

## **1. SCOPE**

Free TV Operational Practice OP 54 is a guideline for the minimum requirements for television coverage of major sporting events involving a combination of multiple fixed and mobile cameras and the infrastructure required for comprehensive TV coverage. Typical of such events are Marathon, Triathlon, Road Cycling, Street Parades and similar large scale, large area events.

OP 54 provides an indication of infrastructure for an outside broadcast production using contemporary production techniques which meet broadcast television presentation requirements.

This Operational Practice has been developed by the Free TV Australia Project Group - Outside Broadcasts in the interests of maximising TV and Radio production potential and productivity at sports venues and avoidance of costly omissions at planning and construction stages.

## **2. TYPICAL COVERAGE**

The Marathon is run over a 40 km course and typically involves fixed camera cover at key vantage points, but relies totally on wireless cameras for full start to finish coverage.

Triathlon events are typically held within a defined precinct which offers scope for distance running, swimming and road cycling. The precinct area can typically be in the order of 20 hectares, with road distances of 5 to 10 km.

Cycle road races can be held in confined area precincts as for Triathlon, or open road events over hundreds of kilometres.

## **3. CAMERAS**

Total camera requirements for a specific event are determined by the geographic features of the course and the TV coverage criteria for the event.

Fixed cameras are deployed at the start and finish areas and at key vantage points along the course. Wireless cameras provide continuity of cover over the entire course and typically require microwave backhaul to the production control centre, via ground based tracking receivers where line of sight transmission is achievable, but in most cases via airborne (helicopter) microwave relay platforms.

Camera configuration for a typical event can be in the order of:

- |   |             |
|---|-------------|
| ▪ Fixed cameras covering start / finish / key locations | 10 – 20     |
| ▪ Portable cameras                                      | 4           |
| ▪ Wireless cameras with ground based microwave backhaul | 1 – 2       |
| ▪ Helicopter mounted cameras                            | 1 – 2       |
| ▪ Wireless cameras (motorbike) with helicopter relay    | typically 3 |
| ▪ Cameras for O/B studio                                | typically 2 |
| ▪ Crane mounted cameras                                 | typically 2 |

### **3.1 Camera Positions**

Camera positions are determined by the director and producer of the television coverage and are subject to the particular requirements of the event.

Cameras are typically mounted on purpose built scaffolds and camera platforms.

A typical working platform for a single camera is in the order of 1.8 metres wide and 1.8 metres deep. Height is determined in survey.

Camera platforms and scaffolds are to comply with relevant work-safe requirements.

Platforms are required to be highly rigid to allow for stable operation of Hi range telephoto zoom lens equipped cameras.

### **3.2 Portable Cabled Cameras**

Portable cabled cameras are utilised at start and finish areas for interview and close up cover of competitors.

Portable cameras require cable assistants to support the camera operator and avoid cable obstruction to competitors, officials and spectators and have severe restrictions on the extent of their area of cover.

Cable laying, cable routing and cable protection is to comply with relevant OH&S regulations.

See Clause 14: Safety.

### **3.3 Portable Wireless Cameras**

Portable wireless cameras are generally equipped with low powered microwave transmitters with omni directional transmit antennas to close sited line of sight receive locations. A "pole-man" traditionally supported the camera man and the receive antennas have typically been narrow beam antennas requiring a pan operator to follow the camera team.

The introduction of digital transmission technology has largely eliminated the need for directional antennas, the pole-man and Rx antenna panner.

Microwave frequency planning for portable wireless cameras is to be co-ordinated with other licensed users operating in the event precinct, or in the near vicinity to minimise risk of mutual interference between the TVOB and other legitimate microwave link operators (eg News ENG services). On major events, it may be necessary to implement an overall frequency management strategy involving statutory regulatory authority control.

See Clause 7: Radio Frequency (RF) Spectrum management.

### **3.4 Mobile Camera Platforms (Vehicle-based)**

A variety of camera types have been developed for vehicle mounted tracking cameras. These range from pedestal mounted manned OB cameras to remote controlled gyro – ball camera systems.

Mobile tracking cameras have been traditionally back hauled to the main technical control centre via ground based microwave link, utilizing omni directional Tx antennas and panned directional Rx antennas. Introduction of digital transmission technology has largely eliminated the need for directional antennas and therefore link pan operators.

### **3.5 Special Mobile Cameras**

Continuous Start to finish cover of Major Distance Events is highly dependent on reliable helicopter mounted cameras and helicopter relay of mobile motor bike cameras.

#### **3.5.1 Helicopter Cameras**

A number of camera systems have been developed for helicopter mounted camera systems, ranging from hand held cameras with stabilized lenses to remote controlled gyro-ball cameras. Backhaul to the main technical control area is typically by 2.5 GHz microwave with auto tracking directional transmit and receive antennas. Camera equipped helicopters generally operate at altitudes between 500 and 1000 feet (approx 150 to 300 metres).

#### **3.5.2 Motorbike Cameras**

Motor bike mounted cameras are typically hand held units operated by the pillion rider on the bike. Stabilised lenses are generally used but in some cases stabilized camera mounts have been adapted to the operation. Cameras can be forward or backward oriented for lead or follow cover of competitors.

Backhaul is typically via 2.5 GHz microwave link relay via a helicopter microwave relay platform.

A clear overhead sight line from the motor bike up link to the helicopter relay platform is required. Where tree canopy obstructs clear line for the up link, ground based receivers can be deployed for "gap fill" service.

Helicopter microwave relay platforms typically operate at altitudes of 2000 to 5000 feet (approx 600 to 1500 metres).

On extreme long distance operations (e.g. motor rally) airborne microwave repeater has been utilised. For this operation, the helicopter platform transmits in turn to a microwave relay equipped light aircraft circling at approx 10000 feet altitude and transmitting to a ground based receiver site with Telco, satellite, or OB microwave connectivity to a main control centre.

This technique is only appropriate for remote areas where the broad-beam transmit characteristic of the aircraft down link antenna does not cause restrictive interference to any normal service ENG operations in the wide area of the aircraft down link pattern.

#### **3.5.3 Helicopter Facilities**

Helicopter operations are an essential requirement for long distance TVOB operations. Flight paths and operation zones are to be planned in accordance with DOA flight operations regulations.

Temporary helipads to be established in the event zone are to be approved to comply with local council and DOA regulations.

Temporary on-site refuelling facilities are to comply with fire safety and environmental protection (fuel spillage) regulations.

#### **4. AUDIO**

Commentary facilities are to be provided at the main control centre, and as required at key locations along the event route.

A hosting position for 3-4 hosts is also typically required at the main control centre with smaller on camera facilities as required at key locations.

Effects audio is required to be married to all camera signals and to be carried with video signals.

#### **5. WIRELESS MICROPHONES**

Wireless microphones are extensively used for TV and radio interviews. Wireless microphones frequency co-ordination is required on a venue by venue basis to avoid interference with TV operations, radio broadcasters, venue officials, public address announcers, entertainment, and other legitimate users of wireless microphone equipment.

See Clause 7: Radio Frequency (RF) Spectrum management.

#### **6. COMMUNICATIONS**

Voice communications between the main control centre, the TV studio complex and secondary OB units shall be via Telco circuits. Voice communications between OB units and cabled cameras shall be via camera circuits.

Voice communications to commentary sites at OB van locations shall be via local OB temporary cabled circuits.

Voice communications between the main control centre and microwave wireless cameras, motor bike cameras, portable wireless cameras, helicopter cameras and helicopter microwave relay platforms shall be primarily via UHF duplex radio telephone equipment.

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## **7. RADIO FREQUENCY (RF) SPECTRUM MANAGEMENT**

Extensive use of the RF spectrum is necessary for comprehensive TVOB cover of major long distance sports events.

Allocation of frequency bands is generally as follows:

- 2.5 GHz microwave band:            Portable wireless cameras  
   Vehicle mounted tracking cameras  
   Motor bike up links  
   Relay helicopter down links  
   Camera helicopter down links
- 7 / 8 GHz microwave band            Medium haul point to point back haul links
- 13 GHz microwave band              Short haul point to point back haul and local  
   interconnect links
- 470 – 520 MHz UHF band              Duplex Radio Telephone (RT) voice  
   communications  
   Telemetry and data communications
- 520 – 820 MHz band                    Wireless microphone operations
- Aggregate RF systems requirements can be in the order of 12 x 2.5 GHz channels, 4 to 6 x 7 / 8 GHz channels, 4 to 6 x 13 GHz channels
- 10 x UHF duplex RT frequencies and 4 to 6 x wireless microphone frequencies

RF spectrum usage is strictly controlled, and specific channel allocations are generally licensed to individual commercial entities. Temporary use of multiple frequencies as is required for operations on the major event scale require frequency co-ordination with established licence holders and special licensing for the complete RF requirements for the period of the event.

Whilst there may be some scope for frequency sharing, and cold standby of transmitters not "on air" at a given time, current production techniques utilise multi channel video servers capable of simultaneous recording of multiple video sources with instant replay access to any recorded incidents of interest. Video server technology also caters for play list compiles and off-line editing in real-time so all camera sources including wireless cameras need to be regarded as "on-air" throughout event time in their operation zone.

It is essential that a rigid frequency management procedure be implemented on a venue by venue basis to ensure non interference between services within the precinct involved in TVOB origination, including authorised unilateral operators, and for other licensed users (ENG etc.) operating in near proximity to the OB precinct.

Wireless microphone frequency management is the prerogative of the event promoter and venue management, but TVOB operators need to be fully involved in channel allocations from the early planning stage of the project.

Microwave and UHF frequencies are licensed but may be subject to frequency sharing arrangements. Co-ordination between users, including news services not directly involved in the event telecast, but licensed to operate in proximity of the event precinct is an essential pre-requisite for event RF spectrum planning.

Major events involving multiple operators of RF services require overall co-ordination to be under statutory authority control of use / misuse of RF spectrum assets.

## **8. DIGITAL TECHNOLOGY**

### **8.1 General**

Advances in digital television technology from the late 1990s to the present time have led to major improvements in microwave transmission path reliability and RF spectrum requirements.

COFDM modulation techniques developed for Digital Video Broadcasting (DVB-T) can be configured for high levels of RF signal robustness in extremely severe RF reflective "multipath" environments, a major limitation of early analog wireless camera systems.

"Diversity" reception (cellular techniques); simultaneous reception by two or more receivers with auto comparison of signal quality and auto switching) in conjunction with COFDM modulation has further enhanced RF path robustness, reducing the previous reliance on highly directional transmit and receive antennas with their consequential reliance on labour intensive manned tracking antennas and / or highly complex and costly auto tracking antennas.

### **8.2 Compression**

Digital compression MPEG-2 / MPEG-4 (future) are a major requirement for successful implementation of COFDM microwave transmission and the resultant reduced RF spectrum requirements for contribution quality wireless camera systems.

The native 270 Megabits per second (270Mbps) data bit rate of SDI video needs to be reduced to the vicinity of 15 to 25Mbps for satisfactory signal handling.

This is currently achieved by utilizing variants of MPEG-2 coder – decoder technology. MPEG-2 configuration can be specified to achieve best compromise of multiple signal quality parameters including resolution, delay time (latency) data bit-rate, RF spectrum bandwidth etc.

Wireless cameras are generally to be considered as contribution quality signals, to be integrated into switched TV programs, and recorded via VTR or multi channel video servers for real time editing and post production operations. 4:2:2 sampling should normally be specified in the MPEG-2 profile selected for wireless camera operations.

Latency is also a major consideration in TVOB operations, particularly when wireless cameras are to be switched into programs along with cabled cameras (minimal latency). Delays in excess of 1x TV frame (40 ms) become observable in lip-sync situations. MPEG-2 coding profiles can be selected for a best compromise between latency and other quality criteria.

### **8.2.1 Compression Technology**

Most current wireless camera systems use MPEG-2 compression. However, rapid advances in compression technology are a continuum in coder- decoder research and development. Next generation encoding profiles (MPEG-4, AVC etc) may deliver performance superior to MPEG-2 without quality sacrifice.

Advanced compression codecs can be incorporated in end to end systems such as mobile camera microwave link Tx / Rx systems independent of pre existing MPEG-2 based systems.

### **8.3. DVB Parameters**

COFDM modulation parameters can be selected to provide an optimum compromise in quality factors to best meet the requirements of a specific operation.

In the case of mobile microwave links high levels of rejection of echo (multipath) signals, along with low latency and low system bit rates / RF bandwidth, consistent with contribution quality video / audio signal throughput are the major considerations in performance level setting.

### **8.4. HDTV**

The native data rate for High Definition TV is 1.485 Gbps.

Currently available MPEG-2 / COFDM link systems can be configured for contribution quality HDTV signal throughput. Continuing advancements in advanced compression technology (MPEG-4 codecs are currently becoming available for end to end systems) will ultimately overtake limitations in RF backhaul of HDTV content.

## **9. MAIN TECHNICAL CONTROL CENTRE**

The main technical control centre is the co-ordination centre for all cameras covering the event. The facility can be located in a TV studio complex providing comprehensive microwave receive capacity and Telco connectivity, or through a purpose configured major OB complex located at a key location (typically start or finish) on the event route. Local cabled cameras would connect directly to the control centre, along with switched output of sub control OB units located at other key areas and connected to the main OB via Telco or OB microwave links.

A purpose configured microwave receive location would be constructed at the main control centre for integration of helicopter down links and point to point microwave backhaul.

## **10. OUTSIDE BROADCAST COMPOUND**

### **10.1 General**

A level hardstand area for outside broadcast control units (OB Units) parking is required for the main technical control centre.

The OB van compound should be fenced off from public access for security of TV operations and for public safety.

Major outside broadcast vehicles are semi trailer units built to Australian road transport regulations. Venue vehicle access and load bearing capacity needs to comply with maximum vehicle dimension and weight specifications. Typical requirements are 17.5 metres combined trailer and prime mover length, maximum height of 4.3 metres, and 8.5 tonne per axle loading.

Typical hardstand area is in the order of 500 square metres either 25 metres x 20 metres or 50 metres x 10 metres, rectangular.

Access to and egress from the OB compound needs to cater for the turning circle and overhead clearance requirements of maximum dimension articulated vehicles.

Special attention to overhead obstructions is necessary where ramps or uneven road surfaces are involved.

Generator hardstand should be incorporated in the OB compound (see below).

Provision is to be made to site a satellite uplink vehicle within the compound, or adjacent to the compound with clear line of sight to the North-East sky.

An additional area of nominal 300 square metres should be available for international unilateral operators.

## **10.2 Personnel Amenities**

Crewing on major TVOB operations can exceed 200 staff.

Adequate personnel services need to be provided in the OB compound.

These amenities should include:

- Toilet facilities, separate male and female facilities
- Sewer connection, town water connection
- Drainage contours such as to minimise “ponding” during heavy rainfalls
- Food preparation area and catering area
- First Aid facility
- Regular cleaning and rubbish removal services

## **10.3 Secondary OB Compounds**

Secondary OB compounds may be specified at key locations along the event route.

General requirements are as per the main compound, with a space provision of 200 square metres typical.

Power requirements for secondary compounds would be in the order of 60 Amps three phase with provision for location of a 50 kVA to 100 kVA standby generator, and provision for satellite uplink as per the main compound.

## **11. POWER**

### **11.1 Typical Requirements**

Typical power requirement is for 150 Ampere per phase three phase supply adjacent to the outside broadcast vehicles hardstand area. Power should be available over 4x three phase outlets or via 'Power-lock' bulk connectors. Industry standard power connections are Cutler Hammer DS63 outlets, Wilco 5 pin 3 phase (40 amp/50 amp) connectors and outlets and / or "Power Lock" bulk supply connectors.

### **11.2 Heavy Neutral Currents**

The high level of use of switch mode power supplies in TVOB technical equipment has resulted in high neutral current drain in three phase mains supplies. High current neutral connections should be specified for mains power installations planned for TVOB compounds.

### **11.3 Circuit Breakers and Safety**

Where mains power supplies are protected by residual current devices (RCDs) trip current of the source RCD should be adjustable, to be set to a higher trip current level than the main OB van circuit breaker, such that the OB van main circuit breaker serves as the prime safety switch for the TVOB operation.

TVOB mains supplies are to be separately protected from other electrical supplies servicing the venue.

Power reticulation ex the OB van to operational areas is to be RCD protected in accordance with Work Safety requirements.

### **11.4 Local and Standby Emergency Generators**

Generator hardstand should be incorporated in the OB compound and should be adjacent to the mains power connect point.

Sourcing of generators is a TVOB responsibility. Generators are to be silenced to EPA requirements and are to be sited to obviate exhaust fume exposure to TVOB staff and patrons.

Where generator hardstand cannot be within the OB van compound interconnect cabling specified to full electrical load (150 Amps / phase, three phase) is required to be installed between the generator site and the OB Compound.

## **12. CABLING**

Simple access is required for cabling from the outside broadcast vehicle hardstand areas to the camera platforms, commentary facilities, on camera positions, to the microwave receive facility and to all other operations areas, TV cable installations are site specific and need to be planned on an individual basis, but provision needs to be made for cable routes which provide ease of access, do not compromise venue aesthetics and do not present risk to workers or public.

Wherever possible, ground level cable paths clear of public traffic areas are preferred. Where cables need to be routed below ground level open cable troughs with removable cover plates are

the preferred option. Where cables need to be routed above traffic area open cable trays with cantilever mounting from below allow for simple cable runs with "lift in" installation possible.

Cable conduits are not recommended for temporary cable installs, but where there is no other option conduits should be a minimum 150mm diameter with draw wire installed. A minimum of 3x conduits should be available in order to separate signal cables from power cables, and to allow for (inevitable) future expansion.

### **13. BACKHAUL**

#### **13.1 General**

TVOB transmission to studio base can be via Telco circuits, satellite uplink or local microwave radio transmission.

The Telco access point should be adjacent to the OB compound.

Space provision for a satellite uplink vehicle with clear view to the North-East sky is required within or adjacent to the OB compound.

#### **13.2. Microwave Link Platform**

A Microwave tower, typically of scaffold construction is required for installation of microwave receivers for helicopter down links, point to point contribution links and for microwave backhaul to the broadcast studio complex.

UHF communications antenna systems would also locate on the microwave tower.

The platform is to be sited to allow clear line of sight radio transmission to the TV studios or to a suitable intermediate relay site.

Structures need to comply with relevant OH&S regulations.

### **14. SAFETY**

All personnel working on TVOBs are to be familiar with and to comply with relevant OH&S regulations.

A site specific risk assessment is to be undertaken by venue management and TVOB operations management during planning stages of the event.

TVOB personnel are to be inducted as to venue and TVOB safety requirements prior to commencement of duties.

Scaffolding, camera tracks, aerial cabling and other constructions are to be installed by suitably licensed persons.

Camera cranes, scissor lifts, fork lifts and other mobile work platforms are to be operated by licensed persons.

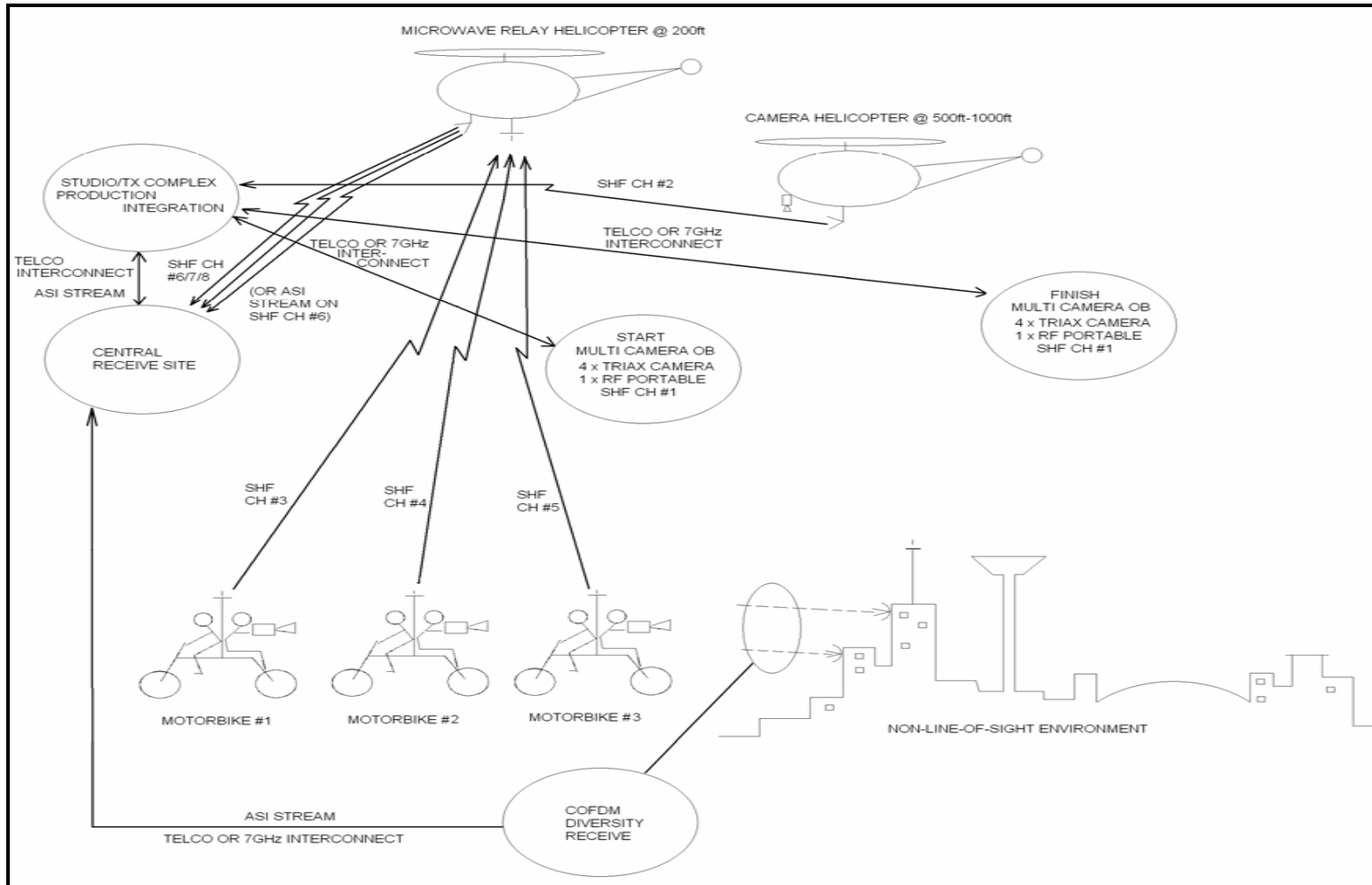
Electrical installations are to be undertaken by licensed persons, and tested and tagged in compliance with statutory regulations.

Temporary TV cable installations are to comply with site hazard reduction policies.

As safety regulations can vary subject to individual state government regulations, applicable requirements need to be determined on a site by site basis.

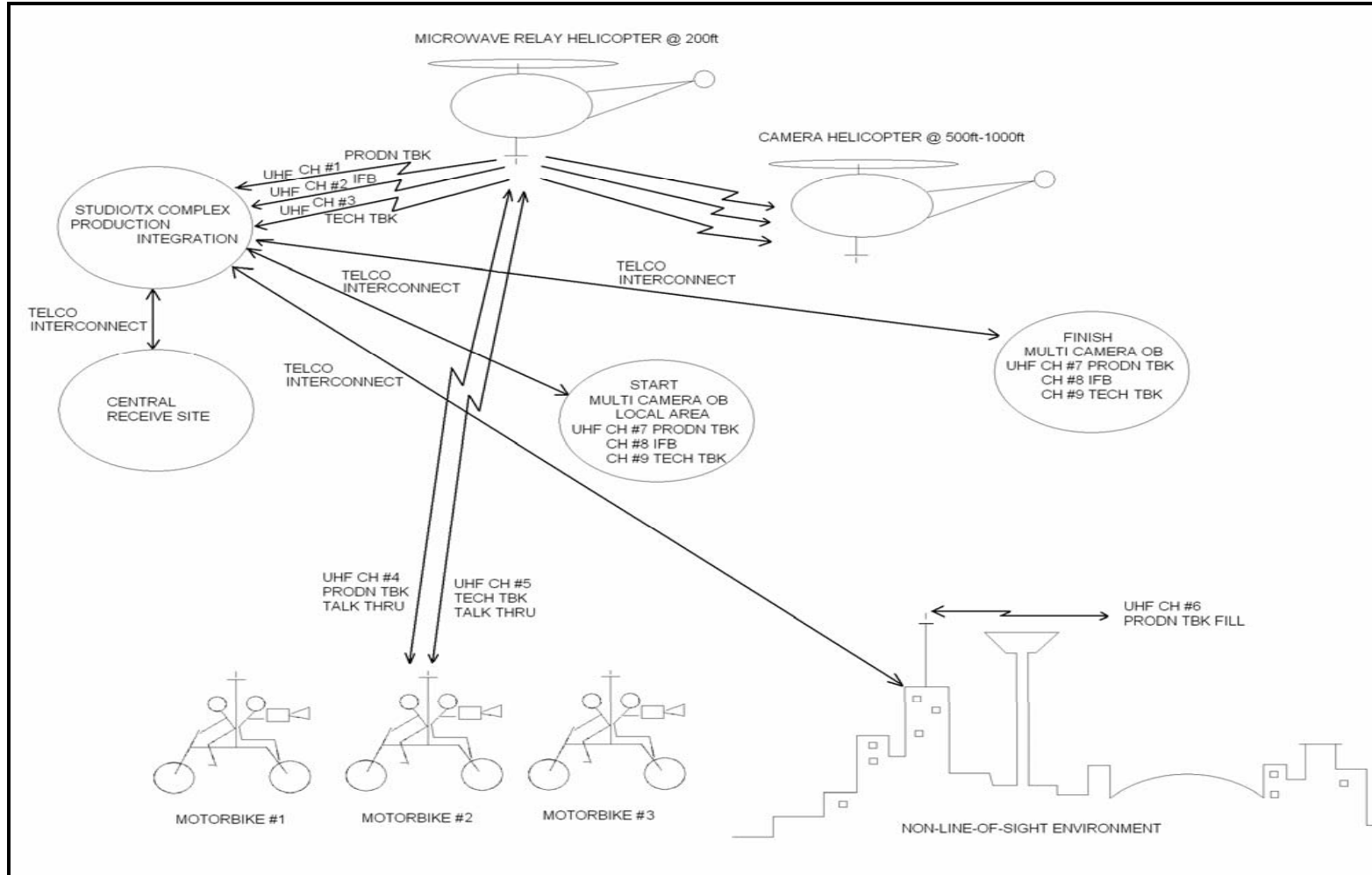
**ADDENDUM # 1**

**MARATHON MICROWAVE PLAN**



**ADDENDUM # 2**

**MARATHON COMMUNICATIONS PLAN**



**ADDENDUM # 3**

**COFDM PARAMETERS**

**DVB-S / DVB-SNG Modulation**

Data Capacity - Single Freq Systems in				23.5 MHz BW			
Modulation	Bits / Symbol	Code Rate	Data Rate (Mbps)				
			$\alpha=0.2$	$\alpha=0.25$	$\alpha=0.31$	$\alpha=0.35$	
QPSK	2	1/2	18.047	17.325	16.532	16.042	
		2/3	24.063	23.101	22.043	21.389	
	3	3/4	27.071	25.988	24.798	24.063	
		5/6	30.079	28.876	27.553	26.737	
		7/8	31.583	30.320	28.931	28.074	
8PSK	3	1/2	27.071	25.988	24.798	24.063	
		2/3	36.095	34.651	33.064	32.084	
	3	3/4	40.607	38.982	37.197	36.095	
		5/6	45.118	43.314	41.330	40.105	
		7/8	47.374	45.479	43.396	42.111	
16QAM	4	1/2	36.095	34.651	33.064	32.084	
		2/3	48.126	46.201	44.085	42.779	
	4	3/4	54.142	51.976	49.596	48.126	
		5/6	60.158	57.752	55.107	53.474	
		7/8	63.166	60.639	57.862	56.147	

Data Capacity - Single Freq Systems in				24 MHz BW			
Modulation	Bits / Symbol	Code Rate	Data Rate (Mbps)				
			$\alpha=0.2$	$\alpha=0.25$	$\alpha=0.31$	$\alpha=0.35$	
QPSK	2	1/2	18.431	17.694	16.884	16.383	
		2/3	24.575	23.592	22.512	21.845	
	3	3/4	27.647	26.541	25.326	24.575	
		5/6	30.719	29.490	28.140	27.306	
		7/8	32.255	30.965	29.546	28.671	
8PSK	3	1/2	27.647	26.541	25.326	24.575	
		2/3	36.863	35.388	33.767	32.767	
	3	3/4	41.471	39.812	37.988	36.863	
		5/6	46.078	44.235	42.209	40.959	
		7/8	48.382	46.447	44.320	43.007	
16QAM	4	1/2	36.863	35.388	33.767	32.767	
		2/3	49.150	47.184	45.023	43.689	
	4	3/4	55.294	53.082	50.651	49.150	
		5/6	61.438	58.980	56.279	54.611	
		7/8	64.510	61.929	59.093	57.342	

Data Capacity - Single Freq Systems in				47.5 MHz BW			
Modulation	Bits / Symbol	Code Rate	Data Rate (Mbps)				
			$\alpha=0.2$	$\alpha=0.25$	$\alpha=0.31$	$\alpha=0.35$	
QPSK	2	1/2	36.479	35.020	33.416	32.426	
		2/3	48.638	46.693	44.554	43.234	
	3	3/4	54.718	52.529	50.123	48.638	
		5/6	60.798	58.366	55.693	54.043	
		7/8	63.838	61.284	58.477	56.745	
8PSK	3	1/2	54.718	52.529	50.123	48.638	
		2/3	72.958	70.039	66.831	64.851	
	3	3/4	82.077	78.794	75.185	72.958	
		5/6	91.197	87.549	83.539	81.064	
		7/8	95.757	91.926	87.716	85.117	
16QAM	4	1/2	72.958	70.039	66.831	64.851	
		2/3	97.277	93.386	89.108	86.468	
	4	3/4	109.436	105.059	100.247	97.277	
		5/6	121.596	116.732	111.386	108.085	
		7/8	127.676	122.569	116.955	113.489	

**OFDM Modulation - Available Bit Rates in 6 MHz, 7 MHz and 8 MHz COFDM Channels**

Data Rate - COFDM 6MHz (in Mbps)					
Modulation	Code Rate	Guard Interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	3.732	4.147	4.391	4.524
	2/3	4.976	5.529	5.855	6.032
	3/4	5.599	6.221	6.587	6.786
	5/6	6.221	6.921	7.318	7.540
	7/8	6.532	7.257	7.684	7.917
16QAM	1/2	7.465	8.294	8.782	9.048
	2/3	9.953	11.059	11.709	12.064
	3/4	11.197	12.441	13.173	13.572
	5/6	12.441	13.824	14.637	15.080
64QAM	7/8	13.063	14.515	15.369	15.834
	1/2	11.197	12.441	13.173	13.572
	2/3	14.929	16.588	17.564	18.096
	3/4	16.796	18.662	19.760	20.358
64QAM	5/6	18.662	20.735	21.995	22.620
	7/8	19.595	21.772	23.053	23.751

Data Rate - COFDM 7MHz (in Mbps)					
Modulation	Code Rate	Guard Interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4.354	4.838	5.123	5.278
	2/3	5.806	6.451	6.830	7.037
	3/4	6.532	7.257	7.684	7.917
	5/6	7.257	8.064	8.538	8.797
	7/8	7.260	8.467	8.965	9.237
16QAM	1/2	8.709	9.676	10.246	10.556
	2/3	11.612	12.902	13.661	14.075
	3/4	13.063	14.515	15.369	15.834
	5/6	14.515	16.127	17.076	17.594
64QAM	7/8	15.240	16.934	17.930	18.473
	1/2	13.063	14.515	15.369	15.834
	2/3	17.418	19.353	20.491	21.112
	3/4	19.595	21.772	23.053	23.751
64QAM	5/6	21.772	24.191	25.614	26.390
	7/8	22.861	25.401	26.895	27.710

Data Rate - COFDM 8MHz (in Mbps)					
Modulation	Code Rate	Guard Interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4.976	5.529	5.855	6.032
	2/3	6.635	7.373	7.806	8.043
	3/4	7.465	8.294	8.782	9.048
	5/6	8.294	9.216	9.758	10.053
	7/8	8.709	9.676	10.246	10.556
16QAM	1/2	9.953	11.059	11.709	12.064
	2/3	13.271	14.745	15.612	16.086
	3/4	14.929	16.588	17.564	18.096
	5/6	16.588	18.431	19.516	20.107
64QAM	7/8	17.418	19.353	20.491	21.112
	1/2	14.929	16.588	17.564	18.096
	2/3	19.906	22.118	23.419	24.128
	3/4	22.394	24.882	26.346	27.144
64QAM	5/6	24.882	27.647	29.273	30.160
	7/8	26.126	29.029	30.737	31.668