Wireless for Spacecraft application Workshop 10-13 July 2006

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The workshop had gathered about 70 participants that included a strong delegation of NASA (JPL, JSC) and US companies and universities contractors of NASA. Most European primes were represented as well as equipment manufacturers as well as Agencies (CNES). It has been noted the very high motivation of most participants and a very high level of interactivity during the sessions and round tables. This was one of the main objectives of the organization of the workshop and was very successful in this aspect.

Introductory session: Visions for Space Exploration

Chair: *Patrick Plancke ESA/ESTEC*

14:15 The Aurora Programme: Europe's Framework for
Pietro Bagnoli ESA/HME-M
14:45 The Exploration Vision (and the Role of Wireless Technologies)
John Saiz, R. NASA/Johnson Space Center (United States)
15:15 Wireless Onboard Spacecraft and in Space Exploration: Wireless Proximity Networks - The ESA TEC-E Wireless Technology Dossier
Rodger Magness, R. ESA/ESTEC (Netherlands)

The introductory session presented a glimpse to the future provided by ESA/Aurora representative, with reference to the Mars missions (Exomars, Mars Sample Return) followed by a presentation of Nasa/JSC integrating already the wireless as one of the technologies that will support the ambitious US exploration program and its initial steps, specially for the Moon and Mars. The latter from ESA/D-TEC was then providing the analysis of wireless and presentation of class of proximity networks able to support a wide range of applications from on board short distance to off board applications, and raised these questions for the workshop participants to ponder and discuss informally during and in between the workshop sessions:

1) Are the roles of wireless as presented this week (and in reviewing and discussing the ESA Technology Dossier Annex A), consistent with the presented (and those not presented) Visions for Space Exploration? We have largely NASA JSC, and ESA Aurora views represented here this week – are there additional views as well as programmes not represented?

2) Where, or, have we gone astray?

3) Are priorities consistent with ESA, NASA and space industry interests?

4) Are ESA and NASA priorities consistent with each other? If there are areas where they are not, how does this impact cooperation and standardisation efforts? Does the fact that ESA-EU is much less HME oriented introduce an interest dichotomy?

5) Where are the justifications most compelling?

6) Can we make a hard business case for several of these roles with costs/benefits quantified in Dollars and Euros?

Session 1: Wireless Flight Experience

Chair: *John Saiz NASA/Johnson Space Center*

16:00 First Data from Nanosat-01 OWLS Experiments
Arruego, I. ; Martinez Oter, J. ; Guerrero, H.
INTA (Spain)
16:30 Wireless Instrumentation Systems for Shuttle and ISS Missions
Walcer, M.; Champaigne, K.
Invocon, Inc. (United States)

This session related to flight experience started by a presentation of INTA (SP) On the Nanosat-1 IR wireless experiment and flying since December 2004 and still alive. It was followed by the experience gained by the US company "Invocon" that has already a long experience in flying wireless systems on US manned mission, the latter being the last Shutlle flight where a wireless network was used to detect eventual shocks of objects on the wings of the S/C. This gives already an idea of the universality of the wireless technology that can address the needs for small magnetic miniaturized experiments on a Nanosat or participate to a critical monitoring function on a multi billions Shuttle. We also acknowledge the impressive experience already gathered by the NASA/JSC in flying wireless systems based on *ad hoc* standards since 1996. Also, we can note that Nasa has presented in one common presentation a view of the exploration integrating the wireless whilst ESA view had been given in two presentations the system view and the technology view. However both NASA and ESA have identified the high potential of wireless applications networks in the frame of the future exploration missions scenarios.

Session 2 and Round Table: Sensing and Control 1

Chair: *Rodger Magness ESA/ESTEC*

09:00 Optical Wireless FOTON-M3 Experiment
Rodriguez, S.; Martin Ortega, A.; De Mingo, J.R.; Arruego, I.
INTA (Spain)
09:30 Requirements for TMTC on launchers
Bry, H EADS Space
Mr Bry was unfortunately not able to join us.
10:00 BioNet: An Enabling Architecture for Advanced Heterogeneous Wireless Applications
Gifford, K.[1]; Kuzminsky, S.[1]; Williams, S.[1]; Saiz, J.[2]
[1]University of Colorado (United States); [2]NASA (United States)
10:30 The Delfi-C3 Student Nanosatellite, an Educational Test-Bed for Wireless Technology in Space

Ubbels, W.J.[1]; Bonnema, A.R.[1]; Hamann, R.J.[1]; Amini, R.A.[1]; Verhoeven, C.J.M.[1]; Leijtens, J.A.P.[2]
[1]Delft University of Technology (Netherlands); [2]TNO Science & Industry (Netherlands)
11:15 Ad-Hoc Wireless Sensor Networks for Exploration of Solar-System Bodies
Dubois, P.[1]; Menon, C.[2]; Shea, H.[3]
[1]EPFL (Switzerland); [2]ESA-EUI-ACT (Netherlands); [3]EPFL-LMTS (Switzerland)
11:45 A Self-Organising and Distributed Platform for Environmental Monitoring using Wireless Sensor Networks
Chatterjea, S.; Havinga, P.
University of Twente (Netherlands)
12:15 Round Table: Wireless Sensor Networks

The session related to the sensor network was among the more important.
The session chair posed these questions during the Round Table:

1) Which of the two, sensing and measurement, or control is the more logical, reasonable and appropriate as a means of introducing wireless onboard ESA spacecraft?

2) What should ESA fund next?

3) Proposition: a practical, sound and likely introduction process would be first to introduce wireless [for unmanned missions] in (a) EGSE, A-I-T and S/C testing, (b) onboard the launcher, (c) onboard payload and (d) planetary surface.

4) Proposition: there is no need to delay in introducing wireless on manned missions for appropriate and needed applications. [This is a rhetorical question, a NASA has already introduced RF wireless onboard both ISS and Shuttle in numerous applications regarding S/C integrity sensing as well as astronaut health monitoring, etc].

On the questions was asking to identify the next steps for developing wireless and in particular to identify the priority to be given between developing sensor oriented applications first or control oriented applications, the consensus had been to put as a priority the development of “sensors” networks. It is seen as the best compromise to inject wireless technology not on the most critical on board functions whilst having a good potential in term of short term return: reduction of on board complexity, harness and AIT. On this last one, it was suggested that AIT domain should be particularly considered as a first beneficiary of wireless techniques and becoming in the same time the best demonstrator of the potential of those technologies for further space applications. This shall be taken into account when defining further activities in this field. In addition, there has been a question to ESA from TNO to define as soon as possible a low cost wireless interface to be used in particular for flight demonstration mission taking as reference the wireless sun sensor developed by TNO and presented during the session (note: the point was further expanded in the presentation of TNO on the session 7)

This could come in two steps: first the definition of a simple "wired" interface to be used in early integration/testing work that can later be directly plugged into a wireless emitter (RF 802.15.4, Optical CAN….) . This will also help the development of small technology demonstrations satellites as many of them can be candidate for flying wireless to support their miniaturised payloads.

Session 3 with Round Table : Biomedics

Chair: ***Nikos Karafolas***

14:00 Optical Wireless Data Handling for Life Science and Crew Health Monitoring
Hernandez, I.[1]; Nasca, R.[1]; Lorza-Pitt, R.[1]; Peran, F.[2]; Perez, R.[3]
[1]ESTEC-ESA (Netherlands); [2]ASTRIUM-CRISA (Spain); [3]ULPGC (Spain)
This talk was not possible to be given due to unavailability of the speaker because of an air-strike. Instead Mr S. De Mey of ESA HME Directorate and System Engineer of the European Physiology Laboratory Facility of Columbus provided a talk on the possible applications of wireless technologies onboard the ISS. The highlight was the remote monitoring of EEG measurements by optical wireless means.
14:30 A Wireless Medical Informatics System Architecture (MISA) for Extended Duration Space Exploration
Gifford, K.[1]; Stanch, P.[2]; Johnson, K.[2]
[1]University of Colorado (United States); [2]NASA (United States)
15.00 Round Table: Biomedics Application

Wireless has no competitor for communicating with mobiles and hence to perform biomedical experiments or simply heath status monitoring of astronauts whilst imposing a minimum constraint on their movements is certainly a key application foreseen for wireless in manned tended vehicles as well as extra vehicular/on surface activities. The extensive use of wireless technologies used in Hospitals for remote patient monitoring (primarily ECGs) provides confidence in applying wireless also on board the ISS.

ESA plans to initiate an activity on astronauts EEG monitoring using optical wireless in order to avoid any possibility of interference with the measurements signals. A question arised on the possibility of wireless links to transmit high data rate signals of tens of Mbps in applications such as for example of a portable mini-videocamera to track the eye movement of the astronauts

Session 4: Sensing & Control II

Chair: ***Gianluca Furano***

15:45 Demonstrator for Wireless RF Intra-Satellite Communication
Feriencik, M.[1]; Wehrle, K.[1]; Hutter, A.[2]; Garcia, L.[3]
[1]Contraves Space AG (Switzerland); [2]CSEM (Switzerland); [3]ERZIA (Spain)
16:15 Modelling Bluetooth and CAN for a Wireless Spacecraft Bus
Arif, M.
University College London (United Kingdom)

Mr Arif, very unfortunately, fell ill while in his hotel in Noordwijk and so was unable to present: Modelling Bluetooth and CAN for a Wireless Spacecraft Bus.

The following questions were posed at the session end:

1) Which level of complexity can we accept in order to substitute such a “silly” thing as a connector? [Ignacio ARRUEGO]

To day it is a hard fact that the mass and volume of on board units is dictated by the number and sizes of the connectors to be accommodated rather than by the complexity of the functions integrated in electronics that is shrinking everyday. However for a certain level of technology, there might be an optimum ratio between the mass/volume/power allocated to the interfaces (that includes the connectors, wires, protocols and their related H/Wand S/W support) and those allocated to the system functions that shall be as small as possible.

2) Which approach is preferred: [Ignacio ARRUEGO]

- Adaptation of existing Space-Standards to wireless
- Adoption of existing Wireless-Standards for Space

There is some relation with the above and there is no black and white answer.
On board implementation is driven by reliability and mass/power considerations. The answer to this question will be to select the option that optimizes these constraints. Typically a 802.11 interface is relatively complex, then can only be an option to connect elements which complexity is at least one order of magnitude above it. In the same order of idea, a well known space interface like the Mil-std-1553-B can also be too bulky for interfacing miniaturised instrument like the star sensor developed by Officine Galileo under CTP where this interface was discarded because taking 50 % of the total mass of the instrument electronics and a large part of the peak power.
In this case, an optical implementation of the 1553 or CAN protocol would be much lighter. For small very simple sensors, the integration of a wireless interface might be too much and preference given to an hybrid configuration where small local cluster of sensors are locally connected to a wireless micro-RTU acting as a concentrator….

3) What is the degree of reliability (level of qualification) of commercial chip-sets related to the different RF standards (ground-based) [Ignacio ARRUEGO]

A priori none although some activity in this area might be performed next year from ESA side.

4) Interest about Wireless must be motivated from the Space Agencies side or from the Space Companies? Who must be the pusher? [Héctor GUERRERO]

Difficult answer: implementation of on board systems has always been a compromise between technologists that know the capabilities of the technology and the system guys that know the system but has only vague idea of the technology state of the art capabilities.

5) Can we find any synergy with other industries (Automotive, Aeronautics, Domotics? [Héctor GUERRERO]

Probably yes, that should be for wireless and power harvesting. Automotive and Aeronautics are already investing into wireless.

Poster Session

17:00 Poster Presentations
Transponder ASIC for Inductively Coupled Sensor Nodes
Fogarty, P.; Tuthill, J.
University of Limerick, Ireland
Simulation Tool for Wireless Optical Links in Intra-Satellite Communications
Rico Escalante, J.; Del Castillo Vazquez, M.
University of Malaga, Spain
Compact Recording Device for Aerospace Equipment with Bluetooth Communications
Garcia-de-Quiros, F1; Carrasco, J.A.1; Van der Heide, E.2; Kruijff, M.2
1Emxys (Embedded Instruments and Systems), SPAIN; 2Delta Utec, Netherlands
Wearable Biomedical Monitoring Device for Manned Habitats using Bluetooth Wireless Network
Garcia-de-Quiros, F.1; Carrasco, J.A.1; Guarnieri, V.2
1Emxys (Embedded Instruments and Systems), SPAIN; 2Alcatel Alenia Space Italia S.p.A., Italy
Single-Channel Optical Receivers for Intra-Satellite Wireless Data Communications
del Castillo, M.; Puerta, A.; Gallego-Roji, A.
University of Málaga, Spain

Session 5 and Round Table : Self Powering Techniques

Chairman: *John Saiz NASA/Johnson Space Center*

09:00 "How the Intra-Satellite Wireless System could be Self-Powered?"
Pelissou, P.; Carron, C.
EADS Astrium (France) .
09:30 Power Scavenging Techniques for Miniaturized Sensors
Nguyen, J.[1]; John Saiz, R.[2]
[1]Jacobs Engineering (United States); [2]NASA/Johnson Space Center (United States
10:00 Self-powering Techniques for Wireless Intra Satellite Communication
Rouault, H. CEA - Grenoble (France)
10:30 Round Table: Self Powering Techniques

The first presentations provided interesting informations on self-powering making use of small batteries showing that a proper selection of the duty cycle and ad-hoc power management strategy, small sensors could be powered up to several years if necessary.
The second presentations provide very interesting information and results on energy scavenging techniques studies performed at NASA with in particular utilization of solar thermal power generation that was able to power a Geophysical experiment

package and emphasize the potential of thermo-electrical generation that has the interesting property to use any heat source, eventually parasitic to produce power whilst helping the temperature control. The third presentation of CEA did provide a very extensive and detailed description of the currently available or under development methods for energy scavenging(also called energy harvesting in the paper considering thermal, irradiative and mechanical sources) and self powering (energy storage from rechargeable lithium batteries to power sources and including supercapacitors and miniaturized fuel cells. From this description, thermo electrical generation is also identified of interest for the short term whilst many of the other options may need a bit more time to mature.

For smalls sensors and for mobile devices, there is no interest to remove the data wires if the power supply is providing via a power cable.
Today, the miniaturization process allows to reduce significantly the size of the electronics. So today, for small sensors, the volume is mainly linked to the size of the power source : it takes close to 50% of the total volume.
In conclusion : we can not obtain miniaturized sensors without improvement/development on self powering and energy scavenging techniques.

From this set of presentations, it is clear that markets like portable systems, wireless, automotive, micro-nano technologies and MEMS are the very strong drivers that feed the development of self powering and energy scavenging techniques. It means that we will have to think in terms of technology transfer (spin-in) where it will be up to us to perform the effort for evaluating, selecting, transferring and qualifying a subset of those techniques. This clear synergy between those techniques, MEMS and wireless should be reflected in our respective R&D developments and eventual inter-agencies collaboration.

Session 6 and Round Table: Data on Powerline

Chairman: ***Jean Didier Gayrard AlcatelAleniaSpace/Toulouse***

11:15 Information & Power Network in Spacecrafts
Gotsmann, M.
EADS Astrium - ASG5 (France)
11:45 Power Line Communications: Application to Space
Oria, C.; Torralba, A.; Baena, V.; Granado, J.; Chávez, J.
AICIA-School of Engineering, University of Sevilla (Spain)
12:15 Round Table: Data on Powerline for Space

A session of the workshop had been reserved for the possibility of transferring data on power lines as it is done on ground on board the S/C. Its introduction in a wireless oriented workshop may have surprised some people however the most successful implementations of data on power lines make use of wireless like techniques (spread spectrum, carrier supported) as already presented in a paper of Alcatel Alenia Space at Dasia 2003, pilot activity sponsored by ESA.
Potential interest is to suppress data links and use the power cables for supporting the transfer of the corresponding data. The first presentation from EADS-Astrium describes an approach (IPONS) where all data communications (except direct high priority commands) are performed using the power lines as carrier and corresponds to

a star architecture centered on the PCDU. The second presentation from University of Sevilla had provided many references to the ground standards for communications on power lines and then describe their proposed approach (project CELPAE).

The discussion highlighted some of the concerns about the merging of a typical data handling function with a power distribution function, two critical functions within a S/C. The issue was already risen two years ago by AAS and compromised in mentioning that such optimization shall probably more easily achievable for Telecom platform where the prime has a very strong control on all the S/C interfaces, that might not be the case for institutional satellites. However the two presented activities are still at an early stage and start from different assumptions and need to mature. Then the question was risen to position the data on power versus the pure wireless and the consensus was to consider that they were more complementary than alternatives as wireless future is probably more on the sensor networking using eventual power harvesting and MOTES rather than on the replacement of the main power/data links. A second question was if standardization is the next step to follow. The consensus was it was premature. Some home work and proof of concepts have to be performed first and only in case of positive outcome, first step towards standardization could be done that shall involve the primes and equipment suppliers.

Session 7 and Round Table: Wireless Standardization

Chairman: ***Adrian Hook NASA/JPL***

14:00 Wireless Communications and Interfaces On Board S/C
Plancke, P.[1]; Saiz, J.[2]; Hernandez-Velasco, I.[1]; Gifford, K.[3]; Carron, C.[4]
[1]European Space Agency (Netherlands); [2]Johnson Space Centre, NASA (United States); [3]University of Colorado (United States); [4]EADS-Astrium (France)
14:30 Architectural Design Implications to Support Wireless QoS for Spacecraft Applications
Gifford, K.; Kuzminsky, S.; Williams, S.
University of Colorado (United States)
15:00 The Need for Single Chip RF Interfaces and Standards
Leijtens, J.A.P.
TNO (Netherlands)

- The first presentation was co-presented by ESA and NASA on the collaborative work initialized as part of the SOIS area to harmonize under the CCSDS umbrellas further development of wireless standards to ensure that from the beginning interoperability, cross support and the definition of a set of compatible interfaces will be defined that can support further collaboration notably in the frame of the man in space and exploration missions. The focus is put on the definition of a set of services supported by of class of proximity networks able to support a wide range of applications from on board short/medium distance ranked by level of criticalities from sensing networking up to command and control, the decision being to start by the definition of the sensing network services as the best and softer way of introducing the wireless technologies is space systems. They should be considered as single sub-network as per the definition of SOIS whilst the end

to end issues shall be covered by the CCSDS/SIS and off board communications by CCSDS/SLS. However architectures based on SOIS or equivalent like the middleware approach described by K Gifford manage easily communications from heterogeneous sub-networks (inter and/or intra).

- The second session was describing an approach for isolating the applications from the physical/data links specificity by a middleware approach that looks very closed in its spirit of the CCSDS SOIS and a point it can be seen as a specific implementation of it if we forget about the very specific data management services provided by SOIS.

The chairman introduced to the participants the CCSDS current organization …

Session 8*:* Wireless Technologies

Chairman: *Francisco Tortosa ESA/ESTEC*

16:15 Photonic Technologies for OWLS (Optical Wireless Links for Intra-Satellite Communications)
Guerrero, H.; Jiménez, J.J.; Tamayo, R.; Sánchez-Páramo, J.; Gallego, P.; Ragel, E.; Álvarez, M.T.
Instituto Nacional de Técnica Aeroespacial, INTA (Spain)
16:45 802.15.4b Implementation/Integration Challenges and Trade-offs
Lyons, R.
Duolog Technologies (Ireland)
17:15 802.15.4b Program & Deliveries Overview
McFadden, W.
Duolog Technologies (Ireland)
17.45 Wi-Fi (IEEE 802.11a) as Baseline Wireless Communication Protocol for the RF Link between the Eurobot and the ISS Station
Cassisa, G.; Battistoni, G.; Lanza, P.
Alenia Spazio (Italy)

The session touched several aspects of most up-to-date wireless technologies and their applications to Space. The first presentation provided a view on the availability of components and the many tests that are being performed by INTA in order to select and qualify the most suitable ones for Space Optical Wireless. New concepts in OWLS technology were also introduced. The two presentations from Duolog introduced the technical and management status of the current development of 802.15.4b (including MAC and Network layers) that is being done in collaboration with ESA. The implementation of this very promising technology (low-size, low-power) for space applications implies some challenges in order to define the optimum hardware/software partitioning, and to adjust it to the real needs. Finally, the presentation from Alenia gave an insight of the study they performed in order to select the most suitable wireless technology for RF link needed between the Eurobot and the

ISS. A deep study and simulations were performed, and a trade-off of the wireless commercial technologies existing at the date of the study. The technology selected as baseline was IEEE 802.11a.

Session 9: Formation Flying

Chairman: ***Guillermo Ortega ESA/ESTEC***

09:00 Wireless Sensor Motes for Small Satellite Applications
Lappas, V.[1]; Prassinos, G.[1]; Smit, G.[2]; Baker, A.[2]
[1]Surrey Space Center (United Kingdom); [2]Surrey Satellite Technology Ltd. (United Kingdom)
09:30 Wireless Communications for Satellite Formation Flying
Gayrard, J.-D.; Baudoin, C.; Miquel, C.
Alcatel Alenia Space France, (France)
10.00 IEEE 802.11 Optimisation Techniques for Inter-Satellite Links in LEO Networks
Sidibeh, K.; Vladimirova T.
Surrey Space Centre (United Kingdom)

The session related to formation flying issues in wireless data handling. The first paper exposed in details how many communication protocols are there in the market now to achieve effective communication. The emphasis was on the newly Motes concept to make fast and cheap equipment. The second presentation targeted in depth the relationship between exchange of navigation data and the exchange of housekeeping data. A much heated discussion was started at the end of the paper when it was debated where or not both types of data could be handled at the same time using the same equipment. Finally, the third presentation focused on much details of new techniques using existing extended WiFi protocols for formation flying.

Session 10: Exploration

Chairman*: **Peter Holster ESA/ESTEC***

10:30 Planetary Exploration in Action: Advanced Wireless Technologies in Actual Human Exploration
Braham, S.; Anderson, P.; Lee, P.; Pires, C.
PolyLAB, Simon Fraser University (Canada)
Mr Braham was unfortunately unable to complete the VodCast (video / audio broadcast) in time for the workshop, given that he is currently on-site at the Haughton-Mars Analogue Project on Devon Island in the artic. If Steve is able to complete the video and audio recording, we may yet include it in the WS proceedings.
11:00 ESA Manned Mission Navigation and Data Requirements for Planetary Surface Exploration: Wireless Standards Utilisation and Frequency Coordination
Perello, J.V.; Holsters, P.
ESA-ESTEC (Netherlands)

11:30 Group Discussion Topic: Wireless as a Disruptive Technology: Implications for Applying Wireless in Space Programmes (see Annex)
Magness, R.
ESA ESTEC, Netherlands

The session was aimed at the use of wireless technologies in the frame of robotic and human exploration. The first paper was not presented. The second paper presented preliminary requirements in terms of navigation accuracy and data-rate for manned but also non-manned missions, mainly in the frame of exploration of the Moon and Mars. Possible scenarios were presented and also a short discussion on the frequency selection was included.

Rodger Magness explained the term Disruptive Technology and presented wireless technologies as a possible example. Comment from the audience that currently there have not been many flight opportunities for wireless when taking the definition of wireless provided for the workshop e.g. that relates to networking.
Comment from audience that rapid evolution of terrestrial wireless technologies does not really comply with long development phase typical in space. This is true but not specific to wireless and this is typical of any "COTS" based approach, as for example the design and manufacturing of on board mass memories. One possible solution is to privilege the selection of standards in domains where it is known that system maintenance will last for a long period of times as it can be the case for industrial control, military, automotive and aeronautics as opposed to the multi medias applications. Although it is important to remind that the introduction of standards as the CCSDS SOIS that isolate the applications from the data-link physical layers allow to keep a stability at system level but still allowing an evolution or a change of technology at the data link/physical layers. An other solution will be to "freeze" a subset of the technologies within few years when the operational flight opportunities are expected to emerge. Anyway it is certain that the wireless technologies that will fly in on board systems in 10 years will not be the latest available on the market taking into account our unavoidable constraints of development and qualification. but it should be considered as a fact of life.

Conclusion
Patrick Plancke / Workshop Chairman

The Workshop has achieved his objectives thanks to the high level of interactions and participation in the discussions and round tables and obviously even outside the conference rooms. If we compare to the situation three years ago where the first workshop had been organized, it is clear that there is to day a real community that takes shape and concepts are maturing. Applications have been presented ranging from nanosats (flying or under design/development) flight demonstrations up to planetary surface communications and navigation passing by the applications already flight proven on board the shuttle and the space station.
We try to resume in few bullets;

- Wireless and miniaturisation: there is a clear link to day established between the use of wireless technologies and the development of micro-systems and small platforms (for intra and inter (formation flying) communications)

- Mobility under different forms appeal for wireless: it is obviously the case of man tended operations (space station, extra-vehicular/on surface activities) but also separable composite elements, flexible/movable structures, robotics, AIT
- Reference to AIT have been made several times and it seems that there is a great potential for those techniques in this area plus a possible introductory step for wireless on board
- Huge interest on the sensors networking or Motes
- Introduction of wireless into space system to consider first the monitoring/housekeeping functions(sensor network) rather than command and control unless in specific cases
- Wireless addresses a wide range of applications from intra to inter communications however architectures as based on CCSDS SOIS or equivalent on middleware approach described by K Gifford manage easily communications from heterogeneous sub-networks
- Standardization is important and more than welcome as long as it does not lead to over-specifications. The target shall be to re-use as much as we can from the available/near to come IEEE standards without modifications. Eventually if additional QOS are required for our applications, they can be built at application level or better using standard services “a la SOIS”
- It is well acknowledged that use of “COTS” standards does not mean use of COTS due our space constraints at least for the flight segment whilst it provides the advantage of reusing many already existing and relatively cheap tools for the design and development. In any cases, we cannot skip the development and qualification effort when addressing commercial and institutional applications (science, telecom….) for what concerns the space segment equipment and components
- CCSDS shall be used to harmonise the future standardisation of wireless between the agencies at least on a basic subset of available standards and crossing the boundaries of several application domains
- Cooperation between Agencies have been called out for topics like standardization but also on issues such as self powering and energy scavenging, biomedical support, exploration.

Annex

The provocation for the discussion:
Contemporary commercially-derived Wireless is considered by many to be a classic "Disruptive Technology" in the academic meaning of the term. The current new generation of various networked and often spread-spectrum RF wireless will likely be considered merely the infancy stages of the continuing development, growth, refinement and increasing specificity of these technologies. We may well recall in 25 years time that, "...in the beginning, there was Bluetooth and WirelessLAN!" Given the recent TEC-EDD survey of new and ongoing space R&D and mission-targeted projects involving various species of wireless, and the increasing interest in them (or at least a persistent curiosity), what is the likelihood of a negative effect with a diversity of wireless solutions or ad hoc adaptations? Or is this a natural and healthy beginning phase for wireless applied to space problems? Are international standards always enabling or perhaps sometimes limiting for space applications? When and how should standards be imposed in the life cycle of new technologies? What is a disruptive technology? How to characterise disruptive technologies? Why and how is "wireless" a disruptive technology? How so for space applications? And, what are the implications? These and other questions will be explored.

A brief discussion followed. There was somewhat of a lack of preparation to fully discuss this issue in the sense that was intended, as only a very few participants delved into the origin and less pedestrian meaning of the term “disruptive technology”. However, there were insightful comments from a number of participants illuminating: the risk of too narrow a view of these wireless technologies, e.g. limiting the vision to intra-spacecraft only; the difficulty of selecting and capturing the appropriate wireless technologies for “spin-in” for space applications, considering the swift progress, and rapidly growing number of COTS standards in this area (56 total currently, optical and RF combined) of the commercial wireless markets. It was also noted that perhaps the ideal standard, i.e. PHY layer and Media Access Layer (IEEE and others) plus High Level Protocols for intra-spacecraft data handling, have not yet been developed. Particular attention was drawn, by the discussion leader, to the tendency of people everywhere, in a diverse array of business, engineers, technology developers, new product developers, and unexpected and even obscure market segments, to attempt to apply these new wireless technologies in situations where they were never intended or originally envisioned to be utilised. Typically these commercial (IEEE) PHY-MAC are designed for only 2 or 3 channel models, typically: (a) outdoor, free range (b) indoor, home-office. Ultimately, their usage in some extreme applications and environments will not be successful. On the other hand, however, it is remarkable in how many use cases for which they were not designed, they are successful. Clearly, we as the space segment should choose carefully.