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# Optical Quantum Ground Station for QEYSSat: Operations Planning Activities

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## Abstract

The Quantum EncrYption and Science Satellite (QEYSSat) mission is designed to demonstrate quantum key distribution (QKD) across extensive distances (i.e. > 400km) between ground and space. The mission includes a microsatellite with a QKD payload. The satellite serves as a QKD receiver, and it is currently in its manufacturing and testing phase. It is expected to be launched late in 2026. The mission also includes an Optical Quantum Ground Station (OQGS) with quantum sources, dome, and a telescope on a tracking mount. The OQGS serves as a QKD transmitter. This paper presents the planning activities required to establish and operate the OQGS. An initial overview of the OQGS is presented, highlighting the selection of a Commercial Off-The-Shelf (COTS) telescope, tracking mount, dome, and Weather and Atmospheric Characterization Equipment (WACE), as well as custom build quantum sources. The paper describes basic planning activities including experiment design and scheduling concept, hardware testing, and development of operation concepts to validate the performance and reliability of the OQGS.

**Keywords:** Quantum communication, quantum key distribution, photon entanglement, quantum security.

## Acronyms/Abbreviations

| | |
|---|---|
| ASCOM | Astronomy Common Object Model |
| ATS | Acquisition and Tracking Subsystem |
| CDK | Corrected Dall-Kirkham |
| COTS | Commercial Off-The-Shelf |
| CSA | Canadian Space Agency |
| EPS | Entangled Photon Source |
| FSOC | Free-Space Optical Communication |
| GPS | Global Positioning System |
| IQC | Institute for Quantum Computing |
| LEO | Low Earth Orbit |
| OQGS | Optical Quantum Ground Station |
| PI | Principal Investigator |
| PPE | Personal Protective Equipment |
| QEYSSat | Quantum Encryption and Science Satellite |
| QKD | Quantum Key Distribution |
| RF | Radio Frequency |
| SOCRATES | Space Optical Communications Research Advanced Technology Satellite |
| SOP | Standard Operating Procedure |
| ST | Science Team |
| TLE | Two-Line Element |
| UPS | Uninterruptible Power Supply |
| URD | User Requirement Document |
| WCPS | Weak Coherent Pulse Source |
| WACE | Weather and Atmospheric Characterization Equipment |

## 1. Introduction

Quantum Key Distribution (QKD) offers a form of communication built on the principles of quantum mechanics [1]. QKD enables the generation of a shared secret key, ensuring that any attempt to intercept the communication would disrupt the quantum states, thus alerting the parties involved. This inherent feature makes QKD exceptionally secure. The commercial application of this technology is emerging. Current ground based QKD systems, limited to distances of a few hundred kilometers due to optical losses in the fibers, could be expanded with the use of terrestrial trusted nodes and satellite based QKD [2].

Unlike ground-based QKD, free-space QKD enables two-way secure communication through optical links over longer distances, overcoming the limitations of fiber optic infrastructure and eliminating the need for traditional physical cables. This technology supports applications such as ground-to-ground, ground-to-satellite, satellite-to-satellite or airborne-to-ground communication.-For example, Japan first evaluated satellite-to-ground single photon transmission for quantum-communication in its SOCRATES mission, aimed at testing quantum communication technologies in space [3]. China has made significant breakthroughs with its Micius mission, which demonstrated QKD between space and ground stations, and the Jinan-1 mission, which further advanced QKD technologies [4, 5]. Germany has contributed the QUBE mission, which includes a number of CubeSats to demonstrate quantum communication capabilities [6]. Singapore has launched the SpooQy-1 satellite and demonstrated the generation and detection of polarization entangled photon-pairs in space [7]. These efforts highlight the global push toward developing secure, satellite-based QKD systems that could revolutionize cybersecurity on a global scale and advance long-distance communications beyond the capabilities of ground-based systems.

The Quantum EncrYption and Science Satellite (QEYSSat) mission aims to leverage Quantum Key Distribution (QKD) for secure communication between ground and space [8-15]. As a new QKD demonstrator it represents a Canadian milestone in the development of a protected data exchange link through a free-space optical channel. The mission includes a microsatellite with a Quantum Key Distribution (QKD) payload in Low Earth Orbit (LEO), primary Optical Quantum Ground Station (OQGS), and one or more secondary Quantum Ground Stations (QGS) hosted by science partners and collaborators. Mission objectives are focused on performing QKD and quantum link experiments and establishing secure quantum communications across extensive distances (i.e. > 400km). The project aims to create and showcase the ability to establish highly secure encryption keys with the satellite as well as between the OQGS and collaborative QGSs using quantum links. Currently, the QEYSSat mission, including the satellite and the OQGS, is in its final construction phase (Phase D). As per current plan the OQGS deployment is planned to be complete in late 2025 and the satellite is going to be launched by the end of 2026.

Unlike conventional communication systems, QKD relies on the transfer of quantum states, which requires specialized ground infrastructure. The ground stations enable this exchange by utilizing quantum sources, optical telescopes, photon detectors and control systems. Several organizations play key roles by contributing their expertise and resources to ensure the success of the quantum communication project. Among those are the Institute for Quantum Computing (IQC), Honeywell Aerospace and the Canadian Space Agency (CSA). IQC, based at the University of Waterloo, is one of the leaders in quantum research in Canada. It serves as a Science Operation Centre (SOC) for the mission and provides scientific and technical expertise, particularly in the areas of quantum sources, quantum communication and QKD. Honeywell Aerospace is the prime contractor for the QEYSSat mission. In this role, it is responsible for the development and delivery of the QEYSSat satellite and the OQGS, satellite launch and commissioning. The CSA oversees the development and deployment of the QEYSSat satellite and the OQGS and ensures that the mission aligns with Canada's space policy and scientific goals. It hosts a Mission Operation Centre (MOC) and manages satellite operations in orbit, including its interactions with ground stations. It also collaborates with interested partners to ensure mission integration into the broader quantum communication infrastructure.

Effective operations planning is crucial to ensure the success of the ground-based infrastructure and the entire QEYSSat mission. This paper describes various OQGS operations planning activities to support the mission, including pre-launch OQGS preparation, SOC and MOC responsibilities, hardware and software components, scheduling, and maintenance aspects.

## 2. Ground Segment Operational Entities and Concept of Operation

### *2.1 Science Operation Center (SOC)*

The SOC is the designated authority for designing and managing scientific experiments for QKD demonstration. The mission Principal Investigator (PI) and the Science Team (ST) at IQC serve as a SOC core. The SOC is equipped with an infrastructure including several key components: a workstation computer for data acquisition, analysis, and mission operations planning, a dedicated storage unit for archiving and storing experimental data, and communication and networking systems for seamless interfacing with the MOC and partners.

The SOC oversees the planning and operation of both the payload and quantum ground segment, as well as performs detailed characterization of the payload system and its components. The infrastructure is essential for generating and validating command sequences for the payload after commissioning. These validated commands are originated at SOC transmitted to the MOC, followed by the reception, processing, and analysis of science data and engineering telemetry from the satellite.

Before the satellite and OQGS are tasked for specific experiment, the experimental concept undergoes SOC approval, scheduling, and validation processes. The SOC ST develops a preliminary experiment schedule that outlines the experiments to be conducted, ensuring they collectively meet the mission requirements and objectives as per the User Requirement Document (URD). The SOC standardizes routine satellite and OQGS operation procedures and is responsible for data processing and sharing. The SOC has direct access to and control of the OQGS by means of a ground network communication channel (e.g. by means of a remote connection with no data transfer ability).

### *2.2 Mission Operation Center (MOC)*

The MOC oversees the spacecraft tasking and planning, monitoring spacecraft health and addressing anomalies, tracking the orbit, and supporting payload tasking and operations. It is also responsible for the validation of the payload schedule and distribution of telemetry and quantum data from the satellite to the SOC and OQGS via a radio frequency (RF) communication channel. The MOC is located at the CSA's headquarters in Longueuil, Quebec and operates a set of RF ground stations across Canada. The MOC also have an agreement with international partners worldwide to access their ground stations for the mission. The data from the satellite received via RF are then distributed to the MOC, SOC and OQGS via ground network communication channel (e.g. by means of Secure File Transfer Protocol).

### *2.3 Optical Quantum Ground Station (OQGS)*

The OQGS plays a critical role in the QEYSSat mission, enabling the secure transmission of optical quantum states (photons) from the ground to the satellite via free-space optical communication channel. As per the mission scope construction of the OQGS is currently underway. The OQGS is co-located with the MOC. The OQGS consists of two major parts.

The first part is a control room with the laser sources, control system as well as data storages. The QEYSSat mission objective is to demonstrate an uplink QKD. For this purpose, the control room hosts two types of quantum laser sources, a Weak Coherent Pulse Source (WCPS) and an Entangled Photon Source (EPS). The WCPS generates single photon sequences from initially weak pulses of light at 785 nm containing a very low average number of photons. These single-photon-level optical pulses are used to establish the quantum bits (qubits) of the cryptographic key. Each pulse is modulated with information using random polarization states (BB84 protocol), which represent the 0s and 1s in the key as well as intensity (decoy) states, used to detect photon-number splitting attacks by an eavesdropper in the communication channel. The EPS generates pairs of entangled photons (790.8 nm), meaning the quantum properties of each photon are linked, such that a measurement on one photon determines the properties of the other. The WCPS is primarily used for QKD demonstration, and the EPS is critical to test long-range entanglement (BBM92 protocol) and conduct the Bell test experiments. Both the WCPS and ECP are designed and built by IQC.

The second part is a dome hosting a telescope on a tracking mount as well as auxiliary hardware. The dome is a commercial robotic clamshell observatory. The dome is placed on a concrete pad at a distance to avoid being blocked by the buildings. It is a fully automatic system designed to provide an unrestricted full hemisphere field of view for the telescope when open. The selected clamshell design features two moving shutters. Both shutters can be opened independently, providing flexibility in dome operation, and allowing for optimal wind and sun shading of the equipment placed inside the dome. The dome is equipped with a weather sensor. The sensor offers continuous readings of temperature, humidity, dew point and wind. It warns when winds speeds are too high for safe operation of the observatory. When closed, the dome protects the telescope and the tracking mount from bad weather. The sensor also detects daylight and precipitation and can be set to automatically close the dome shutters based on preset alarm conditions to prevent any possibility of telescope to be damaged by sunlight or sudden change of weather during operation. The telescope is the Corrected Dall-Kirkham (CDK) optical tube assembly. The telescope features carbon fiber construction for lightweight durability. Its state-of-the-art optical system is designed to eliminate off-axis coma and astigmatism while its fused silica mirrors feature low thermal expansion and enhanced coatings to maximize light transmission. The telescope also includes cooling fans for thermal management and dew control to maintain clear optical surfaces.

The telescope is attached to a tracking mount. The purpose of the mount is to provide a stable, precise platform for the telescope to continuously track and communicate with the QEYSSat payload in orbit. The tracking mount is a high-precision altitude/azimuth mount featuring direct-drive technology, eliminating the need for gears and belts, and providing smoother, quieter, and accurate motion. The mount is attached to a mounting pier with a separate concrete base which is decoupled from the dome concrete pad to minimize vibrations. The mount offers high tracking accuracy and stability, ensuring precise alignment with the satellite during the pass. The mount is fed with an altitude/azimuth pointing file based on ephemerides derived from satellite GPS data, providing higher accuracy than the TLEs and significantly improving the probability of link success. To deliver the photons generated by the sources to the telescope and then to the satellite a ~300 m fiber is buried in the ground between the control room and the dome. The dome, tracking mount and the weather sensor are ASCOM/Alpaca compatible and controlled by a custom-built software using the OQGS control system located in the control room.

The mount also hosts a laser beacon (1575 nm) connected to the telescope and directed at the satellite. It provides a target for the payload pointing system to determine the OQGS's exact location. A linearly polarized laser beacon of different wavelength (976/1545 nm) is placed on the satellite. This beacon provides a light source for the OQGS Acquisition and Tracking Subsystem (ATS) to maintain accurate satellite tracking and to align OQGS polarization reference frame according to the attitude of the satellite. These are necessary conditions to ensure the QKD link can be achieved.

The quantum sources, control computer, control electronics, and data storage system are all placed in the control room. The data storage system is tasked with storing all essential information needed for QKD. This includes local storage for the random number sequences, time tags, GPS data, and other pertinent information. Site security and proximity to network infrastructure were the driving factors during the OQGS site selection stage. The most critical subsystems, including the sources, dome, and OQGS control computer, are placed in a temperature-controlled racks and powered by an uninterruptible power supply (UPS) to prevent failure in the event of a power outage. OQGS specification is summarized in Table 1.

Alongside the quantum channel, QEYSSat also uses RF communication links to exchange additional information required for key sifting, error correction, and privacy amplification processes in QKD. This channel ensures that both the OQGS and the satellite can correctly establish a secure key. The RF link is established by several RF ground stations located across Canada and depends on the satellite location.

Atmospheric conditions, such as turbulence, signal attenuation, sky background, cloud coverage and local weather, can affect the fidelity of the quantum signals. To monitor the conditions, a COTS Weather and Atmospheric Characterization Equipment (WACE) has been procured. The WACE includes all-sky camera, radiance and scintillation sensors, background light sensors and meteorological weather suite. Among the goals of the WACE are characterization and prediction of anticipated transmission losses in real time, and the collection of atmospheric data for the purpose of performance evaluation of the link. The WACE is planned to be installed at the OQGS site in spring of 2025.

Table 1. QEYSSat OQGS specification

| Characteristic | Value |
|---|---|
| *Uplink beacon* | |
| • Wavelength, nm | 1575 |
| • Power, W | 2 |
| • Modulation, Hz | 0 – 10 |
| *Weak Coherent Pulse Source* | |
| • Wavelength, nm | 785 |
| • Modulation, MHz | 400 |
| *Entangled Photon Source* | |
| • Wavelength, nm | 790.8 |
| • Modulation, MHz | 100 |
| *Tracking mount* | |
| • Pointing accuracy, arcsec | <10 (RMS) |
| • Pointing precision, arcsec | 2 at sidereal velocity |
| • Tracking accuracy, arcsec | 0.3 |
| • Weight, kg | 100 |
| *CDK telescope* | |
| • Aperture diameter, mm | 432 |

| | |
|---|---|
| • Focal length, mm | 2939 |
| • Focal ratio, f/# | f/6.8 |
| • Central obstruction, % | 23.7 by surface area |
| • Weight, kg | 48 |

### *2.4 QEYSSat experiment concept*

As it was mentioned earlier QKD experiments are planned and scheduled by the SOC. The SOC considers relevant constraints, such as the availability of the OQGS, expected satellite pass duration, weather conditions and adherence to other usage agreements. Once the experiment is selected, planned, scheduled, and validated, the experimental procedure is uploaded to the satellite and OQGS to task the systems with an appropriate lead time (see Satellite pass timeline planning section) via MOC. The satellite and the OQGS are then scheduled to point to each other and activate their beacons. As soon as the beacons are locked the OQGS initiates QKD transmission while the satellite collects QKD photons during its pass.

In addition to the QKD link, QKD protocols rely on several data post-processing stages facilitated by conventional communication. These stages include time analysis, key sifting, error correction and privacy amplification. It is assumed that such post-processing activities are conducted over a public channel via RF link. The RF ground stations providing the classical communication may not be collocated with the OQGS due to extended communication time requirements or the nature of the experiment. This has to be considered at the experiment planning phase.

## 3. Operations Planning

### *3.1 QEYSSat mission operation phases*

The QEYSSat satellite design lifetime is 1 year, with a goal of 2 years. The mission is divided into three operational phases. The Commissioning Phase, which lasts 3 months after the satellite launch, is focused on ensuring that both the spacecraft and the ground segment are functioning as required. This phase also includes initial calibration and the establishment of optimal settings. Next is the 12 months long Mission Demonstration Phase, during which the PI team leads the demonstration of the mission requirements. After the mission objectives are fulfilled, the Extended Research Phase begins, allowing members of the Canadian and International collaborators to work with the core ST to conduct additional experiments with the satellite for another 12 months. The SOC maintains some flexibility in scheduling quantum experiments and mission objective demonstrations. Some experiments may be moved forward in the timeline, such as when partner OQGSs are used if local OQGS is unavailable due to issues like weather or maintenance.

### *3.2 Prelaunch OQGS testing activities*

As per the current mission timeline the OQGS deployment is going to be completed in late 2025. The satellite launch is expected by the end of 2026. Careful sequencing and completion of the OQGS deployment and planning activities before the satellite launch ensures that all necessary ground systems and resources are in place for the mission to function effectively once the satellite is in orbit. Additionally, this allows the SOC and MOC teams to address any potential issues with ground operations ahead of the satellite launch and activation, minimizing risks and ensuring mission success. Shortly after the OQGS deployment a series of tests listed below is scheduled to verify the functionality and evaluate the performance of the OQGS and its subsystems.

#### *3.2.1 Dome functionality and evaluation test*

This is to verify the dome can open and close its shutter when commanded with no interference with the telescope and the mount. To simulate a power outage conditions similar test is conducted when the OQGS UPS power cables are disconnected from the mains. Finally, to test automatic dome shutdown in case of a rapid weather change (sudden precipitations or strong wind) specific conditions are simulated.

#### *3.2.2 Telescope and mount target pointing/calibration test*

The goal of the test is to verify the ability of the tracking system to accept altitude/azimuth pointing files for a target (satellite, star, or planet) and to be able to tune to the target at any time and to ensure precise pointing is achieved. The test is conducted by tuning the telescope to several targets sequentially over the course of the observation and measuring their position on a sensor relative to some reference target. This approach can be used to derive sky coverage of the OQGS and to create a pointing model of the OQGS to characterize telescope mounting errors.

#### *3.2.3 Telescope and mount tracking accuracy test*

The goal of the test is to evaluate the OQGS ability to accurately track fast-moving satellites and maintain alignment. The test is conducted in the passive and active tracking modes. In the passive mode the tracking is performed based on the ephemeris data only (TLE or GPS data for a satellite). In the active mode the tracking is performed based on the ephemeris data with an error correction factor retrieved using a satellite centroid determination algorithm. In both cases the performance is estimated as a deviation and variation of the satellite centroid position relative to some predefined position on a sensor.

### *3.2.4 Dome and control room thermal performance test*

The goal for the test is to verify the temperature inside the temperature-controlled racks in the dome and control room at various environmental conditions, ensuring that temperature variations don't affect the system performance and to prevent heat-related issues or condensation damage the equipment inside the racks.

### *3.2.5 Control system and software integration test*

The goal of the test is to ensure that software commands translate seamlessly into accurate OQGS actions. Whether this is a command to turn on the laser source or to point the telescope to the satellite, it should be executed in a coordinated manner to ensure both the laser system and tracking mechanisms are properly synchronized. Finally, the procedures for planning file transmission, acceptance, uplink to the satellite, and data downlink, and collection are going to be thoroughly tested during the OQGS commissioning and end-to-end system validation.

### *3.2.6 Environment condition characterization*

This activity is focused on measuring environmental factors such as geographic location, light pollution, and weather conditions using the WACE system at the OQGS site. This process helps to thoroughly characterize the site. By assessing these environmental parameters, the team plan to study the influence of environmental conditions on expected quantum link performance as well as to determine how it can minimize potential disruptions during satellite operations.

### *3.2.7 Operational protocols and communication framework*

Developing operational protocols and standard operating procedures (SOPs) is a crucial step in ensuring that the satellite and the OQGS function optimally. These procedures cover a range of activities, including satellite acquisition, beacon tracking, key management, and troubleshooting. The protocols are designed to handle both routine operations and emergency situations, such as communication dropouts or equipment failure. A key aspect of this planning phase is establishing a robust feedback loop between the ground station and the satellite to adjust for real-time operational adjustments.

### *3.2.8 OQGS staff training and development*

Training and development for using of OQGS and related equipment involves preparing staff to effectively operate, maintain, and troubleshoot the OQGS. The training ensures the staff are authorized and can use the OQGS safely, efficiently, and in compliance with relevant CSA and industrial standards. Training is divided into technical training and safety training.

OQGS technical training is designed to equip the staff with the specific skills and knowledge necessary to operate the OQGS, perform specialized tasks, and manage OQGS subsystems. The training helps ensure that all aspects of operations are systematically planned, executed, and evaluated.

Safety training is required to educate staff on how to perform the job duties related to OQGS operation and maintenance safely, understand workplace hazards, and follow protocols to minimize the risk of accidents and injuries. It includes instruction on using personal protective equipment (PPE), understanding emergency exits, handling hazardous materials, and complying with health and safety regulations. Emergency procedures describe predefined plans and actions designed to manage and mitigate the impact of emergencies such as fires, medical incidents, natural disasters, chemical spills, or other unexpected situations. These procedures outline the steps that should be taken to ensure the safety of staff and minimize damage to property.

### *3.2.9 Cybersecurity measures*

OQGS cybersecurity measures are essential to ensure the integrity, confidentiality, and availability of the data and systems involved in quantum communication and key distribution. Given the sensitive nature of the data handled, such as quantum states of photons and communication signals, robust cybersecurity strategies are in the development to protect against various cyber threats.

### *3.3 OQGS commissioning and end-to-end system validation.*

Once the satellite is launched to its orbit and its health and functionality is confirmed the OQGS commissioning activities are initiated. They include the steps and procedures specified in the prelaunch OQGS testing activities listed above but conducted having QEYSSat satellite as a target. They are also supplemented with link establishing and end-to-end system validation performed between the OQGS and the QEYSSat.

First, the preliminary link evaluation is established by obtaining a clear optical line-of-sight between the OQGS and the satellite. This involves the following steps: pointing, coarse tracking, followed by laser beacon activation, beam acquisition and lock for the fine alignment. After that an initial QKD link testing is conducted by sending QKD test signals from the OQGS to the satellite to verify that the basic link is operational and that the QKD sequence is received at the satellite.

Finally, an end-to-end testing is performed, which involves the transmission of full scale QKD data from the OQGS to the satellite. The primary goal of the end-to-end testing is to ensure that the ground-to-satellite quantum link is reliable and capable of supporting mission objectives. This type of testing also ensures that the system can operate under real-world conditions, handle required data rates and is resilient to environmental factors such as different ambient temperature, wind and, to some extend, atmospheric interference.

### *3.4 Satellite pass timeline planning*

QEYSSat is planned to be launched to a low Earth sun-synchronous polar orbit with ~550 km altitude and 97.6 deg inclination. The orbital period of QEYSSat is approximately 96 minutes. A polar orbit ensures that the satellite can eventually communicate with ground stations at various latitudes, potentially increasing the global reach of the QKD experiment. Since QEYSSat QKD experiments are planned to be conducted between QEYSSat and fixed ground stations and it is reasonable to use position-based planning schedule [16]. This refers to scheduling tasks for the satellite and OQGS based on the satellite's position relative to the OQGS location. Based on the satellite orbital parameters and OQGS elevation angle requirements, QEYSSat passes above the OQGS at the CSA once per night for every 7-8 consequent nights followed by 7-8-night gap. This results in 14-16 nighttime passes per month. Proposed position-based planning timeline for a given QEYSSat pass above a specific OQGS is summarized in Table 2.

Table 2. Timeline of planning for a pass

| Planning horizon | Activity | Input |
|---|---|---|
| > 1 month in advance | SOC conducts preliminary orbital calculations, SOC checks OQGS availability and satellite pass overlap | Satellite TLE, OQGS coordinates |
| 1 month in advance | SOC selects experiments based on research priorities and OQGS conditions | Mission objectives, mission priorities |
| 2 weeks in advance | SOC runs QKD simulation, confirms OQGS selection and availability, selects backup GS if possible | QKD model |
| 1 day in advance | SOC confirms OQGS status, SOC makes changes to backup GS if required, SOC sends tasking instructions to MOC, MOC uploads tasking commands to QEYSSat, MOC executes short term tasking if required | Local weather conditions and resources, tasking commands, scripts and macros |
| Pass day | SOC activates OQGS, OQGS connects with QEYSSat, SOC conducts and completes QKD experiment | Updated satellite TLE or/and GPS |
| Post pass | Intermediate QKD data is generated on the payload, SOC receives all required data from the satellite and OQGS, SOC conducts post possessing and analyzes the data | QKD data, satellite telemetry, weather data |

| | | |
|---|---|---|
| Post processing | SOC confirms experiment success or/and specify experimental priorities for new experiment | Final results |

## 4. Conclusion

OQGS operation planning activities are important in effective QEYSSat mission management. By identifying potential problems, predicting pitfalls, addressing bottlenecks, and optimizing resource use ahead of the satellite launch, planning ensures smoother, more efficient operations. Through predictive modeling the operations are optimized, risks are minimized, and resources are better allocated. Careful operations planning helps to adapt to changing conditions, improve operational performance, and achieve mission objectives with greater confidence and reliability.

In conclusion, the OQGS is currently going through its construction phase. Significant progress has been made towards design completion and COTS hardware selection, procurement, and adaptation. While not all the stages have yet been completed, the ongoing efforts are laying a solid foundation for the successful deployment of the OQGS at the CSA headquarters in Longueuil, Quebec in late 2025. As the remaining steps are carried out, further planning, validation and optimization is performed to ensure the OQGS performance meets the mission objectives and requirements.

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