THE NEXT FRONTIER IN COMPUTING
QUANTUM OPTICAL COMPUTING

Presentation For Venture Capital Investment

Dr. Brian Antao, CEO and Founder
http://www.tundrasystemsglobal.com
1. The Saturation limits fast approaching conventional Semiconductor Technology – Top Clock Speeds and Shrinking further of device sizes.
2. Need to lay the solid foundation for the *Next Frontier of Computing*.
3. Need to be Power and Energy Efficient.

Develop a solid foundation with which the next frontier of computing products in the HPC sector can be built, in future generations to come we expect to see our technology being pervasive in all aspects of computing.
Current hybrid electric/optical systems are limited by the necessary conversion of photons to electronics, and back.

- This is similar to a bullet hitting a lead wall, which then must convert back again into a bullet to complete a computing operation.

New software and models are needed to enhance scalability and performance for large numbers of applications, such as Big Data, financial analysis and more.

The next challenge is developing high performance systems, low latency, easy scalability with low power consumption.

Because of fundamental limits in electronics, the classical semiconductors technology only provides a limited solution.

“There are serious exascale-class problems that just cannot be solved in any reasonable amount of time with the computers that we have today.” Buddy Bland, project director at the Oak Ridge Leadership Computing Facility in Oak Ridge, Tenn.
Eliminate the limits of Electronics approach, replaced by all-optical modes.
Removes propagation delay of electrons resulting in faster CPU clock speed.
Maximises power efficiency and long distance signal transmission enabling Exascale level data-centers.
A new computational paradigm opens up a vast range of applications and advantages.
Optimizes Quantum parallelism/superposition/entanglement.
A large number of processor-cores greatly enhancing the multitasking capabilities of the systems.
To truly capture and enable the opportunities of optical speed of transmission, we will design the *first* commercial Silicon Photonics Quantum Technology Solution.

We will create a packaged product line of “all-optical” high-performance computing (HPC) - Units using the developed *Quantum Silicon-Photonic Technology*.

In contrast to previous optical computing approaches, we are using the state-of-the-art Quantum Models implemented using Photon Polarised Optical Technology in *Silicon Photonics*, for *Room Temperature* operation.
Mission: To develop the Next Frontier of Computing Solutions in a Silicon Photonics Technology that address the limitations of Semiconductors.

We want to do it and We want to get it absolutely right!
Goal:
Introduce a new Manufacturing *Quantum Photonic Technology* which will be used to implement a complete HPC Computing Solution.
MARKETS

• To Exploit in a very timely manner and be the first in class for the Next Frontier of Computing – Quantum Photonics/Optics.

• A very Long term strategic plan to develop as the ultimate end product line of “All-Optical” High-Performance Computing Units that are tailored to the following Market Segments:

- Financial Stock Markets
- Algorithmic Trading Analysis
- Big-Data Analytics
- Medical/Pharma Drug Discovery Analysis & Modelling
- High-end Graphics 3D Motion picture production Data visualisation.
- HPC applications in the Defence Sector
- CyberSecurity applications Cryptography CryptAnalysis
THE BUSINESS MODEL

- Service High-End Market Segments that have the greatest pain in terms of Computational Requirements.
- Use a Direct Go-To-Market Strategy to engage Customers in these Segments.
- Maximise revenue by Maximising Pricing strategies to critical customers.
- Create a Product requirement that these Market Segments cannot do without.
- HPC Units that we develop will be targeted to compose solutions that address low-end High-Compute requirements to top-end Exascale Super-Computer Configurations.
PRODUCT STACK

- Quantum Processing Unit
- QISA and Cross-Compiler
- HPC Units
- Quantum Error Correction
- Quantum Technology Library
• Generalized Hardware-Software Quantum Error Correction Solution
• Finds application in Quantum Computing and Communications
• Includes a Deep-Learning Silicon-Photonics Co-processor.
THE QUANTUM PHOTONIC TECHNOLOGY

• Implement over Silicon Photonics Base
• All-optical ultrafast switches and Qubits.
• Quantum Memory Cells using Phase Change Materials and Rare Earths
• Quantum Gates.
• Quantum Interconnect.
• Using a Fabless Model, Technology implemented at Manufacturing Partners such as LioniX, Mellanox.
• Silicon Photonics Qubits
• Striving for a 64-Qubit Processor
• Employs Deep-Learning based Quantum Error Correction
• Room-Temperature Operation
QISA AND CROSS-COMPILE (SOFTWARE)
The worldwide high-performance computing (HPC) market is expected to grow at an 8.3% CAGR, reaching $44 billion in 2020.

The global HPC market will generate $220 billion in revenues from 2015-2020.

The Quantum Computing Market is expected to grow at a 10.4% CAGR, reaching $26 billion in 2020
Cyber Security Market worth $170.21 Billion by 2020

We expect to capture a significant portion of these markets.
Our main competitor in the Quantum Photonics space is **PSiQuantum**.

The number of specialised Optical Computing endeavours are scant. To name one -- **Optalysys** is a University of Cambridge based effort at Optical Computing, that is developing a very specialised non-linear equation solution strategy using Fourier transforms.

**D-Wave/Rigetti/IBM/Google** are a major development in Quantum Processors but use superconducting Josephson junctions based Qubits that need *deep super-cooling*.

**Microsoft** solution using Topological Qubits.

Implementations using ion traps at **ionQ**.

As of Today we are yet to see a full scale Commercial Universal Quantum Computing Solution.
## COMPETITOR ANALYSIS: TECHNOLOGY COMPARISON

<table>
<thead>
<tr>
<th>TundraSystems Technology</th>
<th>D-Wave/Rigetti Technology</th>
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</thead>
<tbody>
<tr>
<td>Develop a Photonic Microprocessor</td>
<td>Build a SuperComputer</td>
</tr>
<tr>
<td>All-Optical Technology</td>
<td>Superconducting Technology</td>
</tr>
<tr>
<td>Silicon Photonic Qubits</td>
<td>Superconductor Qubits</td>
</tr>
<tr>
<td>More Energy Efficient as All-Optical</td>
<td>High-Power Consuming SuperComputer</td>
</tr>
<tr>
<td>Configurable HPC Systems</td>
<td>$20 Mil. SuperComputer</td>
</tr>
<tr>
<td>Strive for Room-Temp. Operation</td>
<td>Requires Deep Super-Cooling</td>
</tr>
</tbody>
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EXHIBIT 1 | Companies Assume Four Roles Across Layers of the Stack in the Quantum Computing Ecosystem

**COMPETITOR LANDSCAPE**

**End-to-end providers**
- IBM
- Google

**Hardware & systems players**
- Rigetti Computing
- Microsoft
- Alibaba Group
- D-Wave Systems
- Emerging: Honeywell, Xanadu, Qilimanjaro
- IonQ
- Qutech
- Intel
- BraneCell

**Software & services players**
- Zapata Computing
- Cambridge Quantum Computing
- QCCware
- 1Qbit
- Riverlane
- Qiskit
- Quantum Circuits

**Specialists**
- Tellius Matrix Group
- Quantik
- Entanglement Partners
- h-bar Quantum Consultants
- Quantum Benchmark
- Strangeworks
- QCTRL
- QInfer
- ProteinQure
- QbitLogic
- SeeQC
- Silicon Quantum Computing
- PsiQ
- Alpine Quantum Technologies

**Sources:** Quantum Computing Report (quantumcomputingreport.com); BCG analysis.
1 Based on players’ ambitions with varying levels of maturity and service activities.
2 Multiple technologies in the labs with focus on topological qubits.
3 Qilimanjaro is a spinoff from the University of Barcelona.
4 AWS is invested in IonQ.
5 Qutech was founded by TU Delft and TNO, and has collaborations with Intel and Microsoft.
6 Quantum Circuits (QCC) is a spinoff from Yale University.
7 SeeQC is a subsidiary of Hysper.
8 Tundra to become end-to-end provider.
9 Alpine Quantum Technologies (AQI) is a spinoff from University of Innsbruck.
### Quantum Technology Landscape

**Exhibit 7 | Overview of Leading Quantum Computing Technologies During the NISQ Era**

<table>
<thead>
<tr>
<th>Leading technologies in NISQ era*</th>
<th>Candidate technologies beyond NISQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Qubit type or technology</strong></td>
<td><strong>Silicon-based</strong></td>
</tr>
<tr>
<td><strong>Description of qubit encoding</strong></td>
<td><strong>Topological</strong></td>
</tr>
<tr>
<td>Physical qubits**</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Photonic</strong></td>
</tr>
<tr>
<td>Qubit lifetime</td>
<td><strong>Silicon-based</strong></td>
</tr>
<tr>
<td>~50–100 µs</td>
<td>Topological</td>
</tr>
<tr>
<td>Gate fidelity**</td>
<td></td>
</tr>
<tr>
<td>~98.4%</td>
<td>Topological</td>
</tr>
<tr>
<td>Gate operation time</td>
<td>~1–10 ms</td>
</tr>
<tr>
<td>~10–50 ns</td>
<td>Topological</td>
</tr>
<tr>
<td>Connectivity</td>
<td>~10–10 ns</td>
</tr>
<tr>
<td>Near neighbors</td>
<td>Topological</td>
</tr>
<tr>
<td>Scalability</td>
<td>~10–10 ns</td>
</tr>
<tr>
<td>Maturity or technology readiness</td>
<td>~10–10 ns</td>
</tr>
<tr>
<td>Key properties</td>
<td>~10–10 ns</td>
</tr>
</tbody>
</table>

**Sources:** BCD analysis; expert interviews.

*Not all Intermediate-Scale Quantum devices are.
*Currently only technology with external closed access; several forms (charge, flux, phase) of qubits exist but must pursue a less noise-sensitive charge-based qubit (transmon).
*Additional approaches include Si and 3D0 quantum chips.
*Demonstrated ability to perform single and two-qubit gates.
*Demonstrations of next-generation qubit architecture: Intel 49, IBM 50, Google 72, Rigetti 137 (all superconducting qubits), IonQ 50 (trapped ions, Helix University); 60 photons.
*Alpine Quantum Technologies.
*Two-qubit fidelity.
*Microwave roadmap to build first quantum computer in 2023.
*E. Youthful qubits were encoded with six photons using three degrees of freedom.
*Technology readiness level.

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**TUNDRA SYSTEMS GLOBAL LTD.**
1. Our Technology Solutions are matured and entering into TRL-3
2. Development of Ultrafast High Precision and High Fidelity Quantum Devices
5. Partners include:
   a. University of Exeter
   b. Imperial College
   c. Cardiff University
   d. Mellanox Technologies
6. We seek funding to drive our Industrial R&D Capability to advance to TRL-8 and Full Commercialization
TARGET MILESTONES

Currently seek Seed Round of Funding.

Seed Stage 1 – First 12 months Estimated Seed Funding Required £1.6 Millions
  Implement a. High Precision Devices b. QISA and Cross-Compiler.

Stage II – Second and Third year Estimated Funding Required £10.0 Millions
  Develop demonstrable Core TundraProcessor (Microprocessor)

Stage III – Forth year Estimated Funding Required £15.0 Millions
  Start Subsystem Development + Complete Production grade TundraProcessor

Stage IV – Fifth and Sixth year Estimated Funding Required £25.0 Millions
  Complete System Integration of packaged HPC Solutions
FINANCIAL PROJECTIONS

Year 3 Revenue stream begins with marketing of Cross-Compiler

Financial Overview

- Sales
- Net Profit
- Expenses

Year 3

Year 4

Year 5

Year 6
First Seed Round -- £1,600,000/- to fund the first 12 Months of development.

Equity on offer 15% Stake (Negotiable !).

Expense Items:
1. Computer Infrastructure £250,000.00
2. Office Space + Furbishing £100,000.00
3. Management and Technology Team Wages £750,000.00
4. Photonic CAD Software licenses £150,000.00
5. Additional Support Staff Wage Bill £100,000.00
6. Manufacturing Costs £150,000.00
7. Miscellaneous Expenses £100,000.00

Total for the first one year’s of operations £1,600,000.00
Why Should you invest in TundraSystems Global LTD:

• Help in advancing the next frontier of computing for humanity’s benefit.
• A strong Business Case for a Quantum Optical Computing Solution.
• Wide application market segments including CyberSecurity.
• Strong technology team derived from the top global research universities.
• Prospects for a very good Return on Investment.
Our Technical Advisory Board is composed of Experts as follows:

- Professor Xinliang Zhang of Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, China.
- Professor Diana Huffaker, from Cardiff University a specialist in Photonics devices.
- Professor Anna Baldycheva, is a Silicon Photonics and Graphene Expert from University of Exeter, UK.
- Dr. Tsjerk Hoekstra of EFFECT Photonics, Netherlands.
THE TEAM

1. Dr. Mukund Buddhikot – Technical Director of Hardware Design
2. Dr. Steven R. Hutsell – Chief Processor Architect
3. Prof. Anna Baldycheva – Interim Director of Silicon Photonics
4. Dr. Patricia Charlton – Director of Artificial Intelligence
5. Ms. Margaret Morgan – Agile Methodologies Specialist and Coach
6. TBA – Operations Manager
7. Dr. Alessandro Alabastri – Member of Technical Staff/Design Team
8. Dr. Devin S. Vega – Member of Technical Staff/Design Team
9. Dr. Chris Morrison – Member of Technical Staff/Design Team
10. Dr. Liang Ye – Member of Technical Staff/Design Team
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Thank you and we look forward to working with you!

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