Project n° EVG1-CT-2000-00026 SESAME

European Commission – Research General Directorate

SESAME

Site EffectS assessment using AMbient Excitations

Fourth progress report

2nd Year Management report

1 May 2002 – 30 April 2003

SESAME Partnership

1	**UJF**	University Joseph Fourier	Grenoble
2	**Resonance**	Résonance Ingénieurs-Conseils SA	Geneva
3	**UP**	University of Potsdam -	Potsdam
4	**ULg**	University of Liège	Liège
5	**UiB**	University of Bergen	Bergen
6	**ETHZ**	Polytechnic School of Zürich	Zürich
7	**ITSAK**	Institute of Engineering Seismology and Earthquake Engineering	Thessaloniki
8	**ICTE/UL**	Institute of Earth and Space Sciences	Lisbon
9	**INGV**	National Institute of Geophysics and Volcanology	Roma
10	**CNR.GSAQ**	National Research Counsil	Milano
11	**GPISAS**	Geophysical Institute – Slovak Academy of Sciences	Bratislava
12	**CETE.Nice**	Center of Technical Studies	Nice
13	**CNRS**	National Center for Scientific Research	Grenoble
14	**LCPC**	Central Laboratory for Bridges and Roads	Paris

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Content

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SESAME project rules

1. ***All the data lent by one of the SESAME project partners can only be used within the framework of the SESAME project. If one partner wants to use the data for another purpose, it is essential that he asks for an utilization agreement to the data owner.***
2. ***Each time the SESAME project partners make a presentation concerning the project SESAME, they must inform the co-ordinator of the project and as much as possible send a copy of the presentation. Moreover, each presentation on the SESAME project has the mandatory obligation to acknowledge the EC funding and mention the grant identification.***

Introduction

April 2001	***signature of the contract between the partners and the European Commission***	
1 May 2001	beginning of the contract	
May 2001		
June 2001	*First payment of the EC (40%)*	
26-27 June 2001	Kick-off meeting in Grenoble, France	
July 2001		**Work on the field and in the laboratories on the different Tasks**
August 2001		
29-30 August 2001	workshop for TaskC in Zurich, Switzerland	
September 2001		
October 2001		
22-26 October 2001	Instrument workshop (TaskA – WP02) in Bergen, Norway	
November 2001		
	A first progress report has been sent to the EC	
December 2001		
January 2002		
7-8 January 2002	Instrument workshop (Task A – WP02) in Potsdam, Germany	**Work on the field and in the laboratories on the different Tasks**
9-11 January 2002	workshop (TaskA – WP03 & TaskB-WP06) in Potsdam, Germany	
February 2002		
March 2002		
April 2002		
21-27 April 2002	TaskA meeting during the EGS in Nice, France	
May2002		
29-30 May 2002	TaskC meeting in Zurich, Switzerland	
	A second progress report including Cost statements (= D03.01) and two deliverables (D01.02, D02.09) have been sent to the EC.	
June2002		
July 2002		**Work on the field and in the laboratories on the different Tasks**
10 July 2002	Review meeting on seismic risk research in the European Union	
August 2002		
September 2002		
October 2002	*Second payment of the EC (37,99%)*	
22-24 October2002	Work-package meetings in Roma, Italy	
25-26 October2002	General SESAME meeting in Roma, Italy	
November 2002		
December 2002		
	A third progress report including four deliverables D04.04 (draft), D05.06, D05.05, D07.05 has been sent to the EC.	
January 2003		
February 2003		**Work on the field and in the laboratories on the different Tasks**
3-14 February 2003	Task B meeting in Potsdam, Germany	
20-21 February 2003	Task C meeting in Bratislava, Slovakia	
March 2003		
April 2003		
7-11 April 2002	WP02 meeting during the EGS-AGU-EUG in Nice, France	
May 2003		
a fourth progress report including 5 deliverables D08.02, D09.03, D13.08 (first part), D14.07, D15.06 and the final version of D04.04 is sent to the EC.		

Progress of the Work

The following table shows the time table of the SESAME project. We have highlighted in yellow the work planned to be in progress – and effectively is - at the date of April 30, 2003. The work package highlighted in green are finished . This report presents a summary of the work done during Year 2.

TABLE : Project planning and time table

Phases	WP	Tasks	*Year 1*	Year 2	Year 3	Deliverables
P01			xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	
	WP01		xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	
		T01.01	xxxxxxxxxxxx			*D03.01**
		T02.01		xxxxxxxxxxxx		**(D10.01)***
		T03.01			xxxxxxxxxxxx	
P02			xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxx	
Finished ←	WP02		xxxxxxxxxxxx	xxxxxx		
		T01.02	xxxxxxxxxxxx			*D01.02**
		T02.02		xxxxxxxxxxxx		**(D08.02)***
Finished ←	WP03		xxxxxxxxx	xxxxxxxxx		
		T01.03	xxxxxxxxx			
		T02.03		xxxxxxxxx		**(D09.03)***
	WP04		xxxxxx	xxxxxxxxxxx	xxxxxx	
		T01.04	xxxxxx			
		T02.04		xxxxxxxxxxxx		*D04.04**
		T03.04			xxxxxx	
P03			xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxx	
Finished ←	WP05		xxxxxxxxxxxx	xxxxxx		
		T01.05	xxxxxxxxxxxx			
		T02.05		xxxxxx		*D06.05 & D07.05**
	WP06		xxxxxxxxxxxx	xxxxxxxxxxxx	xxx	
		T01.06	xxxxxxxxxxxx			
		T02.06		xxxxxxxxxxxx		*D05.06* ;* **(D15.06)***
		T03.06			xxx	
	WP07		xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxx	
		T01.07	xxxxxxxxxxxx			
		T02.07		xxxxxxxxxxxx		**(D14.07)***
		T03.07			xxxxxxxx	
P04			xxxxxxxxxxx	xxxxxxxxxxx	xxx	
	WP08		xxxxxxxxxxxx	xxxxxxxxxxxx		
		T01.08	xxxxxxxxxxxx			
		T02.08		xxxxxxxxxxxx		**(D13.08)*** –first part
	WP09		xxxxxxxxxxxx	xxxxxxxxxxxx		
		T01.09	xxxxxxxxxxxx			*D02.09**
		T02.09		xxxxxxxxxxxx		D12.09 delayed
	WP10			xxxxxxxxx	xxx	
		T01.10		xxxxxxxxx		D11.10 delayed
		T02.10			xxx	
P05					xxxxxxxxxxxx	
	WP11				xxxxxxxxxxxx	
		T01.11			xxxxxxxxxxxx	
	WP12				xxxxxxxxxxxx	
		T01.12			xxxxxxxxxxxx	
	WP13				xxxxxxxxxxxx	
		T01.13			xxxxxxxxxxxx	

*, the Deliverables in italic have already been sent to the EC with the previous reports;
the Deliverables in brackets are sent to the EC with this report.

I WP01 – T02.01: co-ordination – year 2

The co-ordination is followed by two persons:
Pierre-Yves Bard for the scientific part and Laurence Bourjot for the administrative and financial part.

TABLE 1 : List of the persons working in the project from November 2002 to April 2003

Partners	Name of the person		Task or WP	Time spent
	Bruno Bettig	*S*	-	
	Fabien Blarel	*T*	-	-
1	Sylvette Bonnefoy	*S*	WP08	6 M
1	Laurence Bourjot	*ACo*	WP01	0,6 M
1	Fabrice Cotton	*R*	WP08	0,6 M
1 (13)	Jean-Luc Chatelain	*R*	WP02	3,9 M
	François Dunand	*S*	-	-
1 (13)	Bertrand Guillier	*R*	WP02	2 M
	Jérôme Noir	*S*	-	-
1 (14)	Pierre-Yves Bard	*R*	WP01, Task A,B,C	1,8 M
1 (14)	Philippe Guéguen	*R*	WP02	1 M
2	Martin Koller	*R*	WP01, WP03	0,07 M
2	Corinne Lacave	*R*	WP03, WP12	0,32 M
	Julien Rey	*R*	-	-
3	Matthias Ohrnberger	*R*	TaskB	6 M
3	Andreas Koehler	*S*	Task B	
3	Gudrun Richter	*R*	Task B	
3	Frank Scherbaum	*R*	Task B	
3	Estelle Schissele	*R*	Task B	
	Daniel Vollmer	*T*	-	-
	Hans Havenith		-	-
4	Denis Jongmans	*R*	TaskB	-
4	Marc Wathelet	*S*	WP07	6 M
5	Kuvvet Atakan	*R*	Task A	-
5	Mathilde Bøttger	*S*	WP 02	0,7 M
	Margaret Grandison	*S*	-	
	Jens Havskov	*R*	-	
5	*Jose Asheim Ojeda*	*S*	-	
5	Bladimir Moreno	*S*	WP03	-
	Eirik Tvedt	*S*	-	-
	Terje Utheim	*T*	-	
	Jose Asheim Ojeda	*S*	-	
	Katharina Wolff	*S*	-	-
	Gerardo Aguacil	*R*	-	-
6	Cécile Cornou	*R*	Task A, C	6 M
6	Donat Faeh	*R*	Task A, B, C	
	Fortunat Kind	*R*	-	-
6	*Ivo Oprsal*	*R*	-	-
6	Eva Spühler-Lanz	*R*	Task C	
	Johannes Rippberger	*R*	-	-
6	Daniel Roten	*R*	Task C	
	Jochen Woessner	*R*	-	-
	Jörg Kirsch	*R*	-	-
	Anastasios Anastasiadis	*T*	-	-
7	Petros Dimitriu	*R*	WP04	1 M
	Bassilios Margaris		-	-
7	Areti Panou	*R*	WP04	1 M
7	Alekos Savvaidis	*S*	WP03, WP04	3 M
7	Nikos Theodulidis	*R*	WP04	1,6 M
7	Stratos Zacharopoulos	*T*	WP04	0,5 M
8	Antonio Borges	*S*	WP02,WP03	1 M
	Catarina Paz		-	-
8	Pedro Roquette	*R*	WP03	1,45 M
8	Paula Teves-Costa	*R*	Task A	(1,95 M)
9	Catello Acerra	*T*	WP02	-
9	Riccardo Azzara	*R*	WP02	-
	Roberto Basili	*R*	-	-
	Paola Bordoni	*R*	-	-
9	Fabrizio Cara	*R*	WP04	6 M
9	Giovanna Cultrera	*R*	WP02, WP04	-
9	Giuseppe di Giulio	*R*	WP02, WP04	-

9	*Fabrizio Marra*	*R*	-	
	Sandro Rao	*T*	-	
9	Antonio Rovelli	*R*	WP02, WP04	
9	*Mario La Rocca*		-	-
	Rosalba Maresca		-	-
	Gilberto Saccoroti		-	-
10	Rosastella Daminelli	*T*	WP03, WP04	0,47 M
10	Roberto de Franco	*R*	WP03, WP04	0,52 M
10	Alberto Marcellini	*R*	WP03, WP04	1 M
10	Antonio Morrone	*T*	WP04	0,2 M
10	Marco Pagani	*R*	WP04	-
10	Alberto Tento	*T*	WP03, WP04	1,87 M
11	Lucia Fojtikova	*S*	Task C	0,27 M
11	Josef Kristek	*R*	WP09,WP10	2,87 M
11	Miriam Kristekova	*R*	WP09,WP10	0,7 M
11	Peter Moczo	*R*	Task C	2,4 M
12	Anne-Marie Duval	*R*	WP02,WP03	2,3 M
12	Etor Querendez	*R*	WP02	1 M
	Jean-François Vassiliades	*T*	WP02	1,35 M
12	Sylvain Vidal	*T*	WP02	0,85 M

- *R = Researcher, S = Student, T = Technician, ACo = Assistant Coordinator*

The name in italic are involved in the project, but have not been working in the project during this period.

During the second half of the second year of the project (November 2002 to April 2003), 51 persons (researchers or engineers, students, technicians and 1 assistant-coordinator) have been involved in the project SESAME for a minimum of 68 man-months (**Table 1**)

All these persons have met several times to exchange their work and also to do experiments together.

- ***3-14 February 2003*** – Task B meeting in Potsdam (Germany):
  - to present the results and the progress of the workpackages WP05, WP06 and WP07,
  - to work on computer codes and testing,
  - to perform test on synthetic and real data sets.

- ***20-21 February 2003*** – Task C meeting in Bratislava (Slovekia):
  - to present the results and the progress of the workpackages WP08, WP09 and WP10,
  - to define the near future tasks in noise computation for canonical models and real sites.

- ***7-11 April 2003*** – WP02 meeting in Nice (France) during the EGS-AGU-EUG
  - to make a synthesis of the work with comments on the different test available,
  - to decide on the way to present the numerous tests
  - to decide how to write the final report.

The minutes of the meetings or workshops are presented at the end of this report and are available on the web site:
http://SESAME-FP5.obs.ujf-grenoble.fr

❷ Since November 2002, the partners, in parallel to their work on the project, have participated to different national or international meetings where they have presented a part of the scientific work done in the SESAME project.

- ***AGU*** in San Francisco (USA), 6-10 December 2002

1: Presentation of a paper by Josef Kristek

Kristek J. & P. Moczo, 2002. 3D 4th-order staggered-grid finite-difference modelling of seismic motion in viscoelastic media with material discontinuities. Eos. Trans. AGU, 83 (47), Fall Meet. Suppl., Abstract S51C-01.

2: Presentation of a paper by Peter Moczo

Moczo P., J. Kristek, & M. Gális, 2002. Simulation of the planar free surface in media with near-surface lateral discontinuities in the 3D 4th-order staggered-grid finite-difference modeling of seismic motion. Eos. Trans. AGU, 83 (47), Fall Meet. Suppl., Abstract S61B-1129.

3: Presentation of a paper by Frank Scherbaum

F. Scherbaum), M. Ohrnberger, A. Savvaidis, A. Panou and N. Theodulidis, 2002. Determination of shallow shear wave velocity profiles using ambient vibrations at selected sites in Greece. Eos. Trans. AGU, 83 (47), Fall Meet. Suppl., Abstract S72A-1138.

- ***APMG*** in Aveiro (Portugal), February 2003

1: Presentation of a paper by Paula Teves-Costa

Teves-Costa P., J. Almeida & I. Rio, 2003. Seismic noise analysis in Povoação county (in Portugueses). APMG, February 2003.

2: Presentation of a paper by Dina Vales

D. Vales, P. Teves-Costa, & A. Borges, 2003. Seismic noise analysis in Lagos historical centre (in Portugueses). APMG, Febuary 2003.

- ***EGS-AGU-EUG Joint assembly*** in Nice (France), 7-11 April 2003

1: Presentation of a paper by Sylvette Bonnefoy-Claudet

Bonnefoy-Claudet S., P.-Y. Bard & F. Cotton 2003. Nature of seismic noise wavefield: a litteraure survey. *Geophys. Res. Abstracts*, 5, EGS-AGU-EUG Joint Assembly, Abstract EAE03-A- 09750.

2: Presentation of a poster by Fabrizio Cara

Cara, F., G. Di Giulio, D. Galluzzo, L. Fojtíková, R. Maresca, P. Moczo & A. Rovelli, 2003. Predominant frequency variations in the ambient noise recorded in the Colfiorito basin (Umbria, Italy). *Geophys. Res. Abstracts*, 5, EGS-AGU-EUG Joint Assembly, Abstract EAE03-A-08644.

3: Presentation of a poster by Cécile Cornou

Cornou C., S. Bonnefoy-Claudet, J. Kristek, D. Fäh, P.-Y. Bard, P. Moczo & F. Cotton. Simulation of seismic ambient vibration: characteristics of noise sources and reliability of H/V and array processing techniques, *Geophys. Res. Abstracts*, 5, EGS-AGU-EUG Joint Assembly, Abstract EAE03-A-10125

4: Presentation of a paper by Peter Moczo

Moczo, P. & J. Kristek, 2003. 3D staggered-grid FD modeling of seismic motion in viscoelastic media. *Geophys. Res. Abstracts*, 5, EGS-AGU-EUG Joint Assembly, Abstract EAE03-A-06199.

5: Presentation of a poster by Paula Teves-Costa

Teves-Costa P. & L. Senos, 2003. Noise measurements in Angra do Heroismo (Terceira Island – Azores). *Geophys. Res. Abstracts*, 5, EGS-AGU-EUG Joint Assembly, Nice, April 2003.

The summary of the different communications and posters are presented at the end of this report.

❸ Since the beginning of the project, eight papers have already been accepted or submitted and at least one more is in preparation

- Bard P.Y., 2002. Extracting information from ambient seismic noise: The SESAME project (Site EffectS assessment using AMbient Excitations) – *Synopsis of the first year project* (14 p.) submitted and accepted for the review to the EC.
- Kristek K., Moczo P. and Archuleta R., 2002. Efficient methods to simulate planar free surface in the 3D 4th –order staggered-grid finite-difference schemes. *Studia Geophys. Geod.*, **46**, 2002, 355-381.
- Moczo P., Kristek J., Vavrycuk V., Archuleta R. and Halada L.3D heterogeneous staggered-grid finite-difference modeling of seismic motion with volume harmonic and arithmetic averaging of elastic moduli and densities. *Bull. Seism. Soc. Am.,* **92**, 3042-3066.
- Scherbaum F., Hinzen K.-G. and Ohrnberger M., 2002. Determination of shallow shear wave velocity profiles in the Cologne/Germany area using ambient vibrations. *Geophys. Journ. Int.*, **152**, 597-612.
- Fäh D., Kind F. and Giardini D., Inversion of local S-wave velocity structures from average H/V ratios, and their use for the estimation of site effects. *Journal of Seismology* (submitted)*,* 2002.
- Kristek, J., Moczo, P., Seismic wave propagation in viscoelastic media with material discontinuities – a 3D 4th-order staggered-grid finite-difference modelling. *Bull. Seism. Soc. Am.* (in press), 2003
- Bettig, B., Bard, P.-Y., Scherbaum, F., Riepl, J., and Cotton, F., Analysis of dense array noise measurements using the modified spatial auto-correlation method (SPAC). Application to the Grenoble area, *Bolletino di Geofisica Teorica ed Applicata,* **42-3/4**, p. 281-304, 2003.
- Ohrnberger, M., Scherbaum, F., Krüger, F., Pelzing, R. and Reamer, S.K. How good are shear wave velocity models in the Lower Rhine Embayment (NW-Germany) obtained from inversion of ambient vibrations?, *Bolletino di Geofisica Teorica ed Applicata* (submitted), 2003.
- Kristek J., Moczo P. and Kristeková M.Finite-difference Simulation of Ambient Noise in 3D Surface Sedimentary Structures: Part 1 – Method (In preparation).

In addition, SESAME related papers with contributions by the UP team funded by the German Research Council:

- Hinzen, K.G., Scherbaum, F. and Weber, B. (2003). On the resolution of H/V measurements to determine sediment thickness, a case study across a normal fault in the Lower Rhine Embayment, Germany, *JEEE,* (submitted), 2003.
- Diallo, M.S., Holschneider, M., Kulesh, M., Scherbaum, F. and Adler, F. (2003). Characterization of seismic waves polarization attributes using continuous wavelet transforms, *Geophysics* (submitted), 2003.

In addition, SESAME related papers with contributions by the LGIT team:

- Dunand, F., P.-Y. Bard, Ph. Guéguen, J.-L. Chatelain, B. Guillier, T. Vassail, 2003. Caractérisation du comportement dynamique des sols et structures par mesures de vibrations ambiantes : Développements récents et questions en suspens, *Journée d'étude F²AS "Recalage calcul / Mesures" (25/03/2003, Paris), IPSI, Vol. XXVII, n°1, 15 pages (in French)*

A copy of the papers can be asked to Pierre-Yves Bard

4 At the end of June 2003, thirteen deliverables are available.

- D01.02 "***Controlled instrumental specifications***": a report of 34 pages + 5 appendices.
- D02.09 "***FD code to generate noise synthetics"***: in the form of a CD ROM with a report describing the flow chart of the software and canonical structural models.
- D03.01 "***First year progress report"***: a report of 41 pages + annexes on the financial aspect of the project.
- D04.04 "***Homogeneous data set of noise and earthquake recording at many sites***": a draft report.
- D05.06 "***Quality control software for in-situ checks***": a report of 16 pages + 1 appendix.
- D06.05 "***Array data set for different sites***": a report of 33 pages + 1 appendix + 12 CD ROMs containing the data sets.
- D07.05 "***Optimum development strategy and quality measure for array layout in view of obtaining surface wave***": a report of 41 pages + 3 appendices. The complete report will be available on a CD Rom.

The deliverables D01 to D07 have been sent to the EC with the previous progress reports in June 2002 and January 2003.

- D04.04 "***Homogeneous data set of noise and earthquake recording at many sites***": a report of 55 pages + 1 appendix
- D08.02 "***Measurement guidelines***": a report of 96 pages including 59 figures, accompanied by a DVD archiving all the test data and the corresponding results
- D09.03 "***Multi-platform H/V processing software J-SESAME"***: a report of 37 pages describing the software + 1 CD ROM containing the software
- D10.01 "***Second year progress report"***: a report of 31 pages + annexes on the financial aspect of the project.
- D13.08 "***Report on the nature of noise"***: a report of 45 pages (first part of the deliverable)
- D14.07 "***Report on the inversion of velocity profile and Version 0 on the inversion software***": a report of 40 pages + 2 appendixes including 45 figures
- D15.06 "***Interface software***": a report of 8 pages describing the software tool

The deliverable D4 (final version), D08, D09, D10, D13 (first part) D14 and D15 are sent to the EC with this progress report.
All these deliverables are available on the web site (except the CD ROMs with the data):
http://SESAME-FP5.obs.ujf-grenoble.fr

II WP02 – T02.02: H/V technique – experimental conditions – year 2

Leader : Anne-Marie Duval (Partner 12 : CETEMED.LRE – Nice – France)

The WP02 is devoted to the evaluation of experimental conditions for "H/V on ambient noise" method. All participants have performed very numerous tests during the last months. We decided a common procedure to build and process the individual data set, so that each partner could access and process other data. During Roma meeting (2002 October) we decided a new way to analyse and present the results. As planned, most of the teams sent their reports and data to Nice team in February 2003 (except Grenoble and Thessaloniki). In addition, in January 2003, another work meeting took place between Nice and Grenoble teams, after which it was decided to modify the analysis . In February, a synthesis was written on the available tests performed by all teams. During March 2003, Nice and Grenoble teams performed new tests and processed all their data (together with Swiss data) with the latest version of presentation decided in 2003 January. Then finally the 2003 April meeting held in Nice was devoted to make a synthesis of the work and write the final report. It appeared, however, that all tests had to be processed again for final analysis. Grenoble team has proposed to perform this final processing that will allow more accurate evaluation of experimental condition, with an unbiased, systematic comparison based on the Student test. The processing and synthesis have been performed, and are presented in the deliverable D08.02.

☺☺ The work package is now finished A first deliverable D01.02 ***"Controlled instrumental specifications"*** has been produced in June 2002. The second deliverable D08.02 ***"Measurement guidelines"***, corresponding to the final step of this work package is presented with this report. This Deliverable presents the evaluation of the influence of experimental parameters in stability and reproducibility of H/V estimation from ambient vibrations, together with a DVDROM archiving all the experimental data and the corresponding results (more than 500 tests.

III WP03 – T02.03: H/V technique – data processing – year 2

Leader : Kuvvet Atakan (Partner 5: UIB.ISI – Bergen – Norway)

The main goal of the Work Package 3 (WP03), is to develop a multiplatform processing software (J-SESAME) to be used as a standard procedure in processing the microtremor data using H/V technique. All existing software that was previously used in processing the microtremor data using the H/V technique are tested and an optimum solution for the analysis is deduced. The J-SESAME software is developed using the Java Programming Language, for multiplatform operation capacity. In addition the J-SESAME is designed using a modular concept for the different parts, allowing flexibility for further developments. The user is guided through the browsing module (i.e. graphical user interface, GUI) of the software and the window selection and the processing modules provide the input data selection and computation of the H/V spectral ratios. The display module is then responsible for producing visualization of the processed data in an easy and flexible way. This modular development also allows utilizing the best possible solution for the programming language to be used. In the case of the window selection and processing modules, the software codes are in Fortran, whereas the browsing and the display modules are developed using the Java Programming language.
The general design of the software, its functionalities, and the different modules are finished and a short user manual has been prepared.

☺☺ The time table is respected and the work package is now almost finished. The deliverable D09.03 ***"Multi-platform H/V processing software J-SESAME"*** describe the new software solution to be used in H/V spectral ratio technique. This software is going to be tested by external people and if necessary, further improvements and modifications will be done after the Smolenice castle workshop next fall. A final version of the software with user guidelines will be available during year 3 in the work package 12.

IV WP04 – T02.04: H/V technique – empirical evaluation – year 2

Leader: Nikos Theodulidis (Partner 7 – IESEE – Thessaloniki – Greece)

During the second year of the SESAME project additional noise measurements were performed at a series of sites for which either strong motion data or/and geotechnical data are available. Finally, for about two hundred sites, information on noise and earthquake recordings is presented in the Standard Information Sheets (SIS), that is, a number double of the one initially foreseen. All these data were converted to Sesame Ascii Format (SAF) and stored in a few CDs. The complete set of SIS files was included in the "Homogeneous data set of noise and earthquake recordings at many sites" [Deliverable D04.04 appended to this report]. In order to facilitate data selection with certain criteria, a specific SESAME Database was constructed. For selected sites, (H/V) ratio of ambient noise was compared with (H/V) receiver function of earthquake weak or/and strong motion as well as with standard spectral ratio where data permitted. For a few sites -where geotechnical data were available- theoretically estimated transfer functions were compared with experimentally (H/V) ratios of ambient noise. In addition, for a few selected sites which exhibited non-linearity during strong ground motion, (H/V) noise ratio was calculated to investigate the applicability of the latter. Massive data processing with SESAME code has not yet been completed during the 2nd year of the project, remaining as a task for the next few months.

Ambient noise measurements were performed during the second year of the project into the city of Thessaloniki-Greece and the city of Palermo-Italy, affected by the 20/06/1978 [M6.5] and the 06/09/2002 [M5.9] earthquake, respectively. From preliminary data analyses, it seems that the (H/V) ratio may satisfactorily indicate the areas where soil conditions favour the occurrence of higher damage in urban environment. However, direct quantitative correlation between (H/V) ratio properties and damage distribution (macroseismic intensity, loss of strength of buildings in some cases), is difficult to be established given the complexity of parameters involved. During the summer of 2003, ambient noise measurements will be performed in the city of Kalamata-Greece, which was affected by the 13/09/1986 event [M6.0], to further investigate correlation of the (H/V) noise ratio characteristics with damage distribution in modern cities.

☺ A first deliverable D04.04 ***"Homogeneous data set of noise and earthquake recordings at many sites"*** has been sent with the previous report. The final version of this deliverable is sent with this report, all the data being entered in the data bank with the proper format specifications and information sheets.

V WP05 – T01.05: instrument layout for array measurements – year 2

Leader: Frank Scherbaum (Partner 3 – UPOTS.GEO – Postdam – Germany)

☺☺ This work package is finished. Two deliverables, one on a tentative strategy for array deployment and performance evaluation D06.05 "***Array data set for different sites***", and a second on field survey D07.05 "***Optimum deployment strategy and quality measure for array layout in view of obtaining surface wave***" have been sent with the third report.

VI WP06 – T02.06: array measurements – derivation of dispersion curves – year 2

Leader: Frank Scherbaum (Partner 3 – UPOTS.GEO – Postdam – Germany)

Within the context of WP05 the dependence of the array performance (for phase velocity determination) on the experimental conditions (array geometry, aperture, number of sensors, sensor types, timing accuracy) have been assessed. The inputs needed for this task were existing array measurement data sets from within the consortium, array measurements performed at well known test sites within the consortium, the relative calibration of instruments with respect to a broadband sensor (phase response) and computer codes for the calculation of the array transfer functions. Based on the conclusions drawn from WP05, the objective of WP06 is the development of a semiautomatic processing system for the array analysis of ambient vibrations. The array processing system

is especially designed for the determination of dispersion curve characteristics in order to allow the inversion of shallow shear velocity profiles (WP07) for site effects assessment.

The field measurements in Liege, Brussels (both situated in Belgium), Weil am Rhein (Swiss-German border region), Colfiorito (Umbria, Italy), Lefkas, Thessaloniki and Euroseistest (all located in Greece) test sites, which have been performed during spring and summer 2002, enable us to work on high-quality data sets for specific geological situations within Europe. Both data sets from urban environments as well as open field data have been obtained. The raw data sets and information linked with the measurements have been summarized and presented in the deliverable D06.05 (***"Array data set for different sites"***). The data sets have been organized in a data base structure (GIANT, Rietbrock and Scherbaum, 1998) suited for the array processing software tool "cap" (**c**ontinuous **a**rray **p**rocessing). The raw waveform data is archived in GSE2.0 format. For convenience we will provide a software tool for extracting waveforms in the format SAF (SESAME Ascii Format) directly from the database in the deliverable D15.06. Until May 2003, we have performed a preliminary analysis of the data sets from Liege, Brussels, Weil am Rhein, Lefkas, Thessaloniki and Euroseistest test sites. The evaluation of the Colfiorito data set is still pending in the moment, but will be subject to processing until the end of 2003. The preliminary analysis results of the Greek data sets have been presented at the AGU Fall Meeting in December 2002 (Scherbaum et al., 2002). The array analysis of the measurements at site Weil am Rhein have been subject of a term paper at University of Potsdam prepared by A. Köhler (2003).
In order to assess the dependence of the array performance (for phase velocity determination) on the experimental conditions we have assessed the effect of uncertainties in the seismometer calibration by a relative calibration experiment. The details of the experiment setup and the results are described in the SESAME deliverable D07.05 ("Optimum deployment strategy for array measurements - Instrumental layout for array measurements"). In summary we have found quite large relative differences of the individual seismometers with respect to the introduced phase delays. An independent check of those results has been performed for another calibration experiment using a STS-2 seismometer as reference sensor. The results confirmed the findings described in deliverable D07.05 with reference sensor Geotech KS2000. *Therefore we have to state that relative time delays introduced by seismometer calibration uncertainties can have* ***non-negligible effects*** *on the results of f-k array analysis when operating close to the corner frequency of the used instruments*. Further effects of the instrumental layout on the array performance with respect to the determination of surface wave phase velocity curves have been discussed in deliverable D07.05 by numerically assessing the array response functions for certain single/multi plane wave arrival situations. Using varying array geometries and different frequency bands we could confirm the problem of overestimating phase velocities for lower frequency bands and multiple plane wave arrivals due to the superposition of array responses. In order to strengthen the understanding from the results found in this simplistic numerical approach, we have continued to work on synthetic waveform data sets for simple geologic situations closely related to the test sites of the array measurements performed within the consortium.
The preliminary results of these tests regarding the pros and cons of the individual array processing techniques have been the subject of the WP05/WP06 workshop held from February 3rd to 14th in Potsdam (see also the corresponding Meeting Minutes). One main topic of discussion has been the influence of higher mode surface waves on the results of array analysis as well as the question how to account for higher mode surface waves in the shear wave velocity inversion from dispersion curve data. Among the participants of the workshop it has been agreed to further test the array analysis methods on a more realistic synthetic data set, which includes additionally Love and Body wave contributions. Furthermore it has been decided to include MUSIC (Schmidt, 1981, Schmidt, 1986, Goldstein and Archuleta, 1987) as an alternative high-resolution array processing method, which may allow the resolution of individual mode branches. As pre- and postprocessing strategies for selecting time windows for the array analysis Cecile Cornou (ETHZ) and Estelle Schissele (IGUP) have proposed time-frequency coherency and energy measures which are currently tested.
Another highly interesting outcome of the Potsdam array group meeting in February regards the SPAC-related methods (e.g. modified SPAC, Bettig et al., 2003). In order to derive the dispersion curve from a set of auto-correlation curves a non-linear inversion procedures has to be used. As the dispersion curve itself is actually just a meta-data used for the inversion of a shear wave velocity model, there has been the suggestion to use a single step inversion procedure, instead of the usual two-step inversion. Marc Wathelet (UJF-Grenoble) introduced this strategy into his inversion code for shear wave velocity determination from dispersion curves. Currently, these approaches are tested on synthetic and real data. Within the following months the work on the array processing software will be continued and finally presented in October 2003.

Bettig, B., Bard, P.-Y., Scherbaum, F., Riepl, J., and Cotton, F., *Analysis of dense array noise measurements using the modified spatial auto-correlation method (SPAC). Application to the Grenoble area*, Bolletino di Geofisica Teorica ed Applicata, **42-3/4**, p. 281-304, 2003.

Köhler, A., Anwendung und Vergleich von Verfahren zur Bestimmung des Geschwindigkeitsmodells mithilfe von "Ambient Noise", Report (in German), University of Potsdam, 2003.

Goldstein, P., and Archuleta, R.J., *Array analysis of seismic signals*, Geophysical Research Letters, 14, 1, pp. 13-16, 1987.

Rietbrock, A. and Scherbaum, F., *The GIANT analysis system*, Seismological Research Letters, Vol. 69, No. 6, pp. 40-45, 1998.

Scherbaum, F., Ohrnberger, M., Savvaidis, A., Panou, A., Theodulidis, N., *Determination of Shallow Shear Wave Velocity Profiles Using Ambient Vibrations at Selected Sites in Greece*, Eos Trans. AGU, 83(47), Fall Meet. Suppl., Abstract S72A-1138, 2002.

Schmidt, R.O., *A signal subspace approach to multiple emitter location and spectral estimation*, Ph.D. Dissertation, 201 pp., Stanford University, Stanford, California, 1981.

Schmidt, R.O., *Multiple Emitter Location and Signal Parameter Estimation, IEEE Trans. On Antennas and Propagation*, 34, pp. 276-280, 1986.

☺ Up to now, the time table is respected. The deliverable D05.06 "***Quality control software for in-situ checks***" presenting the software has been sent with the previous report. The final step of this work package is the deliverable D15.06 "**Interface software**" appended to this report. This deliverable present the software tool "retrieve".

VII WP07 – T02.07: array measurements – inversion of velocity profile – year 2

Leader: Denis Jongmans (Partner 4 – ULGG.DGO – Liège – Belgium)

During the period running from October 2002 to May 2003 many improvements of the software have been done such as: a flexible way of defining the parameters, direct inversion of autocorrelation curves, computation of the site response for the ensemble of models, automatic multi mode inversion, and joint inversion of dispersion and H/V curves. Moreover, the portability of the processing software designed by WP05 (Potsdam) has been improved by connecting it to a lighter home made database *("Sardine"*). The possible file formats for recordings are now: SEG-2, SAC, SU, GSE 2.0 and City Shark 2.
A great effort was also put on the processing of real experiments realized last year in Belgium (Liège and Brussels, March 2002). Basic interpretations have been carried out giving interesting results. But more refined approaches are still under study following the code developments, especially the SPAC (Autocorrelation) and multi mode have to be applied to those real cases.

Automatic multi mode inversion and H/V constraint

For both sites, Liège and Brussels, we noticed that the resulting dispersion curves from the FK method do not always correspond to the fundamental mode of Rayleigh waves. This is especially true at high frequencies were the dispersion curves were also measured using active source experiments. Tests on simple synthetics with 2 to 4 layers clearly showed that a misinterpretation of one mode, even on a reduced frequency range, can drastically change the final results.
It was thus important to develop an inversion scheme that takes this aspect into account. In the classical approach, for each frequency sample, the misfit is based on the difference between the calculated velocity for the fundamental mode and the measured velocity. If various modes are clearly identified, each measured velocity is compared with its corresponding calculated value. *If they are not clearly identified but only suspected, the misfit for a particular frequency is defined as the minimum misfit among the misfits calculated between the measured velocity and the calculated velocities for all modes (the maximum number of modes is fixed a priori by the user).* In order to avoid oscillations between modes across the frequency range, a rule states that the best fitting mode index must not increase when the frequency decreases.
Synthetic dispersion curves of layered model have been calculated for the first two modes. At a certain frequency (f_o) it is not unusual to have both curves very close to each other. The final synthetic curve follows the 1st higher mode for all frequencies greater than f_o and the fundamental mode for other frequencies. Using the inversion scheme described before, the inversion of this "mixed modes" curve shows that the non-uniqueness of the problem is not increased too much, and only a reduced number model classes are present: either fitting the whole curve as the 1st higher mode or changing from 1st higher mode to fundamental at the correct frequency. The order of magnitude for depths is different in the two classes.
As the constraint of H/V curves is essentially the travel time between the surface and the top of the bed-rock (Scherbaum et al. 2003), it is an excellent way to remove from resulting models the ones with wrong depths.

The joint inversion of the H/V and of the mixed mode dispersion curves was tested and showed an excellent constraint on the Vs profile across the sediment layers and even in the bed-rock. These results encourage us to continue in this direction.
The proposed scheme has been applied to the real dispersion curve of Liège data. If the inversion results seem to be very robust against any change of the random seed, the inverted depth of the bed-rock is still higher than expected. The inverted value for the fundamental mode at high frequencies still does not match what we measured with active sources. The statistical processing of the FK histogram must probably be revised to include it directly in the computation of the misfits.

Scherbaum, F., Ohrnberger, M., Savvaidis, A., Panou, A., Theodulidis, N., *Determination of Shallow Shear Wave Velocity Profiles Using Ambient Vibrations at Selected Sites in Greece*, Eos Trans. AGU, 83(47), Fall Meet. Suppl., Abstract S72A-1138, 2002.

☺ Up to now, the time table is respected. A first deliverable D14.07 "***Report on the inversion of velocity profile and Version 0 on the inversion software***" is appended to this report. This deliverable describes the inversion procedure developed in the framework of the SESAME project It has been implemented in platform independent software (Qt): Linux OS (free libraries), Windows (proprietary libraries), Mac OS (not tested), Solaris (not tested).

VIII WP08 – T02.08: nature of noise wavefield – year 2

Leader: Pierre-Yves Bard (Partner 1 – UJF.LGIT – Grenoble – France)

As outlined in the previous report and in the attached deliverable D13.08 "Report on the nature of noise", the literature review left a number of questions regarding the quantitative composition of noise wavefield unanswered. It was thus indicated that reliable information could come only from two kinds of data: array data from real sites analyzed with some specific techniques, and noise synthetics from well controlled noise simulation programs in well-known structures (1D to 3D).
Since array data are now available (see report D06.05), we decided to focus our energy for the last 6 months on the noise modelling, in very tight connection with WP09 and WP10, since we faced some unexpected difficulties in the FD code (very long computational times + numerical instability issues, that turned out recently to be linked with machine-dependent compilator problems !…).
In the Roma general meeting, a decision was taken to complement the FD approach to generate noise synthetics, by another approach based on the discrete wave number method, on the basis of Hisada's code. This latter approach is valid only for horizontally layered structures. The first step has consisted in a comparison of noise synthetics obtained with both methods: after some debugging, these comparisons proved very satisfactory in both temporal and spectral domain. As the Hisada DWN code is much faster than the FD code, we decided shift all the work on 1D canonical models from FD code to DWN code, and to share the heavy computations between the Grenoble and Zurich groups (DWN in Grenoble, FD in Zurich, both with important input and exchanges with the Bratislava group). This heavy computational work is still under process right now.
In the same time we have performed some tests to define the nature of noise wavefield in several sets of sources-receivers configuration (near/far, surface/deeper sources). Some results are already available and allowed several presentations (EGS Nice in April 2003, AFPS Paris in July 2003, IUGG/IASPEI Sapporo in July 2003). The next step, now under way for the first sets of synthetics, is to interface the array processing software CAP developed within Task B with the noise modelling results, and to carry out array analysis to determine the waves contained in noise for various sources-receivers configurations.
Since the WP09 Roma meeting and the 18-month 3rd progress report, final debugging of the FD code has been achieved, 3D models have been tested on Lugano and Grenoble computer platforms. The preliminary results now obtained are promising, and the computation of 2D and 3D canonicals models and of real sites (Grenoble, Colfiorito, Liège, Basel) has started.

☺ 😐 The first part of the deliverable presenting the results of the survey of the scientific literature dealing with seismic noise is finished and presented in the deliverable D13.08 "***Report on the nature of noise***". The second part of the deliverable will be presented in May 2004 (see the reason of this delay below).

The main reasons for the delay are the following:
1. problems encountered with noise simulation in the WP09 and WP10, that brought us to shift our focus on the noise modelling issue.
2. as a consequence, the detailed analysis that were anticipated on the array data gathered by the Potsdam team over the first 18 months, and on the noise synthetics from canonical models and real sites could not be performed: it is scheduled to be performed in Fall 2003 and Winter 2003/2004.

IX WP09 – T02.09: numerical simulation of noise – year 2

Leader: Peter Moczo (Partner 11 – IGSAS.SD – Bratislava – Slovakia)

In almost all numerical simulations of noise in canonical models using the program package NOISE, relatively early occurrence of artificial high frequency oscillations, i.e., instabilities, has been observed. 'Relatively early' means earlier than in "usual" simulations with only one point source or plane-wave excitations. There are preliminary indications that the high-frequency oscillations might be caused by the type of the point body force. This hypothesis has to be checked by an alternative way to simulate point body force in the FD calculation.
It was found, however, that it is possible to remove the high-frequency oscillations from simulated noise using a special filtration technique. The technique applies FIR (Finite Impulse Response) filter to field variables at certain time levels during the finite-difference calculation. The characteristics of the filter and times of its application may be determined on the basis of a trial simulation without application of any filter.
It is also possible to reduce the undesired oscillations by filtering the input source-time function by a steep band-pass filter (for example, Butterwoth filter of the 6^{th}-order).
This filtering has now been implemented in the program package NOISE, instructions for the filter-technique application have been written and supplied to users of the program package NOISE.

An important improvement in the finite-difference modelling of seismic motion has been achieved. *Kristek & Moczo (in press)* addressed basic theoretical and algorithmic aspects of memory-efficient implementation of realistic attenuation in the staggered-grid finite-difference modelling of seismic wave propagation in media with material discontinuities. They considered the problem of accounting for a material discontinuity in heterogeneous FD schemes for perfectly elastic and viscoelastic media. They showed that the anelastic coefficients and elastic moduli of the averaged medium representing contact of two media can be determined from averaging applied to viscoelastic and elastic moduli, respectively.
In order to account properly for material discontinuities and, at the same time, be memory-efficient, they defined (1) the anelastic functions in a new way – as being independent of anelastic coefficients (that is, independent of material parameters) and (2) a new coarse spatial distribution of the anelastic functions. As a consequence, in the sum of the anelastic functions in Hooke's law we can, at a given grid position, account for anelastic functions at neighboring grid positions (and thus for other relaxation frequencies) by proper weighted averaging of the anelastic functions from neighboring grid positions without artificial additional averaging of the material parameters themselves.
If the anelastic functions are determined from volume harmonic averages of the viscoelastic moduli, a consistent extension of the new elastic FD scheme developed by *Moczo, Kristek, Vavryčuk, Archuleta & Halada (2002)* is obtained
Numerical tests against the discrete-wavenumber method demonstrate that the developed approach enables more accurate viscoelastic modeling than other approaches.
The method has been implemented in the program package NOISE.

The need of simulation of seismic noise in laterally heterogeneous structures due to distant sources led to an effort to implement the option of a two-step finite-difference computation using program package NOISE. In the first step the radiation of sources and wave propagation in the large-scale structure (for example, crustal structure) is simulated in a certain interval of frequencies. During the computation, the wavefield is recorded along the grid planes which define borders of the so-called ***"excitation box"***. After the first step is completed, the wavefield is interpolated along the borders of the excitation box in order to allow for higher frequencies in the second step calculation. In the second step, the finite differences are used to calculate seismic motion in a localized small-scale near-surface heterogeneous structure inside the excitation box.
The implementation is not a trivial programming task. The implementation is under way at the time of preparation of this report.

Numerical simulations in a set of the canonical models of a homogeneous halfspace and single layer over halfspace have been performed in order to analyze properties of the simulated seismic noise and H/V ratios and their dependence on parameters of the noise generation.

The Fortran95 code for the time-frequency method of the H/V ratio computations with 2 different methods of time-frequency analysis, windowed Fourier transform (WFT) and continuous wavelet transform (CWT), has been written. Since the commonly used wavelets did not work well for this method of the H/V ratio computation, a proper modification of Morlet wavelet has been proposed. Based on the theory and the numerical tests, it has been found that CWT with a modified Morlet wavelet is more suitable for the determination of the H/V ratio based on the time-frequency analysis then the standard WFT. It has been also found that the technique based on the CWT better determines the minimum of the ellipticity curve for the fundamental mode of Rayleigh waves in wave motion composed of several modes of Rayleigh waves than the classical technique of the H/V computation.
A new approach to determine ellipticity curves from the noise measurements using the time-frequency H/V method has been suggested. It is based on a kind of "stacking" in the H/V-frequency plane instead of computing average curve from individual segments of the seismic noise recordings. The first tests with synthetic signals calculated for simple models with different contribution of various modes of Rayleigh and Love waves have been performed. For these signals, the proposed method was capable to better catch the shape of the ellipticity curves and also partly to resolve the contributions of various modes.
A modification of the method for the time-frequency analysis, a "quadratic" matching pursuit decomposition has been developed. This modification allows one to efficiently and much more accurately represent signals with nonlinear dependence of instantaneous frequency on time. The improvement is based on the generalization of Gabor dictionary of the time-frequency atoms and on using proper time-frequency distribution (other than in previous versions of the method).

☺ 😐 A first deliverable D02.09 "***FD code to generate noise synthetics***" in the form of a CD ROM with a report describing the flow chart of the software and canonical structural models has been sent to the EC in June 2002. The next step will be the deliverable D12.09 "***Report on parameter studies***" presenting the numerical simulations for a selected set of canonical models which undergo some delay, and is now scheduled for the end of 2003 (see the reason of this delay below).

The main reasons for the delay are the following:
1. very heavy computational time and memory, which forced the team to apply for computer time on specific high-performance computers in Switzerland ;
2. unexpected problems with high-frequency oscillations in the numerical simulations for certain canonical models. A special effort to optimize the simulations was necessary to start 'routine' simulations.

X WP10 – T01.10: simulation of real sites – year 2

Leader: Donat Fäh (Partner 6 – ETHZ – Zürich – Switzerland)

This work package is dedicated to the finite-difference noise simulations for real sites and cross-checking between noise synthetics and actual noise observations for a few well-known test-sites. The work in the second year has focused on:

1. Solving the numerical problems in the FD simulation, and comparing the results with another independent method (Hisada's DWN code). This part included the adaptation of the Hisada's DWN code to the ambient vibration problem with many sources and receivers. This now allows for a very fast computation of noise synthetics for 1D layered structures.
2. Tests on noise synthetics in order to establish a correct parameter set needed for the numerical modelling (see work progress in WP09).
3. Canonical models in order to determine the effects of the source distribution (density, time function, spatial location) on H/V ratios and on spatial correlations. A good representation of observed noise in terms of H/V shape and spatial correlation is now achieved. This work included comparison of H/V ratios with theoretically computed ellipticities of the fundamental mode Rayleigh wave, as well as a comparison of the spatial correlation properties of the noise synthetics with those of actual noise recordings.

4. The influence of very near source effects on H/V ratios and the influence of source distribution from the surface down to depth.
5. Establishing the models for the real sites. The models for the sites Colfiorito, Liege, Basel, and Grenoble models are ready and encoded for the 3D modelling. Partial information is available for the Volvi basin, but is not yet fully sufficient to implement a 3D modelling.

During the testing of the FD program, it has been recognized that the requirement in computation time is very high. For this reason, the Swiss Seismological Service has submitted a project to the Swiss Center for Scientific Computing (CSCS) in Manno. The proposal was accepted by the end of December 2002. Computation time will restrict the number of models that can be studied within the SESAME project.

A special task is concerned with the use of frequency-time analysis to compute H/V ratios. This method is suitable for the extraction of Rayleigh wavelets, and allows the computation of the ellipticity of these wavelets. A wavelet transformation algorithm has been optimized and compared to classical H/V methods. Several tests have been performed with synthetic signals calculated for some canonical models.

☺ 😐 This work package has started at the beginning of year 2. Due to the heavy computational requirements, some delay is anticipated in the first deliverable D11.10 "Set of noise synthetics for H/V and array studies from simulation of real sites".

The main reason for the delay are the following:
1. the computations for real sites could not start because the simulation code developed within WP09 had to be partly rewritten in order to suppress the numerical instabilities and to better account for anelastic parameters. Most of the problems have been solved, and at the end of May, noise could be simulated for the canonical M6 model, Liege and Grenoble sites.

XI Task D: short description

Task D is devoted to the dissemination and implementation of the scientific results. It will officially start only at the beginning of the 3rd year. It is composed of the following three work-packages:

- WP11: Scientific outcomes
- WP12: H/V user guidelines
- WP13: Recommendations for quality array measurements and processing

During the first year of the SESAME project, a study was done to check Tokeshi's method with real recordings of ambient vibrations. The conclusions were that Tokeshi's method seems to work reliably only in the case where the frequency characteristics of the sources of ambient vibrations correspond to white noise. Therefore, Tokeshi's method cannot be considered to be reliable and thus, its application cannot be recommended. Further tests could be made using Tokeshi's method applied on artificial noise, in order to better constrain the outcomes of this method in comparison with the frequency content of the noise.

As the results of the Tokeshi's method are not promising at all, the second year of the project was devoted to the beginning of the work for the WP12, concerning :

- the dissemination of the results,
- the preparation of the user guidelines.

For the preparation of the dissemination work, a special theme session has been proposed and accepted for the 13th World Conference on Earthquake Engineering (Vancouver, 2004), with the title "Site characterization for site effect studies using ambient vibrations". The proposed theme session would mainly report the results of the SEAME project which will reach its end by summer 2004. The main outcome will be a clear, solid assessment of the meaning of the methods using ambient vibrations, and recommendations as to their practical implementation. This will materialize through user guidelines for each technique, to be discussed in specialized committees of international bodies and thus widely disseminated, in order to provide the basis for a quality label. The consequences will be two-fold: on the one side, their wide dissemination will hopefully prevent misuses, wrong microzonation maps and misleading earthquake safety feelings. On the other side, for countries

which till now have been reluctant to use them, it will offer a validated, simple, low-cost tool to contribute in systematic, first-level evaluations of seismic risk in urban areas.

Concerning the preparation of the guidelines themselves, the work started now by the CR2 partner is to participate to the "results meetings" of the WP02 (Nice, April 2003) and WP03 (Thessaloniki, June 2003), in order to participate in the discussions and to get a synthetic view of the work done so far in these work packages.

XII To conclude this second year report

As outlined in the sections describing each active work package, the project is progressing normally, and there does not exist any major problem that jeopardize the chance of success of this project. Even, if some deliverables undergo some delays, these delays are always well explained, and remain under control. For this reason, we decided, with all the partners, to ask for a six months prolongation to the EC (see appended letter).
The project would thus be finished in October 2004 (against April 2004) with:
- progress reports foreseen for:
  - October 2003 (report 5),
  - April 2004 (report 6),
  - October (report 7);
- and a final report foreseen for December 2004.

The presentations made in various conferences and meetings did show the interest for the SESAME project, its preliminary results and its anticipated outcomes, especially in "third world countries". This interest was lately shown also from Japanese colleagues during a special one-day meeting held in Sapporo in connection with the IUGG/IASPEI General Assembly. For this reason, some representative individuals as "observers" will be invited in the Smolenice workshop near Bratislava.
Having no budget to invite those persons, we have decided with all the partners to withdraw a certain amount from each partner (this was discussed and agreed unanimously during a meeting that took place in Thessaloniki on June 11-14, 2003, and which will be reported in the next 6-month management report). A letter appended to this report therefore asks officially the EC the formal authorization to deduct a sum from each partner when we will transfer the third payment of the EC to the partners (the total anticipated amount for the invited people is about 3000 €).

The final results of the project SESAME will be presented during a Special Theme Session at 13WCEE (Word Conference on Earthquake Engineering), Vancouver, in August 2004: Site characterization for site effects studies using ambient vibration" (see the abstract in the following page).

The idea is to do 4 or 5 synthetic oral presentations, giving the main issues, by Task and to present the more detailed result on posters, in order to leave some time for other people from other continents, not involved in the SESAME project.

The session would be ended with a "round table" discussion to exchange ideas and experiences between SESAME and non-SESAME researchers

13 WCEE – Proposal for Special Theme Session

Site characterization for site effect studies using ambient vibrations

Primary Organizer : Dr. Pierre-Yves BARD, pierre-yves.bard@obs.ujf-grenoble.fr
(LGIT-UJF, Grenoble, France, in association with LCPC, Paris), Coordinator of the SESAME project

Assistant : Dr. Corinne LACAVE, corinne.lacave@resonance.ch (please send all technical information and/or questions about this theme session to this address).

Proposal description:

The proposed theme session would mainly report the results of a large European project which is now under progress and will reach its end by summer 2004. The project named **SESAME** (**S**ite **E**ffect**S** assessment using **AM**bient **E**xcitations) corresponds to a total budget of about 2 M Euros, with 70 persons working on it throughout Europe.

After recent earthquakes, a priori estimations of site effects became a major challenge for an efficient mitigation of seismic risk. Unfortunately, the few methods known as reliable systematically appear as far too expensive for local and national authorities, especially in moderate seismicity countries or in developing countries. There is therefore a drastic need for reliable, low cost techniques. The objectives of the SESAME project are to investigate the reliability of two techniques born in Japan using ambient noise recordings: the very simple H/V technique ("Nakamura"), and the more advanced array technique. They offer many advantages, especially in urban areas, and their use (perhaps misuse) is rapidly spreading world-wide; but their physical basis and actual relevancy for site effect estimates has never reached a scientific agreement. The project goal is to tackle these methods under different viewpoints, understand their physical basis, assess their actual meaning in view of site effect estimation, and propose user guidelines and processing software to ensure a correct use, and thus improve significantly the mitigation tools.

On the upstream side, the project tries to fill the gap concerning the understanding of the real nature of noise, especially in urban areas. On the technical side, series of investigations are carried out to clearly identify the key points in each of these techniques and their reliability, and to clearly assess the conditions under which they have to be performed: experimental conditions for the measurements, and processing techniques as well. Finally, on the downstream side, after - hopefully - having shown that these techniques do provide useful information when applied with care, we want to offer a framework for reliable measurements by proposing user guidelines that could form the basis for a quality label.

The main outcome will be a clear, solid assessment of the meaning of these methods, and recommendations as to their practical implementation. This will materialize through user guidelines for each technique, to be discussed in specialized committees of international bodies and thus widely disseminated, in order to provide the basis for a quality label. The consequences will be two-fold: on one side, their wide dissemination will hopefully prevent misuses, wrong microzonation maps and misleading earthquake safety feelings. On the other side, for countries which till now have been reluctant to use them, it will offer a validated, simple, low-cost tool to contribute in systematic, first-level evaluations of seismic risk in urban areas.

Technical remarks:

The main participants to the SESAME project will be asked to give a presentation to this special theme session (in particular P-Y. Bard, A-M. Duval, K. Atakan, N. Theodulidis, F. Scherbaum, D. Jongmans, P. Moczo, D. Fäh). A Japanese contribution is planned to be invited that will present the corresponding state of the art in Japan.

This special theme session will provide very recent results, coming from the broad SESAME project. The field of site effect evaluation with ambient vibrations now concerns every one involved in the reduction of seismic risk. Many contributions are expected to this special theme session, so we would already ask for the maximum time duration accorded to special theme sessions.

SESAME important dates

	Months	Week 1	Week 2	Week 3	Week 4
1	*May 2001*				
2	*June 2001*				Kick-off Meeting-Grenoble
3	*July 2001*				
4	*Aug. 2001*				**Zürich – Aug 29-30** Task C meeting
5	*Sept. 2001*				
6	*Oct. 2001*				**Bergen – Oct 22-26** TaskA - WP02
7	***Nov. 2001***	**First progress report: 6th months report**			
8	*Dec. 2001*		(AGU)		
9	*Jan. 2002*	**Postdam – Jan 7-8** TaskA-WP02	**Postdam – Jan 9-11** TaskA-WP03 & TaskB-WP06		
10	*Feb. 2002*				
11	*March 2002*				
12	*April 2002*			**During the EGS – Nice – April 21-27** Task A- WP02- WP 03- WP 04 D1, D2 → sent with D3 in June 03	
13	*May 2002*			**Zürich** Task C meeting	D3: Progress report 1 (due on 30/06/02)
14	***June 2002***	**Second report: first year progress report + Deliverables D1, D2 & D3**			
15	*July 2002*				
16	*Aug. 2002*				
17	*Sept 2002*	(ECEE London) (ESC Genoa)			
18	*Oct. 2002*		**Roma – Oct 22-26** Oct 22-24: WP02, WP03, WP04, WP09-10 meetings Oct. 25-26: General SESAME meeting		D5, D6, D7 → sent with the third report
19	*Nov. 2002*				
20	*Dec. 2002*		(AGU)		D4 draft sent with the third report
20	***Dec. 2002***	**Third report: 18th months report + Deliverables D5, D6, D7 & a draft of D4**			
21	*Jan. 2003*				D9 ?
22	*Feb. 2003*	**Potsdam– Feb. 3-14** Task B meeting		**Bratislava– Feb. 20-21** Task C meeting	
23	*March 2003*				
24	*April 2003*		**During the EGS-AGU-EUG Nice – April 7-11** WP02 meeting		D8, D9, D13 (first part), D14, D15 → sent with the fourth report
25	*May 2003*				D10: Progress report 2 (due on 30/06/03)
26	*June 2003*		**Thessaloniki– June 12-13** WP03-WP04 meeting		
20	***July 2003***	**Fourth report: 2nd year report + Deliverables D8, D9, D10, D13, D14 & D15**			
27	*July 2003*			**Grenoble– July 16-17** Task C meeting	
28	*Aug. 2003*				
29	*Sept. 2003*			**Smolenice – Sept 22-24** **Scientific Workshop**	
30	*Oct. 2003*				D11, D12, D13 (second part), D16, D17, D18, D19, D20,D21
31	*Nov. 2003*				
32	*Dec. 2003*		(AGU)		
33	*Jan. 2004*				
34	*Feb. 2004*				EGS – Nice
35	*March 2004*				
36	*April 2004*			General Meeting - Nice	D22, D23, D24
37	*May 2004*				D25: Progress report 3
38	*June 2004*				
39	*July 2004*				
40	*August 2004*		**Vancouver - August** 13th world conference in Earthquake Engineering,		
41	*September 2004*				
42	*October 2004*				
43	*November 2004*				
44	*December 2004*				D25: Final report

Minutes of the meetings or workshops

1. Task B meeting – Potsdam (Germany) 3-14 February 2003

The SESAME task B meeting was held from February, 3rd to February 14th, 2003 in the University of Potsdam. The meeting covered two distinct aspects. First, preliminary results and the progress within the single workpackages (WP05, WP06 and WP07) were shared between the participants. Both scientific issues as well as technical details of the algorithm implementations were discussed and future actions were defined. Second, programming work on the existing computer codes, evaluations of the programs and specific tests have been performed.

I Partners attending the meeting

Cecile Cornou	Swiss Seismological Survey, ETHZ, Switzerland
Alekos Savvaidis	ITSAK, Thessaloniki, Greece
Marc Wathelet	UJF, Grenoble, France
Andreas Köhler, Matthias Ohrnberger, Gudrun Richter	IGUP, Potsdam, Germany
Frank Scherbaum, Estelle Schissele	IGUP, Potsdam, Germany

II Schedule of the meeting

Monday, February 3, 2003:

After the participants arrival, a first meeting was held in the afternoon in order to define the main discussion points regarding the derivation of dispersion curves from ambient vibration array measurements. A list of discussion topics had been distributed in advance by e-mail to the participants:

1) Joining fk-analysis results with dispersion curve inversion

--- In case of non-negligible contribution of higher modes surfaces waves in the ambient noise wavefield: what is the expected influence on the array analysis result: problem of "apparent dispersion curves" - what do we really observe? can we expect to "see" single mode branches or do we actually observe a mixture of surface wave modes <-> implications for inversion scheme (involvement of Green's functions, source mechanism).

--- How to deal with uncertainties in the measurements? What are the errors due to experimental conditions, limitation of accuracy due to applied method and numerical errors? Can we account for those uncertainties ad how to estimate those. How should the errors incorporated into the inversion process?

--- Discussion of preliminary results obtained from array measurements

--- How can we include hazard relevant information into the inversion process <-> Is it possible to define a cost function adjusted to site response?

--- Technical details: interfacing between array analysis codes (e.g. "cap") and the inversion code (os_na, na_viewer).

2) How to improve the dispersion curve estimates from array analysis (resolution, reliability):

a) Preprocessing: automatic selection of appropriate windows for fk-analysis -

What do we consider as an appropriate window? Method dependency?

--- conventional fk-analysis:

time windows should contain a single dominant coherent signal, multiple signal arrivals are not resolvable for reasonable field setups (limited number of stations, feasible aperture size and station spacing which are limited by logistical constraints, heterogeneity of subsurface structure and time resolution of measurements).

--- SPAC: exclusion of single dominant signal arrivals? stationarity test?

--- MUSIC: rank limitation of covariance matrix? Choose windows with a few dominant signals? (experts must tell -> Cecile & Estelle).

b) Postprocessing: automatic selection of dispersion curve and uncertainties

---What implicit assumptions are made when extracting dispersion curves from fk-analysis?

Again: can we expect to observe single mode branches or do we have some apparent dispersion curves which results from mixing of different mode contributions to the wavefield.

--- Discussion about strategy for automatized dispersion curve determination, strongly dependent on method and technical issues (sampling in fk-space, statistics, threshold criteria, etc.)

--- Inversion of spatial autocorrelation curve to dispersion curve seems to be difficult for general situation. How can we approach this inversion task without any a priori knowledge of the site structure (i.e without a sufficiently good starting model?) - what is the influence of higher modes
on the autocorrelation curve observation - can higher modes be included into the inversion process?

c) Implementation of alternative array analysis methods for ambient vibration analysis:
- MUSIC
- Phase stack (complex trace analysis - instantaneous phase beamformer..)
- others??

d) Extensions of array analysis methods:
--- Using 3 component data
--- Incorporation of polarization analysis
--- Preselection of time windows according to wavefield separation (classification approach)

3) Analysis of array data sets for Liege/Uccle and sites in Greece
Use existing array processing software (cap) and inversion code (os_na, na_viewer) to obtain shallow shear wave velocity models. Data sets to be used are from Belgium and Greece.

While addressing the items of the list, a vivid discussion started about the advantages and disadvantages of certain array methods with respect to the tasks defined in the SESAME project. Mainly experiences with conventional f-k, and high-resolution methods (Capon, MUSIC) were reported and discussed. In order to proceed it was decided to dedicate the following day to presentations by M. Ohrnberger, M. Wathelet and C. Cornou to communicate the first preliminary results of array analysis and dispersion curve inversion for both synthetic and real data sets to the other participants.

Tuesday, February 4, 2003:

Morning: presentation of M. Ohrnberger about conventional FK array analysis applied to synthetic ambient noise simulations and real data sets. Comparison to results with Capon's method, resolution tests and limitations of methods in special situations.

Noon: Presentation of M. Wathelet about the nonlinear inversion of dispersion curve data into 1D velocity models. Introduction to the applied inversion method for this purpose (Neighborhood Algorithm NA, Sambridge, 1999a,b). Application to synthetic and real data sets within the SESAME project. Individual testing of the relevance of velocity model parameters on dispersion curves (forward problem) and implications for the inversion problem.

Afternoon: Presentation of C. Cornou about high resolution array analysis (MUISC) and H/V ratios for ambient noise wavefield investigations. Application to ambient noise data from deep sedimentary valleys. Examples of the influence of soil-structure interaction and meteorological conditions on the characteristics of the ambient noise wavefield.

The presentations were accompanied by discussions and at the end of the day, a list of priority tasks was defined which should be addressed in the following days:
- array processing on existing synthetic data sets (deep sedimentary structure, Cologne area, Germany) with existing array processing software (conventional FK, Capon and MUSIC) – comparison and test for different pre- and postprocessing strategies
- improvements to be implemented into existing code: apply spatial smoothing into Capon algorithm (similar to MUSIC) and search for secondary peaks (higher modes?) in fk-map.
- preprocessing strategies of data: coherence processing in adaptive time-frequency cells, energy criteria in time-frequency cells - Pass only those time-frequency cells to array processing which pass selected threshold of coherence or energy.
- stronger focus on horizontal component processing and polarization analysis for preselection of time windows. Needs as input 'full' synthetic wavefield. Existing synthetic datasets at Potsdam contained only Rayleigh wave surface waves. Thus, a computation of synthetic ambient noise data set with the wavenumber integration code of Hisada (brought by C. Cornou) should be performed. For the new computations of data sets, it was decided to use the canonical model for Liege and the array configurations which have been used during the measurements at this site in spring 2002.

Wednesday, February 5, 2003:

Work on data sets and computer codes in groups.

- Preprocessing issues and MUSIC: E. Schissele & C. Cornou
- Inversion code and testing: M. Wathelet & A. Savvaidis
- Spatial smoothing in Capon, interfacing of preprocessing information: M. Ohrnberger
- Work on existing synthetic datasets: all together

- Preparation of new synthetic dataset: C. Cornou

Thursday, February 6, 2003:

Continuation of work on program codes and data

Afternoon: presentation by A. Savvaidis: Evaluation of data sets from selected sites in Greece. Special focus on site Lefkas, Volvi and Thessaloniki. Comparison of preliminary results from Capon and conventional FK analysis obtained within the scope of SESAME to results of Apostilidis (2002) using the spatial autocorrelation method.

Presentation of video of the measurement campaign in summer 2002 by F. Scherbaum.

From the discussion the following propositions were made:

- evaluate H/V ratios from accelerometer stations of ITSAK at site Lefkas for ambient noise recordings, not earthquake recordings.

- forward computation of waveform synthetics for simplified model of site Lefkas in order to evaluate the resolution capabilities of the deployed array for the specific situation.

- comparison of site transfer functions for different models (geotechnical <-> inverted).

- try to obtain the waveform data of Apostilidis (2002) in order to re-evaluate the Autocorrelation curves and try to use improved inversion scheme.

- comparison of Apostilidis (2002) Autocorrelation curves with results obtained from MSPAC processing on datasets acquired within the SESAME project.

Friday, February 7, and Monday 10 to Friday 14, 2003:

Work on computer codes and testing on synthetic and real data sets.

Friday 14, 2003, noon: Closure of meeting, departure of participants.

III Summary

The SESAME task B meeting was held from February, 3rd to February 14th, 2003 in the University of Potsdam. The meeting covered two distinct aspects. First, preliminary results and the progress within the single workpackages (WP05, WP06 and WP07) were shared between the participants. Both scientific issues as well as technical details of the algorithm implementations were discussed and future actions were defined. Second, programming work on the existing computer codes, evaluations of the programs and specific tests have been performed. The main results of this meeting can be summarized as follows:

⇒ All of the investigated array methods so far (conventional FK, Capon, MUSIC, (M)SPAC) can be regarded as at least partially useful for the derivation of dispersion curves from ambient noise data. We will continue therefore the investigation of all array analysis methods with both synthetic and real data sets and focus on further improvement regarding the special application to the derivation of dispersion curves and shallow shear wave velocity structures from ambient noise data.

⇒ The MUSIC algorithm (Schmidt, 1986) is the preferred choice among the frequency wavenumber techniques in terms of its inherent resolution capability in the frequency wavenumber space. This characteristic is of special interest for separating the dispersion characteristics of individual surface wave modes from the ambient noise wavefield. However, there exist some limitation in the practical application. In order to achieve a stable and reliable result high expertise of the user is necessary and a careful analysis of the ambient noise wavefield is required. So far MUSIC based dispersion curve analysis from ambient noise data seems not to be suitable for automatic and fast processing schemes.

⇒ On the other hand, the conventional FK method (in our implementation similar to Kvaerna and Ringdahl, 1986) allows, for realistic array geometries, only limited resolution power. This is especially true for multiple source situations, which is mostly expected to be true for ambient noise data. However, the conventional FK has the striking advantage of being easily applicable without a priori knowledge of particularities of the data and provides robust phase velocity estimates for a wide range of real data sets. An interesting observation could be made from the preliminary results of ambient vibration data acquired within the SESAME project. In almost all ‘real-world’ data examples dominant directions of wave propagation exist at least within a restricted frequency band. In some cases we even observed distinct dominant directions for different frequency bands for one and the same data set at one site.

⇒ The high-resolution frequency wavenumber method after Capon (1969) shows an intermediate performance between conventional FK and MUSIC, allowing for higher resolution with respect to the conventional FK, but still stable enough to be applied ad hoc to real data sets thus allowing fast and effective automatic processing schemes.

⇒ So far the practical experience on the usefulness of the spatial autocorelation methods for real situations is still limited within task B. This is mostly due to the difficulties to derive stable and realistic (not overly smooth or other form restrictions) dispersion curve estimates via inversion from the autocorrelation curves (AC). Regarding this problem, an proposition has been made during the SESAME task B meeting for a new inversion strategy of velocity models from AC-data.

⇒ Instead of a two-step inversion procedure consisting in inverting DC-curves from the autocorrelation curves and further inverting a velocity model from this DC-curve, a direct one-step inversion based on the Neighborhood Algorithm (Sambridge, 1999a,b) from autocorrelation curves into velocity models will be implemented in the next months by M. Wathelet.

⇒ In order to allow a more quantitative comparison of the array methods, it has been decided to conduct further tests on synthetic waveform data for simple 1D velocity models. An unsolved question is the influence of higher mode surface waves on the estimate of dispersion curves and how to incorporate multi-modal dispersion information into the inversion procedure. With respect to the inversion of velocity structures from the derived dispersion curves, it has been agreed among the participants, that a focus should be laid on the quantification of uncertainties of phase velocity estimates. Furthermore, the extraction of dispersion curves from raw array measurements has to be revised. First order statistics in a postprocessing stage, as well as other pre- and postprocessing strategies for the array methods will be addressed in the next months.

2. Task C meeting - Bratislava (Slovakia), 20-21 February 2003

In the following, we give the minutes of the task C (WP08/09/10) discussions during the meeting in Bratislava, February 20-21, 2003. The meeting was mainly focused on informing the partners about what was done and on defining the near future tasks in noise computation for canonical models and real sites. These minutes end with the suggestion for rescheduled deadlines for giving the deliverables

I Partners attending the meeting

Pierre-Yves Bard, Sylvette Bonnefoy	LGIT – Grenoble
Cécile Cornou, Donat Fäh	ETH – Zürich
Lucia Fojtíková, Peter Franek, Martin Gális	GPI SAS – Bratislava
Jozef Kristek, Miriam Kristeková, Peter Moczo	GPI SAS – Bratislava

II Scientific matters

II.1 *Summary of what was done*

The concise review on all papers find on seismic noise was done by Sylvette Bonnefoy-Claudet. The text, now in French, will be translated into English.

Array measurements were done by several other participants in the project. Data from array measurements are available upon request from Sylvette Bonnefoy-Claudet.

Pierre-Yves Bard made brief information about single-station measurements. He informed that they are delayed and moreover different groups got different results.

Peter Moczo made a brief general introduction on NOISE package development. The incorporation of the realistic attenuation is done in a new way. The new definition of anelastic functions leads to better sensitivity of the finite-difference computing on the position of material discontinuity in the computational grid and to more stable numerical results. The necessity of using distant sources of seismic noise in some canonical models and

models of real sites leads to work on incorporation of the so-called 'excitation box' into finite-difference code. The work on it is in the debugging state now and the prospective is that the code could be available at the end of May.

Jozef Kristek briefly informed about possible reasons of instabilities in the numerical modelling of seismic noise. One of the most probable cause is the large number of single-point single-direction forces used as sources of seismic noise. He also told about problems at corners of the computational grid. There were likely due to Day's coarse sampling of the anelastic functions and relaxation frequencies. This is solved by introducing of the new definition of anelastic functions as it was mentioned in the talk by Peter Moczo.

Miriam Kristeková and Donat Fäh briefly informed about development and testing of time-frequency method for H/V computation using wavelets.

II.2 *Discussion*

Donat Fäh and Cecile Cornou are performing comparisons of the package NOISE, Hisada's code and mode-summation method. They observed for the same ELASTIC model and the same receiver

- qualitative difference between seismograms computed using diffuse and localized sources by NOISE ,
- qualitative difference between seismograms computed by NOISE and computed by Hisada's code using diffuse sources.

Donat Fäh sees the disagreement between FD and Hisada above 3Hz in synthetic seismograms computed for canonical model M2. This has to be explained.

Cecile Cornou reported the disagreement between results for different grid spacing h=8m and h=4m for 100 source at one time.

The discussion about using distant sources of seismic noise in the simulation of real sites leads to the following results:

- To save time and memory it is possible to use 2D P-SV input for 3D excitation box.
- Below the real structures use the same crustal model – starting with the velocity equal to highest velocity in real-site structure.
- In canonical models M6, M10a and in real site models Colfiorito, Grenoble, Basel, Volvi use vertical wall of the line sources, one 'point' source = vertical force.
- For local sources do not consider crustal structure.

II.3 *Activities after the meeting*

1D Canonical Models: Cecile Cornou and Sylvette Bonefoy-Claudet will perform the seismic noise simulations in 1D canonical models using Hisada's code.

Real sites: Cecile Cornou and Jozef Kristek will perform the seismic noise simulations in *3D model of Grenoble* valley with only local sources using NOISE.
Martin Galis and Peter Franek will work on preparation of the *Basel model* and perform tests of *Colfiorito model*.
For *Volvi* structure it is necessary to wait for finishing of the work of Greek colleagues.

Around March 10 : Cecile Cornou will go to Bratislava to initiate FD simulations for 3D canonical models and real-site models.

II.4 *Agenda*

Reports and deliverables
The 2nd-year report will contain the 2nd version of the NOISE package; this should be accompanied by the reference to four methodological papers directly linked to the NOISE development.

Deliverables in time:
- D13 – interpretation – will be temporarily replaced by Sylvette's literature survey

Delayed deadlines for deliverables : **+ 6 months**
- D11 – real sites
- D12 – parametric studies for canonical models
- D17 – comparison of real and synthetic records for real sites

Prolongation of SESAME: **+ 3 months**
= final report deadline the end of September 2004

Future meetings
Next SESAME Task C Meeting will be in Grenoble, May 26, 2003
During the Smolenice Workshop there will be also a Task C meeting : Sunday Sept 21 in Smolenice or Thursday Sep 25 in Bratislava

3. Task A meeting - Nice (France), 7-11 April 2003

The WP02 is devoted to the evaluation of experimental conditions for "H/V on ambient noise" method. All participants had to perform numerous test before conclusions can be reached. During the last months, participants agreed on a common procedure to build the data set collected by all of us. During Roma meeting (2002 October) we decided a new way to analyse and present the results. As planed, most of the teams sent their reports and data to Nice team in February 2003 (except Grenoble and Thessaloniki). During this time, in 2003 January, a meeting took place between Nice and Grenoble teams: the analysis was modified another time. In February, a synthesis was written on the available tests performed by all teams. This report also explains the comments made during January 2003 meeting. During March 2003, Nice and Grenoble teams performed new tests and processed all their data (together with Swiss data) with the latest version of presentation decided in 2003 January. Then finally in April the present meeting was devoted to make a synthesis of the work and write the final report. This meeting was also aimed to write a paper with the WP02 results for AFPS conference (July 2003, dead-line for paper submission: end of 2003 April).

I Partners attending the meeting

Jean Luc Chatelain, Bertrand Guillier		LGIT – Grenoble
Mathilde Bøttger Sørensen		UiB Bergen
Anne-Marie Duval		CETE Nice
+ on the 11th April:	Kuvvet Attakan	UiB Bergen
	Donat Faeh	ETHZ Zürich
	Pierre-Yves Bard	LGIT – Grenoble
	Corinne Lacave	Résonnace - Genève

II Scientific matters

II.1 Review on available analysis and data-base

We first made a review on all the works performed by the different teams until April 2003. A synthesis of these works until February 2003 is already performed in document (annexe 1: 23 pages).
As planed during Roma meeting (Oct 2002), the participants processed their data with the common procedure using "student test" algorithm and wrote a report.
The documents available in Nice lab have been gathered in 2003 February in a CD rom sent to all partners with the synthesis report. Data are processed with the SESAME software : winselect3.f rsaf.f hvproc2.f. All the primary data base are not included in CD because of size.

- INGV: WP02 Report January 2003 + graphs (data base is available but not included in the joined CDrom)
- UiB: WP02 Report January 2003 (first version the process is not performed with the common software, data were not available in february; the March version should include data in SAF format and process with the right software)
- CETE: WP02 Report January 2003 including graph (data are available but not included in the joined CDrom) 254 pages
- ETHZ: data were processed by CETE team: graphs are on word document (in each test directory).
- ICTE/UL: WP02 Report march 2003 + data base

- LCPC/LGIT/IRD: Grenoble team did not convert their data in SAF format at that time. They processed it with their own software. Their results are not available in Nice.
- "WP02.state of the survey. march 2003.pdf": review and synthesis (by Nice team) of the work perfomed by all teams (except Grenoble and Thessaloniki) on the bases of the previous reports and data. (annexe 1 of the present minutes)

After February, Nice team recorded new data and perfomed new analyses (on its own data and on swiss data) with the common sofware and parameters. Two new reports were produced:
- "WP02.Zurich.Nice.avril 2003.v1.pdf" (50 pages) is concerned with Swiss data processed by Nice team
- "rapport CETE avril 2003.v1.pdf" (389 pages) is concerned with Nice data

Grenoble team recorded new data and performed new analyses of its data with its own software and parameters.

II.2 Results overview

After gathering all graphs by parameter, we tried to have a new overview of the results including Grenoble ones. For each parameter:
- we gathered all data and graphs from all teams: we systematically reviewed all test performed by all teams, filling tables to control for each parameter the number of test with positive result (same "H/V" curves for test and reference record) on one side, and negative results on the other side;
- we tried to explain the difference of results (in term of "H/V" curves and student curves);
- we drawn some global conclusion and some recommendations;
- we have selected some representative test as examples;
- a first draft of the WP02 final report was therefore produced. This document is available in annexe 2 of the present minutes. But this first draft is now to write again since all data has to be processed again: this new process will change both graphs, analyses and therefore conclusions.

II.3 Choice for final analysis and presentation of results

As we gathered the results we simultaneously argued on the relevance of the process and the presentations of the results.

Grenoble team do not use the same software than other team (the fortran version of winselect.f and Hvproc.f established by SESAME WP03 with common parameters). One sample of data from Nice has been processed by Grenoble to make sure that results were the same, which was established.

The way to present the result was another time argued during several hours: during the previous meetings, we defined clearly a presentation based on "H/V" superposition and student test (see annexe 1). But this point was another time argued and new presentation of results appeared necessary. Here is a brief overview of the discussions that bring to the conclusion that all data had to be processed again:

During the previous meeting (Roma Oct 2002) some of us proposed to compared some remarkable values to quantify the difference between a test and a reference record, both in frequency and amplitude, filling a table for each parameter. The Swiss team sent a Matlab routine that allows to get such information:
- it takes as input the "H/V" curve of the reference and of the tested record.
- it calculates differences between the two "H/V" curves at every point of the curve (in the specified interval e.g. a flank of the peak) as absolute values
- it calculates the mean of these differences (-> now called mean_diff)
- it takes standard deviation values from file of first curve ("log_std")
- it calculates mean of the standard deviation (-> now called mean_std)
- it computes comparison:
    Check if mean_diff < 50% of mean_std (Yes/No)
    Check if mean_diff < 100% of mean_std (Yes/No)

During the present meeting, M. Bøttger Sørensen (Bergen) kindly performed a demonstration of this routine.
The resulting values of this software were another argued. We finally agreed on the fact that at least the frequency of the maximum peak is relevant as well as the variation of amplitude around the major peak. But these values had to be studied for each window of each record.

On the other hand, the computation leading to the curve called here "student test" was another time argued. This curve is plotted between two other curves that form an envelop. At the beginning of the present meeting analysis, we choose to declare that a tested record was significantly different from the reference record when the student curve is out of this envelop. But this case occurred very often. That is why the experimental conditions were argued each time to try to explain this difference. Then the last day of the meeting, after deep discussions it was decided:

- that the student test had to be performed using logarithm values.
- that the major point was to check the variability of Fo between each windows of a record. The aim is to obtain a value comparable to the standard deviation in frequency domain. The student test should be applied in this sense.
- the variability of the amplitude Ao of the major peak of each window should also be studied by the same way.
- this resulting analysis can be illustrated as a box:
  - width of box = frequency mean Fo (over all windows of one reference record) + or- std
  - height of box= amplitude Ao (over all windows of one reference record) + or – std

  when the mean values of the tested record (Fo and Ao) are inside this box following the student test processing, the tested and reference "H/V" curves can be said similar.

III Conclusion of the meeting

From the discussions, it appears that all tests have to be processed again. Indeed, the information both on frequency and on amplitude variability over all windows of each record are now required to give a ruling on the similarity of two curves (tested and reference "H/V") and by the way to reach conclusions about the influence of each parameter. This new requirement implies to process again all the data collected (and already processed) by all teams.

Grenoble team is proposed to perform this final process. All data base (that were not already send in the CD rom of February) are then forwarded to this team so that the process can be performed as quickly as possible.

It is also decided to meet again (Nice and Grenoble teams at least) to have a new overview of the results, draw final conclusions, choose example and finally write the final version of WP02 report. This should be done before the end of May 2003.

C. Lacave (Resonance SA) proposed to participate to the review of the document.

The aims of the meeting were not totally reached:

- the final report is not written.
- the paper for AFPS 2003 is not written.
- but additional work has been decided to improve the accuracy of the evaluation. This work is required before starting to analyse, make the synthesis and then write conclusions: The drawbacks of such an arrangement and that the report will be delayed and only one team will be in charge of the final results. But of course all the data-base will be distributed again to WP02 participants with the used processing code and the results, so that every participant will be able to understand what was done and to reproduce it.

IV Annexes

1. WP02 State of the survey: Comments on available tests performed by several teams March 2003
file: WP02.state of the survey. march 2003.pdf

2. First draft of WP02(Influence of experimental condition for "H/V on ambient noise")
comments, examples and conclusion by parameter written during April 2003 meeting

The annexes are available on the site of the project.

Communications to International conferences

1. AGU in San Francisco (USA), December 2002

3D 4TH ORDER STAGGERED-GRID FINITE-DIFFERENCE MODELING OF SEISMIC MOTION IN VISCOELASTIC MEDIA WITH MATERIAL DISCONTINUITIES

J. Kristek and P. Moczo

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We present a new 3D 4th-order staggered-grid finite-difference scheme for the viscoelastic heterogeneous media with material discontinuities. The scheme is a generalization of the recently developed scheme (Moczo et al., in press) for the perfectly elastic media, which was shown, using extensive numerical tests, to be more accurate than standard staggered-grid schemes. The generalization is based on two key approaches: a) We assume that a contact of two viscoelastic media with the GMB (generalized Maxwell body) rheologies can be approximated by an averaged medium with the GMB rheology. The quality factors are determined from volume harmonic averages of the complex, frequency-dependent torsion and bulk moduli. The quality factors are then used to determine anelastic coefficients of the averaged medium. b) We define anelastic functions in a new way, which allows both Day's (1998) coarse spatial distribution (with a spatial period of 2h, h being a grid spacing) of the anelastic functions and accounting for all relaxation frequencies at any grid position of the anelastic function. This is important especially at the material discontinuities in order to avoid characterization of one medium by relaxation frequencies different from those, which characterize the other medium. We compare synthetics calculated for a set of test models with those calculated using a recent approach by Graves and Day (2002) and confront both with the DWN (discrete wavenumber) solutions.

SIMULATION OF THE PLANAR FREE SURFACE IN MEDIA WITH NEAR-SURFEC LATERAL DISCONTINUITIES IN THE 3D 4TH ORDER STAGGERED-GRID FINITE-DIFFERENCE MODELING OF SEISMIC MOTION

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Recently, Kristek et al. (2002) have developed a new technique to simulate planar free surface in the 3D 4th-order staggered-grid finite-difference (FD) modeling of seismic motion. The technique directly prescribes zero values of the stress-tensor components Tzx and Tzy at the free surface (in one formulation or zero value of Tzz at the free surface in the alternative formulation), applies adjusted 4th-order FD approximations to the z-derivatives at the grid points at and below the free surface, and uses neither virtual values above the free surface nor stress imaging. Numerical tests for a homogeneous halfspace and 1D layered models against the DWN (discrete wavenumber) method proved very good accuracy (also for Rayleigh waves) and efficiency of the technique which requires not more than 6 grid spacings per wavelength in the range of epicentral distances up to 22 times the wavelength. Because in the modeling of the earthquake ground motion material discontinuities reaching the free surface have to be included, we performed numerical tests of our technique for models with vertical and oblique material discontinuities reaching the planar free surface. We compared the synthetics with those calculated by the standard finite-element (FE) method. We used the FE method because, unlike the FD method, satisfying boundary conditions at the free surface and at internal material discontinuities poses no problem for the FE method. The numerical comparisons demonstrate level of accuracy of our technique for simulating the planar free surface in media with lateral discontinuities. We also compare synthetics obtained using our technique with those calculated using the standard stress-imaging technique of Levander (1988).

DETERMINATION OF SHALLOW SHEAR WAVE VELOCITY PROFILES USING AMBIENT VIBRATIONS AT SELECTED SITES IN GREECE

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The use of ambient vibrations for the determination of subsurface shear wave velocity profiles is increasingly gaining popularity as a low cost alternative to elaborate geotechnical site investigations. Based on the analysis of synthetic data, it has recently been suggested that robust constraints on both the shear velocity profile and the depth to the first impedance jump can be obtained if single station H/V spectral ratios are jointly inverted together with dispersion curves obtained from array analysis. In order to test this hypothesis, in August of 2002 we have performed array measurements of ambient vibrations at the Euro-SEISTEST in northern Greece, at six different locations within the city of Thessaloniki, and on the island of Lefkas where strong non-linear effect have been observed in a previous study. At all these locations, the subsurface structures are well known and shear wave velocity profiles have been determined by independent geophysical and geotechnical surveys. Furthermore, information about the intensity and damage distribution is available for the city of Thessaloniki. This detailed knowledge, as well as numerous data from temporary and permanent seismological networks makes these locations unique test cases for site response analysis. We present first encouraging results of the comparison of site models obtained from ambient vibrations with the existing structural models and discuss the consequences for site response prediction using ambient vibration recordings.

2. *APMG* (Portugal), February 2003

ANÁLISE DE REGISTOS DE RUÍDO SÍSMICO NO CENTRO HISTÓRICO DE LAGOS

SEISMIC NOISE ANALYSIS IN LAGOS HISTORICAL CENTRE

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Due to its particular location, the town of Lagos is strongly exposed to the effects produced by large earthquakes. The 1755 Lisbon earthquake produced great damages in this town, due to the strong shaking of the ground and to the action of the tsunami. A seismic risk research project is under development for the historical centre of Lagos, which presents a high level of seismic risk. One of the studies involved in this project is the seismic characterization of the soil formations using microtremor measurements. A detailed microtremor survey was carried out for the historical centre of Lagos. Data were processed according to the Nakamura methodology (Nakamura 1989; 1996) and using routines software developed in the Geophysical Centre of the Lisbon University and in the SESAME project. The first results are presented here.

ANÁLISE DE REGISTOS DE RUÍDO SÍSMICO NO CONCELHO DA POVOAÇÃO

SEISMIC NOISE ANALYSIS IN POVOAÇÃO COUNTY

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A microtremor survey was carried out on three zones of Povoação county, at S. Miguel Island in the Azores, in an attempt to improve the knowledge of the initial cause leading to the site effects observed in this county. We recorded at 303 points (following a grid of 50 meters wide) covering the three zones, which have different geologic and geomorphological characteristics. The data was processed using SPEC (SEISAN 7.2) to estimate the H/V ratio defined using Nakamura methodology. We then compare the results with those obtained in a previous work, using two different software packages, one developed within the SESAME project and other based in traditional routines. The different processing routines gave different results. In order to explain the observed differences we tested the influence of several processing parameters/routines, in particular those concerning the smoothing and the window definition.

3. EGS-AGU-EUG Joint assembly in Nice (France), April 2003

NATURE OF SEISMIC NOISE WAVEFIELD: A LITERATURE SURVEY

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Ambient vibrations measurements have the potential to significantly contribute to seismic risk mitigation, in particular in urban areas (microzonation). Two techniques using such ambient noise measurements are actually used for site effect evaluation: the Nakamura technique indicating the fundamental frequency of soil, and the array techniques leading to the shear wave velocity profile. Fundamental basis of the H/V technique are very tightly connected with the nature of noise wavefield (body or surface waves, relative proportion of Rayleigh and Love waves). Similarly, the inversion of velocity profile also depends on which Rayleigh (or Love) mode is considered (fundamental or harmonics). Therefore, it is important to elucidate the factors influencing the nature and composition of ambient vibrations. Within the framework of the European SESAME project we update a survey of the scientific literature dealing with seismic noise, in order to establish a state of art about the knowledge of the origin and nature of such ambient noise. We highlight different behaviours of noise (in spectral and temporal domain) between periods shorter and longer than one second, i.e. between microseisms and microtremor (respectively from anthropic and natural origin). We synthesize some informations about nature of noise, such as ratios of body waves to surface waves, Rayleigh to Love waves, fundamental Rayleigh waves to higher modes.