

Wide Band High Frequency Communications

2012 UK Trials Summary

James Alexander

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**Rockwell
Collins**

Introduction

- This presentation describes trials conducted under the UK MOD Enabling Secure Information Infrastructure (ESII) programme, as follows:
 - This research was commissioned by the Defence Science and Technology Laboratory (DSTL) and funded by the Ministry of Defence (MOD) Research and Development budget through the MOD's Chief Scientific Advisor.
 - The aim was to investigate and demonstrate Commercial off the Shelf (COTS) alternatives to providing Beyond Line of Sight (BLOS) and reach-back capability at lower cost than extant maritime and land-based reach-back systems in a Satellite Communications (SATCOM) denied and/or bandwidth constrained environment.

Context of UK Trials

- UK trial effort followed on from 2 significant initiatives:
 - Over The Air (OTA) trials conducted by Rockwell Collins Inc, culminating in AUSCANZUKUS Trident Warrior 11 (March 2011):
 - First ever four node HFIP network established over HF skywave circuits between Cedar Rapids, Richardson, Las Cruces, & Ottawa
 - Previous UK MOD ESII Task 7 trialled IP over HF and proved the limited utility of a standard (non-WBHF) channels for IP.
- A team of ESII consortium partners led by RCUK was contracted by UK MOD in September 11 to run WBHF trials in European environment – this became ESII Task 23.

ESII Task 23 Trials - Organisation

Phase 1 – Application Integration

- ACP 142 – STANAG 5066 (HF Messenger) Integration
- SIS and IP layer connectivity
- 3 kHz test environment
- IP Client Integration

Phase 2 – Over The Air Ground Wave (13-17 Feb 2012)

- Land Systems Reference Centre (LSRC) Blandford – QinetiQ Portsdown

Phase 3 – Over The Air Sky Wave (22 Feb to 2 Mar 2012)

- Royal Marines (RM) Condor Arbroath – QinetiQ Portsdown

Phase 4 - Bowman Integration

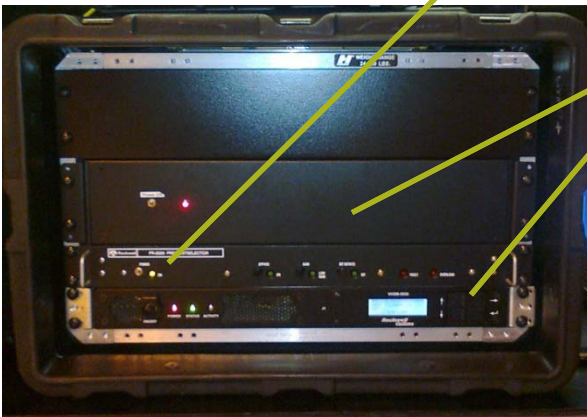
- Lab demonstration of Reachback and Range Extension potential

Radio and Modem Hardware Employed



1kW HF Amplifier and Power Supply
(standard product line item)

An HF Pre/Post Selector (standard
product line item)



A modified VHSM-5000 modem and
associated Pre-Amp (acting as HF
Receiver Exciter)

Inverted "V", Standard Biconical and
Tactical Fanlite HF Antennas

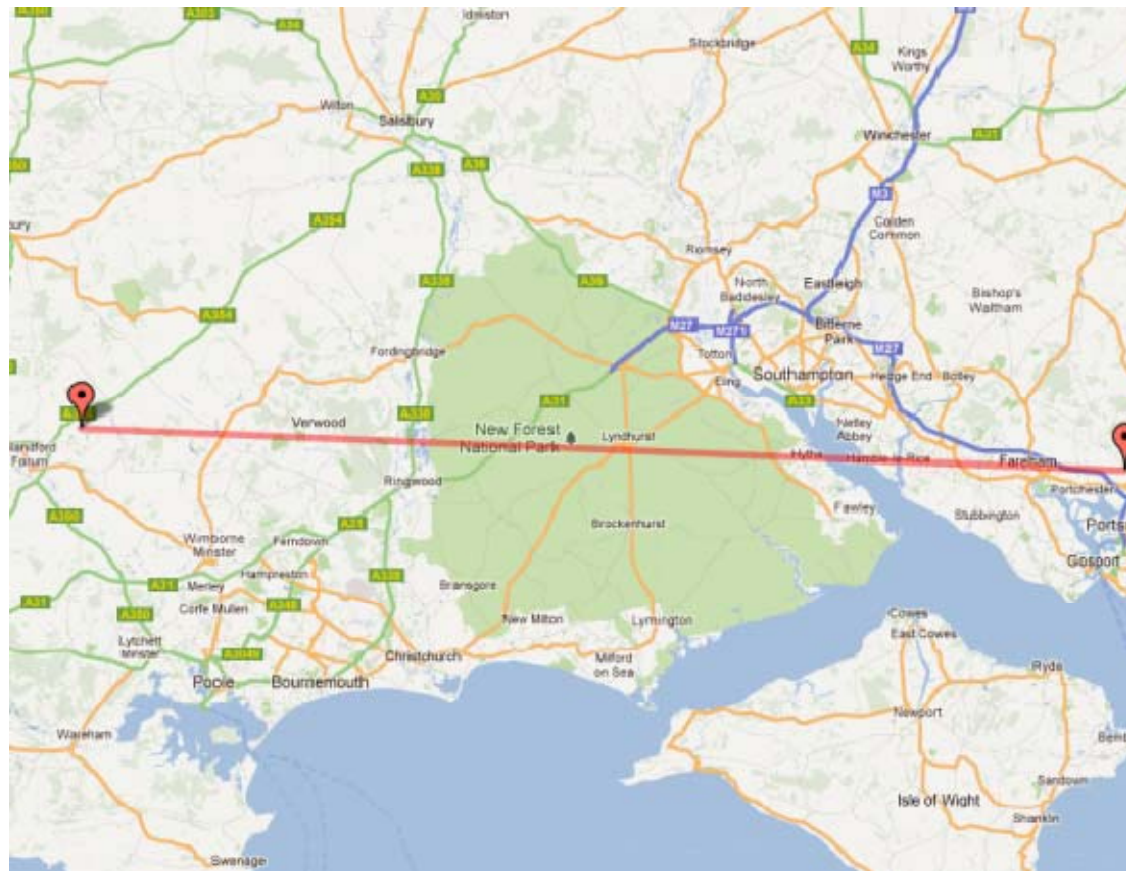


Over The Air Trial Conditions

- Frequencies:
 - OFCOM granted a temporary non-operational licence to use 24 kHz bandwidths at:
 - 3.613 MHz
 - 6.390 MHz
 - 7.975 MHz
 - 13.047 MHz
- Transmit Power limitations were imposed by site and/or power supply limitations
 - 125W maximum at Portsdown (site limitation)
 - 400W maximum at Arbroath (PSU limit)

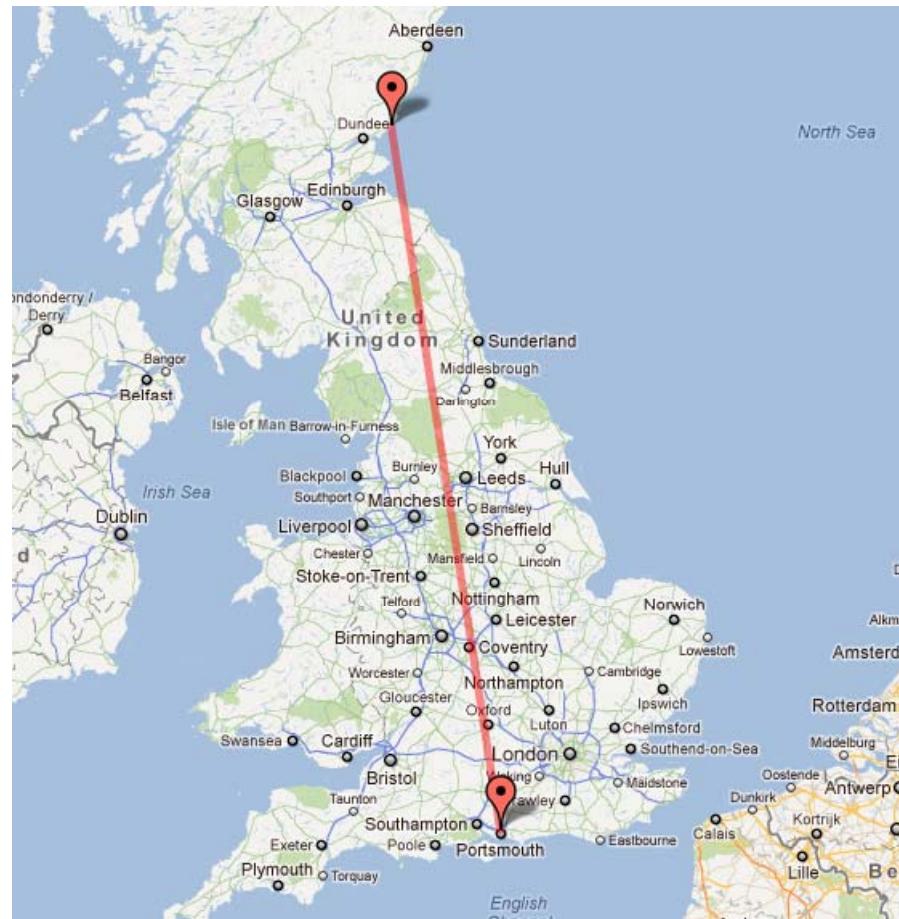
Ground Wave Trial

Blandford – Portsmouth (Approx 40 miles)

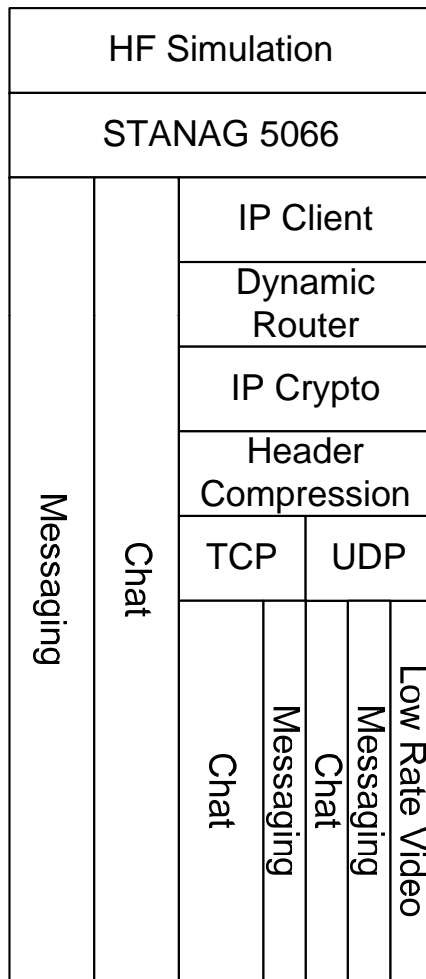


Sky Wave Trial

Arbroath – Portsmouth (Approx 400 miles)



ESII Task 23 Protocol Stack

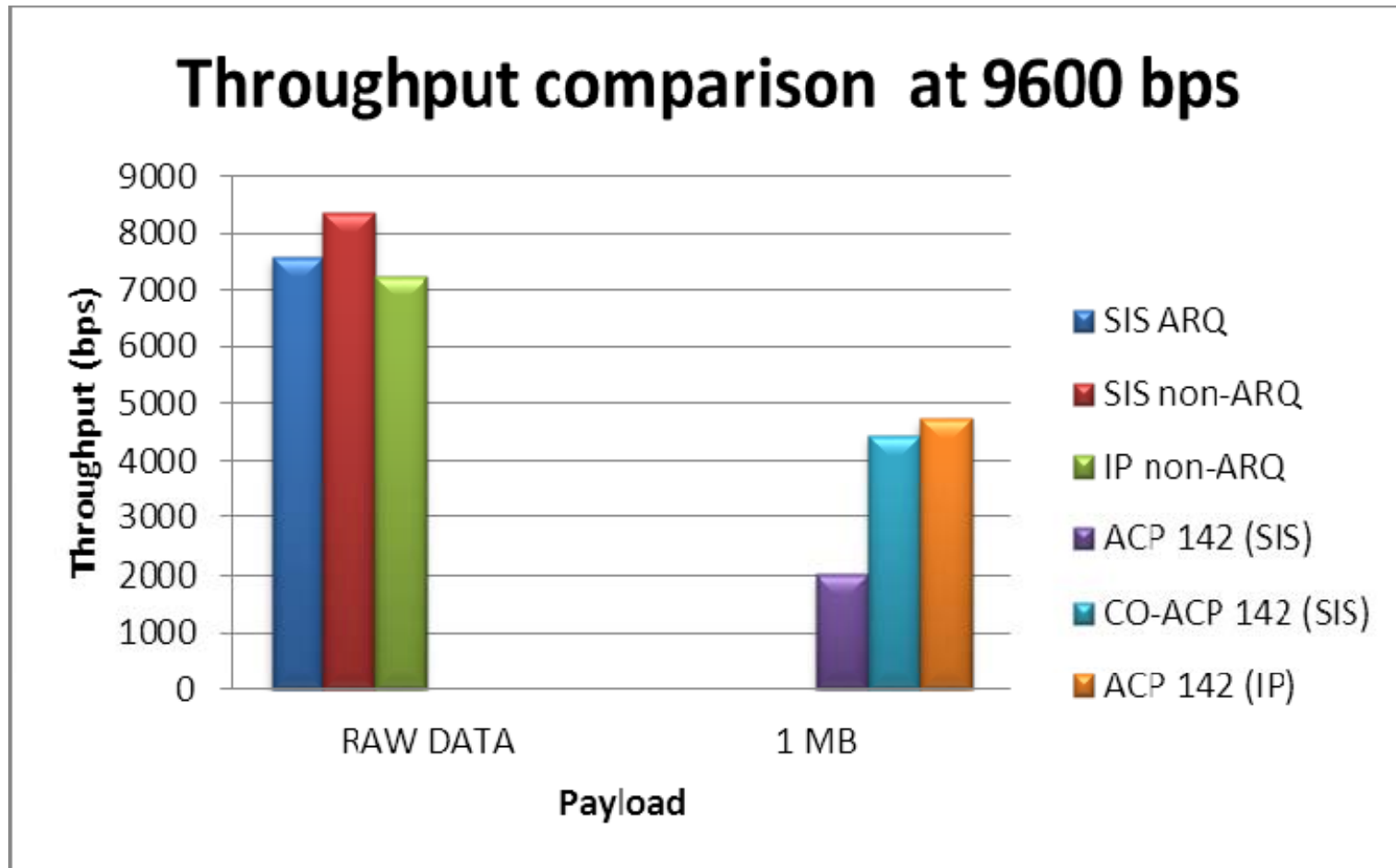


- Third party technologies integrated to demonstrate provision of:
- XMPP Chat
- X.400/SMTP Messaging (email)
- H.264 Low rate video
- FTP

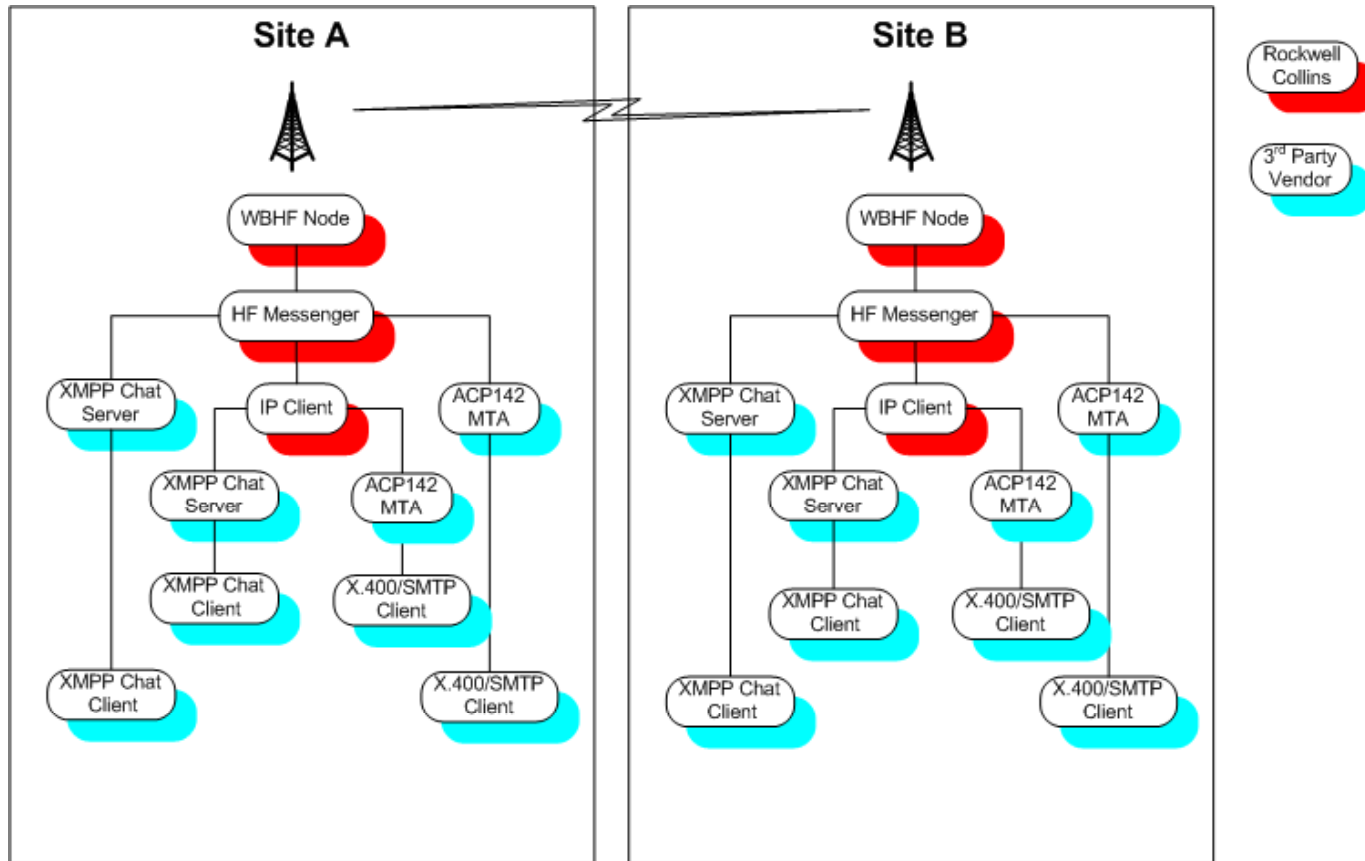
Test Findings

- Phase 1 (Lab Trials)
 - IP Client is resilient and can support IP Encryption
 - ACP142 works well with STANAG 5066 – Areas for potential further development identified
 - Demonstrated Increased throughput and performance when compared to TCP
 - Utilisation of 92% of raw modem data rate
 - IP traffic added 17% overhead for UDP traffic
 - CO-ACP142 achieved 3 fold improvement over SMTP
 - ACP142 achieved 2 fold improvement over SMTP
 - XMPP Chat latency of 7s average @ 4800 bps

LAB - Throughput



ESII Task 23 OTA Architecture



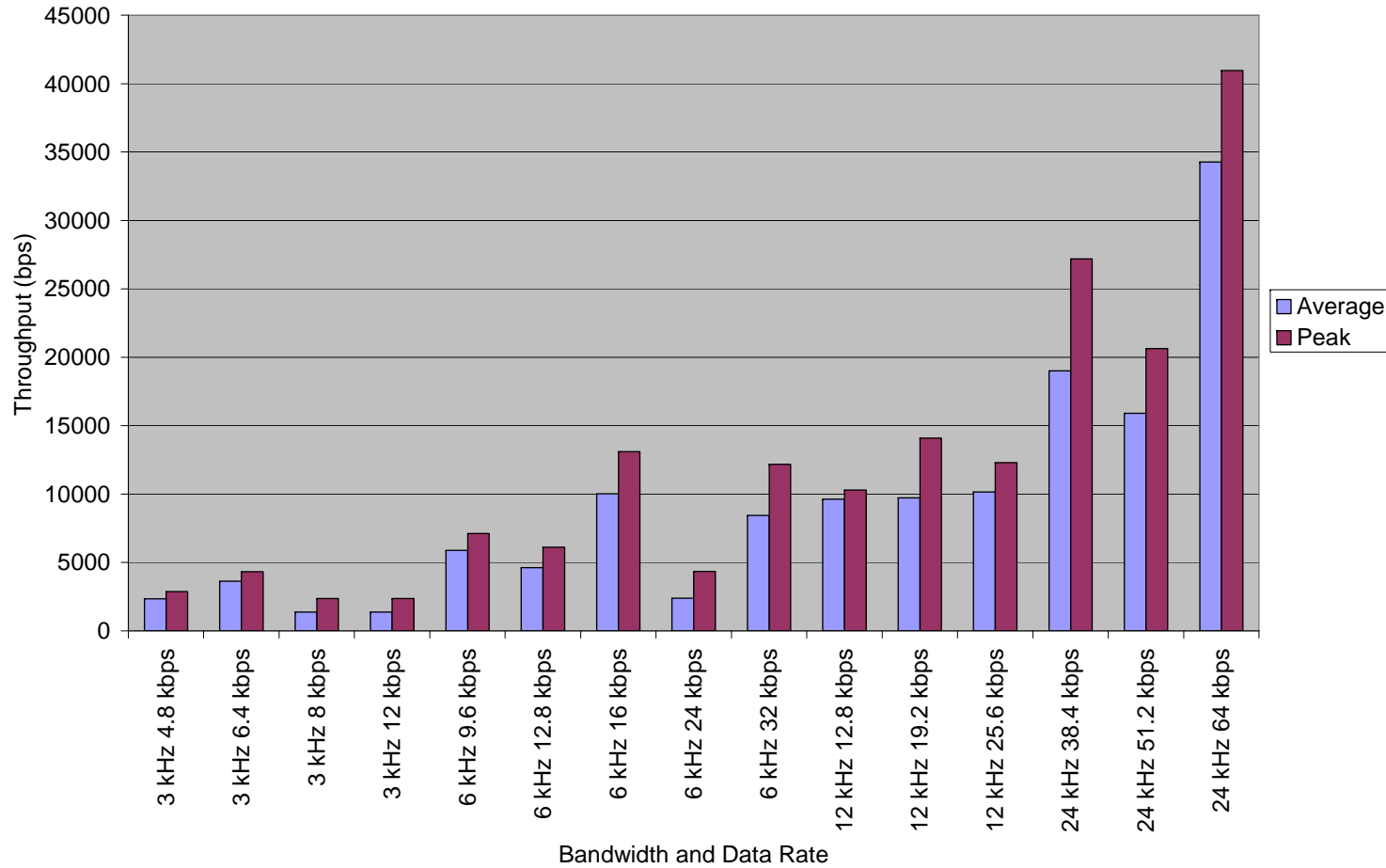
- WBHF radio / modem hardware integrated with protocol stack proven in the lab to enable full OTA trials.

Over The Air Test Findings

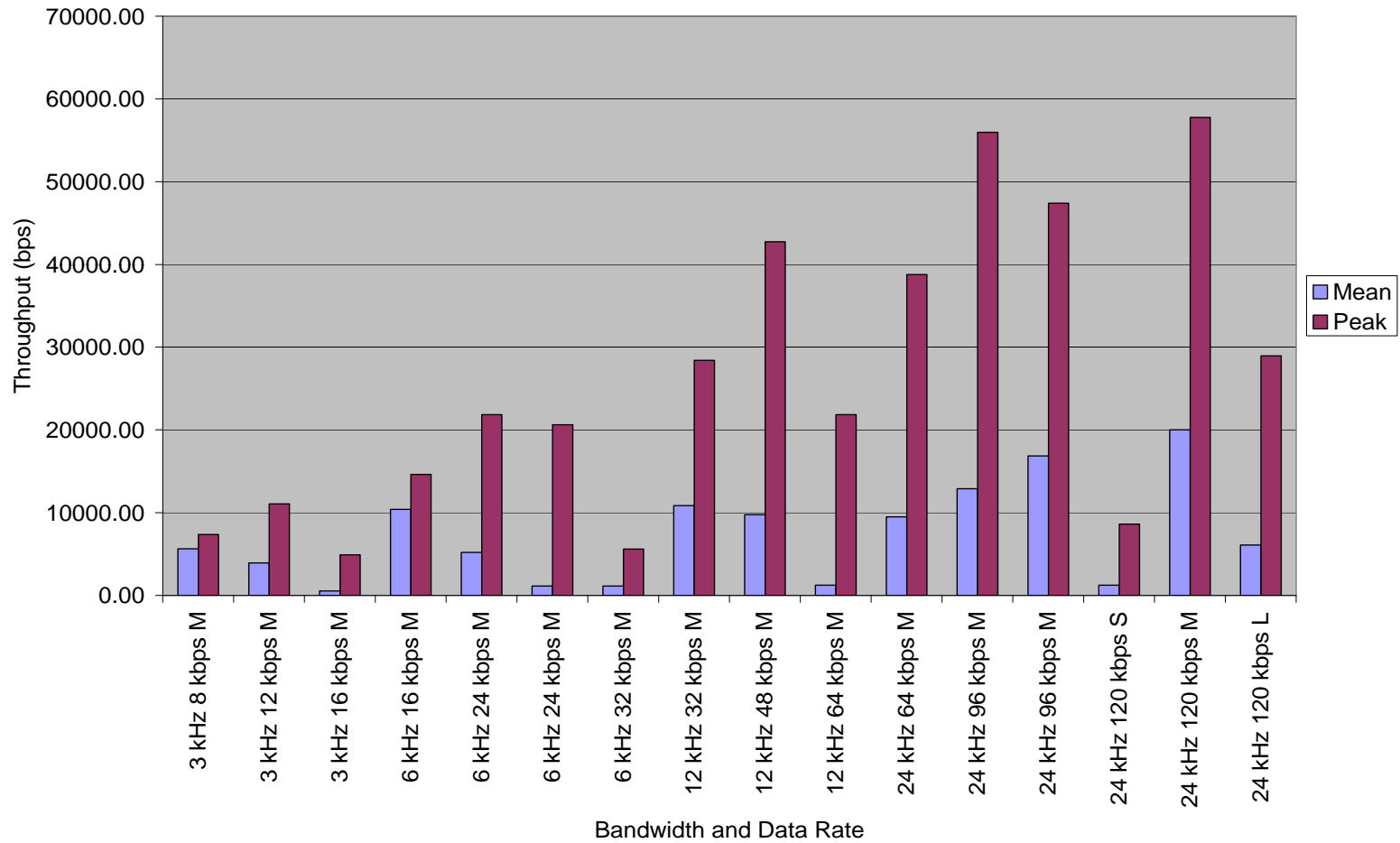
- Phase 2 (Ground Wave Trial)
 - 3, 6 and 7 MHz channels were employed, with best results on 6 MHz
 - Signal to Noise Ratios (SNRs) achieved were typically low, but we were able to achieve:
 - Maximum Data Rate 64 kbps
 - 64 QAM Modulation
 - Maximum throughput 40.96 kbps
 - Utilisation of 66.67 %

- Phase 3 (Sky Wave Trial)
 - All channels were employed, with best results on 6 and 7 MHz
 - Better SNRs were obtained, allowing:
 - Maximum Data Rate 120 kbps
 - 256 QAM Modulation
 - Maximum throughput 57.7 kbps @ 120kbps
 - Utilisation of 48.08 % @120 kbps
 - Peak Utilisation 72% @ 48 kbps
 - MCR – 1400/hour @10 kB Payload = 14 MB

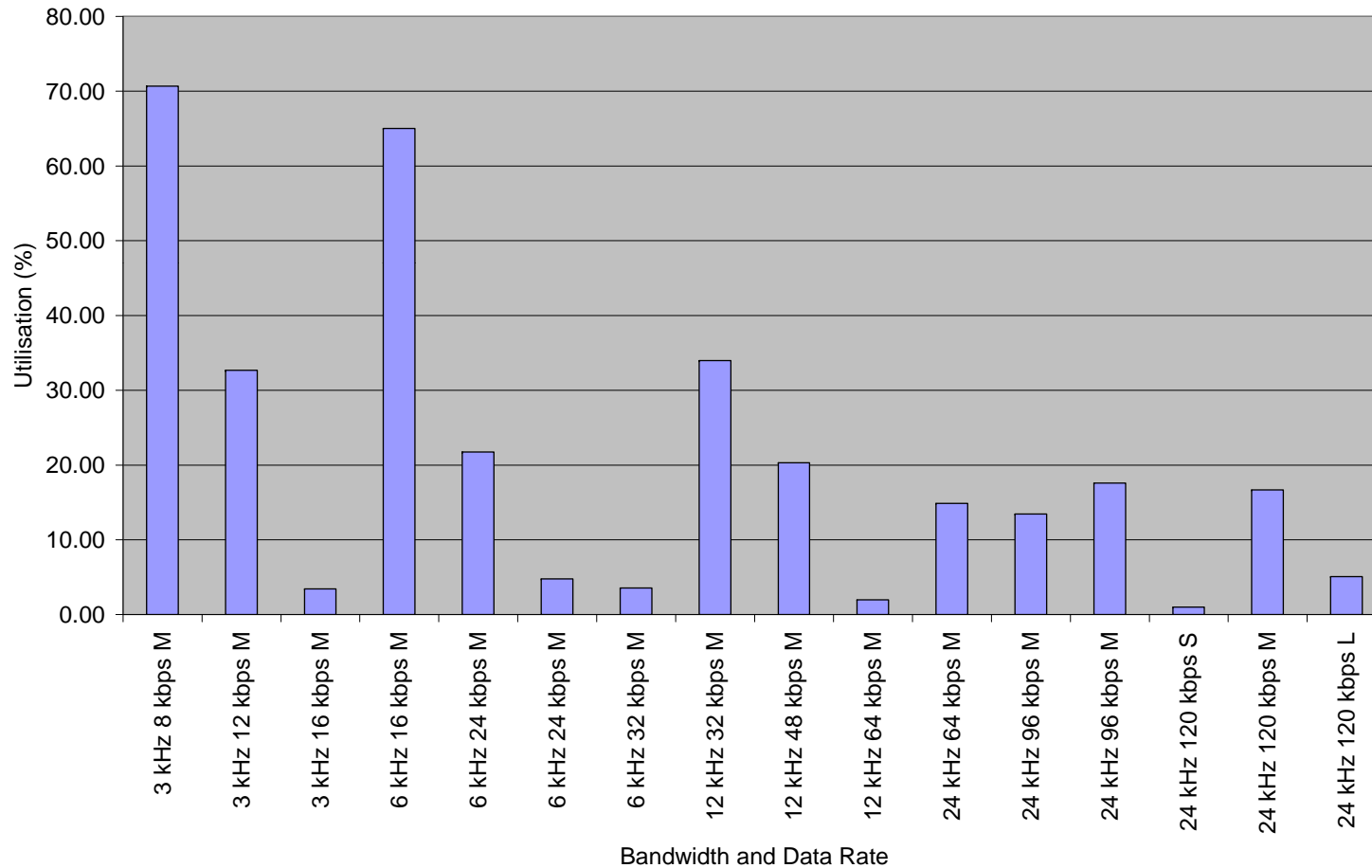
OTA – S5066 Raw Data Throughput



OTA – IP Data (Non-ARQ) Throughput



OTA – IP Data (Non-ARQ) Throughput



OTA – ACP142 Messaging

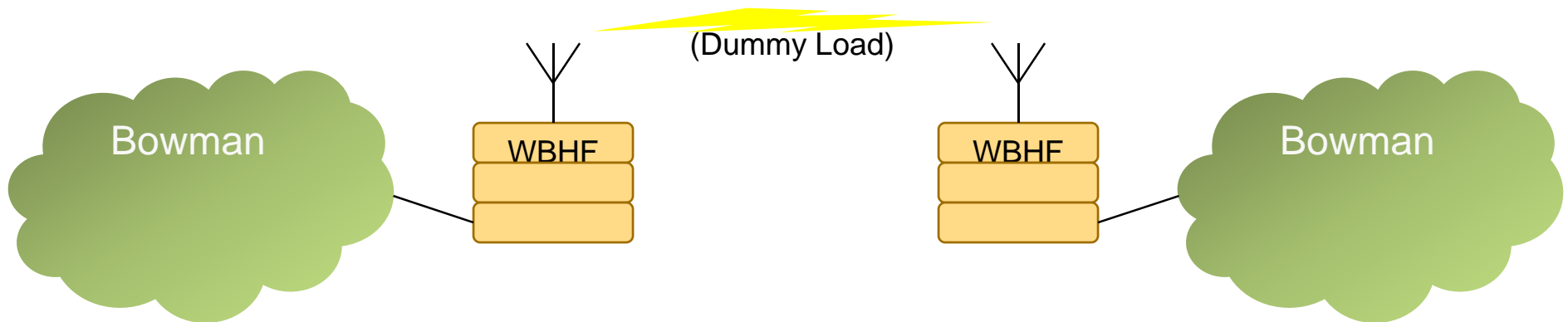
- CO-ACP142
- S5066 ARQ SIS connection
- 100 messages with 10 kByte payload

Test Description	Test (mins:secs)	Duration	Average Message Duration (secs)	Throughput (bps)
120 kbps	4:09		2.5	33 kbps
9.6 kbps	29:51		17.9	4.6 kbps

- *Maximum message rate of 1400/Hour @ 120kbps*
- *ARQ Retransmissions*
- *Limitations due to S5066 128 frame limit*

Test Findings

- Phase 4 (Bowman Lab Trials)
 - Detailed architectures for Internal and External Bowman Messaging
 - ACP142 works well with Bowman – Further development required
 - Achieved 8 MB/hour payload Data Throughput
 - Minimum 2 x Order of Magnitude increase over standard Bowman HF



Conclusions

- These trials represented the first UK over the air transmissions of MIL-STD-188-110C WBHF waveforms.
- Modem data rates of up to 120kbps (Sky Wave) were observed.
- STANAG 5066 as currently written limits higher data rate transmissions in ARQ mode – potential for improvement
- Higher mode modulations (64 and 256 QAM) require high (>24dB) SNR and are more susceptible to multi-mode propagation effects.
- Higher bandwidth transmissions with lower modulations schemes proved resilient to interferer's.
- Maintenance of a link sometimes required significant management:
 - Frequency changes
 - Bandwidth changes
 - Modulation scheme changesWork on automation of these elements is ongoing.

Reccomendations

- Frequency Management and Allocation
 - Investigation into National and International availability
- Waveform Characterisation –
 - SNR
 - Delay Spread
 - Frequency Spread
- Automation of Link Set-Up and Management
 - WBHF ALE
- S5066 adaption
 - Modification of frame limit to permit transmissions from 75 bps up to 120 kbps

Q & A