VARIABILITY OF ENCELADUS' PLUMES REFLECTANCE AS A FUNCTION OF THE POTENTIALLY OCCURRENCE OF MICROBES. N. E. Zalewska[1,2], J. Kotlarz[3] , K. Kubiak[4] [1]Institute of Aviation, Al. Krakowska 110/114, 02-256 Warsaw, Poland (natalia.zalewska@ilot.edu.pl), [2] Space Research Center PAS, Bartycka 18A, 00-716 Warsaw, Poland, [3]Institute of Aviation, Al. Krakowska 110/114, 02-256 Warsaw, Poland (jan.kotlarz@ilot.edu.pl), [4]Institute of Aviation, Al. Krakowska 110/114, 02-256 Warsaw, Poland (katarzyna.kubiak@ilot.edu.pl)

Introduction: Enceladus is particularly attractive place in the outer Solar System where life can thrive and grow because liquid water and energy availability Life finding mission concepts were proposed, analyzed and discussed in recent years [1]. Temporal variations in the plume's gas content and matter fluxes from individual sources were observed [2]. Plume's main component is water in two states: solid and vapor. Also, the other organic and biologically significant compounds were detected during previous missions. Cassini spacecraft during its closest approach to Enceladus' surface in July 2005 collected data using the Ion and Neutral Mass Spectrometer (INMS). The best estimation of the plumes composition gives us: 91(±3)% H_2O, 3.2(±0.6)% CO_2, 4.0(±1.0)% N_2 or CO and 1.6 (±0.4)% CH_4 [3]. H_2 was discovered in the plume's vapor. Multiple stellar and solar occulation measurements of the plumes vapor column density done by ultraviolet spectrograph (UVIS) and INMS data suggests multiple gas jets of different gas emissions: 1) high-speed gas emmision (i.e. thermal expansion of gas through narrow channels, pressure driven acceleration) and 2) low-speed thermal emmision (like solid or liquid near surface sublimation). The occultation data suggests quite homogenous total plume H_2O output between 180 kg/s and 250 kg/s. INMS data in the contrast suggests spatially more varied H_2O stream ranging from 200 kg/s to 1000 kg/s[4]. All these data show that the structure of the plume itself and the structure of geological formation from which it originates may be varied. Detection of sodium-salt-rich ice grains led some researchers to hypothesise that the plumes may contain among others seafloor matter.

In recent years, many researchers have been interested in the possibility of the existence of habitat suitable for microorganisms in their diverse forms. We may distinguish four main types of theoretically habitable areas near Enceladus' south pole:

1. bottom of the ocean in the area of volcanic activity and around it,
2. the surface of the ocean inside rifts,
3. an ice surface around the rifts where the heavier particles fall from the interior of the subsurface ocean and finally
4. geysers themselves.

Our two main goals are: 1) modeling the possibility of finding microorganisms originated from the ocean's floor in plumes and 2) examine the possibility of detection of microorganisms using QUERCUS type multispectral camera directly in plumes and on the ice surface around the rifts.

Bottom of the ocean heating and the plume kinetic model : Giant plumes of water up to several hundred kilometers height with an average particles speed 1.25 km/s may be of two types: high-temperature classic geysers or low-temperature belonging to cold geysers. The first one on the Earth is generated by the hot magma that heats groundwater just below the surface of the shell, while the second type, cold, is formed by the accumulation of evolved gases, most often CO_2, which expel water ejecting it. We can not, however, expect that on Enceladus there could be classical volcanism similar to Earth's or extinct Martian, that is, that it could come to convection of magma in the inner layer of the moon and to get out in the form of lava. The process of ocean's floor heating must be modeled numerically. We applied EMMA particle-in-cell kinetic code developed in Remote Sensing Division (Institute of Aviation, Warsaw, Poland) [5] to model this heating process and also plume curtain form, density, chemical and biological composition (see Fig. 1).

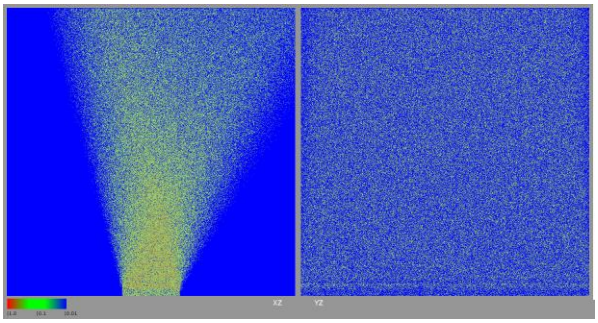

Figure 1. Relative density of the mi H_2O 1μm diameter ice particles in the example Enceladus' plume kinetic model.

Biological component. Assuming that Enceladus cryovolcanism is generated by high-temperature processes that can lead to the effects of these geysers, study of microbial community of chimneys in Lost City hydrothermal field [6,7] provide information about microorganism involved in CH_4- and S cycling and their genoms can potentialy occur in Enceladus' plumes. They occur at a depth about 750 m, where temperatures

reach 40 - 90 C [6]. Assuming low-temperature option we can consider the occurrence of psychrophiles on Enceladus analogously to those that live in the Arctic or Antarctic ice. *Chryseobacterium greenlandensis* - bacterium living in Greenland ice at a depth of 3000 m in low oxygen and temperature conditions and high pressure discovered in 2008 [8], could be a potential organism hidden in Enceladus ice.

Also methanogenic archaeon, *Methanothermococcus okinawensis*, can produce CH_4 under physicochemical conditions extrapolated for Enceladus [9,10]. The detection of H_2 in the moon's plume by Cassini [1] has been interpreted as potential habitat for methanogens consuming H_2 in reaction:

$$4H_2 + CO_2 \rightarrow CH_4 + 2\,H_2O.$$

The set of typical parameters of microorganisms for the bottom of the Enceladus' ocean and for the ice surface near rifts are described (mass, dimensions, biofilm structure, thickness, durability) in the kinetic model. Also reflectance and transmittance spectra in the range 460 – 1200 nm are currently collected.

After obtaining modelling results laboratory experiment will be carried out. We plan confirm some of the results obtained by modeling methodology using the vacuum chamber and the QUERCUS multispectral camera (see Fig. 2).

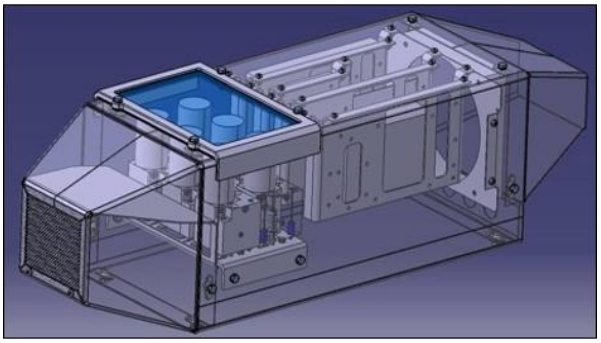

Figure 2. QUERCUS 6 multispectral camera project developed in the Institute of Aviation in 2013-18.

The usability of the middle-angle multispectral four-channel camera proposed for Enceladus Orbiter mission will be investigated.

Results. As the result we will estimate reflectance spectra according to various geological scenarios, biotic activity and chemical composition. The results will be useful for spacecraft missions (i.e. proposed Enceladus Orbiter).

The results will be compared with Cassini plumes images in the following spectral filters: BL1, IR2 and RED.

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