CubeSat Challenge

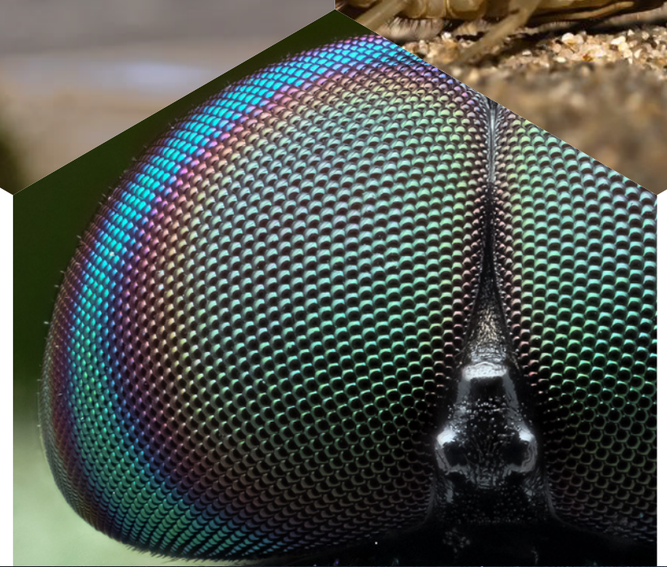
QEBELS Network

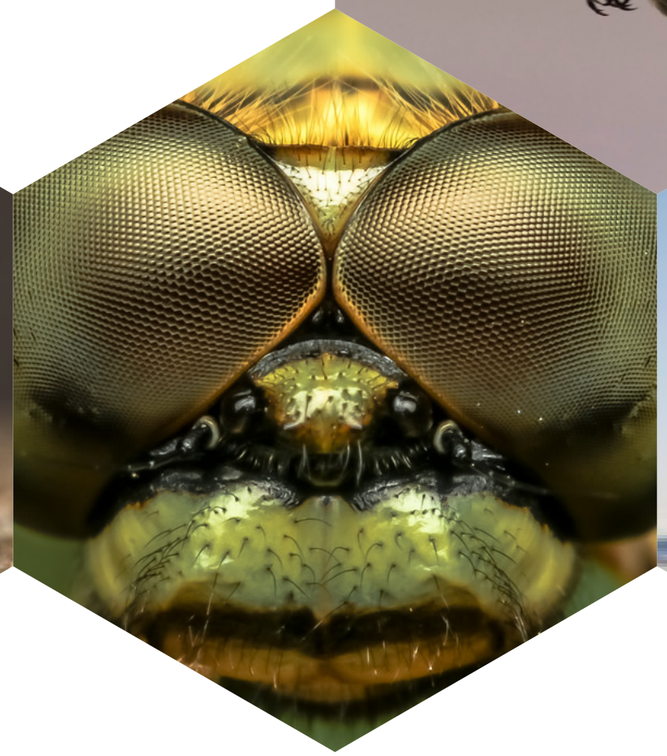
Quantum Enabled Blockchain Encrypted Laser Satellite Network

The proposed solution was developed to provide maximum connectivity, security, seamless user experience and support to USSOCOM missions. To achieve these requirements, we made an extensive research looking for breakthrough technologies that could contribute to the proposed challenge and designed a 360 solution that goes way beyond a single CubeSat design; we found inspiration in nature (hummingbird, eagle, swarm of bees, scorpion and dragonfly) and worked around the following technologies: Laser relay GEO satellite, Swarm of CubeSats, Blockchain Technology, LaserCom, Integrated Photonics, Water Propulsion, Drones, Compound Optics, Augmented Reality, Iris Scanner, Bone Conduction and Quantum Encryption.

Inspired by nature

Synchronization, precision and optical skills.





Geostationary Relay Satellite

- Link between CubeSats and Command center.

BlockChain technology

- Data security.

Cubesat Swarm

- Swarm of CubeSats: Precise Global possition and Tracking.
- Block ChainTechnology: Data security. Advanced communications; including full orbit Command & Control and data exfiltration. Target/assets information.
- Laser Communication & Integrated photonics: High data rate, narrow beam difficult to intercept.
- Water propulsion: Propulsion capabilities to modify or maintain orbits.

Drone

Reaper Drones with ARGUS-IS, enhaced with LaserCom.

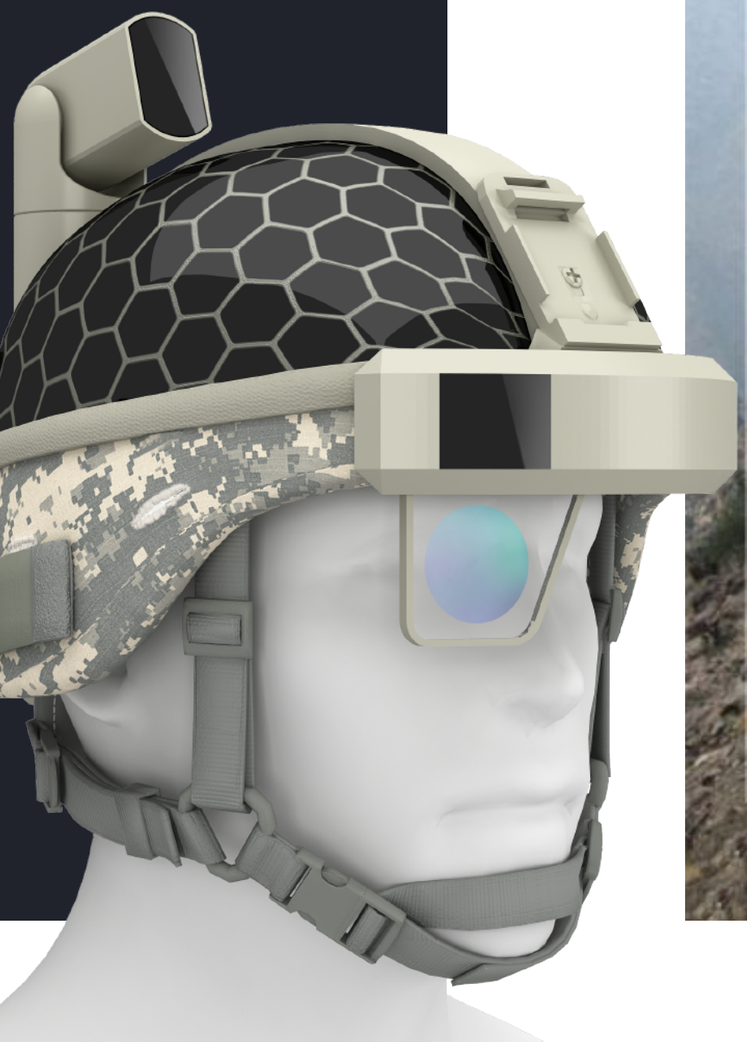
USSOCOM Helmet

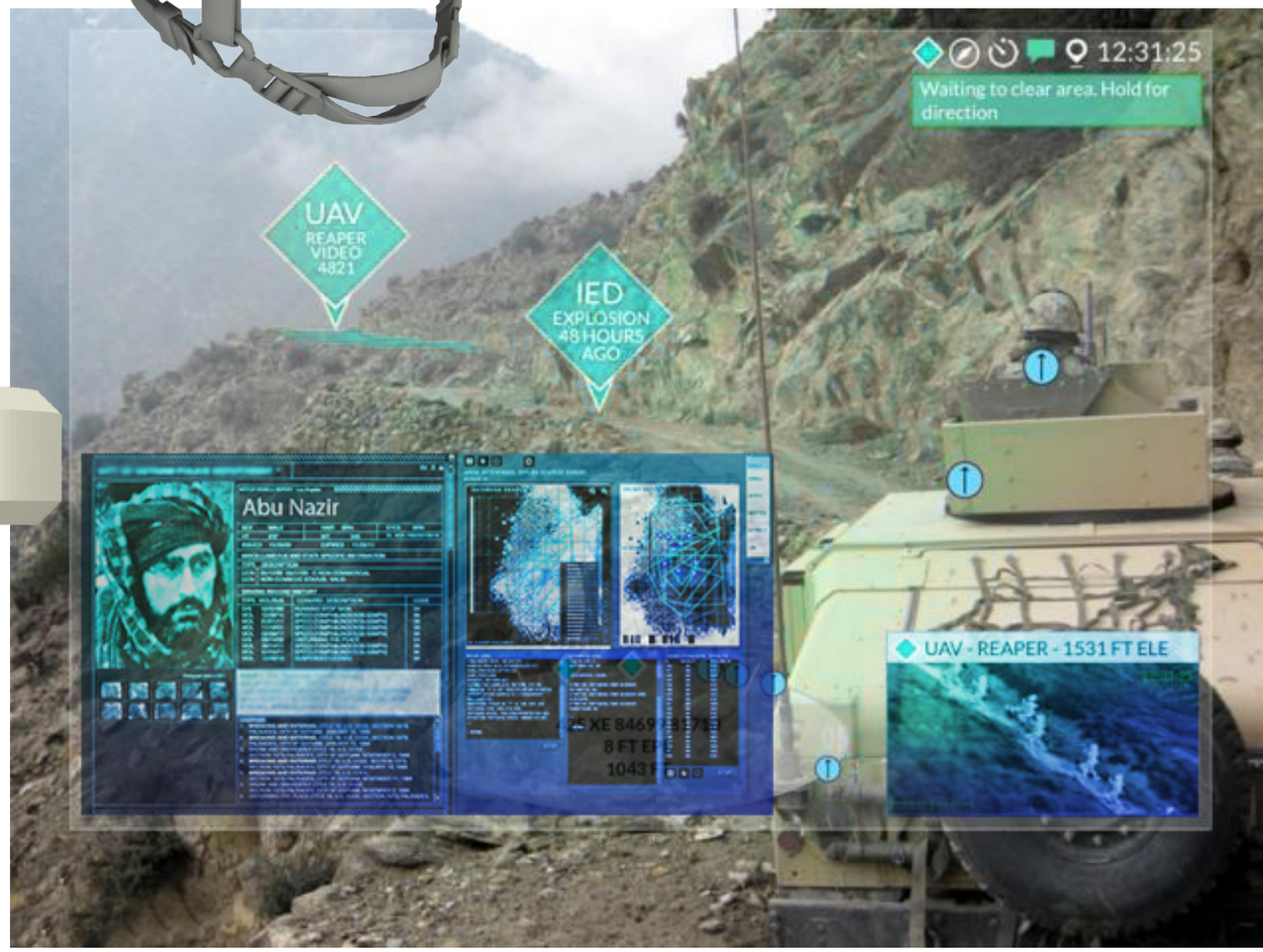
- Laser Communication: High data rate, narrow beam difficult to intercept.
- Data only available to Blockchain registered soldier.
- Quantum encrypted intercom: Secure communication channel.

USSOCOM Helmet

- Laser Communication: High data rate, narrow beam difficult to intercept.
- Compound laser optics laser receiver: Receive data on the move from any direction (CubeSats move fast).
- Laser emmiter with gimbal: Send data to Cubesat & Drones.
- Augmented reality. Relevant Warfare fare data to every soldier.
- Iris scanner: Data only available to Blockchain registered soldier.
- Bone sound conduction: Communication privacy, no third party can hear.
- Quantum encrypted intercom: Secure communication channel.







QEBELS Network: Quantum Enabled Blockchain Encrypted Laser Satellite Network, Inspired by nature.

The proposed solution was developed to provide maximum connectivity, security, seamless user experience and support to USSOCOM missions. To achieve these requirements, we made an extensive research looking for breakthrough technologies that could contribute to the proposed challenge and designed a 360 solution that goes way beyond a single CubeSat design; we found inspiration in nature (hummingbird, eagle, swarm of bees, scorpion and dragonfly) and worked around the following technologies: Laser relay GEO satellite, Swarm of CubeSats, Blockchain Technology, LaserCom, Integrated Photonics, Water Propulsion, Drones, Compound Optics, Augmented Reality, Iris Scanner, Bone Conduction and Quantum Encryption.

Proposed Technologies

Secure bandwidth on the battlefield. With the need for improved targeting accuracy and assured target prosecution, the demand for high-resolution imagery to and from the dismounted soldier is even more pressing now than ever before. Today, airborne and space assets carrying Lidar, high-resolution imaging systems, and multi-spectral imaging systems generate massive volumes of data that must be exfiltrated, processed, and redistributed to a myriad of users, all of whom are fully networked as an integrated fighting force. Technologies that can help us achieve the proposed challenge:

GEO Stationary satellite

+ **GEO Stationary LaserCom relay satellite:** Earth observing satellites in low earth orbit, about 700 km above the ground can only transmit data when they pass above designated ground stations, but this ground stations are permanently visible to geostationary satellites, orbiting much higher at 36.000 km. This allows images transmitted by laser from low earth to geostationary orbit to be relayed to the ground nearly in real-time. A laser relay module for free space optical communications including optics for receiving and transmitting optical beams; an optical diplexer for separating transmitting and received optical beams; an optical amplifier; a modulated beacon laser for line of sight control of a plurality of communicating remote network nodes; a beacon beam detector for detecting an incoming beacon optical beam for line of sight control of the optical array and receiving data from other network nodes; and means for inserting an output of the modulated beacon laser into the optical array for transmission to another network node, and for transporting the incoming beacon optical beam to the beacon detector. **Reference:** LCT by EASA and Airbus defense.

CubeSats with precise Tagging, Tracking and locating capabilities.

+ **Swarm of CubeSats:** Precise Global position and Tracking. The use of an array of CubeSats can provide a wide coverage and support to ground locations and USSOCOM missions. We propose lo deploy a swarm of 1.5- unit (1.5U) CubeSats that will be launched as secondary payloads. Each CubeSat should be about 4 inches x 4 inches x 6.7 inches (10 centimeters x 10 centimeters x 17 centimeters) and weighs approximately 5 pounds (2.5 kilograms). **Reference:** OCSD project funded through NASA's Small Spacecraft Technology Program (SSTP).

+ **Water/Ice propulsion:** Enhances capabilities to modify or maintain orbits. Laser can be hard mounted to the CubeSat and beam steering is accomplished through precision pointing of the spacecraft as a whole. Precision flying: capacity to maneuver CubeSats relative to each other opens the door to servicing or connecting small spacecraft together to form larger systems or networks in space (swarm). **Reference:** MIT Labs Ion Electrospray Propulsion System, or iEPS, and it will use the qualities of space itself to make the ice sublimate, or transform directly from solid water-to-water vapor. By directing these water molecules against a heated plate, the drive causes the water vapor to accelerate out of a nozzle, thus creating thrust.

+ **LaserCom.** High data rate, narrow beam difficult to intercept. 800/1550-nm infrared wavelength band. Low size, weight and power. Can provide high data rates & high-definition video link. LaserCom also provides simultaneous centimeter-class precision ranging, which can be used to enhance CubeSats navigation capabilities. Free-space optical communication (FSOC) using lasers offers the promise of breaking through that RF bottleneck. Laser transmitters, at wavelengths some 10,000 times shorter than RF waves, result in beams that are far narrower for the same unit aperture size—providing more concentrated communications power at the receiver with lower required transmitted power from smaller, lighter apertures. The upshot is a lower size, weight and power requirement for transmit and receive apertures of a laser communications terminal.

+ **Integrated Photonics.** Powered by recent developments in nanostructures, metamaterials and silicon waveguides, integrated photonics could have a significant impact in the evolution of space-based laser communications. The lithographic techniques to create a photonic integrated circuit (PIC)—analogous to CMOS technology, but with photonic components replacing electrical traces—can realize hundred-fold reductions in size, mass, power and especially cost, because the PICs can be printed en masse. While PIC development is currently driven by the need for lower-footprint optical interconnects and transmission in data centers, their attributes are also critical to spreading free-space laser communications. **Reference:** Vescent Photonics low power optical communications modules & Lockheed Martin SPIDER optical system.

+ **Blockchain Technology:** Data security. Advanced communications; including full orbit Command & Control and data exfiltration. Target/assets information. Blockchains are tamper-proof, immutable, time-stamped reliable data ledgers. Unauthorized access or modification of critical USSOCOM mission information could seriously compromise national security. Blockchain technology can ensure security against attacks on satellite network and hardware equipment by ensuring consensus-based access for modification. **Reference:**

The SpaceBelt Information Ultra-Highway™ is a unique satellite network designed to provide secure storage and transport of mission-critical, sensitive data without interruption or exposure to any surreptitious elements or unintended jurisdictions.

Reaper Drones, enhanced with LaserCom.

+ **ARGUS-IS.** The mission of the Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System (ARGUS-IS) program is to provide military users a flexible and responsive capability to find, track and monitor events and activities of interest on a continuous basis in areas of interest. The overall objective is to increase situational awareness and understanding enabling an ability to find and fix critical events in a large area in enough time to influence events. ARGUS - IS provides military users an "eyes-on" or "eagle eye view" persistent wide area surveillance capability to support tactical users in a dynamic battle space or urban environment.

USSOCOM Helmet. Inspired by nature.

+ **Compound optics laser receiver:** The use of fixed compound optics (integrated photonics) over the helmet allows USSOCOM to receive laser link on the move from any direction (CubeSats move fast). Each simple optic provides one small piece of the puzzle, much like the way a screen's pixel delivers one detail of the larger picture. We get a receiving optical area greater than a 15 inch Cassegrain telescope with a fraction of its weight and with extreme portability. This concept was developed 100% by our team and inspired on the compound eye of the dragonfly.

+ **Laser emitter with gimbal:** To track and send data to CubeSats & Drones. This concept was developed by our team and inspired on the Scorpions stinger.

+ **Augmented reality:** To provide relevant warfare data to every soldier. Google Glass-esque headgear will soon become the newest piece of standard-issue equipment for U.S. soldiers, and give them the ability to digitally track friendly and enemy locations, display 3D maps of battlefields, and watch live video from drones — all in real-time. United Kingdom-based BAE systems built the Q-Warrior high-tech headset to live-stream more data to soldiers than ever before, and provides a tremendous battlefield advantage by showing soldiers multi-dimensional, full-color displays of battle zones outside their fields of vision. **Though the equipment itself is complete, the methods by which it will be deployed and secured are not.** Developers still have a number of issues to consider and plan for, including figuring out how to transmit so much data to thousands of soldiers at once without interruption or too much distraction, and how to protect the devices from being hacked or interfered with. **Our team solved this issues by combining the following technologies:** LaserCom, compound optics, laser emitter with gimbal, Blockchain technology, iris scanner, bone conduction and in the near future quantum key encrypted intercom.

+ **Iris scanner:** To provide/secure data only to Blockchain registered USSOCOM soldier. Iris recognition is an automated and well developed method of biometric identification that uses mathematical pattern-recognition techniques on video images of one of the irises of an individual's eyes, whose complex patterns are unique, stable, and can be seen from some distance. Digital templates encoded from these patterns by mathematical and statistical algorithms allow the identification of an individual or someone pretending to be that individual. Databases of enrolled templates are searched by matcher engines at speeds measured in the millions of templates per second per (single-core) CPU, and with remarkably low false match rates. A key advantage of iris recognition, besides its speed of matching and its extreme resistance to false matches, is the stability of the iris as an internal and protected, yet externally visible organ of the eye.

+ **Bone sound conduction:** To provide communication privacy, no third party can hear. The AR device employs bone conduction technology for the relay of information to the user through a transducer that sits beside the user's ear. The use of bone conduction means that any vocal content that is received by the USSOCOM soldier is nearly inaudible to outsiders.

+ Quantum encrypted intercom: Secure communication channel. USSOCOM soldiers can receive and share a quantum encrypted key from CubeSat Blockchain network or Drone. If there are proper atmospheric conditions, all communications between USSOCOM soldiers could be performed using Lasercom relayed from CubeSats or Drones; but if conditions are not optimal, they can still communicate between them using an RF digital module using quantum encryption key provided on a regular basis from above. **Reference:** Recently University of Science and Technology of China in Shanghai got the chance to test the idea sending intertwined quantum particles from Micius satellite (named after an ancient Chinese philosopher) to ground stations separated by 1.200 kilometers. To entangle photons, researchers beamed an ultraviolet laser through a special crystal, which created pairs of photons with opposite — yet unknown — states of polarization. (Polarization is the same property of light that polarized sunglasses and dragonfly compound eye can filter out to improve contrast.) In doing so, they created objects called qubits, or quantum-entangled bits. Mirrors then split up the laser beam and its pairs of quantum-entangled photons. The experiment kept one photon on the ground and sent the other to Micius. Quantum communication is extremely secure because any interference is detectable. Two parties can exchange secret messages by sharing an encryption key encoded in the properties of entangled particles; any eavesdropper would affect the entanglement and so be detected. The Micius team has already done experiments exploring whether it is possible to create such encryption keys using entangled photons, and even 'teleport' information securely between Earth and space.

Inspired by Nature, the best R&D lab in the worlds, with 3,8 billion years of experience. We looked after the hummingbird, bee, eagle, scorpion and dragonfly, to develop a 360 solution that goes way beyond a single CubeSat design.

Hummingbird: Hummingbirds' visual sensitivity allows them to precisely hover in place while in complex and dynamic natural environments, functions enabled by the lentiform nucleus which is tuned to fast-pattern velocities, enabling highly tuned control and collision avoidance during forward flight. While hovering, the visual system of a hummingbird is able to separate apparent motion caused

by the movement of the hummingbird itself from motions caused by external sources, such as an approaching predator. In natural settings full of highly complex background motion, hummingbirds are able to precisely hover in place by rapid coordination of vision with body position. **Inspired: Geostationary relay Satellite. Advance positioning, communication and reference to CubeSat.**

Bee: Flying insects closely related to wasps and ants, known for their role in pollination and, in the case of the best-known bee species, the European honey bee, for producing honey and beeswax. honey bees communicate by the waggle dance, in which a worker indicates the location of a food source to other workers in the hive. He demonstrated that bees can recognize a desired compass direction in three different ways: by the sun, by the polarization pattern of the blue sky, and by the earth's magnetic field. He showed that the sun is the preferred or main compass; the other mechanisms are used under cloudy skies or inside a dark beehive. Bees navigate using spatial memory with a "rich, map-like organization". **Inspired: Swarm of bees: Communication & positioning of Swarm of CubeSats.**

Eagle: Due to the size and power of many eagle species, they are ranked at the top of the food chain as apex predators in the avian world. Most eagles grab prey without landing and take flight with it, so the prey can be carried to a perch and torn apart. The **eagle eye** is among the strongest in the animal kingdom, with an eyesight estimated at 4 to 8 times stronger than that of the average human. An eagle is said to be able to spot a rabbit 3.2 km away. Their eyes are stated to be larger in size than their brain, by weight. Colour vision with resolution and clarity are the most prominent features of eagles' eyes, hence sharp-sighted people are sometimes referred to as "eagle-eyed". Eagles can identify five distinctly coloured squirrels and locate their prey even if hidden. **Inspired: Reaper Drone eagle sight.**

Scorpion: Predatory arachnids of the order **Scorpiones**. They have eight legs and are easily recognized by the pair of grasping pedipalps and the narrow, segmented tail, often carried in a characteristic forward curve over the back, ending with a venomous stinger. **Inspired: Stinger: Precision of Laser communication, location and independent movement of laser emitter gimbal on helmet.**

Dragonfly: Insect belonging to the order Odonata, infraorder **Anisoptera.** Adult dragonflies are characterized by large, multifaceted eyes, two pairs of strong, transparent wings, sometimes with coloured patches, and an elongated body. An adult dragonfly's compound eyes have nearly 24,000 ommatidia each. Unlike humans, day-flying dragonfly species have four or five different opsins, allowing them to see colors that are beyond human visual capabilities, such as ultraviolet (UV) light. Dragonflies (and bees) have the largest compound eyes of any insect;, and the eyes cover most of the insect's head, resembling a motorcycle helmet. In contrast to a human eye, each facet within the compound eye points in a slightly different direction and perceives light emanating from only one particular direction in space, creating a mosaic of partially overlapping images. Dragonflies can also detect the plane of polarization of light, which humans cannot do without the aid of sunglasses. Insects are known to use polarized light as a sort of "sky compass" by which they navigate. **Inspired: Hexagon layout of compound mirrors on helmet. UV light capabilities. Polarized light as aditional source of navigation.**