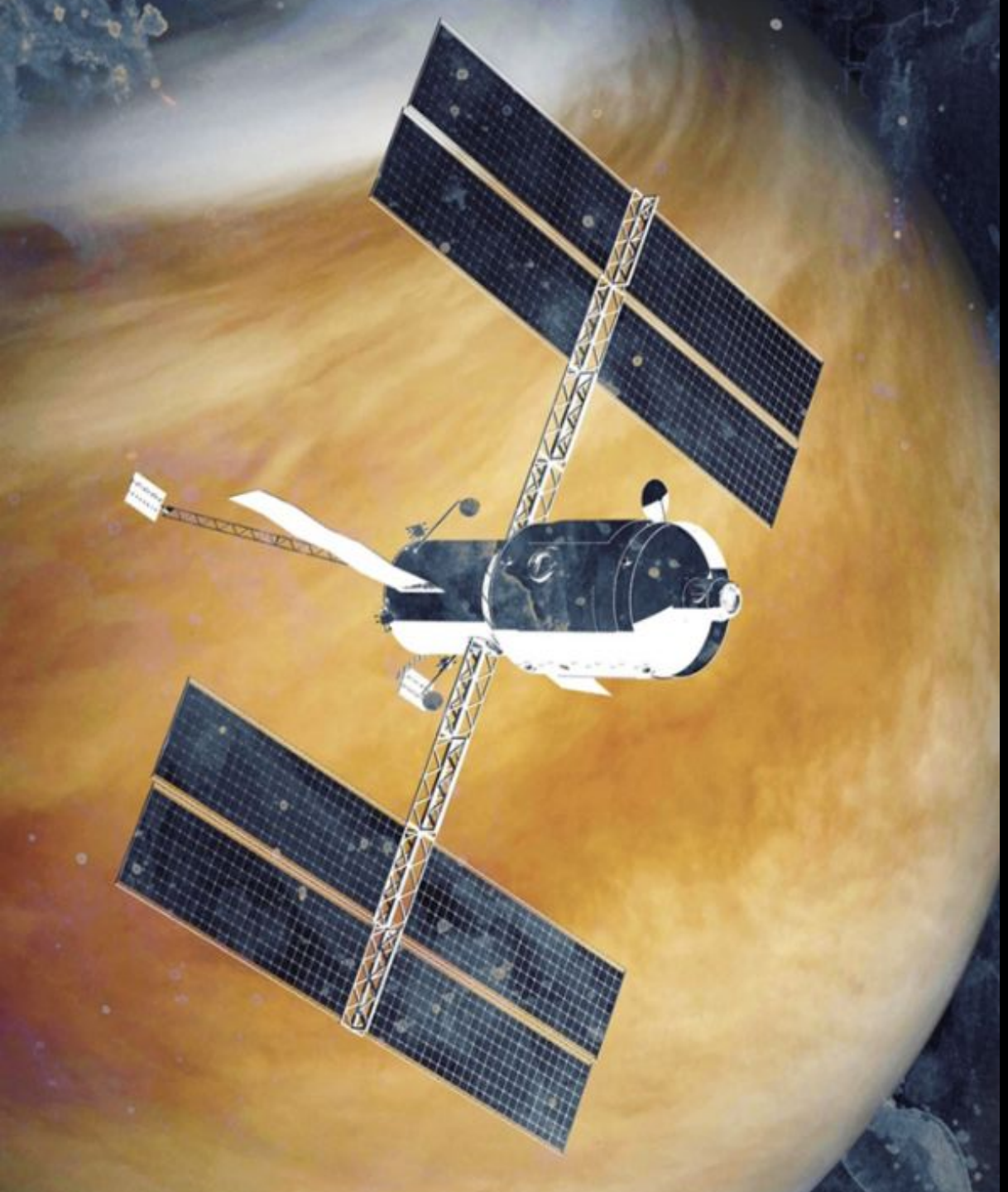


Vanguard to Venus

Crewed Missions to Venus in Historic, Socioeconomic, and Strategic Context

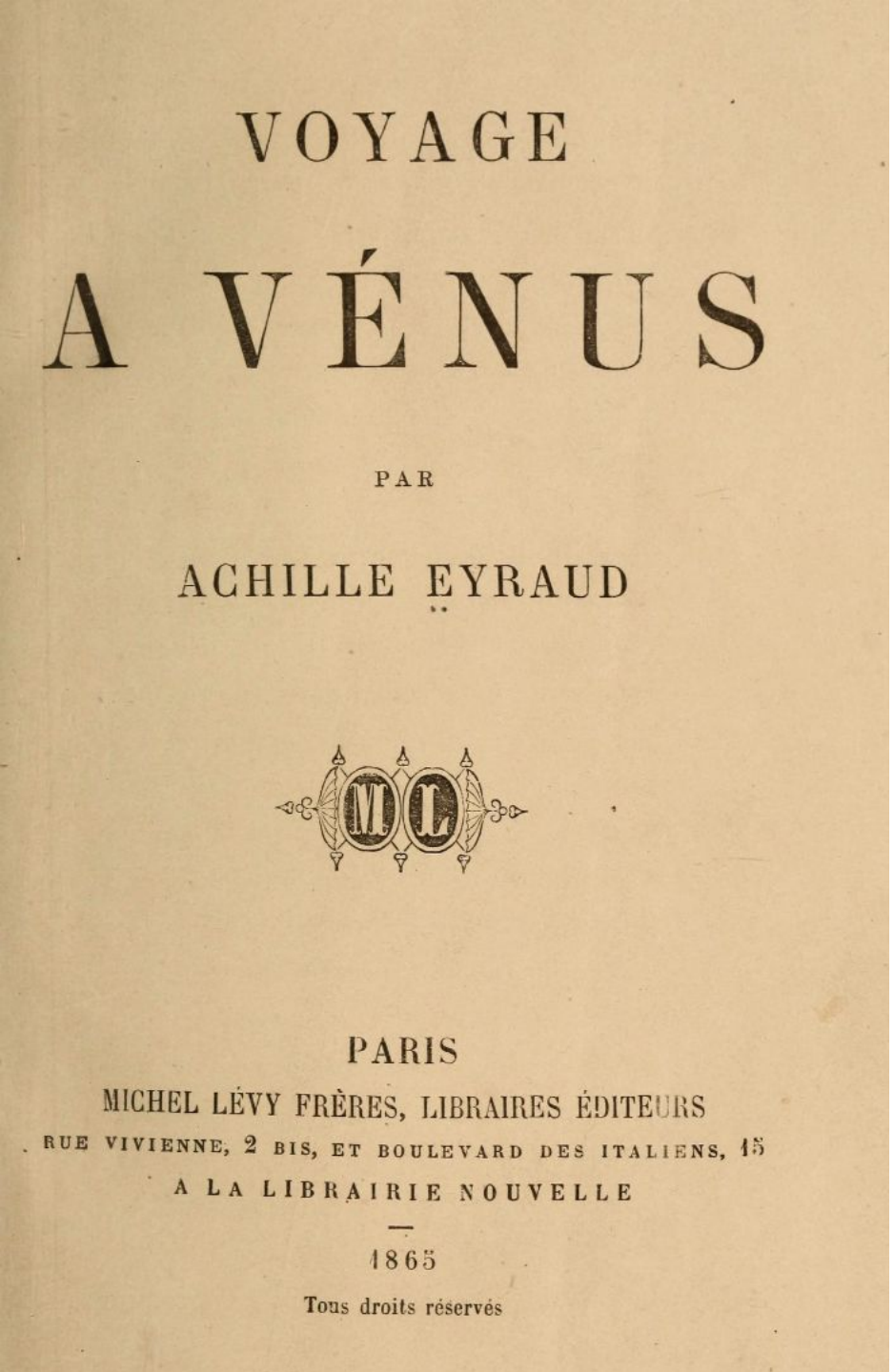
Alexander MacDonald
Chief Economist
NASA Headquarters

Presentation at the Keck Institute for Space Studies
July 20, 2022

How long have humans been thinking about going to Venus?

Why would humans go to Venus?

How might a human mission to Venus happen?


VOYAGE

A VÉNUS

PAR

ACHILLE EYRAUD

PARIS

MICHEL LÉVY FRÈRES, LIBRAIRES ÉDITEURS

RUE VIVIENNE, 2 BIS, ET BOULEVARD DES ITALIENS, 15

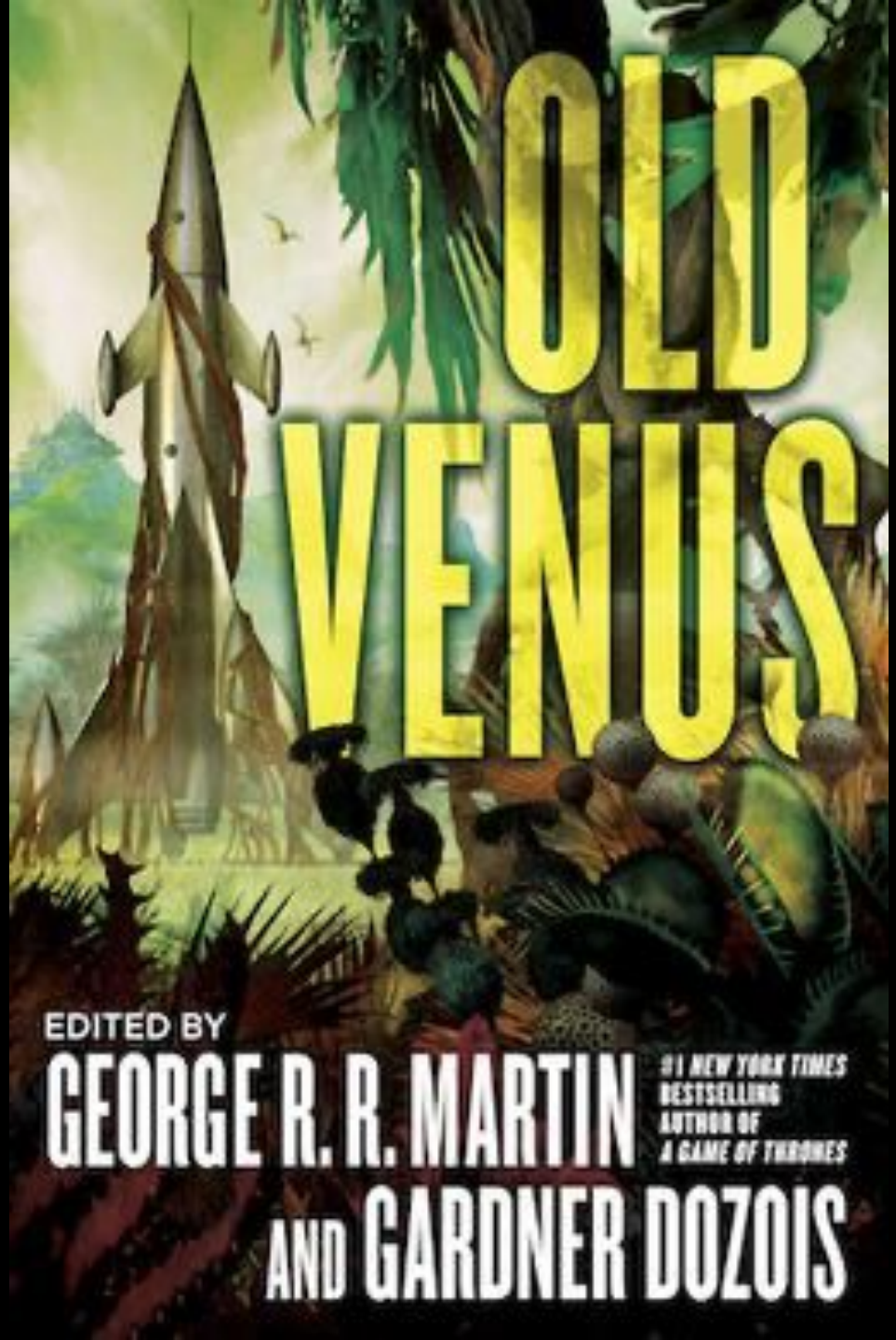
A LA LIBRAIRIE NOUVELLE

1865

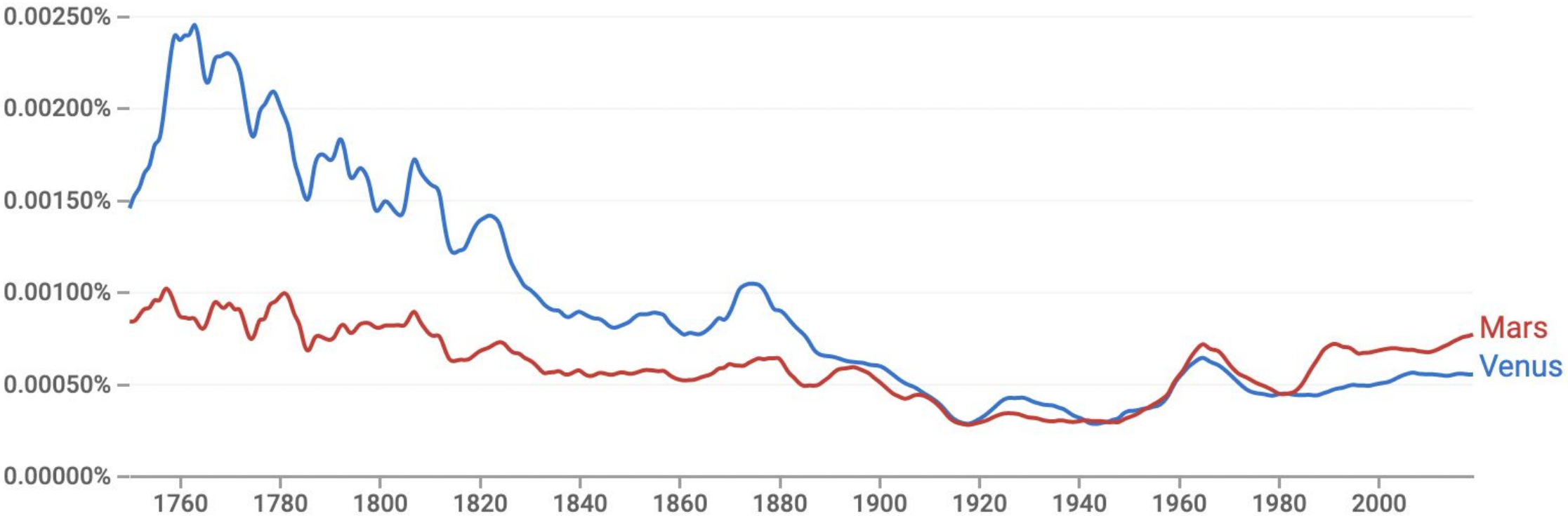
- Achille Eyraud wrote *Voyage a Venus* in 1865 and is arguably the first narrative to describe rocket-powered spaceflight.
- Utopian interest drives narrative. Part of chain of influence including de Bergerac and Poe.
- Overshadowed by another space narrative published in the same year, *From the Earth to the Moon* by Jules Verne.
- Venus exploration narratives would remain popular for almost 100 years, with many science fiction authors writing Venus stories; Garret P Serviss, Edgar Rice Burroughs, Olaf Stapledon, John W Campbell, Robert Heinlein, C.S. Lewis, Isaac Asimov, Arthur C Clarke.

”A very great part of the surface of Venus is no doubt covered with swamps”

Svante Arrhenius, *Nobel-laureate - 1918*

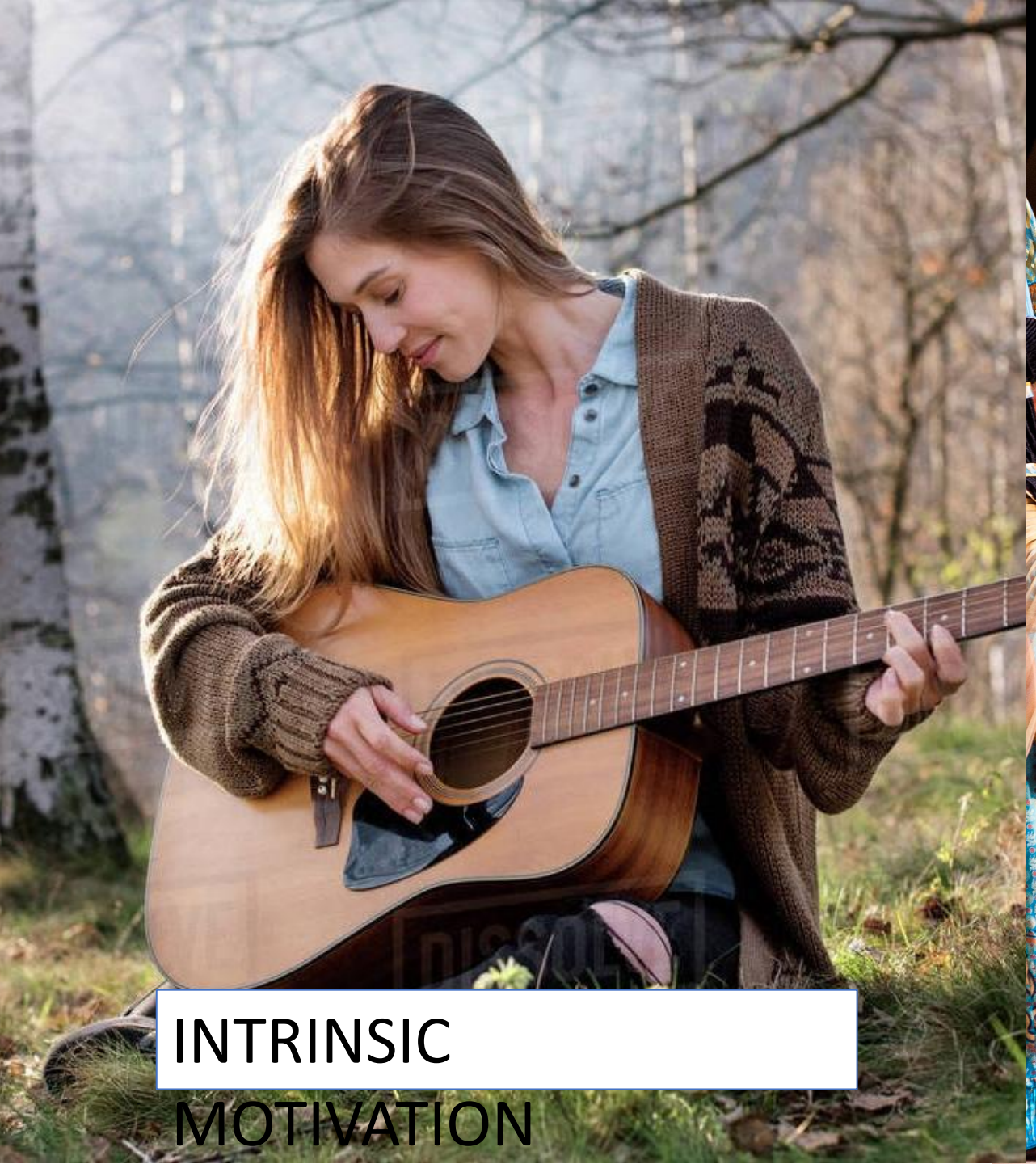

OLD VENUS
EDITED BY
GEORGE R. R. MARTIN
#1 NEW YORK TIMES BESTSELLING AUTHOR OF A GAME OF THRONES
AND GARDNER DOZOIS

First image from the surface of another planet – Venera-9 probe on Venus
(9 months before Martian surface image with Viking 1 July 20, 1976)



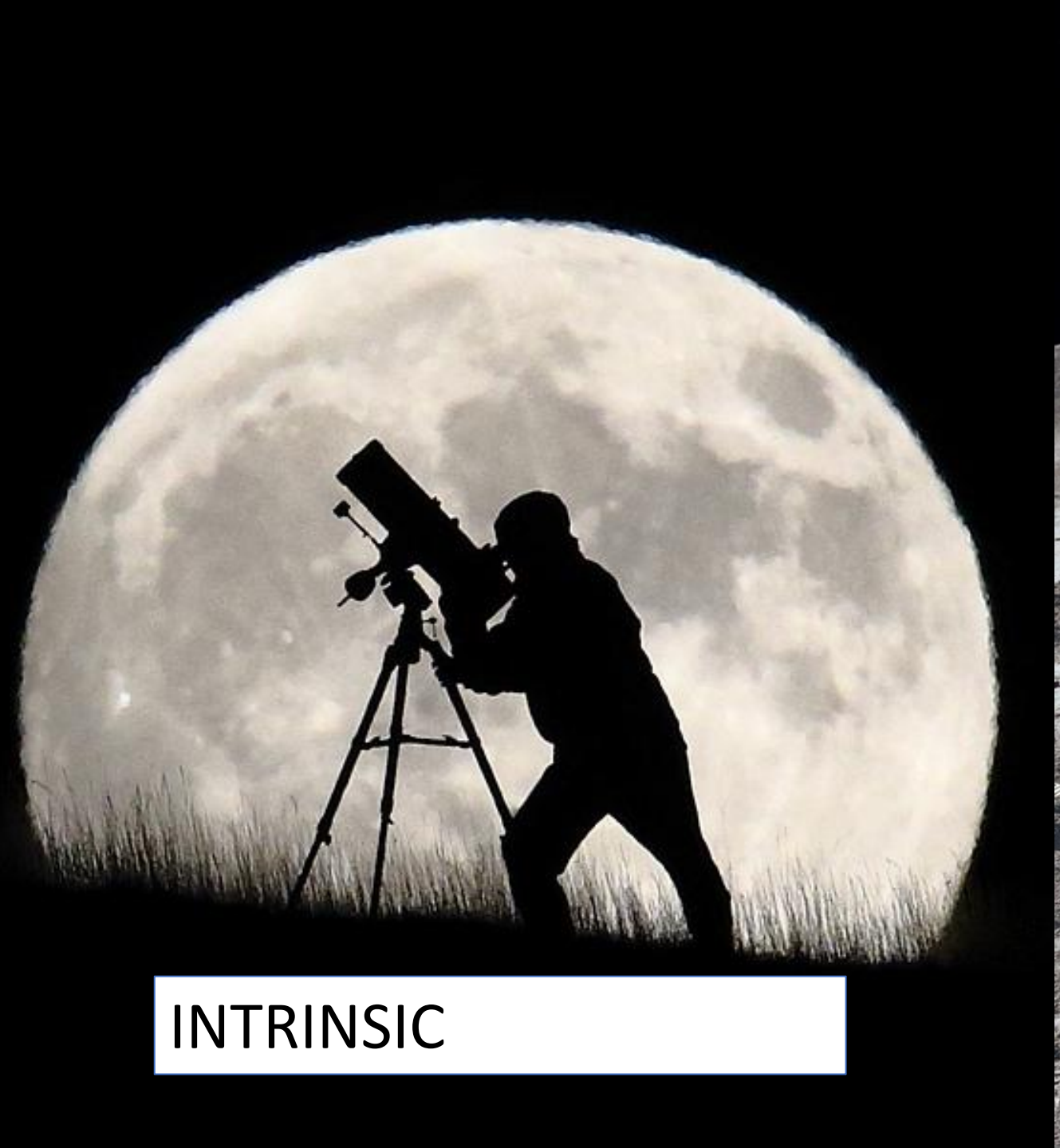
Google ngram search - Venus, Mars – English books, 1750-2019

But why would humans go?



INTRINSIC MOTIVATION

SIGNALING



INTRINSIC

SIGNALING

STRATEGIC GEOGRAPHY OF THE SOLAR SYSTEM AND BEYOND

Introduction

NASA is set to remain the core agent in the development of our collective relationship with the solar system—and, increasingly other solar systems as well—as we continue to explore the cosmos through human spaceflight missions and robotic probes. Our exploration activities take place within a unique physical geography but our explorations are nonetheless governed by the same types of human relationships that exist and develop between people and places everywhere. As such, the disruption of geography the study of the relationships between people and places, offers techniques that can provide useful insight into the strategies that will allow us to manage the political, economic, cultural forces that provide the motivation and resources for our efforts.

A Focus on Human Geography

There are two broad classes of geographic analysis: physical geography and human geography. Human geography the primary focus of this chart, encompasses physical, cultural, and economic considerations.

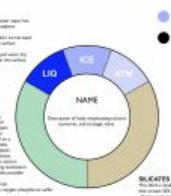
This strategic geography chart considers outer space from a human-interest perspective beyond the traditional focus areas of scientific discovery and technology development. It challenges the viewer to think of the solar system and beyond as a natural environment filled with diverse worlds and geographies with which humanity is in the process of developing economic and cultural relationships and in which there are resources that can be used to advance and support the interests of the United States.

Earth-Moon System Points of Interest

The Earth-Moon system, also referred to as the cislunar environment, is the focal point for human activity in the solar system and will remain so for at least the next few decades. With almost sixty years of space activities and national space policies behind us, the U.S. has arrived at a phase of maturity with regard to understanding the economic, strategic, and geopolitical importance of space activities. This new phase of maturity is defined by an appreciation of the importance of the cislunar environment as a whole in terms of broad national interest. The Earth-Moon system features a number of elements that define its importance, although we will focus here on the low-Earth orbits, geosynchronous orbits, the lunar vicinity, the lunar surface, and near-Earth asteroids. All of these elements interact, or have the potential to interact, with all the others, and therefore should be considered as a whole.

Solar System Points of Interest

Selected points of interest in the solar system are briefly described, with selected terrestrial planets and moons data-based upon using a graphical element that captures captioned data on water, life potential, and composition. Water content is divided into liquid, solid, and gas, with the appropriate wedge colored in if any or all of these have been confirmed through detection and verified. If the composition of the ocean includes a substantial amount of silicates and metals, the appropriate section of the graphic is filled in. The life potential of a particular object is highlighted when it exhibits physical characteristics considered necessary for the development and sustainment of life as we know it. This is based on an assessment of the availability of biochemical ingredients, metabolic sources, and environmental conditions. Finally, concise descriptions are also provided that elaborate on the unique economic and cultural relationships that have been developed with the relevant planetary bodies.



Selected Extrasolar Planetary Systems Within 25 Light Years

The discovery of extrasolar planets around stars relatively near the Earth—particularly those that might have the potential for life—has increased the cultural prominence, and therefore the strategic priority of the serious exploration of these worlds. Since the mid-1990s, over 1,000 extrasolar planets have been identified using various detection methods. Scientists now estimate that nearly every star in the night sky has a system of planets, or a ring of rock and ice around it. The public, as well as the scientific community, has demonstrated significant enthusiasm for efforts to identify and characterize extrasolar planets. With efforts for physical interstellar exploration beginning to receive non-trivial capital investments, extrasolar planets and star systems within 25 light years of Earth are worth preliminary strategic consideration.

The Galaxy and Beyond

The importance of investigations into the origins and fundamental nature of the universe is derived from the internal importance of cosmogony and eschatology in philosophy and religion across global cultures. Advancing our understanding of the phenomena of the observable universe within our galaxy and beyond provides scientific knowledge of intrinsic value and political prestige of socio-cultural value.

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Adam Hodgkinson, Senior Space Industry Analyst
Mitchell Joseph, Technology Analyst

THE SOLAR SYSTEM
Out to 1 light year

THE OORT CLOUD

THE KUIPER BELT

MAIN ASTEROID BELT

EARTH-MOON SYSTEM POINTS OF INTEREST
Out to 1,000,000 km

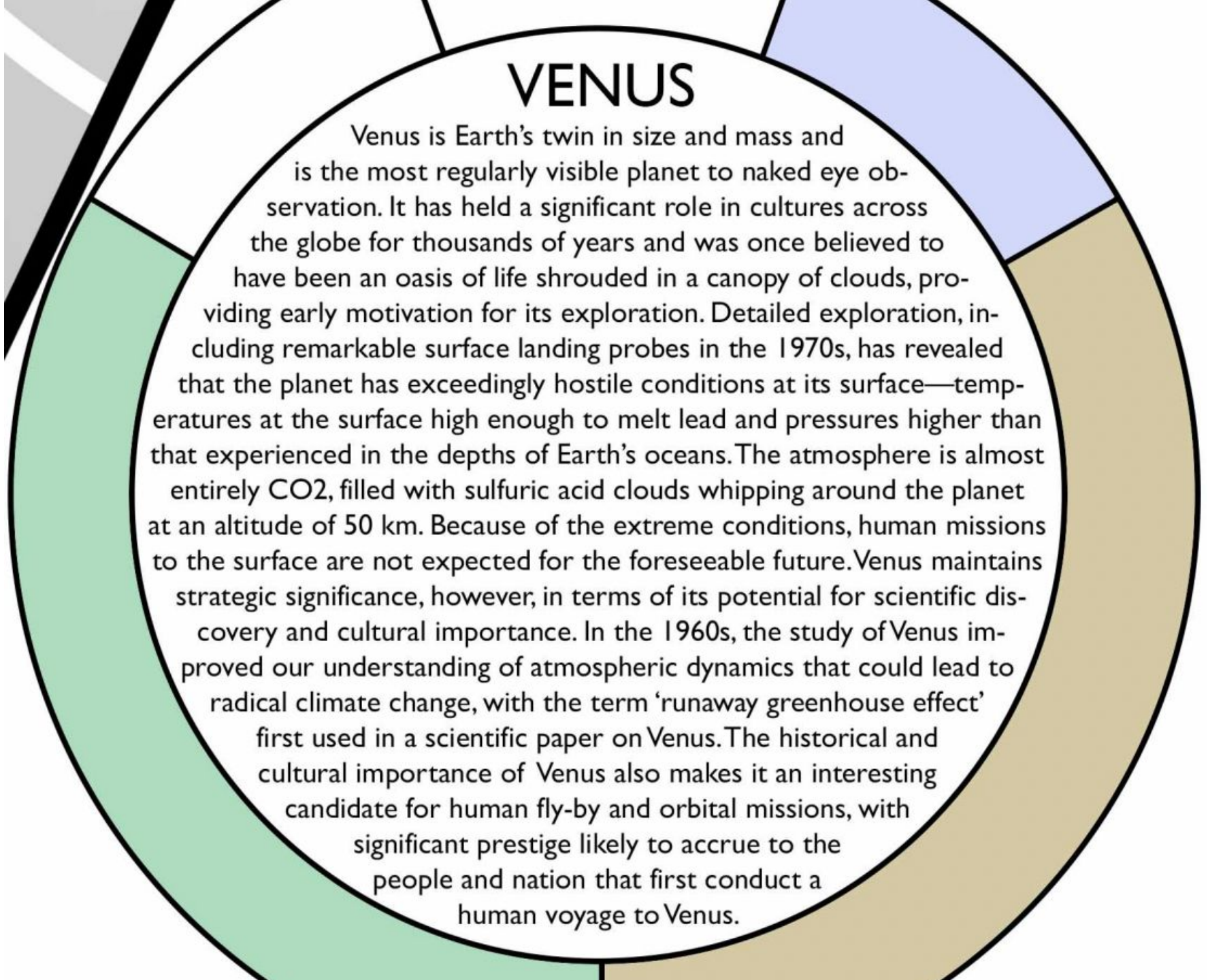
INTERSTELLAR NEIGHBORS
Out to 25 light years

THE GALAXY AND BEYOND
Out to 14,000,000,000 light years

FIRST STARS

DARK AGES

COSMIC MICROWAVE BACKGROUND


VENUS
Venus is Earth's twin in size and mass and is the most regularly visible planet to naked eye observation. It has held a significant role in cultures across the globe for thousands of years and was once believed to have been an oasis of life shrouded in a canopy of clouds, providing early motivation for its exploration. Detailed exploration, including remarkable surface landing probes in the 1970s, has revealed that the planet has exceedingly hostile conditions at its surface—temperatures at the surface high enough to melt lead and pressures higher than that experienced in the depths of Earth's oceans. The atmosphere is almost entirely CO2, filled with sulfuric acid clouds whipping around the planet at an altitude of 50 km. Because of the extreme conditions, human missions to the surface are not expected for the foreseeable future. Venus maintains strategic significance, however, in terms of its potential for scientific discovery and cultural importance. In the 1960s, the study of Venus improved our understanding of atmospheric dynamics that could lead to radical climate change, with the term 'runaway greenhouse effect' first used in a scientific paper on Venus. The historical and cultural importance of Venus also makes it an interesting candidate for human fly-by and orbital missions, with significant prestige likely to accrue to the people and nation that first conduct a human voyage to Venus.

“Some 5 or 6 years ago I was interviewed by a reporter for one of the newspapers in Chicago in regard to the proposals that were being made at the time to explore space and especially to land a man on the Moon. My interview was an exceedingly discouraging one because I was not at all enthusiastic about the plans. I felt that the expense of the program would be all out of proportion to the scientific knowledge to be gained. The next morning I called up the reporter and asked that the interview not be published – in fact, that it be destroyed. The reason for the change in point of view was that overnight it had occurred to me that when men are able to do a striking bit of discovery, such as going above the atmosphere of the Earth and on to the Moon, men somewhere would do this regardless of whether I thought that it was a sensible idea or not. All of history shows that men have this characteristic.”

Harold Urey, 1963

First Mission to Mars or First Mission to Venus?

~2-3 years return trip

~1-1.5 years return trip

NASA TECHNICAL MEMORANDUM

NASA TM X-52311

NASA TM X-52311

MANNED VENUS ORBITING MISSION

by Edward A. Willis, Jr.

Lewis Research Center
Cleveland, Ohio

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION · WASHINGTON, D.C. · 1967

ABSTRACT

Manned orbiting stopover round trips to Venus are studied for departure dates between 1975 and 1986 over a range of trip times and stay times. The use of highly elliptic parking orbits at Venus leads to low initial weights in Earth orbit compared with circular orbits. For the elliptic parking orbit, the effect of constraints on the low altitude observation time on the initial weight is shown. The mission can be accomplished with the Apollo level of chemical propulsion, but advanced chemical or nuclear propulsion can give large weight reductions. The Venus orbiting mission can be done for lower initial weights than the corresponding Mars mission.

CONCLUDING REMARKS

A study has been made of the manned orbiting stopover roundtrip mission to Venus in the 1975 to 1986 time period. The following results were obtained.

1. A typical trip in 1980 has the following characteristics:

Total trip time	565 days
Stay time at Venus	40 days
Earth atmosphere entry velocity	47,000 fps
Venus parking orbit	
Periapse, Venus radii	1.1
Apoapse Venus radii	20.9
Time below 3 Venus radii	2 days
Initial weight in Earth orbit for Apollo level of technology	1.4×10^6 lbs

2. Essential to achieving low initial weights is a highly elliptic ($e = 0.9$) parking orbit at Venus. The elliptic parking orbit may adversely affect information gathering. Further study of the best tradeoffs between parking orbit ellipticity, stay time at Venus, and weight of observation equipment is required.

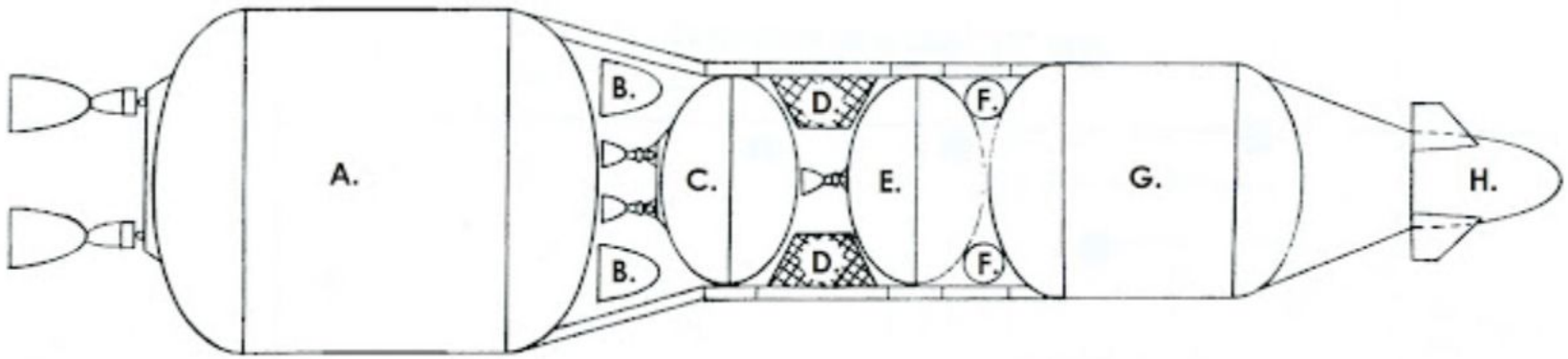
3. A Venus mission can be accomplished using Apollo level technology. S II stages can possibly be used for the Earth departure maneuver. One new stage using Earth-storable propellants is required for the Venus arrival and departure maneuvers.

4. While the Venus orbiting mission can be accomplished using the Apollo level of technology, reductions in weight are possible using advanced propulsion. For example, using a nuclear rocket stage for the Earth departure maneuver can reduce the initial gross weight by 30 percent. If, in addition, OF_2-CH_4 stages are used for the maneuvers to arrive and depart Venus, a total weight reduction of 50% is possible.

5. A single vehicle design for the 1980 launch opportunity can accomplish the Venus mission in any other synodic period.

6. To accomplish a Mars orbiting mission in the easiest year would require a vehicle 70% heavier than that for the Venus orbiting mission in the most difficult year. The disparity can be much larger in other years.

In the years immediately preceding and after Apollo – when NASA engineers were acutely focused on implementation practicalities of human planetary missions – Venus was recognized as providing by far the easiest first planetary human spaceflight mission opportunity.



The 129,250-pound (dry weight) Earth-departure stage (A in the cutaway drawing above) and the Venus orbiter spacecraft would be launched into Earth orbit separately. After the stage was loaded with 942,500 pounds of propellants in orbit, it would link up with the spacecraft. The stage would expend 930,000 pounds of propellants to increase the spacecraft's speed by 2.8 miles per second, launching it out of Earth orbit toward Venus. It would stay attached to the spacecraft until after a course-correction burn halfway to Venus that would expend an additional 12,500 pounds of propellants. The 332,000-pound Venus orbiter spacecraft, which could reach Earth orbit atop a single uprated Saturn V rocket, would comprise 10,000 pounds of Venus atmosphere probes (B), the 103,000-pound Venus arrival rocket stage (C), a 30,000-pound Venus scientific remote sensor payload (D), the 95,120-pound Venus departure rocket stage (E), the 4,000-pound Venus-Earth course-correction stage (F denotes tanks; engines are too small to be seen at this scale), the Command Module (G) for housing the crew, and the Earth atmosphere entry system (H), a 15,250-pound lifting-body with twin winglets for returning the crew to Earth's surface at the end of the mission. Of the Command Module's 66,000-pound mass, food, water, and other expendable supplies would account for 27,000 pounds. Image credit: NASA.


The Venus Underground
Est. 2019
Washington DC

International Astronautical Congress
Washington DC - 2019

Last Updated: 11th July, 2020 13:26 IST

NASA Proposes 'Venus Flyby' During First Crewed Mission To Mars

Curiosity of space has driven countless missions over the years and recently the scientists are now deriving that the only way to reach Mars is to flyby Venus.

Written By Aanchal Nigam

R. REPUBLICWORLD.COM

Acta Astronautica

Volume 180, March 2021, Pages 100-104

Venus Exploration in the New Human Spaceflight Age

Noam R. Izenberg [a], Ralph L. McNutt Jr. [a], Kirby D. Runyon [a], Paul K. Byrne [b], Alexander MacDonald [c]

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https://doi.org/10.1016/j.actaastro.2020.12.020

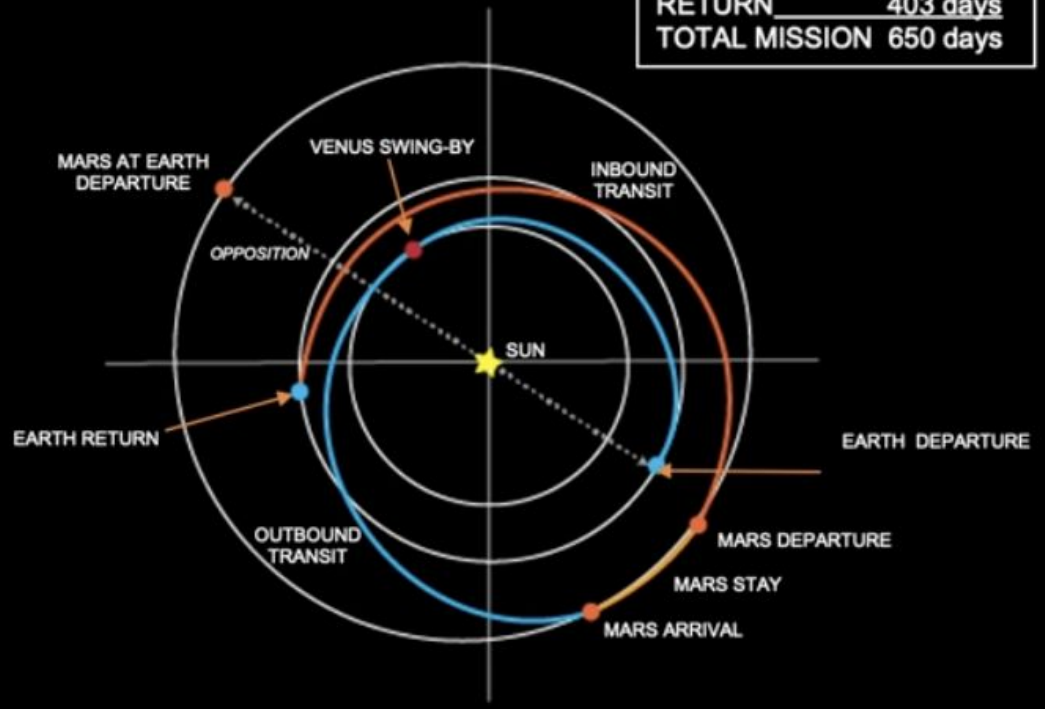
Mars Trajectory Design Reference Architecture

May 17, 2022

Short-Stay Missions

Variations of missions with short Mars surface stays and may include Venus swing-by

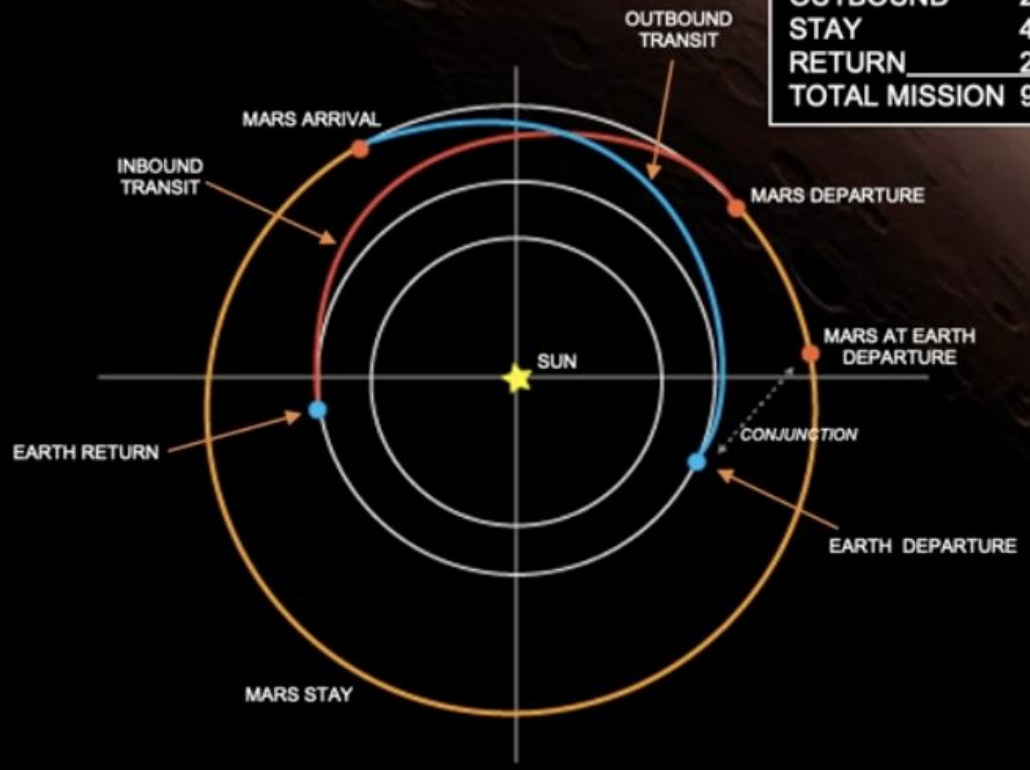
MISSION TIMES	
OUTBOUND	217 days
STAY	30 days
RETURN	403 days
TOTAL MISSION	650 days



Long-Stay Missions

Variations about the minimum energy mission

MISSION TIMES	
OUTBOUND	210 days
STAY	496 days
RETURN	210 days
TOTAL MISSION	916 days



- There is a long-run enduring cultural interest in the planet Venus, with the result that humans have been thinking about expeditions to Venus for over a century and designing missions to Venus for decades.
- As with any major space exploration achievement, there is a potential signaling value to be claimed by anyone who accomplishes a first human mission to Venus.
- The combination of the intrinsic motivation of individuals and the potential signaling value for nation states or individuals suggests that once it is possible and practicable to achieve, someone will try to achieve it.
- Since a mission to Venus could be non-trivially simpler than a mission to Mars, a mission to Venus could be less expensive and become achievable sooner than a mission to Mars.
- With the development of deep space exploration and complementary commercial space capabilities, a first human mission to Venus – orbital or fly-by – could be relatively close at hand (~2030s), *so let's design one.*
- An updated design for a dedicated Earth-Venus-Earth mission could be a good target to change the conversation about the diversity of space exploration opportunities that lie ahead.