TOUTATIS:
2012 RADAR OBSERVATIONS

Michael Busch

Lance Benner, Marina Brozovic, Jon Giorgini, Joseph Jao, Dan Scheeres, Yu Takahashi, and the Goldstone and VLA observing staff
Background: 1992-1996

Observations led by Steve Ostro, shape and spin state models led by Scott Hudson.

1. Toutatis is bilobate, ~4.5 km long.
2. It has an aperiodic NPA spin state.
3. NPA spin depends on Toutatis’ moments of inertia.
Background: 2000-2008

- Radar images: Goldstone ‘00, Arecibo ‘04 & ‘08.
- Mismatch between ‘92-‘96 spin state fit and later images.
Toutatis’ Changing Spin State

Toutatis is torqued by tides from the Sun and Earth. The largest spin state change since 1992 was during the ‘04 flyby.

Moment of inertia ratios from ’92-’08 spin state fit:
$I_s/I_\| = 3.23 \pm 0.01$ and $I/|I| = 3.087 \pm 0.005$

Changes in Toutatis’ angular momentum from Dec 1992 to Dec 2012.
Chart and fit from Yu Takahashi.
Predictions for 2012

1992-2008 spin state fit run forward to **2012 Dec 4 03:30 UT**. Simulated 18.75 m/pixel image (0.125 usec x 0.032 Hz)

Simulated Chang’e 2 out-bound Toutatis image (unblurred).

**Orientation of Toutatis in 2012 December was uncertain by 20°-30°.**
Data from 2012

- Goldstone radar imaging on 16 days between 2012 Dec 4 and Dec 22.
  - Dec 13 images overlap CE2 flyby.
- Image resolution: 18.75 m to 3.75 m per range pixel.
- Radar speckle tracking from Dec 18 to Dec 22.

Goldstone 2012 Dec 12 delay-Doppler radar image, 3.75 m/pixel in range
Images from 2012 Dec 12 & 13 UT

NASA Radar Images
Asteroid Toutatis
7.5 m/pixel and 3.75 m/pixel images of Toutatis show some 10-m-scale bright features. Boulders?
Spin state predictions were quite good.
Radar and Chang’e 2 images imply errors in the shape model of *perhaps 3% by volume*.
Limitations of SHAPE software: initial ellipsoid model of the big end was preserved throughout later shape fits.
What Happens Next?

- Improve the spin state model with both radar imaging and speckle tracking data.
- Correct the shape model:
  - Radar images from this year allow both higher resolution and correction of errors on the big end.
  - Eventually, combine CE2 and radar data (stereo mesh from CE2 + radar over rest of the surface)
- Consider implications for internal structure.