A PROPOSED PLANETARY EXTENSION FOR FGDC GEOSPATIAL METADATA. M. A. Hunter, M. S. Bailen and T. M. Hare, USGS Astrogeology Science Center (2255 N. Gemini Dr., Flagstaff, AZ 86001 (ma-hunter@usgs.gov).

Introduction: The Federal Geographic Data Committee (FGDC) created the Content Standard for Digital Geospatial Metadata (CSDGM), Version 2, which has been a widely adopted metadata standard since its release in 1998 [1]. Its use has enabled description, discovery and interoperability of geospatial data across a variety of disciplines and has been extended by many communities to further enhance these capabilities. Such stability and wide-spread use have also facilitated the development of open metadata writing, validation and conversion tools. While the core standard is robust for general use, many scientific communities have found it necessary to create extensions specific to the data they have to describe. Additional fields, non-standard primitives, controlled vocabularies and data dictionaries reduce barriers for authors to generate consistent, valid metadata.

As part of USGS Astrogeology's ongoing efforts to support planetary spatial data infrastructures (PSDI), this extension seeks to codify common descriptions of planetary geoscience data that do not have an equivalence in the FGDC core standard [2]. This profile will be submitted for adoption by the FGDC so that it may be used by the community and will be revised as necessary to ensure it remains useful to the broadest base of planetary scientists.

Those active in supporting metadata efforts will point out that many users of FGDC CSDGM are transitioning to the more robust International Standards Organization (ISO) geospatial data standards, which is also officially endorsed by FGDC itself. Fortunately, the USGS is actively leading in this migration, but it is expected to take years, and support for the current FGDC CSDGM standard remains widespread.

Methodology: The basis for our proposed <solarsys> metadata extension is the need to 1) represent planetary coordinate reference systems and 2) capture supplemental fields unique to planetary science. Many of these fields are used in Astrogeology's Astropedia, which has evolved over years to support the discovery of a wide variety of planetary data products, from global mosaics to rover observations [3].

As a simple example, the FGDC standard restricts bounding longitude coordinates to +/- 180° so a new set of minimum-maximum coordinate elements were created to support longitude domains from -180° to 360°. Standard geographic information was organized as sub-elements of <body>, and include the target body (e.g. Enceladus), the target system (e.g. Saturn), quadrangle, target radii, latitude type (geocentric or geographic), longitude domain (-180 to 180 or 0 to 360), longitude direction (east or west) and control network (e.g. MDIM 2.1). It should be noted that we recommend the bounding coordinates used within the existing CSDGM sections, if necessary, should always be converted into +/- 180° East longitudes in order to support web-based map interfaces which are commonly locked into East-based coordinates.

The proposed <solarsys> *keyword* elements function the same as the original Theme and Place Keywords in FGDC but are maintained separately with the goal of enabling additional controlled vocabularies. This will facilitate a much higher level of interoperability and machine readability of metadata, which will be most impactful for commonly used tags such as mission (e.g. Lunar Reconnaissance Orbiter) and instrument (e.g. Lunar Orbiter Laser Altimeter). One of the most convenient features made possible by this can be seen in the USGS Metadata Wizard, which is able to populate drop-down lists with controlled vocabularies published to the web, and ensures that users can pull from the same dynamic sources.

Another important consideration is the ability to assess data production, or how it is derived from a source data set. While the FGDC standard already supports the reference of other digital resources, elements were added to explicitly refer to a Planetary Data System (PDS) archive. The continued alignment of key elements in this profile with PDS4 metadata will be important to ensure long-term interoperability, as well as the development of read-write tools.

The extension was purposely kept as flat as possible to make groupings logical and easy to parse. Groups of elements typically apply either in whole or not at all to a data set, such as the <rover> and <sample> (e.g. rock core sample) groups. The schema for these elements has also been kept as unrestrictive as possible so as to support all possible use cases. New primitives were avoided to minimize the use of existing authoring and validation services.

Additional fields not specific to planetary science, but which are missing from the core standard, were added as needed. These include the number of bands in a raster, the scale factor and bit type, as well as a Well-Known Text (WKT) string to capture more detailed geometric footprints than simple bounding coordinates. It is expected that the planetary extension will grow as

new elements are identified by user communities and as metadata standards are further aligned.

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    <hostsrc></hostsrc>
    <body>
        <system></system>
        <target></target>
        <quadsys></quadsys>
        <quadname></quadname>
        <rada></rada>
        <radb></radb>
        <radc></radc>
        <lattype></lattype>
        <londom></londom>
        <londir></londir>
        <ctrlnet></ctrlnet>
    </body>
    <footprin>
        <maxlat></maxlat>
        <minlat></minlat>
        <maxlon></maxlon>
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    </footprin>
    <feature>
        <featkey></featkey>
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    </instr>
    <pdsstat></pdsstat>
    <pdsarch></pdsarch>
    <rover>
        <sol></sol>
        <featname></featname>
        <feattarg></feattarg>
    </rover>
    <sample>
        <strdepth></strdepth>
        <endepth></endepth>
    </sample>
    <bittype></bittype>
    <scale></scale>
    <bands></bands>
    <wkt></wkt>
</solarsys>
```

Table 1. The proposed extension as structured XML.

Future Work: With a completed first draft of the extension ready for community feedback, the next steps are to establish a governance model and submit the profile for endorsement by the FGDC. It is the recommendation of these authors that a group representative of the broader planetary science community should assume stewardship of the metadata profile so that it can be of greatest accessibility and use, and be responsive to changes needed by the user base. An ideal group for this task would be the Mapping and Planetary Spatial Infrastructure team (MAPSIT), though it may be managed in a more distributed manner as a project through GitHub.

Once the governance model is established it may be packaged and presented to FGDC for endorsement. This will aid primarily in the distribution and reputation of the standard, and engage users to provide feedback. It is not expected that the first version of the profile will solve all planetary geoscience metadata needs, but it will be an important step toward the development of open community standards as part of a fully realized PSDI. It is hoped that the formal establishment of the profile will be a subject of discussion at technology-focused planetary science workshops where users and developers can share ideas about how to best improve the profile, and what other relevant standards it should be aligned with.

Another step that may be taken concurrently with the above, is to support the profile in existing metadata authoring and validation tools. As was stated earlier, the effort and investment already put into FGDC metadata tools makes them ideal for integration with this profile. With minimal additional work this extension can put effective tools in the hands of planetary scientists and data managers, lowing the bar for the publication of quality metadata. The first plans are to work with USGS developers of the Metadata Wizard Toolkit to integrate the extension along with controlled vocabularies for planetary bodies, space exploration missions and their instruments [4]. This will also posture the project to participate in the transition from FGDC to ISO.

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References: [1] Pearsall, R. A. and Hogan, R. (2005). *World Spatial Metadata Standards*, 469-489. [2] Laura, J. R. et al. (2017) *ISPRS*: 181. [3] Bailen, M. S., et al. (2012). *LPSC XLIII*, Abstract #2478. [4] Ignizio, D. A. et al. (2014). *USGS OFR 2014-1132*.