



**Jet Propulsion Laboratory**  
California Institute of Technology

# Technical State of the Art

What capabilities exist to enable science, what is on the near horizon

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# Venus Technology Plan (2014)

Mission Modes and applicable technologies shown for surface platforms

Applicable Technology Category		Mission Mode							Maturity Level / Description	MM
		Near Term	Mid-Term		Far Term					
		Lander-Smooth Terrain	Lander-Rough Terrain	Lander-Long Duration	Lander Network	Mobile Surface	Mobile Near Surface	Sample Return Surface		
System Technologies	Aerocapture								Very High. Ready for Flight. Same as TRL6	
	Entry	↑							Mix Maturity. Some ready for flight both others at various maturity levels	MM
	Descent								High. Funding in Place to Develop to Very High in 1-4 Years	↑
	Landing								High. Limited Development and Testing Need	
	Landers-Short Duration								Moderate. Major R&D Effort Needed	
	Landers-Long Duration- Geophysical								Low. Major R&D effort needed with notable technical challenges	
Subsystem Technologies	Mobile Platform - Surface or Near Surface									
	Ascent Vehicle									
	Energy Storage- Batteries									
	Energy Generation -Radioisotope Power									
	Energy Generation - Alternative Sources									
	Thermal Control - Passive									
	Thermal Control - Active									
	High temperature mechanisms									
Instrument	High temperature electronics									
	Communications									
	Guidance, Navigation, and Control									
	Remote Sensing - Active									
	Remote Sensing - Passive									
	In Situ Surface - Short Duration									
Instrument	In Situ Surface - Long Duration - Geophysical									
	In Situ Surface - Long Duration - Mobile Lab									

“Venus Technology Plan,” VEXAG, May 2014.

Top Level Objectives

Science Goals/  
Investigation

# Breaking it Down in More Detail

Investigated  
by

Measurement

Accomplish  
Through

Measurement  
Technique

Which  
Drives

Instrument

Mission Mode

Instrument  
Subsystems

Supporting  
Subsystems

Which  
Requires

Capabilities

Which  
Requires

Capabilities

Enabled  
By

Technology

Enabled  
By

Technology

# Mission Modes (Simplified)

## Short Duration Lander

Point Measurement

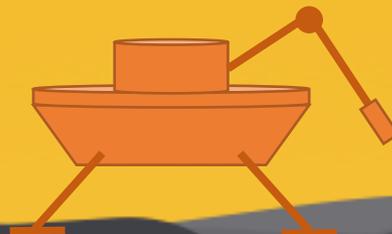
- Current Proposals
- Rough Terrain
- Sample Return



## Long Duration Lander

+Time Dimension

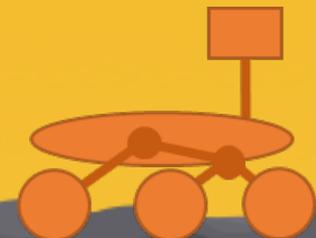
- Rough Terrain
- Network



## Long Duration Mobile Platform

+Spatial Dimension

- Mobile Surface
- Mobile Near Surface (VME)



# Subsystem Categories of Capabilities/Technologies

- Instruments
  - Environmental Sensors
  - Geophysical
  - Imagers
  - Spectrometers
  - Other ???
- Support System Infrastructure
  - Insertion to Venus
  - Entry
  - Descent
  - Landing
  - Orbiting/Flyby Platform
- Landed Subsystems
  - Command and Data Handling
  - Guidance, Nav, and Control Systems
  - Telecommunications
  - Electrical Power
    - Generation
    - Storage
  - Thermal Systems
    - Active
    - Passive
  - Mechanical Systems
    - Structures
    - Mechanisms

“Venus Technology Plan,” VEXAG, May 2014.  
“Subsystem Technologies for Venus Environments”  
Jim Cutts, IPPW-Short Course, June 2016

# Motivating Discussion Questions

- What have been key evolutions in capabilities and technologies since the Venus Technology Roadmap?
- What subsystem categories are the “tall poles” for each mission mode?
  - Which capabilities may be already solved (or almost solved) by current research?
  - Which capabilities are currently being explored by funded research?
  - Which capabilities have not yet had supporting research?
- Which mission modes are enabling for what science? Which capabilities?

# Short Overview Presentations

- The Driving Physics Based Challenges at Venus – Jim Cutts
- High Temperature Electronics – Gary Hunter
- Power Systems for Venus – Geoff Landis
- Mechanical Systems – Jonathan Sauder

# Mechanical Systems at Venus

- Honeybee Robotics Motor/Gearbox
  - Motors/generators are especially inefficient at high temperatures
- Lubrication
  - Best to go with no lubrication (dry or wet)
    - For bearings, use ceramic balls with 440 steel.
- Structures/Materials
  - Many standard aerospace materials are not candidates.
  - Issues related to annealing/aging.
  - Potential issues related to chemical reactions

# Motivating Discussion Questions

- Key evolutions since the Venus Technology Roadmap?
- Subsystem Categories with “Tallest Poles”?
  - Which are almost solved?
  - Which have funded research?
  - Which require support?
- Which mission modes are enabling for what science?
- **Instruments:**
  - Environmental Sensors
  - Geophysical
  - Imagers
  - Spectrometers
  - Other??
- **Support System:**
  - EDL
  - C&DH
  - Telecom
  - Power
  - Thermal
  - Mechanical
- **Mission Modes:**
  - Short Duration Lander
  - Long Duration Lander
  - Mobile Platform

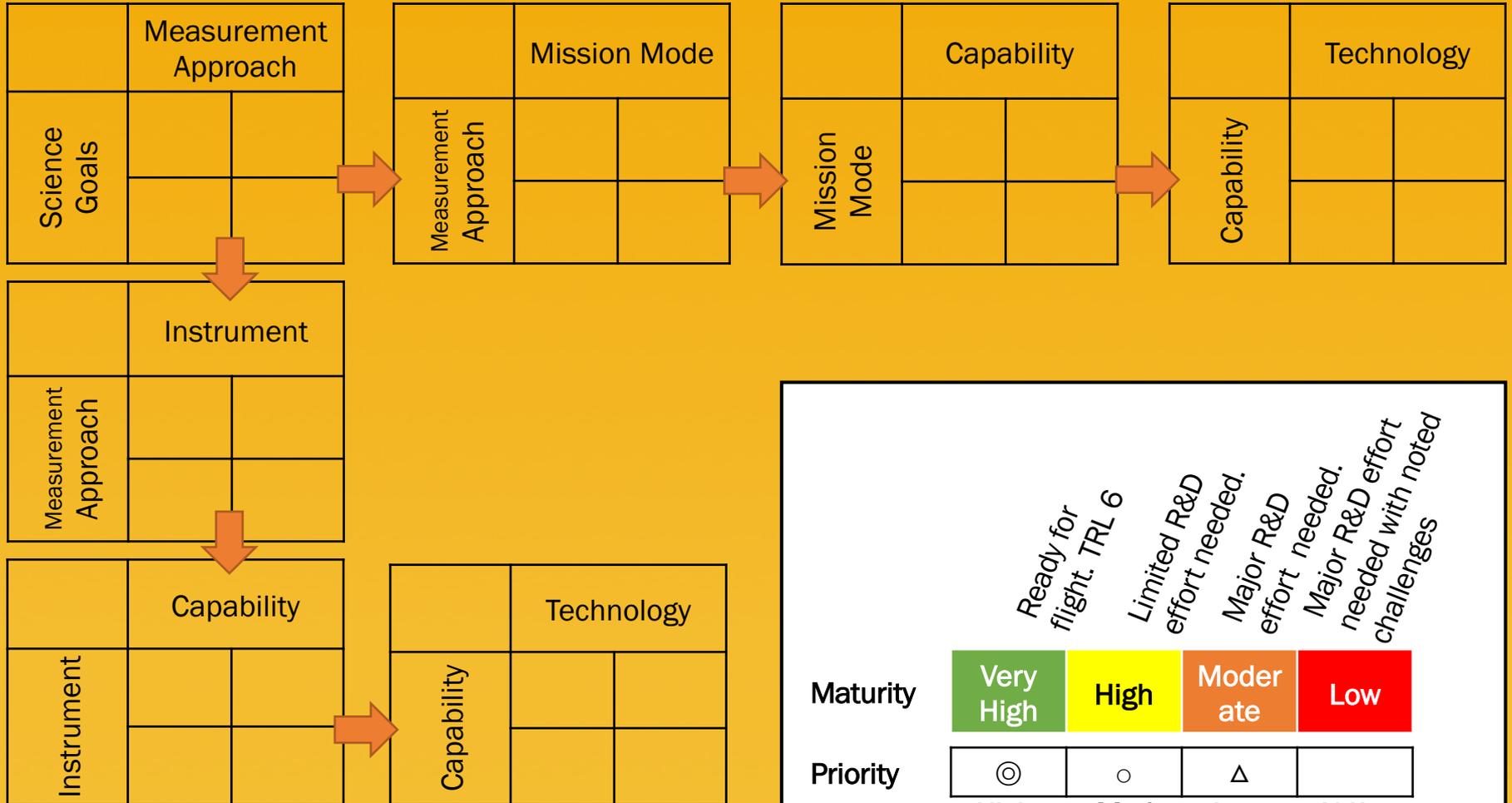
# Backup Slides

9/10/20

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Pre-Decisional Information – For Planning  
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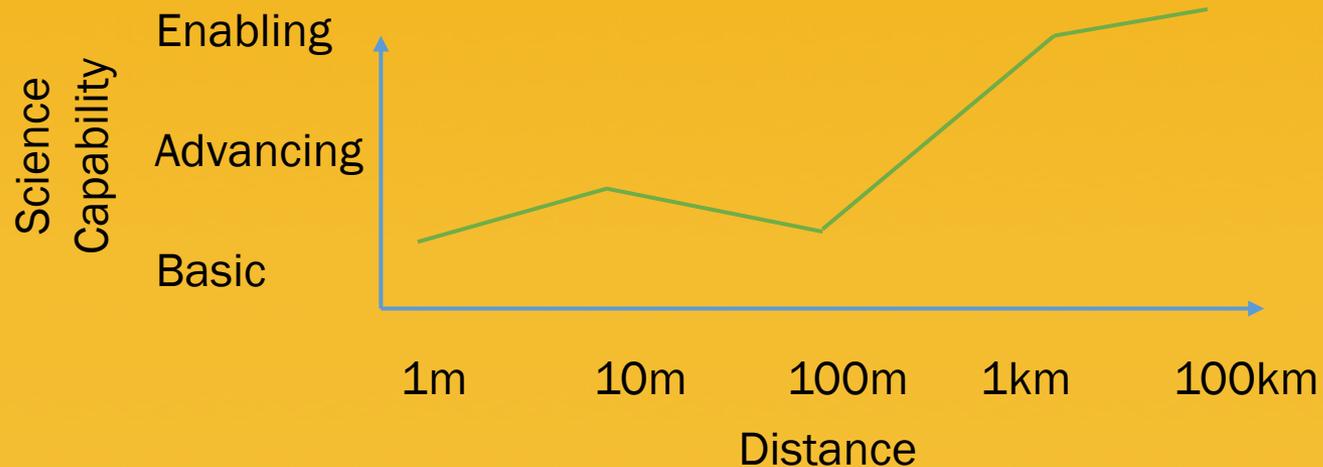
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# Proposed approach for future study work.



# Science Return vs. Dimensions

- For each science goal/measurement type, which is the general result as measurements vary over
  - Time
  - Space (Distance)



# Science Return vs. Dimensions

- Or perhaps just a matrix.

Goals/Objectives/Investigations			Value from Dimensions		
Science Goal/ Objective	Investigation	Measurement Approach	Depth/Height	Time	Distance
			*Value vs. Length *Break Points *Periodicity	*Value vs. Length *Break Points *Periodicity	*Value vs. Length *Break Points *Periodicity

# Imagery

