PLANETARY DATA DISTRIBUTION SYSTEM

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ABSTRACT

A system is described that distributes digitized video, text data, and alarm notifications reflecting constantly changing conditions in the planetary environment as well as high-priority information affecting large populations. Data are delivered in near-real time to users worldwide via existing transmission facilities. The system is intended to warn of conditions such as earthquakes, tsunamis, severe weather, and solar disturbances, providing substantially more information than current methods while also continuously relaying large amounts of scientific and other data. Inputs to the system originate from a network of sensors plus Government and other automated information sources. Data handling speed is significantly enhanced by a DoD-developed data/image compression scheme combining digitized video with text and adapted to the transmission media.

Information on the system is directly accessible almost anywhere in the world via desktop-type computers equipped with special low-cost data converters, decoding hardware, and associated software. Transmission is via conventional television relay satellites and distributed by cable systems, individual satellite receivers, or other bandwidth-capable networks. The system can be configured to distribute information to some users and not others and can accommodate a wide variety of data types.

INTRODUCTION

Despite rapidly broadening commercial and Government efforts to increase information flow to the public via interactive television and related systems, significantly less interest has focused on using emerging distribution technologies for wide area dissemination of emergency and other quickly changing data. Terrestrial phenomena such as earthquakes, severe weather, and tsunamis as well as events affecting the near-earth space environment such as solar flares and geomagnetic storms have significant impacts on human activities but existing warning delivery systems tend to be diverse and provide limited coverage.

The system described below uses a Department of Defense-developed data handling system in conjunction with conventional transmission facilities to deliver time-critical information virtually instantaneously to desktop-type computers in any part of the developed world. Information to be broadcast is assembled at a central location, formatted into data streams, and relayed to satellites for distribution.

The data streams are received via conventional TeleVision Receive Only (TVRO) facilities and then decoded by low-cost ($200-400/user) equipment installed in a desktop-type computer. The system runs in the background on the user's machine, allowing the host computer to perform other tasks while incoming data are automatically retrieved and stored.

Distinct from interactive systems or data bases requiring individual user access, this approach represents a continuous flow of constantly updated emergency, scientific, and educational data while simultaneously providing information useful to the general public.

The PLANETARY DATA DISTRIBUTION SYSTEM (PDDS)

The primary equipment for the current system is located at two sites (see Figure 1): A central data collection and encoding facility at the U. S. Information Agency's (USIA) Network Control Center in Washington, D. C. and a dedicated data acquisition/interface device located at the National Oceanic and Atmospheric Administration (NOAA) Space Environment Laboratory (SEL) in Boulder, Colorado. Other equipment for relaying the data products via satellite is modular and can be installed at any conventional television uplink site.

Necessary equipment to receive the data consists of a satellite dish and receiver capable of recovering the relayed television signal, a signal converter, and a special circuit board for a desktop-type computer. Individual user equipment is described in greater detail below. Significant in this application is the capability for mass distribution of the entire data product via cable TV systems, bandwidth-capable computer networks, and other existing and emerging information distribution systems.

The current system provides two data products: a high data-rate feed (512 kbits/second) intended for the U. S. (all 50 states), Canada, Mexico, and the Caribbean Region plus a slower feed (64 kbits/second) with global coverage.

The domestic 512 kbit/second product is transmitted on a subcarrier accompanying commercial television signals being relayed via conventional TV satellites. Simultaneously, the global 64 kbit/second stream is inserted in the Vertical Blanking Interval (VBI) of the video signal of the USIA WORLDNET Television service. Containing a somewhat smaller data set, the VBI-based transmission product is intended for the worldwide environmental, scientific, technical, and educational communities; it will also be receivable throughout North America.

All data are encoded and prioritized using HORACE[1], a DoD-developed data-transmission protocol, which allows mixing of video and text data. Data flow is configured such that low priority information can be interrupted to send higher priority data and then lower priority flow resumed. HORACE also embodies a video data compression scheme allowing eight-bit video pixels to be compressed to from 1.5 to 2 bits; for most storage and viewing purposes, recovered image quality exceeds the display device capabilities.

This highly flexible, real-time approach to information distribution is not limited to any particular type of data and can, in fact, be used in a wide variety of applications such as information services, advertising, and messaging.

PDDS Inputs and Transmitted Data

Input data for the system come from a worldwide network of sensors, spacecraft, observatories, and Government agencies, whose information is continuously assembled at a central facility in Washington, D. C. Of particular importance is the data from the NOAA Space Environment Laboratory (SEL). That organization tracks conditions in the near-earth space environment and serves as a worldwide warning center for disturbances having significant impacts on spacecraft operations, communications, and navigation; PDDS gives the SEL an unprecedented ability to provide virtually instantaneous global warning.

Current plans include the following products to be carried via both domestic and global feeds:

- Near-real-time earthquake data from the National Earthquake Information Center.
- Tsunami warnings from the NOAA Tsunami Warning Center.
- Warnings of disturbances in the near-earth space environment which pose hazards to human activities (e. g., manned spacecraft, satellites, navigation systems, communications).
- The latest available satellite weather imagery from GOES, METEOSAT 4, and GMS.
- The latest solar images (in hydrogen-alpha and other wavelengths) from solar observatories around the world.
- Continuously updated data on the sun and solar-terrestrial environment from the NOAA Space Environment Laboratory.

In addition to the above products, the domestic feed is projected to also include:

- Detailed earthquake data and maps.
- Severe weather warnings and graphics with affected areas depicted.
- SIGMET, AIRMET, and other high-priority data from the National Weather Service and the Federal Aviation Administration.
- Disaster-related data and graphics from the Federal Emergency Management Agency (FEMA).

Subcarrier-based Distribution

The domestic, subcarrier-based data streams consist of two components: a 1.544 Mbit/second (T-1 rate) product which includes an encrypted component. The combined streams are sent via leased telephone data line to a satellite uplink facility where more data may be added before being put on a subcarrier for transmission.

In the satellite's reception footprint, conventional equipment at a TVRO station (e. g., cable TV companies or individual home receiving dishes) takes the subcarrier from the television signal. One local distribution approach is for a

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[1] U. S. Patent No. 5,062,136, "Telecommunication System and Method."

cable TV company to use commercial equipment to convert the subcarrier signal to a radio frequency and make it available in the FM portion of its cable spectrum. Individual TVRO users can access the subcarrier directly from where it appears at the "wideband output" of their satellite receiver.

A special low-cost circuit board in a desktop-type computer separates the data from the distribution signal, decodes it, and makes it available for use. The circuit board contains its own microprocessor, memory, and instructions so the entire reception, decoding, and data handling operations can take place independent of the computer's main processor.

All arriving data are examined by all user machines but only selected information is accepted. Selections of data to be extracted are made during software initialization and may be changed by the user at any time.

Vertical Blanking Interval (VBI[2])-based Distribution

Using the VBI of a television signal broadcast worldwide to distribute a data/image product appears to represent a cost-effective application of that capability since the technology involved is well established and accessible throughout the world. Emphasis in this global feed is placed on environmental and scientific information and, despite the slower 64 kbit/second data rate, large amounts of information are still transferred.

Devices similar to "closed-caption" encoders pack outgoing data into the VBI of both NTSC and PAL video waveforms which are then uplinked to various satellites for relay throughout the world. Users in the satellites' footprints employ low-cost VBI-based decoders to extract the data and make it available to desktop-type computers. Though data-recovery hardware differs from the subcarrier-based scheme, data handling and software is essentially the same.

An important capability of the global feed is not only providing essentially instantaneous worldwide warning of hazardous events in the solar-terrestrial environment (current warning times range into the tens of minutes--unacceptably long for many emerging high-tech systems), but also serving as a high-speed conduit for important scientific data which would normally take from weeks to months to distribute. The PDDS worldwide service also provides continuously updated weather satellite imagery, solar data, and communications advisories.

Data Format

Because the system continuously broadcasts over a wide area and users anywhere can begin monitoring the system at any time, the delivery method is totally asynchronous and capable of transmitting an entire data package relatively quickly.

To accomplish this, the overall scheme employs a repeating data "frame" containing the most current information and digitized video images. Inside the frame, each piece of data has its own unique and unchanging numerical identity, called a "tag," with a maximum of 65,536 tags possible in this particular application. Once identified by its unique number, user software immediately begins organizing incoming tags according to user-set preferences. Information inside each tag can change at any time with software designed to detect the new data and update accordingly.

The number of tags and the number of data bytes in each tag can vary (e. g., the tag with the current "solar flux" value contains just a few bytes while the tag containing the latest GOES satellite image has many more) with software controlling the process. The design objective was to achieve an approach that allows a user to obtain all current information within a short time after beginning to receive data.

Information is transferred sequentially from the host computer with higher priority data interrupting and replacing the flow of lower priority data. After the higher priority information is sent, the lower priority stream resumes; all data tags are uniquely specified in the stream so user equipment will handle them accordingly.

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[2] In a television set, this is the time the electron gun is turned off while its beam is repositioned back to the top left corner of the screen. This interval is equivalent to the time necessary to sweep out 21 horizontal picture lines and can be seen as a black bar between frames if a television's "vertical hold" control is adjusted to allow the picture to roll. Line 21 is used in the United States to insert "closed captions" for hearing-impaired viewers; PDDS uses lines 10 through 18.

In the current system configuration, there are four levels of data prioritization with others possible:

1. ASCII character-based alarm data.
2. ASCII character-based text that changes rapidly.
3. Digitized image and/or line-drawing files.
4. ASCII character-based text that changes slowly.

Secure Data Capabilities

Encryption technology allows wide flexibility in offering secure data services as part of the domestic product while providing a method to recover system operating costs via subscription fees. A portion of the data frame as well as separate segments of the data stream have been reserved for this purpose.

In addition to each user's unique "address," any number of different tags can possess different encryption/decryption keys such that only authorized user(s) can receive and access their assigned data. Further, these services are based on state-of-the-art techniques allowing continuous changes to encryption keys and secure tag assignments, ensuring a high degree of data security. All text and image transfer capabilities in the unsecured data product are also available in the secure service.

Circuit Board and Software

Recovered data are presented to a circuit board installed in the individual user's desktop computer. The data stream is decoded by software and information routed to destinations determined by the user. Under software control, data can be displayed, stored in files, or both. Boards will possess sufficient RAM capacity to store incoming data such that incoming new information is not displayed until completely received. Unless incoming data in a given tag have been designated for storage in files, new data replace the old as they arrive.

Via software, data priorities originally assigned by the system can be manually overridden and displays selected or deselected at the user's option. Software design allows for archived data files to be compatible with and accessible by data base applications. Depending on the host computer's operating system and machine architecture, the entire PDDS application is also designed to allow itself to run in the "background" so the computer can be used for other purposes simultaneously.

Other software options include the capability to store specified image files and retrieve them sequentially, thus producing "movies" (e. g., automatically storing a series of GOES weather images as they arrive and later playing them back to observe air mass movement patterns). Another option is to enable the computer to enter the PDDS program automatically after a set interval, go to a predetermined data page, and display it; in this application, the latest GOES full-disk earth image could be displayed as a "screen saver."

Initial circuit board design requirements call for compatibility with IBM PC-type desktop computers but additional configurations including a totally external unit for laptops and a Macintosh-based circuit board are planned.

For an individual user, unit cost, including Signal Converter, Circuit Board, Software, and Software Documentation is projected to be approximately US$200-400 which is expected to drop substantially as manufacturing volume increases. Moreover, hardware versions are planned that allow the Signal Converter to reside on the circuit board itself, depending upon the method of distributing data (e. g., subcarriers, RF signals via cable TV, Local Area Networks, etc.).

FUTURE EXPANSION

An important priority in developing PDDS is making the data stream available to the many emerging information services that offer large numbers of television channels. Not only is the present configuration immediately marketable, but additional products are possible which contain specialized data and images. Also ongoing is an effort to include PDDS as part of the National Information Infrastructure (NII) being developed by the U. S. Government.

Both hardware and software capabilities are expected to further expand and develop after the system becomes operational. Specialized software intended to handle certain categories of data is easily designed (e. g., extracting user-specified tags, archiving, processing, analyzing, and displaying the data) as is specific hardware (outside-world interfaces that act on incoming data).

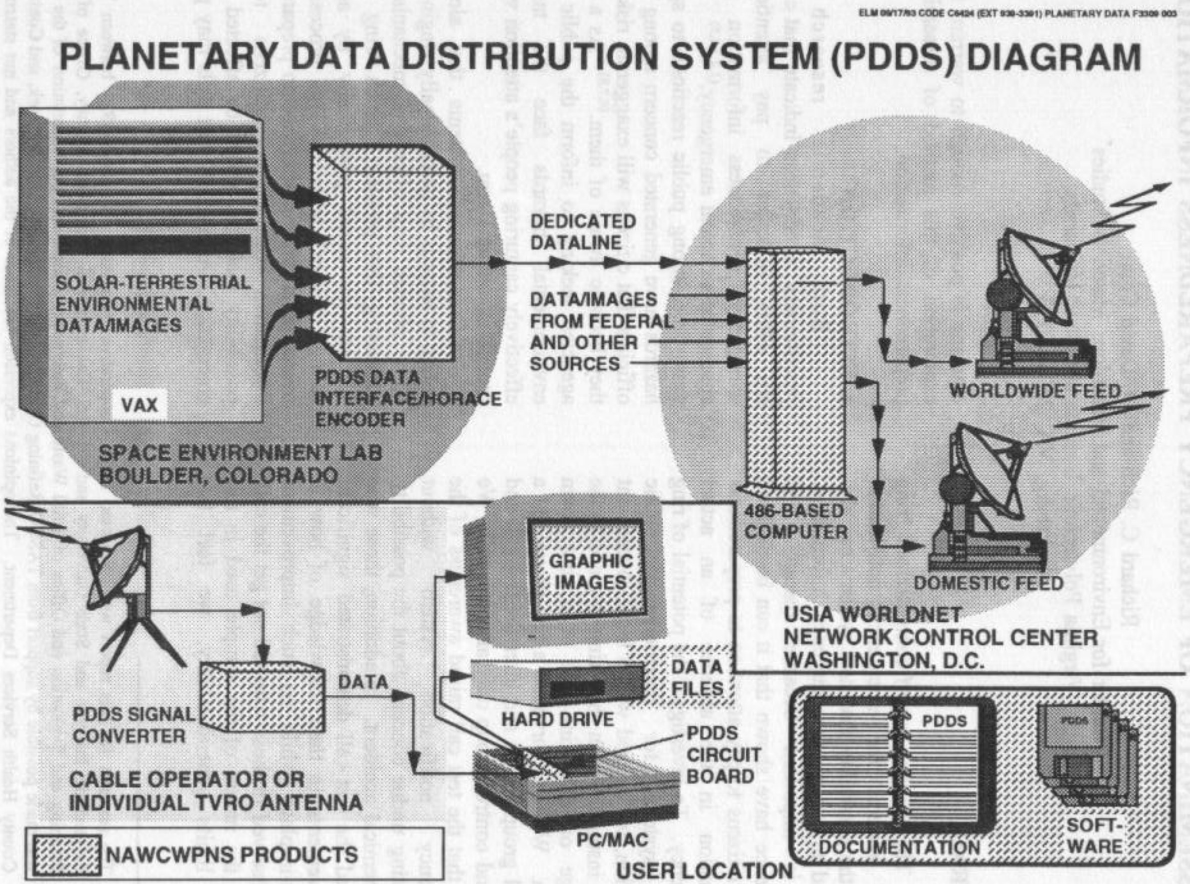
A notable future enhancement to the PDDS will be serving as a primary real-time worldwide relay for data from the Advanced Composition Explorer (ACE) satellite. This spacecraft will orbit a point of gravitational equilibrium near the sun, monitoring solar magnetic fields and particle emissions. As part of the PDDS product, ACE will provide an approximately 30-minute advance warning of high-energy sub-atomic particles and other solar outbursts that have significant impacts on earth-orbiting satellite systems and other terrestrial activities.

CONCLUSION

The potential user community for a system such as PDDS appears substantial. Because the system uses existing resources and reception equipment available at low cost, it appears to represent an excellent opportunity to establish a domestic and international real-time information network. Moreover, a primary design objective of PDDS was to produce a data product inherently distributable via mass broadcast media; this seems to make it marketable not only as a stand-alone system, but also as a potential offering for the quickly emerging family of information delivery systems.

At this writing, several U. S. Government agencies are actively involved in evaluating the capabilities PDDS would provide while several more have already expressed interest in participating. The NOAA Space Environment Laboratory intends to use PDDS as a primary data distribution network while officials in all branches of the U. S. military have plans for the system's capabilities. Also an enthusiastic participant is the solar research community and their worldwide system of observatories, with several major research laboratories currently gathering input from their scientists on ways to use the data PDDS would provide.

But seemingly the most important users would be the world's schools, colleges, and universities as well as the public at large as more and more data becomes available via systems like PDDS. Putting a global and instantaneous source of data literally at the fingertips of anyone with a home computer appears a natural direction for information technology.


ELM 09/17/93 CODE C6424 (EXT 939-3391) PLANETARY DATA F3309 003
PLANETARY DATA DISTRIBUTION SYSTEM (PDDS) DIAGRAM
SOLAR-TERRESTRIAL
ENVIRONMENTAL
DATA/IMAGES
VAX
PDDS DATA
INTERFACE/HORACE
ENCODER
SPACE ENVIRONMENT LAB
BOULDER, COLORADO
DEDICATED
DATALINE
DATA/IMAGES
FROM FEDERAL
AND OTHER
SOURCES
486-BASED
COMPUTER
WORLDWIDE FEED
DOMESTIC FEED
USIA WORLDNET
NETWORK CONTROL CENTER
WASHINGTON, D.C.
GRAPHIC
IMAGES
DATA
FILES
HARD DRIVE
PDDS
CIRCUIT
BOARD
PC/MAC
PDDS SIGNAL
CONVERTER
DATA
CABLE OPERATOR OR
INDIVIDUAL TVRO ANTENNA
NAWCWPNS PRODUCTS
USER LOCATION
PDDS
DOCUMENTATION
PDDS
SOFT-
WARE