1 SPACECRAFT ONBOARD INTERFACE SYSTEMS AREA

1.1 WIRELESS WORKING GROUP

Title of Group	**Wireless Working Group (WWG)**
Chair	**Patrick Plancke/ESA**
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1.1.1 RATIONALE

CCSDS develops communications and mission operation standards that support inter- and intra-agency operations and cross support. CCSDS standards include elements of flight and ground systems that are developed and operated by different agencies and organizations.

The mission of the Wireless Working Group is to investigate and make recommendations pursuant to standardization of applicable wireless network protocols, ensuring the interoperability of independently developed wireless communication assets. The goal of the Wireless Working Group (WWG) is to provide the CCSDS development community and participating members with the standards-based resources to achieve interoperable wireless network communications, including specific protocol recommendations for anticipated communication scenarios associated with, but not limited to, Lunar and Martian exploration activities.

The WWG is focused on wireless, either RF or optical, networks, (i.e., WLAN, WPAN, WMAN) and does not consider point-to-point wireless standards which are addressed by other CCSDS technical areas including Space Link Services (SLS) and Space Internetworking Services (SIS).

The CCSDS has a mature in-place international standard for short-haul communications protocol termed “Prox1”. But international standards for *wireless space networking* do not exist. The CCSDS has subcategorized short-range or surface proximity networks as:

1) **Intra-vehicle**: Internal vehicle (or habitat) extremely short-range wireless links and networking (10 m range).
2) **Inter-vehicle**: Vehicle-to-vehicle short-range and medium range (1 km – 20 km).
3) **Planetary surface-to-surface wireless links and networking** (100 m – several kilometers).

a. EVA (Extra-Vehicular Activity) local links with planetary rover vehicles (RV) and/or habitats;
b. RV-habitat links when RV is close to habitat;
c. Links between independent local systems (e.g., habitats, robots, external assets).

4) **Orbiter relay-to-planetary surface links and networking**.

The recommendations of this Working Group will enable member agencies to select the best option(s) available for space communications and internetworking, based upon industry-standard evaluation metrics such as power expenditure, data rates, noise immunity, and range of communication as well as on space systems metrics such as reliability, availability, maintenance and safety.

Wireless communications is an enabling technology for both manned and unmanned spacecraft – it enables untethered mobility of crew and instruments, increasing safety and science return, and decreasing mass by eliminating expensive cabling. Wireless networks automatically enable communication between compliant devices that dynamically come into and out of range of the network. Wireless communication is fundamental for communicating outside of a spacecraft (e.g., inter-spacecraft communications, planetary surface communications), and provides for mobile crew monitoring within a habitat or spacecraft (intra-vehicle communications). Added value for using wireless communications is also identified for the ground.

From an engineering standpoint, mission managers, along with engineers and developers, are faced with a plethora of wireless communication choices – both standards-based and proprietary. The provision of a CCSDS standard reference that summarizes wireless protocol capabilities, constraints, and typical deployment scenarios, will decrease the up-front engineering evaluation effort significantly, and provide a standards-based common reference to improve interoperability between disparate systems that need to cooperate in wireless data transmission and networking.

1.1.2 STRATEGIES

The Wireless Working Group has formulated the following strategies to assist in meeting the Goals of the WWG enumerated in section 1.1.3:

1) **Identification of *when* we need the standards**: This is a critical strategic issue and will be driven by timeline requirements of the participating agencies. A trade-off exists between early adoption and baseline incorporation of standards with later adoption and the associated advancements anticipated to be incorporated into the evolving/improving standard. The result is that a decision to delay recommendation of a standard is a potential strategy in the case where there is no urgent need for an immediate decision. However, a significant advantage of

specifying baseline standards is that it allows "initial specification" of an evolving wireless networking product development roadmap.

2) **3-Tier Prioritized Approach to Standards:**
   - **a.** Adopt proven standards where practical;
   - **b.** Adapt existing standards to meet defined requirements;
   - **c.** Develop new approaches only where absolutely necessary.

3) **Specify agency-relevant driving scenarios** for which wireless network communications will provide a significant return-on-investment, benefiting the participating international agencies.

4) **Determine the best division of responsibilities** of the 4 functional areas of (a) intra-vehicle, (b) inter-vehicle, (c) planetary surface, and (d) surface-to-orbiter wireless communications that maximizes benefit to the CCSDS member agencies. The division of responsibility could occur within the Wireless Working Group itself, or the different wireless functional areas may be split according to pertinent relevance within Spacecraft Onboard Interface Services (SOIS), Space Link Services (SLS), or Space Internetworking Services (SIS).

1.1.3 GOALS

The goals of this Working Group are to:

1) Use the following scenarios to derive wireless communication requirements for intra-vehicle, surface-to-surface, inter-vehicle, surface-to-orbiter, and terrestrial assembly-integration-test (AIT) activities:

   a. Unmanned robotic planetary surface operations;
   b. A manned planetary (Lunar or Martian) outpost;
   c. Terrestrial ground operations and terrestrial assembly-integration-test, AIT, activities;

   Specifically:
   a. Summary Plan: Publicize initial WWG project plan and technical background material in a Green Book;
   b. Intra-vehicle: Summarize scenarios, requirements, and suggested wireless protocols requirements for asset/inventory tracking and control via wireless communications in a Magenta Book;
   c. Intra-vehicle: Summarize scenarios, requirements, and suggested wireless protocols requirements for intra-vehicle communications (e.g., a spacecraft or habitat), other than inventory management, in a Magenta Book;
   d. Assembly-Integration-Test: Summarize scenarios, requirements, and suggested wireless protocols requirements for terrestrial assembly-integration-test (AIT) activities in a Magenta Book;

e. Surface-to-surface: Summarize scenarios, requirements, and suggested wireless protocols requirements for surface inter-asset communications in a Magenta Book;
f. Inter-vehicle: Summarize scenarios, requirements, and suggested wireless protocols requirements for intra-vehicle communications (e.g., a spacecraft-to-spacecraft) in a Magenta Book;
g. Surface-to-orbiter: This functional area is addressed by the Space Link Services (SLS) technical area.

2) Guide adoption and derivation of interoperable wireless communication protocols in support of CCSDS activities;

3) Interact with the Systems Engineering Security Working Group to ensure security concerns are adequately addressed in all recommended wireless standards;

4) Summarize the interoperability of recommended wireless protocols at the physical, data link, network, and transport layers of the OSI communications protocol stack;

5) Facilitate reference implementations and performance of interoperability testing;

6) Hold working meetings with other Working Groups to develop consistent approaches and formulate plans for integrating wireless communications into the activities of other CCSDS Working Groups.

7) Evolve and maintain the WWG Green Book to provide a comprehensive wireless protocol reference document for use by CCSDS member agencies and Working Groups;

1.1.4 SCHEDULE AND DELIVERABLES

Date	**Milestone**
October 2007	Wireless Working Group established
April 2008	Green Book release to provide CCSDS community with overview information relating to the Wireless Working Group (WWG); will contain design-driving scenarios reached by consensus and outline the expected deliverables of the WWG.
October 2008	Magenta book detailing communication scenarios, requirements, and suggested wireless protocols for internal inventory control
October 2008	Magenta book detailing communication scenarios, requirements, and suggested wireless protocols for intra-vehicle (spacecraft, planetary habitat)

Date	Milestone
April 2009	Magenta book detailing communication scenarios, requirements, and suggested wireless protocols for groundside assembly, integration, and test (AIT)
October 2009	Magenta book detailing communication scenarios, requirements, and suggested wireless protocols for planetary surface (external) communications
October 2009	Magenta book detailing communication scenarios, requirements, and suggested wireless protocols for vehicle-to-vehicle communications
April 2010	Draft Green Book summarizing recommendations concerning intra-vehicle, AIT, and planetary surface wireless communications
October 2010	Green Book submitted to the CESG for review

1.1.5 RISK MANAGEMENT STRATEGY

1.1.5.1 Technical Risks

Agreement needs to be reached as to protocols, protocol configurations and protocol options for the relevant operational scenarios. Technical evaluations and considerations must be unbiased. Harmonization with pertinent CCSDS Working Groups is essential.

1.1.5.2 Management Risks

The quality of the end product relies heavily on the commitment of Agencies to provide support for the work. Representation of all Agencies requiring interoperability for extra-terrestrial wireless network communications is essential. Publishing of deliverables is time sensitive to ensure incorporation in early planetary missions.

Resource Requirements for 3 year Working Group duration:

Working Group Chair: lead working groups - prepare for and attend meetings, present material at working group meetings. 2 mm / yr	6 mm
CCSDS Wireless cross-pollination to ensure inter-areas coordination with in particular SOIS, SIS, SLS, MOIMS, SEA. 2 mm / yr	6 mm
SOIS: Agencies Representative(s) in the working group. 1 mm / yr	3 mm
SLS: Agencies Representative(s) in the working group. 1 mm / yr	3 mm

Technical activities to support Working Group deliverables: 3 mm / yr	9 mm

Expected activities of Working Group Members:

- Periodic (typically monthly) teleconferences that are usually one hour in length;
- Correspondence (e-mail, telecons) to discuss programmatic and technical issues;
- Attendance to bi-annual CCSDS meetings for face-to-face technical presentations, deliberations, and planning sessions;
- Technical research activities in support of Wireless Working Group Goals (enumerated in section 1.1.3) and deliverables.

1.2 REFERENCES

1. Plancke, P., Saiz, J., Hernandez-Velasco, I., Gifford, K.K., and Carron, C., "Wireless Communications and Interfaces onboard Spacecraft" *AIAA SpaceOps 2006 Conference*, Rome, Italy, June, 2006.

2. Gifford, K.K., Braham, S., "Wireless network systems to support NASA's Exploration Vision" *AIAA InfoTech@Aerospace 2007*, Paper # AIAA-2007-2927, Rohnert Part, CA, May, 2007.

3. Plancke, P., Magness, R., "ESA TEC-E Wireless Technology Dossier", *Proceedings of the 9th ESA Workshop on Advanced Space Technologies for Robotics and Automation, ASTRA 2006,* ESTEC, Noordwijk, The Netherlands, November, 2006.

2 GLOSSARY OF TERMS

AIT	Assembly, Integration, and Test.
CCSDS	Consultative Committee for Space Data Systems, www.ccsds.org .
CESG	CCSDS Engineering Steering Group, http://cwe.ccsds.org/cesg/default.aspx .
EVA	Extra-vehicular activity.
Green Book	CCSDS Informational Reports: intended to provide the timely publication of a very broad range of general information in the CCSDS community.
Magenta Book	CCSDS Recommended Practices Book: are the consensus results of CCSDS community deliberations and provide a way to capture

	"best" or "state-of-the-art" approaches for applying or using standards.
MOIMS	Mission Operations and Information Management Services; one of six core CCSDS Technical Areas, http://cwe.ccsds.org/moims/default.aspx.
Prox-1	The CCSDS Proximity-1 space link protocol, recommended for short-range, bi-directional, fixed or mobile radio links, generally used to communicate among probes, landers, rovers, orbiting constellations, and orbiting relays. These links are characterized by short time delays, moderate (not weak) signals, and short, independent sessions.
RF	Radio frequency.
RV	Robotic vehicle.
SEA	Systems Engineering Area; one of six core CCSDS Technical Areas, http://cwe.ccsds.org/sea/default.aspx .
SIS	Space Internetworking Services; one of six core CCSDS Technical Areas, http://cwe.ccsds.org/sis/default.aspx .
SLS	Space Link Services; one of six core CCSDS Technical Areas, http://cwe.ccsds.org/sls/default.aspx .
SOIS	Spacecraft Onboard Interface Services; one of six core CCSDS Technical Areas, http://cwe.ccsds.org/sois/default.aspx .
WLAN	Wireless Local Area Network.
WMAN	Wireless Metropolitan Area Network.
WPAN	Wireless Personal Area Network.
WWG	CCSDS Wireless Working Group.