COST

Technical Committee "Forestry"

COST Action E36

Modelling and Simulation in the Pulp & Paper Industry

PROGRESS REPORT

Period: from (01-04) to (01-05)

(Start date of the Action: 22.1.04)

(last update: 6.2.05)

This Report is prepared by the Management Committee of the Action and presented to the relevant Technical Committee. The report is a "cumulative" report, i.e. it is updated annually and covers the period beginning from the start date of the Action.

CONTENTS

1. OVERVIEW: ACTION IDENTIFICATION DATA

(see attached table "Action identification data" attached at the end)

2. OBJECTIVES

The main objective of the Action is to promote the development and application of modelling and simulation techniques in pulp and paper manufacturing processes. This is intended to e.g. reduce emissions and increase the productivity and cost-efficiency of the processes.

The main benefit will be a better understanding of the mechanisms of the processes and their control loops. This will help to find solutions for currently pending problems in the paper industry: improving the paper quality, optimising the wet end chemistry, enhancing the runnability and reducing emissions by improving process design, process monitoring and decision support during operation. In the long run this action should also contribute to designing superior or new product properties.

3. TECHNICAL DESCRIPTION AND IMPLEMENTATION

3.1 **Items of technical work,**

Scientific area 1: Modelling and Simulation of Pulp and Paper Production

Pulp and paper production processes are complex and cover most of the unit operations known in chemical engineering. Due to the large amounts of water used and the low efficiency of the majority of separation steps, the process includes many re-circulated streams. This applies to all media involved - water, fibres and fillers, air and energy. For this reason, establishing a simple static balance can be a very demanding task. Heat balances have been handled with varying success during the last two decades. More difficult problems such as the simulation of various contaminants like stickies have not yet been handled successfully within the industry. Simulation of pulping processes has further advanced and can feed in some experience of handling multi-component balances including complex chemical reactions. Nevertheless, improved static modelling is the key to a better design of pulping and paper production processes and will therefore be addressed in the Action.

The paper production process is highly dynamic, and only few approaches to the dynamics of a paper machine have been published so far. Especially the dynamics of the paper machine wet end may be described as one of the most complex combinations of hydrodynamics and colloidal chemistry. No simulation model has yet been able to fully describe the processes taking place there. Only if the dynamics are understood can the dynamic optimisation of the paper production process be addressed.

Scientific area 2: Online Use of Simulation and Simulation Based Optimisation in the Pulp and Paper Production Processes

Due to the complexity of the pulping process and the dynamics of the paper production process, process control systems have widely been established in the pulp and paper industry. For a typical application, the number of the I/O connections can vary between 30,000 and more than 100,000. In most cases conventional control technology is used. Operators see the actual values displayed on screens, PID-controllers help to operate the plant.

Various approaches can be followed to manage these complex systems in an optimum way. The first issue to be addressed is to handle the huge amount of data available within the system. Fast data acquisition, high-dimensional data analysis and reduction play a major role in providing the right data set. In addition new sensors that have become available within the past

few years have to be evaluated as additional sources of information.

Based on the information available and processed, two approaches are to be followed depending on the issue addressed: The first approach is an open loop control by simulation-based decision making. Non-linear system modelling combined with multivariable system optimisation is one of the basic principles to be used here. Models are calibrated with real data, scenarios are calculated based thereupon. The results are made available to the operators and technologists who will then decide on the next steps to be taken.

The second approach is a closed loop approach. All quick control functions that are now performed by simple PID controllers are to be evaluated for their performance. Based on this evaluation, a decision can be made whether or not the application of advanced control techniques like multivariable process control will lead to potential improvements of the process.

Up to now some online simulation applications have been implemented in the industry. Most of the software tools have been developed in other sectors. The petrochemical industry has a leading role in applying these technologies. Existing applications in the paper industry are the optimisation of paper machine quality control (basis weight, filler, moisture etc.) in machine direction that is now widely done with MIMO-MPC (multiple input multiple output model predictive control) by commercial systems (Metso, ABB, Honeywell). The optimisation of basis weight, coat weight and moisture in the cross direction of the sheet were actually one of the first (if not the first) high-dimensional MIMO-MPC even though the dynamics was not dealt with quite correctly.

These applications serve as a good starting point for advanced simulation based optimisation. The main goal therefore is to identify new applications and to use all know how concerning the dynamic description of paper making processes to adapt other available solutions to the paper production process.

3.2 **The mode of operation**

The Action is based on a close co-operation and interaction between scientists and engineers from the pulp & paper industry, related research establishments and simulation software suppliers. This is promoted via

- Work group discussion meetings
- Exchange of publications and findings
- Organisation of workshops, seminars, conferences, site visits etc.
- Publication of seminar or conference proceedings
- Publication of the Actions annual interim reports and the final report
- Joint projects on specific topics may be launched by two or more partners

3.3 **Working Groups**

Within the broad terms of the proposed COST Action there is scope for three working groups on modelling and simulation in the pulp and paper industry. The groups will meet to exchange information on developments in the areas mentioned in chapter C. Special attention will be given to software as the major tool for modelling and simulation. Therefore the third working group (C) will consist of participants of all other working groups and additional suppliers. Here

the questions of a “lingua franca” connecting all simulation activities will be discussed in detail. The discussions will include the development and use of software packages.

The working groups shall cover, but not be limited to, applications of modelling and simulation tools in the following technological areas:

A) Modelling and Simulation of Pulp and Paper Production Processes

This working group will cover all topics concerning the modelling and simulation of the whole pulp and paper production process. This includes the chemical reactions in digesters, the complex pulp washing process, the modification of fibre properties during the process of stock preparation, the modelling of the complex wet end chemistry and the modelling of water loops and energy balances. Special attention will be given to the use of dynamic process simulation, real-time simulation tools and model validation tools.

B) Online Use of Simulation in Pulp and Paper Production Processes

This working group will concentrate on the use of simulation models during plant operation. It focuses on simulation-based decision making, multivariable process control, fast data acquisition, high-dimensional data analysis and reduction, non-linear system modelling and multivariable system optimisation.

C) Use of Simulation Software in the Pulp and Paper Industry

This working group intends to bring software developers and (possible) users together in order to reach agreements on the contents, features, relevance and performance of software products. Existing software packages should be evaluated. User needs and goals for further developments are to be elaborated. Discussions will include the development and use of software packages.

The working groups will meet and organise discussion meetings on a regular basis as funded by the COST action framework, which covers the travelling expenses of two representatives from each country. Other activities, such as short study visits and organised conferences, will also be conducted.

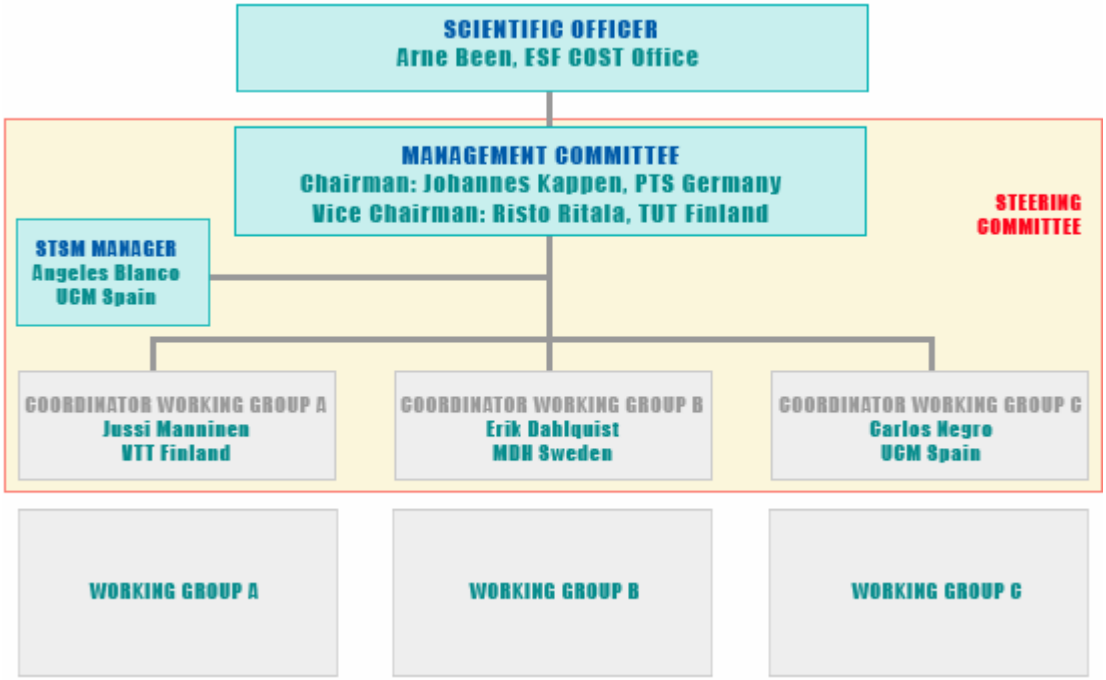
The focus of the third working group is on the exchange of knowledge between the working groups and on fostering the development of simulation tools with a high compatibility across the platforms used. This group will therefore meet on a schedule that is different from that of the other two actions. The third working group will organise dedicated workshops to meet with suppliers and developers of software in order to exchange knowledge and enhance software development.

3.4 **Organisation of secretarial services**

The coordinative work load is shared amongst the Chairman, the Vice-Chairman, the Working Group leaders and the STSM manager. Support is provided by the Cost office. No additional services have been used until now.

4. PARTICIPATION AND COORDINATION

4.1 Overview



4.2 Management Committee

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John Hoffmann, Hartmann A/S, Lyngby

Hans Ole Mathiesen, Hartmann A/S, Skovlunde

FINLAND

Kari EDELMANN, VTT Processes, Jyvskyla

Jussi MANNINEN (Steering Commitee Member, Working Group A Coordinator), VTT

Processes, Espoo

FRANCE

Jean RUIZ, Centre Technique du papier, Grenoble

Guy EYMIN, Centre Technique du papier, Grenoble

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Harald GROSSMANN, Technische Universität Dresden, Dresden

NORWAY

Bernt LIE, Telemark University College, Porsgrunn

ROMANIA

Elena BOBU, Technical University

Livia BUCSA, University "Lucian Blaga"

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Stefan BOHACEK, Pulp and Paper Research Institute, Bratislava

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SWEDEN

Peter AXEGÅRD, Swedish Pulp and Paper Institute, Stockholm

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THE NETHERLANDS

D.M.R. LO CASCIO, TNO-MEP, Apeldoorn

Leon P.A.A. JOORE, Millvision, Raamsdonk

UNITED KINGDOM

Hong WANG, UMIST, Electrical & Electronic Engineering, Manchester

ESF/COST Office

Arne Been, COST Office, Brussels

4.3 **Participating Institutions**

(List: denomination and country without address)

No additional Institutions are taking part in the action.

4.4 **Meetings of the Management Committee**

(List: date, place of each meeting)

Date	Place
22.1. - 23.1.2004	Cost Office, Brussels
8.3.2004	Munich
22.9.2004	Copenhagen
21.10.2004 (only Steering Committee; SC)	Cost Office, Brussels

4.5 **Meetings of the Working Groups**

(List: date, place of each meeting)

Working Group	Date	Place
A, B, C	8.3.2004	Munich
A, B, C	22.9.2004	Copenhagen

4.5 **Short-term scientific missions**

(List: dates, hosts and nationality of scientists and topics)

Date	Host	Name and nationality of scientist	Topic
19.07-23.07.04	PTS, DE	Alvaro Alonso,ES	Comparison of simulation programs.
23.08-27.08.04	KCL, FI	Alvaro Alonso, ES	Exchange of information about different software packages for data analysis and modeling.
06.09-17.09.04	VTT, FIN	Georg Kamml, DE	Exchange of knowledge on simulation models and optimisation tools.
25.10-29.10.04	STFI, SE	Cornelia Lumpe, NL	Applying chemical calculations to WinGEMS models and dynamic modeling.
31.1. – 11.2.2005	PTS, DE	Antti Aikala, FIN	Application of the DOTS toolset.
February 05	UCM,ES	David Ravnjak,SI	Simulation of polymer behavior

5. RESULTS

(Describe in no more than 2 pages the main results achieved indicating the key scientific and technical outcomes of the Action with a comparison with the international state-of-the art and with a self-assessment of results obtained versus objectives. Describe briefly the progress with respect to timetable and possible problems encountered. Additional documentation like extended scientific reports, proceedings of Workshops, Seminars, Conferences may be provided separately as an annex to the annual Progress Report and should be refereed in the report. Describe efforts made and success achieved in involving young scientists).

5.1 **Description of the initial situation as observed in Munich conference**

A first conference was organised in Munich. Being situated in the beginning of the COST Action E 36, it served as an ideal option to define the state, modelling and simulation in pulp and paper has currently reached. Against the background of what has been presented during the two days the following clusters could be identified:

- spreadsheet based object oriented process models,
- tools for monitoring and evaluation of online data,
- model based process optimisation and
- in smaller number, some approaches to model single process steps as the modelisation of the press- or drying section.

One large trend is to upgrade static simulation tools by integration of dynamic abilities into the simulators used. A big issue still to be solved is to define quality parameters for the validity of both, steady state and dynamic simulation models. In many papers more accurate models of the processes were identified as still missing. Thus, one important task will be to develop proper generic models of key processes that ideally will be available for common use within the industry.

5.2 **Working group results**

Working group A

Working group (WG) A looks at the use of modelling and off-line simulation as a R&D tool, for an optimal process design, for use in operator training and trouble shooting. The working group will cover topics that are important for wider use of modelling and simulation for the whole pulping and paper production process. These topics are:

- evaluation, calibration and validation of models
- property characterisation and modelling (e.g. fibres)
- modelling of solid-liquid separation processes (e.g. presses, forming section)
- water system chemistry modelling
- end-product quality modelling

The work is carried out by arranging thematic meetings, where working group members and invited experts present and discuss their approaches to the problem in question. WG A will also help WG C in improving compatibility between different simulation tools for better model portability.

Working group B

WG B will concentrate on the use of simulation models during the operation phase. It focuses on model-based monitoring, simulation-based operations decision support and model-based control.

For this purpose, it is intended to look deeply into multivariable process control, fast data acquisition, high-dimensional data analysis and reduction, non-linear system modelling and multivariable system optimisation.

The thematic focus of the working group is:

- understanding the operator behaviour, decision making
- dynamic optimisation, MPDS, algorithms and applications
- combining physical simulators, grey box models and black box modelling
- model based and/or simulation based diagnostics

Next activities are intended to refine the thematic focus. The benefit and infrastructure analysis on application topics is to be explored. Working group B plans to write a book concerning "Application of Process Simulation in P&P Industry".

Working group C

WG C intends to bring together software developers and (possible) users in order to reach agreements on the contents, features, relevance and performance of software products. Existing software packages should be evaluated. User needs and the goals of further developments are to be established. Discussions will include the development and use of software packages. In addition WG C will take care of integration aspects (simulation software in mill environments).

WG C is specially intended to take care of the knowledge exchange between the WG's and to foster the development of better simulation tools with a high compatibility across the platforms used. This WG will therefore have a different schedule, organising dedicated workshops to meet with suppliers and developers of software in order to exchange knowledge and enhance software development.

WG C has already started a survey of all partners in the COST Action E36 to gather information on current software use. In addition, all available software evaluations performed by the partners have been collected and will be processed by WG C. The results of this survey on software use will be published as a mini-booklet within 2004. Currently 13 organisations in 8 countries are taking part.

Workshops are planned to cover the topics of software evaluation, mathematical tools for data analysis, neural networks, multivariate analysis, data handling and pre-processing before simulation and on requirement specifications for future simulation tools.

5.3. **Competencies directory**

The Action has analyzed competence categories associated with modeling and simulation of pulping and papermaking processes. This categorization is intended to be used with "competence yellow pages" that allow the research groups to present themselves in a compact and coherent way, and which allows new research groups and organizations utilizing the technology to make searches for partnerships."

6. DISSEMINATION OF RESULTS

6.1 Publications and Reports

(Give the total number. Detailed list in an annex)

Total number of Publications: 3

6.2 Conferences and Workshops

(List)

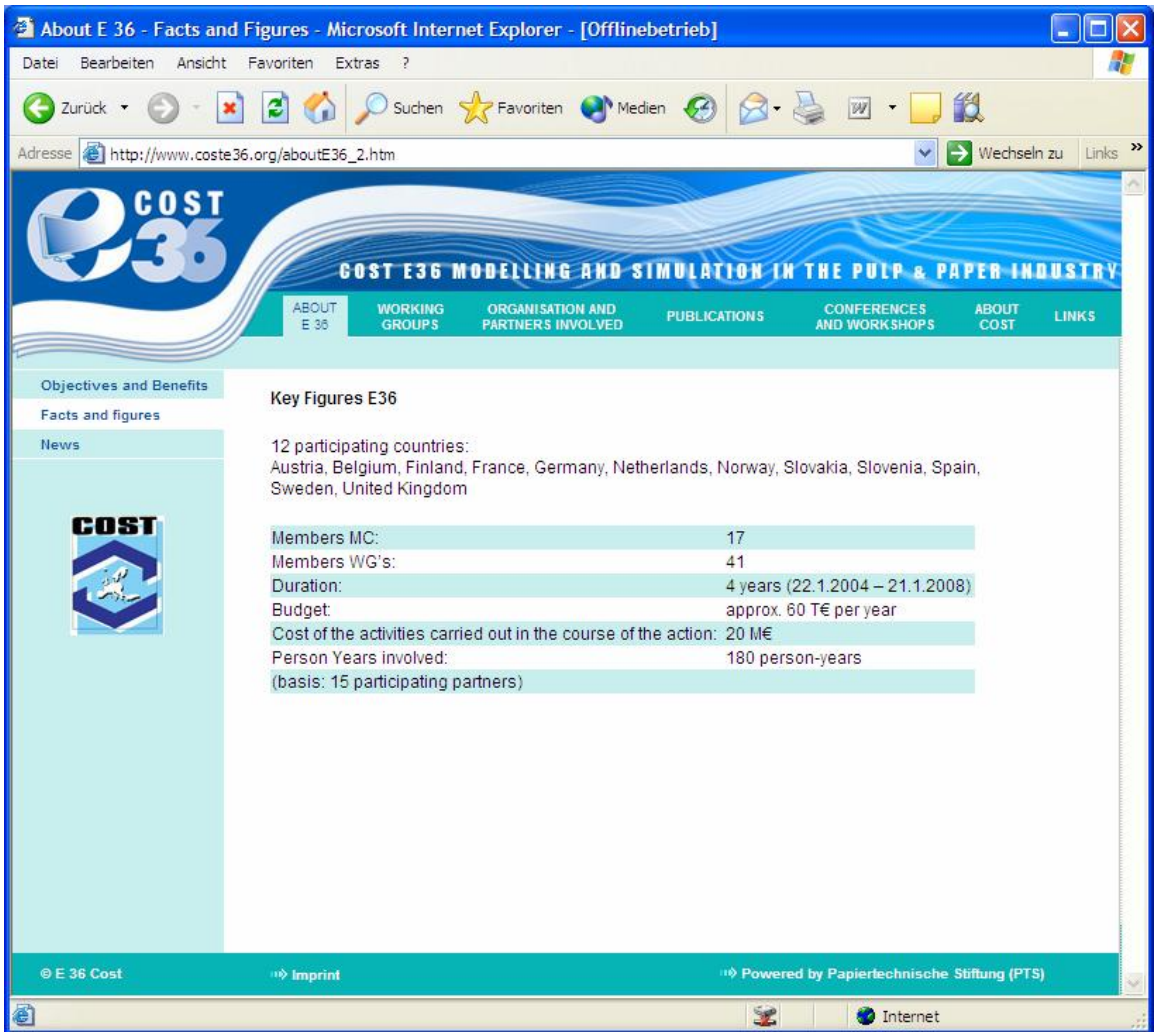
Date	Location	Title
9.3. - 10.3.2004	Munich	Simulation and Process Control

6.3 Web site

(Describe briefly)

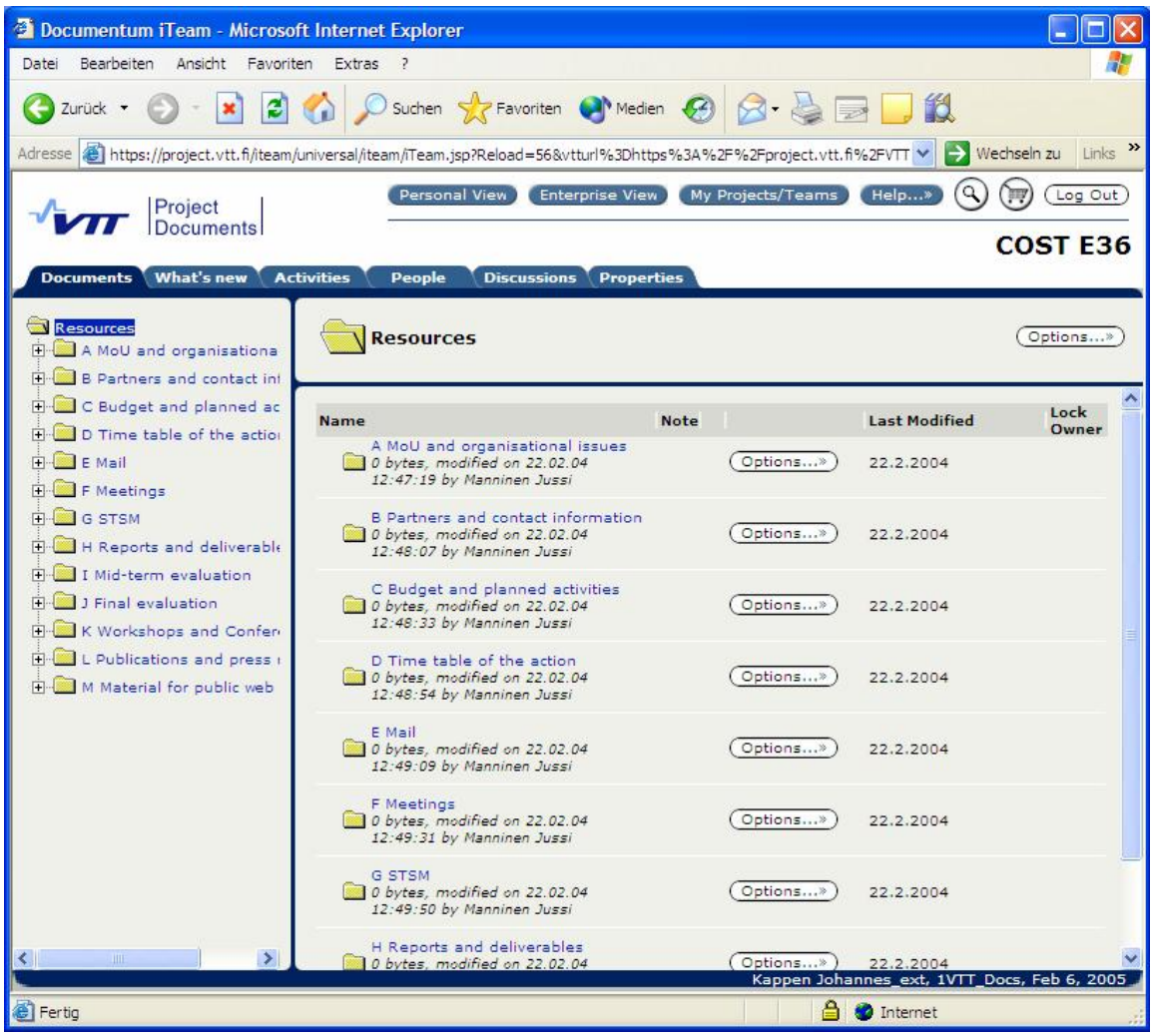
A Homepage has been set up to give a first insight into Cost E36 (Fig. 1). It also is a platform to promote the activities towards the general public. The website is available following the link www.costE36.org. These pages have been set up and are operated by PTS.

Fig. 1 View of homepage Cost E36



In order to support the internal exchange of documents a document system is operated (Fig. 2). This is only available to members of the cost action. These pages have been set up and are operated by VTT.

Fig. 2 View of internal document handling system Cost E36



6.4 Scientific and Technical Co-operation

(List briefly co-operation and contacts established with scientific institutions, with other research programmes, especially in the EU framework programme, and with potential users)

There have been taken actions by Cost E36 to establish a contact with ASIM, the German speaking simulation association and EUROSIM, its European mother institution. To our regret this did not work out until now. Another attempt is planned in 2005.

6.5 Transfer of results

(List briefly co-operation and contacts established with the Commission, with normalisation and standardisation bodies, with industry and operators)

WG B is currently planning a meeting to get operators vies on the use of modelling and simulation results in daily practice.

WG C will have a meeting with simulation software suppliers to evaluate the software and

discuss options for further improvement.

6.6 **Contacts in the ERA**

(List the contacts, if any, with other activities in the European Research Area (ERA), e.g. integrated or targeted projects, NoE, EUROCORES, etc.)

The Action has been in contact with EU/FW5 project DOTS (G1RD-CT-2002-00755) which is developing dynamic optimization for paper machine applications. There is a strong synergy between Cost E36 and DOTS in that DOTS relies on dynamic process models. The results of DOTS have been presented and discussed both in March meeting Munich and in September meeting in Copenhagen. Furthermore, as DOTS is closing in end February, 2005, it has been decided to arrange a back-to-back one-day DOTS post-project seminar and COSTE36 workshop in end of April, 2005. The aim of the event is to raise awareness about DOTS results and their relationship to modeling and simulation within the industrial end-user organization, suppliers to end users and the research community.

SIM-SERV is a FW5 NoE that was completed in the end of October 2004. SIM-SERV promotes simulation as a practical tool for process industries and is thus closely related to COSTE36. SIM-SERV aims to sustain and develop its activities as a not-for-profit organization offering assistance in finding competent partners for building practical simulation applications. COSTE36 will support SIM-SERV in this task by making its partners aware of SIM-SERV and by seeking joint actions.

7 ECONOMIC DIMENSION

7.1 **Total manpower**

(List estimate of total manpower expressed in person-year dedicated to the activities of the action for each year and the total duration of the action)

Year	Manpower (person years)
2004	50
2005	
2006	
2007	
2008	
Total (estimated)	180

7.2 **Funds received**

(List funds received from the COST budget for each year and for the entire duration of the Action utilised for Secretariat, Publications, Workshops and Seminars, MC meetings, Short-Terms scientific missions, other and Total)

Date	Funding	Title
22.1. - 23.1.2004	8867	MC Kickoff Meeting, Cost Office, Brussels
8.3.2004	27508	MC and WG-Meetings, Munich
9.3. – 10.3.2004	3000	Conference, Munich
22.9.2004	22467	MC and WG-Meetings Copenhagen
25.10.2004	4107	SC-Meeting, Cost Office, Brussels
2004 Total	65949	

8. SELF EVALUATION

(only in the last annual progress report)
Indicate, in no more than 1 page, what were, in the opinion of the MC, the main successes, the drawbacks (if any) and the key difficulties encountered (if any).

APPENDIX 1: Action identification data

Action Overview

COST Action E36

Title: *"Modelling and Simulation in Pulp and Paper Industry"*

Domain: Forests and Forestry Products

MoU:

Entry Into Force: 9/10/2003[1] **CSO Approval:** 6/02/2003

End of Action or Prolongation: 21/01/2008[2] **1st MC:** 22/01/2004

Total Number of Signatories: 10

Belgium	9/10/2003	Denmark	6/10/2004	Finland (intention)		Germany	9/10/2003
Netherlands	15/10/2003	Romania	23/03/2004	Slovak Republic	15/10/2003		
Slovenia	9/10/2003	Spain	8/10/2003	Sweden	9/10/2003		
United Kingdom	2/12/2003						

Non Cost Institutions participating:

None

Working Groups:

Working group A looks at the use of modelling and off-line simulation

Working group B will concentrate on the use of simulation models

Working group C intends to bring together software developers and users

Science Officer & Management Committee Chair:

Mr Arne BEEN Secretariat (Science Officer)

Mr Johannes KAPPEN Management Committee (Chair)
Papiertechnische Stiftung
Hess-str. 134
80797 München
Germany

Publications:

Kappen J. und Ch. Bienert (Hrsg.)
München: PTS 2004; PTS Symposium Simulation and Process Control for the Paper Industry PTS-MS 441

Johannes Kappen, Erik Dahlquist, Jussi Manninen, Carlos Negro, Risto Ritala
A big leap forward – The new European COST Action E 36 "Modelling and Simulation in the Pulp & Paper Industry"
Lyngby, SIMS 2004, DTU, Danish Technical University, September 23rd – 24th 2004.

Negro C. and A. Alonso
Mini-Booklet concerning the use of simulation software
Madrid, 2004

Website: http://www.coste36.org