PRELIMINARY MAPPING OF ASTEROID 4179 TOUTATIS; Philip J. Stooke, Department of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2 (e-mail: stooke@sscl.uwo.ca)

INTRODUCTION: The Small Body Mapping Program (1,2,3) is being extended to include asteroids resolved by delay-Doppler radar. In ref. (3) an experimental shape model and map of 4769 Castalia is described, but the radar data for Castalia barely warranted mapping except to build experience and to address issues such as suitable map projections for two-lobed objects. The first object for which well resolved delay-Doppler images were obtained is 4179 Toutatis (4,5). Preliminary work included shape modelling (to convert the polyhedral model of ref. (5) to a latitude-longitude-radius format) and preliminary mapping. Toutatis radar images can be superimposed on the shape model for conventional mapping, but some must be mirror-reversed from their published orientation. This body may possess grooves like those of Phobos, Gaspra and Ida.

MODELLING: Results of the 1992 radar imaging of 4179 Toutatis were reported in 1995 (4,5). The published shape model, a polyhedron defined by 1600 vertices, was reproduced in Small Body Mapping format (latitude, longitude, radius at 5° spacing) by limb matching to radar and synthetic views. The cartographic coordinate system is body-fixed but essentially arbitrary, defined as follows: the coordinate axis is the long axis of the published shape model (5), cartographic north is at the 'small lobe' end of the body, and longitudes are measured relative to the component of rotation about the long axis. This gives retrograde (eastwardly increasing) longitudes. The Prime Meridian is arbitrarily placed on the intermediate axis in the vicinity of the ridge called R1 in (5). An important observation is that the model can be oriented normal to the radar line of sight (Fig. 2) and overlain directly on the radar images to locate features on the surface. This is well illustrated by the very close (though purely fortuitous) similarity between the December 6 1992 high-resolution radar image (4, Figure 2) and the synthetic view from Earth at the time of the HST observations on Dec. 10 1992 (5, Figure 4B). Each radar image can be matched to the model by properly orienting and illuminating the shape model.

IMAGE REVERSAL: However, some images, while correctly displayed in delay-Doppler space, are reversed relative to a conventional optical view. This is not obvious from the images as published but must be taken into account for mapping. The reversal occurs because the view direction is perpendicular to the radar-target vector. If the perpendicular intersects the body of the asteroid, the radar-illuminated part of the surface is being seen, effectively, through the asteroid. While acceptable in delay-Doppler space, this is counter-intuitive in conventional image terms, and is 'corrected' by reversing the image. Reproducibility of feature locations in images and the published shape model confirm this interpretation. Most images with the small lobe nearer the radar must be reversed in this way, the exception being the Dec. 11 image in which the radar crossed the pole to illuminate the opposite side of the object. Figure 1 shows images with 'north' always near the top and left-right reversal where necessary.

MAPPING: A shape model with a conventional surface coordinate system can be mapped in any of the ways which have become standard for other worlds. Here, preliminary outline maps are presented in Morphographic Conformal and Simple Cylindrical projections (Figure 3.) Note that small feature identifications differ slightly between the two versions. Radar mosaics, shaded relief maps, contour maps of radius or relief relative to an ellipsoidal datum, and geological interpretations can be prepared (dynamic height may be more difficult to map on a body in complex rotation). The volume of the model is 7.2 ± 1.0 km³. The high resolution Dec. 10 radar image (Fig. 2 of ref. 4) includes several linear features on both lobes of Toutatis which appear to be real and may be grooves. Similar features are tentatively identified in 2 other images, though resolution or radar illumination are less satisfactory. Confirmation may have to await the very close approach of 2004. Nevertheless, Toutatis may join Phobos, Gaspra, Ida and possibly Epimetheus and Hyperion as a member of the set of objects with grooves.

TOP: Figure 1. Radar images of 4179 Toutatis, courtesy S.J. Ostro and R.S. Hudson. All have the small lobe near the top, and the last three are mirror-reversed from the publication orientation. MIDDLE: Figure 2. Latitude-longitude grids corresponding to the radar image orientation (perpendicular to the radar vector), with dates of image acquisition. BOTTOM: Figure 3. Maps of Toutatis. Left: Morphographic Conformal projection; right: Simple Cylindrical projection. Solid loops: craters; dashed loops: possible craters; lines with ticks: ridges and scarps (ticks downslope); short heavy lines: tentatively identified grooves.