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الأمم المتحدة

الجمعية العامة

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لجنة استخدام الفضاء الخارجي
في الأغراض السلمية

تقرير وأعمال حلقة العمل المشتركة بين الأمم المتحدة والاتحاد الدولي للملاحة الفلكية وكندا بشأن تسخير التكنولوجيات الفضائية لأغراض التنمية ، التي نظمت بالتعاون مع حكومة كندا

(مونتريال ، كندا ، ٢-٥ تشرين الأول/اكتوبر ١٩٩١)

المحتويات

المحتويات (تابع)

المرفقات

مقدمة

ألف - المعلومات الاساسية والاهداف

١ - يتضمن هذا التقرير موجزا لاعمال حلقة العمل المشتركة بين الامم المتحدة والاتحاد الدولي للملاحة الفلكية وكندا بشأن تسخير التكنولوجيات الفضائية لاغراض التنمية والاستنتاجات والتوصيات التي اعتمدها المشتركون في حلقة العمل . ومثلت حلقة العمل جزءا من برنامج الامم المتحدة للتطبيقات الفضائية لعام ١٩٩١ على النحو الذي اقترحه خبير التطبيقات الفضائية وأوصت به اللجنة الفرعية العلمية والتقنية التابعة للجنة استخدام الفضاء الخارجي في الاغراض السلمية . وأقرت اللجنة والجمعية العامة البرنامج فيما بعد .

٢ - وقد استضافت حكومة كندا حلقة العمل واشتركت في رعايتها وقامت بتنظيمها الامم المتحدة (شعبة شؤون الفضاء الخارجي) ، وحكومة كندا (الوكالة الفضائية الكندية) ، والاتحاد الدولي للملاحة الفلكية . وعقدت الحلقة في مونتريال في الفترة من ٢ الى ٥ تشرين الاول/اكتوبر ١٩٩١ .

٣ - وعقدت حلقة العمل توا قبل مؤتمر الاتحاد الدولي للملاحة الفلكية لعام ١٩٩١ ، الذي عقد في مونتريال في الفترة من ٧ الى ١١ تشرين الاول/اكتوبر ، لتمكين المشتركين في الحلقة من الاشتراك أيضا في المؤتمر .

٤ - وتمثلت أهداف حلقة العمل في السماح للمشتركين من مختلف البلدان بتبادل المعلومات المتعلقة بتطبيقات التكنولوجيات الفضائية لاغراض التنمية الاقتصادية والاجتماعية في البلدان النامية ومناقشة احتياجات تلك البلدان وكيفية تلبية تلك الاحتياجات ، عن طريق التنمية المحلية والتعاون الدولي على حد سواء . وعُرضت في محاضرات الخبرات التي اكتسبتها مختلف البلدان في ميداني استحداث وتسخير مختلف التكنولوجيات الفضائية لاغراض التنمية ، وناقش المشتركون الآثار التي رتبتها تلك الخبرات على البلدان النامية .

٥ - وقد قامت لجنة استخدام الفضاء الخارجي في الاغراض السلمية ولجنتها الفرعية العلمية والتقنية بإعداد هذا التقرير ، الذي يشمل المعلومات الاساسية ، وأهداف حلقة العمل وتنظيمها ، ويحتوي على نصوص الورقات التي عرضت على الحلقة وكذلك

الاستنتاجات والتوصيات التي اعتمدها المشتركون . وسيقدم المشتركون تقارير الى السلطات المعنية في بلد كل منهم .

باء – تنظيم حلقة العمل وبرنامجها

٦ - كانت الدول الاعضاء والمنظمات الدولية التالية ممثلة في حلقة العمل : الارجنتين ، واندونيسيا ، وايران (جمهورية - الاسلامية) ، وباكستان ، والبرازيل ، وتايلند ، وتنزانيا ، ورواندا ، وزمبابوي ، والصين ، والفلبين ، وفييت نام ، وكوبا ، وكولومبيا ، ومنغوليا ، ونيجيريا ، والهند ، والمنظمة الدولية للاتصالات اللاسلكية بواسطة التوابع الاصطناعية ، والمنظمة الدولية للاتصالات البحرية بواسطة التوابع الاصطناعية ، وشعبة الامم المتحدة لشؤون الفضاء الخارجي . كما اشترك متكلمون ورئيسا الفريقين العاملين من استراليا ، وكندا ، والمملكة المتحدة لبريطانيا العظمى وايرلندا الشمالية ، والهند ، والولايات المتحدة الامريكية ، واليابان .

٧ - واستخدمت الاموال التي خصصتها الامم المتحدة وحكومة كندا لتنظيم حلقة العمل في تغطية تكاليف السفر الجوي الدولي ، ومصاريف البدل اليومي لـ ١٥ مشتركا لفترة انعقاد حلقة العمل والمؤتمر ، والتسجيل للمؤتمر .

٨ - وافتتحت حلقة العمل رسميا بخطابين رئيسيين ألقاهما الدكتور ي. ر. راو ، رئيس المنظمة الهندية لبحوث الفضاء ، والدكتور لاركن كيروين ، رئيس الوكالة الفضائية الكندية . كما ألقى السيد ن. جاسنتوليانا ، مدير شعبة الامم المتحدة لشؤون الفضاء الخارجي ، خطابا للترحيب .

٩ - وقد أعدت الامم المتحدة برنامج حلقة العمل (انظر المرفق الاول لهذا التقرير) بالتعاون مع حكومة كندا والاتحاد الدولي للملاحة الفضائية . وجرى تسيير أعمال الحلقة عن طريق عقد مجموعة جلسات عامة وجلسات للفريقين العاملين .

١٠ - وأعرب المشتركون عن تقديرهم للامم المتحدة ، وحكومة كندا والاتحاد الدولي للملاحة الفلكية لقيامهم بتنظيم حلقة العمل واستضافتها ، ولما قدموه من مساعدة مالية وللصفة التقنية للبرنامج .

أولا - العروض المقدمة في حلقة العمل

١١ - عرضت عدة ورقات في حلقة العمل . وقد بحثت ورقتان القضايا العامة التي ينطوي عليها تسخير التكنولوجيات الفضائية لأغراض التنمية . وشرحت ورقتان تطبيقات تكنولوجيا الفضاء في مجال الاتصالات المتنقلة ، وأوردت ثلاث ورقات تطبيقات محددة أخرى للتكنولوجيات الفضائية . وبالإضافة إلى ذلك ، قدم ممثلون من بلدان نامية مختلفة ست ورقات عن تطبيقات التكنولوجيات الفضائية في بلدانهم . ويرد النص الكامل للورقات في المرفق الثاني لهذا التقرير .

ثانيا - الاستنتاجات والتوصيات

١٢ - بالإضافة إلى حضور الجلسات العامة ، انقسم المشتركون إلى فريقين عاملين لمناقشة القضايا الرئيسية ذات الصلة بموضوع حلقة العمل . ويتضمن تقريرا الفريقين العاملين استنتاجاتهما وتوصياتهما الموجهة إلى المنظمات الوطنية والدولية المعنية بتطبيق التكنولوجيات الفضائية لأغراض التنمية .

ألف - تقرير الفريق العامل المعني بالاستشعار من بعد وإدارة الموارد (الفريق العامل رقم ١)

١٣ - تناول الفريق العامل رقم ١ القضايا ذات الصلة بالاستشعار من بعد وإدارة الموارد . ووافق المشتركون في الفريق العامل على الاستنتاجات والتوصيات التالية .

١٤ - كثيرا ما تقيد الاعتبارات المالية البلدان النامية في استغلال تكنولوجيا الفضاء لأغراض برامج التنمية الاجتماعية - الاقتصادية التي تدعو الحاجة إليها . وتتضمن التكاليف الكبيرة الاستثمار الأولي لاقتناء التكنولوجيا ، والتكاليف المتكررة لشراء البيانات بصورة منتظمة وتكاليف البحوث لاستحداث منهجيات للاحتياجات المحددة لكل بلد على حدة .

١٥ - وينبغي بذل الجهود لتخفيض تكلفة بيانات مراقبة الأرض بالنسبة للبلدان النامية . وينبغي أن تواصل الدول المتقدمة النمو تقديم الدعم للبلدان النامية في

شراء بيانات الاستشعار من بعد بوضع نظام تسعير مرن ، يأخذ في الاعتبار متطلبات كل بلد على حدة من البلدان المتلقية .

١٦ - وينبغي أن تقدم برامج حلقات العمل المقبلة المزيد من الدراسات الإفرادية مع نتائج موجهة نحو تحقيق الاهداف ، وينبغي أن يضم المشتركون صانعي السياسة ، والمخططين وصانعي القرارات السياسية . وتتضمن المواضيع المقترحة لحلقات العمل المقبلة الكوارث الطبيعية والتأهب لحالات الطوارئ والتعليم في المناطق النائية والريفية .

١٧ - وينبغي أن يتحول التركيز من البرامج التدريبية المحددة إلى الخدمات الاستشارية ، التي يمكنها ، مثلا ، تقييم نتائج البرامج التدريبية القائمة وتعزيز التعاون الثنائي فيما بين البلدان النامية لكي تتمكن من الاستفادة من خبرة بعضها البعض .

١٨ - كما أوصي بإنشاء مشاريع للبيان العملي ، بدعم من الامم المتحدة . وينبغي أن تركز تلك المشاريع على التطبيقات الفعالة من حيث التكلفة ، والموجهة نحو تحقيق الاهداف في ميادين مثل الارض وموارد المياه ، واستغلال الاراضي البور وتعرية التربة . وينبغي أن تتضمن حلقات العمل عروضا من البلدان النامية عن تلك التطبيقات .

١٩ - وجرى التأكيد على الحاجة إلى التعاون فيما بين البلدان النامية ، ولا سيما لمساعدة هذه البلدان في التغلب على ارتفاع تكاليف الاستشعار من بعد . ويمكن أن يؤدي التعاون والتنسيق إلى مساعدة البلدان في تجنُّب الازدواج في اقتناء البيانات ، وتسهيل تقاسم الاستشعارات في المحطات الارضية ، وتشغيلها ، وضمان تطابق البيانات . وقد يؤدي إنشاء وكالة فضائية للبلدان النامية إلى تسهيل بلوغ مستوى التعاون المطلوب .

٢٠ - وجرى التشديد على الحاجة إلى توفير المعدات والمرافق الحديثة . وأوصي بأن توفر الامم المتحدة المكونات المادية والبرامجيات لحواسيب سهلة الاستعمال للبلدان النامية لدراسة البيئة والموارد الطبيعية مع ضرورة البحث عن حلول منخفضة التكلفة لتطبيقات تكنولوجيا الفضاء .

٣١ - وهناك حاجة مستمرة لتوفير التدريب والتعليم والمعلومات المتعلقة بتطبيقات تكنولوجيا الفضاء للبلدان النامية . ولا سيما في ميادين الاستشعار من بعد ، وتجهيز الصور وخدمات المعلومات الجغرافية . وتدعو الحاجة إلى توفير التدريب للمدرسين على صعيدي المدارس الثانوية والجامعات على حد سواء . ومن شأن إنشاء مراكز تدريبية اقليمية في البلدان النامية أن يمكّن البلدان المتجاورة من تقاسم التكاليف مع توفير التدريب في ظل ظروف واقعية بمعدات وهياكل أساسية متاحة محليا .

٣٢ - وتتسم حلقات العمل مثل حلقة العمل المشتركة بين الامم المتحدة والاتحاد الدولي للملاحة الفلكية وكندا بشأن تسخير تكنولوجيا الفضاء لاغراض التنمية بأنها قيّمة . وبخاصة إذا عقدت مقترنة بمؤتمر الاتحاد الدولي للملاحة الفلكية ، مما يتيح للبلدان النامية الفرصة لحضور الحدث . وينبغي الترويج لعقد حلقات عمل مماثلة في المستقبل .

باء - تقرير الفريق العامل المعني بتخطيط
برامج الفضاء والاتصالات الفضائية
(الفريق العامل رقم ٢)

٣٣ - تناول الفريق العامل رقم ٢ القضايا ذات الصلة بتخطيط برامج الفضاء وبالاتصالات الفضائية . وعلى ضوء العروض التي قدمها المتكلمون من اندونيسيا ، والبرازيل ، والصين ، وكندا ، والمنظمة الدولية للاتصالات البحرية بواسطة التوابع الاصطناعية بشأن التطبيقات العملية للتكنولوجيات الفضائية في بلدانهم ومنظماتهم ، أسفرت المناقشات التي دارت في الفريق العامل عن الاستنتاجات والتوصيات التالية .

٣٤ - كثيرا ما يُهمل تخطيط تطوير تكنولوجيا الفضاء تطوير التطبيقات والهياكل الأساسية ، مما يؤدي إلى عدم استخدام المكونات المادية للحواسيب بالقدر الكافي . ويجب أن تظهر بوضوح قيمة برامج الفضاء ، ربما عن طريق تحليل العلاقة بين التكلفة والعائد ، قبل قيام كثير من البلدان بتمويل تلك البرامج من الموارد الشحيحة . وفي حين يوجد قدر كبير من المعلومات فيما يتعلق بالتكنولوجيات والتطبيقات الفضائية ، ينتج كثير منها على نحو مجزأ . وتتضمن التدابير الموصى بها توسيع نطاق توزيع منشورات شعبة الأمم المتحدة لشؤون الفضاء الخارجي ، وقيام الأمم المتحدة بتوفير مكتبة للمواد التعليمية وقيام المنظمة الدولية للاتصالات البحرية بواسطة التوابع الاصطناعية والمنظمة الدولية للاتصالات اللاسلكية بواسطة التوابع الاصطناعية باستخدام تكنولوجيات كل منهما لتعزيز استخدام شبكتيهما على نطاق أوسع .

٣٥ - وينبغي العمل على تحقيق المصالح المشتركة للبلدان عن طريق الرابطات الاقليمية وعن طريق تشجيع الاتصالات والاتفاقات الثنائية . وينبغي أن يشترك العلماء والمهندسون والتقنيون من البلدان النامية في بحوث تطبيقات الاتصالات اللاسلكية الفضائية التي تجريها البلدان المتقدمة النمو ، كلما أمكن ، ربما عن طريق البرامج التدريبية أو الإعارة .

٣٦ - ويمكن تحسين التعاون بين البلدان المتقدمة النمو والبلدان النامية ضمن مشاريع وكالات المعونة باستخدام المعرفة الحالية في البلدان النامية ؛ وباستخدام مقاولي الباطن الموجودين لدى البلد ، ومن ثم تحسين نقل التكنولوجيا ؛ وبإدراج التزام بالمتابعة الطويلة الاجل ، وبالتدريب .

٣٧ - واقترحت مواضيع التأهب للطوارئ في حالات الكوارث الطبيعية وتوفير الخدمات التعليمية للمناطق الريفية باستخدام التكنولوجيات الفضائية بوصفها مواضيع يمكن أن تتناولها حلقات العمل المقبلة .

٣٨ - ولاحظ المشتركون قيمة برنامج الامم المتحدة للتطبيقات الفضائية وأوصوا بتخصيص موارد إضافية للبرنامج . وينبغي أن ينصبّ تركيز الاموال الموجودة على البرامجيات والتطبيقات بدلا من المكونات المادية للحواسيب ، وينبغي أن يولي البرنامج الاولوية إلى خدماته التعليمية والاستشارية .

Annexes

Annex I

PROGRAMME OF THE WORKSHOP

Wednesday, 2 October, 1830-2130

Welcome statement	Mr. N. Jasentuliyana, Director, United Nations Office for Outer Space Affairs
Keynote address: Creating space programmes in developing countries	Dr. U.R. Rao, Chairman, Indian Space Research Organisation and Chairman IAF/CLIODN
Keynote address: Honest doubters into honest believers: the role of space in third world development	Dr. Larkin Kerwin, President, Canadian Space Agency

Thursday, 3 October, 0900-1230 Chairman: M. Jean-Claude Henein (Canada)

Workshop: Planning agricultural development

Satellite data for agricultural information systems	Mr. Bobby Spiers, United States Department of Agriculture
Remote sensing for crop information systems	Dr. Leo Sayn-Wittgenstein Canada Centre for Remote Sensing

Workshop: Rural Services - Water and Transport

International cooperation and coordination in satellite remote sensing	Mr. Ralph Chipman, United Nations Office for Outer Space Affairs
Using remote sensing for developing rural water supplies	Mr. M.G. Chandrasekar, Indian Space Research Organisation

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Thursday, 3 October, 1330-1700 Chairman: Mr. Eric Tsang (Canada)

Workshop: Communications and education

Communication satellites for education and development	Prof. Liu Zhongen, rural INTELSAT
Organizing an educational satellite system	Mr. Fuwen Gao, China

Workshop: Space applications for health and and safety systems

Satellite communications for rural and remote health services	Dr. Max House, Memorial University of Newfoundland

Friday, 4 October, 0900-1200 Chairman: Ms. Irena Streibl (Canada)

Workshop: industrial and commercial opportunities for developing countries

The development of a space industry: niches for developing countries	Mr. Tasuku Tanaka, NASDA, Japan
Industrial participation in space programmes	Mr. Sikander Zaman, Pakistan

Workshop: communications for commercial transportation

Low-cost mobile satellite communications	Mr. J.C. Bell, INMARSAT
Applications of mobile satellite communications Mobile, Inc.	Mr. Orest Roscoe, Telesat

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Friday, 4 October, 1330-1700 Working Groups

Group 1: Planning and communications — Chairman: Mr. Luiz Aires Maranhao Cerqueura (Brazil)

Group 2: Remote sensing and resource management — Chairman: Mr. Sikander Zaman (Pakistan)

Saturday, 5 October, 0900-1100 Working Groups

Review and finalize reports

Saturday, 5 October, 1100-1200 Chairman: Dr. John Carver

Closing plenary session

Presentation and adoption of reports and recommendations

Closing remarks

Annex II

PAPERS PRESENTED TO THE WORKSHOP

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HONEST DOUBTERS INTO HONEST BELIEVERS:

THE ROLE OF SPACE IN THIRD-WORLD DEVELOPMENT

Dr. Larkin Kerwin

President

Canadian Space Agency

WITHIN ONE GENERATION, SPACE RESEARCH HAS GONE FROM SCIENCE FICTION TO REALITY• ASTRONAUTS HAVE SET FOOT ON THE MOON; THE SOLAR SYSTEM HAS BEEN VIEWED FROM BEYOND ITS FARTHEST PLANETS; BLACK HOLES, QUASARS AND NEUTRON STARS HAVE BEEN POSTULATED AND FOUND• TODAY OUR IMAGINATION EMBRACES MARS BASES, TELESCOPES THAT GAZE BACK AT CREATION AND HIGH TECHNOLOGY INDUSTRIES IN LOW EARTH ORBITS• THESE SPECULATIONS HAVE THE NATURE OF FIRM PLANS, FOR TODAY'S SPACE IMAGINING ARE SERIOUS PREDICTIONS• THERE WILL STILL BE ROOM AMONG THE SPACE EXPLORERS OF TOMORROW FOR DREAMERS: BUT MORE AND MORE, THEIR DREAMS WILL REST UPON THE PRACTICAL REALITIES OF ECONOMICS•

AS A SCIENTIST, I FREELY ADMIT THAT IT IS HONESTLY POSSIBLE TO DOUBT SUCH LOFTY STATEMENTS; AND MANY HONEST DOUBTERS MAY HAIL FROM THE THIRD WORLD• TO DATE, DEVELOPING NATIONS HAVE BEEN LARGELY PASSIVE OBSERVERS TO SPACE ACTIVITY• WHAT HARD BENEFITS - FROM A PURSUIT AS ARCANE AND TECHNOLOGY-INTENSIVE AS SPACE RESEARCH - COULD POSSIBLY ACCRUE TO NATIONS SOME OF WHICH ARE STILL STRUGGLING TO SHELTER, FEED AND EDUCATE THEIR PEOPLE ? THEY ALSO FACE WITH ALL NATIONS PROBLEMS OF PLANETARY DIMENSIONS• ALL THE WORLD IS UNITED IN WORRY ABOUT THE BIOSPHERE THEY SHARE:

/...

DESERTS ARE SPREADING, FORESTS ARE RETREATING, DRINKING WATER AND FIREWOOD ARE BECOMING SCARCER, THE COMBUSTION PRODUCTS OF FOSSIL FUELS FORM CORROSIVE ACIDS THAT DISSOLVE CATHEDRALS AND LUNGS WITH EQUAL EFFICIENCY• EVEN IF POTENTIAL APPLICATIONS OF SPACE TECHNOLOGY DID EXIST FOR SUCH COUNTRIES HOW COULD A DEVELOPING NATION WITH AN AGRARIAN ECONOMY AND A SMALL TAX BASE EVER APPLY AND BENFIT FROM THEM ?

MY CENTRAL THESIS THIS EVENING IS THAT THE DEVELOPING WORLD HAS IN FACT A GREAT DEAL TO GAIN FROM SPACE RESEARCH - AS MUCH AS HUMAN IMAGINATION CAN ALLOW•

THE WORD "DEVELOPMENT" IN THE CONTEXT OF THIS MEETING PRESUMABLY REFERS TO A PROCESS WHEREBY A COUNTRY MAKES USE OF ITS RESOURCES AND CONTEXT TO IMPROVE THE QUALITY OF LIFE OF ITS PEOPLE• THE ADVENT OF NEW TECHNOLOGIES CAN SPUR THIS PROCESS•

THE DEVELOPMENT OF CURRENT ELECTRICITY HAS MADE IMMENSE CONTRIBUTIONS TO HUMANITY'S WELLBEING AND IS NOW UBIQUITOUSLY USED ON EVERY CONTINENT OF THE PLANET• THE HARNESSING OF ELECTROMAGNETIC WAVES REVOLUTIONIZED COMMUNICATIONS AND THEIR USE IS POSSIBLY EVEN MORE PERVASIVE•

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THE GROUP OF ENGINEERING PROCESSES KNOWN AS SPACE TECHNOLOGY WILL BE AS IMPORTANT AND EFFECTIVE AS CURRENT ELECTRICITY AND ELECTROMAGNETIC WAVES• ALREADY IN MY COUNTRY, CANADA, FOR VARIOUS GEOGRAPHIC AND HISTORICAL REASONS, SPACE TECHNOLOGY HAS BECOME A NORMAL PART OF OUR DAILY LIVES AND THE QUALITY OF CANADIAN LIFE WOULD BE NOTICEABLY REDUCED WERE THESE TECHNOLOGIES TO BE REMOVED•

A DEVELOPING COUNTRY, BE IT CANADA OR ANOTHER, MUST THEREFORE INCLUDE CURRENT ELECTRICITY, ELECTROMAGNETIC WAVES AND NOW SPACE TECHNOLOGY IN ITS CONSIDERATIONS• DR. RAO HAS SPOKEN OF HOW SPACE PROGRAMMES MAY BE CREATED IN DEVELOPING COUNTRIES•

PERMIT ME TO MENTION FOUR PARTICULAR POINTS THAT SHOULD BE KEPT IN MIND AS THIS TAKES PLACE•

THE FIRST IS THE NEED TO BE SELECTIVE• A COUNTRY USUALLY CANNOT AFFORD TO DO EVERYTHING IN SPACE• IN CANADA, FOR EXAMPLE, WE DO NOT HAVE LAUNCH FACILITIES, WE DO NOT HAVE A SPACE TELESCOPE, WE HAVE NO PLANETARY EXPLORATION PROGRAMME• WE HAVE CONCENTRATED ON THE USER APPLICATIONS, SUCH AS

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TELECOMMUNICATIONS AND REMOTE SENSING. TO CONCENTRATE ON THESE AREAS OPENS A WIDE SPECTRUM OF POSSIBILITIES. ACCESS TO A SINGLE GEOSTATIONARY SATELLITE CAN PROVIDE A VARIETY OF SERVICES SUCH AS NATIONAL TELEPHONE COMMUNICATIONS, RADIO AND TELEVISION BROADCASTING, TELEMEDICAL SERVICES SUCH AS WE SUPPLY TO OUR FAR NORTHERN REACHES, AND EDUCATIONAL SERVICES TO OUTLYING AREAS. IN THE REMOTE SENSING AREA THERE IS FURTHER NEED FOR SELECTION, BECAUSE THERE ARE SEVERAL TECHNOLOGIES INVOLVING DIFFERENT TYPES OF SATELLITES. THUS, THERE ARE THE STATIONARY WEATHER SATELLITES USING OPTICAL SENSORS, INCLINED ORBIT OPTICAL SATELLITES OR THE MORE EXPENSIVE TO LAUNCH POLAR ORBIT VEHICLES FOR TOPOGRAPHY, POLLUTION MONITORING AND THE INVENTORYING OF NATURAL RESOURCES. THE RADAR SATELLITES PROVIDE ALL-WEATHER 24-HOURS-A-DAY SENSING.

ANY OF THESE APPLICATIONS, SELECTED IN THE CONTEXT OF A COUNTRY'S PARTICULAR NEEDS, CAN BE VERY EFFECTIVE, NOT ONLY IN THE SERVICE PROVIDED, BUT AS WELL IN THE OPENING UP OF NEW TECHNOLOGIES, THE DEVELOPING OF NEW EXPERTISE AND THE ACCESSING OF INTERNATIONAL ACTIVITIES.

MY FIRST POINT, THEN, IS THE NEED FOR MOST COUNTRIES TO BE SELECTIVE AND TO CONCENTRATE, IN THE BEGINNING ON ONE SERVICE

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WHICH CAN CONTRIBUTE TO DEVELOPMENT•

A SECOND POINT RATHER FLOWS FROM THIS: THE NEED FOR COLLABORATION• FEW HUMAN ACTIVITIES LEND THEMSELVES TO INTERNATIONAL COOPERATION AS WELL AS DO THE SPACE PROGRAMMES• TO SAY "SPACE" IS TO SAY "INTERNATIONAL"• ALL OF THE CANADIAN SPACE AGENCY'S ACTIVITIES INVOLVE INTERNATIONAL PARTNERS• ONE REASON IS COST: EVEN THE SINGLE GEOSTATIONARY SATELLITE WHICH I MENTIONED A MOMENT AGO CAN BE A CONSIDERABLE FINANCIAL CHALLENGE FOR MANY COUNTRIES; BUT A CONSORTIUM OF FOUR OR SIX COUNTRIES MIGHT FIND THE TASK MORE AMENABLE, AND THE DEVELOPMENT PROSPECTS HELD FORTH FOR SUCH A GROUPING MIGHT INTEREST THE INTERNATIONAL FUNDING AGENCIES• A SECOND REASON IS THE NATURE OF THE ENDEAVOURS: PROJECTS INVOLVING WEATHER, CLIMATE, POLLUTION AND GLOBAL CHANGE KNOW NO NATIONAL BOUNDARIES, AND INTERNATIONAL COLLABORATION IS ESSENTIAL TO THE COLLECTION OF MUCH OF THE DATA AND TO AN UNDERSTANDING OF THE PROCESSES• A DEVELOPING COUNTRY WITH LIMITED RESOURCES MUST THEREFORE SEEK PARTNERSHIPS, AND WILL FIND THAT THE PARTNERS ARE COGNIZANT OF THE MUTUAL BENEFITS THAT WILL RESULT FROM THE COOPERATION•

PARTNERSHIP IN SCIENCE AND ENGINEERING IS A VERY OLD

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TRADITION AND MOST COUNTRIES OF THE WORLD HAVE JOINED TOGETHER IN SCIENTIFIC UNIONS AND ACADEMIES SO AS TO WORK MORE EFFECTIVELY. THE EUROPEAN SPACE AGENCY IS A SUPERLATIVE EXAMPLE. BECAUSE OF THEIR PARTICULAR CIRCUMSTANCES, THIRD WORLD COUNTRIES HAVE FOUND IT USEFUL TO JOIN IN THE INSTITUTE FOR THEORETICAL PHYSICS AT TRIESTE WHICH HAS BEEN SO SUCCESSFUL FOR THE PAST GENERATION UNDER THE GUIDANCE OF NOBEL LAUREATE ABDUS SALAM. MORE RECENTLY THEY HAVE FORMED THE THIRD WORLD ACADEMY OF SCIENCE. MIGHT WE THINK OF THE POSSIBILITY OF A THIRD WORLD SPACE AGENCY ? THIS WOULD PROVIDE AN ORDERLY WINDOW ON THE ACTIVITIES OF THE INTERNATIONAL SPACE COMMUNITY, AND PROBABLY A DOOR TO SEVERAL OF THEM.

THE THIRD POINT WHICH I SUBMIT TO YOU CONCERNS A GROWING AND DIFFICULT PROBLEM IN SCIENCE: THE BALANCE BETWEEN DATA ACQUISITION AND ITS ANALYSIS.

ADVANCES IN THE TECHNOLOGY OF ON-LINE COMPUTERS AND TELEMETRY HAVE RESULTED IN TORRENTS OF DATA BECOMING AVAILABLE. IT IS COMMON TO DISCUSS THE GATHERING OF SUCH DATA IN TERMS OF GIGABYTES PER SECOND.

SCIENTISTS REGULARLY DESCRIBE THE PERFORMANCE OF

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SATELLITES SUCH AS MAGELLAN AS PROVIDING WORK FOR YEARS AND YEARS TO COME• A SINGLE X-RAY SATELLITE PUT ALL OF THE STAR ATLASES OUT OF DATE• IT REQUIRES CRAY COMPUTERS TO MAKE A DENT IN THE METEOROLOGICAL DATA AVAILABLE FOR MODELLING WEATHER DEVELOPMENT• THERE IS AN UNBALANCE IN THE RESOURCES BEING ALLOTTED TO THE GENERATION OF DATA AND THOSE DEDICATED TO ITS ANALYSIS•

THEREIN LIES AN OPPORTUNITY FOR A SPACE PROGRAMME REQUIRING RELATIVELY MODEST FINANCIAL RESOURCES• HOWEVER DISPARATE THE MATERIAL PROSPERITY OF FIRST OR THIRD WORLDS THERE IS THAT QUALITY OF OUR SPECIES - ITS IMAGINATION - WHICH IS A UNIVERSAL PATRIMONY• IT IS MORE FERTILE THAN LAND, MORE DESIRABLE THAN OIL• THE DEVELOPING COUNTRIES CAN HASTEN THEIR DEVELOPMENT BY ACCESSING THE "HIGH GROUND" OF SPACE DATA ANALYSIS• REQUIRING BRILLIANT MINDS AND SOME COMPUTER POWER, DATA ANALYSIS COULD BE ONE OPTION FOR A THIRD WORLD SPACE AGENCY PROGRAMME•

IN THIS CONTEXT CANADA WILL BE ABLE TO SHARE ONE OF ITS OWN ACTIVITIES• AS PART OF OUR CONTRIBUTION TO THE INTERNATIONAL SPACE YEAR OF 1992 CANADA IS PRODUCING A DIGITAL GLOBAL CHANGE ENCYCLOPEDIA• I QUOTE FROM AN ARTICLE DESCRIBING IT BY RÉJEAN

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SIMARD ET AL (1): " THE UNDERLYING PRINCIPLE IS TO ASSEMBLE AND STRUCTURE LARGE SETS OF DIGITAL REMOTE SENSING DATA AND RELEVANT ANCILLARY DIGITAL DATA (MAPS, DEMOGRAPHIC INFORMATION, ETC) AND TO MAKE THEM AVAILABLE IN READILY ACCESSIBLE FORM ON CD-ROMS OR DISKETTES.... SOFTWARE ACCOMPANYING THE DATA WILL ENABLE USERS TO DISPLAY AND MANIPULATE THE INFORMATION IN THE ENCYCLOPEDIA ON A STANDARD MICROCOMPUTER•

THE TARGET AUDIENCE FOR THIS PROJECT INCLUDES HIGH SCHOOL AND UNIVERSITY STUDENTS, YOUNG SCIENTISTS AND MEMBERS OF THE GENERAL PUBLIC INTERESTED IN GLOBAL CHANGE• THIS WORLDWIDE AUDIENCE WILL BE MULTILINGUAL, SO THE ENCYCLOPEDIA WILL BE ADAPTABLE TO MANY LANGUAGES• INITIALLY THE DATA SETS, SOFTWARE AND ACCOCMPANYING DOCUMENTATION WILL BE OFFERED IN ENGLISH AND FRENCH•"

THE ENCYCLOPEDIA WILL CONTAIN ABOUT 2 GIGABYTES OF DATA AND WILL BE ORGANIZED SO AS TO PROVIDE IMAGES, MAPS, SOCIO-ECONOMIC MAPS, ILLUSTRATIVE PHOTOGRAPHS AND SUPPORTING TEXTS• DOZENS OF INFORMATION BANKS AROUND THE WORLD ARE CONTRIBUTING DATA TO THE ENCYCLOPEDIA, WHICH SHOULD BE AVAILABLE AT A COST OF THE ORDER OF $200 CDN•

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SPONSORED BY THE CANADIAN SPACE AGENCY AND PRODUCED BY THE CANADA CENTER FOR REMOTE SENSING, IT IS OUR HOPE THAT UNIVERSITIES, SCHOOLS, LIBRARIES, INDUSTRIAL AND GOVERNMENT LABORATORIES AROUND THE WORLD WILL FIND THE ENCYCLOPEDIA TO BE A DOCUMENT DE CHEVET• A NETWORK OF EXPERTS EQUIPPED WITH THE ENCYCLOPEDIA AND PERSONAL COMPUTERS WOULD BE, IN MY OPINION, AN EFFECTIVE TOOL FOR A DEVELOPING COUNTRY TO HAVE IN ANALYSING THE DEVELOPMENT OF ITS NATURAL RESOURCES AND ITS POTENTIAL PROBLEMS CONNECTED WITH GLOBAL CHANGE•

THE GLOBAL CHANGE ENCYCLOPEDIA IS ADVANCED TO THE EXTENT THAT WE ARE PLANNING TO GIVE YOU A DEMONSTRATION OF IT TOMORROW AT LUNCH TIME• THE PLACE AND TIME WILL BE CONFIRMED TOMORROW MORNING•

MS ANNE MARIE BOTMAN OF THE CANADA CENTER FOR REMOTE SENSING WILL MAKE THE DEMONSTRATION, AND NOTICES TO REMIND YOU OF THIS WILL BE POSTED• YOU ARE CORDIALLY INVITED TO ATTEND, BECAUSE THIS ENCYCLOPEDIA MAY BE A USEFUL TOOL FOR A DEVELOPING COUNTRY PLANNING A SPACE PROGRAMME•

IN SUMMARY, SPACE DATA ANALYSIS APPEARS TO BE AN INTERESTING NICHE FOR DEVELOPING COUNTRIES TO OCCUPY•

/...

MY FOURTH POINT IS NOTHING BUT A REMINDER THAT THERE ARE TWO SIDES TO EVERY HUMAN COIN• ALL OF OUR ACTIVITIES, CARRIED TO SMALL EXCESS, LEAVE IN THEIR WAKE A NUMBER OF PROBLEMS• CURRENT ELECTRICIY, MENTIONED EARLIER, IS A GREAT BOON TO MANKIND, BUT ITS GENERATION BY THE BURNING OF FOSSIL FUELS UNBALANCES THE DYNAMICS OF OUR ATMOSPHERE, CONTRIBUTES TO THE GREENHOUSE EFFECT AND TO THE INEVITABLE GLOBAL CHANGE WHICH, ON BALANCE, DOES NOT APPEAR TO BE FAVORABLE• OUR BEST HOPE TO REGAIN CONTROL IN A CIVILIZED WAY LIES PROBABLY IN THE DEVELOPMENT OF NUCLEAR FUSION• THE USE OF ELECTROMAGNETIC WAVES, WHICH WAS ALSO MENTIONED, HAS RESULTED IN A DETERIORATION OF THE AMBIANCE IN WHICH RADIO TELESCOPES WORK, AND ITS PROLIFERATION HAS REDUCED THE QUALITY OF AMPLITUDE-MODULATED AND FREQUENCY-MODULATED RADIO AS LARGE NUMBERS OF BROADCASTING STATIONS CROWD THE RESTRICTED FREQUENCY BANDS ASSIGNED TO THEM•

SPACE TECHNOLOGY MAY WELL PROVE TO BE NO EXCEPTION• SATELLITE DEBRIS, SATELLITES THEMSELVES AND THE RESULTS OF SPACE EXPLOSIONS HAVE RESULTED IN AN IMPRESSIVE NUMBER OF STRAY OBJECTS IN ORBIT - OVER TEN THOUSAND THE SIZE OF A WALNUT OR LARGER• SPACE IS VAST, AND THE PROBABILITY OF COLLISION IS SMALL, YET THE NASA SHUTTLE TWO WEEKS AGO SAW FIT TO MODIFY ITS FLIGHT PATH SLIGHTLY

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TO INCREASE ITS PASSING DISTANCE FROM A RATHER LARGE PIECE OF SPACE DEBRIS. INCREASING ATTENTION WILL BE PAID TO THIS PROBLEM, AND SOME TENTATIVE SOLUTIONS SUCH AS THE USE OF DECELERATING SAILS HAVE BEEN SUGGESTED. THE FREQUENCY CROWDING OF TELECOMMUNICATIONS AND REMOTE SENSING SATELLITES IS NOT YET A PROBLEM, BUT MUST BE KEPT IN MIND. THE POLLUTION CAUSED BY SOLID STATE ROCKETS IS ALSO A CAUSE FOR CONCERN. IN SHORT, IN SPACE AS ELSEWHERE, THE POTENTIAL CONSEQUENCES OF OUR ACTIVITIES MUST BE CONTEMPLATED, AND THIS CONTEMPLATION MUST BE BUILT INTO OUR PROGRAMMES. HOWEVER, JUST AS THE REGRESSION INTO PRE-ELECTRICITY OR PRE-WIRELESS TIMES IS NOT TO BE CONSIDERED, NEITHER CAN THE IMMENSELY BENEFICIAL RESULTS OF A BALANCED SPACE TECHNOLOGY BE GAINSAID.

SO FAR I HAVE PUT MY STRESS ON THE PRACTICAL CONSIDERATIONS OF ECONOMICS. BUT TO BOTH LARGE AND SMALL NATIONS, SPACE ALSO PROVIDES IMMATERIAL BENEFITS THAT NOURISH THE SPIRIT. OUR VENTURES INTO SPACE HAVE LET US VIEW THE EARTH FROM A NEW PERSPECTIVE, A SINGLE WORLD WHOSE NATIONAL BORDERS ARE UTTERLY INVISIBLE. THIS VISION OF EARTH AS A SEAMLESS, PRICELESS ENTITY IS VITAL IF WE ARE TO EFFECT THE REPAIRS WE MUST. TO CHANGE HUMAN ATTITUDE IS THE FIRST, PERHAPS THE GREATEST, STAGE OF

ACCOMPLISHMENT• SPACE RESEARCH HAS ALREADY BEGUN TO DO THIS•

IN THE LONGER TERM, THESE IMAGINATIVE ASPECTS OF SPACE SCIENCE WILL CONTINUE EVEN AFTER WE HAVE CLEANSED THE EARTH• PARTLY WITH INTENT, PARTLY BECAUSE OF THE VERY RESTLESSNESS WITH WHICH OUR COMMON IMAGINATION ENDOWS US, WE HUMANS ARE SLOWLY PREPARING FOR THE TIME WHEN WE WILL STRIKE OUT TO OUR SOLAR SYSTEM AND BEYOND IT TO THE STARS• I BELIEVE THIS ENDLESS QUEST WILL COMPLETE WHAT OUR CURRENT ECOLOGICAL CRISIS HAS USHERED IN: THE REUNIFICATION OF HUMANITY INTO ITS BEGINNINGS TWO MILLION YEARS AGO IN AFRICA - ONE SINGLE FAMILY•

BUT WHILE GREAT DREAMS MUST PRECEDE GREAT DEEDS, HOW - AGAIN IN PRACTICAL TERMS - MIGHT A THIRD-WORLD COUNTRY SHARE IN THIS GREAT DREAM OF HUMAN UNITY? HOW MIGHT IT BEGIN TO ACQUIRE THE SCIENCE AND TECHNOLOGY OF SPACE TO UNITE ITS PEOPLE - OPTIMIZE ITS TRANSPORT, DATAFLOW, AND AGRICULTURE - AND FINALLY ENTER THE WORLD COMMUNITY AS A MODERN STATE?

ONE WAY MIGHT BE TO TAKE A MEASURABLE COMPONENT OF ITS FOREIGN AID IN THE FORM OF USABLE SPACE TECHNOLOGY• AS WITH, SAY, THE TECHNOLOGY OF BUILDING ROADS OR RAILWAYS, SOME SUCH AID

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WOULD COME PARTLY AS MATERIAL HARDWARE - GROUND STATIONS, COMPUTERS, SOFTWARE - AND PARTLY AS A TRANSFER OF FIRST-WORLD SKILLS• THIS SKILL TRANSFER, BEGINNING WITH THE ARRIVAL OF FIRST-WORLD EXPERTS AND BECOMING PERMANENT THROUGH THE TRAINING OF ENDOGENOUS PERSONNEL, IS AS IMPORTANT AS THE HARDWARE•

ONE CAN FORESEE THE CONSEQUENCES• A NATION BLESSED WITH FREE FLOW OF INFORMATION, ABLE TO SURVEY ITS NAVIGABLE WATERWAYS AND INSPECT ITS CEREAL LANDS, ABLE TO SPOT CROP DISEASE BEFORE IT IS APPARENT EVEN TO THE TENDING FARMER, ABLE TO PLAN ITS TRANSPORTATION AND IMPROVE ITS HEALTH CARE BY REMOTE DIAGNOSIS, WITH ITS PLANNERS CONSTANTLY IN TOUCH WITH THE REALITIES OF THE DOMAIN THEY ADMINISTER FOR THEIR PEOPLE'S GOOD - SUCH A NATION WILL NOT ONLY SURVIVE: IT WILL PROSPER AND BE FREE• AS THE FIRST WORLD'S RECENT HISTORY HAS SHOWN, A LIBERAL DEMOCRACY TENDS TO ESCHEW THE USE OF FORCE• IN HARMONY WITH ONE ANOTHER, THE NATIONS OF WHAT WAS ONCE THE THIRD WORLD CAN THEN ENTER THE TWENTY-FIRST CENTURY NO LONGER AS HAVE-NOTS, NO LONGER AS HOTBEDS OF POLITICAL AND MILITARY UNREST, BUT AS PROSPEROUS PROVINCES OF A UNITED PEACEFUL AND PROSPEROUS WORLD WITH THEIR OWN SPACE AGENCY•

THAT IS THE HOPE HELD UP TO ALL OF US BY SPACE SCIENCE AND TECHNOLOGY. IT IS A HOPE, I THINK, THAT WILL MAKE HONEST DOUBTERS INTO HONEST BELIEVERS IN ALL THE VALID PROMISES AND PROVEN POSSIBILITIES OF SPACE.

SELECTIVITY, COOPERATION, DATA ANALYSIS AND ENVIRONMENTAL SENSITIVITY ARE THE FOUR POINTS I AM PRIVILEGED TO BRING TO YOUR ATTENTION AS WE BEGIN THIS IMPORTANT WORKSHOP. OVER THE NEXT THREE DAYS YOU WILL BE CONSIDERING MANY AREAS TO WHICH THESE POINTS APPLY, WHETHER IT BE AGRICULTURAL OR COMMUNICATIONS APPLICATIONS, OR THE POSSIBILITIES OF EXPANDING A SPECIALIZED MANUFACTURING BASE FOR SATELLITE COMPONENTS. I WISH YOU SPIRITED AND PROFITABLE EXCHANGES.

AND IF I MIGHT BE PERMITTED AN EXTRAPOLATION OF HOPE: HOW PLEASANT IT WOULD BE TO BE INVITED TO A FUTURE WORKSHOP HAVING AMONG ITS SPONSORS THE THIRD WORLD SPACE AGENCY!

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(1) A DIGITAL GLOBAL CHANGE ENCYCLOPEDIA OF SPACE OBSERVATIONS: RÉJEAN SIMARD, ANN-MARIE BOTMAN, RALPH BAKER, JOSEF CIHLAR, DOUG O'BRIEN AND TERRY FISHER

(TO BE PUBLISHED IN THE NEAR FUTURE)

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OVERVIEW OF INDUSTRIAL AND COMMERCIAL OPPORTUNITIES FOR DEVELOPING COUNTRIES

Mr. Tasuku Tanaka
National Space Development Agency of Japan

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1. Background

(1) **Japan is one of the Advanced Industrial Countries in the world.**

(2) **Space Business in Japan is still immature comparing with other Business: Electronics, Automobile, and etc.**

(3) **Most revenue of Space Industries in Japan comes from two governmental Space Agencies: NASDA and ISAS.**

(4) **Potential Business Areas**

- Launching Service
- Space Communications
- Earth Observation
- Space Environment Utilization

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2. Need of the Developing Countries for Space Technology

(1) Space Communications

- More economical than the Ground Network
- Meet the diverse requests by Various Users

(2) Earth Observations

- Agriculture
- Forestry
- Disaster Prevention
- Chartography

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3. Industrial and Commercial Opportunities in Developing Countries

(1) Construct Social Infrastructures using the current and future Space Infrastructures

- Law-Cost Concise Communication System
- Weather Watch System
- Environment Monitoring

(2) Value Added Products

- Higher Level Informations from Earth Observation Data.
- Varieties of Communication Service.

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4. Conclusion (Means and Goals)

(1) Foster Experts through Seminars and Trainings

- Regional Remote Sensing Program (RRSP) by ESCAP / UNDP
- Space Operation Training Course by Japan Int'l Cooperation Agency(JICA)

(2) Technology Transfer

(3) Utilize Space Infrastructure of the Developed Countries.

- Earth Observing Satellite
- Meteorological Satellite
- Communication Satellite

(4) Seek to Business Chance for the Developing Countries' Needs

- Tele-Education
- Weather-Report
- Emergency Call
- Broadcasting

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5. International Space Year

(1) Year 1992 is International Space Year.

(2) The ISY should pay special attention to the needs of developing countries, including the need for technical training: easy and rapid access to data from ISY programs should therefore be an important guidance. (SAFISY #1 Report)

(3) Japan is organizing several ISY Events to enhance Space Technology for the Developing Countries.

- Asia Pacific ISY Conference
- PEACESAT Expansion
  (Pan-Pacific Education and Communication Experiment by Satellite)
- Seminars and Trainings in Earth Observation Area

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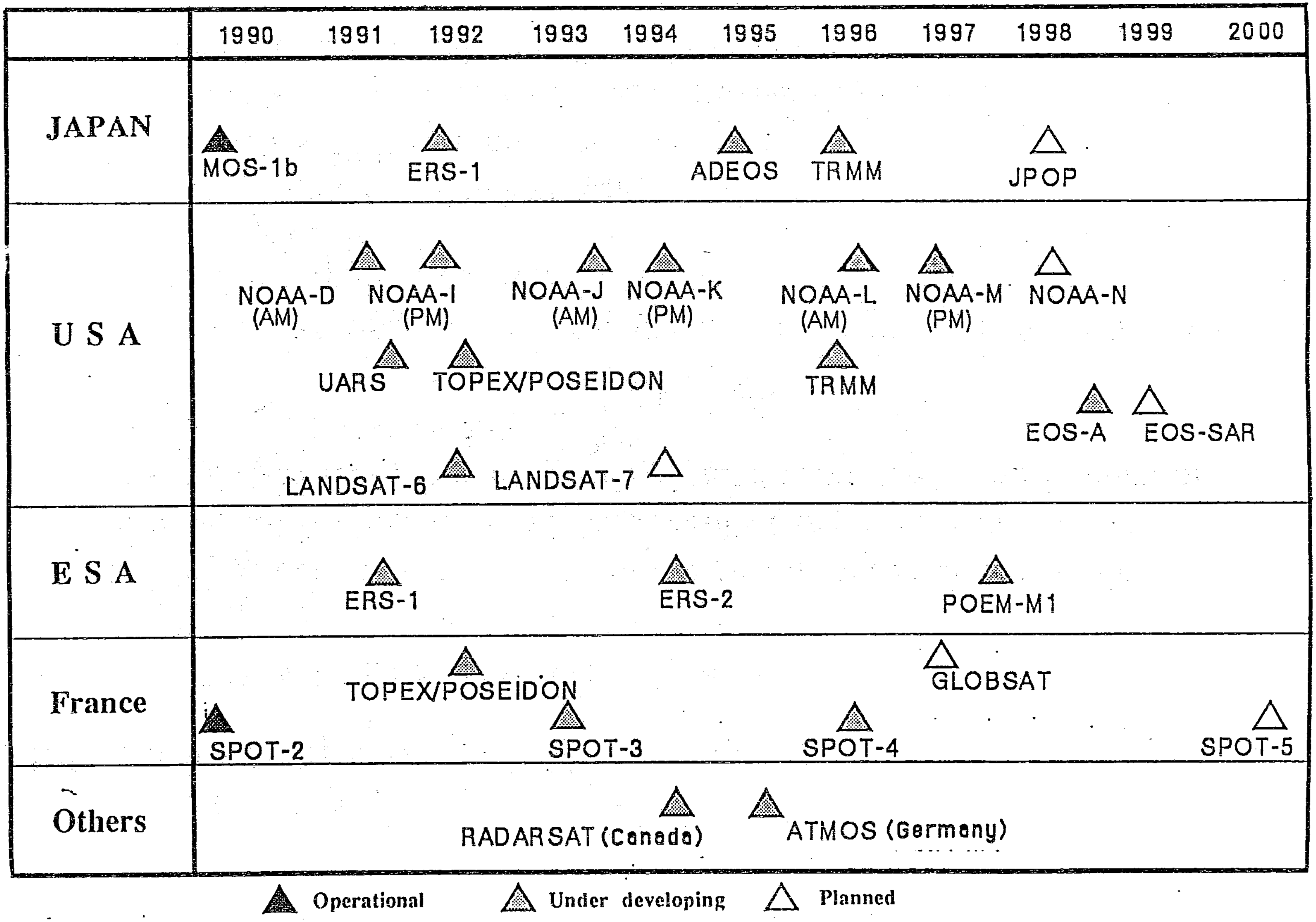
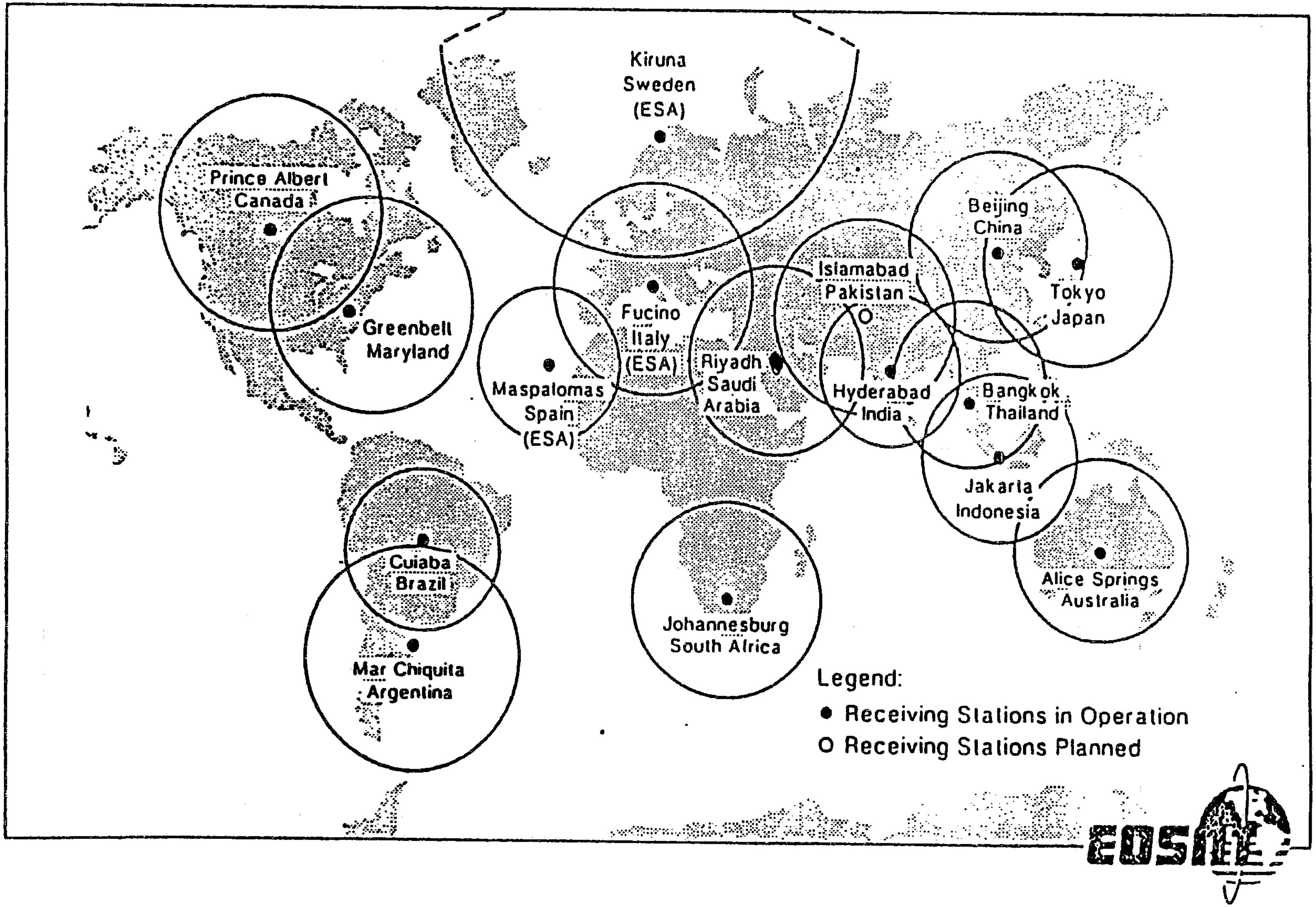
Table 1. World Earth Observation Satellite Programs

As of May, 1991



LANDSAT 4/5 COVERAGE



SAFISY Earth Science and Technology Projects

S D G C : Space data for global change

W G 1 : Global Consequences of Land Cover Change (LCC)

Chairman / Co-Chairmen
- Dr. D. Graetz (CSIRO, Australia)
- Prof. F. Blasco (GSTST, France)
- Dr. Vladimir Kozoderov (Academy of Science, USSR)

W G 2 : Enhanced Greenhouse Effect Detection Experiment (GEDEX)

Chairman
- Dr. Gregory Wilson (NASA,USA)

W G 3 : Ocean Variability and Climate (OVC)

Chairman / Co-Chairmen
- Prof. K. Hasselman (Max Planck Institute, Germany)
- Prof. O.M. Johannessen (NRSC, Norway)

W G 4 : Polar Stratospheric Ozone (PSO)

Chairman / Co-Chairmen
- Dr. R. Watson (NASA, USA)
- Dr. R. Zellner (University of Gottingen, Germany)

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W G 5 : Productivity of the Global Ocean (PGO)

Chairman / Co-Chairmen - Dr. Trevor Platt (BIO-BODO, Canada)
- Dr. Peter Schliettenhardt (EC/JRC/Ispra)

W G 6 : World Forest Watch (WFW)

Chairman / Co-Chairmen - Dr. da Cunha (INPE, Brazil)
- Dr. J.P. Malingreau (EC/JRC/Ispra)

W G 7 : Global Sea Surface Temperature (SST)

Chairman / Co-Chairmen - Dr. T. Teramoto (University of Kanagawa, Japan)
- Dr. David Llewellyn-Jones (RAL, UK)

W G 8 : Polar Ice Extent (PIE)

Chairman / Co-Chairmen - Prof. F. Nishio (Hokkaido University of Education, Japan)
- Dr. K. Strubing (BSH, Germany)

W G 9 : Global Satellite Image Mapping (GSIM)

Chairman - Dr. Lothar Beckel (GEOSPACE, Austria)

W G 10 : Space and Disaster Mitigation (SDM)

Chairman - Dr. Louis S. Walter (NASA/GSFC, USA)

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G C O : Global Change Outreach

W G 11 : Global Change Encyclopedia

Chairman - Dr. Josef Cihlar (CCRS, Canada)

W G 12 : Global Change Atlas

Chairman - Dr. Lothar Beckel (GEOSPACE, Austria)

* W G 13 : Global Change Video

Chairman / Co-Chairmen - Mr. Gunter Schreier (DLR, Germany)

- Mr. Jan-Peter Müller (University C. London)

* adopted Working group at SAFISY #4, Moscow

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SAFISY Education and Applications Projects

Theme A : Training in Remote Sensing Applications

V R : Vegetation Resources : Monitoring and Managing

- Training in Remote Sensing Applications to Deforestation in Southeast Asia	1991.11.11 ~ 11.13	in Bangkok, Tailand
- Reginal Seminar on Tropical Eco-System	1992. 6.	TBD

G N : Geology : Natural Hazards

- Risks of Geological Instabilities, Arrequipa	TBD	in Peru
- Seminar on Technology for Disaster Prevention	1991. 9. 9 ~ 12. 9	in Japan

U E : Urban and Environmental Planning

- Urban Pressure on Farming Land	TBD	in Tunis, Tunisia
- Medgeobase Geographical Information Systems	TBD	TBD

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IMMARSAT-C LAND MOBILE SERVICES AND APPLICATIONS

Mr. J.C. Bell
International Maritime Satellite Organization

/...

INMARSAT-C LAND MOBILE SERVICES AND APPLICATIONS

J.C. BELL

Introduction

Inmarsat-C is one of the most exciting developments in the field of mobile satellite communications as, apart from the very small size, weight and power consumption of the user equipment, it offers great flexibility in the ways in which it can be used and thereby serve many varied user requirements. These may range from the businessman on the move who needs to have reliable communications in remote areas, to the trucking company which needs to follow a vehicle's progress and route, to the water authority remotely monitoring rainfall and controlling the flow of water through a network. All these and more can be achieved through the Inmarsat-C system which now brings the benefits of satellite communications within the reach of everyone.

Background

The Inmarsat-A system is the current workhorse of the Inmarsat network and provides high quality mobile telephony and telex services throughout the world. However, because of its size and weight it is unable to satisfy every potential user requirement. It was for this reason that Inmarsat set about developing the Inmarsat-C system which has now, because of its small size, weight and power requirements, brought mobile satellite communications within reach of anyone who has a need for reliable data and messaging services in remote and other areas not adequately served by the terrestrial public switched networks. The breakthrough occurred with the decision to design a system that was able to operate with an omnidirectional antenna rather than the typical directional parabolic dish. This, in turn, made it possible to eliminate expensive tracking and stabilisation systems and so produce a dramatically small user terminal. Extensive testing of the system under varied conditions throughout the world has proven the reliability and incredible ability of this system which is now in commercial service throughout the world.

THE INMARSAT-C SYSTEM

Inmarsat-C is an advanced packet-data communication system using a small, low-cost mobile earth station suitable for installation in any size of vehicle or vessel, at remote data monitoring and control sites, or it may be carried and used by an individual anywhere in the world. The system provides two-way messaging and data communications on a store and forward basis, one-way position and data reporting, polling and an Enhanced Group Call (EGC) broadcast service able to address both groups and specific geographic areas.

The system provides Public and Private (Closed User Groups [CUG]) access for International, Regional or National services. The store and forward feature enables the system to interconnect with any terrestrial message or data network (Telex, X.400, X.25, X.28, X.32) as the store and forward acts as a buffer between the Mobile Earth Station (MES) and Land Earth Station (LES). Data are transferred between the mobile and LES at an information rate of 600 bits/s.

To keep the mobile equipment small and costs to a minimum a very low G/T of -23dB/k at 5° elevation was selected to permit the use of a non-stabilised, omnidirectional antenna. BPSK modulation is used and this coupled with the relatively low EIRP requirement of 12dBW can be achieved with a class C HPA using existing semiconductors. To alleviate the effects of multipath it was necessary to design a highly robust modulation and coding scheme. After extensive studies Rate 1/2, constraint length 7 convolutional coding and frame interleaving were chosen to ensure that the packet error probability is met for the design link budget. Transmissions from the mobile take place between 1626.5 - 1646.5 MHz and reception between 1530.0 - 1545.0 MHz with tuning increments of 5 KHz. Inmarsat-C is therefore able to operate on all frequencies available on INMARSAT's existing and next generation satellites for Land Mobile use. The narrow channel spacing also helps ensure maximum efficiency of the limited spectrum.

The system has been designed with considerable flexibility in the access control and signalling protocols so that it can handle future new services and applications. The all digital design enables any type of data to be passed through the traffic channels due to the transparent nature of the transmission medium.

Current INMARSAT satellites have global beams providing coverage of about 1/3 the earth surface and to satisfy the design link budget requires a relatively high satellite EIRP of 21 dBw be used. Third generations satellites now being specified will have spot beams and the Inmarsat-C system will be able to automatically identify the appropriate beam. Because of the high satellite power requirements the forward carriers (to the mobile) operate in a demand assigned mode when network conditions require. In addition the store and forward mode ensures maximum loading of the carriers at any given time which results in a highly cost effective service and mode of operation.

Network Coordination Station (NCS)

Each Satellite Network Region is served by an NCS which manages central resources such as traffic channels for demand assigned operation together with signalling and traffic control. Each NCS transmits a NCS Common Channel which is received by all MES's when they are not involved in message transfer. The Common Channel is used to announce calls to mobiles waiting at the LESs, for broadcasting EGC messages and at various stages for protocol signalling packet transfer.

Land Earth Stations

Each LES serves as a gateway between the terrestrial network and the INMARSAT-C communications system. The types of interface provided at the LES are decided by the earth station operator, however, Telex and EGC message processing are mandatory. All MESs that are active in the network region are required to register with the NCS and a copy of the list of all registered MESs is held at each LES and used as a basis for accepting or rejecting calls originating from the terrestrial network. In addition the location of every registered MES is held at the LES so that calls received at the LES for a MES that is in another ocean region may be redirected and the call not lost. LESs may operate their traffic channels in a demand assigned mode. If traffic and satellite power considerations call for this mode of operation to be used, the NCS will allocate on a need basis, LES TDM Channels, MES Signalling Channels and MES Message Channels.

Store and Forward Data and Messaging

This provides the user with a reliable means of sending data or text messages between the mobile and the operators' base station via the satellite and public or private land lines. Full ARQ is provided to ensure error free reception of messages and the originator is informed if the system is unable to deliver the message. In the case of a mobile which might be unable to receive due to obstruction of the satellite, the LES will make a number of repeat attempts to

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establish contact with the mobile. If after a period of time involving a number of repeat calls, (established by the LES operator) contact is still not established with the mobile, the message originator will be informed. Given that the LES will only accept a message when the MES is logged on in the same region, the possibility of non-delivery is only likely to occur if the MES is switched off without first being logged off or is hidden for an extended period where it cannot be seen by the satellite.

Data and Position Reporting

This service provides the mobile with the ability to send position reports or data reports with or without short messages. These reports can contain up to 32 bytes of information contained in 3 packets transmitted via the MES signalling channel. Transmission can only take place when the MES is synchronised and no ARQ or acknowledgement that the message has been received is provided. However, if the LES detects an error in a slot then the slot state marker in the appropriate signalling channel descriptor packet is set to indicate that no packet was successfully received. In the case of such an error being indicated, the MES will retransmit the packet, thereby providing a very high probability of the message or data being correctly received. This service, with its attractive pricing, is ideal where short amounts of data such as remote monitoring (SCADA), position reports, engine performance, cargo temperature and conditions or coded messages need to be sent.

Position and data reporting can operate using two access methods "unreserved" and "reserved". for unreserved access the transmission of the report is initiated by the MES which uses a slotted ALOHA channel to transmit the first packet of the report. Only the slot for the first packet in a sequence is selected randomly; access for subsequent packets uses a reservation scheme to guarantee access. Unreserved access is ideal for users such as the trucking industry where regular position reports are required only while the truck is on the highway and where the precise schedule cannot be determined far in advance. In such an example, the user pays for only those position reports actually required and transmitted. In this mode, the MES can, after initialisation, be programmed to make subsequent reports at specified time intervals without further intervention. Another type of application would be where the MES is used to report data on an exceptional basis only, i.e. seismic activity, sudden rise in a river level, cyclonic winds, tornados or when a temperature goes outside the normal operating range.

For Reserved Access, the slots in which the packets are transmitted are pre-assigned. The slot assignments are pre-programmed into the MES. The pre-programming is arranged by the LES and transferred to the MES by a "poll message". The poll message includes instructions on the starting time and duration of the assignment, the type of report that should be transmitted and the interval between reports. This form of access is ideal when regular reports are required over an extended period of time.

Both these access modes require the user to register with a LES operator as a Closed User Group. This, in turn, simplifies the addressing of each report as it identifies where the data is to be sent and by what means it is to be delivered, i.e. X.25.

Polling

Polling is used by the base station to initiate transmission of a position or data report. The poll command contains information about how and when the mobile should respond. It can also include a coded text message or an ASCII text (up to 256 characters). All polling packets can include instructions for all addressed MESs to respond with data reports that acknowledge the poll. Three types of polling are defined:

- individual poll
- group poll
- area poll

Individual Polling

Individual polling involves sending an explicit poll command to one or more MESs on an individual basis. When the terrestrial circuit is connected between the base station and the LES, the base station enters a list of MES identities to which the individual directed polling commands are to be sent. An individual poll command will be sent for each MES in the list. If the MES is

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busy, the poll is queued until the MES is idle. On receipt of a polling command, the MES responds according to the included instructions.

Group Polling

With group polling, a single poll command is broadcast on the NCS common channel. MESs will respond only if they were idle and if they receive the poll.

Area Polling

Area polling is functionally the same as group polling with the exception that only those MESs that are located in the designated area are addressed.

Enhanced Group Call

The Enhanced Group Call (EGC) service is a message broadcast service within the Inmarsat-C communications system. A sophisticated and flexible addressing technique allows the reception of messages from a variety of information providers. EGC messages are sent to Inmarsat-C LESs by information providers using terrestrial facilities such as telex, X.25, X.400, etc. The messages are processed at the LES and forwarded to a NCS for transmission on the NCS common channel according to their priority and the order in which they are received.

Receiver addressing can be performed on the basis of:

1) individual unique ID
2) group IDs
3) pre-assigned geographical areas
4) absolute geographical area, defined in terms of coordinates. These can be circular or rectangular.

The signal parameters and the receiver performance requirements are identical to those for the Inmarsat-C MESs. To receive geographically addressed messages the MES requires knowledge of its own position. This information can be obtained from the same navigation aid used to provide automatic position reports or entered into the terminal manually on a periodic basis. Two types of services are provided: SafetyNET™ which is for the transmission of Maritime Safety Information and FleetNET™ which is for commercial use by Individual companies wishing to communicate with their mobiles or by an administration wishing to pass a message to all trucks registered in their country, or by value added service companies addressing subscription type information to selected recipients. It could also be used by authorities who need to transmit urgent safety-related information such as weather warnings or information relating to hazards such as flooding, earthquakes, forest fires, civil unrest, hijackings, etc.

Mobile Earth Stations

The mobile equipment can be designed and manufactured by any company. However, before equipment is permitted to operate through the satellite it must first by type approved by Inmarsat to ensure that it conforms to the system specifications set out in the Inmarsat-C technical requirements document which is available from Inmarsat. No licensing or royalty fees are payable and manufacturers each compete to sell systems, thereby ensuring a highly competitive free-market environment. Physically, Inmarsat-C MES equipment is extremely compact, occupying a similar volume to that of a cellular or private mobile radio installation. Consequently, an installation is only identifiable by the small stubby antenna, which, initially at least, carries with it some kudos. No doubt, in due course, low profile antennas will become a desirable alternative. Low power requirements enable the equipment to operate from a normal automotive battery supply.

The MES comprises a data circuit terminating equipment (DCE) which provides the interface to the satellite network and a data terminal equipment (DTE) such as a personal computer or intelligent black box which provides the user or custom interface to peripheral equipment such as monitoring and control systems or a position location device. For mobile-to-base message transfer, the data is formatted in the DTE and then transferred to the DCE for transmission. In the base-to-mobile direction, the DCE receives the complete message from the radio channel before passing it to the DTE for display or control, etc. When idle, the MES tunes to and receives the TDM channel transmitted by the NCS.

Many companies are now providing Inmarsat-C equipment and some of these have been designed as transportable systems. In some cases the design is specifically engineered with the field user in mind so that the familiar portable p.c. can be directly connected to the terminal electronics to send and receive messages. Other equipments are specifically designed to be installed and to operate while a vehicle is moving. In some cases, the design incorporates a GPS receiver which enables the vehicle's location to be automatically transmitted to an operations centre at pre-set regular reporting intervals. Other equipments are designed for static use where thin-route messaging or data communications is required in an area not served by terrestrial systems. Another use of this type of terminal is in Supervisory Control and Data Acquisition (SCADA) [remote monitoring and control] applications. Such use could be particularly appropriate for instrumenting areas known to be vulnerable to natural disasters. In such cases, they could form part of a very effective monitoring network which would be able to immediately alert a control centre of a change in conditions or an impending disaster situation. Such a network could also provide an immediate alerting function and, after a disaster had struck, still be used to provide initial communications from the scene.

APPLICATIONS OF INMARSAT-C

Land mobile applications for Inmarsat-C fall into a number of categories including general mobile use such as by trucks, trains and buses; personal communications for use by reporters, emergency services and businessmen; rural/remote area communications, and for remote monitoring and control (SCADA) applications.

Trucking

Perhaps the biggest and most readily identified Inmarsat-C market is the long haul trucking industry where the inability to locate and advise a truck of a cargo can result in significant revenue losses. When connected to a navigation sensor such as GPS, the Inmarsat-C MES is able to automatically transmit regular position reports (RDSS) to the base station along with manually initiated macro encoded messages indicating status. This enables the dispatcher to monitor progress on a real-time basis and re-schedule or direct a truck as required. For the owner/driver it offers the opportunity to contact brokers and find a cargo rather than deadheading home. For the insurance industry, regular monitoring of a vehicle's progress would help to track and alert the local police whenever an incident such as a theft or hijacking occurs. On a less dramatic front, a refrigerated truck whose plant or prime mover breaks down could quickly result in a perished cargo and large insurance claims. However, by monitoring positions, engine performance and cargo condition, the base station can be quickly alerted to any likely trouble and take remedial action. For long distance bus operators, delays can cause major disruption for passengers needing to make connections. The MES can automatically provide the operator with details of the buses progress and enable them to contact passengers, advising what arrangements have been made for them to continue their journey.

The Inmarsat-C system, when integrated with a suitable navigation system, such as GPS, and other vehicle sensors offers a unique low cost global solution for automatic vehicle location (AVL), messaging and fleet management.

For those hauliers engaged in just-in-time deliveries, such a combination offers the dispatcher a near real-time display of the truck's progress while also providing a means of rapidly exchanging messages between the driver and dispatcher whenever the need occurs.

The great flexibility of the Inmarsat-C system ensures that it is able to satisfy the long-range communications requirements of truck companies throughout the world operating as a closed user group or via the public network. The widespread adoption of the Inmarsat-C system has encouraged manufacturers throughout the world to invest their own development resources in the design and manufacture of mobile equipment which ensures the widest possible choice for the user at very competitive prices.

In the land mobile market there is a real need to develop specific user hardware and software so

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that the capabilities of the system are fully explored and developed by the operators. To promote this, Inmarsat has funded a number of development contracts for position reporting, macro encoded messaging and fleet management software so that users can gain early practical benefits from a system which offers significantly more potential than simple messaging.

With the technologies and systems now available for command, control, communication and navigation, an integrated approach to fleet management can be implemented. Finally, for the driver of the truck there is no longer any excuse for him being lost and, even if this were the case, the dispatcher can always locate the truck and tell the driver where to go!

Navigation

The Global Positioning System (GPS) with its 21/24 satellite constellation can provide civil users with a worldwide real-time accuracy of about 100 metres. Because the GPS frequency, 1575.3 MHz, is located between the Inmarsat-C transmit and receive bands a number of manufacturers have taken the opportunity to integrate the Inmarsat-C and GPS receiver in a single unit and simplify installation through the use of a common antenna and cabling.

Inmarsat will now carry a navigation payload on its 3rd generation satellites which will transmit signals to augment GPS. They will also be able to indicate the health and validity of the data being transmitted by the military GPS satellites. In addition, differential corrections are already being transmitted on a commercial basis to enhance the accuracy of GPS in a local area.

Vehicle Accuracy Requirements

While some vehicles carrying highly sensitive cargoes may need relatively high accuracy, the majority of vehicles have more limited requirements which can be met by almost all the navigation systems now available. In practice, few vehicle need or benefit from knowing precisely where they are, though their dispatcher, who may be in an office hundreds of kilometres away, will be interested in such information. This requires a communication link to be available in either near real time for continuous high accuracy tracking or more likely on a periodic basis every few minutes or even hours for general use. Maximum accuracy can obviously be obtained if the vehicle is stopped. However, when travelling at, say, 90km/hr a vehicle covers 1.5km every minute so there is a practical limit to the accuracy that can be of practical use.

Given the time interval between the transmission being initiated and the time the dispatcher observes the truck's updated position on his screen, the absolute dynamic accuracy achievable is of limited significance. Inmarsat-C is therefore more than adequate in dispatch type operations when the general locations of trucks on the move are likely to be of greatest interest. When stopped, broken down or involved in an incident the precise location will be transmitted and displayed.

Datums

All navigation system fixes are referenced to a specific geodetic datum. GPS uses the World Geodetic Datum WGS 84, while maps in the USA, Europe, Africa, India, Australia and the Far East all use different national ones. This means that a satellite receiver located at a known geodetic mark in any country will display different coordinates unless the same datum is used. What is worse is that they are both right and yet, in some countries, a difference of several hundred metres may exist between a position referenced to the local datum and one using the satellite system!

Therefore, to avoid absurd anomalies it is essential that coordinates from the navigation system be transformed to the appropriate datum before the truck's position is displayed on the map, otherwise it may well appear in the middle of a lake, or worse!

As can be seen, it may be misleading to talk about accuracy unless one is specific about the coordinate system being used otherwise the results will at best be confusing.

Railways

Railways are a particular case where reliable communications can prove invaluable. This is

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especially true where trains travel great distances, often on single track lines. In some areas, there is no trackside communication and little, if any, signalling, with trains still passing the baton on passing loops. In situations like this a breakdown can have a cascade effect on a large portion of the system. Were locomotives to be fitted with a MES, the train's position and progress could be automatically monitored and the signalmen and controllers would be instantly alerted if a problem or breakdown occurred. A defective train could then be put on a loop and others on the line advised to cross at different points. In this type of application, the Inmarsat-C system can function as a primary or back-up signalling system and also provide reliable long distance communication with the train's driver, conductor or guard.

For passenger operations, a late train can mean missed connections and, whilst the problem would still exist, the availability of a MES would enable the traveller to advise others of their own delay and assist the railway company to determine the next best connection before the passenger arrives at the interchange. The movement of freight across countries and continents is routine but so, unfortunately, are cargoes which get "lost". This generally occurs when a wagon is joined to or unhitched from the train at the wrong marshalling yard, as the train's composition changes during its journey. Sensors could be attached to every wagon so that each time the train starts up an inventory of the attached wagons is automatically transmitted. This would at least provide an early indication that wagons are headed the wrong way! It should also help the railway companies to have a better understanding of the whereabouts of their rolling stock. This would help overcome the problem of too many empty wagons being in the wrong place, which results in a need to hold an excessive amount of units. Reducing this excess capacity could lead to considerable capital and operating savings.

Portable Personal Communications

There are many varied uses for a small portable data and messaging system which can be hand carried and Inmarsat-Cs are now available which integrate a MES, power supply and laptop computer into a briefcase. Such a capability will find instant use with the media as journalists frequently find themselves covering stories in areas where unreliable, insufficient or non-existent communication makes it difficult to file their story. Were the journalist to carry his own system the story could be transmitted direct to the editor's own desktop computer and merged into the paper's layout right up to the moment before printing.

Diplomats, visiting dignitaries and businessmen who generally need to communicate with their headquarters may, on occasions, find themselves cut off from the normally available telecommunications services. In such instances, a small hand portable MES will overcome the difficulty and enable the respective parties to keep in touch. Other uses are forest rangers, firefighters, disaster relief field teams, gamekeepers, power transmission and oil pipeline inspection teams, together with medical assistance and schooling in remote areas.

Disaster Relief and Preparedness Communications

Emergency services and disaster relief teams benefit from reliable on-site communications with their field centre or headquarters which might be far away. Recent disasters such as the Armenian and Philippines earthquakes, Columbian, Bangladesh and Chinese floods, Sudanese famine and hurricanes such as Gilbert in the Southern United States show only too well the difficulty in providing relief without adequate communications, which are invariably the first thing to be destroyed and take a long time to restore. For international relief agencies, the difficulty in communicating with field teams is particularly frustrating as it delays their ability to despatch the most appropriate aid to the stricken area. Inmarsat-C is so small and light that it is now possible for each field team to carry their own system when they initially enter the area and so immediately provide their headquarters with an accurate assessment of the situation and the local requirements. The equipment to do this is available now. However, there still remains, in many countries, the problem of obtaining licences to operate communications equipment and trying to obtain permission after a disaster happens can result in very serious delays. Efforts must therefore be made within

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administrations to find ways to provide blanket authorisation for such use before an incident occurs.

Vehicle Reporting in disaster situations

Following a disaster, it is easy for field workers in their vehicles or trucks carrying relief supplies to get lost or become immobilised due to the local conditions. In such cases, the drivers and aid workers can be lost for days or may even be injured. Therefore, the ability for the vehicle to be in regular communication is highly desirable to those co-ordinating the activities as they are able to follow a vehicle's progress and perhaps suggest alternative routings for other vehicles. If the Inmarsat-C is connected to a navigation sensor such as GPS, the precise location of the vehicle can be monitored throughout its journey or easily located and redirected should it become lost in unfamiliar country. For the base station controlling operations, systems exist which are able to automatically display the vehicle's position on a map while also displaying any messages from the vehicle. The same terminal can also be used to send messages to the vehicle. Because of the small size, power consumption and weight it is feasible to install such a system in any type of vehicle in only a few hours.

Fixed Thin Route Applications

Rural and remote areas in many parts of the world have inadequate or even no communication. This is often true where development of roads, railways, dams, etc, take place. In many cases, the areas involved are very remote and normal public telecommunication services either do not extend there or are very unreliable. In other cases, such as exploration work, the requirement is relatively short term and would not warrant the establishment of the necessary infrastructure. For such applications, either a transportable Inmarsat-A with its telex, telephony, fax and voice-band data capabilities or an Inmarsat-C with its data/messaging facilities would provide an ideal, low cost, quick solution to provide the required communications.

One particular type of application would be in the diplomatic field where embassies and consulates around the world would be provided with Inmarsat-C to form a highly reliable primary or back-up message communication network. Where official residences are distanced from the mission it would also be feasible to install Inmarsat-C at those locations and in official cars to ensure that the embassy staff could always be reached. A side benefit is the potential to use the EGC FleetNET™ service to distribute the periodic reports from the foreign ministry to all locations simultaneously. This would make considerable savings in both time and cost when compared with existing methods.

Remote Monitoring and Control (SCADA)

Supervisory Control and Data Acquisition (SCADA) applications are numerous and, by their very nature, are often spread over wide areas in extremely remote regions. The monitoring of geothermal, volcanic, plate movement and pressure ridges to identify potential national disasters are fairly obvious examples. In some cases, regular reporting is desired while in others occasional or exceptional reports only will be necessary. For such applications Inmarsat-C, with its low power requirement, is well suited as the complete installation can be operated from batteries.

The data terminal equipment provides the interface to the sensors and control devices. This unit will most probably be supplied by a specialist systems company familiar with the specific application and the types of sensors and control devices to be used. In practice, any data from sensors which have an electrical interface may be stored for transmission or its output monitored to ensure it remains within specified limits. A typical site could monitor rainfall, water level, seismic activity, barometric pressure, wind speed, temperature, pollution levels, etc.

The Inmarsat-C system architecture is particularly suited to SCADA applications. The system specification separates the Data Circuit Terminating Equipment (DCE) role from the Data Terminal Equipment (DTE) which makes for a simple interface between the communications system - black box - and the terminal device regardless of whether it is a message terminal, a personal computer or another black box connected to sensors and control instrumentation.

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There are many examples where SCADA systems are used (pipelines, river networks, environmental monitoring, etc) but not effectively implemented because of the absence of reliable or cost-effective communications over the distances involved. Frequently, systems are installed that require telegraph poles to link one site with the next. Such a serial network can be very expensive to install over large distances. Such implementation can also be vulnerable in areas where flooding or landslides, earthquakes, etc, occur and result in the loss of significant amounts of data from vital areas. Further, once disrupted, they take a long time to restore. In other systems use is made of data loggers, but this requires frequent periodic site visits to collect the data tapes or discs and does not permit the real time analysis or control which is so often desirable.

Inmarsat-C makes an ideal SCADA communications link as it is easy to install and each site is totally independent which eliminates the domino effect common with many other systems such as those using relays. This means that, should a site get knocked out, the others remain unaffected and data from the rest of the network continues to flow in. It is also relatively easy to visit and restore the defective site as all equipment is located at one point. Restoration can therefore be carried out by either field repair of the equipment or even by exchanging the complete unit.

Due to the remote nature of many SCADA sites, power may not be readily available. Solar systems, wind generators or even thermoelectric devices will therefore be required to recharge the battery system. The recent development of low power consumption equipment employing C-MOS devices helps minimise the power drain and Inmarsat-C is typical of such equipment. Real time clocks in the SCADA system also help conserve power by putting the system into a sleep mode, to save power, when not required to sample data.

A possible SCADA site installation may consist of a totally integrated power system, Inmarsat-C, sensor interface bus, single card microprocessor and memory and real time clock all housed in one environmentally sealed box with the helical antenna connected directly to it. The primary benefit of using a helix rather than the usual omnidirectional antenna is that the gain can be used to eliminate the Inmarsat-C high power amplifier (HPA) and hence significantly reduce power consumption. The other connections to the SCADA unit would be the cables to the sensors, actuators and power source.

Operationally, each site would be independently configured when first commissioned. This could be done either in the field by the crew making the installation, at the depot prior to despatch, or even over the satellite. A relatively simple menu, forms and display system could be used to configure the specific unit. This would entail identifying what type of device is connected to each input port, i.e. TTL, logic, analogue, RS-232C, etc. For each channel of data, the maximum, minimum and normal range would be specified along with the sampling rate and period. The equipment's own microprocessor could then analyse the data and determine whether it is normal or not and, if not, transmit the processed result to the control centre. By analysing the data locally, significant savings in communication costs can be made. Of course, the control centre may wish to receive a periodic or daily "health" report from each site just to confirm that all is working well. This can be done with each site being given a pre-assigned data reporting slot by the Land Earth Station through which the information will be sent. The system could also be used to download new sampling parameters should this be necessary at various times. This also has the benefit of not requiring a person to be sent into the field to make adjustments or change software.

River Basin Management

In many areas of the world, rainfall is now measured using radar techniques. However, it is still necessary to verify these estimates with rain gauges and monitor the soil moisture level and permeability to assess the eventual run-off. Such information needs to be collected at a central point if the most effective use it to be made of the available data, and the flow of water in a basin properly managed. The ability to monitor an entire water catchment area, including the level of water in lakes and rivers, as well as flow rates, can lead to the most effective control and conservation of the available water.

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Additionally, in those regions where flooding may occur, it will also provide maximum advance warning of a potentially serious situation, such as flooding, developing.

The accurate and reliable instrumentation necessary to measure flow rates, rainfall and water level are now readily available. By siting sensors throughout a basin and relaying the information back to a central control station it is feasible to display an accurate real-time assessment of the prevailing situation. In coastal areas it may also be necessary to measure sea level, wind force and direction to prevent or minimise the risk of flooding as these can have a significant impact on the status of a water system. Of course, computer modelling techniques have done much to minimise risks, although real time monitoring and control are necessary if adequate advance warning and suitable flood prevention measures are to be implemented in good time. The potential vulnerability of the monitoring sites makes it preferable that they operate independently of each other. Therefore, communications networks connecting the sites should be designed in such a way that, if the link is broken at one point, the rest of the network remains intact. A satellite-based system such as Inmarsat-C is an ideal solution as every site is independent and any size of scheme, for instance the whole Yangtze river network, including its major and minor tributaries, can be covered. Data from the sites could be transmitted on a routine basis when polled by the control centre and/or when measurements fall outside pre-set limits. As the data content of such messages is very small and transmission costs are related to the message size, such a solution should provide a cost-effective way of obtaining real-time data when compared with existing conventional methods.

At the control centre an accurate real-time assessment of the situation can be obtained and the computer model can make predictions as to how it is likely to develop and suggest appropriate action to control the flow and level of water in the system. Again, Inmarsat-C terminals could be used to control valves and sluice gates remotely throughout the system, enabling rapid action to be taken.

Sewage System Management and Water Pollution Control

Keeping an adequate level and flow of water through a sewerage transportation system is essential for environmental and public health reasons and may be accurately monitored with modern electronic sensors. Recent advances in sensor design have increased their reliability and accuracy so that the actual quality of the water being transported may now be remotely monitored and analysed to give early warning of an adverse change. Key information such as the dissolved oxygen and ammonia levels provide useful indications. This can be augmented by information from other sensors measuring the level of nitrates, phosphates and suspended matter in the water. Alternatively, conductivity of the water can be used to provide a fairly crude indicator of water quality.

While installation of the sensors may be relatively simple, the ability to constantly monitor or be alerted to any detrimental change from widely spaced sites has, until now, been difficult to achieve because it demands a good telecommunications network. Even in developed urban areas, the complexity and cost of installing and maintaining dedicated terrestrial microwave, radio or telephone networks has been very high and dependent upon its design; a single failure in the system might cut off a substantial number of monitoring sites. The situation is much more complex and difficult for the vast rural schemes that are now being developed in many parts of the world. When one considers the relatively low amounts of data which need to be sent, the remoteness and size of schemes such as in Western Australia, South Yemen, Kuwait and Saudi Arabia would make the provision of a dedicated communication network very expensive to install and maintain. A solution is to use a satellite-based network such as Inmarsat-C. With the Inmarsat-C system, no dedicated network installation costs are required. Instead, an Inmarsat-C terminal at each monitoring site would be connected to the sensors and low voltage power supply. Data could then be sent routinely or, in order to minimise the communications costs, only when measurements fall outside pre-set limits. In such a case it may still be desirable to send occasional reports to ensure that all the sensors and the

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communications system is operating correctly. As an Inmarsat-C terminal costs only a few thousand dollars, the total cost for sensor instrumentation and communications at each site would be minimised. Such a network would be highly reliable and only require periodic visits to the sites for maintenance or repair purposes.

Conclusion

The Inmarsat-C system provides a unique global solution to the land mobile communications requirements of a broad range of users. Its international coverage enables mobile users to operate throughout the world, crossing national frontiers while still making use of the same equipment.

Inmarsat-C's unique access and control signalling system provides a means to satisfy almost every conceivable operating scenario. The ability to provide regional, national and closed user group service as subsets of an international service provides a totally unique formula for satisfying different operational requirements at low cost. Further, the size of the global market increases the competition between companies and ensures the availability of low cost reliable user equipment.

The system does not compete with cellular services but complements it by reaching areas that would not otherwise be served. It also provide a solution to the incompatibility that often exists between adjacent national systems.

The 1990s will, for the first time, provide the land mobile community with the capability to communicate reliably anywhere in the world - via Inmarsat's Inmarsat-C system.

Footnote:

Inmarsat publishes 'TRANSAT', a free bi-monthly publication. This provides interested parties with details of ways in which the system is being used, LESs in operation and manufacturers who supply equipment. Copies can be obtained by writing to: The Editor, 'Transat', Inmarsat, 40 Melton Street, London NW1 2EQ, England. Tel: +44 71 728 1450. Fax: +44 71 728 1179. Telex: 297201 INMSAT G.

Presented at the PATU/Inmarsat Conference, Cameroon, 16 - 19 September 1991

APPENDIX

INMARSAT-C CHANNELS

A number of different types of channels are used in the Inmarsat-C system. In addition to those channels required for base-to-mobile and mobile-to-base communications and signalling via the satellite, there are also interstation links on the fixed side for network monitoring and control purposes.

NCS Common Channel

The NCS common channel is a TDM carrier transmitted continuously by the NCS to all MESs in the region. MESs tune to the NCS common channel when they are idle. The channel operates at 1200 symbols/s with a fixed length frame of 8.64s which results in exactly 10,000 frames per day. The information is scrambled, half rate convolutionally encoded and interleaved on a frame by frame basis. The data rate is therefore 600 bit/s and all message and signalling information is conveyed in packets. In each frame, 639 bytes are available for packets. The first packet in every frame is always the bulletin board. This packet is followed by a number of signalling channel descriptor packets used to transfer information concerning MES usage of the signalling channels associated with that TDM.

LES TDM Channel

The LES TDM channel is used for the forward link when the LES is communicating with an MES. Its structure is identical to that of the NCS common channel described above, and is used for carrying call set-up signalling, base-to-mobile messages, acknowledgements and call clear down signalling. Full ARQ is provided to ensure error free reception at the MES. A LES may operate more than one LES TDM channel and each channel may be demand assigned by the NCS.

MES Signalling Channel

The MES signalling channels associated with each forward TDM channel are received both by the NCS and by the LES mainly for signalling from the MES to the base stations.

Access by MESs to a MES signalling channel is by means of a slotted ALOHA scheme with the addition of a mechanism for reserving slots in the channel. More than one MES transmitting in the same slot results in a "collision" as seen at the receiving MES. In order to minimise the time elapsed before an MES is aware that its transmission was not successful, the signalling channel descriptor packet in the forward TDM indicates the status of all slots associated with that signalling channel (i.e. reserved or unreserved collision or available).

Slot timing is based on the TDM frame of 8.64s. Each frame time is divided into 28 slots for the second generation satellites. Information transmitted in a slot is scrambled and half rate convolutionally encoded. The transmission rate is 1200 symbols/s for second generation satellites which are now operational. Each slot can carry a burst of 120 information bits. The bursts transmitted in the slots do not have dedicated acquisition preambles. This feature helps to maximise the signalling channel capacity. This channel can also be used for the data and position reporting service, when a small amount of data - up to 32 bytes - can be transmitted over the link to a closed user group. This is a highly efficient means of sending short regular data reports without the need for resorting to use of the MES message channel. As no ARQ is provided in this mode, the length of message is deliberately restricted to minimise the possibility of undetected errors occurring.

MES Message Channel

MES message channels are used by MESs to transmit their messages to the chosen LES. An MES signalling channel is used during the call setup phase of the transfer but the message itself is sent on an MES channel assigned by the LES.

Access to the channel by MESs is on a TDMA basis. The destination LES instructs each MES waiting to transmit the time at which it may start transmitting. Once assigned a start time, an MES will transmit all of its message without interruption.

The information to be sent is formatted into fixed sized packets and placed into frames. More than one frame size is available although the size will be fixed for a particular transmission. A frame

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may contain between 1 and 5 packets depending on its size. Each packet in turn contains 127 bytes of information. The frames are scrambled, half rate convolutionally encoded and interleaved. Before transmission, an acquisition preamble is added. The transmission rate is 1200 symbols/s for the second generation satellites now in service. Full ARQ is provided to ensure messages are received error free.

Interstation Links

MESs offering Inmarsat-C services have bi-directional links with the NCS in the same region. This link is used to transfer announcements and EGC messages from a LES to the NCS for the subsequent transmission on the NCS common channel. In addition, signalling is exchanged on this link to ensure synchronisation of access to MESs and for the allocation of LES TDM channels by the NCS. The channel uses the CCITT X.25 link access procedures. The transmission rate is 1200 bit/s and no error correction techniques are employed other than those included in X.25.

Inter-Region Link

Each NCS is linked to the other NCSs by an inter-region link channel. This channel is used primarily to update other regions of any registration activity by MESs in a particular region. This link uses automatic dial-up voice band data channels over the PSTN. The link layer procedures of X.25 are used for interchange of information. These links operate at 600 bit/s, using CCITT V22 full duplex modems.

CHANNEL CHARACTERISTICS

Link Budget Considerations

The minimum performance of conventional analogue or continuous data links is usually defined for a specific threshold value of C/No (at the receiver demodulator) and the link availability is defined as the percentage of time that this threshold value is likely to be exceeded. Inmarsat-C is a packet data communication system and makes use of ARQ techniques to re-transmit errored packets. for this reason, variations in C/No do not affect the quality of the received message but only the number of re-transmissions required to ensure that the complete message can be reconstructed error free at the receiver.

In order to minimise the loading on the satellite, the total energy per message transfer transaction must be minimised. In the forward link, which in terms of satellite resources is the more critical, reducing the transmit power will degrade the C/No which, in turn, will lead to increased packet errors. More repeat packet will be required and, as a result, satellite capacity utilisation increase due to the extra total message energy required to transmit the repeat packets. Additionally, the time required to complete the message transfer increases. For optimum satellite capacity utilisation the satellite power should be set at such a level that the total message energy is minimised. In practice, one forward TDM may serve many MESs and the power may be set to ensure a distribution of packet error rate across the MES population.

Signal Processing Features

Half-rate convolutional encoding (constraint length K=7) is used on all channels to provide Forward Error Correction (FEC). A relatively short constraint length allows the use of maximum likelihood decoding techniques (such as the Viterbi algorithm) which can provide in the region of 5 dB coding gain in an unfaded link. As a baseline for defining performance limits, a Viterbi decoder has been assumed operating on a 3 bit soft decision sample. A given data bit passing through the encoder is able to influence a group of 14 consecutive symbols and, since the fading bandwidth is low compared with the data rate, all 14 symbols could be affected by a fade. For TDM and message channels, encoded symbols are assembled into a block before transmission. They are then transmitted in a different order to that in which they were assembled. The effect of this interleaving process is to spread transmission of the 14 symbol associated with a given data bit over a length of time which is large compared with a fade duration.

Deinterleaving of the encoded symbols at the receiver is used to effectively convert the long duration fades into random noise which the decoder is able to handle since only some of the

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14 symbols may be corrupted due to a typical fade. The redundancy built in to the transmitted symbol stream allows reconstruction of the original data. For the burst mode MES signalling channel, interleaving is not employed because the bursts are too short for it to have any useful effect. Data scrambling is also employed on all channels. It is needed to ensure adequate symbol transitions for the demodulator clock recovery.

Every packet transmitted on any of the Inmarsat-C channels contains a 16 bit checksum field. Following deinterleaving, decoding and descrambling operations, the receiver computes the checksum for each packet in order to determine if the packet has been received in error.

Call Set-Up Procedures

Due to the store and forward nature of Inmarsat-C, message transfer can be considered as three distinct processes:

a) DTE to DCE at the MES
b) MES to LES (via the satellite)
c) LES to terrestrial network

Each process can be thought of as a completely independent message transfer process. This allows the satellite portion of the link to be defined as a memory-to-memory transfer between LES and MES.

MES Originated Calls

To transfer a MES originated message, the MES must tune to the LES that the message is to be transferred to. After synchronising to the frame of the LES TDM channel, the MES transmits a request message in a random access slot on a MES signalling channel. When the request is processed, the LES will command the MES to tune to a particular MES message channel frequency and transfer the message. Message packets are checked for errors by the LES and any requiring re-transmission are advised in the LES's acknowledgement packet. Upon completion of transfer, the MES is released and re-tunes to the NCS common channel. Following delivery of the message to the terrestrial subscriber, the delivery may be confirmed to the mobile.

Shore Originated Calls

Transfer of base originated calls follows a procedure similar to that of MES origination. The terrestrial subscriber places a call to the desired MES. The call is routed via the terrestrial network to the appropriate LES and this LES then checks for the availability of the required MES within the ocean region. A call announcement is transmitted on the NCS common channel. If the shore originated call is being transferred over an international public switched network, the subscriber may be billed for the entire message transfer at the time the message is accepted into memory at the LES. Hence steps must be taken to ensue the availability of the address MES.

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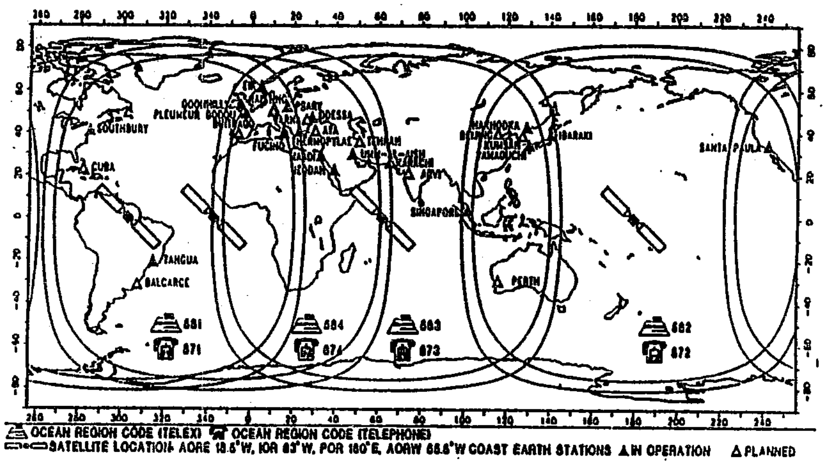
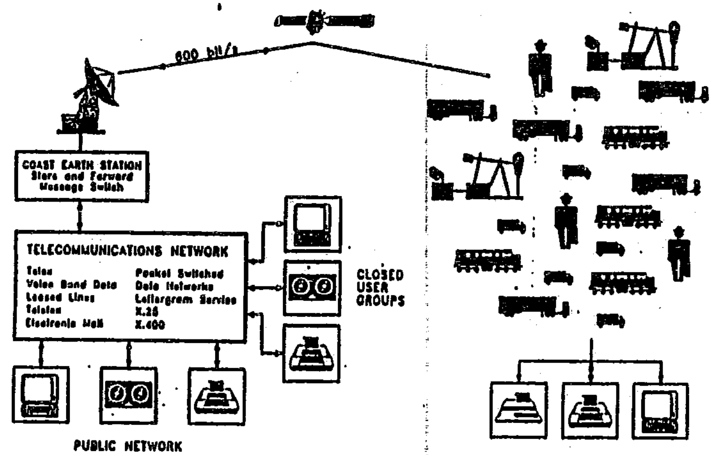
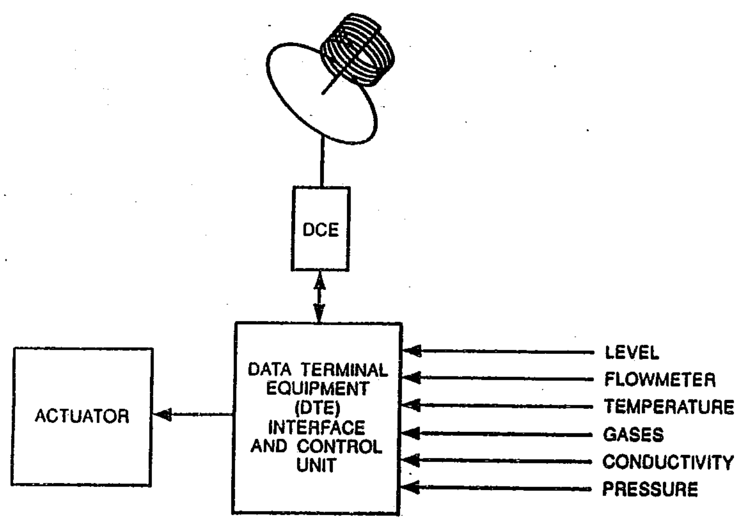


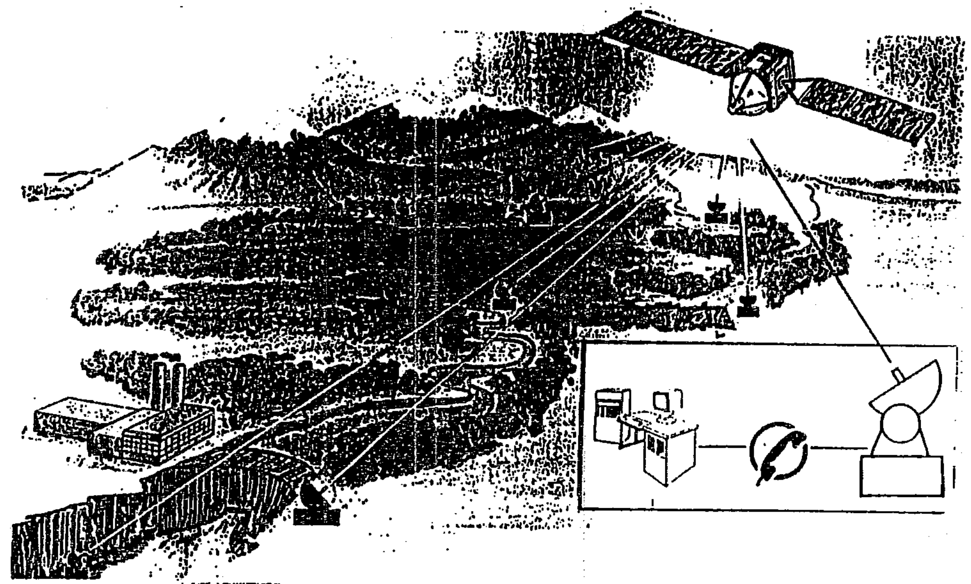
Inmarsat Global Coverage
Showing 0° & 5° Elevation Contours



The Inmarsat-C System



Inmarsat-C for Remote
Monitoring & Control



River Basin Management Scheme

APPLICATIONS OF MOBILE COMMUNICATIONS

Mr. Orest C. Roscoe
Telesat Mobile Inc.
Ottawa, Canada

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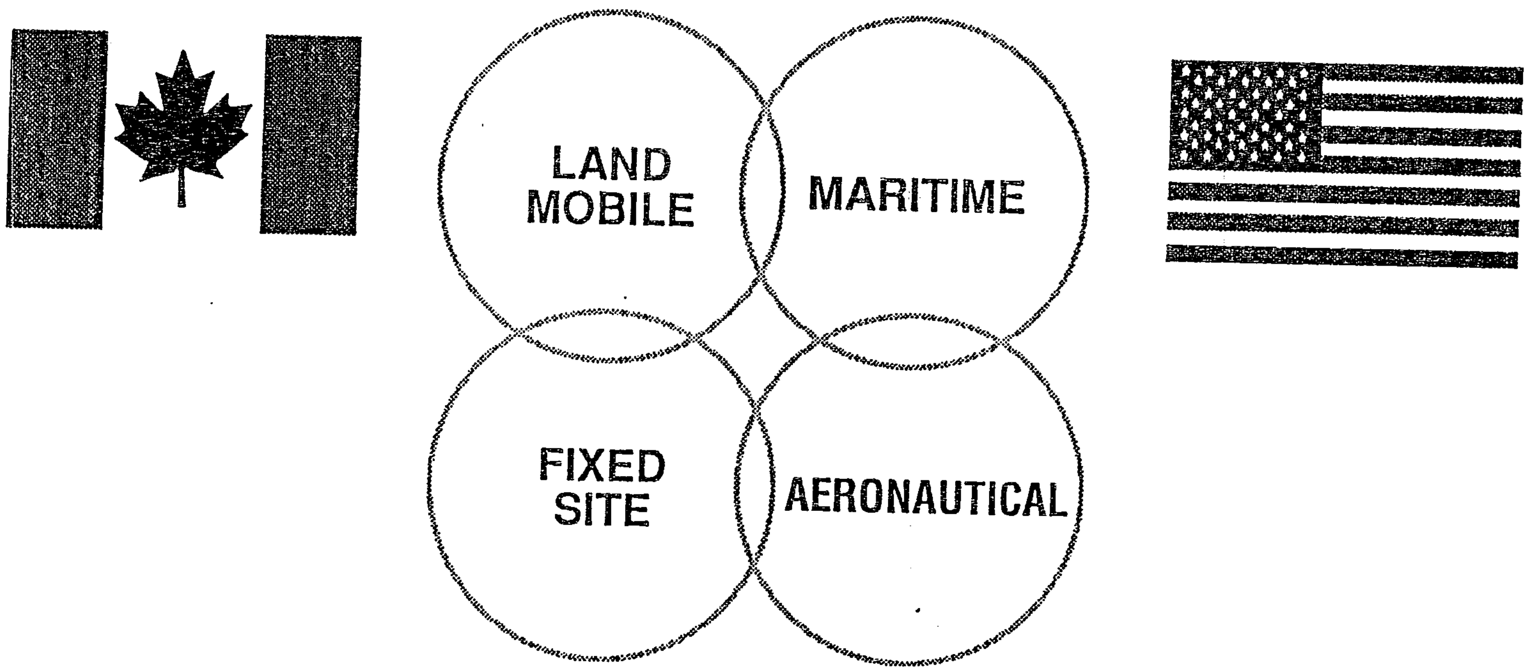
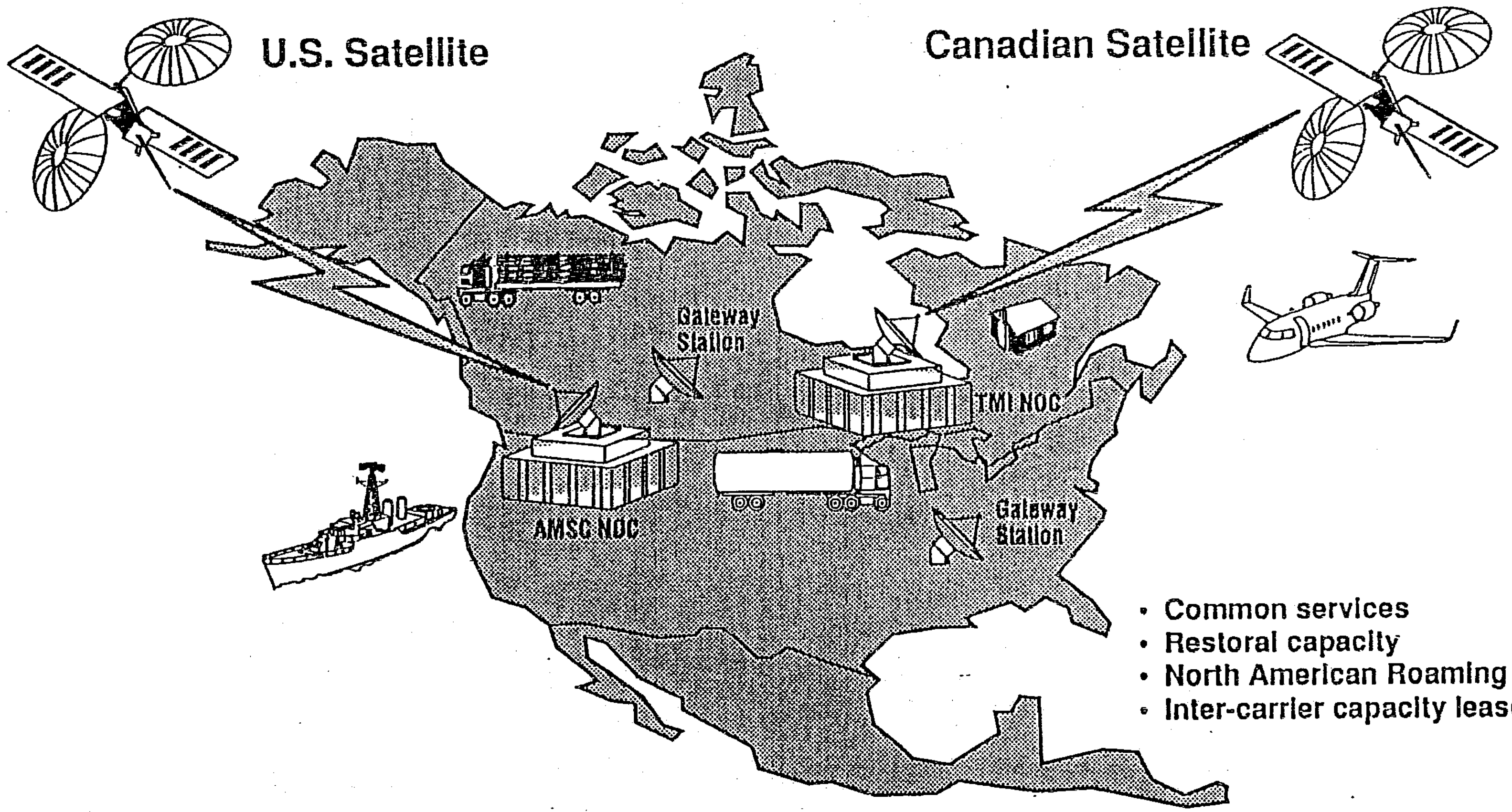
North American Mobile Satellite Service ... A Shared System for Optimum Space Segment Utilization



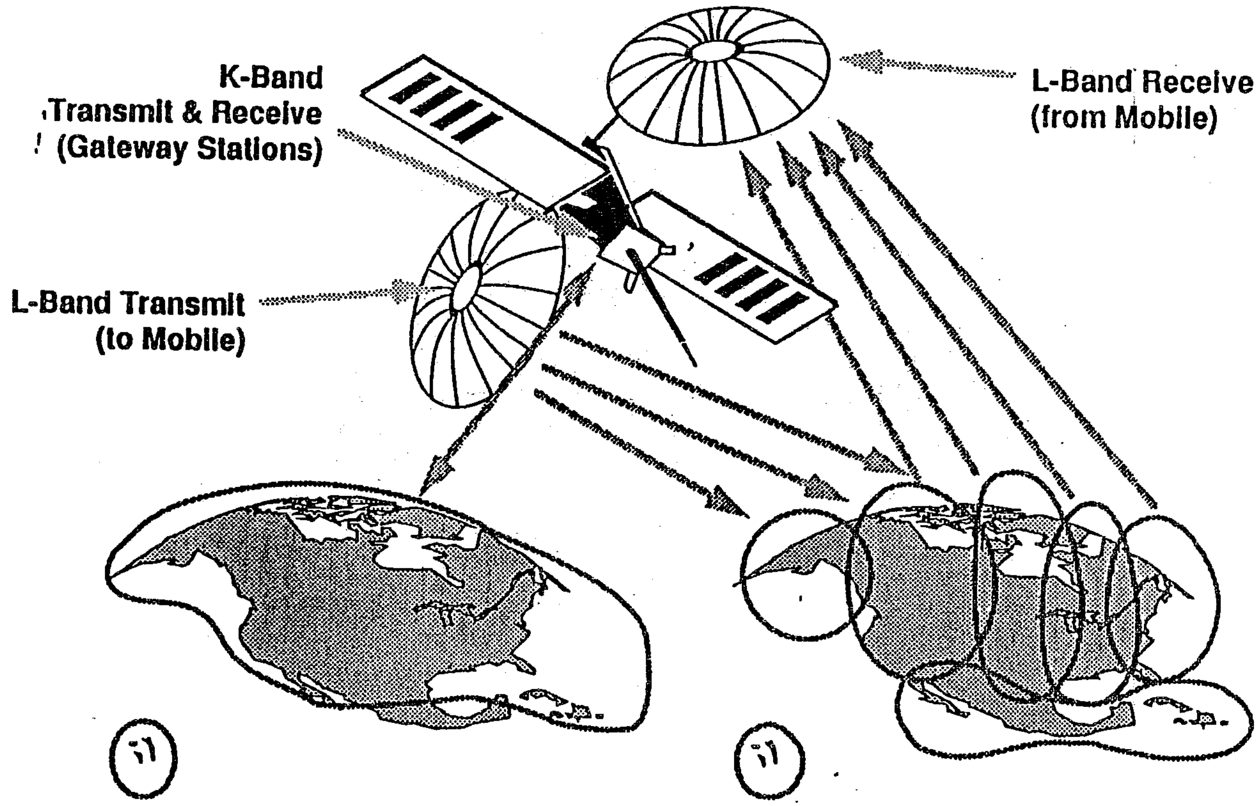
TMI

Integrated North America Operations

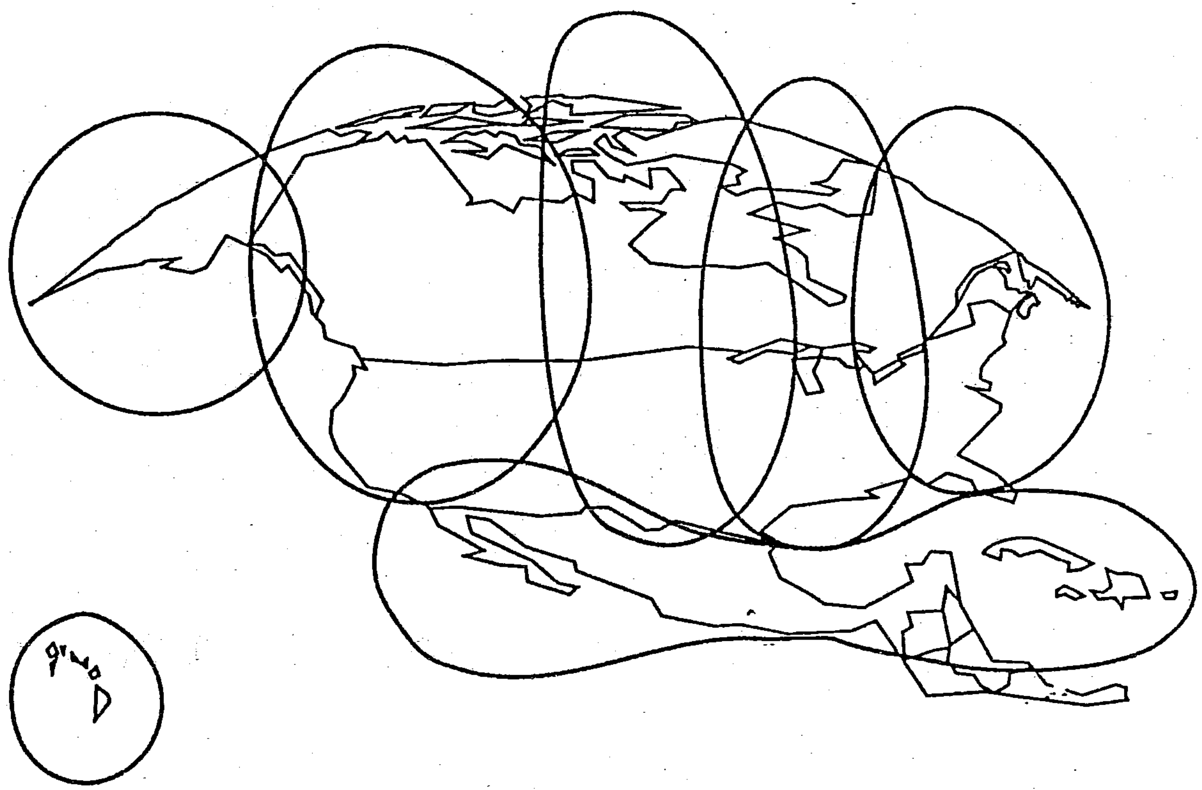


- Common services
- Restoral capacity
- North American Roaming
- Inter-carrier capacity leases

MSAT Coverage Areas



Coverage



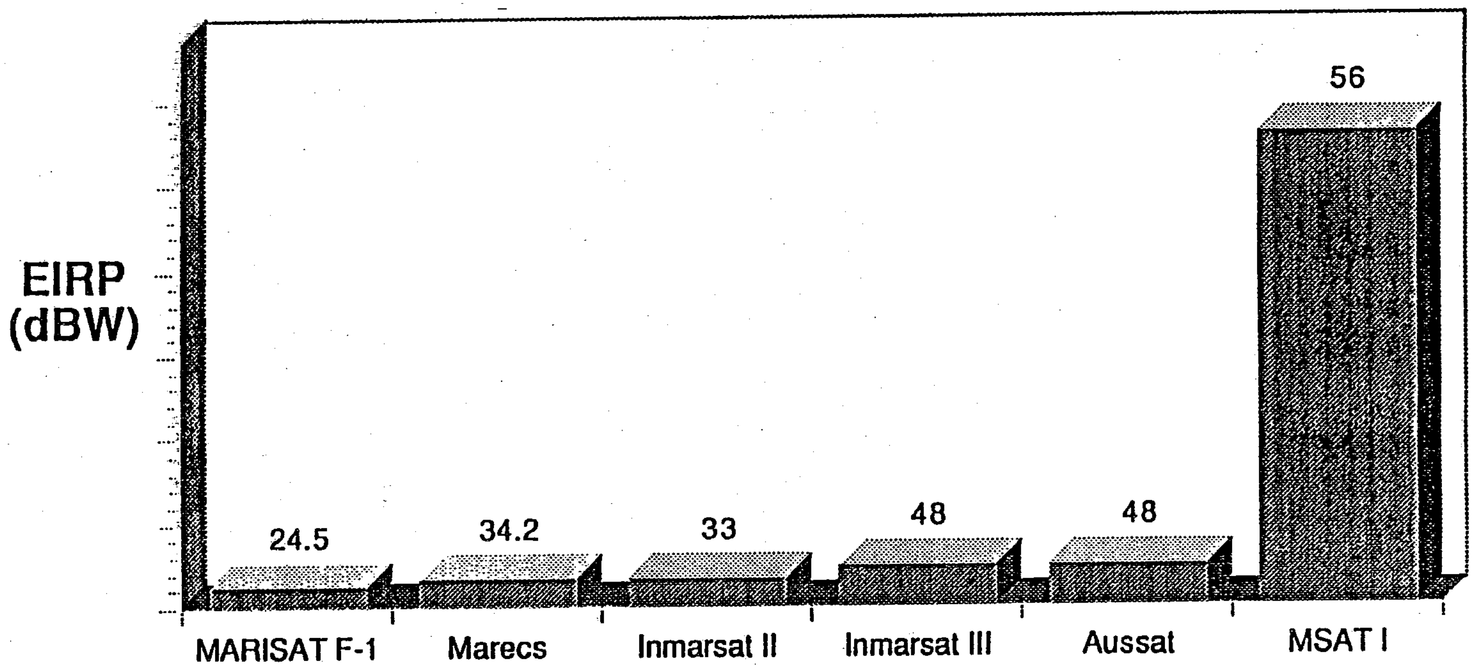
TMI

Timetable

Phase I commercial service introduction	1990
Spacecraft contract	Fall 1990
Launch services contract	Spring 1991
Mobile terminal specifications	Mid-1991
Ground stations contract	January 1992
Spacecraft launch	Spring 1994
Phase II commercial service	Mid-1994

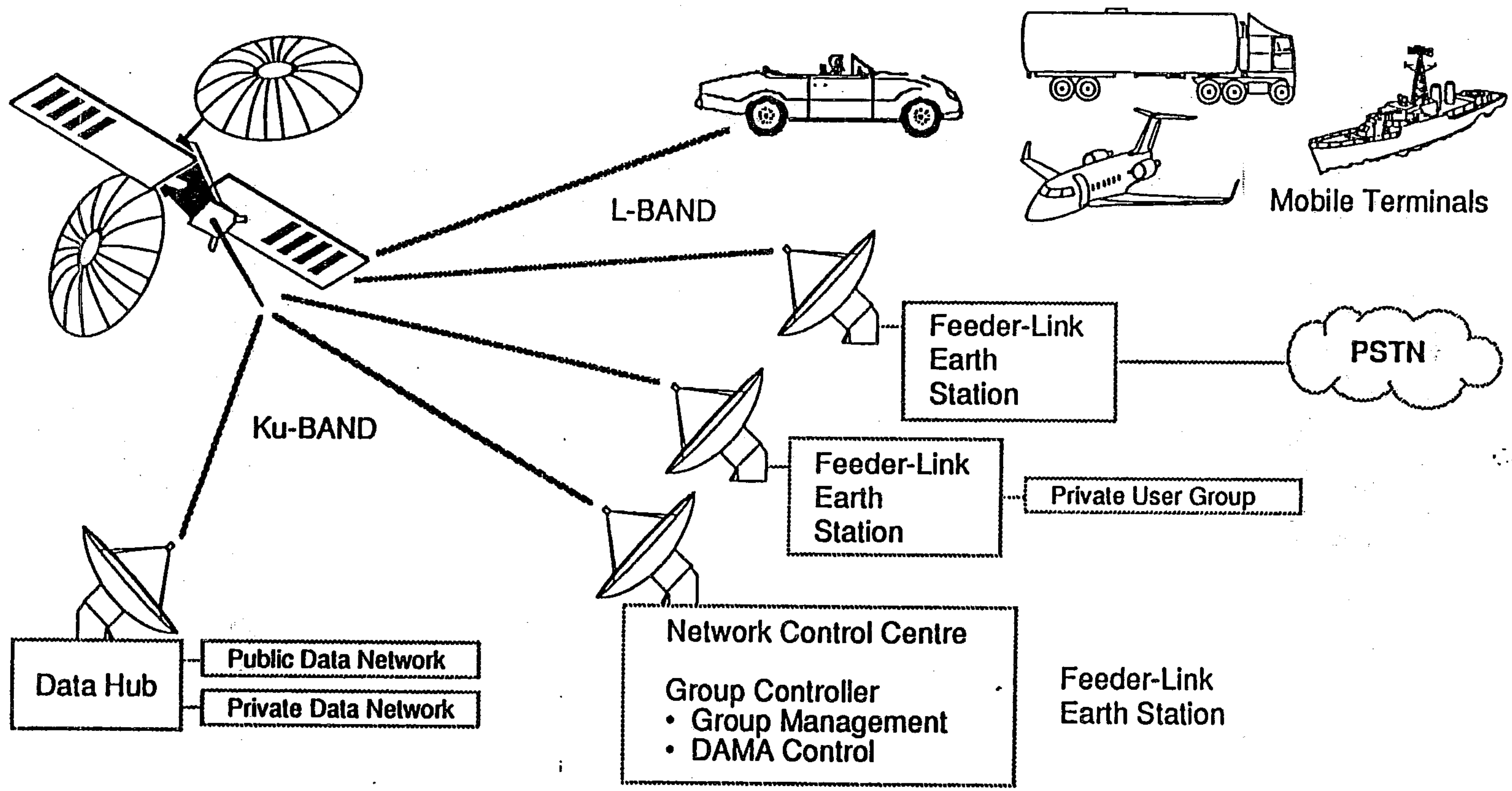
TMI

Capacity Relative to Other Systems



TMI

System Concept



Concept for the communications system to provide MSS in North America

System Concept

- North American-wide mobile communications network supporting a number of voice and data services
- Separate domestic satellites and ground stations which inter-operate to serve both countries
- Compact, low cost integrated voice and data mobile terminals (mobile ISDN)
- Interconnection to PSTN
- Satellite channels assigned on demand

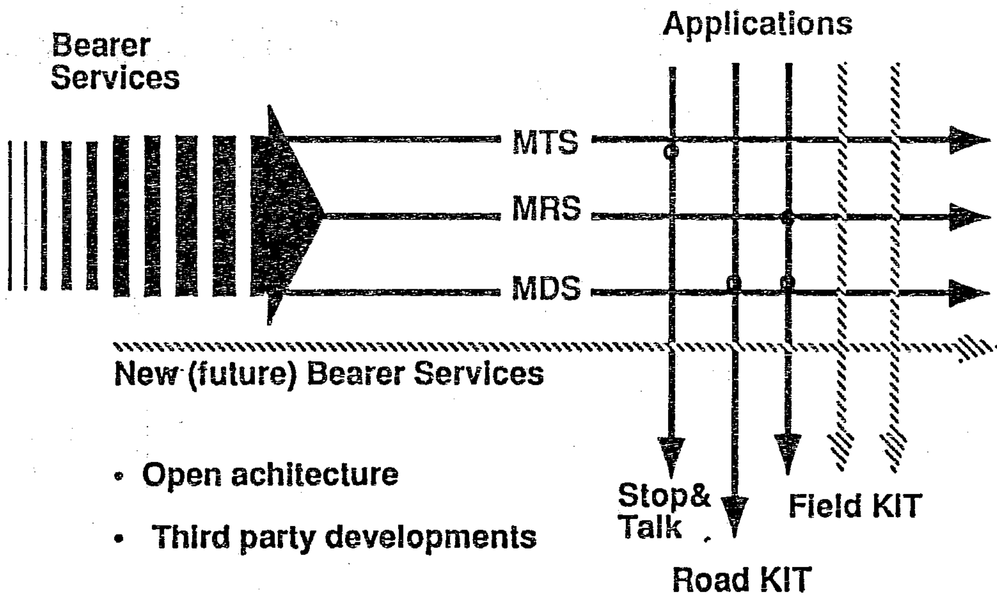
TMI

Service Features

- Continent-wide coverage
- Unrestricted North America roaming
- Flexibility for North America networking
- Platform for new, innovative services
- High quality and reliability
- Complimentary to cellular

TMI

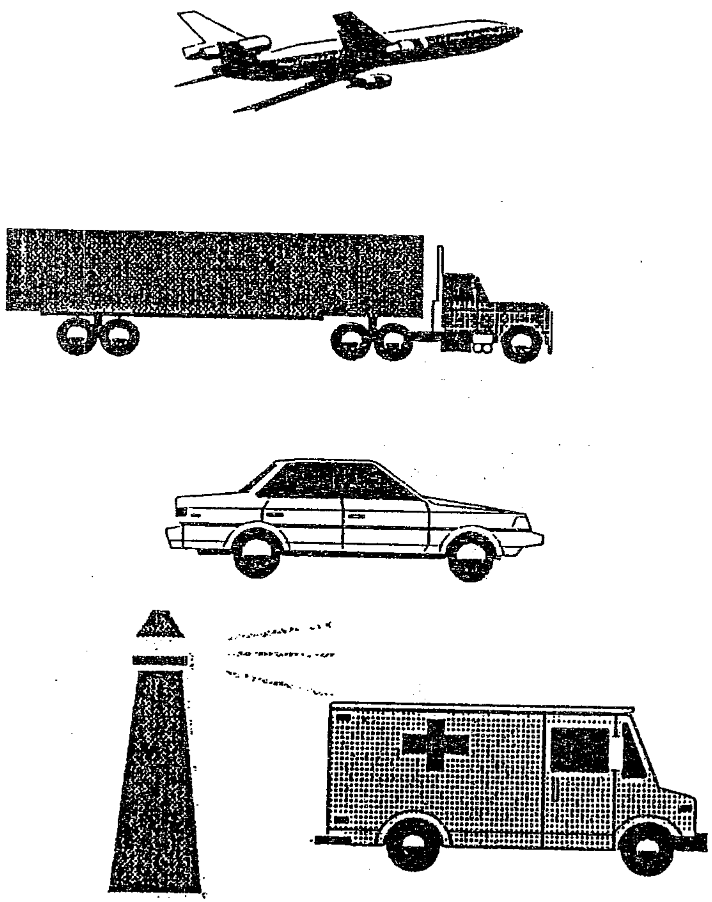
MSAT Applications



- Open achitecture
- Third party developments

TMI

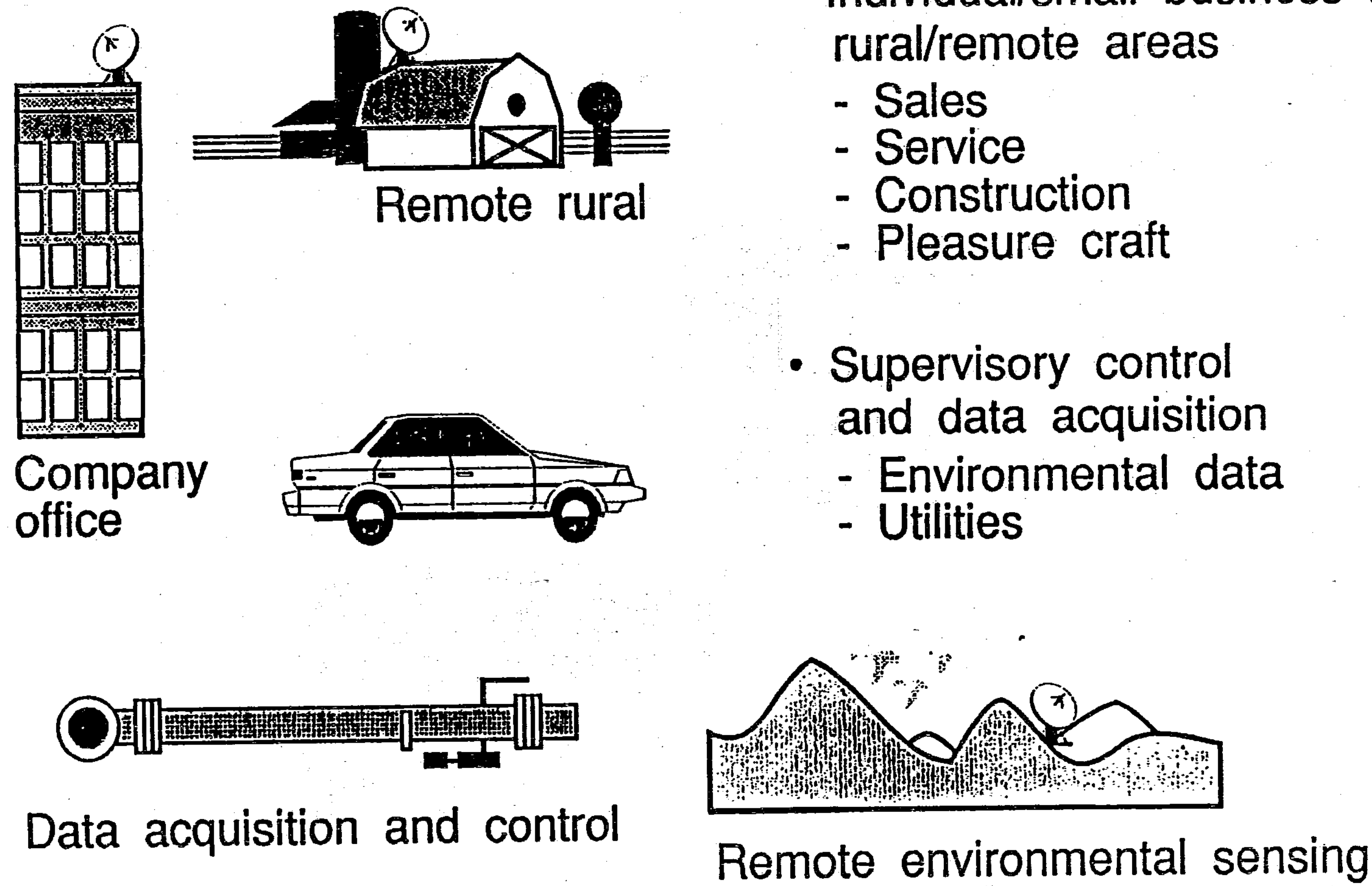
Typical MSAT Applications



- Fleet management
  - For hire and private trucking
  - Fishing fleet operators
  - Commercial aircraft
  - Hazardous cargo
- Resource development
  - Oil & gas
  - Minerals
  - Forestry
- Government & public safety service
  - Police
  - Ambulance
  - Coast Guard
  - Search & rescue
  - Fire fighting
  - Transportation
- Aeronautical services
  - Air traffic control
  - Public correspondence

TMI

Typical MSAT Applications (cont'd)

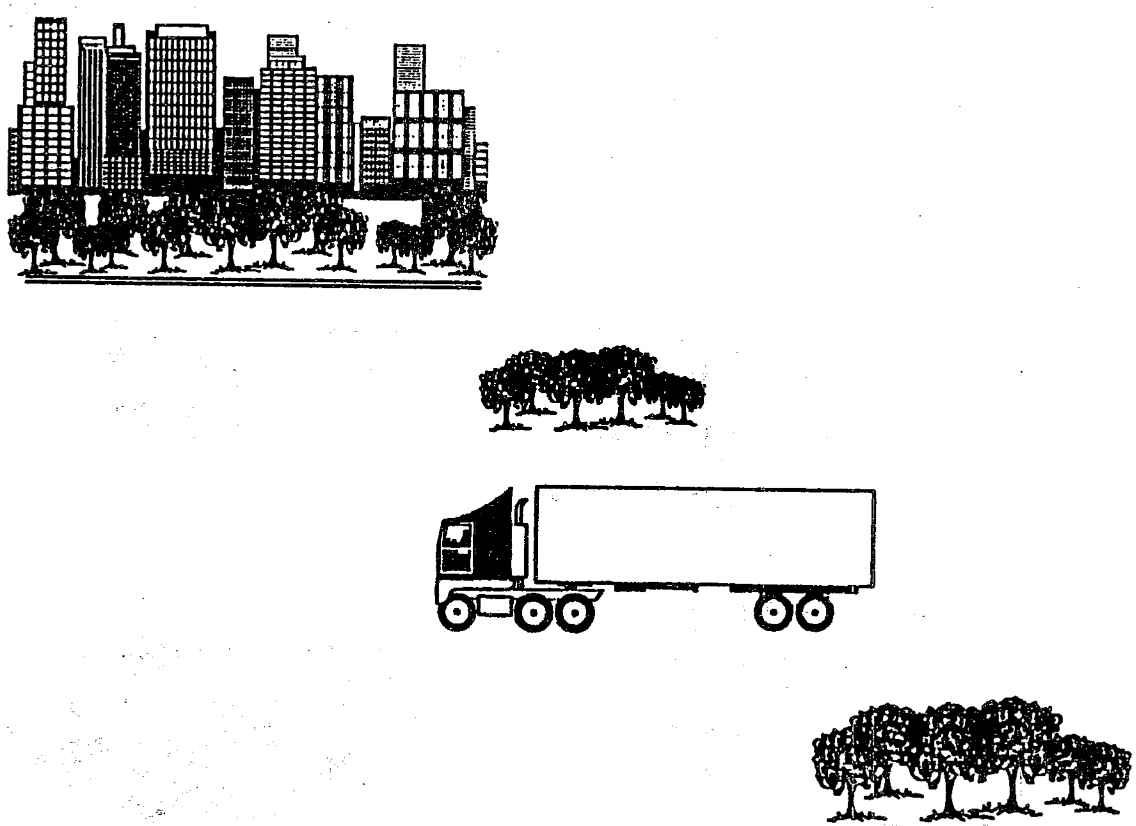


- Individual/small business in rural/remote areas
  - Sales
  - Service
  - Construction
  - Pleasure craft

- Supervisory control and data acquisition
  - Environmental data
  - Utilities

TMI

MSAT Application



TMI

Emergency Communications

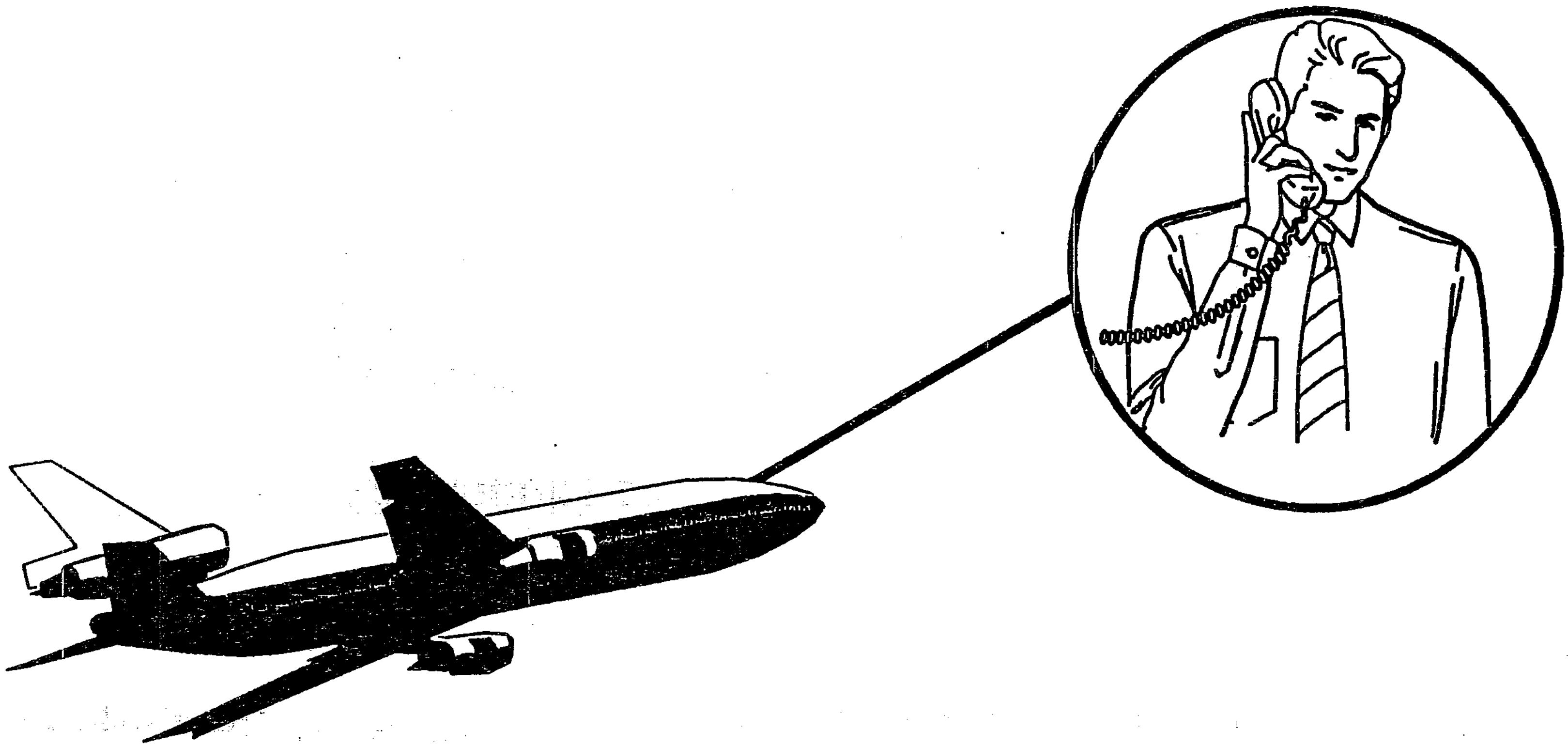
Requirement: Immediate quality communications in temporary locations

- **Police**
- **Air Ambulance**
- **Air safety**
- **Military**

TMI

Aeronautical/Rail Communications

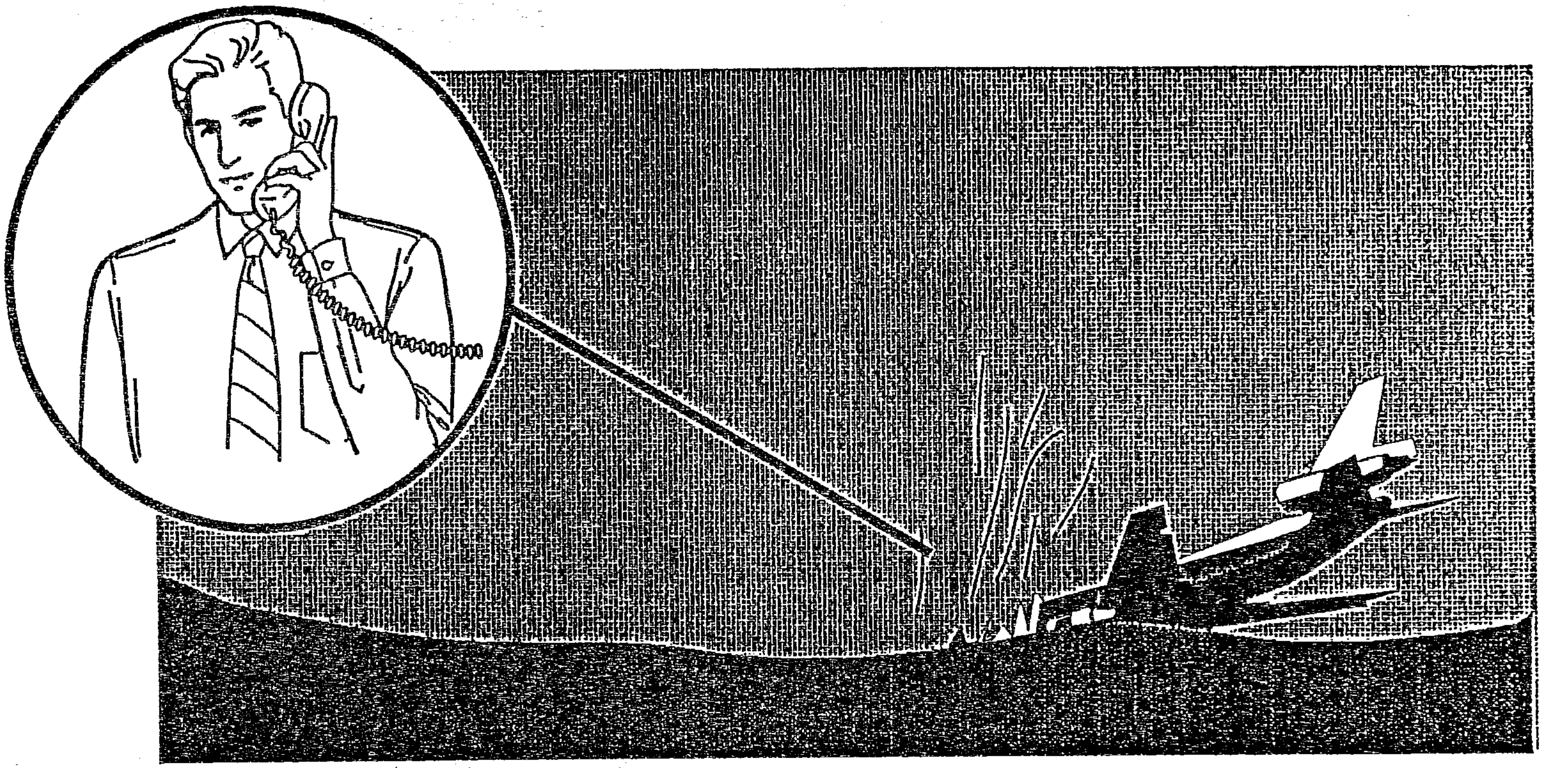
Requirements: Ground/air communications for all aeronautical/rail requirements both for control and passengers



TMI

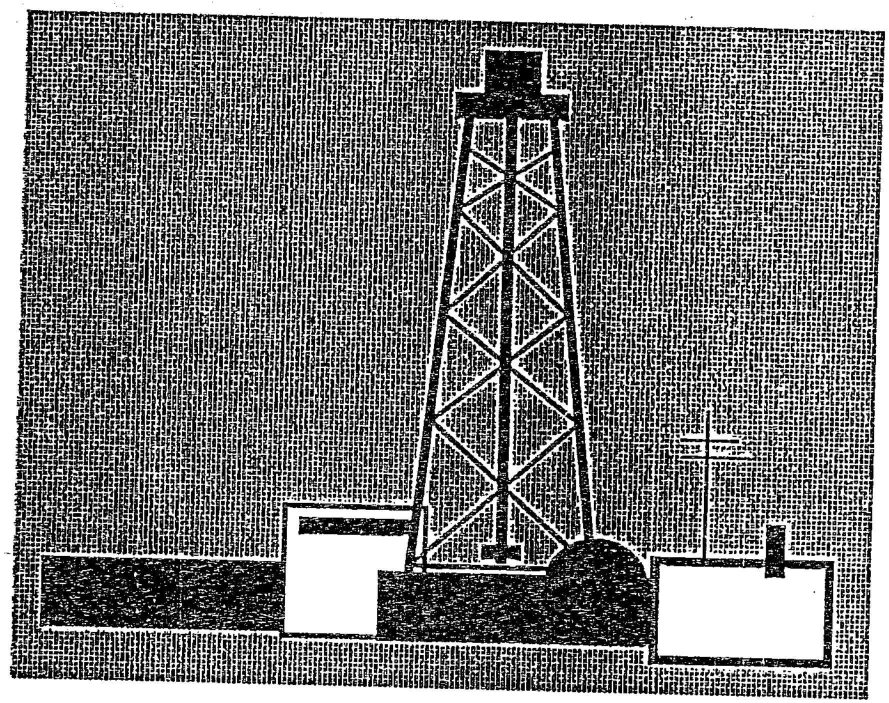
Air Safety Investigations

Requirement: Voice or Voice - data communications when existing methods are not available



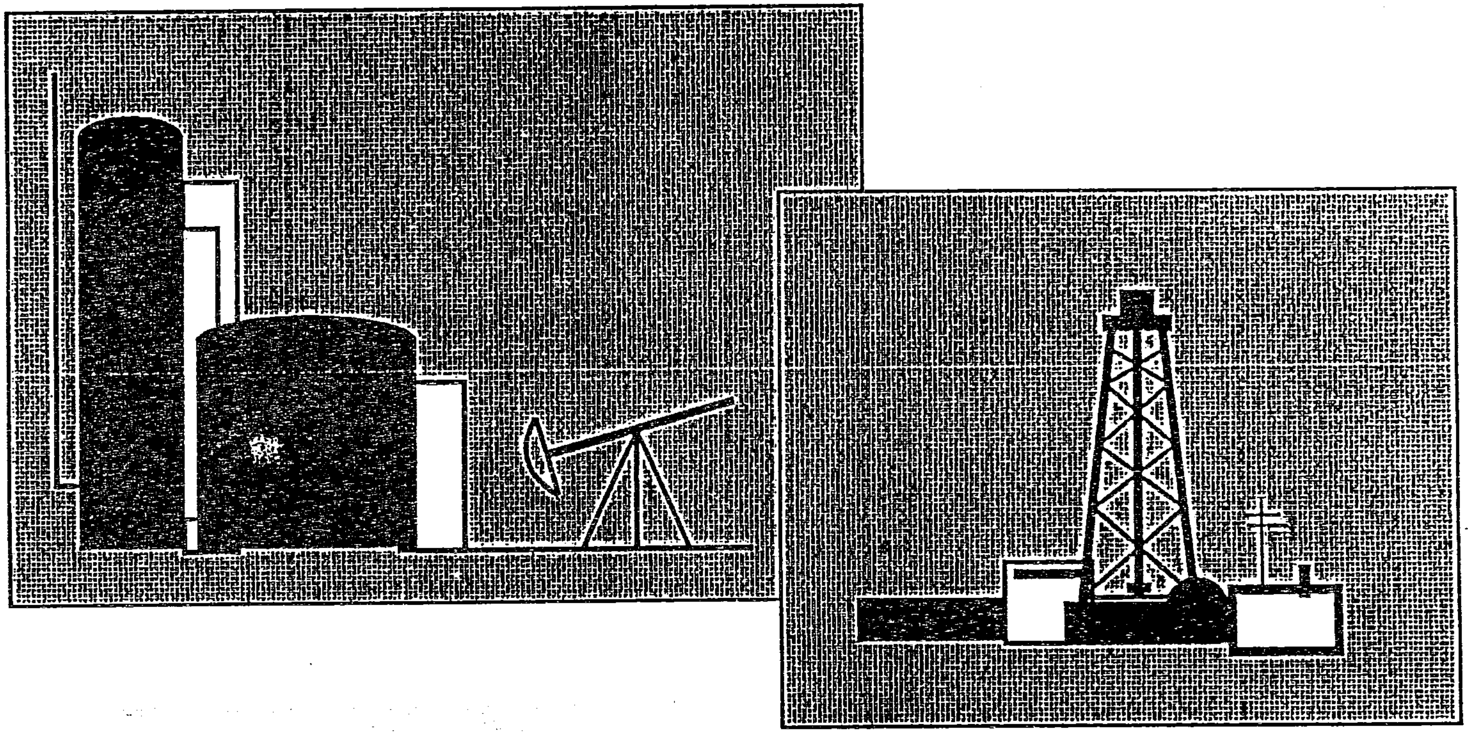
Resource Industry

Requirement: Voice and/or data to remote construction or operating sites



Field Communications and Data Acquisition

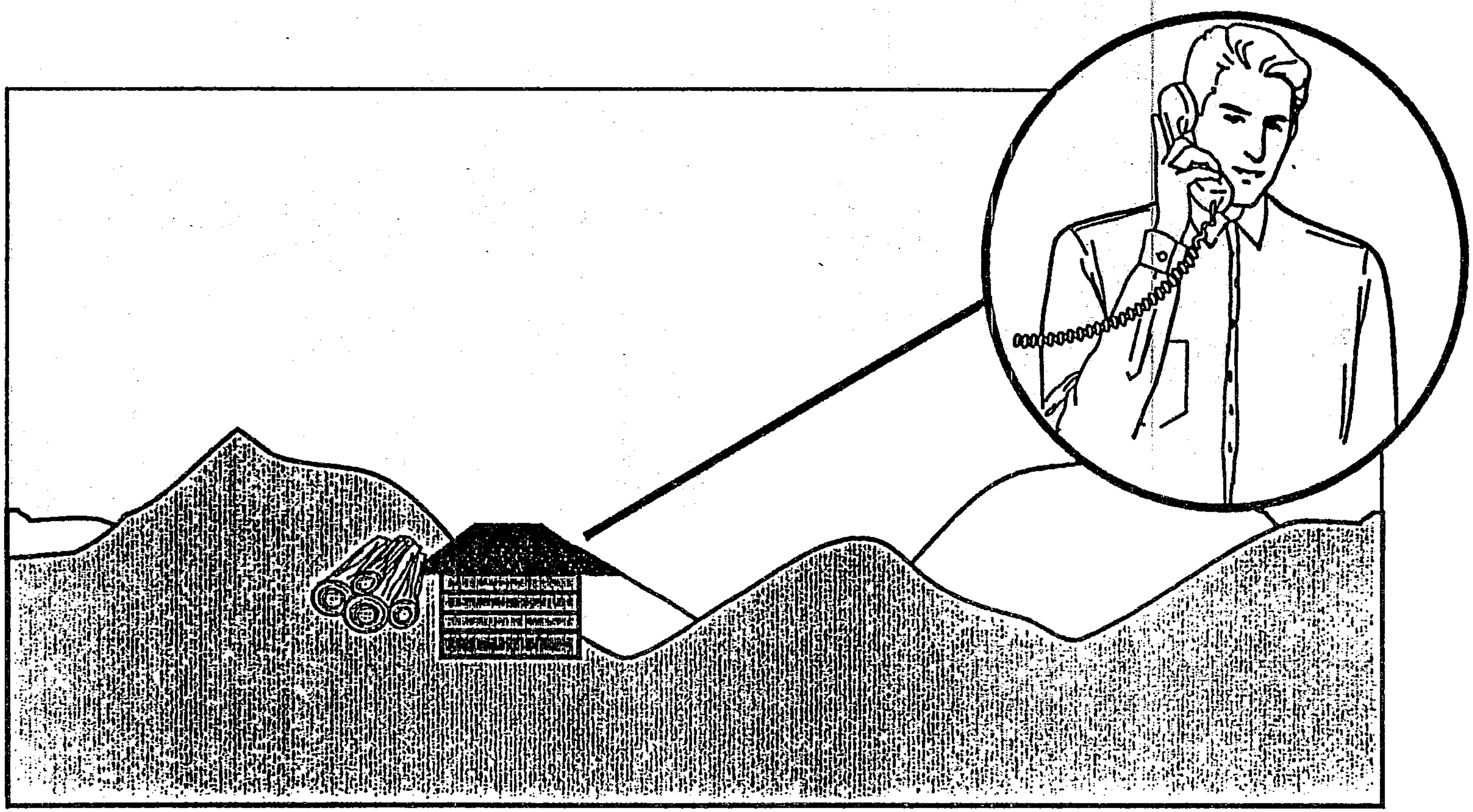
Application: Remote data monitoring and control



TMI

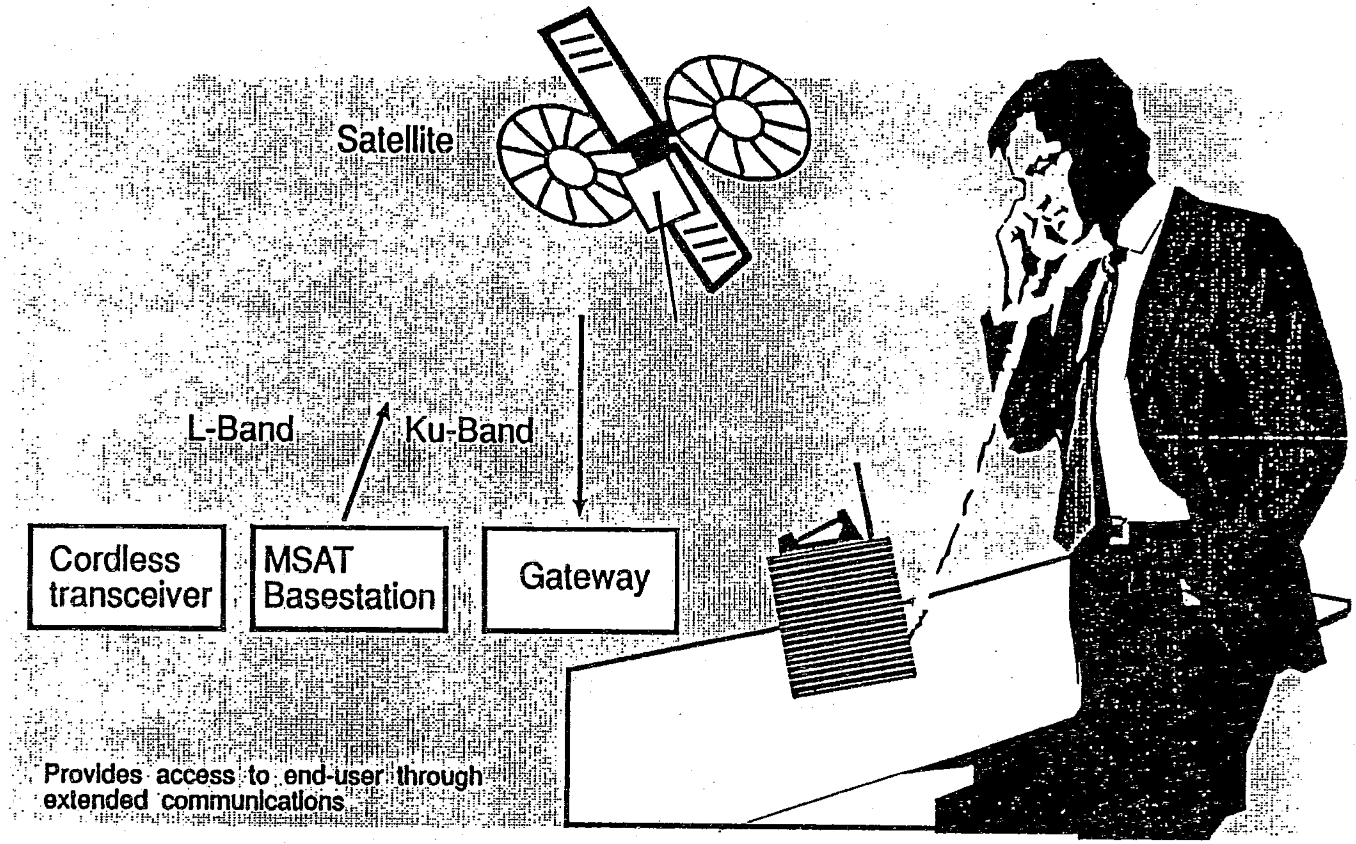
Remote Communications

Requirements: Provide voice and/or data communications to isolated locations where cost of quality service is prohibative



Mobile Voice Extension

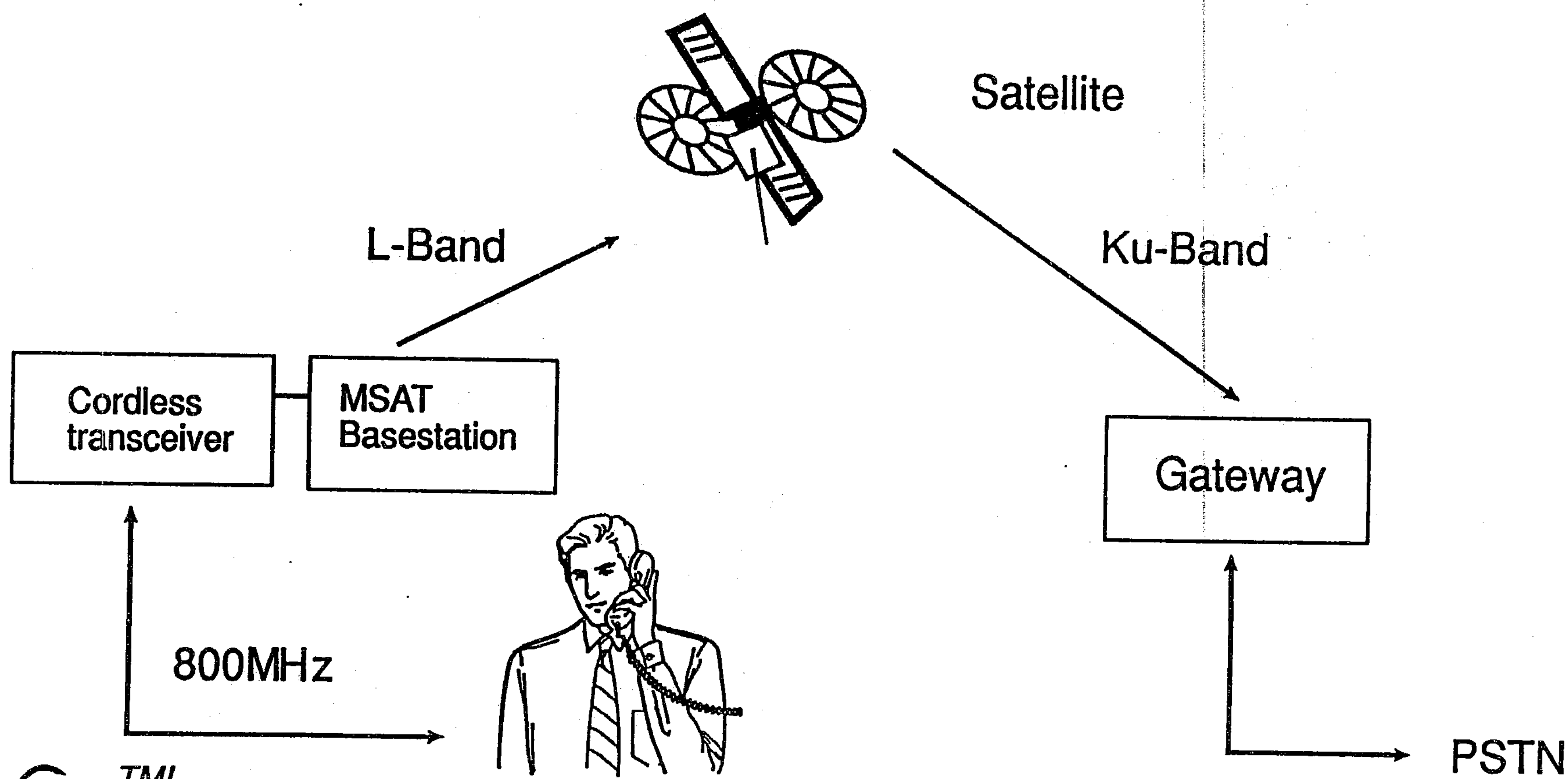
Requirement: To be able to use MSAT as an access technology to other communication services



TMI

Cordless Communications # 2

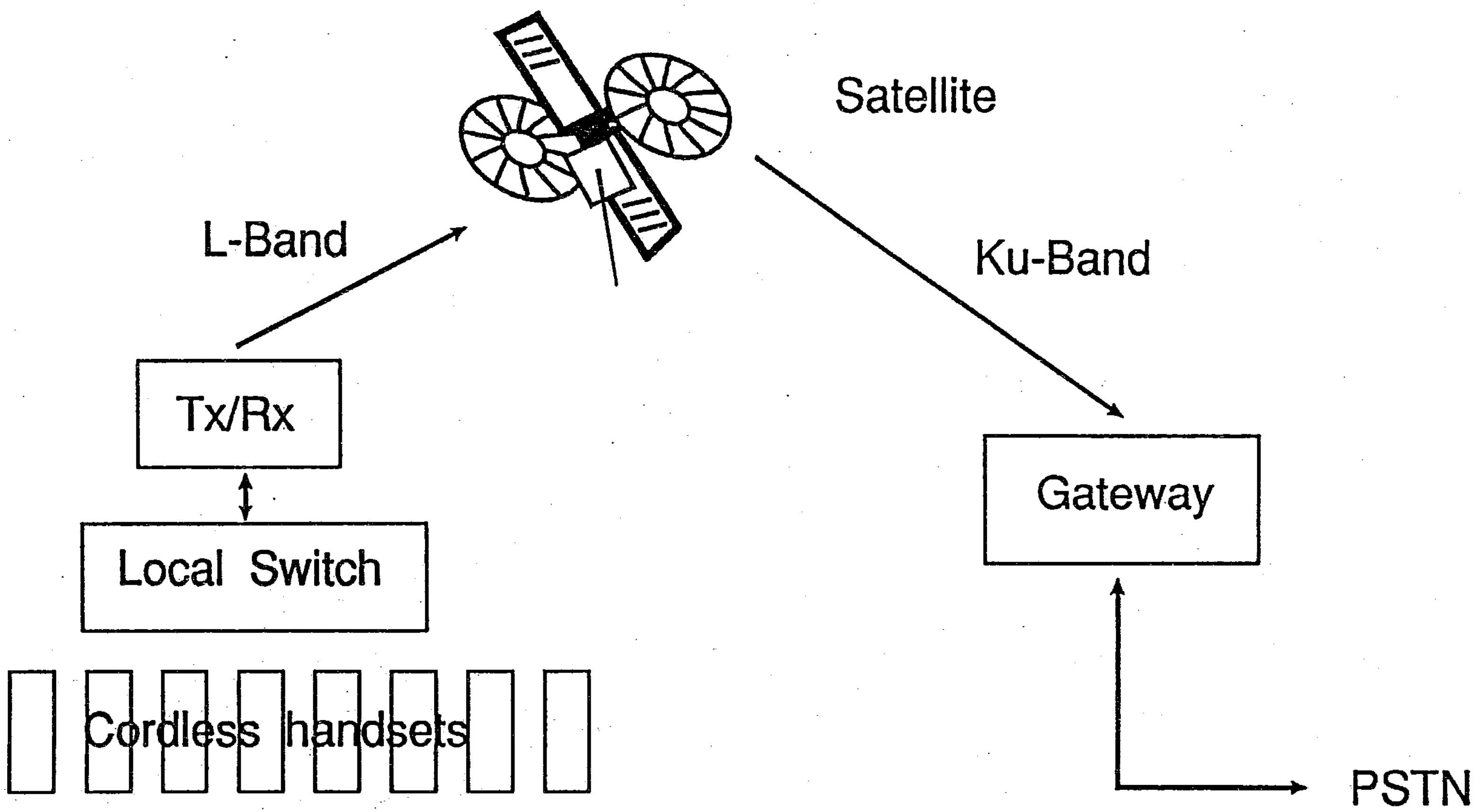
Requirements: Community communications where traditional methods not available or too expensive



TMI

Cordless Communications # 1

Requirements: Community communications where traditional methods not available or too expensive



Stolen Vehicle Tracking

Applications: Built-in radio tagging provides combiled with vehicle location system

TMI

SATELLITE COMMUNICATIONS FOR EDUCATION AND RURAL DEVELOPMENT

Prof. Liu Zhonghen
International Telecommunication Satellite Organization

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Satellite Communication for Education and Rural Development

Introduction

INTELSAT is the commercial international cooperative of 121 member nations that owns and operates the global satellite system to provide the full range of telecommunications services throughout the world. INTELSAT has long been dedicated to the use of telecommunications for development, following the guidelines of the founding INTELSAT Agreement, which calls for the provision of "expanded telecommunications services to all areas of the world...which will contribute to world peace and understanding."

INTELSAT's international and domestic services are provided by 16 satellites ringing the globe in geosynchronous orbit. These satellites link more than 2200 pathways between over 1300 earth stations around the world.

Each member country of INTELSAT holds an investment share based upon that country's current use of the system. Accordingly, each member provides the funds necessary for satellite construction and launch in proportion to its investment share. The revenues of the system come from utilization charges for capacity actually used in the form of individual channels (e.g., voice, data, television), leases (domestic or international) and transponder sales. International earth station facilities are owned and operated by the members and users.

Many countries use INTELSAT capacity to meet domestic communications requirements. At this time, INTELSAT is the preferred satellite system for the domestic services of 40 countries, the vast majority of which are developing. These countries are finding that INTELSAT is not only the right vehicle to take them into the global "Information Age," but that it also offers an extremely cost-effective means of establishing commercial long-distance networks.

INTELSAT commitment to developing countries is evident in other ways as well, namely in helping countries use satellite communications for internal development projects. The object of this paper is to discuss INTELSAT's Program: Satellite Communications for Education and Rural Development.

Project SHARE

INTELSAT's first development activity was Project SHARE, an acronym standing for Satellite for Health and Rural Education. SHARE was announced in August 1984 and had a duration of three and a half years.

Satellite communications may be "high tech" and difficult to understand, but, given a satellite's ability to overcome imposing physical barriers to reach the most remote populations, the uses of satellite technology for health, education or rural services can be

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understood by almost anybody. And, given the scope of the INTELSAT system, many quickly became aware of Project SHARE's potential to provide educational or health assistance to thousands, or even millions, of people who otherwise would receive little or none. In the framework of Project SHARE, INTELSAT and its Signatories would provide the telecommunications technology, while the user would provide the education or health services.

In effect, Project SHARE consisted of "altruistic bartering" -- meaning that everyone had to contribute their part to make the overall program fit together, strengthened the effectiveness of the program. INTELSAT and its Signatories expected, or at least hoped, that others would learn from Project SHARE, but they did not anticipate learning so much from the experience themselves. Today everyone -- the users, program producers, foundations, governmental agencies, INTELSAT and its Signatories -- all understand somewhat better the difficulties, constraints, flexibility requirements, and finally the great potential of rural satellite communications.

Despite the vigorous distribution of hundreds of applications to Signatories, Parties, and scores of potential user organizations, the initial response was rather slow. Although Project SHARE offered free access to the INTELSAT space segment and Signatories offered reduced or no cost earth station access, any particular program was still far from free. For example, Project SHARE participants had to plan and execute an elaborate programs requiring the development of new curricula, the creation of new learning materials, the production of television shows, and much coordination work between partners. In some cases participants also had to pay for terrestrial telecommunications links to the earth station or to find money for the installation of transportable earth stations at the production site. Thus, in several cases the user's cost to participate in Project SHARE varied from $500,000 to $1 million (US) and in the case of China, several million dollars (US).

Due to delays encountered in planning, budgeting and implementing such activities, the first Project SHARE activity, a one-time videoconference, did not take place until 17 July 1985. The first major project with long-term educational importance began one month later, exactly a year after Project SHARE had been announced. Based on this experience, it seems reasonable to expect that any further program will require from nine to 12 months of planning before becoming fully operational. This planning period should include media publicity, widespread distribution of applications to potential users and a considerable degree of interaction between the user organizations.

However, once these obstacles were overcome, Project SHARE enjoyed great success, helping millions of people in over 60 countries. Following are two examples of Project SHARE programs:

<u>**Canada-Indonesia Data Exchange**</u>

The University of Guelph (Canada) and five universities in Indonesia, a dozen Canadian post-secondary institutions and different sections of the Canadian International

Development Agency (CIDA) all participated in a computer conference network established to enable faculty, students and government officials to communicate with each other on topics of mutual academic interest. After three months the project was judged successful and given a further extension of six months.

In Indonesia, dedicated lines and modems were installed (for the first time) at four sites: the Bandung Institute of Technology, the University of Bogor, the University of Diponegoro and the University of Gadjah Mada. From these sites, the lines converged in Jakarta and interconnected with the public-switched telephone network operated by Indosat. From Jakarta, an X.25 synchronous line at 2400 baud was established via the INTELSAT Pacific Ocean region satellite at 174°E to Vancouver. From Vancouver, Teleglobe Canada provided circuits to a computer at the Teleglobe center in Montreal, and from there connected to the public Datapac network connected to the conferencing host at the University of Guelph.

The reverse route was used for communications from Canada to Indonesia. All communication, even communication between the Indonesian sites, was routed through the computer conferencing host at Guelph.

The project encompassed a variety of subjects, including: conferences devoted to regional planning, establishing computer networks, biotechnology, and medicine. Some specific uses included the supervision of graduate students while away from their home institutions, collaboration on research papers between authors in Canada and Indonesia, preparation for visits and lecture, a "meeting" place for Indonesian and Canadian academics of like interests, and the provision of bibliographical search and reference services, particularly for the Indonesian medical faculties.

Many of the participants responded favorably to the results of the project, but perhaps the most important benefits were the opportunity to experiment with computer conferencing (over half of the participants had never used computer conferencing before) and having immediate contact between field projects and home base. Additionally, the quality of the circuits surpassed those provided by more traditional communications methods, such as telephone and telex. And of course, immediate electronic access saved time for all involved.

Tele-Education in China (Full time television)

The first major satellite-based tele-education project under project SHARE was sponsored jointly by the Ministry of Education and the Ministry of Posts and Telecommunications in the People's Republic of China.

The task of educating all of China's student population is obviously an enormous challenge. Part of the solution to this massive problem was envisioned to be Tele-Education via satellite. The project consisted of two phases. Starting in August 1985 and lasting until October 1985, the first phase of the Chinese Project SHARE activity

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established a National TV University. It provided nationwide broadcasts of advanced academic courses for six hours each day to 47 locations.

Phase two expanded the original network to 53 locations and offered more educationally diverse material, including non-degree courses such as, basic health care, self-examinations to detect breast cancer, and lectures on calligraphy and oriental fine arts.

In this project, priority was given to reaching ever more remote areas. To reach these areas, Chinese authorities installed 2000 receive-only terminals of the 6-meter class throughout the country. By mid-year 1988, another 3,000 receive-only terminals had been added to bring the number of 6-meter TVRO (television receive only) antennas to 5,000, all of which were built domestically. The estimated student population is now over 1 million and the Chinese National TV University established under Project SHARE is now the world's largest "tele-university."

Perhaps the most significant result of this project, apart from the high numbers of participants, was the fact that it proved so conclusively successful that the Chinese government decided to continue the program beyond the Project SHARE time-frame. In order to do so, China purchased and leased three satellite transponders from INTELSAT to accommodate the large number of terminals connected to the system.

An analysis of the Project Share applications reveals similarities as to desired technology and applications. Some conclusions then, in no particular order of importance, can be summarized as follows:

- Despite the emphasis that "experts" and INTELSAT itself places on audio or radio applications, most potential users wanted to use interactive television (or, if not possible, one-way);

- Requests for audio or data applications grew out of prior programs where audio or data was the only option available. In essence, virtually all of the "new" programs wanted video;

- Most sponsors of international projects represented either international organizations or developed countries. Although several "South-to-South" international projects were discussed and applied for, all but one ran into difficulties and were subsequently suspended. Developing countries planning domestic use of INTELSAT for tele-education or "tele-health" programs achieved greater success. Explicit efforts to include developing countries in the planning and execution of Project SHARE activities contribute to the success of these programs;

- Project SHARE applications divided almost equally between:

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- video events or videoconferences that were one-time or limited-time events, and
- those that were of recurring and essentially longer-term, program oriented, nature;

Although many one-time video events were significant and covered important subjects, continuing educational and health programs offered the most lasting value and represented the greatest potential for conversion to regular commercial service.

- Essentially only about 10 percent of the Project SHARE activities constituted serious prospects for conversion to commercial service. Only the largest and most extensive users, such as the People's Republic of China, converted.

- Many educational and health uses in developing countries are still economically marginal. New service offerings such as off-off-peak use and special rates on inclined orbit satellites will likely be needed to create commercially viable services.

- Demand for, and applications related to, medical and health-related issues were less frequent than educational uses. Combined programs including both education and health appeared to be the most productive route for the future development of these services.

In other ways, Project SHARE served as a catalyst for other services. Project SHARE contributed to parallel progress towards other INTELSAT services designed for distant and rural users, such as VISTA, volume purchases of VISTA terminals, Super VISTA, and the expanded rural applications of INTELNET. It is also true that Project SHARE has been a stimulus to testing of new small, digital terminals.

Project Access

As a follow-on to the very successful Project SHARE program, the INTELSAT Board of Governors approved Project Access as an on-going program to provide free use of INTELSAT space segment capacity for educational, health or other closely-related social services, or new communication access in areas where current communications are limited.

The program was designed to stimulate service to rural and remote areas while emphasizing the potential for follow-on commercial service. As such, preference is given to applicants that require only audio or data services and have operational and financial plans to implement a regular commercial service. A preference is also assigned to projects that develop or test new technologies.

The approval process for a Project Access proposal encompasses the following steps:

Step 1: Proposal completed by applicant and participating Signatory(ies), to include:

- Detailed description of technical and operational aspects of proposed project.
- Detailed description of proposed project content, duration, list of participants, and funding.
- Plans for conversion to operational service.

Sept 2: Proposal submitted by INTELSAT Signatory(ies) to INTELSAT for review and possible modification.

Step 3: Final decision made by the INTELSAT Director General and Signatory(ies).

Project Access can support a variety of communications applications. Some examples of applications which could be appropriately considered for approval for Project Access are listed below:

- Voice, data, and facsimile network, for long-distance interaction between students and librarian, with high speed capacity to handle inter-library loans or digital report distribution via facsimile.
- Multiple destination voice to extend instruction, administration, and consumer education (e.g., nutrition and family planning) to remote extension sites.

/...

- One-way digital videoconference (64 kbit/s to 1.5 Mbit/s) with audio and data return links for basic teaching and/or adult education or vocational training programs. Additional audio channels could cover two or more different dialects.

- Two-way, "digitally-compressed" video, with two-way audio, for exchange of high-level university course work, medical teleservices to universities, hospitals, research centers, or for government administration and remote extension services.

- Fully-interactive computer network, providing language instruction through time-shared, multi-user access to a central language training facility.

- Audioconferencing, linking agricultural research centers and agricultural extension workers in remote areas, to enable better coordination or research activities, to make information more responsive to farmers' needs, and to disseminate information to extension workers in the field.

- Dedicated voice and data links to connect remote cities and towns to capital city, to support commodity exchange price quotations, electronic funds transfer, and commercial transactions.

- One-way "digitally compressed" video and two-way audio, to provide voice, facsimile, "electronic stethoscope," and electrocardiogram information for teaching and diagnosis from a central hospital to remote areas. Slow-scan video could transmit electrocardiograms or X-rays from remote areas to a central hospital over normal telephone circuits.

- Two-way voice communication between clinics in remote villages (staffed by nurses or medical students) and central hospital (where doctors and more advanced diagnostic tools are available).

- Interactive, low-speed data links between small computers and a central processor for obtaining patient histories, diagnostic data, and information on applicable drugs and vaccines, such as their recommended dosages and availability.

The guidelines planning a project in the Project Access program can be summarized as follows:

- The sponsoring organization(s) with an interest in the developmental uses of satellite communications identifies a target group that can benefit from the transfer to remote areas of health-care, educational or closely-related social services or new communications services. The sponsoring organization(s) is the focal point of all coordinating activity.

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- The sponsoring organization(s) identifies the communications media needed to transfer the necessary information (i.e., radio, voice, printed data, etc.). This organization also identifies the content of the information that will be transferred. An original estimate should be made of the starting time, ending time and, if applicable, the frequency and duration of transmissions.

- The sponsoring organization(s) contacts the INTELSAT Signatories in all countries that will participate in the project. A Signatory representative will be able to identify whether existing earth stations can supply the communication media identified in (2) or, alternatively, if separate earth stations will be required.

- Upon commitment by the Sponsoring Organization(s) and all Signatories who will participate, a signed application form is sent to INTELSAT Headquarters in Washington, D.C.

- After evaluation by INTELSAT and the participating Signatories, each proposal is approved or disapproved.

- Following a favorable decision, the sponsoring organization(s) together with INTELSAT and the participating Signatories will finalize the schedule for the project.

- INTELSAT will work with the participating Signatories and the sponsoring organization(s) to coordinate publicity for the project, before, during, and after the project completion.

- The sponsoring organization(s) will submit documentation to INTELSAT about the project, within three months of its completion, for INTELSAT's use in publicizing the project, informing other Signatories about the project, and for evaluating the effectiveness of Project Access.

In the framework of Project Access, the INTELSAT Board of Governors also approved the provision of free space segment for special global television events that are large-scale world-wide programs for humanitarian purposes. INTELSAT expects to authorize a maximum of two or three of these events per year, utilizing the following guidelines:

- The event must be sponsored by one of the principal organs of the United Nations (neither the Specialized nor the Technical Agencies of the United Nations fall within this definition);

- The purpose should be clearly humanitarian, such as other previously approved broadcasts of programs supporting refugee relief, informational programs on the Foundation for Population Studies, the Hunger Project, or other health-related programs;
- The duration of the transmission should not exceed four (4) hours;
- There should be no direct commercial advertising or other revenue derived from the transmission by the sponsoring organization;
- The space segment requested is not otherwise required for any foreseen revenue-earning service;
- INTELSAT and its Signatories will work together regarding the public relations aspects of publicizing these events.

Requests for free use of space segment in this category are made by the appropriate Signatories. If necessary, INTELSAT will assist in establishing liaison with the appropriate Signatories.

The validity of the special television events will be carefully examined before approval is given for free space segment particularly to ensure that, whenever possible, other essential components of the event are also being contributed on a non-commercial basis, especially by the sponsoring organizations and other facility providers.

Recently, two programs were completed under the auspices of Project Access. In March of this year, INTELSAT cooperated with the Pan American Health Organization and the Ministry of Health and Social Assistance of Venezuela to transmit televised proceedings of the Third Pan American Teleconference on AIDS from Caracas. More than 100,000 health workers in 27 countries throughout the Americas participated in the teleconference that was conducted in English, French, Portuguese and Spanish.

INTELSAT carried the teleconference by using three satellites over the Atlantic Ocean region. The outgoing signal from Caracas was uplinked to INTELSAT V, V-A and VI satellites simultaneously and downlinked throughout the Americas. Incoming signals to Caracas from four countries (Brazil, Chile, Dominican Republic and the U.S.) were downlinked from INTELSAT V-A and V satellites, and were switched into the outgoing signals to establish complete interconnectivity among participants. This transmission plan was developed after a study conducted by INTELSAT and the Venezuelan Signatory. Furthermore, INTELSAT's special projects advisor was present in Caracas to provide assistance.

Another example of this application is the grant approved by the Board of Governors in December of last year on behalf of the signatory of Mauritius, an island nation in the Indian Ocean. This grant provided several hours of satellite time to broadcasters there to televise a program to raise money to repair typhoon-related damage.

For 27 years now, INTELSAT has been a pioneer in developing and applying satellite and earth station technology through its research and development programs. Therefore, INTELSAT is prepared to help with projects on education and rural development. In space, INTELSAT's fleet of satellite cover all corners of the globe and are capable of linking even the most remote locations. And on the ground, INTELSAT's Signatory memebers can assist with earth station and other equipment requirements. This knowledge and expertise can be put to use for people everywhere through participation in Project ACCESS.

It is INTELSAT's sincere wish to organize more Project Access programs in the near future.

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SATELLITE COMMUNICATIONS FOR RURAL AND REMOTE HEALTH SERVICES

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SATELLITE COMMUNICATION FOR RURAL AND REMOTE HEALTH SERVICES

MAX HOUSE

Introduction

Historically, people in rural, remote and isolated areas have not received the same level of health care as those living in urban and more populated regions. While it may never be possible to distribute health services equally throughout a country, the gap between urban and rural areas can and should be narrowed. Traditionally, attempts have been made to provide human and physical resources on site in these areas but recruitment difficulties and high costs have been encountered. In the last two decades experience has shown that the application of telecommunications can contribute to the delivery of affordable distance health services. A list of needs of non-urban areas includes the following: Consulting services, clinical laboratory resources, investigative techniques (e.g., EEG, radiology, ultrasound, nuclear medicine), continuing education for physicians, nurses, and other health professionals, teaching and training programmes for administrative and support staff (dietary, housekeeping, maintenance), community health education and improved general education for health workers and families. Technologies which can be applied partially to meet these needs include those commonly used as well as newer systems currently being developed. Health applications often require only slight modifications of hardware and of method of use.

For nearly three decades physicians and other health care professionals in the United States and Canada have been exploring the application of telecommunications to health care in rural and remote areas. The terms telemedicine and telehealth are used interchangeably to describe this activity. Here the prefix "tele" refers to distance and now includes all types of communication over distance that support health care and health education programmes.

With the demonstrated effectiveness of cable and microwave systems for telemedicine applications there was an active period of research in the field in the early 1970s coinciding with the Space Programmes of the United States and Canada.

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Early Developments

The United States' Applications Technology Satellites ATS I and ATS VI were used for a number of impressive demonstrations in the late 1960s and early 1970s; the Communications Technology Satellite (called Hermes in Canada), which was a joint American/Canadian project, was used in experiments in Canada as well as in the United States. The Moose Factory experiment at the University of Western Ontario in London demonstrated the value of live television and interactive audio systems in the provision of consultations and the transmission of medical data, particularly x-rays. The WAMI (Washington, Alaska, Montana and Idaho) project of the University of Washington in Seattle was mainly an educational project.

Memorial University of Newfoundland (MUN) has had a tradition of outreach since it was established and was an early participant in the Canadian Space Programme. The Telemedicine Centre's experiment with the Hermes satellite involved a one-way television/two-way interactive audio configuration. Four remote hospitals were linked to the University in St. John's.

Continuing education courses for physicians and other health professionals were offered, administrative and committee meetings were facilitated, and there were limited numbers of transmissions of medical data, including electrocardiograms (ECG), x-rays and other images by slow scan television (SSTV).

While this project demonstrated clearly the effectiveness of one-way live television and interactive audio, it was concluded that most of the educational material could have been delivered by audio alone. It was clear that multipoint television with interactive audio would not be economically feasible in the province for the foreseeable future. At Memorial we turned our attention to the development of a mainly terrestrially based teleconference system. A few remote communities are reached by satellite. I shall return to this later.

Anik B Phases I and II

After Hermes, Canada's Anik B satellite was launched and as with Hermes there were a number of health and education experiments. Memorial University's Anik B experiment was in two phases.

The objectives of the first phase were (1) to design and demonstrate a hybrid terrestrial/satellite narrowband network to expand the existing land-based Teleconference System (TCS) to more remote communities, and (2) to evaluate the effect of a dedicated telephone channel link between a drillship sick bay and an emergency department in a tertiary care hospital on offshore medical services.

The hybrid satellite/terrestrial network which linked three land-based sites to the existing teleconference terrestrial network functioned successfully throughout 1980 and 1981.

A manually steerable terminal, designed by the federal Department of Communications (DOC), was utilized in conjunction with dedicated audio channels on the Anik B satellite for transmission. Audio equipment and a SSTV unit were placed on a drillship. Although successful SSTV and audio transmissions were received while the drillship was under sail, mechanical problems with the terminal precluded completion of the offshore activities in this phase.

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During Phase II, which was a joint project with DOC and the Newfoundland Telephone Company, a prototype gyroscopically stabilized terminal designed by DOC for use in the offshore was placed on a semisubmersible oil rig. Through this terminal the rig had access to two dedicated satellite audio channels. One was used in a 2-wire mode as a standard telephone link and the second, a dedicated 4-wire circuit, linked the sick bay to the emergency department of a tertiary care hospital, as in the first phase. In this phase the rig medic was supplied with ECG transmission equipment, as well as audio and SSTV units.

SSTV equipment was used routinely to supplement the audio link for patient consultations between the rig medic and onshore physicians. Transmissions were largely pictures of patient injuries and other abnormalities. Both medics and physicians were satisfied with the quality of transmitted pictures. The petroleum company later installed equipment on both its operational rigs in the region, and commercial satellite channels were used on a dial-up basis whenever consultations with physicians were required.

Terrestrially Based Systems

Since 1977 our Telemedicine Centre has directed its efforts toward the development of interactive audio networks for the delivery of educational programmes and the transmission of medical data. In developing Memorial University's Telemedicine projects a number of guidelines were followed:

~ Use the simplest and least expensive technology that will meet needs.
~ Develop a flexible system.
~ Involve users (participants, audience, clients) from the beginning of the project.
~ Seek the support of administrative personnel in hospitals, clinics, and other agencies.
~ Plan carefully for coordination of the system at all levels.
~ Develop a consortium of users within and outside the health field.
~ Plan for continuity of service beyond the demonstration project.
~ Include evaluation.

Memorial's Teleconference System

Memorial University's Teleconference System, which began programming in 1979, is a dedicated (4-wire) audio system. It is a province-wide network consisting of five dedicated circuits. Programmes can involve any combination of the circuits with up to five sessions running simultaneously. There are installations in all provincial hospitals, community colleges, University campuses, a number of nursing stations, town halls, high schools, and the offices of a variety of associated health and education agencies. Each site has audio teleconferencing equipment. A number are also equipped with video-add-on units, (e.g., slow scan television, telewriters, EEG and ECG transmission units) depending upon their requirements. There are now 170 audio teleconference sites in 80 communities with 100 sites having telewriters (electronic blackboards).

The System carries a variety of programmes including continuing education for health professionals and their support staffs, committee meetings, community based programmes, and patient care activities such as the transmission of medical data. Various government departments hold teleconference meetings with their field staffs or with related agencies throughout the province. Some 40% of the time on the System is devoted to general educational programmes including approximately

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35 university credit courses per semester, high school courses and administrative meetings of various education groups. Memorial's family practice group uses the TCS regularly to communicate with its peripheral clinics.

In addition to the 4-wire network, the Centre also operates a 20-port teleconference (2-wire) bridge to accommodate the conferences that cannot be held on the dedicated system. The 2-wire bridge allows the inclusion of external resource people in conferences, permits access to other teleconference networks, and provides a link for international activities. This bridge can be divided into four sections each of which can be joined to any of the 4-wire circuits.

Medical Data Transmission

Slow Scan Television (SSTV)

Slow scan technology has been available for 15 years and permits the transmission of a picture over an ordinary telephone line. A television camera captures a single frame of a television transmission and converts this to an analogue signal for transmission over a period of time, 15-70 seconds depending on the resolution required. This technique is also called freeze frame or captured frame video. With the advent of digital equipment, there has been an increase in image quality and a shortening of transmission time. Earlier equipment was considered by many radiologists as unacceptable although promising. Current digital equipment appears to be satisfactory for many types of images. For the first time, we at Memorial have decided to offer slow scan in pre-operational mode between two remote hospitals and an urban centre. We have used analogue slow scan experimentally between (a) oil rigs and shore-based hospitals, (b) St. John's and Aberdeen, Scotland, and (c) remote and urban hospitals in Newfoundland.

Electroencephalography (EEG)

Six peripheral hospitals are currently transmitting a total of approximately 1200 EEG tracings per year to the University's main teaching hospital. Remote equipment consists of an electrode cap and a transmitter. A receiver converts the multiplexed eight channels of the EEG which are recorded on a standard EEG machine. At the remote site technical work is done by an ECG technician, x-ray technician or a nurse. Training of the remote technician requires about ten days in the EEG department of the urban hospital. This EEG service, after eight years experience, is acceptable to referring physicians, hospital administration, electroencephalographers and to patients and their relatives.

Electrocardiography (ECG)

A number of remote sites have ECG transmitters which allow a standard ECG to be transmitted around the clock to the ECG department or coronary care unit. This is an inexpensive service which can be used as a clinical laboratory service or as part of a consultation.

Telewriters

For education and training audio teleconferencing can be greatly enhanced by the use of this computer-based system. This is of particular value where real time visual information such as writing, printing symbols, diagrams and graphics are required to support a given lecture or

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presentation. Telewriters are equally effective for business and research meetings. Freehand writing and graphics can be presented and exchanged, annotated, altered and discussed during a conference or teaching session. Telewriters are of particular value in mathematics, engineering, physics as well as in other service applications.

National Project

In 1982, the Royal College of Physicians and Surgeons of Canada and the Toronto General Hospital jointly conducted a national teleconference trial project which lasted two years. All medical schools in Canada, totalling 16, were given a teleconference kit and access to a 20-port teleconference bridge. The objective of the project was to determine the value of teleconferencing at the national level in one health field. The project was jointly funded by the Royal College and the Donner Canadian Foundation. The project, which was done in collaboration with Memorial University, was followed by Telemedicine for Ontario, which is now called Telemedicine Canada.

Electronic Mail Project

Because the circuits of Memorial's Teleconference System are free between the hours of 2200 hours and 0800 hours, it was logical to consider the automatic transmission of data between and among the 80 communities on the network. To this end, a computer software programme was developed to permit IBM compatible XT personal computers to deliver messages throughout the system. This project is now in a pre-operational phase.

International Projects

International Satellite Organization (INTELSAT)

Canadian medical academics, along with those from other countries, played a significant role in the development of the School of Medicine at the University of Nairobi, Kenya in the 1960s and 1970s. Subsequent to this a MUN project, supported by the Canadian International Development Agency (CIDA), was initiated to provide support for the Paediatric Department at Makerere University in Kampala, Uganda. This was called the Child Health and Medical Education Programme (CHAMP).

In 1985 the International Satellite Organization (Intelsat) and the International Institute of Communications established the Satellites in Health and Rural Education (SHARE) project to celebrate the 20th anniversary of the establishment of Intelsat. The Telemedicine group at MUN saw this as an opportunity to establish a link not only between Nairobi and Kampala, but also to provide a teleconference link between those two East African cities and Memorial University in Canada. With the involvement and collaboration of Teleglobe Canada, Post & Telegraphs of Kenya and Uganda, and Intelsat, a 4-wire dedicated system was put in place in December 1985 with Nairobi, and with Kampala in February 1986. Funding for this project came from the Toronto Hospital for Sick Children's Foundation.

Programming

The system was used for teaching sessions, administrative meetings, transmission of EEGs and a variety of other applications. The Hospital for Sick Children in Toronto and paediatric faculty of

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the University of Toronto contributed many programmes using the Telemedicine teleconference bridge. The Janeway Child Health Centre in St. John's and MUN's discipline of paediatrics were responsible for the majority of programmes. EEGs were transmitted from Nairobi for two months and from Kampala for ten months; approximately 100 tracings were transmitted and the majority of these were interpreted with confidence by electroencephalographers in St. John's.

In June 1986 the MUN SHARE project was extended to include the six Caribbean countries on the University of the West Indies Distance Education (UWIDITE) Teleconference System. These sites were accessed through the UWIDITE control centre at the MONA campus in Kingston, Jamaica. The technical configuration allowed the Telemedicine Centre to switch automatically the Teleglobe gateway signal between Africa or the West Indies as required. Because of the nature of the existing UWIDITE system there were some technical problems but these did not interfere with active programming using voice and in many instances slow scan television. The 4-wire dedicated link to the West Indies was terminated at the end of December 1986.

Subsequent to the SHARE project MUN's Telemedicine Centre has received financial support ($625,000 Canadian) from CIDA to develop a 4-wire radio based teleconference system in Jamaica. The project will be jointly carried out by MUN and the University of the West Indies (UWI). The Jamaica network has been designed so that it can be interfaced with the existing satellite network that connects seven island countries. It is anticipated that this design will be used as a model for expansion of UWIDITE in other Caribbean islands. In addition to developing the technical system, MUN is cooperating with UWI in developing appropriate course design techniques for Jamaica.

Successful implementation of the Jamaica project will see an increase in the number of students served by UWI. Agencies and organizations outside of the University will also participate, including the Caribbean Food and Nutrition Institute and the government Departments of Education, Agriculture and Health.

SatelLife

SatelLife is a non-profit international organization committed to using modern communication technologies to link medical centres and physicians throughout the world providing critical information. SatelLife, with an international board of scientists and physicians, is an East-West partnership with offices in Boston and Moscow. The board has four American, four Russian, one Canadian, one Indian, and one United Kingdom member.

One of the projects of SatelLife is called HealthSat. HealthSat will transmit medical literature, including *The New England Journal of Medicine* to five university medical libraries in East Africa. HealthSat is a low orbit satellite built by Surrey Satellite Technology Ltd. of Britain with the payload being owned by SatelLife. This low orbit satellite, UoSat-5, weighs about 50 kg and makes a North-South orbit every 100 minutes. As it passes over a given point on the earth, signals can be sent to and received from ground stations. The messages are stored in the satellite's computer until the satellite, a few hours later, passes over the addressee ground station in Africa. The ground station consists of a radio, a modem and a computer. Memorial has a gateway station for this satellite electronic mail (e-mail) pilot project. E-mail messages received by terrestrial e-mail networks will be transferred manually to the satellite ground terminal. The earth station will be a laptop computer connected to a radio transmitter/receiver. The satellite passes over a given point on the earth twice daily. There will be an 18-minute "window" during which time information will be received and sent

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to the satellite with delivery to other transmitting/receiving stations anywhere in the world. Obviously, the applications will be in areas where no communication system now exists.

It should be noted that amateur radio operators have been using this technology for some time. Motorola with its plans for iridium and its 77 inter-connected small satellites and Russia with its "small sat" project have certainly raised the profile of low orbit communications. Memorial's low orbit satellite project is experimental and we have an experimental license. It may be an understatement to say that it will be some time before the regulatory considerations governing low orbit satellite communication are settled.

Digital Communications Technology

While Canada has been slower than some other counties (US and Scandinavian countries) to digitize its telephone networks, this process is now underway with substantial digitization expected by the mid-nineties.

With this new system it is possible to transmit an increasing amount of data without the need for broadband circuits. There has been an increasing use of intermediate bandwidth circuits (called T_1) in the US and in Scandinavian countries. In June 1990 Nymo and Engum, in a presentation at an OECD conference in Kiruna, Sweden, described the use of T_1 technology to transmit medical data from remote to urban hospitals. The Norwegian Telephone Company had, by early 1991, a 30-point T_1 network with many sites having the capacity to transmit compressed video. ESTEC has supported a number of T_1 projects in Europe, at least one of which used the Olympus satellite. There is currently an interest in a T_1 trial between Canada and Europe again using the Olympus satellite, which covers eastern Canada with its 20/30 Gigahertz "footprint".

Currently, at Memorial we are jointly, with the Newfoundland Telephone Company and DOC, starting a terrestrial based T_1 project with three components including health and education applications. Memorial is also pursuing a joint T_1 project with colleagues in Norway.

The provision of health care in space is of concern to space agencies internationally, and it is because of the European Space Agency's needs that the ESTEC projects mentioned above were supported. Canada has been interested in the Health Maintenance Facility of the NASA Space Station, and as a result of this, the National Research Council carried out a study in 1985 on the feasibility of Canadian participation.

There is an increasing use of satellite television programming in the health field especially to reach large audiences. A number of networks in the US, Canada and Europe offer health education programmes to professionals as well as to other specific interest groups. It seems likely that compressed video using codecs (encoder/decoder) will play an important role in health education in the future. The interactive audio capacity of codecs will greatly enhance the value of the video signal.

This technology is still relatively expensive; and audio conferencing and narrowband transmission of medical data will continue, for some, to provide the most cost effective method of supporting health needs in rural and remote areas.

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Conclusion

In conclusion, I would like to emphasize that satellite technology should be used to meet clearly demonstrated needs and that communication projects and networks should not be "technology driven". Appropriate and cost effective systems are better than the more glamorous and expensive systems. User involvement including a commitment to participate is essential. Particular attention should be given to coordination and administration of all projects and programmes.

Telemedicine and distance education programmes will require the whole range of terrestrial and space based communication systems. Only satellites can provide reliable communications in some geographic locations and offer the easiest method of providing international links.

Space research will most certainly contribute to the development of technology that will be of benefit not only for space activities, but also more broadly for terrestrial applications in health and education.

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APPLICATION OF REMOTE SENSING FOR AGRICULTURAL RESOURCES

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APPLICATION OF REMOTE SENSING FOR AGRICULTURAL RESOURCES

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Operational satellite remote sensing programs covering foreign areas are administered by the Foreign Agricultural Service (FAS) of the United States Department of Agriculture (USDA) and carried out by the Production Estimates and Crop Assessment Division (PECAD) located in Washington, D.C. This function was established in January 1978 to support USDA foreign crop production estimates.

Mission

The mission of the Foreign Agricultural Service is to expand foreign markets for United States farm commodities by gathering, analyzing, and disseminating information on foreign market supply and demand situations; working to gain access to those markets; and working to promote increased foreign consumption and utilization of U.S. agricultural commodities. The function of PECAD is to provide crop condition assessments and production estimates on a wide range of commodities around the world through the use of satellite remotely sensed data, meteorological data, official country statistical data, attache reports and other agricultural reports.

This operation has been providing routine and ad hoc reports on such diverse commodities and agriculturally related subjects as food and feed grains, oil seeds and other industrial crops, winterkill in small grains, deforestation, monitoring water impoundments, plant disease, and moisture stress. Present analyses emphasize the Soviet Union, Eastern Europe, Brazil, Argentina, Mexico, Australia, China and India. Three major data sets are used - remotely sensed satellite data (both Landsat and NOAA meteorological satellites); meteorological data (rainfall and temperature); and ancillary material such as soil, historical statistical data, crop model results, and current situation reports from the USDA foreign agricultural attaché service.

Satellite Application Components

This paper will concentrate on the FAS application of remotely sensed data. The system used to exploit remotely sensed data consists of two major components. They are the data base storage and extraction unit and the imagery process and display unit. The data base unit is dedicated to storage and retrieval of all ancillary data. It

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has a global geographical grid structure with a grid cell size of 25 x 25 nautical miles. Data for selected countries are input at the cell or subcell level. The data base contains soils, daily meteorological parameters, historical statistical data, cropping intensity, model results, remotely sensed greenness vegetative index numbers and geographical hierarchical (map bases). These data elements can be extracted and displayed on graphic terminals or put to hard copy and used by the analyst when information is being developed from the remotely sensed data.

Landsat data used in the FAS system are purchased from the Earth Observation Satellite Corporation (EOSAT) and are available to any user. Metsat data are obtained for the National Oceanographic and Atmospheric Administration (NOAA), an agency of the United States Department of Commerce. Special arrangements must be negotiated to receive this data. The data from both systems are received at our facility at the U.S. Department of Agriculture on a daily basis where it is pre-processed and made available to geographic crop analysts.

These analysts, using techniques derived from past research and development, manipulate the imagery and extract information relative to crop condition. A limited amount of imagery can be stored for historical purposes, but the most important product generated from these data are the Vegetative Index Numbers (VIN). They indicate the "greenness" of the crop and are used to compare crop condition and growth during and between years. By storing the VIN's in the data base, they are available for reference when succeeding data are analyzed.

The hardware and software used to process and manipulate the data are commercially available. Some in-house modification to the software has been made so that operational effectiveness can be obtained.

One of the more important features of the FAS system is the selection and training of crop analysts. They are multidisciplinary with backgrounds in economics, agronomy, geography, and automatic data processing. It is extremely useful to have been brought up in a rural setting and/or a farming background. Each analyst receives intensive training in remote sensing and the area of the world they will be assessing. The intent is to make the analyst a country expert in all aspects of agriculture and remote sensing. This includes, but is not limited to, crop cultural practices, cropping areas, agricultural trends, government agricultural policy, transportation networks, export/import facilities and capabilities, and the interrelationships of the agricultural industry as it relates to the country's overall economy.

The following three scenarios are fairly representative of the operational capabilities of PECAD. Completeness of the data base for any given country is dependent upon the length of time the Division has been working that country. Therefore, the data

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elements used for discussion in these scenarios are not available on a worldwide basis. The total data base will be completed as time and resources permit.

Scenario 1: Crop Condition Assessment

The analyst follows the agricultural area in an assigned country throughout the year as different groups of crops are planted, mature and are harvested. The different model outputs are continuously reviewed against a base period, i.e. vegetative indices at the cell level, soil moisture calculations, crop calendars, stress model results, winterkill model results, precipitation and temperature against norms, in addition to a visual analysis of the imagery itself. From these tools, the analyst can make certain conclusions -- the crop is better or worse than the base period and/or the area devoted to a group of crops appears to be larger or smaller than the reference. Depending on the experience and length of time the analyst has worked a given country, it is possible to estimate the percentage range for the increase or decrease with a fair degree of accuracy. Quantifiable estimates for yields are pending development of an acceptable yield model.

Scenario 2: Evaluation of Change in Cropping Patterns

Through routine viewing of imagery or notification from other sources, the analyst is aware of a change in agriculture such as areas of native vegetation having been brought into cultivation. The analyst will calculate the area change (using classification or clustering routines) and then access the data base for input to analyze the impact. The grid cell overlay would be superimposed on the image to determine the cells involved in the change. Once cells are identified, the analyst will query the data base for the following information:

(1) Type of soil in the cell.

(2) Crop mix customarily found on this soil and climatic regime.

(3) Maximum yield of these crops under these conditions.

Yields must then be evaluated in conjunction with the analyst's knowledge of the country's cultural practices opposed to optimum practices. Again, through the analyst's knowledge of the country, the analyst determines the most probable candidate(s) among the potential crops. At this point, the analyst is prepared to issue a report on the potential increase in production for this area. The final product may be somewhat subjective, but it is based on an objective analysis.

Scenario 3: Assessment of Specific Agricultural Area

An anomaly occurs in a high density agricultural area. A significant deviation is noted in the vegetative indices from the normal or expected value. The analyst can identify the area using cell overlays, vegetative indices, and visual examination of the image. If it is decided that the vegetation is undergoing significant change, the analyst can query the affected cells for the agricultural statistics to determine the crops historically grown in the area. Stress model output, calculated growth stage for the crops, soil type, and soil moisture can then be reviewed. If none of these elements are reflective of the observed stress, the PECAD contacts the Counselor for Agricultural Affairs at the American Embassy via a high-speed communications network for assistance. The aerial extent and geographic location of the anomaly, as well as the PECAD's analysis, are related to the Counselor. If the Counselor or staff has no current knowledge of conditions in the specified area, the Counselor schedules field travel to the affected area. Once the area has been observed first hand, information on the cause and associated impact can be relayed back to PECAD through the advanced telecommunication network.

Conclusion

The use of remote sensing resources on agriculture applications must be made on a case by case basis. Generally speaking, remote sensing is used as a tool to provide important information and should not be used by itself. FAS uses satellite data in addition to meteorological data (rainfall and temperature), historical statistical data, crop model results, and current situation reports from the USDA foreign agricultural attaché service. All of these sources are used as a total integrated package to perform the mission of the Division.

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THE DEVELOPMENT OF REMOTE SENSING AND THE NEXT PLAN IN CHINA

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THE DEVELOPMENT OF REMOTE SENSING AND THE NEXT PLAN IN CHINA

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1. Organization of Remote Sensing in China

As a governmental organization of the country, the National Remote Sensing Centre (NRSC) has been in operation for ten years, since its founding in April 1981. Under the leadership of the State Science & Technology Commission of China (SSTCC), the centre is authorized to conduct many tasks in national remote sensing development, such as formulation of policies on remote sensing development, coordination of remote sensing activities, drawing up of long-term national plans, and promotion and coordination of international cooperative activities.

The NRSC consists of eight departments with more than 3,000 scientists and engineers. The departments are: research and development, technical training, information service, remote sensing, ground stations, land resources, aerial remote sensing and Geographic Information Systems (GIS).

2. Main Remote Sensing Activities

During the last few years, especially in 1990, NRSC has organized and coordinated several key projects, experiments, demonstrations and popularization activities to promote the application of remote sensing in national development projects. They include the following:

(a) Remote Sensing for Monitoring Natural Disasters

This past summer a big flood occurred in Southeast China, striking both Jiangsu and Anhui provinces. The water level of all rivers, lakes and reservoirs in the region rose dramatically. The Flood Remote Sensing Information System was used for flood monitoring in the disaster areas, including the Huaihe River and Taihu Lake areas. The system is composed of airborne synthetic aperture radar (SAR), radar transmitters, an imaging processing system and a GIS. In harsh weather conditions, a remote sensing aircraft flew 13 times at 10,000 metres altitude. An area of roughly 160,000 square kilometres was surveyed and many high-quality imagery maps were produced. The maps are very clear, and include images of inundated fields, villages, roads and dams. With the help of this system and other associated technical means (including GIS, radar mosaic maps with 3-10 metre resolution) and

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local government statistics, positive results were achieved. Some data were provided to high level government agencies.

(b) Remote Sensing for Forest Inventory

An integrated remote sensing inventory of the "Three-North" forest shelter belts has been undertaken. The main tasks are using remote sensing information to inventory and monitor the types of forest resources, distribution and forest disasters in the North, Northwest and Northeast regions of the country. This equals roughly 42 per cent of national territory. The resources and environment system for this region has been developed. Forest maps, grassland maps, and landuse maps with a scale of 1:100,000 have been produced.

(c) Remote Sensing for Soil Erosion

An integrated remote sensing inventory of soil erosion in the Loess Plateau is being developed. The GIS for this region has been developed. Based on the inventory, which took more than five years to develop and involved 10,000 people, an important mechanism for regional development and much valuable data has been gained.

(d) Other Remote Sensing Activities

Development of GIS software and hardware includes a remote sensing processing system and a fastlooking information system.

Remote sensors, covering visible, infrared and microwave spectra of operation, and an airborne remote sensing data acquisition processing system have been developed.

Remote sensing systems have been used to aid exploration for mineral resources.

(e) Technical Training

Several hundreds of technicians, not only from China, but also from other developing countries, including Bangladesh, Iran, Malaysia and Mongolia have been trained in remote sensing techniques.

The 11th Asia Conference on Remote Sensing was held in Guangzhou, China from 2 to 15 November 1990. There were 118 participants from 23 countries, regions and international organizations, as well as 395 Chinese participants. There were 190 technical papers presented.

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A United Nations/ESCAP/OSD Workshop on Applications of Space Technology to Combat Natural Disasters was held in Beijing this year. A total of 88 participants, including 34 foreigners, attended this workshop. The Chinese government provided financial assistance for all participants from developing countries.

3. Future Developments in China

The application of remote sensing techniques has been included in the eight five-year national science and technology development programmes of China. This indicates that the Chinese Government has attached much importance to remote sensing. According to China's remote sensing development policy, the emphasis of remote sensing projects should be on solving the vital problems of the country's social-economic development. The main subjects are: "Natural Disaster Prevention and Harnessing" and "Crop Yield Estimation." Systems should have great storage capacity, real-time transmission and rapid processing capabilities.

A planned monitoring and evaluating system for natural disasters will be supported by an all-weather remote sensing monitoring network for floods, forest fires, earthquakes, droughts, and other disasters. It will include area and/or satellite data collection, processing and application systems.

Global environmental change programmes could include monitoring of global change such as desertification, atmospheric chemistry, vegetation, soil erosion, deforestation and the marine environment.

The basic goal of remote sensing development is its applications. So, since its establishment, the NRSC has effectively promoted its utilization in many fields, such as natural resources surveys, monitoring of dynamic change, gathering of pollution data and national development projects.

Nowadays, the Chinese Government clearly understands the directions of the commercialization of remote sensing in the world. These include microwave remote sensing technology and applications and the application of remote sensing technology to natural disaster monitoring.

4. Suggestions About Remote Sensing Development

The Chinese Government is also interested in the establishment of the ESCAP Regional Education Centre on Space Science and Technology. China would offer excellent experts and facilities for this establishment.

To strengthen international cooperation with other countries, NRSC can provide test areas for experiments, carry out joint research projects, transfer experience and technical achievements and exchange information. China will also continue to participate in international cooperative programmes on global study, and will contribute to active efforts such as the Ten-Year International Disaster Reduction Programme, the International Space Year and the International Geosphere-Biosphere Programme.

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BUILDING COMPONENTS FOR A SATELLITE COMMUNICATIONS SYSTEM IN INDONESIA

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BUILDING COMPONENTS FOR SATELLITE COMMUNICATIONS SYSTEM IN INDONESIA

by

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ABSTRACT

Domestic Satellite Communications System has been in used in Indonesia since 1976. Now Indonesia entering into third generation satellite, PALAPA C. The demand in communication services is very high. Satellite communication services need to be improved for domestic and regional used especially with the availability of other services namely : mobile communication, maritime and direct tv broadcast. The SKSD PALAPA existence drives the growth of industry to build the components for satellite communication in Indonesia, eventhough limited in the ground segmnet only.

Indonesia had the advantage being located right at the equator for launching the GSO and sub low earth orbit satellite. The spaceport development in Indonesia will be beneficial both national as well as international used.

1. INTRODUCTION

Initial efforts to gain physical access to space in Indonesia started way back in 1963, when a socalled **"pencil rocket"** was launched by students of the Gajah Mada University, followed by the GANESHA X1 and X2 rockets launched by the Institut Teknologi Bandung. The launching of the two-staged KARTIKA scientific and meteorological sounding rocket in 1964, the result of a joint cooperation program between LAPAN, the Institut Teknologi Bandung, and the Indonesian Air Force marked the beginning of a first serious endeavour to develop space capabilities. In 1964 LAPAN, in cooperation with the University of Tokyo, was actively involved in the International **Quiet Sun Year** research program, with the launchings of a series of Japanese built **KAPPA-8 and 9** sounding rockets.

The **KARTIKA** program was the first of a series of national sounding-rocket development programs, which in the past decades have produced the **RX-150, the RX-250**, and the current two stage sounding rocket development programs.

In the year 1972, utilization of environment and natural resources satellite had begun and followed by utilization of GMS and NOAA satellites as well as earth station for EART-I and LANDSAT Satellite.

On July 9, 1976 Indonesia entered into start of sattellite communication era with succesfully launched of PALAPA A1 satellite.

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It is a fact that Indonesia is the first developing country utilizing a satellite communication system. The second generation PALAPA satellite was launched in 1983, and Indonesia is now planning to launch the third generation communication satellite, the PALAPA-C. Indonesia is committed to take part in the design and development of this PALAPA-C satellite, to be launched in the second half of this decade. Indonesia intends to design, develop and manufacture the PALAPA-D generation of communication satellites for domestic and regional use. A Space Division was recently established at the IPTN, responsible for the design, development and manufacturing of communication satellites.

2. DEVELOPMENT OF TELECOMMUNICATIONS IN INDONESIA

Indonesia is a dynamically growing country with a population of 180 million inhabitants, streched over a wide area with a distance of approximately Moscow to Dublin in the East-West longitude and Amsterdam to Rome in the North-South latitude, covering over 13,600 islands and the total area is 1,919,318 sq. km.

During the last decade, the world has experienced a dramatic growth in satellite communications, with assosiated improvements in quality and service alternatives. Telecommunications have played a major role in the implementation of the development policy of the country. The Indonesian PALAPA Domestic Communication Satellites System (SKSD) was celebrate its 15 years of operation since August 1976. The PALAPA system is

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Within the national telecommunication network PALAPA has an increasingly important role in bringing telephone service to many remote or isolated community within the Indonesian archipelago's many island. The telecommunication services are : telephony, data, business network dan TV broadcast distribution.

The total channels available now are 6535 channels to consist of:

3360	channels	FDM-FM
844	channels	TDMA
2331	cahannels	SCPC

Satellite transmission expected to be able to support the developing of terrestrial system to business services. The program will be implemented up untill 1993 as shown as per Table.2.

Table.2 PERUMTEL's until the year 1993

PROGRAM	YEAR	WILAYAH
o TDMA LOW BIT RATE, PACKET-1, 4470 CHNS., 30 LOCATIONS	1991-1993	BALI, NTB, NTT, IRIAN JAYA, KALIMANTAN, SULAWESI, MALUKU
o TDMA LOW BIT RATE, PACKET-2, 660 CHNS., 22 LOCATIONS	1992-1994	Sumatera
o TDMA LOW BIT RATE, PACKET-3, 1265 CHNS., 34 LOCATIONS	1992-1994	SULAWESI, MALUKU, IRIAN JAYA
o FDMA DIGITAL 20 LOCATIONS	1992-1993	Seluruh Indonesia
o BUSINESS NETWORK	1991-1992	Seluruh Indonesia

Source : Prospek Pengembangan SKSD, oleh Herawan Suhardjo, 6 September 1991, PERUMTEL

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The PALAPA new services plan will be consist of :

- o Rural
- o Land Mobile
- o Maritime
- o Telematique
- o Direct Broadcast

Satellites have make clear, direct communications between ship and shore possible. They are serving rural and other remotes areas where terrestrial lines are lacking. They have been a proven technology in a range of domestic communications services from telephone system to cable TV in countries around the world. Directories of downlinks and uplinks are available that list thousands of earth station sets. Plans are under way for entire new services, and new competitive satellites technologies lies ahead, such as fiber optics, submarine cables and terrestrial satellites system.
Provides even better services for users. As the size and cost of earth stations also have decreased substantially in recent years and as the trend to more and better services and product as lower prices of increasing numbers continue, satellites communication will be within the reach of increasing numbers of business and people, escpecially telecommuniction managers.

Communications satellites have a long evolutionary growth rate. They must increase their ability overtime withouth eclipsing the service they currently provide. Once satellite system has been established and begin to serve a population of users, each generation of replacement or expansion satellites must be able to maintain service to those users while also providing greater com-

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munications capability for them or for new services.

There are many different satellites, both domestic and regional, in space to day, performing many different kinds of communication for many different kind of purposes and users.

New technologies in satellite communication continued to be developed. Prices for international satellite services have declined dramatically by 19-fold. Eventhough there is a tendency that satellite communication may be replaced by marvel fibre optics or various forms of wireless communication, satellite communication for Indonesia will still be a most important system in the next few more decade, for domestic communication services. Especially as Indonesia consists of thousand islands.

In addition to the series launched of PALAPA second generation which consist of PALAPA B1, B2P and B2R, the last series PALAPA B4 is planed to be launched in April 30, 1992, to replace the PALAPA B1. The transponder's utilization of PALAPA B-2P and B-2R as shown in Table.3.

PALAPA C, the third generation satellite either will be a multiband satellite which will include Ku-band frequency for direct TV broadcast as well as for maritime or similar to the previous generation.

Table.3 PALAPA's Transponders Utilization

	TRANSPONDERS UTILIZATION	B-2R	B-2P	TOTAL
1.	PERUMTEL	18	-	18
2.	TVRI (DOMESTIC)	1	-	1
3.	PRIVATE TV	-	12	12
4.	PRIVATE BUSINESS	3	6	9
5.	VOICE MESSAGE	-	1	1
6.	OCCASIONAL USE	1	1	2
7.	a. SPARES (CONTRACTUAL PROCESS)	-	1	1
	b. BACK UP (EMERGENCY)	1	3	4
	TOTAL NUMBER OF TRANSPONDERS	24	24	48

Source : Prospek Pengembangan SKSD, Hernawam Suhardjo, 6 September 1991, PERUMTEL

Satellite's transponder and power in C-band frequency will be increased, also will have wider coverage area which include Papua Nugini and north part of Australia.

Satellite is a vehicle by which television can be broadcast to all areas, including rural communities other wise in accesable mountain valleys and remote areas.

Other new services are also being introduced in the PALAPA system, such as business communication network using ALOHA type multiple acces and a satellite based interactive educational communication system.

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3. POTENTIAL OVERVIEW

Space science and its applications, important in the past, will play an even more important role to secure future existence of developing nations. In this context, cooperation and mutual benefits must be considered as obligations and as conditions for all peaceful space activities, be it scientific or commercial.

The common thread that links these current and future activities is the need for a sustainable growth of mankind and its habitat, the Planet Earth, and the scientific exploration of the planetary system and the universe. **LAPAN** is currently committed to reexamine in detail the alternative options and possibilities for future research and development in space science and applications, space missions and operations, and advanced technology applications that could be implemented in the next decades.

SKSD PALAPA DEVELOPMENT has delivered a positive aspect for nation building, among other more unification of Indonesian geography, and also development in the industrial activities. PALAPA satellite provide services for South East Asia country, Malaysia, Thailand and Philipine.

Indonesia human resources were drastically developed via training abroad for hardware, software and also system communication operation, in conjunction with PALAPA satellite implementation.

And also the national and wellfare which could not measured in the form of financial form were improved.

The Indonesian Institute for Aeronautic and Space, LAPAN the research and technologiy institute, since 1963 provide service and assistance to the Indonesian government in the National space consideration. Among other LAPAN activity in the space technology conduct reasearch and development in the field of meteorological sounding rocket for scientific purposes, sub low earth orbital satellite for scientific and satellite payload.

LAPAN research activities. In cooperation with other institution, foreign institute and university, LAPAN setup a goal to launch the low earth orbit satellite by 20005. This goal were set based on LAPAN succes and ability to launch the scientific sounding rocket RX150 and RX 250.

The PT Industri Pesawat Terbang Nusantara, or IPTN, the Nusantara Aircraft Industries was established in 1976 under the energetic leadership of **Prof. Dr.-Ing B.J.Habibie**. IPTN manufactured under license around 150 helicopters and 100 plus fixed wing aircraft, among others the NBO-105, the Puma and Super-Puma, the NBK-117 helicopters, and the CN-212 aircraft.

Indonesia intends to design, develop and manufacture the PALAPA-D generation of communication satellites for domestic and regional use. A Space Division was recently established at the IPTN, responsible for the design, development and manufacturing of telecommunication satellites.

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PERUMTEL, is a government institution which is now become a private company who operate the SKSD PALAPA and also provide telecommunication services with total employes more than 30.000 with total of telephone 1.4 million line units to day. And forcasted to be 3,5 million line units by 1994 offer a big opportunity in the near future.

Other national entities. There are a number of companies within the telecommunication industry ranging from cable manufacturers, PT. INTI, Lembaga Elektronika Nasional (LEN), PT. Radio Frequency Communication and PT. Elektrindo Nusantara. The product delivered not entirely domestic product, some of the nobel part still need to be imported with the licency from the manufacturer now.

The research institutions in the field of aerospace and universities, such as Institut Teknologi Bandung (ITB), Gajah Mada Univerversity, Indonesia University (UI) and Institut Teknologi Surabaya are part of our national asset in the field of aerospace.

National longterm goal. It is the political will and commitment of the Government that one day Indonesia will be able to launch its own satellite from Indonesia. In order to achieve this, cooperation between Indonesian industry and foreign expertise are needed. It is a fact that is very hard to have the possibility of transfer of technology from developed countries.

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The most possible, was buying the technology. Included at the training for personnel involved has to be considered and prepared.

We wish the foreign industries willing to come and meet in Indonesia, in cooperation with our existing companies. One of the components, which is part of the communication satellite system is space launch facility. Indonesia is geographically located at the equator, and therefore is in a very good position to satellite launching, GSO and low equatorial orbit.

The advantage of Indonesia's location along equator are energy savings which in return extend the life time of the satellite. Indonesia, in this case LAPAN is at present conducting a study for the possibility to build a spaceport at Biak, West Irian (0^{o}52'30" South Latitude; 136o3'43" East Longitude). Before the final decision is made, detailed and comprehensive studies must be carried out, to determine wether the above mentioned location is suitable, included technological, economical, social and culture as well as defence and security aspects has to be considered.

4. CONCLUSION

From the above explanation, the conclusion is that Indonesia has a solid base to build components of communication satellite systems. Most of the ground segment equipment can be produced in Indonesia with some part still to be imported, to be assembled in Indonesia.

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Foreign investment are most wellcome to be invest in our country, by means of setting up manufacturer assembly lines for both hardware and software while transfering technology from foreign technology manufacturers, scientists and engineers involved in the training in Indonesia or abroad.

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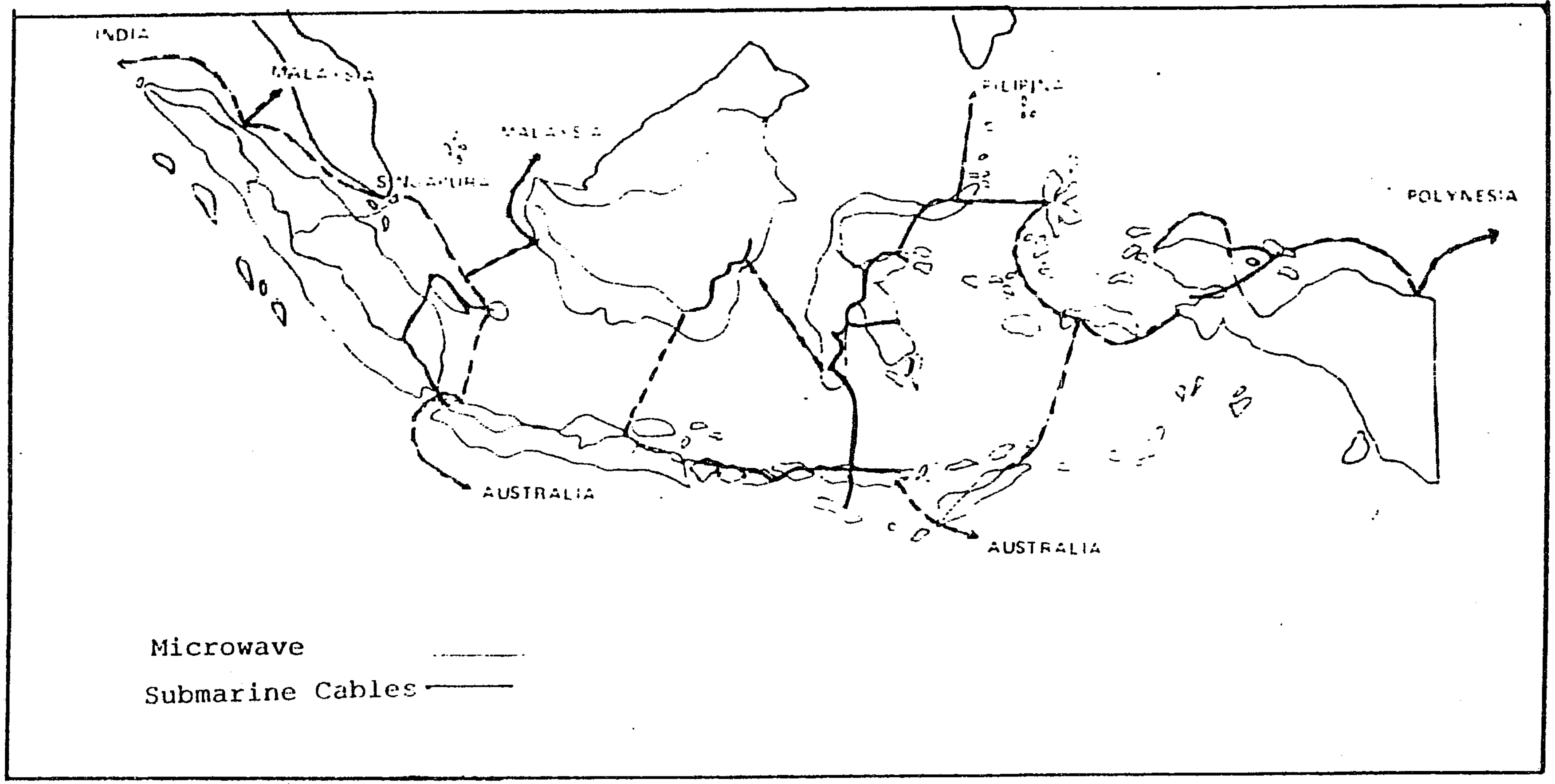

Figure.2 Terrestrial Transmission in the Year 2000

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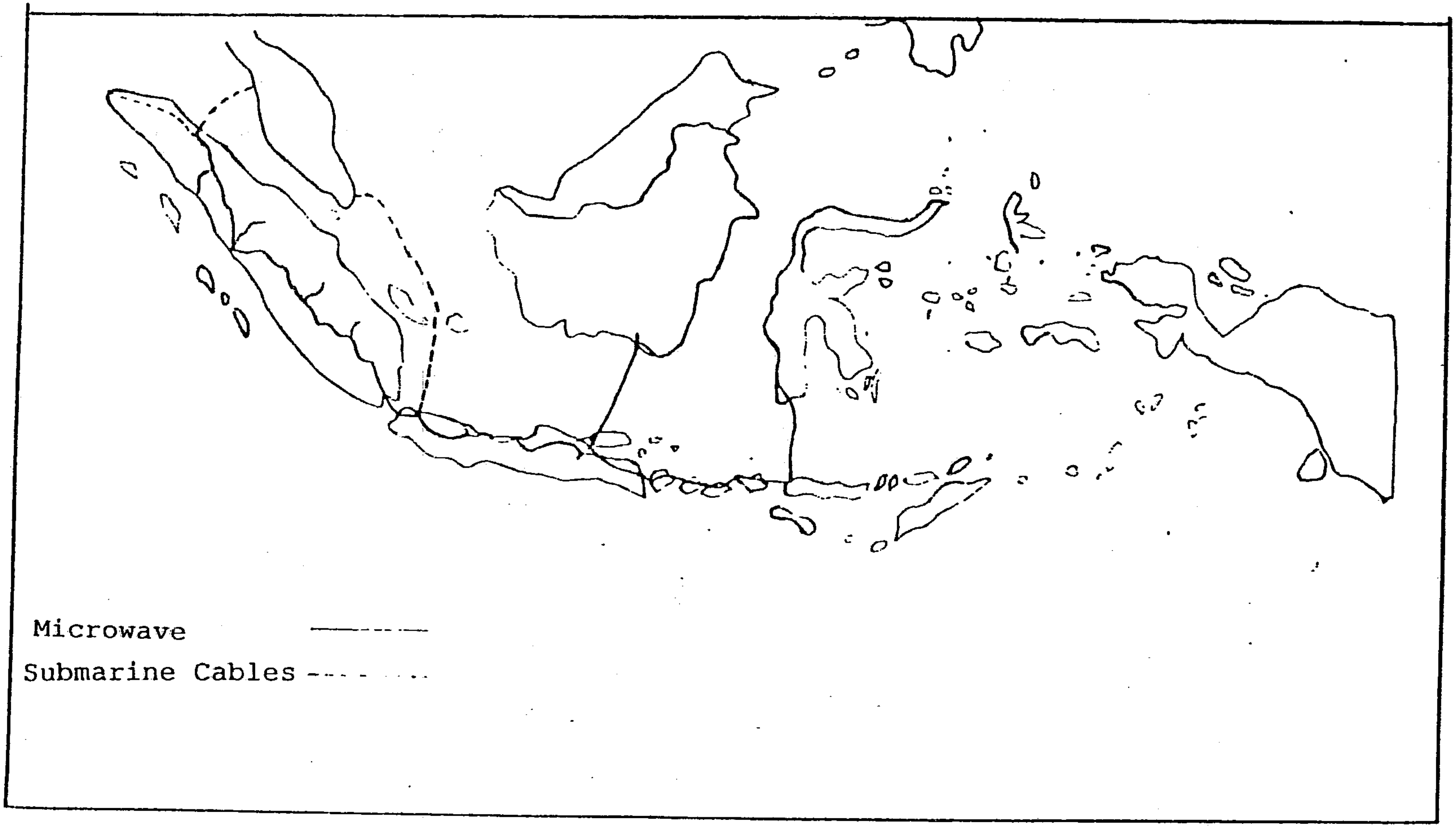

Figure.1 Terrestrial Transmission (End of The Third Five Year Plan)

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part of the national telecommunication network which consist of terrestrial networks, including local cable, a microwave system spanning the major islands, tropo system and submarine cable. Figure.1 and Figure.2 indicate the existing plan of the microwave system and submarine cable in Indonesia. Since that time, the PALAPA system has experienced a substantial growth in space capacity, as well as greatly expanded earth segment network.

The introduction of PALAPA A1 made it possible to provide for improved telephone and telex services among forty ground station locations which were integrated into the national telecommunication network. The satellite's transponder have incresed from 12 in PALAPA A1 to 24 transponders in PALAPA B, and the number of ground stations from initial 40 stations to more than 200 stations. Also the power have doubled increased from 5 to 9.6 Watt as shown in Table.1.

Table.1 PALAPA Satellite's Parameter

PARAMETER	UNIT	PALAPA-A	PALAPA-B
TRANSPONDERS		12	24
T W T A'S		15	30
TRANSMIT POWER	[WATT]	5	9.6
EIRP-INDONESIA	[DBW]	32	34.3
EIRP-ASEAN	[DBW]	27	32.3
G/T -INDONESIA	[DB/DEK.K]	-7	-5
G/T -ASEAN	[DB/DEK.K]	-9	-7
IN ORBIT WEIGHT	[KG]	294	638
DESIGN LIFE TIME	[YEAR]	7	8
POWER AT EOL	[WATT]	300	798.4

Source : Palapa's Current and Future Role (A Fact and Prospect) by Hermawan Suhardjo, Perumtel.

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REMOTE SENSING ACTIVITIES IN VIET NAM IN THE LAST DECADE

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REMOTE SENSING ACTIVITIES IN VIETNAM DURING THE LAST DECADE

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A. INTRODUCTION

Like many other developing countries, the increasing need for natural resource and environmental management has significantly promoted the development of remote sensing technology in Vietnam.

This report covers the activities and developments in remote sensing during the decade of the 1980s.

The most significant segment of development has been the application of remote sensing in different areas of natural resource and environmental management. Several application projects are being conducted, with many of them now in the final stages of completion. Themes such as landuse, coastal management, integrated assessment of natural resources and natural conditions to economic planning, soil erosion, ground water potential, and zone mapping have received attention. Remote sensing has now become operational in landuse mapping, mapping of water resources (flood affected areas, ground water potential zone) soil erosion mapping, regional geology and geomorphology and the mapping of forested and vegetated areas.

The benefits resulting from the use of remotely sensed data to monitor, map and manage the natural resources and environment of the country, are clear and have led to the extensive use of these data.

B. REMOTE SENSING HAS BECOME AN IMPORTANT TOOL FOR RESOURCE AND ENVIRONMENT MANAGEMENT IN VIETNAM

Vietnam is a developing country covering a large territory of about 30 million hectares with a coast line of more than 3,200 kilometres. The landscape of the country varies from coast zone, plains, plateau and high mountains. The country is confronted with two problems: how to more reasonably utilize its very limited natural resources for social-economic development and what to do about environmental degradation in the country. The main problems associated with the above issues are as follows:

(1) Deforestation

The percentage of forest coverage in the country has been decreasing over the past decade. It has caused the deterioration of the ecological environment, especially in the Northern region, central plateau and coastal areas of the Red and Mekong river plains. Examples include desertification and soil erosion in the highland region and shoreline erosion in coastal areas. Forest-covered areas are being reduced yearly. A 1989 Ministry of Forestry and General Department for Land Use Management study estimated that in 1945 the total forest area of the country was 14.5 million hectares (about 47.8 per cent of Vietnam's territory) but in 1975 this area had been reduced to 29.2 per cent and by 1983 to 23.6 per cent. Since the 1950s, the area of desertified land increased on average by 100,000 hectares per year. The total area of desertified land in Vietnam has reached about 10 million hectares, or 33 per cent of the country. The total area affected by the salinity process caused by mangrove deforestation is about 716,000 hectares.

(2) Degradation and decrease of land resources

Vietnam is situated in a monsoon, humid, tropical environment and soil erosion is a major concern on 75 per cent of its highland land area.

A study conducted by the State Committee for Vietnam Soil Mapping concluded that about 8 million hectares of midland and mountainous areas have such serious erosion problems that they cannot be used for agriculture.

Soil erosion and unreasonable use of land have caused a rapid decrease in the availability of land for agricultural uses.

(3) Natural disasters

Disasters such as flooding, forest fires, landslides, shoreline erosion, mud-rock flows and tropical cyclones have caused enormous losses of life and property and have affected the social-economic development of the country.

Most of the above mentioned resource and environmental problems are the result of excessive human activity in Vietnam's long history. To protect the environment we are living in, we urgently need to clarify the situation and dynamic changes of spatial distribution and quality of resources and the environment. In fact, remote sensing is an effective means to quickly answer these questions. The principle for remote sensing development in Vietnam has been formulated so that applications of remote sensing technology are geared to the urgent social-economic development and environmental needs of the country. In this connection, several programmes and projects of remote sensing applications and technology of national importance have been organized and carried out. Hundreds of researchers from institutions, universities and remote sensing organizations are involved in these programmes and projects.

C. RECENT REMOTE SENSING DEVELOPMENTS

Recognizing the benefits of using remotely sensed data in the study of natural resources, natural conditions for social-economic planning and development and environmental management, the National Scientific Project for Remote Sensing, with a duration of five years (1980-1985), was organized by the National Centre for Scientific Research (NCSR).

That was followed by the Project on Cartography and Remote sensing, which was conducted for four years (1986-1990). In 1990, another scientific Project for Remote Sensing Applications, supported by NCSR, was begun.

The main purpose of these projects is the development of remote sensing and GIS technology and remote sensing applications for resource and environmental management.

1. Development of Remote Sensing and GIS Technology

(a) Three-layer experiment

In order to effectively use remotely sensed data for thematic mapping, the interpretation keys were requested. In connection with this, the three-layer experiments were conducted on five polygons located in different geographical areas of the country in 1980 and 1985 using the multispectral cameras MKF-6 and MKF-4. Many institutions/organizations, such as the Space Research Centre (now called the Remote Sensing Application Division), the Centre of Geography and Natural Resources, the Institute of Forest Planning, the Institute of Agricultural Planning, the Institute of Geology and Mineral Resources, the Institute of Pedology and Fertilizer and the General Department for Land Use Management were involved in these experiments.

(b) Study of the optical landscape characteristics

The spectral reflectance curves in the VIS and NIR regions of the electromagnetic spectrum of more than 100 natural objects located in different geographical areas of the country were studied by the Remote Sensing

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Application Division (RSAD) and Centre for Space Physics and Remote Sensing Techniques. Some types of handspectrometers made in Germany, Hungary and Vietnam, with spectral resolution ranging from 8 to 10 millimetres, were used for the study.

In addition, some related studies such as "Influence of sun altitude on spectral reflectance ability of some natural objects in Vietnam," and "Influence of humidity on spectral reflectance curves of some Vietnamese soil types," were also conducted by RSAD.

The results of these studies are valuable not only for thematic interpretation using remotely sensed data but also for development of low-cost optical and opto-electronic equipment needed for ground truth measuring and visual and digital interpretation.

(c) Microwave remote sensing action experiment

The experiment was begun in 1989 with the purpose of applying new techniques to the study of natural conditions such as soil humidity and soil salinity for coastal land use management.

The experiment was conducted jointly by researchers from the Institute of Physics and the Institute of Oceanography in cooperation with the Space Research Centre of the Academy of Sciences of the USSR.

(d) Development of image processing system and GIS software system

Several image processing software systems and GIS software systems have been developed by various institutions and centres. They include the following:

MIPS - The Multi-purpose Image Processing System which can be used for general image processing, thematic and statistical mapping and multi-data image analysis. It is based on IBM PC/AT compatible microcomputers. The software system was developed by RSAD

DIPS - The Digital Image Processing System was developed by the Institute of Physics and the Centre for Space Physics and Remote Sensing Techniques. The system is also based on PC/AT compatible microcomputers and can be used for general image processing, especially for land use analysis.

GESSE - The Geo-Expert System for Soil Evaluation is an expert GIS software system with an English version of user interface. The system is based on IBM PC/AT compatible microcomputers and consists of a knowledge base, thematic data base and graphic data base. The system was developed by RSAD and the Advanced Information Technology Corporation. Recently it has been used for soil erosion assessments and for development of a soil erosion and soil erosion hazard map of the northern mountainous region of the country. The programme will be continued in the coming year.

GIS - The Geographic Information System is a general GIS, based on IBM PC/AT compatible microcomputers. It is capable of data digitization and editing, manipulating (polygon-based overlay, merge, map join, clip and select), map drawing and DTM processing. Development of the system began in 1990 under the direction of RSAD and the Remote Sensing Data Centre. The programme will be continued over the next two years.

2. Remote Sensing Applications for Resource and Environmental Management

Beside the above mentioned remote sensing application projects, several projects covering various fields of natural resources and the environment which have been begun at the national and regional levels. The main areas where remote sensing has been effectively applied are: land use mapping, flood mapping and damage assessment, geological and geomorphological mapping, soil mapping, ground water potential zone mapping, forest mapping and tropical cyclone forecasting. The projects include the following:

(a) Tropical Cyclone Forecasting Using NOAA, METEOR and GMS

Under the first National Project for Remote Sensing (1980-1985), a study of tropical cyclone development, determination and movement, and detection of the "eye" using remotely sensed data such as NOAA, METEOR and GMS was completed by the State Department for Hydro-Meteorological Forecast. Together with other traditional forecasting methods, the analysed results of the study are effectively used in forecasting tropical cyclone development and movement in the East Sea region that directly influences the weather of the country.

(b) Land use mapping

Based on the results of the first Project for Remote Sensing, in 1984, for the first time a land use map of Lam dong Province was completed on the scale of 1:250,000. RSAD conducted the task using Landsat images combined with ground truth data.

The land use of different geographical areas, including the Central Plateau Tay nguyen, Northern mountainous provinces, the coastal zone and a great number of other provinces and districts in the country have been mapped on a scale ranging from 1:500,000 to 1:50,000 using remotely sensed data such as Landsat, SPOT, Soyuz and aerial photos.

The technology for land use mapping using remote sensing is widely applied and has been transferred to some user organizations in the country.

At the end of 1990, a Government-supported project for land use mapping of the entire country at a scale of 1:250,000 using high resolution satellite data was begun. The program is being conducted jointly by RSAD, the Remote Sensing Data Centre, the General Department for Land Use Management, the Institute of *Forest Planning and the Institute of Agricultural Planning. This project is expected to be completed in 1991.

(c) Forest mapping

Based on the results of the First National Project for Remote Sensing, the forest mapping of the entire country, including forest cover estimation and forest classification, on a scale ranging from 1:250,000 to 1:500,000, was conducted in 1985, 1987 and 1990 by the Institute of Forest Planning in cooperation with RSAD.

(d) Soil erosion mapping

Under the National Centre for Scientific Research-supported Project for Remote Sensing Applications, RSAD in 1990 conducted a study of potential soil erosion and soil erosion hazard mapping. The Institute for Pedology and Fertilizer, Institute of Agricultural Planning, Institute of Forestry, the Centre of Geography and Natural Resources and the Centre for Forest Data Processing cooperated with RSAD on this study.

Multi-level remote sensing information will be used for production of thematic maps needed for soil loss analysis using the Universal Soil Loss Equation of Wishmeier and Smith and for maps of potential soil erosion and soil erosion hazards. The Geo-Expert System for Soil Evaluation is a key component of this study.

The study will be continued over the next two years but preliminary results show that remote sensing, combined with other data sources, can provide unique and useful information for the determination of soil erosion risks at a scale ranging from 1:50,000 to 1:250,000.

(e) Flood mapping

Most of the major floods that have occurred in Vietnam since 1988 have been mapped in near real-time using Landsat data and maps handed over to state governments/user agencies, providing necessary data such as the mapping of flood affected areas and the assessment of flood-caused damage. The operational mapping of floods has been conducted for the past five years using satellite remote sensing data.

(f) Ground water potential zone mapping

About one-third of the provinces and cities in the country have been mapped on the scale of 1:250,000 for potential ground water zones in the framework of several projects supported by government and local user agencies. Organizations involved in this work include the Centre of Geography and Natural Resources, the Institute of Water Resources and the University of Mining and Geology.

(g) Coastal management

Information on coastal land use, coastal processes and sediment dynamics are vital for coastal management. The coastal environment is very dynamic and greatly affected by human and marine activities. Hence, it requires periodic monitoring. In view of this, a study on the applications of multi-temporal satellite data covering the entire coastal zone to land use was conducted, and a shoreline change and turbidity/suspended sediment distribution map on the scale of 1:250.,000 was developed. The project was conducted jointly by RSAD, the State Department of Geodesy and Cartography, the General Department for Land Use Management, Remote Sensing Data Centre, Centre for River and Sea Dynamics and the Institute of Oceanography in the framework of the National Scientific Programme for Marine and Coastal Research 48-B.

(h) Integrated assessment of natural resources and natural conditions for development planning

Conventional methods used for conducting integrated assessments of natural resources and conditions have the following limitations:

- Numerous agencies generating similar but incompatible data sets.

- No regular procedures for periodically updating the data.

- Practices of storing data are not amenable to efficient retrieval.

The advantages of remote sensing data such as synoptic view and repetitive coverage allow the above limitations to be overcome enough so that some integrated studies for development planning at the district level have been undertaken using high resolution satellite and airborne data as well as other data sources. Many scientists from RSAD, the Centre for Geography and Natural Resources, the Institute of Agricultural Planning, the Institute of Forest Planning, the Institute of Pedology and Fertilizer and the General Department for Land Use Management, were involved in these studies.

In 1989, through Project RAS/86/141, supported by the ESCAP Regional Remote Sensing Programme (RRSP), a similar study on "Analysis of remote sensing data for assessment of natural conditions and natural resources and their dynamic on some coastal zones for inventory and economic development and for the environment," was conducted jointly by RSAD, the Centre of Geography and Natural Resources and the Institute of Physics.

The coastal zones of the Red and Mekong river deltas were chosen as study areas for this project because they are becoming increasingly important economic development areas due to exploitation of their natural resources through fisheries, sea production plantations, seaweed harvesting and the development of chemical, petrochemical, fertilizer and related industries, as well as for, most importantly, petroleum exploration.

The results obtained, such as methodology for integrated assessments using remotely sensed data and thematic mapping of coastal zones through remote sensing techniques, were presented and assessed at the Regional Seminar on Applications of Remote Sensing Techniques to Coastal Studies and Environmental Monitoring, held in Hanoi from 12-15 September 1989. The Seminar was organized by the ESCAP RRSP in cooperation with the National Committee for Space Research and Application of Vietnam.

(i) Environment

In recent years, safeguarding of the ecology and the environment has become a matter of major concern for scientists, politicians and the public. As a result, many projects have been initiated to study the impact on the environment of hydro-electric power stations, deforestation, and coastal erosion. The use of remote sensing techniques have been well demonstrated in these studies. Five such projects have been approved by RSAD, the Centre of Geography and Natural Resources, the Centre of Environment and the Institute of Forestry. They include the following:

(1) Environmental impact assessment of the hydro-electric power stations at Hoa binh and Tri an.

(2) Environmental impact assessment of deforestation in the northern mountainous region, central Tay nguyen plateau and the Minh hai mangrove forest area.

(3) Study of changes in the coastal environment due to coastal erosion by the sea and pollution caused by industries situated near the coast of the Red River delta.

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D. REMOTELY SENSED DATA RECEIVING AND SUPPLY

Although Vietnam has for a long time been interested in remote sensing for natural resource management and environmental monitoring, until now only a few receiving stations for meteorological satellites have been operated.

The first APT ground meteosatellite receiving station was built in Hanoi in 1975 through technical cooperation between Vietnam and the USSR. Until 1983, this APT station was the only operational ground receiving station in Vietnam.

At the end of 1987, a GMS autoreceiving station became operational under the framework of Project VIE/83/004, a cooperative effort between UNDP and the National Centre for Scientific Research. The GMS station can only receive LR/FAX images. These images are produced by the sampling and relocating of original VISSR images. The primary spatial resolution of GMS VISSR is 5 x 5 kilometres for the infrared channel at the subsatellite point.

Since 1988, under Project VIE/87/015 of UNDP and the General Department of Meteorology and Hydrology, three more similar stations were built in Hanoi, Danang and Ho Chi Minh City. All three were operational at the end of this year.

Currently, Vietnam everyday receives several cloud field and ground surface images in the VIS and IR regions of the electromagnetic spectrum from meteosatellites such as NOAA 10-11, METEOR-16, GMS, and COSMOS-1939.

The processing and data supply of these meteosatellite images are conducted by all the above mentioned receiving stations.

Because of the lack of ground receiving stations, some types of satellite imagery, such as Landsat, SPOT, and Soyuz, are primarily supplied through international cooperative scientific-technical projects. The original satellite data that is obtained in the form of positive/negative, false colour or B & W film or on printed copies, are chemically processed by RSAD's Photolaboratory, which was equipped through Project VIE/83/004. The produced copies can be supplied to user organizations at their request. Soyuz photos are supplied by the State Department of Geodesy and Cartography.

CCT data can be copied or recorded onto floppy disks at the National Centre for Scientific Research for supply to users with access to the German-made Digital Image Analysis System A6471 "Robotron", and the French-made Digital Image Processing System "Pericolor 2001." These systems were provided through Project VIE/83/004. Since early 1991, another digital image processing system, the French-made DIDACTIM system, has been available at the Institute of Geology.

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According to current national plans, B & W aerial photography of the country at scales between 1:20,000 and 1:75,000 is regularly conducted by the State Department of Geodesy and Cartography. Since 1985, aerial photography has utilized the Hasselbad multispectral camera and associated equipment provided to RSAD through Project VIE/83/004. The multispectral photos in the VIS and IR regions are available upon request at RSAD.

E. TRAINING AND MANPOWER DEVELOPMENT

Training of personnel in remote sensing has been an important element in the utilization of remote sensing technology. However, due to various economic, educational and administrative problems, activity in this field has been limited. Up to the present time, under Project VIE/83/004, RSAD organized two official training courses on the background of remote sensing and remote sensing applications in 1983 and 1984. Remote sensing specialists from Germany, India and the Netherlands participated in these courses. Between 1985 and 1990, local training courses, each 10 days long, were organized by RSAD in the field of aerial and satellite remote sensing applications to various natural resource themes. Although educational courses on remote sensing are not currently offered by universities, specialized sessions, featuring an introduction to remote sensing, have been organized jointly by scientists from RSAD, the Centre of Geography and Natural Resources, the Institute of Agricultural Planning and the State Department of Geodesy and Cartography.

As a part of a plan to meet long-term requirements for trained remote sensing personnel, the University of Mining and Geodesy was the first university to start teaching remote sensing as part of already existing courses that deal with natural resources and related fields. Many other universities are expected to include programmes on remote sensing in their curricula in the near future.

In addition, in order to increase the level of knowledge of remote sensing, over the past decade approximately 50 scientists from remote sensing and other organizations have been sent abroad to train at remote sensing institutions and organizations. Of these, several have returned with M. Tech. degrees in remote sensing.

F. INFRASTRUCTURE DEVELOPMENT

In order to effectively utilize remote sensing techniques for different applications in the fields of natural resources and the environment, institutions and departments such as the Institute of Agricultural Planing, the Institute of Forest Planning, Institute of Meteorology and Hydrology and the General Department of Geodesy and Cartography, have established their own remote sensing centres. Of the six above mentioned Centres, four are currently operational and these take part in major applications projects. In addition, they are also conducting projects on remote sensing applications covering applications of specific importance to their specialized fields.

G. CONCLUSION

Remote sensing activities in Vietnam have made remarkable progress over the past decade. In brief, significant progress has been made towards utilization of remote sensing technology in many natural resource fields for economic planning and development and for environmental management at the national and regional levels.

The promotion of remote sensing to achieve optimum utilization of these technologies must be undertaken with an integrated approach that includes a review of existing resources, and the development of greater awareness, particularly through education and training. Recognizing the above mentioned problems, and in order to accelerate the use of and benefits derived from remote sensing technology in Vietnam, it is therefore recommended that:

(1) As a matter of critical and immediate importance, an inventory of existing remote sensing resources be conducted.

(2) Projects and programmes designed to increase public awareness of remote sensing applications that have been supported by the government, as well as research and training, be continued in the coming years.

(3) Remote sensing applications, image processing and geographic information systems be included in university and high school curricula.

(4) Agreements be reached between the Government of Vietnam and provider countries, especially Thailand, on the regular supply of remotely sensed data.

(5) International cooperative efforts covering information and experience exchange, joint research projects, the holding of international seminars, workshops and conferences should be developed and support solicited from the United Nations and industrial countries.

In the coming years remote sensing is expected to paly an increasingly important role in all major decisions related to national planning, development and harvesting of natural resources in Vietnam.

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H. ACKNOWLEDGEMENTS

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THE GREAT IMPACT OF THE EDUCATIONAL SATELLITE SYSTEM IN CHINA

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THE GREAT IMPACT OF THE EDUCATIONAL SATELLITE SYSTEM IN CHINA

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ABSTRACT

As a developing country, China has the goal of developing its industry, agriculture, science and technology and national defence. The Chinese Government, however, faces various problems in reaching this goal. Among its problems, the education of the Chinese people is the most important task, since on a vast scale education is the way to speed up the economic development of a country. The Chinese Government chose satellite television broadcasting to deliver educational programmes. So that a countrywide educational satellite system has been established in a very short period of time. The practice and experiences in China have proved that using a satellite can offer educational programmes to the people throughout China efficiently and rapidly. Through the promotion of education, the economics and society of China have been promoted significantly. Further applications of space technology are considered to offer integrated services in the rural areas. An interactive satellite education system is also under consideration.

INTRODUCTION

Due to the fact that China is a developing country with a huge population, the Chinese Government has been seeking methods to increase access to education. Correspondence study and radio broadcasting have been widely used since 1949, when the People's Republic of China was founded. The people who are working in government, schools and factories are allowed to study new laws, new policies, new technology, and new skills in the workplace. When television (TV) technology became available in the big cities in 1960, the earliest TV universities were established in Beijing, Shanghai and Shenyang. Courses in the natural sciences, engineering and the humanities were offered to primary and secondary school teachers and people working in industrial areas. Because there was only one TV channel per city at that time, courses were broadcast in the early morning and late at night. Students were urged to absorb knowledge, so they went to their workplace, the only place equipped with a TV set, to watch programmes at 5 am.

In the late 1970s an evolutionary change began. The country attempted to modernize industry, agriculture, science and technology and national defence. Also, a new "open-door" policy to the world began to be implemented. In this new situation, great educational demands are being made of the Government and educators. After studying other countries' distance education programmes, such as the Applied Technology Satellite (ATS) educational programmes in the United States and India, the programmes of TV Ontario in Canada and Learn Alaska in the United States, the Government decided to build a satellite television based multimedia education system.

After only a few years, the largest distance education network in the world is running successfully. Students are taking courses every day. The impact of distance education on the development of China has been significant. Also, what happened in China is also very important for the entire world.

Demand for education in China

When China opened its door to the world, the gaps between the developing countries and the developed countries were recognized. We realized the need for economic, scientific and technologogical development to catch up to the advanced countries. Modernization of industry, agriculture, science and technology has become our goal. How to reach that goal, however, was the big question. Investing a lot of capital to import equipment, assembly lines and factories represented one method for modernization in a short time. But high technology cannot be imported so quickly. The people must have basic knowledge and skills to master the use of new machines. That is to say, we can buy modern equipment easily, but we cannot buy technological knowledge in the same way. We need to educate personnel to control new technology. Obviously, there is a link between education and social economic progress. Education on a vast scale is the way to bridge the gaps between China and the developed countries. First, education will be used to raise the cultural level and understanding of people and this in turn will stimulate their desire for modernization. Secondly, the knowledge and skills necessary to qualify personnel at various levels will be offered through different kinds of education. A highly skilled labour force will be prepared through education for production of advanced industry and agriculture.

But in a country like China, which has 1.2 billion people, the demand for education is so great that the traditional education cannot be expected to meet the needs. For example, according to the census of 1986, there are 8 million primary and secondary schoolteachers in China. Three million of them are not qualified. These teachers should be retrained first, because the quality of the school depends mainly on them. There are not, however, enough places for these teachers in traditional universities. Also, because these teachers are the only available people in their

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respective areas to teach, they cannot leave school to study. Even if they could enter a university, it would take too long to finish their studies, and students would be left without teachers. Distance education appears to be the only available solution to this problem.

Satellite TV based multimedia education system

In 1986, the first satellite TV channel began offering education at a distance. Since then a satellite TV education-based multimedia distance education system has written a new chapter in the history of Chinese education.

Different kinds of media are used in distance education in the world, but it was necessary to analyse which one was most suitable for our situation. The media should be made easily available and convenient for teachers and students. In our case, 1 billion people are distributed in an area of about 9.6 million square kilometres. About 80 per cent of the territory is mountain and desert. The farthest distance from east to west or from north to south is as much as 5,000 kilometres. Transportation in remote areas, mountain regions, islands and deserts is poor, and communication is difficult. There is no telephone, television or mail service. It is also difficult to establish cable, microwave trunk or television stations there. Satellite TV broadcasting is an ideal medium to overcome the difficulty in delivering programmes directly to the learners located all over the distance education system based on satellite transmission. Taking advantage of the social system, the Chinese Government devoted considerable effort, money, materials and human resources to make television education available.

The project was planned to have three phases. In the first phase, a series of pilot programmes for distance education was carried out by leasing and purchasing transponders from the INTELSAT. The success in the programmes has shown that a 6-meter antenna for a C-band TV receiving Earth station can meet the requirement of television relaying on the condition of the hemispheric beam transponder of International Telecommunications Satellite Organization (INTELSAT). Four-metre antennas, even three meter antennas can still meet the needs of TV transmission for signal quality when they use a domestic coverage beam. This has resulted in promoting greatly the development of a ground network. China has mature techniques to produce lower cost Earth stations for educational uses. In the second phase, China's communications satellite was made and launched. This satellite is complemented by the leased and purchased transponders. A second Chinese-made communication satellite with 24 transponders will be launched to form the domestic satellite communication system. Additional channels will be devoted to distance education. The Chinese Government provides a space segment for distance education continuously and increasingly.

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The whole satellite delivery system is a hierarchical structure. At the highest level, the State Educational Commission has established the China Education TV (CETV) Station, which is responsible for editing and broadcasting educational programmes that use a satellite. Cooperating with the Post and Telecommunications Ministry, CETV manipulates an Earth station to up-link programmes into INTELSAT V and CHINASAT. These satellites cover all of China and some countries in South-East Asia, such as Thailand and Myanmar. Every day the two channels broadcast for 31 hours in total. The rest of the broadcast day is shared by provincial educational stations that broadcast their own programmes.

At the local level of the delivery system, TV relay stations are built in big cities and population centres. People can receive programmes using their TV sets at their workshops and at home. Because of the country's varied geography, it is more efficient to build many TV relay stations with small transmitting power rather than fewer stations with great power. Television receiving only (TVRO) Earth stations are widely used in small towns, villages or organizations and schools. Usually these stations are equipped with video cassette recorders. Programmes are recorded for later viewing or for delivery to learning centres. Print materials, including textbooks, reference books, and study guides, are combined with videotapes to form a learning package.

At the bottom lowest of the delivery system are the learning centres, which provide the study places, where people gather together to watch tapes if they do not have access to a TVRO. There they meet tutors and classmates to discuss their lessons. They have opportunities to ask for clarification and explanation of material covered in the TV programmes. For some courses, tutorials are also used for assigning and correcting homework and for assigning projects for which credit is given.

By the end of 1990, the delivery system had broadcast 36,000 hours of educational programmes through two TV channels. More than 600 TV relay stations and 4,000 TVRO stations have been set up in 29 provinces. About 20 million people view educational programmes or take courses either at home or at 30,000 learning centres.

Administrative system

The administrative system is also a hierarchical structure, with two parallel subsystems. China TV Normal College (CTVNC) and China Central Radio and TV University (CCRTVU) are at the highest level.

CTVNS's main task is primary and secondary school teacher retraining. Professional education is also included. CTVNC is responsible for formulating

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teaching guidelines, programme planning, adopting relevant regulations and rules and broadcasting lectures. It is also in charge of setting norms and standards for each category and level of students for organizing the production of teaching materials. CTVNC works in very close partnership with universities. CTVNC asks the university, with its high-quality video production team, video studios and better teachers, to produce video programmes. Outstanding teachers in secondary schools are invited to teach as good role models.

At the local level of the administrative system, the executive organizations of teacher training projects are the institutions and schools in provinces, counties and districts.

CCRTVU is at the apex of the second subsystem. It serves a radio and TV university providing a large number of people with access to higher education through distance education. Its responsibility included evaluating curricula, offering courses, producing syllabuses, offering reading materials, administering examinations and training teachers and administrative staffs.

There are 37 branch TV universities in provinces, autonomous regions and municipalities. A total of 1,550 work stations are located in all counties to organize students to study TV courses.

During the 10 years from 1978 to 1988, the TV University published 150 million copies of textbooks which are used to teach 300 courses in twenty-one specifications. The results include: 20,000 hours of video programming have been produced; 1.2 million students have graduated from CCRTVU, 37 per cent of the total number of graduates from traditional higher education. About three million people have taken continuing educational courses from CCRTVU.

CCRTVU has produced 10,000 hours of video programming. Over 1 million teachers are enrolled in courses and 1 million teachers watch teaching demonstration programmes. One million principals of primary and secondary schools attend workshops to update their administrative capabilities.

<u>Contents of distance education in China</u>

The first satellite TV broadcasting channel is used primarily for the delivery of training courses. When the second channel was added, professional, vocational and continuing education for adults became the three aspects of Chinese distance education programming.

Courses for teacher training are emphasized. Mathematics, physics, chemistry, history, geography, Chinese language and literature, physical training and English are offered. Students can select a group of courses which are closely related to their area of teaching. After two years, they can be qualified in one subject.

Teachers chosen from Beijing represent a good teaching model. Teachers and students in the remote areas watch the programmes and practice in their classes what is demonstrated.

The State Education Commission has organized training courses to train the principals of primary and secondary schools. They study educational policy, evaluation methods and administration methods, etc. There are 120 million young people who have finished school and returned home to work. They need to study literature and to learn new technology to improve the country's production and economic development.

Channel II offers courses, lectures and video programmes to teach science and technology in agriculture. The programmes are interesting, easy to understand and of relevance to actual agricultural problems. A wide variety of continuing education courses are offered in engineering, including computer programming, electronics, graphics, mechanical, chemical, civil and architectural engineering (advanced computer technology courses are taught on weekends). There are also courses in economics and administration, such as business, accounting, statistics, finances and taxation and banking. CCRTVU also offers a continuing education programme for engineers.

Impact of distant education on the development of China

Over a few years the scale of distance education in China has expanded considerably and its impact on the development of China has been tremendous. Distance education offers the Chinese people access to educational opportunities, which have raised their levels of literacy and updated their skills. They have become more knowledgeable and qualified. Therefore, the levels of the economy, literature, industry and agriculture have been raised.

Due to the fact that more people have recognized that distance education is an efficient way to develop society, more money is being spent to establish TV relay stations or TVRO stations. Usually, in a developing country backwardness of education leads to an underdeveloped economy, which leads to backwardness of education; it is a vicious circle. But now this pattern is changing. We see a bright future for education in China.

During the period of eighth five-year plan, one more satellite TV channel will be dedicated to primary and secondary students. More TV relay stations will be

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established so that 70 per cent of the areas in all counties will be covered. The distance education system will be set up so as to be completely supplemented by correspondence education, radio and TV education. We now are thinking of ways to build and to integrate the satellite system for the rural areas in China, which will include offering better education opportunities for school students and

adults, and improving the communications between these areas and big cities. An interactive tele-teaching and teleconferencing system using space technology is also research phase.

The education system has a great impact on the development of the economy, literature and society of China. We are sure that the more space technology we use, the more progess we will have.

SURVEYING THE LOESS PLATEAU FROM SPACE

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SURVEYING THE LOESS PLATEAU FROM SPACE

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ABSTRACT

The remote sensing of the Loess Plateau is a complex project which comprises part of the key national projects for science and technology development in China. These projects were set up to contribute to the development of applied remote sensing techniques and an inventory of agricultural resources, such as land use, forest, grasslands, soil erosion, land type and land evaluation.

The methods used, the inventory of environmental resources that will be developed and the experiences gained through of the project should be applied to important areas of national economic development. Being an applied engineering effort requiring a large investment to study a vast land area which has suffered from severe soil erosion and intensive coal mining, the organizers of the project used a set of remote sensing techniques to meet the development needs of this region. Hundreds of scientists and technicians from dozens of institutes or universities carried out the comprehensive and practicable RS-GIS-RD project, which included data gathering, processing, interpretation, information system development and modelling, as well as suggestions for sustainable resources management. A systematic mapping method was also developed.

Development of the Loess Plateau through integrated management has become a hot topic among scientists both in and outside China. Remote sensing has played an important role in the intensive research of this area and continues to do so.

A. THE RS-GIS-RD PROJECT AND THE DESIGN AND IMPLEMENTATION OF APPLIED REMOTE SENSING FOR REGIONAL DEVELOPMENT.

The Loess Plateau is situated in the middle of the Yellow River region. It covers seven provinces or autonomous regions with a total area of about 630,000 square kilometres, and has a population of more than 80 million people.

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The region suffers from serious water and wind erosion, desertification, drought and other natural calamities, as well as poor communications, poverty, general backwardness, a high rate of illiteracy and a high birth rate. But, it's very rich coal resources constitute two-thirds of the total reserves in China. For this reason, it is imperative that development of the Loess Plateau be undertaken (See table 1). The three main goals of development of this region should be focused on the following objectives:

- Developing a national base of coal mining, energy and heavy-chemical industry.

- Soil conservation and harnessing of the Yellow River.

- General regional development in the Loess Plateau area.

Table 1. The Importance of the Loess Plateau for China

Items	Total of China	Loess Plateau	
Land	9.60 million km^2	0.63 million km^2	6.5%
Population	1.10 billion	84.00 million	7.8%
Coal reserve	782.20 billion tons	545.70 billion tons	70.0%
Coal output	1.09 billion tons	0.48 billion tons	40.0%
Silt of the Yellow River	1.60 billion tons annual average	90% comes from Loess Loess Plateau	

According to project plans, remote sensing technology will be applied to investigate the state of the resources and environment of the Loess Plateau. Applications include land use, water and soil erosion, the characteristics of the distribution, quality and quantity of forest and grassland, the surviving rate and preserving rate of afforestation and the type, suitability, change and degradation of land resources. Relevant maps will also be compiled. The principal objective of the projects is to provide solid scientific data for decision-making and territorial management in the Loess Plateau region. Mutli-thematic remote sensing mapping research methods are being used to conduct these studies (See fig. 1).

Other elements of the program include the following:

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1. General Survey

Maps of the resources and environment (RE) of the entire Loess Plateau region, covering some 640,000 km^2 on the scale of 1:500,000, will be compiled using TM images. A study of of the principle, characteristics and zoning of RE association will also be conducted.

2. Typical Survey

Maps of the areas that have suffered most from severe erosion, which cover an area of roughly 60,000 km^2, will be compiled based on the precise geometric correction of the TM images of nine scenes. RE maps will be compiled on the scale of 1:100,000 in concert with a 320 km sampled belt with IR aerial photo crossing the region for supervising interpretation. The quality, quantity and distribution of major kinds of RE will be studied.

3. Semi-detailed Survey

In severely eroded areas and those degraded by desertification, as well as in the the key coal mining area, covering a total of 24,000 km^2, IR aerial photos were taken for compiling multi-thematic maps on the scale of 1:50,000 for qualitative and quantitative analysis.

4. Detailed Survey

A series of maps will be compiled on the scales of 1:500 to 1:10,000 in two small basins, within which the area ranges from 5 to 20 km^2, by means of IR photography on the scale of 1:10,000, micro-plane, constant position balloons, ground photography, as well as intensive ground surveys. Qualitative, quantitative, position study and monitoring will also be conducted.

5. Important Topic Study

A monographic study on soil erosion will be conducted.

6. Information System

A multi-purpose, multi-functional and multi-level Geographic Information System is being developed for use at the regional, county, or stream basin level.

7. Application of remote sensing achievements for regional development and management (See fig. 2).

The Chinese Academy of Sciences (CAS) is in charge of the projects. For tracking the work, it has organized a multi-department, multi-subject and multi-link task group. Information on progress of the projects is provided to the decision-making and planning departments of the Government. This close integration of remote sensing (RS) techniques, geographic information system (GIS) technology and regional development (RD) programmes, is a practical form of systematic engineering to serve our national economic reconstruction. (RS-GIS-RD fig. 3).

B. TECHNICAL PROGRESS

The project has obtained and processed vast amounts of images, from both spaceborne and airborne systems, and has evaluated their potential value for development of the Loess Plateau.

Infrared aerial photos were taken with a camera with the principal focus of 152.77 mm, the format of which is 23 x 23 cm^2 on the scale of 1:50,000. An area greater than 40,000 km^2 has been photographed. The general replacement is about 0.6 - 1.3 mm within 5 cm around the principal point with the relief of from 100 m to 200 m. It is easy to orient with the natural density gully system on the photos.

Because the photos have the proper resolution, terraced land, silted land, dams and other ground objects are easily identified on the photos, and stereo measurements can also be done.

It is advantageous to use TM images for vegetation interpretation because of its high spectral resolution. The boundaries bounding the subjects, such as waters, forests, grassland, cultivated land and bare land, can be easily delineated on the TM images.

1. The Advance of Systematic Mapping

Systematic mapping is a technique of compiling a set of maps, which have a vertical and horizontal link in an area. The method is used to map land use, forest, grassland, soil geomorphology and soil erosion and to conduct land type, land evaluation and soil conservation measurements for the Loess Plateau projects. Referring to systematic mapping in a given region, a series of maps on the same subject can be compiled using different scales. The technique is practiced to coordinate the systematic mapping in groups and stages (Fig. 3). Progress in both theory and technology has concluded the following:

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a) The natural object is the mother of the image. Understanding the characteristics of the physical body is the scientific foundation needed to integrate and classify their images. Image classification should serve the classification of the subject of sciences.

b) Standardization of base maps, information resources, interpretation marks and technical methods, are the technical guarantees of the achievements.

c) The standardization of information resources is by no means confined to a single resource of an image or discriminating against others, but integrating multi- data resources. Thus, the attributes of mapping objects can be brought to light.

d) Classification of images and multi-levelled resolution of mapping boundaries which could be classified into groups, subgroups or unit levels, from which the lines commonly used could be determined to be key boundaries. This method can also save time and improve map quality.

e) Establish and emphasise the GIM (Ground, Image, and Map) feedback triangle of remote sensing mapping. This triangle (see Fig. 4) is formatted with three aspects:

- G: Physical bodies, the natural resources and environment

- I: Images, the remote sensing data

- M: Maps, the mapping language

This new triangle system has changed traditional mapping methods within which there is only a GM relationship. The following questions have to be posed:

1) What is the image feature of a given object?

2) What kind of object does a given image represent?

3) How do you select a suitable mapping language to express classified ground objects?

2. Pioneering Studies In Establishing Regional Geographical Information Systems With Multi-Levels, Multi-Objectives And Multi-Functions.

The systems are supported with VAX II, I^2S, IBM-PC and other instruments, including several regional information systems, such as the LP-TIS, LP-ARC/INFOR

System, Knowledge-Based Geographic Information System (MCGIS), Mini-Film Optics Information System (MIFM), and others which are located in various institutes. These systems are capable of performing international/external data exchange, system analysis models, expert systems and remote sensing tasks. Also, these systems serve customers on different levels, and provide indexing services as well as analyse regional information and decision- making.

3. Establishment of DTM

Besides adapting map grid sampling input and simulation by tracing contour lines to establish DTM, we have developed software to automatically produce an ortho-photomap and digital elevation database with stereo photo reading. Also, we suggested the inclusion of density sampling on the feature lines, such as hill foot lines and slope-gully lines, to improve the ability of DEM to simulate the topographic features of the Loess Plateau.

4. Progress on the Establishment and Application of Geomodels

a) Remote sensing analysis and computer support mapping for landslide in Loess Plateau.

With the support of the dBASEIII with raster data structure, the type, scale, stability, and characteristics of space distribution of landslides in Ansai county have been studied. Landslide data have been provided for the first time and a relevant software package has been developed.

b) Improvement of USLE by DR factor.

Provide improved formulations of soil erosion:

$$PSL = K \times C \times LS \times R \times P \times DR$$

in which, K: soil erosion factor; P: management factor;
LS: slope length factor; R: rainfall factor;
C: vegetation cover factor; DR: dynamic transmitting factor for water and soil loss

$$DR = 10 \times h / D$$

in which: h, height gap; D, the shortest distance from the nearest channel, can be calculated with searching window of DEM.

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By testing, we obtained the following results:

PSL max = 661.1 t/acre/a = 165275 t/km² /a
PSL aver = 30.78 t/acre/a=7695 t/km² /a

c) Soil Erosion Information Entropy Model and Application

This concept was formed to give the relevant significance of soil erosion factor and mapping units.

$$H = C \sum_{i=1}^{n} W_{ij} \; A_{ij} \log (W_{ij} \; A_{ij})$$

where, A_{ij} : the probability of factor i in the erosion type j:
W_{ij} : the silt contribution of factor i in the erosion type j;

In addition, we have studied land use planning model for regulating land use structure, expert system for evaluating land resources, and the silting rate in reservoirs.

5. <u>Integrated Remote Sensing Study of Soil Erosion Based on Interpretation of Remote Sensing Data: Mapping Soil Erosion of Types and Intensity</u>

A soil map based on erosion type and form with the erosion intensity as a guideline has been compiled. The comprehensive research was based on the following:

(1) + (2) + (3) + (4) + (5)

(1) Factor interpretation with RS data, slope, vegetation, geomorphology, and surface rock or soil.

(2) The soil erosion type interpretation and mapping with RS data.

(3) Special classification of erosion intensity in the Loess Plateau region (Table 2), and legend system.

(4) Erosion modules (intensity calculation) analysis according to hydro-station data and investigation.

(5) Integration with climate, hydrology, sedimentation, and ground surveys, field and laboratory test, and modelling.

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Table 2. Soil Erosion Intensive Classification

Intensity (Class)	Modulus (t.km^2 /a)
1 Very Weak	1000
2 Weak	1000 - 2500
3 Moderate	2500 - 5000
4 Strong	5000 - 8000
5 Very Strong	8000 - 15000
6 Violent	15000 - 25000
7 Specific High	25000

6. Systematic Research on Land Resources:

Space Data + Statistics Data + Modelling

Using this method, multiple data integration, conversion and extraction were accomplished, including both tabular and spacial (polygon) information, as well as the thematic map reproduction.

(1) Comprehensive land type remote sensing mapping.

(2) Land characteristics data bank construction based on the land type mapping unit.

(3) Multiple matching among land type units and LSC (Lan Suitability Classification) and LCC (Land Capability Classification). The conversion matrix between the land type and land assessment systems was established.

(4) Land information system construction: maps were digitized with ARC/INFO in VAX-II and a land evaluation expert system was established within the ALES framework in IBM/AT.

(5) Extraction, integration and conversion of the space (polygon) data was conducted in the following way:

Goal + Expert Knowledge + GIS/LIS

(6) Study on the population supporting capacity of the land and the wise use of natural agriculture resources.

A typical gullied and hilly Loess Plateau area, Mizhi county, with an area of about 1,187 km^2, was chosen as a sample, in which 97 land units were classified and

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mapped and about 25,000 polygons were produced in a land type map. Both land type and land cover maps were digitized.

Based on the above results, a set of various aspect maps were reproduced with the following method: Goal + Expert Knowledge + GIS/LIS (supported with ARC/INFO system). They are the Land Capability map, Land Suitability map, Irrigation Farming Land map, Rainfed Farming land map, Extensive Grazing Grassland map, Rainfed Tree Crops, Terraced and Dam Earthed Farming Land map and Gully System map. In addition, physical factor extraction or integration and the space data conversion were combined to reproduce new thematic maps.

1) Land Use: Farming land takes 34.5% of total land cover, which suggests a high cultivation index in this kind of hilly area. According to the survey, the land under cultivation is 2,850,600 ha., but the statistics recorded only 1,250,000 ha. The actual amount of practical farming land is as much as 228% higher than government statistics. The farming land also has unstable and changeable features and differs greatly from region to region.

2) Forest: Forests occupy 16.4% of the territory, are small in quantity and low in quality. Bush land accounts for a greater amount of land. Due to human activity and low levels of rainfall, trees have a low survival rate.

3) Grasslands: A variety of grassland types account for 26.3% of the area. The natural grassland has been severely degraded due to overgrazing and planted forage area accounts for only 0.7% of the total rangelands. According to our calculations within the key areas, the stock carrying capacity is 7.22 million dry ewe sheep units, but there are now 8.27 million units of animals grazing in this area, which amounts to overstocking by 0.94 million units.

4) Soil Erosion: Roughly 80% of the key area (or around 84,000 km^2) suffers from erosion with the modules more than 1,000 ton/km^2 /a. Water erosion is an important factor and contributes to 90% of the silt in the Yellow River. Besides the physical conditions, land misuse and vegetation degradation are also important factors.

5) Land Evaluation: The amount of land in the area that is suitable to cultivation amounts to 12.2% of the total, of which the cultivation index is 22.2 points higher, causing environmental problems. The material of the Loess region most notably deep workable silt, is the treasure of this region and forms the soil that supports agriculture.

A number of measures were proposed, including, for example, terraced farming of the land on hill slopes, building dam systems to catch the silt and earth up the high quality farmland, development of tree crops, improvement of rangelands with reseeding or destocking, increasing agricultural input, as well as development of rural industry, and improvement of education and family planning.

C. THE FUTURE APPLICATION OF REMOTE SENSING IN THE LOESS PLATEAU

The achievements of remote sensing application engineering in the Loess Plateau region have been put into practice. Now, the relevant deparments of the Government have been adopting these aerial photos, maps, data and proposals. Also, the published album and collection of these data have been used in college education and have been compiled into various textbooks.

The comprehensive harnessing and development of the natural resources in the Loess Plateau region will be a long and difficult task. During the next step of this effort we will concentrate our attention on dynamic RE monitoring, collection of ground truth data and improvements of parameters, evaluating crop yield, and comprehensive application and analysis of multi-remote sensed information and other information. The study of the models, both of water and soil erosion and silt origination, will take the most time and be the most complex subject.

Additionally, the application of remote sensing and informations systems to an intensive research and development programme in the areas of land reclamation, industry, mining and town planning will be a major challenge for the future.

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Fig. 1 REMOTE SENSING APPLICATION IN LOESS PLATEAU

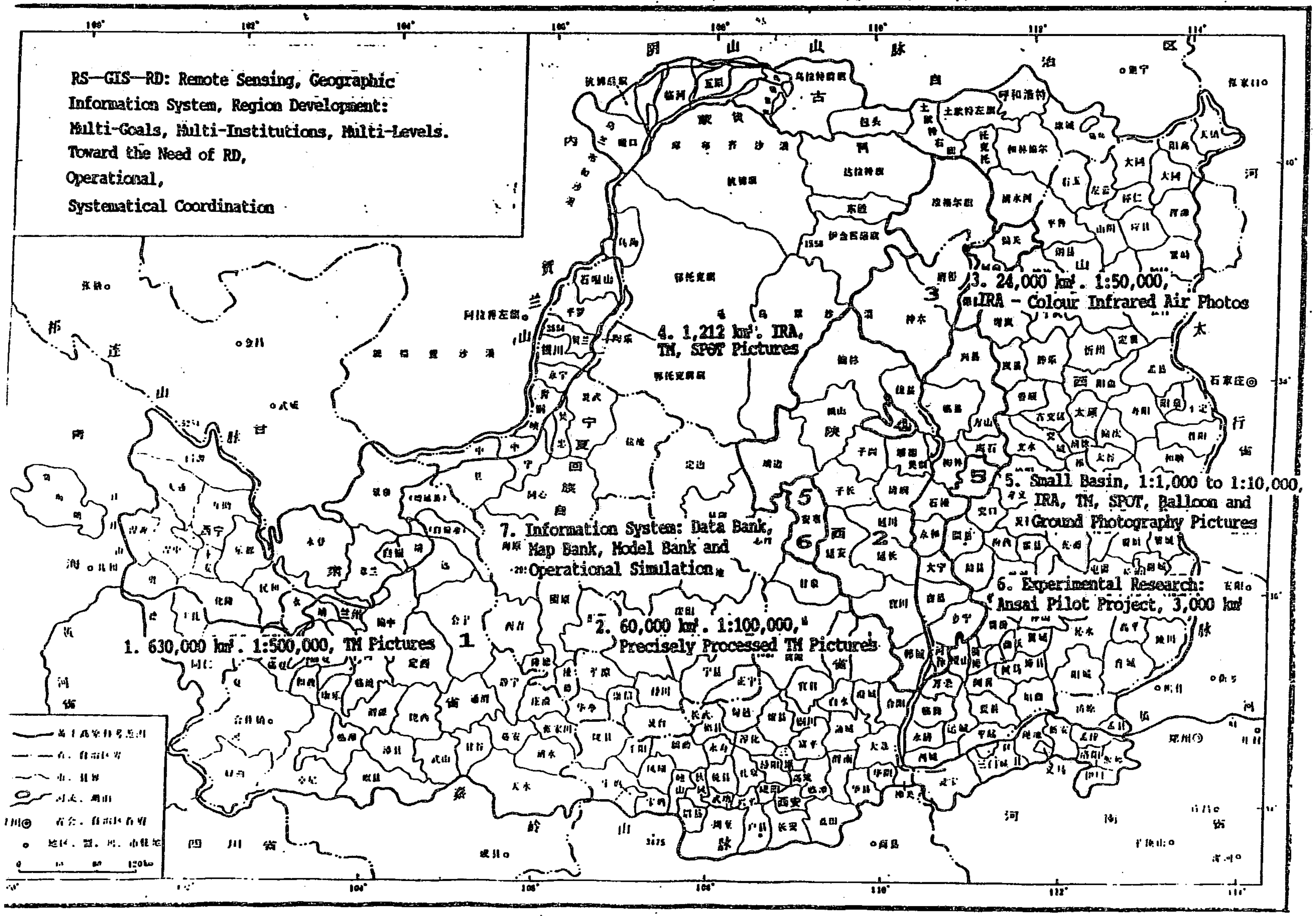
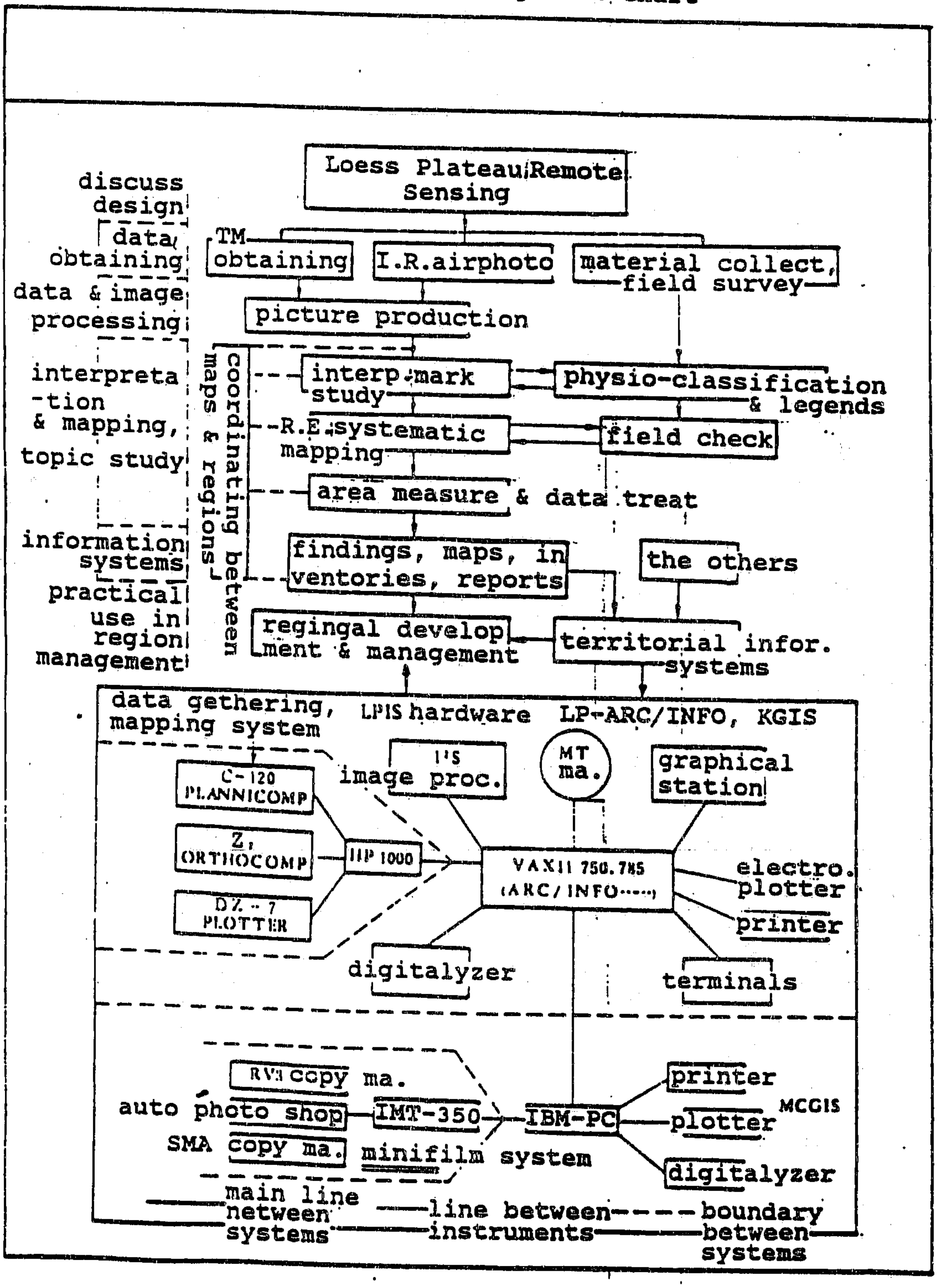


Fig. 2 Engineering Flow Chart



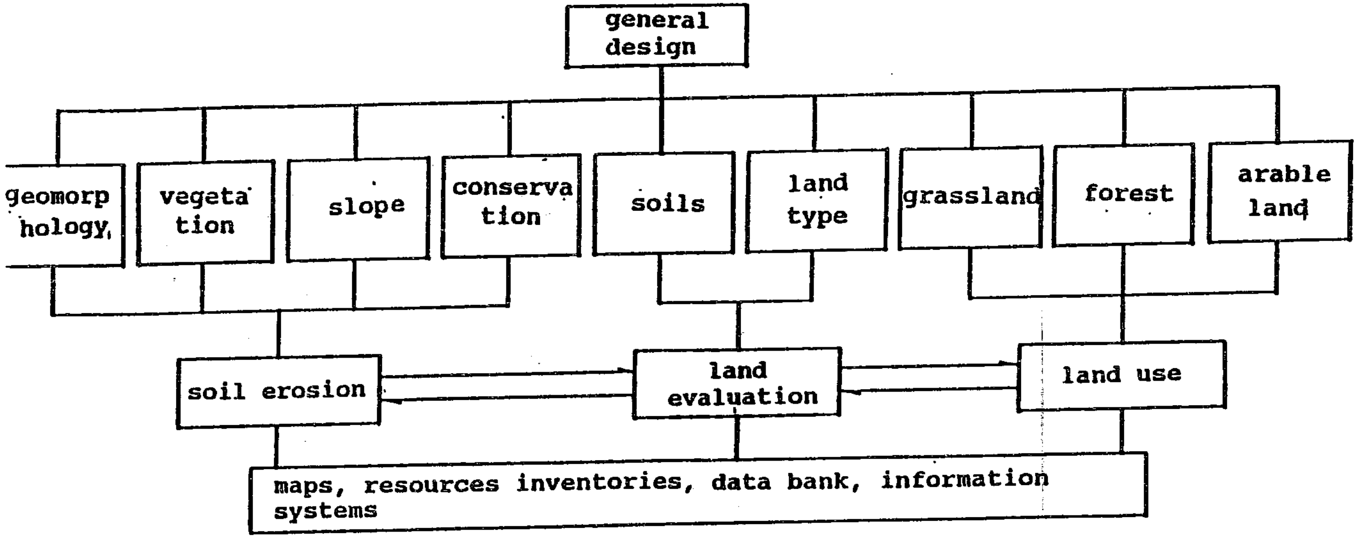


Fig. 3 Illustration of Systematic Mapping and Coordinating

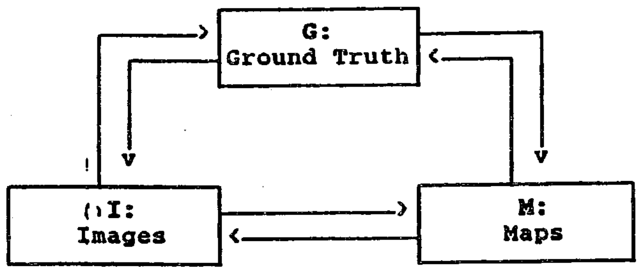


Figure 4 GTM Feedback Triangle Relationship In RS Mapping

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INTRODUCTION

The amount of fresh water that is more or less readily available on land is less than 3 per cent of the total amount of terrestrial water. The terrestrial surface water comprises less than 0.15 million km^3/(0.25 per cent) and the rest is all underground water. These water sources in principle should be adequate to meet foreseeable human needs on this planet. However, the uneven distribution of these water resources combined with the explosive growth of population, the increase in demand for agriculture and industry and rapid urbanization in developing countries has resulted in the severe scarcity of freshwater availability in many areas. As a 1989 United Nations Children Education Fund (UNICEF) study revealed, "over 800 million people in developing countries live without access to a safe potable water supply and 1.8 million lack adequate sanitation services." In many developing countries, nearly 35 per cent of the people do not have easy access to drinking water.

India receives annually an estimated precipitation of about 400 million hectares metres (M ha m), of which about 70 M ha m is lost to the atmosphere as evaporation and about 115 M ha m flows as surface runoff. Of the remaining 215 M ha m that soaks to the ground, about 165 M ha m is retained as soil moisture allowing 50 M ha m to be stored as groundwater. In addition, lateral seepage of 5 M ha m from irrigation systems and 30 M ha m from rivers and streams together constitute about 85 M ha m of ground water. As per the estimates by the Indian Central Groundwater Board, India's annual exploitable groundwater potential is about 42.3 M ha m. At present, the groundwater utilization in the country is about 13.5 M ha m of which 85 to 90 per cent is used for irrigation and the remainder is used for other purposes. Notwithstanding this fact, due to uneven distribution in space and time of these water resources, there have been about 165,000 villages without adequate supply of potable water since the 1980s in India.

The majority of the minor irrigation programmes in rural India are achieved through groundwater development. Groundwater systems provide an instant and reliable source of irrigation. Nearly 50 per cent of the cropped area under irrigation (68 million hectares) is irrigated through groundwater. This dependence of groundwater became a necessity owing to the high cost and long time required to construct major irrigation projects and dams, as well as from environmental considerations. Thus, there is a constant increase in the demand for groundwater resources.

A closer look at the groundwater development indicates that: (a) there are areas where groundwater development has already attained a maximum; (b) there are areas endowed with high ground water potential but the utilization has remained at a low level; (c) even in most of the drought-prone areas, ground water development and utilization has not been commensurate with natural replenishment potential (recharge); (d) there are areas where the ground water has declined and sea water ingress has taken place in coastal areas due to overexploitation of ground water. It is in this context that scientific methods of source finding and optimum utilization of this resource for meeting the rural water supply needs became very relevant.

India has made great strides in using the sophisticated remote sensing technology for rural development. Even with the relatively modest investment made, the nation has established a self-reliant base in this technology, which is now playing a crucial role in the management of natural resources. India is developing space and ground segments indigenously as well as the necessary expertise and infrastructure for implementing various remote sensing application projects.

Remote sensing applications in India, under the umbrella of the National Natural Resources Management System (NNRMS), cover diverse fields such as agricultural crop acreage and yield estimation, drought warning and assessment, mapping and damage assessment of flood-affected areas, mapping for agro-climatic planning, waste management and water resources management. Thus, it touches almost all facets of national development. Active involvement of the users in the government ministries and departments, including both Central and State, has ensured effective harnessing of this technology in solving problems relevant to the country.

APPLICATION OF REMOTE SENSING IN GROUNDWATER EXPLORATION

Groundwater occurrence

Groundwater holding capacity and yield of hard-rock terrain depends on compactness of rocks. Compactness in turn depends on presence of pore spaces within rocks (porosity) and their interconnectedness (permeability), which is enhanced by the presence of weak planes (fractures, joints, rock contacts, shear zones, etc.) and weathering of rocks. Groundwater movement within rocks and sediments is controlled by permeability of the rocks, and geological structures. Groundwater occurrence in the semi-consolidated sandstone formations and unconsolidated alluvial plains is determined by the porosity and permeability. Remote sensing techniques provide a synoptic view of the interactions of physiographic and hydrogeological factors contolling the occurrence and movement of groundwater. One of the advantages of using remote sensing techniques is that certain features which are often missed in ground surveys, for want of a synoptic view, could be easily identified.

Remote sensing satellites such as Landsat, the Indian Remote Sensing Satellite (IRS) and the Systême Probatoire l'Observation de la Terre (SPOT) have been extensively used in the survey and exploration of water resources. Sometimes information is supplemented by aerial photos. Hydrogeologists have explored various spatial and spectral data offered by these satellites in addition to microwave regional and thermal remote sensing data (10.3 - 12.5 micrometer region) for differentiating the moist from the dry lineaments.

Scale and resolution of satellite data

The scale of satellite data for mapping of groundwater- related features depends on the degree of details required on various factors controlling the occurrence of groundwater. Whereas small scales (1:250,000 or 1:125,000) have been found useful for regional scale mapping of groundwater features, the 1:50,000 scale has been found suitable for detailed mapping and ground follow up of the identified groundwater prospective zones for further developing. Mapping on a 1:50,000 scale has, however, been found to be about 8-10 times (Rs.25 per sq. km.) which costs more than mapping 1:250,000 (Rs.2.70 per sq. km.) or 1:125,000 (Rs.3.67 per sq.km.) scales and is also equally time consuming. 1/ Low resolution satellite data was found suitable in mapping of ground water features at a regional scale (1:250,000 and 1:125,000 scales) while higher resolution data have been found adequate to map the potential groundwater zones at a 1:50,000 scale. However, the use of high- resolution data (20-40 m) for small scale (1:250,000/1:125,000) mapping provided more details that are not seen on low resolution remotely sensed data (70-80 m) on the same scale.

Image interpretation and data analysis

Inferences regarding the occurrence of groundwater are derived by identifying the hydrogeomorphological features on the satellite images or aerial photographs through visual interpretation and digital analysis. Various visual interpretation elements such as tone, texture, pattern and association are used in identification and delineation of various surface expressions which are indicative of groundwater occurrence. Using these techniques groundwater prospective zone maps of all of India have been prepared on a 1:250,000 scale. Image processing technqiues such as filtering, linear stretching, rationing, principal component analysis, band combination, specific colour composites, etc., are useful for extracting the various groundwater

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related features. A flow chart of methodology adopted for ground water exploration is given in figure 1.

The approach used involved stratification of the prospective zones into relative groundwater yield potential areas/zones (viz., Excellent, Good, Moderate, Poor, Nil) with likely yields assigned to each of the prospective zones based on the ground data. This stratification is supported by information on drainage, topography, landforms (geomorphology), rock types and their composition and compactness, nature of aquifers (weathered, fractured, jointed, etc.) through which the groundwater moves, weathering status of rocks, presence of geological structures (lineaments, fractures, faults, joints, shear zones, intersection of lineaments, sink-holes, etc.), annual recharge, rainfall status, nature of soils (sandy, clayey, loamey, etc.), hydrologic characteristics of rocks such as porosity, permeability, grain sizes, etc. The presence of anomalies indicative of groundwater, such as vegetation, fracture pattern, lineament intersection, cut-off meanders, sand bars, burried paleochannels, abandoned channels and valley fill, are identified.

National Drinking Water Mission

The experience gained in the use of remote sensing for groundwater resource development prompted the Government of India to adopt this technology for scientific source finding of groundwater under the National Technology Mission on Drinking Water. This mission is aimed at providing 40 litres per capita per day (lpcpd) of potable water (with an additional 30 lpcpd for cattle in desert areas). The water should be available within a distance of 1.6 km from the village for about 1.62 lakh problem villages where potable water in adequate quantity of acceptable quality was not available. The approach adopted had three components, viz.: (i) remote sensing based investigation;
(ii) conventional hydrogeological investigation, and (iii) ground geophysical investigation. A combination of all three led to identification of an aquifer. For the first time, the entire country was mapped on a 1:250,000 scale for groundwater potential zones using satellite data, and the maps are being used by the concerned state government agencies for further exploitation of groundwater resources. The approach for development of drinking water sources is shown in figure 2.

Success rate of borewells

Comparison observations have shown that groundwater prospect maps prepared using remote sensing methods, having success rates of locating borewells with good yield have gone up to about 90 per cent, as against 45 to 55 percent achieved using conventional methods alone. This feedback was received through many state governments and the Directorate of the National Drinking Water Mission. The success rates of wells drilled in different states (see table 2) have thus proved the

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capability of satellite remote sensing as a scientific source location methodology for groundwater exploration.

Time and cost effectiveness of remote sensing technology

Information contained in groundwater potential zone maps prepared from remote sensing methods has been very useful in narrowing down the target areas for groundwater exploration in a given region. Detailed hydrogeological and geophysical investigations on the ground are carried out based on information extracted from these maps/satellite data. This approach significantly saved time and money for ground water exploration. Use of groundwater potential zone maps along with the conventional system of locating well sites has resulted in a very high success rate in locating wells with good yield. Experience has shown that remote sensing surveys are about 10 times faster and cheaper than the conventional groundwater surveys.

Site location for water harvesting structures

Apart from mapping of Groundwater Prospect Zones, remote sensing has been found highly successful in the location of favourable areas for water harvesting structures such as check dams, anicuts, subsurface dikes, percolation/recharge tanks and inverted wells, etc., for augmenting the groundwater recharge. Sites for water harvesting structures have been located with the help of remote sensing imagery in several states under the National Drinking Water Mission.

Role of remote sensing in conjunctive use of surface and ground water

Conjunctive use of surface and groundwaters is fast emerging as an important water management issue, since several of the existing irrigation projects suffer from inadequate supplies. It has been observed that the available supply in many of the canal systems is one fourth to one third the amount equidistant for intensive agriculture; nor is it supplied satisfactorily in time. Moreover, neglect of the groundwater component in irrigation planning is one of the main causes of waterlogging and the attendant problems of salinity in the command areas (as it causes the water table rise in the process bringing up the subsoil salts). Therefore, conjunctive use of both the surface and groundwater resources is of the utmost importance to avert water abuse, to make optimum use of available water resources and avert problems caused due to mismanagement of water resources such as waterlogging, fall of the groundwater table, salinity/alkalinity of soils, salinization of aquifers in coastal zones, etc.

WATER MANAGEMENT IN COMMAND AREAS

Nearly 80 per cent of rural water needs are for irrigation of agricultural crops. Most of the green revolution in the developing countries is essentially due to the increase in irrigated area. Notwithstanding the fact that the majority of the irrigation projects have brought tremendous prosperity, the associated problems of salinity/alkalinity, waterlogging, etc., call for a scientific approach to the management of these water resources. Remote sensing technology can play a useful complementary role in managing the land and water resources of command areas to maximize production.

Reservoir operational and storage assessment

By combining the waterspread area of a reservoir obtained from satellite data with the area-storage curve of the reservoir, the storage volume may be estimated. This information, together with the crop types and acreage information, is used to develop reservoir optimization models for determining the reservoir operating schedules. Repetitive coverage permits estimation of volume change in reservoir storage during the crop growing period. Quantitative estimates of demand and supply enable determination of a number of irrigation schedules possible from the reservoir (see figure 3).

Irrigation scheduling

Management of water supplies for irrigation in command areas is an essential component in increasing agricultural production and efficient water use management. The usefulness of remote
sensing techniques in making an inventory of irrigated lands and identifying of crop types, including their extent and condition and production estimation, has been demonstrated in various investigations 2/ 3/.

Multi-date satellite data was used to inventory a surface water tank water spread area, irrigated cropland and their acreage. A water tank inventory was conducted of Araniar-Kortaliyar basin of Tamil Nadu using aerial photographs on 1:60,000 scale. Water spread areas, cropland and catchment areas of tanks were estimated and compared with those of conventional data.

Irrigation requirements of crops are determined by assessing the soil moisture and crop condition over an area so that the crop water demand can be estimated and irrigation scheduling planned accordingly. The measurement of canopy temperature and spectral reflectance of the crops through remote sensing techniques is an indirect method of assessing the plant stress. Studies on crop canopy temperature and spectral indices revealed that estimates of leaf area index (LAI) as well as evapotranspiration could be integrated into irrigation scheduling programmes.

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Microwave remote sensing would be useful for the detection of soil moisture 4/. It has been found that the scattering coefficient for microwave radar could be related to soil moisture, crop classification and plant moisture.

INTEGRATED LAND AND WATER RESOURCES STUDIES

A unique area where satellite remote sensing has been effectivey utilized for resource management is in surveys for rural development. It is ideally suited to bring out the inter-relationships of various disciplines. These surveys involve preparation of a set of resource maps using remotely sensed data, such as surface water bodies, groundwater potential zones, zones requiring groundwater recharge, types of soil, salinity/alkalinity and erosion status, existing land use and distribution of wastelands, etc. Based on these maps, an integrated land and water resource map, highlighting priority areas for agriculture development, fuel and fodder development, soil conservation and afforestation, etc., is prepared in order to arrive at a package of practices and strategies to address the local problems at the village/tehsil/district level.

Making use of such surveys, strategies can thus be worked out for ensuring all round development of vast rural areas of the country without upsetting the ecological balance. This integrated approach has been effectively used in India for combating/mitigating the effects of drought. Integrated resource maps are being prepared to assist in optimum management of land and water resources in drought-prone districts of India.

USE OF GIS IN THE MANAGEMENT OF WATER RESOURCES

The Geographic Information System (GIS) is an important tool for efficient storage retrieval, analysis and presentation of geographical data. This technology has tremendous potential in almost every discipline concerned with spatial information management. GIS is emerging as an important technology for natural resources management in India. As part of NRIS, under NNRMS (National Natural Resources Management System), several GIS projects in specific resources management areas, viz., wasteland development, hill area development planning, land use planning, district level planning, groundwater development and environmental management of watersheds have been taken up.

A pilot study for a wasteland development programme carried out by the Space Applications Centre (SAC) in parts of the Palitana taluka in the Bhavnagar district of Gujarat yielded encouraging results on the socio-economic aspects, fodder requirements of (village-wise) and identification of wastelands for the purpose of agricultural development. Work done in these projects and experience gained are indicative of the fact that GIS is rapidly becoming one of the most useful and powerful analytical tools of resource planners and managers.

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One of the GIS projects specific to water resources development has been taken up for the Subarnrekha River Basin, for the development of water resources on a regional scale. GIS will also be applicable to the micro and detailed level of water management. The project involves planning for water resources development, sharing of water by riparian states, regional economy, environmental management, watershed management, watershed prioritization, water quality assessment, flood monitoring and site location for dairy and poultry development.

In addition to spatial data provided by remote sensing socio-economic and meteorological data are integrated using GIS techniques. GIS is being used in carrying out locale-specific packages of practices to provide better management of water resources in drought-prone areas such as identification of sites for groundwater recharge, rainwater, harvesting, etc.

FUTURE THRUST AREAS

The future research areas in the field of remote sensing of groundwater will require the development of remote sensing models for prediction of groundwater depth and yield. Hydrogeological medels are being developed for quantifying the groundwater
yields. Such models are based on correlations between various parameters that govern the groundwater regime. The zones identified using remote sensing data are correlated with well
yield data available from the wells already existing in the area. Yield test/pump test data of borewells with a minimum density of at least one well in every 50 sq. km. is being used in developing the model.

Efforts have been made to quantify the likely yield of the groundwater prospect zones delineated from space imagery 5/. Efforts are being made by the Department of Space for depth-yield estimation of groundwater prospect zones by combining remote sensing information with the well data. Other recent areas include the use of artificial intelligence for groundwater prospect zone mapping, depth-yield estimation and the use of GIS for optimum management of groundwater resources.

Several studies have been made using images in the thermal infrared and microwave (radar) region, indicating the usefulness of these spectral regions for geological and groundwater applications.Estimation of groundwater quality, especially salinity, of aquifers from remote sensing is yet another important area of research. Also, salinization of aquifers is a common problem in coastal areas.

CONCLUSION

In India, remote sensing has been successfully used to provide information on groundwater potential zones of the country and to meet the supply requirements for

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drinking water of the rural population. The use of remote sensing for mapping of groundwater potential zone as part of National Drinking Water Mission has resulted in considerable time and cost saving. The groundwater potential zone mapping has been completed in a record time of one year for the entire country on 1:250,000 scale using satellite data. The maps prepared from remote sensing have been effectively used to locate high yielding groundwater sources for further development by respective state governments. Use of maps (prepared from interpretation of remote sensing data) has shown about a 90 per cent success rate of borewells, as against about 45-50 per cent achieved conventionally. The success story of the use of remote sensing for ground water mapping and surface water monitoring to meet rural water demand in India is very relevant in the context of using remote sensing for rural development. Methodologies developed for watershed prioritization, integrated resources development at the micro level and crop production forecasting and command area water management are equally important for developing nations.

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