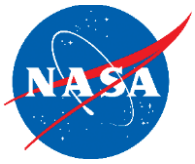
National Aeronautics and Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 38512



EV44 (15-006)

TO: Mr. Ron Suggs, EV44 Export Control Officer
Mr. Glenn Overbey, EV44 Branch Chief

FROM: Dr. Victoria Coffey, EV44
Dr. Joseph Minow, EV44

SUBJECT: Classifying Floating Potential Measurement Unit data products as science data
DATE: 24 July 2015

Purpose:

We are Co-Investigators for the Floating Potential Measurement Unit (FPMU) on the International Space Station (ISS) and members of the FPMU operations and data analysis team. We are providing this memo for the purpose of classifying raw and processed FPMU data products and ancillary data as NASA science data with unrestricted, public availability in order to best support science uses of the data.

Background:

The FPMU is a suite of four plasma instruments on the International Space Station (ISS) including a Wide Langmuir Probe (WLP), Narrow Langmuir Probe (NLP), Floating Potential Probe (FPP), and Plasma Impedance Probe (PIP). FPMU data is encoded into a video signal on-orbit and downlinked through the ISS Ku band telemetry stream to Johnson Space Center (JSC). FPMU video signals received by JSC are encoded into User Datagram Protocol (UDP) packets and transmitted through the internet to multiple ground station computers running software for acquiring the video signal, extracting the FPMU data packets, and archiving the binary data in Level 0 (L0) telemetry files.

Each L0 telemetry file contains raw FPMU records in a packed binary format including:

- Time information for the data packet,
- WLP currents and voltages,
- NLP currents and voltages,
- FPP voltages,
- PIP phase and magnitude, and
- Diagnostic records of key FPMU hardware voltages, currents, and temperatures

The initial step in ground processing of L0 data is extracting instrument records from the raw binary data files and then converting the instrument records to engineering parameters using instrument calibration files. WLP and NLP current and voltage records ("I-V" curves) and PIP phase and magnitude records are then processed using data reduction algorithms to obtain the reduced (or scientific) parameters. The final set of FPMU processed records include electron and ion density, electron temperature, and vehicle floating potential relative to the ambient plasma environment. A complete description of the FPMU data packets, calibration files, and outline for processing is available in Thompson (2003) and will not be repeated here. FPMU data is currently available from the operational unit (serial number 03) on ISS with a second spare unit (serial number 05) stored on board ISS. A third flight unit (serial number 02) is in storage at Kennedy Space Center.

FPMU is primarily an ISS program engineering instrument for use in characterizing ambient ISS plasma environments along the vehicle trajectory and vehicle potential variations due to ISS interactions with the orbital plasma environment. FPMU was originally deployed on the ISS in August of 2006 for the purpose of verifying that the ISS Plasma Contactor Units (PCU) are capable of controlling ISS floating potentials to within +/- 40V of the ambient plasma environment and to provide data necessary to validate the ISS Plasma Interaction Model (PIM) spacecraft charging code. These goals were largely met within the first few years of FPMU operations. FPMU is currently operated by the ISS space environments engineering community to obtain plasma environment data in support of EVA safety operations, characterize ISS interactions with the plasma environment, collection of ionospheric science data, and for anomaly investigations when required.

FPMU data is a resource capable of supporting multiple uses beyond ISS engineering. The same data that is collected for engineering functions is now being used to support ISS science payloads or payloads on other low Earth orbit satellites, collaborating with ground based observations of the ionosphere (e.g., during overflights of incoherent scatter radar and ionosonde facilities), and for providing important data validation data for testing first principle physics and assimilative ionospheric models. The US and international ionospheric science community has an interest in access to FPMU records since ISS is one of the few spacecraft regularly operating at altitudes near the peak electron density of the F2-region ionosphere. Sharing FPMU data with the science community benefits NASA in general, the ISS Program in particular, and the ionospheric research community by supporting a number of important activities that include (but are not limited to):

- FPMU data comparisons against independent measurements of ionosphere plasma density and temperature supports FPMU data validation efforts,
- Collaborations with ISS science payloads, other spacecraft payloads, and ground based remote-sensing instruments,
- Technical feedback and support from the ionospheric physics science community on FPMU data quality and data interpretation,
- FPMU data for validation of sophisticated ionosphere models and ISS access to output from the models,
- Enhanced science and engineering utilization of ISS assets.

Collaborations involving FPMU data with groups external to the ISS program to date have required a process where individual data sets are evaluated for export control and management approval before public release on a case-by-case basis. The process is cumbersome since it involves developing memos describing individual applications of FPMU data for specific data sets that are then attached to NF 1676 for appropriate NASA export control and management reviews before release of the data. The contents of raw and processed FPMU data is similar to ionospheric data from NASA and Air Force spacecraft that is already available for unrestricted distribution to the general public and we believe that FPMU data should be treated in the same manner.

Recommendation:

We recommend that all raw and processed FPMU data products along with necessary ancillary records required for use of the data be classified as "*raw and processed scientific and technical data*" consistent with NPD 2200.1C *Management of NASA Scientific and Technical Information* and can therefore be made generally available to the US and international (where appropriate) science and engineering communities for the purpose of basic scientific research. This recommendation includes historic FPMU records starting in August 2006 through the current time and all current and future FPMU data collections.

The recommendation to classify FPMU data as scientific and technical data is consistent with NASA guidelines on management of NASA scientific and technical information as described in the relevant sections of NPD 2200.1C:

> ***Section 1.d:***
> *d. Unless restricted by U.S. statute, regulation, or Agency policy, NASA will provide for the "widest practicable and appropriate dissemination" of STI resulting from NASA's research effort, while precluding the inappropriate dissemination of restricted or Sensitive But Unclassified (SBU) information, in keeping with the National Aeronautics and Space Act.*
>
> ***Section 1.e:***
> *e. All NASA STI that is loaded to a public Web site must be reviewed and approved via the NF-1676 (DAA) prior to publishing on the Web site.*
>
> ***Section 1.h.5:***
> *(5) Raw and processed scientific and technical data and data sets independent of the analysis of the data and resulting conclusions. However, STI publications or presentations that include such data are subject to this directive and NPR 2200.2.*

FPMU data, data products, and ancillary information covered by this request are listed in Table 1. The contents of these records constitute basic science and are therefore do not constitute SBU information. A completed NASA Form 1676 accompanies this recommendation per Section 1.e of NPD 2200.1C to allow the FPMU to not only provide data files to interested users but also to place the data on a public web site. Distribution may be accomplished by e-mail, transfer of electronic data records on digital media, or placing FPMU records on public web site such as NASA's Space Physics Data Facility (http://spdf.gsfc.nasa.gov/). Only raw and processed data itself is covered by this recommendation. STI publications or presentations that include the

analysis of FPMU data and resulting conclusions will continue to be reviewed following the appropriate NASA guidelines.

Table 1. FPMU Data, Data Products, and Ancillary Information

- FPMU metadata including information on dates and times when FPMU data is available, data quality, and other general information about FPMU records without including the specific data itself
- FPMU Level 0 (archival) binary telemetry files and FPMU calibration data files
- ISS time codes (year, day of year, hour, minute, second, milliseconds) and times derived from these parameters (e.g., decimal days, decimal years), run time clock, and other time information
- FPMU housekeeping data including currents and voltages from key instrument components and temperatures at selected locations within FPMU probes and electronics, check sums, up/down sweep codes)
- Data processing information such as time code correction parameters
- WLP data including voltage sweeps and measured currents ("I-V" curves) and processed electron density, ion density, electron temperature, floating potential, and space plasma potential derived from the I-V curves
- NLP data including I-V curves and processed electron density, ion density, electron temperature, floating potential, and space plasma potential derived from the I-V curves
- FPP floating potential
- PIP frequency sweeps and measured amplitude and phase and the processed electron density derived from the measurements
- ISS ephemeris including geographic coordinates, geomagnetic coordinates
- ISS solar illumination information including solar zenith angle and local solar time
- ISS attitude information required to process NLP data
- Ancillary data derived from models used to process FPMU data including geomagnetic field and solar illumination along the ISS orbit

Specific data sets released for science will depend on application but will typically contain a subset of the parameters from Table 1 as required to support the specific scientific goals intended for its use. One example is the FPMU Level 0 and calibration data along with files of housekeeping data that may be provided to specialists with expertise in FPMU data operation and data processing (most likely members of the FPMU instrument development team) when there is a need for expertise external to NASA to understand FPMU instrumentation issues. Another example is time series of electron density and vehicle potential provided by FPMU that can be used by ISS payloads to better understand the data collected from their instruments. Finally, Table 2 provides an example of an FPMU data file intended for use by the ionospheric science community to validate and improve ionospheric models. Parameters included in the file are ISS time codes and geographic ephemeris data, FPMU electron density and electron temperature, ISS attitude, percent solar illumination, and a time code correction (TCC) variable used to indicate where corrections have been made for bad time codes. Only a few records from the start and end of the file are included in the example here (FPMU records are obtained once a second and a complete file could be up to 86,400 records if data is collected continuously over a 24 hour period).

Table 2. Example FPMU Ionospheric Science Data Product

```
#ISS/FPMU Ionosphere Ne,Te records        Format:  Ionosphere
#POC:   J. Minow/EV44, NASA, Marshall Space Flight Center
#Systime(): Sun Dec 16 14:46:31 2012
#Ground Station:  MSFC
#Missing Ne,Te data: -1
#Approved for unrestricted distribution
#
#
#
#
#YYYY   DecDOY(UT)  Lat(deg) Lon(deg) Alt(km)     Ne(#/m3)  Te(K)  Attitude(deg) Sun(%) TCC
#-------------------------------------------------------------------------------------------
 2011  293.95450171  -49.003  119.839  403.214   2.220e+11  2610.    357.10     100.000  0
 2011  293.95451329  -49.025  119.928  403.208   2.170e+11  2719.    357.10     100.000  1
 2011  293.95452486  -49.046  120.017  403.202   2.350e+11  2616.    357.10     100.000  0
 2011  293.95453648  -49.067  120.107  403.197   2.230e+11  2224.    357.10     100.000  0
 2011  293.95454806  -49.089  120.196  403.191   2.150e+11  2598.    357.10     100.000  0

       < records deleted  >

 2011  294.33185662  -26.387  299.820  402.701   6.240e+11    -1.    357.10     100.000  0
 2011  294.33186819  -26.434  299.866  402.707   6.300e+11    -1.    357.10     100.000  0
 2011  294.33187051  -26.444  299.875  402.708   6.100e+11    -1.    357.10     100.000  0
 2011  294.33187051  -26.444  299.875  402.708   5.960e+11    -1.    357.10     100.000  0
 2011  294.33187051  -26.444  299.875  402.708   6.030e+11    -1.    357.10     100.000  0
#-------------------------------------------------------------------------------------------
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References:

Thompson, D., FPMU Data Archive, Format, Calibrations, and Data Reduction Algorithms, SLS/03-300 Rev. C, Rev 10 October 2003.

NPD 2200.1C, *Management of NASA Scientific and Technical Information*, (effective dates 9 December 2014 to 9 December 2019).

JOSEPH MINOW

Signature

Digitally signed by JOSEPH MINOW
DN: c=US, o=U.S. Government, ou=NASA, ou=People, cn=JOSEPH MINOW, 0.9.2342.19200300.100.1.1=jminow
Date: 2015.07.28 14:14:25 -05'00'

27 July 2015

Date