Appendix – Details of Emirates Mars Mission

1. The Journey

The Emirates Mars Mission orbiter is set to arrive at Mars in 2021 to coincide with the 50th anniversary of the founding of the UAE.

The rocket must blast off from Earth during a brief "launch window" in July 2020. This is because the Earth and Mars orbit the Sun at different rates, and are aligned at their closest point only once every two years. If any part of the mission is not ready in time or fails at the last minute, there may be no second chance.

The Probe will be housed in the nose cone of a rocket similar to those used to launch satellites and astronauts visiting the International Space Station. When the countdown reaches zero, the rocket will blast off. In order to break free of Earth's gravity, the probe will need to accelerate to an escape velocity of 39,000 km/h.

After around one minute, the first set of rocket boosters will detach and fall away, followed by three more rocket stages which will fire up and fall away in turn until the launcher releases the spacecraft onto its journey across the Solar System to Mars.

At this time the probe will be tumbling rapidly, and will need to manoeuvre to stabilise itself. This will be a tense moment at Mission Control in the UAE as the team waits for the first signals to come in, because it will be impossible to communicate with the probe until it stops spinning.

Next, it will unfold its three solar panels and orient itself towards the sun to charge the batteries that will power its computers, transmitters and equipment.

Once it reaches full speed, the probe will need no more energy to propel itself through the vacuum of space: with nothing to slow it down, it will coast at the same speed all the way.

During its seven-month journey, the probe may need to manoeuvre around from time to time to point its solar panels at the sun to charge its batteries, and to point its antenna back at Earth to communicate with Mission Control.

As it travels, the probe will need to know where it is in space, and exactly where to point its narrow-beam antenna in order to communicate with Earth. It will use star trackers to navigate using the patterns of constellations, in much the same way as Bedouin travellers and seafarers in ancient times would use the stars to find their way.

The probe will approach Mars in early 2021. This will be another critical moment: the probe must use its thrusters as brakes to slow down and enter Mars orbit.

By this time, the probe will be so far away that its radio signals will take 13-20 minutes to reach Earth. This makes it impossible to control the spacecraft in real time, and so its software has been designed to be as autonomous as possible and make its own decisions to correct its course without human intervention in real time.

The engines must be fired for 30 minutes at this time, otherwise the probe would speed on past Mars and be lost. This will be another tense moment at Mission Control as the team waits for the probe to signal that it has successfully been captured into orbit around the Red Planet.

The probe will first enter a wide oval-shaped orbit, then later move into a closer scientific orbit. Its speed relative to the planet will vary between 3,600-14,400 km/h, travelling fastest when its elliptical orbit brings it closest to the planet. It will turn on its sensors and begin collecting data to be transmitted back to Earth.

Facts about the Journey

Launch date:	July 2020
Cruising distance from Earth to Mars:	More than 60 million kilometres
Cruising time from Earth to Mars:	200 days (approx.)
Arrives in Mars (“Mars Orbit Insertion”):	First Quarter 2021
Orbit shape:	Elliptical (oval)
Orbit period:	55 hours
Altitude of science orbit:	22,000-44,000 km
Science operation begins:	Mid-2021
Primary science operations duration:	Two years
Extended science operations duration:	Potential for two further years

2. The Probe

The Emirates Mars Mission spacecraft will be a compact, hexagonal-section spacecraft. It will be built from **aluminium** in a stiff but lightweight honeycomb structure and surfaced with a strong composite face-sheet. Its overall size and weight are comparable to a small car: it will weigh approximately 1,500 kg including fuel, and measure 2.37m wide by 2.90m tall.

Once in space the craft will charge its **batteries** using three 600-watt **solar panels**. (For comparison, that is enough power to run around 20 laptop computers). The solar panel arrays will be folded flat against the sides of the probe for launch, and will unfold once the probe is in orbit.

The spacecraft will communicate with Mission Control on earth using a **high-gain antenna** with a 1.5m wide dish. This antenna will produce a narrow radio-wave beam that must point directly at Earth in order to make contact. The probe will also have low-gain antennas, which are less directional.

Communication bandwidth will drop from 1.6mbs to 250kbps as the probe journeys further from Earth (equivalent to cell-phone data speeds).

The spacecraft will be equipped with **star tracker** sensors that will help it to determine its position in space by studying the constellations in relation to the sun.

It will be equipped with **two sets of rocket thrusters:** four to six large "Delta V" thrusters which are used to speed up and slow down, and eight to 12 small Reaction Control System (RCS) thrusters for delicate manoeuvring.

From time to time the spacecraft will need to reorient itself, for instance to point its solar panels at the sun, to point its antenna at Earth, or to point its scientific instruments at Mars. For this purpose it will use a set of internal **reaction wheels –** flywheels that are spun to create momentum that rotates the probe precisely around any axis.

The spacecraft's brain is a computer equipped with sophisticated software that can manoeuvre it into Mars orbit autonomously without human guidance from Earth. This is important because by the time the probe reaches Mars, there will be a 13-20 minute communication delay due to the huge distance involved, and this will prevent real-time communication and control.

The spacecraft carries three scientific instruments for its mission to study the Martian atmosphere:

1. **An Imager** – a digital camera that will send back high-resolution colour images.

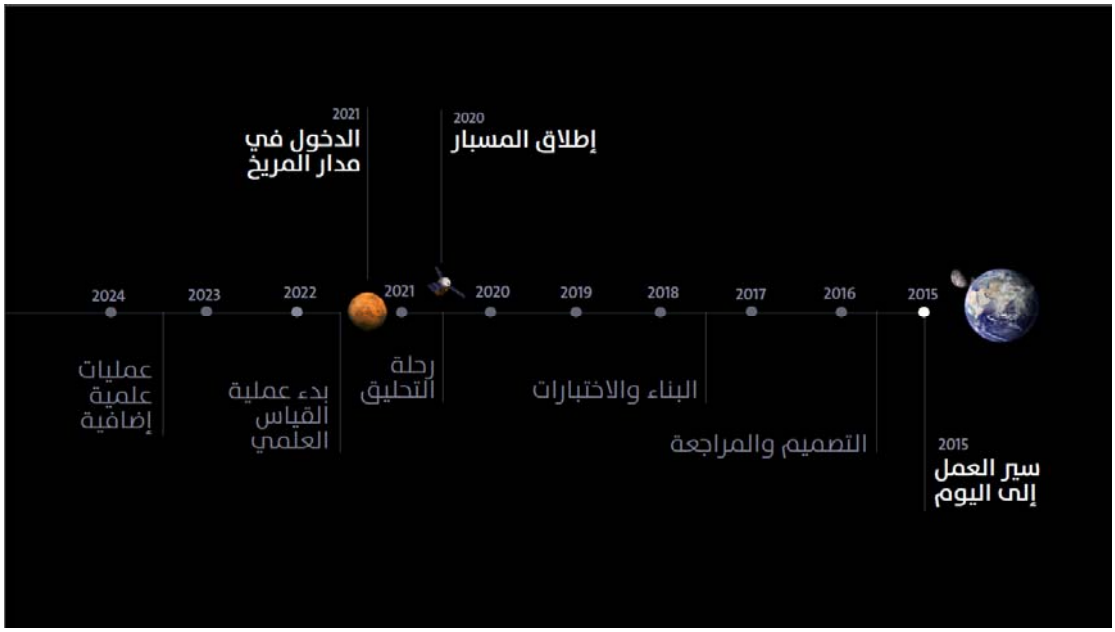
2. **An Infra-Red Spectrometer** – which will examine temperature patterns, ice, water vapour and dust in the atmosphere.

3. **An Ultraviolet Spectrometer** – which will study the upper atmosphere and traces of oxygen and hydrogen further out into space.

Facts about the Probe

Weight:	1,500 kg including fuel
Dimensions:	2.37m wide, 2.90m tall (excluding solar panels)
Structure:	Aluminium frame with lightweight aluminium honeycomb panels
Solar panels:	Three extendable 600W solar panels
Antennae:	High-gain (directional) antenna with 1.5m dish
	Additional non-directional low-gain antennas
Data bandwidth:	1.6 mbps at Mars's closest point to earth.
Navigation sensors:	Star trackers
	Sun sensors
Thrusters:	Four to six large 120-Newton thrusters for acceleration and braking
	Eight to 12 small 5-Newton thrusters for delicate manoeuvring
Positioning:	Set of internal Reaction Wheels to rotate the probe around three axes

3. Project Timeline



4. Science objectives

The Emirates Mars Mission probe will advance human knowledge about the atmosphere and climate on Mars, about which very little is known. This mission will produce the first truly global picture of the Martian atmosphere. It will study how the lower and upper layers of the atmosphere interact with each other. It will search for connections between today's Martian weather and the ancient climate of the Red Planet.

Why is Mars losing its atmosphere?

Long ago, Mars had an atmosphere that could sustain liquid water on the surface. Liquid water is key to life on Earth. But unlike Earth, Mars has been steadily losing its atmosphere over time. The Martian atmosphere is now so cold and thin that water can exist only as ice or vapour.

The Emirates Mars Mission probe will study how the climate, cycles and behaviour of the lower atmosphere affect the escape of oxygen and hydrogen from the upper atmosphere. The science team hopes to discover why these elements – the building blocks of water – have been escaping into space.

The probe will investigate how the atmosphere changes throughout its daily and seasonal cycles. The Mars science community will gain new insights about the weather on Mars, such as its famous dust storms. On Earth, dust storms are brief and localised, like the sandstorms that we see in the UAE. On Mars, massive storms of red dust are known to engulf the entire planet.

A partnership with the international Mars exploration community

The Emirates Mars Mission team has coordinated closely with the global Mars science community from the outset in order to identify gaps in human knowledge that no other missions have studied. In this way, it will provide answers to the global scientific community's most pressing questions about Mars. This process has been managed through the international Mars Exploration Program and Analysis Group.

Specifically, the Emirates Mars Mission will be the first probe to study climate throughout daily and seasonal cycles – previous probes took snapshots only at a certain time of day. It will be Mars's first true weather satellite. It will the be the first to study the effects that events in the lower atmosphere, such as changes in temperature and dust storms, can have in the upper atmosphere days or weeks later. It will be the first to examine the interaction between climate and geography, such as links and differences between weather on the peaks of Mars's massive volcanoes and in the depths of its canyons.

Advancing human knowledge

Today, almost all of our understanding of climate comes from scientific studies of the atmosphere here on Earth. Mars is a valuable laboratory for atmosphere science

because conditions there are very different. The insights and data we gain from understanding the Martian climate will add new dimensions to human knowledge about how atmospheres work. This is important not just for Mars and Earth, but also for the millions of other potentially habitable planets recently discovered in our galaxy. Studying the atmosphere on Mars will help scientists evaluate distant worlds for conditions that might support life.

How will the data be used?

The spacecraft will collect and send back to Earth over 1000 gigabytes of new Mars data. This information will be received in the Science Data Center in the UAE via different ground stations spread around the world. These never-seen-before data will be catalogued and analysed in the UAE by the Emirates Mars Mission science team, and then shared freely with the international Mars science community as a service to human knowledge.

The data will be used by thousands of members of the world science community for many years to come in ways that, today, we cannot even begin to imagine. Faculty, research scientists, postdocs, and students worldwide will use these findings to better understand planetary and climate development throughout our solar system and, ultimately, to further our understanding of Earth's place in the Universe.

Factsheet

Key science goals

- Integrate with the global Mars science community on key questions that no other mission has addressed.
- Search for connections between today's weather and the ancient climate of the Red Planet.
- Study why Mars is losing its atmosphere to space by tracking the behaviour and escape of hydrogen and oxygen, which are the building blocks of water.
- Investigate how the lower and upper levels of the Martian atmosphere are connected.
- Create the first global picture of how the Martian atmosphere changes throughout the day and between the seasons.

Science data

- The probe will send to Earth over 1000 gigabytes of new data about Mars

Mission team

- More than 90 Emiratis will work on the Emirates Mars Mission team
- More than 200 other personnel at U.S. partner institutions will also contribute

5. UAE Space Vision

As well as expanding human knowledge about space, the Emirates Mars Mission will have a profound impact here on earth. It is a major milestone in the UAE government's space strategy.

A symbol of capability and hope

As the first-ever Arab Islamic mission to another planet, the project demonstrates the capability of the Arab people as contributors to humanity and civilisation. It proves that optimism, confidence and ambition can deliver the greatest achievements no matter the place. It is a symbol of hope for a new era of peaceful human development. It will inspire a young generation to think positively and see a future filled with possibility.

A catalyst for knowledge and skills

The mission is planned, managed and executed by a team here in the UAE. They will do it the hard way: key technologies will be designed, built and assembled locally, not imported. Technical knowledge will be developed in the UAE and transferred through collaboration with partners, not outsourced.

This approach ensures that the mission will leave behind a valuable and enduring legacy in the form of human capital: a generation of experienced scientists and engineers trained and inspired by the Mars mission.

An anchor project for a new space industry

The UAE government sees the Red Planet project as a turning point in the nation's development. It will establish the space technology sector as a key economic sector for years to come. The UAE aims to be among the top countries worldwide in the field of space technology by the time the orbiter arrives at Mars in 2021.

Globally, space technologies are becoming increasingly important to the security and economy of nations, in many cases backed by massive national programmes and institutions. The sector is integral to many aspects of life from telecommunications and navigation to broadcasting and monitoring of weather and natural disasters.

The industry is estimated to be worth around $300 billion globally and growing by around 8% annually. The Mars mission will be an anchor project for a new space technology industry here in the UAE.

Factsheet

Emirati Mars Mission team personnel	70+ scientists and engineers, expected to reach 150 before 2020
Organisations benefiting from mission	200 academic and research institutions locally and globally
Academic knowledge transfer partners	University of Colorado/Laboratory for Atmospheric and Space Physics
	University of California Berkeley Space Sciences Lab
	Arizona State University School of Earth and Space Exploration
Global space industry value	$300 billion
Predicted space industry growth	8% per annum
Value of existing UAE space investments	More than AED20 billion
UAE spacecrafts already in Earth orbit	DUBAI SAT 1 (imaging satellite, launched 2009)
	DUBAI SAT 2 (imaging satellite, launched 2013)
	Yahsat Y1A (communication satellite, launched 2011)
	Yahsat Y1B (communication satellite, launched 2012)
UAE spacecraft under construction	KHALIFA SAT (imaging satellite, launch scheduled for 2018)

For more information please visit:

www.emiratesmarsmission.ae