DIGITAL TRUST CENTRE (DTC)

RESEARCH GRANT CALL

RULES AND GUIDELINES

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1. Overview

1.1 The Digital Trust Centre (DTC) is a national centre for research in trust technology for spearheading efforts to develop trust technologies and strengthen Singapore's status as a trusted hub in the digital economy. The key objectives of DTC are to advance scientific research capabilities to be at the forefront of trust technology, grow Singapore's trust technology industry, and build a strong core of talent.

1.2 The programme aims to strengthen Singapore's Trust Tech ecosystem and accelerate the research and translation of trust technologies. Hosted at the Nanyang Technological University (NTU), DTC will engage in:

- Coordinating research grant calls in identified trust technologies to address industry problem statements and help industry build a competitive edge through novel IP.
- Developing sandboxes together with industry to experiment with trust technologies and prove value and viability of technology solutions through demonstrators and MVPs.
- Providing research engineering support to co-develop solutions with leading enterprises and high-growth start-ups who have the capability and penchant to adopt early solutions in trust technologies.
- Cementing Singapore as a thought leader in the field of digital trust and governance through international exchanges, allowing Singapore to build mindshare and influence global standards in the digital trust domain.

- Grooming talent and scaling up research capabilities as the key substrate for indigenous capabilities in trust technologies.

1.3 DTC will be launching the DTC Call for Trust Tech Research Excellence ("DTC Research Grant Call") to support the development of trust technologies and innovation that solve real world problems to create a digital world that is safe, transparent and accountable, while generating national benefits for Singapore.

1.4 The DTC Research Grant Call is a competitive research funding initiative that seeks to support research projects that advances the science of trust technologies across Singapore-based Institutes of Higher Learning (IHLs)[1] and Research Institutes (RIs)[2]. We encourage proposals from multidisciplinary teams and consortia of academics, researchers, scientists, engineers, domain experts, and other professionals.

1.5 Please refer to paragraph 6.7 for the timeline of DTC Research Grant Call and deadline for submission of proposals.

2. Scope of Research Grant Call

2.1 In line with goals and directions above, this research grant call will focus on trust technologies. We are particularly interested in research that have great potential to:

- Advance the science of trust technologies, and
- Partner industry to explore and solve systemic real-world problems that once solved, can be scaled for other players in the sector or industry.

2.2 The proposed opportunities and focus areas shall include, but not limited to, the following:

Trusted Analysis

The main focus will be related to the sharing of sensitive data in artificial intelligence and machine learning. The emphasis will be on the trust tech enhanced computation without disclosing the actual raw data and/or the analytic model:

a) **Searchable Symmetric Encryption (SSE):**
   i. Leak user access / search patterns to servers, and
   ii. Insufficient complex query expressiveness for search on encrypted data.

b) **Full Homomorphic Encryption (FHE):**
   Performance issues due to algorithm complexity and large ciphertext sizes which lead to high computational intensiveness and communication overhead and latency.

c) **Private Set Intersection (PSI):**
   i. Performance and scalability issues when the number of parties involved increases, and

[1] Institutes of Higher Learning (IHLs): National University of Singapore (NUS), Nanyang Technological University (NTU), Singapore Management University (SMU), Singapore University of Technology and Design (SUTD), Singapore Institute of Technology (SIT), Singapore University of Social Sciences (SUSS).
[2] Research Institutes (RIs): Such as the Agency for Science, Technology and Research (A*STAR) institutes.

ii. limited expressive queries and functionalities (e.g. lack of support for range, threshold, and conjunctive queries).

d) **Multi-Party Computation (MPC):**
Practicability and scalability issues as protocols are communication and computationally intensive, particularly when dealing with a large number of parties or complex computations.

e) **Differential Privacy (DP):**
How to strike a balance between privacy and utility when applying DP.

f) **Federated Learning (FL):**
How to develop mechanisms for collaborative model selection, model aggregation, and model update strategies in FL minimising impact on training accuracy.

g) **Data Synthesis (DS):**
How to handle complex data types, capture spatio-temporal dependencies, and incorporate privacy-preserving mechanism in data synthesis process.

Trusted Digital ID and Web 3.0

The focus will be on verifiable credentials/documents and transferable records in decentralised environments, track and trace in supply chain, digital identity, and analytics on decentralised finance:

a) **Trusted Digital Identity Network** with emphasis on credentials and verification for digital ID, digital wallet and credential management, and digital ID network reference architecture. Issues include:
   i. What efficient data structures, cryptographic techniques, and distributed systems should be used to support scalable credential creation and verification.
   ii. What secure encryption techniques, access control mechanisms, and secure hardware solutions can safeguard the digital wallet contents, (ii) how techniques such as zero-knowledge proofs, selective disclosure mechanisms, and privacy-preserving authentication protocols can be used for credential governance in digital wallet.
   iii. How to develop ontologies, metadata standards, and semantic mapping techniques that enable identity attributes and credentials to interoperate and be exchanged across multiple Digital ID networks.

b) **Tokenisation** and token standards for digital assets to support security and auditing. Issues include:
   i. How to develop decentralised tokenisation systems that can effectively handle the blacklisting and revocation of tokens without compromising the core principles of decentralisation, immutability, and transparency.
   ii. How to ensure transparent and auditable processes throughout the lifecycle of tokens.

c) **Biometric-assisted authentication** in Web 3.0. Issues include:
How standardisation frameworks, interoperability protocols, and cross-platform libraries should be designed to support seamless integration and consistent performance of biometric authentication methods across diverse Web 3.0 environments.

d) **Trust in Web 3.0 applications** through blockchain traceability and analytics, risk assessments and verification of smart contracts against legal contracts and the use of self-sovereign identity (SSI). Issues include:

i. How to develop formal verification techniques that can handle the features and constructs specific to smart contract languages, including contract invariants, authentication requirements, and access control policies.
ii. How to bridge the semantic gap between legal contract and smart contract by developing methods for interpreting legal texts, identifying contract terms and obligations, and mapping them to the corresponding smart contract logic.

Trusted Compute

The focus will be on how trusted execution environment (TEE) will impact to the design and analysis of trusted applications. Such impacts include the specialised knowledge and understanding of the security features and programming models offered by the given specific TEE platform. Furthermore, data provenance and evidence will be important to enhance the trust in the computation.

a) Design and analysis of system environment for trusted compute based on applications of **TEE**.
   i. How to reduce computational complexity of privacy-enhanced algorithms when executed in resource-constrained TEE.
   ii. How to design and execute cryptographic primitives (e.g. one-way hash function, digital signature) for privacy-preserving algorithms that are specially tailored for TEE.
b) **Verifiable Computing (VC)** for the correctness in distributed, decentralised infrastructure for specific computation tasks, e.g. e-voting tally.
   i. How to develop more efficient and scalable VC protocols that minimise the computational and communication overhead and protect sensitive data during verification process.
   ii. How to develop non-interactive protocols that reduce the asynchronous communication complexity between verifiers and provers from multiple servers.
c) **Digital Evidence:** An important part of digital trust is the ability to establish accountability and liability in case of fraud, transaction failure or abnormal behaviour. To achieve this, digital evidence borrows digital forensic concepts and techniques that are relevant in a holistic approach to digital trust.
   i. How to analyse cross-chain transactions and tracing assets across different blockchains, making use of the interoperability protocols.
   ii. How to identify and link real-world identities to blockchain addresses, enabling more transparent and accountable transactions.

Trusted Accreditation

The focus will be on trusted AI model testing – (i) Research into scientific techniques for testing covering Fairness, Explainability, Robustness, Hallucination, (ii) For various AI / Machine Learning (ML) models, including supervised vs. unsupervised learning, and non-generative vs. non-generative AI, with respect to some of the following challenges.

a) **Hallucination** – Tackle factually inaccurate or fake outputs in Generative AI.
   i. Scientific methods to reduce hallucinations during decoding and pre-empt incorrect associations learned.
   ii. Fine-tuning or distillation strategies to train models to have accuracy of output.
   iii. Technical strategies to detect hallucinations in output and check output with sources of factuality.

iv. Ground truth/ benchmark data and evaluation metrics to objectively assess amount and types of hallucinations.

b) **Fairness** – No unintended bias: AI system makes same decision even if an attribute changes, and data used to train model is representative.
   i. New testing algorithms for fairness in different types of data for binary and multi-class classification and regression models.
   ii. Fairness metrics and break down bias in different applications and use cases.
   iii. Bias mitigation and assessments techniques that handle multi-lingual input and generated output.
   iv. Investigate bias at data processing and learning stage to address any imbalances.
   v. Benchmark data to measure degree of social biases in SG/Asian contexts.

c) **Explainability** – Explain behaviour of AI models and/or multi-modal models to understand how the inner mechanics impact the generated output. Examples of problem include lack of transparency, non-deterministic outputs, high dimensionality, and overfitting.
   i. New techniques to understand local vs. global model structure for binary and multi-class classification and regression models in (i) different types of data, and (ii) multi-modal AI models that correlate results from individual components.
   ii. Research into different architectures (e.g. neural network architecture) that support explainability.
   iii. Attribution methods to identify important training instances used to create better training data to fine-tune AI models.

d) **Robustness** – Address issues relevant to robustness e.g., include non-adversarial robustness and privacy related attacks.
   i. New measures to detect non-adversarial examples on binary and multi-class classification and regression models and in different types of data, and to demonstrate how remediation can be done.
   ii. Robustness metrics to quantify and new methods to improve non-adversarial robustness.
   iii. Building and training foundation models with data protection and privacy enhancing technologies.
   iv. Different benchmark data used for robustness testing.

2.3 The proposed research, problem scope, technical approach, and potential impacts of the proposal shall be defined by the team. Moreover, proposals should clearly state the following:

- Alignment of proposal to DTC's objectives and direction.
- Explaining novelty of research and the needle-moving research challenge that the proposal will solve.
- Explaining potential industry application or impact.
- Justifying benefit of the research to digital trust.
- Explaining relevance of research to Singapore.

3. Funding Support

3.1 Funding quantum available to each selected team is up to **S$2 million and not exceeding three (3) years**, subject to an Interim Review (refer to Section 7: Research Project Performance Assessment).

3.2 The proposal shall be based on a realistic budget with appropriate justifications that correspond to the scope of work to be accomplished.

3.3 The corresponding budget requested **includes** 30% Indirect Research Costs (IRC).

3.4 The total cost of each project includes all approved direct costs[3] and indirect research costs/overheads[4]. All expenditure budgeted should be inclusive of any applicable Goods and Services Taxes (GST) at the prevailing rates.

3.5 For all direct cost items proposed for the project, please refer to Annex C – Guidelines for the Management of DTC Research Grants, including the list of "Non-Fundable Direct Costs" and note the following:

- Host Institutions must strictly comply with their own procurement practices.
- Host Institutions must ensure that all cost items are reasonable and are incurred under formally established, consistently applied policies and prevailing practices of the host institution.
- All items/services/manpower purchased/engaged must be necessary for the R&D work.

3.6 Research Scholarships are not eligible for support under the DTC Research Grant Call.

3.7 Funds awarded cannot be used to support overseas R&D activities. All funding awarded must be used to carry out the research activities in Singapore.

4. Project Deliverables and Outcomes

4.1 Each project is expected to produce most, if not all, the following deliverables:

- Publications in top 10% journals.
- Industry R&D jobs.
- PhDs and Masters trained.
- Technologies deployed, including licences.

[3] Direct costs are defined as the incremental cost required to execute the project. This excludes in-kind contributions, existing equipment and the cost of existing manpower as well as building cost. Supportable direct costs can be classified into expenditure on manpower (EOM), expenditure on equipment (EQP), other operating expenses (OOE) and overseas travel (OT).

[4] Indirect costs are expenses incurred by the research activity in the form of space, support personnel, administrative and facilities expenses, depending on the host institution's prevailing policy. Host institutions will be responsible for administering and managing the support provided by DTC for the indirect costs of research.

4.2 In addition to the above deliverables, each team may state deliverables applicable to the project.

5. Eligibility

5.1 The grant call is open to researchers from all Singapore-based Institutes of Higher Learning (IHLs) and Research Institutes (RIs)[5].

5.2 At the point of application, the Principal Investigator (PI) must hold a full-time[6] appointment in one of the eligible institutions. The PI must be a subject matter expert in the proposed domain, with strong record of publications in the proposed domain's conferences and journals.

5.3 If applicable, Co-PIs must hold a full-time appointment in one of the eligible institutions at the point of application. At least one of the Co-PIs must be a subject matter expert in the proposed domain.

5.4 Researchers from Medical Institutions[7], start-ups in Singapore, private sector and other entities are eligible to apply as Collaborators.

5.5 Company collaboration(s) with in-kind contribution is encouraged, but not compulsory.

5.6 The team must have the right skills and experience to deliver the project and demonstrate sufficient engagement with stakeholders to scope the proposal.

5.7 The overseas collaborators and/or visiting experts may be invited to Singapore on short-term engagements to assist with specific project tasks. In this arrangement, the costs of airfare, accommodation and per diem can be budgeted under the other operating expenses of the project.

5.8 Only research conducted in Singapore may be funded under DTC Research Grant Call. Please refer to Annex B – Terms and Conditions of DTC Grant.

5.9 Lead PI and Co-PIs should note that parallel submissions are not allowed – i.e., applicants must never send similar versions or part(s) of the current proposal application to other agencies or grants for funding (or vice versa). Proposals should not be funded, or currently considered for funding, by other agencies. Details of all grants currently held or being applied for by the Lead PI and Co-PIs in related areas of research must be declared in Annex A - DTC Research Grant Call Proposal Template.

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[5] National University of Singapore (NUS), Nanyang Technological University (NTU), Singapore Management University (SMU), Singapore University of Technology and Design (SUTD), Singapore Institute of Technology (SIT), Singapore University of Social Sciences (SUSS) and A*STAR Research Institutes.

[6] Defined as at least 9 months of service a year based in Singapore or 75% appointment.

[7] Researchers from Medical Institutions in Singapore who hold at least 25% joint appointment in a Singapore-based IHL and/or A*STAR RI may apply as Lead PI or Co-PI. If awarded, the grant will be hosted in the IHL / A*STAR RI.

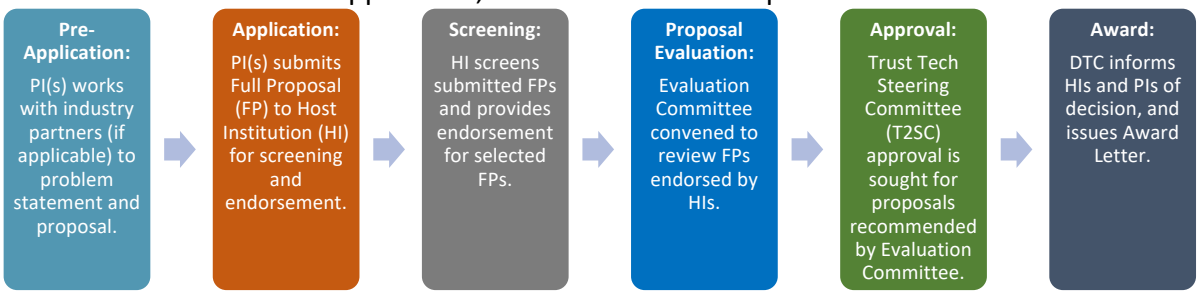
6. Review and Selection

6.1 Full proposals are to be submitted using the Proposal Template for DTC Research Call in Annex A and must also adequately address the pointers stated in therein.

6.2 Full proposals will be reviewed by the Evaluation Committee, based on the quality of the proposals in the key aspects listed in paragraph 2.3 as well as the following:

- Past research accomplishments of the PI, Co-PI and any collaborators
- Project management plan

6.3 An illustration of the application, review and selection process is shown below:



6.4 The review will be carried out by the Trust Tech Technical Committee (T2TC) but based on reviews of the proposals solicited from local and overseas experts.

6.5 Reviewers should not be asked to review proposals from their affiliated institutions.

6.6 The review process is expected to take approximately 12 weeks. **All decisions are final, and no appeals will be entertained.**

6.7 The timeline for this DTC Research Grant Call is shown below:

Event	Date
Opening date for submission (softcopy via email)	30 June 2023
Submission deadline	30 August 2023, 5:00 pm
Evaluation and approval of proposals	August – October 2023
Release of outcome and award	30 November 2023
Project commencement	December 2023 onwards

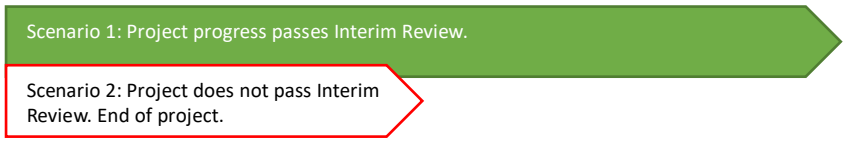
6.8 Please note that respective institutions' internal deadline for full proposal submission may differ. However, all proposals selected and endorsed by the Host Institutions must be submitted in via email to DTC@ntu.edu.sg according to the above timeline.

6.9 DTC reserves the right to reject late or incomplete submission, and submissions that do not comply with application instructions.

7. Research Project Performance Assessment

7.1 The performance and potential of the team's research project will be evaluated during an interim review, which will be carried out by the Evaluation Committee before the end of 18 months. The interim review will be conducted approximately 15 months into the project. Teams will be required to give a presentation for the review. **The project will be assessed primarily based on the progress of promised deliverables and quality of research outcomes**.

7.2 If the team passes the Interim Review, funding support for the team to continue the research project will be made available. DTC reserves the rights to terminate, after Interim Review or at any point in time, a project that does not meet the minimum expectations of progress and achievement, upon recommendation by the Evaluation Committee.



7.3 **The Evaluation Committee may also make recommendations to maximise the outcomes of funded projects** which include, but are not limited to, adjustments to proposed durations, and qualifying only certain components of a project to proceed to completion.

7.4 Teams will be required to give a presentation after the end of term for final assessment.

8. Application

8.1 All applicants must fully comply with Annex A - DTC Research Grant Call Rules and Guidelines, Annex B – Terms and Conditions of DTC Grant and Annex C - Guidelines for the Management of DTC Research Grant, which can be downloaded from www.ntu.edu.sg/dtc.

8.2 Interested applicants should submit the DTC Research Grant Application Form and other supporting documents in PDF (and Word if applicable). All applications must be submitted through the Host Institution via email to DTC@ntu.edu.sg according to the timeline specified in paragraph 6.7.

8.3 Only complete application with the endorsement of the relevant institutional authority / director of research (or equivalent), will be accepted by DTC.

8.4 Late submissions or submissions from individual applicants without the endorsement of the relevant institutional authority / director of research (or equivalent), will not be entertained.

9. Other Guidelines and Information

A. Proposal Content

9.1 The Proposal must adhere to the page limit, prescribed format and address the points as stated in Annex A-Proposal Template for DTC Research Grant Call.

9.2 When applicable, a letter of support from the industry partner(s) is required. Commitment by the industry partner to provide the relevant proprietary datasets, a portion of project costs in cash and in kind will be viewed favourably.

9.3 Research support office from the IHLs and/or Research institutes are required to ensure that information submitted by their researchers is complete and compliant with the requirements outlined in the application guidelines. Failure to do so will result in rejection without review.

B. Intellectual Property

9.4 Intellectual Property ("IP") developed under the grant call ("Research IP") shall be co-owned by the Institutions and Collaborators in accordance with their inventive or creative contributions, where such agreed terms shall be set out in a written agreement between the Institutions. The Investigators and Collaborators shall identify and disclose to the Institutions, details of all such Research IP.

9.5 The Institutions shall keep and maintain a fully comprehensive and updated list of all such Research IP and make such details available to DTC and/or the grantors for inspection at any time.

9.6 The Institutions shall grant DTC a non-exclusive, non-transferable, sub-licensable, perpetual, irrevocable, worldwide, royalty-free right and license to use, modify, reproduce and distribute the Research IP (excluding any Research IP that is solely developed by a Collaborator) for research, development and/or commercial purposes (The "DTC License").

9.7 Except the rights expressly licensed or otherwise provided in this Rules and Guidelines or Annex B – Terms and Conditions of DTC Grant, the Institutions shall in any event retain all rights, title and interest in all Research IP and shall have the free and unfettered right to use and commercialise (which include granting licenses to third parties) the Research IP for any purpose on a non-exclusive basis without seeking the consent of DTC.

9.8 Management of all Research IP shall have reference to and be guided by the NTU IP Policy and key principles of the Singapore National IP Protocol for Publicly Funded R&D. In general, Research IP may be open-sourced for research and experimentation and licensed for commercial deployment.

9.9 The Institutions shall use best efforts to ensure that the Research IP is properly managed and wherever feasible, fully exploited and commercialised (including being made available for research and development or commercial purposes). Where required to do so by DTC, the Institutions shall attend such meetings as DTC may direct to discuss the potential for exploitation and commercialisation of Research IP.

9.10 The Institutions shall reserve a royalty-free, irrevocable, worldwide, perpetual and non-exclusive right for the Singapore Government and public sector agencies to Research IP for their statutory functions, non-commercial and R&D purposes.

C. Ethics and Confidentiality

9.11 All the Investigators, Collaborators, staff, and students working on the project must comply with the relevant local laws or regulations governing the research.

9.12 All teams are responsible for ensuring that ethical issues relating to their respective projects are identified and brought to the attention of the relevant regulatory bodies for approval. Approval to undertake the research must be granted before any work requiring approval begins.

9.13 Ethical issues should be interpreted broadly and may encompass, among other things, relevant codes of practice, the involvement of human participants, tissue or data in research, the use of animals, research that may result in damage to the environment and the use of sensitive economic, social or personal data.

9.14 The work should be conducted under strict international, national, and/or institutional guidelines on privacy and confidentiality protection of personal data use.

9.15 Whenever possible, all datasets used should be de-identified and anonymised, and/or proper consents and approvals should be obtained for the use of the data.

9.16 All the Investigators, Collaborators, staff, and students working on health and biomedical related projects should obtain CITI certification (https://about.citiprogram.org/en/homepage/) on biomedical data use or similar training and certification.

D. Project Support and Facilitation

9.17 DTC is equipped with common research-engineering capabilities to facilitate or support the Trust Tech community. With respect to the grant call, the potential resources that applicants may leverage include:

- Sandbox environment – The sandbox environment that DTC can potentially offer to the applicant is an isolated, trusted virtual/physical machine in which potentially unsafe software code can execute without affecting network resources or local applications. This is mainly for testing specific code development under trusted execution environment (TEE) rather than just for compute power.

- Industry contacts and matchmaking – The skillsets, needs and interests of Trust Tech from industry will be collected and regularly posted on the DTC's website. Interested applicants may search for information and identify potential industry partner(s).
- System engineering and fast prototyping – DTC has a common engineering pool of manpower with skill set related to software and network engineering, web services, privacy-preserving related applications and AI/ML. Potentially, this group of DTC's manpower can help in project prototyping or Proof of Concept (PoC) developments.
- Advice on opportunities for translational efforts – Applicants are welcome to communicate with DTC and ask questions related to the translational efforts of their ideas.

9.18 Requests for resources listed in paragraph 9.17 should be aligned with current research focus of DTC. In their proposals, applicants are expected to quantify their need, if applicable, of such resources from DTC. This will be considered as part of their proposal request. Due to the constraints of limited resources, the applicants will need to justify their requests and DTC reserves the right to turn down the requests.

9.19 Note that some of the resources listed above might not be available immediately. For example, the Sandbox environment is expected to be available in 2024, and the list of industry contacts is expected to be available at the end of 2023.

E. Contact Information

9.20 For any enquiries, please contact DTC@ntu.edu.sg.