

NASA Collaboration with SpaceX 's Red Dragon Mission

House Committee on Science, Space, and Technology

July 11, 2016



Background

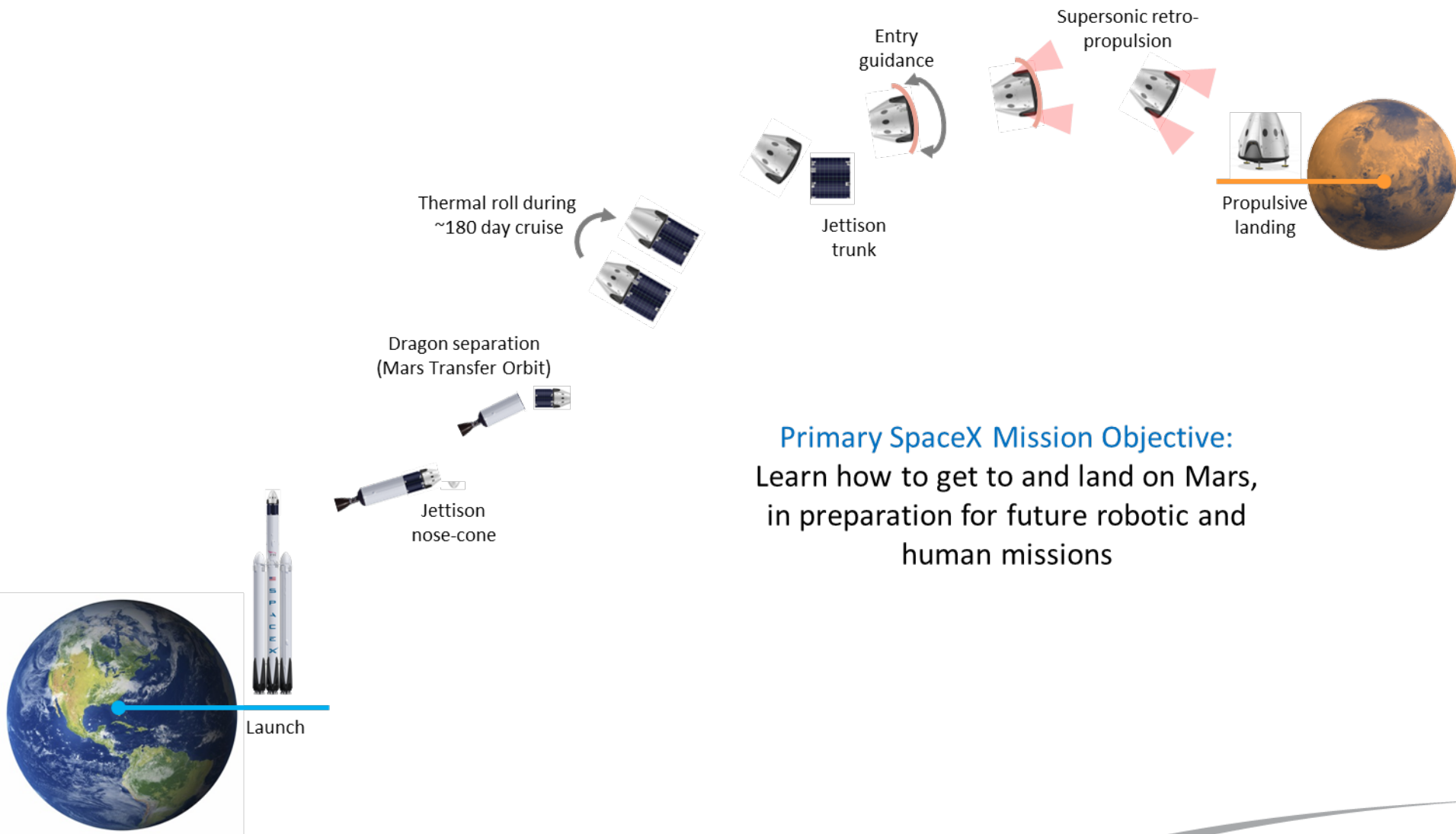
- **December 2014:** NASA's HEOMD competitively awarded Collaborations for Commercial Space Capabilities (CCSC) Space Act Agreements to four firms, agreeing to provide them with NASA's technical insight and assistance on a **no-exchange-of-funds basis**:
 - SpaceX – develop Mars cargo transportation system
 - ATK Space Systems - develop space logistics, hosted payload and other space transportation capabilities
 - Final Frontier Design - develop intra-vehicular activity space suits
 - United Launch Alliance - develop new launch vehicle capabilities to reduce cost and enhance performance
- **Late 2015:** SpaceX requested an expanded level of assistance from NASA under this existing agreement to support a planned **uncrewed technology demonstration mission** to Mars with its Dragon spacecraft
- **October 7, 2015:** NASA Agency leadership briefed on this concept
 - Directed STMD Associate Administrator to form a small team, led by senior leaders throughout the Agency, to conduct a preliminary concept feasibility study.
 - Feasibility study analyzed the technical areas of expanded assistance, identified benefits to NASA, and developed initial cost estimates for NASA's expanded level of assistance.
- **January 26, 2016:** NASA Agency leadership approved additional areas of assistance to the existing collaboration and directed the CCSC agreement be modified to accommodate
- **April 26, 2016:** NASA and SpaceX finalized modification to the CCSC agreement (SAA-QA-14-18883)



Agreement and Approach

- SpaceX is responsible for and will maintain control over Red Dragon design, hardware, and operations. NASA is only providing specific technical support in several technical areas.
- The modification to the CCSC SAA with SpaceX establishes NASA support as defined in six Technical Exchange Documents (TEDs):
 - TED 1. Deep space communications, data relay, and tracking
 - TED 2. Deep space trajectory design and navigation support
 - TED 3. Entry, descent, and landing (EDL) system engineering and analysis
 - TED 4. Aerosciences activities
 - TED 5. Flight system technical review and advice
 - TED 6. Planetary protection consultation and advice
- In return, NASA obtains EDL flight data for a critical technology in the Mars environment
- NASA's support is coordinated across three Mission Directorates:
 - **Human Exploration and Operations Mission Directorate (HEOMD):** (a) manage the overall SpaceX CCSC agreement, and (b) provide communications and tracking support to the mission (TED 1)
 - **Space Technology Mission Directorate (STMD):** lead the Red Dragon technology demonstrator mission design and EDL (entry, descent, and landing) support (TEDs 2-5)
 - **Science Mission Directorate (SMD):** provide planetary protection support (TED 6)
 - An Executive Committee has been established to ensure cross-directorate coordination
- This will be a SpaceX-funded mission:
 - NASA's support is primarily from existing Civil Service and JPL workforce, employed as needed depending on the requested support.
 - Generally will not be full-time activities.
 - Preliminary estimated cost of NASA's workforce support is ~\$32M over 4 years with ~\$6M in FY16

Red Dragon Mission Architecture



Primary SpaceX Mission Objective:
Learn how to get to and land on Mars,
in preparation for future robotic and
human missions

Red Dragon Participation - Benefits to NASA



- **Supports NASA's authorization to help enable the commercial space industry**
- **Offers flight technology demonstration of critical EDL technologies needed for human exploration (particularly supersonic retro-propulsion) in the Mars atmosphere about a decade sooner and at a fraction of the cost to NASA for a future technology demonstrator mission**
 - All candidate EDL architectures for Mars human exploration rely on supersonic retro-propulsion
- **Provides EDL flight data for supersonic retro-propulsion in Mars atmosphere to improve models**
- **Enhances NASA's EDL capability development/sustainment – preparing the workforce for challenges of landing greater mass on Mars**
 - Aero/aeroheating/trajectory performance data on the largest mass and largest ballistic coefficient ever flown at Mars
 - Entry surface heating and pressures
 - Entry guidance performance
 - Supersonic retro-propulsion performance and guidance during power-on flight
 - Ground surface interaction insight for large rocket plumes
- **Industry is focusing effort that will aid the long term challenge of heavy mass Mars landings**



Summary of NASA Technical Support

- **Deep-Space Communications, Data Relay and Tracking**
 - Support the SpaceX mission operations team to develop and execute a concept of operations for deep-space communications, data relay and tracking. Includes providing support and advice on developing deep-space communications and tracking approach, frequency channel assignment and spectrum coordination, and provision of Deep Space Network use.
- **Deep-Space Navigation and Trajectory**
 - Support mission design and navigation including launch/arrival space analysis and trades, cruise trajectory assessments, mission strategies and navigation design assessments, navigation training and certification for operations, and participation in operational readiness tests.
- **Entry, Descent, and Landing System Engineering and Analysis**
 - Provide Mars EDL lessons learned, review and advice.
 - Support simulation development and model validation.
 - Provide landing site selection advice and engineering support.
- **Aerosciences Activities**
 - Coordinate with SpaceX to develop analysis plans for development of engineering source data and perform certain analysis related to EDL.
- **Flight System Technical Review and Advice**
 - Review end-to-end flight system, esp. autonomy, fault tolerance, operability, and qualification approaches.
 - Provide assessment of technical risks associated with flight system design, development, and testing.
- **Planetary Protection Consultation and Advice**
 - Advise SpaceX in the development and implementation of their Planetary Protection Plan (PPP).



Status and Next Steps

- **NASA conducted a fairly high-level technical feasibility assessment and determined there is a reasonable likelihood of mission success that would be enhanced with the addition of NASA's technical expertise**
- **First NASA/SpaceX quarterly review (with the expanded level of assistance) was held on April 13, 2016**
 - Work underway on all TEDs
- **2016: Focus on system design, based heavily on Dragon 2 version used for ISS crew and cargo transportation**
- **Commitment on flight date will be after system design progresses**
 - First launch opportunity is May 2018 for favorable Earth/Mars alignment
 - Additional opportunities every 26 months