e.g. Haystack, FGAN, or the combined use of FGAN with the 100 m Effelsberg radio telescope, statistical information on 1 cm size objects in Low-Earth orbit (LEO) can be gained.

With an uncontrolled growth orbital debris could become a major hazard for all human activities in space. Already now orbital debris is a potential risk in two important regions, namely at low Earth altitude, and in the geostationary ring. An indication of the degrading quality of the space environment are the first confirmed collision of an operational spacecraft (Cerise) with a rocket fragment, avoidance manoeuvres of the US Space Shuttle and of unmanned spacecraft in LEO, and the more than 60 replacements of windows of the US Space Shuttle damaged by impacts of small-size debris and meteoroids. Space debris is also degrading astronomical observations as large scale exposures of the sky may contain satellite trails.

This presentation will provide an overview of the terrestrial space debris environment. Sources for the catalogued objects and small-size space debris will be reviewed. Models for the spatial distribution will be presented. Explosions and collisions as the main debris sources will be addressed. Finally, the long-term evolution and debris reduction measures will be reviewed.

12. ENVIRONMENTAL DISTURBANCES OF ASTRONOMICAL OBSERVATIONS

J. Kovalevsky (CERGA, Observatoire de la Côte d'Azur)

This presentation is aimed at describing several effects, generally of geophysical origin, which contribute, in addition to sky glow or electromagnetic wave interferences, to degrade astronomical observations from the ground.

The efficiency of an astronomical instrument must be considered together with all the atmospheric layers crossed by the incoming light. This optically active element affects the shape of the image and the apparent direction of the observed celestial body. Astrometric measurements may be significantly biased by un-modelled spurious refraction effects. But the most important source of disturbances is the local atmospheric turbulence which is the major factor of astronomical seeing. The height of the boundary layer is function of the existence of heat sources. In day-time, it is governed by the Sun, but in night-time, the presence of buildings, roads, vegetation of various types, has a definite influence on the quality of the atmospheric images, increasing their unstability and introducing sometimes an inclination of the atmospheric layers, causing abnormal refraction.

The chemical composition of the atmosphere has evidently a direct effect on spectroscopy. This is particularly important in millimeter and submillimeter band astronomy, in the research of various interstellar or circumstellar molecules. The atmospheric emissions and opacity in this wavelength domain are major perturbations in recognizing the spectral lines of these extraterrestrial emissions. Increase in opacity may also occur after major geophysical events such as aerosols or dust from volcanos.

Optical interferometres are very sensitive to any perturbation of the optical path lengths. This can be produced by deformations of the wavefront due to turbulence, and particularly long period deformations in the higher atmospheric layers. Another cause is the variation of the baseline, consequence of seismic activity. Very significant perturbations are produced by oceanic waves which and are important even several hundreds of kilometers away. Storms on the ocean may be sources of important deterioration of interferometric observations.

Some of the atmospheric dynamical effects may be compensated using active or adaptative optics. It has however to be noted that these techniques correct the wavefront only within a few arc seconds. This is certainly the solution when a single star is being observed, but does not apply for larger field studies. It is also conceivable that is the future, interferometric baselines could be corrected in real time from seismic simultaneous readings. Millimetric and submillimetric observations can get rid of a large part of spectroscopic pollution in hight altitude sites. But most of the ground based astronomical observations will continue to be highly sensitive to these environmental perturbations.

13. THE AVOIDANCE OF MAN-MADE POLLUTION IN INTERPLANETARY SPACE

C. S. L. Keay (University of Newcastle)

At the 20th General Assembly of the International Astronomical Union in Baltimore, U.S.A., in 1988 members of Commission 22 and several Commissions in what is now the Division of Plan-

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etary Sciences expressed deep concern that no work was being undertaken to identify and avoid pollution problems in interplanetary space. Commission 22 set up small a working group with I P Williams as convenor. It identified several problems requiring further study and recommended further investigation.

At the 22nd General Assembly in The Hague in 1994 a formal Working Group on The Prevention of Interplanetary Pollution was set up with members from each of the Commissions in the Division of Planetary Sciences. Care was taken to include members from each of the international powers with a presence in space operations and research. Astronomers from Australia, China P R, the Czech Republic, France, Japan, the Russian Confederation and the United States of America. Largely through e-mail contact the convenor, C S L Keay, drew on the expertise among the nominated members to expand the earlier report.

The principal areas of concern dealt with by the Group are:

* Environmentally harmful propellant residues;
* Unconfined debris from impacting objects;
* Pollution from explosives, particularly nuclear;
* Radionuclide pollution from nuclear power generators;
* Undesirable transfers of surface materials;
* Biocontamination prevention and quarantine measures.

It was stessed that the challenge is to devise cost-effective techniques and procedures acceptable to mission planners which will prevent or at the very least minimise pollution outcomes. To achieve success a program of careful preliminary research will be necessary, paying attention to the following points in regard to all aspects of space missions:

* Identify likely sources of undesirable pollution;
* Measure present levels and predict future levels;
* Assess future impact of pollution on research goals;
* Investigate likely severity and irreversibility;
* Formulate preventative or minimisation procedures;
* Set guidelines for assessing preservation values;
* Develop means to protect sensitive environments;
* Seek ways to increase awareness of the issues.

The working Group recommended the establishment of an international scientific committee to involve all relevant agencies and draw up suitable procedures and protocols for achieving success. It should be very much less costly to be proactive in this endeavour than to allow permanent harm to sensitive regions of the interplanetary environment.

14. THE PROCESS OF FREQUENCY MANAGEMENT, INTERNATIONAL TREATIES AND THE RESPONSIBILITY OF ASTRONOMERS

J. Tarter (SETI Institute)

Working with national and international regulatory bodies to allocate the radio spectrum, and monitoring regional applications for spectrum usage are increasingly becoming the cost of doing radio astronomy. Economic incentives are enormous, with new services constantly seeking additional allocations within the radio spectrum. Radio astronomers cannot depend on the goodwill of for-profit service providers to keep portions of the spectrum free for the use of the passive services (radio astronomy and remote sensing). At present, a small number of senior scientists and managers are struggling against this tide. They should not only be praised, and thanked, but joined. It is imperative that current and future generations of radio astronomers learn the business of frequency management and participate in the distribution of this scarce resource.

15. EDUCATING THE PUBLIC ABOUT PRESERVATION OF THE ASTRONOMICAL WINDOWS

W. T. Sullivan, III (Univ. of Washington)

If astronomers are going to succeed in their efforts to keep the skies free of light pollution and radio interference, then they must deal not only with lighting and radio engineers, business concerns, and politicians, but also the general public. If the public becomes persuaded that clear, pristine skies are worth having for the same sorts of reasons that we value drinkable water and