CGMS XXXII NOAA-WP-33
Prepared by USA
Agenda Item: IV.2

MULTI-CONSTELLATION USER TERMINAL (MCUT) DEVELOPMENT

NOAA has developed a prototype Multi-Constellation User Terminal (MCUT) to help facilitate, explore and promote technology that could enable the commercial development of Direct Readout user stations that would receive and process signals from multiple satellite constellations. NOAA-WP-33 summarizes this effort including the advanced technologies employed by the prototype station.

The development effort is proceeding to further extend the MCUT capabilities. Additional meteorological services will be addressed. The ability to operate at higher data rates and to use other error correction decoding will be investigated to meet the requirements of future services such as METOP and the NPOESS LRD systems. Presently, the GOES GVAR service is the highest data rate service at L-band frequencies. This service, however, requires a larger aperture than other services. The existing antenna feed and receiver will be installed in a suitable reflector antenna to demonstrate the flexibility with which this prototype technology can be applied. Because a positioner capable of tracking polar satellites is not required for GOES GVAR reception, the implementation cost would actually be less than a design capable of tracking polar satellites. Other future high data rate services will be available at X-band. An examination will be made of technology for a similar architecture for these services. The existing high resolution geostationary services and these future X-band services require about the same aperture size. A dual frequency L- and X-band design would provide a higher resolution capability for polar satellites and a higher resolution, refresh capability following the same design philosophy as the existing MCUT prototype. Antenna tracking requirements are more stringent with the narrower X-band antenna beamwidth; application of open loop antenna tracking techniques is being done as a lower cost alternative to the traditional closed loop tracking designs.

Report on the Status of Multi-Constellation User Terminal (MCUT) Development

1. Introduction

The number and capabilities of meteorological satellites is rapidly expanding on an international scale. An examination of individual satellite systems reveals that, while the systems employ a variety of data rates, modulation formats, and error correction techniques, there is a commonality of frequency range of operation and requirements for antenna aperture diameter for direct readout of the downlink data. The MCUT development was motivated by the belief that technology with the suitable flexibility to accommodate different modulation formats could be used to configure user terminals that can sequentially receive data from a variety of meteorological services. Not only can using a single user terminal in place of several dedicated terminals for different meteorological services reduce costs, but also the available technology, developed chiefly for wireless applications, offers the required flexibility at affordable prices. In operation, such a user terminal can receive data from polar satellites when in view and geosynchronous satellites at other times. Such operation affords meteorologists with the resolution capabilities of polar satellites and the rapid refresh of geostationary satellites to serve the majority of meteorologist's needs for satellite data in an affordable package. This reasoning resulted in the MCUT development.

2. NOAA Directive

NOAA funded a feasibility study to determine the practicability of achieving reception from multiple satellite sources. The particular meteorological constellations and associated direct broadcast services being considered for this development are as follows:

Satellite	Service	Freq (MHz)	BW MHz	Data rate (Mb/s)
Metop	LRPT	137.9	.150	.072
Metop	AHRPT	1701.3	4.5	3.5
NPOESS	LRD	1706	8.0	3.88
NOAA/POES*	APT	137.5 – 137.62	.034	.017
NOAA/POES*	HRPT	1698 /1702.5	2.66	.665
FY-1 *	CHRPT	1698-1710	5.6	1.3308
FY-3A	AHRPT	1698-1710	5.6	4.2
Meteor 3M N2	LRPT	137.89 / 137.1	0.15	0.064
Meteor 3M N2	HRPT	1700	2.	0.665
DMSP		??	??	
GOES *	LRIT	1691.2		.128
GOES *	GVAR	1685.5		2.2
MSG *	LRIT	1691.		.128
MTSAT	LRIT	1691.		.15

The MCUT system employed a two phase development. Phase one development represents only those constellations marked with an asterisk (*). These services shall be operationally

tested and demonstrated. Currently, NOAA has successfully acquired the NOAA HRPT, GOES LRIT and the CMA FY-1 broadcast services.

The MCUT configuration will consist of the following components:

1. A tracking antenna (includes positioner)
2. Pre-amplifier
3. Down-converter
4. Demodulator
5. Processor with basic data management and display capabilities

This existing version of the MCUT station uses a receiver that is configured from Common-Off-the Shelf (COTS) Application Specific Integrated Circuit (ASIC) technology. The ASIC design option is a complete MCUT station consisting of the entire list of components above for its initial implementation.

The ASIC design option has L and S-band RF front ends that are designed with attention to potential interference from other microwave systems. Also, there is a VHF input for reception of APT like services.

The software design option supplies compatible frequency conversion components, to interface with the IF signal frequency of the ASIC option and employs two high-end standard PC compatible processors, which performs the demodulation, bit-synchronization, Viterbi Decoding, frame synchronization, Reed-Solomon decoding, and any government supplied application layer processing.

3. Multi-Constellation User Terminal Development

3.1 Existing MCUT Prototype

A prototype user terminal was delivered to the NOAA location in Suitland MD in February 2004. This prototype has the capability to receive both the L-band downlink transmissions and S-band transmissions used by military meteorological satellites. A four foot diameter reflector antenna is used to provide design margin and two antenna feed designs were demonstrated, one having a wide bandwidth response and the other having a dual-band capability to cover the L- and S-band frequencies. Novel features are incorporated into the design to control the feed side-lobe and back-lobe levels to increase RF efficiency. An ASIC-based receiver has the capability to receive VHF, UHF, L- and S-band downlink services in a compact package. The digital technology used in the receiver includes an A/D, a tuner/demodulator chip set, and a Viterbi decoder. This technology affords the flexibility to receive existing and future satellite downlinks with a minor impact on implementation costs. An examination of the terminal hardware cost reveals that the most expensive component is an antenna positioner capable of tracking polar satellites. The MCUT development pursued a positioner design comprised of commercial components, e.g., motors, gear drives, encoders, bearings, etc. whose total cost was less than $3,000 US. This positioner was designed to allow operation with wind gusts up to 40 mph. A USB interface between the integrated antenna/receiver and a remotely located laptop computer is used. The laptop computer

provides the commanding for the antenna positioner and receiver, image processing, and data storage.

This prototype has been used to receive and display data for the HRPT and CHRPT polar services meteorological services; additional effort is required to display the GOES LRIT service. Exclusive of local obscure limitations, the prototype terminal provides reliable horizon-to-horizon reception of these services.

3.2 Future Development Efforts

The development effort is proceeding to further extend the MCUT capabilities. Additional meteorological services will be addressed. The ability to operate at higher data rates and to use other error correction decoding will be investigated to meet the requirements of future services such as METOP and the NPOESS LRD systems. Presently, the GOES GVAR service is the highest data rate service at L-band frequencies. This service, however, requires a larger aperture than other services. The existing antenna feed and receiver will be installed in a suitable reflector antenna to demonstrate the flexibility with which this prototype technology can be applied. Because a positioner capable of tracking polar satellites is not required for GOES GVAR reception, the implementation cost would actually be less than a design capable of tracking polar satellites. Other future high data rate services will be available at X-band. An examination will be made of technology for a similar architecture for these services. The existing high resolution geostationary services and future X-band services require about the same aperture size. A dual frequency L- and X-band design, similar to the existing MCUT prototype, would provide a higher resolution capability for polar satellites and a higher refresh capability for geostationary satellites. Antenna tracking requirements are more stringent with the narrower X-band antenna beamwidth; application of open loop antenna tracking techniques is being done as a lower cost alternative to the traditional closed loop tracking designs.

4. Conclusion

NOAA has demonstrated the capability of a multi-constellation user terminal to receive geostationary satellite data (LRIT) and polar-orbiting satellite data (HRPT). The existing MCUT system will continue to undergo evaluations and improvements at the NOAA facility in Sutiland, Maryland. The next phase of the MCUT development will include enhancements to increase the data type reception and its processing capacity. As with the first MCUT prototype, NOAA will make every effort to make the second MCUT prototype a low cost system for world wide use.

5. References

1. J. T. Shaffer and R. B. Dybdal, “Dual Frequency Tactical Antenna,” 1998 IEEE AP-S Symposium Digest, Atlanta GA, pp 58-61, June 21-26, 1998.
2. J. D. Michaelson and R. B. Dybdal, “Development/Demonstration of a Tactical RDS Terminal,” 2003 MAXI Symposium.