The mission would be designed in such a way that it performs a scientific study on the surface of the Moon, gaining data from the lunar surface that is as valuable as possible for advancement of the knowledge about the Moon's composition and the environment around it. This is a mission operating with extreme autonomy, having continuous contact between the space vehicle and Earth Mission Control. All these operations' central entity is the CDH subsystem, which serves as the center for command management, data processing, and communication with other onboard systems and Earth. It supports mission-critical functions such as scientific data gathering, control of the spacecraft's subsystems, and transmission through this sub-system. Thus, the constitution of the CDH will be based on a radiation-hardened processor, data storage systems, communications interfaces, and power management units integrated in such a way as to maintain the autonomy of the spacecraft and to preserve in a kept-safe environment the data processed in space. The paper summarizes the status of the currently designed status of the CDH subsystem; subsequently, it breaks down its subassemblies by looking into their functionality and an assessment in terms of technology readiness level (TRL) for each component. It also covers a breakdown in terms of mass, dimensions, and power requirements of the CDH subsystem, accompanied by an associated flow chart detailing the subsystem's data-handling architecture.

The Command and Data Handling subsystem is designed with several major subassemblies that integrate together to ensure that the spacecraft can receive commands, manage critical data, and interface effectively with mission control. The processing unit, as the brain of the system, executes commands from Earth and coordinates the spacecraft's real-time operations. It must be radiation-hardened due to the extreme conditions it will face during its space mission, especially from high levels of radiation. It is powered by the RAD750 processor, which is widely used for radiation-hardened microprocessors, operating onboard computation up to 200 MHz and previously being quite reliable during missions such as NASA's Mars Curiosity rover. The Field Programmable Gate Array complements the processor, offering hardware configurations that, given the mission requirements, the spacecraft could adapt to. The flexibility will be very handy regarding response to changes in the mission environment or objective, since the FPGA provides for changes in hardware functions even post-launch.

One more critical component of the CDH subsystem is data storage, which stores all telemetry, scientific measurements, and command logs securely. It consists of a subsystem that provides at least 256 GB storage capacity; this is provided by radiation-hardened SSDs. The capacity allows the spacecraft to store a volume of mission data accumulated throughout its journey. The SSDs are designed such that they can resist space radiation, retaining data intact without corruption during the mission. Complementing the SSDs, the non-volatile memory ensures that critical data is retained should power be disrupted, and even during system resets. This is significant in the case of deep space missions, where partial loss of data would amount to jeopardizing mission objectives, hence resulting in a chain of drawbacks. The Power Management Unit does this through the distribution of power from the primary spacecraft power system to the different components of the CDH for efficient operation. This has to be well regulated because each component would require a stable supply of electricity for its optimal performance. The DC-DC converters in the PMU ensure proper conversion of power provided from the main systems of the spacecraft to the proper voltage levels for each component of the CDH. On the contrary, it is the battery management system within this section that perceives the health and efficiency of the batteries within the spacecraft to guarantee continuation of the power supply without any disruption, even on occasions when the spacecraft itself is not generating any energy-for example, during an eclipse. This system is crucial in keeping the functions running on the CDH, taking into consideration that any stop in power would directly affect performance related to major subsystems. Communication interfaces of the CDH subsystem are crucial in supporting information flow between all the spacecraft subsystems and also in ensuring that communication to Earth remains unbroken. Internal and external communication falls under the logic of this subassembly, which sends out crucial information on telemetry, scientific data, and system health reports. These include the internal communication interfaces connecting the CDH subsystem with other onboard systems like power and propulsion, scientific instruments, etc. In general, external interfaces provide links with mission control on Earth for continuous contact; therefore, data and commands can be exchanged. That necessitates the reliability and low latency of communication interfaces for the large volume of data exchange over huge distances during space missions. Among others, some communication protocols used within the CDH subsystem include I2C, UART, and CAN bus protocols-which are follow-on large and well-established protocols for their reliability and efficiency. These protocols allow communications between CDH and several sensors and actuators located within every part of the spacecraft to enable smooth coordination of operations regarding the spacecraft. I2C is intended for short-distance communication of low-speed devices and therefore is suited best for inter-subsystem data transfers. More complex communicational needs are handled by UART and CAN bus to make sure all subsystems keep up with the critical operations in sync. Moreover, SpaceWire-a high-speed data bus specifically designed for space missions-will enable fast data transfers with negligible latency. The SpaceWire is also supposed to handle the volume of data that emanates from scientific instruments onboard so that the processed information will be forwarded with much success by the CDH subsystem.

Data integrity assurance with minimal delay in transport over huge distances is indeed one of the critical problems of space communication. SpaceWire responds to this challenge by providing a high level of fault tolerance and data integrity, both critical in ensuring continuous, reliable communication between the spacecraft and mission control. Particularly, this aspect is critical when scientific data is being downloaded from onboard instruments: any loss or corruption of data will undermine the scientific objectives of the mission. Apart from that, the communication interfaces will work together with the redundancy implemented at the spacecraft level in such a way that, even in the event of an failure on any of the subsystems, the communication will be maintained continuously without amber. In addition, the redundancy and fault tolerance contributory features are innate to the CDH subsystem, which allow the continuity of operation of the spacecraft even in the event of any occurrence that results in hardware failure. In deep space flight missions, where repairs cannot be affected, the factors of redundancy become of essence for mission success. The CDH subsystem has duplicate processors, data buses, and power lines to preclude a single-point failure taking out an entire system. Besides having a standby processor, in case of failure of the primary one, a backup processor would automatically take over within a fraction of a second without affecting the operations of the spacecraft. This switch-over would be done automatically, so that the spacecraft can continue its mission uninterruptedly by manual intervention from mission control. The redundant data buses act like alternative paths for subsystems to communicate. In case one of the data buses experiences failure, the CDH subsystem can forward data using another bus, hence ensuring that the integrity of the communication network is retained.

This is particularly important at mission-critical phases such as during the landing of data collection, where continuous communications between the subsystems are necessary for successful operation. In addition to mechanisms for fault tolerance, the subsystem will continuously monitor and diagnose health, locate potential problems that may become critical, and take preventive action. Diagnostic tools may enable the spacecraft to detect anomalies at an early stage and take corrective actions such as switching over to backup systems or rerouting data, for instance, to prevent mission failure. Such redundancy does not relate to only processing and communication components but further extends to the power management system. The PMU is designed with backup power lines, such that whenever there is failure in a primary power line feeding the CDH subsystem, there is an assurance of a continuous power supply in the CDH system. This ensures that the CDH system is always on, even when there's an unexpected disruption in power distribution. One interesting aspect of the design in the CDH subsystem is that it needs to function in less-than-ideal power environments by scaling back non-essential functions in case the spacecraft operates on a limited power supply. This would keep those few most important components, like the processor and communication interfaces, running even at reduced power availability. Integration with these subsystems empowers the CDH to execute not only complex operations of spacecraft but also to recover from malfunctioned hardware and continue further operations autonomously. Finally, the CDH subsystem is among the most important segments in a spacecraft since it is entrusted with the processing of all onboard data, executing commands from Earth, and maintaining communication between the spacecraft and mission control. Be it a processor, data storage, communication interfaces, or power management unit, each module has its contribution to enable the spacecraft to carry out its tasks for which it was launched into space.

The CDH subsystem integrates high-order hardware with software that enables the spacecraft to operate reliably in the harsh environment of space. The communication interfaces ensure proper effectuation of data transfer and execution of commands, while redundancy and fault tolerance exist as a safeguard for long-duration missions. Capabilities such as these make the CDH subsystem an integral part of the spacecraft that will perform all autonomous data processing, command execution, and operability for the duration of the mission.

Component Name	**Subsystem**	**Function**	**TRL**	**Remarks**
RAD750 Processor	CDH (Command Processing)	Executes spacecraft commands from Earth	TRL 9	Flight-proven in space missions like NASA’s Mars Curiosity rover
Field-Programmable Gate Array	CDH (Command Processing)	Customizes hardware functions post-launch	TRL 9	Allows dynamic reconfiguration of the spacecraft's hardware
Radiation-Hardened SSD	Data Storage	Stores mission data, telemetry, and command logs	TRL 7-8	Tested in space, withstands radiation
Non-Volatile Memory	Data Storage	Retains critical data during power	TRL 7-8	Common in deep space missions to

		disruptions		ensure data safety
I2C, UART, CAN Bus Protocols	Communication Interface	Manages internal spacecraft data communication	TRL 8-9	Reliable, industry-standard protocols for subsystem communication
SpaceWire Data Bus	Communication Interface	High-speed communication between subsystems	TRL 8-9	Proven for handling large data volumes and low-latency transfers
DC-DC Converters	Power Management Unit	Regulates power supply to CDH components	TRL 8-9	Flight-proven in spacecraft for power efficiency and stability
Battery Management System	Power Management Unit	Monitors battery health and ensures power flow	TRL 8-9	Ensures continuous operation during power fluctuations
Backup Processor	Redundancy System	Takes over if the primary processor fails	TRL 9	Standard in long-duration missions for ensuring redundancy and reliability
Redundant Data Buses	Redundancy System	Provides alternate data paths for communication	TRL 9	Ensures uninterrupted communication in case of failure
Diagnostic and Monitoring Tools	Health Monitoring	Continuously checks subsystem health	TRL 8-9	Detects anomalies and initiates corrective actions