Stardust Sample

INVESTIGATOR'S GUIDEBOOK

Astromaterials Acquisition and Curation Office/KT
Astromaterials Research and Exploration Science Directorate/KA

NASA

Lyndon B. Johnson Space Center
Houston, Texas

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1.0 STARDUST SAMPLE RETURN

In January 2006, the Stardust spacecraft returned the first *in situ* collection of samples from a comet, and the first samples of contemporary interstellar dust. Stardust is the first US sample return mission from a planetary body since Apollo, and the first ever from beyond the moon.

This handbook is a basic reference source for allocation procedures and policies for Stardust samples. These samples consist of particles and particle residues in aerogel collectors, in aluminum foil, and in spacecraft components. Contamination control samples and unflown collection media are also available for allocation.

2.0 STARDUST SAMPLE SUMMARY

2.1 Introduction

During two periods, February-May 2000 and August-December 2002, the Stardust spacecraft collected interplanetary and interstellar dust in the interstellar collector. Interstellar and interplanetary dust particles were collected in aerogel tiles, aluminum foils and in exposed surfaces of the sample tray and arm. The collection speed for interstellar dust was not measured, but is expected to have been ~20 km sec^{-1}. Also, some parts of the Stardust sample return capsule (SRC) were exposed to interplanetary and interstellar dust and may contain impact residues, and will be available for allocation.

In January 2004, the Stardust spacecraft collected cometary dust during a close encounter with the Jupiter-family comet Wild2. The relative speed of the spacecraft with respect to the comet was 6.1 km sec^{-1}. Cometary dust particles were collected in aerogel tiles, aluminum foils and in exposed surfaces of the sample tray and arm. The cometary dust collectors also contain interplanetary dust impacts, because they were exposed to interplanetary space during the interstellar dust collection periods.

In addition to collection media, there are spacecraft contamination control materials (one each sapphire and aluminum disk, and one aerogel block), which are available for allocation under extraordinary conditions. Other components of the SRC that are not expected to contain residues of extraterrestrial impacts are available for allocation under a different program. Contact the Stardust Curator for further information.

In addition, the Curator has many examples of unflown aerogel available for allocation for techniques development, contamination studies, etc.

In summary, the Stardust sample inventory consists of

- Aerogel tiles containing cometary and interplanetary dust impacts
- Aluminum foils containing cometary and interplanetary dust impacts
- Cometary tray and arm containing cometary and interplanetary dust impacts
- Aerogel tiles containing interstellar and interplanetary dust impacts
- Aluminum foils containing interstellar and interplanetary dust impacts
- Interstellar tray and SRC components containing interstellar and interplanetary dust impacts
- Two contamination control disks (one sapphire, one aluminum)
- One contamination control aerogel block
- Unflown aerogel tiles

2.2 Cometary sample collection media

The inventory of collecting media from the cometary side of the Stardust collector is:

- 124 aerogel tiles measuring approximately 4cm length by 2cm length by 3cm depth.
- 2 irregular aerogel tiles
- ~120 aluminum foils, each measuring ~1.7mm by 35mm.
- ~120 aluminum foils, each measuring ~1.7mm by 15mm.
- Exposed surfaces of the cometary tray and collector arm
- Contamination witness materials

2.3 Interstellar and interplanetary dust collection media

The inventory of collecting media from the interstellar side of the Stardust collector is:

- 124 rectangular aerogel tiles measuring approximately 4cm length by 2cm length by 1cm depth.
- 2 irregular aerogel tiles
- ~120 aluminum foils, each measuring ~1.7mm by 35mm.
- ~120 aluminum foils, each measuring ~1.7mm by 15mm.
- Approximately 4 cm^2 of exposed surface of the interstellar tray and collector arm
- A diverse variety of surfaces within the SRC capsule that have been exposed to interplanetary and interstellar dust

3.0 STARDUST SAMPLE PREPARATION

The Curatorial Facility at JSC is responsible for the preparation of Stardust samples, within the capabilities of the Curatorial operation.

3.1 Particles and particle residues in aerogel collectors

Analytical preparation of particles and particles residues in aerogel collectors is time-consuming, is not always successful, must be tailored to the specific needs of the Investigator, and is highly dependent on the physical state of the sample. Investigators are strongly encouraged to consult closely with the JSC curatorial staff regarding sample preparation before making a sample request. The Curator may in turn refer the Investigator to others in the community with expertise in specific areas of sample preparation.

A comprehensive description of the wide variety of sample preparation techniques is beyond the scope of these guidelines. The types of samples available are all described in the Stardust Catalog. These include naked grains, microtomed slices and potted butts prepared from grains, grains or grain tracks enclosed within small bits of aerogel (keystones and quickstones), and in exceptional circumstances, entire aerogel blocks.

3.2 Particles and particle residues in aluminum foils

Analytical preparation of particles and particles residues in foil collectors has a longer history and is much better established in comparison with sample preparation from aerogel collectors. Nevertheless, Investigators are encouraged to consult with the curator regarding sample preparation before making a sample request. The Curator may in turn refer the Investigator to others in the community with expertise in specific areas of sample preparation.

3.3 Spacecraft components containing particle residues

Analytical preparation of particles and particles residues in spacecraft components is highly dependent on the specific component under consideration. Investigators are strongly encouraged to consult closely with the Curator regarding sample preparation before making a sample request.

4.0 STARDUST SAMPLE ALLOCATION

Stardust samples are the property of the United States Government, are considered irreplaceable, and are therefore made available to Investigators only under a carefully controlled and monitored program.

The Stardust Sample Curator (SSC) is responsible for the preservation of the Stardust sample collection and for provision of appropriate samples to Investigators.

The Curator will allocate Stardust samples to Investigators on the advice of the Stardust Sample Allocation Subcommittee (SSAS) of the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). Allocation plans will be approved by the Associate Administrator, Science Mission Directorate or designee.

Requests for samples from the cometary collector will be accepted at any time, in accordance with information posted on the JSC Curation website http://curator.jsc.nasa.gov Requests will be considered at periodic meetings of the SSAS, with no priority given to order of receipt.

4.1 General Proposal Guidelines

The Stardust samples are extremely precious. No more than several hundred particles larger than 10 microns were collected. The next cometary sample return is not expected for at least two decades. Investigators should therefore anticipate that the supply of samples will not satisfy the strong demand. Investigators are strongly encouraged to form consortia in order to maximize the science yield from each sample. Coordinated analyses are considered to be especially important for those studies that will result in destruction of the samples. Preference will be given to Investigators or consortia that have a demonstrated capability of analyzing particles or particle residues captured in aerogel. Stardust analogs are available from the Curator, and may be requested through a Stardust sample request.

The Curator does not have resources for extensive characterization of samples before allocation. Investigators should therefore anticipate that most samples will not have been extensively characterized before allocation. Investigators should be prepared to do pre-analysis characterization of samples allocated to them, and should be prepared for the strong possibility that the allocated samples may not match their expectations. Preference will be given to Investigators who commit to reporting pre-analysis characterization to the Curator.

Investigators are also encouraged to make the minimum request that meets the requirements of the proposed measurement. It is expected that most sample allocations will consist of extracted particles or tracks, and that allocations of whole tiles or substantial fractions of tiles will be rare.

Samples lost during shipping may have to be re-requested in a completely new request, at the discretion of the Curator.

4.2 Proposal Submission

Guidelines and requirements for Stardust Allocation proposals are described in Appendix A of this document.

Proposals should be submitted electronically in pdf format to the Stardust Sample Curator, michael.e.zolensky@nasa.gov.

4.3 Proposal review

Proposals are reviewed by a subcommittee of CAPTEM, the Stardust Sample Allocation Subcommittee (SSAS). In considering allocation requests, SSAS will assess the scientific content of the proposal, capability of the proposers, availability of requested samples, and the realism of the investigation. SSAS will also weigh the overall merit of the proposal with the required amount of sample and any possible collateral damage to the remainder of the collector. The subcommittee will consist of approximately five scientists from diverse fields, and will be appointed by the Chair of CAPTEM. The membership term on SSAS will be approximately two years, with systematic rotation of members to provide new points of view while maintaining a continuity of oversight over the Stardust Allocation process.

4.4 Sample Preparation Priority

Some types of sample preparation are time-consuming and risky, while others are relatively straightforward. Allocations may not, therefore, be made in the order in which proposals are received. While the SSAS may make recommendations for ordering of sample requests, the decisions for prioritization of sample preparation in order to maximize the number of allocations that will be made solely by the Curator. All proposals accepted by the SSAS will be regarded to have equal scientific merit for the purpose of prioritization of allocations.

4.5 Alteration of samples

Any procedure that is likely to result in a major change in the final state of allocated samples (e.g., subdivision, complete destruction, substantial radiation damage, substantial heating) as compared with that described in the initial sample request must be approved by the SSAS. Such requests should be made in writing through the Stardust Sample Curator.

4.6 Other Use of Samples

Samples are provided to Investigators for research purposes only. Requests for samples for display or educational purposes will be considered in the future, but are not currently considered.

4.7 Preliminary Examination Samples

Samples which were utilized during the 7 month preliminary examination period, and which are still being held by participants at the close of the preliminary examination, must be returned immediately to the Curator, unless a new sample request is submitted. Samples which are not re-requested promptly will be recalled by the Curator.

5.0 STARDUST SAMPLE SECURITY AND ACCOUNTABILITY

The Stardust samples are the property of the United States Government. It is NASA's policy that samples are used only for authorized purposes.

5.1 Stardust Investigators

Investigators who wish to analyze Stardust samples or spacecraft components must become Stardust Investigators before receipt of any Stardust samples, either from the Curator or from any Investigator. To become a Stardust Investigator, an Investigator must make a written commitment to abide by a certain set of rules, procedures and restrictions, as outlined below. Investigators make this commitment by signing and returning to the Curator the Stardust Sample Loan Agreement. A sample Loan Agreement is shown in Appendix B, and can be downloaded from the web at http://curator.jsc.nasa.gov/stardust/sampleforms.cfm .
The form must be signed and returned by fax or mail to the Stardust Curator (Fax: 281-483-5347 Mailing Address: Stardust Sample Curator, Mail Code KT, Johnson Space Center, Houston, TX 77058.

5.2 Sample Receipt

A Sample Documentation form will accompany each sample distributed by the Curator. ***The sample documentation form must be signed and returned by mail upon receipt of the samples.*** A blank copy of this form is included in Appendix C.

5.3 Sample Transfer between Investigators

Samples may be transferred between Stardust Investigators without permission of the Curator. ***Both the transmitting and receiving Investigators must complete and return transfer forms by e-mail or fax to the Curator***. Blank transfer forms may be downloaded from the web at: http://curator.jsc.nasa.gov/stardust/sampleforms.cfm After receipt of the transferred sample, care for the sample becomes the responsibility of the receiving Investigator.

5.4 Sample Security

Stardust Investigators who are allocated Stardust samples are responsible for the security of the samples, and will be held accountable in the event that samples are lost, stolen or misused. When analyses require facilities outside of the laboratory of the Investigator, the samples should be maintained under the supervision by the Investigator or the Investigator's research team. The Investigator should prevent unsupervised access to the samples by anyone not on the research team. However, the Investigator should exercise reasonable judgment in the handling and security of these samples in order to maximize the scientific yield of sample analysis.

5.5 Sample Storage

Samples should be stored in clean and secure conditions, commensurate with the preciousness of these samples. They should be carefully stored and handled so as to prevent cross-contamination with other extraterrestrial samples.

5.6 Lost Samples

In the event that a sample cannot be accounted for, the Investigator must report the loss to the Stardust Curator immediately, by completing and faxing or mailing a Sample Loss or Consumption form. This form can be downloaded from the web at: http://curator.jsc.nasa.gov/stardust/sampleforms.cfm .

5.7 Sample Accountability

Each Stardust Investigator is required to maintain records of the use of allocated samples. Samples become the Investigator's responsibility when the Investigator accepts delivery of the samples from NASA. That responsibility ends only when the samples have been returned to NASA or transferred to another Stardust Investigator in a manner described in this handbook, and all sample material has been accounted for.

A dedicated laboratory notebook, in addition to any other laboratory notebooks used by the Investigator, should be used to maintain records of the receipt, transmittal, and treatment of samples, including any intentional or accidental damage, contamination or destruction.

Investigators are required to maintain complete inventory of samples. Investigators are required to complete, sign and return an inventory to the Curator annually. Investigators are reminded that their records and inventory may be audited by the US Government at any time. Such audits have occurred under the Apollo Lunar Sample Program.

5.8 Destruction during analysis

Many types of analysis are highly destructive to extraterrestrial dust samples. ***If, in the course of analysis or handling, samples are destroyed, whether intentionally or unintentionally, a Sample Loss or Consumption form indicating this fact should be completed and returned by fax or mail to the Curator.*** Blank forms may be downloaded from the web at: http://curator.jsc.nasa.gov/stardust/sampleforms.cfm . No form is needed in the event of intentional or accidental damage or contamination, but details should be documented in the Investigator's Stardust sample notebook.

5.9 Division of samples

In the event that Investigators subdivide samples, the Curator will assign new identification numbers. The Curator should be contacted for new assignments as soon as possible after the subdivision. Subdivisions should be documented by faxing or mailing a Request for New Sample Numbers form. Blank forms may be downloaded from http://curator.jsc.nasa.gov/stardust/sampleforms.cfm

5.10 Sample transfer methods

These guidelines apply to transfers from the Curator to Stardust Investigators, from Stardust Investigators to the Curator, and to transfers between Stardust Investigators.

Samples can be sent by an overnight package delivery service that allows packages to be tracked online (e.g., FedEx, DHL). ***Before shipment, the sender and the recipient must agree on a date on which the recipient or the recipient's designee can receive the allocation.***

The value of the shipment must be recorded on the shipping form as "zero". To preclude inadvertent opening by mailroom employees, place inside the box a prominent message "MAIL ROOM EMPLOYEES: THIS PACKAGE CONTAINS MATERIALS TO BE OPENED ONLY IN A CLEAN ENVIRONMENT". Samples should be sealed in at least two layers of packaging so that exterior packaging can be removed prior to clean environment entry.

Samples may also be carried by hand from and to JSC. If samples are hand-carried by air, an accompanying letter from NASA should be carried with the samples indicating the value of the samples and cautioning airport security personnel against opening or touching the samples. ***The samples should not be put in checked luggage.***

Appendix A:

PROPOSAL GUIDELINES

Proposals should be as long as necessary to clearly meet the proposal requirements as defined below. Investigators are encouraged to be concise. If necessary, the Allocation Subcommittee may set up a teleconference with the applicant to discuss requests.

At a minimum, proposals should include

- A clear statement of research objectives
- A clear description of the measurements to be made
- A summary of relevant previous experience, if any, of the Investigator in analysis of similarly prepared samples or analogs
- Relevant recent publications, for those new to the field
- A discussion of the analytical issues arising from the capture medium (aerogel, foil or other surface)
- A detailed description of the sample requirements, including a description of the selection criterion for the sample, and a detailed sample preparation plan
- A sample transfer plan (for example, shipping requirements)

Appendix B:

STARDUST SAMPLE
LOAN AGREEMENT

The Johnson Space Center of the National Aeronautics and Space Administration, a Federal Agency, hereinafter referred to as JSC, desires to enter into a Loan Agreement and to make certain material available to **«institution»**, hereinafter referred to as the INSTITUTION. The INSTITUTION proposes to use said material to undertake, at its own direction, scientific investigations proposed to the Stardust Allocation Subcommittee of the Curation, Analysis and Planning Team for Extraterrestrial Materials (CAPTEM).

The use of the material by the INSTITUTION will permit beneficial contact between representatives of JSC and the INSTITUTION to provide opportunities for discovery and dissemination of information concerning the Stardust collector samples, promote maximum utilization of material by JSC and provide opportunities for dissemination of information concerning the activities of the National Aeronautics and Space Administration.

It therefore is agreed as follows:

1. The samples (hereinafter referred to as the PROPERTY) made subject to this agreement will be assigned to [INSTITUTION] on Stardust Sample Assignment Forms signed by the JSC Stardust Curator and the Investigator of [INSTITUTION NAME].

2. The PROPERTY is the property of the United States Government, is considered irreplaceable, and is therefore made available to users only under a carefully controlled and monitored program. It is therefore essential that rigorous security and accountability procedures be followed by all persons who have access to the PROPERTY. The Investigator will be responsible for the receipt, use (including security during use), accountability, and return of the PROPERTY at the end of the designated time. The INSTITUTION will agree to strictly adhere to the following procedures for the security of the PROPERTY:

    a. Only persons authorized by the Investigator may receive and open the package. The authorized official shall record all of the PROPERTY promptly upon receipt, and it shall be so identified so long as it remains in the custody, possession, or control of the INSTITUTION.

    b. Verification of sample transfers by electronic media shall be from persons authorized by the Investigator using institutional computer accounts secured with password protection under the exclusive control of the authorized person.

c. During use the PROPERTY must be under the control of the Investigator. At the end of each use of the PROPERTY, an inventory shall be made to insure the accountability of the PROPERTY. Such inventories shall be maintained as a permanent record and shall be made accessible to NASA at all reasonable times.

d. When not in use, the PROPERTY must be locked in a safe or secure storage cabinet equipped with a combination padlock, or, if controlled environment is required, in a locked laboratory.

e. Combination to the storage safe or cabinet will be under the exclusive control of authorized officials.

f. Report immediately the loss or damage of the PROPERTY to the Stardust Curator, Johnson Space Center, Houston, Texas 77058, telephone (281) 483-5128, michael.e.zolensky@nasa.gov.

g. Transfer of samples among collaborators is allowed if each collaborator has submitted a signed Stardust Sample User Agreement to the Stardust Curator. Upon receipt of the sample, the receiving collaborator becomes responsible for the sample. The Stardust Curator should be notified of samples transferred to collaborators.

h. The PROPERTY shall be either hand-carried by the INSTITUTION's authorized official or mailed via FedEx or equivalent responsible, real-time tracking courier. The JSC reserves the right at the INSTITUTION's expense, to direct the mode of transportation for the PROPERTY. Shipping of samples among collaborators shall be carefully tracked and consists of 3 steps: 1) verify recipient is available to receive package on arrival date, 2) recipient immediately acknowledges receipt, and 3) sender inquires about package receipt if recipient does not respond by day after expected arrival.

3. NOTWITHSTANDING any other provision of this agreement, the INSTITUTION shall not be liable for loss of or damage to the PROPERTY, or for the expenses incidental to such loss or damage, except that the INSTITUTION shall be responsible for any such loss or damage (including expenses incidental thereto):

a. which results from willful misconduct or lack of good faith on the part of the INSTITUTION's directors or officers, or on the part of any of its managers, superintendents or any other equivalent representatives, who have supervision or direction of all or substantially all of the INSTITUTION's business; or

b. which results from a failure on the part of the INSTITUTION due to the willful misconduct or lack of good faith on the part of any of its directors,

officers, or other representatives mentioned in (a) above (i) to maintain and administer, in accordance with the provisions of this agreement, the program for delivery, protection, and preservation of Government property, or (ii) to take all reasonable steps to comply with any written directions from JSC with respect to the delivery, protection, and preservation of Government property.

HOWEVER, loss or damage to the PROPERTY caused by failure to follow proper safeguarding standards as set forth in this agreement will be considered in selecting participants in future agreements.

4. Title to the PROPERTY shall remain with NASA and shall not be affected by the incorporation, attachment, or mixture thereof to or with property not owned by NASA.

5. To the extent permitted under the law of the State of **«state»**, the INSTITUTION shall be liable for all claims, demands, actions, costs, and charges made, asserted, or incurred by reason of any injury to any person or property, or loss of life or property, suffered or sustained during the period of the use and enjoyment when the injury, loss of life, or property damage is caused by any act or omission of any agent or employee of the INSTITUTION.

6. This agreement shall become effective upon the date of the last signature hereto and will remain in effect for four years.

Signature of Investigator Date	**Signature of Curator Date**

Appendix C

STARDUST SAMPLE DOCUMENTATION FORM

Date:
CO:

Event: __Transmittal __Receipt __Loss or Destruction __Subdivision

JSC Tracking Number:	**Stardust Sample Description**
Transfer from: **_____** **–** **Date:**	**Processor:**
Transfer to:	

JSC Stardust Form #100 January 4, 2006

PLEASE RETURN THIS FORM TO:

STARDUST SAMPLE CURATOR
MAIL CODE KT
JOHNSON SPACE CENTER
HOUSTON, TX 77058