ULTIMA THULE CARTOGRAPHY: NEW APPROCHES, NEW CHALLENGES. H. I. Hargitai and A. Dorsánszki[2], [1]ELTE Eotvos Lorand University Budapest Hungary hargitaih@caesar.elte.hu, [2] MKE, Hungarian University of Fine Arts Budapest Hungary adrienndorsanszki@gmail.com

Introduction: Mapping Ultima Thule (2014 MU69) presents unparalleled cartographic challenges. We are creating a map that shows this distant world for a young audience.

Previous work: In the last decade we have produced seven planetary maps for children in the framework of the program Europlanet 2012 [1, 2] and created map-based activities for educators [3]. The maps of the seven bodies resulted from the cooperation of planetary scientists and graphic artists. A specialty of these maps compared to other, "scientific" maps is that while they keep cartographic accuracy, they also link arts and science, and visualize scientific data in a way that is immediately transparent for the non-experts. This is the first project in which such detailed, hand-drawn lunar and planetary maps were created specifically for children, in the most common spoken languages of Europe. The latest in this series shows the encounter hemispheres of Pluto and Charon [2] and was published shortly after the successful New Horizons Pluto flyby.

Discussion. Ultima Thule is small, bilobate, contact binary Kuiper Belt Object that has been observed by the New Horizons spacecraft. Utilizing the first published images we have created a preliminary map concept draft *(Fig. 1)* that we would refine as the high-resolution images are received. We are also in the process of developing an accompanying tabletop game where the game board would be the map of Ultima Thule.

Cartographic challenges. For most cratered bodies it is difficult to estimate scales and distances because of the lack of familiar objects, "standing" landmarks [4]; additionally, on a map the lack of prominent linear objects (such as hydrology and socially constructed imagined lines) makes orientation difficult. Bilobate bodies, such as Ultima Thule makes another orientation dimension difficult to estimate intuitively: the directions of "up" and "down" on the surface. Slopes may not slope the way that are suggested intuitively. In planetary cartography, the reference surface is typically an ellipsoid that provides geometric height. On irregular asteroids, however, a height calculated from a combined gravitational and centrifugal equipotential (*geopotential height*) may greatly differ from those measured from a mathematically defined shape that approximates the shape of the body. Within a reference frame used for irregular asteroids, slopes are defined relative to the local gravity vector [6].

This is also reflected in the definition of height values. For irregular bodies, the vector from the (mass) center of the body may intersect the surface in more than one place, therefore surface coordinates can only be identified by latitude, longitude and radius values [5]. While this is a problem of the definition of cartographic standards for Ultima Thule, it is also one of how to visualize heights and topography in general on an outreach map.

One way of visualization is the use of divergence lines ("drainage divides") and convergence areas or points that signify special points for these bodies, unlike any on spherical planets. Similar to the "hot poles" of tidally locked bodies or those with resonant orbital motions, adequate cartographic representation and symbology of these special regions should be developed. Alternatively, or additionally, slope arrows showing gradient vectors can help understand topography and consequent geologic processes. Apart from impact processes, mass movements are a major process on airless planetary bodies. Mass movement includes long-term creep and short-term landslide type processes. Mass movements may remove or accumulate materials depending on slope angles and positions. The neck regions of contact asteroids have a highly variable topography relative to a gravitational equipotential. Thus, both long-term material removal and accumulation regions are expected to be situated in this region. The accurate cartographic representation this region poses special challenges.

Preliminary theme. The map theme of Ultima Thule would reflect the "ultimate frontier" concept stemming from the informal name of 2014 MU69, which, in turn, reflects the solar distance of this body and also the fact that it is currently the farthest solid surface object from the Sun visited and observed by spacecraft, situated in the coldest outer realm of the Solar System.

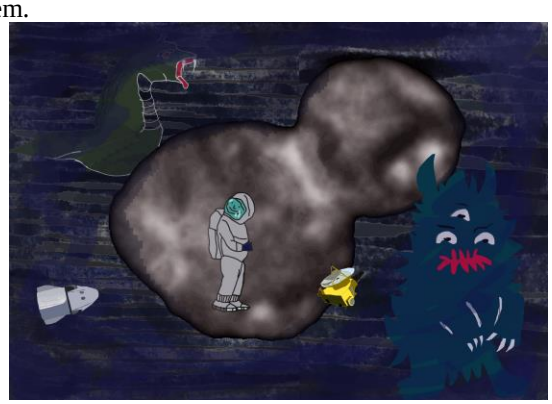

Fig. 1. Concept draft of the map elements on the Ultima Thule map designed for children.

The theme of this map would use the emotions of loneliness invoked by the distance and by the coldness and darkness at this distance. In addition, the name was used in 16th century maps (such as the famous Carta Marina map of Olaus Magnus) that were populated by the monsters of the unknown seas, a parallel of which is the unknown "endless" space, parts of which becomes known with these discoveries.

A game built on the map would simulate a human space mission to this world that should be investigated and mapped by the players.

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