

**SEVENTH FRAMEWORK PROGRAMME  
THEME 3  
ICT - INFORMATION AND COMMUNICATION TECHNOLOGIES**

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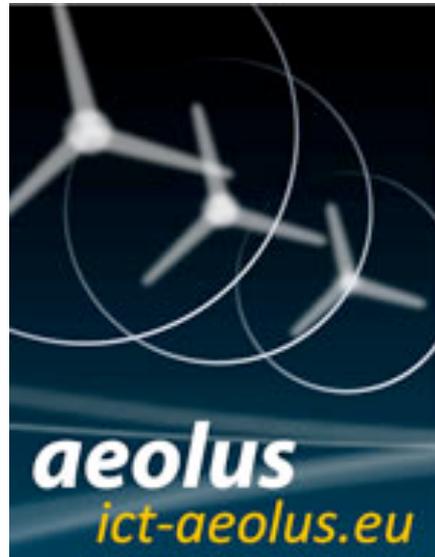
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**Summary:**

This deliverable describes the dissemination exploitation of knowledge gained during the project work for each of the participants in the project.



# Final report on dissemination and exploitation

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Rev 1	30 Sep. 2011	Martin de Maré	Added contributions up to September 2011

# 1. Abstract

This deliverable describes the dissemination exploitation of knowledge gained during the project work for each of the participants in the project.

## 2. Introduction

### 2.1. Scope

This document is the Final report on dissemination and exploitation prepared for the project Aeolus under Work Package 5 (Case study, dissemination and exploitation), Task T5.7 (Final report on dissemination and exploitation).

The intended readership of this document is comprised by all project participants and the European Commission.

## 3. General activities

### 3.1. Publications in Journals

The mixture of the AEOLUS consortium has ensured that the dissemination of project results has taken place on a broad platform. The AEOLUS project partners published articles and news about AEOLUS in relevant national and international journals, both in paper and in electronic form.

The use of a large variety of journals, has presented the project not only to the world of libraries and archives but also to a larger interested public.

Scientific journals include [Wind Energy](#), [IEEE Tran. on Aut. Con.](#), [Automatica](#), and [Mechatronics](#).

### 3.2. Presentations at Conferences and Meetings

As is the case with all European projects, AEOLUS was justifiably expected to observe current developments in the area of its activities.

The attendance of project partners at relevant conferences and meetings ensured that the public has been informed at all stages about the work of AEOLUS and that AEOLUS has been aware of other projects' and research groups' activities world wide. Attended conferences include EWEC, EOW, and TORQUE (organized by [EWEA](#)), and WindPower (organized by [AWEA](#)) and [AIAA Aerospace Sciences Meeting](#) (organized by AIAA and ASME). In addition there is the annual PhD Seminar on Wind Energy in Europe (organised by [EAWE](#)), control conferences such as ACC, CDC, ECC, CCA, and other IEEE and IFAC conferences which are relevant to control have been attended by Aeolus partners.

### 3.3. Public Project Reports

Public versions of progress reports to the Commission has been prepared. They have been made available through the website in the form of executive summaries and will give detailed information about the AEOLUS activities of every institution involved in the project. Thus, all major project activities and proceedings has been reported to the public and are therefore traceable.

#### 3.4. Partners descriptions of dissemination

The remaining chapters of this document are dedicated to partner's description of their dissemination activities.

## 4. Aalborg University

#### 4.1. Partner role and nature of results

The Department of Electronic Systems is the biggest department at Aalborg University with 75 faculty staff and 70 PhD students, and is active primarily in mobile communication, acoustics and automatic control. The control group is actively involved with modelling, analysis and synthesis of control systems and has a strong industrial profile and presence.

Aalborg has been coordinator of the project, lead WP2 on dynamic models for wind field predictions and has also been active on several subtasks of WP5 and WP1.

#### 4.2. Target groups for dissemination and use

The scope of dissemination strategy at Aalborg University covered mostly the research publications at international scientific journals and conferences. The target groups were the researchers at institutions, and companies who do research, design, and development in the area of wind farm modelling and control.

#### 4.3. Dissemination actions

##### 4.3.1 Publications and conference participation

- Prediction models for wind speed at turbine locations in a wind farm. / Knudsen, Torben; Bak, Thomas ; Soltani, Mohsen. In: Wind Energy. (2011). DOI: 10.1002/we.491.
- A Wind Farm Controller for Load and Power Optimization in a Farm. / Soleimanzadeh, Maryam ; Brand, Arno; Wisniewski, Rafal. In: IEEE Conference on Control Applications. Proceedings , 2011.
- Estimation of Wind Turbulence Using Spectral Models. / Soltani, Mohsen ; Knudsen, Torben ; Bak, Thomas. In: IEEE Conference on Computer-Aided Control Systems Design , 2011.
- An Optimization Framework for Load and Power Distribution in Wind Farms. / Soleimanzadeh, Maryam H ; Wisniewski, Rafal. In: I F A C Workshop Series , 2011.
- Controller design for a Wind Farm, Considering both Power and Load

- Aspects. / Soleimanzadeh, Maryam ; Wisniewski, Rafal. In: Mechatronics , Vol. 21, 2011, p. 720.
- Wind deficit model in a wind farm using finite volume method. / Soleimanzadeh, Maryam ; Wisniewski, Rafal. In: American Control Conference (ACC) , 2010, p. 4343 - 4348.
  - Wind speed dynamical model in a wind farm. / Soleimanzadeh, Maryam ; Wisniewski, Rafal. In: 8th IEEE International Conference on Control and Automation (ICCA), 2010 . IEEE Press, 2010. p. 2246-2250.
  - Aeolus Toolbox for Dynamics Wind Farm Model, Simulation and Control. Grunnet, Jacob Deleuran ; Soltani, Mohsen ; Knudsen, Torben ; Kragelund, Martin Nygaard ; Bak, Thomas . In: European Wind Energy Conference and Exhibition, EWEC 2010 : Conference Proceedings. 2010.
  - Distributed Control of Large-Scale Offshore Wind Farms. / Knudsen, Torben ; Bak, Thomas ; Soltani, Mohsen. 2009. 8 p. Conference: European Wind Energy Conference and Exhibition (EWEC) 2009, Marseille, France, March 16, 2009.
  - Modeling and Simulation of Offshore Wind Farms for Farm Level Control. / Soltani, Mohsen ; Knudsen, Torben ; Bak, Thomas. In: Proceedings of The European Offshore Wind 2009.
  - Prediction Models for Wind Speed at Turbines in a Farm with Application to Control. / Knudsen, Torben ; Soltani, Mohsen ; Bak, Thomas. 2009. Conference: Euromech Colloquium 508 on Wind Turbine Wakes, Madrid, Spain, October 20, 2009. .

#### 4.3.2 Exhibitions and meetings

- 28-30 September 2011: IEEE Multi-Conference on Systems and Control, Denver, CO, USA.
- 28 August – September 2, 2011. IFAC World Congress, Milano, IT.
- 2-4 August 2011. PhD course on Wind Turbine Control, Aalborg University, DK.
- May 25-26, 2011, Aeolus workshop on Improved Control of Wind Farms, Glasgow, Scotland.
- 14 March 2011, Aeolus hosted a side-event at EWEA 2011 in Brussels, BE.
- 14-17 March 2011: European Wind Energy Conference and Exhibition, Brussels, BE.
- 27-29 September, 2010: ICT2010, Brussels, BE.
- 9-11 June 2010: IEEE International Conference on Control & Automation.
- 12-16 April 2010: CPS Week, Stockholm, SE.
- 22–26 March 2010. Finish PhD course, "Advanced and nonlinear system identification". FI.
- 14 November 2009, Wind and Energy dissemination, Lund, SE
- 19-20 mar 2009, High Level Event on Information and Communication Technologies for Energy Efficiency, Brussels, BE
- 16 - 19 March 2009. European Wind Energy Conference and Exhibition,

Marseilles, FR.

- 2-3 June 2009. Czech Innovation Day, Brno, CZ
- 1-2 September 2009, PHYSCON 09, Catania, IT
- 20-22 October 2009: Euromech Colloquium, Madrid, ES
- 16 October 2009: CPS workshop, EESW, Grenoble, FR
- 10 October 2009: Workshop on R&D collaboration with Brazil in the ICT field, Sao Paulo, Brazil
- 5-6 October 2009: Concertation Meeting on Control of Large-Scale Systems, Brussels, BE
- 14-16 September 2009: Offshore Wind conference
- 2 September 2009: PHYSCON 09, Catania, IT.
- 10-12 June 2009: American Control Conference, US
- 19-20 March 2009: Participation in ICT4EE, Brussels, BE
- 16-29 March 2009: European Wind Energy Conference, Marseilles, FR
- 21 October 2008 Concertation Meeting on Control of Large-Scale Systems, 21 oct 08, Brussels, BE
- 20 October 2008: Workshop on Monitoring and Control for Energy Efficiency, Brussels, BE
- 7 October 2008, Meeting with the EU project TOPFARM, Risø, DK
- 26-27 June 2008: Concertation Meeting on Control of Large-Scale Systems, Brussels, BE

#### 4.4. Planned future dissemination activities

- A Ph.D thesis submitted by end November 2011. Title: Wind Farms: Modeling and Control.

## 5. Lund University

### 5.1. Partner role and nature of intended results

The Faculty of Engineering (LTH) is one of the most important faculties of Lund

University, one of Scandinavia's largest establishments for higher education and research. LTH is also one of Sweden's largest higher educational institutes for the technical and engineering sciences. The Department for Automatic Control is recognized world-wide for contributions to modelling, analysis and synthesis of control systems, with particular attention to optimisation, real-time aspects and distributed control.

Lund University has lead WP4 but has also been active in other work-packages.

In WP4 distributed algorithms based on virtual price mechanisms has been developed.

### 5.2. Target groups for dissemination and use

The dissemination strategy aims mainly at research publications, and international conferences.

### 5.3. Dissemination actions

#### Publications and conference participation:

- Anders Rantzer, "Dynamic Dual Decomposition for Distributed Control", In Proceedings of American Control Conference, St. Louis, June 2009
- Pontus Giselsson and Anders Rantzer, "Distributed Model Predictive Control with Suboptimality and Stability Guarantees", In Proc. 49th IEEE Conference on Decision and Control, Atlanta, GA, December 2010.
- Pontus Giselsson: "Adaptive Nonlinear Model Predictive Control with Suboptimality and Stability Guarantees". In Proc. 49th IEEE Conference on Decision and Control, Atlanta, GA, December 2010.
- Daria Madjidian, Karl Mårtensson, Anders Rantzer: "A Distributed Power Coordination Scheme for Fatigue Load Reduction in Wind Farms". In Proc. American Control Conference, San Francisco, CA, USA, June 2011.
- Daria Madjidian, Anders Rantzer. "A Stationary Turbine Interaction Model for Control of Wind Farms ". In Preeprints of the 18th IFAC World Congress, Milano, Italy, August 2011.
- Javad Lavaei, Anders Rantzer, Steven Low, "Power flow optimization using positive quadratic programming", In 18th IFAC World Congress, Milano, Italy, August 2011
- Maxim Kristalny and Daria Madjidian. "Decentralized feedforward control of wind farms: prospects and open problems", In Proc. 50th IEEE Conference on Decision and Control, Orlando, FL, December 2011 (to appear)
- Maxim Kristalny and P. Shah. "On the fully decentralized two-block H2 model matching with one-sided dynamics". Submitted to ACC2012

#### Talks:

- Anders Rantzer, "Distributed Control Using Positive Quadratic Programming". Plenary Lecture at Chinese Control Conference, July 2011.
- Maxim Kristalny. "Distributed feedforward control of wind farms: prospects and open problems", Aeolus side event at EWEA 2010, March 14, 2011 Brussels, Belgium.
- Maxim Kristalny. "Distributed feedforward control of wind farms: prospects and open problems", French-Israeli Workshop on Delays & Robustness, April 3-5, 2011, Technion—IIT, Haifa, Israel
- Daria Madjidian, "Optimal Power Distribution in Wind Farms", Aeolus workshop on Improved Control of Wind Farms, May 25-26, 2011, Glasgow, Scotland.
- Daria Madjidian. "Addressing wake effects in wind farms", Workshop on modeling and simulation of modern electricity networks, September 22, 2011, Lund, Sweden

#### Misc

- Poster presentation of AEOLUS at CPSWEEK, April 12-16, Stockholm 2010.

## 6. Industrial Systems and Control Ltd

### 6.1. Partner role and nature of intended results

ISC has the lead WP3 on wind farm power/load optimisation and has also been active on several subtasks of WP2, and WP5. Furthermore, ISC has been involved in WP0 (Management).

ISC is an SME providing clients with consultancy in the form of solutions to specific problems, training and technology awareness in the field of control. ISC's application experience ranges from large process plant through ship systems to servomechanisms, with many multinational clients.

ISC has established an optimal control method that utilises available system models and data.

The method is scalable to systems of large complexity, where the major activities will be:

- Implement this method in software, in a simulation environment.
- Determine performance of optimal controller against conventional control.
- Ensure or adjust the optimisation method such that it is reconfigurable with respect to turbine availability. This includes (basic) fault detection.

### 6.2. Target groups for dissemination and use

ISC wholly owns and administers the Applied Control Technology Consortium (ACTC). A self-funding organisation, the ACTC provides members with case studies, training courses and regular meetings held throughout the UK and internationally, on a variety of classical and advanced control topics. Its current members are 30 'world-class' companies. These companies include operators of wind farms such as RWE, Scottish Power and Scottish and Southern Energy. Other companies operating in industries as diverse as Automotive, Aerospace & Defence, Chemical & Petrochemical, Energy, Marine, Metal Processing and Food and Drink Manufacturing. The ACTC also develops demonstrator software for certain new technologies.

ISC has used the supervisory control experience developed in other application areas, for example water supply networks (water companies, large process plants) and air supply systems (compressed air in chemical and pharmaceutical plant, large HVAC systems).

### 6.3. Dissemination actions up to 30<sup>th</sup> September 2011

#### 6.3.1 ACTC Newsletter

Updates of the Aeolus project, its objectives and ISC's participation in the regular ACTC Newsletters and on ISC's web site:

<http://www.actc-control.com/enews/web/enews0808.asp#TBA1>

<http://www.actc-control.com/enews/web/enews1105.asp>

### 6.3.2 Contributions to journals, conferences, exhibitions and meetings

- Yan Pang and M J Grimble, “NGMV control of delayed piecewise affine systems”, *IEEE Transactions on Automatic Control*, vol. 55, no. 12, pp. 2817–2821, December 2010.
- Professor Mike Grimble made a presentation at the IEEE Workshop on “Problems of Transport Delay Systems in Control Applications”, held in Glasgow on 28/4/2010, and entitled “Transport Delay Compensation for Linear and Nonlinear Stochastic Systems with Application to Offshore Wind Farms”.
- Presentation on ISC’s wind farm supervisory control results by Gerrit van der Molen in Aeolus side event at EWEA 2011 in Brussels on 14<sup>th</sup> March 2011.
- Professor Mike Grimble made a presentation on the Nonlinear Control of Wind Turbines (Advanced Control for Offshore Wind-farms to Reduce Failures and Maintenance), at the University of San Diego, June 2011.
- Professor Mike Grimble made a presentation on the Use of Nonlinear Predictive Control in Offshore Wind Farms, at a Symposium on Advanced Control in Honor of Edoardo Mosca & Roberto Genesio - Firenze, September 5, 2011

### 6.3.3 Organisation of workshop

ISC organised the two-day “Tutorial Training Workshop: Improved Control of Wind Farms”, combining lectures on basic control and signal processing theory with research results from Aeolus. The workshop was held in Glasgow, UK on 25-26 May 2011. It included presentations from all Aeolus partners and attracted approximately 40 attendees (attendance was somewhat limited due to flight restrictions because of a volcanic ash cloud).

For those that could not attend the workshop another two-day course has been prepared. The course repeats the workshop content but has to include more tutorial information and include overviews of AEOLUS member workshop outputs that could not be presented by them. It includes a brief overview of all of the original talks and encourages contacts/links with the appropriate AEOLUS members in the different speciality areas. This course has recently been delivered to two groups of trainees at RWE in Swindon, UK on 27-30 September 2011. The aim is to take the course to other company premises for in-house presentations to promote the project outcomes. Wind turbine companies and energy consultancies throughout Europe will be notified of the opportunity to host this workshop course event.

#### 6.4. Planned future dissemination activities

To encourage dissemination to ACTC members, public reports from the project can be made downloadable from the ACTC web-site. Presentations at ACTC meetings are planned, to be given by ISC and other Aeolus partners where appropriate.

Petros Savvidis will use his project research towards his PhD thesis, which is expected to be published in 2012. Conference papers on generic advances in nonlinear control are also being organized with the University of Strathclyde.

ISC plan to repeat the very successful Training Workshop after the end of the project with input when possible from other Aeolus participants on an annual basis. The advice provided from feedback from participants in the first event has been that the workshop should be split into two parts: the first part dealing with individual turbine modelling, simulation and control and the second on offshore wind farm modelling, simulation and control. The next event is scheduled for May 2012.

## 7. Energy Research Centre of the Netherlands

#### 7.1. Partner role and nature of intended results

The Energy research Centre of the Netherlands (ECN) is an independent market oriented knowledge centre for energy research and development with approximately 900 staff members. ECN's mission is to develop knowledge and technology and bring those to the market.

ECN has led WP1 and contributed to WP2, and WP5. ECN has also given access to several years of meteorological, mechanical loads and electrical power measurements.

ECN will bring in the software WAKEFARM, PHATAS and SWIFT.

#### 7.2. Target groups for dissemination and use

Wind turbine (rotor blade) designers/manufacturers and designers/developers of offshore wind farms.

#### 7.3. Dissemination actions

The material in deliverable D1.3 was presented at Euromech Colloquium 508 "Wind Turbine Wakes" (Madrid, October 2009).

The material in D1.1-D1.3 was presented as scientific poster and has been published as scientific paper in the Scientific Track of EWEC 2010 (Warsaw, April 2010).

The material in D1.3-D1.4 was presented with full paper at Torque 2010 (Heraklion, June 2010).

The material in D1.1-D1.5 was presented as poster with paper at iTi 2010 Conference on Turbulence (Bertinoro, September 2010).

The progress in D1.1-D1.5 was presented at Dutch Wind Workshop 2010 (Wieringerwerf, 14-15 October 2010)

A side event on the whole project was organised at EWEA 2011 Annual Event (Brussels, 14-17 March 2011), and the material in D1.5-D1.8 has been presented in that side event.

The material in D1.8 was presented with paper at EWEA 2011 Annual Event (Brussels, 14-17 March 2011).

The material in D1.1-D1.8 was presented at the Aeolus Work Shop on Improved Control of Wind Farms (Glasgow, 25-26 May 2011).

Amongst others the material in D1.8 was presented at 2011 IEEE Multi-Conference on Systems and Control (Denver, 28-30 September 2011).

NB: A side event at EWEC 2010 on the whole project was organised but was cancelled because of flight disruptions.

## 8. University of Zagreb

### 8.1. Partner role and nature of intended results

University of Zagreb, Faculty of Electrical Engineering and Computing is the largest technical faculty and the leading educational and R&D institution in the fields of electrical engineering and computing in Croatia. UZAG-FER is organized in 12 departments with 130 professors and 200 research assistants

UZAG-FER has contributed to WP3 on wind farm power/load optimisation, disturbance rejection and reconfigurable control. Furthermore, UZAG-FER has been active on several subtasks of WP5 and WP1.

### 8.2. Target groups for dissemination and use

Primary target group for dissemination and use is scientific community, from both wind energy and control system field.

### 8.3. Dissemination actions

- Full paper and oral presentation at Torque 2010 (Heraklion, June 2010) (material from D3.1)
- Participation in Aeolus workshop at EWEA 2011
- Full paper and oral presentation at 18<sup>th</sup> International Conference on Process Control (material from D3.3)
- Original scientific paper published in *Automatika – Journal of Control, Measurement, Electronics, Computing and Communications* (material from D3.3)

- Presentation at Vestas Control Seminar Series in July 2011
- Full paper and oral presentation at IFAC World Congress 2011 (Milan, September 2011)

#### 8.4. Planned future dissemination activities

- two journal paper submissions by the end of 2011
- At least one Ph.D. thesis will cover parts of project research (Submission expected in 2012)

## 9. Vestas Wind Systems A/S

### 9.1. Partner role and nature of intended results

Vestas Wind Systems A/S is the world's leading producer of high-tech wind power systems. Vestas' core business comprises the development, manufacture, sale, marketing and maintenance of wind power systems that use wind energy to generate electricity.

Vestas Wind Systems A/S has lead the development on the case study, dissemination and exploitation. The main focus area has been modelling by providing a basis for coherent model development and validation. Vestas Wind Systems A/S will contribute to the activities in the other work package to guide the research activities in terms of relevance for the Aeolus consortium.

### 9.2. Target groups for dissemination and use

The dissemination strategy aimed mainly at research publications, international events, presentations and workshops.

### 9.3. Dissemination actions

D5.3 has been frequently updated during the project period and published at the official project homepage <http://www.ict-aeolus.eu/index.html> .

Participation in EWEC2009 and EWEC2011 for supporting Aeolus publications and gain personal relation to project participants as well external contacts.

Participation in the two-day "Tutorial Training Workshop: Improved Control of Wind Farms" organised by ISC in Glasgow, Scotland.

Internal Vestas workshop for gather relevant information for D5.5 Plan for performance assessment.

Project objectives and deliveries have been presented for Vestas internal people for disseminate knowledge generated in Aeolus.