Request for Proposals

Posting Date: July 1, 2024
Responses Due: Aug. 16, 2024
Contact: Electronics Research Department (ERD), Toyota Research Institute of North America (TRINA)
Email for Questions & Submission: TRINA.ERD@toyota.com

BACKGROUND:

Toyota recently announced its vision for a future mobility society [1]. The concept of mobility 3.0 is synergy of mobility and infrastructure. As autonomous transportation become more integrated into infrastructure, communication technology is expected to become increasingly important in the societal fabric.

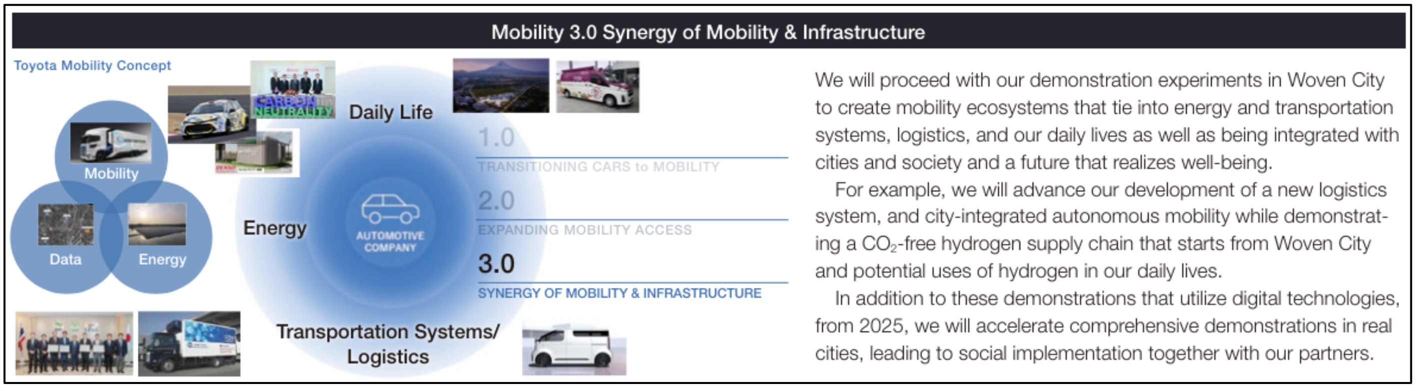

Fig. 1: Toyota's 3.0 Synergy of Mobility and Infrastructure Concept [1]

DESCRIPTION:

This open call seeks hardware-focused, future-looking communication technologies (e.g., beyond 5G/6G) that are intended to be incorporated into future vehicles and/or associated infrastructure. Communication systems used in vehicles can be divided into internal communication sub-systems and methods for external communication outside of the vehicle. Means for external communication are typically directed towards purposes such as safety, collection of driving data, entertainment, and autonomous driving functionality, to name a few. These external communication technologies are expected to evolve in the far future, and the focus of this open call is to conceptualize functional devices for new purposes (Fig. 2, left image, Target 1) as well as for existing purposes (Target 2) in the beyond 5G/6G era. An example of a new purpose is ensuring good communication in poor communication environments, such as between buildings in urban areas.

Communication Network	Network Category / Generation			
Internal Comm. (Wire)	CAN	Ethernet	Optical	Quantum
External Comm. (Wireless)	3G	5G	Beyond 5G/6G	
Purpose: Safety			Target 2	
Purpose: Data Correction			Target 2	
Purpose: Entertainment			Target 2	
Purpose: Autonomous			Target 2	
Purpose: **New Purpose**			Target 1	

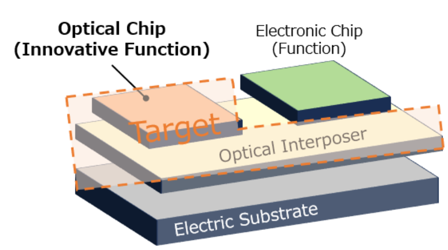

Fig. 2: Table explaining the targets of this project relative to current and future communication networks (left), and conceptual diagram of targeted heterogeneously integrated electro-optical device (right).

More specifically, Toyota is interested in opto-electronic device integration technology, where the speed, efficiency, and new functionality of optical components may be leveraged in a heterogeneously integrated package; refer to Fig. 2, right image. As a representative example, Tasker et al. [2] describe a quantum light detector that comprises grating couplers, waveguides, and beam splitters in combination with photodiodes and detectors to realize an electronic photonic integrated circuit (ePIC). Such ePIC devices are anticipated to be critical in advancing far future quantum communication and computing technologies and are thus considered a key technology for future mobility and infrastructure. While the scale of the device (80 µm x 220 µm) demonstrated in [2] is quite small, proposals are not necessarily limited to devices realized via complimentary metal-oxide semiconductor (CMOS) processes.

As referenced above, Toyota is also interested in quantum network and quantum communication technologies. In relation to Target 1 "new purpose," highly secure communications will be essential in the future and quantum networks have been proposed to meet this challenge. Quantum network associated studies include the work by NICT [3], where they are researching a device that converts the wavelength of photons to one suitable for long-distance communication, as shown in Fig. 3, and the work by the team at Leibniz University Hannover [4] related to realizing a quantum light source on-chip, as shown in Fig. 4. Edge sensors or other devices benefitting from direct connection to specialized networks such as reservoir computing as summarized by Liang *et al.* [5] is also a possible target. The research and development of novel opto-electronic network edge devices, as opposed to quantum cryptography, is of greater interest for submitted proposals.

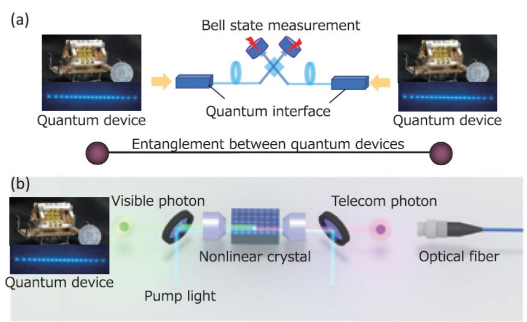

Fig. 3: Proposed quantum device by NICT [3].

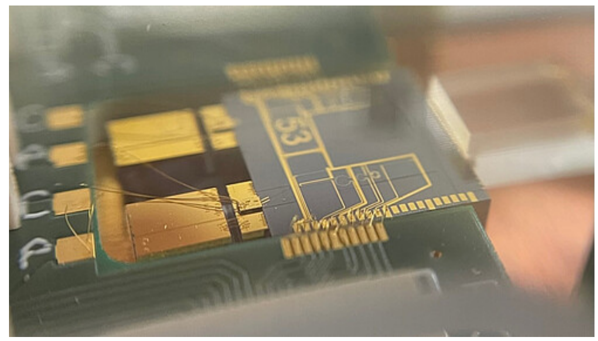

Fig. 4: A quantum light source on-chip [4].

RESOURCES AND OUTPUT PLAN:

This project has three phases including the Initial Concept - Phase 1, Detail Design - Phase 2, and Demonstration - Phase 3. In this open call, we are soliciting proposals to study initial concepts in Phase 1 to be funded at the $40K level. There will be a Go/No-Go decision gate before proceeding to Phases 2 and 3. The total budget for Phases 2 & 3 is $400K for two years, as shown in Fig. 5. Proposals shall be 4-pages maximum in length, not including references and sent by email. Proposals shall include an Executive Summary, Technical Approach, List of Facilities, Detailed Budget, Project Schedule, and References.

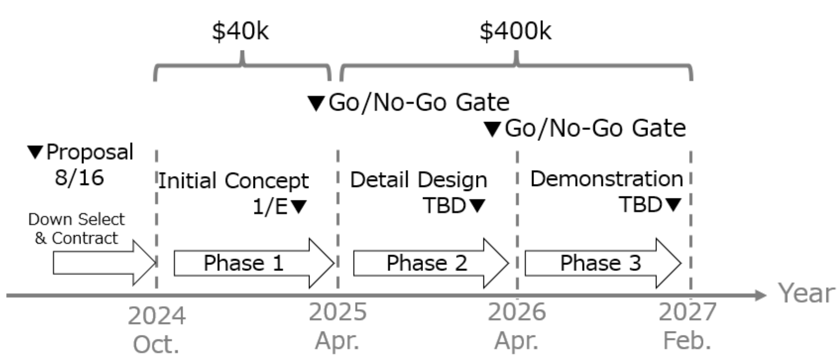

Fig. 5: Approximate multi-year project timeline.

REFERENCES:

[1] https://global.toyota/pages/global_toyota/ir/library/annual/2023_001_integrated_en.pdf

[2] J. F. Tasker, J. Frazer, G. Ferranti, and J. C. F. Matthews, A Bi-CMOS electronic-photonic integrated circuit quantum light detector, Science Advances, Vol. 10, No. 20, (2024).

[3] https://www.nict.go.jp/en/data/nict-news/NICT_NEWS491/book/html5.html#page=1

[4] Quantum light source goes fully on-chip, bringing scalability to the quantum cloud – Leibniz University Hannover (uni-hannover.de)

[5] Liang, X., Tang, J., Zhong, Y. *et al.* Physical reservoir computing with emerging electronics. *Nat Electron* **7**, 193–206 (2024).