PROGRESS REPORT

CONTRACT N° : IST-2000-29266

PROJECT N° : 29266

ACRONYM : VIRTUALFIRES

TITLE : Virtual Real Time Fire Emergency Simulator

PROJECT CO-ORDINATOR :
Institute for Structural Analysis/ SiTu-Research
Lessingstrasse 25/II
A-8010 Graz Austria

PARTNERS :
Christian Doppler Laboratory for Applied Computational Thermofluiddynamics (CD), Austria
Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung e.V. (FIGD); Germany
Kungl Tekniska Högskolan (KTH), Sweden
Lyon Turin Ferroviaire (LTF), France
Ministere de l´Equipement, du Logement et des Transports (METL), France
Stadt Dortmund, StA 37 Feuerwehr (FDDO), Germany
European Virtual Engineering, S.A. (EUVE), Spain

REPORTING PERIOD : FROM 01.05.2002 TO 31.10.2002

PROJECT START DATE : 01.11.2001 DURATION : 30 Months

Date of issue of this report : 19.12.2002

Project funded by the European Community under the 'Competitive and Sustainable Growth' Programme (1998-2002)

1 Table of contents

2 Executive publishable summary

A Virtual Reality Real Time Fire Emergency Simulator (VIRTUALFIRES) will be developed using techniques of virtual reality. In the simulator, the observer will be able to visualise the fire and smoke development and the transport of heat and toxic combustion products inside a tunnel and walk or run through the virtual structure in the same way as through a real tunnel. The simulator will use and access a data base, which contains the results of three-dimensional transient combustion (Computational Fluid Dynamics - CFD) simulations for particular tunnel geometries with associated safety installations, particular fire hazard scenarios, etc.

It is planned to develop the system as a fixed installation in a CAVE virtual environment and as a portable installation using a PC and a head-mounted display (HMD). Two systems are planned: one where the CFD simulation is pre-calculated, stored into a data base and then displayed another where it is carried out in parallel to the visualisation. In the first system the user will be able to move through the data but will not be able to change the characteristics of the simulation, for example the ventilation characteristics. In the second system the user may change the properties of the simulation while the data are displayed.

The VIRTUALFIRES system will be a unique system that can be used for assessing the fire safety of tunnels and aircraft, for training of rescue personnel and for planning rescue scenarios and will be able to replace or supplement real fire tests. The end users of this system will be rescue organisations such as the fire brigade and police, tunnel operators and government organisations concerned about tunnel safety. The system can be used for making an objective assessment of the fire safety of existing European tunnels. It can also be used for training drivers on how to behave in the case of a fire emergency in a tunnel.

3 Objectives and strategic aspects

We propose, to apply the method of virtual reality to develop a simulator for assessing the fire safety of tunnels and for training rescue personel. In a virtual computer-simulation-based environment all data about the structure, the safety equipment, ventilation, the fire and smoke development and vehicles/passengers exist in computer memory only. These data are displayed in such a way that the user has the possibility to study all the hazardous effects of a real fire emergency. The project therefore aims to contribute to efforts by the Community to increase the fire safety of European tunnels. It also aims to extend the range of application of virtual reality techniques.

The objective is to develop and implement a Virtual Reality Real Time Fire Emergency Simulator (VIRTUALFIRES). In the simulator, the observer will be able to visualise the fire and smoke development and the transport of heat and toxic combustion products inside a tunnel and walk or run through the virtual structure in the same way as through a real tunnel.

By the end of this project a prototype of the VIRTUALFIRES simulator will have been developed which can be used by government authorities, tunnel operators and rescue personal. Currently the only method available to assess the fire safety of tunnels is to perform real fire tests. The advantages of virtual reality based simulations are that they offer virtually unlimited scope, are economical (the only expense being the computer time) and are environmentally friendly because no toxic waste is produced. As a result of the project's activity, through the availability of VIRTUALFIRES, the fire safety of tunnels will be increased because all European tunnels can be tested for fire safety and virtual fire tests can be made obligatory for new tunnels.

The work plan is to develop computer software, which together with specialised hardware can be used to display in a virtual reality environment the geometry of a tunnel with all its structural elements and safety installations together with the results of computer simulations of fires. The simulator will use and access a data base, which contains the results of three-dimensional transient combustion (Computational Fluid Dynamics - CFD) simulations for particular geometries, hazard scenarios, etc. It is planned to develop the system as a fixed installation in a CAVE virtual environment and as a portable installation using a PC and a head-mounted display (HMD) although emphasis will be placed on the development of the CAVE installation.

The applications on which we will concentrate the development include:

Training of rescue personnel. Currently this can be only done with real fire test which are expensive and produce toxic material.

Objective assessment of the fire safety of tunnels. This is currently either done using a list of rather arbitrary rules or by performing real fire/smoke tests (i.e. Mont Blanc Tunnel).

The simulator can also be used for:

Training of drivers. Using the simulator truck and other drivers can be trained on how to behave in a case of a fire accident.

Intervention management. The tunnel operators will be able to train the intervention procedures in order to mitigate the effects of a fire emergency.

4 Scientific and technical performance

4.1 Objective summary

4.1.1 Workpackage 3

The objective is to specify the database for geometrical input data for the VR-System and the CFD-Calculation, which should be done in Task 1. The work of task 2 is to specify the format of data which are necessary for visualisation (i.e. display of smoke and fire). In task 3 the existing data compression and optimisation techniques are evaluated to provide a real time visualisation with a given I/O rate. After specification the work must be done in task 4 and be tested in task 5. Task 6 closes WP3 by writing the documentation.

4.1.2 Workpackage 4

The objective is to implement the VIRTUALFIRES functionality specified in WP2 in the VR environment. The same software will run both in the CAVE environment and in a Head Mounted Display (HMD) system with some modifications. The HMD-version of VIRTUALFIRES is designed to run on a well-equipped graphics workstation or PC. To display CFD data requires many optimisations because of the size of the data and is also demanding from a user interface perspective. The coupling of real-time generation of CFD-data to the VR-environment is highly innovative and rises many unsolved problems.

4.1.3 Workpackage 5

The objective is to develop advanced, efficient and user-friendly simulation tools for the computer aided analysis of tunnel fire hazards and embedding them into the VR environments (CAVE and HMD) of the other partners. Two approaches have been followed during the past period concerning the development of these tools. The first one was the a-priori generation of CFD data for various anticipated tunnel fire hazards (MontBlanc and Gleinalm tunnel) using the commercial CFD package FLUENT™, whose underlying numerical algorithms are based on implicit time integration schemes and body fitted computational meshes. The results of these computations have been stored in the central VIRTUALFIRES database and can now be accessed by the different VR systems for the visualisation of flame front and smoke movement.

Whilst the above approach represents a standard way to display data in a VR environment, the second solution strategy persuade is much more challenging and definitely contained some technical risk. Here it was envisaged to run the CFD simulations in real time embedded in the VR systems. The numerical methodology is based on the Lattice-Boltzmann method and utilizes explicit time integration schemes. Initial tests, which have been already performed, proved the feasibility of the proposed solution strategy. However, it is obvious that this approach requires significant computing resources and it will not be feasible to compute in a concurrent fashion the fire hazard taking place in the entire tunnel geometry. The solution method proposed therefore is to only solve in those regions were user interaction takes place the fluid mechanics conservation equations in real time, whilst those regions of the flow field who can be considered as "passive" will be only updated if the user-interaction region changes. The transient boundary conditions for the real time flow solver are obtained by coupling a 1D CFD solver to it.

4.2 *Technical progress*

4.2.1 Workpackage 2

4.2.1.1 WP 2.4: "Specification of planned system capabilities (software)"

The delivery report of WP 2.4 was revised according to the comments of the reviewers. It´s content was extended and the mentioned lacks and unclear formulations were removed. Now the specifications of the planned system capabilities and the software architecture structures and interfaces are defined. The implementation details of the several interfaces between simulation and data management and between data management and visualization is the topic of the corresponding other workpackes. The result of this Workpackage is available in the revised delivery report for WP 2.4.

4.2.2 Workpackage 3

4.2.2.1 WP 3.1:"Specification of geometrical database"

Based on the system specification (D2.4) SiTu specified the Design Model for the implementation of the geometrical database part of VIRTUALFIRES. A well documented file format for all visual objects within the system was selected and a multi-state model for the support of visual feedback of the degradation was defined.

4.2.2.2 WP 3.2:"Specification of CFD database"

SiTu specified the Design Model of the CFD-related parts of the VIRTUALFIRES database. As the file format for import of CFD data CGNS was selected and the minimal set of values and their names were specified. Also the requirements for the grid data and their description were defined.

4.2.2.3 WP 3.3:"Data compression/optimisation techniques"

SiTu has performed an evaluation of existing compression software for CFD data in CGNS format (D3.3). It was shown that there is currently no specifically software for the compression of CGNS-files available and that the standard compression tools are not suitable for this task due to a lack of performance and poor compression ratio. So it is necessary to develop a new compression tool rather than adapt an existing one.

4.2.3 Workpackage 4

4.2.3.1 Regarding the research and implementation work at FIGD

FIGD implemented a central parallelized processing kernel for the generation of visualization data for CFD as planned. (Its layout was presented in the last progress report). Some more visualization methods were analysed and implemented as prototypes. Furthermore. FIGD has begun to integrate some of the visualization method prototypes realized in the past implementation section (see the last progress report) into the new parallel calculation kernel.

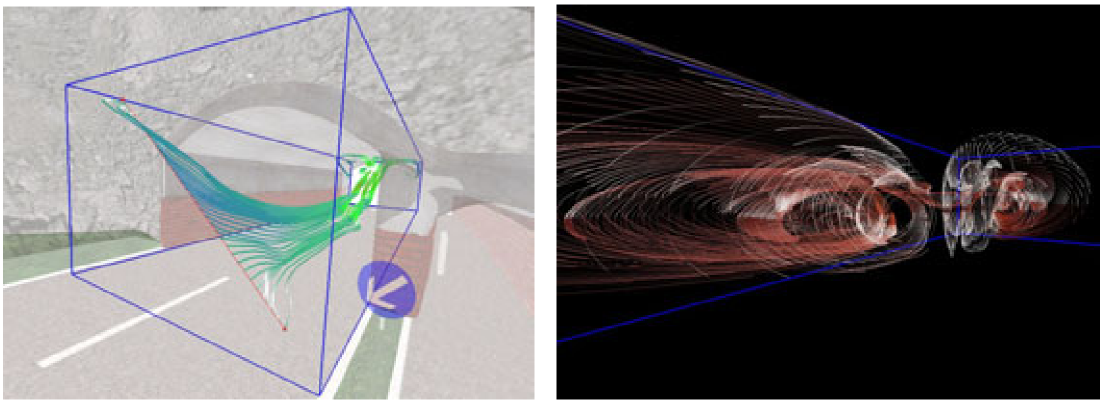


Fig.1: Left: Combined visualization: Geometry (Tunnel) and CFD (Stream Lines)
Right: Timelines Visualization

4.2.3.2 User Interface (KTH)

KTH has specified an architecture for the user interface to the system (D4.2), which should be usable in both the HMD and the CAVE case. The suggestion is for an interface that can be displayed on a PDA in the CAVE case and on a normal PC screen in the HMD case or when running a desktop version of the system. This part of the user interface will be implemented in Java to be portable between different systems. An early prototype of the user interface will be presented at the PCC/TCC meeting in Darmstadt

4.2.3.3 WP 4.1:"Selection and integration of hardware for HMD system"

SiTu has selected an HMD based on the requirements for the system (D4.3). This HMD is able to operate in 3DStereo mode and comes with an integrated 3DOF tracker. It was verified during testing that this HMD can be operated on any standard VGA card that supports field- or line sequential stereo mode at a resolution of 800x600 pixels at 60 Hz. Proper operation of the tracker software and support for the required screen modes was also verified under Windows 2000 and Linux .

4.2.4 Workpackage 5

4.2.4.1 CFD Coupling of 3D and 1 D case

The available computational resources are not sufficient for computing the flow in a tunnel which is several kilometers long, with the high resolution required to caputure the flow near the fire. We will therefore replace the full three-dimensional computation by a less expensive one-dimensional model wherever possible. Possible one-dimensional models, and techniques how to treat the interface between the 3D and 1D models are currently under investigation at KTH.

4.2.4.2 Task 5.1

A complete description of the work done within the reporting period is contained in Deliverable 5.1 "CFD Simulations of Fire Hazards in the Mont Blanc and Gleinalm Tunnel", therefore only a short summary is given here.

As part of Workpackage 5 of Virtualfires a priori computations of fire hazards in two alpine tunnels have been performed. Various anticipated heat loads ranging from a single passenger car fire up to a tanker disaster have been investigated for characteristic sections of the Mont Blanc tunnel (France) and the Gleinalm tunnel (Austria) geometries. The objective was to illustrate the influence of different ventilation system operating conditions on flame and smoke propagation behaviour.

A database containing the results of all computations is now available to the project partners responsible for the visualisation part of Virtualfires. All results have been obtained using the commercial flow solver FLUENT [1].

First the Mont Blanc tunnel was considered. The old ventilation system as it was before the fire disaster in 1999 was considered as well as the new ventilation system now in operation since the tunnel has been reopened. The effect of different hazard scenarios and hence heat loads on the efficiency of the extraction system configurations has been computed.

It was found that both, the old and the new ventilation system, work well for passenger car fires. The new system is also able to keep the tunnel partly free of smoke for a HGV hazard. Nevertheless computations of a fuel tanker disaster showed, that the ventilation system still has little impact on the propagation of combustion gases and smoke in this case .

Considering the Gleinalm tunnel as a second case, in total three different scenarios have been investigated. All scenarios assumed a HGV burning inside a tunnel section.

In the first scenario the ventilation system as it was before 2002 and its effect on smoke propagation was considered. The second scenario comprised of the new ventilation system with working fresh air supply, whereas in the third case the fresh air supply was turned off. From this it can be concluded, that the new ventilation system is superior to the old one with respect to hot exhaust gas removal. Furthermore it was shown that deactivation of the fresh air supply during a hazard pronounces stratification of hot gases to exist for a longer time. A region of favourable low temperatures can be observed in this case close to the hazard origin.

As such the project phase concerned with the a-priori computations of tunnel fire hazards and the generation of CFD data (Workpackage 5.1) using the commercial flow solver FLUENT is now finished. The next project phase, which for the first time also will involve real time CFD simulations of tunnel fire hazards (WP 5.2) will rely on the ICE flow and combustion solver, where the development work on software version 1.0 at the Christian-Doppler-Laboratory for Applied Computational Thermofluiddynamics currently is in its final stages. The release of this version according to the workplan is due by project month 14.

4.2.4.3 Task 5.2

Development status of the flow and combustion model

The development of the Lattice-Boltzmann based flow and combustion simulation code ICE is proceeding as scheduled.

A three dimensional version of the programme has been implemented. The combustion process can either be simulated as a source of energy placed within the tunnel or by defining a fuel source which is ignited at the beginning of the simulation. An arbitrary number of static objects can be placed within the computational domain as long as they can be represented by cubic elements.

Various types of flow boundary conditions can be set to model the ventilation system. Usually the mass flow is specified at the inlet openings and the pressure is set at the ventilation outlets and the tunnel portals.

Concerning the energy equation constant wall temperature boundary conditions are applied. Furthermore buoyancy effects due to the combustion process are taken into account by the flow solver. Turbulence effects are modelled using a Smagorinsky type sub grid scale turbulence model with constant cut off filter [2].

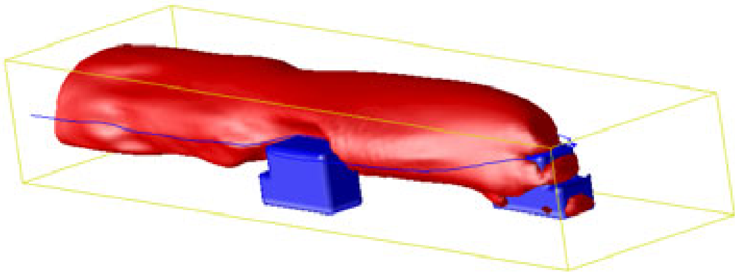


Fig. 1: Burning truck/isosurface 350 K

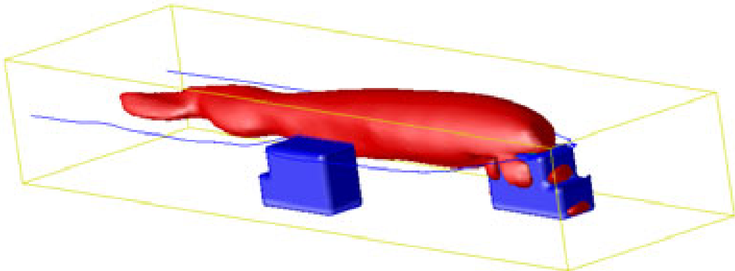


Fig. 1: Burning truck/isosurface 370 K

Parallelisation issues

Introduction

For the solver parallelisation a multiple program multiple data (MPMD) programming model has been selected. It is the model of choice for distributed memory systems like the IBM SP at KTH.

Distributed memory systems are characterised by a high scalability and the large physical memory available normally. The performance is influenced by the balance between CPU speed and network speed and depends heavily on the programmer.

In the MPMD programming model each processor executes its own program [3]. The communication between the processors is performed by sending and receiving messages. A subroutine library which contains functions for sending and receiving messages is provided to the software developer. The data distribution and communication must be explicitly defined by the programmer.

Although it is probably the most difficult approach to parallel programming, it is selected due to the following reasons :

It promises the highest performance on distributed memory systems with a large number of processors.

It is the most portable approach.

The programmer has all freedom to optimise communication.

There are a few message passing libraries available, but for VirtualFires the Message Passing Interface (MPI), the de facto standard, is used for portability.

Although MPI consists of a library of more than 120 functions, only a small subset is used for the current project. The more exotic MPI functions often do not have the same degree of optimisation than the basic ones.

Domain decomposition methods

There exist a number of possibilities for decomposing a computational domain. The most popular are geometry based methods (e.g. cartesian coordinate bisection, coordinate bisection, recursive coordinate bisection) and graph based methods (e. g. recursive graph bisection, Greedy algorithm, recursive spectral bisection, Kernighan-Lin method).

For the strictly regular computational meshes used within the Virtual Fires project two simple domain decomposition methods promise the best performance due to a minimum of communication between the processors.

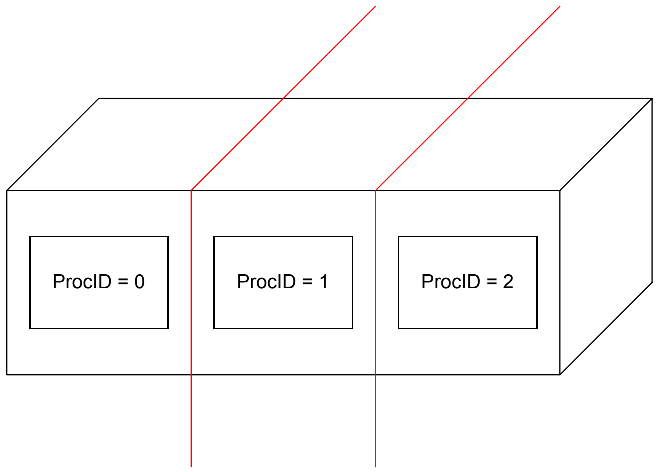


Fig 3: One-dimensional coordinate decomposition

The most simple one is a one-dimensional decomposition, which works along the direction of longest extend of the computational domain. This method works for any number of processors, but will lead to bad surface/volume ratios for a higher number of processors as can be inferred from Fig **3**. The term surface/volume ratio characterises the number of computational mesh cells located on an inter processor communication boundary to the number of computational mesh cells allocated to an individual processor.

Alternatively for the recursive coordinate bisection method the number of sub domains must be a power of 2, but in most cases it delivers better topologies of the sub domains (Fig. 4).

Both decomposition methods are currently being implemented. The preferred method will be found by performance tests after the flow solver parallelisation has been finished. The finally chosen method will be an integral part of the Virtual Fires Simulator. It leaves to say that the program is designed in a way that also more elaborated domain decomposition methods can be used without much effort.

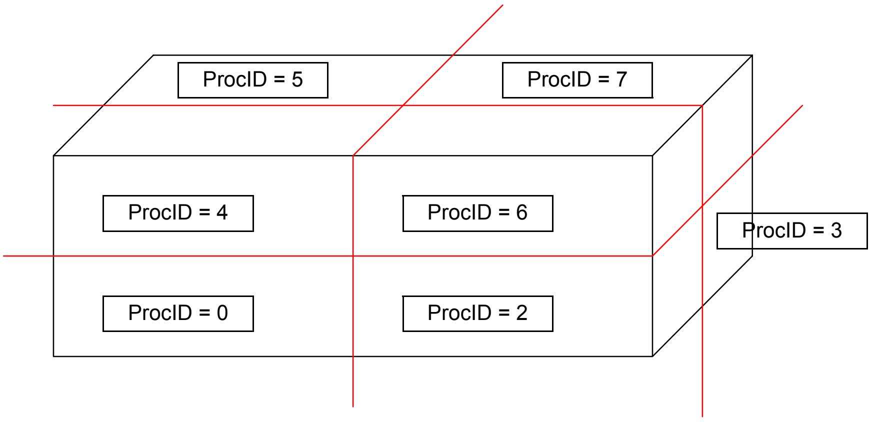


Fig. 4: Recursive coordinate bisection

4.3 Comparison planned activities and actual work

4.3.1 Reports

A number of deliverable reports were produced, which are listed in Table 2. In general all the planned activities were carried out successfully. The completion of some reports was delayed for a short time because information was not available in time.

Deliverable	Title	Planned Closing date	Achieved closing date	Reason for delay
D2	Dissemination and use plan	30.04.2002	30.11.2002	
D2.4a	Report of selected developer tools D 2.4 update according reviewer comments	not planned from the beginning	14.08.2002	D2.4a was not planned from the begin of the project
D3.1	Specification of geometrical database	30.03.2002	20.09.2002	D2.4a finished in August
D3.2	Specification of CDF database	30.03.2002	20.09.2002	D2.4a finished in August
D3.3	Report on available compression/ optimisation techniques	30.04.2002	31.10.2002	D2.4a finished in August
D4.1	Specification on methods of displaying CFD-data	31.10.2002	13.12.2002	D2.4 was not completed in time
D4.2	Specification of user interface in VR-environment	31.10.2002	13.12.2002	D2.4 was not completed in time
D4.3	Specification of hardware requirements for HMD system	30.11.2002	31.10.2002	
D5.1	CFD Simulations of Fire Hazards in the Mont Blanc and Gleinalm Tunnel	30.09.2002	30.09.2002	
D5.2	Interactive Field Simulation Techniques; Solver and Data Flow Parallelization	30.09.2002	31.10.2002	
D7.1	Accurate definition of cases	30.06.2002	15.12.2002	

Table 2: Planned activities and actual work done

4.4 *State of the art review*

4.4.1 CGNS data file compression

There is currently no tool available to compress CGNS files except the standard generic ones like zip or rar, which were not designed to take advantage of the special layout of the data. SiTu is trying to implement a compression scheme for CGNS files that will support resampling to regular grids and support multiresolution compression based on wavelets.

4.4.2 HMD + Tracker

At the time of selection several vendors had HMDs with like specifications to the selected Cybermind HiRes900, but no one of them was able to deliver a model - especially for testing. On the other hand there are far more powerful HMDs available. These support higher resolutions and, more important, a greater field of view, which results in a much better immersion due to the elimination of the the "tunnel-vision"-effect. Unfortunately these HMDs are far off the budget, like KEOs SimEye XL 100A for about $87500 USD.

4.4.3 CFD Display methods

There are many tools on the market for displaying CFD datasets. Most of them operate sequentially and/or are limited to certain data input formats. Dealing with large datasets, as they are the contents of the VIRTUALFIRES project, these already available tools run into non negligible performance problems. They cannot handle these arising amounts of simulation data in real time or interactively. For that reason a development of massive parallel visualization methods was initiated. These methods, which utilize partly sophisticated hardware capabilities of new graphic cards available on the market, are integrated in a state of the art visualization system (Visicade / OpenSG).

4.5 *Planned activities for the next period*

4.5.1 Proposed changes in project plan

The project plan has been updated and is attached to this report. The main changes are:

- A loop has been included to revise the system specifications
- Some work in WP 3 has been changed

The changes in WP 3 are:

- The <u>geometrical data generation</u> is no longer needed because the model for the tunnel is created by different commercial software packages and will be converted in a OBJ-File format.
- A separate <u>CFD input data generator</u> in no longer needed because the generation of input data is now handled by the CFD software. Some conversion modules must be developed after testing the first prototype
- <u>Data management</u> was left out in the initial work plan but turned out to be an important issue. Therefore this has been added and now replaces the above mentioned items.

As a consequence Deliverables 3.4 , 3.5 and 3.6 were changed in name and content. We ask for approval of this change. A revised copy of the WP3 description and of the table of deliverables is attached to this report. This table has also been updated to remove inconsistencies with the WP descriptions which was pointed out by the reviewers at the last meeting.

4.5.2 Workpackage 2

Review system specifications and change as required.

4.5.3 Workpackage 3

The following activities are planned for the next period at SiTu:

- Finish the implementation of the database management
- Building a client to set up a tunnel configuration for the simulator
- Building a client for the import of externally calculated mission data
- Connecting KTHs/FIGDs VR part and CDs CFD part together with the data management
- Getting a first prototype to run on the HMD version of the system
- Investigate multi-resolution compression schemes for reduction of CFD data
- Generate visualisation models for the VR system at different states of degradation due to temperature exposure

4.5.4 Workpackage 4

There are several activities planned for the next period (reps. the 2nd half year) at FIGD. At the moment FIGD is working on

- Progressive grids for faster visualization
- Complete the interfaces between visualization and data management (CORBA Definitions)
- Wavelet compressed grids
- Complete / improve central parallelized kernel for visualization calculations
- Integrate further visualization methods
- Parallelize visualization methods
- Realize a converter from the interface data to the format processed in the visualization methods
- Bring this converter together with the CORBA interfaces
- Investigate COVISE and realize prototypes with it
- Integrate OpenSG if possible
- Investigate the expansion of the system to a cluster

- Realize a space mouse bases user interface
- Realize a management for time varying data on the visualization side
- Integrate intelligent buffering
- Realize a kind of automated system check which is able to adapt and scale the system capabilities to the found hardware resources
- Adapt the parallelized processing unit to the new grid types (progressive & wavelet)

At the moment it is not quite clear which of these task will be already finished till the end of the next period.

4.5.4.1 User interface

We will implement a full prototype (as far as the functionality of the rest of the system allows) and start running test scenarios to determine that we have properly captured the necessary functionality. In all probability this will uncover the need for functions that have not been specified yet in the rest of the system. In parallel with the desktop development work we will develop the connection to the PDA and test that the performance is sufficient for our needs. We expect that some re-implementation will be needed as so far undiscovered problems and limitations present themselves in the future.

4.5.5 Workpackage 5

For the coupling of 3D and 1D CFD models, described in 4.2.5, we will develop a method for switching adaptively between the 3D and 1D models. In previous work in this area, the location of the 3D/1D boundary is known and fixed. For a developing fire, it can not be known beforehand at which parts of the tunnel the flow will behave approximately one dimensionally. We will also study zonal models, and extend the 1D model to a model with two 1D flow fields, one hot 1D flow near the ceiling of the tunnel, and one cold 1D flow near the floor of the tunnel.

4.5.5.1 Parallelisation

As mentioned before the main task within the next period is to finish the parallelisation of the fluid flow solver.

The work on the first prototype of the VirtualFires CAVE version, i.e. the coupling of the ICE flow and combustion simulator and the CAVE, is scheduled to start in November 2002. For this purpose a visit of one researcher of CD at KTH is planned. It is to be expected that basic functionalities can be implemented within two weeks by joint effort of CD and KTH personnel. It has to be mentioned that this coupling in this early stage of development will only include the serial version of the flow and combustion simulator.

Parallel to the code development several test cases will be simulated for software validation in order to assure the correctness of the results. Furthermore it is planned to test a recently published generalised BGK model based on individual relaxation of the kinetic modes [4]. This model seems to be very promising for improving code stability.

5 List of deliverables (Month 7 – 12)

No.	Deliverable (D) or Milestone (M) name	WP no.	Lead Particip ant	Estimated person-months	Del. type*	Delivery (proj. month)	Delivered (proj. month)
D2	Dissemination and use plan	7	METL		Report	6	13
D3.1	Specification of geometrical database	3	SITU	3	Report	5	11
D3.2	Specification of CDF database	3	SITU	2,5	Report	5	11
D3.3	Report on available compression/ optimisation techniques	3	SITU	3,5	Report	6	12
D3.4	Beta version of data management for first prototype	3	SITU	6	Prototype	12	16
D4.1	Specification on methods of displaying CFD data	4	KTH	4	Report	12	14
D4.2	Specification of user interface in VR-environment	4	KTH	4	Report	12	14
D4.3	Report on hardware HMD specification	4	KTH	2	Report	13	12
D5.1	CFD Simulations of Fire Hazards in the Mont Blanc and Gleinalm Tunnel	5	CD	30	Report	11	11
D5.2	Interactive Field Simulation Techniques; Solver and Data Flow Parallelization	5	CD	37	Report	11	11
D7.1	Definition of cases	7	METL	2	Report	8	14
D7.4	Web page	7	METL		Website	6	6
M1	CFD computation of fire reference simulations completed	1-5	CD		Demonstration	6	6
M5.1	Release of VIRTUALFIRES a-priori results database	5	CD		Demonstration	11	11
M3.1	Beta testing of software completed successfully	3	SITU		Demonstration	12	16

* A short, self-evident description e.g. report, demonstration, conference, specification.

** Int. Internal circulation within project (and Commission Project Officer if requested)

Rest. Restricted circulation list (specify in footnote) and Commission PO only

IST Circulation within IST Program participants

\+ Publicity means actions to promote the existence of the project and its aims by press conferences/releases, TV appearances etc.

6 Exploitation and dissemination of results

6.1 Exploitation

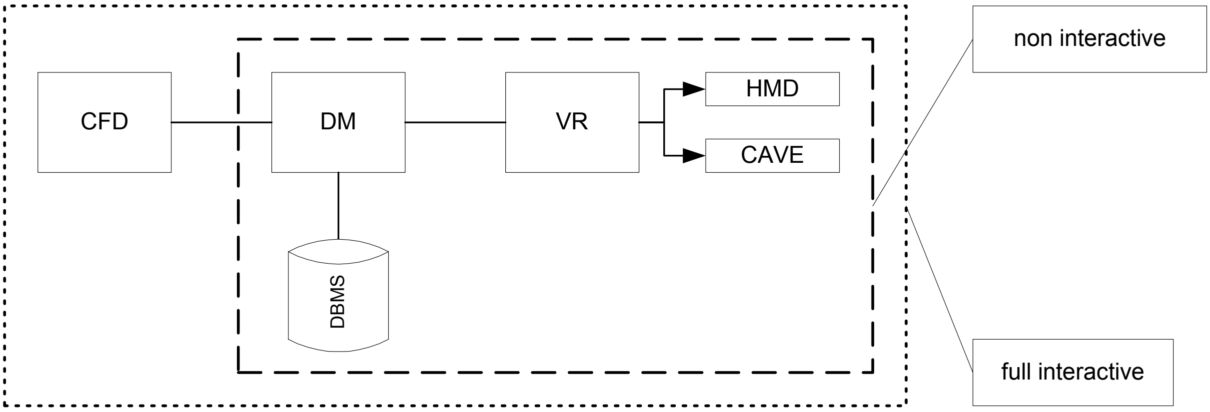
At the last consortium meeting a draft of a plan for exploitation was discussed.

It was decided to focus the development on two main user groups: firemen and tunnel operators.

There are basically two versions of the system possible:

- a non-interactive version excluding the steerable CFD calculation and
- an interactive version (see following sketch).

Based on the used computing platform the interactive version can be split up into two different versions: the smaller HMD PC based portable system, which will allow only for non-real time interaction and the CAVE environment system which will allow for interaction in real time.



3 Systems:

1) simple playback, no CFD
2) interactive with ICE
3) concurrent

Estimates of price for complete system (only very preliminary)

VIRTUALFIRES System 1 (VF1)

Hardware:	Laptop (top of the range)	
	HMD or Projector (Screens)	
	Space Mouse	~10.000,00 €
Software:	COVISE License (5.000,00 €) **???**	
	"VIRTUALFIRES Software" (10.000,00 €)	
	Data Base Software (500,00 €)	~15.500,00 €
		~25.500,00 €

VIRTUALFIRES System 2 (VF2)

Hardware:	Laptop (top of the range) + PC Cluster	
	HMD or Projector (Screens)	
	Space Mouse	10.000,00 € - 100.000,00 €
Software:	COVISE License (5.000,00 €) **???**	
	"VIRTUALFIRES Software" (10.000,00 €)	
	Data Base Software (500,00 €)	
	ICE (3.000,00 – 5.000,00 €)	30.500,00 €
		40.500,00 € - 140.500,00 €

<u>VIRTUALFIRES System 3</u> (VF3)

<u>Hardware:</u> Supercomputer
Cave

<u>Software:</u> COVISE License (?)
"VIRTUALFIRES Software" (10.000,00 €)
Data Base Software (500,00 €)
ICE (3.000,00 – 5.000,00 €)

(Charge for Usage of CAVE System will be on an hourly basis).

<u>Potential Markets (in Europe) for sale of portable systems VF1 and VF2 (estimated):</u>

Fire Brigades (Schools, Academies): 500
Tunnel Operators: 100
Train/Truck Companies: 20
Authorities: 14
Tunnel Designers: 50
Selling Software to Caves (Pay per use): 10

It was decided to approach VIRCINITY (the company who markets COVISE) to ask them if they would be interested in marketing VIRTUALFIRES. The issue of COVISE license fees still has to be resolved. It is planned to distribute the royalties for the VIRTAULFIRES software (i.e. the software developed within the project) to each partner according to their contribution.

6.2 Dissemination

The coordinator participated in the VR world congress which was held in Paris on September 9 and 10, 2002 and presented a lecture on the project VIRTUALFIRES for about 20'. A poster prepared by METL was displayed in the foyer of the conference venue. Information material was distributed.

The coordinator also participated in a concertation meeting in Brussels on November 13, 2002 and presented the VIRTUALFIRES project there.

FIGD published a report regarding the VIRTUALFIRES project in the Computer Graphics Topics magazine 6/2002 (http://www.inigraphics.net/press/index.html)

7 Management and coordination aspects

No mayor problems were experienced with the management of the project and it is running according to plan.

A combined PCC/TCC/WP meeting was held in Darmstadt on November 4 and 5, 2002. Among the items discussed were:

- The importance of calculating and displaying smoke was pointed out by the partners representing the end users. All the results for the test cases calculated by the partner CD so far concentrated on temperature distribution. It was resolved that the generation and spread of smoke will be the focus of further developments.

- The importance of being able to simulate fire fighting measures such as fire extinguishers was also pointed out. This is sought to be feasible. However, moving a vehicle (such as a fire truck) during the simulation was thought to be beyond the current scope of the project.

- Some changes in the Workplan is required because of new developments. This is detailed under section 4.5.1.

- More man months than planned were spent in WP2 by SiTu and FIGD. The reason for this in the case of SiTu was that the specification of the data base originally planned for WP 3 was shifted to WP 2 and included in the deliverable 2.4. Therefore the man months are simply shifted from WP 3 to WP 2. FIGD gave the reason for overspending that the consortium was slow to supply the required input for deliverable 2.4 which was subsequently rejected. It was resolved that the responsible WP leaders should convene a WP meeting as soon as they experience such problems. In case this is not successful a PCC/TCC meeting should be called. This has now been clearly spelt out in the project handbook so that any such problems will be avoided in the future.

8 Glossary

SiTu	Institute for structural analysis, Graz University of Technology, Austria
CD	Christian-Doppler-Laboratory for Applied Computational Thermofluiddynamics, Austria
FIGD	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, Germany
KTH	Kungl. Tekniska Högskolan, Sweden
METL	Ministere del'Equipment des Transport et du Logement, Centre d'Etudes de Tunnel, France
FDDO	Stadt Dortmund, Feuerwehr (fire brigade), Germany
EUVE	European virtual engineering, Spain

9 Annexes

9.1 Revised WP 3 description

WORKPACKAGE DESCRIPTION		
Workpackage Title: **Data processing / Compression**		WP no. **3**
Starting date: month no. **4** Duration: **11** months		Total Effort in Man-months: **24**
Member involved	Task description / Contribution of Member	Effort man-months
SITU	**WP Leader,** Implementation of software, data compression techniques	**16**
CD	Participant	**1.5**
KTH	Participant	**1.5**
FIGD	Participant	**1.5**
Alpe/LTF	Participant	**1.5**
METL	Participant	**0.5**
FD DO	Participant, Testing	**0.5**
EUVE	Participant, Testing	**1.0**

Objectives

The objective is to specify the database for the geometrical input data for the VIRTUALFIRES and the CFD program and the data base containing the CFD data to be displayed. Userfriendly software for the input of data will be developed by adapting existing programs. WP 3 is also concerned with the selection and development of efficient data compression methods for a large amount of CFD data.

Description of work / tasks

The work will comprise the following tasks:

WP 3.1. Specification of geometrical database

The geometrical database contains information about the tunnel shape, the safety equipment, position of ventilation outlets etc. One of the objectives is to specify the geometrical data base in such way that real time navigation and collision detection can be easily implemented. All participants of the project will be involved by the verification of the draft. The specific tasks are:

- Write draft specification
- Verification of the draft (Agreement with end users on geometrical data base)
- 1 Meeting
- Report on geometrical data base

WP 3.2. Specification of CFD database

The objective of this task is to specify the format of the data which are necessary for visualisation of smoke and fire development in VIRTUALFIRES. This data format should enable data compression/optimisation techniques to be implemented efficiently. The specific tasks are:

- Write draft specification
- Verification of the draft (Agreement with end users on CFD data base)
- 1 Meeting
- Report on CFD data base

WP 3.3. Data compression / optimisation techniques

In this task existing data compression and optimisation techniques are evaluated. The data compression should permit the real time visualisation with a given I/O rate. The criterion for the quality of the compression/optimisation technique is that a maximum of compression is achieved without significant loss of information. In this task there will be a close cooperation with the CFD simulation participants and the visualisation participants. The specific tasks are:

- Evaluation of existing data compression / optimisation techniques
- 1 Meeting
- Report on compression/ optimisation techniques

WP 3.4. Implementation of data management for first prototype

This task is concerned with the implementation of the data management, using the first calculated data from the CFD calculation and geometry data for testing the VR-system. The specific tasks are:

- Design and setup database.
- Design and implement interfaces.
- Generate content with geometry and CFD data.

WP 3.5. Update of data management for second prototype

After verification of first prototype the data management must be adapted and new features will be implemented. The new version of data management will be verified.

- Implementation of all features as timelines, scenarios, …
- Evaluation of techniques for selective transmission of CFD data
- Filling database with new tunnel configurations

WP 3.6. Release version and documentation of data management

This task is concerned with preparing release version of data management and writing documentation for end users.

Deliverables

The deliverables of WP 3 are :

D 3.1. Specification of geometrical data base (month 5)
D 3.2. Specification of CFD data base (month 5)
D 3.3. Report on available compression / optimisation techniques (month 6)
D 3.4. Beta version of data management for first prototype (month 15)
D 3.5. Beta version of data management for second prototype (month 20)
D 3.6. Release version of data management (month 26)

Milestones and criteria

M 3.1. Beta testing of first prototype completed successfully (month 16)

Interrelation with other workpackages

Relies on input from WP 2 (System specification) Provides necessary information for WP 4 (HMD and CAVE implementation of VIRTUALFIRES).

9.2 *Deliverable and major milestone list*

No.	Deliverable (D) or Milestone (M) name	WP no.	Lead Participant	Estimated person-months	Del. type*	Security**	Delivery (proj. month)
D2.1	Report on available developer tools	2	FIGD	1,5	Report	Int.	2
D2.2	Selection of developer tools	2	FIGD	1,4	Spec.	Int.	2,5
D2.3	Report on available system capabilities (hardware)	2	FIGD	1,8	Report	Int.	2
D2.4	Specification of planed system capabilities (software)	2	FIGD	7,5	Spec.	Int.	2,5
D2.5	Report on existing VR-systems, Adaptability to VIRTUALFIRES	2	FIGD	1,1	Report	Int.	3,5
D2.6	Specification of selected VR System & required extensions	2	FIGD	2,2	Spec.	Int.	4
D1	Project presentation	1	SITU		Publicity	Ext.	3
D2	Dissemination and use plan	7	METL		Report	IST	6
Total		**WP2**		**15,5**			
D3.1	Report on geometrical data base	3	SITU	3	Report	Rest.	5
D3.2	Report on CFD data base	3	SITU	2,5	Report	Rest.	5
M1	CFD computation of fire reference simulations completed	1-5	CD		Demonstration	IST	6
D3.3	Report on compression/ optimisation	3	SITU	3,5	Report	Rest.	6
M5.1	Release of VIRTUALFIRES a-priori results database	5	CD		Dem.	IST	11
D3.4	Beta version of data management for first prototype	3	SITU	6	Prototype	Rest.	15
D3.5	Beta version of data management for second prototype	3	SITU	5	Prototype	Rest.	20
M3.1	Beta testing of software completed successfully	3	SITU		Demonstration	Rest.	16
D3.6	Release version of data management	3	SITU	4	Serial	Rest.	26
Total		**WP3**		**24**			
D4.1	Specification on methods of displaying CFD data	4	KTH	4	Report	Rest.	12
D4.2	Specification of user interface in VR-environment	4	KTH	4	Report	Rest.	12
D4.3	Report on hardware HMD specification	4	KTH	2	Report	Rest.	13
D4.4.	Integration of HMD system completed	4	KTH	6	Prototype	Rest.	16
M5.2	Software release V1.0	5	CD		Dem.	IST	17
D4.5.	VR implementation with limited functionality and speed	4	KTH	13	Prototype	Int.	18
D4.6.	VR implementation with full functionality optimised for speed	4	KTH	8	Prototype	Int	25
D4.7.	VR integration with real-time CFD data generation	4	KTH	8	Prototype	Int	25

No.	Deliverable (D) or Milestone (M) name	WP no.	Lead Participant	Estimated person-months	Del. type*	Security**	Delivery (proj. month)
D4.8	VIRTUALFIRES users manual	4	KTH	4	Report	Int.	26
Total		**WP4**		**49**			
D5.1	CFD database containing results of 6 computational studies	5	CD	30	Database	Int.	11
D5.2	Report: Interactive Field Simulation Techniques; Solver and Data Flow Parallelization	5	CD	37	Report	Int.	11
D5.3	Parallelisation efficiency report	5	CD	1,5	Report	Int.	24
D5.4	Software User Guide V1.0	5	CD	5,5	User guide	Int.	14
M5.3	Software release V2.0	5	CD		Demonstration	IST	26
D5.5	Software User Guide V2.0	5	CD	5,5	User guide	Int.	26
Total		**WP5**		**79,5**			
D6.1	Report on CAVE/ HMD installation	6	EUVE	12	Report	Int.	26
M4.1	Beta testing of software completing successfully	4	KTH		Demonstration	Rest.	27
M6.1	Requirements accomplishment	6	EUVE		Demonstration	IST	27
D6.2	VIRTUALFIRES results report	6	EUVE	6,5	Report	Int.	28
Total		**WP6**		**18,5**			
D7.1	Definition of cases	7	METL	2	Report	Int.	8
D7.2	Journal articles	7	METL	2	Report	Ext.	28
D7.3	Conference papers and exhibition at conferences	7	METL	2	Report	Ext.	28
D7.4	Webpage	7	METL	3	Website	Ext.	6
Total		**WP7**		**9**			

* *A short, self-evident description e.g. report, demonstration, conference, specification.*

** *Int.* *Internal circulation within project (and Commission Project Officer if requested)*

Rest. *Restricted circulation list (specify in footnote) and Commission PO only*

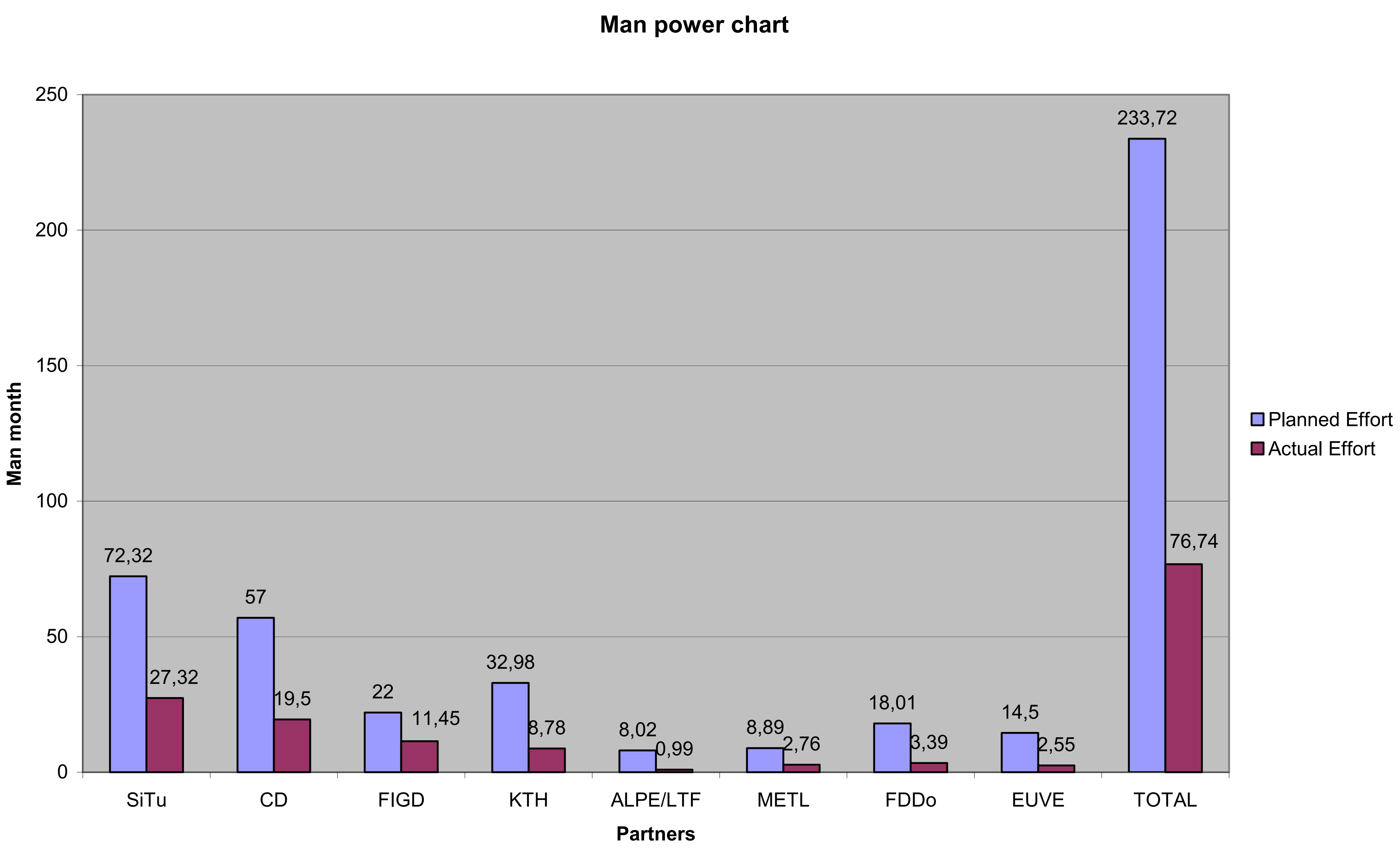
IST *Circulation within IST Programme participants*

FP5 *Circulation within Framework Programme participants*

Table 1 Man power use plan

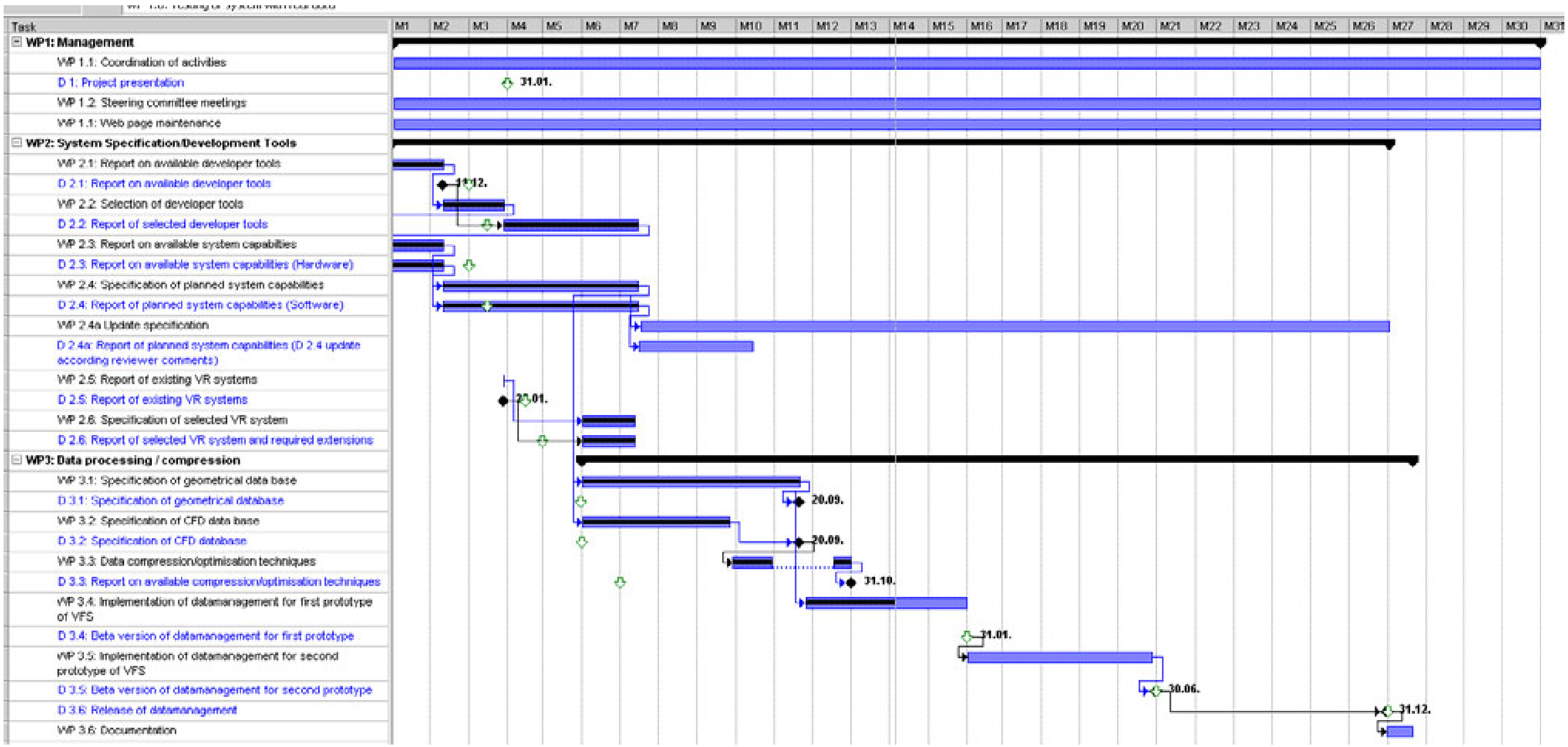
		- - - - - - - - - Man-Month - - - - - - - - - - -									- - - - - - - Technical Progress % -- - - - -		
Task/Subtask (N°/title)	Partner (Name/ abbrev.)	Planned efforts - at start of period (MM)				Actual effort (MM)	Forecast effort (MM)			*Devia-tion (MM)*	Planned (%)	Assessed (%)	*Devia-Tion (%)*
		Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Total	*Totals*	Year 1	Year 1	*Year (now)*
		a	b	c	d	a1	b1	c1	d1	d1-d			
1. Management	SiTu	9	7	4	**20**	9,41	7	4	**20,4**	***0,41***	45%	46%	*1%*
	CD			1	**1**			1	**1**				
	FIGD	0,34	0,33	0,33	**1**	0,34	0,33	0,33	**1**			34%	*34%*
	KTH	0,4	0,4	0,2	**1**	0,44	0,4	0,2	**1,04**	***0,04***		42%	*42%*
	ALPE/LTF	0,4	0,4	0,2	**1**	0,37	0,4	0,2	**0,97**	***-0,03***		38%	*38%*
	METL	0,5	0,3	0,2	**1**	0,53	0,3	0,2	**1,03**	***0,03***		51%	*51%*
	FDDo	0,1	0,2	0,2	**0,5**	0,28	0,2	0,2	**0,68**	***0,18***	20%	41%	*21%*
	EUVE	0,4	0,4	0,2	**1**	0,4	0,4	0,2	**1**				
	Total	**11,1**	**9,03**	**6,33**	**26,5**	**11,8**	**9,03**	**6,33**	**27,1**	***0,63***	**42%**	**44%**	***2%***
2. System Specification	SiTu	3			**3**	5,23			**5,23**	***2,23***	100%	100%	
	CD	1,5			**1,5**	1,5			**1,5**		100%	100%	
	FIGD	3			**3**	6			**6**	***3***	100%	100%	
	KTH	2,5			**2,5**	2,36			**2,36**	***-0,14***	100%	100%	
	ALPE/LTF	1,5			**1,5**	0,17			**0,17**	***-1,33***	100%	100%	
	METL	1			**1**	0,48			**0,48**	***-0,52***	100%	100%	
	FDDo	3,5			**3,5**	2,93	0,4		**3,33**	***-0,17***	100%	88%	*-12%*
	EUVE	1,5			**1,5**	0,75			**0,75**	***-0,75***	100%	100%	
	Total	**17,5**			**17,5**	**19,4**	**0,4**		**19,8**	***2,32***	**100%**	**111%**	***11%***
3. Data Processing	SiTu	11	5		**16**	11,07	5		**16,1**	***0,07***	69%	69%	*0%*
	CD	1,5			**1,5**	1,5			**1,5**		100%	100%	
	FIGD		1,5		**1,5**		1,5		**1,5**				
	KTH	0,3	1	0,2	**1,5**	0,08	1	0,2	**1,28**	***-0,22***	20%	6%	*-14%*
	ALPE/LTF	0,2	0,8	0,5	**1,5**	0,17	0,8	0,5	**1,47**	***-0,03***	13%	12%	*-2%*
	METL	0,25	0,25		**0,5**	0,25	0,25		**0,5**		50%	50%	
	FDDo	0,5	4		**4,5**	0,13	4,37		**4,5**		11%	3%	*-8%*
	EUVE	0,8	0,2		**1**	0,7	0,3		**1**				
	Total	**14,6**	**12,8**	**0,7**	**28**	**13,9**	**13,2**	**0,7**	**27,8**	***-0,18***	**52%**	**50%**	***-2%***
4. VR Implementation	SiTu	1	15	4	**20**	0,95	15	4	**20**	***-0,05***	5%	5%	*0%*
	CD	1	1		**2**	1	1		**2**		50%	50%	
	FIGD	3	7,5	1	**11,5**	5	6,5		**11,5**		26%	43%	*17%*
	KTH	4	5	2,5	**11,5**	4,89	5	2,5	**12,4**	***0,89***	35%	39%	*5%*
	ALPE/LTF		0,8	0,7	**1,5**		0,8	0,7	**1,5**				
	METL		0,8	0,2	**1**	0,02	0,78	0,2	**1**			2%	*2%*
	FDDo	1	2		**3**		3		**3**		33%		*-33%*
	EUVE	0,5	1,3	0,2	**2**	0,5	1,3	0,2	**2**				
	Total	**10,5**	**33,4**	**8,6**	**52,5**	**12,4**	**33,4**	**7,6**	**53,3**	***0,84***	**20%**	**24%**	***4%***
5. CFD Data Generation	SiTu		10	2	**12**		8	2	**10**	***-2***			
	CD	12,5	18	18	**48,5**	15,5	18	15	**48,5**		26%	32%	*6%*
	FIGD												
	KTH	3	7	4	**14**	0,86	9	4	**13,9**	***-0,14***	21%	6%	*-15%*
	ALPE/LTF	0,2	0,4	0,4	**1**	0,11	0,4	0,4	**0,91**	***-0,09***	20%	12%	*-8%*
	METL	0,2	0,8	0,5	**1,5**	0,11	0,8	0,5	**1,41**	***-0,09***	13%	8%	*-6%*
	FDDo		0,5	0,5	**1**		0,5	0,5	**1**				
	EUVE		1,5	0,5	**2**		1,5	0,5	**2**				
	Total	**15,9**	**38,2**	**25,9**	**80**	**16,6**	**38,2**	**22,9**	**77,7**	***-2,32***	**20%**	**21%**	***1%***
6. Evaluation/Validation	SiTu			3	**3**			3	**3**				
	CD			2	**2**			2	**2**				
	FIGD			1,5	**1,5**			1,5	**1,5**				
	KTH			1,5	**1,5**			1,5	**1,5**				
	ALPE/LTF			2	**2**			2	**2**				
	METL			1,5	**1,5**			1,5	**1,5**				
	FDDo			3,5	**3,5**			3,5	**3,5**				
	EUVE			5	**5**		0,75	5	**5,75**				
	Total			**20**	**20**		**0,75**	**20**	**20,8**	***0,75***			
7. Dissemination	SiTu	0,5			**0,5**	0,66			**0,66**	***0,16***	100%	100%	
	CD			0,5	**0,5**			0,5	**0,5**				
	FIGD			0,5	**0,5**	0,11		0,39	**0,5**			22%	*22%*
	KTH	0,1	0,1	0,3	**0,5**	0,15	0,1	0,3	**0,55**	***0,05***	20%	27%	*7%*
	ALPE/LTF	0,2	0,4	0,4	**1**	0,17	0,43	0,4	**1**		20%	17%	*-3%*
	METL	1,5	0,9	0,6	**3**	1,37	1	0,6	**2,97**	***-0,03***	50%	46%	*-4%*
	FDDo		1	1	**2**	0,05	1	0,95	**2**			3%	*3%*
	EUVE	0,7	0,9	0,4	**2**	0,2	0,9	0,9	**2**		35%	10%	*-25%*
	Total	**3**	**3,3**	**3,7**	**10**	**2,71**	**3,43**	**4,04**	**10,2**	***0,18***	**30%**	**27%**	***-3%***
TOTALS	SiTu	24,5	37	13	**74,5**	27,32	35	13	**75,3**	***0,82***	33%	37%	*1%*
	CD	16,5	19	21,5	**57**	19,5	19	18,5	**57**		29%	34%	*6%*
	FIGD	6,34	9,33	3,33	**19**	11,45	8,33	2,22	**22**	***3***	33%	60%	*73%*
	KTH	10,3	13,5	8,7	**32,5**	8,78	15,5	8,7	**33**	***0,48***	32%	27%	*25%*
	ALPE/LTF	2,5	2,8	4,2	**9,5**	0,99	2,83	4,2	**8,02**	***-1,48***	26%	10%	*25%*
	METL	3,45	3,05	3	**9,5**	2,76	3,13	3	**8,89**	***-0,61***	36%	29%	*44%*
	FDDo	5,1	7,7	5,2	**18**	3,39	9,47	5,15	**18**	***0,01***	28%	19%	*-30%*
	EUVE	3,9	4,3	6,3	**14,5**	2,55	5,15	6,8	**14,5**	***-0,75***	27%	18%	*-25%*
	TOTAL	**72,6**	**96,7**	**65,2**	**235**	**76,7**	**98,4**	**61,6**	**237**	***2,22***	**31%**	**33%**	

**) Please note that the actual technical progress percentage and the updated remaining efforts must reflect the physically assessed status of the work.*



Man power chart
Man month
250
200
150
100
50
0
72,32
27,32
57
19,5
22
11,45
32,98
8,78
8,02
0,99
8,89
2,76
18,01
3,39
14,5
2,55
233,72
76,74
SiTu
CD
FIGD
KTH
ALPE/LTF
METL
FDDo
EUVE
TOTAL
Partners
Planned Effort
Actual Effort

Table 2: Project plan



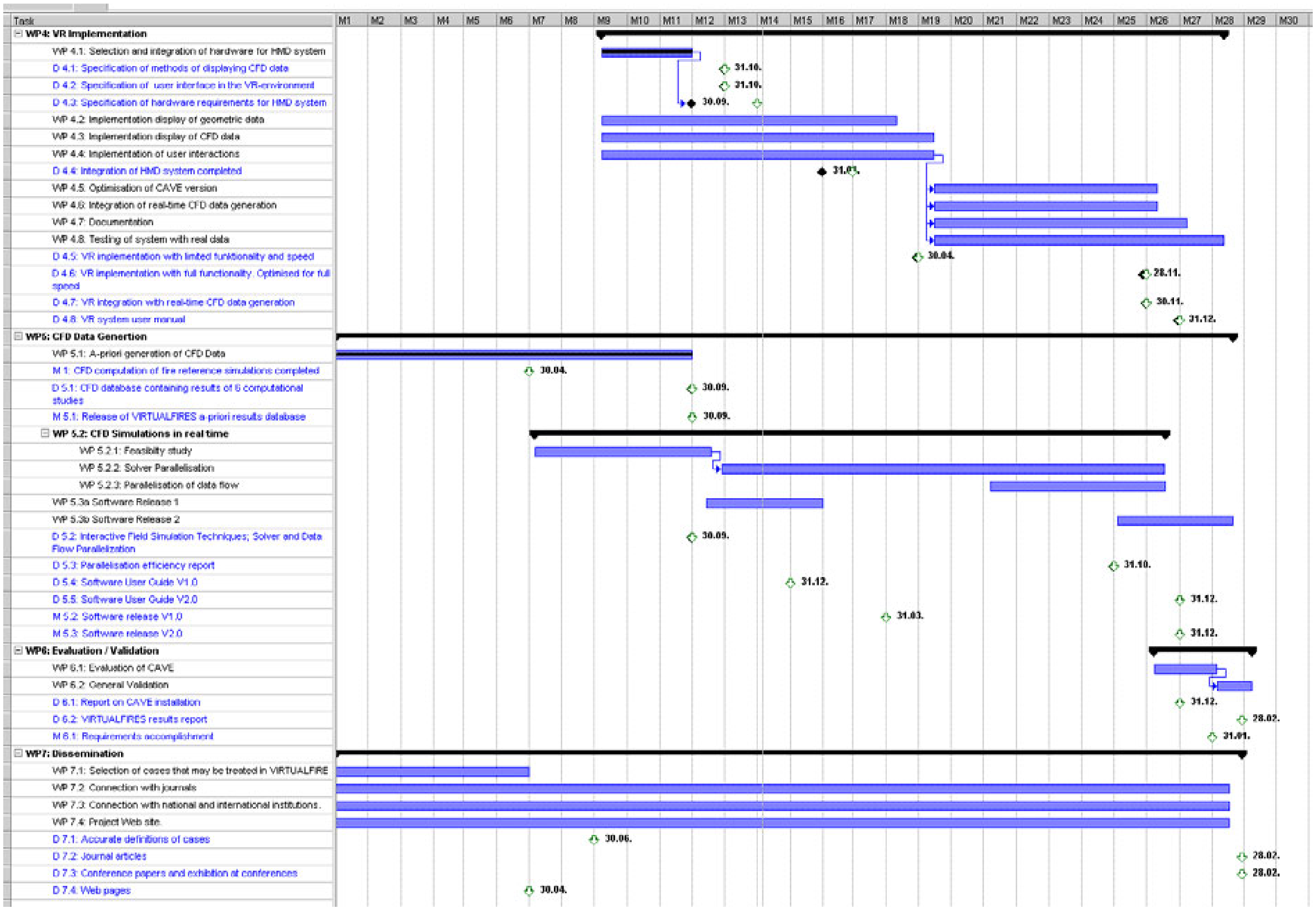

Task
WP4: VR Implementation
WP 4.1: Selection and integration of hardware for HMD system
D 4.1: Specification of methods of displaying CFD data
D 4.2: Specification of user interface in the VR-environment
D 4.3: Specification of hardware requirements for HMD system
WP 4.2: Implementation display of geometric data
WP 4.3: Implementation display of CFD data
WP 4.4: Implementation of user interactions
D 4.4: Integration of HMD system completed
WP 4.5: Optimisation of CAVE version
WP 4.6: Integration of real-time CFD data generation
WP 4.7: Documentation
WP 4.8: Testing of system with real data
D 4.5: VR implementation with limited funktionality and speed
D 4.6: VR implementation with full functionality. Optimised for full speed
D 4.7: VR integration with real-time CFD data generation
D 4.8: VR system user manual
WP5: CFD Data Genertion
WP 5.1: A-priori generation of CFD Data
M 1: CFD computation of fire reference simulations completed
D 5.1: CFD database containing results of 6 computational studies
M 5.1: Release of VIRTUALFIRES a-priori results database
WP 5.2: CFD Simulations in real time
WP 5.2.1: Feasibility study
WP 5.2.2: Solver Parallelisation
WP 5.2.3: Parallelisation of data flow
WP 5.3a Software Release 1
WP 5.3b Software Release 2
D 5.2: Interactive Field Simulation Techniques; Solver and Data Flow Parallelization
D 5.3: Parallelisation efficiency report
D 5.4: Software User Guide V1.0
D 5.5: Software User Guide V2.0
M 5.2: Software release V1.0
M 5.3: Software release V2.0
WP6: Evaluation / Validation
WP 6.1: Evaluation of CAVE
WP 6.2: General Validation
D 6.1: Report on CAVE installation
D 6.2: VIRTUALFIRES results report
M 6.1: Requirements accomplishment
WP7: Dissemination
WP 7.1: Selection of cases that may be treated in VIRTUALFIRE
WP 7.2: Connection with journals
WP 7.3: Connection with national and international institutions.
WP 7.4: Project Web site.
D 7.1: Accurate definitions of cases
D 7.2: Journal articles
D 7.3: Conference papers and exhibition at conferences
D 7.4: Web pages
M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30
31.10.
31.10.
30.09.
30.04.
28.11.
30.11.
31.12.
30.04.
30.09.
30.09.
30.09.
31.10.
31.12.
31.12.
31.03.
31.12.
31.12.
28.02.
31.01.
30.06.
28.02.
28.02.
30.04.

Table 3: Budget plan

PARTNER	Cost Category	BUDGET (EUR)	ACTUAL COSTS (EUR)					Total Pct. Spent (%)				Remaining Budget (EUR)
			Year 1	Year 2	Year 3	Year 4	Total	Year 1	Year 2	Year 3	Year 4	
		e	a1	b1	c1	d1	e1	a1/e	a1+b1/e	a1+b1+c1/e	a1+b1+ c1+d1/e	e-e1
Partner 1 SiTu	Labour	332443,00	111267,70				111267,70	33%				221175,33
	Overheads	83658,00	26843,82				26843,82	32%				56814,18
	Labour+Overheads	416101,00	138111,50				138111,50	33%				277989,51
	Travel	25000,00	13122,11				13122,11	52%				11877,89
	Durable Eqmt.	57501,00	4470,86				4470,86	8%				53030,14
	Consumables	3340,00	5358,49				5358,49	160%				-2018,49
	External Assistance	4766,00	200,00				200,00	4%				4566,00
	Other											
	..											
	Total	506708,00	161263,00				161263,00	32%				345445,05
Partner 2 CD	Labour	206126,00	91339,17				91339,17	44%				
	Overheads	56109,00	24757,95				24757,95	44%				31351,05
	Labour+Overheads	262235,00	116097,10				116097,10	44%				146137,88
	Travel	10000,00	8989,07				8989,07	90%				1010,93
	Durable Eqmt.	50421,00	19641,24				19641,24	39%				30779,76
	Consumables	14000,00	3820,28				3820,28	27%				10179,72
	External Assistance											
	Other											
	..											
	Total	336656,00	148547,70				148547,70	44%				188108,29
Partner 3 FIGD	Labour	160334,00	95612,62				95612,62	60%				160334,00
	Overheads	153976,00	112689,90				112689,90	73%				153976,00
	Labour+Overheads	314310,00	208302,50				208302,50	66%				314310,00
	Travel	15000,00	5218,39				5218,39	35%				15000,00
	Durable Eqmt.											
	Consumables	5000,00	1600,00				1600,00	32%				5000,00
	External Assistance											
	Other											
	..											
	Total	334310,00	215120,90				215120,90	64%				334310,00
Partner 4 KTH	Labour	163065,00	32983,86				32983,86	20%				130081,14
	Overheads	44240,00	8450,37				8450,37	19%				35789,63
	Labour+Overheads	207305,00	41434,23				41434,23	20%				165870,77
	Travel	24138,00	6308,64				6308,64	26%				17829,36
	Durable Eqmt.	5000,00										5000,00
	Consumables	4000,00	1636,17				1636,17	41%				2363,83
	External Assistance											
	Other											
	Computing	25000,00	1321,09				1321,09	5%				23678,91
	Total	265443,00	50700,13				50700,13	19%				214742,87
Partner 5 ALPE	Labour	48713,00	53130				5313,00	11%				43400,00
	Overheads	9742,00	1062,60				1062,60	11%				8679,40
	Labour+Overheads	58455,00	6375,60				6375,60	11%				52079,40
	Travel	15000,00	1565,92				1565,92	10%				13434,08
	Durable Eqmt.											
	Consumables											
	External Assistance											
	Other											
	..											
	Total	73455,00	7941,52				7941,52	11%				65513,48
Partner 6 METL	Labour	48713,00	14041,40				14041,40	29%				34671,60
	Overheads	9742,00	2808,28				2808,28	29%				6933,72
	Labour+Overheads	58455,00	16849,68				16849,68	29%				41605,32
	Travel	15000,00	2761,20				2761,20	18%				12238,80
	Durable Eqmt.											
	Consumables											
	External Assistance											
	Other											
	..											
	Total	73455,00	19610,88				19610,88	27%				53844,12
Partner 7 FDDo	Labour	45021,00	13347,90				13347,90	30%				31673,10
	Overheads	12004,00	2669,58				2669,58	22%				9334,42
	Labour+Overheads	57025,00	16017,48				16017,48	28%				41007,52
	Travel		4185,76				4185,76					-4185,76
	Durable Eqmt.											
	Consumables											
	External Assistance	52500,00	15000,00				15000,00	29%				37500,00
	Other											
	Computing	15000,00										15000,00
	Total	124525,00	35203,24				35203,24	28%				89321,76

PARTNER	Cost Category	BUDGET (EUR)	ACTUAL COSTS (EUR)					Total Pct. Spent (%)				Remaining Budget (EUR)
			Year 1	Year 2	Year 3	Year 4	Total	Year 1	Year 2	Year 3	Year 4	
		e	a1	b1	c1	d1	e1	a1/e	a1+b1/e	a1+b1+c1/e	a1+b1+ c1+d1/e	e-e1
Partner 8 EUVE	Labour	54648,00	11187,36				11187,36	20%				43460,64
	Overheads		8949,89				8949,89					-8949,89
	Labour+Overheads	54648,00	20137,25				20137,25	37%				34510,75
	Travel	15000,00	4827,88				4827,88	32%				10172,12
	Durable Eqmt.											
	Consumables	2000,00										2000,00
	External Assistance											
	Other		1600,00				1600,00					-1600,00
	..											
	Total	71648,00	26565,13				26565,13	37%				45082,87
TOTAL	Labour	1059063,00	375092,98				375092,98	35%				683970,02
	Overheads	369471,00	188232,38				188232,38	51%				181238,63
	Labour+Overheads	1428534,00	563325,36				563325,36	39%				865208,64
	Travel	119138,00	46978,97				46978,97	39%				72159,03
	Durable Eqmt.	112922,00	24112,10				24112,10	21%				88809,90
	Consumables	28340,00	12414,94				12414,94	44%				15925,06
	External Assistance	57266,00	15200,00				15200,00	27%				42066,00
	Other		1600,00				1600,00					-1600,00
	Computing	40000,00	1321,09				1321,09	3%				38678,91
	Total	1786200,00	664952,46				664952,46	37%				1121247,54

Literature/Links

[1] Fluent Inc.: "User's Guide for Fluent 6" Lebanon, USA, 2001

[2] Smagorinsky, J.: General circulation experiments with the primitive equations Mon. Weather Rev. 91, 99 – 152 (1963)

[3] Foster, I.: Designing and building parallel programs Addison-Wesley (1995)

[4] Krafczyk, M., Tölke, J., Luo, L.-S.: Large eddy simulation based on a multiple relaxation time lattice Boltzmann model Int. J. Mod. Phys. C, In press (2002)