.

423-PLAN-001, Revision A

Earth Science Data and Information Systems Project (ESDIS), Code 423

Operation IceBridge Data Management Plan

Operation IceBridge Data Management Plan
Signature/Approval Page

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Preface

This document is under ESDIS Project configuration control. Once this document is approved, ESDIS approved changes are handled in accordance with Class I and Class II change control requirements described in the ESDIS Configuration Management Procedures. Changes to this document shall be verified by a document change notice (DCN) and implemented by change bars or by complete revision.

This document contains information pertaining to the Operation IceBridge Data Management Plan.

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Abstract

This document is a detailed plan for all management of Operation IceBridge data throughout its project lifecycle ending in 2020. Its content is applicable to all data providers and all data sets unless specific exceptions are made.

Keywords : *IceBridge, NSIDC DAAC, CReSIS, LIDAR, WFF, GSFC, NSERC, CIRRUS, UARC, DMS, Lamont-Doherty, WISE*

Change History Log

Revision	Effective DATE	DESCRIPTION of Changes
Original, Baseline	05/01/2013	CCR 423-ESDIS-43; CCB approved 04/30/2013 Pages: All
Revision A	09/24/2018	CCR 423-ESDIS-195; CCB approved 09/07/2018 Pages: Cover through 25 Acronyms; Extended project lifecycle; revised to current; see DCN for full details

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1 INTRODUCTION

1.1 Purpose

The purpose of a Data Management Plan (DMP) is to address the management of data from Earth science missions, from the time of their data collection/observation, to their entry into permanent archives. The NASA Procedural Requirements (NPR) 7120.8 document states the requirement for a data management plan. Consistent with this requirement, for each of the Earth science missions, NASA Earth Science Division (ESD) requires the responsible projects to develop a DMP as stated in the Level 1 Requirement below:

"All terms and conditions of the transfer of data products and associated information to the NASA Earth Science Division (ESD)-assigned data center shall be documented in a Data Management Plan that has been approved by the Earth Science Data and Information System Project."

1.2 Scope

This document outlines a detailed plan for all aspects of Operation IceBridge data management throughout its project lifecycle until 2020. Its content is applicable to all data providers and all data sets unless specific exceptions are made.

1.3 Related Documentation

The latest versions of all documents below should be used. The latest ESDIS Project documents can be obtained from URL: https://ops1-cm.ems.eosdis.nasa.gov. ESDIS documents have a document number starting with either 423 or 505. Other documents are available for reference in the ESDIS project library website at: http://esdisfmp01.gsfc.nasa.gov/esdis_lib/default.php unless indicated otherwise.

1.3.1 Applicable Documents

The following documents are referenced within or are directly applicable, or contain policies or other directive matters that are binding upon the content of this document.

NPR 7120.8	NASA Research and Technology Program and Project Management Requirements
	NASA Earth Science Data and Information Policy
423-SPEC-001	NASA Earth Science Preservation Specification

1.3.2 Reference Documents

The following documents are not binding on the content but referenced herein and, amplify or clarify the information presented in this document.

	NASA Operation IceBridge Level-1 Science Requirements and Scientific Basis.

2 OVERVIEW

2.1 Mission Description

The Operation IceBridge mission, initiated in 2009, collects airborne remote sensing measurements to bridge the gap between NASA's Ice, Cloud and Land Elevation Satellite (ICESat) mission and the upcoming ICESat-2 mission. Operation IceBridge survey areas include the Greenland and Antarctic ice sheets, Canadian ice caps, Alaskan glaciers, and sea ice in the Arctic and Southern oceans.

Operation IceBridge combines multiple instruments to map ice surface topography, bedrock topography beneath the ice sheets, grounding line position, ice and snow thickness, and sea ice distribution and freeboard. Data from laser altimeters and radar sounders are paired with gravimeter, magnetometer, mapping camera, and other data to provide dynamic, high-value, repeat measurements of rapidly changing portions of land and sea ice.

3 REQUIREMENTS

3.1 Science Data Generation and Documentation

3.1.1 All Operation IceBridge data products shall conform to the terms and conditions of the NASA Earth Science Data and Information Policy, which can be found at: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

3.1.2 Operation IceBridge data providers shall be assigned the responsibility of producing data products for their respective instruments.

3.1.3 To keep end-to-end consistency, Operation IceBridge data providers shall reprocess any given data product (in its entirety, including data from earlier IceBridge campaigns) that requires an algorithm change.

3.1.4 To keep end-to-end consistency, Operation IceBridge data providers shall reformat any given data product (in its entirety, including data from earlier campaigns) that requires a format change.

3.1.5 By the end of mission, Operation IceBridge data providers shall provide all documentation necessary for final archival purposes as spelled out in the NASA Earth Science preservation document at: https://earthdata.nasa.gov/user-resources/standards-and-references/preservation-content-spec

3.1.6 Operation IceBridge data providers shall provide documentation, as specified by NASA/ NSIDC documentation content requirements to facilitate users' understanding and use of their data products. NSIDC User Services will provide template documentation upon request and

will work with data providers to develop appropriate documentation.

3.1.7 Operation IceBridge data providers shall submit product documentation to the National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC) as early as possible before the first delivery of a new product, and be available to work with NSIDC technical writers, to facilitate establishment of the new product. For subsequent data deliveries, data providers shall submit updates to documentation within one week after the submission of data to the NSIDC DAAC for ingest, archive and distribution.

3.1.8 Operation IceBridge L1B and L2 data products shall be organized and partitioned temporally, following each flight's trajectory.

3.2 Science Data Format and Metadata

3.1.1 Operation IceBridge data product formats, with the exception of Level 0 or raw data, shall conform to one of the NASA ESD approved Data System standards. The formats will be selected in collaboration with the ESDIS Project and documented in the Data Stewardship section of this Data Management Plan. The list of existing approved standards, along with guidelines for approval of new standards, can be found at: https://earthdata.nasa.gov/user-resources/standards-and-references . Once decided upon and agreed to, a data set's format should be kept consistent for all future deliveries, unless renegotiated with a plan for reprocessing of existing data.

3.1.2 All data submissions to the NSIDC DAAC shall have accompanying spatial, temporal, and product metadata that adhere to ESD-approved specifications at: https://earthdata.nasa.gov/user-resources/standards-and-references .

4 PROVIDERS, PRODUCTS, AND DEADLINES

This section describes each of the individual data providers, their instruments, the data products that they generate, and their associated submission deadlines. For each data product, the following information is provided.

- Product collection short name
- A brief product description
- Data processing level
- Data format
- Estimated data volume per campaign (GB)
- Submission schedule
- Provider contact information
- Delivery mechanism

Individual providers are required to work with NSIDC on the most appropriate delivery mechanism to use based upon current NASA security requirements, data volume and ease of delivery. Current delivery mechanisms include File Transfer Protocol (FTP_, GridFTP, Secure FTP (SFTP), Serial Converter Processor (SCP), and the shipping of physical hard-drives.

4.1 NASA Wallops Flight Facility

NASA Goddard Space Flight Center's (GSFC) Wallops Flight Facility (WFF), located on Virginia's Eastern Shore, was established in 1945 by the National Advisory Committee for Aeronautics, as a center for aeronautic research. The research and responsibilities of WFF are centered on the philosophy of providing a fast, low cost, highly flexible and safe response to meet the needs of the United States' aerospace technology interests and science research.

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4.1.1 Instruments and Science Data Products

4.1.1.1 Airborne Topographic Mapper

The Airborne Topographic Mapper (ATM) is a scanning Laser Imaging Detection and Ranging (LIDAR) developed and used by NASA for observing the Earth's topography for several scientific applications, foremost of which is the measurement of changing Arctic and Antarctic ice sheets and glaciers. It typically flies on aircraft at an altitude between 400 and 800 meters above ground level, and measures topography to an accuracy better than ten centimeters by incorporating measurements from global positioning system (GPS) receivers and inertial navigation system (INS) attitude sensors.

Table 4-1. ATM Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILATM0	IceBridge ATM L0 Raw Ranges	0	Binary	175	6 months	FTP or equivalent
ILATM1B	IceBridge ATM L1B Qfit Elevation and Return Strength	1B	HDF5	500	6 months following deployment end	FTP or equivalent
ILATMW1B	IceBridge ATM L1B Elevation and Return Strength with Waveforms	1B	HDF5	75	6 moths following deployment end	FTP or equivalent
ILATM2	IceBridge ATM L2 Icessn Elevation, Slope, and Roughness	2	Fixed format ASCII	2	6 months following deployment end	FTP or equivalent
IDHDT4	IceBridge ATM L4 dh/dt	4	Fixed format ASCII	0.2	6 months following deployment end	FTP or equivalent

4.1.1.2 Narrow Swath Airborne Topographic Mapper

The NASA IceBridge Narrow Swath ATM Level-1B Qfit Elevation and Return Strength (ILNSA1B) data set contains spot elevation measurements of Greenland, Arctic, and Antarctic sea ice acquired using the NASA ATM 4CT3 narrow scan instrumentation.

Table 4-2. Narrow Swath ATM Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILNSA1B	IceBridge Narrow Swath ATM L1B Elevation and Return Strength	1B	HDF5	30	6 months following deployment end	FTP or equivalent

4.1.1.3 Continuous Airborne Mapping By Optical Translator

The NASA IceBridge Continuous Airborne Mapping By Optical Translator (CAMBOT) L1B Geolocated Images data set contains images taken over Antarctica and Greenland. The data set contains original CAMBOT files and full

size Joint Pictures Expert Group (JPEG) images, with associated Keyhole Markup Language (KML) files, rotated and reduced-resolution Portable Network Graphics (PNG) image files, and position, altitude and trajectory files.

Table 4-3. CAMBOT Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IOCAM1B	IceBridge CAMBOT L1B Geolocated Images	1B	jpeg	500	6 months following deployment end	Hard drive

4.1.1.4 KT19 Infrared Radiation Pyrometer

The NASA IceBridge KT19 IR Surface Temperature data set contains surface temperature measurements of Arctic sea ice and land ice acquired using the Heitronics KT19.85 Series II Infrared Radiation Pyrometer alongside the NASA ATM instrument.

Table 4-4. KT19 Infrared Radiation Pyrometer Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAKST1B	IceBridge KT19 IR Surface Temperature	1B	Fixed format ASCII	0.5	6 months following deployment end	FTP to NSIDC

4.1.1.5 Pathfinder Advanced Radar Ice Sounder

The IceBridge Pathfinder Advanced Radar Ice Sounder (PARIS) data set contains Greenland ice thickness measurements acquired using the Pathfinder Advanced Radar Ice Sounder (PARIS). The transmit waveform of this radar sounder is a 5 MHz bandwidth chirp generated by a commercial Direct-Digital Synthesizer (DDS) chip. The chip also applies a trapezoidal envelope to the pulse, minimizing unwanted sidebands. The 250 W amplifier uses a class AB mode of operation to ensure high linearity and thus preserve the pulse's low sidebands. Bench tests of the amplifier demonstrated a two-tone third-order inter-modulation of better than -20 dBc measured at PO = 250 W

Table 4-5. KT19 Infrared Radiation Pyrometer Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRPAR2	IceBridge PARIS L2 Ice Thickness	2	ASCII	<1	6 months following deployment	FTP to NSIDC

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
					end	

4.2 University of Kansas Center for Remote Sensing of Ice Sheets

The Center for Remote Sensing of Ice Sheets (CReSIS) is a Science and Technology Center (STC) established by the National Science Foundation (NSF) in 2005, with the mission of developing new technologies and computer models to measure and predict the response of sea level change to the mass balance of ice sheets in Greenland and Antarctica. The NSF's STC program combines the efforts of scientists and engineers to respond to problems of global significance, supporting the intense, sustained, collaborative work that is required to achieve progress in these areas. NSF STC support ended in 2015, but CReSIS continues to operate with other external awards and university support.

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4.2.1 Instruments and Science Data Products

4.2.1.1 Multichannel Coherent Radar Depth Sounder

This Multichannel Coherent Radar Depth Sounder (MCoRDS) radar typically operates over the frequency range from 180 to 210 MHz on the NASA P-3 and 165 to 215 MHz on the NASA DC-8 with multiple receivers developed for airborne sounding and imaging of ice sheets. Multiple receivers permit digital beam-steering for suppressing cross-track surface clutter that can mask weak ice–bed echoes and strip-map Synthetic Aperture Radar (SAR) images of the ice-bed interface. With 1225 W of peak transmit power on the P-3 and a peak transmit power of 6000 W on the DC-8, a loop sensitivity of >230 dB is achieved.

Table 4-6 MCoRDS Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRMCR1B	IceBridge MCoRDS L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	100	6 months	FTP
IRMCR2	IceBridge MCoRDS L2 Ice Thickness	2	CSV	1	6 months	FTP
IRMCR3	IceBridge MCoRDS	3	ASCII	1	6 months	FTP

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
	L3 Gridded Ice Thickness, Surface, and Bottom					

* IRMCR3 volume per campaign is dependent on availability of flight grids and community need for gridded products.

4.2.1.2 Snow Radar

This ultra-wideband radar operates over the frequency from 2 to 8 GHz to map near-surface internal layers in polar firn with fine vertical resolution. Starting in 2017 the Snow Radar was replaced with a single system which operates from 2-18 GHz, sub-band processing of the data will be done to provide simulated data from the historic 2-8 GHz system. The radar also measures the thickness of snow over sea ice. Information about snow thickness is essential to estimate sea ice thickness from ice freeboard measurements performed with satellite radar and laser altimeters.

Table 4-7. Snow Radar Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRSNO1B	IceBridge Snow Radar L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	250	6 months	FTP

4.2.1.3 Accumulation Radar

This radar provides fine depth resolution profiling of the top 100 m of the ice column. It is designed to map variations in the snow accumulation rate. When operated from aircraft, it operates from 600 to 900 MHz providing 28-cm depth resolution in ice.

Table 4-8. Accumulation Radar Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRACC1B	IceBridge Accumulation Radar	1B	NetCDF	150	6 months	FTP, sftp, or scp

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
	L1B Geolocated Radar Echo Strength Profiles					

4.2.1.4 Ku-Band Radar Altimeter

This wideband radar altimeter operates over the frequency range from 12 to 18 GHz. The primary purpose of this radar is high precision surface elevation measurements over polar ice sheets. The data collected with this radar can be analyzed in conjunction with laser-altimeter data to determine thickness of snow over sea ice. Starting in 2017, the Ku Radar was replaced with a single system which operates from 2-18 GHz (3.2.1.2), sub-band processing of the data will be done to provide simulated data from the historic 12-18 GHz system.

Table 4-9 Ku-Band Radar Altimeter Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRKUB1B	IceBridge Ku-Band Radar L1B Geolocated Radar Echo Strength Profiles	1B	NetCDF	250	6 months	FTP

4.3 NASA Goddard Space Flight Center

NASA's Land, Vegetation and Ice Sensor (LVIS), which also includes data from an integrated INS and GPS, is designed, developed and operated by the Laser Remote Sensing Laboratory, at NASA's GSFC.

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4.3.1 Instruments and Science Data Products

4.3.1.1 Land, Vegetation and Ice Sensor

LVIS is a scanning laser altimeter instrument that is flown, by aircraft, over target areas to collect data on surface topography, surface roughness, and vegetation coverage. LVIS has a scan angle of 12°, which produces a 2-km wide swath from a 10-km flight altitude. LVIS is a full-waveform laser altimeter, and, as such, the transmit and return waveforms are collected for each laser shot and released as the LVIS L1B product.

Table 4-10. LVIS Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILVIS0	IceBridge LVIS L0 Raw Ranges	0	Binary	500	1 month following deployment end	Hard drive
ILVGH1B	IceBridge LVIS GH L1B Geolocated Return Energy Waveforms	1B	HDF5	300	6 months following deployment end	FTP
ILVGH2	IceBridge LVIS GH L2 Geolocated Surface Elevation Product	2	Fixed format ASCII	30	6 months following deployment end	FTP
ILVIS1B	IceBridge LVIS L1B Geolocated Return Energy Waveforms	1B	HDF5	300	6 months following deployment end	FTP
ILVIS2	IceBridge LVIS L2 Geolocated Surface Elevation Product	2	Fixed format ASCII	30	6 months following deployment end	FTP
IPPLV1B	IceBridge LVIS POS/AV L1B Corrected Position and Attitude Data	1B	sbet	20	6 months following deployment end	FTP

4.4 National Suborbital Education and Research Center

The National Suborbital Education and Research Center (NSERC) is the product of a cooperative agreement between NASA and the University of North Dakota. NSERC supports science mission operations and aircraft deployments for Earth science research campaigns conducted by the NASA Airborne Science Program. NSERC provides payload integration engineering, data display and networking, and facility instrumentation for NASA's fleet of research aircraft, including the DC-8 and P-3B airborne laboratories, the WB-57 high altitude platform, and the Global Hawk Uninhabited Aerial Vehicle, among others.

NSERC is also responsible for education and outreach activities for the Airborne Science Program, including organization and operation of the Student Airborne Research Program (SARP), a college-level summer internship that provides hands-on research experience in airborne science using NASA's flying laboratories.

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4.4.1 Instruments and Science Data Products

4.4.1.1 On-board Meteorology Suite

This is a collection of airborne in-flight meteorological and in-cabin measurements, and thermal emission measurements of near-nadir surface skin temperature. Instruments flown over Antarctica include cabin pressure transducer, 3-stage hygrometer, 2-stage hygrometer, total air temperature sensor, and infrared surface temperature pyrometer. The data files contain measurements for 36 meteorological, surface characteristic, and positional variables.

Table 4-11. On-board Meteorology Suite Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAMET1B	IceBridge NSERC L1B Geolocated Meteorological and Surface Temperature Data	1B	ICARTT	<1	1 month after deployment	FTP

4.5 The Airborne Sensor Facility

The Airborne Sensor Facility (ASF) at NASA Ames (ARC) and Armstrong Research Centers provides data system development and operations, and payload integration services for the Airborne Science Program. It is also responsible for the development and operation of remote sensing instruments for the NASA Earth Observing System (EOS) Project Science Office, that are used for satellite calibration and validation, process studies, and algorithm development. This includes field operations, data processing, and the operation of a NIST-traceable calibration laboratory

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4.5.1 Instruments and Science Data Products

4.5.1.1 Digital Mapping System Camera

The Digital Mapping System (DMS) is an airborne digital camera that acquires high resolution natural color and panchromatic imagery from low and medium altitude research aircraft. Data acquired by DMS are used by a variety of scientific programs to monitor variation in environmental conditions, assess global change, and respond to natural disasters.

The DMS instrument is maintained and operated by the ASF located at the NASA ARC in Mountain View, California, under the oversight of the EOS Project Science Office at NASA Goddard.

Table 4-12. Digital Mapping System Camera

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IODCC0	IceBridge DMS L0 Camera Calibration	0	PDF	1	90 days	Hard Drive
IODMS0	IceBridge DMS L0 Raw Imagery	0	jpg	5120	90 days	Hard drive
IODMS1B	IceBridge DMS L1B Geolocated and Orthorectified Images	1B	geotiff	9216	90 days	Hard drive
IPAPP1B	IceBridge POS/AV L1B Corrected Position and Attitude Data	1B	sbet	35	90 days	FTP

4.6 Cirrus Digital Systems

Cirrus Digital Systems is a California based company that processes DMS stereographic imagery and ATM Lidar into a Level 3 Hybrid Surface Model (HSM). The HSM possesses the elevation accuracy of ATM and visual realism and surface resolution of DMS imagery.

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4.6.1 Instruments and Science Data Products

4.6.1.1 Cirrus HSM

Table 4-13. Cirrus HSM

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IODMS3	IceBridge DMS L3 Photogrammetric DEM	3	geotiff	~2000	6 months (requires L1B ATM data)	Hard Drive or BD-ROM

4.7 Lamont-Doherty Earth Observatory

Lamont-Doherty Earth Observatory seeks fundamental knowledge about the origin, evolution and future of the natural world. Its scientists study the planet from its deepest interior to the outer reaches of its atmosphere, on every continent and in every ocean, providing a rational basis for the difficult choices facing humanity.

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4.7.1 Instruments and Science Data Products

4.7.1.1 Magnetometer

The NASA IceBridge Scintrex CS-3 Cesium Magnetometer records magnetic field readings and fluxgate values.

Table 4-14. Magnetometer

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IMCS30	IceBridge Scintrex	0	ASCII	20	5 Months	FTP

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
	CS-3 Cesium Magnetometer L0 Raw Magnetic Field				after campaign	
IMCS31B	IceBridge Scintrex CS-3 Cesium Magnetometer L1B Geolocated Magnetic Anomalies	2	ICART T	4	5 Months after campaign	FTP

4.7.1.2 Gravimeter

This gravimeter is a Sander Geophysics AIRGrav airborne gravity system. The AIRGrav data consist of measurements of aircraft attitude and acceleration. Aircraft attitude is provided as one file per flight. Gravity data include latitude and Eötvös corrected values, and the free air correction at various along-flight-line spatial filtering scales. Gravity data are organized temporally.

Table 4-15. Gravimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IGGRV1B	IceBridge Sander AIRGrav L1B Geolocated Free Air Gravity Anomalies	2	ICART T	4	5 Months after campaign	FTP
IGBTH3	IceBridge Sander AIRGrav L3 Bathymetry	4	ASCII	1	1 year	FTP
IGBTH4	IceBridge Sander AIRGrav L4 Bathymetry	4	ASCII	2	1 year	FTP

4.8 University of Texas

The University of Texas Institute for Geophysics (UTIG) is an academic research center best known for projects with an international scope. Prominent research areas include marine geology and geophysics, tectonics, terrestrial and lunar seismology, quantitative and exploration geophysics, and geophysical studies of ice sheets and of climate.

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4.8.1 Instruments and Science Data Products

4.8.1.1 GPS / Inertial Measurements

Two GPS-aided Inertial Measurement Units (IMU) are included in this suite. One is standalone and one is integrated with the Scanning Lidar.

Table 4-16. GPS / IMU

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IPUTG0	IceBridge GPS L0 Raw Satellite Navigation Data	0	ELSA/ NMEA	1	2 months post field; non critical	FTP
IPUTI0	IceBridge IMU L0 Raw Inertial Measurement Unit Data	0	ELSA/ MMQ-50/Novatel	1	2 months post field; non critical	FTP
IPUTG1B	IceBridge GPS/IMU L1B Primary Position and Attitude Solution	1B	ASCII	<1	4 months post field	FTP
IPUTN1B	IceBridge GPS L1B Time-Tagged Real-Time Position and Attitude Solution	1B	ASCII	<1	2 months post field	FTP
ITKTC0	IceBridge L0 Raw Kinematics GPS Time Codes	0	ELSA/ ASCII time stamps	<1	2 months post field; non critical	FTP

4.8.1.2 Gravimeter

Three gravimeters have been used by Texas for Operation IceBridge: a Bell Aerospace BGM-3 (#203); a ZLS Corporation ZLS (#S-83); and a Canadian Microgravity GT-1A (#3).

Table 4-17. Gravimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IGBGM0	IceBridge BGM-3 Gravimeter L0 Raw Accelerations	0	ELSA/ Counts per second	<1	2 months post field; non critical *(retired after AN11)*	FTP
IGBGM1B	IceBridge BGM-3 Gravimeter L1B Time-Tagged Accelerations	1B	ASCII	<1	2 months post field; *(retired after AN11)*	FTP
IGBGM2	IceBridge BGM-3 Gravimeter L2 Geolocated Free Air Anomalies	2	ASCII	<1	4 months post field; *(retired after AN11)*	FTP
IGZLS1B	IceBridge ZLS Dynamic Gravity Meter Time-Registered L1B Vertical Accelerations	1B	ASCII	<1	2 months post field; *(only used for AN11)*	FTP
IGCMG1B	IceBridge CMG 1A Dynamic Gravity Meter Time-Tagged L1B Vertical Accelerations	1B	ASCII	<1	2 months post field; *(only used for AN12)*	FTP
IGCMG2	IceBridge CMG GT-1A Gravimeter L2 Geolocated Free Air Gravity Disturbances	2	ASCII	<1	4 months post field; *(only used for AN12)*	FTP

4.8.1.3 High Capability Radar Sounder (HiCARS)

This is a Very High Frequency (VHF) ice-penetrating radar which operates in frequency-chirped mode from 52.5 to 67.5 MHz. HiCARS allows for phase coherent recording of radar returns for advanced processing. For antennas the system uses twin flat dipoles, one mounted under each aircraft wing providing approximately 18 dB of two-way antenna gain. The peak instantaneous output power is 8kW.

Table 4-18 HiCARS

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IR1HI0	IceBridge HiCARS 1 L0 Raw Return Energy Amplitudes	0	16-bit offset video Binary	1500	2 months post field; non critical *(retired after AN10)*	Hard drive
IR1HIB	IceBridge HiCARS 1 L1B Time-Tagged Echo Strength Profiles	1B	NetCDF	120	2 months post field; *(retired after AN10; format pending NSIDC approval)*	Hard drive
IR1HI2	IceBridge HiCARS 1 L2 Geolocated Ice Thickness	2	ASCII	<1G	4 months post field; *(retired after AN10)*	FTP
IR2HI0	IceBridge HiCARS 2 L0 Raw Return Energy Amplitudes	0	16-bit offset video Binary	1500	2 months post field; non critical *(used after AN10)*	Hard drive
IR2HI1B	IceBridge HiCARS 2 L1B Time-Tagged Echo Strength Profiles	1B	NetCDF	120	2 months post field; *(used after AN10 format pending NSIDC approval)*	Hard drive
IR2HI2	IceBridge HiCARS 2 L2 Geolocated Ice Thickness	2	ASCII	<1	4 months post field; *(retired after AN10)*	FTP

4.8.1.4 Laser Altimeter

This is a fixed, nadir pointing Riegl laser altimeter, which is the predecessor to the scanning, Sigma Space lidar.

Table 4-19 Laser Altimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILUTP0	IceBridge Riegl Laser Altimeter L0 Raw Ranges	0	ELSA/ Riegl	<1	2 months post field; non critical	FTP
ILUTP1 B	IceBridge Riegl Laser Altimeter L1B Time-Tagged Laser Ranges	1B	ASCII	<1	2 months post field	FTP
ILUTP2	IceBridge Riegl Laser Altimeter L2 Geolocated Surface Elevation Triplets	2	ASCII	<1	4 months post field	FTP

4.8.1.5 Scanning Lidar

This is a multi-beam, scanning photon-counting lidar built by Sigma Space. It images the surface below the aircraft with one hundred laser beamlets. This system is mechanically scanned in a swath either side of the flight path. A one hundred channel photon counting receiver captures return photons and records time of flight and time tag data allowing a three-dimensional reconstruction of the surface. At a survey altitude of 800 m, swath width is around 400 m.

Table 4-20 Scanning Lidar

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILSSP0	IceBridge Sigma Space Prototype L0 Raw Time-of-Flight Data	0	Sigma Space binary	~1000 to 3000	2 months post field; non critical *(Retired after AN09)*	Hard drive
ILSIG0	IceBridge Sigma Space Lidar L0 Raw Time-of-Flight Data	0	Sigma Space binary	~1000 to 3000	2 months post field; non critical	Hard drive
ILSIG1	IceBridge Photon	1B	HDF	250	4 months	Hard

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
B	Counting Lidar L1B Unclassified Geolocated Photon Elevations					drive
ILSNP1B	IceBridge Sigma Space Photon Counting Lidar L1B Time-Tagged Nadir Photon Ranges	1B	HDF5 (details TBD)	~1000	4 months post field	Hard drive
ILSNP4	IceBridge Merged Photon Counting Lidar/Profiler L4 Surface Slope and Elevations	4	HDF	<1	4 months post field	FTP

4.8.1.6 Magnetometer

There are two magnetometers used for these products. One is a cesium vapor magnetometer used for scalar geomagnetic field strength measurements. The other is a three-axis fluxgate magnetometer used to provide vector magnetic field data for use by the cesium magnetometer.

Table 4-21. Magnetometer

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IMFGM0	IceBridge Flux Gate Magnetometer L0 Raw Magnetic Field	0	ELSA/3 channel voltages (HEX)	<1	2 months post field; non critical	FTP
IMGEO0	IceBridge Geometrics 823A Cesium Magnetometer L0 Raw Magnetic Field	0	ELSA/ Geometr ics	<1	2 months post field; non critical	FTP
IMGEO1 B	IceBridge Geometrics 823A Cesium Magnetometer L1B Time-Tagged Magnetic Field	1B	ASCII	<1	2 months post field	FTP
IMGEO2	IceBridge Geometrics 823A Cesium Magnetometer L2 Geolocated Magnetic Anomalies	2	ASCII	<1	2 months post field	FTP

4.8.1.7 Pressure Altimeter

This instrument measures air pressure via a Paroscientific S-1000 Digiquartz Transmitter.

Table 4-22. Pressure Altimeter

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAPRS0	IceBridge Paroscientific S-1000 L0 Pressure Altimeter Raw Air Pressure	0	ELSA	<1	2 months post field; non critical	FTP

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IAPRS1B	IceBridge Paroscientific S-1000 L1B Pressure Altimeter Time-Tagged Air Pressure	1B	ASCII	<1	2 months post field	FTP

4.9 University of Alaska Fairbanks

The University of Alaska Fairbanks (UAF) is a public research university home to seven major research areas. The Geophysical Institute is one of the seven that conducts research into space physics, atmospheric science, seismology, tectonics, and sedimentation.

Provider POCs	Email Address
Christopher Larsen	cflarsen@alaska.edu

4.9.1 Instruments and Science Data Products

4.9.1.1 Glacier Lidar

This Glacier Lidar system is capable of generating both surface profiles and scanned altimetry data.

Table 4-23 Glacier Lidar

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
ILAKP1B	IceBridge UAF Lidar Profiler L1B Geolocated Surface Elevation Triplets	1B	Binary	20	3 months	FTP
ILAKS1B	IceBridge UAF Lidar Scanner L1B Geolocated Surface Elevation Triplets	1B	LAS	135	3 months after campaign	FTP
IPUAF1B	IceBridge UAF GPS/IMU L1B Corrected Position and Attitude Data	1B	ASCII	1	3 months after campaign	FTP

4.10 University of California Irvine

The University of California Irvine's (UCI) department of Earth System Science supports the Rignot Research Group. Relative to Operation IceBridge, the group measures ice thickness with an airborne ground penetrating radar called the Warm Ice Sounding Explorer (WISE) which operates at a center frequency of 2.5 MHz and is optimized to probe temperate ice.

Provider POCs	Email Address
Eric Rignot	eric.j.rignot@jpl.nasa.gov
Jeremie Mouginot	jmougino@uci.edu
Bernd Scheuchl	bscheuch@uci.edu

4.10.1 Instruments and Science Data Products

4.10.1.1 WISE

This sounder uses 120-mlong wavelengths to penetrate past rough ice surfaces, voids, water pockets, water-filled cracks, and temperate ice (ice at the in-situ-pressure melting point) before they are reflected by the interface between ice and the glacier bed. This makes the system well suited for the study of outlet glaciers with challenging internal structure, i.e. highly absorptive or scattering heterogeneities associated with the presence of liquid water pockets within the ice.

Table 4-24. WISE

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRWIS2	IceBridge WISE L2 Ice Thickness and Surface Elevation	2	ASCII	14	6 months	FTP

4.11 Miscellaneous

4.11.1 Data Products

4.11.1.1 Flight Reports

Table 4-25. Flight Reports

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IFLTRPT	IceBridge Mission Flight Reports	n/a	ASCII and PDF	1	6 months	FTP

4.11.1.2 Derived Products

The NASA IceBridge Sea Ice Freeboard, Snow Depth, and Thickness (IDCSI4) data set contains derived geophysical data products including sea ice freeboard, snow depth, and sea ice thickness measurements in Greenland and Antarctica retrieved from IceBridge Snow Radar, DMS, CAMBOT, and ATM data sets. The data were collected as part of Operation IceBridge funded campaigns, are stored in American Standard Code for Information Interchange (ASCII) text files, and are available via FTP for periodic, ongoing campaigns from 31 March 2009 to the present.

Provider POCs	Email Address
Nathan Kurtz	nathan.t.kurtz@nasa.gov

Table 4-26. Sea Ice Science Data Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IDCSI2	IceBridge Sea Ice Freeboard, Snow Depth, and	2	ASCII	< 1	12 month following deployment	FTP

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
	Thickness				end	
IDCSI 4	IceBridge L4 Sea Ice Freeboard, Snow Depth, and Thickness	4	ASCII	<1	12 months	FTP

The Bed Machine data set contains a bed topography/bathymetric map of Greenland based on mass conservation, multi-beam data, and other techniques. The data set also includes surface elevation, ice thickness and an ice/ocean/land mask

Provider POCs	Email Address
Mathieu Morlighem	mathieu.morlighem@uci.edu

Table 4-27. Sea Ice Science Data Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IDBMG 4	IceBridge BedMachine Greenland	4	NetCDF	3	12 months	FTP

The following Tomographic derived products were developed by NASA Jet Propulsion Laboratory (JPL) for swath ice sounding. Data was collected by the MCoRDS instrument and processed into bed topography products: ice thickness maps, ice thickness error maps, basal elevation maps, and basal reflectivity maps.

Provider POCs	Email Address
Xiaoqing Wu	Xiaoqing.Wu@jpl.nasa.gov

Table 4.28. Tomographic Products

Short Name	Product Description	Data Level	Format	Volume per Campaign (GB)	Submission Schedule	Delivery Mechanism
IRTIT 3	IceBridge Radar L3 Tomographic Ice Thickness	3	HDF5	2	12 Months	FTP
IRTTE 3	IceBridge Radar L3 Tomographic Thickness Error	3	HDF5	2	12 Months	FTP

5 DATA STEWARDSHIP

The NSIDC DAAC, with support from the ESDIS Project, is responsible for ingest, archive, and distribution of all IceBridge data products. This includes Level 0 data (where specified), higher level products, ancillary data, metadata, algorithm source code, documentation, and other information in accordance with EOS Data and Information System (EOSDIS) archive policies. Responsibilities also include the distribution of the above-mentioned products to users in accordance with the IceBridge mission and EOSDIS data distribution policies. Public release of these data shall conform to the NASA Earth Science Data and Information Policy, which can be found at: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

Previously, NSIDC used an abbreviated ingest process ("fasttrack") which circumvented the approved NASA processes and standards in order to make data available as quickly as possible, and enabled data providers to deliver data with minimal metadata and documentation. That process will no longer be available. All data will be delivered to NSIDC using the steps described below unless ESDIS and the IceBridge Project Science Office grant specific exceptions.

In order to ensure that NASA's expectations for data preservation and usability are met, NSIDC may delay publication of any data set that is not delivered with full documentation (as specified in the NASA documentation content specifications) or that does not meet delivery requirements.

5.1 Acceptance of New Data Sets

Before a new IceBridge data product is sent to the NSIDC DAAC, the following steps must first be implemented:

5.1.1 A description of the data product in question will be documented by the provider and sent to the Operation IceBridge Project Science Office, the ESDIS Project, and the NSIDC DAAC. This description will include:

> a) A description of the science content of the data product and its relevance to Operation IceBridge science requirements.
> b) Level of product (0-4)
> c) Expected data volume (per life of mission)
> d) Current archive location

5.1.2 Review by ESDIS and the Project Science Office. Any new product that is proposed will be reviewed by ESDIS and the Operation IceBridge Project Science Office to make sure that the product is scientifically relevant, within the scope of the Operation IceBridge mission objectives, and that sufficient resources are available to support it. An evaluation of its current archive status will be made to determine if the product can be "brokered", or linked, from its existing location rather than ingested into NSIDC's data archive. Only when data is judged to be safely archived and sufficiently documented will a brokering arrangement be considered. In the case of brokering, NSIDC enables discovery of the data through appropriate links,

but bears no further responsibility to the data.

5.1.3 Create appropriate short names and long names for each data product. NSIDC will do this in conjunction with the provider.

5.1.4 ESDIS will update this Data Management Plan.

5.2 Data Submission Process

This process applies to all IceBridge data sets that are not currently archived in NSIDC's Earth Core System (ECS) system (unless ESDIS and the IceBridge Project Science Office grant an exception). As of March 2013, only UARC has been granted said exception for the DMS data sets.

As part of each new submission, each provider must provide NSIDC with the information required to create and validate an Earth Science Data Type (ESDT) that defines the structure of the data set. Once created, the ESDT is maintained as long as the data set structure does not change.

The provider is responsible for providing NSIDC with information required for any updates to the ESDT and notifying NSIDC if changes are planned to the content or structure of the data set. The ESDT must be consistent with the content of expected data delivery.

In order to efficiently ingest data into NSIDC's ECS system, ESDIS has created (through its ECS contractor) a generic tool for creation of necessary metadata and associated files. This tool, called "SIPSMetGen", is given to each provider along with associated configuration files for its correct operation.

Details of how to run the SIPSMetGen tool will be included with the tool package. Details of how data ingestion to NSIDC will now work using SIPSMetGen can be found in the IceBridge Science Investigator-led Processing System (SIPS) Operational Concept Document located at:

https://n5eil01u.ecs.nsidc.org/PullDir/OIB_SIPSMetGen/latest/SIPSMetGen_2.0.1_UserGuide.pdf

The providers retain full responsibility for data and control over metadata quality. This process is simply a mechanism for automated ingest to NSIDC.

5.2.1.1 Before the first submission, the provider is responsible for performing integration testing with NSIDC to ensure that data will routinely be ingested successfully without excessive manual intervention by NSIDC's Operations staff.

5.2.1.2 The provider is responsible for running the SIPSMetGen tool and creating the necessary metadata and Product Delivery Record (PDR) files before each data submission. After receipt of ingest status notices from ECS, the provider (with support from NSIDC and the ECS contractor) is responsible for all error correction and re-delivery.

5.3 Naming Conventions

Science data files and their associated supporting files (such as browse, quality assurance, preliminary metadata ("premet"), and spatial files) must use a standard naming convention. A file and its associated files should use the same name; the file extension distinguishes the data file from the associated files. File names should include the ESDT shortname, date and time of data collection, version identification, and any additional information that might be needed to uniquely identify the data file.

Example, for ATM L1B data:

Data file: ILATM1B_V01_04212010_04452366_A.h5

Premet file: ILATM1B_V01_04212010_04452366_A.premet

Spatial file: ILATM1B_V01_04212010_04452366_A.spatial

Abbreviations and Acronyms

AK	Alaska
ARC	AMES Research Center
ASCII	American Standard Code for Information Interchange
ASF	Airborne Sensor Facility
ATM	Airborne Topographic Mapper
CAMBOT	Continuous Airborne Mapping by Optical Translator
CReSIS	Center for Remote Sensing of Ice Sheets
CSV	Comma Separated Value
DAAC	Distributed Active Archive Center
dB	Decibel
DCN	Document Change Notice
DDS	Direct-Digital Synthesizer
DMS	Digital Mapping System
ECS	EOSDIS Core System
EED	EOSDIS Evolution and Development
ELSA	Environment for Linked Stream Acquisition
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESD	Earth Science Division
ESDIS	Earth Science Data and Information System
ESDT	Earth Science Data Type
FTP	File Transfer Protocol
GB	Giga Byte 10^9 bytes
GHZ	Giga Hertz
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HEX	Hexadecimal
HiCARS	High Capability Radar Sounder
HSM	Hybrid Surface Model
ICARTT	International Consortium for Atmospheric Research on Transport and Transformation
ICESat	Ice, Cloud and Land Elevation Satellite
IMU	Inertial Measurement Units
INS	Inertial Navigation System
JPEG	Joint Pictures Expert Group
JPL	Jet Propulsion Laboratory
Km	Kilometers
KML	Keyhole Markup Language
L0 – L4	Level 0 through Level 4
LAS	Live Access Server
LIDAR	Laser Imaging Detection and Ranging

LVIS	Land, Vegetation, and Ice Sensor
MB	Mega Byte 10^6 bytes
Mbps	Mega bits per second
MCoRDS	Multichannel Coherent Radar Depth Sounder
MHz	Mega Hertz
NASA	National Aeronautics and Space Administration
NMEA	National Marine Electronics Association
NetCDF	Network Common Data Form
NIST	National Institute of Standards and Technology
NSERC	National Suborbital Education and Research Center
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
PARIS	Pathfinder Advanced Radar Ice Sounder
PDF	Portable Document Format
PDR	Product Delivery Record
PNG	Portable Network Graphics
POC	Point of Contact
POS	Product Order Status
SAR	Synthetic Aperture Radar
SARP	Student Airborne Research Program
SCP	Secure Copy Protocol
SFTP	Secure FTP
SIPS	Science Investigator-led Processing System
STC	Science and Technology Center
TBD	To Be Determined
UAF	University of Alaska Fairbanks
UARC	University Affiliated Research Center
UC	University of California
UCI	University of California Irvine
UTIG	University of Texas Institute for Geophysics
VHF	Very High Frequency
WFF	Wallops Flight Facility
WISE	Warm Ice Sounding Explorer
ZLS	Zero-Length Spring Corporation