Mars Atmosphere and Volatile Evolution (MAVEN) Mission

Langmuir Probe and Waves Instrument (excluding EUV)

PDS Archive

Software Interface Specification

[Rev. 1.0 June 17, 2014]

Prepared by

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[Rev. 1.0 June 18, 2014]

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1 Introduction

This software interface specification (SIS) describes the format and content of the Langmuir Probe and Waves Instrument (excluding EUV) (LPW) Planetary Data System (PDS) data archive. It includes descriptions of the data products and associated metadata, and the archive format, content, and generation pipeline.

1.1 Distribution List

Table 1: Distribution list

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1.2 Document Change Log

Table 2: Document change log

Version	Change	Date	Affected portion
0.0	Initial template	2012-Aug-24	All
0.1	Updated template	2013-Feb-13	All
0.2	Updated template	2013-Apr-03	All
0.3	Updated template	2014-Jan-30	All
0.4	First draft	2014-Mar-1	All
0.5	Second draft	2014-June-4	All
1.0	First Version of the Document	2014-June-18	All

1.3 TBD Items

Table 3 lists items that are not yet finalized.

Table 3: List of TBD items

Item	Section(s)	Page(s)
Full references for PDS4 Standards Reference, and Data Provider's Handbook documents (to be provided by PDS/PPI)	1.9	
Sample labels (to be provided by PDS/PPI)	Appendices C, D, and E	

1.4 Abbreviations

Table 4: Abbreviations and their meaning

Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
Atmos	PDS Atmospheres Node (NMSU, Las Cruces, NM)
CCSDS	Consultative Committee for Space Data Systems
CDR	Calibrated Data Record
CFDP	CCSDS File Delivery Protocol
CK	C-matrix Kernel (NAIF orientation data)
CODMAC	Committee on Data Management, Archiving, and Computing
CRC	Cyclic Redundancy Check
CU	University of Colorado (Boulder, CO)
DAP	Data Analysis Product
DDR	Derived Data Record
DMAS	Data Management and Storage
DPF	Data Processing Facility
E&PO	Education and Public Outreach
EDR	Experiment Data Record
EUV	Extreme Ultraviolet; also used for the EUV Monitor, part of LPW (SSL)
FEI	File Exchange Interface
FOV	Field of View
FTP	File Transfer Protocol
GB	Gigabyte(s)
GSFC	Goddard Space Flight Center (Greenbelt, MD)
HK	Housekeeping
HTML	Hypertext Markup Language

Abbreviation	Meaning
ICD	Interface Control Document
IM	Information Model
ISO	International Standards Organization
ITF	Instrument Team Facility
IUVS	Imaging Ultraviolet Spectrograph (LASP)
JPL	Jet Propulsion Laboratory (Pasadena, CA)
LASP	Laboratory for Atmosphere and Space Physics (CU)
LID	Logical Identifier
LIDVID	Versioned Logical Identifer
LPW	Langmuir Probe and Waves instrument (SSL)
MAG	Magnetometer instrument (GSFC)
MAVEN	Mars Atmosphere and Volatile EvolutioN
MB	Megabyte(s)
MD5	Message-Digest Algorithm 5
MOI	Mars Orbit Insertion
MOS	Mission Operations System
MSA	Mission Support Area
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautics and Space Administration
NGIMS	Neutral Gas and Ion Mass Spectrometer (GSFC)
NMSU	New Mexico State University (Las Cruces, NM)
NSSDC	National Space Science Data Center (GSFC)
PCK	Planetary Constants Kernel (NAIF)
PDS	Planetary Data System
PDS4	Planetary Data System Version 4
PF	Particles and Fields (instruments)
PPI	PDS Planetary Plasma Interactions Node (UCLA)
RS	Remote Sensing (instruments)
SCET	Spacecraft Event Time
SDC	Science Data Center (LASP)

Abbreviation	Meaning
SCLK	Spacecraft Clock
SEP	Solar Energetic Particle instrument (SSL)
SIS	Software Interface Specification
SOC	Science Operations Center (LASP)
SPE	Solar Particle Event
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPK	Spacecraft and Planetary ephemeris Kernel (NAIF)
SSL	Space Sciences Laboratory (UCB)
STATIC	Supra-Thermal And Thermal Ion Composition instrument (SSL)
SWEA	Solar Wind Electron Analyzer (SSL)
SWIA	Solar Wind Ion Analyzer (SSL)
TBC	To Be Confirmed
TBD	To Be Determined
UCB	University of California, Berkeley
UCLA	University of California, Los Angeles
URN	Uniform Resource Name
UV	Ultraviolet
XML	eXtensible Markup Language

1.5 Glossary

Archive – A place in which public records or historical documents are preserved; also the material preserved – often used in plural. The term may be capitalized when referring to all of PDS holdings – the PDS Archive.

Basic Product – The simplest product in PDS4; one or more data objects (and their description objects), which constitute (typically) a single observation, document, etc. The only PDS4 products that are *not* basic products are collection and bundle products.

Bundle Product – A list of related collections. For example, a bundle could list a collection of raw data obtained by an instrument during its mission lifetime, a collection of the calibration products associated with the instrument, and a collection of all documentation relevant to the first two collections.

Class – The set of attributes (including a name and identifier) which describes an item defined in the PDS Information Model. A class is generic – a template from which individual items may be constructed.

Collection Product – A list of closely related basic products of a single type (e.g. observational data, browse, documents, etc.). A collection is itself a product (because it is simply a list, with its label), but it is not a *basic* product.

Data Object – A generic term for an object that is described by a description object. Data objects include both digital and non-digital objects.

Description Object – An object that describes another object. As appropriate, it will have structural and descriptive components. In PDS4 a 'description object' is a digital object – a string of bits with a predefined structure.

Digital Object – An object which consists of real electronically stored (digital) data.

Identifier – A unique character string by which a product, object, or other entity may be identified and located. Identifiers can be global, in which case they are unique across all of PDS (and its federation partners). A local identifier must be unique within a label.

Label – The aggregation of one or more description objects such that the aggregation describes a single PDS product. In the PDS4 implementation, labels are constructed using XML.

Logical Identifier (**LID**) – An identifier which identifies the set of all versions of a product.

Versioned Logical Identifier (LIDVID) – The concatenation of a logical identifier with a version identifier, providing a unique identifier for each version of product.

Manifest - A list of contents.

Metadata – Data about data – for example, a 'description object' contains information (metadata) about an 'object.'

Non-Digital Object – An object which does not consist of digital data. Non-digital objects include both physical objects like instruments, spacecraft, and planets, and non-physical objects like missions, and institutions. Non-digital objects are labeled in PDS in order to define a unique identifier (LID) by which they may be referenced across the system.

Object – A single instance of a class defined in the PDS Information Model.

PDS Information Model – The set of rules governing the structure and content of PDS metadata. While the Information Model (IM) has been implemented in XML for PDS4, the model itself is implementation independent.

Product – One or more tagged objects (digital, non-digital, or both) grouped together and having a single PDS-unique identifier. In the PDS4 implementation, the descriptions are combined into a single XML label. Although it may be possible to locate individual objects within PDS (and to find specific bit strings within digital objects), PDS4 defines 'products' to be the smallest granular unit of addressable data within its complete holdings.

Tagged Object – An entity categorized by the PDS Information Model, and described by a PDS label.

Registry – A database that provides services for sharing content and metadata.

Repository – A place, room, or container where something is deposited or stored (often for safety).

XML – eXtensible Markup Language.

XML schema – The definition of an XML document, specifying required and optional XML elements, their order, and parent-child relationships.

1.6 MAVEN Mission Overview

The MAVEN mission is scheduled to launch on an Atlas V between November 18 and December 7, 2013. After a ten-month ballistic cruise phase, Mars orbit insertion will occur on or after September 22, 2014. Following a 5-week transition phase, the spacecraft will orbit Mars at a 75° inclination, with a 4.5 hour period and periapsis altitude of 140-170 km (density corridor of 0.05-0.15 kg/km^3). Over a one-Earth-year period, periapsis will presses over a wide range of latitude and local time, while MAVEN obtains detailed measurements of the upper atmosphere, ionosphere, planetary corona, solar wind, interplanetary/Mars magnetic fields, solar EUV and solar energetic particles, thus defining the interactions between the Sun and Mars. MAVEN will explore down to the homopause during a series of five 5-day "deep dip" campaigns for which periapsis will be lowered to an atmospheric density of 2 kg/km^3 (~125 km altitude) in order to sample the transition from the collisional lower atmosphere to the collisionless upper atmosphere. These five campaigns will be interspersed though the mission to sample the subsolar region, the dawn and dusk terminators, the anti-solar region, and the North Pole.

1.6.1 Mission Objectives

The primary science objectives of the MAVEN project will be to provide a comprehensive picture of the present state of the upper atmosphere and ionosphere of Mars and the processes controlling them and to determine how loss of volatiles to outer space in the present epoch varies with changing solar conditions. Knowing how these processes respond to the Sun's energy inputs will enable scientists, for the first time, to reliably project processes backward in time to study atmosphere and volatile evolution. MAVEN will deliver definitive answers to high-priority science questions about atmospheric loss (including water) to space that will greatly enhance our understanding of the climate history of Mars. Measurements made by MAVEN will allow us to determine the role that escape to space has played in the evolution of the Mars atmosphere, an essential component of the quest to "follow the water" on Mars. MAVEN will accomplish this by achieving science objectives that answer three key science questions:

- What is the current state of the upper atmosphere and what processes control it?
- What is the escape rate at the present epoch and how does it relate to the controlling processes?
- What has the total loss to space been through time?

MAVEN will achieve these objectives by measuring the structure, composition, and variability of the Martian upper atmosphere, and it will separate the roles of different loss mechanisms for both neutrals and ions. MAVEN will sample all relevant regions of the Martian atmosphere/ionosphere system—from the termination of the well-mixed portion of the atmosphere (the "homopause"), through the diffusive region and main ionosphere layer, up into the collisionless exosphere, and through the magnetosphere and into the solar wind and downstream tail of the planet where loss of neutrals and ionization occurs to space—at all relevant latitudes and local solar times. To allow a meaningful projection of escape back in time, measurements of escaping species will be made simultaneously with measurements of the energy drivers and the controlling magnetic field over a range of solar conditions. Together with measurements of the isotope ratios of major species, which constrain the net loss to space over time, this approach will allow thorough identification of the role that atmospheric escape plays today and to extrapolate to earlier epochs.

1.6.2 Payload

MAVEN will use the following science instruments to measure the Martian upper atmospheric and ionospheric properties, the magnetic field environment, the solar wind, and solar radiation and particle inputs:

- NGIMS Package:
  - Neutral Gas and Ion Mass Spectrometer (NGIMS) measures the composition, isotope ratios, and scale heights of thermal ions and neutrals.
- RS Package:
  - Imaging Ultraviolet Spectrograph (IUVS) remotely measures UV spectra in four modes: limb scans, planetary mapping, coronal mapping and stellar occultations. These measurements provide the global composition, isotope ratios, and structure of the upper atmosphere, ionosphere, and corona.
- PF Package:
  - Supra-Thermal and Thermal Ion Composition (STATIC) instrument measures the velocity distributions and mass composition of thermal and suprathermal ions from below escape energy to pickup ion energies.
  - Solar Energetic Particle (SEP) instrument measures the energy spectrum and angular distribution of solar energetic electrons (30 keV – 1 MeV) and ions (30 keV – 12 MeV).
  - Solar Wind Ion Analyzer (SWIA) measures solar wind and magnetosheath ion density, temperature, and bulk flow velocity. These measurements are used to determine the charge exchange rate and the solar wind dynamic pressure.
  - Solar Wind Electron Analyzer (SWEA) measures energy and angular distributions of 5 eV to 5 keV solar wind, magnetosheath, and auroral electrons, as well as ionospheric photoelectrons. These measurements are used to constrain the plasma environment, magnetic field topology and electron impact ionization rate.
  - Langmuir Probe and Waves (LPW) instrument measures the electron density and temperature and electric field in the Mars environment. The instrument includes an EUV Monitor that measures the EUV input into Mars atmosphere in three broadband energy channels.
  - Magnetometer (MAG) measures the vector magnetic field in all regions traversed by MAVEN in its orbit.

1.7 SIS Content Overview

Section 2 describes the LPW instrument. Section 3 gives an overview of data organization and data flow. Section 4 describes data archive generation, delivery, and validation. Section 5 describes the archive structure and archive production responsibilities. Section 6 describes the file formats used in the archive, including the data product record structures. Individuals involved with generating the archive volumes are listed in Appendix A. Appendix B contains a description of the MAVEN science data file naming conventions. Appendix C, Appendix D, and Appendix E contain sample PDS product labels. Appendix F describes LPW archive product PDS deliveries formats and conventions.

1.8 Scope of this document

The specifications in this SIS apply to all LPW products submitted for archive to the Planetary Data System (PDS), for all phases of the MAVEN mission. This document includes descriptions of archive products that are produced by both the LPW team and by PDS.

1.9 Applicable Documents

[1] Planetary Data System Data Provider's Handbook, TBD.

[2] Planetary Data System Standards Reference, Version 1.2.0, March 27, 2014.

[3] Planetary Science Data Dictionary Document, TBD.

[4] Planetary Data System (PDS) PDS4 Information Model Specification, Version 1.1.0.1.

[5] Mars Atmosphere and Volatile Evolution (MAVEN) Science Data Management Plan, Rev. C, doc. no. MAVEN-SOPS-PLAN-0068.

[6] Archive of MAVEN CDF in PDS4, Version 3, T. King and J. Mafi, March 13, 2014.

1.10 Audience

This document serves both as a SIS and Interface Control Document (ICD). It describes both the archiving procedure and responsibilities, and data archive conventions and format. It is designed to be used both by the instrument teams in generating the archive, and by those wishing to understand the format and content of the LPW PDS data product archive collection. Typically, these individuals would include scientists, data analysts, and software engineers.

2 LPW Instrument Description

The LPW instrument measures the electron density (n_e) and temperature (T_e) of Mars ionosphere and detects waves that can heat ions in resulting in atmospheric loss. The instrument is designs to measure three different types of quantities using three sensors located on the spacecraft as shown in Figure 1. First is the Extreme UltraViolet (EUV) sensor monitoring the irradiance of the Sun. The details of the EUV sensor and higher order data products are described in a separate SIS document [7]. The other two quantities are using the same sensors to measure the in-situ plasma. The sensors are two cylindrical sensors mounted on two ~7-meter booms shown as LPW sensor 1&2 in Figure 1. Electronically the LPW sensor 1&2 are either operated as two separate Langmuir probe (LP) instruments or as one electric field instrument. The Boom Electronics Board (BEB) and the Digital Fields Board (DFB) controls the three sensors and process the three sensor information. The LPW is a part of the Particle and Fields (PF) suite and controlled by Particle and Fields Digital Processing Unit (PFDPU) described in another document [8]. The BEB and DFB are part of the PFDPU located inside the spacecraft body, Figure 1.

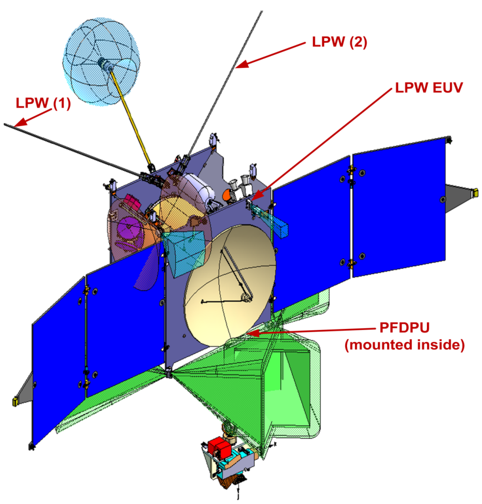

Figure 1: The location of the LPW sensors on MAVEN.

2.1 Science Objectives

The LPW instrument is designed to measure the electron density and temperature in the ionosphere of Mars and to measure the spectral power density of waves in Mars' ionosphere, including waves that can heat the ions resulting in atmospheric loss. The LPW [9] is part of the Particle and Fields (PF) suit on the MAVEN spacecraft [10]. The LPW instrument utilizes two, 40 cm long by 0.635 cm diameter cylindrical sensors, which can be configured to measure either plasma currents or plasma waves. The sensors are mounted on two, ~7-meter long stacer booms. The sensors and nearby surfaces are controlled by a Boom Electronics Board (BEB), which allows for operation as either a Langmuir Probe or a wave electric field receiver. The Digital Fields Board (DFB) conditions the analog signals, converts the analog signals to digital, processes the digital signals including spectral analysis, and packetizes the data for transmission. The BEB and DFB are located inside of the Particle and Fields Digital Processing Units (PFDPU) [8]. One part of the instrument, the Extreme UltraViolet sensor [11], is described in a companion SIS [7]. The EUV signals are received and processed by the LPW so the EUV signal processing is included to some extent in this document.

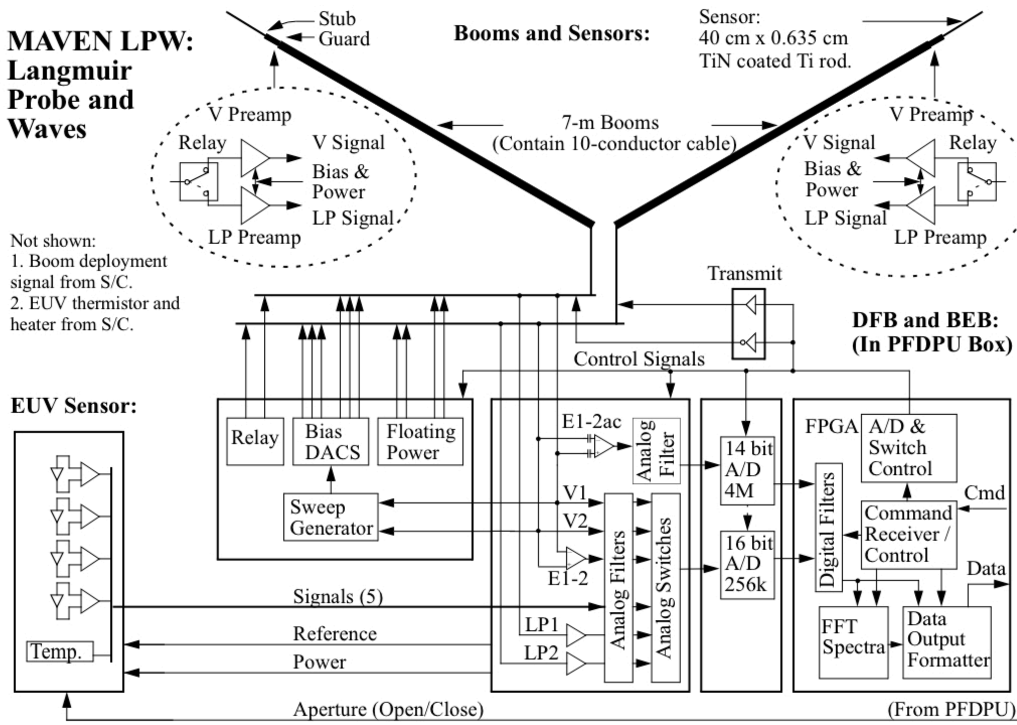

Figure 2: Block diagram of LPW instrument (including EUV)

2.2 Measurement techniques

The electron density and temperature are derived from the current-voltage (*I-V*) characteristic, a well-established technique. With this technique, the current from the plasma to a voltage-biased probe is measured over a range of probe voltages, creating an *I-V* characteristic. *I-V* characteristics are fit to determine the n_e, T_e, ion density (n_i), and spacecraft potential (V_{SC}). The "LP sweep" contains 128 programmable voltages inside of -50 V to 50 V range. The minimum step size is ~25 mV. The sweeps are performed in one second (configurable) and are pseudo-logarithmic, designed to have the smallest steps near zero potential. The dwell time at each step 7.8 ms in the nominal configuration for Mars' ionosphere.

To cover the large range of n_e and T_e, the LPW sensors detect a wide range of probe current (I_P), from -0.02 mA to 0.2 mA at ~30 nA resolution. Here, positive current is electron collection. The resolution is limited by the analog-to-digital conversion (16 bit).

This measurement technique, when implemented on a spacecraft, requires several other factors to be taken into consideration. Two sensors are used for the LP sweep since one or the probes could be in the spacecraft wake. The ratio of conductive surface area of the sensors to that of the spacecraft needs to be such that V_{SC} does not significantly change during a sweep. When biased at a positive voltage, the probe attracts electrons, so the spacecraft must attract an ion current or emit photoelectrons. Since the ion thermal velocities are considerably lower than that of electrons, the spacecraft must have a significantly larger collection area compared to the probe area. On MAVEN, the area ration of the spacecraft to probe surface is ~100. However, the ion collection by the spacecraft can vary depending on the spacecraft attitude and velocity. The LPW has an additional feature such that, during an LP sweep, one probe performs the sweep while the other probe monitors the plasma potential so that a change in V_{SC} can be detected.

V_{SC} is influenced by plasma conditions, spacecraft attitude and velocity, and sunlight so it may vary dramatically during an orbit. The LP sweep is automatically adjusted to account for V_{SC}. The "sweep offset" is adjusted to a voltage level at which the absolute value of the current was at a minimum in the previous sweeps. The instrument can enable an automatic offset adjustment. The LPW can operate with -45 V < V_{SC} < 45 V.

Photoelectron currents can interfere with the fitting process that determines n_e and T_e. These currents come in two forms. The photoelectron fluxes from the spacecraft to the probe are minimized by a combination of long booms (7 m) and biased surfaces near the sensors (guards and stubs). The photoelectron currents emitted by the probe to the plasma (or spacecraft) must be removed in data analysis. Surface treatments of the probe are designed to have small variations in photoelectron emission.

The absolute accuracy of the n_e measurement can be greatly improved (to <5%) if the frequency of Langmuir waves or upper hybrid waves can be determined. The LPW includes an electric field wave receiver that covers the frequency range from ~1 Hz to 2 MHz. These data are called "passive spectra". The wave power is calculated on board and separated into three different frequency ranges low (LF), medium (MF) and high (HF). The HF spectra are designed to contain the plasma line when available (50kHz to 2MHz) and have two gain stages (HF and HF-HG). The upper hybrid or plasma frequencies within the HF frequency range it correspond to densities between ~30 cm^{-3} and $5x10^4$ cm^{-3}. The LF spectrum is designed to monitor the available power to heat ions close to the ion gyro-frequencies. These spectrums are derived using 1048 points. The receiver can be sensitive to plasma waves with a spectral power density as low as $3x10^{-14}$ $(V/m)^2/Hz$ at 1 MHz. The electrostatic cleanliness program on the MAVEN spacecraft did not include conductive solar arrays, as the process was deemed to expensive, so spacecraft noise may dominate the noise floor of the plasma wave receiver. The noise floor is to be determined once MAVEN is in orbit around Mars.

Since naturally occurring plasma waves may not be detected frequently, the MAVEN LPW can stimulate the surrounding plasma with a 5 V pseudo-random sequence using the stacer booms as transmitting elements. This relaxation sounding technique measures the plasma frequency in quiet environments. The sequence is to broadcast simultaneously on both antennas, receive the plasma wave electric field immediately after the broadcast is turned off, and record the spectra. These data are called "active spectra".

The low-frequency electric field measurement includes piecewise continuous waveforms of one component of the electric field with a range of $\pm$1 V/m and a resolution 0.3 mV/m. The data processing also includes LF spectra (10 Hz – 1 kHz) and MF spectra (100 Hz – 16 kHz).

The instrument can also record the time series of the electric field measurements that is the base for the onboard spectra in special operation modes. In the High Speed Burst Mode (HSBM) high-resolution time series are recorded. The number of points used for the three time series are 1048, 4096, and 4096 for LF, MF, and HF, respectively. Only the largest amplitude cases of HSBM is recorded and sent to the archive memory in PF. The data stored in the archived memory can be selected from ground to be downloaded later. Due to the data volume, the HSBM data is infrequently collected.

2.3 Detectors and Electronics

Following text is a brief description of the instrument, a more detail description is provided in Andersson et al. [9].

The two cylindrical sensors are mounted on two ~7-m long stacers. They are mounted approximately 90 degrees to each other and on the spacecraft so that most of the time always one of the booms is outside any spacecraft wake and far away from the solar panels (Figure 1). The line between the two sensors is along the y-axis of the spacecraft coordinate.

The LPW sensors are diagramed in Figure 3. The sensor or "whip" is a 40 cm by 0.635 cm titanium tube with a TiN surface Erikson et al. [12], which acts as the physical collection area (~80 cm^2). This area is roughly 100 times smaller than the expected collection area of the spacecraft. The sensor is electrically connected to the inputs of the preamplifiers. The collection area results in ~20 nA at the lowest densities (~10^2 cm^{-3}) and ~0.2 mA if the density were to reach 10^6 cm^{-3}. The cylindrical sensor has the advantage that the current collection properties (e. g., focus factor) are well behaved and well understood (analytically).

The signal-processing unit for the LPW instrument contains two circuit boards, the Boom Electronics Board (BEB) and the Digital Fields Board (DFB), which are located in the PFDPU. The LP and W preamplifiers on the 2 booms and the EUV sensors are connected to the BEB or DFB as illustrated in Figure 2. The LPW commands arrive via the PFDPU and data packets from the LPW are sent via the PFDPU for transmission (survey data) or stored in the archive location in the PFDPU to be later selected for down link (archive data).

The LPW, once configured, operates the sweeps and cycles through the measurements independently. The spacecraft controls the one time boom deployment, the one time EUV door deployment, and the heaters on the EUV and the boom. The spacecraft provides alerts to the PFDPU for the LPW. The PFDPU holds configuration tables for the LPW in EEPROM. The PFDPU also passes operation commands to the LPW and maintains the archive memory. The PFDPU controls the EUV aperture.

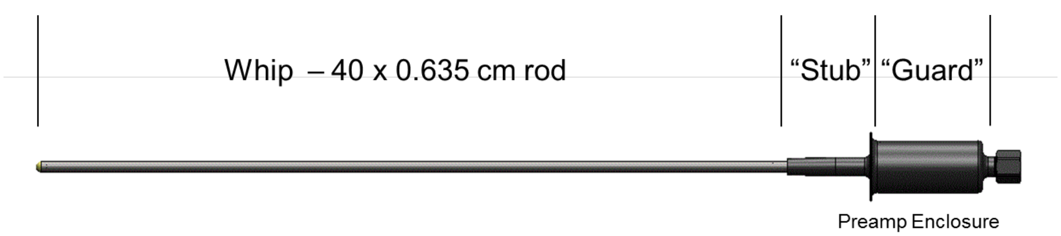

Figure 3: LPW mechanical design of the sensor and preamp.

The DFB receives and conditions the science and engineering signals listed in Table 5: The low-pass poles of the analog filters. All filters are designed to have linear phase delay (Bessel) so that the signal shape is preserved. The E_{MF} and E_{HF} signals have a 1-pole high pass filter at 100 Hz. for A/D conversion. All signals are conditioned by Bessel filters. Two A/D converters are employed. The E_{HF} signal is converted by a 14-bit A/D at 4.19x10^6 samples/s. All of the other channels share a 16-bit A/D running at 262,144 samples/s. The signals are channeled to the A/D via a series of analog switches controlled by the FPGA.

Table 5: The low-pass poles of the analog filters. All filters are designed to have linear phase delay (Bessel) so that the signal shape is preserved. The E_{MF} and E_{HF} signals have a 1-pole high pass filter at 100 Hz.

Signals	Filter Freq.	Poles	Sample Rate (s^{-1})	Signals	Filter Freq.	Poles	Sample Rate (s^{-1})
$LP_{1,2}$	400 Hz	3	16,384	EUV_A	25 Hz	3	1,024
$V_{1,2}$	400 Hz	3	1,024	EUV_B	25 Hz	3	1,024
E_{LF}	400 Hz	5	1,024	EUV_C	25 Hz	3	1,024
E_{MF}	26.2 kHz	5	65,536	EUV_D	25 Hz	3	1,024
E_{HF}	1.62 MHz	5	4.19x10^6	EUV T	25 Hz	3	1,024
$Guard_{1,2}$	25 Hz	3	1,024	$Bias_{1,2}$	25 Hz	3	1,024
$Stub_{1,2}$	25 Hz	3	1,024	$Temp_{1,2}$	25 Hz	3	1,024

2.4 Operational Modes

The LPW performs both LP sweeps and wave (W) measurements by cycling through the measurements. An individual sensor cannot operate in LP mode and W mode simultaneously. A master cycle (Figure 4) is defined to contain four sub-cycles, which performs specific measurements (e.g. an LP sweep or wave measurement). Each of the four sub-cycles has the same time duration, ¼ of the time duration of the master cycle. The master cycle length can be 4 s (1 s sub cycles) to 256 s (64 s sub-cycles).

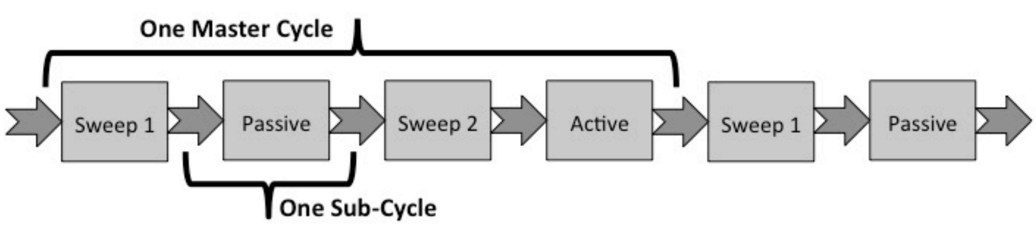

Figure 4: The planned LPW operation cycle. The LPW cycles through LP and W subcycles to measure n_e, T_e, and plasma waves.

The planned master cycle is outlined in Figure 4. The LPW instrument begins by performing a 128-point LP sweep on sensor 1, labeled Sweep 1 in Figure 4, while recording the DC potential on sensor 2. Next, both sensors are set to W mode and wave spectra and time series of the electric field are taken. The LPW then performs a LP sweep on sensor 2 while recording the DC potential on sensor 1. The last sub-cycle executes the relaxation sounder. A white-noise transmission is made on the stacers and the wave spectra are recorded.

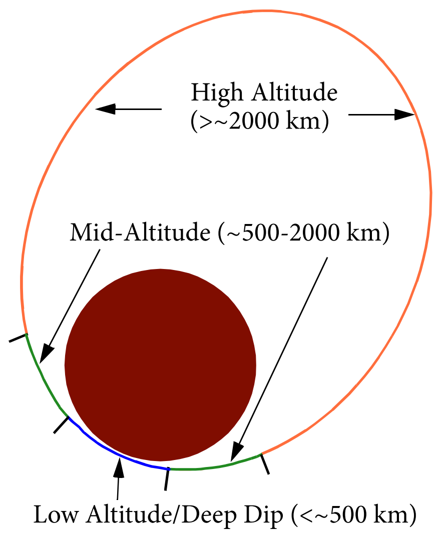

Figure 5: The LPW basic configuration is to operate with a 4 s master cycle at the lowest altitudes (< ~500 km), a 8-16 s master cycle at mid-altitudes (~500 km to ~2000 km), and a 64-128 s master cycle at high altitudes.

Since the science focus of the LPW instrument is at low-altitudes (< ~500 km) and during deep dips, the master cycle length at low altitudes is configured to 4 s, the fastest operation (Figure 5). Between ~500 km and ~2000 km there are several important plasma boundaries. The plasma density is lower, so the master cycle is set to 8-16 s. For a 16 second master cycle, this allows for 4 s sweeps with ~30 ms dwell times. At higher altitudes, the master cycle is set to 64-128 s, primarily for solar wind monitoring. Data limitations play an important role in the LPW operations. Roughly 80% of the data allocation is used below ~500 km.

The LWP sweep tables, sensor biasing, and biasing tables for the guards and stubs are re-configured to optimize the measurements over a large range of plasma conditions. The sweep tables, for example, have a narrow voltage range at low altitudes where dense plasma is expected (-5 V to 5 V; see discussion on automatic offset adjustment). The voltage range is expanded when in the solar wind to -45 V to 45 V. Adjustments are also made if the spacecraft is in Mars' umbra. These adjustments are based on the predicted orbit (time-tagged commands).

2.5 Measured Parameters

The LPW measure different products depending on which sub-cycle the instrument is in. There is some flexibility to modify the products, but presented below is the baseline.

Sweep 1 sub-cycle: The current at each 128 point voltage sweep on Boom 1 are recorded together with the potential on boom 2, also 128 points. The cadence depends on the master cycle length.

Sweep 2 sub-cycle: Exactly the same as Sweep 1 but the boom numbers is reversed.

Active sub-cycle: Low frequency potential on boom1 (V1), boom2 (V2), and the electric field (E12). There are 64 points per sub-cycle and the cadence depends on the master cycle length. Also the there spectrum LF, MF, and HF is produced.

Passive sub-cycle: Produces the same products as the Active sub-cycle but also can produce the LF, MF, and HF HSBM time series.

EUV parameters: When LPW is on EUV is sampling data. During normal operation EUV produce 1 sample per second. EUV sampling cadence is independent on the master cycle period.

House keeping parameters: Infrequent data information for monitoring the instrument health and operation state. There are three different sets of data; engineering information about the instrument, the active mode tables sent down and the active settings read back.

Table 6: Characteristics of the E_{LF}, E_{MF} and E_{LF} spectra.

		Analog Filtering		**Digital Processing**							**Power Spectral Density**	
Signal	Gain	Low Pass -3 dB (Hz)	High Pass -3 dB (Hz)	Sample Rate (s^{-1})	Freq. Min. (Hz)	Freq. Max. (Hz)	# Freq. Bins	($\delta f/f$) Ave.	(df/f) Min.	(df/f) Max.	Receiver Sensitivity $(V/m)^2/Hz$	Narrow Band Range $(V/m)^2/Hz$
E_{LF}		DC	400	1024	0.5	7.5	8	$\delta f = 1$ Hz			$8x10^{-12}$	$6x10^{-2}$
					8.5	496	48	9%	6.5%	12%	$3x10^{-12}$	$6x10^{-2}$
E_{MF}		100	$2.6x10^4$	$6.6x10^4$	32	480	8	$\delta f = 64$ Hz			$5x10^{-15}$	$4x10^{-5}$
					544	$3.2x10^4$	48	9%	6.5%	12%	$2x10^{-15}$	$4x10^{-5}$
E_{HF}	Low	100	$1.6x10^6$	$4.2x10^6$	2048	$9.6x10^4$	24	$\delta f = 4096$ Hz			10^{-15}	$2x10^{-6}$
					$1x10^5$	$2.1 x10^6$	104	3.1%	2.1%	4.1%	$5x10^{-16}$	$2x10^{-6}$
	High	100	$1.6x10^6$	$4.2x10^6$	2048	$9.6x10^4$	24	$\delta f = 4096$ Hz			10^{-17}	10^{-7}
					$1x10^5$	$2.1 x10^6$	104	3.1%	2.1%	4.1%	$2x10^{-17}$	10^{-7}

2.6 Operational Considerations

There are multiple external effects that will impact the quality of the LPW instrument. The instrument is designed to be on a sun-pointing platform. Due to different restrictions, the spacecraft platform will not always be sun-pointing, impacting the data quality. Also, some of the flow direction of the plasma with respect to the instrument mounting on the spacecraft can influence the measurement quality but also the plasma flow depending on the spacecraft conducting surfaces might impact the measurement quality. Since the conduciveness of the spacecraft body is important, the angle of plasma flow will change the spacecraft potential to stay close to the plasma potential. The instrument and spacecraft will behave differently in sunlit and darkness; therefore especially at the transition between the two regions the instrument operation might not be operated in the most optimal way.

The instrument is designed to be in different operation modes that match best local environmental. Operationally, sharp changes in the plasma conditions will result in the instrument is not always in optimal setting. The timing of changing the modes will be based on best available information on ground. The largest operational consideration is to get the instrument in to the appropriate mode for the plasma conditions without switching mode too often. The instrument will always complete a master cycle before change to the new mode.

2.7 Ground Calibration

Ground calibrations of the instrument were preformed on ground in control environment to calibrate the instrument response.

TBR. In Figure 6 is the instrument response to the frequency presented.

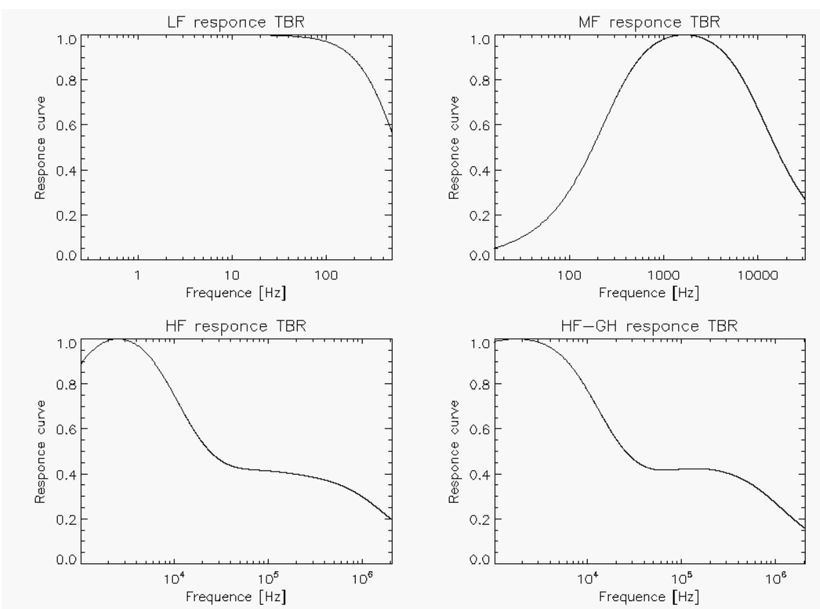

Figure 6: TBR Amplitude response as function of frequency for the different frequency filters. HF can be operated with a high gain setting (HG).

2.8 Inflight Calibration

Once the spacecraft is in orbit several calibration activities will be done to maximize the instruments performance. Some of them are the settings of the instrument bias, stub, guard, sweep tables, and master cycle length. All of these calibrations need to be done with respect to which plasma environment the instrument is in and if the instrument is sunlit or not.

As expected, the instrument in stowed configuration is impacted by thruster firing and reaction wheel activity. This will be corrected for in the archived L2-data products.

2.9 References

[7] EUV SIS document TBR

[8] Particle and Fields Digital Processing Unit (PFDPU) paper TBR

[9] LPW paper TBR

[10] Particle and Fields suite paper TBR

[11] EUV paper TBR

[12] TiN surface Eriksson et al, 2007 TBR

[13] MAG SIS document TBR

[14] MAG paper TBR

3 Data Overview

This section provides a high level description of archive organization under the PDS4 Information Model (IM) as well as the flow of the data from the spacecraft through delivery to PDS. Unless specified elsewhere in this document, the MAVEN LPW archive conforms with version 1.1.0.1 of the PDS4 IM [4] and version 1.0 of the MAVEN mission schema. A list of the XML Schema and Schematron documents associated with this archive are provided in Table 7 below.

Table 7: MAVEN LPW Archive Schema and Schematron

XML Document	Steward	Product LID
PDS Master Schema, v. 1.1.0.1	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-xml_schema
PDS Master Schematron, v. 1.1.0.1	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-xml_schema
MAVEN Mission Schema, v. 1.0	MAVEN	
MAVEN Mission Schematron, v. 1.0	MAVEN	

3.1 Data Processing Levels

A number of different systems may be used to describe data processing level. This document refers to data by their PDS4 processing level. Table 8 provides a description of these levels along with the equivalent designations used in other systems.

Table 8: Data processing level designations

PDS4 processing level	PDS4 processing level description	MAVEN Processing Level	CODMAC Level	NASA Level
Raw	Original data from an instrument. If compression, reformatting, packetization, or other translation has been applied to facilitate data transmission or storage, those processes are reversed so that the archived data are in a PDS approved archive format.	0	2	1A
Reduced	Data that have been processed beyond the raw stage but which are not yet entirely independent of the instrument.	1	2	1A
Calibrated	Data converted to physical units entirely independent of the instrument.	2	3	1B

PDS4 processing level	PDS4 processing level description	MAVEN Processing Level	CODMAC Level	NASA Level
Derived	Results that have been distilled from one or more calibrated data products (for example, maps, gravity or magnetic fields, or ring particle size distributions). Supplementary data, such as calibration tables or tables of viewing geometry, used to interpret observational data should also be classified as 'derived' data if not easily matched to one of the other three categories.	3+	4+	2+

3.2 Products

A PDS product consists of one or more digital and/or non-digital objects, and an accompanying PDS label file. Labeled digital objects are data products (i.e. electronically stored files). Labeled non-digital objects are physical and conceptual entities which have been described by a PDS label. PDS labels provide identification and description information for labeled objects. The PDS label defines a Logical Identifier (LID) by which any PDS labeled product is referenced throughout the system. In PDS4 labels are XML formatted ASCII files. More information on the formatting of PDS labels is provided in Section 6.3. More information on the usage of LIDs and the formation of MAVEN LIDs is provided in Section 5.1.

3.3 Product Organization

The highest level of organization for PDS archive is the bundle. A bundle is a list of one or more related collection products which may be of different types. A collection is a list of one or more related basic products which are all of the same type. Figure 7 below illustrates these relationships.

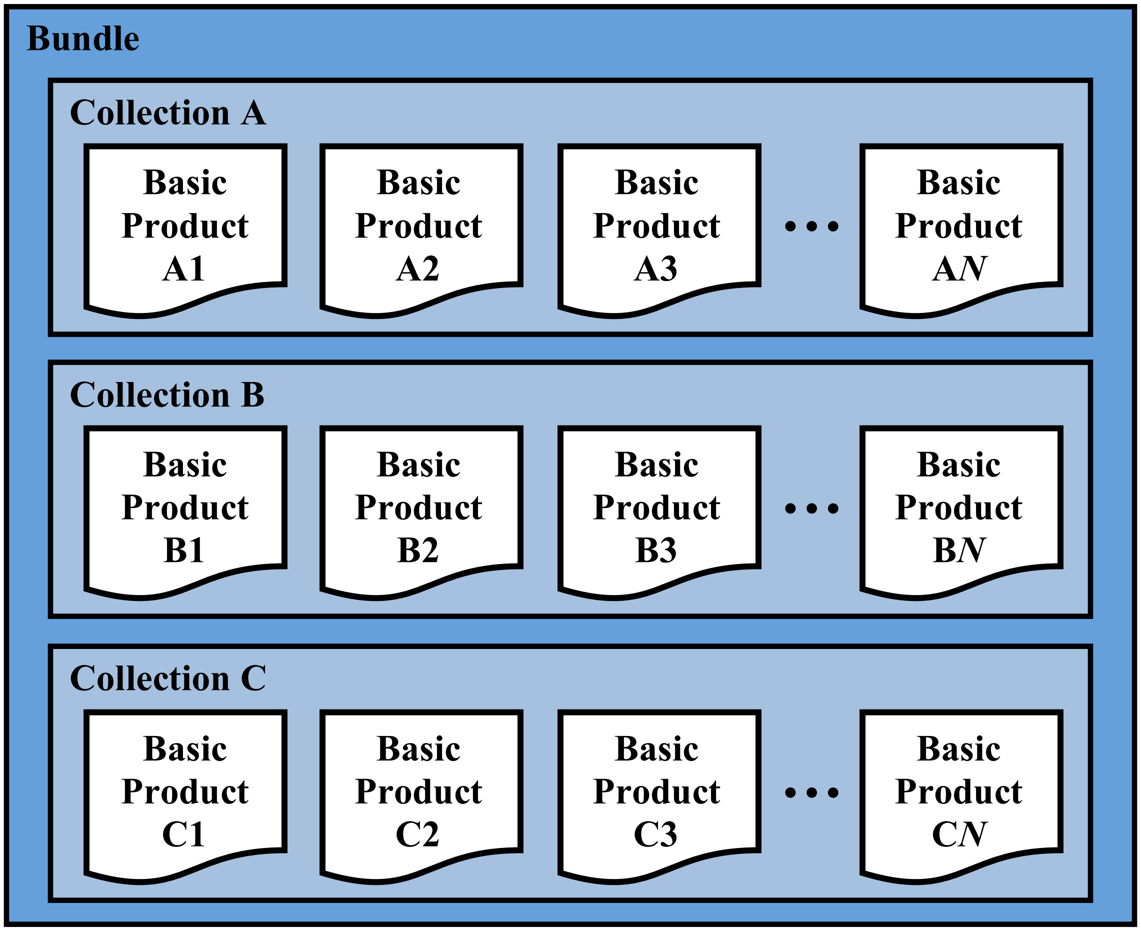

Figure 7: A graphical depiction of the relationship among bundles, collections, and basic products.

Bundles and collections are logical structures, not necessarily tied to any physical directory structure or organization. Bundle and collection membership is established by a member inventory list. Bundle member inventory lists are provided in the bundle product labels themselves. Collection member inventory lists are provided in separate collection inventory table files. Sample bundle and collection labels are provided in Appendix C and Appendix D, respectively.

3.3.1 Collection and Basic Product Types

Collections are limited to a single type of basic products. The types of archive collections that are defined in PDS4 are listed in Table *9*.

Table 9: Collection product types

Collection Type	Description
Browse	Contains products intended for data characterization, search, and viewing, and not for

	scientific research or publication.
Calibration	Contains data and files necessary for the calibration of basic products.
Context	Contains products which provide for the unique identification of objects which form the context for scientific observations (*e.g.* spacecraft, observatories, instruments, targets, etc.).
Document	Contains electronic document products which are part of the PDS Archive.
Data	Contains scientific data products intended for research and publication.
SPICE	Contains NAIF SPICE kernels.
XML_Schema	Contains XML schemas and related products which may be used for generating and validating PDS4 labels.

3.4 Bundle Products

The LPW data archive is organized into 7 bundles; of which LPW will deliver 4 of the PDS via SDC for archiving. A description of each bundle is provided in Table 10. A more detailed description of the contents and format of each bundle controlled by the LPW ITF is provided in Section 5.2.

Table 10: LPW Bundles

Bundle Logical Identifier	PDS4 Reduction Level	Description	Data Provider
TBD	Raw	PF packets – all packets together, describe in separated document. This are L0 files	SDC
urn:nasa:pds:maven.lpw.raw	Raw	LPW packets in separate CDF files. These are regarded as L0b files	TBD
maven.lpw.l1a – not delivered to PDS	Calibrated/ Derived	Preliminary data, CDF files that might be deliver to SDC but not to PDS. These are regarded L1a files. Contains identical files to urn:nasa:pds:maven.lpw.calibrated/ urn:nasa:pds:maven.lpw.derived	ITF
maven.lpw.l1b – not delivered to PDS	Calibrated/ Derived	Preliminary data, CDF files that might be deliver to SDC but not to PDS. These are regarded L1b files. Contains identical files to urn:nasa:pds:maven.lpw.calibrated/ urn:nasa:pds:maven.lpw.derived	ITF
urn:nasa:pds:maven.lpw.calibrated	Calibrated	Fully calibrated: spacecraft potential, electric field waveforms and wave power. Provided by the LPW team in CDF files. These are L2 files.	ITF
urn:nasa:pds:maven.lpw.derived	Derived	Derived L2 quantities: density, temperature, Poynting flux. Provided by the LPW team in CDF files. These are L2 files.	ITF
urn:nasa:pds:maven.lpw	N/A	LPW Documentation	ITF

3.5 Data Flow

This section describes only those portions of the MAVEN data flow that are directly connected to archiving. A full description of MAVEN data flow is provided in the MAVEN Science Data Management Plan [5]. A graphical representation of the full MAVEN data flow is provided in Figure 8 below.

Reduced (MAVEN level 1) data will be produced by RS and NGIMS as an intermediate processing product, and are delivered to the SDC for archiving at the PDS, but will not be used by the MAVEN team.

All ITFs will produce calibrated products. Following an initial 2-month period at the beginning of the mapping phase, the ITFs will routinely deliver preliminary calibrated data products to the SDC for use by the entire MAVEN team within two weeks of ITF receipt of all data needed to generate those products. The SOC will maintain an active archive of all MAVEN science data, and will provide the MAVEN science team with direct access through the life of the MAVEN mission. After the end of the MAVEN project, PDS will be the sole long-term archive for all public MAVEN data.

Updates to calibrations, algorithms, and/or processing software are expected to occur regularly, resulting in appropriate production system updates followed by reprocessing of science data products by ITFs for delivery to SDC. Systems at the SOC, ITFs and PDS are designed to handle these periodic version changes.

Data bundles intended for the archive are identified in Table 10.

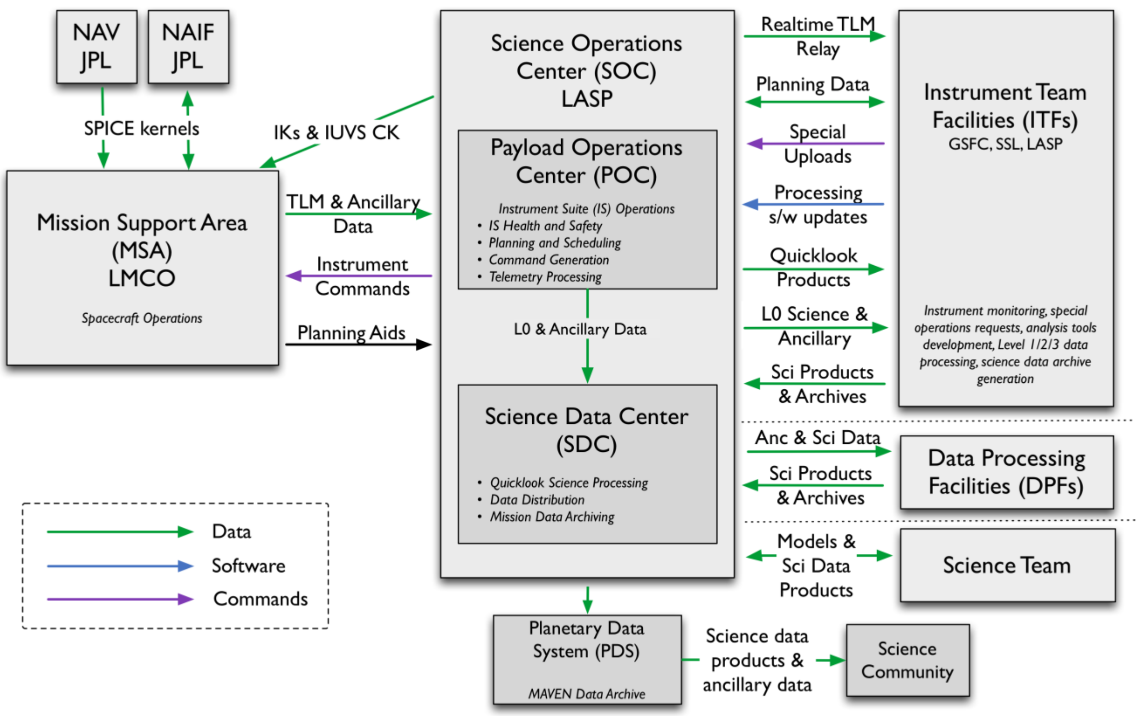

Figure *8*: MAVEN Ground Data System responsibilities and data flow. Note that this figure includes portions of the MAVEN GDS which are not directly connected with archiving, and are therefore not described in Section 3.5 above.

4 Archive Generation

The LPW archive products are produced by the LPW instrument team in cooperation with the SDC, and with the support of the PDS, Planetary Plasma Interactions (PPI) Node at the University of California, Los Angeles (UCLA). The archive volume creation process described in this section sets out the roles and responsibilities of each of these groups. The assignment of tasks have been agreed upon by all parties. Archived data received by the PPI Node from the LPW team are made available to PDS users electronically as soon as practicable but no later two weeks after the delivery and validation of the data.

4.1 Data Processing and Production Pipeline

The following sections describe the process by which data products in each of the LPW bundles listed in Table 10 are produced.

4.1.1 Raw Data Production Pipeline

The LPW team use a dedicated decomutator to extract the LPW packets from the raw PF-L0 file called Pf-L0-file by the MAVEN team. The data from the individual instrument packets is then extracted and saved as separate CDF files for PDS archiving urn:nasa:pds:maven.lpw.raw, internally called 'L0b'-files to separate from the 'L0' files. The decomutator software will be archived at PDS as a reference manual for the future in the Document bundle.

4.1.2 Calibrated Data Production Pipeline

The LPW team use a dedicated decomutator to extract the LPW packets from the raw PF-L0 file called Pf-L0-file by the MAVEN team. The raw LPW data is then calibrated with the calibration information derived from ground testing in the instrument constants routine provided in the Document bundle.

After the individual packets are calibrated using the ground testing data from different packets it is merged together with ancillary data and evaluated to created the calibrated science products - L2 (urn:nasa:pds:maven.lpw.calibrated and urn:nasa:pds:maven.lpw.derived). This software is archived as documentation of the process in the Document bundle.

For processing purposes, the achievable products will be created as L1a and L1b files while waiting on al ancillary data to become available (the content of these files are identical to the L2 files). The L1a is automatically produced as soon as L0-files are available but before all ancillary data are available. The L1b is the next step for the products that need manually interaction. The software to produce L1a, L1b and L2 is the same.

One example of manual interaction is to identify the plasma conditions for fitting of the I-V sweep. During the production of the L1b files, the sweeps will be analyzed to identify if the I-V sweep analysis should be assuming a single plasma distribution or multiple. The selected option will be stored in a separate file and when the automatic L2 production is executed, that process reads the stored file. This makes any reproduction of the archived data set to be fully automatic since reprocessing the L2 files will not need any manual interaction.

4.2 Data Validation

4.2.1 Instrument Team Validation

Since the quality of the LPW is sensitive to SC attitude and plasma conditions etc the data will be evaluated by a scientist through overview plots and spot-checking. At interesting/active periods the production of the data can be manually optimized. The LPW use confidence flags to indicate when the SC attitude (or other reasons) degrades the instrument measure quality.

4.2.2 MAVEN Science Team Validation

The calibrated/derived/modeled files will be used by the MAVEN Science team. This will provide a second validation of the science data. Many of the particle instruments will use the plasma density derived from the wave measurements for their absolute inflight calibration.

4.2.3 PDS Peer Review

The PPI node will conduct a full peer review of all of the data types that the LPW team intends to archive. The review data will consist of fully formed bundles populated with candidate final versions of the data and other products and the associated metadata.

Table 11: MAVEN PDS review schedule

Date	Activity	Responsible Team
2014-Mar-24	Signed SIS deadline	ITF
2014-Apr-18	Sample data products due	ITF
2014-May to 2014-Aug	Preliminary PDS peer review (SIS, sample data files)	PDS
2015-Mar-02	Release #1: Data due to PDS	ITF/SDC
2015-Mar to 2015-Apr	Release #1: Data PDS peer review	PDS
2015-May-01	Release #1: Public release	PDS

Reviews will include a preliminary delivery of sample products for validation and comment by

PDS PPI and Engineering node personnel. The data provider will then address the comments coming out of the preliminary review, and generate a full archive delivery to be used for the peer review.

Reviewers will include MAVEN Project and LPW team representatives, researchers from outside of the MAVEN project, and PDS personnel from the Engineering and PPI nodes. Reviewers will examine the sample data products to determine whether the data meet the stated science objectives of the instrument and the needs of the scientific community and to verify that the accompanying metadata are accurate and complete. The peer review committee will identify any liens on the data that must be resolved before the data can be 'certified' by PDS, a process by which data are made public as minor errors are corrected.

In addition to verifying the validity of the review data, this review will be used to verify that the data production pipeline by which the archive products are generated is robust. Additional deliveries made using this same pipeline will be validated at the PPI node, but will not require additional external review.

As expertise with the instrument and data develops the LPW team may decide that changes to the structure or content of its archive products are warranted. Any changes to the archive products or to the data production pipeline will require an additional round of review to verify that the revised products still meet the original scientific and archival requirements or whether those criteria have been appropriately modified. Whether subsequent reviews require external reviewers will be decided on a case-by-case basis and will depend upon the nature of the changes. A comprehensive record of modifications to the archive structure and content is kept in the Modification_History element of the collection and bundle products.

The instrument team and other researchers are encouraged to archive additional LPW products that cover specific observations or data-taking activities. The schedule and structure of any additional archives are not covered by this document and should be worked out with the PPI node.

4.3 Data Transfer Methods and Delivery Schedule

The SOC is responsible for delivering data products to the PDS for long-term archiving. While ITFs are primarily responsible for the design and generation of calibrated and derived data archives, the archival process is managed by the SOC. The SOC (in coordination with the ITFs) will also be primarily responsible for the design and generation of the raw data archive. The first PDS delivery will take place within 6 months of the start of science operations. Additional deliveries will occur every following 3 months and one final delivery will be made after the end of the mission. Science data are delivered to the PDS within 6 months of its collection. If it becomes necessary to reprocess data which have already been delivered to the archive, the ITFs will reprocess the data and deliver them to the SDC for inclusion in the next archive delivery. A summary of this schedule is provided in Table 12 below.

Table 12: Archive bundle delivery schedule for LPW

Bundle Logical Identifier	First Delivery to PDS	Delivery	Estimated Delivery

		Schedule	Size
urn:nasa:pds:maven.lpw.raw	Represent L0 data (LPW team call this is L0b). No later than 6 months after the start of science operations	Every 3 months	TBD
urn:nasa:pds:maven.lpw.calibrated	Represent L2 data. No later than 6 months after the start of science operations	Every 3 months	TBD
urn:nasa:pds:maven.lpw.derived	Represent L2 data. No later than 6 months after the start of science operations	Every 3 months	TBD
urn:nasa:pds:maven.lpw	This SIS document and the analysis/production documented software	TBD	TBD

Each delivery will comprise both data and ancillary data files organized into directory structures consistent with the archive design described in Section 5, and combined into a deliverable file(s) using file archive and compression software. When these files are unpacked at the PPI Node in the appropriate location, the constituent files will be organized into the archive structure.

Archive deliveries are made in the form of a "delivery package". Delivery packages include all of the data being transferred along with a transfer manifest, which helps to identify all of the products included in the delivery, and a checksum manifest which helps to insure that integrity of the data is maintained through the delivery. The format of these files is described in Section 6.4.

Data are transferred electronically (using the *ssh* protocol) from the SOC to an agreed upon location within the PPI file system. PPI will provide the SOC a user account for this purpose. Each delivery package is made in the form of a compressed *tar* or *zip* archive. Only those files that have changed since the last delivery are included. The PPI operator will decompress the data, and verify that the archive is complete using the transfer and MD5 checksum manifests that were included in the delivery package. Archive delivery status will be tracked using a system defined by the PPI node.

Following receipt of a data delivery, PPI will reorganize the data into its PDS archive structure within its online data system. PPI will also update any of the required files associated with a PDS archive as necessitated by the data reorganization. Newly delivered data are made available publicly through the PPI online system once accompanying labels and other documentation have been validated. It is anticipated that this validation process will require no more than fourteen working days from receipt of the data by PPI. However, the first few data deliveries may require more time for the PPI Node to process before the data are made publicly available.

The MAVEN prime mission begins approximately 5 weeks following MOI and lasts for 1 Earth-year. Table 12 shows the data delivery schedule for the entire mission.

4.4 Data Product and Archive Volume Size Estimates

LPW data products consist of files that span 24 hours, breaking at 0h UTC SCET. The break point depends on the time tag of the instrument packets, not when the individual measurement was made. All different data packets or products might not be available for all days. Files vary in size depending on the telemetry rate and allocation.

4.5 Data Validation

Routine data deliveries to the PDS are validated at the PPI node to ensure that the delivery meets PDS standards, and that the data conform to the SIS as approved in the peer review. As long as there are no changes to the data product formats, or data production pipeline, no additional external review will be conducted.

4.6 Backups and duplicates

The PPI Node keeps three copies of each archive product. One copy is the primary online archive copy, another is an onsite backup copy, and the final copy is an off-site backup copy. Once the archive products are fully validated and approved for inclusion in the archive, copies of the products are sent to the National Space Science Data Center (NSSDC) for long-term archive in a NASA-approved deep-storage facility. The PPI Node may maintain additional copies of the archive products, either on or off-site as deemed necessary. The process for the dissemination and preservation of LPW data is illustrated in Figure 9.

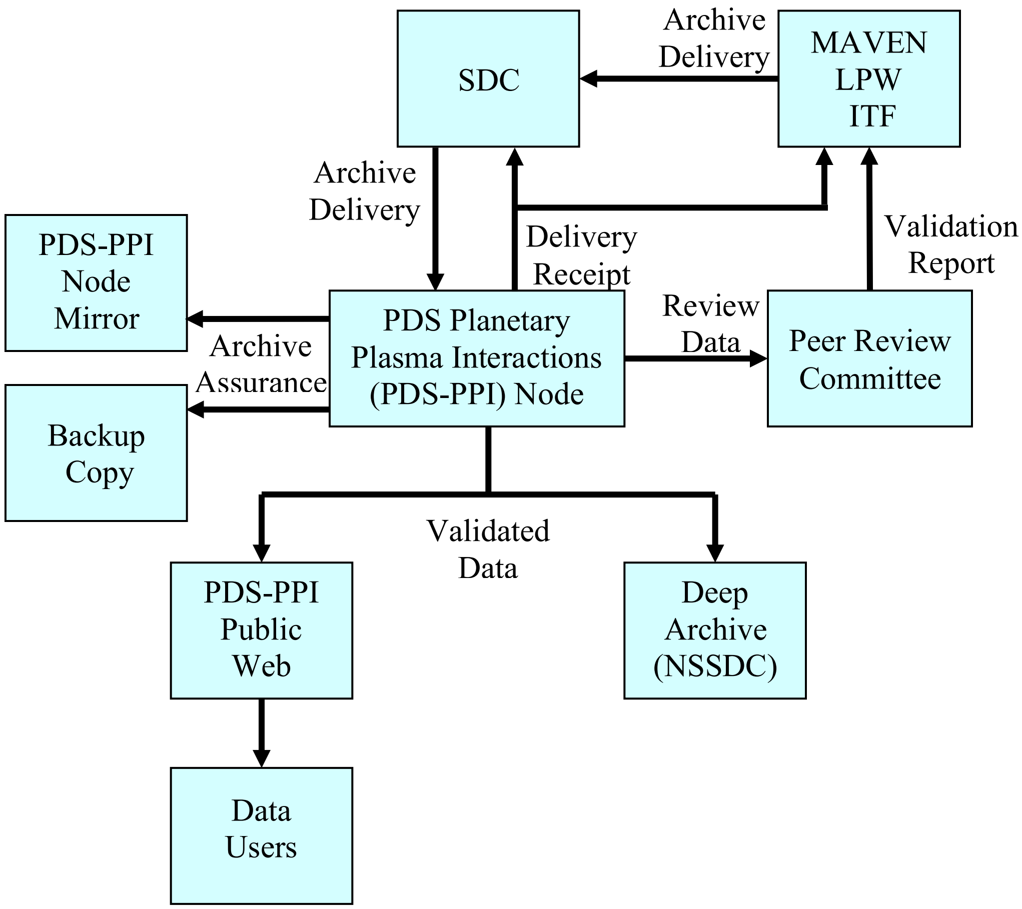

Figure 9: Duplication and dissemination of LPW archive products at PDS/PPI.

5 Archive organization and naming

This section describes the basic organization of an LPW bundle, and the naming conventions used for the product logical identifiers, and bundle, collection, and basic product filenames.

5.1 Logical Identifiers

Every product in PDS is assigned an identifier which allows it to be uniquely identified across the system. This identifier is referred to as a Logical Identifier or LID. A LIDVID (Versioned Logical Identifier) includes product version information, and allows different versions of a specific product to be referenced uniquely. A product's LID and VID are defined as separate attributes in the product label. LIDs and VIDs are assigned by the entity generating the labels and are formed according to the conventions described in sections 5.1.1 and 5.1.2 below. The uniqueness of a product's LIDVID may be verified using the PDS Registry and Harvest tools.

5.1.1 LID Formation

LIDs take the form of a Uniform Resource Name (URN). LIDs are restricted to ASCII lower case letters, digits, dash, underscore, and period. Colons are also used, but only to separate prescribed components of the LID. Within one of these prescribed components dash, underscore, or period are used as separators. LIDs are limited in length to 255 characters.

MAVEN LPW LIDs are formed according to the following conventions:

- Bundle LIDs are formed by appending a bundle specific ID to the MAVEN LPW base ID:

  urn:nasa:pds:maven.lpw.<bundle ID>

  Since all PDS bundle LIDs are constructed this way, the combination of maven.lpw.bundle must be unique across all products archived with the PDS.

- Collection LIDs are formed by appending a collection specific ID to the collection's parent bundle LID:

  urn:nasa:pds:maven.lpw.<bundle ID>:<collection ID>

  Since the collection LID is based on the bundle LID, which is unique across PDS, the only additional condition is that the collection ID must be unique across the bundle. Collection IDs correspond to the collection type (e.g. "browse", "data", "document", etc.). Additional descriptive information may be appended to the collection type (e.g. "data-raw", "data-calibrated", etc.) to insure that multiple collections of the same type within a single bundle have unique LIDs.

- Basic product LIDs are formed by appending a product specific ID to the product's parent collection LID:

  urn:nasa:pds:maven.lpw.<bundle ID>:<collection ID>:<product ID>

  Since the product LID is based on the collection LID, which is unique across PDS, the only additional condition is that the product ID must be unique across the collection.

A list of LPW bundle LIDs is provided in Table 10. Collection LIDs are listed in Table 14 through Table 26.

5.1.2 VID Formation

Product version ID's consist of major and minor components separated by a "." (M.n). Both components of the VID are integer values. The major component is initialized to a value of "1", and the minor component is initialized to a value of "0". The minor component resets to "0" when the major component is incremented.

All produced CDF-filed from the LPW instrument will contain one version number and one revision number in the file name. The version number will reflect which version of the data structure the CDF has. When the CDF structure changes the version number will change. The revision number represents re-processed data. The re-processing of data can either be that a newer version of L0-file exists or that the software has been updated.

5.2 LPW Archive Contents

The LPW archive from the LPW team includes the 4 bundles listed in Table 10. The following sections describe the contents of each of these bundles in greater detail.

5.2.1 LPW raw

The bundle raw contains uncompressed uncalibrated data from the individual instrument packets Table 13. This document covers 17 (of 18) of the instrument's different packets that is archived. The packet htime is only used for operation purposes. The data is stored as CDF-files and each time step represent a new packet. The exception are spec*, these packets can contain a number of spectrum within one packet, for these packets each time step in the CDF file represent derived time for each new spectrum based on the packet time and master cycle length. The LPW ITF is responsible for producing the processing code and the production of the CDF.

Table 13: LPW raw Collection LID

Collection LID	Description
data.adr	Active DAC read back information
data.atr	Active table read back, the active tables used for the instrument operation
data.euv	EUV data including EUV temperature
data.hsk	House keeping information including LPW temperature
data.swp1, data.swp2	Sub-cycle Langmuir probe: the current information from the boom where the potential is swept and the potential from the other probe. The number of measurement point's fix but the duration of the sub-cycle depends on the master cycle length.

Collection LID	Description
data.pas, data.act	Sub-cycle Waves: the potential of each probe (mono-pole), and the potential between the two probes (di-pole). The number of measurement point's fix but the duration of the sub-cycle depends on the master cycle length.
data.passpeclf, data.passpecmf, data.passpechf, data.actspeclf, data.actspecmf, data.actspechf	Sub-cycle Waves: The onboard calculated FFT for three different frequency bands from ACT or PAS sub-cycle
data.hsbmlf, data.hsbmmf, data.hsbmhf	Sub-cycle Waves: Only created in PAS sub-cycle. The time history of the potential between the two probes (di-pole) for three different frequency bands. The number of measurement points and the duration of each time series is fix, independent of master cycle length.
htime – not archived	Indicating when HSBM data was recorded. HSBM-packets are normally stored in the PF archive memory. htime provides which data is stored in the PF archived memory and then can be requested to be submitted down to Earth. This is an operational packet that contains no scientific information, therefore not archived.

5.2.1.1 lpw.raw:data.adr

Active DAC Readback (ADR) RAW information is created infrequently. This provides information from the board of the board current and voltages for the active mode.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_adr_<yyyy><mm><dd>_v<xx>_r<yy>.cdf

5.2.1.2 lpw.raw:data.atr

Active Table Readback (ATR) RAW information is created infrequently. This provides information of what table from the 16 different modes is used for the active mode.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_atr _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.3 lpw.raw:data.hsk

This collection contains the LPW housekeeping information such as temperatures and voltages and is infrequently produced.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_act _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.4 lpw.raw:data.euv

The EUV packet contains information of the digital number of the 3 science diodes, the 1 dark diode, the instrument temperature, and how many measurements each data point is averaged over (this is normally not changed). Each packet always contains 16 measurements and the cadence is independent of master cycle, depends only on the sampling average. Default setting is 1 measurement per second.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_euv _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.5 lpw.raw:data.pas

This packet is from the passive (PAS) sub-cycle and contains mainly the potentials to both probes (V1 and V2) and the common mode (e12). The cadence of this data depends on the cadence of the instrument.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_pas _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.6 lpw.raw:data.act

This packet is from the active (ACT) sub-cycle and contains mainly the potentials to both probes and the common mode. Packet is identical to the lpw.raw:pas.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_act _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.7 lpw.raw:data.hsbmlf

This packet is data taken from the PAS sub-cycle containing the common mode signal (e12). This is a burst product. All modes do not produce this product and only the largest amplitude burst is selected. The data cover 1 seconds using 1024 points. The first points in the time series is set to zero.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_hsbmlf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.8 lpw.raw:data.hsbmmf

This packet is data taken from the PAS sub-cycle containing the common mode signal (e12). This is a burst product. All modes do not produce this product and only the largest amplitude burst is selected. The data cover 62.5 seconds using 4096 points.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_hsbmmf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.9 lpw.raw:data.hsbmhf

This packet is data taken from the PAS sub-cycle containing the common mode signal (e12). This is a burst product. All modes do not produce this product and only the largest amplitude burst is selected. The data cover ~1. millisecond using 4096 points.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_hsbmhf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.10 lpw.raw:data.actspeclf

This packet is data taken from the ACT sub-cycle containing the common mode signal. This is onboard-calculated wave power in the low frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_actspeclf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.11 lpw.raw:data.actspecmf

This packet is data taken from the ACT sub-cycle containing the common mode signal. This is onboard-calculated wave power in the medium frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_actspecmf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.12 lpw.raw:data.actspechf

This packet is data taken from the ACT sub-cycle containing the common mode signal. This is onboard-calculated wave power in the high frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_actspechf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.13 lpw.raw:data.passpeclf

This packet is data taken from the PAS sub-cycle containing the common mode signal. This is onboard-calculated wave power in the low frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_passpeclf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.14 lpw.raw:data.passpecmf

This packet is data taken from the PAS sub-cycle containing the common mode signal. This is onboard-calculated wave power in the medium frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_passpecmf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.15 lpw.raw:data.actspechf

This packet is data taken from the PAS sub-cycle containing the common mode signal. This is onboard-calculated wave power in the high frequency range.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_actspechf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.16 lpw.raw:data.swp1

This packet is data taken from the Langmuir probe sweep on boom 1 sub-cycle.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_swp1 _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.1.17 lpw.raw:data.swp2

This packet is data taken from the Langmuir probe sweep on boom 2 sub-cycle. Packet structure identical to lpw.raw:swp1.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l0b_swp2 _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2 LPW calibrated

This bundle of products is science quality data that directly is produced by the LPW instrument. In the production process information such as spacecraft attitude has been considered. The different collections are explained in Table 14. The different products are presented and briefly explained in Table 15. The following sections describe the products in more detail. The production and validation is of LPW ITF's responsibility.

Table 14: LPW calibrated Main Collection LID

Main Collection LID	Description
lpw.calibrated:data.w	These are data products derived using only sub-cycle PAS and/or ACT (W sub-cycle)
lpw.calibrated:data.lp	These are data products derived using only the Langmuir probe (LP) sub-cycle.
lpw.calibrated:data.mrg	Merged data. These are data products using both waves and Langmuir probe sub-cycles, or a combination of data from different sub-cycles

Table 15: LPW calibrated:data sub-Product LID

Collection LID	Description
lpw.calibrated:data.mrg.scpot	The spacecraft potential based on all 4 sub-cycles and from both booms merged to one time series.

Collection LID	Description
lpw.calibrated:data.w.e12	Low frequency electric field measurements from every other sub-cycle
lpw.calibrated:data.w.e12burstlf	Burst data LF: the largest amplitude data recorded and selected from interesting time periods. Only one of the sub-cycle can produce this data product and instrument need to be in high telemetry mode.
lpw.calibrated:data.w.e12burstmf	Burst data MF: the largest amplitude data recorded and selected from interesting time periods. Only one of the sub-cycle can produce this data product and instrument need to be in high telemetry mode.
lpw.calibrated:data.w.e12bursthf	Burst data HF: the largest amplitude data recorded and selected from interesting time periods. Only one of the sub-cycle can produce this data product and instrument need to be in high telemetry mode.
lpw.calibrated:data.w.specpas	The Passive spectra from 1 out of 4 sub-cycles. The three different frequency ranges merged.
lpw.calibrated:data.w.specact	The Active spectra from 1 out of 4 sub-cycles (active if ping-option is enabled). The three different frequency ranges merged.
lpw.calibrated:data.lp.iv	Current-Voltage relation ships from the voltage sweep on the probes. One sweep is recorded every other sub-cycle

5.2.2.1 lpw.calibrated:data.mgr.scpot

This is a draft section to be revised when the booms are deployed

The spacecraft potential is based on the measured potential between the spacecraft and the cylindrical probes. This quantity is produced in all 4 sub-cycles from one or both booms. Spacecraft potential can also be derived from the Langmuir sweep's I-V curve. The information has been merge into one Level 2 spacecraft potential product. The spacecraft potential is measured at different cadence in the different sub-cycles and depending on which sub-cycle the data comes from. The merging is done by evaluating the quality of the different measurements and evaluating the location of the two booms with respect to spacecraft shadow wake etc. The merging algorithm will be fine tuned once the LPW booms have been deployed.

The product is the spacecraft potential measured in Volts. The provided measurement error reflects the quality of the measurement in combination of the booms attitude (how well LPW can make this observation) and if the spacecraft is moving in a rapidly changing plasma environment. If there is no good measurement available, such times are completely removed from the time series. For each measurement a quality flag is also provided ranging from the integer of 0 to 100 where 0 represent no confidence at all while 100 represent a good confidence based on in which plasma environment is located in (sunlit, shade, wake, solar angle). The source of the potential will be provided in the decimal information of the flag. Boom 1 is represent by .1, boom 2 by .2, a combination of both booms .4 and if the Langmuir sweep information has been used by .5.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_mrgscpot_<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.2 lpw.calibrated:data.w.e12

This is a draft section to be revised when the booms are deployed

The electric field measured in waves mode with normally 64 points per sub-cycle. There are regular data gaps in this quantity when the instrument is in sweep mode. The temporal resolution depends on the master cycle length.

The product is the calibrated electric field measure between the two cylindrical sensors measured in milliVolts/meter. The provided measurement error reflects how good the measurement was in combination of the booms attitude (how well they can make this observation) and if the spacecraft is moving in a rapidly changing plasma environment. Also a 'focus' factor is used. For each measurement a quality flag is provided ranging from 0 to 100 where 0 represent no confidence at all while 100 represent a good confidence based on in which plasma environment is located in (sunlit, shade, wake, solar angle).

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_we12 _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.3 lpw.calibrated:data.w.e12burstlf

This is a draft section to be revised when the booms are deployed

This is the low frequency electric field measured in waves mode (1-direction) with 1024 measured points over 1 second period. Burst is only measured sporadic and the largest bursts is stored on the onboard memory. Then the data from the onboard memory is selected based on interesting events. The first points in this time series is always set to zero (how many TBD) due to operational effects.

The product is the calibrated electric field measured between the two cylindrical sensors measured in milliVolts/meter. The provided measurement error reflects how well the measurement was in combination with the booms attitude (how well the sensors are in undisturbed plasma) and if the spacecraft is moving in a rapidly changing plasma environment. For each measurement is a quality flag provided ranging from 0 to 100 where 0 represent no confidence at al while 100 represent a good confidence based on in which plasma environment is located in (sunlit, shade, wake, solar angle).

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_we12burstlf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.4 lpw.calibrated:data.w.e12burstmf

This is a draft section to be revised when the booms are deployed

This is the medium frequency electric field measured in waves mode (1-direction) with 4096 measured points over 62.5 milliseconds time period. This is only measured sporadic and the largest bursts is stored on the onboard memory. Then the data from the onboard memory is selected based on interesting events.

The product is the calibrated electric field measure between the two cylindrical sensors measured in milliVolts/meter. The provided measurement error reflects how good the measurement was in combination of the booms attitude (how well they can make this observation) and if the spacecraft is moving in a rapidly changing plasma environment. And finally for each measurement is a quality flag provided ranging from 0 to 100 where 0 represent no confidence at all while 100 represent a good confidence based on in which plasma environment is located in (sunlit, shade, wake, solar angle).

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_we12burstmf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.5 lpw.calibrated:data.w.e12bursthf

This is a draft section to be revised when the booms are deployed

This is the high frequency electric field measured in waves mode (1-direction) with the 4096 points measured over a time period of ~1. milliseconds. This is only measured sporadic and the largest bursts are stored on the onboard memory. Then the data from the onboard memory is selected based on interesting events.

The product is the calibrated electric field measure between the two cylindrical sensors measured in milliVolts/meter. The provided measurement error reflects how good the measurement was in combination of the booms attitude (how well they can make this observation) and if the spacecraft is moving in a rapidly changing plasma environment. And finally for each measurement is a quality flag provided ranging from 0 to 100 where 0 represent no confidence at all while 100 represent a good confidence based on in which plasma environment is located in (sunlit, shade, wake, solar angle).

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_we12bursthf _<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.6 lpw.calibrated:data.w.specpas

This is a draft section to be revised when the booms are deployed

During the Passive sub-cycle the instrument processing onboard three spectra's, low-, medium- and high-frequency. Multiple spectra's can be averaged onboard prior to the final product is sent down. The merged spectrogram from the three spectra is used to create the Level 2 Passive spectra. The three separate spectra's has been combined in to the same spectra with the break points at: XX Hz and xx Hz (TBD once the booms are out).

The product is the wave power for different frequency bins. For each time stamp the wave power, the respective center frequency, the uncertainty, and quality flag is stored.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_wspecpas_<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.7 lpw.calibrated:data.w.specact

This is a draft section to be revised when the booms are deployed

During the active sub-cycle the instrument processing onboard three spectra's, low-, medium- and high-frequency. Multiple spectra's can be averaged onboard prior to the final product is sent down. The merged spectrogram from the three spectra is used to produce the Level 2 Active spectra. The three separate spectra's has been combined in to the same spectra with the break points at: XX Hz and xx Hz (TBD once the booms are out).

The product is the wave power for different frequency bins. For each time stamp the wave power, the respective center frequency, the uncertainty, and quality flag is stored

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_wspecact_<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.2.8 lpw.calibrated:data.lp.iv

This is a draft section to be revised when the booms are deployed

Nominally, for every other sub-cycle a Langmuir sweep is preformed. The sweep contains 127 points table driven potential sweep and the current is measured and recorded. The Voltage potential is based on a look up table; one for each different Instrument Mode. The Voltage sweep in the CDF-file is in time order, i.e. the user needs to sort the data if the voltage magnitude needs to be sequential for display/analysis purposes. The instrument has a function to adjust the voltage table so the zero-crossing location is centered in the sweep (this functionality can be turned off).

For each time step is the voltage sweep (in Volt) as swept, the representative current values (nanoAmps TBR), the uncertainties in the current, (uncertainties in the Voltage), and a quality flag. The quality flag and the error bars are weighted to indicate when the probe is in wake, solar incident angles and other things that can impact the measurements (this software needs to be fine tuned once the booms has been deployed TBR). Flag sunlit/shadow/wake

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_lpiv_<yyyy><mm><dd>_ v<xx>_r<yy>.cdf

5.2.3 LPW derived

The LPW derived bundles uses information from different types of measurements and/or make data fits to get science quality products. Explanation of the derived collections is given in Table 16 and the derived products are presented in Table 17. The LPW ITF is responcible for the production and verification of these products.

Table 16: LPW derived Main Collection LID

Main Collection LID	Description
lpw.derived:data.w	These are data products derived using only sub-cycle PAS and/or ACT
lpw.derived:data.lp	These are data products derived using only the Langmuir probe sub-cycle.
lpw.derived:data.mrg	Merged data. These are data products using both waves and Langmuir probe sub-cycles, or a combination of data

Table 17: LPW derived Collections

Collection LID	Description
lpw.derived:data.w.n	Electron density derived from Langmuir line in the Passive/Active spectra's.

Collection LID	Description
lpw.derived:data.lp.nt	The electron temperature and density derived based on the IV-curves (lpw.calibrated:data.lp.iv) and when available adjusted based on wave derived electron density (lpw.derived:data.w.n). Floating potential between spacecraft probe and ambient plasma (incl photoelectrons) (u_0) Potential between spacecraft and second product (u_1) Spacecraft potential (u_{sc}) Electron density, total (n_e) Electron density population 1 (n_{e1}) Electron density population 2 (n_{e2}) Electron temperature mean (T_e) Electron temperature population 1 (T_{e1}) Electron temperature population 2 (T_{e2}) Density proxy based on spacecraft potential (n_{sc})
lpw.derived:data.mrg.exb	Poynting flux derived using L2 magnetometer data and lpw.calibrated:data.w.e12

5.2.3.1 lpw.derived:data.w.n

This is a draft section to be revised when the booms are deployed

When the Langmuir line is recorded (in Passive spectra, Active spectra, or Wave-form from Burst data) the electron density can be derived with high accuracy. The electron density product is derived when the Langmuir line is visible in the LPW data. The accuracy of the density is high (~<5%); however how easy it is to identify the line varies. Therefore a quality flag is provided with the density measurement associated to indicate how easy the line was identified. How often the Langmuir line can be detected and how much noise the spacecraft will produce in the LPW observation region will be known first after the booms is deployed.

The product is the electron density. This product is produced when the Langmuir line is detectable the data stored contain time stamp, density, error of the density and a quality flag. The quality flag and the density error both indicate how well the Langmuir line was identified rather than the accuracy of the observed frequency (which is accurate to ~<5%).

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_wn_<yyyy><mm><dd>_ r<xx>_v<yy>..cdf

5.2.3.2 lpw.derived:data.lp.nt

This is a draft section to be revised when the booms are deployed

Based on the I-V sweep (lpw.calibrated:data:lp.iv) the electron density and temperature is derived through curve fitting. In the process spacecraft potential and photoelectron current can also be derived. The error bars and flags represent how well the fitting of the I-V curved was achieved. When Langmuir line is available (lpw.calibrated:data.w.n) is available this will be used improve the accuracy of this fit. The density and the temperature software will not only take into consideration the instantaneous I-V sweep but also the change of the surface characteristics as function of both time and orbit. The sweep can be modeled as one or two (TBR) population plasma. The product has therefore multiple fields for the individual temperatures and density and one set for the total density and the mean temperature. The fine-tuning of this software will first be made once the booms are deployed.

The product is the electron density and temperature. For each time step the density, temperature, photocurrent (byproduct in the fitting routine), errorbars, and quality flags will be provided. Use the flag for indicating which approximation is used where.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_lpnt_<yyyy><mm><dd>_ r<xx>_v<yy>.cdf

5.2.3.3 lpw.derived:data.mrg.exb

This is a draft section to be revised when the booms are deployed

The 1-dimentional Poynting flux is derived using the 3D magnetic field (TBD) and the 1D electric field measurement. Four different vector products are created, Poynting Flux (S_x, S_y and S_z), total magnetic field (B_x, B_y and B_z), the change in the magnetic field over the selected time period, (dB_x, dB_y and dB_z), and the change in the 1-D electric field over the selected time period, (dE_x, dE_y and dE_z). All four vectors is presented in MSO coordinates. This product will be of lower cadence than the MAG and LPW instrument is operated over. The cadence will be determined once data from Mars is available.

For detail information about the magnetometer see details in separate document [13, 14] .

The error of the quantity is based on signal quality of electric and magnetic field and the position of the LPW booms with respect to flow direction and sun.

The LPW ITF will produce this products, with one file per UT day, with the naming convention mvn_lpw_l2_mrgexb_<yyyy><mm><dd>_ r<xx>_v<yy>.cdf

5.2.4 LPW documentation

The information of the archived data is presented in this archived SIS document. Additional documents archived are the production software algorithm. The software algorithm is commented as the documentation. The archived products are presented in Table 18. Other documentation important to LPW is presented in Table 19.

Table 18: Documentation Collection LID

Collection LID	Description
lpw:document.sis	This document
lpw:document.process	The IDL programs in ASCII files
lpw:document.operation_guide	Keeps specific information of what EEPROM loads are made, how the instrument is operated, and if specific problems with the data is found not captured elsewhere in the MAVEN documentation.

Table 19: Key Documentation associated with LPW

Document Name	LID	Responsiblility
MAVEN Science Data Management Plan	urn:nasa:pds:maven:document:sdmp	MAVEN Project
MAVEN Mission Description	urn:nasa:pds:maven:document:mission.description	MAVEN Project
MAVEN Spacecraft Description	urn:nasa:pds:maven:document:spacecraft.description	MAVEN Project
MAVEN LPW Archive SIS	urn:nasa:pds:maven.lpw:document:sis	LPW Team
LPW Software Description	urn:nasa:pds:maven.lpw:document:process	LPW Team
LPW L0 Users Guide	urn:nasa:pds:maven.lpw:document:users_guide	LPW Team

MAVEN Science Data Management Plan – describes the data requirements for the MAVEN mission and the plan by which the MAVEN data system will meet those requirements

MAVEN Mission Description – describes the MAVEN mission.

MAVEN Spacecraft Description – describes the MAVEN spacecraft.

5.2.4.1 lpw:document:sis

MAVEN LPW Archive SIS – describes the format and content of the LPW PDS data archive, including descriptions of the data products and associated metadata, and the archive format, content, and generation pipeline (this document)

5.2.4.2 lpw:document:process

LPW Software Description – the commented software describes how the data is processed.

The commented IDL software provides information how to read urn:nasa:pds:maven.pf.l0 and how the maven.lpw.raw, maven.lpw.calibrated, and maven.lpw.derived is derived. This is provided as a number of ascii files. Any ascii file that is used for the processing routines will be included in this bundle.

5.2.4.3 lpw:document:operation_guide

In the MAVEN_LPW_User_Guide the LPW Team keeps track on what instrument settings are loaded in to each instrument mode. This information can be of interest if the user is working the raw L0-LPW files. This allows the used to see what products are expected from the different modes. A PDF file of this contents will be archived ~12 month after the start of science phase. After that, this document needs only minor corrections/additions to it.

The document will provide with descriptions of how to read the different EEPROM tables in the document. Additional instrument specific information will also be provided in this document.

6 Archive product formats

Data that comprise the LPW archives are formatted in accordance with PDS specifications [see *Planetary Science Data Dictionary* [4], *PDS Data Provider's Handbook* [2], and *PDS Standards Reference* [3]. This section provides details on the formats used for each of the products included in the archive.

6.1 Data File Formats

This section describes the format and record structure of each of the data file types.

LPW data files will be archived with PDS as Common Data Format (CDF). In order to allow the archival CDF files to be described by PDS metadata a number of requirements have been agreed to between the LPW ITF and the PDS-PPI node. These requirements are detailed in the document *Archive of MAVEN CDF in PDS4* (T. King and J. Mafi, July 16, 2013). These CDF files will be the same one's used and distributed by the LPW ITF internally. The contents of the LPW CDF files are described in the tables below.

All CDF files have a set of Field Names populated as presented in Table 21 and Table 21. Each CDF file have one set of the Field Names (no A1 to A18) but all Field names (B1-B43) are not populated for all products. The fix set of Field names and Header Field Names are followed by time-arranged data that is presented in the following subsections.

Table 20: CDF specific information in the CDF header in each CDF file. See individual products for further information (Table 22 to Table 29)

No	Field Name	Type	Description
A1	Project	String	"MAVEN Project"
A2	Source_name	String	"MAVEN> Mars Atmosphere And Volatile EvolutioN Mission"
A3	Discipline	String	"Planetary Physics > Particles and Fields"
A4	Var_type	String	"Data"
A5	Data_type	String	"CAL> Calibrated" or "RAW> Raw"
A6	Descriptor	String	Varies, depending on CDF file
A7	Data_version	String	"Constant_ver #"
A8	PI_name	String	"Data Production PI: *name*, LASP/CU" Name of responsible archivist
A9	PI_affiliation	String	"LASP University of Colorado"
A10	Text	String	Text: Description of data/instrument
A11	Instrument_type	String	For EUV: "Gamma and X-rays". For LPW: "Electric fields (space), plasma and solar wind"
A12	Mission_group	String	"MAVEN"
A13	Logical_File_ID	String	"Logical file ID" - not used
A14	Logical_source	String	"Logical Source" - not used
A15	Logical_source_description	String	"Logical Source Description" - not used

No	Field Name	Type	Description
A16	Monoton	String	"INCREASE"
A17	Scalemin	Float	Scalemin: min of data.y
A18	Scalemax	Float	Scalemin: max of data.y

Table 21: LPW Header information that exists in each CDF file but might not always be used. See the individual products which fields are used (Table 22 to Table 29)

No	Header Field Name	Type	Description
B1	generated_date	String	"Gives the date and time the data was processed and the CDF
B2	t_epoch	Double	What zero time the spacecraft clock is correlated too.
B3	Time_start	Double Array	The first data packet presented with different clocks TBR
B4	Time_end	Double Array	The last data packet presented with different clocks TBR
B5	Time_Field	String Array	Description of the different clocks used TBR
B6	SPICE_kernel_version	String	SPICE Kernel version
B7	SPICE_kernel_flag	String	If SPICe kernel was used
B8	Flag_info	String	Normally flag represent 'confidence level' if not stated differently. 0 no confidence at all. Can be used for aperture open/close etc.
B9	Flag_source	String	Contain information of what is considered when the flag is created (such as sc-attitude)
B10	L0_datafile	String	Gives the name of the L0 file used.
B11	cal_vers	String	Gives the calibration file version
B12	cal_y_const1	String	Fixed convert information from measured binary values to physical units, variables from ground testing and design
B13	cal_y_const2	String	Fixed convert information from measured binary values to physical units, variables from space testing
B14	cal_datafile	String	If one or more calibration files has been used the file names is located here (file names of the calibration files included dates and version number of when the are created)
B15	cal_source	String	Information of what has been considered in the data production (sc attitude, other instruments etc)
B16	xsubtitle	String	Units
B17	ysubtitle	String	Units
B18	cal_v_const1	String	Fixed convert information from measured binary values to physical units, variables from ground testing and design
B19	cal_v_const2	String	Fixed convert information from measured binary values to physical units, variables from space testing
B20	zsubtitle	String	Units
			- Blank intentionally – as a jump in the numbering

No	Header Field Name	Type	Description
B30	char_size	String	Suggested information for plotting purposes.
B31	xtitle	String	Suggested information for plotting purposes.
B32	ytitle	string	Suggested information for plotting purposes.
B33	yrange	Float array	Suggested information for plotting purposes.
B34	ystyle	Integer	Suggested information for plotting purposes.
B35	ylog	Integer	Suggested information for plotting purposes.
B36	ztitle	String	Suggested information for plotting purposes.
B37	zrange	Float array	Suggested information for plotting purposes.
B38	zlog	Integer	Suggested information for plotting purposes.
B39	spec	Integer	Plotting option, Data type (spectrogram = 1)
B40	labels	String Array	When different data sources and products are combined in the y-filed for the CDF file, this fields provide the information of in which order the products are written
B41	colors	Integer Array	Suggested information for plotting purposes.
B42	labflag	Integer	Suggested information for plotting purposes.
B43	noerrorbars	Integer	Suggested information for plotting purposes.

6.1.1 Raw file data structure

LPW raw data files will be archived with PDS as Common Data Format (CDF). The contents of the LPW raw CDF files are described in Table 22.

This information of the raw data files urn:nasa:pds:maven.lpw.raw are self documented to some extent. Each recorded instrument packet is stored in the CDF-file with the spacecraft clock time stamp. The context of each packet is described in the LPW Header Labels (no 40 in Table 21).

Table 22: Contents for lpw.raw data files.

Field Name	Product Name	Type	Description
A1-A18 B1-B12 B30-B34	LPW_header		The information for the header provided in the rows presented in Table 21. One element per file
x	TIME	DOUBLE	Spacecraft clock taken from each packet header
y	RAW INFO	FLOAT	The RAW information from each packet. The information in the packet is described by the Field Name given in Row B40 in Table 21

6.1.2 Calibrated data file structure

LPW calibrated data files will be archived with PDS as Common Data Format (CDF). The contents of the LPW CDF files are described in Table 21 to Table 26.

Table 23: Contents for lpw.calibrated:data.mgr.sc_pot data file.

Field Name	Product Name	Type	Description
A1-A18, B1-B12, B15-B17 B30-B34, B43	LPW_header		The information for the header provided in the rows presented in Table 21. One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per measurement (sc_pot)
y	SC_POT	FLOAT	Spacecraft potential, one element per time step
dy	SC_POT_ERR	FLOAT	The uncertainty of the measured value. Same number of elements as sc_pot.
flag	SC_POT_FLAG	FLOAT	A quality flag for each time step

Table 24: Contents for lpw.calibrated:data.w.e12, lpw.calibrated:data.w.e12burstlf, lpw.calibrated:data.w.e12burstmf, and lpw.calibrated:data.w.e12bursthf data files.

Field Name	Product Name	Type	Description
A1-A18 B1-B12, B15-B17 B30-B34, B43	LPW_header		The information for the header provided in the rows presented in Table 21, One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per measurement (W_E12)
y	W_E12	FLOAT	Electric field measurement, one element per time step
dy	W_E12_ERR	FLOAT	The uncertainty of the measured value. Same number of elements as W_E12.
flag	W_E12_FLAG	FLOAT	A quality flag for each time step

Table 25: Contents for lpw.calibrated:data.w.specact and lpw.calibrated:data.w.specpas data files.

Field Name	Product Name	Type	Description
A1-A18 B1-B20 B30-B39	LPW_header		The information for the header provided in the rows presented in Table 21, One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per spectra (SPEC)
y	SPEC	FLOAT	The electric field power for 200 (TBD) frequency bins for each time step.

v	FREQ	FLOAT	The center frequency of each 200 (TBD) frequency bin for the respective value in SPEC one element per file Same number of elements as SPEC.
dy	SPEC_ERR	FLOAT	The uncertainty of the electric field power weighted with the spacecraft attitude for each frequency step and time. Same number of elements as SPEC.
dv	FREQ_WIDTH	FLOAT	Provide information of the frequency width Same number of elements as SPEC.
flag	SPEC_FLAG	FLOAT	A quality flag for each time step

Table 26: Contents for lpw.calibrated:data.lp.iv data file.

Field Name	Product Name	Type	Description
A1-A18 B1-B20 B30-B39	LPW_header		The information for the header provided in the rows presented in Table 21, One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per sweep (LP_I)
y	LP_I	FLOAT	The measured current from the probe as the potential of the probe is changed in the time order of the sweep, 128 points for each time step
v	LP_V	FLOAT	The sweeping potential in the time order of the sweep, 128 points for each time step. Same number of elements as LP_I.
dy	LP_I_ERR	FLOAT	The uncertainty in the measured current, 128 points for each time step (or a % value TBD), 128 points for each time step. Same number of elements as LP_I.
dv	LP_V_ERR	FLOAT	The uncertainty in the applied potential, 128 points, one per file (or do we need one for each time step TBD). Same number of elements as LP_I.
flag	LP_IV_FLAG	FLOAT	A quality flag for each time step

6.1.3 Derived data file structure

LPW derived data files will be archived with PDS as Common Data Format (CDF). The contents of the LPW CDF files are described in Table 21 and Table 28 to Table 29.

Table 27: Contents for lpw.derived:data.w.n data files.

Field Name	Product Name	Type	Description
A1-A18 B1-B12, B15-B17 B30-B34, B43	LPW_header		The information for the header provided in the rows presented in Table 21, One element per file

x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per measurement (W_N)
y	W_N	FLOAT	The derived electron density from the Langmuir line, one element per time step, data only when plasma line is observed
dy	W_N_ERR	FLOAT	‘Quality’ of how easy the Langmuir line was identified. Same number of elements as W_N.
flag	SPEC_FLAG	FLOAT	A quality flag for each time step

Table 28: Contents for lpw.derived:data.lp.nt data files.

Field Name	Product Name	Type	Description
A1-A18 B1-B12, B15-B17 B30-B34, B40-B43	LPW_header		The information for the header provided in the rows presented in Table 21, One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per measurement (LP_N_T)
y	LP_N_T	FLOAT	Presently planned [‘T1’, ’n1’,’T2’,’n2’,’t_tot’,’n_tot’ ’sc_pot’, ’Photo_e_I’,’euv’] The quantities derived from line fits. The fit can either be for a single maxwellian of a double maxwellina. The n1 & n2 and T1 and T2 provide this information.
dy	LP_N_T_ERROR	FLOAT	The uncertainty in all of the fitted parameters.
flag	LP_N_T_FLAG	FLOAT	The quality of the measured IV-measurement. One element per time step.

Table 29: Contents for lpw.derived:data.mgr.exb data file.

Field Name	Product Name	Type	Description
A1-A18 B1-B12, B15-B17 B30-B34, B40-B43	LPW_header		The information for the header provided in the rows presented in Table 21. One element per file
x	TIME_UNIX	DOUBLE	Unix time for this data record, one element per 256 sec (TBD)
y	S_E_B	FLOAT	Presently planned information [‘S’, ‘B’, ‘dB’,’dE’]. The 1-D smoothed electric field measurement presented in MSO coordinate system, each quantity is describe with three components (x, y, z)
dy	S_ERR	FLOAT	The uncertainty of the four different quantities

flag	S_FLAG	FLOAT	Indicating how turbulent the low frequency electric and magnetic field that was used for each averaged data point (alternative, how much the magnetic field was rotating during one point), one element per time step

6.2 Document Product File Formats

LPW will provide the raw data and the calibrated/derived data in CDF formats. The processing from raw to calibrated/derived is documented with the archiving ASCII files with the IDL program scripts. The SIS document (this document) will be archived in word-format (PDF? TBR).

6.3 PDS Labels

PDS labels are ASCII text files written, in the eXtensible Markup Language (XML). All product labels are detached from the digital files (if any) containing the data objects they describe (except Product_Bundle). There is one label for every product. Each product, however, may contain one or more data objects. The data objects of a given product may all reside in a single file, or they may be stored in multiple separate files. PDS4 label files must end with the file extension ".xml".

The structure of PDS label files is governed by the XML documents described in Section 6.3.1.

6.3.1 XML Documents

For the MAVEN mission PDS labels will conform to the PDS master schema based upon the 1.1.0.1 version of the PDS Information Model for structure, and the 1.1.0.1 version of the PDS schematron for content. By use of an XML editor these documents may be used to validate the structure and content of the product labels.

The PDS master schema and schematron documents are produced, managed, and supplied to MAVEN by the PDS. In addition to these documents, the MAVEN mission has produced additional XML documents which govern the products in this archive. These documents contain attribute and parameter definitions specific to the MAVEN mission. A full list of XML documents associated with this archive is provided in Table 14. A list of the XML documents associated with this archive is included in this document in the XML_Schema collection section for each bundle.

Examples of PDS labels required for the LPW archive are shown in Appendix C (bundle products), Appendix D (collection products), and Appendix E (basic products).

6.4 Delivery Package

Data transfers, whether from data providers to PDS or from PDS to data users or to the deep archive, are accomplished using delivery packages. Delivery packages include the following required elements:

1. The package which consists of a compressed bundle of the products being transferred.

2. A transfer manifest which maps each product's LIDVID to the physical location of the product label in the package after uncompression.
3. A checksum manifest which lists the MD5 checksum of each file included in the package after uncompression.

LPW archive delivery packages (including the transfer and checksum manifests) for delivery to PDS are produced at the MAVEN SDC.

6.4.1 The Package

The directory structure used in for the delivery package is described in the Appendix in Section F.1. Delivery packages are compressed using either [zip, or tar/gzip – SDC text] and are transferred electronically using the ssh protocol.

6.4.2 Transfer Manifest

The "transfer manifest" is a file provided with each transfer to, from, or within PDS. The transfer manifest is external to the delivery package. It contains an entry for each label file in the package, and maps the product LIDVID to the file specification name for the associated product's label file. Details of the structure of the transfer manifest are provided in Section F.2.

The transfer manifest is external to the delivery package, and is not an archive product. As a result, it does not require a PDS label.

6.4.3 Checksum Manifest

The checksum manifest contains an MD5 checksum for every file included as part of the delivery package. This includes both the PDS product labels and the files containing the digital objects which they describe. The format used for a checksum manifest is the standard output generated by the md5deep utility. Details of the structure of the checksum manifest are provided in section F.3.

The checksum manifest is external to the delivery package, and is not an archive product. As a result, it does not require a PDS label.

Appendix A Support staff and cognizant persons

Table 30: Archive support staff

LPW team			
Name	**Address**	**Phone**	**Email**
Dr. Laila Andersson	3665 Discovery Drive	303 492 1689	Laila.andersson@lasp.colorado.edu

UCLA			
Name	**Address**	**Phone**	**Email**
Dr. Steven Joy PPI Operations Manager	IGPP, University of California 405 Hilgard Avenue Los Angeles, CA 90095-1567 USA	+001 310 825 3506	sjoy@igpp.ucla.edu
Mr. Joseph Mafi PPI Data Engineer	IGPP, University of California 405 Hilgard Avenue Los Angeles, CA 90095-1567 USA	+001 310 206 6073	jmafi@igpp.ucla.edu

Appendix B Naming conventions for MAVEN science data files

This section describes the naming convention used for science data files for the MAVEN mission.

Raw (MAVEN Level 0): This is not used for LPW data

mvn_<inst>_<grouping>_l0_< yyyy><mm><dd>_v<xxx>.dat

Level 0b, 1a, 1b, 2, 3+:

mvn_<inst>_<level>_<descriptor>_<yyyy><mm><dd>T<hh><mm><ss>_v<xx>_r<yy>.<ext>

Code	**Description**
<inst>	3-letter instrument ID
<grouping>	Three-letter code: options are all, svy, and arc for all data, survey data, and archive data respectively. Primarily for PF to divide their survey and archive data at Level 0.
<yyyy>	4-digit year
<mm>	2-digit month, *e.g.* 01, 12
<dd>	2-digit day of month, *e.g.* 02, 31
<hh>	2-digit hour, separated from the date by T. OPTIONAL.
<mm>	2-digit minute. OPTIONAL.
<ss>	2-digit second. OPTIONAL.
v<xx>	2-digit CDF file structure version.
r<yy>	2-digit the revision version of the data product
<descriptor>	A description of the data. Defined by the creator of the dataset. There are no underscores in the value.
.<ext>	File type extension: .fits, .txt, .cdf, .png LPW will only use CDF
<level>	A code indicating the MAVEN processing level of the data, LPW will use for archiving purpose the following levels: raw, calib, merged, derived, and modeled. L0b, L1a and L1b are in the process stored for the team, since they are temporary, incomplete, they are not archived at PDS.

Instrument name	**<instrument>**
IUVS	iuv
NGIMS	ngi
LPW	lpw
EUV	euv
MAG	mag
SEP	sep
SWIA	swi
SWEA	swe
STATIC	sta
PF package	pfp

Appendix C Sample Bundle Product Label

This section provides a sample bundle product label.

Appendix D Sample Collection Product Label

This section provides a sample collection product label.

Appendix E Sample Data Product Labels

This section provides sample product labels for the various data types described in this document.

Appendix F PDS Delivery Package Manifest File Record Structures

The delivery package includes two manifest files: a transfer manifest, and MD5 checksum manifest. When delivered as part of a data delivery, these two files are not PDS archive products, and do not require PDS labels files. The format of each of these files is described below.

F.1 Transfer Package Directory Structure

[Insert a description of the directory structure contained in the delivery package.]

F.2 Transfer Manifest Record Structure

The transfer manifest is defined as a two field fixed-width table where each row of the table describes one of the products in the package. The first field defines the LIDVID of each product in the package. The second field defines the file specification name of the corresponding product label in the package. The file specification name defines the name and location of the product relative to the location of the bundle product.

F.3 Checksum Manifest Record Structure

The checksum manifest consists of two fields: a 32 character hexadecimal (using lowercase letters) MD5, and a file specification from the root directory of the unzipped delivery package to every file included in the package. The file specification uses forward slashes ("/") as path delimiters. The two fields are separated by two spaces. Manifest records may be of variable length. This is the standard output format for a variety of MD5 checksum tools (*e.g.* md5deep, etc.).