

COST

Domain Committee “Transport and Urban Development”

COST Action TU0903

Start Date (04/10/2009)

Methods and tools for supporting the use, calibration and validation of traffic simulation models (MULTITUDE)

MONITORING PROGRESS REPORT

Reporting Period: from 01/03/2012
to 28/02/2013

This Report is presented to the relevant Domain Committee.
It contains three parts:

- I. Management Report** prepared by the COST Office/Grant Holder
- II. Scientific Report** prepared by the Chair of the Management Committee of the Action
- III. Previous versions of the Scientific Report;** i.e., part II of past reporting periods

The report is a “cumulative” report, i.e. it is updated annually and covers the entire period of the Action.

Confidentiality: the documents will be made available to the public via the COST Action web page except for chapter *II.D. Self evaluation*.

Based on the monitoring results, the COST Office will decide on the following year’s budget allocation.

Executive summary (max.250 words):

So far the Action addressed the majority of the ambitious objectives set out in the MoU. All the active working groups produced new notable achievements in the last reporting period. The following are among those worth mentioning:

- A new simulation platform to benchmark dynamic origin-destination (OD) estimation and prediction algorithms;
- The starting of work on a “Case for guidelines” support and strategy document, based on the performance of a web based survey and stakeholder meetings;

(cont.)

Executivesummary (cont.):

- A methodology to reconstruct trajectory data from noisy measurements and its application to NGSIM and MoCoPo datasets;
- The completion of a successful training school on “Assessment of ITS solutions” and the organization of the third and last school on “Uncertainty in traffic simulation” (only one school was planned in the MoU).

The multidisciplinary work on uncertainty quantification and sensitivity analysis techniques applied to traffic simulation, that is an entirely new contribution of the Action to the field research, substantiated in several scientific papers, some presented at the two special sessions promoted by the Action at the 2012 IEEE ITS Conference and at the 2013 TRB, respectively.

A special call for papers has also been made through the IEEE Transaction on ITS that will contain papers summarising and detailing many of the technical achievement of the project.

Along the same line is the Action contribution to the multi-disciplinary workshop “Monte Carlo Methods in the Natural Sciences, Engineering and Economy”, held at DESY, Hamburg that provided a forum for discussing state-of-the-art technology from various fields.

Overall, a role of leadership in researching the field of uncertainty in traffic simulation is worldwide acknowledged to the Action, whose work recently inspired also some research programmes issued by the US FHWA.

I. Management Report prepared by the COST Office/Grant Holder



Title

Methods and tools for supporting the use, calibration and validation of traffic simulation models (MULTITUDE)

Contacts

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Details

Draft Mou:	Mou: 244/09
Start of Action: 04/10/2009	Entry into force: 26/06/2009
End of Action: 03/10/2013	CSO approval date: 26/05/2009

Objectives

The main objective of the Action is to develop, implement and promote the use of methods and procedures for supporting the use of traffic simulation models, especially on the topics of model calibration and validation. To this date, the bulk of resources and effort in the field of traffic simulation have focused on model development, leading to many simulation models being available on the market. These models are extensively used in applications that have great potential impact on the safety, capacity and environmental efficiency of the road system. However the fidelity of results and conclusions drawn from a simulation study, as well as the range of possible applications the tools can reliably be used for, are questionable: the same simulation study carried out by different people, even when using the same tool, is likely to give different results. Thus, the trustworthiness of the results almost entirely depends on the ability of the model users and on their intuition. Moreover, the increasing complexity of models makes appropriate and correct use a difficult task even for experts, requiring very specific calibration and validation methodologies. For these reasons the main objective of this Action is to develop, implement and promote methodologies and procedures to support the use of traffic simulation, especially on the topics of calibration and validation. To this aim the sharing and exchanging of available traffic datasets will also be a key task of the Action.

Parties

Country	Date	Country	Date	Country	Date	Country	Date
Belgium	22/03/2010	Finland	16/12/2009	France	10/08/2009	Germany	26/06/2009
Greece	26/06/2009	Ireland	07/01/2010	Israel	26/06/2009	Italy	26/06/2009
Latvia	22/12/2009	Netherlands	25/09/2009	Poland	21/10/2010	Portugal	29/07/2009
Spain	10/09/2009	Sweden	03/12/2009	Switzerland	31/07/2009	Turkey	15/08/2011
United Kingdom	26/06/2009						

Total: 17

Participating Institutions from the European Commission

Institute for Environment and Sustainability- Joint Research Centre
Institute for Environment and Sustainability- Joint Research Centre
Institute for Environment and Sustainability- Joint Research Centre

Working Groups

Website

<http://www.multitude-project.eu/>



I.B. Management Committee member list

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Grant Holder		
Executive	Finance Officer	Legal Representative



I.C. Overview activities and expenditure

(year) Budget

Total Action Budget: 139'090

Remaining Action Commitment: 112'933.20 + secretariat (excluded that for the final event)

* these costs are still to be paid

Meetings

Meeting Type	Date	Place						Cost	Total
WG4	13/3							2570,36	
WG2	22-23 /4							1796,45	
MC	30-31 /5							11650,40*	
WG3	t.b.c.							5982,79*	22000

STSM

Beneficiary	Date	Place						Cost	Total
Manuel Bullejos	12/5- 13/7	Rome						2500	
Costantinos Antonios	28/6- 4/7	Bristol						1150	
Vittorio Marzano	10/9- 24/9	Chania						2300*	5950

Workshops

Title	Date	Place						Cost	Total
Final Conference	3/12	6/12	Naples					57000*	
									57000

General Support Grants

Beneficiary	Date							Cost	Total
									0

Schools

Title	Date	Place						Cost	Total
Uncertainty in traffic simulation	3-6/9	Chios GR						36000*	36000

Dissemination

Title	Date	Place						Cost	Total
									0

Others

Action Total : 120950,
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II. Scientific Report prepared by the Chair of the Management Committee of the Action, describing results achieved during the Action operation in this period, in no more than 3 pages (the report is “cumulative”). All items listed in Sections A, B, and C, below, must be addressed.

Additional documentation such as extended scientific reports, proceedings of workshops, seminars or conferences may be provided separately as an annex to this report, and should be referenced in the report.

II.A. Innovative networking

- *Innovative knowledge resulting from COST networking through the Action. (Specific examples of Results vs. Objectives)*

In the past year, innovative knowledge resulting from COST networking through the Action concreted in the following major achievements:

1. The development of a common simulation platform to benchmark different dynamic origin-destination (OD) estimation and prediction algorithms;
 2. The starting of work on a “Case for guidelines” support and strategy document, based on the performance of a web based survey and stakeholder meetings;
 3. The development of a methodology to reconstruct trajectory data from noisy measurements and its application to NGSIM and MoCoPo datasets.
 4. The completion of a successful training school on “Assessment of ITS solutions” and the organization of the last Action training school on “Uncertainty in traffic simulation”.
1. The developed simulation platform aims at providing a common evaluation and benchmarking framework for origin-destination (OD) estimation and prediction algorithms. The evaluation and fair comparison of different algorithms has been never possible so far, representing a major limitation to the scientific progress in the field. In fact, all the methods proposed in the literature have been tested on different networks and traffic conditions, with different type of data, applying different traffic simulation tools and often using different evaluation metrics that made impossible the fair comparison of results. The objective is therefore to illustrate the advantages and disadvantages of the various approaches, highlighting the conditions under which each might become more relevant. To this aim, the framework is based on the validation through laboratory experiments, a paradigm that has been strongly promoted within the Action.

Several experienced OD estimation researchers are involved in this task, including several TRB’s TFT and SimSub members, bringing expertise from diverse fields of OD estimation.

The framework is implemented in Matlab and python and uses the AIMSUN traffic simulator for the function evaluation/assignment. Besides providing a common platform, the developed framework requires each participant to simply implement their algorithm (in Matlab), while taking advantage of the remaining infrastructure for the tedious tasks of interfacing with the simulator, performing (and averaging the output of) the replications and computing the goodness-of-fit statistics. An experimental design has been performed along multiple dimensions, including *i*) OD estimation and prediction algorithms *ii*) networks *iii*) data sources *iv*) demand levels and *v*) levels of sensor coverage.

More details can be found in the issue of the TRB SimSub newsletter attached here (appendix A).

A paper presenting the evaluation framework and the first results will be submitted to the special issue of IEEE Transactions on ITS, “Emerging techniques for the management of uncertainty in computational traffic models”, promoted by the Action (deadline July 15th, 2013. See the attached call for papers: appendix B). The

final results will be presented at the Action final conference in Naples (4-6 December 2013) and, hopefully, at the TRB 2014 (deadline August 1st, 2013).

2. In WG4, the project undertook a review of existing guidelines for model calibration and started work on a '*Case for guidelines*' that will review the context of this area, and strengths and weaknesses of current documents, demonstrating the implications of improper calibration, and suggest a roadmap for future developments in this area, forging a link between academics and practitioners. The document is based on the results of an internet survey on the issue of guidelines performed in 2012, and the findings of face to face stakeholder meetings held by the Action in the UK, Germany, France and Holland with Government representative and Consultants. The document includes examination of 'hot issues', currently perceived as being problematic, including:

- How to structure a simulation project/calibration activity.
- How to handle model 'warm up'/run duration.
- Number of runs to perform.
- Sensitivity analysis, how to perform it.
- The relative effect of parameters (and different types of parameters) on output.
- Appropriate definitions of calibration and validation.
- Calibration methodologies.
- Differences in procedure according to scale /model purpose.
- What to do in the absence of appropriate data, potential 'fall-back strategies', transferability of data between calibrations etc.
- Which indicators to use/not use, for calibration and validation.
- What data to use for validation and when to perform it.

The document will be available in the autumn 2013 on the Multitude website.

More details can be found on the attached flyer delivered to the commercial software partners of the Action (TSS, SIAS and PTV) for advertising the forthcoming guidelines in their training courses and events over the summer of 2013 (appendix C).

3. A methodology has been developed to reconstruct the trajectory of vehicles from noisy measurements. It has been applied to the complete dataset I80-1 of NGSIM trajectory data and the resulting dataset will be posted on the Action website after the summer 2013. The reconstructed trajectories resolve most of the errors and inconsistency in the original data and the resulting dataset is expected to become a world reference for researchers in traffic flow theory and simulation. An amended version of the methodology has been also applied to the trajectory measurements resulting from the MoCoPo project (France).
4. The second edition of the MULTITUDE training school on the "*Assessment of ITS solutions*" took place at the Ispra site, Italy, of the European Commission JRC, on June 6-8, 2012. It was co-organised and co-sponsored by the JRC and by NEARCTIS. Its main objective was to provide attendants with training on the evaluation of Intelligent Transportation Systems (ITS), including the core methodologies for the quantification of the impacts, the multi-criteria analysis and the management of uncertainty. In total, 44 persons participated in the training school. The participants were affiliated to 28 institutes in eleven different countries. 28 evaluation forms were collected during the school. On average the 'overall quality' of the school was judged very positively, with nobody giving a score lower than sufficient.
Full details about the students' evaluation are given in the attached confidential evaluation report (appendix D).
During the reporting period the Action also started the organization of the third and last training school (against the only one foreseen in the MoU), entitled "*Uncertainty in traffic simulation*", that will aim at disseminating the last advancements and the

emerging trends in the core topics of the Action. The intensive four day school will provide attendants with training on the reliability of predictions made by traffic simulation models, and tools and frameworks for the management of uncertainty, and their systematic calibration and validation. Several case studies will be presented and a practicum will guide attendants through the application of the whole process of uncertainty management in traffic simulation. The school will be hosted by the University of Aegean in Chios, Greece, from the 3rd to the 6th of September 2013. Attached is the school leaflet (appendix E).

In addition the project is also set to produce a '*Simulation Primer*' intended to cover the core topics of simulation and focus on issues that, have been found to be poorly understood by practitioners.

- *Significant scientific breakthroughs as part of the COST Action. (Specific examples)*

A major scientific breakthrough is expected from the application of the framework for the benchmarking of OD estimation and prediction algorithms.

The scientific paper illustrating the methodology and the results of a benchmarking exercise of all the calibration settings applied to microscopic traffic flow models so far in the field literature, has been awarded with the Greenshield Prize by the TRB of the National Academies, USA (at the 2013 TRB Annual meeting).

Many scientific works on the topic of model output sensitivity analysis arising from the Action are getting the interest of the field scientific community. Some of them have been presented at two special sessions promoted by Multitude at the IEEE ITS Conference 2012 and at the TRB 2013.

In general, the international scientific community is very highly valuing the role of the Action in the development, diffusion and promotion of systematic methods to manage the uncertainty in traffic simulation. Such role is well acknowledged also in the USA where the work made in Multitude has inspired two recent bids by the FHWA: an update of the "*Guidelines for Applying Traffic Microsimulation Modeling Software (Traffic Analysis Toolbox Volume III)*" (some Multitude participants are also serving in the FHWA Traffic Analysis Tools (TAT) Expert Panel) and the "*Analysis, Modeling, and Simulation (AMS) Testbed Development and Evaluation to Support Dynamic Mobility Applications (DMA) and Active Transportation and Demand Management (ATDM) Programs*".

- *Tangible medium term socio-economic impacts achieved or expected. (Specific examples)*

European traffic micro-simulation software makers are actively contributing to the Action. This is expected to sensibly increase the quality of their products and therefore their competitiveness on the global market.

The diffusion of the new concepts and techniques among practitioners and public agencies will make the decision making process more transparent with beneficial socio-economic impacts. The quantification of such impacts is not easy to make.

- *Spin off of new EC RTD Framework Programme proposals/projects. (List)*

- ✓ PREMMIUS (A SaaS Collaborative Exchange Framework for Personal Real-Time Multimodal Mobility Information for Urban Services) FP7-SMARTCITIES-2013

- *Spin off of new National Programme proposals/projects. (List)*

- ✓ "Assessment of Level of Service by Traffic Flow Simulation in Compliance with the German Highway Capacity Manual" funded by the German Federal Highway Research Agency (BASt).
- ✓ CISMOTU (Ciudadanos Sensores de información sobre Movilidad y Transporte Urbano), Spanish Ministry of Economy and Competitiveness, Funding Agency FECYT

- ✓ MOCOPo (Measuring and modelling traffic Congestion and Pollution) (France)
<http://mocopo.ifsttar.fr>
- ✓ "Calibration of simulation tools in Finland" (2012 - onwards):
http://civil.aalto.fi/en/research/transportation/research/research_areas/its_research/capacitycalibration/
- ✓ "Effects of Attractions on Pedestrian Flow" (2011- onwards): microscopic pedestrian flow simulation (pedestrian-attraction interaction) (Finland)
- ✓ "MUSIG - Multi-Objective Optimization of Signal Control (Aalto-KTH 2012-)" (Finland)
- ✓ Project: "Highway P133 and Ziemelu street intersection simulation and capacity estimation" Head of the project: I.Yatskiv, Executers: M.Sc.Comp. MihailsSavrasovs, M.Sc. Oec. LevsFainglozs, Vladimirs Vents

II.B. Inter-disciplinary networking

- *Additional knowledge obtained from working with other disciplines within the COST framework. (Specific examples)*

Theoretical methods and practical codes for the uncertainty management in transportation and traffic models have been disseminated and discussed within the Action community following an intense exchange with researchers from the EC-JRC. Such experts have contributed to the 2nd edition of the summer school and will also join the Action final conference.

The Action has also contributed to the multi-disciplinary workshop "Monte Carlo Methods in the Natural Sciences, Engineering and Economy", held on February 19-21, 2013, at DESY, Hamburg. The aim of the workshop has been to bring together experts on Monte Carlo simulation in the natural sciences, in engineering and in economy. The focus was on providing a forum for discussing state-of-the-art technology from various fields such as to seed interdisciplinary exchange of knowledge and potentially common efforts or development.

- *Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide scientific impacts. (Specific examples)*

The level of inter-disciplinarity achieved with the work on the "uncertainty management" (as also described at the previous point) is already producing scientific impacts.

- *Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide socio-economic impacts. (Specific examples)*

The level of inter-disciplinarity is deemed sufficient to produce an increase in the reliability of traffic simulation models and in their ability to serve planning, design and operations of efficient and sustainable transportation systems, thus also potentially providing significant socio-economic impacts.

II.C. New networking

- *Additional new members joining the Action during its life.*
None
- *Total number of individual participants involved in the Action work. (Number of participants. Give % of female and of Early Stage Researcher participants)*
Around 90 researchers have been involved in the Action with 22% female and 35% Early Stage Researchers.
- *Involvement of Early Stage Researchers in the Action, in particular with respect to STSMs, networking activities, and Training Schools. In addition, justification should be provided if less than 4 STSMs were carried out during the year.*
The percentage of ESRs involved in the Action is notable. 4 out of 9 WG leaders/co-leaders

are ESRs and the chairman and the vice-chairman were ESRs at the beginning of the Action. The involvement of ESRs in the Action activities is also significant.

- *Involvement of researchers from outside of COST Countries. (Number of participants from non-COST Countries approved by the CSO. Give % of such participants from countries with reciprocal agreements. Specify their contribution)*

At the moment there are no participants from non-COST Countries approved by the CSO. However a number of researchers from non-COST contribute as experts (also at the school).

- *Advancement and promotion of scientific knowledge through publications and other outreach activities. (Number of publications and other outreach activities that resulted from COST networking through the Action. Complete list should be given in an annex)*

A special call for papers has been made through the IEEE Transaction on ITS with three COST Action members (including the project chair) acting as guest editors. It is hoped that this issue will contain papers summarising and detailing many of the technical achievement of the project and be a lasting academic record of its achievement. It is hoped that this Special Issue will go to print in mid 2014 publishers schedules allowing.

Two call for papers and related special sessions have been held at the 2012 IEEE ITS conference in Alaska and at the 2013 TRB Annual meeting.

Q Fu was sponsored by COST MULTITUDE Conference Grant to take part in the 5th International Symposium on Transportation Network Reliability, and the 17th International Conference of Hong Kong Society for Transportation Studies (HKSTS), both were held in Hong Kong in December 2012. He was the Runner-up for the Best Paper Award for a Young Scientist at the HKSTS conference.

An incomplete list of the scientific publications on the Action themes is attached (AppendixF).

- *The capacity of the Action members to raise research funds.*
The capacity of the Action members to raise funds in the Action topics is explained by the list of national projects funded provided at point II.A.

II.D. Self evaluation

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

The main successes obtained during the current reporting period refer to the four major achievements previously described (see details in section II.A). They concern, respectively, with *i)* the framework for the evaluation of OD estimation and prediction algorithms, *ii)* the work on the "Case for guidelines", *iii)* the trajectory reconstruction methodology and resulting dataset and *iv)* the training schools.

The common framework for the evaluation of OD estimation and prediction algorithms developed in the Action is an absolutely new contribution and will hopefully constitute a scientific breakthrough in the field literature. Of course, its conception and development were all but simple. One of the challenges was to produce an interface to the traffic simulator that was sufficiently general and flexible to be useful and fair with all the algorithms to be tested. In addition to the work of the deputed group of code developers, some workshops were needed to define the requirements and to give feedbacks to the developers. In addition to the technical challenges, the main difficulty was to maintain the level of involvement of people in-between the workshops as high and homogeneous as possible, which implied some delay in the scheduling (in fact only a small minority of people involved had research funds to support the activity).

The work on the guidelines on traffic simulation was continued with stakeholder meetings in Holland (Delft) and France (Paris) allowing a perspective to be gained on how this issue is viewed across EU states. This, combined with an online survey has given rise to a better understanding as to where gaps lie in our understanding and above all what needs still exist for guidance on calibration related issues in practice. This has led to work on a 'Case for guidelines' to be issued later in 2013 that will set the scene for future work in this area and bring academia and practice

closer together. It is expected to be a major inheritance of the Action indeed.

Another major Action legacy is expected to be the new vehicle trajectory dataset reconstructed from the NGSIM database. Severe errors which limit the applicability of the precious NGSIM data were identified as part of the Action activities and acknowledged by the scientific community. The methodology that fixes most of data inconsistencies is a notable contribution to the traffic research community.

Finally, the training school held at JRC in Ispra, Italy, has been a clear example of very effective synergy among different actors to deliver good training on a complex topic. It put together outstanding speakers from Multitude, Nearctis, the European Commission and the broader academia, around a hot theme (the assessment of ITS) that required rich multidisciplinary competences. As a result, it also gained a high level of appreciation from the students.

As a final consideration on the value of the work and the results achieved so far, it has to be stressed that a leadership role in researching traffic simulation is worldwide acknowledged to the Action by now, the last evidence being the two recent projects inspired to the FHWA by the work in Multitude (see details in section II.A).

Concerning the difficulties encountered, the main one has been that of raising funds at national level which made life harder to researchers committed to carry on the ambitious Action plan.

III. Previous scientific report(s)

**Reporting Period: from 01/03/2011
to 29/02/2012**

II.A. Innovative networking

- In the past year, innovative knowledge resulting from COST networking through the Action has resulted in the following major achievements:
 1. the web-based survey on the state of the practice in traffic simulation (task 1.1) performed earlier in the project was analysed and disseminated at the 2012 TRB meeting;
 2. the state-of-the-art report in research related to the development, calibration and validation of traffic simulation models, and corresponding data collection (tasks 1.2, and 1.3) was updated and passed through external reviewers
 3. the census of existing traffic datasets was updated and continued (tasks 2.1 and 3.1);
 4. techniques for sensitivity analysis of models were spread and applied within the community (task 2.3);
 5. an exhaustive exploratory study was carried out to compare the different optimization settings applied so far for the calibration of microscopic traffic flow models (task 2.4);
 6. a new task was initiated relating to the benchmarking of different OD estimation and prediction algorithms (task 3.3)
 7. a range of end user stakeholder interviews regarding simulation guidelines were performed and an active sub group examining this area was formed (task 4.3).
 8. the training school "Traffic modelling for traffic management and cooperative systems" was completed and a new one was organized for the new year (task 4.3).

1. The web survey undertaken in previous years was fully analysed and was the focus of a paper at the 2012 TRB meeting in Washington D.C, attracting particular interest from the AHB45(1) Traffic flow theory (simulation) committee, and leading to links with the ITE (Institute of Transportation Engineers) who have offered to re-circulate the survey to their members in 2012, allowing new data to be obtained from a sector that has until now been mostly unavailable.
2. The scientific report has been updated up to the 2011 and has gone through an external revision process since the beginning of 2012.
3. The census of existing datasets made in the previous year has been updated and expanded. In the last MC meeting in London (February 2012), it was also decided to upload on the Action website the diagrams - produced within the Action - of the complete set of vehicle trajectories from the NGSIM project. This was thought to be a significant contribution to the research community as such diagrams (not available at the source) will allow for a quick and effective inspection of the data and their accuracy.
4. After the dissemination of the theoretical bases and the practical methods for 'global sensitivity analysis of models' within the Action community, a joint program of application of such methods to traffic simulation has been set, in line with the task 2.3 "Understanding the role and impact of parameters on model outputs". Since the Naples meeting on February 2011, 15 researchers from 8 different Institutions in 6 COST Countries, indeed, have started to apply such techniques for enhancing model comprehension, simplifying models and supporting calibration, uncovering technical errors or identifying critical regions in the space of the inputs. After almost six months, at the meeting in Ispra (November 2011), results from the application to different models (3 micro, 1 meso, 1 macro and many car-following models) confirmed the powerfulness of SA in supporting the model development.
5. In line with the task 2.4 ('Developing techniques for highway model estimation and validation') an exhaustive exploratory study has been carried out to compare the different optimization settings applied so far for the calibration of microscopic traffic flow models. Main objective of the study was to inspect the reliability and robustness of calibration results (the corresponding paper, published in Transportation Research Record: Journal of the Transportation Research Board, has been awarded with the Greenshield Prize 2012).
6. A new task has been initiated within WG3, relating to the benchmarking of different OD estimation and prediction algorithms. In order to progress towards this goal, a number of subgroups of project participants have been mobilized. In particular, one group of volunteers have indicated their interest to evaluate one or more OD estimation algorithms, while another group is developing a software module that will be used to interface the algorithms with a traffic simulator (AIMSUN has been selected for this task). The script is developed using MATLAB and python. A rigorous experimental design has been developed in order to ensure that the results obtained by the various groups will be comparable and useful in the context of this exercise. The current state of this task is the integration of the various components. The process was kick-started in the meeting in Ispra in November 2011. Another major milestone was the meeting in London in May 2012.
7. A specialist sub group (task 4.2) has formed and activity taken place in reviewing and considering guidelines for calibration and validation. As part of this process existing documents have been reviewed and links made with active individuals in Australia, New Zealand and the USA who have joined the group as 'observers'. The group has organised and held two stakeholder meetings in London, UK, and Karlsruhe, Germany in Feb 2012 in order to find out what practitioners most want from guidelines and indeed how aware they are of existing documentation. This has revealed an interesting mis-match between academic and end user concerns. These meetings are to be followed up by additional meetings in France and Holland in the next year of the project and an analysis undertaken of end user needs in this area.
8. Building on the success of the training school "Traffic modelling for traffic management and cooperative systems" held during the current reporting period (and already described in the previous annual report; see part III) a second edition of the training school has been organized. It will be on the "assessment of ITS solutions" and will take place at the EC Joint

Research Centre in Ispra on June 6-8, 2012 (<http://www.multitude-project.eu/its-school.html>). It is worthwhile mentioning that in the Action MoU a training school was foreseen only in the last year of the Action, while, actually, two editions are going to be completed soon and a third edition is foreseen for the last Action period.

The school 2nd edition is organised and co-sponsored by JRC and NEARCTIS. Its main objective is to provide attendants with training on the evaluation of Intelligent Transportation Systems (ITS) measures, including the core methodologies for the quantification of the impacts, the multi-criteria analysis and the management of uncertainty..

- Notable scientific achievements have been attained in different specific tasks of the Action. Some examples are *i)* the proposal of sensitivity analysis methods to support the traffic flow model calibration (tasks 2.2-3), *ii)* the benchmarking of the different settings applied in the calibration of car-following models so far (task 2.3), and *iii)* the proposal of innovative techniques for addressing the problem of the OD matrix estimation (task 3.3).
- It is rather difficult to point out tangible medium term socio-economic impacts accomplished as part of the Action, though the problem of model results reliability and robustness is starting to be acknowledged also in the community of practitioners and the application of the developed methods also by the model developers involved in the Action to their commercial products, is expected to yield socio economic impacts in the medium term.
- *Spin off of new EC RTD Framework Programme proposals:*
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- *Spin off of new National Programme projects:*
 1. Energy efficient city and model city for renewable energy – MD-E4 Sub-project Traffic management center (German Federal Ministry of Education and Research, grant number 03SF0407E)
 2. Project titled 'An integrate system for freeway ramp control' is submitted to national research council (TUBITAK) for participation to COST TU1102 'Towards Autonomic Road Transport Support Systems'.
 3. Title of the project: 'Analysis of network flow propagation: model development and utilization of simulation models in calibration process' Funded by: the Scientific and Technological Research Council of Turkey (TUBITAK)

II.B. Inter-disciplinary networking

- Theoretical bases and practical methods for the uncertainty management in transportation and traffic models have been disseminated and discussed within the Action community following an intense exchange with researchers from the EC-JRC. Such experts will also provide a contribution to the 2nd edition of the summer school.

The Action will also contribute to the multi-disciplinary workshop “Monte Carlo Methods in the Natural Sciences, Engineering and Economy”, which will be held on February 19-21, 2013, at DESY, Hamburg. The aim of the workshop is to bring together experts on Monte Carlo simulation in the natural sciences, in engineering and in economy. The focus is on providing a forum for discussing state-of-the-art technology from various fields such as to seed interdisciplinary exchange of knowledge and potentially common efforts or development.

- The level of inter-disciplinarity achieved with the work on the “uncertainty management” (as also described at the previous point) is already producing scientific impacts.
- The level of inter-disciplinarity is deemed sufficient to produce an increase in the reliability of traffic simulation models and in their ability to serve planning, design and operations of efficient and sustainable transportation systems, thus also potentially providing significant socio-economic impacts.

II.C. New networking

- 71 researchers are involved in the Action with 25% female and 40% Early Stage Researchers.
- As just noted the percentage of ESRs involved in the Action is notable. 4 out of 9 WG leaders/co-leaders are ESRs and the chairman and the vice-chairman were ESRs at the beginning of the Action. The involvement of ESRs in the Action activities is also significant.
- At the moment there are no participants from non-COST Countries approved by the CSO. However a number of researchers from non-COST contribute as experts (also at the school).
- New Links have been forged with the ITE in the USA who are collaborating on disseminating and further adding to the state of the practice questionnaire that was undertaken earlier in the project.
- Two call for papers and related special sessions have been proposed at the 2012 IEEE ITS conference in Alaska and at the 2013 TRB Annual meeting.
- An incomplete list of the scientific publications on the Action themes is attached.
- The capacity of the Action members to raise funds in the Action topics is explained by the list of national projects funded provided at point II.A.

II.D. Self evaluation

The workshops organized around the topic of the uncertainty management in traffic modelling have seen the enthusiastic participation of many members and constitutes one of the main successes achieved in this reporting period.

Also the new task of comparing different OD matrix techniques is completely new in the field literature as to the wide coverage of the techniques analysed and the rigorous experimental design settled. It will produce results in the last Action year and is expected to yield a major scientific breakthrough.

The work on the guidelines on traffic simulation was brilliantly initiated with a thorough review of the existing guidelines and, above all, with two stakeholders meeting (in London and Karlsruhe) which received passionate contributions by many national stakeholders. Such work allowed the MC, in its last meeting in London (February 2012), to discuss effectively the next year strategy and plan the activities in the “guidelines task”.

The training school organized in Delft was also a major success.

No key difficulties were encountered during the current reporting period.

Reporting Period: from 15/10/2009 to 28/02/2010

The first 6 months of the project (October 2009 – February 2010) have been devoted to definition of the research to be done within the COST project and to allocation of the various tasks to the participants based on their interests and related activities.

III.A. Innovative networking

- The main activity that the Action is undertaking in this is the creation of a comprehensive review of traffic simulation practice and research, which will benchmark the current state and form the basis for the directions for next steps advancements within the Action. This activity includes two parts: a web-based survey on the state of the practice has been designed, implemented and tested in a pilot survey. We are seeking responses to the survey from transportation and traffic professionals at all level of engineering, planning and research. In order to facilitate a wide response it is being translated to several European languages. The second part of this activity is the development of a scientific report summarizing the state of the art in research related to the development, calibration and validation of traffic simulation

models, and the related data collection. An outline for this report has been developed and various members have volunteered and are now working on writing parts of the document. It is expected to be completed in the coming months.

- It is too early at this stage to point out significant scientific breakthroughs and tangible medium term socio-economic that were accomplished as part of the Action. At this point the main scientific achievement that is materializing is the development of the state of the art and state of the practice document. We expect that this report will quickly become a benchmark and reference point to researchers and practitioners in the field throughout the world and so positively affect future developments and applications of traffic simulation models and their ability to serve planning, design and operations of efficient and sustainable transportation systems.
- It is too early at this stage to point out spin off of new proposals and projects, at the EC RTD Framework Programme level or at the National Programme level that have come out of the Action.

III.B. Inter-disciplinary networking

- The COST network of this Action is multi-disciplinary by its nature. Current members come from a variety of backgrounds, such as engineering, physics, mathematics and operations research. In addition, the Action intends to promote the practice of joining the Action meetings with relevant international meetings as a means to enlarge the Action basis and promote inter-disciplinarity.
- Along with the constant multi-disciplinary nature of the COST Action work plan, some specific tasks with crucial inter-disciplinary characteristics are intended to provide significant scientific impacts. For example, the analysis of how innovative detailed data collection methods through specific electronic instruments should be integrated in traffic modelling (such as image recording and processing for vehicle trajectory data collection) and the calibration of driver behaviour parameters will rely on electronic, mechanical, computer science and behavioural expertise.

Besides the crucial benefits regarding more trustworthy evaluations of design interventions in planning of road infrastructures, the COST Action outputs will clearly provide indirect impacts in terms of environmental, economical and safety effects of these interventions. The assessment of the inter-disciplinary boundary regarding these socio-economic impacts has been already considered in the web-survey and state-of-art review recently launched, by seeking to evaluate the range of the relationship between current traffic simulation applications and different impacts assessment.

III.C. New networking

- The Action started with 10 participating countries that signed the MoU by the kick-off meeting. In the period since then 5 additional countries – Finland, Ireland, Latvia, Sweden, and Belgium have signed the MoU and Poland has manifested the intention to sign. In addition 1 non-COST organization, the Institute for Environment and Sustainability of the Joint Research Centre - European Commission has requested, and was accepted as participant in this Action.
- The participation in terms of individual has grown tremendously since the kick-off meeting. At the Kick-off meeting, 13 researchers from 12 countries were present. In the next Action meeting that was held in Barcelona, Spain there were 33 participants from all the 15 countries involved in the Action. At the moment 51 participants are involved in the Action. Out of these 7 (14%) are female, and 25 (49%) Early Stage Researchers.
- As noted above there is significant involvement of Early Stage Researchers in the Action. The Chairman and the Vice-Chairman are Early Stage Researchers as well as 5 out of the 11 members of the Action Steering Committee. In addition, to the Action meetings, the MC has recently approved the first application of an STSM within the Action. Although the Action

is still at an early stage, the MC has encouraged STSM applications, and the STSM coordinator is going to launch a specific call for STSM applications.

- The Action meeting in Barcelona did not include any researchers from outside of COST Countries, as it was primarily intended for planning of the Action future. However, the scientific workshop of our next meeting, planned in July in Annecy France has been set-up to coincide with the Summer Meeting of the US Transportation Research Board Traffic Flow Theory and Characteristics Committee. The MC has extended invitations to the COST meetings to some of the participants of the joint conference. We therefore expect that this will allow us to attract a significant number of non-COST participants. This practice of joining the Action meetings with relevant international meetings is also foreseen for future meetings, and thus in the next meeting in Annecy, the MC will decide whether to join a meeting to e.g., the 2011 "Highway Capacity and Quality of Service Committee Meeting" in Stockholm or the 2011 International Conference "Reliability and Statistics in Transport and Communication" in Riga. An invitation to participate has also been extended to Japanese colleagues.
- A website has been setup for the Action at <http://www.multitude-project.eu>. It is intended as a place for discussion for the members and an outlet for outreach and dissemination activities of the Action outcomes. In particular, it also contains the web-survey on the state of the practice. It has also been decided that a newsletter would be assembled twice a year. The first one will be produced by the Summer.
- Presentations made at our first Workshop in Barcelona have been disseminated through the Action website. The papers that will be presented at the Workshop in our next meeting in Annecy will also be disseminated through the proceedings.
- A selection of eight papers from the next Action scientific meeting in Annecy will be published on a special issue on Transportation Research Part C, Elsevier, a leading scientific journal in the field.

III.D. Self evaluation

As noted above, the first few months of this Action have been devoted to definition of the tasks and setting the timetable for the work to be done. Work is already on-going in creating a comprehensive review of the state of the art and state of the practice of traffic simulation modelling and application. This activity, which includes a web-based survey of simulation users and a review of the relevant literature, will establish the benchmark for our future research and development activities.

The main success of this Action in its initial stages so far has been that already now, it is clear that it is attracting considerable attention within Europe and elsewhere. There are some 50 active participants in the Action. The Action chair and other members have presented the Action and its goals in relevant conferences and meetings. Researchers from North America, Australia, Japan and the Far East have expressed interest in participation in the Action meeting. Our next meeting in Annecy France has been scheduled together with a large meeting of an international group with overlapping interests. We expect that this will facilitate significant participation from outside Europe. It should be noted that we did not have any outside participants in our meeting in Barcelona. To some extent this is due to lack of experience on our part with the administrative and financial aspects of the Action. We do not expect that this will be an obstacle in the future.

In addition to planning of the Action future, our meeting in Barcelona also included a scientific workshop in which participants presented their recent and on-going research in this area. The workshop included 17 presentations from 12 member countries and was very positively perceived by the attendees.

***Reporting Period: from 1/03/2010
to 28/02/2011***

II.A. Innovative networking

- In the past year, innovative knowledge resulting from COST networking through the Action has resulted in four major achievements:
 1. a web-based survey on the state of the practice in traffic simulation (task 1.1);
 2. a state-of-the-art report in research related to the development, calibration and validation of traffic simulation models, and corresponding data collection (tasks 1.2, and 1.3);
 3. a census of existing traffic datasets (tasks 2.1 and 3.1);
 4. a training school entitled "Traffic modelling for traffic management and cooperative systems" (task 4.3).

1. The web survey was translated in 5 languages and received 215 responses from 37 countries: Europe (150), Asia and Australasia (16), Middle & Far East (6), North America (31) and Latin America (12). The answers were gathered from transportation and traffic professionals and researchers and provide a comprehensive picture on the current use and applications of traffic simulation models, also on the key issues of model calibration and validation. A power point presentation with first results and graphics is available on the Action website (www.multitude-project.eu). Statistical analysis and examination by model are forthcoming in a journal publication in the Autumn.

2. The scientific report is an attempt to summarize the state-of-the-art in research in the key themes of the Action. It includes six chapters ranging from the traffic data collection and enhancement techniques to the sensitivity analysis of model outputs, to the calibration and validation of models. It also includes a chapter about the national guidelines on the use of traffic simulation models and a glossary. It will be delivered at the MC meeting in Stockholm, 27-28 June.

3. A census of existing datasets was made, and guidelines for the description of different data types (trajectory data, section data and local detector data) were drawn. This is a key task for the realization of the Action objectives, as these datasets are central in developing and calibrating highway and network models and will serve the research community also in the future. The list of available datasets is accessible on the Action website.

4. As part of task 4.3, a training school was held in Delft (www.summerschool2011.org) on May 2-4, 2011, two years in advance with respect to the project schedule.

The school has been organised by the Delft University of Technology and it has been co-sponsored by NEARCTIS and the Dutch Research School TRAIL. Its main objective was to get the participants acquainted to the principles of the use of traffic models for ITS, including calibration and validation, how these models can be applied for ex-ante evaluation of DTM measures, which traffic phenomena should be covered by the models and to let them get hands-on experience with different types of models.

The lectures were based on cutting edge knowledge on the Action topics making the school an important moment of knowledge sharing among the lecturers too.

The programme was split into two parts: in the mornings lectures were given on more theoretical issues and backgrounds, while during the afternoons the participants could work themselves on exercises, thus applying directly the theories taught in the morning. Both lectures and exercises were provided by a total of 10 professors, all experts in their fields and coming from various countries in Europe and the United States. In total, 44 persons participated in the summer school. The participants were affiliated to fifteen institutes in nine different countries. 28 of the participants were affiliated to an institute participating in the Multitude COST Action. An evaluation held under the participants showed that they were very positive on the course, with scores of the overall quality ranging from sufficient (20%) to excellent (10%).

- As mentioned before, a major scientific breakthrough was the issue of the state-of-the-art report on traffic simulation. It is expected to become a benchmark and reference point to researchers in the field, and it represents a key milestone to identify future research directions and prioritize research efforts.

Notable scientific achievements have been attained in other specific tasks of the Action.

Some examples are the proposal of *i*) methods to inspect the accuracy of microscopic traffic measurements (task 2.2), *ii*) of a general mathematical framework for microscopic traffic flow models (task 2.3), and *iii*) of innovative frameworks for addressing the problem of the OD matrix estimation in dynamic and quasi-dynamic contexts, and in presence of new ITS measurements (task 3.3).

- It is too early at this stage to point out tangible medium term socio-economic impacts which were accomplished as part of the Action.
- *Spin off of new EC RTD Framework Programme proposals:*
 1. EU VII FP STREP: "Crowdsourced Governance (crowNgov) Public participation in municipal and regional policy-making (local governments in web-based public participation policy-making) with the participation of EC-JRC. Currently under review.
 2. EU Marie-Curie ITN: SITAR+, with MULTITUDE partners from Leeds, KTH, EPFL, UPC (Barcelona), Technion and NTUA (Athens), currently under review.
- *Spin off of new National Programme projects:*
 1. City of Zurich, Switzerland - ETH, "Urban calibration of micro-simulation model VISSIM";
 2. Traffic Department of Riga City Council, Riga, Latvia -Transport and Telecommunication Institute, "Pedestrian and transport flows analysis for pedestrian street creation in Riga city".
 3. National Technical University of Athens, Greece - "Investigation of dynamic on-line calibration algorithms' performance characteristics for large scale systems".
 4. Regione Campania, Italy - University of Naples Federico II, "Network of Excellence: Technological Innovation in Transport Systems - INSIST"

II.B. Inter-disciplinary networking

- As part of task 2.3 (Understanding the role and impact of parameters on model outputs), a significant effort has been made to disseminate within the Action community, theoretical bases and practical methods for 'global sensitivity analysis of models'. Such effort followed an intense exchange of knowledge with a group of researchers from the EC-JRC, experts in 'uncertainty management in scientific modelling', not directly involved in the Action. In a dedicated workshop organized by the University of Naples Federico II and the Institute for Environment and Sustainability - JRC, such experience has been shared within WG2 also through the direct implementation of these techniques to different case studies brought by the attendants. To this aim a specific computer code was developed and distributed to the participants. Initial approaches have also been made to the IEEE and IFORS-EURO (Operational research) and discussions are ongoing as to the most appropriate links/sub-groups with which to link. (Membership of MULTITUDE already includes members from the traffic groups within both these organisations, however effort is being made to establish ties with individuals involved in more specific activities related to particular technical questions that will come to the fore within WGs 2 and 3). Links have been made to EU funded data collection projects (Naturalistic driving data, viz. PROLOGUE and others) in order to identify new sources of data and expedite their availability to the community once collected.
- The dissemination and the application of the sensitivity analysis techniques in the traffic research field are expected on their own to sensibly increase the knowledge about traffic models and traffic simulation. Given also the other ongoing exchanges the level of inter-disciplinarity is deemed sufficient to potentially provide scientific impacts.
- The level of inter-disciplinarity is deemed sufficient to produce an increase in the reliability of traffic simulation models and in their ability to serve planning, design and operations of efficient and sustainable transportation systems, thus also potentially providing significant socio-economic impacts.

II.C. New networking

- Poland joined the Action in the last year bringing the total number of parties involved to 17.
- 71 researchers are involved in the Action with 25% female and 40% Early Stage

Researchers.

- As just noted the percentage of ESRs involved in the Action is notable. 4 out of 9 WG leaders/co-leaders are ESRs and the chairman and the vice-chairman were ESRs at the beginning of the Action. The involvement of ESRs in the Action activities is also significant. For instance, at the last meeting of the reporting period (Naples, February 7-8, 2011) 12 out of 17 participants were ESRs. All the 4 STSMs completed were carried out by ESRs (one of those was performed by a researcher from the EC-JRC and does not appear in the e-cost system as not funded by the Action). At the Delft training school 2 out of 10 teachers and 3 teaching assistants were ESRs.
- At the moment there are no participants from non-COST Countries approved by the CSO. However a number of researchers from non-COST Countries have been invited and contributed to the Action meetings as experts (also one teacher of the training school was from the USA).
- Liaison continues to occur with TRB through seven Standing Committees with reciprocal linking and dissemination of findings (AHB15 ITS; AHB30 Vehicle Highway Automation; AHB45 Traffic Flow theory; ABJ70 IA; AND10 Vehicle user characteristics; AND20 User information systems and AND30 Simulation and measurement). Publications are planned on results of the online survey in an International Engineering magazine (allowing dissemination to practitioners) and a major academic journal allowing outreach to both industry and the academic community. A website upgrade has been undertaken allowing access to a wider range of links and resources, a web forum and a full set of proceedings and presentations from previous meetings. An incomplete list of the scientific publications on the Action themes is attached.
- Networking has led to the establishment of two partnerships for the submittal of proposals VII RTD FP, as detailed at point II.A.
- The capacity of the Action members to raise funds in the Action topics is explained by the list of national projects funded provided at point II.A.

II.D. Self evaluation

The way in which the first years Action's objectives were fulfilled was the main success of the Action.

A high number of members actively participated in the long process of the web-survey creation and dissemination, finally achieving a high quality product. The number and international coverage of the answers obtained was in line with the best expectations of the MC. Results are going to be the subject of an invited paper on a technical journal and of further scientific publications.

Also the state-of-the-art report benefited from the involvement of a numerous and highly qualified parterre of researchers. Its publication is expected to become a world reference and to drive future research efforts in the field.

The copious outreach activities - including the web-survey, reciprocal linking with several international scientific committees and the careful mastering of the contents of the Action web site (at the moment second ranked in google's results for a search with the words 'multitude'and'project') - have drawn attention to the Action topics by a vast community of researchers and professionals in the transportation and traffic field, becoming the promise for a significant socio-economic impact of the Action. A confirmation of the interest in the Action's topics and in the project itself was also shown through the number of applications received for the training school, which rapidly exceeded the available places. The students' evaluation of the school was also very satisfying, as mentioned in II.A. It is also worth remembering that the training school was held two years in advance with respect to the Action schedule in the MoU.

From the research point of view, the organization of the Action activities is evolving towards a specialization in small groups of researchers devoted to specific project tasks. While in the first year the most of the work has been performed in large assemblies, due to the need to establish a common language and draw on a shared state-of-the-art in the Action themes, in the first half of the second year a significant effort has been produced by the WG leaders to define and rank research needs and to form sub-groups aiming at investigating specific research topics. In this view, two meetings have been organized, one on sensitivity analysis of model outputs (Naples,

February 2011) and the other on the dynamic OD estimation problem (Barcelona, May 2011). Such work reorganization and its promotion among the Action participants, has probably been the key difficulty encountered in this reporting period. It is the MC's opinion that the true success of the Action will depend on the successful establishment and multiplication of these researchers' sub-groups.