The evolution of an Educational WAN

Robin Williams (yes really!)

robin.williams@tnp.net.uk

Overview

- Snapshot in time at Lancaster Uni networking team from mid to late 2000's and the external networks managed by the team
- Disclaimer: Not speaking today as Lancaster Uni, Lancashire CC or Cumbria CC
- Prof Barry Forde was Chief Architect & Head of Technical Services for Lancaster Uni ISS Dept
  - Barry now architects B4RN – see next talk by Tom!

Networks run by Lancaster University (2005-2011 snapshot)

- University Campus Network (obviously)
- University residences network (RESNET)
- CaNLMAN (Cumbria & North Lancashire MAN) – Regional Janet MAN
  - Connecting higher education establishments
  - Generally higher bandwidths
- CLEO (Cumbria & Lancashire Education Online) – Regional Broadband Consortium (RBC) & NGFL (National Grid for Learning)
  - Connecting schools, colleges & local gov sites
  - Taken in house by LCC under a wider strategic partnership with BT in 2011
- Small scale commercial connectivity for University interests
  - E.g. shared ownership buildings etc - whose traffic couldn't transit Janet

Terms

- The National Grid for Learning (NGfL) was a United Kingdom Government-funded gateway to educational resources on the Internet. It featured many individually selected links to resources and materials deemed to be of high quality.
- Regional Broadband Consortia (RBCs) were created in 2000 under the auspices of what was at the time the Department for Education and Skills, (DfES) to secure lower prices for broadband connections and services for schools by aggregating demand across a region and entering into region wide contracts.

CaNLMAN

- CaNLMAN HE partners
- Backhauled via Janet initially in Lancaster (SJ4) from Warrington, but later SJ5 in Lancaster and Carlisle
- CaNLMAN recently taken in house by JANET along with other MANs

CLEO (Cumbria & Lancashire Education Online)

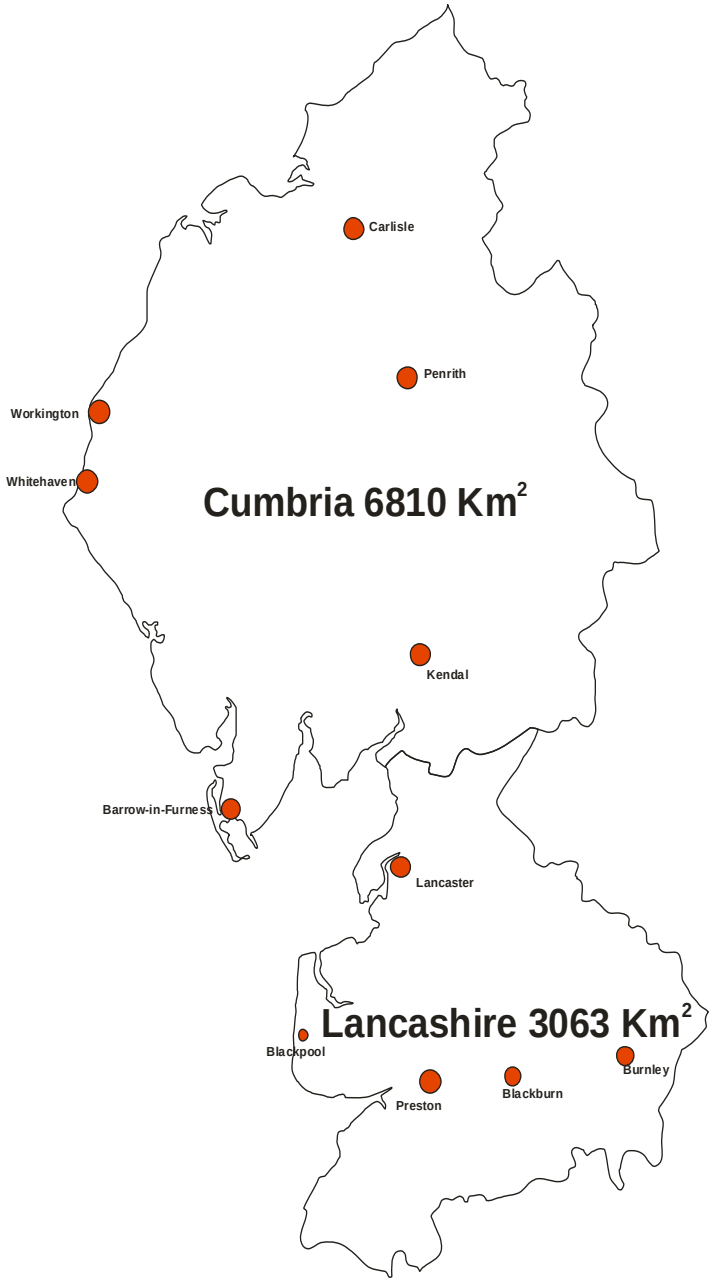
- This talk focuses primarily on CLEO, the larger of the WAN networks.
- Backstory:
- Pre 1996 most schools were on ISDN 128k or with no connection at all
- University Involvement
  - University formed “EdNet” (1996/97)
  - Initially to connect schools local to the University to Janet
  - 2Mb/s symmetrical, via microwave or SDSL
  - Connected around 12 sites, mainly local high schools
- 1999 announced pilot broadband for schools
  - >= 2Mb/s symmetrical
  - 2001 this became =>8Mb/s for secondary schools

CLEO (Cumbria & Lancashire Education Online)

- CLEO was formed
  - Three way partnership between Lancashire CC, Cumbria CC & Lancaster University
  - Lancaster University was the technology & delivery partner
  - The university was the natural choice due to heritage in the region
  - Initial funding was 50% county council and 50% DFES.

Geography

- Many rural areas
- Difficult terrain
- Cumbria in particular is sparsely populated
- Many parts of Lancashire are also very rural

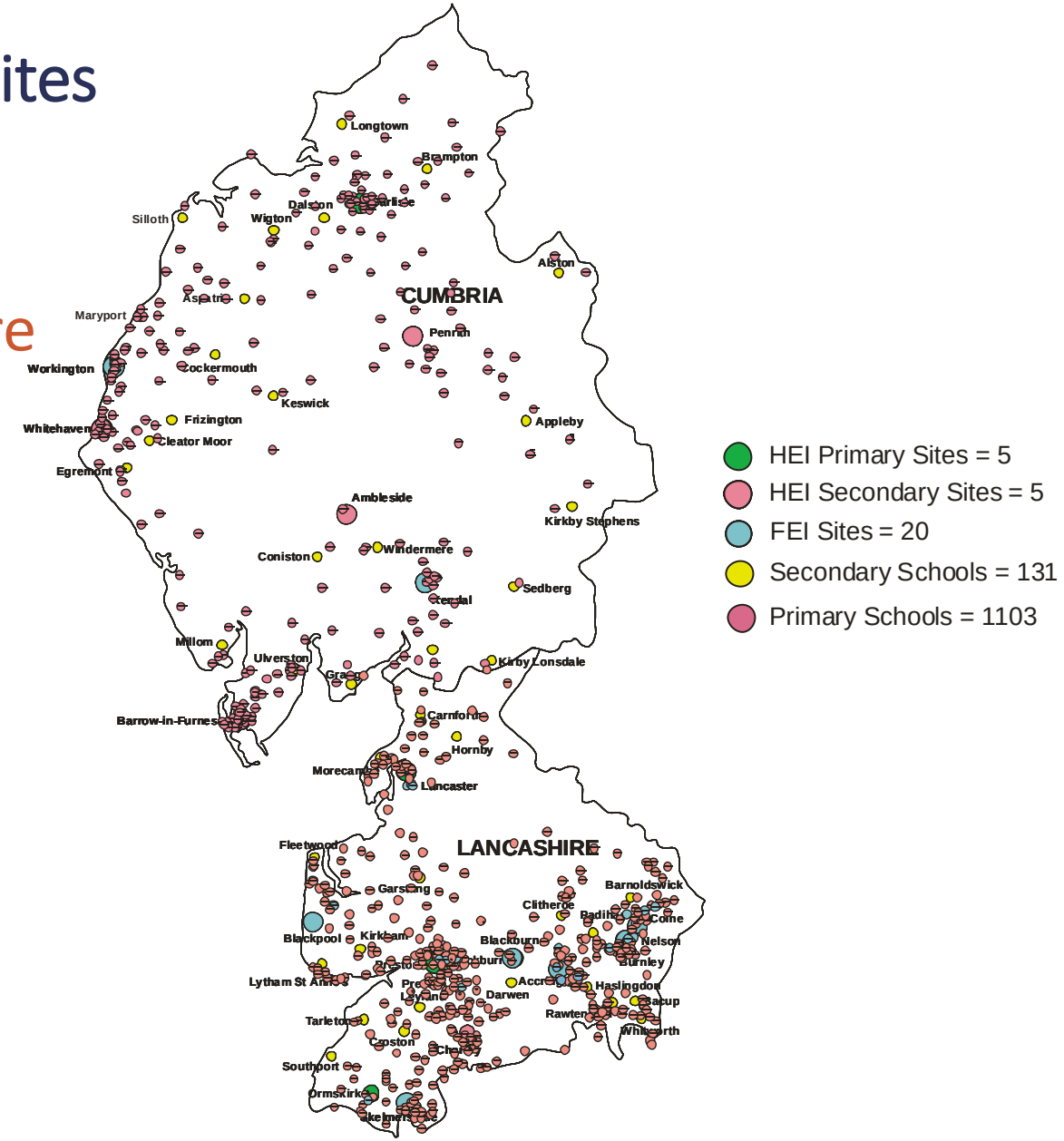


Pop 487,000

Pop 1,429,000

Initial Connected Sites

- > 250,000 pupils
- > 1200 sites (more later)
- Connect all sites natively



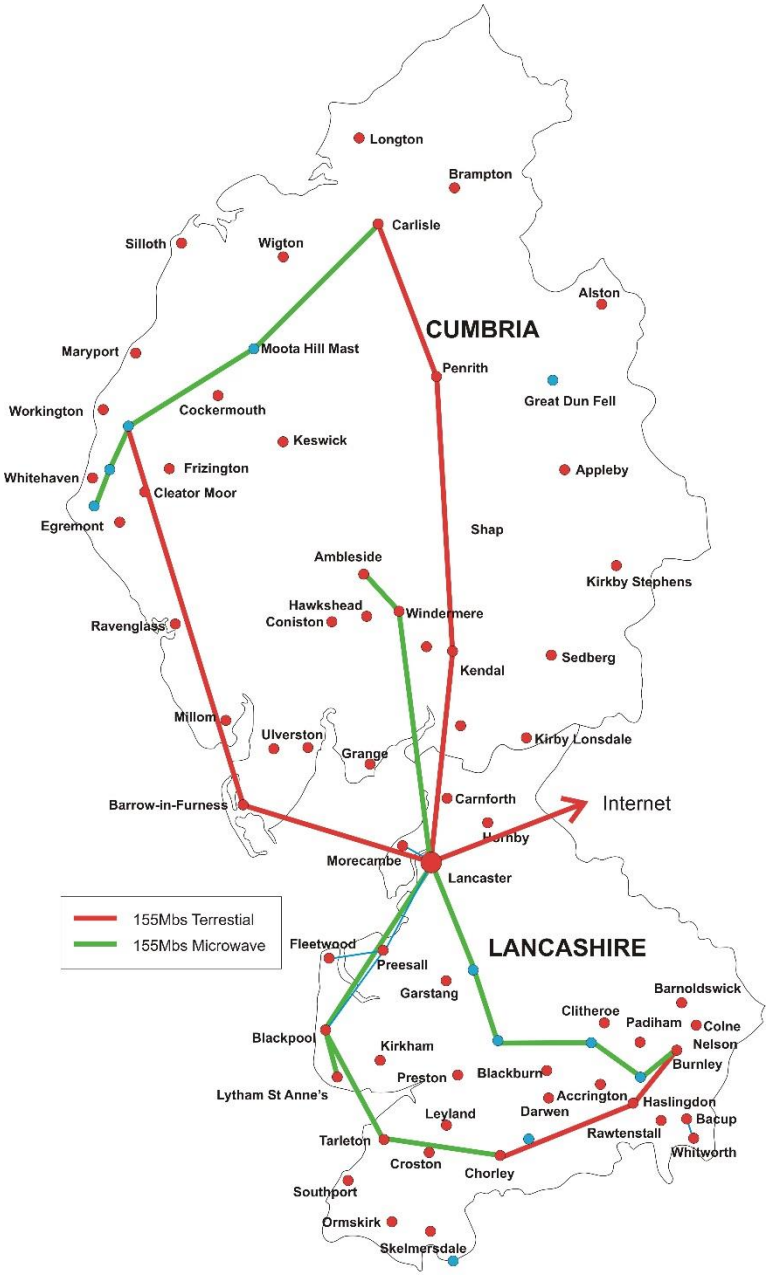
- HEI Primary Sites = 5
- HEI Secondary Sites = 5
- FEI Sites = 20
- Secondary Schools = 131
- Primary Schools = 1103

Initial Phase

- Drive to get all the sites connected
- Core network consisting mainly ATM (later POS) links
- Mainly unlicensed band radio or LES circuits from core radio POP sites to strategic aggregation sites (often high schools).
- EPS8/9 private copper circuits then used to onward connect smaller sites (multi-pair SDSL) – EPS = Engineering Performance Specifications
  - Up to ~9.2Mb/s achievable via 2x EPS8 circuits (4 pairs running at 2.3Mb/s) on a provider/subscriber CPE pair or DSLAM/subscriber CPE

Phase 1 backbone

- Circa 2000-2003
- Core speed 155Mb/s via fibre or microwave running ATM
- Many POP sites are masts (YC/Crowncastle/NTL, as were pre-Arqiva)
- Figure of 8 topology for resilience
- Core hardware consisting mainly of Cisco 8510s at this point



Phase 1 backbone

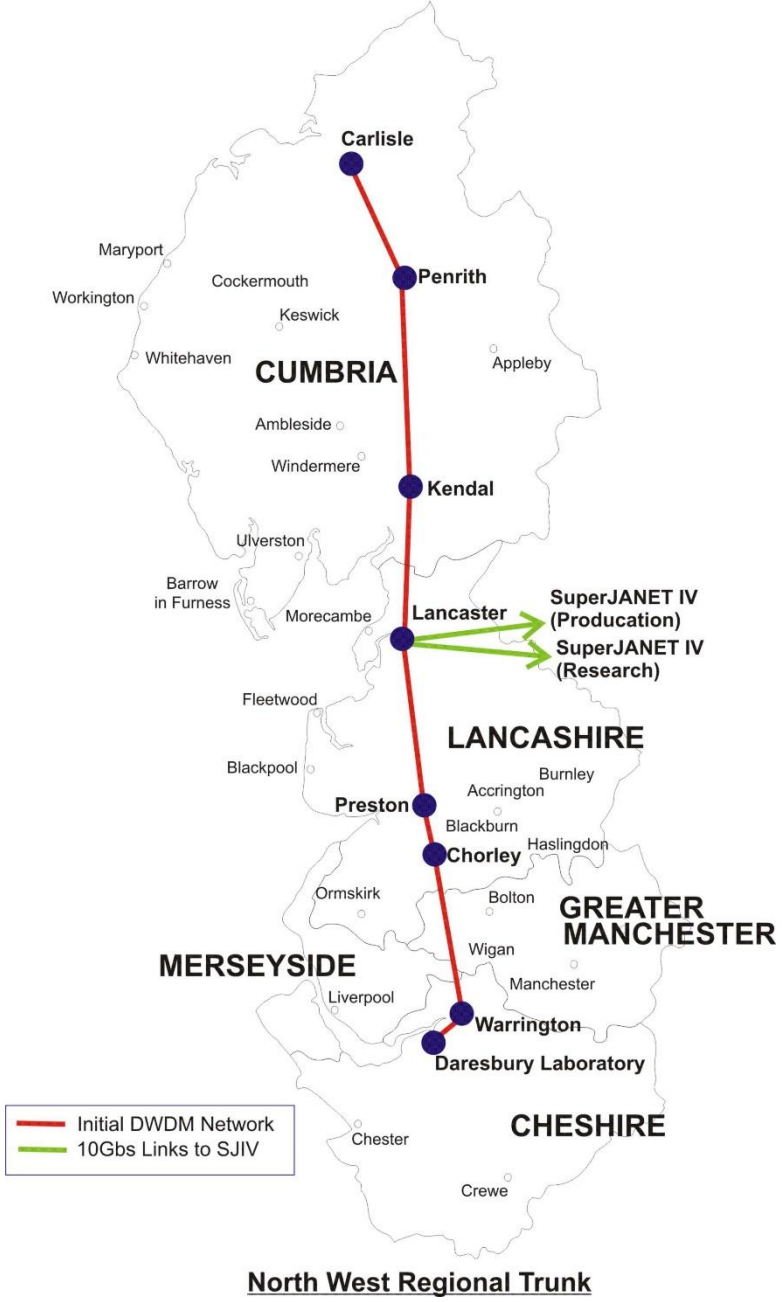
Example POP fit-out

Phase 1 radio access

- 2.4Ghz radio
- 18dBi antenna
- 15km range

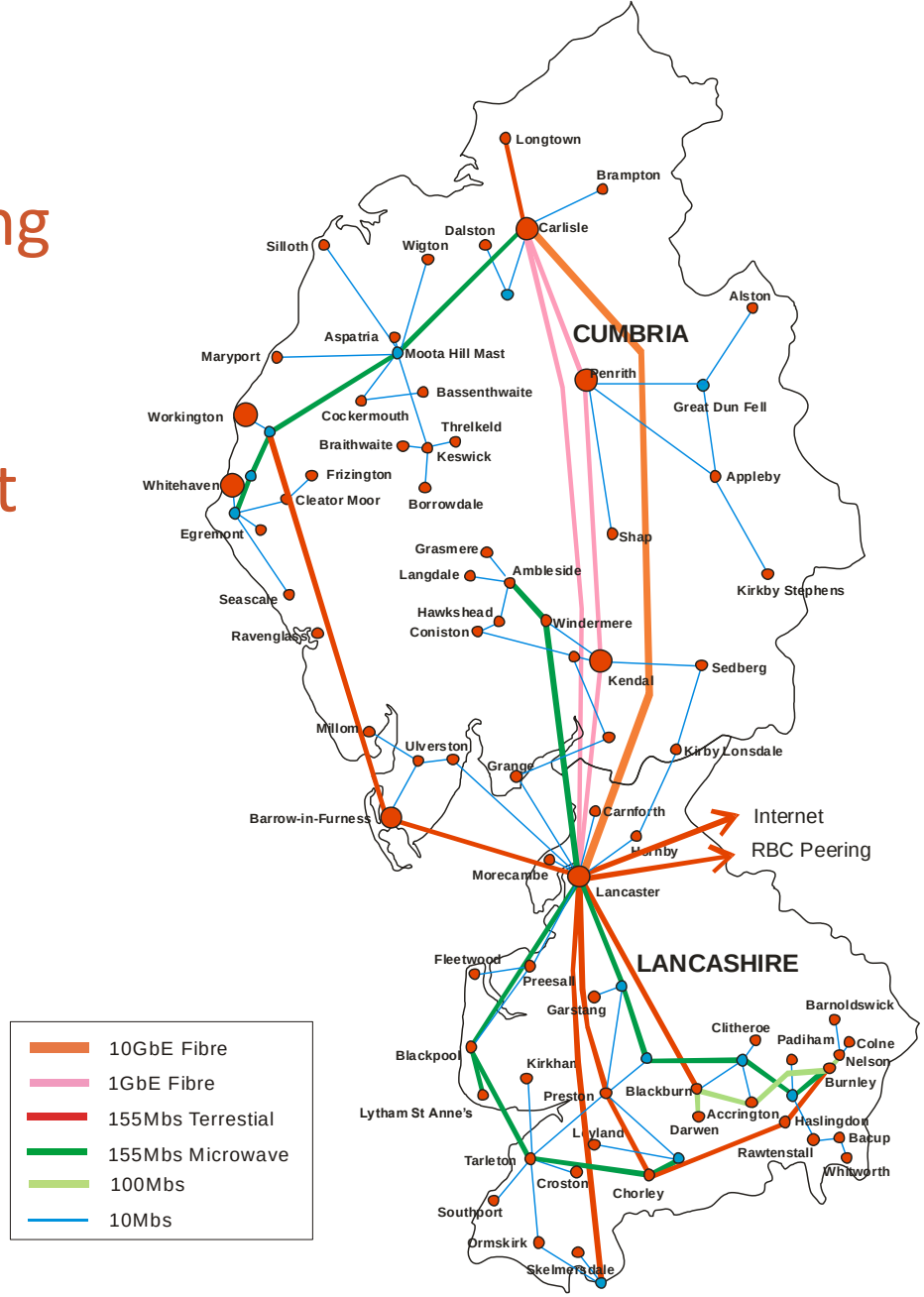
Phase 2 backbone

- 2003
- Access to trans-regional fibre
- DWDM
  - YC fibre – would later become Thus, C&W then Vodafone



Phase 2 backbone

- … augmented the existing core as bandwidths increased.
- Several core links now at 10Gb/s



Equipment refresh

- Core routers
  - 33 new routers procured (circa 2005) consisting of Juniper M7i/M10i and M320
  - One of the first educational references for Juniper in UK
  - Move to IP over POS
  - Introduction of L2 and L3 VPN simplified network design for separating multiple clients groups
  - RSVP rather than LDP to allow for traffic engineering and finer grained control of LSPs

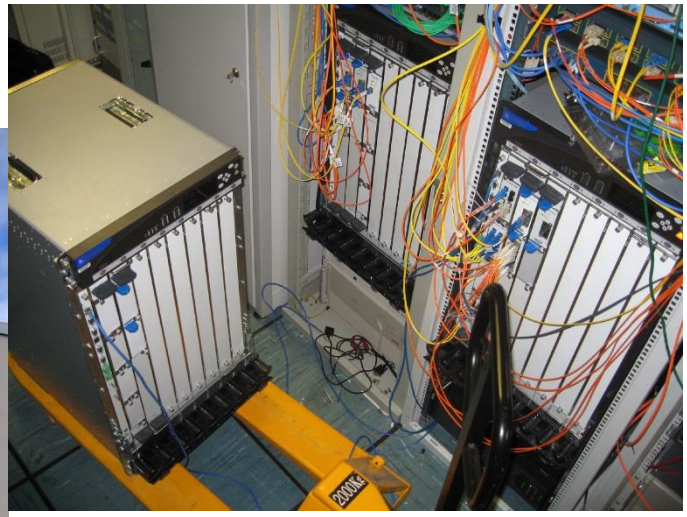
Equipment refresh

- Unlicensed band radios
  - Existing 2.4Ghz Aries radios swapped for 5.8Ghz radios
  - Alvarion P2P and P2MP (point to multi-point) radios selected
  - Offered higher bandwidths
    - Up to 30Mb/s rather than 10Mb/s
    - Higher power
    - Still only 4 non-overlapping channels
    - Ranges very good where no interference present (~30km)
    - Wide beam sector antennas effective (90 or 120 degree)

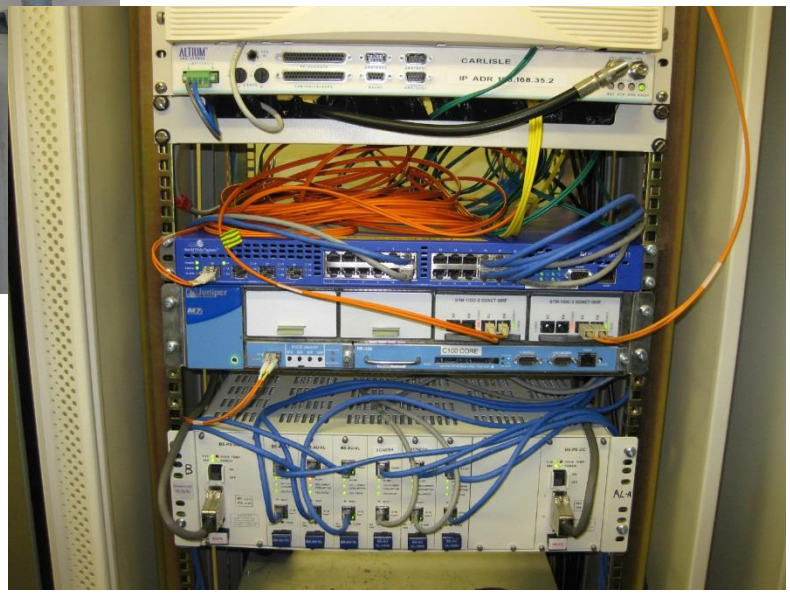
Equipment refresh

5.8Ghz
sector on tower

5.8Ghz
Subscriber/P2P unit



New cores being fitted out



2004-2006 – Openreach & LLU

- Telephone exchanges and the local loop become accessible
- ~125 telephone exchanges unbundled
  - Reach to 95% of population
  - Microwave fill-in
- First exchange delivered October 2004 – last by Dec 2005
- MPF (metallic path facility) provides direct copper circuit from exchange to site
- Cost effective fibre tails from local exchange
  - Was all BES/WES/LES, now EAD/EAD-LA
- More control over POP sites (power etc)

Transition to Exchanges

- Exchanges initially fed in chains via existing core
  - Some exchanges temporarily fed via MPF or radio from existing aggregator or core sites
- MPF circuits beneficial over EPS which are gradually phased out
  - Actually qualified for data usage unlike EPS
  - Better range
  - Supplied insertion loss figures (syn spec)
  - Regulated pricing
- ADSL2+ and SDSL DSLAMs installed
  - ADSL2+ available years before it was commonplace
- Exchanges become primary means of last mile/access

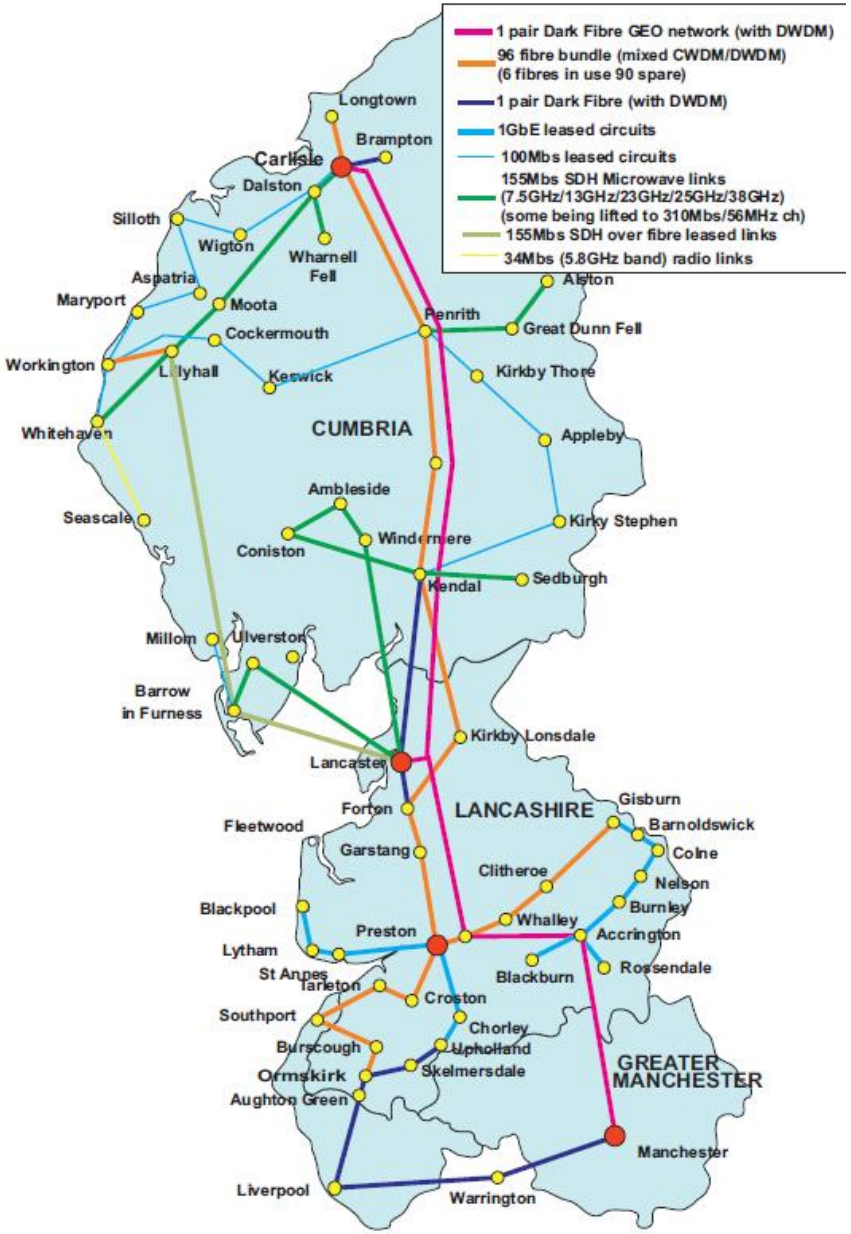
Transition to Exchanges

“CLEO2” Core

- Refresh of core network from 2007 onwards
- Procurement of Juniper MX480 routers
  - Rationalisation down to ~6 primary core locations
    - Lancaster, Carlisle, Kendal, Accrington, Preston (x2)
  - Metro edge via exchange chains
  - Some M7i/M10i remain at mast sites for MPLS drop off
- Addition of GEO fibre from Manchester to Carlisle
  - Installation of DWDM providing many 10G channels
  - Driven long-distance to avoid drop-out to active kit
    - Raman amplifier used on (what was then) fairly long legs

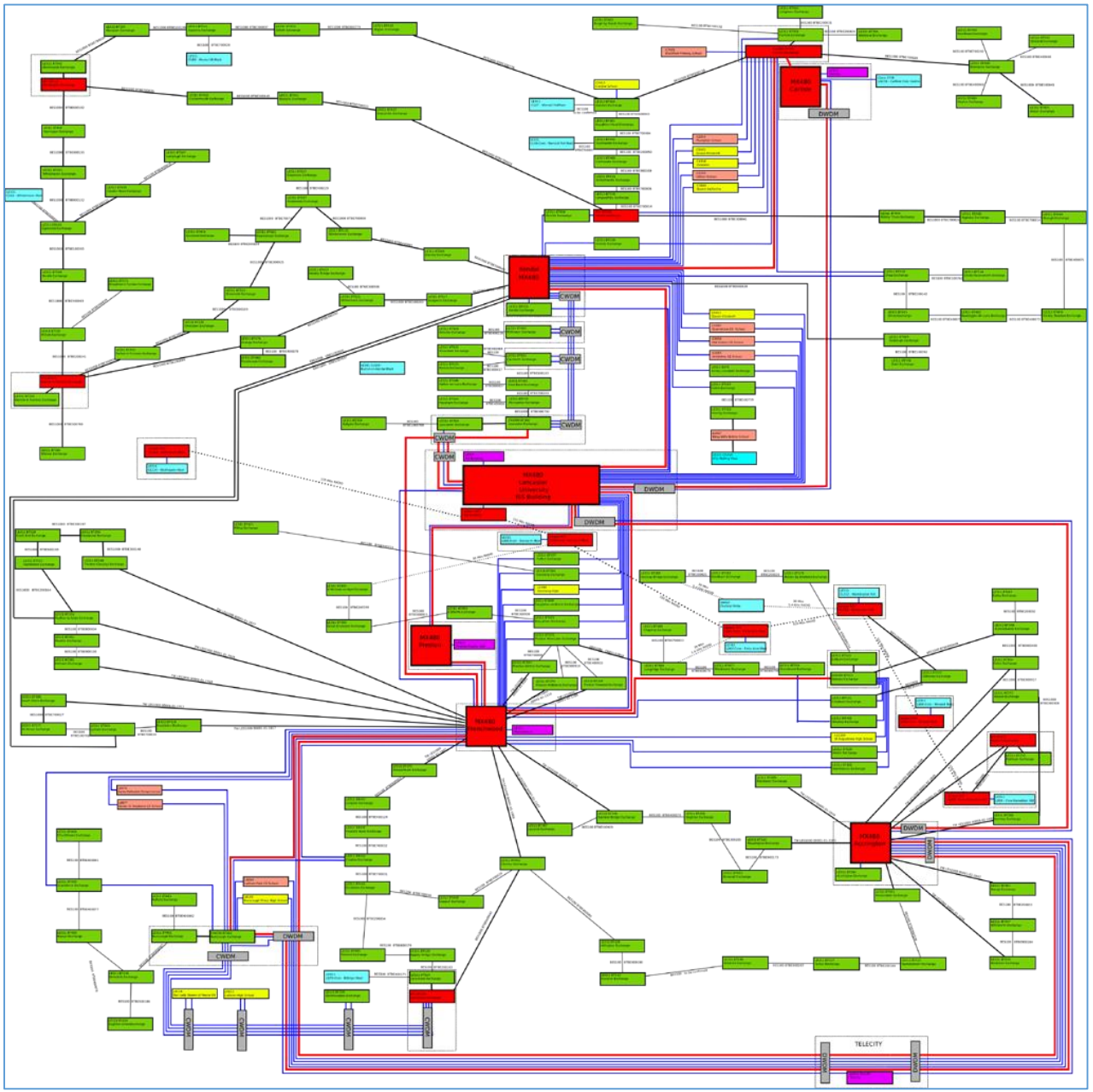
Towards CLEO2 Core

- 2008-9
- Some core dual running during transition
- New links and routers bought into place one by one
- Standard CLEO2 site bandwidths
  - 100Mb/s for secondary school sized sites
  - 10Mb/s for primary school sized sites
  - Some 1Gb/s sites



CLEO2 Core

- Circa 2010 snapshot
- Core POPs (red)
- Exchanges (green)
- Masts (blue)
- Dual fed dark fibre connected edge sites (Yellow/Orange)



“CLEO2” SDSL/EFM

- Procurement for replacement SDSL equipment begins in 2008
- Hatteras EFM equipment chosen
  - Line speeds at the time of 5Mb/s per line
  - Standard CPEs could bond up to 8 lines
  - DSLAMs could be stacked
    - Load-balance lines across stack members for redundancy
- DSLAMs in most larger exchanges
  - Provider/subscriber pairs used in smaller exchanges where only 1 or 2 sites connected via EFM

“CLEO2” SDSL/EFM

Exchange equipment

Site CPE & router in cabinet

“CLEO 2” DC Fitouts

- Procurement of new Eltek DC equipment for Exchanges/ Cores/ Masts
  - Self provided DC allowed for ‘self monitoring’
- 40 & 100Ah battery strings (48v) depending on size/location of site
  - Provided run-time into the days

“CLEO2” Microwave

- 5.8Ghz C-Band is becoming more commonplace
  - Particularly in built up areas
  - Interference becoming a problem
- 3rd radio refresh, predominantly to “B-Band” 5.4Ghz equipment
  - Remains with Alvarion
  - Staying ahead of the ‘spectrum popularity’ curve
  - Lower possible TX power but less interference in general
- In CLEO2, radio is less used, but still important
  - Exchanges cover most of the last mile
  - Radio fill in for lines > 3km and rural sites
- Licensed band Nera (now Ceragon) links used for some exchange backhaul and resilience

Backhauling Rural Broadband Projects

- With rural projects, backhaul is often the hardest part
- CLEO was in the right locations to provide rural backhaul
  - Wray Village, Wennington, Great Asby, Barley Village, Alston Cybermoor
- In several cases the university became involved with the last mile delivery (sometimes as a research platform)
  - Allowed trials and research on mesh networking, v6/multicast testing, mobile ipv6, video on demand
  - Not enough time to cover!
  - See Dr Nick Race from Lancaster University, here today (n.race@lancaster.ac.uk)
    - http://www.lancaster.ac.uk/scc/about-us/people/nicholas-race
    - Wray village mesh network slides - https://www.dropbox.com/s/5375qq3z5g64tyy/Wray_ACS.pptx

Anecdotes – No power

- Exchange backhaul not ready
- Site desperately needed connection from exchange
- No problem! – drop pole and cabinet outside exchange
- Backhaul exchange via radio…

Anecdotes – No power

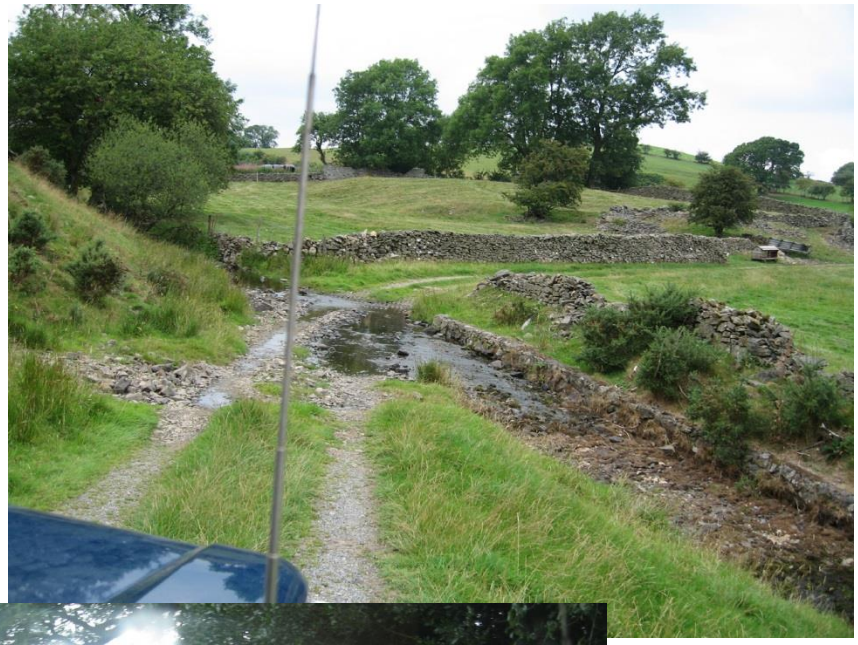
- … power for cabinet has long lead time
- No problem! - install batteries & wind generator

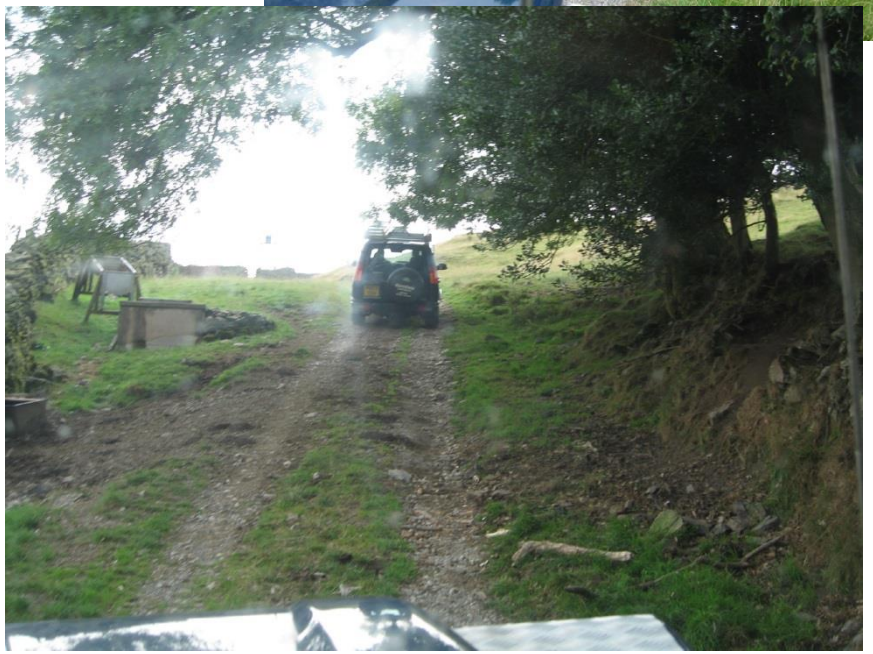
Anecdotes – No power

- One day, a call comes in;
- Them “Internet is down”
- Monitoring hadn’t picked up lack of charge -
- Us “Is it windy”?
- Them “?????”
- Power (and fibre) eventually went in -

Anecdotes - Sheep

- Reports connection down on A-Level results day (siiigh)
- Team roll out to climb at rural mast site in Cumbria





Anecdotes - Sheep

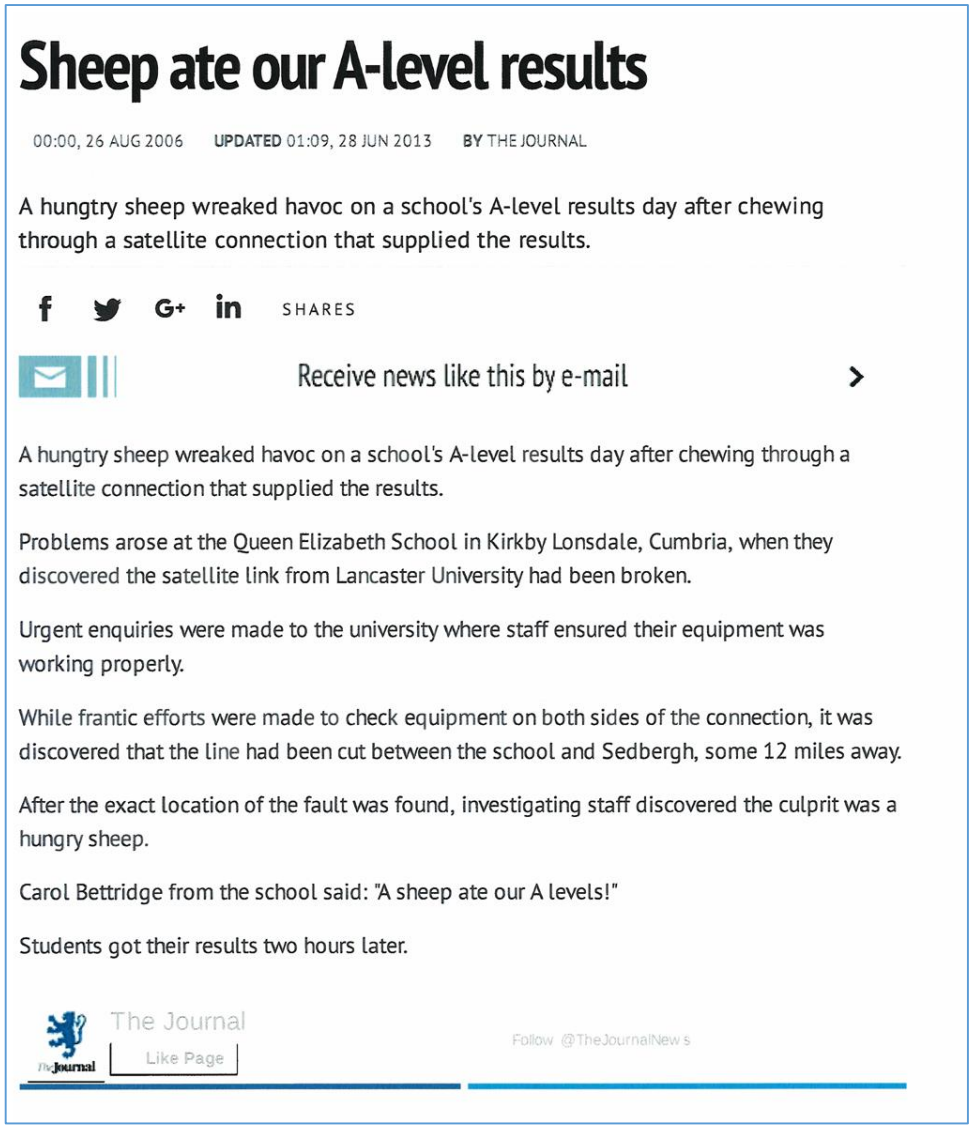
- Get out to mast site
- Find sheep in compound (uh oh) and damaged fence
- Climb to test cable end-to-end

Anecdotes - Sheep

- Cable broken in several places by sheep nibbling
- Deeper burying (or steel wire armour cable)
- Cable re-ran end to end (up tower) to fix
- Fence repaired!

Anecdotes - Sheep

- Call back to site to explain
- Them “?????”
- Site translate as ‘sheep ate A-levels’
- (“satellite” in article in this case = microwave)



Sheep ate our A-level results

00:00, 26 AUG 2006 **UPDATED** 01:09, 28 JUN 2013 **BY** THE JOURNAL

A hungtry sheep wreaked havoc on a school's A-level results day after chewing through a satellite connection that supplied the results.

SHARES

Receive news like this by e-mail

A hungtry sheep wreaked havoc on a school's A-level results day after chewing through a satellite connection that supplied the results.

Problems arose at the Queen Elizabeth School in Kirkby Lonsdale, Cumbria, when they discovered the satellite link from Lancaster University had been broken.

Urgent enquiries were made to the university where staff ensured their equipment was working properly.

While frantic efforts were made to check equipment on both sides of the connection, it was discovered that the line had been cut between the school and Sedbergh, some 12 miles away.

After the exact location of the fault was found, investigating staff discovered the culprit was a hungry sheep.

Carol Bettridge from the school said: "A sheep ate our A levels!"

Students got their results two hours later.

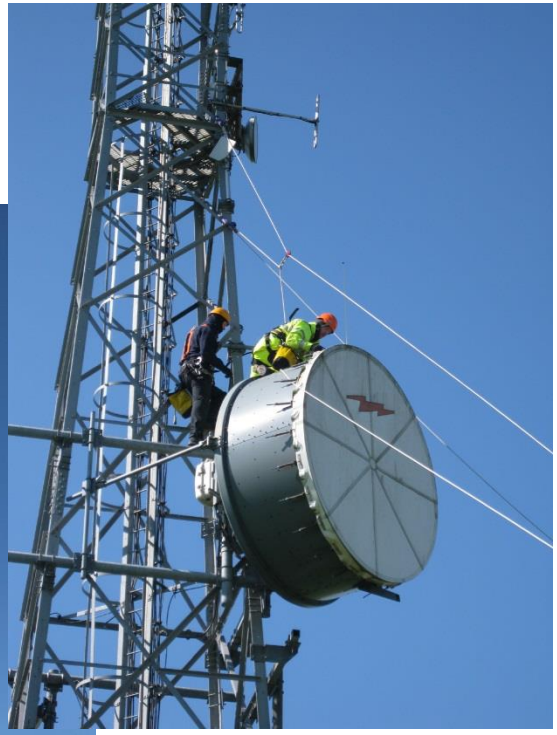
The Journal

Like Page

Follow @TheJournalNews

Anecdotes – Dish Decom

- Some microwave dishes larger than others
- This one was 2.4M
- Wind can be an issue (both kinds)



Anecdotes – Dish Decom

- Who brought that trailer??
- Looks bigger on the ground!

Anecdotes - Rope Access

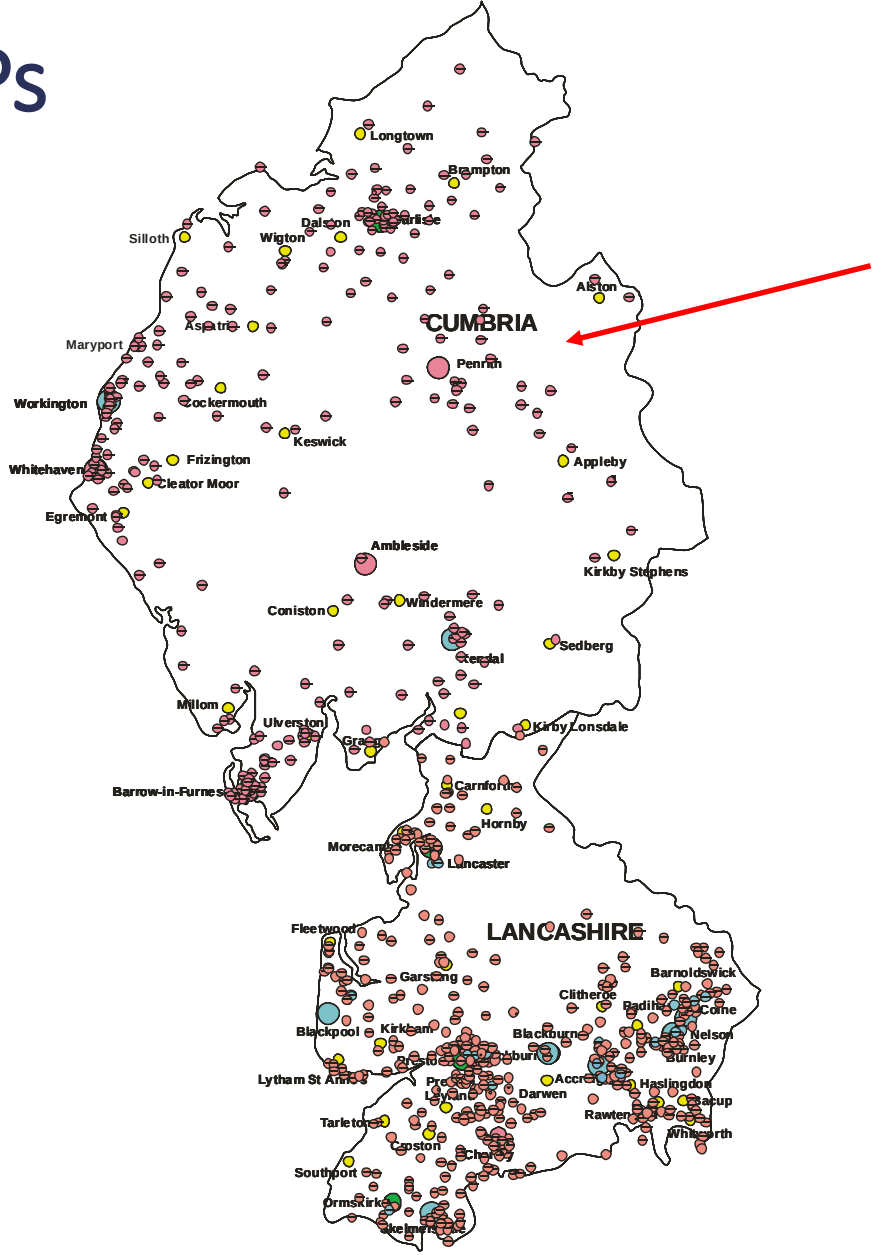
- Fibre run under bridge

Interesting POPs

- Great Dun Fell Radar Station

Interesting POPs

- Great Dun Fell Radar Station



Interesting POPs

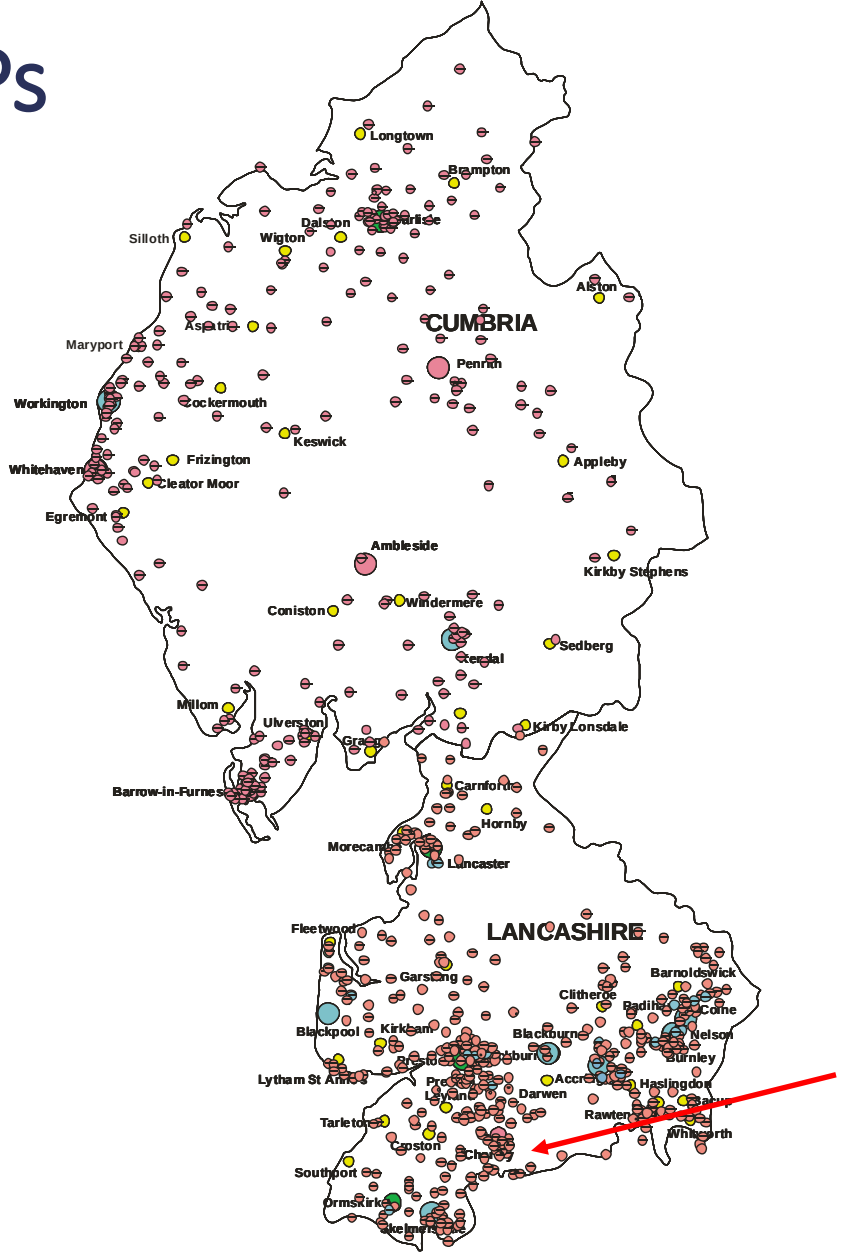
- Great Dun Fell Radar Station

Interesting POPs

- Winter Hill
- > 1000ft transmitter site
  - Highest TV transmitting station in UK at 2500ft above sea level
  - Serves 6.3 million people
- TV transmission for large area of NW and North Wales

Interesting POPs

- Winter Hill



To finish: Some lessons learnt

- Use DC power where possible
  - (though sometimes good reasons not to)
  - Runtime++
  - Usually fails ‘on’ if rectifier blows
  - Unfortunately vendors know you’re a telco £££
- Always clean/scope fibre patches properly before use
  - Drum it into the field teams
  - Can be difficult where 3rd party DCs/colo ODFs involved
- Easy to underestimate supporting systems requirements
  - Systems/databases to tracking of orders/circuits/exchange patching
  - Nowadays tracking of GEA VLANs/cable links
  - Monitoring
  - Spreadsheets only work for so long

To finish: Some lessons learnt

- OR MPFs/copper lines
  - Always use a wetting current/dial tone where possible or pairs will go walkabout
  - Have a test-head or set of handheld testers to verify problematic lines
- Weather-proof outdoor microwave radios well
  - Use denso or self amalgamating tape on all joints/glands
  - Use good quality double jacketed or gel filled cable to avoid water running down cables into mast hut/kit if water enters radio or cable gets cut
- Unlicensed band sectors in built up areas challenging
  - Too much interference & misconfiguration around – bar has been lowered through cheap 5ghz equipment
  - Unlicensed P2P links with higher gain antennas still usable
  - 60-80ghz light-touch licensed useful for higher bandwidths over short distances

Thanks!