

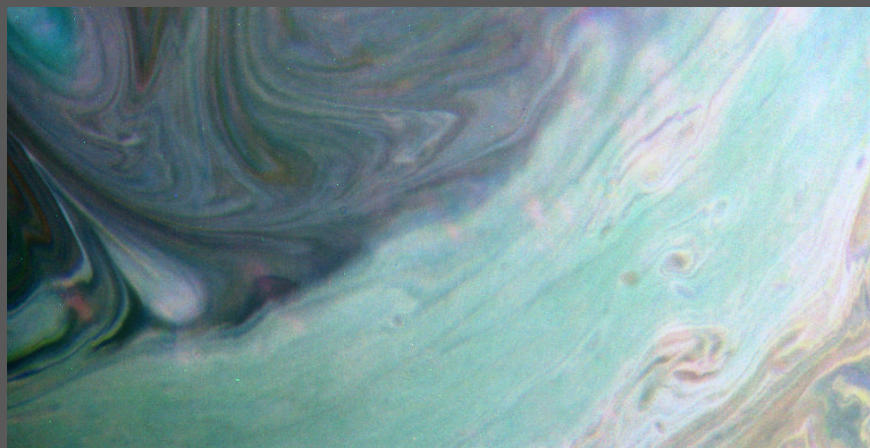
**NASA Space  
Science Data  
Coordinated  
Archive**

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**2016 ANNUAL  
STATISTICS AND  
HIGHLIGHTS**

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**Cover Photo Credit:** False-color view of clouds in Saturn’s northern hemisphere produced from images taken by Cassini’s wide-angle camera on 20 July 2016. The image utilized a combination of infrared-sensitive spectral filters at 750, 727 and 619 nm. This image is a cropped version of one produced by Kevin M. Gill, Caltech/Space Science Institute.

## Preface

The NASA Space Science Data Coordinated Archive (NSSDCA) serves as the deep archive for NASA's Space Science community. A major component of its mission is to ensure data accessibility and usability far into the future. NSSDCA also provides current data access, complementary to the efforts of other NASA active archives, in support of NASA and international research enterprises. Finally, NSSDCA is a conduit for the general public and education community to acquire NASA space science data that may be of interest to them.

Herein we report on the activities of the NSSDCA for the calendar year 2016. As much as possible, we report the same statistics as in previous years to enable interested parties who wish to compare accomplishments year-to-year. Nevertheless, as the NSSDCA evolves, some statistical tables have been updated to better reflect current operations. These are noted in the text.

NSSDCA is pleased to issue this 2016 Annual Report describing the growth and evolution of the data archive and other tools and services, as well as the access to those data and services by NSSDCA's customer communities. This report has been made web accessible in the hope that readers will avail themselves of the opportunity to link to the services reported herein.

We welcome suggestions from users for improvements to this Annual Report and to NSSDCA services.

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Acting Head, NASA Space Science Data Coordinated Archive

## Introduction

This report characterizes NSSDCA's data holdings, metadata holdings, access pathways and services at the end of 2016, with a focus on the 2016 activities leading to that end-of-year state. In addition this report characterizes the nature of and access to NSSDCA's data and services by its many users from various communities. It is assumed the reader will have a general familiarity with NSSDCA and its mission. For more information see the top level NSSDCA web page at <https://nssdc.gsfc.nasa.gov/>.

## Highlights

The most important result of NSSDCA's 2016 continuing activities is the preservation of growing space science data volumes, ensuring their continuing and future accessibility to the space science, education and general public communities. The archive has grown to 956 TB of space science data, a growth of about 400 TB in planetary data alone. The largest data contributor was again the Planetary Data System (PDS).

In 2016, as in 2015, the major development effort has been preparing to receive and archive data in PDS4 format, which some PDS nodes began using operationally in late 2014 starting with the LADEE mission. Nevertheless, the majority of data submitted from the PDS continues to be data in PDS3 format, a large fraction of which was data from the Lunar Reconnaissance Orbiter Camera (LROC).

NSSDCA also continues to provide off-site backup service for selected data submitters' original media. Levels of archive services that are provided by NSSDCA are discussed in more detail at [https://nssdc.gsfc.nasa.gov/nssdc/submitting\\_data.html](https://nssdc.gsfc.nasa.gov/nssdc/submitting_data.html).

## Data Managed at NSSDCA

### State of the Archive

There are several ways to characterize the multi-disciplinary NSSDCA archive and we use an assortment of them herein to give a true sense of the archive, *i.e.*, byte counts, numbers of distinct data collections, and numbers of media volumes managed, as well as the diversity of data collections and of media types. For the remainder of this section we will present this variety of statistics primarily in tabular form, similar to prior years' reports as much as possible.

Discipline	Digital	Analog	Total
Astrophysics	231	129	360
Heliophysics	1,286	731	2,017
Planetary Science	1,927	766	2,693
Earth Science	105	42	147
Other	125	432	557
<b>Total*</b>	<b>3,675</b>	<b>1,959</b>	<b>5,634</b>

Table 1: Counts of data collections at NSSDCA on 31 December 2016. See text for explanation.

Table 1 shows a summary of the variety of data collections held in the archive. Shown in the table are the science discipline areas covered by those collections as well as whether or not the collections are digital or analog. (Analog collections include those on film and paper.) Planetary science continues to be the only discipline in which significant growth in terms of digital data occurs. Please note that this table differs from the information presented in previous reports. First, previous reports counted data collections only by a *primary* discipline as indicated by the discipline prefix assigned to the collection. This document reports collections by all potential science disciplines associated with the collection (*e.g.*, a collection may be primarily a Planetary collection, but may have observations useful to Heliophysics studies as well). Second, the totals at the bottom are, consistent with previous reports, the total number of *unique* collections of that type (*e.g.*, digital or analog), not the sum of the column.

Discipline	Digital Data (TB)
Astrophysics	194.21
Heliophysics	359.38
Planetary Science	400.93
Earth Science	0.00
Other	1.53
<b>Total</b>	<b>956.05</b>

Table 2: Total volume of the NSSDCA digital archive on 31 December 2016.

AIPs. The totals shown in the table have also been adjusted to take into account any data released due to replacement (*e.g.*, PDS or HEASARC) or any data transferred to ESDIS. For 2016 there was significant growth (about 400 TB) in Planetary Science resulting from data submitted by PDS. Figure 1 shows the same information as Table 2, but includes information from 2005-2015 as well.

Table 2 presents a different view of the digital archive. It shows the total volume (in TB) for each discipline. Byte counts for older data collections (and some collections held on media from projects such as the High Energy Astrophysics Science Archive Research Center (HEASARC)) are estimates assuming a mean number of bytes depending on the medium. Data archived since 2000 are packaged in Archive Information Packages (AIPs) that hold both data files and accompanying attribute files that are media and platform independent. File sizes are available for data preserved in

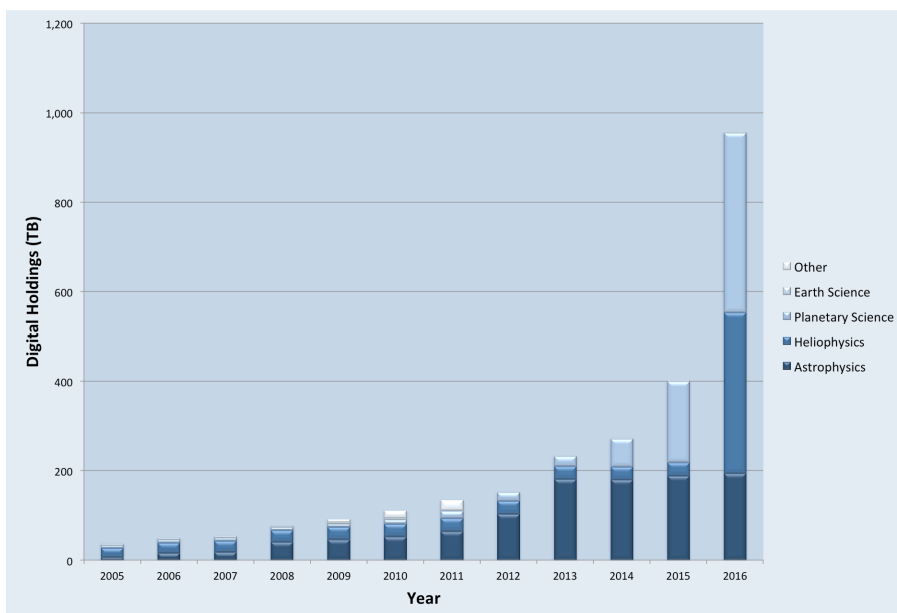


Figure 1: Total volume of the NSSDCA digital archive (2005-2016).

	2013 (GB)	2014 (GB)	2015 (GB)	2016 (GB)
Legacy Data	19.17	15.58	13.42	0
Data Conversion	0.65	0	0	2.73
Gravity Probe-B	0	326.84	3.74	586.02
PDS	3,093.75	50,558.88	119,698.75	207,600.03
RHESSI	591.61	617.01	616.02	401.28
COBE	0	0	0	47.45
Wind	0.21	0.20	0.11	0
<b>Total</b>	<b>3,705.39</b>	<b>51,518.51</b>	<b>120,332.04</b>	<b>208,637.51</b>

**Table 3: Data ingested to near-line permanent archive.**

Table 3 shows the volume of data ingested to this portion of the archive for the years 2013-2016. The total volume of data ingested as AIPs in 2016 was nearly 75% more than 2015. Nearly all of this increase is not simply due to PDS, but almost 65% of the PDS increase is due to data arriving from the PDS Cartography and Imaging Sciences Discipline Node, all data from the Lunar Reconnaissance Orbiter Camera (LROC).

Media Type	Astrophysics	Heliophysics	Planetary Science	Earth Science	Total
4-mm Tape	1,194	94	3	0	1,291
8-mm Tape	205	199	77	0	481
9-track Tape	531	4,795	1,401	33	6,760
3480 Cartridges	474	1,983	1,155	10	3,622
DLT	84	101	2	0	187
LTO	90	164	0	0	254
CD	519	23,183	2,533	0	26,235
DVD	1,012	1,047	206	0	2,265
12-in WORM	0	4	0	0	4
<b>Total</b>	<b>4,109</b>	<b>31,570</b>	<b>5,377</b>	<b>43</b>	<b>41,099</b>

**Table 4: Counts of media volumes at NSSDCA on 31 December 2016. Backup volumes and those not attributable to the four disciplines listed are not included.**

Table 4 presents a characterization of the various off-line media that are managed within NSSDCA. These are data that are not a part of the near-line system. These data are replicable. Data on tape media generally have one backup volume. The items listed under Earth Science represent a negligible amount of the overall data holdings, so 0.0 TB was entered into Table 2 above. The increase from 2015 in the number of Astrophysics Linear Tape-Open (LTO) tapes resulted from more data being served by HEASARC. Similarly the increase in LTO tapes in Heliophysics resulted from backup data received from the Space Physics Data Facility (SPDF). Legacy data on tape continues to be migrated into AIP form as well and will result in a decrease in media from this table in the future when those volumes are released.

Media Type	Astrophysics	Heliophysics	Planetary Science	Earth Science	Other	Total
Microfilm (reels)	2,382	34,915	2,095	38	3,061	42,651
Microfiche (cards)	5,963	30,507	13,492	548	3,620	54,565
Film (feet)	100	580	409,081	0	3,785	426,613
Film (frames)	11,971	6,173	333,218	31,368	6,206	422,140
Movie (reels)	0	2	181	4	20	207
Maps	0	0	1,773	0	0	1,773
Slides	62	36,893	768	0	2,112	39,835

Table 5: Counts of analog products by form at NSSDCA on 31 December 2016.

Table 5 lists the analog holdings at NSSDCA by discipline and by form. Reels of uncut sequences of still photos are listed as Film (feet). Photographic stills are also held as cut frames. No images are double-counted nor are backup or extra copies counted. The entries are unchanged from last year.

## Data Inflow

In previous years we reported on data arriving on various media types. With the sole exception of those entities for which NSSDCA is holding data as a backup function (*e.g.*, SPDF), all data are now being put in the near-line archive as AIPs and any media on which they arrive is treated as transfer media.

Table 6 lists by project the volume of data received by NSSDCA in 2016, nearly 500 TB of data via a combination of electronic deliveries as well as on media. The large increase in Heliophysics data is due to NSSDCA now keeping track of backup data from SPDF in the same manner as backup data from HEASARC.

Discipline/Project	GB	Totals by
<b>Astrophysics</b>		<b>183,957.45</b>
COBE	47.45	
Fermi	15,000.00	
HEASARC	168,910.00	
<b>Planetary Science</b>		<b>207,597.32</b>
PDS Atmospheres	1,562.68	
PDS Geosciences	66,679.44	
PDS Imaging	133,181.80	
PDS NAIF	549.23	
PDS PPI	662.06	
PDS PSI	4,244.32	
PDS Rings	717.79	
<b>Heliophysics</b>		<b>104,001.28</b>
RHESSI	401.28	
SPDF	103,600.00	
<b>Miscellaneous</b>		<b>588.75</b>
Gravity Probe-B	586.02	
Data Conversion	2.73	
<b>Grand Total</b>		<b>496,144.80</b>

Table 6: Data arriving at NSSDCA during 2016.

Affiliation Category	Requests
No Affiliation (General Public)	2
Non-US	2
US Academic Institutions	6
US Private Industry	0
NASA/GSFC	13
NASA Centers (excluding GSFC)	4
Other Government Agencies	0
<b>Total</b>	<b>27</b>

**Table 7: NSSDCA off-line request user community for 2016.**

## Data Dissemination

NSSDCA also responds to *ad hoc* requests for data. Such requests are now provided in digital form (including digital forms of previously analog materials) and are staged for retrieval on a server.

Requests for data come from a wide user community. Table 7 shows the number of requests for 2016. There were fewer requests for NASA/GSFC

compared to 2015 as the number of Heliophysics data collections to the Space Physics Data Facility (SPDF) continues to decrease. Of the 13 requests originating at GSFC, 9 of them were from this transfer of data. Excluding these, there were a total of 18 requests for off-line data in 2016, a net increase of 50% over 2015.

Requests for off-line data are also tracked by science discipline. Table 8 presents the number of requests by science discipline for 2016. The total number of requests by discipline (32) exceeds the requests by affiliation (27) because requests can include data associated with more than one discipline. In addition, some requests are for documentation or other forms that are not included in Table 8. Finally, as with Table 7,

Discipline	Requests
Astrophysics	6
Earth Science	0
Heliophysics	14
Planetary Science	10
Ephemeris	2

**Table 8: Number of off-line requests for data by discipline for 2016.**

discounting the large number of requests supporting the transfer of data to SPDF greatly reduces the number of requests, not only in Heliophysics, but in the other disciplines as well. Excluding these requests reduces the overall total discipline requests to 13, eliminating all but two in Astrophysics, one in Heliophysics and the 10 in Planetary Science.

In 2016 all data distribution was via electronic distribution. Table 9 presents the distribution of requested data by discipline for recent years. The information provided does not include any repeat requests for data previously made available electronically, but only data that were newly posted in response to a request.

Discipline	2012 (files)	2013 (files)	2014 (files)	2015 (files)	2016 (GB)
Astrophysics	48	0	8,674	0	459
Heliophysics	10,517	11,512	15,643	6,568	1,066
Planetary Science	453	32,387	5,216	6,136	104,530
Other	1,376	0	34	1	1,210
<b>Total</b>	<b>12,394</b>	<b>43,899</b>	<b>29,567</b>	<b>12,705</b>	<b>107,265</b>

**Table 9: NSSDCA off-line data dissemination statistics, 2012-2016. Note that for years prior to 2016 that files were reported. Beginning in 2016 the volume of data began to be tracked.**



## Additional Services and Activities

In addition to its archive of scientific data, NSSDCA offers a number of additional services that are described below.

### NSSDCA Information Management System (NIMS)

The NSSDCA Information Management System (NIMS) encompasses most of the separate databases that have been used to track data and information through the years. Table 10 summarizes pertinent statistics for NIMS for 2016. NIMS identifies virtually all launched spacecraft, the experiments carried by many of these spacecraft, and data collections from these spacecraft, primarily as archived at NSSDCA. This portion of the database is the source of information for many of NSSDCA's web pages. The NSSDCA Master Catalog (NMC) dynamically generates web pages so that the latest information is presented to the user. A number of discipline and project pages are also based on information derived from NIMS or utilize the NMC to generate such information. The counts of new records are also detailed, but because of routine database maintenance do not exactly predict the totals from year to year.

Partition	Records	Records Added
Spacecraft	7,541	149
Experiment	5,553	6
Data Collection	6,711	68
Total	19,805	223

**Table 10: NIMS database statistics for 2016. Also of note: Spacecraft with experiments (1,100); Experiments with collections (1,677); Data collections associated with only spacecraft, not experiments (821); and, Data collections not associated with spacecraft/experiments (558).**

### PDS4 Support

NSSDCA staff continued to work toward a model for archiving data in PDS4 form. Staff met periodically, mostly via teleconference, with PDS Engineering Node personnel to resolve a number of technical issues with data to be submitted to the deep archive.

Meanwhile, staff continued to define requirements and develop designs for software as well as a provisional data model for the identification and archive of PDS4 data. A prototype database to support analysis and requirements definition for the ingest of PDS4 data continued to be tested and modified. Prototype software was developed to provide the up-front validation of Submission Information Packages (SIPs) from PDS in PDS4 format.

### SPASE Data Model and Virtual Observatories (VOs)

NSSDCA staff has been involved in the Heliophysics Data and Model Consortium for many years. This organization composed of a wide representation of the Heliophysics data holding and archiving community, is attempting to unify and facilitate access to Heliophysics data for the research community. A key aspect of this work is the development of a common data description model named the Space Physics Archive Search and Extract (SPASE) Data Model. NSSDCA staff has been involved with it since it was proposed in 1998, providing coordination of the development of the SPASE Data Model.

The latest version (2.2.8) of the SPASE Data Model was released 27 October 2016. The basic model has been stable for more than a year. Work on SPASE continues, however, with a goal toward extending the data model to support modeling and simulation data through an API Reference Implementation Subgroup. For more information on the model, see <http://www.spase-group.org/>.

## **Data Recovery Support**

NSSDCA archived several Cosmic Background Explorer (COBE) data collections recovered from antiquated magnetic tapes. These collections included calibrated time-ordered data (TOD) collected prior to COBE's cryogen depletion from the Diffuse Infrared Background (DIRBE) and Far Infrared Absolute Spectrophotometer (FIRAS) instruments, and DIRBE TOD collected after cryogen depletion.

NSSDCA staff have been locating and restoring Apollo data and making them available to researchers through the Lunar Data Project and the PDS Lunar Data Node. The effort involves taking data and metadata from microfilm, microfiche, hard-copy documents, and older digital media and putting them into a well-documented data/metadata collection for archive with PDS and NSSDCA.

In addition to the effort specific to Apollo data, the Planetary Science Division of NASA Headquarters is supporting a preservation effort to scan high-priority NSSDCA data collections on microfilm and microfiche in order to be saved in digital form and made more accessible to external users.

## **Other Staff Projects**

NSSDCA staff was also involved in the coordination of the Radio Jove program that enables students, informal education groups, and other interested individuals to learn about radio astronomy by building their own radio telescope for observing radio emissions from the Sun, Jupiter, the galaxy and the Earth itself. More than 2,000 kits have been distributed by the project worldwide and amateur radio observers continue to contribute the results of their observations through email to a general distribution list as well as to a general archive of observations. In 2015 several Radio Jove project activities were included in the Planetary Plasma Interactions (PPI) node proposal to the PDS and in the Heliophysics Education Consortium proposal to the NASA Science Mission Directorate Science Education Cooperative Agreement Notice. Both proposals were funded. The activities resulting from the funding include archiving of Radio Jove data at the PPI node and also at the Paris Astronomical Data Center (PADC). There are also plans to supplement standard Radio Jove single-frequency observations with several multi-frequency spectrographs and to use this network to provide ground-based data for augmenting the Juno mission's study of Jovian radio emission.

NSSDCA staff is interacting with the JPL Records Office, helping to assess and archive spacecraft data stored on hard-copy media there.

## Glossary

AIP	Archive Information Package
ASWS	Australian Space Weather Service
CCSDS	Consultative Committee for Space Data Systems
COBE	Cosmic Background Explorer
DAI	Data Archive Ingest
DIRBE	Diffuse Infrared Background Experiment
DLT	Digital Linear Tape
DVD	Digital Versatile Disk (originally, V = video)
ESDIS	Earth Science Data and Information System
FIRAS	Far Infrared Absolute Spectrophotometer
GB	Gigabyte
GSFC	Goddard Space Flight Center
HEASARC	High Energy Astrophysics Science Archive Research Center
ISO	International Organization for Standardization
JPL	Jet Propulsion Laboratory
LADEE	Lunar Atmosphere and Dust Environment Explorer
LROC	Lunar Reconnaissance Orbiter Camera
LTO	Linear Tape-Open [i.e. open standard]
MOU	Memorandum of Understanding
NAIF	Navigation and Ancillary Information Facility
NIMS	NSSDCA Information Management System
NMC	NSSDCA Master Catalog
NSSDCA	NASA Space Science Data Coordinated Archive
OAIS	Open Archival Information System
PADC	Paris Astronomical Data Center
PDS	Planetary Data System
PPI	Planetary Plasma Interactions
PSI	Planetary Science Institute (PDS Asteroid/Dust Subnode)
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
SIP	Submission Information Package
SPASE	Space Physics Archive Search & Extract
SPDF	Space Physics Data Facility
TB	Terabyte
TOD	Time-Ordered Data
VO	Virtual Observatory
WORM	Write-Once, Read-Many