
Azea was purchased
by Xtera in Nov. 2007


# Upgrades
# Theory and practice

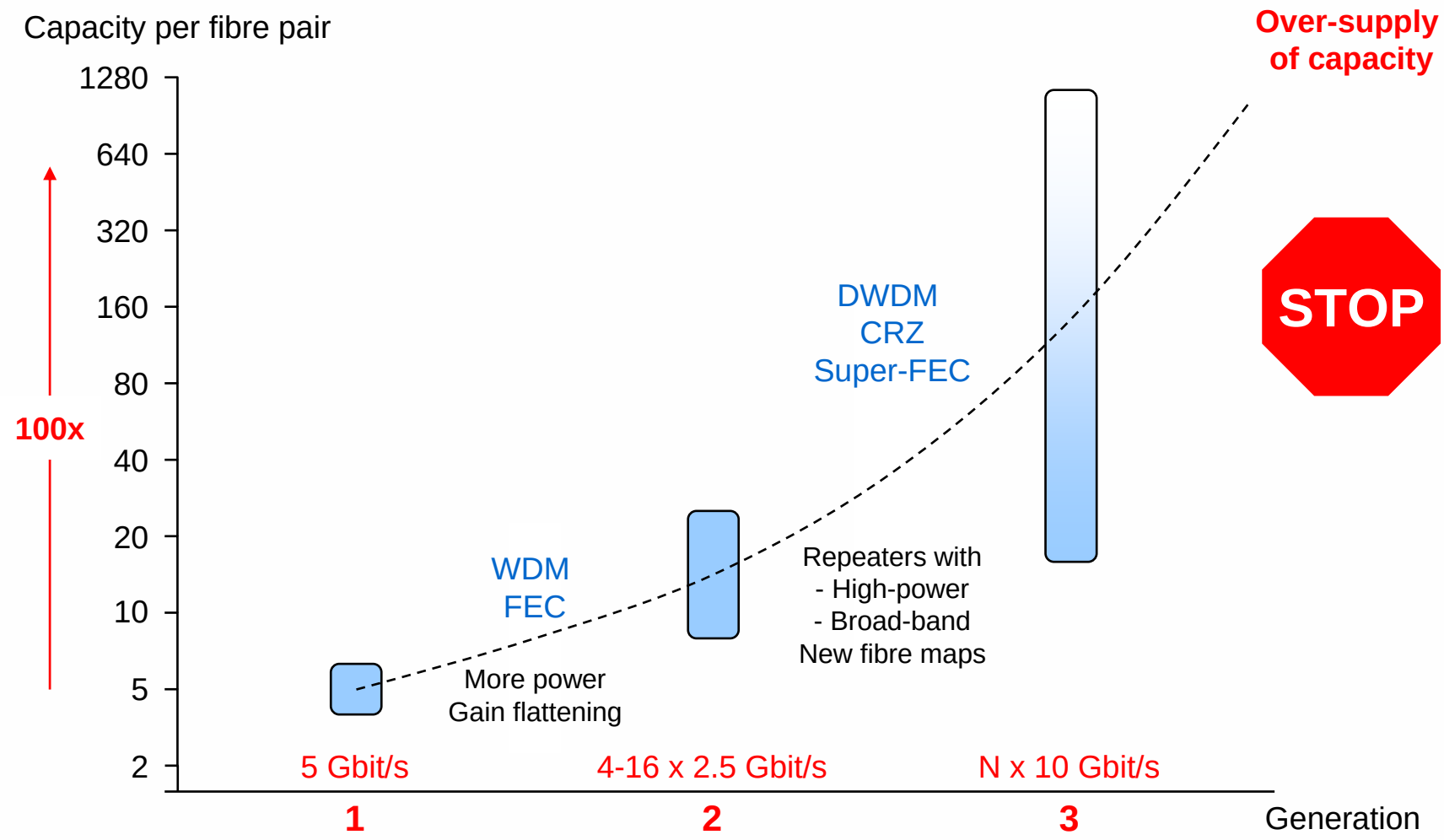
**Tony Frisch**

# Content of talk

- A brief history
- Upgrades compared with alternatives
- How upgrades work in theory
- Some practical issues
- Future developments

- ***NOTE***
  ***Most slides present simplified explanations, in some cases missing details***

# History – technical



# History – legacy

1 **Reluctance to invest in telecommunications**
- ⇨ Hard to fund expensive new cable builds

2 **Technical**
- ⇨ New FEC with higher coding gain
- ⇨ Better transmission formats
- ⇨ Improved understanding of long-span transmission

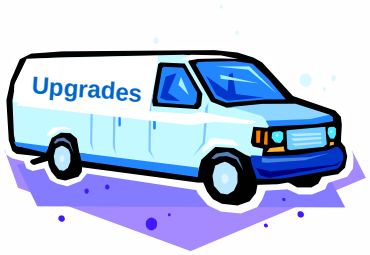
3 **Components**
- ⇨ Lack of cash stopped investment in 40 Gbit/s etc.
- ⇨ Competition made 10 Gbit/s components very cost-effective

4 **Capacity demand continues to grow**

# Possible ways to get extra capacity

## Build a New System

- ⇨ Huge potential capacity
- ⇨ Long lead time (~12 months)
- ⇨ Large up-front expense
- ⇨ Long term commitment




## Upgrade an Existing System

- ⇨ Limited potential capacity – depends on system
- ⇨ Medium lead time (~6 months)
- ⇨ Modest up-front expense


## Lease (or purchase) capacity

- ⇨ Significant availability in some markets
- ⇨ Short lead-time (< 1 month possible)
- ⇨ Can be short-term
- ⇨ Expensive for large volumes / long periods

# New Build or Upgrade?

- New build – large cost
  – large capacity

  Upgrade – modest cost
  – limited capacity

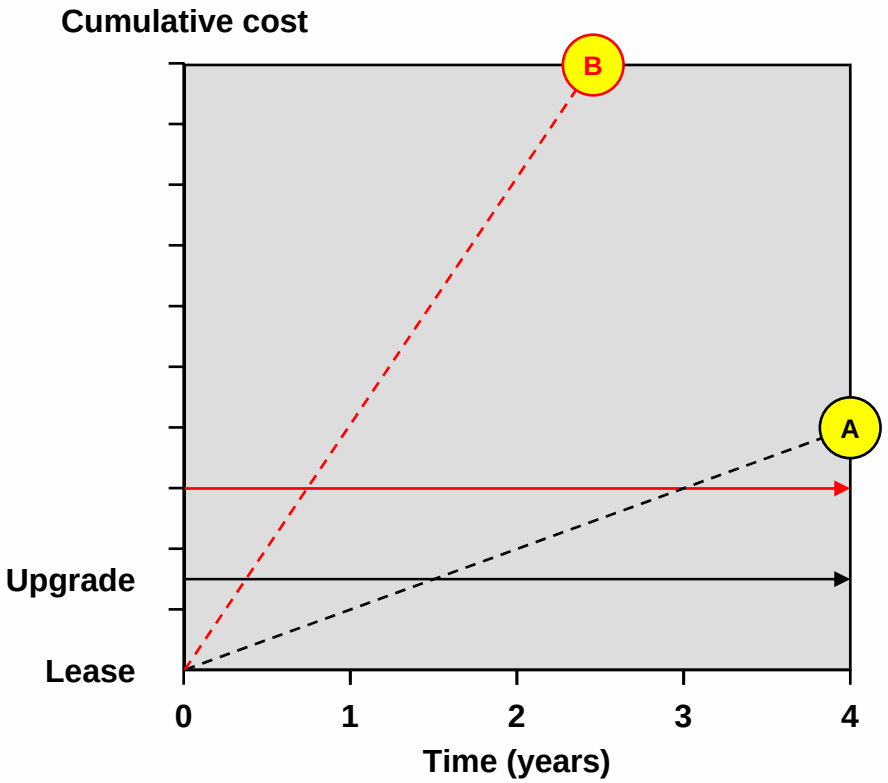
- Upgrade delays the need to purchase a new cable

+ Significant benefit from deferred CapEx

+ Possibility to benefit from new advances in technology

# Lease or upgrade?

- **Lease is an enduring cost**
  - ⇨ A and B represent different cost leases
- **Upgrade is one-off**
- **After some time leasing will always be more expensive**
- **Depends on**
  - ⇨ Lease price
  - ⇨ Capacity required



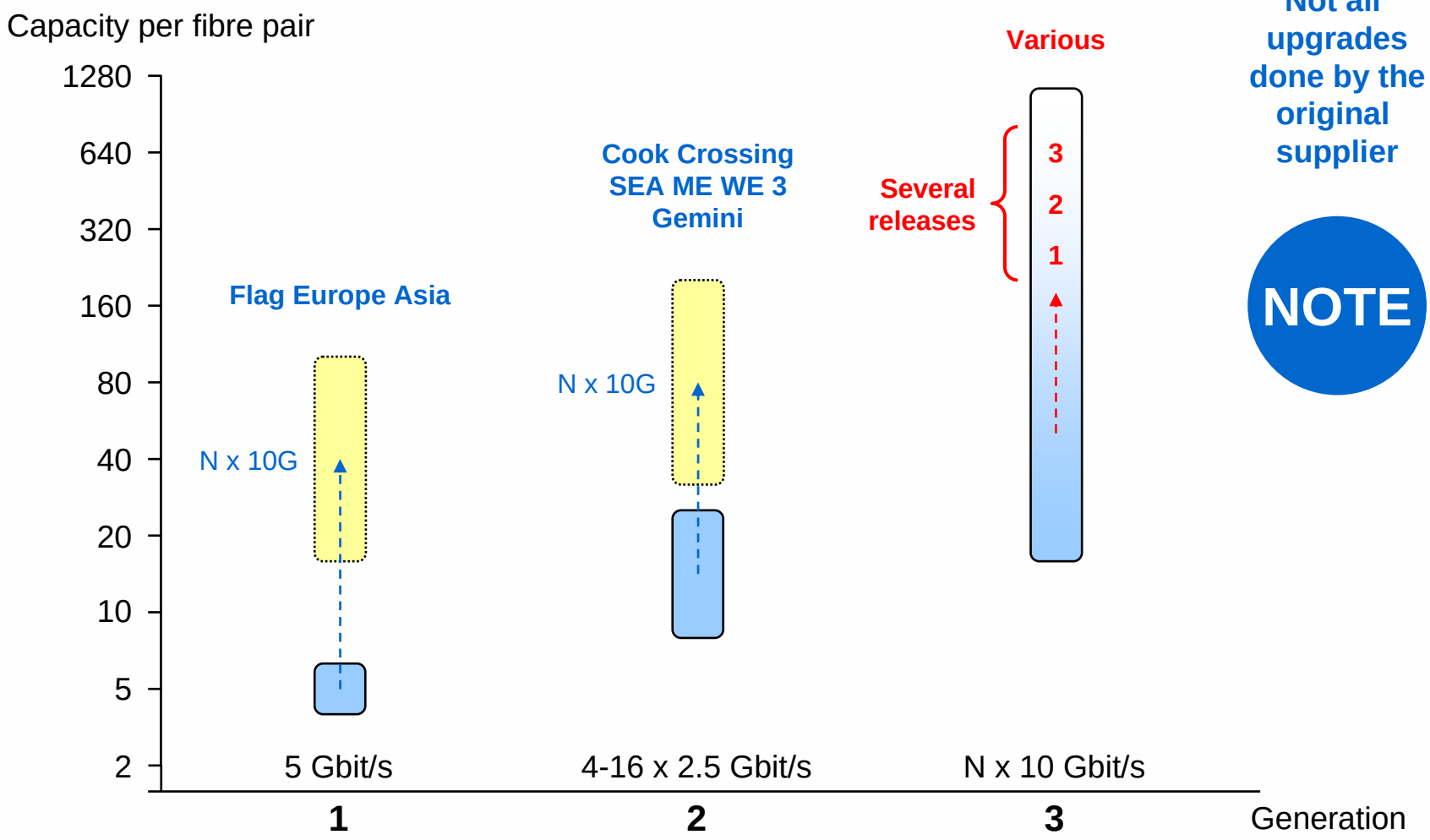

- **Lease advantageous for**
  - ⇨ Very low capacity
  - ⇨ Short duration

# Upgrade possibilities and benefits

- Any amplifier-based system: not those with regenerators

| | | |
|---|---|---|
| • Generation 2 | 2.5 Gbit/s | 0.8 – 1.0 nm spacing |
| • Upgrade today | 10 Gbit/s | 0.3 – 0.4 nm spacing |
| | 4x | 2x |
| • Suggests | 8x original design capacity typically<br>but depends on specific system | |
| • Generation 3 | 10 Gbit/s | 0.3 – 0.4 nm spacing |
| • Suggests | no significant increase in maximum today<br>but lower cost, more compact, up-to-date … | |

# History – upgrades




**Not all upgrades done by the original supplier**

**NOTE**

# Types of upgrade

- **Planned upgrade e.g. on under-equipped system**
  - ⇨ Adding channels up to maximum design capacity
- **Extra upgrade**
  - ⇨ Beyond the original design capacity
  - ⇨ New technology

**1 Complete terminal replacement** — **Always possible**

**2 Overlay of new equipment** — **Generally possible**

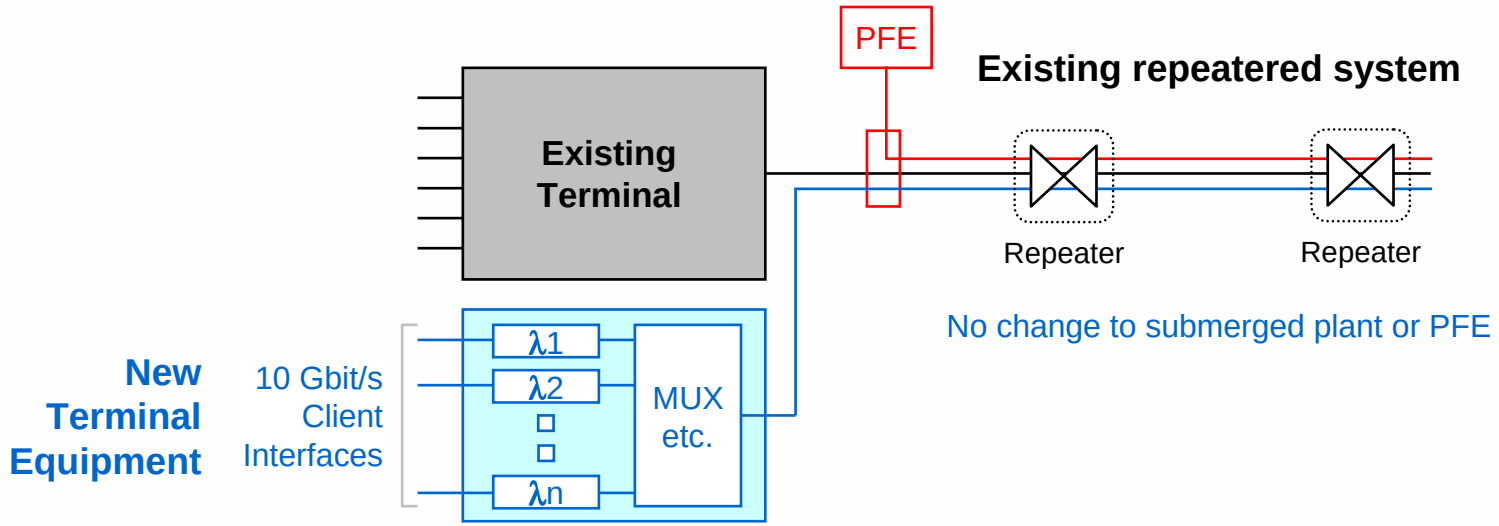
- ⇨ Keeping original equipment and traffic

**3 Upgrade submerged plant** — **Difficult, slow, expensive**

- ⇨ Change repeaters or add gain-flattening units
- ⇨ Not covered here

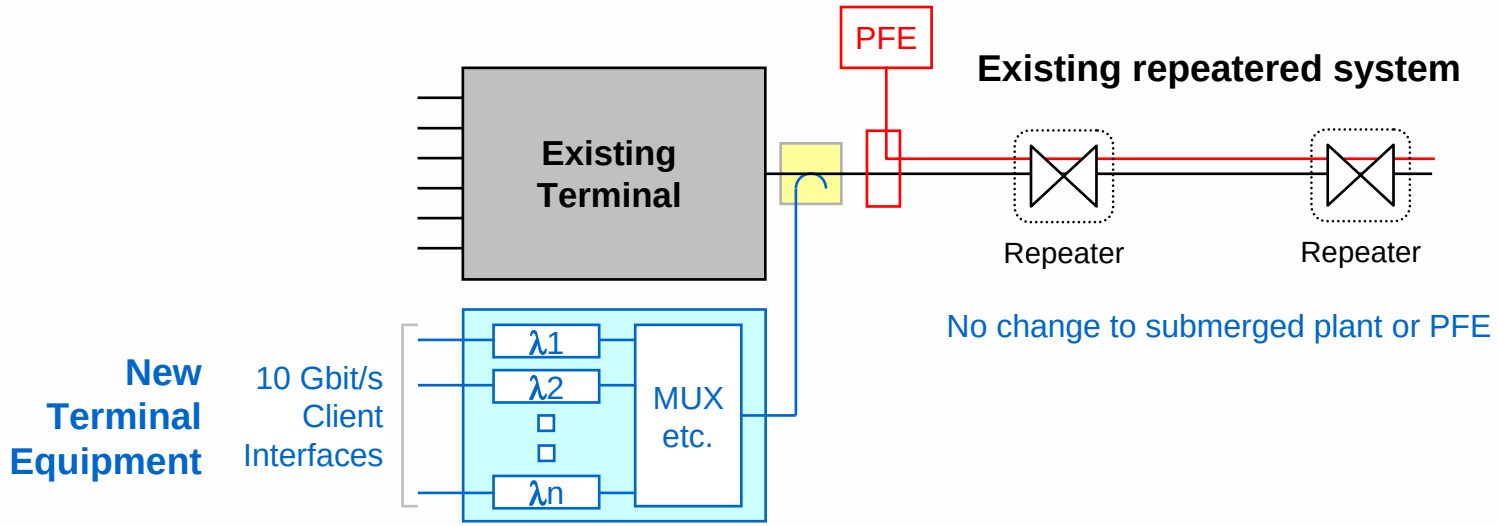
# Dark fibre or full replacement upgrade

- **Essentially very straightforward**
  - ⇨ Dark fibre – no risk of traffic disruption
  - ⇨ Full replacement – the major consideration is what to do with the traffic during the upgrade
    - Some alternative path is needed



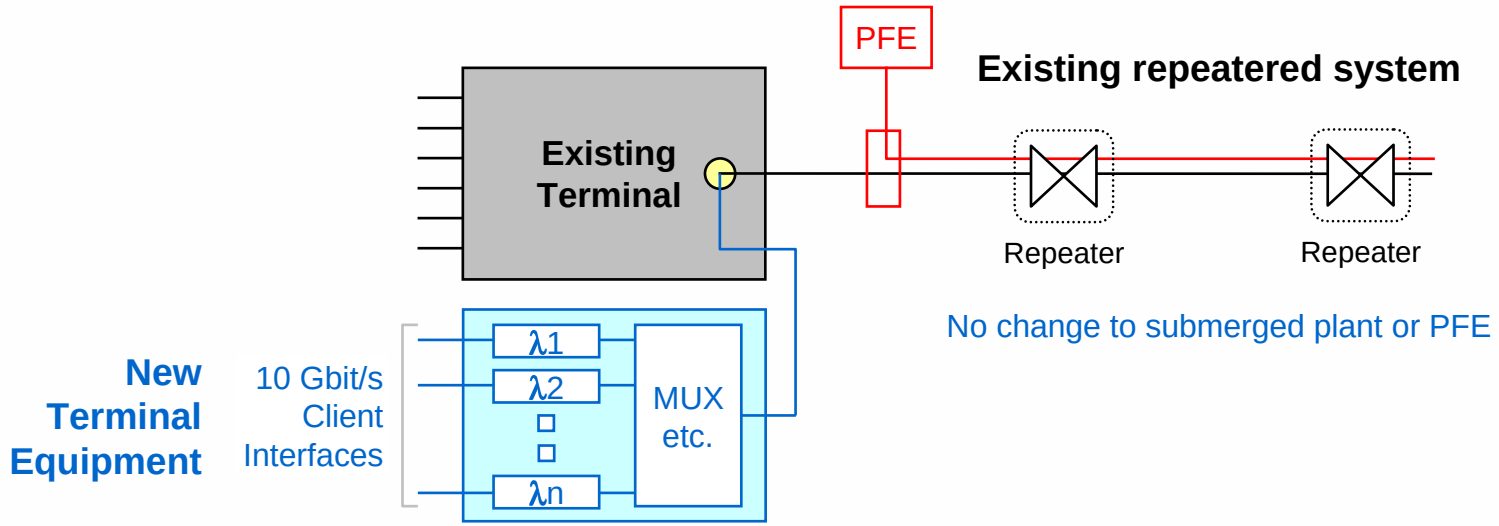
# Overlay upgrade

- **Used in parallel with existing equipment**
  - ⇨ Uses new wavelengths – usually via a coupler
- **Keeps existing traffic, needs care to minimise traffic disruption**
- **Offers less traffic than full replacement**

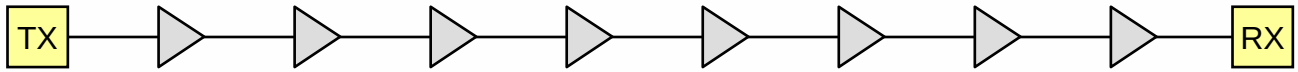


# Hybrid upgrade

- **Uses couplers / multiplex in existing equipment**
  - ⇨ No traffic disruption
- **Issues**
  - ⇨ May "confuse" existing management system
  - ⇨ Potential for contractual issues e.g. warranty



# Optical power budget fundamentals



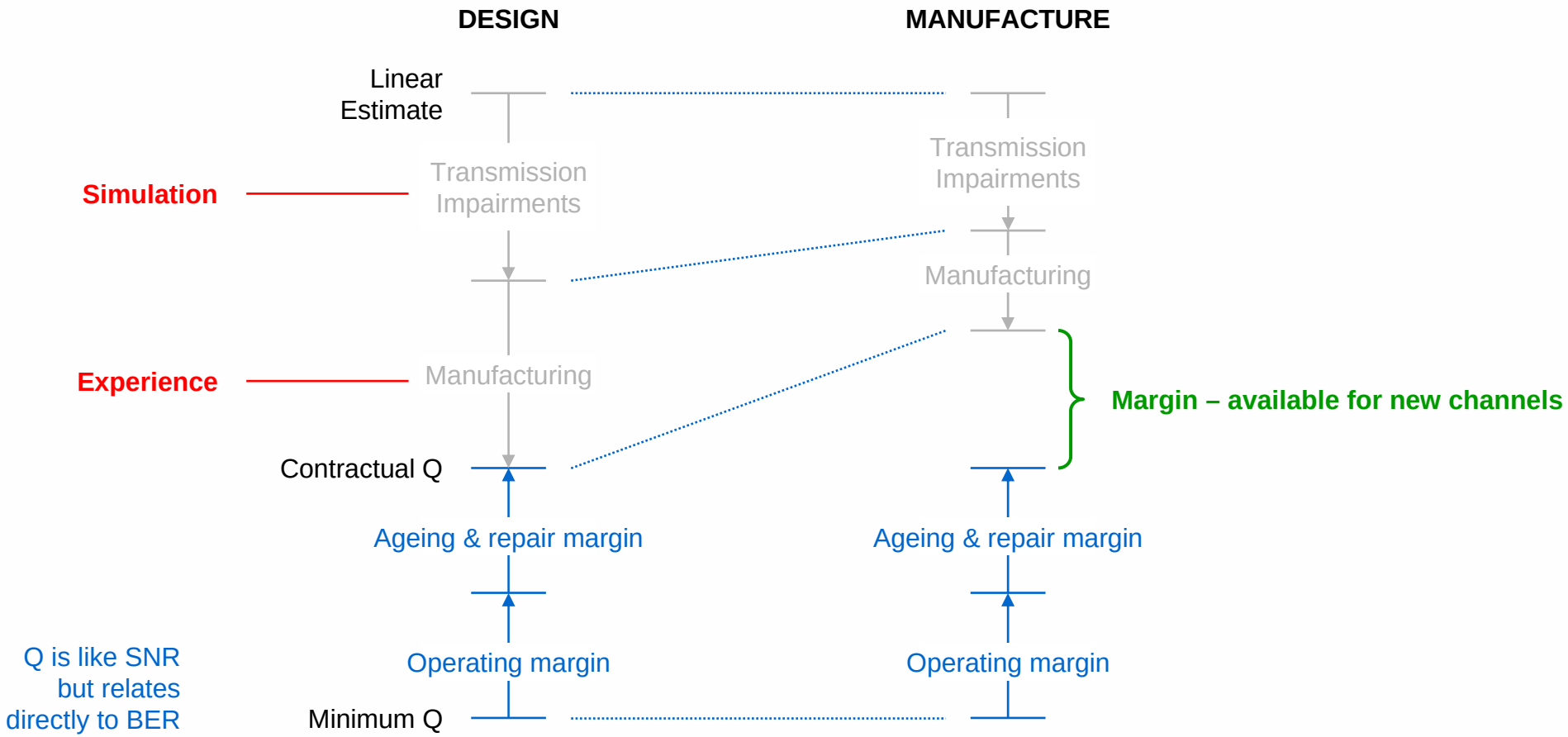

1 **Each amplifier generates noise, which accumulates**
   - ⇨ Simple to calculate

2 **There are fibre non-linear effects which distort the signal**
   - ⇨ Hard to calculate – needs computer simulation
   - ⇨ Some effects fluctuate …

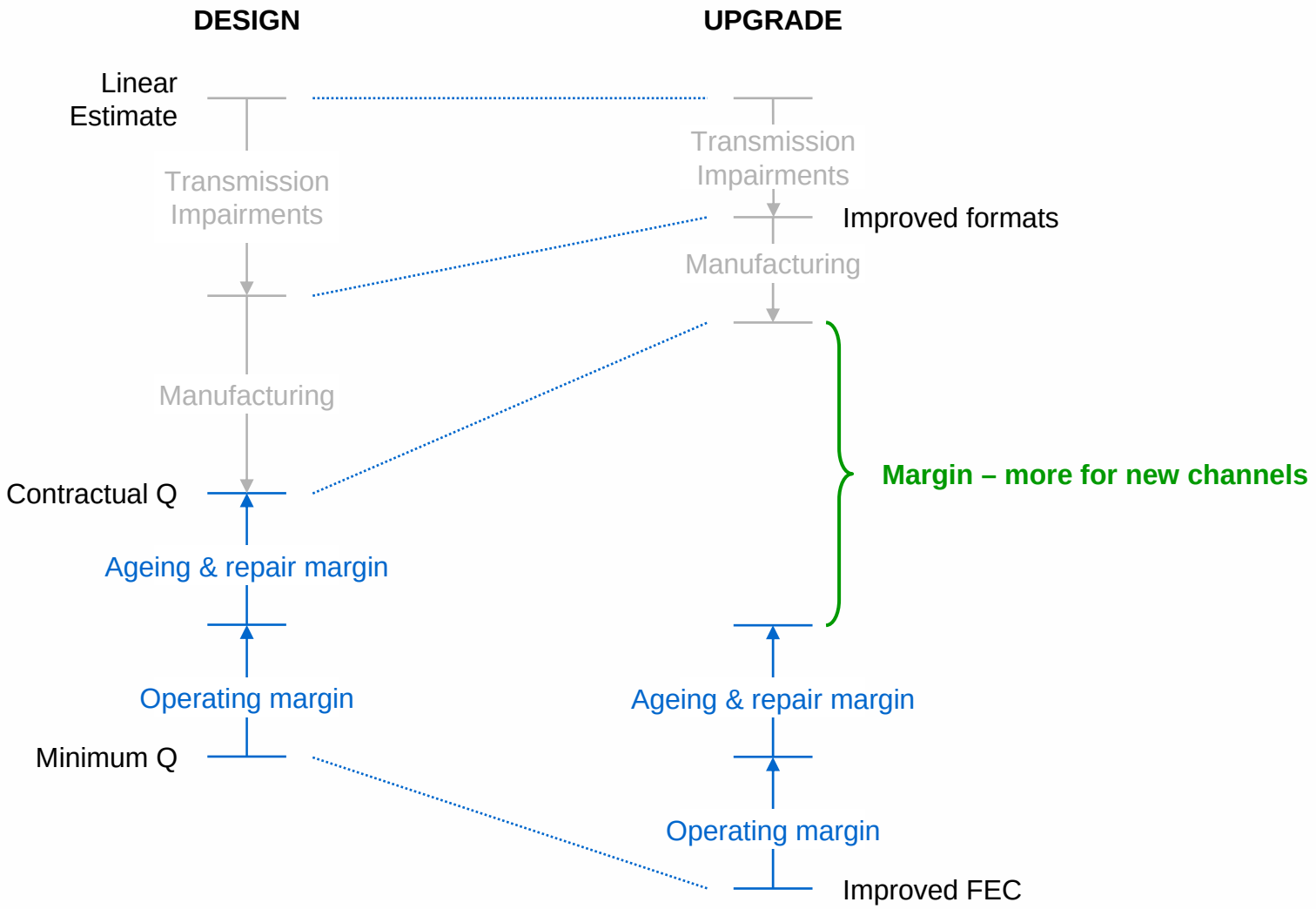
3 **Each repeater has limited output power**
   - ⇨ Adding channels means less power per channel ⇨ worse Signal/Noise

- **In general, there are two power budgets**
   - ⇨ For existing channels – how much power can they give away?
     i.e. how much available for upgrades?
   - ⇨ For new channels – how many can be added?
     takes new technology into account

# Optical budget – existing channels

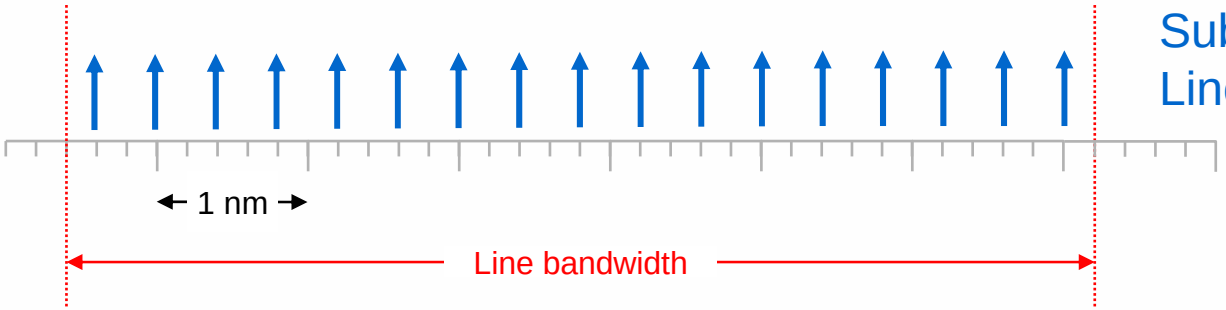


# Optical budget – new channels



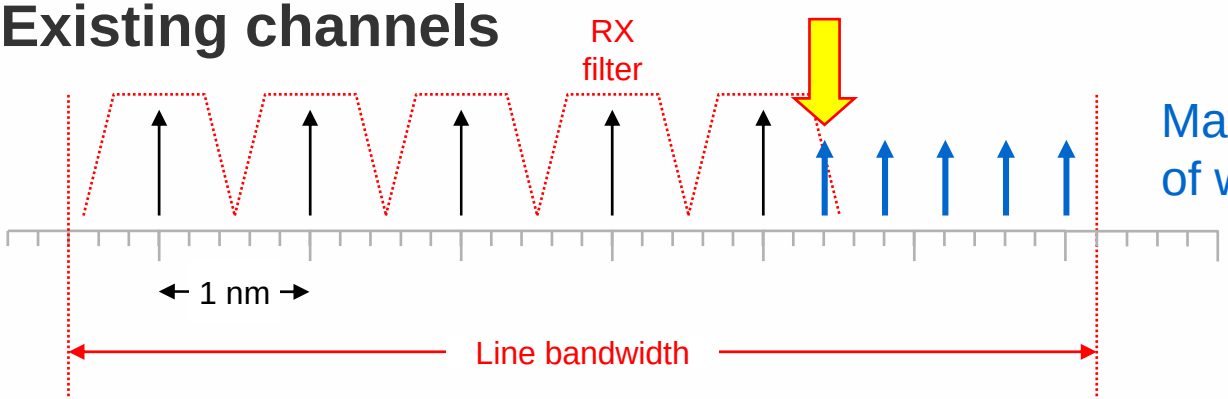
# Other relevant factors

- **Line bandwidth and channel spacing**




Subject to
Line performance

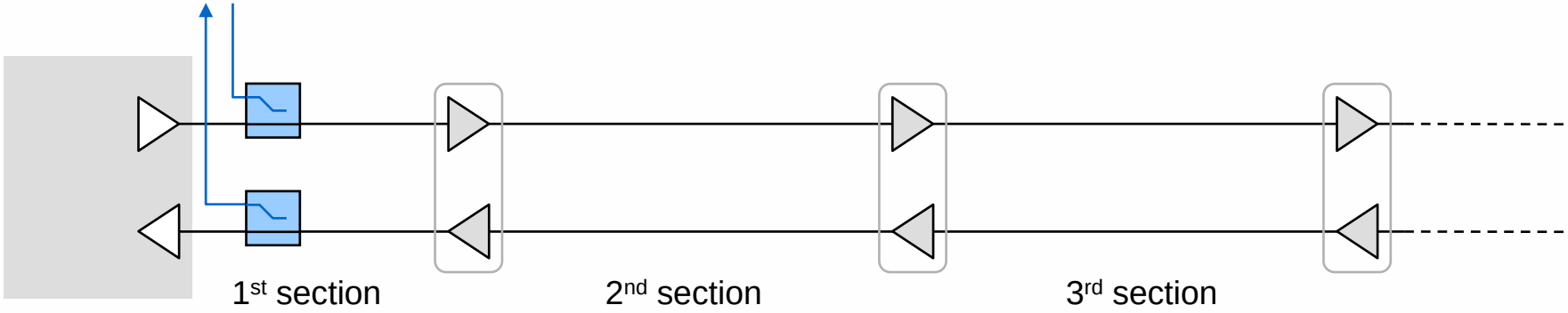
- **Existing channels**



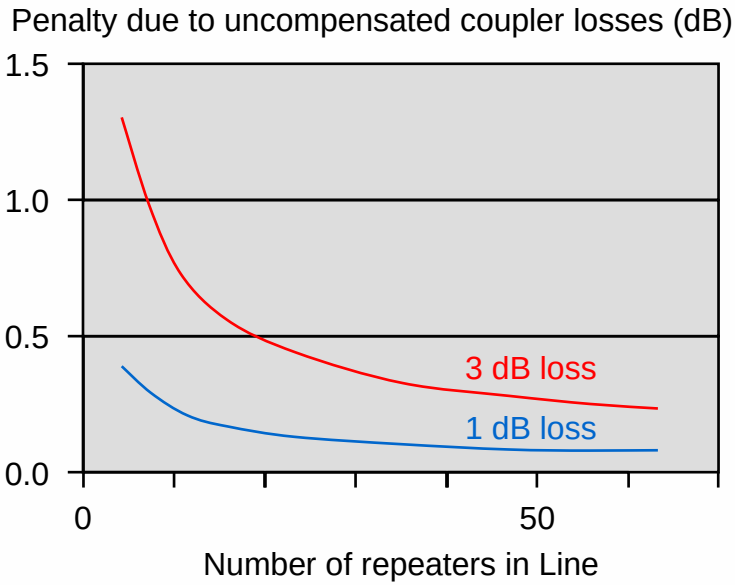

May limit number
of wavelengths

- **Any optical filtering**
  - ⇨ Terminal receivers
  - ⇨ BU filters e.g. SMW-3 and SAT-3

# The optical coupler




- **Only minutes to insert**
- **Adds some loss**
- **First section is usually short**
  - ⇨ Often are attenuators which may be removed
- **Otherwise, penalty depends on**
  - ⇨ Number of amplifiers
  - ⇨ Coupler loss

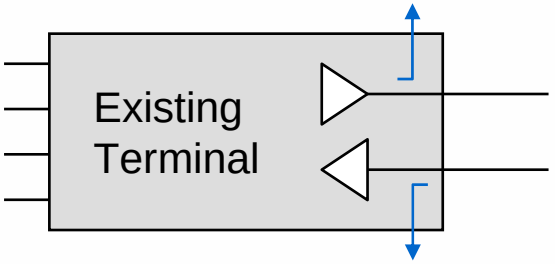


# How to avoid problems

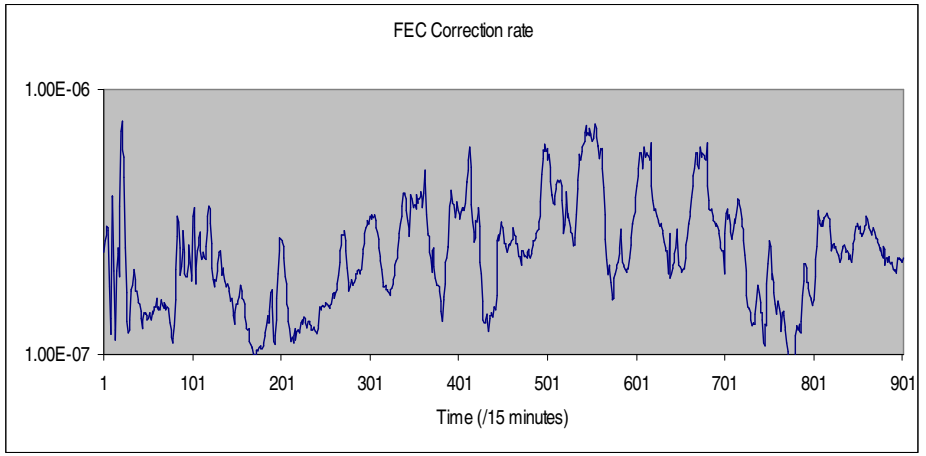
- **Preparation, preparation, preparation … and co-operation**
- **Gather as much information as possible**
  - ⇨ SLD, dispersion map and fibre types, repeater parameters etc.
  - ⇨ Check for repairs
- **Measure the system in ways that don't affect traffic**
- **Perform precise computer simulations**
  - ⇨ Accurate predictions are possible with good inputs
- **Determine the wavelength plan**
- **Check station details**
- **Plan the upgrade to allow a roll-back at each stage**

# Measurements that don't affect traffic

- **Optical spectra**
  - ⇨ TX confirms wavelengths
  - ⇨ RX gives OSNR




- **FEC correction rate**
  - ⇨ Gives Q and thus margin
  - ⇨ But fluctuates, so need more than a single measurement

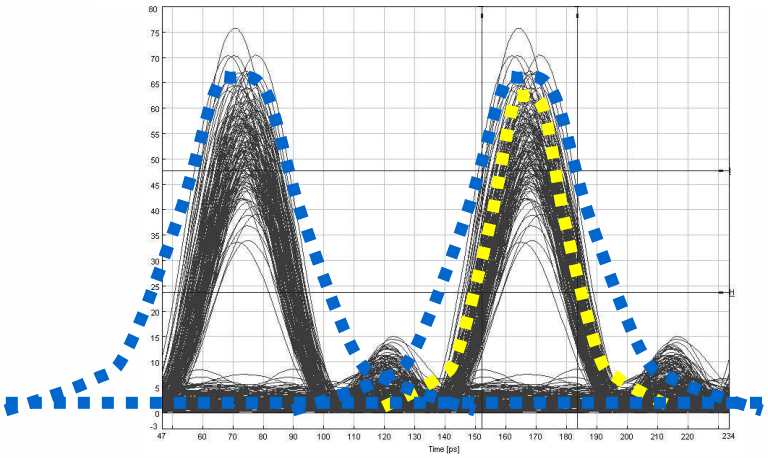



- **Line monitor history**
  - ⇨ Can give indication of significant line changes

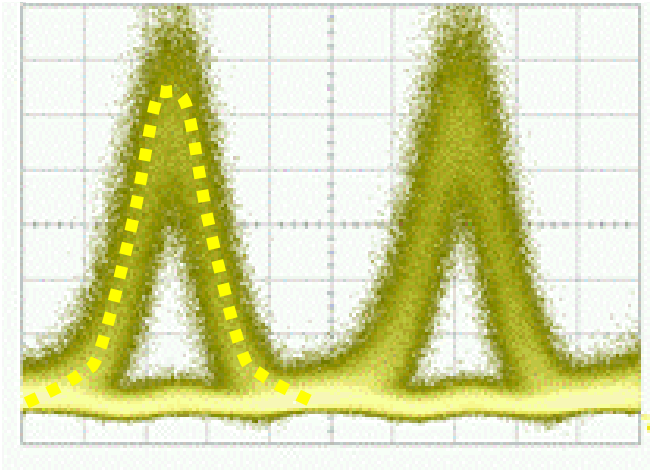
# Simulation accuracy

- **The example shows pulse narrowing due to non-linear effects, caused by a non-optimal dispersion map after a major repair**

Simulation



Measurement

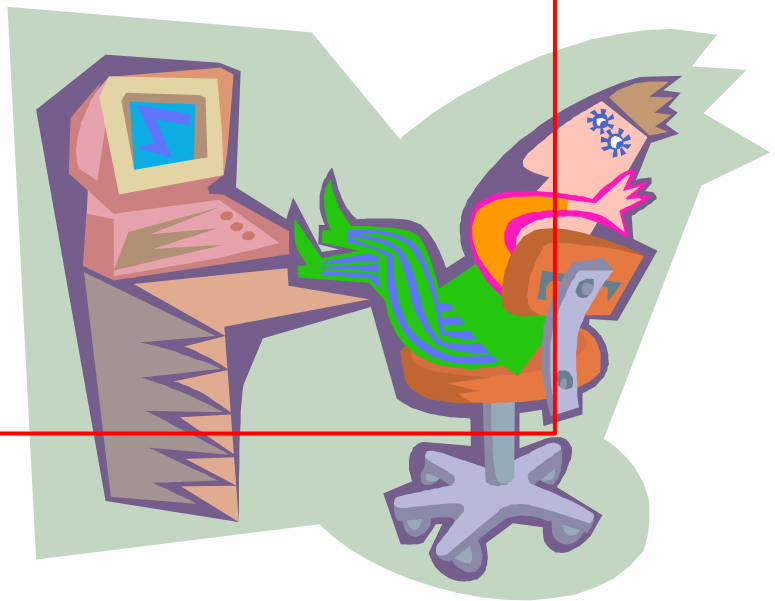


- **Simulation very close to the real world**
- **Very important to check repair data**

# Simulation – the other side of the story …

- **Is more than just software … the people are important**
- **Initial set-up needs a number of parameters**
- **Repeat several times, varying SLTE parameters**
  - ⇨ Dispersion compensation
  - ⇨ Pulse width
  - ⇨ Phase modulation
  - ⇨ Relative power (pre-emphasis)
  - ⇨ …
- **Takes a lot of time, depending on**
  - ⇨ Number of channels
  - ⇨ Number of repeaters
- **Worth checking**
  - ⇨ In the lab
  - ⇨ In the real world

Modify with experience



# Original supplier / New supplier

- **The original supplier**
  - \+ Should know all the system details
  - \+ Can offer plug and play upgrade for same release equipment
  - \+ Use existing spares for same release equipment
  - \+ No change to management system for same release equipment
  - \+ Established relationship with operator
  - – May no longer make that generation of equipment

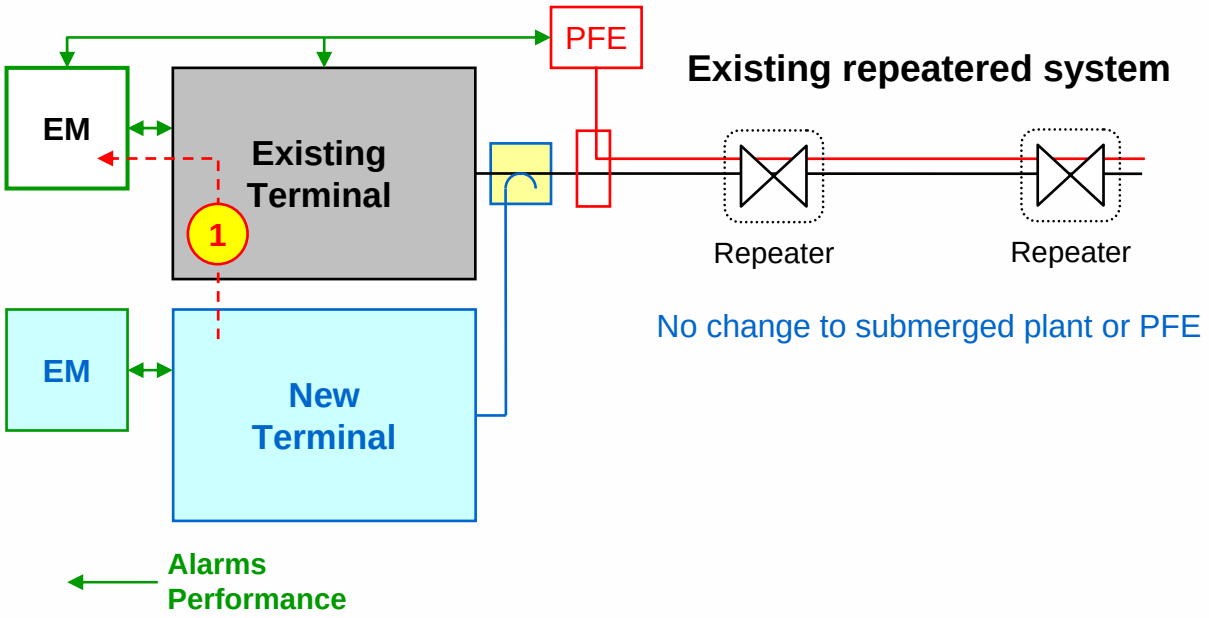
May not be true if equipment is obsolete

- **A new supplier**
  - ? May be needed if the original supplier doesn't wish to supply
  - – Will need to acquire system details
  - – Will add a new management system in any case
  - \+ Offers better features
  - \+ Offers better commercial conditions
  - \+ **Makes future upgrades dual-supply,**
    **which implies long-term competitive supply**

- **In several cases purchasers have chosen a new supplier…**

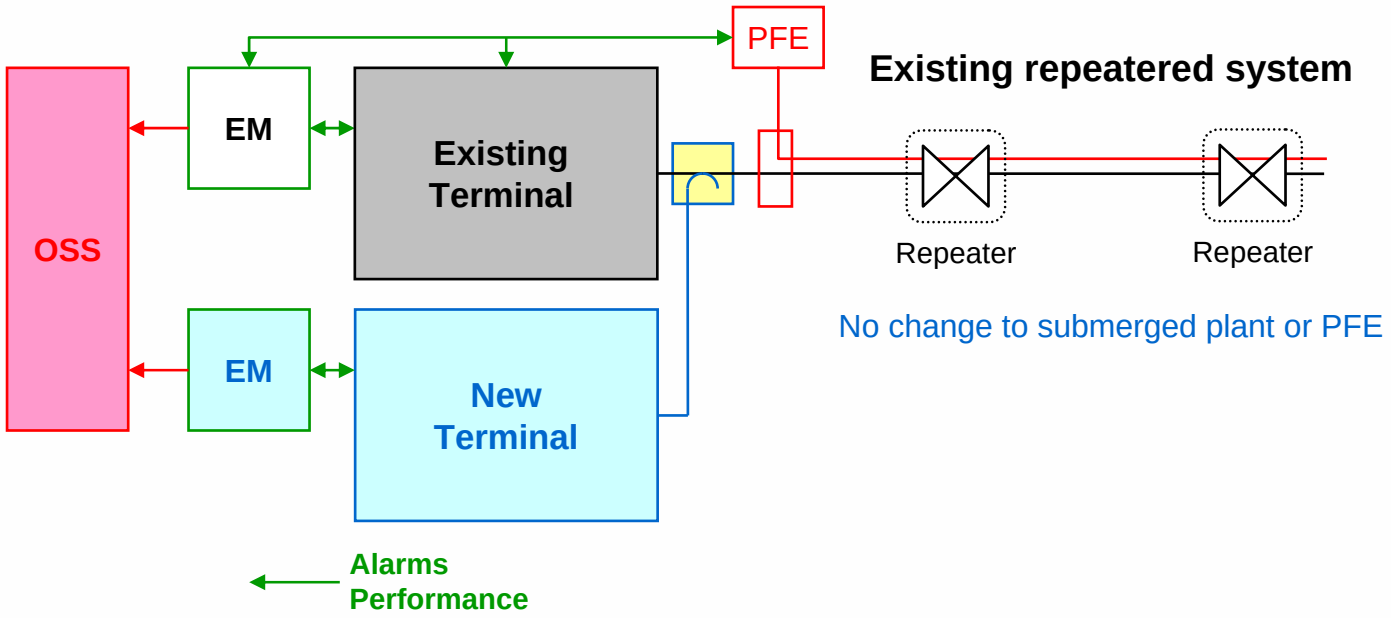
# Management Solution 1

- **SLTE configuration is static – except when adding capacity**
- **Communication using simple contact closures**
  - ⇨ The existing management will be aware of these as alarm conditions



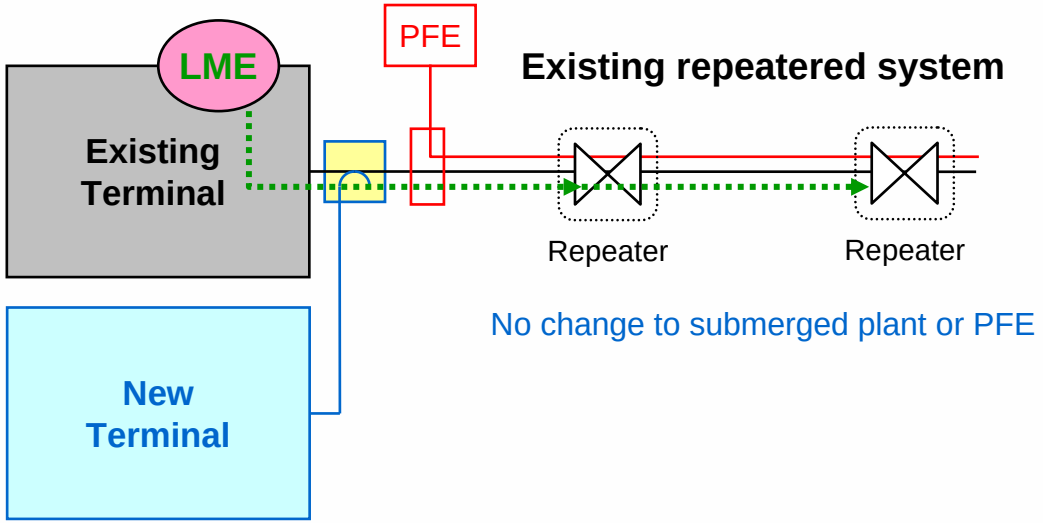
# Management Solution 2

- SLTE configuration is static – except when adding capacity
- Integration by exporting alarms (maybe PM) to an OSS



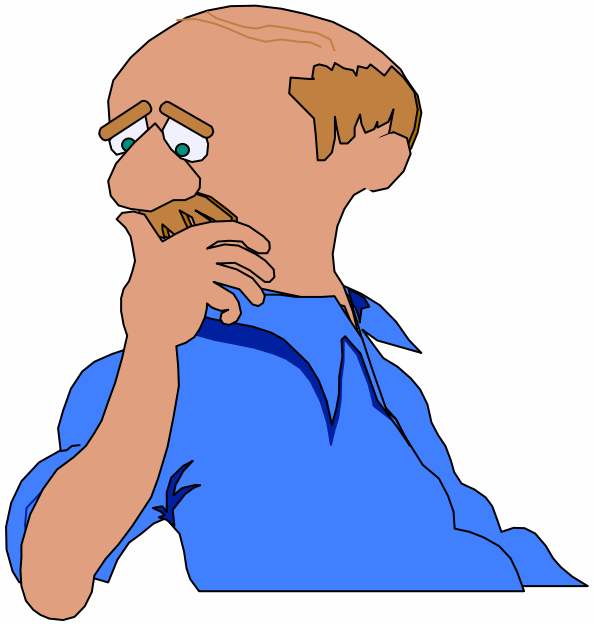
# Monitoring wet-plant

- **In many cases the existing LME can remain**
  - ⇨ Possible with "overlay", as all original equipment remains
  - ⇨ Some LMEs designed to monitor dark fibres
- **Potential issues**
  - ⇨ May need to adjust modulation levels
  - ⇨ Some very complex wet-plant e.g. BUs with supy-controlled latching



# Warranties / support

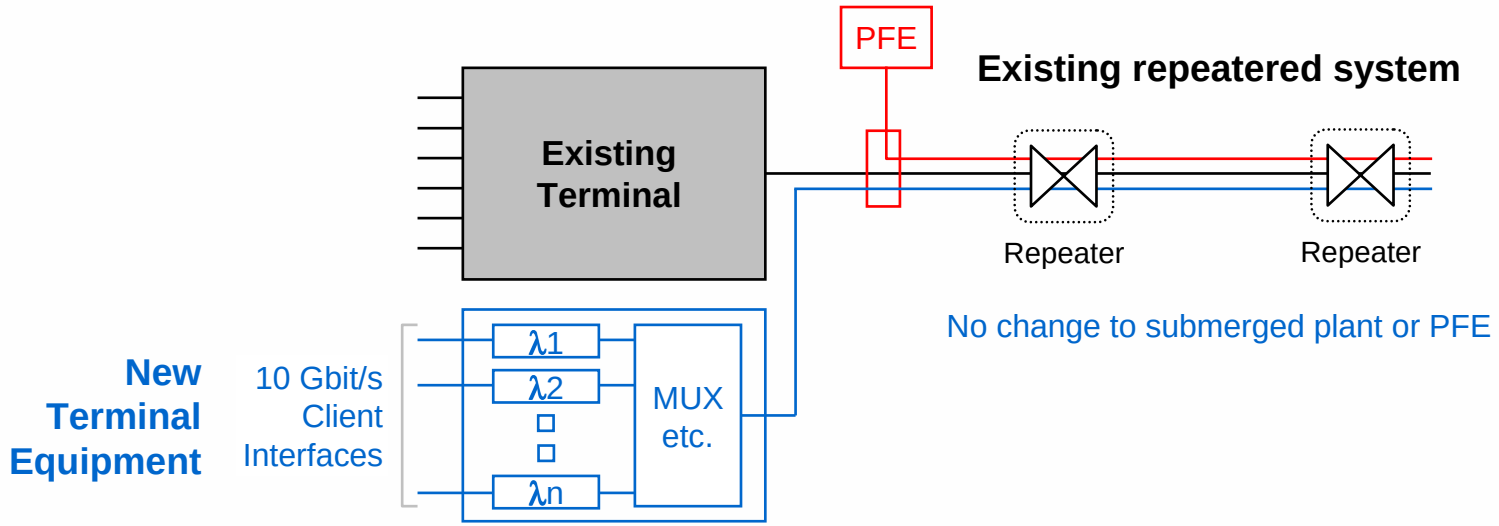
- Warranties typically 5 years
- Would a new supplier upgrade invalidate the warranty?
- Contractually unlikely – based on customer checks
- Practically the original supplier needs to remain "reasonable" in order to be considered for future supply contracts



**Good suppliers driven by the market**

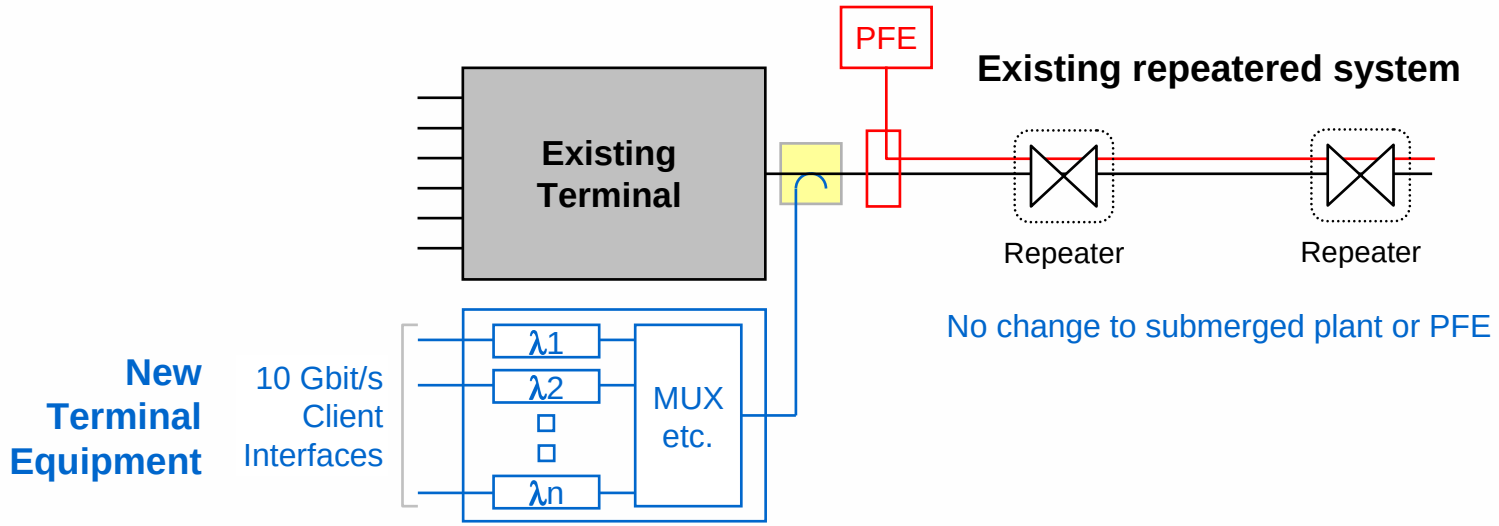
# Side-by-side operation – Dark fibre

- **No real issues**
- **Wet plant is very simple and robust**
  - ⇨ Impossible to damage with normal optical power levels
  - ⇨ Power-Feed might be an issue, but needs no changes



# Side-by-side operation – Overlay

- **Works providing wavelengths and power are very stable**
  - ⇨ Essential for any WDM equipment
- **Could imagine issues with auto-adjusting systems**
  - ⇨ Pre-emphasis for example
  - ⇨ Experience shows this is not a problem

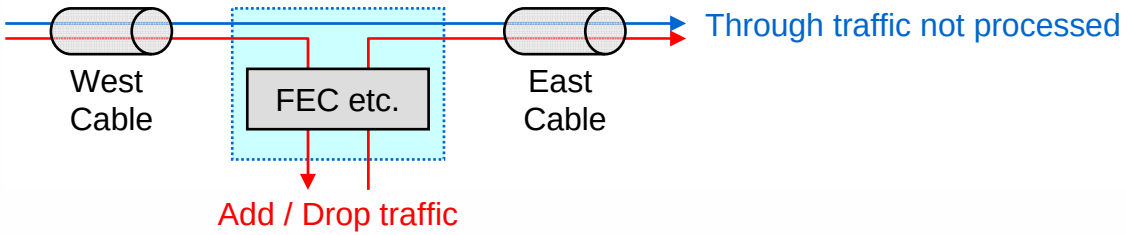


# Future developments

- **New interfaces e.g. 10GEthernet**
- **Better FEC – higher NCG**
  - ⇨ 10 dB already possible
- **New transmission formats**
  - ⇨ Improved performance
  - ⇨ Narrower channel spacing

Give possibility of adding further capacity

- **Add/Drop SLTEs to allow economic bypass**




- **Existing line design isn't suitable for 40 Gbit/s line-rate**
  - ⇨ 40 Gbit/s interfaces when native 40 Gbit/s used in terrestrial network

# Upgrades – summary

- **Well suited to today's economic/technical climate**
  - ⇨ Increasing interest and activity
- **Offer rapid, cost-effective capacity increases**
  - ⇨ No need to buy more capacity than is needed
  - ⇨ Extends the life of an expensive asset
  - ⇨ Optimises the point at which a new-build is required
- **Can be relatively pain-free, but need careful preparation and attention to detail**
- **In the future we can expect**

  **1 Further increases in capacity and new interfaces**

  **2 New architectures**