Thoughts on the “Role of CCSDS with respect to PNT at the Moon, Mars, and Beyond.”

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Here’s some observations:

1. Other organizations are already tasked with position finding, navigation, and timing – ICG, for instance.
2. The existing model for GNSS (GPS, GLONASS, GALILEO, BEIDOU, etc) is one where each system is similar, but use different orbits, techniques, and signal processing. However, all the systems do provide most of their signal details publicly, as well as (at some level) the information needed to get a position or time fix.
3. They are not interoperable at the signal level (that is, a GLONASS only receiver cannot decode and use GPS signals), but they all produce some form of position and time, which in turn is referenced to some standard reference frame. These are not necessarily the same data nor reference frame for all systems.
4. There are also some features of each system which are not publicly available (P code for GPS, GALILEO has some subscription only features), and there are “add on” systems that have been created to add to the public systems (various differential correction systems).
5. Industry has responded to this situation by producing multi-system receivers which combine the multiple system outputs in some way. Whether by combining raw observables, or somehow combining separate fixes for each system into a composite fix.
6. The same is true, to a lesser extent, for other positioning systems (TDMA cellphones supporting the E-911 feature, although I believe most of them have been supplanted by some form of augmented GPS, in the US)

Therefore, I think a useful role for CCSDS would be more along the lines of providing an example (or reference?) architecture for PNT systems at the Moon, along with guidance on how some of the features of existing and proposed systems would be represented in that architecture. This is a cross cutting activity within CCSDS, so this would be appropriate to be done by the Systems Engineering Area, possibly in the Systems Architecture Working Group, collaborating with the Navigation WG (because they would be a “consumer” of a PNT system’s outputs), the Time Management WG (because they all need to transmit time in some form), and some of the Link WGs (because there are PN signals, and data carried on top of the PN). Finally, there is a need for the Security WG – specifically, I’m thinking authentication of the received signals as well as the calculated position and time fixes.

All GNSS systems have common elements – a user receiver and algorithms, some signal transmitting component (mostly orbiting, but pseudolites also exist) which transmits a signal from which time, frequency, and range can be determined (almost always a PN code), and finally, some sort of control segment, that is responsible for things like validating the performance of the transmitters, updating transmitter parameters, disseminating reference information (i.e. the ephemeris of orbiting transmitters). There are new architectural challenges for Lunar systems in that highly accurate clocks and Lunar based control systems, similar to what is needed to sustain these systems on Earth, would appear to be needed. The question of adopting some sort of shared, or common standards, or of some common infrastructure also should be explored, but national interests may prevent this.

CCSDS could provide an architectural Recommended Practice (Magenta Book) that would include terminology, how to describe the pieces of a PNT system, define interfaces and support systems that require definition, and, perhaps, recommendations for interoperability (i.e. what time scale should be the basis, how should ephemeris information be provided).

This would require agencies to agree to supporting this new work product and to providing the needed expertise. It would also require establishing working relationships with the other WGs that need to be involved. This last aspect might be enacted by identifying a small number of the members of these other WGs who would be willing to keep a leg in each camp.