# SECTOR CONSORTIA HANDBOOK

CANEUS 2009

## CANEUS 2009 WORKSHOPS

International Collaborative Aerospace Development
Micro Nanotechnologies: From Concepts to Systems

**March 1-6, 2009**
**NASA Ames Research Center**
**Moffett Field, California**

**www.caneus2009.org**

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# 1.0 Preface

**Objective of the CANEUS 2009 Workshop Sessions**

We have restructured the CANEUS 2009 Workshops Program to focus on the projects being developed in each of the Sector Consortia. We would like to see that we have well-defined projects, roadmaps, goals, and mission statements, come out of these activities. Therefore, we would like to review with the Sector Consortia leaders the sections of the program that are particularly relevant to them. These are highlighted in the Executive Summary below. The below information is all accessible in the CANEUS 2009 Program.

**EXECUTIVE SUMMARY**

The goal of the CANEUS 2009 Workshops is to significantly advance each of the CANEUS Sector Consortia by creating their roadmaps and articulating well-defined MNT infusion projects for the aerospace industry. In order to accomplish these ambitious goals, the 2009 program has been structured in four parts:

**Case for CANEUS Sector Consortia:** The first half-day of the Workshops will provide participants with the raison d'être of CANEUS International and its Sector Consortia, as well as the CANEUS approach to implementing its goals.

**Panel Sessions:** The goal of the subsequent 21 Panel Sessions and the talks from world-class experts is to update partici¬pants on the needs and lessons learned of the aerospace (aeronautics, space and Defence) industries, the state-of-the-art in Micro and Nano-technologies, and current challenges related to investments and international collaboration.

**Poster sessions:** Poster sessions featuring presentations from world experts complement the topics covered in the panel sessions.

**Sector Consortia Development and Deliverables:** Topics covered in the panel sessions will feed into the third part of these workshops: participants will apply the knowledge acquired during the panels towards formulating and implementing Sector Consortia roadmaps and projects. Finally, as a measure of success of the event, each Sector Consortium will present the findings and outcome from the previous five days of workshops.

The "Case for CANEUS Sector Consortia" is a block of four sessions that will occur on the Monday morning: (1) Mission, Vision & Goals, (2) Aerospace Technology Gap: The Case for Sector Consortia, (3) Implementation Approach and Success Criteria, and (4) Programmatic Issues for the Sector Consortia.

For those participants who may be unaware of the CANEUS framework and the raison d'être of the CANEUS Sector Consortia, this acts as a preliminary introduction to the days to come during the Workshops. Additionally, these sessions will help participants particularly in the Workshop sessions

to understand the success criteria that CANEUS can use to gauge project completion and milestone achievements, and the avenues to be pursued to overcome challenges such as intellectual property, funding, and government regulations (such as ITAR).

A more detailed description of these four sessions follows:

**CASE FOR THE CANEUS SECTOR CONSORTIA**
**Monday March 2, 2009**

**CANEUS: Mission, Vision & Goals:** This plenary session outlines the mission, vision, and goals of CANEUS International, as well as the inno¬vation framework and the methodology of CANEUS' current projects. The details of CANEUS membership and the process for applications will be described.

**Aerospace Technology Gap:** Case for Sector Consortia This plenary session makes a case for the "Valley of Death." This session will also cover the process for launching Sector Consortia and projects within the CANEUS organization structure.

**Implementation Approach and Success Criteria:** This plenary session will outline the approach of Sector Consortia to implement their roadmaps, covering the needs and technology assessment, roadmap and business development, technology transition plan, and success metrics.

**Programmatic Issues for the Sector Consortia:** This plenary session will address the key challenges faced by all Sector Consortia in working on collabora¬tive high-risk, high-cost projects. Issues to be addressed include intellectual property, non-disclosure agreements, funding, and government regulations.

**MONDAY, MARCH 2, TUESDAY, MARCH 3, AND THURSDAY, MARCH 5** (Panel Session 1 to 21)

The presentations of the Panel Sessions on March 2, 3, and 5 are intended to provide input to the Sector Consortia Development sessions. We are providing speakers a list of questions to address in their respective presentation. In order to obtain maximum output from these sessions to be relevant to the Sector Consortia, please provide any and all questions that you would like answered for any of the Panel Sessions 1 to 21 to the session Chairs.

**WEDNESDAY, MARCH 4 TO FRIDAY, MARCH 6**

The Sector Consortia Development and Deliverables Sessions are the heart of this event. We have endeavoured to create a program that optimizes the use of our time to produce measurable deliverables to advance the goals and activities of each of the Sector Consortia.

To update participants on the Sector Consortia activities, we have blocked off a plenary session for introductions of each of the Sector Consortia, to be led by the Sector Consortia leaders. This is followed by concurrent split sessions to establish the mission, goals, and roadmap, and project development of each of the Sector Consortia. Materials and Devices are concurrent; Small Satellites and Fly-by-Wireless are concurrent; and Reliability and SHM are concurrent. It is our hope that we will be able to

include the participation of those who are interested in more than one area, and include the participation of a wide range of expertise.

There will be a collection of panel members (numbers vary according to the Sector Consortium) to assist participants in these activities.

Returning to the program; one session is insufficient to establish an actionable roadmap and well-defined projects, so we have allocated time for additional review on Friday morning, March 6. Here participants may delve further into these activities to include tasks, responsibilities, timelines, teaming, budget, and success evaluation metrics.

Lastly, to demonstrate the deliverables of these Workshops, we have included a plenary report session for each Sector Consortium (SHM will be included in the Fly-by-Wireless Report). A nominee or participant can present on the activities of the preceding 2 days. We conclude of course with a plenary session called “Workshops Conclusion.”

**SECTOR CONSORTIA DEVELOPMENT AND DELIVERABLES SESSIONS – Wednesday March 4, 2009 to Friday, March 6, 2009**

**Sector Consortia Workshops Tutorial and Sector Consortia Leaders Panel**
This plenary session aims to guide workshop participants in understanding the CANEUS process for formulating missions, goals, roadmaps, and projects for the Sector Consortia, as well as the ROI and the business justifica¬tion for each project. In this session, Sector Consortia leaders will give a brief overview of the current status of their consortium.

**Sector Consortia: Mission, Goals, and Roadmap**
The goal of these breakout sessions is to create and formalize the Roadmap of each of the Sector Consortia. The roadmaps will include each Sector Consortium’s goals and missions, in addition to its scope of work and the vision of both its short- and long-term activities. An overview of each Consortium’s past activities and achieve¬ments will precede discussion.

**Sector Consortia: Project Development and Framework**
The goal of these breakout sessions is to define projects and project concepts. A general project plan coherent with the roadmap outlined in the previous session will be drafted (6 months, 1 year, 2 years). Participants will address business development issues, such as NDA, IP, and government regulations.

**Sector Consortia: Roadmap Refinement**
These breakout sessions aim to refine the Roadmaps previously laid out. Participants in each Sector Consortium will specify tasks and assign responsibilities with timelines to execute the Roadmap.

**Sector Consortia: Project Refinement**
These breakout sessions aim to refine the well-defined projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones

from which to gauge success of the project.

**Sector Consortia Reports**
These plenary sessions aim to summarize the output of each of the Sector Consortia workshop sessions. In these sessions, workshop participants have the opportunity to learn about the activities and roadmaps of other Sector Consortia.

**Workshops Conclusion**
This plenary session will summarize the output of the CANEUS 2009 Workshops.

RESOURCES OF SECTOR CONSORTIA PANELISTS AND PARTICIPANTS

The additional planning period that the postponement has afforded gave us some time to reflect on the role of Sector Consortia leaders. We would like to see at the CANEUS 2009 Workshops that you have the maximum amount of resources to take advantage of the gathering of participants, so for the CANEUS 2009 Workshops we propose a different approach.

For the CANEUS 2009 workshop participants, we have prepared a Sector Consortia handbook, including

- The Mission and Vision statements of the Consortium and each of its initiatives
- The Goals of the Consortium
- The past activities of the Consortium
- The upcoming activities of the Consortium
- The project definitions of each of the initiatives
- The Roadmaps of each of the Consortia.

Some of these bullet points may or may not be relevant to each Consortium, depending on its growth stage. There are many additional documents instead that may be relevant to specific activities.

Please note:
**Throughout the week's activities, you will be given extra documents and notes to add to this manual in order to supply you with the tools needed to participate in all the planning processes. Please make a special effort to keep your guide up-to-date by adding documents and presentation notes when instructed by Sector Consortium Chairmen and Workshop Organizers. Doing so will enable you to maximize the benefits from this workshop.**

**By Friday March 6th this document will be complete and an accessible, take-home guide for the entire workshop.**

# 2.0 Workshop Schedule



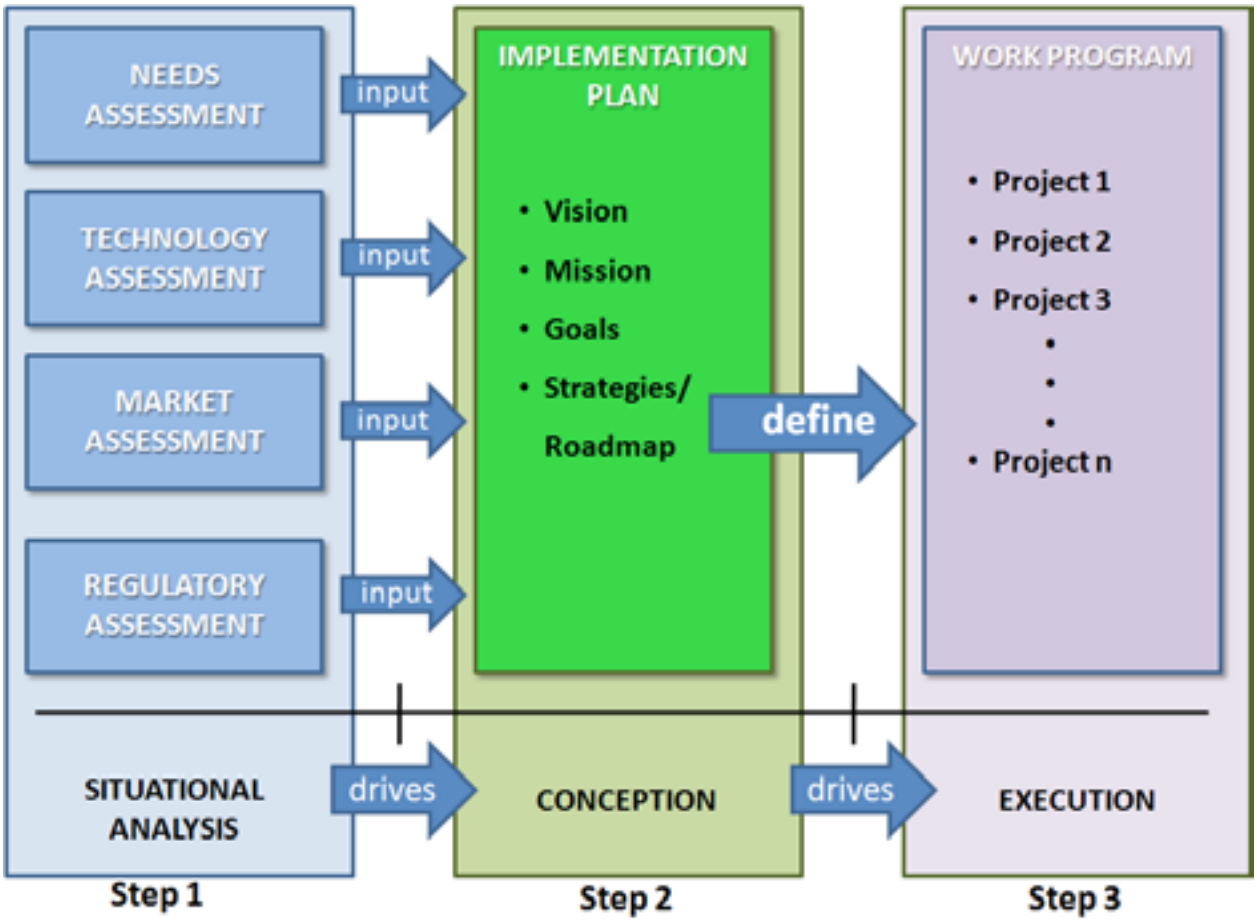
| | Sunday<br>March 1 | | | Monday<br>March 2 - Aerospace Needs and Lessons Learned | | Tuesday<br>March 3 - Aerospace Technology Assessment | |
|---|---|---|---|---|---|---|---|
| | | | | Workshop Implementation Approach | | State-of-the-art in Low TRL | |
| 0800-0830 | Registration Opens | | 0800-0830 | Welcome<br>Opening Remarks<br>Plenary Address<br>*S. Pete Worden - NASA Ames* | | Daily Overview | |
| 0830-0845 | Golf Tournament + Short Course Registration | Short Course Introduction | 0830-0900 | | | Keynote Address<br>*Howard Alper - Science, Technology and Innovation Council, Government of Canada* | |
| 0845-1015 | | **Short Course 1:**<br>From Concept to Commercialization<br>*Elias Carayannis* | 0900-1015 | CANEUS Mission, Vision, and Goals<br>Aerospace Technology Gap: Case for Sector Consortia<br>Implementation Approach and Success Criteria | | **Panel 9:**<br>Low TRL Materials (Bottom-up) | **Panel 10:**<br>Low TRL Devices (Sensors and Instrumentation) |
| 1015-1045 | | Coffee Break | 1015-1045 | Coffee Break | | Coffee Break | |
| 1045-1225 | | **Short Course 2:**<br>Standards and Metrology for Micro and Nanotechnology<br>*Jon Pratt* | 1045-1200 | **Panel 1:**<br>Unmanned Space Needs | **Panel 2:**<br>Aeronautics Needs | **Panel 11:**<br>Low TRL Materials (Top-Down) | **Panel 12:**<br>Low TRL Devices (Optoelectronics) |
| | | | | Aerospace Needs Assessment and Lessons Learned from Technology Infusion | | State-of-the-art in Mid/High TRL | |
| | Lunch | | 1200-1330 | Working Lunch<br>Topic: IP/Funding/ITAR issues for the Sector Consortia<br>*John Miller - US Army* | | Technical Tours | |
| 1330-1400 | Golf Tournament | Brief Overview of Tuesday's Short Course 3:<br>Small Satellites: Past, Present, and Future<br>*Henry Helvajian* | 1330-1445 | **Panel 3:**<br>Manned Space Needs | **Panel 4:**<br>Defence Needs | Technical Tours (cont'd) | **Short Course 3:**<br>Small Satellites: Past, Present, and Future (Related to Micro, Nano and Pico Satellites)<br>*Henry Helvajian and Siegfried W Janson* |
| 1400-1530 | | **Short Course 4:**<br>ITAR-Inter-Governmental Agreements, Flight Opportunities, Standards, Export policy restrictions, Environmental, Safety.<br>*George Grammas* | 1445-1600 | **Panel 5:**<br>Lessons Learned from Space | **Panel 6:**<br>Lessons Learned from Aeronautics | **Panel 13:**<br>Mid TRL Materials | **Panel 14:**<br>Mid TRL Sub-Systems |
| 1530-1600 | | Coffee Break | 1600-1630 | Coffee Break | | Coffee Break | |
| 1600-1730 | | **Short Course 5:**<br>Funding<br>*David Oppenheimer* | 1630-1745 | **Panel 7:**<br>Reliability Packaging | **Panel 8:**<br>Lessons Learcned from Defence | **Panel 15:** High TRL Materials | **Panel 16:**<br>High TRL Systems |
| | | Short Course Conclusion | 1745-1800 | Poster Session | | Poster Session | |
| | Reception | | 1800-1930 | Reception | | Reception | |

| | Wednesday<br>**March 4 - Sector Consortia Development** | Thursday<br>**March 5 - Programmatic Investment and International Collaboration** | Friday<br>**March 6 - Sector Consortia Deliverables** |
|---|---|---|---|
| | Sector Consortia Tutorial | Sector Consortia Roadmap and Projects cont'd | Roadmap and Project Refinement |
| 0800-0830 | Daily Overview | Daily Overview | Daily Overview |
| 0830-0900 | Keynote Address<br>*Minoo Dastoor - NASA and NNI*<br>*Reinhard Schulte-Braucks - European Commission* | Keynote Address<br>*Michel Courtois - ESTEC* | Keynote Address<br>*General John Sheridan - US Air Force* |
| 0900-1015 | Sector Consortia Tutorial and Sector Consortia Leaders Panel | Reliability:<br>Mission, Goals, and Roadmap | Roadmap Refinement:<br>Tasks, Responsibilities, and Timeline<br>Devices · Materials · Small Satellite · Reliability · Fly-by-Wireless |
| 1015-1045 | Coffee Break | Coffee Break | Coffee Break |
| 1045-1200 | Small Satellite:<br>Mission, Goals, and Roadmap<br>Devices:<br>Mission, Goals, and Roadmap | Reliability:<br>Project Development and Framework<br>Devices · Materials · Small Satellite · Reliability · Fly-by-Wireless | Project Refinement:<br>Teaming, Budget, and Success Evaluation<br>Devices · Materials · Small Satellite · Reliability · Fly-by-Wireless |
| | Sector Consortia Roadmap and Projects | Programmatic Investments and International Collaboration | Sector Consortia Reports |
| 1200-1330 | Lunch + Keynote Address<br>*Doug Comstock - NASA IPP* | Lunch + Keynote Address<br>*Gwynne Shotwell - SpaceX* | Sector Consortia Summary Presentation |
| 1330-1445 | Small Satellite:<br>Project Development and Framework<br>Standards · Launch · Stakeholder · Export Control<br>Devices:<br>Project Development and Framework<br>HE Sensors · Photonics · Bio-Astra · Envi. Monitoring | Panel 17:<br>Low-High TRL Governmental Investment<br>Panel 18:<br>Low TRL International Collaboration | Devices Report<br>Materials Report<br>Fly-by-Wireless Report<br>Small Satellite Report |
| 1445-1600 | Fly-by-Wireless:<br>Mission, Goals, and Roadmap<br>Materials:<br>Mission, Goals, and Roadmap | Panel 19:<br>Low-High TRL Private Investment<br>Panel 20:<br>Mid/High TRL International Collaboration | |
| 1600-1630 | Coffee Break | Coffee Break | Coffee Break |
| 1630-1745 | Fly-by-Wireless:<br>Project Development and Framework<br>Less-Wire Technology · SVHM · Sensor-DAQ · Passive Sensor<br>Materials:<br>Project Development and Framework<br>Micro-Energetics | Panel 21:<br>CEO/CTO Panel | Reliability Report<br>Workshops Conclusion |
| 1745-1800 | Poster Session | | |
| 1800-1930 | Banquet and Competition Awards and Presentations | | |

# 3.0 Workshop Process

Along with the implementation of the new CANEUS 2.0 innovation model comes a new planning process that drives the definition of a work program plan comprised of member prescribed MNT projects. As figure 1 illustrates, we will be using a very simple planning process consisting of 3 steps: **Step 1** - situational analysis; **Step 2** – conception; and **Step 3** – execution. The workshop sessions are laid out to support this process. In this process, the **SITUATIONAL ANALYSIS** activities in **Step 1** provide the input needed for the **CONCEPTION** activities in **Step 2** and subsequently, the "Implementation Plan/Roadmap" documents from **Step 2** provide the definition and input for the **EXECUTION** activities in **Step 3**. The culmination of **Step 3** is a "Work Program" document that lists and describes vetted MNT Projects that are phased in over a three to five year period.

Figure 1 Diagram of New Planning Process




On **Monday** of the workshop, the panels and presentations support the "needs assessment" as required for **Step 1**. Notes will be taken to capture the salient points and will be distributed in hard copy form to each workshop participant at the "Mission, Goals and Roadmap" sessions on Wednesday and Thursday. This will be done so that the participants have the input they need for the development of the "Implementation Plan/Roadmap" document.

On **Tuesday** of the workshop, the panels and presentations support the "technology assessment" as

required for **Step 1**. Notes will be taken to capture the salient points and will be distributed in hard copy form to each workshop participant at the "Mission, Goals and Roadmap" sessions on Wednesday and Thursday. This will be done so that the participants have the input they need for the development of the "Implementation Plan/Roadmap" document.

Starting on **Wednesday**, each Sector Consortia has two sessions:

1. "Mission Goals & Roadmap", session where the "Implementation Plan/Roadmap" document is developed (Step 2 – Conception)and;
2. "Project Development and Framework" session where a "Work Program" document is developed that lists and describes vetted MNT Projects which are the realization of the "Implementation Plan/Roadmap" (Step 3 – Execution).

Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. End-users of the aircraft, spacecraft, and defense industries join technology developers from Europe, Canada, USA, Brazil, and other countries to pool their resources and define collaborative Projects and select Project Teams.

Assistance will be provided to take notes and facilitators will be available in each session to assist the participants with the development of the documents and formulation of the strategies and roadmaps.

On **Thursday**, the morning sessions are organized in the same manner as the Wednesday sessions. In the afternoon, the session deal with market/business needs, regulatory compliance and funding issues associated with the Aerospace community. The information presented and comments captured in these sessions will further support the activities of Step 1 - Situational Analysis.

On **Friday**, the opportunity for participants to further refine the roadmaps (part of Step 2 – Conception) and further refine project definitions (part of Step 3 – Execution) is provided. Also, each Sector Consortium is responsible for summarizing the previous week's activities including the actions taken to create or refine the Implementation Plan/Roadmap document; the project planning activity; the action steps for subsequent project development efforts.

# 3.1 Session Objectives

- **Mission, Goals & Roadmap objective**: The goal is for participants to create and/or formalize the vision, mission, goals, and strategies/roadmap for their CANEUS Sector Consortium for the next three to five years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities (conferences and workshops) and achievements.

- **Roadmap Refinement objective**: Participants in this session will specify tasks and assign responsibilities with timelines to execute the Roadmap.

- **Project Development & Framework objective**: Two to three invited participants will present a project currently being undertaken within their organization. A general project plan coherent with the Roadmap outlined in the previous Roadmap Session will be drafted. Participants will address business development issues, such as NDA, IP, and government regulations.

- **Project Refinement objective**: Participants will refine the projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the project.

**For a further and more detailed set of Consortium-specific guidelines please refer to Consortium Session Guidelines at the beginning of each section.**

# 4.0 CANEUS Projects

## 4.1 Scope

CANEUS' primary mission is to rapidly and cost-effectively bridge the mid-TRL "Valley of Death" for transitioning emerging micro-nano technologies to aerospace systems, thereby enabling next generation missions with advanced capabilities. Since the nature of these transitioning projects varies on a project-by-project basis, CANEUS has put in place an extremely "lean" and flexible core organization that relies primarily on its membership to create the collaborative virtual organizations necessary for the advocacy and ultimately the manufacture and demonstration of specific MNT-based systems for aerospace end users. CANEUS adds value by bringing together its global network of professionals with complementary skill-sets, from the low TRL researchers to the mid-TRL system developers and the high-TRL system testing, integration and reliability assurance personnel. As the premier advocacy organization for aerospace MNT system development, CANEUS has gained the trust of both private and government sponsors as a reliable, due-diligence body for vetting and "packaging" system development projects to minimize the investment risks by these sponsors.

Potential MNT system development projects are proposed, defined, and peer-reviewed by the members of CANEUS for completeness and soundness, prior to submission to potential sponsors for funding. CANEUS provides its many Conferences and Workshops as the forums for members to network and discuss these projects, and to form the teams that will be responsible for the generating the system-level end products. The most compelling reason to become a member of CANEUS is to have the many opportunities to collaborate across organizations, and, if necessary, across international boundaries, on these high-risk, high-cost MNT system development projects that are beyond the resources of any single member. In essence, effective risk mitigation can be achieved under the auspices of CANEUS for the generation of new intellectual property. The primary cause for the failure of a great majority of MNT development projects in their inability to make the transition to system level, is because these projects have been largely developed in response to the inventors' vision, i.e. a "technology push" approach, and therefore stand the great risk of wrongly predicting customer demand. CANEUS overcomes this key transitioning challenge by first determining if a sustainable customer base exists for the proposed MNT system, in other words, CANEUS uses a "technology pull" approach instead to evaluate the economic viability of a specific project prior to embarking on the development effort. The system need could either be an existing customer need, or a need that is created as a result of CANEUS' advocacy activities with potential customers and end-users.

Because CANEUS activities, by necessity, have to span the continuum of technology development and commercialization, CANEUS projects could be conducted in either a small, focused collaborative group effort approach or, alternatively, as a much larger, consortium-style, development of precompetitive intellectual property that is subsequently licensed by several aerospace companies and other organizations that see the benefit in mitigating their risk for expensive, high-risk, high-payoff technology development. It is then highly probable that these precompetitive developments will spawn a host of proprietary development projects within the licensee organizations.

# 4.2 Project Classifications

CANEUS Projects are classified in one of three ways:

- **Development** (product, process or service);
  - Or -
- **Initiative** (such as establishing aerospace industry standards for technology acceptance, performing a market study or creating a position paper, etc.);
  - Or -
- **Sector Consortium** (a thematic program of developments and initiatives with a technology, application, or stake holder focus to mitigate the risk for expensive, broad-based technology developments by creating pre-competitive intellectual property to be subsequently licensed by companies/ organizations developing their own proprietary systems).

## 4.2.1 Development - Project

A Development Project can be product related, process related or service related and in general, provides a total solution to an identified customer or end-user need.

## 4.2.2 Initiative - Project

An Initiative is typically established to either promote industry-wide benefits across the Aerospace community or to overcome any of the challenges that potentially impede the acceptance of advanced MNT concepts. Examples include: the establishment of standards to promote technology acceptance, performing a market study or creating a position paper, or establishing a data base that includes a description of all the member's facilities, capabilities and in- house expertise, etc.

## 4.2.3 Sector Consortia - Project

A Sector Consortium Project is a broad program of developments and initiatives that centers on a technology, application, or stakeholder theme. The development efforts are primarily aimed at risk mitigation for expensive technologies, in order to generate pre-competitive intellectual property for participants. The programs of each Sector Consortium are extensive enough that they are required to establish an Implementation Plan and Roadmap that is continually updated. CANEUS has currently initiated 5 Sector Consortia:

- Materials Sector Consortium (a technology theme)
- Devices Sector Consortium (a technology theme)
- Small Satellite Sector Consortium (an application theme)
- Fly-By-Wireless Sector Consortium (an application theme)
- Reliability Sector Consortium (a technology theme)

# 4.3 CANEUS Resources

CANEUS assists its membership by creating a systematic framework within which new projects can be created, reviewed and approved. The framework is similar to that used by most organizations with one significant difference. Once a peer-reviewed MNT system-development project has been approved by its membership, the CANEUS organization becomes actively involved in “shepherding” the project through its various life-cycle phases with the close involvement of both the financial sponsors and the end-customers. CANEUS strongly believes that such an intimate collaboration between all the stake-holders is necessary right from the inception of the project in order to ensure the ultimate success in transitioning MNT concepts to the aerospace system level.

Among the various project development resources provided to its membership by CANEUS, are the following:

- **Quad Chart Wizard** on the CANEUS website for providing the end-customer/sponsor requested information (the submitter is directed through a list of critical factors). A narrative document can also be attached to the Quad Chart site to provide additional background. Once a Quad Chart is created, CANEUS assists the proposer in using the document as a “sales brochure” to garner support and refine the concept.
- **Project Concept** proposal format which provides a quick overview of a particular opportunity to aid the CANEUS membership in the project definition and review process. The proposal is considered a public domain document and should not contain proprietary information. A Project Concept proposal contains all the essential elements of a business plan to be jointly developed and refined by the collaborative team consisting of the technology developers, end-customers and financial sponsors. As with a business plan, the Project Concept proposal describes the innovative technology or initiative, state of the art, current maturity level of the technology, and projected maturity level at the conclusion of the project, commercial viability, participating organizations – both the technology developers and the end-customers, and any challenges or outstanding issues (such as government regulations) that may be involved.
- **Detailed Project Plan** - Following approval of the Project Concept by the CANEUS membership, a Detailed Project Plan is prepared that includes proprietary content and is restricted to the selected collaborative team. The plan contains detailed descriptions of standard plan elements such as the business case, work breakdown structure, team responsibilities, budget, IP sharing and confidentiality agreements etc.

## 4.4 Project Execution

As with all new projects, a well-thought out management and project execution structure is critical for ensuring the successful transition of a new MNT concept to the aerospace system level. Here again, the CANEUS organization actively participates in assisting and providing the project teams and Sector Consortia with the necessary resources for incorporating best business practices, including the establishment of the Boards of Directors and other performance review Boards. Each project has access to CANEUS' "Innovation Environment" where the issues of confidentiality, regulatory compliance, and intellectual capital value are all addressed and the terms of team member interaction are all pre-established through the execution of team membership agreements. In the final analysis, it is indeed the CANEUS organization's deep involvement in all aspects of the project from inception to final product delivery, that makes its unique vision, for rapid, cost-effective transition of MNT from concepts to systems, possible.

# 5.0 CANEUS Project Support Structure

# 6.0 CANEUS Work Program Planning Process

# 7.0 Expected Outcomes from CANEUS 2009 Workshop

The results from the planned activities of the CANEUS 2009 Workshop should culminate in a series of strategic plans, roadmaps and Project concepts that will lay the foundation for a strong and enduring Work Program of high-risk, high-cost MNT Projects defined by the Aerospace community.

If the Workshop participant has contributed to the planning and project definition process throughout the week, they will end up with a Sector Consortium Handbook containing a new or revised Implementation Plan and Roadmap, a Project List of agreed upon target projects, a Project Action Plan describing the next steps in the project definition process, and a Sector Consortia Report that captures all the strategic input and decisions made at the CANEUS 2009 Workshop.

In addition, the candidates for the remaining seats of the transitional Board of Directors and the candidates for Chairman of the transitional Work Program Boards (all six) will be named.

## 7.1 Sector Consortium Implementation Plan/Roadmap

Each Sector Consortium should end up with an Implementation Plan/Roadmap that contains a:

- Vision statement
- Mission statement
- List of Goals
- List of Strategies and a Roadmap that provides the Consortium with a focused Work Program of projects.

## 7.2 Project List

A list of projects for each consortium should result from the strategies and roadmap outlined in each Sector Consortium's Implementation Plan/Roadmap document and each project will be prioritized based on strong team buy in and support.

## 7.3 Project Action Plan

Each Sector Consortium must end up with a list of action items describing the next steps in the Project definition process that the members of the Sector Consortium and Project Team are willing to establish. The list should include a schedule of meetings and workshops and establish milestones for submission of Project Concept Proposals and Detailed Project Plans.

## 7.4 Sector Consortium Report

Each Sector Consortium will prepare a summary of: the actions taken to create or refine the Implementation Plan/Roadmap document; the project planning activity; the action steps for subsequent Project development efforts. This is the report that will be shared with all the participants of CANEUS 2009 on Friday of the workshop. This report, along with all supporting documentation and session notes, will be posted on the CANEUS website after the end of the Workshop.

# Workshop Program

# 8.0 Small Satellite Sector Consortium

## Consortium Session Guidelines

Dear Colleagues,

On behalf of the CANEUS 2009 Planning Committee, thank you for accepting our invitation to be a panellist at the CANEUS 2009 Workshops! Here are some CANEUS guidelines for your role. Each Sector Consortia has two sessions: 1) Mission Goals & Roadmap, and 2) Project Development and Framework. Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. I have taken the liberty of placing you on a panel according to my understanding of your expertise: however if you would prefer to be in a different panel, please alert me immediately and I will have your position changed. You are currently scheduled in the Small Satellite Sector Consortium (SSSC). The SSSC is an international consortium dedicated to the micro and nano technology implementation, coordination, and standardization of the small (1-100 kg) satellite industry. The Assessment Study will focus on the unique way that the CANEUS SSSC positions Standards Activities to deliver value to its members, partners, and various other CANEUS stakeholders.

Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Your sessions are scheduled for **Wednesday, March 4th in the afternoon**, followed by a project refinement session on Friday. (Please refer to the Workshop Schedule section 2.0 for more details)

Panellist will attend either one or both of the following session (Please refer  to the Program f
or further details).

If you are a panellist scheduled for the **Roadmap** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

### Mission Goals & Roadmap

Objective of session: The goal is for participants to create and/or formalize the mission, goals, and roadmap for your CANEUS Sector Consortium for the next three years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities and achievements.

### Roadmap Refinement

Objective of session: Participants in this session will specify tasks and assign responsibilities with timelines to execute the Roadmap.

The role of panellists in both of these sessions is to lend your expertise and experience in visualizing the future of the industry, providing your perspective on what the goals and roadmap should look like, and identifying the milestones needed to implement the roadmap.

Should you require anything, whether it be pens, pointers, papers, presentations or panellists, please contact Lauren Thomas (CANEUS International) as your main point of contact.

If you are a panellist scheduled for the **Project** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

### Project Development & Framework

Objective of session: Two to three invited participants will present a project currently being undertaken within their organization. A general project plan coherent with the roadmap outlined in the previous Roadmap session will be drafted (6 months, 1 year, 2 years). Participants will address business development issues, such as NDA, IP, and government regulations.

## Project Refinement

Objective of session: Participants will refine the projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the project.

The role of panellists in both of these sessions is to lend your expertise and experience and evaluate the projects presented, and provide comments as to their improvement, feasibility, etc.

# 8.1 Background

## 8.1.1 Consortium Profile

### Director and Coordinator:

ANDREW QUINTERO, THE AEROSPACE CORPORATION

### Project Chairs:

Standards Development:
John Hines, NASA Ames Research Center

Launch Services:
Gerard (Jake) Szatkowski, United Launch Alliance

Stakeholder Liaison and Strategic Development:
TBC

Intellectual Property and Export Control:
George Grammas (Export Control), Squire, Sanders & Dempsey;
Andrew H. Quintero (Intellectual Property), The Aerospace Corporation

Launch Certification:
Lt. Col. Douglas Taffinder, Space Missile Command

Education/Outreach:
William Edmonson, North Carolina State University, Co-Chair Andrew H. Quinter, The Aerospace Corporation;

### Participants:

Standards Development:
(Session Chair John Hines, NASA Ames); Francesco Svelto, ASI; Craig Day, AIAA; Johan Kohler, ESA; Adarsh Deepak, STC; Todd Mosher, Microsat Systems(TBC); Chad Fish, Space Dynamics Lab; James Lyke, AFRL; Linda Herrell, NASA-JPL; Wanping Zheng, CSA; Michael Enoch, LMCO, USA; Donald Knight, General Dynamics; Dean Wiberg, NASA-JPL; Hannah Goldberg, NASA-JPL; Leon Alkalai, NASA-JPL; Marcello Romano, NPS; James Slavin, NASA GSFC(TBC); Peter Mendham, STAR-Dundee; Dino Laurenzini, SpaceQuest; Eric Bobinsky, Terasphere; Siegfried Janson, Aerospace Corporation; Rick Groom, Aerospace Corporation

Launch Services:
(Session Chair Jake Szatkowski, United Launch Alliance);Stuart Waterman, Alliance Space Sys-

tems; Max Vozoff, SpaceX; Gary Rodriguez, sysRAND; David Zimcik, NRC-IAR; Bob McCoy, ORS; Steve M. Francois, NASA KSC(TBC); Dino Laurenzini, SpaceQuest; Marco Villa, SpaceX; Jean-Marie Muylaert, ESA(TBC); Jason Armstrong, TriSept Corp; Bruce Yost, NASA Ames; Debra Lepore, Air Launch LLC; John Garvey, Garvey Spacecraft; Amanda Mitskevich, NASA KSC(TBC); Johan Kohler, ESA; Max Vozoff, SpaceX; Bill Wrobel, NASA SMD(TBC)

Stakeholder Liaison and Strategic Development:
TBC

Intellectual Property and Export Control:
(Session Chair George Grammas, Squire Sanders and Dempsey); Bob Pugh, AFRL; Jay Middour, NRL; Adam Baker, SSTL(TBC); Donna Avila, Aerospace Corp; Raj Shea, NASA Ames; Peng Zong, Nanjing University

Education/Outreach:
(Session Chair William Edmonson, North Carolina State University, Co-Chair Andrew H. Quinter, The Aerospace Corporation);
Bob Meurer, ATK Space; Henry Helvajian, Aerospace Corporation; Jenny Servo, Dawnbreaker; Rick Earles, CANEUS USA; Jacques Lyrette, CANEUS; Roland Coelho, CalPoly; John Davey, BNSC(TBC); Carles Ferrer, CNM-IMB; Jordi Puig-Suari, CalPoly; Norman Fitz-Coy, University of Florida(TBC); Bob Twiggs, Stanford University; Robert Weigel, George Manson University

## Presenters:

Standards Development:
Fred Slane, Space Infrastructure Foundation Inc.; Peter Mendham, STAR-Dundee;

Launch Services:
Gil Moore, Project POPACS & STARSHINE; Gerard (Jake) Szatkowski, United Launch Alliance

Stakeholder Liaison and Strategic Development:
Bob Twiggs, Stanford University

Intellectual Property and Export Control:
Raj Shea, NASA Ames; George Grammas, Squire, Sanders & Dempsey; Bob Pugh, AFRL

## 8.1.2 Activity Update

The CANEUS SSSC aims to provide value to the space industry by coordinating and consolidating information on various Small Satellite efforts around the globe. The CANEUS SSSC serves not only as an information dissemination body, but also works actively on focusing the work of disparate organizations worldwide in working towards a commonly accepted standardized approach, thus enabling each participating organization to benefit from the collective developments within the small satellite community. The unique constituencies that CANEUS SSSC represents may turn out to be the door opener to create one or more globally accepted standard. Such standards ultimately help facilitate more robust collaborations between participating organizations via the use of standardized interfaces, and thereby minimizing loss of time and effort. Hand-in-hand with the development of globally accepted standards is the development of standardized small satellite platforms for achieving various military, scientific and commercial missions in a rapid and cost-effective manner.

### Past Activities

**Small Satellite Working Group Meeting in Montreal, Canada: October 24-25, 2006**

The Small Satellite Working Group, now called the Small Satellite Sector Consortium (SSSC) held their first meeting convened within the CANEUS framework in Montreal from October 24 - 25, 2006 in order to define the objectives, modus operandi and way forward of the Small Satellite Working Group.

At the meeting, the following points were identified: mission statement, overall objective, specific goals, modus operandi, stakeholders, end-user markets for small sat applications, technology validation markets for small satellites, funding for operations, way forward, challenges foreseen, and measure of success.

Attendees agreed that Working Group Members would advocate membership in the Small Satellite organization from candidate organizations in their respective regions: Canada, Europe, U.S.A., and Asia. They also agreed that the ideal time-frame for sponsorship of activities is five years. The Small Satellite organization will measure its success by “launched operating Small Satellite systems.” In this regard, it was deemed necessary to find a hardware commitment opportunity as soon as possible.

**Small Satellite Working Group meeting in Littleton, Colorado: March 22-23, 2007**

The Small Satellite Sector Consortium (SSSC) convened for their second meeting from March 22 - 23, 2007 in Littleton, Colorado at the headquarters of MicroSat Systems Inc.

The meeting built upon the foundation established at the Group’s first meeting in October 2006, focusing specifically on international collaborations within the small satellite industry. Whereas the first Small Satellite Working Group meeting established the structure, mandate, objectives, and action items for the working group, the second meeting served to identify and formalize the diverse needs of its members, such as mission customer/agencies, mission systems providers, systems integrators, launch service providers, operations providers, component/sub-system providers, and technology providers.

**Small Satellite Workshop in El Segundo, California: January 31-February 1, 2008**

Following the second meeting held in March 2007, CANEUS collaborated with The Aerospace Corporation to deliver the Small Satellite Workshop in El Segundo, California, from January 31 - February 1, 2008.

This workshop aimed to:

- Update the participants on the activities of the CANEUS Small Satellite Sector Consortium (CANEUS SSSC);
- Discuss the selection of applicable global standards for small satellites;
- Discuss the design of a reference small satellite platform for the application of the standards;
- Discuss the selection of applicable military, scientific and commercial small satellite missions.

Three of the five projects that exist today were established at this Workshop: Standards Development, Launch Services, and Stakeholder Liaison and Strategic Development.

Participants at the Small Satellite Workshop worked actively towards defining the road map for future Small Satellite missions. Among the precursor flights to be considered prior to the establishment of a standardized small satellite platform are the following:

1. Flight of an in-space test bed for various applicable small satellite standards including rapid assembly and PnP interoperability for components and sub-systems acquired from several manufacturers around the world.
2. Flight of a prototype “standard” small satellite bus embodying the finalized set of requirements by the small satellite standardization sub-group of the CANEUS SSSC.
3. Flight of a “real” science mission or in-space demonstration of a small satellite mission designed to achieve a particular agency customer’s requirements.

Shortly after the workshop in El Segundo, CANEUS International drafted a roadmap for the Small Satellite Sector Consortium entitled “Implementation Plan for International Cooperation on Small Satellite Development” which can be found in this Workshop Handbook.

## Upcoming Activities

In the Standards Development initiative of the SSSC, Fred Slane of Space Infrastructure Foundation Inc. is conducting a preliminary Standards Assessment Study. The objective is to compile the various standards that currently exist for small spacecraft, and to then conduct a survey among the participants of the SSSC and achieve consensus in identifying common standards from both user and provider points of view.

# 8.2 Implementation Plan/Roadmap

## MISSION

The CANEUS Small Satellite Sector Consortium (SSSC) is an international consortium dedicated to the micro and nano technology (MNT) implementation, coordination, and standardization of the small (1-100 kg) satellite industry. Taking an approach similar to that designed for the semiconductor industry, namely the SEMATECH industry group, the SSSC focuses on providing opportunities for industry representatives to participate in cutting-edge technical discussion and high-risk, high-cost developments while establishing the future direction of the micro, nano, and pico satellite industry.

The CANEUS SSSC emphasizes the identification of end-users of small satellite missions and their specific needs. Members collaborate to establish how the small satellite industry can respond to these mission or product requirements. This has the effect of opening up the small satellite market and providing business and investment opportunities by facilitating dialogue and the establishment of cooperative relationships.

The mission of the CANEUS SSSC has three elements:

- To provide advocacy for its members and foster the advancement and increased use of MEMS and nano technology toward the expansion of the small satellite market;
- To be the world's catalyst for the small (1-100 kg) satellite industry to bring breakthrough ("disruptive") technologies to the space sector by ensuring space qualification, reliability, lower cost and added value;
- By setting a global direction, to create opportunities for the flexible collaboration and conduct of strategic research and development (R&D) so as to yield a significant return on investment (ROI) to the small satellite industry partners.

## OBJECTIVES

The core objectives of the CANEUS Small Satellite Sector Consortium (SSSC) include:

- Advancing the maturity of emerging MNT concepts via the development of end-to-end system development strategies;
- Encouraging an attractive investment environment focused on the rapid, cost-effective development of MNT and related technologies that will lead to an expansion of the small satellite market;
- Fostering increased access to space by enabling the periodic and routine availability of primary and secondary space lift opportunities for small satellites;
- Leading in the development of functional and performance standards for small, micro and nano satellites;
- Working with members to be a rapid and cost-effective mechanism that drives the pervasive use of next-generation micro, nano, and pico space satellite systems;
- Addressing critical challenges in advanced micro, nano, and pico satellite technologies, and finding ways to speed development, reduce costs, share risks, and increase utilization;
- Mitigating risks and costs collectively for the SSSC stakeholders by:
- Providing space flight arrangements to validate MNT and related technologies;
- Arranging nano and pico satellite constellations;
- Expediting launch on demand.

# STRATEGY

## 8.3 Projects

8.3.1 Standards Development

8.3.2 Launch Service

8.3.3 Stakeholders

8.3.4 Intellectual Property and Export Control

8.3.5 Launch Certification

8.3.6 Education/Outreach

8.3.7 _____

8.3.8 _____

8.3.9 _____

8.3.10 _____

## 8.3.1 Standards Development

### Mission & Vision Statement:

The purpose of this subgroup is to provide a platform for developing satellite subsystems standards to insure interoperability amongst international partners. This will result in small satellites that are cheaper to develop with a shortened development time to launch.

### Objectives & Goals:

The objectives are to:

1. Define form factors for nano and micro platforms
2. Develop a collection of existing/emerging standards relevant to the sector
3. Establish onboard data interface requirements
4. Ensure interoperability for international operations

The goals will facilitate the reduction of development cost and shorten the development cycle by:

1. Identifying task-groups around technology/platform areas, such as:
    - Electrical interfaces
    - Physical form factors
    - Plug-and-play formats
    - Data bus protocols
    - Communications interface, protocols and frequency spectrum
    - Systems engineering
2. Defining technical requirements for each technology/platform area
3. Surveying the existing standards within other CANEUS sectors
4. Performing technology gap analysis

### Strategies and Tasks:

The strategy of this subgroup is to develop a set of small satellite standards that will allow international teams to share and incorporate new technologies based on a plug-and-play philosophy. Tasks include convening industrial, governmental, and university stakeholders that will develop a long term vision for standardization based on application drivers, e.g. space science, earth observation, and education.

## Activities:

Initial activities consist of assembling a small team of stakeholders that have plug-and-play small satellite programs to provide a framework document that includes lessons learned and future technology directions. The next step is to form a standardization committee to begin the process of developing a set of standards based on the goals stated above.

## 8.3.2 Launch Services

### Mission & Vision Statement:

The Launch Services subgroup is mandated to establish a set of specifications consistent with a variety of launch systems and to ensure the compatibility of secondary payloads with these specifications. The subgroup aims to provide secondary satellite developers with a current list of candidate launches detailing carrier type, carrying capacity, and key contact information.

### Objectives & Goals:

1. Advocate secondary satellite accommodations to primary payloads
2. Assist secondary satellites in getting rides on primary missions
3. Sponsor standards and qualification specifications

### Strategies and Tasks:

Strategies to accomplish the first objective include appealing to funding sources of primary payloads and acquiring agency-level mandates and directives to fly secondary satellites. In assisting secondary satellites, the Launch Services subgroup shall establish an evaluation agency and an Executive Committee to rank and recommend small payloads for rides, acting as a broker between the primary and secondary payload communities. Funds shall be directed to development and verification of small satellites standards, small satellites integration costs, and future CANEUS-sponsored small satellites missions. CANEUS shall own and publish standards, the certification process, and the list of vendors able to assist in it.

### Activities:

Details on some activities advancing the Launch Services Subgroup's mission for Atlas and Delta Programs are available in the document entitled "EELV Payload Accommodation".

## 8.3.3 Stakeholders

### Mission & Vision Statement:

The Stakeholder Liaison subgroup is chartered to compile the necessary critical processes, procedures, and needs documents from the community of SSSC stakeholders. These will ultimately be of value to all stakeholders who aim to benefit from a streamlined international collaboration.

### Objectives & Goals:

1. Bring all the stakeholders, individuals and organizations (such as in the U.S.A., the DDR&E, ORS, NASA, ULA,AFRL, NRL, etc.) that could benefit from a sustainable Small Satellite industry sector
2. Identify and prioritize the key technology elements required for the Small Satellite sector
3. Develop and maintain the supply chain infrastructure. Goals are oriented to benefiting governmental laboratories and university research groups and include:
    a. Ensuring greater mission assurance through improved reliability
    b. Providing an alternate means to rapidly qualify new technologies
    c. Lowering costs to demonstrate new technologies in space
    d. Expanding launch opportunities
    e. Supporting plug-and-play developmental efforts
    f. Advancing concepts in modular design methods
    g. Accelerating technology maturity up the TRL curve
    h. Enabling university TRL 3 projects to get flight experience and facilitating moving to TRL 6 and beyond
    i. Helping with efforts to shorten the acquisition timelines;
    j. Improving the alignment with emerging technology development cycle
    k. Enhancing the space industrial base
    l. Supporting educational outreach and human capital for future jobs in the space industry

### Strategies and Tasks:

An important deliverable consists of developing content for the CANEUS website that will facilitate dealing with processes and timelines for working with the collective international community and make the best use of the CANEUS SSSC membership in doing so. This deliverable may also take the form of a document or handbook. The strategy will also include collecting high interest technology needs from the stakeholder community to enable identification of projects that should be funded, thus addressing many of the objectives cited above.

## Activities:

Primary activities to date include coordinating with the US Air Force on identifying and validating the value proposition of the international consortium.  Coordinated meetings at the Los Angeles based Space and Missile Systems Center (SMC) have resulted in support from the Engineering and Architecture (SMC/EA) organization.

## 8.3.4 Intellectual Property and Export Control

### Mission & Vision Statement:

The purpose of this subgroup is to establish a clear process for defending intellectual property rights and a streamlined process for members of the CANEUS SSSC to resolve export control issues.

### Objectives & Goals:

The goal of the subgroup is primarily a clear process outcome. The outcome for intellectual property will be a guideline for how smaller companies can address intellectual property concerns while engaging with larger firms or government agencies. The outcome for all entities will be a clear construct for dealing with export control restricted technologies of interest. Member organizations will greatly benefit from a framework that defines pre-approved technology areas of interest.

### Strategies and Tasks:

The strategy will include a coordinated effort from public and private organizations to identify critical elements for handling intellectual property and export control issues. The current players include Squire, Sanders & Dempsey, L.L.P., the General Counsel of the Department of Defense (DoD), The Aerospace Corporation's export control office, Air Force representatives, and other SSSC participants. Tasks include defining a framework for launch providers and satellite suppliers such that the international community can benefit from a more efficient means to receive a Technical Assistance Agreement (TAA). Intellectual Property tasks include working with the DoD and industry to establish guidelines on the handling of intellectual property rights with multi-party arrangements.

### Activities:

Initial introductions from Squire Sanders, USAF, DoD, The Aerospace Corporation and industry have commenced. Next steps include formal meetings to begin work on laying out the detailed tasks and timelines.

## 8.3.5 Launch Certification

### Mission & Vision Statement:

This initiative aims at addressing launch certification services.  Many launch organizations and government customers will require a certification sign off process and this initiative will compile a list of certification organizations and help facilitate the introduction and interactions.

### 8.3.6 Education/Outreach

Education/Outreach is comprised of a Chairman and Project Leaders, it is responsible for:

- establishing an academic global network of micro and nano technology capabilities related to the aerospace market;
- short courses that support aerospace applications;
- a global web portal of academic capabilities for aerospace applications and related technologies;
- and a global student web portal for aerospace related opportunities.

It is also responsible for developing a harmonized technology transfer policy for spin-off intellectual property.

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## 8.3.8

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## 8.3.10

## 8.4 Implementation Plan/Roadmap Revisions

# 8.5 CANEUS Proposed Work Program Project List

## 8.6 Action Plan

# 8.7 Workshop Report

# 9.0 Devices Sector Consortium



## Sector Consortium Session Guidelines

Dear Colleagues,

On behalf of the CANEUS 2009 Planning Committee, thank you for accepting our invitation to be a panellist at the CANEUS 2009 Workshops! Here are some CANEUS guidelines for your role.
Each Sector Consortia has two sessions: 1) Mission Goals & Roadmap, and 2) Project Development and Framework. Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. I have taken the liberty of placing you on a panel according to my understanding of your expertise: however if you would prefer to be in a different panel, please alert me immediately and I will have your position changed. You are currently scheduled in the Devices Consortium.

Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Your sessions are scheduled for **Wednesday, March 4th in the afternoon**, followed by a project refinement session on Friday. (Please refer to the Workshop Schedule section 2.0)

If you are a panellist scheduled for the Roadmap sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

### Mission Goals & Roadmap

Objective of session: The goal is for participants to create and/or formalize the mission, goals, and roadmap for your CANEUS Sector Consortium for the next three years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities and achievements.

### Roadmap Refinement

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Should you require anything, whether it be pens, pointers, papers, presentations or panellists, please contact Lauren Thomas (CANEUS International) as your main point of contact.

If you are a panellist scheduled for the Project sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

## Project Development & Framework

Objective of session: Two to three invited participants will present a project currently being undertaken within their organization. A general project plan coherent with the roadmap outlined in the previous Roadmap session will be drafted (6 months, 1 year, 2 years). Participants will address business development issues, such as NDA, IP, and government regulations.

## Project Refinement

Objective of session: Participants will refine the projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the project.

The role of panellists in both of these sessions is to lend your expertise and experience and evaluate the projects presented, and provide comments as to their improvement, feasibility, etc.

# 9.1 Background

## 9.1.1 Consortium Profile

### Sub-Group Chairs:

Environmental Monitoring:
Meyya Meyyappan, NASA Ames

Photonics:
Iain MacKenzie, ESA

Bio-Astronautics:
Sumitra Rajagopalan, Bio-Astra Technologies Inc. McGill University (TBC)

Harsh Environment Sensors:
Jan Suski, MEMSFIELD

### Participants:

Environmental Monitoring:
(Session Chair) Meyya Meyyappan, NASA Ames; (Session Co-Chair) Harry Partridge, NASA Ames

Photonics:
(Session Chair Iain MacKenzie, ESA); (Session Co-Chair Glenn Unger, NASA); Alan Scott, Comdev; Dean V. Wiberg, NASA-JPL; Lun Cheng, TNO; Martin Seifert, Nufern; Raj Gupta, CEO, TeraHz; Caterina Ciminelli, Politecnico di Bari; Connie Chang-Hasnain, University of California; Cun-Zheng Ning, Arizona State University; Paul Rudy, Modulight; Carles Ferrer, CNm Spain

Bio-Astronautics:
(Session Chair Sumitra Rajagopalan, Bio-Astra Technologies Inc. McGill University, TBC); Chih-Ming Ho, UCLA; Juergen Drescher, DLR; Francisw Tay, Institute of Bioengineering and Nanotechnology (IBN)

Harsh Environment Sensors:
(Session Chair Jan Suski, MEMSFIELD); (Session Co-Chair Nico de Rooij, University of Neuchatel); NASA-JPL; Jih-Fen Lei, NASA GRC; Tay Eng Hock, NUS; Newton C. Frateschi, State University of Campinas;

## Presenters:

Environmental Monitoring:
Jing Li, NASA Ames

Photonics:
Stan Williams, HP; William Tang, UCI

Bio-Astronautics:
Sumitra Rajagopalan, Bio-Astra Technologies Inc. McGill University (TBC)

Harsh Environment Sensors:
Bertrand Rue, UCL

## 9.1.2 Activity Update

### Introduction:

The CANEUS Devices Sector Consortium coordinates the activities of several sub-disciplines including Harsh Environment Sensors, Photonics, Bio-Astra, and Environmental Monitoring.

### Past Activities:

**Harsh Environment Sensors Workshop, University of Neuchatel Switzerland: September 25-26, 2008**

Harsh Environment (HE) Sensors are a key challenge, especially for low volume and high reliability applications in various fields like Space, Aerospace, Defense, and Energy. Aircraft, Spacecraft, and Defense Industries and Agencies End-Users and HE Sensors technology developers from Europe, Canada, USA, Brazil and other countries are coming together to form the International Aerospace MNT Harsh Environment Sensors/Systems Sector Consortium under the auspices of CANEUS International. These organizations are all agreeing to pool their resources in order to create a collaborative environment where the membership's proceeds are joined to focus on high-risk, high-cost Aerospace HE Sensors initiatives. The unique innovation environment provided by CANEUS' Sector Consortia Model forms the basis for this collaborative undertaking. The objectives for this workshop were:

- To establish a direct communication between Space/Aerospace End-Users and MEMS/Microsystems Technology providers in order to accelerate the use of MEMS sensors in HE.
- To enable End-Users to explain their requirements for harsh environment sensors, and to allow technology providers to show how their MNT solutions can be used in Aerospace applications.
- To bring these two communities together to understand each other's capabilities and needs in order to develop joint projects on MNT sensors for harsh environments.

At the workshop, participants were able to:

- Define the needs for HE MNT systems.
- Define adequate technology routes, complete missing process/materials steps.
- Define long-term cooperation procedures with these new Development & Production Centers.
- Build Consortia and funding proposal submission to be put together.

The Workshop developed the HE roadmaps to address Aerospace needs for MNT sensors/systems. The proposed Consortium Project will be based on a clear identification of the end-user needs and technical capabilities provided by involved laboratory and manufacturer know how. National and International Agencies will also be involved in the project.

Parts of the 2006 Conference objectives are currently being realized in the framework of an EU FP7 project. The 2008 HE Sensors workshop consequently extends this work, enlarging the MNT R&D

and manufacturing offer for HE.

## Upcoming Activities:

The next annual Devices Sector Consortium Workshop is proposed to be held in the U.S. in the fall of 2009 where the Harsh Environment Sensors project will be presented and discussed.
The Photonics sub-disciplines first workshop is to be held in fall 2009 at either ESTEC or one of the NASA centers. At this workshop, the sub-discipline hopes to define and identify projects and teams.

# 9.2 Implementation Plan/Roadmap

As Devices Consortium is comprised of four sub-divisions, each project has individual specific missions, visions, objectives and strategies.  Some of these are already outlined in the 9.3 Projects section; however more information will be distributed throughout the course of the workshop.
Please insert this information under the appropriate tabs.

## 9.3 Projects

9.3.1 Environmental Monitoring

9.3.2 Photonics

9.3.3 Bio-Astronautics

9.3.4 Harsh Environment Sensors

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# 9.3.1 ENVIRONMENTAL MONITORING

## Workshop Handout

## 9.3.2 Photonics

### Mission & Vision Statement:

Fiber-optic communications offer a low power, high-bandwidth solution that is robust against electrical interference effects, and is subject to graceful degradation rather than catastrophic failure that electrical systems are often prone to during in-space operations.  We propose to design, fabricate, assemble and test an integrated, fiber-optic, inter-subsystem communications system that will be ultimately be demonstrated in space via a near-term launch opportunity.

## 9.3.3 Bio-Astronautics

### Mission Statement

The Bioastronautics Working Group strives to play a key role in developing the next generation of miniaturized technologies to support humans in space and other harsh environments.

### Vision

The Bioastronautics working group will develop a range of micro-and nano-technologies to both monitor and mitigate the physiological effects of long-duration spaceflight.

This would include lightweight, wearable sensors for health monitoring as well as technological countermeasures to mitigate the adverse health effects of long-duration spaceflight and other extreme environments. These technologies, originally developed for high-end Aerospace and military applications, will then be adapted for wide-ranging applications in the medical, consumer and protective garment sectors.

### Strategy

- To identify key health issues in human spaceflight that could benefit for an MNT application.
- Establish a multidisciplinary group of researchers and end-users to develop a comprehensive bioastronautical MNT roadmap.
- To develop technologies that are lightweight, multifunctional and that can be easily incorporated into existing or future EVA suits.
- To leverage the profile and prestige of the space sector to create commercially viable spin-off applications in other sectors.
- Forge Alliances with CANEUS Materials and Fly-by-Wireless to co-develop common platform technologies for our respective applications
- Leverage the expertise in smart polymers and electrospinning of nanofibres at Bioastra Technologies Ltd., Montreal, to develop mulitifunctional polymer nanocomposites for a range of bioastronautic and medical applications.

### Short-term Goals and Action Plan

As part of CANEUS 2009 workshops, the Bioastronautics Group will propose the following technologies for implementation within a time frame of two years:

**Physiological Monitoring:**

Laboratory-on-Chip: An integrated system containing microneedles, microfluidics, smart valves and CMOS electronics for the painless extraction and testing of blood and urine samples from astronauts and others.

Wearable health monitors: A lightweight conductive fabric embedded with “Quantum Tunneling Nanocomposites” for continuous wireless monitoring of vital signs of astronauts and others.

**Physiological Countermeasures:**

Thermoregulatory Textiles: A smart multifunctional cooling vest based on phase change materials, microfluidics and conductive fabric to maintain body temperature in extreme environments.

Artificial Muscles for Lower Body Negative Pressure: A smart pant embedded with artificial muscle actuators to counter orthostatic tension in astronauts, pilots and certain medical patients.

## Education and Outreach

In addition to R&D, the Bioastronautics consortium will also:

- Create course modules in bioastronautics at McGill University and within the space engineering programs at York and Carleton University in Canada.
- Raise awareness among biomedical engineers of the nascent field of bioastronautical engineering, through review papers, conference presentations and monographs.

## 9.3.4 Harsh Environment Sensors

### Mission & Vision Statement:

This sub-discipline is mandated to address the key challenge of Harsh Environment Sensors, especially for low volume and high reliability applications in various fields. End-users of the aircraft, spacecraft, and defense industries join technology developers from Europe, Canada, USA, Brazil, and other countries to pool their resources and create a collaborative environment. The focus is on high-risk, high-cost Aerospace Harsh Environment Sensors initiatives.

## 9.3.5

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## 9.3.10 _____

## 9.4 Implementation Plan/Roadmap Revisions

# 9.5 CANEUS Proposed Work Program Project List

## 9.6 Action Plan

# 9.7 Workshop Report

# 10.0 Fly-By-Wireless Sector Consortium

## Sector Consortium Session Guidelines

Dear Colleagues,

On behalf of the CANEUS 2009 Planning Committee, thank you for accepting our invitation to be a panellist at the CANEUS 2009 Workshops! Here are some CANEUS guidelines for your role.
Each Sector Consortia has two sessions: 1) Mission Goals & Roadmap, and 2) Project Development and Framework. Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. I have taken the liberty of placing you on a panel according to my understanding of your expertise: however if you would prefer to be in a different panel, please alert me immediately and I will have your position changed. You are currently scheduled in the Fly-by-Wireless Consortium. The CANEUS Fly-by-Wireless Sector Consortium is chartered to precipitate cooperation and partnerships between industry/government customers, system innovators, and technology developers, while exchanging public and published information on wireless alternatives and new innovations, such as no-power sensor-tag systems. Ultimately, the Consortium's efforts will contribute to minimizing cables and connectors across the aerospace industry by providing reliable, lower cost, and higher performance alternatives for a vehicle's or program's life cycle.

Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Your sessions are scheduled for **Wednesday, March 4th and Thursday, March 5th in the morning**, followed by a project refinement session on Friday. (please refer to the Workshop Schedule section 2.0)

If you are a panellist scheduled for the Roadmap sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

### Mission Goals & Roadmap

Objective of session: The goal is for participants to create and/or formalize the mission, goals, and roadmap for your CANEUS Sector Consortium for the next three years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities and achievements.

### Roadmap Refinement

Objective of session: Participants in this session will specify tasks and assign responsibilities with timelines to execute the Roadmap.

The role of panellists in both of these sessions is to lend your expertise and experience in visualizing the future of the industry, providing your perspective on what the goals and roadmap should look like, and identifying the milestones needed to implement the roadmap.

Should you require anything, whether it be pens, pointers, papers, presentations or panellists, please contact Lauren Thomas (CANEUS International) as your main point of contact.

If you are a panellist scheduled for the **Project** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

## Project Development & Framework

Objective of session: Two to three invited participants will present a project currently being undertaken within their organization. A general project plan coherent with the roadmap outlined in the previous Roadmap session will be drafted (6 months, 1 year, 2 years). Participants will address business development issues, such as NDA, IP, and government regulations.

## Project Refinement

Objective of session: Participants will refine the projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the project.

The role of panellists in both of these sessions is to lend your expertise and experience and evaluate the projects presented, and provide comments as to their improvement, feasibility, etc.

# 10.1 Background

## 10.1.1 Consortium Profile

### Director and Coordinator:

Rodger Magness, Aerospace-Wireless

### Subdivision Leaders:

Leader of Structural Vehicle Health Monitoring (SHM) Initiative, Robab Safa-Bakhsh,Boeing
Co-Leader of Sensor DAQ Miniaturization Initiative, David Russel, NRC-IAR
Leader of Passive Sensor Tag Initiative, Ali Abedi, University of Maine
Leader of Less-Wire / Architectures Initiative, Brian McCabe, Sikorsky Aircraft

### Participants:

David Russel, NRC-IAR; Brian McCabe, Sikorsky Aircraft; Ali Abedi, University of Maine; Jim Castellano, Industry Canada; Wanping Zheng, CSA; Marc Lienard, L-3 Communications; Ion Stiharu, Concordia University; Clément Fortin, École Polytechnique Canada; Sharon Smith, LMCO; David Morgan, Boeing; Bruce Donham, Boeing; Bruce Swanson, Invoncon Inc.; Don Malocha, University of Florida; Craig Weich, Visible Assets

### Subdivision Participants:

Sensor DAQ Miniaturization:
Ion Stiharu, CRIAQ; Peng Zong, Nanjing University; Clément Fortin, École Polytechnique, Canada; Bruce Donham, Boeing; Bruce Swanson, Invoncon Inc.

Passive Wireless Sensor Tag:
Cy Wilson, NASA LaRC; Carles Ferrer, CNM, Spain; Serdar Sezen, University of Minnesota; Don Malocha, University of Florida

Less-Wire Technologies:
Marc Lienard, L-3 Communications; Gulfstream(TBC); Craig Weich, Visible Assets

SHM:
Sharon Smith, LMCO; Bruno Foucher, EADS; David Morgan, Boeing

### Additional Participants:

Somen Chowdhury, Bell Helicopter; Wanping Zheng, Canadian Space Agency (CSA); Jules O'Shea, Ecole Polytechnique de Montreal; Jim Castellano, Industry Canada; Claude Perron, NRC; Yves Plourde, NRC; Carles Ferrer, CNM-IMB; George Studor, NASA JSC

## 10.1.2 Activity Update

### Introduction:

In March 2007, NASA and CANEUS teamed together to hold the first Fly-by-Wireless (FBW) Workshop in conjunction with RFID World 2007 Conference. The U.S. and international organizations participating have taken steps to continue development of their wireless programs and some teaming has resulted. Many have committed to participation in future FBW workshops, working groups, and projects, including EADS, ESA, CSA, Brazil, NASA IPP, and Aviation Safety Program.

Wired data systems have huge life-cycle costs and limited reliability for aerospace vehicles. Depending upon the application, the data necessary for making many decisions can be acquired more reliably and cheaply if wireless systems are used. Ten years of operational experience in Space Shuttle and International Space Station missions have shown that low-power wireless data acquisition and communication are reliable and very useful. While RFID tags can be used for identification and tracking of objects, recent breakthroughs have resulted in devices that can provide data from sensor-tags that have no power source: their electromagnetic reflected response varies according to the sensor attached. It is clear that maturity and confidence in the safety and operations of wireless interface needs to increase if there is to be hope for widespread use. For non-critical applications, wireless interfaces are already showing to be a practical solution.

### Past Activities:

**CANEUS/NASA Fly-By-Wireless Workshop for Aerospace Applications: March 27-28, 2007**

On March 27-28 2007, CANEUS and NASA held a joint workshop on FBW for Aerospace application in conjunction with the 5th Annual RFID World Conference and the IEEE International Conference on RFID 2007. This workshop addressed the need to follow-through with the organizations that expressed strong interest in wireless technology from the CANEUS 2006 conference.

### Workshop Objectives

1. Communicate the CANEUS FBW Vision and Project Partnering
2. Develop cooperating Application/End User and Technology Provider Groups that intend to further the FBW Vision
3. Provide communication of results and additional opportunities for further development of cooperative work and partnerships

Keynote speakers introduced the FBW Vision to participants of the workshop, and highlighted the advantages of reducing wired interconnects. The NASA Wireless and RFID Working Group for space vehicle were strengthened. It was found that many areas of stand-alone wireless, passive sensor-tags and integrated architectures were further along than anticipated. Participants discussed potential partnering to further the FBW Vision, and partnerships that are developing to advance passive sens-

ing technologies promise to be fruitful if they keep momentum.

## Upcoming Activities:

The next FBW Workshop is proposed to be held in Montreal in June 2009.

The objectives for this workshop are:

- Establish an international forum through the CANEUS Organization to exchange public and published information on applications and technology alternatives to wires, which precipitate cooperation and partnerships between industry/government customers, system innovators and technology developers.
- Promote understanding of the capability, maturity and challenges of alternatives to wired infrastructures/enabling technologies in order to facilitate timely regulatory and programmatic changes, vehicle architecture accommodations and prioritization of technology development.
- Enable key partnerships between End Users and technology providers on an individual and working group level.
- Formulate Working Groups from participants with common interests to identify and clarify their key common interests and formulate forward planning and potential projects. Life-cycle return on investment, Safety, Security and Mission Success are other primary drivers for working together. Leadership, purpose, products and membership are key initial objectives.
- Identify and enable proposed CANEUS FBW Projects which CANEUS membership dues are used to prepare and coordinate. These projects are then funded by a project unique routes and methods by both participating CANEUS and outside organizations.

Below is a list of potential topics at this Workshop:

- Next Generation Micro-Wireless Instrumentation
- Active/Passive RFID sensing & RF Sensor-Tags
- Wireless On-board Commercial Aircraft
- Wireless Avionics Plug-n-Play Spacecraft
- Wireless for Launch Vehicles
- Wireless for Small Space Vehicles
- Wireless Engine Controls and Instrumentation
- Vehicle Architecture Provisions/Design Sys Eng
- Wireless Flight Control/control augmentation
- RF Interference Countermeasures
- Wireless Aircraft Flight Test Beds

- Wireless Ground and Flight Test Systems
- “Fly-by-Wireless” Strategic Planning
- Wireless & Less Wire TRL Assessment
- Life-cycle Cost-benefits/Lessons Learned
- Commonality with other industries
- Wireless/Connectorless Avionics Power
- Nano-tech Implications/applications
- Wireless IVHM/Prog Health Monitoring
- Wireless Standards/Interoperability
- Vertical Take-off Vehicles
- Unmanned Aerial & Surface Vehicles
- Large Area Composite Health Monitor
- FPGA/ASIC Enabling Technologies
- Wireless Habitats/Habitable Vehicles

# 10.2 Implementation Plan/Roadmap

## Mission

The CANEUS Fly-by-Wireless Sector Consortium is chartered to provide a platform for cooperation and partnerships between industry/government customers, system integrators, and technology developers, while exchanging public and published information on the state-of-the-art wireless alternatives and new innovations. Ultimately, the Consortium's efforts will contribute to minimizing cables and connectors across the aerospace industry by providing reliable, lower cost, and higher performance alternatives for a vehicle's or program's life cycle.

## Vision

Aerospace vehicle programs have always relied on the cables and connectors to provide power, grounding, data and time synchronization throughout a vehicle's life-cycle. Even with numerous improvements, wiring and connector problems and sensors continue to be key failure points, causing many hours of troubleshooting and replacement. Costly flight delays have been precipitated by the need to troubleshoot cables/connections and add or repair a sensor. Even with the weight penalties, wiring continues to be too expensive to remove once it is installed. Miles of test instrumentation and low flight sensor wires still plague the Aerospace industry. New technology options for data connectivity, processing and micro/nano manufacturing are making it possible to retrofit existing vehicles like the Space Shuttle. New vehicles can now develop architectures that provide for and take advantage of alternate connectivity to wires.

This project motivates the aerospace industry and technology providers to establish:

1. A new emphasis for system engineering approaches to reduce cables and connectors
2. Provisions for modularity and accessibility in the vehicle architecture
3. A set of technologies that support alternatives to wired connectivity

## Objectives

Establish an international forum through the CANEUS Organization to provide a transition path for state-of-the-art wireless technologies at lower maturity levels by:

- Promote understanding of the maturity and capability of alternatives to wired infrastructure, such as no-power instrumentation, standalone wireless data acquisition and processing systems, and wireless control redundancy improvements, in order to facilitate timely vehicle architecture accommodations and prioritize technology development;
- Identify solution paths for key challenges such as FAA regulations, certification requirements, RF interference, structural design and access and spectrum management;
- Quantify the life cycle return on investment or mission need for various applications and opportunities to establish which investments and partnerships are most likely to succeed;
- Identify and enable key partnerships toward implementing “Fly-by-Wireless” (FBW) in Aerospace vehicles where the market shows the highest payback; develop project plans for technology maturation, and put in place the architecture and infrastructure that supports incremental implementation of anticipated technological advancements;
- Provide advocacy for its members and foster the advancement and increased use of MEMS and Nano Technology toward the expansion of the FBW market;
- Be the world’s catalyst for the FBW industry to bring breakthrough (disruptive) technologies to the Aerospace and space sectors by ensuring aerospace qualification, reliability, lower cost and added value;
- By setting a global direction, create opportunities for the flexible collaboration and conduct of strategic research and development (R&D) so as to yield a significant return on investment (ROI) to the FBW industry partners.

## Strategy

At the upcoming CANEUS 2009 Workshops at NASA-Ames, March 1-6, we envision that the FBW sector Director will hold ad hoc voting on all previously proposed and newly (during the sector meetings) proposed FBW projects to lead the working body to a forced-consensus on additional activities to be funded. Each potential FBW Project will be scored and weighted-by-agreement by the participants. Afterward, each newly formed working group, as part of the FBW Sector Consortium, will generate an initial plan and outline a roadmap for each specific, agree-to project and seek confirmed participation. From these, a detailed plan and roadmap will be constructed by the CANEUS FBW Sector participants, led by the Consortium Director, over the following calendar quarter.
Templates for Roadmap and Timeline Development during the Workshop
Roadmaps and Timelines are to be developed for both short-term and long-term objectives.

Template: Overall Long-Term Roadmap for Composite FBW Initiatives Implementation:

| **Fly-by-Wireless Project "N"** | $t_0$ | $t_0$ + 1 yr | $t_0$ + 2 yr | $t_0$ + 3 yr | $t_0$ + 4 yr |
|---|---|---|---|---|---|
| *End-Users Initiative Implementation Plan* | | | | | |
| *Technology Developers Initiative Implementation Plan* | | | | | |
| *Standards & Guidelines Initiative Implementation Plan* | | | | | |
| *Other (TBD) Implementation Plan* | | | | | |
| *Other(TBD) Implementation Plan* | | | | | |

Template: Overall Short-Term Roadmap for Composite FBW Initiatives Implementation:

| **FBW Activity** | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2-1 | | | | | |
| 2-2 | | | | | |
| 2-3 | | | | | |
| 2-4 | | | | | |

Deliverables:

1. Available pieces of information and gaps
2. Action plan to fill the gaps (with budget)

After one year, the action plans from Consortium Users and Developers may be compared and CANEUS Scientific Committee may choose and decide on further actions. After one year, one may assess whether steps have been made forward.

Template: Short-Term Roadmap for EACH FBW Initiative Implementation:

| **Fly-by-Wireless Project "N"** | $t_0$ | $t_0$ + 4 mo | $t_0$ + 6 mo | $t_0$ + 8 mo | $t_0$ + 12 mo |
|---|---|---|---|---|---|
| *End-Users Initiative Implementation Plan* | | | | | |
| *Technology Developers Initiative Implementation Plan* | | | | | |
| *Standards & Guidelines Initiative Implementation Plan* | | | | | |
| *Other (TBD) Implementation Plan* | | | | | |
| *Other(TBD) Implementation Plan* | | | | | |

# 10.3 Projects

10.3.1 Less-Wire Technologies

10.3.2 Structural Vehicle Health Monitoring (SVHM)

10.3.3 Sensor-DAQ

10.3.4 Passive Sensor-TAG System

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10.3.6 _____

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10.3.10 _____

## 10.3.1 Less-Wire Technologies

**Objective:** To realize mature MNT and "Less-Wire" technologies, devices and systems coupled with new methods in systems engineering processes, management and engineering techniques that utilize wireless interconnectivity.

**Background:** Future aircraft and spacecraft simply cannot continue following the historical exponential rise in wiring complexity and mass as they have been doing for the past 30 years. As avionics, data handling and command and control elements become more intelligent, capable, and complex, yet increasingly dense and miniaturized; following mere convention in point-to-point wiring, in lieu of a multi-drop or networked design for literally thousands upon thousands of measurement and control points is sheer folly. There is need of new concept wired "Less-Wire" architectures development, both separately, as well as in concert with wireless command and control.



## CANEUS FLY-BY-WIRELESS APPROACH

The Aerospace community overwhelmingly accepts the premise that wireless technologies are a part of the solution to these challenges. However, the diversity of likely use cases, along with significantly varying wireless technologies' complexities, diversity of needed performances, and very often severe environmental requirements, impose a multitude of constraints and difficult-to-achieve needs upon these devices and systems.

The Consortium considers the referenced four FBW Projects as key elements within the CANEUS purview, composed of activities:

- Identifying user needs and technology providers;
- Reviewing the current state of the art w.r.t the four identified projects;
- Matching users (those with needs) with providers (technology, intellectual property, capability);
- Mapping this need-supplier matching to specific new technologies or devices to develop
- the specific Project Plan;
- Folding the specific project into the envisioned strategic CANEUS FBW portfolio and Strategic
- Plan.

## 10.3.2 Structural Vehicle Health Monitoring

### Mission & Vision Statement:

### Background:

Aging aircraft and perhaps more importantly new aircraft and spacecraft, increasingly employing composites, gossamer or lightweight structures, advanced metallurgies, in new, conventional and increasingly in harsh environment applications, require revised approaches to Structural Health Monitoring. These additional equipment, material and structure monitoring, diagnostics and prognostics require a higher order of magnitude in complexity, scope and in the sheer numbers of sensing elements. The Aerospace community overwhelmingly accepts the premise that wireless technologies are a part of the solution to these challenges. However, the diversity of likely use cases, along with significantly varying wireless technologies' complexities, diversity of needed performances, and very often severe environmental requirements, impose a multitude of constraints and difficult-to-achieve needs upon wireless VSHM.

## 10.3.3 Sensor-DAQ

### Mission & Vision Statement:

To realize mature MNT and Wireless Sensor - DAQ Micro-Miniaturization technologies, devices and systems coupled with new methods in systems engineering processes, management and engineering techniques that utilize wireless interconnectivity.

### Vision Statement Elaboration:

New designs of aircraft and spacecraft require large amounts of data gathering for in-flight validation. The precursors to these normally-flown onboard, highly miniaturized and wirelessly enabled DAQ systems may be termed Low Mass Modular Development Flight Instrumentation Systems (LMMDS). This Vision Statement is intended to identify Low Mass Modular Development Flight Instrumentation Systems (LMMDS) that can provide the capability to optimize the number and quality of measurements made per flight at a reduced life cycle cost as compared to conventional data gathering systems.

This, as a potential CANEUS project, focuses on low mass, highly modular, non-critical flight data gathering and processing technology that could be integrated into upcoming development tests as well as the operations of future aircraft and aerospace vehicles.

Development Flight Instrumentation Systems (DFI), are systems intended to collect data which is primarily intended for validation of vehicle systems, environments and operations and models/assessments of them.  DFI data may be relied on for critical analyses/decisions for future flight tests and missions but will not be used directly for critical decisions on the mission they fly on. DFI systems may also be thought of as precursor / prototype systems and their mission performance a validation or technology readiness level step towards the system use in more critical applications.

Sensor Applications: - Vehicle systems / structure - Environments - Crew/Ops - Flight Tests / Payloads / possibly experiments - System Growth: - Capability to increase the number of sensors or system applications - Sensor installation interfaces: - From Non / Velcro to Bond-on / Embedded - Sample Rates: - From very high to very low - Mission Data transmit needs: - None to very high (short bursts) - DAQ Complexity: - Continuous sample-store to Triggered / Scheduled / Commanded - Data will have to be recorded either by LMMDS or through interface with vehicle recording capability - DAQ Types Supported: - Passive Tag interrogators to multi-channel systems with synchronization provided by the network of DAQ / Loggers themselves - integrated with or separate from the vehicle - Sensor type: - From sensors that could be matured for use in safety critical applications to sensors that could support science experiments onboard spacecraft- Data Processing / Reduction: - From none to summary data files to answers at the DAQ - Data Synchronization: - Data from LMMDS will be time synchronized as needed - System life: - Ranges from short (e.g. pre-launch / pre-take-off events) to long (e.g. contamination or deterioration sensing over the life of the vehicle).

Technology Objectives: The following list shows some examples of these technologies, but is by no means intended to be an exhaustive list. (1) Micro-size and minimum weight, including connectivity.

(2) Very low power, low maintenance, long-life between servicing. (3) Least number of wires/connectors required, including wireless or no connectivity. (4) Minimum integration and operations to achieve for modularity. (5) Smart DAQs with User Specifiable calibration, scheduled and even-triggered modes. (6) Smart DAQs with Processing / Storage allowing reduction of total data transfer. (7) Robust/Secure Wireless networking and synchronization between DAQs and even between sensor and DAQ. (8) Plug-and-play wireless interoperability. (9) Plug-and-play DAQ to avionics integration. (10) Open architecture standards to promote multiple vendors with competitive solutions. (11) Wide variety of data acquisition rates - 1 sample per hour to 1 mega-sample / sec (12) Robustness with respect to projected environments. (13) Wide variety of sensor types, including: temperature, dynamic and quasi-static acceleration, dynamic and static strain, absolute and dynamic pressure, high rate acoustic pressure, calorimeters, dosimeters, radiometers, shock, air flow, various hand-held sensors etc.

## 10.3.4 Passive Sensor-Tag System

### Mission & Vision Statement:

To realize mature MNT and Passive Wireless Sensor Tag technologies, devices and systems coupled with new methods in systems engineering processes, management and engineering techniques that utilize wireless interconnectivity.

**Background:** Aging aircraft and perhaps more importantly new aircraft and spacecraft, increasingly employing composites, gossamer or lightweight structures, advanced metallurgies, in new, conventional and increasingly in harsh environment applications, require revised approaches to Structural Health Monitoring. These additional equipment, material and structure monitoring, diagnostics and prognostics require a higher order of magnitude in complexity, scope and in the sheer numbers of sensing elements. The Aerospace community overwhelmingly accepts the premise that wireless technologies are a part of the solution to these challenges. However, the diversity of likely use cases, along with significantly varying wireless technologies' complexities, diversity of needed performances, and very often severe environmental requirements, impose a multitude of constraints and difficult-to-achieve needs upon Passive Wireless Sensor Tags.

Passive Sensor Tags Utilizing SAW Technology:
Surface Acoustic Wave (SAW) tags do not contain a battery or an IC chip. The tags are completely passive, and transmit information simply by reflecting energy back to the reader. SAW tags have no memory but can be interrogated at far lower received power levels (hence far longer ranges) than IC-based tags. In addition, the tags have some inherent sensing capabilities. The operation of a SAW tag is illustrated in Figure 1.

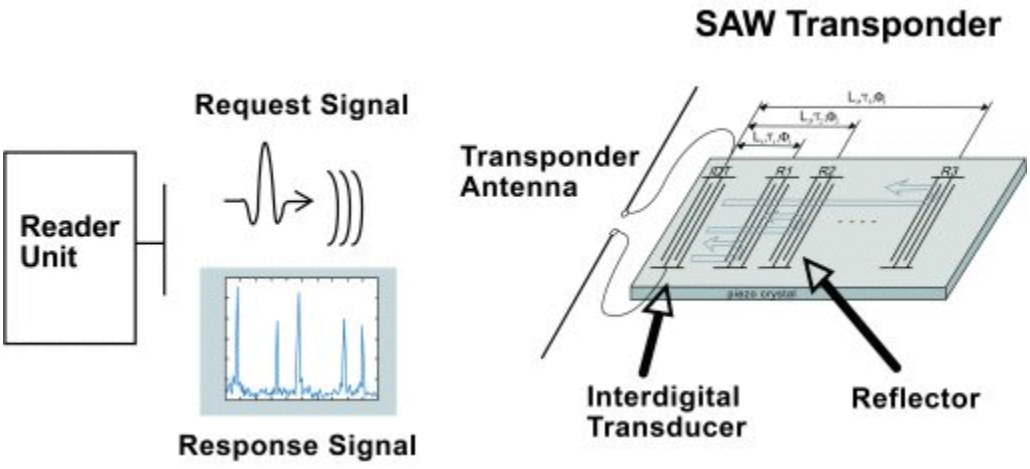


Figure 1

As the figure indicates, a pulse transmitted by the reader is received at the tag antenna and converted into an acoustic signal by the inter-digital transducer (IDT) connected to the antenna. The acoustic signal propagates as a compression wave along the surface of the piezoelectric tag substrate and is partially reflected back to the IDT at each of the reflectors etched onto the substrate. When the reflected pulses reach the IDT, they are converted back into electrical signals and re-radiated from the antenna as a sequence of pulses that constitutes the impulse response of the tag. The relative timing and/or phase of the sequence of reflected pulses encodes the ID of the tag and is determined by the position and reflection coefficient of each of the tag reflectors.

The impulse response of a SAW tag changes in response to both the temperature of the tag and the stress on the tag substrate. Hence, the tag can be used to sense both temperature and stress. The temperature sensing modality is common as well as strain modality.
The temperature of a SAW-based Passive Sensor Tag can be estimated by direct measurement of the time dilation (or contraction) of the tag impulse response. In an alternate manner, strain may be accurately determined.



This initiative aims to focus on developing a many-channelled system that requires no wires with applications for the commercial aircraft fleet based on perceived high market demand in non-aerospace fields. It aims to increase accessibility of data acquisition while reducing the cost of system test and verification, increase passive sensor performance by enabling high frequency readout, and decrease parasitic effects and assembly challenges for a variety of applications, including traffic, biomedical, and automotive sensors.

**Additional Projects could include:**

1. Next Generation Micro-Wireless Instrumentation*
2. Active/Passive RFID sensing & RF Sensor-Tags*
3. Wireless On-board Commercial Aircraft
4. Wireless Avionics Plug-n-Play Spacecraft Power
5. Wireless for Launch Vehicles
6. Wireless for Small Space Vehicles
7. Wireless Engine Controls and Instrumentation
8. Vehicle Architecture Provisions/Design Sys Eng
9. Wireless Flight Control/control augmentation
10. RF Interference Countermeasures
11. Wireless Aircraft Flight Test Beds
12. Wireless Ground and Flight Test Systems
13. “Fly-by-Wireless” Strategic Planning
14. Wireless & Less Wire TRL Assessment*
15. Life-cycle Cost-benefits/Lessons Learned
16. Commonality with other industries
17. Wireless/Connector-less Avionics
18. Nano-tech Implications/applications
19. Wireless IVHM/Prognostics Health*
20. Wireless Standards/Interoperability
21. Vertical Take-off Vehicles
22. Unmanned Aerial & Surface Vehicles
23. Large Area Composite Health Monitor
24. FPGA/ASIC Enabling Technologies
25. Wireless Habitats/Habitable Vehicles

* Initiated

# Appendix

**CANEUS Fly-by-Wireless Sector Consortium**
**WORKSHOP, NASA-AMES**

The two-day Fly-by-Wireless portions of the Ames workshop sessions may be organised the following way:

## Fly-by-Wireless Sessions

Session 1:
Third half-day: Wednesday Afternoon
MISSION GOALS and ROADMAP

- Introduction by FBW Sector Consortium Director, Rodger Magness
- Brief comments on the upcoming CANEUS Fly-by-Wireless Workshop, Montreal
- Briefly present each of the four the above projects (10 minutes each by 4 Champions)
- Discuss these four projects - vote on variant to pursue for each (reach a consensus)
- Session 1 ends with a direction agreed upon for each of the four projects

Session 2:
Third half-day: Wednesday Afternoon
DEVELOPMENT and FRAMEWORK

- Keep on discussing, refine target project objectives, scope
- Identify key steps and milestones
- Identify users
- Identify technology providers if possible
- Confirm the Project Champion
- Develop the initial Technical Roadmap
- Develop the Timeline
- Define Deliverables (generally)
- Confirm Project / WG Participants
- FBW Session 2 ends with very rough drafts of these

## SHM Sessions

Session 1:
Fourth half-day: Thursday Morning
MISSION GOALS and ROADMAP

- Introductions by FBW Consortium Director and SHM Lead, Robab, Safa-Bakhsh
- Briefly present each of the projects (10 minutes each by SHM Champion)
- Discuss these projects - vote on variant to pursue for each (reach a consensus)
- Session 1 ends with a direction agreed upon for the project

Session 2:
Fourth half-day: Thursday Morning
DEVELOPMENT and FRAMEWORK

- Keep on discussing, refine target project objectives, scope
- Identify key steps and milestones
- Identify users
- Identify technology providers if possible
- Confirm the Project Champion
- Develop the initial Technical Roadmap
- Develop the Timeline
- Define Deliverables (generally)
- Confirm Project / WG Participants
- Wireless SHM Session 2 ends with very rough drafts of these

Session 3:
Last half-day: Friday Morning
ROADMAP REFINEMENT, TASKS, RESPONSIBILITIES and TIMELINE

- Formal agreement to launch the updated / modified Work Plan
- Generate List : Points of Contact

Session 4:

Last half-day: Friday Afternoon

FLY-BY-WIRELESS RPORT

- Overall FBW Report by FBW Sector Consortium Director
- Sub-groups presentations by initiative
- Present Work Plan and work share for each initiative

## 10.3.5_____

## 10.3.6

## 10.3.7

## 10.3.8_____

## 10.3.9_____

## 10.3.10_____

## 10.4 Implementation Plan/Roadmap Revisions

# 10.5 CANEUS Proposed Work Program Project List

## 10.6 Action Plan

## 10.7 Workshop Report

# 11.0 Materials Sector Consortium

## Sector Consortium Session Guidelines

Dear Colleagues,

On behalf of the CANEUS 2009 Planning Committee, thank you for accepting our invitation to be a panellist at the CANEUS 2009 Workshops! Here are some CANEUS guidelines for your role.

Each Sector Consortia has two sessions: 1) Mission Goals & Roadmap, and 2) Project Development and Framework. Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. I have taken the liberty of placing you on a panel according to my understanding of your expertise: however if you would prefer to be in a different panel, please alert me immediately and I will have your position changed. You are currently scheduled in the Materials Consortium. This mission of this consortium is:

- Identify the main technological roadblock (or gaps) and possible solutions to overcome them
- Build demonstrator prototypes of integrated devices using the multifunctional (meta)material of choice
- Suggest a metric to measure the real technological and economic impact of the novel materials proposed Identify and design multifunctional materials and materials systems (heterostructures, composites, metamaterials), especially micro- and nanostructured ones, which will lead to miniaturization of various devices by combining various functionalities, while at the same designed to withstand the harsh high altitude & outer space environments

The visions and objectives of the Materials Consortium are as follows:

- Plays a pivotal role among the CANEUS consortia in that it will support and provide advanced materials solutions for various areas such as micro-and nano-satellites, structural health monitoring, fly-by-wireless, bioastronautics and energetics (including micropropulsion)
- Will focus on high-risk, high-reward materials development with a special emphasis on smart, multifunctional materials and structures for the aerospace sector.
- Will bring together materials scientists spanning a range of disciplines and will be conducted in close collaboration with end-users in the aerospace sector.
- Will co-ordinate the materials R&D in a rigorous and structured framework with clear objectives, milestones and a timeframe, in response to the needs of the end-user.
- Will, through CANEUS, seek adequate funding for each of these projects, given the high cost associated with the design and manufacture of materials at the micro- and nano-scale.
- In addition to developing new materials, create, as research progresses, an expert database containing structure-property relationships of micro and nanostructured materials, as well as who and where to find the related expertise. [The Material Sector Consortium expert database of identified

functional materials and related technical and scientific expertise will be part of a larger relational database fed by each Sector Consortium]

- Help develop an academic concentration in aerospace/MNT materials within an existing materials science degree program at INRS. This program one piloted and tested at INRS can be extended to other institutions.
- Offer an aerospace materials program as part of the summer school offering at the International Space University.
- Create a co-op study program for students in materials science to pursue internships at participating space agencies and aerospace companies.
- Create alliances with other key aerospace organizations such as CRIAQ (CREER) to gain visibility and reach out to end-users.Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Your sessions are scheduled for **Wednesday, March 4th in the afternoon**, followed by a project refinement session on Friday.

If you are a panellist scheduled for the **Roadmap** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

## Mission Goals & Roadmap

Objective of session: The goal is for participants to create and/or formalize the mission, goals, and roadmap for your CANEUS Sector Consortium for the next three years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities and achievements.

## Roadmap Refinement

Objective of session: Participants in this session will specify tasks and assign responsibilities with timelines to execute the Roadmap.

The role of panellists in both of these sessions is to lend your expertise and experience in visualizing the future of the industry, providing your perspective on what the goals and roadmap should look like, and identifying the milestones needed to implement the roadmap.

Should you require anything, whether it be pens, pointers, papers, presentations or panellists, please contact Lauren Thomas (CANEUS International) as your main point of contact.

If you are a panellist scheduled for the **Project** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

## Project Development & Framework

Objective of session: Two to three invited participants will present a project currently being undertak-

en within their organization. A general project plan coherent with the roadmap outlined in the previous Roadmap session will be drafted (6 months, 1 year, 2 years). Participants will address business development issues, such as NDA, IP, and government regulations.

## Project Refinement

Objective of session: Participants will refine the projects previously reviewed: participants will outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the project.

The role of panellists in both of these sessions is to lend your expertise and experience and evaluate the projects presented, and provide comments as to their improvement, feasibility, etc.

# 11.1 Background

## 11.1.1 Consortium Profile

### Director and Coordinator:

ALAIN PIGNOLET, INRS CANADA (TBC)

### Sub-Discipline Chair:

Micro-Energetics:
Eugene Zakar, U.S. Army

Micro-Hydrogen Storage:
Johan Koler, ESA

### Participants:

Chuck Smith, NASA; Les Lee, AFOSR; Katie Weihong, University of Washington and Boeing; Max Lake, APSCI; Osman Levent Eryilmaz, Argonne National Laboratory; Ozden Ochoa, ASC; Karla Strong, AFRL (TBC); Suraj Rawal, LMCO; Mia Siochi, NASA; Jim Arnold, NASA Ames; Michael Meador, NASA Glenn; Amish Desai, Tanner Research; Demetris Lagoudas, Texas University; Sylvia Johnson, NASA Ames; Abdel Abusafieh, Cytec; Wei Jun, SIMTech; Robert Plana, LAAS; Mohan Aggarwal, Alabama A&M University; Deepak Srivastava, NASA Ames; Carlos R. Cabrera, University of Puerto Rico at Río Piedras; Jacques Lyrette, Innovative Materials ; Ali Shakuri, UC Santa Cruz; Federico Micculla, Uni. Roma La Sapienza ; Stefano Bellucci , Isituto Nazionale di Fisica Nucleare ; Linruo Zhao IAR-NRC; Peter Lillehei, NASA Langley; Matt Gasch, NASA Ames; Steve Winzer, Lockheed Martin; Raj Venkatpathy, NASA Ames ;Alan Cassel, NASA Ames; Anthony Calomino, NASA Ames

### Presenters:

Alain Pignolet, INRS Quebec (TBC)
Eugene Zakar, U.S. Army
Representative for Johan Koler, ESA

## 11.1.2 Activity Update

### Introduction:

At the CANEUS 2006 Conference in Toulouse, France, the Nano-Composite Materials Pilot Project was led by Les Lee of US AFOSR and Deepak Srivastava of NASA. CANEUS created three concept papers on nano-composite materials for load-bearing applications, nano-composite materials for thermal protection and MNT embedded composite materials. Based on these concept papers in 2006, the Materials Sector Consortium was formed.

### Past Activities:

Nano-Composite Materials and Micro-Energetics Pilot Projects at the CANEUS 2006 Conference in Toulouse, France: August 27-September 1, 2006

The Nano-Composite Materials workshop at the CANEUS 2006 Conference in Toulouse, France, addressed the creation of a business case for an advanced nano/bio-sensor fabrication platform using "Fountain Pen" Nanolithography, based on Scanning Probe Lithography (SPL). This novel Nanolithography technique is a flexible and cost-effective method for integrating microfluidics with nano-fabrication, thus combining both top-down and bottom-up paradigms. The sensor components can be made up of soft materials (e.g., bio-polymers, functional molecules, etc.) and hard materials (e.g., metals, opto-electronic materials, etc.). This concept addresses a critical need for aerospace systems, namely for rapid materials and devices prototyping at nano-scales, and will lead to rapid adoption by the aerospace industry once successfully demonstrated.

The overall objective of the Micro-Energetic Pilot Project Workshop was to examine the feasibility of setting up a for-profit company to develop Micro and Nano Technology (MNT) products for power generation and micro propulsion applications in close collaboration with end-users in Aerospace industry, defense related sciences, and civilian applications. Participants at the workshop discussed enabling and disruptive technologies, and business opportunities leading to a pilot project for developing the MNT-based micropropulsion and micro batteries for Aerospace and defense applications.

### Upcoming Activities:

The first Materials meeting is proposed to be held in summer 2009.

At the CANEUS 2009 Workshop, the Materials Sector Consortium expects to identify specific projects and create a roadmap with which to pursue these projects.

# 11.2 Implementation Plan/Roadmap

## Mission

- Identify and design multifunctional materials* and materials systems (heterostructures, composites, metamaterials), especially micro- and nano-structured ones, which will lead to miniaturization of various devices by combining various functionalities, while at the same time designed to withstand the harsh high altitude & outer space environments
- Identify the main technological roadblock (or gaps) and possible solutions to overcome them
- Build demonstrator prototypes of integrated devices using the multifunctional (meta) material of choice
- Suggest a metric to measure the real technological and economic impact of the novel materials proposed

* Examples of such multifunctional composite structures include:

- Structure Power Composites such as the Lithium Battery Core Program jointly developed by the AFRL/VS and ITN Energy Systems Inc.
- Thermal protection/radiation protection combined with actuation in the Chameleon spacesuit from Hamilton Sundstrand Space System International [Gravitational and Space Biology Bulletin 16(2),p 107-119, June 2003]

## Vision and Objectives

- Play a pivotal role among the CANEUS Consortia in that it will support and provide advanced materials solutions for various areas such as micro-and nano-satellites, structural health monitoring, fly-by-wireless, bioastronautics and energetics (including micropropulsion).
- Will focus on high-risk, high-reward materials development with a special emphasis on smart, multifunctional materials and structures for the Aerospace sector.
- Will bring together materials scientists spanning a range of disciplines and will be conducted in close collaboration with end-users in the Aerospace sector.
- Will co-ordinate the materials R&D in a rigorous and structured framework with clear objectives, milestones and a timeframe, in response to the needs of the end-user.
- Will, through CANEUS, seek adequate funding for each of these projects, given the high cost associated with the design and manufacture of materials at the micro- and nano-scale.
- In addition to developing new materials, create, as research progresses, an expert database containing structure-property relationships of micro- and nano-structured materials, as well as who and where to find the related expertise. The Material Sector Consortium expert database of identified functional materials and related technical and scientific expertise will be part of a larger relational database fed by each Sector Consortium.
- Help develop an academic concentration in Aerospace/MNT materials within an existing materials science degree program at INRS. This program, once piloted and tested at INRS, can be extended to other institutions.
- Offer an Aerospace Materials Program as part of the summer school offered at the International Space University.
- Create a co-op study program for students in materials science to pursue internships at participating space agencies and Aerospace companies.
- Create alliances with other key Aerospace organizations such as CRIAQ (CREER) to gain visibility and reach out to end-users.

# Strategy

Workshop Handout

## 11.3 Projects

11.3.1 Micro-Energetics

11.3.2 Thermal Barrier

11.3.3 Hydrogen Macrospheres

11.3.4 _____

11.3.5 _____

11.3.6 _____

11.3.7 _____

11.3.8 _____

11.3.9 _____

11.3.10 _____

## 11.3.1 Micro-Energetics

### Mission & Vision Statement:

The Micro-Energetics sub-discipline seeks to develop Micro and Nano Technology (MNT) products for power generation and micro propulsion applications. Members discuss enabling and disruptive technologies and business opportunities for MNT-based micro propulsion and micro batteries for Aerospace and defense applications.

### Objectives:

1. Identify lessons learned and maturity of emerging MNT concepts.
2. Address critical challenges, leverage enabling technologies to speed the development of products.
3. Lead in the development of functional and performance standards for MNT.

### Goals:

1. Create opportunities for rapid and cost-effective manufacturing technologies.
2. Seek useful energetic material forms on length scales 1nm to 1mm.
3. Motivate synthesis, assembly, and understanding of energetic materials in small dimensions.
4. Promote the development of methodologies leading to safe processing, storage, and handling of Micro-Energetics.
5. Foster the development of green end-user integrateable energetic materials.

## 11.3.2 Thermal Barrier

### Mission & Vision Statement:

The concept being proposed in this submission involves the tailoring of coatings to produce a bimodal structure consisting of zones of nano-structured material encompassed by a micro-structured matrix of the same composition.

The scale of the porosity in these two types of zones is similar to the scale of the material structure (nano or micro) within which the porosity is located. The enhanced sinterability of the nano-structured zones is used to advantage in that, at higher temperatures, differential sintering occurs due to the differences in the sintering rates between the zones of the two types of structures. Under such conditions the nano-structured regions shrink away from the coarser structured regions, thereby replacing some of the fine-scale pores with a new class of larger pores.

This process provides a sintering-tolerant material and imparts a degree of stability to the properties of the coatings. Investigations on ultra-stabilized zirconium coatings produced by thermal spray processing have shown that following exposure at 1400°C values for both the thermal properties (thermal conductivity) and the elastic properties (Young's modulus) were only one-half those observed for typical TBCs currently in use on aero engines. The trends also indicated a projected lower rate of increase in these properties over extended time periods.

### 11.3.3 Hydrogen Macrospheres

**Mission & Vision Statement:**

The Micro Mechanical Hydrogen Storage in MacroSpheres is a novel highly efficient concept for transport and storage of hydrogen gas suitable for small quantities as well as for very large quantities. The system can very well be an answer to the Hydrogen Storage problem and an important stepping stone towards the Hydrogen Society.

Two ideas form the MacroSphere concept, the distributed tanks idea and the integrated gas handling chip idea. Advanced Micro System Technology (MST) is the key enabling element in the gas handling chip. Hydrogen is stored under high pressure in a large number of small autonomous sub-tanks, the MacroSpheres. The difference between internal and external pressure controls the gas flow to or from the MacroSpheres. A gas handling micro chip is mounted inside each sub-tank. The system combines the best storage performance available with focus on a convenient and non-dramatic handling for the user.

## 11.3.4

## 11.3.5_____

## 11.3.6

## 11.3.7_____

## 11.3.8_____

## 11.3.9_____

## 11.3.10_____

## 11.4 Implementation Plan/Roadmap Revisions

# 11.5 CANEUS Proposed Work Program Project List

## 11.6 Action Plan

# 11.7 Workshop Report

# 12.0 Reliability Sector Consortium

## Sector Consortium Session Guidelines

Dear Colleagues,

On behalf of the CANEUS 2009 Planning Committee, thank you for accepting our invitation to be a panellist at the CANEUS 2009 Workshops! Here are some CANEUS guidelines for your role.

Each Sector Consortia has two sessions: 1) Mission Goals & Roadmap, and 2) Project Development and Framework. Each session is 75 minutes in length (please refer to Workshop Schedule 2.0 for details), and has one chair, 3-10 panellists, and a few presenters. I have taken the liberty of placing you on a panel according to my understanding of your expertise: however if you would prefer to be in a different panel, please alert me immediately and I will have your position changed. You are currently scheduled in the Reliability Consortium. The CANEUS International Reliability Sector Consortium is the steward of the aerospace industry's strategic and technology roadmap for reliability technologies. It provides an international forum for the advancement of reliability issues and technical solutions. It is open to participation from the global aerospace industry. Membership in the Consortium includes all the primary industry stakeholders.

The Consortium also acts as the broker for licensing intellectual property jointly developed by its collaborative consortia. System integration efforts focus on the development of the appropriate supply chain organizations. The Consortium is the premier advocacy group addressing regulations and the development of standards and certification requirements for RF and other MEMS devices. It manages an industry portal for members' technologies.

Panelists will attend either one or both of the following sessions (refer to Programme for further details).

Your sessions are scheduled for **Wednesday, March 4th in the afternoon**, followed by a project refinement session on Friday.

If you are a panellist scheduled for the **Roadmap** sessions of your Sector Consortium, the CANEUS 2009 Planning Committee requests your participation in two sessions:

### Mission Goals & Roadmap

Objective of session: The goal is for participants to create and/or formalize the mission, goals, and roadmap for your CANEUS Sector Consortium for the next three years. Participants will specify the scope of work and the vision of both the short and long-term activities of the Consortium. The chair of the session will provide a brief overview of the Consortium's past activities and achievements.

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The role of panellists in both of these sessions is to lend your expertise and experience and evaluate the projects presented, and provide comments as to their improvement, feasibility, etc.

# 12.1 Background

## 12.1.1 Consortium profile

### Director and Coordinator:

BRUNO FOUCHER, EADS

### Radiation Chair:

Oudea Coumar, EADS

### Participants:

Jean-Claude Tual, Astrium; Bill Atwell, Boeing; Francis Pressecq, CNES; Alan Scott, Comdev; Wanping Zheng, CSA; Remi Gaillard, EADS; Laurent Marchand, ESA; Raffaella Borzi, IMEC; Bruno Levrier, IMS Bordeaux; Robert Plana, LAAS; Rajeshuni Ramesham, NASA JPL; Dean Wiberg, NASA-JPL; Alan Johnson, NASA-JPL, Jeffrey DeNatale, Rockwell Scientific; Sammy Kayali, Sandia; Ernest Garcia, Sandia; Claude Drevon, Thales Alenia Space; Wanping Zheng, CSA; Laurent Francis, UCL

### Presenters:

Remi Gaillard, EADS; Earnie Garcia, Sandia; Bruno Foucher, EADS

## 12.1.2 Activity Update

### Introduction:

To date, efforts regarding MNT reliability, particularly failure mechanism, physics of failure, tests of each mode, and standardization, have been primarily ongoing within several organizations in Europe, USA, Canada, Japan, Taiwan, Korea, Brazil and elsewhere. This effort, however, needs to be based on a global consensus.

### Past Activities:

**MNT Reliability for Aerospace Workshop, CNES, Toulouse, France: May 29-30, 2008**

The last MNT Reliability for Aerospace Workshop was held on May 29-30, 2008 at the French Space Agency (CNES) in Toulouse, France.

The vision of the 2008 MNT Reliability for Aerospace Workshop was to address a broad range of issues related to reliability of Micro and Nano-devices and systems for use by the global aerospace industry that increase safety, reliability, and performance while lowering costs throughout their life-cycle. As part of the Sector Consortium's activities, this Workshop encouraged focused collaboration between application and technology development partners in the aerospace industry to implement this vision and reap the resulting advantages.

The 2008 MNT Reliability for Aerospace Workshop aimed to mitigate risk collectively for all participants by investigating various issues such as Standards and Guidelines for Aerospace missions (TRL 5 and higher), Structuring the Roadmap for Space Agencies worldwide, POF (Physics of Failure), and Space radiation effect on MEMS. The two-day meeting represented a crucial step towards creating international standards.

The cross fertilization of inputs from end users, manufacturers, and test, characterization and FA labs will trigger new opportunities for MEMS reliability activities.

Conclusions emphasized the possibility of setting up a worldwide cooperation structure. At the end of the two-day workshop, participants defined:

- The extent of the reliability and testing market for MNT systems
- A list of competitors
- How to build a consortium and how to put together a funding proposal submission

### Upcoming Activities:

Insert Workshop Handout here.

# 12.2 Implementation Plan/Roadmap

## MISSION

The CANEUS MNT Reliability Sector Consortium is chartered with creating and sustaining the entire MNT reliability requirements for aerospace applications. Beginning with a strong participation by MNT developers and worldwide industry stakeholders, the Consortium will establish a robust supply chain to sustain the entire technology development pipeline.

## VISION

The CANEUS International Reliability Sector Consortium is the steward of the aerospace industry's strategic and technology roadmap for reliability technologies. It provides an international forum for the advancement of reliability issues and technical solutions.  It is open to participation from the global aerospace industry. Membership in the Consortium includes all the primary industry stakeholders.

The Consortium also acts as the broker for licensing intellectual property jointly developed by its collaborative consortia. System integration efforts focus on the development of the appropriate supply chain organizations. The Consortium is the premier advocacy group addressing regulations and the development of standards and certification requirements for RF and other MEMS devices. It manages an industry portal for members' technologies.

## OBJECTIVES

MEMS reliability is a key challenge, especially for low volume and high reliability applications in various fields like Space, Aerospace, Defence, and Energy.

The goal of CANEUS' MNT Reliability Sector Consortium is to develop a MNT reliability and testing program with broad applicability for dealing with a diverse set of MNT systems and vendors for these systems.

The Consortium is based on a clear identification of the end-user reliability and radiation tolerance needs, and technical solutions to deal with MEMS design for reliability, virtual prototyping, technology analysis, failure analysis, test, qualification, and system versus component reliability trades.

# Strategy

## Objective:

Develop a risk assessment methodology to assess the capability of MNT for aerospace applications as far as reliability is concerned.
Identify, quantify, and specify the parameters of this methodology.

## Methodology of Strategic Work Plan:

From the objective, one must start with the top-down approach and the associated needs (see the following table). The requirements of aerospace applications are obviously taken into account.

Part I: Top-down approach – gaps

| Objective | Sub-topics | Needs | Examples | Examples of solution providers | **Action needed from CANEUS GAPS** |
|---|---|---|---|---|---|
| Ensure capability & reliability | • Reliability<br>• Functionality<br>• Manufacturability | Demonstrate all 3<br>Define the elements necessary for the demonstration | DO-254-like (and light) | | **Apply DO-254-like (and light) on 2 / 3 examples to define the elements necessary for the demonstration** |
| Address Space radiation effects | | • Identify sources of information<br>• Gather first results<br>• Identify gaps in information | | | |

Once a demonstration (through e.g., DO254-like and –light method) is successful, one may implement MNT on aerospace applications. It is hence important to have access to the elements / parameters which are needed for the demonstration. This will define another list of needs, which may be obtained from a Bottom-up approach (see the following table).

These needs are already taken in charge by networks, companies, technology providers, and universities … All these actors do cover some of them partly, or fully. CANEUS will not do the work again. Rather, CANEUS will play the role of:

1. Listing what is needed for demonstration,
2. Telling whether these parameters are available, where (supplier),
3. And, possibly, explain how to rate suppliers (labelling),
4. Or suggest relevant standards (after analysis),
5. Identify the gaps in the necessary proofs or resources,
6. Prioritize the gaps,
7. Suggest actions (standards, common programmes, …).

Part II: Bottom-up approach - gaps

| Objective | Sub-topics | Needs | Examples | Examples of solution providers | **Action needed from CANEUS GAPS** |
|---|---|---|---|---|---|
| Predict reliability | Reliability assessment tools | TTF assessment tools | PoF models | LAAS, QinetiQ, Epsilon | **Matrix "who knows what"**<br>**How to label suppliers**<br>**Relevant standards (existing or to be created)**<br>**Identification of gaps**<br>**Suggest actions** |
| | | assessment tools | Statistics | | |
| | | Similarity analysis | Test return data base | | |
| | Reliability engineering tools (assessment + DfR) | Technology provider data | FIDES | Eurelnet, Euceman, EuMiRel | |
| | | Knowledge database | REMM | | |
| | Reliability management | Standards | IEEE1312, IEEE1413, IEC62308 | | |
| Assess & Increase reliability | Production stability | Control variation | Test structures for technology providers | LIRMM, NIST | |
| | | Measure variation | Metrology | Süss/Polytec/FhG IZM/Delta | |
| | Analyze failures | | | Novamems<br>EuFaNet | |
| | Screening methodology | Apply and justify accelerated tests on numerous samples | Test procedures<br>Test standards | | |
| | | Virtual qualification based on PoF models & parameter characterization | PoF models for each failure mechanism<br>Material parameter database<br>Product parameter (and variation) database | | |
| | Assess reliability real-time & on-board – assess real life environment | TSMD, HUMS | Midisppi | MEMUNITY | |
| | Field return data base | From qualification, production & tests | | | |

## Advantage:

This plan has an advantage: one may begin to work without spending many resources. This means that results and deliverables are achievable, progress is possible and outputs may be put forward in front of senior executives. This should prove essential to go further.

## Outputs from previous actions:

This section is a reminder of questions and issues that were previously raised during the first workshops on MNT reliability. The section intends to show how the Strategic Work Plan answers these points.

1. How to bring together existing (and various) networks, labs, university dealing with MEMS reliability (August 2006)?
   *Suggested answer today: CANEUS will not bring them together – instead, CANEUS will identify them, their competences and knowledge and create a matrix of "who knows what". The "What" will be the gaps identified towards the demonstration of the capability of MNT to fly (in terms of reliability)*

2. End user requirements: low volume, high reliability, specific products
   *End-user requirements are taken into account into activity two*

3. Proposed pilot project: fully integrated MNT reliability framework: based on an existing cluster, a future company performing reliability and testing services for MNT + world wide database exchange layout
   *The idea of clustering everything together (from characterization to material databases, from Academic teams to NoE, from design software to MNT testing companies and failure analysis labs) may have been too ambitious (Toulouse 2006, Milan 2007)*

4. How to disseminate EU funded data bases (from NoE, from EU project) to third part countries?
   *In the "who knows what" matrix, reliable supplier of knowledge will be identified. It will then be the responsibility of each end-user to take in charge the knowledge transfer (paying fees, exchange information, licensing …). It is not part of CANEUS business. CANEUS may label "knowledge suppliers" to help end-users, no more.*

5. How to share without clear identified funding?
   *This first set of activities does not imply any IP, nor NDA activity. The funding is the companies' own funding and should be reasonably moderate. Further, the outputs are intended to show the management that it is possible to get results, so that we may go further with more developed action plans.*

## 12.3 Projects

12.3.1 MNT End-Users

12.3.2 MNT Technology Developers

12.3.3 Standards and Guidelines

12.3.4 Database and Technology Portal

12.3.5 Space Radiation Effects on MEMS

12.3.6 _____

12.3.7 _____

12.3.8 _____

12.3.9 _____

12.3.10 _____

## 12.3.1 MNT END-USERS

**Activity one: identify acting partners (CANEUS members)**

PoC should be nominated for Europe, USA, Japan, Brazil, and Canada. Consortium Director and PoC will constitute the Consortium Committee (CC-U). PoC will identify the needs (or PoC for needs), who may run a DO254-like (and –light) demo on MEMS to give the list of necessary pieces of information. For example, Airbus (J.-P. Daniel), and EADS ST (O. Coumar).

**Activity two: find the parameters which are needed for a DO254 demo**

End-users will run a DO254-like (and –light) demo for one MNT each. The more demos, the more pieces of information, we will get. Members will do that step on their own budget. They will not share information at system level, but only the outputs at reliability level. We are not interested in the system where they intend to implement MNT. We are rather interested in the pieces of information they require from the MNT supplier to allow the implementation.

**Activity three: identifying the network of actors, their specificities, competences and knowledge**

The CC-U will identify the actors and clarify their activity. CC-U will identify where the information is already available from whom:

1. Identify existing projects,
2. Clarify activity of networks,
3. Identify technology providers,
4. Identify Universities,
5. List knowledge and competences fields,
6. List existing standards.

The deliverable is the “who knows what” matrix.
In order to prepare further steps, CC-U will identify the possibilities of co-operation, and, especially the NDA or IP limitations. This is another deliverable. CC-U will work without expensive resources (phone calls, e-mail) under the member’s own funding.

**Activity four: address the gaps**

Once the previous tables are filled in, the gaps will emerge. CC-U will then prioritize the gaps depending on the analysis made in activity two.
Action plan and budget will then be derived by CC-U. This action plan will include proposals for funded actions under European, US or else R&D funding scheme. Co-operation and exchanges with other CANEUS partners should be included in the plan. The action plan is another deliverable.

**Roadmap for implementation:**

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |

**Deliverables:**

1. Elements necessary for the demonstration,
2. Matrix “who knows what”,
3. How to label suppliers,
4. Relevant standards (existing or to be created),
5. Identification of gaps,
6. Suggested actions (with budget).

Example of what an action could be: suppose virtual qualifications of RF MEMS were possible (this is an area where already some results are available), then action could be to define (and demonstrate the usefulness of) an accelerated test plan to fulfil aerospace applications – demonstrate the Proof of Test (representativeness, % of failures, same failures …).

## 12.3.2 MNT TECHNOLOGY DEVELOPERS

Technology developers will develop in parallel their own network (CC-P) and start activity one, three and four (same as above).

The roadmap for implementation will be the same.

**Roadmap for implementation:**

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 3 | | | | | |
| 4 | | | | | |

**Deliverables:**

1. Matrix “who knows what”,
2. Relevant standards (existing or to be created),
3. Identification of gaps,
4. Suggested actions (with budget).

Example of what an action could be: define (and fill in) a field return database format, that technology providers could supply to users.

## 12.3.3 STANDARDS AND GUIDELINES

After the first 6 months of activities of the first two groups, a clearer view of the lacking standards and guidelines will be available. Both MNT users and developers will set up a group (CC-S) to launch a standardisation activity. This group will be in charge of proposing:

1. A list of standards to be developed (chosen among the above mentioned gaps),
2. The choice of the relevant standardization body(ies),
3. Draft versions of the relevant standards,
4. Action plan towards standardization (with budget).

**Roadmap for implementation:**

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |

**Deliverables:**

1. Draft standards,
2. First actions / contacts with standardization bodies.

Example of what an action could be: draft a standard for screening tests for MEMS and / or MEMS-equipped sub-systems in aerospace applications.

## 12.3.4 DATABASE AND TECHNOLOGY PORTAL

After the first 6 months of activities of the first two groups, a clearer view of the needed parameters for a database and technology portal will be available. Similarly, a clearer view of potential providers of such database and technology portal will also be available. Both MNT users and developers will set up a group (CC-D) to launch a standardisation activity. This group will be in charge of proposing:

1. A draft specification / description of the needed database and technology portal,
2. A list of possible providers / solutions,
3. A draft implementation plan (NDA, IP, funding …),
4. Action plan towards implementation (with budget).

**Roadmap for implementation:**

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |

**Deliverables:**

1. Draft specification of the database,
2. Draft implementation plan.

## 12.3.5 SPACE RADIATION EFFECTS ON MEMS

**Activity one: identify acting partners (CANEUS members)**

PoC should be nominated for Europe, USA, Japan, Brazil, and Canada as far as Space Radiation Effects are concerned. Consortium Director and PoC will constitute the Consortium Committee Space Radiation Effects (CC-SRE). PoC will identify the needs (or PoC for needs).

**Activity two: collect information**

CC-SRE will collect information on the sensitivity of MEMS on Radiation:

1. Identify sources of information (labs, publications…),
2. Gather first results (failure mechanisms, sensitivity level depending on radiation nature and power as well as MEMS type (membrane, metal-metal, metal /oxyde…),
3. Identify gaps in information,
4. Action plan towards filling the gaps.

Members will do that step on their own budget. They will not share information at system level, but only the outputs at reliability level. We are not interested in the system where they intend to implement MNT. We are rather interested in the pieces of information they require from the MNT supplier to allow the implementation.

**Roadmap for implementation:**

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2-1 | | | | | |
| 2-2 | | | | | |
| 2-3 | | | | | |
| 2-4 | | | | | |

**Deliverables:**
Available pieces of information and gaps,
Action plan to fill the gaps (with budget).

**Summary:**

After one year, the action plans from Users and Developers may be compared and CANEUS Scientific Committee may choose and decide on further actions. After one year, one may assess whether steps have been made forward.

| Activity | $t_0$ | $t_0$ + 4 month | $t_0$ + 6 month | $t_0$ + 8 month | $t_0$ + 12 month |
|---|---|---|---|---|---|
| *MNT End-Users Initiative Implementation Plan* | | | | | |
| *MNT Technology Developers Initiative Implementation Plan* | | | | | |
| *Standards and Guidelines Initiative Implementation Plan* | | | | | |
| *Database and Technology Portal Initiative Implementation Plan* | | | | | |
| *Space Radiation Effects on MEMS Initiative Implementation Plan* | | | | | |

# CANEUS MNT Reliability Sector Consortium

**WORKSHOP**

The two-day workshop may be organised the following way.

## Session 1:

First half-day
Present the above strategic work plan (SWP)
Discuss the above SWP

## Session 2:

Second half-day
Keep on discussing
Improve the SWP
Session 2 ends with a draft SWP agreed upon.

## Session 3:

Third half-day
Formal agreement to launch the updated / modified SWP
List PoC
List CC-U, CC-P, CC-S, CC-D, CC-SRE members

## Session 4:

Last half-day
Sub-groups by initiative
Prepare detailed work plan and work share for each initiative.

## 12.3.6 _____

## 12.3.7_____

## 12.3.8_____

## 12.3.9_____

## 12.3.10_____

## 12.4 Implementation Plan/Roadmap Revisions

# 12.5 CANEUS Proposed Work Program Project List

## 12.6 Action Plan

# 12.7 Workshop Report

# 13.0 CEO/CTO Panel Section

# 14.0 Needs Assessment

# 15.0 Technology Assessment

# 16.0 Appendices