Environmental Data Production and Delivery for NPOESS

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***Abstract*-The NPOESS program will include a ground data processing system that is designed from the outset to provide outstanding speed and flexibility in product delivery to its users.**

I. INTRODUCTION

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will produce an unprecedented quantity, quality, and variety of operational remote sensing information that must be distributed in near real time to its user community. The NOAA/DoD/NASA Integrated Program Office is working to develop operational concepts, architectures, interfaces, and standards to handle the information production needs, in a cost effective manner, over the life cycle of the NPOESS program. First data will be delivered after the launch of the NPOESS Preparatory Program (NPP) satellite in 2006, which will serve as a risk-reduction mission for the operational 3-satellite polar constellation.

The ground data processing concepts and architecture have been refined over the past five years, in consultations between the government program office, users and advisory scientists, support contractors, and potential developers of the NPOESS system. The present system requirements [1] are based on the Integrated Operational Requirements Document [2], approved by the three agencies which guide the program.

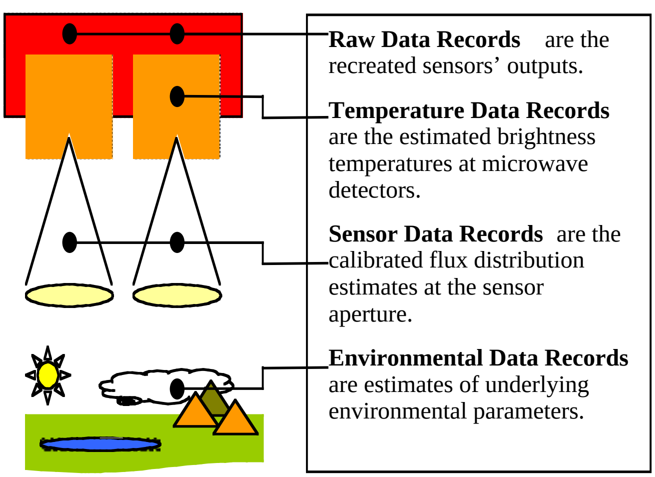

Fig. 1. Each NPOESS xDR product on the ground corresponds to a specific point in the remote sensing process. A product is a measure (re-creation or estimate) of an observed parameter, over a certain range of space and time.

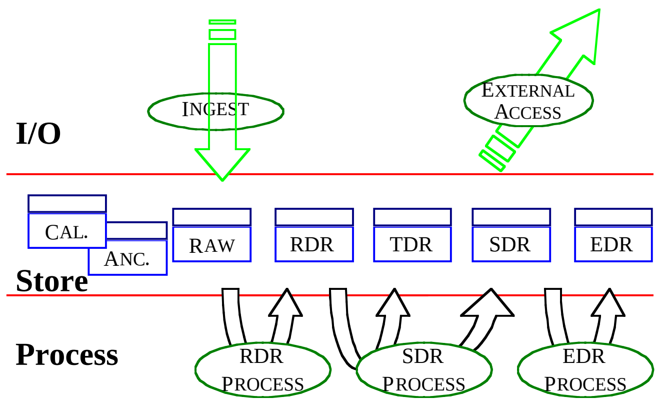

Fig. 2. A common processing architecture produces all data products. Different processes may operate in parallel, as fast as available hardware permits. All products and associated metadata are available to IDPS users.

II. PRODUCTS

NPOESS data will be delivered at three progressive levels of processing: Raw Data Records (RDR), Sensor Data Records (SDR), and Environmental Data Records (EDR). An SDR variant for microwave sensors, called a Temperature Data Record (TDR), will also be produced. RDRs will be processed to eliminate communications artifacts only; SDRs remove the sensor signature and apply calibration to recreate the flux distribution at the sensor aperture; and EDRs will employ environmental models – simple or complex – to estimate the causal geophysical parameters. There is one RDR for each sensor, one SDR for each sensor or each sensor channel, and one EDR for each of 60-odd specified environmental products. RDRs are generated at an average data rate of 15-20 Mbps for each operational satellite. The volume of SDR and EDR products is estimated to be at least four times as great.

III. TIMELINESS

Centrals: Products will be delivered by the NPOESS Interface Data Processor Segment (IDPS) at the four U.S. weather Centrals: NOAA's National Environmental Satellite, Data, and Information Service (NESDIS - Suitland MD), Navy's Naval Oceanographic Office (NAVO - Stennis MS), Navy's Fleet Numerical Meteorology and Oceanography

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Center (FNMOC - Monterey CA), and the Air Force Weather Agency (AFWA - Omaha, NE). Products will be delivered in less than 90 minutes from the time of observation, with a goal of 15 minutes for critical products. To achieve this timeliness, the ground data processing function -- hardware and software -- will be replicated at each Central. Data will be relayed from ground stations to the colocated IDPS elements at each Central as they are received. For the purposes of analysis, the program office assumes that there will be at least two ground contacts with the satellite each orbit, leading to a significant reduction in data latency (Table I). This reduction in data latency is complementary to the increase in revisit frequency offered by placing sensors in three orbital planes. Products and telemetry will be delivered from the NESDIS Central to long term archives, to the mission control centers for SARSat and the ARGOS data collection service, and to NASA.

Field Terminals: Products will also be available to local ground receivers worldwide, using an IPO-developed software processing package. Two classes of field terminals (FTs) are defined. High Rate Data FTs will be capable of processing the full 20 Mbps realtime raw data stream from the spacecraft at X-band. Low Rate Data FTs will handle a predefined 4 Mbps subset from the spacecraft at L-band.

IV. Delivery

The interface with the users will be based on several fundamental concepts. Some of these concepts are based on modern system engineering concepts which could not be implemented in previous environmental data systems [3], which often evolved piecemeal over the years. The need for some other concepts was highlighted by the difficulties experienced in developing similar systems. From the experience of EOSDIS [4], we have learned the importance of simple, open, flexible interfaces, and the importance of allowing each participant to control those activities which it does best.

First, the IDPS will not duplicate the unique value added

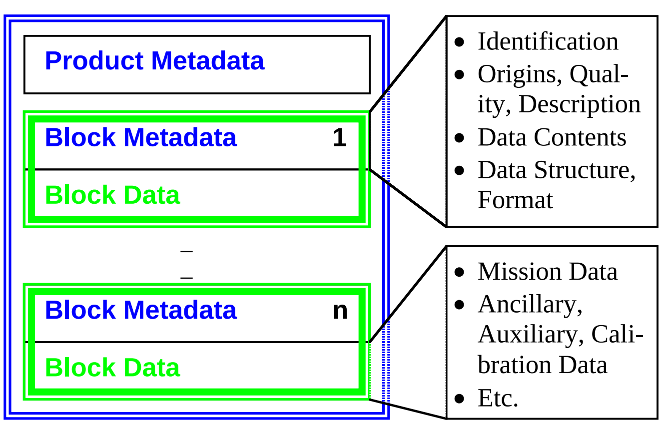

Fig. 3. Products will consist or one or more blocks of data, with metadata that describes both the product and the blocks.

TABLE I
Overall Timeline Concept to Achieve 90 min. Delivery

	Duration (minutes)	
Step	Oldest Data	Latest Data
Data collection	nil	nil
Hold on spacecraft	60	nil
Downlink	nil	nil
Terrestrial data return	nil	30
Accumulate data block	5	5
Process	25	25
Deliver to user	nil	nil
Total, collection to user	*90*	*60*

processing, formatting, and end-user distribution functions performed at the Centrals. IDPS will perform NPOESS-unique processing: products will be swath oriented, at full resolution, not resampled, and delivered in data blocks convenient for communications and storage, not full orbits as is typical today. Identical product processing will be implemented at each site. The NPOESS processing may be customized, within narrow limits, to the needs of the host Central or the host Field Terminal. Local ancillary data sources, algorithm parameters, and product needs may be accommodated.

Second, the interface will be simple and based on open standards. To satisfy the need for functional and hardware interoperability between IDPS and various user configurations, interfaces will be consistent with the DoD Joint Technical Architecture (JTA) [5]. Since the IDPS will be closely and statically connected with its direct users (Centrals and FTs), communications standards should be straightforward, and will take into consideration communications efficiency and network security.

Data products will be formatted in a self-describing, platform-independent format. The data rates, complexity, and variability of NPOESS data makes it unsuitable for the most common current formats used for operational environmental data sets, particularly GRIB and BUFR. netCDF and HDF have both been evaluated by the program. HDF version 5 [6] offers many attractive performance and supportability features, and is currently being recommended as a JTA interoperable format. Extensive hierarchical metadata (Fig. 3) will be included, to permit the sensed information to be selected, identified, and interpreted. Metadata definition will be guided by the Federal Geospatial Data Committee standards [7].

Information product processing, scheduling, and data management will be largely automated. While people are needed to provide quality control and anomaly resolution, routine operations can be conducted in a “lights out” environment, with hardware and process monitoring performed locally or remotely. An automated resource manager will coordinate data ingest from the ground stations, data push to the users, and the alternative processing steps in between. To meet timeliness requirements, data will be made available to users in data units corresponding to a few minutes. To assure robust delivery, data will be held 24 hours for the Centrals.

V. Flexibility

IDPS must evolve to accommodate changes in sensors, in sensor combinations on follow-on spacecraft, and in the algorithms which process the data. Among the flexibility features in IDPS will be the availability of a non-operational processing string at each Central, with access to current and archived data, on which new designs can be developed and evaluated. The IDPS will be architected so that data and processing are modular: data sets and processing will share hardware resources in an efficient manner, orchestrated by a processing manager function. New algorithms or data sets can be accommodated with minimum impact on other ongoing operations. There should be no stovepipes, or other algorithm- or sensor-unique hardware or processing strings.

Although it is understood that the transition to this new paradigm will not be painless, the flexibility should permit other sensors and satellite programs to be assimilated into the NPOESS ground processing architecture over time. For example, future data sets from METOP-3 might be processed within IDPS by adding sensor-unique ingest, RDR and SDR processes, and by sharing existing EDR processes.

VI. User Processing

NPOESS ground processing is not designed to replace the functions of the existing Centrals, nor to provide end solutions at the field terminals. IDPS delivers structured information in the form of satellite data to the users. The data are not, in general, structured for a specific application. The data *will* be structured to retain the full available information content, as captured by the satellite and processed into sensor and environment estimates.

Centrals and FTs will continue to provide such functions as mapping, mosaicking, subsetting, interpolation, spatial filtering, and temporal averaging. Users will fuse NPOESS data with similar and complementary data, and perform data assimilation. Centrals will provide standard and custom product distribution -- via broadcast, standing and special orders -- as printed pages, digital media, and communications messages. Centrals and their researchers will perform specialized calibration and climatology studies. FT developers will provide user displays, visualization software, and additional environmental applications. The forthcoming NESDIS CLASS archives [8] will provide the long-term repository for NPOESS data products and documentation, and distribution to specific user communities and the public.

VII. Next Steps

Currently, a team led by Lockheed Martin and Harris Corp., and a team led by TRW and Raytheon are completing the program design and risk reduction phase of the project. A prime contractor will be picked by the end of September to perform final design and implementation of the space and ground components. The first IDPS installation will be available to process data from the NPP satellite before its launch in 2006. NPP will provide information which extends EOS observations for research, and which reduces the risks when the operational NPOESS sensors are launched. Before the operational mission begins, the IDPS will complete its initial operational configuration by developing detailed interfaces with its users, installing requisite communications and processing equipment at user Centrals sites, incorporating best practices from information system design, and adopting the most appropriate processing and calibration algorithms from the sensor and environmental science communities.

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