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ANTICIPATED CHALLENGES & OPPORTUNITIES WITH NASA COMMERCIAL LUNAR PAYLOAD SERVICES MISSIONS

FIRST MODE

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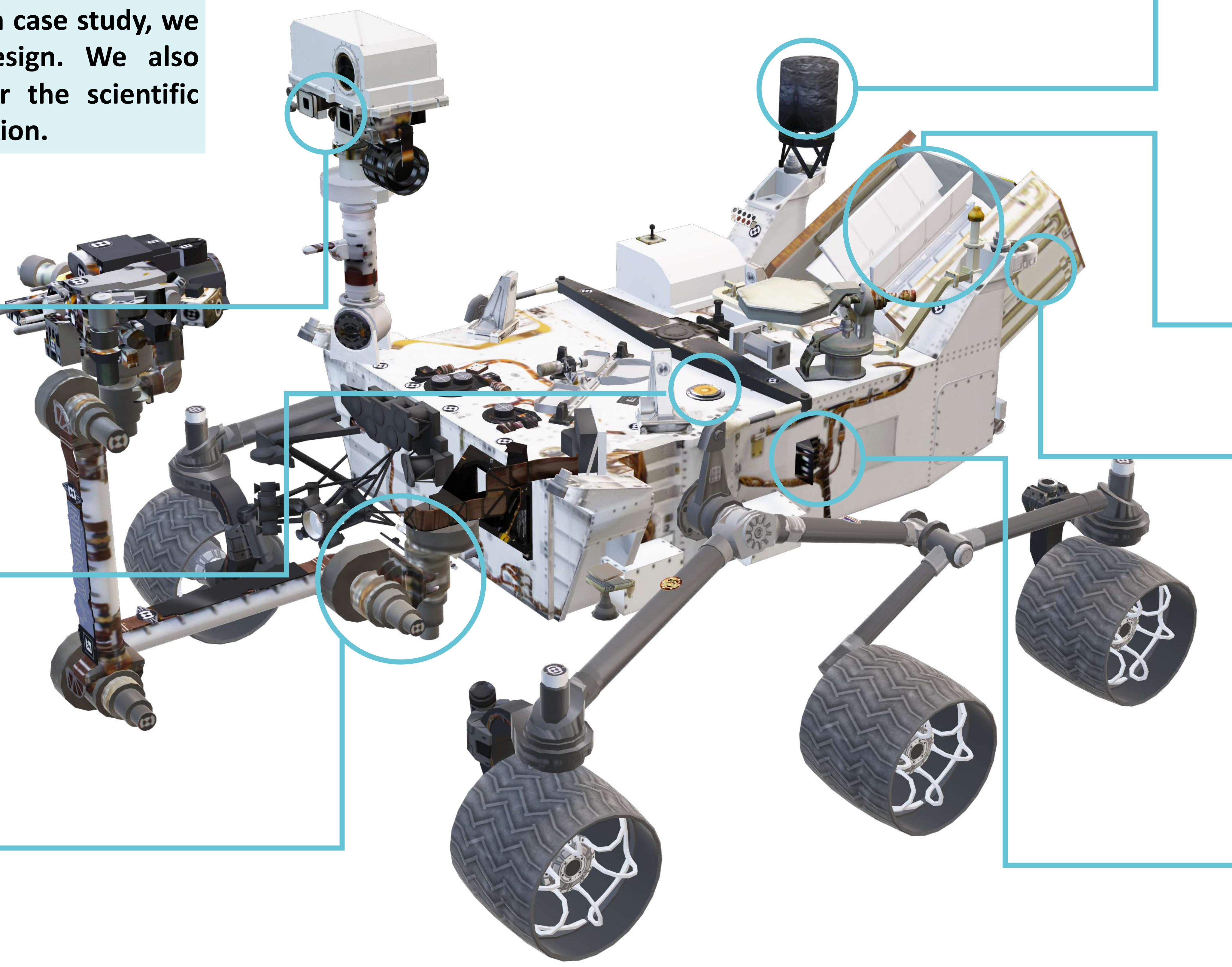
1. DESIGN & INTEGRATION CHALLENGES WITH CURIOSITY

Missions through NASA's Commercial Lunar Payload Services (CLPS) program will be a departure from the traditional spacecraft development approach in which payloads are designed concurrently with the spacecraft. Using NASA's Curiosity Rover as a case study, we describe how payloads can impact spacecraft design. We also describe potential challenges and opportunities for the scientific community with this novel approach to space exploration.



Configuration

One payload can have multiple components with mutually exclusive needs. Curiosity's 10 scientific investigations resulted in 23 components. Camera optics such as PanCam's are located outside the rover body, but their electrical units are inside for thermal control and radiation protection.

Contamination

The Radium Assessment Detector (RAD) contains a cesium iodide crystal that could not be exposed to humidity. Protecting RAD throughout integration until the rocket launched required a nitrogen gas purge. Planning for the gas purge began at the initial rover design phase.

Arms & Masts

Robotic arms and masts cannot be designed without knowing what payload they will support. Electrical and mass needs from MAHLI, ChemCam, and other mounted instruments drove the arm/mast diameter, motor size, and cabling.

Electromagnetic Interference

Scientific payloads and engineering subsystems such as the RUHP Antenna, used for communication, can easily interfere with each other unless they are purposefully designed not to.

Active Radiation Sources

The MMRTG and Dynamic Albedo of Neutrons (DAN) active source must be physically isolated from other instruments due to the radiation they emit. When DAN is operating, the other instruments must be powered off for safety.

Thermal Control

Detectors and other thermally sensitive components require careful thermal management, so the rover has multiple thermally isolated zones for components with different temperature requirements. Heat from the MMRTG is rejected or accepted as needed to maintain a constant temperature range.

Routing Management

The routing of cables, fluids, and fiberoptics is a nontrivial task. Power lines and signal lines require shielding from each other, but shieldings limit range of motion by increasing the cable's diameter. The Sample Analysis at Mars (SAM) instrument alone contains 600 m of wiring.

2. CLPS: POTENTIAL CHALLENGES

Non-Scientific Payloads

CLPS companies are service providers, and NASA is but one customer. Non-scientific payloads could come from companies doing a marketing campaign, individuals sending mementos, or other non-traditional payloads. It is unclear how the behavior of these other payloads in space may affect scientific operations and who is responsible for managing potential impacts.

Unprecedented Complexity

Initial CLPS missions are flying as many as 28 payloads, more than any other NASA mission has ever flown. As demonstrated above, many of the challenges with integration are related to managing the interactions of payloads and other subsystems with each other.

Scientific Decision-Making

A traditional scientific NASA mission has a centralized science team, led by a PI or project scientist. In the CLPS model, there is no science team and not all payloads are even scientific. Scientists may not be as empowered to impact technical and operational decision-making as they are on NASA missions.

Cost and Schedule Pressure

Based on the CLPS program structure, providers are incentivized to deliver payloads to the Moon as cheaply and quickly as possible. While not inherently bad, technical compromises to meet these terms could affect payload science return in ways outside of the control of the scientists.

3. CLPS: POTENTIAL OPPORTUNITIES

Technology Development

By providing more flight opportunities for scientific instruments, the planetary science community will be able to iterate on new technology more rapidly. This could also result in a shift from flying high-heritage instruments to more technical risk-taking.

Reduced Cost

The transportation service model of CLPS, like NASA's Commercial Crew program with SpaceX and Boeing, is intended to reduce mission costs to the Moon by stimulating competition and incentivizing technical innovation.

Higher Mission Cadence

Decades can pass between planetary science missions to a particular target. If the CLPS program is successful, this new model of exploration can be applied to other planetary bodies and decrease the time between missions to a particular target.

Lower Barrier to Entry

With lower mission costs and more flight opportunities, a greater number of scientists will have the opportunity to fly scientific payloads and gain hardware and mission experience, which can in turn benefit NASA-led missions.

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