

Wireless Video Integrator

Frequently Asked Questions

Purpose

The following Frequently Asked Questions (FAQ) are designed to educate new DTC customers by first helping to identify key factors affecting their equipment needs such as the frequency bands they are authorized to use, link distances required, and environmental characteristics. Next, video technologies are examined along with any tradeoffs of the competing technologies. Equipment performance specifications are reviewed in detail. Finally, actual product offerings are considered along with accessories. This is the logical approach that should be taken by a first time customer who is unfamiliar with wireless video system design. This process should help to clear up many of the mysteries associated with this task. It is assumed that the reader has a communications engineering background. The theory and formulas presented here are relatively simple and extremely useful but may be confusing to people without a technical background.

Services

DTC service offerings range far beyond standard pre- and post-sales product support to deployment services for risk-reducing installation and startup, implementation, and integration. We offer services to help you proactively reduce setup time and performance services to provide objective technical assistance to help you make the most of your investments.

DTC offers innovative support services to complement your internal capabilities with proven surveillance products expertise. We offer consulting services to integrators who utilize our products onto their platforms such as unmanned vehicles. We also offer consulting to design and deliver custom covert surveillance solutions.

Rely on the support professionals who know DTC products the best.

DTC Service capabilities include:

- Total lifecycle support for all DTC products
- A full range of proven preventive, diagnostic, remedial, and repair services
- Flexible purchase options to simplify DTC service planning, acquisition, and budgeting
- Post standard warranty service
- Consulting services for integrators
- Custom covert surveillance solutions utilizing standard DTC modules

Frequently Asked Questions

1. What frequency band should I use?

This depends on the end use for your video system. Who is going to be using it? Where is it going to be used? Different frequency bands have been authorized by the National Telecommunications and Information Administration (NTIA) to be used by federal agencies and the Department of Defense (DOD). The Federal Communications Commission (FCC) is in charge of spectrum for state and local law enforcement agencies and commercial entities such as television broadcast stations. In many cases the end user will already know the frequency range that they will require. If the equipment is going to be used for state and local law enforcement or non-commercial public service, spectrum use and licensing is covered under Part 90 of the FCC rules. Generally speaking there are two Part 90 bands commonly used for wireless video transmission: the 2450-2483.5 MHz Public Service Band and the 4940-4990 MHz Public Safety Band.

A final consideration is where the equipment will be used. Obviously if the equipment is used in a foreign country then the video system will have to comply with that country's local spectrum use policies. In the case of DOD use, certain frequency bands are North Atlantic Treaty Organization (NATO) harmonized, which simplifies compliance in other NATO countries.

2. Does the end user need to get a license to legally operate the video system?

If the end user is authorized to use NTIA controlled spectrum then a license is usually not required, although the NTIA has rules for coordinating channels to avoid interference. The DOD also does not require a license but may coordinate channels to avoid interference. If you represent a state or local law enforcement agency, you need to apply for a Part 90 license. There is no charge for this and the license is easy to get. Commercial broadcasters have specific spectrum set aside for their exclusive use and need to get an FCC Part 74 license in order to legally use this spectrum. Anybody can operate license-free on spectrum covered under FCC Part 15, but to avoid interference, Part 15 users have to run low power, which severely restricts the range of the video system. The FCC Parts 15, 74, and 90 rules can be found on the FCC web site (www.fcc.gov) along with license application information.

3. I notice that DTC and others offer video systems in a variety of different frequency bands. Which ones are for Federal/DOD, Commercial Broadcast, and State & Local law enforcement use?

Things change all the time with spectrum use authorization but the following is a rough guide of typical bands employed for mobile video transmission systems:

*300 – 400MHz	DOD (NATO Harmonized), International
*1100 – 1400MHz	DOD International, UK 1389-1399MHz license-free video
*1700 – 1850MHz	DOD NTIA Federal L band, 1755 –1850MHz in the USA
1990 – 2110MHz	FCC, Broadcast Auxiliary Services Part 74 license required recently reduced to 2025-2110MHz (Nextel relocation)
*2200 – 2300MHz	NTIA Federal, DOD, Satellite downlink band
*2400 – 2500MHz	FCC Part 15, Part 90 2450-2483.5MHz (State & Local LE)
2500 – 2700MHz	International
3100 - 3500MHz	International
*4400 – 5000MHz	NTIA Federal (4400-4500, 4800-4940MHz), FCC 4500-4800MHz, FCC Part 90 Public Safety Band 4940-4990MHz

* Bands covered by DTC video products.

- UHF Band 300-400MHz
- L1 Band 1150-1450MHz
- L Band 1710-1850MHz
- S2 Band 2200-2300MHz
- S Band 2400-2500MHz
- C Band 4400-5000MHz

4. Should I be concerned about interfering with other services?

Yes, there are certain parts of the spectrum that are heavily used for revenue-making services such as mobile phone and broadcast services. A good rule of thumb is to *stay off of spectrum that a private enterprise actually owns or has paid good money for a license to operate on*. Other parts of the spectrum to avoid are search-and-rescue frequencies, satellite navigation downlink channels (GPS), early-warning radar, nuclear event detection channels (you don't want to be responsible for starting WWII), and clear channels used for radio astronomy (receive only). The list below gives some (but not all) of the services to avoid. Remember, just because the radio will tune to these services does not relieve you of responsibility for causing interference. Finally and perhaps most importantly, you should consider interference to you. Are there nearby wireless systems you are using that will cause interference or be interfered with? Careful channel/frequency/band selection, antenna placement, and RF filtering may be required.

North American Services in or near microwave video transmission bands:

- Military Aircraft Air to Ground Communications 225-400 MHz
- *Aircraft Emergency Beacon 406 MHz
- GPS 1176.45 MHz (L5), 1227.60 MHz (L2), 1379.513 MHz (L4), 1381.05 MHz (L3), 1575.42 MHz (L1)
- *Radio Astronomy 1400-1427 MHz, 1660-1670 MHz, 4990-5000 MHz
- *3G Wireless Services 1432-1435 MHz, 1710-1755 MHz, 2110-2170 MHz, 2500-2690 MHz
- Mobile (Phone) Satellite 1518-1559 MHz, 1610-1675 MHz, 1980-2010 MHz, 2170-2200 MHz, 2483.5-2520 MHz, 2670-2690 MHz
- *Cellular PCS 1850-1910 MHz (Handset), 1930-1950 MHz (Base)
- Military Satellite Down-link 2200-2300 MHz
- *Satellite Radio Broadcast 2310-2360 MHz

Note: In some cases a band can be used on a secondary basis as long as interference to the primary user is not incurred. Consult with the NTIA www.ntia.doc.gov for primary/secondary user status of your Service. Bands marked with an asterisk * are not shared under any condition. This list is not all inclusive, other services that may need protection could be missing. Some Services are protected on a geographic basis.

5. I see several frequency bands that my end user is authorized to use. Which would be the best?

The first thing to consider is where the end user plans to use the video system. Will it be in an area where the spectrum is heavily used and finding a clear channel may be difficult? If this is the case, go with the band that has the most available spectrum. Usually this is the higher frequency band.

The second thing to consider is the desired range of the video link. If you think the user will be trying to get maximum possible distance then consider the lowest frequency band where propagation losses will be lower. Also, pick the band that allows the most transmitter output power. Remember that in many cases the extra propagation loss encountered in the higher frequency bands can be overcome with additional antenna gain. Also consider that if the antenna is mounted low to the ground on either end of the link then path performance will be compromised (see FAQ number 9). Because of this you might find that the actual link range difference between a high frequency band and a lower frequency band is minimal.

The third thing to consider is self-interference. Assess what other communications platforms are co-located with the video system. In particular, look at receivers that are in the same vicinity as transmitters. Small unmanned vehicles (robots) are particularly challenging because they typically have a video transmitter, a telemetry transceiver (for operator controls), and a GPS receiver on board. It is very likely that a video transmitter operating in the lower portion of L band could overload the front end of a GPS receiver if measures are not taken to prevent this. Another typical scenario would be a video transmitter in the S band interfering with a telemetry link that is also operating in the S band. The cure for these issues is to *plan for the bands these communications systems will be operating in*. Separate the communication systems in frequency as much as possible. Separate the antennas on these systems as much as possible. If signal overload is still a problem, it can be cured with additional band pass filters on either the receiver of the system experiencing interference or to the output of the interfering transmitter. *Add band pass filters on the receiver of the system experiencing interference (due to front end overload) or if the interference is due to out of band emissions from a transmitter spilling over into the receive frequency of the receiver experiencing interference, a filter can be added to the output of the interfering transmitter.* Rearranging antennas in both horizontal and vertical planes may also provide a cure. Having to fix the problem with band pass filters is both expensive and introduces filter losses that will reduce link range.

6. I notice that the frequency bands for portable/mobile video links stop at about 6000 MHz. Why don't they go above that?

6000 MHz is roughly the point where mobile services stop and fixed services begin. Fixed services are point-to-point links that carry dedicated digital or video wireless traffic. At 6000 MHz and above, the highly directive antennas used for these long-haul links get reasonably small in size and make the 6000 MHz and up range viable for these crucial services. Conversely, the range from about 300 MHz to 6000 MHz is better suited for portable and mobile services due to lower absorption and propagation losses. Below about 300 MHz the video channel bandwidth is too wide and would interfere with narrowband voice and data services.

7. I may need to deploy my system internationally in the future and cannot predict where it will go. Isn't there any international authority that can coordinate spectrum and services that are used on a world wide basis?

There are international standards organizations such as the European Telecommunications Standards Institute (ETSI) and the International Telecommunication Union (ITU) that make recommendations for spectrum utilization and, to a large extent, ensure that services do not interfere with each other. This is especially true in parts of the world where there are many smaller industrialized countries in close proximity to each other such as Western Europe. Unfortunately, the international standards organizations make recommendations and do not participate in issuing licenses or other regulatory activities; this is the responsibility of each individual country. If a wireless system is deployed in a certain region where it might be used in multiple countries it would be best to pick a band that is recognized by all countries in the region as being usable for portable video and/or data transmission. If the system is going to be used for DOD applications, contact the DOD for recommendations.

8. How can I tell what the range of my wireless video link will be?

This is the most frequently asked question and also the hardest to answer accurately. If the link is deployed in such a way that there are no obstructions between the transmitter and receiver antennas and the antennas are mounted high off the ground then we have a condition known as a Line-of-Sight (LOS) path. This is typical of fixed point-to-point links but is almost never the case with portable and mobile links. The best that we can do is to calculate the LOS range and ensure that it is sufficiently longer than the maximum distance you are ever going to need in a Non-Line-of-Sight (NLOS) or obstructed path.

To calculate the link margin you need to know the following:

Frequency of operation (f) in GHz. The center frequency of the frequency band you are using is sufficient.

The desired link distance (d) in miles.

Propagation loss (L_p). $L_p = 96.6 + 20 \log f + 20 \log d$

The **threshold sensitivity of the receiver (P_{in})**. This is the point where the signal level into the receiver is on the verge of going from useable to not useable and is defined in terms of input power (in dBm or decibels referenced to 1 Milliwatt). This value can change depending on transmitter modulation and bandwidth. Actual receiver threshold values will be found in the equipment data sheets. Note: P_{in} will always be a negative number; when plugging P_{in} into the system gain equation, *use the absolute value of P_{in}* .

The gain of the transmitter and receiver antennas less antenna feed cable losses (dBi). The antenna gain can be found on the manufacturer's data sheet. Add the gain of the transmitter and receiver antennas and subtract the cable losses to arrive at a total antenna gain figure (G_{ant}). Note: If a diversity receiver is being used *just take the gain value of one receiver antenna*. If a low noise amplifier (LNA) is used between the antenna and the receiver *just subtract the loss of the cable between the antenna and the input of the LNA*.

The output power of the transmitter or RF power amplifier (P_{out}) if so equipped (in dBm).

Calculate **system gain (G_{sys})** in dB using the following formula ($G_{sys} = |P_{in}| + P_{out} + (G_{ant}) - (L_p)$).

Calculate **link margin** (G_{link}) in dB using the following formula ($G_{\text{link}} = G_{\text{sys}} - L_p$). If G_{link} is a negative number then you will need more transmitting power, or more antenna gain. The value of G_{link} is known as the *link margin* or *fade margin*. It is the excess gain that is available at the receiver to ensure reliable signal power. Too much link margin means wasted transmitter power. Not enough link margin means the possibility of losing the signal if the path becomes obstructed. Generally speaking, a fade margin of between 10 to 20 dB is desirable.

The formulas can be worked in reverse where system gain is calculated first then the link margin is subtracted from the system gain. A propagation distance is determined using the propagation loss equation such that $L_p = G_{\text{sys}} - G_{\text{link}}$.

It should be noted that *every 6 dB of additional system gain will double the propagation distance*, or put another way, a 6 dB increase is equivalent to quadrupling the transmitter output power. It works the other way also; if you reduce the path distance by one half you can reduce the transmitter power to one quarter of its present output power and maintain the same link margin. Keep in mind that having excess link margin is not going to hurt anything.

9. I know my antennas are going to be low to the ground and that the link path will be obstructed by different objects from time to time. How can I predict how much this will degrade my path?

Different obstructions have varying amounts of RF absorption. A general statement can be made that the lower the frequency the lower the absorption. Obstructions that reflect rather than absorb RF can be problematic with some modulation schemes and beneficial with other schemes. We will discuss this in more detail as well.

Having antennas low to the ground can cause problems with ground absorption/reflection and, on long paths, earth curvature (not usually a problem on portable links). A general rule of thumb is that the higher in frequency the lower the antenna can be before ground obstruction is a problem. The minimum antenna height (H) in feet above ground to clear obstructions is determined by the following equation.

$$H = 43.3\sqrt{(d/4f)}$$

d = path distance in miles
f = Link frequency in GHz

10. You mentioned that different modulation schemes affect link performance. Can you go into more detail on this?

This relates to determining (P_{in}) from Question 8. DTC offers two distinct technologies for the wireless transmission of video; one is FM analog video transmission and the other COFDM digital video transmission. The two systems are very different from each other. Each has its strengths and weaknesses.

Analog video works by taking a composite video signal, usually from a camera and using this to frequency-modulate (FM) a microwave carrier signal. If audio or data channels are required, these are put onto FM subcarriers that are placed with the video. Analog's strong points are simplicity, reliability, power efficiency, low delay, and low cost. Analog's weakness is that it is wide-band technology and thus it occupies more valuable frequency spectrum and allows more noise into the receiver. DTC's analog receiver sensitivity specification is -83 dBm for a 40 dB SNR (noise-free picture). Analog is also susceptible to multipath which is video distortion and cancellation caused by reflected signals combining with the direct-path signal from the transmitter. The reflected signals which are delayed combine with the direct path signal and cancel each other at the receiver antenna. This will happen regardless of the distance between the receiver and transmitter and is particularly bad at locations where there are flat, highly-reflective surfaces such as indoors, over bodies of water, or dense urban settings.

DTC's Palladium™ digital video products use a method of modulation known as Coded Orthogonal Frequency Division Multiplexing (COFDM). COFDM video works by first taking the video input from the camera, digitizing it, then compressing the video data stream. Conventional wireless data transmission is sent by modulating a single microwave carrier with a high-data-rate stream. COFDM is a way of wirelessly sending data by dividing up (multiplexing) the high-data-rate stream into *many low-data-rate streams* and modulating *many carriers* with these *low-data-rate streams*. The carriers are all closely spaced to each other in an orthogonal (90 degree) relationship so there is no cross-talk interference between adjacent carriers.

By utilizing this technique of putting small amounts of data on many closely-spaced carriers versus putting a large amount of data on a single carrier, multipath effects are virtually eliminated. This is because a *low-data-rate* carrier is much more tolerant of signals that are delayed (due to reflections) than a *high-data-rate* carrier would be. In fact, COFDM actually takes advantage of signals that arrive by non-direct paths. Because of this, they can work well in non-line-of-sight, high multi-path environments.

If some of the carriers are lost due to multipath cancellation, another technique is employed, called FEC (or Forward Error Correction) which can recover lost data by *coding* data before it is sent. In order to do this effectively, a certain amount of redundant *coding data* is introduced into the data stream. Unfortunately the coding data will reduce the amount of capacity available for the video and audio *payload data* that needs to be sent over the link. The more coding data that is introduced the better the performance of the link will be in low signal strength conditions (*threshold*). If payload data capacity is reduced, the quality of the video will degrade since the video compressor will have to work harder to compress the video down to a lower data rate.

An important concept to be aware of in Digital Video systems is that the video compressor is always aware of the available video payload capacity in the link. Available video payload capacity will change depending on modulation, FEC, and bandwidth settings as well as other services being sent over the link such as digitized audio. If the compressor has to work hard to compress the video down to a low data rate, the time required to compress the video goes up. This is known as *latency* and under high payload capacity (greater than 3 Mbits) can be as low as 50 mS but under low payload capacity (less than 1.5 Mbits) can exceed 200 mS.

COFDM wireless links are very flexible in how they can be configured to suit different wireless link requirements, let's explore the tradeoffs.

Bandwidth: DTC's Palladium™ systems are fixed at 2.5 MHz -- this is not configurable. Palladium II systems can be set for 1.25 MHz (ultra narrowband), 2.5 MHz (narrowband) and wideband (6, 7, or 8 MHz). Payload capacity increases linearly with an increase in bandwidth. Unfortunately receiver sensitivity degrades with increased bandwidth at the rate of $10 \log N$, where N is the ratio that the bandwidth changed by. Put more simply, if the bandwidth decreased from 2.5 MHz to 1.25 MHz (a ratio of 2) the receiver sensitivity would improve by 3 dB. Link payload capacity decreases with decreasing bandwidth, and receiver sensitivity increases with decreasing bandwidth.

Modulation: Palladium systems allow different levels of Quadrature Amplitude Modulation (QAM) to be selected. Modulation, simply put, defines how many bits of information will be put on the carrier per unit of time (symbol rate). The Palladium series supports QPSK (2 bits per symbol) and 16QAM (3bits per symbol). The PalladiumII series supports QPSK and 16QAM in narrowband mode and QPSK, 16QAM and 64QAM (5 bits per symbol) in wideband mode. Higher levels of modulation will provide increased data capacity at the expense of decreased receiver sensitivity, approximately 6 dB for every additional bit per symbol. For example, a receiver set for 16QAM is 6 dB less sensitive than when it is set for QPSK. As you can see it is a better tradeoff in terms of receiver sensitivity to go with a *wider bandwidth* than to go with a *higher level of modulation* (3dB vs. 6dB). For this reason, it is recommended to always use QPSK modulation and if more payload capacity is required use a wider bandwidth setting. However, in some cases, available spectrum could be very limited and you may be forced to use a narrow bandwidth mode. If this happens, a higher level of modulation to obtain acceptable payload capacity would be the preferred solution.

FEC Rate: The FEC rate is specified as the ratio of payload bits/link bits. Link bits are the total amount of data sent over the wireless link and is = Payload bits + FEC bits. For example an FEC rate of 2/3 means that for every 3 bits of data transmitted over the link 2 bits will be payload and 1 bit will be FEC. The Palladium series supports FEC rates of 1/3 and 2/3 and the Palladium II series supports 1/3 and 2/3 FEC in narrowband mode and the DVB-T standard rates of 1/2, 2/3, and 3/4 in wideband mode. DTC recommends starting with a 2/3 FEC rate. If better threshold performance is desired, a 1/3 or 1/2 rate can be selected; however video quality could be noticeably degraded. A typical threshold sensitivity improvement of 2 dB has been observed when going from 2/3 to 1/3 FEC.

Guard Interval: The guard interval is a period of time, appended to each symbol period, which allows delayed path symbols to reach the COFDM demodulator before the next symbol begins. By implementing a guard interval, symbols that reach the receiver via delayed reflections can still be used and will not overlap other received symbols. This is part of the reason COFDM can work well in non-line-of-sight paths. If a link is experiencing a long delayed path due to a reflection from a very distant object, longer guard intervals may be necessary. The guard interval is expressed as a ratio of the total symbol period. DTC recommends starting with a 1/16 guard interval and increasing it if necessary. The Palladium series supports a 1/16 guard interval, the Palladium II series supports a 1/16 or 1/8 guard interval in narrowband mode and a 1/32, 1/16, 1/8 or 1/4 guard interval in wideband DVB-T mode. The larger the guard interval, the lower the link bit rate since a portion of time that could be used to transmit data is idly waiting for delayed symbols.

It should be noted that the Palladium Receiver can sense and configure itself automatically to the incoming signal modulation, FEC, and guard interval settings.

A typical Palladium Transmitter configuration would be as follows:

Bandwidth: 2.5 MHz

Guard Interval: 1/16

FEC: 2/3

Modulation: QPSK

Audio and data channels: OFF

With these setting we will have:

Payload Bit Rate: 2.3204 Mbits

RX Threshold: -99 dBm

The following information is important because you need the receiver sensitivity number in the link distance equation (Question 8). The Payload Bit Rate will allow you to understand link performance trade offs. Using the above example, if you changed the FEC setting to 1/3 the sensitivity would increase to -101 dBm but the Payload Bit Rate would decrease to 1.1266 Mbits. This would be a noticeable degradation in video quality but may be a worthwhile one.

Alternatively, if using a Palladium II system, you can change to a 1.25 MHz bandwidth and leave the FEC at 2/3. You would then get a threshold of -102 dBm. This would still give a Payload Bit Rate of 1.1266 Mbits. The Palladium II system allows a reduced frame rate which is very helpful in low Payload Rate configurations. The ultimate threshold performance would be with a 1.25 MHz bandwidth and 1/3 FEC setting which would give a threshold of -104 dBm at a Payload Bit Rate of 530 Kbits, which, with a low enough frame rate, would still transmit useable images.

One big advantage of transmitting video as a data stream is that noise is eliminated from the video. There is a perfect picture until the digital errors caused by noise are so great that the FEC can no longer effectively correct them. At this point, the link will start to drop frames, frames will freeze, and then the link will go away completely without warning (sometimes called the cliff effect). DTC Palladium receivers have diagnostics that can be viewed through the serial diagnostics port or as an on-screen video overlay. The receiver will display the receiver's center frequency, the input signal level, signal to noise ratio, and the pre- and post-FEC bit error rate. There is also a useful spectrum monitor that can be used to determine if the channel is clear of interference. By monitoring this diagnostic information, an operator can quickly judge whether a link is nearing the edge of reliable performance. This is particularly useful when one or both ends of the link are mobile.

The advantages of COFDM are immunity from multipath and excellent performance in non-line-of-sight paths. Since COFDM is digital, it is noise-free.

Additional services can also be multiplexed with the digitized video onto the Payload data stream such as digitized audio channels and data channels. It is much easier and economical to encrypt digital data than it is to encrypt analog video and digital encryption is much more sophisticated.

The disadvantages of COFDM are its complexity (as a result of the digital signal processing involved), greater power requirements, and expense. Since COFDM is a multi-carrier type of transmission, the RF amplifiers need to be very linear; peak to average ratio is about 10 to 1. This means that the power amplifier in the transmitter must be capable of making 10 times more output power than the average transmitter power. For example a 1 Watt COFDM Transmitter actually uses a 10 W power amplifier. Since the power amplifier is linear it is always drawing current and a 10W amplifier draws considerably more current than a 1W amplifier. The output power issue with COFDM is a little misleading since the COFDM receiver is considerably more sensitive than an analog video receiver. The transmitter does not have to be running anywhere near the amount of power an analog video transmitter would need to run to get the same link distance. There is considerable engineering effort taking place to reduce the power consumption, size, and cost of COFDM equipment and, as a result, the disadvantages will soon be minimized.

11. Please describe the type of encryption used in both the DTC analog and Palladium digital products.

The DTC analog video wireless links use a *cut and rotate* type of encryption developed by Ovation (Micro-Viewlock II).

The DTC Palladium products come standard with AES128 (16 bit key) encryption with AES256 (32 bit key) as an option.

12. What is diversity? What DTC products have it and why would I want it?

Diversity is the process of implementing some form of redundancy into the transmission link to minimize signal impairment. The idea being that if one path is impaired, the odds are good that the other path will be unharmed as long as the two paths are not identical. There are several ways to make the paths different. The most common and lowest cost is called space diversity and involves using a common transmitter and multiple receivers each with its own antenna and each antenna placed in a different location. The receiver uses a voting system that selects the signal of the highest quality from the receivers and passes it on to the demodulator. Multipath tends to be the main impairment to a microwave link and space diversity is very effective in mitigating multipath fades.

Other forms of diversity include frequency, polarization, and phase diversity. Most of these other forms involve using multiple transmitters and thus are not spectrally efficient.

DTC offers diversity in both its analog and digital product line. The analog system employs a unique voter that checks signal quality at the horizontal retrace rate (15,750 Hz) and can switch during the horizontal retrace interval so that the switchover between receivers does not show up in the visible video field. DTC analog video receivers are available in up to 5-way diversity, however, the standard OEM Vortex™ “brick” and open frame receiver uses a two-way diversity system. The analog receiver is also available without diversity.

The DTC Palladium digital receiver comes standard with dual-diversity. An expansion board is available to provide quad-diversity. The Palladium product does its diversity switching digitally employing a *maximal ratio combining* algorithm that combines signals from all the receivers to obtain the best possible signal to noise ratio. Because the Palladium signal occupies such a narrow bandwidth it is possible that a multipath cancellation could cancel out a significant amount of the COFDM carriers and as a result severely impair link performance. Space diversity provides reasonable assurance that this will not happen.

13. Could you give more details on the auxiliary channels?

The DTC analog video links can support up to two audio subcarriers. The subcarrier frequency is programmable from 6.0 to 7.5 MHz in standard channels. The subcarrier is activated by plugging-into the microphone Lemo connector associated with each audio channel. If nothing is plugged in, the subcarrier is switched off. The audio is passed through an automatic gain control (AGC) amplifier to maintain a relatively constant audio level. Phantom power is provided at the microphone input for condenser microphones. Audio input impedance is 10 K Ohms. The receiver provides two 600 Ohm line-level audio outputs with each output corresponding to a subcarrier.

DTC Palladium digital video products provide two audio channels and one RS-232 data channel. The audio and data channels are activated and configured through the configuration interface using the supplied configuration utility (software application). The user has the option of turning off the audio channels or activating one or both channels and setting the quality of each channel. The more audio channels activated and the higher the quality of the audio channels the more payload bandwidth required to transport the audio and the less available for video. There is a built-in preamp for each audio channel with gain configurable in 12 dB steps from 0 to 48 dB. 24 dB is nominal for DTC supplied microphones. Each audio input has phantom power supplied for condenser microphones. Audio input impedance is 10K Ohms.

The Palladium serial data channel is compliant with the RS-232 interface standard and will work at standard RS-232 levels. The channel is in one direction (half-duplex) from the transmitter to the receiver. The baud rate can be set for standard rates from 1200 to 115 K baud, parity (none, even or odd). DTC can supply interface cables with either male or female DB-9 connectors wired for the RS-232 interface. Hardware flow control is not implemented.

14. What video formats are supported by DTC wireless video products?

DTC analog video links will support standard NTSC (pedestal) or PAL composite video. The equipment is manufactured to the desired format. NTSC is the format used in North America and Japan. PAL is used in most other parts of the world. The cameras used with the transmitter have to be purchased with the proper video format. Video monitors are frequently multi-standard but this should be checked before a monitor is selected.

The video interface is a standard BNC connector: 75 Ohms, 1 Vpp. NTSC has a full frame rate of 30 frames per second interlaced with a vertical resolution of 525 lines. PAL has a frame rate of 25 frames per second interlaced with a vertical resolution of 625 lines. At this time DTC does not support High Definition (HD) video.

DTC Palladium digital video products can be set through the user configuration interface for either PAL or NTSC (pedestal or no pedestal). Horizontal resolution can be selected from 352 to 704 pixels. For best performance, the horizontal resolution should be selected for a pixel rate equal to or just greater than the horizontal resolution of the video source (camera). The Palladium receiver OEM board set has a PCB connector available with component YUV video as well as composite video. The composite video interface is a standard BNC connector: 75 Ohms, 1 Vpp.

15. You mention that the video is compressed in the COFDM products. Can you explain this in more detail?

DTC Palladium products utilize MPEG2 video compression. Palladium II products use either MPEG2 or MPEG4 compression. MPEG stands for Motion Picture Expert Group and was originally developed as a tool kit of techniques to compress file sizes down on motion pictures, which make extensive use of Computer Generated Imagery (CGI). The MPEG tool kit is extensive and since it was originally developed for non-real-time applications, latency was not a big issue. When using MPEG to compress real-time video, latency is a major issue and only the tools that can rapidly perform compression are utilized. This is referred to as the *simple profile*. Compression ratios of 100-1 or more are possible even using the *simple profile*. MPEG2 is the compression standard used in the DVB-T digital television broadcast standard used in Europe and other parts of the world. DVB-T utilizes 2000 carrier COFDM in a bandwidth that is selectable between 6, 7, or 8 MHz. The DTC PalladiumII products offer a wideband mode that is DVB-T compliant to allow interoperability with other manufacturers' DVB-T compliant equipment. MPEG4 is similar to MPEG2 but offers some enhanced capabilities. Among them is the ability to work with video running at reduced frame rates. In subjective tests it was found that video running at frame rates as low as 15 frames per second did not appear to be of poorer quality to video running at full frame rates. Palladium II offers an ultra-narrow band mode that can send full resolution video at a reduced frame rate in a very narrow bandwidth for extended range. In order to support the reduced frame rate in ultra-narrow band mode, MPEG4 compression needs to be used.

16. How well do the DTC wireless video products work with camera multiplexers?

On the analog wireless video link, camera multiplexers work as well as they would in a wired application. On the COFDM digital video products, this becomes a little more complicated.

Since all forms of compression throw away redundant and non-essential information, one has to be careful when sending multiplexed video over a COFDM link. Two problems occur when multiplexing cameras. The first is that the demultiplexing information is typically sent in lines of video that are in the non-visible portion of the Field. Compressors will typically throw away non-visible field lines and thus throw away the demultiplexing information. The second issue is how MPEG utilizes motion prediction to perform compression. Simply put, MPEG looks for changes in pixel position from frame to frame and tries to predict how the pixels will move over time; it then sends updated information to correct any differences from predicted and actual position. Unfortunately when frames from different video sources are interlaced with each other as sometimes happens with multiplexing the motion prediction becomes very inefficient and thus latency increases and video quality decreases (more artifacts). Consult with your multiplexer manufacturer and ask them how to configure their multiplexer to work with an MPEG compressor. It has been DTC's experience that a maximum of two full-frame-rate video sources can be multiplexed on to the Palladium in narrow-band mode with good video quality.

17. How does the DTC analog video product differ from low-cost security wireless video products?

Although most analog video wireless products use about the same modulation and are often interoperable with DTC equipment in the same band there is a big difference between the DTC analog products and the low cost "nanny cam" products. The signal transmitted by the DTC transmitter is up to *500 times more powerful* than the low-cost products and as a result has a much greater range. DTC products are fully compliant with FCC rules and regulations and have gone through rigorous lab testing to certify their compliance in order to get an FCC ID number. The DTC signal is very clean and stable, thanks to phase-locked frequency synthesis on the main carrier and the audio sub-carriers. This also allows convenient channel changing anywhere within the band in 250 KHz increments. There are also 10 configuration memory locations that can be selected with a channel switch. The DTC receiver is designed to be very sensitive and also employs very good channel filters that minimize susceptibility to interference. DTC products are built to be rugged, compact, and reliable. This is due to the type of customer (military & law enforcement) and how these products are used. Unlike low cost consumer products, DTC products are also available in federal and DOD frequency bands.

18. How do DTC digital video products differ from wireless IP web cam products?

DTC Palladium products are based on current digital video COFDM transmission technology in use in broadcasting worldwide. COFDM is very different from the OFDM modulation used in WiFi wireless IP routers and Webcams. WiFi uses a 64 carrier OFDM modulation while the Palladium uses a 400 or 2000 carrier COFDM modulation that has immunity to multipath that is more than 1000 times greater than WiFi. WiFi is only intended for very short ranges. WiFi uses wide bandwidth channels and is only available in license-free bands that are very susceptible to interference. Because WiFi is covered under FCC part 15 it is restricted to power levels much lower than those available with DTC products licensed under FCC part 90.

19. What is DTC's philosophy for OEM product offerings?

DTC realizes that each Original Equipment Manufacturer (OEM) has unique requirements and we work with the OEM to tailor a solution based on our array of DTC products. In some cases, modifications to standard products may be needed. DTC will work with the OEM to best address how to do this. The most important issue with an OEM is price. DTC's OEM products include only what the OEM requires. Packaging, manuals, and accessories are all broken out as separate line items. You only buy what you need. DTC also makes special accessory items available only to OEMs such as unboxed receivers (open frame/board set), and accessory cables of various lengths with stripped and tinned leads on one end for interconnection to the OEM customer's system. DTC can also provide mechanical outline drawings, interface connection information, detailed electrical specifications, operating instructions, and configuration software to OEM engineers. DTC also realizes that OEMs need strict configuration management to assure consistency in delivered product. We are ISO-9001 registered and have extensive quality management processes in place to ensure a consistent high quality product is always delivered.

20. Could you give an overview of DTC analog video OEM products?

All DTC analog video products are available to our OEM customers; however our mainstream OEM analog video transmitters are:

- VMX-250, 250 mW output power
- VMX-2000, 250 mW or 2 W output power switchable
- VMX-5000, 2 W or 5 W output power switchable

Transmitter accessories include microphones, power/video input cable, programming cable, DTC programmer (software), battery packs, AC power supply, and heatsink.

Note: Transmitters are only available as housed units.

DTC's mainstream OEM analog video receiver is the Vortex™ brick receiver. The Vortex is available in either non-diversity or dual-diversity configurations. The Vortex can also be purchased by OEMs in an open-frame version that eliminates the housing and front panel board and is intended for integration into OEM hardware. The open-frame Vortex is also available in diversity and non-diversity. Receiver accessories include power/programming cable, AC power supply, DTC programmer (software), audio cable, and battery pack.

DTC analog video products are available in L, S2, and S band.

Analog video systems need to be ordered in either NTSC or PAL video format.

21. Could you give an overview of the DTC digital video OEM products?

As with DTC analog products, any Palladium or Palladium II digital video product is available to an OEM, however the mainstream OEM COFDM video transmitters are as follows:

- Pd-TX-100, 100 mW output power
- Pd-TX-250, 250 mW output power
- Pd-TX-2000, 2 W output power consists of Pd-TX-100 and external Power Amp
- Pd-TX-5000, 5 W output power consists of Pd-TX-100 and external Power Amp

Transmitter accessories include microphones, power/video input cable, programming cable, battery packs, AC power supply, carrier plate, and GPS interference filter.

Note: Transmitters are only available as housed units.

DTC's mainstream OEM COFDM video receiver is the Pd-RX diversity brick receiver. This receiver is also available as a board set consisting of two down-converters and the main receiver board. An optional membrane switch mini-control panel is also available. All Palladium receivers can be equipped with an optional IP network engine board that will allow the receiver to stream low latency, full resolution video over IP (multicast). Another option (that is only available with the board set) is a quad diversity board that will allow 4 antenna inputs to the main receiver board. Receiver accessories include power/programming cable, AC power supply, audio cable, and battery pack. AES 256 encryption is available as an option. The Palladium products are available in L1, L, S2, and S bands. Palladium II is currently available in UHF and C band.

22. What does DTC recommend for antennas?

DTC can work with the OEM to make recommendations on the best antenna for the application. DTC has its own in-house antenna products and as part of Cobham Avionics and Surveillance has access to the resources of a number of Cobham owned antenna companies as well as independent antenna manufacturers. When it comes to antennas we will strive to identify the best antenna at the best price for the application even if we do not manufacture it.

As a rule, analog video systems should use circularly polarized antennas because circular polarization offers a level of multi-path mitigation. Another recommendation is in a mobile transmitter/fixed receiver situation the transmitter should use an omni-directional antenna. The receiver can use either omni-directional or directional antennas depending on the antenna gain required to get sufficient distance. In the case of using directional receiver antennas, a determination should be made of the antenna coverage pattern, whether the mobile transmitter will always be within that pattern, and if not, if the antennas can be conveniently repositioned as the transmitter moves.

If you are using a diversity receiver, you can try antenna techniques such as connecting an omnidirectional antenna on one antenna input and a directional on the other. Or, connecting directional antennas on each receiver input but aiming them in different directions to get a wider coverage pattern. If a central receiver is used with quad diversity, a 360 degree coverage pattern can be achieved using 90 degree or greater horizontal beamwidth sectored antennas (similar to how cellular telephone base station antennas are implemented). The sectored antenna can be purchased with different vertical coverage patterns, which, along with down tilt, will determine the coverage pattern of that sector.

Ultimately the system designer needs to consider the antenna coverage pattern and gain. Antenna gain will give you *greater range* at the expense of a *narrower coverage pattern*. Carefully consider what is really important for coverage pattern. For instance, an omnidirectional antenna can be made with considerable gain by having a narrow elevation pattern. In many instances, this is perfectly acceptable.

Antenna gain is measured in dBi which is dB of gain compared to an isotropic radiator. An isotropic radiator is a theoretical construct. It is a point source that radiates in a spherical pattern with equal power in all directions. Almost any decent antenna is going to have gain over an isotropic radiator. The manner in which the power is radiated (coverage pattern) is determined by the antenna design. The antenna gain is important to know because it is one of the variables needed to determine the range of the wireless link as outlined in question 8.

Besides coverage pattern and gain the system designer also has to consider antenna polarization. Polarization is how the E-field portion of the electromagnetic wave (microwave signal) is launched into space (radiated). Antenna polarization comes in two varieties: circular or linear. The antennas at both ends of the link should be of the same polarization. Do not confuse polarization with coverage pattern they are not the same thing. A circularly polarized antenna launches the signal into space in a cork screw manner. Circularly polarized antennas come in two varieties left hand or right hand. If a circularly polarized signal reflects off an object it will reverse its polarization, right hand will become left hand for instance. The receive antenna will reject signals of the opposite polarization thus giving rejection to multipath signals that are caused by reflections. Linearly polarized antennas are what we recommend to use with our COFDM products since they can utilize reflected signals to work in non-line-of-sight situations. Unlike circularly polarized antennas, signals from linearly polarized antennas do not change polarization when the signal is reflected. Linear antennas can be either horizontally or vertically polarized. For omnidirectional antennas, the polarization corresponds with the orientation of the antenna. For directional antennas, the proper orientation is usually marked on the antenna.

23. Does DTC provide technical assistance to OEM integrators?

DTC finds that OEMs require moderate up-front technical assistance. We always have engineers available from both our Sales and Research and Development (R&D) groups to assist in assuring a successful completion to your project. Technical assistance requests are directed through your Sales representative and will be forwarded to the individual in the factory who has the best skills to fulfill the request.

We also offer consulting services to integrators who utilize our products onto their platforms (such as unmanned vehicles). We can also design and deliver custom covert surveillance solutions on a consulting basis.