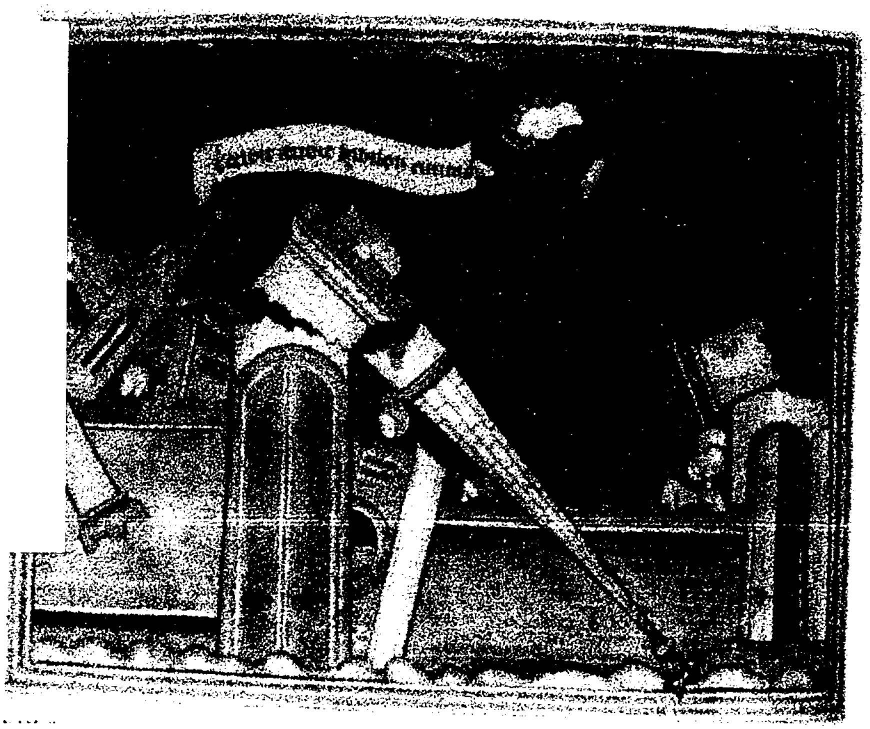
EXECUTIVE SUMMARY

STUDY ON THE USE OF SPACE TECHNIQUES FOR MAJOR RISK MANAGEMENT

- Phase 3 -

TIDC-CR-8075



nuova telespazio

Daimler-Benz Aerospace
Dornier

NIERSC

EUROPEAN ESYS SYSTEMS

ESA CONTRACT N. 11603/95/F/FL

STUDY ON THE USE OF SPACE TECHNIQUES FOR THE MAJOR RISKS MANAGEMENT

PHASE 3

EXECUTIVE SUMMARY

June 1996

Prepared by: Paolo Tozzi

Paolo Tozzi

Approved by: Mario Caporale

Mario Caporale

THE STUDY TEAM and its RESPONSIBILITIES

NUOVA TELESPAZIO (I)	Study management and coordination Forest fires, floods, seismic and volcanic risks Italian command chain analysis Telecommunications space based resources Overall scenarios definition Real case analysis and validation: Irpinia earthquake (I) Implementation plan and cost
DASA Dornier (D)	Industrial and transportation risks German command chain analysis Earth observation and meteorological space based resources Real case analysis and validation: derailment in Ghent (B) Implementation plan and cost contribution.
CISI (F)	Nuclear, storms and droughts risks Earth observation and data collection resources Interoperability issues Real case analysis and validation: forest fires in Var region (F) Implementation plan and cost contribution
ESYS (UK)	UK command chain analysis Needs versus resources cross-coupling Modelling of the three real cases
NIERSC (Russia)	Pipelines, forest fires, nuclear risks Russian command chain analysis Russian space resources and their applicability to the real cases

Executive Summary Contents

1. INTRODUCTION

Natural disasters have a significant impact on the progress in social and economic development, making it necessary to aim at natural disasters reduction in the various countries development plans.

Space resources can provide a significant contribution to this reduction in improving all the necessary data gathering, either in mitigating existing disasters or in reducing the impact of potential ones or, last but not least, in supporting the territory management activities addressed to reduce the vulnerability to disasters.

This document presents the summary of results of the "Study on the use of space technologies for major risk management" that Nuova Telespazio and its partners, namely DASA, CISI, NIERSC and ESYS, have performed in the course of first half of 1996.

These results highlight that all categories of space based services, including communications, data collection, meteorology, localisation and remote sensing systems, wouldprovide essential information and operational support during all phases of risk management.

This study has utilised as inputs the results of ESA's Phase 1 and Phase 2 Studies which identified respectively the high level user needs and the inventory of existing and planned space based resources. The study has validated, complemented and compared the results of previous phases providing scenarios of gradual implementation and introduction of space resources and services into the European national civil protection command chains.

A parallel analysis of a sample of national command chains of civil protection has been conducted on Italian, German, UK and Russian national risk management command chains. Each country has developed various levels and protocols of organisation in response to natural and/or technological catastrophes. Deep knowledge and analysis of those mechanisms are of great importance in order to tailor the products and services specifications to an operational environment.

Three scenarios of implementation have been addressed for space resources' utilisation for risk management support:

<u>Scenario 1:</u> Short-Term. In this first step the information system for risk management is designed and described on the basis of currently available space resources, with minor modification to the related ground segment (1997-1998).

<u>Scenario 2:</u> Medium-Term. Building up on the risk management information system described for scenario 1, the resources and infrastructures that are planned, say until 2001-2002, will be additionally implemented into the concept.

<u>Scenario 3:</u> Long-Term. On the basis of the analysis of the user needs which cannot be fulfilled neither with existing resources nor with planned ones, the third scenario provides suggestions on the system which would be needed to cover all identified service gaps.

2. STUDY LOGIC

The study started with the validation of the results achieved during the phase 1 and 2 of the overall ESA study.

User requirements generically defined in phase 1 have been detailed and validated by the user community with the support of the experts belonging to the prime and sub-contractors. Each specific topic has been addressed by a lead company and a set of supporting companies to allow a complete review of the needs and to take into account specific national needs.

Phase 2 space based resources inventory results have been also validated in terms of space and ground resources available today and planned in the near future. Russian resources have been specifically addressed for validation.

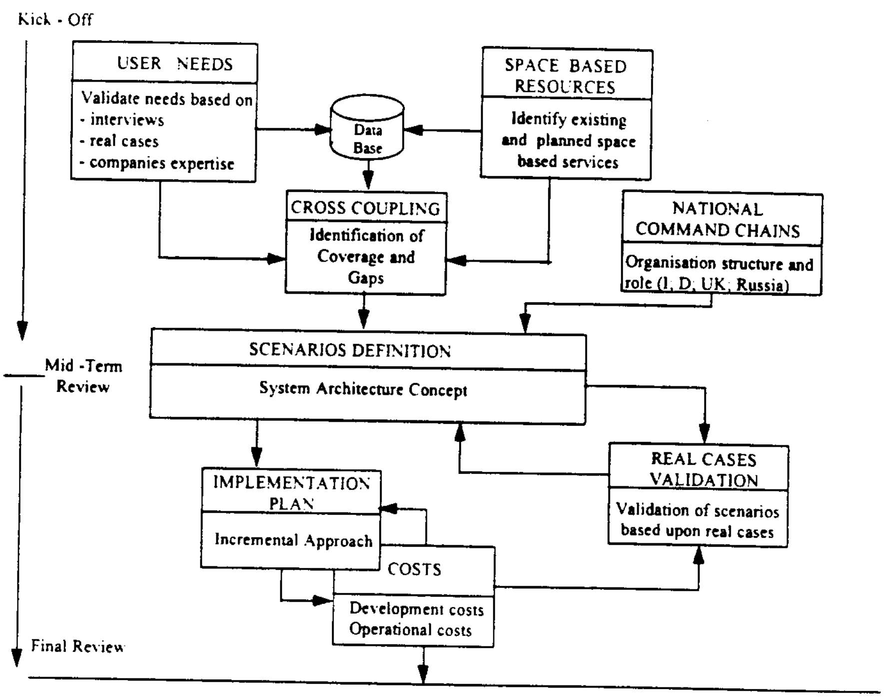
Some national command chains (i.e. Italy, Germany, UK and Russia) have been also analysed, in order to tailor the proposed space based services to the national structures in charge of risk management activities.

An analysis of fulfilment of user needs by the currently available space resources and the planned ones has been performed in order to assess the coverage potential of space services.

In order to perform a gradual introduction of space services into the civil protection command chains, a scenario definition has been conceived starting from the current status in the Greater Europe and comprising three scenarios ranging from a short term scenario, which implies the utilisation of currently available space services, up to a medium term and a long term scenario which, respectively, take into account the use of planned and potential future space based services.

A parallel validation analysis has been performed on three real accident cases which allowed to verify the suitability of space services in supporting the risk management activities in all the phases (ranging from the knowledge and prevention up to the post crisis phase).

A rough order of magnitude costing analysis for the suggested space based services has been also performed, both for development and operation aspects. Further, an overall implementation planning has been sketched which comprises the three scenarios identified.



3. USER NEEDS ANALYSIS

User needs coming from the ESA phase 1 Study have been systematically analysed in order to check their consistency and completeness. Additional risks types have been studied and the associated information needs added.

Further, the level of depth of requirements has been expanded in order to allow the possibility to perform a technical correlation with the space based services.

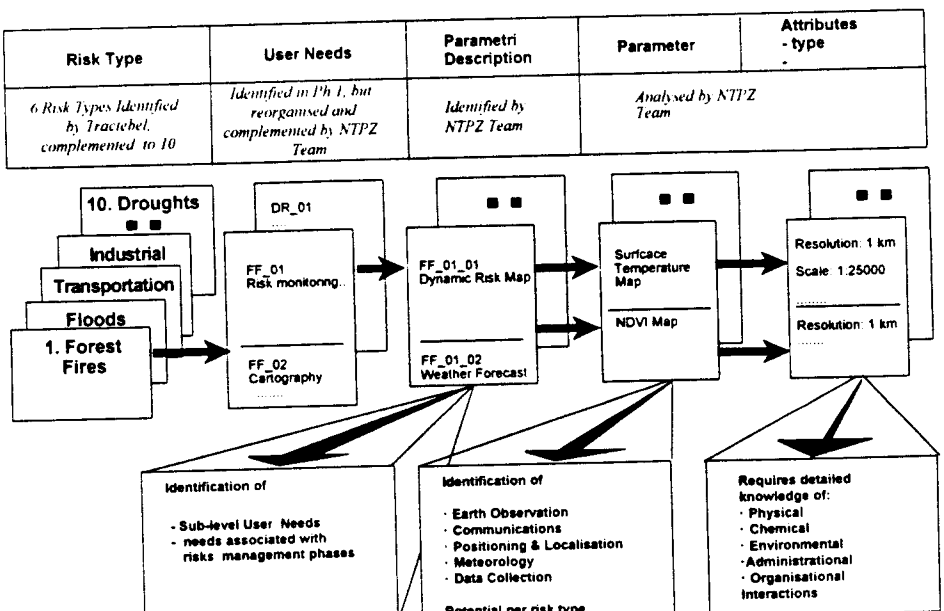
The methodology applied to verify the completeness of user needs coming from ESA phase 1 study and reach the needed level of depth, is presented in the following picture, which highlights:

1. The identification of low level attributes of parameters relevant to each high level user need.
2. Three different levels of analysis have been performed: high level user needs (as in phase 1); parametric description of each user need; a set of parameters for each item of the parametric description, with an associated set of attributes types and values. Space based resources and possible alternative sources of information (e.g. ground based, aircraft based, etc.) have been addressed in this analysis.
3. The operational environment of risk management has been considered in order to be sure of the completeness of the analysis. In this perspective, all risks have been addressed in terms of phases and sub-phases.

A quantitative information of the analysis performed is given below:

- Number of examined risk types 10 (of which 4 additional)
- Total Number of identified user needs 59 (of which 19 additional)
- Total Number of parametric descriptions 172
- Total number of parameters 251

The exercise performed in this step of the study allowed the Team to facilitate the cross coupling analysis, aimed to identify the potential of space based services in fulfilling the identified user needs.



Methodology applied to identify requirements and relevant detailed attributes

Forest Fires	Seismic	*Volcanoes*	Floods	*Storms*	*Drought*
improvement of routine risk monitoring	cartography availability	***cartography availability***	geographical cartography of exposed areas	***tide and surge forecasts on vulnerable zones***	***monthly continental weather forecast***
cartography of exposed areas	vulnerability data scales and quality	***vulnerability data scales and quality***	vulnerability data availability	***damage evaluation on infrastructures and land use***	***cartographic and topographic data for water work projects***
reinforcement of communication during crisis	reinforcement and extension of monitoring networks	***improvement of routine risk monitoring***	development of automated monitoring of water level and other hydrological data	***improvement of communications with and among rescue teams***	***forestry and crop water stress monitoring at regional scale***
vulnerability data availability	development of basic research concerning precursors and models		development of meteorological environment monitoring	***forecast of storm trajectories and wind fields***	***water resource monitoring***
Aggravating weather monitoring during crisis (wind)	reinforcement of communication during crisis		reinforcement of communication during crisis		***monitoring of urban unmanaged extensions***
location of the means	location of the means		location of the means		
damage assessment			reinforcement of observation during crisis		
			development of post-crisis observation		
			assessment of frozen soil depth and snow cover reserve (*)		

High Level User Information Needs for Natural Risks Management

Pipelines	*Radiological*	Transport	Industrial
risk area cartography including areas of increased vulnerability	meteorology monitoring for radionuclides dispersion assessment (**)	models for the estimation of spread of water-endangering substances	toxic cloud contour prediction including local meteorological conditions around site
routine monitoring of pipeline state and leakage detection	***monitor pollution in the water resources***	communication system	accident monitoring
substance propagation observation	communication for accident monitoring (**)	product identification in case of an accident	3d cartography of exposed area
released substances volume and polluted area estimation	***identify the potentially polluted water resources***	meteorological information	***spread prediction of toxic substances in rivers***
substance propagation modelling	***cartography of exposed area***	location systems	communication
monitoring of the environmental consequences of pipeline accident	***monitor pollution extent in soils***		***toxic cloud contour prediction modelling***
weather forecast			location of rescuers
management of means			
damage assessment			

High Level User Information Needs for Technological Risks Management

(*) Specific need for Russia

(**) Identified in Phase 1 only during real case analyses and not reflected in the user needs report

In Bold Italic user needs added by NTPZ Team which was not covered during Phase 1 Study

4. SPACE BASED RESOURCES

The methodology applied to perform the space resources inventory validation is represented in the following picture. The input has been the contents of an ESA inventory developed during phase 2 and the data base designed and developed in cooperation with the ALCATEL Espace Team.

The validation process has been performed along the following steps:

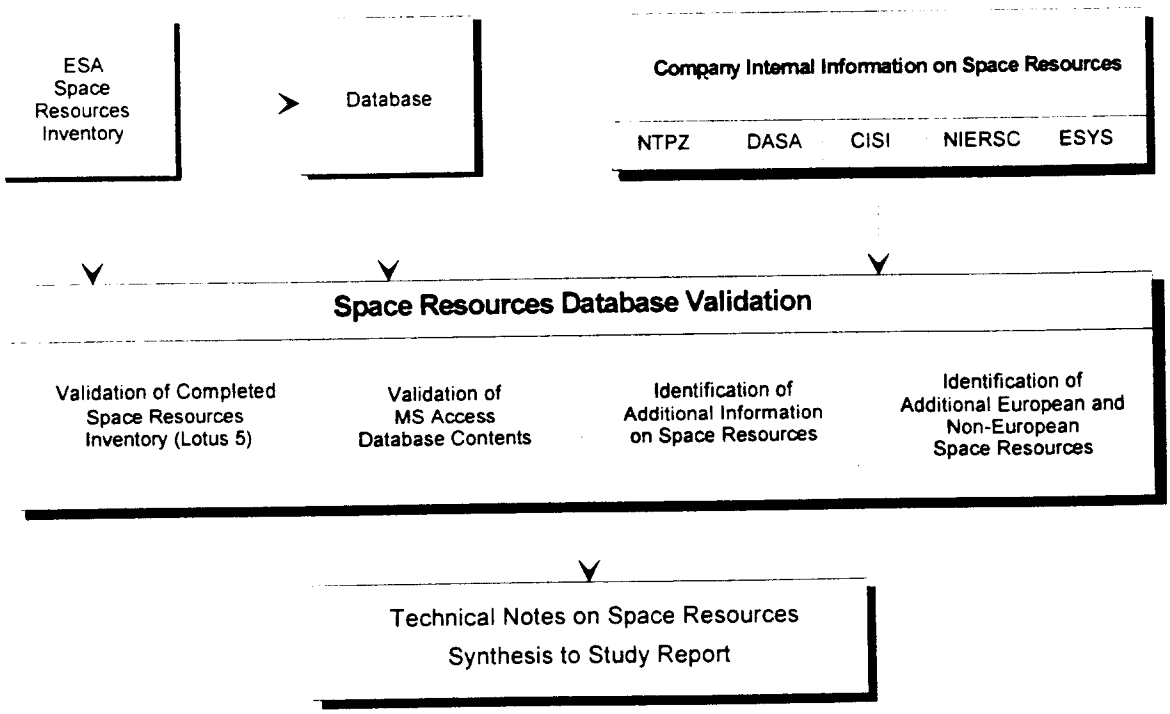
- Review, for each described mission, of the information contents in both databases
- Identification of any discrepancies between the ESA database and the new database
- Provision, where necessary, of updated information to be included in the new database
- Inclusion of additional instruments and services, identified as important for the study tasks

Space based resources have been categorised in:

- Meteorology;
- Earth Observation;
- Communication;
- Navigation and Localisation;
- Data Collection.

The existing and planned resource information have been validated and complemented with the detailed information about:

- type of resource;
- nominal utilisation;
- payload/ instrument description;
- offered product;
- offered services;
- system description;
- ground segment description;
- specific applications for major risks management;
- mission planning.



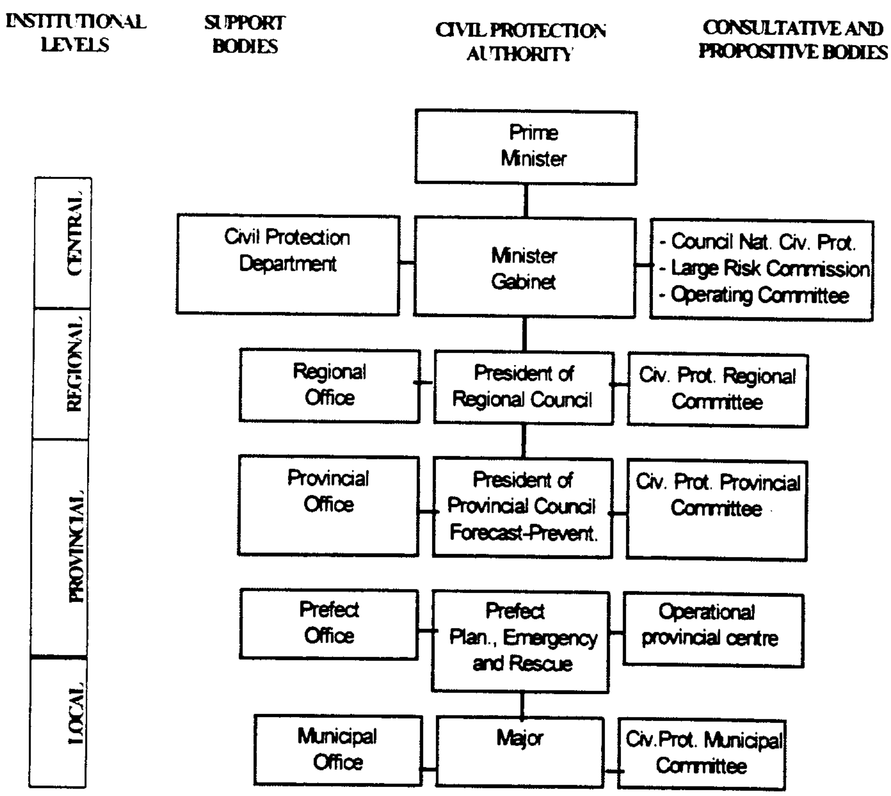
5. CIVIL PROTECTION COMMAND CHAIN ANALYSIS

The command chain Analysis has been performed in order to analyse the following aspects:

- Organisational structure versus risks types, to emphasise the major risks which affect the national territory, the risk levels in the territory and how the risk types have affected the organisation of the command chain.
- The command chain structure. This task produced a description of the command structure where the various entities involved in the command chain, during the various phases of risk management, have been outlined by hierarchy level and/or relationships.
- Identification of the main organisations which play fundamental roles for risk management, their responsibilities and operational roles.

The nations for which the command chains have been analysed are Italy (example provided in the next figure), Germany, UK, Russia.

Commonalities among the command chains have been highlighted.



COMMAND CHAIN IN ITALY

6. USER NEEDS VERSUS SPACE RESOURCES CROSS-COUPLING

The purpose of this analysis has been to compare all the identified user needs for the 10 major risk types with the currently available and planned space-based satellite services.

A three-step methodology was utilised as follows:

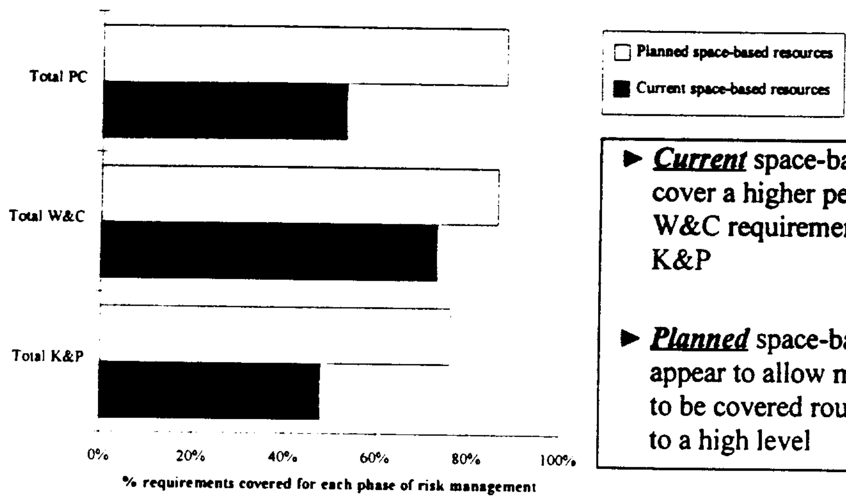
Step 1: Availability of current space resources (1996)	Reviews the attributes for each parameter and determines whether currently available (to European organisations) space-based resources can meet these requirements.
Step 2: Additional space-based services required	Assesses whether any of the planned space-based resources will be able to meet the requirements in addition to any current resources. This section focuses primarily only on those planned space resources which have a high probability of being available over the next 5-10 years. Additionally, however, this section also indicates the type of new space-based resources which may be required to meet the requirements.
Step 3: Assessment	An assessment is performed as to how well current and planned space-based resources meet the requirements. For both a 0-3 rating is chosen, where "0" reflects that none of the requirements can be met by space-based resources whereas a "3" reflects a situation where the requirements can be fully met by space-based resources. As part of this assessment, an indication is presented as to whether new space-based resources would be needed to fulfil the requirements.

The vast majority of the needs appear to be met by space-based resources. This is especially the case once the planned high spatial resolution satellites are launched However it is to be said that the satellites are not necessarily the most cost-effective solution in every case and the choice of space versus ground resources depends on the risk case. An efficient access to data products and services is clearly fundamental. Certainly a new "high resolution, frequent revisit, all-weather" Earth observation capability would benefit most of the risks.

One potentially important conclusion is that there appears to be recurring requirements (except for forest fire and nuclear risks) for new space-based resources involving a constellation of SAR sensors able to provide precise digital elevation maps (by interferometry) and all-weather/high revisit coverage.

USER NEEDS FULFILMENT VERSUS RISK MANAGEMENT PHASES

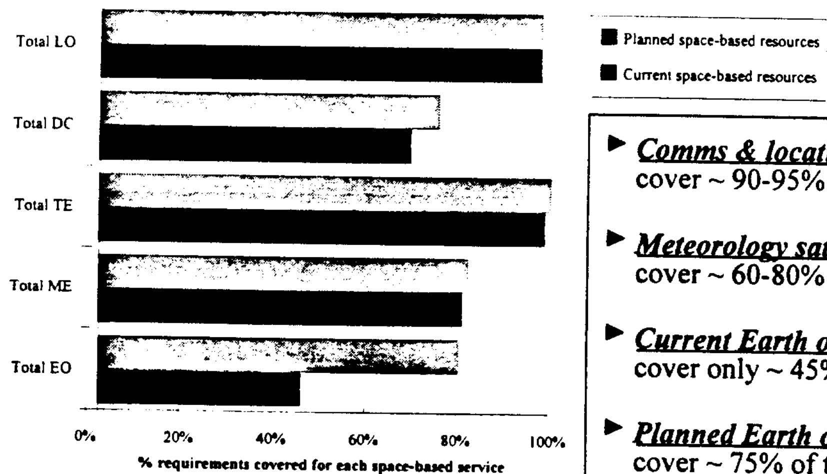
This figure provides an overall assessment of the extent to which the total identified user needs are met for each risk phase.



- ***Current*** space-based resources cover a higher percentage of W&C requirements than PC or K&P
- ***Planned*** space-based resources appear to allow most risk phases to be covered roughly equally and to a high level

OVERALL ASSESSMENT FOR EACH SPACE-BASED SERVICE TYPE

This figure shows the extent to which each of the various space-based services are able to meet the identified user needs.



- ***Comms & location satellite data*** cover ~ 90-95% of the needs
- ***Meteorology sat. and data coolect.*** cover ~ 60-80% of the needs
- ***Current Earth observation satellites*** cover only ~ 45% of the needs
- ***Planned Earth observation satellites*** cover ~ 75% of the needs

7. CRITICAL ISSUES FOR RISK INFORMATION NEEDS

A qualitative assessment of the critical issues for each risk type is summarised as follows.

Forest Fires

Potentially, all the requirements for reinforcing communications, location of means and vulnerability data availability can be met by current and planned space-based resources. The availability of high resolution sensors beginning in late 1996/early 1997 will allow all the requirements for damage assessment cartography of exposed areas to be realised. As far as the improvement in routine risk monitoring, satellite can play a role but it will always be limited from the point of view of cloud cover There could possibly be a need for an infrared sensor (or constellation of) optimised specifically to search for forest fires.

Earthquakes

Many identified user needs can be met by current and planned space-based services. However, the availability of high spatial resolution satellites will potentially increase the fulfilment of these requirements. The availability of a constellation of SAR satellites could provide interferometer data which would enable any changes to the land structure to be detected. This has been demonstrated during the ERS-1 and ERS-2 tandem operations, albeit with a revisit period of one to two weeks.

Volcanic

Only a small percentage of the identified user needs can be met by space-based resources. In particular, current satellites are able to provide some information useful in the detection of SO2 emissions. The planned deployment of various satellites intended to detect aerosols and other emissions will greatly improve the accuracy by which SO2 is detected. However, these data are considered complementary to ground-based emission detection. The availability of 1 m high spatial resolution data will enable the identified user needs for vulnerability of data and cartography availability to be fully achieved.

Floods

The identified user needs for reinforcing communications, location of means, development of automated monitoring of water level and development of meteorological environment monitoring can all potentially be met by current and planned space-based resources. Requirements covering vulnerability data availability and development of post crisis observation cannot be met by current services because of the need for very high resolution and low scale data. The requirements of geographical cartography can only be partly met by current space-based resources. However, the planned availability of high spatial resolution data will allow all of these requirements to be met. Only a few of the requirements to reinforce observations during crisis can be met with current and planned space-based services. Satellites can provide weather maps, but parameters such as soil moisture and monitoring of flooded regions cannot easily be achieved with satellite data particularly as floods are usually associated with cloud cover. Further, a revisit frequency as high as a few hours is needed.

Industrial

The identified user needs covering communications and location of rescuers can all be met potentially with current and planned space-based resources. Also, the vast majority of requirements for toxic cloud contour prediction can be met with current and planned using space-based resources. The observation requirements for accident monitoring cannot be achieved because of the need for real-time imagery at 0.1 to 0.2 m resolution. However, the communications requirements can be met to a significant level. In the case of planned services, future broadband satellites will allow two way high data rate video link from the aircraft directly back to the disaster headquarters. Requirements for spread prediction of toxic substances and toxic cloud contour can only be partially met with current and planned space-based resources. However, parameters such as wind speed and direction history, snow cover history, precipitation rate history, air pressure history and air temperature history are difficult to measure directly from space. The requirements for 3D cartography can only be partially met with current space-based resources. The availability of 1 m high spatial resolution data would increase the extent to which these requirements can be met.

Transportation

Almost all of the requirements for transportation risks can be met using current and planned space-based resources. This is because the vast majority of the identified user needs are for communications infrastructure and location information. The only parameter which cannot be partially or fully achieved is associated with the measurement of the degree of actual high water under model for estimation of the spread of water and dangerous substances. The requirements for a daily update frequency cannot be met today, and is unlikely to be achieved with planned satellites. Planned optical high spatial resolution satellites can achieve the required revisit frequency, but only during times of limited cloud cover.

Pipelines

The identified user needs for damage assessment, monitoring the environmental consequences, management of means and weather forecasts can be met with current and planned space-based resources. Cartography requirements can be partially met with current space-based resources, and then fully covered following the deployment of satellites providing at least 5 m spatial resolution. The requirements of released substance propagation monitoring cannot be met with current space-based resources and can only be partially covered with planned space-based resources. The critical driving requirement for both is a 1 day revisit.

Nuclear

Only the identified user needs for communications for accident monitoring can be fully met by current and planned space-based services. Transportable VSAT terminals and mobile voice, data and fax terminals using an Inmarsat-M and the planned MSS service like Iridium are all adequate for these needs. Future broadband satellite services such as Spaceway will provide even greater flexibility at lower cost than is currently possible with VSATs. The remaining requirements can only be met partially with current and planned space-based resources. There is a possible need for new satellite services to achieve some of the identified meteorology monitoring requirements.

Storms

Only the identified user needs for improved communications with and among the rescue teams can be met by space-based resources. There is a wide variety of satellite communications available to support all the voice, fax, mobile, video and data collection needs. Satellite communications are fully interoperable with the terrestrial communications infrastructure and PSTN.

Drought

All the identified user needs for water resource monitoring (data collection) and forestry and crop water stress (Earth observation) can be met by current and planned space-based services. The requirements for monitoring of urban unmanaged extensions can be fully covered by the planned high spatial resolution requirements as a resolution of up to 5 m is needed. The requirements for cartographic and topographic data for water work projects can be partially met by current and planned services, although they are limited by the need to achieve vertical resolution of up to 1 m. Monthly continental weather forecast requirements can be met except for the parameters associated with detecting aerosols.

8. SCENARIOS OF IMPLEMENTATION

The introduction of space based services into the European civil protection command chains has to be implemented in a gradual and progressive fashion which can be envisaged comprising three essential scenarios: a short term one (scenario 1), a medium term (scenario 2) and a long term scenario (scenario 3).

A proficient utilisation of available and planned space based services for major risks management demands for a rationalisation of the systems. A the time being there is a large dishomogeneity in the European scenario as far as satellite mission operators, service providers, service brokers, added value service providers, research and development institutions are concerned. Possible operational scenarios can range from an extreme decentralisation up to a sensible centralisation. The need for rationalisation implies a coordination activity which can be exploited conceiving an Integrated European Management Structure.

This so called Integrated European Data Management System is primarily a distributed system which, for a smooth running of the system, needs a centralised set of core activities. A Central Information and Coordination entity can be conceived which can play a main role of promoting the space based applications for the use by major risk management entities. In order to fulfil this goal, the centre is required to operate on different levels of activities, which are briefly summarised below:

1. Promotion for New Applications

   To organise on a regular basis meetings with the European research organisations in order to identify new applications, which can be offered to the national risk management authorities in the fields of telecommunications, data collection, navigation and Earth observation.

2. Launch of Validation Projects

   When new applications have been identified, which are of high importance for the risk management community, validation projects shall be initiated to demonstrate the operational usefulness of those applications.

3. Help in providing interface to Service Providers

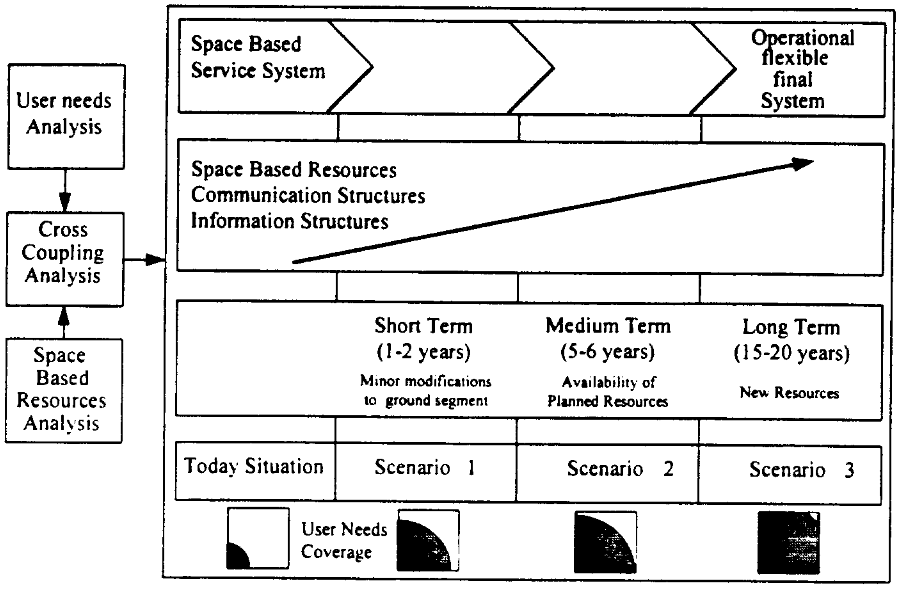
   When new applications could successfully be demonstrated or are of interest for risk management entities, possible service providers shall be identified, which are able to convert the scientific technology to commercial services.

4. Coordination of European Space Resources

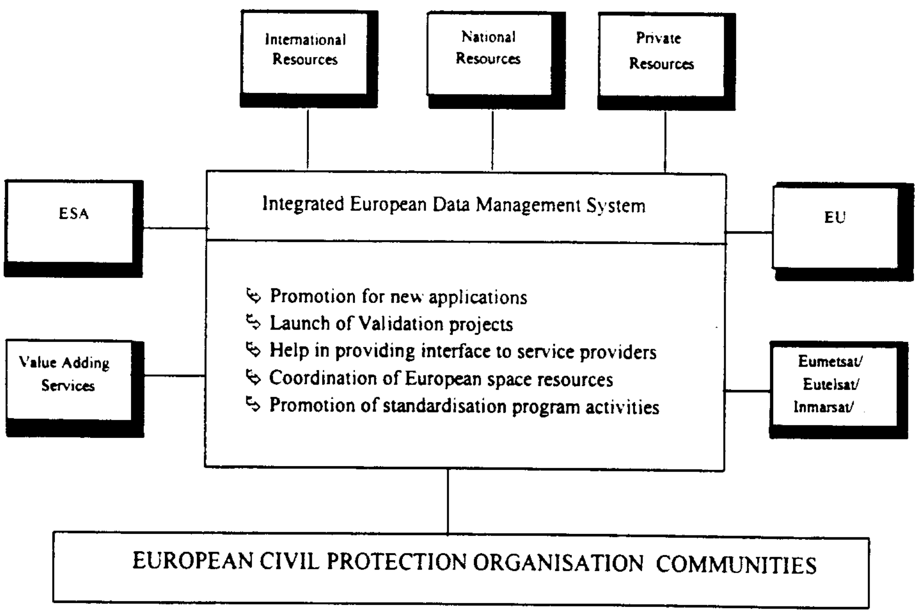
   When setting up new operational services, the data and information demand of the service providers shall be supported by a suitable coordination of the relevant space resources. This shall cover ESA originated space resources as well as resources set up by other international space resource providers (e.g. USA, Japan, India, Canada, etc.).

5. Promotion of Standardisation Program Activities

   The standardisation of space based risk management resources and services is a key factor for the usefulness and acceptance by national command chain authorities. It is therefore necessary, that the end products will be standardised in such a way that the type of information, its format and the contents is nearly independent of the data source or instrument.



Incremental evolution of space based services for risk management support



9. REAL CASE ANALYSIS

The real case analysis has been performed to assess and validate the results of fulfilment of civil protection user needs by space based services. Three real cases have been analyzed:

- The earthquake accident of Irpinia region in Italy on 1980 *(Natural disaster)*
- The forest fire accident in the Var region in France on 1990 *(Natural disaster)*
- The derailment accident of Ghent in Belgium on 1995 *(Technological disaster)*

For each accident and for each scenario, the validation has been performed with the support of a simulator tool which helped in assessing the quality factors (such as response time, early estimate damages, situation knowledge, quickness of intervention, operational means management effectiveness.....). The activities for that validation have been as follows:

a) analysis of available documentation (official reports, newspapers, interviews, etc.), to address chronology of events, specific needs, deployments of means, operations, etc.;

b) analysis of the services which could have been used to manage the accident, in the different risk phases (scenario 1, 2 &3).

c) rough order of magnitude cost analysis for scenario 1 services, with relevant trends for scenarios 2 and 3

d) high level implementation plan definition for the identified services

e) analysis of the costs and damages caused by the disaster

f) analysis of the potential benefits in using such services with respect to the actual situation occurred

Only the analysis of Irpinia earthquake is hereinafter summarised.

Irpinia Earthquake

At the time of the disaster (1980), civil protection policy was governed by the concept of post-disaster relief being understood as the only possible operation.

Yet to be cultivated were philosophies based on:

- forecasting, understood as activities aimed at identifying the types of risk threatening the territory, the affected areas, the possible amount of risk, and the territory's vulnerability to the specific event;
- planning, understood as activities aimed at reducing the vulnerability of the affected territory, in order to ease or reduce the effects that the disaster has on populations, assets, and the environment;
- relief, understood as an activity that long precedes the event, since as soon as the results of the forecast and prevention are made available;

Management took place based on criteria and procedures defined depending on a number of contingent situations, with non-optimised solutions.

Bodies responsible for local risk management were without the means and infrastructures that were affected by the event.

Relief operations prepared and conducted by military, police, and fire department authorities in the two regions affected were activated immediately after the seismic event and directed towards those localities from which there was reliable information that there had been destruction and damage.

One of the first measure taken was to develop a system for field telecommunications which was completed on the seventh day after the quake.

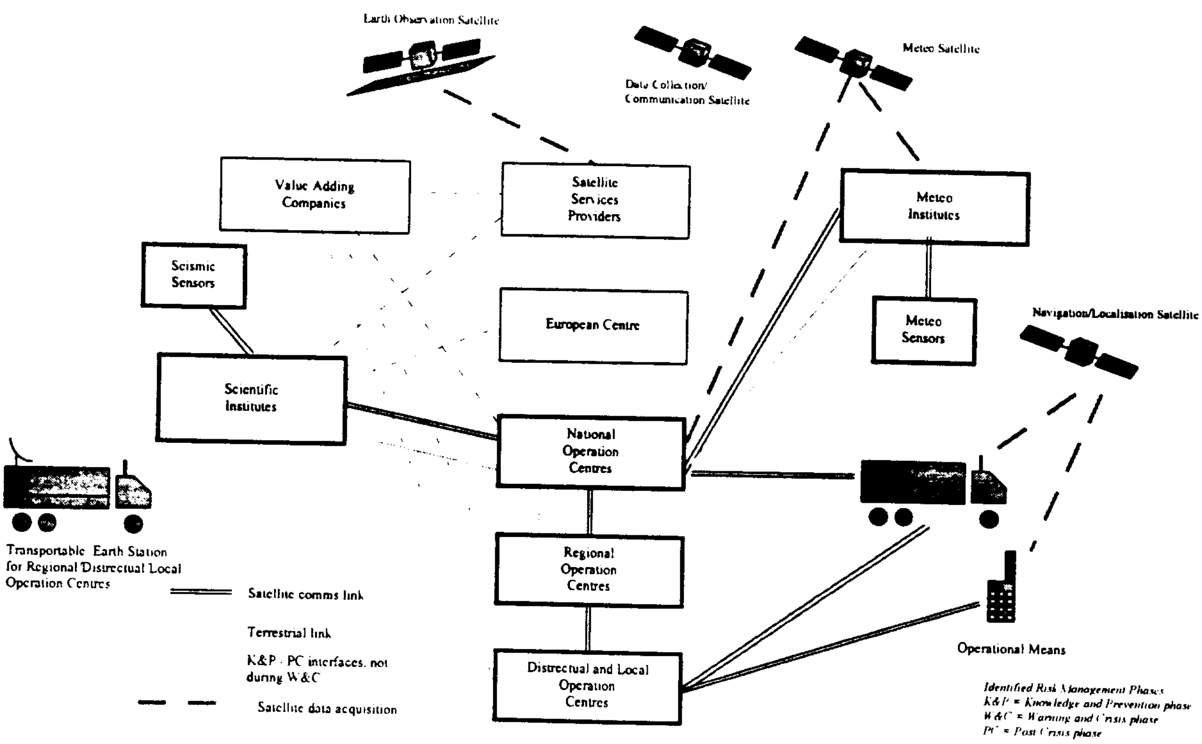
Identified Services for Scenario 1: Irpinia earthquake

Products and Services Definition: **Scenario 1 - existing space resources**	**Category**	**Phase**
GEOSTRUCTURAL MAP	EO	K&P; W&C
LAND USE MAP	EO	K&P; W&C
LANDSLIDE HAZARD MAP	EO	K&P; W&C
MANAGEMENT OF MEANS ON THE SCENE	LOC	W&C
IMPROVED INFORMATION EXCHANGE	COM	W&C
MOBILE COMMUNICATIONS SERVICES	COM	W&C
ITALIAN NATIONAL SEISMIC NETWORK	DC	K&P; W&C
ACCELEROMETERS NETWORK	DC	W&C
SLOW MOTION MONITORING (TYRGEONET)	DC	K&P
MEDITERRANEAN NETWORK	DC	K&P

Used Abbreviations:

- COM Communication
- NAV Navigation
- EO Earth Observation
- DC Data Collection

Scenario 1 Definition for seismic risk



Summary of the conclusions - Irpinia earthquake

Data collection satellites can support already today the seismic network. An additional cost reduction is expected with the new low earth orbit data collection satellites planned for the near future.

Existing communication satellites already meet the needs to improve the information exchange during warning and crisis phase.

Navigation and meteorological satellites fulfil the expressed user needs.

Earth Observation (EO) satellites can today only partially provide information for knowledge and prevention phase of seismic risk management. Improvements are expected with planned high resolution resources.

EO can even today provide most of basic information needed to set-up a GIS which , developed by value added companies and used at operation centre level, can support operations and decision making during warning and crisis phase.

Services for the three scenarios and general system architecture for the first two, are summarised in the previous and next pages.

Summary of the conclusions - Derailment at Ghent

Navigation satellites and data collection satellites can already today support the knowledge of the location of train, but require a special system to be used in tunnels.

Existing communication satellites already meet the needs to improve the information exchange during knowledge and prevention as well as warning and crisis phases.

Planned meteorological satellites will fulfil in the near future the expressed user needs.

Earth Observation (EO) satellites can today only partially provide information for knowledge and prevention phase of transportation risk management. Significant improvements are expected with planned high resolution resources.

EO can even today provide most of basic information needed to set-up a GIS which , developed by value added companies and used at operation centre level, can support operations and decision making during warning and crisis phase.

Summary of the conclusions - Forest Fire at Collobrière

Navigation satellite and data collection satellites can already today support the management of operational means.

Data collection systems can already today support fire front contouring and hot spot detection, with an expected cost reduction in the near future.

Existing communication satellites already meet the needs to improve the information exchange during knowledge and prevention as well as warning and crisis phases.

In the near future planned meteorological satellites will better fulfil the user needs.

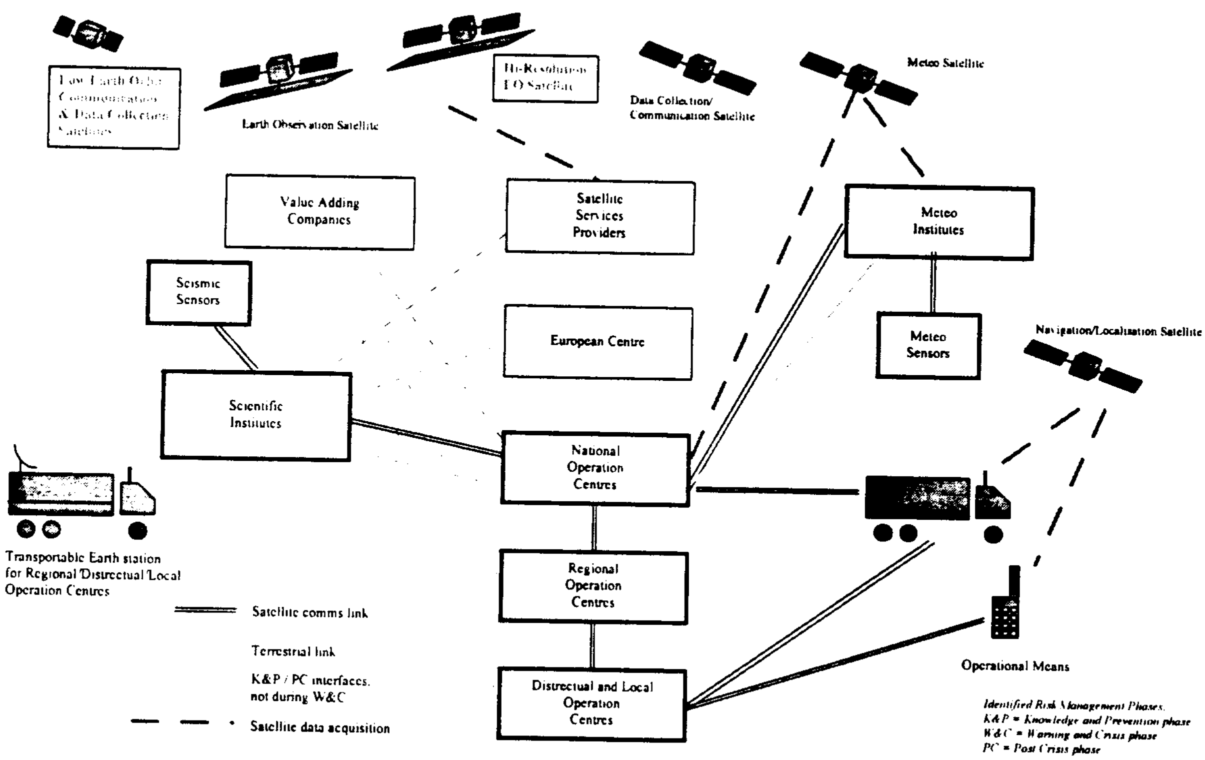
Earth Observation (EO) satellites can today provide cartography, vulnerability and daily risk index maps at a satisfactory level for knowledge and prevention phase of forest fire risk management. Damage assessment can also be performed by using satellite resources.

Significant improvements are expected by using planned Earth observation satellites.

Identified Services for Scenario 2: Irpinia earthquake

Additional Products and Services Definition: Scenario 2 - planned space resources	**Category**	**Phase**
SEISMIC MICROZONING MAP	EO	K&P; W&C
URBAN AREAS MAP	EO	K&P; W&C
ROADS AND RAILWAYS MAP	EO	K&P; W&C
DAMAGE ESTIMATION MAPS	EO	PC

Scenario 2 Definition for seismic risk



Identified Services for Scenario 3: Irpinia earthquake

Additional Products and Services Definition: Scenario 3 - potential space based services evolution	**Category**	**Phase**
REAL TIME DAMAGE ESTIMATION MAP	EO	W&C (*)

(*) No system for the time being planned or announced

10. ROUGH ORDER OF MAGNITUDE COSTING FOR SPACE SERVICES

A rough order of magnitude cost analysis has been performed based on the following assumptions:

- market prices of standard equipment, raw Earth Observation data and value adding services;
- investment cost for equipment;
- depreciation of investment costs during a period of 10 years;
- costs of system operations and maintenance.

Benefits deriving from the use of these services can have direct, indirect or intangible impacts. Direct benefits can be probably better understandable, even if savings due to space based services are potential and not easily quantifiable (e.g. reduction of operation costs, etc.). Indirect benefits (e.g. reduction of vulnerability by means of medium-long term activities, reduction of insurance rates, etc.) or intangible benefits (reduction of pains, preservation of natural resources and reserves, etc.), which have impact on political or economic means need to be better and deeply analysed.

The cost figures are provided for the first scenario and for the second scenario. The third scenario is not costed due to the high number of unknowns.

Seismic Risk cost assumption

The period of 30 years is assumed to estimate the annual cost of damages produced by an earthquake (i.e. annual cost of earthquake = overall cost of Irpinia earthquake divided by 30 year). This assumption is based on the estimated average time between seismic disasters in Italy. Considering this century, in fact, Italy was stricken by four major earthquakes (Messina 1908, Avezzano 1915, Friuli 1976, Irpinia 1980).

Transportation Risk cost assumption

Cost estimation for Germany, EU and Greater Europe. Costs have been detailed for Germany, and an extrapolation from Germany to EU and Greater Europe is performed by applying actual"tons * km" factor to EU Member States and Eastern Europe States.

Hazardous goods transportation on rail will represent a major risk due to future increased traffic load (due to political effort to convert road traffic to rail traffic).

During the study, on 2 June 1996, near Magdeburg, a derailment of a wagon with Vinyclorid followed by an explosion, caused 21 injuries in a nearby urban area.

Forest Fire Risk cost assumptions

Cost have been detailed for France and an extrapolation is performed to obtain an estimation of EU and Greater Europe related costs.

Summary of Service Costs: Seismic Risk

Cost Item	Average Investment Cost per year (ROM estimate KECU)	Average Operation Cost per year (ROM estimate KECU)	Overall Cost Per Year (ROM estimate - KECU)
Communications	644	6000	6644
Data Collection	72	90	162
Earth Observation	265	265	530
Meteorology	5	4	9
Navigation	380	370	750
Overall Costs	1366	6729	8095

Disaster Cost Estimates

Disaster consequences	Damages to population for Irpinia Earthquake
Dead	2735
Injured	8884
Homeless	346500

Cost Item	Cost and Damages for Irpinia Earthquake (MECU)
First relief activities	1000
Operational Personnel Costs	1250
Operational Means Cost	2500
Economical and Artistic assets	15000
Grand Total of Costs	19750

Total yearly service costs

Yearly Risk Damages (MECU)	Real Case Total yearly service costs	Total yearly service costs		
		Single Nation (MECU)	EU (MECU)	Greater Europe (MECU)
(Italy) (*) 673	***Irpinia Earthquake***	8.1	**	**
(Germany) 60	***Transportation accident at Ghent***	5.5	25.0	33.0
(France) 135	***Forest Fire in Collobriere region***	8.3	41.4	75.0

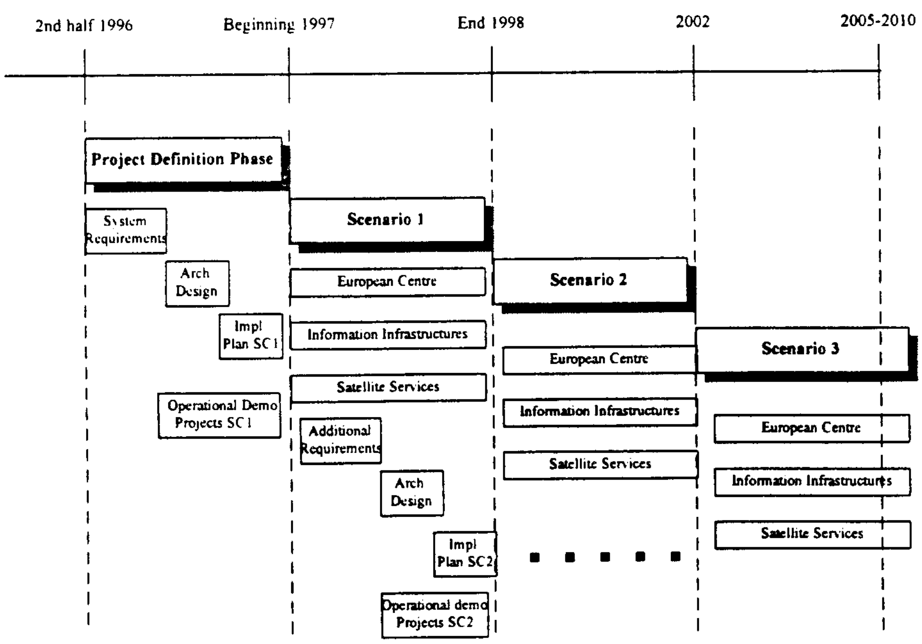
(*) 30 years period considered

(**) Unpredictable

11. OVERALL SCENARIOS PLANNING

The overall scenarios planning takes into account the need for a project definition phase which is aimed at:

- Defining functional and operational requirements for a risk management system, based on specific risks and nations. Operational requirements are driving factors mainly during warning and crisis phase.
- Defining system requirements and functional analysis, identifying functions, interfaces, performances, with relevant availability and reliability figures of the system to be implemented for scenario 1.
- Performing the architectural design.
- Launching specific operational demonstration projects to demonstrate operational advantages that satellite services can supply with respect to presently used procedures.
- Detail the implementation plan for the scenario 1 where the major elements to be covered are:
  - ⇒ European Centre
  - ⇒ Distributed equipment (single unit) for networking, telecommunications, Earth observation, navigation and positioning, meteorology, data collection
  - ⇒ processing and GIS facilities at operational centres
  - ⇒ preliminary estimation of the number of items needed to cope with seismic risk management.



12. CONCLUSIONS

Present space systems already offer a large number of potential risk management applications in the frame of communications, Earth observation, meteorology, navigation, localisation and data collection disciplines. Limitations are presently in the Earth observation area, where immediately up-to-date products are required.

The already initiated global communication systems will significantly ease the information exchange between the different risk management authorities during a warning and crisis situation.

Planned commercial Earth observation systems with spatial resolution in the 1-5 meter domain will improve the product quality also for local risk management applications. The suitability of these products is however strongly dependent on the final implemented product extraction and distribution concept

The vast majority of the needs appears to be met by space-based resources. This is especially the case once the planned high spatial resolution satellites are launched. However what can be said is that satellites not necessarily represent the most cost-effective solution in every case and the choice of space versus ground resources depends on the risk case. An efficient access to data products and services is clearly fundamental.

A new "high resolution, frequent revisit, all-weather" Earth observation capability would benefit 8 out of 10 risks.

The benefits of satellite based services for risk management operations, considering the activities performed in all the risk management phases, could be validated throughout some *operational validation projects*. These projects could start very soon, having as inputs the global results of this phase 3 study. It is important to emphasise the operational aspects in these projects since civil protection organisations need systems able to solve operational problems, not (only) technological problems.