Proposal

GALLIOC Space Settlement Contract

Project Manager and presentation Lead: Hassan Namwar
Safety and Human Factors Lead: Shubham Tumulu
Structural Design Lead: Max Li
Operations and Infrastructure Lead: Aryan Pothapregada
Automation and Technology Lead: Venoj Suthan

Slide Author/s: Shubham

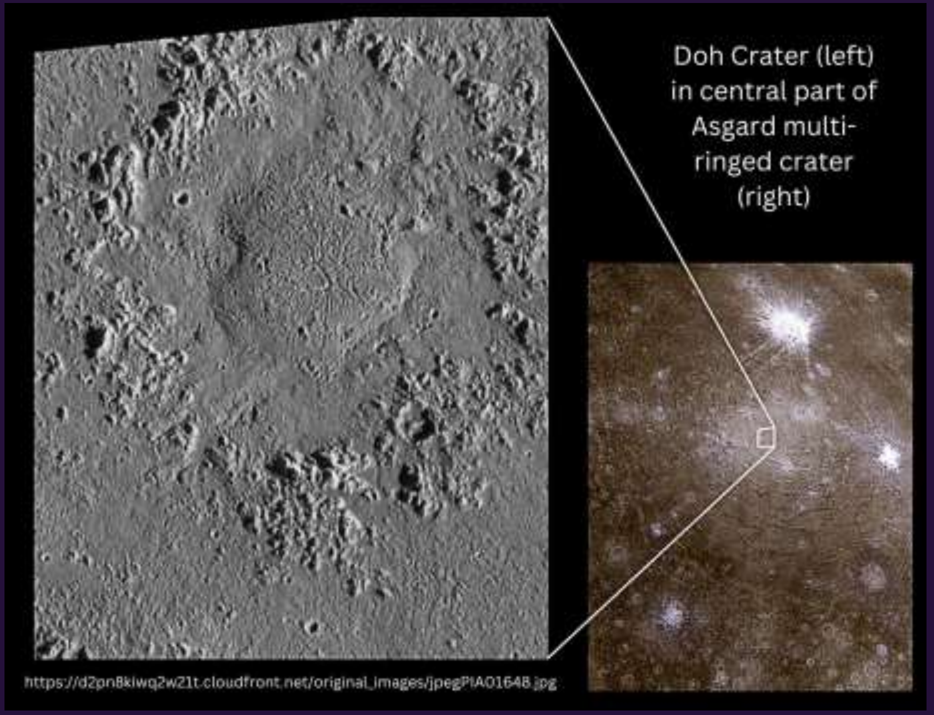
RfP: 1

Callisto:

- **Location**: The second-largest moon of Jupiter and the third-largest moon in the Solar System.
- **Size**: Diameter of about 4,820 km, similar in size to the planet Mercury.
- **Surface**: Callisto's surface is heavily cratered, icy, and one of the oldest in the Solar System, with minimal geological activity.
- **Atmosphere**: Extremely thin, composed mainly of carbon dioxide and possibly molecular oxygen.
- **Magnetosphere**: No significant magnetic field, but it interacts with Jupiter's magnetosphere.
- **Water**: There may be an ocean around 100–150 km below the ice crust surface.
- **Habitability**: Low radiation compared to other Galilean moons like Europa and Io.
- **Temperature**: Surface temperatures can drop as low as -139°C (-218°F).
- **Asgard Multiringed Crater:**
- **Location**: One of Callisto's largest and most prominent impact structures.
- **Size**: Approximately 1,600 km in diameter.
- **Structure**: A multiringed basin, likely formed by a massive impact, featuring concentric rings of ridges and troughs.
- **Central Region**: The central part of Asgard is relatively smooth due to impact-related processes or later geological activity.
- **Doh Crater:**
- **Location**: Impact crater within the Asgard multiringed structure on Callisto.
- **Size**: Roughly 80 km in diameter.
- **Significance**: Its position within the larger Asgard basin suggests it was formed after the initial Asgard impact.

1. Basic Requirements for the Gallioc Settlement Community

- **Design:**
- **Location**: Doh Crater, Asgard multiringed structure, Callisto, 30.6°N 141.4°W.
- **Architecture**: Modular and prefabricated designs. Insulated for extreme cold and designed to withstand low gravity.
- **Community Layout**: Central communal areas (e.g., dining, recreation), residential modules, workspaces, and essential services (medical, maintenance).
- **Environmental Considerations**: Utilise local materials for construction where possible, reducing the need for transport. Account for radiation protection and life support systems.
- **Sustainability**: Incorporate systems for food production, water recycling, and energy generation to support long-term habitation.
- **Habitat Systems**: Life support systems, including air recycling, CO2 removal, and humidity control, to ensure a safe living environment.
- **Automated Processes**: Use construction robots and 3D printers for efficient building, utilising in-situ resources. Swarm robotics may assist in rapid assembly.
- **Modular Assembly**: Prefabricated units transported to the site for assembly.
- **Landing and Launching Facilities**: Design a dedicated area for the safe landing and launching of spacecraft.
- **Landing Pads**: Reinforced surfaces capable of withstanding the weight of various vessels.
- **Fueling Stations**: Facilities for refueling and maintenance of spacecraft.
- **Resupply Facilities**: Establish logistics systems for regular resupply missions.
- **Storage Depots**: Secure areas for food, equipment, and materials.
- **Processing Facilities**: For preparing incoming supplies and managing waste.
- **Transport Systems**: Develop transportation links between the settlement and landing facilities.
- **Transport Vehicles**: Rovers or automated systems for moving people and goods.



RfP: 2.1-2, 4.4

Slide Author/s: Max

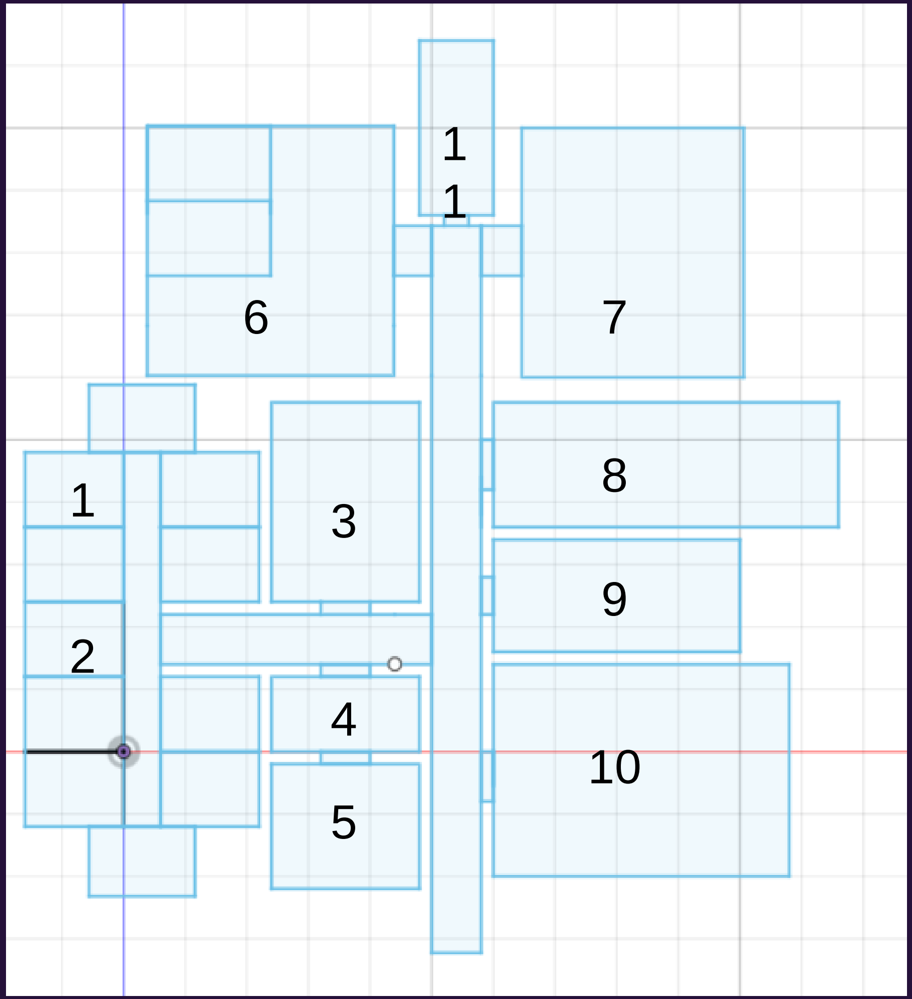
The Gallioc will provide a safe and pleasant working environment for up to 250 occupants plus a transient population of up to 50. It will do this by using modules, each serving a different purpose:

- **- <u>Living pods</u>**: The living pods will feature a communal bathroom and beds to house 10 people. This will be a space for occupants to sleep
- **<u>- Entertainment areas</u>**: The entertainment areas will feature board games, television, comfortable seating areas and more. This is a space for occupants to relax and socialise.
- **- <u>Cafeteria areas</u>**: Gallioc will use kitchen-dining areas in each module where occupants come to eat and drink.
- **- <u>Work areas</u>**: Each module will have a lab for scientific research, including a sample testing space, scientific equipment and more. It will be used to research potential uses for the resources on Callisto. The airlock will feature exploration suits, exploration vehicles, and more. This is where long-distance exploration over the Callistan Surface will begin. Most personnel will spend the majority of their time in these labs.

- **<u>Tourism opportunities:</u>**
- **Crater Expeditions**: Explore Doh Crater and the massive Asgard multiringed crater, revealing Callisto's geological history.
- **Low-Gravity Adventures**: Experience walking or driving across the moon's surface in low gravity.
- **Jupiter Viewing**: Observe Jupiter and its dynamic cloud systems up close from Callisto's surface.
- **Ice Cliff Exploration**: Hike alongside or climb Callisto's icy cliffs and glacial fields.
- **Aurora Viewing**: Witness Jupiter's vibrant auroras lighting up Callisto's night sky.
- **Astrobiology and Geological Tours**: Join scientific missions to study potential signs of life and Callisto's ancient ice layers.

RfP: 2.3-4, 4.1-3

Slide Author/s: Max



1-Bedrooms
- 4 by 3 meters
- Private space for occupants
- Sleeping

2-Bathroom
- 4 by 3 meters
- Toilet and shower

3-Lab
- **Dimensions:**
- **Size**: 6 by 8 meters
- **Equipment for Sample Storage:**
- **Cryogenic Freezers**: For long-term sample preservation at ultra-low temperatures.
- **Refrigerators**: Maintain samples at controlled temperatures.
- **Secure Storage Cabinets**: Lockable units for hazardous or valuable materials.
- **Contamination Prevention Precautions:**
- **HEPA Filtration System**: Filters air to remove airborne particles and contaminants.
- **Laminar Flow Hood**: Provides a sterile workspace for handling samples.
- **Sterilisation Units**: Equipment like autoclaves to sterilise tools and lab surfaces.
- **PPE Stations**: Stations stocked with lab coats, gloves, masks, and goggles for personnel safety.
- **Decontamination Area**: A section dedicated to decontaminating samples and equipment before entry/exit.

4- Communal area
- Space for occupants to socialise
- Has TVs, board games- place to relax

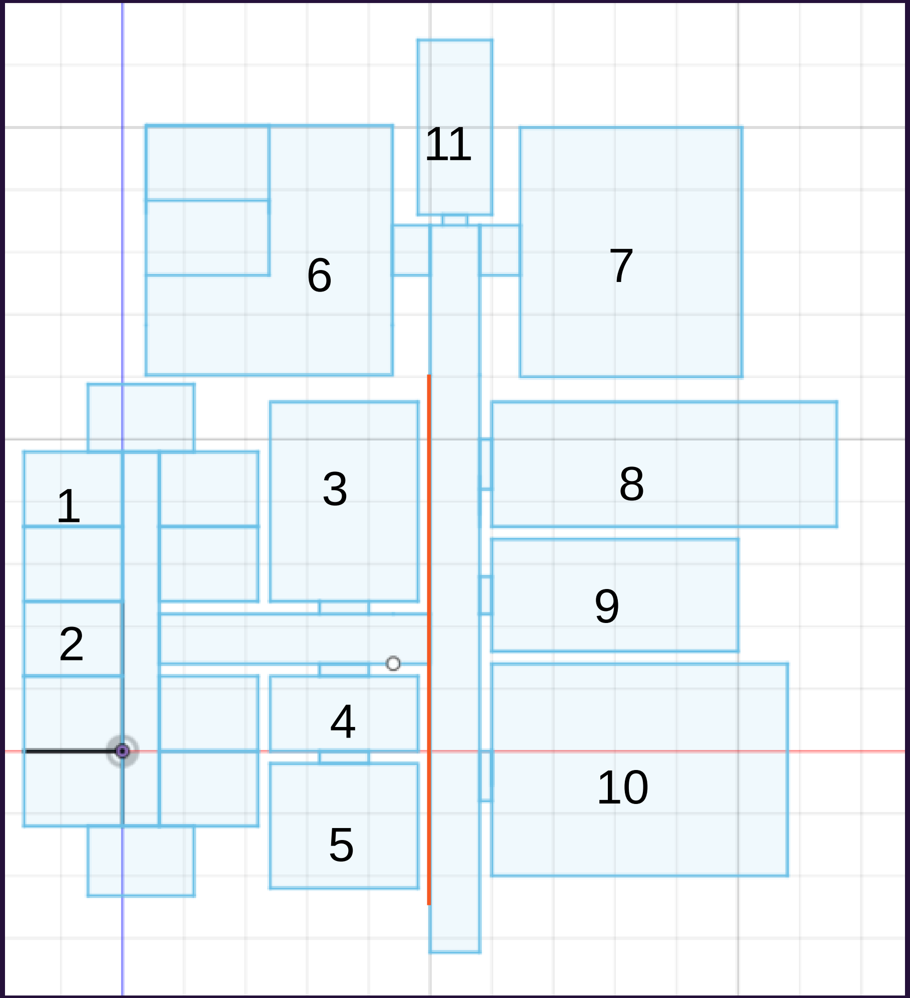
5-Food production block
- Place to grow food for each pod
- Insect Farm (Mealworms): Breeding and harvesting mealworms, providing a sustainable source of protein.
- Hydroponic System: A soil-free system for growing vegetables and herbs, optimising space and water use.
- LED Grow Lights: Energy-efficient lighting to promote plant growth in low-light environments.
- Automated Watering and Nutrient System: Sensors and pumps to deliver precise amounts of water and nutrients to plants.
- Environmental Controls: Systems to maintain optimal temperature, humidity, and CO2 levels for plant and insect farming.

6-Garage/Airlock
- 10 by 10 meters
- Has a two-stage airlock, 5 by 6 meters
- Extra space used for storage of suits, rovers and maintenance
- Also used for analysing samples from Callisto's surface

7-medical bay
- 10 by 9 meters
- Has space for 14 beds
- 2 beds for triage and examination.
- 1 operating tables (usually not counted as “beds” since they are for specific procedures, but you would want at least one dedicated space for surgery).
- 3 beds in the recovery area.
- 5 beds in isolation rooms.
- 3 beds for general medical needs.

RfP: 2.3-4, 4.1-3

Slide Author/s: Max



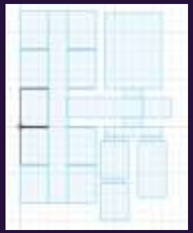
8- Gym- 5x14M
- 1. Cardiovascular Equipment:
- 1 Treadmill with Harness System
- 1 Stationary Bicycle
- 1 Resistance Rowing Machine
- 2. Strength Training Equipment:
- Wall-Mounted Resistance Bands and Cables
- 1 Flywheel System (e.g., kBox)
- 1 Compact Multi-Gym Machine (for lat pull-downs, leg presses, etc.)
- 3. Functional Fitness & Bodyweight Training:
- Wall-Mounted Pull-Up Bar and Dip Station
- 1 Suspension Trainer (e.g., TRX)
- Exercise Mats (for floor exercises like push-ups, sit-ups, and core work)
- 4. Flexibility and Core Training:
- Foam Rollers
- Stretching Area with Mats
- Core Stability Tools (e.g., stability ball, balance boards)

9-dining area
- Cooking/Preparation Area:
- Multi-functional Cooking Stations (electric stoves, induction cookers, combination ovens)
- Counter Space (stainless steel)
- Food Processors/Blenders
- Refrigerators and Freezers (commercial-grade)
- Hydration Systems (water dispensers, filtration units)
- Storage Cabinets/Pantry (for dry goods and ingredients)
- Large-Scale Ovens (convection)
- Induction Cooktops
- Microwaves
- Dishwashers
- Composting Units
- Dining Area:
- Modular Tables (foldable/stackable)
- Seating (stackable chairs/benches)
- Self-Serve Stations (buffet-style)
- Beverage Dispensers
- Trash Bins
- Washbasins, hand sanitisers)

10- server room
- Blade Servers
- Storage Arrays (SSD/HDD)
- Switches, Routers, Firewalls
- PSUs
- AC Units (Precision Cooling)
- Hot/Cold Aisle Setup
- UPS & PDUs
- Data Backup Systems (External or Cloud)
- Redundant Network Connections
- Firewall and IDS
- Environmental Monitoring Sensors
- Access Control Systems (Biometric)
- AI and Automation Servers
- Real-Time Monitoring Systems
- Cable Trays and Structured Cabling
- Fire Suppression Systems (Gas-based)

11- Environment and Electricity
- Life Support Systems:
- Components: Air recycling, CO2 removal, temperature control.
- Oxygen Generator:
- Components: Equipment for oxygen generation (e.g., PSA systems).
- Humidification System:
- Components: Humidifiers for maintaining environmental conditions.
- Electrical and Control Systems:
- Components: Control panels, power management systems, and monitoring equipment.
- Additional Equipment and Utilities:
- Components: Backup systems, additional sensors.

NB: Each module will have 5 pods, but only one is pictured here. The pod is made of parts 1-5. This means that the corridor will be extended down 46m, with 2 pods on either side. For reference, the orange line is 23m long.



Version 1

RfP: 3

Slide Author: Aryan

Material and Equipment Sources:

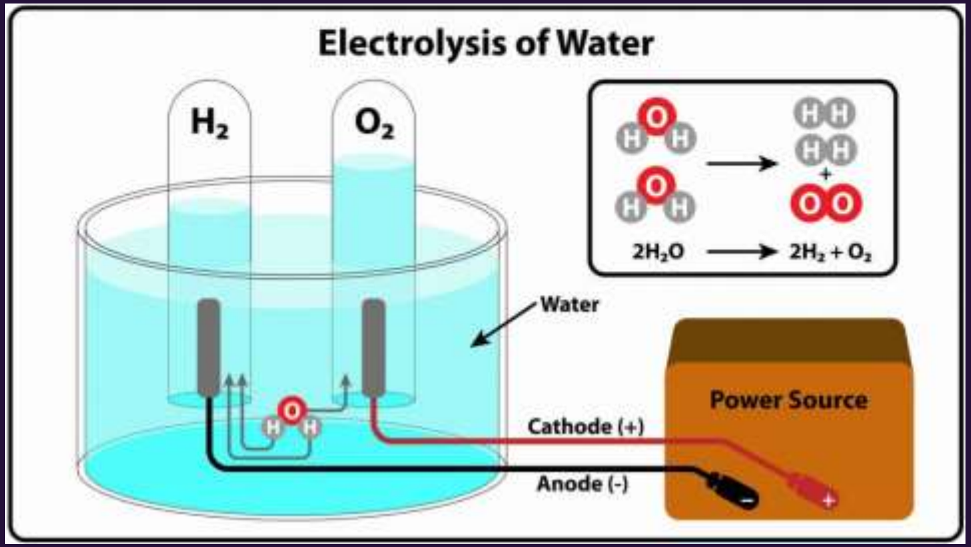
- Utilise local resources on Callisto: Extract water from ice deposits and mine regolith for basic construction materials (e.g., insulation, shielding).
- **Imported Materials**: Key components such as high-grade metals, glass, and life-support tech will be transported from Earth. Regular supply missions will ensure the necessary equipment for both construction and operation.

Basic Operational Infrastructure:

- **Food Production and Storage**:
- **Protein Production**: A mealworm farm in each pod will produce up to 200 kg of protein yearly (10 people need 182.5 kg annually). Mealworms are low-maintenance, requiring minimal water and feed. They can thrive on organic waste, making them ideal for closed-loop recycling systems in space environments.
  - **Storage**: Maintain a 15-ton climate-controlled food reserve, offering 6 months' worth of emergency provisions for 30 people.
    - Freeze-dry food to extend shelf life.
- ***Water Production and Recycling:***
  - **Water Extraction**: Automated systems will extract 1,000 gallons of water daily from Callisto's ice deposits.
  - **Water Storage**: Install a storage system with a capacity of 20,000 gallons to meet daily needs and emergency reserves. Organic waste will be sent to the mealworms and the hydroponic farm.
  - **Recycling**: A closed-loop water recycling system capable of reclaiming 95% of wastewater, processing up to 800 gallons per day, will reduce the need for fresh - water extraction.
- ***Electrical Power Generation and Storage:***
  - **Primary Power**: Solar arrays covering 5,000 square feet will generate 2 MW of power.
  - **Backup Power**: A 2 MW biofuel incinerator will ensure stable energy supply during low-sunlight conditions.
  - **Energy Storage**: Batteries with a storage capacity of 10 MWh will cover fluctuations in energy demand.

RfP: 3

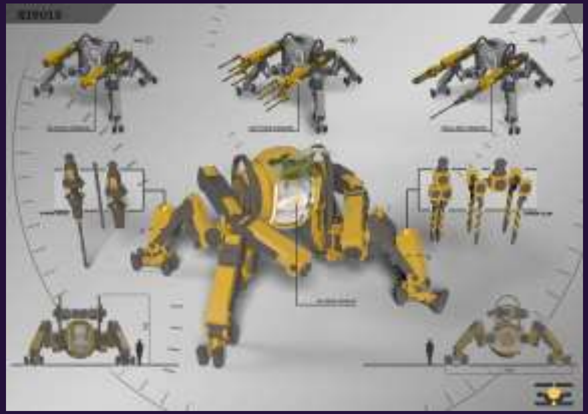
Slide Author/s: Aryan



- ***Waste Management*:**
  - A compact bioreactor will process 300 kg of organic waste per month, converting it into nutrient-rich material for hydroponics.
  - Efficient waste treatment units will process 150 liters of human waste daily, converting it back into clean water and biofertiliser.
  - Waste compaction systems will reduce non-recyclable waste to 5% of its original volume, with secure storage for later disposal or repurposing.
- ***Atmospheric Composition and Regulation*:**
  - Oxygen Production: Electrolyse 500 gallons of water per day, producing enough oxygen for 30 people and supporting plant life.
  - CO_2 Scrubbing: Install CO_2 scrubbing units capable of removing 50 kg of CO_2 daily.
  - Climate Control: Maintain stable atmospheric pressure and regulate the temperature between 18°C and 22°C, with humidity levels kept between 40% and 60%.
- ***Rocket Propellant Storage*:**
  - **Sc**aled Storage: 28 underground tanks will store 500,000 liters of propellant each for local refueling, with automated pressure control and safety systems to prevent leaks or accidents.
- ***Contingency Plans for Disasters*:**
  - Fire: Fire suppression systems using inert gas will be installed in key areas. Emergency fire drills and safety training will be mandatory.
  - Loss of Atmospheric Pressure: Emergency airlocks and pressure doors will seal off affected areas in less than 10 seconds. Personal oxygen kits will provide each occupant with 30 minutes of air.
  - Evacuation: Two escape pods capable of carrying 15 people each will be on standby. These pods will have supplies for 1 month of independent operation. Regular evacuation drills will ensure readiness in case of emergencies.

RfP: 5

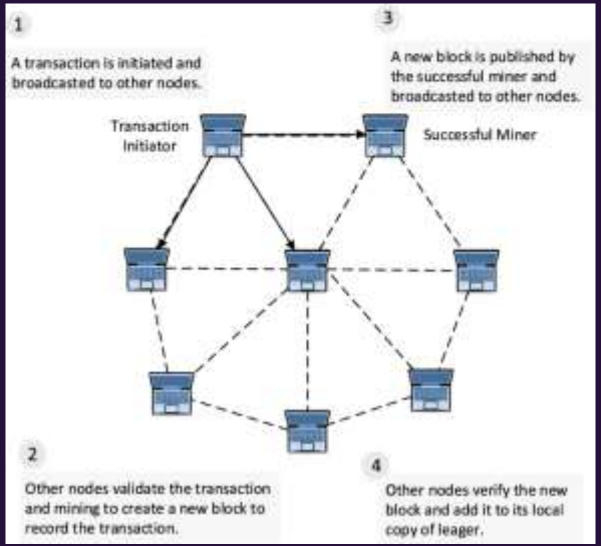
Slide Author/s: Venoj



- The Golliac will be constructed using prefabricated modular parts and supplemented by 3D printers. Large construction robots will assemble the modules, while some resources may be locally sourced to reduce material transport. The modular design allows for rapid assembly and future adaptability, with the ability to expand or reconfigure the settlement as needed. Swarm robots will accelerate construction by efficiently assembling modules, assisted by AI-driven drones that monitor progress and optimise resource use.
- After construction, automated systems will manage ongoing maintenance. Self-repairing materials in the modules will detect and fix cracks or damage using embedded nanoparticles. A network of sensors throughout the base will monitor life support, power systems, and structural integrity, proactively identifying potential failures. For more severe issues, robotic drones will patrol the settlement, deploying autonomous repair units to address any detected problems. These drones will operate with AI coordination to ensure continuous functionality.
- Sensors will detect threats like solar flares, activating radiation shields and triggering backup systems. Automated evacuation procedures and multiple airlocks will ensure safety during emergencies like depressurisation. AI will manage emergency systems, including life-support backups, power sources, and fire suppression, ensuring regular testing and recalibration. Should failures occur, contingency systems will switch power sources between solar, biofuel, or alternative energy.
- Modularity: This modularity means sections of the settlement can be isolated, expanded, or repaired independently without disrupting overall functionality.
- Resource Utilisation: Local materials, such as regolith for radiation shielding or metals from nearby asteroids, will be processed on-site using automated systems. This reduces dependency on extra-terrestrial resources and ensures Golliac's sustainability.
- AI Redundancy: All critical AI systems, from maintenance to safety, will operate on redundant networks to ensure no single point of failure. .
- Energy Efficiency: Solar power and biofuel will be the primary energy sources. with biofuel and other alternatives as backups. Advanced energy storage systems will ensure uninterrupted power, and AI will manage energy distribution to prioritise critical functions during emergencies.

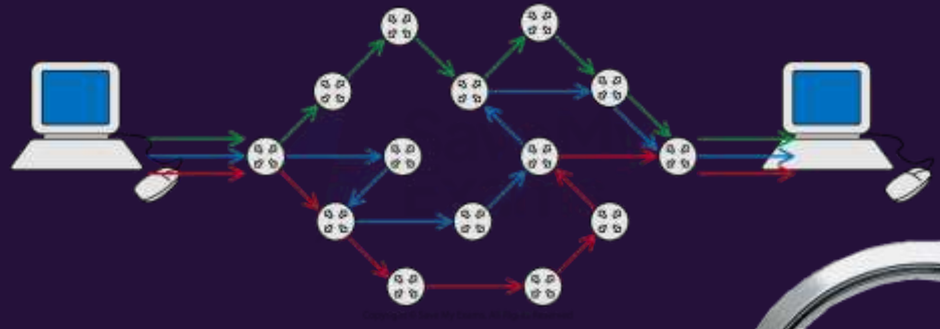
RfP: 5

Slide Author/s: Hassan



- Physical and Cyber Security: The communication system integrates several security measures:
  - Multi-Factor Authentication (MFA): Users are required to complete MFA, combining physical security, such as biometrics, with digital authentication methods like one-time passcodes.
  - Encryption: All communication packets are encrypted using advanced cryptographic protocols to prevent interception and unauthorised access to data.
  - Access Control and Permissions: Each server enforces strict user roles and permissions, ensuring only designated users can access specific data or initiate certain communications.
  - Tamper Detection: The ring devices have tamper-proof hardware, with alerts sent to the server if any unauthorised physical access or attempts to breach the device's integrity are detected.
  - Network Monitoring: Each server has cyber-defence mechanisms, such as IDS and firewalls,. If an anomaly is detected, the affected server can be isolated while traffic is redirected.
  - Decentralisation: All network access is logged using blockchain, ensuring an unalterable record of activities for accountability. This, along with physical node separation (one per module), also allows for decentralisation, preventing a single point of failure.
  - Key computer systems are housed in shielded bunkers to protect them against radiation, environmental hazards, and external threats.

RfP: 5

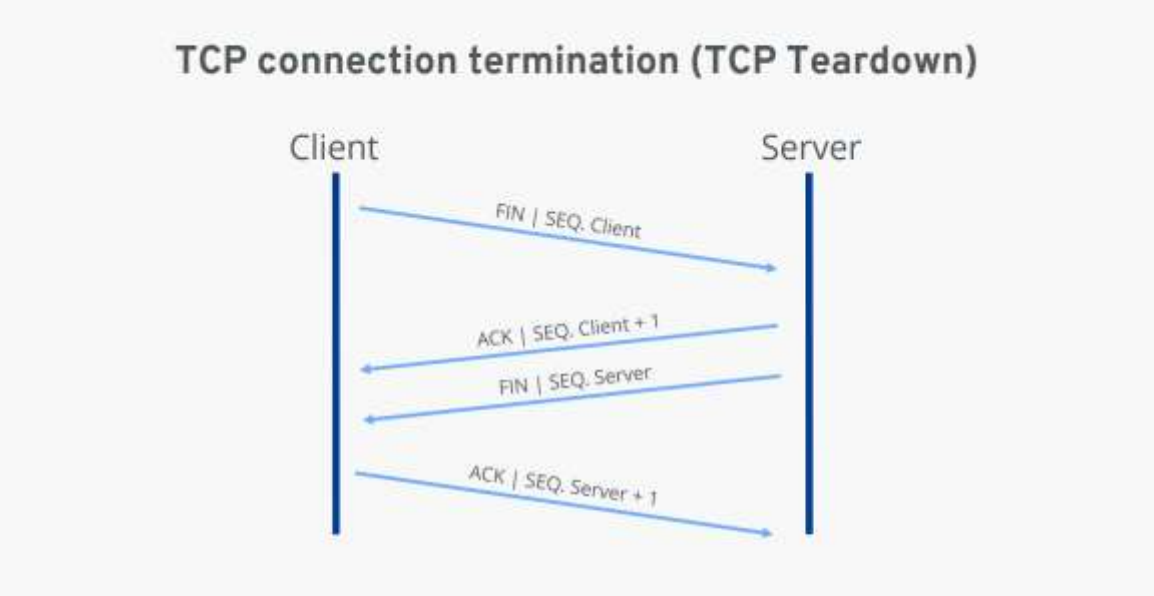


Slide Author/s: Hassan, Venoj

- Each crew member uses ring-shaped devices for direct, peer-to-peer communication in a decentralised network. Each module in the settlement has its own server, with a limit of 100 users per server to prevent crowding. If a server reaches capacity, users are automatically redirected to the next available server.

- A sessionless, TCP-style protocol is used, with data in packets and no continuous connections. Here's how the protocol works:

  1. **Packet-Based Data Transmission:** Communication data is divided into smaller packets. These packets are sent individually,. They may take different routes and are reassembled by the receiving device.
  2. **Packet Confirmation:** Devices wait for server confirmation after sending each packet. If none is received, the packet is stored locally and retransmitted until the server confirms receipt.
  3. **Flow Control and Redirection:** Each module's server supports up to 100 users. If the server reaches its limit, new users are redirected to another available serverin the network.
  4. **Internal Communication:** The ring devices use laser-based technology for high-speed data transmission over distances of up to 1 km within the settlement, with each server managing packet flow.
  5. **Interplanetary Communication:** The same packet-based system is used, offering low latency. If this fails, the network switches to a radio-based backup, continuing to send packets without requiring a persistent session.
  6. **Error Detection and Data Integrity:** Each packet contains error-checking information. If an error is found, the packet is retransmitted to ensure data integrity



RfP: 6

Slide Author/s: Hassan

- The total cost of constructing and operating the **Golliac Space Settlement** by 2054, excluding inflation, is estimated to be **$44.95 billion**. Construction costs alone are projected at **$35.5 billion**, with **$15 billion** allocated for fabricating prefabricated modular units from high-grade metals, insulation, and glass, and **$10 billion** for transportation to Callisto. Mining regolith for local resource extraction will add **$1.5 billion**. Robotic systems, including swarm robots and 3D printers, will cost **$7 billion**, and energy for construction will require **$2 billion**.

- Operational infrastructure is projected to cost **$4.85 billion**. Life support systems, such as air recycling and CO_2 scrubbing for 300 people, will cost **$1.5 billion**, and oxygen generation and temperature control, including redundancy, will require **$1 billion**. Food production and storage systems, including a 2,500 sq. ft. hydroponic farm (producing 1 ton of food annually) and mealworm farms (producing 200 kg of protein annually), will cost **$1.25 billion**. Water extraction from Callisto's ice and water recycling systems will add **$1.1 billion**.

- Energy systems will total **$3.1 billion**, including **$800 million** for a solar array generating 2 MW of power, **$1.5 billion** for a 2 MW nuclear reactor, and **$800 million** for 10 MWh of battery storage. Safety and security systems will cost **$1.5 billion**, covering **$400 million** for radiation protection and AI detection systems, **$700 million** for automated emergency systems (fire suppression and evacuation pods), and **$400 million** for backup power and life support systems.

- Once the **Golliac Space Settlement** is fully operational, the **annual operating costs** are estimated at **$1.28 billion per year**. This includes **$200 million** for life support systems like air recycling and CO_2 scrubbing, and **$150 million** for oxygen generation and temperature control. Food production through hydroponic farming and mealworm farms will cost **$50 million** and **$20 million** respectively, while maintaining food storage and emergency reserves will add another **$30 million**. Water extraction from Callisto's ice and recycling systems will require **$100 million** and **$50 million** annually. Energy costs include **$50 million** for solar power, **$150 million** for the nuclear reactor, and **$30 million** for battery storage. **Robotic maintenance** and **self-repairing materials** will cost **$100 million** and **$50 million** per year, respectively. Finally, **resupply missions** and logistics are expected to cost **$200 million**, with another **$100 million** for maintaining infrastructure like landing pads and transport systems.