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لجنة استخدام الفضاء الخارجي
في الأغراض السلمية

العروض العلمية والتقنية المقدمة الى اللجنة الفرعية العلمية والتقنية في دورتها الثالثة والثلاثين

تقرير مقدم من الأمانة

١ - خلال الدورة الثالثة والثلاثين للجنة العلمية والتقنية التابعة للجنة استخدام الفضاء الخارجي في الأغراض السلمية ، نظمت لجنة أبحاث الفضاء (كوسبار) التابعة للمجلس الدولي للاتحادات العلمية (إكسو) والاتحاد الدولي للملاحة الفلكية (إياف) ، بالاتصال مع الدول الأعضاء ، ندوة حول موضوع "استخدام السواتل الميكروية والسويتلات للتوسع في الأنشطة الفضائية المنخفضة التكاليف ، مع مراعاة الاحتياجات الخاصة للبلدان النامية" ، تكملة للمناقشات بشأن هذا الموضوع في اطار اللجنة الفرعية . وقد عقدت هذه الندوة وفقا للتوصية التي اتخذتها اللجنة الفرعية في دورتها الثانية والثلاثين (A/AC.105/605 ، الفقرة ١٣٦) ، والتي أقرتها لاحقا لجنة استخدام الفضاء الخارجي في الأغراض السلمية في دورتها الثامنة والثلاثين[1] ثم الجمعية العامة في قرارها ٢٧/٥٠ المؤرخ في ٦ كانون الأول/ديسمبر ١٩٩٥ .

٢ - وكانت هذه هي الندوة الثانية عشرة التي تنظمها لجنة الكوسبار واتحاد الإياف أثناء الاجتماعات السنوية للجنة الفرعية العلمية والتقنية ، وتختار اللجنة الفرعية موضوع كل سنة في دورتها السابقة . وقد عقدت الندوة على جزأين ، في يومي ١٢ و ١٣ شباط/فبراير ١٩٩٦ ، بعد اكتمال المناقشة في جلسات بعد الظهر التي عقدتها اللجنة الفرعية خلال الأسبوع الأول من دورتها .

٣ - وعلاوة على العروض الخاصة التي نظمتها لجنة الكوسبار واتحاد الإياف بناء على طلب اللجنة الفرعية ، قدمت وفود الدول الأعضاء عددا من العروض العلمية والتقنية أعدها اخصائيون في علم الفضاء وتطبيقاته تتعلق بمختلف البنود المدرجة في جدول أعمال اللجنة الفرعية . وقدمت أيضا عدة منظمات وطنية ودولية عروضا خاصة بشأن أنشطتها العلمية والتقنية .

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٤ - ومن أجل توسيع النطاق في توافر ما قدم أثناء الندوة والعروض الأخرى من معلومات عن آخر التطورات في علم وتكنولوجيا الفضاء والتطبيقات الفضائية ، أعدت الأمانة ملخصا لهذه المعلومات يرد عرضه أدناه .

٥ - ويتضمن المرفق وصفا أكثر تفصيلا للعروض العلمية والتقنية التي قدمت أمام اللجنة الفرعية العلمية والتقنية في دورتها الثالثة والثلاثين . ويرد المرفق باللغة الانكليزية وحدها . وترد في تذييل المرفق قائمة بالعروض وبأسماء المتكلمين .

أولا - ملخص العروض

ندوة حول استخدام السواتل الميكروية والسويتلات للتوسع في الأنشطة الفضائية المنخفضة التكاليف ، مع مراعاة الاحتياجات الخاصة للبلدان النامية

٦ - قيل انه ، في معظم البلدان النامية ، يمكن استبانة فئتين على الأقل من الاحتياجات الى نظم السويتلات والسواتل الميكروية . ويمكن وصف المجموعة الأولى من الاحتياجات بأنها احتياجات مباشرة تتصل بالمشاكل الاجتماعية والاقتصادية التي يمكن التصدي لها عن طريق مختلف تطبيقات التكنولوجيا الفضائية . أما المجموعة الثانية من الاحتياجات فهي ذات طابع غير مباشر وتتعلق بالتوصل الى وضعية الاستفادة الكاملة من استثمارات البلد في اقتناء النظم والخدمات الفضائية .

٧ - ويسمح استخدام نظم اتصالات المدار الأرضي المنخفض بتقديم الكثير من الخدمات ؛ ومن أكثر تلك الخدمات مدعاة للاهتمام الاتصالات بين طرفية قابلة للنقل وهاتف عادي من هواتف شبكة الاتصالات السلكية واللاسلكية الثابتة الموجودة حاليا . وفي تلك الحالة ، يمكن أن يكون المستعملان موجودين في أي مكان في الاقليم ، ولاسيما في الجهات أو المناطق النائية المفتقرة الى المرافق الأساسية للاتصالات . ويمكن أيضا الاتصال بين مستخدمي هاتفين نقّالين وكذلك بين مستخدم هاتف نقال ومستخدم نظام شبكة ثابتة في أي مكان في العالم .

٨ - ويسمح استخدام منصات جمع البيانات ، مقرونا بخاصيات الاتصال المتبادل التي تتميز بها اتصالات المدار الأرضي المنخفض ، بتنصيب شبكة لجمع البيانات تتميز باتساع نطاق التغطية وتقدم خدمات آنية في وقتها الحقيقي . وعلاوة على ذلك ، يمكن لنظام اتصالات المدار الأرضي المنخفض أن يحدد ، بدقة في نطاق ١٠٠ متر ، موقع أي شخص يستخدم طرفيات نقالة . ويمكن أيضا وصل الطرفية النقالة المرتبطة باتصالات المدار الأرضي المنخفض بجهاز فاكس من أجل بث الرسومات البيانية . وبذلك يتسنى للمستخدم ، مثلا ، أن

يبعث ، عند وجود حالة طبية طارئة في منطقة نائية ، رسالة فاكس الى جهاز تخطيط بياني كهربائي لعمل القلب .

٩ - وتناقل البيانات الطبية عن بعد (الطب البعادي) هو تطبيق من شأنه أن يزيد كفاءة الخدمات الطبية باتاحة ارسال المعلومات المتأتية من أجهزة استشعار زهيدة التكلفة وبسيطة ارسالها مباشرا الى وحدات معقدة لمعالجة البيانات توجد في المراكز الطبية الكبيرة حيث يمكن للأطباء المتخصصين تفسير تلك البيانات . وسيتسنى بذلك وصول خدمات متينة فعالة لمواجهة الطوارىء الى الجهات الفقيرة والمتخلفة النمو ، مما ينقذ حياة الكثيرين ومن شأنه ملافاة الانتقال غير الضروري للمتعالجين . ومشروع الساتل الصحي مثال جيد لتطبيقات الطب البعادي يستخدم فيه ساتل ميكروي وزنه ٦٠ كيلوغراما في مدار أرضي منخفض لبث المعلومات البيانية الطبية بين نيجيريا وأمريكا الشمالية . ويمكن أيضا أن تؤدي الاتصالات بالأجهزة النقالة دورا هاما في حالات الكوارث الطبيعية ، بتيسير وصول المساعدة الى ضحايا الكوارث في وقت أبكر وبتقديم دعم العمليات الادارية الى فرق الانقاذ .

١٠ - وقد أتيحت للكثير من البلدان النامية فرصة مبكرة للحصول على منافع الاستشعار الساتلي عن بعد ، ولكن لا يزال الطريق أمامها طويلا للحصول على الحد الأقصى من المنافع من القدرات الموجودة حاليا . غير أنه توجد على الصعيدين الوطني والاقليمي احتياجات فريدة تتطلب حلولا جديدة . فمثلا تقوم البرازيل وجمهورية كوريا بصوغ برامج ساتلية جديدة بغية تلبية احتياجاتهما المحددة . وتحتاج البلدان النامية الموجودة في أمريكا اللاتينية وجنوب شرقي آسيا وفي مناطق أخرى الى أجهزة استشعار ذات خواص معينة ، مثل النطاقات الطيفية ، واستبانة التفريق الحيزية ، واستبانة التفريق الزمنية ، وتكلفة الصورة ، ومستوى الاستثمار في المعدات الأرضية ، والخبرة الفنية اللازمة لاستخدام الأجهزة .

١١ - وكثيرا ما تدعم الأنشطة الفضائية التعاونية بنوع من أنواع نقل التكنولوجيا . والنجاح في نقل التكنولوجيا في تطوير مشروع الساتل الصغير يستلزم عملية يكتسب بها فريق من العاملين زخما يكفي للتمكن من انتاج الجيل التالي من السواتل الصغيرة . وهناك عدة آليات يمكن بها تحقيق نقل التكنولوجيا ، ولكن لكي يكون النقل ناجحا ينبغي أن يكون نقل معرفة وليس نقل مجموعة من التكنولوجيات (أي معرفة الأسباب علاوة على معرفة طريقة العمل) . وهناك العديد من الأمثلة لبرامج جرى فيها تدريب مهندسين من البلدان النامية على تصميم السواتل الصغيرة وانتاجها وتشغيلها . فمثلا قدمت جامعة سري "Surrey" في المملكة المتحدة لبريطانيا العظمى وايرلندا الشمالية هذا النوع من المساعدة على تطوير السواتل الصغيرة التي يقل حجمها عن ١٠٠ كيلوغرام الى كل من باكستان وجمهورية كوريا وشيلي ، بل حتى الى بلدان صغيرة في أوروبا قررت الشروع في برنامج فضائي .

١٢ - ويجري في الأرجنتين ، بالتعاون مع الولايات المتحدة الأمريكية (جهاز الاطلاق بيغاسوس) ، اعداد مشروع ساتل صغير هو ساتل التطبيقات العلمية - ب "ساك - ب" (B(SAC-B) والغرض الرئيسي من هذا المشروع هو تصميم ساتل ذي حمولة علمية بغية احراز تقدم في دراسة الفيزياء الشمسية والفيزياء الفلكية . وتبلغ كتلة الساتل ١٨٠ كيلوغراما ، والحد الأدنى لعمره النشط المتوقع ثلاث سنوات ، ومن المقرر اطلاقه في عام ١٩٩٦ . ويجري اعداد جيل جديد من السواتل هو ساك-سي SAC-C وساك-دال : SAC-D والهدف منها البحث العلمي والاستشعار عن بعد ، ويعتزم اطلاقها في الفترة من عام ١٩٩٩ الى عام ٢٠٠٦ .

١٣ - وفي البرازيل تعلق أهمية كبيرة على جمع البيانات من المنصات البعيدة بالاستفادة من التكنولوجيا الفضائية . وبدأت بنجاح في شباط/فبراير ١٩٩٣ "البعثة الفضائية الكاملة البرازيلية" بإطلاق الساتل البرازيلي لجمع البيانات (SCD 1) . وظل الساتل عاملا لمدة سنتين بعد انتهاء عمره المجدي المتوقع . وسيطلق ساتلان مماثلان ، على الأقل ، لضمان استمرارية البعثة . وعلاوة على ذلك ، سيستخدم في البعثة أيضا الساتل المحسّن SCD 3 (٢٠٠ كيلوغرام) للايضاح العملي لمفهوم الاتصالات الصوتية والبيانية في المنطقة الاستوائية .

١٤ - وفي شيلي ، سيكون الساتل التشغيلي الأول هو FASat-Bravo الذي تم تطويره بالتعاون مع جامعة سري (المملكة المتحدة) . وسيوضع هذا الساتل الميكروي الذي يبلغ وزنه ٦٥ كيلوغراما في آب/أغسطس ١٩٩٦ في مدار دائري على ارتفاع ٦٥٠ كيلومترا بانحراف ٨٢ر٥ درجة ، وسيحمل تجربة لرصد طبقة الأوزون ، ومعدات لنقل البيانات ، ونظاما تجريبيا لتصوير الأرض ، ومعدات أخرى منها تجربة تعليمية . وباستخدام وصلة الاتصالات التي يهيؤها الساتل ، سيتمكن الطلاب من مزاولة أنشطة دراسية (الميكانيكا المدارية ، وتحليل الاتصالات الساتلية ، وتحليل القياس عن بعد ، الخ .) لمدة يوم أو يومين في الشهر .

١٥ - وبدأ مركز بحوث السواتل التابع للمعهد المتقدم للعلم والتكنولوجيا في كوريا (كايست) ، باطلاق ساتلين ميكرويين علميين وتجريبيين هما كيتسات ١ وكيتسات ٢ في الفترة ١٩٩٢/١٩٩٣ برنامجه الخاص بتطوير تكنولوجيا الفضاء . ويعمل معهد كايست حاليا على تصميم ساتله الجديد المطور محليا وهو "كيتسات ٣" لتعزيز قدرات الساتلين الميكرويين السابقين . ومن الأهداف الأساسية للبرنامج تطوير نظام سواتل ميكروية تتميز بدقة عالية في التحكم في الوضعية وسرعة عالية في بث البيانات وقدرة على اتاحة خبرة مباشرة للصناعات الفضائية ومعاهد البحوث الكورية . وستتمكن حمولة "كيتسات ٣" الخاصة بالاستشعار عن بعد من رصد الكوارث البيئية ، مثل الفيضانات والانفجارات البركانية والأضرار التي تحدثها الزلازل في منطقة آسيا والمحيط الهادىء .

١٦ - وفي جنوب افريقيا ، أسس في عام ١٩٩٢ مشروع السواتل الميكروية سنسات (SUNSAT) لزيادة الفرص المتاحة في مجال التصميم الهندسي لطلاب الدراسات العليا ولتعزيز التفاعل الصناعي والدولي مع جامعة ستيلينبوش . وسيتمكن الساتل الميكروي البالغ وزنه ٦٠ كيلوغراما من اتاحة صور للحقول المزروعة والنباتات الطبيعية والتلوث في جميع أنحاء المعمورة . وسيكون هذا الساتل أيضا صندوق بريد الكترونيا يدور حول الأرض لتلقي وارسال الرسائل وكذلك التجارب التي تقوم بها المدارس في مجال بث الأحاديث والبيانات . وسيقوم جهاز الاطلاق "دلتا" التابع للولايات المتحدة باطلاق "سنسات" في آذار/مارس ١٩٩٧ الى مدار قطبي على ارتفاع يتراوح بين ٤٥٠ كيلومترا و ٨٥٠ كيلومترا ، وسيطلق معه الساتل الدانمركي "اويرستد" الخاص ببحوث الغلاف المغنطيسي . وسيحمل "سنسات" أيضا جهاز الاستقبال الملاحي الخاص بالشبكة العالمية لتحديد المواقع والتابع للادارة الوطنية للملاحة الجوية والفضاء (ناسا) ، ومجموعة من عاكسات أشعة اللازر خاصة بتجارب التحديد الدقيق للمواقع .

١٧ - وعهدت اللجنة المشتركة بين الوزارات للعلم والتكنولوجيا في أسبانيا في عام ١٩٩٢ الى المعهد الوطني للتكنولوجيا الفضائية الجوية في مدريد بمشروع فضائي أسباني هو مينيسات (MINISAT) . وستطلق ابتداء من عام ١٩٩٦ بواسطة أجهزة اطلاق بيغاسوس المحمولة جوا سواتل أنموطية تتراوح أوزانها بين ١٨٠ كيلوغراما و ٥٠٠ كيلوغرام (رهنا بعدد وحدات الأنموطات المستخدمة) . وسيتألف الساتل الأول "مينيسات ٠١" (MINISAT 01) من المنصة الرئيسية وسيستخدم للبحوث العلمية . وسيكون الساتل "مينيسات ١" نسخة مطورة مزودة بأجهزة للاستشعار عن بعد ، وسيستخدم الساتل مينيسات ٢ المنصة الرئيسية لاتاحة الاتصالات البعيدة المدى حتى من المدار الثابت بالنسبة الى الأرض .

١٨ - وأطلق في ٣ آب/أغسطس ١٩٩٥ ساتل فرعي صغير هو ماغيون ٤ (MAGION 4) مع الساتل "الأم" انتربال ١ (INTERBALL 1) . وانفصل "ماغيون ٤" عن الساتل الأم بعد الوصول الى المدار المقصود (نقطة الأوج ٩٠٧ ١٩١ كيلومترات ، نقطة الحضيض ٧٩٣ كيلومترا ، الميل ٦٣ درجة) . وكانت كتلة الساتل تزن ٦٠ كيلوغراما ، وجرى تطويره بالتعاون بين معهد فيزياء الغلاف الجوي (الجمهورية التشيكية) وجامعة التكنولوجيا في غراتس (النمسا) ومعهد بحوث الفضاء (الاتحاد الروسي) . وكانت حمولته العلمية تهدف الى دراسة المجال المغنطيسي الأرضي والظواهر الموجية والبارامترات البلازمية للغلاف المتأين ، في اطار المشروع الفضائي انتربال INTERBALL . وقيام ساتلين يبعد أحدهما عن الأخر مسافة صغيرة بقياسات متزامنة يسمح باستبانة التفريق الزمانية والمكانية للظواهر المرصودة .

١٩ - وساتل أوروبا الوسطى للأبحاث المتقدمة (سيزار) (CESAR) هو مركبة فضائية تزن كتلتها نحو ٣٠٠ كيلوغرام يعتزم اطلاقها في عام ١٩٩٨ وستطير في مدار حضيضة ٤٠٠ كيلومتر وأوجه ٠٠٠ ١ كيلومتر وميله ٧٠ درجة . وستكون هذه البعثة العلمية متصلة بدراسة بيئة الغلاف المغنطيسي والغلاف المتأين والغلاف الحراري . وستحمل على متن المركبة الفضائية ، التي تقوم بتشييدها الوكالة الفضائية

الايطالية (أسي) (ASI) ، عشر تجارب مختلفة يقدمها علماء من بولندا والجمهورية التشيكية وسلوفاكيا والنمسا وهنغاريا .

٢٠ - وأنشىء في الوكالة الفضائية الفرنسية في نهاية عام ١٩٩٣ فريق عامل معني بالسواتل الصغيرة ، لاقتراح توصيات لتطوير سلسلة من السواتل الصغيرة متممة لمجموعة سواتل النظام التجريبي لرصد الأرض ، بتكلفة لا تقل عن ٣٠٠ مليون فرنك فرنسي لكل بعثة ، وستبلغ فترة التطوير عامين . وأطلق على النظام الموصى به اسم "المنصة القابلة لإعادة التشكيل والخاصة بالرصد والاتصالات السلكية واللاسلكية والاستخدامات العلمية" (بروتيوس) (PROTEUS) . ويتوخى أن تكون الرحلة الأولى في عام ١٩٩٩ ، استمرارا لمشروع سواتل قياس الارتفاعات "طوبيكس - بوزيدون" المشترك بين فرنسا والولايات المتحدة ، وهو مشروع ناجح .

٢١ - ويمكن وصف البعثات التي ينظر فيها في اطار مبادرة "فرص البعثات الصغيرة" التابعة للوكالة الفضائية الأوروبية ، بواسطة البارامترات التالية : كتلة الاطلاق من ١٥٠ كيلوغراما الى ٥٠٠ كيلوغرام ، والمدار بين ٦٠٠ كيلومتر و ٩٠٠ كيلومتر ، ووقت التطوير نحو سنتين ، والتكلفة أقل من ٤٠ مليون وحدة نقدية أوروبية للمنصة والتجميع ، والاطلاق للدفع الى المدار ، والاختبار ، والمحطة الأرضية الخاصة بالمستعملين . والفكرة الأساسية من مبادرة فرص البعثات الصغيرة هي الشراء الجماعي لجزء من عناصر البعثات التالية أو كلها : الاطلاق ، وتجميع المنصة ، والقطاع الأرضي . ويفترض أن يحقق هذا النهج منافع تخفيض التكاليف المتعلقة بهذه العناصر المتكررة من عناصر البعثات .

٢٢ - والى جانب الدعم (المساعدة التكنولوجية وترتيبات الاطلاق) التي تقدمها وكالة ناسا الى الدول الآخذة في ارتياد الفضاء ، اعتمدت "مبادرة تكنولوجيا المركبات الفضائية الصغيرة" الخاصة بها . ويتوقع أن يؤدي هذا البرنامج التكنولوجي الى تخفيض التكاليف ووقت التطوير للبعثات العلمية الخاصة بالتطبيقات العلمية والتجارية . ويفترض أن يحقق نسبة حمولة الى الكتلة الكلية تصل الى ٧٠ في المائة وأن يكون الزمن اللازم منذ التطوير الى الأهبة للطيران سنتين . ولتحقيق هذه الأهداف ، ينبغي اجراء تجارب ايضاح عملي للطرائق الجديدة لتصميم واثبات أهلية المركبات الفضائية الصغيرة باستخدام مواصفات تجارية ومستندة الى الأداء ، وادماج تكنولوجيا الآلات الصغيرة في تصميم حافلة السواتل ، وتطوير المنتج من البداية الى النهاية ، والتحقق من الرحلة . ويتوقع أن تحقق قدرات وكالة ناسا مستقبلا في مجال البعثات الفضائية تخفيضا بنسبة ٣٠ - ٦٠ في المائة في التكاليف وادخال تكنولوجيا جديدة في البعثات .

٢٣ - وتقوم وكالة ناسا أيضا باعداد مجموعة من البعثات العلمية الكوكبية الصغيرة الزهيدة التكلفة في اطار برنامجها "ديسكفري" . وهذه البعثات مصممة لإتاحة فرص متواترة للبحوث (اطلاق واحد كل ١٢ - ١٨ شهرا) لأوساط البحوث الكوكبية ، مع تشجيع الشراكات مع الصناعة . ويمكن ترشيح جميع الأهداف

والغايات الخاصة بالمجموعة الشمسية للاستفادة من برنامج "ديسكفري" ، ولكن تكلفة المركبات الفضائية ينبغي أن تكون منخفضة وينبغي أن تكون مركبة الاطلاق من طراز مركبة الاطلاق "دلتا" أو أصغر منها . وقد ورد ما مجموعه ٢٨ اقتراحا تلبية لاعلان الفرص الأول ، شملت كامل نطاق الغايات العلمية الكوكبية (سيصدر اعلان الفرص التالي في أيار/مايو ١٩٩٦) . وقد وفر التمويل الكامل للبعثات الأربع الأولى ، ويجري تطويرها على حسب الجدول الزمني المقرر وفي حدود التوجيهات الخاصة بالتكلفة .

ثانيا - العروض العلمية والتقنية الأخرى

ألف - الحطام الفضائي

٢٤ - أفيد بأن نظام الرصد الفضائي الخاص بالقيادة الفضائية التابع للولايات المتحدة يجري بانتظام عمليات تعقب وتصنيف مصور للأجسام المتحركة في الفضاء القريب من الأرض . ويشغل هذا النظام أكثر من ٢٤ رادارا وعدة مرافق بصرية لرصد الفضاء القريب من الأرض ، ويحتفظ بفهرس مصنف للعناصر المدارية لكل الأجسام التي تم تعقبها (يزيد عددها حاليا على ٠٠٠ ٨) . ويبلغ القطر الأدنى للأجسام التي أمكن رصدها ١٠ سنتيمترات تقريبا فيما يتعلق بالأجسام الموجودة في المدار الأرضي الأفقي ، ويبلغ مترا واحدا فيما يتعلق بالأجسام الموجودة في المدار الثابت بالنسبة للأرض . ففيما يتعلق بالأجسام الموجودة في المدار الثابت بالنسبة للأرض ، يتم تعقبها بشكل رئيسي بواسطة النظام البصري المخصص لهذا الغرض وأسمه نظام رصد (المدار التزامني بالنسبة للأرض) ورصد الفضاء السحيق . وبالاضافة الى ذلك ، يوجد رادار خاص في هايستاك (بالقرب من بوسطون في ولاية ماساتشوستس) قادر على اكتشاف الأجسام التي يقل قطرها على سنتيمتر واحد والتي توجد في المدار الأرضي المنخفض وعلى الحصول على معلومات احصائية عن عددها وتدفقها وحجمها وارتفاعها . وهنالك فيما يبدو أكثر من ٠٠٠ ١٠٠ حطام فضائي في المدار الأرضي المنخفض بأحجام أقل من سنتيمتر واحد .

٢٥ - وأفيد بأن أكبر مرفق راداري للتعقب في أوروبا الغربية ، وهو يوجد في المؤسسة البحثية للعلوم التطبيقية في فاختبرغ - فرتهوفن (ألمانيا) ، يستخدم طبقا هوائيا مكافئا قطره ٣٤ مترا . وتشكل البيانات المستمدة من ذلك الموقع اضافة هامة الى البيانات المفهرسة المصورة في حالة التنبؤات برجوع الحطام الفضائي الذي يمثل خطورة كبيرة . وقد تولت الوكالة الفضائية الأوروبية الاضطلاع ببحث يتعلق بجدوى تعقب وكشف الحطام المتوسط الحجم (الذي يتراوح حجمه بين ١ و ٥٠ سنتيمترا) . وفيما يتعلق بقياس الحطام بواسطة المقراب البصري ، سوف تستخدم الوكالة الفضائية الأوروبية مقرابا من نوع "زايس" طوله متر واحد ويجري تركيبه حاليا لأغراض أخرى في مرصد تايد في تينيريف (جزر الكناري ، في خط العرض الشمالي بدرجة ٣ر٢٨) . وسيكون الحجم الأدنى للأجسام التي يمكن كشفها متراوحا بين ٢ و ٦ سنتيمترات فيما يتعلق بالأجسام الموجودة في المدار الأرضي المنخفض وبين ٢٠ و ٤٠ سنتيمترا فيما يتعلق بالمدار

الثابت بالنسبة للأرض . ومن المتوقع أن يكون المقراب جاهزا للاستخدام في عمليات رصد الأجسام الفضائية في مطلع عام ١٩٩٧ .

٢٦ - وأفيد بأن المعلومات عن الجسيمات التي هي أصغر من ميليمتر واحد يتم الحصول عليها بشكل رئيسي ، بواسطة مكاشيف خاصة محمولة على متن مركبات فضائية أو بواسطة تحليل الارتطام بالمواد التي عرضت للبيئة الفضائية . وقد حلل العديد من الباحثين الأوروبين ملامح الارتطام على مرفق ناسا لدراسة التعرض الطويل الأمد ، وذلك بعد استرجاعه في كانون الثاني/يناير ١٩٩٠ ، وعلى الناقلة الأوروبية التي يمكن استردادها وعلى الصفيفة الشمسية المستردة من مقراب "هابل" الفضائي . وتبلغ أقطار أكبر الثقوب ٥ ميليمترات تقريبا . وسوف تستخدم نتائج هذه التحاليل لاثبات صحة نماذج الدفق المرجعية الحالية فيما يتعلق بالنيازك الصغيرة والحطام الفضائي .

٢٧ - وأفيد بأن عمليات فحص النوافذ ولوحات أجهزة الاشعاع وغيرها من السطوح الخاصة بالأجسام المدارية التي يطلقها مكوك الفضاء التابع للولايات المتحدة تكشف أن النماذج البيئية تقدر كمية الحطام الدقيق تقديرا ناقصا وأن هذه الكمية آخذة في الازدياد مع مرور الزمن . وفي حين أن المصد النموذجي لضرر الحطام الفضائي التابع لوكالة ناسا تنبأ بتغيير ١٣ نافذة في ١٢ رحلة من رحلات المكوك ، فان العدد الفعلي للتغييرات بلغ ١٩ . وفي فرنسا ، استخدمت بيانات اضافية مستمدة من التعرض طيلة عام واحد للبيئة الفضائية على متن محطة مير الفضائية (رحلة آراغاتس) ، وذلك للمقارنة مع نماذج بيئة الحطام الفضائي .

٢٨ - وأفيد بأنه درست في المملكة المتحدة مخاطر الحطام المتفردة المقترنة بمجموعات السواتل المقترحة . وتمثل المجموعات الساتلية عددا من السواتل موزعة هندسيا تمكن من تحديد المواقع عالميا أو رصد الأرض أو الاتصالات الشخصية بالأجهزة المحمولة باليد ، أو الارسال أو نقل البيانات . وثمة اقتراحات بشأن عدد كبير من الأنشطة الجديدة ، وهذا يعني أن أكثر من ٠٠٠ ١ ساتل جديد ستوضع في مدارات شديدة الانحناء على ارتفاعات تتراوح بين ٧٠٠ - ٨٠٠ كيلومتر و ٢٠٠ ١ - ٤٠٠ ١ كيلومتر في غضون ٤ - ٦ أعوام . وسوف يفضي تحقيق هذه المشاريع الى تركزات للكتلة الساتلية في بعض مناطق الفضاء حول الأرض .

باء - استخدام مصادر القدرة النووية في الفضاء الخارجي

٢٩ - أفيد بأن الاتحاد الروسي أجرى تحليلا رقميا يتصل باحتمالات تصادم مصادر القدرة النووية مع الحطام الفضائي . وقد بحثت بوجه خاص الاحتمالات التالية : تحطم هيكل مصادر القدرة النووية ؛ وتغير البارامترات المدارية لمصادر القدرة النووية بعد التصادم ؛ ودخولها في الغلاف الجوي ؛ والتحطم المحتمل في الغلاف الجوي ؛ وسقوط جسيمات لمواد سامة اشعاعية وأجزاء من هيكل مصادر القدرة النووية . وقد

بحث التصادمات مع الحطام الفضائي فيما يتعلق بالمفاعلات التي أطلقت في الفترة ١٩٧٠ - ١٩٨٨ وقذفت في مدارات يتراوح ارتفاعها بين ٧٠٠ و ١٠٠٠ كيلومتر . وخلص الى أن احتمالات التصادم مع الحطام الفضائي ، الكفيل بالحاق ضرر بالغ بمصادر القدرة النووية ، كبيرة بالقدر الكافي وتصل الى مرة في كل ٥٥ عاما .

٣٠ - وأفيد بأن الأبحاث المتعلقة بالتدمر الدينامي - الهوائي لمصادر القدرة النووية ولمجموعة قضبان الوقود خلال نزولها الى الغلاف الجوي بعد تصادمها في مسار العودة الأولي (الارتفاع ١٦٠ كيلومترا) تؤكد أن هيكل مصادر القدرة النووية يتحطم وأن أوتاد وقود المفاعل (سبيكة اليورانيوم - الموليبدين) تذوب الى أن تصبح جسيمات يقل حجمها عن مليمتر واحد . وقد كشفت النتائج أن السقاطة من جسيمات الوقود النووي هذه ، مما يفضي الى اضمحلال ناتج انشطار اليورانيوم وقت التصادم ، لن يؤدي الى تغير هام في مستويات الاشعاع على منطقة السقوط . ويمكن أن يمثل سقوط أجزاء عاكس البيريليوم وحجاب الاشعاع المخفق جزئيا والمتكون من هيدريد الليثيوم تهديدا من حيث السمية ، وهذا ما يستدعي اتخاذ تدابير عاجلة تتعلق بالبحث والتطهير (الازالة) .

٣١ - وأفيد بأن الدراسات ما زالت متواصلة في المملكة المتحدة بشأن امكانية اضافة ملحقات الى المبادىء ، المتصلة باستخدام مصادر الطاقة النووية في الفضاء الخارجي ، التي اعتمدتها الجمعية العامة في قرارها ٦٨/٤٧ المؤرخ ١٤ كانون الأول/ديسمبر ١٩٩٢ . ففي حين أن هذا القرار تضمن اتفاقات قيمة بتوافق الآراء بشأن مواضيع كالتشاور ومساعدة الدول المتضررة من حادث والتبعات والتعويض ، فهو يشوبه عدد من النقائص ، منها عدم شمل قواعد الدفع والقواعد الموجودة خارج الأرض ؛ وصوغ المبادىء بحيث تتعلق بتكنولوجيات محددة ؛ وتجاهل الآثار المحتملة الناجمة عن الحطام الفضائي ؛ وحالات التضارب مع مبادىء السلامة التي تتسم بنضج أكثر والتي صيغت بشأن التطبيقات الأرضية للطاقة النووية . لذلك ، اقترح تنقيح المبادىء الآنفة الذكر بحيث تعمم النوايا المجسدة في قرار الجمعية العامة ٦٨/٤٧ على نحو يتسق مع التطورات الدولية اللاحقة تحت اشراف اللجنة الدولية المعنية بالحماية من الاشعاع والوكالة الدولية للطاقة الذرية .

جيم - الاستشعار عن بعد

٣٢ - أفيد بأن الهند ، بنجاحها في تصميم الجيل الأول من الساتل الهندي للاستشعار عن بعد ، وانشائه واطلاقه وبنجاح أداء هذا الساتل في المدار ، بدأت تمضي قدما في سبيل توفير خدمات محسنة ومطورة للبيانات بفضل الجيل الثاني من سواتل الاستشعار عن بعد IRS-1C و IRS-1D . فالساتل IRS-1C ، الذي أطلق في ٦ كانون الأول/ديسمبر ١٩٩٥ ، يتميز بقدرة أفضل على التحليل أو التفريق الحيزي ، وموجات طيفية أطول ومشاهدة مجسمة وقدرة أسرع على المعاودة . والى جانب التطبيقات المتعلقة برسم الخرائط ،

تتطرق رحلة الساتل IRS-1C بشكل رئيسي الى المجالات التالية : التطبيقات المتعلقة بالمحاصيل والنبات مع الاشارة بشكل محدد الى التمييز بين النباتات والمحاصيل المختلطة ؛ والبارامترات البيولوجية والتطبيقات الأوقيانوغرافية - وبوجه خاص عمليات رصد بارامترات أوقيانوغرافية مادية كالرياح ودرجة الحرارة على سطح البحر والأمواج ، الخ ؛ والتطبيقات المتعلقة بالغلاف الجوي لرصد تغيرات عالمية كاستنفاد طبقة الأوزون فوق منطقة القطب الجنوبي .

٣٣ - وأفيد بأن أنشطة أبحاث الفضاء في المغرب ، فيما يتصل بالاستشعار عن بعد والرصد البيئي ، تتميز بسياسة عامة نشيطة وواقعية وطويلة الأجل على كل من الصعيد الوطني (التنسيق والاعلام والتدريب وصوغ المشاريع) والصعيد الدولي (المشاركة في المحافل واللجان الدولية والمشاريع الثنائية والمتعددة الأطراف) . وبدأ استخدام الفضاء الخارجي في المغرب يزداد تطورا واتساعا وتنوعا أكثر فأكثر . وفيما يتعلق بالبيانات الساتلية ثمة حاليا محطات عاملة لتلقي البيانات من ساتل الأرصاد الجوية "ميتيوسات" ، وذلك مثلا في الادارة الوطنية للأرصاد الجوية . وثمة خطط لانشاء محطتين للادارة الوطنية بدراسة المحيطات والغلاف الجوي ، احداهما تخصص للدراسات المتعلقة بالأرصاد الجوية في الادارة الوطنية للأرصاد الجوية ، والأخرى في المركز الملكي للاستشعار عن بعد في المغرب لاستقبال بيانات المقياس الاشعاعي المتقدم ذي القدرة التحليلية العالية جدا . ومن المعتزم انشاء هذه المحطة في اطار مشروع GLOVE الذي تشترك الجماعة الأوروبية في تمويله .

٣٤ - وأفيد بأن جيوسبيس GEOSPACE ، وهي شركة توجد في النمسا ، تدير مشروعا لرسم خريطة عالمية بغية انتاج أطلس رقمي للعالم . ويهدف مشروع رسم خريطة العالم بواسطة الصور الساتلية الى وضع نظام عالمي للمعلومات الجغرافية يكون سهل الاستخدام وفعالا من حيث التكلفة وفي المتناول بسهولة حتى يتسنى تحديثه باستمرار بما يستجد . ويجري القيام بالدراسات على كل من الصعيد المحلي والاقليمي والدولي .

٣٥ - وأفيد بأن الأمين العام للجمعية الدولية للمسح التصويري والاستشعار عن بعد استعرض الوضع فيما يتعلق بالسواتل التجارية الجديدة للاستشعار عن بعد . ويقصد من هذه السواتل الجديدة أن توفر بيانات ذات قدرة تحليلية عالية تصل الى ما بين مترين و ٥ أمتار في مجالات الرصد الجوي ورسم الخرائط والموارد الطبيعية والتصوير لأغراض تجارية . أما البلدان التي اشتركت في الآونة الأخيرة في انشاء هذه السواتل التجارية للاستشعار عن بعد فهي الاتحاد الروسي وألمانيا وفرنسا والهند والولايات المتحدة واليابان . وعلاوة على ذلك ، فان الوكالة الفضائية الأوروبية تضطلع بدور رئيسي في انشاء سواتل جديدة للاستشعار عن بعد . وعند القاء نظرة استشرافية على العقد المقبل ، يتبين أن من المعتزم تنفيذ ٩٩ حمولة من حمولات سواتل رصد الأرض ، ومن المقرر انشاء ٥٧ حمولة منها في غضون الأعوام الخمسة القادمة . وسوف يكون

للحمولات الجديدة ، دور هام في احراز تطور في سبيل التصوير المسحي الرقمي والاستشعار الرقمي عن بعد .

دال - الجامعة الدولية للفضاء

٣٦ - أفيد بأن الجامعة الدولية للفضاء ، التي أنشئت في عام ١٩٨٨ تركز الاهتمام على برنامج دولي متعدد التخصصات ومتعدد الثقافات للتثقيف في مجال الفضاء . وتساهم الجامعة الدولية للفضاء في تكوين الفنيين اللازمين في الأوساط الدولية المعنية بالفضاء ، ومنهم المبدعون والمبتكرون والمديرون والقادة . وتكرس الجامعة جهودها لتثقيف الفنيين من كل الاختصاصات في المجالات ذات الصلة بالفضاء وايجاد المعرفة وتوسيع نطاقها من خلال البحث وتبادل المعرفة والأفكار وتعميمها .

٣٧ - وتقدم الجامعة في برامج دورتها الصيفية محاضرات شاملة في جميع الاختصاصات ذات الصلة بالفضاء وتفاعلاتها . وعلاوة على ذلك ، جرى تصميم مشروع دولي بشأن الفضاء خلال المنهاج الدارسي الصيفي ، ويفضي هذا المشروع الى صدور تقرير فني ذي فائدة عملية بالنسبة لأوساط الفضاء الدولية . وبالاضافة الى برامج الدورة الصيفية ، استحدثت الجامعة في الآونة الأخيرة برنامجا للدراسات الفضائية يتوج بشهادة الماجستير ، وذلك في ستراسبورغ ، فرنسا . ويتألف برنامج التخرج هذا الذي يدوم سنة واحدة من العناصر الرئيسية التالية : (أ) العلوم والتطبيقات ؛ و (ب) الهندسة والنظم والتكنولوجيا ؛ و (ج) الادارة والعلوم الاجتماعية .

هاء - النقل الفضائي

٣٨ - أفيد بأن الاتحاد الروسي ما زال يستخدم أجهزة الاطلاق من الفئة المتوسطة والثقيلة ، وهي من نوع سويوز ومولنيا وبروتون ، وذلك لاطلاق حمولات للاتصالات وحمولات علمية وحمولات عديدة أخرى في مدارات مختلفة (منها المدار الثابت بالنسبة للأرض) . وقد أنشىء جهازا الاطلاق تسيكلون وزينيت بالتعاون مع أوكرانيا . وتعد أكثر محطات الاطلاق استخداما في العالم - وهي المحطة الموجودة في بليستسك - مسؤولة عن نسبة ٦٠ في المائة من عمليات الاطلاق الروسية ونسبة ١٠ في المائة من عمليات الاطلاق العالمية الأخرى . وخلال الأعوام الـ ٣٠ من وجودها (منذ آذار/مارس ١٩٦٦) ، أنجزت ما يقرب من ٥٠٠ ١ عملية اطلاق ناجحة . ويجري احراز تقدم في الخطط المتعلقة بامكانية القيام تدريجيا ببناء محطة اطلاق روسية جديدة في سفوبودني (منطقة آمور) في الجزء الشرقي من البلد .

٣٩ - وتستخدم الصواريخ العسكرية المحولة التي هي من طراز ستارت - ١ Start-1 والصواريخ الأقوى منها والتي هي من طراز ستارت Start وروكوت Rockot الوقود الصلب ، وهي ستستخدم أيضا في برنامج

الفضاء . وثمة مؤسسة فضائية روسية ومركز أوكراني للبحث والانتاج يسمى يوجنيه Yuzhnoe وشركة تابعة للولايات المتحدة وشركة نرويجية لبناء السفن ، تتعاون كلها في اطار كونسورسيوم دولي على اعداد عمليات اطلاق تجارية من منصة بحرية بالقرب من خط الاستواء .

٤٠ - وتؤيد رابطة مكتشفي الفضاء وتقر مفهوم "الجائزة إكس" ، وهي جائزة قدرها ١٠ ملايين دولار أمريكي لتشجيع الصناعة الخاصة على انشاء مركبة قابلة للاستخدام المتكرر وأحادية المراحل ودون مدارية ، تكون قادرة على حمل ثلاثة أشخاص كبار (٣٠٠ كغم) الى ارتفاع لا يقل عن ١٠٠ كيلومتر فوق الأرض . وتعتقد الرابطة أن الجائزة إكس ستستثير الاهتمام العام باستكشاف الفضاء والتنمية ، وأنها ستفضي الى امكانية تحليق عديد من الناس في الفضاء ، وهي أهداف تسعى الرابطة الى تحقيقها .

واو - علم الفلك واستكشاف الكواكب

٤١ - في مطلع عام ١٩٩٥ ، استاءت الأوساط الفلكية الدولية لصدور اقتراح نشر نيابة عن منظمة الأمم المتحدة للتربية والعلم والثقافة ويتعلق بالاحتفال بالذكرى الخمسين لتأسيسها بواسطة اطلاق جهاز انعكاس شمسي يسمى "نجمة التسامح" وكان معتزما أن يكون على شكل نجمتين تشملان منطادين انعكاسيين (أحدهما قطره ٥٠ مترا والآخر ٣٠ مترا ، ويكونان موصولين ببعضهما برباط طوله كيلومترين) . وهو مصمم لكي يكون في مدار الأرض على ارتفاع ٢٥٠ ١ كيلومترا وأن يسطع مثل النجمة سيريوس بل وحتى مثل الكوكب المشتري . ولحسن الحظ ، تم التخلي عن هذا المشروع . و"النجمة" في حد ذاتها لم تكن لتمثل كارثة من حيث علم الفلك ، مع أنها كانت ستمثل خطرا كبيرا . فالذي أثار قلقا كبيرا في الأوساط الفلكية هو ما كان سيشكله هذا المشروع من سابقة فيما لو تم تنفيذه . فهو كان سيمثل اشارة واضحة الى أن من المقبول ثقافيا وعلميا وتربويا استخدام أجهزة عاكسة شمسية محمولة جوا لبث رسائل على صعيد دولي .

٤٢ - وفي مجال علم الفلك الراديوي ، أفيد بأن هنالك مشاكل ذات صلة بالارسال الراديوي الاصطناعي انطلاقا من السواتل المدارية . فقد تم في الآونة الأخيرة حل مشكلة التشويش الناجم عن الشبكة العالمية لسواتل الملاحة البحرية (غلوناس) على التردد ٦١٢ ١ ميغاهرتز . وبالتالي ، فان ظروف رصد خط ميزر الهام بشأن الأوكسجين - الهيدروجين على تلك التردد سيتحسن بسرعة . ولكن ، ثمة نظام جديد مقترح للاتصالات الساتلية ، هو الايريديوم ، يهدد من جديد الاستخدام الفلكي الراديوي لتلك الموجة . وبالرغم من أن الايريديوم والمرصد الوطني لعلم الفلك الراديوي التابع للولايات المتحدة توصلا الى مذكرة تفاهم ، فقد اعتبرت بقية الأوساط الفلكية الراديوية ، لأسباب وجيهة ، هذا الاتفاق الثنائي أساسا ضعيفا للاستناد اليه في المستقبل . فما يحتاج اليه هو نوع من التفويض التشغيلي الذي يتيح تعايش علم الفلك والحضارة والصناعة والتجارة .

٤٣ - وأفيد بأن مشروعا متنقلا آخر للاتصالات ، يدعى تيليديسك Teledisc ، يسعى الى أن يخصص له تردد في نطاق التردد العالي جدا والمتراوح بين ١٩ و ٢٩ غيغاهرتز ، وهو طول موجة ميليمترية غير مخصص حتى الآن . وهذه المنطقة الطيفية ذات أهمية بالغة لدى علم الفلك الراديوي ، حيث ان هنالك انبعاثات خطية عديدة بين الكواكب . فالتقاط تلك الاشارات التي هي ذات طبيعة كيميائية كونية سيكون ذا أهمية حاسمة في تحديد حجم الجزيئيات الكيميائية التي يمكن تكونها وتحديد المكان الذي تحصل فيه تلك العمليات . وسوف يتعين التزام عناية كبيرة في تخصيص نطاق التردد الميليمتري للاتصالات ، اذا أريد الحفاظ على امكانية الحصول على هذه المعلومات الفلكية البعيدة المدى .

٤٤ - وقد عقد المؤتمر الدولي المعني بالأجسام القريبة من الأرض في نيويورك في الفترة من ٢٤ الى ٢٦ نيسان/أبريل ١٩٩٥ . واشترك في رعاية هذا المؤتمر كل من نادي المكتشفين وجمعية الدراسات الكوكبية والأمم المتحدة . وكان موضوع المؤتمر ، وهو الأجسام القريبة من الأرض ، يتعلق أساسا بالمذنبات والكويكبات السيارة التي يمكن أن تتقاطع مداراتها مع مدار الأرض حول الشمس . وبما أنه كان هنالك ادراك عام أن ارتطام جسم قريب من الأرض حجمه كيلومتر واحد ستكون له نتائج وخيمة على الغلاف الحيوي الأرضي ، فان تقدير مدى احتمالات وقوع ذلك له بعض الأهمية . وقد بين علم الفلك وعلم الكواكب أن الفوهات سمة منتشرة ان لم تكن سائدة على الكواكب والأقمار والكويكبات السيارة الموجودة في النظام الشمسي الداخلي . وتدل دراسات مفصلة لسجل حدوث الفوهات على أن ارتطام جسم قريب من الأرض حجمه كيلومتر واحد أو أكثر هو حدث حافل بانتظام وله استمرارية على مدى مقاييس زمنية كبيرة .

٤٥ - وينبغي أن ينصب التركيز الرئيسي للبحث في مجال الأجسام القريبة من الأرض في الوقت الحاضر على السعي الى اكتساب معرفة أوسع بمصدر الكويكبات السيارة و المذنبات التي يمكن أن تتفاعل مع البيئة الفضائية المباشرة للأرض ، وتطورها وخصائصها الدينامية والمادية . ويجب الاستجابة لوعي الناس المتزايد بالأجسام القريبة من الأرض وما يقترن بها من مخاطر ناجمة عن احتمال ارتطامها بتفسير ينم عن مسؤولية ويقوم على معرفة علمية . ومن ذلك المنظور ، تتيح الأبحاث في مجال الأجسام القريبة من الأرض فرصة للقيام بأبحاث علمية متعددة التخصصات في مجال علوم الفضاء الأساسية وذلك عن طريق التعاون الدولي .

الحواشي

(١) **الوثائق الرسمية للجمعية العامة ، الدورة الخمسون ، الملحق رقم ٢٠** (A/50/20) ، الفقرة ١٠٢ .

*Annex**

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 UTILIZATION OF MICRO- AND SMALL SATELLITES FOR THE EXPANSION OF LOW-COST SPACE ACTIVITIES

A. Use of Small Satellite Technology in Developing Countries

In view of the growing interest in the subject of small satellites, the International Academy of Astronautic (IAA) established in 1993, the Subcommittee on Small Satellites for Developing Nations. The Subcommittee considers small satellites to be a driving force for developing countries to initiate a space programme, train their personnel and develop their research and technological infrastructures. In most developing nations, at least two categories of needs for small and micro-satellite systems can be identified. The first group may be classified as direct needs, and relates to social and economical problems which may be addressed through various applications of space technology. The second group may be classified as indirect needs and deals with attaining the condition of taking full advantage of a country's investments in acquisition of space systems and services.

Direct needs can be further classified by geographic location, types of services and products or types of applications. Although some developing nations present some developed areas where the needs are very similar to those of developed nations, today it is more significant to focus on problems such as communications and monitoring of remote areas, agricultural land use and environmental protection.

The use of Low Earth Orbit Communications (LEOCOM) systems allows many services. One of the most interesting is the communication between a portable terminal and a normal telephone connected to the existing fixed telecommunication network. In this case, the two users may be located anywhere in the territory and, in particular, in remote areas or regions lacking a communications infrastructure. Communication between two mobile users as well as between a mobile user and a user of the fixed network system anywhere around the globe is also possible.

The use of automatic Data Collection Platforms (DCP), in conjunction with the two-way characteristics of LEOCOM allows for the installation of a data collection network which features wide coverage and provides real-time service. In addition, the LEOCOM system can provide the location of any user of mobile terminals with an accuracy in the hundred meter range. The LEOCOM mobile terminal can also be coupled to a facsimile machine for the transmission of graphical data. In this regard, for instance, it allows a user to send a facsimile of an electrocardiogram in the case of a medical emergency in a remote area.

Telemedicine is an application which will increase efficiency of medical services by allowing the transmission of information obtained by inexpensive and simple sensors directly to complex processing units in large medical centres where it might be interpreted by specialized physicians. This makes it possible for powerful and effective emergency services to reach poor and undeveloped areas, saving many lives and avoiding unnecessary displacement of patients. The Healthsat project is a very good example of a telemedicine application using a 60 kg micro-satellite in low Earth orbit (LEO) to relay medical data information between Nigeria and North America. Mobile communications may also play an important role in the case of natural disasters, allowing for help to reach the disaster victims earlier and providing logistic support to rescue teams.

Many developing nations have had an early access to the benefits of satellite remote sensing, but still have a long way to go in order to maximize the benefits allowed by the existing capabilities. There are, however, unique needs at both national and regional levels that demand new solutions. Brazil and the Republic of Korea for instance, are already developing new satellite programmes to address their specific needs. Developing countries in Latin America, South-East Asia and in other regions require special sensor parameters such as spectral bands, spatial resolution and time resolution. This in turn merits an examination of the cost of images, the level of investment in ground equipment, and the expertise required for utilization.

As a consequence of the relative lack of space science studies in the southern hemisphere, several natural phenomena that occur in the upper atmosphere in the tropical and southern hemisphere zones are not adequately understood. This concerns, for example, the ionospheric plasma depletions which occur over South America and strongly interfere with radio communications as well as the South Atlantic Anomaly which is well known for the occurrence of energetic particles stemming from the inner radiation belt and causing severe damage to, or even complete destruction of, satellite instrumentation. Therefore, it seems highly advisable that developing countries that are located in the southern hemisphere and, in particular, in the tropical zone, join the global effort towards improving the knowledge of their own space environment. Many such countries have been engaged in astrophysical studies (particularly of the sky regions which are not observable from the northern hemisphere) in the past few decades and small satellites would be an important means of complementing these ground-based studies.

Cooperative space activities are often supported by some kind of technology transfer. A successful technology transfer in the development of a small satellite project implies a process by which a team acquires sufficient momentum to be able to produce the next generation of small satellites. There are several mechanisms whereby technology transfer can be achieved, but to be successful, the transfer should be a transfer of understanding, not the transfer of a technology package (know-why as well as know-how). Examples of programmes where engineers from developing countries are trained on small satellite design, production and operations are numerous. The University of Surrey of the United Kingdom has, for example provided such assistance in the development of small satellites weighing less than 100 kg to Chile, Pakistan and the Republic of Korea, as well as to small countries in Europe that have decided to initiate a space programme.

There are several ways to obtain launch access for small satellites, either on a purely commercial basis or through participation in international cooperative agreements. A country may also consider developing its own launch capability. A driving force in pursuing this approach is the lack of available low cost launchers and an inability for the country to meet their launch requirements on a timely basis if the country views access to space as critical to their national development. Acquisition of launch services from international commercial sources is sometimes preferable to cooperative arrangements, due to difficulties in finding an appropriate exchange opportunity. In particular, countries seeking their first launch may find a commercial acquisition the most effective route open to them.

Cooperative missions may be considered when a clear programmatic benefit is shared by more than one country with a mutual desire to maximize their unique national resources and available funding. International cooperative agreements vary from mission to mission and country to country. Most require a particular country to assume full financial and technical responsibility for its portion of the cooperative effort. In general, in the event of such a division of labor, clean and distinct managerial and technical interfaces should be detailed in such agreements.

B. Example of Cooperative Microsatellite Projects

Microsatellites UoSAT 3 and 5, KITSAT 1 and 2 and PoSAT 1 provide examples of the use of a microsatellite platform for collaborative space science research between the University of Surrey (United Kingdom), the Korea Advanced Institute of Science and Technology (KAIST) and Portuguese research institutions. A small payload monitors the near-Earth radiation environment and provides an important opportunity to validate ground-based numerical models with flight data yielding simultaneous measurements of the radiation environment and its effects upon on-board systems.

The University of Surrey has pioneered microsatellite technologies since beginning its UoSAT programme in 1979. The need to accommodate a variety of payload customers within a standard Ariane Structure for Auxiliary Payloads (ASAP) launcher envelope, coupled with increased demands on packing density, economy of manufacture and ease of integration, catalyzed the development of a novel modular design of a multi-mission platform. It is based around a series of standard module trays which house the electronic circuits and themselves form the mechanical structure onto which solar arrays are mounted. Electronically, the microsatellite uses modern, sophisticated (but not necessarily space-proven), electronic circuits to provide a high degree of capability. These are underpinned by space-proven subsystems resulting in a layered architecture that achieves redundancy by using alternative technologies rather than by simple duplication.

Communications and Earth observation payloads require an Earth-pointing platform. Therefore, the microsatellite is maintained to within two degrees of the center of the Earth line by employing a combination of gravity-gradient stabilization (using a six meter boom) and closed-loop active damping using electromagnets operated by the on-board computer. Attitude determination is provided by Sun, Earth horizon, star field, and geomagnetic field sensors, while orbital position is determined by an on-board Global Positioning System (GPS) receiver. Electrical power is generated by four body-mounted Germanium Arsenic (GaAs) solar array panels (each generating around 35W) and is stored in a 7Ah NiCd rechargeable battery. Communications are supported by VHF up links and UHF down links, capable of transferring several hundred kBytes of data to brief-case sized communications terminals.

Various constellations of small satellites in LEO have been proposed to provide world-wide communications using only hand-held portable terminals which broadly fall into two main categories: real-time voice and data services and non-real-time data transfer. The close proximity of the satellites in LEO to the user and the consequent reduction in transmission loss and delay time appear attractive when compared to traditional communications satellites in a distant geostationary orbit. This holds out the promise of less expensive ground terminals and regional frequency reuse. The communications characteristics associated with a LEO constellation pose however, quite different and demanding problems, such as varying communications path and links, high frequency shifts, and hand-over from satellite to satellite.

Microsatellites can offer quick turn-around and inexpensive means of exploring well-focused, small-scale scientific objectives (*e.g.* monitoring the spacer radiation environment, updating the international geomagnetic reference field. etc.) or providing early proof-of-concept prior to the development of large-scale instrumentation in a manner, fully complementary to expensive, long-gestation, large-scale space science missions. The UoSAT missions have demonstrated that it is possible to progress from concept through to launch and orbital operation within 12 months and a budget of $4 million. This not only yields early scientific data, but also provides opportunities for young scientists and engineers to gain "real-life" experience of satellite and payload engineering and to be able to initiate a programme of research, propose and build an instrument, and retrieve space data for analysis and presentation for a thesis within a normal period of postgraduate study.

Conventional Earth observation and remote sensing satellite missions are extremely costly - typically over $200 million each. The development of high-density two-dimensional semi-conductor charged coupled device (CCD) optical detectors, coupled with low-power consumption microprocessors, presents a new opportunity for remote sensing using inexpensive satellites. Clearly, the limited mass, volume, stability and optics of microsatellites cannot compete with traditional large-scale missions such as Landsat, SPOT and ERS. However, for medium resolution and meteorological-scale imaging, the KITSAT and PoSAT satellites have demonstrated a comparable facility but at a tiny fraction of the cost. This is attractive for developing nations in particular that are interested in possessing an independent remote sensing facility under their direct control at a very modest cost, even if the resolution is limited.

The latest PoSAT 1 microsatellite carries two independent cameras providing a wide-field ground resolutions of 2 kilometers for meteorological imaging and a narrow-field ground resolution of 200 meters for environmental monitoring with 650 nanometers optical filters providing good separation of arid/vegetation and land/sea boundaries. The future mini-satellites of this series will support Earth imaging cameras yielding better than 100 meter resolution with three spectral bands.

Microsatellites also provide an attractive and low-cost means of demonstrating, verifying and evaluating new technologies or services in a realistic orbital environment and within acceptable risks prior to commitment to a full-scale, expensive mission. Examples of this opportunity include new solar cell technologies, modern Very Large Scale Integration (VLSI) devices in space radiation as well as demonstrations of advanced communications. Because satellites depend upon the performance of solar cell arrays for the production of primary power to support on-board housekeeping systems and payloads, knowledge of the long-term behavior of different types of cells in the radiation environment is essential. Unfortunately, ground-based, short-term radiation susceptibility testing does not necessarily yield accurate data and hence there is a real need for evaluation in an extended realistic orbital environment. This can be accomplished easily and cheaply on-board microsatellites.

Although microsatellites are physically very small, they are nevertheless complex and exhibit virtually all the characteristics of a large satellite. This makes them particularly suitable as a focus for the education and training of scientists and engineers by providing a means for direct, hands-on experience in all stages and aspects (both technical and managerial) of a real satellite mission - from design, construction, testing and launch to orbital operation. The very low cost, rapid time frame and manageable proportions makes this approach very attractive to countries wishing to develop and establish a national expertise in space technology. In this connection, according to the experience of the University of Surrey, collaborative education programmes typically have the following elements: academic education (MSc., PhD degrees), on-the-job training on a real microsatellite mission, cooperation on establishing and operating ground stations with participating countries, and finally the necessary technology transfer (design license).

C. Small Satellite Projects in Latin America

A small satellite project in Argentina, Scientific Application Satellite B (SAC-B), is being prepared in cooperation with the United States. The main purpose of the project is to design a satellite with a scientific payload to advance the study of solar physics and astrophysics. The mass of the satellite is about 180 kg with an expected active lifetime of a minimum of three years. It will have a circular orbit at 550 kilometers that has an inclination of 38 degrees. On-board experiments include an examination of energetic particles and radiation from solar flares, the localization of sources of intense transient emissions of gamma ray radiation, the monitoring of galactic and extragalactic X-Ray diffuse background and examination of energetic neutral atoms in radiation belts (in cooperation with Italy). The launching of this satellite is scheduled for 1996. A new generation of satellites designed for scientific research and remote sensing, SAC-C and SAC-D, is being prepared for launch in 1999 through 2006.

In Brazil, great significance is attached to the collection of data from remote platforms using space technology. The Brazilian Complete Space Mission (MECB) successfully started in February 1993 by the launch of the Satelite de Coleta de Dados (SCD 1) satellite. It is a small 105 kg spinning satellite for collection and distribution of environmental data acquired by data collecting platforms distributed over Brazilian territory, mainly in the Amazona region. The satellite has remained operational for two years after its expected useful life (1 year). At least two similar satellites will be launched to ensure continuity of the mission. In addition, the improved SCD 3 satellite (200 kg) would have the mission of proving the concept of voice and data communications in the equatorial region.

The Equatorial Communicator (ECO-8) study is funded mainly by the Brazilian government. A system of 8 satellites in equatorial orbit at 2,000 kilometers altitude can provide constant coverage of regions up to 30 degrees on both sides of the equator. It is intended for voice communications between mobile terminals or between a mobile and a fixed terminal. It can also provide a real-time, uninterrupted dissemination of data collected by automatic platforms located anywhere in this equatorial belt. ECO-8 would require no communication links between satellites and allow for at least 200 simultaneous connections. The Equatorial Constellation Communication Organization (ECCO) is planned for the implementation and operation of wide area personal communications (including cellular-quality voice, data and fax) to rural and remote areas in the equatorial region. The ECCO system, scheduled to begin full operation in the first quarter of 1998, will consist of 12 satellites (including one spare). It will reach over 100 countries in Latin America, South Asia, Africa and the Middle East. This would mean that more than 35 percent of the total land mass and more than 40 percent of the world's population would be covered by this system.

The first Brazilian microsatellite for scientific application, SACI-1, should be launched in October 1997 as a piggyback to the China-Brazil Earth Resources satellite (CBERS). The payload of SACI-1 is composed of four scientific experiments - measurement of Earth air glow emissions, measurement of the anomalous cosmic radiation fluxes, investigation of plasma bubbles and investigation of the geomagnetic field effect on charged particles. The ground segment should consist of two receiving stations in Brazil and users ground data collecting stations. A cost effective LAN PC-based tracking and control system will be implemented and scientific data as well as payload on-board configuration will be distributed through the Internet in order to decentralize and facilitate the interfacing between the payload and its customers.

In Chile, the first operational satellite will be FASat-Bravo, developed in cooperation with the University of Surrey. This 46 kg microsatellite would be put into circular orbit at 650 kilometers with an inclination of 82.5 degrees in August 1996. It will carry ozone layer monitoring experiment, a data transfer experiment, an experimental Earth imaging system and other equipment, including an educational experiment. Using the communications link provided by the satellite, students will be able to engage in study activities (orbital mechanics, satellite communications analysis, telemetry analysis etc.) one or two days per month. In fact, a similar microsatellite, FASat-Alpha, was launched into orbit as a piggyback to the Sich-1 satellite on-board a Tsiklon booster on 31 August 1995. The object separated normally from the booster, but the microsatellite failed to separate from Sich. The problem with the pyrotechnic device is now being studied to assure its proper functioning next time.

D. Microsatellite Project of the Republic of Korea

The Satellite Research Center of the Korea Advanced Institute of Science and Technology (KAIST) began its programme to develop space technology with the launch of two scientific and experimental microsatellites KITSAT 1 and 2 in 1992/93. An agreement worth $4.6 million was signed in 1990 by KAIST with the University of Surrey, covering training, two microsatellites and a ground station. Students took the university MSc courses in Satellite Communications and Spacecraft Engineering. The second microsatellite was build in Korea, using the experience gained during the preparation of the first microsatellite in the United Kingdom. Through this first step into space, the KAIST has trained many engineers and scientists and successfully acquired microsatellite systems technologies.

Currently, KAIST is involved in designing its new indigenous satellite KITSAT 3 to enhance the capabilities of the previous two microsatellites. A primary objective of this programme is to develop a microsatellite system which has highly accurate attitude control and high speed data transmission. It shall also provide hands-on experience to Korean space industries and research institutes. KITSAT 3 will carry a remote sensing multispectral pushbroom CCD camera and several space science experiments. The remote sensing payload will be able to monitor environmental disasters such as floods, volcanic eruption and earthquake damage in the Asia-Pacific Region. The space science experiments should measure the distribution of highly energetic particles in Earth radiation belts and geomagnetic field intensity around the mission orbit and also monitor the total dose of radiation encountered by the solid state memory device.

The total mass of the KITSAT 3 microsatellite will be less than 100 kg and the dimensions of the main box-like body are approximately 45 cm by 45 cm by 60 cm. The satellite consists of a sensor platform, a payload platform, a reaction control unit, a bus platform and a battery with adaptor. The GaAs solar cells are expected to generate more than 100 watts when fully illuminated and not to be degraded by more than 30 percent after three years of mission life. There are three solar panels; two of which are deployable (unlike the first two microsatellites), while the third is fixed on the main body. The attitude control system uses reaction wheels and enhanced magnetorques to achieve full 3-axis stabilization.

The KITSAT 3 is expected to be launched into heliosynchronous polar orbit with an altitude of about 800 km in the middle of 1997. An engineering model will be completely manufactured and tested by the end of April 1996. It also includes a qualification test for the launcher which should also be selected this year. Future planned missions in Korea include the development of the advanced small satellite KITSAT 4, based on KITSAT 3 architecture. This small satellite of a 300 kg should include a new 5 meter resolution linear CCD camera system and a demonstration of a hybrid propulsion system.

E. Microsatellite Project of the Republic of South Africa

In South Africa, the SUNSAT microsatellite project was started in 1992 to increase engineering design opportunities for graduate students and to increase industrial and international interaction with the Stellenbosch University. The microsatellite has the mass of 60 kg and is basically box-shaped with dimensions 45 cm by 45 cm by 60 cm and should provide satellite images of cultivated fields, natural vegetation and pollution around the globe. It shall also include an electronic mailbox orbiting Earth to receive and deliver messages; speech and data relay experiments to schools; a unique method of training graduate students; and research in satellite engineering. SUNSAT should be launched by a United States Delta launcher in March 1997 into polar orbit at 450 to 850 kilometers (originally, heliosynchronous circular orbit had been envisioned), together with the Danish magnetospheric research satellite Oersted. SUNSAT will also carry the GPS navigational receiver of the National Aeronautic and Space Administration (NASA) of the United States, and a set of laser reflectors for precise positioning experiments.

The SUNSAT microsatellite was developed by about 28 graduate students who designed and built most of the electronics and about half of the mechanics, with the assistance of technical personnel of the Engineering Faculty (technical drawings, printed circuit board layout and manufacturing of the body structure). Solar panels are located on all four sides of the satellite and can deliver 140 watts of power to rechargeable NiCd batteries. Attitude determination is made by horizon, Sun and star sensors as well as by a magnetometer. Orientation control is provided by reaction wheels, magnetorquers and a gravity gradient boom. A high resolution camera can image the Earth in three colours and stereo. Its spatial resolution is 20 meters from 800 kilometers altitude.

F. Small Satellite Projects in Spain

Spain was one of the first countries to develop its own satellite. On 15 November 1974, a United States Delta launcher put into orbit, the INTASAT satellite weighing about 25 kg with a 45 cm diameter, corresponding to what is now called a microsatellite system. This technological satellite measured space radiation and, using its solar batteries, functioned in a 1450 km orbit for a full two years. Unfortunately, there was no immediate continuation of this successful project and Spain got involved in larger scale projects (communications satellites of the HISPASAT series and participation in ESA projects). It was only on 7 July 1995 that a second Spanish microsatellite UPM-Sat 1 was launched by an Ariane 4 rocket into a 650 kilometer circular heliosynchronous orbit. It was developed at the Universidad Politécnica in Madrid and has a mass of 47 kg.

UPM-Sat continues experiments started twenty years ago by INTASAT and its development has strengthened cooperation between academic and industrial entities in the country. There are plans for the launching of satellite UPM-Sat 2 (nicknamed MATIAS, for Mediciones Atmosféricas, Telecomunicationes, Ingenieria y Aplicaciones de los Satélites) in 1998. The main purpose of this satellite is to investigate atmospheric pollution and provide for data collection and transmission. Another project, Vehicle for Education of the Network of Universities in Space (VENUS) is currently being negotiated with several interested universities in Europe and Latin America. It could be realized under the UPM-Sat 3 series of satellites.

Another Spanish space project, MINISAT, was entrusted to Instituto National de Técnica Aerospacial (INTA), by the Spanish Inter-ministerial Commission for Science and Technology (CICYT) in 1992. Modular satellites of 180 to 500 kg mass (depending on the number of modules used) would be launched by Pegasus airborne launchers starting in 1996. The first satellite MINISAT 01 will consist of the basic platform and will be used for scientific research (monitoring of the diffusion of extreme ultraviolet radiation in the atmosphere, detection of low-energetic gamma radiation and materials science). Satellite MINISAT 1 will be an upgraded version, equipped for remote sensing observations. MINISAT 2 will use the basic platform to provide long-distance communications even from the geostationary orbit. In addition, INTA has been recently involved in the programme NanoSat, aimed at the development of a 20 kg microsatellite for communication with the Spain's scientific base Juan Carlos I in Antarctica. The project was initiated in 1995 and targeted for satellite launch in 1998.

G. Small Satellite Projects in Central Europe

A small scientific sub-satellite MAGION 4 was launched on 3 August 1995 together with the INTERBALL 1 "mother" satellite. MAGION 4 separated from the mother satellite after reaching the planned orbit (apogee 191,907 kilometers, perigee 793 kilometers, inclination 63.0 degrees). The satellite has a mass of 60 kg and was developed by the Institute of Atmospheric Physics (Czech Republic), the Technical University Graz (Austria) and the Space Research Institute (Russian

Federation). Its scientific payload is aimed at the study of geomagnetic field, wave phenomena and plasma parameters of the ionosphere in frame of the INTERBALL space project. Simultaneous measurements from two satellites, which move along practically the same orbit at a relatively small distance from each other, allow for temporal and spatial resolution of the observed phenomena.

During the initial period of about two months after launch, the spatial orientation of the orbit enabled study of the magnetopause and bow-shock regions, while from October 1995 to January 1996, the satellite orbit was in the region of geomagnetic tail. On 9 January 1996, the distance between the two spacecraft reached 43.5 minutes along the orbit (MAGION 4 crossed "the same" region of space 43.5 minutes earlier). The MAGION 4 on-board thruster (using pressurized gas designated also for reorientation of the spin axis to the Sun) changed the orbit several times in January-February 1996, so that both satellites should again be close together in May 1996. The ability to control the separation distance is important for the study of fine structures of the magnetopause, bow-shock and solar wind plasma. Similar twin satellites should be launched into the geomagnetic polar region as part of the INTERBALL project in July 1996.

The Central European Satellite for Advanced Research (CESAR) is a spacecraft of about 300 kg that will fly in orbit with a 400 kilometers perigee, 1000 kilometers apogee and 70 degree inclination. The scientific mission is related to the study of the magnetosphere, ionosphere and thermosphere (MIT) environment. Ten different experiments, provided by scientists from Austria, Czech Republic, Hungary, Poland and Slovakia will be accommodated on-board the spacecraft which is funded by the Italian Space Agency, ASI, and designed by Alenia Spazio. This mission is one of the objectives of the cooperation among the countries of the Central European Initiative (CEI).

A feasibility study for CESAR has been started and a detailed technical study funded by ASI will be conducted by Alenia Spazio concerning the spacecraft's system engineering. The participating countries will develop the experiments they are responsible for and will collaborate with each other regarding on-board accommodations for the experiments.

The nominal mission lifetime will be two years which will allow a sufficient period of observation of the complex MIT phenomena. The evolution of the initial orbit will be determined by natural perturbations since no propulsion capability is provided on-board. The once-per-orbit perigee-apogee excursion, combined with the slow procession of the orbital plane with respect to the Sun and the Earth, will provide the payload with complete sampling of the near-Earth environment between 400 and 1000 kilometers and ±70 degrees latitude in all conditions of illumination over the lifetime of the mission.

The spacecraft should be launched by direct injection into its required orbit by a small launcher (either an improved Scout or Pegasus). Deployment of the solar array and S-band antennas will follow separation. The spacecraft will be attitude stabilized by spinning around a sun-pointing axis with a rate of 4 rpm. The spin rate will provide the experiments with a fast scan and sampling of the environment surrounding the spacecraft. Boom mounted experiments will be deployed after attitude acquisition. About one month of spacecraft commissioning and experiment calibration will follow. After the nominal operation of the satellite has been certified, the science mission will be carried out for the following two years.

The present configuration foresees a mass budget of about 151 kg of service module and 95 kg of payload module for an operative launch configuration mass of 246 kg. A mass margin of 20 percent is accounted for in the next phase of the project to take into account increases that will surface during the development process. The spacecraft is expected to be completed before the end of 1997 for a launch at the beginning of 1998. CESAR will be the first spacecraft of a series that will also include a second spacecraft currently in preparation, the Joint Ultra Violet Night Sky Observer (JUNO), a UV astronomy satellite being developed in cooperation with NASA. A definition phase study for JUNO is underway.

H. French Small Satellite Projects

A working group on small satellites was created by the Centre National d'Études Spatiales, France (CNES) at the end of 1993 to propose recommendations for the development of a series of small satellites complementing the SPOT system, at a cost of less than 300 million French francs per mission and development time of two years. The recommended programme, Platforme Reconfigurable pour l'Observation, les Télécommunications et les Usages Scientifiques (PROTEUS) is a satellite that should have a mass less than 500 kg (including 250 kg of useful payload), available power of 100 to 300 watts and pointing accuracy of 0.1 to 3 degrees. Technological studies were performed during 1994/95, ending by the selection of industrial partners. The first flight is envisioned in 1999 as a continuation of the successful France - United States altimetric satellite project Topex-Poséidon. Possible orbits are at 500 to 1400 kilometers and satellite should be able to maneuver and change its orbit with a total velocity change of 60 to 180 m/s.

Possible scientific missions using the PROTEUS platform include astronomy (project SAMBA for registration of local fluctuations of 3K background radiation from the Big Bang and COROT for asteroseismology), space environment (IBIZA for registration of the plasma accelerated in the geomagnetic aurora regions), Earth sciences (TPFO, Vagsat, Irsute, Tropiques), and fundamental physics (QUICK-STEP for verification of the equivalence of inertial and gravitational mass). From applications missions, priority is given to radio communications and optical observations. In parallel with the PROTEUS platform, CNES is making studies of a microsatellite with less than 100 kg of mass. It would be used mainly as a test platform for new technological concepts.

I. Small Satellite Missions of ESA

The missions which are being considered by the Small Missions Opportunities (SMO) initiative of the European Space Agency (ESA) may be classified by the following parameters: 150 to 500 kg launch mass, orbit between 600 and 900 km, development time of about two years, cost of less than 40 million ECU for platform and integration, delivery on orbit, commissioning and user ground station. This is a class of small missions which is generating a lot of interest, and where the European industry is not yet as competitive as it is in the microsatellite field. In this regard, European industry, through its trade association Eurospace, came to ESA with the suggestion that ESA should pool together a sufficient number of missions, from ESA's own programs and from those planned by Member States. Various ESA Member States have flown, are developing or are planning small missions. With few exceptions, these missions have involved or will involve development of a single spacecraft. When more spacecraft are to be realized, this will happen at 3 to 4 year intervals.

The basic idea of the SMO initiative is to have a common procurement of part or all of the following mission elements: launch, platform integration and ground segment. This approach should achieve low cost benefits for recurrent elements of a mission, while preserving the user's control over the mission payload and operations. The possibility of efficiently integrating a number of different missions on a common subset of equipment has already been demonstrated by various small satellite programs, such as NASA's Small Explorers. Actual contents of the SMO initiative will be defined after an analysis of proposed mission requirements, which will be performed in the second phase of on-going studies. At present, the launch opportunity seems to be the strongest common denominator.

If the SMO initiative is successful, Europe will have an SMO Operator, able to deliver a scientific or commercial payload in orbit at low cost. Because this initiative addresses a user community with different levels of capability (some Member States have an autonomous SMO capability, some do not), the SMO Operator will be ideally suited to fulfill the different needs of emerging countries. Participation in the SMO initiative could take at least two forms: via another international organization, with a mission dedicated to emerging countries, or via agreement with a participating ESA Member State. Assuming a Member State decides this year to support the SMO initiative, a program could start as early as 1997 and the first launch would take place towards the end of 1999.

J. Small Satellite Technology in the United States of America

In addition to the support (technological assistance, launching arrangements) provided to emerging space-faring nations, as described in other parts of this report, NASA has adopted its own Small Spacecraft Technology Initiative (SSTI). This technology programme should reduce the cost and development time of space missions for science and commercial applications. It should achieve a payload/total mass fraction of up to 70 percent. Time from development to flight readiness should be two years. To achieve those goals, new design and qualification methods for small spacecraft should be demonstrated using commercial and performance-based specifications, integration of small instrumentation technology into the satellite bus design and end-to-end product development and flight verification. The future NASA mission capability should result in 30 to 60 percent reduction of costs and new technology insertion into missions.

The first two satellites, named Lewis and Clark, will carry more than 30 different technology demonstrations. Lewis will fly three instruments, including a "hyper-spectral imager" having 384 spectral bands (the operational LANDSAT satellite only has seven bands). It is designed to enhance traditional remote sensing applications in agriculture, global environmental monitoring, forestry, land management and industrial planning. Clark will carry four scientific payloads combining a very high 3 m resolution optical imager with stereo-imaging capabilities. This will be used for commercial remote sensing, disaster management and urban planning. The satellites will have a mass of 272 and 317 kg respectively, from which about 70 percent accounts for the scientific payloads (in existing satellites, it is typically 40 percent). The launch vehicle will most likely be the Pegasus-XL. The Integrated Product Development team, which will manage the project, consists of more than 35 members from the manufacturing company, NASA centers, universities and high schools.

One of the innovative, yet not well publicized projects, is the GPS Gravity field modeling. The first satellite to carry a precise GPS receiver was Topex/Poseidon oceanographic satellite. Its data had been combined in a new model of the Earth gravity field which illustrated the power of this method. To improve this model, the GPS atmospheric occultation project needs many transmitters and receivers aloft at once, densely sampling the global atmosphere every few hours. The preliminary proposal is for twelve satellites launched at once into a single orbit plane by 1998. Until the arrival of GPS and low cost microsats, the evident cost of such an enterprise made it impractical within Earth science programmes. Space borne GPS imaging will have a profound impact on ionospheric science. The ability to image ionospheric structures continuously in three dimensions will help scientists to examine in detail the evolution of "space weather", to trace the formation of geomagnetic storms, and perhaps one day to predict when an observed solar flare will cause disruption on Earth.

NASA is also preparing a series of small, low-cost planetary science missions under its Discovery programme. They are designed to provide frequent investigative opportunities (one launch every 12 to 18 months) to the planetary research community while encouraging partnerships with industry. All solar system targets and objectives are valid candidates for the Discovery programme, but the spacecraft cost should be low and the launch vehicle will be limited to Delta class or smaller. A total of 28 proposals had been received in response to the first announcement of opportunity, covering the full range of planetary science objectives (next announcement of opportunity is to be released in May 1996). The first four missions are now fully funded, and their development is on schedule and within cost guidelines.

The first of the Discovery missions, called NEAR (Near Earth Asteroid Rendezvous) was launched on 17 February 1996 towards an encounter with asteroid 433 Eros. The initial close pass at Eros will occur on 6 February 1999 at a distance of about 500 kilometers. The spacecraft should be then maneuvered even closer to the asteroid (below 25 kilometers) and orbit it for about one year, making precious measurements of its characteristics. Mars Pathfinder is the second Discovery mission planned for launch on 2 December 1996, and should land on Mars on 4 July 1997. It should investigate the structure of the Martian atmosphere, monitor surface meteorology, observe surface geology and measure elemental composition of the rocks and soil. The third small planetary mission, Lunar Prospector, will be launched in June 1997. Its science objectives include a global mapping of surface chemistry, search for the presence of ice near lunar poles, detailed investigation of magnetic and gravity fields at high resolution and identification of possible gas release events. A comet-sample return mission (launch in February 1999) will be the fourth Discovery flight during which Stardust will rendezvous with comet Wild-2 in January 2004. It should return to Earth the first samples of comet material in January 2006.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

A. Measurements of Space Debris

The largest radar tracking facility in western Europe is at FGAN (Research Establishment for Applied Science) at Wachtberg-Werthhoven (Germany). FGAN operates an L-band tracking and Ku-band imaging radar using a 34 meter parabolic dish antenna. Data from this site are an important addition to the catalogue of data in the case of re-entry predictions for high-risk space debris. ESA has sponsored research of the feasibility of detecting and tracking medium-size debris (1 to 50 centimeters) with L-band radar. Metal spheres of 5 centimeter diameter are measured frequently and one meter objects are detectable in the geostationary orbit (GSO) using a multi-pulse signal processing techniques. A one day beam park (fixed antenna position) experiment has been carried out jointly with the Fylingdales station (United Kingdom). Hardware and software upgrades are being implemented to enhance the detection performance of the existing Tracking and Imaging Radar (TIRA) for medium-size debris in Low Earth Orbit (LEO). A further beam park experiment is planned in the bi-static mode with the radiotelescope at Effelsberg. The measurements will be used to validate and improve current environmental models.

Regarding the debris measurement by optical telescopes, ESA will use a one-meter Zeiss telescope which is currently being installed at the Teide Observatory on Tenerife (Canary Islands, 28.3 degrees north latitude) for other purposes. The configuration of this Ritchey-Chrétien-Coudé system has been extensively analyzed with respect to possible changes and upgrades to enable space debris observation and tracking. The optical system dedicated to space debris measurement will cover the spectral range from visible to near infrared and will have a field of view of 0.6 degrees. As a detector, a nitrogen cooled CCD camera with a mosaic of four 2048x2048 chips is under consideration. Special methods and computer algorithms are required to extract from CCD data the orbital parameters and other characteristics of space objects. The minimum size of detectable objects will be 2 to 6 centimeters in LEO and 20 to 40 centimeters in GSO. The telescope should be operational for space object observations at the beginning of 1997.

Objects moving in near-Earth space are regularly tracked and catalogued by the United States Space Command (USSC) Space Surveillance System. This system operates more than two dozen radar and several optical facilities to monitor near-Earth space. It also maintains a catalogue of orbital elements of all tracked objects. The minimum diameter of observable objects is about 10 centimeter for LEO and 1 meter for GSO. Objects in GSO are tracked mainly by the dedicated optical system GEODSS (Geosynchronous and Deep Space Surveillance). Currently, orbits are maintained for over 8,000 objects and the USSC Catalogue is the main source of essential information for detecting breakups and monitoring growth of the debris environment. Current surveillance systems have difficulties in cataloguing some space objects in highly elliptical orbits (HEO) and low-inclination orbits. Objects in HEO are more difficult to detect because they spend a large fraction of their time at very high altitudes, and objects in low-inclination orbits because of the relative lack of sensors at low latitudes.

In addition, a special radar located at Haystack (near Boston, Massachusetts) is capable of detecting objects less than 1 centimeter in diameter in LEO and obtain statistical information on number, flux, size and altitude (but not complete orbital information). There seems to be over 100,000 pieces of space debris in LEO at sizes down to 1 centimeter. The Haystack data suggest that there may be major sources of centimeter-sized orbital debris other than previously recorded breakups. The large number of objects in orbits between 900 and 1,000 kilometers with orbital inclinations between 60 and 70 degrees have relatively smooth and spherical shapes (according to the polarization data), rather than the irregular shapes that would typically be created in a breakup. This combination of orbital and physical characteristics suggests that these objects may be tens of thousands of 0.6 to 2.0 centimeter liquid droplets of a sodium/potassium coolant leaking from the nonfunctional cores of Russian nuclear power sources (NPS) satellites. Also NASA's deep space tracking radar at Goldstone (California) confirms the existence of this type of debris. This radar, capable of detecting 2 millimeter objects at 600 kilometers is only available for space debris measurements for a few hours per year.

A dedicated optical Schmidt telescope with a main mirror of 32 centimeter aperture, located at Haleakala site (Maui, Hawaii) is able to detect 60 centimeter objects in the GSO. During 252 total hours of observation from 1992 to 1994, it revealed that about 30 percent of objects detected by its CCD sensor appeared to be debris. In the future, much larger liquid surface mirror telescope will be used for observation of GSO objects. Recent new technology enables construction of the 3 meter diameter rotating mercury mirror, equipped with a hypersensitive CCD detector and with full computer control.

Information on particles smaller than about 1 millimeter is obtained mostly through special detectors carried by spacecraft or through the analysis of impacts on material that has been exposed to the space environment. For the first time, an impact detector will be placed on a geostationary spacecraft. A spare dust detector of Galileo/Ulysses probes, developed by the Max-Planck Institute for Nuclear Physics at Heidelberg (Germany), will be flown this year on the Russian EXPRESS 2 spacecraft. In the framework of the EUROMIR 95 project, dust and debris impact experiments are carried out outside the MIR space station. On the external platform European Science Exposure Facility (ESEF), a number of experimental cassettes have been installed. The cassettes have been retrieved during the extra-vehicular activity of the cosmonauts on 8 February 1996 and returned to Earth on 29 February 1996.

Many European researchers have analyzed impact features on NASA's Long Duration Exposure Facility (LDEF) after its retrieval in January 1990, following 69 months in orbit at altitudes between 340 and 470 kilometers. Of the more than 30,000 LDEF craters visible by naked eye, 5,000 have diameters larger than 0.5 millimeter. The largest crater (5 millimeters) was probably caused by a 1 millimeter particle. In general, it is difficult to determine the composition of an impacting particle and therefore to distinguish between impacts of micrometeoroids and artificial space debris. The European Retrievable Carrier (EURECA) spacecraft, launched in July 1992 was retrieved by the space shuttle after 326 days in orbit at a mean altitude near 500 kilometers. The spacecraft has since then undergone extensive post-flight analysis with regard to impact features. It revealed 71 impact sites on the thermal blankets, and 14 impacts on the body plates, including the largest impact feature with 2 millimeter crater diameter. Also EURECA's solar arrays of 96 square meters total surface area were scanned by different European research groups. More than 1,000 impacts were detected on the front side of each of the two wings, while only about 44 were noticeable on the rear sides. From a total of 847 of the larger impact sites, high resolution microphotographs were taken. The largest impact crater diameter is 6.4 millimeters, resulting from an object of 0.5 to 1 millimeter diameter. Further analysis will concentrate on impactor characterization (e.g. mass, direction, velocity, chemical composition) and on hypervelocity calibration experiments conducted with the spare solar array surface material.

A similar analysis programme is also ongoing for the solar array retrieved from the Hubble Space Telescope (HST) in December 1993, after 3.62 years in an orbit of about 600 kilometers mean altitude. Due to the high operating altitude and extended dwell time, a larger number of impacts is observed on its total surface area of 62 square meters. The largest hole diameter is 2 to 3 millimeters.. As the flexible HST blankets have a total thickness of 710 microns, several impacts (2 to 4 per square meter) have completely penetrated the material. On the other hand, it appears that the HST array did not suffer any functional damage from the many impacts. The European Space Technology Centre, Netherlands (ESTEC) is currently developing a database to archive images and analysis results of impact features on the EURECA and HST surfaces. Results of these analyses will be used to validate the present reference flux models for small size meteoroids and space debris.

Examination of windows, radiator panels and other surfaces of the United States Space Shuttle orbiters show that environmental models underestimate the microdebris population and that this population is growing with time. While the NASA space debris damage model Bumper predicted 13 window replacements in 12 shuttle missions, the actual number of replacements was 19. The source of actual window damage (i.e. meteoroid or debris) was determined by scanning electron microscope analysis and compared to Bumper predictions, While micrometeoroid damage was predicted correctly (10 actual over 11 predicted), microdebris damage is underestimated more than three times (8 actual over 2 predicted).

B. Modelling of the Space Debris Environment and Technical Assessment

Models of the space debris population are needed to fill in gaps in existing measurement data, to interpret new data, and to project the characteristics of the future debris environment. There are two major classes of debris models in use today. Population characterization models take information about the orbital elements and other characteristics of space objects and convert them into measurable parameters such as flux, detection rate for an instrument, or collision velocity. More complex models are used to understand the future growth in the debris population. These model types are not entirely distinct; the output of a model of one type is often used as the input for a model of the other type.

A comparison of different space debris models with observations have been performed by a special working group of CNES. It is a first step of a three-step programme. The second step is an accurate risk analysis for space missions followed by the third step, proposals for space debris mitigation procedures. For "small" debris (below 10 centimeters), mathematical models should give the flux of particles for calibration with observations on-board spacecraft. For a more detailed comparison with observations, current detectors are not sufficient and a new generation of detectors is therefore proposed. The main reference model considered by CNES for space debris population is that of D. J. Kessler (NASA, Johnson Spaceflight Center, Houston, Texas) and for micrometeoroids, the model of E. Grün (Max-Planck Institute, Germany). The main inputs are the size of particles, altitude, inclination and date. Main outputs of these models are: the flux in orbit (number of impacts per square meter per year), consisting of micrometeoroids flux, debris flux and total flux. The total number of impacts also depends of course on the duration of the mission and the effective area of the spacecraft involved.

For comparison with models, the following data have been used: from the FRECOPA experiment (5.7 years in orbit) on the LDEF satellite, from the ARAGATZ mission (1 year in orbit) on the Mir space station, from the analysis of solar panels (11 months in orbit) of the EURECA platform and from the solar panel (3.6 years in orbit) of the HST observatory. The method of analysis consists of localization of the impacts, identification of the particle nature (debris or micrometeoroids), and conversion from the diameter of the crater to the size of the particle. Finally, the number of impacts as a function of particle diameter and histogram of frequencies (number of impacts per diameter class) led to the estimation of the cumulative flux which can be compared with model prediction.

In general, good accordance between model predictions and measurements has been found. There are some discrepancies for small particles of 10 to 100 micrometer in size as well as a slight underestimate of the model for the Mir station orbit. To improve the data sources, a new generation of detectors is prepared with low mass and energy consumption, but enabling estimation of instantaneous (not only cumulative) flux. The on-board recording of the time of impacts is also important for estimation of debris environment evolution as a function of time. Mock-ups of the new detectors are now tested in hypervelocity chamber and in a short time, new detectors should be available for use in different orbits (on Mir and SPOT 4 spacecraft).

Unique debris hazards associated with the proposed satellite constellations have been studied by the United Kingdom. A satellite constellation is a distributed architecture of satellites to provide global positioning, Earth observation, hand-held personal communications, messaging or data transfer. There are proposals for a large number of new systems, which means that over 1000 new satellites will be placed into high inclination orbits at altitudes between 700 and 800 kilometers and 1200 to 1400 kilometers within 4 to 6 years. Among the most advanced projects, the communication satellite constellation Iridium should consist of 77 satellites, Teledesic of 924, Globalstar of 48, Orbcomm of 26, etc. Realization of such projects will result in concentrations of satellite mass at certain regions of space around Earth.

To keep the constellation operational, frequent satellite replacement launches are envisioned. During the launch and deployment phase, there are usual problems associated with the explosion of launch vehicles or explosion and collision with fragments from un-passivated upper stage or with some non-tracked object. In addition, there is a possibility of collision with other satellites being deployed. At the operational orbit, additional hazards include collisions with uncontrolled constellation satellites, fragments from constellation satellite breakups or from launch vehicle breakups. Also de-orbiting of non-operational satellites should be planned so as to avoid collision with other satellites in the constellation.

The probability of collisions with debris within the constellation was modelled using different assumptions on the number of orbital planes and frequency of catastrophic collision breakups and explosion-induced breakups. It was found that there is a low probability of short-term collision cascading effect, but a high probability of cascades with background debris population. A careful selection of operational practices will be needed to guarantee long-term functioning of the proposed satellite constellations.

To acquire an unbiased technical assessment of the research needed to better understand the debris environment, the necessity and means of protecting spacecraft against the debris environment, and potential methods of reducing the debris hazard, NASA asked the National Research Council to form an international committee to examine the orbital debris issue. The committee was asked to draw upon available data and analyses to: (i) characterize the current debris environment; (ii) project how this environment might change in the absence of new measures to alleviate debris proliferation; (iii) examine on-going alleviation activities; (iv) explore measures to address the problem; and (v) develop recommendations on technical methods to address the problems of debris proliferation.

In the summer of 1993, the National Research Council formed a committee of eleven technical experts from six spacefaring nations to perform this task. In 1995, a report "Orbital Debris - A Technical Assessment" was published, representing the consensus view of the committee. The committee strove to ensure that the study focused on technical issues. This report does not suggest appropriate funding levels for future debris research, nor propose specific protective measures for particular spacecraft, nor lay out detailed implementation strategies for techniques to contain the future debris hazard. Decisions on such matters involve political and economic as well as technical considerations and must be made by entities capable of weighing all these factors. Rather, this report seeks to provide engineers, scientists, and policy makers with the sound technical information and advice upon which such decisions must be based.

C. The Use of Nuclear Power Sources in Outer Space

A numerical analysis related to possible collisions of NPS with space debris has been performed by the Russian Federation. The following contingencies have been examined in particular: destruction of the NPS structure, change of orbital parameters of NPS after collision, its entry into the atmosphere, and possible atmospheric destruction and fallout of radioactive toxic material particles and parts of the NPS structure. Collisions with space debris have been considered for reactors launched in the period 1970 - 1988 and injected into orbits within the 700 to 1000 altitude range. A typical reactor has a mass of 1250 kg, a diameter of 1.3 meters and a length of 5.7 meters incorporating fuel rod assembly and radiation shield. A fuel-element assembly of 53 kg contains 37 fuel rods, each with steel cladding, fuel pin of uranium-molybdenum alloy and axial reflectors of beryllium.

Collisions with space debris capable of considerable or catastrophic (e.g. 10 percent of mass) NPS damage down to small fragments and particles or creation of such velocity impulse that could lead to substantial change of orbital parameters and untimely re-entry from initial orbit were considered. For typical NPS orbits (altitude 930 to 970 kilometers, inclination of 65 degrees), the most probable relative velocity of collision is about 12 kilometers per second at an angle of collision of 108 degrees. Estimated probabilities of collision with space debris larger than 0.5 centimeters were computed for 250 years into the future using model distribution of debris as of 1994 and corresponding to the present rate of spacecraft launchings. The probability of collision is sufficiently high and reaches 1 in 55 years. For space debris more than 2 centimeters in diameter (capable of considerable NPS destruction), the collision probability should be lower and is subject to further computations.

Research on aerodynamic destruction of NPS and the fuel rod assembly during their descent into the atmosphere after collision at the initial re-entry trajectory (altitude 160 kilometers) has confirmed, that the NPS structure destructs in a range of altitude between 74 and 64 kilometers, the reactor and fuel rod assembly between 64 and 50 kilometers and reactor fuel pins (uranium - molybdenum alloy) down to particle dimensions of less than 1 millimeter in the range between 50 and 47 kilometers. Only partial destruction of the beryllium axial reflectors (melting of the external layer) occurs.

The fallout of millimeter size nuclear fuel particles, allowing for uranium fission product decay at the moment of collision, will not lead to a significant change in the radiation levels over the fall-out territory. The fall of beryllium reflector parts and partially failed radiation shield of lithium hydride may constitute a threat from the point of view of toxicity, which will prompt search and clean-up (removal) measures. The set of measures on the prediction of NPS re-entry orbital parameters, region of re-entry into dense layers of the atmosphere, territory of the fall-out of radioactive particles and NPS structure parts were developed by the Russian Federation earlier. They may be used in the event of detection of the collision between NPS and space debris. Similarly, inspection and control of radiation situation procedures on the fall-out territory, search, location and removal of fallen parts were applied in connection with NPS reactor launchings.

In the United Kingdom, studies continued on possible supplements to the Principles relevant to the use of nuclear power sources in outer space, adopted by the General Assembly on 14 December 1992. While this Resolution includes valuable consensus agreements on topics such as consultation, assistance to States affected by an accident, liability and compensation it suffers from a number of limitations. Among these are the exclusion of propulsion and extra-terrestrial bases; their formulation in terms of particular technologies; ignoring the potential effects of space debris; and inconsistencies with the more mature safety principles developed for the terrestrial applications of nuclear power. Therefore, a revision is suggested which generalizes the intentions embodied in Resolution 47/68 in a way which is consistent with subsequent international developments under the aegis of the International Commission on Radiological Protection (ICRP) and IAEA. The revision takes the form of six Supplementary Principles incorporating developments in probabilistic risk assessment, safety culture and radiological protection together with the recognition of the importance of safeguards. Subject to a consensus being reached on these Supplementary Principles and their associated numerical risk values (A/AC.105/C.1/L.203), this opens the way to eliminating the need for exceptions so that the revised principles are of universal applicability.

D. Remote Sensing Applications for Global Mapping and Environmental Monitoring

With the successful design, development, launch and in-orbit performance of the first generation of the Indian remote sensing satellite IRS, India is surging ahead to provide improved and enhanced data services from the second generation of remote sensing satellites, IRS-1C and 1D. IRS-1C, launched on 6 December 1995, is characterized by an improved spatial resolution, extended spectral bands, stereo viewing and faster re-visit capability. Besides cartographic applications, the IRS-1C mission mainly addresses the following areas:

- Crops and vegetation applications with specific reference to mixed crops and vegetation discrimination;

- Oceanographic applications, in particular observations of physical oceanographic parameters such as winds, sea surface temperature, waves, etc., and biological parameters;

- Atmospheric applications for monitoring global changes such as the depletion of the ozone layer over the Antarctic region.

The major elements of the IRS-1C mission, besides the spacecraft itself, are the Space Craft Control Centre, the Payload Data Reception Stations and the Data Products Generation Centre. IRS-1C operates in a circular, heliosynchronous, near polar orbit with an inclination of 98.69 degrees, at an altitude of 817 km in the descending node. IRS-1C needs approximately 100 minutes to orbit Earth, which means that the satellite completes 14 orbits each day. The entire surface of Earth is covered after 341 orbits during a 24 days cycle.

IRS-1C carries three imaging sensors which are characterized by enhanced resolution. The Panchromatic camera (PAN) has a spatial resolution of 5.8 meters, operates in the spectral range of 0.5 to 0.75 micrometers and employs three CCD devices of 4096 elements each. A multispectral Linear Imaging Self-Scanner (LISS-3) camera provides images with a spatial resolution of 23 m. This camera is also capable of producing images in the near infrared band (1.55 - 1.70 micrometers wave length). The Two-Band-Wide Field-Sensor (WiFS) operates in the visible and near-infrared region with a swath width of 810 km and resolution 190 meters.

Space research activities in Morocco, related to remote sensing and environmental monitoring, are characterized by an active, realistic and long-term policy at both the national level (coordination, information, training and project formulation) and the international level (participation in forums, international committees and bilateral and multilateral projects). The use of outer space in Morocco is becoming ever more developed, extensive and diversified.

With regard to satellite data, stations are currently in operation to receive METEOSAT weather satellite data, such as the National Department of Meteorology (DMN) station. There are plans to set up two NOAA stations, one for meteorological studies at the DMN and the other at the Royal Centre for Spaceborne Remote Sensing (CRTS) for receiving advanced very high resolution radiometer (AVHRR) data. This station is to be set up within the framework of the GLOVE project, which is co-financed by the European Union.

In the fields of data exchange and remote sensing networks, CRTS is coordinating Moroccan efforts to set up the Cooperation Information Network (COPINE) project launched by the United Nations Office for Outer Space Affairs. This project aims to establish satellite communication stations (INTELSAT) in a number of African countries enabling them to exchange data with each other and with European countries, particularly in the areas of the environment, natural resources and tele-medicine. The opening up of rural areas is a facet of the project of particular interest to national users.

A number of projects combining spaceborne remote sensing and geographic information systems (GIS) are in the process of development or implementation. These projects are designed to meet needs in the areas of natural resource inventory and management, environmental protection and town and country planning within the context of national and regional development programmes.

In the area of on-going training, CRTS has continued organizing short (one-week) and longer (two-week) courses to provide an introduction into the basic principles of spaceborne remote sensing, geographic information systems, and applications in areas of particular interest to the Kingdom of Morocco and the region. These courses, especially those relating to water resources, desertification, common grazing land and the management of fishery resources, are regularly attended by African participants in positions of responsibility.

GEOSPACE, a company located in Austria, is currently conducting a global mapping project to produce a digital atlas of the world. This global satellite image mapping project aims at developing a global geographic information system, which is easy to use, cost-effective and easily accessible for frequent updates. Studies are performed at the local, regional and international level.

The global mapping project, in particular has arisen due to recent regional and global environmental and economic changes, such as increasing pollution of land and water, dramatic population growth and changing consumption patterns. Such a project would be an essential contribution to sustainable development and the preservation of the environment. The project shall also play a vital role in the overall process of homogenizing spaceborne data, which would tremendously facilitate the timely provision of satellite derived information on the environment and natural resources.

The main benefits to be obtained through the global mapping project will be the availability of a cost-effective high resolution global geographic information system. Funding for the project shall be provided by national, regional and international organizations, and it is hoped that both the governmental and the private sector will contribute to the project.

The status of new commercial remote sensing satellites was reviewed by the Secretary General of ISPRS. These new satellites are intended to provide high resolution (up to 2 to 5 meters) data in the areas of meteorology, cartography, natural resources and commercial imaging. Countries who in the recent past have been involved in the development of such commercial remote sensing satellites are France, Germany, India, Japan, the Russian Federation and the United States. Furthermore, the European Space Agency plays a major role in the development of new remote sensing satellites.

An outlook for the next decade indicates that 99 Earth observation satellite payloads are planned to be implemented, out of which 57 payloads should be established within the next five years. These new payloads will play a significant role in developments towards digital photogrammetry and remote sensing.

Photogrammetry and remote sensing are the key ingredients in the spatial information sciences for monitoring Earth's environment, assessing and predicting natural disasters, thematic mapping, preservation of national and international security and sustainable development. In the near future, spacefaring nations will develop remote sensing satellites with spatial resolutions in the range of 1 meter.

In the context of accelerating economic and environmental development, a programme entitled "Resource 21" will be launched in the near future. Resource 21 is an information service company with the objective to improve agriculture, environment and natural resource monitoring. It is a market driven programme and combines satellite remote sensing, telecommunications and information systems technology. Resource 21 shall provide information products within hours of satellite data acquisition. It will also provide coverage of Earth every three days with a spatial resolution of 10 m. The system will be comprised of four satellites with a swath width of 205 km. Resource 21 should be operational in 1999.

A further system to be implemented in the near future is the geophysical and environmental Earth resource observation system (GEROS), aiming to provide timely and accurate information on agriculture, forestry and coastal zones. This system will be comprised of six satellites, the first of which is scheduled to be launched in 1998.

E. International Space University - Providing Education Programmes to Professionals

The International Space University (ISU), established in 1988, places emphasis on an interdisciplinary, international and intercultural space education programme. ISU is dedicated to the education and development of professionals in all disciplines (such as creators, innovators, managers and leaders) in space-related fields, the creation and expansion of knowledge through research, and the exchange and dissemination of knowledge and ideas. All of the above activities contribute to the development of space-related activities for peaceful purposes, the improvement of life on Earth and the education and inspiration of leaders and innovators who will guide humanity beyond the next frontier.

During the course of the summer session programmes of ISU, comprehensive lectures are provided in all space-related disciplines as well as discussions on how these disciplines can interact. Furthermore, an international space project is designed during the summer curriculum, resulting in a professional report with practical utility for the international space community. Overall, these summer curricula strengthen the development of professional skills and personal qualities required to design, implement, lead and manage major phases of space programmes.

The ISU summer session provides an intensive 10-week programme hosted at a different location each year. To date, nearly 1,000 students have participated in summer session programmes. In addition, 450 internationally recognized space experts (astronauts and cosmonauts, designers and engineers, space medical doctors, scientists, physicists, historians, policy makers, lawyers, managers, entrepreneurs, etc.) from 25 countries have contributed as lecturers since 1988.

During the summer curriculum, a series of core lectures are held, providing an introduction to basic concepts of the following disciplines: System Architecture & Mission Design; Business & Management; Engineering; Life Sciences; Policy & Law; Resources, Robotics & Manufacturing; Satellite Applications; Physical Sciences; Space & Society and Informatics. Following the core lectures, a series of themes and specialized lectures intends to deepen the knowledge in specific areas, containing contemporary and future issues.

In addition to the summer session programmes, ISU has recently launched a "Master of Space Studies" Programme, held at its Central Campus in Strasbourg, France. This one-year graduate level programme comprises three major elements: (a) Sciences and Applications, (b) Engineering, Systems and Technology, and (c) Management and Social Sciences.

F. Space Transportation

The Russian Federation continues the use of middle and heavy class launchers of the Soyuz, Molniya and Proton type to launch communication, scientific and many other payloads into different orbits (including GSO). In addition to the Russian national space transportation programme, these launchers are also used in furtherance of international cooperation. The Tsiklon and Zenit launchers are produced in cooperation with Ukraine. The most used cosmodrome in the world - Pleseck - is responsible for 60 percent of Russian launchings and for 10 percent worldwide. During the thirty years of its existence (since March 1966), there were almost 1,500 successful launchings. Plans are progressing for a possible gradual building of the new Russian cosmodrome at Svobodny (Amur region) in the eastern part of the country.

To prolong the exploitation cycle and improve ecological parameters, a small modernization of launchers is to be made by the year 2000. The modified Proton-M launcher has the capacity to carry

21,700 kg to LEO instead of the current 20,600 kg capacity. It will have an advanced guidance system, more powerful first stage engine as well as improved ecological parameters. Tests of the modified, ecologically clean version of the Soyuz launcher should start soon at the Pleseck cosmodrome under the name Rus. It will have new engines at all three stages and an improved guidance system. In addition, development of the perspective, ecologically clean two-stage launcher Angara is continuing. It is made up solely of Russian components and will be also launched from the Pleseck cosmodrome. It can deliver 25 metric tons of payload into a 200 kilometer LEO with 63 degrees inclination. All fluid components - oxygen, kerosene and hydrogen are non-toxic.

Converted military rockets Start-1 and the more powerful Start use solid fuel and will also be used in the space programme. Another converted military launcher, Rokot, can be launched from its underground silo. It will be used for launching of smaller payloads into low and middle orbits for purposes of the Russian national space programme and also for international cooperation efforts. The integrated operation system also includes a launching complex (based on the complex used for Kosmos launchers), a service complex (based on Tsiklon serving) and tracking and telemetry, transport etc.

The Russian space corporation Energiya, the Ukrainian research and production centre Yuzhnoe, the Boeing corporation of the United States and a Norwegian shipbuilding company, are cooperating in the form of an international consortium named Sea Launch on the preparation of commercial launchings from a sea-based platform near the equator.

Another project of interest is the aircraft-launched booster Burlak. It is a two-stage liquid fuel rocket that can deliver 500 kg payload into LEO. A detailed proposal is also being worked out for the Aerokosmos two-stage rocket that separates from the aircraft on a parachute. Other ideas being developed in this area include the light two-stage launchers, Kvant and Ricksha, the latter aiming to deliver about 5 metric ton of payload into LEO.

The Association of Space Explorers (ASE) presented the concept of the "X-Prize" - a prize of $10 million designed to promote private industry development of a reusable, single stage, sub-orbital vehicle capable of carrying three adults (300 kg) to an altitude of at least 100 kilometers above Earth. ASE believes that the X-Prize will stimulate public interest in space exploration and development, and lead to the capability to fly many people into space, a goal which ASE actively promotes. The spacecraft must be privately financed and privately built. It must be flown twice within a 14-day period. Each flight must carry at least one adult to a 100 kilometer minimum altitude, but it must be built with the capacity to carry a minimum of three adults. The second flight must demonstrate a low per-flight cost and vehicle reusability. Both crew and spaceship must return to Earth, "substantially unharmed", from both trips. Entrants must specify their take-off and landing location prior to the flight. The spacecraft must make a controlled landing within five kilometers of the chosen landing site. The X-Prize is international and open to anyone who abides by the rules.

G. Astronomy and Planetary Exploration

In early 1995, the international astronomical community was dismayed by the publication of a proposal on behalf of UNESCO, to mark its 50th anniversary by the launch of a solar reflector - the "Star of Tolerance". It was to have been in the form of a double star comprised of two reflecting balloons, one of 50 meters and the other of 30 meters in diameter connected by a 2 kilometer tether. The Star would transmit radio messages and, with the right receivers, be able to activate additional ground based events such as switching on floodlighting of buildings, etc. It would appear as bright as the star Sirius, or even as the planet Jupiter, orbit the Earth every two hours at a height of 1250 kilometers. Its visibility would be confined to the twilight sky. It was suggested that after four years in orbit, the "Star" would have its orbit lowered in order to re-enter the atmosphere. The "Star" itself would not be a disaster for astronomy, even though it would be a significant hazard. What did cause major concern within the astronomical community was the precedent it would set, if implemented. It would be a clear signal, that it was culturally, scientifically and educationally acceptable to use spaceborne solar reflectors to convey messages on an international scale.

But development may not stop with solar reflectors - they are of limited usefulness for advertising because their brightness is limited by the efficiency of reflecting sunlight. The existence of such a fundamental limit, diluted by the inverse square law, reflection inefficiency and atmospheric extinction, seems to be recognized already. In 1994, SKY TV announced that it was considering space projection of its logo as a hologram produced by spaceborne lasers. In this situation, there is no limitation of visibility close to twilight and the energy expended is only bounded by engineering and financial constrains. Were such schemes demonstrably feasible (SKY TV based its suggestion on a NASA authority that stated that it was possible), then multiple space holograms would ensure not just the demise of deep sky astronomical imaging, but the whole of astronomical observation at optical wavelengths.

In the field of radio astronomy, there are problems with artificial radio transmissions from orbiting satellites. The interference caused by the GLONASS (Global Navigation Satellite System) at 1612 MHz has been resolved recently. Thus the conditions for observing the important OH maser line at that frequency should rapidly improve. However, the newly proposed satellite communication system Iridium is again threatening radio astronomical use of that band. The down link frequency from the satellites at 1620 MHz will be adjacent to the reserved radio astronomy band at 1610.6 to 1613.8 MHz. Since commercial transmissions must use higher power and astronomy is endeavouring to detect a weak cosmic signal, the possible spill of artificial transmission could mimic emissions from radio galaxies. Although Iridium and the United States National Radio Astronomy Observatory have reached a Memorandum of Understanding, the remainder of the radio astronomical community, with good reason, regards that bilateral agreement as a very poor basis for the future. What is needed is some kind of operational mandate which would allow astronomy, civilization, industry and commerce to coexist.

Another mobile communication project, Teledesic, is looking for an allocation of frequency in the hitherto non-allocated millimeter wavelength, very high frequency range in the 19 to 29 GHz band. This spectral region is one of peculiar importance to radio astronomy since there are many interstellar line emissions. It is subject to absorption (mostly by water vapour) so that there are only a limited number of transparent windows at these frequencies. Satellite up and down links must use these windows for commercial exploitation, and radio astronomy needs them to detect the faint interstellar spectrum lines emitted by a wide range of molecular species. Such studies contribute to understanding the structure and evolution of our own and other galaxies, formation of stars and planetary systems and, possibly, the development of life. The detection of these signatures of the nature of cosmic chemistry will be of crucial importance in discerning how large chemical molecules can be constructed and where in the Universe such processes take place. Very great care will have to be exercised in assigning the millimeter frequency range for communications if access to such far reaching astronomical information is to be maintained.

In addition, mobile multi-satellite systems, like Iridium, Teledesic and others, are demanding very large numbers of satellites in LEO. These satellites will reflect sunlight and exacerbate the worsening space debris problem. A study of the United Kingdom Schmidt Archive at the Royal Observatory Edinburgh has shown that satellite trailings on precious astronomic plates has increased from 1.5 trails per hour of exposure in 1978 to 2.5 in 1994. More deep sky imaging and photometry will be degraded as a consequence when such projects become operational. Clearly, systematic thought is urgently needed to minimize the impact on both radio and optical astronomy. Attention should be given to restoration of astronomic observing conditions to a state where the hazards are as close to natural limitations as may yet be practicable. Above all, no activity of itself should be permitted which would terminate unilaterally major techniques for obtaining astronomical information and data.

The International Conference on Near-Earth Objects was held in New York on 24 to 26 April 1995. It was co-sponsored by the Explorers Club, the Planetary Society and the United Nations. The subject of the conference, Near-Earth Objects (NEO), was comets and asteroids whose orbits could intersect the orbit of the Earth around the Sun. The possibility of collision between the Earth and NEO has been the subject of much speculation regarding the likelihood and consequences of such an event. Since it has been generally understood that the impact of a kilometer size NEO would have severe consequences on the terrestrial biosphere, it is of some interest to estimate its probability. Astronomy and planetary science have shown that craters are an ubiquitous, if not dominant, feature on planets, moons and asteroids within the inner solar system. Detailed studies of cratering records indicate that the impact of a kilometer or greater sized NEO was a regular occurrence, with continuity over large times scales. The fossil records appear to suggest that our own progression from mammalian ancestors was assisted by a NEO impact that eliminated a vast number of species, including, at the cretaceous tertiary boundary (K/T), the predator dinosaurs.

The main focus of NEO research at this time should be towards generating more knowledge about the origin, evolution, and dynamical and material characteristics of asteroids and comets that can interact within Earth's immediate space environment. The heightened public awareness about NEO and hazards associated with possible impacts must be met with a responsible explanation based on scientific knowledge. From this perspective, NEO research is an opportunity to pursue interdisciplinary scientific research in the basic space sciences through international cooperation. Of prime operational importance is the creation and maintenance of an internationally organized NEO catalog and ephemeris (predictions) computation service. To this end, improved observational data are needed from both northern and southern hemispheres, especially for NEO under one kilometer diameter.

To underscore the importance of these observations and the uncertainty in determining a value, albeit approximate, for the probability of collision with the Earth, an analysis of the Earth crossing asteroid (Apollo, Amok, and Athens families) and comet (Jupiter and Halley families) statistics was carried out. It is suggested that the overall collision probability may be uncertain by a factor as large as five. This is primarily due to the relatively large number of smaller objects (below 200 meters) and the fact that only a very small percentage of this population has been discovered. To determine this population more accurately, observations must be extended to higher magnitude ranges and spectral classes wherever possible.

Obtaining an accurate number for the comet population does not appear to be so straightforward, since a determination of the ratio of passive to active comets proved to be extremely difficult. Therefore, further NEO studies should center around extensive and detailed observational work, from which modelling and other assessments could follow. Until this empirically based research is carried out, it will not be possible to realistically characterize the NEO threat, nor will the likelihood of a successful outcome from NEO countermeasures be assured in any way.

Appendix

LIST OF SCIENTIFIC AND TECHNICAL PRESENTATIONS

I. SYMPOSIUM ON UTILIZATION OF MICRO- AND SMALL SATELLITES FOR THE EXPANSION OF LOW-COST SPACE ACTIVITIES, TAKING INTO PARTICULAR ACCOUNT THE SPECIAL NEEDS OF DEVELOPING COUNTRIES, ORGANIZED BY COSPAR AND IAF

The first session of the symposium, entitled "Small satellite activities", was co-chaired by Mr. K. Doetsch, representing IAF, and Mr. W. Riedler, representing COSPAR. The second session of the symposium, entitled "The potential of micro- and small satellites", was co-chaired by Mr. J. Ortner, representing IAF, and Mr. K. Szegö, representing COSPAR. Mr. S. Grahn of COSPAR was the Rapporteur for both sessions of the symposium.

"Small Satellite Programmes in Developing Countries (Keynote Address)," Mr. P. Molette, Chairman of the Subcommittee on Small Satellites for Developing Nations, International Academy of Astronautics (IAA).

"The European Space Agency's Small Missions Opportunities (SMO) Initiative," Mr. F. Ongaro, Strategy Office, European Space Agency.

"Small Satellite Projects in Latin America," Mr. C. Puebla Menne, Comité de Asuntos Espaciales de Chile, Chile.

"An Introduction to KITSAT Program," Mr. S. Kim, Deputy Project Manager, Satellite Technology Research Center, Korea Advanced Institute of Science and Technology, Republic of Korea.

"Small Satellite Projects in Spain," Mr. A. Giménez, Director General, Instituto Nacional de Técnica Aeroespacial (INTA), Spain.

"Contribution of Small and Micro-Satellites to Scientific Research (Keynote Address)," Mr. K. R. Sridharamurthy, Indian Space Research Organization (ISRO), India.

"French Experience and Prospects in the Use of Small and Micro-Satellites for Space Science and Applications," Mr. P. L. Contreras, System Division Head, Toulouse Space Center, Centre National d'Etudes Spatiales (CNES), France.

"NASA Cooperation with Developing Nations on Small Satellite Programs," Mr. J. Mansfield, Associate Administrator, Office of Space Access and Technology, National Aeronautics and Space Administration (NASA), United States.

"Brazilian Small Satellite Program and its Particularities on Space Needs," Mr. D. Ceballos, Instituto Nacional de Pesquisas Espaciais (INPE), Brazil.

"The Sunset Project," Mr. S. Mostert, University of Stellenbosch, Republic of South Africa.

"Summary of the Symposium," Mr. S. Grahn, COSPAR.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

"Space Debris Related Research at the Research Establishment for Applied Sciences (FGAN)," Mr. D. Mehrholz, FGAN, Bonn, Germany.

"Measurements of the Orbital Debris Environment," Mr. A. Potter, National Aeronautics and Space Administration (NASA), United States.

"Modelization of Space Debris and Comparison with Observations, Mr. F. Alby, Centre National d'Etudes Spatiales (CNES), Toulouse, France.

"Space Debris Research in ESA," Mr. W. Flury, ESOC, European Space Agency.

"Summary of the United States National Research Council Report on Orbital Debris: A Technical Assessment," Mr. G. Levin, National Aeronautics and Space Administration (NASA), United States.

"The Unique Debris Hazards Associated with Satellite Constellations," Mr. R. Crowther, Defence Research Agency, Farnborough, United Kingdom.

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

"Interpretation and Development of the Safety Principles for Nuclear Power Sources in Space," Mr. B. Wade, AEA Technology, United Kingdom.

"Russian Space Transportation System," Mr. A. V. Yakovenko, Ministry of Foreign Affairs, Russian Federation.

"X-Prize: Development of a Reusable, Single-stage, Sub-orbital Vehicle," Mr. D. Prunariu, cosmonaut, Association of Space Explorers (ASE).

"ISU Design Projects on Small Satellite for Earth Observation for Polar Regions," Ms. L. Stojak, International Space University (ISU).

"Application Potential of Indian Remote Sensing satellite (IRS-1C)," Mr. R. R. Navalgund, Space Applications Centre, Ahmedabad, India.

"Applications of Remote Sensing in Cartography and Mapping," Mr. M. Saoud, Responsable technique (CRTS), Morocco.

"Status of New Commercial Remote Sensing Satellites: High Resolution Imaging Systems," Mr. L. W. Fritz, International Society for Photogrammetry and Remote Sensing (ISPRS).

"Geospace Global Mapping Project and the Digital Atlas of the World," Mr. L. Beckel, Geospace, Austria.

"Central European Satellite for Advanced Research (CESAR)," Mr. Z. Klos, Polish Academy of Sciences, Warsaw, Poland.

"Cooperation on Small Satellites," Mr. Y. B. Zoubarev, State Scientific Research Institute of Radio, Russian Federation.

"Solar Reflectors, Radio Astronomy and Access to the Sky," Mr. D. McNally, International Astronomical Union (IAU).

"Report on the International Conference on Near-Earth Objects," Mr. J. Remo, Organizer.

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