2. OVERVIEW/ SYSTEM DESCRIPTION

2.1 General System Description

The Weehawken tunnel radio system is designed to amplify various bands of radio frequencies, in either channelised or band selective modes. All the hardware is built into standard 19" rack mounted cabinets which have an environmental IP rating of 54. There is also a single, free standing wall mounted amplifier which carries the whole signal network to the River Portal area.

The system in this document will be described separately, as individual shelves (900MHz Pager) and the various passive combiners, splitters and cross-band coupler shelves will also be described in separate documents. Every active module in the entire system has a dedicated alarm and these are series wired within the shelves to a relay which gives a volt-free output pair for each shelf which is wired to a 'krone-block' termination in the rack cabinet.

3.2 Weehawken System Frequencies Look-up Table

Agency	Channel Number	Uplink Tx	Downlink Rx
New Jersey Transit Paging	900 CHN 1		929.5875
New Jersey Transit Paging	900 CHN 2		929.6125

4. DOWNLINK PAGING AMPLIFIER

4.1 Two Channel 900MHz Pager Cell Enhancer (50-118501)

4.1.1 Two Channel 900MHz Pager Cell Enhancer Description

The pager cell enhancer provides two channels (downlink only) in the 900MHz band for the NJ Transit system. These two frequencies are relayed to all the sites (leaky feeders) in the system.
All amplifiers have built-in alarms which are configured as a summary, volt-free relay contact pair terminating at pins 1 & 2 on the 'D' type alarm connector.

4.1.2 Two Channel 900MHz Pager Cell Enhancer Technical Specification

PARAMETER		SPECIFICATION
Frequencies:		929.5875MHz (Downlink)
		929.6125MHz (Downlink)
Gain:		>90dB
Gain Adjustment:		0 - 30dB (in 2dB steps)
Shelf size:		4U
Uplink Power:		>1.0Watts
Maximum uplink output:		+30.8dBm
Downlink Power:		>5.0Watts
Maximum downlink output power:		+37.5dBm
IP3:	Uplink	+44dBm
	Downlink	+50dBm
Downlink Ch. module AGC level:		-17dBm
Uplink Ch. module AGC level:		-8dBm
Noise Figure:		<6dB (at maximum gain)
AGC:		Fitted in channel modules
VSWR:		better than 1.5:1
RF Connectors:		N type, female
Temperature range:	operational:	-10°C to +55°C
	storage:	-40°C to +70°C
Finish:	Case:	Alocrom 1200
	Heatsinks:	Matt black
	Handles:	Silver anodised alloy
	Fascia:	Painted to RAL 7035
Alarms Fitted: (volt-free contacts/TTL)		1 Downlink amplifiers
		2 Uplink amplifiers
		3 Each channel module

5. POWER SUPPLIES & ALARMS

5.1 800MHz Power Supply (80-231302)

5.1.1 800MHz Power Supply Description

The power supply for the 800MHz cell enhancer uses 15V PSU modules 'turned down' to 12V (all the amplifiers in the 800MHz CE use 12V DC supply). It is a standard power supply shelf using two PSU modules with their outputs combined through power diodes and terminating in six, dedicated 12V outputs. Failure of either PSU module will trigger a non-latching summary alarm, (short-term mains failures will allow the system to return to a 'non-alarmed' state). The alarm interface is on the alarm 'D' connector pins 1 & 2.

5.1.2 800MHz Power Supply Technical Specification

PARAMETER		SPECIFICATION
	Input:	110V AC @50/60Hz (single port)
	Outputs:	6 x 12V DC @ 20A each
	Front panel indicators:	(x 2) Green LED for 'PSU1/PSU2 ON''
	Fuses	1 x 20A each outlet socket
	DC Socket	XLR
Temperature range	operational:	-10°C to +55°C
	storage:	-40ºC to +70ºC
	Alarmed devices:	Either PSU failure
	Alarm interface (volt-free contacts):	'D' type alarm connector, pins 1 & 2
	MTBF:	>50,000 hours
	Earthing:	M8 stud

5.1.3 800MHz Power Supply System Diagram

The system diagram is not available at the time of writing this document.

5.2 Alarm/Monitor Shelf (80-231303)

5.2.1 Alarm/Monitor Shelf Description

The alarm shelf acts as an alarm concentrator for all the alarms in the system. Firstly, within each shelf containing active components, the individually alarmed modules are 'summed' and presented to that shelves' 9-way alarm connector as a volt-free relay contact pair. These alarm contact pairs are wired to the krone block in the lower rack space and from there the pairs are presented to the alarm shelf. At the alarm shelf the pairs are summed together to form an overall system alarm. In this way a system alarm may be broken down to scrutinise the shelf alarm and ultimately to the individual modules' alarms.
This shelf has its own dedicated mains-driven power 12V DC supply.

As all the alarms in the system are 'held closed loops', should any power supply fail, the main system alarm will be triggered.

5.2.2 Alarm/Monitor Shelf Technical Specification

PARAMETER		SPECIFICATION
Operating voltage:		12V (floating earth)
Alarm output relay contacts:		
Max. switch current:		1.0Amp
Max. switch volts:		120Vdc/60VA
Max. switch power:		24W/60VA
Min. switch load:		10.0µA/10.0mV
Relay isolation:		1.5kV
Mechanical life:		>2x10^{7} operations
Relay approval:		BT type 56
Connector details:		25 Way 'D' Connector
Temperature range	operational:	:-10°C to +55°C
	storage:	:-40°C to +70°C

6. SUB-UNIT MODULES

Note that the sub unit modules are tabled in part number order – the modules pertinent to any particular shelf will be found in the parts list under the heading of that shelf.

6.1 Bandpass Filter (02-004502)

6.1.1 Description

The bandpass filters are multi-section designs with a bandwidth dependent upon the passband frequencies, (both tuned to customer requirements). The response shape is basically Chebyshev with a passband design ripple of 0.1dB. The filters are of slot coupled, folded combline design, and are carefully aligned during manufacture in order to optimise the insertion loss, VSWR and intermodulation characteristics of the unit. The tuned elements are silver-plated to reduce surface ohmic losses and maintain a good VSWR figure and 50Ω load at the input and output ports.

Being passive devices, the bandpass filters should have an extremely long operational life and require no maintenance. Should a filter be suspect, it is usually most time efficient to replace the module rather than attempt repair or re-tuning.

No adjustments should be attempted without full network sweep analysis facilities to monitor both insertion loss and VSWR simultaneously.

6.1.2 Technical Specification

PARAMETER		SPECIFICATION
	Response Type	Chebyshev
	Frequency:	920MHz (tuned to spec.)
	Bandwidth:	3MHz (tuned to spec.)
	Number of Sections:	5
	Insertion Loss:	1.2 dB
	VSWR:	better than 1.2:1
	Connectors:	SMA female
	Power Handling:	100W max
Temperature range:	operation:	-10°C to +60°C
	storage:	-20°C to +70°C
	Weight:	3 kg (typical)

6.2 Bandpass Filter (02-007206)

6.2.1 Description

The bandpass filters are multi-section designs with a bandwidth dependent upon the passband frequencies, (both tuned to customer requirements). The response shape is basically Chebyshev with a passband design ripple of 0.1dB. The filters are of slot coupled, folded combline design, and are carefully aligned during manufacture in order to optimise the insertion loss, VSWR and intermodulation characteristics of the unit. The tuned elements are silver-plated to reduce surface ohmic losses and maintain a good VSWR figure and 50Ω load at the input and output ports.

Being passive devices, the bandpass filters should have an extremely long operational life and require no maintenance. Should a filter be suspect, it is usually most time efficient to replace the module rather than attempt repair or re-tuning.

No adjustments should be attempted without full network sweep analysis facilities to monitor both insertion loss and VSWR simultaneously.

6.2.2 Technical Specification

PARAMETER		SPECIFICATION
Response Type		Chebyshev
Frequency range:		800 - 950MHz (tuned to spec.)
Bandwidth:		25MHz (tuned to spec.)
Number of sections:		8
Insertion Loss:		1.2 dB
VSWR:		better than 1.2:1
Connectors:		SMA female
Power Handling:		100W max
Temperature range:	operation:	-10°C to +60°C
	storage:	-20°C to +70°C
Weight:		3 kg (typical)

6.3 900MHz Splitter/Combiner (05-002602)

6.3.1 Description

The Splitter/Combiner used is a device for accurately matching two or more RF signals to single or multiple ports, whilst maintaining an accurate 50Ω load to all inputs/outputs and ensuring that the VSWR and insertion losses are kept to a minimum. Any unused ports will be terminated with an appropriate 50Ω load.
Being passive devices, the splitters should have an extremely long operational life and require no maintenance. Should a unit be suspect, it is usually most time efficient to replace the whole module rather than attempt repair or re-tuning.

Being passive devices, the splitters should have an extremely long operational life and require no maintenance. Should a unit be suspect, it is usually most time efficient to replace the whole module rather than attempt repair or re-tuning.

6.3.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency range:	Narrowband:	815 – 960MHz
	Broadband:	800 – 1200MHz
Bandwidth:	Narrowband:	145MHz
	Broadband:	400MHz
	Input ports:	1
	Output ports:	2
Insertion loss:	Narrowband:	3.3dB
	Broadband:	3.5dB
Return loss input & output:		1.3:1
	Impedance:	50Ω
Isolation:	Narrowband:	>20dB
	Broadband:	>18dB
	MTFB:	>180,000 hours
Power rating:	Splitting:	20Watts
	Combining:	0.5Watt
	Connectors:	SMA female
	Weight:	200g (approximately)
	Size:	54 x 44 x 21mm (including connectors)

6.4 ¼Watt 0- -30 & Switched Attenuator (10-000701)

6.4.1 General Application

In many practical applications for Cell Enhancers etc., the gain in each path is found to be excessive. Therefore, provision is made within the unit for the setting of attenuation in each path, to reduce the gain.

6.4.2 Switched Attenuators

The AFL switched attenuators are available in two different types; 0 – 30dB in 2 dB steps, or 0 – 15dB in 1 dB steps. The attenuation is simply set using the four miniature toggle switches on the top of each unit. Each switch is clearly marked with the attenuation it provides, and the total attenuation in line is the sum of the values switched in. They are designed to maintain an accurate 50Ω impedance over their operating frequency at both input and output.

6.5 Low Noise Amplifier (11-005902)

6.5.1 Description

The Gallium-Arsenide low noise amplifier used in the unit is a double stage, solid-state low noise amplifier. Class A circuitry is used throughout the units to ensure excellent linearity and extremely low noise over a very wide dynamic range. The active devices are very moderately rated to provide a long trouble-free working life. There are no adjustments on these amplifiers, and in the unlikely event of a failure, then the complete amplifier should be replaced. This amplifier features its own in-built alarm system which gives a volt-free relay contact type alarm that is easily integrated into the main alarm system.

6.5.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency range:		800 – 960MHz
Bandwidth:		<170MHz
Gain:		19.5dB (typical)
1dB Compression point:		21dBm
OIP3:		33dBm
Input/Output Return Loss:		>20dB
Noise Figure:		1dB (typical)
Power consumption:		190mA @ 24V DC
Supply voltage:		10-24V DC
Connectors:		SMA female
Temperature range:	operational:	-10°C to +60°C
	storage:	-20°C to +70°C
Size:		90 x 55 x 30.2mm
Weight:		0.28kg

6.5.3 LNA 'D' Connector Pin-out details

Connector pin	Signal
1	+Ve input (10-24V)
2	GND
3	Alarm Relay O/P bad
4	Alarm Relay common
5	Alarm Relay good
6	No connection
7	TTL voltage set
8	TTL alarm/0V (good)
9	O/C good/0V bad

6.6 Low Noise Amplifier (11-006702)

6.6.1 Description

The Gallium-Arsenide low noise amplifiers used in the system are double stage, solid-state low noise amplifiers. Class A circuitry is used throughout the units to ensure excellent linearity and extremely low noise over a very wide dynamic range. The active devices are very moderately rated to provide a long trouble-free working life. There are no adjustments on these amplifiers, and in the unlikely event of a failure, then the complete amplifier should be replaced. This amplifier features its own in-built alarm system which gives a volt-free relay contact type alarm that is easily integrated into the main alarm system.

6.6.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency range:		800 – 1000MHz
Bandwidth:		<200MHz
Gain:		29dB (typical)
1dB Compression Point:		20dBm
OIP3:		33dBm
Input/Output Return Loss:		>18dB
Noise Figure:		1.3dB (typical)
Power Consumption:		180mA @ 24V DC
Supply Voltage:		10-24V DC
Connectors:		SMA female
Temperature range:	operational:	-10°C to +60°C
	storage:	-20°C to +70°C
Size:		90 x 55 x 30.2mm
Weight:		290gms (approximately)

6.6.3 LNA ‘D’ Connector Pin-out details

Connector pin	Signal
1	+Ve input (10-24V)
2	GND
3	Alarm Relay O/P bad
4	Alarm Relay common
5	Alarm Relay good
6	No connection
7	TTL voltage set
8	TTL alarm/0V (good)
9	O/C good/0V bad

6.7 20W Power Amplifier (12-018002)

6.7.1 Description

This amplifier is a Class A 20W power amplifier from 800-960MHz in a 1 stage balanced configuration. It demonstrates a very high linearity and a very good input/output return loss (RL). It has built in a Current Fault Alarm Function.
Its housing is an aluminium case (Alocrom 1200 finish) with SMA connectors for the RF input/output and a D-Type connector for the power supply and the Current Fault Alarm Function.

6.7.2 Technical Specification

PARAMETER	SPECIFICATION
Frequency range:	800-960MHz
Small signal gain:	30dB
Gain flatness:	±1.2dB
I/O Return loss:	>18dB
1dB compression point:	42.8dBm
OIP3:	56dBm
Supply voltage:	24V DC
Supply current:	5.0Amps (Typical)
Temperature range – operational:	-10°C to +60°C
Temperature range – storage:	-20°C to +70°C
Weight:	<2kg (no heatsink)

6.7.3 PA 7-Way Connector Pin-outs

Connector Pin	Signal
A1 (large pin)	+24V DC
A2 (large pin)	GND
1	Alarm relay common
2	TTL alarm/0V good
3	Alarm relay contact (bad)
4	Alarm relay contact (good)
5	O/C good/0V bad (TTL)

6.8 D.I.P Channel Control Module (17-002101)

6.8.1 Description

The operating frequency for each channel in each repeater is programmed by 16 DIL (Dual In Line) switches. The programming switches are mounted in the Channel Control Module. The Channel Selectivity Modules are connected to the Channel Control Module via multi-way ribbon cables.

Adjacent to the DIL switches for each channel is a toggle switch to turn on and off individual channels as required. A green LED indicates the power status of each channel.

A red LED shows the alarm condition for each channel. An illuminated alarm LED indicates that the synthesiser has not achieved phase lock and that the module is disabled. There is a problem which requires investigation, often a frequency programmed outside the operating frequency range.

The following information is necessary before attempting the programming procedure.

1) operating frequency
2) synthesiser channel spacing (step size)
3) synthesiser offset (IF)

6.8.2 Programming Procedure

Check that the required frequency falls within the operational frequency limits of the Cell Enhancer.

For each channel required, subtract the synthesiser offset from the required operating frequency and record the resulting local oscillator frequency.

Divide each local oscillator frequency by the channel spacing and check that the result is an integer (i.e: no remainder).

If the synthesiser division ratio is not an integer value, check the required operational frequency and repeat the calculation checking for mistakes.

Convert the required local oscillator frequency to synthesiser programming switch state patterns according to the following table.

6.8.3 12.5kHz step size switch functions

Switch Number	Synthesiser offset added when switch in UP position
1	+12.5kHz
2	+25kHz
3	+50kHz
4	+100kHz
5	+200kHz
6	+400kHz
7	+800kHz
8	+1.6MHz
9	+3.2MHz
10	+6.4MHz
11	+12.8MHz
12	+25.6MHz
13	+51.2MHz
14	+102.4MHz
15	+204.8MHz
16	+409.6MHz

6.8.4 25kHz step size switch functions

Switch Number	Synthesiser offset added when switch in UP position
1	+25kHz
2	+50kHz
3	+100kHz
4	+200kHz
5	+400kHz
6	+800kHz
7	+1.6MHz
8	+3.2MHz
9	+6.4MHz
10	+12.8MHz
11	+25.6MHz
12	+51.2MHz
13	+102.4MHz
14	+204.8MHz
15	+409.6MHz
16	+819.2MHz

6.8.5 Programming Example

Frequency required: 454.000MHz

Channel spacing: 12.5kHz

Synthesiser offset: -21.4MHz

The Local Oscillator frequency is therefore:
454.000 – 21.4 = 432.600MHz

Dividing the LO frequency by the channel spacing of 0.0125MHz:

$$\frac{432.600}{0.0125} = 34608$$

This is an integer value, therefore it is OK to proceed.

Local Oscillator Frequency	Switch settings 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
432.600 MHz	1	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0

Switch setting: 0 = switch DOWN (ON, frequency ignored)
1 = switch UP (OFF, frequency added)

6.8.6 17-002101 Controller Module DIP Switch Connector Data

IDC PIN	25-way Connector	Function (12.5kHz steps)
1	**13**	**Freq. bit 1 (12.5kHz)**
2	**25**	**Freq. bit 2 (25kHz)**
3	**12**	**Freq. bit 3 (50kHz)**
4	**24**	**Freq. bit 4 (100kHz)**
5	**11**	**Freq. bit 5 (200kHz)**
6	**23**	**Freq. bit 6 (400kHz)**
7	**10**	**Freq. bit 7 (800kHz)**
8	**22**	**Freq. bit 8 (1.6MHz)**
9	**9**	**Freq. bit 9 (3.2MHz)**
10	**21**	**Freq. bit 10 (6.4MHz)**
11	**8**	**Freq. bit 11 (12.8MHz)**
12	**20**	**Freq. bit 12 (25.6MHz)**
13	**7**	**Freq. bit 13 (51.2MHz)**
14	**19**	**Freq. bit 14 (102.4MHz)**
15	**6**	**Freq. bit 15 (204.8MHz)**
16	**18**	**Freq. bit 16 (409.6MHz)**
17	**5**	**Module alarm**
18	**17**	**Gain bit 1**
19	**4**	**Gain bit 2**
20	**16**	**Gain bit 3**
21	**3**	**Gain bit 4**
22	**15**	**+5V**
23	**2**	**0V**
24	**14**	**Switched 12V**
25	**1**	**0V**
26	**---**	**---**

6.9 Channel Selective Modules (17-003033, 17-009143, 17-009127 & 17-010803)

6.9.1 Description

The channel selectivity module is employed when the Cell Enhancer requirement dictates that very narrow bandwidths (single operating channels), must be selected from within the operating passband. One channel selectivity module is required for each channel.

The Channel Selectivity Module is an Up/Down frequency converter that mixes the incoming channel frequency with a synthesised local oscillator, so that it is down-converted to an Intermediate Frequency (IF) in the upper HF range. An eight pole crystal filter in the IF amplifier provides the required selectivity to define the operating passband of the Cell Enhancer to a single PMR channel. The same local oscillator then converts the selected IF signal back to the channel frequency.

Selectivity is obtained from a fixed bandwidth block filter operating at an intermediate frequency (IF) in the low VHF range. This filter may be internal to the channel selectivity module (Crystal or SAW filter) or an externally mounted bandpass filter, (LC or Helical Resonator). Various IF bandwidths can therefore be accommodated. A synthesized Local Oscillator is employed in conjunction with high performance frequency mixers, to translate between the signal frequency and IF.

The operating frequency of each channel selectivity module is set by the programming of channel selectivity module frequencies and is achieved digitally, via hard wired links, banks of DIP switches, or via an onboard RS232 control module, providing the ability to remotely set channel frequencies.

Automatic Level Control (ALC) is provided within each channel selectivity module such that the output level is held constant for high level input signals. This feature prevents saturation of the output mixer and of the associated amplifiers.

Alarms within the module inhibit the channel if the synthesised frequency is not locked. The synthesiser will not usually go out of lock unless a frequency far out of band is programmed.

The channel selectivity module is extremely complex and, with the exception of channel frequency programming within the design bandwidth, it cannot be adjusted or repaired without extensive laboratory facilities and the necessary specialised personnel. If a fault is suspected with any channel selectivity module it should be tested by substitution and the complete, suspect module should then be returned to AFL for investigation. The channel selective modules fitted to the VHF cell enhancers in the Weehawken system are all hard-wired and therefore not adjustable, however, the modules fitted to the UHF and 800MHz enhancers have DIP switch controller modules fitted, allowing the set frequency to be changed on site. There is no functionality to change the frequencies remotely.

6.10 12 & 24V Relay Boards (20-001601 & 20-001602)

6.10.1 Description

The General Purpose Relay Board allows the inversion of signals and the isolation of circuits. It is equipped with two dual pole change-over relays RL1 and RL2, with completely isolated wiring, accessed via screw terminals.
Both relays are provided with polarity protection diodes and diodes for suppressing the transients caused by "flywheel effect" which can destroy switching transistors or induce spikes on neighbouring circuits. It's common use is to amalgamate all the alarm signals into one, volts-free relay contact pair for the main alarm system.
Note that the board is available for different voltages (12 or 24V) depending on the type of relays fitted at RL1 and RL2.

6.10.2 Technical Specification

PARAMETER		SPECIFICATION
Operating voltage:		8 to 30V (floating earth)
Alarm Threshold:		Vcc - 1.20 volt ±15%
Alarm output relay contacts:		
Max. switch current:		1.0Amp
Max. switch volts:		120Vdc/60VA
Max. switch power:		24W/60VA
Min. switch load:		10.0µA/10.0mV
Relay isolation:		1.5kV
Mechanical life:		>2x10^7 operations
Relay approval:		BT type 56
Connector details:		Screw terminals
Temperature range	operational:	:-10°C to +55°C
	storage:	:-40°C to +70°C

6.11 12 & 24V Single Relay Board (80-008901 & 80-008902)

6.11.1 Description

The General Purpose Relay Board allows the inversion of signals and the isolation of circuits. It is equipped with a single dual pole change-over relay RL1, with completely isolated wiring, accessed via a 15 way in-line connector.

The relay is provided with polarity protection diodes and diodes for suppressing the transients caused by "flywheel effect" which can destroy switching transistors or induce spikes on neighbouring circuits. It's common use is to amalgamate all the alarm signals into one, volts-free relay contact pair for the main alarm system.

Note that the board is available for different voltages (12 or 24V) depending on the type of relay fitted at RL1.

6.12 JWS150-12/A PSU (96-300052)

6.12.1 Description

The power supply unit is a switched-mode type capable of supplying 15V DC at 12Amps continuously. The equipment in this system requires 12V DC so the output voltage has been factory adjusted to 12.3V. Equipment of this type typically requires approximately 4-6Amps at 12V DC, so the PSU will be used conservatively ensuring a long operational lifetime.

No routine maintenance of the PSU is required. If a fault is suspected, then the output voltage from the power supply may be measured on its output terminals. This is typically set to 12.3V. The output voltage may be varied using a multi-turn adjustment potentiometer mounted close to the DC output terminals.

All the PSU's used in AFL Cell Enhancers are capable of operation from either 110 or 220V nominal AC supplies. The line voltage is sensed automatically, so no adjustment or link setting is needed by the operator.

6.12.2 Technical Specification

AC Input Supply:	
Voltage:	110 or 220V nominal
	90 to 132 or 180 to 264V (absolute limits)
Frequency:	47 to 63Hz
DC Output Supply:	
Voltage:	15V DC (nominal)
	12.3-17V (absolute limits)
Current:	12A