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EXECUTIVE SUMMARY

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1. Management and organization

The Work Breakdown Structure and Work Package Document have been upgraded to include the ultimate decisions concerning Data Analysis, and Site Operation.
The Virgo annual review took place on January 17th to 19th and has been largely devoted to the assembly and commissioning of the CITF and to data analysis.

The site organization reaches certain stability though many problems remain in particular that of the personnel. Though temporary short-term contracts have been found in many cases, more permanent solutions that will allow getting highly experienced staff are urgently needed.

2. Infrastructures

2.1. Central area

In the last 6 months, important improvements have been undertaken in the central area: access roads, isolation of control buildings, more powerful generator, active drainage.
The call for tender for the additional building has been concluded. It can be reasonably expected to have it delivered for March 2001.
The access control to the site and buildings is under operation and a preliminary plan for the site security has been prepared.

2.2. Clean areas

Clean rooms are in regular operation.
The washing and cleaning equipment has been ordered and partially delivered.

2.3. Arms and terminal buildings

The piles for the North arm have been completed and the ones for the west arm initiated.
The concrete beams for the North arm are expected to be completed in June for the first half. The covers are partially installed and the mid-arm assembly building and the first bridge will be completed by this summer. However, a number of technical difficulties encountered by the contractor for reaching the desired quality and production rate resulted into a delay which is estimated to be of 3 months for the first part.

3. Vacuum

3.1. Tube

The serial production of tube modules is reaching a rate close to 5 modules per week, followed by the transport to Belleli (Mantova).
The final prototype of support has been built and resulted to be satisfactory.

3.2. Large valves

The first large valve is already installed at Cascina. A small leakage with a welded glass window has been found and is being evaluated from the point of view of performance and safety.

3.3. Towers

All the 3 short towers have been completed with the installation of the suspensions and are maintained under vacuum at the expected performance.
A few experimental tower bake-outs will be done in view of studying the stability behavior of suspensions and payloads under thermal load.

3.4. Pumping system

The central area pumping system has been completed, including the remote control system. The safety procedures have been completely reviewed and improved.
The call for tender for the tube pumping system has been launched.

4. Interferometer

4.1. Laser and input system

The 10W-laser bench is completely installed on site and in operation with the injection locking servo-loop and its local monitoring.
The residual movements achieved for the masses are of the order of 1micrometer rms in translation, and 1 microradiant in angle.
The integration of Laser, Input bench and Mode Cleaner has started and the pre-alignment of the first suspended long cavity (144 m) in Virgo has been realized
The software and hardware control have been installed and tested on site. It acquires data since a few months on the real experimental set-up and is currently used to monitor the laser behavior (drifts, diodes aging, etc…).
The control is completely integrated with the supervisor.

4.2. Detection Bench

The detection sub-system is in local operation since September 1999. The internal bench is suspended and controlled inside the vacuum chamber. Its position has been controlled locally with a precision better than 1 micron using the CCD camera signal. Both the external bench and the suspended bench have been aligned on the west arm.

4.3. Mirrors

4.3.1. Metrology

The three metrology benches (absorption, reflection and birefringence) realized at ESPCI have been installed successfully in Lyon.
Silica samples of Virgo beam-splitters have been found to be around 1.4 ppm/cm.
The problems encountered with the Micromap profilometer are completely solved. Substrates up to 400 mm in diameter can be qualified.
The Phase Shift interferometer at 1064 nm shows a reproducibility of 0.06 nm RMS ($\lambda/15000$).
All the mirrors for the CITF have been coated within specifications and are available for the integration on site.
The coater integration is nearly completed. A number of difficult leak problems have been encountered with the robot substrate holder but have been recently fixed.

The contract with General Optics for polishing the large mirrors was finally signed in January. All large silica blanks have been delivered to the polisher.

Two end mirrors have been coated for GEO.

4.4. Alignments

Cameras for the non-linear alignment have been installed and are operational.
The installation of the end benches and of the optical and mechanical components is in progress.

4.5. Calibration

A Monte-Carlo study to assess the precision required on the determination of the interferometer response function has been achieved.

4.6. Suspensions mechanics

The construction and assembly of the three short suspensions for the VIRGO central interferometer has been achieved at the end of 1999.
The first three long Superattenuators (Beam Splitter, North Input and West Input) have been assembled and are ready for the integration of the optical payload.
The integration of the Power Recycling long Superattenuator will be completed by the end of July.
The integration of the last two long Superattenuators for the 3 km-far mirrors will start as soon as the terminal buildings are made available and the towers installed.

4.7. Last suspension stage

Three marionette for the short suspensions have been integrated with the optical benches and assembled on the short superattenuators.
All marionettes and reference masses for the long suspensions of the central interferometer are available.
The installation of the first optical payload on the beam splitter tower has been delayed because of a number of difficulties encountered with the handling and clean room equipment.

4.8. Clamps and wires

All clamps and wires have been realized. The first set has been installed on the beam splitter payload.

4.9. Suspension Electronics

All the electronics for the short towers suspensions has been installed. All other electronics boards for the CITF are ready and are being integrated when needed.
The software for the inertial damping is operational on the three short suspensions and is yet to be done for the long ones.
The integration with the data acquisition will be achieved by Summer 2000, while the integration with the VIRGO supervisor will be performed only after completion of the other software activities. The integration of local control with global control will be tested as soon as the global control is installed on site.

5. Electronics and Software

In the first semester of 2000 most of the electronics has been integrated in Cascina. In May, 34 of the 36 VME crates needed for the CITF are installed at the site. In June the two remaining ones plus a few boards for the suspension control will be installed and the cabling completed. These operations will end the installation of the CITF electronics.
There is at least one prototype version of most software applications which are being tested and integrated.
Since November 1999, Virgo-Cascina is connected at 2 Mbs to the new national network infrastructure GARR-B and therefore has a good connectivity to the European TEN155 and the rest of the Internet. This has substantially improved the connectivity to/from Cascina for the different laboratories of the collaboration.
The local area network VIRGOnet installed in the main buildings (Central, Control, Mode Cleaner, Technical) is operational since summer 1998 and is working well. The first extension for the north arm is planned by end of 2000.
The Data quality and Trigger Manager computers are being purchased together with the Mainframe builder computer and DAQ dedicated Gigabit switches. The purchase of a first cluster of PC's or workstations to test the pre-selection and support the CITF operation is foreseen for the beginning of 2001.
The prototype of the Online Pre-selection software is under test with bursts algorithms. The development will continue during the second semester along with the development of the Online Processing supervisor.
All the components for the completion of the raw data archiving system have been ordered in the first semester.
The installation of the Data Distribution System is started in Cascina. The hardware section of the on-line data storage has been completed with the installation of the 500 Gbyte disks.
The supervisor has been integrated in the Vacuum Control, Beam Source Control (Laser, Mode Cleaner, Input Bench) and Global Control. It is expected that other sub-systems be integrated soon.
The environment monitoring system is operational with a limited number of sensors. Long acquisition runs of the Central Building and Mode Cleaner Building temperatures have been done since the beginning of the year and will be used to tune the air conditioning system. A review of the number, type and location of sensors has been performed.

6. Assembly, Integration and Commissioning

6.1. Assembly and Integration

Assembly and integration of the CITF have proceeded satisfactorily, and no major technical problem was encountered. Some schedule slippage still occur due to the necessity to solve a number of minor technical problems, inevitable since most operations are done for the first time.
All three short suspensions, Mode Cleaner, Injection, Detection, have been integrated with their final payloads and the inertial damping is operating. The laser bench, located in the laser laboratory has been installed and running for many weeks.
The locking of the mode cleaner is expected in June.
The electronics group of Pisa moved temporarily at Cascina in order to avoid time-consuming commuting.

6.2. Commissioning

Following the decision to focus on the aspect of interferometer control, a detailed review of the first phase of commissioning was held during the project annual review and the corresponding part of the planning adjusted. The total time foreseen to complete this phase is now 38 weeks (see annual review transparencies for details). The CITF commissioning is foreseen to start at the end of September 2000 with some overlap with the last integration steps.

7. Data Analysis

The description of tasks and responsibilities concerning data analysis has been completed. The final Work Package Description is now approved by the collaboration, except for a few points yet to be definitively settled. Yet, many of the data analysis tasks are still in an R&D phase, and will keep evolving during the next years. Furthermore, we have started the study of "network data analysis", meaning the parallel analysis of several detectors data. This will imply new developments, and later, a sharing of activities with other G.W. detection groups.

The problem of the data pre-selection (initially called triggers) has much evolved in the last years, particularly for what concerns coalescing binaries. The optimal search (using matched filters) has become possible in a large fraction of the parameter space, and the pre-selection has evolved towards a real online data analysis, rather than just triggering. This activity now belongs mainly to the data analysis system.

It appeared that re-processing and other offline activities would be difficult without a convenient way to re-access the older data, which would have migrated on tapes. The only easy access to data was initially foreseen through the online cluster, a solution that we consider now as dangerous (because too many requests could perturb the data acquisition system), and insufficient (because older data ought to be re-analyzed)
Therefore, it becomes necessary to install, on site, an offline cluster (tape robot, disk storage, book keeping database, re-processing capacity), in order to provide access to old data, and to some computing power, for all users.

An evaluation of the computing power necessary as well as a preliminary market survey have been done in view of determining the necessary budget envelope for the next 4 years. We have defined what seems to be at the moment the best policy in terms of cost and efficiency. The conclusions of this work are reported in separate documents.

Simulation
The development of realistic simulations is important for a better understanding of the noise and to provide the essential algorithms for signal reconstruction. One of the problems to be addressed is that of the computational speed which has to be improved either by increasing the computing power or through smarter algorithms.

8. R&D

Since many years, R&D is not anymore an official part of the Virgo budget, except for what concerns thermal noise and an upgrade of the laser power.
The ongoing or projected activities which will have to be organized and supported, for the French-Italian GW community to remain competitive in the longer term are listed below:

8.1. Monolithic last stage (Perugia)

This activity is performed in Perugia and consists in studying the possibility of replacing the last suspension stage steel wires, by silica fibers which would be connected to the mirrors and to the marionettes via a silicate bond. This technique would improve the suspension thermal noise, and the Virgo sensitivity by nearly an order of magnitude, in the frequency region below 20 Hz giving Virgo a much better chance of detecting low frequency pulsars, and coalescing binaries.
The decision to implement this technology for Virgo will be taken around the end of this year, if the technology appears sufficiently mature at that time.

8.2. 25 W laser (Nice)

The laser power has to be increased from 10W to 25W for the final Virgo. The laser itself will be realized by the LZH group of the GEO project.

8.3. Outside Virgo budget

8.3.1. LFF (Low Frequency Facility, Pisa)

LFF aims to measure the spectral density of the suspension thermal noise out of resonance, and consists of a Fabry-Perot cavity, suspended to a Virgo suspension especially built in the Pisa Laboratory.

8.3.2. UVVV (Pisa)

The goal is to set up a method to detect pressure fluctuations in the 3-km vacuum tubes. The method, consisting in the measurement of absorption and fluorescence of UV light in the residual gas, could allow to study the existence of gas releases from the tube walls or from the ion or titanium pumps.

8.3.3. A.E.A. (Acoustic Emission Absorption)

(I.N.F.N. Pisa, Roma 1, Istituto di Acustica "O. M. Corbino", C.N.R. Roma, Universita' di Pisa.)
The main goal of this project is the study of the creep noise coming from metallic structures under high stress conditions, by means of Acoustic Emission.

8.3.4. High power lasers and optical components (Nice)

With the future high power laser beams (above 25W), many optical components, including the interferometer mirrors, will produce thermal lenses which could be corrected using adaptive optics techniques.
The next generations of interferometers will require laser powers of 100W to 1 kW. These will require new technologies for pumping and cooling the laser amplifier and possibly other active material.

8.3.5. Cleaning of Optics (ESPCI)

In-situ cleaning of optical components through laser pulses is very promising and should be better investigated.

8.3.6. New optical materials (ESPCI)

Up to now fused silica was the best choice for making the Virgo mirror substrates.
Nevertheless there may be better materials such as sapphire or fluorine. An in depth mechanical and optical analysis of these materials as well as the possibility of production in larger sizes needs to be investigated.

8.3.7. Low absorption coatings (Lyon)

Absorption of mirror's coatings by more than an order of magnitude (down to 1ppm) has been achieved for Virgo but this may be a limiting factor in the future. Further improvements seem possible.

8.3.8. Newtonian noise (Urbino)

Theoretical studies are now being developed in collaboration between Florence/Urbino and Pisa, in order to obtain a good (realistic) model of the ground on which the Virgo antenna has been built. By using a suitable ground model, it is possible to find a configuration of surface sensors that would fully describe the displacement field around the Virgo test masses, generated by seismic noise and determine the corresponding signal to be subtracted from the data.

8.3.9. Improved accelerometers (Urbino)

Prototype of capacitive sensors for six degrees of freedom is under study.

8.3.10. Computing R&D

Small-scale studies are being initiated in Rome and Perugia and Napoli concerning parallel computing for the data analysis.
A mid-size parallel machine is being acquired in Nice, with CNRS and Regional funds. It will be used to test algorithms, and to develop noise analysis techniques for the Virgo central interferometer.

8.3.11. The Virgo/Grid R&D proposal. (Italy)

The objectives of the Virgo/Grid R&D project are to develop and deploy a small scale prototype computational and data GRID capable to efficiently manage and provide effective usage of the large commodity components-based clusters and supercomputers distributed in the nodes of the research network Garr-b.

9. Cascina Operation

Site operation is running satisfactorily though many improvements are still necessary.
The main ones concern the central area infrastructure in particular the auxiliary equipment (air conditioning, generators, clean rooms etc...) which are not yet fully reliable and which need an integrated control system.

A number of resignation and temporary absences of some key people, as well as the precarious contractual situation of some others are making the situation rather difficult.

10. External collaborations

Collaboration with GEO:

A proposal for a study of a future high-tech European interferometer has been prepared with GEO and sent to the institutions concerned.

Collaboration with LIGO:
An agreement on "Joint data analysis requirements to coherent process multiple interferometer data for binary inspiral detection" has been drafted with LIGO. The basic idea is to make the analysis fully coherent through a complete exchange of data among all detectors.

Collaboration with AIGO:
Virgo was invited to the AIGO opening ceremony held in Gin-Gin (Perth) on march 10th. The Australians are actively working for promoting the construction of a 4km detector having characteristics very similar to Virgo.

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FINANCIAL REPORT

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1. Introduction

This report deals with the accounting and financial situation of Virgo.
Annexed to this report are:

- **the balance of accounts for 1999 which shows a deficit of payment of INFN with respect to CNRS of 872 KE.**
- the provisional budget for 2001 in which we have integrated the real commitments and payments for 1999 issued from the annual accounts.

2. Financial situation at June 2000

The commitments really effected in 1999 are about 2 ME lower than foreseen in the 1999 budget. This results from a number of shifts in the ordering of items in particular for the auxiliary equipment for the coater of Lyon. These missing commitments will appear in the 2000 expenditures which have been accordingly updated.

The financial situation in 2000 remains dominated by the few large contracts still running, by the operation costs for Cascina and for the collaboration (travel and running costs).

3. 2001 provisional budget.

The budget proposal is given in annex. It calls the following comments and explanations.

- The payment schedule for major contracts has been updated.
- For the arms construction, the budget indicates only the part expected to be borne by the project. In reality there is only one contract which includes also the part to be supported by INFN only (works done outside Virgo premises). The final evaluation of this part will be done after the construction.
- The budget projection is provided till 2001. A specific operation budget is expected to be available beyond this date.
- Relatively large payments will occur in 2002. For the sake of coherence, we have integrated these payments in 2001.
- A budget for the Data Analysis preparatory activities has been introduced in 2001. The budget for the development of the computing facility at Cascina is made explicit in a separate document annexed to the progress report.

4. Annex

- Balance of payments 1999
- Provisional budget proposal for 2001.

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PLANNING REPORT

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The contractor for the arms civil engineering has acknowledged a schedule shift of 1.5 months with respect to the contractual dates due to a few initial technical problems (see progress report). We think that even this new schedule will be difficult to hold considering the actual state of the works. We have therefore integrated 1.5 months more delay in our planning to make it as realistic as possible.
The manufacturing of the tube modules is progressing well. There were difficulties in reaching the production schedule foreseen, but a production schedule of 4.5 modules per week has been recently reached which will avoid any schedule conflict with the tube assembly. The preparation for the tube assembly is in progress and will start as soon as the tunnel is available. Some acceleration of the tube assembly may be possible but this will be ascertain only after successful installation of the first hundreds meters.
There have been difficulties in the administrative processing of the contract for the large mirrors polishing. The contract was finally signed on January 10th. As a result, this contract becomes now rather critical. The contract foresees a target delay of 17 months for which it is expected that at least one set of mirrors could be delivered.

The assembly integration proceeds technically well but has been slowed down essentially because of a few practical difficulties which often necessitated to modify mechanical elements and because of the necessity to understand the origin of more complex problems which might affect the functioning and performance of Virgo. For instance, despite the assembly of the suspensions has been progressing very smoothly, tests performed on the inertial damping have put into evidence some effects which have necessitated a considerable time to be understood and then cured. Many iterations between the mechanics adjustment and the control were necessary. As these effects get progressively understood the time required for the remaining suspensions should be much reduced. Also, considerable difficulties were encountered with the assembly of the first payload as the clean room equipment and assembly tools were used for the first time and necessitated a number of interventions and modifications.
Time losses due to the interference with other works and incidents such as power shut downs has much decreased but were not negligible during the last period. The installation of a more powerful generator should make the site practically independent from short power cuts.

The CITF commissioning will have to stop when the upgrade of the central interferometer starts. The time left at disposition appears quite sufficient to carry out the commissioning program foreseen.

Annex: Planning Overview.