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Measurements of the Magnetism of the Mars–96 Small Station at the Nurmijärvi Geophysical Observatory

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Abstract

Two US spacecraft are presently exploring Mars, and several scientific Martian missions are planned for the next years. The Martian magnetic field is of great interest in many respects, and so magnetometers are included in payload plans of the missions. Since the magnetic field of Mars is very small compared with that of the Earth (≈ 0.1 %), fields due to the spacecraft and its instruments can essentially distort the recordings of a magnetometer. Incorrect interpretations and conclusions may result unless the distorting fields are known and carefully taken into account. Each of the two (identical) Small Surface Stations belonging to the Russian "Mars–96" mission, which was launched, although unsuccessfully, in November 1996, contained a magnetometer. Before the launch, the problem of a disturbing magnetism of the Small Station was investigated at the Nurmijärvi Geophysical Observatory, Finland. Distortions of several tens of nanoteslas were indicated, which are of importance when measuring the weak Martian magnetic field. The main result of the work done and of this paper is that the applicability of the Nurmijärvi facilities to this kind of a "magnetic cleanliness" study was clearly demonstrated. Due to the catastrophe of Mars–96, the scientific goals will, of course, never be reached. However, a lot of important work was done, which can directly be utilized in future Martian missions. A careful documentation of the work is therefore necessary, and this paper is a contribution about the Nurmijärvi facilities for magnetic cleanliness measurements.

Key words: Martian magnetic field, magnetic cleanliness, planetary exploration

1. Introduction

Mars is the goal of intensive scientific exploration. Two US spacecraft, Mars Pathfinder and Mars Global Surveyor, arrived at the planet in July and September 1997, respectively. The former is a lander with a small rover, called Sojourner, and the latter, still in operation, is an orbiter. Activities in Martian exploration will be in continuous increase in the coming years. The importance of international collaboration in this respect is widely recognized. The missions planned contain both orbiters to make scientific observations in the Martian near-space, including careful imaging of the planet, and landers to operate on the surface of the planet. The latter may be fixed possibly forming a stationary network or rovers moving across the surface even some hundreds of kilometres. Future plans also contain penetrators investigating the planet's subsurface at a depth of a few metres and balloons floating in the Martian atmosphere. Later sample return missions and even manned missions to the red planet will probably be carried out.

An opportunity, i.e. a window, to launch a spacecraft from the Earth to Mars occurs about every twenty six months on average (*Smith*, 1989; *Lewis and Prinn*, 1984). The existence of launch windows is dictated by celestial mechanics because a sun-centred trajectory shall be used for the cruise from the Earth to Mars. Utilizing such a trajectory, the spacecraft moves guided by the Sun’s gravitational field without any fuel consumption, consequently greatly decreasing the amount of fuel to be carried and making the flight even possible in practice. The length of a window is roughly one month, and due to the eccentricities of Mars' and the Earth's orbits the intervals between the windows somewhat vary.

The previous window, in which the Russian Mars–96 spacecraft was launched, occurred at the end of 1996. The launch of Mars–96 started successfully, but unfortunately, the spacecraft was never able to get a trajectory towards Mars and crashed on the Earth after a flight of a few hours. The United States had the two successful launches mentioned above in the 1996 window. Several launches are being planned for the coming windows in 1998–1999, 2001, 2003 and 2005. They contain orbiters and landers, and a participation from the United States, Russia, Japan and Europe is included. The European Space Agency (ESA) is currently investigating possibilities of a mission, called Mars Express, in the 2003 window.

The scientific objectives of the coming Martian missions involve a great variety of topics from investigations of the structure of the atmosphere and meteorology to observations of the chemical composition of the surface material and seismological studies of the planet's interior. The establishment of a network of small meteorological stations operating on the Martian surface is planned. The cruise time from the Earth to Mars is from several months to roughly a year depending on the window. In 2003 the time is short, from June to the end of December, and also otherwise the 2003 opportunity is favourable. Therefore 2003 is termed the "International Year of Mars Exploration".

The magnetic field of Mars is of a great and versatile scientific interest because it essentially affects physical processes occurring in the planet's near-space and also carries information of the internal structure of the planet. Magnetic recordings may be performed by magnetometers located either on orbiters or on surface stations. However, magnetic measurements are apt to be distorted by magnetic fields created by the orbiter or the station itself. Consequently, the recorded data may be completely useless unless such a disturbing magnetism is known and carefully taken into account. This paper concentrates upon issues of this kind, known as magnetic cleanliness questions, in connection with the Small Stations belonging to the Mars–96 mission. Investigations of any disturbing and interfering electric and/or magnetic fields belong to the important topic of today generally called Electromagnetic Compatibility (EMC) (e.g. *Pirjola*, 1997), so magnetic cleanliness may be considered an EMC problem as well.

Magnetic cleanliness measurements of the engineering models of the Mars–96 Small Station equipment were carried out at the Nurmijärvi Geophysical Observatory, Finland, in the beginning of 1994, and the final flight models were checked at Nurmijärvi in 1995 to 1996. This paper deals with the engineering model measurements, so the main issue of the paper is to demonstrate the applicability of the Nurmijärvi facilities to magnetic cleanliness studies of space equipment rather than to give an accurate description the magnetism of the equipment launched in the Mars–96 spacecraft. To obtain a detailed understanding of the magnetic properties of the spacecraft, several laboratory analyses of pieces of the materials used could have been carried out but such investigations are outside the topic of this paper which, as mentioned, concentrates upon introducing the Nurmijärvi possibilities of examining magnetic cleanliness.

It should be emphasized that, although the crash of Mars–96 was a great disappointment, the studies, measurements and work carried out and the experience obtained in the course of the project are directly applicable to future Martian programs. Consequently, the different aspects related to Mars–96 should be documented in the form of papers and publications. *Linkin et al.* (1997) describe the Mars–96 Small Stations, and *Harri et al.* (1997) discuss the meteorological equipment on board the Small Stations and the Penetrators (see Section 3). This paper contributes to the documentation of the Small Station magnetic cleanliness investigations.

Magnetic cleanliness requirements are sometimes hard to fulfill in space missions but on the other hand without their thorough examination magnetic data collected in space may sometimes be completely useless. *Acuña et al.* (1997) discuss the magnetic investigation associated with the US Near-Earth Asteroid Rendezvous (NEAR) mission aimed at establishing the global characteristics and geometry of the magnetic field of asteroid 433 Eros. The magnetic sensor was not placed on a boom away from the spacecraft but on an antenna feed structure. Magnetic cleanliness issues were carefully analyzed before the launch, which took place in February 1996, and later applying preliminary in-flight calibration data. The magnetic distortions are mostly known and may be removed from NEAR magnetometer data.

2. Magnetic field of Mars

The magnetic field of the Earth, and obviously also Mars as well as any planet or moon, can in principle be divided into two parts (*Viljanen and Pirjola*, 1994):

1. The *main field* which may usually be considered static but which exhibits a "secular variation" with time scales greater than, say, a month.

2. The *variation field* which is characterized by rapid temporal changes in times from seconds to a day. Intense variations are known as magnetic disturbances or storms.

Three different contributions are further included in the main field:

1. The *global field* whose origin is deep within the planet. This field corresponds to a dipole and multipoles with spherical harmonic terms having n and m less than about 12.
2. The *regional field* produced by anomalies at different depths. This field is generally regarded as having a crustal origin, and it is characterized by spherical harmonic terms with n and m much larger than 12.
3. The *small-scale field* caused by local magnetized rocks.

The variation field is composed of two parts:

1. The *primary field* due to currents in the planet's near-space (ionosphere and magnetosphere).
2. The *secondary field* created by currents induced within the ground.

Observations of all five contributions are scientifically interesting and valuable. However, their separation from each other is a hard task, in particular if the data is distorted by magnetized equipment lying near to the magnetometer.

So far, no magnetic measurements have been made on the surface of Mars, and most of our knowledge about the Martian magnetic field was collected by the Soviet Phobos–2 mission at the end of the 1980's (*Zakharov*, 1992; *Kallio*, 1992). The field is very weak with values in the order of tens of nanoteslas at the surface being thus only about one thousandth of the geomagnetic field of the Earth. Mars obviously has a core (*Blanc et al.*, 1992), but it is not fully known whether active dynamo processes that would generate a magnetic field are (still) going on. These issues are discussed in greater detail for example by *Russell* (1980; 1987) and by *Menvielle et al.* (1996). Recent observations made by the Mars Global Surveyor soon after arriving at Mars support the conclusion that Mars has a planet-wide magnetic field with a polarity similar to that of the Earth's field with a maximum strength not exceeding 1/800 of the geomagnetic field (*Isbell et al.*, 1997).

A Martian magnetic field in the order of tens of nanoteslas is exactly in the range where a balance between the magnetic pressure and the solar wind exists forming a magnetosphere comparable with that of the Earth although much smaller (*Kallio*, 1992). Thus, the Martian magnetic field should be measured as accurately as possible.

It is strongly believed that shergottite, nakhlite and chassignite (SNC) meteorites found on the Earth are of a Martian origin (*Laul*, 1986; *Cisowski*, 1987). *Collinson* (1986; 1997) has analyzed the natural remanent magnetization (NRM) of SNCs and concluded that the most likely source of NRM was an ancient magnetic field at Mars at the time when the meteorite material cooled from a high temperature about a hundred million to a billion years ago. The magnitude of the ancient field would have been 500...5000 nT, i.e. at least an order of magnitude greater than the present field. Modelling studies based on magnetic properties of SNCs indicate the possibility of positive and negative magnetic anomalies of hundreds or even thousands of nanoteslas in the vicinity of local magnetized rocks or boulders on the surface of Mars (*Terho et al.*, 1993; 1996). Thus the static main field as defined above may greatly vary locally from site to site, and so a measurement at a single site is practically impossible to be interpreted.

Similarly to the Earth, the variation field recorded on the surface of Mars may be utilized in the determination of near-space currents and/or in studies of the structure of the ground. Such possibilities are thoroughly discussed by *Menvielle et al.* (1996). *Viljanen and Pirjola* (1994) also evaluate the applicability of magnetic data to be collected at Mars, and they conclude that difficulties may be encountered in the interpretation. On the other hand, however, the knowledge of the Martian magnetic environment is so poor until now that all new data, even difficult to be interpreted, are welcome. Therefore the inclusion of magnetometers in future Martian missions shall be supported.

3. Mars-96

"Mars–96", whose purpose was to be an unmanned scientific mission to Mars, was led and coordinated by the Russian Space Agency (*Mars–94,* 1992). Altogether about twenty countries participated in the project with substantial contributions from France, Germany and Finland. The mission was first planned to be be launched in the 1992 window, later postponed to 1994 and finally launched in 1996, but as mentioned above, without success.

Mars–96 consisted of an Orbiter, two Small Surface Stations and two Penetrators. The total launch mass was roughly 6000 kg, half of which was fuel. A Small Station and a Penetrator weighed about 33.5 kg and 50 kg, respectively. The landing sites of the Small Stations and Penetrators would have been located at the latitudes 30 to 40 °N and close to the longitude 160 °W except for a Penetrator that would have landed at about 250 °W (*Harri et al.*, 1997). Thus a regional surface network would have been created by the three landers. The landing accuracy is in the order of hundreds of kilometres. Each of the four surface stations contained a magnetometer. The total number of scientific instruments and instrument systems included in Mars–96 was about 40, and the nominal lifetimes of the Orbiter, Small Stations and Penetrators are one to two Earth years (i.e. half to one Mars year). The data to be collected on the Martian surface was planned to be relayed to the Earth via the Orbiter and the US Mars Global Surveyor Orbiter.

An artist's impression of the landing of a Small Station on the surface of Mars is shown in Fig. 1. The atmosphere causes deceleration, and a parachute would have attenuated the impact velocity to about 20 m/s. To soften the landing, an airbag was designed around the station. The whole descent through the atmosphere would have taken some minutes, during which scientific measurements, including magnetometer recordings (1 sample per second), would have been performed. After the landing the Small Station should have opened its petals and a mast, so scientific measurements might have begun. The ring-core fluxgate magnetometer, which was provided by German and French teams, was located at the end of a non-magnetic carbon-fibre boom that was fixed to a petal making the distance from the disturbing station itself as large as possible (= roughly 1 m). The schematic and inaccurate drawing in Fig. 2 would indicate a somewhat smaller distance between the magnetometer and the central axis of the station but the value of about 1 m is more accurate (see *Linkin et al.*, 1997). On the surface the magnetometer was planned to normally take samples of the three-component magnetic field every 30 to 60 s with a resolution of 0.25 nT, and the dynamic range of the instrument was ± 8000 nT permitting observations of also very large magnetic variations (*Mars–94,* 1992; *Musmann and Menvielle*, 1994).

Fig. 1. Landing of a Mars–96 Small Station on the Martian surface. For further details, see the text.

The mechanical structure of the Small Station as well as two Radioactive Thermoelectric Generators (RTGs) and a rechargable battery were provided by the Russians but the Finnish Meteorological Institute (FMI) was responsible for the design and manufacturing of the Central Electronics Unit (CEU), whose purpose was to control electric power distribution and data processing at the station. Consequently, integration tests of the different subsystems, whose total number was seven, with the CEU were carried out in Finland. Thus, it is natural that the EMC testing of the magnetism of the Small Station was also performed in Finland in the same connection. The Nurmijärvi Geophysical Observatory of FMI offered this possibility.

4. Magnetic measurements of the Mars–96 Small Station at Nurmijärvi

The magnetic distortion caused by a spacecraft or a lander to magnetometer recordings can be divided into three parts (*Musmann and Menvielle*, 1994):

1. There may exist permanently magnetized material in the equipment or structural elements of the spacecraft ("hard" magnetism). Such permanently magnetized parts easily create magnetic fields that exceed the noise level of the magnetometer.
2. There may be magnetically susceptible material in the equipment or structural elements of the spacecraft which becomes magnetized in an external magnetic field ("soft" magnetism).
3. Currents in the electric harness of the spacecraft or lander create magnetic fields.

A simple means to avoid the interferences with the magnetometer is to install the magnetometer at the end of a sufficiently long boom made of non-magnetic material. However, there are usually several other requirements, for example associated with mass limitations, which dictate constraints to such boom constructions. As mentioned above, the magnetometer of the Mars–96 Small Station would have lain at a distance of roughly one metre from the station itself during the operations at the Martian surface. During the descent phase towards Mars, when the station would have still been in a stowed configuration, the magnetometer would have been located inside the station, as depicted in Fig. 2. This is significant regarding possible distortions in planned magnetic measurements during the approach of the station to the surface of the planet.

Distortion 3 can be avoided by a careful design of the wiring and by using twisted pairs in the cables. Additionally, it may be possible to switch off at least most of the currents at the times of measuring activities of the magnetometer.

Distortion 1 (obviously) remains constant and can thus be eliminated computationally from the data provided it is measured (or calculated) before the launch of the spacecraft. Permanent magnetization may also be technically removed from the material, and the use of compensating magnets is the final possibility.

Fig. 2. Schematic picture of the Mars–96 Small Station with an opened mast and deployed petals starting scientific measurements on the Martian surface. The size of the station is roughly indicated in centimetres. The magnetometer and CEU locations are also depicted.

Distortion 2 might basically be considered insignificant at Mars because, as mentioned above, the Martian magnetic field is a very small external field. However, as also pointed out, local magnetic anomalies on the surface of Mars can have values of hundreds to thousands of nanoteslas, and then Distortion 2 may also become important. The same situation might occur during an intense Martian magnetic storm when the field may probably vary a few thousand nanoteslas from its normal value to the positive or negative direction within time periods of seconds to a day. Besides, the presence of susceptible material near permanently magnetized equipment means a more complex case, which becomes even more difficult if the susceptibility changes with time.

The Nurmijärvi Geophysical Observatory located about 40 km north of Helsinki was founded in the beginning of the 1950's (*Pajunpää*, 1990). In a way Nurmijärvi continues, after an interval of some decades, the series of geomagnetic observations performed in the city of Helsinki from the first half of the 1800's to the beginning of the 1900's when disturbances caused by electric tram traffic made the recordings impossible (*Nevanlinna et al.*, 1993; *Nevanlinna and Kataja*, 1993). The main duties of Nurmijärvi (as well as of all the about 150 geomagnetic observatories of the world) are to monitor rapid geomagnetic variations and to measure the absolute value so that the secular variation of the geomagnetic field can be followed. It may roughly be stated that the accuracy achieved is about 0.5 to 1 nT in the main field measurements at Nurmijärvi.

To improve the facilities for the testing and calibration of magnetometers regarding both ground-based and space projects, a large three-axis coil system was constructed at Nurmijärvi in the 1980's (*Häkkinen et al.*, 1990). The three perpendicular coil sets generate the (geographic) northward, eastward and vertical magnetic components. Each set is composed of four square coils following the Alldred-Scollar design in which two larger coils are located between two smaller ones. The sizes of the coils as well as their spacing somewhat vary from one magnetic component to another, but typically the length of the side of the square is about 2 m and the spacing equals 0.5 to 1 m. The purpose of the coil system is to create a uniform field in as large an area as possible. Theoretically and also verified experimentally, the field is homogeneous with the accuracy of 10^{-5} within a sphere of about 30 cm in diameter at the centre of the coil system.

The magnetic measurements of the Mars–96 Small Station engineering model equipment were made at Nurmijärvi in two stages in January–February 1994: First, only the CEU box was measured concerning both the "hard" and the "soft" magnetism, and later the "hard" magnetism of the whole station was studied. The magnetic field was observed with a one-component fluxgate magnetometer which is connected to the telescope of a non-magnetic theodolite. This kind of a device is used at magnetic observatories to measure the declination (*D*) and inclination (*I*) angles of the geomagnetic field and is therefore called a DI-fluxgate magnetometer (*Kring Lauridsen*, 1985).

For practical reasons due to the short preparation time for this pilot project in magnetic cleanliness investigations at Nurmijärvi, the measurements of the “hard” magnetism had to be made outside the coil system, i.e. in the Earth’s magnetic field. Consequently, the measured results theoretically consisted of the “hard” magnetic field and of the “soft” field due to magnetization induced in the equipment in question by the geomagnetic field. However, the geometrical arrangements of the measurements, as described below, implied that in each case the “soft” field was perpendicular to the DI-fluxgate sensor, thus not affecting the measurements.

The CEU is a rectangular box (length 160 mm, width 90 mm, height 100 mm, weight ≈ 1.3 kg) containing seven circuit boards. When measuring the "hard" magnetic field caused by the box, the DI-fluxgate sensor was kept directed perpendicular to the Earth's field (i.e. parallel to the magnetic east-west direction) in order to get the best resolution of the magnetometer. The temporal variations of the geomagnetic field during the measurement were taken into account and their effects eliminated in the processing of the data. The CEU box lay in the same horizontal plane as the magnetometer sensor, and the line between the CEU and the sensor was either parallel or perpendicular to the axis of the sensor; in the former case the "radial" field and in the latter the "tangential" field was obtained. Four different distances between the CEU and the magnetometer sensor were used: 0.3, 0.5, 1.0 and 1.5 m. Because the CEU is not symmetric, the magnetic field does not only depend on the distance but the orientation of the box affects, too. Table 1 shows the largest and the smallest radial and tangential fields found by using different orientations.

Table 1. The "hard" magnetic field created by the engineering model of the Mars–96 Small Station Central Electronics Unit. The most realistic distances in the “petals closed” and “petals opened” situations are indicated by (*) and (**), respectively. For further explanations, see the text.

	Radial [nT]		Tang. [nT]	
Dist. [m]	Large	Small	Large	Small
0.3 (*)	583	–70	–417	–1
0.5	124	–4	–82	0
1.0 (**)	16	1	–11	0
1.5	6	1	–4	0

The schematic picture shown in Fig. 2 indicates that the distance between the magnetometer and the CEU would have been in the order of 1.0 m during the operation on the Martian surface (see a comment on the accuracy of Fig. 2 in Section 3). Even then a distortion of several nanoteslas due to the CEU could have been expected, which is considerable when measuring the small field of Mars. During the descent towards the surface of the planet, the petals of the station would have been closed so the distance of the magnetometer from the CEU is shorter, only a few tens of centimetres, causing a larger distortion approximated by the “0.3 m” row of Table 1.

The "soft" magnetism of the CEU was studied using the coil system described above. The DI-fluxgate magnetometer sensor lay at the centre of the coils parallel to the geographic east-west direction. The CEU box was installed in the same horizontal plane, first east of the sensor at distances 0.3 and 0.6 m and later north of the sensor at a distance 0.3 m. According to the definitions above, the eastern and northern locations of the CEU yielded the "radial" and "tangential" fields, respectively. The external field that caused the "soft" magnetism in the CEU was 10000 nT eastwards. This value certainly represents an ultimate upper limit for Martian conditions. By making additional measurements without the external field and also without the CEU in the vicinity of the sensor, and by eliminating the effect of geomagnetic variations, the mere "soft" magnetic field due to the CEU was possible to be calculated. As in the examination of "hard" magnetism, different orientations of the CEU were studied. Similarly to Table 1, the largest and smallest "soft" fields are indicated in Table 2. These two tables show that the "soft" magnetism of the CEU may be regarded as negligible in comparison with the "hard" magnetism.

As indicated above, the "soft" magnetism of the whole station was not investigated. It was partly due to the short time available between different integration tests and environmental tests of the engineering models of the Small Station equipment, and partly due to the slightly too large a size of the station to be installed inside the coil system. The "hard" magnetism was first measured with the petals stowed simulating the descent phase to the surface of Mars, and later the petals were deployed. As in the case of the measurement of the CEU box, the DI-fluxgate magnetometer sensor was in a constant position parallel with the geomagnetic east-west direction, and the effect of geomagnetic variations was reduced from the results. The "radial" and "tangential" fields were measured again. The station was lying on a marble plate whose location and height were possible to be changed.

Table 2. The "soft" magnetic field created by the engineering model of the Mars–96 Small Station Central Electronics Unit in an external field of 10000 nT. The more realistic distance in the “petals closed” situation is indicated by (*). For further explanations, see the text.

	Radial [nT]		Tang. [nT]	
Dist. [m]	Large	Small	Large	Small
0.3 (*)	11	7	–8	–4
0.6	2	0		

In the case "petals closed" the distance between the DI-fluxgate sensor and the vertical symmetry axis of the station was equal to 0.6 m, and the height difference between the sensor and the bottom of the station was 4 or 30 cm (the sensor locating higher). The station was rotated in 10 ° intervals around the vertical axis. The largest and smallest values of the "hard" magnetic field then found are given in Table 3.

Table 3. The "hard" magnetic field created by the engineering model of the Mars–96 Small Station with the petals closed. The more realistic height is indicated by (*). For further explanations, see the text.

	Radial [nT]		Tang. [nT]	
Height [cm]	Large	Small	Large	Small
4	–84	–2	60	–1
30 (*)	148	0	45	–2

Table 3 shows the possibility of significant distortions in the magnetic data planned to be collected at Mars. Concluding from Fig. 2, the height difference 30 cm rather than 4 cm corresponds to the location of the magnetometer of the station but the DI-fluxgate sensor used in this study was naturally outside the station. Thus the distortion at the real location of the magnetometer during the descent phase is evidently larger than the values in Table 3, and it would be possible to extrapolate the exact magnitude of the distortion from a greater number of measurements, which was, however, not included in this study. It should also be noted that the search for the rotation angle that gives the largest and smallest distortion field is a little misleading because the magnetometer is at a fixed angle position in the station. Anyway, also at that particular angle and at the distance 0.6 m the "hard" magnetic field is quite large: about 90 nT and –30 nT for the radial and tangential fields at the height of 30 cm, and about 30 nT and –25 nT for the radial and tangential fields at the height of 4 cm. The fact that the “30 cm” fields clearly differ from those at 4 cm, the former being generally larger, is an indication of the complicated asymmetric structure of the magnetic field produced by the station.

The number of measurements with the petals opened was smaller with only two different rotation angles. The more interesting of them and considered now corresponded to the situation in which the DI-fluxgate sensor lay close to the location of the magnetometer of the station. The distance used was then about 1.3 m. (see the comment on the distance and Fig. 2 in Section 3.) Different values of the height (–5, 4, 17 and 30 cm) were studied, which is also realistic because the Martian surface is certainly not even and thus the exact height cannot be known in advance. The results are shown in Table 4. Distortions of several nanoteslas are seen again. A comparison of the field values shown in Table 4 with the values corresponding to the distances of 1.0 m and 1.5 m in Table 1 implies that the mere CEU box plays an important role in the "hard" magnetism of the Small Station since the field values are in an equal magnitude range (1...10 nT).

Table 4. The "hard" magnetic field created by the engineering model of the Mars–96 Small Station with the petals opened. For further explanations, see the text.

Height [cm]	Radial [nT]	Tang. [nT]
–5	2	–2
4	4	–1
17	6	–1
30	7	–1

5. *Concluding remarks*

Extensive scientific exploration of Mars will be performed as international cooperation in the next years and decades both by orbiters operating in the near-space of the planet and by stations landing on the surface. The Martian magnetic field, not yet fully known and understood, is of great interest in many respects extending from the interaction between the solar wind and planets to the internal structure and evolution of planets. Therefore magnetometers are included in the scientific instrumentation of the missions. However, without careful analyses and investigations, recordings of the magnetic field of Mars may be seriously distorted by magnetism of the spacecraft or the station itself. This can be regarded as an Electromagnetic Compatibility (EMC) problem, whose solution requires examinations and measurements on the Earth before the launch.

The Finnish Meteorological Institute (FMI) was a major contributor to the design, construction and testing of the two Small Stations launched, although unsuccessfully, in the Russian Mars–96 mission in November 1996. As a pilot project in space-related magnetic cleanliness investigations at the Nurmijärvi Geophysical Observatory of FMI, the magnetism of the Small Station equipment was measured in connection with other testing activities in Finland.

Results of the magnetic measurements concerning the Central Electronics Unit (CEU) of the Small Station and of the whole station outlined in this paper indicated the possibility of distorting magnetic fields of several nanoteslas at the planned magnetometer location at the surface of Mars. Such magnitudes are certainly of importance when observing the weak Martian magnetic field. The situation would have been even more critical during the descent phase of the Small Station towards the Martian surface, when magnetic measurements were also planned to be performed, because the stowed installation of the station makes the distance of the magnetometer from other equipment smaller thus enlarging the magnetic distortion up to several tens or even hundreds of nanoteslas.

To know the magnetism of a spacecraft thoroughly, detailed laboratory analyses of the magnetic properties of the materials included in the spacecraft should be performed. The magnetic cleanliness measurements should concern all parts separately and also together in their final configuration. The investigations presented in this paper do not fulfill these requirements. But, besides indicating the magnetism of the CEU, they anyway demonstrate the applicability of the Nurmijärvi Observatory, equipped with accurate magnetometers, good calibration facilities and a great experience in geomagnetic research, to this kind of space-related magnetic testing, which is the main result of this paper. The magnetic cleanliness measurements can be considered an important and valuable part of the work done in connection with the Mars–96 project in Finland. It should also be noted that equipment belonging to other space projects have been measured magnetically at Nurmijärvi, too.

The Mars–96 measurements carried out at the Nurmijärvi Observatory also suggested improvements to be implemented particularly regarding future magnetic cleanliness measurements. It would be useful to make the measurements with a three-component magnetometer while in the work described in this paper the sensor observed only one horizontal component in one measurement. Therefore complete three-dimensional pictures of the distorting magnetic fields were not obtained. The software processing the data should also be developed. Improvements are presently going on.

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