SCIENCE INSTRUMENTS FOR VENUS EXPLORATION: J. A. Cutts[1,] R Grimm.[2], Pl. Steffes[3], N. Izenberg[4], [1]Jet Propulsion Laboratory, California Institute of Technology, MS 321-550, 4800 Oak Grove Drive, Pasadena, CA 91109, James.A.Cutts@jpl.nasa.gov [2] South West Research Institute, Boulder, CO 80302, [3] Georgia Tech, Atlanta, GA 30332, [4]Applied Physics Lab, Laurel, MD 20723

Venus presents unique challenges and opportunities for scientific exploration. The dense atmosphere and high surface temperatures at the surface render many techniques irrelevant that are routine for use at the other inner planets. The environmental conditions have the greatest impact on remote sensing measurements from orbit and in situ measurements at the surface. However, the deep atmosphere with regions of benign temperatures permits long duration aerial platforms to operate with conventional sensors and electronics and apply both remote sensing and in situ techniques to observations of the surface, atmosphere and interior.

From orbit, a rich variety of remote atmospheric investigations are practical but the deep atmosphere blocks surface signals for vast region of the electromagnetic spectrum. As a result, UV, visible and infra instrumentation has played a key role in investigating the atmosphere on ESA's Venus Express mission and now on JAXA's Akatsuki mission. However, when it comes to investigating surface features at high resolution radar is the preferred technique. The VERITAS mission, selected as a candidate NASA Discovery mission, uses radar in conjunction with infrared in narrow spectral windows. Advances in both radar and infrared instrument technology will provide a major advances over what was accomplished by Magellan.

For in situ missions, there has been a long hiatus since the lander and balloon missions performed by the Soviet Union in the mid-1980s. Although there is little immediate prospect of extending the lifetime of these missions beyond a few hours, advances in instrumentation will enable remarkable gains in science. For example, the DAVINCI probe mission, also selected as a Discovery candidate mission in 2015, will be able to conduct descent imaging and high precision molecular analysis not possible with the Soviet technology of 30 years ago. Equally, the Venus In Situ Explorer, A New Frontiers class mission that NASA plans to issues a solicitation for this fall, requires the adaptation of the technologies developed for Mars and lunar surface in situ exploration to the high temperature and pressure of the Venus surface environment.

Prospects for long duration surface operation on Venus hinge on the development of sensing and electronics technologies that can function for weeks to months at almost 500C. Although individual components have been developed, we are far from having the range and complexity of components needed for a spacecraft system. Refrigeration systems that could allow the use of conventional components are also decades away from feasibility and would require powerful energy sources that have yet to be defined.

For long term in situ observations on Venus the near future lies with floating or flying platforms that operate in the upper atmosphere where temperatures are clement. From this vantage point it is possible to both conduct long term observations of the atmosphere and also use infrasound and magnetic and electrical signatures to investigate seismicity, explosive volcanic events and interior structure.

A series of documents prepared by VEXAG and published in 2014 (1),(2),(3), lay out the science goals for future Venus exploration, a mission roadmap and the technologies needed to realize these objectives. This information was supplemented in May 2014 with targets and target zones on the surface and in the atmosphere and measurement details by the with the Venus Exploration Targets workshop (4). A month later a Venus Seismology workshop(5) was sponsored by the Keck Institute for Space Studies (KISS) and compared in situ surface, atmospheric platforms and orbital platforms for seismic investigation of the Venus interior

Most recently, a detailed examination of the state of spacecraft and instrument technologies for exploring Venus was provided in a short course held in conjunction with the International Planetary Probe Workshop (IPPW) held in June 2016 and titled Destination Venus: Science, Technology and Mission Architectures (6). VEXAG is now working on defining needs for laboratory measurements to support the exploration of Venus.

References:

(1) Goals, Objectives and Investigations for Venus Exploration, 2014 http://www.lpi.usra.edu/vexag/reports/GOI-140625.pdf

(2) Roadmap for Venus Exploration, 2014 http://www.lpi.usra.edu/vexag/reports/Roadmap-140617.pdf

(3) Venus Technology Plan 2014 http://www.lpi.usra.edu/vexag/reports/Venus-Technology-Plan-140617.pdf

(4) Venus Targets Workshop Final Report 2015 http://www.lpi.usra.edu/vexag/WorkshopTargets20160115.pdf

(5) Probing the interior of Venus http://kiss.caltech.edu/study/venus/2015_KISS_Venus_Final_Report.pdf

(6) IPPW Short Course Destination Venus, Science, Technology and Mission Architecture http://ippw2016.jhuapl.edu/course.php