STANDARDS PROPOSAL TO SUPPORT PLANETARY COORDINATE REFERENCE SYSTEMS IN OPEN GEOSPATIAL WEB SERVICES AND GEOSPATIAL APPLICATIONS. T. Hare[1], B. Archinal[1], L. Plesea[2], E. Dobinson[2] and D. Curkendall[2], [1]U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, thare@usgs.gov, [2]Jet Propulsion Laboratory, Caltech, 4800 Oak Grove Drive, Pasadena, CA, 91109-8099.

Introduction: This abstract outlines a proposal to improve support for planetary coordinate reference systems (CRS) within existing open geospatial standards and geospatial applications. This will allow mapping applications, whether they are using streamed or local data sets, to recognize a defined planetary CRS and give them the ability to overlay multiple data sets from different sources and implement accurate geodesic calculations.

Motivation: We are adapting well-defined open geospatial standards and technologies for the access, processing, and display of geo-spatial data to the planetary domain as discussed in a companion abstract in this volume [1]. To fully understand this proposal, we must briefly discuss the current open spatial technologies as they have been developed for Earth-based applications [2].

The Open Geospatial Consortium (OGC) was built to help establish and promote a series of Internet protocols and file specifications for sharing geospatial data [3]. One of these standards, called Web Mapping Services (WMS), has become an extremely popular method used to stream simple geospatial data sets across the Internet to mapping applications or simple web browsers. For each data set provided, the data server must define a minimum set of information such that the client application understands not only the data layer but the current CRS or map projection. Currently, web mapping servers normally default to using the numeric European Petroleum Survey Group (EPSG) codes to define the CRS or SRS (Spatial Reference Systems) [4]. For example, code "4326" is the EPSG identifier for Earth's "WGS 84" geographic CRS. The server and client relay this code by passing an in-line SRS request using the string "SRS=nameSpace:code" (e.g. "SRS=EPSG:4326").

Additional EPSG codes were generated to attempt to catalog the most widely used cartographic map series from all countries (e.g. "32612" = WGS 84 / UTM zone 12N; "21413" = Beijing 1954 / Gauss-Kruger zone 13). One will quickly realize the options for these codes would be infinite. And if the CRS is not part of the EPSG database, and no planetary definitions are, there is the option to explicitly define custom settings. However, using these custom settings are rarely supported in software packages. And while folding planetary CRS definitions into the EPSG standard is an option, it is not ideal.

Proposal: To help solve this incompatibility among planetary servers, we have approached the issue from several different avenues. Here we discuss three approaches.

1.) WMS codes: To help support the widely used EPSG coded method for the WMS protocol, we will derive our own planetary coded system using a combination of International Astronomical Union (IAU) and International Association of Geodesy (IAG) published documents [5] and previously coded values as defined by the Navigation and Information Facility (NAIF) [6]. Each IAU published document, which is released every 3 to 5 years, will define the necessary namespace (e.g. IAU1979, IAU2000, IAU2003, etc.). This is analogous to the "EPSG" namespace. The new planetary codes will be modeled after the NAIF coding system [6]. In short, the NAIF system defines the barycenter (center of mass) of the solar system as 0 and defines the Sun as 10. This leaves 1 through 9 to classify the planets starting with Mercury out to Pluto. The NAIF planet ID is then defined as the planet barycenter ID * 100 + 99. Thus Mars, in the NAIF system, is defined as "499". The new geospatial planetary code for the would now be derived as:

Planetary GIS code = NAIF planet center code * 100
example: Mars GIS-IAU code = 499 * 100 = 49900
example WMS call: SRS="IAU2000:49900"

The moons for each body, as defined by NAIF, start at planet barycenter ID * 100 + 1. For example, Phobos is defined as "401" and Deimos as "402". The new planetary code would be defines as:

example: Phobos GIS-IAU code = 401* 100 = 40100
example WMS call: SRS="IAU2000:40100"

To continue with the Mars example, the first 10 numbers, 49900 to 49909, are reserved for geoid definitions (Table 1). Starting from 49910 to 49959, the codes are reserved for predefined projection definitions. Codes from 49960 to 49999 are for AUTO projections. AUTO projections allow the user to also submit the projection parameters (e.g. SRS="IAU2000:49964,9001,100,45". Where 49964 is Transverse Mercator, 9001 is the EPSG code for meters, center longitude=100º and center latitude=45º). Note that the namespace "Auto" maybe substituted for the IAUxxxx namespace for auto projections.

2.) WTK (Well Known Text): The WMS specification also allows for a CRS registry system (on-line look-up database). So instead of sending a SRS code, the server provides a URL that points to a CRS registry catalog which will return a WKT string defining the SRS. WKT strings are a verbose listing of the CRS and SRS. Here is a WKT CRS for Mars:

```
GEOGCS["GCS_Mars_2000",DATUM["D_Mars_2000",
SPHEROID["Mars_2000_IAU",3396190.0,
169.89444722361]],PRIMEM["Reference_Meridian",0.0],
UNIT["Degree",0.0174532925199433]
```

This method seems like the best approach currently within the specification, however, most WMS servers and clients do not yet support it. Thus we will continue to push the use of WTK and registry systems as well as eventually host a planetary registry service which will be available to the community.

3.) GML (Geographic Mark-up Language): Lastly, we also believe GML, geographic XML specification, will be used for WMS and other data streaming standards. Like WKT, GML allows for the CRS and map projection to be verbosely spelled out. Currently, the only deficiency for a completely valid planetary GML definition is the keyword "Greenwich". Fortunately, you can create a XML substitution to rename the keyword to "Reference Longitude". This "Greenwich" keyword originated from the International Standards Organization (ISO) 19111 specification. The ISO specification is currently up for review and will hopefully resolve this issue before the new version is released.

Conclusion: While the proposal to support EPSG-like planetary codes is not ideal, we feel it is a start to improve planetary research collaboration. And we will continue to push the more robust WTK and GML standards for file-based and streamed data, so that planetary data sets are more easily supported. This final proposal will be fully described and soon available at the OGC website [3]. Please relate any concerns or ideas about this topic to the author.

References: [1] Dobinson, E., et. al., (2006), LPSC XXXVII, abs. 1463. [2] Hare, T., et. al., (2005), LPSC XXXVI, abs. 2213. [3] OGC, URL: http://www.opengeospatial.org/ [4] Coordinate Reference System Definition, European Petroleum Survey Group (EPSG) URL: http://www.epsg.org/ [5] Seidelmann, P. et al. (2002) Celest. Mech. Dyn. Astron, 82, 83-110; Seidelmann, P., et al. (2005) Celest. Mech. Dyn. Astron., 91, 203-215; [6] URL: http://naif.jpl.nasa.gov/naif/tutorials.html .

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IAU Name	**Mars GIS-IAU**	**GEOIDS**
IAU2000	49900	Mars2000, areocentric latitudes, positive East longitudes
IAU2000	49901	Mars2000, areographic latitudes, positive West longitudes
IAU2000	49902 - 49909	Available
		PROJECTIONS - **Even codes**=areocentric, **Odd codes**=aerographic **NOT all shown**)
IAU2000	49910	Equirectangular (Simple Cyl), clon=0º, spherical equation, areocentric
IAU2000	49911	Equirectangular (Simple Cyl), clon=0º, spherical equation, aerographic
IAU2000	49912	Equirectangular (Simple Cyl), clon=180º, spherical equation, areocentric
IAU2000	49914	Sinusoidal, clon = 0º, spherical equation, areocentric
IAU2000	49916	Sinusoidal, clon = 180º, spherical equation, areocentric
IAU2000	49918	Polar Stereographic, clat = 90º, clon = 0º, spherical eq, polar radius, areocentric
IAU2000	49920	Polar Stereographic, clat = -90º, clon = 0º, spherical eq, polar radius, areocentric
IAU2000	49922 ~ 49959	Available (1:2M Mars series handled by AUTO below)
		AUTO PROJECTIONS (parameter order)
IAU2000 or Auto	49960	Auto Sinusoidal, spherical equation, areocentric, (clon)
IAU2000 or Auto	49961	Auto Sinusoidal, spherical equation, aerographic, (clon)
IAU2000 or Auto	49962	Auto (Polar) Stereographic, spherical equation, areocentric, (clon, clat, scale)
IAU2000 or Auto	49964	Auto Transverse Mercator, areocentric, (clon, clat, scale)
IAU2000 or Auto	49966	Auto Orthographic, spherical equation, areocentric, (clon, clat)
IAU2000 or Auto	49968	Auto Equirectangular (Simple Cylindrical) , areocentric, (clon, clat)
IAU2000 or Auto	49970	Auto Lambert Conformal Conic, areocentric, (clon, clat, std_p1, std_p2, scale)
IAU2000 or Auto	49972	Auto Lambert Azimuthal Equal Area, areocentric, (clon, clat)
IAU2000 or Auto	49974	Auto Mercator, areocentric, (clon, clat)
IAU2000 or Auto	49976	Auto Albers, areocentric, (clon, clat, std_p1, std_p2)
IAU2000 or Auto	49976	Auto Albers, areocentric, (clon, clat, std_p1, std_p2)
IAU2000 or Auto	49978	Auto Oblique Cylindrical Equal Area, areocentric, (clon, clat, scale)

Table 1. The example planetary codes to support planetary WMS servers for Mars using the "IAU2000" namespace. Other bodies will follow similar definitions as derived from the NAIF planetary codes.