SATELLITE AND SPACE COMMUNICATIONS **SSC**

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IEEE COMMUNICATIONS SOCIETY

SSC Newsletter **Vol. 23, No. 2, December 2013**

CONTENTS

The Satellite and Space Communications (SSC) Committee is a volunteer group actively involved in advancing satellite and space communication technologies within the IEEE. This committee is approved by the IEEE Communications Society and is governed by the constitution and bylaws of the IEEE as well as the other twenty-three Technical Committees in the Society. The committee belongs to the Technical Committee Clusters of Communication/Signal Processing (C/SP).

SATELLITE & SPACE

- JOIN US -

All conference attendees are welcome to join us in the SSC Committee meeting.
Location: Room 315/3rd floor-Atlanta Hilton and Towers Hotel
Date: Tuesday 10 December 2013
Time: 18.00-19.00 (EST)

Future SSC Meetings
June 2014, Sydney, Australia
Dec. 2014, Austin, TX, USA
June 2015, London, UK

GLOBECOM 2013 SSC Committee Activities:

Symposium on Selected Areas in Communications:

- *Wednesday, 11 December 2013 • 11:30-13:00*
  Location: Exhibit Hall, Lower Level
  SA-SSC3 Topics in Satellite and Space Communications (Interactive Session)
- *Wednesday, 11 December 2013 • 14:30-16:00*
  Location: Room 309/310, 3d Floor
  SA-SSC1 Satellite Communications and Navigation
  Chair: Claudio Sacchi (University of Trento, Italy)
- *Wednesday, 11 December 2013 • 16:30-18:00*
  Location: Room 302/303, 3rd Floor
  SA-SSC2 Satellite and Space Networking
  Chair: Hiroki Nishiyama (Tohoku University, Japan)

HOW TO JOIN SSC COMMITTEE AND MAILING LIST

If you like to join SSC Technical Committee: Please send your name and e-mail address to the SSC Secretary, optionally include your mail address, telephone and fax numbers.
If you like to join SSC Mailing List: Instructions on how to subscribe/unsubscribe are available at http://lists.scnl.dist.unige.it/listinfo/ssc/.

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MESSAGE FROM THE CHAIR

Prof. Igor Bisio

The Satellite and Space Communications (SSC) Technical Committee (TC) members will meet again during IEEE GC2013.

In my previous messages, I've discussed and shared some ideas about possible actions, discussed with the Officers and during the last SSC meetings held in Anaheim and Budapest, where took place IEEE GC2012 and ICC2013, respectively. Quoting my previous message "*The ideas and the consequence actions are aimed at reaching very important goals such as the publication of the SSC related research in prestigious journals and magazines, the organization and endorsement of Symposia, conferences and workshops.*", I consider necessary a further updating of the officer team work and of the TC activities.

In more detail, a new Charter have been prepared by maintaining the previous version and integrating it with more recent hot topics in the field of Satellite and Space Communications and Networking. Moreover, a new version of the *Operative Policies and Procedures (OP&P)* has been proposed. Even if the previous version was coherent with the IEEE ComSoc bylaws, the new version includes several aspects that ware not included before.

Concerning *Membership Management*, we can confirm that SSC TC has a good number of members but, recently, a limited number of researchers asked to be member of our Committee but, the good news is that, they are very active and have been already involved, actively, in the SSC TC main activities. This goes in the direction of persevering with the action of involving old and, in particular, new members in the TC activities.

As surely all of you remember we starts several initiatives to develop the SSC activities more intensively. Two work-groups were set up to work on two very important editorial proposals: one in IEEE Communications Magazine (COMMAG) and one in the IEEE JSAC. Quoting again one of my previous messages: "*The work-groups are composed by Kul Bahsin (NASA, USA), Naoto Kadowaki (NICT, Japan), Fred Vong (AsiaSat, China) e Claudio Sacchi (University of Trento, Italy) in the case of the COMMAG initiative and by Nei Kato (Tohoku University, Japan), Sandro Scalise (German Aerospace Center, Germany), Frederik Simoens (Newtech, Belgium), Alessandro Vanelli-Coralli (University of Bologna, Italy) in the case of the JSAC. Prof. Sacchi and Prof. Vanelli-Coralli are leading the two teams*". The proposal of the COMMAG special issue has been submitted and a preliminarily positive feedback has been provided by the Editor in chief of the Magazine, Dr. Sean Moore. The proposal for the JSAC special issue is under construction but it is quite ready to be submitted. On behalf the TC members, I want to deeply thank the two work-groups for their hard and precious effort.

Again concerning the TC activity, I want to deeply thank Prof. Hiroki Nishiyama who is the TC representative of our committee for IEEE ICC'14. He kindly provided the report about the SSC Track submission statistics: the SAC Symposium received 407 submissions and concerning each single track the submissions are: Access Networks ans Systems Track 18 (4%), Cloud Computing 67 (16%), Communications for Smart Grid 43 (11%), Data Storage 15 (4%), E-Health 42 (11%), Green Communications and Computing 105 (26%), Internet of Things 21 (5%), Nanoscale, Molecular, and Quantum Networking Track 22 (5%), Satellite and Space Communications 34 (8%), Social Networking 40 (10%). The result is coherent with the last years results. Nevertheless, the work-groups related to the two parallel editorial initiatives are with Academia, Industries, Research Institutes and Space Agencies of several World regions the issue related to the *Extended Cooperation* should be further enforced: the SSC TC should favorite the cooperation with Industries, Research Institutes, Standardization Institutes (e.g., CCSDS, ETSI), Space Agencies (such as NASA, JAXA, ESA) and other Societies such the IEEE Aerospace & Electronic Systems Society, the IEEE Signal Processing Society and the AIAA an other similar societies.

As usual the *SSC Newsletter* has been prepared. It has been edited by our Vice-Chair Dr. Hiromitsu Wakana that I want to deeply thank. As discussed in Anaheim, starting from the meeting in Budapest held during ICC'13, the Newsletter is managed electronically. It will be sent to all members before the meeting and few printouts will be distributed to the TC meeting attendants. This modality has been explicitly reported in the new *OP&P* document.

Concerning the *SSC Website and Mailing List*, it has been agreed that the SSC web site needed a partial revision by reporting only essential information. The Secretary Dr. Tomaso de Cola has evaluated, proposed and implemented several modifications. I want to deeply thank the Secretary for this precious contribution.

Finally, I want to remember the SSC Award initiative. This year the Selection Commitee that I have nominated were composed by Prof. Mario Marchese, Prof. Takaya Yamazato, Prof. Nei Kato, Dr. Hiromitsu Wakana and me. On the basis of a nomination provided by an illustrious SSC member, Prof. G. E. Corazza (University of Bologna, Italy), the 2013 SSC Distinguished Service Award has been assigned to Prof. Erich Lutz and Dr. Sandro Scalise of the German Aerospace Center (DLR) for their distinguished contributions and the firm and visionary leadership in the field of Satellite Communications.

Finally, a really important reminder. The term of the current officer team is approaching. On the basis of the new *OP&P* my duty is to nominate the so called Nominations & Elections (N&E) Committee whose aim is finding suitable candidatures among the SSC members for the three officers positions. Obviously, suggestions about nominations and/or self-nominations are welcome and will be carefully evaluated by the N&E Committee. Elections, as recently done, will be carried out electronically by using the TC mailing list and obviously by rigorously following the new fixed procedures.

Prof. Igor Bisio, Chair
Satellite and Space Communications TC

SCANNING THE WORLD

Dr. Hiromitsu Wakana

I would like to begin this "Scanning the World" by expressing my gratitude to the SSC Chair, Dr. Igor Bisio, for our challenging actions which are described in the "Message From The Chair" in this issue, about OP&P, COMMAG, IEEE JSAC, N&E etc. Your cooperation with these actions to enhance our TC's activities would be greatly appreciated.

I thank to the past officers of the SSC, who left Newsletters achieves since vol. 3, no. 2, November 1994 in the SSC's website. The early "Scanning the World", as future technology trends, described Ka-band and higher frequencies (Q/V-bands), personal/mobile satellite communications, non-geostationary satellites, satellite radio services, broadband IP services, etc. Prof. Abbas Jamalipour reported in "Scanning the World", vol.13, no.2, Dec. 2003, that during the period of 2000 to 2003 C-band capacity and Ku-band capacity have grown at 9% and 20%, respectively, but Ka-band capacity has fallen as much as 29%, due to the growth in data and video applications. The Ka-band frequency provides broader frequency bands and enables high data throughput with smaller end-user antennas, but it has drawbacks such as rain attenuation, hardware costs both for suppliers and for purchasers, and higher-level technologies. Countries other than Japan, Italy and Germany have stopped short of a full-scale introduction of Ka-band satellite communication services.

Despite these challenges, recently, several satellite companies have invested in the Ka band. Table 1 shows examples of Ka-band satellite systems, spacecraft bus, location, weight, the number of Ka-band transponders and launch date. The demand is growing not only in North/South America and Europe but also in the Middle East, Africa, and Southeast Asia. One of triggers for expanding Ka-band services is that mass-produced modems, cost 300 to 500 dollars, and high-throughput satellites with spot beams and a large capacity became available. Mass production of Ka-band space segments will improve hardware reliability and decrease the costs. Will Ka-band win the competition with Ku-band VSAT and terrestrial wireless like WiFi and WiMax systems? Who will find new broadband mobile applications in Ka-band? Wonders will never cease.

Dr. Hiromitsu Wakana, Vice Chair
Satellite and Space Communications TC

Table 1. Features of recent Ka-band satellites

Satellite Name	Satellite Bus	Location	Weight (launch)	Ka-band Transpond-er	Launch Date
Anik-F2	BSS-702	111.1°W	5910kg	38+12	2004/7/17
WildBlue-1	LS-1300	111.1°W	4,735kg	48+6	2006/12/8
ViaSat-1	LS-1300	115.1°W	6,740kg	59	2011/10/19
Spaceway-3	BSS-702	95°W	6,075kg	72	2007/8/14
Jupiter-1/ Echostar 17	LS-1300	107.1° W	6100kg	60	2012/7/5
AMC-15/16	A2100AXS	105/85°W	4021/4065kg	12 (24Ku)	2004/10/14, 12/17
Galaxy-28	SSL-1300	89°W	5493kg	24 (36Ku)	2005/6/23
KA-SAT	Eurostar E3000	13°E	6150kg	82 beams	2010/12/26
Eutelsat 8 West C (Hot Bird 6)	Spacebus-3000B3	8°W (13°E)	3905kg	4 (28Ku)	2002/8/21
Astra-4A	A2100AX	5°E	4600kg	2 (52Ku)	2007/11/18
Astar-2E, 2F	Eurostar-3000	28.2°E	6000 kg 5968 kg	3 (60Ku)	2013/9/29, 2012/9/28
Athena-Fidus	Spacebus-4000B2	25°E	3000kg	EHF/Ka	2014
Amazonas 3	LS-1300	61°W	6265kg	9 (33Ku)	2013/2/7
O3b	ELiTeBus	MEO (8063km)	700kg	12	2013/6/25
Arabsat-5C	Eurostar-3000	20°E	4630kg	12	2011/9/21
Inmarsat-5	BSS-702HP	TBD	5,900 kg	89	2014
Superbird B2	BSS-601	162°E	4057kg	6	2000/2/18
WINDS		143°E	4850kg	10	2008/2/23
Koreasat-5	Spacebus-4000C1	113°E	4465kg	4	2006/8/22
ABS-2, ST3, (Koreasat 8)	LS-1300	75°E	6000kg	78 in C/Ku/Ka	2014
iPSTAR-1 (Thaicom 4)	LS-1300S	119.5°E	6505kg	10 (87Ku)	2005/8/11

FORTHCOMING GLOBECOM AND ICC CONFERENCES

ICC 2014

June 10-14, 2014, Sydney, Australia

http://www.ieee-icc.org/2014/

The 2014 IEEE International Conference on Communications (ICC) will be held in the beautiful city of Sydney, Australia from 10-14 June 2014. Themed "Communications: The Centrepoint of the Digital Economy," this flagship conference of IEEE Communications Society will feature a comprehensive technical program including twelve Symposia and a number of Tutorials and Workshops. IEEE ICC 2014 will also include an exceptional expo program including keynote speakers and Industry Forum & Exhibition.

GLOBECOM 2014

December 8-12, 2014, Austin, TX, USA

http://www.ieee-globecom.org/2014/

IEEE GLOBECOM is one of two flagship conferences of the IEEE Communications Society, together with IEEE ICC. Each year the conference attracts about 3000 submitted scientific papers. A technical program committee of more than 1,500 experts provides more than 10,000 reviews, and from this a small fraction of the submitted papers are accepted for publication and presentation at the conference. The conference meets once a year in North America and attracts roughly 2000 leading scientists and researchers and industry leaders from all around the world. IEEE GLOBECOM is therefore one of the most significant scientific events of the networking and communications community, a must-attend event for scientists and researchers from industry and academia.

ENDORSING/ RELATED CONFERENCES AND WORKSHOPS

MILCOM 2014

October 6-8, 2014, Baltimore, MD, USA

http://www.milcom.org/

The MILCOM 2014 - Military Communications Conference is dedicated to military communications networking, services, timing and applications, including:

- Waveforms and Signal Processing view details
- Selected Topics in Communications view details
- International Perspectives on Communications
- Networking Protocols and Performance view details
- Services and Applications view details
- Cyber Security and Trusted Computing view details
- System Perspectives view details

The MILCOM 2014 - Military Communications Conference brings together professionals from the industry, academia, and government.

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
IEEE Aerospace Conference	March 1-7, 2014 Yellow Stone Conference Center in Big Sky, Montana, USA	http://www.aeroconf.org/
WCNC 2014 IEEE Wireless Communications and Networking Conference	April 6-9, 2014 Istanbul, Turkey	http://wcnc2014.ieee-wcnc.org/
International Conference on Localization and GNSS	June 24-26, 2014 Helsinki, Finland	http://www.icl-gnss.org/
SPECTS 2014 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	July 6-10, 2014 Monterey, CA, USA	http://atc.udg.edu/SPECTS2014/
CITS 2014 International Conference on Computer, Information and Telecommunication Systems	July 10-11, 2014 Jeju Island, South Korea	http://atc.udg.edu/CITS2014/
ASMS/SPSC2014 7th Advanced Satellite Multimedia Systems Conference & 13th Signal Processing for Space Communications Workshop	September 8-10, 2014 Livorno, Italy	http://www.asms2014.org/
19th **Ka and Broadband** Communications Navigation and Earth Observation Conference 2013	October 1-3, 2014 Salerno, Italy	http://www.kaconf.org/
ITST-2014 International Conference on Telecommunications for Intelligent Transport Systems	2014 TBD	http://

To all SSC members: If your postal address, telephone or fax numbers have changed, please update them with the committee secretary. You can review our current records on our web page at http://committees.comsoc.org/ssc/.

Satellite/Terrestrial Integrated Mobile Communications System for Safe and Secure Society

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Abstract — **The research and development of Satellite/Terrestrial Integrated Mobile Communications System (STICS) has been conducted to aim at the integration of satellite and terrestrial mobile communications and efficient spectrum utilization by frequency sharing between satellite and terrestrial mobile communications. Sub-projects "the satellite/terrestrial cooperative control technology" and "the technology on interference avoidance between satellite/terrestrial system and frequency allocation", and the integration test was carried out to conduct the R&D.**

INTRODUCTION

The effectiveness of satellite-based mobile phone system in disaster management is well known. However mobile phone system is more effective if terrestrial mobile phone in daily use is connected via satellite link in disaster scene.

In recent years, mobile communication systems with integrated satellite/terrestrial functions have been planned and developed to provide wide-ranging services. They are called MSS/ATC (Ancillary Terrestrial Component) system [1] or MSS/CGC (Complementary Ground Component) system [2]. These systems are the communication systems that will make up for the lack of coverage in satellite systems by effectively employing a terrestrial system. These systems will also improve frequency utilization efficiency by sharing the frequency band between terrestrial and satellite systems. Typically, the system applies large satellite antenna with a diameter of 10-20 m with operating frequency of L or S band to cover the service area with hundreds of spot beams.

To verify feasibility of integration of satellite and terrestrial mobile phone system with integration of the frequencies of the terrestrial and satellite systems, we have conducted research and development on Satellite/Terrestrial Integrated Mobile Communications System (STICS) for safety in disaster management [3]. The communications system suitable for service area and population distribution in Japan has been designed.

OVERVIEW OF R&D

Figure 1 illustrates a conceptual sketch of STICS. A common handheld terminal is used for terrestrial and satellite communications. To realize "dual" communication, the system is managed using a dynamic network controller. The system is assumed to share frequency bands 1980–2010 MHz and 2170–2200 MHz (assigned for Mobile Satellite Service (MSS) in Radio Regulations) between satellite and terrestrial system. These issues are mainly classified into the system-side technologies. The system also requires high EIRP and G/T communication satellite using a multibeam antenna with the 30m-class-diameter reflector. The satellite employs around 100 high gain multibeams to realize Japanese islands and the Exclusive Economical Zone (EEZ) as satellite system service area. Satellite communication resource needs to be dynamically reallocated to accommodate traffic demand which drastically increases in disaster area in disaster scene. These functions are mainly classified into the technologies onboard satellite.

Therefore we conducted the R&D project by dividing the project to two sub-projects. Sub-project A focuses on the satellite/terrestrial cooperative control technology, which is a dynamic control system of integrated satellite/terrestrial communication system and study for frequency sharing. Sub-project B is technology on interference avoidance between satellite/terrestrial system and frequency allocation, which includes technologies on the communication payload onboard satellite such as high linearity amplifier, digital beam-forming technology for hundred-class super-multi-beam and low-sidelobe antenna, and digital channelizing technology for resource allocation. Integration test of sub-project A and B is planned to verify feasibility of overall system.

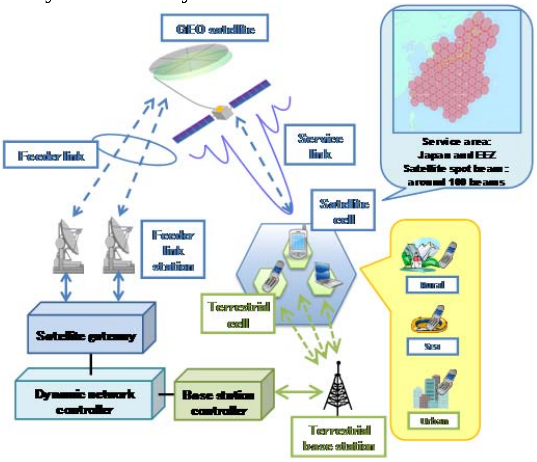

Figure 1. Conceptual sketch of STICS.

Satellite/Terrestrial Cooperative Control Technology

1) Frequency sharing technology

There are two frequency allocation scheme, frequency sharing and frequency division scheme. Effectiveness of frequency sharing scheme is compared to frequency division scheme by means of spectral efficiency. Result of theoretical study indicates that satellite system bandwidth in frequency sharing scheme is twice as much as that in frequency division scheme, and that terrestrial system bandwidth in frequency sharing scheme is larger than that in frequency division scheme (becomes twice with increase of cluster size). Simulation considering satellite-terrestrial interference shows that spectral efficiency in frequency sharing scheme is larger than that in frequency division scheme.

In frequency sharing scheme, co-channel interference exists between four desired links. Especially, interference caused from terrestrial system to satellite is important issue because aggregate interference from large number of terminals/base stations is received at the satellite. Measuring transmit power of existing W-CDMA system is useful in estimating the interference power from terrestrial system to satellite in STICS system. Therefore we carried out the measurement campaigns of W-CDMA cellular phone system transmit power by using test van (Fig. 2), aircraft (Fig. 3), and handcart.

Figure 2. Test van for transmit power measurement.

Figure 3. Aircraft for or transmit power measurement.

Measurement campaign for output power of the W-CDMA cellular phone with test van was conducted at several locations from dense urban to rural area around Kanto district in Japan including Tokyo. Result indicates that the average transmit power from cellular phone is below -5dBm in urban area and that transmit power is inversely proportional to population density. To estimate the interference power caused by base stations and terminals towards satellite in STICS, experiments using aircraft has been conducted in which the radiation powers of the existing W-CDMA mobile base stations and mobile terminals were measured by the aircraft. Result indicates that received signal power from W-CDMA uplinks (interference from terminal) is 25 to 30 dB lower than that from W-CDMA downlink (interference from base stations). It implies that interference power to satellite in normal mode is lower than that in reverse mode.

Based on these measurement results, system capacity of the STICS based on required C/N_0 is calculated in the normal mode by the developed interference calculation simulator and channel capacity calculation subroutine. Detailed interference model is constructed and measured data on transmit power is used as input data for the model. Calculation result shows that maximum number of satellite channels (10,000) and over ten million terrestrial channels are able to be shared in usual traffic scenario (and in one example scenario of disaster). From this result, frequency sharing between satellite and terrestrial system is feasible.

2) Dynamic network control technology

Network architecture and dynamic control algorithm has been studied to flexibly assign frequency band depending on temporal change of satellite and terrestrial traffic. Moreover, hardware emulator is developed to verify this dynamic control algorithm.

Proposed network architecture is based on 3GPP (3rd Generation Partnership Project) architecture. Satellite and terrestrial systems are connected to each other via administrator server which has a capability of dynamic network control. In administrator server, usage ratio, variation ratio and abnormal detection of the terrestrial and satellite network is monitored and used for an integration control.

A hardware simulator has been developed to verify this dynamic network control algorithm as shown in Fig. 4. It consists of terminal, satellite, satellite gateway, terrestrial mobile base station/control station, and dynamic network controller to simulate communication process such as call connection, handover, etc.

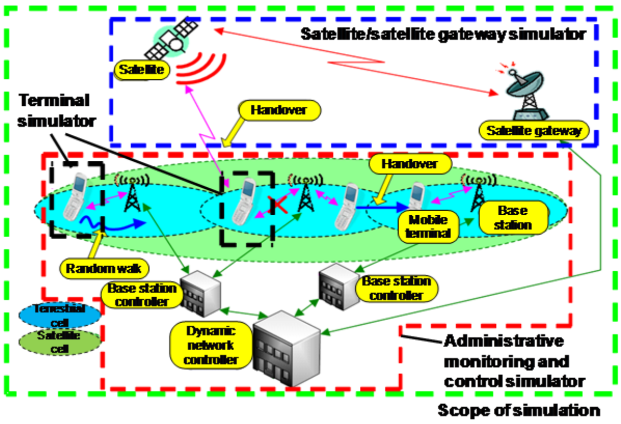

Figure 4. Schematic diagram of hardware simulator.

The test by using the hardware simulator was carried out which is a large-scale simulation mimicking disaster scene by using actual traffic data in the Tohoku-Pacific Ocean Earthquake in Japan. High traffic and base station damage at disaster area are simulated. Simulation result shows that it is difficult to satisfy all traffic demand in large-scale disaster. However, it is also observed from the simulation that priority calls in the disaster area are able to be connected when most of bandwidth is assigned to the satellite beam in the disaster area. From these observations, it is concluded that priority-based access control enables priority call connection to satellite link and cooperative control technology including dynamic control algorithm is effective.

Technology on Interference Avoidance between Satellite/Terrestrial System and Frequency Re-allocation

1) Concept of satellite onboard communications system

To cover the required service area by using 30m-class-diameter large satellite antenna, around hundred super-multibeam system is required. Sidelobe level of the satellite antenna needs to be maintained in low level to suppress beam-to-beam interference level in multibeam system, and to suppress interference level to/from other systems. To satisfy these requirements, analog beamforming is not practical. Onboard digital beamforming is advantageous in realizing these requirements because of its scalability and flexibility.

Satellite and terrestrial traffic is asymmetrically distributed in wide area and changing temporally. Especially in emergency situation such as disaster, large traffic happens in disaster area. Therefore satellite resource (e.g. frequency, power) needs to be flexibly allocated to each satellite beam depending on the traffic state. Onboard digital channelizing is a candidate technology to satisfy this requirement because of its flexibility.

Figure 5 illustrates the schematic diagram of satellite onboard communications system. It consists of user-link RF section in S-band with 30-m-class large reflector antenna, digital section, and feeder-link section. Digital section has digital beamformer and digital channelizer (DBF/channelizer) for transmit and receive section to meet these requirements. To verify feasibility of functions needed for onboard satellite, small-scale models of user-link RF section (S-band radiating elements, diplexers, LNAs, SSPAs, D/Cs and U/Cs) and digital section (DBF/channelizer dedicated for sixteen elements

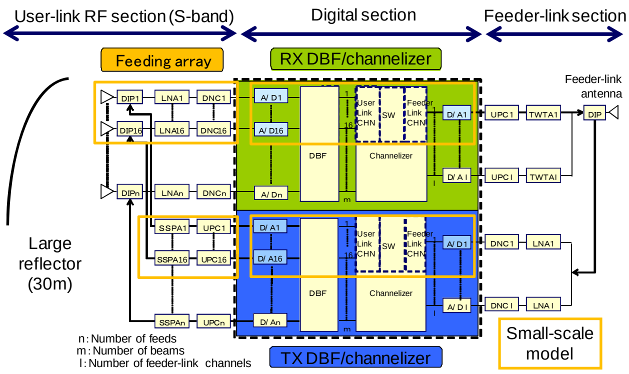

Figure 5. Schematic diagram of satellite onboard communications system.

and sixteen beams) has been developed and tested. Figure 6 shows the outlook of small-scale models.

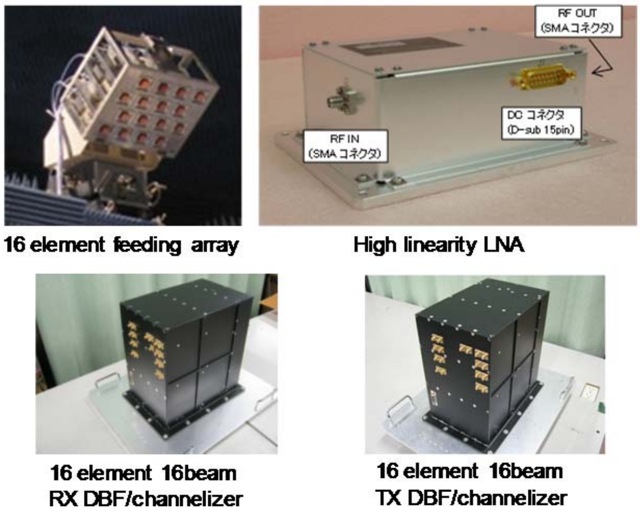

Figure 6. Outlook of small-scale models.

2) Super-multibeam forming technology

We developed prototype DBF/channelizer with sixteen-elements and sixteen-beams as part of hundred-elements and hundred-beams DBF/channelizer. As shown in Fig. 7, DBF, sixteen element feeding array, and 3.3m deployable mesh reflector was applied to multi beam measurement in anechoic chamber. Measurement of hundred beams is realized by multiple repetitive measurements of sixteen-beam DBF. Hundred beams with multi color frequency allocation (number of frequencies=seven) is allocated in service area. The result indicates that hundred beams are formed to expected directions and that the measured radiation patterns agreed with the calculated patterns. From these observations, effectiveness of super-multi-beam forming technology is confirmed.

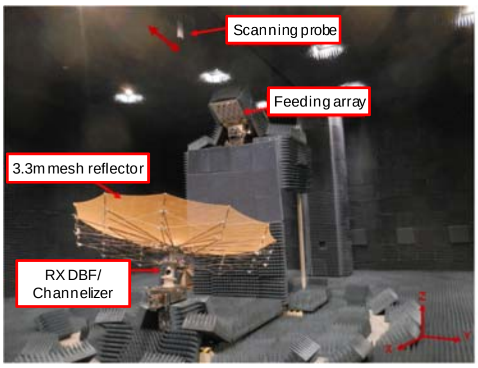

Figure 7. Outlook of multibeam measurement system.

3) Low sidelobe antenna technology

To verify low-sidelobe in STICS satellite antenna, the antenna sidelobe suppression test based on DBF weight control has been conducted. Sixteen element DBF and feeding array is dedicated to the measurement. At first, radiation pattern of sixteen element feeding array with sixteen element DBF is measured by using near-field measurement system. Then, electromagnetic field on virtual large reflector (27m diameter) illuminated by the feeding array is calculated from measured near-field of the feeding array. Finally, Secondary radiation pattern is calculated by the electromagnetic field on the virtual large reflector. Four repetitive measurements of sixteen element DBF and feeding array is conducted to obtain secondary radiation pattern of the reflector with 64 element feeding array. Exciting coefficient of DBF for low-sidelobe antenna is calculated and set to the DBF before the measurement. The evaluation result indicates that low sidelobe with 20 dB from peak gain of main beam was obtained. Furthermore, several tests were carried out to study the distortion of radiation pattern of large mesh reflector antenna caused by heat distortion of reflector and compensation of its radiation pattern. One of the test was antenna sidelobe suppression test in anechoic chamber using DBF/channelizer, feeding array and 3.3m deployable reflector. In this test, reflector surface shape was intentionally distorted and was measured. Sidelobe level was successfully suppressed based on DBF weight control. Throughout this test, we confirmed that distorted radiation pattern is able to be compensated with DBF technology, and that in future deployment of this technology, onboard measurement methodology for reflector surface shape is required.

4) Frequency re-allocation technology

Channelizer realizes efficient spectrum usage by re-arrangement of feeder link channel. It also has resource re-allocation function by which frequency band allocation for each satellite beam is dynamically changed. Required feeder link bandwidth for channelizer in STICS is 120 MHz. However, we developed digital channelizer with feeder link bandwidth of 200 MHz to meet future requirement for future broadband satellite transponder. With this channelizer, the feeder-link bandwidth is reduced from 400 MHz to 200 MHz (400 MHz is feeder-link bandwidth without using channelizer).

Performance test for DBF/channelizer by the coupling test of transmitting and receiving DBF/channelizer successfully verified basic functions and performances such as resource re-allocation, dynamic range, spectrum efficiency, and transmission performance. A measured example of resource allocation test is shown in Fig. 8.

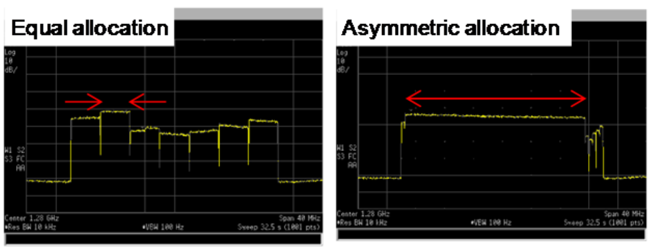

Figure 8. Example of resource allocation test using channelizer.

Integration Test

Finally, an integration test of sub-project A and B has been demonstrated to evaluate effectiveness of STICS as the communication system. The integration test equipment consists of a feeder-link station (dynamic network controller), a satellite station (DBF/channelizer, feeding array, and 3.3m deployable reflector), and user terminals (voice/video communication equipment). Traffic data and communication outage status of terrestrial base stations based on the Tohoku-Pacific Ocean Earthquake in Japan are input to the dynamic controller. Dynamic controller selects an appropriate satellite frequency band assignment for seven satellite beams depending on this traffic data and sends control signal on the frequency band assignment to the DBF/channelizer.

Using the integration test equipment, a dynamic resource allocation test was conducted. The result indicates that the frequency band assignment in DBF/channelizer was dynamically changed based on the control signal from the dynamic controller and that most of the satellite resource was allocated to the satellite beam for disaster area. As is verified in the test in sub-project A, priority calls in the disaster area are able to be connected when most of bandwidth is assigned to the satellite beam in the disaster area. These results indicate that the limited satellite resource is utilized efficiently in disaster scene. From these test, the effectiveness of STICS as the communication system was verified.

Conclusion

Throughout the R&D, we proposed the concept of STICS, conducted the R&D project and verified feasibility of the concept by conducting two sub-projects and the integration test.

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