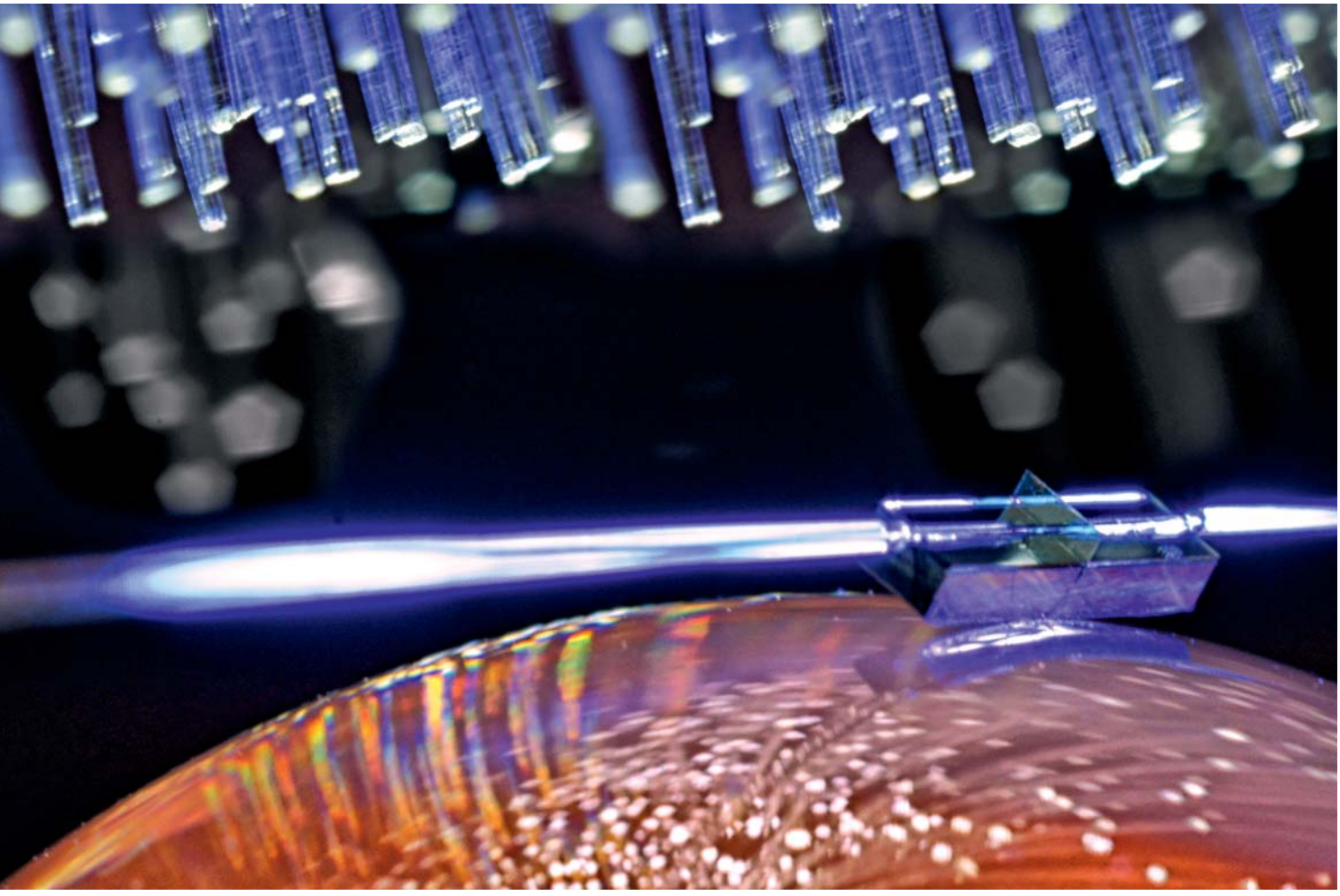
fibre optical components GmbH **At the speed of light into the future.**



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September 2012

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Contents

Editorial

Photo: Rico Prauss

The principle of quality covers the best possible fulfilment of the customer requirements and the resulting customer satisfaction. This philosophy can be derived from the ISO 9000:2005 standard. I am sure, many will agree with this introduction. On our market those products and solutions will play a pioneering role, which show a high degree of compatibility. A mass market cannot be established on the basis of isolated solutions. However, broadband development is the convincing step requiring the employment of optical transmission equipment as a mass technology.

How can a quality concept develop on a mass market with mostly internationally oriented supply channels? Here we have very reliable bodies which, with their committed work, have laid the foundations for standards which today are the guiding principles on which procurement on the mass market is based and which provide the specifications for product parameters for future developments. In this context the International Electrotechnical Commission, IEC for short, is recognised for the good job it does as an independent international standardisation body. In addition to the formulation of quality parameters, the generally valid measuring procedures are developed and specified.

Today the supplier is required to ensure quality, while the purchaser/user of the products frequently is no longer able to verify the parameters. A verification and control system for quality assurance has to be established, also under the conditions of fierce international competition. Only accredited measuring and testing laboratories can doubtlessly verify whether a product complies with the very high demands and whether all possible suppliers will also be able to fulfil these requirements.

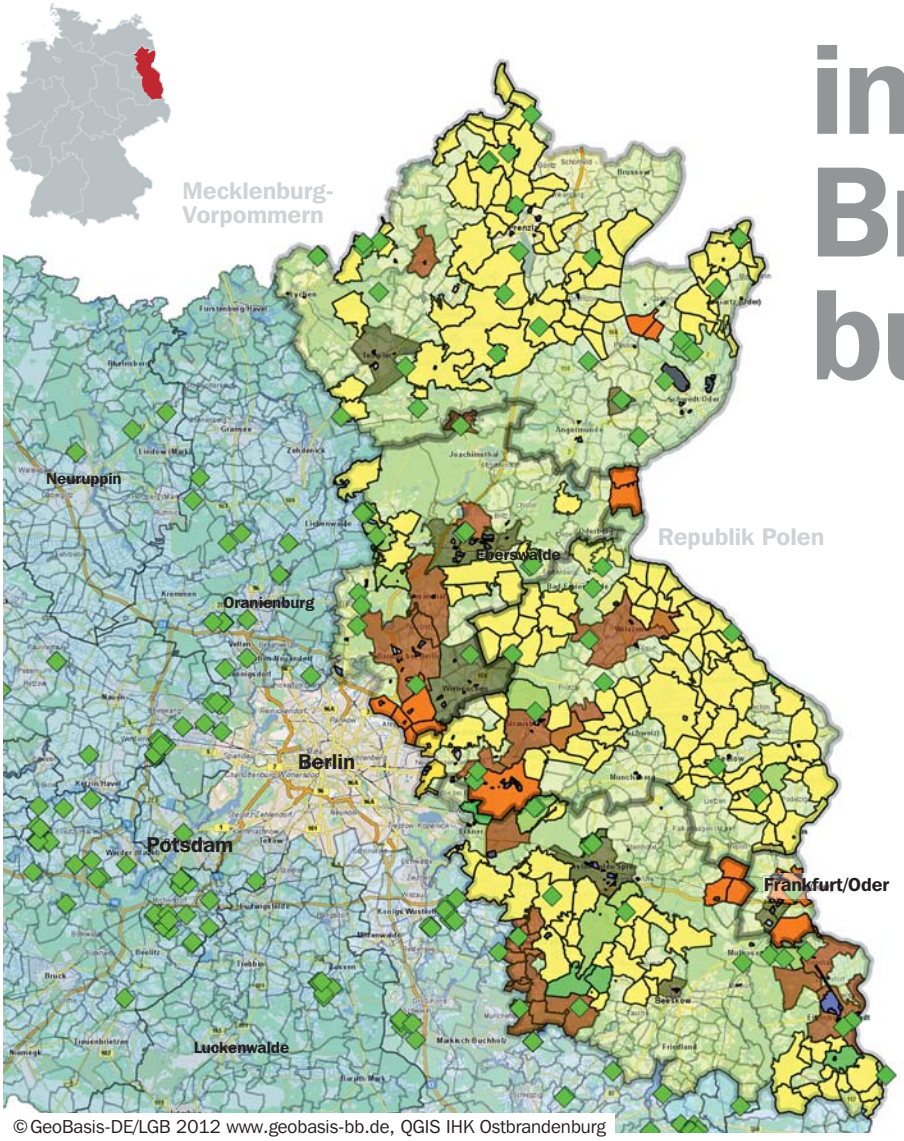
We have taken such a step with our LSH Class A connector. Thus we have been able to prove, that—also in the field of optical components—customer requirements, standardisation activities and compatibility are not mutually exclusive.

Quality, considered in isolation, must not constitute a cost driver. With our monitoring technology a quality assurance step for the installation acceptance of optical networks will even contribute to saving costs. Thus not only OPEX but also CAPEX can be reduced clearly and quality improved.

Customer satisfaction, improving quality and decreasing costs—this is not an easy task to fulfil, but we will rise to this challenge!

Christian Kutza, Managing Director

Broadband development in Eastern Brandenburg



Map 1 Current situation in Eastern Brandenburg

Since 2007 the topic of broadband access in the German state of Brandenburg has developed from a rather casual infrastructure development measure to a significant location factor. During this time the responsibilities for broadband expansion had to be defined, the different supply technologies understood, and the support of many people from politics, business and the population gained. However, to convince the state's government to work for broadband development was the easiest task to complete. The broadband atlas of Brandenburg collected requisition notes from companies and private individuals. Rapidly more than 10,000 requisitions were registered showing the problem regions in Brandenburg transparently in the Internet. Even today this atlas covers more than 14,200 individuals waiting for a faster Internet. The mass media always like to mention the numerous ISDN and modem users in order to attract the attention to the current undersupply. Even today is has not been possible to achieve the ambitious aim of providing "the whole area of Brandenburg with broadband Internet by the end of 2009".

However, there are many positive supply projects which have successfully been implemented over the past five years. As an example, 419 communities have started about 220 development projects supported by the GAK and GRW-I government programmes and/or an advanced Internet access has already been implemented (as of March 2012: https://www.breitbandatlas-brandenburg.de/förderung-der-breitbandversorgung). The illustration (Map 1) shows the current situation in Eastern Brandenburg.

LTE-based Internet access in the region has contributed to achieving that many users now can move faster in the Internet. The feedback from connected Internet users (◆ green squares) can also be seen in the map.

Although communal infrastructure development (streets, gas, electricity) might offer particular synergies, we can say that – even after fiver years – broadband development has not yet reached the same significance as road construction. The Chambers of Industry and Commerce (IHK) in Brandenburg have submitted a proposal on the adjustment of the legal regulations for infrastructure development to the government. These should include an obligatory revision of broadband development to promote a sensible extension to the existing optical fibre networks and ducts.

Frequently the question arises of whether the state government is making sufficient efforts to promote the development of broadband access. In addition to the support measures mentioned above a concept paper "Brandenburg – Optical Fibre 2020" was prepared for broadband development.

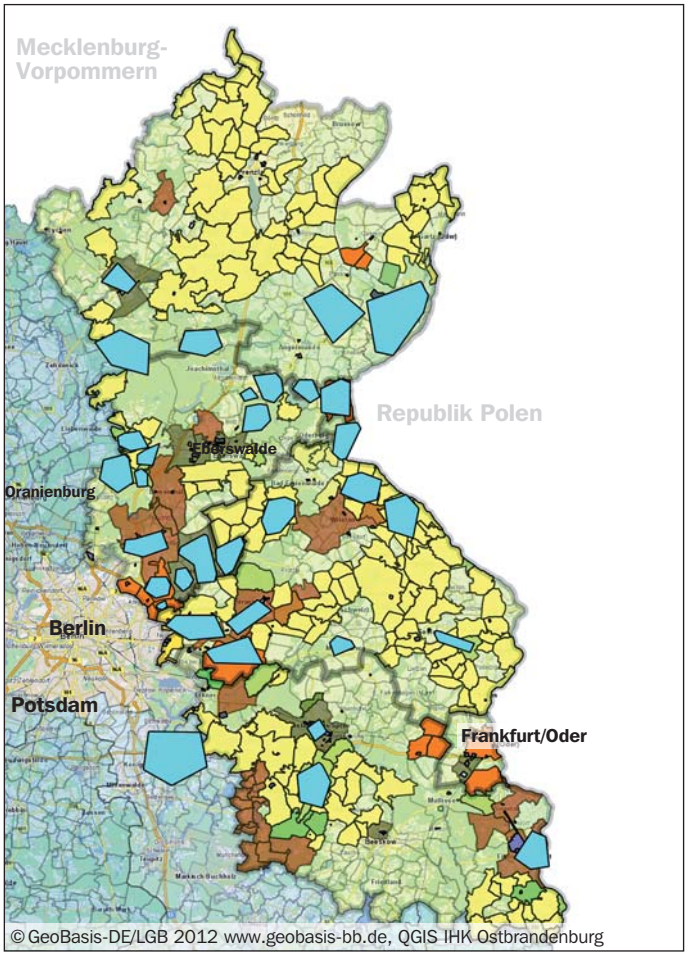
Within the framework of an analysis of existing infrastructures more than 3,000 undersupplied distribution cabinets (less than 6 Mbps) were identified which shall be developed using corresponding ducts and fibre optic technology. Moreover the next stage of broadband development from 2014 shall be implemented with an optimized coordination and with a better support of the local communities. Brandenburg is planning the installation of a central coordinating body which shall take the form of a supporting organisation. But discussions in the industry have shown so far that this new supporting organisation currently is contested because the tasks and responsibilities have not yet been clearly defined. It has been known for quite some time already that an economical development in the remaining undersupplied regions will not be as possible as currently handled by the communication providers.

In particular the communications equipment installed in the period from 1993 to 1997 on the basis of optical fibres ("Hytas" regions: Hybride Subscriber Access System) causes the Eastern Brandenburg region some headache at the moment. There seems to be no solution in sight even after some pilot projects in the German federal area.

Interestingly, in such areas we often have owner-occupied settlements with clearly more than 50 households. But also some industrial areas, such as Neuenhagen near Berlin and Werneuchen, are affected.

So far the Eastern Brandenburg Chamber of Industry and Commerce has identified approximately 30 Hytas regions (see map 2, light-blue marking). This picture surely is not yet complete and an exacter analysis of possible solutions will be required. If you as a businessman or a representative of a community have any idea on how to solve the Hytas problem, you are invited to make your contribution. In addition to a confirmation and update of the data situation on the Hytas areas, an awareness-raising process shall be started at communal level and in the state government in Brandenburg. A first kick-off event will be held in autumn 2012. Interested companies can register at Jens Jankowsky, Specialist for Technology and Innovation at the Eastern Brandenburg Chamber of Industry and Commerce (IHK).

Many obstacles still have to be overcome



Map 2 "Hytas" regions (Hybride Subscriber Access System)

From 2014 broadband development in Brandenburg will continue to be supported on a permanent basis with EU money. By then the companies and citizens in the areas, where development has already started, will hopefully have received their fast Internet access. However, in many locations in Eastern Brandenburg it will still take some time till they will be provided with FTTH connections.

The Eastern Brandenburg IHK and the Centre of Competence for Electronic Commerce in the Oderland region will continue to work for broadband development in the Eastern Brandenburg region.

Links: www.breitbandatlas-brandenburg.de, www.kego.de

Jens Jankowsky

IHK Eastern Brandenburg

Jens Jankowsky
Specialist for Technology and Innovation
SIU – Standortpolitik, Innovation und Umwelt

IHK Ostbrandenburg
Puschkinstraße 12b, 15236 Frankfurt (Oder), Germany
Phone: +49 335 5621-1302
E-mail: jankowsky@ihk-ostbrandenburg.de
www.ihk-ostbrandenburg.de

The regional Ruhr carrier Telekommunikation Mittleres Ruhrgebiet *relies on components made by FOC*

The Ruhr region, so far known as the "heart" of the German coal, iron, steel and heavy industries, has been experiencing an industrial transformation for quite a long time already. In order to overcome the accompanying challenges, a secure communications infrastructure is indispensable. "Telekommunikation Mittleres Ruhrgebiet", TMR for short, is the regional carrier with its headquarters at Bochum, which has been fulfilling this task for more than 16 years now. TMR has continuously built on its strengths and focussed its range of performance on its core business, including its certification according to ISO 9001:2008. Its mother companies are the utility companies from Bochum, Herne, Witten and Hattingen as well as the saving banks from Bochum and Herne.

TMR is also an excellent "social networker" in the region

Apart from the various telecommunications offers, social "networking" in the region plays an important role for TMR. TMR is well aware of its social responsibility and sponsors different activities, such as the Bochum Educational Network in cooperation with the Ruhr-University Bochum, the "Kabelab" of the city of Bochum, which provides free Internet surfing at public places in the Bochum city centre, as well as amateur and top-class sports. And it supports the Erich-Kaestner School in Bochum in the area of IT. Of course, TMR has been training apprentices for the Chamber of Industry and Commerce (IHK) for years.

TMR DataCenter offers flexible areas – just a individual as your IT

Independent network infrastructure

TMR has its own secure and powerful network consisting of fibre-optical (FO) and copper cables in the central Ruhr region. In order to guarantee a smooth and highly reliable data traffic TMR installed coupled FO routes in the cities of Bochum, Herne and Witten.

Meanwhile the network resources have been expanded to cover almost 700 km of FO cables. The ring structure with fail-safe SDH equipment forms TMR's backbone network. In addition TMR has approximately 600 km of copper cables in the central Ruhr region. Thus TMR offers its customers connections ranging from 2 Mbps to 8 Mbps SDSL in the upload and download directions via copper cables and from 2 Mbps to 100 + Mbps in the upload and download directions via optical fibres.

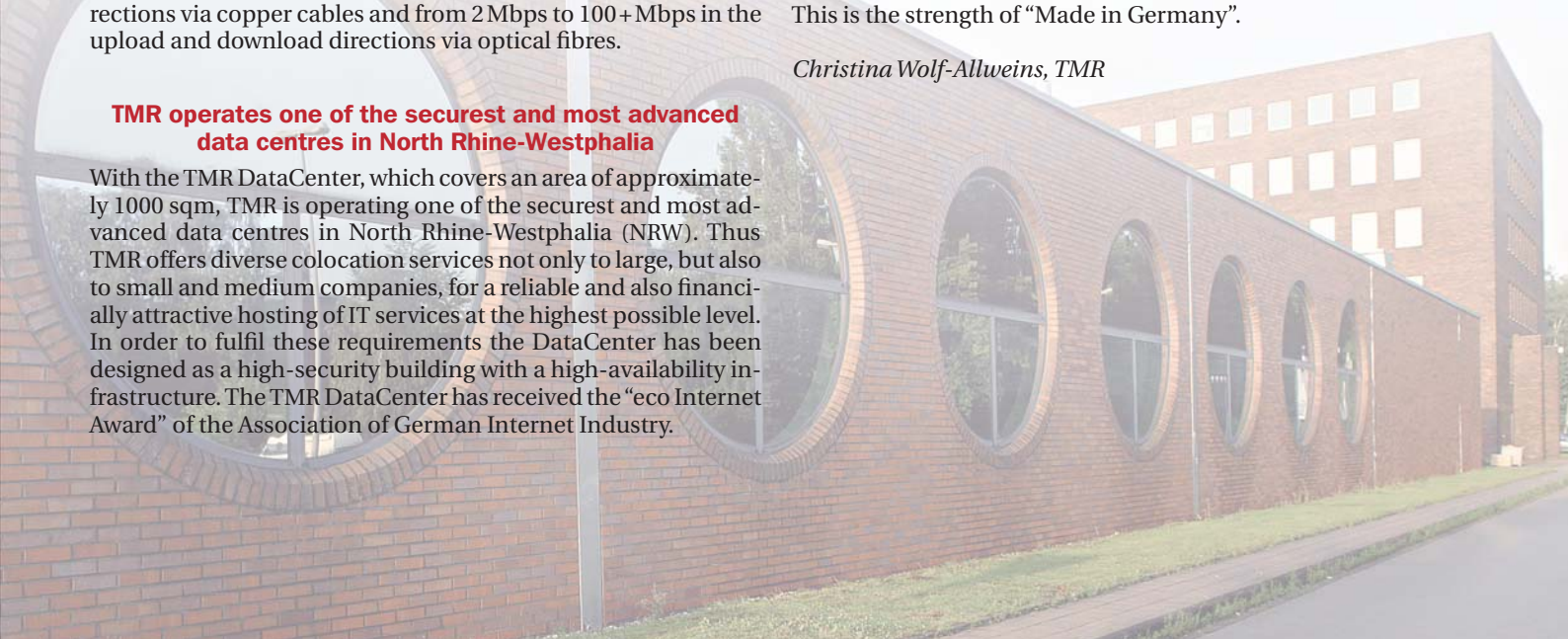
TMR operates one of the securest and most advanced data centres in North Rhine-Westphalia

With the TMR DataCenter, which covers an area of approximately 1000 sqm, TMR is operating one of the securest and most advanced data centres in North Rhine-Westphalia (NRW). Thus TMR offers diverse colocation services not only to large, but also to small and medium companies, for a reliable and also financially attractive hosting of IT services at the highest possible level. In order to fulfil these requirements the DataCenter has been designed as a high-security building with a high-availability infrastructure. The TMR DataCenter has received the "eco Internet Award" of the Association of German Internet Industry.

TMR and FOC

In order to fulfil the demanding requirements TMR also uses components from FOC fibre optical components GmbH. TMR has decided early to employ the E-2000™ fibre optic connecting system in 0.1dB quality to be able to guarantee the desired network security. With the market launch of the technologically equivalent Class A fibre-optical connecting system from FOC, TMR also uses this alternative while maintaining its high-quality standards with a view to their network equipment. This has helped FOC to establish itself as a reliable supplier. This reliability is particularly important, when an "emergency" occurs and patchcords and other installation material is needed at short notice. This is the strength of "Made in Germany".

Christina Wolf-Allweins, TMR



Acceptance and commissioning of FTTx links

In the course of the global expansion of the FTTH infrastructure frequently the installation and commissioning of new links, which are routed right into the house or even the flat of the end customer, are on the agenda to an unprecedented extent. Here it is worthwhile to consider new ways of accepting and commissioning FTTx links in order to leverage efficiencies.

Frequently the installation and acceptance of FTTx networks are performed in two stages of construction. In the first stage, starting from the Central Office (CO), a bundle of optical fibres, the "trunk cable" TC, is laid, connecting the CO with the newly developed residential area. As a rule, the network operator instructs an installation company to execute the installation and cable laying work, whose performance needs to be checked after installation. As a basis for the acceptance to be performed by the network operator the installation company performs OTDR backscatter measurements on the installed optical fibres from the end of the trunk cable to the CO. After verifying these measurements the network operator accepts the newly installed link, if it complies with the specifications.

The second stage of constructions covers the connection of the housing units to the trunk cable and possibly the commissioning in three steps: First the optical distributor (splitter) is connected to the trunk cable's fibres. Afterwards the optical fibres are routed from the splitter to the end customer's house or flat. This step is finally followed by the acceptance of the second stage of construction and the commissioning of the end customer's connection. As a rule the network operator instructs one or more installation companies to execute these works. Similar to the first stage of construction, the newly installed link is checked after completion of the installation work using a backscatter measurement. So far there has been a general agreement that a meaningful measurement of the last link section can only be performed from the end customer's connection due to the "impossibility of measuring through the splitter".

In order to limit the effort needed, so far the network operator performs the acceptance of the stages of construction on the basis of documents and measurements, which he has not produced or executed himself, but which have been made available to him by the instructed installation companies. It goes without saying that this situation is not ideal considering that hardly any house builder would instruct the construction company also with performing the acceptance tests for the house they themselves have built.

This concept can also be questioned from an economical perspective: The acceptance test, including its documentation, is a considerable cost factor in the service offer of installation companies. The network operator incurs further costs because it is necessary for him to manually verify the acceptance tests documented by the installation company. Today these documents are frequently exchanged by e-mail or sometimes still in the form of paper documents which have to be tediously entered into an electronic documentation, e. g. a data base system. Such an approach is error-prone and does not really leverage the potential of advanced data processing.

The use of a centrally organised OTDR measurement from the CO would result in a drastic modernisation of the described procedure. The basic idea is to perform all routine OTDR measurements, such as the acceptance tests, no more manually by the installation technician, but remotely controlled from the CO, i. e. in the opposite direction, in a dedicated monitoring channel in the range of 1625 … 1675 nm. For this purpose an OTDR instrument is installed in the CO – either temporarily during the installation phase or later permanently – which via an optical switch can be connected with all fibres of one or several trunk cables. Both the OTDR and the optical switch have an IP interface, which is driven by a web or smartphone application. In order to be able to measure through the splitter, first the end customer's ports muss be fitted with special optical reflectors which will be used as identification points. Although these reflectors will slightly increase the costs for the infrastructure, this investment will more than pay-off by providing a higher efficiency during installation, commissioning and also during later network operation.

For the first time the network operator can perform independent acceptance tests

Installation and acceptance using central OTDR measurements

In future the commissioning and acceptance of PON networks might be performed as follows (see Figure 1). In the first stage of construction the installation company as usual first lays the trunk cable. However, the subsequent OTDR measurement will not be performed manually, but via remote control through the

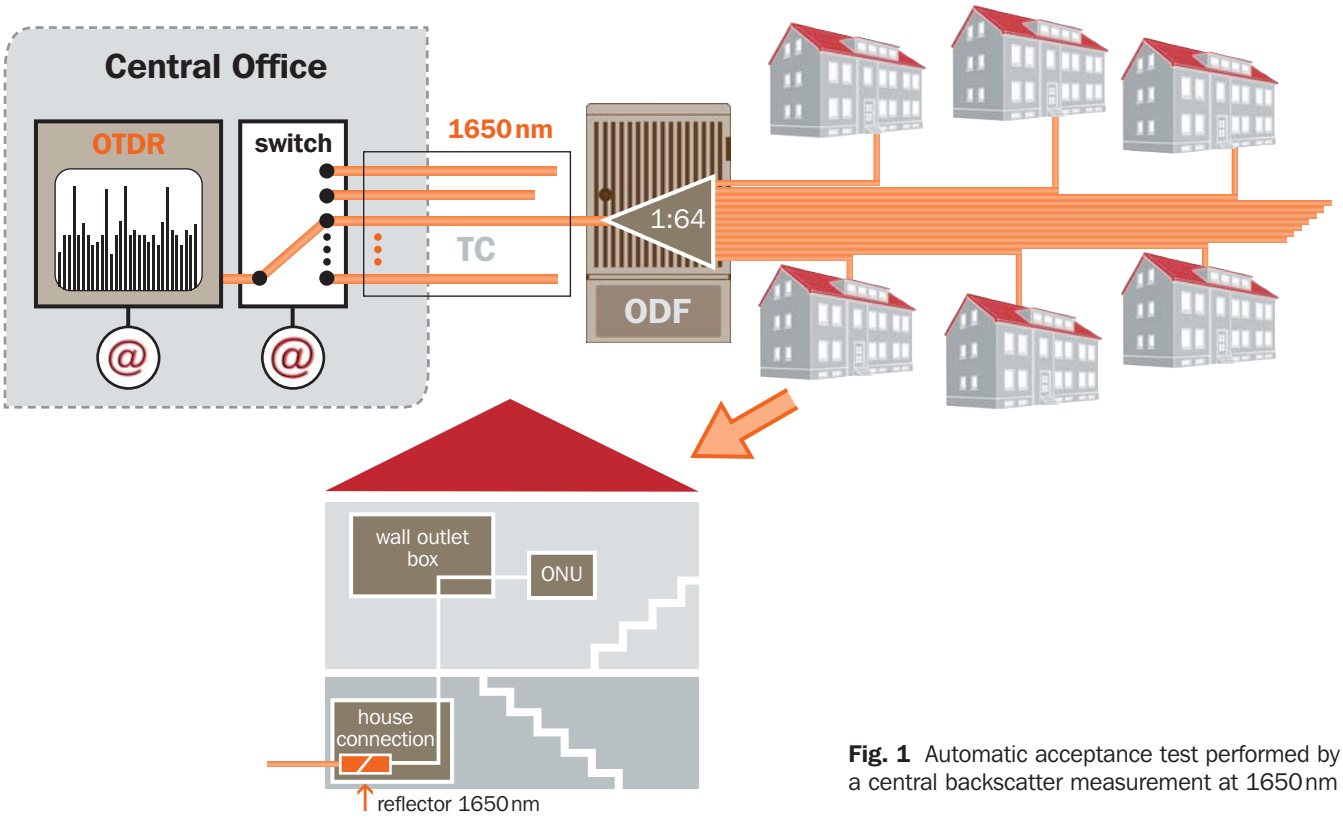


Fig. 1 Automatic acceptance test performed by a central backscatter measurement at 1650 nm

network operator's central measuring system.

In order to verify his installation work the technician triggers the central OTDR measurement via his smartphone. While he is already working on other tasks, the system successively measures all fibres of the trunk cable and performs an automatic pre-check of the acquired measurement traces, detecting, for example, an excessive link loss. This pre-check result is immediately sent to the technician's smartphone. In case of need, he can view the measurement traces on the display of his smartphone. Afterwards the system will archive the whole measurement procedure, i. e. the measurement parameters, test data and image files in a data base.

For the acceptance procedure the network operator can either use the already archived data or – at no noteworthy additional cost – trigger his own up-to-date acceptance measurement. There will be no manual checking of the measurement data required, since the system is checking independently, whether the acceptance conditions for the link section have been fulfilled or not.

In order to be able to use this form of automation also for the second stage of construction, first a reflector has to be installed at each of the customers' ports as part of the cable routing work. For example, the reflector might be integrated in the house distributor, see Figure 1. Apart from the hardware costs for the reflectors no further costs are incurred, since meanwhile the reflectors have been integrated in optical connectors (Fig. 2) and thus no additional installation work is involved. The reflectors are required in order to be able to separate the PON links after the splitter in the OTDR measurement. On the other hand the reflection height can be used to determine the link loss.

The procedure for the second stage of construction could then be as follows: The installation company first installs the splitter and routes the cabling to the house distributor. There the technician will install a junction box, where the reflector has already been integrated into. Then a barcode is affixed onto the box providing information on the network plan and the end customer's port. After completion of the installation work the technician will scan the barcode (e. g. using his smartphone) and trigger with the push of a button (smartphone application) the acceptance tests in the CO. While the technician defines the time of the acceptance test, the measurement itself as well as its verification is performed using the network operator's system. The barcode largely prevents any faulty correlation of end customer and link or measurement trace and it is also used to correctly position the optical switch in the CO for the OTDR measurement as well as to assign the measurement trace in the data base to the link and the customer.

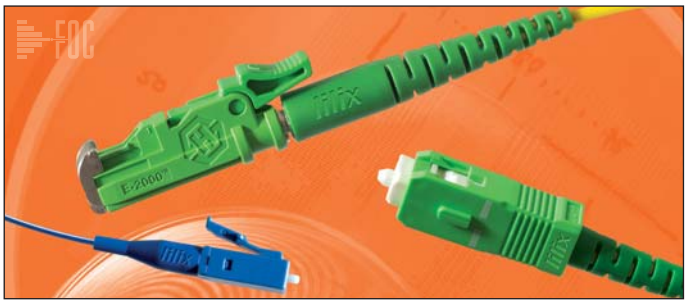


Fig. 2 FOC's lilix Fttx reflectors can be integrated into the connector

What benefits and, above all, cost savings does this approach provide? During the installation phase the initial advantage is that the number of OTDR instruments can considerably be reduced, because the technicians need not perform any measurements themselves. Moreover there is no more booting, warming-up and connecting the individual OTDR, when the technician upon completion his installation work triggers the acceptance test just by pushing a button while the OTDR instrument in the CO is permanently in operation. Another advantage is the better comparability of the traces which is due to the fact that all OTDR traces are generated by the same instrument. However, the decisive point is that the described method will enable the network operator for the first time to perform a truly independent check of newly installed links with little effort. In future the network operator himself will thus be able to execute the acceptance tests. Consequently he will be able to save costs on the one hand and to professionally and rapidly check the performance of the installation company prior to final acceptance, on the other hand. In addition to the described possible savings during the installation phase, the centrally managed testing infrastructure with reflectors paves the way for link monitoring on a purely passive level, which might be attractive also during later network operation.

Smooth commissioning of dark fibres

This might be necessary, if after installation and acceptance no services have been transmitted over the respective link, e. g. when an end customer has terminated his contract, or because it might be more cost-efficient in certain cases to equip all end customers in an area en bloc with FTTx connections and to commission them step by step. Without active equipment these so-called dark fibers cannot be checked during normal network operation. Thus link defects, if any, will not be noticed. However, through routine testing of dark fibers on a passive level, defects could be detected in a timely manner, correlated to their root cause and removed. Potential savings are possible because the producer of the defect can be held accountable and the commissioning of dark fibres will largely be free from unexpected surprise. In particular in urban areas with much construction work going on and frequent change of end customers through moves or change of provider an automatic monitoring of the infrastructure on a passive level is an essential precondition for a smooth customer service.

Isolation of faults during the commissioning procedure

The central OTDR measurement offers the interesting possibility of connecting two reflectors "in series" thus separating different link sections from one another.

Such a configuration might be helpful for commissioning links, in particular if different link sections have different legal owners. A typical example would be, if the network operator's network ends at the house distributor and the following house cabling is owned by the end customer (Fig. 3). The service provider, making the ONU (Optical Network Unit) available to the end customer, is the third party involved in the commissioning procedure. If

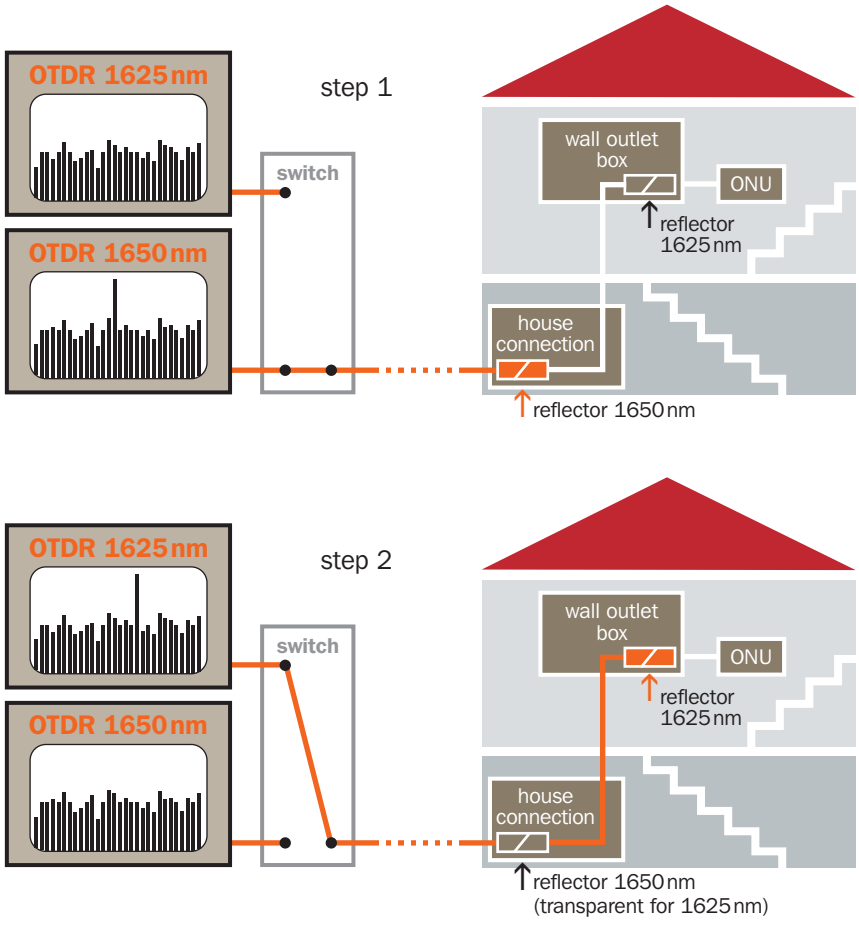


Fig. 3 Configuration for checking individual link sections

the commission procedure fails the configuration shown in Fig. 3 offers the possibility of performing an automatic pre-check of the "access network" and "house cabling" link sections, thus isolating the fault in advance and putting the blame correctly on the responsible party.

However, today the commissioning procedure is frequently such, that the end customer receives a pre-configured ONU from the service provider for connection to the wall socket in his flat. In real life, however, this seemingly simple procedure is much error-prone. But about 80% of these errors are so-called „false" faults, where no real fault is the cause, but where operating errors or wrongly connected or configured terminal units are to blame. Although these faults are not caused by real infrastructure defects, they cause a lot of costs on the network operator's side, because the fault has to be analysed. Checking the active equipment is reaching its limits here, because the preconditions, on which active equipment is based, are frequently not fulfilled for the specific fault configurations in question. Thus often the particularly cost-intensive "truck roll" to the customer will be the only solution.

But with the configuration shown in Figure 3 the automatic analysis and assignment of responsibilities will be as follows: In a first step the line is checked up to the house distributor at a wavelength of 1650 nm. The corresponding reflection in the OTDR trace shows no fault. In a second step the line is checked up to the wall socket at a wavelength of 1625 nm. A missing reflection in the OTDR trace indicates a fault in the house cabling. If the reflection is present, the fault must be on the side of end customer and/or service provider.

Consequently, the centrally managed OTDR measurement using reflectors enables the network operators to automate independent OTDR measurements for checking the network infrastructure thus performing them rapidly and cost-efficiently. These measurements can be used for accepting stages of construction and for verifying and/or analysing faults during the commissioning of operating and non-operating (dark fibre) links. At the same time the foundation is laid for a permanent monitoring of the network infrastructure during later operation of the network.

Dr. Martina Vitt, lilix Project Manager, FOC

1 The wavelength range of the monitoring channel is standardised in ITU-T Recommendation G.984.5, Amendment 1.
2 However, for a better graphic presentation of the OTDR traces a tablet PC is recommended instead of using a smartphone.

Monitoring and management of FTTx networks by technology convergence

The companies Jo Software Engineering GmbH and FOC - fibre optical components GmbH combine their unique technologies to form one single system with excellent properties in order to systematically leverage synergie.

Feedback from our customers showed that:

- Only a complete solution will allow us to reach our objective.
- Not only the long-term use and thus the operational expenditure (OPEX), including its reduction, are in the focus of attention, but that already during the commissioning phase the installation costs, i. e. capital expenditure (CAPEX), should be considerably reduced.
- An inventory system (network management system) should be used, if available.
- As usual in the access and transport area, the network providers or operators have a fundamental economic interest to be always informed about the condition and/or proper operation of the network infrastructure.
- This informational advantage can only be efficiently gained through an ideal mix of documentation and high-grade automation.
- It should always be possible to verify the network infrastructure any time during its operation without disturbing data transmission as well as independent of the use and status of active equipment

This new understanding and the mutual market penetration providing a lot of common ground promote our cooperation and have produced the solution described below.

The holistic system solution combines the monitoring of the infrastructure on a passive level with an established network management system. This solution includes the following key technologies:

- FOC *lilix Reflektor*
- FOC *Monitoring System consisting of: Element Manager (EM) with Remote Test Unit (RTU)*
- JO Software Engineering *Central Network Management System (NMS) based on cableScout®*

The schematic system overview in Figure 1 shows how the system components interact with one another and where they are physically housed.

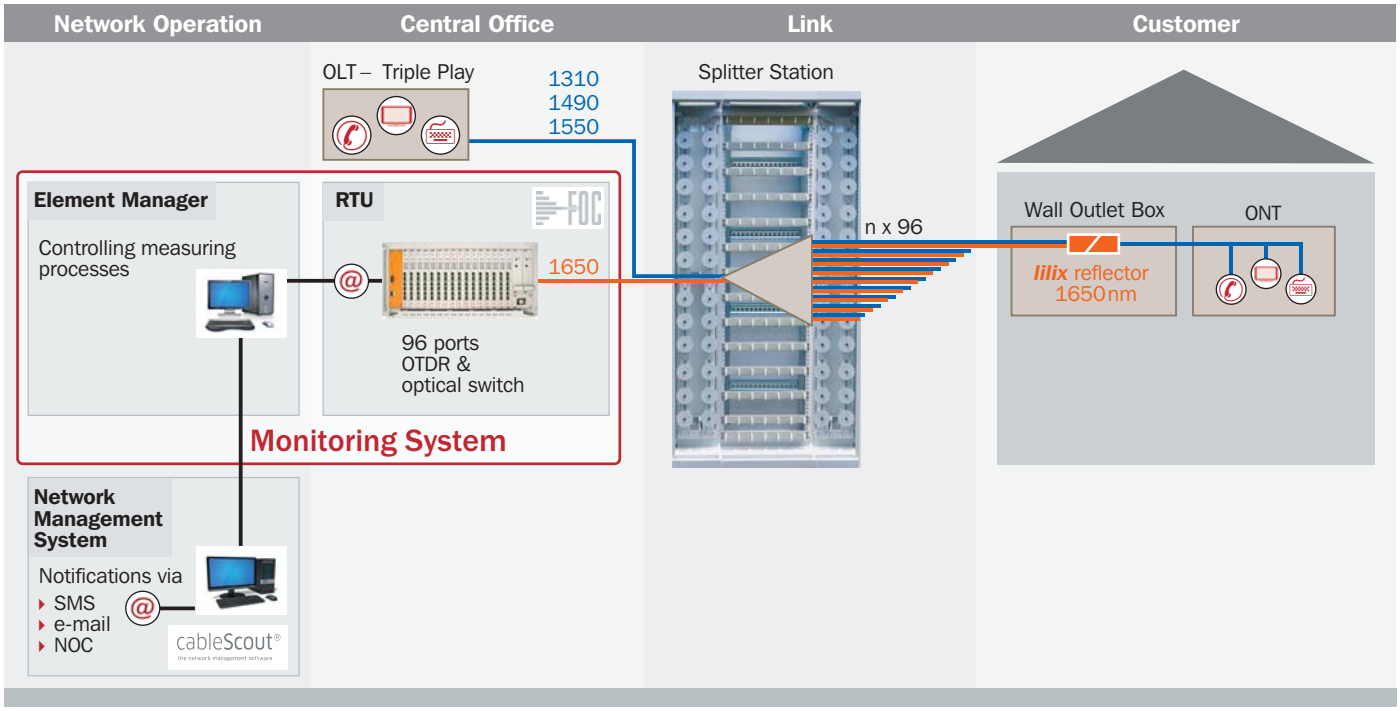


Fig. 1 Permanent monitoring of FTTx networks

The lilix reflector – installed at each customer port – provides the basis for any successful and robust analysis of the backscatter traces.

Lilix reflects the portions of light used for monitoring while allowing the portions of light needed for data transmission to pass freely. For this monitoring task special reserved wavelength channels at 1625 nm or 1650 nm are available.

In the backscatter trace each reflector provides a characteristic signal peak, whose position is determined by the length of the link between reflector and OTDR. In PON structures the overlay of the individual reflections produces a characteristic overall picture, similar to a fingerprint, which is recorded at the initial commissioning of the network and later used as a reference.

interfaces to the infrastructure. The optical switch allows you to systematically select the desired PON infrastructure for injecting the measurement signal.

All measurement and/or monitoring operations of the infrastructure are controlled by computer-based software, the Element Manager (EM), which in turn is directly linked with the RTU.

The EM software particularly contains a numerical kernel analysing measurement results, interpreting them based on the reference measurement acquired during commissioning and generating corresponding messages for transmission to the superior NMS.

The parameters of the measurement procedures as well as all measurement traces are stored in the related EM data base.

The interface to the outside is implemented via the NMS, e. g. the customer is provided with a solution which allows him to control all monitoring operations from the NMS. The condition of the infrastructure after the test is specifically visualized in the NMS adjusted to the customer's requirements. The visualisation can be performed via coloured (green/red) changes of status and/or as a status message (warning, main alarm, etc.). Vice versa it is possible to systematically trigger measurement procedures and/or testing requests via the NMS.

The central NMS is based on cableScout®, a documentation and information platform specifically designed for the management of telecommunication networks. It allows you to record and efficiently administer all types of optical fibre and copper net-

Advanced technologies guarantee maximum network reliability

In the functional EM unit the Remote Test Unit (RTU) is housed. It contains an OTDR assembly, an optical switch and the optical

works on physical, logical and also virtual levels, i. e. from the geo-referenced location down to signal level. The platform sup-

ports all technologies in the transport and access area such as SDH, PDH, xWDM, xPON, Ethernet/IP, xDSL or, as in the described example, FTTx.

cableScout® allows you to visualize networks in their entirety with all buildings, routes, ducts, manholes, cables, connections, active and passive components, signals and services, terminals, connectors and sockets. Great importance is attached to the geo-referenced, correctly positioned, true-to-scale and realistic presentation of the objects, which is achieved both by a location-related list of objects and by presenting the objects in their relation with one another (e. g.: cable >duct >route). Any attributes and documents can be assigned to each of these objects. So it is possible to assign contracts, OTDR reports or billing information to each single fibre in the network.

cableScout® is a modular system equipped with numerous functional modules. Thus it can be customized to the individual requirements of the respective company.

An open data base structure ensures an easy integration with the existing IT infrastructure.

Due to the modularity and the open IT structure notifications are sent via SMS or e-mail to the assigned receivers in the case of fault. As a rule this will be the service and operation team.

Parallel to the cableScout® system in the Central Office it is furthermore possible to place a remote computing unit in an NOC (Network Operation Center), where the entire customer network is housed for monitoring purposes. Here the NOC team (24/7 operation) will initiate the corresponding measures in order to maintain operation and/or to interpret the status messages and coloured status changes in case of fault.

In combination with an automated and customized escalation process the service is then activated guaranteeing the highest possible reliability.

Jo Software Engineering and FOC will present an operational demo system at international fairs (see below). In addition to the above trade fair presence, towards the end of the year a permanent pilot project in the Stuttgart metropolitan area will be launched to provide a long-term presentation of the sustainability of the above system.

A description and presentation of details will be given in one of the next issues of this magazine.

Frank Sommerfeld, Head of Branch Office, FOC

FOC at international fairs

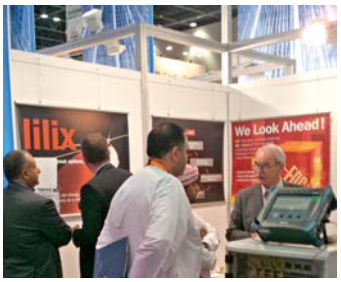
Dates

This year you can still visit FOC GmbH at the following fairs:

ECOC Amsterdam
- from 17 to 19 September, Booth 532, directly at the main entrance

GITEX Dubai
- from 14 to 18 October, Booth Z-H13, in the ZA'ABEEL Hall – Gulfcomms

TeleNetfair Luzern
- from 23 to 25 October, Booth 44, Hall 4



FOC workshop talks 2012

Topics and dates

Many of our customers have asked us to hold further workshop talks this year. We would like to offer you these three dates covering the following topics:

1. LSH-HRL Class A GHMT Certificate of Conformity
2. Measuring and testing LSH-HRL Class A at the building site
3. Wavelength splitters today and in the future – practical experiences

We would be pleased to welcome you and/or your colleagues in our house.
Please select a date and register via
fax (+49 30 565507-19) or e-mail (info@foc-fo.de).
Keyword: "2012 Workshop Talks"

The workshop talks will be held from 11 hrs to 15 hrs on:

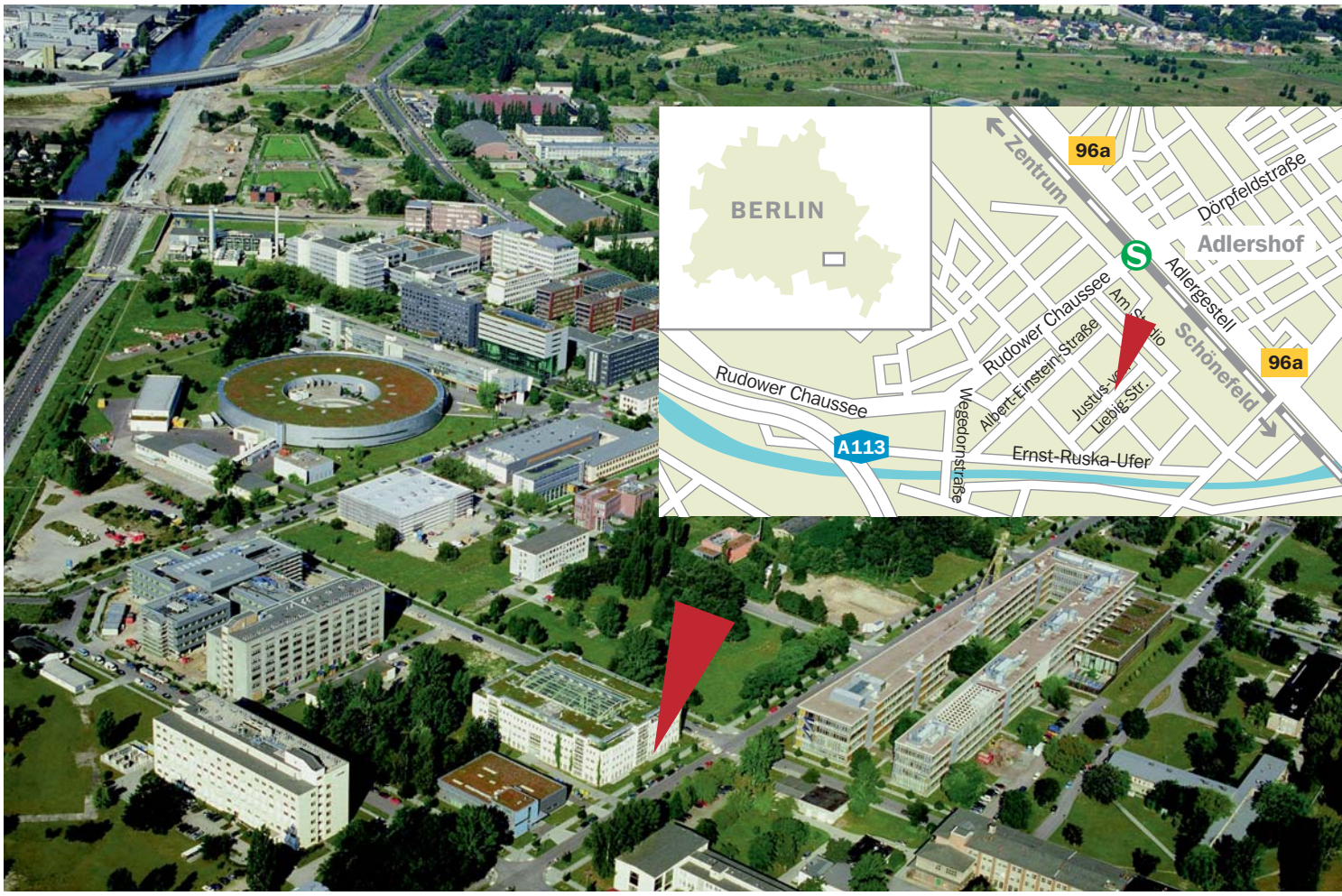
- Thursday, 18. October, at the Berlin central office ☐
- Thursday, 8. November, Düsseldorf, Park Inn Hotel ☐
- Thursday, 15. November, at the Berlin central office ☐

We look forward to interesting talks with you.
Yours sincerely,

Christian Kutza, Managing Director

fibre optical components GmbH

In the Berlin-Adlershof Technology Park.



www.foc-fo.com

Contacts

FOC – fibre optical components GmbH

Headquarter
Justus-von-Liebig-Straße 7
12489 Berlin / Germany
phone: +49 30 565507-0
fax: +49 30 565507-19
e-mail: info@foc-fo.de

Sales region south
Zettachring 10a
70567 Stuttgart / Germany
phone: +49 711 745191-90
fax: +49 711 745191-91
e-mail: sued@foc-fo.de

Sales region west
Ansbacher Straße 19
40597 Düsseldorf / Germany
phone: +49 211 695176-09
fax: +49 211 59841871
e-mail: west@foc-fo.de

Details on how to contact our staff can be found in the Internet at www.foc-fo.com, Contacts, Direct contacts.

Overall production: Eyck-Media • Berlin, uta.eyck@gmail.com