2001 MARS ODYSSEY GAMMA-RAY SPECTROMETER SCIENCE DATA PRODUCTS. M. K. Crombie. K. P. Harshman, G. K. McArthur, C. Shinohara, and W. V. Boynton, Department of Planetary Science, Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson, AZ 85721-0092.

Introduction: The Mars Odyssey Gamma-Ray Spectrometer (GRS) is a suite of three instruments working together to collect data that will permit the mapping of elemental concentrations on the surface of Mars. The gamma sensor head (GS), the neutron spectrometer (NS) and the high-energy neutron detector (HEND), are a complementary set of instruments in that the neutron instruments have better counting statistics and sample to a greater depth than the GS, but the GS determines the abundance of many more elements. A full description of the Mars Odyssey Gamma-Ray Spectrometer instrument can be found in [1].

The GRS collects a new spectrum approximately every 20 seconds, 360 times per orbit. Approximately 4200 spectra are expected to be received every day. Science and engineering data are downloaded from the spacecraft by the Jet Propulsion Laboratory (JPL) into the Telemetry Data System (TDS). The TDS sends data to a process that translates data packets and examines instrument health. Data are passed via a spooler to the University of Arizona (UA) database ingest process. The ingest process inputs raw data and the associated timing and spatial information into the UA database. The data are then processed through a number of programs that result in a calibrated data set. Raw data including the timing and spatial information are retrieved from the UA database to produce the GRS EDR data sets. Data processed through calibrations are retrieved from the UA database and are used to build intermediate science data products such as corrected gamma spectra (CGS) and special products.

GRS EDR Data Product: The GRS EDR (experiment data record) data product is intended to be the lowest level (level 0) data available for the GRS, and is composed of a series of date stamped files that contain 1 days worth of data for the 10 basic data types produced by the GRS. Data sets are also identified by the mission phase during which the data were collected (Table 1.)

Table 1

Mission Phase	Start Date	End Date
Launch	04/07/2001	
Cruise	04/07/2001	10/23/2001
Aerobraking	10/24/2001	02/18/2002
Primary Mapping	02/19/2002	09/2004
Stowed Mapping	02/19/2002	06/01/2002
Deployed Mapping	06/05/2002	Mission End

Gamma Spectra: A gamma spectrum is the cumulative counts of gamma-rays seen by the detector during one collection interval binned into 16384 channels based on energy. The collection interval is ~19.7 seconds, but may vary over the course of mapping. Timing and spatial data provided with gamma spectra includes spacecraft clock values and geometric data recorded at the middle of the collection interval.

Neutron Spectra: Neutron Spectra data are 15 histograms, event data and associated timing and spatial information. The neutron histogram data are the cumulative counts of neutrons detected at one of four prisms over the collection interval (~19.7 sec). The timing and spatial data provided with the neutron spectra includes spacecraft clock values and geometric data recorded at the middle of the collection interval.

HEND Data: There are three types of HEND records, nominal, profile, or status. The nominal frames consist of six sixteen channel spectra. The profile frame consists of the six spectra plus two time profiles, and the status records consist of command information. The timing and spatial data provided with the HEND data includes spacecraft clock values and geometric data recorded at the middle of the collection interval.

Pulser Spectra: Pulser Spectra are spectra that include data from three artificially produced pulses of energy. During the normal spectrum collection time voltage pulses of known amplitudes, and a flag labeling them as pulsers, are sent to the GRS detector at a frequency of 10Hz. These pulses are interpreted by the detector as events and are binned in the appropriate energy channels, but saved in a separate memory location. Pulser spectra are used to evaluate the frequency response and drift of the detector and electronic components as functions of instrument temperatures, voltages, and other variables.

Profile Data: Profile data are an array of the raw gamma events continuously binned at high time resolution and limited energy resolution. These data are sent from the instrument when a gamma-ray burst is detected. At the time of detection the collection interval's profile data are packaged for downlink along with the standard data sets.

Engineering Data: Engineering data are composed of the 66 different engineering readings monitored by the GRS. The engineering readings can be taken at several different time intervals that can be changed depending on spacecraft operation.

Channelized Data: Channelized data are 26 engineering readings from the spacecraft. These data are taken by the spacecraft, and sampling intervals are set by the JPL spacecraft team.

Command List: Command List data are a record of the commands that have been sent to, or executed from the spacecraft. Timing information stored with the commands indicates when the command was sent, the time the command was received, and when the command was executed.

Message Log: Message Log data is the data sent in response to an action taking place in the GRS. The message data includes general messages and warnings. Timing information associated with each message is the time the message was produced.

E-Kernel: The E-Kernel data are the Experimenter's Notes, the list of commands sent, and the associated timing information.

GRS CGS Data Product: The corrected gamma spectra (CGS) data are raw gamma spectra that have been processed through a number of calibrations to have a common energy scale. The common energy scale allows the spectra to be compared directly. The direct comparison of gamma spectra is important because there are relatively few counts in each individual spectrum. In order to accumulate enough counts to separate the signal peaks from the background it is necessary to sum spectra together. The sums are only meaningful if the spectra to be summed have a common energy scale. The following paragraphs are a summary of the process used to create CGS records.

Once raw gamma data, with associated timing, spatial and engineering data are entered into the database, a series of computer processes are initiated to prepare the data for correction. The engineering data is smoothed by a gaussian-weighted smoothing algorithm to remove noise. The temperature for the 170k board, an electrical component used for signal amplification in the GS that is not directly monitored, is calculated. The digital housekeeping information that identifies the state of various components on the spacecraft is extracted and deciphered. The engineering interpolator does a linear interpolation from the engineering records before and after each gamma record to fill in the engineering fields in the gamma record of interest, and the digital housekeeping information is used to insert the shaping amp gain values into each gamma spectrum record. Once these steps have been completed the gamma spectrum is ready for correction.

The correction process calculates the gain, offset, and linearity of the uncorrected gamma spectrum based on measured temperatures of various spacecraft subsystems. Since there are not enough counts in any given collection interval to establish a calibration, the correction process uses a spectrum shifting algorithm to re-bin the counts in each spectrum, aligning the channels in all of the spectra to a common energy scale. The corrected spectra can then be directly compared and are a scientifically useful data product.

Special Data Products: The GRS Science Team released a set of six special products with data used in a series of publications [2], [3], [4]. These special products included portions of a gamma spectrum showing an emission line due to capture of thermal neutrons by hydrogen, neutron spectrometer thermal, epithermal and fast neutron flux maps, and HEND epithermal and fast neutron flux maps. It is the intention of the GRS Science Team to release additional special products upon the publication of future papers.

All current data products are available online from the 2001 Mars Odyssey Data Archives web site, http://wwwpds.wustl.edu/missions/odyssey/.

Future Data Products: The GRS Science Team will release additional derived science data products in future PDS releases. Summed gamma spectra (SGS), corrected gamma spectra that have been summed over a time range and a latitude and longitude range, will be produced. Manipulated neutron data (MND) and normalized neutron data (NND) are currently under development. Eventually, gamma and neutron maps will be produced.

References: [1] Boynton, W. V. et al. (2002) Space Sci. Rev. Submitted. [2] Boynton, W. V. et al. (2002) Science., 297, 81-85. [3] Feldman, W. C. et al. (2002) Science., 297, 75-78, [4] Mitrofanov, I. et al. (2002) Science., 297, 78-81.