Contract Number 14069/99/NL/SB

Space Weather Market Analysis

Summary Report for the ESA Space Weather Working Team

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1. EXECUTIVE SUMMARY

This report draws on an extensive literature review and one-on-one interviews with almost 40 end users of space weather data to understand the present perception of the market and to develop a set of recommendations that ESA may employ in the development of its space weather programme.

A model of the space weather supply chain is developed, which shows that current space weather products are defined by the scientific community. Products that are marketed to other industrial customers are not necessarily a good fit to those users' needs. The supply chain is dominated by a few large data providers. The service provider segment of the market is becoming more competitive, as data providers move into it to capitalise on value-added services, and as new entrants compete for a limited customer base. An ESA space weather programme could re-define this supply chain, primarily by supporting the injection of customer requirements into the hardware and missions that generate space weather data. This may be a challenge, as customers are beginning to look upon space weather as a trend. Their history with the 'push' model of commercialisation leaves them sceptical that products will truly meet their needs.

A review of data and service providers highlights that Europe has existing assets on which it can build. Service providers in Scandinavia, Belgium, and Germany are developing reputations in the market for good practice. On-line modelling systems such as SPENVIS are gaining the attention of world-wide users from scientific and commercial sectors. During the course of this study, no privately-owned, European service providers were brought to the attention of the study team.

An analysis of customer segments documents unmet data needs for each sector. The geological/offshore sector is an attractive one because it is in early stages of problem definition, it has limited knowledge of space weather issues, and ESA has competitive advantages in building relationships with companies in it because of its involvement in the Harsh Environments Initiative. All segments require more and better education about space weather and how it affects commercial markets and technical systems.

Opportunities that exist in the near-term include sponsoring technical improvements, generating new, customer-driven data, and supporting commercial development. Key activities should include performing further studies to better understand what assets are available and required in Europe and to constantly monitor customer requirements. ESA can also create marketing and education programmes to stimulate market demand, and should work to help build an infrastructure for European data and service providers.

A long-term strategy could be for ESA to work as an educator, co-ordinator, and enabler in the development of a commercial network of privately-owned service providers. This network would work directly with customers to drive space weather data provision and products. ESA's main role would be to support the common needs of the service providers. This model will enable ESA to create a 'second generation' space weather marketplace with a strong commercial focus and a role for Europe as a market leader.

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2. ABBREVIATIONS AND SYMBOLS

2-D	Two Dimensional
3-D	Three Dimensional
ACE	Advanced Composition Explorer
GEO	Geostationary Orbit
GOES	Geosynchronous Operational Environmental Satellites
LEO	Low Earth Orbit
MeV	Mega-electron-volt
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
SEC	Space Environment Centre
SOHO	Solar and Heliospheric Observatory Joint US/Europe solar observatory
SPENVIS	Space Environment Information System
UK	United Kingdom
US	United States

3. INTRODUCTION

This report, prepared for the ESA Space Weather Working Team, describes a summary of final results of WP120: 'Market Analysis' of the ESA Space Weather Study (ESTEC/Contract No. 14069/99/NL/SB), 31st January 2001. This report is an edited version of the WP120 document and does not contain a breakdown of the detailed information provided by the market analysis survey respondents. The ESA Space Weather Working Team report is broken into the following sections:

- An explanation of the methodology used to perform this work package, including a breakdown of the end user interviews that were completed.
- A discussion of the space weather supply chain.
- An analysis of space weather customers, divided into key market segments.
- An outline of opportunities in the space weather marketplace that current service providers do not fill, and in which end users have reported needs.
- A short-list of recommended actions for ESA to draw from in developing the space weather programme in the short-term.
- Study conclusions.
- A proposal of a future strategy for ESA's long-term involvement in space weather.

4. METHODOLOGY

The methodology undertaken to complete the market analysis for this work package is outlined herewith.

4.1 Secondary Sources

As a first step, a literature review of space weather and business references was undertaken in order to identify data sources, service providers, end users and their possible requirements, and to develop an overview of the space weather marketplace that could be further tested during later activities in the work package. More than 60 print sources were reviewed, and a comprehensive bibliography of the 35 papers and articles with direct relevance to end user requirements and this market analysis was prepared.

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4.2 Space Weather Workshop

A study web page was created and posted on-line to generate awareness of the study and to encourage a dialogue with customers and service providers. The idea of the virtual workshop was also presented, and participants were requested to register for the on-line discussions. Although 35 individuals logged-on to the site, only 8 registered for the workshop. Because it was felt this was not a critical mass for discussions, the workshop was cancelled. The list of people who logged-on to the site was carried forward into the primary source phase of the work package.

4.3 Primary Sources

An end user questionnaire was developed, and is included as an appendix to this report. The development of this document was based on key issues drawn out of the literature review. A draft questionnaire was circulated among the project team of space weather experts for comments and finalisation. This questionnaire was neither distributed to the end users nor aimed at collecting quantitative data, but was instead used as a guidance document during all interviews with end users and service providers.

A target list of interview subjects was compiled and reviewed with the study team. This list included the individuals who logged onto the study team web site, personal contacts with relevance to the study, names that were consistently referenced in literature, and points of contact on web sites of potential end users. A number of target companies were also placed on the list for cold-call interviews.

Close to 100 hours were spent arranging and completing one-on-one interviews with almost 40 interview subjects. A breakdown of the segments represented by the interviewees is as follows:

Segment	Direct	Indirect
Commercial airlines and other air safety organisations	6	1
Electricity and power distribution companies	1	3
Satellite operators and users of satellite services	5	4
Military and defence	7	1
Geological prospectors	2	2
Insurance and financial services	4	-
Tourism/Aurora prediction	-	2
Service provider	14	-

Table 1 Breakdown of interviews by market segment

The ‘indirect’ column represents first-hand information reported to the study team by service providers regarding end user requirements in a specific market segment. Although this is not direct information from a customer, the data was relevant and valid to this study. The low figures in the ‘direct’ column of Table 1 for the electricity and geological segments are an appropriate reflection of the difficulty in reaching these markets. Although existing service providers had good relationships with these sectors and provided a great deal of useful information regarding them, without an existing relationship or direct point of contact, cold calling into companies was a time-consuming and inefficient process.

In the context of an emerging space weather market, the data and analyses presented in this report are based on individual views expressed by the primary sources of information.

4.4 Analysis and Report Generation

A comparison and analysis of data from both the literature review and personal interviews was completed to develop a picture of the market and to formulate recommendations that are appropriate and applicable to this study. A draft report was compiled and subsequently reviewed by the project team, in order to produce a final report for ESA.

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4.5 Synergies with Analysis of Remote Sensing Markets

The market definition and evolution of activities that have shaped the remote sensing markets have provided us with a framework for the definition of the emerging space weather market. A short overview of that market is presented here.

The remote sensing market is emerging but is more mature than the space weather market analysed in this report. The remote sensing market maturity is defined by the length of time and the types of products and services have been made available by service providers. The market is also evolving due to recent technology developments, resulting in improved quality of data acquisition and more rapid data access. There are new service providers entrants to this market, using new technology (high resolution data) to provide new products. These new products have more value added and their definition has been driven by the need to meet customer requirements.

The remote sensing market is currently expanding.

The remote sensing market model is outlined in the figure below.

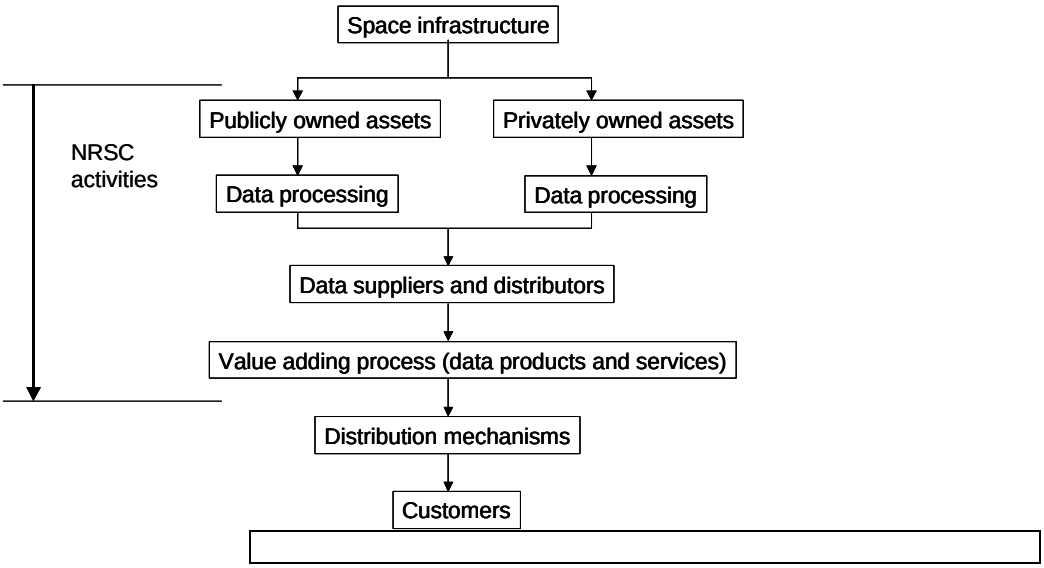

Figure 1 Overview of remote sensing products and services supply chain

The UK National Remote Sensing Centre (an Astrium subsidiary company) carries out a number of roles within the remote sensing market place, from data processing of raw data (from publicly funded space assets) to the provision of value added products. An example of a privately owned space asset is the Ikonos spacecraft, providing 1 m resolution optical data. The data are processed and distributed by Space Imaging, a US company. Space Imaging often uses data from other distributing organisations such as the NRSC in their value adding process. A number of different distribution mechanisms (internet, franchises, joint ventures etc.) are used by the service providers in order to distribute their products to the customers.

5. SPACE WEATHER SUPPLY CHAIN

5.1 Overview

Currently, space weather data requirements are primarily being defined by the scientific community, a select portion of the customer base. The main players in the market are the space weather data and service providers, with the main end users being the service providers and a variety of scientific and industrial

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customers. As there is a broader focus on commercialising space weather activities, the separation of these roles is beginning to blur, and data providers are trying to create more value-added services that will place them closer to the customers.

It is interesting to note that in interviews, customers were becoming more sceptical of space weather products, as they see more and more organisations jumping on the bandwagon. They are starting to feel that space weather is a 'trend', and that soon there will be little differentiation among the service providers in the market. There is presently a feeling that existing service providers are creating a dialogue with their customers in an attempt to meet their needs. There is a growing fear among customers that as new players join the market, there will be more focus on generating data, and this focus will force the customer base to acquire services that they originally did not need.

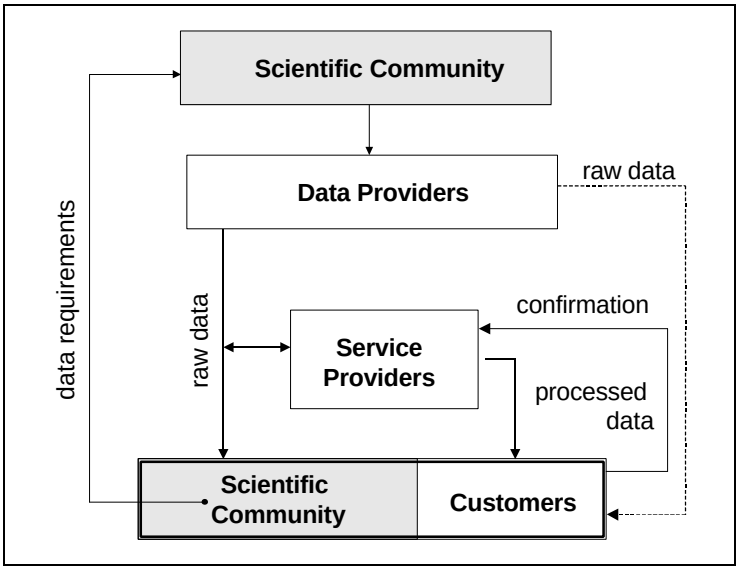

Figure 2 Current overview of space weather supply chain

The structure of the space weather supply chain is depicted in Figure 2, above. Section 5.2 defines the traditional roles among the actors in the supply chain. This supply chain model is presented as a simple overview model. Further definition of a model optimised for Europe will occur as part of the task to define of a European space weather programme.

5.2 Definitions

The ***scientific community*** is comprised of researchers and research establishments who have projects that require data on the space environment. Currently, it is this section of the customer population that defines data requirements in the missions and hardware that they propose. The data that is gathered for these projects is then pushed to the data providers, who supply it to the community at large. Figure 3 depicts this process in the European context.

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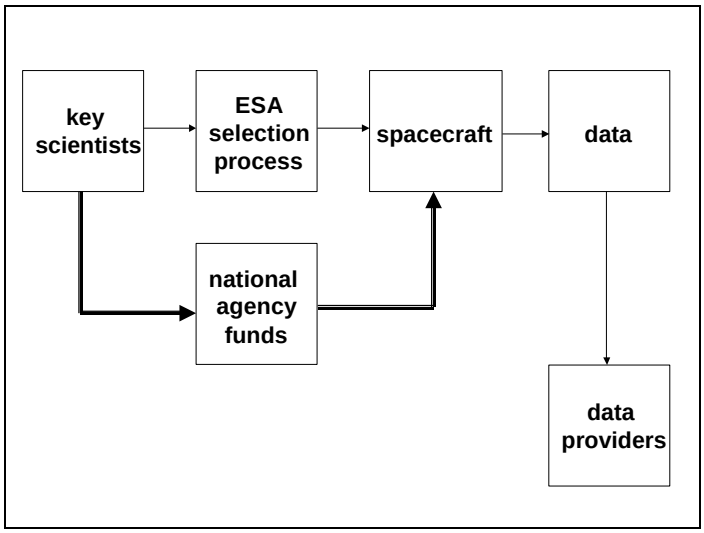

Figure 3 Current data development process in Europe for space data.

For the European model, ESA's present role is shown in Figure 3. Specific actions for ESA are outlined in the Recommendations section (Section 8) of this report, based on the market analysis results.

Data providers distribute raw data that have been gathered at no-to-low cost to end users, and will provide a broad spectrum of data. The data provider section of the market is currently dominated by NOAA/SEC, which has also been a force in defining a framework for the market. Along with its extensive provision of data, NOAA has created a 'common language' for the market in the form of a space weather scale that is used to rank the severity of events.

There is some ad hoc diversification occurring within the data provider section of the market, particularly as organisations focus more on commercialisation. In an attempt to move closer to the customer, some data providers are issuing forecasts and alerts, and are creating other value-added services. However, the customers do not see these as main activities for these organisations.

End users for space weather data include both the service providers and the customers.

Service providers are usually organisations which use space weather data for their own research purposes and may even generate and supply raw data of their own, where cost-effective. The key difference between service providers and data providers is that a main activity of the service provider is to translate data for the needs of a targeted customer base, as opposed to providing a broad spread of data to a wide user community. Because customers see the service providers as adding value to the data, they are more willing to pay for products generated from this segment. Good examples of service providers are the geological survey organisations, which typically acquire some data from data providers, but also produce their own magnetospheric data. These organisations routinely target customers from the power and offshore industries to sell value-added services to.

Customers are space weather data users who do not generate any data of their own, but whose businesses are affected by space weather events. Although space weather effects are becoming a more visible phenomenon across a variety of industrial sectors, the scientific community and the data providers have traditionally defined space weather products. Customer-based products have become a more recent phenomenon with the emergence of space weather service providers.

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5.3 Supply Chain Interfaces

The data providers, service providers, and customers defined in (previous section) interface as defined in Figure 2 “Overview of space weather supply chain”. These players interface and exchange data products/scientific knowledge and person to person contact and conversation.

The players in Figure 2 can also be divided into three communications protocol categories:

- scientific (two-way free exchange of information)
- commercial (information is commercially sensitive, two-way exchange of information governed by contract)
- military (information exchanged on a need-to-know basis, strong emphasis on national/security aims)

These three communications protocols are common to all of the players defined in section 5.2 (Table 2). Each of these players has different “communications protocols” regarding data products/scientific knowledge and person to person contact and conversation. (The category of data providers is considered to include the data provider funding body).

Category of player	Scientific	Commercial	Military
Data providers	Yes	Yes	Yes
Service providers	Yes	Yes	Yes
Customers	Yes	Yes	Yes

Table 2 Communication protocols used in the space weather supply chain

These three categories are not uniquely defined by the funding body, although it is likely that a player primarily governed by the military “communications protocol” is funded by a military budget. A player may use different communications protocols for when exchanging different space weather data products or interfacing with different categories of players, as summarised in Table 3.

The space weather market is defined and limited by the nature of these interfaces. Different strategies must be applied in order to encourage and develop the space weather market, as a function of communications protocol type.

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	Scientific customers	Commercial customers	Military customers
Scientific data providers	scientific communications protocol	commercial communications protocol	military communications protocol
Scientific service providers	scientific communications protocol	commercial communications protocol	military communications protocol
Commercial data providers	commercial communications protocol	commercial communications protocol	military communications protocol
Commercial service providers	commercial communications protocol	commercial communications protocol	military communications protocol
Military data providers	military communications protocol	military communications protocol	military communications protocol
Military service providers	military communications protocol	military communications protocol	military communications protocol

Table 3 Communication protocols between different categories of player

5.4 Implications of the Supply chain

Data providers were the original players in the space weather market and have worked to define it. They have traditionally supplied data to end users free-of-charge, and this is the economic model that end users have grown accustomed to. Not a single person interviewed for this study was willing to pay for raw data, particularly because there is such a glut of this information in the market. Many customers expressed the opinion that, not only is raw data of little direct benefit to them (customers), but often data is pooled together so that they (customers) must sort out what is relevant to their business and what is not. Bits of data are also scattered among data providers, so the customer must go to multiple sources to develop the picture that they need. In order to commercialise space weather data, a level of processing must be added.

Because end users have the notion that raw data should be free, as more potential suppliers enter the market, the expectation exists that taxpayer-funded government agencies will play the role of data supplier. End users also envisage that agencies such as ESA, who are in the process of developing their programmes, will design end user-oriented missions, but will still provide the raw data from these missions at no charge to the public. Customers would then work with service providers to capitalise on the 'value-added' these players can provide from the ESA-sponsored work.

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Although end users, particularly customers rather than service providers, were reluctant to discuss specifics about paying for space weather services, they did not have issues with paying for services that manipulated the raw data into a useful format in order to address specific business issues. Customers tended to have the attitude that their tax-money paid for the generation of the raw data; therefore, that raw data should be accessible at no charge to the public, and most government policies support this practice for their national customers. If someone could add value to that data, by compiling it together from different sources or creating working models with it, for example, customers were willing to compensate the provider for that work.

Most interviewees did not indicate that they relied upon their data provider to also act as their service provider. Only two of the people interviewed had any sort of personal relationship with their data provider, and these were both from space-related fields. This disconnect is relevant not only from the point of view that customers do not feel they have a personal relationship with their data providers, but also from the perspective of the data provider being ill-equipped to handle large numbers of inquiries from customers.

It is interesting to note that a great deal of the customers interviewed admitted to receiving raw data for very little cost on a regular basis, but still paid a service organisation to either add additional input or to confirm customer interpretations of the raw data. Inferences from this could be that:

- Customers are insecure with their own interpretations of data and in the short-term will look to experts for support.
- Space weather is not the prime focus for most customers' businesses, and they do not have time to play 'catch-up' with new developments in the field.
- Customers do not feel comfortable approaching data providers for expert opinions.
- Data providers may not be prepared to work directly with customers, and may find it difficult to transition into the role of service provider.
- Raw data provision may be a redundant service that will never be profitable in the marketplace.

Figure 4 represents the dynamics of the market from the point of view of the customer.

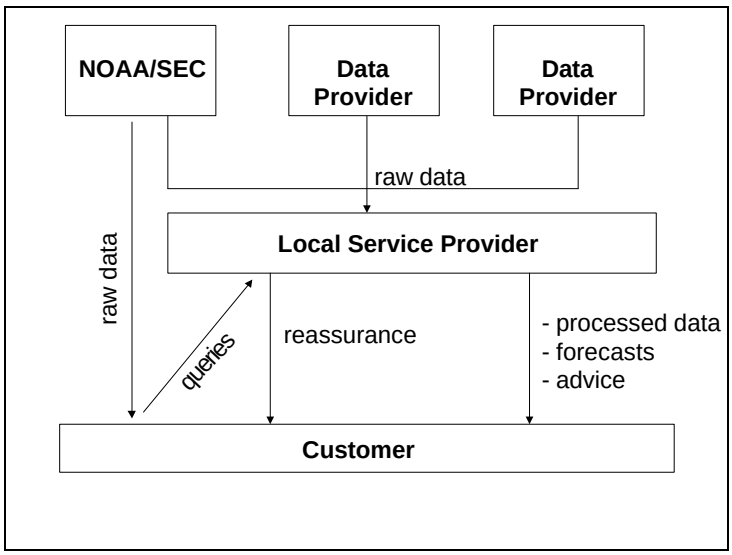

Figure 4 Market dynamics from customer viewpoint

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6. CUSTOMER ANALYSIS

The following section provides an overview of the market requirements identified during the customer interviews (MIR = market interview requirements). The customers have been divided into the following market segments:

- Airlines and air safety
- Electric power
- Geological/Offshore
- HF radio
- Insurance and financial services
- Military and defence
- Satellite and satellite applications
- Tourism/Aurora prediction

A more detailed review of these sectors is provided in the report, “Benefits of a European Space Weather Programme” (WP110).

Requirement	Market segment	User requirement	Timeliness requirement
MIR1	Airlines & air safety	Warnings of increased radiation levels that may be dangerous to aircrew or that may affect avionic systems	Forecasts of extreme radiation levels up to 18 hours ahead desirable, otherwise real-time warnings (nowcasts)
MIR2	Airlines & air safety	Post-event information on extreme radiation levels at specified times and altitudes	Within 2-3 months of the event
MIR3	Electric power transmission	Geomagnetic storm warnings based on spatially resolved forecasts of large, rapid magnetic field variations (start time, end time, maximum intensity, magnitude plus rate of change of dB/dt, specific regions affected, prediction uncertainty). Need for improved forecast reliability compared to current performance (ie. >30%).	Warnings 1-2 days in advance desirable; shorter-term warnings more than 1 hour in advance useful
		Other users re-stated the above requirement in a less comprehensive way and suggested data sources that may be appropriate, e.g.:	
		Forecasts of duration of magnetic storms	At least 1 hour before onset of event
		ACE-type data for forecasts of solar wind effects preferably with improved lead-time	Lead-time of 2-3 hours (instead of present 0.5-1 hour) highly desirable
		Forecasts of auroral electrojet current intensities	
		World-wide magnetometer data	Real-time (or better than the 12-24 minutes currently achieved in North America)
		Continued availability of SOHO (LASCO, EIT and ACE-type data beyond the end of the current missions	As for SOHO and ACE, ie. 0.5-1 hour in advance
		Geomagnetic data measurements at 1	

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Requirement	Market segment	User requirement	Timeliness requirement
		minute sampling intervals	
MIR4	Geological prospecting & offshore industry	Forecasts of space weather events affecting the earth's geomagnetic field	2-4 weeks in advance
		Some users indicated that prediction of one related parameter would assist them in meeting the above requirement:	
		Forecasts of X-ray flares	1-3 days in advance
MIR5	Geological prospecting & offshore industry	Post-notification of events affecting the earth's geomagnetic field	Within 1 day
MIR6	RF systems	Ionospheric forecasts	
MIR7	RF systems	Total electron content of the ionosphere	Every few minutes
MIR8	Insurance & financial services	Hindcast data for events affecting satellite systems (including systems beyond LEO)	
		Other users showed particular interest in a sub-set of these data:	
		Information on plasma effects affecting high-energy solar arrays	
MIR9	Military & defence	Ionospheric forecasts	
		Real-time information on radio energy bursts from solar flares	Real-time
MIR10	Military and Defence	Information on hazardous satellite environments	
		One user clearly uses existing trapped proton models but finds them limited:	
		Low energy (<5 MeV) proton models	Static or long-term models
		One user has a particular problem with internal dielectric charging:	
		Predictions of energetic electron environment	1-2 days in advance
MIR11	Satellites & satellite applications	Monitoring of satellite environments	
		Users appear quite knowledgeable and have specified some aspects of the environment where information is poor, e.g.	
		Improved timeliness of NOAA-type data	
		Electron monitoring down to the eV and high-Z (atomic number) levels	
		Updated models of the satellite environment covering the 11-year solar cycle	
		Short-term variation dose data (wrt internal charging)	1-5 minute samples
		Short-term magnetic field variations	

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Requirement	Market segment	User requirement	Timeliness requirement
MIR12	Satellites & satellite applications	Operational measurements of electrons in transfer orbit altitudes	
MIR13	Satellites & satellite applications	Improved predictions of ionisation in the upper atmosphere at high latitudes	
MIR14	Satellites and satellite applications	Atmospheric density and temperature measurements for drag calculation.	Every few minutes (to the users)
MIR15	Satellites and Airlines	Proton flux measurements	Every few hours or days
MIR16	Tourism	Auroral forecasts	1 day in advance ?
MIR17	General	More robust space weather monitoring systems to ensure continued data availability during and after extreme events	
MIR18	General	Improved redundancy in key space weather monitoring systems (e.g. SOHO and ACE)	
		This is restated by other users who request:	
		Provision of more solar and solar wind data	
MIR19	General	Provision of data between standard prediction timeframes	Various intervals between the standard 1 and 72 hour timeframes (?)
MIR20	General	More accurate forecasts, in particular of solar storms, their magnitude and time of arrival	

Table 4 Summary of user requirements identified in market interview (MIR: market interview requirements)

6.1 Attractiveness of Customer Segments

Table 5 below provides a side-by-side comparison of the different market segments with respect to their attractiveness as space weather customers, based on the results of the interviews with the market analysis participants.

	Air.	Elec.	Geo.	HFRad.	Ins.	Mil.	Sat.	Tour.
Well-defined space weather issues	yes	yes	no	Yes	yes	no	yes	yes
Awareness of benefits of space weather to sector	high	high	low	High	med	low	high	med
Willingness to pay for services	yes	yes	no	No	no	yes	yes	yes
Needs addressed by service providers	yes	yes	no	Yes	yes	no	yes	no
Easy to access	yes	yes	yes	Med	yes	no	yes	yes

Table 5 Relative attractiveness of market segments

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The analysis indicates that several market segments, such as airline, electric power, insurance, and satellite, are currently well served in the marketplace. Although these segments do have some needs for new space weather products and services, it is likely that competition for the attention of these segments is currently high.

Because of their accessibility and their need for services, it is likely that the aurora/tourism and geological/offshore segments will be targeted by existing service providers as growth segments. ESA could have some advantage in reaching the geological/offshore segment because of the relationship it has developed with the offshore, mining, and tunnelling industries through its Harsh Environments Initiative.

Many governmental and public-funded research organizations, such as ESA, have policies or over-arching restrictions that prevent them from working in support of the military sector. However, in time this segment could be a very substantial customer base for the right service provider because of the broad range of opportunities and likely lack of competition within it.

7. MARKET OPPORTUNITIES

7.1 Introduction

Based on the fact that customers already employ space weather data and services, it is clear that there is a market for such products. It is unclear, however, how well the market will support the growth of incoming data and service providers, particularly with a reluctance on the part of customers to pay for data. New entrants to the market would be well-advised to identify value-added services, and to carefully match those services to customer segments. Based on activities of current players and comments from interviewees, it is doubtful that another broad-scale data provider is needed or wanted in the marketplace. However, interviewee comments stated that a more focussed approach towards meeting user needs would be welcomed.

Some near-term roles did emerge for ESA programmes to potentially fill during the course of this study, and these are outlined in the following sections. Sections 7.2 and 7.3 describe roles and activities that end users described for ESA to fill. Section 7.4 presents opportunities with a more commercial focus that ESA could help support through a variety of mechanisms. The term ESA is used to represent ESA activity (as a space agency), or as a future ESA space weather programme. It should be noted that future space weather activities in Europe might also be coordinated by a European space weather agency or programme.

7.2 Sponsoring Technical improvements

Along with data and service requirements, end users felt that routine updates to the technology used in space weather services could benefit the entire marketplace, and should be the particular responsibility of space agencies like ESA and NASA. In particular, end users requested:

- More focus on designing better space weather equipment so that monitoring and measuring systems do not get damaged during events.
- Better redundancy in designing missions such as ACE and SOHO. There was a large concern demonstrated during interviews about the loss of data if a spacecraft providing data should fail.

Referring back to the supply chain model developed in Section 5 of this report, ESA would be influencing the data requirements and specifications coming from the scientific community and later feeding into the data providers. Although this activity would not re-define the marketplace, it would serve to increase the trust that users have on the reliability of space weather data, and they might then be more likely to incorporate space weather services into their businesses. A likely end result could be more consistent demand for data from commercial customers. Figure 5 represents ESA's interaction in the supply chain model for this role.

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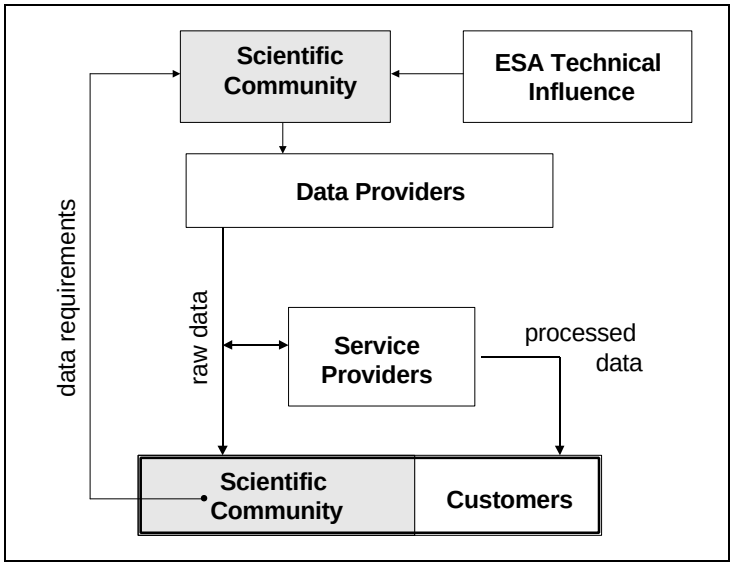

Figure 5 Supply chain model: ESA as a sponsor of technical improvements

7.3 Provision of Selected Unavailable Space Weather Data

Although most end users do not want to pay for raw data, they do still see gaps in the space weather data market, which they expect a government agency will fill. Rather than having someone create a new, all-encompassing service, customers are hoping that someone will design a data service particular to their segment's needs, as described in more detail in Section 6.

The biggest complaint from customers across all segments is that there is too much data in the market that is not relevant to their needs. This statement reflects the difficulty that users have in filtering through the existing data in order to identify data for their use (a "data overload" scenario). Within this context, this statement is consistent with the numerous market analysis participant replies identifying their unmet data needs.

Taking this "data overload" into consideration, this existing data gap limits the models and products that service providers can offer to customers. The end result is that customers find space weather of low usefulness to their business. If a data provider could turn the proportions of that scenario around, for example focusing only on providing data relevant to a specific market segment, the end result would be customers who could never imagine running their businesses without space weather products. Figure 6 depicts the idea of minimising these data gaps.

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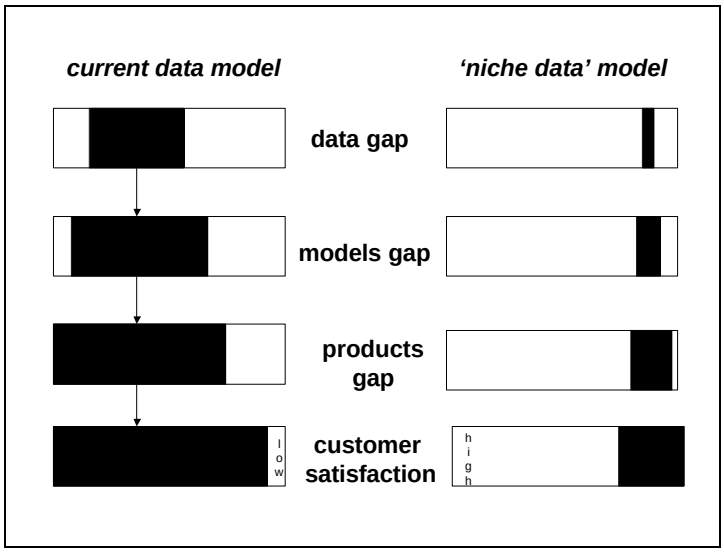

Figure 6 Data gaps model

Other requests for data that had cross-over among segments include:

- Atmospheric density and temperature measurements made available to users every few minutes.
- Total electronic content of the ionosphere made available every few minutes.
- Proton flux measurements made available every few hours or days.
- More frequent and timely GOES (currently one reading every 1 or 5 minutes) data.
- Better qualification of forecast verification – there are still a lot of errors in forecasts.
- Provision of data between standard prediction timeframes. Data providers collect data either at 72 hours out, or one hour out, but nothing in-between.
- More research is needed into the way storms propagate towards earth. In particular, better reliability is needed in predicting that storms are coming, and better accuracy in determining when they will arrive.
- More solar and solar wind data is needed.
- Good quality ionospheric data needs to be distributed in a more timely manner
- Better prediction of the magnitude of storms is required. The visualisation of the storm on the Sun is not enough to predict how the storm will affect systems. Storms may look similar on the Sun, but the end effect away from the Sun can be different.

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Looking at ESA's new position as data provider in the supply chain model shows how ESA might be able to re-define the marketplace so that customers have a voice and an influence over the type of data that is being provided. Although it is not anticipated that ESA would be responsible for having regular direct contact with customers (which should be a role for service providers), comprehensive studies such as this one can provide ESA with outstanding needs of customer segments from which they can work within the European community to develop new data products. Figure 7 illustrates this new model for space weather data provision.

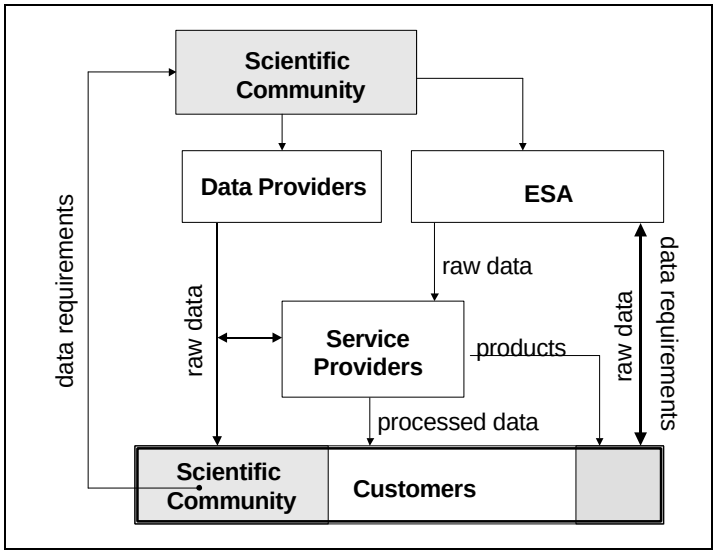

Figure 7 Supply chain model: ESA as data provider

7.4 Opportunities With a Commercial Focus

While the above two sections have described roles that ESA could play within its sphere of existence as a taxpayer funded body working for the public good, there are a variety of mechanisms that ESA could address that would better support the commercial side of the space weather market, particularly in terms of creating a better playing field in Europe for local service providers. There are two main roles that ESA could play: acting as a co-ordinator of data and services and acting as a watchdog and activist for the European community. These roles are described in more detail in the following sections. Figure 8 depicts how ESA will interact with the service provider segment of the supply chain.

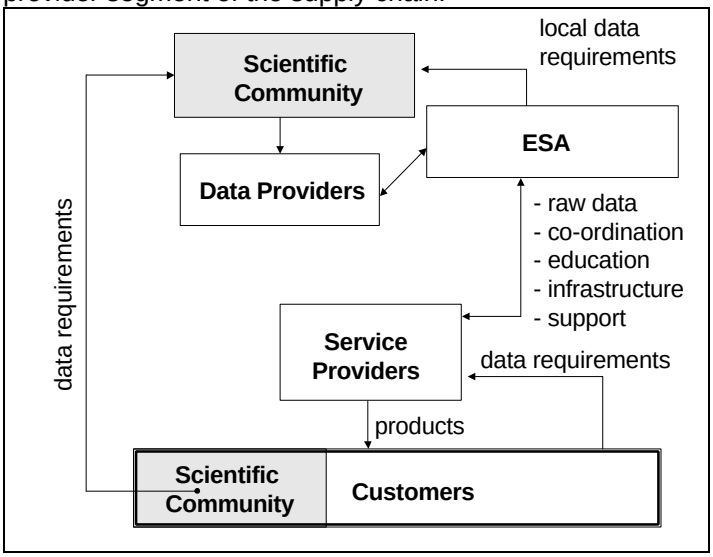

Figure 8 Supply chain model: ESA support for commercial services

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7.4.1 Co-ordination of Space Weather Data and Services

It was interesting to note that although most of the people that were interviewed stated that there is too much data in the current space weather market, all of them also had requests for different types of data that would better match their segment's needs. This apparent inconsistency is due to the fact that the "data overload" syndrome (discussed in section 7.3) exists in parallel with unmet user needs. Above all, a request was made for someone to work on co-ordinating the data availability and requirements, particularly by:

- Instigating and managing more collaborative and co-operative research among the different national and international programmes, which could allow for more equipment being launched and more redundancy in data sources.
- Building single repositories of data, particularly for spacecraft environment data, data from the WDCs, and data from the observatory networks.
- Working with data providers to simplify data formats so that they read as 'go/no go' recommendations.
- Spearheading a campaign to verify a more reasonable academic consensus about what causes storms.
- Providing more basic education to customers on the cost-effectiveness and relevance of space weather solutions.
- Developing and implementing better data transfer systems, such as satellite links.
- Building a proper infrastructure to offer accessible/reliable data and services during both calm and storm conditions, which many customers felt is a major challenge to the space weather industry.
- Supporting global measurement instruments by a 24-hour (daily) operating service.

7.4.2 Addressing Local Issues

Many end users felt that the current space market is dominated by the Americans, who tend to neglect space weather issues that are relevant to specific geographies. Rather than providing space weather services that are redundant to those in the US, ESA could choose to attack diversified geographic markets by:

- Doing more cost-effective research at ground level using Earth based sensors rather than with spacecraft.
- Developing and supporting more spacecraft/missions that are specific to European needs.
- Using information from existing factities to improve space weather models of specific interest to European users.
- Focusing data services on 'uncovered' geographies. NOAA and the US military focus on sun-synchronous polar orbits, which means that there are parts of the world where no space weather data is available. These geographies are currently paying for their own data collection. One end user interviewed would benefit from having someone launch a satellite at equatorial orbit, with 10° inclination at 600 km altitude that would take real-time measurements of:
    - Ionospheric electron density.
    - Electric fields.
    - 3-D ionospheric drift.
    - Horizontal neutral winds.

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8. RECOMMENDATIONS

The space weather market is developing into a very competitive arena, with lots of existing and new data and service providers targeting a limited customer base that has some intolerance to paying for products. It is important for ESA to focus on attractive customer segments and value-added activities while they are expanding the design of their space weather programme. Thus, the following sections describe activities that are recommended for ESA to undertake in the short term. It should be noted that the evaluation of assets will be carried out as part of the existing contract (Catalogue of European Space Weather Resources).

8.1 Perform Further studies

- Complete a thorough evaluation of the assets that are available for the production of space weather data and products both world-wide and specific to ESA, and analyse the relevance of the data generated by these assets.
- Continue to study the needs of customers on a regular basis, either by contracting out or developing an in-house business development function.

8.2 Stimulate Demand

- Work to increase general awareness of space weather issues through the media.
- Anticipate having to educate some market segments about the significance space weather has to their business, and consider this a priority in the design of the service.
- Provide users within segments opportunities to share experiences in space weather and possible solutions to space weather issues with each other and industry experts possibly through pilot projects.
- Help to formulate solutions (not data) that are relevant and meaningful directly to attractive market segments, most likely via electronic channels.

8.3 Unite the European suppliers

- Co-ordinate the design of space weather missions in response to specific end user needs.
- Support the creation of a ‘one-stop’ shop for key market segments, where unique, obscure, or hard-to-find data is consolidated into services.
- Help to make data available on a wide-scale basis. This work will have three points of focus:
  - Identifying and defining priority end users in Europe.
  - Ensuring that future European assets will complement existing ones.
  - Helping to form collaborative partnerships with data and service providers.
- Provide users with direct access to experts and expertise. This could include creating a directory of European space weather services and experts, who are willing to have direct contact information distributed to customers.
- Provide better training for individuals in Europe who could model space weather data for industrial applications. It may be necessary for ESA to complete a benchmarking assessment of current modelling activities and data processing techniques, and to form ties to academic institutes who could develop qualified programmes.

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9. CONCLUSION

It is clear that a market exists for space weather data and services. A customer-driven approach to the development of products and services will lead to better commercialisation of space weather products. Unfortunately, it is difficult to place a financial value on this commercial market. Products that are currently available do not always closely match the needs of the customer; therefore, it is likely that customers would be more willing to pay for better-designed services. Customers are also unable to estimate their willingness to pay for products that are in a pre-definition phase, as ESA's product currently is. Discussions with customers have identified that a cost-plus model (long term ongoing funding targeted for specific developments) for pricing services would most likely apply to this market, as customers are willing to pay for the value their service providers give them, but also require cost-effective solutions.

Although NOAA has benefited from their dominant position as a data provider in the space weather market and provide a high-quality, web-based space weather information service, it is not part of their role, as a US government agency, to create customer-focused services that will generate revenue streams beyond cost recovery. Thus their activities do not inhibit the development of commercial services. ESA would be wise to work towards re-defining the current scientifically-driven marketplace, and positioning itself as co-ordinator and advocate of the service providers, and as an educator of the general public.

ESA should also have a strong focus on capitalising on business development and customer education opportunities, both to maintain familiarity with the customer base to enhance service provision, and to encourage interaction between targeted customers and the agency and its experts. As opposed to replicating existing programmes and creating an even more competitive market environment, ESA should work to fill the gaps in the market, as identified in this report, and focus on re-defining the market as a customer-driven one. This would help ensure that resources are well utilised, and improves Europe's chances for gaining returns on investments.

10. PROPOSED FUTURE STRATEGY

A commercially-driven market requires a commercial focus. ESA has neither the goal nor the resources to become a commercial organisation; however, by acting in the roles of educator, co-ordinator, and enabler, as discussed in Section 8, ESA can support the creation of commercial space weather service providers in Europe over the long-term.

In addition to the near-term mechanisms that ESA should put in place, the agency may wish to invest some resources into developing an infrastructure for commercial service providers. ESA's technology transfer programme has developed a model for this type of activity, and it has been well-tested over the past 10 years. The technology transfer programme office subsidises the work of a consortium of privately-owned technology brokers that represent every ESA member state. On behalf of the agency, these brokers develop links with customers, provide value-added services to their markets, and negotiate and generate revenues from technology licensing agreements. The eventual goal of this programme is for the technology brokers to become self-sustaining with respect to the work they do on behalf of ESA. On their part, ESA helps to compile lists of space technologies that are available for licensing, generates education and marketing materials in support of the programme, and works at the 'top level' to co-ordinate industry and pan-European events.

Figure 9 depicts how the commercialisation model for the technology transfer programme could be adapted to serve the commercial requirements of the space weather market. A highlight is included that shows how ESA would interact with each service provider in the network.

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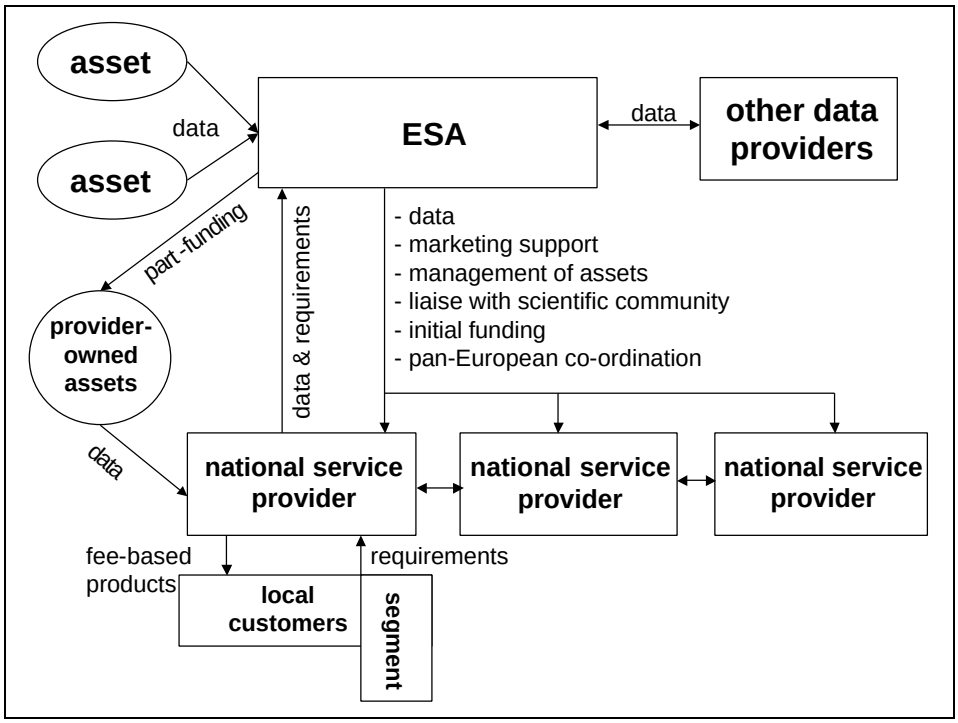

Figure 9 Space weather commercialisation model

This model could well serve the space weather market. Working with a base of existing European assets and service providers, ESA could support the development of a network of service providers across Europe. These organisations would work in a matrix fashion, where they would each be responsible for understanding and servicing the needs of their country, but would also be responsible for tracking the business and data needs for a specific market segment, as discussed in Section 7. For example, Country A would be responsible for its own national customers, and also for monitoring and servicing the offshore sector. If Country B has an offshore customer that needs a specific service, Country B could either refer the customer to a contact in Country A, or work directly with their counterparts in Country A to create a locally-implemented service for that customer. It is envisaged that these service providers would also work with ESA to develop and operate their own assets that would meet the needs of their markets.

ESA would probably need to raise funds for initial support and development of these companies and the network, but with the understanding that subsidies would decline as the national service providers generate revenues. ESA would also work as an overseer of the network, managing a set of assets, providing infrastructure, developing marketing support materials, and promoting missions and hardware within the scientific community that are designed to meet customer requirements. Basically, ESA would work to support the common needs of the service providers.

With this commercialisation model, ESA could retain its role as a non-commercial, scientifically-oriented organisation, while also creating a ‘second generation’ space weather marketplace with a strong commercial focus. This re-definition could place a spotlight on European expertise, so that ESA and Europe would be renowned world players in the market.

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