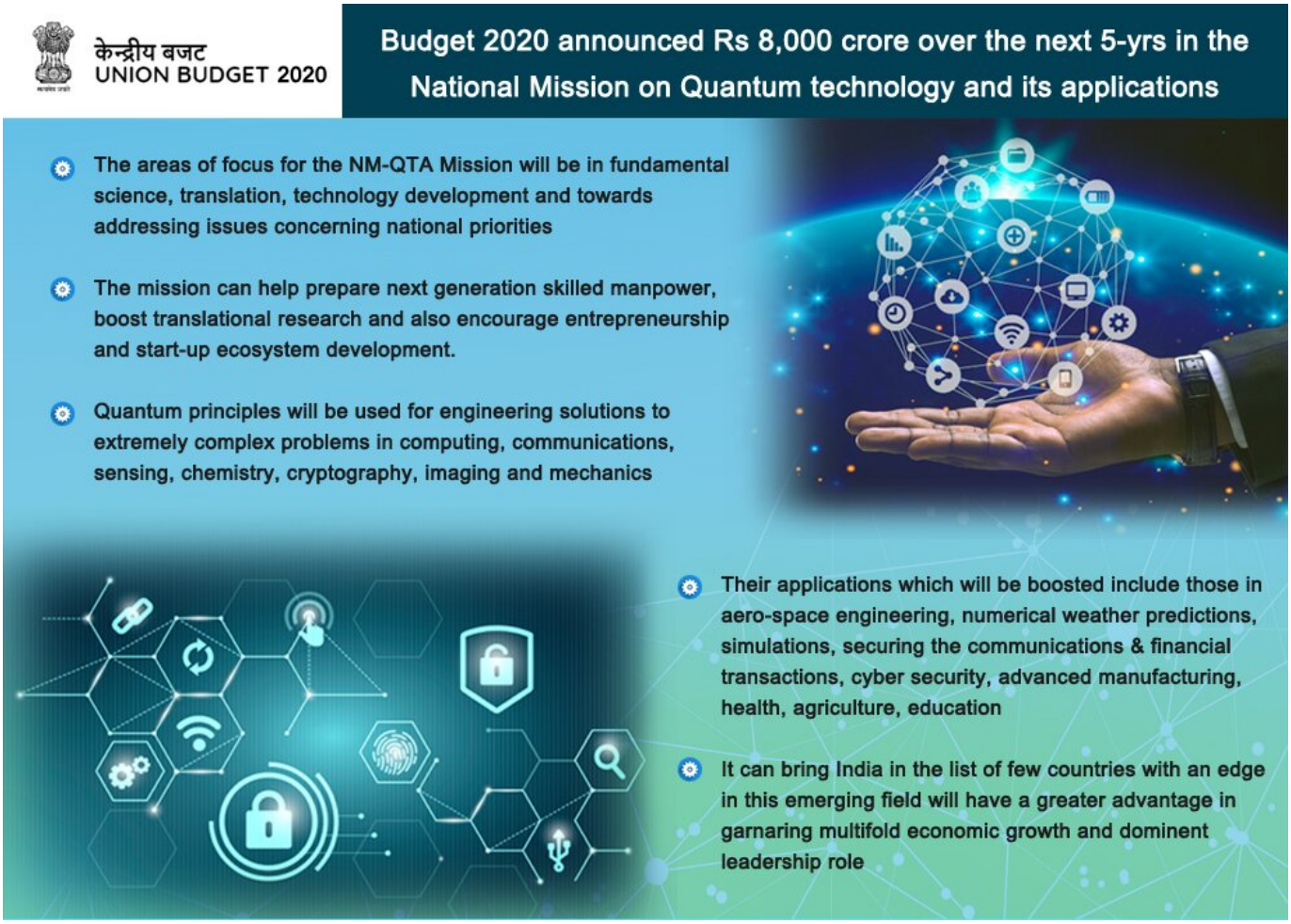
Quantum Technology

This article is based on "Picking up the quantum technology baton" which was published in The Hindu on 23/03/2020. It talks about opportunities and challenges associated with **Quantum technology.**

Union Budget 2020-21 proposed to spend ₹8,000 crore ($ 1.2 billion) on the newly launched **National Mission on Quantum Technologies and Applications (NMQTA).** The mission seeks to develop quantum computing linked technologies amidst the second quantum revolution and make India the world's third biggest nation in the sector after the US and China.

Quantum Technologies not just have ultra fast computing capabilities, but it also has strategic and economic advantages.



What is Quantum Computing?

- Quantum Technology is based on the principles of Quantum mechanics, that was developed in the early 20th century to describe nature in the small — at the scale of atoms and elementary particles.
- The first phase of this revolutionary technology has provided the foundations of our understanding of the physical world, including the interaction of light and matter, and led to ubiquitous inventions such as lasers and semiconductor transistors.
- However, despite a century of research, the quantum world still remains mysterious and far removed from our experiences based on everyday life.
- Thereby, a second revolution is currently underway with the goal of putting properties of quantum mechanics in the realms of computing.
- Conventional computers process information in **'bits' or 1s and 0s,** following classical physics under which our computers **can process a '1' or a '0' at a time.**
- Quantum computers compute in **'qubits' (or quantum bits).** They exploit the properties of quantum mechanics, the science that governs how matter behaves on the atomic scale.
    - In this scheme of things, processors **can be a 1 and a 0 simultaneously,** a state called **quantum superposition.**
    - Because of quantum superposition, a quantum computer — if it works to plan — can **mimic several classical computers working in parallel.**

- However, the actual realization of this path breaking technology remains one of the great challenges faced in the fields of Quantum Computing. Though, the announcement by Google, in October 2019, where they claimed to have demonstrated the so-called **"quantum supremacy"**, is one of the first steps towards realization of this goal.

Applications of Quantum Technology

Besides computing, exploring the quantum world promises other dramatic applications. For example:

- **Secure Communication:** China recently demonstrated secure quantum communication links between terrestrial stations and satellites.
  This area is significant to satellites, military and cyber security among others as it promises unimaginably fast computing and safe, unhackable satellite communication to its users.
- **Research:** It can help in solving some of the fundamental questions in physics related to gravity, black hole etc.
  Similarly, the quantum initiative could give a big boost to the Genome India project, a collaborative effort of 20 institutions to enable new efficiencies in life sciences, agriculture and medicine.
- **Disaster Management:** Tsunamis, drought, earthquakes and floods may become more predictable with quantum applications.
  The collection of data regarding climate change can be streamlined in a better way through quantum technology. This in turn will have a profound impact on agriculture, food technology chains and the limiting of farmland wastage.
- **Pharmaceutical:** India's interest in the pharmaceutical and healthcare industry is huge.
  - Quantum computing could reduce the time frame of the discovery of new molecules and related processes to a few days from the present 10-year slog that scientists put in.
  - For instance, tracking protein behaviour or even modelling new proteins with the help of quantum computers could be made easier and faster.
  - Tackling chronic diseases like cancer, Alzheimer's and heart ailments is a big possibility of the technology.
- **Augmenting Industrial revolution 4.0:** Quantum computing is an integral part of Industrial revolution 4.0.
  Success in it will help in Strategic initiatives aimed at leveraging other Industrial revolution 4.0 technologies like the Internet-of-Things, machine learning, robotics, and artificial intelligence across sectors will further help in laying the foundation of the Knowledge economy.

Associated Challenges

- The challenge lies in harnessing the properties of quantum superposition in a highly controlled manner. The qubits tend to be very fragile and lose their "quantumness" if not controlled properly. Also, a careful choice of materials, design and engineering is required to get them to work.
- On the theoretical front lies the challenge of creating the algorithms and applications for quantum computers.
- These projects will also place new demands on classical control hardware as well as software platforms.

- Further, Information technology-based security infrastructure would never be the same once quantum systems become a reality, given the ultra fast speed of computing power.
- Warfare and conflict strategists will have new challenges to face.
    In such scenarios India's current plans may have to be reworked to develop integrated war-theatre strategies factoring in quantum technologies.

India's Effort

- Globally, research in this area is about two decades old, but in India, serious experimental work has been under way for only about five years.
- In 2018, the government initiated serious discussions in quantum technologies and kick started research projects across 51 organisations under **QUEST – Quantum Enabled Science and Technology.** However, no significant progress is made in this field until NMQTA.

Way Forward

With NMQTA announcement, the government seeks to provide investment on a massive scale and on a par with similar programmes announced recently by the United States and Europe. However, there is an urgent need to address challenges associated with Quantum technology.Pursuing these challenges will require:

- An unprecedented collaboration between physicists (both experimentalists and theorists), computer scientists, material scientists and engineers.
- Government needs to partner institutions and the scientific community to work out details of the mission and roll it out quickly.
- Private funding, both via industry and philanthropy, can play an outsized role even with much smaller amounts.
    - For example, unrestricted funds that can be used to attract and retain high quality manpower and to build international networks — all at short notice — can and will make an enormous difference to the success of this enterprise.
    - This is one of the most effective ways (as China and Singapore discovered) to catch up scientifically with the international community, while quickly creating a vibrant intellectual environment to help attract top researchers.

Drishti Mains Question

India needs to harvest quantum technology for strategic and economic development. Discuss.