ALBERTA INNOVATES

NSERC ALLIANCE – ALBERTA INNOVATES

ADVANCE PROGRAM

2026/27 PROGRAM GUIDE

ABOUT ALBERTA INNOVATES

Innovation is the catalyst for sustainable jobs, economic and community strength, improved health, and environmental benefits. Alberta Innovates leads and accelerates innovation from discovery to use across all sectors in all parts of the province. As Alberta's largest research and innovation agency, we are uniquely positioned to propel great ideas forward to improve the lives of Albertans today and for generations to come.

Alberta Innovates believes the research and innovation (R&I) ecosystem is stronger and more sustainable when it is broadly representative of the overall diversity of our community. We strive to ensure that all interested and qualified parties have an equitable opportunity to participate and contribute to the ecosystem and that our processes are inclusive.

The projects that our programs invest in are critical to how Alberta Innovates achieves positive impact for Albertans in alignment with the Government of Alberta's R&I priorities, as expressed in our corporate Business Plan. (See the most recent Business Plan on our Publications page on our website.) Accordingly, it is essential for project outcomes to align with those of the program.

The Advance Program is managed by Alberta Innovates' Emerging Technology and Talent (ET&T) team. The ET&T team provides funding, enabling, and matchmaking support to emerging technology researchers to increase the volume of commercial outcomes for Alberta's future prosperity. To learn more, visit albertainnovates.ca or see the contact information section below.

PROGRAM OVERVIEW

Alberta's post-secondary institutions produce a steady stream of promising discoveries every year. These discoveries do not always reach the market. The distance between a research finding and a commercial technology isn't only a funding gap — it's a pathway gap: the step-by-step support that helps a researcher recognize an emerging technology's commercialization potential, develop and protect it, and carry it forward. **We encourage every applicant to see the Advance Program as more than a technology research & development grant — it's an invitation to ask, early, whether a discovery could become something to build a company around**, and to start conversations about commercialization and knowledge mobilization before the next paper is published or proposal is due.

The Advance Program helps close the gap between early discovery and commercial technology. Advance grants support Alberta researchers to develop their new discoveries and emerging technology concepts into early-stage technology solutions (TRL 2 to TRL 4), toward an identified high-potential market opportunity. In addition, funds provided connect researchers with commercialization support- knowledge, people and processes- to increase innovation readiness level and enable pathways to market, including new venture creation.

PROGRAM OBJECTIVES

The objectives of the Advance Program are to:

- Support applied research efforts that could lead to the proof of new ideas, the development and advancement of emerging technologies, the transfer and commercialization of such technologies, and the use of these technologies in various industry sectors in Alberta
- Augment the Alberta academic researcher's capacity to accelerate and advance research excellence in Alberta's emerging technology areas
- Develop an enhanced skill and knowledge base (HQP) in emerging technologies for Alberta

PROGRAM KEY OUTCOMES

The key outcomes the program will accomplish for the benefit of Albertans are:

- Increased commercialization-focused emerging technology R&D at Alberta post-secondary institutions
- Development of emerging technologies, advanced products and services toward validated market opportunities, commercialization, and downstream venture creation

- A pipeline of highly qualified talent with the technical, entrepreneurial, and business capabilities needed to drive innovation and commercialization
- Increased researcher & HQP engagement with innovation and commercialization pathways, while expanding awareness of non-academic career opportunities in Alberta.

In alignment with Alberta Innovates Innovation Priority Areas and Alberta's Technology and Innovation Strategy 2.0, and in partnership with NSERC, the program invests in projects that develop and use emerging technologies with the potential to generate economic, environmental, health and social benefits for Albertans.

ALBERTA INNOVATES INNOVATION PRIORITY AREAS

All Advance projects must align with at least one of Alberta Innovates' Innovation Priority Areas:

- Applied Digital and Emerging Technologies
- Health, Agricultural, and Life Science Innovation
- Advanced Materials, Defence and Aerospace
- Natural Resource Recovery

See Appendix A for a full description of each priority area.

FUNDING

The Advance Program offers two funding streams:

- **NSERC-Matched:** A cost-matched funding stream in partnership with NSERC open to eligible researchers at Alberta universities currently holding an NSERC peer-reviewed grant. Alberta Innovates provides up to $100,000 per year, and NSERC matches at a ratio of 50%, up to $50,000 per year for a maximum two-year project.
- **Alberta Innovates Direct:** For eligible researchers at Alberta's publicly-funded post-secondaries whose projects align with the program but do not have an NSERC-matched route available, Alberta Innovates provides up to $100,000 per year for a maximum two-year project.

New: all new Advance awards granted in 2026-27 will include an additional $20,000 in commercialization pathway support. The primary research & development award amount maximum remains the same ($200,000); going forward *an additional* $20,000 for each Advance project will be provided to the institution's innovation unit to fund wrap-around

commercialization support for the project and research team — for example, market validation, IP strategy, and investor-readiness coaching.

Funding parameters by stream.

Funding Item	NSERC-Matched Stream	Alberta Innovates Direct Stream
Maximum request to Alberta Innovates (Alberta Innovates contribution)	Up to $100,000 per year, to a maximum of $200,000 over two years	Up to $100,000 per year, to a maximum of $200,000 over two years
Project duration	Up to two years	Up to two years
Alberta Innovates Commercialization Pathway Support (new)	$20,000 per award, fixed — in addition to the research funding above. Paid to the Applicant's institution innovation unit to fund wrap-around commercialization support for the research team.	$20,000 per award, fixed — in addition to the research funding above. Paid to the Applicant's institution innovation unit to fund wrap-around commercialization support for the research team.
Additional NSERC- Match contribution	will match the Alberta Innovates contribution on Projects NSERC also approves, at a ratio of 50%, up to $50,000 per year, to a maximum of $100,000 over two years	Not applicable — no NSERC match under this pathway
Applicant Contribution	Applicant Cash contribution is not required under this program	Applicant Cash contribution is not required under this program

The funding amount for individual projects is based on the expected outcomes and impact of the proposed project.

Funding is intended to help bridge the gap between academic research and technology validation within Technology Readiness Levels (TRL) 2 to 4.

Eligible technology development can begin as early as the conceptual research stage, starting at TRL 2, and may continue up to testing or validation of ad hoc component integration in a laboratory setting, up to TRL 4. Projects developing technologies at later stages are not eligible for this program.

ELIGIBLE COSTS

Alberta Innovates only funds reasonable costs incurred after an Investment Agreement is signed by Alberta Innovates and the Applicant. Costs incurred before the Investment Agreement is signed, costs greater than market prices, and costs incurred between non-arm's-length entities are ineligible. Please refer to Schedule C in the Investment Agreement posted on the Advance web page for detailed information, including eligible and ineligible expenses.

KEY DATES

2026/27 ALBERTA INNOVATES DIRECT STREAM INTAKE

2026/27 Intake Opens	October 30, 2026
Expression of Interest Closing Date	December 4 2026, at 4:00 pm
Targeted Full Proposal Invitation Date	By January 11, 2027
Full Proposal Closing Date	February 3, 2027
Targeted Agreement Execution Date	By February 28, 2027

ELIGIBILITY

APPLICANT ELIGIBILITY

The Alberta Advance Program is open to:

- Researchers and teams from Alberta post-secondary institutions listed on the Government of Alberta publicly funded institution list. (The "Applicant" is the Institution; the "Applicant Representative" named in the application is the Principal Investigator or other representative leading/developing and submitting the application.
- To be eligible for NSERC-Matching, the Applicant Representative/Primary Applicant on an application must hold an NSERC peer-reviewed grant at an NSERC-eligible Alberta University and meet NSERC eligibility criteria when funding is released.
- Applicant Representatives cannot hold more than one Advance grant simultaneously (excluding NSERC Discovery Grant top-up grants); only one application per Applicant Representative (PI) per intake cycle is permitted.

All Applicants must also:

- Be authorized to undertake the proposed project and execute a grant agreement with Alberta Innovates on our standard terms
- Not otherwise be prohibited from receiving Alberta Innovates funding, for instance, due to past bad debt or otherwise not in good financial standing with Alberta Innovates, InnoTech Alberta and C-FER Technologies
- Have a physical presence in Alberta

PROJECT ELIGIBILITY

To qualify for funding, all Projects must:

- Align with the Advance Program objectives;
- Meet Alberta Innovates' eligibility criteria and, for NSERC-Matching, NSERC's eligibility requirements;
- Align with an Alberta Innovates Innovation Priority Area in Appendix A, and to be eligible for NSERC-matching, align with an emerging technology area in Appendix B
- Be completed within the two-year term;
- Develop technology within Technology Readiness Levels 2 to 4
- Comply with other criteria that Alberta Innovates may develop from time to time.

HOW TO APPLY

The Advance Program application process proceeds in phases. If you have determined your project aligns with program objectives and requirements, proceed to Phase 1.

PHASE 1: CONNECT WITH YOUR INSTITUTION'S INNOVATION / TECHNOLOGY TRANSFER OFFICE

Before applying, researchers are strongly encouraged to reach out to their institution's innovation/technology transfer office to understand how the commercialization process works at their institution — including how intellectual property, industry engagement, and spin-out pathways are typically handled. This conversation helps applicants come into Phase 2 with a clearer sense of their project's commercialization path.

PHASE 2: ENGAGE WITH THE ALBERTA INNOVATES ET&T TEAM

Applicants connect with the Emerging Technology & Talent (ET&T) team to discuss project scope and alignment (optional but strongly recommended).

Applicants should be prepared to discuss the intended project, market opportunity, alignment to Alberta Innovates Innovation Priority Area (Appendix A), and if relevant, emerging technology topic (Appendix B) the project will address.

NOTE: Contact the ET&T team for advice before submitting an application for a project previously submitted / similar to a previous application (re-application).

PHASE 3: EXPRESSION OF INTEREST (EOI) SUBMISSION

Register on SmartSimple, our online application portal. Complete and submit an Expression of Interest (EOI) in SmartSimple.

PHASE 4: FULL PROPOSAL SUBMISSION

Applicants who receive EOI approval are invited to submit a full proposal. Applications are reviewed according to the published intake timelines, subject to available annual budget.

- For NSERC-Matching: include on your Full Proposal application to Alberta Innovates the draft NSERC application (prepare the NSERC application in NSERC's online portal without submitting it, generate a PDF version, and attach it to the Alberta Innovates application form in attachments section in SmartSimple. If the application is approved, Alberta Innovates will sign NSERC's "joint call funding partner" form; the applicant then submits the application to NSERC through the appropriate NSERC online system.

- Alberta Innovates Direct Stream: complete the Alberta Innovates application form in SmartSimple. No NSERC submission is required.

By submitting an application, applicants and co-applicants consent to the sharing of all information, including personal information, between Alberta Innovates and — for NSERC-Matched Stream projects — NSERC, for the purpose of application adjudication and awards.

PHASE 5: AGREEMENT

Successful applicants execute an Investment Agreement with Alberta Innovates to commence project activities. NSERC-Matched Pathway projects also execute a separate agreement with NSERC.

Once agreements are executed, the ET&T team will work with the researcher / team and the associated University innovation team to develop the project's wrap around commercialization support plan.

ALBERTA INNOVATES EVALUATION PROCESS

Alberta Innovates' evaluation process leverages internal and external subject-matter and business expertise to evaluate applications submitted.

Applications are assessed by Alberta Innovates to determine alignment with the Advance Program objectives and intended outcomes. Alberta Innovates evaluates applications submitted to the program based on the following criteria:

- Eligibility criteria, as outlined in this guide;
- future market opportunity,
- project feasibility (technical, plan and team),
- training opportunities,
- impact and benefits to Alberta

Strong emphasis is placed on the future market opportunity and potential impacts of the proposed technology.

At the expression of interest stage of evaluation, applications will be ranked, and a limited number of applications will be selected to go to the next stage of full application submission.

For NSERC-Matched applications: upon receiving a recommendation from Alberta Innovates to proceed to NSERC, and NSERC will review and evaluate the application.

Successful applicants execute an Investment Agreement with Alberta Innovates to commence project activities. For NSERC-Matched grants, NSERC will execute a separate agreement with the applicant.

Alberta Innovates retains the sole right to determine the evaluation process and assessment criteria and does not disclose the names of its reviewers to ensure their objectivity and impartiality. Internal and external parties involved in the evaluation are subject to confidentiality and conflict-of-interest policies set by Alberta Innovates.

PERFORMANCE MEASUREMENT

Alberta Innovates invests in research and innovation activities on behalf of Albertans to help build a prosperous future for the province.

To maximize the impact of these investments, our funding is tied to the achievement of results and outcomes. For this reason, Alberta Innovates funds on a milestone completion basis. This means the Applicant must submit a Progress and/or Final Report and demonstrate sufficient progress before Alberta Innovates advances the next milestone payment.

The Investment Agreement outlines the responsibilities the Applicant has in reporting Project outcomes to Alberta Innovates over the course of the Project and following completion of the Project. Outcomes of the Project may be monitored for up to five years after Project completion, so Alberta Innovates can evaluate the economic, social, health and/or environmental benefits to Alberta resulting from our investments.

Alberta Innovates has a common set of performance metrics it monitors, both at the individual Project level and for the aggregate Program. These metrics may evolve over time.

TERMS AND CONDITIONS

Once we have evaluated and approved an application for funding, Alberta Innovates will require the Applicant to sign our standard-form Investment Agreement. A copy of the Investment Agreement is available on the Alberta Innovates website https://albertainnovates.ca/programs/advance/ for your reference.

The Investment Agreement sets out in detail the roles, responsibilities, and obligations of the various Parties to ensure a successful Project. Alberta Innovates will not provide any funding until the Investment Agreement has been signed by all Parties.

Alberta Innovates will only fund Applicants who have satisfied all eligibility criteria. Meeting the eligibility criteria does not guarantee access to funding, and all funding decisions will be made by Alberta Innovates at its sole discretion.

Alberta Innovates will only correspond in writing and provide copies of the Application to the person named in the Application form as the one authorized to speak for the Applicant.

Should you have any questions about this guide or what is expected, please contact Alberta Innovates (see contact information below). Please note that Alberta Innovates may modify this guide from time to time in keeping with any changes to the program.

CONTACT INFORMATION

EMERGING TECH & TALENT TEAM - ADVANCE PROGRAM

Arash Mollahosseini, MBA, PhD
Business Partner, Emerging Tech & Talent
Arash.Mollahosseini@albertainnovates.ca
587-986-6815

Alaine Jaque, BCom
Business Partner, Emerging Tech & Talent
alaine.jaque@albertainnovates.ca
587-686-7585

NSERC INQUIRIES:

NSERC Advance Program webpage

Irene Mikawoz,
Deputy Director, NSERC Pacific and Prairies
irene.mikawoz@nserc-crsng.gc.ca
204-290-7738, 1-877-767-1767

APPENDIX A: ALBERTA INNOVATES INNOVATION PRIORITY AREAS

APPLIED DIGITAL AND EMERGING TECHNOLOGIES

Harnessing data, artificial intelligence (AI), and cybersecurity to enable smarter industries and a stronger economy.

Alberta's digital future depends on strategic investments in artificial intelligence, quantum computing, and secure data infrastructure. These technologies will power next-generation industries, enable precision medicine and digital health breakthroughs, and transform how businesses and governments make data-driven decisions.

- AI, Quantum Technologies & Cybersecurity: Building Alberta's leadership in advanced computing and secure digital infrastructure.
- Digital Health: Using AI and real-time data analytics to improve health outcomes and healthcare innovation while promoting responsible AI development/adoption.
- Data-Driven Decision Making and Smart Infrastructure: Strengthening Alberta's digital backbone, from smart cities to industrial automation.
- Data Centres: Expanding Alberta's capacity to process and store high-value data for industry applications.

HEALTH, AGRICULTURAL, AND LIFE SCIENCE INNOVATION

Unlocking Alberta's potential in health, biotechnology, life sciences, sustainable agriculture, and bio-industrial solutions.

Innovation in health, agriculture, and environmental science will ensure Alberta's long-term economic diversification and global leadership in biomanufacturing, regenerative medicine, and environmental sustainability.

- Next-Generation Therapeutics: Driving innovation in drug discovery, precision health, medical devices, diagnostics, natural health products, and clinical trials that reach all Albertans.
- Sustainable Agriculture and One Health Approaches: Developing advanced agricultural technologies and integrating human, animal, and environmental health research to tackle emerging diseases and ecosystem challenges.
- Bio-Industrial Technologies for Agriculture and Environment: Developing bioplastics, biofuels, and sustainable biomaterials to reduce environmental impact and support a greener economy.

ADVANCED MATERIALS, DEFENCE AND AEROSPACE

Transforming Alberta's natural resources into high-value materials and cutting-edge aerospace innovations.

By investing in novel materials and aerospace technologies, Alberta can move beyond raw resource extraction and position itself as a leader in advanced manufacturing, automation, and high-technology aviation.

- Novel Materials Development: Advancing carbon fibre, critical minerals, and bioplastics to create high-value industrial applications.
- Aerospace and Aviation Innovation: Supporting next-generation aviation initiatives, drone technology, and space-related research and development (R&D).
- Advanced Manufacturing and Automation: Investing in robotics, additive manufacturing, and AI-driven industrial processes to modernize production.

NATURAL RESOURCE RECOVERY

Maximizing Alberta's resource potential through innovation in extraction, processing, and value-added energy applications.

Alberta's resource economy is a pillar of its prosperity. By investing in advanced recovery methods, critical mineral processing, and next-generation energy solutions, we are ensuring that the province remains a leader in responsible resource development, enhanced efficiency, and new value-added industries. These investments will strengthen Alberta's energy sector while unlocking new opportunities in industrial transformation and global supply chains.

- Advanced Resource Recovery and Processing: Developing cleaner, more efficient methods for extracting and processing Alberta's energy resources, including enhanced bitumen recovery and low-impact extraction techniques.
- Critical Minerals and Alternative Resource Utilization: Expanding Alberta's role in supplying critical minerals for global markets and repurposing natural resources for high-value applications, such as advanced materials and energy storage technologies.
- Next-Generation Energy Solutions: Investing in hydrogen, waste-to-energy, CCUS, and new energy technologies to ensure Alberta's long-term leadership in industrial innovation and global energy markets.

APPENDIX B: EMERGING TECHNOLOGY TOPICS

For NSERC-Matching, projects must additionally align to an emerging technology topic within these areas:

Category	Emerging Technology topic
INFORMATION AND COMMUNICATIONS TECHNOLOGIES	Communications networks and services
	Internet of Things (IoT)/Machine-to-machine systems
	Advanced data management and analytics
	Cybersecurity
	Human interaction with digital media
	Quantum computing
ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGIES	Automation (including robotics)
	Lightweight materials and technologies
	Additive manufacturing
	Nanotechnology
	Quantum materials

The detailed description of the emerging technology topics is presented below.

INFORMATION AND COMMUNICATIONS TECHNOLOGIES (ICT)

The overall objective for proposals in the information and communications technologies (ICT) target area is to empower and protect individuals, organizations and society by leveraging ICT at scale. Indeed, many research challenges in the ICT area are focused on enabling humans to access the benefits latent in systems and data at scale while ensuring privacy and data security. Individuals can be empowered by utilizing data to improve their health, reduce environmental impact, increase personal productivity and enhance social interactions. Private and public organizations can use data analytics to enhance context awareness, leading to better decision-making. Innovative ICT helps societies to create successful economies while minimizing environmental impacts. Information is at the heart of these opportunities; however, information needs to be protected as well as responsibly and securely shared to gain the anticipated societal benefits.

Systems and data at scale require dealing with increasing data volume and velocity, data validity and veracity, and network and system diversity and complexity. Six research topics in ICT have

been identified in support of this common thrust. Transformative research on communication networks and services is required to satisfy future bandwidth, energy and service needs. The Internet of Things (IoT) will allow unprecedented and fine-grained awareness of the surroundings but will require overcoming communications and data-fusion challenges. Advanced data management, artificial intelligence and analysis techniques will allow humans and organizations to make better decisions on crucial social and/or economic issues. Cybersecurity is required to protect the confidentiality, privacy, integrity and availability of data and the systems over which it travels. Rethinking human interactions with digital media will improve the usability and usefulness of access to overwhelming amounts of information. Quantum computing is the next frontier of ICT, enabling improvements in sensor sensitivity and computational power by many orders of magnitude.

A strategic investment in ICT will allow Alberta's researchers to position at the forefront of innovation, leading to economic opportunities for Alberta companies as well as social benefits for Albertans. Research in this target area must specifically address one of the ICT research topics below.

Research topics

-Communications networks and services-

Transformative research on software-defined networks: Future communication networks need to be scalable, flexible, agile, secure, and cost-effective to offer an array of end-to-end communication services and applications that meet the requirements of big data, cloud computing, mobility and IoT.

Software-defined networks will scale by control and adaptive management and will handle changing demand and resources to achieve energy and resource efficiency and sustainability. Orchestration of services built on cloud computing and virtualized resources will support a dynamic applications environment. Architectures and methods will scale by enabling end-to-end connectivity spanning heterogeneous networks, including wired and wireless segments. They will deliver quality of experience and real-time and bandwidth-intensive applications and also tolerate transient disconnection. Wireless networks will scale by exploiting dynamic spectrum to provide higher bandwidth, with reliability and low power, leveraging future radiofrequency and millimetre

wave. Heterogeneous radio networks will interoperate to support services in IoT and 5G networks and to replace existing wired access, as well as new satellite and airborne networks. Wireline networks will be transformed by software-defined network elements (switches, routers, appliances) and virtualized network functions that will leverage scalable photonic and electronic technologies.

-Internet of Things (IoT)/Machine-to-machine systems-

Scaling IoT infrastructure: The next-generation IoT has the potential to change the way people and systems live in a world of massive and disparate data sources, and to provide opportunities for connectivity at different scales. It needs to include advanced communications with a wide range of low-power, low-cost, software-enabled devices. It should accommodate stationary, autonomous and wearable elements, in robust self-reconfiguring arrangements.

Integration, analysis and consumption of sensor data: Next-generation IoT systems need to operate in real or near-real time in a context of extreme data diversity and volumes. Information architectures and standards are needed to enable the reliable fusion of sensor data of disparate types from the full spectrum of data sources. The resulting systems must support the efficient extraction and rendering of relevant information to allow timely decisions and actions by users and systems, while enforcing appropriate requirements for data authentication and verification.

-Advanced data management and analytics-

Management, analytics and information extraction of data at scale: The volume, velocity, variety and veracity of data demand new approaches to the management of that data. New analytical methods, including the ability to predict, optimize and anonymize at scale—in real or near-real time—are required to derive useful information from the data. Information needs to be extracted from a spectrum of data sources, such as numeric, textual, image, audio and video data, as well as social interactions and personal data.

Analytics for decision-making: Data at scale need to be analyzed to enable decision-making by people, applications, machines and systems. This includes interactive visualizations, query systems and other analytics that allow decision participants (human or software) to dialogue with the data and the analytics to arrive at a decision that is accurate and effective.

Artificial intelligence and machine learning: There is a need to develop artificial intelligence/machine learning capacity and develop opportunities to optimize artificial intelligence/machine learning use for application and digital transformation across one or multiple sectors.

-Cybersecurity-

Secure authentication and authorization at scale: New and improved methods to authenticate the identities of people, sensors, processes and systems, and to authorize access to services and information, will mitigate a fundamental weakness exploited by many cyber attacks. Useable, effective and scalable security interfaces and protocols are required. With increasing amounts of data, progress in this area will aid data security and privacy.

Quantitative approaches to cybersecurity: Quantitative approaches to cybersecurity will facilitate the application of data analytics and other metric-based approaches to protecting information and systems. The development of ontologies, behavioural and mathematical models, analytics, metrics, patterns, use cases and datasets will further the understanding, detection and prevention of both existing and new cyber threats—such as those being driven through the emergence of personal informatics, the IoT and quantum computing.

Advanced threat detection and defence systems: Advanced threats that are difficult to detect and defend against include moving and polymorphic targets that change over time, "low and slow" attacks and targeted attacks, which avoid detection by simple alert-based systems, in an ever-increasingly complex network of participants and targets. Advanced threat detection and defence systems will require coordination and correlation across different points in time and data sources and will leverage analytics and other approaches such as polymorphic defence.

-Human interaction with digital media-

Designing effortless interactions: Interactions must become invisible and engaging, as well as transparently indicate data quality. *Invisibility:* Sensors and intelligence that make the interface disappear can address challenges of wear ability, minimization of mental load and actionable feedback. *Engagement*: Gamification, for example, can sustain motivation for challenges such as health, sustainable practices and people-centric security. *Transparency of data quality:* In the face of noisy data, information display should convey data uncertainty at a cognitively acceptable level.

Application examples include novel interaction techniques; interactions for special groups, places and contexts; collection and collation of personal data for personal use; living in information spaces; and augmented reality and virtual environments.

Effective tools for creating and populating physical and virtual objects and spaces: For designers ranging from professionals to hobbyists, software tools are needed to support maker and do-it-yourself cultures, to facilitate seamless transition between physical and virtual worlds and objects, and to leverage interactive modelling and animation. Design tools must support practices including sharing and collaboration, iterative prototyping, and stages of creative inception, refinement and deployment. Individuals and groups require tools for customization of interfaces to specific use cases, demographics, context and individual preferences, with as little training as possible. Individuals need tools to deploy their own approaches to information management. Designers of varying expertise need tools to create virtual and augmented environments, and to build social information spaces.

-Quantum computing-

Exploitation of quantum devices: The challenge involves exploiting quantum engineering for improved performance and efficiency of useful devices. In particular, it includes development of quantum devices and applications that use multiple qubits, entanglement and quantum algorithms for sensors, actuators and communication systems that outperform their classical counterparts. Examples include deploying and improving navigation tools; quantum sensors for chemistry, magnetic fields, electron transport and photon detection; quantum actuators for interconversion of information (spin/charge/photon/phonon); and quantum communication for physics-based information security. The challenge is to develop devices and applications that can be deployed with near-term impact to areas such as medicine, environmental monitoring, materials and chemical characterization, security, improved nanofabrication and metrology.

Special-purpose quantum processors: A quantum computer is the ultimate quantum device and has broad applications, from breaking classical security protocols to machine learning. The challenge is to realize special-purpose quantum computers and in particular to deliver a well-working processor of 100 qubits. Examples include one optimized for running quantum simulations of materials and another for testing the robustness of quantum error correcting methods. These two building blocks are essential to the continued development of yet more

complex and capable quantum processors. In addition to new hardware devices, the challenge includes new algorithms for quantum computing, particularly for small, noisy processors.

ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGIES (AMM)

The overall objective for proposals in the Advanced materials & manufacturing technologies (AMM) target area is to lead to innovations and improvements in both the manufacturing process and the products produced. The overarching research thrust for all proposals must be to expand knowledge of the interactions between the material/part behaviour, machines and the final product performance. Proposals in this area must address these through a combination of science-based modelling and experimentation. This involves the integration of mathematical models of processes, materials, products and machines across manufacturing operations.

Research topics

-Automation (including robotics)-

The goal of research proposed under this topic is to design innovative machines and their efficient utilization to improve quality and productivity in manufacturing, transportation or farms through experimentally proven science-based digital models.

Design: Projects under this research topic should focus on design and digitally model intelligent, modular, reconfigurable and multi-functional machines that are easy to adapt to products. The following areas are specifically targeted: development and modelling of modular kinematic arrangements of the multi-axis machines, robots and material- handling devices; development and integration of novel smart sensors, actuators, robots and devices; multi-body dynamics and vibration modelling of machines; computer control modelling of multi-axis, multi-functional machines; digital modelling of physical interaction between machine structure, computer controller and processes.

Utilization of machines: Projects under this research topic should focus on developing methods and instruments to improve the productivity, accuracy, operation and safety of manufacturing, transportation or farms with the following target areas: integration of smart devices to machines,

robots and assembly systems; human-machine/robot interaction; digital modelling of the manufacturing process physics for predictive process planning; on-line calibration and adaptive adjustment of digital models with sensory feedback; sensor-fused monitoring and adaptive control of processes; on-line and off-line part and machine metrology; energy-efficient and/or environmentally friendly manufacturing, transportation or farm processes; development of methods to improve safety in the manufacturing, transportation or farm environment.

-Lightweight materials and technologies-

Lightweight product design, assembly and use: Projects should focus on the development of innovative materials, material structures, designs and manufacturing methods, including fabrication technologies, that are needed to create lightweight multi-material products and assemblies of equivalent or superior performance in use and for maximum life- cycle energy efficiency. Projects that address component- level product development or system-level approaches will be considered. Specifically, projects are to address optimization for manufacturing (material and machine) built on a framework of integrated computational materials engineering (ICME), linking structure/process/property relationships to accelerate and enhance future product and process design. In the development of lightweight products and assemblies, care should be given to identify potential integration issues and formulate possible mitigation strategies.

-Additive manufacturing-

Projects in this area must integrate innovative solutions from more than one of the described research topics.

Process stability, monitoring and control: This research topic focuses on the development of the next generation of additive manufacturing technologies, integrating in-process monitoring, sensing and close-loop control strategies that allow for simultaneous improvement in manufacturing speed, repeatability and product consistency. Included in this challenge are hardware and algorithms adapted to process dynamics encountered during additive manufacturing processing and the response of the deposited material.

Development of tailored materials for additive manufacturing: This research topic focuses on the improvement and development of new additive manufacturing-specific categories of materials with adapted printability, allowing for new additive manufacturing opportunities,

improved deposition quality/utilization (including recyclability and re-use) and response to post-processing operations. These will lead to superior process sustainability, part quality and performance.

Design for additive manufacturing: This Research Topic focuses on the development of integrated computation and design methodologies linking additive manufacturing process characteristics, part functionality, component and feature geometries, topology and internal structure optimization, and adaptive slicing strategies, to fully capture the novel disruptive potential of additive manufacturing.

-Nanotechnology-

Design and synthesis of nanomaterials: Projects should focus on the understanding of structural/functional properties and self-assembly characteristics that enable the synthesis of functional hierarchical 3D systems. Advantages of the material at the nanoscale and the impact of dimensionality on product properties of interest must be demonstrated. Emerging nanomaterials of interest include hybrid materials such as graphene, quantum dots, metal oxides, polymer-nanocomposites and their assemblies, based on Earth-abundant and Earth-friendly materials. A theoretical understanding, based on science-based modelling, of how these materials can be designed and integrated into manufactured products must be provided.

Scalability of synthesis and deposition/manufacturing processes: Projects in this research topic must focus on novel, efficient and sustainable manufacturing techniques for mass production of nanomaterials. Techniques to realize mass production on scales required for their integration into manufacturing processes or products, using either top-down or bottom-up processes, must be demonstrated. Clean manufacturing techniques, such as those using Earth-abundant and Earth-friendly materials, green solvents or solvent-free techniques, are encouraged. Reproducibility of the production process and engineering scale-up is required to produce high-quality nanomaterials, addressing safety aspects in handling and use. Modelling of the process and key parameters are required to demonstrate scalability.

-Quantum materials-

Scalability and manufacturing of graphene or graphene-like materials: Projects in this area must address the mass production of graphene or graphene-like materials. Graphene, the two-

dimensional atomic crystal, possesses superior physical properties that include extreme mechanical strength, exceptionally high electronic and thermal conductivities and impermeability to any gas. The laboratory process of mechanical exfoliation of graphene is simple and cheap for small graphene sheets; however, a major challenge is to mass-produce graphene sheets (both small and large) with the same outstanding performance as those created in laboratories. Manufacturing of several new two-dimensional materials that have many of the properties of graphene is also important for future applications. These include a single layer of silicon (silicene), germanium (germanene) and black phosphorus (phosphorene) or other similarly structured materials.

Integration of graphene or graphene-like materials into devices: Projects should address the possible applications of small and large graphene (or similar materials) sheets and projects in the area of integration into future devices. For example, the small sheets of these materials could be used in composites, functional coatings, batteries and supercapacitors. Large graphene films could be used in touch panels; low-cost photovoltaic devices; next-generation flexible, wearable electronics and optoelectronics; high-frequency transistors; photodetectors; optical modulators; energy generation and storage; sensors; and bioapplications. The films of silicene and germanene could be directly integrated into the current electronics industry, once the hurdles of manufacturing these materials on a large scale are resolved. A single layer of black phosphorus is promising for novel applications in nanoelectronics and nanophotonics.