VENERA-D
TECHNOLOGY IMPLICATIONS

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OUTLINE

- Technology assessment objectives for the Venera-D JSDT
- Assessment approach
- Summary of top technology needs
- High impact technology demonstration opportunities
- Conclusions

TECHNOLOGY ASSESSMENT OBJECTIVES AND APPROACH

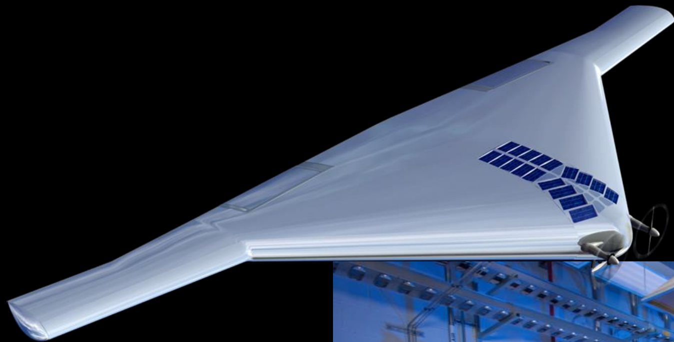
TECHNOLOGY ASSESSMENT OBJECTIVES FOR VENERA-D

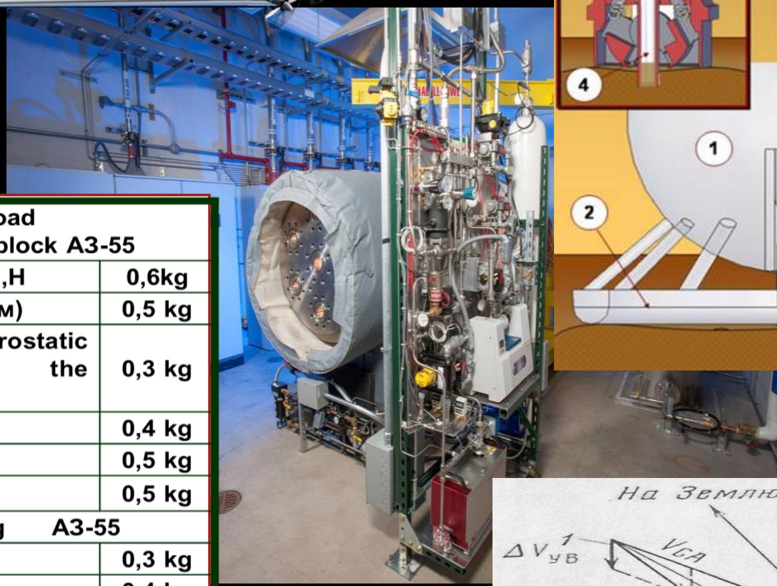
- Assess technology readiness level to implement the mission concept and identify areas for which development is required
  - Not a requirement but may identify high impact technology demonstration opportunities
- Assess the precursor observations and instrumentation validation experiments needed to enable or enhance the Venera-D mission

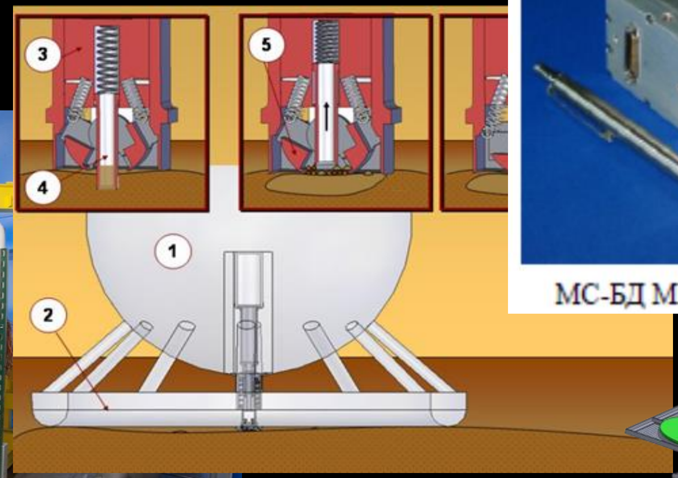
ASSESSMENT APPROACH

- Capture each instrument identified in the original IKI presented Venera-D mission concept
- Identify each subsystem on possible mission elements that could potentially require technology development
- Identify other mission support systems that may require technology or infrastructure development (e.g. test facilities)
- Capture the available relevant data on maturity, development status, and applicability of all the above for Venera-D
- Discuss and reassess during SDT to inform team and support evolving mission concept needs
- Organize and summarize for reports and decision making

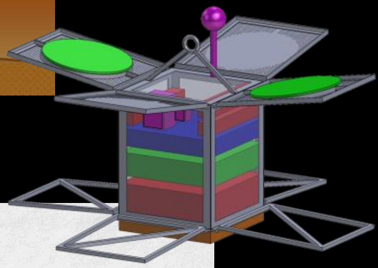
CONDUCTED NUMEROUS TELECONFERENCES / BRIEFINGS TO GET NECESSARY INSIGHT



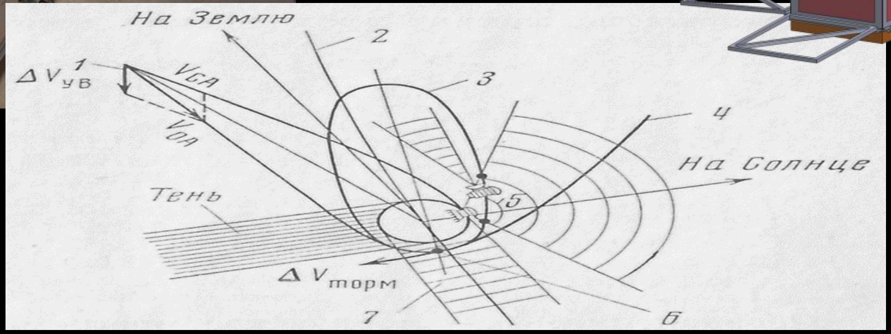




МС-БД MIMOS2



Scientific payload atmospheric block A3-55	
T,P,W,W',dT,E,ω,H	0,6kg
Camera(~ 1мкм)	0,5 kg
Acoustic & electrostatic processes in the atmosphere	0,3 kg
Acoustic	0,4 kg
Lidar	0,5 kg
Infrasound	0,5 kg
Housekeeping A3-55	
Solar panels	0,3 kg
storage battery	0,4 kg
Control system	0,3 kg
Radio system with the antenna	0,9 кг
Frame	1,2 кг
Balloon with helium reserve	1,0 кг
Total	6,9 кг



VENERA-D Technology Data Sheet

Technology Item: ____________________

Instrument: ☐ Spacecraft Subsystem: ☐ Mission Support: ☐ Other: ☐

Description: ____________________

Technology Features/Contact Information

Principle Contact: Name ____________ Org: ____________

Contact Information: Phone: ____________ Email: ____________

Volume: ______ Power: ______ Mass: ______ Data Volume: ______

Measurement/Use: ____________________

Duration/Frequency: ____________________

Does the technology fully meet the science measurement requirements for resolution, mission duration and all other requirements? Yes: ☐ No: ☐ If not, what are all the gaps?

Special Interface or Location/Placement Needs ____________________

Does the mass/power/volume (MPV) specified above include cabling and all support subsystems needed? Yes ☐

If not, where is that MPV allocation assumed to be? ____________________

Applications on Venera-D *Instructions: Check all that apply*

Orbiter: ☐ Lander: ☐ Sub-Satellite: ☐ Mobile Aerial: ☐ Long-Lived Lander: ☐

Dropsonde: ☐ Launch Vehicle: ☐ Cruise: ☐ Entry: ☐

Technology Heritage

Has this technology ever flown? Yes: ☐ No: ☐

If Yes, last used? Where? ____________ When? ____________

What new upgrades, components, etc., are required? ____________________

Current Status of Technology

What is current TRL(s) for the intended Venus application? ____________________

If further development is required for Venera-D Application, describe what development is used.

Is that development currently funded/in process? ____________________

How long is development expected to take? ____________________

Other Information

Does this technology rely on other subsystems/technologies (e.g. sample collection system, avionics) shared with another instrument, etc.? Yes: ☐ No: ☐ If Yes, what is the relationship? ____________________

Any supporting Lab work needed to develop, test, or interpret results?

Any supporting Qualification/Test facilities needed to qualify and test hardware?

Are there other options/technology solutions if this technology isn't ready? What are they?

GENERATED DATA SHEETS TO CONSISTENTLY CAPTURE DESIRED INFORMATION

COMPLETED BY INSTRUMENT PI OR KNOWLEDGEABLE TECHNOLOGIST FOR THE RESPECTIVE ITEM

TABLE TO COMMUNICATE SUMMARY

Data Sheet Com-pleted	Instrument or specific subsystem	Description	Physical Properties	Source/ Contact Info	Heritage	Science Priority High, (H) Med (M), Low (L)	Current TRL 1-3, 4-5, 6 and higher	Time (years) required to be ready for mission (1-3 yrs., 4-5, >5yrs)	What further development is required?	What testing / Lab Experiments Required?	Rationale / Other Comments
Orbiter											
Instrument											
✓	UV mapping spectrometer	Imaging ultraviolet spectrometer 190-490nm, Δλ=0.3nm, Continuous imaging during mission, ~1 s/image	$0.003\ m^3$, 4W, 3kg, (cm3), 40 kB/x, 60 MB/sess. (30 min)	Italy (IAPS INAF) or Russia (IKI)	Flew on Omega -VIS /MEX . Alternatively, "Ozonometer" (IKI, O. Korablev, Yu. Dobrolensky) 2003	H	4-7		Performance upgrades desired. New space qualified electronics need to be identified. Working Engineering model in hand ...	Qualification testing in Venus like orbit temperatures. Low risk	
✓	PFS-VD Fourier transform spectrometer	Thermal IR Fourier transform spectrometer Spectrum 250-2000 cm^{-1} λ=5-45 µm, Δν=1cm^{-1} 1 s/spectrum, whole mission	$0.015\ m^3$, 15 W 15 kg, 400x300x200 mm 5 kb/s	Moshkin B., Grigoriev A., Zasova L. IKI Russia (IKI), Germany (DLR), Italy (IAPS INAF)	PFS Mars Express, PFS Venus Express (development team), AOST/Phobos Grunt, ACS-TRVIM/ExoMars TGO (PI & development team)–2016	H	6-7		Instrument design is very similar to ACS-TIRVIM/ExoMars TGO, but CsI beam splitter, pyroelectric detector without cooling. Radiative stable electronics	Calibration facilities	
✓	VMC Monitoring camera	Monitoring camera 4 channels, λ=0.285, 0.365, 0.500, 1µm	1 dm^3 13/21 W 1 kg 126 MB/image set	D. Belyaev IKI	VMC/Venus Express, FCB/SAGE 2006-2014	H	5-7		Adaptation of modern detectors and latest optics technologies for best instrument performance. Electronics components review to further enhance reliability.	Calibration and tests with new filter on 0.285 µm	

SUMMARY OF TOP NEEDS

DEVELOPMENT NEEDS (HIGH PRIORITY SCIENCE BUT LOW MATURITY, AND OR LONG DEVELOPMENT TIME)

Platform	Instrument/Subsystem	Development Required	Assessment Summary
Orbiter	Millimeter Wave Radiometer	Development of W channel, scanning antenna	
Orbiter/ Sub-Satellite	Radio-science two-frequency duplex occultation in (L?) S- and X-bands.	Develop test L band	
Orbiter/ Sub-Satellite	Suite of 3 plasma instruments Panoramic energy mass-analyzer of ions CAMERA-O, electron spectrometer ELSPEC, fast neutrals analyzer FNA	ELSPEC and NPD use existing technology but prototypes are still under development	
Orbiter	IVOLGA infrared heterodyne spectrometer	Coupler technology needs development.	
Main Lander	Mossbauer Spectrometer / APXS	Unclear if measurement can be made with mission / environmental constraints	
Main Lander	Chemical analyses package (CAP)--Gas Chromatograph Mass Spectrometer	Sampling System for atmospheric gases/aerosols, Coupling of MS with LIMS	
Main Lander	METEO-Lander-VD Fields Package	Requires constructive integration to the lander and design work	
Main Lander	VERBA (infrared radiometer)	New electronic and optical components and electric and optical design	

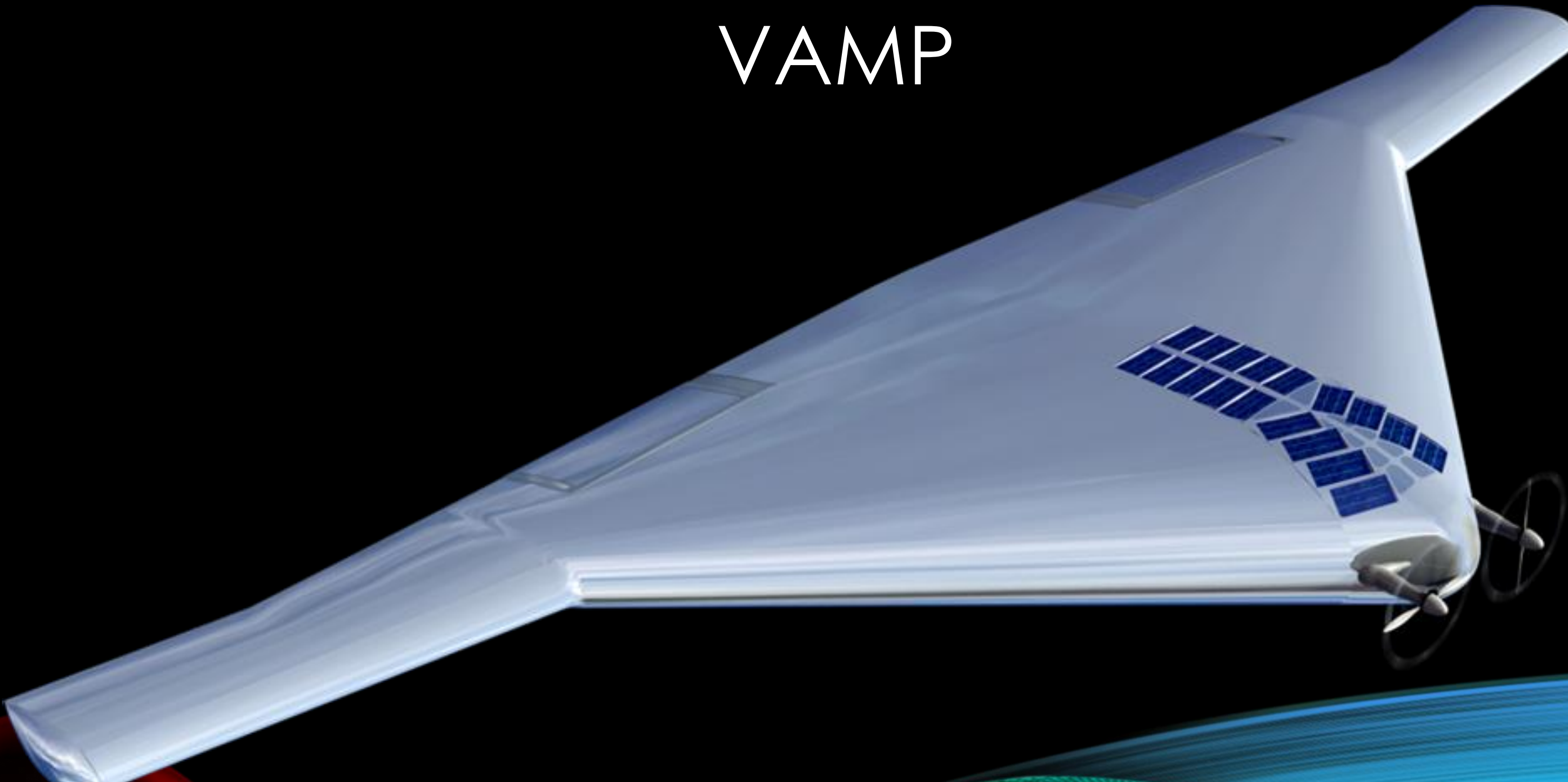
Colors signify relative level of development attention recommended: red suggesting more attention may be warranted

DEVELOPMENT NEEDS (HIGH PRIORITY SCIENCE BUT LOW MATURITY, AND OR LONG DEVELOPMENT TIME)

Platform	Instrument/Subsystem	Development Required	Assessment Summary
Main Lander	Sample handling processing	Design, build, test, for integration with up to 4 instruments	
Main Lander	Lander test and qualification facility	Need to design and build test capability scaled to accommodate full size lander	
Mobile Aerial	Balloon	Confirm full scale performance with prototype testing. Integration with lander	
Mobile Aerial	VAMP	Develop final designs to accommodate launch vehicle, and mission interfaces, prototype development including test flights, entry tests, deployment, and entry	
Long-Live Station	Weather package	Requires design and test of wind sensor. Demonstration of life of other sensors	
Long-Live Station	Integrated system	Requires circuit designs and demonstration of live and performance.	

Colors signify relative level of development attention recommended: red suggesting more attention may be warranted

TECHNOLOGY DEMONSTRATION OPPORTUNITY: VAMP

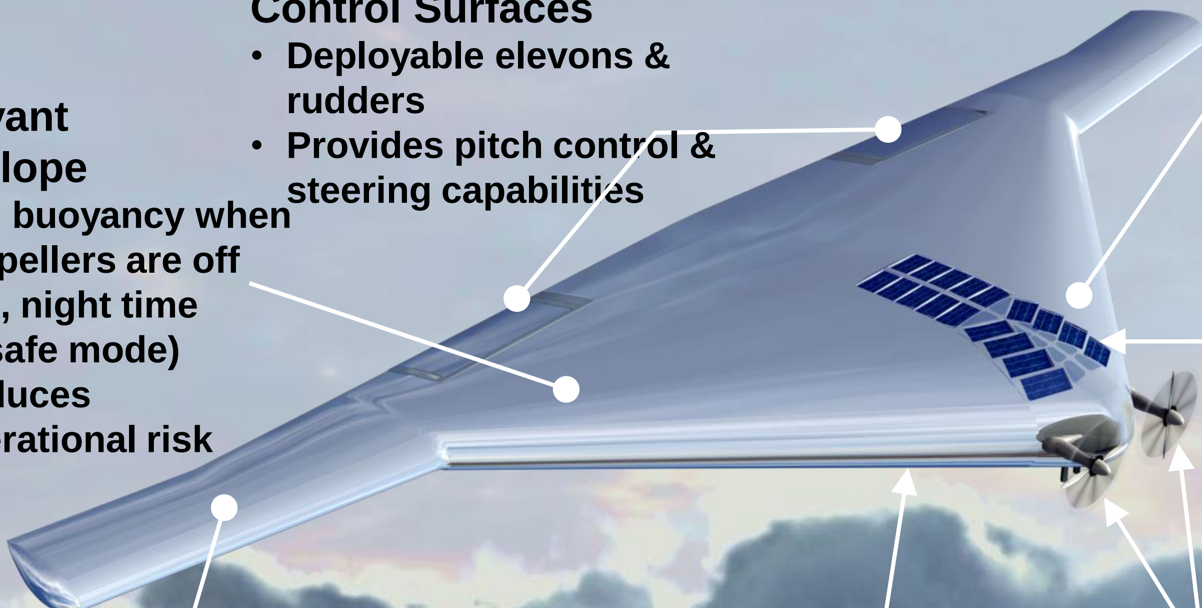


VAMP AIR VEHICLE KEY FEATURES

Buoyant Envelope
- Full buoyancy when propellers are off (i.e., night time or safe mode)
- Reduces operational risk

Control Surfaces
- Deployable elevons & rudders
- Provides pitch control & steering capabilities

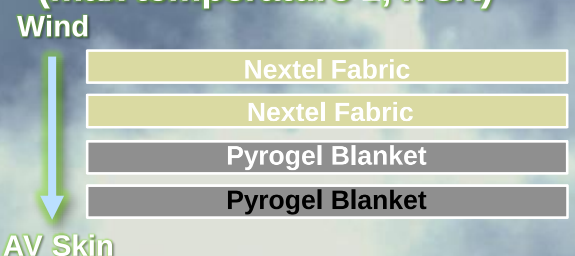
Equipment Bay
- ~30 m^3 of volume for instruments & avionics
- 50kg instrument capacity
- Houses avionics & instruments



Electrical Power Subsystem
- Solar array (> 8 kW capability)
- Powers propellers, avionics & instruments

AV Skin
- Teflon-Al-Vectran laminate
- Protects against sulfuric acid & solar heating
- Retains buoyancy gas inside the envelope

Thermal Protection System
- Protects air vehicle during entry
- Nextel fabric/Pyrogel laminate (max temperature 1,478K)



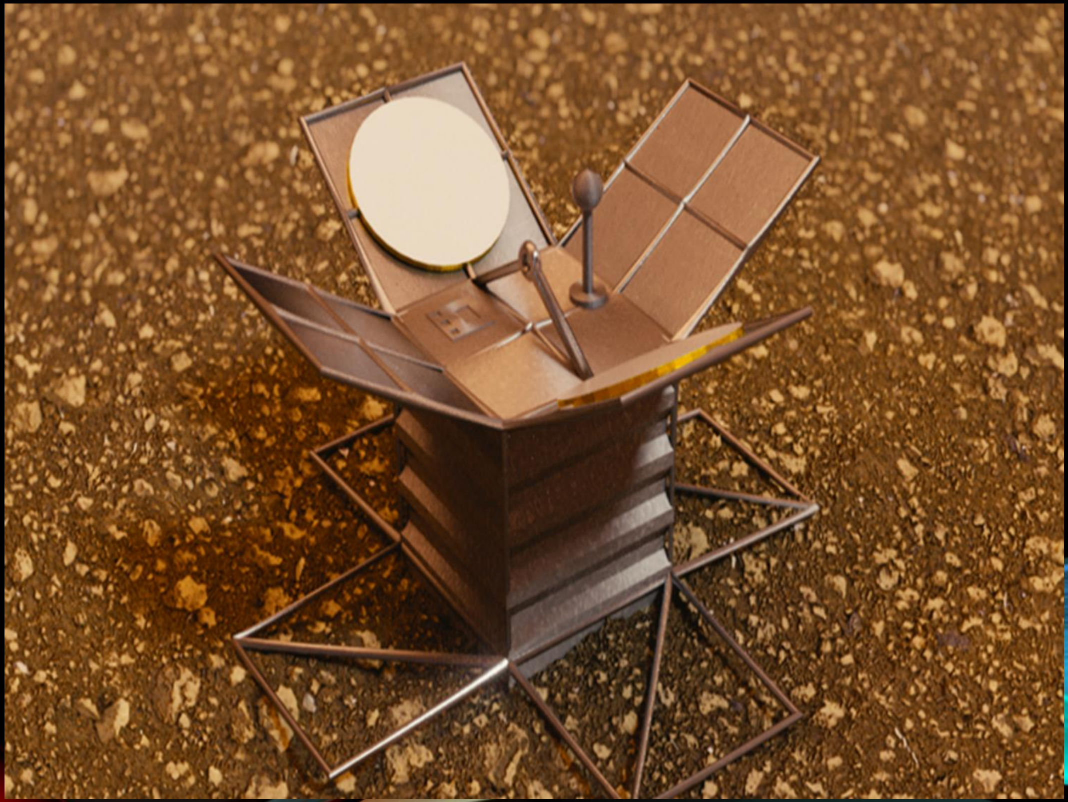
Propulsion Subsystem
- Provides altitude control & lift capability
- 2-blade, 2.5m diameter propellers
- Total of 400 – 450 N thrust
- Max speed ~30 m/s
- Max climb rate ~1.5 km/hr

DIFFERENT VAMP CONFIGURATIONS

	Baseline VAMP	Pathfinder VAMP	Tech Demo VAMP
Objectives	Powered flight Full climb ability to 68 km altitude Greatly expanded science	**Powered flight** **Limited climbing ability** **Nighttime science operations** **Expanded science**	Lifting entry Operation in H_2SO_4 environment Basic science (temperature, pressure, wind speed, etc.)
Nominal Science Ops Duration	Up to 1 year	**1 – 3 Months**	1 – 4 Weeks
Nominal Altitude Range	50 – 65 km	**Low to mid 50 km (52-54 km)**	Fixed (~50 km)
Science Instruments & Capabilities	See next slide	**See next slide**	See next slide
Minimum Power	8,000 w (day); 100 w (night)	**300 w (day); 100 w (night)**	100 w (day); 20 w (night)
Notional Wing Span	59 m	**30 m**	6 m
Vehicle Mass	880 kg including instruments	**450 kg including instruments**	90 kg including instruments
Launch Vehicle	Atlas V 551 or Equivalent	**Atlas V 401 or Equivalent**	Piggy-back on Venus flyby spacecraft

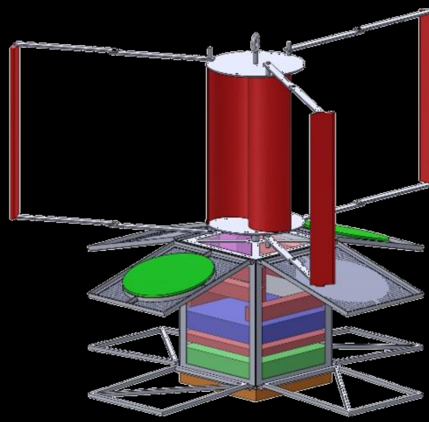
Main considerations include completing the development effort, which is significant, and mission impacts (mass, volume and Venus entry constraints)

TECHNOLOGY DEMONSTRATION OPPORTUNITY: LONG-LIVE STATION (LLS)



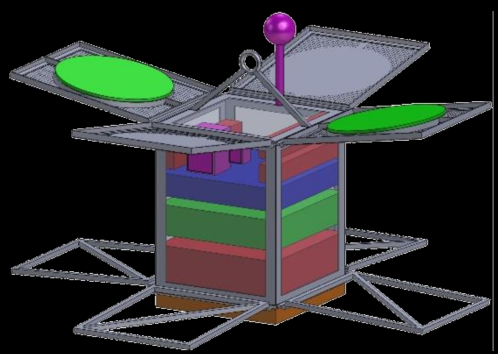
MEASUREMENTS

- Surface wind speed
- Wind direction (relative to surface)
- Surface temperature and pressure
- Near-surface chemical composition
- Incident radiance (TBD)



~ 20 cm / side (stowed, 60cm tall) & 8 kg

- Measurements to be made over a long time period
  - Goal: minimum ~ 60 Earth days (one Venus "daylight period" & the day / night transitions at each end)



~ 20 cm / side (stowed) & 8 kg

LLS CONSIDERATIONS

- Data captured and transmitted in real time – not stored
  - Timing of transmits will be tuned with orbiter period and science needs
- Battery version is TRL 3-4 (comm system driven), most components around TRL 5
- Wind powered version is TRL 2-3 (turbine system driven)
- Battery version is simple with long life – but not indefinite
- Wind powered version is higher risk and transmission could be variable (depends on surface wind speeds)
  - However, a strong step toward future surface exploration

- Can be deployed a number of ways – with lander but independent, attached to lander, dropped from aerial platform, or deployed in own aeroshell (which could enable deployment of multiple stations)

OVERALL CONCLUSIONS

- Venera-D can be a highly capable mission with no heroic technology development efforts.
- As far as the core mission elements, the sample manipulation and processing system is viewed as needing the most development – particularly integration with up to 4 instruments.
- Most instruments will require some work to accommodate the specific environmental conditions and mission constraints.
- The Venus atmosphere and surface offer many opportunities for demonstrating new technologies – 2 have been considered to some degree by the JSDT - VAMP and the Long Live Station.
  - VAMP offers powered flight (~50-55 km), but needs significant development including demonstration of inflation, then entry from space
  - The Long-Live Station offers opportunity to take first ever long-duration surface data. Some high-temp circuit development along with system level demonstrations, including life, is required