

# Working Group on Extending the life of Submarine Cable Systems

Dubai  
18th-21st April 2016

## Addressing Issues and Challenges

SubOptic Interim Activities

*Thanks for your voluntary support!*

Presenter: Keith Schofield (Moderator)

Company: Pioneer Consulting

Emerging Subsea Networks



Celebrating  
30  
years  
of SubOptic

## Presenter Profile



Keith has worked in the submarine cable industry since 1981, joining it at the dawn of the submarine fibre optic cable era. Initially working in optical cable development, process development and qualification, he moved on to project management at STC Submarine Systems. Later, Keith joined Cable & Wireless Network Services, handling design and implementation of numerous cable systems. In 2007 he joined Pioneer Consulting, advising project developers, manufacturers, cable owners and investors in the development and acquisition of both new and existing submarine cable network infrastructure, where he has been required to opine on both economic and technical lifetime predictions.

- Name: Keith Schofield
- Title: Managing Partner (Pioneer Consulting)
- Email: [k.schofield@pioneerconsulting.com](mailto:k.schofield@pioneerconsulting.com)

## Meet the Panellists



**Keith Schofield**

Managing Partner, Pioneer Consulting



**Francis Charpentier**

Head of Submarine Systems Deployment, Orange



**Carl Osborne**

Associate Vice President,  
International Network Development,  
Tata Communications



**José Chesnoy**

Independent Expert



**Tony Frisch**

SVP Repeaters and Branching Units, Xtera Communications

# Schedule for today

1. What's gone before – a description of what the working group considered
2. Commercial matters
3. Technical Matters
4. Questions & Answers

# Purpose of Group – *Greater Clarity on Issues*

- ***The move from regenerated submarine cable systems to optically amplified systems initiated a dramatic technological paradigm shift as the dream to upgrade capacity from the landing stations (without touching the submerged cable and repeaters) became a reality. With it came the tantalising prospect not only of upgrading but also extending the economic, technical and operational life of systems.***
- Today, as the early optically amplified systems continue to be upgraded and progress towards their design life, owners, suppliers and customers are developing ways confidently to assess the risks, extend the economic life of systems already in the water, and even to recover, redeploy and re-use systems. In the last two years, this cross-sectoral SubOptic Working Group of industry insiders has grappled with the issues that anyone thinking of upgrading, owning or taking capacity on an extended-life system needs to consider.
- ***There will be ample chance to quiz our panel to see if they can address what's on your mind. In this vibrant workshop we gather the experts, review the technical and commercial issues, answer your questions, and at the very minimum, our aim is that those who join us will emerge with greater clarity on the issues to be addressed, the challenges to be overcome, and maybe even a few answers!***

# Terms of Reference – *Consider the issues*

- a. ***What technical performance parameters can be reviewed by the owner in order to characterise system performance to date?***
- b. ***What commercial issues can be taken into consideration when seeking to assure owners and customers that system performance will remain acceptable?***
- c. ***What risks must be taken into consideration and how can these be mitigated?***
- d. ***In the absence of experience regarding the performance of systems whose life has already been extended, what predictions can be made through statistical methods with a reasonable level of confidence in order to characterise risk***  
***and assist owners in making an informed choice as to whether to extend the life of systems?***
- e. ***When additionally considering repositioning a system so its life can be extended by the incorporation of new submarine and/or terrestrial equipment:***
  - i. *How can the owner be assured that the system has been recovered without damage?*
  - ii. *How can the owner be comfortable that the system can be redeployed effectively?*
  - iii. *How is the system's performance with the new equipment verified?*

# Terms of Reference – Technical / Commercial

*Many submarine cable systems approaching 15 years in service will soon be reaching key decision points around rebuilding or upgrading and extending the system. There are various unique and important factors that need to be considered when looking at whether to extend the technical life of a system including:*

- a) Technical aspects - such as existing versus new technology, upgradeability, cable life, equipment, repeaters, laser pumps failure rates etc*
- b) Operational aspects - The people and support side. The O&M aspect and how to deal with this.*
- c) Commercial aspects - Contracts, landing party agreements licences etc (this may also suggest what should be done now for new builds to ensure options are retained in the future). The Sales factor; what to do with new vs existing contracts with different term dates.*
- d) Financial aspects - the accounting and tax treatments*

*e) Legal aspects - directors' and management's responsibilities and issues around payment of dividends and liability.*

*f) The working group will work by a combination of conference calls, occasional face-to-face-meetings and correspondence to agree actions, monitor progress, agree output, resolve difference and present its results (first to SubOptic EC, then to the wider cable community)*

*g) The Working Group will be inclusive in nature and agrees not to promote or discourage one particular method or solution related to the issue of extending cable system lifetimes. It agrees to encompass the needs of consortium, private and government-owned telecommunications systems.*

*h) The Working Group will be constituted and will operate in a non-commercial-way and in particular will seek not to harm competition in any part of the marketplace.*

# Deliverables and Achievements

**a. Drawing on the input from group participants, the working group will prepare a summary report (including, where possible, recommendations) covering its findings on each aspect of the scope.**

*- Result: three papers on related topics*

**b. Working Group will, upon successfully completing its goal, seek to prepare a presentation or panel session on this topic at SubOptic 2016**

*- Result: This session*

**c. SubOptic will publish the findings on its website and by other means (such as a magazine article or equivalent)**

*- Result: these slides as a permanent record*



# Rationale for extending cable system life

Presenter: Francis Charpentier

Company: Orange

## Presenter Profile



Francis Charpentier is the Head of the purchasing and deployment of submarine systems for Orange. He and his team take part actively to the Procurement Groups of many submarine cables (ACE, SMW3, SMW4, SMW5, IMW, SAT3/SAFE, LION1/2/3, TAT14, Americas-2, ECFS, CBUS).

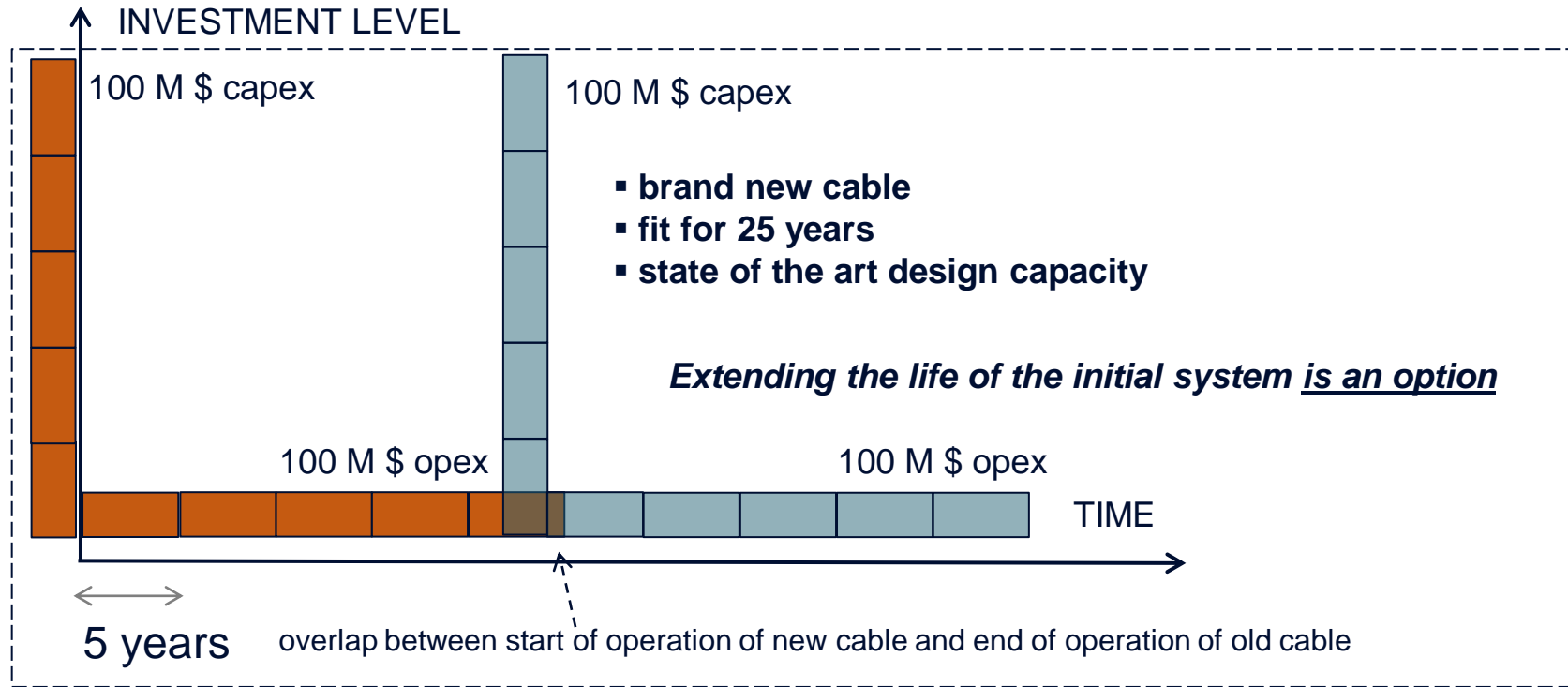
- Name: Francis Charpentier
- Title: Head of Submarine Systems Deployment (Orange)
- Email: [francis.charpentier@orange.com](mailto:francis.charpentier@orange.com)

# Rationale for extending cable system life

- Let's assume a system is near its end of life (25 years)
  - It is still in good working order: there is no sign of degradation, and we expect its **remaining life time** to be at least 5 more years
  - Its owners all want to continue operations
- It may be economically interesting:
  - to extend the system for the expected **remaining life time**
  - rather than build a new cable from scratch
  - in spite of the lower performance of the existing cable w.r.t. a brand new cable (eg smaller repeater bandwidth)

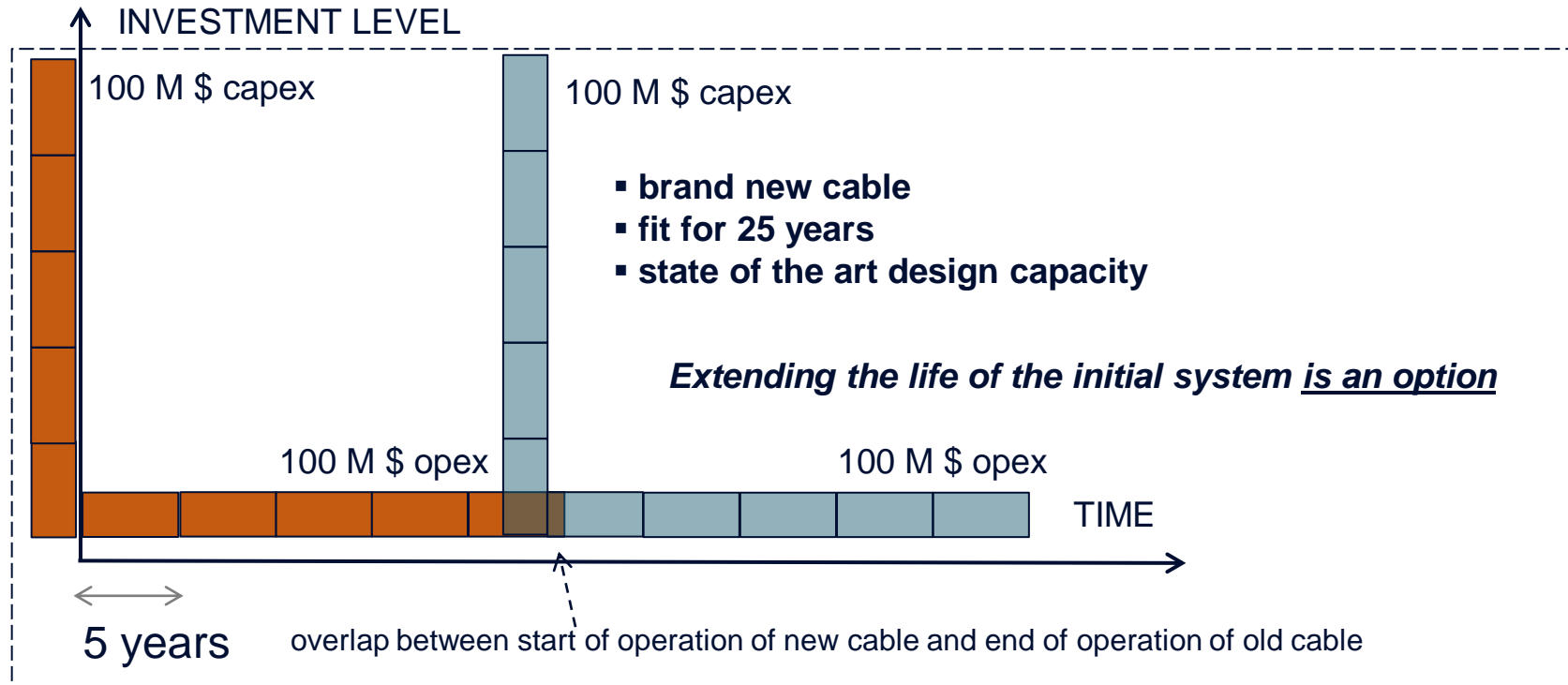
# Rationale for extending cable system life

## Investment profile for a building brand new cable



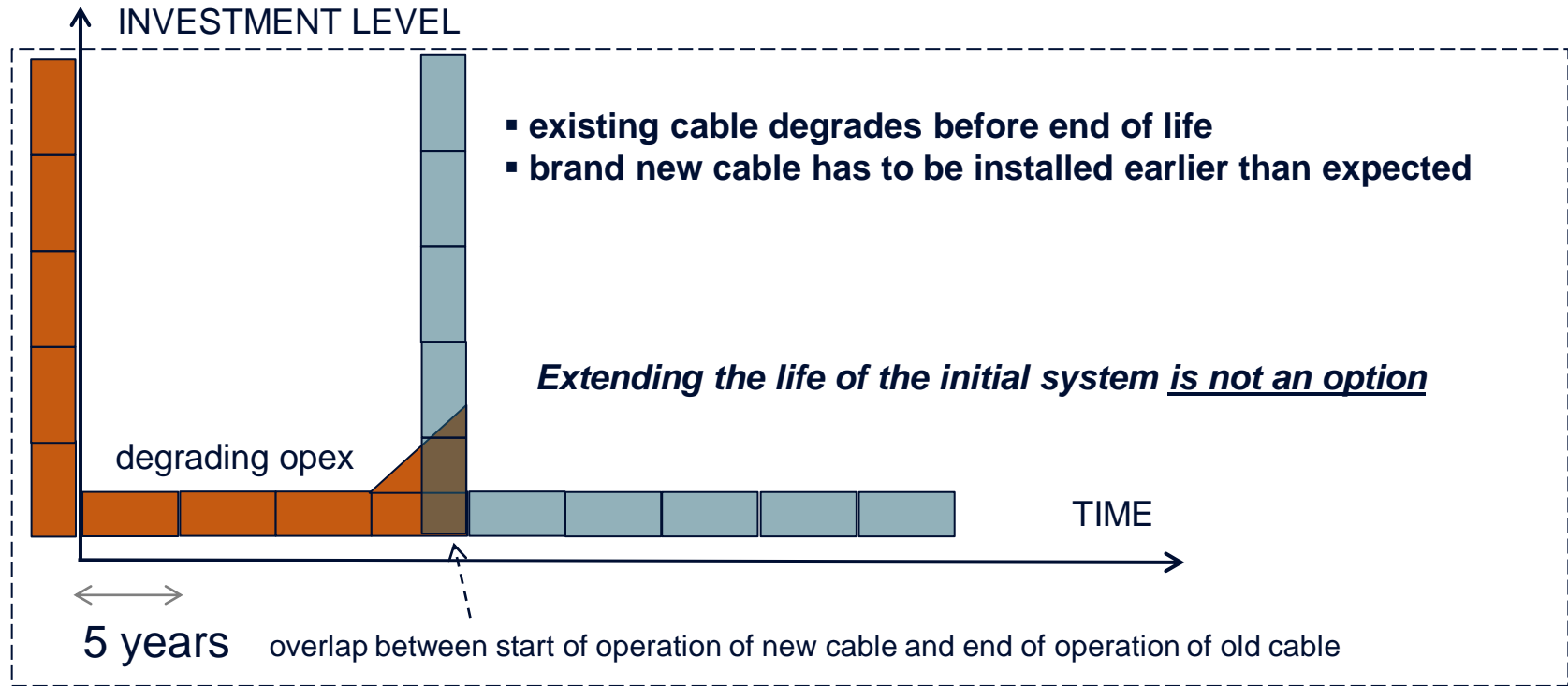
# Rationale for extending cable system life

## Investment profile for a building brand new cable



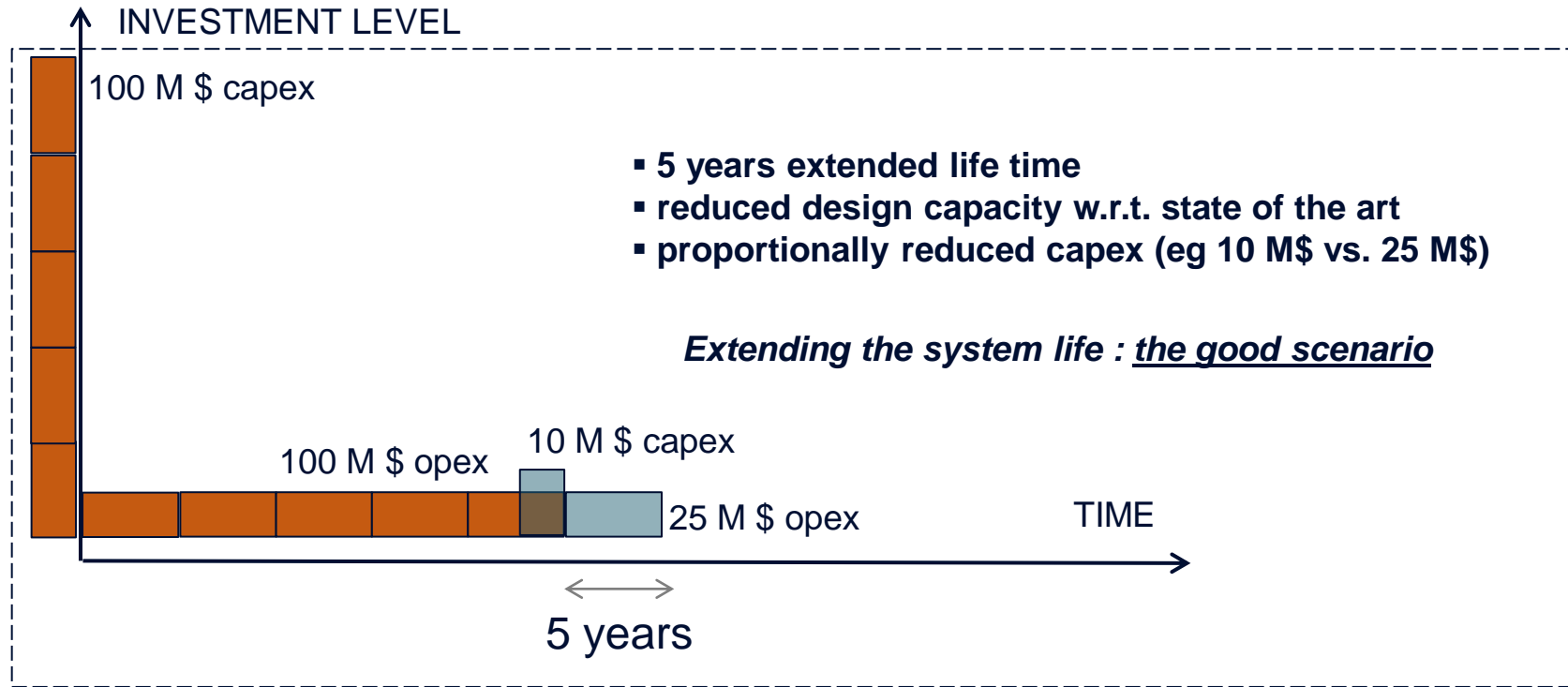
# Rationale for extending cable system life

## Early retirement of an existing cable



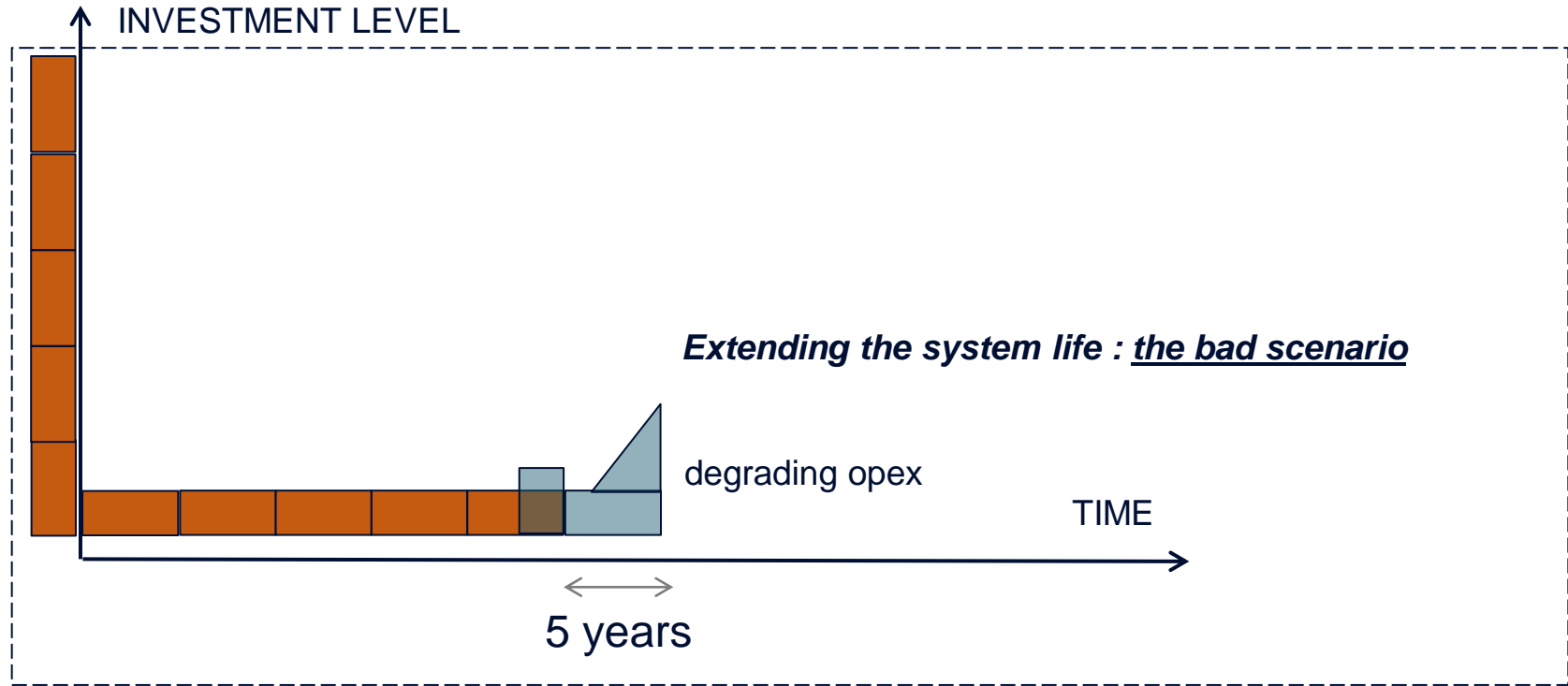
# Rationale for extending cable system life

## Investment profile for extending the life of a cable



# Rationale for extending cable system life

## Early retirement of an extended life cable





## Challenges:

- System (wet plant) must be in good working order after 25 years
- System (wet plant) must be well monitored to make sure there is no sign of degradation and to be capable to detect any in the future
- Aging system components (repeater, fibre) still allow for a competitive capacity unit cost in comparison with brand new cables
- Make sure critical spares are still available
- Buy a sufficient quantity of spares for the remaining life time
- Make sure the investment required (buy spares, etc) allows for a good business plan w.r.t. a brand new cable (e.g. 10 M\$ vs. 100 M\$)
- Extend the contracts

## Benefits:

- Simply extend the cable life time by continuing operations
- For the customers: avoids the effort to move to a new cable system.
- Avoid time lost in overlap with the construction of a brand new cable
- Reduced capex: just buy spares and pay fees for extending permits
- High investment into a brand new cable is pushed back by several years
- Definitely a green approach: resource depletion (building cable and new components, fuel for marine operations) is avoided for the duration of the life extension

# Commercial Considerations

Presenter: Carl Osborne

Company: Tata Communications

*(with acknowledgement to Francis Charpentier (Orange), Shota Masuda (NEC) and Maja Summers (Apollo SCS)).*





Carl Osborne is Associate Vice President, International Network Development for Tata Communications. As a member of the management team for the Global Network, Cloud & Data Centre Services line of business, Carl is responsible for establishing and implementing strategies for global network development and investments encompassing both private TGN cable systems and consortium cable systems.

Prior to joining Tata Communications, Carl worked at Cable & Wireless companies in a variety of International Network Planning and Carrier Sales roles. Carl is a graduate of the University of Warwick, with a Bachelors degree in Applied Mathematics and Business Studies.

- Name: Carl Osborne
- Title: Associate Vice President, International Network Development (Tata Communications)
- Email: [Carl.Osborne@tatacommunications.com](mailto:Carl.Osborne@tatacommunications.com)

## Contractual Arrangements:

1. With Providers to the cable system.
2. Between the cable system owners.



## Contractual - With Providers



- Governmental submarine cable landing licenses & permits
- Permit and/or lease for use of seabed in territories through which cable passes
- Permit and/or lease for use of seabed in landing country
- Permit and/or lease for use of beach landing area.
- Permit and/or lease for use of ocean ground bed area.
- Permit / Wavleaves for fronthaul infrastructure between beach and cable station.
- Permit and/or lease for cable station building & land.
- Permit / Wavleaves for any backhaul infrastructure.

## Contractual - With Providers

- Crossing Agreements (Cable / Pipeline / Concession)
- Agreements with Fisheries / other seabed users
- Vendor Support Agreement
- Marine Infrastructure Maintenance Agreement
- Terrestrial Infrastructure Maintenance Agreement



## Contractual – Between Owners

- Consortium System
  - » Construction & Maintenance Agreement
  - » Internal service providers: NOC / NA / CBP
- Private System
  - » Landing Party Agreements





## Challenges / Issues

- Contracts have differing durations and end dates.
- Sometimes no provision for extension.
- Whether to go for fixed duration extension or rolling extension?
- Will all parties agree to extension?
- Will any commercial / financial terms be impacted by extension?



# Technical Scope

Emerging Subsea Networks

Presenter: José Chesnoy  
Company: Independent Expert



## Presenter Profile



José Chesnoy graduated from Ecole Polytechnique in 1977. After receiving a PhD in 1981 in femto-second laser physics, he entered the French Centre National de la Recherche Scientifique (CNRS). In 1989, José joined Alcatel's research organization and worked in this area of the advent of amplified submarine cables.

Later in 1999 José became head of System Development in the Submarine Business Division, then extended into the Terrestrial Network Division. He then moved successively to development of terminal WDM equipment, submarine product management and technical offers, and became CTO of Alcatel-Lucent Submarine Networks until the end of 2014.

During the course of his technical career, José has been granted more than 50 patents in the field of fiber optics and was nominated a Bell Labs Fellow in 2010. He organized many international workshops, including the chair of the program committee for SubOptic 2004, and was editor of the first edition of the book "Undersea Fiber Communication Systems" in 2002 and with a second edition in 2015.

José Chesnoy is retired from Alcatel, but remains an active expert inside the ecosystem of the submarine cable community. He has been nominated Legal Expert at the Paris court in 2015.

- Name: José Chesnoy
- Title: Independent Expert
- Email: [jose.chesnoy@free.fr](mailto:jose.chesnoy@free.fr)

## Three areas for cable lifetime extension:

1. **extend life by providing extra system margins**
2. extend life by recovering and relay on another route
3. extend the working life above the 25 years design life

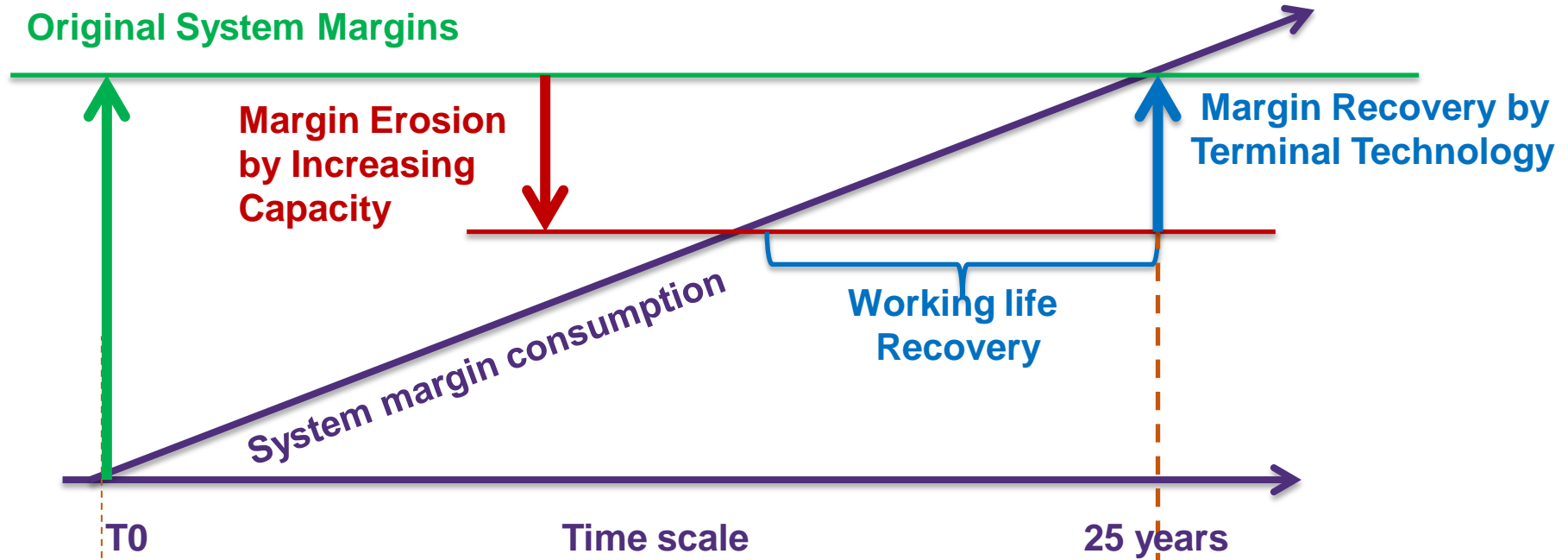
# 1-extend life by providing extra system margins

- Margins are consumed more or less regularly during cable system design life
  - By fiber ageing
  - By component ageing
  - By cable repair
- High performance terminal can provide extra capacity and/or extra margins
  - Power budget can be balanced between higher capacity and higher system margins
  - Coherent submarine terminals can share extra margins between higher capacity and higher margins

# 1-extend life by providing extra system margins

- Margin consumption vs upgrade

## Original System Margins



# 1-extend life by providing extra system margins

- Margin recovery done today by coherent SLTE during upgrades
  - it helps to increase capacity and to keep margins for future events
- But getting **extra margins does not mean extending the design life !**
  - “wear out” will happen in any case
  - In addition some failures or degradations will lead to margin erosion that may not be compensated by SLTE, but only by an action on wet plant, ie:
    - Tilt accumulation by failures, attenuations, repairs,...
    - Pump failures on successive repeaters

## Three areas for cable lifetime extension

1. extend life by providing extra system margins
2. **extend life by recovering and relay on another route**
3. extend the working life above the 25 years design life



## 2- extend life by recovery and relay on another route

- Recovery of a system can be motivated by:
  - A trunk cable that ends its business life and becomes too low capacity for a given route, but still fair capacity for a shorter distance regional application
- Advantage of cable recovery and relay
  - Up to around 50% savings compared to a new system
    - Limited by marine costs (recovery + relay)

## 2- extend life by recovery and relay on another route

- Possible limits of cable recovery and relay
  - Hidden cost may arise from need to rebuild armoured cables
  - Ultimate capacity will be limited compared to a new system
- Questionable contractual support by the original cable supplier
  - A cable is designed for a given route.
  - A relayed cable will be under completely new maintenance conditions
- After relay, what becomes:
  - Design life ?
  - FIT rates ?

## 2- extend life by recovery and relay on another route

- Optimum application cases:
  - Relay on a shorter system than original
  - Relay on a route with no or few armouring
  - Relay on a low capacity demand route
  - Availability of spares from the original system
- Not forgetting commercial questions concerning after sales
  - After sales support by the wet plant supplier?
  - Relevance of the technical specification after relay?

## Three areas for cable lifetime extension

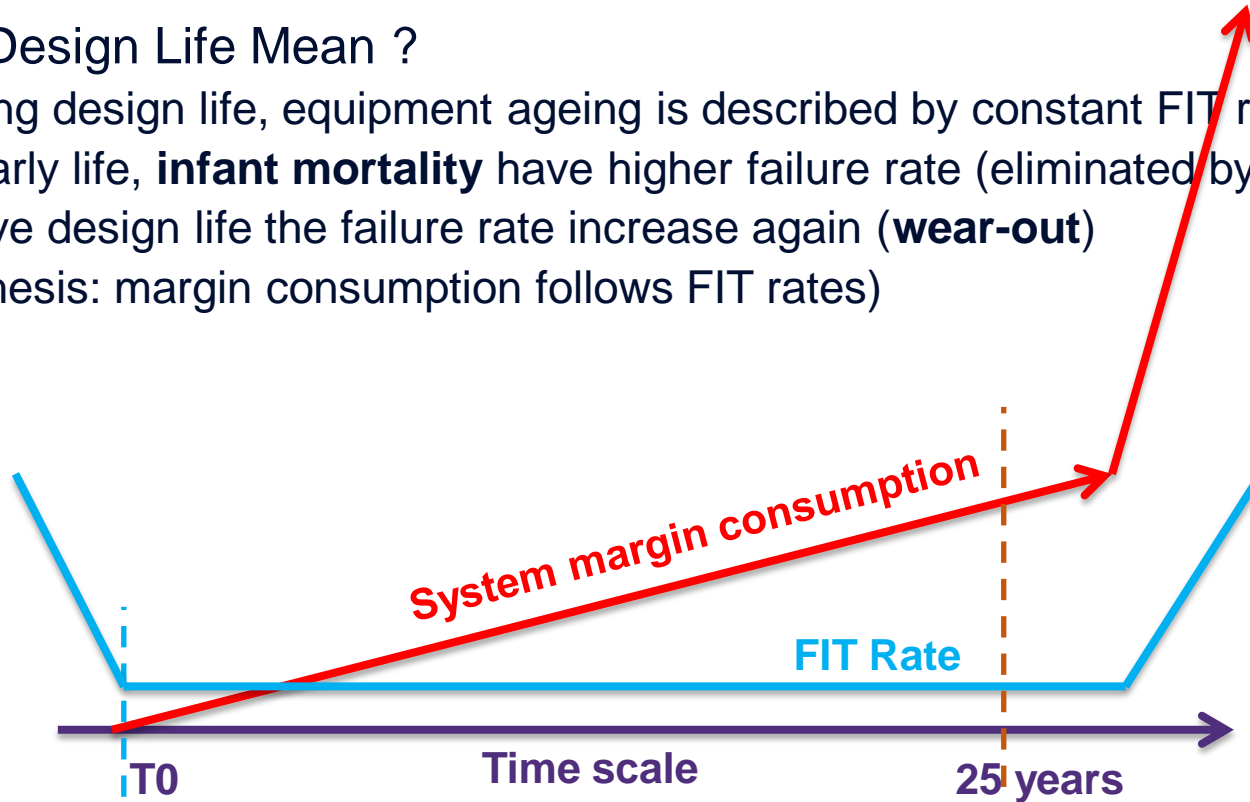
1. extend life by providing extra system margins
2. extend life by recovering and relay on another route
3. **extend the working life above the 25 years design life**

### 3- extend the working life above the 25 years design life

- The more interesting question ?
  - Pre-EDFA systems were obsolete much before 25 years
  - Amplified systems have a design capacity increasing with terminal technology
- **A amplifier system designed 15 years ago is far from obsolete:**
  - have a present ultimate capacity 10 times its design capacity
    - ie. Design in 2000 for 64x10G -> transporting today 64x100G !
  - Have a present ultimate capacity only 2 times below present designs ie:
    - Year 2000 design transports today 7 Tbit/s over transatlantic
    - Year 2014 design transports ~12 Tbit/s over transatlantic
- **A wet plant designed in years 2000 can stay competitive during more than 10 years again....**
  - In case it survives after its design life !!!

### 3- extend the working life above the 25 years design life

- What Design Life Mean ?
  - During design life, equipment ageing is described by constant FIT rates
  - At early life, **infant mortality** have higher failure rate (eliminated by screening)
  - Above design life the failure rate increase again (**wear-out**)(Hypothesis: margin consumption follows FIT rates)



### 3- extend the working life above the 25 years design life

- wear-out mechanisms have many possible origins:
  - Active optical components: the more obvious being pumps,
  - Passive optical components (alignments, glue, coatings,...)
  - Active electronic components (low and high voltage)
  - Passive electronic components (low and high voltage)
  - Mechanical (water ingress, joints robustness,...)
  - Hydrogen or water effects (ie on fibre attenuation)
  - Corrosion (that will prevent recovery)
  - Insulation ageing (that will induce electrical breakdown)
- Wear out is unplanned...

### 3- extend the working life above the 25 years design life

- Why design life is today 25 years ?
  - Wet plant suppliers are qualifying technologies and components to keep FITs acceptable at 25 years for all items
  - Accelerated ageing burn-in stops when extrapolated life is > 25 years
  - Cost of qualification is directly linked to the committed design life (number of samples, accelerated ageing time)
  - Wet plant supplier commitment is based on the 25 years design life based on their qualification
  - Supplier commit to repair during the 25 years design life...



### 3- extend the working life above the 25 years design life

- How to cope technically with this 25 years lifetime approach ?
  - Be ready to replace the cable in case of accelerated ageing, or to move capacity on other cables...
  
- **How to get an early warning to get more time to react ?**
  1. Keep unallocated margins to tolerate unexpected events
  2. Keep additional spares of key specific equipment since they may no longer be built after contractual 25 years (repeaters, BU, cable, joints,...)
  3. Improve the preventive maintenance plan
    - The same idea than for medical check-ups!
    - Keep a closer eye on early symptoms

### 3- extend the working life above the 25 years design life

- **Early warning from a preventive maintenance plan**
  - Do measurements with higher precision and shorter periods to identify early trends
  - Measure all losses: spans, repeater inputs/outputs, internal equipment losses
  - Analyze all recorded failures in detail (component, material,...)
    - and put in place specific future measurements based on result
  - Measure OSNR versus wavelengths with a reference comb
  - Record detailed COTDR traces and compare them along time
    - Including wavelength information induced by local tilt (**refer to Wednesday session “managing system lifetime”**)

# Pumps

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Will they last more than 25 years?

Presenter: Tony Frisch  
Company: Xtera Communications

*(with acknowledgments to J Chesnoy, S Dawe,  
S Desbruslais, P Lancaster, P Murphy and D Welt*

Emerging Subsea Networks



Celebrating  
30  
years  
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## Presenter Profile



Tony Frisch started at BT's Research labs and then moved to Alcatel Australia, becoming involved in testing submarine systems. A move to Bell Labs gave him experience in terminal design and troubleshooting, after which he went back to Alcatel France, where he worked in Alcatel Submarine Networks' Technical Sales before moving to head Product Marketing. He is now SVP, Repeaters and Branching Unit for Xtera Communications.

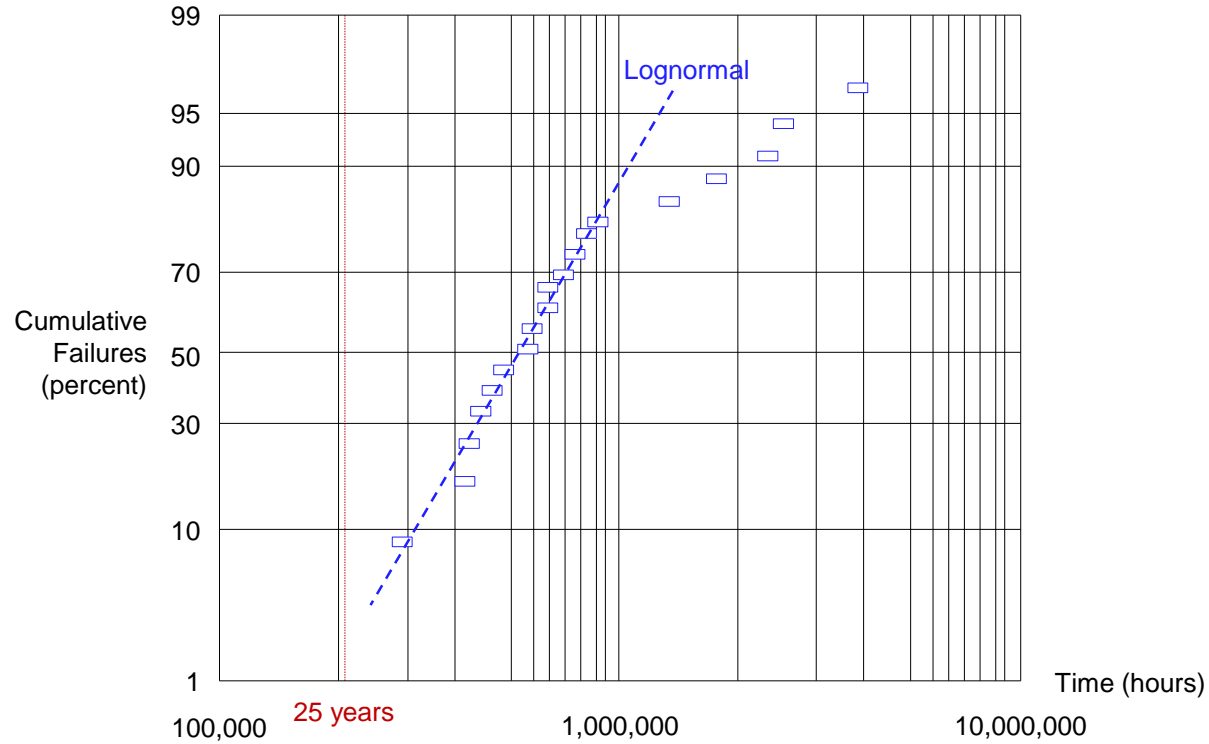
- Name: Tony Frisch
- Title: SVP Repeaters and Branching Units (Xtera Communications)
- Email: [Tony.Frisch@xtera.com](mailto:Tony.Frisch@xtera.com)

# Why pump lasers?

- They will wear out eventually
- High power and current density
- History of 980 nm sudden failures
- Repair will be difficult well outside warranty  
Replacement with a newer unit could be an option?
- Other components appear quite reliable  
No obvious reasons for failure once on sea-bed

# How do they fail – theory

- Lognormal statistics a fair approximation
- Life-test data based on temperature acceleration
- Suggests >25 years if most pumps are at low temperature
- Accumulates gradually



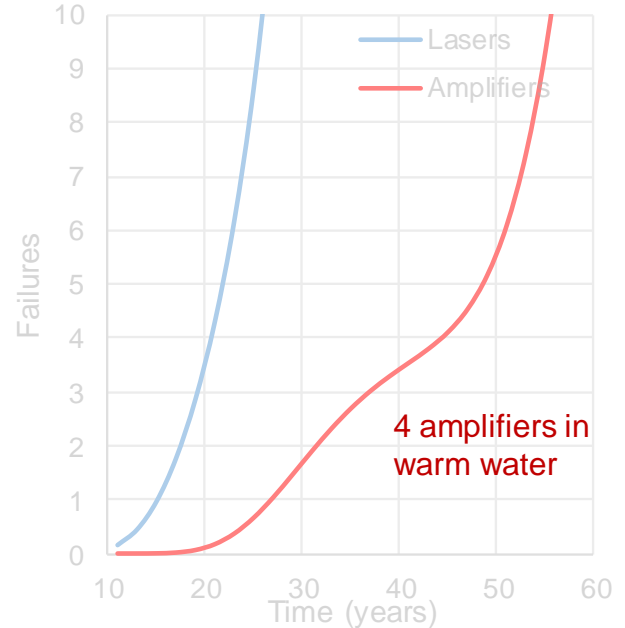
# How do they fail – experience

- Two classes of pump in older systems
  1. Bad pumps (or circuitry)    lots of failures  
   especially during power-up/down
  2. Good pumps                            almost no failures during 15-20 years
- Quite easy to tell which type you have

# What might happen – large system

- Predictions are very difficult – particularly when they concern the future!  
[ Y Berra, N Bohr ]
- Depends on water temperature, pump power, number of amplifiers ... and pump redundancy
- The first pump failure is never fatal, but after several pump failures it is likely that an amplifier will no longer work
- Best estimate – in reality there will be statistical scatter

500 amplifier-pairs  
4 pumps / amplifier-pair

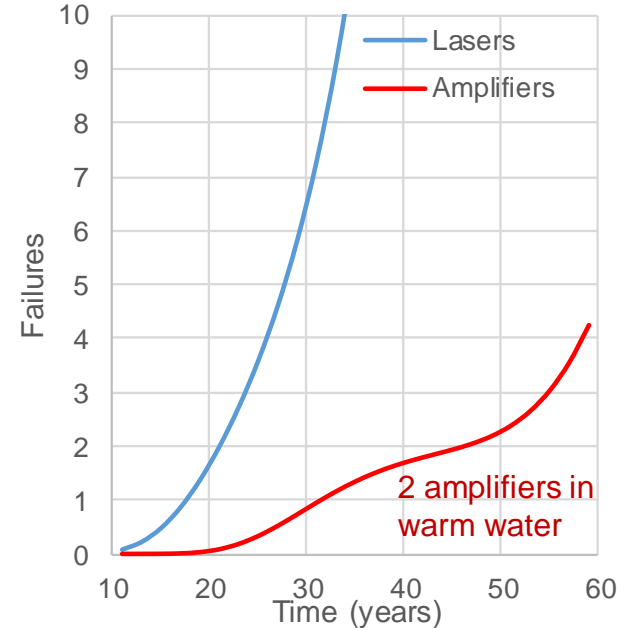




# What might happen – smaller system

- Should be fewer pump failures
- Higher chance that a failed pump will kill an amplifier
- What-if? computation NOT Prediction

100 amplifier-pairs  
4 pumps / amplifier-pair



# Summary

- Extension generally for systems with "good" pumps only
- Behaviour will vary a lot from system to system  
Size, temperature, power [a possible way to extend lifetime?](#)
- Redundancy makes system failure relatively slow  
Can observe effects of first few failures and extrapolate
- Some cause for optimism, but remember
- "Predictions are very difficult ..."

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