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Advancing Astronomy and Geophysics

Royal Astronomical Society: Written submission to the House of Commons Transport Committee call for evidence on the Galileo programme

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Introduction

The Royal Astronomical Society (RAS) has the aim, as expressed in its charter, of "the encouragement and promotion of astronomy". Those aims have been extended to embrace the study of geophysics (i.e. the physics of the Earth as a planet), and this include subjects (a) where scientific research is relevant to the development of Galileo and (b) where scientific research will be advanced by the higher quality data that Galileo will produce. Members of the Society are actively working on both of these aspects.

The following evidence consists of two parts: first an explicit response to the questions asked by the Committee, and second annexes providing concise summaries of some key science issues for Galileo.

Response to the committee's questions

Q1. What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?
R1. Galileo will bring a significant improvement in the accuracy of position measurements. The Galileo aim is to provide a routine accuracy of 1 metre. This should be compared with the 5 metre accuracy provided by EGNOS and the 20 metre accuracy provided by the basic GPS service. Improved accuracy will be a great benefit for science because it will help scientists to understand phenomena that involve small scale movements. This is important in many geophysics disciplines including geodesy, seismology and vulcanology. We also note that there is much interest in developing advanced applications of Galileo that can give accuracy at the centimetre level. These applications will be of great interest to both industry and science - but will require scientific research to improve understanding of the sources of position uncertainty and to develop ways to mitigate those sources. The potential value of Galileo to scientific research is recognised by the Galileo Joint Undertaking. It currently (September 2004) has an open call for proposals to study and promote use of Galileo by Special User Communities including Scientific Research [reference 1].
Q2. How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?
R2. Independence will intensify competition in the provision of services. This is likely to drive up quality and reliability - and drive down costs. These improvements will be of benefit to science as much as other users.
Q3. What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?
R3. This topic is outside the scope of the Society's competence.
Q4. Are the arrangements to prevent military use of Galileo sufficiently robust?
R4. This topic is outside the scope of the Society's competence.
Q5. Are arrangements to oversee the security aspects of Galileo appropriate?
R5. These arrangements must include the ability to distinguish between human threats to Galileo and disruption of the system by extreme but rare natural phenomena, e.g. severe radio scintillation events during the large magnetic storms that occur from time-to-time. The threats to the security of Galileo are very similar to the threats to the GPS system in the US, which have been subject of open study (Volpe report – reference 2).

Q6. What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?

R6. The programme will scientific research in the UK both by stimulating research to support Galileo and by providing better tools for scientific research in other areas. The first benefit is already underway:

- through funding of research by the Galileo Joint Undertaking and by EPSRC
- through DTI's establishment of a Faraday partnership (Pinpoint) to coordinate academic and industrial research on GNSS applications

The scope of UK research to support Galileo is not limited to quantifying and improving the accuracy and reliability of position data. As an important space-based application Galileo is stimulating research in broader areas of space science and technology, e.g. a better understanding of the Earth's radiation belts and their impact on spacecraft operations (the Galileo spacecraft will operate in the outer radiation belt, where our scientific understanding is limited and further research is needed). The UK community is a strong player in these areas and works closely with colleagues in other countries.

Galileo will be an important tool in many areas of scientific research. As already noted the basic position data is of great interest in many geophysics disciplines such as geodesy, seismology and vulcanology. The higher accuracy of Galileo will act as further stimulus to existing UK work in these areas. But position data are not the only Galileo output that science can exploit. The signals from Galileo can be used to monitor a range of geophysical phenomena including the density of the ionosphere, the distribution of water vapour in the lower atmosphere and the roughness of the sea surface. Thus the higher performance of Galileo will improve data quality and thus stimulate research.

In summary Galileo has great potential to stimulate scientific research both in support of Galileo development and through exploitation of the higher quality data that Galileo will produce. The UK scientific community is well-positioned to exploit this potential.

Finally we note that the scientific exploitation of Galileo data should not conflict with commercial exploitation. The industrial interest in Galileo applications lies mainly in near-real-time use of its data, so the commercial value of those data decline quickly with time. In contrast, the scientific interest lies mainly in careful analysis after the event and thus will rarely require access to high-economic value real-time data.

References

1. GALILEO Research and Development Activities, Call 2412, GNSS for Special User Community
2. Vulnerability assessment of the transportation infrastructure relying on the global positioning system, Report prepared by the John A. Volpe National Transportation Systems Center, August 2001.

Annexes – science issues for GNSS

A1. Space Weather. The radio signals from the Galileo spacecraft (as for GPS) will have to traverse the Earth's ionosphere[1] and plasmasphere[2] to reach receivers on ground and sea or in the air. This traverse affects the signals in two main ways:

- It introduces a small but variable delay in the time taken for the signal to travel the approximately 20000km from spacecraft to receiver. If not corrected, this can give an error of many metres in the measured position. Various correction schemes are already in operation, e.g. EGNOS. The Galileo system will provide a further and significant advance.
- It causes the frequency and strength of the signal to vary slightly. In severe cases, this "scintillation" can cause temporary loss of the radio signal and thus loss of position data. It is most likely to occur in polar and equatorial regions.

These effects are one aspect of "Space Weather" - namely the effect of solar activity on phenomena in near–Earth space and the consequential effects on a growing range of technologies. The study of Space Weather is proceeding at a European level through a number of ESA initiatives to promote assessment studies and develop pilot systems. UK scientists are playing an active role in these initiatives.

A2. Use of GNSS position data for science. Data from the existing GPS service is widely use as a tool in disciplines such as geodesy, seismology and vulcanology, where accurate position measurements allow scientists to monitor movements of the Earth's surface and interpret these in terms of geophysical phenomena such as earthquakes and volcanic activity. The higher accuracy of Galileo will act as further stimulus to that work. UK scientists are active in this area of science. For example:

- NERC has funded a Centre for the Observation and Modelling of Earthquakes and Tectonics (COMET - http://comet.nerc.ac.uk/) whose remit includes the exploitation of position data from the existing GPS service.
- The University of Nottingham hosts a major research group, the Institute of Engineering Surveying and Space Geodesy (IESSG - http://www.nottingham.ac.uk/iessg/) and is now working to create a new Centre for Satellite Navigation.

[1] The ionised part of the Earth's upper atmosphere at altitudes between 100 and 800 km.

[2] The plasmasphere is the tenuous extension of the ionosphere up to altitudes of 20000 km or more, but with very different physics controlling its behaviour. Although more tenuous than the ionosphere, its much greater size means it has an almost equal effect on propagation of radio signals.