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Power cable modelling for WIPS
electromechanical chain

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Deliverable 7

PUDF, Plan for the Use and Dissemination of Foreground
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1.	INTRODUCTION	4
2.	PROJECT SUMMARY.....	6
3.	TARGET GROUPS.....	6
4.	DISSEMINATION CHANNELS	8
4.1	SCIENTIFIC AND TECHNICAL EVENTS.....	8
4.2	INTERNET WEBSITE	10
4.3	PRINT MEDIA AND LEAFLETS	12
4.4	NETWORKING.....	13
5.	PARTICULAR AGREEMENTS REGARDING PUDF	13
	CONCLUSIONS	15



Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

1. Introduction

This document presents and clarifies the general considerations about the Plan for the Use and Dissemination of Foreground, PUDF, generated into the Project. It should be noted that although the Clean Sky JU launches Calls for Proposals per Topics instead of per research Themes under the European Framework Programmes ('FP7', H2020), Clean Sky Grant Agreements are subject to similar applicable rules relating to IPRs.

Participants of the MultyCab CS Project ("the parties") are:

- Universitat Politècnica de Catalunya · BarcelonaTech (UPC), a public institution dedicated to higher education and research, specialised in the fields of engineering, architecture and science, with VAT num. Q-08.18003F, and registered office at C/Girona, 31, 08034, Barcelona Spain,

Hereinafter "**UPC**"

- The Topic Manager, a leader of a specific ITD activities,

Hereinafter "**The Topic Manager**"

- The Associated Contributors, which work together the Topic Manager for fixing project specifications and perform models test and company's level validation.

Hereinafter "**Associated**"

The Document lists also a number of activities that are relevant for the dissemination of the project results as well as raise awareness on the topics of the project. Among others, the document lists journals, conferences and seminars and events that are targeted for the disseminating.

An important part of the dissemination activities focus on the dissemination via media. This includes the creation and maintenance of the project website, which contains all relevant information about the project and its results. The project website is in place since the end of 2014 and can be found under <https://multycab.upc.edu/en>. It provides rough basic project information such as project title, project objectives and results, funding scheme, download section of public reports, external links to relevant websites (Clean Sky, Partner details, etc.) and contact data for Coordinator.

The target groups of Deliverable are two:

- Project participants - The report is a guideline for the dissemination activities of project participants, as well as a summary of agreements between participants for a further use and exploitation of the results.
- Stakeholders/End-Users - The report will also provide an overview on dissemination activities to scatter project results, in order to enhance awareness of that target group about the developed solutions.



MULTYCAB

January 2016 Deliverable 7

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016



Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

2. Project Summary

The aircraft systems use converters to drive power loads such as motors and other high power loads such as resistive heaters for anti icing and deicing in thermo electric Wing Ice Protection Systems, WIPS.

The power cables used for transmitting energy cover a wide frequency range up to several hundreds of Hertz. The power cable currently used have cylindrical conductor part which, taking into account skin effect are not optimized for a weight. However, high frequency signals due to power converters are also transmitted by power cable and more specifically to switching frequency on the level of the order of several tens of kHz, together very high frequency harmonics due to switches turn-ON, which are the reason for standing waves and resonances. Therefore, it is necessary to construct a precise model taking into account various phenomena that appear when the frequency increases.

In this context, the Multi Layer Cable Model (MultyCaB) project have researched and developed advanced parametric power cable models for aeronautical applications, specifically, thermo electric WIPS. Apart from basic voltage and current analysis, models allow simulating and studying high frequency effects, such as skin and proximity effects, standing waves and resonances, conductive and isolation losses and temperature effects. Two different layers of the model, which are related to accuracy of results and computational burden, have been considered in the project.

To implement the model has been used a lumped parameters based model, which are frequency dependents and must replicate the frequency response of the full cable for all the frequencies of interest. It means that not only the fundamental frequency has to be taken into account in the model simulation, but also harmonics, switching frequency and high frequencies due to trise and tfall at the power converter must be considered for the complete results.

Taking into account these conditions, a specific research in cable models and high frequency effects, a powerful methodology based on experimental measurements and if appropriate, FEM simulations, and experimental validation of developed models and methodologies have been performed in the project.

The MultiCaB project has been developed by researches and technicians from the MCIA Research Center of Universitat Politècnica de Catalunya (www.mcia.upc.edu), with proven experience in high frequency modeling of electric and electronics components and power electronics applications and control, as well as in European projects' management and execution. MCIA researchers have worked together the Topic Manager towards the best tool for the aforementioned cable models.

A proper management, a well-defined topic manager relationship and an adequate consideration of intellectual property rights and exploitation have been also implemented during the project. Results are aligned with expectations, and a powerful tool for cable design and cable model in WISP applications is now available in public website of the project.

3. Target Groups

The MultyCaB project will have a high contribution to the European competitiveness with a potential for a reduction of energy consumption and environmental pollution while developing a tool with large possibilities of industrial and sector-wide applications. High-frequency cable models such as those studied and developed in the project have a wide variety of direct applications because of the massive introduction of PWM (pulse-width-modulated) power converters in many applications including the industry, automobile and aeronautics sectors among others.

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

Therefore, the project has several target groups that have to be addressed. Targeting the most relevant groups allows for raising the impact of the project results and enables the diffusion of solutions.

The main focus for all dissemination activities are towards the electricity, industry and transport's sectors. The objective of dissemination activities is to reach the target groups by informing them about the project, its methodology and results. This should raise awareness on the project topic as such, foster stakeholders' interest and ensure engagement for future use of the developed models.

The Multy Layer Cable Model developed in the project could potentially be applied to several other industrial sectors, including:

- The manufacturing industry, helping to model quickly and efficiently productive plants and motion systems that require high power. Pulse-width-modulated power converters such as variable speed drives commonly used in the industry to drive rotating field machines such as induction motors, permanent magnet synchronous motors or synchronous reluctance motors. In such applications, two main problems arise, high-frequency common-mode currents and transient overvoltage at the motor terminals which can lead to premature failure of the variable speed drive system. These problems increase when increasing the switching frequencies and cable length. Different unwanted consequences emerge from this situation since transient overvoltages can damage stator winding insulation systems whereas common-mode currents that flow to ground following the capacitive couplings of the motor and the cables can generate bearing faults, electromagnetic interference (EMI) problems, or malfunction of ground-fault protection among others. Therefore, the usage of an accurate cable model will help industrial integrators and designers to design a more efficient and safe plant against the electrical disturbances.
- The industry for design and manufacturing of electric cables for industrial applications, electric energy production and distribution, energy management, electric transport, etc. Commercially available vehicles include ICE-based vehicles, hybrid and full electric vehicles. Current vehicles include a wide variety of electric motors, some of them requiring variable speed drives. Therefore the models developed in the MultyCab project can assist the design of the system including power converter, cable and motor to minimize the harmful effects of the common mode currents and transient overvoltage surges. On the other hand, of course aeronautical sector can take advantages of project's results. Aside from the increasing number of electrical machines and electrical actuators fed by power converters, modern aircrafts include other systems fed by power converters. The natural switched operation of solid state technology introduces new challenges related to switching frequencies, switched voltage and (sometimes) switched current on the electric and electronic circuits of the aircraft, including of course the wiring for the Electrical Wiring Interconnection System (EWIS) of the aircraft and specifically for the WIPS. With the power converter operating as ON-OFF, unipolar and bipolar PWM, switched AC or DC voltage source, etc., new effects such as switching and commutation harmonics, skin effect, high dv/dt, EMI, etc., need to be considered and conveniently modelled on basic the cable model. This advanced cable model will facilitate the analysis of complete electrical system simulations with high degree of accuracy, and will contribute to the development of cabling and connections on the aircraft, , minimizing design errors and helping to determine components specification
- The industry of renewable energy generators (wind, tide, water, etc.), including all energies using an electrical machine which should provide energy through an electrical cable, and power converters used in the deployment and installation of Smart Grids for industrial and tertiary sector. Current power converters that use modern semiconductors with very fast turn on time, generate harmful overvoltage surges even when dealing with small cable lengths. Very fast pulse

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

rise time means very high frequencies. Therefore high frequency models up to MHz level of the power converter, the cable system and the generator are required to accurately predict their effects.

- Any stage of electric energy conversion by using power converters.

Considering these industrial sectors, for the dissemination of results the following target groups have been identified:

- **Manufacturers of industrial cables** for power connections and transport – MutyCaB offers solutions that should enter the market in future, to model, simulate and characterize the behavior of electrical cables when are used to transport energy with switched voltage, i.e., managed by electronic power converters. For instance, cable manufacturers for frequency converters to drive electrical motors, for active and reactive power supply in electrical micro grids, for electric motion control and powertrains, etc.
- **Users of power cables in aeronautical, terrestrial and maritime transport**, for transporting electrical energy up to electric machines, devices and storage systems. Users must know how to use and which consequences have the use of power cables in their applications when energy is delivered under switched waveform, and accurate cable models as developed in this project will help to do that.
- **Electric Systems designers**, in different industrial fields, who need know the behavior of the full system under design, including cable connections and electric effects: overvoltage, heating, leakage currents, etc. , especially when the system is operated under switched waveforms because the use of electronic power converters.
- **Scientific community** – the results of MutyCaB project are of relevance for the scientific communities within the scope of the project. Especially researchers in the field of power electronics, and energy management & controls can profit from the results of the project.

4. Dissemination Channels

This chapter explains the implementation of the dissemination measures. It is structured according to dissemination channels that are used to reach the target groups, i.e., scientific and technical events, including scientific papers and presentations in journals and conferences, internet dissemination, including the project website, and suitable existing collaboration spaces, print media, including MCIA leaflets and presentations, and networking, which includes involvement in research and industrial networks and other activities for the dissemination of foreground. Dissemination activities including but not restricted to publications and presentations shall be governed by Article II.30 of the relevant Grant Agreements.

4.1 Scientific and technical events

Participants in the project, and especially UPC, will participate to relevant conferences in their specific field within the scope of MutyCaB project. The conference participation requires the presentation of project results and/or achievements.

Regarding conferences, papers summarizing the GUIs developed for the MutyCab project are planned to be submitted at one of the following conferences during the next months (these conferences are periodical, and therefore, new submissions are possible with the latest results of the project):

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

1.- IEEE 2017 Aerospace Conference. Session 7.08 Power Electronics for Space Applications to be held in Big Sky, Montana, USA, March 4-11, 2017. The international IEEE Aerospace Conference, with AIAA and PHM Society as technical cosponsors, is organized to promote interdisciplinary understanding of aerospace systems, their underlying science and technology, and their application to government and commercial endeavors. The annual, weeklong conference, set in a stimulating and thought-provoking environment, is designed for aerospace experts, academics, military personnel, and industry leaders.

2.- 20th 2018 Power Systems Computation Conference (PSCC). Technical Co-Sponsor: IEEE Power & Energy Society. PSCC is a n international conference that addresses developments and computational aspects with respect to power system applications. There is an emphasis on modelling and simulation for understanding a system of components, plant or actors, the interactions between them and their collective behavior, and methods to inform decision-making in power systems. Contributions might comment on the analytical techniques, modelling challenges and complex software engineering issues, or what the analyses say in respect of today's and the future's power system challenges. Thus, papers from utility and manufacturing industry engineers are just as welcome as those from academic researchers. One of the topics is Modelling and analysis of a power system's performance and its control.

3.- 26th Institute of Electrical and Electronics Engineers (IEEE) International Symposium on Industrial Electronics (ISIE) 2017. IEEE-ISIE is the largest summer conference of the IEEE Industrial Electronics Society, which is an international conference for sharing breakthroughs in research, emerging technologies, and success stories in industrial electronics and its applications. Among others, some topic of the conference are related to Power Electronics and Energy Conversion, and Power Electronics Modelling and Simulation and PWM Systems.

4.- 2017 IEEE Industry Applications Society Annual Meeting (IAS) to be held in October 2017 in Portland, USA. The Annual Meeting has a long tradition of providing an international forum for researchers, students and Industry experts to present and discuss the latest developments in the application of electrical technology to industry. At the same time, this conference is specifically designed for the practicing engineer interested in this field. It therefore emphasizes professional development, learning from experts, sharing of experiences, and networking with peers. This meeting has a full complement of tutorials, as well as technical presentations about both new research and practical solutions developed in the field.

5.- IEEE 2017 43rd Annual Conference of the IEEE Industrial Electronics Society (IECON), which is focusing on industrial and manufacturing theory and applications of electronics, controls, communications, instrumentation, and computational intelligence. Topics of interest for IECON 2017 include, but are not limited to power electronics and energy conversion, renewable energy and sustainable development and power system.

Regarding scientific journals, many publications include into scope electric systems and devices modelling, in the fields of energy analysis, energy conversion, energy modelling and prediction, integrated energy systems, energy planning and energy management. Also, journals exit on topics such as energy conservation, energy efficiency, renewable energy, electricity supply and demand, energy storage, mechatronics and motion control. Among other, some of these journals with high Impact Factor are Energy (Elsevier), which is an international, multi-disciplinary journal in energy engineering and research, International Journal of Electrical Power & Energy Systems (Elsevier), whose scope is focused on electrical power generation, transmission, distribution and utilization, from the viewpoints of individual power system elements and their integration, interaction and technological advancement, Aeronautical Journal (Royal Aeronautical Society), with the aims and scope to encourage and foster the advancement of all aspects of aeronautical and space science, including avionics and electric systems, IEEE Transactions

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

on Industrial Electronics (Institute of Electrical and Electronics Engineers) that is published monthly. Its scope encompasses the applications of electronics, controls and communications, instrumentation and computational intelligence for the enhancement of industrial and manufacturing systems and processes, including power electronics and drives modelling and control techniques, modeling and simulation of electric systems and motion control.

By now (July 2016), a journal paper summarizing the novel results attained in the MultyCab project has been submitted for review at the International Journal of Electrical Power & Energy Systems (IJEPES, Quartile 1 at JCR index, Electrical & Electronic Engineering category) (Elsevier), which is the following:

- S. Bogarra, J.-R. Riba, V. Sala-Caselles, A. Garcia, Optimal Fitting of High-Frequency Cable Model Parameters by Applying Evolutionary Algorithms, International Journal of Electrical Power & Energy Systems, Elsevier.

The target audience of the IJEPES journal is both academia and industry. The aims and scope of the Journal of Electrical Power & Energy Systems (Elsevier) is the dissemination of the newest technologies and theoretical research in the area of electrical power and energy systems, aiming at inspiring interdisciplinary research across academia and industry and contributing to the prosperity of modern societies. It includes topics such as electrical power generation, transmission, distribution and utilization, from the viewpoints of individual power system elements and their integration, interaction and technological advancement. The scope covers modelling of power system elements, their design, analysis of their performance and their implementation in specific aspects typical for modern electrical power and energy systems of various size and complexity.

Regarding technical events, results of the project are expected to be presented by Topic Manager and Associated in fairs and technical workshops, as well as in the wide range of courses that are periodically organized by them. For such events the Project's Coordinator will provide technical and scientific support, if necessary.

4.2 Internet Website

The aim for the website is to increase the visibility of the MultyCaB" project to the general public and specialists, to provide them the basis of the technology developed and the software tools to apply in a number of different applications in the technical fields former described.

Cable models of developed samples and methodology for use them and generate new models for different cable configurations are described in public Deliverables. These Deliverables are maintained in the public Web Page of the Project, website <https://multycab.upc.edu/en>. Models and Settings can be downloaded and simulations can be run without dedicated simulation license. Methodology to be applied to model and test the cables is fully developed into Deliverables, and it can be used for further use of the project results on different applications and cable configurations.

Website freely allows sharing models and simulation results and observations with all project stakeholders: end-users, customers, contractors, marketers, other engineers, and managers. The website was also developed to decrease the amount of paper used during the dissemination process; by just referring to a link and thanks to the wide use of internet, the public will easily understand and learn additional information related to the project which may not be described solely in a pamphlet.

The project website is in place since the end of 2014 and can be found under <https://multycab.upc.edu/en>. It provides information on the reasons for undertaking the project, its objectives, background on the technology the project intends to utilize and expected outcomes, as well as main results and software tools developed during the project execution. It is also contact details for anyone interested in more information. The Web page site map is organized as follows:

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

- WELCOME PAGE
- ABOUT
- OBJECTIVES
- PARTNERS
- CONTACT
- INTRANET

Following is presented the Welcome page and some technical information included in the site, as examples of this MultyCaB Project Web page.

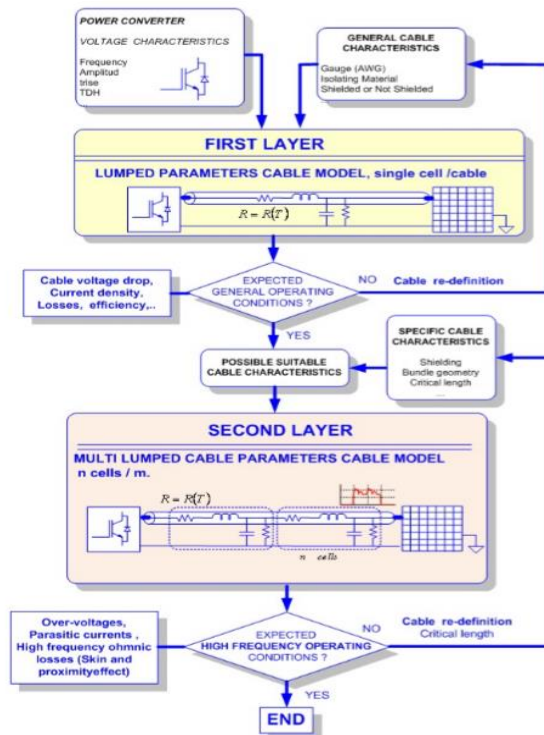


Fig. 1 : Software work flux and different layers of the parameter cable model.

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

4.3 Print Media and leaflets

Leaflets, pamphlets, flyers and other printed media provide marketers a versatile approach to a wide variety of audiences, and will help to disseminate project's results.

MultyCab project information has been summarized and introduced into the MCIA Research Center media and printed information. Summary of the project and access to its Web Page can be found in MCIA main Web page, and then extending the visibility of the project to all the visitors. This information can be copied and printed freely by visitors.

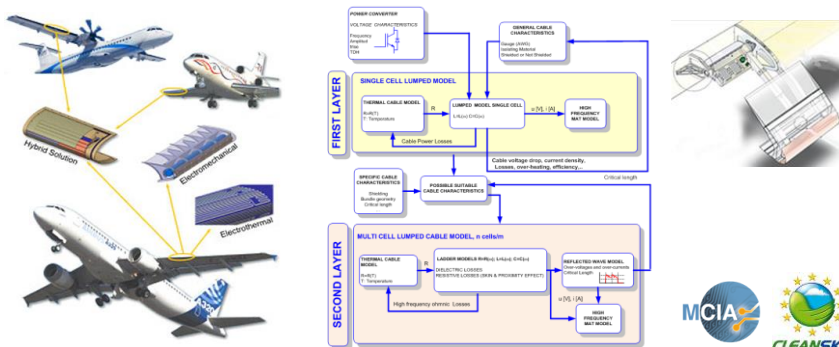
The screenshot shows the MCIA website interface. At the top, there's a navigation bar with 'home', 'site map', 'contact', and 'log in' links, along with a search box. The main header reads 'Center Innovation Electronics. Motion Control and Industrial Applications. MCIA'. Below this is a 'research' section with a background image of a circuit board. A breadcrumb trail indicates 'You are here: Home > Projects > Research'. A sidebar on the left contains a menu with 'About us', 'Services', 'Facilities', 'Projects', 'Scientific research', and 'Partners'. The 'Projects' section is expanded to show 'Research', 'Innovation and Technology Transfer', and 'Scientific research'. The main content area displays the project title 'MULTYCaB, Power cable modelling for WIPS electromechanical chain.' with logos for REA, CLEAN SKY, and MCIA. It lists the project as 'FP7 - CleanSky; Jan. 2014 - Dec. 2015' and identifies the organization as 'UPC-MCIA Innovation Electronics (Spain)'. The text describes the project's goal: 'The Multi Layer Cable Model *MultiCaB* project aims to research and develop advanced parametric power cable models for aeronautical applications, specifically, thermo electric Wing Ice Protection Systems, WIPS. Apart from basic voltage and current analysis, models must allow to simulate and study high frequency effects, such as skin and proximity effects, standing waves and resonances, conductive and isolation losses and temperature effects.'

Also, some printed information (leaflets and flyers) have been edited and currently used to present and disseminate MultyCaB objectives and results, including information for a consumer to digest. See below an example of a poster presentation used in workshops and MCIA presentations.

MultyCaB Project

Power cable modelling for WIPS electromechanical chain; R+D Project (EU funding – FP7 - Clean Sky); 2014 – 2015. MCIA budget 200k€

The Multi Layer Cable Model *MultyCaB* project proposal aims to research and develop advanced parametric power cable models for aeronautical applications, specifically, thermo electric Wing Ice Protection Systems, WIPS.



Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

4.4 Networking

The partners are free to choose the most suitable way in disseminating through their network or project involvement. Some of the partners are already members, and/or are in close relationship with some of the networks that could be considered. The benefits from the engaging the networks, are the followings:

- Wider list of the contacts for Stakeholder/End-Users,
- Participation in the relevant events for the industrial and aeronautical sectors,
- Availability to well know dissemination tools, such as forums, newspapers, etc.

MCIA Center is member of the TECNIO Network, the innovation technology network maintained by the Local Govern of Generalitat of Catalonia to promote the technology diffusion and technology transfer to industry. Through workshops and presentation of TECNIO, project results can be disseminate and presented to potential users interested in these technologies.

MCIA is also member of CRAE (<https://recerca.upc.edu/crae>), the Aerospace and Research Center (CRAE) of the Universitat Politècnica de Catalunya (UPC) to foster R&D in the Aeronautics and Space fields, by increasing the collaboration between UPC groups and acquiring the critical mass required for large projects. CRAE is a virtual center that tries to coordinate the different actors at UPC that work in the Aeronautics and Space fields, and it is UPC's window to the world for Aeronautics and Space activities. CRAE articulates the participation of UPC researchers within the Institut d'Estudis Espacials de Catalunya (IEEC: <http://www.ieec.fcr.es/>), and it is the UPC representative in BAIE platform. BAIE is a platform created in November 2000 that aims to promote the metropolitan area of Barcelona and Catalonia as a competitive scenario for activities related to the aviation industry and space., and it is now integrated in Andalusian cluster for aeronautics companies (<http://helicecluster.com/>), which in turns is a member of the association of European Aviation Clusters Partnership, EACP (<http://www.eacp-aero.eu/>). These connections allows to MCUIA Center to have access to a wide number of companies and stakeholders, to whom results of the project can be presented and disseminated.

On the other hand, the Topic Manager and Associated Company maintain their own web pages and social media activity, and they can present and promote the project concept and results for a wider dissemination. The diffusion of knowledge in cooperation with European organizations, such as the Advisory Council for Aeronautics Research in Europe (ACARE), the European Technology Platform for aeronautics and the Aerospace and Defence Industry Association for Europe (ASD Europe) is foreseen. As a member of the ACARE technological platform, which brings together all stakeholders in the aeronautics business, the Topic Manager can present and disseminate the project objectives and results. Through the websites and annual meetings of these organizations, the present project can have a direct link with their related scientific community, public aeronautics actors, industry, and affiliations

5. Particular agreements regarding PUDF

According to the European Research and Development Frameworks, the Foreground, which are the results generated by the project, is the property of the beneficiary carrying out the work generating that Foreground. Specifically for Clean Sky Projects, it should be noted that beneficiaries are not subcontractors of the Clean Sky JU, so IPRs are not the property of the Topic Manager or of the Clean Sky JU. For the avoidance of doubt, a Party shall not publish Foreground or Background of another Party, even if such Foreground or Background is amalgamated with Party's Foreground, without the other Party's prior written approval.

Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

Considering these general advises regarding Foreground or Background, the Partners have decided the following as a final statement, which shall prevail over all other provisions for the MultyCab project:

- As partners of Clean Sky, ITD member, the Topic Manager and its project Associate Company agree that the « Clean Sky Joint Undertaking Gant Agreement fort Partners, Annex II General Conditions (hereinafter the “General Conditions”) are applicable to this MultyCab project.

Notwithstanding anything to the contrary, the above partners and UPC also agree the following regarding the software, property of UPC:

- The Topic Manager and its Associated Company will receive from UPC free of charge a worldwide license of developed software (foreground) to use for their own business (research, development, exploitation with third party) without any restriction and with right to sublicense to third parties.
- The right of ITD member (the Topic Manager) and the other industrial partner (Associated) to use freely the foreground is recognized. It is also stated that other issues related to exploitation of developed software of the project will be discussed and agreed with the Topic Manager, although Foreground of the Project shall be property of the beneficiary carrying out the work generating that foreground.
- UPC will use the foreground for research activities, and commercialization of the software developed in the Project, if applicable.

Regarding the use of the Foreground, UPC will have support from the Research Valorisation Department of the University. This department is in charge of providing legal support on knowledge protection, and will assess the licensing aspects of the software developed by UPC.

Regarding and dissemination and exploitation interests:

- The coordinator will take appropriate measures to engage with the public and the media about the project and to highlight the CSJU financial support.
- Dissemination activities relating to maximizing to a wider audience will be proposed and promoted, which must be discussed and approved by the Topic Manager.

Any dissemination activity shall include sufficient details/references to enable the CSJU to trace the activity. With regard to scientific publications relating to foreground published, an abstract of the publication must be provided to the CSJU at the latest two months following publication.

Other subject related to dissemination activities and access rights will be managed as defined in the CSJU Grant Agreement for partners, Annex II, General Conditions, which was signed once finalized the negotiation process



Document	Deliverable 7
Facilities	-
Revision	Revised
Date	January 2016

Conclusions

This deliverable has reviewed different aspects of the PUDF, Plan for the Use and Dissemination of Foreground of the project SGO-02-077 - MultyCaB – 632458.

Among other subjects, Target Groups, Dissemination Channels and Particular Agreements for the Use and Exploitation of the Foreground have been presented and discussed. As a general conclusion, the right of ITD member and Associate member to use freely the foreground is recognized. UPC will use the foreground for research activities, and also for its commercialization, if applicable.