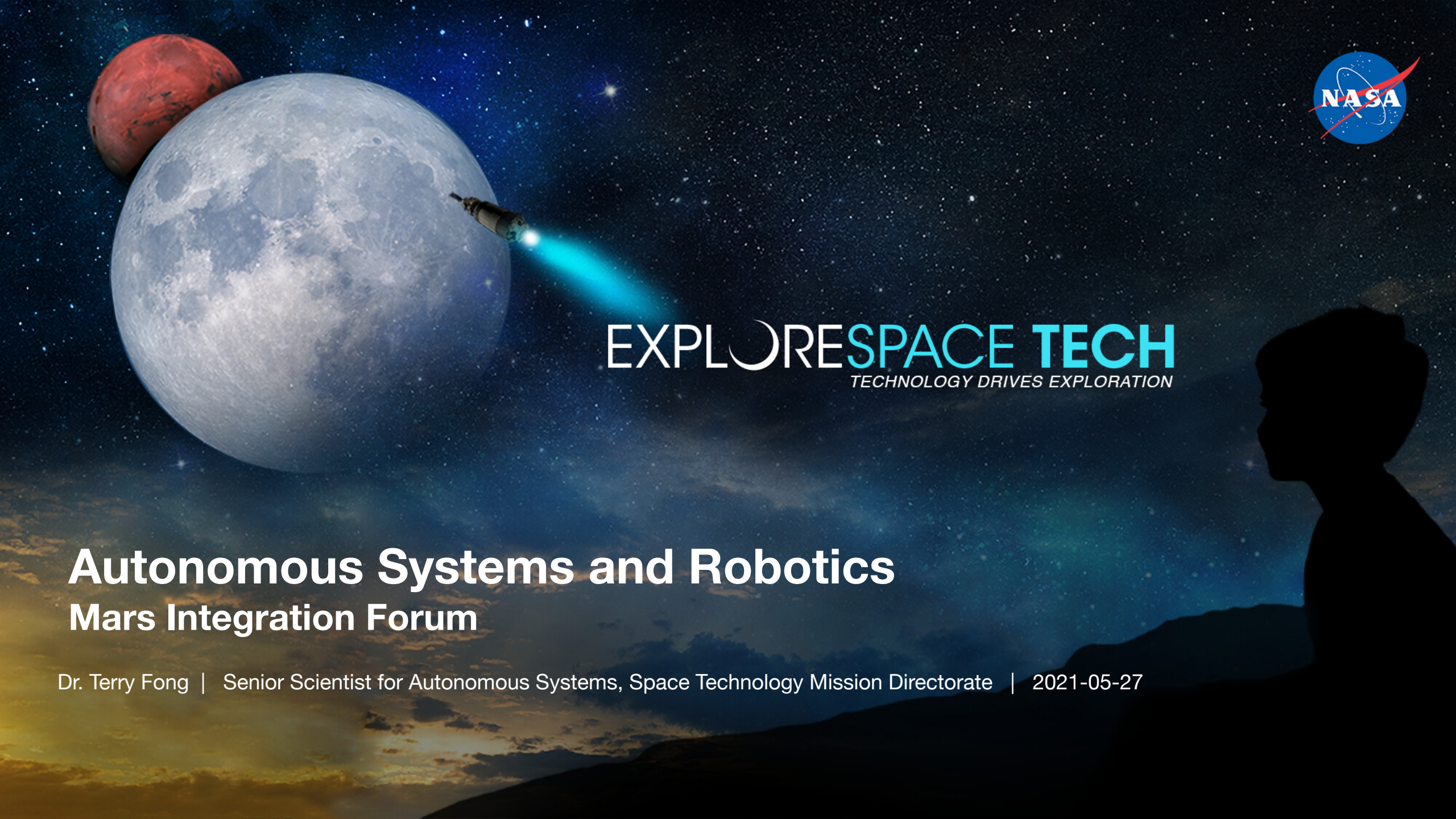


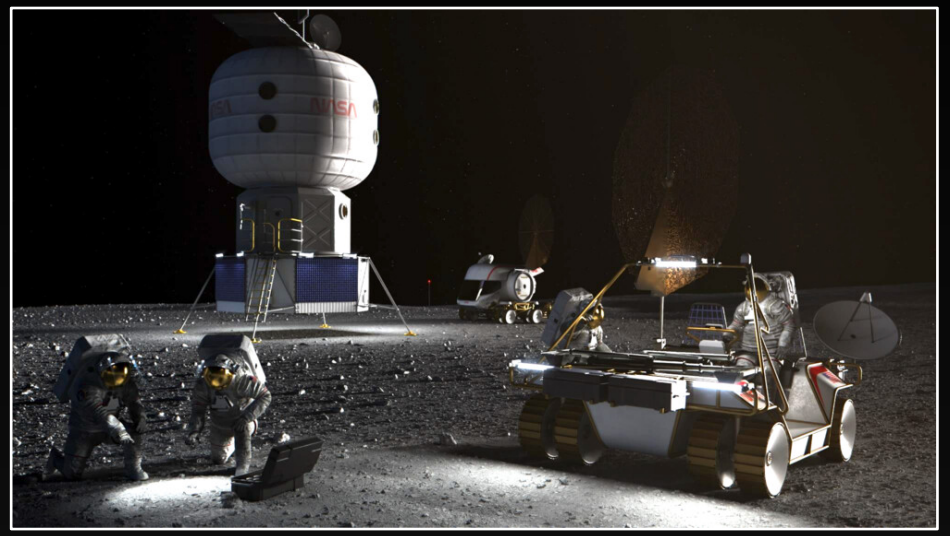
Autonomous Systems and Robotics

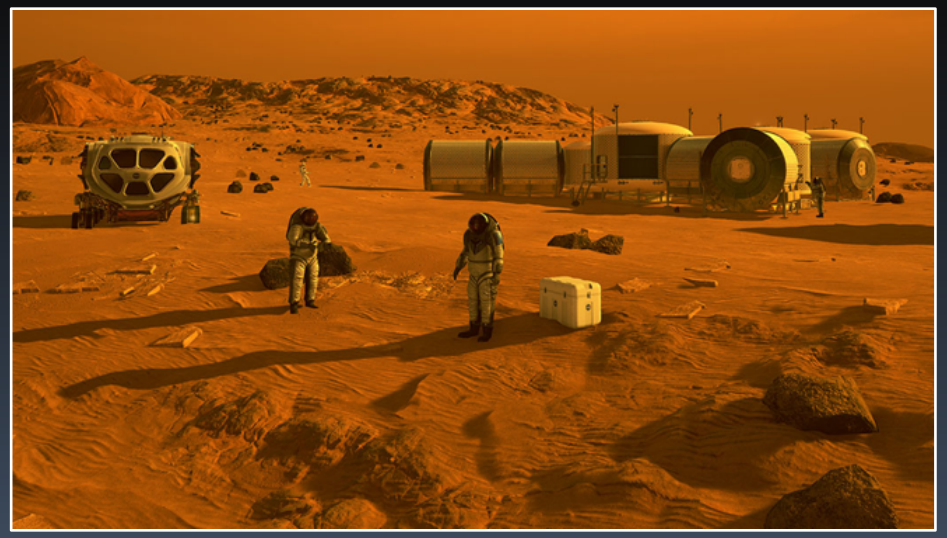
Mars Integration Forum

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