**Artemis Research**

Below is a summary of our research into the real-life Artemis missions, with proposals for naming of the Systems and Elements comprising the game, as well as names and descriptions for the 4 stages of development upgrade for each element.

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| **3 Element System** | **Space Launch System** |  |  |
| **Element Name** | **Avionics** | **Core Stage & Propulsion** | **Interim Cryogenic Propulsion Stage** |
| **Minor 1:**  **Description:** | **Rocket sensors**  Sensors form a crucial part of the avionics setup, allowing for continuous monitoring of the rocket components and the effect of external factors on their operation. | **Fuel tanks**  The liquid hydrogen fuel tank consists of five welded barrel sections and two end domes. The aft end of the liquid hydrogen tank includes four liquid hydrogen feedlines to the RS-25 engines. | **Orion Stage Adapter**  The highest SLS element in the SLS stack, the Orion stage adapter, connects the ICPS to the Orion spacecraft. The Orion stage adapter is 18 ft. (5.5 m) in diameter, 5 ft. (1.5 m) tall, and is made of lightweight aluminium. |
| **Minor 2:**  **Description:** | **Controller boxes & cabling**  Avionics act as the 'central nervous system' for the SLS, coordinating its actions, with the controller boxes and over 55 miles of cabling forming a complex web to allow for intercommunication between avionics components | **Propellant**  The main propulsion system flow rates and interfaces were designed around the RS-25 configuration and the need to supply propellants to the engines under temperature and pressure conditions required by the engines. | **Liquid oxygen tank**  The ICPS is a single-engine liquid hydrogen/liquid oxygen-based system that provides in-space propulsion after the solid rocket boosters and core stage are jettisoned. |
| **Minor 3:**  **Description:** | **Virtual launch environment**  The VLE allows engineers to fully simulate the integration of systems in virtual space prior to hardware manufacturing and test flight. Engineers in the lab also create and run end-to-end simulation environments in support of the entire project life cycle. | **4 RS-25 Engines**  Each of the RS-25 engines burn cryogenic liquid hydrogen and liquid oxygen propellants, with each engine producing 1,859 kN of thrust at lift-off. | **Liquid hydrogen tank**  Based on the proven Delta Cryogenic Second Stage, the ICPS will include a lengthened liquid hydrogen tank, and added hydrazine bottles for attitude control |
| **Major:**  **Description:** | **Flight computers**  Three redundant flight computers, monitors the rocket’s condition, senses vehicle motion, generates navigation and control data, actuates main propulsion system valves, monitors the main propulsion system and engine controls, and routes flight-critical commands to engine thrust vector control systems, and controllers. | **Rocket Boosters**  A pair of solid rocket boosters attached to the core stage supply more than 75 percent of total SLS thrust for the first two minutes of flight. They are the largest, most powerful solid propellant boosters ever built for flight. | **Aerojet Rocketdyne engine**  The Rocketdyne RL10 has been in use for more than 50 years to launch numerous military, government, and commercial satellites into orbit and send spacecraft to every planet in the solar system. |

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| **3 Element System** | **Orion Spacecraft** |  |  |
| **Element Name** | **Crew Module** | **Launch Abort Systems** | **Service Module** |
| **Minor 1:**  **Description:** | **Power generators**  The four Orion solar arrays generate about 11kW of power and spread 62 feet when extended. Orion’s batteries use small cell packaging technology to ensure crew safety when providing 120V power to the many systems on Orion. | **Fairing Assembly**  The Fairing Assembly will shield the crew module from the severe vibrations and sounds it will experience during launch. One of the fairing panels has a hatch to allow access to the crew module before launch. | **Spacecraft adapter**  During launch the service module is held in place by the Spacecraft Adapter and is connected to the capsule where the astronauts are by the Crew Module Adapter. |
| **Minor 2:**  **Description:** | **Crew quarters**  Inside Orion's cabin are four adjustable seats, which can accommodate a range of different body sizes and shapes. While the astronauts are strapped into them, they can see out through four windows located above the head rests. | **Attitude Control Motor**  On an aborted launch, the Attitude Control Motor will steer and orient the Orion capsule for a safe ocean landing. | **Power & thermal control**  Radiators and heat exchangers keep the astronauts and equipment at a comfortable temperature, while the module’s structure is the backbone of the entire vehicle, like a car chassis. |
| **Minor 3:**  **Description:** | **Guidance, Nav & Control Systems**  A control console with three display screens and 67 physical switches allows the pilot and commander to monitor the spacecraft during flight. For comparison, each space shuttle had 10 displays along with more than 1,200 switches, dials, and gauges. | **Jettison Motor**  The jettison motor will be used during every launch whether an issue occurs or not. That’s because, even when everything goes according to plan, the LAS needs to safely separate from the crew module so Orion can continue its mission. | **Water & air support**  The service module will provide enough water and air for up to four astronauts on a 20-day mission. |
| **Major:**  **Description:** | **ECLSS**  Orion Environmental Control and Life Support System (ECLSS) will allow for a speedy abort of the mission should issues be found in the system which may compromise crew safety. | **Abort Motor**  Pulls the Orion capsule away from the rocket in the event of an aborted launch. | **Orbital transfer propulsion**  Three types of engine push Orion to its destination and can turn it in all directions to align the spacecraft as needed. |

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| **“Start”** | **Mission Control** |
| **“Free Parking”** | **Exploration Ground Systems** |

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| **2 Element System** | **Gateway**  (cheapest) |  |
| **Element Name** | **Power & Propulsion Element** | **Habitation & Logistics Outpost** |
| **Minor 1:**  **Description:** | **Solar arrays**  Two Roll-Out Solar Arrays will provide a staggering 65 kilowatts of power to the largest solar electric propulsion system ever produced for a civilian spacecraft | **CAPSTONE Cubesat**  The satellite will be launched into the lunar Near Rectilinear Halo Orbit (NRHO), testing new navigation techniques to validate predictive models, reducing uncertainties about the orbit, and paving the way for the eventual launch of the Gateway. |
| **Minor 2:**  **Description:** | **S-band comms system**  Today's the public expects high-definition video and images from Artemis. Gateway will support  near 24/7 communication with Earth when crew is present, either on board Gateway or via the relay capability to crew ascending or descending to the lunar surface or living on the Moon. | **Pressure control systems**  Thales Alenia Space has been commissioned to design and build the HALO's primary structure (the pressurised module), and the pressure control system for the module and vestibule, part of the protection system against micrometeorites. |
| **Minor 3:**  **Description:** | **Science payload**  The unique environment in lunar orbit, one that cannot be duplicated on Earth or on the International  Space Station, will provide new opportunities for scientific investigation. | **Lunar Surface Comms**  Unlike typical science missions which require a very low data rate to support commanding, crewed missions require much higher uplink rates with low latency to support synchronized audio with video transfer, family communications, and private medical conferences. |
| **Major:**  **Description:** | **Ion thrusters**  PPE’s 50kW electric propulsion system will be the most powerful electric propulsion spacecraft ever flown and it will manoeuvre Gateway around the Moon, opening up more of the lunar surface for exploration than ever before. | **Docking Ports**  HALO will be equipped with 3 docking ports for visiting vehicles and future modules, as well as space for science and stowage. |

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| **2 Element System** | **Lunar Base Camp**  (most expensive) |  |
| **Element Name** | **Human Landing System** | **xEMU Spacesuit** |
| **Minor 1:**  **Description:** | Super Heavy Booster  The first stage, located at the bottom of the rocket, housing up to thirty-three sea-level-optimized Raptor engines. The engine cluster may be more than twice as powerful as the Saturn V. | Portable life support system  The familiar backpack astronauts wear on spacewalks that houses the suit’s power and breathable air and removes exhaled carbon dioxide and other toxic gasses, odours and moisture from the suit. |
| **Minor 2:**  **Description:** | Surface transportation  As the habitable module will be located well above ground level, the HLS will provide an elevator system to allow for crew and payload transportation to the lunar surface. | High-speed data comms system  The new audio system includes multiple, embedded, voice-activated microphones inside the upper torso that automatically pick up the astronaut’s voice when they speak to their fellow spacewalker, their crewmates aboard the Gateway, or mission control in Houston. |
| **Minor 3:**  **Description:** | Payload storage & habitable module  As the Starship HLS will never re-enter an atmosphere, it does not have a heat shield or Flight control surfaces, allowing maximum weight and space for payload volume and crew quarters. | Membrane evaporative cooling system  An innovate approach to temperature regulation. Miniaturization of electronics and plumbing systems have made it possible to build in duplicates for much of the system, making some failures less of a concern. |
| **Major:**  **Description:** | Reaction Control System thrusters  When operating within tens of meters of the lunar surface the HLS will use high‑thrust RCS thrusters located mid‑body to avoid plume impingement problems with the lunar soil. The thrusters burn gaseous oxygen and methane. | Enhanced mobility system  Includes advanced materials and joint bearings that allow bending and rotating at the hips, increased bending at the knees, and hiking-style boots with flexible soles. On the upper torso, shoulder enhancements allow astronauts to move their arms more freely and easily lift objects over their heads in the pressurized suit. |

**Game introduction from Presidential Statement**

“[Player 1], … & [Player n] will lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to earth new knowledge and opportunities. Beginning with missions beyond low-earth orbit, the US will lead the return of humans to the Moon for long-term exploration and utilisation, followed by human missions to Mars and other destinations.”

**Timeline of milestones for use in epilogue**

1. **First CLPS Mission**

In 2021, first CLPS deliveries will begin with two companies delivering 16 instruments to the lunar surface that will pave the way for human explorers.

1. **VIPER**

Golf-cart sized rover will be first to investigate lunar polar soil samples to characterise the distribution and concentration of volatiles, including water, across a large region on the Moon.

1. **CAPSTONE CubeSat**

First spacecraft to enter the lunar Near Rectilinear Halo Orbit – the future home of the Gateway. There it will test new navigation techniques to validate predictive models, reducing uncertainties about the orbit.

1. **Artemis I**

Uncrewed maiden flight of SLS and Orion – verify spacecraft performance and test Orion’s heat shield during its high-speed Earth re-entry at nearly 5000F.

1. **PPE & HALO Launch**

The PPE and HALO are first pieces of the Gateway. On-board science investigations from NASA and European Space Agency will conduct early characterization of the deep space environment.

1. **Artemis II**

10-day crewed test flight, record-setting for farthest human travel from Earth. Will validate deep space comms and nav systems and ensure that life-support systems keep them healthy and safe.

1. **Artemis III**

Orion and its crew will once again travel to the Moon, this time boarding the HLS that will bring the first woman and next man to the lunar surface.