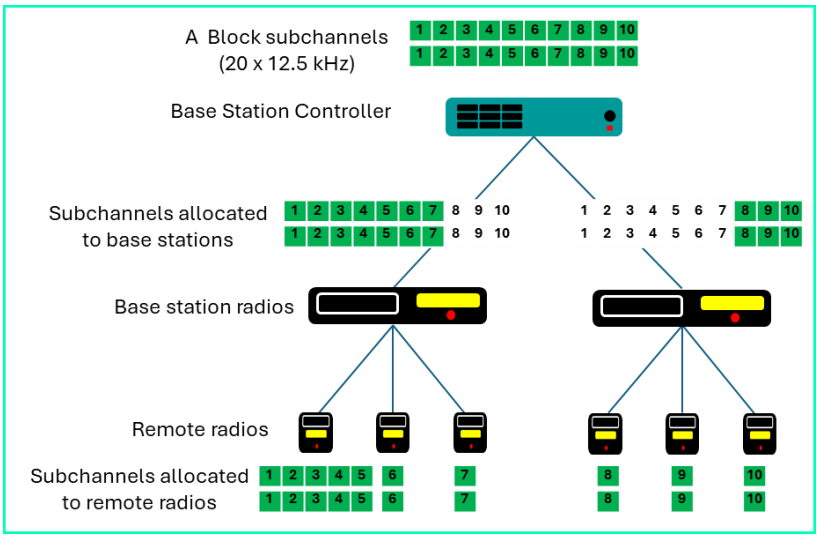
Base Station Controller

Bandwidth Multiplier for 802.16t Networks

ONDAS NETWORKS



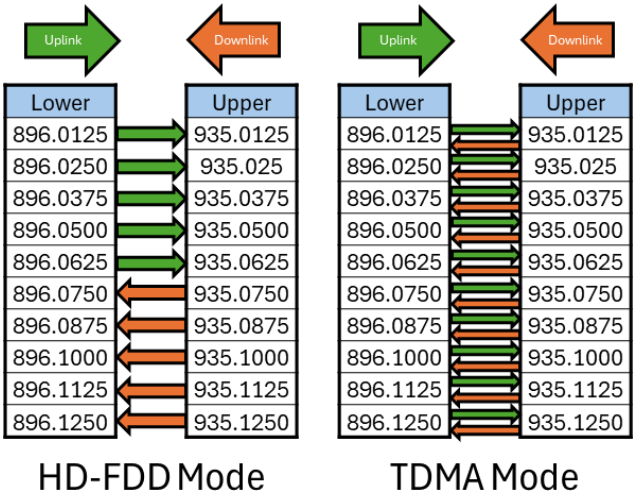
The **Base Station Controller (BSC)** is a central manager of Air Interface Resources (AIRs) utilized by 802.16t base stations and their connected remotes within a general purpose 802.16t radio network. The BSC is the foundation of an 802.16t network and provides bandwidth multiplication and self-interference avoidance which greatly optimizes the utilization of all available spectrum across all users. The BSC is a key building block within the Ondas 802.16t Point-to-Multipoint (PtMP) multicell, multisector system.

The BSC maintains a "control area" comprised of one or more "sectors" (a base station and its associated remotes) in order to ensure self-interference is avoided between all radios in the control area. The BSC assigns bandwidth to base stations for communication in the downlink and uplink directions. The BSC employs a Self-Interference Matrix (SIM) to re-use AIRs whenever possible – the same AIRs can be assigned to multiple sectors which do not interfere with each other. This can be considered a **bandwidth multiplier** capability, allocating unused bandwidth to base station radios in the downlink direction to support high traffic demands from remote radios in the uplink direction. Due to this capability, the total bandwidth available to the users of a band managed by a BSC far exceeds the bandwidth available with no BSC.

Base Station Controller Application in the 900 MHz A Block

In contrast to the way legacy ATCS channels were assigned to individual railroads, a BSC allows all sectors within its control area to have access to the entire available bandwidth in the new 900 MHz A Block (for example, all 20 x 12.5 KHz channels). As such, rigid partitioning of the A-Block to multiple railroads or rigid frequency partitioning of the bandwidth to sectors of one railroad is not needed. The BSC dynamically assigns the available AIRs to a sector in need at any moment in time. This dynamic assignment capability is aligned with the typical railroad application characterized by a low offered load most of the time and a higher load when events occur (such as train movements or messages to the dispatching system).

A BSC can operate in either Time Division Duplex (TDD) or in Half-Duplex Frequency Division Duplex (HD-FDD) mode depending on whether the underlying IEEE802.16t system operates in TDD or HD-FDD mode. For example, the 900 MHz A -Block is paired with two sub-bands spaced 39 MHz apart. Each sub-band contains 10 x 12.5 kHz channels. When operating in HD-FDD mode, the AIRs consist of time slots with 10 x 12.5 kHz channel pairs. However, the AIRs consist of time slots with 20 x 12.5 kHz channels when operating in TDD mode – providing twice the frequency utilization of HD-FDD.



The BSC can be deployed using the following strategies:

1.) A **common central BSC** serving all railroads within a given geographical area. It is most effective to utilize a single control area over a geographical area regardless of which railroads operate within that area - one BSC will control all base stations of all railroads operating on the A Block in the area. In this case, all available bandwidth is consolidated and managed by the BSC, and the BSC assigns AIRs to any base station within the control area.

2.) An **Independent BSC** for each railroad operating in a geographical area. In this case, partitioning of AIRs between the BSCs is needed. The AIR partitioning can be performed in the frequency domain only or in both the frequency and the time domain. AIRs assigned to a BSC are considered owned by this BSC. Unlike the previous scenario, however, BSCs of different railroads communicate with each other to enable a BSC in need

to borrow idle AIRs from a BSC which owns them.

Airlink Base Stations Utilized with the BSC
The BSC can be utilized with any 802.16t-compliant radio such as the Siemens Airlink family of software-defined radios. The Siemens Airlink base station, fixed, and mobile remote radios are based on IEEE 802.16t which enables wide-area, Internet Protocol connectivity. This allows railroads to transition from multiple, single-purpose networks to a common, managed, multi-purpose/multiband network and realize a significant reduction of infrastructure and operating costs.

The Siemens versatile, high-performance A53682 Airlink BCP Radio Hardware Platform is capable of operating in a dual-mode simultaneously in the newly available 2 x 125 kHz subchannels of the AAR A Block (HD-FDD and TDD mode) as well as the legacy 12.5 kHz ATCS bands. This allows railroads to migrate seamlessly from purpose-built ATCS networks to general purpose IP networks in support of a wide array of railway applications.

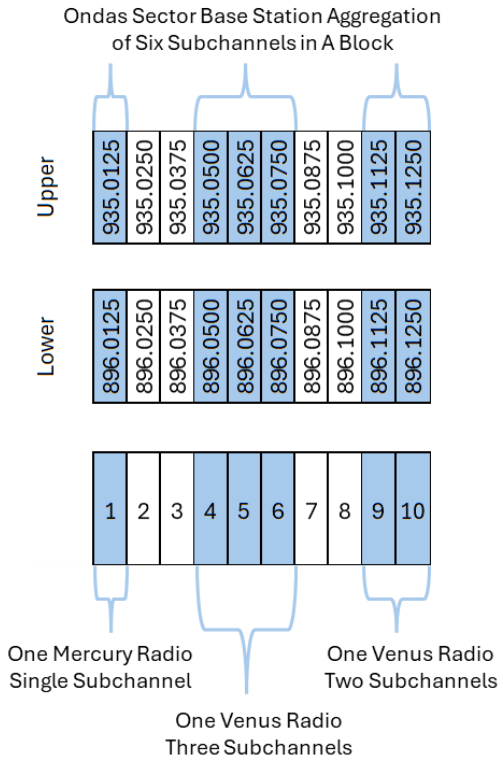
In addition to the Airlink BCP, the Siemens family of Airlink products also includes other base stations such as Airlink Venus which operate within other AAR frequency bands including spectrum in the 44 MHz, 160 MHz, 220 MHz, 450 MHz, and 900 MHz (AAR A Block) bands. Furthermore, the Airlink base station hardware supports flexible channel sizes ranging from as narrow as 12.5 kHz up to 10 MHz. The Airlink base stations support transmit power ranging from 4 Watts up to 100 Watts.

Key Characteristics of the Ondas MC-IoT Architecture:

Sector Bandwidth
The bandwidth available in the sector may consist of a contiguous band or an aggregation of multiple adjacent or nonadjacent channels within the 900 MHz A Block.

Sub-channels
The sector bandwidth is partitioned into multiple sub-channels. When the sector bandwidth consists of multiple adjacent or nonadjacent channels, the individual channels will be configured as sub-channels.

Subchannel Aggregation
An Ondas 802.16t Base Station (such as Airlink BCP) can aggregate channels over the entire A Block while 802.16t remote radios (such as Venus and Mercury) will operate over a single sub-channel or multiple sub-channels



Base Station Controller Hardware Requirements

Processor	Dual Intel Xeon Scalable (latest generation) or equivalent AMD EPYC processors, with a

	minimum of 32 cores per processor
Memory	256 GB DDR4 ECC RAM, expandable to 512 GB or more
Storage	2 TB NVMe SSD
Network interface	Dual (or multiple) 10 GbE (or 25 GbE) Network Interface Cards (NICs)
Power supply	Dual 2000W redundant power supplies with 80 Plus Platinum certification for high energy efficiency and uninterrupted power, even in the case of a power supply unit failure
Cooling system	Advanced liquid cooling system designed for high-performance servers, capable of maintaining optimal temperatures under continuous heavy loads
TPM	2.0
Operating system	Ubuntu 22.04
Maximum backhaul latency	50 ms