SoDa

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Integration and exploitation of networked Solar radiation Databases for environment monitoring

FINAL REPORT

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http://www.soda-is.com

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?? JRC (Joint Research Centre) - ISIS/Reliable Information Technologies Unit, Italy
?? HuMet (Hungarian Meteorological Service), Hungary
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1. Project Overview

1.1. Background

The Sun is the primary source of energy for the Earth. Beyond its direct impact on human being and human health, solar radiation concerns many domains: environment, air quality in cities, photo-chemical conversion, primary production and photo-biological processes, weather forecasting, prediction of meteorological extreme events, agro-meteorology, agriculture, oceanography, climate, global change, water supplies (evaporation in reservoirs, water quality), renewable energies (solar energy, energy from biomass, energy-conscious building design …), solar chemistry, durability of materials (polymers, coatings), cosmetics, tourism etc.

There is a strong need for information on solar radiation. It is measured by ground networks, but well-controlled measurements have only been available in a limited number of sites, and since the middle of the 20th century or so. Investment and maintenance costs for each site are large. Consequently, national networks often comprise only a few stations, even in Western Europe and Northern America. In other parts of the world, it is scarce. Such data are non-existent for the oceans. Adding to this the fact that the types of measured data: sunshine duration, cloudiness, global irradiation, its diffuse and direct components, vary from site to site, the result is that there is a large discrepancy between user request and available information. Large gains in terms of efficiency, costs, etc. will be attained by engineers, companies, agencies and research institutes if relevant information were more easily available for virtually any geographical location at any time. Information and Communications Technologies (ICT) play a major role in solving this problem.

1.2. The Problems to Solve

Three major problems have to be solved to supply the customers with relevant information:

?? *Improved access.* The access to the relevant information is poor and is complicated by the various types of data, various storage standards, various units, various ways of expressing time, diversity in properties of the information, etc.

?? *Improved space and time structure*s. Space and time characteristics of presently available data are unsatisfactory. Interpolation / extrapolation techniques can be employed to gain knowledge at any geographical location and any time, but the present techniques lead to poor quality estimates.

?? *Improved matching to actual customer needs.* Raw measurements are stored in and supplied by the present databases. Most often, they are not what are really needed by the customer. More advanced information should be supplied to the customer.

The project SoDa is based on considerable previous experience gained by the partners, and used this as a springboard to answer customer needs by an efficient use of advanced ICT.

1.3. The Objectives of the Project

The five objectives of the project SoDa are:

1. To **answer the needs** for high quality customer-tailored information on solar radiation,

2. To integrate diverse sources of information of different natures presently available separately within a **smart integrating network**. These sources include databases containing solar radiation parameters, derived from satellite data, and other relevant information (meteorology, geography, terrain elevation). The information sources also include application-specific user-oriented numerical models and advanced algorithms,

3. To develop and operate a **prototype service**, which efficiently exploits this smart network, and which will be used and gauged by customers. The project SoDa focuses on several applications in environment and connected domains: air quality in cities, vegetation, coastal zones, health, energy-

conscious building design and daylighting, industrial use of renewable energies, materials weathering. For each domain, the benefits of the SoDa service is assessed by customers,

4. To **increase the quality** of the delivered information through improved modelling of time and space structures of the solar radiation, and improved matching to actual customer needs. The appropriate processing of satellite data offers a wide geographical coverage with a fine sampling in space and time. Algorithms based on innovative techniques in data fusion and on recent advances in modelling of optical properties of the atmosphere are developed that better fit the users requirements,

5. To **disseminate** the achievements of the project, and assess the **sustainability** of a permanent commercial service.

1.4. The Consortium and its Approach

In order to meet these objectives, a consortium has been assembled, gathering the necessary expertise in a complementary way. It comprises companies and research institutes with skills in solar radiation, databases, networking, image processing, applied mathematics, WWW-based technologies and services, customers needs and satisfaction assessment, information and communications technologies, market assessment and development of business plan for products and services. Two vendors of existing solar radiation databases and products are involved.

The project SoDa received support from the customers and the market. Several companies, international environmental research programmes, research institutes, authorities, agencies etc. are paying attention to its outcomes and collaborate actively. Their involvement especially focus on the use of the service and on the expression of benefits with respect to their best practices.

The methodology is **user-driven**. The user needs are taken into account to design the intelligent system, which, in turn, is tested by users, by the means of rapid prototyping combined with several improvements and tests cycles.

1.5. The Achievements

All objectives were attained in a satisfactory manner according to the criteria of success established *a priori*. All deliverables were remitted.

The major deliverables and outcomes are:

?? A prototype Web service. Three prototypes were developed. The latter is in operation since September 2002 and will be operated by the Consortium at least till the winter 2003,

?? A service delivering information tailored to users needs in several domains. Presently, 46 services are available; 31 were developed by the Consortium as planned. Demonstrating the networking capabilities of the SoDa service as well as its benefits to stakeholders, 15 others were developed on a voluntary basis, 9 of which by the Consortium, 4 by other persons belonging to the SoDa partners but not involved in the project and 2 by third parties,

?? Test of service and validation by customers. Two cycles (prototype, test, feedbacks) were organised, involving hundreds of customers,

?? A series of Web technologies, databases, algorithms and methods that can stand as international references. Twenty-six results were identified. Seven of them constitute scientific and technological breakthroughs:

1. development of Web tools and XML schema for the co-operation of distributed services,
2. a method Heliosat-II for the assessment of global irradiation from satellite images,
3. a method for the synthesis of gridded data at a higher spatial resolution by fusion of various modalities,
4. a set of algorithms for the production of solar radiation and temperature quantities derived from global irradiation measurements,

5. a refined version of the clear-sky model proposed in the European Solar Radiation Atlas,
6. a database containing climatological values of atmospheric optical parameters,
7. a database containing time-series of global irradiation values for any site in Europe and Africa since 1985,

?? Exploitation of results by third parties, commerce, research, education, government. Third parties routinely exploit the SoDa service because it is a very valuable and unique service. This includes activities for the certification of solar energy systems and the support to the EU policies. Contributions to 15 regulations or directives, to 3 international regulations and to 12 policies of the EU were identified. The SoDa service supports several educational activities for students at University level, technicians, engineers and researchers. The SoDa Intelligent System, an Open Source, is re-used in the European project DISMAR (IST—2001-37657) and within the GMES programme (Global Monitoring for Environment and Security). Some results (databases, methods, applications) are integrated into commercial softwares and products and have been adopted by companies, large and small, and by European projects: Heliosat-3 (ENK5-CT-2000-00332), SISCAL (IST-2000-28187), and other international or national projects: UNEP-SWERA, UKCIP (UK Climate Impacts Programme),

?? A promotion of the European skills in the field of ICT and environment. The SoDa service is the only one available in many domains and is the European counterpart of other services in renewable energies offered by the USA, Canada or by UNEP or WMO (World Meteorological Organization). Six PhD were generated by the project, all students being of European citizenship.

1.6. Dissemination and Use Intentions

The dissemination took several aspects. Five peer-reviewed articles and one chapter in a book were published. Several articles were submitted or are in preparation. The Consortium presented 36 communications in 29 international conferences. The Consortium organised 9 workshops with attendance by third parties. Six softwares are freely downloadable on the Web site. Lecturing based on the use of the SoDa service to solve problems was also part of the dissemination activities as well as the inclusion of the SoDa service or results in several R&D proposals. The project is collaborating with the programme LEARN-IST for the dissemination of the results towards media.

Partners expressed intentions for use of the outcomes. Besides the adoption and use of the SoDa service and the project outcomes for their own purposes, they express their will to maintain on a voluntary basis the service for at least one year. Several activities are running: refinement of the GUI (Graphical User Interface) with particular emphasis on the graphical representation of the geographical information, creating awareness on the service and its content for the adoption by customers, refinement of databases.

The achievement of the SoDa service highlights the expertise of the whole consortium and of individual partners. It results in several invitations to participate to R&D projects by third parties and an increase in opportunities for collaboration for each partner.

Several results are included in a commercial CD-based software Meteonorm V5, produced by the partner Meteotest. There is an effective transfer of technology towards several EU-funded projects and other products and softwares. Efforts are made to

- ?? contribute to standards: demonstrating networking capabilities, contribution to XML standards for meteorological data, making the databases and algorithms as standing references,
- ?? improve best practices by offering easy access and high quality information in environment, energy, climate, agriculture, fisheries, health, materials,
- ?? increase enterprise competitiveness by integration of some results into their products or practices.

Finally, efforts are made to identify parts of the SoDa service that may go commercial, adopting a model based on a partly free, partly commercial service, and to develop additional features to answer comments made on the present service by these specific classes of customers. As a preliminary step, a database is marketed by a subsidiary of the partner Armines.

2. Project Objectives

The main purpose of the project SoDa is to help filling the strong need for information on solar radiation, considering three major problems that create the present large discrepancy between user request and available information. These three major problems are:

?? **Improved access**. The access to the relevant information is poor for many reasons. Access is complicated by the various types of data, various storage standards, various units, various ways of expressing time (universal time, mean solar time, true solar time, local time), diversity in information properties stored in databases: sampling support (e.g., pixel size or pin-point measurement), observational period, frequency of individual observations and averaging time intervals, etc.

?? **Improved space and time structures**. Space and time characteristics of presently available data are unsatisfactory. Interpolation / extrapolation techniques can be employed to gain knowledge at any geographical location and any time, but the present techniques lead to poor quality estimates. Consequently more R&D effort is mandatory.

?? **Improved matching to actual customer needs** . Raw measurements are stored in and supplied by the present databases. Most often, they are not what are really needed by the customer. More advanced information should be supplied to the customer, such as the fraction of radiation available for photosynthesis processes (APAR: available photosynthesis active radiation) or for driving photochemical transformations causing problems of air quality in cities.

The project SoDa is based on considerable previous experience gained by the partners in previous realisations of databases, softwares and other products and uses this as a springboard to answer customer needs by an efficient use of advanced ICT. More precisely, an integration of information sources of different natures within a smart network is realised. These sources include databases containing solar radiation parameters and other relevant information (meteorology, geography, terrain elevation, satellite-borne sensor parameters). Several of these databases originate from an advanced processing of remote sensing images. These databases are presently available separately. The information sources also include application-specific user-oriented numerical models and advanced algorithms. Algorithms based on innovative techniques in data fusion and recent advances in modelling of optical properties of the atmosphere are developed and tested to **supply value-added information on solar radiation**. The service is validated through users trials, and its benefits are assessed. The project SoDa focuses on several applications in environment and connected domains: air quality in cities, vegetation, coastal zones, energy-conscious building design and daylighting, and industrial use of renewable energies.

The objectives of the project SoDa are:

?? to answer the needs for high quality customer-tailored information on solar radiation,

?? to integrate diverse sources of information presently available separately within a smart integrating network,

?? to develop and operate a prototype service, which efficiently exploits this smart network, and which will be used and gauged by selected users,

?? to increase the quality of the delivered information through improved modelling of time and space structures of the solar radiation, and improved matching to actual customer needs,

?? to disseminate the achievements of the project, and assess the sustainability of a permanent commercial service.

3. Approach

In order to meet these objectives, a consortium has been assembled, gathering the necessary expertise in a complementary way. It comprises companies and research institutes with skills in solar radiation, databases, networking, image processing, applied mathematics, WWW-based technologies and services, customers needs and satisfaction assessment, information and communications technologies, market assessment and development of business plan for products and services. Two vendors of existing solar radiation databases and products are involved.

The project SoDa received support from the customers and the market. Several companies, international environmental research programmes, research institutes, authorities, agencies etc. are paying attention to its outcomes and collaborate actively. Their involvement especially focus on the use of the service and on the expression of benefits with respect to their best practices.

The methodology is **user-driven**. The user needs were taken into account to design the intelligent system, which, in turn, was tested by selected users. The connection between design and development and the potential users was effective; rapid prototyping combined with several improvements and tests cycles improved the dialogue and lead to better products and services.

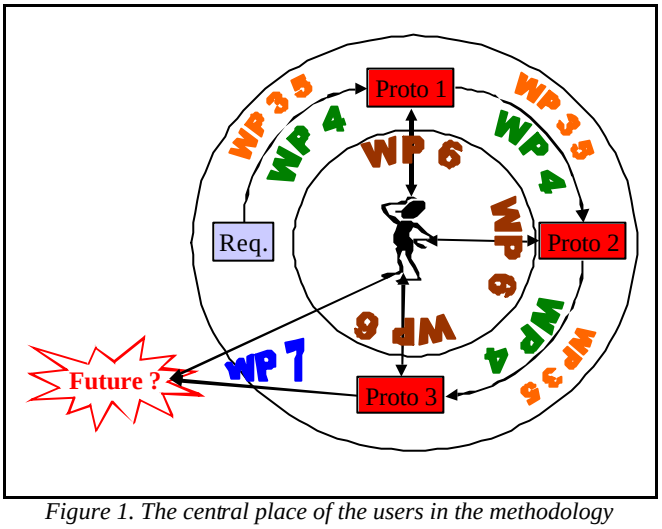


Figure 1. The central place of the users in the methodology

Figure 1 illustrates the central place of the users in the methodology. This figure also describes the role of several Work Packages (WPs). In particular, the WP 6 *Customers community* deals with the concerns of the users and ensures the liaison between customers and the project. Starting from users requirements already known and completed by a survey in the early stage of the project (blue box Req in the figure), developments are made on the Web technologies for integration of resources (WP 4 *Realisation of an intelligent system*), on the databases and means to create them (WP 3 *Consolidation of databases*) and on algorithms and methods for advanced exploitation of the databases content and applications-oriented tools (WP 5 *Advanced information*). This creates a first prototype of the SoDa service after 1st year (red box Proto 1 in the figure), which is gauged and refined taking into account the users feedback to produce the second prototype after 2nd year (red box Proto 2). Same approach is followed to gauge this prototype and develop the third and final one (red box Proto 3). The user is also central in the market analyses and the construction of the technology implementation plan for the preparation of the future of the SoDa service (WP 7 *Dissemination and exploitation*).

3.1. The Rationales for this Approach in Software Development

This approach was selected because the SoDa consortium includes all the main European vendors of solar radiation data, and most of its partners have participated in previous research programmes on solar radiation. This experience, as agreed with the Commission Services during the project

negotiation phase, constituted the most important knowledge for the issue of a first series of user requirements which served as input to the development and the finalisation of the prototype of the SoDa service. Therefore, the SoDa prototyping work could not be seen under the point of view of a waterfall-type development approach, *i.e.* putting the collection of the user requirements before starting software development. In the case of SoDa the adoption of this approach would have implied the loss of the added value derived from the enormous experience of SoDa partners in development of solar radiation commercial products. In fact, the SoDa workplan included a number of preliminary software development activities (namely in WP 4 and WP 5, see below), which took place independently from the collection of the SoDa user requirements. Incidentally, it is a well-known fact that the approach adopted by SoDa is also the consolidated approach to software development and prototyping adopted in the scientific and academic domain.

During the activity WP 6.2 "Use of the prototype", a number of selected users entered in the software development process, as they acted as beta-testers of the first prototype of the SoDa service. This group of users provided input to the SoDa prototyping work giving structured feedback on functionality, system usability, time response, etc. This group of early SoDa adopters was then progressively enlarged up to constitute the first kernel of the SoDa customers' community and to gauge the second prototype. Under a quantitative point of view, the users who indirectly entered in the SoDa user requirements constitute a qualified majority of all of the users of solar radiation data in Europe. Several hundreds of users entered in the user requirements development process for products, prototypes and algorithms already developed by the SoDa partners.

The software system behind the prototype of the SoDa service consists of three parts. One part deals with bringing together distributed heterogeneous resources and another part deals with the Web-based access to these combined resources. The last part concerns the presentation of the data to the user. The technology that underlies the user interface is well understood, namely HTML. The technology that allows the combination of the resources however is more complicated and needs to be investigated and tested within a cycle of testing-improvements.

The software was developed under a model of rapid prototyping with regular user feedback. This is very much in line with current thinking for Web systems, which must remain competitive in "Internet time". This methodology ensures a good mix of userability and early evaluation and adoption of emerging new tools, and standards for web based services. It allows early user feedback both from services providers and from end users. The user interface of these prototypes initially reflected the underlying capabilities of the system, but using user feedback the interface was tuned to more accurately reflect the true needs of the users. The classical waterfall software development approach does not work well in a scientific technical environment where the user requirements of the final system are driven to a large extent by the experiences of the users gathered during try-out phases. In addition Internet technologies are evolving rapidly, and are not compatible with the classic waterfall model of software engineering. The development approach is more of the spiral model[1], as adopted by the European Environment Agency (EEA) for the ReportNet system, a technology developed for the European Environment Information and Observation Network (EIONET)[2]. The considerable experience of the Consortium ensured that the initial release of the first prototype was of sufficient quality for the stakeholders to continue collaboration and bring further improvements towards the 2nd and 3rd prototypes.

Therefore, a first prototype has been brought on-line building on existing experience, using the HGSS protocol for service activation calls and XML for the service description and the resulting output. In order to be able to apply a geospatial search, an OpenGIS WMT tool has been re-used for part of the user interface. Though the thematic contents of the services are strongly relating to the solar radiation, the pre-knowledge of the Consortium shows that the domains of usage of the SoDa services are numerous and distinct. This diversity is strengthened by the need for advanced information rather

[1] B. Boehm "A Spiral Model of Software Development and Enhancement", *IEEE Computer*, vol.21, #5, May 1988, pp 61-72.
[2] http://eionet.eu.int/

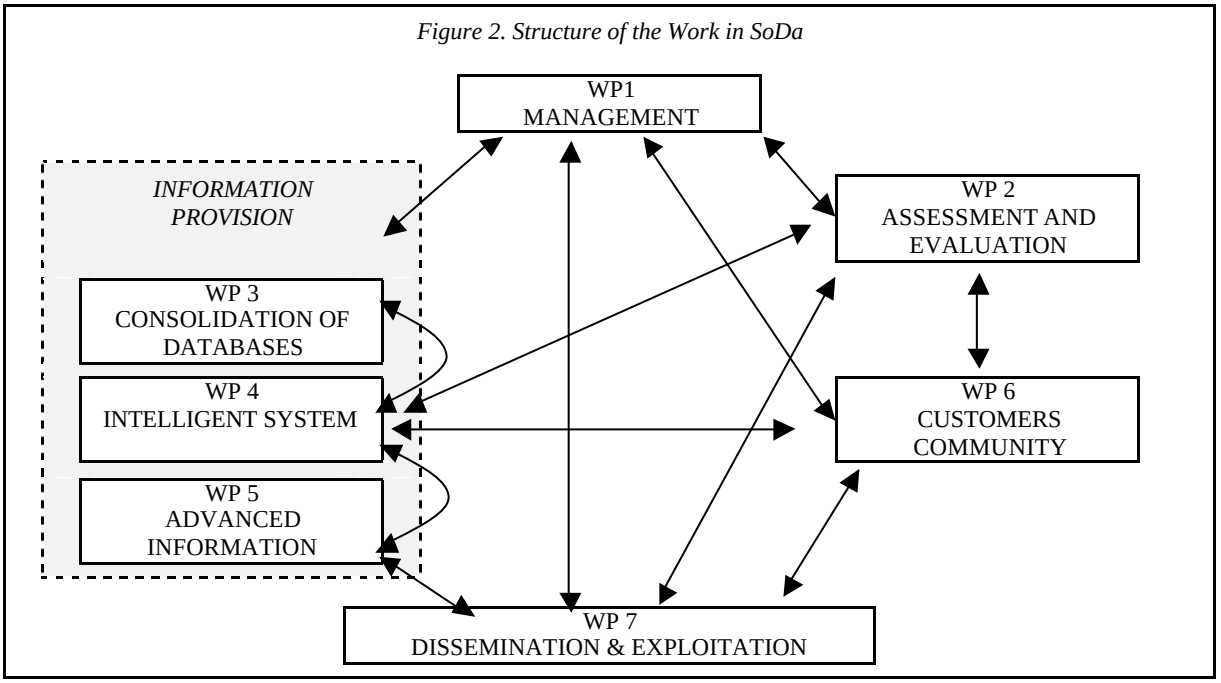
than for basic measurements and data. Therefore, service description and discovery took into account typical customer profiles. Considering the limited resources for software development, emphasis was put on the ability of the system to dynamically create a user interface based on the service description and to address one or more resources with the correct parameters, possibly using the result of a resource invocation as the input for a subsequent resource invocation. In addition, the development methodology tended to ease the work to be done at provider level, in order to facilitate the integration of services not provided by the Consortium. The intelligence of the SoDa system is firstly in the service description metadata (defined in the XML Schema) and secondly, in the interpretation of that description by the software to generate user defined instantiations of a service from a remote provider site. The interoperability of data and process services is underpinned by the use of XML throughout as the message transfer layer.

The experiences gathered during the development of the first prototype was then used to re-evaluate the adopted technologies and to define and implement a second prototype, based on feedback from providers and test users. The second prototype carried a user interface specified on the basis of this feedback. The same approach was followed for the development of the third final version of the prototype of the SoDa service and also for the refinements that are currently brought to this 3rd prototype after completion of the project.

3.2. The Description of the Work Packages

The work in the project SoDa was broken down into seven work packages (WPs), as shown in the following diagram (Fig. 2).

Figure 2. Structure of the Work in SoDa



Four major work activities were identified: management aspects, information provision, customers' community, and dissemination and exploitation of results. Each major work activity was split into work packages (WPs). For the sake of clarity in management, only a limited number of work packages were defined, and each WP has a clearly defined leader. These work packages are in turn broken into several sub-tasks, with also a well defined leadership and involvement of partners.

The management activities included two work packages, one dealing with the management (WP 1) while the other aims at assessing the progress of the work by performing an on-going evaluation (WP 2). The "information provision" deals with all efforts related to the creation of the intelligent system. Because of the amount of work involved, these activities have been split up into three components

(WPs 3, 4 and 5). The "customers community" deals with those related to the users of the system (WP 6), and the "dissemination and exploitation plan" deals with the exploitation of the knowledge gained during the project (WP 7).

The WP 1 *Management* co-ordinates the activities of all WPs, under the responsibility of the partners Armines and ENSMP. It deals with on the one hand the scientific and technical management, and on the other hand the administrative, financial and legal coordination of the project. It provides administrative support services that ensure proper organisational co-ordination and financial accounting. This WP is an intermediary between the Consortium and the Commission. It also ensures effective flow of communications inside the consortium and outside through proper reporting activities.

The WP 2 *Assessment and evaluation* aims at assessing the progress of the work by performing an on-going evaluation, under the responsibility of the partners Armines and ENSMP. This is done by analysing the progress of the study against baseline data and measures of success established for each WP or each Partner if relevant. A monitoring plan describes the baseline data, the measures of success and the methodology used to assess the progress. This WP informs management in a timely fashion in order to take appropriate actions.

The WP 3 *Consolidation of databases*, under the responsibility of the partner EhF, produces an inventory of the content of the databases and of other sources of information of relevance (algorithm, model...), which are available within the consortium or within institutes outside the consortium and willing to co-operate. For an efficient exploitation and better services, the databases are consolidated. Additional information is incorporated (e.g. temperature), and the time and space coverage is increased, mostly by the means of an appropriate processing of images taken by Earth observation satellites, but also by techniques for the fusion of ground based measurements and satellite-derived assessments or gridded values.

In the WP 4 *Realisation of an intelligent system*, the partner JRC produces three successive prototypes of an intelligent system for the integration and exploitation of diverse networked information sources. It creates a common access point, implemented as an Internet server. These prototypes are capable of extracting the most relevant information, according to the user request. The request may be beyond the content of these databases (e.g., APAR) and the system has capabilities of synthesising the relevant answer from the databases using application-oriented algorithms. The system is flexible and not closed: it is capable of integrating other databases and new application-oriented algorithms.

Advanced exploitation of the databases content is developed in the WP 5 *Advanced information*, under the responsibility of the partner Meteotest. Its objective is to improve the quality, taken in a broad sense, of the delivered information. It takes into account the expression of the user needs. Efforts are put on the assessment of parameters in any geographical location at any time (interpolation schemes), and on the provision of advanced parameters and application-oriented information. Here, advanced parameters denote parameters that can be obtained by the application of a fairly simple algorithm or scheme on the databases and other resources (e.g., direct and diffuse components, illuminance). User-oriented applications denote information that results by performing a sophisticated calculation using the SoDa resources as inputs (e.g., available photosynthetically active radiation (APAR) at sea, potentials of daylight in a room, performance of solar home PV system).

The WP 6 *Customers community* deals with the concerns of the users and ensures the liaison between customers and the project, under the responsibility of the partner iCons. Strong relationships with user communities are established by the means of the participation of users in the project and of involvement of partners into other international and national activities. They are invited to integrate some of their information sources into the services on a voluntary basis. The user communities are encouraged to use the prototype and to gauge it with respect to their best practices. A major task for this WP is the evidence of benefits from the use of the SoDa services and the issuing of conclusions and recommendations for a future service from the users point of view, two key deliverables of the project. They express the success of the project SoDa in achieving certain socio-economic objectives.

They are also a key input in the technology implementation plan, as well as in the marketing and business plans of the partners.

The WP 7 *Dissemination and exploitation*, under the responsibility of the partners Armines and ENSMP, elaborates and proceeds with the exploitation of the knowledge gained during the project. The first activity is to effectively communicate with parties outside the consortium, to create awareness on this project and to disseminate the intermediate or final results by current means (Web site and publications in scientific and technical journals and conferences) and through co-operation with international research programmes in environment. The technology implementation plan describes how the knowledge gained in the course of the project, will be used.

4. Project Results and Achievements

The project SoDa is a real breakthrough in the provision of solar radiation information. It represents a significant step forward beyond the current state of the art and includes substantial original work. The main innovations of SoDa are to offer a smart access to diverse networked sources of information, and to supply the customers with information of high quality. High quality means an improved matching to actual customer needs: the supplied information is relevant to the different user needs and not just raw observed data. It also means an improved access. Finally it means improved time-space coverage and improved time-space sampling. These innovations are based on the use of ICT. The key deliverable is a prototype service, which integrates and efficiently exploits diverse information sources presently available separately (i.e. not networked), of different types and of different formats.

4.1. Scientific / Technological Quality and Innovation

The main result is the availability of the SoDa Web service. The SoDa service: http://www.soda-is.com is made of several services (databases, methods, applications) that are geographically dispersed. The SoDa Intelligent System (IS) realises a smart networking of these services, offering a unique access to the customer. This service is unique in the world and offers an excellent basis for demonstration for a sustainable service. It is a comprehensive source of radiation and meteorological data and has capabilities to include new services (applications or databases) that are geographically dispersed. Its potentials are large and it can be customised to specific usages and specific customers. The features it contains can be improved, extended and refined. Applications are numerous. The SoDa service is a major partner for education of engineers and scientists in the field of the solar radiation. It is used and recommended by, or integrated in, several services and commercial products or existing projects.

The users' evaluations are quite convergent as for the high quality, usefulness, and user friendliness of the service. Users also recognise that the development of SoDa service and of the SoDa IS has been driven by their indications. All users, regardless their application domain or type of organisation, agreed that the SoDa services were highly relevant to their activities and were matching their basic needs.

The SoDa project has, in fact, responded to 90% of the user requirements and suggestions expressed regarding the first prototype. Wherever the implementation was not possible, SoDa has tried to provide alternative solutions. Though SoDa is still considered by many users complementary to other web sources (especially weather bureaus), as they are reluctant to abandon their own routines and adopt those of SoDa, there is nevertheless a growing appreciation in the solar radiation users community on the customer-tailored integrated services offered by the SoDa IS.

Users have declared that SoDa provides an important improvement in their access to information by making available a common access point for information on solar radiation, tailored to their needs, within which different data sets are integrated and linked with spatial properties. This advance constitutes a clear benefit for the efficiency and quality of their activities.

A highly important benefit, specifically for the resource providers, lies in the Soda concept itself. In contrast to many services, in fact, the service SoDa is decentralized. This allows the resources (data, applications) to remain with their owners, an aspect that is highly appreciated by potential providers and by other stakeholder. This is relevant to the cultural and social assessment of the project. By transcending the barrier of "property" for the resource providers, the SoDa project has considerably facilitated the availability of resource providers to link to the Soda network, to the benefit for both the users and the service providers themselves.

Presently, 46 services are available (see following table); the Consortium as planned developed 31. Demonstrating the networking capabilities of the SoDa service as well as its benefits to stakeholders, 15 others were developed on a voluntary basis, 9 of which by the Consortium, 4 by other persons belonging to the SoDa partners but not involved in the project and 2 by third parties.

Table 1. Content of the SoDa Service (Dec. 2002)

Long-Term Time-Series of Data	Daily Irradiation	MARS project - one site – Europe MARS project - an area - Europe Meteosat-derived data – Europe / Africa
	Daily Irradiation and Other Data	NCEP/NCAR reanalysis daily averages
	Other Data	Global, diffuse and beam radiation Global radiation on inclined surfaces - Europe Air temperature Radiation on inclined surfaces and air temperature - Europe Radiation on inclined surfaces and air temperature - World Longwave radiation - Europe Longwave radiation - World Monthly means of net radiation balance - Europe 10-day land surface temperature - Central Europe
Climatological Data and Derived Quantities	Climatological Data	Monthly means of daily global irradiation resulting from interpolation Monthly values of Linke turbidity factor Monthly means of air temperature resulting from interpolation Degree Days below a Base Temperature Degree Days above a Base Temperature
	Simulations of Normal Years	Global, diffuse and beam radiation Global radiation – Inclined surfaces Air temperature Radiation on inclined surfaces and air temperature Longwave radiation
	Other Data and Derived Quantities	Frequency of types of sky - Europe Statistics of hourly irradiation - Europe
Simulation of Radiation under Clear Skies		Position of the Sun in the sky Hourly irradiation for one day Time-series of daily radiation
Solar Energy Systems	Application	Long-term performance of a solar water heater Simulation of solar domestic water heating systems Modeling performance of solar home PV-systems Modeling performance of grid connected PV-systems Slope leading to maximum total irradiation - Europe
Daylighting	Application	Potentials of daylight in a room
Building Engineering	Application	Spectral radiation
Vegetation	Application	Dry matter production Synthetic time-series for crop simulation (not yet active) 10-day vegetation index - Central Europe
Oceanography	Application	Time-series of Photosynthetically Available Radiation (PAR) at sub-surface Vertical profile of PAR for a day
Health	Application	UV irradiation UV irradiation - Europe
Pollution modelling		*ABLE* - A meteorological pre-processor for dispersion codes
Weather forecast		Forecasts by the model BOLAM for Europe (depending on agreement with CNR – Bologna) (not yet active)
Education		Climatology of the solar radiation over Europe
"Hidden" resources	(available but not listed in the HGSS directory)	Elevation from the database GTOPO30 (30" resolution, Europe) Elevation from the database TerrainBase (5' resolution, world) Elevation profile from the database TerrainBase (5' resolution, world)

4.1.1. Web Technologies for Distributed Resources Networking

Realisation of a Web server for the dissemination of solar radiation-related information

The Web server SoDa: http://www.soda-is.com, permits an access to very valuable and sometimes unique information on the solar radiation that is available at ground level. It comprises measurements and assessments made from satellite images and simulations of radiation under clear-skies. Algorithms can be launched that converts the global irradiation into its direct and diffuse components, possibly on

inclined slopes or for specific spectral ranges. Applications are available for the sizing of solar energy systems or for primary production or for daylighting in building etc.

This service is unique in the world and offers an excellent basis for demonstration. It is a comprehensive source of radiation and meteorological data and has capabilities to include new services (applications or databases) that are geographically dispersed. Its potentials are large and it can be customised to specific usages and specific customers. The features it contains can be improved, extended and refined. Applications are numerous. The SoDa service is a major partner for education of engineers and scientists in the field of the solar radiation.

SoDa Middleware Software - Development of Web tools and XML schema for the co-operation of distributed services - Development of Web tools for service discovery
The software system, which drives SoDa, allows the connection of disparate remote databases and services over the Web. In SoDa this is used to create a single portal allowing a unified interface to both data and algorithms hosted by the SoDa partners at their sites. The design choices made to implement SoDa have proved the correct ones as they are fully compatible with the emerging web services standards of W3C. The software is written in JAVA and uses XML message passing to invoke the remote services. The directory information is held in XML and allows for the dynamic configuration of the client side GUI. This is very important to provide the user with a single look and feel. Furthermore it is possible to "chain" services meaning that the output of one service can be used as input to another service. This is something unavailable in any other system we are aware of.

The SoDa Middleware Software (written in JAVA) is being implemented on LINUX platform and will be released under an open source license for wide dissemination. It was adopted by the EC project DISMAR for benchmarking and as basis for some development. It is also used in the framework of the Global Monitoring for Environment and Security (GMES° programme.

4.1.2. Information Science (Image Processing, Data Fusion)

A fast method (incl. software and Web service) for the spatial interpolation of point data
A method to be executed on fly through a standard Web browser for the interpolation of climatological data. The algorithm (published) is based on a distance that takes into account the anisotropy of the atmospheric dynamics (latitudinal effects) and the elevation.

This algorithm is integrated into a commercial product: Meteonorm v. 5 by the partner Meteotest, in agreement with the owner of the result (Armines/ENSMP).

A method for the production of net radiation balance
A method and a FORTRAN program package was developed for the calculation of the net radiation balance for Europe using images form the satellite Meteosat and atmospheric profiles delivered by the ECMWF (European Centre for Medium-range Weather Forecast). The method can be extended to other parts of the world. Publication is available.

A method (incl. software) Heliosat-II for the assessment of global irradiation from satellite images
Satellite images, such as those taken by the series Meteosat, can be converted into images of the global irradiation available at ground level. The method Heliosat-II is follow-on of the previous versions. It is easier to implement, more robust with respect to changes in sensors or acquisition material, and offers a better quality in retrieval. Scientific publication is available. Software (libraries in C) as well as documentation (50 p.) is available as well as on the server http://www.helioclim.net.

The method was adopted by the EC project Heliosat-III for benchmarking and as basis for some development.

A method (incl. Web service) for the automatic calibration of satellite images in the visible range
Space-borne imaging sensors in the visible range rarely possess an internal calibration system. A method is proposed for the in-flight calibration of images taken by meteorological geostationary satellites that is based upon the analysis of each image. Two peer-reviewed articles were published.

The proposed method has been applied to thirteen years of images taken by the Meteosat satellites on an operational basis and has been validated against concurrent results. Results are available for each day through a Web site: http://www.helioclim.net. The principles of the method can be applied to other space-borne sensors and also to other optical imaging sensors.

A method for the synthesis of gridded data at a higher spatial resolution by fusion of various modalities
In climatology and other domains, data are available in a gridded format with a coarse spatial resolution. Examples are worldwide maps of ozone content, water vapour or aerosol optical thickness. Other data that have links, direct or indirect, with the parameters of interest, and that are available at a better spatial resolution, can be used by the means of fusion methods to synthesize the original gridded data of interest at a better spatial resolution. Publications are available.

The method is based upon a series of libraries that can be assembled to provide a method suited to many applications, even outside climatology. It can be performed on images or gridded data. It is adopted by the EC project Heliosat-III for the production of maps of optical properties of the atmosphere.

4.1.3. Environmental Algorithms

A set of algorithms (incl. Web service) for the production of solar radiation and temperature quantities derived from global irradiation measurements
A set of algorithms based on known methods of proven quality and whose assemblage offers the best quality available presently. The "concurrent" families of algorithms for computing advanced parameters from meteorological measurements of the *de facto* standards established by the commercial products ESRA and Meteonorm were merged in a synergistic way, together with other advanced elements found in recent publications, forming a new standard in the modelling of solar radiation parameters. Publications are available.

A fast method (incl. Web service) for producing normal years of meteorological data
Normal years are a series of typical values of meteorological data that are useful for simulation of solar energy systems. This method permits to generate such normal years for any geographical site. Publications are available.

A method (incl. Web service) for assessing UV irradiation from global irradiation measurements
Solar irradiation measurement is usually performed in a broadband range. This method permits to derive the UV part of the irradiation in several spectral ranges: UV-A, UV-B, erythemal. Publications are available.

A refined version (incl. software and Web service) of the clear-sky model proposed in the European Solar Radiation Atlas
Modelling the broadband solar irradiation under clear-sky is an important task in many applications. This model is a refined version of that of the European Solar Radiation Atlas (ESRA). It has been widely tested and its applicability worldwide was demonstrated. Publications are available.

It is available as downloadable free software in C (http://www.helioclim.net). It can be run through the Web SoDa service. It has been adopted by the company Alcatel Space for its simulators of landscapes in infrared.

These four above-mentioned algorithms are integrated into a commercial product: Meteonorm v. 5 by the partner Meteotest, in agreement with the co-owners of the results.

A method for using meteorological data for the verification of the weather forecast mode BOLAM
This document is an example for meteorological community of application of the SoDa service. It contains a description of the verification of capacities of BOLAM model to predict solar global irradiance using Meteosat-retrieved data.

The result demonstrated the benefits of the SoDa service over standard practices. Publications are available.

A method (incl. Web service) ABLE – a meteorological pre-processor for dispersion code
ABLE is an algorithm for the calculation of mixing height and other meteorological quantities useful for the run of atmosphere dispersion codes. The integration of ABLE within the SoDa service provides the user with an easier calculation of these quantities and allows the direct exploitation of SoDa database for the solar information needed by ABLE.

The result demonstrated the benefits of the SoDa service over standard practices. Publications are available.

A method (incl. database) for the production of half hourly temperatures coherent with half hourly irradiances available from the European Database of Daylight and Solar Radiation
This method produces half hourly temperatures coherent with half hourly irradiances available from the European Database of Daylight and Solar Radiation. It results into a database that is exploited by the SoDa service. Publications are available.

A method (incl. Web service) SODALIGHT for the assessment of the potential of daylight in a room
This daylighting application service (SODALIGHT 1.0) allows evaluating the potential of daylight in a room defined by the user, at a location specified by the user. Further refinements will include a more sophisticated description of the room and the orientation of the walls. This would be an operational tool for architects for the design and sizing of windows. Publications are available.

Methods for the production of land surface temperature and vegetation index
Two methods were elaborated: first one for the calculation of the atmospherically corrected Normalised Differential Vegetation Index for Central Europe using NOAA AVHRR images and ECMWF data. Second method is suitable for the calculation of the Land Surface Temperature for Central Europe using NOAA images and ECMWF data. Two databases were constructed that are exploited by the SoDa service. Publications are available.

Methods (incl. Web service) for the assessment of the photosynthetically available radiation (PAR) at sub-surface of the ocean
The photosynthetically available radiation (PAR) is a key component for the primary production in the ocean and other water bodies. Methods were devised and implemented in the SoDa service for the assessment of the PAR at sub-surface (including vertical profile) for the European and African regions.

This service is a valuable tool that offers a unique knowledge on the PAR for any geographical site in Europe and Africa. It was developed in cooperation with the company HyGeos and the French University du Littoral. Publications are available.

4.1.4. Databases

Three databases for radiation balance, land surface temperature and vegetation index
First database is a 5-year database of monthly and annual average net radiation balance for Europe (1992-96) with a 0.25-degree resolution in latitude and longitude. Second database includes 10-day NDVI composite data for Central Europe for the period 1996-98 with whole NOAA resolution (1.3-1.5 km). Third database contains 10-day composite LST data for Central Europe for the period 1996-

98 with whole NOAA resolution (1.3-1.5 km). These databases are exploited by the SoDa service. Publications are available.

In the future, the databases may be extended to other parts of the world. They can be used for specific usage, e.g. agronomy and crop prediction.

Extension from 2 to 5 years of the European Database of Daylight and Solar Radiation based on Meteosat images

Extension from 2 to 5 year of the European Database of Daylight and Solar Radiation based on Meteosat images (2 years were available as part of the Satellight European project). This database is exploited by the SoDa service for application in daylighting. Publications are available.

Database containing climatological values of parameters in relation with atmospheric optics

The Linke turbidity factor characterises the optical purity of the clear atmosphere seen from ground level. This parameter is a combination of the water vapour content and the aerosol optical thickness. It is a key input to many methods used for simulation of the solar radiation or for the assessment of the diffuse and direct components of the radiation starting from measurements of global irradiation. This factor is presently available at a limited number of sites. Twelve maps (one per month) of this factor were constructed offering a worldwide coverage and a grid cell of 5' (approx. 10 km at mid-latitudes). The accuracy (rmse) is 0.7. A fusion method was employed. Publications are available.

The database is exploited by the SoDa service. It is available either through the Web service SoDa or at reproduction costs at Armines / ENSMP (Les Presses), in agreement with the co-owner Meteotest. The commercial product Meteonorm v. 5 by Meteotest, in agreement with the co-owner Armines/ENSMP, also exploits this database.

Database containing statistical values on solar radiation and temperature over Europe

Production of pre-computed statistical results (min, max, average, difference between years) regarding solar radiation, daylight and temperature. This database is exploited by the SoDa service. Publications are available.

Database containing global irradiation assessments for Europe and Africa since 1985

Satellite images provided by the series of Meteosat satellites were processed by the means of the method Heliosat-II to produce assessments of the global irradiation for Europe and Africa since 1985 onwards. Theses assessments were compared to ground measurements and proved to be of very good quality.

This database is unique in the world. Combined to available exploitation tools, it offers a very valuable knowledge on the solar radiation available at ground level. It is currently expanding in collaboration with Eumetsat and should integrate Meteosat Second Generation in collaboration with DLR and the partner EhF. This database is exploited by the SoDa service. Publications are available.

Database on orography for the world, based on TerrainBase
The digital terrain model, TerrainBase, has been transformed for its specific usage within the SoDa service. Especially, water bodies have elevation equal to 0 and there is no negative elevation. This database is exploited by the SoDa service. This database is disseminated by Armines / ENSMP (Les Presses) together with the database of the Linke turbidity factor.

4.1.5. Miscellaneous

Structuration of efforts and activities of major European partners involved in provision of solar radiation information
European providers of solar radiation information have collaborated for the development of a service. Mutual awareness has grown and several methods have been developed together. The team is functioning well and collaboration is on going after the end of the project SoDa.

The team offers a very valuable knowledge on solar radiation and its properties as well as on means to collect information, on how to network dispersed resources and how to disseminate the information through the Web.

Survey of the market, present status and expectations
The exploitation perspective of a Web-based service delivering information on solar radiation was assessed. Several scenarios were studied. It was concluded that presently the market is not ready for such a service and that the service should evolve to better reach the expectations for each market segment. A scenario based on a partly free, partly commercial service is recommended. This result was used for decision-making as for the strategy of each partner and of the Consortium.

Furthermore, a methodology was developed for assessing the value and perspective of a Web-based commercial service that can be re-used.

A bi-lingual service providing educational material on climatology of the solar radiation over Europe
HTML pages were developed that describe in English and French, the climatology of the solar radiation over Europe. The target is students in the first years of the University cursus in geography. These pages are accessed *via* the SoDa service.

We possess a high quality content and the collaboration with the University of Paris I permits very valuable tests. Collaboration between this university and Armines/ENSMP is on going for e-learning development.

4.1.6. Contributions to standards

The project contributes to standardisation in Web technologies by building its prototype on proven key technologies: HGSS and XML, such contributing to increase the global expertise. The project followed the Dublin Core for XML.

By validating an automatic calibration procedure for broadband optical sensors and publishing it, the project contributes to the standardisation in procedures for in-flight calibration of visible space-borne sensors, a critical issue for low-cost sensors.

The method Heliosat-2 is an improved unification of several previous methods, in use in several places in Europe and worldwide. The method is significantly more accurate and has firm explicit physical backgrounds, which may further enhanced. Performing this unification is a step forward standardisation in processing of data from the geostationary satellites for mapping the global radiation. Many users of previous methods will adopt it, thus dramatically increasing the share of expertise. An effort is being made towards the Comité International pour l'Eclairage for preliminary steps in adopting this method as a standard.

In the domain of information and environment, we propose a new distance that can be used in any of the standard interpolation methods and that provides better results.

The method for the fusion of gridded values having various spatial resolutions, may be applicable to other domains, outside environment.

The model for the irradiation under clear-skies has been widely tested and its applicability worldwide was demonstrated.

The "concurrent" families of algorithms for computing advanced parameters from meteorological measurements of the *de facto* standards established by the commercial products ESRA (Armines/ENSMP) and Meteonorm (Meteotest) were merged in a synergistic way, together with other advanced elements found in recent publications, forming a new standard in the modelling of solar radiation parameters.

Using benchmarks, SoDa has proven the benefits of using fine-scale gridded values in global radiation for detailed weather forecasting at local area, and for accurate forecasts of air quality in cities. Recommendations will be issued to the community of modellers, a preliminary step towards standardisation in approaches.

Finally, establishing co-operation with other EC funded projects contributes to standardisation, by sharing knowledge and best practices.

4.2. Community Added Value and Contribution to EU Policies

The Consortium comprises all the necessary expertise in a complementary way with little redundancy in the various domains covered by the objectives: solar radiation, databases, networking, image processing, applied mathematics, WWW-based technologies and services, customers needs and satisfaction assessment, information and communications technologies, market assessment and development of business plan for products and services. It comprises companies, research institutes, potential users as well as vendors of existing solar radiation databases. The community added value is expressed through a large pan-European co-operation between companies, research institutes, and environmental authorities. The project offered opportunities to partners located in Western, Southern, Central and Eastern Europe to work together, increasing their mutual knowledge in scientific approaches, and also in the cultural heritage of the diverse Europe. This cross-cultural multi-lingual environment in turn benefited to the project and will benefit to the present SoDa service.

The ICT and the Earth observation from space are recent technical sciences developed in the last twenty years or so, and evolving rapidly with the impulse of new technologies and new applications. The SoDa project contributes to disseminate this knowledge on a multi-disciplinary basis, encouraging *Closer co-operation and "Flexibility"* as suggested in the Amsterdam Treaty.

The SoDa project contributed to increase awareness of the pan-European expertise and created links that will result in further collaboration.

The project has contributed to several EU regulations / directives, as follows.

Because it offers unique and valuable information of solar irradiation, it contributes to

- the Common Agriculture Policy (assessment of crop yield and monitoring),
- monitoring aquaculture and quality of water for fish-breeding (Council Regulation No 1181/98 of 4 June 1998 and Directive 91/692/EECof 23 December 1991),
- monitoring quality of drinking water, surface freshwater and bathing water (Directives 98/83/EC of 3 November 1998, 91/692/EEC of 23 December 1991 and 91/692/EEC of 23 December 1991),
- monitoring air ambient quality and assessing pollutants ceilings (Directive 96/62/EC of 27 September 1996, and 2001/81/EC of 23 October 2001),
- combating pollution (Directive 96/61/EC of 24 September 1996), helping the EEA to better assess the state of the environment (Regulation No 933/1999 of 29 April 1999) and the effects of certain plans and programmes (Directive 2001/42/EC of 27 June 2001),
- promoting renewable energies (Directive 2001/77/EC of 27 September 2001) and energy efficiency and certification of buildings (Proposal for a Directive of the European Parliament and of the Council of 11 May 2001 [COM (2001) 226], Directive 93/76/EEC of 13 September 1993),

The geographical coverage offered by the SoDa service is worldwide and this contributes to the co-operation with third countries for the formulation and implementation of energy policy (SYNERGY program: Council Regulation No 2598/97 of 18 December 1997).

The SoDa service ensures freedom of access to information on the environment (Directive 90/313/EC of 7 June 1990).

The project support the following international regulations: the Energy Charter Treaty and Energy Charter Protocol on energy efficiency and related environmental aspects, the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the Partnership Agreement signed in Cotonou (2000) and the UN Convention (Aarhus Convention) on access to information, public participation and access to justice in environmental matters.

The results of the project contribute to several policies of the EU, such as the Common Agricultural Policy and the Common Fisheries Policy. They support the Community actions in the field of public health (Decision No 521/2001/EC), in energy and rational use of energy, including the Euro-Mediterranean cooperation on transport and energy and the cooperation with third parties (Decision 1999/22/EC). They help in integrating the environment into Community energy policy and the energy dimension of climate change. They support the Community environmental policy "Environment 2010: Our future, our choice" and help in implementing the European Climate Change Programme and the Community post-Kyoto strategy. The environmental dimension into the urban environment will be better integrated (Decision No 1411/2001/EC). The project supports the Community policy "Towards a global partnership for sustainable development" and the strategy for sustainable development. It also supports the multiannual programme for enterprise and entrepreneurship, and in particular for SMEs (Decision 2000/819/EC) and helps several of them to "go digital" (COM/2001/136 final). It contributes to the growth of electronic commerce in Europe and helps in bringing the benefits of the information society within reach of all European citizens, thus supporting realising European policies for the knowledge society as reflected in the e-Europe Action Plan.

4.3. Contribution to Community Social Objectives

The SoDa service contributes to improving the quality of life in the community because it helps in better understanding and monitoring appearances of skin cancer due to solar irradiation and helps in promoting mitigation regulations and advices, thus improving health care in Europe.

The SoDa service helps in a better sizing of window architecture in buildings, thus contributing to *i)* a better use of daylight in buildings with a proven impact on human health and spirit, and *ii)* savings in energy.

The SoDa service helps European companies and customers in sizing their future solar energy system for domestic purposes. This will increase the market for solar energy systems. Increasing the market of solar energy systems for individual houses participates to the improvement of the quality of life in the European Community, and the SoDa service participates to this improvement.

The project SoDa contributed to efficiency in RTD, which has been noted as one of the major factors for developing sustainable employment in Europe (communication COM (98) 718 of the European Commission to the Council, the European Parliament, the Committee of the Regions and the Economic and Social Committee).

This project strengthens the competitiveness of Europe, leading *inter alia* to a strengthening of employment in the activities related to solar radiation: industries, agriculture, services, research. New knowledge will be applied more effectively in existing industries, resulting in an increase in competitiveness of these industries in an international market where Europe already plays a major role. This increase of knowledge of engineers and managers in such a developing market will stimulate the creation of new-added value enterprises, and stimulate the supply / delivery of value-added information from companies to customers, which better meet the needs of the customers

The knowledge / expertise / tools gained in the course of this project help the companies / institutes commercially offering solar radiation or ICT tools, techniques, methods and services, to strengthen the position of Europe in the world by the use of advanced information and communication technologies. The exploitation of this expertise also leads to the improved awareness of the European citizen of the role of solar radiation as the key force in global sustainability, and to the dissemination of a better knowledge on solar radiation with the consequent enhancement of the quality and health life, the

preservation and/or enhancement of the environment and the improvement of employment prospects in the EC.

Delivering high quality information on solar radiation is instrumental for several companies which use this information in sophisticated way to deliver services in various domains such as air quality in urban areas, impact of climate changes on agricultural practices, on building technologies, on urban planning and zero-emission policies, or on materials weathering (especially polymers). The better the inputs, the better the services to the customers. By delivering high quality tailored information, the SoDa service contributes to an increase of efficiency of European companies. This enforces their position and result in improvement of several aspects of the social life, from quality of life to employment. The advanced information available through the SoDa service will lead to a development of the skills of engineers and researchers in several domains.

Several results (the service itself, Web technologies, databases, algorithms, methods) are expected to become *de facto* international references and this will contribute to the promotion of European skills.

The proposed system that should spread with electronic commerce is distance and language-independent, and supports a service handling for all EC citizens. This will favour interactions between all specialists in multi-disciplinary fields, ensuring that the needs of individuals and enterprises are met. It contributes to the knowledge society as reflected in the e-Europe Action Plan.

Individual houses are consuming, in the European Community, about 20 % of primary energy. Each new solar system installed in Europe is able to save half of the energy needs for each individual house. Larger solar energy systems are being implemented and the accurate knowledge of the solar resource is a key element for their sizing and their funding. This will be a major participation to the supporting of sustainable development, and the substitution of classical fuels by solar energy will participate also in the conservation of natural resources. This is true in Europe and in other parts of the world, since SoDa has a worldwide coverage.

This accurate knowledge of the properties of the solar irradiation plays a role in the analysis and modelling of the photochemical transformation of air primary pollutants into secondary nocive pollutants that affects human health, especially in urban areas, but also preservation of cultural heritage.

This role also holds in the analysis and modelling of

- the eutrophication of waters, with impacts of drinking water, bathing water and fish-breeding waters,
- the vegetation primary production, especially in horticulture with a better management of the energy used in greenhouses, and agriculture with a better practice in the fertilizer usage.

4.4. Economic Development

The SoDa service is a relevant, useful and appreciated service which its users have encouraged to go on. It needs some improvements to match the needs of its community and further applications for new users' groups. The improvements needed have been identified clearly as well as the actions planned to implement them and to broaden the service.

SoDa is nevertheless a young service that still has to put in place a number of actions to create and/or stimulate the demand. There are two main aspects that need to be taken into consideration regarding further action: the awareness in the market on the SoDa service and the readiness of the users to use web-based services.

The users base reached by the consortium is really interested, but SoDa is not well known outside the nearby community. SoDa has contributed to the knowledge in solar radiation but the market needs to grow both in size and awareness about the potential to exploit in this field. There are also new market niches to seize that the consortium has identified and are in course of exploitation. The strong positioning of the alternative sources of information and the presence of subsidized/free climate data products place suggest that SoDa will need to emphasize the uniqueness of its feature to gain the market.

At the same time the overall demand for environmental service is probably not yet fully mature for on-line only services. Meteotest, partner of the Consortium, has decided to proceed with its CD product and to publish the version that includes several outcomes of SoDa.

All these considerations suggest that market efforts need to be increased; in particular it will be necessary to enhance the communication about quality and origin of data and to put in place promotion and communication actions, to stimulate the demand for specific services and to promote the delivery via web. The lacking of actions of this kind have been identified as weakness points of the offer so far, but they would have probably been useless if put in place before the full deployment of the service and before creating the right market conditions. Therefore they should be seen more as suggestions for the future rather than lack of actions in the past. In fact, the Consortium is already implementing actions in this field.

For the market growth of SoDa, also broadening and strengthening of collaboration and cooperation agreements is needed. With respect to this, new contacts with service providers and user communities (projects) have been established or are in discussion. It can also be expected that SoDa will benefit of the word of mouth effect but this will require time to take place.

In conclusion, the basis is laid, improvements have been planned but SoDa is too young to launch itself on the commercial market at the end of the project.

The consortium came to the conclusion that SoDa will hold on for a year on a voluntary basis, with the support of private funding provided by the organisations that are part of the consortium. It was decided that the consortium would maintain the service during at least one year as it is with possible refinements of resources or addition by the Consortium or other providers. During this period the operational conditions will be regulated according to the legal and administrative provisions of the SoDa contract, its amendments and the consortium agreement.

Several activities are running:

- refinement of the GUI (Graphical User Interface) with particular emphasis on the graphical representation of the geographical information. The effort is on the geospatial search, the GeoSearch tool, an OpenGIS WMT tool, which needs corrections and refinements. Another feature to be added is a gazetteer for the whole world, for searching by names of sites, instead of mouse clicking or geographical coordinates. This is performed by the partner Armines/ENSMP, in collaboration with the partner JRC and a third party, the Institut des Applications Avancées de l'Internet, in Marseille, France,
- creating awareness on the service and its content for the adoption by customers, including publications,
- refinement of databases and some applications,
- analysing the opportunities and elaborating strategies to seize the identified niches.

The consortium feels that in one year time the market conditions will have evolved favourably, SoDa will have got enough references and therefore it will be possible to decide on if and how to enter the market.

A meeting will be held in January 2004 to decide how to proceed according to the experience gained and the state of the market.

5. Deliverables and Other Outputs

5.1. Deliverables

Deliverable Code & Name	*Planned delivery date*	*Actual delivery date*	*Comments*
MANAGEMENT			
D1-1. Project presentation	Mar. 2000	Mar. 2000	
Annual Progress Report for Year 2000	Feb. 2000	Feb. 2000	*incl. Cost Statements*
Quarterly Monthly Report # 1, 2, 3, 4	2000	2000	
Annual Progress Report for Year 2001	Feb. 2001	Feb. 2001	*incl. Cost Statements*
Quarterly Monthly Report # 5, 6, 7, 8	2001	2001	
Annual Progress Report for Year 2002	Feb. 2002	Feb. 2002	*incl. Cost Statements*
Quarterly Monthly Report # 9, 10, 11, 12	2002	2002	
Final Report (D7-4)	May 2003	May 2003	*incl. Cost Statements*
ASSESSMENT AND EVALUATION			
D2-1. Monitoring Plan	Aug. 2000	Apr. 2001	*Revised Version*
CONSOLIDATION OF DATABASES			
D3-1. Inventory of Information Sources	February 2000	April 2001	*Revised Version*
D3-2. Heliosat version 2	Nov. 2000	Apr. 2001	*Report has been delayed to integrate more results.*
D3-3. Database "orography"	Jun. 2001	Jun. 2001	*Documentation of resource and service (WP 5.3o)*
D3-4. Database "Linke turbidity"	Oct. 2001	Jan. 2002	*Report and database and resource (WP 5.3q)*
D3-5 Net radiation database for Europe. Activities of WP 3.3c and WP 5.3l	Dec. 2001	Dec. 2002	*Report, database and resource*
D3-6 Atmospherically corrected NDVI and surface temperature maps retrieved from NOAA/AVHRR data	Mar. 2002	Oct. 2002	*Report, database and resource*
D3-7 Temperature Information Database	Jun. 2002	Dec. 2002	*Report and database*
D3-8 and D5-1-4, Joint Report on the Meteosat climatology, including the outcomes of WP 5.3f and 5.3r	Dec. 2001, May 2002	Jul. 2002	*Report, database and resource*
D3-9 and D5-1-3 Joint Report on Interpolation Scheme "Climatology", Database "Climatology II" and resource "Climatology"	Dec. 2001, Mar. 2002, May 2002	Jan. 2003	*Report, database and resource*
D3-10 Database Meteosat-derived cloud indices for solar radiation	Jun. 2002	Feb. 2003	*Report (database is available since March 2002)*
D3-11 High resolution solar radiation information database	Jun. 2002	Dec. 2002	*Report and database*
INTELLIGENT SYSTEM			
D4-1. SoDa XML Schema	May 2000	Apr. 2001	*Revised Version*
D4-2. 1st Prototype of the SoDa Service, including documentation: *(i)* Overview of the Web site, *(ii)* Overview of the Prototype, Architecture and Design, *(iii)* Specification of SoDa XML, *(iv)* Description of the Potential Resources of the SoDa Service	Jan. 2001	Apr. 2001	*It comprises several resources, including external contributions*
D4-3. Documentation of the 2nd version of the Intelligent System of the prototype of the service SoDa	Dec. 2001	Jan. 2002	*Prototype and documentation*

D4-4 Final version of the prototype service, including description of resources and related documentation	Oct. 2002	Jan. 2003	*Prototype and documentation*
D4-5. Update of the Documentation of the 1st Prototype.	Jun. 2001	Dec. 2001	
ADVANCED INFORMATION – Interpolation Schemes			
D5-1-1. Interpolation scheme (profile)	Jun. 2001	Jul. 2001	*Report and resource (WP 5.3m)*
D5-1-2. Interpolation scheme "temperature"	Dec. 2001	Jan. 2002	*Report and resource*
D5-1-3, cf. D3-9			
D5-1-4, cf. D3-8			
ADVANCED INFORMATION – Advanced Parameters			
D5-2-1. Advanced parameters "turbidity"	Aug. 2001	Jan. 2002	*Report and database*
D5-2-2 (joint with D5-2-3), 2nd version (revised), including the activities and outcomes of WP 5.2b and WP 5.3d, j, k, n	Nov. 2001	Jun. 2002	*Report and resources*
D5-2-4. Advanced parameters "temperature generation"	Oct. 2001	Jan. 2002	*Report*
D5-2-5 Advanced Parameters "Spectral Model" - Joint Report on Activities in WP 5.2d, WP 5.3j and WP 5.3k	Dec. 2001	Dec. 2002	*Report and resource*
D5-2-6 Algorithm for satellite based computation of net radiation for the region of Europe	Sep. 2001	Aug. 2002	*Report*
ADVANCED INFORMATION – User-oriented Applications			
D5-3-1 Weather Forecast	Mar. 2002	Feb. 2003	*Report*
D5-3-2 "ABLE: a meteorological pre-processor for dispersion codes"	Mar. 2002	Sep. 2002	*Report*
Documentation of Resource and Service, WP5.3c "SODALIGHT 1.0, a daylighting service for SoDa"	Dec. 2001	Dec. 2001	*Report and resource*
Documentation of Resource and Service, WP5.3g "Grid PV"	Apr. 2002	Feb. 2003	*Report and resource*
Documentation of Resource and Service, WP5-3h "Solar Home system"	May 2002	Jun. 2002	*Report and resource*
Documentation of Resource and Service, WP5.3i "Water Heater"	May 2002	Feb. 2003	*Report and resource*
Report on WP 5.3s "Vegetation"	Mar. 2002	Dec. 2002	*Report and resources*
CUSTOMERS COMMUNITY			
D6-1. User Requirements	Mar. 2000	Oct. 2001	*Report – Rev. Version*
D6-2 Conclusions and Recommendations from Users	Oct. 2002	Feb. 2003	*Report*
D6-3 Update of SoDa User Requirements	Mar. 2002	Jul. 2002	*Report*
DISSEMINATION AND EXPLOITATION			
D7-1 WWW pages describing the project	Jan. 2000	Jan. 2000	*Web site*
D7-2 Dissemination and Use Plan	Jun. 2000	Jun. 2000	*Report*
D7-3 Towards a Sustainable Commercial Service	Oct. 2002	Feb. 2003	*Report*
D7-4 Final Report	May 2003	May 2003	*Report*
D7-5 Technology Implementation Plan	May 2003	May 2003	*Report*
D7-7 Commercial Solutions	Jun. 2002	Jul. 2002	*Report*

5.2. Synthesis of Dissemination and Promotional Activities

Number of articles (peer-reviewed) / books published	6
Number of articles submitted	5
Number of articles in preparation	4

Number of international conferences attended by the project (2000-2003)	29
Number of communications presented to these conferences	36
Number of downloadable softwares (free, OpenSource)	6
Number of workshops and meetings organised or co-organised by the project	9

5.3. The Web Site - Software

The Web site of the SoDa project has been, and is, an important means of dissemination for documents and software. This site is the same than for the service.

Several documents were made public, including drafts of submitted articles, abstracts of documents published in journals or proceedings of conferences. Some of the reports of unrestricted access were made available that provide valuable results before their submission to journals.

Software was made available in December 2002. It comprises several libraries describing the solar geometry, the satellite geometry and the SoDa clear-sky model, as well as the method Heliosat-2. For the period December-January, the solar geometry software has been downloaded 74 times and the others approximately 30 times.

The solar geometry is also the subject of an applet, a resource of the SoDa service provided by a person of ENSMP outside the project. This applet can be downloaded (French or English). By writing some links, the SoDa project permitted to increase the downloading of this applet by a factor of three. The average amount of downloading is approximately 100 per month.

The software of the Intelligent System is now an OpenSource.

5.4. Articles Published , Press Coverage

Date and Type	***Details***
SoDa information leaflet in German language, to be finished in January 2003	Resulting from the experience with EST and other test users in Germany, the benefits of an information leaflet in German language were recognized. The leaflet will give a short introduction to SoDa and present two examples step by step
2000, Article, Published, Int. Solar Energy Society.	Rigollier C., Bauer O., Wald L., 2000. On the clear sky model of the 4th European Solar Radiation Atlas with respect to the Heliosat method. *Solar Energy*, 68(1), 33-48.
2000, Article, Published, Taylor & Francis.	Lefèvre M., Bauer O., Iehle A., Wald L., 2000. An automatic method for the calibration of time-series of Meteosat images. *International Journal of Remote Sensing*, 21, 5, 1025-1045.
2001, Article, Published, International Solar Energy Society & Elsevier	J. Page, M. Albuisson, L. Wald, 2001. The European Solar Radiation Atlas: a valuable digital tool. *Solar Energy*, 71, 81-83. This article presents the European Solar Radiation Atlas; it also shows how such Atlases evolve from books to CD-ROMs and then to services like SoDa.
Article published in a peer-review international journal, 2002, American Meteorological Society	Rigollier C., Lefèvre M., Blanc Ph., Wald L., 2002. The operational calibration of images taken in the visible channel of the Meteosat-series of satellites. *Journal of Atmospheric and Oceanic Technology*, vol. 19, no 9, pp. 1285-1293
Article published in a peer-review international journal, 2002, Int. Solar Energy Society.	Geiger M., Diabaté L., Ménard L., Wald L., 2002. A web service for controlling the quality of measurements of global solar irradiation. *Solar Energy*, vol. 73, no 6, pp. 475-480.
Dec. 2002. Article submitted in a peer-review international journal	Diabaté L., Remund J., Wald L., Linke Turbidity factors for several sites in Africa. Submitted to *Solar Energy*, Dec 22
Jan 2003. Article submitted in a peer-review international journal	Page J., A site elevation based methodology for the estimation of the Linke turbidity factor. Submitted to *Solar Energy*
Jan 2003. Article submitted in a peer-review international journal	Page J., The relationship between the Angstrom turbidity coefficient and Linke turbidity factor at sites of different elevation with different amounts of precipitable water vapour in the atmosphere. Submitted to *Solar Energy*
Jan. 2003. CD-ROM in preparation	UV calculations and applications (UMIST)
Mar. 2003. In preparation	Chapter on Solar Radiation Climatology. In Practical Handbook of Photovoltaics: Fundamentals and Applications, T. Markvart and L. Castaner (eds), Elsevier, Oxford, to appear in June 2003.

May 2003. In preparation, Energy International Agency	The Availability of Irradiation Data. D. Mayer, L. Wald, First Draft presented at Energy International Agency, Task II – Operational Performances of PV Systems, Wien, Austria, September 2002.
May 2003. Article submitted in a peer-review international journal. In preparation	Diabaté L., Blanc Ph., Wald L., Solar radiation climate in Africa. To be submitted to *Solar Energy*
In 2003 and early 2004	Four articles, already in preparation, about the method Heliosat-II for the mapping of solar radiation and the resulting database HelioClim accessible through the SoDa service.

5.5. International Conferences Attended/Foreseen by the Project

Date	***Title***	***Comment***
Apr. 2000	European Geophysical Society	1 presentation (L. Wald)
Apr. 2000	EOGEO 2000	Presentation of OpenGIS & HGSS developments made at JRC (C. Best)
May 2000	IST concertation meeting, Brussels	1 presentation (L. Wald). 4 from the Consortium + contacts with potential customers, and potential partners on technical matters. A proposal, named CLUSDAF, was made to the EC for a clustering of several projects on data fusion and was rejected.
Jun. 2000	IN-WIND-2000	2 communication (C. Ratto)
Jun. 2000	EuroSun 2000	2 presentations (C. Rigollier, D. Heinemann)
Nov. 2000	IST conference, Nice, France	2 attendees from the project (M. Martinoli, E. Gaboardi)
Jun. 2001	CIE (Commission Internationale de l'Eclairage) division 3 meeting and the Lux Europa Conference, both held in Reykjavik, Iceland	The CIE is the International Commission of Illumination, its division 3 focuses on interior lighting. The Lux Europa conference is the major international conference on lighting and daylighting organised by CIE. Presentation of the project SoDa (D. Dumortier).
May 2001	EARSeL Symposium, Paris, France	EARSeL (European Association of Remote Sensing Laboratories) is one of the major associations in the world for remote sensing. Presentation of the project SoDa (L. Wald).
Jun. 2001	14th Workshop "Simulation of Solar Energy Systems - PV meets Thermal and Light", Oldenburg, Germany	Presentation of the project SoDa (D. Heinemann). Potential SoDa users from 21 German institutions and engineering companies attended this meeting.
Sept. 2001	EO Week, EC, Brussels	Organised by the European Commission, programme EESD. Preparation of the activities in remote sensing and environment, including GMES, for the next years. Presentation of SoDa (L. Wald). Awareness of the SoDa technologies that can be re-used.
Sep. 2001	IST Clustering meeting, Brussels	Presentation of the project SoDa. Emphasis on the standardisation issues (L. Wald)
Sept. 2001	European Society for Photobiology, Lillehammer, Norway	Presentation of the project SoDa (A. Webb) with emphasis on UV
Nov. 2001	2001 Solar World Congress, Adelaide, Australia	Communication "Satellite-Based Techniques for the Retrieval of Solar Radiation Data - A Review of Current European Activities" (D. Heinemann)
Mar. 2002	32nd Plenary Assembly of the French Meteorological Council (Conseil Supérieur de la Météorologie)	Approx. 200 attendees, including the Ministry of Equipment and the Director of Meteo-France. Informal presentation of the SoDa activities, especially relating to health (L. Wald)
Apr. 2002	22nd Assembly of the European Geophysical Society, Nice, France	Approx. 6800 attendees. L. Wald presented two communications: ?? study of effective distances for interpolation schemes in meteorology, ?? controlling the quality of solar irradiation data by means of a web service.
Apr. 2002	Symp. on the Visual Environment, its Descriptors and Consequences for Human Endeavour, The Royal Society, London, UK	Two communications presented: ?? J. Page 'A user friendly IT based spectral module for estimating beam and diffuse UVA and UVB irradiances on horizontal and inclined surfaces structured within the EU sponsored SoDa programme' ?? D. Dumortier 'The Satel-Light web server'

May 2002	EU – NATO course on renewable energy, Tashkent, Uzbekistan	Presenting several outcomes on solar energy systems and radiation measurements (D. Mayer)
Jun. 2002	22nd EARSeL Annual Symposium, Prague, Czech Republic (European Ass. of Remote Sensing Lab.)	Communication on the radiation database for Europe and Africa (L. Wald)
Jun. 2002	Symposium "En route vers GODAE" (Global Oceanic Data Assimilation Experiment), Biarritz, France	Presentation of the project SoDa and its possible benefits to the GODAE (L. Wald)
Sept. 2002	2002 EUMETSAT Meteorological Satellite Conference, Dublin, Ireland	Presentation of the radiation climatology established from satellite imagery (S. Cros)
Sept. 2002	Conf. Int. Energy Agency "Operational Performances of PV Systems", Wien, Austria	Presentation of the use of the SoDa service to obtain meteorological information or performing simulations (D. Mayer)
Sept. 2002	Symposium EnviroInfo, Wien, Austria	The project SoDa, its IT aspects and its possible benefits to the knowledge and management of the environment (L. Wald)
Oct. 2002	Joint Conf. of Int. Commission of Illumination and the Int. Energy Agency "Daylighting buildings in the 21st century", Ottawa, Canada	Presentation of the project SoDa with emphasis on daylighting (D. Dumortier).
Oct. 2002	Conf. on Climate Change & Medicine, Univ. East Anglia, UK	UV aspects of the SoDa service (J. Page)
Mar. 2003	3rd Workshop on Satellites for Solar Energy, Les Marécottes, Switzerland	Daylighting (D. Dumortier) and Heliosat-II (L. Wald)
Jun. 2003	23rd EARSeL Annual Symp. (European Ass. of Remote Sensing Lab.), Gent, Belgium	Radiation climatology established from satellite imagery (S. Cros).Fusion techniques for establishing climatic gridded maps (L. Wald)
Jun. 2003	Annual Meeting Int. Solar Energy Society, Goeteborg, Sweden	Presentation of the work on the Linke turbidity factor (2 communications by J. Remund)
Jul. 2003	Int. Conf. Fusion'2003, Cairns, Australia	The fusion of gridded data (L. Wald)
Jul. 2003	Workshop on Data Fusion, Australian Ministry of Defence, Adelaide, Australia	The general concept for the fusion of image / gridded data (L. Wald)

5.6. Workshops Organised by the Project. Creating Opportunities. Meetings for Technology Transfer from the Project to Third Parties

Date	***Title***	***Comments***
May 2000	IST concertation meeting, Brussels, Belgium	Following contacts made with other projects on technical matters about data fusion, a proposal, named CLUSDAF, was made to the EC for a clustering of several projects but was rejected.
Dec. 2001	Discussion on the links with other projects funded by the DG "Research" (energy), Muenchen, Germany	Relationship with the project Heliosat-III is clearly established. There is no clear common interest between SoDa and the follow-on of the project PVSAT.
Jan. 2002	Preparation of a proposal DISMAR to a DG-INFSO IST call (GMES), Paris, France	Introducing the SoDa Web technologies into this proposal that has been funded (IST—2001-37657)
Apr. 2002	Informal meeting called by the SoDa co-ordinator, Nice, France, with co-ordinators of other EU-funded projects relating to radiation and clouds	Four attendees. Exchange of information, exploration of possible co-operations between projects
May 2002	Informal meetings within the EESD programme, Brussels, Belgium	L. Wald from the SoDa Consortium. Exchange of information, exploration of possible co-operations
Aug. 2002	Kick-Off Meeting, EU (DG INFSO) funded DISMAR project, Bergen, Norway	One person from the JRC to discuss the technology transfer to the DISMAR project
Sept. 2002	JRC, Ispra, Italy	Three persons from the DISMAR Consortium to detail the technology transfer

Sept. 2002	Informal meeting during the Symposium EnviroInfo, Wien, Austria	Approx. 60 attendees. Preparation of a Network of Excellence "BENIGN" for IST. The SoDa web service as one of the four test cases. Proposed to the EU in April 2003
Nov. 2002	SoDa Users Meeting, Paris, France	A forum to exchange views on the SoDa service and its future and to collect users' comments. 32 attendees, incl. 12 from Consortium
Nov. 2002	Informal Meeting, UNEP, Paris, France	Possible links between UNEP, the SWERA (Solar and Wind Energy Resources Assessment) project and SoDa
Nov. 2002	Informal Meeting, Paris, France	Possible exploitation of the SoDa service by the SISCAL project (Satellite-based Information System on Coastal Areas and Lakes, IST-2000-28187), funded by the DG-INFSO
Nov. 2002	Heliosat Users Meeting, Paris, France	Presentation of the method Heliosat-2 and its associated software freely available. 15 attendees, incl. 2 from Consortium
Nov. 2002	Kick-Off meeting of the DG "Research"-funded project ANEMOS, Sophia Antipolis, France	Advocating the adoption of the SoDa Web technologies for this project on the development of next generation of wind resource forecasting systems for the large-scale integration of onshore and offshore wind farms
Dec. 2002	Informal Meeting, Geneva, Switzerland	Possible links between WMO and SoDa
Dec. 2002	4th Meeting of the project Heliosat-III, funded by the DG-Research, Las Palmas, Spain	?? Presentation of the method Heliosat-2 and its use as for benchmarking advances of the new method exploiting the advanced capabilities of the 2nd generation of Meteosat satellites ?? The service SoDa to be used for the dissemination of the databases ?? The SoDa resources, especially those relating to energy-specific needs, will be part of the baseline to assess the outcomes of the project Heliosat-III ?? Also to be used is the method for the fusion of gridded data ?? The SoDa users requirements served as a baseline for establishing the Heliosat-III users requirements
Mar. 2003	3rd Workshop on Satellites for Solar Energy, Les Marécottes, Switzerland	Research proposal made to the Int. Energy Agency, using several results of SoDa (satellite processing, daylighting and Web technologies)

5.7. Other Means for Dissemination

Other types of actions were performed: *i)* lecturing, *ii)* towards the adoption/recommendation of the SoDa service, *iii)* participation to proposals, *iv)* initiatives towards the Technology Opportunities published by CORDIS Focus.

One may add the visits paid to the Consortium by two University Professors, from Africa (Cameroon, Mali), in Nov-Dec 2001 and 2002 and Apr-Jul 2003, for the exploitation of several outcomes of SoDa with respect to the solar climate in Africa. Articles were submitted and are in preparation.

5.7.1. Lecturing

Lecturing helps in creating awareness about the SoDa service, especially in the European Master on Renewable Energies, since these young persons will be working in the domain of renewable energies next year. This Master was launched by the EUREC Agency, an independent association of 45 R&D institutes in the EU (see CORDIS Focus, n° 208, 4 Nov. 2002).

The activities with University of Paris should lead to a contribution of the SoDa service to an e-learning platform in Geography.

Outside ENSMP, the partners FhG-ISE, EHF, DIFI and ENTPE intend to use the SoDa service in lecturing on a routine basis.

Date and Type	*Details*
Lecture, October 2002, University Paris-1, France	Lecture on the climatology of the solar radiation at Earth surface, based on the exploitation of the SoDa service. Approx. 30 students 1st year in Dept of Geography
Lecture, October 2002, University Paris-1, France	Lecture on the possible benefits of the SoDa service in teaching climatology of the solar radiation at Earth surface. Approx. 10 teachers, Dept of Geography
Training, education of engineers at Ecole des Mines de Paris (ENSMP)	Exploitation of the SoDa service and the ESRA CD-ROM for a weeklong exercise on the sizing of a solar energy system. held at Sophia Antipolis, 25-29 November 2002, 9 students
Training, education of African engineers and researchers at Ecole des Mines de Nantes (EMN), Autumn 2002	Lecture on measurements of solar radiation and their provision (1 day). Exploitation of the SoDa service for test cases in Africa. Persons from the university of Benin, Lome, Togo.
Lecture and training, European Master on Renewable Energies, December 2002	Lecture on measurements of solar radiation and their provision (1 day). Half-day training on the SoDa service. Eight European students. Held in Sophia Antipolis, France
Lecture, Institute for Advanced Applications of Internet, Marseille, France, Jan. 20 2003	Lecture on the SoDa Web technologies, 12 students One student-engineer to spend six months (Mar-Sep 2003) at ENSMP for improving the interactivity in the GUI

5.7.2. Adoption / Recommendation of the SoDa Service (outside research projects)

Several researchers are currently using the SoDa service. The case of the EU-funded projects DISMAR, HELIOSAT-III and SISCAL has already been discussed. This section only deals with existing services, projects and activities that are currently using or recommending the SoDa service and that have a sustainable development.

Certification of solar energy systems:

- The Web-based service SWITCH promotes the use of solar energy in domestic water heating. It is offering means for the sizing of systems and for the establishment of certificates guarantying the efficiency of a system. The service is making full use of several resources of the SoDa service since January 2002. See at http://fernande.cma.fr/switch/welcome.html.
- The service SoDa (namely, the resources Linke turbidity factor, position of the Sun in the sky, simulation of the clear-sky irradiation, time-series of irradiation) is used to design, validate and monitor a platform for the certification of solar thermal panels under the European standard CEN prEN 12975-1, -2 "Thermal solar systems and components - Collectors - Part 1: General requirements and Part 2: Test methods". Each panel-maker should certificate its products. For this, some panels are analysed and the certificate is delivered or not. The platform is operated by Armines/ENSMP on behalf of the Centre Scientifique et Technique du Bâtiment, the French authority for certification in buildings.

Support to the EU policies:

- The MARS programme (Monitoring Agriculture using Remote Sensing, an essential element of the Agricultural Common Policy) of the European Commission, agreed by letter to collaborate with the SoDa Consortium and is offering since January 2001 an access to its databases on radiation to the public through the SoDa service.
- The Institute for Environment and Sustainability, JRC-Ispra, has adopted the SoDa service for assessing the potentials for using solar energy in the EU-newly accessed countries, to support the European Policy on the promotion of renewable energy.

The Association of German Engineers (Verein Deutscher Ingenieure) asked authorisation to publish some outcomes of the SoDa service in a technical note about solar systems for the production of domestic hot water (VDI-Richtlinie 6002).

The Austrian company Bartenbach LichtLabor GmbH (Innsbruck) has been granted a specific access to the resource "Linke turbidity factor" to be encoded in their commercial software on daylighting.

The company Alcatel Space has adopted several libraries made available by the SoDa project for two industrial simulators of landscapes (OSIRIS, SPIROU).

The Swiss Weather Bureau, Climatology Department, recommends the SoDa service to its customers for solar radiation climatology and applications.

The connection of the SoDa service to a well-known system, the DODS, and especially to the databases of the NCEP/NCAR (National Center for Environmental Prediction / National Center for Atmospheric Research, USA), via an appropriate collaboration with the French CNRS (Laboratory for Meteorological Dynamics) acting as an external provider, is a success in dissemination.

The HelioClim project of the Ecole des Mines de Paris has decided to abandon its own dissemination service in place since 1998 and to disseminate its databases on solar radiation through the SoDa service.

Eumetsat, the European organisation for meteorological satellites, recognises the project SoDa as a regular and valued user of Meteosat product and support it by offering favourable access conditions to data.

UKCIP cites the SoDa project (April 2002). Set up by the U.K. Government in April 1997, the UK Climate Impacts Programme (UKCIP) helps organisations assess how they might be affected by climate change, so they can prepare for its impact. UKCIP provides support and guidance throughout the process for both stakeholders and the researchers, so providing a bridge between the researchers and the decision-makers in government organisations and business. The Web server of UKCIP explicitly sends to the SoDa project for solar radiation: *Radiation data can be analysed by using the European Solar Radiation Atlas and a toolkit to explore solar radiation has been developed by the SoDa project.* The SoDa project is one of the 13 on-line sources cited for climate in page 3 of the UKCIP report (April 2002), entitled "Climate Change Scenarios for the United Kingdom".

The Web site of the UNEP (United Nations Environmental Plan) SWERA project (Sun and Wind Energy Resource Assessment) cites the SoDa service as one of the very few delivering solar radiation information. For solar energy, the SWERA project may re-use some of the outcomes of the SoDa service, namely some Web technologies (XML, service discovery, networking), some methods and databases over Africa and Europe.

5.7.3. Participation to Proposals

A proposal to the ESA (European Space Agency, in response to an Invitation To Tender) was made by the DLR, the German Aerospace Centre, and several SoDa partners for the establishment of a service delivering energy weather data from satellite data, that should have used SoDa service for delivery. Discussion is still pending.

A proposal was made to the French team "Défi Français" in the sailing event "America's Cup" under the supervision of the French company Bertin Technologies and the EARTO (European Association of Research and Technology Organisations) and financially partly supported by the European Space Agency, about meteorological conditions in New Zealand. This proposal was not accepted. It would have exploited some scientific achievements: calibration of sensors, method Heliosat-2, data fusion techniques, and interpolation distance.

In addition, the SoDa outcomes and expertise are part of some proposals submitted to the FP 6 or under preparation:

- an Integrated Project, Next-Gen, under the supervision of Electricité de France (Non-Nuclear Energy, submitted),
- a Network of Excellence, called BENIGN, under the supervision of Prof. Hilty, EMPA (Swiss Federal Laboratories for Materials Testing and Research), submitted to IST,
- a Network of Excellence, called EuroMelSCa (European Network for Prevention and Control of Melanoma and Non-Melanoma Skin Cancer), under the supervision of Prof. Boyle (European Institute of Oncology - Milan).

The SoDa technologies and its scientific outcomes were part of several research proposals submitted in 2001 to the Commission DG "Research". The modelling / assessment of the irradiation in space and time as well as data fusion techniques were the SoDa features interesting all these projects. These projects were in ocean climatology (project THIRST), air quality (project Map'Air), pollution in

coastal areas (project PollSAIR, incl. algae blooms), renewable energy (project Sim-Net) or DG "Agriculture" (project SatFish in fisheries). In addition, the Web technologies were of interest in the projects THIRST and SatFish. None of these projects was accepted.

5.7.4. Integration of SoDa Outcomes in Advanced Technologies

The CORDIS publishes regularly a document called "Technology Opportunities". E-mails were sent to proposers of advanced technologies in order to integrate SoDa outcomes within such technologies or to accompany / help them through collaboration. These initiatives listed below have not yet been fruitful:

- ?? Conphoebus SpA, Italy. Testing hybrid energy systems for efficiency. Outcomes of a project funded under FP 3 (JOULE),
- ?? Observatoire Méditerranéen de l'Energie, France. Assessing Mediterranean potential for renewable energy. Outcomes of the project IRESMED (FP 4, NNE-JOULE),
- ?? Center for Renewable Energy Sources, Greece. PV systems to power isolated regions. Outcomes of a project funded by FP 4, NNE-JOULE,
- ?? Finnish Meteorological Institute, Finland. European icing map. Outcomes of the project WECO (FP 4, NNE-JOULE),
- ?? Institute of Communication and Computer Systems, National Technical University of Athens, Greece. Making renewable energy more feasible. Outcomes of the project CARE (FP 4, NNE-JOULE),
- ?? EARS company, The Netherlands, managing a Web site for Water Management. Outcomes of a project funded by FP4, EESD,
- ?? A Dutch company (through the Innovation Relay Centres Network). Solar energy, zero-emission and material saving building concept, supported with positive feasibility study results,
- ?? Bayerisches Zentrum fuer Angewandte Energieforschung e.V., Germany. Solar energy for cooling systems. Outcomes of a project funded by FP 4, NNE-JOULE,
- ?? Bar Project Management Ltd, Israel. The EWA technology extracts water vapour from the air as to produce liquid water. Through the Innovation Relay Centres Network,
- ?? A Bulgarian company (through the Innovation Relay Centres Network). New technological systems, using concentrated and super concentrated solar energy and their utilisation for power supply,
- ?? A Dutch company (through the Innovation Relay Centres Network). Energy saving solar dryer for domestic laundry,
- ?? Joint Research Center, Italy. Improving global climate models,
- ?? A Scottish company (through the Innovation Relay Centres Network). A generation of better 3D graphics. May help in presenting SoDa results to customers.

6. Project Management and Co-ordination Aspects

Overall project co-ordination is the responsibility of the Joint Research Unit ARMINES/ENSMP – T&M. The project management is split between the Scientific and Technical Management and the Administrative, Financial and Legal Management, keeping in mind that the quality of the scientific work and the respect of the general conditions of the contract have to be guaranteed, on the one hand, and taking into account that the scientific and technical and the financial, administrative and legal environments could be in opposition and required different but complementary skills, on the other hand.

This two-heads management permits to face the achievement of the project and of its objectives in the best conditions. Both have clearly defined the structures of management, the management mechanisms and procedures and the management tools.

Each work package has a Work Package Leader (WPL), responsible for the achievements in this WP, and an exhaustive list of partners involved in. Moreover, each task in a work package has a Task Leader (TL), responsible for the achievements in this task, and an exhaustive list of partners involved in. This was synthesised in the Partner Involvement Breakdown Chart in the Technical Annex.

The Consortium Agreement adopted in the 1st year provides additional tools for management and especially defines voting rights for taking decision. This facilitates a dynamic management that is illustrated by early termination of a task and by re-allocation of resources and manpower towards tasks of higher priority. This would not have been possible without the **strong dedication of the consortium and individual partners to the objectives of the project**, given the fact that several partners got fewer resources than planned.

After a bad start, corrective actions were taken that were based upon:

- the use of the voting mechanism,
- a dynamic re-allocation of tasks, resources and manpower between partners,
- a better follow-on of the time schedule by the WP leaders and the co-ordinators,
- an analysis of the manpower spent and the outcomes of a task,
- and two documents: the Monitoring Plan and the Action Plan.

These actions permitted a better monitoring of the progress of the work of each partner and of the consortium with respect to the objectives of the project. Efforts were also made to improve the communication about the progress of the work between the consortium and the Scientific Officer.

The Monitoring Plan is an ensemble of elements set up in order to monitor the progress of the work in a timely fashion. These elements permit to check the appropriateness and the consistency of the proposed tasks for meeting the overall objectives. They permit to assess the performances of each task and to check the scheduling arrangements. It is composed of a methodology, a time schedule and of a list of measures of success and of baseline data. These measures of success and baseline data are defined for each Work Package and its tasks and sub-tasks. The methodology is based upon the Action Plan, a detailed dynamic description of the work to be performed by each partner in each work package until the end of the project. The role of the Quarterly Progress Reports and of the Annual Progress Reports is enhanced in the on-going evaluation. The role of the WP leaders is enforced and full benefit is drawn from the mechanism for taking decision set up in the Consortium Agreement.

The Action Plan describes in great details the activities of the work to be performed by the Consortium of the project SoDa. In particular, it

- better specifies the objectives of each task to be undertaken,
- better specifies its rationales (why performing this task?), its methodology, its expected outcomes, and the measures of success,
- better specifies its planning and the allocated resources, the role of participants and their interactions,
- provides means for looking for back-up scenarios,
- proposes more milestones, if necessary to improve efficiency.

6.1. Deviations from Time Schedule – Threats and Mitigations

Though the Action Plan is respected from the point of view of methodology, there are clear departures from the time schedule. The duration of the contract was extended by three months and it ends in March 2003.

The deviations originate from the delays encountered in 2001 in WPs 3 and 5, due to either scientific obstacles met in the WP 5 (especially the activities on the Linke turbidity factor, a fundamental parameter in atmospheric optics, and as such useful in many tasks) or to technical obstacles (e.g., loss of data, difficulties in getting information from external providers) in the WPs 3 and 5. In addition, broken hardware prevented the partner HuMet from meeting the planned deadlines.

This leads to delays in these activities and further in the supply of the deliverables to the Commission. The user test phase was delayed in the WP 6 by 6 months.

An extension of three months was requested to and granted by the Commission. This induces an automatic shift of the three deliverables that were planned for the end of the project.

The major technical deliverable of the project, the third prototype, was delivered in December 2002, with a delay of three months.

An analysis of the delays in delivering documentation was performed. It shows that the administrative documentation, *i.e.*, Quarterly Progress Reports and Yearly Reports, are remitted in due time, given the two months delay and the shift of the end of the project. The deliverables in the WP 7 are also delivered in due time.

For the WP6, the situation is strongly dependent upon the status of the technical WPs. For the more technical WPs 3, 4 and 5, approximately 70 % of the deliverables are late by more than 2 months with a mean delay of 4.2 months. Detailed analysis reveals that the problem lies in the writing of the documentation: very often, the work is made in due time or with little delay but the documentation is not immediately available. The co-ordinator pushes partners to provide the documents and is at times offering models. In several cases, and especially in the second and third quarters, the deliverable was set aside temporarily in order to put all efforts on the completion of resources for their testing by customers.

This inability to deliver in time documentation for the technical aspects is a weakness of the Consortium.

The delays encountered in the WPs 3, 4 and 5 were threatening the methodology for the WPs 6 and 7. They were also a threat for the achievements of 3 of the 5 objectives. The problem was mitigated by an extension of the duration of the contract by 3 months. In contrast, this extension opened several opportunities that were seized by the Consortium and that are detailed in the next section.

The Consortium estimated that the SoDa prototype should offer the expected service to the customers in due time for the gauging activities, even in a degraded mode. Thus, the Consortium managed to find ways to replace / substitute the resources that were delayed. Of course, these temporary resources are less accurate than those planned. However, they permit to mitigate the delays and to offer similar services to customers who may gauge these services with respect to their current practices.

The delays in the activities "net radiation" (WPs 3.3c, 5.2e, 5.3l) were mitigated with respect to service offered to the customers by an appropriate exploitation of the existing resource "chain of algorithms" (WP 5.3n). Since April 2002, customers were able to get information on net radiation. The resource was planned for February and was made available only in December. In that way, there was no harm to customers.

The delays in the activities "climatology Meteosat" (WPs 3.5c, 5.1d, 5.3f, 5.3r) were mitigated by the availability of the resource NCEP/NCAR (an external provider) in March 2002. Though of lower quality in spatial resolution and accuracy, this resource palliated the planned one. It may be noted that finally the work progressed faster than thought and that the Meteosat resource was made available in June 2002 as planned.

To mitigate the delays in the activities "climatology II" (WPs 3.5d, 5.1c, 5.3p), to be completed in April 2002, a resource was established in January 2002 that is providing the same information but by

performing the on-fly interpolation scheme of deliverable D5-1-1. There is thus no harm to customers. Note that finally the database developed is of lower accuracy than the interpolation resource. The latter remains in force in the service.

6.2. Amendments to the Contract and New Opportunities

The EC accepted the Amendment No 1 to the contract on 21 October 2002. This amendment was forwarded to each partner in two copies for their signature and sent back to the Commission with all signatures on 28th November 2002. This amendment was requested for four reasons:

- a request for a prolongation of 3 months of the project (ending date: 31st of March 2003);
- the modification of the financial basis from AC to FF for the partner HuMet;
- the introduction of the special condition relative to the Joint Research Unit (JRU) Armines - ENSMP in the contract terms;
- an agreement on the budget modification for HuMet, JRC and Armines - ENSMP. The latter includes an increase of manpower of JRC by 3 months.

Because of the changes of typology of cost for partner HuMet and the introduction of the Joint Research Unit Armines - ENSMP, it was necessary to produce new CPFs. Due to technical reasons (necessary change in the reference year for cost basis), this induces changes in budget for these three partners without changing the financial contribution of the Commission, except for a slight decrease.

In addition, given the fact that the financial requests by the partner HuMet are less than planned, extra resources were allocated to the partner JRC, following the recommendations made by the panel of reviewers in February 2002. The tasks undertaken by JRC are:

- Open Source. Although not initially foreseen the SoDa Intelligent System prototype source code was reworked in order to be able to present this project as an Open Source project. The code was revisited, cleaned up, sometimes rewritten, and documented;
- Added functionality and cosmetic changes. Possibility to produce graphs and have the SoDa IS displays them. Multiple subset selection from table output;
- Help system. A help system was set up and integrated with the SoDa IS.

The Acceptance of the Amendment No 1 by the Commission opened several very important opportunities in the SoDa project:

- it permitted to achieve the third prototype in a very satisfactory manner, with several added functionalities. The first version of this third prototype was in operation in September 2002. Time was available for test and improvement before the final version provided in December 2002;
- it permitted to rework the code in order to be able to present it as an OpenSource project;
- a Users Meeting was organised on 18 November 2002, gathering selected users representing the various communities of users. This Users Meeting was helpful
  - to strengthen links between the Consortium and the users,
  - for the Consortium to listen to the customers needs that evolve as the offer of SoDa service is increasing,
  - to obtain users comment on the service,
  - to obtain strong expressions of users with respect to the expected benefits of the SoDa service, and further the achievements of three of the five objectives of the project SoDa,
  - to discuss several exploitation strategies.
- it favoured the dissemination of the Heliosat-II software that occurred through the venue of a SoDa-Heliosat Meeting on 19 November 2002, a highlighting event, preceding the opening of a download service for this software,
- by offering time, it permitted to perform an additional gauging of the SoDa service via an on-line questionnaire. Unplanned, this activity was established in order to add evidence and sustain comments made by customers on the SoDa service through another mean and another panel of users,

?? the opportunity was taken to hold a SWOT exercise (Strengths, Weaknesses, Opportunities, Threats) within the Consortium. It was felt as being of high benefit for the establishment of exploitation strategies for each partner and for the Consortium.

7. Outlook

The foreseen exploitation of the SoDa service from a commercial point of view has been discussed in the section 4.4. In this section, are briefly described the intention of each partner.

All partners have a clear interest to increase reputation. As such, they will all undertake the following actions:

- ?? publish results,
- ?? contribute to standards: demonstrating networking capabilities, contribution to XML standards for meteorological data, making the databases and algorithms as standing references,
- ?? increase awareness of the customers communities on the SoDa service,,
- ?? identify parts of the SoDa service that may go commercial, adopting a model based on a partly free, partly commercial service, and to develop additional features to answer comments made on the present service by these specific classes of customers,
- ?? look for opportunities to exploit, refine and develop their results.

All partners are using the SoDa service for

- ?? their own R&D activities,
- ?? promoting their expertise towards third parties.

The achievement of the SoDa service highlights the expertise of the whole consortium and of individual partners. It results in several invitations to participate to R&D projects by third parties and an increase in opportunities for collaboration for each partner. More specifically:

- ?? the partner JRC joined the European project DISMAR (IST—2001-37657) because of its role in the SoDa project and its expertise in the networking of services. For the same reasons, JRC is well anchored within the GMES programme (Global Monitoring for Environment and Security),
- ?? the partners Armines/ENSMP, Meteotest, EhF, ENTPE and FHG-ISE were invited to join a proposal to the ESA (European Space Agency, in response to an Invitation To Tender) made by the DLR, the German Aerospace Centre, and other partners for the establishment of a service delivering energy weather data from satellite data, that would use SoDa service for delivery,
- ?? the same partners, except Meteotest, were invited to join a proposal made to the International Agency for Energy (IEA) on the development of R&D tools in solar energy,
- ?? the partners Armines/ENSMP and iCons were invited to join an Integrated Project, Next-Gen, under the supervision of Electricité de France (Non-Nuclear Energy, submitted), and a Network of Excellence, called BENIGN, under the supervision of Prof. Hilty, EMPA (Swiss Federal Laboratories for Materials Testing and Research), submitted to IST,
- ?? actually, several opportunities in the form of participation to EC-funded R&D projects were opened to the partners but with no success (see section 5.7.3).

Several partners are exploiting the SoDa service for their own educational purposes: Armines/ENSMP, DIFI, EhF, ENTPE and FHG-ISE.

Outside these activities that are common to all though performed individually and outside those already cited, there are activities that are specific to a partner.

The partner Armines/ENSMP is currently exploiting its results as follows:

- ?? marketing the database of the Linke turbidity factor (in agreement with Meteotest) *via* a French company Transvalor S.A., a subsidiary of Armines,
- ?? using the SoDa service (several resources) for the certification of solar thermal panels under the European standard CEN prEN 12975-1, -2 "Thermal solar systems and components - Collectors - Part 1: General requirements and Part 2: Test methods", an activity performed on behalf of the Centre Scientifique et Technique du Bâtiment, the French authority for certification in buildings,

- the method for the spatial interpolation is routinely used as well as the clear-sky model and the database of the Linke turbidity factor and the orography,
- the method Heliosat-II is routinely applied for the processing of the Meteosat data that are periodically received from Eumetsat,
- the database HelioClim containing global irradiation assessments for Europe and Africa since 1985 is routinely accessed for inner use and by third parties. Efforts are being made to promote this database HelioClim that is disseminated *via* the SoDa service. Thorough analyses of quality are underway. Several publications are foreseen. The project SWERA (Sun and Wind Energy Resource Assessment) of UNEP expressed its interest in using this database,
- the method for the fusion of gridded data is currently exploited for other purposes. Efforts are made to integrate this method within the well-known concept ARSIS for the fusion of images.

The partner Meteotest is currently preparing a commercial CD-based software, called Meteonorm V5, to be produced and sold by the partner Meteotest, in agreement with the co-owners of results. The results to be used are

- the clear-sky model,
- the methods for the spatial interpolation, the production of solar radiation and temperature quantities derived from global irradiation measurements, the production of normal years and the assessment of UV irradiation,
- the databases of the Linke turbidity factor and other atmospheric optical parameters and the orography.

8. Conclusions

The users feedbacks reveal that all objectives were fulfilled.

1. To answer the needs for high quality customer-tailored information on solar radiation

A service was developed, starting from users requirements.
Forty-six resources were developed and brought on-line. Among them, 31 were planned and the others are additional features, made in collaboration with persons outside the consortium.
The survey shows satisfaction of users.

2 To integrate diverse sources of information within a smart integrating network

The SoDa Intelligent System, an Open Source, was developed, that creates a common access point, implemented as an Internet server. Six-six resources were integrated, demonstrating the flexibility of the system: it is capable of integrating other databases and application-oriented algorithms.

3. To develop and operate a prototype service, exploiting this network, which will be used and gauged by selected users

Three prototypes of the SoDa service were developed during these three years. The first one was developed starting from users requirements assembled by the consortium before the start of the project and completed by a survey in the early stage of the project. The first prototype was gauged and refined taking into account the users feedback to produce the second prototype after 2nd year. The same approach was followed to gauge this prototype and develop the third and final one. Hundreds of gaugers were involved.
The service is in full operation since February 2002 with regular access.

4. To increase the quality of the delivered information through improved modelling of time and space structures of the solar radiation, and improved matching to actual customer needs

Activities took into account the expression of the user needs and the feedbacks from the gaugers. The databases were consolidated. Additional information (temperature, statistics, climatological values for atmospheric optical parameters) was incorporated. The time and space coverage was increased, mostly by the means of an appropriate processing of images taken by Earth observation satellites, but also by techniques for the fusion of ground based measurements and satellite-derived assessments or gridded values. Beyond "basic" data, that is global irradiation and temperature, specific resources were developed for specific domains, better meeting the actual needs.

5. To disseminate the achievements of the project, and assess the sustainability of a permanent commercial service

There is an effective uptake of technological achievements by external stakeholders (software, algorithms, databases …). Usual scientific dissemination was performed and is on-going. The technology implementation plan describes how the knowledge gained in the course of the project, will be used by each partner and on a collective way. Commercial issues were analysed. Scenarios were drawn up and assessed in collaboration with customers. The market is not ready to support a commercial SoDa service but opportunities may appear within one year that the Consortium should be ready to seize. As a preliminary step, a database is marketed and a CD-based product is being developed that includes many results.

SoDa is a relevant, useful and appreciated service. Its users are encouraging the service to go on. It needs some improvements to match the needs of its community and further applications for new users' groups that have been identified.

However, the SoDa service still has to put in place a number of actions to create and/or stimulate the demand. There are two main aspects that need to be taken into consideration regarding further

action: the awareness in the market on the SoDa service and the readiness of the users to use web-based services.

The users base reached by the consortium is really interested, but SoDa is not well known outside the nearby community. SoDa has contributed to the knowledge in solar radiation but the market needs to grow both in size and awareness about the potential to exploit in this field. There are also new market niches to seize which the consortium has identified and are in course of exploitation. The strong positioning of the alternative sources of information and the presence of subsidized/free climate data products place suggest that SoDa will need to emphasize the uniqueness of its feature to gain the market.

At the same time the overall demand for environmental service is probably not yet fully mature for on-line only services.

A number of market efforts have been identified that are taking place now that would have been useless if put in place before the full deployment of the service. In particular it will be necessary to enhance the communication about quality and origin of data and to put in place promotion and communication actions, to stimulate the demand for specific services and to promote the delivery via web.

In conclusion, the basis is laid, improvements have been planned but SoDa is too young to launch itself on the commercial market at the end of the project.

The consortium decided to hold the SoDa service on for a year on a voluntary basis, with the support of private funding provided by the organisations which are part of the consortium. During this year, refinements of resources or addition by the Consortium or other providers will take place. The consortium feels that in one year time the market conditions will have evolved favourably, the SoDa service will have got enough references and therefore it will be possible to decide on if and how to enter the market. A meeting will be held in January 2004 to decide how to proceed according to the experience gained and the state of the market.