

The work leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 249025.



G-PON migration to new technologies

Field tests in ■ ■  Slovak Telekom G-PON network

Life is for sharing.



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Target

The **goal** of this initiative is to test migration scenarios from GPON to new technology of access network in real field implementation for the following target scenarios:

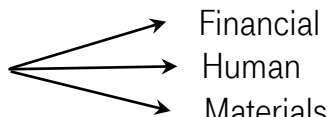
- Co-existence new technology with GPON in common passive network
- Pure new technology

Subject of migration was not implementation to OSS/BSS .

Migration way consist:

- Basic Lab tests and configuration 3PP services (voice, data, TV)
- Field installation including four friendly customers connected
- Configuration setup
- Functionality tests

Expected migration **outcome**:

- Time
 - Resources
- 
- ```
graph LR; Resources --> Financial; Resources --> Human; Resources --> Materials;
```

# Initialization setup - technology



## OLT

### Huawei MA5600T GPON

- 16 × slots for services cards (positions 1-8 a 11-18)
  - 64/128 aggregates (4/8 per card)
- Uplink up to 4x10Gbps
- Dynamic range 28/32dB (B+/C+)
- Maximal splitting ration 1:128
- Range for 1:64 splitting ration and C+ card - 20km



## ONT

### Huawei

- both devices are deployed in network
- they provide interfaces for connection of home network devices – Internet router, STB for IPTV service, IP phones
- they also provide analogue interfaces for connection of legacy telephones

HG850



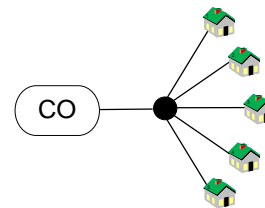
HG850a



# Initialization setup - configuration

## Structure of network:

Point - to - MultiPoint

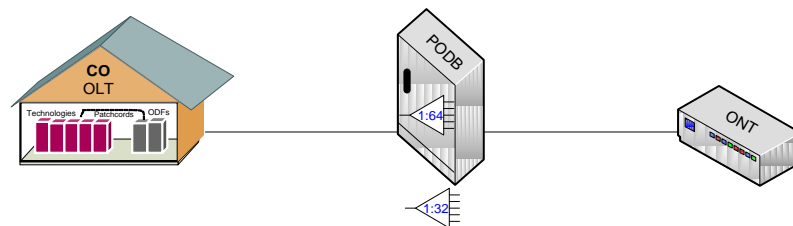


## Splitting ration:

1:64 (preferred), in some case 1:32 (extend reach reason for 354HHs)

## No. of splitting stages:

1 (preferred), in some cases used 2 stages for rural area - long drop fibre



## Distribution points:

PODB are outdoor street cabinets (in some case are located inside)

## Technology:

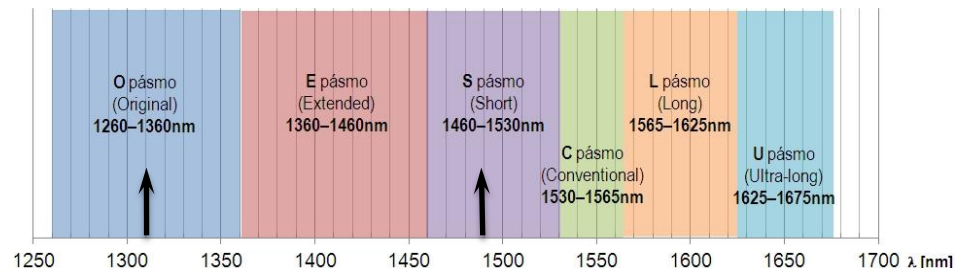
G-PON according to



ITU-T G.984

## Configuration:

2,5GB/1,25GB (down/up),  
1490nm / 1310nm (down/up),  
1550nm is not used



## Services:

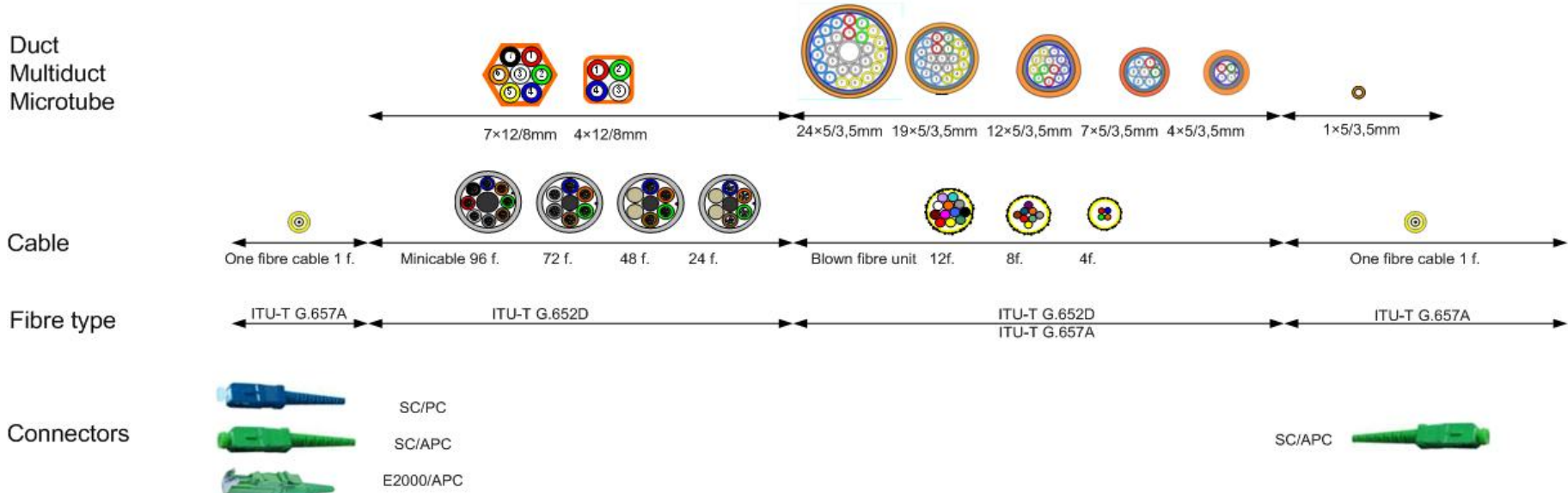
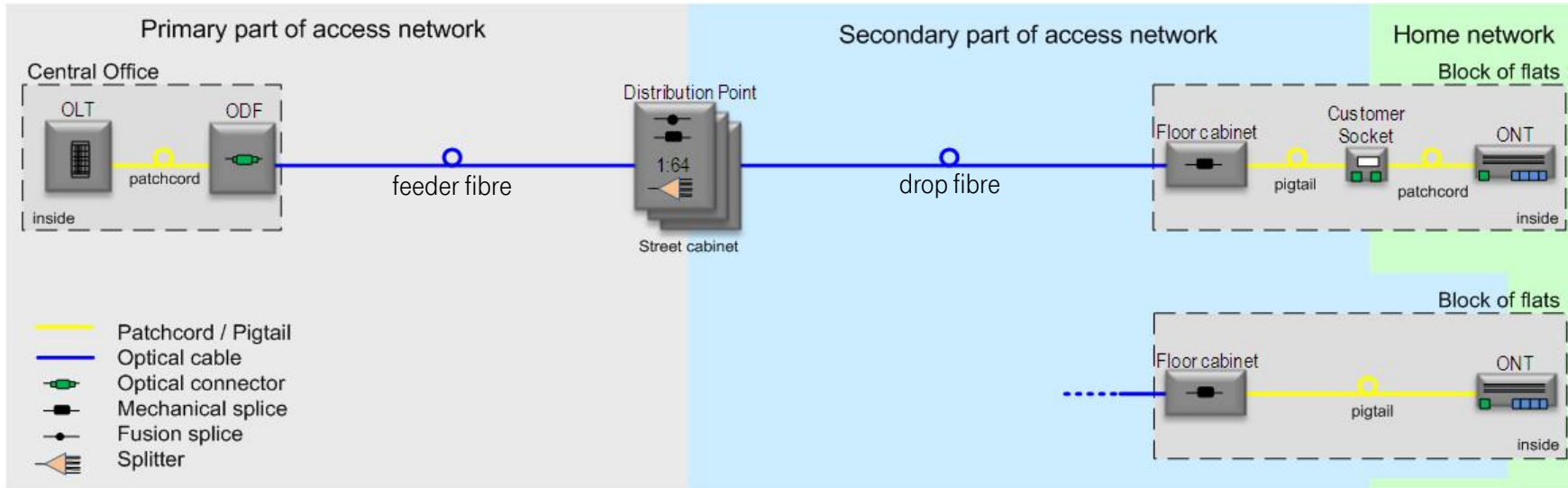
3PP (video - IPTV, voice, data) + services with added values

### Present status (end of May 2012) - statistical network parameters

|                  |             |                            |               |                         |              |
|------------------|-------------|----------------------------|---------------|-------------------------|--------------|
| Home passed:     | 360ths. HHs | OLT aggregate utilization: | ≈49%          | No. of splitters :      | 1975 pcs.    |
| Home connected:  | 55ths. HHs  | No. of PO DBs:             | 1610 pcs.     | No. of splitting ports: | 121 089 pcs. |
| HHs Penetration: | ≈15%        | No. of OLT site:           | 60 localities |                         |              |



# Initialization setup - network



## OLT

### LG-Ericsson **EAST1100** WDMPON

8 service slots: for PON, CES, and Eth. Interface cards

2 Switch slots: for Switch/Network Interface card

Up to 8 SFP+ uplinks (GE/10GE) per Switch card

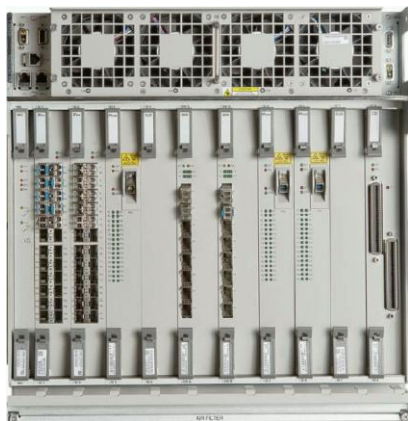
32 wavelength / 100M PON card

- 16/32 wavelength / 1G PON card
- up to 8 PON IF cards per shelf

Downstream 1573-1600nm – 100GHz channel interval

Upstream 1533-1559nm -- 100GHz channel interval

Range 20km



## ONT

### LG-Ericsson

100Mbit/s US/DS symmetrical WAN, plug and play colourless optics

4x10/100BT LAN, POTS

Comprehensive Service Mappings: 802.1q, QiQ

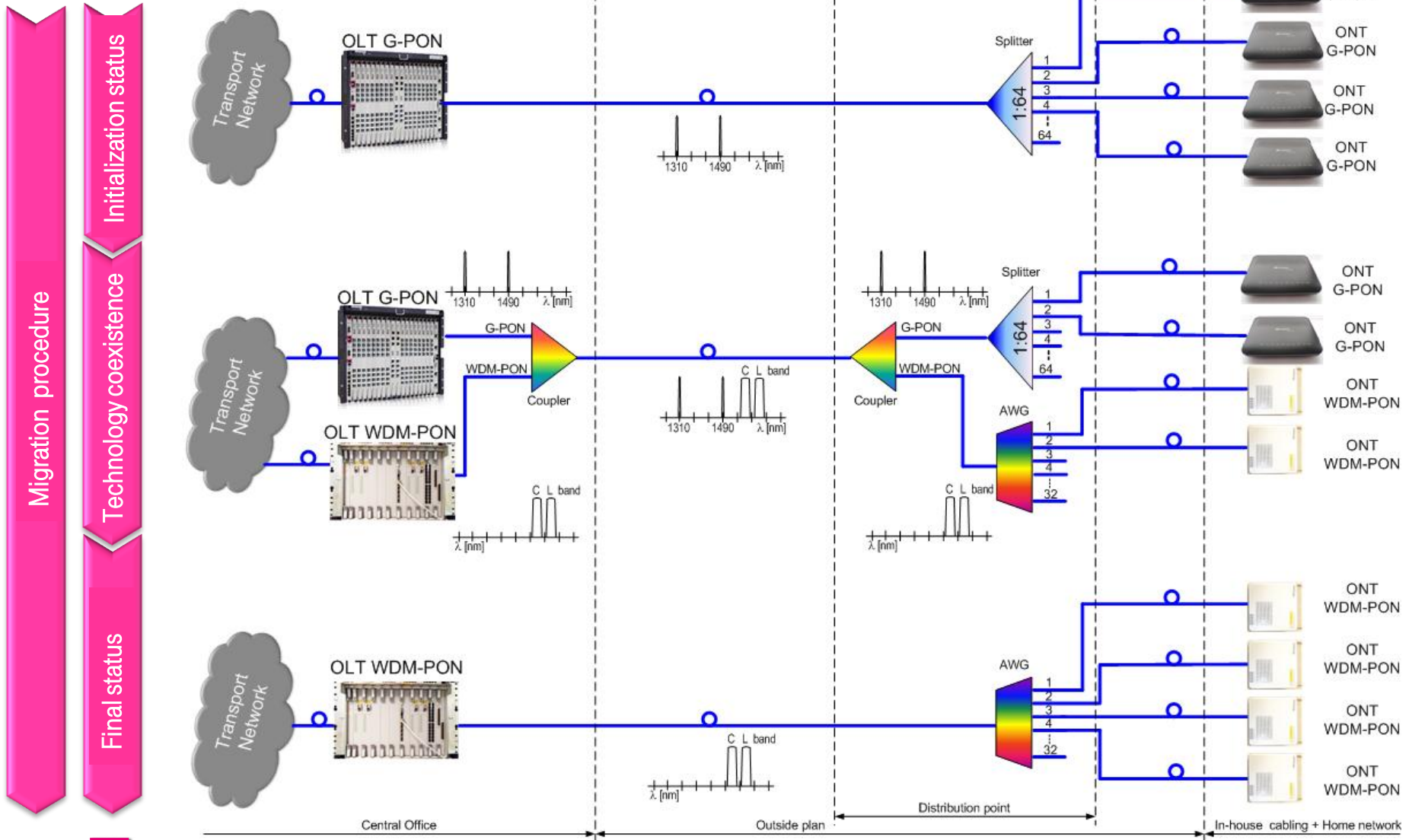
Advanced QoS and Classification Capabilities

Dying gasp & Ethernet OAM

### EARU 1212 – residential ONT



# Migration procedure WDM-PON

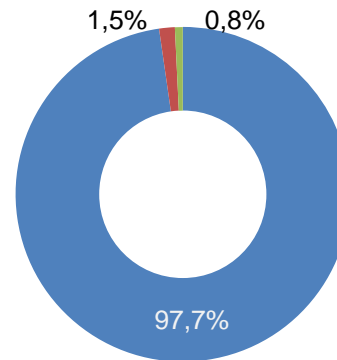




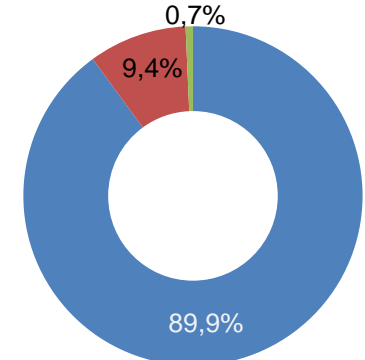
# Outcome WDM-PON; Time consumption - migration phases

| Phase                  | Location       | Tasks                                   |
|------------------------|----------------|-----------------------------------------|
| Preparation procedures | Laboratory     | OLT commissioning, configuration        |
|                        |                | ONT configuration                       |
|                        |                | Connectivity tests & service simulation |
|                        |                | Coexistence tests GPON/WDM PON          |
|                        |                | AWG & Coupler examination               |
|                        |                | Throughput, latency, frame loss tests   |
| Coexistence            | Street cabinet | AWG & Coupler installation              |
|                        |                | Customer migration                      |
|                        |                | Documentation & administration          |
|                        | Central office | Patchcords/cabling preparation          |
|                        |                | GPON disconnection                      |
|                        |                | Coupler installation                    |
|                        |                | WDM PON & GPON connection               |
|                        |                | Documentation & administration          |
| Pure WDM PON           | Street cabinet | Coupler dismantling                     |
|                        |                | Power splitter dismantling              |
|                        |                | Documentation & administration          |
|                        | Central office | Coupler dismantling                     |
|                        |                | Disable GPON aggregate port OLT         |
|                        |                | Documentation & administration          |

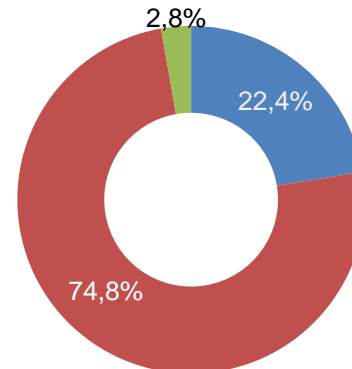
| One customer                 |       |
|------------------------------|-------|
| Phase                        | hours |
| Preparation procedures       | 84,00 |
| Coexistence GPON and WDM PON | 1,30  |
| Pure WDM PON                 | 0,65  |



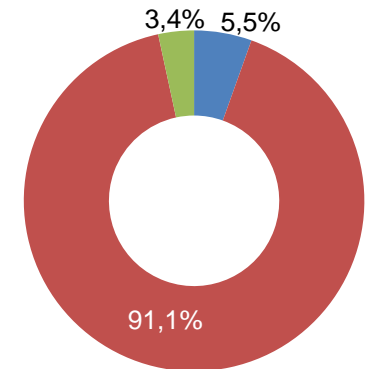
| 32 customers                 |       |
|------------------------------|-------|
| Phase                        | hours |
| Preparation procedures       | 84,00 |
| Coexistence GPON and WDM PON | 8,75  |
| Pure WDM PON                 | 0,65  |



| 1 024 customers              |        |
|------------------------------|--------|
| Phase                        | hours  |
| Preparation procedures       | 84,00  |
| Coexistence GPON and WDM PON | 298,00 |
| Pure WDM PON                 | 12,40  |



| 5 120 customers              |          |
|------------------------------|----------|
| Phase                        | hours    |
| Preparation procedures       | 84,00    |
| Coexistence GPON and WDM PON | 1 480,00 |
| Pure WDM PON                 | 72,00    |



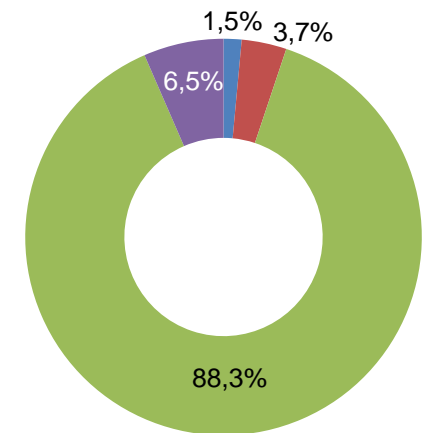
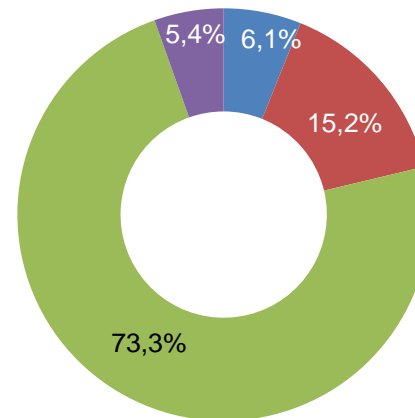
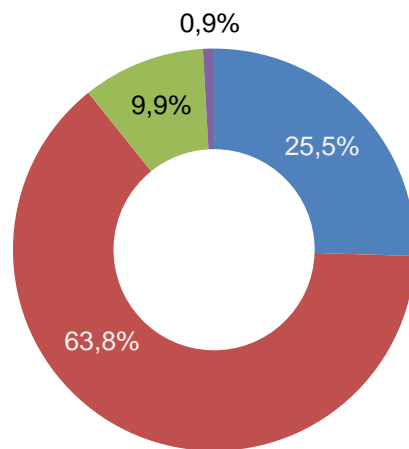
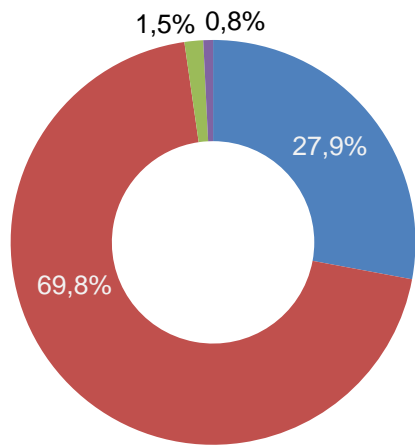
# Outcome WDM-PON; Time consumption – skills/knowledge of staff

| One customer     |       |
|------------------|-------|
| Skills/Knowledge | hours |
| Expert           | 24,00 |
| Engineer         | 60,00 |
| Technician       | 1,28  |
| Support          | 0,67  |

| 32 customers     |       |
|------------------|-------|
| Skills/Knowledge | hours |
| Expert           | 24,00 |
| Engineer         | 60,00 |
| Technician       | 9,28  |
| Support          | 0,83  |

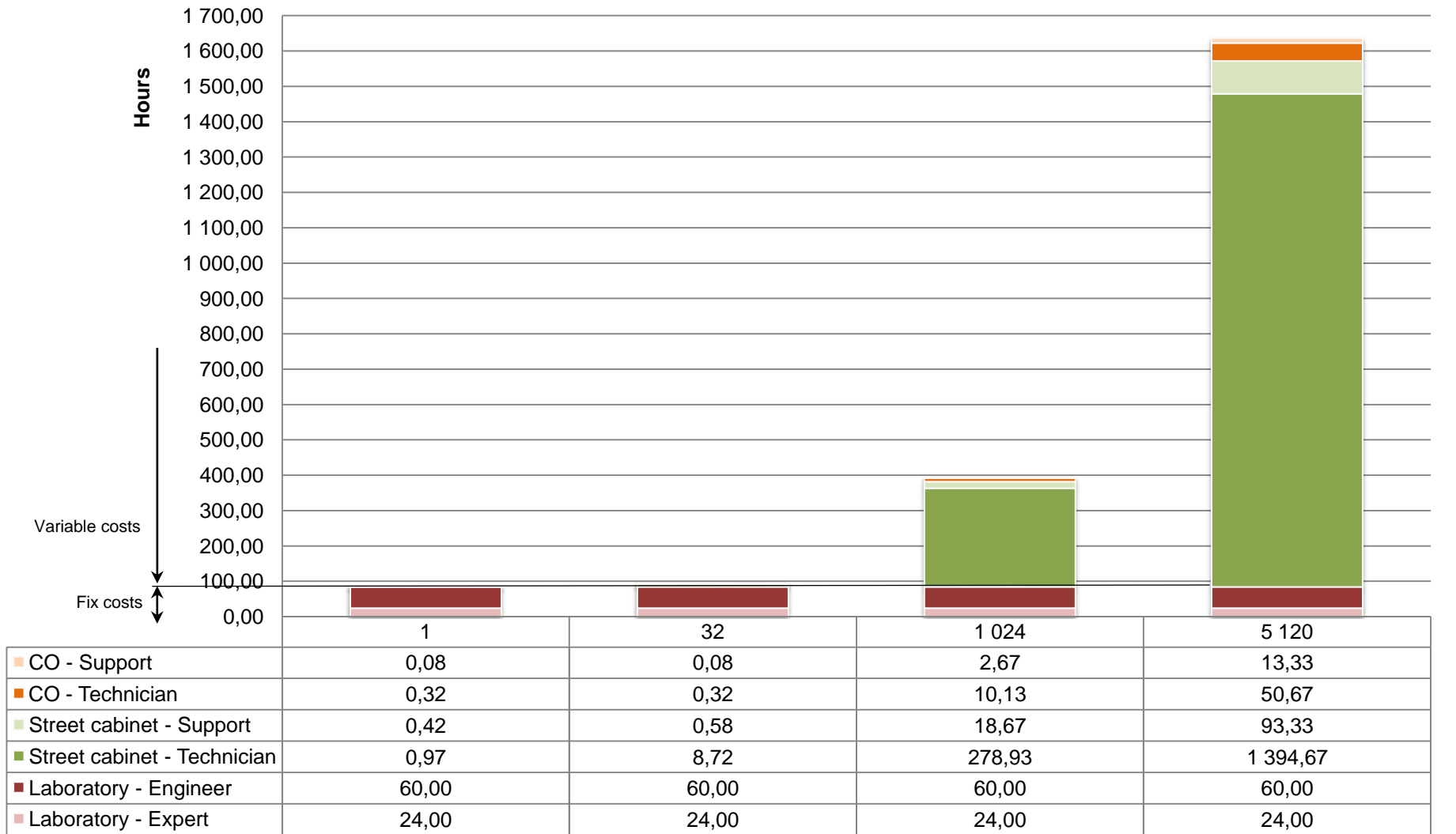
| 1 024 customers  |        |
|------------------|--------|
| Skills/Knowledge | hours  |
| Expert           | 24,00  |
| Engineer         | 60,00  |
| Technician       | 289,33 |
| Support          | 21,50  |

| 5 120 customers  |          |
|------------------|----------|
| Skills/Knowledge | hours    |
| Expert           | 24,00    |
| Engineer         | 60,00    |
| Technician       | 1 446,67 |
| Support          | 106,83   |



Remark: Time consumption for travelling and logistic are not included.

# Outcome WDM-PON; Time consumption according to skills/knowledge staff



# customers



# Migration technology TWDM-PON

|                             | Operator requirements of NG-PON2                     | 40G-PON                                                  |
|-----------------------------|------------------------------------------------------|----------------------------------------------------------|
| Co-existence                | Co-exist with legacy PONs on the same ODN            | Same ODN as G-PON/XG-PON1                                |
| ONUs per feeder             | ≥ 1:64 split ratio                                   | 20km reach + 1:512 split ratio                           |
| Fiber reach                 | ≥ 40km fiber reach                                   | 60km reach + 1:32 split ratio                            |
| Provisioning and Management | It is important that the deployed ONUs are colorless | Colorless ONU                                            |
| Capacity                    | DS: 40G,US:10G                                       | DS: 4*10G , US: 4*2.5G                                   |
| Open access                 | Optional                                             | Wavelength stacking                                      |
| Service                     | TBD                                                  | Dynamic wavelength management                            |
| Power budget                | TBD                                                  | 38dB(DS: Tx=+10dBm,Rx=-28dBm;<br>US: Tx=+2dBm,Rx=-36dBm) |

OLT



ONT

MA 5612 prototyp ONT



MA 5616 prototyp ONU



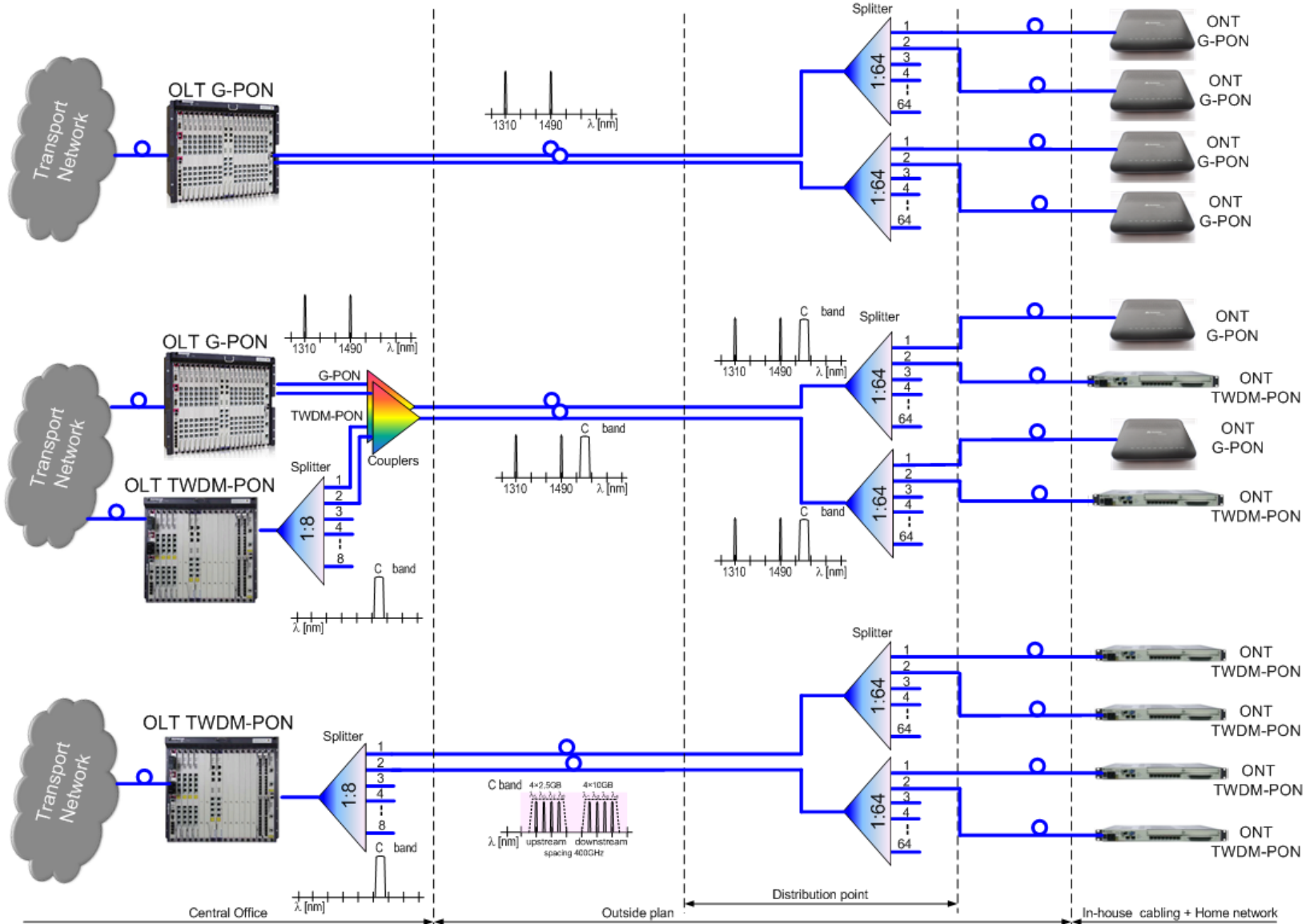
Standardization status: ITU-T Q2: 2011/2012, G.multi (MAC for 40G TWDM-PON) standard project was approved and may complete in the end of 2012.

# Migration procedure TWDM-PON

Migration procedure

Technology coexistence

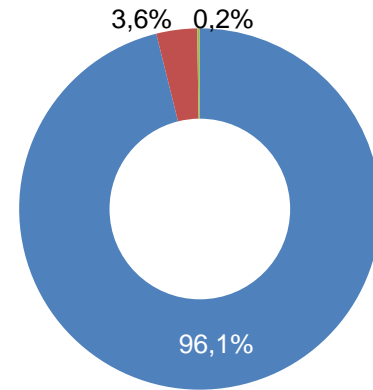
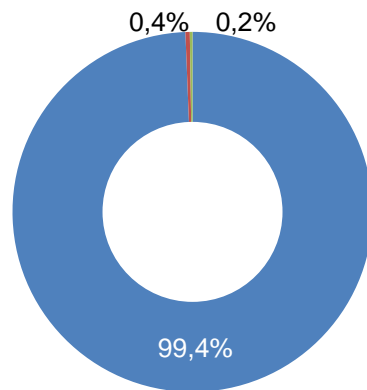
Final status



# Outcome TWDM-PON; Time consumption - migration phases

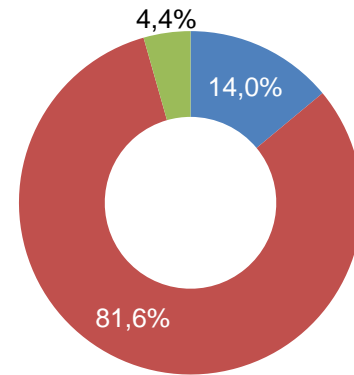
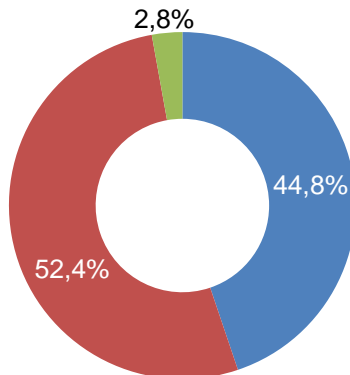
| One customer                 |       |
|------------------------------|-------|
| Phase                        | hours |
| Preparation procedures       | 76,00 |
| Coexistence GPON and WDM PON | 0,30  |
| Pure WDM PON                 | 0,18  |

| 32 customers                 |       |
|------------------------------|-------|
| Phase                        | hours |
| Preparation procedures       | 76,00 |
| Coexistence GPON and WDM PON | 2,88  |
| Pure WDM PON                 | 0,18  |



| 1 024 customers              |       |
|------------------------------|-------|
| Phase                        | hours |
| Preparation procedures       | 76,00 |
| Coexistence GPON and WDM PON | 88,80 |
| Pure WDM PON                 | 4,80  |

| 5 120 customers              |        |
|------------------------------|--------|
| Phase                        | hours  |
| Preparation procedures       | 76,00  |
| Coexistence GPON and WDM PON | 444,00 |
| Pure WDM PON                 | 24,00  |



| Phase                                 | Location       | Tasks                                   |
|---------------------------------------|----------------|-----------------------------------------|
| Preparation procedures                | Laboratory     | OLT commissioning, configuration        |
|                                       |                | ONT configuration                       |
|                                       |                | Connectivity tests & service simulation |
|                                       |                | Coexistence tests GPON/TWDM PON         |
|                                       |                | Coupler examination                     |
| Throughput, latency, frame loss tests |                |                                         |
| Coexistence                           | Central office | Patchcords/cabling preparation          |
|                                       |                | GPON disconnection                      |
|                                       |                | Coupler installation                    |
|                                       |                | TWDM PON & GPON connection              |
|                                       |                | Documentation & administration          |
| Pure TWDM PON                         | Central office | Coupler dismantling                     |
|                                       |                | Disable GPON aggregate port OLT         |
|                                       |                | Documentation & administration          |



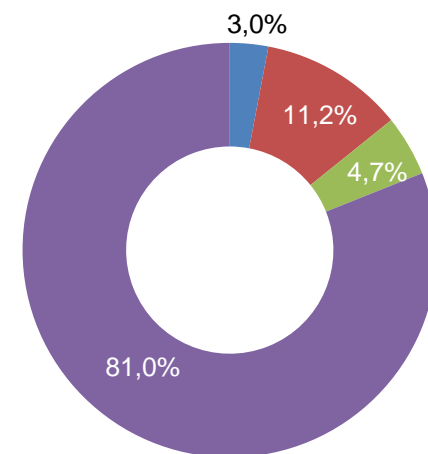
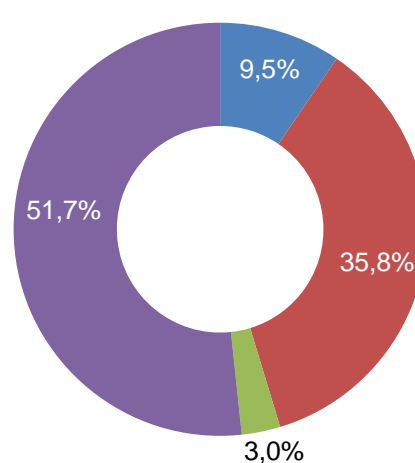
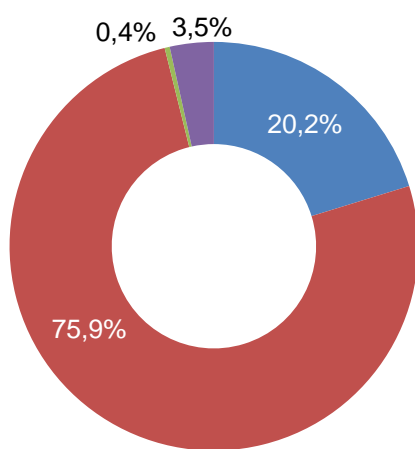
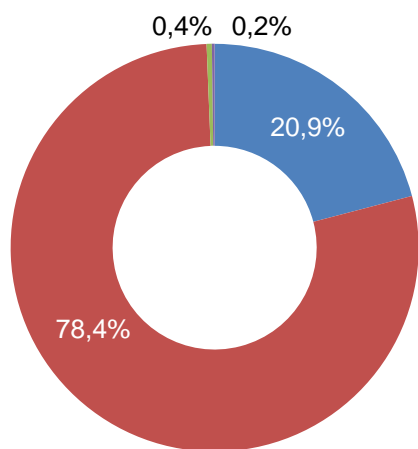
# Outcome TWDM-PON; Time consumption – skills/knowledge of staff

| One customer     |       |  |
|------------------|-------|--|
| Skills/Knowledge | hours |  |
| Expert           | 16,00 |  |
| Engineer         | 60,00 |  |
| Technician       | 0,32  |  |
| Support          | 0,17  |  |

| 32 customers     |       |  |
|------------------|-------|--|
| Skills/Knowledge | hours |  |
| Expert           | 16,00 |  |
| Engineer         | 60,00 |  |
| Technician       | 0,32  |  |
| Support          | 2,75  |  |

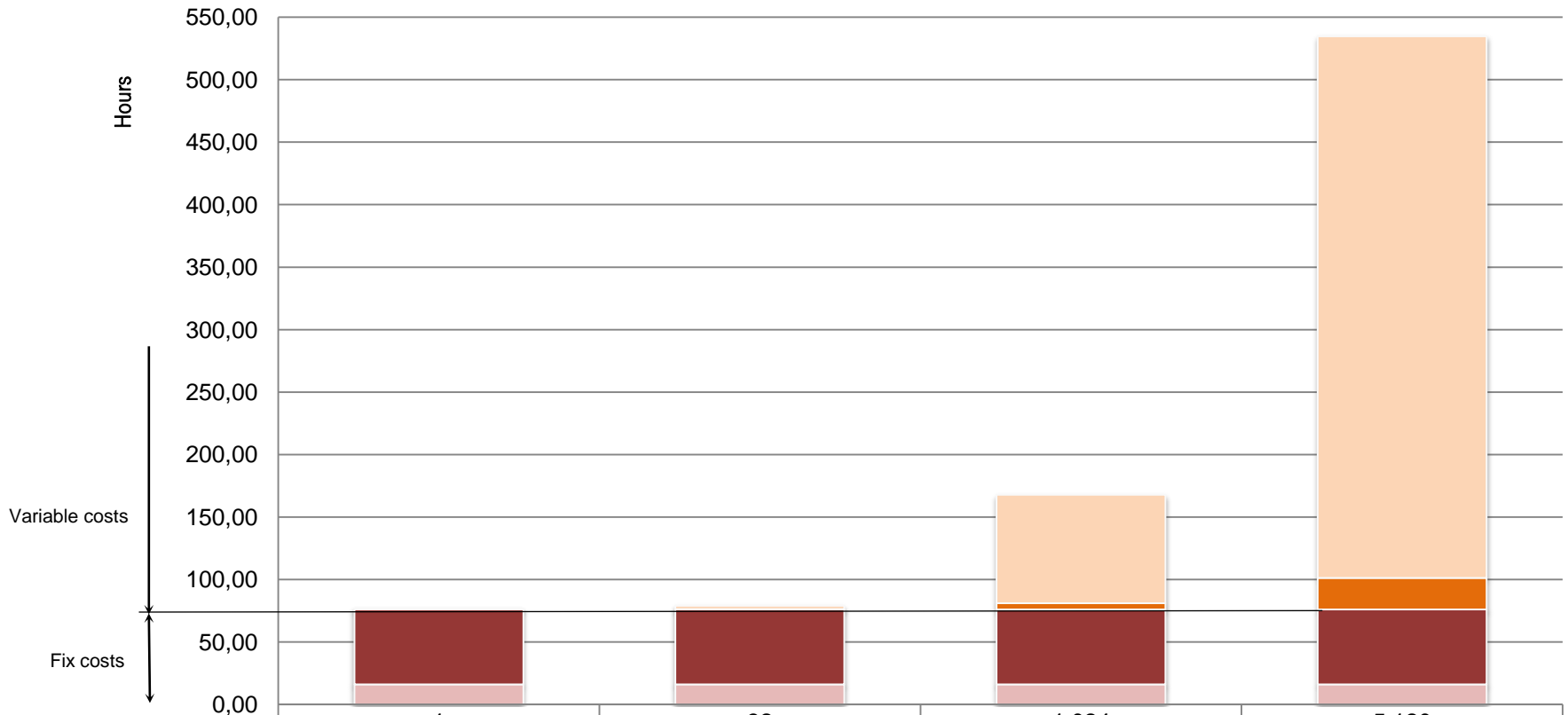
| 1 024 customers  |       |  |
|------------------|-------|--|
| Skills/Knowledge | hours |  |
| Expert           | 16,00 |  |
| Engineer         | 60,00 |  |
| Technician       | 5,07  |  |
| Support          | 86,67 |  |

| 5 120 customers  |        |  |
|------------------|--------|--|
| Skills/Knowledge | hours  |  |
| Expert           | 16,00  |  |
| Engineer         | 60,00  |  |
| Technician       | 25,33  |  |
| Support          | 433,33 |  |



Remark: Time consumption for travelling and logistic are not included.

# Outcome TWDM-PON; Time consumption according to skills/knowledge staff



|                             | 1     | 32    | 1 024 | 5 120  |
|-----------------------------|-------|-------|-------|--------|
| CO - Support                | 0,17  | 2,75  | 86,67 | 433,33 |
| CO - Technician             | 0,32  | 0,32  | 5,07  | 25,33  |
| Street cabinet - Support    | 0,00  | 0,00  | 0,00  | 0,00   |
| Street cabinet - Technician | 0,00  | 0,00  | 0,00  | 0,00   |
| Laboratory - Engineer       | 60,00 | 60,00 | 60,00 | 60,00  |
| Laboratory - Expert         | 16,00 | 16,00 | 16,00 | 16,00  |

# customers

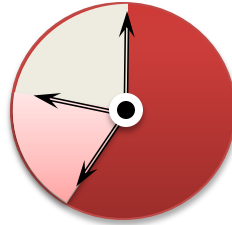




# Conclusion; Interruption time of services

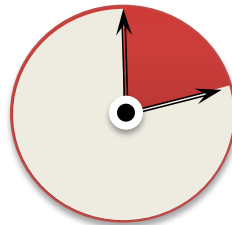
## WDM-PON

|                            |                   | Location       | Activities                  | Interruption | Min. **       | Max. **       |
|----------------------------|-------------------|----------------|-----------------------------|--------------|---------------|---------------|
| Preparation of coexistence | <b>I. phase</b>   | CO             | Coupler installation        | 4min.        | 20min.        | 24min.        |
|                            |                   | Street cabinet | AWG, Coupler installation   | 20min.       |               |               |
| Customer migration         | <b>II. phase</b>  | Street cabinet | Reconnection Splitter ->AWG | 15min.       | 15min.        | 18min.        |
|                            |                   | Customer       | ONT connection & setup      | 3min.        |               |               |
| Final status*              | <b>III. phase</b> | CO             | Coupler dismantling         | 3min.        | 3min.         | 6min.         |
|                            |                   | Street cabinet | Coupler dismantling         | 3min.        |               |               |
| <b>Σ</b>                   |                   |                |                             |              | <b>38min.</b> | <b>48min.</b> |



## TWDM-PON

|                            |                   | Location | Activities             | Interruption  |
|----------------------------|-------------------|----------|------------------------|---------------|
| Preparation of coexistence | <b>I. phase</b>   | CO       | Coupler installation   | 4min.         |
| Customer migration         | <b>II. phase</b>  | Customer | ONT connection & setup | 5min.         |
| Final status*              | <b>III. phase</b> | CO       | Coupler dismantling    | 3min.         |
| <b>Σ</b>                   |                   |          |                        | <b>12min.</b> |



\* in interruption time is not included re-setup all ONTs

\*\* minimum is meaning full coordination all activities and maximum is coordination nothing

# Conclusion; Time consumption

## Implementation time

|                              | WDM-PON     | TWDM-PON  |                               |
|------------------------------|-------------|-----------|-------------------------------|
| Migration of 1 024 customers | 395 hours   | 170 hours | WDM-PON is <b>2,3×</b> longer |
| Migration of 5 120 customers | 1 637 hours | 544 hours | WDM-PON is <b>3,0×</b> longer |

Implementation time is approximately **3 times longer** for WDM-PON as TWDM-PON!

## Skills/knowledge of staff

|            | 1 024 customers |          | 5 120 customers |           | coefficients |                           |
|------------|-----------------|----------|-----------------|-----------|--------------|---------------------------|
|            | WDM-PON         | TWDM-PON | WDM-PON         | TWDM-PON  |              |                           |
| Expert     | 24 hours        | 16 hours | 24 hours        | 16 hours  | 8.x          | where „x“ is basic salary |
| Engineer   | 60 hours        | 60 hours | 60hours         | 60 hours  | 4.x          |                           |
| Technician | 289 hours       | 5 hours  | 1 447hours      | 25 hours  | 2.x          |                           |
| Support    | 22 hours        | 87 hours | 107hours        | 433 hours | x            |                           |

Then for 5 120customers and

|           |                                               |                                  |
|-----------|-----------------------------------------------|----------------------------------|
| WDM-PON:  | $24.8.x + 60.4.x + 1447.2.x + 107.x = 3433.x$ | $\Delta$ is 2 582x/5120customers |
| TWDM-PON: | $16.8.x + 60.4.x + 25.2.x + 433.x = 851.x$    | what is approx. 0,5x/customer.   |

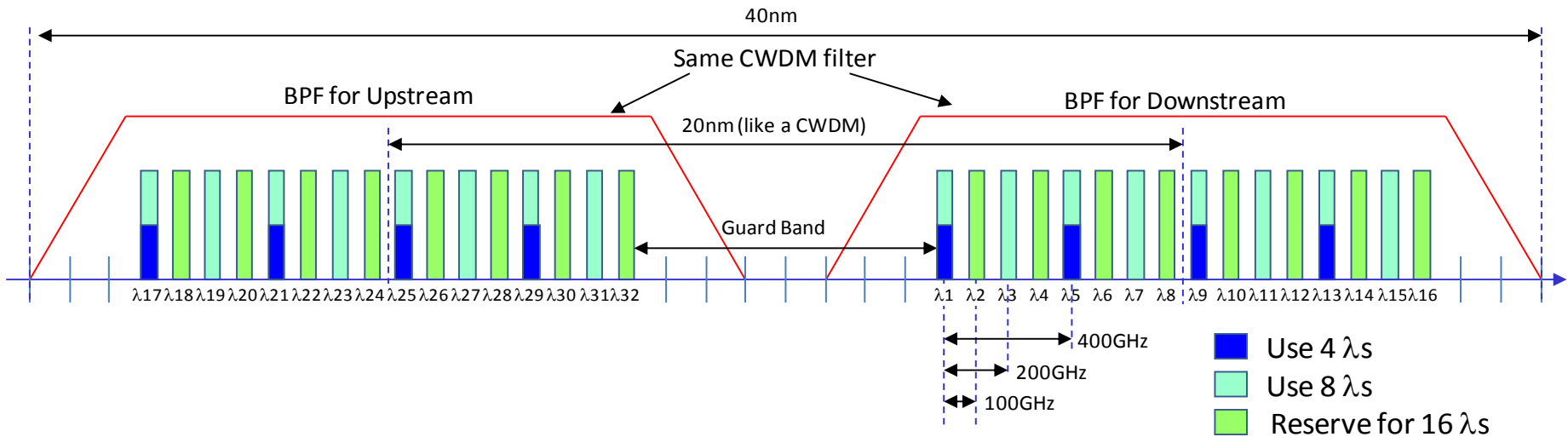
For example if x = 500€ (basic salary) then implementation WDM-PON will be expensive about 250€/customer like TWDM-PON.

**Remark:** Time consumption for travelling and logistic are not included.



Thank you for your attention.

# Backup; TWDM-PON spectral range



# Backup; AWG

