

# IDS Data Flow Coordination (2016)

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## Introduction

Two data centers support the archiving and access activities for the IDS:

- Crustal Dynamics Data Information System (CDDIS), NASA GSFC, Greenbelt, MD USA
- l'Institut National de l'Information Géographique et Forestière (IGN), Marne la Vallee France

These institutions have archived DORIS data since the launch of TOPEX/Poseidon in 1992.

## Flow of IDS Data and Products

The flow of data, products, and information within the IDS is similar to what is utilized in the other IAG geometric services (IGS, ILRS, IVS) and is shown in Figure 1. IDS data and products are transmitted from their sources to the IDS data centers. DORIS data are downloaded from the satellite at the DORIS control and processing center, SSALTO (Segment Sol multi-missions d'ALTimétrie, d'Orbitographie et de localisation précise) in Toulouse, France. After validation, SSALTO transmits the data to the IDS data centers. IDS analysis centers, as well as other users, retrieve these data files from the data centers and produce products, which in turn are transmitted to the IDS data centers.

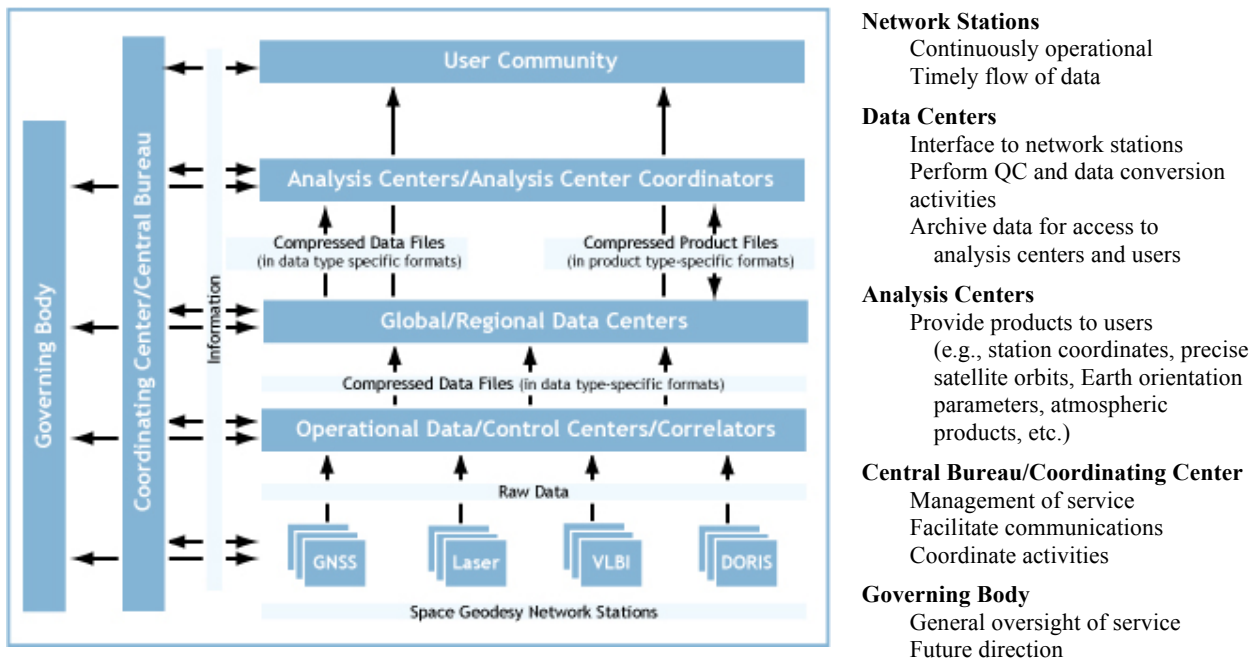


Figure 1. Routine flow of data and information for the IAG Geodetic Services

The IDS data centers use a common structure for directories and filenames that was implemented in January 2003. This structure is shown in Table 1 and fully described on the IDS website at

<http://ids-doris.org/analysis-documents/45-analysis-coordination/analysis-documents/55-struct-dc.html>. The main directories are:

- */doris/data* (for all data) with subdirectories by satellite code
- */doris/products* (for all products) with subdirectories by product type and analysis center
- */doris/ancillary* (for supplemental information) with subdirectories by information type
- */doris/cb\_mirror* (duplicate of the IDS Central Bureau ftp site) with general information and data and product documentation (maintained by the IDS Central Bureau)
- */doris/general* (for miscellaneous information and summary files)

The DORIS mission support ground segment group, SSALTO, and the analysis centers deliver data and products to both IDS data centers (CDDIS and IGN) to ensure redundancy in data delivery in the event one data center is unavailable. The general information available through the IDS Central Bureau ftp site are mirrored by the IDS data centers thus providing users secondary locations for these files as well.

Table 1. Main Directories for IDS Data, Products, and General Information

Directory	File Name	Description
<b>Data Directories</b>		
<i>/doris/data/sss</i>	<i>sssdataMMM.LLL.Z</i> <i>sss.files</i>	DORIS data for satellite <i>sss</i> , cycle number <i>MMM</i> , and version <i>LLL</i> File containing multi-day cycle filenames versus time span for satellite <i>sss</i>
<i>/doris/data/sss/sum</i>	<i>sssdataMMM.LLL.sum.Z</i>	Summary of contents of DORIS data file for satellite <i>sss</i> , cycle number <i>MMM</i> , and file version number <i>LLL</i>
<i>/doris/data/sss/yyyy</i>	<i>sssrXYYDDD.LLL.Z</i>	DORIS data (RINEX format) for satellite <i>sss</i> , date <i>YYDDD</i> , version number <i>LLL</i>
<i>/doris/data/sss/yyyy/sum</i>	<i>sssrXYYDDD.LLL.sum.Z</i>	Summary of contents of DORIS data file for satellite <i>sss</i> , cycle number <i>MMM</i> , and file version number <i>LLL</i>
<i>/doris/data/yyyy</i>	<i>yyddd.status</i>	Summary file of all RINEX data holdings for year <i>yy</i> and day of year <i>ddd</i>
<b>Product Directories</b>		
<i>/doris/products/2010campaign/ccc/cccYYDDDtVV.sss.Z</i>		Time series SINEX solutions for analysis center <i>ccc</i> , starting on year <i>YY</i> and day of year <i>DDD</i> , type <i>t</i> (m=monthly, w=weekly, d=daily) solution, content <i>u</i> (d=DORIS, c=multi-technique), and solution version <i>VV</i> for satellite <i>sss</i>
<i>/doris/products/eop/</i>	<i>cccWWtuVV.eop.Z</i>	Earth orientation parameter solutions for analysis center <i>ccc</i> , for year <i>WW</i> , type <i>t</i> (m=monthly, w=weekly, d=daily), content <i>u</i> (d=DORIS, c=multi-technique), and solution version <i>VV</i>
<i>/doris/products/geoc/</i>	<i>cccWWtuVV.geoc.Z</i>	TRF origin (geocenter) solutions for analysis center <i>ccc</i> , for year <i>WW</i> , type <i>t</i> (m=monthly, w=weekly, d=daily), content <i>u</i> (d=DORIS, c=multi-technique), and solution version <i>VV</i>
<i>/doris/products/iono/</i>	<i>sss/ccssVV.YYDDD.iono.Z</i>	Ionosphere products for analysis center <i>ccc</i> , satellite <i>sss</i> , solution version <i>VV</i> , and starting on year <i>YY</i> and day of year <i>DDD</i>
<i>/doris/products/orbits/</i>	<i>ccc/ccssVV.bXXDDD.eYEEEE.sp1.LLL.Z</i>	Satellite orbits in SP1 format from analysis center <i>ccc</i> , satellite <i>sss</i> , solution version <i>VV</i> , start date year <i>XX</i> and day <i>DDD</i> , end date year <i>YY</i> and day <i>EEE</i> , and file version number <i>LLL</i>
<i>/doris/products/sinex_global/</i>	<i>cccWWuVV.snX.Z</i>	Global SINEX solutions of station coordinates for analysis center <i>ccc</i> , year <i>WW</i> , content <i>u</i> (d=DORIS, c=multi-technique), and solution version <i>VV</i>
<i>/doris/products/sinex_series/</i>	<i>ccc/cccYYDDDtVV.snX.Z</i>	Time series SINEX solutions for analysis center <i>ccc</i> , starting on year <i>YY</i> and day of year <i>DDD</i> , type <i>t</i> (m=monthly, w=weekly, d=daily) solution, content <i>u</i> (d=DORIS, c=multi-technique), and solution version <i>VV</i>
<i>/doris/products/stcd/</i>	<i>cccWWtu/cccWWtuVV.stcd.aaaa.Z</i>	Station coordinate time series SINEX solutions for analysis center <i>ccc</i> , for year <i>WW</i> , type <i>t</i> (m=monthly, w=weekly, d=daily), content <i>u</i> (d=DORIS, c=multi-technique), solution version <i>VV</i> , for station <i>aaaa</i>
<b>Information Directories</b>		
<i>/doris/ancillary/quaternions</i>	<i>sss/yyyy/qbodyYYYYMMDDHHMISS_yyyym</i> <i>mddhhmiss.LLL</i>	Spacecraft body quaternions for satellite <i>sss</i> , year <i>yyyy</i> , start date/time <i>YYYYMMDDHHMISS</i> , end date/time <i>yyyymmddhhmiss</i> , and version number <i>LLL</i>
	<i>sss/qsolpYYYYMMDDHHMISS_yyyymmddh</i> <i>hmiss.LLL</i>	Spacecraft solar panel angular positions for satellite <i>sss</i> , year <i>yyyy</i> , start date/time <i>YYYYMMDDHHMISS</i> , end date/time <i>yyyymmddhhmiss</i> , and version number <i>LLL</i>
<i>/doris/cb_mirror</i>		Mirror of IDS central bureau files

## DORIS Data

SSALTO deposits DORIS data to the CDDIS and IGN servers. Software at the data centers scans these incoming data areas for new files and automatically archives the files to public disk areas using the directory structure and filenames specified by the IDS. Today, the IDS data centers archive DORIS data from six operational satellites (CryoSat-2, HY-2A, Jason-2, Jason-3, SARAL, and Sentinel-3A); data from future missions will also be archived within the IDS. Historic data from Envisat, Jason-1, SPOT-2, -3, -4, -5, and TOPEX/Poseidon, are also available at the data centers. A summary of DORIS data holdings at the IDS data centers is shown in Table 2. The DORIS data from select satellites are archived in multi-day (satellite dependent) files using the DORIS data format 2.1 (since January 15, 2002). This format for DORIS data files is on average two Mbytes in size (using UNIX compression). SSALTO issues an email notification through DORISReport once data are delivered to the IDS data centers. The number of days per file and average latency in 2016 of data availability after the last observation day satellite specific are shown in Table 3.

Table 2. DORIS Data Holdings Summary

Satellite	Time Span	Data Type
CryoSat-2	30-May-2010 through present	Multi-day, RINEX
Envisat	13-Jun-2002 through 08-Apr-2012	Multi-day
HY-2A	01-Oct-2011 through present	Multi-day, RINEX
Jason-1	15-Jan-2002 through 21-Jun-2013	Multi-day
Jason-2	12-Jul-2008 through present	Multi-day, RINEX
Jason-3	17-Feb-2016 through present	RINEX
SARAL	14-Mar-2013 through present	Multi-day, RINEX
Sentinel-3A	23-Feb-2016 through present	RINEX
SPOT-2	31-Mar through 04-Jul-1990	Multi-day
	04-Nov-1992 through 14-Jul-2009	
SPOT-3	01-Feb-1994 through 09-Nov-1996	Multi-day
SPOT-4	01-May-1998 through 24-Jun-2013	Multi-day
SPOT-5	11-Jun-2002 through 30-Nov-2015	Multi-day
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004	Multi-day

Table 3. DORIS Data File Information (2016)

Satellite	DORIS-Format Data			RINEX Data		
	Number of Days/Multi-Day File	Average Latency (Days)	Average File Size (Mb)	Number of Daily Files	Average Latency (Days)	Average File Size (Mb)
CryoSat-2	8	24	2.9	364	3.9	1.6
HY-2A	8	25	3.2	349	3.9	1.9
Jason-2	11	26	6.5	364	3.9	2.6
Jason-3	N/A	N/A	N/A	314	3.2	2.6
SARAL	8	26	3.2	354	3.9	1.8
Sentinel-3A	N/A	N/A	N/A	221*	4*	1.8

\*Note: Over 200 Sentinel-3A files were delivered to the DCs in early 2017; latency figure does not include these new files.

DORIS phase data from CryoSat-2, HY-2A, Jason-2, Jason-3, SARAL, and Sentinel-3A are also available in the format developed for GNSS data, RINEX (Receiver Independent Exchange Format), version 3.0. These satellites have the newer, next generation DORIS instrumentation on

board, which is capable of generating DORIS data compatible with the RINEX format; future satellites will also utilize this type of DORIS receiver. These data are forwarded to the IDS data centers in daily files prior to orbit processing within one-two days (typically) following the end of the observation day. Data from Jason-3 and Sentinel-3A are only available in the RINEX format.

The delay in data delivery to the data centers (in days by satellite) in 2016 is shown in Figure 2. This figure includes an average latency across all satellites providing data in daily files in RINEX format.

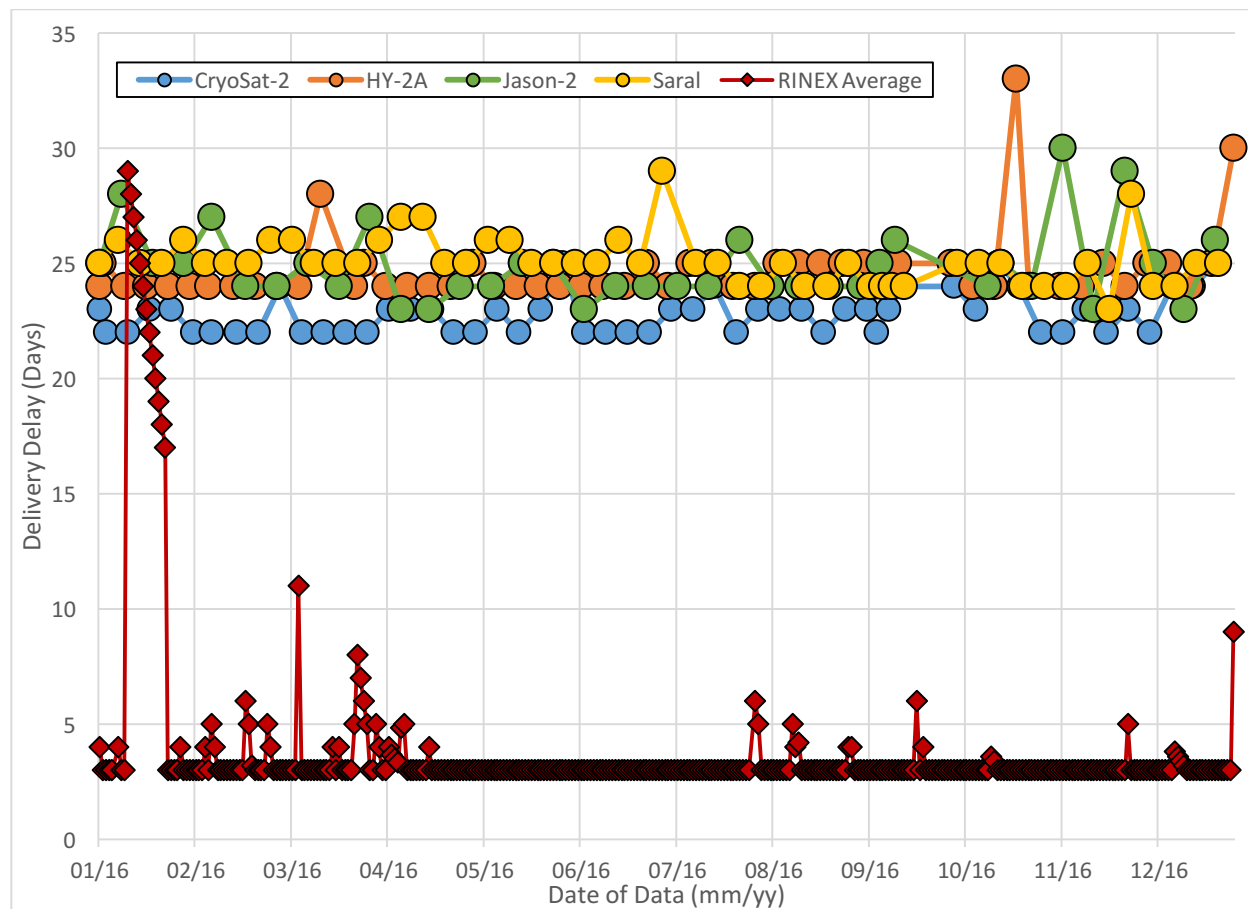


Figure 2. Delay in delivery of DORIS data to the CDDIS (all satellites, 01-12/2016; both multi-day and daily RINEX files)

In the fall of 2012, the IDS Analysis Working Group requested a test data set where data from stations in the South Atlantic Anomaly (SAA) were reprocessed by applying corrective models. Data in DORIS V2.2 format from the Jason-1 satellite (cycles 104 through 536, Jan. 2002 through Jun. 2013) have been submitted to the IDS data centers; a set of SPOT-5 data (cycles 138 through 501, Dec. 2005 through Nov. 2015) have also been submitted and archived. These files are archived at the IDS data centers in campaign directories, e.g., at CDDIS:

*ftp://cddis.nasa.gov/doris/campdata/saacorrection/ja1*  
*ftp://cddis.nasa.gov/doris/campdata/saacorrection/sp5*

## DORIS Products

IDS analysis centers utilize similar procedures by putting products to the CDDIS and IGN servers. Automated software detects any incoming product files and archives them to the appropriate product-specific directory. The following analysis centers (ACs) have submitted products on an operational basis to the IDS; their AC code is listed in ():

- European Space Agency (esa), Germany
- Geoscience Australia (gau) (historic AC)
- Geodetic Observatory Pecny (gop), Czech Republic
- NASA Goddard Space Flight Center (gsc) USA
- Institut Géographique National/JPL (ign) France
- INASAN (ina) Russia
- CNES/CLS (lca historically, grg starting in 2014) France
- CNES/SOD (sod) France (historic AC)
- SSALTO (ssa) France

A solution (designated “ids”) produced by the IDS combination center from the individual IDS AC solutions started production in 2012. IDS products are archived by type of solution and analysis center. The types and sources of products available through the IDS data centers in 2005-2016 are shown in Table 4. This table also includes a list of products under evaluation from several DORIS analysis centers.

Table 4. IDS Product Types and Contributing Analysis Centers

Type of Product	ACs/Products										
	ESA	GAU*	GOP	GRG**	GSC	IDS	IGN	INA	LCA**	SOD*	SSA
Time series of SINEX solutions ( <i>sinex series</i> )	X	X	X	X	X	X	X	X	X	X	X
Global SINEX solutions ( <i>sinex global</i> )				X			X		X		
Geocenter time series ( <i>geoc</i> )							X	X	X		
Orbits/satellite ( <i>orbits</i> )				X	X				X		X
Ionosphere products/satellite ( <i>iono</i> )											X
Time series of EOP ( <i>eop</i> )							X	X			
Time series of station coordinates ( <i>stcd</i> )	X		X	X	X	X	X	X	X		X
Time series of SINEX solutions (2010campaign)		X	X		X		X	X	X		

\*Note: GAU and SOD historic solutions

\*\*Note: CNES/CLS transitioned their AC acronym from LCA to GRG in 2014.

## Supplementary DORIS Information

In 2009 an additional directory structure was installed at the IDS data centers containing ancillary information for DORIS data and product usage. Files of Jason-1, -2, and -3 satellite attitude information were made available through the IDS data centers. Two types of files are available for each satellite: attitude quaternions for the body of the spacecraft and solar panel angular positions. The files are delivered daily and contain 28 hours of data, with 2 hours overlapping between consecutive files. Analysts can use these files in processing DORIS data to determine satellite orientation and attitude information.

## **Future Plans**

The CDDIS and IGN provide reports that list holdings of DORIS data in the DORIS format. The IDS data centers will also investigate procedures to regularly compare holdings of data and products to ensure that the archives are truly identical.

## **IDS Data Centers (2016)**

### **Crustal Dynamics Data Information System (CDDIS)**

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#### *Introduction*

The CDDIS is a dedicated data center supporting the international space geodesy community since 1982. The CDDIS serves as one of the primary data centers for the following IAG services, projects and international groups:

- International DORIS Service (IDS)
- International GNSS Service (IGS)
- International Laser Ranging Service (ILRS)
- International VLBI Service for Geodesy and Astrometry (IVS)
- International Earth Rotation and Reference Frame Service (IERS)
- Global Geodetic Observing System (GGOS)

The CDDIS is one of NASA's Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs); EOSDIS data centers serve a diverse user community and are tasked to provide facilities to search and access science data and products. The CDDIS is also a regular member of the International Council for Science (ICSU) World Data System (WDS).

#### *Operational Activities*

By the end of 2016, the CDDIS has devoted nearly 100 Gbytes of disk space (47% for DORIS data, 29% for DORIS products, and 23% for DORIS ancillary data and information) to the archive of DORIS data, products, and information. During the year, users downloaded approximately 550 Gbytes (805K files) of DORIS data, products, and information from the CDDIS. On average, approximately 200 distinct hosts downloaded DORIS-related files from the CDDIS each month.

The CDDIS automated software archives data submitted by SSALTO and performs minimal quality-checks (e.g., file readability, format compliance) resulting in a summary file for each data file. Software extracts metadata from all incoming DORIS data. These metadata include satellite, time span, station, and number of observations per pass. The metadata are loaded into a database and utilized to generate data holding reports on a daily basis.

The CDDIS provides a file that summarizes the RINEX-formatted data holdings each day. Information provided in the status file includes satellite, start and end date/time, receiver/satellite configuration information, number of stations tracking, and observation types. These files are accessible in yearly sub-directories within the DORIS data subdirectory on CDDIS, <ftp://cddis.nasa.gov/doris/data>.

The CDDIS provided special, limited access space in its archive for IDS Analysis Working Group (AWG) test solutions. This area allowed AWG members to exchange SINEX and orbit files for analysis development and testing.

The CDDIS provides access to two applications for querying site information or archive contents. The Site Log Viewer (accessible on the CDDIS website at URL [https://cddis.nasa.gov/Data\\_and\\_Derived\\_Products/SiteLogViewer/index.html](https://cddis.nasa.gov/Data_and_Derived_Products/SiteLogViewer/index.html)) is an application for the enhanced display and comparison of the contents IAG service site logs; currently the IGS, ILRS, and IDS site logs are viewable through this application. Through the Site Log Viewer application, users can display a complete site log, section by section, display contents of one section for all site logs, and search the contents of one section of a site log for a specified parameter value. Thus, users can survey the entire collection of site logs for systems having particular equipment or characteristics.

The CDDIS Archive Explorer application (accessible on the CDDIS website at URL [https://cddis.nasa.gov/Data\\_and\\_Derived\\_Products/CddisArchiveExplorer.html](https://cddis.nasa.gov/Data_and_Derived_Products/CddisArchiveExplorer.html)) allows users to discover what data are available through the CDDIS. The application allows users, particularly those new to the CDDIS, the ability to specify search criteria based on temporal, spatial, target, site designation, and/or observation parameter in order to identify data and products of interest for download. Results of these queries include a listing of sites and additional metadata satisfying the user input specifications. Such a user interface also aids CDDIS staff in managing the contents of the archive. Future plans for the application include adding a list of data holdings/URLs satisfying the search criteria.

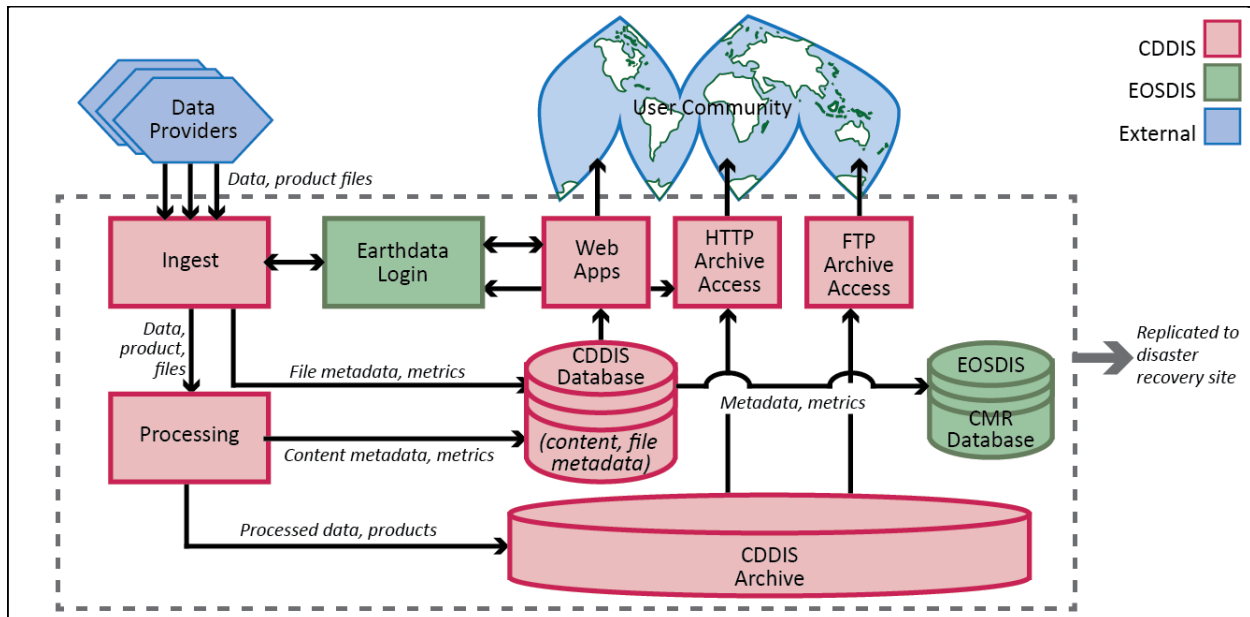
### *Recent Activities and Developments*

Transition to the new CDDIS computer hardware was completed in late November 2016. This new system configuration now provides a more reliable/redundant environment (power, HVAC, 24-hour on-site emergency personnel, etc.) and network connectivity for CDDIS; a disaster recovery system is installed in a different location on the GSFC campus. The new system location addresses a long-time concern for the CDDIS, namely, the lack of consistent and redundant power and cooling in its existing computer facility. Multiple redundant 40G network switches are utilized to take full advantage of a high-performance network infrastructure by utilizing fully redundant network paths for all outgoing and incoming streams along with dedicated 10G network connections between its primary operations and its backup operations. The CDDIS transitioned the majority of its operation services to virtual machine (VM) technology for both multiple instance services in a load balancing configuration which allows additional instances to be increased or decreased due to demand and allows maintenance (patching, upgrades, etc.) to proceed without interruption to the user or any downtime. CDDIS now utilizes a unified storage system (100 Tbytes in size) to easily accommodate future growth of the archive and facilitate near real-time replication between its production and disaster recovery sites. A schematic diagram of the new CDDIS architecture is shown in Figure 1.

One requirement of the new CDDIS computer system involved a change to the file upload process. In the old system, CDDIS used ftp for delivery of data for the archive from both data centers and analysis centers. While this has worked well over the years, transition to the new



system provided an opportunity to update this method to a web-based approach that can utilize a different user sign-on/authentication infrastructure. CDDIS developed a web-based application that allows users to use existing scripts without significant modification but also tie authentication into the NASA system. Staff worked with the groups who submit DORIS data and IDS products to CDDIS to transition their procedures to the new file upload system.



**Figure 1:** System architecture overview diagram for the new CDDIS facility installation within the EOSDIS infrastructure.

CDDIS performed complete rewrite of its file ingest processing software in 2016. This rewrite incorporated numerous disparate programs developed over the years into a single, easily maintained software base which incorporates all the CDDIS requirements for data ingest while also allowing additional flexibility in meeting future metadata requirements. The software was initially modified for incoming GNSS files but will be extended to all incoming files, including DORIS data and products, in the near future.

### *Future Plans*

The CDDIS staff will continue to interface with the IDS Central Bureau (CB), SSALTO, and the IDS analysis centers to ensure reliable flow of DORIS data, products, and information. Enhancements and modifications to the data center will be made in coordination with the IDS CB.

The CDDIS has established Digital Object Identifiers (DOIs) for several of its GNSS data sets; website “landing” pages have been established for these published DOIs. DOIs for additional items, including DORIS data and products, are under development and review prior to registering and implementation.

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