TaitNet P25 Digital Simulcast

Easy to use, with built-in intelligence

Position Paper

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INTRODUCTION

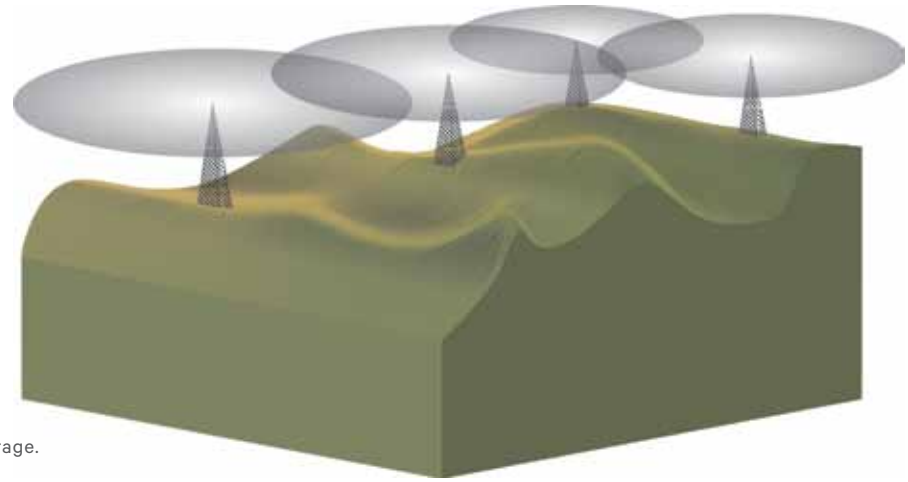
Agencies looking to upgrade their radio communications network, perhaps because of narrowbanding requirements, may find that they need to opt for a simulcast solution. There just isn't the spectrum available, or frequency licenses are too expensive, to implement any other solution. It is estimated that some 30 per cent of public safety networks in the US are simulcast.

P25 digital simulcast networks make using a radio simpler. You can move anywhere within coverage—no action required. The radio just works, letting you get the job done without distractions. No need for the user to change channel, and no risk of ending up on the wrong frequency.

Simulcast networks require additional intelligence, and Tait has built this intelligence directly into its TB9100 base station/repeater, increasing reliability and saving valuable rack space.

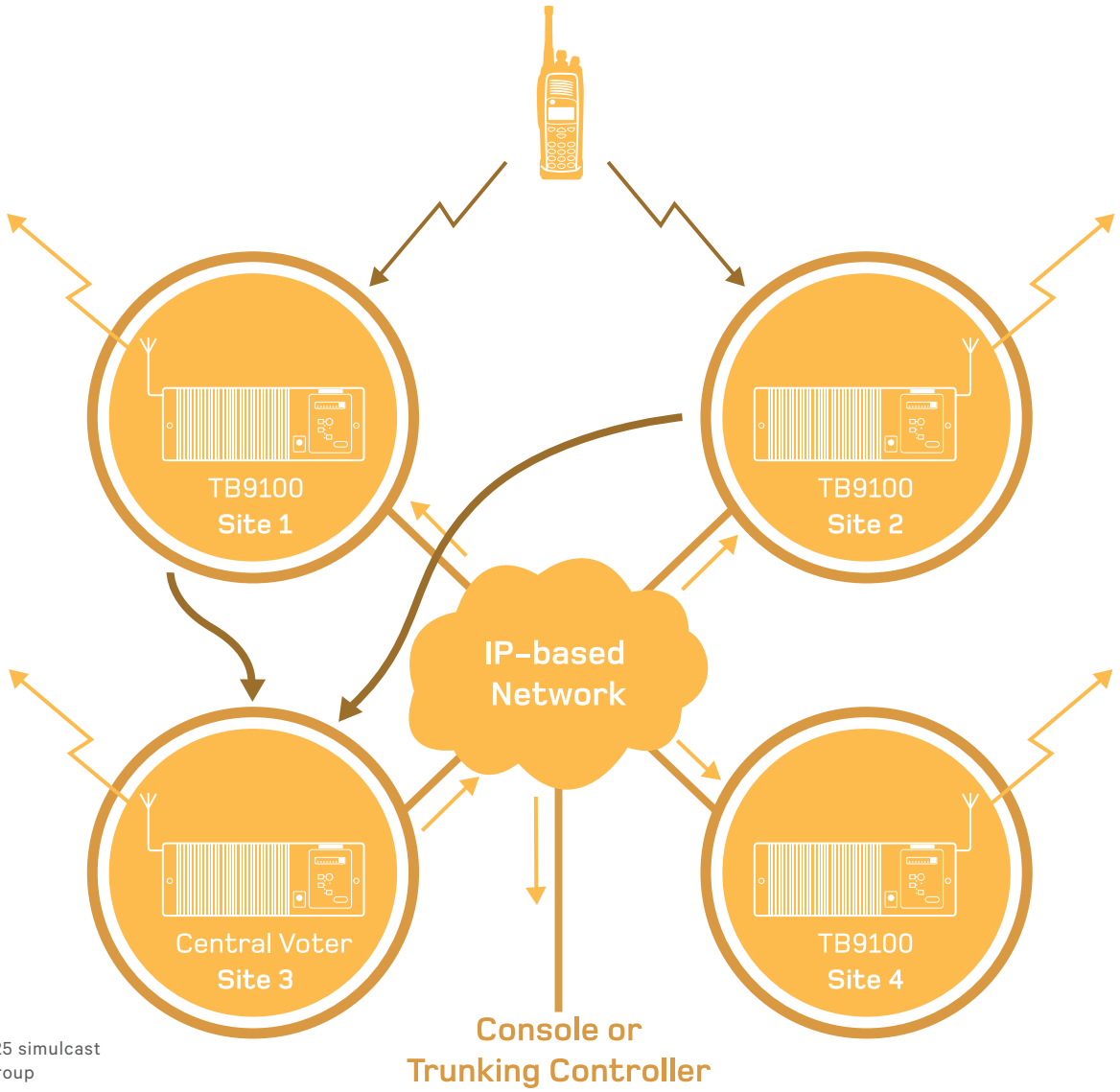
WHAT IS SIMULCAST?

Simulcast (simultaneous broadcasting) is the simultaneous transmitting by multiple base station/repeaters of the same signal on the same frequency. This makes it possible to extend the coverage of a single frequency pair to a very wide area. Using the very exact timing signal provided by GPS receivers located at each site, simulcast transmitters transmit together at a precisely defined time. In some areas of the network, one transmitter's signal is much stronger, capturing the radio's receiver so that other signals have no effect. In other areas, the radio will receive signals of a similar strength from two or more transmitters. In these overlap areas, the signals may add together, making them stronger, or they may interfere with each other, causing a gap in coverage. Careful network design, coverage modeling and configuration adjustments are needed to minimize this interference and ensure good reception in these overlap areas.



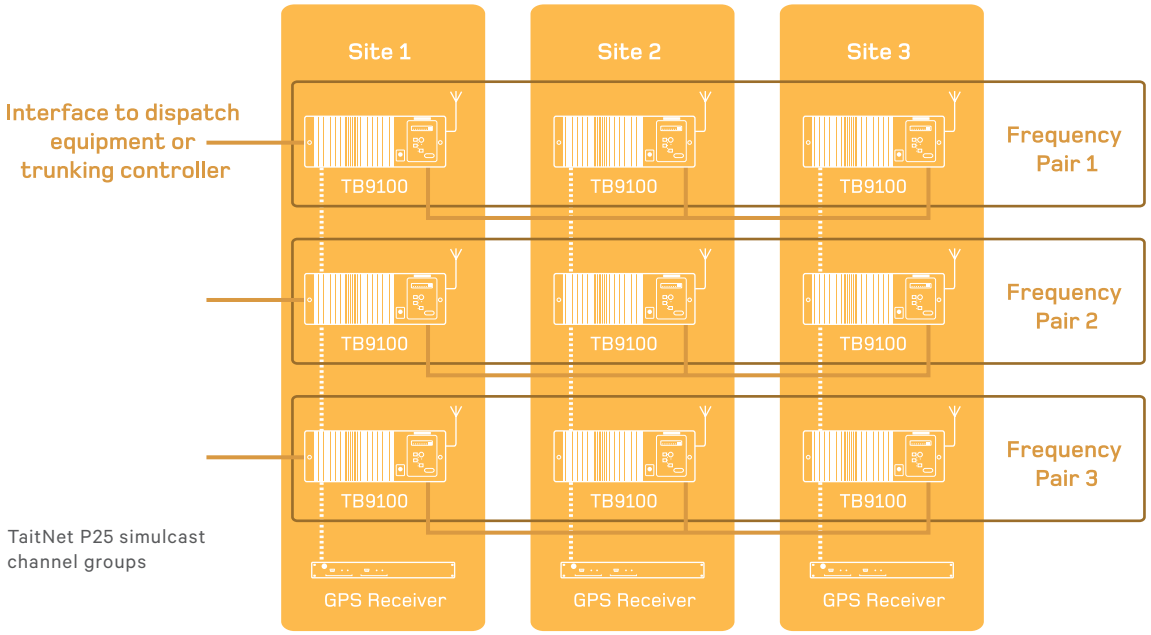
Simulcast network coverage. Overlapping areas show possible interference zones.

A simulcast network may need only one frequency pair; this will provide wide area coverage but can only carry one conversation at a time. While such a network may be ideal for a remote rural area, most networks need to be able to handle several conversations at once. To achieve this, several sets of base stations are installed, each set operating on its own frequency pair. TaitNet conventional networks consist of several sets of TB9100 base stations. Each set forms a channel group, in which the TB9100 base stations operate together in a coordinated way to provide a single wide-area channel. This makes these base stations ideally suited for simulcast.



TaitNet P25 simulcast channel group

In a TaitNet P25 simulcast network, each site will have one base station for each channel group, together with a single GPS receiver, which provides all the equipment at each site with its timing signal.



When a radio user speaks, all the base stations in the simulcast channel group are listening. Voting selects the best signal for repeating and for providing to the dispatcher. Other simulcast networks use comparators, but Tait TB9100 base stations have this voting capability built in. Using voice over IP (VoIP), they send the voice they receive from the radio to the channel group's multicast IP address. One of the base stations in the channel group acts as the central voter, combining the best possible signal from all those that were received and then providing it to the dispatcher and all the other base stations for re-transmitting.

THE ADVANTAGES OF SIMULCAST

Simulcast networks bring the following benefits:

- **Spectrum efficient:** Simulcast re-uses the same frequencies at all sites. Non-simulcast networks need many more frequency licenses. For example, a 7-site, 4-channel simulcast network needs four frequency pairs. If that network were non-simulcast, it would need 28 (this number could be reduced, through re-use of the same frequency pair, but only for base stations that are so far apart from each other that there is no overlap in coverage). That many frequency pairs may simply not be available or might be prohibitively expensive to obtain.

- **Seamless roaming:** Radio users can migrate anywhere within the coverage of multiple transmitters. There are no voice drop-outs when the radio moves from one site coverage area to another, and no call setup delays while the radio scans for the best channel. Radio communications just work, allowing users to concentrate on their task.
- **Better in-building coverage:** In overlap areas, the network provides signal from multiple directions. This improves coverage within buildings and in high-rise areas, reducing the risk that communications will be lost.
- **Easier expansion:** The coverage area of a conventional simulcast network can be increased without requiring additional frequency licenses or the time-consuming recall of radios for re-programming.

THE TAIT SIMULCAST SOLUTION

TaitNet P25 digital simulcast is a mature, fully featured solution, available for particular trunked sites or for whole trunked or conventional networks. TaitNet simulcast channel groups can also be easily integrated with other TB9100 base stations and channel groups to give the network a mix of simulcast and non-simulcast functionality that is tailored to your requirements.

The heart of the solution is the TB9100 base station, with its built-in simulcast intelligence, remote diagnostics, remote firmware upgradability and programmable Task Manager. There is no need for a prime site with its additional equipment. TB9100 base stations only need the correct software feature licenses to carry out the simulcast controller and voting comparator functions.

TaitNet simulcast is available in VHF, UHF and 700/800 MHz bands, to suit the availability of frequency licenses. Available with standard P25 C4FM modulation, TaitNet P25 simulcast can optionally use CSM (Constant-Envelope Simulcast Modulation), a modulation scheme developed by Tait for simulcast networks. CSM extends radio coverage without needing linear transmitters, reducing the number of sites required.

BUILT-IN IP

Voice and signaling are transported as IP packets. Because the TB9100 base station is designed from the ground up to use IP, no additional equipment is needed for protocol conversions from older circuit-switched technologies. These base stations are designed to also use IP for their work together as a channel group. An IP-based backbone brings major advantages compared with the leased lines traditionally used by analog networks. This backbone uses commercial off-the-shelf equipment such as routers and switches and can be based on a variety of linking media, giving agencies a choice between microwave, fibre-optic cable, and data-capable lines.

BUILT-IN VOTING

One base station in the channel group carries out the voting function. The centrally voting base station receives multiple voice streams over IP. Using a combination of

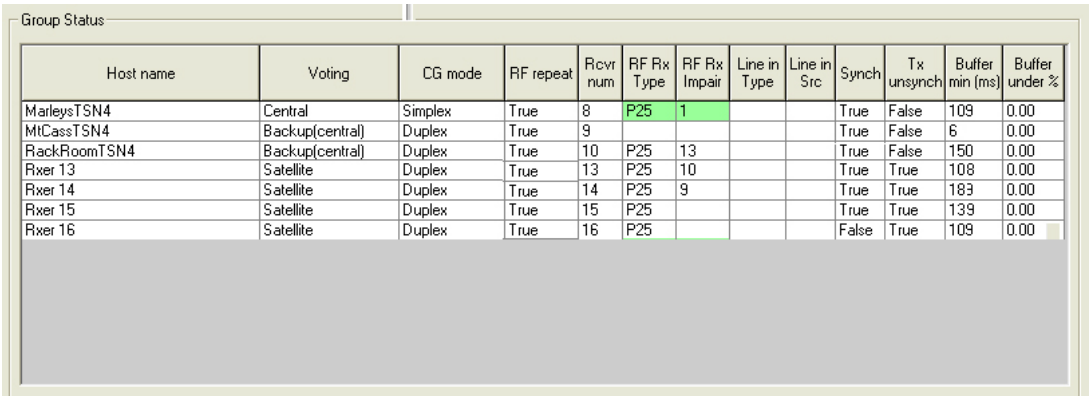
quality measures—of each 20 ms block of voice as well as the running average from each receiver—it weaves together the best inputs from different receivers, ensuring reliably high audio quality.

BUILT-IN SIMULCAST CONTROL

Simulcast control is also built into the base station. The central voter time-stamps the voice to be transmitted, telling the other base stations when to transmit. The central voter also receives regular reports from these base stations, which enable it to adjust the timestamps automatically as needed, to give more or less time for the voice to travel across the IP network. In this way, TaitNet simulcast overcomes network delay and jitter, an intrinsic characteristic of IP networks. This technique can even handle the failure of a link; if the linking infrastructure provides a redundant, but slower path, the central voter automatically lengthens the traveling time allowance to compensate.

BUILT-IN MONITORING

The network administrator can remotely connect to the central voter and monitor the simulcast operation of the whole channel group in real time.


Group Status

Host name	Voting	CG mode	RF repeat	Rcvr num	RF Rx Type	RF Rx Impair	Line in Type	Line in Src	Synch	Tx unsynch	Buffer min (ms)	Buffer under %
MarleysTSN4	Central	Simplex	True	8	P25	1			True	False	109	0.00
MtCassTSN4	Backup(central)	Duplex	True	9					True	False	6	0.00
RackRoomTSN4	Backup(central)	Duplex	True	10	P25	13			True	False	150	0.00
Rxer 13	Satellite	Duplex	True	13	P25	10			True	True	108	0.00
Rxer 14	Satellite	Duplex	True	14	P25	9			True	True	183	0.00
Rxer 15	Satellite	Duplex	True	15	P25				True	True	139	0.00
Rxer 16	Satellite	Duplex	True	16	P25				False	True	109	0.00

Monitoring screen

From this screen you can see which receiver is winning the vote, whether the transmitters are synchronized, if any buffer underflows are occurring (these cause voice drop-outs), and what the current size of each transmit buffer is.

NO SINGLE POINT OF FAILURE

Failure of a comparator generally means failure of an uplink over a wide area. For other vendors, providing a redundant prime site to eliminate this single point of failure is difficult, expensive, and requires additional equipment that mostly lies idle. TaitNet P25 simulcast has no need for prime sites. The most centrally located site generally handles the central voting and simulcast control, but other sites can easily be configured to take over these functions should that site fail. No additional hardware is required.

INDUSTRY-LEADING COMPACT DESIGN

Having so much intelligence built into the TB9100 base station saves rack space, rental costs and power consumption. There is no need for comparators, IP converters or simulcast controllers. Two 50-watt transmitters, with their associated receivers and power management unit supporting AC and DC, occupy only four rack units of site space.

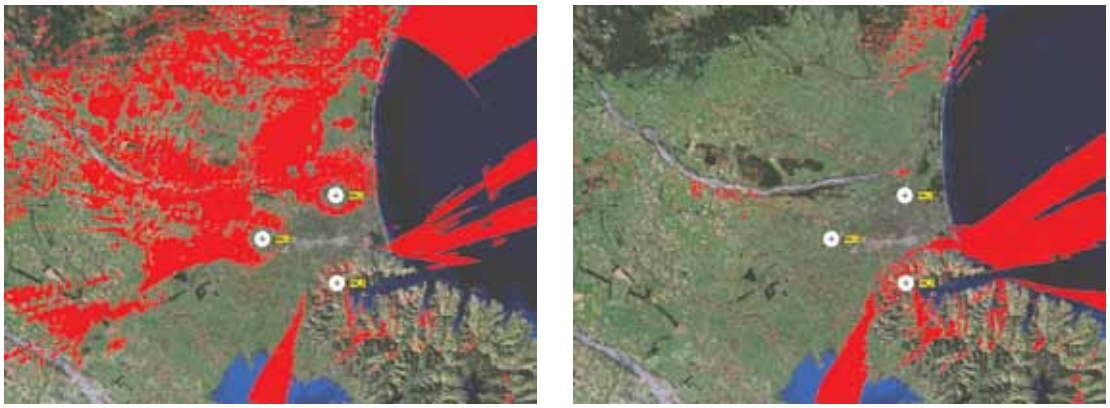
DESIGNING, DEPLOYING AND SUPPORTING A SIMULCAST NETWORK

Simulcast networks are challenging because of the interference issues that arise from having many sites transmitting on the same frequency. Careful network design and coverage modeling, together with optimization and thorough coverage verification at commissioning time, are needed to ensure that the solution meets your needs. Tait has experienced engineers who can work with you and your consultants designing, deploying and maintaining a simulcast solution that conforms to TSB-88 guidelines.

In non-simulcast networks, coverage modeling is mainly about estimating signal strength or signal-to-noise ratio. In a simulcast network, delay spread is the key parameter, requiring the use of sophisticated coverage modeling. If signals are of similar strength, but come from transmitters that vary greatly in their distance from a radio, the delay spread will be too great causing poor reception. Areas of high delay spread need to be identified and minimized or eliminated, for example by configuring some transmitters with a very small built-in delay, by using directional antennas, or by adding transmit towers to the design.

In the following example coverage models, the red areas indicate that the bit error rate would be too high for reliable reception. The first map shows the initial result of coverage modeling, while the second shows that adding small delays is able to shift the red areas out to where coverage is not required, such as at sea.

COVERAGE MODELING



(Left) Three-site simulcast network: No optimization

(Right) Three-site simulcast network: Optimized for best coverage

Once the network is installed, coverage tests are carried out. Here is where the built-in intelligence of the TB9100 again proves itself. From their vehicle, engineers can switch a simulcast channel group into a synchronized transmission test mode, by sending a special signal from their Tait mobile or portable. In this mode, the channel group transmits a test pattern, which Tait radios can decode and use to provide an accurate measure of the signal's bit error rate. In this way, a single Tait engineer can measure the quality of the signal across the network's coverage area quickly and efficiently. Bit error rate values can be output to a data collector, for overlaying on a map of the terrain. This allows the engineer to compare the predicted and the actual coverage and to make final changes to optimize coverage.

CONCLUSION

When your coverage is non-negotiable, your frequency allocation struggles to keep up with channel demand, and when every dollar counts, choose a TaitNet P25 simulcast network. Simulcast requires a minimum of radio spectrum and simplifies radio operation. TaitNet P25 networks harness the built-in intelligence of the TB9100 base station and reduce the rack space required. Experienced Tait engineers can work with your consultants to predict simulcast coverage, design the network to your requirements, install it and optimize it for best signal quality.

TAIT COMMUNICATIONS

Tait Communications is a global leader in designing and delivering radio solutions which are the right fit for a variety of industries including; public safety agencies, government services, utilities and urban transport providers.

MORE INFORMATION

For more information on TaitNet P25 simulcast, please contact your nearest Tait dealer.

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