Post-Venus Express exploration of Venus : the Venus Entry Probe Initiative

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The planet Venus – our neighbour in the solar system and twin sister of the Earth - was once expected to be very similar to the Earth. However the space missions to the planet discovered a world completely different from ours. The fundamental mysteries in the physics of Venus are related to the composition and dynamics of the atmosphere, physics of the cloud layer and greenhouse effect, surface mineralogy, evolution of the surface and volatile inventory. Despite the fact that both Earth and Venus were formed in the same region of the solar system, the planets followed dramatically different evolutionary paths. Understanding the reasons for this divergence would shed a light on the processes of origin and evolution of all terrestrial planets including Earth.

Early missions to Venus in 1960-90 included a great variety of robotic spacecraft: fly-bys, orbiters, landers and balloons. They established basic understanding of the conditions prevailing in the atmosphere and on the surface of Venus. In the same time they raised a number of fundamental questions concerning the mechanisms and processes that formed and are maintaining these conditions. The new era of Venus exploration began with the launch of the ESA Venus Express spacecraft in November 2005. The spacecraft will deliver a powerful suite of remote sensing instruments into orbit around the planet. The mission will perform a global survey of the Venus atmosphere and plasma environment. The Japanese Planet-C mission scheduled for launch in 2010 will focus on meteorological monitoring from orbit. These missions are expected to make a breakthrough in Venus exploration. A natural next step after these investigations are completed would be a mobile geochemical/ geophysical mission to Venus that would fully exploit *in situ* techniques and provide a detailed picture of molecular and isotopic composition of the deep atmosphere and the surface.

The future missions to Venus should aim at the science goals that could not be covered by the remote sensing investigations. 1) Study of the isotopic composition especially that of noble gases which preserves a record of origin and evolution of Venus. 2) Measurements of chemical composition below the clouds with both vertical and horizontal sampling capabilities in order to characterize in detail the present chemical cycles. 3) Investigation of the surface composition and mineralogy at several locations represent-

ing the main types of Venus landforms. 4) Search for seismic activity and seismological measurements on the surface to sound the planet's interiors. 5) In situ investigation of the atmospheric dynamics. 6). Study of the composition of the cloud layer at different altitudes and locations. 7) Characterization of solar wind- atmosphere interaction processes and measurement of atmospheric escape.

The above mentioned objectives of the future missions may be achieved by a mission composed of an orbiter, entry probes, and balloons. The experience gained in the earlier Soviet and American missions should be expanded by the Venus entry probe study recently carried out by ESA. The technological developments made for this mission can be also re-used for *in-situ* exploration of other planets and satellites with dense atmospheres like Titan.

The missions for in-situ exploration of Venus can be scheduled for launch in 2015-2020 after the results of Venus Express and Planet-C would be analyzed and assimilated. These missions will be strongly supported by the European scientists from the field of geochemistry, geophysics, and atmospheric science. Cooperation with Russia that included Venera-D mission in its Federal Programme can open promising opportunities for joint activities. This mission, scheduled for launch in 2016, consists of an orbiter, long-living lander, and balloons. The orbiter will perform remote sensing observations from orbit. The entry probe and balloons will carry out in-situ measurements of atmospheric and surface composition including isotopic analysis, and meteorological investigations. Also in the United States there is a strong interest for further exploration of Venus and similar goals have recently been formulated by the American scientists in so called "White Paper on Venus Exploration".