Technical Proposal in response to: ESDIS "Adaptive Approach" for Standard Product Generation using Science Investigator-led Processing Systems.

Title: ICESat Science Investigator-led Processing Systems (I-SIPS) for GLAS

SIPS Manager:

______________________ Date___________
H. Jay Zwally
Code 971
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Ph: 301-286-8239
FAX: 301-286-0240
Jay.Zwally@gsfc.nasa.gov

Business Contact:

H. Jay Zwally
Code 971
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Ph: 301-286-8239
FAX: 301-286-0240
Jay.Zwally@gsfc.nasa.gov

Concurrence:

_____________________ Date___________
Bob E. Schutz, Leader
GLAS Science Team

Authorizing Officials for Goddard Space Flight Center:

______________________ Date __________
Chet Koblinsky, Head
Oceans and Ice Branch

______________________ Date __________
Antonio J. Busalacchi, Chief
Laboratory for Hydrospheric Processes

______________________ Date __________
Vincent V. Salomonson
Director of Earth Sciences

Table of Contents

1.0 Abstract

The Geoscience Laser Altimeter System (GLAS) is a nadir-pointed laser altimeter designed to measure ice sheet topography and associated temporal changes, cloud and atmospheric properties, land topography and vegetative canopy. GLAS will be flown on the Ice, Cloud, and Elevation Satellite (ICESat).

Our plan is to augment the functions of the ICESat Scientific Computer Facility (SCF) to produce all GLAS standard data products. The plan has been developed in response to the Science Investigator-led Processing Systems (SIPS) "adaptive approach” proposal request for the future Earth Observing System Data and Information System (EOSDIS). The GLAS Science Team (GST) believes this will improve the efficiency of the GLAS standard data processing. In particular, both the development of the data processing software and the implementation of SIPS will be closely coordinated activities under the direction of the GLAS Science Team member, Dr. Jay Zwally. The GST leader, Dr. Bob Schutz, will maintain the responsibilities as described in the GLAS statement of work for the ICESat data production operations support.

The SIPS activity will produce all the Level 1 and Level 2 data products from the GLAS instrument data and will deliver them to the Earth Science Data and Information System (ESDIS) Project for archiving and for general distribution to the scientific community. The modest data rate for GLAS and the experience of the team members enables an efficient approach that will insure the production of optimum data products in a timely and cost-efficient manner for distribution to the user community.

2.0 Project Description

This proposal defines how the ICESat Project GLAS Science Team (GST) and the ESDIS Project will jointly satisfy the NASA operational production and distribution of data product for the GLAS science experiment. The GST will perform product generation data processing. The DAAC will archive and distribute the GLAS data products. This adaptive approach has been described by ESDIS in the Interface Requirements Document (IRD) "Interface Responsibilities for Standard Product Generation Using Science Investigator-led Processing Systems (SIPS)." The ICESat SIPS (I-SIPS) is fully compliant with the IRD.

2.1 Standard Product Generation Concept

Since ICESat became an approved EOS project, the GLAS data products have been carefully reviewed and redesigned so that they more closely align to the algorithms and to the expected software design that will produce them. There are fifteen GLAS standard data products and a number of associated ancillary files. These products have been divided into Level 1A, 1B, 2A and 2B categories. Figure 2-1 shows the data flow between the GLAS SCF, NSIDC and other facilities. A number of the Level 1 products are organized by time without any earth location.

- Level 1A Data Product: GLA01 - altimetry range and waveforms after calibration for temperature and instrument effects.
- Level 1A Data Product: GLA02 - atmospheric data after calibration for temperature and instrument effects.
- Level 1A Data Product: GLA03 - engineering data.
- Level 1A Data Product: GLA04 - Stellar Reference System and GPS data.
- Level 1B Data Product: GLA05 - waveform post-processing range and surface roughness algorithm results, special algorithms expected for land, sea ice, ocean, and ice sheets.
- Level 1B Data Product: GLA06- Geodetic Data Record for altimetry with range, position, surface roughness, and all geodetic and post-processing corrections required to calculate an accurate elevation.
- Level 1B Data Product: GLA07 - atmospheric backscatter.
- Level 2A Data Product: GLA08 - boundary layer height.
- Level 2A Data Product: GLA09 - cloud height for multiple layers.
- Level 2A Data Product: GLA10 - aerosol vertical structure.
- Level 2B Data Product: GLA11 - Thin cloud/aerosol optical depth.
- Level 2B Data Products: GLA12-15 - corrected surface elevations, position, and associated geodetic corrections for the type of topography (land, sea ice, ocean, ice sheets).

The products with their sizes and parameters are defined in Table 2-1 through Table 2-4.

The level 1A and some of the level 1B GLAS standard data products are not geo-located. The geo-located level 1B GLAS products are mainly used to generate the level 2 products. While it is not planned to widely distribute the geo-located level 1B GLAS products, the GST will archive and make them available for those who require this data.

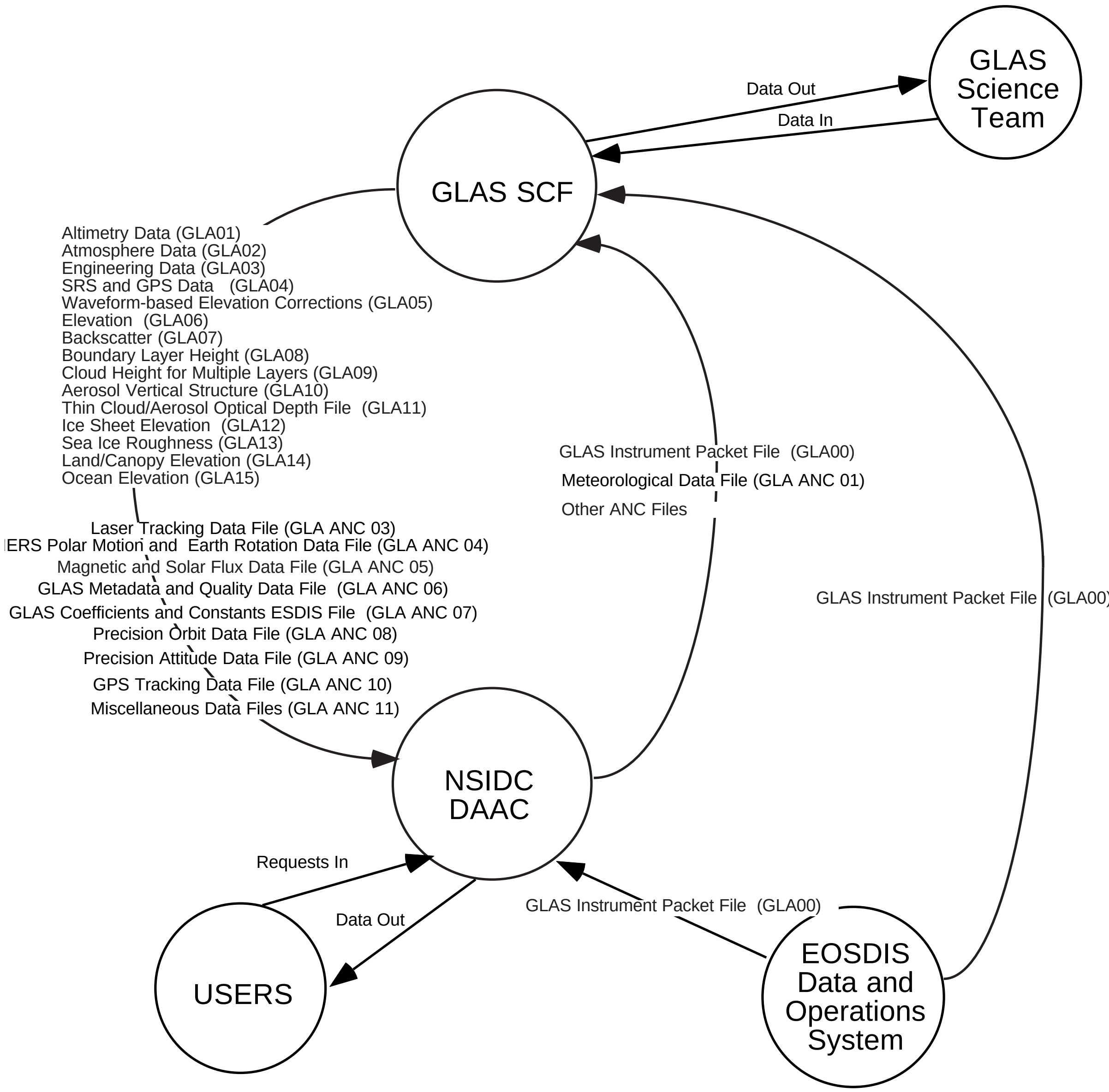

Figure 2-1 Data Flow Between GLAS SCF and NSIDC

We have used for this study a generic 24-hour day block for file sizing of each data product. The exact packaging, formatting, and granules for each data product will be defined during the detailed design phase of the science data software development.

Table 2-1 GLAS Level 0 Standard Data Products

Product ID	Product Name	Product Level	Number of Parameters	Volume (MBytes per Day)
GLA00	GLAS Instrument Packet	0	7	5086.39

Table 2-2 GLAS Level 1 Standard Data Products

Product ID	Product Name	Product Level	Number of Parameters	Volume (MBytes per Day)
GLA01	Altimetry Data	1A	5	1531.83
GLA02	Atmosphere Data	1A	7	4791.83
GLA03	Engineering Data	1A	4	71.32
GLA04	SRS and GPS Data	1A	7	2414.06
GLA05	Waveform-based Elevation Corrections	1B	5	797.74
GLA06	Elevation	1B	8	537.24
GLA07	Backscatter	1B	5	5674.75

Table 2-3 GLAS Level 2 Standard Data Products

Product ID	Product Name	Product Level	Number of Parameters	Volume (MBytes per Day)
GLA08	Boundary Layer Height	2A	6	6.43
GLA09	Cloud Height for Multiple Layers	2A	6	184.20
GLA10	Aerosol Vertical Structure	2A	8	448.98
GLA11	Thin Cloud/Aerosol Optical Depth	2B	7	9.94
GLA12	Ice Sheet Elevation	2B	8	167.10
GLA13	Sea Ice Roughness	2B	8	158.80
GLA14	Land/Canopy Elevation	2B	10	180.58
GLA15	Ocean Elevation	2B	8	158.63

Table 2-4 GLAS Ancillary Data Products

Product ID (Identification)	Product Name	Volume (MBytes per Day)
GLA ANC 01	Meteorological Data File	2.07
GLA ANC 03	Laser Tracking Data File	2.07
GLA ANC 04	IERS Polar Motion and Earth Rotation Data File	1.04
GLA ANC 05	Magnetic and Solar Flux Data File	1.04
GLA ANC 06	GLAS Metadata and Data Product Quality Data File	2.07
GLA ANC 07	GLAS Coefficients and Constants ESDIS File	1.00
GLA ANC 08	Precision Orbit Data File	2.07
GLA ANC 09	Precision Attitude Data File	2.07
GLA ANC 10	GPS Tracking Data File	2.07
GLA ANC 11	Miscellaneous	1.00

All delivered standard data products will be in either HDF or HDF-EOS format, and the current recommendation is level 1 in HDF and level 2 in HDF-EOS. The final design will provide all the standard data products in formats agreed to by ESDIS and established in the I-SIPS ICD. Each data product will contain metadata describing and summarizing the product so that users can quickly determine if the product contains sufficient data in the user's area of interest and has the quality to be worth retrieving for detailed analysis.

In addition to the GLAS standard data, the I-SIPS will provide metadata and browse data to the NSIDC in EOSDIS standard formats. The I-SIPS team will assist NSIDC as appropriate with the development of any added value or metadata products that are required for the archive, advertisement, and distribution of GLAS data to the user community.

Under this proposal, the DAAC would not produce any GLAS Standard products. The SIPS would depend on the ESDIS to provide level 0 data, to provide some ancillary files and to receive all processed products.

Within our understanding of the changes to the ESDIS baseline, we believe that the SIPS IRD has redefined the ESDIS baseline in some areas, but still fulfills all the ESDIS requirements. We intend for this proposal to meet all the requirements as defined in the SIPS request for proposal and the referenced IRD. Therefore, we are not asking for any relaxation of the baseline requirements.

2.2 I-SIPS Operations Concept

The GLAS standard data product generation data hierarchy and flow are illustrated in Figure 2-2. The data flow is to create the Level 1A data products as soon as the Level 0 data are delivered from EDOS. The Level 1A products are divided into altimetric and atmospheric products, plus engineering and SRS/GPS products. The Level 1B elevation correction product is produced by

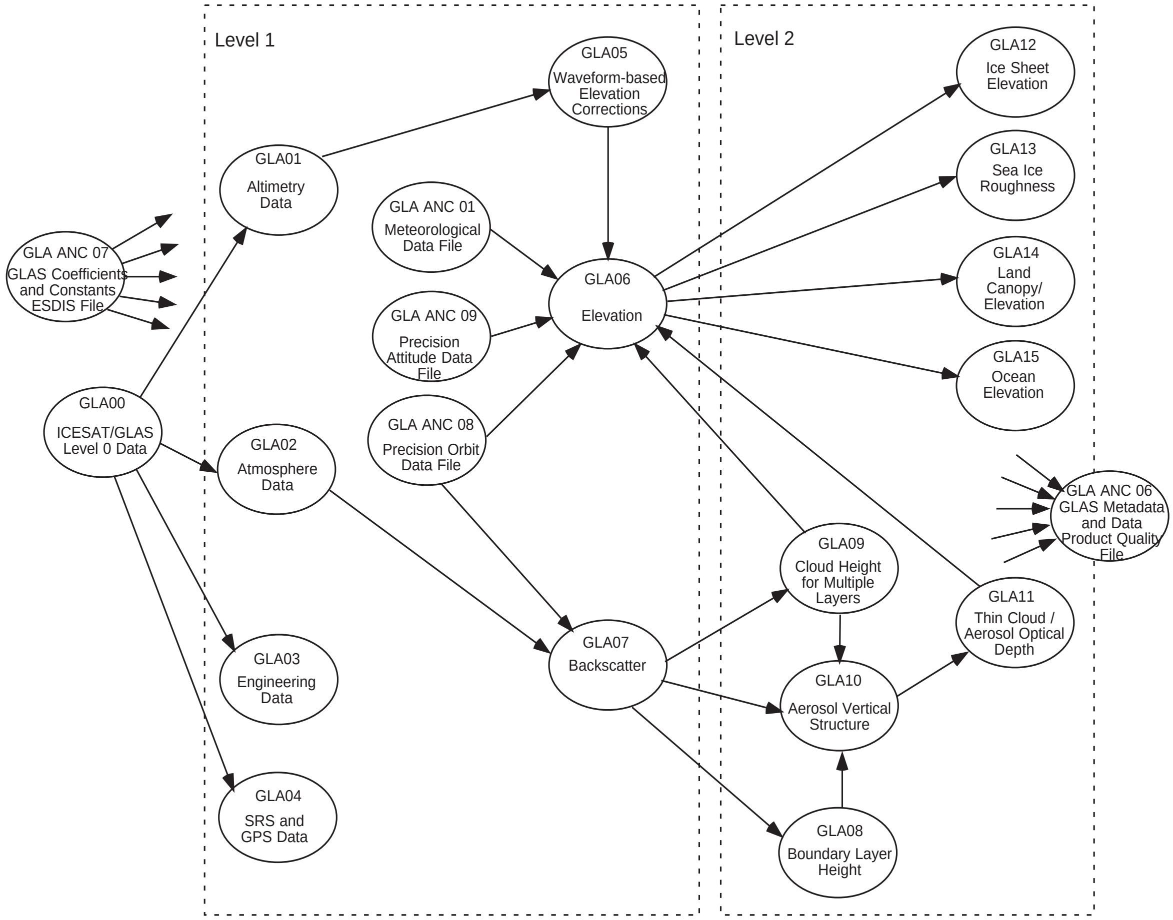

Figure 2-2 GLAS Standard Data Product Generation Data Hierarchy and Flow

analysis of the waveform data contained in the altimetry Level 1A product. The engineering data are available for instrument calibration. The SRS/GPS data are used in generating the precise orbit and attitude ancillary data. After the orbit and attitude have been determined, the remainder of the GLAS products can be produced. The atmosphere backscatter Level 1B product is produced next, followed by the remaining Level 2 aerosol and cloud products. The orbit and attitude data are used with the Level 1B waveform parameters (GLA05), and with the other ancillary files to compute the earth-located elevation Level 2A product that will also contain the needed geodetic corrections and earth dynamics to determine the precise elevation. The final process selects regional data and surface-type specific corrections to create the ice sheet, sea ice, land, and ocean Level 2B products with the proper corrections applied. All data will be written to an on-line processing database in SCF formats that will be similar to the HDF products. A set of programs will extract data from this database and will write the HDF formatted files for delivery to NSIDC.

All processes will be designed such that reprocessing can be done in a selective manner. This selective method will allow only those parameters that are affected on each product to be updated in the processing database during the reprocessing. Once the reprocessing for each segment is completed, the entire product will be extracted and remade into HDF formatted files for new releases to the NSIDC. Table 2-5 is our estimate of the reprocessing requirements for the GLAS data products.

Table 2-5 Estimated Reprocessing Events for GLAS Data Products

Time of Event	Cause of Reprocessing	Products Affected
90 days	Initial calibration, modified algorithms, revised orbit	All level 1 and 2 products
1 year	Recalibration, modified algorithms, revised orbit	All Level 1 and 2 products
Laser change + 3 mos (can occur up to 2 times during mission)	Calibrate new laser	All level 1 and 2 products from date of laser change
Detector change + 3 mos (can occur up to once during mission)	Calibrate new detector	All level 1 and 2 products from date of detector change
6 mos, 2 yrs and 5 yrs	Altimeter retracking algorithm change	GLA05, GLA11-15
3 mos, 6 mos, annually	Backscatter algorithm changes	GLA06-10
annually	Revised orbits and attitude	GLA06-15

Table 2-6 and Table 2-7 summarize the GST requirements for Level 1 and 2 data products and for the archiving plan, respectively.

Table 2-6 Science Team Processing and Delivery Requirements for Level 1 and 2 Data

Science Team Requirements for Level 1 and 2 Production Processing		
Mission Time Line	**Task**	**Response - turnaround time**
15 mos before launch	Receive SDP_V0	Install and test software/procedures
9 mos before launch	Receive SDP_V1	Install and test software/procedures
3 mos before launch	Receive SDP_V2	Install and test software/procedures
0-30 days	Process data as received - SDP_V2	24 hr turnaround on all products created with predict ancillary data
30-90 days	Process data as received - SDP_V2	Products not requiring POD/PAD - 24 hr Products requiring POD/PAD - 24 hr after receipt of POD/PAD
launch +75 days	Receive SDP_V2.1	Install and test software/procedures
launch +90 days	Process first 90 days with SDP_V2.1	Complete within 20 days from receipt

Table 2-6 Science Team Processing and Delivery Requirements for Level 1 and 2 Data (Continued)

Science Team Requirements for Level 1 and 2 Production Processing		
Mission Time Line	**Task**	**Response - turnaround time**
90-270 days 1st repeat cycle of operational mission	Process data as received - SDP_V2.1	Products not requiring POD/PAD - 24 hr Products requiring POD/PAD - 24 hr after receipt of POD/PAD
launch +270 days	Receive SDP_V3	Install and test software/procedures
launch +285 days	Process first 285 days with SDP_V3	Complete within 60 days
285-450 days 2nd repeat cycle of operational mission	Process data as received SDP_V3	Products not requiring POD/PAD - 24 hr Products requiring POD/PAD - 24 hr after receipt of POD/PAD
launch +450 days	Receive revised orbits for complete mission	Process first 450 days of all products requiring orbit with SDP_V3 and revised orbits complete within 100 days
450-810 days 3rd and 4th repeat cycle of operational mission	Process data as received SDP_V3	Products not requiring POD/PAD - 24 hr Products requiring POD/PAD - 24 hr after receipt of POD/PAD
launch + 765 days	Receive SDP_V4	Install and test software/procedures
launch + 810 days	Receive revised orbits for complete mission	Process all 810 days with revised orbits and SDP_V4 complete within 180 days
810 days - end of mission	Process data as received SDP_V4	Products not requiring POD/PAD - 24 hr Products requiring POD/PAD - 24 hr after receipt of POD/PAD
launch + 1170 days	Receive revised orbits for complete mission	Process all 1170 days of products dependent on orbit using SDP_V4 - complete within 260 days
launch +1530 days	Receive revised orbits for complete mission	Process all 1530 days of products dependent on orbit using SDP_V4 - complete within 340 days
end of mission: 5 yrs	Receive revised orbits receive SDP_V5	Process full mission using revised orbit and SDP_V5 within 405 days

.

A subscription will be set up with the EDOS to automatically push the Level 0 data electronically to the SCF as it becomes available. Software and associated scripts will be in place at the SCF prior to launch to allow for turnkey operation of this processing.

The first version of the Scientific Data Processing (SDP) software used at launch, referred to as SDP-V2 (V0 and V1 are internal development versions for testing), will be based on the Algorithm Theoretical Basis Documents (ATBDs) produced by the GST. For the first 90 days of GLAS

Table 2-7 Archival Processing and Delivery Requirements for Level 1 and 2 ICESat Data

Archival Processing and Delivery Requirements for Level 1 and 2 ICESat Data		
Mission Time Line	**Task**	**Response**
90 - 270 days	Process using SDP_V2.1	HDF format products produced within 8 wks of real time
270 - 450 days	Process using SDP_V2.1	HDF format products produced within 4 wks of real time
450 - 810 days	Process using SDP_V3	HDF format products produced within 4 wks of real time
launch + 270 days	Process first repeat 90-270 days using SDP_V3	HDF format products produced within 60 days
launch + 450 days	Remake all POD/PAD dependent products using revised orbits SDP_V3	HDF format products produced within 100 days
810 days - end of mission	Process using SDP_V4	HDF format products produced within 2 wks of real time
launch + 810 days	Process 90- 810 days using SDP_V4	HDF format products produced within 180 days
launch +1170 days	Remake all POD/PAD dependent products using revised orbits SDP _V4	HDF format products produced within 260 days
launch +1530 days	Remake all POD/PAD dependent products using revised orbits SDP _V4	HDF format products produced within 340 days
end of mission	Process all data SDP_V5	HDF format products produced within 405 days

operations, referred to as the calibration period, we will process all data using SDP-V2. Level 1 and 2 output will be made available to the GST in the internal SCF format as soon as possible, with a goal of 24-hour turnaround after receipt of all Level 0 data and ancillary files. For the first few weeks, predicted or non-optimal orbits will be used if there is a delay in the precision orbit calculations, to assure the GST has access to data to evaluate the instrument and algorithms. After 45 days, we expect the GST to deliver updated calibration constants and algorithms. These updates will be incorporated into the next version of the SDP software, SDP-V2.1.

At the end of the 90 day calibration period, the SCF will put SDP-V2.1 into its operations. ICESat will at this time go into its operational 180-day repeat cycle orbit, and the SCF will begin processing the operational data using SDP-V2.1. The SCF will prepare the data for archive in HDF format and deliver it to the NSIDC, along with the software and scripts used to process the data. Detailed documentation will be provided for all archived products. The documentation, software, scripts, and the initial set of data from the first cycle will be sent to the NSIDC on Digital Linear Tapes (DLTs) within 8 weeks of the beginning of the operational phase. The rest of the first cycle data will be sent to the NSIDC on DLTs weekly within 8 weeks of data acquisition. We expect a new set of calibration and algorithm updates from the GST by 4.5 months into this repeat cycle. These updates will be incorporated into the next version of the SDP software, SDP-V3.

For the second repeat cycle, 9 months into the mission, we will begin processing using SDP-V3. The archived products will be prepared for the NSIDC in the same manner as before with a projected turnaround of 4 weeks from data acquisition. In addition to processing the new data, the SCF will simultaneously reprocess the first operational repeat cycle of GLAS data with SDP-V3 and deliver this to the NSIDC as it is reprocessed, with a projected turnaround goal of 6 times real time, so it should be finished within 1 month.

Starting with the beginning of the third operational cycle, we plan to reduce the turnaround time for normal processing to 2 weeks. After the second operational repeat cycle, and at annual intervals thereafter, we expect to receive algorithm updates and/or revised orbits from the GST. These will affect all Level 1B and Level 2 data. Therefore, we plan regular processing for new data throughout the mission using the latest version of the SDP, and we plan to be reprocessing the previously processed operational data according to the timeline in Table 2-7. At the completion of the hoped-for 5 year mission, we plan to reprocess all the data one more time using updated algorithms. For each new version of software, the first delivery of data processed with that version will also include the software and scripts for that version and the documentation of changes.

All the times cited above for delivery of data to the NSDIC are the preliminary design recommendations from the I-SIPS Team and are subject to agreements they will establish with the EOS project. The GST will not hold data for exclusive access, except for the 90-day calibration data as allowed in the SIPS IRD. During the first 90 days, the spacecraft will be in a special orbit to obtain a data set to be used by the science team to quickly calibrate the instrument and data products. For this proposal, the Science team does not consider this data set to be a standard data product, and it will be delivered to the project as a special data product. Under this proposal, the science team will have completed its data quality assessment before the product is delivered to NSDIC for archive. Some initial longer delays will be required in the design to allow for normal start-up delays that will occur until the operations team becomes experienced, the operations become routine, and quality assurance is established. The main reason for the varying delivery times for initial release of standard data products is the science team's concern that data of questionable quality might be distributed to the science user community. The first products after launch will take longer to verify and assess the proper quality control information to be applied to the product. It is considered the science team's responsibility to insure that the GLAS data products distributed to the science user community is of the highest quality possible for the phase being released.

The system will be able to produce 10% percent of the data in a quick-look mode using the University of Texas (UT) predict orbit to support the science team calibration requirements. This quick-look data is considered by the science team not to be of useful quality to be distributed to the research community. It is required by the GST to perform proper planning, mission evaluation, and instrument monitoring for the EOS project.

2.3 I-SIPS System Description

The I-SIPS team will design and procure extensions to the GLAS SCF to establish a processing system capable of producing the standard products and performing Quality Assessment (QA). Figure 2-3, the GLAS Standard Data System Architecture, shows that the production part of the ICESat SCF receives the Level 0 data and produces the standard data products that are provided to the NSIDC.

The I-SIPS operations team will be formed at the SCF and will use the GST-developed standard data software to provide data products to the NSIDC. The I-SIPS design approach is based on the above data products description and the latest GST algorithms. Based on these data products, processing loads have been determined by sizing similar functions from other altimeter missions including TOPEX and ERS-2, and were submitted to ESDIS for DAAC sizing related to GLAS. These are summarized by ESDIS at http://spso.gsfc.nasa.gov/board_dv.html.

The initial plan is to size the extended SCF hardware such that all processing for one day of GLAS data can be completed in a 4-hour period. This will allow processing and reprocessing to be done within an extended 12-hour day, 5-day work week, expanded as needed. This satisfies the ESDIS SIPS requirement for reprocessing at twice the original processing rate; i.e., in one 12-hour shift, we can process 1 day of new data and reprocess 2 days of data. The processing loads have been used to define hardware requirements that will allow implementation of this plan. The I-SIPS Team will make available to the NSIDC these data products along with associated metadata, ancillary data, and documentation.

The rationale for defining the equipment and personnel requirements is based on the experience of the I-SIPS team in processing satellite radar altimetry and aircraft LIDAR data. Figure 2-4 summarizes our processing benchmarks based on the operations concept in the previous section. Table 2-8 shows actual system times for processing radar altimetry and LIDAR data on existing equipment. We used these numbers to estimate the time for each major processing step for ICESat, the results of which are summarized in Table 2-9.

When the processing step requires mostly i/o and is dependent on the speed of the i/o media or communication connections, we estimated the time based on the sizes of the input, output, and ancillary data sets and the estimated i/o speed of the media involved. At the bottom of Table 2-9, we list the values used for data set sizes and i/o speed of disk, DLT, and electronic communications.

We combined the time estimates from Table 2-9 and the processing interdependencies shown in Microsoft Project to develop an estimate for system time required for end-to-end processing. We ignored any delays due to lack of availability of data (POD, PAD, or other ancillary data files). The Gantt chart in Figure 2-4 shows that with current equipment, it would take 8 hours for end-to-end processing.

As stated earlier, the design goal was established to process 24 hours of input raw GLAS instrument data into all standard data products within four hours of lapse time after receipt of data. The GLAS standard data products have a block of products that can be produced quickly once the Level 0 data are received and another block of data that can be produced 2 days later after ancillary data are available. Both blocks, the one-day-old and the three-day-old, are considered to be being processed during this four hour lapse time to make 24 hours coverage of data products. The

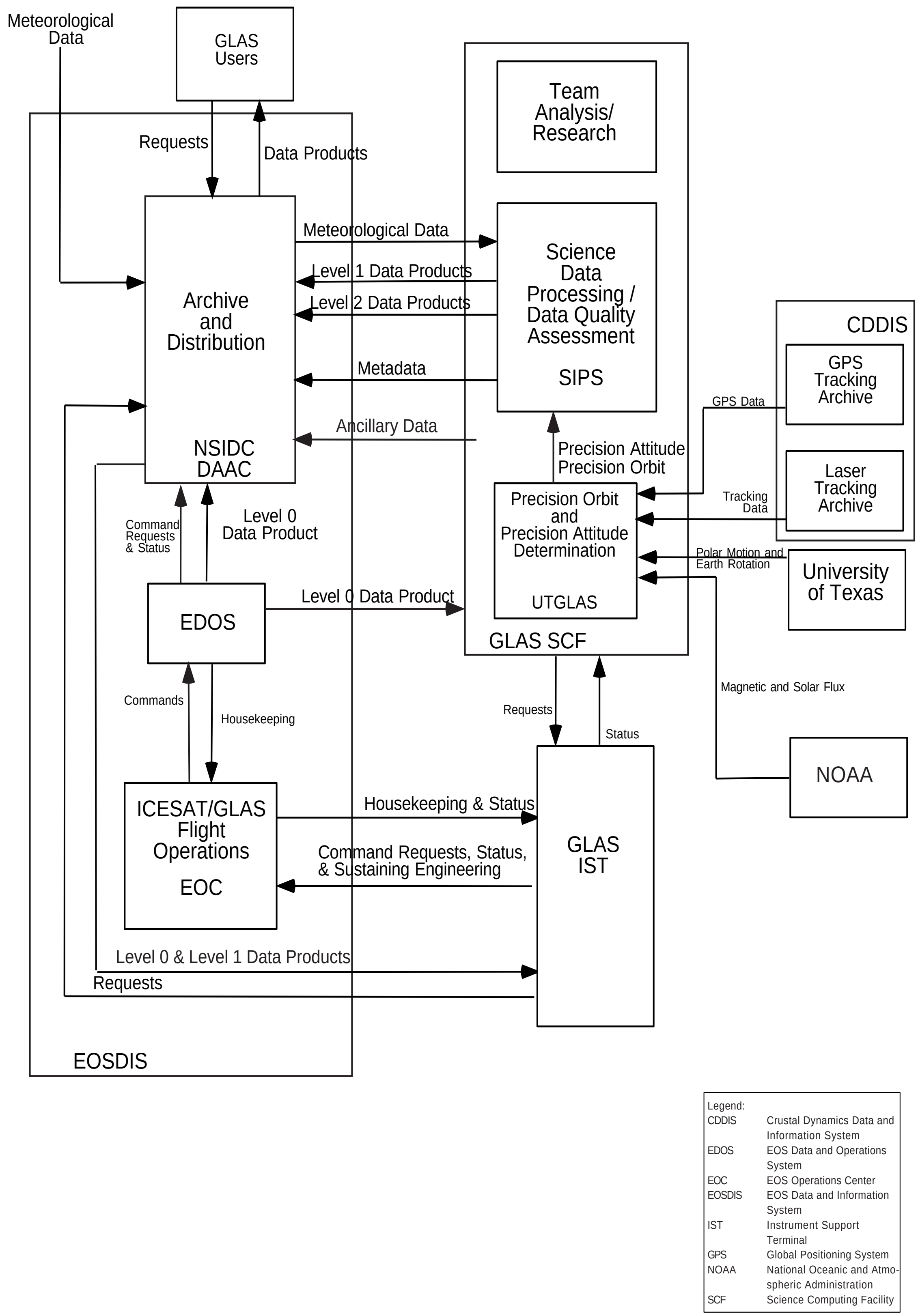

Figure 2-3 GLAS Standard Data System Architecture

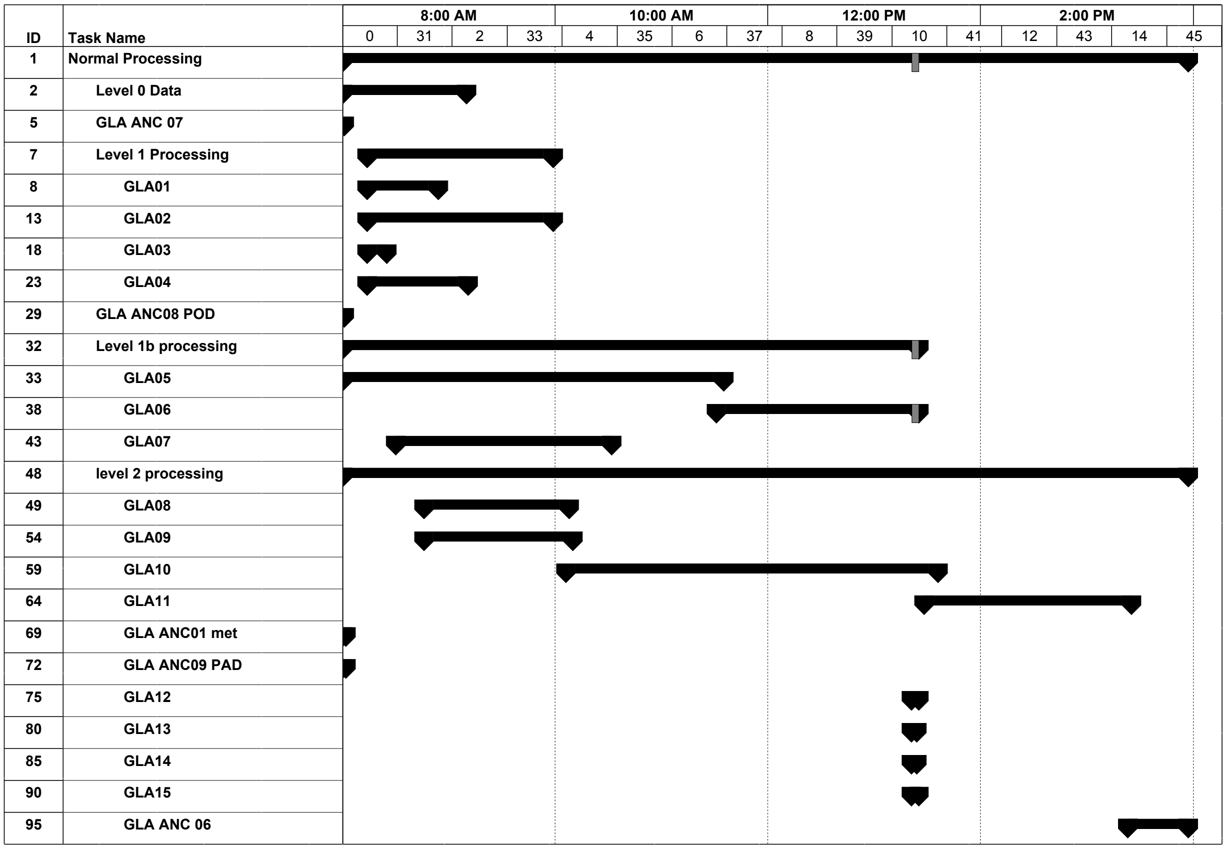

Figure 2-4 Time to Create 24 hrs of GLAS Level 1 and 2 Products Using Existing Hardware

four hour goal allows reprocessing to be accomplished without delay of current data product production. This will also allow us to take care of the large amount of quick look processing which we expect for a new instrument such as GLAS, and still have time to process the normal product. For example, if 16 hours each day (providing a factor of 4 times real time) are allowed for reprocessing, a year of backlog can be completed within 3 months. We know that at the end of the first year of GLAS operations, the full year will need to be reprocessed. Later in the mission, this becomes even more important.

Table 2-8   System Time Requirements

Type of Action	HP9000/735/ 99MHzsystem time in min	K460/PA8000 2 CPUs	SGI 195 MHz R10000	Amount of Data
Orbit Interpolation	6.50			1 day 20/sec ERS1
Tide Calculation	56.20	37.62		1 day 20/sec ERS1
Troposphere Corr	5.33			1 day 20/sec ERS1
Apply Corr	7.27			1 day 20/sec ERS1
Retracking	73.82	46		1 day 20/sec ERS1
Data selection of 1/3rd data	1.62			63MB out of 172MB
GLA02			1	1 90 min orbit
GLA06			1	1 90 min orbit
GLA07			12.6	1 90 min orbit
GLA08			5	1 90 min orbit
GLA09			5	1 90 min orbit
GLA10			7.2	1 90 min orbit
GLA05 estimate based on 3.5 * ERS-1 GSFC V4 retracking*2 for double the data rate				
GLA11 estimate based on 2*POD+tide+trope+applycor to account for POD and PAD merging with other parameters and then multiplied by 2 for double the data rate				

To achieve the design goal would require processors with specifications that are twice that of the K460/8000 used for Figure 2-4 and DLT drives that have three times the throughput used. DLT drives that meet the higher specifications already exist, DLT7000. At least one manufacturer is designing processors with the required specifications with a projected delivery date in the 2nd quarter of 1998. An example hardware solution is provided in section 2.4, I-SIPS Development Approach. Specific model numbers may change by the actual purchase dates. We believe that a complement of COTS hardware will perform the required processing and do not propose to develop any custom hardware. This hardware design meets this goal and satisfies the SIPS IRD requirements.We have placed a requirement to have some level of redundancy in the actual computer system with both systems able to reach common file systems and/or sufficient disk to keep normal daily input data processed.

The GST science software will almost totally be custom developed based on the ATBDs. As part of the design to facilitate reprocessing, database structures will be used internal to the science pro-

Table 2-9 System Requirements for Processing 24 hrs of Level 1 and 2 Products

Processing Step	Input Data Volume (MB)	Output Data Volume (MB)	CPU - I/O (min) (Note 1)	Disk Space (MB) (Note 2)	DLT space (MB)
Level 0 ingest/archive	5086.39	5086.39	70.08	35604.73	5086.39
level 1					
GLA01	5086.39	3553.06	45.40	14730.73	3553.06
GLA02	5086.39	11193.76	159.03	46408.48	11193.76
GLA03	5086.39	166.18	10.72	688.95	166.18
GLA04	5086.39	5624.62	90.81	23319.24	5624.62
level 1B					
GLA05	1524.92	1202.23	199.36	4984.37	1202.23
GLA06	716.00	727.15	118.84	3014.69	727.15
GLA07	4806.26	13189.97	157.40	54684.58	13189.97
level 2A					
GLA08	5660.93	11.18	80.07	46.37	6.38
GLA09	5660.93	428.72	146.57	1938.96	428.72
GLA10	5660.93	971.61	214.02	4028.22	971.61
level 2B					
GLA11	417.00	22.83	115.49	94.67	22.83
GLA12	312.08	142.13	3.21	589.26	142.13
GLA13	312.08	142.13	2.90	589.26	142.13
GLA14	312.08	153.78	3.05	637.56	153.78
GLA15	312.08	284.26	4.72	1178.52	284.26
totals				192538.58	42895.21

Note 1 - K460/8000(2 processors) or RT1000
10.8 SPECint_95, 18.3 SPECfp_95 523 MFLOPS
Note 2 - Keep 7 days of SCF format and 2 days of HDF-EOS format on line

cessing software. Where practical, the GST will integrate COTS software. The GST science software will be developed under the guidelines of the SIPS IRD and I-SIPS ICD. The ECS SDP toolkit will be used to produce the delivered products in the agreed-upon HDF formats. Internally, the GST software will not be using the full functions of the SDP toolkit, to allow more efficient development and execution of the software that will be designed to provide selective reprocessing with the regeneration of entire working datasets.

The GST and the I-SIPS team recognize that all I-SIPS software must be highly portable in order to reduce the life cycle cost over the long mission. It is planned that the software will be written in ANSI Standard FORTRAN 90 using additional standards that draw heavily on the F language subset rules. Special routines will be developed in ANSI C. This will make the code highly portable. Ease of software updates, flexibility to hardware upgrades, and ease of possible use by other sites are some of the prime considerations.

The delivered software, if properly ported, will be able to take Level 0 data and produce all standard data products. Where the software works with database management techniques for production, this capability will be part of the software delivered for archive.

2.4 I-SIPS Development Approach

The development phase spans from the time ESDIS approves the GST I-SIPS proposal until the ICESat launch. It is assumed that during this phase, the main functions will be to perform a more detailed design of the hardware and facility space required for the I-SIPS, procure the hardware, install and accept the hardware, work with the GST software development team to insure compatible hardware and software design, accept and test versions of the GST I-SIPS software, hire and train staff for the maintenance and operation, work with ESDIS and the NSIDC team to establish the I-SIPS ICD, and to test all interfaces.

The first step will be to provide the individual for the production lead. This person will support the development of the I-SIPS ICD and handle the procurement of the hardware. Additional staff will be added on the appropriate schedule to help facilitate the installation and acceptance of the hardware and support testing of the GST SIPS software. As needed, this staff will work with ESDIS and NSIDC to insure that the entire system is ready, prior to launch, to handle GLAS data product generation and distribution.

Table 2-10 provides the general I-SIPS Development schedule.

Table 2-10 I-SIPS Development Schedule

- FY98
- Hire lead production manager
- FY99
- Add staff members
- Work interfaces with NSIDC
- Support software development testing of Version 0 algorithms
- ICD development
- FY00
- Add staff members
- Purchase hardware and software to extend the SCF for the production processing
- Install and test Version 1 algorithms
- FY01
- Complete staff hiring
- Purchase redundant hardware to support the production processing
- Install and test Version 2 algorithms
- Provide test data products to NSIDC
- Support prelaunch mission operation readiness test
- Support launch and 90 day calibration orbit activities

Hardware requirements and a suggested timeline for acquisition that will meet the four hour processing goal are defined in Table 2-11. Hardware specifications are provided in Table 2-12.

Table 2-11 Purchase Plan for GLAS Production Processing

GLAS Computer Equipment Phase-In Plan	
Fiscal Year	Hardware/Software Description
2000	• Production Processing Server #1 • 2 High Availability Disk Arrays • 2 Sun Workstations for HDF-EOS Processing • DLT Autochanger for Server Backups • Fibre-channel Hub • 3 X-Windows Terminals or PCs with X-Windows Server • 2 Standalone DLT drives for Data Backups • Software to allow sharing of fibre channel disk arrays on multiple servers • HP OpenView Network Management Software • Interactive Data Language (IDL) software from Research Systems Incorporated for Data Visualization • Fortran 90 Compiler • C/C++ compiler
2001	• Production Processing Server #2 • 1 High Availability Disk Array • Fibre-channel Hub • 3 X-Windows Terminals or PCs with X-Windows Server • 2 Standalone DLT drives for Data Backups • Software to allow sharing of fibre channel disk arrays on multiple servers • HP OpenView Network Management Software • Interactive Data Language (IDL) software from Research Systems Incorporated for Data Visualization • Fortran 90 Compiler • C/C++ compiler • Binary Sorting Software
2002	• Additional Processors for production servers • Add 100GB Hard Disk Space split among 3 disk arrays • Add 1GB memory to each production server
2003	• Add 200GB Hard Disk Space split among 3 disk arrays • Standalone DLT drive replacements • PC or X-windows terminal replacement
2004	• Replace production Server 1 • Replace 1 High Availability Disk Array
2005	• Replace production Server 2 • Replace 1 High Availability Disk Array
2006	• Replace 1 High Availability Disk Array • Add 200GB Hard Disk Space split among 3 disk arrays
2007	• Add 200GB Hard Disk Space split among 3 disk arrays • Standalone DLT drive replacements • PC or X-windows terminal replacements

Table 2-12 Hardware Description for I-SIPS

Hardware Specifications	
Production Servers	a. 4 processors expandable to at least 8, each must meet the following specs: i. SPECint_base95: 21.6 ii. SPECfp_base95: 36.6 iii. Cache size: 2MB data and 2MB instruction b. GB RAM - expandable to 16 c. Fibre Channel interface cards - expandable to 4 d. 6 independent I/O channels of 240 MB/s or greater e. Fast/Wide and Single ended SCSI I/O capability f. High Speed I/O backplane offering peak bandwidth over 15 GB/s g. Gigabit Ethernet Networking
High Availability Disk Arrays	a. Dual redundant power supplies b. Multiple fibre channel interface connectivity c. 2-4 GB cache d. Raid levels 1-5 e. 100 GB Hard drive space expandable to over 500
HDF-EOS workstations	a. Single processor i. SPECint_base95: 9.0 ii. SPECfp_base95 10.0 b. 400MB Ram c. 100 GB Hard Disk Space d. Fast/Wide and Single ended SCSI I/O capability e. 100BaseT and FDDI networking capability
DLT Autochanger	a. Drives with 5MB/sec sustained transfer rate b. 4 drives c. 48 tape slots
Standalone DLT Drive	a. Drives with 5MB/sec sustained transfer rate

Based on experience from TOPEX and the Pathfinder Ice Altimetry program, a development staff team has been sized. The estimated staffing required for this phase is provided in Table 2-13. The staff workforce is ramped up in the years prior to launch so that the team is ready to generate products in a timely matter. The team will support I-SIPS software delivery and interface development with NSIDC. Training of the operations team will also be accomplished.

Table 2-13 GLAS Adaptive Approach Development Staff Estimates

GLAS Adaptive Approach Development Cost (6/10/98) Additional manpower above what has been proposed for GLAS GDS development												
			Launch									
FY	98	99	00	01	02	03	04	05	06	07	08	Totals
On-Site Manpower in Man-Years												
Production Operation Lead	0.5	1.0	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
Programmer	0.0	1.0	1.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
Technical Specialist	0.0	0.0	0.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Data Librarian	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Operator	0.0	0.0	0.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Quality Assurance	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
System Support	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Contract Lead	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Civil Service	0.0	0.2	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
TOTAL	0.5	2.4	4.4	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2
Off-Site Manpower in Man-Years												
Analyst	0.0	1.0	1.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4
Computer Scientist	0.0	0.4	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
TOTAL	0.0	1.4	2.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
TOTAL ON-SITE AND OFF-SITE MANPOWER	**0.5**	**3.8**	**6.5**	**7.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**18.2**

2.5 I-SIPS Maintenance & Operations

The concept for maintenance and operations is that, after the I-SIPS Team production is fully operational, the products for all levels for each day of data will be delivered as a unit within 14 days after the telemetry are received at the I-SIPS. As described more fully in Section 2.2, I-SIPS Operations Concept, the ICESat spacecraft will be in a calibration orbit for the first 90 days to allow quick-repeat groundtracks. After 90 days, it will be put into the mission orbit which is a 180-day repeat cycle. Since the first 90 days are a special data collection to aid the GST, data products from the first 90 days will not be delivered to the NSIDC until late in the mission.

The general schedule for FY02 is to produce routine data products with an 8-week delivery time for the 1st cycle and 4-weeks for the 2nd cycle, to install and test post-launch algorithm updates, and to support reprocessing as required.

For FY03 thru FY06, I-SIPS will produce products on a routine basis delivering within 2 weeks, provide for reprocessing, replace hardware that is over 5 years old, install new software and provide sustaining engineering.

For FY07 and FY08, I-SIPS will provide reprocessing of the complete GLAS dataset.

Again based on experience from TOPEX and the Pathfinder Ice Altimetry program, an operational staff team has been sized. The estimated staffing required to produce the GLAS standard data products and to provide sustaining engineering is provided in Table 2-14. The first year after launch involves extra staff to handle the need to provide data quickly to the science team for cali-

Table 2-14 GLAS Adaptive Approach Maintenance & Operations Staff Estimates

GLAS Adaptive Implementation Maintenance, Operations, Sustaining Engineering(6/10/98 Hancock) Additional manpower above what has been proposed for GLAS GDS development												
			Launch									
FY	98	99	00	01	02	03	04	05	06	07	08	Totals
On-Site Manpower in Man-Years												
Production Operation Lead	0.0	0.0	0.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.4
Programmer	0.0	0.0	0.0	0.3	1.0	1.0	1.0	1.0	1.0	1.0	0.0	6.3
Technical Specialist	0.0	0.0	0.0	0.6	3.0	2.0	2.0	2.0	2.0	2.0	1.0	14.6
Data Librarian	0.0	0.0	0.0	0.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.3
Operator	0.0	0.0	0.0	0.6	2.0	2.0	2.0	2.0	2.0	1.5	1.0	13.1
Quality Assurance	0.0	0.0	0.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.4
System Support	0.0	0.0	0.0	0.4	1.0	1.0	1.0	1.0	0.5	0.5	0.5	5.9
Data Librarian	0.0	0.0	0.0	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	1.0
Civil Service	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.8	0.5	6.3
TOTAL	0.0	0.0	0.0	3.1	11.3	10.1	10.1	10.1	9.6	8.9	6.1	69.3
Off-Site Manpower in Man-Years												
Analyst	0.0	0.0	0.0	0.6	1.5	1.5	1.5	1.5	1.5	1.5	1.0	10.6
Computer Scientist	0.0	0.0	0.0	0.4	1.5	1.0	1.0	0.7	0.7	0.6	0.4	6.3
TOTAL	0.0	0.0	0.0	1.0	3.0	2.5	2.5	2.2	2.2	2.1	1.4	16.9
TOTAL ON-SITE AND OFF-SITE MANPOWER	**0.0**	**0.0**	**0.0**	**4.1**	**14.3**	**12.6**	**12.6**	**12.3**	**11.8**	**11.0**	**7.5**	**86.2**

bration and to reprocess the data several times as the algorithms are tuned. The staff size is comparable to the team for similar functions that were in place at JPL for the TOPEX at launch.

Sustaining engineering of hardware is covered under the planned replacement of processor systems over 5 years old with new technology systems, and storage media will be incrementally added to handle data growth and aged device replacement. All new versions of I-SIPS software delivered from GST will be fully tested before the system is accepted for production use. Each version of software will be delivered to the NSIDC for archive. Table 2-14 includes the staffing for sustaining engineering.

3.0 Management Approach

3.1 I-SIPS Team Description

Dr. Jay Zwally will be the SIPS manager responsible for the development, maintenance and operation, and sustaining engineering. Mr. David W. Hancock will be deputy manager and Ms. Anita C. Brenner will be contractor lead. Dr. Bob Schutz (GLAS Science Team Leader) will lead the processing for Precision Orbit Determinations (POD) and Precision Attitude Determination (PAD), including the Stellar Reference System (SRS) data, at the University of Texas.

The principals mentioned above have been involved in processing satellite altimetry data since the mid-1970s in both production and Research and Development modes, and have been active members of the worldwide scientific community that uses satellite altimetry data over ice sheets, sea ice, oceans, and land. For the past 5 years, they have been PI's and Co-I's on the NASA Pathfinder Projects (both ice and ocean), leading teams that are processing ice and ocean altimetry for the scientific community. Dr. Zwally's team has processed the Level 1 and 2 polar altimetry data for every satellite altimetry mission since Seasat in 1978. For polar altimetry, this team has been responsible for archiving all Levels of data from the Sensor Data Records (1.5 Terabytes) through Level 4, and have produced Levels 1 through 4 data (400 Gbytes) for all the missions. In addition, they have: 1) created Data Base Management Systems that allow scientists efficient, interactive access to the Level 1B and 2 data over the internet; 2) distributed Level 3 and 4 data in easily usable formats on CD-ROM with accompanying GUI software; 3) provided interactive browsing facilities for all Level 1B and 2 data; and 4) created and maintained WWW pages with tutorials, algorithm, and format documentation for the scientific community (http://crevasse.stx.com). Mr. Hancock's team for the past 5 years has been responsible to the TOPEX project at JPL for the daily monitoring and the long-term instrument calibration of the NASA TOPEX radar altimeter. In addition, this team provides data quality assurance on all the NASA TOPEX data products that are distributed by the project. They create and maintain WWW pages (http://topex.wff.nasa.gov) that make this calibration information available to the altimeter user community.

3.2 Key External Interfaces

The I-SIPS external interfaces are the ESDIS Project and NSIDC DAAC. The general functions and requirements on these interfaces are fully defined in the SIPS IRD. The outlines below provide some of the GLAS-specific related responsibilities.

The I-SIPS Team jointly, with ESDIS as the lead, will maintain an Interface Control Document (ICD) to document the interface between the systems developed to fulfill the operational responsibilities. The I-SIPS Team and ESDIS Projects will agree on scheduling milestones and coordinate reporting to Earth Sciences Enterprise management. The ESDIS Project is responsible for arranging funding for the activities to achieve operational capability by the time of the ICESat launch in 2001.

The ESDIS Project Responsibilities are:

- Distribute to the I-SIPS the GLAS Level 0 data.
- Assign the NSIDC responsibility for ingesting, archiving, and distributing the GLAS data products.

- Coordinate the testing of the interface between the I-SIPS and the ECS.
- Fund the processing of the Level 1 and Level 2 data products for the life of the ICESat mission at the I-SIPS.
- Fund and provide software licenses and support for the SDP toolkit.
- Fund the NSIDC for GLAS project support.
- Provide support to the GLAS SCF as described in the GSFC ECS/SCF ICD 505-41-33.
- Insure I-SIPS receives requested ancillary files via the DAAC.

The ESDIS Project, using the University of Colorado National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC), will distribute science products to the general science community and other data users. NSIDC will archive all processed GLAS data and relevant material, as agreed. The NSIDC will also: 1) install and test, with the GLAS Project, communication and other necessary archiving and distribution capabilities; 2) document any agreed NSIDC value-added processing; 3) assist data users with information related to archiving and distribution functions; 4) populate appropriate directories and inventory entries with descriptive information and metadata provided by the GST; and 5) report distribution statistics.

The NSIDC Responsibilities are:

- Establish and operate the communication link between the I-SIPS and the EOSDIS in coordination with the I-SIPS Team.
- Support the GST in defining metadata contents to be used by the EOSDIS for describing and advertising GLAS data products.
- Lead the testing of the interface between the I-SIPS and the ECS.
- Distribute to the I-SIPS ancillary data from the DAAC archive needed for GLAS processing (for example, meteorological data).
- Receive algorithm packages, including GLAS data processing source code and documentation, from the I-SIPS for archiving.
- Receive GLAS data products, associated metadata, and product version histories from the I-SIPS for archiving.
- Receive ancillary data associated with the production of GLAS products from the I-SIPS for archiving.
- Distribute GLAS data products to the NASA Earth Science data user community.

The GLAS Science Team Responsibilities are:

- Assess the quality of the team's standard data products.
- Provide assistance to I-SIPS operations in solving problems when appropriate.
- Maintain tables and coefficients required by the team's operational data production software.
- Provide new versions of Standard Data Processing software and constants as required.

- Provide expert consultation to the I-SIPS and the scientific community regarding the team's standard and special data products.

3.3 Internal Management

The I-SIPS management style will be based on the experience of the team in similar projects. The I-SIPS manager will provide the overall guidelines, direction and requirements, and will be responsible for setting priority of operations. The deputy manager and contractor lead will ensure these top level requirements are met by interaction with the I-SIPS production lead and will be responsible for setting production schedules. The production lead will be responsible for the day-to-day operations of the I-SIPS, ensuring that schedules are met, and for the identification of problems. Weekly status meetings will be conducted between the deputy manager, contractor lead, and the production lead. With regard to SIPS IRD requested monthly reporting to the ESDIS Project, we will use the generation of this reporting as our overall review of the I-SIPS status, determine progress, and the means to identify problems, reduce risk, and propose resolutions of conflicts. Any conflicts will be tracked through the monthly reporting until successful resolution.

All hardware and software will be maintained under configuration control. Any proposed changes will be reviewed by a change control board consisting of the I-SIPS manager, deputy manager, contractor lead, and production lead that will examine the effects of the changes on the data products, the delivery of the data products, and on staffing requirements.

The I-SIPS software will be designed so that all data are version labeled and identified with the version control software that produced it. The I-SIPS team will develop some scripts and possible software that distributes and maintains records of the data processing, but all software that produces data products that are delivered to the DAAC will be developed by the GST SDT. This GST Standard Data Software is configuration control managed by the GST, and updated versions are released to the I-SIPS team by change control approval. The I-SIPS change control board will approve the installation testing before it is used to produce routine data products.

The ICESat SIPS Requirements are:

- Produce the GLAS Level 1 and Level 2 standard data products using the extended SCF with algorithms developed by the GST, and deliver these data products to the NSIDC for archiving.
- Deliver algorithms and documentation to the NSIDC for archiving.
- Deliver ancillary data used in the production of the GLAS products to the NSIDC for archiving.
- Provide processing histories associated with the production of the GLAS products to the NSIDC for archiving.
- Provide quality assessment for the GLAS products to the NSIDC for archiving.
- Support the ESDIS Project and the NSIDC in testing the interface between the GLAS SCF and the EOSDIS.
- Receive data from the EOSDIS archive needed for GLAS processing.

- Receive, install, and test new versions of Standard Data processing software and constants from the GST.

These requirements are provided in more detail in the SIPS IRD that is controlled by ESDIS. Any changes to the basic requirements will have to be negotiated with ESDIS and placed into the I-SIPS ICD. This process provides a defined control on requirement changes. The contractors that form the part of I-SIPS team will be part of a GSFC support services contract that is planned to exist for the duration of the ICESat project. Hardware procurements will be completed using the normal GSFC government procurement system.

3.4 External Progress Reporting and Information Flow

The I-SIPS team will provide monthly status reports on SIPS activities to the ESDIS project as requested in the SIPS IRD. These reports will also be made available to the Science team leader and science team.The I-SIPS team will provide support reviews of ESDIS as agreed upon in the ICESat SIPS ICD that will be developed after proposal approval. When requested by the GST leader, the I-SIPS team will present I-SIPS design and production details at GST meetings.

4.0 Personnel

H. Jay Zwally, a NASA senior scientist, has been extensively involved in observing the dynamics and variability of polar ice, including analysis of long-term sea ice variations, determination of ice sheet mass balance, and studies of atmosphere-ice-ocean processes. He led NASA's effort to develop methods to extract ice-surface elevations from radar altimetry, is on the Mars Orbiter Laser Altimeter Team, the EOS Geoscience Laser Altimeter System (GLAS) Team, and is Project Scientist for ICESat. He is an ERS-1 and 2 investigator under INT-8 for ice sheet research.

David W. Hancock, III, a NASA AST Mathematician, has been involved with the calibration and development of data processing for U.S. satellite altimeter programs (SEASAT, GEOSAT, TOPEX, and GFO) for 20 years, is the TOPEX Radar Altimeter instrument scientist responsible for its continuing calibration, led the development of the TOPEX instrument-related algorithms, is a member of the TOPEX operations team, led the development of the MOLA-1 ground data processing system, is a PI on the JASON-1 to assist with the calibration of the radar altimeter, and is manager of the software implementation for GLAS algorithms.

Anita Brenner, a chief scientist at RSTX, has been involved in processing and analyzing radar polar, ocean and land altimetry for 20 years. She is a Co-I on the polar and ocean altimetry NASA Pathfinder Projects where she led the reprocessing of all Seasat, Geosat, ERS-1 and 2 data into data sets with a consistent set of geodetic corrections, and orbits from which to study surface change. She is also a Co-I for calculating continental topography and river height variations from satellite radar altimetry.

5.0 References

Interface Responsibilities for Standard Product Generation Using Science Investigator-led Processing Systems (SIPS). NASA/GSFC Publication No. 423-42-03, May 1998.

GLAS Software Management Plan, NASA /GSFC Wallops Flight Facility, June 1998.

GLAS Science Software Data Management Plan, NASA /GSFC Wallops Flight Facility, June 1998.

GLAS Standard Data Product Specification, Level 1, NASA /GSFC Wallops Flight Facility, March 1998.

GLAS Standard Data Product Specification, Level 2, NASA /GSFC Wallops Flight Facility, March 1998.