OSIRIS REx
Science Processing & Operations Center (SPOC) and Science Engineering Peer Review

April 21 - 23, 2015

OSIRIS-REx™
ASTEROID SAMPLE RETURN MISSION

26 - Sampleability maps

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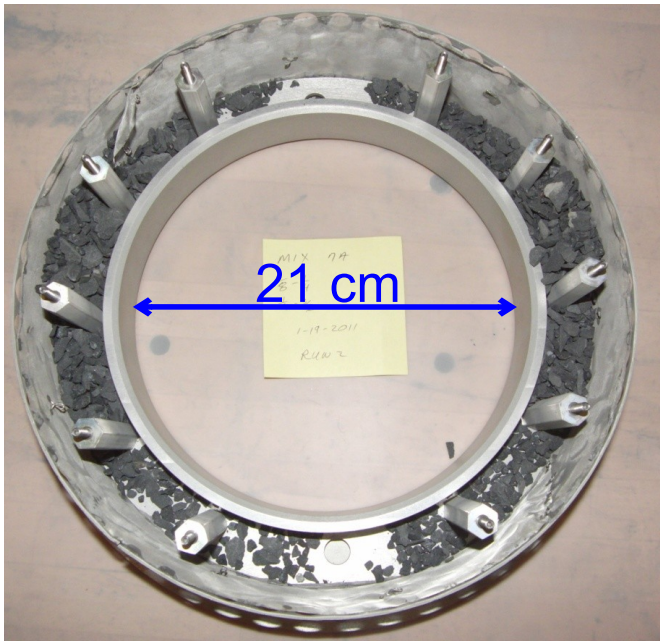
Sampleability Map Driving Requirements

- MRD-570c – OSIRIS-REx shall select a sample site that satisfies the following criteria: ≥80% probability of acquiring **≥60g of bulk sample** per sampling attempt
- Sampleability requires an assessment of the asteroid surface properties vs. TAGSAM capabilities
- Sampleability needs to be assessed at two different scales
  - Global
  - Site specific

Related Requirements

- TAGSAM is required to obtain **≥ 150 grams of bulk sample** under the following surface conditions
  - **Surface angle ≤ 14°** - the angle between a **32-cm-diameter** sample-area-average normal vector and the commanded-spacecraft negative-Z axis (MRD-40)
  - **Grains that are ≤ 2 cm** in their longest dimension – smaller than the narrow point in the annular throat (MRD-80)
  - In contact with a **5-cm obstruction** – the part of the tilt budget allocated to TAGSAM (MRD-574)

- In addition,
  - A **boulder ≥ 21cm** in size can block the TAGSAM collection inlet – the inner annulus diameter (MRD-121 and MRD-137)



Requirements for Map Processing Software

- Layer and combine the input maps to visualize and verify the operation of the Sampleability algorithm
  - PSFD – min/max grain sizes
  - Thermal Inertia
  - Tilt

- The Sampleability thresholds and weighting factors for the Sampleability input maps shall be configurable.

Global and Site-Specific Maps Needed

Sampleability Driver	Surface Parameters	Global Map?	Site-Specific?
Particle Size Frequency Distribution Critical component of the Sampleabilty algorithm	Particle SFD for particles larger than 21-cm (global), and 1-cm (site-specific)	Yes	Yes
Maximum Particle Size Critical component of the Sampleabilty algorithm Minimize number particles too large to ingest	Max particle size within 25m of facet	Yes	Yes
Minimum Particle Size Critical component of the Sampleabilty algorithm Assurance of ingestible particles	Min particle size within 25m of facet	Yes	Yes
Sample at less than a 14 degree angle (MRD-573)	Tilt @ 1m	Yes	Yes
Thermal Inertia Map Indicator of particle size distributions	Thermal Inertia at each facet (MRD-155)	Yes	Yes
Dust Cover Index Indicator of minimum grain sizes	Spectral indications of adhering dust (<65 microns)	Yes	Yes

Sampleability Map Requirements

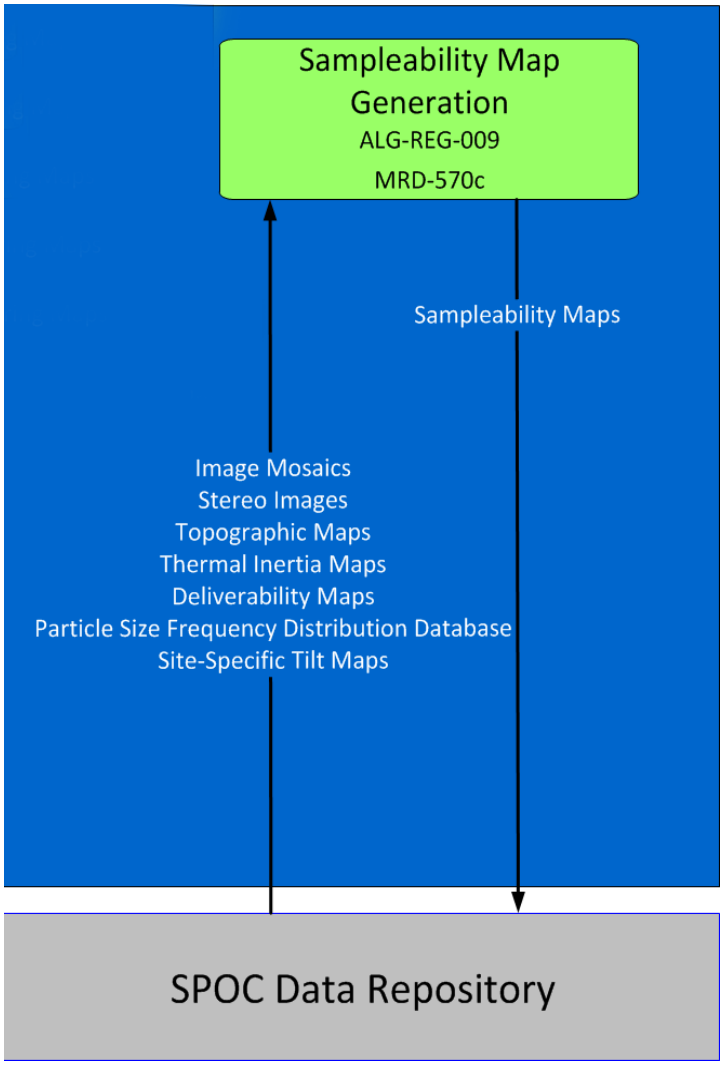
Number	Requirement	Rationale
SampM.GMAP.01	SPOC shall compute the global probability of sampleability for each facet of the GSM. The probability shall be a value between 0 (0% sampleable) and 100 (100% sampleable).	This requirement specifies the need to generate a probability (i.e. uncertainty) of sampleability for each facet of the GSM. The resolution is dictated by the GSM resolution and follows the distribution of error (eg Gaussian or Poisson…).
SampM.GMAP.02	SPOC shall generate a global sampleability map by visualizing the probability values on the GSM	Builds on the previous requirement. Once the probability is computed per each facet, it can be visualized
SampM.GMAP.03	SPOC shall compute the global sampleability probability map by convolving the sampleability probability with deliverability at the GSM resolution. The sampleability probability shall be a value between 0 (0% mission success) and 100 (100% mission success)	This requirement specifies the need to convolve the sampleability map with the deliverability and to compute the overall sampleability. The probability will be generated for each facet within the contact area based on the probability of contact (ie deliverability).
SampM.GMAP.04	The global sampleability map shall be generated within 5 days of SPOC receipt of the input parameter maps.	Define time constraints for generating the global sampleability map
SampM.GMAP.05	The global sampleability map shall have the spatial resolution equivalent to that of the GSM.	Defines the resolution of the global sampleability map to be equivalent to the global shape model

Sampleability Map Requirements

Number	Requirement	Rationale
SampM.SSMAP.01	SPOC shall compute the site-specific probability of sampleability at the resolution of the DTM. The probability shall be a value between 0 (0% safe) and 100 (100% sampleable)	This requirement specifies the need to generate a probability (ie uncertainty) of sampleability for each DTM element at the potential TAG site. The resolution is dictated by the resolution of the DTM and follows the distribution of error (eg Gaussian or Poisson…)
SampM.SSMAP.02	SPOC shall generate a site-specific sampleability map by visualizing the probability values for each pixel in the TAG ellipse at the resolution of the DTM	Builds on the previous requirement. Once the probability is computed per each pixel in the TAG ellipse, it can be visualized
SampM.SSMAP.03	SPOC shall compute the site specific sampleability by convolving the sampleability probability with deliverability at the DTM resolution. The probability of safety shall be a value between 0 (0% mission success) and 100 (100% mission success)	This requirement specifies the need to convolve the sampleability map with deliverability map to compute the overall mission safety. The probability will be generated for each facet within the contact area based on the probability of contact (ie deliverability) and whether any mission safety factors are exceeded.
SampM.SSMAP.04	The Site-specific sampleability probability map (SSMAP.03) shall be compatible with the OSIRIS-REx data visualization tool.	Compatibility means the data product can be ingested by, visualized by, and have all the functionality of the visualization tool applied to the input maps. The output formats for the safety map shall include at least two versions: (i) one version in the shape model format, (ii) one version in the Project-defined map-projection format.
SampM.SSMAP.05	The Site-specific sampleability map shall be generated within 5 days of SPOC receipt of the input parameter maps.	Define time for generating the site-specific safety map
SampM.SSMAP.06	The site-specific sampleability map shall have the spatial resolution equivalent to that of the GSM.	Defines the resolution of the site-specific sampleability map to be equivalent to the global shape model

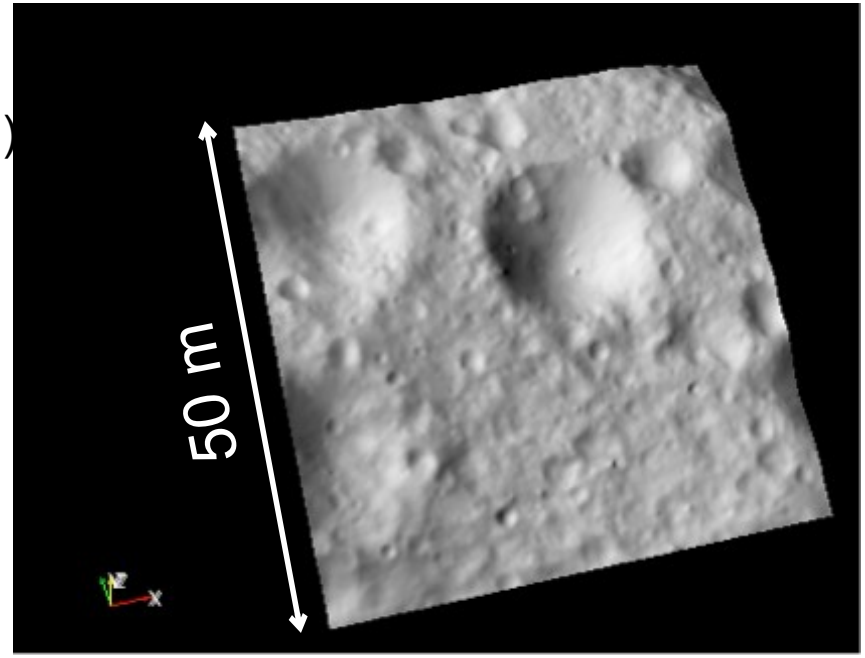
Global Sampleability – Input Data Products

- **Global Sampleability** is based on the following Global data products:
  - Image Mosaics (MRD-121)
  - Stereo Images (MRD-121)
  - Topographic map (MRD-122)
  - Thermal Inertia Map (MRD-155)
  - Deliverability Map (MRD-570b)
  - PSFD Graphs and Maps (MRD-121)
    - (1-m and 21-cm resolution)
  - Spectral Analysis: Dust Cover Index

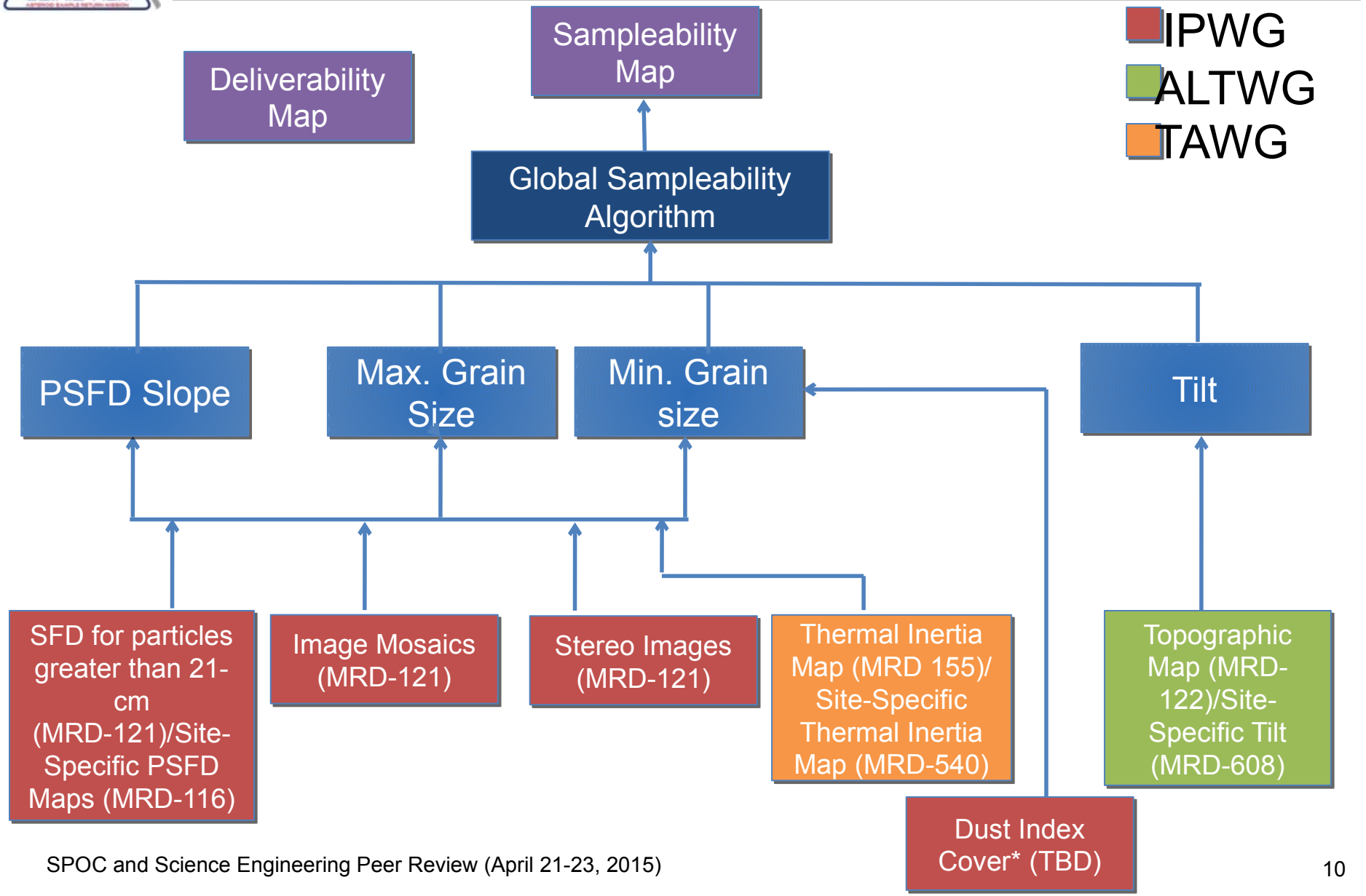


Site-specific Sampleability – Input Products

- **Site-specific sampleability** is based on the following Site-specific data products:
  - Stereo images of sample sites (MRD-116)
  - Topographic Maps (MRD-115)
  - Thermal Inertia Maps (MRD-540)
  - Deliverability Maps (MRD-570b)
  - PSFD Graphs and Maps (MRD-116)
    - (5-cm and 2-cm resolution)
  - Tilt Maps (MRD-608)
  - Spectral analysis: Dust cover index

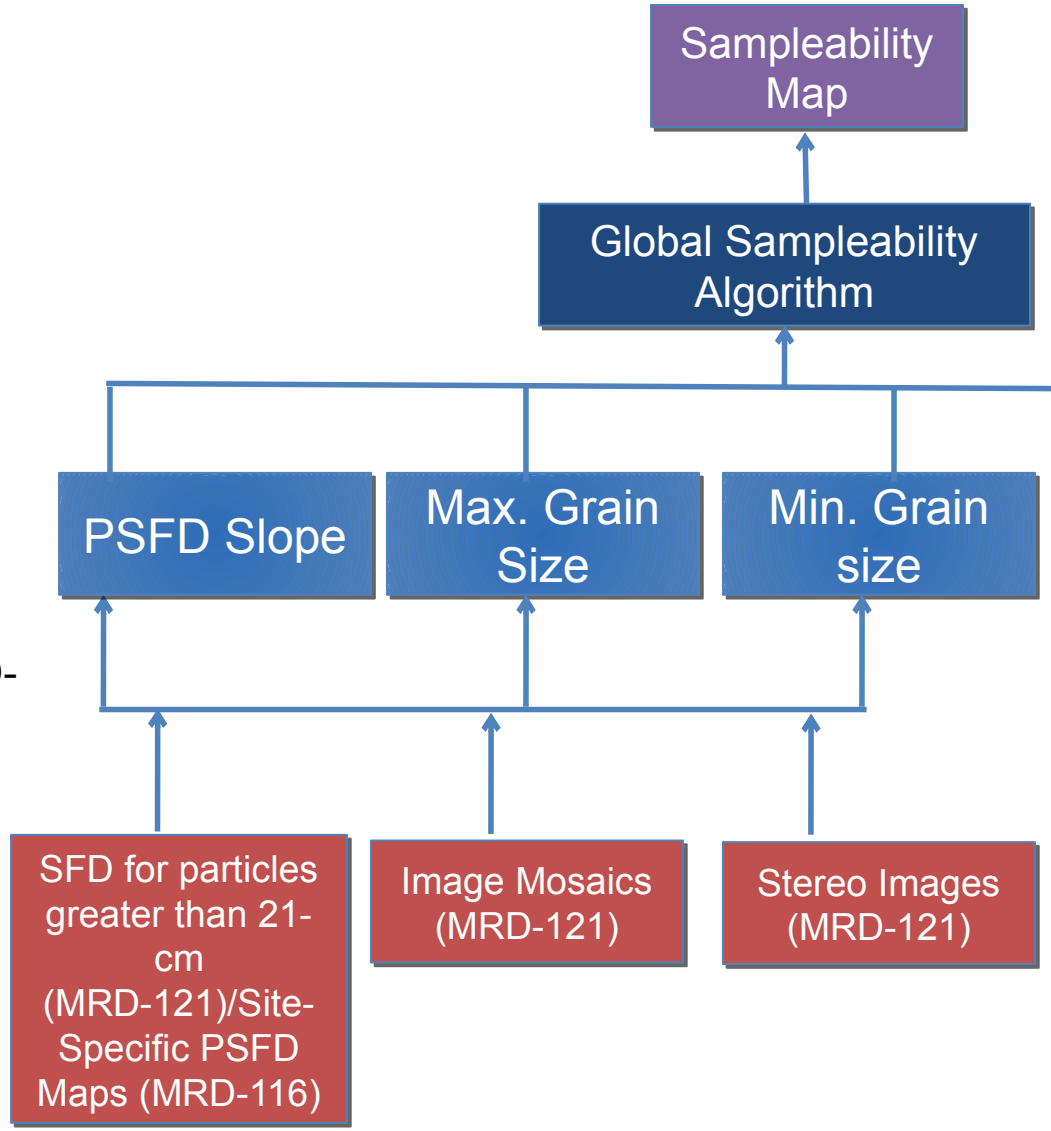


Sampleability Map Development Process



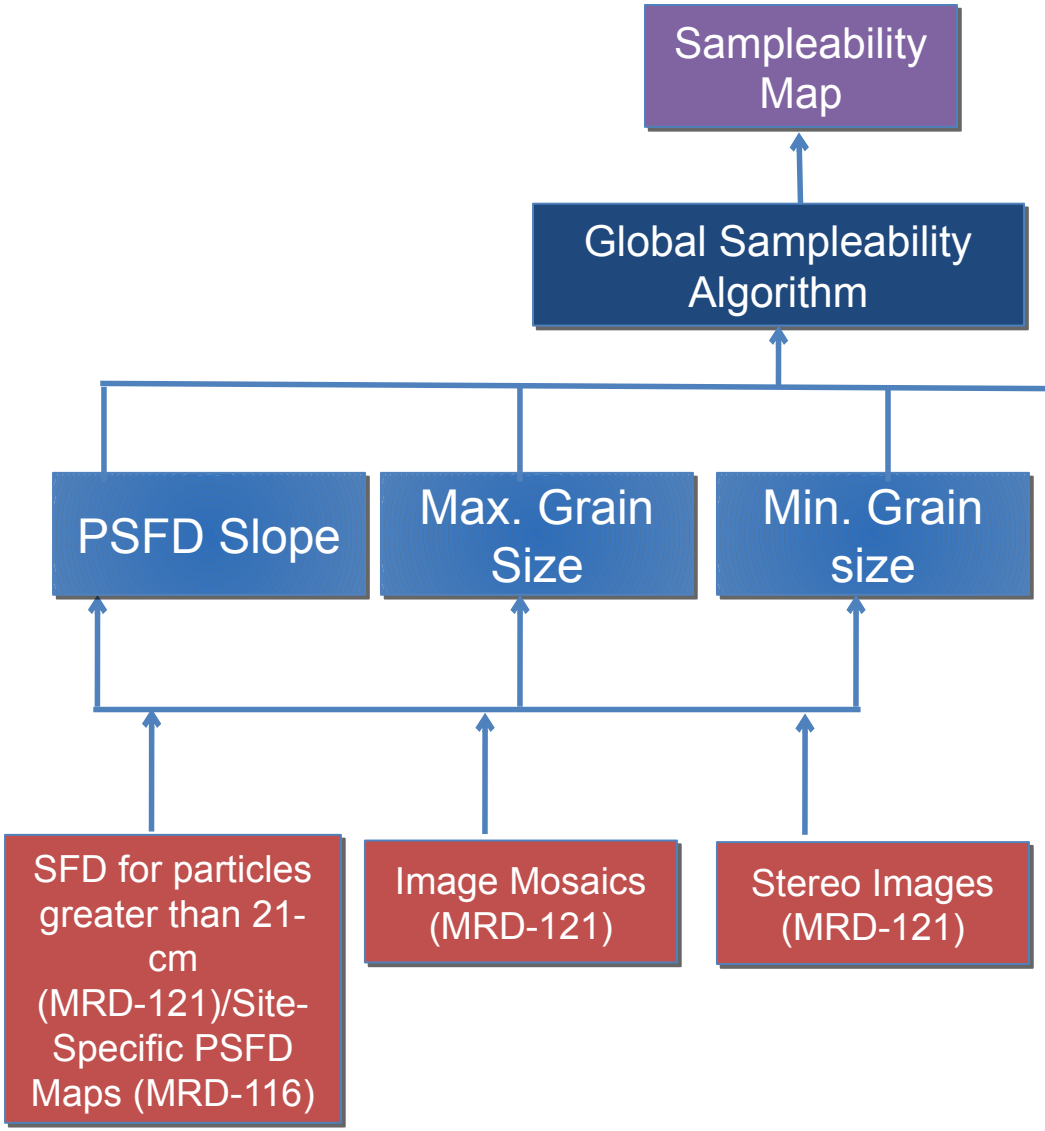
Operation schedule/process (Global)

- **Analysis and processing of PSFD maps/graphs to produce Min and Max particle size (MRD-121)**
  - **Ingested on 1/31/2019 (North) and 2/8/19 (South)**
- *Analysis and processing of Topographic Maps to generate tilt (MRD-122)
  - Ingested 3/19/2019
- *Analysis and processing of Thermal Inertia Map to estimate grain sizes (MRD-155)
  - Ingested 4/17/2019
- **Nominal Delivery of Global Sampleability Map**
  - **4/22/2019**
  - Schedule allows ~5 days for production
- **Work to go*



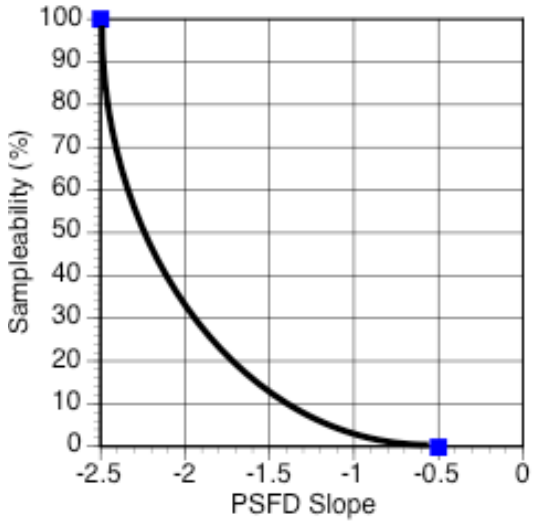
Operation schedule/process (Site-Specifc)

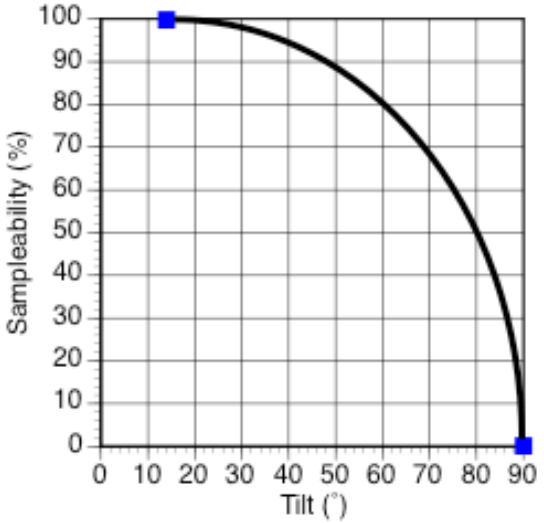
- **Analysis and processing of *site-specific* PSFD maps/graphs to produce Min and Max particle size (MRD-116)**
  - **Ingested on 4/30/2019-5/17/2019**
- *Analysis and processing of *site-specific* Topographic Maps to generate tilt (MRD-115)
  - Ingested 4/16/2019-5/2/2019
- *Analysis and processing of *site-specific* Thermal Inertia Map to estimate grain sizes (MRD-540,411)
  - Ingested 4/15/2019-5/2/2019
- **Nominal Delivery of *Site-Specific* Sampleability Map**
  - **5/8/2019 – 5/22/19**
  - Schedule leaves ~3 days for production of each Site.

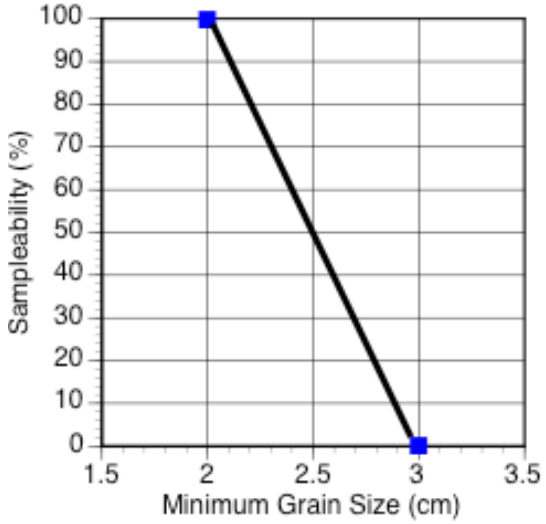


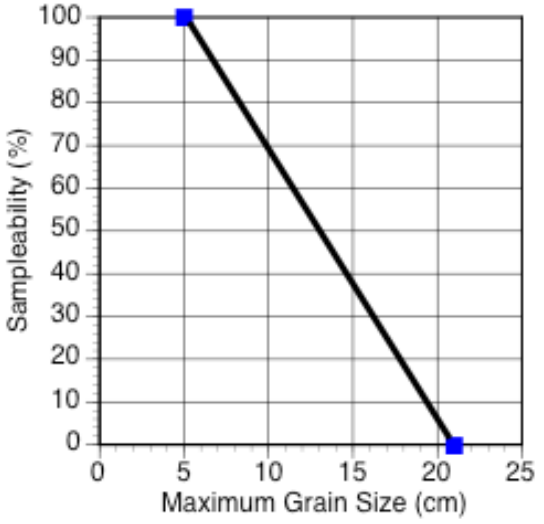
Status of Algorithm Development

- Sampleability Algorithm is largely defined
  - Will not be finalized until the completion of the TAGSAM Characterization Testing and the analysis of the results.
    - Will use parameterization and “pluggable” functions to permit easy incorporation of test results into software once available
  - *Statistics will be done using Bayesian network for easy ingestion and convolution with Deliverability Map*
  - Role of Dust Cover Index is not fully defined
  - Role of Thermal Inertia in determining particle size distribution is not fully defined.









Relevant Schedule and Inputs

- Inputs for product begin:
  - 1/15/2019 (Global PSFD maps/graphs: MRD-121)
  - 4/30/2019 (Site-Specific PSFD maps/graphs: MRD-116)
- All observations for product in to SPOC:
  - 4/17/2019 (Thermal Inertia Map: MRD-155)
  - 5/17/2019 (Site-Specific PSFD maps/graphs: MRD-116)
- Deliverability Map available:
  - 1/29/2019 (Global MRD-570b)
- Processing begins on
  - 1/15/2019 (Global Sampleability Map)
  - 4/30/2019 (Site Specific)
- Safety Map available:
  - 4/16/2019 (Global)
  - 5/8/2019 – 5/22/2019 (Site Specific)
- Data product lead: Kevin Walsh
- Backup data product lead: Tim McCoy

Minimal Mission Scenario

- With complete MRD for Safety and Deliverability most of the products for Sampleability will be available
  - MRD-121 is primary input into Sampleability algorithm
- The Sampleability algorithm can be calculated with any subset of the input products

- **Global Sampleability** is based on the following Global data products:
  - Image Mosaics (MRD-121)
  - Stereo Images (MRD-121)
  - Topographic map (MRD-122)
  - ~~Thermal Inertia Map (MRD-155)~~
  - Deliverability Map (MRD-570b)
  - *PSFD Graphs and Maps (MRD-121)*
    - *(1-m and 21-cm resolution)*
  - ~~Spectral Analysis: Dust Cover Index~~

Off-Nominal Discussion

- Sampleability Map is designed with significant redundancy
  - Different maps are weighted by confidence levels to determine weighting in final Sampleability Map – explicitly allowing for the reduction or absence of entire datasets

- Proxies for lost data
  - Thermal Inertia serves as a proxy for particle sizes
  - *Roughness via Topography/OLA provide estimates for largest particle sizes*

Summary

- Sampleability has to map TAGSAM capabilities to observed asteroid properties
  - TAGSAM design and V&V plan define endpoints of Sampleability function
  - TAGSAM capabilities testing defines the functional form of the Sampleability algorithm
- Input data products are identified and prioritized
  - One new data product needed
- Algorithm is simple
  - Four variables input to an empirical Sampleability function
  - Confidence Level assigned based on data quality and resolution
  - Stoplight chart used to determine red-yellow-green pixels
- Work to go:
  - TAGSAM capabilities test matrix
  - Bayesian Statistics
  - Incorporating Dust cover index
  - Generation of test data

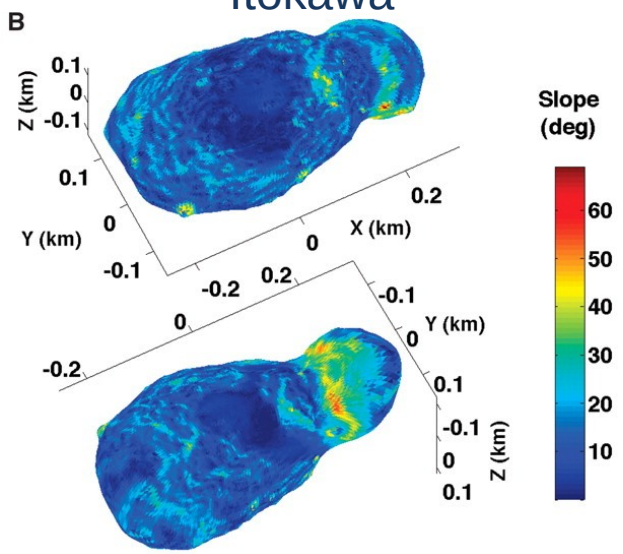
Backup

Itokawa Defines the "Worst-case" for OSIRIS-REx

- Radar Polarization (SC/OC)
  - **Transition to radar roughness occurs at a scale < 3.5 cm**
  - Bennu
    - 0.18 ± 0.01 (3.5 cm)
    - 0.18 ± 0.05 (13 cm)
  - Itokawa
    - 0.24 ± 0.02 (3.5 cm)
    - 0.27 ± 0.04 (13 cm)
- Thermal Inertia (Γ)
  - **Average grain size on Bennu is <1 cm – smaller than Itokawa**
  - Bennu: 310 ± 70 J m^{-2} s$^{-0.5}$ K^{-1}
  - Itokawa: 750-800 J m^{-2} s$^{-0.5}$ K^{-1}

Slope Distribution

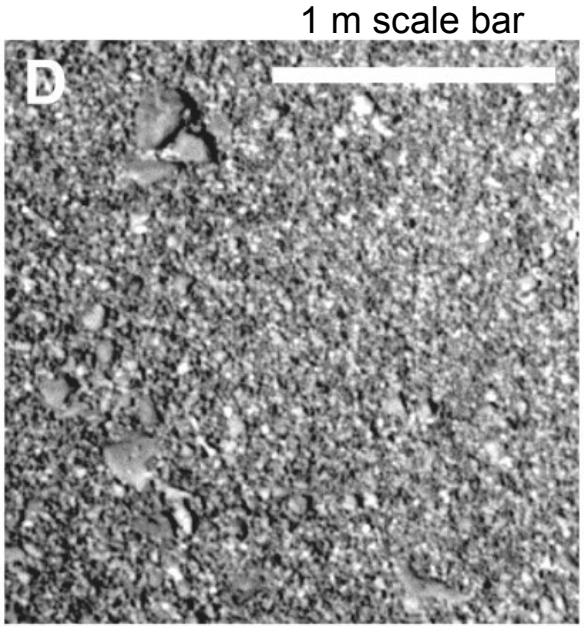
Itokawa



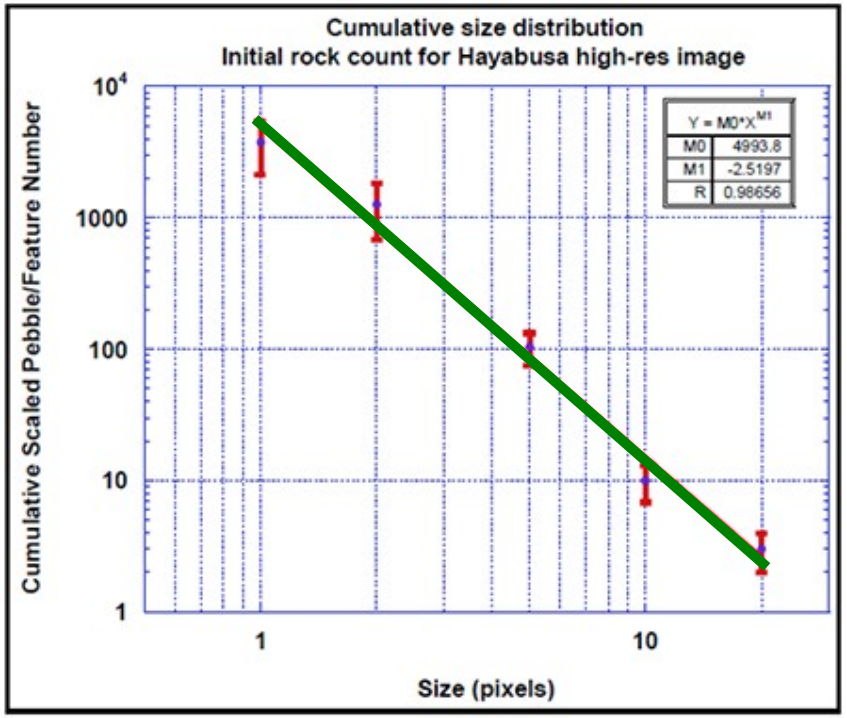
Bennu

TAGSAM Verification – Based on Muses Sea

- TAGSAM collection requirements are verified using the project's "Itokawa-7c" gravel mix
  - Min particle size: 0.32 cm
  - Max particle size: 1.9 cm
  - **PSFD slope = -2.5**



Particle Size Frequency Distribution (PSFD) for Itokawa Muses Sea



Sampleability Ellipse Coverage

MRD	Rqt Language TAG Radius	Inferred TAG Radius (meters)	Sensor	Data Product
13	25 m - 98.3% (2.85σ)	25	Spacecraft	Deliverability Map
56	26 m	26	OLA	< 5cm spatial res. and < 5cm (1σ) vert. precision
115	3σ	26.3	OCAMS and OLA	Topographic Map
116	>80% of 2σ	17.5	OCAMS	PSFD < 2-cm
540	>80 % of 2σ	17.5	OTES	Thermal Inertia <8-m res.
570b	25 m	25	Spacecraft	Deliverability Map
576	23 m	23	OCAMS	Panchromatic <5-cm res.
578	>90% of 11-m	11	PolyCam	PolyCam images
582	>40% of 20-m	20	OVIRS and OTES	<5-m res.
608	3σ	26.3	OCAMS and OLA	Tilt Map <32-cm res.
618	>80% of 16.5 m	16.5	OTES	<8-m res.

2cm/5px Site Coverage STK Simulation, Single Recon Flyover

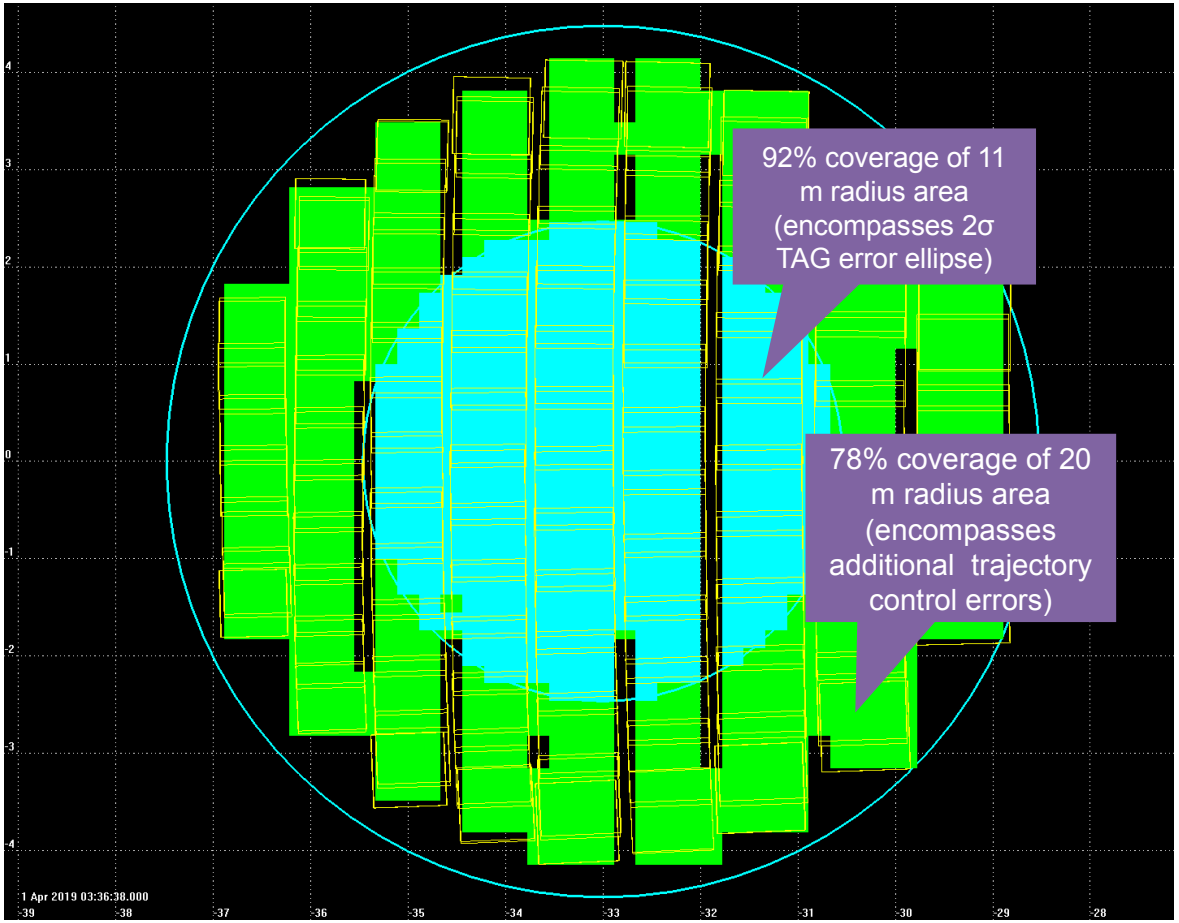
ID	Requirement
MRD-578	OSIRIS-REx shall collect PolyCam data over > 80% of an 11m-radius area in not more than two flyovers from a nominal range of 225m.

STK simulation included:

- Worst-case trajectory (site on equator)
- Spacecraft slew behavior (decel/accel at end of each slew) for raster scan
- Timing of PolyCam images accounting for refocus command cycle

What STK does not show:

- All images are in focus (PolyCam depths of focus at each focus setting and S/C-estimated range measurement error accounted for)



Relevant Requirements

Sampling Requirements	
40	Site has surface angle < 14°, the angle between a 32-cm-diameter sample-area-average normal vector and the commanded spacecraft negative-Z axis.
80	Site has > 80% probability of the TAGSAM contacting grains that are < 2cm in their longest dimension
574	Site has < 20% probability of the TAGSAM contacting a rock > 5cm high
611	Site has < 20% probability of the TAGSAM contacting a rock > 21cm in its longest dimension parallel to the sampling plane
626	Collect sample with a contact angle not greater than 15°
643	Image site with spatial resolution not greater than 0.9cm over 3 pixels
Global Requirements	
121	Image ≥80% of the surface of Bennu with ≤ 21-cm spatial resolution (4-pixel criterion)
122	For ≥80% of the asteroid surface, produce a topographic map at spatial and vertical resolution ≤1-m
137	Map boulders on ≥80% of the surface of Bennu ≥21-cm
155	For ≥80% of the asteroid surface, measure the absolute flux of thermally emitted radiation with 3% accuracy and produce maps of the temperature at seven different local solar times plus the derived thermal inertia at a spatial resolution ≤ 50 m

Sampler Heads and Regolith Simulants

6 flight-like TAGSAM heads for testing
- 5 concept heads fabricated, tested and modified for design development
  - Used in reduced gravity flights and sample collection tests
- 1 EDU sampler head fabricated for TRL6 Testing
  - Concept heads to be modified to current EDU / Qual head configuration

2 Qualification heads to be fabricated
- One for clean testing and one for sample collection testing

1 Flight head to be fabricated concurrent with Qualification heads
- Maintained clean thru-out, to ensure the return of pristine sample

Mix 7C defined by the
Regolith Design Working Group
for V & V material.
- Tagish lake represents low density
- Basalt represents high density

Size fraction	Mass Percent
3.2 to 6.4 mm	43 %
6.4 to 9.5 mm	24 %
9.5 to 12.7 mm	18 %
12.7 to 15.9 mm	15 %

Calculate Mass

Exponent (integral) -2.5

Table 1. Put in desired mass to get the proportions to mix

		screen fraction		Desired total mass (kg)	25.0	25.0	25.0	25.0	25.0	25.0	25.0
					Mix 7a	**Mix 7b**	**Mix 7c**	**Mix 7d**	**Mix 7e**	**Mix 7f**	**Mix 7g**
		screen fraction			mass	mass	mass	mass	mass	mass	mass
(mm)	(mm)	(inches)	(inches)		(g)	(g)	(g)	(g)	(g)	(g)	(g)
0.79	1.59	1/32	1/16								
1.59	3.2	1/16	1/8								
3.2	6.4	**1/8**	**1/4**		16.0	12.6	10.8	9.6	7.8	6.8	6.1
6.4	9.5	**1/4**	**3/8**		9.0	7.1	6.1	5.4	4.4	3.8	3.4
9.5	12.7	**3/8**	**1/2**			5.3	4.5	4.0	3.2	2.8	2.5
12.7	15.9	**1/2**	**5/8**				3.7	3.3	2.7	2.3	2.1
15.9	19.1	5/8	3/4					2.9	2.3	2.0	1.8
19.1	25.4	3/4	1						4.6	4.0	3.6
25.4	31.8	1	1.25							3.3	3.0
31.8	38.1	1.25	1.5								2.5
38.1	50.8	1.5	2								
50.8	63.5	2	2.5								
				Total Mass	25.0	25.0	25.0	25.0	25.0	25.0	25.0

Operational Schedule

- Nominally due 4/2/2019
- Walsh is the primary expeditor, with Tim McCoy and Harold Connolly Jr. as backups.
- Expeditor responsibilities:
  - Produce and verify minimum and maximum grain sizes uses MRD-121 and MRD-116
  - Process MRD-122 for tilt data and MRD-155 for Grain size data

Ingested Data Product	Source	Duration of production
(1) PSFD Graphs and Maps 21cm and greater (MRD–121)	IPWG	**1/11/19**
(2) Image Mosaics (MRD-121)	IPWG	**1/8/19**
(3) Stereo Images (MRD-121)	IPWG	**1/15/19**
(4) Topographic Maps (MRD-122)	ALTWG	**3/19/19**
(5) Thermal Inertia Map (MRD-155)	TAWG	**3/28/19**
(6) Dust Cover Index (TBD-End of Detailed Survey)	SAWG	TBD

TAGSAM Verification Tests

Test Description	Environment	Rationale
Earth-g, basalt 7c, flat + 5 cm obs.	1 g, ~vacuum	Verification test material (basalt 7c) at near-vacuum conditions
Earth-g, TLS 7c, flat + 5 cm obs.	1 g, ~vacuum	Verification test material (TLS 7c) at near-vacuum conditions
Earth-g, basalt 7c, flat + 5 cm obs.	1 g, 0.5 atm	1 g test of reduced-gravity pressure environment
Earth-g, TLS 7c, flat + 5 cm obs.	1 g, 0.5 atm	1 g test of reduced-gravity pressure environment
Earth-g, low-density simulant, flat + 5 cm obs	1 g, 0.5 atm	Low-density material enables weight comparable to 0.05 g test
Earth-g, low-density simulant, flat + 5 cm obs	1 g, ~vacuum	Low-density material enables weight comparable to 0.05 g test
Earth-g, basalt 7c, flat + 5 cm obs.	1 g, 0.1 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step
Earth-g, TLS 7c, flat + 5 cm obs.	1 g, 0.1 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step
Earth-g, low-density simulant, flat + 5 cm obs	1 g, 0.1 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step
Earth-g, basalt 7c, flat + 5 cm obs.	1 g, 0.01 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step
Earth-g, TLS 7c, flat + 5 cm obs.	1 g, 0.01 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step
Earth-g, low-density simulant, flat + 5 cm obs	1 g, 0.01 atm [TBR]	Evaluate effect of ambient atmosphere in logarithmic step

1 2 3 These tests explore the effect of the ambient atmosphere in a logarithmic fashion.

TAGSAM Modeling Analysis

	Test Description	Environment	Rationale
	TAGSAM flow field, flat	Vacuum	Necessary to understand behavior at Bennu conditions
	TAGSAM flow field, 5 cm obs	Vacuum	Necessary to understand behavior at Bennu conditions
1	TAGSAM flow field, flat	0.5 atm	Necessary to correlate existing reduced-gravity results with modeling
	TAGSAM flow field, 5 cm obs	0.5 atm	Necessary to correlate existing reduced-gravity results with modeling
	TAGSAM flow field, flat	0.001 atm	Correlate existing ground-based vacuum chamber results with modeling
2	TAGSAM flow field, 5 cm obs	0.001 atm	Correlate existing ground-based vacuum chamber results with modeling
	TAGSAM flow field, flat	0.01 atm	Optional. Understand gas densities, pressures, velocities in an intermediate value. Would add constraint to pressure dependency, and inform the viability of lower-fidelity tests.
	TAGSAM flow field, 5 cm obs	0.01 atm	Optional. Understand gas densities, pressures, velocities in an intermediate value. Would add constraint to pressure dependency, and inform the viability of lower-fidelity tests.
3	TAGSAM flow field, flat	1 atm	Optional. Understand gas densities, pressures, velocities in ambient. Will inform if ambient testing (e.g. no vacuum chamber) has any value.
	TAGSAM flow field, 5 cm obs	1 atm	Optional. Understand gas densities, pressures, velocities in ambient. Will inform if ambient testing (e.g. no vacuum chamber) has any value.

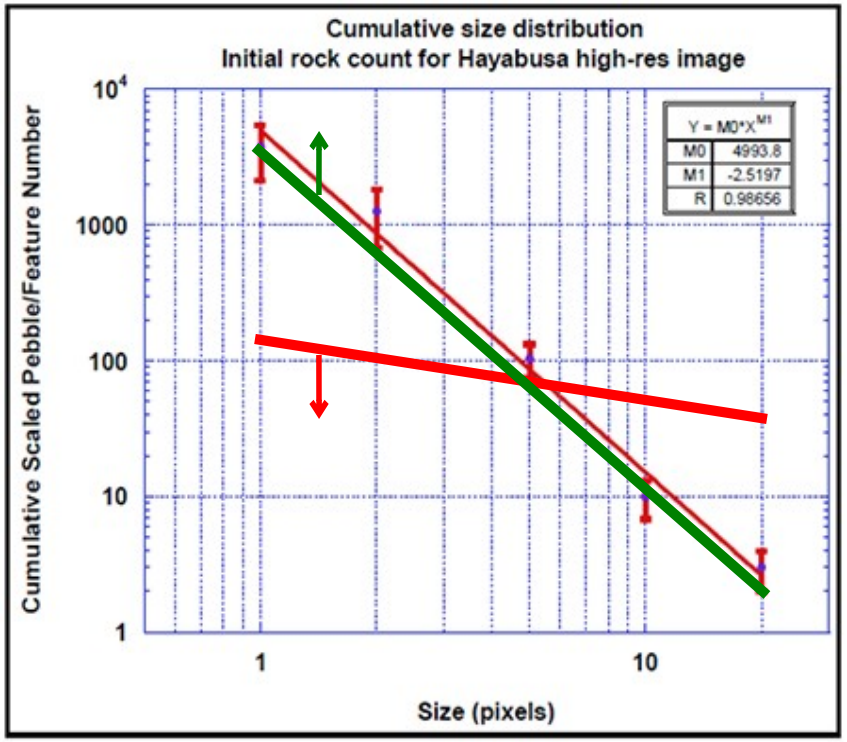
1. Baseline
2. Ground-tests are rough-vac pressures, about 0.001 atm. Modeling this case would be an evaluation of true vacuum vs. the rough-vac pressures.
3. Optional. Would provide additional constraints on system performance as a function of pressure, and would inform the viability of lower-fidelity or ambient pressure testing has any value.

Constraining the Global Sampleability Function

- TAGSAM design requirements define the 100% and 0% endpoints of the Sampleability Function

Global Sampleability has a value of **100% (≥150 g)** if
- **PSFD slope ≥ -2.5**
  - Itokawa Muses-C condition
- **Maximum grain size < 21 cm**
  - TAGSAM obstruction
  - Global mapping resolution
- **Tilt ≤ 14˚ over 1-m**
  - TAGSAM surface compliance
  - Global topographic resolution

Global Sampleability has a value of **0% (0 g)** if
- **PSFD slope ≤ -0.5** (TBR)
- **Boulders ≥ 21-cm** cover ≥ 80% of the surface area
- **Tilt ≥ 90˚ over 1-m** (TBR)



Constraining Site-specific Sampleability

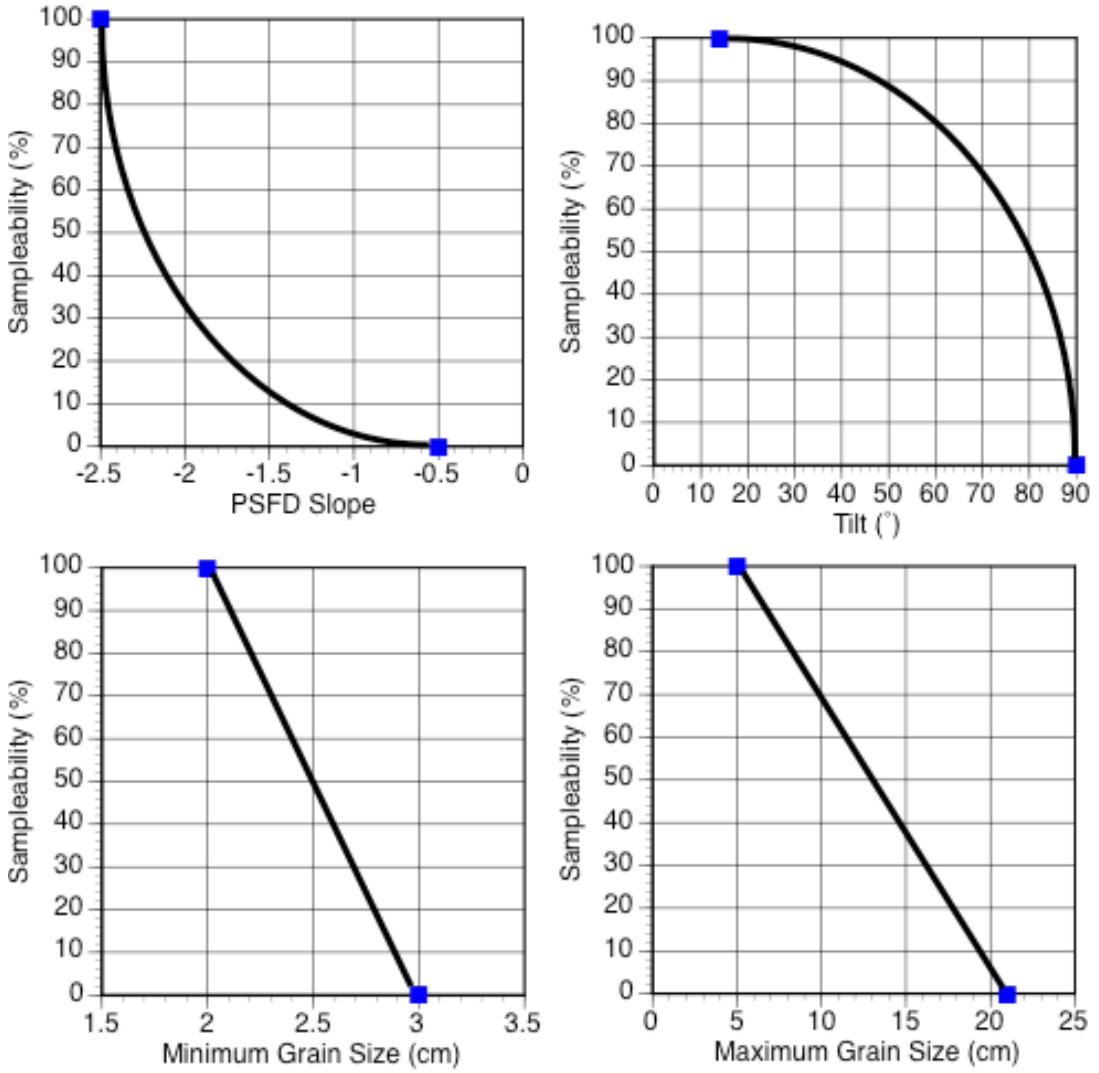
- Site-specific data allow us to further constrain Sampleability using:
  - Slope of the PSFD
    - **Down to 2 cm**
  - Maximum Grain Size
  - **Minimum Grain Size**
  - Local tilt
    - **Over 32-cm** length scales

Site-specific sampleability shall have a value of **100% (≥ 150 g)** if
- **PSFD slope ≥ -2.5** (7c regolith simulant)
- **Maximum grain size ≤ 5 cm** (MRD-574)
- **Minimum grain size ≤ 2 cm** (MRD-80)
- **Tilt ≤ 14˚ over 32-cm** length scale (MRD-40).

Site-specific sampleability shall have a value of **0% (0 g)** if
- **PSFD slope ≤ -0.5** (TBR)
- **Minimum grain size ≥ 3 cm**
- **Maximum grain size ≥ 21 cm**
- **Tilt ≥ 90˚ over 32-cm** (TBR)

Sampleability Algorithm

- The functional form between end-member conditions will be determined empirically
  - Note: Functional relationships are notional
- TAGSAM capabilities testing is required to determine the Sampleability Algorithm as well as variable interdependency

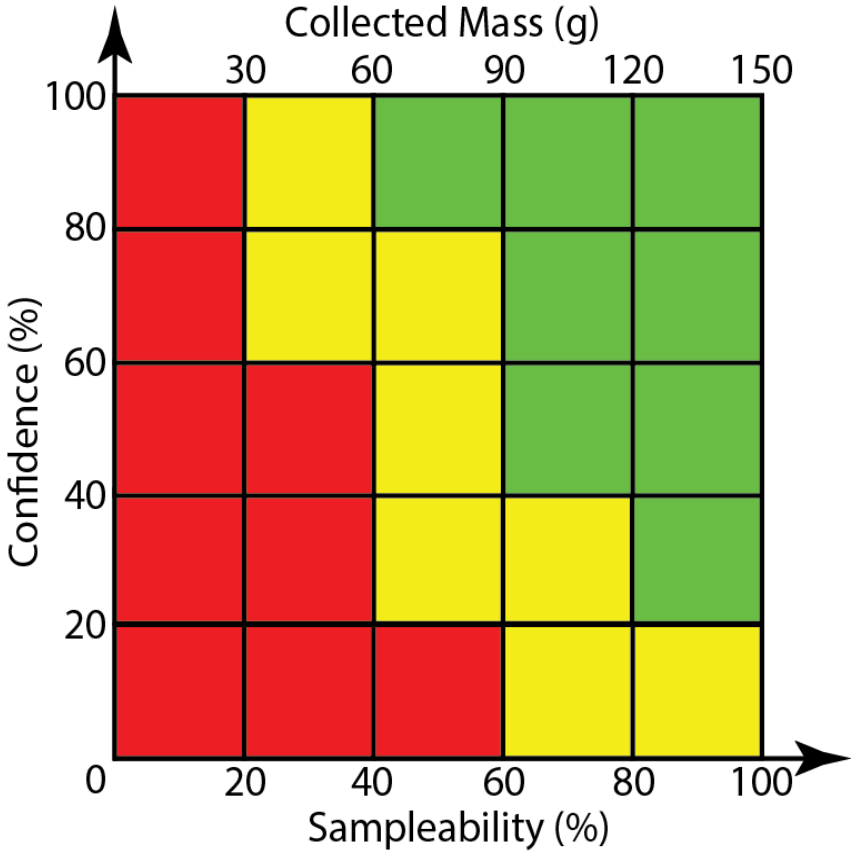


Sampleability and Confidence Levels

- For each sampleability value, a confidence level will be assessed

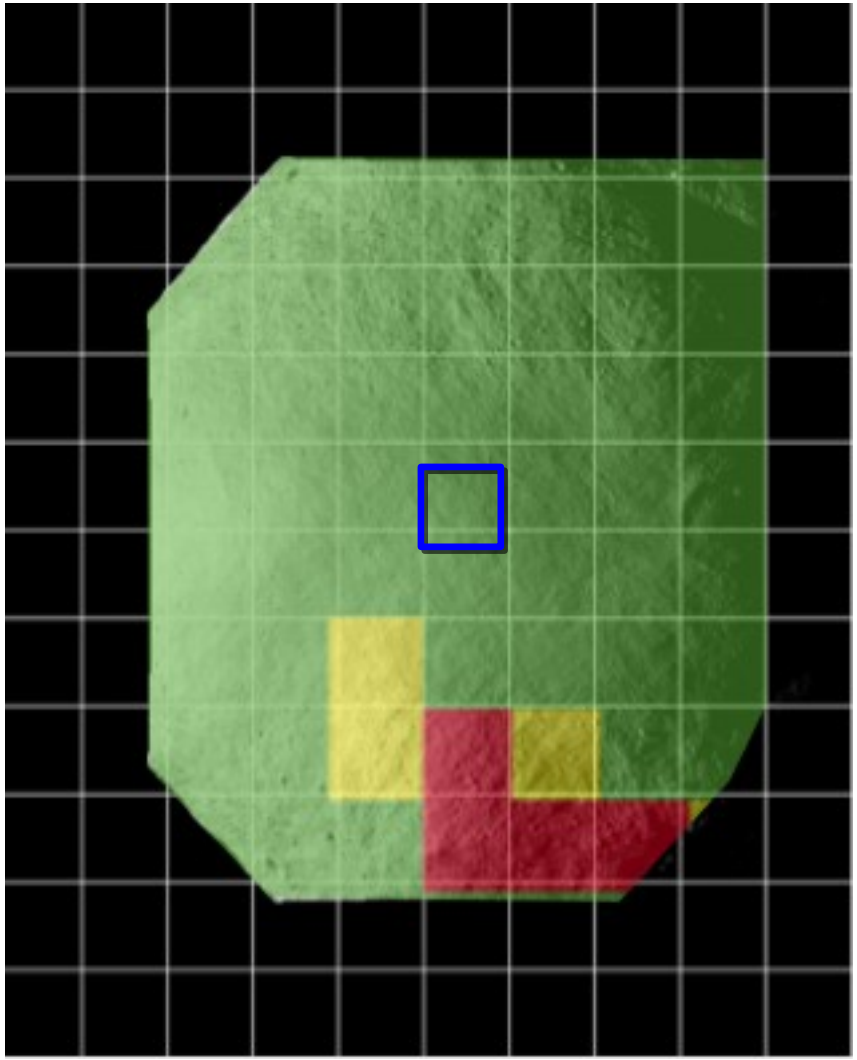
- Confidence Level is a function of
  - Accuracy
  - Precision
  - Spatial Resolution
  - Degree of Model Dependency vs. Direct Measurement
  - Correlation with Other Sampleability Assessments

- Confidence Level will be 0% if
  - The 1-sigma accuracy is >100% of the required value
  - The 1-sigma precision is >100% of the required value
  - The spatial resolution is
    - >400 meters – Global Sampleability
    - >40 meters – Site-Specific Sampleability



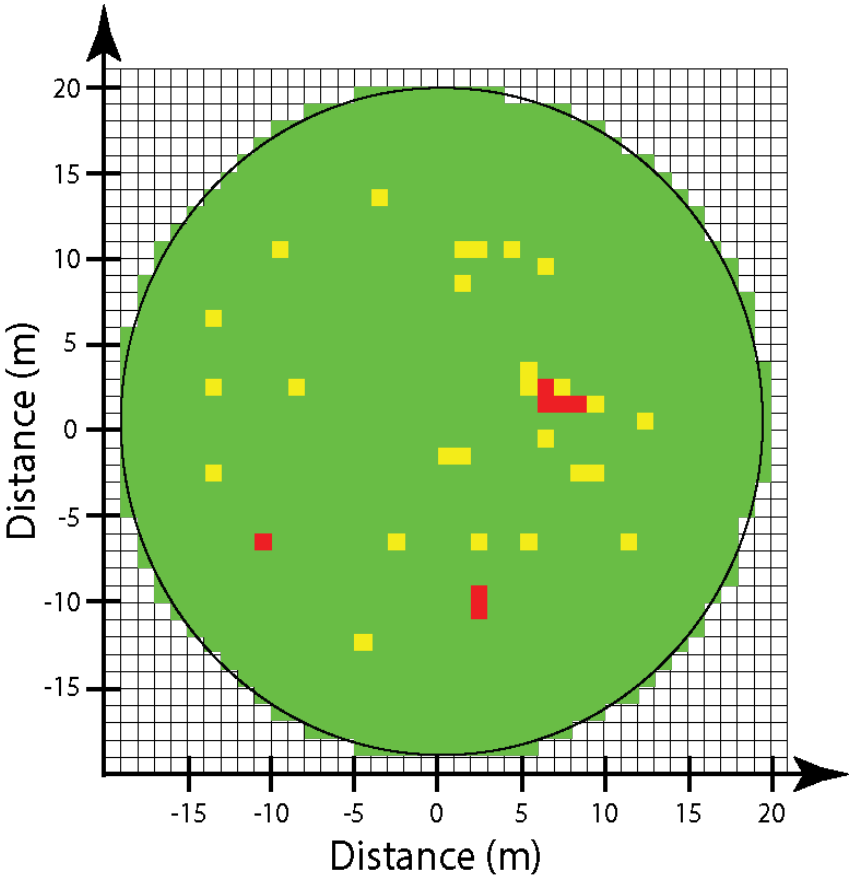
Global Sampleability – Data Product

- The combination of individual ROIs will cover ≥ 80% of the asteroid surface
- The Global Sampleability Map will be convolved with the Global Deliverability Map (MRD-570b) to identify ROIs with the highest sampleability for detailed characterization and production of Site-Specific Sampleability Maps



Site-specific Sampleability – Data Product

- A Site-specific Sampleability Map shall meet Requirement MRD-570c if ≥ 83.8% of the grid points that fall within the 2-sigma (95.4%) ellipse on the Site-specific Deliverability Map (MRD-570b) are green



Next Topic (This slide will be done for you)

#	Start Time	Topic	Presenter
	7:45 AM	Coffee/Refreshments	
1	8:00 AM	Welcome	E. Beshore
2	8:10 AM	OSIRIS-REx Mission Overview and Priorities	D. Lauretta
3	9:10 AM	DRM Science Collection Overview	B. Boynton/J. Kidd
	9:55 AM	Break	
4	10:10 AM	Ground System Overview	J. Gal-Edd
5	11:10 AM	SPOC Overview	C. Shinohara
	11:55 AM	Lunch	
6	12:55 PM	Operations Overview	S. Barnes
7	1:40 PM	SPOC/Science Planning Process	B. Boynton/C. Hergenrother
	2:40 PM	Break	
8	2:55 PM	SPOC Implementation Process	S. Barnes
9	4:25 PM	SPOC Downlink Process	S. Balram
	4:55 PM	Board Caucus	Board

Backup