# USER REQUIREMENTS

The Market Analysis report [WP120 Draft 4.0: 1 November, 2000] provides the key input to creating these requirements. The Market Interview Requirements (MIR) themselves, as listed in table 5 of that report, include both top-level and detailed data requirements, depending on the viewpoint of the user. In order that these user needs can be used to establish the detailed system requirements, it has been necessary to combine these into a more uniform set of User Requirements (URs). At the same time, duplication of requirements requested by different user groups needed to be eliminated. Some additional user groups, not specifically mentioned in the MIRs but identified in the 'Space Weather Effects Catalogue' [ESWS-FMI-RP-0001], have been added where they are expected to share similar requirements. Some MIRs do not specify whether information is required before during or after real time. Also, some users who specified a need for forecasts did not state whether now-cast or post-event data were also valuable, in the event that forecast data was unavailable or of insufficient accuracy. (In general, it is to be expected that forecasts will be of much lower accuracy than real-time data.) Hence some interpretation of the MIRs has been necessary.

Some of the requirements obtained from the market interviews are *system* rather than *user* requirements, eg. MIR15 refers specifically to proton flux measurements. In this case, the underlying user requirements for information has been captured and the MIR mapped to this requirement (or requirements).

Timeliness indicates how far in advance forecasts should be, how near real-time now-casts should be and how soon after the event post-event information should be. Most MIRs contain a timeliness requirement and some contain more than one. Some interpretation has been necessary to determine which is most relevant and to prevent an unachievable timeliness requirement being specified. However, those times should be treated as reasonable goals and not as minimum thresholds for any benefit. Poorer performance can often still have benefits, albeit diminished ones.

From the 'Space Weather Effects Catalogue' [ESWS-FMI-RP-0001], two significant effects were identified for which no MIRs had been specified. These were areas (manned space flight and launchers) where no market interviews had been carried out. Since manned space flight is not yet a commercial market, its absence is not surprising. The small number of launch providers within Europe may explain why a suitable interviewee was not identified. The report on 'Benefits of a European Space Weather Programme' [ESWPS-DER-TN-0001] has identified that there are significant financial benefits to be generated in both these areas. Hence, even though it has not been established that there is a market for space weather information, user requirements have been specified in both these areas.

Most of the MIR's identified in [WP120] relate to specific market areas. However MIRs 17-20 are classified as .
MIR17 and MIR18 as given in [WP120] are essentially direct statements of *system* requirements. The underlying *user* requirements have been interpreted as a user need for continuous data availability during and after extreme events (MIR17) and in the event of premature failure or end-of-life of key space weather systems (MIR18). To this has been added a further user requirement on data distribution and availability. This was implicit in the earlier MIRs but needs to be explicitly stated here to ensure that data handling is given appropriate weight in the system definition phase that follows.

MIR19, which specified prediction timeliness, was too unclear to be translated into a user requirement. It presumably related to a specific problem a user had in obtaining an unspecified type of data. MIR20, which requested storm forecasts without stating which users requested it, was too general to be explicitly converted into a user requirement. However, storm forecasts are an implicit part of all the forecasts that have been specified.

The resulting User Requirements (UR1-24) plus interpretation of the MIRs is tabulated below. UR1-21 are essentially information product requirements, in that they entail the provision of certain types of data. UR22-24 are essentially service requirements since they relate to data availability, continuity and distribution.

| UR no. | User Requirement | Timeliness | User | Market Evidence | Interpretation |
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| UR1 | Forecasts of hazardous radiation levels at altitudes and on routes used by commercial airlines, that may be dangerous to aircrew or may affect avionics systems. | ~18 hours preferred | Airlines and air safety organisations | MIR1 | Forecasts need to be early enough to change crew and/or flight-plan. 18 hours ahead was identified as preferred by users in the market interviews but it is anticipated that some appropriate action could be made with shorter warnings. |
| UR2 | Now-casts of hazardous radiation levels at altitudes and on routes used by commercial airlines, that may be dangerous to aircrew or affect avionics systems. | Near real-time (<30 minutes) | Airlines and air safety organisations | MIR1, MIR15 | Now-casts need to be sufficiently close to real-time to enable mitigation procedures to significantly reduce dose during extreme radiation events. Intercontinental flights last several hours and so real-time data must be available in a shorter time to be of any use. |
| UR3 | Post-event information on radiation levels at altitudes and on routes used by commercial airlines to allow calculation of crew [and passenger] radiation exposure and investigation of equipment anomalies. | <1 week (2-3 months if no severe events occur) | Airlines and air safety organisations | MIR2 MIR15 | MIR2 specifies that only information on extreme radiation levels is required. However, to compute crew exposure, information at all levels is required. MIR2 specifies 2-3 months timeliness. This seems appropriate for routine crew dose calculations. However, in the event of a severe solar energetic particle event it is likely that more rapid information will be required. |
| UR4 | Spatially resolved forecasts of large geomagnetically induced currents, to allow mitigation measures to be taken to protect distributed conductor networks e.g. power grids | >1 hour (1-2 days preferred) | Electric power transmission organisations (also pipeline operators and railways and telephone companies) | MIR3 | 1-2 days warning is preferred since it allows rescheduling of generator and circuit downtime. However, useful mitigation can be taken based on warnings at shorter notice. |
| UR5 | Spatially resolved now-cast information on large geomagnetically induced currents. | < 5 minutes | Electric power transmission organisations (also pipeline operators and railways and telephone companies) | MIR3 | Market requirements, summarised in MIR3 and described in more detail in the text of the Market Analysis Report, showed a strong desire for real-time magnetic field data from users. Whilst power transmission companies can monitor induced currents |

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| | | | | | in their systems directly, real-time geomagnetic data is needed to establish the cause of anomalous currents. |
| UR6 | Spatially resolved post-event information on geomagnetically induced currents of all sizes. | < 1 month | Electric power transmission organisations (also railways and telephone companies) | MIR3 | Whilst no explicit market interview requirement was specified in MIR3 for post-knowledge of geomagnetically induced currents, it is assumed to be implicit. Such information has been used in the past to diagnose the cause of failures in relays and transformers and has enabled sensitive equipment to be identified. This need is likely to continue. |
| UR7 | Forecasts of perturbations in the geomagnetic field | >1 day (2-4 weeks preferred) | Geological prospectors and military | MIR4 | The 2-4 weeks specified in MIR4 is an aspiration that will be very hard to meet to a reasonable degree of accuracy. This amount of warning would act as input to planning of surveys but it is anticipated that, even with shorter warnings fruitless surveying could be avoided. This is backed up by a supplementary comment under MIR4 stating that certain users requested flare data 1-3 days in advance. Detection of submarines by magnetic anomaly detection uses similar technology and warnings would enable periods of detector blindness to be anticipated. Whilst MIR4 includes offshore drilling as a potential beneficiary, it is not clear that this is true. |
| UR8 | Post-event knowledge of perturbations in the geomagnetic field | <1 day | Geological prospectors and drilling industry | MIR5 | It is estimated that correction of magnetically oriented drilling requires a time-scale of about 1 day to prevent drilling errors becoming unacceptable. |
| UR9 | Forecasts of ionospheric disturbances leading to loss of range, degradation and outage of radio communications e.g. fadeout, polar cap absorption and scintillation | > 1 day | RF systems (civil and military) | MIR6, MIR9, MIR13 | RF systems include radar and comms to and from spacecraft. Timeliness requirements depend strongly on the user. 1 day is taken as a typical time for alternative communications to be arranged. |
| UR10 | Now-casts of ionospheric reflection properties for HF frequency selection | < 5 minutes | RF systems (civil and military) | MIR6, MIR9 | MIR6 requires only forecasts but, for HF frequency selection, now-casts should be the main requirement. Frequency selection may require the complete density profile, not just $f_0F2$. These data also give |

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| | | | | | real-time information on over-the-horizon radar range and blind-spots. |
| UR11 | Now-casts of ionospheric total electron content | < 5 minutes | GNSS location systems. Radar systems. (civil and military) | MIR7, MIR9 | Real-time data are needed for correction of GNSS positions. Users may not be affected if they have access to 2-frequency GNSS systems. Trans-ionospheric radar systems are affected however. Radio tracking of satellites and radio-location of emergency beacons are similarly affected. |
| UR12 | Post-event information on environments affecting operational satellite systems, e.g. radiation and charging environment | < 1 day | Satellite operators (civil and military) and Insurance and financial services | MIR8, MIR10, MIR11, MIR12, MIR15 | MIR8 requires post-knowledge. MIR 10, 11 and 12 do not explicitly state whether forecasts, now-casts or post-knowledge is required. Post-knowledge is considered most valuable since it is used for diagnosis of anomalies. MIR12 refers to transfer orbits but is combined here since operational orbits cover LEO, MEO and GEO, and hence transfer orbit altitudes. |
| UR13 | Forecasts of hazardous environments affecting operational satellite systems. | >1-2 days | Satellite operators (civil and military) | MIR10, MIR11, MIR12 | As stated above, MIR 10, 11 and 12 do not explicitly state whether forecasts, now-casts or post-knowledge is required. However, forecasts are considered useful since they enable some preventative measures to be taken and recovery procedures prepared. |
| UR14 | Now-casts of hazardous environments affecting operational satellite systems | < 5 minutes | Satellite operators (civil and military) | MIR10, MIR11, MIR12, MIR15 | As stated above, MIR 10, 11 and 12 do not explicitly state whether forecasts, now-casts or post-knowledge is required. However, now-casts are considered useful since disturbed environments are often long-lasting and it is often not too late to enable some preventative measures to be taken and recovery procedures prepared, |
| UR15 | Now-casts of atmospheric drag for LEO spacecraft | < 5 minutes | Satellite operators (civil and military) (and ballistic missile defence) | MIR13 | MIR13 is assumed to be a LEO requirement only. Drag information is needed for orbit, re-entry and attitude perturbation calculations. In military use, LEO spacecraft orbit calculations are required as a part of ballistic missile defence. |
| UR16 | Forecasts of auroral intensity and location | >12 hours | Tourism | MIR16 | Whilst 1 day was specified in MIR16, it is expected that notification during the preceding daylight hours should be useful. |
| UR17 | Forecasts of all hazardous | > 1 day | Space Agencies | - | A 1 day warning would allow early return of crew |

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| | environments affectinghumans in space | | | | from LEO in the event of an extreme forecasted event. |
| UR18 | Now-casting of all hazardous environments affecting humans in space | < 30 minutes | Space Agencies | - | Real-time data could enable crew to move to a less exposed part of the space station in the case of intense radiation or meteoroids. |
| UR19 | Post-event knowledge of radiation environments affecting humans in space | <2-3 months | Space Agencies | - | As with aircrew, routine information on radiation is needed for crew dose assessments. |
| UR20 | Forecasts of severe solar proton events affecting spacecraft launch operations | >1 day | Launch Providers | - | Warnings of severe events more than 1 day ahead would allow a planned launch delay. |
| UR21 | Post-knowledge of solar proton fluxes affecting spacecraft launch operations | <1 day | Launch Providers | - | In the event of an imperfect launch, the solar proton environment would form part of the diagnostic process. |
| UR22 | Continuous data availability during and after extreme events | | General | MIR17 | Space weather monitors must not become inoperative during severe space weather events. This implies a system requirement for more robust space weather monitoring systems. |
| UR23 | Continued data availability in the event of premature failure or end-of-life of key space weather systems | | General | MIR18 | MIR18 reflected concern amongst users in the limited life-span and lack of redundancy of SOHO and ACE. |
| UR24 | Efficient distribution of data to users and continuous availability. | | General | - | This is an essential requirement if a Space Weather System is to be trusted. |