

# Orbiter Reconnaissance for Landing Sites for Humans

*October 27, 2015*

*Current Data & Capabilities  
Next Orbiter Capabilities*

Mars Reconnaissance Orbiter Project (MRO)  
MEPAG Next Orbiter Science Analysis Group (NEX-SAG)

*Presented by Richard Zurek  
Jet Propulsion Laboratory, California Institute of Technology*



Mars Express

Mars Odyssey

Mars  
Reconnaissance  
Orbiter

SHARAD

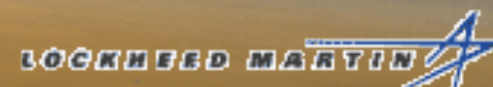
HiRISE

UHF

CTX  
MARCI

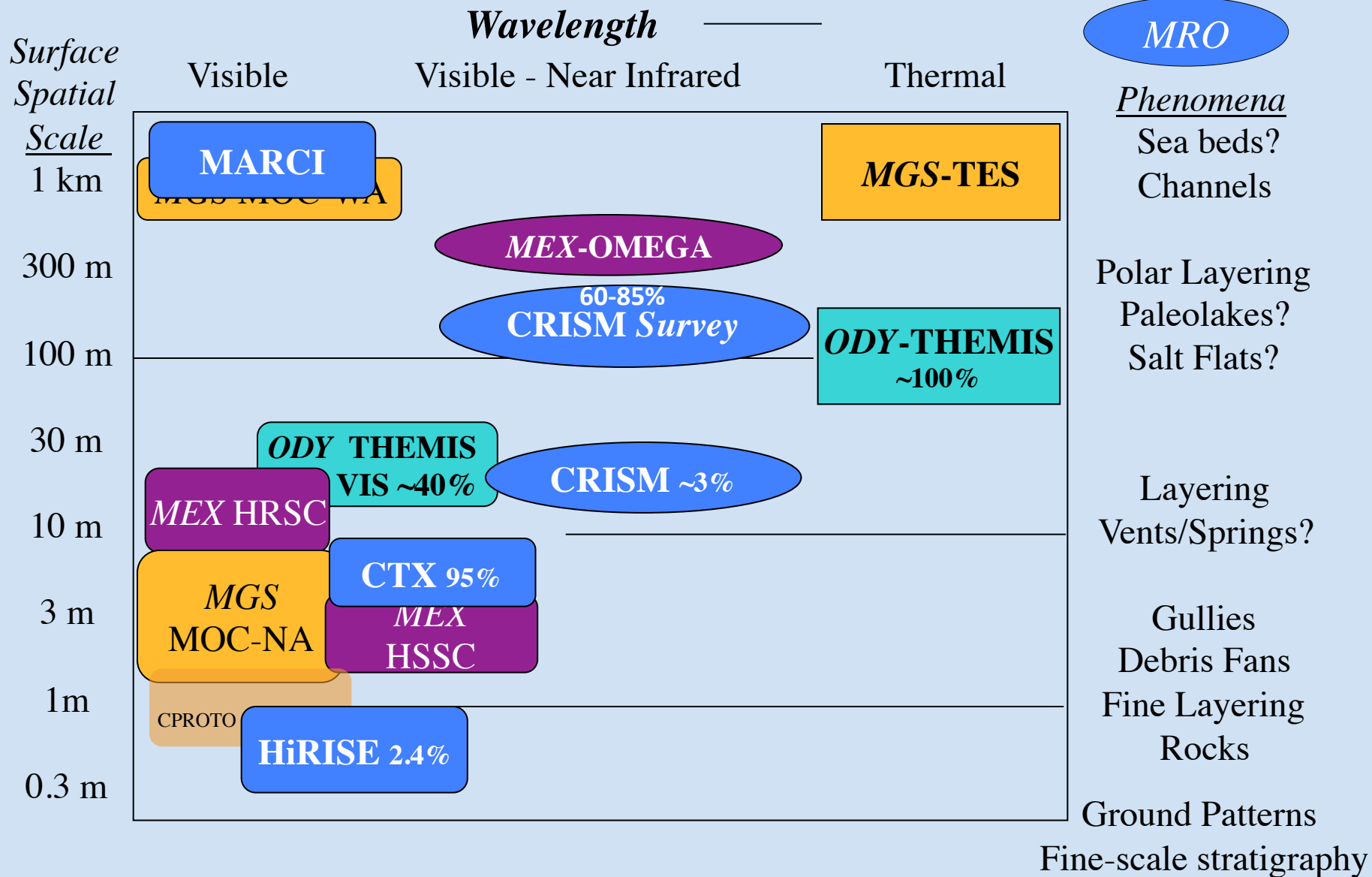
MCS

CRISM

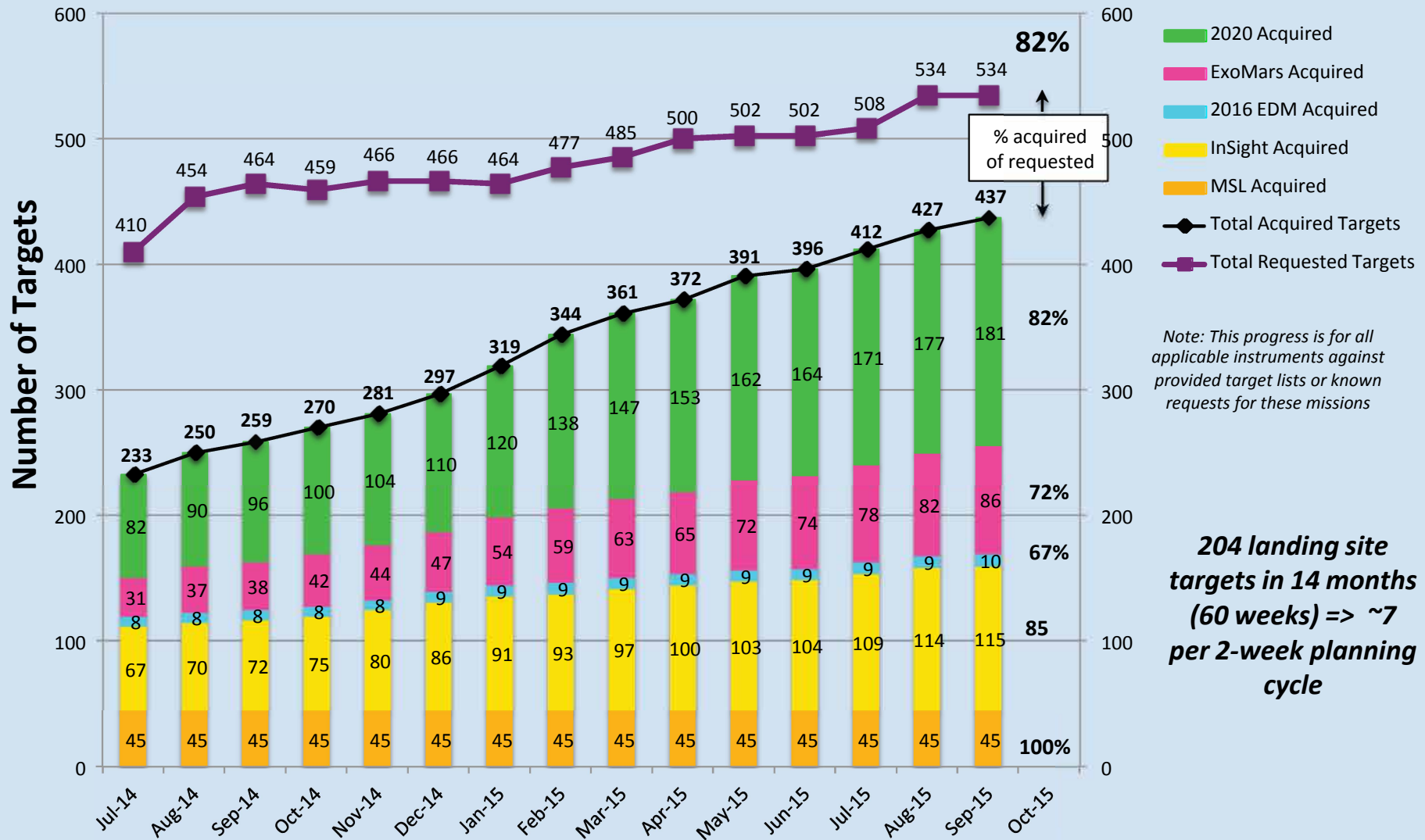




# Horizontal Spatial Sampling

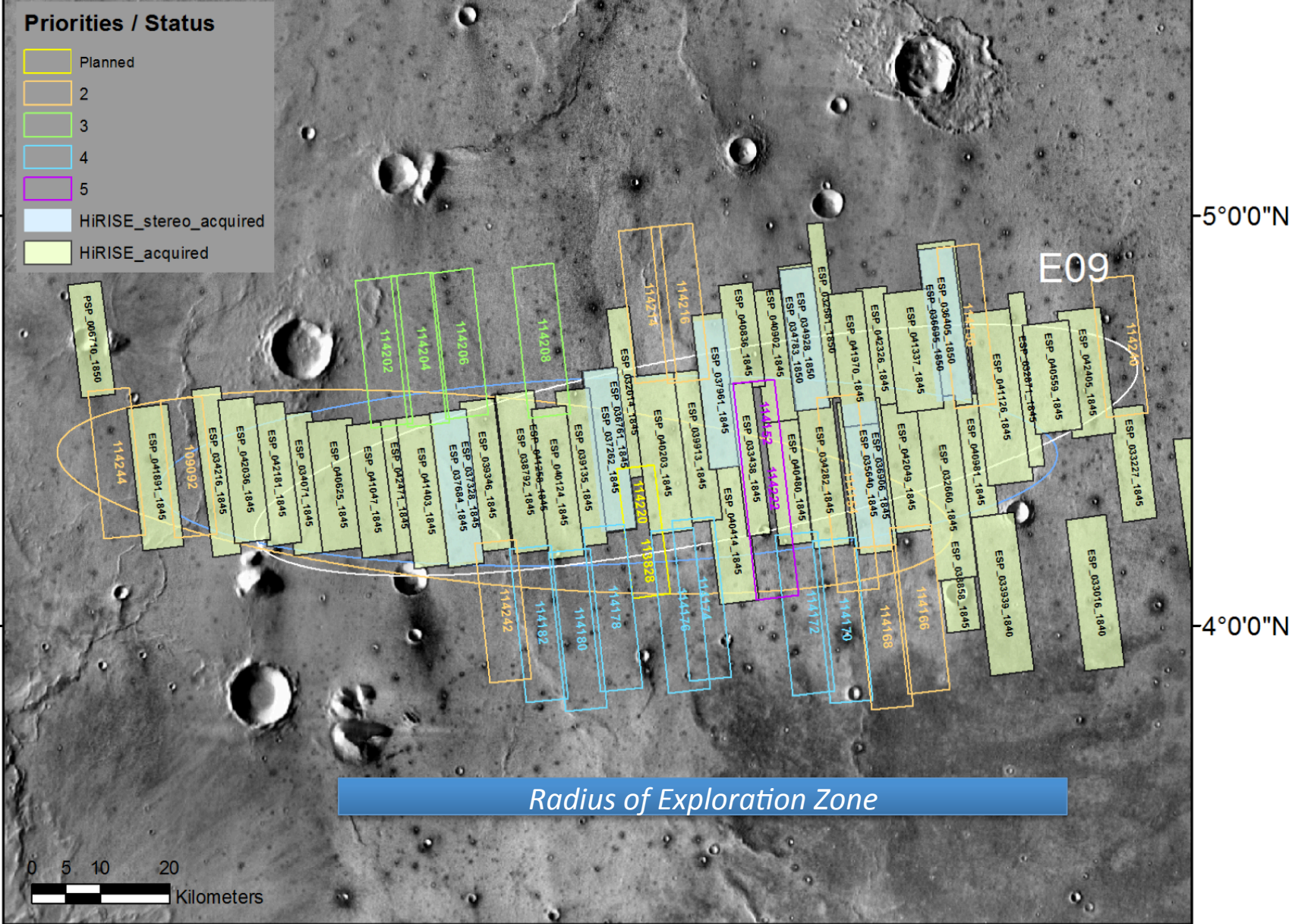


# MRO Progress on Present Landing Site Surveys





as of cycle 231

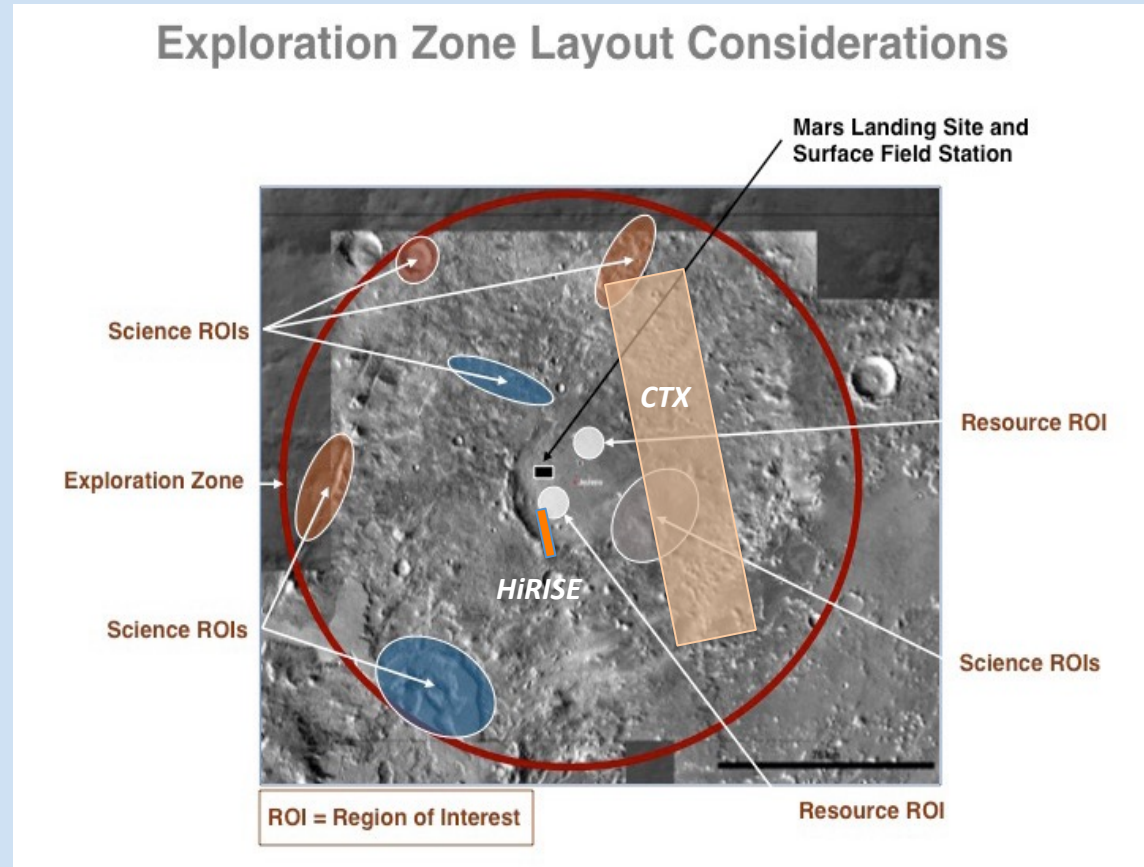


### Radius of Exploration Zone

0 5 10 20 Kilometers

# Exploration Zone Coverage

- **THEMIS coverage:**
  - ~100% IR 100m mosaics
- **Typical HiRISE image size:**  
**5.4 km x 15 km = ~80 km<sup>2</sup>**
  - ~ 400 images to cover 1 EZ (double for stereo)
  - ~ 8 images to cover 1 ROI (varies, but ~ 600 km<sup>2</sup>)
  - ~ 10 Resource and Science ROIs  
=> ~ 80 HiRISE images
- **Typical CTX image size:**  
**30 km x 120 km = 3600 km<sup>2</sup>**
  - ~9 images to cover 1 EZ (double for stereo)
  - 1 image per ROI
  - Much of the planet (~94%) is already covered (~20% in stereo)
- **Targeting Frequency:** At low latitudes, a given target may come up only twice in a two week period



# Contributions by the New Mars Orbiters

- **MAVEN—finishing prime mission (approved for extended mission), focused on upper atmospheric state & escape**
- **Trace Gas Orbiter—Launch period opens March 4**
  - NOMAD/ACS focused on atmospheric trace gas measurement (e.g., methane)
  - CaSSIS: 3-4 m/pixel from 400 km, 3-band color in all channels, & fast stereo
  - FREND: Neutron epithermal spectroscopy (footprint ~ 40 km?)
- **Missing**
  - Replenish and augment telecommunications & reconnaissance capabilities
  - Detection of ground ice in top 10 meters in localized areas
  - Continuity of ground ice and hydrated minerals at exploration scales (< 100 m)
  - Special region candidate (e.g., RSL): process and water source
  - Phobos & Deimos as targets for in situ exploration and operations by humans
- **HEO *In Situ* Resource Utilization (ISRU) & Civil Engineering (ICE) Working Group has set preliminary resource prospecting objectives (next slide); Strategic Knowledge Gaps from MEPAG Goal IV.**
- **SMD/HEO MEPAG Science Analysis Group set in motion (following charts) for science objectives and for measurement approaches.**



# From ICE-WG & MEPAG Goal IV: Resource & SKG Objectives

***The highest priority resource is water for surface operations, life support, etc. Materials for civil engineering purposes are also of interest. Thus, the following are identified as orbiter objectives:***

- A. Find and quantify the extent of **shallow ground ice** within a few meters of the surface and its ice-free overburden;
- B. Identify deposits of **hydrated minerals** as a water resource, and potential contaminants; map the distributions of possible special regions (e.g., RSL)
- C. Identify site-specific mineral resources and **geotechnical properties**;
- D. Extend the atmospheric climatology with **diurnal coverage and wind measurements**;
- E. Provide key information about the Martian **moons**.

## NEX-SAG Membership

Co-chairs/Support			
Co-chair	Bruce	Campbell	Smithsonian Institution
Co-chair	Rich	Zurek	Jet Propulsion Laboratory (JPL)/Mars Program Office
Orbiter Study Team	Rob	Lock	JPL/Mars Program Office
Executive Officer	Serina	Diniega	JPL/Mars Program Office
Members of NEX-SAG			
Aeolian Processes	Nathan	Bridges	JHU Applied Physics Laboratory
Polar Science	Shane	Byrne	University of Arizona
Prior Orbiter SAG / Geology	Wendy	Calvin	University of Nevada, Reno
Radar / Geology	Lynn	Carter	Goddard Space Flight Center
Photochemistry	Todd	Clancy	Space Science Institute
Geology / Mineralogy	Bethany	Ehlmann	Caltech & JPL
Polar Science / Radar	Jim	Garvin	NASA Goddard Space Flight Center
GCM / Climate Modeling	Melinda	Kahre	NASA Ames Research Center
Climate Modeling / Geology	Laura	Kerber	JPL/Mars Program Office
VIS-NIR / Geology	Scott	Murchie	JHU Applied Physics Laboratory
SubSurface Ice / Geology	Nathaniel	Putzig	SWRI-Boulder
Thermal IR / Geology	Mark	Salvatore	University of Michigan, Dearborn
Prior Orbiter SDT	Michael	Smith	Goddard Space Flight Center
Atmosphere	Leslie	Tamppari	Jet Propulsion Laboratory
Radar/Geology	Brad	Thomson	Boston University
Prep for Humans	Ryan	Whitley	NASA Johnson Space Center
Imaging / Geology	Becky	Williams	Planetary Science Institute
Upper Atmosphere	Paul	Withers	Boston University
Mineralogy / Geology	James	Wray	Georgia Tech
Ex-Officio			
HEO	Ben	Bussey	NASA Headquarters
Mars/SMD	Michael	Meyer	NASA Headquarters
MEPAG Chair	Lisa	Pratt	Indiana University

# NEXT ORBITER SAG: Science Objectives

***In addition to telecommunications support and preparation for possible future Sample Return, the compelling new science objectives are\*:***

- A. Map and quantify shallow **ground ice deposits** across Mars to better understand the global water inventory and atmospheric exchange today and how ground ice records climate change on longer time scales (e.g., obliquity variation);
- B. Detect and characterize areas of possible brine flow (**RSL**), and link these observations with ground ice, temperature, and atmospheric properties to understand the distribution and potential for habitability of **volatile reservoirs**; representative coverage at different times of day is key.
- C. Measure **winds** and characterize dynamical processes, to understand current climate, water, and dust cycles, with extrapolation to past climates;
- D. Characterize the occurrence and timing of **major environmental transitions** recorded in compositional stratigraphic records, such as discrete hydrated mineral assemblages, sedimentary bedding, and shallow polar cap layering.
- E. In SEP missions, carry out high-value, close-approach investigations of **Phobos and Deimos**.



# NEXT ORBITER SAG: Resource, SKG & Science Synergies

***NEX-SAG finds a high degree of synergy between the science goals identified and the human exploration resource prospecting interests and derived objectives.***

***The considerable synergy between requested functions enables selection of instruments that may individually address multiple science, resource and reconnaissance needs.***

***Launch in 2022 would expedite providing information needed to make further progress in choosing landing sites for exploration by humans on Mars and the architecture of that landed exploration.***

# NEXT ORBITER SAG: Measurement Approach

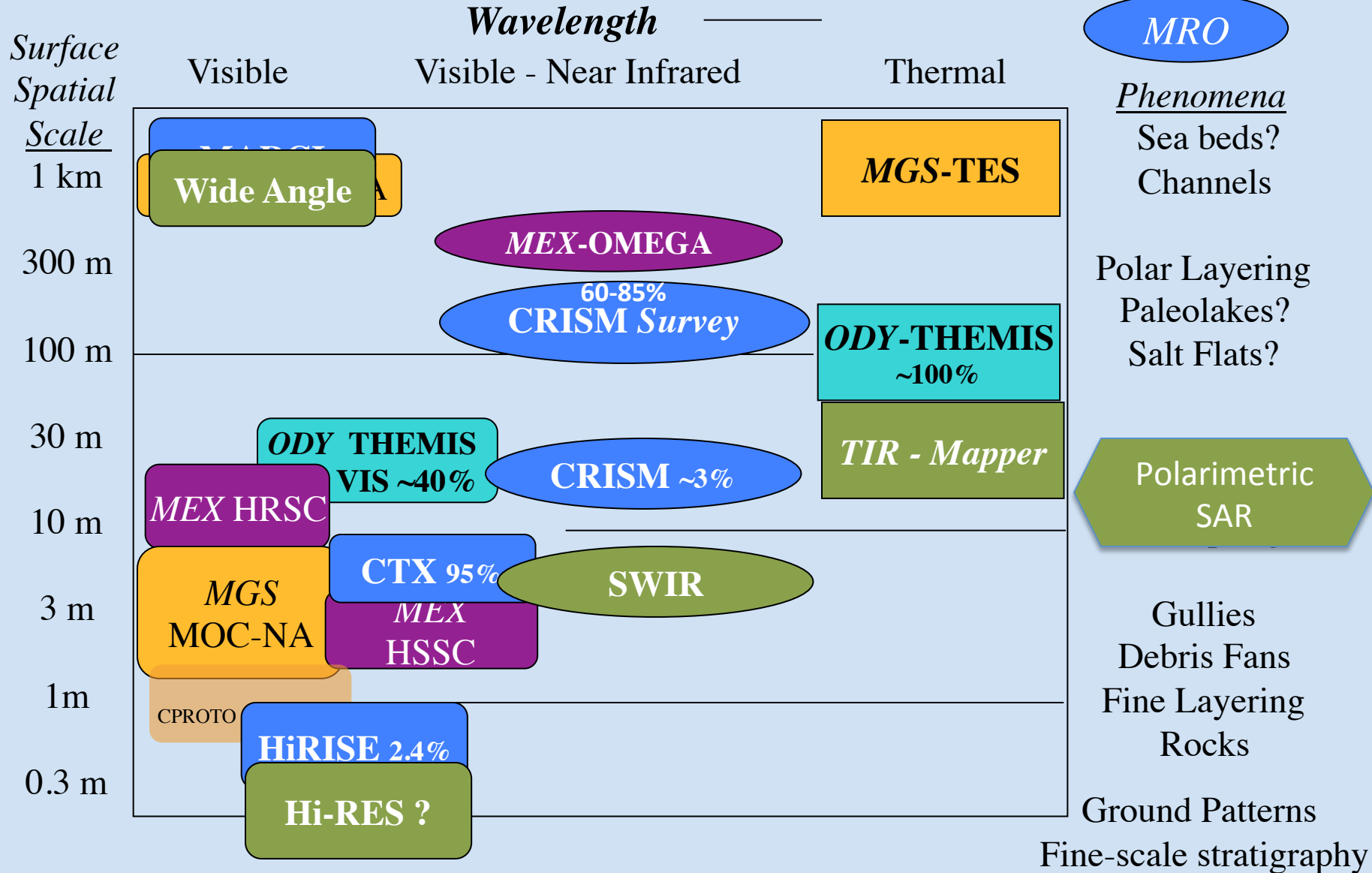
***NEX-SAG identified instrument proof-of-concept measurement capabilities required to address the resource, science, and reconnaissance objectives:***

- **Visible imaging** of HiRISE-class (30 cm/pixel) or better (~15 cm/pixel);
- **Polarimetric synthetic aperture radar (PSAR)** with penetration depth of a few (<10) meters and spatial resolution of ~15 m/pixel;
- **Short-wave IR (SWIR) mapping** with a spatial resolution of ~6 m/pixel with sufficient spectral resolution to detect key minerals;
- **Long-wave atmospheric sounding** for wind, temperature, & water vapor profiles;
- **Thermal IR sounding** for aerosol profiles;
- **Multi-band thermal IR (TIR) mapping** of thermo-physical surface properties (e.g., ice overburden) and surface composition;
- **Wide-angle camera** to globally monitor weather and surface frosts at km-scale.

These proof-of-concept instrument approaches were identified; other approaches may apply.

***Such a multi-function orbiter mission appears feasible only with advanced telecommunications capability and the use of Solar Electric Propulsion.***

# Horizontal Spatial Sampling





# Capability and Mission Range for Possible Next Orbiter

## Class 3: Exploration SEP

NASA Components  
1000 – 2000 kg Bus  
**200 – 800 kg P/L**  
**>5 kW for P/L**

## Class 2: Commercial SEP

COTS Components  
500 – 1000 kg Bus  
**100 – 200 kg P/L**  
**>2 kW for P/L**

### *Solar Electric Propulsion*

Multi-function SEP Orbiter  
Advanced (10 x MRO) Telecom/  
Recon/Resource/Rendezvous  
(new class)

Telecom (3 x MRO) /Recon/Resource/  
Science Rendezvous Orbiter (MRO upgrade)

## Class 1: Chemical Prop.

800 kg Bus  
**80 kg P/L**  
**~150 W for P/L**

Telecom/Recon/Science  
Orbiter (MRO-class)

***Pre-Decisional;  
for Discussion  
Purposes Only***

# Orbiter Site Reconnaissance for Human Mars Missions:

## Summary

*A multi-purpose orbital mission launched in 2022 could pioneer resource prospecting for humans on Mars and would make major advances in our scientific understanding of Mars and its evolution, while providing reliable telecommunications and reconnaissance for future human and robotic missions on Mars.*

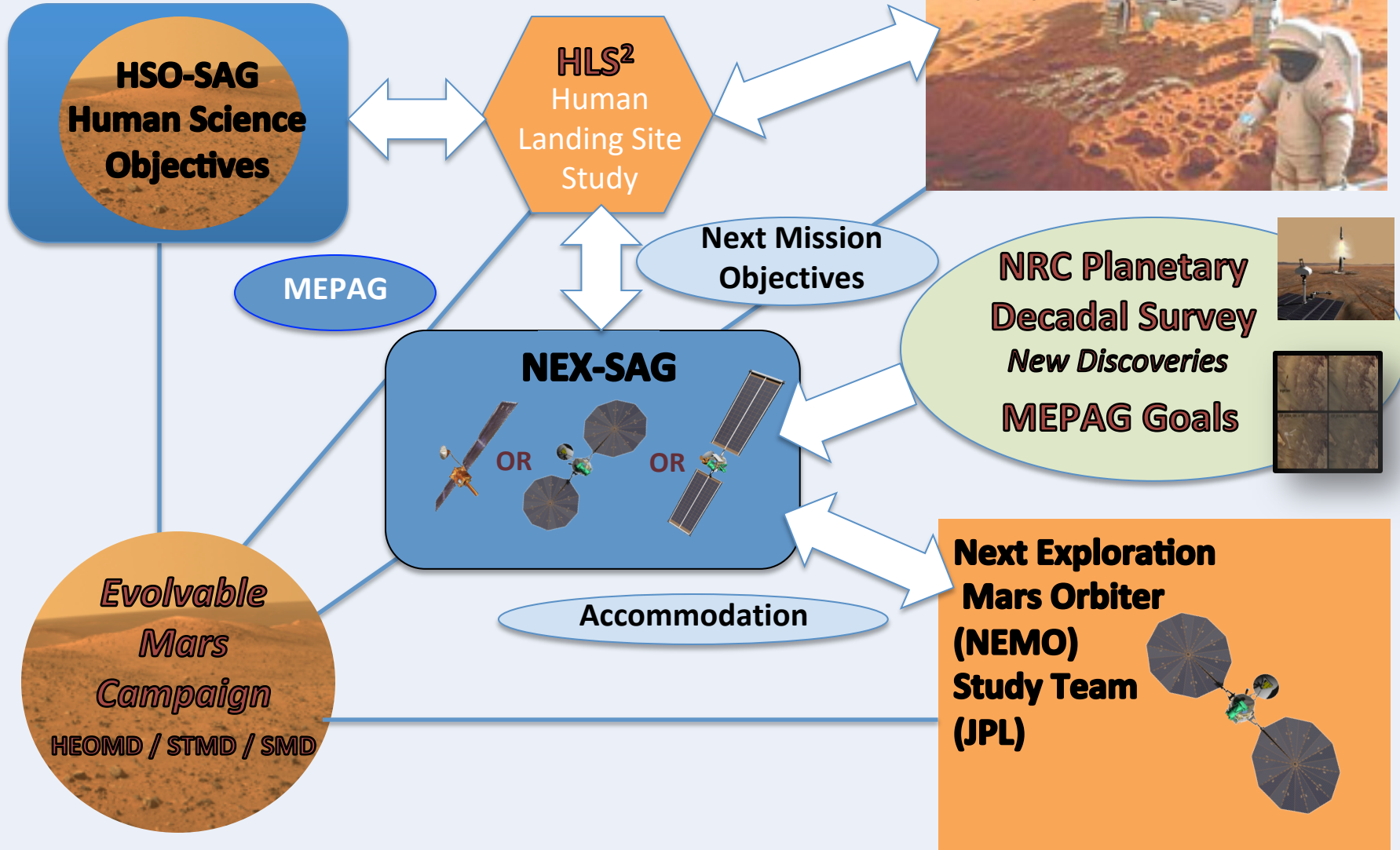
- *Such a mission is substantially enhanced by the use of advanced communications and Solar Electric Propulsion*
- *Follow-on landed missions will be needed to confirm and quantify accessible resources*
- *NEX-SAG is interested in the experience of those at this workshop regarding what you think will be needed to ultimately choose a landing site for humans to explore Mars.*
- *MRO Project is interested in what data collected in the next few years will make the greatest difference in terms of choosing a safe and productive Exploration Zone on Mars, recognizing the limits of current orbiter and payload capabilities and target accessibility.*

# Back-Up



# Context for NEX-SAG Study

HSO-SAG Report  
available @  
[MEPAG.jpl.nasa.gov](http://MEPAG.jpl.nasa.gov)



*Pre-Decisional; for Discussion Purposes Only*

# Available orbital datasets

Dataset	Instrument	Coverage	Spatial Res./Footprint	Where to look (in addition to PDS)
Surface images	HiRISE, MRO	2.4%	Res- 0.25-1 m/px; Length- 15-30 km; Width- Panchromatic: 5.4 km, Color: 1.2 km central stripe	<a href="http://hirise.lpl.arizona.edu/">http://hirise.lpl.arizona.edu/</a>
	CTX, MRO	95%	Res- 6 m/px; Width- 30 km; Length- variable	<a href="http://global-data.mars.asu.edu/bin/ctx.pl">http://global-data.mars.asu.edu/bin/ctx.pl</a>
	MOC (-2006), MGS	6%	Res- <12 m/px	<a href="http://www.msss.com/moc_gallery/">http://www.msss.com/moc_gallery/</a>
	HRSC, MEX	>90%	Res- 10-60 m/px; Swath width- 60 km; stereo	<a href="http://www.rssd.esa.int/PSA">http://www.rssd.esa.int/PSA</a> , <a href="http://ode.rsl.wustl.edu/mars/">http://ode.rsl.wustl.edu/mars/</a>
NIR spectral data (e.g., composition)	CRISM, MRO	98% msp VIS 58% hyper VIS 83% msp NIR ~3% targeted	Res-200 m/px, selected channels Res- 100 m/px, full spectral VIS Res- 100 m/px, selected channels Res- 18 m/px, full spectral VNIR	<a href="http://crism.jhuapl.edu/gallery/featuredImage/index.php">http://crism.jhuapl.edu/gallery/featuredImage/index.php</a>
	OMEGA, MEX	Near global	Res- <2 km/px, some areas down to 300 m/px	<a href="http://pds-geosciences.wustl.edu/missions/mars_express/omega.htm">http://pds-geosciences.wustl.edu/missions/mars_express/omega.htm</a>
TIR spectral data (e.g., surface properNes)	TES (-2006), MGS	Near global	Res- 3 km; Footprint- 5.3 x 8.3 km	<a href="http://tes.asu.edu/data_archive.html">http://tes.asu.edu/data_archive.html</a>
	THEMIS, ODY	Near global	Res- 100 m; Width- 20 km	<a href="https://themis.asu.edu/gallery">https://themis.asu.edu/gallery</a>
Digital Terrain Models/ slope maps	HiRISE, MRO	274	Meter-scale postings	<a href="http://www.uahirise.org/dtm/">http://www.uahirise.org/dtm/</a>
	HRSC, MEx	75%	~50 m/px	<a href="http://hrscview.fu-berlin.de/">http://hrscview.fu-berlin.de/</a>
	MOLA (-2001 as altimeter), MGS	global	100's m spacing of points	<a href="http://mola.gsfc.nasa.gov/">http://mola.gsfc.nasa.gov/</a>
Radar	SHARAD, MRO	40%	Fresnel width- 3 km; Depth res.- 10 m and pen.- 300 m* *depending on composition	<a href="http://pds-geosciences.wustl.edu/missions/mro/sharad.htm">http://pds-geosciences.wustl.edu/missions/mro/sharad.htm</a>
	MARSIS, MEX	80%	Swath width- 10 km; Depth res.- 100 m; Depth pen.- 1 km or more	<a href="http://pds-geosciences.wustl.edu/missions/mars_express/marsis.htm">http://pds-geosciences.wustl.edu/missions/mars_express/marsis.htm</a>

**Notes:** Atmospheric datasets (not listed) are also available. Global maps can be found at: <http://www.mars.asu.edu/data/>. A useful (free) tool for looking at and analyzing multiple datasets: <http://jmars.asu.edu/>