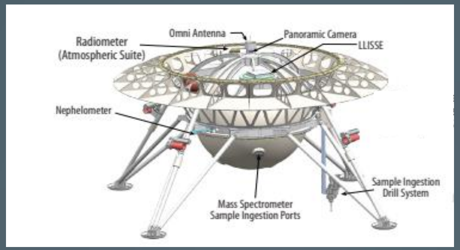
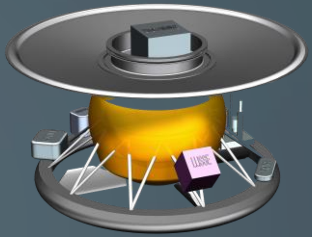
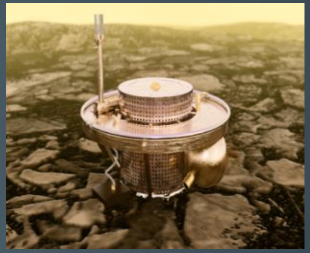
(1)




(2)



(3)



(4)

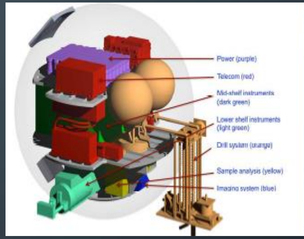
(5)

(6)

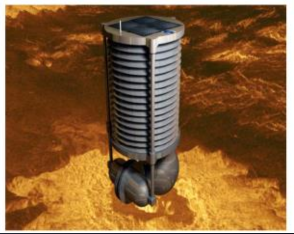
(7)

# VENUS SURFACE PLATFORM STUDY UPDATE

VEXAG – NOVEMBER 2020



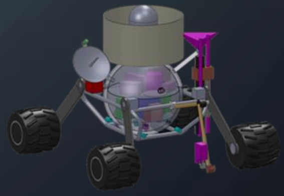

(8)



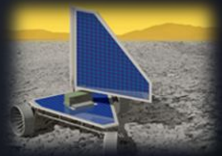
(9)

Prepared by T. Kremic[1] and M. Amato[2], [1]NASA Glenn Research Center, [2]NASA Goddard Space Flight Center and the study organizers / leads

(10)



(11)



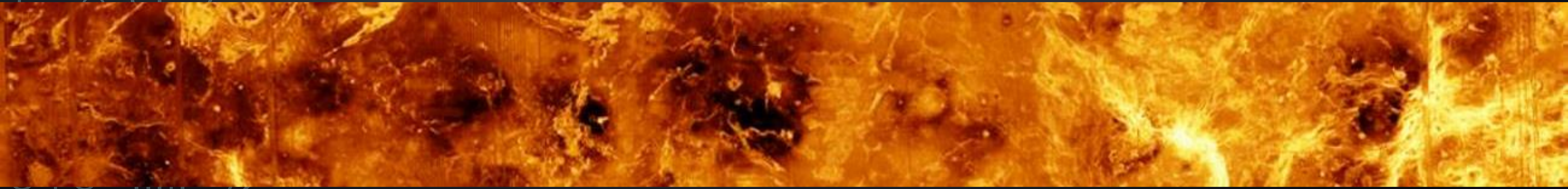


Figure descriptions provided on slide 8

# THANK YOU TO STUDY ORGANIZERS/ LEADS AND PARTICIPANTS

| Name (Alphabetical) | Affiliation | Role |
|---|---|---|
| **Mike Amato** | NASA Goddard Space Flight Center | Co-Chair |
| **Jeff Balcerski** | Ohio Aerospace Institute (OAI) | Organizing Committee |
| **Noam Izenberg** | Johns Hopkins Applied Physics Lab (APL) | Organizing Committee |
| **Natasha Johnson** | NASA Goddard Space Flight Center | Organizing Committee |
| **Tibor Kremic** | NASA Glenn Research Center (GRC) | Co-Chair |
| **Thomas Thompson** | Jet Propulsion Laboratory (JPL) | Organizing Committee |
| **Carol Tolbert** | NASA Glenn Research Center | Organizing Committee |
| | **Sub-Groups** | |
| | **Interior: Geophysics, Geodynamics** | |
| **Walter Kiefer** | Lunar and Planetary Institute (LPI) | Lead |
| **Jeffrey Balcerski** | Ohio Aerospace Institute (OAI) | Sub-Group Member |
| **Robbie Herrick** | University of Alaska Fairbanks | Sub-Group Member |
| **Sue Smrekar** | Jet Propulsion Laboratory (JPL) | Sub-Group Member |
| | | |
| | **Surface Geology** | |
| **Martha Gilmore** | Wesleyan University | Lead |
| **Lynn Carter** | University of Arizona | Sub-Group Member |
| **Darby Dyar** | Mt. Holyoke College | Sub-Group Member |
| **Richard Ghail** | Imperial College, UK | Sub-Group Member |
| **Tracy Gregg** | University at Buffalo College | Sub-Group Member |
| **Misha Ivanov** | Vernadsky Institute | Sub-Group Member |
| | | |
| | **Surface Atmosphere Interactions: Composition, Chemistry And Geochemistry** | |
| **Natasha Johnson** | NASA Goddard Space Flight Center | Lead |
| **Joern Helbert** | DLR Institute of Planetary Research | Sub-Group Member |
| **Sebastian Lebonnois** | Laboratoire de Météorologie Dynamique | Sub-Group Member |
| **Sara Port** | University of Arkansas | Sub-Group Member |
| **Misha Zolotov** | Arizona State University | Sub-Group Member |
| | | |
| | **Technology/Capabilities** | |
| **Jonathan Sauder** | Jet Propulsion Laboratory | Lead |
| **James Cutts** | Jet Propulsion Laboratory | Sub-Group Member |
| **Jeffrey Hall** | Jet Propulsion Laboratory | Sub-Group Member |
| **Gary Hunter** | NASA Glenn Research Center | Sub-Group Member |
| **Geoffrey Landis** | NASA Glenn Research Center | Sub-Group Member |
| **Fredrick Rehnmark** | Honeybee Robotics | Sub-Group Member |
| **Thomas Spilker** | Orbital Assembly Corporation | Sub-Group Member |

# STUDY STATUS

General:

- The Venus Surface Platform Study was implemented to understand the state of capability for Venus surface exploration and to explore what additional science can be achieved with increasing lander capability
- Two face-to-face meetings with experts from various Centers and Institutions were held as were numerous telecoms
- The study team (comprised of 4 subgroups) have produced a draft report and submitted a white paper to decadal process
- Report went through two long review cycles – few community comments
  - Another revised draft (final) can be available for comment

# STUDY STATUS

Current State:

- White paper of report summary submitted to decadal
- Report text essentially complete
  - Final chance to comment
  - Working “polish” and, after incorporating any remaining comments, – will start release process

- Thank you for your comments!

# KEY STUDY RESULTS

- The study team identified key capabilities that will drive in situ surface related science (lifetime, mobility, smarts, and multiple simultaneous measurements)
- Different degrees of these can enable unique and compelling new science. A couple examples of how platform capabilities can drive science:
  - Increased surface platform lifetime can enable temporal measurements thus helping understand surface weather / climate. Lifetime is also critical to enable seismology and thus to gain insight into interior structure
  - Situational awareness (provided by smarts) and ability to make autonomous data based decisions can enable more productive targeting and/or sample acquisition and thus enable better knowledge of Venus composition, weathering, and history.
- These capabilities are created and/or enhanced with specific technology investments
  - Some examples include: surface power, high-temperature systems (sensors and electronics, memory, power), mechanisms (actuators, drills, tools), and autonomy

# POTENTIAL SCIENCE FROM LANDER PLATFORMS

Science returned by lander platforms is driven by key capabilities

| Science Field | Capability | | | |
|---|---|---|---|---|
| **Interior** | **Time** | **Smarts** | **Mobility** | **MSM** |
| Structure | H | | | H |
| Composition | H | S | | H |
| Dynamics | H | | | H |
| Heat Flux | S | | | S |
| **Surface** | | | | |
| Composition | | S | | S |
| Dynamics (Eruptions, flows, …) | H | S | H | |
| Diversity (Spatial) | H | S | H | S |
| Morphology | H | H | S | H |
| Age | S | H | S | S |
| Geologic Record (Layers, craters, ...) | H | H | H | H |
| **Surface/Atmosphere Interactions** | | | | |
| Gas and Surface Composition | H | H | | H |
| Winds | H | | | H |
| Reactions | H | H | | S |
| Momentum Exchange | H | | S | H |

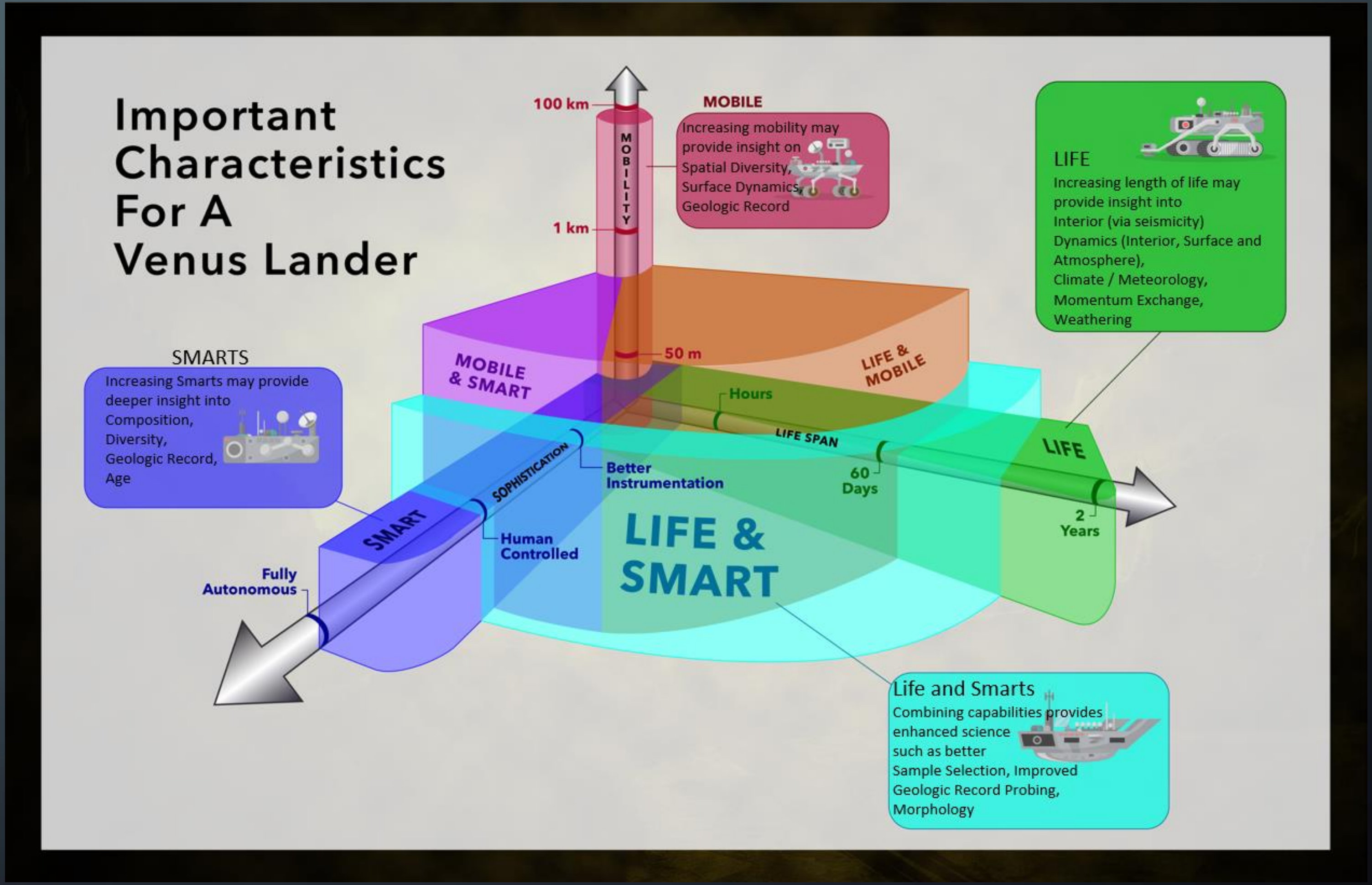
Lander platform capability is enabled by key technologies

| | Capability | | |
|---|---|---|---|
| Critical Underlying / Supporting Technology | Time | Smarts | Mobility |
| Power (Low – 10's of watts or less) | H | H | |
| Power (High - 100's of watts) | | | H |
| Cooling [Will also need Power (High)] | S | H | S |
| High Temp Electronics / Memory / Power Processing | H | H | H |
| Mechanisms (Drills, Wheels, …) | | | H |
| Autonomous Ops, Nav | | H | H |
| State-of-art Instruments | | H | |

Table Legend: "H" designates highly impactful, "S" somewhat impactful, and MSM = Multiple simultaneous measurements

# POTENTIAL SCIENCE FROM LANDER PLATFORMS

Capabilities may be synergistic




Sustained technology investments will enable capabilities – particularly power, high temp electronics/memory / processing, and autonomous ops and Nav

# COVER SLIDE IMAGE DESCRIPTIONS

- Images reflect platforms with varying degrees of development and planned lifetime, smarts, and / or mobility.
  - 1) DaVINCI +: Discovery mission concept – currently in competitive review process 2020
  - 2) Venus Flagship Mission Concept 2020: Study recently completed in under review in decadal survey process 2020
  - 3) Venera-D: Study lander concept developed by a Joint Science Definition Team (JSDT). Phase 2 report completed 2019
  - 4) SAEVe – small, long-lived (120 days), seismic and meteorology station (~25kg). Completed NASA funded study 2018
  - 5) LLISSE – Small 60 day lander in development (~10kg), image shows early integrated test setup 2020
  - 6) LLISSE/HEEET – TD Technology Demonstrator concept – Days of operations proving survivability and data return
  - 7) Mechanically oriented Venus rover concept, NASA NIAC funded study
  - 8) Lander concept from the 2009 NASA funded Venus Flagship mission study
  - 9) Concept for surface sampling balloon system from "*Probing the Interior Structure of Venus*" Report , a 2015 Keck Institute for Space Studies report
  - 10) Concept by for a cooled / mobile, long-life mobile platform
  - 11) Venus wind sailor concept, NASA NIAC funded study

Unless otherwise noted images are from NASA or NASA funded study efforts. More detail on all these concepts available publicly online