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<tr><td colspan="4">ESA STUDY CONTRACT REPORT
No ESA Study Contract Report will be accepted unless this sheet is inserted at the beginning of each volume of the Report.</td></tr>
<tr><td></td><td colspan="2">SUBJECT
EXECUTIVE SUMMARY REPORT ON USE OF SPACE TECHNOLOGY FOR RISK MANAGEMENT</td><td>CONTRACTOR
ALCATEL-ESPACE
G. Tarel, study manager</td></tr>
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<tr><td colspan="4">ABSTRACT:
The present document is the Executive summary report of the phase 3-study on the use of space technology for risk management. It gives the results of such study ,as follows:
a- Conclusions on compliancy analysis between end-users requirements and space resources
b- Definition of a concept of user oriented space based Information & Communication Service System
c- Real-cases study conclusions (analysis of 2 floods cases)
d- Cost & implementation plans of the System
e- General conclusions and recommendations</td></tr>
<tr><td colspan="4">The work described in this report was done under ESA contract. Responsibility for the contents resides in the author or organisation that prepared it.</td></tr>
<tr><td colspan="4">Name of authors: Alcatel Telecom with Scot-Conseil, Planeta, Geste, Eurospace, and LHF companies</td></tr>
<tr><td colspan="2">**NAME OF ESA STUDY MANAGER
Mrs. G. NAJA
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DIRECTORATE: HQ - PARIS</td><td colspan="2">**ESA BUDGET HEADING</td></tr>
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* Section to be completed by ESA
** Informations to be provided by ESA Study Manager

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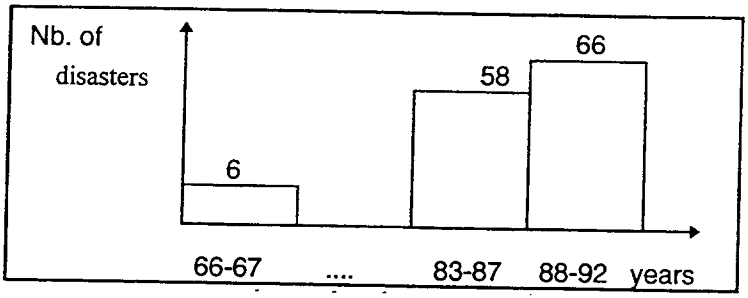
LIST OF ACRONYMS

E.O.	*:*	*Earth Observation*
G.I.S.	*:*	*Geographical Information System*
D.B.	*:*	*DataBase*
V.S.A.T.	*:*	*Very Small Antenna Terminal*
I.S.D.N	*:*	*Integrated Switch Data Network*
P.S.T.N.	*:*	*Public Switch Telecommunication Network*
Comms	*:*	*Communications (Abbreviation)*
P.A.B.X.	*:*	*Private Automatic Branch Exchange*
P.C.	*:*	*Personal Computer*
H.Q.	*:*	*Headquarter*
P.S.D.N.	*:*	*Public Switch Data Network*
I/F	*:*	*InterFace*
D.C.	*:*	*Data Collection*
Loc.	*:*	*Localisation (Abbreviation)*
R.O.M.	*:*	*Rough Order of Magnitude*

INTRODUCTION

The management of major risks has always been an important issue for the functioning of a country, as the effect of a natural or technological catastrophe or accident may concern the whole population in terms of its health of welfare. Statistics publicly available at the Suisse Re- Insurance Company indicate a strong increase in the world of the major risks (natural & technological) during the past 20 years (source : Suisse Re). For the period of 1988 to 1992, a total of 65 Billion $ losses (worldwide) was counted by the insurance company, whereof 30 Billion $ refunded by the Re-insurance companies. Only for the territory of the European Union several major catastrophes are still in our mind : Seveso (1976), Earthquake - Frioul (1976), Tchernobyl (1986), Tanneron forest fire, France (1986), Camargue flood (1994), Rhine flood (1995), etc...



During all the catastrophes ,reality has shown that the success of risk management largely depends on the **availability, dissemination** and **effective use** of information. In order to better understand their problematic, a study program was initiated by the Executive Secretariat of the Council of Europe (European Partial Open Agreement named EUROPA) on request of the signatories of the Agreement, in order to investigate the use of satellite systems for the management of Major Risks.ESA has been requested to give its technical assistance to the Executive Secretariat for that purpose The whole study was steered by a tri-partite entity (ESA,European commission & EUROPA Agreement representatives). In the present phase 3 ,the user requirements were gathered and analysed in detail. A Compliance analysis, comparing user requirements and current and planned space technologies, was carried out. The results of this analysis showed that many of the requirements can already be met by existing space resources.However, major technical limitations still exist in the field of Earth observation. In fact, some important information can only be produced when using all available Earth Observation satellites. For other information , no products or services are currently available. Several technical parameters need also further research. A Database containing the different information was implemented. Furthermore, a **Space-based Information & Communication Service System** architecture was defined and its development, implementation and operational costs were defined. The intermediate and final results obtained during the different phases of the study have been presented to the Civil Protections of the permanent members of the EUROPA Agreement during two workshops.The first workshop was held in the ESRIN at FRASCATI (Italy) from 13 to 15 november 95 and the second one has been organised in the JRC-ISPRA establishment of the European Commission on 1st and 2 july 96.

The overall **ESA study program** has been divided into 4 phases:

- **Phase 1** (performed by Tractebel (B) and Geste (F) consultants): Identification of user needs for six major risks management : (three natural risks and three technological risks), represented on the one hand by **floods, forest fires and earthquakes risks**, and on the other hand by **industrial, hazardous transportation and nuclear risks**.
- **Phase 2**: Inventory of relevant space resources (available or planned) in the greater Europe. This part was performed internally by ESA.
- **Phase 3** (present phase): Definition of a space based Information and Communication Service System. Two complementary and parallel contracts have been awarded by ESA,the first one to **a consortium lead by ALCATEL Telecom,** and the second one, to a consortium lead by Nuova Telespazio.
- **Phase 4** (future phase): Analysis of the benefits versus cost of the space systems to support the management of major risks.

1. CONTEXT OF THE STUDY PROGRAM

The EUROPA Agreement's prime objective is the prevention , protection and organisation of relief ,in major natural and technological disasters.

It must be kept in mind that national sovereignty is a basic principle. This will be of particular importance regarding the definition of any ground segment and command chain involved in any future system.

The countries signatory of the Agreement are presented in the following table with a comparison to the ESA states. It also indicates the countries belonging to the Council of Europe and to the European Union.

EUR-OPA Agreement countries	ESA member states	Council of Europe	European Union
ALBANIA		X	
ALGERIA			
ARMENIA			
AZERBAIDJAN			
BELGIUM	X	X	X
BULGARIA		X	
SPAIN	X	X	X
FRANCE	X	X	X
GEORGIA			
GREECE		X	X
ISRAEL			
ITALY	X	X	X
LUXEMBOURG		X	X
MACEDONIA		X	
MALTA		X	
MAROCCO			
MONACO			
PORTUGAL		X	X
SAN-MARIN		X	
RUSSIA		X	
TURKEY		X	
*GERMANY**	*X*	*X*	*X*
*SWITZERLAND**	*X*	*X*	
*JAPAN**			

* Observer countries, only.

2. RESULTS OF THE PREVIOUS PHASE 1 - ESA STUDY

Previous phase 1 study has shown that there is a **great convergence on needs and wishes** expressed by the countries, as follows:

1) **Basic informations needs:**

- general **cartography** of risks and damaged areas maps (including vulnerability) as basic information,
- Systematic **experience feedback,** as basic information .

2) Support to **Decision-making for:**

- **routine monitoring** of selected parameters in areas exposed to major risks as a decision-making aid tool, which implies availability of proper modelling of the risk area and in-situ data collection in addition with the imagery of the risk areas.
- availability of efficient and reliable **telecommunication** means in an operational way.
- rescue operation assistance: **radiocommunication, localisation and navigation** in an operational way also.

The following issues have ,also been ,emphasis in the phase 1 study:

(a) All updated and new data should be transmitted to operational entities under an **adequate format adapted to their needs** through already existing organisations.

(b) All countries consider that the major impediment to progress is a lack of financial means. It is stressed that cost will be a key point for the use of space systems. So any system acceptance is linked to financial considerations and should prove, **economically, justified**.

(c) Lastly, any efficient major risk management is also linked with factors such as population training and information, availability of expert teams in the technical and scientific fields involved in the risk domains etc...

3. OBJECTIVES OF THE PHASE 3 STUDY

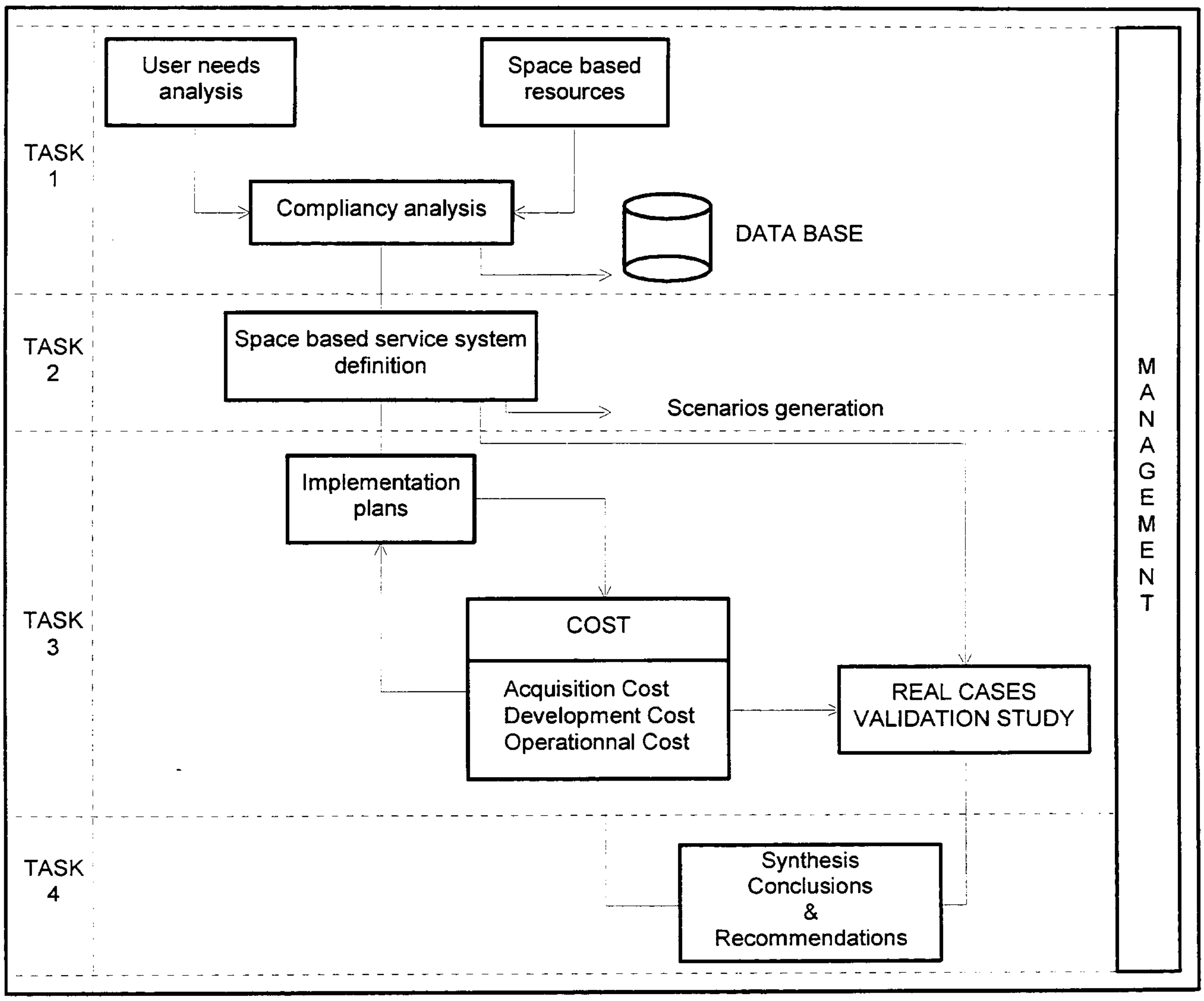
The phase 3 study work was divided into 4 main tasks, as follows:

- **Task 1:**
  - Establishment of a consolidated table of user needs
  - Analysis of fulfillment of the user needs by space resources
  - Validation of space resources & implementation of a database on major risks management
- **Task 2:**
  - Definition of space based information & communication Service System to support major risks management
  - Generation of 3 scenarios in which space resources involvement is progressively increased
  - Recommendations on the organisation to be created in charge of interfacing between end-users and space data providers
- **Task 3:**
  - Implementation plan of the space based service system in accordance with user needs and space resources availability
  - Cost estimates for:
    - space data and communications services acquisition,
    - necessary development to be done for establishing a space based service
    - operational costs of the Service,
  - Two real cases disaster studies (floods in Russia and Belgium)
- **Task 4:**
  - Synthesis of the study findings
  - Recommendations on essential aspects

4. COMPANIES INVOLVED IN THE STUDY

		Responsibility
Study leader:	Alcatel Telecom (F): G. TAREL	Project management, (tasks 3 and 4)
Partners:	• Alcatel Telecom (B): K. PETIT with CLEO support: J.P. DECOSTRE	Responsible task 2, contribution to task 3
	• Scot-Conseil (F): J. HARMS, J.F. CAZAUX	Responsible task 1, contribution to task 3
	• Planeta (Russia): E. MANAENKOVA	Contribution to tasks 1, 2 and 3
	• Eurospace (G): A. KOHLHASE & HANTSCHEL	Contribution to task 2 (scenarios analysis)
	• LHF (F): J.CUNGE	Consultancy service for flood cases analysis
	• GESTE (F): M. LEYGHES	Consultancy services for user requirements analysis and real-case studies

5. STUDY LOGIC (PHASE 3)



6. SYNTHESIS OF USER REQUIREMENTS

The user requirements have been split according to the three risks phases considered in the study, as follows :

- Prevention phase (including preparedness & knowledge improvement)
- Crisis phase (including crisis monitoring)
- Post-crisis phase (including damage assessment and rehabilitation)

The potential user communities addressed in the study are:

- Civil Protections, (mainly concerned by the crisis phase),
- Governmental Authorities and collaborating scientific Institutes, in charge of the prevention and post-crisis phases, such as : Ministry of Environment, dedicated governmental Agencies, and European institutions involved in risk management
- Insurance companies for damage assessment.

The user communities need to get reliable and timely information for risk management purpose,. Use of space technologies can efficiently complement the sources of necessary informations. Five space technologies have been considered for that purpose :

1. Meteorology
2. Data collection and localisation
3. Navigation
4. Telecommunications
5. Earth observation from space, both passive (optical imagery) and active instruments (radars in several frequency bands)

The detailed analysis of the existing space systems supporting the hereabove technologies 1 to 4, has shown they are already fully operational through **existing** service providers in Europe including the Russian facilities. The planned space systems will bring later both an improvement in system performances and operational cost reduction.

The existing space Earth Observation Systems are still in an exploratory pre-operational phase and even in the research field for some technical areas.Applications in the area of risk management still have to be developed through a better knowledge of user needs, easier access to data and decreasing cost of space images.

6.1 INFORMATION NEEDS

The category of information needs corresponds to what the user communities have expressed during the first phase of the ESA study program. The first task of our study was to build upon these user requirements, and translating them into technical characteristics (parameters), which can be easily compared to space system capabilities (existing and planned).

The appendix 1 hereto shows the synthesis of the information needs ,as expressed by the end-users.

6.2 PARAMETERS OBTAINED FROM USE OF SPACE TECHNOLOGY

- The appendix 2 shows the list of the **54 required parameters** which could be obtained, by the different space technologies.
- Attached to each parameter is a set of technical specifications (spatial and temporal resolution, data rates, accuracy of measurements, frequency band to be used ...)
- The values of each set of technical specifications attached to a given parameter are depending of type of risk and risk phase.

7. COMPLIANCY ANALYSIS BETWEEN USER REQUIREMENTS AND SPACE RESOURCES

The compliancy analysis between parameters which could be obtained from space systems (existing and planned), and the user requirements has been performed by using a Database especially implemented for that purpose. This database has been developed under the ACCESS 2.0 software.

Such compliancy analysis was performed on several levels. The first, and basic level of compliancy consisted in comparing the different parameters which have to be measured within the various information needs against the capabilities of the different sensors to measure these parameters. On second level, the technical feasibility was investigated using the technical requirements (spatial and temporal resolutions, as well as positioning accuracy). On the third level the operational feasibility was investigated taking into account the delivery delay and the availability of space products and services.

Conclusions:

Among the 54 retained parameters, 30 are in the field of Earth Observation, 6 in the field of meteorology, 13 are requiring data collection space systems, 1 can be obtained from navigation satellite systems, 2 from space localisation systems and 2 are obtained through the the direct use of telecommunication satellite systems.

Furthermore, among these 54 parameters, 37 can be obtained with current space technologies(scenario 1), 2 will benefit from improved future space missions (scenario 2), while for 15 parameters neither current or planned European space technologies can fulfil the requirements (scenario 3).

The following table shows the results of this compliancy analysis, (as performed by Scot-Conseil):

Compliancy level / Space Functionality	parameters	Scenario 1			Scenario 2			Scenario 3
	TOTAL	A	B	C	A	B	C	A
Earth Observation	30	6	6	4	1	1	0	12
Meteorology	6	3	-	-	-	-	-	3
Data Collection	13	13	-	-	-	-	-	-
Navigation	1	1	-	-	-	-	-	-
Localisation	2	2	-	-	-	-	-	-
Telecommunication	2	2	-	-	-	-	-	-
TOTAL	54	27	6	4	1	1		15

Legend :

Column A: number of parameters **fully** compliant with the technical & operational user requirements,.
Column B: number of parameters **partly** compliant only with the technical user requirements,
Column C: number of parameters **partly** compliant,only with the operational requirements,but fully compliant with the technical requirements.

CONCLUSIONS:

a-) The table hereabove shows clearly that about **50 %** (27/54) of the parameters can be presently delivered by the existing space systems in full compliancy (technical and operational) with the user requirements.Six parameters out of 30 accessible to Earth observation systems can be measured operationally from space, by current existing satellites.

b-) 6 additional parameters are technically compliant but not operationally compliant due to the delay to get space images. This delay can be reduced by increasing the number of Earth observation satellites e.g. creating a constellation of satellites and in parallel reducing the delivery time to the users of the processed images. Today, the minimum delivery time for an image from a purchase order, is not less than 24 hours. This time should be reduced to a few hours by using electronic delivery, or direct image satellite receiving stations, and by shortening the time to prepare and load on board of the satellite the parameters of the mission. If the above is achieved in the coming years, about 70% of the Earth observation user requirements should be fulfilled by space systems (existing and planned).

c-) 3 meteorological parameters are not compliant with the user requirements for risk situations like forest fire, industrial disaster, transport disaster, They are related to the needs for local weather forecasts (e.g. forecast on a few kms area).

d-) All parameters accessible through data collection, localisation navigation and telecommunications are compliant with the user requirements.

e-) It is to be noted that the above compliancy considers the use of all the European space resources available or planned, in particular the mobilization of the Russian space systems which should be made available, in Western Europe, through an adequate organisation and technical connection with the Russian space organisation.
Nowadays, image providers in the field of Earth Observation manage their space systems on a single mission planning basis. There is a need for a multi-satellite mission planning management. The real-case studies (floods), have clearly demonstrated the possibility of satisfying the user needs only by using all the available Earth Observations satellites during the crisis and post-crisis phases.

f-) The study has clearly shown that direct detection and monitoring from space of the radiation level of nuclear disaster is presently not feasible. Nuclear monitoring could only be done from ground detectors with data collection from space, if there is an economical benefit to do so, instead of using standard public telephone lines. It has been noted that the increase of temperature of a nuclear power-plant could be detected from space (SPOT,LANDSAT) but the revisit time of existing Earth observation systems is too long, for the time being, to provide a reliable nuclear plant monitoring system.

g-) The forecast of earthquakes remains with the research domain,but space can usefully contribute by the monitoring of crust movements (few mm or cm) with accurate space localisation systems, already available, like DORIS, GPS, GLONASS... Accurate and permanent crust movement records could constitute a valuable pre-alert information.

h-) A major study conclusion is that space use is fully justified for supporting the risk management in all phases. Space data used together with the ground data and/or airborne data provide excellent synergy for the overall management of risk situations, in all phases.
We believe that such use should be developed ,especially considering the fact that the cost of the space technology are decreasing every year. This is particularly true in competitive technology area, like telecommunications, data collection, localisation and navigation. The Earth observation will certainly follow the same trend in the coming years.

8. CONCEPT OF A SPACE BASED INFORMATION & COMMUNICATION SERVICE SYSTEM

8.1 NEED FOR SUCH SERVICE SYSTEM FOR SUPPORTING THE USE OF SPACE TECHNOLOGIES

In Europe, the management of risks is shared among several actors like national & governmental organizations and Institutions (scientific and technical).The civil protections are usually,only, in charge of the management of the crisis phase.

On the one hand, the different actors form an user community of more than 100 potential users of space technologies, and on the other hand ,a lot of space resources (more than 30 space systems) are already existing and could be mobilized for risk management purpose in synergy with other technologies (information technology, software processing and telematics, ...) and ground data. It is a clear fact that the space potential is not today currently mobilized for such risk management purpose and nor well integrated in the decision chain, even in some important space country ,like Russia.

The main reasons are:

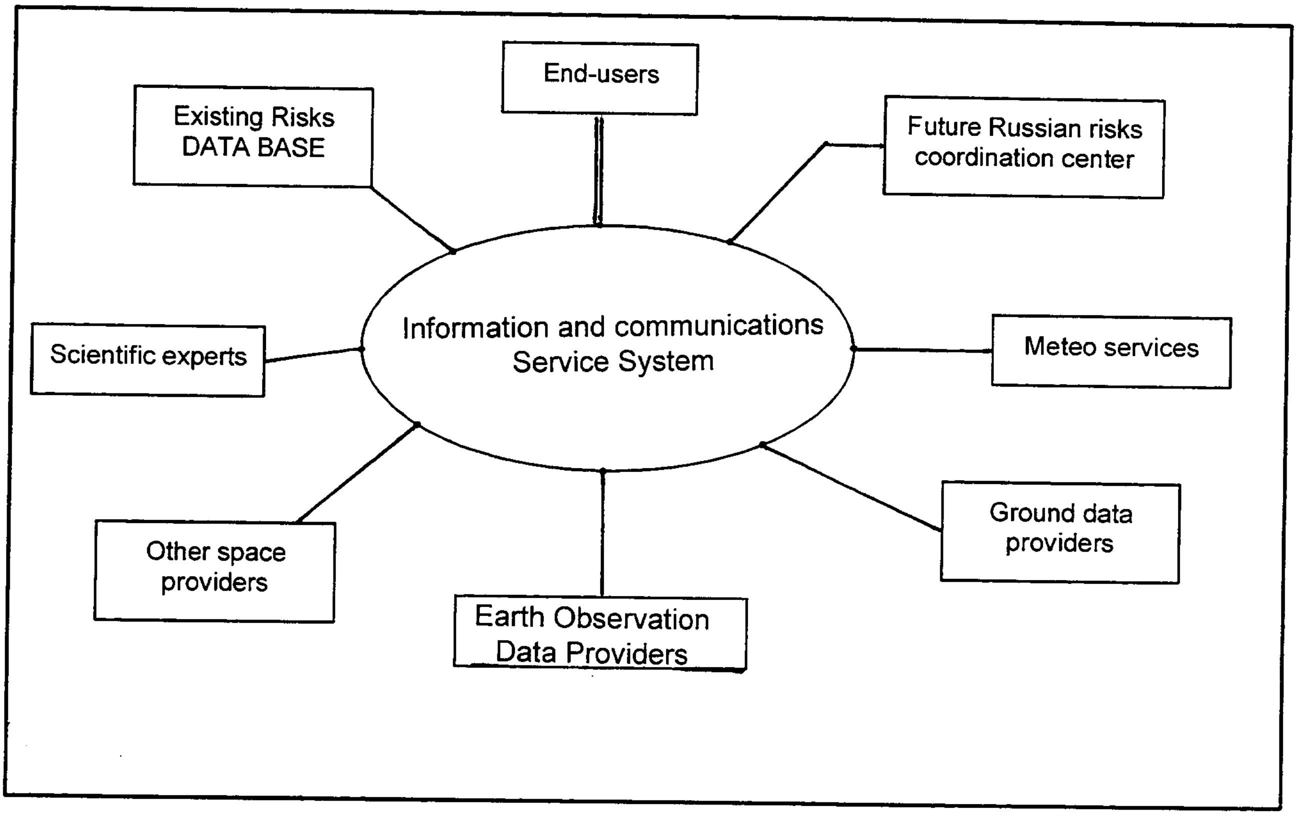
- Authorities are not convinced of the technical and economical usefulness of space, except for navigation ,telecommunications and meteorology.
- No contingency plans and procedures are prepared with full integration of space means.
- Lack of adequate organization for making an efficient use of space technology.
- Lack of full awareness of space system capabilities towards effective use.
- Feeling that the use of space is too costly.
- Lack of an adequate space based Service system able to interface efficiently between space service providers like Spot-Image, Planeta (R), Eurimage, Cls, Euteltracs, Eutelsat, etc... and the user communities.
- Only few Space Information Products and services directly available for use by end-users.
- Operational availability of space imagery not considered as satisfactory for adequate crisis and post-crisis management

There is, therefore,a need to bridge the gap between the space data/service providers and the user communities in order to:

- guide and support the user communities for more efficient use of space,
- reduce the cost of use by a centralized procurement of space data ,
- ensure the supply of space data/service in an operational way within a well defined and short delivery time by mobilizing the full available space resources at an acceptable price.

The Service System that it is needed, is a space- based Information and Communication System, able to directly interface through some remote stations with the risk management Command Chain of the users .Such System has, obviously, an economical justification only at an **European level.**

We believe that such space-based Information & communication **Service System** should have its technical functions decentralised through Europe ,but its management should be centralized in order to ensure effectiveness of the SERVICE. However, such System will not compete or replace any national Risk management System. It is clear that such new space-based Service System should have, *only, a complementary use.*



8.2 FUNCTIONS OF THE SERVICE SYSTEM

The functions of the space based Information and Communication **Service System** are:

1) Management functions :

- Implement a policy of products/services (telecommunication, data collection, Earth Observation, meteorology, etc...)
- Define the applicable procedures for images/products & services to be supplied. This implies an adequate image product definition, multi-satellite missions operations & data archiving facilities ....
- Standardize the data and the exchanges of data,
- Guarantee the security of the Information,
- Assure the quality of products and services delivered to end-users
- Train and inform the end-users upon effectiveness of use of space technology,
- Support the development of any operational applications in risk area (GIS, simulation, models, ...), when and if needed,
- Supply expertise, on request, by mobilizing the relevant experts.

2) Technical functions :

- Assure the interfaces (end-user request handling, orders to the various space providers, image acquisition, ...),
- Assure the communications (nodal point) and broadcast the information to end users, as required,
- Monitor the communications system (network management),
- Define the satellite mission requirements for prevention, crisis, post-crisis phases,
- -Obtain the Earth observation data from data providers, interpret, process and disseminate these informations,
- Archive the data for further use (play- back for further prevention purpose, ...),
- Technical support: help desk, statistics,etc ... .

The *Service system* should produce operational information, value added data (like parameters for simulation models) and products (simulation models, ...) to be integrated in any national System. Such space-based **Service System** is thus a complementary system to any operational national Systems. It must be interoperable with any operational systems.Its characteristics could be the following:

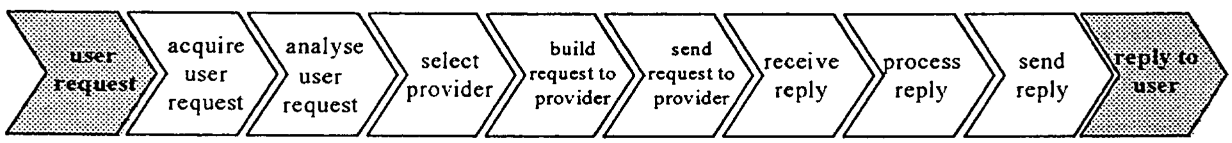
- Except for the Earth Observation products, the other data service providers (meteorology, localisation, data collection etc...) should be directly connected to the end users (no transit via the space based Service System), nevertheless, a returnlink from end users to the Service System could be useful for alert purpose and mobilization of emergency means
- System modularity allowing a centralized and/or a distributed architecture,
- Direct interface with end-user facilities which can be widely different, allowing ,for example, to deliver high level processed and interpreted images to the end-users .
- Flexibility of the proposed service to user communities: direct services (e.g.: supply of pre-processed data to collaborating Institutes), standard services (e.g.: interpreted data) or specific services,such as extraction of same parameter values etc....

8.3 SUB-SYSTEMS PRESENTATION

The different sub-systems are:

- Management subsystem:
  Management of data for the benefit of user communities, orders to relevant service providers , accounting, & billing of services...
- Earth observation data **server** subsystem :
  Interface with data providers: acquisition of user request analysis, satellite multi-mission selection, request to provider, answer acknowledgment and control, on-line processing (image interpretation) and delivery to the end users...

  The following figure gives a sketch of the steps in the processing of a user request:



- Monitoring expert subsystems:
  For example: monitoring of the risk degree of forest fires
- Processing subsystem:
  Off-line processing, modelling and simulation support, GIS services, ...
- Archiving subsystem:
  Delivery of archived data related to previous crisis cases
- Expert database subsystem:
  Management and search of Experts (persons or organisations) in various domains (nuclear, hydraulic, chemical, etc....).
- Telecommunication subsystem:
  Network management (channels and protocols), data transmission, ...

The services to be directly supplied to the end users require some additional functions, as follows:

- *Data analysis tools* (Collaborating institutes):

  Local models, GIS, risk monitoring & alert

- *Meteorology subsystem* (Collaborating institutes & operational management):

  Acquisition of meteorological data and local forecast

- *Data collection subsystem*

  Collection of data from in situ sensors

- *Localisation & Navigation subsystems* (Operational management):

  Localisation and guidance of entities acting on the field (rescue means, ...)

- *Telecommunications* (Collaborating Institutes & operational management):

  Communication tools

8.4 RECOMMENDATIONS ON ORGANISATION OF THE SPACE-BASED SERVICE SYSTEM

From an operational point of view, this Service System could be shared into 3 organisational entities:

- an *Executive Unit* concerned by: management, administration, product & service policy, procurement, standardization, contractual matters, training , & accounting,
- an Earth observation *data server & Monitoring facilities*, operational 24/24 hours, in charge of the requests handling, the multi-satellite mission selection, the Earth observation data reception, control and on-line processing (standard image interpretation for transmission to crisis Centres), the dissemination to end users, the risk monitoring by Expert systems),
- the *Data processing & Archiving facilities* which produce value added data and products based on GIS (Geographic Information System) tools, modelling and simulation tool, archiving and retrieval of required data (either internal or external) .

The organisational entities in charge of risk management can be centralized and better distributed between several sites. Figures A and B hereafter give the concept of a System resulting from the present study. The architecture of such space-based **Service System** has been properly defined and detailed. A specific focus has been made upon the required communication facilities, which are the "glue" of the System and essential for efficient of Service.

More specifically, as far as communications are concerned, our Recommendations are:

- only *image products* should be transmitted over the network, and **no raw data** which needs high data rate i.e rate currently of more than 50 Mbits .An high rate communications service(rate above nx64 kbts/s)could be implemented for transmission of image products only when is required a short delivery time.Low rate communication services (below or equal to 64 kbts/s) is needed only for transmission of other information.
- all communications could be done by using existing telephone, and data networks (n x 64 kbits) and Electronic-mail for exchange of messages and consulting of data bases. Data rate is to be adapted to the risk phase.
- use of broadcast technique with small satellite stations (VSAT) is recommended for some operational direct connections between the space based Service System and the operational units in charge of crisis management.
- use of standardised communications protocols and services (TCP/IP ...)

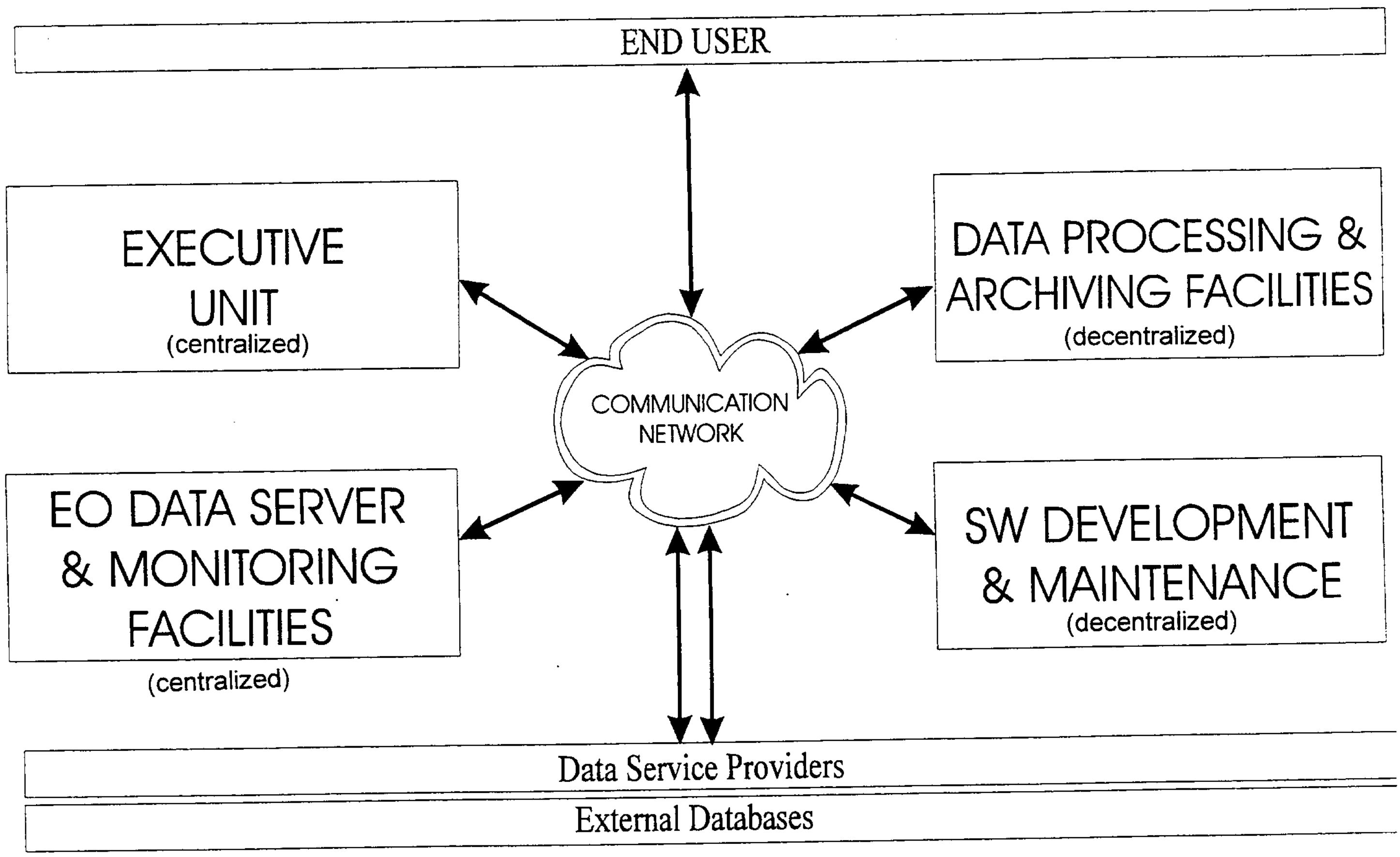

END USER
EXECUTIVE UNIT
(centralized)
DATA PROCESSING & ARCHIVING FACILITIES
(decentralized)
COMMUNICATION NETWORK
EO DATA SERVER & MONITORING FACILITIES
(centralized)
SW DEVELOPMENT & MAINTENANCE
(decentralized)
Data Service Providers
External Databases

Figure A

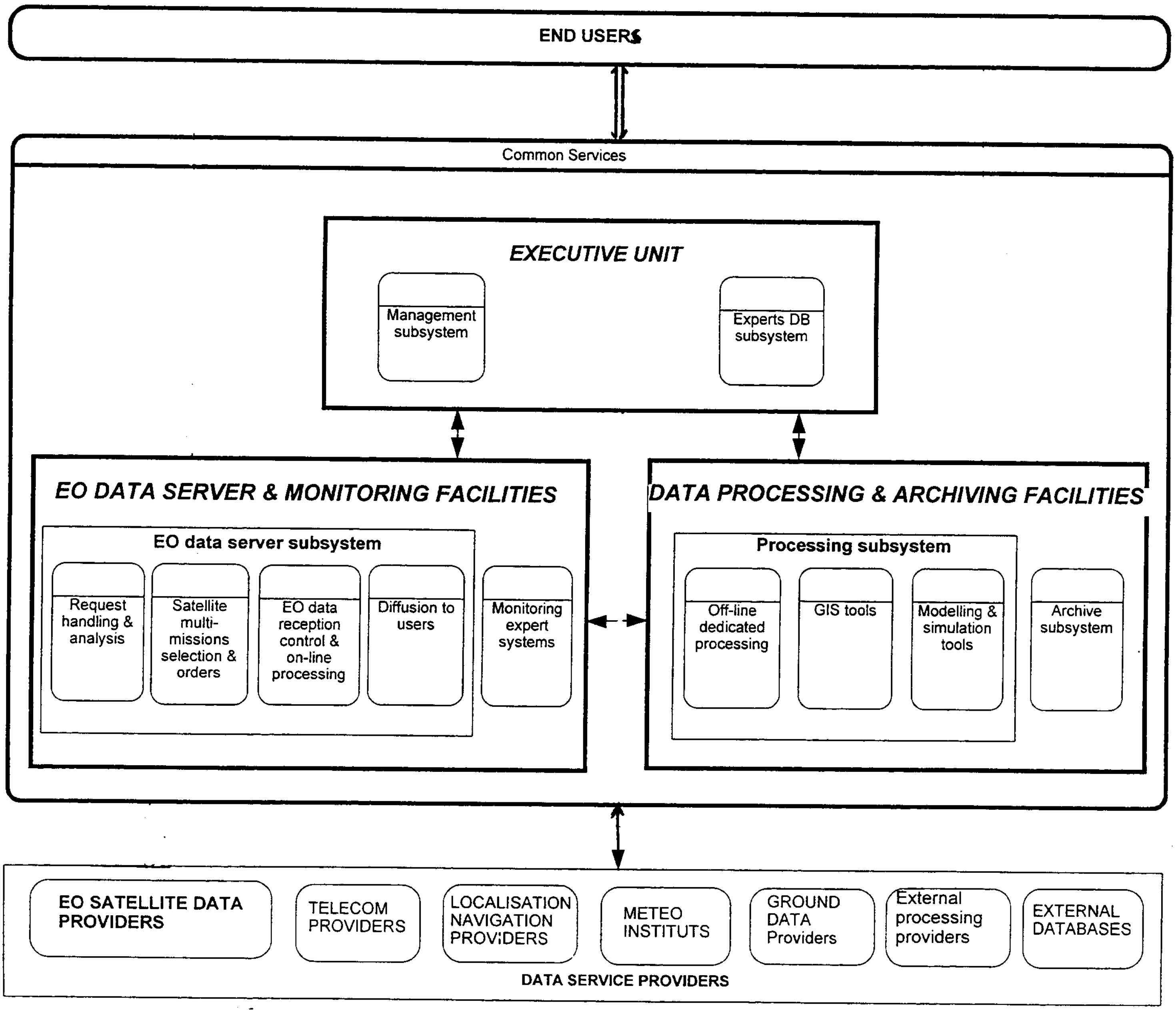

END USERS
Common Services
EXECUTIVE UNIT
Management subsystem
Experts DB subsystem
EO DATA SERVER & MONITORING FACILITIES
EO data server subsystem
Request handling & analysis
Satellite multi-missions selection & orders
EO data reception control & on-line processing
Diffusion to users
Monitoring expert systems
DATA PROCESSING & ARCHIVING FACILITIES
Processing subsystem
Off-line dedicated processing
GIS tools
Modelling & simulation tools
Archive subsystem
EO SATELLITE DATA PROVIDERS
TELECOM PROVIDERS
LOCALISATION NAVIGATION PROVIDERS
METEO INSTITUTS
GROUND DATA Providers
External processing providers
EXTERNAL DATABASES
DATA SERVICE PROVIDERS

Figure B

8.5 Communication Architecture

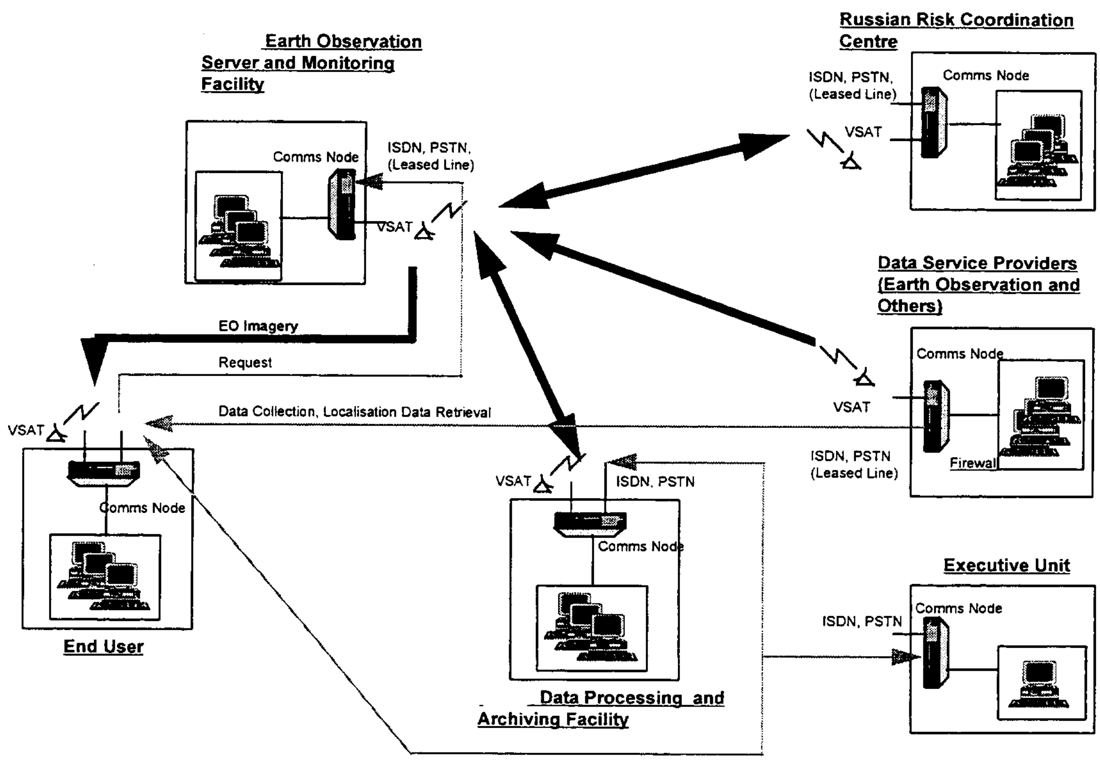
Rationale and Concept

The mission requirement analysis has identified the need for reliable communications with the different data Providers. For some services, integrated and off-the-shelf solutions can be provided (e.g. data collection, localisation, navigation). For other type of services (dissemination of Earth Observation data and general interconnectivity of the different centres and facilities), the study has shown that satellite links supplied through Operators are suitable for high data rates only. For low data rate transmission, the existing public switched (e.g. PSTN, ISDN) services or Internet service can be used.

The use of VSAT (very small antenna terminal) satellite network - with the Service System being a hub (i.e. a central focal point for coordination with Service Providers) - is justified for cost and flexibility reasons (flexible broadcast, easy installation, bandwidth allocation only on demand). For emergency operational communications in the field, it is the only alternative , when terrestrial infrastructures are damaged.

Candidate communication System Architecture:

It has been established in the study that a decentralised architecture with a centralised coordination is a good approach. A possible communication architecture is shown below:

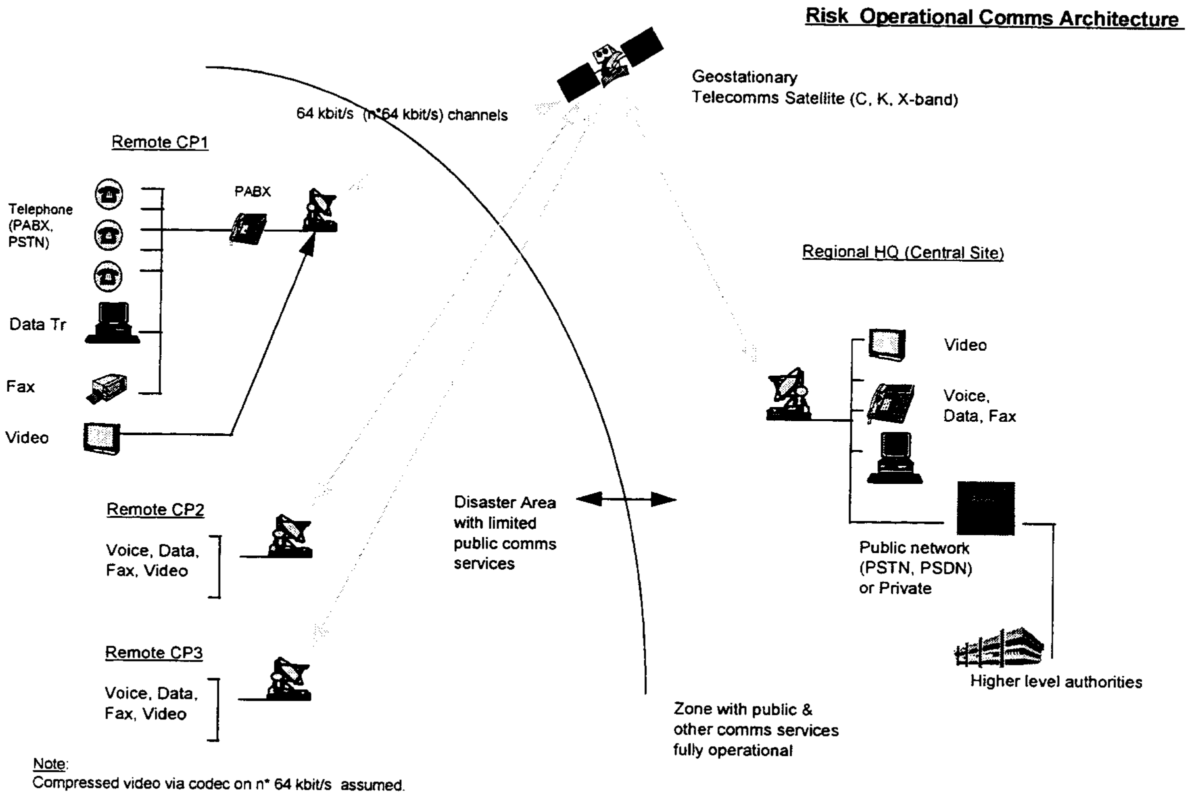


The major high rate (**bold** arrows) and low rate data flows are shown.

Candidate Architecture for the Emergency / Operational Communications

Operational communications in the field:
Semi-mobile small satellite receiving stations (VSAT) equipped with peripherals: fax, PABX,, PC (data transfer) and compressed video equipment are recommended.

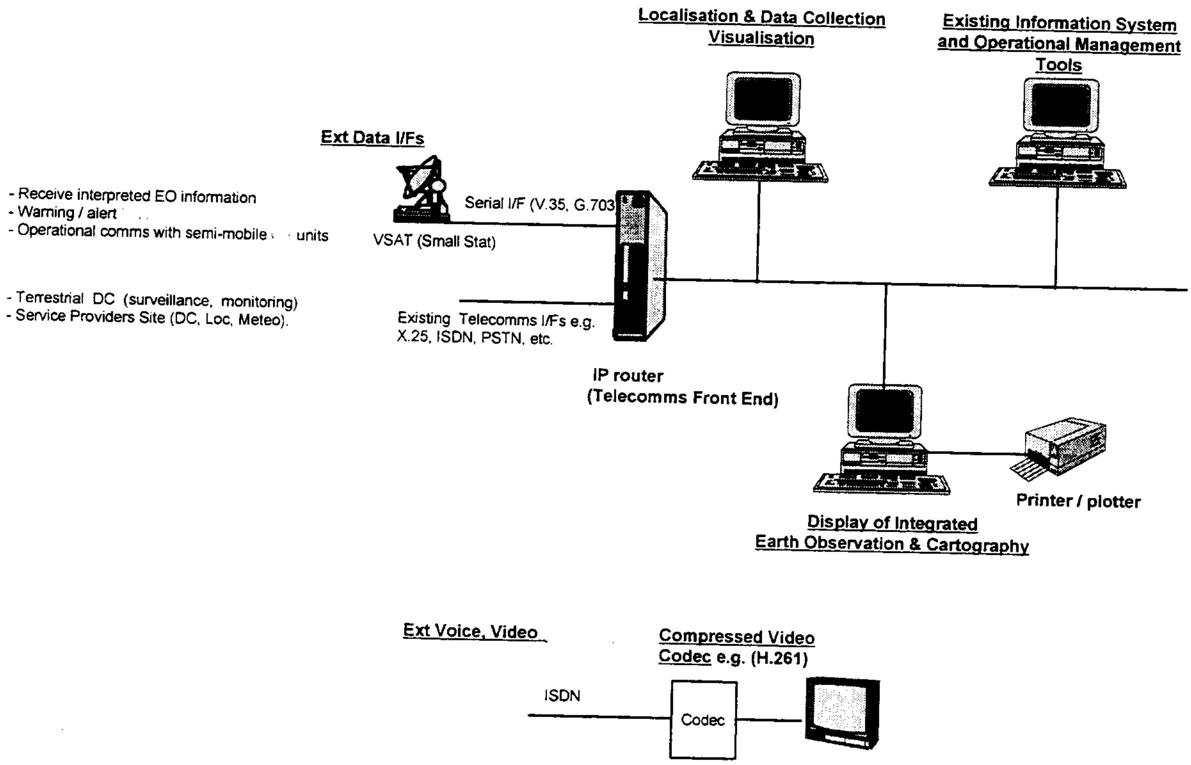
For the emergency communications:
The same type of equipment is recommended but with an extended configuration in order to cope with the required capacity (e.g. about 1000 lines).
This is illustrated on the diagram shown below:



In the field Operational Communications

Candidate Architecture for the interfaces at the End Users

The interfaces with the end users could be done at any required level of the Command of the civil protections. A typical end user communication infrastructure is shown below :



9. CONCLUSIONS ON TWO REAL-CASE STUDIES (FLOODS)

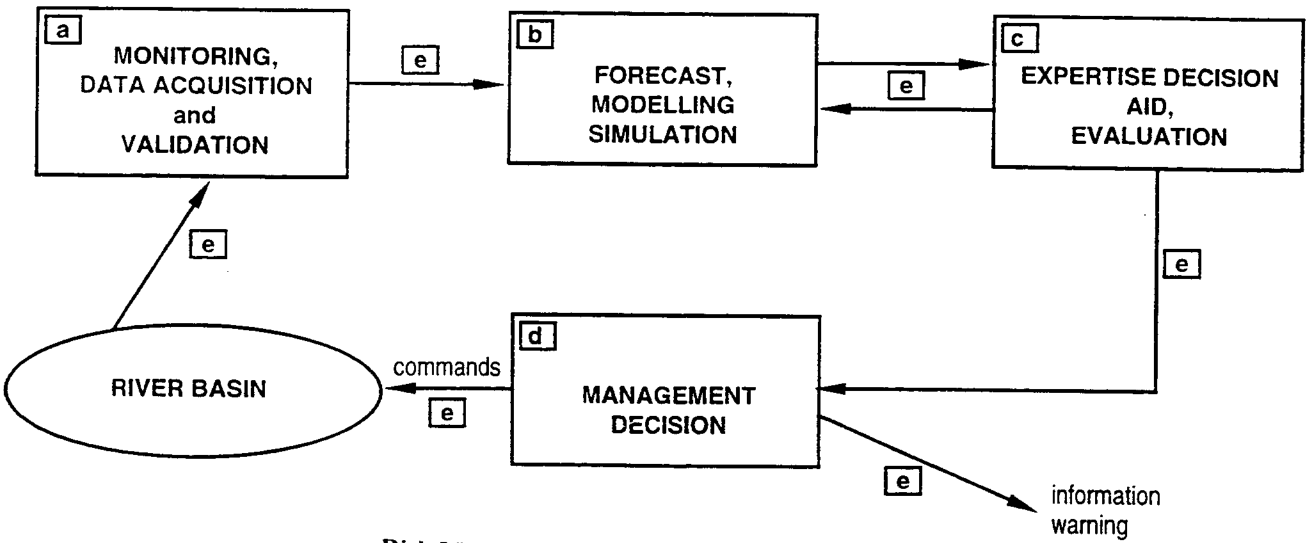
The results of the real case-studies have been presented and discussed with the relevant Authorities involved in the risk case both in Belgium (Meuse river plain floods of mid-Jan 95 in Dinant area), and in Russia (Tobol river snow melt floods of March 94 in KURGAN region).

The methodology of the real-case study has consisted in analysing:

- the requirements made by the Authorities ,and the compliancy of such requirements with the space resources,
- the space means needed during the 3 phases of risk,
- the usefulness of space and why space facilities were not used for managing the crisis,as well as before and after the crisis,
- what could be done to improve the use of space technology.

The mechanism of floods in both real cases is very similar. The rainfall covers a large part of a rather large basin. The time scale of the phenomenon is such that alert threshold can be reached in time to give proper warning.

The figure given hereafter shows the control loop of real-time risk management system for a typical river basin :



- **Risk Management Decision Support System**

The study has shown that space systems could contribute efficiently to the needs of information required in several sub-systems, as follows :

(a) data acquisition ,by using data collection satellite systems,

(b) modelling ,by provided cartography and land use maps through Earth Observation Systems,

(c) evaluation of extent of a flooded area, by using satellite imagery during crisis and post-crisis phases.

Space systems can also support the management of means (emergency vehicles and teams) during crisis and post-crisis through the telecommunications and localisation space systems.

One major conclusion is that a significant part of data and services can be supplied from space systems. However, it is clear that space technology inputs and other technology inputs (or methodologies) should be considered as a whole. Not only because space technologies cannot solve alone current problems, but also because space applications together with other terrestrial technologies should create a synergy leading to a very important qualitative jump. In order to list the future potential benefits of space technologies, one must not simply list existing needs and then investigate if space technologies can fill the gap. This is only the first step. One has to think in terms of the future. It is likely that new needs will arise with the progress of both information and space technologies. Finally ,one should envisage how the integration of existing and future space and terrestrial means can be achieved in order to create added value much higher than the simple addition of capabilities of these technologies.

The most evident progress which can be expected from such a systemic approach would be attained through:

- fusion of space and ground data,
- improvement of preparation works (scenarios definition, threshold level definition, vulnerability estimates) during knowledge and prevention phase,
- implementation of a dedicated and integrated data communication network.

Existing space means, or available in near future , if applied in synergy with terrestrial means, would comply not only with all current requirements, but also with requirements which today are not yet considered,due to a lack of definition of the needs for such fusion.

It is also clear that existing space means, are today not used as they would be . No service exists for faciliting the access to and informing the users of space resources capabilities.

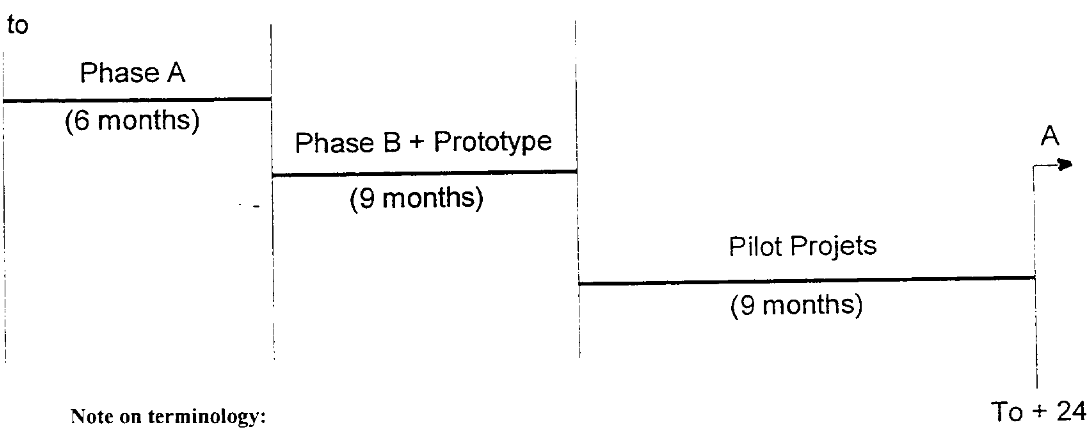
As far as communications and data transmission are concerned, it seems that in the near future, space means will be able to supply all required operational services .

Where space imagery is concerned, and in order to move towards a solution integrating the space data , it is also necessary to move towards a solution allowing an end-user to benefit from all facilities offered by the various space data providers, through means such as dedicated space data server(s).

Thus,the final space based conclusion of the present real-case studies is that a feasibility study ,aimed at implementation of a complementary Service System, using existing means, should be initiated, as soon as possible, through pre-operational pilot projects .

10. IMPLEMENTATION PLAN

Then,our clear recommendation is to implement at an European level a space-based Service system with a phased approach, as shown below. Space technologies, when available and cost effective, could be smoothly and progressively integrated within a global Risk System, as soon as ,the relevant procedures and plans for use are settled by the competent Authorities.

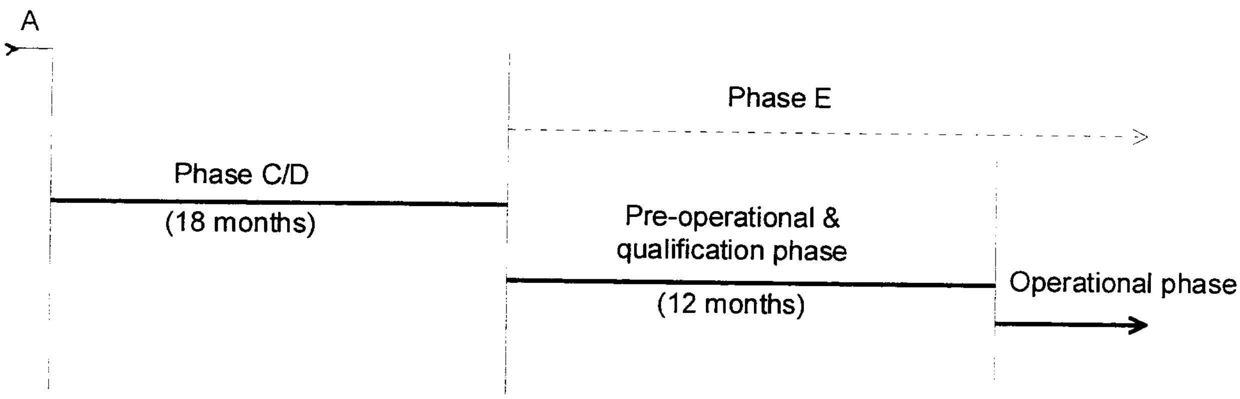


Note on terminology:

- Phase A : System feasibility study
- Phase B: Preliminary definition and prototyping

Such **pilot projects should be implemented** with the user communities ,as soon as, a prototype of a Service system is ready in order to test and evaluate the pre-operational feasibility of any future space based Service System.

At the end of the pilot projects phase, the final space based Service System should be defined in detail with feedback of pilot project operations (phase C), then implemented, tested and pre-qualified by the user communities (phase D). After about one year of full operations (phase E), it should be able to be qualified for full operational use.



It is obvious ,that the applications of existing operational and qualified space technologies ,such as:

- navigation (GPS - GLONASS)
- localisation and data messaging (Euteltracs, Inmarsat , Argos, Goniez, Meteosat DCP, ...)
- space telecommunications

should be promoted and developed without more delay for the benefit of the user communities and integrated progressively in a more system approach of risk management . On that purpose ,it should be mentionned that the INMARSAT Organisation offers already ,free of charge, 3 weeks of communication channels , together with the supply of 8 ground terminals,under the condition that a Country has **declared** herself in an **emergency situation** to the international authorities (UNO Organisation). .

11. COST FIGURES

11.1 SYSTEM COSTS

a) System development cost estimates (ROM estimates,year 96)

			TOTAL Kecus
(1) Phase A:	feasibility study:		300
	• information system:	240	
	• Telecommunications:	60	
(2) Phase B:	Definition study incl. prototype		700
	• Information system:	600	
	• Telecommunications:	100	
(3) Phase C/D:	System implementation and testing		2200
	• Information system:	1700	
	• Telecommunications:	500	
		Total (a):	**3200**
b) Pilot projects technical support :			100
c) Operational exploitation (one year) (10 persons) :			1500
d) Monthly average cost for operational communications are estimated to be 60 KECU. It is assumed that these costs should be supported by the users of the Service			

11.2 TYPICAL DATA AND SERVICE ACQUISITION COSTS:

ROM (rough order of magnitude) cost estimates should be drastically reduced when large quantity are bought .

11.2.1 Typical communication costs:

a) Emergency communications restoration:

- Price for a single transportable station (VSAT) unit providing 100 voice channels: 100 KECU
  (Hub station for 1000 lines including 10 remote stations)
- Required satellite bandwidth (n*64 kbit/s),as follows :
  price for one 64 kbit/s duplex channel: 2230 ECU/month i.e. approximately 35 KECU/month for 1 Mbit/s
  (about 1Mbits/s is required for 100 telephone lines)

b) Satellite telecommunication services:

Per 64 kbit/s duplex channel:

- On-demand: 2230 ECU/month for use,
- Permanent channel: 1600ECU/month

It is obvious that telecommunications are an highly competitive market and that costs are decreasing every year. Future planned mobile satellite systems like: Globalstar, Iridium, P21... should generalize the use of satellite handsets , at similar price level than the existing GSM.

11.2.2 Navigation cost through satellite systems :

Equipment cost: 400 ECU per terminal (GPS).

The service is free of charge (up to now).

11.2.3 Localisation and data collection services :

Actual: (geostationary satellite)	• Terminal cost: 3 - 4 KECU • Service cost: 0.5 - 1 ECU per message
Planned: (little leo satellites constellation)	• Terminal cost: 100 - 200 ECU • Service cost: 0.25 - 0.5 ECU per message

11.2.4 Satellites images

Today, the cost of high resolution images (optical like SPOT, or Radar like ERS) are depending on the level of processing and in the range of 0.1 to 1 ECU per square km.

For example: 0.5 ECU per square km for a land cover map,
1 ECU per square km for a digital elevation model map.

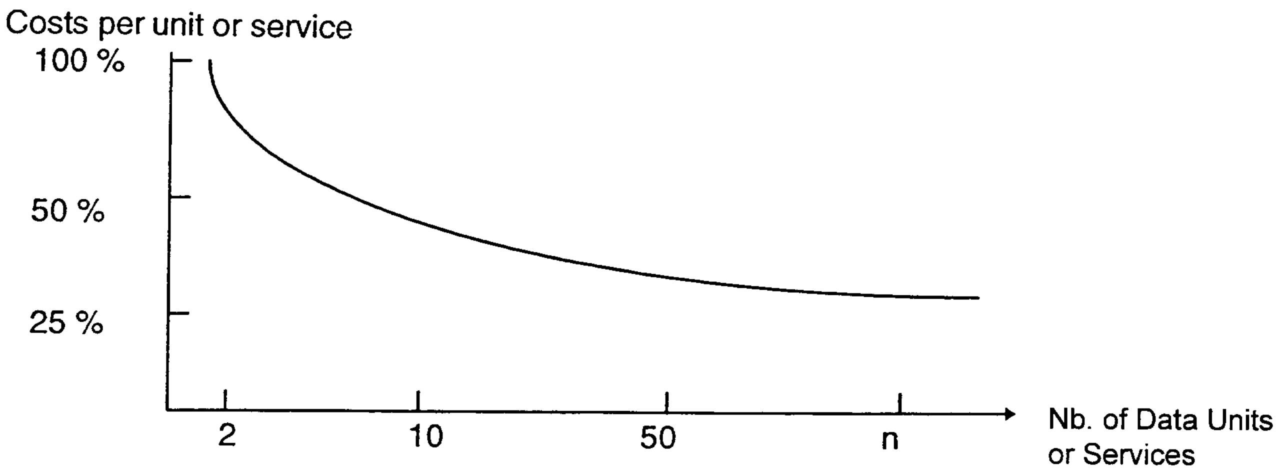
11.2.5 Meteorology forecast services

Up to now, this service to the public is free of charge.

Conclusions

Results of our detailed cost analysis have clearly lead to the recommendation of establishing a Service System, at the benefit of the whole European user communities.Considering that **cost can be substantially reduced** when, development, implementation and operations costs are shared by a large number of users.

The following curve is given ,as an example, for illustrating the possible cost reduction for the purchase of data:



Another point, which might become important, is the **priority of access** to the space services. Taking the example of Earth Observation, various experiences have shown that the current available satellites are saturated in some period. If the priority of access is not negotiated in due time with the data providers, the users in emergency situation could be treated as ordinary users only. It is anticipated that only an European Service System will be capable to impose its priority to the space data providers, as it represents an important potential demand. The same should apply for other space technologies like telecommunications ,where priority of service access plays a major role in any crisis situation.

Among the different space technology, Earth Observation is considered to be more crucial in terms of level of cost. In fact, the limiting factor for its effective use , is the discrepancy between the user needs and the data products currently offered on the market. Earth observation data are currently, available only in the form of scenes. So, the user has to purchase such complete image scene, although his real interest might only correspond to a very limited area of 10x10 km for example. When calculating the cost for the Meuse flood (over 350 km river length),the estimated costs for image procurement, assuming 3 acquisition periods, about: 2x3x4000 ECU (average price for one image). This can be considered to be largely above the financial capabilities of the user versus its real need.

If the user area of interest is only 20km left and right of the image ,i.e 7000 square km, the normal price per square km is between 0.1 and 0.5 ECU. If we consider that the double (1 ECU) would be counted for this image sub-set per square km, the total cost should be : 7 ECU x 3 = 21 KECU, which is less then 1/3 of the previous cost.

Thus, we believe that the change of product policy of data providers allowing to bill only for the area of interest is required .This change could be brought by a Service System, operating at an European level, as it will be certainly backed by a large number of users.

12. OVERALL CONCLUSIONS:

12.1 COMPLIANCY ANALYSIS BETWEEN SPACE RESOURCES AND USERS NEEDS

Results of first task have shown the usefulness of space data and services for supporting risks management activities. Synergy is achieved only when space data are used in an integrated approach ,together with the use of other ground data and technology (software processing and communications).

12.2 USER ORIENTED RISK MANAGEMENT SERVICE SYSTEM

In order to more efficiently use and improve the use of space for risk management purpose,a Service System has been defined at an European level:

- Information System definition,
- Communication service definition,

A distributed architecture has been recommended ,consisting of:

- one executive unit, responsible for the overall Service management
- an information server (s)
- several distributed European facilities for data processing & archiving on a regional basis (decentralized processing approach).

12.3 A set of recommendations has been given for supporting the development of space applications e.g. data and communications standardisation, use of direct broadcast and receiving stations for image transmission, etc...

12.4 Two real cases have been studied in close relation with the operational users. Assessment of space use and needs for multi-satellites mission have been shown ,together with the benefit of mobilising all the ESA, French and Russian space resources., as, available in Europe.

12.5 Cost assessment (development and operational) has been given for the Service System implementation.

12.6 Phased implementation plan has been shown. Smooth integration of space technologies is recommended. Implementation of pilot projects is, also, strongly recommended, as soon as, a prototype of a space-based Service System is implemented (12 - 15 months) in order to validate the concept and conduct several real-time pre-operational operations in order to demonstrate the benefits of use of space and to speed up its effective use.

Appendices

to

the Summary Report

of

Phase 3-Study

Appendix 1

Synthesis of user information needs

The major information needs are synthesised in the following way:

1. **Risk Phase: Knowledge & Prevention**

- **Routine Monitoring** of the different phenomena for each risk case. This includes the availability of basic cartography as well as data on the state of the phenomenon. For example, within the risk case "Plain Floods" this concerns the monitoring of water height and river flow.

- **Models** are very important for supporting the risk management equally used during the prevention and crisis phases. These models can be simple (a person involved extrapolating data on river flow in order to define the time and height of the flood) or most complex and accurate (using mathematical models with different parameters). For example, hydrological models currently used for flood simulation are rather complex and based on :

  - Land use
  - Topography (Digital Terrain Models)
  - Soil Humidity
  - Surface Temperature
  - River Flow and Water Height
  - Meteorological Parameters (Precipitation, Air Temperature etc.).

  All these parameters can be accessed from space. But, there are additional parameters, where the use of space is not appropriate, like:

  - River bed depth and size,
  - Archives on previous floods, maps,
  - Ground water level,
  - Soil type,
  - Detailed information on geology, etc...

  There are basically two kinds of models which are needed for the risk management. The first type model is used during the prevention phase. These models allow the simulation of disaster impacts. For example, the earthquake model in the prevention phase, will help to model the impact of an earthquake on infrastructures. In general these models are using archived data. The second kind of model is used during crisis. Then, data just measured and transmitted in real or near real time, are used to evaluate the crisis extent and damage. For example, for floodings, how far the water will rise could be forecasted. For the forest fires, the area which could be burnt, is anticipated.

- The term « **Risk Area Cartography including Areas of Increased Vulnerability** » is also used for the majority of risk cases within the prevention phase. In order to satisfy this information need, several parameters have to be obtained. For floods, this mainly concerns data on land use and topography. Additionally, archived information on water level and river flow as well as past floods are necessary. Furthermore, outputs from models can be used to define different scenarios for floods. A given area might be flooded after a certain amount of rain, so that housing area should not be established there. In the case of earthquake risk, a nuclear installation should not be built upon an area which was identified to be vulnerable to earthquake.

- In some cases a **weather forecast** is mandatory in the prevention phase. For example, for the forest fires, weather conditions have a major impact on whether a fire will break out and/ or propagate.

2. Risk Phase :Warning & Crisis

During this risk phase the first function is **alert monitoring**. This means ,generally, the gathering of data on a more frequent basis as during the routine monitoring. In addition, means that will act on the scene will be put in alert conditions. Reliable communications have to established.

The second step of this risk phase is **cartography of the damage** (eg. caused by floods or earthquakes, etc...). In addition to the cartography of the damage, basic cartographic (land use) and topographic information are necessary.

In parallel, **models** are necessary to define, for example, the highest water level that will be reached during a flood.

Finally, the most important task will be the **management of means** on the scene during the crisis phase. Information on land use and topography as well as other data on air or water pollution ,fire extension and propagation (forest fire risk) or flooded areas etc.... are necessary. The navigation and localisation of means in the crisis situation are also important needs. Communications between the operational means in the field (voice, data, image/video) are, also, basic needs.

3. Risk Phase: Post Crisis

The post crisis phase mainly consists of one information need : **damage assessment**. Here again, basic information on cartography and topography are very important. Furthermore, information on damage extent will be used later to understand the reasons of the disaster event.

Nothing more concerning industrial type risks, why?

Appendix 2

Parameters addressed by the space technologies

The following table shows the parameters necessary to fulfil the user information needs and the space technology from which they can be obtained.

Space technology / parameters	Parameter Nb	Earth Observation	Meteorology	Data Collection	Navigation	Localisation	Telecommunication
3 D Imaging	1	X					
Areas damaged by Fire	2	X					
Cloud Cover	3		X				
Damage Extent (1/100.000)	4	X					
Damage Extent (1/25.000)	5	X					
Dangerous Substances in Air, Water and Soil	6			X			
Detection of Oil in Soil and Water by data collection (DC)	7			X			
Dryness and Hydric Stress	8	X					
Fire Detection by DC	9			X			
Fixed Services	10						X
Flooded Areas (1/50.000)	11	X					
Flooded Areas (1/10.000)	12	X					
Forest Fire Contours	13	X					
Forest Fire Detection	14	X					
Frozen Soil Depth	15	X					
Geological Structure	16	X					
Hot Spot Detection	17	X					
Hydrological Cartography	18	X					
Infrared Cameras	19			X			
Infrastructure Assessment	20	X					
Land Surface Temperature	21	X					
Land Use including Urban Areas (1/100.000)	22	X					
Land Use including Urban Areas (1/25.000)	23	X					
Leak Detection by DC	24			X			
Lightning Impact	25			X			
Localisation of Means on the Scene	26				X	X	
Mobile Services	17						X

Space technology / parameters	Parameter Nb	Earth Observation	Meteorology	Data Collection	Navigation	Localisation	Telecommunication
Management of Means on the Scene	28				X	X	
Nuclear Installations	29	X					
Oil in Soil & Water	30	X					
Pipeline Fire Detection	31	X					
Pipeline Leak Detection	32	X					
Precipitation	33		X				
Pressure	34		X				
Radioactive Substance in Air, Soil & Water	35			X			
River Flow	36			X			
Seismic Movements	37			X			
Snow Cover	38	X					
Soil Humidity/Moisture	39	X					
Temperature	40		X				
Topographic Height (1 m)	41	X					
Topographic Height (5 m)	42	X					
Transport Security	43			X			
Transported Materials	44			X			
Transport of dangerous materials	45					X	
Vegetation	46	X					
Vegetation Structure	47	X					
Valve Pressure	48			X			
Water level	49			X			
Water Pollution (surface film)	50	X					
Water Temperature	51	X					
Water Vapour/Humidity	52		X				
Wind Speed/Direction	53		X				
Windy Zones	54	X					

Appendix 3

List of satellite systems considered in the study

EARTH OBSERVATION SATELLITES AND INSTRUMENTS								
Satellite	Instrument	Active or Planned	Parameters mesured (see list)	Spatial Reso. (horizontal)	Spatial Reso. (vertical)	Temporal Reso.	Information Delivery Delay	Coverage L, R, C
ERS (1,2)	SAR	Active	3,4,15, 22, 31, 39, 44, 45	20 m	5 m	8 days	3-10 days	L & R
	ATSR	Active	5,12,22,23, 26,27,42,45	1000 m	no	1 day	2 days	R & C
SPOT(2,3)	HRV	Active	1,3,15,22,24, 30,32,39,40	10/20 m	10 m	5 days	2-5 days	L & R
RADARSAT	SAR	Active	3,4,15,16,22, 31, 39, 44, 45	7-100 m	10 m	3 days	2-5 days	L & R
NOAA 13,14	AVHRR	Active	5,12,22,23, 26,27,42,45	1000 m	no	0.5 days	2 days	R & C
LANDSAT 5	TM	Active	1,3,15,22,24, 27,28,30,32, 39,40,42	30/120 m	no	16 days	5-10 days	L & R
COSMOS	KWR	Active	2,16,20,32	2 m	no	18 days*	30 days	L
	TK-350		2,16,20,32	10 m	5 m	18 days*	30 days	L & R
RESURS-01 (3)	MSU-E	Active	1,3,15,22,24, 30,32,39,40	45 m	no	16 days	15 days	L & R
	MSU-SK	Active	5,12,22,23, 26,27,42,45	250 m	no	16 days	15 days	R
RESURS-F1	RFA-1000	Active	2,16,20,32	5 m	5 m	12 days	5-15 days	L
	MK-4	Active	2,16,20,32	10 m	10 m	12 days	5-15 days	L & R
	KATE-200	Active	1,3,15,22,24, 30,32,39,40	30 m	30 m	12 days	5-15 days	L & R
OKEAN	MSU-M	Active	5,12,22,23, 26,27,42,45	1000 m	no	0.5 day*	15 days	R & C
	MSU-S	Active	5,12,22,23, 26,27,42,45	345 m	no	5 days*	15 days	R
	RSBO	Active	5,12,22,23, 26,27,42,45	2500 m	no	0.5 day*	15 days	R & C
RESURS-01 (4)	MSU-E	Planned	1,3,15,22,24, 30,32,39,40	45 m	no	16 days	15 days	L & R
ENVISAT	ASAR	Planned	3,4,15, 22, 31, 39, 44, 45	20 m	10 m	8 days	5-10 days	L & R
	MERIS	Planned	5,12,22,23, 26,27,42,45	250 m	no	2 days	2 days	R
	AATSR	Planned	5,12,22,23, 26,27,42,45	1000 m	no	0.5 day	1 day	R & C
SPOT 4	HRV	Planned	1,3,15,22,24, 27, 28, 30,32, 39, 40,42	10/20 m	10 m	5 days	2-5 days	L & R
SPOT 5	HRV	Planned	2,16,20,32	5/10 m	5 m	5 days	2-5 days	L & R

* Revisit time estimated on the basis of satellites with similar charateristics
L= Local coverage, R= Regional Coverage, C=Continental Coverage

METEOROLOGICAL SATELLITES AND INSTRUMENTS								
Satellite	Instrument	Active or Planned	Parameters mesured (see list)	Spatial Reso. (horizontal)	Spatial Reso. (vertical)	Temporal Reso.	Information Delivery Delay	Coverage L, R, C
ERS (1,2)	ATSR	Active	5, 22, 23	1000 m	no	1 day	2 days	R & C
NOAA 13,14	AVHRR	Active	5, 8-14, 22, 23	1000 m	no	0.5 days	1 hour	R & C
METEOSAT	MVRI	Active	8-14	2500 m	no	0.1 day	1 hour	R & C
METEOR	MR	Active	8-14	2000 m	no		1 hour	R & C
OKEAN	MSU-M	Active	5, 8-14, 22, 23	1000 m	no	0.5 day	15 days	R & C
	RSBO	Active	5, 8-14, 22, 23	2500 m	no	0.5 day	15 days	R & C
MSG	SEVRI	Planned	8-14	2000 m	no	0.1 day	1 hour	R & C
ENVISAT	ATSR	Active	5, 22, 23	1000 m	no	1 day	2 days	R & C
ELECTRO	BTUK	Active	5-8-14	1500 visible	no	0.1 day	1 hour	R, C
METOP	AVHRR	Planned	5-8-14	1000 m	no	0.5 day	1 hour	R, C

DATA COLLECTION SATELLITES AND INSTRUMENTS						
Satellite	Instrument	Active or Planned	Parameters mesured (see list)	Temporal Reso.	Information Delivery Delay	Coverage L, R, C
NOAA 13,14	Argos	Active	6,7,21,33,36,37, 41,43,44,45,46	3 hours	3-6 hours	L, R, C
EUTELSAT	Argo	Active	6,7,21,33,36,37, 41,43,44,45,46	3 hours	3-6 hours	L, R, C
METEOSAT		Active	6,7,21,33,36,37, 41,43,44,45,46	< 1 min	Real Time	L, R, C
INMARSAT		Active	6,7,21,33,36,37, 41,43,44,45,46	< 1 min	Real Time	L, R, C
COSPAS-SARSAT		Active	6,7,21,33,36,37, 41,43,44,45,46	3 hours	3-6 hours	L, R, C
STARSYS		Planned	6,7,21,33,36,37, 41,43,44,45,46	15 min	15 min	L, R, C
ORBCOM		Planned	6,7,21,33,36,37, 41,43,44,45,46	15 min	15 min	L, R, C
GONEZ		Planned	6,7,21,33,36,37, 41,43,44,45,46	15 min	15 min	L, R, C

NAVIGATION & LOCALISATION SATELLITES AND INSTRUMENTS							
Satellite	Instrument	Active or Planned	Parameters mesured (see list)	Positioning Accuracy	Temporal Reso.	Information Delivery Delay	Coverage L, R, C
NOAA 13,14	Argos	Active	17, 38	1000 m	6 hours	6 hours	L, R, C
EUTELSAT	Euteltracs	Active	17, 38	150 m	Real Time	Real Time	L, R, C
INMARSAT		Active	17, 38	150 m	Real Time	Real Time	L, R, C
GPS	GPS	Active	17, 38	15 m	Real Time	Real Time	L, R, C
COSPAS-SARSAT		Active	17, 38	1000 m	6 hours	6 hours	L, R, C
GLONASS		Planned	17, 38	150 m	Real Time	Real Time	L, R, C

TELECOMMUNICATION SATELLITES AND INSTRUMENTS							
Satellite	Access	Active or Planned	Parameters mesured (see list)	Voice	Data	Image/ Video	Coverage L, R, C
INTELSAT	Network	Active	18, 19	yes	yes	yes	L, R, C
EUTELSAT	Network	Active	18, 19	yes	yes	yes	L, R, C
INMARSAT	Direct	Active	18, 19	yes	yes	yes	L, R, C
TELE-X	Network	Active	18, 19	yes	yes	yes	L, R, C
HISPASAT	Network	Active	18, 19	yes	yes	yes	L, R, C
TELECOM 1/2	Network	Active	18, 19	yes	yes	yes	L, R, C
ITALSAT	Network	Active	18, 19	yes	yes	yes	L, R
IRIDIUM	Direct	Planned	18, 19	yes	yes	yes	L, R, C
GLOBALSTAR	Direct	Planned	18, 19	yes	yes	yes	L, R, C
ICO (P21)	Direct	Planned	18, 19	yes	yes	yes	L, R, C
ARTEMIS	Network	Planned	Relay only	yes	yes	yes	L, R, C