CONTROL OF A REMOTE RECEIVING STATION AND DATA PROCESSING AT RA RANGE HEBRIDES

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Abstract The Royal Artillery Range (RA Range) is the British Army's weapons practice range in the Outer Hebrides of Scotland. The large sea range is also used by the Royal Air Force and Royal Navy for new weapons system evaluation and in service practice firing.

This paper describes the telemetry facility comprising of two prime sites separated by 40 miles of open sea.

Tracking antennas and receivers are at the remote island site of St Kilda with data processing and control at the Range Control Base (RCB), Benbecula.

To improve operational capabilities and effectiveness, full remote control and monitoring of the multiple receivers and combiners has been installed.

Radar tracking outputs are processed in the telemetry computer to produce individual antenna pointing demands.

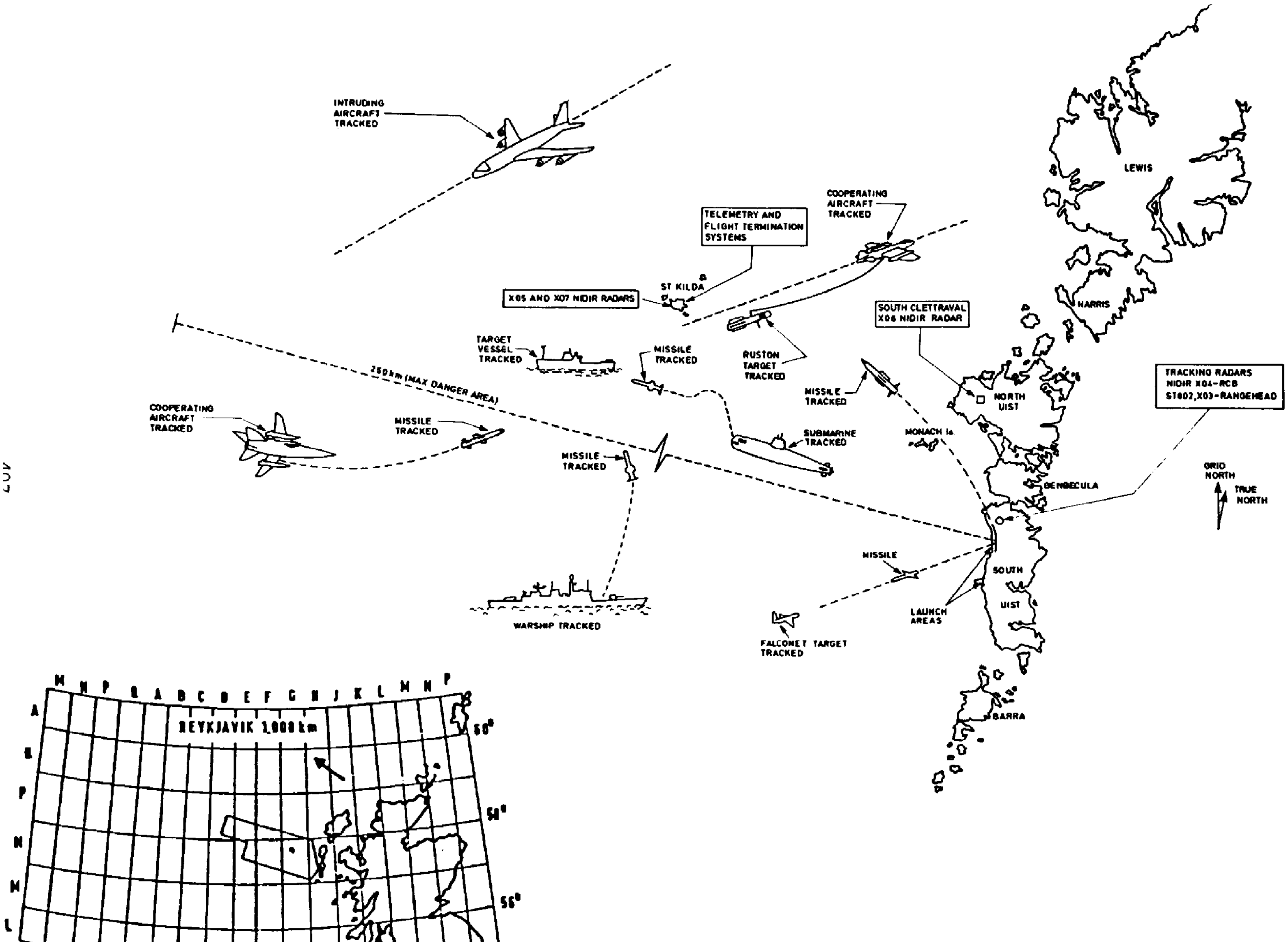
Keywords: **Remote Control, Diversity Combining, Antenna Control**

BACKGROUND

The RA Range Hebrides is situated on the island of South Uist about 50 miles from the Scottish mainland. Its prime purpose is to provide a safe area to fire a wide variety of weapon systems from small arms through to ground to air, air to air, air to surface and surface to surface missiles.

The Range provides air and sea radar coverage over the Range area and provides accurate tracking radar data from missile targets, co-operating aircraft and ships. It also provides telemetry reception and decommutation over the D and E land frequencies.

The Range boundaries take up an area some 250 Kilometres long by 50 Kilometres wide with an unlimited ceiling within the Range area. This Range area also takes in



Range Tracking Systems schematic

Fig.1.

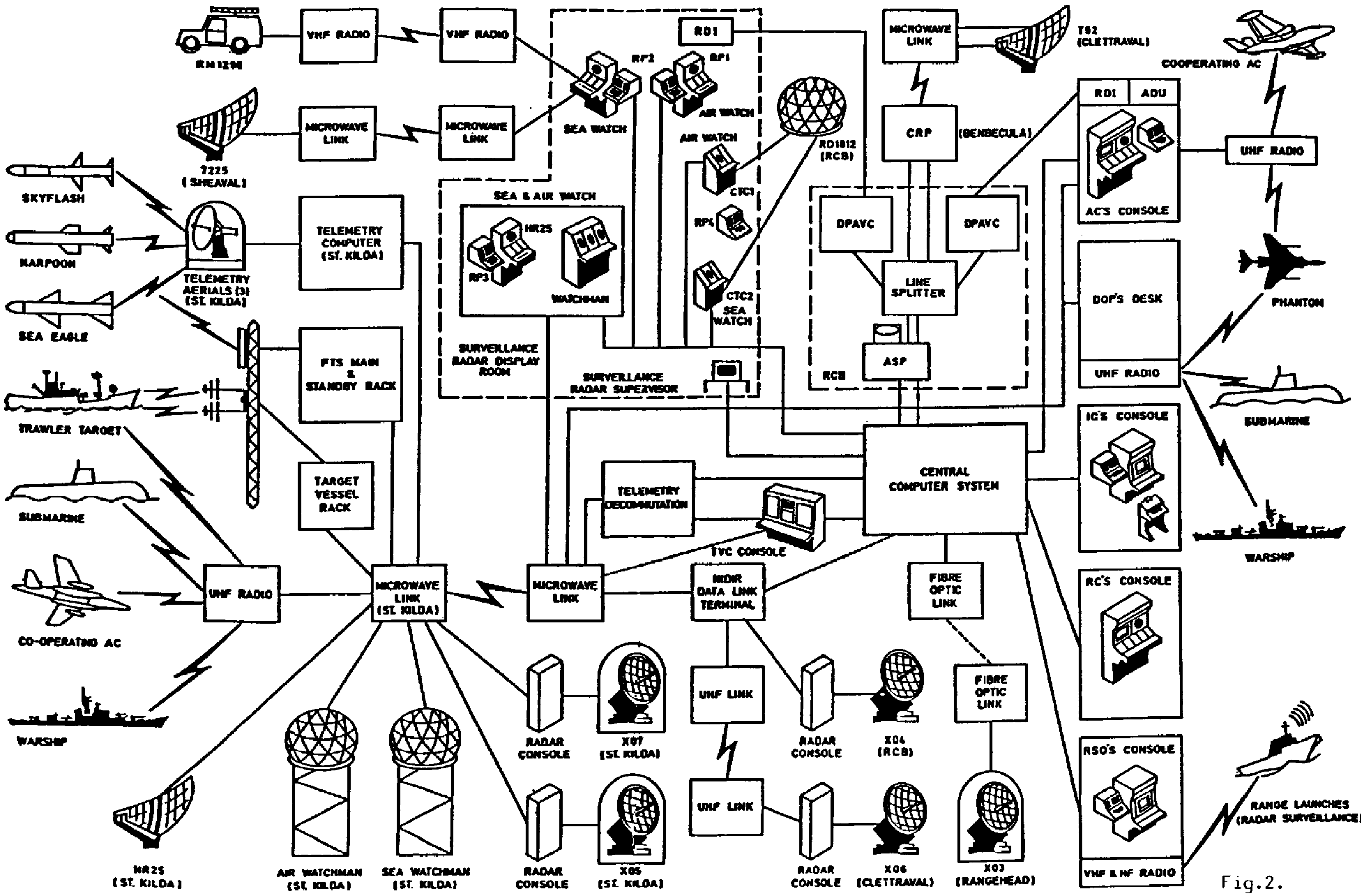

RM1290
VHF RADIO
VHF RADIO
MICROWAVE LINK
MICROWAVE LINK
7225 (SHEAVAL)
SKYFLASH
HARPOON
SEA EAGLE
TRAWLER TARGET
SUBMARINE
CO-OPERATING AC
WARSHIP
TELEMETRY AERIALS (3) (ST. KILDA)
TELEMETRY COMPUTER (ST. KILDA)
FTS MAIN & STANDBY RACK
TARGET VESSEL RACK
UHF RADIO
MICROWAVE LINK (ST. KILDA)
HR2S (ST. KILDA)
AIR WATCHMAN (ST. KILDA)
SEA WATCHMAN (ST. KILDA)
RDI
RP2
RP1
SEA WATCH
AIR WATCH
AIR WATCH
RD1812 (RCB)
CTC1
RP4
CTC2
SEA WATCH
SEA & AIR WATCH
HR2S
RP3
WATCHMAN
SURVEILLANCE RADAR DISPLAY ROOM
SURVEILLANCE RADAR SUPERVISOR
MICROWAVE LINK
T82 (CLETTRAVAL)
CRP
(BENBECULA)
DPAVC
DPAVC
LINE SPLITTER
ASP
RCB
CENTRAL COMPUTER SYSTEM
TELEMETRY DECOMMUTATION
TVC CONSOLE
MICROWAVE LINK
MDIR DATA LINK TERMINAL
FIBRE OPTIC LINK
FIBRE OPTIC LINK
UHF LINK
UHF LINK
RADAR CONSOLE
X07 (ST. KILDA)
RADAR CONSOLE
X05 (ST. KILDA)
RADAR CONSOLE
X04 (RCB)
RADAR CONSOLE
X06 (CLETTRAVAL)
X03 (RANGEHEAD)
RDI
ADU
AC'S CONSOLE
UHF RADIO
COOPERATING AC
PHANTON
DOF'S DESK
UHF RADIO
SUBMARINE
WARSHIP
IC'S CONSOLE
RC'S CONSOLE
RSO'S CONSOLE
VHF & HF RADIO
RANGE LAUNCHES (RADAR SURVEILLANCE)

Fig.2.

the island of St Kilda on the northern end of the Range boundary about 91 Kilometres West of South Uist.

The Range is run by a mixture of soldiers, civil servants and Serco who are the prime contractors on the Range, operating, maintaining and repairing the Range Instrumentation.

The abilities of the Range are greatly enhanced by having St Kilda within the Range area as some of the radars and all telemetry receivers and antennas are situated there. This gives extended (over the horizon) radar and telemetry coverage.

The telemetry data is brought back to the Range Control Building on South Uist where it is decommutated and processed.

While St Kilda is vital to long range firings it has several problem areas, one of which is weather. This causes the operational site on St Kilda to be abandoned from time to time thus precluding Range use. It is also remote with transport only once a fortnight.

This isolation and severe weather means that any equipment installed has to be reliable, controllable from the main instrumentation site at the Range Control Building and that there has to be a 100% spares back up in the case of critical failures.

The Range Control Building on South Uist contains the main operations centre, where all the radar plotting and tracking information is processed by the central computer system.This information is used for Range safety and to slave the telemetry aerials on St Kilda on to their target.

The telemetry information coming back from St Kilda is recorded, decommutated and sent out to chart recorders for real time analysis of missile performance. Part of this decommutation data is also sent to the central computer system to form part of the range safety picture.

THE PROBLEM

The demands on Range Telemetry, with respect to available facilities and personnel, are continually under pressure to become more efficient. In terms of personnel this normally means staff reductions and facilities , flexibility, maintainability and growth potential to meet new requirements.

The former RA Range system was built around 1970's technology and was suffering from maintainability problems due to obsolescence and, because the system was missile specific, lack of flexibility. This caused a drain on resources, resulting in system down time and rapidly became non cost effective. As new missiles are now more complex the technology aspect follows suit. Formats are more inventive, data rates are much higher and require state of the art technology to receive, process and, due to the ever increasing needs for "real time", display.

The RA Range is classified as "all weather" and maintains a constant state of readiness. Range down time is at a premium and a way to install a major new telemetry system had to be investigated. It was decided to break down the required installations into phases beginning with, what was considered the most troublesome and resource draining link, the telemetry receivers. Phase two replaced the telemetry computer system incorporating all PAM and PCM documentation.

The specification of both phases was form, fit and function (FFF). This was essential to maintain Range Systems operation continuity and meant that all existing systems in the complex Range facility would continue operation unhindered and the new installations would remain transparent. As well as satisfying the FFF requirement, the phased installation not only had to deal with the current missile trial requirements (both PAM and PCM), but meet the needs of the future requirements foreseen to the end of the decade also. Systems design was limited to meet all the mentioned requirements, budget and time scales. The benefits of using newer technologies were capitalised on and naturally enhanced the overall performance beyond the FFF going a long way to meet the future needs.

THE SOLUTIONS

PHASE 1 - TELEMETRY RECEIVERS AND COMBINERS

The original system combined the antenna outputs in a polarisation diversity mode. A PDP 11/34 on St Kilda, apart from antenna control duties, performed best signal selection of the receivers and combiner outputs. Maintainability of the PDP was a major cause of concern to the Range and deviation from the FFF was requested to remove this function, later with phase 2, all functions and remove the PDP 11/34 completely. In addition, because of the logistic problems in reconfiguring the receivers on St Kilda, remote control both local on St Kilda and Range Control Building (RCB) was highly desirable, if the budget allowed.

Of the three missile formats catered for (PAM/FM, FM/FM and PCM/FM), the PAM/FM consistently gave the poorest overall S/N. It was decided to use PAM/FM as a reference and to install a dual receiver/combiner set up on St Kilda to get a better understanding of the island system performance and operation. More importantly to get some valued experience in the logistics of installing equipment on a remote island that is supplied by ship or helicopters every 2 weeks.

A Microdyne 1400 - MRA receiver/3200 - PCA combiner combination was chosen to perform this test case.

Setting up the equipment using standard manufacturers recommended calibrations, a 9db improvement, comparing test signal attenuations with received S/N, was achieved. The test signal was generated from RCB using a PAM missile simulator modulating a 2 watt E Band transmitter with output attenuation to the antenna.

Following the successful pilot tests, a Microdyne unit based system was chosen. Microdyne offered off the shelf equipment to meet the requirements and had systems application software, PC based, to cater for the desired remote control needs. It was also within the Range budget. Figure 3 shows the final system solution that was installed.

The 3 Scientific Atlanta antennas are dual band (D and E) with individual LNA and BPF's. Power to the LNA's are passed via the RF downlead and individually switched depending upon the frequency band in operation.

Each antenna LHCP and RHCP output connects to a purpose designed power switch unit that is controlled from 1 of the receivers. Each receiver is configured with a dual D and E band RF tuner and a TTL output whose state is dependant on the band the RF frequency is selected in, controls the LNA power switch rooting.

At Mullach Sgar, the 2nd IF (20 MHz) outputs are distributed to Mullach Mor, for combining via wideband Optronics fibre optic links. A FM demodulator and spectrum display module are installed in 1 receiver only, per antenna, for test and calibration purposes. AGC and combiner logic outputs are multiplexed through another fibre optic channel.

At Mullach Mor, each of the 3 antenna polarised outputs are IF and AGC combined. The Mullach Sgar combined outputs are further combined and then combined with the Mullach Mor combined output. The result is the "Best Signal" previously produced by the PDP 11/34, but still at a 2nd IF frequency.

The 3200 PCA has built in selectable down converters which are utilised to record the individual receiver outputs on a Honeywell 101 wideband tape recorder.

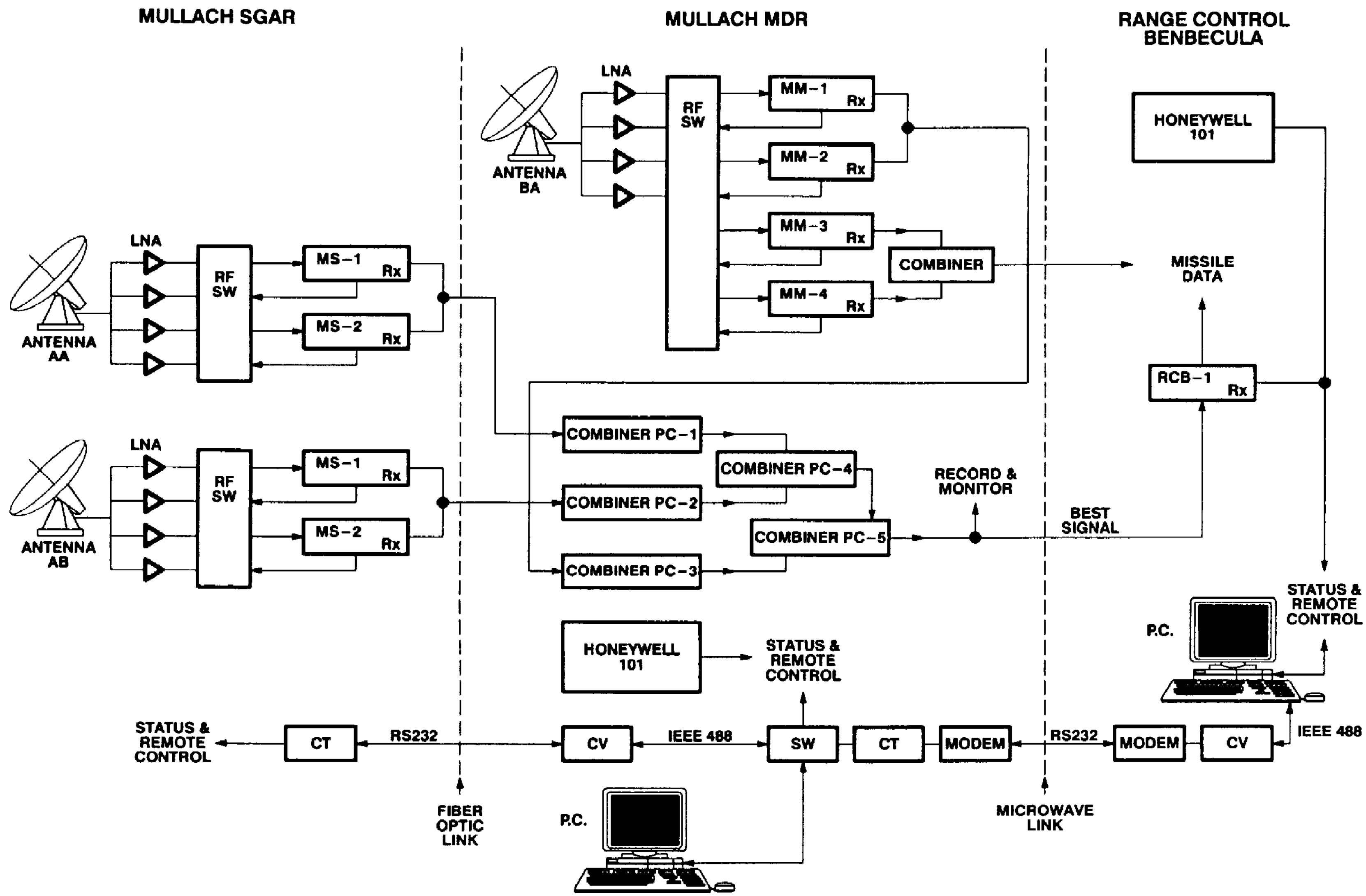


Fig.3.

RECEIVER SYSTEM BLOCK DIAGRAM

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The final combiner down converted output is sent to RCB via microwave as the best signal, previously controlled by the PDP 11/34. A 1400-MRA receiver with playback tuner is installed at RCB for real time data demodulation. The receiving system configuration allows full redundancy. Only 1 receiver needs to be operational to send data to RCB.

Remote control is via PC's using Microdyne IEEE 488 Systems Applications Software configured to the Range requirements. The PC at RCB controls its local receiver and also connected to a National Instruments GP1B/RS232 converter and modem for transmission over the microwave link. A modem at Mullach Mor is connected to a NI controller giving access to the receivers and combiners at this site. A second GPIB/RS232 conversion process takes place at Mullach Mor interfacing to a serial RS232 channel on the fibre optic link for Mullach Sgar Control. An operator at RCB can set up the complete receiving link from a previously saved set up configuration in less than 20 secs.

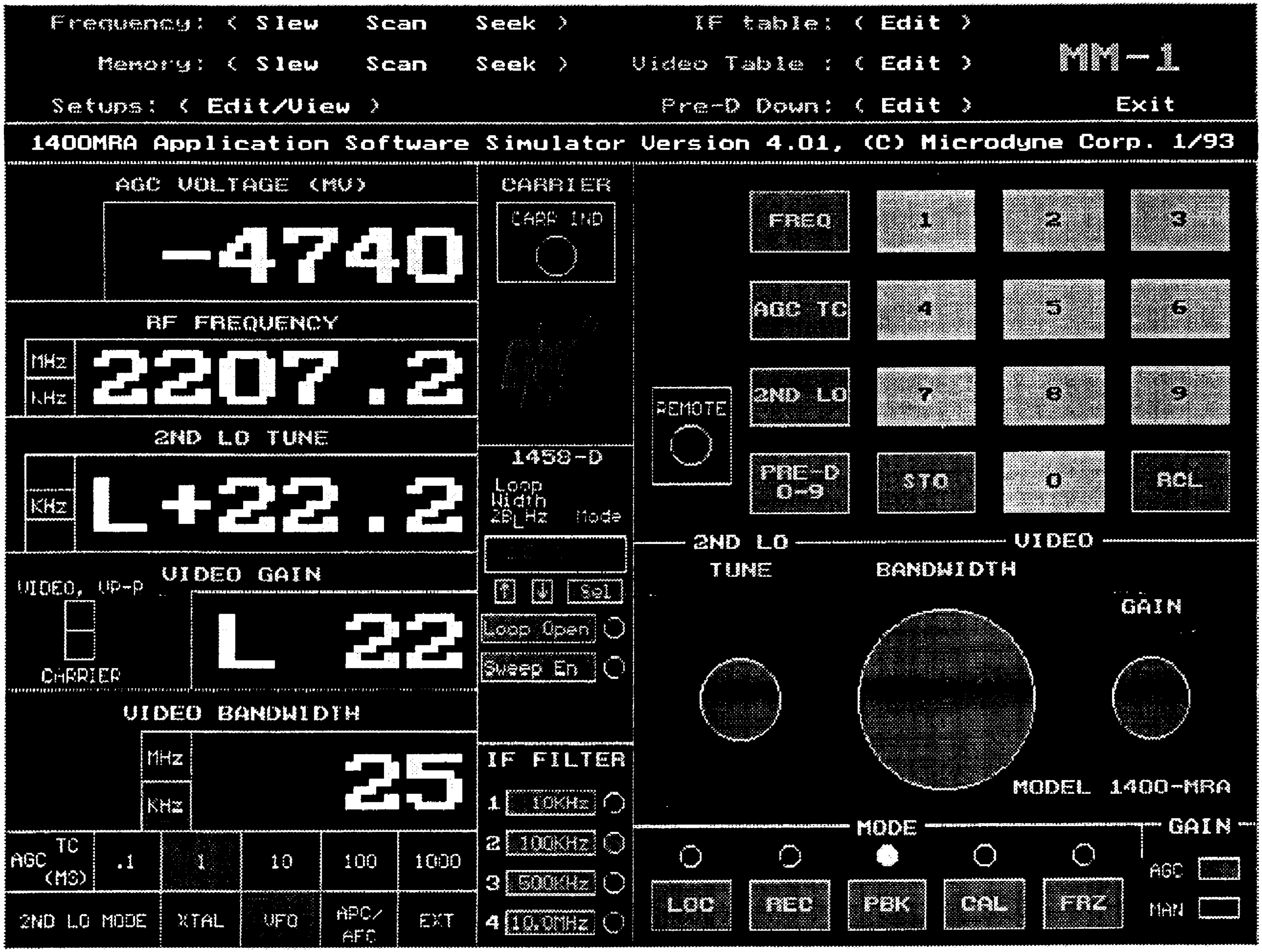
The Software, DOS based, allows an operator to configure the system layout, access/set up individual components in the chain, monitor status and save/load set ups to and from disk. Each piece of equipment has its own software module and easily allows new equipment to be added to the software loop.

It was felt that a rapid status of all the equipment on the remote bus should be accessible, especially during a trial countdown. Working with Microdyne, a new "page" was added that read back, from a poll routine, the most important information, see fig 5, up to 9 such pages can be accessed. All the receivers and combiners can be displayed on a single text page. AGC voltage is red text when above threshold.

Additional modules have been added to control both RCB and St Kilda Honeywell 101 tape recorders with one touch record and copy features. New chart recorders have been added at RCB and software modules can be appended.

PHASE 2 - TELEMETRY COMPUTER SYSTEM

Range Radars distribute missile and/or target information to Central Computer System (CCS). The CCS processes the information and performs corrections to the data transforming this in to antenna position data. The data, in Cartesian form, is passed via a high speed serial link (250 KBPS) to the Telemetry Computer (LTIS EMR O/S 90).


Frequency: (Slew Scan Seek)
IF table: (Edit)
Memory: (Slew Scan Seek)
Video Table : (Edit)
MM-1
Setups: (Edit/View)
Pre-D Down: (Edit)
Exit
1400MRA Application Software Simulator Version 4.01, (C) Microdyne Corp. 1/93
AGC VOLTAGE (MV)
-4740
RF FREQUENCY
MHz
KHz
2207.2
2ND LO TUNE
KHz
L+22.2
VIDEO GAIN
VIDEO, VP-P
CARRIER
L 22
VIDEO BANDWIDTH
MHz
KHz
25
AGC TC (MS)
.1
1
10
100
1000
2ND LO MODE
XTAL
VFO
APC/AFC
EXT
CARRIER
CARR IND
1458-D
Loop Width 2BLHz
Mode
Sel
Loop Open
Sweep En
IF FILTER
1 10KHz
2 100KHz
3 500KHz
4 10.0MHz
FREQ
1
2
3
AGC TC
4
5
6
REMOTE
2ND LO
7
8
9
PRE-D 0-9
STO
0
RCL
2ND LO
TUNE
VIDEO
BANDWIDTH
GAIN
MODEL 1400-MRA
MODE
GAIN
AGC
MAN
LOC
REC
PBK
CAL
FRZ
Fig.4.

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Unit	RF	2nd LO	Fine	IF	Video	Video	AGC	AGC	PRED
Name	Frequency	Mode	Tune	BW	BW	Gain	Voltage	T/C	Freq.
MM-1	2201.5MHz	VFO	+ 0.0KHz	100KHz	25KHz	22dB	-2.172V	1mS	100KHz
MM-2	2201.5MHz	VFO	+ 0.0KHz	100KHz	25KHz	22dB	-2.244V	1mS	100KHz
MM-3	2201.5MHz	VFO	+ 0.0KHz	100KHz	25KHz	22dB	-2.244V	1mS	100KHz
MM-4	2201.5MHz	VFO	+ 0.0KHz	100KHz	25KHz	22dB	-2.244V	1mS	100KHz

Unit	RF Frequency	Speed	Logic	Width	Status	Post-D	Pre-D	Loop Stess
PC-1	225KHz	Slow	In	Narrow	Unlock	2.3VDC	2.7VDC	+0.6VDC
PC-2	225KHz	Slow	In	Narrow	Unlock	2.3VDC	2.7VDC	+0.6VDC
PC-3	225KHz	Slow	In	Narrow	Unlock	2.3VDC	3.7VDC	-1.4VDC
PC-4	225KHz	Slow	In	Narrow	Unlock	2.3VDC	3.7VDC	-1.4VDC
PC-5	225KHz	Slow	In	Narrow	Unlock	2.3VDC	3.7VDC	-1.4VDC

Fig.5.

The Aerial Control Software Segment (ACS) is a set of related processes required to collect and redistribute data throughout the RA Range antenna system and to provide antenna commanding functions. These functions include collection and redistribution of antenna position and status, issuance of positioning commands to each antenna from either manual commanding by operators or automatic commanding sent by the CCS. Other functions include gathering telemetry and antenna position data and delivering that data to the CCS for the Range Controllers displays.

User interface to the ACS is via a window generated on the workstation. Error logging is another process performed by the ACS and allows logging to disk, screen or printer detected errors from any of the sub processes.

The ACS resides on a Sun Sparc le processor in the EMR 8715 Pre Processor unit and uses a Data Bridge to transfer data to the O/S90 telemetry system. The Sparc le uses 3 RS232 parts attached to modems to drive each antenna individually across the microwave and fibre optic links.

The ACS receives packets of Cartesian antenna pointing data at 5 times per second from the CCS. Cartesian to Polar conversions are performed and the resulting data is packetised before being sent to the 3 antenna controllers.

ACU Status is pulled, processed and displayed on the workstation in both alphanumeric and graphical forms. Data returned to the CCS is selective and can include the antenna status/pointing position, telemetry and Flight Termination data.

If, as is common with low level radar tracking over the sea, radar lock is lost, most missile telemetry signals give access to velocity, acceleration, altitude and attitude data. This data can be used to estimate tracking data backing up the normal antenna pointing. Specific data is processed and distributed by the O/S90 to the CCS for this purpose. Inclusion of this process with radar track and autotrack, if used, further enhances the chances of continuous data reception.

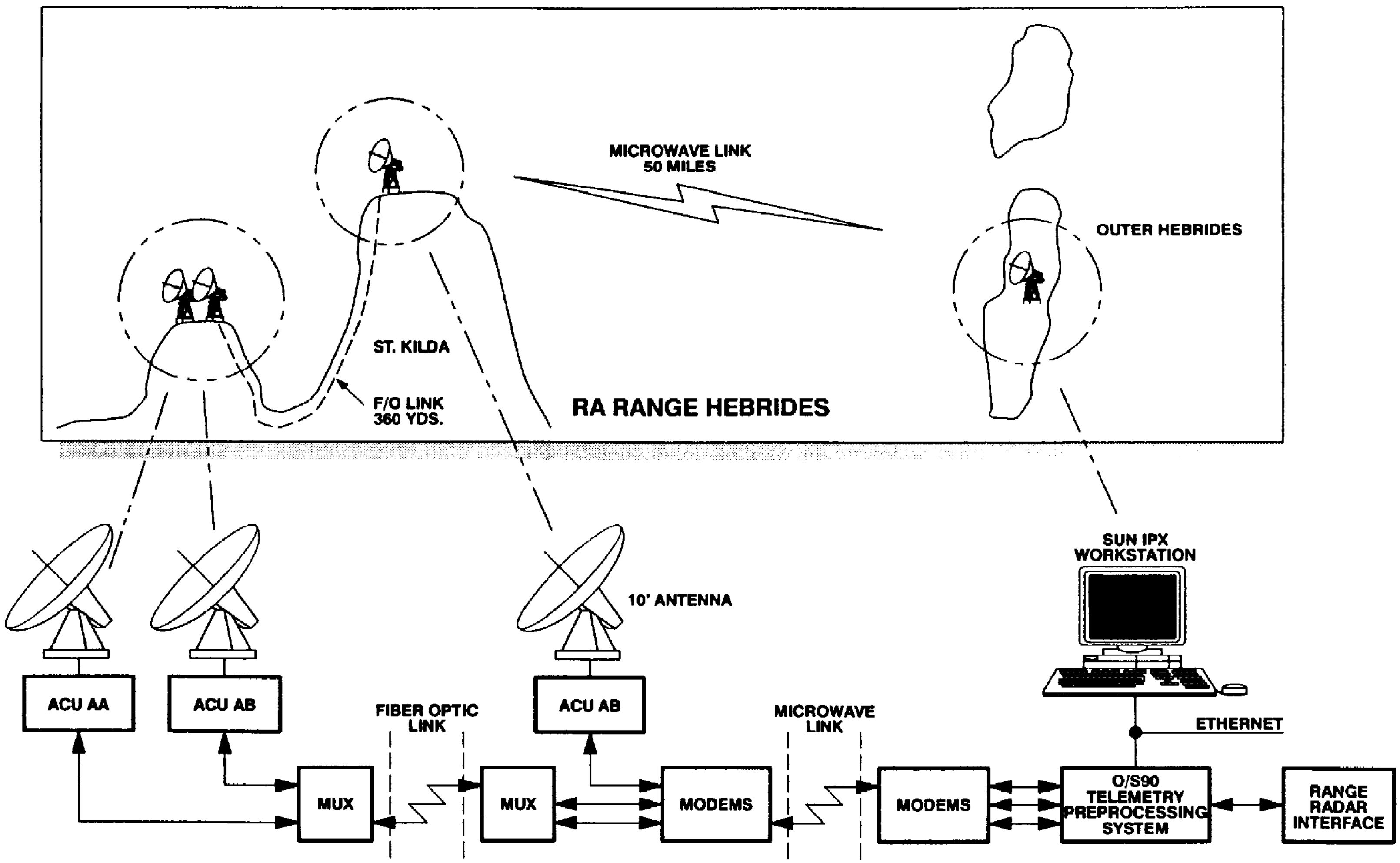

Fig.6.

ANTENNA CONTROL SYSTEM BLOCK DIAGRAM

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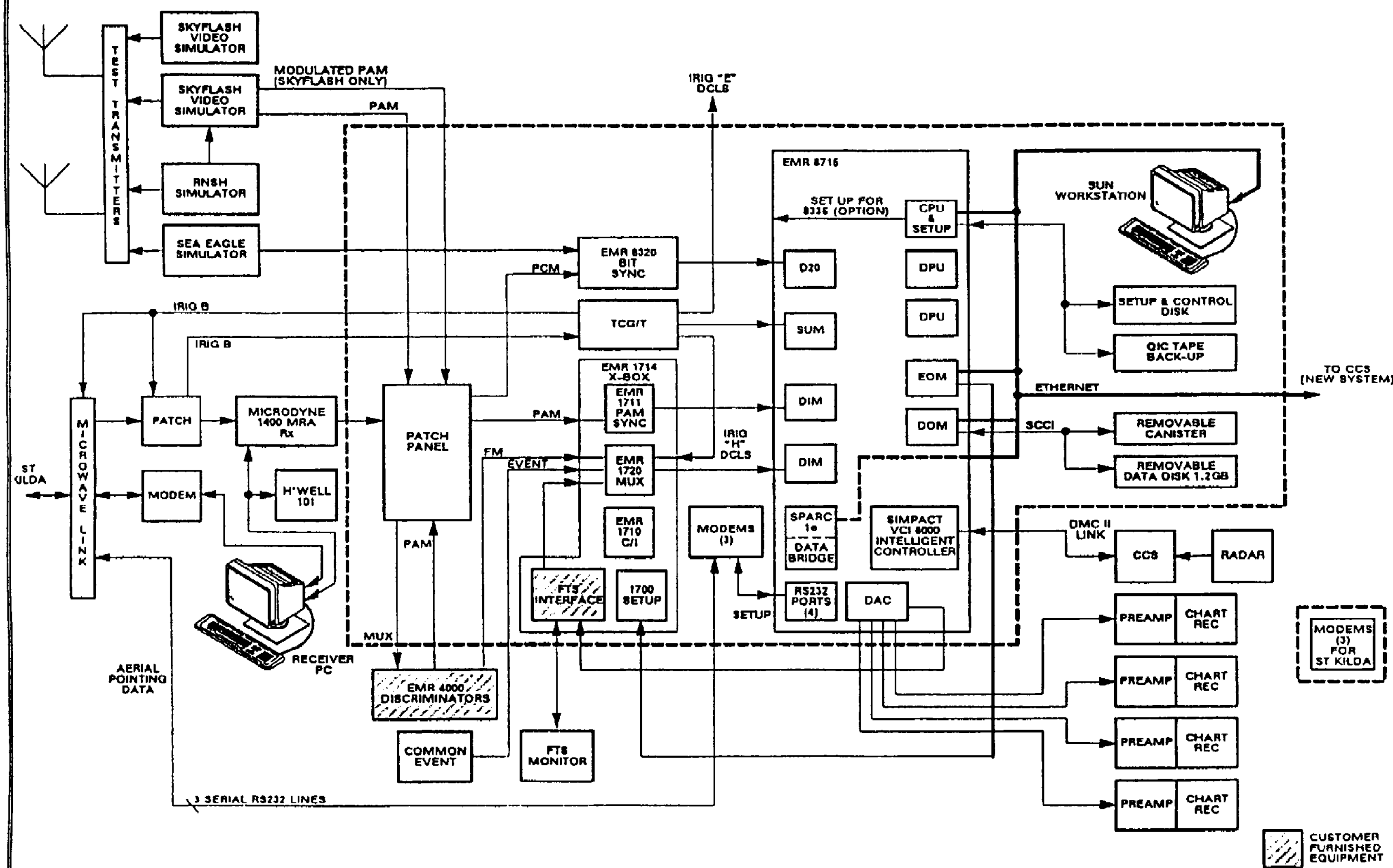

Fig.7.

TELEMETRY COMPUTER SYSTEM
BLOCK DIAGRAM

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