THE SMALL BODY GEOPHYSICAL ANALYSIS TOOL. Benjamin Bercovici[1] and Jay McMahon[2], [1]Pre-PhD Candidate, University of Colorado Boulder (benjamin.bercovici@colorado.edu), [2]Assistant Professor, University of Colorado Boulder (jay.mcmahon@colorado.edu)

Introduction: The Small Body Geophysical Analysis Tool (SBGAT) that we are developing aims at providing scientists and mission designers with a comprehensive, easy to use, open-source analysis tool. SBGAT is meant for seamless generation of valuable simulated data originating from small bodies shape models, combined with advanced shape-modification properties. The SBGAT software architecture is provided on Figure 1.

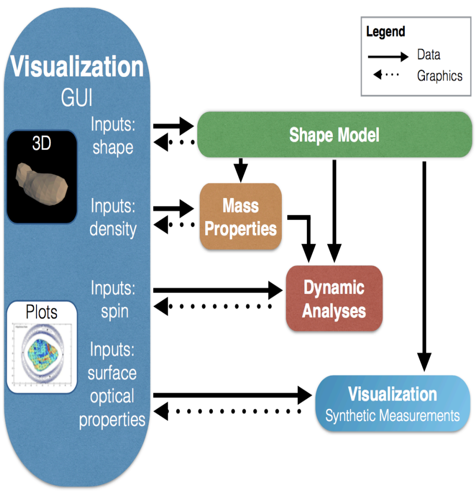

Figure 1 SBGAT software architecture

A short description of the achieved milestones is provided below:

Software solutions selection: our first task consisted in selecting the software solutions to develop SBGAT's visualization module. The frontend of this module was built around Qt, due to its proven capabilities and ease of use. The visualization module's backend is the most critical component of SBGAT. We were thus looking for an existing framework that was highly optimized, high-level, object-oriented and actively maintained by a community of developers and users. Our choice therefore consisted in picking the Visual Toolkit library (VTK) in its C++ implementation as the core of SBGAT's visualization module.

I/O and shape model display: our second task consisted in adding I/O and shape model display functions to SBGAT, leveraging both Qt and VTK. In particular, we focused on using the Wavefront format to display structured shape models.

Surface modification: Our third task pertained to the implementation of surface selection/alteration. This feature of SBGAT is key to facilitate quick surface modification and *subsequent* analysis cycles. Thanks to VTK's features, surface patches can now be selected and applied a range of surface transforms. This functionality is illustrated on Figure 2.

PGM model: Our fourth and current task consists in building the Dynamic Analysis module, starting with the implementation of a Polyhedron Gravity Model[1] algorithm and subsequent results visualization, as shown on Figure 3.

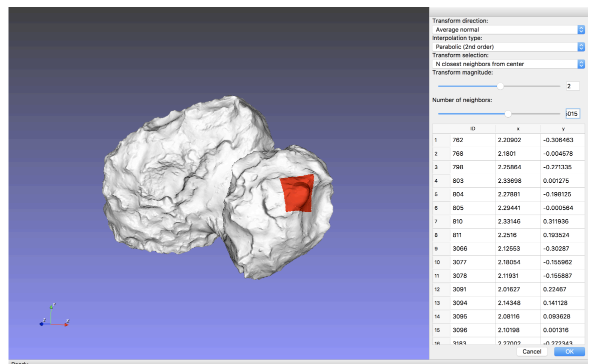

Figure 2 - View of the surface modification module of SBGAT. The shape model being represented is a high-resolution scan (~1.3M facets) of comet 67P/Churyumov Gerasimenko. The rectangular patch shown in red is operated on to create a local volume increase.

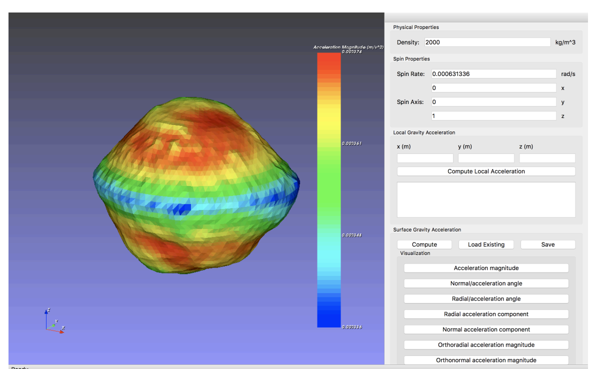

Figure 3 - Surface accelerations obtained after computation of the Polyhedron Gravity Model of asteroid KW4 Alpha[2]. The PGM module that is shown on the image allows for the modification of the physical properties of the small body being investigated (density, spin rate, spin axis...) and output/input of previously computed PGM models

Current work: We are currently focusing on optimizing the PGM computation by means of VTK's data containers. This way, recomputing a PGM after applying an arbitrarily large transform to the body's surface would only require re-evaluating the contribution to the PGM of the modified surfaces areas. This way, tremendous speed gains will be achieved.

SBGAT is presently being hosted on a GitHub repository owned by SBGAT's main developer. This repository is public and can be accessed at https://github.com/bbercovici/SBGAT. Along with the commented code, one can find the code documentation at https://bbercovici.github.io/sbgat-doc/index.html.

Finally, a User's Manual is currently being written. It will eventually be available at https://github.com/bbercovici/SBGAT/wiki. This document will eventually contain a comprehensive tutorial indicating how to retrieve, compile and run SBGAT from scratch.

Future work: The successful implementation of the previous milestones has validated our software choices (VTK + Qt) to create SBGAT's backbone. Some of the upcoming development goals are listed below:

Dynamics module extension: the PGM algorithm is the only type of analysis method currently implemented. Future work will therefore consists in broadening SBGAT's capabilities with the Spherical Harmonics Expansion of the gravity field and the calculation of YORP coefficients.

Synthetic measurements: SBGAT will eventually be able to generate synthetic observations of different type (radar, lightcurve, point clouds,...) from the shape model currently displayed.

Improved user/surface interaction: for now, surface patches can only be formed via a bounding box selection. A future goal will be to enable individual facet selection and creation of a selection patch, by adding a prescribed number of neighboring facets to the patch centered at the selected facet.

Linux deployment and support: SBGAT is already available on GitHub in its macOS X version. Linux systems will soon be supported as well. The installation procedure for both platforms will be added to SBGAT's Wiki.

References: [1] Werner, R. A., & Scheeres, D. J. (1997). Exterior gravitation of a polyhedron derived and compared with harmonic and mascon gravitation representations of asteroid 4769 Castalia. *Celestial Mechanics and Dynamical Astronomy*, *65*(3), 313–344. [2] Scheeres, D. J., Fahnestock, E. G., Ostro, S. J., Margot, J.-L., Benner, L. A. M., Broschart, S. B., … Jong, E. M. De. (2006). Dynamical Configuration of Binary Near-Earth Asteroid (66391) 1999 KW4. *Science*, *314*(November), 1280–1283. https://doi.org/10.1126/science.1133622