

## Sampling Assessment Meetings

### Sampling Assessment Meeting, Day 295 (10/21/20).

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IPWG have constrained the touch location; it is close to the preliminary NFT location reported last night:

- NFT (Recon C mosaic): 55.9055, 41.8292
- IPWG (Recon C mosaic): 55.9047, 41.9783
- N.B. Shape model caveats apply when reporting coordinates.

Recon C particle counting of the contacted area reported diameters down to 0.77 cm, with (even smaller) unresolved material present. Particle counts will be repeated in the best pre-contact SamCam image.

The TAGSAM head partially overlapped a 21-cm, apparently flat (lacking an obvious shadow) rock. There is no indication at this time of severe or moderate tilt of the head, but tilt is still under investigation. Preliminarily (not to be shared in the daily brief), SamCam videos of wrist motion indicate that the U-joint tilted by about 5 deg at contact, but a firm calculation is TBD. The wrist then moved by ~15 deg.

SamCam images show movement of rocks more than a TAGSAM head diameter away from the TAGSAM head, on all sides. This suggests that the head was flush or nearly flush with the surface.

Estimates of penetration depth are ongoing. Early estimates from the science reconstruction are 2 to 3 cm.

Significant amounts of material were mobilized from pre-contact mechanical impact, gas firing, and backaway. A debris cloud can be seen at or near the moment of contact in SamCam images in the 12 o'clock position. This cloud may be composed of existing particulates that were mobilized, or it may have been created by the head crushing rock. Material mobilization was expected from ground testing.

Contact was first detected at 21:49:49.421 UTC (contact declared 0.9 seconds later), and duration of contact was about 6 seconds. No evidence of head hopping has been observed, suggesting that the head was in contact with the surface for the full duration.

Preliminary accelerometer data show an expected spike when the gas was released; the curve then decays with bottle pressure, exhibiting some modes possibly related to the TAGSAM arm being out. No debris on the arm has been observed yet. The bottle pressure blowdown resembles curves from ground testing.

There is little indication of acceleration from the pogo spring itself, suggesting that the surface did not push back much. We are confident that the head was actually in contact because acceleration passed a predetermined threshold.

SamCam and NavCam 2 backaway movies both show trenches in the surface apparently excavated by the firing of the thrusters (particularly by the two on the left). In the NavCam 2 movie, material can be seen flowing in response to the thruster plume.

A 66% signal reduction was observed in NavCam 1 images between pre- and post-TAG. This may have implications for OpNav and Star Tracker data.

Action items/next up:

- Mike Moreau requested context for movies, including how movies from different cameras relate to each other; Dani DellaGiustina will assign someone from IPWG to this task.
- The TAG-force data package is expected tomorrow.

### **Sampling Assessment Meeting, Day 296 (10/22/20).**

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All TAG data have been downlinked.

SamCam images show particles as large as pebbles emanating from the TAGSAM head at slow speeds of millimeters or centimeters per second. The mylar flap appears to be wedged open in at least three places, allowing material to leak.

The contact pads and interior of the TAGSAM head are darker in post-TAG images than in pre-TAG images, where light can be seen passing through the head and illuminating the pads.

The most likely explanation of these observations is that the head is full of material, which has rendered it opaque, and some pieces of which have jammed the mylar flap. The idea that the head is fully packed with regolith is supported by the new estimated penetration depth of at least 24 cm.

In the SamCam images, leaking particles seem to be correlated with wrist movement, so the head may be leaking material whenever the wrist or arm moves. As a result, a decision is needed on whether to proceed with the Sample Mass Measurement (SMM) exercise on Saturday, which would involve dramatic movement.

A possible decision may be to skip the SMM and accelerate the decision to stow, given the evidence suggesting that more than enough material has been captured. TAGSAM lead Beau Bierhaus expressed confidence in stowing without an SMM.

Some small particles appear to be stuck to the contact pads. Stuck particles large enough to interfere with stow are not observed.

Action items/next up:

- A maneuver is planned for tomorrow to settle the fuel in the tank as an error source reduction before the SMM. A rapid decision is needed on whether to proceed with this maneuver given the leaking material. Bashar Rizk and Christian will present the best images to the Lockheed Martin team this afternoon.
- The reconstructed trajectory and TAG force telemetry report are on track for delivery by EOD tomorrow.

### **Sampling Assessment Meeting, Day 297 (10/23/20).**

For materials on ODOCS, click [here](#) then follow the path: Folders \ Documents and Drawings \ OSIRIS-REx Bennu Proximity Operations \ Sampling Assessment Meetings \ 23 Oct.

Bashar Rizk reported results of an imaging analysis based on the size of visible particles, assumptions about packing density, and the TAGSAM head volume. The best estimate from this analysis is 150 g of sample, with low- and high-end estimates of just over 60 and just under 600 g, respectively. The low-end estimate may not be consistent with the amount of particle loss observed. Both the high and low ends are limited by assumptions.

Beau Bierhaus estimated mass three ways: direct measurement of visible particles (28 g), estimated mass using the area of the screen and the observation that it is opaque (35 to 65 g; N.B., this is simply the minimum mass needed to make the screen opaque assuming 3-mm particles), and estimated volume visible at the smallest wrist angle (314.4 g assuming a packing density of 1200 kg/cm<sup>3</sup>). These values together represent only about one-fifth of the TAGSAM's capacity, so the mass can be scaled up accordingly.

Kevin Walsh presented an analysis based on the visible particles on the surface prior to sampling and assuming no tilt (head flush with surface). The number of particles is likely underestimated because unresolved material is present and new particles may have been created by crushing. About 5 cm of pre-gas penetration is estimated, indicating that fluidized granular material was available to the TAGSAM head. The head was likely packed with regolith (400 to 1000 mL, depending on penetration estimate) before gas firing.

The “nominal” and “upper bound” scores from this analysis were respectively reported as 252 and 575 g, but it was noted that the “upper bound” is really a “lower bound of the upper bound”

as the downward velocity of the sampler head is not taken into account. Kevin also presented a preliminary comparison with ground tests.

Bashar, Beau, and Kevin, as well as Dani DellaGiustina, were asked to report their confidence in sampling success (at least 60 g of material) based on their expertise as analysts. All expressed high confidence, although concern was noted about mass being progressively lost from the head.

Ron Mink initially called on the MPB to vote on go versus no-go for a second TAG (a no-go would mean that the team stops preparing in parallel for a second TAG and focuses efforts on stow). The vote was revised to be a yes or no on whether sampling success has been achieved (though the implications for a second TAG are the same). Because we do not have SMM results, it was not possible to use the quantitative terms of assessment decided upon at OKDP-2, so confidence had to be assessed qualitatively.

All members present voted yes on sample success having been achieved, informed by the expert analysts' assessments. The only member not present was the PI, who is believed to be a yes vote. However, some members expressed caveats that their decision to vote yes was based more on the likelihood of a worse outcome if we attempt a second TAG than on confidence about the amount of sample that we have.

Other notes:

- In analyses, a value of 1200 kg/cm<sup>3</sup> should be used for packing density and 1800 kg/cm<sup>3</sup> for particle density.
- The SFD differential slope for the observed particles on/in the TAGSAM head is about – 2.
- The mylar flap is being held open by several particles (more than the three identified previously).
- Beau showed a progression of images that show a particle departing the TAGSAM head through a gap.

Action items/next up: By EOD today,

- Bashar will add slides for each of the three scenarios he calculated, with assumptions and caveats specified.
- Beau will add clarifications to his charts to make them understandable for an unformed reader and to demonstrate how the mass estimates scale up to the full volume of the TAGSAM head.
- Kevin will add caveats to his charts as appropriate, clarify wording to avoid confusion around the “lower bound of the upper bound”, and, in collaboration with Beau, provide a comparison of the most applicable ground test results (including results from reduced-gravity tests before the design was complete, as well as the test cases currently in the slides).

Updated charts will be posted on ODOCS.

Stow will be the team's focus going forward.

- Tomorrow morning's meeting with Thomas Zurbuchen will focus on reviewing procedures, risk assessments, and contingencies for stow.
- SPOC will stand down from parallel planning of a second TAG.

Future Sampling Assessment Status meetings are canceled given that the question of sampling success is now moot.