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COMISIÓN SOBRE LA UTILIZACIÓN DEL ESPACIO
ULTRATERRESTRE CON FINES PACÍFICOS
40ª período de sesiones
Viena, 2 a 13 de junio de 1997

DISERTACIONES CIENTÍFICAS Y TÉCNICAS PRESENTADAS A LA SUBCOMISIÓN DE ASUNTOS CIENTÍFICOS Y TÉCNICOS EN SU 34º PERÍODO DE SESIONES

Informe de la Secretaría

1. Durante el 34º período de sesiones de la Subcomisión de Asuntos Científicos y Técnicos, el Comité de Investigaciones Espaciales (COSPAR) del Consejo Internacional de Uniones Científicas (CIUC) y la Federación Astronáutica Internacional (FAI) organizaron, en cooperación con Estados Miembros, un simposio sobre sistemas espaciales de transmisión directa de radiotelevisión y sistemas mundiales de información para investigaciones espaciales como complemento de las deliberaciones de la Subcomisión sobre ese tema. El simposio se organizó de conformidad con la recomendación hecha por la Subcomisión en su 33º período de sesiones (A/AC.105/637, párrafo 192) y que posteriormente hicieron suyas la Comisión sobre la Utilización del Espacio Ultraterrestre con Fines Pacíficos, en su 39º período de sesiones[1], y la Asamblea General, en su resolución 51/123 de 13 de diciembre de 1996.

2. Fue este el 13º simposio organizado por el COSPAR y la FAI durante las reuniones anuales de la Subcomisión de Asuntos Científicos y Técnicos, habiendo escogido el tema cada año la Subcomisión en su período de sesiones precedente. El simposio se celebró los días 17 y 18 de febrero de 1997, tras haber concluido el debate en las sesiones de la tarde de la Subcomisión.

3. Además de estas disertaciones especiales organizadas por el COSPAR y la FAI a petición de la Subcomisión, diversos Estados Miembros trataron, en una serie de disertaciones científicas y técnicas presentadas por especialistas en ciencias y aplicaciones espaciales, diversos temas del programa de la Subcomisión. Varias organizaciones internacionales y nacionales también hicieron disertaciones especiales sobre sus actividades científicas y técnicas.

4. Para que la información sobre las novedades más recientes de la ciencia, la tecnología y las aplicaciones espaciales presentadas durante el simposio y las demás disertaciones tengan mayor difusión, la Secretaría ha preparado un resumen de esa información, que figura a continuación.

5. En el anexo figura una descripción detallada de las disertaciones científicas y técnicas presentadas ante la Subcomisión de Asuntos Científicos y Técnicos en su 34º período de sesiones. El anexo se publica en inglés únicamente. En el apéndice del anexo se incluye una lista de las disertaciones y de los oradores.

I. SIMPOSIO SOBRE SISTEMAS ESPACIALES DE TRANSMISIÓN DIRECTA DE RADIOTELEVISIÓN Y SISTEMAS MUNDIALES DE INFORMACIÓN PARA INVESTIGACIONES ESPACIALES

6. Las funciones principales de todo medio de transmisión son proporcionar información, entretenimiento y educación. La radio fue el principal medio de transmisión durante mucho tiempo, hasta la aparición de la televisión. Pero aun hoy día, algunos usuarios todavía utilizan la radio más que cualquier otro medio para oír las noticias. La radio cumple un importante objetivo social al difundir programas educacionales, especialmente para escolares. También proporciona, a veces hasta en forma interactiva, servicios especiales como asesoramiento para agricultores, obreros industriales, las mujeres, los jóvenes y los niños.

7. El número de aparatos de radio en todo el mundo está en los millardos. Sin embargo, al igual que el teléfono y la televisión, el número de aparatos de radio por cada mil habitantes muestra una importante variación entre los Estados, en función de su situación económica (desde 1.050 en países desarrollados hasta unos 180 en países en desarrollo). Hay algunos países en que el 30 por ciento de su territorio no está cubierto por ninguna estación de radio nacional. Los sistemas de radio actuales son predominantemente analógicos, con difusión por sistemas terrestres. Los sistemas de satélite se usan principalmente para dar una distribución más amplia a los programas mediante retransmisión o para servir de cabeceras de sistemas de cable. Tomará algún tiempo hasta que los sistemas de satélites digitales pasen a predominar, dado que hay que recuperar plenamente el costo de la infraestructura existente, y que el costo de los receptores digitales será elevado durante los períodos iniciales.

8. En la India, desde hace varios años se vienen realizando transmisiones de sonido digitales por satélite. Desde la introducción del sistema nacional de satélites de la India (INSAT) en 1983, la modalidad principal para la distribución de programas de radio es a través del sistema de la red de satélites de radio (RN). La utilización mensual acumulativa del repetidor de satélite para los 28 canales RN supera las 13.000 horas. Pese a su extensa red de radio, la India, con sus variados idiomas y poblaciones, está tratando de proporcionar un número adecuado de canales de audio en todo el país.

9. El satélite GSAT-1, cuyo lanzamiento está previsto en el primer vuelo de desarrollo del Vehículo de Lanzamiento de Satélites en Órbita Geoestacionaria, de la India, tiene dos repetidores de banda S de gran potencia para proporcionar un total de 96 canales de audio. Se prevé que la disponibilidad de un número tan grande de canales revolucionará el sector de las transmisiones de radio de la India. Aparte de los canales de naturaleza general, también serán viables los canales de uso exclusivo para noticias, deportes, diferentes tipos de música, información de negocios, desarrollo de las comunicaciones y otras esferas de interés. La naturaleza digital del sistema puede proporcionar un gran número de servicios de transmisión de datos, como la difusión de notas de conferencias a estudiantes de universidades abiertas, la distribución electrónica de periódicos, la información de agencias de servicios públicos o la descarga de grandes volúmenes de datos de la Internet.

10. El crecimiento exponencial sin precedentes de la Internet, cuyo tamaño se duplica cada año, ha creado una demanda igualmente creciente de servicios de transmisión y audiovisuales. Dado que las aplicaciones integradas de computadora, de video y sonoras exigen más anchura de banda, será preciso mejorar sustancialmente la infraestructura terrestre: redes de fibra óptica, red digital de servicios integrados, técnicas de modulación avanzadas, compresión y otras. Esto también es necesario para lograr una combinación óptima con los sistemas de satélite que están apareciendo, que son complementarios de los sistemas terrestres y fundamentales para la rápida expansión mundial de los servicios. Joanneum Research y la Universidad de Salzburgo (Austria) están desarrollando, en virtud de un contrato de la Agencia Espacial Europea (ESA), un sistema experimental de interconexión de LAN por satélite,

que podrá abarcar hasta 64 estaciones activas en una red con una tasa máxima por usuario de 2 megabitios por segundo.

11. Los sistemas de transmisión directa de radiotelevisión (TDRT) pueden reducir significativamente el costo de trasmitir programas de televisión a los suscriptores, particularmente en áreas extensas con densidades de población bajas, que son típicas de la Federación de Rusia. Las terminales pequeñas conectadas a satélites TDRT en órbita geoestacionaria son fáciles de usar y ofrecen más canáles de alta calidad que los sistemas terrestres. La Federación de Rusia lanzó el primer satélite del sistema GALS en 1994 y el segundo en 1995. Un nuevo satélite que se está desarrollando para 1998-2000, el GALS-R 16, tendrán 16 haces de transmisión en la banda de 18/12 gigahercios. Está previsto para cubrir principalmente las regiones europeas del país, y su vida activa se aumentará a 7 a 10 años. Se pueden distribuir hasta 4 programas de televisión analógicos y 32 digitales a cada receptor con antena de 50 a 90 centímetros de diámetro.

12. En el Japón hay una empresa comercial en preparación que proporcionará transmisiones radiotelevisivas digitales de prueba y servicios TDRT digitales ordinarios con casi 100 canales. Asimismo, muchas empresas de Europa, Asia y América del Sur están proporcionando o preparando servicios TDRT digitales. El primer satélite Koreasat fue lanzado a una órbita geoestacionaria en una longitud de 116º este en agosto de 1995 y el segundo en enero de 1996. Cada Koreasat tiene tres repetidores TDRT de 27 megahercios y 120 vatios, y haces de transmisión concentrados a una frecuencia de 12 gigahercios. Por lo tanto, en el territorio de la República de Corea se puede recibir una señal de televisión de alta calidad con un disco de sólo 40 centímetros, y en muchos países vecinos, donde viven muchos coreanos, basta con una antena de un metro. El sistema puede sostener un futuro servicio de transmisión de datos de hasta 2 megabitios por segundo. Esto permitirá ofrecer servicios como los de compras desde el hogar, educación a distancia, distribución electrónica de periódicos, fotos, programas de juegos y Karaoke. Asimismo, se está desarrollando un sistema de televisión de alta definición (TVAD) que entrará en servicio a prueba en 1999 y que se utilizará en la Copa del Mundo del 2002.

13. Los objetivos de la Misión al Planeta Tierra (Mission to Planet Earth-MTPE) de los Estados Unidos de América son ampliar los conocimientos científicos sobre el sistema de la Tierra, difundir información y facilitar el uso productivo de la ciencia y la tecnología MTPE en el sector privado, por lo que la creación de redes y los sistemas de archivos de datos son una parte inseparable de esa empresa. Unos 10.000 usuarios científicos y 100.000 no científicos buscarán datos obtenidos por una armada de satélites internacionales y nacionales, plataformas *in situ* y muchos proveedores comerciales. Además del sistema principal de información y datos de observación de la Tierra, la MTPE utilizará diferentes redes y archivos para distribuir y archivar todos los datos pertinentes. Por ejemplo, en virtud de una iniciativa conjunta del Japón y los Estados Unidos se establecerá una red mundial de información de observaciones para fortalecer la cooperación bilateral en materia de redes de información para la observación de la Tierra.

14. Los objetivos de las investigaciones del Programa Internacional de la Geosfera y la Biosfera (PIGB) son proporcionar una base para determinar cómo funciona el sistema Tierra y desarrollar capacidades prácticas de pronóstico para aplicar respuestas de política eficaces. La explotación de nuevas oportunidades para reunir datos a escala mundial se efectuará por conducto del sistema de información y datos PIGB (IGBP-DIS). El IGBP-DIS no es un sistema convencional de información y no ofrece grandes conjuntos de datos o servicios de computadora. Su función consiste en identificar deficiencias clave de los datos mundiales para las investigaciones sobre cambios mundiales e identificar a los organismos nacionales e internacionales que estén dispuestos a aplicar respuestas correctivas. Debido a su naturaleza mundial, las observaciones espaciales constituyen un centro de interés importante del IGBP-DIS.

15. La participación activa y las contribuciones de los países en desarrollo al estudio sobre los cambios mundiales es crucial. En primer lugar, los países en desarrollo están causando cambios ambientales significativos. El tamaño de sus poblaciones tiene un impacto sobre el medio ambiente debido a la deforestación, la erosión del suelo causada por la actividad humana, la agricultura rural y otros factores. Sus economías se basan principalmente en los recursos

naturales, y sus estrategias de desarrollo económico suelen partir del supuesto de un crecimiento rápido y una productividad baja. El resultado es que los países en desarrollo hacen frente a serios problemas ambientales mundiales como una reducción de la cubierta vegetal, la degradación de la tierra, los desastres naturales y la contaminación. Por lo tanto, deben participar en programas relativos a los cambios mundiales como cuestión de interés nacional y deben también aportar su contribución a la comunidad internacional.

16. China ha aportado contribuciones sustantivas a los estudios sobre los cambios mundiales. El Comité Nacional Chino sobre el Clima fue fundado en 1987 y el Comité Nacional Chino para el PIGB en 1988. Varias instituciones nacionales realizan investigaciones ambientales. Entre los proyectos de investigación en marcha figuran: estudios de predicción de tendencias en el medio ambiente vital de China en los próximos 20 a 50 años; procesos dinámicos y predicción de tendencias de los cambios ambientales en las regiones áridas y semiáridas de China; investigaciones sobre cambios ambientales mundiales en la Antártida; el experimento de campo en la cuenca del río Heihe, relativo a la interacción entre la atmósfera y la superficie de la tierra; experimentos sobre la circulación de los océanos en el Pacífico occidental tropical; y estudios sobre la formación, la evolución y los cambios ambientales del ecosistema de la altiplanicie Qinghai-Tibetana.

17. La World Wide Web se ha utilizado hasta ahora para distribuir información y datos (texto, video y sonido), y se está comenzando a utilizarla también para distribuir programas de computadora y capacidad de cómputo. El lenguaje de programación Java ofrece ahora la posibilidad de vincular programas independientes a las páginas de la Web. Los programas se usan luego en la máquina cliente, utilizando el sistema de lectura de la Web para descargar el servidor. Esto elimina todos los problemas relacionados con la distribución de programas a sitios remotos y su mantenimiento en esos sitios. La Instalación Europea de Coordinación del Telescopio Espacial Hubble comenzó a utilizar el lenguaje de programación Java en forma experimental para dar a la Web más utilidad y eficacia para la astronomía. Un objetivo a largo plazo es delegar a la máquina cliente en el sitio del usuario tareas como la calibración de datos.

18. Tras las estaciones de trabajo personales, el paso siguiente parece ser la red de estaciones de investigación. Estas estaciones consisten en un procesador local potente conectado (a través de redes de anchura de banda alta) a otras máquinas y a bases de datos y de conocimientos. Tiene una interfaz configurable y personalizada que permite el acceso a todos los servicios y funciones de manera coherente y eficaz. Se hace hincapié en la visualización y la conceptualización (creación de modelos). Esto se puede hacer mediante pantallas múltiples, proyecciones en pantalla grande (simulador de vuelo), o grabadores de video.

II. OTRAS DISERTACIONES CIENTÍFICAS Y TÉCNICAS

A. Desechos espaciales

19. El Centre national d'études spatiales (CNES) de Francia, continuó sus observaciones experimentales de los desechos espaciales utilizando el telescopio Schmidt de 1,5 metros del Observatoire de la Côte d'Azur, que es capaz de detectar desechos de 20 centímetros en la órbita geoestacionaria. En 1996 se realizó el primer estudio utilizando películas fotográficas y un escáner, y en 1997 se ensayó una cámara con un dispositivo de acoplamiento por carga (CCD). También se han hecho observaciones ópticas de objetos geoestacionarios en el Laboratorio de Investigación de Comunicaciones del Japón, utilizando el telescopio de 1,5 metros de diámetro con una cámara CCD en Koganei, Tokio.

20. Varios grupos de estudio japoneses realizaron análisis posvuelo de la Unidad Volante Espacial (SFU), que fue recuperada por el transbordador espacial de los Estados Unidos después de estar 10 meses en órbita. En total, se dispuso de unos 20 metros cuadrados de superficies expuestas de la SFU. En estudios visuales se había observado un total de 337 impactos con diámetros mayores de unos 200 micrómetros, y unos 180 impactos en estudios de alta

definición de superficies seleccionadas. El diámetro de daño máximo es de unos 13,4 milímetros, con un cráter de impacto de 2,5 milímetros de diámetro.

21. En el Organismo de Investigaciones para la Evaluación de la Defensa, del Reino Unido de Gran Bretaña e Irlanda del Norte, el Programa integrado de seguimiento de la evolución de los desechos combina la construcción de modelos deterministas de las partículas de más de 10 centímetros de diámetro con modelos estocásticos de las partículas de menos de 10 centímetros. La Universidad de Pisa, en Italia, está desarrollando, en virtud de un contrato de la ESA un mecanismo semideterminístico para el análisis a largo plazo de la población de desechos. El modelo Nazarenko, desarrollado en la Federación de Rusia, proporciona distribuciones de velocidad y densidad espaciales, sobre la base del catálogo de datos de la Federación de Rusia y los Estados Unidos. En el CNES se hace especial hincapié en el impacto de desechos sobre materiales frágiles (vidrio, silicio), que pueden producir una gran cantidad de pequeñas partículas (impacto secundario). La masa de las partículas secundarias puede llegar a 1000 veces la masa de las partículas primarias.

22. En Alemania, la preparación de modelos de desechos espaciales está financiada por el Ministerio de Investigaciones y Tecnología y por la Agencia Espacial Alemana. La labor está a cargo del Instituto de Mecánica de Vuelo y Tecnología de los Vuelos Espaciales de la Universidad Técnica de Branschweig (TUBS); IFR ha desarrollado el modelo de referencia de los desechos espaciales (MASTER) en virtud de un contrato del Centro Europeo de Operaciones Espaciales de Darmstadt. Ese modelo abarca los desechos artificiales y los meteoroides naturales (el modelo de distribución de los meteoroides fue preparado por el Instituto Max Planck de Heidelberg (Alemania)).

23. Desde 1990, la cooperación patrocinada por los gobiernos entre TUBS y el Centro Espacial Johnson de la Administración Nacional de Aeronáutica y del Espacio (NASA) ha facilitado provechosas discusiones sobre enfoques a la preparación de modelos y los resultados obtenidos por ambas partes utilizando sus propios instrumentos. El modelo CHAIN, desarrollado inicialmente en 1993 en la TUBS, ha sido mantenido y mejorado en el Centro Espacial Johnson, y la extensión europea de CHAIN (CHAINEE) se ha preparado también en la TUBS. Los códigos se pueden utilizar para identificar tendencias relativas asociadas a políticas de mitigación específicas, y más tarde se pueden realizar evaluaciones de mayor fidelidad utilizando el modelo EVOLVE.

24. El programa de desechos orbitales de los Estados Unidos está concebido para garantizar la seguridad de los vuelos espaciales tripulados, proteger el patrimonio nacional y las inversiones espaciales de los desechos orbitales y, por último, asegurar la protección a largo plazo del medio ambiente espacial. El modelo técnico de desechos orbitales (ORDEM) se utiliza para calcular los peligros planteados por los desechos orbitales actuales y a corto plazo a la misiones en órbita terrestre baja. Con respecto a los vuelos de transbordadores tripulados y a una futura Estación Espacial Internacional, los Estados Unidas han iniciado un programa especial de evaluación previa al vuelo del riesgo de los desechos orbitales y los meteoroides, y de evaluación de los daños posvuelo. Mediante un código de computadora BUMPER se puede determinar la probabilidad de daños de niveles específicos causados por impactos de desechos, utilizando especificaciones pertinentes de insumos y productos.

25. Las naciones con programas espaciales deben desarrollar y aplicar medidas para limitar la generación de desechos espaciales. La Agencia Nacional Japonesa de Desarrollo Espacial (NASDA) estableció el 28 de marzo de 1996 la norma NASDA-STD-18 de mitigación de los desechos espaciales. La norma de la NASDA incluye las siguientes medidas de mitigación: pasivación de la nave espacial y de las etapas superiores al final de la misión; la reinserción en órbita de la nave espacial y de las etapas superiores al final de la misión; eliminación de objetos en órbita geoestacionaria de transferencia a fin de no crear riesgos para la órbita geoestacionaria; reducción al mínimo de la liberación de desechos durante las operaciones normales; y eliminación posterior a la misión de la nave espacial en órbita terrestre baja.

26. En todos los lanzamientos del CNES se aplican estrictas medidas de mitigación. El requisito básico es no dejar más de una pieza de desecho pasivada en órbita por carga útil. Esto significa la etapa superior del lanzador en el

caso de lanzamiento único, y la etapa superior con la estructura de conexión en el caso de un lanzamiento doble. La separación de la carga útil de la última etapa del lanzador Ariane 4 no debe generar ningún otro desecho (la separación pirotécnica debe ser limpia, y se deben recoger los restos de los bulones). El uso normal de la etapa superior no debe generar otros desechos; se evitan, por lo tanto, los propulsantes sólidos en órbita y el agotamiento de la vida de baterías y células no debe dar lugar a explosiones. A fin de pasivar la etapa superior se añaden válvulas pirotécnicas para vaciar los tanques y reducir las presiones internas.

27. En 1993 se estableció formalmente un Comité Interinstitucional de Coordinación sobre Desechos Espaciales (CICDE) para intercambiar información sobre las actividades de investigación de los desechos espaciales entre las agencias espaciales miembros; examinar los progresos de las actividades de cooperación en marcha; facilitar las oportunidades de cooperación en las investigaciones sobre desechos espaciales; y determinar las opciones de mitigación de desechos. Los miembros fundadores fueron la ESA, el Japón, la NASA y la Agencia Espacial Rusa. En 1995 China se asoció al CICDE y en 1996 lo hicieron la Agencia Espacial Británica, el CNES y la Organización India de Investigaciones Espaciales. Las reuniones oficiales del CICDE se realizan una vez al año. Todos los acuerdos del CICDE se adoptan por consenso.

28. En la Federación de Rusia, las consecuencias de una colisión entre fuentes de energía nuclear (FEN) abandonadas y desechos espaciales durante su prolongada permanencia en órbita son el tema principal de las investigaciones sobre contaminación radiactiva, química y ambiental del espacio ultraterrestre. Las posibles consecuencias de una colisión entre desechos y un reactor lanzado al espacio y colocado en una órbita suficientemente alta son: destrucción de reflector radiador del reactor (berilio); destrucción del blindaje contra las radiaciones (hidruro de litio); destrucción del circuito de metal líquido y posible escape de refrigerante (sodio-potasio); y destrucción de los componentes estructurales de la FEN, con la consiguiente fragmentación de materiales estructurales.

B. Utilización de fuentes de energía nuclear en el espacio ultraterrestre

29. Con el objeto de mantener condiciones térmicas especificadas y abastecer de energía eléctrica a pequeñas estaciones autónomas del proyecto Mars 96, se desarrollaron generadores termoeléctricos de radionucléidos especiales (GTR) y unidades térmicas de radionucléidos (UTR) basadas en el plutonio 238. Las unidades térmicas son universales (cada una con una potencia calórica de unos 8,5 vatios), por lo que también se utilizan como fuente primaria de calor del conmutador termoeléctrico de los GTR. Esto permitió simplificar el diseño de seguridad de ambos tipos de unidades, dado que las cápsulas con plutonio 238 son idénticas. El diseño y desarrollo de las unidades se realizó en consonancia con los Principios pertinentes a la utilización de fuentes de energía nuclear en el espacio ultraterrestre, adoptados por la Asamblea General en su resolución 47/68, y también en consonancia con las normas nacionales de seguridad de la Federación de Rusia

30. La sonda espacial Mars 96 contenía 18 UTR con una masa total de dióxido de plutonio de no más de 300 gramos (270 gramos de plutonio 238) y una actividad total de unos 4.700 curios. En cada una de las dos pequeñas estaciones científicas había dos GTR (cada uno contenía una única UTR) y dos UTR para calefacción. Asimismo, cada uno de los dos penetradores Mars contenía una GTR (alimentada por dos UTR) y tres UTR para fines de calefacción. La energía eléctrica para la nave espacial principal debía haber provenido de paneles de baterías solares convencionales.

31. Las cápsulas con material radiactivo están especialmente protegidas para resistir a una explosión y a la combustión del propulsante del vehículo espacial Protón con temperaturas de llama de hasta 3.600 grados kelvin durante 4.000 segundos; el reingreso de la nave espacial a la atmósfera, con velocidades espaciales primera y segunda (hasta 11 kilómetros por segundo); y el impacto con la superficie de la Tierra (incluidos el cemento y las rocas) a velocidades de hasta 80 metros por segundo. Además, las cápsulas de dióxido de plutonio (cerametales) no son solubles en agua dulce ni en agua de mar (hasta una profundidad de 10 kilómetros), ni en medios básicos o

ácidos. La imposibilidad de escapes de las cápsulas se había confirmado en pruebas en la superficie utilizando modelos y cápsulas reales realizadas por una comisión de expertos insterinstitucional.

32. El lanzamiento de la sonda espacial Mars 96, con equipo científico internacional a bordo para la exploración a fondo de Marte tuvo lugar el 16 de noviembre de 1996 a las 20.49 Hora Universal, desde el cosmódromo de Baikonur. Los motores del lanzador Protón funcionaron correctamente, pero si bien el primer encendido de la unidad especial de aceleración se produjo con arreglo a lo previsto, el segundo falló y la sonda Mars 96 permaneció en una órbita terrestre baja. Los sistemas automáticos de la nave espacial realizaron la separación de la unidad de aceleración y el encendido de su propio motor, pero esto no fue suficiente para lograr un incremento sustancial de la órbita. La unidad de aceleración, que fue rastreada con precisión en su órbita baja, se desintegró el 18 de noviembre de 1996 a la 1.20 Hora Universal sobre el océano Pacífico, varios miles de kilómetros al este de Australia (unos 51º sur y 168º oeste).

33. El rastreo de la sonda Mars 96 no fue continuado, y el lugar de su desintegración fue mucho más difícil de determinar. Tras un cuidadoso análisis de toda la información disponible, se pudo confirmar que la sonda, incluidas las cápsulas con los radioisótopos, había ingresado en la atmósfera el 17 de noviembre de 1996 aproximadamente a la 1.00 Hora Universal, al final de su tercera circunvalación de la Tierra. La probable zona de caída se situó en el océano Pacífico, de 800 a 200 kilómetros a lo largo de la órbita, al oeste de la costa de Chile. Su centro se situó en 25,1º sur y 75,4º oeste.

34. Tras la destrucción aerodinámica de la nave espacial Mars 96 y de los componentes estructurales de acero y aluminio de los GTR durante el reingreso a la atmósfera, las cápsulas de dióxido de plutonio cayeron dentro de la zona de caída de los fragmentos, en forma prácticamente inalterada. Dado que no hubo liberación de dióxido de plutonio en el medio ambiente, se desechó toda posibilidad de contaminación radiactiva o efectos radiológicos para la población. El depósito de la UTR en el fondo del océano Pacífico a considerable profundidad puede considerarse como una eliminación ecológicamente segura de una cantidad relativamente pequeña de plutonio 238.

C. La teleobservación y el medio ambiente mundial

35. El Comité de Satélites de Observación de la Tierra (CEOS) se encuentra abocado enérgicamente al desarrollo de la Estrategia Integrada de Observación Mundial, a fin de aprovechar con más eficacia las inversiones en esta esfera y satisfacer la demanda mundial de un conjunto complejo de instrumentos para reunir y distribuir datos pertinentes y crear y distribuir productos de datos. No parece que los sistemas existentes satisfagan la demanda. Las necesidades de los usuarios se podrían satisfacer mejor mediante una mejor coordinación y cooperación entre organismos. Se debe desarrollar una estrategia para integrar la planificación entre organismos con miras al desarrollo de sistemas basados en el espacio más eficaces en función de su costo, la intercalibración, la compatibilidad de los sistemas de suministro de datos y el establecimiento de mejores lazos entre los usuarios y los proveedores. Hay que diseñar los servicios de suministro para satisfacer las necesidades sociales, económicas y ambientales de los usuarios. Los países en desarrollo están reconocidos como proveedores y como usuarios de datos.

36. Marruecos estableció en 1989 el Real Centro de Teleobservación (RCT), lo que significó un importante avance en la producción de información espacial. El RCT tiene a su cargo, entre otras diferentes tareas relacionadas con el espacio, la distribución de imágenes obtenidas con satélites y la centralización de los registros nacionales de datos de satélites y datos de proyectos que utilizan sistemas espaciales de teleobservación e información geográfica. Hay varios proyectos en marcha o en preparación que utilizan esas técnicas para responder a las necesidades de Marruecos en materia de inventario y ordenación de los recursos naturales, protección ambiental y aprovechamiento de la tierra. El RCT también está organizando el desarrollo del primer microsatélite nacional experimental, con una carga útil de equipo de teleobservación y transmisión de mensajes. La labor está a cargo de la Universidad Técnica de Berlín, que proporcionará una plataforma TUBSAT-C para el proyecto. Se prevé que la instalación de los sistemas componentes está terminada en 1997.

D. Medicina espacial y ciencia de los materiales

37. Los notables avances en la cristalización de proteínas en microgravedad logrados en los últimos años han aumentado la esperanza de que se puedan desarrollar drogas para curar la enfermedad de Chagas, una infección endémica de la mayoría de las zonas rurales de América Central y del Sur. Desde 1984, en varias misiones del transbordador espacial de la NASA se vienen realizando experimentos de cristalización y se ha desarrollado el equipo necesario. En febrero de 1996, durante la misión STS-75 del transbordador espacial Columbia, se realizó el primer experimento médico diseñado por investigadores latinoamericanos. Durante 16 días se cultivaron cristales de una enzima específica asociada al parásito que transmite la enfermedad. Sobre la base de los resultados logrados, en abril de 1997 se prepararon nuevos experimentos para la misión STS-83. Los científicos participantes de la Argentina, el Brasil, Chile, Costa Rica, los Estados Unidos, México y Uruguay tienen la esperanza de que el diseño racional de drogas resultará en el desarrollo de un nuevo medicamento contra esta enfermedad silenciosa pero fatal.

E. La astronomía y la ciencia planetaria

38. El Instituto Japonés de Ciencias Aeronáuticas y Espaciales lanzó con éxito el satélite de interferometría de base muy larga MUSES-B (que una vez en órbita fue rebautizado con el nombre de HALCA, Laboratorio muy Avanzado de Comunicaciones y Astronomía); para el lanzamiento, que tuvo lugar el 12 de febrero de 1997, se utilizó el nuevo vehículo de lanzamiento M-V. Con el advenimiento del nuevo lanzador, la ciencia espacial japonesa entró en una nueva era en la que se podrán realizar proyectos más ambiciosos, incluida la exploración planetaria y de la Luna. Ya se ha aprobado el lanzamiento de otras cinco naves espaciales con el M-V: el LUNAR-A para la misión de penetración de la Luna (ejercicio económico de 1997); el PLANET-B a Marte (ejercicio económico de 1998); el ASTRO-E para un satélite astronómico de rayos X (ejercicio económico de 1999); el MUSES-C para obtener muestras de asteroides (ejercicio económico de 2001) y ASTRO-F para astronomía de rayos infrarrojos (ejercicio económico de 2002).

39. La primera misión de la ESA para un estudio *in situ* del entorno del núcleo de un cometa y su evolución en el sistema solar interior se denomina Rosetta. Este proyecto tiene por objeto realizar una exploración detallada del núcleo de un cometa y su entorno inmediato, y proporcionar capacidades únicas de análisis de muestras, satisfaciendo de esta forma en gran medida los objetivos de la misión original de recolectar muestras del núcleo de un cometa. La carga útil científica del vehículo orbital Rosetta fue seleccionada y aprobada por el Comité del Programa Científico de la ESA en su reunión de febrero de 1996. La carga útil del vehículo orbital comprende 11 investigaciones. Austria es responsable del experimento del sistema de análisis de polvo por microimágenes (MIDAS), en cooperación con investigadores de otros seis Estados. El instrumento MIDAS se considera esencial para la misión Rosetta dado que, por primera vez, permitirá obtener imágenes tridimensionales de partículas de polvo en la gama de nanómetros a micrómetros.

40. Ya está claro que las naves espaciales operacionales y gastadas, así como las piezas más grandes de los desechos espaciales identificables, son los elementos principales que permiten seguir el paso de un objeto a través del campo visual de un telescopio astronómico, que se registra tanto fotográficamente (durante los estudios del espacio profundo) como fotométricamente. La calidad de las placas del espacio profundo se degrada, las observaciones fotométricas se pierden y está siempre presente el peligro de que se dañen detectores sensibles. En junio de 1996, el Laboratorio de Investigaciones Navales de los Estados Unidos lanzó el satélite experimental doble TIPS, cuyos dos componentes están conectados por una atadura de cuatro kilómetros de largo. Con esas dimensiones, el satélite TIPS puede producir una traza en lugar de un rastro, traza comparable en tamaño al campo visual de un CCD que los astrónomos profesionales y aficionados pueden obtener en el comercio.

41. En 1996 se anunció que la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura se estaba apartando del concepto de la “Estrella de la Tolerancia” para celebrar sus cincuenta años de existencia. Este sistema supuestamente consistiría en dos globos reflectores unidos por una atadura de dos kilómetros de largo en una órbita a 1.250 kilómetros de altitud. Al igual que TIPS, hubiera sido visible al atardecer, pero tenía el potencial

para ser visible en el cielo oscuro y con un brillo similar al de Sirius. Lamentablemente, el concepto quizá se reactive como un proyecto del milenio. El lanzamiento de este proyecto enviaría un mensaje desastroso, es decir, que la publicidad en el espacio se considera aceptable. La firme posición adoptada por la ESA contra el proyecto fue sumamente apreciada por toda la comunidad astronómica.

Notas

[1]Documentos oficiales de la Asamblea General, Quincuagésimo primer período de sesiones, Suplemento Nº 20 (A/51/20), párr. 115.

*Anexo**

SCIENTIFIC AND TECHNICAL PRESENTATIONS TO THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE AT ITS THIRTY-THIRD SESSION

CONTENTS

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*This annex has not been formally edited.

I. SYMPOSIUM ON SPACE SYSTEMS FOR DIRECT BROADCASTING AND GLOBAL INFORMATION SYSTEMS FOR SPACE RESEARCH

A. Satellite Radio and Digital Audio Broadcasting

The primary functions of any broadcast medium are to provide information, entertainment and education. Radio was the primary mode of news broadcast for a long time until the advent of television. But even today some users still rely more on radio news than any other medium. The popularity of some radio channels is linked to their easy accessibility and the quality of their news coverage. In developing countries, radio is the major source of information for large segments of the illiterate, and it caters to communication needs in development, with broadcasts targeted for rural audiences on agricultural practices, agro-products, animal husbandry, health, hygiene and the like. Radio also fulfills a very important social objective of broadcasting educational programmes, especially for school children. The distance education system, which began in the ’60s, has adopted a multi-media approach to reach students. Radio also provides, sometimes even in an interactive way, special services such as counselling to farmers, industrial workers, women, youth and children.

Worldwide, the number of radio sets runs into the billions. But as with other elements of the communications infrastructure like the telephone and the television, the number of radio sets per thousand population shows significant variations between countries, depending on their economic status (from 1,050 in developed countries to around 180 in the developing ones). There are certain countries where 30 percent of the territory is not covered by any domestic radio station. The present day radio systems are predominantly analogue and broadcast by terrestrial systems. Satellite systems are used mostly for wider programme distribution by rebroadcasting or to serve the cable head-ends. It will take some time before digital satellite systems take over because the costs of the existing infrastructure have to be fully recovered and the cost of digital receivers will be high during the initial periods.

Advances in compression techniques and digital signal processing chips have enabled the introduction of compressed audio at bit rates significantly lower than uncompressed audio without decreasing the quality. Two distinct approaches related to digital sound broadcasting (DSB) coding and modulation methods have emerged. The Eureka 147 (ITU-R SYSTEM A) digital audio broadcast (DAB) system consists of analogue to digital conversion, compression through source coding, convolutional coding, data multiplexing, and time and frequency interleaving with differential modulation of a number of carriers. The main advantage of this system is that it is largely immune to multipath propagation effects because different carriers constructively enhance each other.

The second system, called IN-BAND (ITU-R SYSTEM B) digital audio radio (DAR) system and developed in the United States, is required to operate simultaneously with terrestrial frequency and amplitude modulated systems in the frequency channels allocated to the latter (this is why it is called "in-band"). The DAR services conform to the prevailing regulations on interference and power spectral density. Some of these systems use new source coding and bit reduction techniques, forward error correction, time and frequency interleaving and shaped guard band pulses. An auxiliary data channel is also provided. SYSTEM B is a single-channel-per-carrier system which can operate over a wide range of data rates. It allows a service provider to use only as much transmitter power and bandwidth as necessary for the selected service quality.

The world’s first operational terrestrial DAB was introduced in September 1995 and currently more than 25 pilot service trials and field tests at VHF and in L-band are being introduced in 13 European countries, with plans to begin pre-operational terrestrial services this year. Outside Europe, tests are being conducted in Australia, Canada, China, India, Mexico and the United States of America. It is expected that by 1998, when the initial DAB systems are established, about 100 million people will be covered in Europe using hardware from different manufacturers at hopefully affordable prices.

Satellite sound broadcasting (SSB) has been the subject of discussion over the past twenty years and has been viewed as the potential candidate for reaching the vast majority of people not adequately covered by either good quality audio or an adequate number of channels. A number of studies and experiments have been conducted, especially in Canada, France, Germany, Japan, United Kingdom of Great Britain and Northern Ireland and United States. In the early ’80s, the emphasis was on the use of analogue frequency modulation (FM), which required large-powered satellites or large on-board antennas to provide an adequate number of channels. During the ’90s, the emphasis shifted to digital techniques that did not demand as much power or antenna areas.

A logical extension of the terrestrial Eureka 147 system would be to consider the same scheme for satellite systems as well. Substantial space segment resources are required for the implementation of satellite DAB (S-DAB). To provide a sufficiently-high ground elevation angle in Europe, the proposed Archimedes system is considering an eight-hour highly elliptic orbit (inclination 63 degrees, altitude 26,800 to 1,000 km) instead of the geostationary orbit (GSO). The L-band satellite trials were conducted in Mexico in 1995 using the Solidaridad satellite in GSO and a number of technical parameters were established for fixed and mobile reception. Similarly, satellite trials using Eureka 147 DAB were carried out in Australia via the Optus-B satellite in 1995.

Digital Sound Broadcasting System B provides digital sound and ancillary digital data broadcasting for reception by indoor/outdoor fixed and portable receivers and also by mobile receivers. It is designed for either satellite or terrestrial emission. Several audio compression schemes have been demonstrated via the TDRS satellite in the 2.1 GHz band. The implementation of a variant of the Digital System B is being carried out by World Space Inc. of the United States. The proposed AfriStar (to cover Africa) is planned for launch in 1998, followed by AsiaStar (to cover some regions in Asia) and CaribStar (for the Caribbean, Central America and South America). Each satellite can support, through three emission beams, 288 audio channels at 16 KB/s. The target is to provide audio channels of acceptable quality to fixed and portable receivers for those segments of population not adequately covered by the present system.

In India, studies on satellite digital sound broadcasting have been going on over the past few years. Since the inception of the INSAT system in 1983, the primary mode for radio programme distribution is via the satellite radio networking (RN) system. The cumulative monthly satellite transponder utilization for the 28 RN channels exceed 13,000 hours. In spite of its extensive radio network, India, with its varied population and languages, is looking towards ways of providing an adequate number of audio channels across the country. The GSAT-1 satellite scheduled for launch on the first development flight of India’s Geostationary Satellite Launch Vehicle (GSLV) carries two high-powered S-band transponders so that it can provide a total of 96 audio channels. The availability of such a large number of channels is expected to revolutionize the radio broadcasting scenario in India. Apart from channels of general nature, dedicated channels for news, sports, different types of music, business information, development communications and others are also feasible. The digital nature of the system could provide a host of data broadcast services, such as dissemination of lecture notes to students of Open Universities, distribution of electronic newspapers, information by utility agencies or downloading large volumes of Internet data.

B. Satellite Multimedia and Broadcasting Services

The unprecedented exponential growth of the Internet, where the network size doubles every year, also created a similarly increasing demand for multimedia and broadcasting services. In Europe, there are over 22 million analogue television receivers, with 10 million digital receivers expected in the next three years. In the United States, 2.5 million digital receivers already exist and estimates for the end of the decade project 20 million units. Because integrated video, voice and computer applications demand more bandwidth, the terrestrial infrastructure—optical fibre networks, Integrated Service Digital Network (ISDN), advanced modulation techniques, compression and others—should substantially improve. This is also necessary for an optimal combination with emerging satellite systems, which are complementary to terrestrial systems and fundamental for the rapid global expansion of services.

For multimedia services, the use of the Ka-band (33 to 36 GHz) of the radio spectrum is steadily increasing. Since the United States’ initial application for use of the Ka-band in 1995, EUTELSAT has applied for 12 orbital positions in this frequency region and ASTRA for 10 positions over Europe and 11 over the American and

Asia/Pacific regions. Most of the Ka-band satellite systems utilize inter-satellite links and the typical subscriber terminal has a 60-70 cm diameter dish antenna. Typical data rates are 16 to 384 KB/s, but with larger dishes, rates up to 155 Mbps are possible. Since the protocols for data transmission on the Internet were designed for terrestrial networks, the introduction of GSO satellites with longer time delays and possibilities of errors during the signal fading will force their adaptation to these new conditions. This will enable efficient exploitation of the broadcast capacities of satellite systems, such as multi-casting web-based information (newspapers, magazines, stock exchange information), updating corporate databases, multi-casting e-mail or newsletters from head offices to branches, and distribution of new software. An experimental LAN Interconnection Satellite System (LISSY) is being developed by Joanneum Research and the University of Salzburg (Austria) under an ESA contract. It can accommodate up to 64 active stations in a network with a maximum user rate of 2,048 KB/s.

C. Direct Satellite Television Broadcasting in the Russian Federation

Direct Broadcasting Systems (DBS) can significantly decrease the expense of delivering television programmes to the subscriber, particularly in large areas with low population densities, which is typical of the Russian Federation. Small terminals in connection with DBS satellites in GSO are easy to use and offer more high-quality channels than terrestrial systems. The first satellite of the GALS system was launched by the Russian Federation in 1994 and the second in 1995. They have an expected operation lifetime of five to seven years and carry up to three transponders transmitting in the 11.7-12.5 GHz band. Receiving antennas in the European regions should have a diameter of 60 cm, in other parts of the territory up to 150 cm. To make the commercial system cheaper, broadcasting is in the analog form with frequency modulation.

A new satellite, GALS-R16, which is under development for 1998-2000, should have 16 transmitting beams in the 18/12 GHz band. It is designed to serve mainly the European regions of the country and its active lifetime should be increased to seven to 10 years. Up to four analogue and 32 digital television programmes can be distributed to individual receiver sets with antenna diameters of 50 to 90 cm. This satellite system will also be available to foreign users. The Russian Federation is performing studies on data compression regarding the most effective algorithms of picture compression conforming to the MPEG-2 standard.

D. Satellite Digital Television Broadcasting Systems

Digitalization, particularly new modulation and compression technologies, makes bandwidth utilization efficient and multi-channel DBS possible. The MPEG (Motion Picture Experts Group) standards were first published in November 1994 and modified in 1995. They specify all of the syntax and semantics of the data stream and decoding process, but not the coding process itself in order to allow future improvements. This technology can compress video data into less than 1/30th of the original and audio data into 1/6th of the original. Therefore, four to 10 television channels could be transmitted by a single 27 MHz transponder. At the same time, laser-disk-quality video and compact-disk-quality multichannel sound are possible. In addition, digital technology provides for easy interoperability with communications and computers so that multimedia integrated service and continuing improvements are possible. Among the benefits, there is the possibility of permanent storage of the programme into digital storage media, loss-less scrambling for pay television service and easy animation toward the virtual studio.

In Japan, a commercial company providing test digital broadcasting and regular digital DBS services with almost 100 channels is in the preparation stage. Also, many broadcasting companies in Europe, Asia and South America are already providing or preparing digital DBS services. The first Koreasat satellite was launched into GSO position at 116 East longitude in August 1995 and the second in January 1996. Each Koreasat has three 27 MHz, 120 Watt DBS transponders and concentrated transmission beams at 12 GHz frequency. Therefore, within the territory of the Republic of Korea, a high-quality television signal can be received with only a 40 cm dish and in neighbouring countries where many Koreans live, a one metre antenna is sufficient. The system could support future data broadcasting service up to 2 Mbps. This could provide for services like home shopping, remote education, electronic delivery of newspaper, still pictures, game programmes and Karaoke. Furthermore, a high definition television system (HDTV) is being developed for trial service in 1999 and for the 2002 World Cup.

E. International Networks and Satellite Data Archiving Systems for Mission to Planet Earth

Since the objectives of the United States Mission to Planet Earth (MTPE) are to expand scientific knowledge of the Earth system, disseminate this information and enable the productive use of MTPE science and technology in the private sectors, networking and data archiving systems are an inseparable part of this research endeavour. About 10,000 science and 100,000 non-science users will be searching through data obtained by an armada of international and national satellites, *in situ* platforms and many commercial providers.

MTPE Science Themes for 1996-2002 comprise: land cover and land use research; seasonal-to-interannual climate variability and prediction; natural hazards research and applications; long-term climate (natural variability and change research); and atmospheric ozone research. In addition to the main Earth Observation Data and Information System (EOSDIS), MTPE will use different networks and archives to distribute and archive all relevant data. For example, a Global Observation Information Network (GOIN) will be established according to a joint United States-Japanese initiative to strengthen bilateral cooperation in Earth observation information networks. NASA is one of the participants from the United States and the goal of GOIN is to achieve comprehensive connectivity and interoperability among existing and planned networks.

The MTPE programme would also use the International Directory Network (IDN), sponsored by the Committee on Earth Observation Satellites (CEOS) Access Subgroup. The IDN provides open, on-line access to information on Earth science, space physics and other disciplines. It contains descriptions of data located in archives held by universities, government agencies and other organizations. NASA serves as the American Coordinating Node of IDN. Similarly, the CEOS Catalog Interoperability Experiment (CINTEX), designed to demonstrate interoperability through international data exchange, would be used in MTPE as well. A common interface, designed for access from Germany, Italy and United Kingdom to the EOSDIS, has already successfully demonstrated interoperability.

F. Data and Information System on Global Climate Change

The objectives of the International Geosphere-Biosphere Programme (IGBP) research are to provide the foundation for determining how the Earth system functions and to develop practical predictive capabilities for effective policy responses. Observations and models are key items in the process; existing and emerging knowledge has to be made available to all and properly disseminated. Therefore, IGBP has established mechanisms to define research priorities in global change, open traditional disciplinary barriers, and coordinate national efforts and resources. The exploitation of new opportunities to gather data on a global scale is critical in this process. This includes remote sensing from space, new ground-based initiatives and the use of information technology for data processing and dissemination. The objective of the IGBP-DIS (Data and Information System) Framework Activity is "to improve the supply, management and use of data and information that are needed to attain IGBP's scientific goals". This is achieved by carrying out activities leading to the generation of global data sets and ensuring the development of effective data and information systems for IGBP.

IGBP-DIS is not a conventional information system and does not have large data sets or computer facilities. Its role is to identify key global data deficiencies for global change research and to identify national or international agencies ready to implement remedial responses. Because of their very global nature, space observations have represented a major focus of interest in IGBP-DIS. Its structure consists of the Scientific Steering Committee, the Project office in Toulouse, France, and has three focuses: data set development; data management and dissemination; and data coordination and international context.

One of the new approaches in data retrieval takes into account that the user increasingly wants to broaden his/her data sources and get away from the focus on a single instrument (so-called data fusion). Also, the user wants to be in a position to quickly assess the availability of a wide range of data and products over a particular area and/or period of interest. To this end, "one-stop shopping" and "data harvesting" concepts are taken as starting points. Data harvesting means that metadata are automatically retrieved and assembled in a logical homogenous data base. This highly facilitates standard queries.

G. The Role of Developing Countries in Programmes on Global Environmental Change

The active involvement and contributions of developing countries to the study of global change is crucial. First of all, developing countries are causing significant environmental change. They have tremendous populations, which influences the environment (deforestation, human erosion of soil, rural agriculture, among others). Their economies are mostly based on natural resources and economic development strategies often assume rapid growth and low productivity. Because of this, developing countries have to face serious global environmental problems such as vegetation coverage decrease, land degradation, serious natural disasters and environmental pollution. Therefore, developing countries have to participate in global change programmes out of their own national interest and also to make their contribution to the international community.

China has made substantive contributions to global change studies. The Chinese National Climate Committee was founded in 1987 and the Chinese National Committee for IGBP in 1988. A number of national institutions are conducting environmental research. Some of the specific on-going research projects include: predictive study on trends in the life-supporting environment in China over the next 20 to 50 years; dynamic processes and prediction of trends in environmental changes in arid and semi-arid regions of China; global environmental change research in Antarctica; the Heihe river basin field experiment on the atmosphere-land surface interaction in western China; experiments on ocean circulation of the tropical western Pacific; and studies on the formation, evolution and environmental changes of the ecosystem in the Qinghai-Tibetan Plateau.

H. Software Packages and the Use of the World Wide Web

The ultimate goal of any research activity in space science (and science in general) is to generate a theoretical model, able to explain, in as simple as possible physical terms, the phenomenon being studied. To achieve this goal, a scientist needs data, data analysis software, display software; and modelling software. Most of these products, or at least some information on them, are available through the World Wide Web. The main problem of a researcher is how to select the optimal software and how to tailor it to particular needs. During the ’80s, data analysis was mainframe-based and computational resources were expensive. Therefore, the users pushed for uniformity with the aim of having a minimum number of data analysis packages in order to maximize the efficiency of the system. Later on, it was realized that as long as a full description of the package exists, the user was able to implement it and only standard interfaces were needed. This can best serve the users, but it is not possible to provide even a partially complete list of available software.

Until now, the World Wide Web has been used for the distribution of information and data (text, video, sound). The Web is beginning to be used also for software distribution and computational capability. It has already become possible to access computational services through the Web: parameters are entered at the client site, the computation is done at the server site and the results go back to the client. The Java programming language now offers the possibility of linking platform-independent software to Web pages. This software then runs on the client machine, using the Web browser as the runtime environment and off-loading the server. This eliminates all the problems related to software distribution to remote sites and maintaining it there. It also eliminates all installation problems; all that is needed is a good Web browser. The Hubble Space Telescope European Coordinating Facility (ST-ECF) started to use Java experimentally to provide astronomically useful functionality on the Web. A long-term goal is to delegate tasks like data calibration to the client machine at the user site.

However, the hardware and software market is still developing vigorously. For image processing, the bottleneck is not processing speed but input/output transfer rate. Low-cost co-processors are available for compute-intensive tasks. The most significant current development is the spread of computer networks on a global scale, and their application for tasks which were not initially envisaged. Computer networks are unexpectedly becoming indispensable for science activities like photocopiers and fax machines.

The next step after the personal workstation seems to be the research station. It consists of a powerful local processor which is connected (via high-bandwidth networks) to other machines and databases/knowledge bases. It has a configurable personalized user interface which allows access to all services and functions in a consistent and efficient manner. The emphasis is on visualization and conceptualization (model building). This can be realized through multiple screens, big screen projection ("flight simulator"), or through video recorders.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

A. Measurements of Space Debris

The French space agency CNES continued its experimental observation of space debris using the 1.5 metre Schmidt telescope of the "Observatoire de la Côte d'Azur". It should be able to detect 20 cm size debris in GSO. The first study using photographic films and scanner were performed in 1996, and tests of a CCD camera have been conducted in 1997. CNES is also developing on-board debris detectors to be implemented on commercial satellites in order to get telemetry data on the flux of meteoroids and space debris in different orbit. The feasibility study prepared in 1996 was followed by qualification model and flight model development for a flight on the Mir station in 1999. A complex data base is under development using the results of in-orbit experiments to get a reference for the improvement and validation of space debris models and a catalogue of consequences of impact of particles on different materials.

Optical observations of geostationary objects have been made by the Communication Research Laboratory of Japan using the 1.5 m diameter telescope with CCD camera in Koganei, Tokyo. Objects as small as 20 cm can theoretically be observed at GSO altitudes. As a collaborative study with the National Space Development Agency of Japan (NASDA), similar observations have been conducted since 1992 using the Schmidt telescopes of the Kagoshima Space Centre (KSC) and Kiso Observatory of the University of Tokyo. Experimental radar observations of satellites have been successfully demonstrated using the 20 metre antenna at KSC as a transmitting station and the 64 metre antenna at the Usuda Deep Space Centre. By means of modern communications technology, objects as small as 2 cm at 500 km altitude can be detected. Debris observations have been made by the Middle and Upper Atmosphere (MU) radar which has an active phased array antenna 103 metres in diameter and peak output power of 1 MW. The greatest advantage of the MU radar is its beam steerability, which makes it possible to observe variations of the radar scattering characteristics of unknown objects for a period of 20 seconds and to observe in different directions almost simultaneously.

Several Japanese study groups performed the post-flight analysis of the Space Flyer Unit (SFU) which was recovered by the U.S. Space Shuttle after 10 months in orbit. In total, some 20 square metres of exposed surfaces were available on SFU for analysis. The main surfaces consist of multi-layer insulation (MLI), second surface mirrors and the painted alloy structure. According to the preliminary results, no significant outgassing or off-gassing have been detected. A total of 337 impacts with diameters greater than about 200 micrometers have been observed in visual surveys, and 180 impacts in high-resolution surveys of selected surfaces. The diameter of maximum damage is about 13.4 mm, with an impact crater diameter of 2.5 mm.

B. Modelling of Space Debris Environment and Risk Assessment

The measurement of space debris does not cover the total debris size distribution in all altitude regimes of interest. In many cases, measurements provide only statistical information (e.g. number of objects passing the beam of a radar antenna). In order to understand the dynamics of the debris population, it is essential to also analyse the time-dependent numbers of smaller objects. Finally, relying only on measurements is not sufficient to understand the sources and dynamics of the debris population and to analyse the risk for future missions. A detailed analysis of future scenarios and of the effectiveness of debris minimization and mitigation measures can be performed only by using space debris population models. The space debris environment is currently modelled in many countries.

In the Defence Evaluation Research Agency of the United Kingdom, the Integrated Debris Evolution Suite (IDES) combines deterministic modelling of particles over 10 cm size with stochastic modelling for particles below 10 cm. Altitudes covered are from 100 to 2000 km. Orbital situations can be computed in one-month time steps to predict possible collision events (including catastrophic, damaging or just surface erosion effects). A semi-deterministic code SDM/STAT, for the long-term analysis of the debris population, is being developed under an ESA contact at the University of Pisa (Italy). It has features similar to CHAIN and is based on the background population which is modulated by traffic and mitigation dependent overlay populations. The Nazarenko Model (CPS) developed in the Russian Federation is a semi-analytical, stochastic model for medium and long-term forecast of the LEO debris environment. It provides spatial density and velocity distributions, based on Russian Federation and United States space catalogue data.

In CNES, special emphasis is given to impact of debris into fragile materials (glass, silicium) which can produce a great number of small particles (secondary impact). The mass of these secondary particles can reach 1000 times the mass of the primary particles. A study group at the Institute for Space and Aeronautical Sciences of Japan (ISAS) studied the debris flux as a function of altitude and showed that it peaks at the altitudes of 1000 and 1500 km and that the flux in the year 2000 should be twice the 1982 value. Since no fragments have been tracked in GSO, even though there have been at least three explosions there, models are extremely important for understanding the dynamics of objects in this region. According to the study performed at Kyushu University, the estimated number of objects that regularly cross the geostationary band depends mainly on the explosion rate, followed by the rate of re-orbiting the satellite at the end of lifetime. Therefore, the passivation measures for spacecraft are necessary to reduce the possibility of explosion on GSO.

In Germany, the space debris modelling is financed by the German Ministry of Research and Technology and by the German Space Agency (DARA). The work has been carried out by the institute for Flight Mechanics and Spaceflight Technology (IFR) of the Technical University of Braunschweig (TUBS), Germany. Based on these activities IFR/TUBS has developed the ESA Space Debris Reference Model (MASTER) under a contract of the European Space Operation Centre in Darmstadt (ESOC). This model covers man-made debris and natural meteoroids (meteoroids distribution was modelled by the Max Planck Institute in Heidelberg, Germany). Since 1990, government-sponsored cooperation between TUBS and NASA Johnson Space Centre (JSC) led to fruitful discussions concerning the modelling approaches and the results obtained by both parties using their own tools. The debris models developed in Germany are concentrating on man-made objects larger than 0.1 mm; with respect to the risk posed to spacecraft, objects larger than 1 cm are of special interest.

For the purpose of long-term population modelling, the analytical computer code CHAINEE (CHAIN European Extension) was developed. This code describes the population and collision fragments up to an altitude of 2000 km using four altitude bins and six mass classes. The main advantage of CHAINEE is the extremely low computer time needed (approximately 10 seconds for a simulation of one hundred years); however, its low spatial resolution is a major disadvantage. Therefore, it is mostly a tool to analyse some basic effects of future scenarios. For detailed analysis, especially if a high resolution concerning the orbital altitude is required, a new tool called LUCA has been developed at TUBS. It combines the advantages of a high spatial resolution and a tolerable amount of computer time needed to run a simulation. In order to calculate the time-dependent collision risk, a special tool has been implemented, which analyses the geometry of the orbits of all population members and determines the probability that members of the population will have a collision. This tool is used once in a year of simulated time and guarantees that changes in the population properties are reflected in the collision probabilities. This ability is also an enhancement with respect to the modelling methodology compared to the former programmes used.

The United States orbital debris programme is aimed to ensure safety of human space flight, protect national assets and investments in space from orbital debris and finally to ensure long-term protection of the space environment. The orbital debris engineering model (ORDEM) is used to compute the current and near-term orbital debris hazard for low Earth orbit missions. The ORDEM91 model was baselined before the STS-80 flight, the ORDEM96 model is baselined on data starting with STS-80. It provides low Earth orbit debris flux levels and directionality as a function of particle size. It is based on the latest remote and *in situ* measurements of the near-Earth environment.

Because of the importance of the manned space shuttle flights and of a future International Space Station, the United States has initiated a special pre-flight meteoroid/orbital debris risk and post-flight damage assessment programme. A BUMPER computer code can determine the probability of specified damage levels caused by debris impacts, using relevant input and output specifications. In addition to the spacecraft configuration and mission profile, a concrete meteoroid/orbital debris environment model (e.g. ORDEM96) is part of the input data. As an output, probability of particle impacts from given size, probability of the impact damage (necessity of the window replacements, reinforced carbon-carbon and radiator impacts and probability of "critical" damage) are obtained regarding both meteoroid and debris particles.

There are different thresholds of "critical" damage: For example, the windows should be replaced if impacted by a 0.04 mm particle, a space suit could be penetrated by a 0.1 mm particle, an orbital radiator tube by a 0.5 mm particle, the reinforced carbon-carbon panels (as well as payload bay) by a 1.0 mm particle, the thermal protection system by a 3-5 mm particle and the orbiter crew cabin by a 5 mm or larger particle. Comparisons of the real and predicted replacements of the shuttle windows after the last nine flights show that the real replacements are 30 percent more frequent than predicted (the total of 63 is up to STS-80). Similar results have been obtained from data on the first repair mission to Hubble Space Telescope in December 1993. In general, the use of the BUMPER assessment process has reduced meteoroid/space debris damage on the shuttle and enhanced the safety of the shuttle missions.

Another computer code, EVOLVE, simulates historical and projected space operations, including satellite fragmentations, to create mathematical descriptions of the satellite population. It combines historical data with special purpose routines to simulate semi-deterministically the evolution of the orbital debris environment to the present. Then, Monte Carlo techniques are employed for investigations of future evolutionary characteristics under various debris mitigation practices.

Developed initially in 1993 at TUBS Germany, the CHAIN model has been maintained and improved by the JSC. CHAIN is a lower fidelity model employing the so-called "particle-in-a-box" technique to permit fast running, Monte Carlo simulations of the long-term evolution of the Earth's satellite population. CHAIN can be employed to identify the relative trends associated with specific mitigation policies, while higher fidelity assessments can later be performed by the EVOLVE model.

C. Space Debris Mitigation Measures

Measures to limit space debris generation must be developed and implemented on a multilateral basis by the spacefaring nations. The Japan Society for Aeronautical and Space Sciences (JSASS) committee on space debris prevention design standards published in March 1996 the final report for the Japanese National Space Development Agency (NASDA) standards and design criteria. Based on this report, NASDA established the NASDA-STD-18 "Space Debris Mitigation Standard" on 28 March 1996. The NASDA Standard includes the following mitigation measures: passivation of the spacecraft and the upper stages at the end of the mission; re-orbiting the spacecraft and upper stages at the end of the mission; disposition of objects in geostationary transfer orbit in order not to pose a risk to the geostationary orbit; minimizing the debris released during normal operations; and post-mission disposal of spacecraft from low Earth orbit.

The current NASDA Standard acknowledges that a plan for space debris mitigation control should be tailored for each programme, but requests each NASDA Project Manager to prepare a Space Debris Mitigation Plan, including an adequate rationale for items for which an exception is requested. Manufacturers are also requested to present a similar plan. Each plan is subsequently reviewed by the NASDA Safety Review Committee. An exception will be granted only under certain conditions; some projects currently well into their development cycle may be allowed to violate some requirement of the standard.

NASDA has already implemented the draining of residual propellants and helium gas from the H-I/H-II second stage. The release of mechanical devices at satellite separation and solar paddle deployment has been avoided except in some particular missions, such as the separation of spent apogee motors for the geostationary meteorological satellites. In order to prevent unintended destruction of H-II second stages in space, the command destruct system is disabled immediately after injection into orbit and its pyrotechnics are thermally insulated to prevent spontaneous initiation. The measures adopted for NASDA programmes seem to be relatively inexpensive and have been proven to be very effective. For example, the orbital life of the ETS-VI H-II second stage (1994-056B) was reduced to about seven months as a result of deorbiting. The stage re-entered the Earth’s atmosphere on 31 March 1995.

Strict mitigation measures are applied to all CNES launches. The basic requirement is to leave no more than one piece of passivated debris in orbit per payload. This means the upper stage of the launcher in the case of a single launch, and the upper stage with link structure in the case of a dual launch. The separation of the payload from the last stage of the Ariane 4 launcher should not generate any other debris (pyrotechnic separation should be "clean" and remains of pyro bolts should be trapped). The normal use of the upper stage should not generate other debris; therefore solid propulsion in orbit is avoided and the end of life of the batteries and cells should not lead to explosions. To passivate the upper stage, pyrotechnic valves to empty the tanks and decrease the internal pressures are added.

To avoid overcrowding the useful orbits with "dead satellites" and reduce pollution and collision risks, CNES is developing disposal procedures at the end of a satellite’s useful life. For low Earth orbits, de-orbit manoeuvres should induce a destructive reentry of the satellite into the atmosphere. For GSO, manoeuvres are required to put the satellite on a graveyard orbit, typically 300 km above GSO. Software to predict potential collisions between the operational satellites and registered space debris and other related studies are also under development.

From the German modelling studies, two mitigation measures can be identified. First, there is explosion prevention. Most of the historical unintentional explosions were due to the residual fuel of spent rocket bodies. Hence, passivation of spent rocket bodies by venting the residual fuel is appropriate to avoid self-triggered explosions. Prevention of collisions, in particular of those debris which generate most of the collisional debris, can only be performed by removing large objects from space. Spent rocket bodies and spent satellites are large objects with significant masses and areas. It can be seen from the models that substantial reduction of the population growth can be achieved this way, but there still would be a tendency toward a growing population.

In 1993, an Inter-Agency Space Debris Coordination Committee (IADC) was formally founded in order to exchange information on space debris research activities between member space agencies; to review progress of ongoing cooperative activities; to facilitate opportunities for cooperation in space debris research; and to identify debris mitigation options. The founding members were ESA, Japan, NASA and the Russian Space Agency (RSA). In 1995, China joined IADC and the British Space Agency (United Kingdom), CNES (France) and the Indian Space Research Organization (ISRO) did so in 1996. Working Group Chairs are elected to serve a term of two consecutive meetings. Each member (nation or organization) must be represented in the Steering Group and in Working Group 4 on mitigation. Representation in other Working Groups is desirable but not mandatory. Formal meetings of the full IADC are scheduled about once a year. All agreements of IADC are made by consensus.

D. Collisions of Nuclear Power Sources with Space Debris

In the Russian Federation, the consequences of a collision between decommissioned nuclear power sources (NPS) and space debris during their protracted stay in orbit are prime targets of research on radioactive, chemical and environmental contamination of outer space. The possible consequences of a collision between debris with a reactor NPS launched into space and placed into sufficiently high orbit are: destruction of reactor radiator reflector (beryllium); destruction of radiation shield (lithium hydride); destruction of liquid metal circuit and possible outflow of coolant (sodium-potassium); and destruction of reactor NPS structural components with concomitant fragmentation of structural materials.

Interaction of space debris with secondary liquid metal circuits and the resulting circuit destruction might lead to possible coolant drops into outer space. The investigation of these processes involve the character of the NPS motion around its centre of mass; the thermal state of the radiator and the circuit; the coolant overflow due to the punctured radiator and circuit components; the thermal state of coolant drops; and the probability of interaction with the radiator and subsequent radiator puncture.

The following pattern of coolant drop egress can be assumed. Immediately after tube destruction, coolant pressure inside the tube substantially exceeds external pressure, hence the coolant reaches a boil and splashes out in small portions. Calculations confirm that the condition whereby pressure is exceeded due to centrifugal forces is pertinent only to Cosmos 1900 and 1932 satellites transferred into high orbits in 1988. Destruction of their radiators or manifolds after collision with space debris can lead to coolant outflow from the secondary circuit and formation of sodium-potassium drops (which seems to be confirmed by some space debris observations). The lifetime of coolant drops with initial diameter from 5 to 20 mm in the 950-1000 km altitude range is 7.5 to 32 years. At the 900-950 km altitude range, the corresponding lifetime is four to 14 years. The evaporation time is much longer: 145 to 580 years.

The computed probability of a collision between space debris and the coolant circuit of one of the 28 reactors in orbit is one per year for particles of 1-1.5 mm in size and 7.10^{-3} to 2.10^{-3} events per year for 6-12 mm size. The former particles can make holes in the tube, but the coolant would outflow only after impact of the latter ones. Depending on the construction, seven NPS (Cosmos 1670 type) can be sources of sodium-potassium drops upon impact with particles over 6 mm size and nine NPS (Cosmos 1579 type) with the size over 12 mm.

E. The Use of Nuclear Power Sources in Outer Space

To maintain specified thermal conditions and provide electrical power for small autonomous stations of the Mars 96 project, special radionuclide thermoelectric generators (RTG) and radionuclide heat units (RHU) based on plutonium 238 were developed. The heat units are universal (heat power about 8.5W each), so that they are used also as a primary source of heat for the thermoelectric changer of the RTGs. This simplified the safety design of both types of units, since the ampules with plutonium-238 are identical. The design and development of the units were performed in full compliance with the Principles Relevant to the Use of NPS in Outer Space, adopted by the General Assembly in its resolution 47/68 of 14 December 1992, and also with national safety standards of the Russian Federation.

Each RHU has a carbon-carbon heat shield and contains about 17 grams of plutonium-238 dioxide having activity of 260 Ci in a special capsule. The inner part of the capsule shield is made of platinum-rhodium alloys and can absorb the helium created during the alpha-type decay of plutonium-238. The external shield is made of extremely hard alloys of tantalum and wolfram with a special cover layer of other high thermal resistance materials. Therefore, each capsule has more than double shielding against thermal and mechanical shock disturbances.

The capsules could withstand an explosion and burning of the Proton space vehicle propellant with flame temperatures up to 3600 K for 4000 s; spacecraft atmospheric re-entry with the first and second space velocities (up to 11 km/s); and impact with the Earth surface (including concrete and rocks) with velocities up to 80 m/s. In addition, plutonium dioxide (cermet) tablets are not dissoluble in the fresh and sea water (to a depth up to 10 km) and base or acid environments. The leak-proof capacity of the capsules has been confirmed by ground tests using model and full-scale RHU specimens and carried out by the inter-agency commission of experts.

The Mars 96 contained 18 RHU with total mass of plutonium dioxide not more than 300 g (270 g of plutonium-238) and the total activity of about 4700 Ci. At each of the two small scientific stations, there were 2 RTGs (each containing a single RHU) and 2 RHUs for heating. Similarly, each of the two Mars penetrators contained one RTG (powered by 2 RHU) and 3 RHU for heating purposes. The electrical power for the main spacecraft should have been provided by conventional solar battery panels.

The launching of the Mars 96 space probe with international scientific equipment on board for complex exploration of Mars took place on 16 November 1996 at 20.49 Universal Time from the Baikonur cosmodrome. The engines of the Proton launcher worked out after 583s as scheduled. After 6 minutes, a special accelerating unit engine was ignited for 100s. As a result, the unit and the Mars 96 probe were injected into a circular parking orbit around the Earth. These events were observed and controlled from the ground. After 51.5 minutes of orbital flight, near the equator and outside the visibility of the Russian ground tracking stations, the engine should have been ignited for the second time to provide an additional velocity of 3,146 m/s. After that, the Mars 96 probe should have separated from the unit and by the use of its own engine acquire an additional 536 m/s needed for entering the interplanetary orbit towards Mars.

However, while the first ignition of the accelerating unit took place as planned, the second one failed and the unit with the Mars 96 probe remained in a low Earth orbit. The automatic systems of the spacecraft performed the separation from the accelerating unit and ignition of its own engine. According to the telemetry data, it worked for about 6s and provided a velocity impulse of 10 m/s. This was not enough for a substantial increase of the orbit and moreover, the impulse was given in a wrong direction. The acceleration unit was precisely tracked in its low orbit and decayed on 18 November 1996 at 1.20 Universal Time over the Pacific Ocean, several thousand kilometres east of Australia (about 51 degrees South, 168 degrees West).

The tracking of the Mars 96 probe was not continuous and the location of its decay was much more difficult to determine. After careful analysis of all available information (telemetry, tracking and aerodynamic modelling), it was confirmed that the probe, including radioisotope capsules, entered the atmosphere on 17 November 1996 around 1.00 Universal Time at the end of its third revolution around the Earth. The probable fall-zone is located in the Pacific Ocean, 800 to 200 km around the orbit, west of the coast of Chile. Its centre is at 25.1 degrees South and 75.4 degrees West. In addition to the notification of the incident to the United Nations, representatives of Argentina, Bolivia, Chile and Peru were informed on 28 November 1996 of the circumstances of the accident. A special commission was set up to investigate all its aspects, including the reasons for the failure. The commission recommended an increase in quality control during all stages of production of the accelerating unit and cleared it for the use in future launchings of the Proton booster into highly-elliptical and geostationary orbits.

After the aerodynamic destruction of the Mars 96 spacecraft and the RTG aluminium and steel structural components during the atmospheric re-entry, the capsules with plutonium dioxide fell within the fall-zone of the fragments, in a practically unchanged form. Since there is no plutonium dioxide release into the environment, it rules out any possibility of radioactive contamination and radiological effects on the population. Deposition of the RHU in the Pacific Ocean floor at considerable depth should be regarded as an ecologically-safe disposal of a relatively small quantity of plutonium-238.

F. International Cooperation in Space Research and Applications

The Committee on Earth Observation Satellites (CEOS) strongly pursues the development of the Integrated Global Observing Strategy (IGOS) in order to make more effective use of investments in this field and to support the world-wide demand for a complex sets of instruments to collect relevant data, distribute them and create and distribute data products. The existing systems do not seem to meet the demand. User needs could be met more effectively through better inter-agency coordination and cooperation. Strategy should be developed to integrate inter-agency planning for cost effective space-based systems, inter-calibration, compatibility of data delivery systems and by establishing better links among the users and providers. The delivery of services should be aimed to satisfy social, economic and environmental needs of the users. Developing countries are recognized as both providers and users of data.

CEOS encourages data providers to make additional investments in calibration of measurements and validation of derived geophysical products and to extend data acquisition benefits to a broader user community. It recognizes *in situ* observations as a necessary complement of space-based observations and the need to develop data assimilation programmes to maximize the value of both types of data. A framework for private sector data providers and value-adding companies should intersect with publicly supported agencies. In general, an IGOS will demand new heights of mutual responsiveness between communities whose members measure phenomena of the Earth surface and atmosphere, and communities whose members make use of this information.

The development of IGOS should be gradual to accommodate a variety of data policies and voluntary commitments, but at the same time it should contain some measurable benchmarks for gauging the progress of implementation. The structure of IGOS should satisfy a formal set of users' data requirements for continuity of data provision (coverage and characteristics); minimization of data gaps; maintenance of the long-term data record; reduction of unnecessary duplication of instruments; development of partnerships between data users and data providers for definition and complementary funding of observing programmes; and a high level of political support. The Task Force on Planning and Analysis, established in 1994, has already collected user requirements and defined a database structure to conform with data availability. The CEOS meetings provide a key forum to address the space component; an IGOS Strategic Implementation Team was established at CEOS's 10th plenary meeting in November 1996 in Canberra (Australia). The work of the Task Force will be continued and expanded by an Analysis Group. An international peer review of pilot projects should begin in 1999 and an operational system, based on the lessons learned, would be established after that.

During a meeting at the Vienna International Centre in February 1997, the representatives of Bulgaria, Greece, Poland, Romania, Slovakia and Turkey agreed to establish a network of space science and technology education and research institutions for central eastern and south-eastern European countries. The activities of the network would be in the harmony with the relevant work of existing institutions in Europe and would be open to international cooperation. The objective of the network will be to promote, by space specific multidisciplinary and interdisciplinary methods, higher level capacity building in the region; develop future specific regional space education, research and applications projects; and develop joint space scientific and operational programmes and benefit from them at the regional level. A study on the technical requirements, design and operation mechanism and funding of the network will be prepared by the experts in cooperation with the United Nations Office for Outer Space Affairs.

Satellite communications, which makes it possible to collect, transmit, disseminate and exchange information among all the regions of the world, could be of particular use to developing countries, especially in the rural areas, which tend to be isolated and lack communications infrastructures. Satellite communications increase domestic, regional and national traffic and have a substantial impact on national economies. A number of projects are currently being implemented in Europe and Africa for information exchange using satellites, and the installations involved could be used for the Mediterranean region, such as:

- COPINE, proposed by the United Nations Office for Outer Space Affairs and the World Health Organization, which aims to establish a network of satellite telecommunications stations for information exchange on the environment, education and medicine between Africa and Europe;

- MEDSAT, a project directed by France, involving the launch of a communications satellite to cover the Mediterranean basin (Morocco, Tunisia and Egypt are potential southern partners);

- EAST, another project announced by France, involving the launch of a powerful geostationary satellite over central and eastern Europe and North Africa to provide telephone and data transmission services;

- COSMO/SKYMED, a project directed by Italy, involving a constellation of small satellites to observe the Mediterranean basin; and

- FUEGO, a project directed by Spain, involving a constellation of small satellites for the management and monitoring of forest fires in the Mediterranean basin.

With the establishment of the Royal Centre for Remote Sensing (CRTS) in 1989, Morocco took an important step forward in space information production. The Centre is responsible, among its different space-related tasks, for distributing satellite images and centralizing the national records of satellite data and data from projects using spaceborne remote detection and geographic information systems. A number of projects using these techniques are currently in progress or being set up in Morocco in response to needs in the areas of natural resource inventory and management, environmental protection and land development. The aim of the projects is to generate the information needed for development.

There are currently stations for receiving Earth observation data from the METEOSAT meterological satellite, mainly in the National Department of Meteorology (DMN). A NOAA meteorological satellite data receiving station has also been set up in the DMN for meteorological studies. Another station of this type is planned for CRTS to receive satellite radiometric data, which is useful for agriculture, forestry and oceanography. Management of scarce water resources in Morocco is extremely important. In order to access data from other Earth observation satellites, the CRTS has concluded contracts with international image distributors: SPOT IMAGE in France for Spot data, EURIMAGE in Italy for NOAA, Landsat, ERS data *etc*.

The CRTS is also organizing development of the first national microsatellite, experimental in nature, which will be launched into low Earth orbit, with a payload of messaging and remote sensing equipment. The work is being carried out with the collaboration of the Berlin Technical University (TUB), which is providing the TUBSAT-C platform for the project. Installation of the component systems is expected to be completed in 1997.

G. Space Medicine and Materials Science

Chagas’ disease, also called American trypanosomiasis, is an infection caused by a parasite, the flagellate protozoan Trypanosoma cruzi, transmitted to humans most often by an insect carrier (particularly by a bloodsucking bug called "vinchuca" in Chile), but also transmitted by some other indirect ways (i.e. through blood transfusions and organ transplants or through the handling or ingestion of the blood and meat of infected animals). The disease is endemic in most rural areas of Central and South America, and causes local swellings, fever and prostration. When the disease enters a chronic stage, it can affect the heart, and may end in death, especially in children. To date, no known drug cures the T. cruzi infection at this chronic stage. According to the World Health Organization (WHO), 20 million people are infected in a territory that spans from the Southern United States to the end of the Patagonia. Every year, 80,000 people die, and 250,000 are infected.

The outstanding advancements in the crystallization of proteins in microgravity achieved during the last few years has opened a light of hope towards the development of medical drugs to eventually cure Chagas’ disease. Since 1984, a number of NASA Space Shuttle missions have carried out crystallization experiments and have developed the necessary hardware. As a result, crystals of numerous proteins have been grown in space, having a higher quality and a bigger size than those grown on the ground, subject to Earth's gravity. One of the biggest advances concerning crystal growth in the microgravity environment in space has been the introduction of a new method, called "vapour diffusion using hanging drop". This method has allowed for the crystallization of innumerable macro-molecules in space, particularly of proteins.

The bigger size and the higher quality of space-grown crystals make them particularly appropriate for the study of their three-dimensional structure by means of high-resolution analysis with X-rays diffraction. This technique, "computer molecular modelling," is performed with the help of modern computer software. The knowledge of the three-dimensional structure of protein molecules is essential in order to determine their mechanisms of action and their biological functions, and subsequently to develop new drugs able to interact with these bio-molecules in a specific, desired way. This process is known as "rational design of drugs".

In February 1996, during the STS-75 mission of the Space Shuttle Columbia, the first medical experiment designed by Latin American researchers was carried out. For 16 days, crystals were grown of Tripanotion Reductase, a specific enzyme of the T. cruzi. Based on the results, new experiments were prepared for the STS-83 mission in April 1997. The aim was to grow, in a microgravity environment, crystals of the parasite's other enzymes (11 different proteins in 80 crystallization chambers), in order to determine their molecular structures. Participating scientists from Argentina, Brazil, Chile, Costa Rica, Mexico, Uruguay and the United States hope that using the rational design of drugs will result in the development of a new medicament against this silent but fatal disease.

H. Astronomy and Planetary Exploration

The Japanese ISAS successfully launched the Very Long Base Interferometry (VLBI) satellite MUSES-B (renamed in orbit as HALCA - Highly Advanced Laboratory for Communications and Astronomy) by the new M-V launch vehicle on 12 February 1997. The M-V is a solid, three-stage rocket with an optional kick stage. It is about 30 metres long, with a diameter of 2.5 metres, and total mass about 140 tons. It can carry an approximate two-ton payload into low Earth orbit. With the advent of this new launcher, Japanese space science entered a new area, namely a stage which foresees more ambitious projects that include lunar and planetary exploration. Five more spacecraft have already been approved for launch by the M-V: the LUNAR-A for the Moon penetrator mission (fiscal year 1997); the PLANET-B to Mars (fiscal year 1998); the ASTRO-E for an X-ray astronomy satellite (fiscal year 1999); MUSES-C for asteroid sample returns (fiscal year 2001); and ASTRO-F for infrared astronomy (fiscal year 2002).

Despite a large amount of data collected by the Apollo and Luna missions, the structure and composition of the lunar interior is still poorly understood. The planned LUNAR-A mission will send three penetrators from the lunar orbit onto its surface. The penetrators, each having a cylindrical shape with a frustum nose of 80 cm long and 12 cm in diameter, will hit the surface at a velocity of about 300 m/s and penetrate two metres deep (two will be aimed to the near side of the Moon, a third to the far side). The penetrators will constitute a seismic and heat flow measurement network in order to better understand the origin and evolution of the Moon.

The PLANET-B is the first Japanese mission to Mars and is due for launch in July 1998. After an interplanetary cruise, it should enter the orbit around Mars with periapsis as low as 150 km. This is where the interaction of the solar wind with the Martian atmosphere could be most effectively studied. The on-board camera and radiometer will provide information on the global atmospheric conditions near the surface. Other instruments should provide data on magnetic fields, the vertical structure of the atmosphere and plasma, high energy particles, surface temperature, and images of the surface and dust storms. The spacecraft should operate in areocentric orbit for at least two years after insertion in 1999.

The ambitious first launch of the M-V in the 21st century will carry an asteroid sample return mission, MUSES-C, to the near-Earth asteroid Nereus. The mission should be launched early in 2001 and will arrive back on Earth in January 2006. Since Nereus seems to be one of the most primitive bodies in the solar system, the mission should provide a better picture of the early history of the solar system. The astronomical mission ASTRO-E (a successor to the Advanced Satellite for Cosmology and Astrophysics (ASCA) satellite launched in 1993) will be equipped with soft and hard X-ray telescopes to cover a very wide energy range. The ASTRO-F infrared astronomy satellite should explore the riddles of galactic evolution, interstellar objects, brown dwarfs, dark matter in the Universe and other topics, using a complex of instruments, cooled by a new mechanical cooling technique which has rapidly progressed in the past decade as an auxiliary cooler. This should substantially prolong the mission lifetime in comparison with previous infrared astronomy satellites.

The first ESA mission for the *in-situ* study of a cometary nucleus environment and its evolution in the inner solar system is called Rosetta. The main Orbiter spacecraft is developed, operated and fully funded by ESA, with the exception of the scientific payload, which is under the responsibility of the Principal Investigators. To enhance the scientific capabilities of the mission, the Orbiter will carry one Lander called the Surface Science Package. The Rosetta project is ready to enter Phase B with system and subsystem design and analysis to be completed in the third quarter of 1998. The spacecraft is scheduled to be launched in January 2003 by an Ariane 5 launcher. It will employ three planetary gravity assist manoeuvres (Mars in August 2005 and Earth in November 2005 and November 2007) to acquire sufficient energy to rendezvous with the comet Wirtanen in May 2012. After each Earth assist, an asteroid fly-by is planned (asteroid Mimistrobell in September 2006 and Shipka in October 2008).

The comet rendezvous manoeuvre is currently scheduled to occur approximately 4.8 astronomical units (AU) from the Sun and is aimed to match the spacecraft orbit with the comet so that the relative velocity is reduced to about 100 m/s. The rendezvous will be followed by a drift phase of three to six months as the spacecraft slowly closes on the comet. After that, there should be enough power from the solar array to bring the spacecraft to full operational status and acquire the comet with the on-board navigation camera. The final manoeuvre would then be completed and the spacecraft placed in a mapping orbit. The nominal operations on the comet are expected to commence approximately 3.25 AU from the Sun through to perihelion, a period of about one year. Early in the operational phase, the landing sites for the Lander will be selected and its separation and delivery accomplished. The Lander will nominally operate on the surface of the nucleus for several months, while the Orbiter will orbit or escort the nucleus to carry out scientific operations with its payload.

The scientific objective of the Rosetta mission is to investigate the origin of the solar system by studying the origin of comets and to study the relationship between cometary and interstellar material. It will provide for the detailed exploration of the comet nucleus and its close environment and will provide unique sample analysis capabilities, thus satisfying to a large extent the objectives of the original comet-nucleus sample-return mission.

The scientific payload of the Rosetta Orbiter was pre-selected and endorsed by the ESA Science Programme Committee at its February 1996 meeting. The Orbiter payload comprises 11 investigations and one radio science investigation using the on-board spacecraft telecommunications system. They comprise remote sensing (four experiments), composition analysis (four), nucleus large-scale structure (one), dust flux, dust mass distribution (one), and comet plasma environment and solar wind direction (one). The Lander payload consists of a complex of investigations which will characterize the comet surface and sub-surface (a total of nine experiments).

Austria is responsible for the MIDAS (Micro-Imaging Dust Analysis System) experiment on the Rosetta Orbiter (in cooperation with co-investigators from six countries). MIDAS is dedicated to the micro textual and statistical analysis of cometary dust particles. It is based on the technique of atomic force microscopy which has made rapid progress in recent years after the discovery of the principle in 1986. Textural and other analysis of dust particles will be performed in the size range of 4 to 5000 nanometres. The MIDAS instrument is considered essential for the Rosetta mission as, for the first time, it will provide the capability of imaging in three dimensions dust particles in the nanometre to micrometre range. This size range covers the building blocks of pristine interplanetary and cometary particles, i.e. the silicate core particles (100-200 nanometres), refractory organic mantle (about 10 nanometres) and possible crystalline structure of the material. The instrument will collect and image particles irrespective of their shape and electrical conductivity. It should perfectly complement the data on the chemical composition obtained by other instruments such as the Cometary Secondary Ion Mass Spectrometer (COSIMA).

I. Adverse Environmental Effects on Astronomy

It has become clear that operational and spent spacecraft, as well as the larger pieces of trackable space debris, are the greatest contributors to "trailing": a passage of an object across a telescopic field of view, which is recorded both photographically (during the deep space studies) and photometrically. The quality of deep space plates is degraded, photometric observations are lost and there is an ever present danger of damage to sensitive detectors. The phenomenon is not new, but with the launch of multi-satellite systems such as Iridium now and, perhaps, Teledesic in the future, there is likely to be a considerable growth in the population of both active and spent satellites. Also, the issue of radio interference produced by Iridium satellites at 1612 MHz with astronomical OH maser emission remains unresolved, despite the very considerable efforts of the Inter-Union Committee on the Allocation of Frequencies to obtain a resolution through the International Telecommunication Union (ITU).

In June 1996, the United States Naval Research Laboratory launched the TIPS experimental double satellite, the two components of which are connected by a four kilometre-long tether. The announced objective is to test survivability of the 2.5 mm diameter tether in orbit at 1000 km altitude, because tethers are believed to be fragile in respect of small debris impact. A tether 4 kilometres long subtends an angle of 14 minutes of arc and has the 6th magnitude - just visible to the naked eye. With these dimensions, TIPS can produce a smear rather than a trail - a smear which is comparable in size to the field of view of a CCD commercially available for professional and amateur use. Since some astronomical observations should be performed during astronomical twilight, TIPS is a hazard for observational optical astronomy. For example, observations at the beginning of April of the appulse of an early type star and the comet Hale-Bopp with the Keck Telescope had to be planned so as to not coincide with the passage of the TIPS satellite.

It was announced last year, that UNESCO was moving away from the concept of the "Star of Tolerance" to mark its first fifty years of existence. It was supposed to be a system of two reflecting balloons, kept together by a two kilometre long tether in an orbit at 1250 km altitude. Although, like TIPS, it will be seen largely in twilight, it has a potential to appear in the dark sky and to be as bright as Sirius. Unfortunately, the project might be back, this time as a Millennial Project. The putative launch of this project would send a disastrous message: that advertising from space is considered acceptable. The firm stand taken by ESA against this project was very warmly appreciated by the whole astronomical community.

Appendix

LIST OF SCIENTIFIC AND TECHNICAL PRESENTATIONS

I. SYMPOSIUM ON SPACE SYSTEMS FOR DIRECT BROADCASTING AND GLOBAL INFORMATION SYSTEMS FOR SPACE RESEARCH, ORGANIZED BY COSPAR AND IAF

The first session of the symposium, "Direct broadcasting systems", was co-chaired by Mr. K. Doetsch, representing IAF, and Mr. G. Haerendel, representing COSPAR. The second session of the symposium, "Global information systems for space research, was co-chaired by Mr. K. Doetsch, representing IAF, and Mr. K. Kasturirangan, representing COSPAR.

"Global Perspectives of Satellite Radio and Digital Audio Broadcasting," Mr. K. Kasturirangan
Indian Space Research Organisation (ISRO), India.

"Multimedia and Broadcasting Services via Satellite," Mr. O. Koudelka, Technical University Graz, Austria.

"Current Status of Satellite Direct Television Broadcasting in Russia", Mr. Y. B. Zoubarev, State Radio Research and Development Institute, Russian Federation.

"Satellite Digital Television Broadcasting Technology and the Koreasat DBS System," Mr. J. S. Chae, Electronic Communications Research Institute, Republic of Korea.

"International Networks and Satellite Data Archiving Systems in Support of Mission to Planet Earth," Mr. R. Schiffer, National Aeronautics and Space Administration (NASA), United States.

"Software Packages Including the Use of World Wide Web (WWW) for Research Purposes in Space Science," Mr. M. Machado, Commissión Nacional de Actividades Espaciales, Argentina.

"Data and Information System on Global Climate Change (IGBP-DIS)," Mr. J.-P. Malingreau, Joint Research Centre of the European Commission.

"The Role of Developing Countries in Global Change and Establishment of a Global Information System," Mr. Zhou Chenghu, Chinese Academy of Sciences, China.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

"Scientific and Technical Aspects of the STS 78 Mission" (video presentation), Mr. J.-J. Favier, spationaute, Centre National d'Etudes Spatiales (CNES), France.

"Software Packages Including the use of World Wide Web for Research Purposes in Space Science," Mr. R. Albrecht, European Space Agency.

"Space Activities of Developing Countries: Technical Possibilities and Perspectives," Mr. M. M. Kabbaj, Royal Centre for Remote Sensing (CRTS), Morocco.

"Space Debris Research in France in 1996," Mr. F. Alby, Centre National d'Etudes Spatiales (CNES), France.

"Integrated Global Observation Strategy," Mr. G. Brachet, Centre National d'Etudes Spatiales (CNES), France.

"Research on Developing Medicaments for Chagas' Disease through Protein Crystallization in Microgravity Conditions," Ms. S. Sepulveda, Universidad de Santiago de Chile, Chile.

"Network of Space Science and Technology Capability Building Centres in Central Eastern and South Eastern Europe," Mr. M.-I. Piso, Romanian Space Agency, Romania.

"Mars 96 Mission," Mr. V. I. Lisitsin, Russian Space Agency, Russian Federation.

"Japanese Space Science in 1997," Mr. Y. Matogawa, Institute of Space and Astronautical Science (ISAS), Japan.

"Austrian Contribution to the Cometary Probe Rosetta," Mr. K. Torkar, Austrian Academy of Sciences, Austria.

"Some Topics of Space Debris Research in Japan," Mr. S. Toda, National Aerospace Laboratory, Japan.

"German Space Debris Modelling Activities," Mr. J. Bendisch, Technical University Braunschweig, Germany.

"Orbital Debris Modelling in the United States of America," Mr. N. Johnson, National Aeronautics and Space Administration (NASA), United States.

"Inter-Agency Space Debris Coordination Committee (IADC)," Mr. G. M. Levin and Walter Flury, on behalf of IADC.

"NASDA Space Debris Mitigation Standard," Mr. A. Kato, National Space Development Agency (NASDA), Japan.

"Space Shuttle Program Pre-Flight Meteoroid/Orbital Debris Risk and Post-Flight Damage Assessments," Mr. G. Levin, National Aeronautics and Space Administration (NASA), United States.

"Modelling the Orbital Debris Population," Mr. R. Crowther, Defence Evaluation Research Agency (DERA), United Kingdom.

"Modelling of the Space Debris Environment and Risk Assessment," Mr. W. Flury, European Space Agency.

"Collision of Nuclear Power Sources with Space Debris." Mr. V.S. Nikolaev, Ministry of Atomic Energy, Russian Federation.

"Nuclear Power Sources on Board of Mars 96 Spacecraft," Mr. A. Pustovalov, Russian Academy of Sciences, Russian Federation.

"Management of Water Resources in Developing Countries," Mr. D. El Hadani, Royal Centre for Remote Sensing (CRTS), Morocco.

"Adverse Environmental Impacts on Astronomy," Mr. D. McNally, International Astronomical Union.