



Knowledge Inn (in nature). 22

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**Professional Profile of
Dr Swati Mohan**

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Conspectus: Swati Mohan was born in Bangalore (India), and emigrated to the US in her first year itself along with her family. She was raised in Northern Virginia and Washington DC metro area. Swati was graduated in Mechanical engineering from Cornell Univ. After working as Mission Operations Systems Engineer in JPL for a year, she did Ph.D. in MIT Space Systems Laboratory. Dr Swati, had been with NASA since 2010 and now is a Lead G&C Systems Engineer for Mars 2020. Swati was married to Santhosh, Pediatrician (Research scientist) and the couple have two daughters.

Swati Born in the year 1981



At Bengaluru, Karnataka, India

**Lead GN&C Systems Engineer for Mars
2020**

**National Aeronautics and Space
Administration**



Noble achievements for scientific attempts
Nobel awards for scientific achievements

Biological Family of Dr Swati Mohan

| | | | | | |
|----------|-------------------|--|---|-------------|-----------|
| Father | Srinivas Mohan | Worked in private sector | Mother | Jyoti Mohan | Homemaker |
| Husband | SanthoshNadipuram | <ul style="list-style-type: none"> ○ Pediatric infectious disease physician ○ Research scientist | Cedars-Sinai in Los Angeles | | |
| | | <ul style="list-style-type: none"> ○ Clinical instructor in pediatric infectious disease | David Geffen School of Medicine at UCLA | | |
| Children | Two daughters | | | | |

Academic profile of Dr Swati Mohan

| | | | |
|------------|----------------|-----------------|--------------------------------------|
| | Schooling | | Hayfield High School, Alexandria, VA |
| 2000– 2004 | B.S graduation | Mechanical Eng. | Cornell University, Ithaca, NY |

| | | | |
|---------------------|------|--|------------------------------|
| Aug 2005 – Mar 2010 | M.S | Aerospace Aeronautical and Astronautical Engineering | MIT Space Systems Laboratory |
| | Ph D | | |

| | | |
|------|------------|---|
| Ph.D | Thesis | Quantitative Selection and Design of ModelGeneration Architectures for On-Orbit Autonomous Assembly |
| | Supervisor | Dr. Dave W. Miller |

Employment. Dr Swati Mohan

| | | |
|--------------------|--|---------------------------------|
| | | |
| Mar 2004 –Aug2005 | Mission Operations Systems Engineer | NASA, Jet Propulsion Laboratory |
| Aug 2010 – Present | Mars 2020 Guidance, Navigation, & Control Systems Engineer, Lead | |
| | | |

Inspiration at childhood

1990

- ✓ At the age of 9, Swati watched (for the first time) 'Star Trek', a sci-fi (science fiction) show.
→ She remained astounded by the wonderful scenes in the new regions of the universe

2020

- ! Dr Swati recently recalled in a Q&A on NASA's website that
 - "I remember thinking" like "I want to do that. I want to find new and beautiful places in the universe."
- ✓ Now, being one of the leads of MARS-2020 mission, her feeling is
 - 📖 The vastness of space holds so much knowledge that we (human scientists) have only begun to learn."

Career Life Goal when in School

- ! Her career choices also included becoming a pediatrician until she was 16 years old.

Inspiration at under graduation

- ! I took my first physics class when I was 16. Everything was so easy and understandable.
- ! I was lucky enough to have a great teacher.
- ! That was when I really considered engineering, as an academic channel to pursue my interest in space exploration

Work place (JPL) --serine yet esoteric Environment

All the projects at JPL

- ! Seek to expand human understanding
- ! Almost always first of a kind in some way
- ! Every day, there are so many exciting things happening
- ! Mostly difficult, but made Possible by incredibly talented people
- ➔ Provides a lot of inspiration
- ➔ It's incredibly motivating to work
- ➔ What we get to do, to see, to learn, to wonder at amazing outcome
- ! I am always in constant awe
- 📖 It is an honor and privilege to work at JPL
- ✓ There are many things that have to go right to get Perseverance on to the ground safely
How to make it happen? Not simple. The word 'Complex' is too simple to portray even a bit/pixel/voxel of what happens vs what has to happen in safe landing of Percy in spatio-temporal subsystem

Landmarks in Career of Dr Swati at JPL

| | |
|-----------|---|
| 2004-2005 | Systems engineer on Cassini during Saturn Orbit Insertion and Huygens Probe release |
| 2010- | <ul style="list-style-type: none"> ➔ Cassini (a mission to Saturn) during Saturn Orbit Insertion and Huygens Probe release Systems engineer ➔ GRAIL (a pair of formation flown spacecraft to the Moon) ---mapped the gravitational field of the Moon--- Navigation Orbit Determination analyst ➔ Co-founded and managed the Small Satellite Dynamics Testbed ➔ OCO-3-- Lead Pointing Systems Engineer |

| | |
|-----------|--|
| | <ul style="list-style-type: none"> 📖 Dr Swati performed multiple tests on the International Space Station (ISS) with SPHERES (Synchronized Position Hold Engage and Reorient Experimental Satellite) 📖 Worked on the SPHERES Zero Robotics competition for middle and high school students 📖 SWARM, ALMOST testbeds |
| 2013-2021 | <p>Mohan joined in 2013 team of Mars 2020, Team was assembled just before that</p> <ul style="list-style-type: none"> ➔ Lead to ensure the spacecraft that carries the rover was properly oriented <ul style="list-style-type: none"> ○ During its travel to Mars ○ While landing on the Mars surface ➔ Headed the attitude and control system of the mission ➔ Responsible for GN&C <ul style="list-style-type: none"> ○ Training of team ○ Scheduling the mission control staffing ○ Policies/procedures ➔ Primary point of communication between the GN&C (Guidance, Navigation & Control) subsystem and the rest of the project |

! Landing –
! Landing Autonomous
! Landing Autonomous Safe
! Landing Autonomous Safe on Mars
! Landing Autonomous Safe on Mars without human maneuvering

| Open heart talk of Dr Swati | |
|---|---------------------------------------|
| ! I was always interested in space ! But, I didn't really know about opportunities to turn that interest into a job/profession | |
| I really think the path to success starts with being honest to yourself about | |
| <u>?</u> What your skills are | <u>?</u> Where you're not good at |
| <u>?</u> What you're good at | <u>?</u> What you don't like |
| <u>?</u> What you like | <u>?</u> What you not interested in |
| <u>?</u> What your interests really are | <u>?</u> What does not make you happy |
| <u>?</u> What makes you happy | |

Research papers of Dr Swati Mohan

| | | |
|--|----|----------------|
| Some Publications | of | Dr Swati Mohan |
| <ol style="list-style-type: none"> 1. Babuscia, Alessandra; Van de Loo, Mark; Wei, Quantum J.; Pan, Serena; 2. Mohan, Swati; Seager, Sara (2014). "Inflatable antenna for cubesat: fabrication, | | |

deployment and results of experimental tests". *2014 IEEE Aerospace Conference*. Big Sky, MT: IEEE: 1–12

3. **Mohan, Swati**; Miller, David (18 August 2008). "SPHERES Reconfigurable Control Allocation for Autonomous Assembly". *AIAA Guidance, Navigation and Control Conference and Exhibit*. Honolulu, Hawaii: American Institute of Aeronautics and Astronautics
4. Scharf, Daniel P.; Regehr, Martin W.; Vaughan, Geoffery M.; Benito, Joel; Ansari, Homayoon; Aung, MiMi; Johnson, Andrew; Casoliva, Jordi; **Mohan, Swati**; Dueri, Daniel; Acikmese, Behcet (2014-03). "ADAPT demonstrations of onboard large-divert Guidance with a VTVL rocket". *2014 IEEE Aerospace Conference*. Big Sky, MT, USA: IEEE: 1–18
5. **Mohan, Swati**; Miller, David (10 August 2009). "SPHERES Reconfigurable Framework and Control System Design for Autonomous Assembly". *AIAA Guidance, Navigation, and Control Conference*. Chicago, Illinois: American Institute of Aeronautics and Astronautics
6. **Mohan, Swati**; Miller, David W. (2014-09). "Dynamic Control Model Calculation: A Model Generation Architecture for Autonomous On-Orbit Assembly". *Journal of Spacecraft and Rockets*. **51** (5): 1430–1453



| Web site | Content | Date | min | # Views |
|---|---|--------------|-------|------------|
| https://youtu.be/4czjS9h4Fpg | Descent and touchdown on Mars | Feb 23, 2021 | 3.25 | 15,640,760 |
| https://youtu.be/Cr56P7K2zuQ | Watch Perseverance's landing video (and hear Mars for the first time) | Feb 23, 2021 | 5.33 | 426,123 |
| https://youtu.be/rzmd7RouGrM | NASA's Mars 2020 Perseverance Rover Landing Animations | Dec 22, 2020 | 3.10 | 4,313,936 |
| https://youtu.be/GUqsH5y1j1M | Watch NASA's Perseverance Rover Land Video from Mars! | Feb 23, 2021 | 1.08 | 1,150,503 |
| https://youtu.be/kNVzxeYjE9Q | NASA Science Live: We Landed on Mars | Feb 20, 2021 | 29.12 | 984,045 |
| https://youtu.be/L1Ok2v-0xzM | Who is Swati Mohan? | Feb 19, 2021 | 3.04 | 24,992 |
| https://youtu.be/tLaUM2XbyJc | Mars Mission Update: June 2021 | Jun 16, 2021 | 48.31 | 899,230 |

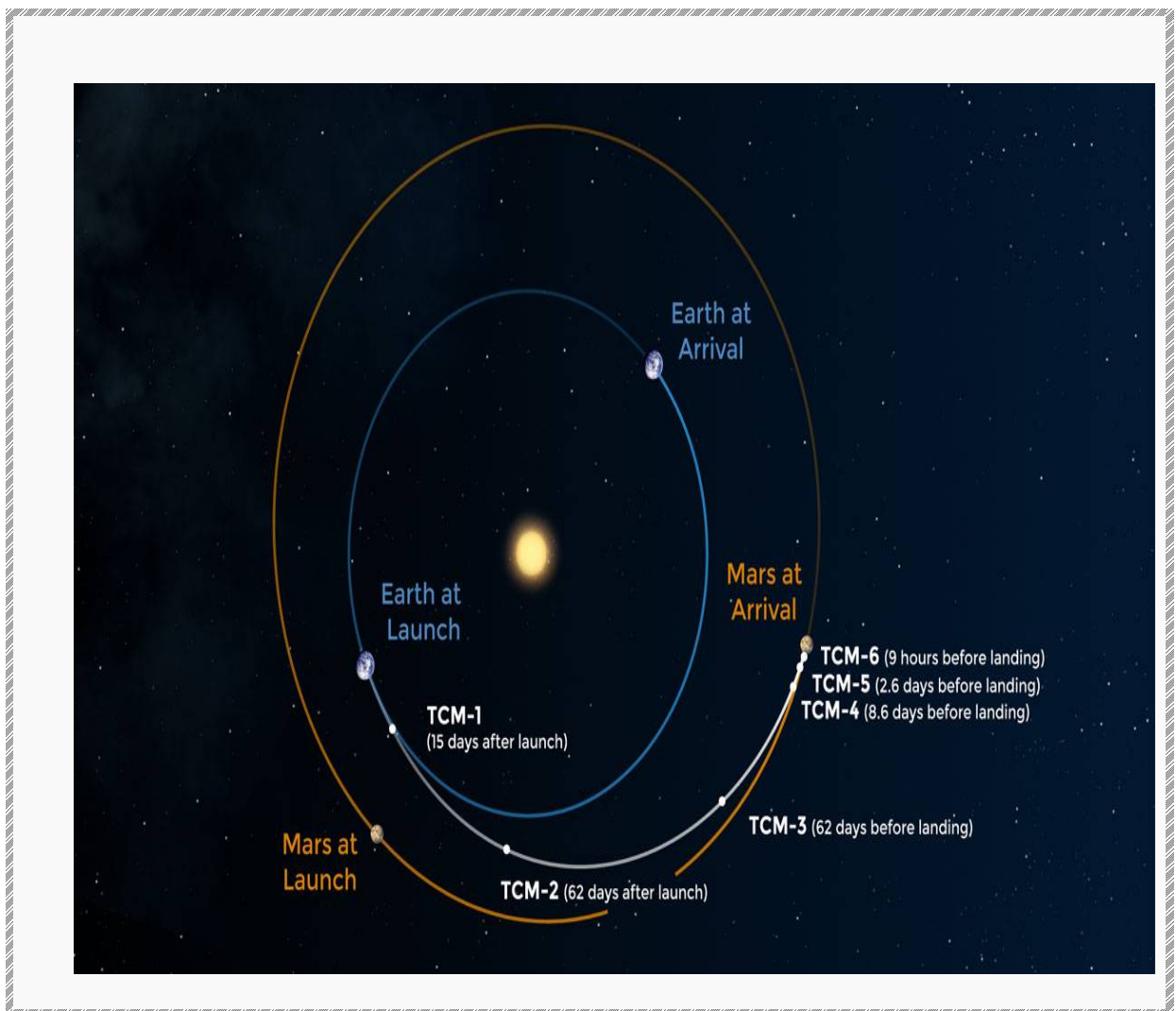
Supplementary information (SI)

Credit: NASA/JPL-Caltech-

SI-1: Before Launch

Credit: NASA/JPL-Caltech -

| Date (subject to change) | Trajectory Correction Maneuvers | Operations | #days after launch |
|--------------------------|---------------------------------|--|--------------------|
| Aug. 14, 2020 | TCM-1 | Point spacecraft toward Mars, fine-tune its flight path after launch | 15 |
| Sept. 30, 2020 | TCM-2 | | 62 |



Cruise phase Mars-2020 heading toward Mars

- ➔ To figure out how the spacecraft is oriented
- ➔ Make sure it is pointed correctly in space
 - ✓ Solar arrays to Sun
 - ✓ Antenna to Earth
 - ✓ Maneuver the spacecraft to get it where we want to go



SI-2: Before landing

Credit: NASA/JPL-Caltech -

| Date (subject to change) | Trajectory Correction Maneuvers | Operations | # days before landing |
|--------------------------|---------------------------------|--|-----------------------|
| Dec. 18, 2020 | TCM-3 | To make sure the spacecraft travels at the right speed and direction to arrive at the correct location at the top of the Martian atmosphere before landing | 62 |
| Feb. 10, 2021 | TCM-4 | Refine flight path | 8.6 |
| Feb. 16, 2021 | TCM-5 | | 2.6 |
| Feb. 17, 2021 | TCM-5X | Backup maneuver, if needed | 1.6 |
| Feb. 18, 2021 | TCM-6 | Contingency maneuver, if needed. Final opportunity to adjust where the spacecraft will enter the Mars atmosphere | 9 hours |

SI-3: Entry, descent and landing (EDL) of Mr Percy on Mars

Credit: NASA/JPL-Caltech -

- ! In the control room, Dr Swati was
 -  Communicating
 -  Coordinating between GN&C (Guidance, Navigation & Control) (often pronounced 'Gintsee') subsystem (eyes and ears" of the spacecraft) and the rest of the project's team

- ! It takes seven minutes to travel from entry into Mars's atmosphere to the landing (touching ground) on Martian surface.

Terrain-Relative Navigation: Perseverance is the first mission to use this method. While it's descending on the parachute

- + Allows Perseverance to land in much more challenging terrain than Curiosity, or any previous Mars mission

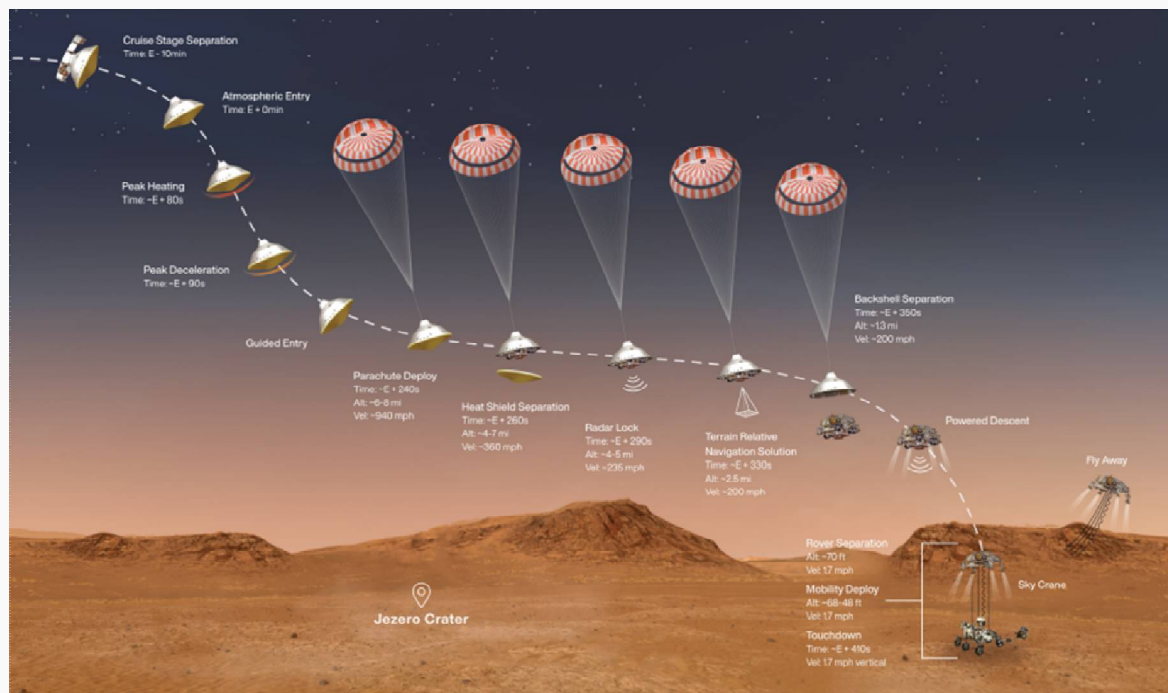
Method

- ! It will actually take images of the surface of Mars
- ! Determines where to go based on what it (machine) sees

This is finally like a (human) pilot landing a plane with eyes wide-open

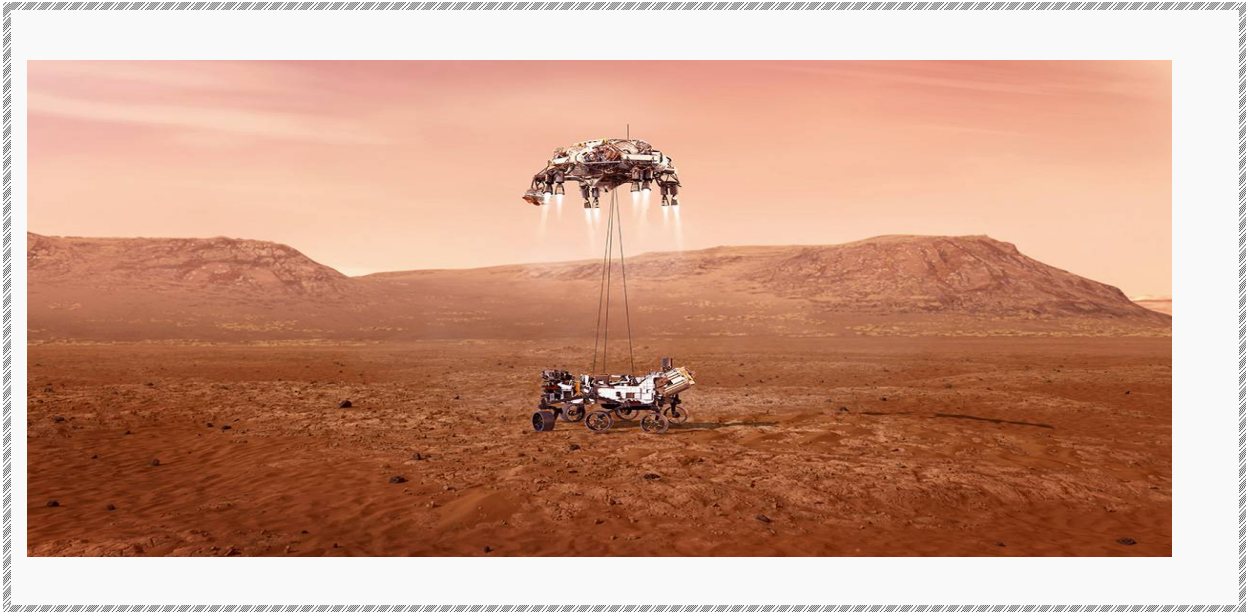
- ➔ But, the one-way communication time from Mars to Control station on earth is >11 min
 - ➔ It was indispensable to have a robust navigation system with no room for error
- The system proved successful against unknown/unnoticed odds even if they occurred

- ➔ Touchdown happened



Key steps in entry, descent and landing sequence of the Mars 2020 mission on Feb. 18, 2021.

Image credit: NASA/JPL-Caltech



SI 4: Dr Swati was commentator for landing of the Perseverance rover on February 18, 2021



Perseverance Touchdown Announcement

- ✓ After more than 11 min confirmation arrived to control systems
- ✓ Dr Swati Mohan exclaimed saying
- ✓ **"Touchdown confirmed!** Perseverance is safely landed on the surface of Mars, ready to begin seeking the signs of past life," It is She who first delivered the news to earthlings.

- ✓ The scientists of Mission Control Center of NASA's Jet Propulsion Laboratory in Pasadena, California erupted in celebration, clapping, roaring applause and fist bumping (socially distant due to COVID-19)

Success and Future endeavors

- ✓ Mr(s) P is physically present on Mars surface ...
 - ✓ That mission completed successfully
- ✓ But research for discoveries just began
- ! Be ready to start seeking signs of past life on Mars
- ➔ Mr(s): (Master/Mars Robot/Rover (s/surface/) P(erseverance))

