networks and start-up infrastructure complement research; quantum venture-debt support through InvestEU links to market readiness.[309,310,311]

EIC combines technology maturation and market creation through grants, equity, portfolios and Business Acceleration Services. Coaching, procurement training and access to testing, customers and investors build commercial capability. Global Business Expansion helps firms understand overseas ecosystems, regulations and business cultures; programme managers use

[309] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[310] European Commission. Cluster 4: Digital, Industry and Space - Research and innovation
[311] European Commission. (2025). Horizon Europe work programme 2026-2027: 7. Digital, industry and space.

research, investment and market intelligence to shape technology visions and project portfolios.[312,313,314]

TechEU primarily provides finance for R&D, commercialisation, scale-up and exits: debt, equity, guarantees, infrastructure investment and advice. Its exit toolbox prepares firms for IPOs or strategic sales; ETCI connects institutional investors, fund managers and growth firms.[315,316,317] EIB economic analysis informs strategy and investment trajectories, while advice supports project skills, readiness and compliance with standards and state-aid rules.[318,319]

IPCEIs address technological, financial and coordination risks through cross-border R&D, first industrial deployment and strategic open infrastructure. Eligible first deployment includes pilot upscaling, demonstrators, testing and batch production; mass production and commercial activities are excluded. Projects must offer significant innovation or infrastructure value and EU-wide benefits.[320,321]

Two battery IPCEIs involve 59 companies in twelve Member States, up to €6.1 billion state aid and over €13.8 billion expected additional private investment. They cover raw materials, advanced chemicals, cells, smart-system integration and recycling, targeting performance, safety, sustainability, skilled jobs and ecosystem coordination.[322,323] Four hydrogen IPCEIs involve 99 companies from sixteen Member States and Norway, up to €18.9 billion state aid and over €27.1 billion expected private investment. Hy2Move supports hydrogen mobility, fuel cells and storage, alongside scalable manufacturing, knowledge transfer and jobs.[324,325]

The instruments are complementary: Pillar II builds collaborative knowledge and technologies; EIC supports maturation and market uptake; IPCEIs enable high-risk first deployment and

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[312] European Innovation Council. EIC Business Acceleration Services.
[313] European Innovation Council. EIC Global Business Expansion Programme.
[314] European Innovation Council. Shape the future of innovation in Europe – become an EIC Programme Manager and EIC Programme Managers.
[315] European Investment Bank Group. TechEU - European innovators one-stop shop.
[316] European Investment Bank Group. TechEU platform | What we offer and Investment Report 2025/26: Capitalising on Europe's strengths
[317] European Investment Fund. The European Tech Champions Initiative - ETCI 2.0 Fundraising
[318] European Investment Bank Group. Investment Report 2025/26: Capitalising on Europe's strengths
[319] European Investment Bank. *Advisory services*
[320] European Commission. Important Projects of Common European Interest (IPCEI) and Background Information for Important Projects of Common European Interest (IPCEI) and European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex.
[321] European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex.
[322] European Commission. Approved IPCEIs in the Batteries value chain.
[323] IPCEI Batteries. About IPCEI
[324] European Commission. Approved IPCEIs in the Hydrogen value chain.
[325] IPCEI Hydrogen. Hy2Move.

integrated value chains; TechEU mobilises company growth finance. Their functions connect to competitiveness, green/digital transition and strategic autonomy.

The map therefore presents a sequence of complementary functions rather than a single linear pipeline. Collaborative research can generate technologies and networks, but later instruments are needed to validate applications, establish manufacturing capacity, create markets and finance company growth. Projects may move between several programmes, and effective translation depends on the links among grants, shared infrastructure, state aid, procurement and private investment.

Functional mapping

FIGURE G.2. INNOVATION FUNCTIONS FRAMEWORK: EU PROGRAMMES AND INSTRUMENTS

INSTITUTION	FAMILY A FUNCTIONS FOR TECHNOLOGY DEVELOPMENT									FAMILY B FUNCTIONS FOR SECTORAL INDUSTRIAL DEVELOPMENT								
	F1 Proof of concept (TRL 2-3)	F2 Lab validation (TRL 4-5)	F3 Prototype demonstration (TRL 6-7)	F4 System demonstration (TRL 8-9)	F5 Standards, regulation and IP	F6 Knowledge exchange	F7 Technology intelligence	F8 Training and skills	F9 Expertise and facilities	G1 Sector roadmapping	G2 Demand articulation	G3 Direction of search	G4 Supply chain qualification	G5 Cluster building	G6 Venture building	G7 Patient capital	G8 Investment anchoring	G9 Industrial skills
EU · SUPRANATIONAL PROGRAMMES (4 institutions)																		
Horizon EuropePillar II	C	C	C	P	P	C	P	P	P	P	P	P	P	P	P	P		P
EIC	C	C	C	C	P	C	P	P	P	P	C	C	P	P	C	C	P	P
IPCEIs		C	C	C	P	C	P	P	C	P	P	P	C	C	P	P	P	P
EIB - TechEU		P	P	C	P	P	P	P	P	P	P	P	P	P	C	C	C	P

C A defined responsibility (••• in the source) P Done, but alongside other work (• or ••) Function not mentioned in the source

Source: summarised and illustrated by the author

3. Programme and instrument deep dives

TABLE G.1. INSTITUTIONAL PROFILES AT A GLANCE

Institution	Position	Principal contribution	Funding and scale
Horizon Europe Pillar II	Supranational collaborative research instrument	Collaborative R&D, demonstrations, knowledge exchange and innovation uptake	Mainly grants; over €53 billion for 2021–2027
European Innovation Council (EIC)	Horizon Europe Pillar III innovation and scale-up instrument	High-risk innovation, commercialisation, scale-up and investment	€10.1 billion for 2021–2027; EIC Fund capitalisation over €4 billion
IPCEI	Member State-led projects within EU industrial and competition policy	Breakthrough innovation, first industrial deployment and major infrastructure	National state aid and beneficiary co-financing; over €92.2 billion in approved aid and expected private R&D investment across ten IPCEIs since 2018

3.1 Horizon Europe Pillar II

Mission. Strengthen Europe's industrial competitiveness through collaborative research and innovation. Maximise Union added value by concentrating on goals and activities that cannot be effectively achieved at the level of a single Member State but can be achieved through cooperation. Generate and disseminate high-quality knowledge and technologies within the thematic intervention areas. Enable adoption of innovative solutions by industry, particularly among SMEs and start-ups.[326] General Horizon Europe performance is measured against indicators such as peer-reviewed scientific publications, innovations, innovative products and IPR applications, market share of companies, FTE jobs created, among other indicators.[327]

Services provided. Develop technological and non-technological solutions; bring technologies from the laboratory to the market; develop applications, including pilot lines and demonstrators; stimulate market uptake; and encourage private-sector involvement in standardisation. Accelerate the introduction of first-of-a-kind innovations across the EU by implementing a wide array of activities, including communication, dissemination, exploitation, and standardisation; support

[326] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695

[327] European Commission, Horizon Europe Performance Indicators. 2021-2027 metadata set.

innovative delivery mechanisms; contribute to creating innovation-friendly societal, regulatory, and market conditions through initiatives such as innovation deals.[328]

Functions for technology development. Support collaborative research and technology development and dissemination through a wide TRL coverage. Enhance innovation delivery and contribute to favourable regulatory conditions for innovation. Support implementation and exploitation of solutions by industry (tests, pilots, demonstrations). Facilitate networks and knowledge exchange among researchers, industry, public entities and end users, and strengthen complementarities. Stimulate private sector engagement for standardisation.

Functions for sectoral industrial development. Stimulate market uptake of innovations. Support sector coordination across research and industry actors, strengthen supply chains, contribute to industrial roadmaps. Establish pipelines for innovations targeting public and private investments.[329] Key and distinctive functions include support for collaborative research and development, technology demonstration, wide coverage of TRL levels, enabling transnational and cross-sectoral collaborations.

Key partners and users. The programme is led by the European Commission's Directorate-General for Research and Innovation (DG RTD), in cooperation with other relevant DGs and agencies. It is assisted by programme committees composed of representatives from EU Member States and associated countries, as well as expert groups. DG RTD meets with interest representatives, including industrial actors (e.g. a presentation of BMW's views on the needs for research and innovation in the automotive sector).[330][331][332][333]

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[328] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj
[329] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj and Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[330] European Commission Horizon Europe the EU's funding programme for research and innovation
[331] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj
[332] European Commission. Register of Commission expert groups and other similar entities
[333] European Commission. Meetings held by the Directorate-General for Research and Innovation with interest representatives.

Key users: Legal entities established in EU Member States and Associated Countries can receive funding.[334] The main beneficiaries of Pillar II include higher education institutions, SMEs, research organisations and private companies.[335]

Position. A supranational instrument managed by the European Commission at the European level, involving representation from Member States and associated countries on its programme committees. It connects stakeholders from research, industry and public bodies across participating countries.

Funding model and budget. Grants are the main form of support.[336] The budget exceeds €53 billion for 2021–2027.[337]

Pillar II's principal value is scale and connection. It enables universities, research organisations, firms and public bodies from several countries to work on common challenges and to combine research with demonstrators, standards, roadmaps and market uptake. This breadth can link technical development to sector coordination, although it also creates demanding programme and consortium structures. Clear exploitation plans and links to later finance and deployment instruments are therefore essential if collaborative results are to move beyond the project period.

3.2 European Innovation Council (EIC)

Mission. Enhance Europe's global competitive position by supporting all forms of innovation, mainly focusing on breakthrough and disruptive innovation, especially market-creating innovation.[338]

Services provided. Support to identify, advance and deploy high-risk innovations (including incremental) to create new markets. Support the rapid scale-up of innovative companies (mainly SMEs, including start-ups) internationally. Access to skills, facilities and networks for technology

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[334] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[335] Horizon Dashboard, R&I Projects, Horizon Europe, Pillar II, Overview by Organisation Type (access: 12.08.2026)
[336] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[337] European Commission: Directorate-General for Research and Innovation, *Horizon Europe, pillar II - Global challenges and european industrial competitiveness*, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2777/881197
[338] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
and Jean David Malo (2019) Introduction presentation (2 April 2019), The European Innovation Council Pathfinder and the Future and Emerging Technologies Info Day in Brussels.

and business growth.[339] Key impact indicators include the number of unicorns and start-ups created, innovations generated, successful exits, large-scale equity rounds, cross-border deals, companies reaching commercialisation, and investment mobilised.[340]

Functions for technology development. Support to early-stage scientific and technological R&D, proof of concept and prototypes for technology validation. Demonstration and feasibility to assess potential business cases. Enable access to technical and business expertise. Manage project portfolios, develop common technology visions, enhance recent and new research fields. Structure new multidisciplinary research communities through thematic portfolios. Analyse investment and market developments to identify future technology trends, opportunities and challenges.

Functions for sectoral industrial development. Support the creation of spin-offs and start-ups. Financial support to SMEs to develop and deploy breakthrough innovations and to scale up. Blended finance for various stages of innovation. Equity investment in start-ups, SMEs, and small mid-caps for scaling up strategic technologies. Provide patient capital through EIC Fund. Enable sector coordination by developing communities of EIC awardees and relevant partners to support market-creating innovations. Help companies access debt financing (such as loans or guarantees) and equity financing. De-risk market deployment by stimulating co-investment from alternative sources and, where necessary, substituting for investors. Connect EIC innovators to investors, partners and public buyers.[341]

Key and distinctive functions include support for scale-up and innovation maturation, the provision of blended finance and equity investment, portfolio management, and programme managers who shape technology visions.

Key partners and users. The EIC is implemented by the European Innovation Council and SMEs Executive Agency (EISMEA) of the European Commission.[342] The EIC Board assists EIC implementation, advises on EIC work programmes and the project-selection process, among other matters. EIC programme managers, appointed temporarily, assist with business- and technology-related vision and operational guidance.[343]

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[339] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj
[340] European Innovation Council. Impact - EIC Impact Report.
[341] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj and European Innovation Council. *STEP Scale Up* and European Innovation Council. Shape the future of innovation in Europe – become an EIC Programme Manager, EIC Programme Managers and European Innovation Council. EIC Fund.
[342] European Innovation Council and SMEs Executive Agency (EISMEA)
[343] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj

Key users: All types of innovators from individuals to universities, research organisations and companies.[344] The main beneficiaries of Pillar III include SMEs, higher education institutions, research organisations and private companies.[345]

Position. Embedded in Horizon Europe Pillar III, the EIC has a specialised role in innovation and scale-up, bringing together public and private resources. It connects with European and global investors. European-level governance and management involve representation from Member States and associated countries on its programme committee.[346]

Main actors of EIC Fund: The European Commission acts as shareholder; EIB serves as investment adviser and future investor of record. Portfolio and investment decisions are managed by an external Fund Manager. Qualified investors validate prospects, and co-investors invest alongside the Fund. **EIC Fund governance**: EIC Fund Board (investment strategy and decisions), EIC Fund Advisory Committee (independent advice to EIB and Fund Manager), Company Board Representatives (helping companies grow), EIC Fund Manager (investment management and decisions with EIB), European Commission / EISMEA (manages and implements the programme), EIB (investor and investment adviser).[347]

Funding model and budget. Funding takes the form of grants, blended finance (combining grants with equity investments), equity investment, prizes and innovative procurement. The EIC has a budget of €10.1 billion for 2021–2027. The EIC Fund, a venture-capital fund with capitalisation of over €4 billion, is financed by the European Commission with investment advice from the European Investment Bank.[348][349][350]

The EIC concentrates on the transition from promising technology to a company capable of creating and serving a market. Pathfinder and Transition support early technical and commercial development, while Accelerator and the EIC Fund combine grants, equity and business support at later stages. Programme managers and thematic portfolios add strategic direction across individual projects. The model seeks to address both innovation risk and financing risk, but it also

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[344] Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe—the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. (2021). Official Journal of the European Union, L 170, 1–68. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0695
[345] Horizon Dashboard, R&I Projects, Horizon Europe, EIC, Overview by Organisation Type (access: 12.08.2026)
[346] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj
[347] European Innovation Council. About the EIC Fund
[348] Council of the European Union. (2021, May 10). *Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU (Text with EEA relevance)*. *Official Journal of the European Union, L 167I*, 1-80. https://eur-lex.europa.eu/eli/dec/2021/764/oj, European Innovation Council. EIC Funding opportunities and European Innovation Council. EIC Fund.
[349] European Commission. About the European Innovation Council.
[350] European Innovation Council. EIC Fund.

depends on follow-on investors, customers and procurement opportunities outside the programme.

3.3 Important Projects of Common European Interest (IPCEI)

Mission. Strengthen the Union's competitiveness and open strategic autonomy through public support for investments in breakthrough innovations and important open cross-border infrastructure by overcoming market failures. Support the achievement of the clean and digital transitions.[351]

Services provided. IPCEIs support research, development and innovation projects with significant impact; first industrial deployment projects (upscaling of pilot facilities, demonstration plants, testing phase, bringing batch production to scale excluding mass production or commercial activities); infrastructure projects with significant importance for the environmental, climate, energy, transport, health, industrial or digital strategies of the Union.[352]

Functions for technology development. Support high-risk, high-impact research and development activities for technologies not yet available. Bring together key industrial actors and research and technology organisations across Member States to support competitive value chains. Facilitate access to and complementarity among knowledge, expertise, financial resources and economic actors to address market and system failures and deliver large-scale projects with significant impact for the Union.

Functions for sectoral industrial development. Establish efficient manufacturing processes and value chains for technologies in the concerned sector. Transfer knowledge to different sectors through stakeholder cooperation. Enhance sectoral ecosystems and sectoral value chains by bringing together key industry actors, national authorities, research and technology organisations and clusters. Contribute to the development of new jobs, skills and growth in new markets. [353]

Key and distinctive functions include first industrial deployment, large-scale infrastructure projects, state-aid provision and the integration of sectoral ecosystems and value chains.

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[351] European Commission. Important Projects of Common European Interest (IPCEI) and
[352] European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex.
[353] European Commission. Approved IPCEIs in the Batteries value chain, IPCEI Batteries. About IPCEI, European Commission. Important Projects of Common European Interest (IPCEI), Background Information for Important Projects of Common European Interest (IPCEI) , European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex, IPCEI Hydrogen. *Hy2Move, and* IPCEI Batteries. About IPCEI.

Key partners and users. Member States, European Commission, Directorate General for Competition (DG COMP) and Directorate General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW).[354] Key users include SMEs, large companies, start-ups.[355]

Position. Joint European Forum for IPCEI (JEF-IPCEI) as the steering forum composed of Member States and the European Commission.[356] Shared governance between Member States and the European Commission is positioned within industrial and competition policies. Operated through Member State-led consortia. Member States identify project scope, select companies through calls and agree on project governance. The Commission is notified for assessment and approval. [357]

Funding model and budget. Funding combines state aid and beneficiary co-financing. IPCEIs are funded from national budgets. Public support by Member States for projects and companies constitutes state aid under EU rules.[358] [359] Since 2018, approved state aid and expected private R&D investment in ten integrated IPCEIs have exceeded €92.2 billion.[360]

The three programme deep dives represent different points in this system. Pillar II builds cross-border research and industrial collaboration; the EIC concentrates on high-risk innovation, commercialisation and scale-up; and IPCEIs support coordinated first industrial deployment where individual projects or Member States cannot carry the full risk. Their effectiveness therefore depends both on their individual design and on the quality of the transitions between collaborative research, company growth and industrial investment.

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[354] European Commission. Joint European Forum for IPCEI.
[355] European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex.
[356] European Commission. Joint European Forum for IPCEI.
[357] European Commission, Press Release, State aid: Commission adopts revised State aid rules on Important Projects of Common European Interest.
[358] European Commission. (2021). Communication from the Commission: Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest (2021/C 528/02). Official Journal of the European Union, C 528, 10–18, EUR-Lex - 52021XC1230(02) - EN - EUR-Lex.
[359] European Commission, Press Release, State aid: Commission adopts revised State aid rules on Important Projects of Common European Interest.
[360]European Commission. Approved IPCEIs.

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