DIGITAL MICROWAVE LINK FOR UNMANNED VEHICLES

DTC Communications, Inc. *part of Cobham Surveillance*
486 Amherst St. • Nashua, New Hampshire USA 03063
Phone: 603 880-4411 • FAX: 603 880-6965

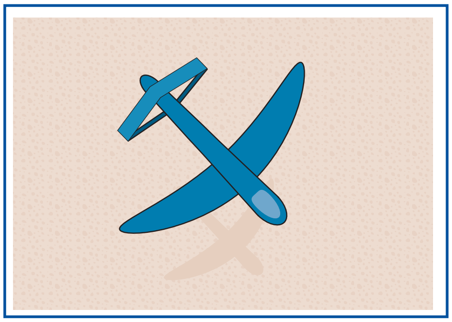
ABSTRACT

Real-time UAV/UGV command and control links are made more robust by using a two way microwave system, based on advanced digital technology. The operation of low flying, man-portable UAV's and low-to-the-ground UGV's in hilly and urban terrain, test the practical limits of conventional analog microwave video downlinks and narrowband digital control links. Multipath interference is the main culprit, generated by various reflective objects such as buildings and hills. A transmission, which provides multipath immunity and works well in non-line-of-sight situations, is Coded Orthogonal Frequency Division Multiplex or COFDM. Up to this point, COFDM has been deemed as a one-way single transmitter to receiver technology. This system leverages COFDM in a two-way digital cellular network methodology, capable of handling two-way communications with the UAV/UGV. The heart of the technology is a digital base station, which is able to transmit and receive data and video signals in high multipath environments. The system provides UAV/UGV command and control as well as transmitter downlink management in order to optimize the network. Features include an ultra-efficient 2.5 MHz bandwidth, MPEG compression, COFDM 400 carrier downlink channel using 2.3 Mb/s data rate, and 48 kb/s on the control uplink. Security is maintained using AES 128-bit encryption.

DTC COMMUNICATIONS

INTRODUCTION – THE MISSION (UAVS)

Small-sized platform UAV's are generally classified as having a wingspan of less than 10 feet, and are generally lightweight, most weighing in at less than 10 pounds. Such small UAV's can be hand launched (HL) by a one man or via a simple launcher. These have a limited flight time and operational range, usually limited to an hour and several kilometers. Power consumption, size and weight are natural limiters on any technology. Small UAV's operate at low altitudes, providing real-time visual data to infantry and reconnaissance units. These UAVs can not perform the classic big UAV "over the horizon" mission, rather they provide a close-in picture of what is going on in the village, around the buildings or over a rise. This mission turns out to be a difficult one for the UAV pilot. In a tight urban environment, the operator has no chance of eyeballing the UAV much beyond the launch; he is steering essentially 100% by microwave video camera or by relayed GPS signals or both. That means that the down link must be 1. Solid and at the full camera frame rate and 2. Real-time with no or low latency. Furthermore the uplink or command and control side must be similarly solid and responsive. At these low altitudes, there is little room for error. Relying on infrastructure such as a deployed or airborne repeater or AD HOC mesh networking is possible, but unlikely in such a tactical scenario. Basically the bird is on its own, with only the operator control unit (OCU) and pilot-operator at the controls.



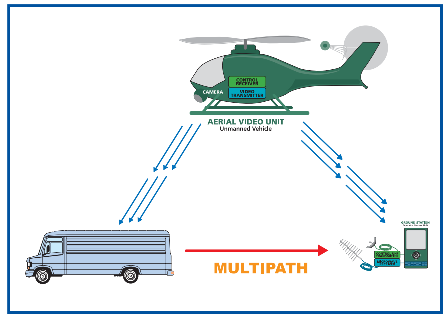
WHY BIRDS ARE LOST:

A simple link equation can be written that will predict the range of a particular transmitter to receiver in link terms if information about the modulation, power sensitivity and the gain and height of the antennas employed are plugged in. This all works fine if we have a true line-of-sight (LOS) condition between the UAV and the Operator Control Unit (OCU). You may be surprised to find out that a 100 mW transmitter and a modest antenna mounted on the UAV could be expected to cover a distance of 8 km if we could rely on true line-of-sight conditions. On the other hand, the UAV's signal could be completely lost when it drops behind a large building or hill. Obviously, this effect is called non-line-of-sight. Walls, metal fencing, buildings, vehicles, foliage and the general terrain all contribute to signal attenuation in the non-line-of-sight scenario. Complete attenuation is called signal blockage. With luck, the UAV eventually flies out of the blocked signal condition and makes it home.

The non-line–of-sight condition also causes a particular problem with conventional RF links due to a phenomena called multipath interference. Multipath Interference or simply "multipath" is caused by signals bouncing off reflective surfaces: reflective to RF, that is

This includes the ground, hills and mountains, buildings, water: even vehicles and planes flying overhead.

The effect is that several reflections arrive at the receiver at varying delays and signal strength along with the main (desired) signal. Unless steps are taken to sort things out or correct the signal, effects ranging from temporary signal breakup or distortion to complete drop-out may occur.



The third problem is that of motion. Microwave links work very well when the transmitter and receiver antennas are fixed. Having either or both in motion simply enhances the blockage and reflection problems. A particularly difficult situation would be if the UAV was being piloted by a mobile (chase) OCU unit mounted on a HMMWV through a dense urban setting.

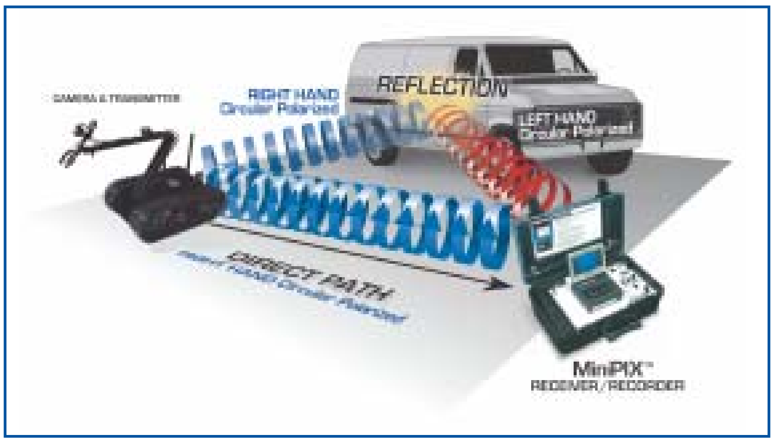
The fourth problem is that of poor antennas. The small UAV designer really has no choice but to equip the bird with a rather simple omni directional antenna such as a vertical monopole. These include quarter wave and vertical dipoles and discs. Some are conventional and some are printed circuit types which can be conformal mounted on the wing or fuselage. All are low gain by nature and most are not circularly polarized.

On the OCU side, the UAV pilot is probably also using a simple vertical dipole or rod antenna. The UAV pilot has learned that he needs to get the OCU antenna in an effective location for a good picture and solid vehicle control. But realistically, the operator is probably taking cover at a safe standoff distance. He may have significant obstructions around him. Deploying a more effective panel or dish antenna mounted as high as possible in the clear (above the OCU position) can provide multipath mitigation by eliminating many of the reflective vectors and extending range, (provided the operator knows where to point the antenna and he doesn't steer the UAV out of the beam!). Deploying a better antenna is always an effective technique. Automatic tracking systems are generally out in man-portable situations.

While useful for the long range UAV's, this equipment has limited utility in a man-portable scenario. Also consider that the signal that you need could be from the reflection coming off the building in back of you!

A final practical problem is that of interference; this is particularly troublesome in battle zones or military exercises where many different systems are operating simultaneously on the same or nearby channels. In battlefield situations it is uncommon for frequency coordination to take place prior to equipment activation. In some cases high output power systems will be operating in close proximity to the UAV or OCU also the UAV may travel to an area or altitude where an interferring signal will be received that was not detected at ground level.

When a system is experiencing interference the natural inclination is to increase transmitter output power and/or use a higher gain antenna. This is certainly possible at the OCU end but is not possible or practical on the UAV end of the link. It is best to keep the UAV power as low as possible to conserve battery power and the antenna should have an omni-directional pattern. Finally, increasing signal power opens the operator to RF interception and targeting via RDF (radio direction finding) techniques.



One way to combat interference is to "correlate out" the interfering signal as is done in direct sequence CDMA and hopping spread spectrum systems. Unfortunately these types of systems, by the nature of their modulation technique require, a large bandwidth or many channels. The other approach is to use a form of modulation which produces a narrower bandwidth signal and hop it to another channel if interference is detected on the primary channel. The default backup channels can be predetermined before launch and a handshaking protocol can be established between the UAV and OCU to make the channel transition as seamless as possible. With narrow bandwidth channels and a wide tuning range, many alternative channels are available and almost certainly one will be interference free. A similar system already exists in cordless home telephones where a limited number of channels are available and no channel coordination exists.

Of all of the problems discussed, complete signal blockage is the most ominous. Some type of fail-safe approach program such as a "gain altitude and circle" or "come home to these coordinates" (on command or automatically), may be called for in this case. Fortunately, complete signal blockage is not usually the culprit with a UAV operating at close range. The real problem boils down to multipath, and the RF system's ability to deal with it. In practice, there is likely a signal path. In fact there are probably several. The *urban* or *hilly* scenarios definitely fall under the non- line-of-sight scenario. The microwave signal from the UAV will ricochet. So far we have been discussing the rather fragile video downlink, but be assured, without a scheme to deal with multipath, the uplink will suffer similarly . The point is that the link signals are going to suffer and something must be done to correct them or make them robust enough to deal with the non-line-of-sight conditions.

THE MISSION - UGV's

A ground-based unmanned vehicle has all of the problems discussed, but with more intensity! Consider that the antenna on a UGV is no more than a few feet off the ground. LOS is basically non-existent in most urban and rough terrain scenarios with such a low antenna. In most situations, multipath is a blessing; it may actually be the only way to obtain an RF path to the OCU and back. This plays havoc with most analog systems. Unlike the UAV, once the UGV gets into a bad RF area, it is more difficult to get it back into range..

The use of circularly polarized antennas on the transmit and receive sides of a microwave link is an effective way to reduce multipath effects in mobile systems and has been used extensively in mobile, airborne and spacecraft links.

LPI/LPD

Low Probability of Intercept (LPI) and Low probability of Detection (LPD) are terms which have practical meaning in a battlefield scenario. Can the enemy compromise the operation or even use the OCU's own control signal to guide a counter strike? The Probability of Intercept for the video link certainly exists for systems which are sending analog FM video "in the clear". An enemy's conventional FM microwave receiver could be employed to demodulate the video signal. Many users have reduced this problem at least from a tactical standpoint, with scrambling and encryption electronics.

The uplink control signal also can be intercepted. For instance if this was a simple narrowband signal such as that used for common RC model control, jamming or spoofing this signal is only a minor difficulty.

The probability of detection of the OCU control signal itself can be problematic for a small infantry unit, which is trying to avoid being targeted. Radio Direction Finder (RDF) electronics can be employed to guide a mortar team or an RF seeker on a warhead can be employed.

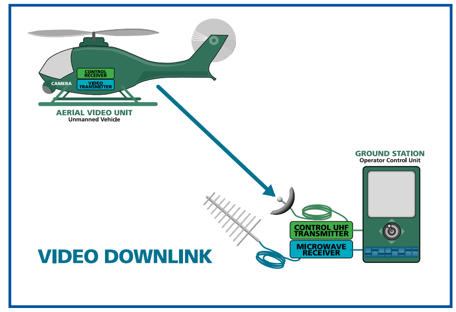
The UAV/UGV's microwave links can be optimized for LPD/LPI based on the frequencies or bands, RF power, encryption, modulation techniques, antenna pattern, duty factor and the general system design.

EXISTING LINKS

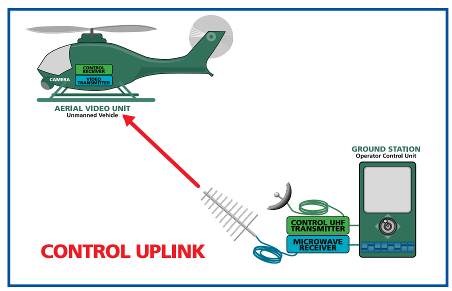
Most UAV/UGV's are equipped with one of two types of link systems; 1. Conventional Analog Video Link–RF Modem Command Link. 2. Two-Way Commercial Spread Spectrum Modem technology.

The first solution involves a small analog wideband FM microwave transmitter capable of 100 mW to 2 Watt for the video link. This is usually equipped with some kind of realtime video encryption. The FM video method can be fairly power efficient, since it can employ non-linear power amplification, reaching around 25% at L-Band. A small narrowband wireless modem board capable of 100 mW to 1W of output power may also be installed on the Mini-UAV side with a modest data rate of 2,400 to 19, 200 baud. A similar modem at the OCU with higher power, perhaps 1–5 Watts is also typically employed. These RF modems are usually either conventional "narrowband" digital in UHF or 900 MHz or a commercial microwave spread spectrum modem which occupies wider bandwidth. With a UAV, it is this which provides the control uplink and the data downlink which may include GPS coordinates and other useful UAV sensor data. On the UGV, the links may also contain two-way voice information (audio). This is used to hear what the robot hears and to allow the transmission of announcements or commands or even music though a UGV-mounted speaker.

The total bandwidth occupied on this system would be 15 MHz for the video link and 100 kHz to 10 MHz for the two-way data link depending on the rate required and the spreading. Sometimes only a high power one-way uplink is used, say an FSK data link with a 9600 baud rate. In this arrangement, the ancillary downlink information is carried along with the video signal on an RF subcarrier. This data could include GPS and UAV/UGV sensor information. This is a slightly more efficient and simpler variation.



The second solution is to use a high speed wireless modem that is capable of handling both the video downlink and the command and control aspects, in one duplex set of data streams. This could be modified or standard spread spectrum gear like 802.11b or even an Orthogonal Frequency Division Multiplex (OFDM) system like 802.11g. These WI-FI kinds of systems have the advantages of being easy to configure and reasonably modest in bandwidth requirements; with the OFDM example occupying around 25 MHz.



Both of these systems can work effectively, if the equipment is configured to use appropriate (and uncongested) bands suited for tactical military operations. Both systems consume upwards of 15-25 MHz of bandwidth. Both systems can further benefit from the use of repeaters or AD-HOC mesh networking arrangements. Performance with either system in commercial bands or in high multipath environments will be somewhat limited however. Frame rates can suffer and dropouts can occur with the WI-FI systems depending upon signal conditions. Analog downlinks have no error correction and suffer severely from multipath, but analog has one big advantage - full video frame rates 100% of the time. Commercial modems have some multipath rejection capability due to the error correction built into their standards, but they generally have to scale back data rates (and thus, video frame rates) under poor signal conditions.

COFDM DIGITAL:

Coded Orthogonal Frequency Division Multiplex (COFDM) was initially fielded for digital video broadcasting and it is quickly becoming a familiar scheme employed in urban environments for the back feed of live microwave from the street to the studio. This more robust version of the OFDM digital modulation technique (as utilized in 802.11g for data networks), takes full rate video and compresses, codes, protects and transmits it in several thousand equally weighted orthogonally spaced carriers. Digital Video Broadcast Television (DVB-T) utilizes 1705 – 2000 of these carriers and the resulting spectrum occupies 6, 7 or 8 MHz of bandwidth depending on the mode selection. The MPEG video compression encoding requires a significant amount of digital signal processing. Additional processing is required for chores like forward error correction, interleaving, encryption and modulation. This type of transmission demands a very high amplifier linearity specification which translates into power consumption. However, this amount of digital processing and power consumption was worth it in video quality alone to the broadcasters. Cutting the bandwidth by 2 over analog FM, adding signal robustness and protection were also primary design goals. Reducing power consumption, size and weight although desirable, were of secondary importance.

A NEW COFDM APPROACH:

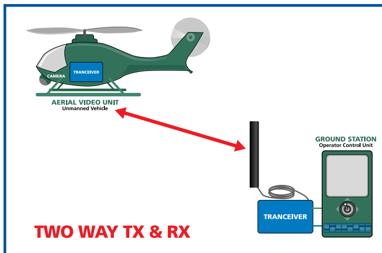
DTC has implemented a new form of two-way COFDM that is more suited to the needs of the UAV market. First of all, some of the processing power of the COFDM transmitter is devoted to a receiver role. Since the uplink requirements are modest in speed (9600 – 48 kbps) compared to the video link transmission (2.3 Mbps), robust reception can be achieved with as few as 25 carriers. Such a transmission is scarcely wider than a conventional wideband FSK signal, but exhibits greatly improved multipath characteristics. Such an approach also can be configured to provide effective anti-jam (AJ) properties, compared to FSK, an important benefit in a UAV/UGV control receiver.

Any practical approach must also reduce power consumption. Conventional COFDM comes in at four times the power consumption of analog FM with today's technology. DTC's approach cuts that number in half to just over twicethat of analog. Reducing the number of carriers to 400 means that the power consumption is closer to 6 Watts and it results in an occupied bandwidth of 2.5 MHz. To make up for the reduced number of carriers, space diversity maximal ratio combining (MRC) techniques are employed at both receive sites; in the UAV/UGV and at the OCU.

The MPEG-2 coder algorithm itself is also modified so that the interframe loss is reduced. This means that more data is saved in a damaged frame during the error correction process. Synchronization (and resynchronization) times and end-to-end latency is greatly reduced over the broadcast standard. The resulting is a much narrower, more tactically appropriate signal.

DTC COFDM TRANCEIVER:

Two-way communication must be accomplished by Time Division Duplex or by Frequency Division Duplex. In Time Division Duplex, the transceiver spends part of its time transmitting data and part of the time receiving data. This is the principle of Time Division Multiple Access (TDMA) as used in many cellular phone systems like GSM and in two-way systems like TETRA. In Frequency Division, two actual frequencies are employed, one for the video link and one for the control link. This is the principle used in the old AMPS phone system and in Project 25 two-way radio. The use of frequency division method produces high system performance when the uplink and downlink data rates (and processing power) are somewhat uneven as in this case. Frequency Division is somewhat easier to implement, technically uses less power, and carries less risk. It is most appropriate for single systems – one OCU and one UAV/UGV. The approach can use small filtering elements, similar to those used in cellular phones, if the frequencies are separated. An example might be a downlink in L-Band and a control uplink in the UHF band. This approach has the advantage that control range is somewhat uncoupled from video range since they are at two different frequencies and are at two different data rates. This means that UAV/UGV control range can be made somewhat greater than video link range by design.



Two Way Digital

The TDD (Time Division Duplex) approach is more elegant and suitable to multiple systems which must share spectrum in a single band. Somewhat more complex to achieve in a practical system, Time Division Duplex allows the camera link and control link to use the exact same channel. There is a slight penalty in power since the processor must do more work, with a percentage of its time taken away for managing transmission and reception slots. With one-way COFDM, essentially 100% of the processor power can be devoted to transmission. With FDD (Frequency Division Duplex), some amount of processing time must be devoted to transmission (80%), and some to reception (20%). With TDD, some amount of processing time must still be devoted to transmission (75%), some to reception (15%) and some to guard interval (10% - switching time in this case). This means turning up the data rate and speed of the DSP which translates into more power consumption. In TDD the video and command links generally drop out at the same time. One final approach at power savings is obtained by using another cellular idea, power cutback during strong signal (high signal to noise) conditions when the UAV/ UGV is close to the OCU. This not only reduces power consumption slightly, it more importantly, reduces the possibility of intercept and interference to other systems on nearby channels. For instance, the OCU's data terminal could automatically adjust the power from the UAV/UGV transmitter by 20 dB (from the 1 mW level to 150 mW power level in 5 steps). Data protection is also important in real-time tactical UAV/UGV operations. Full-time AES encryption can be employed on both sides of the link.

SUMMARY:

UAV/UGV Data Links represent the classic uneven link, that is, high video link rate and relatively low control link data rate. DTC Communications Inc., a supplier of OEM (COTS) microwave video links (transmitters and receivers and antennas), to the military robotics manufacturers, has proposed a proprietary two-way narrowband COFDM transceiver based on existing IP. Digital COFDM transmissions along with maximal ratio combining provide significant improvements in UAV/UGV control reliability and video and data quality when compared to traditional link system approaches. With modest DC power requirements, this device can be used for the complete air-to-ground (AG) link on the UAV or (GG) link on the UGV. The OCU side is equipped with a similar receiver and more powerful transmitter in order to optimize the link budget.

EFFICIENT SPECTRUM UTILIZATION SUMMARY:

Digital video systems operate in a fraction of the spectrum utilized by typical analog transmitters, offering up to 7 digital video streams in the spectrum previously used to transmit a single analog channel. DTC's Palladium Series supports 2.5 MHz channels in the narrowband configuration or 6-8 MHz channels in the full DVB-T compliant configuration.This compares to 17 MHz for a typical analog channel. In addition, digital channels can be located adjacent to each other without a guard band. Analog systems tend to bleed over their allotted spectrum, requiring several Megahertz of separation between channels at a minimum.

As regulatory agencies worldwide reallocate spectrum, it's clear that digital transmission enables more users to co-locate channels in an increasingly crowded RF spectrum.

References:

[1] David Ledger, Electronic Warfare Capabilities of Mini UAV's, Aerosonde Program Manager, White Paper, Sept. 2002

[2] Daniel Lihui Gu, Guangyu Pei, Henry Li, Mario Gerla, Beichuan Zhang and Xioyan Hong, CSD, UCLA, UAV Intelligent Routing for Ad-Hoc Wireless Network in Singlearea Theater.

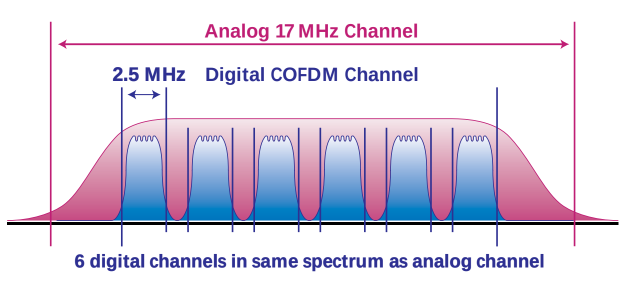
[3] H.H. (Sam) Khatib, Theater Wideband Communications, IEEE MILCOM, pp 378 Nov.1997

[4] Michael Ryan, Michael Frater, The Utility of a Tactical airborne Communications Subsystem in Support of Future Land Warfare, copyright Land Warfare Studies Centre 2001 ISBN 0 642 29546 8.

[5] Hamid R. Saeedipour, MD. Azlin Said MD. And P. Sathyanarayana, Data Link Functions and Attributes of an Unmanned Aerial Vehicle (UAV) System Using Both Ground Station and Small Satellite, University of Science Malaysia.

[6] Karl Murphy, Maris Juberts, Steven Legowik, Marilyn Nashman, Henry Schneiderman, Harry Scott, Sandor Szabo, Ground Vehicle Control at NIST: from Teleoperation to Automony, Robot Systems Division, 1993

[7] DISA - JITC CDL, Common Data Link Definitions, http://jitc.fhu.disa.mil/cdl/define.html



Glossary of UAV Acronyms and Terms:

Glossary of UAV Acronyms and Terms:

Ad-Hoc Wireless Network – a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all wireless devices within range of each other to discover and communicate in peer-to-peer fashion without involving central access points (including those built in to broadband wireless routers). In a UAV example, the UAV, several repeaters and the OCU could be configured to form an Ad-Hoc network.

ADR-Airborne Data Relay – An airborne repeater that is used to extend the range of a UAV over the horizon from the OCU. The ADR may itself be another UAV.

AES - AES stands for Advanced Encryption Standard. AES is a symmetric key encryption technique which will replace the commonly used Data Encryption Standard (DES). It was the result of a worldwide call for submissions of encryption algorithms issued by the US Government's NIST. (NSA) announced that AES is secure enough to protect classified information up to the TOP SECRET level.

A/J Anti Jam – Any radio or radar system that is resistant to RF Jamming. A UAV control link receiver should have a high A/J *Margin.* This means that the system should be resistant to interference jamming and spoofing.

A/G--Air to Ground Link. Sometimes called the ground-link

Antenna Elevation Angle – For ground level OCU operation in highly dense urban terrain, antennas with a very low elevation angle maynot be effective. An up-angle of the main lobe of no less than 10 degrees should be used. Simple dipoles and collinear rod antennas meet these criteria; high gain panel antennas will not unless tilted upwards.

Auto-Land Mode – A preset "safe" landing mode which can be initiated by remote control or by a timer or sensor. This usually initiates a stable steep stall condition.

BER Bit Error Rate – The percentage of received bits in error compared to the total number of bits received expressed as a power of 10.

COFDM – Coded Orthogonal Frequency Division Multiplex A form of spread spectrum that has particularly effective multipath interference rejection properties.

Command Link – Also called the control or Up-Link (on a UAV platform).

Data Rate – The speed that video, telemetry and control data is sent back and forth between the UAV and the Ground Station or OCU.

DF – Direction Finder

Endurance – The time that a UAV can remain operational before having to land and be refueled.

EW – Electronic Warfare – a general term used to describe any means used to control, defeat, destroy, make ineffective, or change the function of an enemy system using RF signals and systems combined with intelligence.

Footprint Diameter – The Platforms rated Range expressed in Miles or km.

Full Fuel Load – The combined weight of the vehicle payload and fuel expressed in lbs or kg.

G/A– Ground to air link. Sometimes called the up-link, command link or control link.

GCU – Ground Control Unit (also called OCU).

GDT - Ground Data Terminal – Yet another term meaning OCU, but sometimes describing a larger mobile Ground Station consisting of the transmitters, modems, terminals, computers, receivers and antennas.

GPS Auto Loiter – A program that tells the UAV to circle or perform a set maneuver onstation (usually until control is restored in the case of a mini-UAV)

Ground Station – The pilot and OCU that is handling the UAV.

Kb/s or kbps – Kilobits per second – one thousand data bits, zeroes and ones, per second. This is a measure of data rate.

Latency – The delay usually caused by processing and transmission and reception and display of the video or sensor data from the UAV. Also important on the control link. A UAV data-link with high latency makes the vehicle hard to control.

Launch System – The method and equipment used to launch the UAV. For mini-UAV's, HL or VL systems are commonly used.

Link Margin – The amount in dB above that required to overcome path loss for minimum safe control of the UAV. Most UAV systems should have a minimum of 30 dB of link margin at their maximum rated range.

Loiter Altitude – The altitude that the platform is designed to maintain on-station when commanded to or under preset conditions are met (such as when a GPS waypoint is crossed or loss of signal occurs).

LOS Line-of-sight – straight line path with no obstructions between transmitter and receiver antennas sometimes called DLOS or Direct Line of Sight. With DLOS, range is governed only by the UAV's link margin and altitude!

HL – Hand Launched (UAV)

LRE – Launch and Recovery Element Mb/S or Mbps Megabits per second

NLOS – Non-Line-Of-Sight – An obstructed RF path

OCU – Operator Control Unit. This man-portable packaging of the basic ground station is the current trend.

Onboard Avionics – The computer and sensors which can autonomously pilot the UAV or send data back to the OCU.

Payload – The design maximum weight that a UAV/UGV can carry beyond that required for basic operations and fuel expressed in ounces or kg. Examples: IR Camera, Laser, Ordnance, EW, DF.

Platform – The name of the UAV/UGV.

RF Radio frequency – Also used generally to refer to the radio waves themselves.

Range – The maximum distance in a straight line that the platform can cover usually expressed in Miles or km.

RAV – Remote Autonomous Vehicle – An unmanned vehicle capable of executing a preset mission plan with no guidance from a human pilot, other than initial takeoff and landing.

RPV – Remote Piloted Vehicle – An unmanned vehicle capable of being controlled from a distant point through a communications link sometimes called a data link. It is normally designed to be recoverable.

Small Area Theater – The immediate area that the mini-UAV operates in.

Link Margin – The amount in dB above that required to overcome path loss for minimum safe control of the UAV. Most UAV systems should have a minimum of 30 dB of link margin at their maximum rated range.

Loiter Altitude – The altitude that the platform is designed to maintain on-station when commanded to or under preset conditions are met (such as when a GPS waypoint is crossed or loss of signal occurs).

LOS Line-of-sight – straight line path with no obstructions between transmitter and receiver antennas sometimes called DLOS or Direct Line of Sight. With DLOS, range is governed only by the UAV's link margin and altitude!

LRE – Launch and Recovery Element
Mb/S – or Mbps Megabits per second
NLOS – Non-Line-Of-Sight – An obstructed RF path
OCU – Operator Control Unit. This man-portable packaging of the basic ground station is the current trend.
Onboard Avionics – The computer and sensors which can autonomously pilot the UAV or send data back to the OCU.
Payload – The design maximum weight that a UAV/UGV can carry beyond that required for basic operations and fuel expressed in ounces or kg. Examples: IR Camera, Laser, Ordnance, EW, DF.
Platform – The name of the UAV/UGV.
RF Radio frequency – Also used generally to refer to the radio waves themselves.
Range – The maximum distance in a straight line that the platform can cover usually expressed in Miles or km.
RAV – Remote Autonomous Vehicle – An unmanned vehicle capable of executing a preset mission plan with no guidance from a human pilot, other than initial takeoff and landing.
RPV – Remote Piloted Vehicle – An unmanned vehicle capable of being controlled from a distant point through a communications link sometimes called a data link. It is normally designed to be recoverable.
Small Area Theater – The immediate area that the mini-UAV operates in.
Small UAV – also called Mini-UAV - are generally classified as having a wingspan of less than 10 feet, and are generally lightweight, weighing in at less than 10 pounds. The range of such a vehicle is usually limited to several miles. Small-UAV's providing near real-time situational awareness to close in war fighters.
Tactical Vulnerability – Small-UAV's can become tempting targets. The attrition rates for UAVs of any type are higher than for manned combat planes. Most danger is from below. The possibility of air attack is remote for the small-UAV.
Telemetry – The actual data that is sent between the UAV and the Ground Station. The term is sometimes restricted to describe command, control and sensor data, rather than video.
Terrain Screening – The effect of buildings and natural features on the RF propagation, between the UAV to the OCU.
UAV – Unmanned (or Uninhabited) Aerial Vehicle - A powered, aerial vehicle that does not carry a human pilot. UAV's are primarily used for intelligence gathering; intelligence, surveillance, direction finding and reconnaissance. The UAV can fly autonomously (RAV) or it can be remotely piloted (RPV) and it can be expendable or recoverable.
UGV – Unmanned Ground Vehicle – A powered ground vehicle that does not carry a human driver. An unmanned ground vehicle may be remotely driven (RPV) or it may be autonomous (RAV). UGV's are used for many roles, from surveillance, direction finding and reconnaissance to armed soldier. UGV's have been used extensively in bomb disposal and rescue operations.
Video Link – Also called the Back-Link or Down-Link (UAV). This data stream is normally wide (high data rate) and includes real-time video from one or more cameras, sensor data and possibly, audio information.
VL – Vehicle Launched or Vehicle Launcher.
802.11 – A CDMA (code division multiple access), TDMA (Time Division Multiple Access) or OFDM (orthogonal frequency division multiplex) spread spectrum wireless network standard which when configured properly can permit a small Ad-Hoc wireless network to be setup for instance between one or more ground stations, one or more UAV's and one or more repeaters. 802.11 systems do have the basic problem that the bandwidth available to any one mobile user decreases as the number of nodes increases or the interference increases.

COMMUNICATIONS