CAPTEM March 19 2016

Astromaterials Research and Exploration Science (ARES) Division Overview

Lisa Pace

Exploration Integration and Science Directorate (EISD)

Chief Technologist, Douglas Terrier
Chief Scientist, Eileen Stansbery

Director, Vanessa Wyche
Deputy Director, Eileen Stansbery
Associate Director, Glenn Lutz

Performance Management & Integration
Manager, Cathy Claunch

Strategic Partnerships
Manager, Yolanda Marshall
Deputy Manager, Linda Ham

Exploration Mission Planning Office
Manager, Joe Caram
Deputy Manager, Brenda Ward

Exploration Project Formulation
Future Capabilities – M. McDonald
Asteroid Redirect Mission – J. Gard

Exploration Development Integration Office
Manager, Burt Laws
Deputy Manager, Michele DiGiuseppe

EVA Management Office
Manger, Chris Hansen
Deputy Manager, Mike Mankin

Astromaterials Research and Exploration Science Division
Chief, Greg Byrne
Deputy Chief, Lisa Pace

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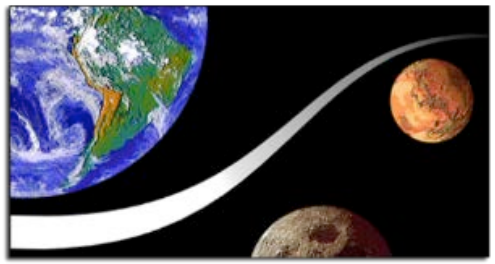
Astromaterials Research & Exploration Science (ARES)



ARES Division (XI)

Greg Byrne – **Chief**
Lisa Pace – **Deputy Chief**
Doug Ming – **Chief Scientist for Exploration**

Astromaterials Acquisition & Curation Office (XI2)

Cindy Evans – **Manager**
Ryan Zeigler – **Deputy**
Francis McCubbin – **Curator**

Astromaterial Research Office (XI3)

Dave Draper – **Manager**
Lindsay Keller – **Deputy**

Human Exploration Office (XI4)

Tracy Calhoun – **Manager**
Sue Runco – **Deputy**

Business Units

XI: Management & Infrastructure – Lisa Pace
XI: Exploration – Doug Ming
XI2: Astromaterials Curation – Cindy Evans
XI3: Research – Dave Draper
XI4: Orbital Debris Program Office – Gene Stansbery
XI4: Hypervelocity Impact Technology – Eric Christiansen
XI4: Image Science & Analysis Group – Randy Moore
XI4: Earth Science & Remote Sensing – Will Stefanov

ARES Strategic Planning Efforts Underway

Vision/Mission
Dave Draper

Draft Mission: *ARES advances knowledge of potential exploration destinations, meshing scientific and engineering expertise to integrate terrestrial and planetary science research, advanced curation, and risk mitigation for operational spacecraft. We are Agency leaders in the formulation and operation of robotic and human exploration missions, enabling a sustainable presence beyond Earth.*

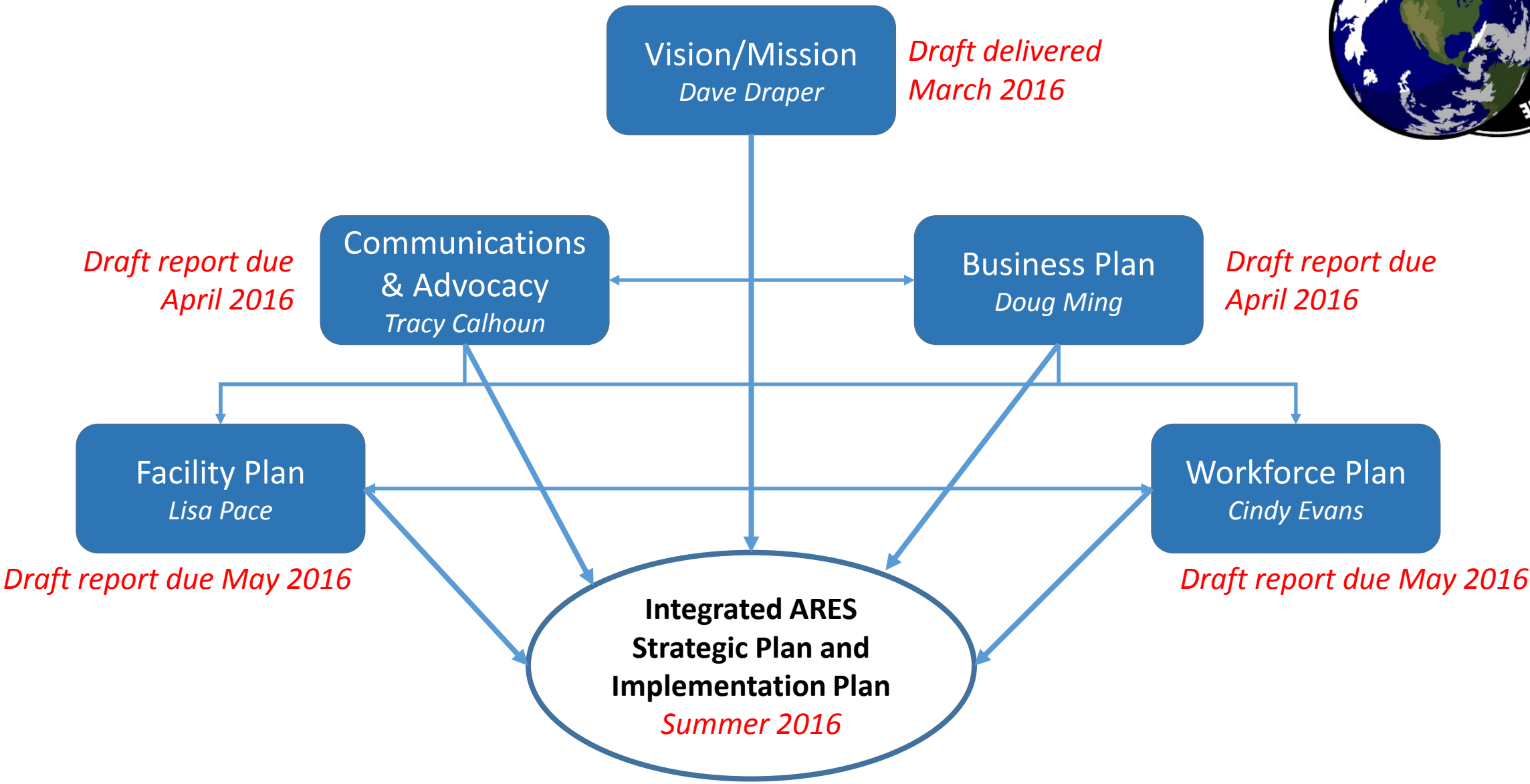
Communications & Advocacy
Tracy Calhoun

Business Plan
Doug Ming

Facility Plan
Lisa Pace

Workforce Plan
Cindy Evans

ARES Strategic Planning Efforts Underway



The 1965 Manned Spaceflight Center, starting the 2nd floor of the Lunar Mission and Space Exploration Facility (B31)

B31's 50th Anniversary

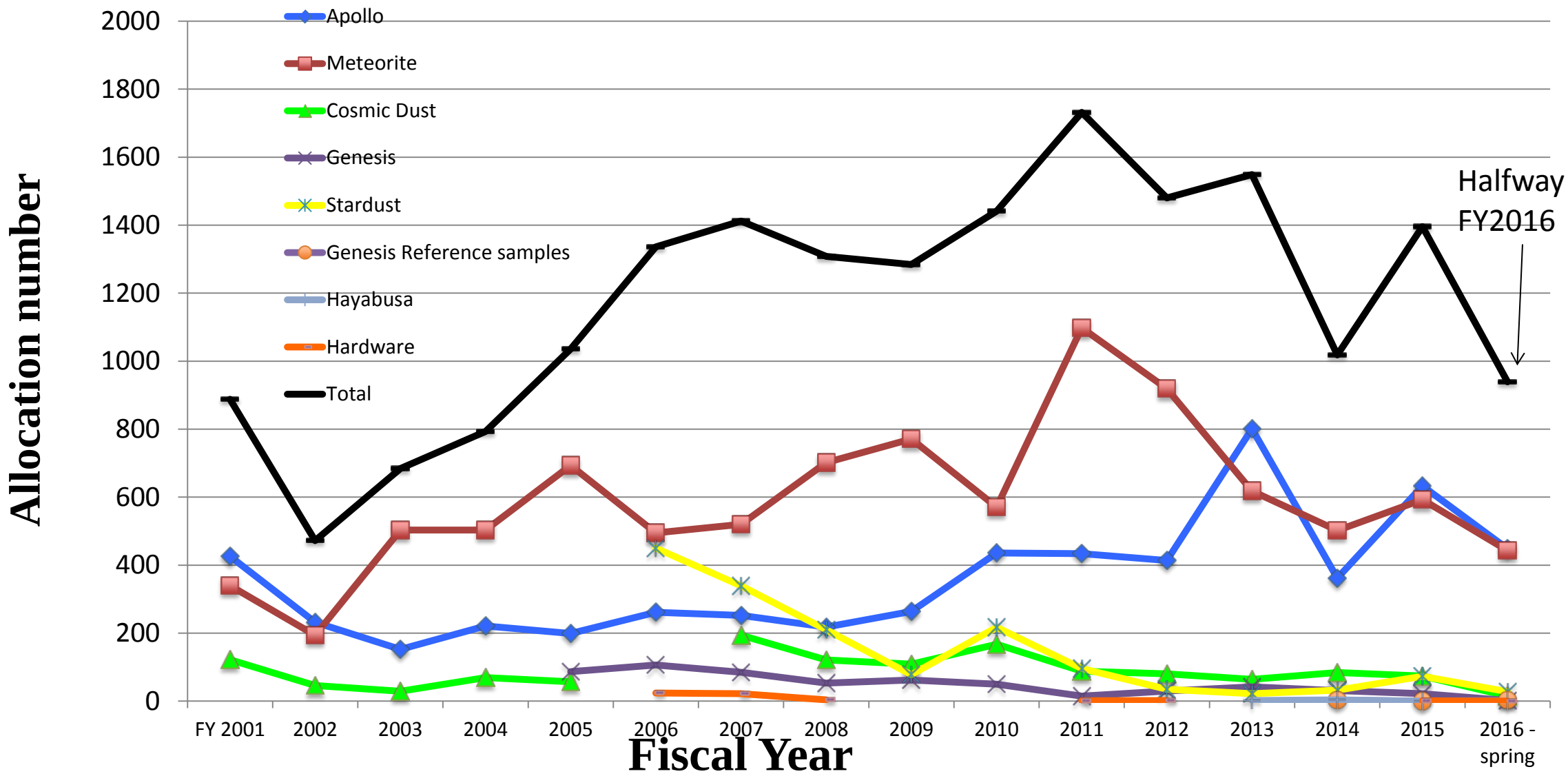
March 23, 2016

CAPTEM March 19 2016

Astromaterials Acquisition and Curation Overview

Francis McCubbin and Cynthia Evans

Astromaterials Allocation Numbers



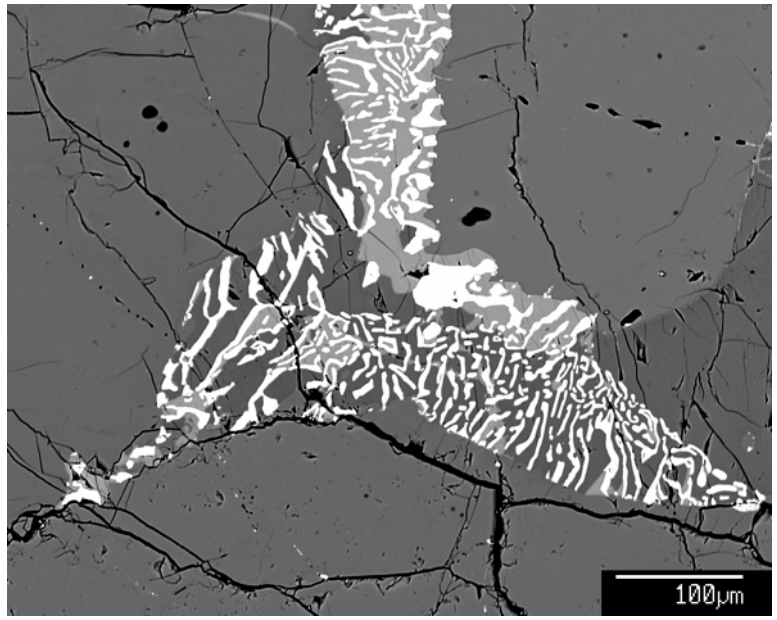
Allocation and Curation Highlights

- Sample traffic through Curation is high
  - Midway through 2016, overall approved allocation numbers are high (~950), especially for lunar and meteorite samples
  - Still receiving high numbers of return samples (thousands) – both Lunar and Meteorite
  - 865 meteorite samples transferred to Smithsonian
  - Total of 215 new meteorites announced in spring 2016 newsletters from ANSMET 2010-2014 seasons
  - Anticipating 569 new specimens in April from successful 2015-16 ANSMET mission to the Miller Range
  - More than 100 items curated for OREx Contamination Knowledge
  - Nearly 800 shipments of education materials (disks, thin sections, simulants)
  - Outreach events reach >5000

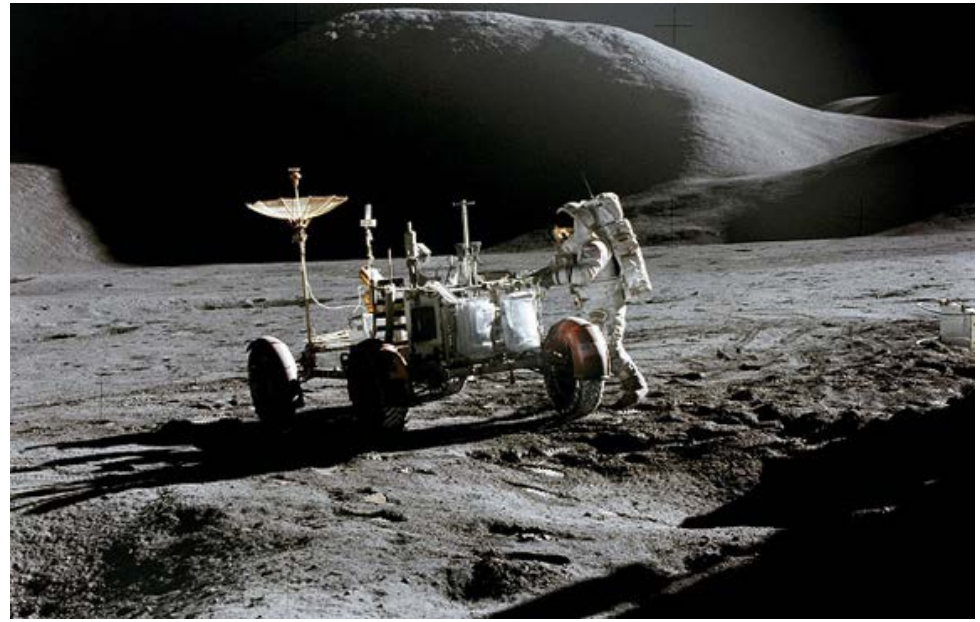
Apollo and Luna Samples

Ryan Zeigler – Curator

- Allocation of 448 samples (since 10/1/2015)
- Received 27 Apollo sample requests for Spring 2016: 9 curatorial and 18 to be considered by LSS
- Many samples have been returned and are being checked back in, including several large returns
- Will be reorganizing 20,000 lunar thin sections
- Nikon XTH 320 micro-CT scanner will be installed in the large lunar thin section lab by 9/2016



BSE image of Troctolite 76535



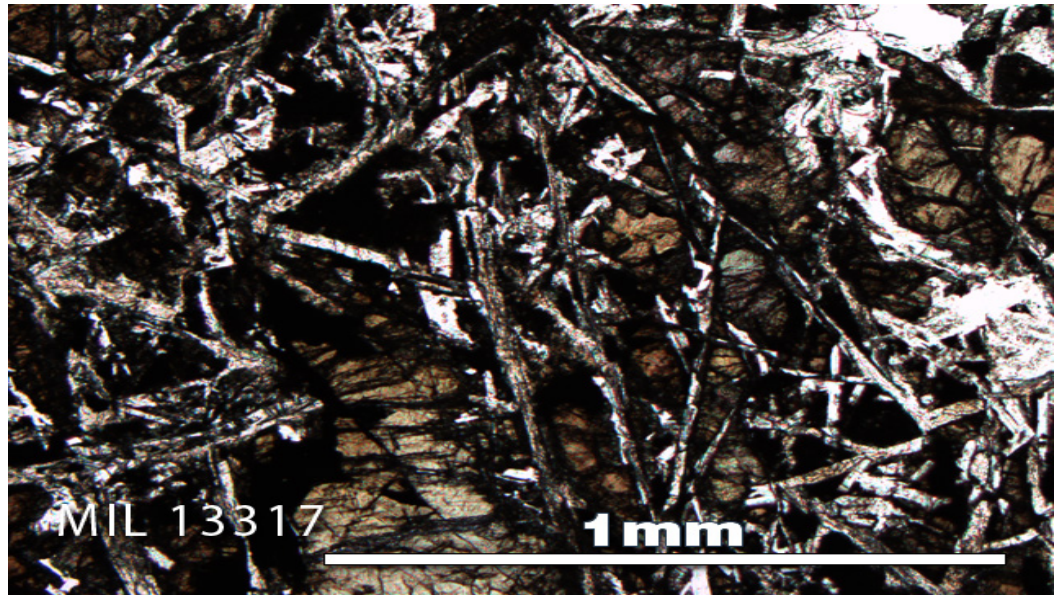
Apollo 15 Hadley-Apennine

Antarctic Meteorites

Kevin Righter – Curator

- Allocation of 757 samples to 79 investigators (1 yr); 443 samples to 45 investigators (6 mo)
- 46 + 215 new meteorites (2010, 2012, 2013, 2014 seasons) published in Fall 2015 and Spring 2016 newsletters
- 865 samples transferred to Smithsonian
- ~569 new specimens collected in Miller Range for 2015-16 ANSMET season; will be returned to Houston in Spring 2016
- Ongoing work on Meteorite database
- Compiled >1500 US Antarctic meteorite references (peer reviewed papers) from 1978 to present; added feature online that lists references for any sample.
- Received 43 requests for Spring 2016

6328 g EH3 chondrite

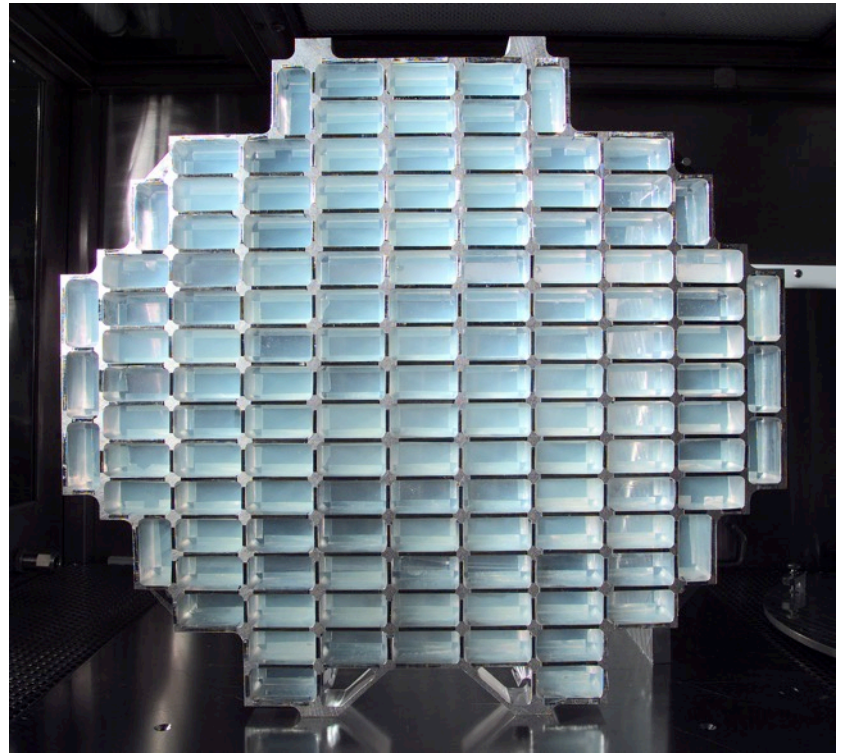


32.25 g lunar breccia

Small Particles

(Cosmic Dust, Stardust, and Hayabusa)

Mike Zolensky – Curator



Cosmic Dust:

- Allocation of 30 samples (1 yr); 15 samples (6 mo)
- Cosmic Dust catalog 20 is in the works
- Cosmic Dust database is on our external website

Stardust:

- Allocation of 46 samples (1 yr); 28 samples (6 mo)

Hayabusa:

- Allocation of 0 samples (1 yr); 2 sample allocations are being processed now

WB-57's in formation over Houston

Genesis

Judith Allton – Curator

- Allocations
  - Genesis –flown samples – 2
  - Non-flight reference samples-3
- Non-wafer materials added to catalog (concentrator target, gold foil, polished aluminum)
- Canister flight hardware inventoried (potential solar wind collector and contamination reference material)
- Support OREx witness coupon cleaning
- Genesis Science meeting on 3/20/2016

Imaging canister hardware

~~Space Exposed Hardware~~
Microparticle Impact Collection Lab

Mike Zolensky – Curator

- The SEH lab was renamed to the MIC Lab and includes hardware that has microparticle impacts

- Overlaps between MIC lab and other collections have been mitigated
  - Hardware from a sample-return mission now considered part of the returned samples

- The handbook, loan agreements and website have all been updated and provide internally consistent information

MIC Laboratory and Stardust Parachute

LDEF in orbit viewed from Space Shuttle

Asteroid Bennu (formerly 1999 RQ36)
OSIRIS-REx - New Frontiers sample return mission

Kevin Righter – Curation Lead
Keiko Nakamura-Messenger - Deputy

Launch	Sept. 2016
Encounter	2018-9
Earth return	2023

Phase C/D activities (in last year):

- Feb. 24-26 SIR and June 23-26 MOR completed
- Archiving of materials from spacecraft (MIC lab) – 108 items archived so far
- Deployed 12 contamination knowledge witness plates (Si wafers and Al foil) so far during ATLO in Denver starting March 2015 to present; curated at JSC and will continue deployments at KSC right up to launch.
- Defined cleanroom requirements for design companies to make a bid to design cleanrooms for both O-REx and Hayabusa 2; design on schedule to finish in September – will have 30, 60, 90% reviews.
- Science team meetings in Pasadena (3/15), Maryland (10/15), and Tucson (3/16)

Curation Support to New Missions

Hayabusa 2

- Keiko Nakamura-Messenger coordinating with JAXA team about Curation

Mars 2020

- Francis McCubbin on RSS Board
  - Report on maximum allowable temperature of samples available on MEPAG website
  - Contamination Knowledge plan for Mars 2020 mission operations currently being developed, initial results to be presented at MSR workshop on 3/20/2016 in Woodlands, TX
- Curation will begin working with Mars 2020 project to develop a curation plan before CDR

Astromaterials Curation Office – Outreach Highlights

Educational Disk and Outreach programs reach > 5000

- Total FY16 sample disk certification workshops – 26 (>350 people)
- Total FY16 authorized certifier newsletters – 2
- Total FY16 authorized certifier on line training – 2
- Total FY16 public outreach with displays – 9 (~5000)

•Short term loans:

- Total FY16 loans – 375 disks (206 lunar/169 meteorite)
- Total FY16 loans – Thin sections: 27 thin section packages (17 lunar/10 meteorite)
- 382 Lunar & Mars Soil Simulant sample packs to educators, museums, students

•Virtually sharing Astromaterials

- Lunar & Meteorite Disk overview video upgraded to 508 compliance & posted on line
- Society for the Advancement of Chicanos & Native Americans in Science (SACNAS) Virtual Classroom Connection Webinar focusing on ANSMET
- Blog: myares.wordpress.com, Facebook (NASA ARES), Twitter, Instagram

Follow NASA_ARES @ any of our social media sites!

Curation Database

- Continued work on collection databases
  - New Lunar Sample-Photo Database online, enabling access by mobile devices
  - Developing searchable database for Cosmic Dust
  - Updated Genesis catalog (concentrator target, gold foil and polished Al samples)
  - Renamed Space Exposed Hardware (Microparticle Impact Collection), updated all of the forms and documents
  - Stardust – migration to non-flash dependent website in work
  - Compiled >1500 US Antarctic meteorite references (peer reviewed papers) from 1978 to present; added feature online that lists references for any sample.

Curation Database

- MoonDB (Lunar Data Rescue)– built on PetDB framework, http://www.moondb.org/
  - Data system that will preserve, digitize and curate lunar geochemical, geochronological and petrological data and their associated metadata (sample and analytical metadata)
  - Ingesting and formatting references (BibTex, RTF, EndNote tagged, xml, RIS)
  - LPSC workshop for collaborators and interested investigators
  - Stop by posters Thursday evening
- New award (PDART)
  - Collect and serve detailed 3D photography combined with microCT data for key lunar and meteorite samples
- PDS RFI – Curation submitted a response

Curation archives - digitization

Lunar Sample Return Form Scanning Project

Scanned Lunar sample return forms (F75, F73, F72, F71, and F70 forms) filled out by principle investigators

- 98% handwritten
- Valuable research tool for the Curation staff
- Comprised 42,552 scanned documents (48 storage boxes and 1536 lbs)
- Total sample return form E-files online to date: 45,937

Ongoing scanning

- Miscellaneous documents (lunar datapacks, COs, etc)

Curation Facilities

- Thin section (and soon-to-be CT) lab (more detail in Ryan's discussion)
  - MicroCT instrument was awarded to Nikon
    - Nikon XT H 320 micro-CT
  - Room design is complete and room modifications will begin this month

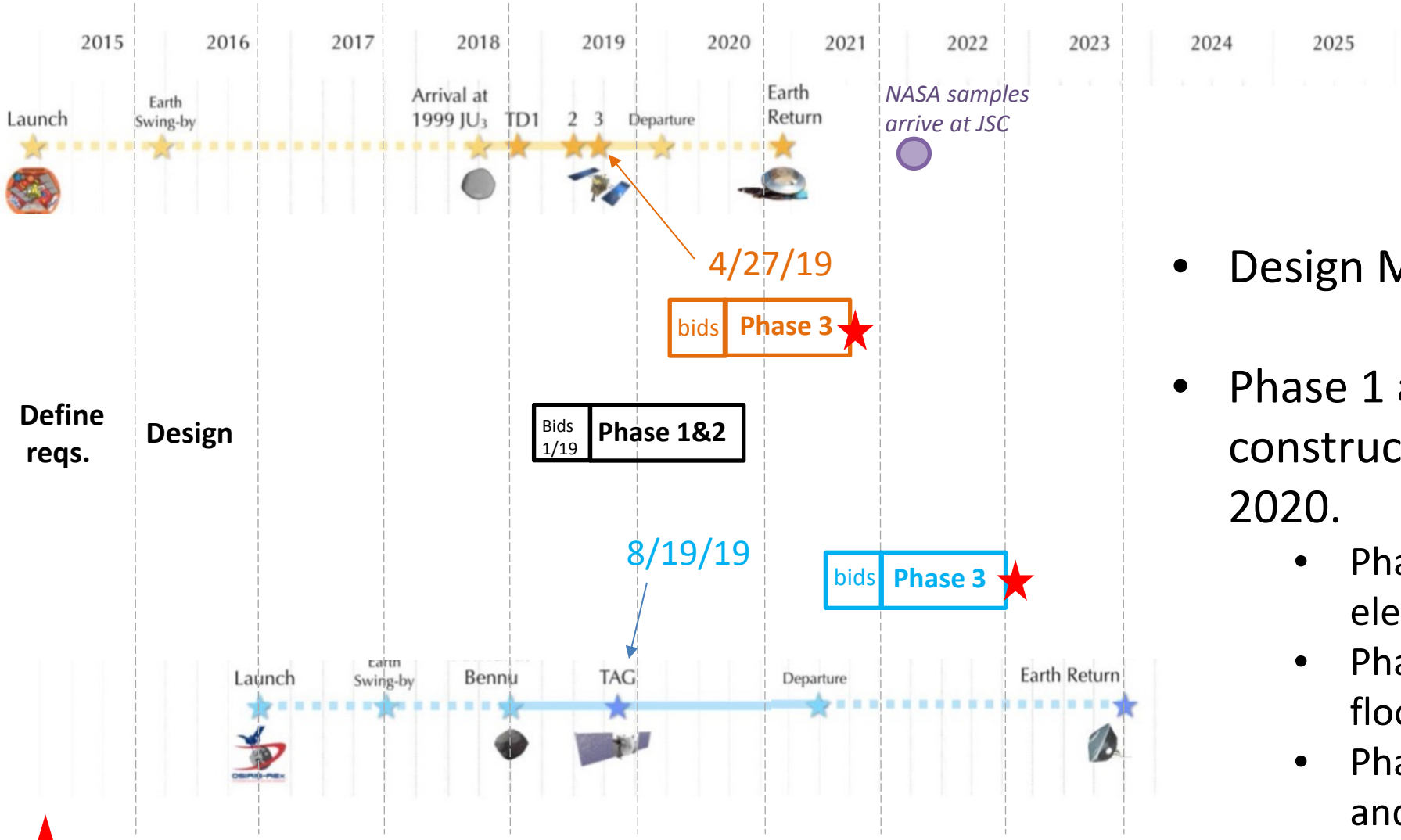
Curation Facilities

OREX and Hayabusa 2 Labs

- Laboratory Design period, now-Sept 30, 2016
- RS&H selected engineering design firm (*award pending*)
- 50+ years of design experience with NASA
- Designed many laboratories and cleanrooms for NASA as well as pharmaceutical and medical device industry
- Past experience:
  - ISO Class 8 payload change-out room at KSC
  - University of South Florida's 35,000 sq ft Science & Technology Building
  - **Nano Therapeutics' 160,000 sq ft laboratory and vaccine manufacturing facility for biopharmaceutical products, including ISO 6, 7, 8 & 9 cleanrooms and biological safety level 3 (BSL3) containment areas.**
  - Walter Reed Army Institute of Research, 24,000 sq ft Vaccine Research and Production facility, including ISO Class 5, 7, 8, & 9 laboratory space.

Above is RS&H's recently constructed vaccine manufacturing facility (design completed in 2014). Lab space includes ISO class 6, 7, 8 & 9 as well as BSL3 containment.

OSIRIS-REx/Hayabusa2 Lab

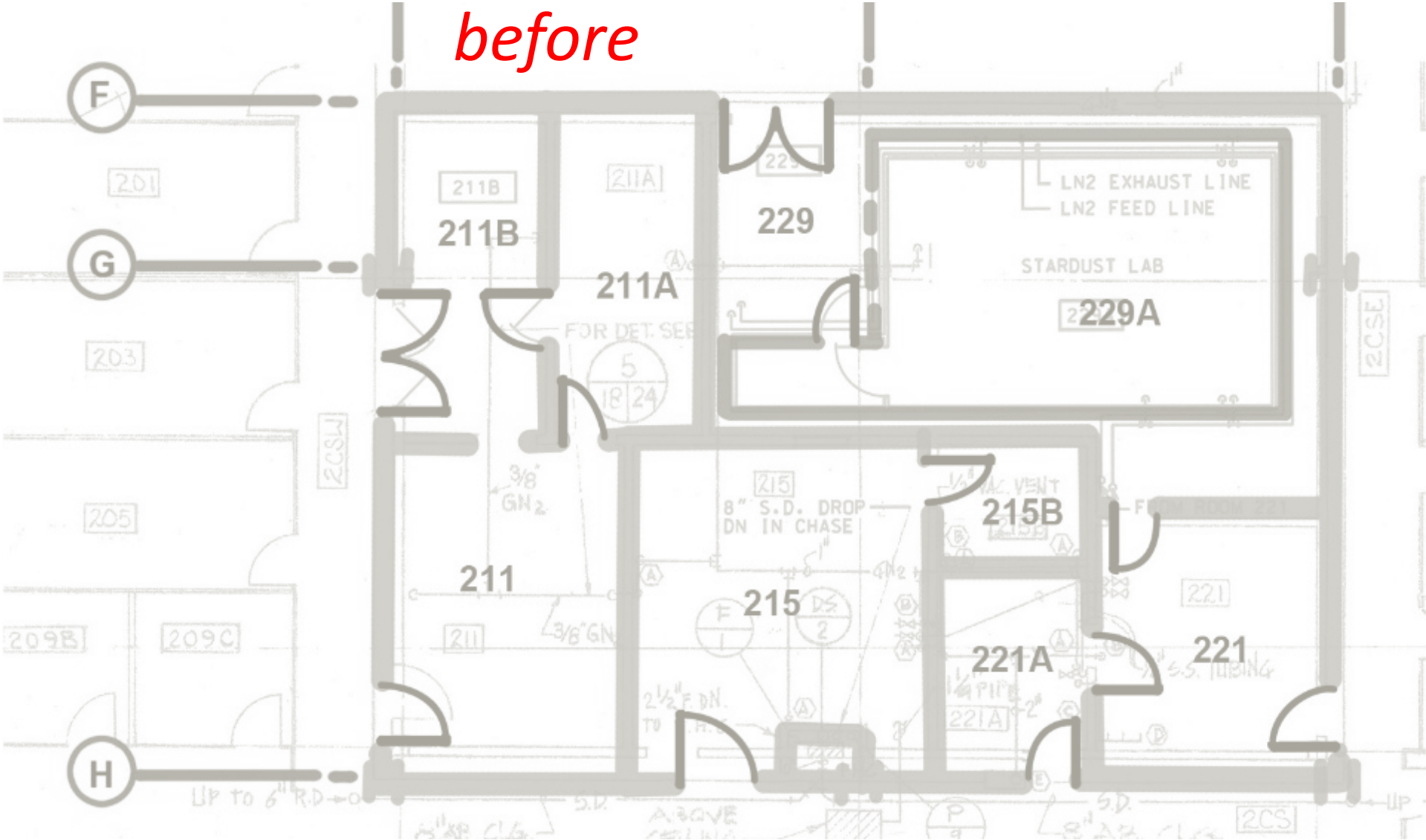


- Design Mar 2016 - Sept 2016
- Phase 1 and 2 bid in Jan 2019, construction June 2019 to June 2020.
  - Phase 1: asbestos abatement, electrical, GN_2, air handler(s)
  - Phase 2: cleanroom ceilings, floors, walls
  - Phase 3 : lab outfitting FY20 (H2) and FY21 (OREx)

★ = *Operationally ready labs (1 year prior to sample arrival at JSC)*

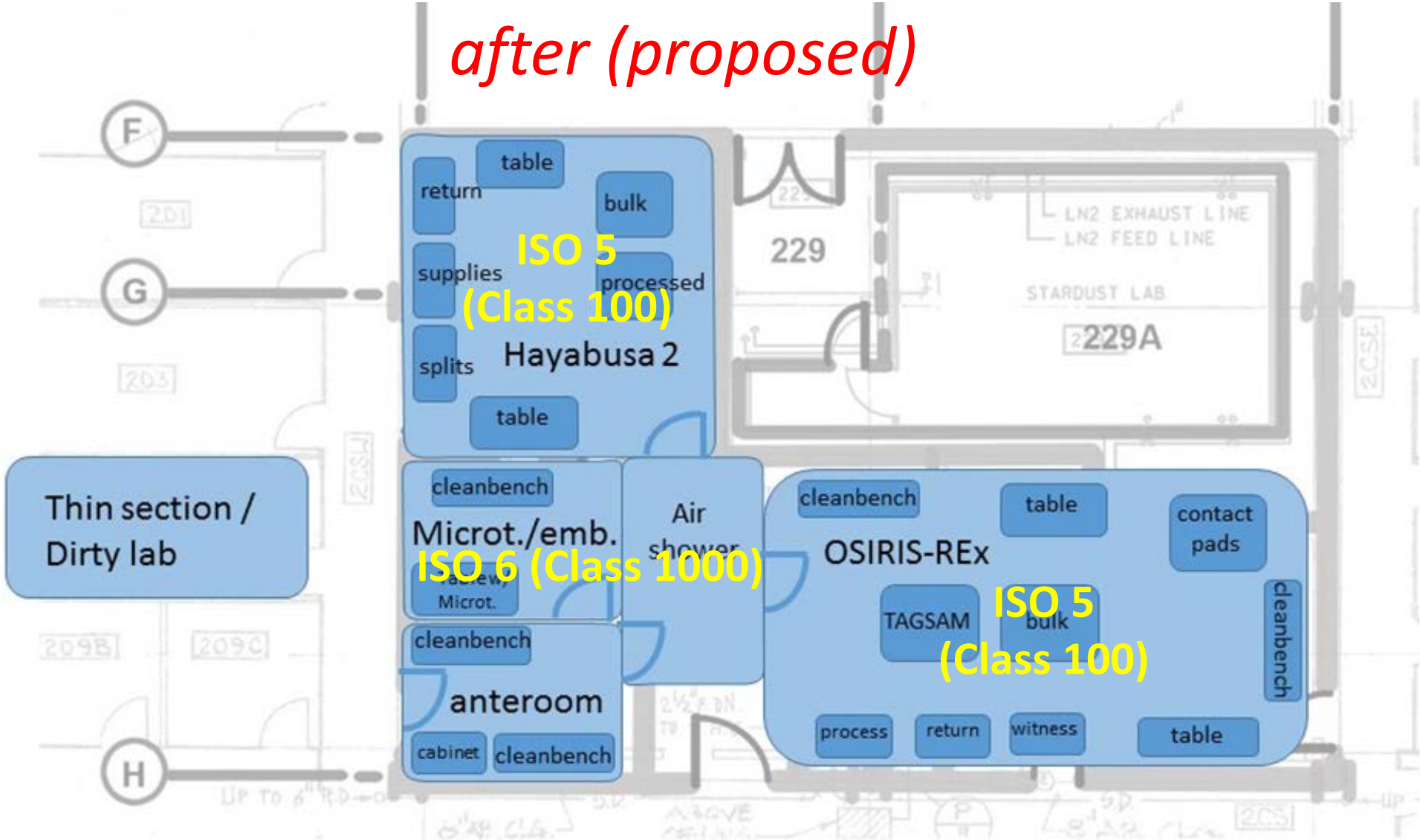
OSIRIS-REx/Hayabusa2 future lab space

before



OSIRIS-REx/Hayabusa2 future lab space

after (proposed)



Curation Facilities

Conducted whole system assessments for all of Curation facilities (labs, and subsystems like gloveboxes) to complement last year's end-to-end N_2 and UPW assessments. This study will enable future planning and proactive maintenance

- We have solid maintenance schedules, but nearly all of our clean rooms and major hardware subsystems are near or beyond published life expectancy.
- Strategic plan for facilities will build on these studies, assemble risk matrix to prioritize work.

Curation Infrastructure

Areas included in study

Cleanrooms & Controlled Environments

Preclean & Final Clean

Liquid & Gaseous Nitrogen System

End-to-end nitrogen system assessment in 2015 by Jacobs Engineering.

Gloveboxes & Desiccators

Ultrapure Water System

Two independent UPW system reviews:

- Evoqua Water Technologies of Texas
- Air Liquide Balazs Nanoanaylsis

CURATING NASA'S PAST, PRESENT, AND FUTURE EXTRATERRESTRIAL SAMPLE COLLECTIONS

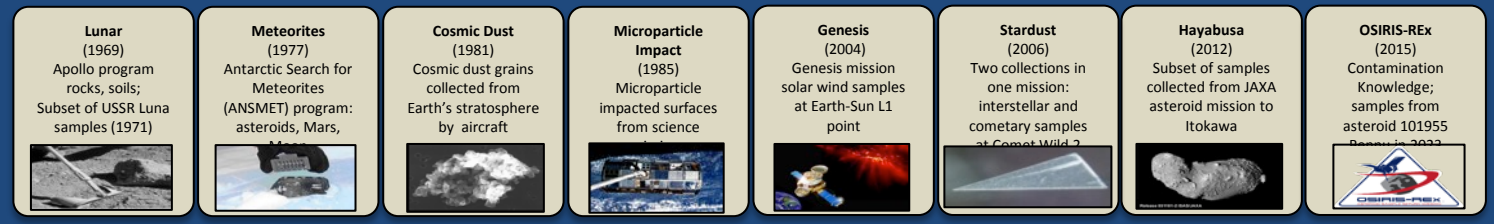
Francis M. McCubbin, Judith H. Allton, Cynthia A. Evans, Marc D. Fries, Keiko Nakamura-Messenger, Kevin Righter, Ryan A. Zeigler, Mike Zolensky, and Eileen K. Stansbery
NASA Johnson Space Center, 2101 NASA Parkway, Mail Code XI2, Houston, TX 77058. francis.m.mccubbin@nasa.gov

Introduction: NASA's Astromaterials Acquisition and Curation Office at the Johnson Space Center (JSC) is responsible for curating all of NASA's extraterrestrial samples under the governing document, NASA Policy Directive 7100.10E. JSC is charged with "...curation of all extra- terrestrial material under NASA control, including future NASA missions" that includes documentation, preservation, preparation, and distribution of samples for research, education, and public outreach.

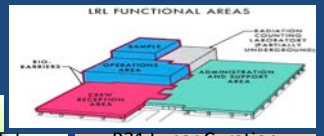
A founding principle for NASA's curation of extraterrestrial samples was established in 1964 – well before the return of the first lunar samples:

Curation begins as soon as a sample return mission is conceived.
This practice continues to return dividends today.

Astromaterials Curation: NASA's Current Collections at JSC



Fifty Years of Advances in NASA Facilities for Astromaterials Curation



LRL Planning 1964 – 1966
LRL Construction 1966 – 1967
LRL Check-Out 1967 – 1969
B31 Lunar Curation 1972 – 1979
Apollo Thin Section Lab
First Apollo Samples 1969
Meteorite Curation 1977 (including thin section)
Cosmic Dust Curation 1981
Microparticle Impact Curation 1985
Genesis Assembly 1998 – 2001
Stardust Curation 2006
Genesis Curation 2004
Hayabusa Curation 2012
OREX Contam. Curation 2015
B31N Lunar Curation 1979 – Present
Brooks Remote Storage 1975 - 2002
WSC Remote Storage 2002 – Present

1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

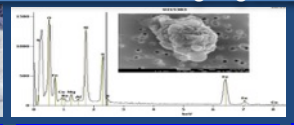
Vacuum Containment Apollo 11 – 12, 1967 -70
Gaseous Nitrogen System for Gloveboxes and Desiccators: 1970 to Present
Freon 113 Final Cleaning 1968 – 1994
Ultrapure Water Final Cleaning 1994 to Present

Fifty Years of Curation Innovation for Receiving, Handling, Preliminary Examination & Processing and Preservation of Extraterrestrial Samples

Ongoing Curation Activities

Lunar Sample Curation
Curation & early mission plans
Large rock, bulk regolith, core samples
- Collaboration on sample collection hardware
- Processing in gloveboxes with controlled atm.
- Quarantine facility
- High precision contamination control-inorganic and organic
- Prelimi Exam aids allocation
- Cleaning validation, monitoring
- State-of-art analytical facilities co-located with samples

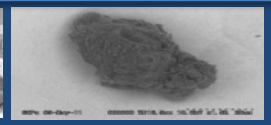
Meteorite Curation
Curation prior to field/flight activities
Samples from many diverse bodies
- Clean collection, storage of 100s of samples/yr from Antarctica
- Curation protocols adopted for field
- Collaborative PET with National Museum of Natural History (Smithsonian)
- Collection growth



Cosmic Dust Curation
Curation prior to field/flight activities
Micron-scale samples from diverse bodies
- ISO5 Cleanroom
- Specialized handling techniques for manipulating,preservation of tiny samples from comets, asteroids, and interstellar dust
- New techniques for small particle preparation
- New techniques for small particle allocation

Solar Wind Curation
Curation part of early mission planning
Solar wind atoms in various materials
- ISO 4 Cleanroom
- Payload collection HW cleaning and assembly
- Curation plan for recovery of sample return capsule
- Mobile cleanroom for recovery
- Curation contingency plan enables mission objectives

Stardust Comet-ISD Curation
Curation part of early mission planning
Micron-scale samples embedded in aerogel
- Archiving, removal, and sub-sectioning of aerogel-embedded grains
- New imaging protocols for preliminary examination
- Crowd-sourced track identification
- Preservation of sampling hardware enables science (eg . Aluminum strips)



Hayabusa 1 Asteroid Sample Curation
JAXA mission
Micron-scale samples from an asteroid
- Joint JAXA- NASA-Australia mission
- Partnership with foreign space agency for sample allocation
- New methods for PI sample handling
- Sample inventory continues to grow

Future Curation Activities

Hayabusa 2 Asteroid Sample Curation
Curation part of early mission planning
Sample range (< 10 to >>100 microns) from an asteroid
- Witness Plate cleaning and deployment

- Carbon-rich sample handling
- Volatile sample handling
- International collaboration for 2 missions
- Joint Curation Lab requirements
- Advancing techniques for handling small particles

OREX Asteroid Sample Curation
Curation part of early mission planning
Samples with different physical states and sizes
- Samples could come from Mars, icy worlds, or gaseous samples from planetary atmospheres
- Organic contamination control: <ng/cm² TOC
- Robotic sample handling
- Cold curation
- Planetary Protection level 5 sample handling
- Biological cleanliness

Future Astromaterials Collections