THE ROLE OF TECHNOLOGY IN A PLANETARY SPATIAL DATA INFRASTRUCTURE J. R. Laura, L. R. Gaddis, T. M. Hare, and J. J. Hagerty. U.S. Geological Survey, Flagstaff Arizona (jlaura@usgs.gov)

Introduction: Spatial Data Infrastructure (SDI) is a theoretical framework to support user driven spatio-temporal data discovery, access, and utilization [5]. NASA has long supported the broad goals defined by SDIs without explicit identification of the components or how they might interact. Given the potentially significant challenges and costs of spatial data acquisition, it is necessary to treat spatial data as a multi-use product [5] that provides the foundation for leveraging spatial expertise from multiple institutions. Simplistically, spatial data should “just work” for the non-spatial expert. Realizing this goal requires spatial and technical expertise, inter- and intra-organization coordination, transparent policies, shared interoperability standards, and buy-in by the user community.

Components of Spatial Data Infrastructure: The terrestrial geospatial community asserts that spatial is special [1], whether in reference to the increased demands on data collection and storage, the additional information embedded within a spatial data product, the inherent challenges in statistical inference when issues of spatial autocorrelation exist, the need to model spatial error, or the increased computational costs associated with handling all of the above. Likewise, a PSDI is special and is clearly distinguished from terrestrial counterparts. For example, the breadth of planetary data products is small compared to terrestrial products, making data fusion activities that much more critical. Likewise, planetary foundational data products are iteratively refined, while terrestrial products take a more hierarchical approach. A significant amount of overlap does exist, and we can leverage the successes and failures of previously proposed and developed SDIs. SDIs are a combination of people, regulatory mechanisms and policies, access technologies, standards, and spatial data themselves [8, 10], Figure 1.

People: Theoretically, spatial data users should be the primary drivers of all PSDI components[7]. Management of the human components includes the development and stewardship of the critical skills necessary to realize a PSDI, the communication mechanisms to engage and educate stakeholders (data collectors, providers, and users), and the techniques to connect with non-expert and new users [3]; this is a user-centric and not techno-centric view.

Standards: Data standards support accurate geopositioning, interoperability, and usability. Spatial location is critical for both horizontal and vertical integration of spatial data sources (data fusion between instruments and between derived products). Accurate positioning is a function of effective pre-launch sensor calibration, in flight calibration, and data-driven in situ calibration. Interoperability and usability of complex spatial data are also major concerns for terrestrial SDIs and significant effort has been dedicated to the development of robust specifications (e.g., the Open Geospatial Consortium (OGC) spatial standards or the Community Sensor Model (CSM)).

Policies: SDI as a regulatory mechanism is successful through a combination of stakeholder engagement, organizational (whether government or otherwise) policies, and volunteer compliance. The Federal Geographic Data Committee (FGDC) releases periodic policy guidelines and NASA is in an ideal position to echo these guidelines and modify as required to more fully address the needs of planetary data users. These policies assist in ensuring that standards for data creation and access are consistent, as well as supporting the necessary infrastructural components of the PSDI with respect to user engagement. This is a process that requires information gathering across the planetary community.

Access Network: SDIs exist to share data and it is essential that data providers with appropriate spatial data expertise are identified. The federated nature of the science discipline nodes within the NASA Planetary Data System (PDS) provides a template for future PSDI access requirements and the FGDC model of organizational leads spearheading individual foundational data products and supporting framework elements is ideally suited for two reasons. First, distributed ownership of the PSDI significantly increases institutional buy in. Second, distributed ownership allows for specialization within the sub-domains described herein. SDI is an inherently complex system [5].

Data: OMB [9] identifies 34 terrestrial data themes critical to national spatial data utilization. Of these, seven are considered foundational data sets; the remainder are more specialized, framework (ancillary) data sets with smaller user bases. We identify three foundational
data themes: geodetic coordinate systems, elevation, and orthoimagery (the remaining four are Earth centered). Geodetic coordinate systems provide the basic positional framework upon which all other data themes are registered. Within the planetary context the International Astronomical Union has traditionally defined geodetic control through a cadenced revision schedule [2]. Elevation data, whether point observation, vector TIN or gridded is a critical data product and key input for derived data products. Digital orthimagery is the third foundational data theme. Digital orthimagery includes not just the availability of the highest quality available imagery, but also governs methodologies for the registration of data and accurate reporting of accuracy metrics to other data products.

The Role of Technology: Figure 1 illustrates technology as bounding all of the PSDI concepts. We suggest that technology permeates all of the PSDI components, from supporting the collaboration of cross domain, spatially distributed science teams, to facilitating efficient storage or Petabytes of planetary data. We also suggest that technology is inherently dynamic (transient) and the cutting edge today is superseded tomorrow. This simple fact highlights the importance of the PDS [4] in providing a solid, long-lived foundation from which a dynamic PSDI can be maintained. Using the PDS as the foundation, we explore technology from the perspective of theoretical data access.

Data access can be conceptualized as being composed of three primary components with differing technical lifetimes. First, the PDS is an exemplar of the long-term storage of data and the technical requirements that this imposes on formats and archiving. This includes the distribution of data across nodes and standardization to a single archival compliant format. In arguing that spatial data should just work, we are suggesting that the calibration, corrections, and processing to spatially enabled product should not be a requirement for the end science user. In making that argument, we push the spatial expertise requirement back onto the spatial experts. This also requires that data be processed and made available in this new, spatial form. In the medium term, standards compliant, infrastructural data availability is a prerequisite for consumption by any number of clients. Standards compliance is supported both by NASA policy and community adherence. That is, as standards gain weight they become enforced by the broader community. Finally, we see front-end clients, whether Geographic Information Systems, web applications, or full desktop applications as being developed at the technical cutting edge (and therefore having the shortest technical lifespans). The development and use of these interfaces is supported only by the existence of long- and medium-term access mechanisms.

While the above is technology centered, we caution that support of the user is the paramount goal of any SDI [6]. Technology is one component of a holistic solution that removes the requirement for spatial expertise from the non-spatial data user and in developing a PSDI, we must focus on how technology can fulfill user goals.

The Role of Missions: A frequent concern when presenting PSDI materials is the role of planetary missions within the PSDI framework when faced with the multitude of science goals and contractual obligations. We suggest that missions teams are broadly already fulfilling the necessary steps to support a PSDI. This assumes that (1) the data mission collected are associated with standards based metadata (e.g., including rigorous sensor models and error reporting) and (2) the data are submitted to the PDS in using the approved PDS standard and in a calibrated (science ready, but not photogrammetrically controlled) form. In this way the data are ‘ready’ for integration into a PSDI. Having the data available, with errors reported and models to generate standardized spatial products, it is possible for either the mission, or other entities to begin integrating the data into the broader PSDI. For example, with the processing, co-registration, and integration into a PSDI. Having the data available, with errors reported and models to generate standardized spatial products, it is possible for either the mission, or other entities to begin integrating the data into the broader PSDI.

Conclusion: PSDI explicitly frames the components to support a rich spatial data infrastructure for the planetary science community. Technology is a key, dynamic component to the PSDI ecosystem. In developing and operationalizing PSDI we, as the technical community, must strive to create cutting edge standards compliant solutions, with long-term data infrastructures that allow innovation in the forward facing user interfaces.

References: