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Preface

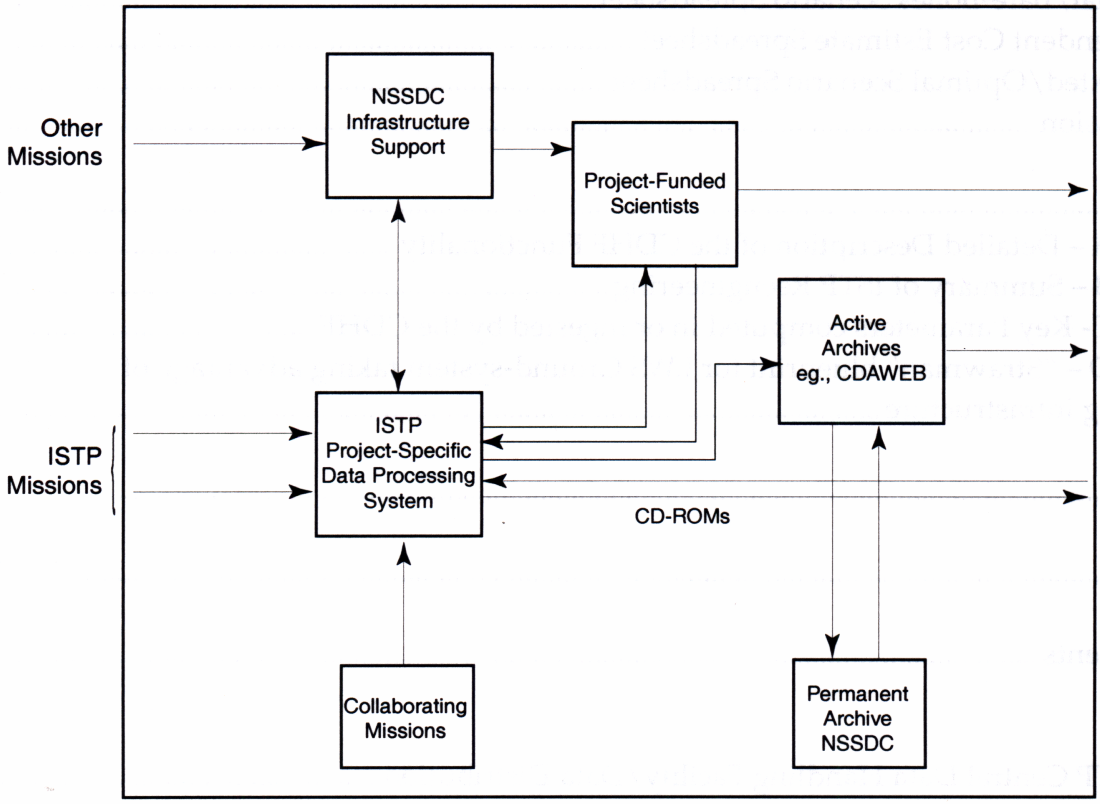
The subject of this Proposal is the Central Data Handling Facility (CDHF) of the ISTP Mission. There are three "data centers" being reviewed by NASA Headquarters: *the Solar Data Analysis Center, the ISTP Central Data Handling Facility, and the National Space Science Data Center* (*services related to Sun-Earth connection data*[1]). These three data centers are synergistic and without overlap in their functionality.

In building these data systems one of the considerations was to take advantage of existing infrastructure, where possible, to avoid overlap. For example, in the case of the ISTP CDHF the CDAWeb facility (provided by the NSSDC affiliated Space Physics Data Facility, SPDF) is used to provide open access to the display and retrieval of ISTP science data products; the CDHF puts the science products into Common Data Format, which was developed and is maintained by the National Space Science Data Center (NSSDC). The NSSDC also is used for archival storage of the level zero data and science data products; the ISTP Science Planning and Operation Facility (SPOF) uses the Satellite Situation Center (SSC) software developed and maintained by the SPDF for purposes of science coordination between the missions. The US Cluster Science Data Center, an integral part of the CDHF, leverages CDAWeb to make the Cluster Prime and Summary Parameters available in the US.

The Solar Data Analysis Center is a *solar* data analysis facility that serves the data analysis and access needs of the solar physics community.

The generic diagram below depicts these relationships.

Current ISTP Data Flows



[1] The Space Physics Data Facility (SPDF), and National Space Science Data Center (NSSDC) or under the Space Science Data Operations Office, GSFC/Code 630, Chief Dr. James L. Green.

Executive Summary

Of the 14 space science missions participating in this 2001 Senior Review over one-third are directly dependent on the ISTP Central Data Handling Facility (CDHF) and associated infrastructure to process the telemetry, monitor instrument health and safety, produce and integrate science products, provide data distribution, handle a variety of ancillary computations, and coordinate and enable the science. Five more of these missions contribute survey and/or event data, making the CDHF a primary data source for space scientists worldwide. Beginning with ISTP, NASA's Office of Space Science is maintaining the missions needed to study the Sun-Earth connected system on a global scale. The CDHF, providing data from all relevant missions in a common format along with common access and visualization tools, is at the heart of the required infrastructure to tackle such "system-level" science. These functions have been routinely and reliably provided on a 7X24 basis for many years. This, in turn, has played an essential role in enabling ISTP science.

This carefully architected system provides telemetry and science measurements in real-time that allow the investigators to: monitor instrument health, monitor and provide early warning of space weather and Gamma Ray events, produce images of the aurora, and helps determine launch times for sounding rockets. The system also provides level zero and science data on CD-ROMs and electronically to the investigators within a few days of real-time, which allows preliminary science analysis to be accomplished on the order of days rather than months.

To enable rapid surveying of the vast array of scientific data being gathered by ISTP, Key Parameters (KPs) are computed by the CDHF or are ingested into the CDHF (collaborative missions, ground-based instrumentation, and high-resolution "event" data). These Key Parameters and high-resolution "event" data are written to CD-ROMs, and are distributed electronically via the CDHF and CDAWeb (Coordinated Data Analysis on the WWW). About 0.2 Terabytes of ISTP Key Parameter data have been computed and made open and available since the launch of Geotail in 1992.

This system, originally dedicated in 1991, was reengineered in the 1996-1998 time frame resulting in a system that has now been reduced to its minimum functional level, including staffing. Historically, the CDHF and associated infrastructure have been enhanced multiple times, at small incremental cost, to incorporate data products from additional space science missions. In the fall of 1998 this system became part of the Consolidated Space Operation Contract (CSOC).

As we transition to this next phase of ISTP we have in-place, at considerable time and expense, an enormously capable one-of-a-kind "system" to accomplish SEC system science. This system consists of a fleet of space and ground-based instrumentation, a sophisticated ground-system, theory, simulations, data products, and tools that will permit us to use these extensive single-point measurements, in conjunction with the theory and simulations, to develop a much more detailed understanding of the physical processes being studied and will enable ISTP to transition to the Solar Terrestrial Probes and the Living With a Star Programs. It is expected that this system will play a critical science role as major solar disturbances occur during the declining phase of this Solar Cycle. Thus it is essential to keep this system viable.

To avoid duplication the relevance of the CDHF and associated infrastructure to the Space Science Enterprise Strategic Plan is discussed in the individual Mission Proposals, as is Education and Public-Outreach (EPO).

Science Section

1.0) Introduction:

At the start of the 17th Century Francis Bacon is said to have proposed: "experiments in concert" as the most effective way in which to understand the world around us.

In April 1979 the Final Report of the OPEN Science Definition Working Group (SDWG) was released titled "Origin of Plasmas in the Earth's Neighborhood". The SDWG had been asked to define a realistic program comprising complementary theoretical and experimental studies (space and ground-based), i.e., "experiments in concert", that would make a major advance in our understanding of the near-Earth space environment (Sun-Earth Connection in modern parlance).

It took nearly 15 years for the theoretical, space, ground, and computational resources recommended by the SDWG to be put in place. The "heart" of this undertaking is the International Solar-Terrestrial Physics (ISTP) Ground-System and particularly the ISTP- Stanley Shawhan[1] Central Data Handling Facility (CDHF) – the subject of this proposal. The CDHF and associated infrastructure exists for the sole purpose of enabling ISTP science. The rest of this proposal is in support of that objective.

2.0) Discussion of the ISTP Stanley Shawhan CDHF including spacecraft telemetry processing, the Science Planning and Operation Facility (SPOF), and the ISTP Web-site:

This Proposal covers all of the elements shown in Figure 1, except for those that are "hatched". As is evident from this Figure, ISTP casts a wide net and of the 14 space science missions participating in this 2001 Senior Review 36% (Geotail, WIND, POLAR, SOHO, and IMP-8: a total of 53 instruments) are *directly dependent* on the ISTP Central Data Handling Facility (CDHF) and associated infrastructure for:

- telemetry processing to produce level zero data, for Geotail, WIND, and POLAR (IMP-8 and SOHO telemetry processing are discussed and costed in their own Proposals),
- the CDHF ingests all of the level zero data from Geotail, WIND, POLAR , IMP-8 and SOHO, i.e., 24 hours of data from each of these 5 missions, 24 hours per day, every day,
- real-time data flows used for: monitoring instrument health and safety, producing images of the aurora, providing early warning of space weather and Gamma Ray events,
- direct computation of Key Parameters, including parameters from IMP-8 and SOHO, and ingestion of externally computed Key Parameters and higher resolution data,
- ancillary computations, and ingestion of ancillary data,
- science enablement via the SPOF and CDHF,
- science and level zero data distribution, including IMP-8 and SOHO,
- science coordination across the primary and collaborative missions via the SPOF,
- serving as the US Cluster Science Data Center,
- providing an extensive ISTP Web site (over 1 million visits per month) used for science operations, education and public-outreach http://www-istp.gsfc.nasa.gov. The EPO aspects of this Web-site are discussed in detail in the ISTP Proposal.

The above listed functions, described in greater detail in Appendix A, have been routinely and reliably provided on a 7X24 basis for many years. This, in turn, has played a critical role in enabling the ISTP science.

Figure 2 summarizes the flow of "Data Days" (One Data Day = 24 hrs of data from a single instrument) through the ISTP Ground-System for the entire year of 1999. Note that in 1999 the system ingested nearly 75,000 Data Days (Level Zero and Key Parameters); and distributed 275,000 Data Days electronically and via CDs (> 12K). While the original ISTP Program involved collaborations with scientists from many countries, the ready availability of synoptic observations from a large number of regions within the Sun-Earth system has led to substantially enlarged international partnerships. Today, mirror sites of ISTP data exist in at least 6 different countries, while ISTP data and information are routinely distributed to a large international community covering Europe, Japan, and South America (see Figure 3).

2.1) Science Enablement and Science Processing in the CDHF:

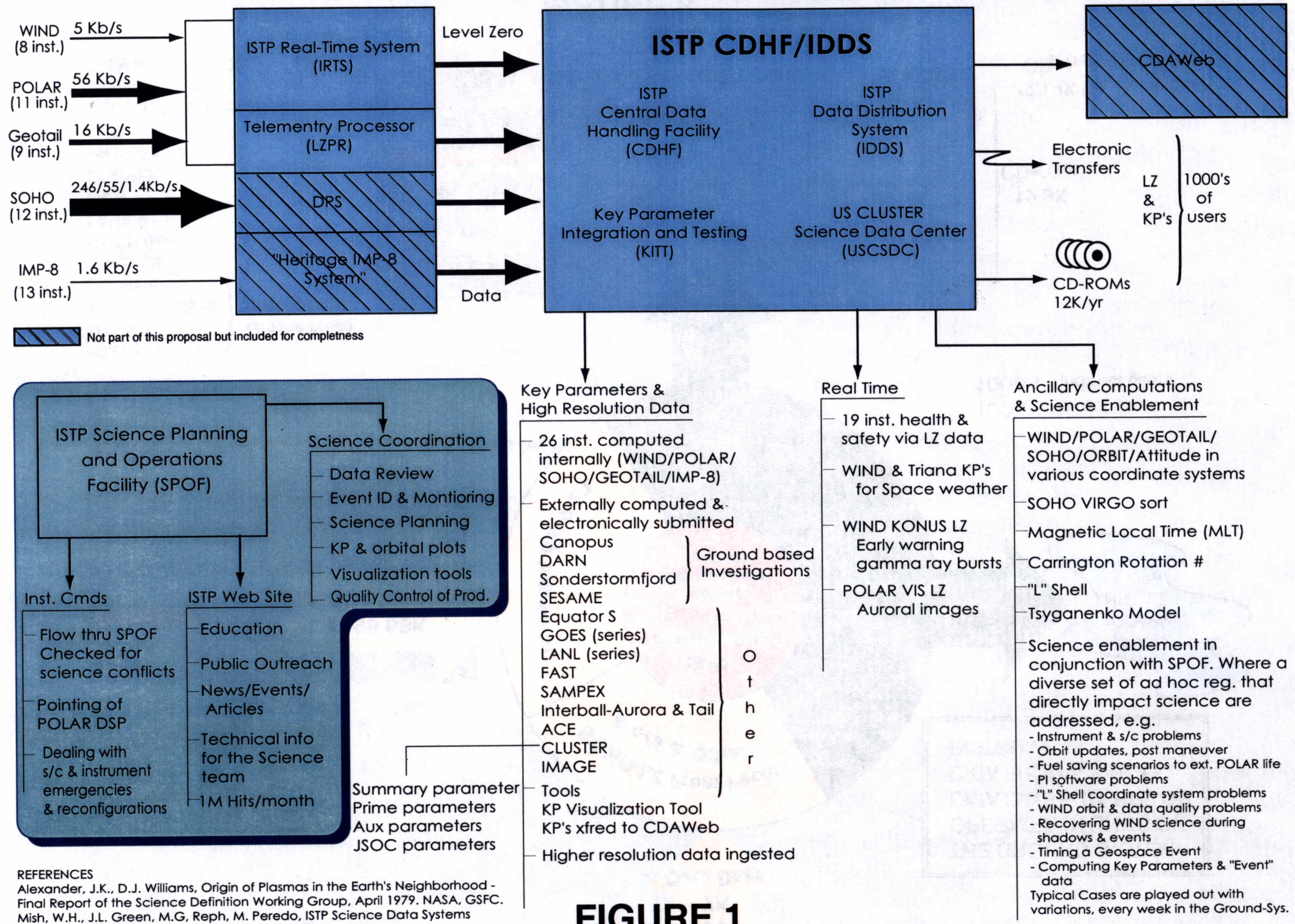
Following the precedent set by Dynamics Explorer and ISEE "Data Pool" datasets, it was recognized that to accomplish the ISTP scientific goals, there would need to exist the ability to quickly survey, in a coordinated and on-going fashion, the vast array of scientific data being gathered by the instrumentation. Such a timely survey should reveal scientifically interesting phenomena (*events*) almost immediately, and should be of great value during the scientific campaigns. Thus, the concept of ISTP Key Parameters (KPs) was implemented. In general, KPs are low resolution observations (on the order of 1 min) computed from each instrument. KPs computed internally to the CDHF are based on Level Zero data (cleaned up and decommutated telemetry). There are also KPs generated externally to the CDHF, electronically ingested from a variety of ground-based instruments and collaborating spacecraft (see Figure 1 and Appendix C). A KP data set covers one complete day in time. Software for internally-generated KPs is provided by the PI teams for each instrument. As mentioned, the KP data sets are used to identify interesting scientific "events". In general, this identification results in the production of higher resolution scientific products by the PI teams. The higher resolution products, now called event data, after being put into ISTP/IACG CDF (see below) are submitted back to the CDHF for subsequent joint analysis and electronic distribution as well as being put on CD-ROM. *It is important to note that the KP and event data sets are immediately open to the scientific community worldwide.*

2.2) CDHF Data Management:

One of the functions of the CDHF is the management of the large and diverse number of data products ingested, computed and distributed by the system (see Figure 2). At the outset, it was recognized that these data products should be self-documenting and should also use existing standards and schemes for management, where possible.

[1] The CDHF was officially dedicated in memory of Dr. Stanley D. Shawhan on October 30, 1991. The plaque reads "His vision of space physics for the 1990's became reality through his untiring efforts and leadership."

ISTP CENTRAL DATA HANDLING FACILITY/DATA DISTRIBUTION



REFERENCES
Alexander, J.K., D.J. Williams, Origin of Plasmas in the Earth's Neighborhood - Final Report of the Science Definition Working Group, April 1979. NASA, GSFC.
Mish, W.H., J.L. Green, M.G, Reph, M. Peredo, ISTP Science Data Systems and Products, Space Science Reviews, 71:815-878, 1995.

FIGURE 1

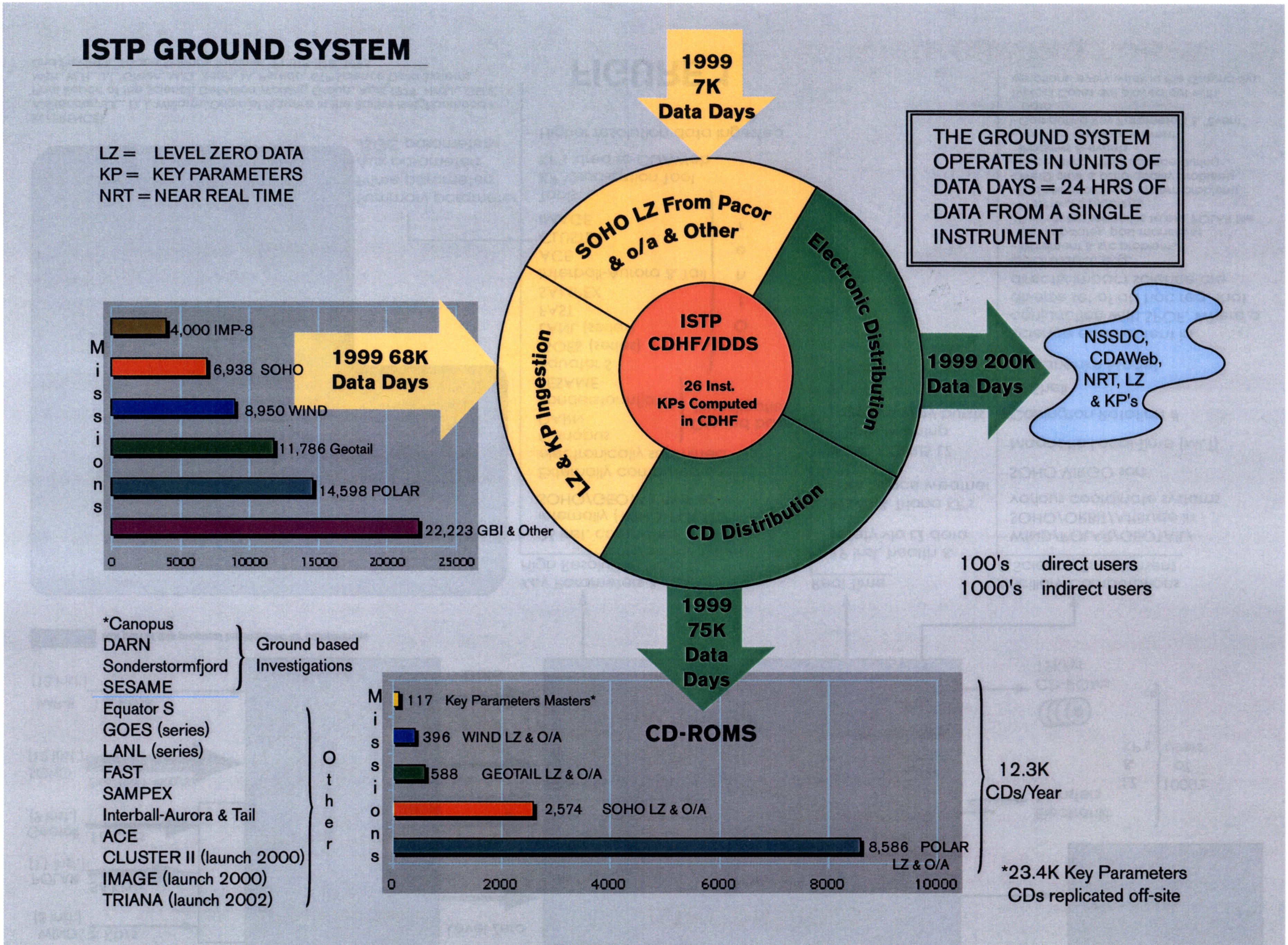

ISTP GROUND SYSTEM
LZ = LEVEL ZERO DATA
KP = KEY PARAMETERS
NRT = NEAR REAL TIME
Missions
4,000 IMP-8
6,938 SOHO
8,950 WIND
11,786 Geotail
14,598 POLAR
22,223 GBI & Other
0
5000
10000
15000
20000
25000
1999 68K Data Days
1999 7K Data Days
SOHO LZ From Pacor & o/a & Other
LZ & KP Ingestion
Electronic Distribution
CD Distribution
ISTP CDHF/IDDS
26 Inst. KPs Computed in CDHF
1999 200K Data Days
NSSDC, CDAWeb, NRT, LZ & KP's
THE GROUND SYSTEM OPERATES IN UNITS OF DATA DAYS = 24 HRS OF DATA FROM A SINGLE INSTRUMENT
100's direct users
1000's indirect users
1999 75K Data Days
*Canopus
DARN
Sonderstormfjord
SESAME
Ground based Investigations
Equator S
GOES (series)
LANL (series)
FAST
SAMPEX
Interball-Aurora & Tail
ACE
CLUSTER II (launch 2000)
IMAGE (launch 2000)
TRIANA (launch 2002)
Other
CD-ROMS
Missions
117 Key Parameters Masters*
396 WIND LZ & O/A
588 GEOTAIL LZ & O/A
2,574 SOHO LZ & O/A
8,586 POLAR LZ & O/A
0
2000
4000
6000
8000
10000
12.3K CDs/Year
*23.4K Key Parameters CDs replicated off-site

FIGURE 2

Consequently all data sets have an associated, separate, Standard Formatted Data Unit, (SFDUs). This small ASCII file identifies and describes each data product, and is used by the CDHF data base management system for cataloging. With few exceptions all data products are one Data Day in length making for simplified logistics.

Key Parameters, event data, orbit, attitude, spin phase, and POLAR de-spun platform attitude are encapsulated in the ISTP/IACG Common Data Format (CDF) developed by the NASA/GSFC NSSDC to facilitate joint display and analysis of diverse scientific data sets. CDF's allow organization of the data elements of a file in a meaningful and flexible fashion and provides metadata relevant to these data elements that facilitates the search, display and analysis of these data. Standard tools have been developed to work with CDF's, e.g., CDAWeb (see below) and the Key Parameter Visualization Tool (KPVT).

These data products are distributed both electronically and on ISO 9660 Compatible CD-ROMs. All CD-ROMs have a Table of Contents and a Cumulative Index that allows for unambiguous determination of where a particular Data Day is located across a collection of CD-ROMs.

2.3) CDHF Reengineering:

During the1996 - 1998 time frame the demanding task of reengineering this complex Ground-System was carried out with the goal of increasing its efficiency and reducing costs with minimal impacts to the users. The reengineered system successfully transitioned into full operations January 1999 (some fine-tuning continues) and the system was concurrently moved to the Completion Form/Performance-based side of the CSOC Contract. The fact that this system has now been reengineered and reduced to its minimum functional level, is a critical point for this Senior Review – *there simply is no "fat" left*. Further details of the reengineering effort appear in Appendix B.

2.4) CDAWeb:

CDAWeb is a *complementary* system to ISTP used for viewing essentially *any* data produced in Common Data Format/CDF with the ISTP/IACG Guidelines. CDAWeb, the Coordinated Data Analysis (Workshop) Web, supports interactive plotting of variables from multiple instruments on multiple investigations simultaneously on arbitrary, user-defined time-scales. It also supports data retrieval in both CDF or ASCII format. CDAWeb is a joint effort among the Space Physics Data Facility (SPDF/GSFC), the National Space Science Data Center (NSSDC/GSFC) and the ISTP project and its Science Planning and Operations Facility (SPOF). CDAWeb is most easily accessed at the URL http://cdaweb.gsfc.nasa.gov/ or via that of SPDF (http://spdf.gsfc.nasa.gov/). *All science data generated by or ingested into the CDHF are ingested into CDAWeb as well (see Figure 4).* Note that CDAWeb is being reviewed as part of the NSSDC/SPDF Senior Review Proposal.

2.5) The Science Planning and Operations Facility (SPOF):

One of the fundamental concepts coming out of the ISTP, essential to the upcoming LWS program, is an entity that coordinates the science across the entire Program. This system-science coordination function is multi-dimensional, sometimes ad-hoc, event-driven, and serendipitous activity closely coordinated with the CDHF, the Flight Operations Team, and, of course, the science community. It ranges from monitoring instruments commands for conflict, pointing the POLAR de-spun platform in accordance with the science plan, planning spacecraft maneuvers, reviewing Key Parameters and identifying and monitoring SEC Events, producing data product and orbital and other graphics, developing "tools" that serve the community, pre-conditioning data products for ingestion into the CDHF, participating in spacecraft and instrument emergencies, quality control of products, and managing the ISTP Web site. The SPOF is absolutely critical to the conduct the system-science being done by ISTP.

3.0) Enabling Science through the Ground-System:

The extraordinarily successful functioning of the ISTP Ground System over the last decade has enabled the space science community to:

- exploit the processing and distribution of Level Zero, Ancillary, Key Parameters, and higher resolution data in order to publish well over a thousand referred papers – many dealing with leading edge space science issues (addressed in some detail in the ISTP, SOHO, and IMP-8 Senior Review Proposals);
- use the *real-time* science data provided by the system to: determine launch times for sounding rockets; provide an early warning system for Gamma Ray Burst; provide monitoring and early warning of space weather events; monitor spacecraft and instrument health and safety; provide real-time images of the aurora;
- develop an unprecedented scientific data base (Key Parameters and higher resolution data derived from the primary and collaborative missions) resident on CDs and in CDAWeb that has been and is distributed internationally (see Figure 3). Figure 4 summarizes the breadth and extent of this database by mission/instrument. Appendix C contains a detailed listing of most of the Key Parameters computed internally and ingested from external sources. About 0.2 Terabytes of Key Parameter data have been computed and made open and available since the launch of Geotail in 1992;
- identify scientific events and produce event unique products, available electronically, on CD's, and over the WWW – for example, a list of science products produced/assembled by the SPOF for the "Bastille Day" Event – this is just one of the many events identified by the SPOF and available at the ISTP Web site http://www-istp.gsfc.nasa.gov/istp/events/;
- perform/develop the scientific planning, coordination, and operational constraints for this complex system, including pointing of the POLAR de-spun platform and checking GGS instrument commands for conflict.

4.0) The Future:

As over a third of the missions participating in this Senior Review are currently critically dependent on a functioning CDHF, implicitly their plans for the future assume that it will continue to be completely functional. New missions supported by the CDHF are currently being implemented, e.g., real-time Triana telemetry packets will flow into the CDHF where real-time solar wind data will be computed and sent out to the space weather community; or are just starting into their prime phase, e.g., Cluster, where the CDHF serves as the US Cluster Data Center in conjunction with CDAWeb. Because ISTP was the first NASA effort at studying the system wide impact of the Sun on the near Earth' environment, ISTP acts as a technology and scientific pathfinder for the Living with a Star initiative. The integrated flight operations facility, the Science Planning and Operations Facility, the Central Data Handling Facility, the data products, and the tightly coupled Theory, Modeling and ground-based components of ISTP are the test-bed technologies for enabling a successful Living with a Star program which are, along with Solar Terrestrial Probe missions, and Sun-Earth Connections-related Explorers being architected to contain many of the same elements as ISTP. Also it is likely that the WIND spacecraft, with its substantial reserve of fuel, will continue to serve as a full-time upstream solar wind monitor, particularly post 2006 when ACE fuel supplies are depleted. And POLAR will provide invaluable and irreplaceable science support for ongoing and future magnetosphere imaging missions. For example, the IMAGE and TWINS missions have assumed that there will be in-situ measurements of the inner magnetosphere to support their remote sensing and global ENA imaging observations.

Thus it would certainly make sense, rather than reinventing the wheel for LWS, to enhance the existing extensive capabilities of the CDHF and its infrastructure including the SPOF, to process the telemetry, do the necessary ancillary computations, compute the science parameters[2], use the same proven standards, and perform the science enablement and coordination for the LWS missions. For LWS data distribution and permanent storage the CDHF has infrastructure that routinely produces level-zero and science data CD's and protocols that routinely transfer the science data to CDAWeb for access by the general research community, and the level zero data to the PI teams. As LWS telemetry will use CCSDS packets (the same as SOHO and Triana which is currently handled by the CDHF) these individually addressed packets would leverage the internet for transfer to the appropriate locations using standard internet protocols. Appendix D is a "strawman" blueprint of how ISTP existing infrastructure can be augmented to support the LWS program.

5.0) Conclusions:

The ISTP CDHF system and the associated data products provide the science community with an integrated environment, uniform standard products, and science planning that was designed and implemented from the outset to substantially enhance both the quantity and timeliness of the science return. Unique to ISTP is the integration of, and subsequent electronic distribution (and on CD-ROM), of a large number of Key Parameters derived from the space segments, ground segments and other collaborative missions in a standard format (SFDUs and Common Data Format) with display/analysis tools (CDAWeb and KPVT) provided by the Project for immediate use by the scientific community. This carefully architected system provides these data to the investigators within a few days of real-time (and for some measurements in real-time), which has allowed preliminary science analysis to be accomplished on the order of days rather than months. As the level zero data is also available to the science community electronically (later on CD-ROM), instrument health and safety can be monitored, real-time science products are produced, and the detailed analysis of the event data proceeds at a rapid pace. The Project and all PI/CoI teams make extensive use of the SPOF and the WWW for science planning, data display/analysis, and data access and distribution. All data products, including event data and display/analysis tools, are presently open and available via the WWW.

As we transition to the next phase of ISTP we now have in-place, at considerable time and expense, an enormously capable one-of-a-kind "system" to accomplish SEC system-science. The system consists of a fleet of space and ground-based instrumentation, a sophisticated ground-system, theory, simulations, data products, and tools that will permit us to use these extensive single-point measurements, in conjunction with the theory and simulations, to develop a much more detailed understanding of the physical processes being studied and will enable SEC to transition to the Solar Terrestrial Probes and the Living With a Star Programs. Thus it is essential to keep this system viable for the foreseeable future.

Technical/Budget Section:

1.0) Introduction:

This Section covers the costs of the CDHF and associated infrastructure. The costs presented here are for the Four-Way Breakdown provided in the Proposal directions, Item number 3 – *Sequence Generation, Science Planning, & Data Processing*, i.e., the functions discussed in this Proposal and shown in Figure 1 and in Appendix A. They do *not* include items such as flight operations, flight dynamics, DSN support, or communications services, which are covered separately in the ISTP Proposal. Also, at the request of the IMP-8 and SOHO Project Scientists, the costs for Level Zero processing for IMP-8 and SOHO appear in their respective Senior Review Proposals and *not* in this one.

The CDHF and associated infrastructure has now been under the SOMO/CSOC contract[1] for over two and half years (phase-in started 10/1/98). There have been, and continue to be, problems associated with the Completion Form side of this contract that, for the most part, boil down to the fact that a "factory" paradigm is not appropriate for a science driven system (we are not manufacturing widgets) and the fact that the "factory" and its attendant bureaucracy is very expensive because of the *indirect costs* we are charged. Science advances when the systems supporting the science are permitted to operate in a flexible and interactive fashion allowing the scientific community to take advantage of serendipitous situations (e.g., "Bastille Day" event), respond to unique circumstances (e.g., instrument emergencies), go in unanticipated directions (e.g., incorporation of new missions of opportunity such as Triana and LWS), and generate new unique products (e.g., products covering events). Under the *Completion Form/Performance-based* part of the CSOC contract it is a real struggle to maintain the kind of flexibility required to enable the ISTP science effort (see right-hand bottom corner of Figure 1 for some examples) and continue to do the re-engineering that will make the system more efficient.

One of the goals of LWS is to have the fleet of spacecraft in place for the next Solar Max (2010) with some launches (Solar Dynamics Observatory) as soon as 2006. Thus augmentation of the CDHF budget to support LWS could start in FY04/FY05 but has *not* been included in this analysis. However, we have included, in Appendix D, a "strawman" blueprint of how the existing ISTP ground-system infrastructure can be enhanced to support LWS.

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[2] Another approach is to have the instrument teams compute the "summary" science parameters, i.e., Key Parameters, at their institutions to a *specific set of standards* and make them available in a timely fashion to the science community over the WWW.

2.0) FY01 Actual MO&DA Plan Spreadsheet:

The first is the required "FY01 Actual MO&DA Plan" spreadsheet showing the estimated *direct* costs for FY 2001, with additions of $0.5M for necessary things that are not now paid for by CSOC (see the right-hand side of the INDEPENDENT COST ESTIMATE SPREADSHEET for the details of the non-CSOC costs). The estimated direct cost for FY01 is $4.2M.

3.0) Minimal/Bare-Bones Scenario Spreadsheet:

The second is the required "Minimal/Bare-Bones Scenario" spreadsheet showing the *direct* costs for FY 02 through FY 05. The costs in this spreadsheet are from the CSOC FY02 (April 20, 2001 version) PSLA "Science Data Processing Category" again with additions of a $0.5M for necessary things that are not paid for by CSOC. *As a result of the reengineering done in the 1996 – 1998 time frame, the ISTP Project considers the CDHF and associated infrastructure to be operating at Minimal/Bare-Bones level.* The direct cost is $4.75M for FY 02 inflated at approximately 3% for subsequent years. Note that these numbers do *not* contain funding for incremental reengineering of the system as technology advances (because the CDHF and associated infrastructure are for the most part in the Completion Form side of the CSOC contract *where such reengineering*[2] *is not done by definition*). Such incremental reengineering has the potential to reduce personnel costs over time – see "Requested/Optimal Scenario" below. Because of this the Minimal/Bare-Bones scenario is actually more expensive that the Optimal Scenario.

4.0) Independent Cost Estimate Spreadsheet:

The third part is our *independent* estimate of what we believe this system should cost (see spreadsheet titled "INDEPENDENT COST ESTIMATE COMPARED WITH CSOC COSTS"). In making this estimate we used the same FTE count as in the CSOC FY02 PSLA (April 20, 2001 version), and industry standard salaries for these positions were used with an overhead multiplier of 1.65. In some categories it was necessary to make realistic estimates for costs and FTE's as the numbers were not available to us. Referring to this spreadsheet, the elements with a "gray" background were used in making this estimate. This independent estimate, to cover the functions described in this proposal, is $4.76M and is essentially the same as the CSOC direct costs. Thus we conclude that the CSOC direct costs are reasonable – it's the indirect costs that are the problem (see Discussion below).

5.0) Requested/Optimal Scenario Spreadsheet:

The forth part is "Requested/Optimal Scenario", which includes funding for specifically reengineering the IMP-8 level zero processing hardware/software ($150K; IMP-8 Proposal has additional $350K- savings achieved shown in IMP-8 Proposal) in the FY02 time frame, and funding for incremental reengineering across the entire CDHF and associated infrastructure in FY 03 and 04 at $200K each year. This reengineering has the potential to make the system more reliable and reduce personnel costs, without reducing functionality, and the spreadsheet reflects this. *Note that this Optimal Scenario requires that the CDHF and associated infrastructure be moved out of the Completion Form side of the CSOC Contract so that the incremental reengineering can take place.*

6.0) Discussion:

There are a number of good reasons why the CDHF (and associated infrastructure) should be moved from the Completion Form/Performance Based side to a CSOC Space Operations Directive Agreement that will benefit science and save money:

- science/mission/system flexibility is improved as described in the Introduction to this Section,
- the ability to perform the additional reengineering (prohibited, by definition, in the Completion Form/ Performance Based side of contract) that will lower costs over time,
- elimination of the indirect costs now charged to this facility - not shown in the spreadsheets are the indirect CSOC costs ($1.72M in FY02) that are charged to this facility each year providing little or no benefit to the ISTP Program,
- will enable the enhancement of the system to support LWS.

A legitimate question to ask is - if this move is so beneficial, why has it not already been done? The answer is that, for over a year despite our best efforts, the Space Operations Management Office (SOMO) at JSC and Lockheed has consistently resisted, and of course, it cannot be accomplished without their agreement. We believe that, in this fiscally constrained environment, these efficiencies must be implemented by FY02.

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[1] The CSOC contract is primarily a Completion Form/Performance-based contract with some small provision for what is called Space Operations Directive Agreement (SODA), level-of-effort type work. Only the KITT & SPOF are in a CSOC SODA whereas the CDHF, IDDS, LZPR, and DPS are in the Completion Form part of the contract (see Figure 1).

[2] As called for in the Completion Form side of the Contract, ownership of the CDHF hardware and software has been transferred to CSOC.

Appendix A – Detailed Description of the CDHF functionality (see Figure 1):

- **Telemetry processing:**

This is the process of ingesting, refining, and decommutating (to individual instrument files) the spacecraft telemetry sent from the Deep Space Network[1], via JPL, to GSFC. As an integral part of this process real-time telemetry is also sent to the Flight Operations Teams for WIND/POLAR for real-time monitoring of the spacecaft, the SOHO Experiment Operations Facility, and the CDHF. The CDHF ingests all of the telemetry from Geotail, WIND, POLAR, SOHO, and IMP-8, i.e., 24 hours of telemetry from each of these 5 missions 24 hours per day, every day.

- **Real-time data flows and monitoring instrument health and safety:**

Via the CDHF 19 WIND/POLAR instruments are monitored for health and safety, near real-time auroral images are generated by POLAR VIS PI team, the WIND KONUS instruments provides a Gamma Ray Burst Early Warning System, and the real-time space weather parameters (Magnetic field and plasma) are computed from fields and plasma instruments on WIND and the upcoming Triana spacecraft.

- **Internal computation of Key Parameters and ingestion of externally computed Key Parameters and higher resolution data:**

Internal to the CDHF 26 instruments compute Key Parameters using algorithms developed by the individual PI teams. External to the CDHF, four Ground-Based investigations, and 10 collaborative missions compute Key Parameters which are then electronically submitted to the CDHF. Higher resolution data are also routinely ingested by the CDHF both from the primary missions and collaborative missions. All of these Key Parameter and higher resolution data are put on CD-ROM and transferred to CDAWeb for public access.

- **Ancillary computations and ingestion of ancillary data:**

The CDHF computes/ingests and distributes: Geotail, WIND, POLAR, SOHO, and IMP-8 orbit and attitude[2], Magnetic Local Time (MLT), L Shell, Carrington Rotation Number, the Tsyganenko Model, POLAR Despun Platform attitude, refined SOHO attitude, and WIND/POLAR spin period and phase.

- **Science enablement:**

Scientific Event Identification, Science Planning, KP and orbital plots, KP reviews. Made available from the CDHF are a number of tools and algorithms for community use, e.g., KP visualization tools, coordinate rotation software, Tsyganenko Model, etc.

- **Science data and Level Zero data distribution:**

Scheduled and on demand Science data and Level Zero data distribution, both electronic and on CDs are available from the CDHF on a routine basis.

- **Science coordination across the primary and collaborative mission:**

Including pointing of the POLAR Despun Platform, and checking the WIND/POLAR instrument commands for science conflicts, planning and coordinating scientific campaigns.

- **US Cluster Science Data Center:**

Each country providing science instruments to Cluster Mission is responsible to provide a Country Data Center to compute that countries instrument data products and ingest the data products from the other Country Data Centers and make them available to the scientific community in that country. In the case of the US the CDHF serves this function. That is, the CDHF ingests the Prime, Summary, Auxiliary, and JSOC products (see Appendix C, last page) for use by the US CoI's and PI.

- **ISTP Web server:**

An ISTP Web site exists (over 1 million visits per month) used for science operations, education and public-outreach (http://www-istp.gsfc.nasa.gov). The EPO aspects of this Web site are discussed in the ISTP Proposal.

Appendix B - SUMMARY of ISTP REENGINEERING

- Conversion of DSN telemetry transfer protocols for WIND, POLAR, Geotail, & SOHO from the traditional NASCom blocks to IP & FTP (in the case of real-time data, UDP) – required a new NASCom IP external interface (IRTS),
- telemetry processing at GSFC (clean-up, and the generation of instrument files) for WIND, POLAR, Geotail, & SOHO moved from heritage systems to automated workstation based system (LZPRs & DPS) – hardware/software completely redone,
- telemetry archive for WIND, POLAR, Geotail, and SOHO converted to a COTS solution - the Raw Data Archive (RDA),
- CD-ROM production moved from the institutional Data Distribution Facility, (DDF) to a dedicated ISTP system – ISTP Data Distribution System (IDDS) an integral part of the CDHF – hardware/software completely redone, including a new mass store,
- CDHF modified to handle new interfaces,
- Delivery of Flight Dynamics products (orbit & attitude) to CDHF reduced from once per week to once per month, definitive delivery eliminated, only predict provided,
- Reduction in the amount of reprocessing of Key Parameters on the CDHF,
- Reduction in the number of CDs produced & shipped by CDHF,
- The Integrated Mission Operations Control Center (IMOC) for WIND & POLAR was updated with new hardware, and updated software versions – IRTS, LZPR, and RDA co-located in the IMOC area,
- Overall staff reductions across the ground-system, including Flight Ops, on the order of 50%.

[1] IMP-8: Wallops Island VA, Canberra Australia, and Redu Belgium

[2] Three different coordinate systems: GCI, GSE, & GSM

Appendix C – Key Parameters computed in or ingested by the CDHF

KPs Computed Internal to CDHF

GEOTAIL

Investigation	Key Parameters	Time resolution
CPI	SOLAR WIND ANALYZER Ion number density, avg energy & bulk flow vel HOT PLASMA ANALYZER Ion number density, avg energy & bulk flow vel Electron avg energy, plasma pressure COMPOSITION ANALYZER H^+, He^+, He^{++}, O^+ flags	64 sec
EPIC	Spin-averaged ion differential intensities, ICS; Uncertainties ion differential intensities, ICS; Ion chan energy band, ICS; Ion Channels, ICS; Ion chan energy plus, ICS; Ion chan energy minus, ICS; Spin-averaged proton differential intensities, STICS; Uncertainties proton differential intensities, STICS; H chan energy band, STICS; H channels, STICS; H chan energy plus, STICS; H chan energy minus, STICS; Spin-averaged electron integral intesity (>34 keV), ICS; Uncertainty electron integral intesity, ICS; e chan energy band, ICS; e channels, ICS; e chan energy plus, ICS; e chan energy minus, ICS;Spin-averaged He/H diff intensity ratios (82 & 233 keV/67 keV), ICS; Uncertainties He/H diff intensity ratios (82 & 233 keV/67 keV), ICS; He/H channels, ICS; Spin-averaged O/H diff intensity ratios (203 & 1244 keV/67 keV, ICS; Uncertainties O/H diff intensity ratios (203 & 1244 keV/67 keV), ICS; O/H channels, ICS; Spin-averaged He++/H+ diff intensity ratio (9.4 - 212 keV/67 keV), STICS; Uncertainty He++/H+ diff intensity ratio (92 & 233 keV/67 keV), STICS; He++/H+ channels, STICS; Spin-averaged O+/H+ diff intensity ratio (9.4 -212 keV/67 keV), STICS; O+/H+ diff intensity ratio (82 & 233 keV/67 keV), STICS; O+/H+ channels, STICS; >34 keV electron anisotropy parameters, ICS; uncertainties electron anisotropy parameters, ICS; 9.4-212.1 keV/e proton anisotropy parameters, STICS; Uncertainties proton anisotropy parameters, STICS67.0 keV proton anisotropy, ICS; Uncertainties proton anisotropy parameters, ICS; 128.7 keV proton anisotropy parameters, ICS; Uncertainties proton anisotropy parameters, ICS	96 sec
HEP LD-spectrometers	Electrons J (E > 20 keV, az = 0°, 90°, 180°, 270°) Protons J (E > 20 keV, az = 0°, 90°, 180°, 270°) Helium J (E > 20 keV, az = 0°), Oxygen J (E > 50 keV)	180 sec 180 sec 180 sec
HEP BD-spectrometers	Electrons J (E > 0.12 MeV, az = 0°, 90°, 180°, 270°) Protons J (E > 0.4 MeV, az = 0°, 90°, 180°, 270°)	180 sec 180 sec
MGF	|B|, B_x, B_y, B_z, σ (GSE), X_{GSE}, Y_{GSE}, Z_{GSE}	64 sec
EFD	Sphere Probe: E_x, E_y, Residue, s/c potential, bias value Wire antenna: E_x, E_y, Residue, s/c potential, bias value Half-time resolution, X_{GSE}, Y_{GSE}, Z_{GSE}	64 sec
LEP	e, ion energy spectra per sector, n, T, vel, θ, φ ave H^+, O^+, counts per sector	5.6 min 2.8 min 5.6 min
PWI	Peak and average of spectral intensity for the **E** of the Multi Channel Analyzer (**E** at 10 Hz, 100 Hz, 1 kHz, 10 kHz and 100 kHz), Peak and average of spectral intensity for the **B** of the Multi Channel Analyzer (**B** at 10 Hz, 100 Hz, 1 kHz, and 10 kHz), Peak and average of the spectral intensities for the Sweep Frequency Analyzer, Frequency corresponding to the peak of the spectral intensities, X_{GSE}, Y_{GSE}, Z_{GSE}	64 sec

IMP-8

Investigation	Key Parameters	Time resolution
MAG	|<B>|, <|B|>, magnitude/components RMS (GSE), B_x, B_y, B_z, |B|, B-Lat/Long (GSE & GSM), $(x,y,z)_{GSE\&GSM}$, R, N	61.4 sec
PLA	V(RTN), V(GSE), V(GSM), V_{polar}(GSE) proton number density, most probable thermal speed, $(x,y,z)_{GSE\&GSM}$, R	1 min

WIND

Investigation	Key Parameters	Time resolution
WAVES	N_e, Peak, ave for E_x, E_y, B_x, B_y, per freq decade	2 min
SWE	Bulk velocity: $(V_x, V_y, V_z)_{GSE}$, $(V_x, V_y, V_z)_{GSM}$, $(V, V_{long}, V_{lat})_{GSE}$, proton density, 100 * (alpha part. density/proton density) Most probable proton thermal speed Delta time (1/2 length of spectra) $(X,Y,Z)_{GSE}$, $(X,Y,Z)_{GSM}$, R	At least every 2 min
3-D PLASMA	e flux: 7 energies (.1-225 keV), ion flux: 7 energies (.07 - 400 keV)] N_e, N_i, $\mathbf{V_e}$, $\mathbf{V_i}$, T_e, T_i, e heat flux along **B**, $\mathbf{V}_{s/c}$ (GSE), $(X,Y,Z)_{GSE}$	46 or 92 sec[1]
MFI	|<B>|, <|B|>, RMS, Num. pts. in avg., $(B_x, B_y, B_z, B, \phi, \lambda)_{GSM}$; $(B_x, B_y, B_z, B, \phi, \lambda)_{GSE}$, $(X,Y,Z)_{GSE}$, $(X,Y,Z)_{GSM}$, R	46 or 92 sec[1]
SMS	PARTICLE FLUXES Differential Intensity (10^{-6} - 10^{-5} part/cm^2-sec-sr-keV/e) SOLAR WIND PARAMETERS Solar wind speed: H^+ (150 - 2370 km/sec) Fe^{+10} (60 - 1000 km/sec) Solar wind density (10^{-6} - 10^2 cm^{-3}) Solar wind kinetic temperature (10^4 - 10^8 K)	2.0 min 3.0 min 3.0 min 3.0 min 3.0 min
TGRS	Major Frame Number, Instrument Mode, Fast Rate Counter Major Frame Accumulation, Average Fast Rate	5 min.
EPACT	STEP fluxes: He^3 (80-160 keV/n), He^5 (320-640 keV/n), CNO^3 (80-160 keV/n), CNO^5 (320-640 keV/n), Fe^3 (80-160 keV/n), Fe^6 (320 to 640 keV/n) LEMT fluxes: He (3.2-6.2 keV/n), O (3.2-6.2 keV/n), Fe (3.2-6.2 keV/n) APE-A fluxes: Electrons (0.2-2 MeV/n), Protons (4.6-6.6 MeV/n) Protons (6.6-25 MeV/n), He (4.6-6.6 MeV/n), He (6.6-25 MeV/n) APE-B: Electrons (1-10 MeV), Protons (19-28 MeV/n) Protons (28-72 MeV/n), He (19-28 MeV/n) He (28-72 MeV/n)	46 or 92 sec[1]
KONUS	n/a	

SOHO

Investigation	Key Parameters	Time resolution
CELIAS	Solar wind speed, Solar EUV rate (2 values 0., 1. order), heavy ion rate	5 min
COSTEP	electron flux: 0.25-0.7, 0.67-3, 2.64-6.18, 4.8-10.35 MeV; proton flux: 0.31-0.76, 0.76-1.99, 1.99-6.03, 4.3-7.8, 7.8-25.0, 25.0-40.9, 40.9-53.0 MeV; Helium flux: 4.3-7.8, 7.8-25, 25-40.9, 40.9-53 MeV/n	5 min
ERNE	electron flux: 4-16, >16 MeV; proton flux: 2-4, 4-8, 8-16, 16-32, 32-64, 64-128 MeV; 4He flux: 2-4, 4-8, 8-16, 16-32, 32-64, 64-128 MeV/n; abundance ratios: deuteron-to-proton (4-8, 32-64 MeV/n), 3He-to-4He (4-8, 32-64 MeV/n)	1 min

KPs Computed Internal to CDHF

POLAR

Investigation	Key Parameters	Time resolution
TIMAS	Partial density for H^+ (low, med, high energy range), O^+ (low, med, high energy range), He^+ (full energy range) and He^{++} (full enregy range); Three dimensional velocity for H^+ (low, full energy range), O^+ (low, full energy range), Temperature (parallel, perpendicular to **B**) for H^+ (low, full energy range), O^+ (low, full energy range) NOTE: Energy ranges not final until after instrument calibration, but best guess about ranges is: density_low_E_range (15 eV to 100 eV), density_medium_E_range (100 eV to 1 keV), density_high_E_range (1 keV to 30 keV), vel_temp_low_E_range (15 eV to 1 keV) and vel_temp_full_E_range (15 eV to 30 keV)	1 min
MFE	POS-GSE, POS-GSM, RAD-DIST, (T,H)=tilt anlge of dipole axis using dipole moment of date (IGRF with secular correction), B-Total (every 9.2 sec), BSC (**B** in s/c coords., every 9.2 sec), Comp_Delta (compressional standard deviation of the magnetic field in nT calculated over 6 vectors), Trans_Delta (Square root of the sum of the variance in the x, y and z direction less the compressional variance, BTAV (average magnitude of the magnetic field, averaged over 0.92 min from magnitudes taken every 9.2 s, **B**–GSE, **B**-GSM, BTIGRF (IGRF magnetic field magnitude calculated at the epoch of the measurements using the IGRF and secular terms), BCIGRF_GSE (Components of the IGRF magnetic field calculated at the epoch of measurement in GSE coords.), BCIGRF_GSM (Components of the IGRF magnetic field calculated at the epoch of measurement in GSM coords.), BT_Model (Magnitude of the Tsyganenko magnetic field model using the tilt of the dipole and the T89c model for the Kp=3-, 3, 3+ range, calculated every 9.2 sec and averaged over the 0.92 min of the observed field), BC_MODEL_GSE (the 3 components of the Tsyganenko magnetic field model using the tilt of the dipole andthe T89c model for the Kp=3-, 3, 3+ range, calculated every 9.2 sec and averaged over the 0.92 min of the observed field; rotated into GSE coordinates; epoch of the measurements is used to calculate model), BC_MODEL_GSM (the 3 components of the Tsyganenko magnetic field model using the tilt of the dipole and the T89c model for the Kp=3-, 3, 3+ range, calculated every 9.2 sec and averaged over the 0.92 min of the observed field; rotated into GSM coordinates; epoch of the measurements is used to calculate model), FOOT_PRINT (the northern geographic longitude and latitude and the southern geographic longitude and latitude respectively of the foot print of the field line that passes through the spacecraft in the model field)	0.92 min
HYDRA	Mean electron energy, Mean ion energy, Index indicating detection of statistically significant beam or void in the source/loss cone region, Energy at which the structure in the source/loss cone is inferred to be present	~ 1 min
EFI	E-spin plane (V12), E_{rms} (V12); E_x, E_y (V12), avg. sigmas (V12); $E_{x'}$, $E_{y'}$ (V34), avg. sigmas (V34); s/c potential, band pass filters 1-3, V34 potential; probe bias currents (V12, V34, V56)	9.2 sec
CEPPAD/ SEPS	Angular distribution (flux) Electrons (zenith) E>50keV background,3deg,9deg,15deg,21deg Electrons (nadir) E>50keV background,3deg,9deg,15deg,21deg Protons (zenith) E>50keV background,3deg,9deg Protons (nadir) E>50keV background,3deg,9deg Energy spectra (flux) Electrons (zenith) loss cone 50keV, 150keV,300keV,1MeV Electrons (nadir) source cone 50keV, 150keV,300keV,1MeV Protons (zenith) loss cone 50keV, 150keV,300keV,1MeV Protons (nadir) source cone 50keV, 150keV,300keV,1MeV	

POLAR

Investigation	Key Parameters	Time resolution
PWI	Δt (half a time interval), $f_{c,p}$, MLAT, MLT, R (geocentric radial distance), **E** peak, **E** average, **B** peak, **B** average, Freq., SFR_Mode	5 min
CAMMICE	Integral Spin Averaged Fluxes: He^+ (~40 keV - ~400 keV), He^{++} (~30 keV - ~400 keV), O^+ (~80 keV - ~400 keV), $O^{\geq 2+}$ (~50 keV - ~400 keV), He (~300 keV - ~10 MeV), CNO (~300 keV - ~15 MeV), >CNO (2 MeV - ~15 MeV) Angular Distributions (Anisotropy parameters): He^+, He^{++} (~50 - ~ 100/keV/amu), O^+ (~50 - ~ 200/keV/amu), He, O (> 100/keV/amu) Spectral Fits (Cubic in Log J vs. Log E space): He^+, He^{++}, O^+	96 sec
VIS	1. Pixels (image pixel counts range from 0 to 255); 2,3. Center time (the time assigned to an image is the center time of the integration period within a resolution of 50 millisec); 4. Image source (sensor number, 1=low res, 2=med res, 3=Earth sensor); 5. Half integration time; 6. Filter wheel position; 7. Field-stop wheel position; 8. Platform pitch angle; 9,10. Mirror pointing angles - elevation and azimuth in s/c coordinates; 11,12. Geographic coordinates every 15th row and every 15th column; 13. Spacecraft position vector in GCI coords. for the image center; 14. Presumed altitude of emissions; 15,16,17. Image-to-GCI rotation matrix; 18. Zenith angle of center line-of-sight at presumed altitude; 19. Sun vector in GCI coords. for the image center time given in KPs 2 and 3; 20. Solar zenith angle at observed point of center line-of-sight; 21,22. Low and high color mapping limits; 23. Display orientation flag	5 min
UVI	Poleward/Equatorward extent of auroral oval, Energy flux in 4 quadrants, sector, Characteristic energy, LBH_long Auroral Image (228 x 200), row number, column number	10 min
PIXIE	Accumulation half-interval, energy bin endpoints, energy bin upper limits, energy bin lower limit, energy range specifiers, energy range upper limit, energy range lower limit, X-ray source array, vertical pixel coord., horizontal pixel coord., X-ray source array - high & low energy, total X-ray flux - high & low energy, location of terminator - markers 1 & 2, pixel coords., location of Greenwich meridian, location of geographic pole, location of geomagnetic pole, location of sub-satellite point, MLT - markers 0, 6, 12 & 18 hrs, geographic long/lat map, MLT map, magnetic lat map, number of sub-images, aperture size	10 min/image
TIDE	First 13 moments of the ion velocity distribution function for each mass species sampled within the period of integration: N1, V1, T1, H1, N2, V2, T2, H2, N3, V3, T3, H3, N4, V4, T4, H4, N5, V5, T5, H5 (N=density, V=velocity, T=temperature, H=heat flux)	1 min
CEPPAD	Angular Distribution: Proton anisotropy parameters (>25 keV), error of fit (rms) Electron anisotropy parameters (>25 keV), error of fit (rms) HIST anisotropy parameters (>300 keV), error of fit (rms) Pitch Angle Flux Ratios (spin averaged, >25 keV: j(0)/j(90), j(45)/j(90), j(180)/j(90) for protons and electrons Energy Spectra: Cubic Fit IPS Protons, error of fit (rms), Cubic Fit IES Electrons, error of fit (rms) Integral Energetic Particle Fluxes: Proton flux > 25 keV, Electron flux > 30 keV, Electron flux > 300 keV Key Parameter Quality Flags: IPS (protons), IES (electrons), HIST (electrons)	96 sec

KPs Computed Externally to CDHF

GROUND BASED

Investigation	Key Parameters	Time resolution
CANOPUS/BARS	North & East components of drift velocity, number of measured vectors, eccentric dipole field line latitude	1 min
CANOPUS/MARIA	Riometer absorption corrected for instrument characteristics, CU & CL indices, CU lat/lon (geodetic) CL lat/lon (geodetic), site availability, sites, sites lat/lon	1 min
CANOPUS/MPA	λ5577 intensity (latitude scan for each photometer, 17 bins each scan)	5 min
CANOPUS/ASI	λ5577 image (One 16 x 25 pixel image)	5 min
DARN/PACE	GEO position, half scan time, half range in GEO coords., velocity components	~ 100 sec
DARN Goose Bay	GEO position, half scan time, half range in GEO coords., velocity components	~ 100 sec
DARN Saskatoon	GEO position, half scan time, half range in GEO coords., velocity components	~ 100 sec
DARN Iceland West	GEO position, half scan time, half range in GEO coords., velocity components	~ 100 sec
DARN Kapuskasing	GEO position, half scan time, half range in GEO coords., velocity components	~ 100 sec
SONDRESTROM	Begin/end/half integration time, GEO lat/lon, altitude, normalized power, N_e, T_i, T_e, N_e error, T_i error, T_e error, V_{ions}, V_{ions} error	10 sec to 5 min
SESAME/Advanced Ionospheric Sounder	f_{min}: lowest plasma frequency recorded (MHz) fE_{max}: highest plasma frequency recorded from E-region (MHz), fF_{max}: highest plasma frequency recorded from F-region (MHz)	15 min
SESAME/ELF-VLF Logger Investigation	VLF-1: mean, omni-directional logarithmic intensity of 1 kHz signal with 1 kHz bandwidth (dB) VLF-3: As above, but for 3 kHz signal (dB), 1/2-duration of observation	1 min
SESAME/Fabry Perot Interferometer	U_S: Horizontal Doppler velocity in geographic South direction (m/s), U_E: As above, but for geographic East direction, indicator to show emission wavelength	30 min (Apr - Sep only)
SESAME/Fluxgate Magnetometer	HDZ_system (components in Cartesian coords.), B_HDZ (Magnetic field components H, D, Z in nT; H=Horizontal (+) North, (-) South; D=Horizontal (+) East, (-) West; Z=Vertical (+) Down)	1 min
SESAME/Riometer	Absorption (dB): A_N (North), A_E (East), A_S (South), A_W (West). Note: in each case direction shifted onto an L-shell-aligned coordinate system	1 min

LANL

Investigation	Key Parameters	Time resolution
LANL/SOPA	Electrons: 50-225 keV & 315-1500 keV flux, density, temperature; Protons: 50-400 keV & 1.2-5 MeV flux, density, temperature; He (0.9-1.3 MeV) flux, Heavy ions (C, N, O): 5-15 MeV flux, $(lat, lon, R)_{GEO}$	61.44 sec
LANL/MPA	Low_Ions (1-130 ev): partial density, flow velocity, temperature ($T_\perp$, $T_\parallel$), temperature eigenvalue ratio ($T_\perp/T_{mid}$); High_Ions (130-43,000 eV): partial density, flow velocity, temperature ($T_\perp$, $T_\parallel$), polar angle of symm. axis (rel. to s/c-Earth direction), azimuth of symm. axis (rel. to North), temperature eigenvalue ratio ($T_\perp/T_{mid}$); Electrons (30-45,000 eV): partial density, temperature ($T_\perp$, $T_\parallel$), polar angle of symm. axis (rel. to s/c-Earth direction), azimuth of symm. axis (rel. to North), temperature eigenvalue ratio ($T_\perp/T_{mid}$), s/c potential, background $(lat,lon,altitude)_{GEO}$, $(mlat, mlt,altitude)_{MAG}$	172 sec

INTERBALL/Aurora[5]

Key Parameters	Contributing Instrument(s)	Time resolution
High-temperature plasma: F(e-), <Ee>, F(H+), <E H+>	ION, SKA-3, PROMICS-3A	TBD
High-temperature plasma: F(O+), <E O+>, azimuth angle O+ and polar angle O+	PROMICS-3A	TBD
High-temperature plasma: Fluxof ions 27-32 keV (1 detector directed from Sun, 2 directed at angle 45° to Sun or in scanning mode) Flow of electrons 27-32 keV (1 detector directed from Sun, 2 directed at angle 45° to Sun or in scanning mode) Pitch angle curve	DOK-2A	TBD
Cold plasma: Density of O+ ions, Density of H+ ions, Temperature of O+ ions, Temperature of H+ ions, Velocity of O+ ions (V_x, V_y, V_z), Velocity of H+ ions (V_x, V_y, V_z)	HYERBOLOID	TBD
Cold plasma: Temperature of electrons	KM-7	TBD
Cold plasma: Plasma density	AP-3A	TBD
Cold plasma: Beam current, probe potential	RON	TBD
Wave investigations: Spectrogram of HF E, Spectrogram of HF B (cyclotron gyrofrequency F_{ce} added)	POLRAD	TBD
Wave investigations: Spectrogram of HF E, Spectrogram of HF B (cyclotron gyrofrequency F_{ce} added)	MEMO	30 sec
VLF E, VLF B, ELF/VLF SFA E, ELF/VLF SFA B, Service parameter (SFA) [SFA = Sweep Frequency Analyzer]	MEMO	30 sec
Electric and Magnetic fields: Spectrogram of ULF E (orthogonal), Spectrogram of ULF B (orthogonal), Spectrogram of ULF E (parallel), Spectrogram of ULF B (parallel)	IESP-2	TBD
3 components of magnetic field, total magnetic field	IMAP-3	TBD
2 components of electric field, electric field DC	IESP-2	TBD
Auroral image	UVAI	30 min
Auxiliary information on s/c position (GSE & GSM)		every 1-3 hrs

INTERBALL/Tail[6]

Descriptors	Key Parameters	Contributing Instrument(s)	Time resolution
EMFT	Magnetic field: B_x, B_y, B_z, $\|B\|$	IMAP, MIF-M	~ 2 min
EMFT	Fluctuations: Electric field (1-8 Hz, 530-750 Hz, 20kHz)	OPERA	~ 2 min
EMFT	Fluctuations: Magnetic field (1-4 Hz, 600-800 Hz)	MIF-M/PRAM	~ 2 min
EMFT	Fluctuations: Electron flux (1-4 Hz)	IFPE/PRAM	
GPPT	Thermal plasma: n_e, T_e,	ELECTRON	~ 2 min
GPPT	Thermal plasma: n_i, V_i, T_i	MONITOR (solar wind) AP (plasmasphere) EU-1 or CORALL (other regions)	~ 2 min
EPTP	Oxygen: E_{O+} F_{O+},	PROMICS	~ 2 min
EPTP	Energetic particles: fluxes of ions and electrons (two directions, energy ranges TBD)	DOK-2	~ 2 min
EPTP	Energetic partilces: fluxes of ions (1-5 meV) and electrons 150-500 keV	SKA-2	~ 2 min
	Tail probe coordinates		1 hr
	PC (polar cap) geomagnetic index (from Thule and Vostok stations)		15 min

Appendix D – "Strawman" blueprint for LWS Ground-system taking advantage of existing infrastructure

APPENDIX D - "STRAWMAN" BLUEPRINT FOR LWS GROUND-SYSTEM TAKING ADVANTAGE OF EXISTING INFRASTRUCTURE - W. Mish (4/27/01)

FUNCTION	INFRASTRUCTURE LEVERAGED	NOTES
Flight Operations	Integrate LWS with SOHO or GGS MOC	Operation of LWS missions integrated for efficiency
Flight dynamics	Integrate LWS Flight dynamics with SOHO or GGS MOC	Compute Orbit, attitude, spin phase, etc. Xfr to EOF & CDHF for ancillary & summary parameter computation & xfr over internet to PI team
Instrument commands	xfrd from PI teams over internet to EOF/SPOF onto MOC	Use existing enhanced SOHO/GGS infrastructure
Telemetry Processing	Use SOHO DPS & IRTS technology (CCSDS Packets) co-located with MOC	LWS will use CCSDS packetized telemetry that can be dist. via internet to EOF, CDHF, & PI teams for inst health/safety and for instrument data distribution
Real-time science data	CDHF used for computation of real-time science para.	Real-time science data dist. by CDHF to end user over internet just as it is currently done for WIND/POLAR & Triana
Instrument health/safety	Use SOHO DPS & IRTS technology (CCSDS Packets)	CCSDS packetized telemetry quick-look distribution via internet to PI teams in real-time
Data Distribution level zero (packets)----> summary science para--> & high resolution science	use internet directly from DPS for non real-time PI teams compute science from LZ data @ institution or CDHF & use WWW for distribution	Accessed by CDAWeb & general science community over the WWW
Ancillary computations	Compute in CDHF just as done now & dist. Via WWW Solar Models,Tsyganenko Model, Magnetic Local Time, Carrington Rotation #, "L" Shell, other value added calc.	There are many "value added" functions now performed by the CDHF that help enable the science that would continue and be enhanced
Summary Parameters computation & ingestion from collaborative missions	Continue to Compute and ingest into CDHF the ISTP KP's & higher resolution data	LWS PI teams would have the choice of computing summary parameters within the CDHF or @ their institution
Archieval functions level zero---------------> science parameters----->	Write to CD's/DVD's using existing CDHF/IDDS Use the existing CDAWeb to make the science parameters available to the community	Archieves uses existing augmented infrastructure Archieves uses existing augmented infrastructure NSSDC continues to serve as deep archieve for level zero and science
Standards	Use existing Solar Physics & ISTP standards	Use FITS & IACG/ISTP Common Data Format for science products
LWS WWW-site	Use existing augmented SOHO & ISTP WWW-sites	SOHO/ISTP WWW-sites are highly developed, functional, & well accepted
Science coordination	Use existing augmented ISTP SPOF/EOF	Science Planning & Operations Facility/Experiment Ops. Facility