|  |  |  |  |
| --- | --- | --- | --- |
| **3 element** | **Space Launch System** |  |  |
|  | **Avionics** | **Core Stage & Propulsion** | **Interim Cryogenic Propulsion Stage** |
| **Minor 1** | Rocket sensors | Fuel tanks | Orion Stage Adapter |
| **Minor 2** | Controller boxes & cabling | Propellant | Liquid oxygen tank |
| **Minor 3** | Virtual launch environment | 4 RS-25 Engines | Liquid hydrogen tank |
| **Major** | Flight computers | Rocket Boosters | Aerojet Rocketdyne engine |
|  |  |  |  |
| **3 element** | **Orion Spacecraft** |  |  |
|  | **Crew Module** | **Launch Abort Systems** | **Service Module** |
| **Minor 1** | Power generators | Fairing Assembly | Spacecraft adapter |
| **Minor 2** | Crew quarters | Attitude Control Motor | Power & thermal control |
| **Minor 3** | Guidance, Nav & Control Systems | Jettison Motor | Water & air support |
| **Major** | ECLSS | Abort Motor | Orbital transfer propulsion |
|  |  |  |  |
| **2 element** | **Gateway** |  |  |
|  | **Power & Propulsion Element** | **Habitation & Logistics Outpost** |  |
| **Minor 1** | Solar arrays | CAPSTONE Cubesat |  |
| **Minor 2** | S-band comms system | Pressure control systems |  |
| **Minor 3** | Science payload | Comms to lunar surface |  |
| **Major** | Ion thrusters | Docking ports |  |
|  |  |  |  |
| **2 element** | **Lunar Base Camp** |  |  |
|  | **Human Landing System** | **xEMU Spacesuit** |  |
| **Minor 1** | Super Heavy Booster | Portable life support system |  |
| **Minor 2** | Surface transportation | High-speed data comms system |  |
| **Minor 3** | Payload storage & habitable module | Membrane evaporative cooling system |  |
| **Major** | Reaction Control System thrusters | Enhanced mobility system |  |
|  |  |  |  |
| **“Start”** | **Mission Control** |  |  |
| **“Free Parking”** | **Exploration Ground Systems** |  |  |

My thinking was that to provide an educational element to the game, the upgrades should have a sentence, when the upgrade is completed by a player, demonstrating the importance of each upgrade to the overall element.

I haven’t included a lot of the ‘Core Mission Elements’ from Appendix 3 of the NASA pdf linked in the ArtemisLite document as I don’t think many of the more fanciful things, like the “Habitable Mobility Platform’, are actually planned to be part of the first moon landing. I think if it happens at all it’ll be focussed on the basics. Although having said that putting some of the cooler stuff in might make the game more interesting… Happy to hear anyone’s thoughts on it anyway, just thought I’d put this together as I enjoy the space stuff!

**Possible game intro 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.”

**SLS (probable 3 element)**

* **Avionics** (3 flight computers)
* Virtual launch environment for testing
* Rocket sensors
* Avionics controller boxes & over 55 miles cabling to communicate between sensors and computers)
* assembled at Kennedy Space Centre
* **Interim Cryogenic Propulsion Stage** (ICPS) pushes Orion to Moon, separates from Orion and releases 13 CubeSats for science missions
* Orion Stage Adapter (partially covers ICPS, connects Core stage to upper part of rocket)
* **Core Stage** (5 components including fuel tanks)
* **4 RS25 engines** (use liquid hydrogen & liquid oxygen stored in core stage tanks)
* at side of core stage are 2 solid **rocket boosters**, provide most of thrust to get SLS to space (top and bottom (or forward and aft), central section stores propellant and motors)

**3 elements proposed: avionics, core stage & propulsion, ICPS**

**avionics:**

**Orion Spacecraft (probable 3 element)**

* **Launch abort system** (positioned on a tower atop crew module, can activate within milliseconds to propel vehicle to safety and position crew module for a safe landing) LAS comprises:
* Jettison Motor – will pull the LAS away from the crew module, allowing Orion’s parachutes to deploy and the spacecraft to safely land in the ocean
* Attitude Control Motor – Solid propellant gas generator with 8 proportional valves equally spaced around the outside of the three-foot diameter motor. Motor can exert up to 7000 lb of steering force to the vehicle in any direction upon command from the Orion crew module
* Abort Motor – produces approx. 400000 lb thrust to quickly pull crew module away from danger if problems develop on the launch pad or during ascent
* Fairing assembly – lightweight composite structure that protects the capsule from heat, wind and acoustics
* **Crew module** (advances in life-support, avionics, power systems, advanced manufacturing techniques)
* Service module (provides support to the crew module from launch through separation prior to entry. Provides in-space propulsion for orbital transfer, power and thermal control, attitude control and high-altitude ascent aborts. also provides water and air support to crew whilst mated with crew module.
* Spacecraft Adapter (attaches the Orion spacecraft to the SLS rocket)

**3 elements proposed: crew modules, launch abort system, service module**

**Gateway (probable 2 element, cheapest)**

* **Power and Propulsion Element**
* solar arrays
* ion thrusters
* attitude control motor
* S-band communications systems
* Science payload
* **Habitation & Logistics Outpost (HALO)**
* CAPSTONE Cubesat – test and verify the calculated orbital stability of a near rectilinear halo orbit (NRHO) around the Moon
* docking ports for Orion, HLS and Cargo
* environmental control systems
* Life support systems to augment the Orion spacecraft and support crew members

**Artemis Base Camp (probable 2 element, most expensive)**

* **Exploration Extravehicular Mobility Unit xEMU (spacesuit)**
* Integrated high-speed data communication system
* Enhanced Mobility System
* Environment Protection Garment (EPG) w/Dust Mitigation
* Membrane Evaporative Cooling System
* Modular Portable Life-Support System
* Vacuum Regenerative Carbon Dioxide Removal System
* **HLS**
* Super Heavy Booster – 33 Raptor Engines
* Reaction Control System thrusters
* Habitable module & payload storage
* Main hatch and surface transportation

**Exploration Ground Systems (Free Parking?)**

**Partners (possible ideas for external events?):**

1. Canadian Space Agency (CSA)

* advanced robotics for Gateway

1. European Space Agency (ESA)

* provide International Habitat (IHab)
* ESPRIT module, delivering additional comms capabilities, science airlock for deploying science payloads and CubeSats, and refuelling gateway

1. Japan Aerospace Agency (JAXA)

* habitation components
* logistics resupply

1. Commercial Lunar Payload Services (CLPS)

* US commercial space industry suppliers
* introduce new lander technologies to deliver NASA and commercial payload to moons surface

**Timeline of milestones**

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.