Mars Program Update

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September 3, 2014

#JOURNEYTOMARS

Mars Calendar of Events

2013

May – November – *Mars As Art* Exhibit at Dulles Airport Gallery

July 31 – Curiosity Day on the Hill

August 6 – One Year Anniversary of Curiosity Landing on Mars

September 13 – Curiosity on Cover of Science

October 1 –Comet ISON observed with Mars missions

October 30 – Mars2020 enters Phase-A

November 18 - Launch of MAVEN from Cape Canaveral, FL

December 6 – InSight confirmed for flight

2014

January 24 – Cover of Science

April 30 – MOMA/NASA confirmed for flight

July – Mars 2020 instrument selection announcement

August 6 – 2nd Year Anniversary of Curiosity Landing on Mars

September 21 - MAVEN arrives at Mars

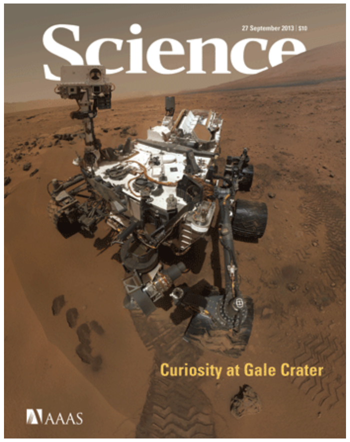
September 24 – India's Mission to Mars (MOM) arrives at Mars

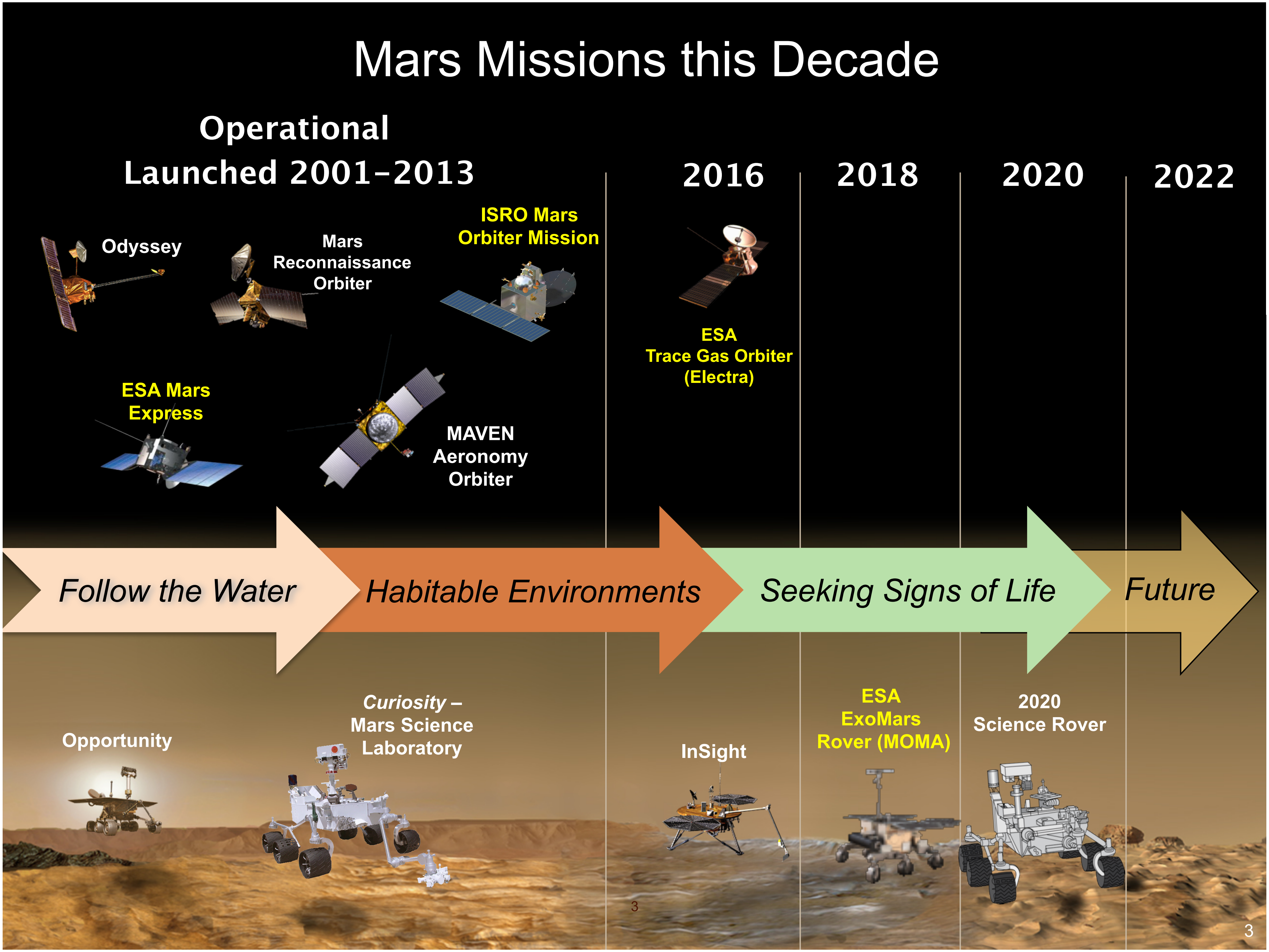
October 19 – Comet Siding Spring encounters Mars

Fall – Discussions with Indian Space Research Organization (ISRO)

Late Fall - Curiosity arrives at Murray Buttes, Mt. Sharp

*** Completed**




Mars Missions this Decade
Operational
Launched 2001-2013
2016
2018
2020
2022
Odyssey
Mars Reconnaissance Orbiter
ISRO Mars Orbiter Mission
ESA Trace Gas Orbiter (Electra)
ESA Mars Express
MAVEN Aeronomy Orbiter
Follow the Water
Habitable Environments
Seeking Signs of Life
Future
Opportunity
Curiosity – Mars Science Laboratory
InSight
ESA ExoMars Rover (MOMA)
2020 Science Rover
3

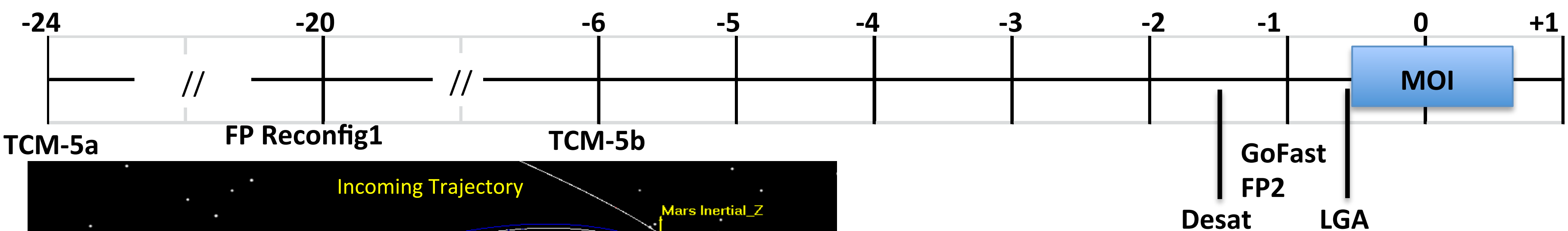
Operating Missions:
Orbiters & Rovers

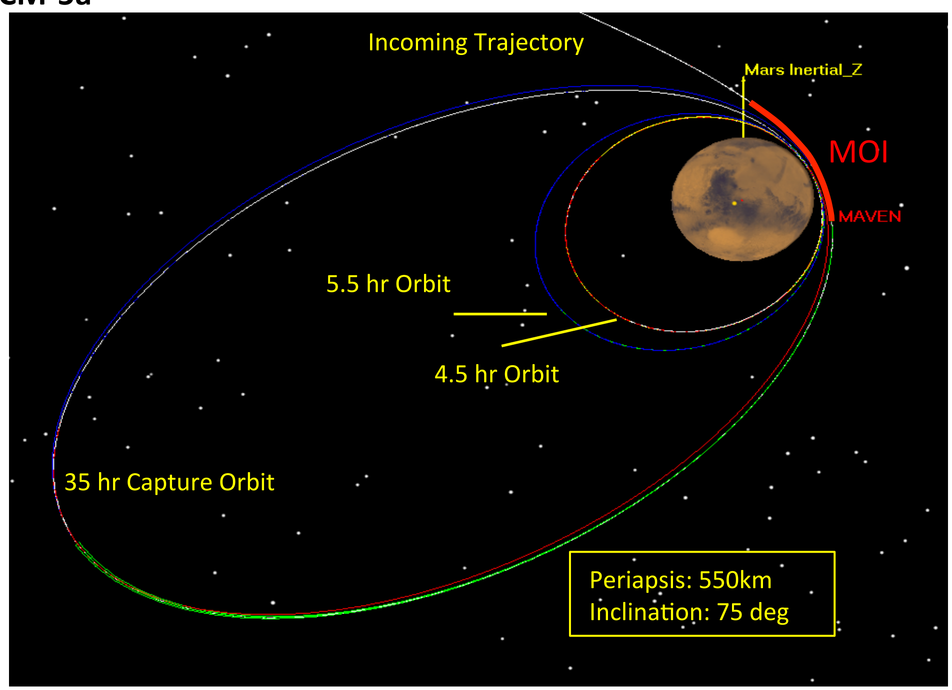
Mars Orbit Insertion (MOI) Preparations

Sept	12	13	14	15	16	17	18	19	20	21	22	23
MOI Rel		-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1

- TCM-4 (Sept 12)
- CLT 27 Hrs, Battery 100%, Pre-MOI Uplinks (Sept 16)
- Prop Tank Preheat, CMIC Copies, LV30 Open, Phase = MOI, Start moi_nom (Sept 19)
- MOI (Sept 21/22)
- A1 (Sept 22)
- End MOI Phase (Sept 23)

MOI Countdown (Hrs)

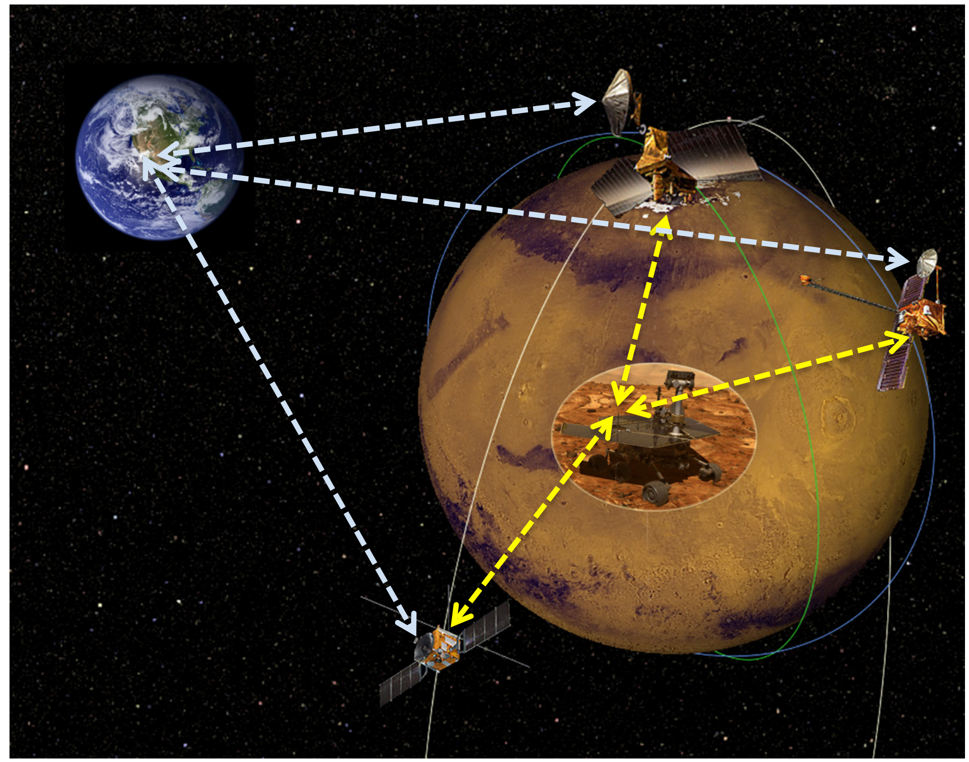




- MOI will occur on 9/21/14 (ET)
- Sequence activates 3 days out
- Emergency TCM 5a and 5b opportunities at MOI-24 hours and MOI-6 hours
- Configure for GoFast Recovery (MOI-1 hour)
- In contact with Earth during the entire burn sequence
- Primary operations at LM-Denver, backup operations at Goddard

Mars Commercial Telecomm RFI

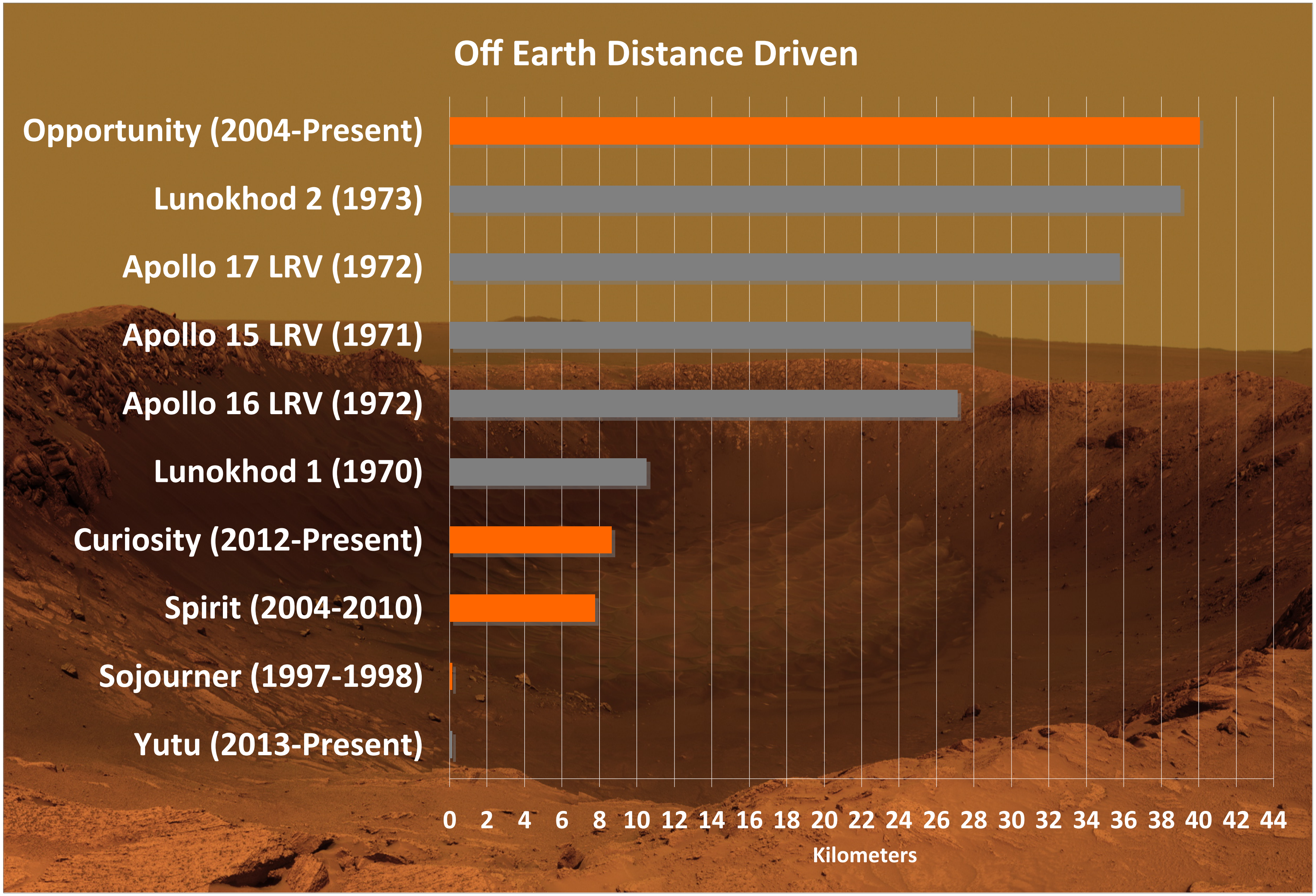
- Seeking business models for data-relay services
  - Orbiter to surface or orbiter-to-orbiter
- Also options to upgrade service at Mars starting in the 2020s
  - Optical comm, other ideas
- For planning purposes only; understanding the range of options is key
  - What is possible and what makes sense to potential providers
  - Range of possible costs and implementation models



RFI response: Ten pages due August 25th

http://go.nasa.gov/1kV6KYj

Off-Earth Odometry Records



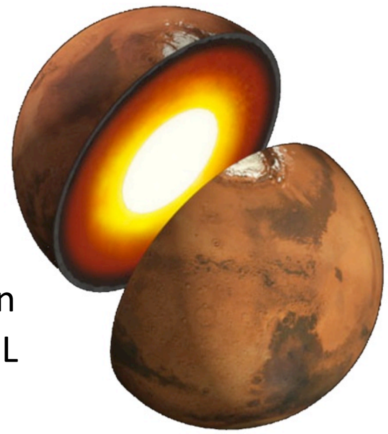
2014-07-20

Developing Mars Missions
- InSight
- Mars 2020

InSight – Interior Structure from Seismic Investigations, Geodesy and Heat Transport

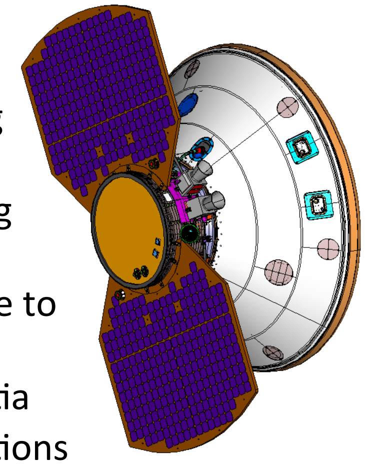
Mission Team

- PI: Bruce Banerdt, JPL
- Dep. PI: Sue Smrekar, JPL
- Science Team: International
- PM: Tom Hoffman, JPL
- Project/Science Mgmt.: JPL
- Spacecraft: Lockheed-Martin
- Payload: CNES, DLR, CAB, JPL
- Operations: JPL/L-M



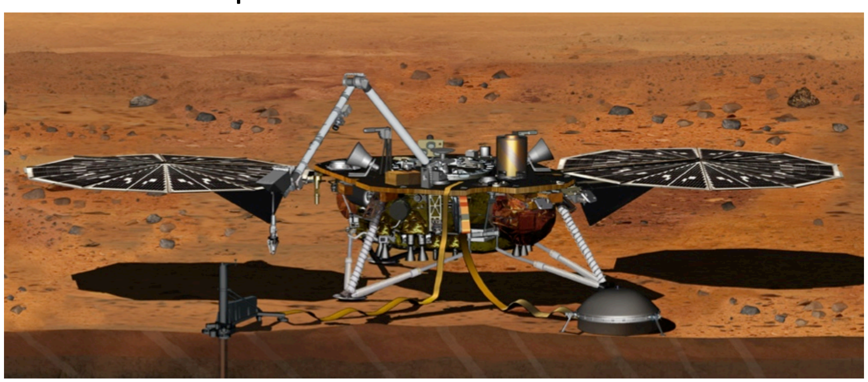
Mission Description

- Stationary, long-duration geophysical lander mission using Phoenix heritage spacecraft
- Launch 3/2016 from Vandenberg AFB on Atlas V 401
- Type 1 trajectory, 6 month cruise to Mars
- Landing 9/2016 in Elysium Planitia
- One Mars year of surface operations



Science Goals

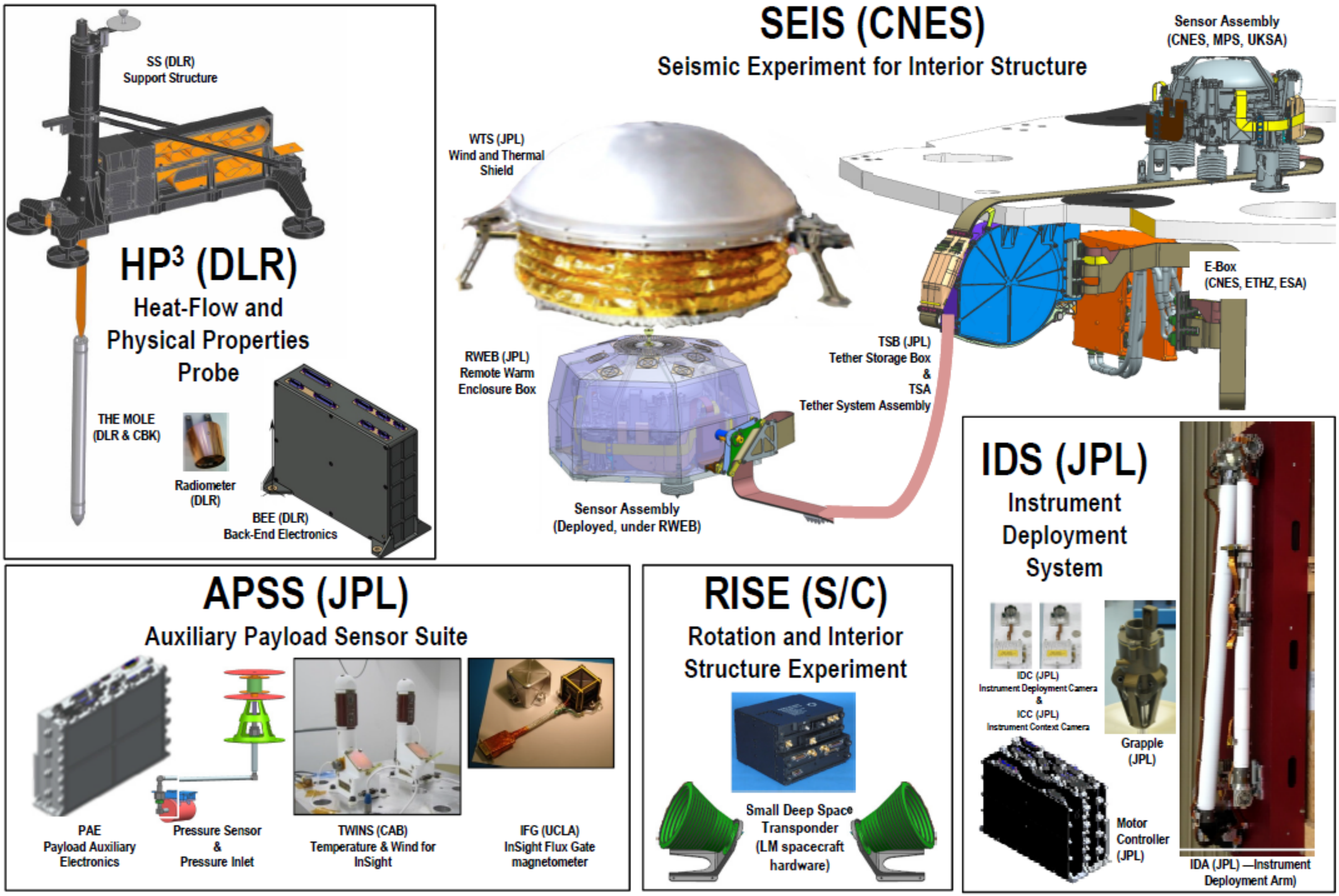
- Understand the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars
- Determine the present tectonic activity and meteorite impact rate.



Payload

- SEIS – Broad-band seismometer: Measures seismic waves from 0.01 mHz to 50 Hz (France, Switzerland, UK, Germany, USA)
- HP^3 – Heat Flow/Physical Prop. Package: Measures heat flow from Mars' interior (Germany, Poland)
- RISE – Rotation and Interior Structure Experiment: Uses S/C comm. system to measure motion of Mars' rotational pole (USA)
- IDS – Instrument Deployment System: Robotic arm and cameras to deploy instruments to surface (USA)
- APSS – Auxiliary Payload Sensor Subsystem: Environ-mental measurements (wind, pressure, and magnetic field) to support the SEIS experiment (USA, Spain)

InSight Payload

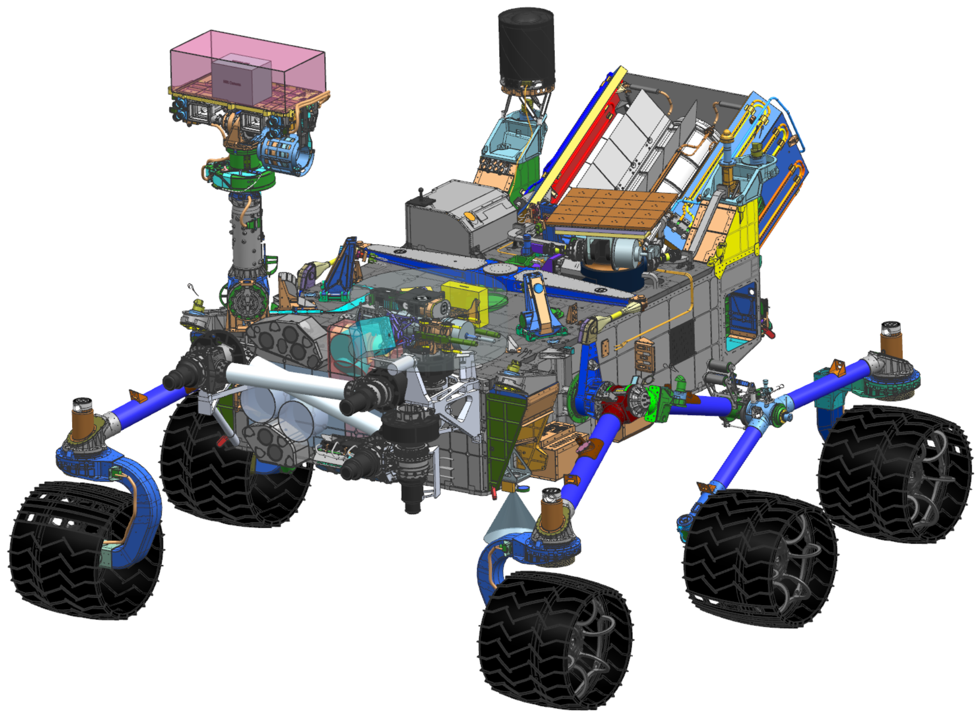


Seeking signs of life: Mars 2020 Rover

<u>Conduct rigorous *in situ* science</u>

Geologically diverse site of ancient habitability

Coordinated, nested context and fine-scale measurements

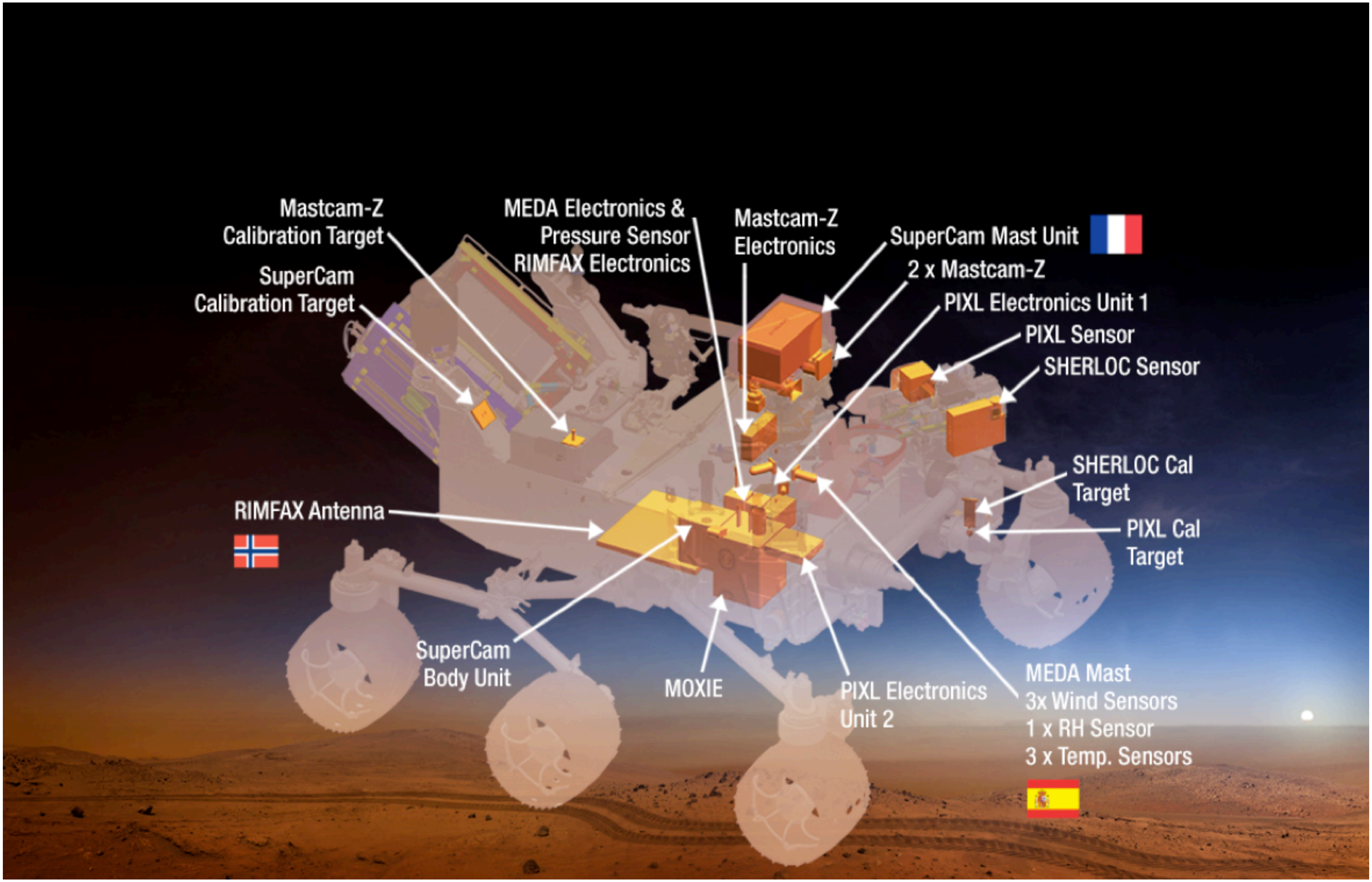


<u>Enable the future</u>

Critical ISRU and technology demonstrations for future Mars exploration

Returnable cache of samples

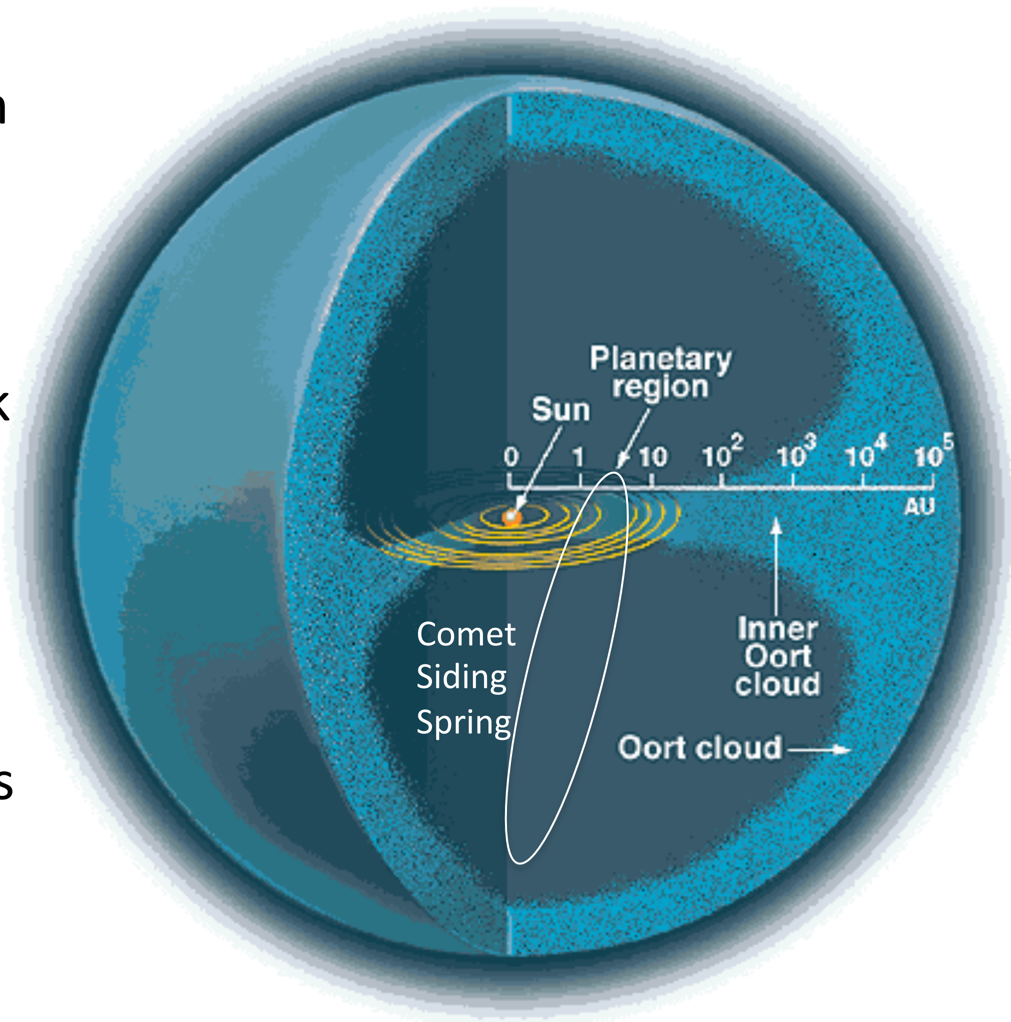
Mars 2020 Selected Payload Suite



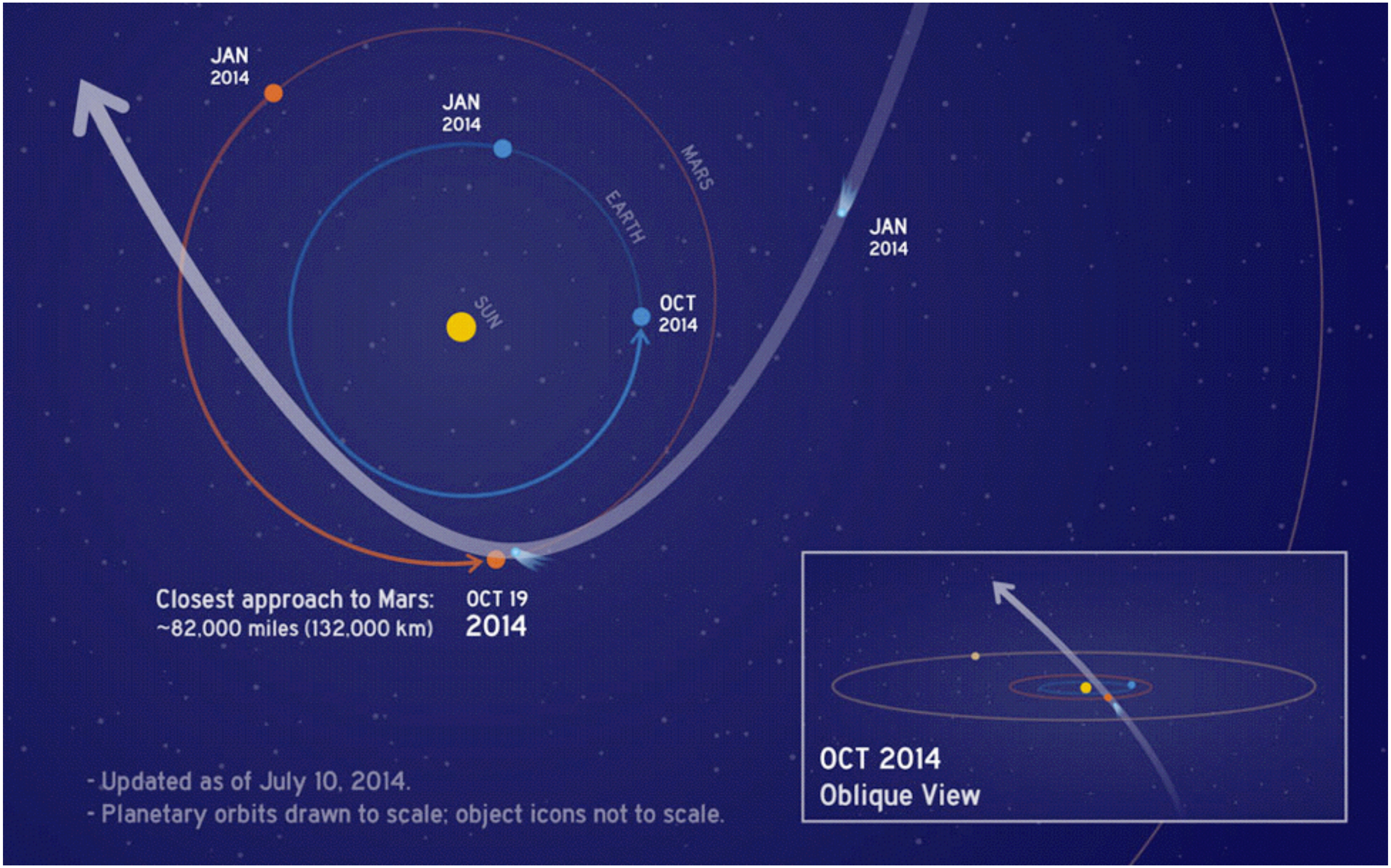
Comet Siding Spring (CSS) Encounter with Mars

Overview of Siding Spring

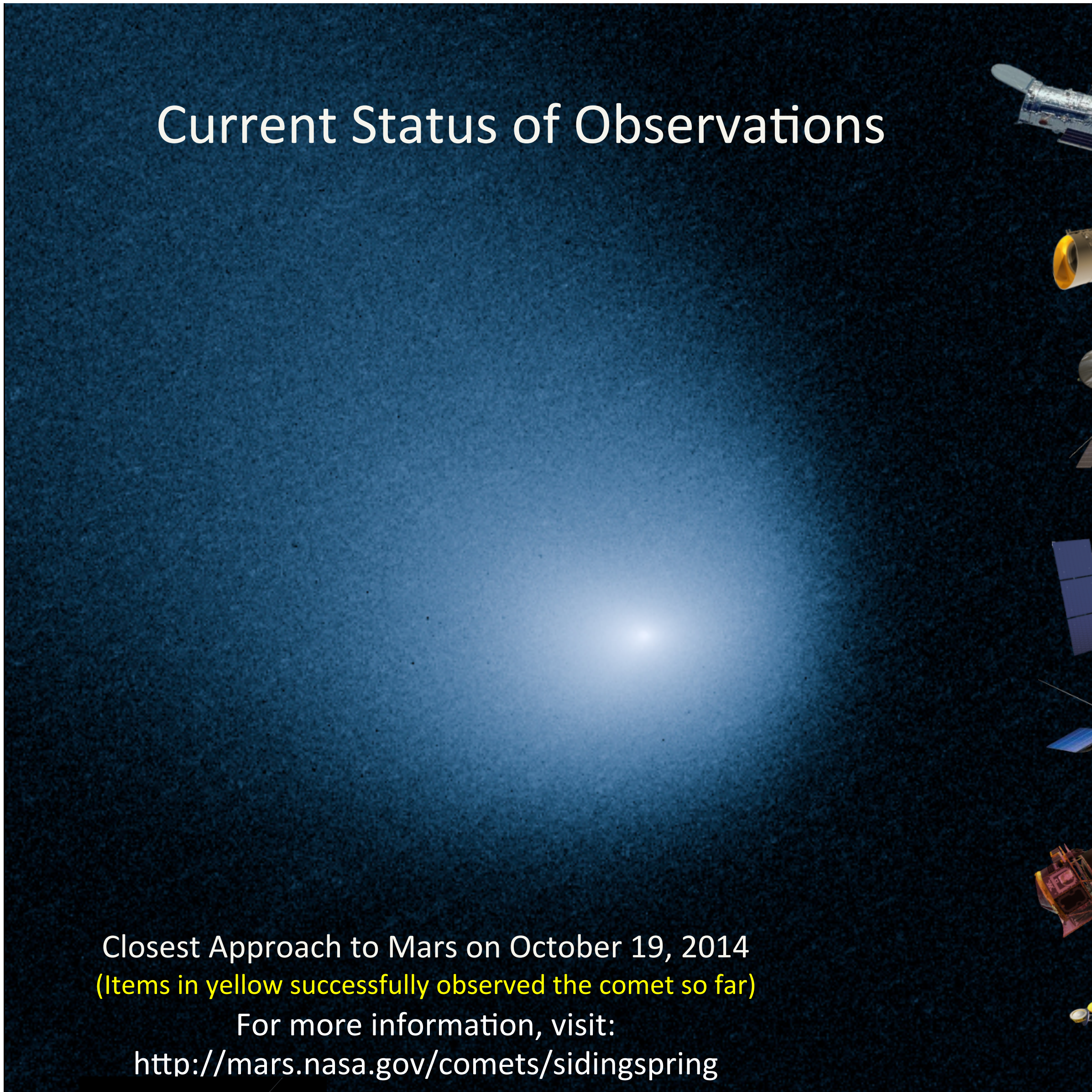
- C/2013 A1 (Siding Spring) is an Oort cloud comet discovered on January 3, 2013, by Robert McNaught at Siding Spring Observatory at 7.2 AU
- Comet C/2013 A1 probably took millions of years to come from the Oort cloud and will return
- It is believed that this is its first passage by the Sun
- On October 19, 2014, it will pass within 130,000 km from Mars
- Mars will be in the coma/tail of the comet

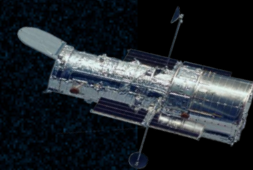


CSS Trajectory

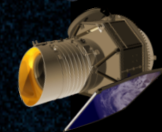


Current Status of Observations

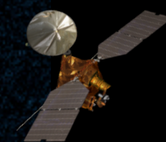




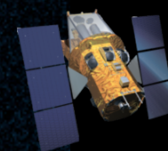
Hubble observed Siding Spring in October 2013, and Jan/Mar 2014



NeoWISE observed the comet in January and will again in July 2014

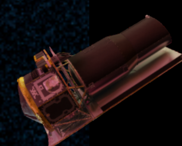


Mars Reconnaissance Orbiter will attempt observations beginning in October 2014

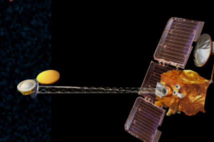


Swift observed the comet three times between Nov 2013 and February 2014

ESA's Mars Express may attempt observations in October 2014



Spitzer observed the comet March 2014



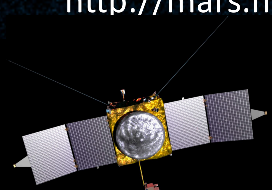
Mars Odyssey will attempt observations beginning in October 2014

Closest Approach to Mars on October 19, 2014

(Items in yellow successfully observed the comet so far)

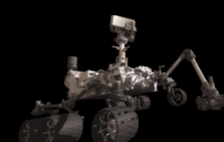
For more information, visit:

http://mars.nasa.gov/comets/sidingspring



MAVEN will l make long-term observations on how Mars responds to processing the deposited cometary material.

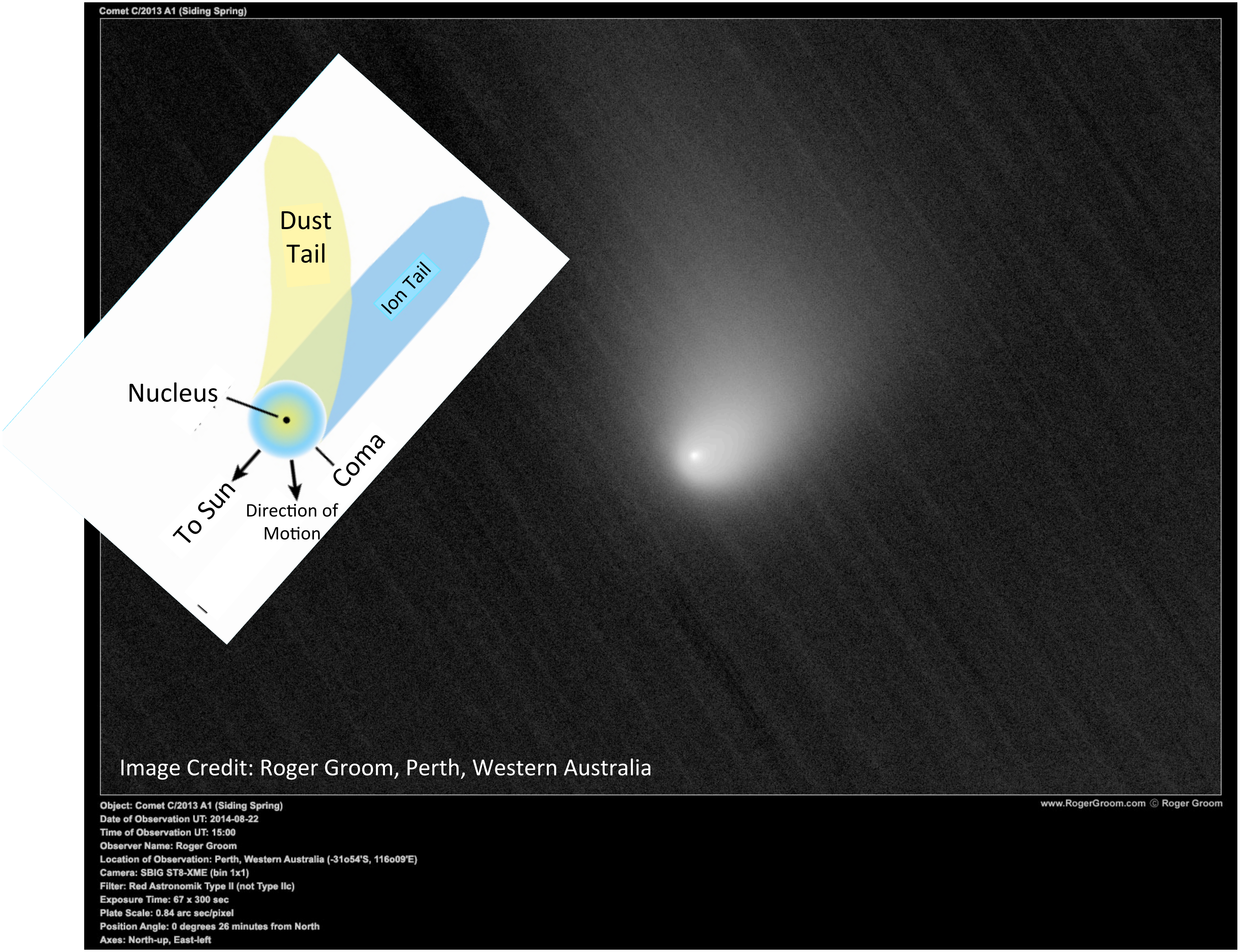
Opportunity will attempt observations in October 2014 as the comet passes by Mars



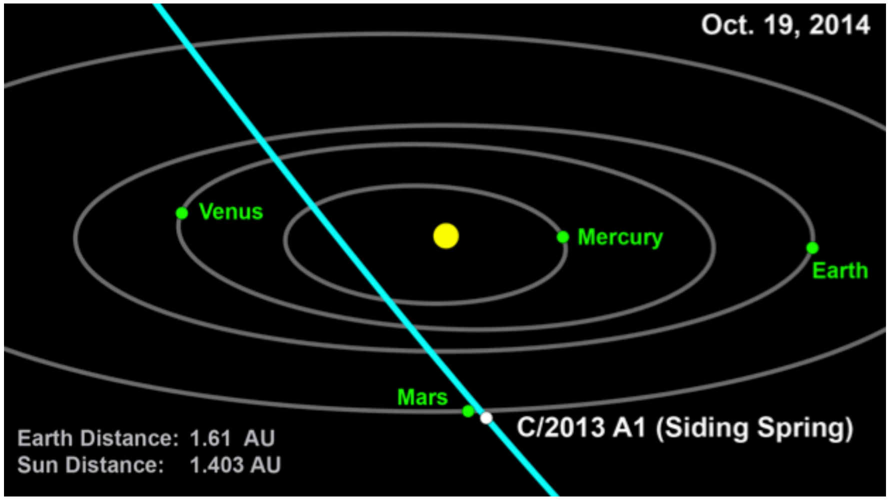
Curiosity will attempt observations in October 2014

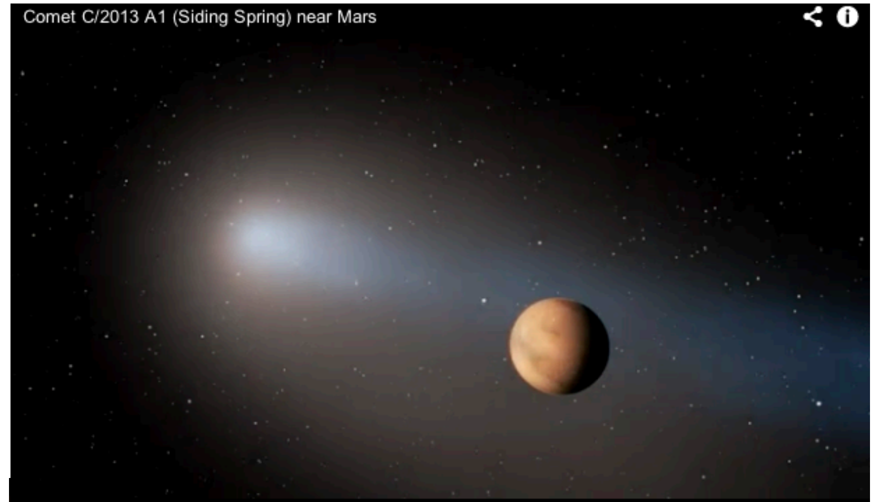
Comet Image shown was processed by Hubble on March 11, 2014.

Rev. 05/06/14


Comet C/2013 A1 (Siding Spring)
Dust Tail
Ion Tail
Nucleus
Coma
To Sun
Direction of Motion
Image Credit: Roger Groom, Perth, Western Australia
Object: Comet C/2013 A1 (Siding Spring)
Date of Observation UT: 2014-08-22
Time of Observation UT: 15:00
Observer Name: Roger Groom
Location of Observation: Perth, Western Australia (-31o54'S, 116o09'E)
Camera: SBIG ST8-XME (bin 1x1)
Filter: Red Astronomik Type II (not Type IIc)
Exposure Time: 67 x 300 sec
Plate Scale: 0.84 arc sec/pixel
Position Angle: 0 degrees 26 minutes from North
Axes: North-up, East-left
www.RogerGroom.com © Roger Groom

Comet Siding Spring – Oct. 19, 2014





- Oort Cloud Comet
  - Relative speed is 56 km/s
  - Perihelion (1.4 AU) on Oct. 25th
- All Mars orbiters and rovers become comet observers
  - Oppy close to local dawn
  - Curiosity close to local dusk
- Observe Mars' response

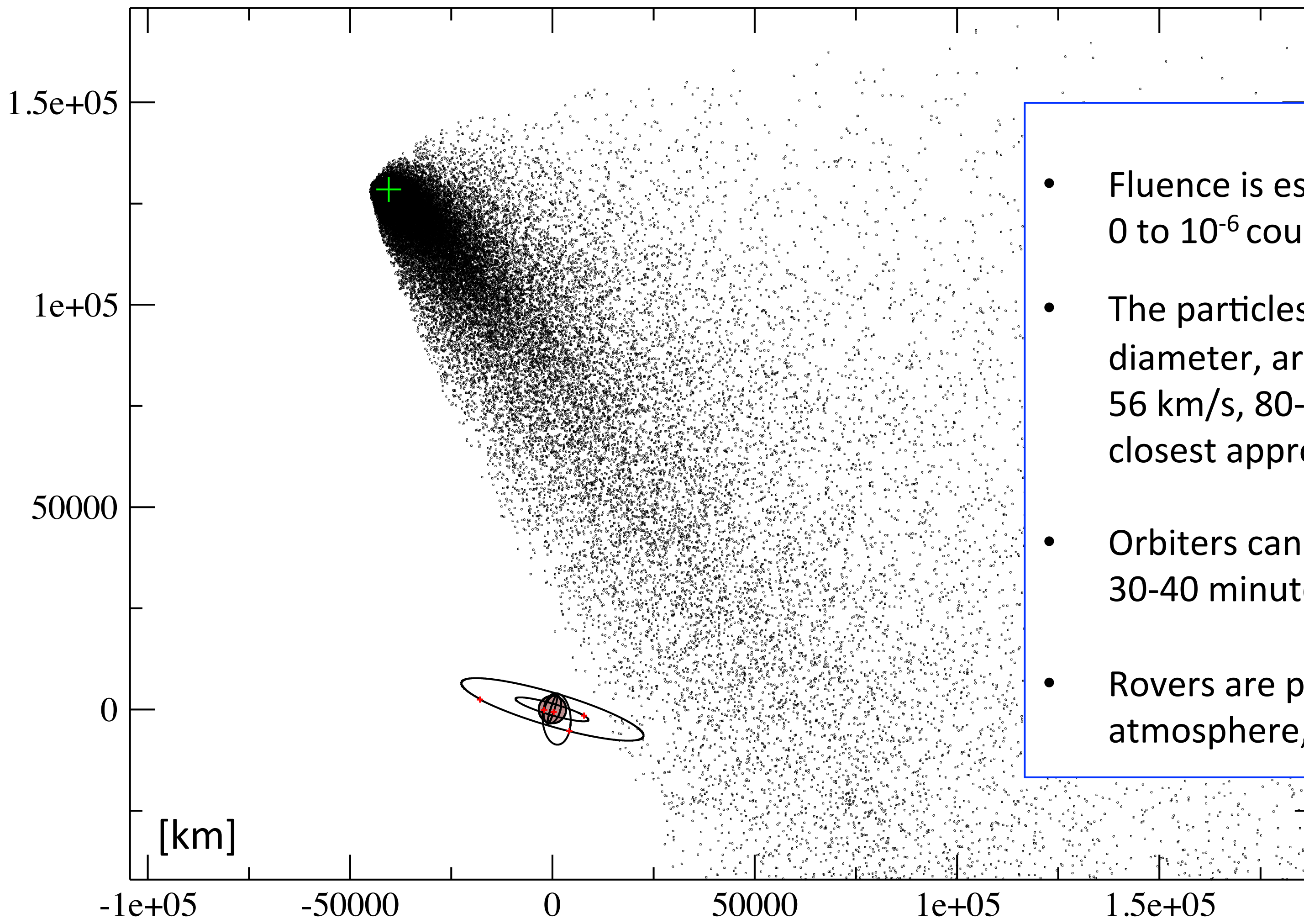
Comet Siding Spring Workshop - Aug 11, 2014

- Comet science community organized into the Coordinated Investigations of Comets (CIOC)
- CIOC Workshop hosted by APL designed to:
  - Review current knowledge about CSS
  - Coordination Future Observations (ground, space, at Mars)
  - Understand how Mars missions will survive the event and make unique and historic observations
- Results Include:
  - Comet acting like ISON, but 0.5-0.75 magnitude brighter than JPL predicts; H_2O emissions have been observed
  - Range of Predictions for Dust, Gas Effects on Mars from Encounter; major effects likely to be from heating of Mars Mesosphere/Exosphere

CSS Dust Modeling With Time

- In fall of 2013, two modeling groups were selected through the MEP Critical Data Products program to perform dust analysis/predictions
  - *Pasquale Tricarico, Nalin H. Samarasinha, Mark Sykes, PSI*
  - *Tony Farnham, Mike S. P. Kelley, Dennis Bodewits, U. Maryland*
- Time-of-arrival of comet nucleus and debris team:
  - *Farnocchia, Chodas, Chesley, JPL Solar System Dynamics Group*
- Reports will be published:
  - P. Tricarico et al., *Astrophysical Journal Letters*, 787, L35, 2014
  - Farnocchia et al., *in press*, *Astrophysical Journal*
  - Farnham et al., in preparation
  - Reports and overviews posted http://mepag.jpl.nasa.gov/cdp.cfm
- Results of the modeling activity:
  - Modeling results were constrained using available observations of the comet.
  - Provided arrival timing & duration of the comet-associated particle flux at Mars
  - Characterized the comet-derived particles in terms of size and number density

Comet Siding Spring Dust Field Predictions

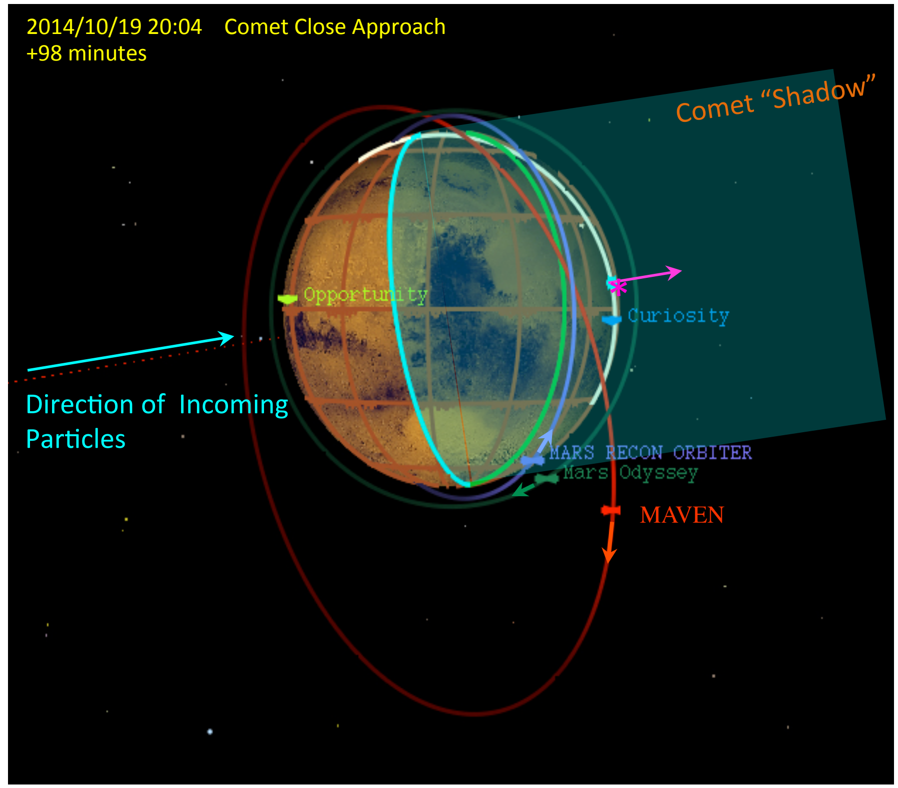


- Fluence is estimated to be in the 0 to 10^{-6} counts/m^2 [1/km^2] range
- The particles, from 1 to 10 mm in diameter, arrive at Mars travelling 56 km/s, 80-110 minutes after closest approach of the nucleus.
- Orbiters can hide behind Mars for 30-40 minutes, by phasing in orbit.
- Rovers are protected by the Mars atmosphere, thin as it is.

CSS Encounter Goals for Mars Assets

- Want the Mars missions to survive the encounter
  - Extensive analysis has been performed on the expected Dust environment
- Orbit phasing take care of the *predicted* low fluence of dust from the Comet

- Science Objectives Focus on Two Areas:
  1. The comet itself
  2. Its potential impact on the Mars atmosphere



New Comet Science

- First-ever resolution of the nucleus of an Oort Cloud comet
  - MRO HiRISE: 140 m/pixel on a nucleus ~ 0.5 to 2.5 km across
- Characterize CSS coma & tail: Particle size, gas composition, surface activity
  - The Mars spacecraft instruments weren't designed for high-spectral resolution gas survey or for imaging diffuse, faint objects (as compared to Mars), but a best effort will be undertaken
  - The best instruments for comet composition may well be on MAVEN, which will follow orbit insertion on Sept. 21 with maneuvers and instrument deployments as they transition to their nominal science orbit

New Mars Science

- Observe impacts of cometary gas & dust on the Mars atmosphere
- Observe how Mars processes the cometary material it has obtained over time
- Initial expectations are:
  – Ionospheric enhancement
  – Upper Atmospheric heating (>150 km)
  – Cloud seeding? Models indicate mid-latitudes would be warmer and polar regions colder increased winds
  – Expect fewer effects in the lower atmosphere

Science Observations - *Preliminary*

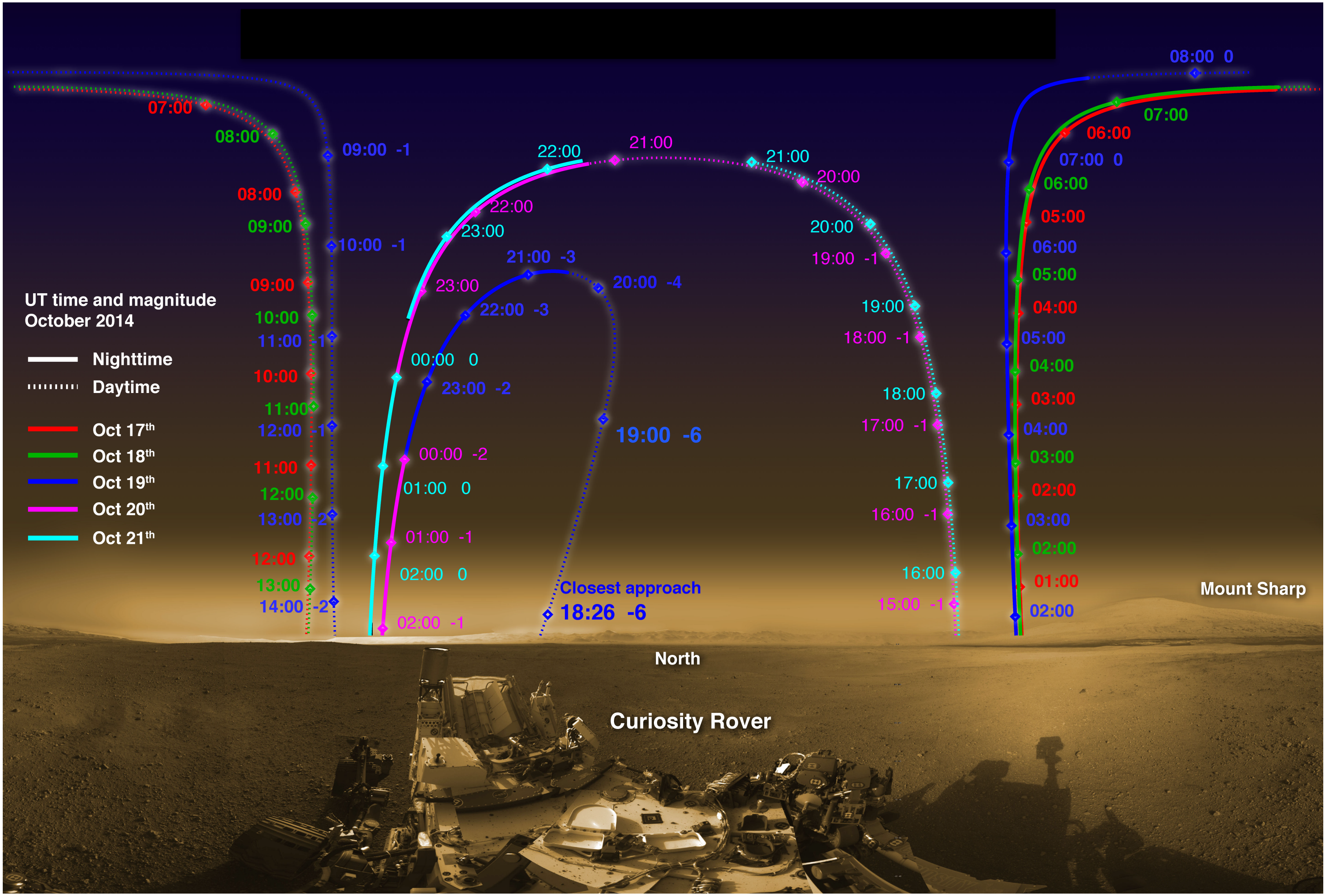
NASA Missions

Target	Observation Objective	MRO						ODY		ROVERS		MAVEN[1]		
		HiRISE	CTX	CRISM	MCS	MARCI	SHARAD	THEMIS VIS & IR	HEND/NS	PANCAM	MastCAM CHEMCAM?	IUVS	LPW,MAG, SEP	NGIMS,STATIC SWEA,SWIA
Comet	Comet General Features					❖		❖		◆	◆	◆	◆	
Comet	Comet Nucleus: Size, Shape & Rotation	◆												
Comet	Comet Activity: Jets & Variable Brightness	◆	◆	❖				❖				◆		
Comet	Comet Coma: Variability, particle size, gas composition	◆	❖	◆	◆	◆		◆				◆		
Comet	Comet Tail: Particle Size		◆	❖	❖	❖		❖				◆	◆	
Mars Response	Mars Upper Atmosphere Composition: Neutrals, ions & electrons; meteor trails						❖		❖	◆	◆	◆	◆	◆
Mars Response	Mars Lower Atmosphere: Temperature and Clouds			❖		❖		❖		❖	❖	❖		

Key: major contribution ◆ contribution ❖

[1]*Conducted only if transition to science orbit is nominal*

View From Curiosity of CSS

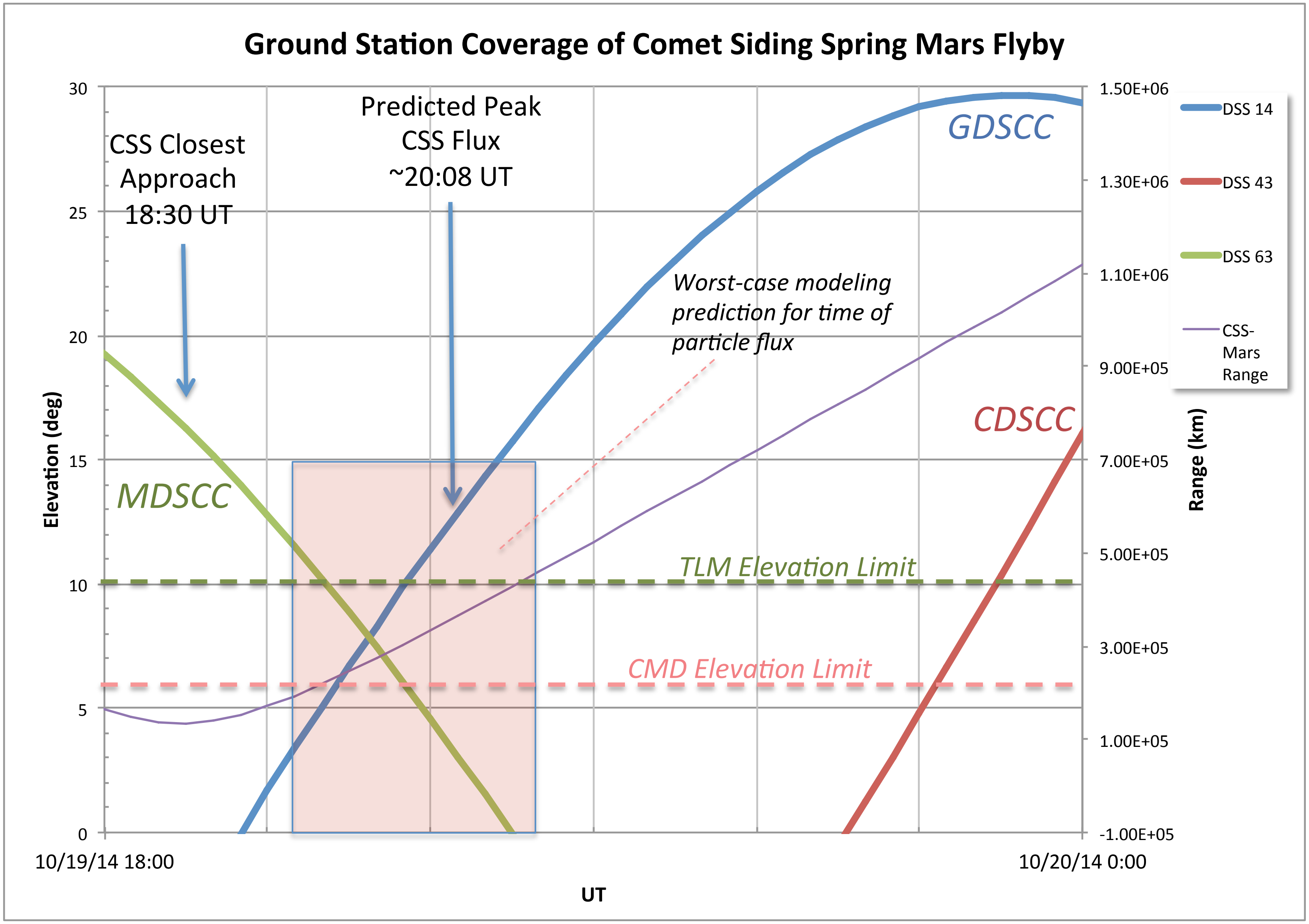


Deep Space Network (DSN) Tracking Configuration

- Utilize standard DSN Multiple Spacecraft Per Aperture capability to enable support for all five Mars orbiters
  - Two simultaneous downlinks per aperture
  - One uplink per aperture, swappable once per pass
- Schedule 70m and all available 34m antennas at Madrid and Goldstone for the period around closest approach
- Augment with additional Radio Science Receivers to provide 70m signal reception for all missions

Note: All antennas at the complex (Madrid or Goldstone) are utilized only for CSS while Mars is in view of that complex (on 10/19/14)

DSN Coverage (Madrid-Goldstone Handover)



Getting Ready for CSS: Next Steps

- Phasing maneuvers completed
- Comet encounter observation sequences being finalized
- Next CIOC Workshop on Sept 19th
  - Review latest comet observations: Is CSS following predictions?
  - Give status on final science observing plans by Mars Projects
- Determine if any additional changes need to be made to the existing plans and make adjustments
- October 19: Closest Approach of Comet Siding Spring to Mars
  - Prime observing campaign ±2.5 days around nucleus closest approach