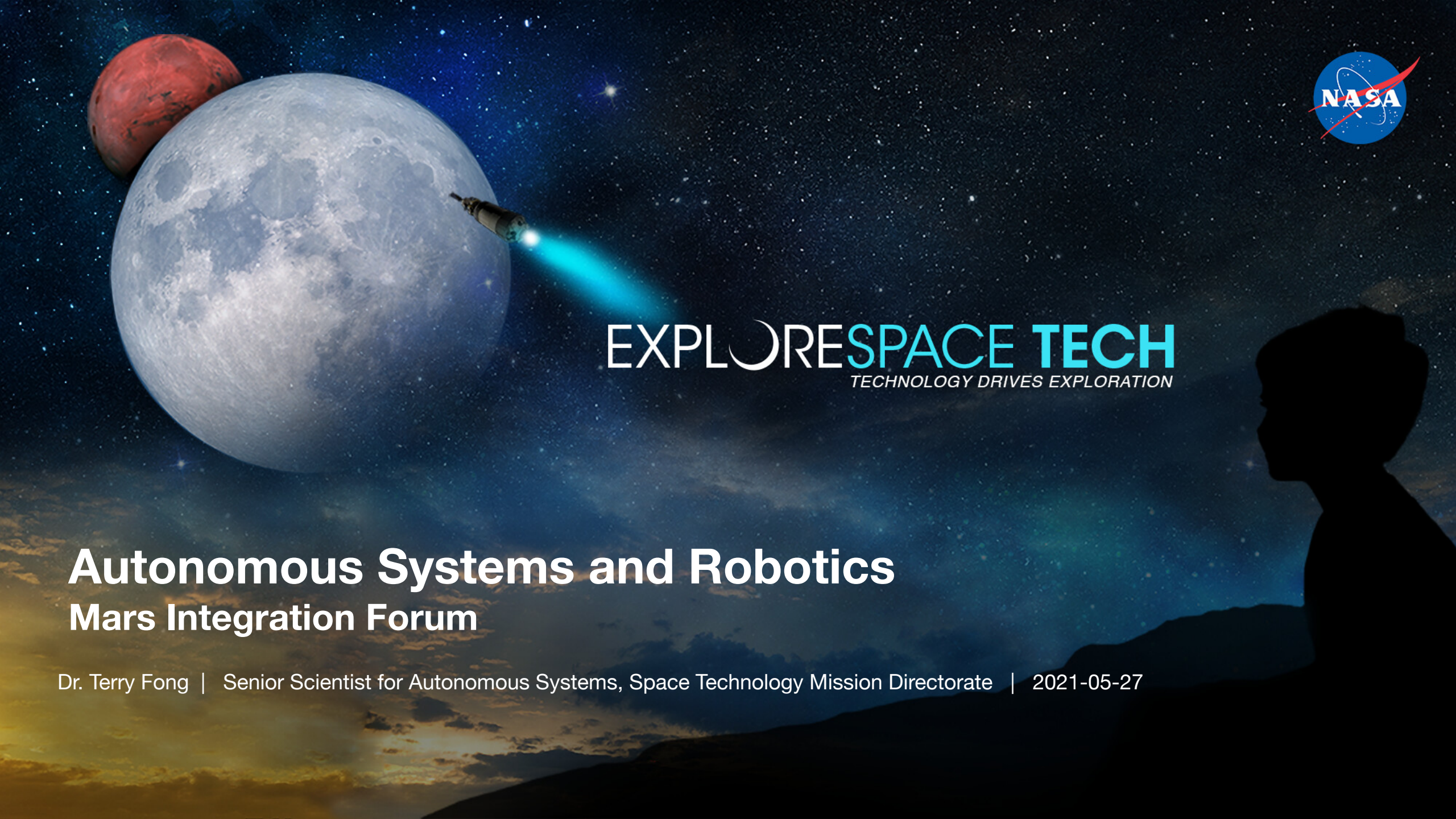


The background of the entire slide is a composite image of space exploration. On the left, a large, detailed Earth is shown. To its right, a smaller, reddish planet (Mars) is visible. A rocket is depicted in the center, moving from left to right, leaving a bright blue and white trail. The sky is a deep blue with numerous white stars. In the bottom right corner, the silhouette of a person's head and shoulders is visible, looking towards the left. The overall theme is space exploration and technology.

EXPLORESPACE TECH
TECHNOLOGY DRIVES EXPLORATION

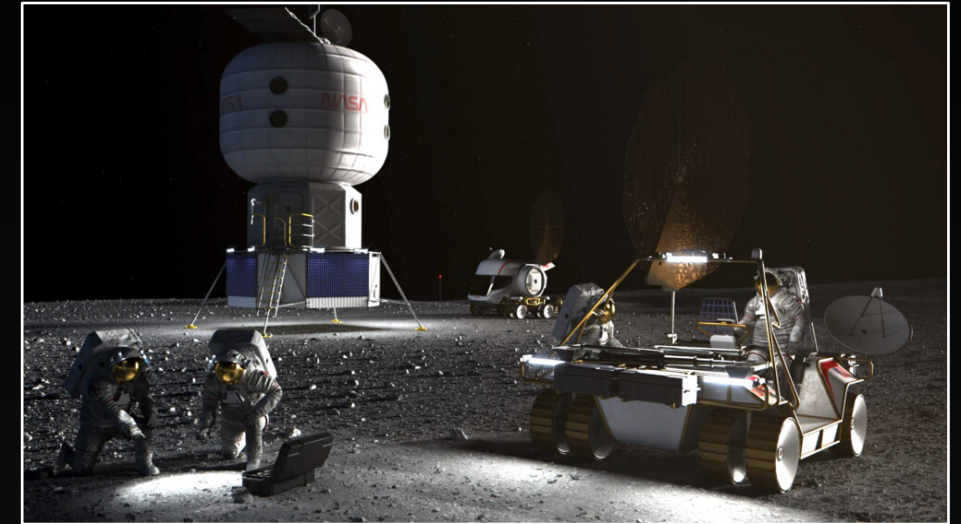
Autonomous Systems and Robotics

Mars Integration Forum

Dr. Terry Fong | Senior Scientist for Autonomous Systems, Space Technology Mission Directorate | 2021-05-27

Human-System Interaction on Mars

- **Lunar missions as precursors to Mars**
 - NASA is currently planning near-term human and robotic missions to the Moon – focus on south polar region
 - Early missions will be short-duration – probably 3 to 7 days
 - Human Mars missions can benefit from lunar proving ground – architecture (orbital & surface), conops, systems
- **Mars conops**
 - Given Earth-Mars communications latency, crew will need to operate autonomously for routine real-time operations and urgent, real-time problem-solving
 - Mission control role will become more focused on strategic planning, rather than detailed system management
 - Smart systems are required to support crew / spacecraft autonomy and time-critical response
- **Human-robot teaming**
 - Robots can be used to increase crew productivity
 - Robots can be deployed before & after crew for scouting, site prep, maintenance, long-duration / repetitive tasks
 - Robots can be used to support crew to augment human capacity and to perform coordinated / parallel activities



STMD Autonomous Systems & Robotics Investments

- **Game Changing Development Program**
 - Cold Operable Lunar Deployable Arm (JPL)
 - Cooperative Autonomous Distributed Robotic Exploration (JPL)
 - Distributed Spacecraft Autonomy (ARC)
 - Fail-Operational Capabilities for Caretaking & Utilization Scenarios (JSC)
 - Integrated System for Autonomous and Adaptive Caretaking (ARC)
 - High TRL Rover Lidar (GSFC)
 - Lunar Camera (JPL)
 - Lunar Navigation (JPL)
 - Lunar Surface Innovation Consortium (APL)
- **Commercial Partnerships (Tipping Points & ACOs)**
 - Cube Rover: Astrobotic
 - Space Robot Operating System: Blue Origin
- **Early-Stage Innovation**
 - Coordinated Multi-Robots: Arizona State University, UC Berkeley, UC Santa Barbara
 - Advancing Human-Robot Teams For Space Exploration: Colorado School of Mines, Georgia Tech, Univ. of Rochester
 - Smart and Autonomous Systems for Space: CU Boulder, Stanford, U Illinois Urbana-Champaign, U Mass Amherst
 - Smart Deep Space Habitat Institutes: UC Davis & Purdue

