Application of Polaris PNT PBC
2018-02-16

Response to Question 6: Research Project

The FCC provides the following guidance for this Response (numbers in brackets added):[1]

> **Question 6: Research Project**
> Click on the appropriate button in response to the question. If the answer to this question is YES, please provide an exhibit with the following information**:**
> **[1]** A description of the nature of the research project being conducted, a showing that the communications facilities requested are necessary for the research project involved, and
> **[2]** a showing that existing communications facilities are inadequate.
> Exhibits may be entered immediately after submitting this form or later by clicking on the ADD ATTACHMENTS button.
> NOTE: When submitting this exhibit, please enter "QUESTION 6: STATEMENT OF RESEARCH PROJECT" in the description field and select "Text Documents" as the document type.

Responses

[1] Description of the nature of the research project being conducted:

Non-interfering bench and low-power testing of radios with non-radio devices for very wide-area precise Position, Navigation and Timing applications with licensed and unlicensed spectrum under sections 22.521,90.259, 90.357, 90.377, 15.707.

[2] **S**howing that existing communications facilities are inadequate:

This following shows **that the existing communication facilities are inadequate** for the above [1] description of the nature of the research project being conducted:

In the Appendix hereto, below, the numbered items and www links pertain to the Applicant, Polaris PNT PBC, and its President Warren Havens, as manager of FCC radio spectrum licenses and systems, and related research: In addition to the following text of this section [2], these numbered items and links further shows why there are insufficient communication facilities.

A. The "[1] very wide-area precise Position, Navigation and Timing applications involved," are based in large part upon using low-band VHF 'paging' spectrum in the 35 and 43 MHz ranges for "Meteor Burst Communications" ("MBC") and other "Meteor Burst" radio signaling, for which currently there are no communication facilities in the United States at all.

In this regard, in this low-band VHF spectrum range:

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[1] From: Federal Communications Commission (FCC) Experimental Licensing System – Conventional License User Manual Prepared for: Federal Communications Commission Office of Engineering Technology October 2016.

1. There are MBC radio systems used by the US Department of Agriculture ("DOA") in its "SNOTEL" systems covering much of the United States for certain environmental monitoring (including the levels of snowpack in the mountain regions):

However, these do not provide for any [1] very wide-area precise Position, Navigation and Timing applications, and also these are not available for non-DOA uses.

2. Also, there are some University lead programs, such as the MIT programs at or based at its Mount Haystack facilities and programs in Massachusetts, that have antenna arrays used for radio astronomy, and earth-atmosphere meteor detection, that may be used for aspects of the facilities that the Applicant, Polaris, plans for the subject "[1] very wide-area precise Position, Navigation and Timing applications involved."

However, these antenna arrays do not provide for the majority of the components needed, and they would need too much work to reconfigure for the research involved: some of the technologies in these arrays, and some parts used, are practically usable, but not these constructed operational facilities per se.

B. The "[1] very wide-area precise Position, Navigation and Timing applications involved," are also based in large part upon use of spectrum in the mid to higher parts of the VHF range, up to 222 MHz, as well as some spectrum in the UHF range including in the 902-928 MHz range, on licensed and unlicensed basis.

The use of this spectrum involves, for the most part, one-way digital-radio broadcast to send GPS, GNSS correction signals to mobile things using "Network Real Time Kinematic ("Network RTK" or "N-RTK") devices and systems, which obtain the correction data from the US NOAA CORS program (Continuously Operating Reference Station (or "CORS"): see https://www.ngs.noaa.gov/CORS/ program that coordinates hundreds of N-RTK reference stations in the United States).

In this regard, in this these VHF and UHF spectrum ranges, there are no existing digital-radio broadcast communication facilities that have the required installed and configured equipment to support the "[1] very wide-area precise Position, Navigation and Timing applications involved."

Appendix

1. Mr. Havens is the sole author of and has a depth of knowledge in the radio-systems and methods described in the following websites and all of the contents but for the publishes materials by listed other sources used in these websites: www.polarispnt.space and www.terranautx.com.

2. Mr. Havens was the originator, a contributor to, and the grant provider to the University of California Berkeley Study on high accuracy location wireless. Copy at: https://people.eecs.berkeley.edu/~kannanr/assets/project_loc/CHALOCBA.pdf. The Acknowledgements refer to a gift from ATLIS Wireless, LLC that was formed and managed by Havens, of Berkeley California to support various FCC-licensed spectrum based programs.

3. Mr. Havens was invited to, and prepared and submitted the following presentation to, the National Public Safety Telecommunications Counsel on certain new digital radio technologies and systems. Copy at: http://www.npstc.org/download.jsp?tableId=37&column=217&id=1094&file=20080618-Havens-TETRA-v2.pdf

4. Mr. Havens is the originator and author of "Advanced Railroad Wireless Using PTC as a Foundation...". January 2014. By Warren Havens involving the 'Skytel' companies he managed. Copy at: https://ecfsapi.fcc.gov/file/7521064429.pdf

5. Mr. Havens is the originator, commissioned, and contributed to the paper: "LTE Deployments in the LMS band for ITS Radio Communications and Location," by Nishith D. Tripathi, Ph. D. Copy at:
https://wireless2.fcc.gov/UlsEntry/attachments/attachmentViewRD.jsp?applType=search&fileKey=96967609&attachmentKey=18943468&attachmentInd=applAttach
As this paper states, it was commissioned by the 'Skytel' companies (listed in item 4 above) managed by Mr. Havens. This paper is in FCC docket 06-49 regarding the LMS radio service.

6. Mr. Havens prepared the radio-frequency and licenses partition and disaggregation design for the Amtrak "corridor" license using AMTS spectrum shown in FCC records. See FCC DA 15-287 and related granted assignment applications, attached below with the corridor map.

7. Mr. Havens is the originator, commissioned and contributed to the study and paper: "Nationwide High Accuracy Positioning Infrastructure and Services, Including for Intelligent Transportation Systems: Background, Technology, Uses, Developments and Challenges. April 2, 2010, by C. Rizos to Skybridge Spectrum Foundation... Berkeley California ("SkyTel"). Copy at:
https://www.scribd.com/document/31932756/Chris-Rizos-to-Sky-Tel-Nationwide-High-Accuracy-Positioning-Infrastructure-and-Services-GNSS-Terrestrial-Including-for-Intelligent-Transportation-S

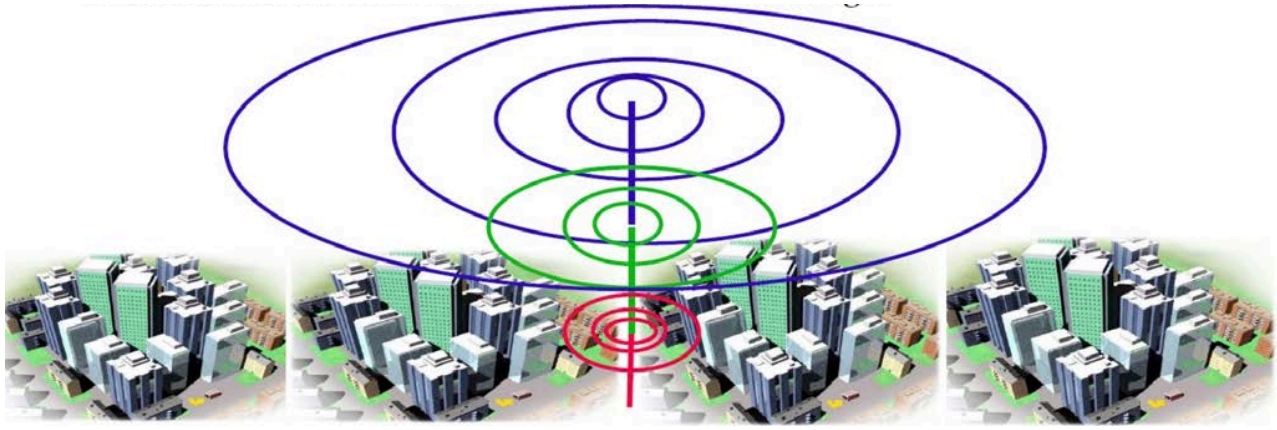
8. Mr. Havens is the originator, commissioned and contributed the paper: Wireless for Railroads, by Ron Linsay, 2011. Copy at:
https://www.scribd.com/document/53478557/Wireless-for-Railroads-By-Ron-Lindsey-April-2011

9. The value of digital radio broadcast systems, in the VHF and UHF ranges indicated in this Attachment above, for the "[1] very wide-area precise Position, Navigation and Timing applications involved," described above, is further shown in *following* Appendix attachment.

/ / /

Appendix attachment

[i] General



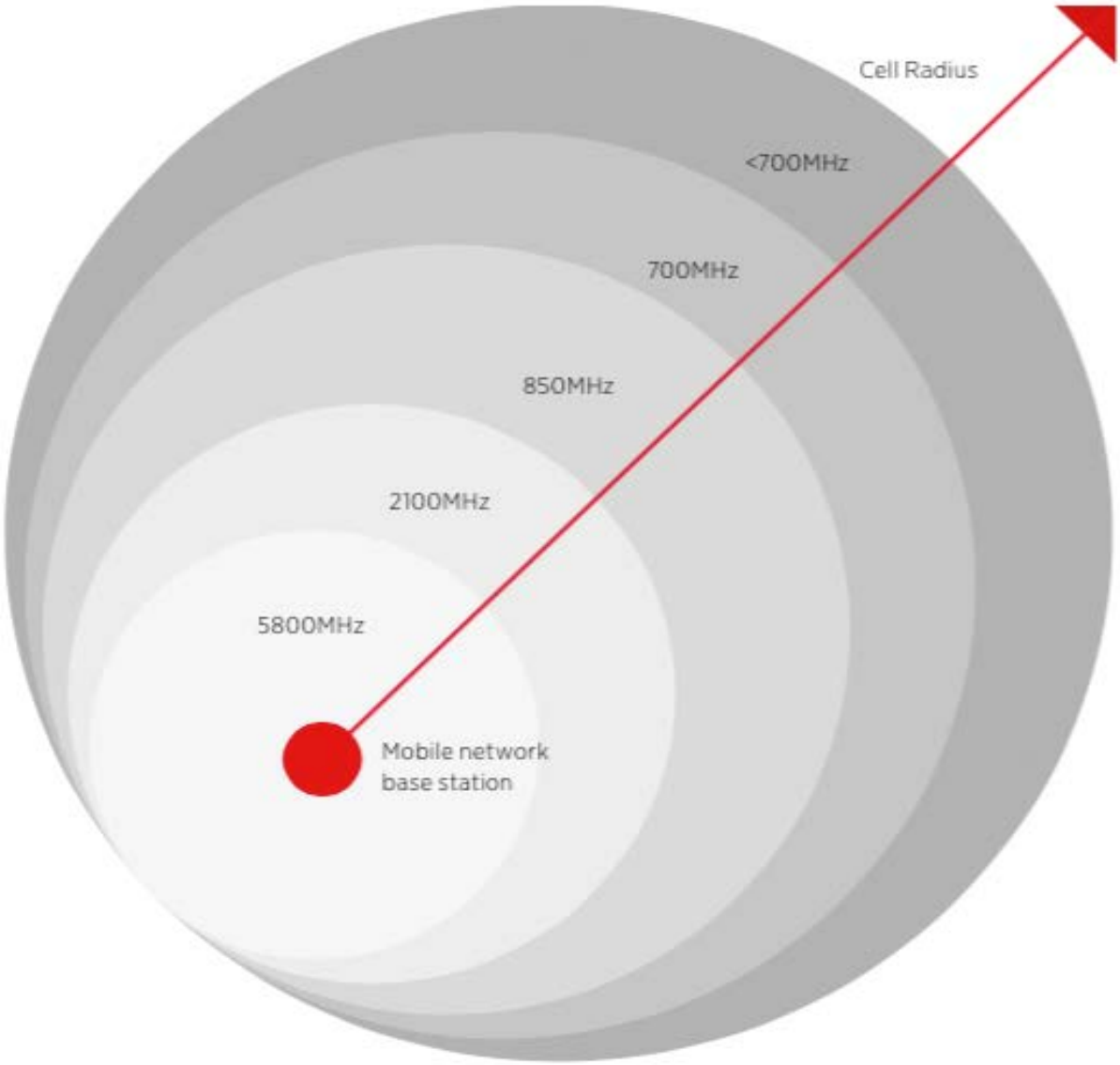
The higher the *height* of a transmit (or transmit-receive) station antenna, for given transmit *power*, the longer- wider the coverage range, and the lower the cost of given coverage area, and the less time to deploy a network for given coverage (less antenna sites to secure, establish, interconnect etc.)
This provides critical economic advantages, where the range and cost of coverage for the target applications is more important than the total amount of capacity (including real-time service capacity).

This is especially the case with *one-way broadcast* stations as we intend to focus on in all ranges: the wideband lower 900 MHz LMS licenses (and the narrowband 900 MHz MAS and Paging), the 200 MHz, and the 35-43 MHz.

Note: The LMS licenses are **high-**antenna-height, **high**-power FCC licenses *that overlay and have use-priority* over the ***low***-antenna-height, ***low***-power 902-928 MHz "ISM/ Part 15" unlicensed-device networks and apps which include much of existing and planned **IOT** wireless in the nation.

These LMS licenses can be used at high height and high power *for the station to remote device transmissions*, and *other parts of* 902-928 MHz can be used, on unlicensed basis, for device-to-device (mesh net, or star) and device-to-station links. This will provide major IOT network advantages in the US. (LMS will also provide radio location, and can use LTE and other tech.) Use of the lower 200 and 35-43 MHz will further expand this advantage to remote areas, and provide critical coverage redundancy and reliability. (There are also other attractive combinations and uses of these licenses.)

The *lower* the frequency the longer-wider the coverage (for given transmit power and antenna heights). The 'Polaris' spectrum is far lower, by multiples, than any other greenfield (clear to use) nationwide or regional spectrum holdings of any entity or group. It is 'off-the-charts' lower than shown below.



Continued...

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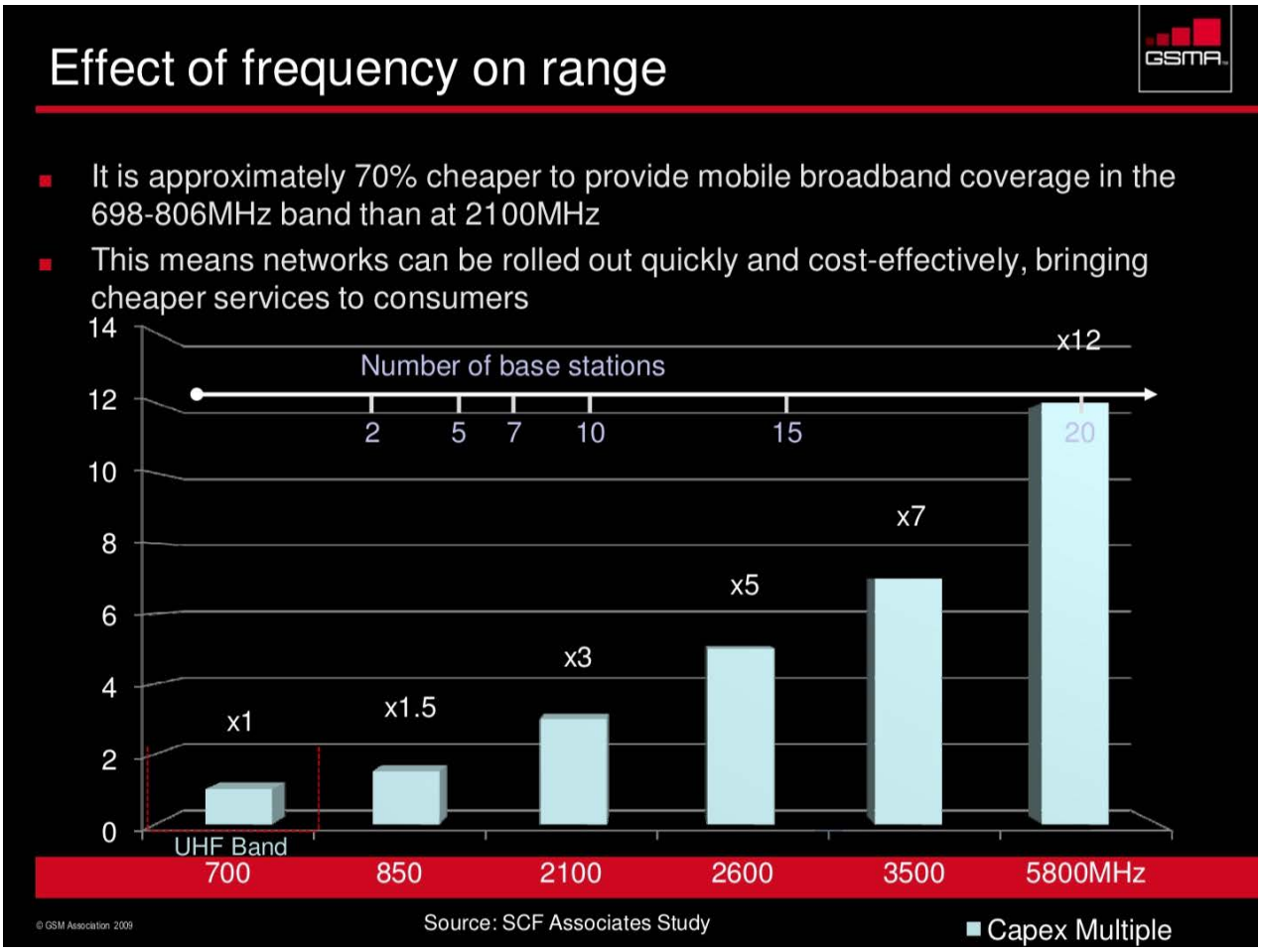

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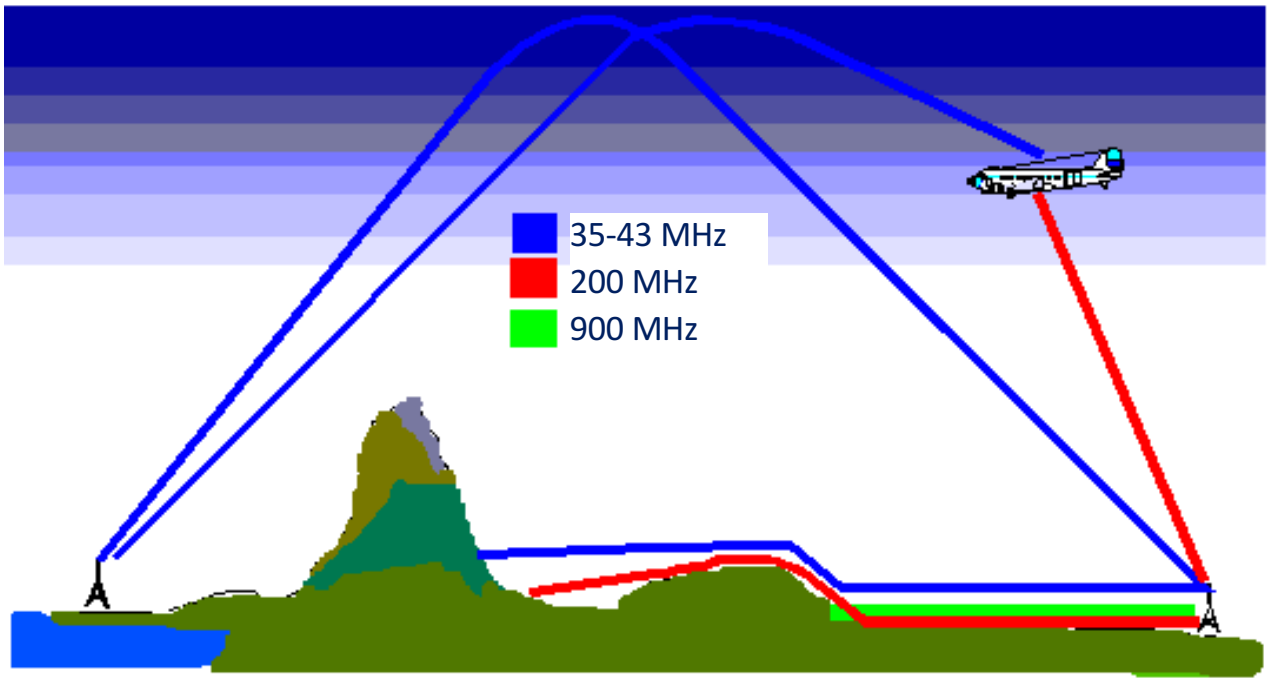
The *lower* the frequency the longer-wider the coverage (for given transmit power and antenna heights). The relative range of the 'Polaris' spectrum is generally shown below.



[1] In: LTE 5G
(and LTE 4G to 5G)

[1a] 5G. The following slides are primarily from material with a recent publication prepared for the European Union and International 5G PPP called “5G Xcast.”

Broadcast and Multicast Communication Enablers for the
Fifth Generation (5G) of Wireless Systems

Executive Summary

This document describes the use cases identified in task T2.1 and specifies their respective requirements and Key Performance Indicators (KPIs) as defined in task T2.2. These use cases, requirements and KPIs will be the target for the developments within the other Work Packages (WPs) of the Project.

The use cases are intentionally high-level and broad in nature with the specification of detailed technical requirements and KPIs being carried out in the technical Work Packages, specifically WP3, WP4 and WP5.

The requirements and KPIs will be used to benchmark both the state-of-the-art technologies as well as the new techniques developed within 5G-Xcast.

The use cases focus on applications that have the most to gain from the concepts being developed within the 5G-Xcast project, specifically:

- enhanced point-to-multipoint (PTM) capabilities;
- a dynamically adaptable network architecture with layer independent network interfaces;
- dynamic and seamless switching between unicast, multicast and broadcast modes or their simultaneous use;
- the potential to exploit built-in caching capabilities; and
- the convergence of mobile, fixed and terrestrial broadcast networks.

In total, six high-level use cases are presented. The use cases target four vertical sectors encompassing *Media & Entertainment (M&E)*, *Public Warning (PW)*, *Automotive (Auto)*, and *Internet of Things (IoT)*. While all considered use cases will be used for the definition of KPIs and requirements to be met by the 5G system developed within the project, only a subset of the use cases will be experimentally demonstrated.

The demonstration use cases within the project come from the Media & Entertainment and Public Warning verticals.

As well as describing the actual use cases, the document outlines the methodology developed within the Work Package for both the definition of the use cases themselves and their related requirements. Finally, discussion of wider issues relating to the use cases is also presented.

1 Introduction

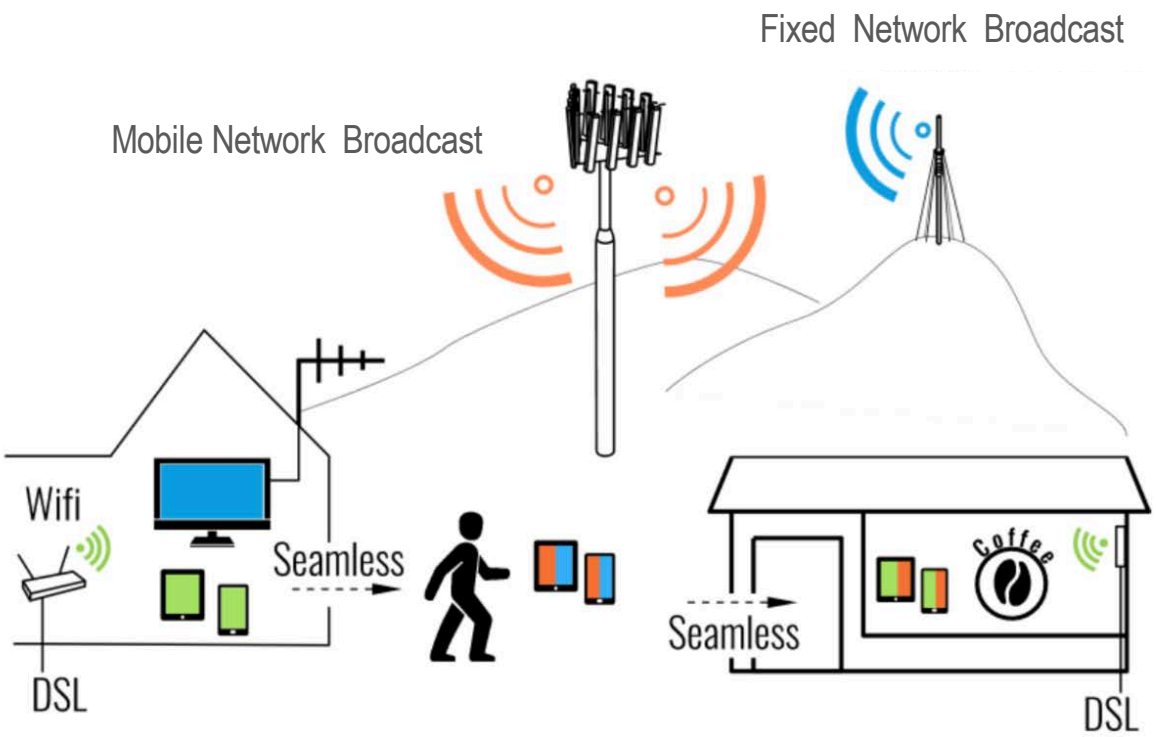
Point-to-multipoint[1] (PTM) transmission could be a more efficient delivery mechanism compared to point-to-point (PTP) whenever a service or an application requires the same content to be delivered to multiple users or devices at the same time. This is why PTM is considered to be an essential feature for 5G applications in a number of vertical sectors, namely *Media & Entertainment (M&E)*, *Public Warning (PW)*, *Automotive (Auto)* and *Internet of Things (IoT)*.

In M&E use cases, PTM will facilitate the distribution of audio-visual media content and services, in particular when covering popular live events that attract large concurrent audiences. PTM network coverage could either be localized to a specific venue or extended to a wide area, potentially the size of a whole country. Efficiency gains that might be achieved with PTM will be even more significant when the emerging high quality (and hence potentially bandwidth hungry) immersive content formats such as UHD, 360 deg., virtual and augmented reality (VR/AR) become more prevalent.

A novel use case based on 5G PTM is a dedicated wide-area coverage broadcast network, potentially shared among several network operators and initial standardisation work on this has been undertaken in 3GPP Release 14 [7] with further service requirements for 5G Stage 1 considered under 3GPP Release 15 [8].

5G PTM in combination with caching capabilities would facilitate time-shifting and non-real-time media consumption. At the same time, pre-emptive delivery of content to the storage in the device could help to balance the network load over time and reduce expensive capacity over-provisioning, hence making the delivery more cost-efficient. This method could be applicable to non-time-critical information services (e.g. news alerts) that could be conveniently 'pushed' (content pre-positioning) to the devices rather than being 'pulled' by the end users at the time of the consumption.

Another M&E use case is the use of 5G PTM in TV production. IP-based technology is increasingly being used to carry the audio and video involved in the production of TV and Radio programmes. The ability to move from the use of broadcast-specific equipment, cabling and signals towards commodity IT equipment and infrastructure is an active area of research in the field.



Cost effective super wide area (1) mobile (persons and things) and (2) fixed things one-way wireless Broadcast networks are needed – to combine with (3) Mobile networks (to mobile devices of persons, vehicles, and other things) that ideally should also be super wide area - “Msw”.

For (1), (2) sufficient high-power FCC- licensed radio spectrum in the VHF range (30 to 300 MHz) is needed or is by far the best. For (3)-Msw sufficient high-power spectrum in sub-GHz (sub- 1,000 MHz) is needed or is by far the best.

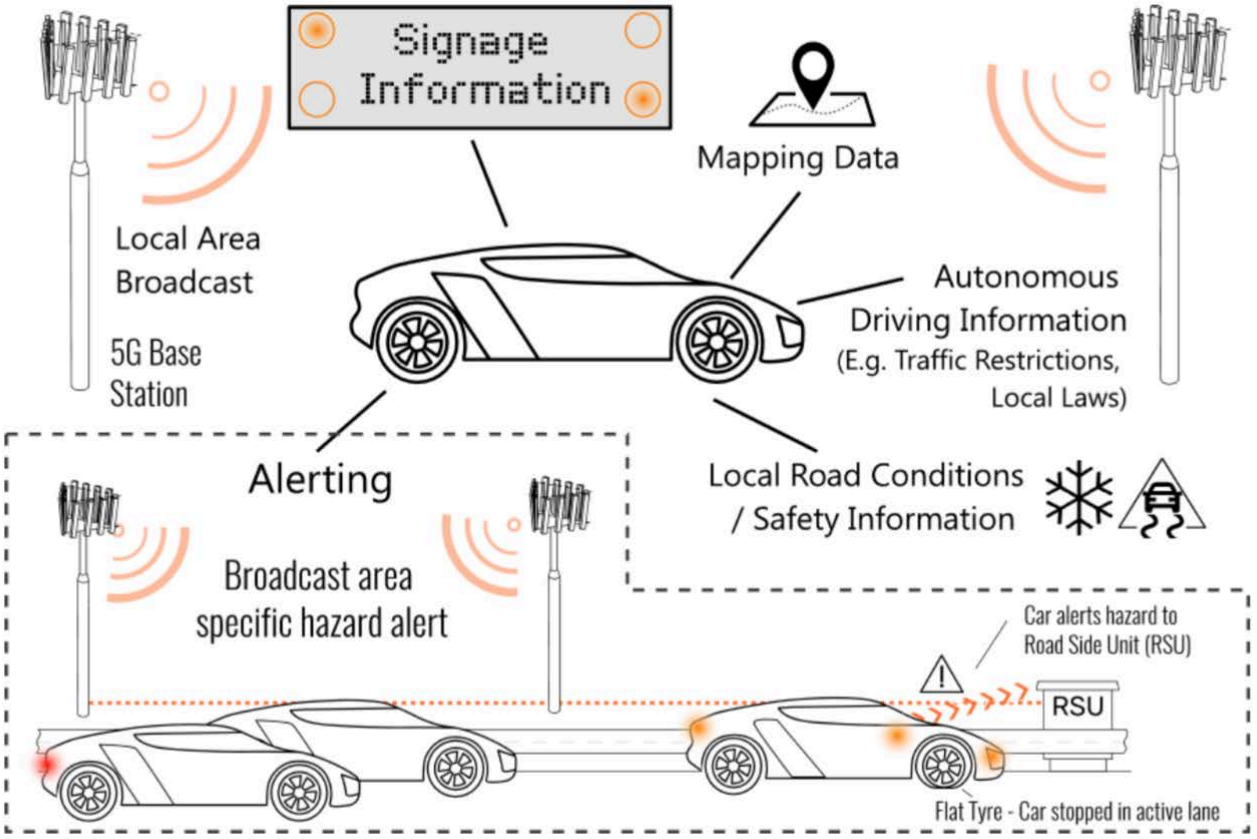


Figure 5 – Use case Auto 1: V2X broadcast service

This depict one type of mobile-broadcast-network applications: critical data to vehicles on roadways.

There are a host of other likewise critical highly valuable applications for both mobile and fixed broadcast, and super-wide area mobile networks.

[1c] (Self Explanatory)

5G: Bridging mobile broadband and broadcast networks

0123 GMT (0923 HKT) October 26,2017

[….] The efficient and cost-effective broadcasting of TV programmes to smartphones and tablets [….]

[….] broadcast content delivery in large-cell 4G and 5G networks, and offers characteristics that approximate those enjoyed with classical terrestrial broadcast methods.

"It might be possible that a future 5G broadcast media network can be operated by either a traditional mobile network operator (MNO), an independent broadcast network operator (BNO), or by the broadcaster itself as a standalone network."

— Jochen Mezger, General Manager, Network Technologies,IRT, a member of the 5G Media Initiative

[….] The new specification from the 3GPP also includes features such as reception without a SIM card and without authentication, as well as the option of using up to 100% of the available transmission capacity for broadcast applications. "Significantly larger" transmitter spacings permit the use of broadcast transmitter stations for more economical area coverage, while a receive-only mode that does not require a return channel has also been established. [….]

Transmission via a separate broadcast transmitter network would also be possible, allowing all wireless devices to receive TV programmes, whether or not a contract is in place. The standard also specifies that transport and coding formats currently employed in broadcasting shall also be available for use in 4G and 5G networks.

The first version of a new 5G standard is expected to be available by next year, after which it will be continually enhanced to become a universal

standard for high-bandwidth data applications. Starting in 2020, additional enhancements for broadcast applications are expected as part of 5G — these could be available by 2025 as popular broadcast services for the mass market, predicts the 5G Media Initiative.

"In the context of the 5G-Xcast project, Nokia is working with broadcasters and mobile network operators to develop 5G solutions tailored for the media and broadcast industries."

— Dr Simone Redana, Head of Mobile Network Architecture and Systems, Bell Labs Research, Nokia

[….] Mezger explains: "It might be possible that a future 5G broadcast media network can be operated by either a traditional mobile network operator (MNO), an independent broadcast network operator (BNO), or by the broadcaster itself as a standalone network.

"Of course, the distinct free-to-air media services need to be accessible in all networks and on all devices — without the need of a SIM card." […]

"The latter one is particularly interesting for public service broadcasters as they consider smartphone and tablet devices as being of growing importance," Mezger says. […]

[….] flexible and efficient delivery content through Xcast, suggests Dr Simone Redana, head of mobile network architecture and systems, Bell Labs Research, Nokia.

He explains to APB: "Here, Xcast means delivering the content over the access network, using an efficient mix of uni-cast, multi-cast and broadcast. This would enable mobile network operators to deliver media content in the most spectrally efficient manner. For fixed and converged network operators, Xcast would lead to significant gains in the transport network load, thereby enabling cost-efficiencies."

Nokia is also a driving member and technical coordinator of the 5G-Xcast consortium, a 5GPPP phase-2 project started on June 1 this year. (5GPPP is a joint initiative between the European Commission and the European ICT industry, and aims to deliver 5G solutions, architectures, technologies and standards.)

[….] Dr Redana explains: "While, in LTE eMBMS, a lot of broadcast functionalities have been developed with a strong focus on broadcasters' requirements, the 5G-Xcast project targets to change the paradigm compared to 4G.

"In 5G multicast, broadcast and caching will be treated in a holistic way as built-in internal network delivery optimisations, which will be implemented and operated in a flexible and dynamic way. The technology will be flexible enough to efficiently distribute content over fixed, mobile and broadcast-only networks."

5G, Dr Redana adds, represents an "unprecedented opportunity" for the convergence of mobile broadband and broadcast networks. [….]

A cornerstone of the project thus is network slicing, Dr Redana reveals. "That is, service-, application- or vertical industry-specific logical networks sharing a common physical/virtual infrastructure.

"With the approach of network slicing, media, entertainment and broadcast services for end-users can share the mobile infrastructure with other services having different quality and performance requirements, such as smart city, industry, transportation, healthcare or public safety."

[….]

[2] Digitial Radio Mondiale+ (international standards-based radio broadcast)

Following are materials about DRM+ which can be used with the Polaris **35**, **43**, and **217-218**, **219-220 MHz** licenses for very cost effective, robust, super wide area broadcasts of data (voice also) including to smart phones, tablets, automobiles, industrial workers, and fixed things (Internet of Things, etc.). This can be for real-time, and other applications such as for data-cached apps on mobile and fixed wireless devices..

DRM+ in VHF band III

German DRM Platform

► ***Worldwide basic for DRM+ in VHF bands I, II, III***

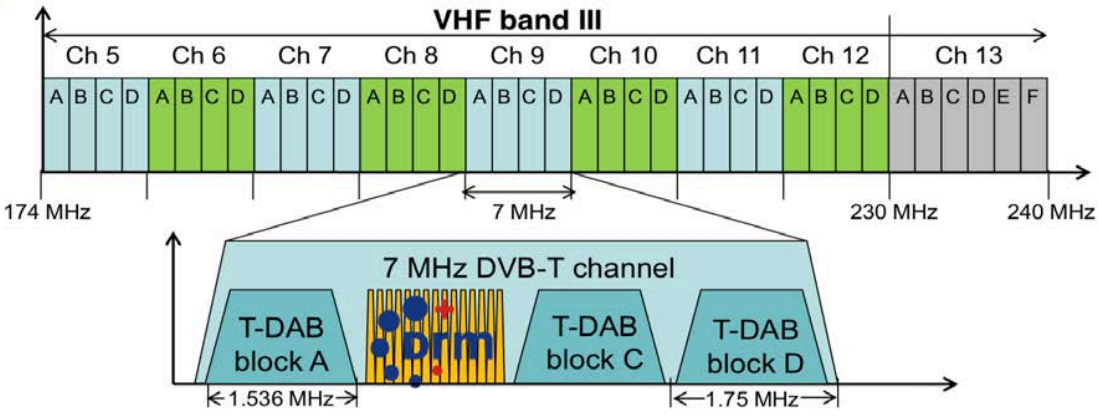
ITU Rec. BS.1114-9 „Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30 - 3 000 MHz"

- **describes DRM+ (DRM robustness Mode E, ITU-System G) as designed for all the VHF bands**

ITU-Rec. BS.1660-7 „Technical basis for planning of terrestrial digital sound broadcasting in the VHF band"

Report ITU-R BS.2214-1 "Planning parameters for terrestrial digital sound broadcasting systems in VHF bands"

- **give all the core technical parameters for the use of DRM+ in all VHF bands (30 – 300 MHz):**
  - Required minimum field strength levels for the given reception modes
  - Frequency grid of 100 kHz (in FM band and VHF band III)
  - Out-of-band spectrum mask
  - Protection ratios of DRM+, FM,T-DAB, DVB-T interfered with by DRM+



The frequency grid of 100 kHz and the low protection ratios of DRM+ gives a flexible use without avoiding the T-DAB development

- 70 DRM+ channels in one 7 MHz DVB-T channel
- 15 DRM+ channels in one DAB block (1.536 MHz, without guard band)

Siano* DMR+ chipset on Polaris's **35**, **43**, and **217-218**, **219-220 MHz,** for uses (see next page)
* Other chipset makers have similar.

Siano Launches Advanced Multi-Standard Digital Radio Receiver Chip Supporting T-DMB/DAB/DAB+, DRM+ and Legacy FM Radio

Targeting automotive and portable/mobile devices

February 25, 2014 10:30 PM Eastern Standard Time

NETANYA, Israel--(BUSINESS WIRE)--Siano, the world's leading supplier of mobile broadcast DTV solutions, today announced the launch of SMS2160, a new multi-standard digital radio receiver chip designed for automotive and portable/mobile consumer electronics applications. The SMS2160 is the world's most versatile digital radio IC to support T-DMB/DAB/DAB+, DRM+, and FM Radio, including RDS/TMC. The newly released chip is particularly addressed to the emerging markets of DAB+ in Europe, and DRM+ in Asia and around the globe.

The SMS2160 is the first chip of its kind to support 2-way antenna diversity (MRC) for DRM+, T-DMB/DAB/DAB+. DRM+ (the FM mode of the all-band Digital Radio Mondiale standard) is the digital open candidate for FM band radio when FM broadcasts start phasing out. An extension of the DRM digital radio broadcasting system, DRM+ works in frequency bands over 30 MHz (Band I, II and III), delivering enhanced audio quality and multimedia broadcasts. With DRM+'s growing popularity worldwide, especially in Asia and Latin America, Siano's SMS2160 offers users in these regions exceptionally high sensitivity and mobility performance in a variety of mobile devices.

"We are excited about the prospects of a dedicated DRM+ receiver chip to potentially support India's massive mobile device market," said Ruxandra Obreja, DRM Consortium Chairman and President of the DRM Association. "The nationwide All India Radio (AIR) DRM Rollout Plan will support digital radio broadcasts in 23 languages and 146 dialects, covering 92% of the country and reaching 99% of the population. Making Siano's SMS2160 receiver chip available to the national effort open to public and commercial broadcasters will open new horizons for quality mobile broadcasts all over India."

The SMS2160 is a highly integrated, small-size (5x5 mm) receiver chip with optional 2-way antenna diversity (MRC) and multiple frequency band support: VHF Band III (174-240 MHz), VHF Band I (47-88 MHz), VHF Band II (88-108 MHz), and L1-Band. Tailored to meet the challenging demands of automotive applications, the chip offers superior mobility algorithms and is environmentally friendly (RoHS and REACH compliant).

Samples of the SMS2160 are already in use by select Siano customers including Hirschmann Car Communication, one of the world's leading suppliers of automobile communications and TV receivers. "The collaboration with Siano provides our customers with high value for their automotive infotainment applications," said Thomas Adam, Head of Development at Hirschmann Car Communication. "This new Siano receiver chip delivers uncompromised performance and will allow us to expand our global customer base. This is the high level of quality and reliability we have come to depend on from Siano."

Alon Ironi, CEO of Siano, comments, "The increased popularity of DRM+ technology translates into winning partnerships for Siano's mobile digital TV solutions. Already having several customers such as Hirschmann Car Communication and others, we are confident that this new chip will lead the steadily growing DRM+ market."

Siano* DMR+ chipset (continued) - in smartphones, tablets, vehicles, etc., for for voice, data, multimedia

About DRM

Digital Radio Mondiale™ (DRM) is the only universal, openly standardized digital broadcasting system for all broadcasting frequencies. The DRM standard comprises of two major configurations: 'DRM30' intended for broadcasts on short, medium and long wave up to 30 MHz and providing large coverage areas and low power consumption. The configuration for the VHF bands above 30 MHz is called 'DRM+', tailored for local and regional coverage with broadcaster-controlled transmissions. All DRM configurations share the same audio coding, data and multimedia services, service linking, multiplexing and signaling schemes. DRM provides high quality sound combined with a wealth of enhanced features: Surround Sound, Journaline text information, Slideshow, EPG, and data services. For more information and DRM updates please visit www.drm.org or subscribe to DRM news by writing to pressoffice@drm.org. Click here for the Newsletter with all the latest DRM news from around the world.

About Siano

Siano is the world's leading supplier of mobile broadcast DTV solutions. Pioneers of the multi-standard approach, Siano provides high-performance and fast time-to-market digital TV solutions for mobile and consumer electronics, automotive and public transportation device makers and solution/service providers. Siano has close collaborations with global tier-1 makers of tablets, smartphones, car TVs, and electronic accessories such as Nokia, Huawei, ZTE, Sharp and others, as well as service providers including KDDI-au, Softbank, DStv Mobile, and the Mobile Content Venture in the U.S. Headquartered in Israel, Siano has offices in the U.S., China, Korea, and Japan. For more information, visit us at www.siano-ms.com.

Contacts

Siano
Rose Wolfe, +972-9-8656993
rosew@siano-ms.com

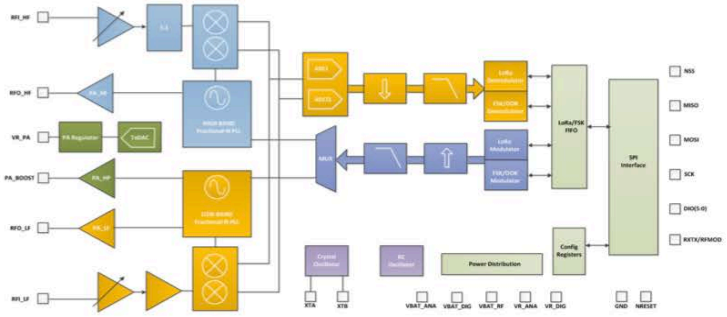
[3] LoRa

Ultra long range two-way (for the power and battery life) in Polaris 217-220, and 904-910 MHz.
There are other similar technologies that can be used as well.

SEMTECH LoRa™ **SX1276/77/78/79**

WIRELESS, SENSING & TIMING **DATASHEET**

SX1276/77/78/79 - 137 MHz to 1020 MHz Low Power Long Range Transceiver



GENERAL DESCRIPTION

The SX1276/77/78/79 transceivers feature the LoRa™ long range modem that provides ultra-long range spread spectrum communication and high interference immunity whilst minimising current consumption.

Using Semtech's patented LoRa™ modulation technique SX1276/77/78/79 can achieve a sensitivity of over -148dBm using a low cost crystal and bill of materials. The high sensitivity combined with the integrated +20 dBm power amplifier yields industry leading link budget making it optimal for any application requiring range or robustness. LoRa™ also provides significant advantages in both blocking and selectivity over conventional modulation techniques, solving the traditional design compromise between range, interference immunity and energy consumption.

These devices also support high performance (G)FSK modes for systems including WMBus, IEEE802.15.4g. The SX1276/77/78/79 deliver exceptional phase noise, selectivity, receiver linearity and IIP3 for significantly lower current consumption than competing devices.

ORDERING INFORMATION

Part Number	Delivery	MOQ / Multiple
SX1276IMLTRT	T&R	3000 pieces
SX1277IMLTRT	T&R	3000 pieces
SX1278IMLTRT	T&R	3000 pieces
SX1279IMLTRT	T&R	3000 pieces

- QFN 28 Package - Operating Range [-40;+85°C]
- Pb-free, Halogen free, RoHS/WEEE compliant product

KEY PRODUCT FEATURES

- LoRa™ Modem
- 168 dB maximum link budget
- +20 dBm - 100 mW constant RF output vs. V supply
- +14 dBm high efficiency PA
- Programmable bit rate up to 300 kbps
- High sensitivity: down to -148 dBm
- Bullet-proof front end: IIP3 = -11 dBm
- Excellent blocking immunity
- Low RX current of 9.9 mA, 200 nA register retention
- Fully integrated synthesizer with a resolution of 61 Hz
- FSK, GFSK, MSK, GMSK, LoRa™and OOK modulation
- Built-in bit synchronizer for clock recovery
- Preamble detection
- 127 dB Dynamic Range RSSI
- Automatic RF Sense and CAD with ultra-fast AFC
- Packet engine up to 256 bytes with CRC
- Built-in temperature sensor and low battery indicator

APPLICATIONS

- Automated Meter Reading.
- Home and Building Automation.
- Wireless Alarm and Security Systems.
- Industrial Monitoring and Control
- Long range Irrigation Systems

[4] General - example to show current broadcast tech capabilities

Covers Polaris 35, 43, 217-220, and 904-910 MHz – software upgradeable re various standards.

DTA-2111

Multi-Standard VHF/UHF Modulator

Features

- Multi-standard modulator for PCI Express with support for most QAM-, OFDM- and VSB-based modulation standards
- Digital upconversion for excellent signal quality without need for calibration
- Supports all constellations and modulation modes for each supported standard
- All-channel upconverter 36 to 1002MHz fully agile over VHF and UHF band
- Digital channel simulator option
- RF output for direct connection to the antenna input of a digital receiver
- Free Windows and Linux SDK (DTAPI) is fully compatible with other DekTec digital-video output adapters
- PCI Express x1, low profile

Applications

- General purpose test modulator
- SMATV, hotel server, shows and exhibitions
- OEM applications

PCI Express

PCI EXPRESS

All-digital multi-standard modulator
Fully agile from 36 to 1002MHz
Upgradable to support new standards

Key Attributes

Parameter		Value
RF connector		75-Ω F female
Frequency range		36 to 1002MHz ±3ppm
Bandwidth (max)		8MHz, 16MHz (option)
I/Q sample rate		4.7 to 9.375MHz
Level	Range	-32 to -9dBm (QAM) -35 to -12dBm (OFDM)
	Step size	0.1dB
	Accuracy	±2dB
MER		>40dB
Adjacent channel		-54dB (QAM) -52dB (OFDM)
Phase noise		<-95dBc @ 100kHz
Spectral purity		>50dB @ -9dBm
Wideband noise		35dBµV (B=1MHz)
PCI Express		PCIe1 x1 low profile
OS		Windows 7, 8, 10 Linux ≥2.6.18, 3.x, 4.x

Modulation Standards

Standards
ADTB-T*, ATSC, ATSC-M/H*, CMMB*, DAB+*, DMB-T/H*, DVB-C, DVB-C2*, DVB-T, DVB-T2*, I/Q samples*, ISDB-T*, ISDB-Tmm*, QAM-B, QAM-C, T-DMB*

* Option

Ordering Information

Type	Description
DTA-2111-SP	VHF/UHF modulator with *StreamXpress®*
DTA-2111-GOLD	DTA-2111 with all options
DTC-371-IQ	I/Q sample playout option
DTC-380-16MHZ	16-MHz bandwidth option
DTC-381-T2SPLP	DVB-T2 single PLP option
DTC-382-Tmm	ISDB-Tmm option
DTC-384-SWMC	Multi-channel software modulation option

[5] N-RTK (Network RTK: principal mode for nationwide pPNT)

for Delivery by Polaris 35, 43, 217-220, and 904-910 MHz – mainly by one-way BROADCAST.

(W.. Havens initiated the below study and obtained financing for it.)

Cooperative High-Accuracy Location (C-HALO) service for Intelligent Transportation Systems: A Cost Benefit Study

Adam Goodliss*, Christian Manasseh*, Venkatesan .N. Ekambaram**, Raja Sengupta*, Kannan Ramchandran**
*Institute for Transportation Studies, University of California, Berkeley
**Department of EECS, University of California, Berkeley

This paper presents a cost benefit study of a Cooperative High-Accuracy LOcation (C-HALO) service as a nationwide service capable of providing decimeter level positioning accuracy to enable several new applications across various industries. We survey and summarize work by others quantifying the benefits reaped from enabling applications that require C-HALO. However, benefits to the economy from enabling C-HALO for Intelligent Transportation Systems (ITS) have not been quantified in the literature. This study estimates these benefits. We also provide an order of magnitude rough estimate of the cost of implementing part of a C-HALO infrastructure based on N-RTK technology.

After completing all these individual analyses, the sum of these benefits ranges from $160 billion to $320 billion. This range depends on whether one uses the low-level safety application efficacy rates or the mid-level efficacy rates. This translates into 1.1 to 2.2 percent of GDP. The safety benefits in the analysis dominate, making up over 90 percent of the total benefits calculated.

[...] This is the representative cost given average levels of all the above costs. There are low and high estimates for each cost category, including the useful life of the hardware, which ranges from 7 to 15 years. This useful life changes the 22-year horizon cost of the hardware. The range of infrastructure costs is from $220K to $615K per base station for the life of the system. Using a range of annual contingency expenses from $25K to $70K the range of infrastructure costs increases to $570K to $1.6M per base station for the life of the system. If one were to provide N-RTK coverage over the entire US land mass for the horizon of this project, approximately 2,730 base stations would be needed. Using this figure, nationwide N-RTK coverage would cost between $1.6 billion to $4.4 billion. This may be compared to benefits ranging between $160 and $300 billion from the Intelligent Transportation Systems Sector alone.

The authors gratefully acknowledge a gift from ATLIS Wireless, LLC that has, in part, made this work possible. The content of this paper is solely determined by its authors.

THE COMMUNICATION SATELLITE BASED NETWORK RTK SOLUTION FOR ROAD TRANSPORTATION

Dr. Lei Yang, Dr. Chris Hill, Prof. Terry Moore and Dr. Xiaolin Meng

Institute of Engineering Surveying and Space Geodesy, The University of Nottingham
The University Park, Nottingham, UK NG7 2RD

In recent years, GNSS positioning and navigation technology and its applications have experienced a rapid growth, especially in the intelligent transportation systems and services (ITSS). Advanced ITSS applications have shown great potential in changing people's driving behaviour and a promising future in the mass market applications. For these applications, a high level of positioning accuracy, reliability, coverage and mobility is demanded. Research has shown that a real-time positioning system of decimetre accuracy will be a typical requirement for the next generation of GNSS applications.

Network Real Time Kinematic (NRTK) is a proven technique to deliver a cm-level accuracy with more efficient and inexpensive infrastructure than traditional RTK positioning. However, it requires a two-way communication link between the rover and Central Processing Facility (CPF), unless the rover is constrained within a fixed reference stations cell. Due to the capacity of the CPF server and the communication channel, a two-way service is limited when adopted in mass market applications. Besides, a good NRTK system relies heavily on the quality of the wireless communication media. A wide coverage is required, especially in remote rural areas, which cannot be satisfied by the current commercial cell phone network services.

The Satcoms in Support of Transport on European Roads (SISTER) project promotes the integration of satellite communications with [...]

With the pursuing of a higher level of convenience, efficiency and safety, more advanced ITSS applications have been proposed and are currently under development, which includes road pricing, assisted driving, interactive junction control, emergency positioning reporting, lane detection, parking space guidance etc. They have shown a promising future in the mass market applications and a great potential in changing people's driving behaviour. For these applications, a high level of positioning accuracy, reliability, coverage and mobility is demanded. Most of them require a real-time positioning accuracy of metre or even sub-metre level, which can be hardly satisfied by the conventional satellite navigation technology. [...]

Another drawback of the current NRTK is it requires a two-way communication. Although NRTK has several working mode, VRS, MAX, iMAX and so on, most of them need the rover provides its approximate coordinates to the CPF, either for the estimation of the rover local correction, or for the determination of the RS cell where the rover sits in. This two-way communication mechanism implies a Peer-to-Peer link; the CPF capability will limit the number of supporting rovers and is a barrier for the NRTK towards mass market.

Thus a one-way communication with wider service coverage is desired for the future NRTK data transmission.

[7] Ultra long-range 'skywave' radio

on low VHF - 35, 43 MHz and adjacent - for radio communication, location, etc.

(The following are from a longer presentation on these matters by W. Havens)

Advanced Meteor Burst Radio Signaling

Billions of small meteoroids enter the atmosphere daily, few large enough to be visible, and create no-cost, ever-renewed, smart, plasma antenna arrays in the sky, responsive to 25-55 MHz.

With new radio, antenna and computer techniques, this will enable '4G' and '5G' Meteor Burst Radio Signaling services that are robust, secure, continent wide with no coverage gaps, at low-cost-of-coverage.

It will deliver n-RTK for precision GPS nationwide. It will also provide Position, Navigation and Timing services independent of GPS and far more secure from sky or terrestrial attacks. It will also improve atmospheric and weather science that is much needed, and provide other major benefits.

NTIA and FCC spectrum is available, and otherwise is little used.

Reception of the many key data services will be via one-way broadcast, receivable in any radio device, even consumer smart phones.

http://www.oceanlight.com/log/category/new-work | light@yosemite.earth

United States Department of Agriculture
NRCS Natural Resources Conservation Service

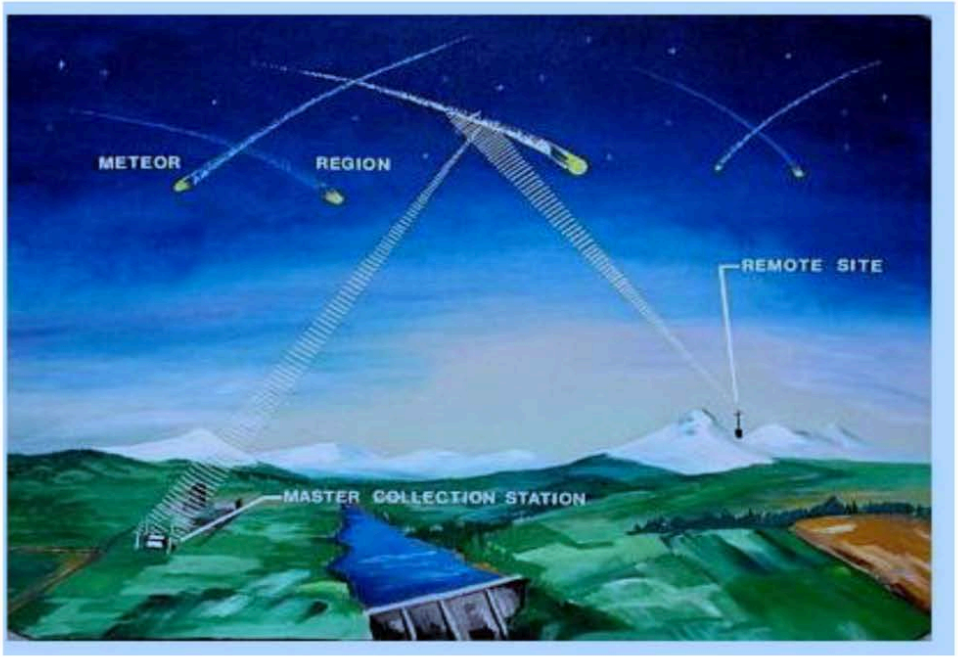
National Water and Climate Center

The National Water and Climate Center (NWCC) has developed efficient and highly effective technology to provide the data needed for water supply, climate, analysis, and conservation planning. NWCC acquires additional data sets that are needed from other networks and designs local data networks and sophisticated national networks. NWCC operates a variety of networks that use different data acquisition technology. We offer our expertise to others through documentation, training, partnership, on-site assistance, and participation in professional forums. Briefly, some of the types of data acquisition technology that are currently established are:

NRCS SNOTEL shows MBRS is successful for NCRS's critical purpose. Advanced MBRS discussed herein may, under on plan, complement SNOTEL in a 'partnership' – see left.

Meteor Burst Communication Technology

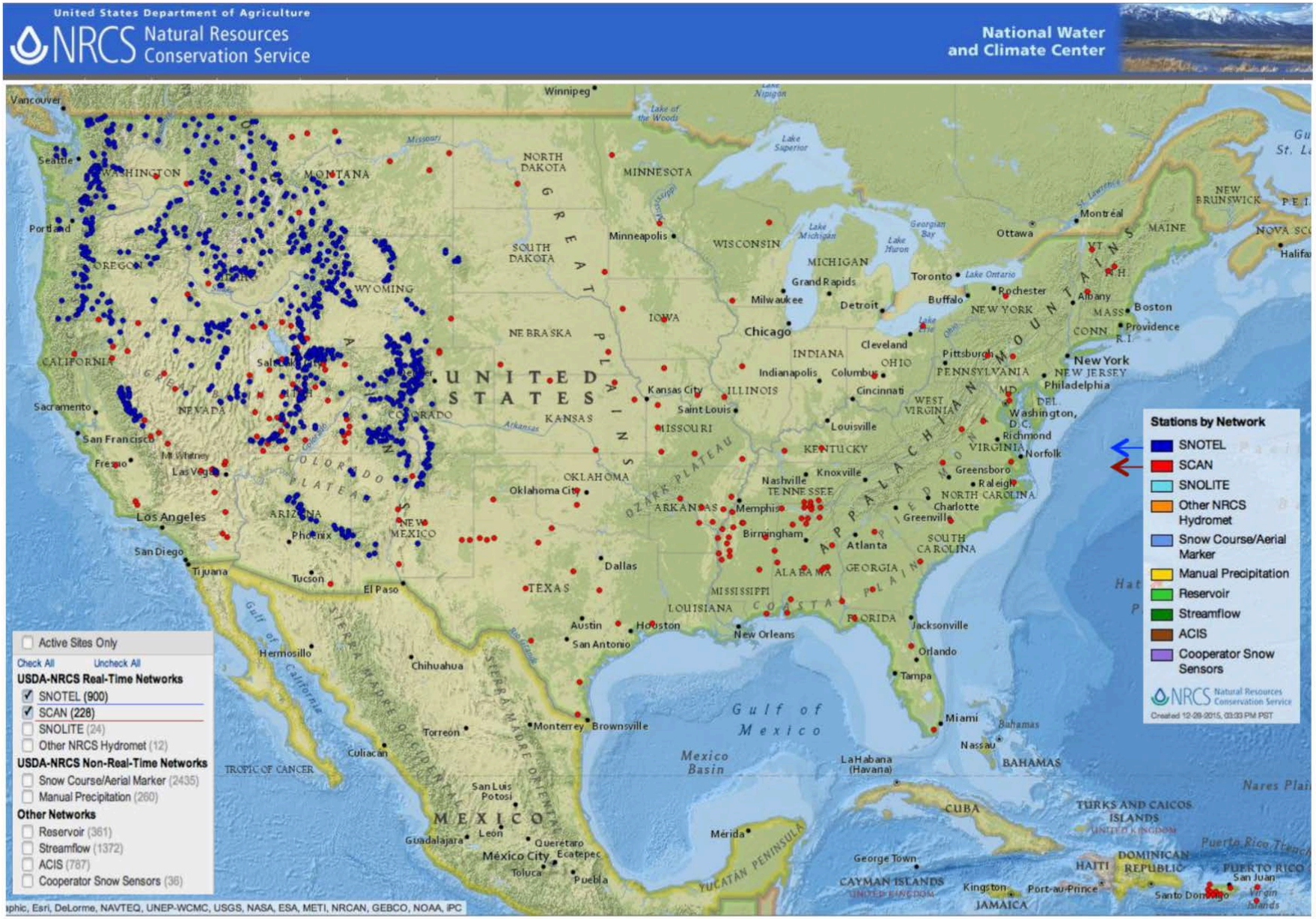
Meteor burst communication was discovered by the military in the 1950's. NRCS implemented this technology and developed SNOTEL in 1975. Meteor burst communication uses the billions of sand sized particles (1 gram or larger) that burn up in the 50 to 80 mile high region of the atmosphere to relay radio signals back to the earth. This technique allows communication to take place between remote sites and a master station up to 1200 miles away. At the master station, the remote site data is checked for completeness. If so, an acknowledgment message, returning over the same path, tells the remote site not to transmit again during this polling period. The entire process takes place in less than a tenth of a second. Meteor burst communication has proven to be extremely reliable. From the master stations, the data are sent via telephone line to the NWCC Central Computer Facility.



Electronics Maintenance Facility

The NWCC operates a SNOTEL electronics maintenance facility that maintains a fully functional complement of modular SNOTEL components that can be sent overnight, worldwide if a component fails. The facility also repairs data acquisition systems sent in from the field, designs custom interface boards, tests sensors, keeps abreast of latest technology, and provides answers to technical questions related to data acquisition technology.

http://www.wcc.nrcs.usda.gov/publications/Briefing-Book/bb25.html



Note: This shows the current MBRS-based SCAN and SNOTEL stations (SCAN is described below). SNOTEL - 900 stations. SCAN - 228 stations (see legend bottom left). The next slide displays all of these NRCS "Networks" stations in the legend. The map was generated at the NRCS online interactive mapping tool, on 12-28-14. I unchecked "active sites only," since doing so showed a few more stations (those apparently not "active" at this date).

Management of Natural and Environmental Resources for Sustainable Agricultural Development

Proceedings of a Workshop

November 2008

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

WMO OMM World Meteorological Organization Agricultural Meteorology Division

waob

Over the past two decades, there has been an increasing awareness of the potential damages that climate change, air and water pollution and inadequate natural resources management could induce upon human health, natural ecosystems and the economy. To address these concerns, considerable emphasis has been placed on sustainable development by many countries and international organizations. Accordingly, sustainable agricultural development has become a

The U.S. Department of Agriculture's Natural Resources Conservation Service Soil Climate Analysis Network

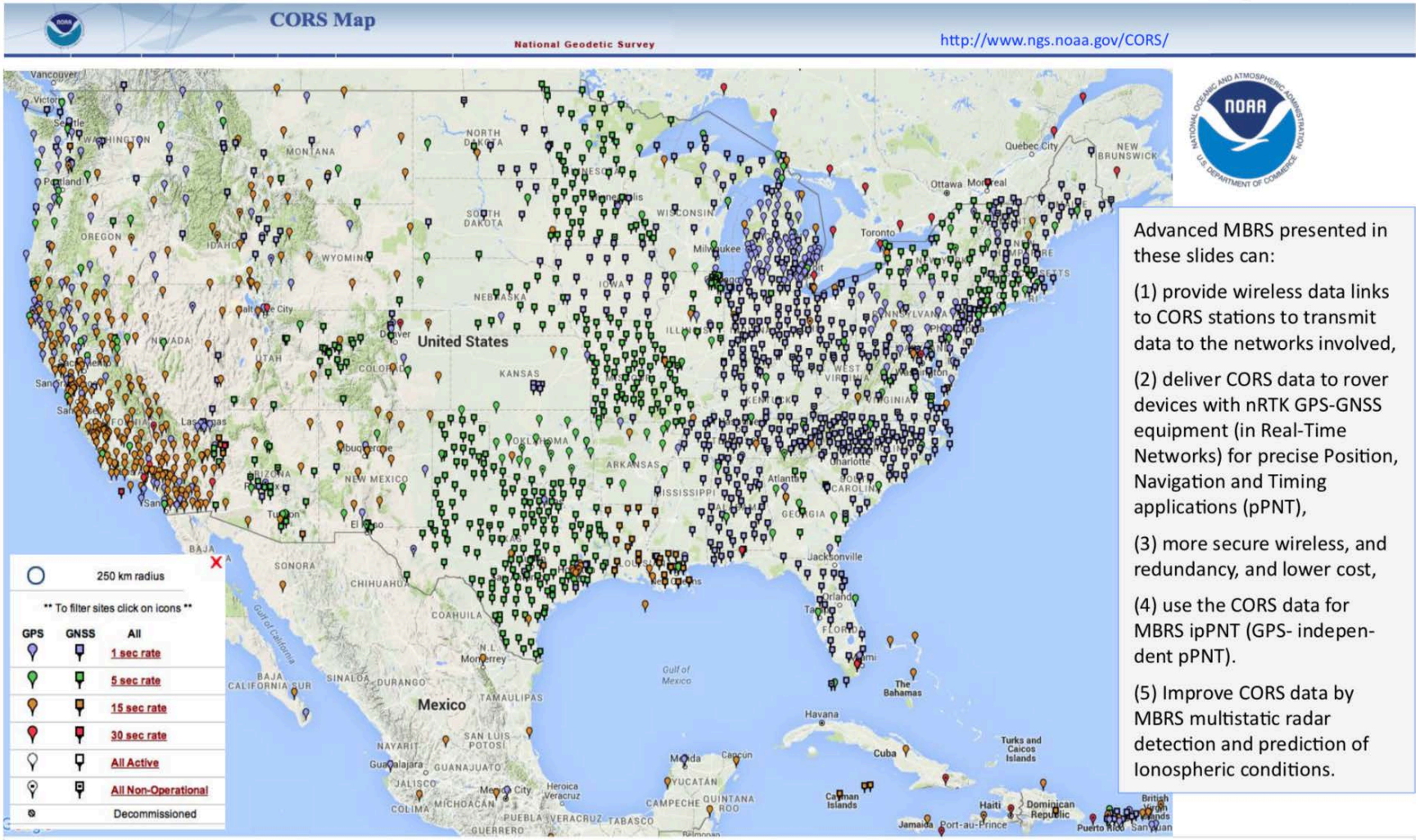
There is a need for a national network that provides near real-time soil moisture and temperature data combined with other climate information for use in natural resource planning, drought assessment, water resource management, and resource inventory. In 1991, a 10-year pilot project was started to test the feasibility of such a network. Initially, 21 stations were established in the pilot project. Over the span of the project, an array of above ground and below ground sensors were tested along with a unique meteor burst communication system. This pilot led to the development of the Soil Climate Analysis Network (SCAN). The network now has 115 stations, of which most have been installed since 1999, located in 39 states. The stations are remotely located and collect hourly atmospheric and soil moisture and temperature data that is made available to the public via the Internet. Future plans for the network include locating new stations on benchmark soils, increasing the number of stations, making data summaries more user-friendly, and increasing data quality.

Note: This was a major international conference on the topic at top left- and, now even more critical, with increasing evidence of "global warming" in high probability to stop the causes and effects.

US DOA NRSC presented its meteor-burst communication (an aspect of MBRS) SCAN system and expansion plan.

SCAN is like SNOTEL – both use MBRS and both are by DOA NRCS.

The advanced MBRS presented in these slides can assist and expand SCAN and SNOTEL, among other federal and federal-goal programs.



Advanced MBRS presented in these slides can:

(1) provide wireless data links to CORS stations to transmit data to the networks involved,

(2) deliver CORS data to rover devices with nRTK GPS-GNSS equipment (in Real-Time Networks) for precise Position, Navigation and Timing applications (pPNT),

(3) more secure wireless, and redundancy, and lower cost,

(4) use the CORS data for MBRS ipPNT (GPS- independent pPNT).

(5) Improve CORS data by MBRS multistatic radar detection and prediction of Ionospheric conditions.

The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service, manages a network of Continuously Operating Reference Stations (CORS) that provide Global Navigation Satellite System (GNSS) data consisting of carrier phase and code range measurements in support of three dimensional positioning, meteorology, space weather, and geophysical applications throughout the United States, its territories, and a few foreign countries.

Surveyors, GIS users, engineers, scientists, and the public at large that collect GPS data can use CORS data to improve the precision of their positions. CORS enhanced post-processed coordinates approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

The CORS network is a multi-purpose cooperative endeavor involving government, academic, and private organizations. The sites are independently owned and operated. Each agency shares their data with NGS, and NGS in turn analyzes and distributes the data free of charge. As of August 2015, the CORS network almost 2,000 stations, contributed by over 200 different organizations, and the network. continues to expand.

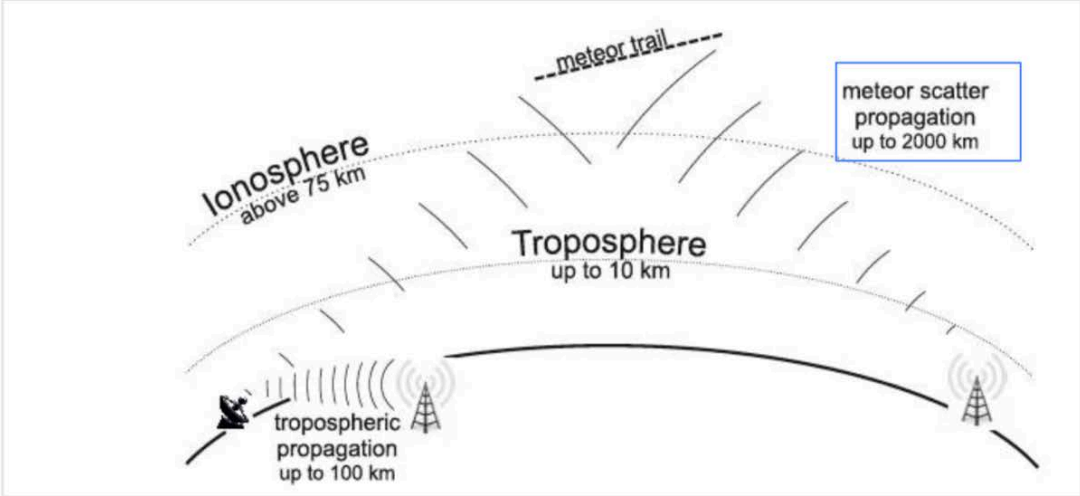


Fig. 1.— The principle of meteor scatter phenomenon.

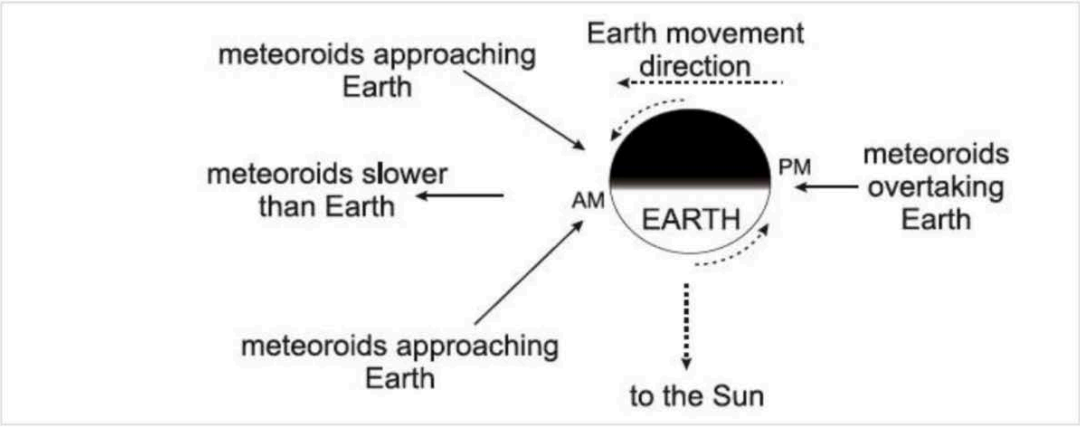


Fig. 2.— The visualization of the Earth in meteoroids environment.

Note: Copy at: http://arxiv.org/pdf/1505.02366.pdf / Other depictions of MBRS elements are provided below.

Note: The most complete work on "traditional" MBRS is:

Meteor Burst Communications: Theory and Practice, Donald L Schilling, editor. Wiley, 1993. See following pages.

Traditional MBRS is all that can be found in coherent form in public records, even current papers.* I have found indications of "advanced" MBRS in development in China and Russia, but the details do not appear to be publicized, and the authors and institutions do not respond to my inquires. In any case, I believe I have a more full and effective approach outlined herein.

The advanced MBRS outlined herein probably exceeds 1,000-fold in total performance and value as compared to "traditional" or modestly augmented MBRS found in most all papers on MBRS.

This is supported by assumptions using best-available MBRS system parameter data and what-if calculations.

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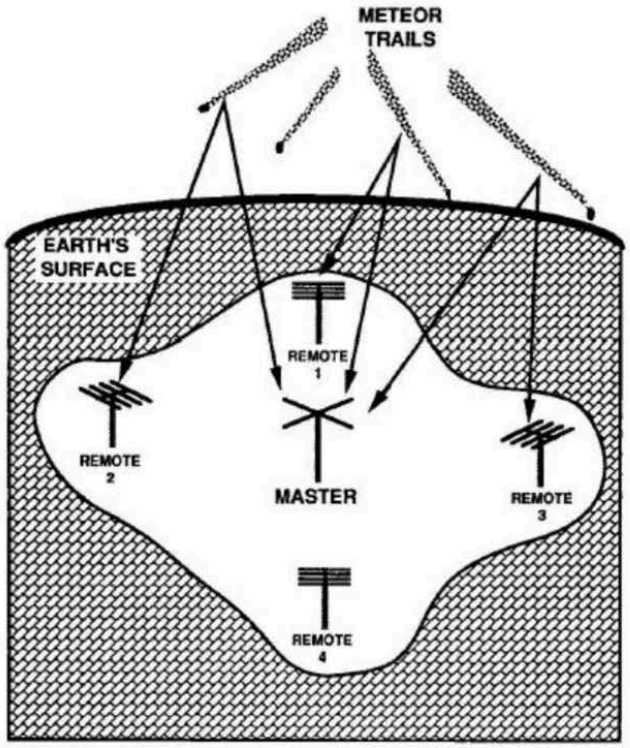
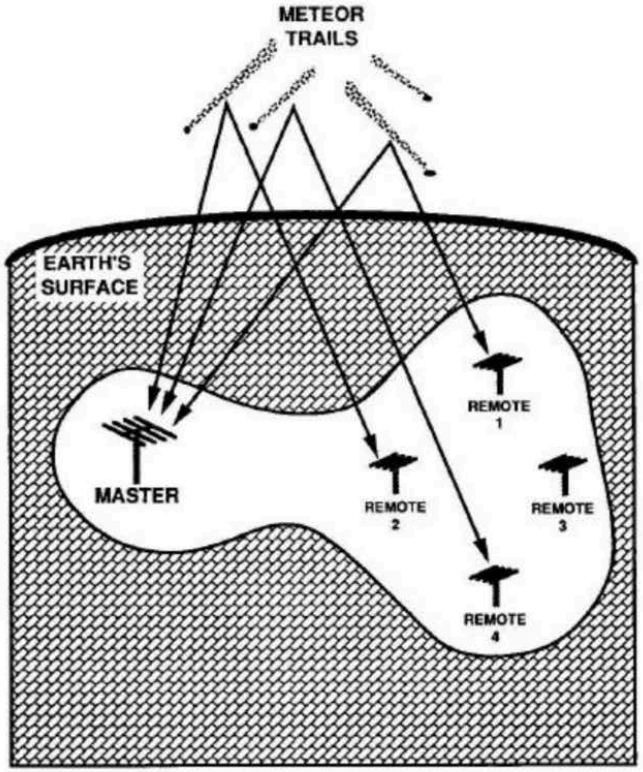
* E.g.
http://www.ijetie.org/articles/IJETIE_201518006.pdf



(a)

Figure 3.16 (a) Centrally-located master station

Typically, for a base station well inland to cover in all or many directions. With base station antenna arrays, the array could simultaneously cover in many directions.



(b)

Figure 3.16 (b) Stand-off master station

Typically, for a base station on or near a coastline or other territorial border to cover offshore or beyond the border (with any permissions needed by another jurisdiction).

Here we examine the way the incident radar wave interacts with the ionized trail. In Figure 3.3 we see the wave approaching a stream of ionized particles represented by a mix of positive ions, negative electrons and neutral molecules. It is only the electrons that respond significantly to the electric field in the incident wave. The ions are heavy and do not move a significant amount and play little part in re-radiation of the pulse. The neutral molecules carry no net charge and cannot interact with the wave electric field. The strength of the returned signal is dependent on…electron density in the trail… this varies with time, so does the signal strength.

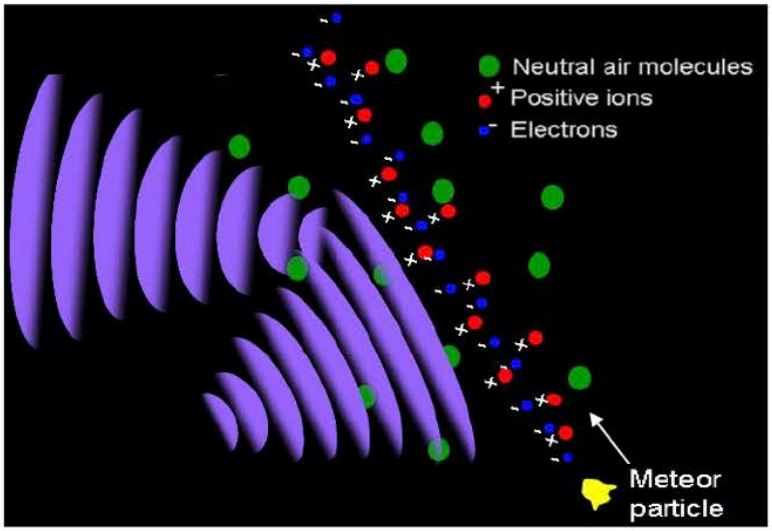


Figure 3.3 Wave interaction with the Ionization Trail

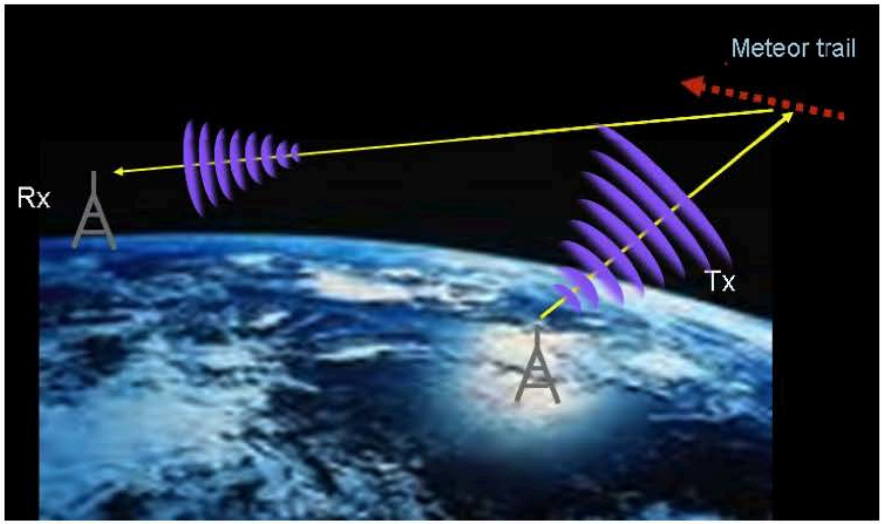
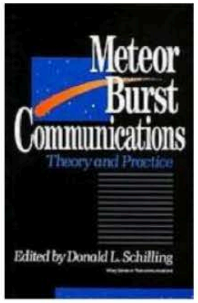


Figure 4.4 Reflection from a meteor trail

Meteor Scatter communication systems are highly efficient in its use of the radio spectrum. Radio frequencies are a scarce commodity and the increasing appetite for information demands economical use of the radio spectrum. Because in a large service area different users are "served" by different meteors, interference between the users is virtually ruled out, even if the same frequency is used over a very large area. In this way, the whole of Europe can be served by using only one or two channels, dependent upon the configuration of the communication network.

Note: The advanced MBRS outlined herein probably exceeds 1,000-fold in performance and value as compared to "traditional" or modestly augmented MBRS found in most all papers on MBRS, including the most advanced MBRS described in this 1993 book.



Meteor Burst Communications:
Theory and Practice
Donald L Schilling, editor. Wiley, 1993

Part 1 below is from Mr. Shilling's oral history

Part 2 below has experts from the book

Part 1 From: http://ethw.org/Oral-History:Donald_Schilling

I co-authored 12 texts and more than 200 papers. I advised more than 75 Ph.D. students, many of who wrote their Ph.D. dissertations on CDMA related topics. In the 1960's I was involved with adaptive delta modulation, a voice digitization technique which was used by the military at that time; it is still used to perform analog to digital conversions.... I did the work initially for NASA, then after NASA I did it for the Army, and then for several other government agencies.

After the adaptive delta modulator I became involved in meteor burst communications, which was a wireless system used to transmit signals beyond the line of sight, using the meteor channel. Meteors are formed all the time, and we bounced our waves off of the meteors. If you do it right, you can get continual voice. A lot of this was done for the Air Force in Anchorage, where they transmitted between Anchorage and Kozebue, which is a city in Alaska right off the Russian border across the Bering Sea. It was a lookout station, and there was no real ionosphere to communicate back and forth, so they communicated off the meteors. We built the equipment and demonstrated that continual voice could actually be achieved if it was done properly. We had an adaptive system.

I edited a textbook for ... Wiley on Meteor Burst Communications, which dealt with that whole area.

Part 2

....Today, we know that to be true because man has walked on the moon, space travel has become... common..., high-energy lasers are used in the medical...and other areas, communication satellites carry voice and data circuits to all points of the globe, and there is meteor burst technology. Meteor burst technology? ["MB"] What's this? Are we bursting meteors? No, just another communications medium...until the early 1970s...virtually ignored.

Discovered in 1935 by a gentleman named Skellet, the technology was considered antediluvian in face of the then current communication systems.... Skellet found that when a meteor entered the earth's atmosphere, the denser air caused the meteor to heat up and eventually burn, creating an ionized trail. He discovered that the ionized trail could be used to bounce a radio signal back to earth. Scientists have known for decades that the earth is continually bombarded by meteors.... One hundred billion meteors have been estimated to enter or pass through the earth's atmosphere in a 24-hour period.

From the 1950s through the 1970s, meteor burst technology was studied and actual tests were conducted to determine the feasibility of using the meteor trails to an advantage. The result of that research produced some interesting information....

Ionized trails were found to have a lifetime of only a few tenths of a second, creating the need for rapid exchange of communication. The transmission rate had to be very fast (a burst of data if you will) to take advantage of the ionized trail. Hence the term "meteor burst" was coined. [U]ntil the availability of integrated solid-state micro-computers, meteor burst as a communication medium was not considered practical except for slow-speed data.... * * * * These short-lived... signals, or meteor bursts, may last from several milliseconds to many seconds.

Signal duration depends on trail line density, initial radius, diffusion rate, electron attachment and the state of upper atmospheric winds. Digital communications is possible during these brief, intermittent meteor bursts, thus forming the basis for an over-the-horizon digital radio link. Since persistent meteoric ionization useful for trail-scatter occurs between 80 and 120 km above the earth's surface, maximum propagation distances of 2400 km are possible. The maximum usable distance for communications, however, is generally below 2000 km because of earth blockage, terrain obstructions, and antenna pattern ground tuck. The time dependence of the trail-scattered RSL depends on the electron volume density in the meteor trail as well as atmospheric parameters.... * * * *

The Alaskan Air Command was the first to install a high-powered, 8kb voice-synthesized MB system as an operational commun-ication medium. Uniquely designed, it supports the operational requirements for Air Sovereignty in Alaska. Other uses may come to light that will parallel those of the Alaska Air Command. However, there will always be a need for inexpensive data systems within the military and in industry. Currently, NORAD is testing a C3 meteor burst network that will connect the Continental United States, Alaska and Canada.

The Alaska National Guard recently installed a MB system that ties the headquarters to remote locations throughout the state. Again, the cost of acquiring a MB system is considerably less than that of other systems, especially in the Alaskan environment. Other countries are now looking into the benefits of a MB system for specific applications, applications where great distances are involved and civil engineering support is too costly for other remote systems. A MB system has been installed between Sondres- trom AB and Thule AB, Greenland. The north-south link operates be- tween 45 and 104MHz. The system is a test bed to investigate performance during polar cap absorption (PCA) events.
...Popular Mechanics that described a MB system for truckers....

In the tactical arena, small portable transceivers could be used by the military in a variety of applications such as resupply nets, status of forces nets, intelligence nets, and others. The Navy could make use of a MB unit that was released under water and brought to the surface by buoy. This application would enable communications while minimizing detection. An oil platform out in the middle of a sea is the ideal application for MB. Red Cross and Civil Defense organizations could use portable MB systems to provide logistic support during natural disasters such as earthquake, flood, and fire. Alarm systems, emergency or logistical networks, and similar systems could be provided in remote locations at a fraction of the cost of comparable systems. Anywhere there is a need for data, MB is an inexpensive alternative that warrants consideration. The applications are limitless and await only the imagination of the far-sighted.... * * * *

It is true that faster is better in terms of system processing times.... However, there are applications where "instant" is not part of the vocabulary. The Alaska SNOTEL net is a good example. Meteorological information is required on a regular basis; however, it is collected over a 24-h period. A slow data base update is acceptable and is tailored to the data collection requirement. The prerequisite for that system is that the data must get through in a timely manner....

One only need analyze the basic information requirement, that is, life-cycle and time-to-live needs, to make decisions in choosing a baseline communications medium. Immediate update is not always the best answer to an equation.... In spite of the popular demand for more speed, systems like meteor burst still fill special application needs. Certainly, MB systems can be designed to perform as quickly as other systems through the use of new products now available in today's market.

In terms of cost, survivability, and intrusion resistance, meteor burst is hard to beat. Furthermore, it has that special Buck Rogers mystique... how else MB can be used.

Coded continuous wave meteor radar

Atmospheric Measurement Techniques Discussions

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Published by Copernicus Publications on behalf of the European Geosciences Union.

Abstract

The concept of coded continuous wave meteor radar is introduced. The radar uses a continuously transmitted pseudo-random waveform, which has several advantages: coding avoids range aliased echoes, which are often seen with commonly used pulsed specular meteor radars (SMRs); continuous transmissions maximize pulse compression gain, allowing operation with significantly lower peak transmit power; the temporal resolution can be changed after performing a measurement, as it does not depend on pulse spacing; and the low signal to noise ratio allows multiple geographically separated transmitters to be used in the same frequency band without significantly interfering with each other. The latter allows the same receiver antennas to be used to receive multiple transmitters. The principles of the signal processing are discussed, in addition to discussion of several practical ways to increase computation speed, and how to optimally detect meteor echoes. Measurements from a campaign performed with a coded continuous wave SMR are shown and compared with two standard pulsed SMR measurements.

The type of meteor radar described in this paper would be suited for use in a large scale multi-static network of meteor radar transmitters and receivers. …. For example, a continuous transmission would result in 14 dB of increased signal processing gain when compared to a pulsed system with a duty-cycle 25 of 4.4%. This additional gain can be either used to increase the fidelity of measured signals, or to reduce the peak transmit power requirements of a meteor radar system, in order to e.g., reduce the cost of a radar system….

The main advantages of a coded CW SMR are: (a) it can operate with less peak power, (b) it is suitable for a large scale multi-static radar network, (c) it does not suffer from the range-Doppler ambiguity problem, (d) there is no inherent limit to time resolution, and (e) it is less susceptible to false detections due to radio interference when compared with pulsed systems. The latter is possible since the pulse-like interferences would be 25 spread in range and Doppler in the decoding process. We would like to stress the suitability for a large scale-multi-static radar network. Not only would the low power transmitting systems with coded wave forms be more friendly with other radio users in nearby-bands, but also the

Coded continuous wave meteor radar
(Continued)

receiving systems could be simplified, by allowing the reception of multiple transmitters on the same antenna and same frequency. The separation of the different transmitted signals would be done by knowing the code of each transmitter site.

We have shown that with modest CW system transmitting 30W average power, one can obtain results not too different from those obtained with standard pulsed transmitter. Already the existing prototype used to demonstrate the principle of coded CW SMR could be used to derive winds in the mesosphere and lower thermosphere. We expect that better results, i.e., more meteor counts, could be easily obtained by increasing the transmitter power; or by adding more transmitters and receivers to measure the same volume.

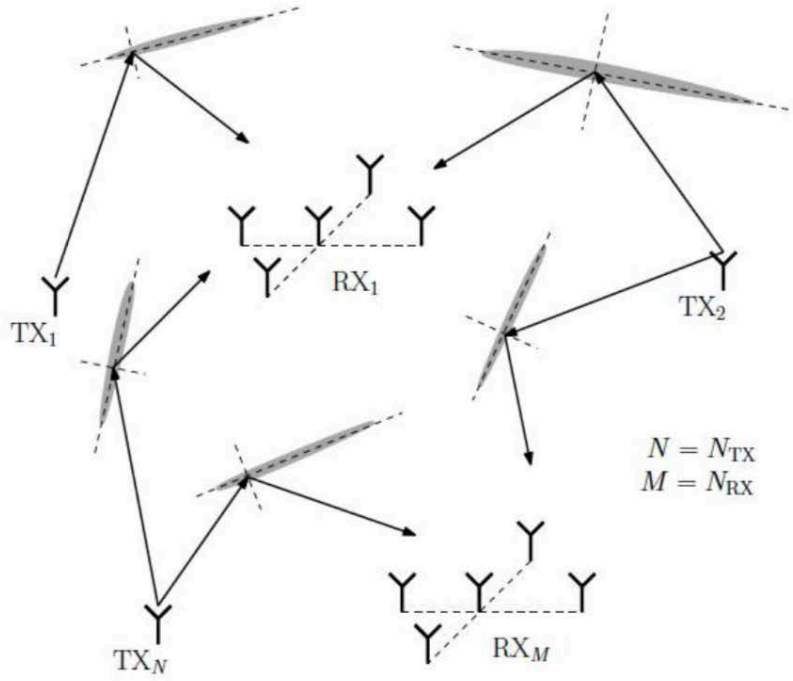


Figure 1. A depiction of a multi-static meteor radar network with multiple transmitters and multiple interferometric receivers. Each transmit-receiver pair observes meteors that match the specular condition, which is usually not met between two different transmit-receiver paths, and therefore to first order, each transmit-receiver path observes an independent set of meteor trails.

Conclusions

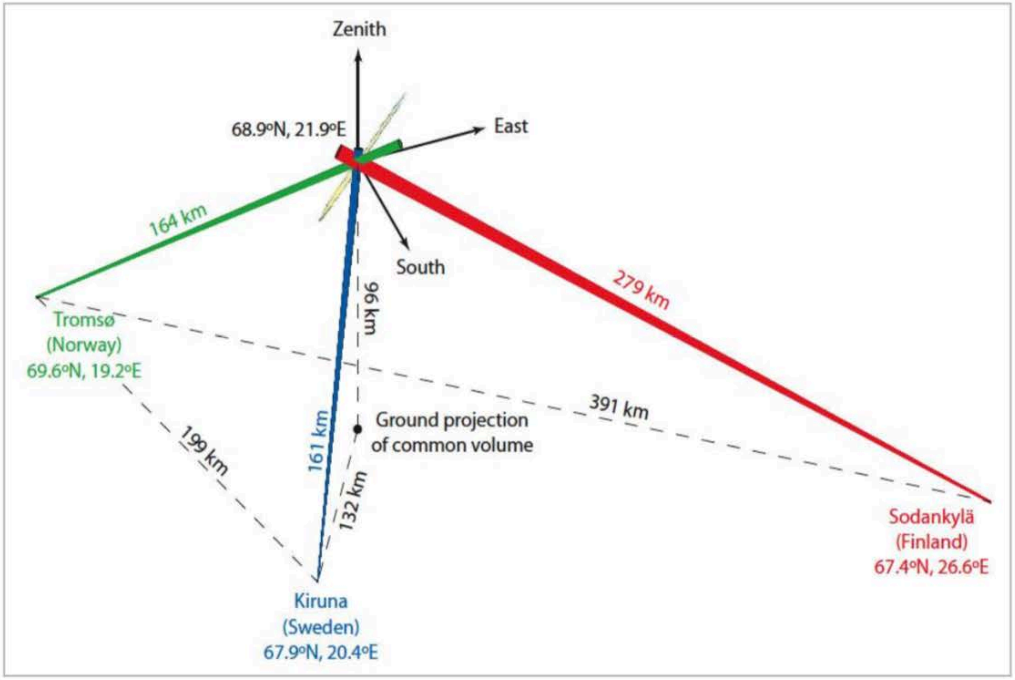
We have described the concept of a coded CW specular meteor radar, which can be used to build a large scale multi-static network of meteor radars, in which each single frequency receiver can listen to all of the transmitters that are within vicinity. The only restriction is that the transmitter cannot be extremely close to the receiver. Our measurement campaign results indicate that the 30W coded CW meteor radar is nearly as sensitive as a standard pulsed meteor radar with 15kW of peak power and 770W of average power. …

significant contributions to understanding the impact climate change has on the upper layers of the atmosphere by measuring any changes.

The radar will also be able to aid satellite observations of the ice and snow in polar areas, which are also feeling the effects of changing climate conditions.

An emerging type of environmental problem which EISCAT_3D will be able to observe is space junk also known as space debris. The term refers to all of the manmade objects that are left in orbit around the Earth after they can no longer fulfill any purpose. Observing these objects allows ISR to play a role in risk management since they pose a threat to space missions and satellites which could enter their path. Since EISCAT_3D will be 10 times more sensitive than any radar currently available, the accuracy in detecting space junk will be greatly increased.

Another major benefit of this new model is that it will be designed to allow for upgrades: "It is important to note that since the EISCAT_3D facility will be constructed for an operational period of several decades, the software radar concept allows the upgrading and enhancement of the measurement capability according to new solutions in computing and data storage".



Comment. Above depicts functions of EISCAT. It is from the paper: "HIGH-RESOLUTION METEOR EXPLORATION WITH TRISTATIC RADAR METHODS," Johan Kero, IRF Scientific Report 293, Swedish Institute of Space Physics, Kiruna 2008

[8] Ultra long-range ‘skywave’ (meteor burst) radio - for needed precise timing
(as alternative and back of of GPS and other methods)

The following concerns a new generation of Loran radio location systems, but it also applies to a new generation of meteor burst radio (MBR) systems. MBR has many advantages over Loran, and can be used with Loran.

ars TECHNICA STORE SIGN IN

GIMME A FIX —

Radio navigation set to make global return as GPS backup, because cyber

GPS killed the radio nav in 2010, but a high-def version is set to return.

SEAN GALLAGHER - 8/7/2017, 11:40 AM

National Air and Space Museum

Enlarge / This is the way we used to find our way around.

Way back in the 1980s, when I was a young naval officer, the Global Positioning System was still in its experimental stage. If you were in the middle of the ocean on a cloudy night, there was pretty much only one reliable way to know where you were: Loran-C, the hyperbolic low-frequency radio navigation system. Using a global network of terrestrial radio beacons, Loran-C gave navigators aboard ships and aircraft the ability to get a fix on their location within a few hundred feet by using the difference in the timing of two or more beacon signals.

An evolution of World War II technology (LORAN was an acronym for long-range navigation), Loran-C was considered obsolete by many once GPS was widely available. In 2010, after the US Coast Guard declared that it was no longer required, the US and Canada shut down their Loran-C beacons. Between 2010 and 2015, nearly everyone else shut down their radio beacons, too. The trial of an enhanced Loran service called eLoran that was accurate within 20 meters (65 feet) also wrapped up during this time.

But now there's increasing concern about over-reliance in the navigational realm on GPS. Since GPS signals from satellites are relatively weak, they are prone to interference, accidental or deliberate. And GPS can be jammed or spoofed—portable equipment can easily drown them out or broadcast fake signals that can make GPS receivers give incorrect position data. The same is true of the Russian-built GLONASS system.

Over the past few years, the US Coast Guard has reported multiple episodes of GPS jamming at non-US ports, including an incident reported to the Coast Guard's Navigation Center this June that occurred on the Black Sea. South Korea has claimed on several occasions that North Korea has jammed GPS near the border, interfering with aircraft and fishing fleet navigation. And in the event of a war, it's possible that an adversary could take out GPS satellites with anti-satellite weapons or some sort of cyber-attack on a satellite network.

As Director of National Intelligence Dan Coates told the Senate Select Committee on Intelligence in May:

> The global threat of electronic warfare (EW) attacks against space systems will expand in the coming years in both number and types of weapons. Development will very likely focus on jamming capabilities against dedicated military satellite communications (SATCOM), Synthetic Aperture Radar (SAR) imaging satellites, and enhanced capabilities against Global Navigation Satellite Systems (GNSS), such as the US Global Positioning System (GPS).

The risk to GPS has caused a number of countries to take a second look at terrestrial radio navigation. Today there's broad support worldwide for a new radio navigation network based on more modern technology—and the system taking the early lead for that role is eLoran. As Reuters reports, South Korea is preparing to bring back radio navigation with eLoran as a backup system for GPS, and the United States is planning to do the same.

Diff-e-q

The eLoran system gets its enhanced accuracy in much the same way that enhanced GPS gear squeezes greater accuracy out of the civil GPS signal for tasks such as surveying and mapping—by using differential correction. A stationary receiver at a known fixed location checks the signal arriving from the beacon and measures the difference between its actual distance from the beacon and the distance calculated from the signal (based on the difference between the signal's timestamp and the

time it was actually received).

In differential GPS, the differential information is broadcast by a base station at the known differential point; in eLoran, the data is fed back to the eLoran transmitter, and the transmitter applies the differential correction to its own signal. Since eLoran is regional, the differential calculation remains relatively accurate for its entire coverage area.

Because it uses low-frequency radio waves (in the 90 to 110 kHz range), it's not likely that you'll see eLoran integrated into your smartphone. While the antenna required for receiving eLoran signals is relatively small (about two inches square), that's a fairly massive amount of real estate for a smartphone to dedicate to a backup navigation system. But that size could be reduced with some investment in antenna miniaturization. And while eLoran only works in two dimensions (it doesn't provide altitude data) and only works regionally (with a range of 800 miles), it has one major advantage over GPS: its powerful low-frequency signals are far less susceptible to jamming or spoofing. The signal from eLoran beacons is 1.3 million times stronger than GPS signals. A 2006 MITRE study found that attempts to jam or spoof eLoran would be highly unlikely to work.

"[eLoran] is a deterrent to deliberate jamming or spoofing, since such hostile activities can be rendered ineffective," said Brad Parkinson, the retired US Air Force colonel who managed the original GPS development program, according to Reuters. A report Parkinson contributed to for an Institute for Defense Analyses Independent Assessment Team in 2014 found that "eLoran is the only cost-effective backup for national needs."

The administrations of both George W. Bush and Barack Obama pushed for a national eLoran system, but their efforts were never funded by Congress. However, the version of the Department of Homeland Security funding bill for 2018 just passed by the House of Representatives in July includes language calling for DHS to fund the construction and maintenance of a new eLoran system "as a complement to, and as a backup for" the GPS system. And the South Korean government already has pushed forward plans to have three active eLoran beacons by 2019—that's enough to provide accurate fixes for all shipping in the region should North Korea (or anyone else) attempt to block GPS again.