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NASA'S ESCAPADE
(Escape and Plasma Acceleration and Dynamics Explorers) Mission

REPORT

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EXECUTIVE SUMMARY

NASA's ESCAPADE (Escape and Plasma Acceleration and Dynamics Explorers) mission represents a turning point in planetary exploration. Two identical spacecraft, nicknamed Blue and Gold, will journey to Mars to solve one of the Red Planet's greatest mysteries: how did Mars transform from a potentially habitable world with a thick atmosphere into the frozen desert we see today?

This mission combines cutting-edge science with commercial innovation. Led by UC Berkeley's Dr. Robert Lillis, built by Rocket Lab, and launched by Blue Origin's New Glenn rocket, ESCAPADE demonstrates that world-class planetary science doesn't require billion-dollar budgets. The entire mission costs less than $80 million a fraction of traditional Mars missions.

Blue Origin plays a critical role beyond just providing launch services. The company's New Glenn rocket, making only its second flight carrying ESCAPADE, represents America's entry into heavy-lift commercial spaceflight. This partnership between NASA and commercial space companies signals a new era of accessible, affordable planetary exploration.

INTRODUCTION: MARS' CLIMATE CATASTROPHE

Imagine standing on Mars four billion years ago. Above you stretches a thick atmosphere. Rivers flow through valleys. Lakes dot the landscape. The temperature is warm enough for liquid water to persist on the surface. Life might even exist in those ancient Martian waters.

Fast forward to today. That same Mars is a frozen wasteland. The atmosphere is so thin that it contains less than 1% of Earth's atmospheric pressure. Water can't exist as a liquid on the surface it either freezes solid or evaporates instantly. Average temperatures hover around -80°F (-60°C). The planet appears dead.

What happened? Where did all that atmosphere go? Why did Mars die while Earth thrived?

These questions drive NASA's ESCAPADE mission. Understanding Mars' atmospheric loss isn't just about satisfying scientific curiosity. It helps us understand planetary habitability throughout the universe, prepares us for future human exploration of Mars, and might even teach us about Earth's own atmospheric future.

The story of Mars is a cautionary tale written in planetary scale. ESCAPADE will help us read that story.

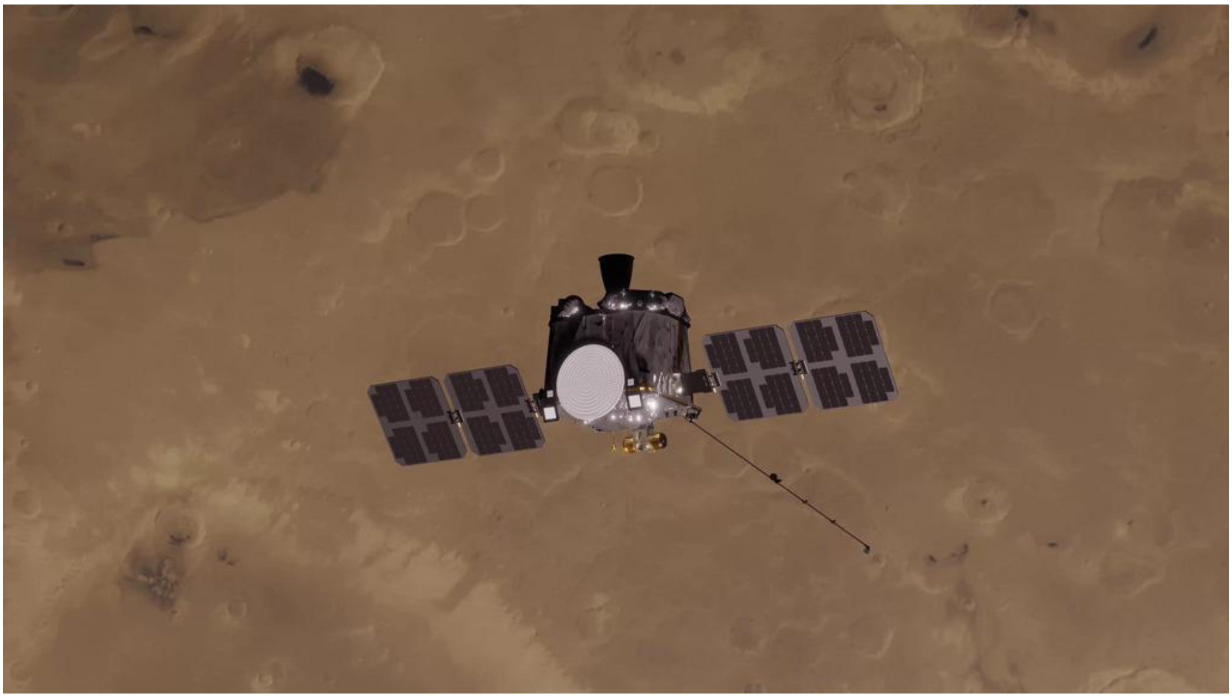

Figure-4: ESCAPASDE Mission spacecraft

WHAT IS ESCAPADE?

MISSION OVERVIEW:

The ESCAPADE mission will send two identical satellites to orbit Mars and study how space weather affects the planet's unique "hybrid" magnetosphere, which plays a role in atmospheric loss. By collecting data on how solar wind interacts with Mars' thin atmosphere and magnetized crust, the mission hopes to understand how Mars lost its once-thick atmosphere an atmosphere that may have supported liquid water and possibly life.

Mars' magnetosphere is made up of leftover magnetic fields from an ancient core and a weaker magnetic field in its upper atmosphere. The solar wind, charged particles, and Mars' atmosphere constantly interact, contributing to the planet's atmospheric loss. ESCAPADE's twin satellites will measure Mars' upper atmosphere and magnetosphere at altitudes between 100 and 6,200 miles (160 and 10,000 km), giving important insights into how Mars' space weather affects its atmosphere.

The ESCAPADE mission is managed by the Space Sciences Laboratory at the University of California, Berkeley, with key partners Rocket Lab, NASA's Goddard Space Flight Center, Embry-Riddle Aeronautical University, Advanced Space LLC, and Blue Origin.

PART OF NASA'S SIMPLEX PROGRAM:

ESCAPADE is part of NASA's Small Innovative Missions for Planetary Exploration (SIMPLEx) program, which aims to conduct high-value planetary science at significantly reduced costs by accepting higher risks and faster development timelines.

Traditional Mars missions often take a decade to develop and cost hundreds of millions to billions of dollars. ESCAPADE flips this model:

- **Development Time**: 3.5 years (compared to typical 10+ years)
- **Total Mission Cost**: Less than $80 million
- **Spacecraft Cost**: $55 million for both spacecraft and all instruments
- **Launch Cost**: $20 million

For comparison:

- NASA's MAVEN mission: $582 million
- Mars 2020 (Perseverance rover): Over $2 billion
- The failed 1999 Mars Polar Lander: $165 million

ESCAPADE proves that affordability doesn't mean compromising on science quality. The mission carries sophisticated instruments and will return data that complements observations from much more expensive missions.

LEADERSHIP AND TEAM:

Principal Investigator: Dr. Robert Lillis, UC Berkeley Space Sciences Laboratory

Key Partners:

- **Rocket Lab**: Spacecraft design and construction
- **Blue Origin**: Launch services with New Glenn rocket
- **NASA Goddard Space Flight Center**: EMAG magnetometer instrument
- **Embry-Riddle Aeronautical University**: ELP Langmuir Probe Suite
- **Advanced Space LLC**: Mission trajectory design

This collaborative approach leverages the strengths of academia, commercial space companies, and government agencies.

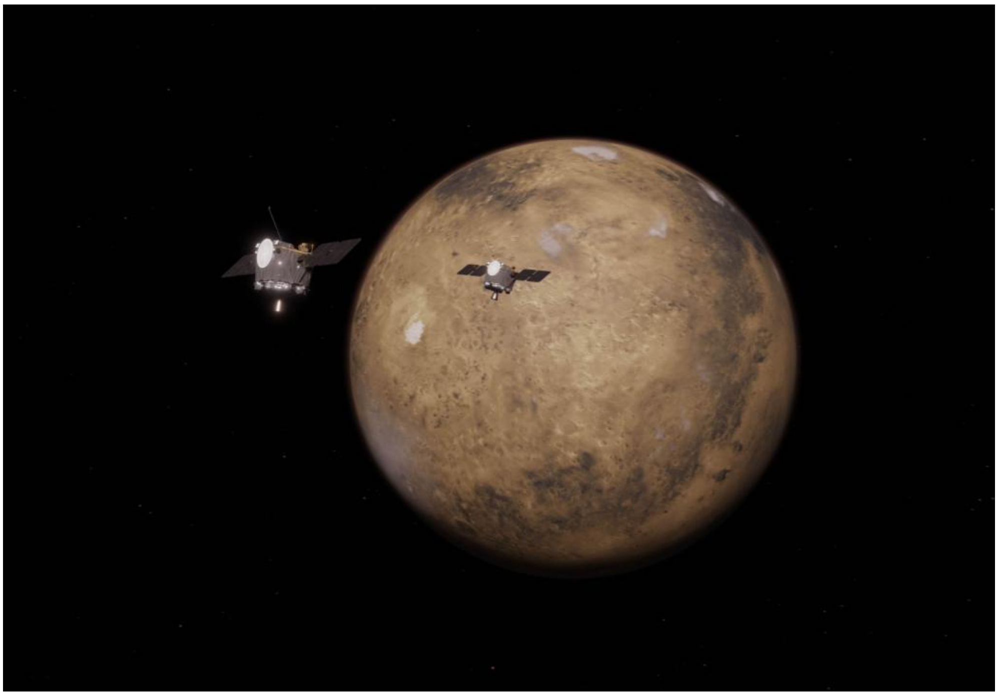

Figure 1-Preaparing for martin explorers

THE SCIENCE BEHIND MARS ATMOSPHERIC LOSS

ANCIENT MARS: A DIFFERENT WORLD

Mars wasn't always the cold, barren desert we observe today. Multiple lines of evidence indicate that early Mars was dramatically different:

Geological Evidence:

- Valley networks resembling dried river systems
- Ancient lakebeds and deltas
- Minerals that only form in the presence of liquid water
- Rounded pebbles smoothed by flowing water

Atmospheric Evidence:

- Isotope ratios in the current atmosphere indicate massive loss over time
- Approximately 65% of Mars' argon has escaped to space
- The majority of Mars' carbon dioxide is gone

For liquid water to exist on the surface, ancient Mars needed:

- A much thicker atmosphere (possibly similar to Earth's)
- Temperatures above freezing point
- Atmospheric pressure sufficient to prevent water from instantly evaporating

THE SOLAR WIND: MARS' ATMOSPHERIC ENEMY:

The solar wind is a continuous stream of charged particles (primarily protons and electrons) blasting from the Sun at roughly one million miles per hour. On Earth, we're protected by our strong magnetic field, which deflects most solar wind particles around the planet like a shield.

Mars lost its global magnetic field billions of years ago when its core cooled and solidified. Without this protective shield, the solar wind directly attacks the Martian atmosphere through several mechanisms:

1. Sputtering High-energy ions from the solar wind physically knock atmospheric particles off Mars and into space. Imagine a cosmic sandblaster working continuously for billions of years.

2. Ion Pickup Solar wind particles can strip electrons from neutral atmospheric atoms, creating ions. These newly created ions are then swept away by the solar wind's magnetic field.

3. Charge Exchange Fast-moving solar wind ions can steal electrons from slower atmospheric particles, accelerating the atmospheric particles to escape velocity.

NASA's MAVEN mission confirmed that Mars currently loses about 100 grams (roughly a quarter pound) of atmosphere every second to the solar wind. While that sounds small, over four billion years, it adds up to catastrophic atmospheric loss.

The Hybrid Magnetosphere:

Although Mars lacks a global magnetic field like Earth's, it does have localized magnetic fields frozen in ancient crustal rocks, particularly in the southern highlands. These create a unique "hybrid" magnetosphere part crustal fields, part induced fields from solar wind interaction.

This hybrid structure is one of the most complex and least understood magnetospheric configurations in the solar system. ESCAPADE will study how this hybrid magnetosphere controls ion flows, how energy and momentum transfer from the solar wind through Mars' magnetosphere, and how these processes drive atmospheric escape.

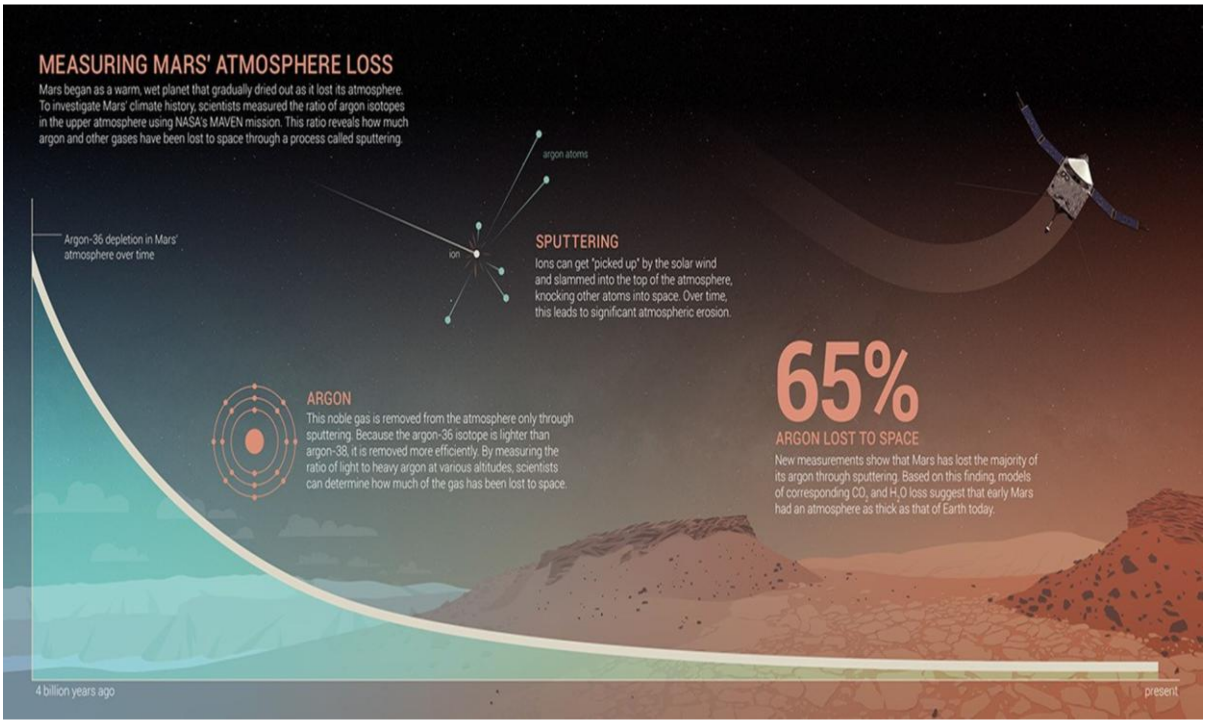

Figure:2- Measuring Mars’ Atmosphere Loss

MISSION OBJECTIVES

ESCAPADE has three primary scientific objectives: understand the processes controlling the structure of Mars' hybrid magnetosphere and how it guides ion flows; understand how energy and momentum are transported from the solar wind through Mars' magnetosphere; and understand the processes controlling the flow of energy and matter into and out of the collisional atmosphere.

Let's break these down:

OBJECTIVE 1: MAPPING THE HYBRID MAGNETOSPHERE

Mars' magnetosphere is unlike any other in the solar system. Without a global magnetic field, but with strong crustal magnetic fields in certain regions, the interaction between solar wind and Mars creates a complex, dynamic structure.

What ESCAPADE Will Do:

- Map magnetic field strength and direction throughout Mars' space environment
- Track how crustal magnetic fields deflect solar wind
- Observe how the magnetosphere changes during solar storms

Why It Matters: Understanding this structure tells us how effectively Mars' remaining defenses work against atmospheric loss. It also provides insights into how other planets without global magnetic fields (like Venus) interact with their space environment.

OBJECTIVE 2: ENERGY AND MOMENTUM TRANSFER

When the solar wind impacts Mars, enormous amounts of energy and momentum must be transferred and redistributed. This energy drives atmospheric escape, heats the upper atmosphere, and creates spectacular auroras.

What ESCAPADE Will Do:

- Measure energy flow from the solar wind into Mars' magnetosphere
- Track how this energy is redistributed
- Observe momentum transfer that accelerates particles to escape velocity

Why It Matters: Energy and momentum transfer rates determine how quickly Mars loses its atmosphere. By measuring these processes in real-time, scientists can calculate past and future atmospheric loss rates.

OBJECTIVE 3: ATMOSPHERIC ESCAPE MECHANISMS

Multiple processes drive atmospheric escape: sputtering, ion pickup, charge exchange, photochemical escape, and thermal escape. Each mechanism operates differently under varying conditions.

What ESCAPADE Will Do:

- Measure particle flows entering and leaving the atmosphere
- Distinguish between different escape mechanisms
- Observe how escape rates change with solar activity

Why It Matters: Understanding which mechanisms dominate under which conditions allows scientists to model Mars' atmospheric history. This helps answer fundamental questions: Was Mars ever habitable? For how long? Could life have emerged?

THE POWER OF TWO SPACECRAFT:

What makes ESCAPADE truly revolutionary is having two spacecraft taking measurements simultaneously from different locations. This provides:

Temporal vs. Spatial Separation:

- Is something changing over time at one location, or is it different in two locations at the same moment?
- Single spacecraft can't answer this question
- Two spacecraft can

Cause and Effect:

- One spacecraft can observe incoming solar wind conditions
- The other observes Mars' atmospheric response
- Scientists can directly connect cause (solar wind) to effect (atmospheric loss)

Real-Time Response:

- How quickly does Mars' magnetosphere respond to changes in solar wind?
- How do different regions respond differently?
- What drives these variations?

This will be the first multi-spacecraft mission wholly dedicated to orbital science around Mars.

THE SPACECRAFT: ENGINEERING EXCELLENCE

BUILT BY ROCKET LAB:

Each ESCAPADE spacecraft is built by Rocket Lab using their Photon spacecraft platform, with a dry mass of approximately 200 kg (440 pounds) and fully fueled mass of less than 550 kg (1,210 pounds). The compact dimensions roughly 60 × 70 × 90 cm when stowed belie their sophisticated capabilities.

Rocket Lab completed both spacecraft in just three and a half years, a remarkably short timeline for an interplanetary mission. As Christophe Mandy from Rocket Lab noted, typical Mars missions take a decade to develop. ESCAPADE's rapid development demonstrates what's possible when commercial space capabilities meet streamlined mission requirements.

SPACECRAFT DESIGN:

Based on Photon Platform: Rocket Lab's Photon is a proven spacecraft bus originally developed as an upper stage. For ESCAPADE, it's been adapted for deep space operations with several key modifications:

Power System:

- Two fixed solar array wings, each 480 × 70 cm
- Total power generation: 260 watts
- 7s5p battery assembly for energy storage
- Arrays tilted at a fixed angle to maximize solar illumination while minimizing electrical noise

Propulsion System: Chemical propulsion uses hypergolic bipropellant: monomethyl hydrazine (MMH) as fuel and mixed nitrogen oxides (MON) as oxidizer. Rocket Lab's HyperCurie engines provide over 2,500 m/s of delta-V capability enough for Mars orbit insertion and all orbital maneuvers.

The spacecraft design features an extremely high propellant mass fraction nearly 70% of total mass is fuel. This allows for the substantial velocity changes needed to reach Mars and maneuver into science orbits.

Attitude Control:

- Four reaction wheels for precision pointing
- Two star trackers for navigation
- Four fine Sun sensors for solar orientation
- Cold nitrogen gas thrusters as backup and for reaction wheel desaturation
- Inertial measurement units for motion sensing

Communications:

- X-band radio system
- 60 cm diameter high-gain dish antenna for primary communications
- Four low-gain patch antennas for backup
- Two medium-gain patch antennas for intermediate ranges

Thermal Control: Fixed solar arrays and careful instrument placement minimize thermal variations. The spacecraft must operate in environments ranging from the cold of deep space to the warmer conditions near Mars.

The Boom: A 2-meter boom extends from each spacecraft, hosting critical instruments that must be isolated from spacecraft magnetic interference. This boom is essential for accurate magnetic field measurements.

Figure 3-

SCIENTIFIC INSTRUMENTS

Each spacecraft carries three sophisticated scientific instruments working together to create a comprehensive picture of Mars' space environment.

EMAG: ESCAPADE MAGNETOMETER

Developer: NASA Goddard Space Flight Center

Location: Mounted at the end of the 2-meter boom

EMAG measures DC magnetic fields from 0 to 2 microTesla (up to 1000 nanoTesla) with an accuracy of 0.5 nanoTesla and angular resolution of 20 degrees.

Heritage: EMAG is nearly identical to the magnetometer that flew on NASA's Insight Mars lander, providing proven, reliable technology.

What It Measures:

- Magnetic field strength in three dimensions
- Magnetic field direction
- Temporal variations in magnetic fields
- Spatial structure of Mars' magnetosphere

Why the Boom: Magnetometers are exquisitely sensitive instruments. Even small magnetic fields from spacecraft electronics can interfere with measurements. The 2-meter boom places EMAG far enough from the spacecraft to minimize this interference.

Scientific Importance: Magnetic fields guide charged particle flows around Mars. By mapping these fields, EMAG reveals the invisible structure controlling atmospheric escape. The simultaneous measurements from Blue and Gold will show how this structure varies in space and time.

EESA: ESCAPADE ELECTROSTATIC ANALYZER

Developer: UC Berkeley Space Sciences Laboratory

Location: Mounted on the upper deck of the spacecraft

EESA consists of two electrostatic analyzers: EESA-i measures suprathermal ions between 0.5 eV and 30 keV, while EESA-e measures suprathermal electrons between 10 eV and 10 keV, both with an energy resolution of 17% and angular resolution of 23° × 23°.

What It Measures:

- **EESA-i (Ion sensor)**:
    - Ion energies from 0.5 eV to 30 keV
    - Ion mass composition (distinguishing light ions like protons from heavy ions like oxygen)
    - Ion flow directions
    - Ion density distributions

- **EESA-e (Electron sensor)**:
    - Electron energies from 10 eV to 10 keV
    - Electron flow directions
    - Electron pitch angle distribution (20° to 160°)
    - Electron density variations

Field of View:

- EESA-e: 240° × 120° for electrons
- EESA-i: 247.5° × 90° for ions

Scientific Importance: Charged particles carry energy and momentum from the solar wind into Mars' magnetosphere and atmosphere. EESA reveals how these particles are accelerated, where they flow, and how much energy they carry. This is essential for understanding atmospheric escape mechanisms.

The ability to distinguish ion masses is particularly important. Oxygen ions escaping from Mars represent direct atmospheric loss, while hydrogen and helium ions come from the solar wind. EESA can tell them apart.

ELP: ESCAPADE LANGMUIR PROBE SUITE

Developer: Space and Atmospheric Instrumentation Lab at Embry-Riddle Aeronautical University **Location**: Components mounted on boom and spacecraft deck

ELP consists of three separate sensors: multi-needle Langmuir Probe (mNLP) with four thin needles mounted about three-quarters up the boom measuring thermal electron density; two Planar Ion Probes (PIPs) mounted on the instrument deck measuring thermal ion density from 20 to 30,000 particles per cubic centimeter; and a Floating Potential Probe (FPP) mounted on the spacecraft deck measuring changes in spacecraft electrostatic potential and solar EUV flux from 5 to 20 milliwatts per square meter.

What It Measures:

- **mNLP**: Thermal electron density and temperature
- **PIPs**: Thermal ion density in the lower energy range
- **FPP**: Floating Potential Probe

Scientific Importance: Langmuir probes measure the "background" thermal plasma that EESA doesn't capture. This thermal plasma fills Mars' ionosphere and plays a crucial role in atmospheric chemistry and escape processes.

Solar EUV radiation ionizes atmospheric gases, creating the ionosphere. By measuring EUV intensity, ELP helps scientists understand ionization rates and how they vary with solar activity.

The floating potential measurement reveals how the spacecraft charges in the plasma environment, which affects other instrument measurements. This data is essential for calibrating EESA and understanding spacecraft-plasma interactions.

Instruments Working Together

These three instruments provide complementary data:

- **EMAG** maps the magnetic structure
- **EESA** measures energetic charged particles
- **ELP** characterizes the thermal plasma and radiation environment

Together, they create a complete picture of Mars' space environment from the cold plasma in the ionosphere to the hot particles escaping into space.

THE JOURNEY: LAUNCH AND LOITER STRATEGY

ESCAPADE's path to Mars is unconventional, innovative, and demonstrates remarkable mission flexibility.

ORIGINAL PLAN

ESCAPADE was initially designed as a ride-along mission with NASA's Psyche spacecraft, which was heading to study a metal-rich asteroid. The plan was simple: ESCAPADE would hitch a ride and drop off during Psyche's Mars flyby. Since Psyche was paying for the launch, ESCAPADE's launch cost would be nearly zero.

However, when NASA awarded the Psyche launch contract to SpaceX's Falcon Heavy instead of the originally planned rocket, the mission profile changed. Falcon Heavy's greater power meant Psyche would make a faster, higher-energy flyby of Mars one that ESCAPADE couldn't handle with its limited propulsion capabilities.

Rather than cancel the mission, NASA sought alternative launch options.

BLUE ORIGIN ENTERS THE PICTURE:

In February 2023, Blue Origin won the contract to launch ESCAPADE on its New Glenn rocket for approximately $20 million. The mission was initially scheduled for October 2024 on New Glenn's inaugural flight.

However, the October 2024 launch was postponed by NASA to avoid potential complications. Moving the mission to New Glenn's second flight reduced risk and provided Blue Origin more time to validate the rocket's systems.

THE "LAUNCH AND LOITER" STRATEGY:

Because ESCAPADE missed the optimal Mars transfer window in 2024, mission designers at Advanced Space developed an innovative approach called "launch and loiter."

Dr. Jeffrey Parker, who designed the trajectory, explained: "The idea is launch anytime, loiter until the planets are just perfectly aligned, and then to depart on your interplanetary cruise to Mars."

Phase 1: Journey to L2 Lagrange Point After launch from Cape Canaveral, instead of heading directly to Mars, ESCAPADE will travel to the Sun-Earth L2 Lagrange point a gravitationally stable location about 1.5 million kilometers from Earth, on the opposite side from the Sun.

At this cosmic balance point, the gravitational influences of the Sun and Earth combine to allow spacecraft to maintain position with minimal fuel consumption.

Phase 2: Loitering at L2 (~12 months) Blue and Gold will spend approximately one year at L2, essentially following Earth along its orbit around the Sun. During this time, they're not idle they'll conduct valuable observations of space weather at distances up to 3.5 million kilometers from Earth, a region not studied extensively since NASA's Wind mission in the 1990s.

Phase 3: Trans-Mars Injection (Late 2026) When Mars and Earth are properly aligned, ESCAPADE will perform a Trans-Mars Injection (TMI) burn, leaving L2 and beginning the 11-month cruise to Mars. Throughout the journey, smaller adjustment burns will fine-tune the trajectory.

Phase 4: Mars Arrival (September 2027) Both spacecraft will enter Martian orbit in September 2027, regardless of when they launched from Earth.

ADVANTAGES AND TRADE-OFFS:

Advantages:

- **Launch Flexibility**: Can launch on any day of any year
- **Risk Mitigation**: Not constrained to narrow launch windows
- **Bonus Science**: Space weather observations at L2
- **Schedule Flexibility**: Accommodates rocket development delays

Trade-offs:

- **Extended Mission Duration**: Adds about one year to total mission time
- **Increased Radiation Exposure**: More time in space means more cosmic radiation
- **Component Wear**: Longer exposure to space environment
- **Higher Risk**: Spacecraft components could degrade before reaching Mars

This approach fits perfectly with NASA's SIMPLEx philosophy: accept higher risk in exchange for lower cost and greater flexibility.

LAUNCH DELAYS AND SPACE WEATHER

The road to launch hasn't been smooth. Launch attempts on November 9 and November 12, 2025, were scrubbed due to weather conditions first terrestrial weather (clouds and rain), then space weather.

Ironically, ESCAPADE's mission to study space weather at Mars was delayed by severe space weather at Earth. A powerful solar storm created conditions too risky for launching sensitive spacecraft, though it also produced stunning auroras visible as far south as Florida.

BLUE ORIGIN'S NEW GLENN: AMERICA'S HEAVY-LIFT CHAMPION

Blue Origin's role in ESCAPADE extends far beyond simply providing launch services. The company's New Glenn rocket represents America's commercial entry into heavy-lift spaceflight, competing with SpaceX's Falcon Heavy and setting the stage for ambitious government and commercial missions.

THE ROCKET: ENGINEERING MARVEL

Named After an American Hero New Glenn is named after John Glenn, the first American astronaut to orbit Earth in February 1962 aboard the Friendship 7 mission. The name honors a pioneering spirit that Blue Origin aims to continue.

SPECIFICATIONS AND CAPABILITIES:

Physical Dimensions:

- **Height**: 98 meters (321 feet) comparable to NASA's Space Launch System
- **Diameter**: 7 meters (23 feet)
- **Mass at Liftoff**: Over 1,000 tons
- **Configuration**: Two stages (originally three-stage variant planned but cancelled)

First Stage (GS-1):

- **Height**: 57.4 meters
- **Engines**: Seven BE-4 engines
- **Propellants**: Liquid oxygen (LOX) and liquefied natural gas (LNG)
- **Thrust per Engine**: 550,000 pounds-force (2,450 kilonewtons) at sea level
- **Total First Stage Thrust**: 3,850,000 pounds-force (17,150 kilonewtons)
- **Design Life**: Minimum 25 flights per booster
- **Special Features**: First American oxygen-rich staged combustion engine using LNG

The BE-4 Engine: The BE-4 is Blue Origin's flagship engine and represents a major technological achievement:

- Most powerful LNG-fueled rocket engine ever developed
- Uses oxygen-rich staged combustion cycle for maximum efficiency
- Deep-throttle capability for controlled landings
- Manufactured entirely in the United States, ending American reliance on Russian rocket engine technology
- Also powers United Launch Alliance's Vulcan rocket

Second Stage (GS-2):

- **Engines**: Two BE-3U engines
- **Propellants**: Liquid oxygen and liquid hydrogen (cryogenic)
- **Thrust per Engine**: 160,000 pounds-force (710 kilonewtons) in vacuum
- **Total Second Stage Thrust**: 320,000 pounds-force in vacuum
- **Special Features**: In-space restart capability for versatile mission profiles
- **Heritage**: Leverages more than a decade of operational experience with LOX/LH2 engines from New Shepard suborbital flights

Performance Capabilities: New Glenn can deliver 45,000 kg (99,200 pounds) to Low Earth Orbit, 13,600 kg (30,000 pounds) to Geostationary Transfer Orbit, and 7,000 kg (15,400 pounds) via Trans-Lunar Injection.

For comparison:

- **SpaceX Falcon 9**: 22,800 kg to LEO
- **SpaceX Falcon Heavy**: 63,800 kg to LEO
- **ULA Vulcan**: 27,200 kg to LEO

New Glenn sits in the heavy-lift category, with capabilities exceeding Falcon 9 but less than Falcon Heavy's three-core configuration.

Payload Fairing: The 7-meter diameter fairing offers double the volume of traditional 5-meter class fairings, providing significant advantages for missions involving bulky payloads or complex multi-satellite deployments.

LAUNCH INFRASTRUCTURE: LAUNCH COMPLEX 36

Historical Significance: Launch Complex 36 at Cape Canaveral Space Force Station has a storied history. Built in the 1960s, it hosted more than 140 Atlas II/III launches, including missions that sent Mariner, Pioneer, and Surveyor spacecraft on historic journeys. The last launch before Blue Origin's renovation was NROL-23 in 2005.

Blue Origin's Transformation: Blue Origin invested more than $1 billion to completely rebuild LC-36 from the ground up, completing the renovation in 2021. The facility includes:

- Modern launch pad with advanced systems
- Vehicle integration facilities
- First-stage refurbishment capabilities
- Propellant production and storage facilities
- Environmental control systems
- Mission control center

Integrated Operations: The entire New Glenn ecosystem operates within a remarkably compact area. From manufacturing to launch to refurbishment, everything happens within a nine-mile radius:

- **Rocket Factory**: Located in Exploration Park just outside Kennedy Space Center's gates
- **Launch Complex 36**: Nine miles away at Cape Canaveral Space Force Station

- **Landing Platform**: Atlantic Ocean recovery zone

This geographic concentration improves efficiency and reduces transportation costs.

Future Expansion: Blue Origin is also leasing Space Launch Complex 9 at Vandenberg Space Force Base in California for polar orbit missions, providing flexibility for different orbital inclinations.

REUSABILITY: FOLLOWING SPACEX'S LEAD

Like SpaceX's Falcon 9, New Glenn's first stage is designed for reusability a key factor in reducing launch costs.

Landing Sequence:

1. **Liftoff**: Seven BE-4 engines ignite, producing 3.85 million pounds of thrust
2. **Stage Separation**: Approximately three minutes after liftoff at high altitude
3. **Reentry Burn**: Three gimbaling BE-4 engines relight, slowing the booster as it plunges back through the atmosphere
4. **Landing Burn**: The engines fire again for the final landing burn
5. **Touchdown**: The booster lands vertically on the recovery vessel

Landing Platform: Jacklyn: The first stage attempts to land on a barge positioned about 375 miles downrange in the Atlantic Ocean. For the ESCAPADE mission, the booster is nicknamed "Never Tell Me the Odds," and the landing platform is called "Jacklyn," named after Jeff Bezos' mother.

After landing, a Recovery Remotely Operated Vehicle deploys, providing power, communication, and pneumatic connections between the booster and ship for transport back to port.

First Flight Performance

On January 16, 2025, at 2:03 AM EST, New Glenn launched for the first time. Blue Origin successfully reached orbit on its first attempt, injecting the second stage and Blue Ring prototype payload into medium Earth orbit.

However, the first-stage landing attempt was unsuccessful. Telemetry showed the booster was traveling at approximately Mach 5.5 at an altitude of 84,226 feet before it was deemed lost. The mishap investigation led by Blue Origin with FAA involvement was successfully completed by March 31, 2025.

Despite the landing failure, reaching orbit on the first flight is a significant achievement. Most new rockets require multiple attempts to reach orbit. Blue Origin CEO Dave Limp stated: "I'm incredibly proud New Glenn achieved orbit on its first attempt. We knew landing our booster was an ambitious goal."

The $20 Million Launch Contract

When NASA solicited bids for ESCAPADE's launch in late 2022, Blue Origin's offer was compelling: launch the mission on New Glenn for approximately $20 million.

Value Proposition: For NASA:

- Affordable access to Mars
- Support for American commercial space industry
- Risk-sharing through SIMPLEx program philosophy
- Demonstration of commercial launch capabilities for planetary missions

For Blue Origin:

- First interplanetary mission for New Glenn
- Demonstration of heavy-lift capability
- Entry into NASA's trusted launch provider network
- Validation of rocket performance for high-energy missions
- Valuable publicity and prestige

Risk Considerations: Using an unproven rocket for a planetary mission involves inherent risk. NASA mitigated this by:

- Moving ESCAPADE from New Glenn's first flight to its second
- Accepting SIMPLEx program's higher risk tolerance
- Ensuring spacecraft design robustness
- Developing the flexible "launch and loiter" trajectory

Blue Origin's Broader Vision

ESCAPADE is just one piece of Blue Origin's larger ambitions:

Current Contracts:

- 12 flights (with option for 15 more) for Amazon's Project Kuiper satellite constellation
- Multiple commercial satellite launches for Eutelsat, Sky Perfect JSAT, and others
- AST SpaceMobile Block 2 satellite launches
- Various national security missions

Future Goals:

- Regular launch cadence of up to eight launches per year
- Competing for NASA's Artemis lunar missions
- Supporting commercial space stations
- Deep space missions beyond Mars

Competing in the Market: Blue Origin faces stiff competition from SpaceX's established Falcon 9 and Falcon Heavy, as well as ULA's Vulcan rocket. However, New Glenn's capabilities, particularly its large payload fairing and heavy-lift capacity, position it uniquely in the market.

The success of ESCAPADE will be crucial for Blue Origin's reputation in the planetary science community and could open doors to future NASA missions.

Secondary Payload: Viasat InRange

The ESCAPADE mission includes a secondary payload: Viasat's InRange launch telemetry relay demonstration, which will remain integrated with New Glenn's upper stage throughout the flight as part of NASA's Communications Services Project.

InRange tests advanced launch telemetry relay capabilities, potentially providing better coverage and higher data rates than traditional ground-based tracking stations. This demonstrates New Glenn's ability to accommodate both primary and secondary payloads on a single mission.

Figure 4- NASA, Blue Origin Launch

MISSION OPERATIONS AT MARS

Once ESCAPADE reaches Mars in September 2027, the mission unfolds in carefully choreographed phases designed to maximize scientific return.

PHASE 1: MARS ORBIT INSERTION (SEPTEMBER 2027)

Both spacecraft will arrive at Mars and independently execute their Mars Orbit Insertion (MOI) burns. This is one of the most critical and risky phases of any Mars mission approximately 50% of Mars missions have failed, many during orbit insertion.

Initial Orbit Parameters:

- **Periapsis** (closest point): 160-170 km altitude
- **Apoapsis** (farthest point): 8,400-8,500 km altitude
- **Orbital inclination**: 60 degrees
- **Orbital period**: Approximately 60 hours

This highly elliptical "capture orbit" allows the spacecraft to be captured by Mars' gravity while minimizing fuel consumption.

Challenges:

- No real-time communication (signal takes 10-20 minutes each way)
- Spacecraft must execute maneuvers autonomously
- Precise timing and navigation required
- Any failure means mission loss

Phase 2: Orbit Adjustment (6-7 months)

Over roughly seven months following orbit insertion, Blue and Gold will gradually lower and circularize their orbits through a series of propulsive maneuvers until they reach their nominal science orbits.

Target Science Orbit Parameters:

- **Periapsis**: ~170 km altitude
- **Apoapsis**: ~8,400 km altitude
- **Inclination**: 60-65 degrees
- **Orbital Period**: Approximately 5.66 hours

This slow, methodical approach conserves fuel and allows the team to precisely position the spacecraft. Each maneuver is carefully planned to avoid collisions with other Mars-orbiting spacecraft and to optimize scientific coverage.

Why This Orbit: The orbital parameters are carefully chosen to sample multiple regions of Mars' space environment:

- **At periapsis** (170 km): The spacecraft pass through the upper atmosphere and ionosphere
- **At mid-altitudes** (1,000-4,000 km): The spacecraft sample the transition region where atmospheric escape is most active
- **At apoapsis** (8,400 km): The spacecraft observe the outer magnetosphere and solar wind interaction

The 60-degree inclination provides good coverage of Mars at various latitudes while maintaining efficient fuel use.

PHASE 3: SCIENCE CAMPAIGN A (6 MONTHS)

In this phase, both spacecraft fly in the same orbit but are positioned at varying distances from one another. This configuration allows scientists to observe how conditions at Mars change over time and how they vary with distance from the planet.

Key Objectives:

- Separate temporal variations (changes over time) from spatial variations (differences in location)
- Observe how solar wind disturbances propagate through Mars' magnetosphere
- Study the structure and dynamics of the magnetosphere at different locations simultaneously
- Measure atmospheric escape rates under various solar wind conditions

Operational Strategy:

- Blue and Gold follow each other in the same orbit
- Separation distance varies from a few hundred to several thousand kilometers
- Both spacecraft continuously collect data from all instruments
- Data is downlinked to Earth during communication windows
- Ground teams analyze data and adjust operational parameters as needed

PHASE 4: SCIENCE CAMPAIGN B (5+ MONTHS)

After the first science campaign, the orbits will be adjusted to maximize spatial coverage by creating different orbital periods for each spacecraft.

Orbital Modifications:

- **Blue** will lower its apoapsis to ~7,000 km, resulting in an orbital period of about 4.9 hours
- **Gold** will raise its apoapsis to ~10,000 km, resulting in an orbital period of about 6.6 hours

Why Different Orbits: With different orbital periods, the spacecraft naturally precess (rotate) at different rates due to Mars' non-uniform gravity field. Over time, their orbits gradually separate, allowing simultaneous measurements from widely separated parts of the Martian magnetosphere.

This elegant approach maximizes scientific coverage without burning extra fuel. As the orbits drift apart, the spacecraft can observe how Mars' space environment varies across large distances.

Extended Mission Possibility: The primary science mission is planned to last at least 11 months beyond orbit insertion, making the total mission duration about 2.5 years from launch. However, if the spacecraft remain healthy and fuel reserves allow, the mission could be extended significantly.

Extended missions often provide the most valuable science because:

- Initial operations reveal unexpected phenomena requiring follow-up observations
- Long-term monitoring captures rare events like major solar storms
- Seasonal variations at Mars become apparent over multiple Martian years
- Scientists develop better understanding of the data and can optimize operations

Data Collection and Analysis

Data Volume: Each spacecraft generates approximately 3 gigabits of science data per day. Over the primary mission, ESCAPADE will collect over 6 terabits of data enough to revolutionize our understanding of Mars' atmospheric escape.

Communication Windows: The spacecraft communicate with Earth through NASA's Deep Space Network (DSN), a global array of large radio antennas. Communication sessions occur several times per week, each lasting several hours.

Ground Operations:

- Mission operations are conducted from UC Berkeley
- Science data is archived at NASA's Planetary Data System
- Data is made publicly available after validation and calibration
- International collaborations allow scientists worldwide to analyze ESCAPADE data

CONCLUSION

NASA's ESCAPADE mission represents far more than two small spacecraft journeying to Mars. It embodies a fundamental shift in how humanity explores the solar system a shift toward accessibility, affordability, and innovation.

A Mission Born from Collaboration

ESCAPADE's success depends on unprecedented collaboration between government, academia, and commercial partners. UC Berkeley provides scientific leadership. Rocket Lab delivers cutting-edge spacecraft engineering. Blue Origin offers affordable heavy-lift launch capability. NASA coordinates this diverse team and provides decades of planetary science expertise.

This model proves that the future of space exploration lies not in any single entity, but in partnerships that leverage the unique strengths of each participant..

Pioneering Affordable Planetary Science

At less than $80 million, ESCAPADE costs a fraction of traditional Mars missions while delivering world-class science. This efficiency doesn't come from cutting corners it comes from innovation:

- Accepting higher risk through the SIMPLEx philosophy
- Leveraging commercial spacecraft platforms designed for efficiency
- Using proven instruments adapted from previous missions
- Developing creative trajectories that provide operational flexibility
- Embracing rapid development timelines

If ESCAPADE succeeds, it validates an approach that could enable dozens of future missions. Imagine planetary science not constrained by billion-dollar budgets and decade-long development cycles. Imagine missions to Venus, Neptune, asteroids, and countless other destinations that currently seem too expensive to explore.

ESCAPADE makes this future possible.

Blue Origin's Coming of Age

For Blue Origin, ESCAPADE marks a crucial milestone. New Glenn's successful second flight and historic booster landing demonstrate that the company has graduated from suborbital tourism to serious heavy-lift capability.

By launching an interplanetary science mission, Blue Origin joins an elite group of launch providers trusted with humanity's most ambitious space endeavors. The successful landing of "Never Tell Me the Odds" proves that reusability the key to affordable space access is within reach.

As Blue Origin scales up operations, launches Amazon's Kuiper constellation, and competes for NASA's Artemis missions, the ESCAPADE launch will be remembered as the moment when Blue Origin truly arrived as a major player in space exploration.

The Bigger Picture

ESCAPADE matters because it changes what's possible:

For Scientists: Proves that important planetary science doesn't require flagship-mission budgets

For Engineers: Demonstrates rapid development timelines and innovative mission designs

For Commercial Space Companies: Shows that partnerships with NASA create opportunities beyond commercial satellites

For Students: Provides hands-on experience operating an interplanetary mission

For Humanity: Advances our understanding of planetary habitability and prepares us for Mars exploration

Final Thoughts

The story of ESCAPADE is still being written. The spacecraft are just beginning their journey. Challenges lie ahead orbit insertion, instrument commissioning, years of operations in the harsh space environment.

But the mission has already succeeded in one crucial way: it has shown that planetary exploration can evolve, that new approaches can work, that partnerships between government and commercial entities can achieve extraordinary things.

When future historians write about the era when humanity began exploring the solar system in earnest, ESCAPADE will be remembered not just for its scientific discoveries, but for proving that space exploration could be accessible, affordable, and achievable.

Two small spacecraft, named Blue and Gold, are heading to Mars to solve ancient mysteries and pioneer new approaches to planetary science. Whatever they discover about Mars' lost atmosphere, they've already proven something equally important: the future of space exploration is brighter, more accessible, and more exciting than ever before.