

ACTION PLAN FOR THE INTEGRATION OF ON-DEMAND RIDESHARING AND ADAPTATION OF HIGHLY AUTOMATED DRIVING IN PUBLIC TRANSPORT OF LEIPZIG (GERMANY)

DELIVERABLE D.T1.2.3

ACTION PLANS FOR NEW INNOVATIVE LOW-CARBON MOBILITY SOLUTIONS & IMPROVED AIR QUALITY IN FUA

FINAL
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Development of action plans for new innovative mobility solutions & improved air quality in FUAs

- Project overview

Leipzig Transport Company (LVB) has a sound history of participation in Interreg Central Europe Projects and now contributed to Dynaxibility4CE. Within this project the focus was on gaining knowledge on the transformation from first DRT pilots towards a standard product in the portfolio of modes provided by a public transport Company. Two projects already existed in LVB in this context prior to Dynaxibility4CE. **Flexa** - The LVB DRT pilot was launched in a pilot area in the north of Leipzig in October 2019. The **ABSOLUT** project aiming for highly automated driving of public transport compatible vehicles commenced work already in January 2019. A third project was started almost at the same time with Dynaxibility4CE. The preparations for a fundamental PT network reform called Netz24 started in summer 2020 aiming for a rebuild from scratch of the LVB PT network including Tram, Bus and Flexa with implementation between in 2024 and 2026.

With Dynaxibility4CE LVB sought to merge developments and insights of both projects Flexa and ABSOLUT in a unified strategy towards potentials and challenges of public transport with small and in the future highly automated vehicles. Partial implementation of DRT service was aimed for Netz24.

The transformation from one or two single DRT pilots into everyday usage at a larger scale for the typical public transport customer and company was the key objective of the Dynaxibility4CE project. Locally this project was referred to as “Flexa wird groß” - Flexa grows up.

- Description and objectives of the action planning process

In contrast to a classical approach with broad conceptual phases followed distinctively afterwards by implementation, LVB opted for a more agile approach. Due to the Flexa project, LVB was in the position to start with this planning process from a DRT pilot in operation. Software (DRT Routing, Pooling, Avoidance of parallel service to bus lines, Combined DRT+Line Service Routing, Driver App, Customer App, Callcenter App) had been development before in close collaboration with scientists from Max-Planck-Institute for Dynamics and Self-Organization. The actual transport service was in operation partly by LVB personnel, partly contracted by a local Taxi company. Company processes around this service were mainly defined to ensure secure and high level operation within a pilot. Based on this service in operation and its success, awareness on DRT increased within LVB to mature this new product.

With the beginning of Dynaxibility4CE this awareness resulted in a set of requirements for the project and a brief strategic vision phase. Requirements were collected within LVBs marketing unit and considered as a starting point for the project work plan and the action plan (cf. Fig 1). Revisiting of these requirements was planned during project life time in a broader context from more LVB units and beyond. The vision phase asked: What could a network based on tram, bus AND Flexa look like? As a first step we agreed to focus with DRT on substandard served peripheral areas of Leipzig and think of DRT as the potential to extend the main frequency of trams and main bus lines into the periphery (cf Fig 2).



Previously there were areas served only every 20 min or less or partially not at all since the street network was impassable for busses.



Figure 1: Initial clustering of “Dynaxibility4CE/Flexa wird groß” work packages and attribution to the business units Research & Development, Traffic Planning and Operations Management



Figure 2: Initial abstract vision of the role of LVBs DRT product Flexa among Tram and bus lines. DRT should complement/replace line based services at the periphery, where the structure of settlement and road network disqualifies line based services.

To substantiate this vision, the goal of Dynaxibility4CE was to project and prepare a new set of pilot areas that will (partially) replace existing bus service. All requirements for this goal should be identified along the way, clarified and potentially resolved. These pilots will be launched in late 2022. Hence, the action plan is a work in progress. A number of requirements could be completely resolved, some are in implementation prior to the pilot start, other remain to be resolved.

- Relation to other project activities

Diagnosis Workshops

Shared visions were formed for DRT services and user stories among the traffic planning section, R&D and operations. This took place in the series of diagnosis workshops as a hybrid event on 12 July 2021.

Another Workshop with current drivers of the DRT services was held to acquire feedback on operational deficits and potential customer needs.

This series of Input was closed with actual user interviews stimulating another view on customer needs and in addition benefits of this transport mode.

Consultation of disabled rights organizations



To make Flexa a regular product in the PT of Leipzig, vehicles and booking channels have to be accessible to all citizens. Therefore, relevant disabled rights organizations from Leipzig were consulted in a hands-on meeting in a Flexa area. The current Flexa vehicles were presented and critically reviewed together with the representatives. The strategic vision of Flexa partially substituting bus services was openly discussed and demands of people with special needs were considered. One central point was the request for transport of large electric wheel chairs within public transport and the upcoming DRT system. No current passenger group should be excluded from potential future services. The results were considered in the recent tender for the Flexa operation.

Consultation by City of Leipzig on DRT regulations beyond PT

The renewal of the German law for passenger transport, the PBefG, introduced three forms of DRT as distinct legal mode of transport for the first time. These are DRT tightly embedded in PT, such as Flexa and other forms of DRT between PT and Taxi services. Here, the city of Leipzig defined a general framework for such services. This new regulative framework was developed in collaboration with LVB.

Exchange with VRS on their simulations for the Schurwald area

During partner meetings it was possible to gain insights on the scenarios and results of the transport simulation initiated by VRS on the Schurwald area. Interestingly, different assessments existed on the efficiency of such systems. Expectations were high on the pooling rate, i.e. the mean number of passenger per vehicle of such a system. Simulations revealed a pooling rate comparable to the average occupancy of private cars. This matches the observation in real life pilots. The ecologic benefit of such systems originates from the pooling during the entire journey in particular after the trip with these small vehicles. In their role as feeder service to capable mass transit system, the systemic advantages are superior with respect to emission and energy consumption.



Executive Summary

The long-term vision are autonomous vehicles (AV) and the preparation for the connected business cases. E.g. questions of ownership and access, sharing or exclusive usage, and full journey or intermodal combination with others sustainable modes of transport.

We advocate for an early adaption of services and technology by public transport to prepare for the most sustainable implementation of shared, publicly operated AV as feeders for mass transport. Otherwise, technology companies might enter the market with either privately owned AVs or shared AVs imprinting their business model on our cities with all shortcomings for traffic volume, parking demand, pricing and equal participation. If public transport would wait for proper PT suitable vehicles, the transport market might be disrupted years before. In contrast by early adaption PT operators might become the prime integrators of the preform of AVs - highly-automated vehicles - with their demand for more or less frequent interventions by a remote operator.

This action plan summarizes the findings of the strategic process during the funding project Dynaxibility4CE on the further development of DRT in Leipzig called “Flexa”. It lists what has been identified and prioritized for further development to mature the DRT pilots towards a future standard product in the mode of transport portfolio of the LVB the Leipzig transport company.

It sketches a way towards merging the LVB initiatives (ABSOLUT and Flexa) on highly automated vehicle fleets for demand responsive traffic (DRT). Flexa will be piloted with new and extended foci by the end of 2022 in two more Leipzigs areas. The new goal is to study operation and acceptance of the (partial) substitution of line-based bus services with Flexa. Afterwards these results will enter the planning process of the Netz24 PT network reform. This reform planned for 2024 - 2026 will optimize tram and bus lines and DRT areas in an integrated city-wide approach for the first time.

Caveats and challenges along this way have been identified, explained, and partially resolved. For the LVB this vastly improves planning, investment and fund-raising processes in the near future.



1. Introduction

- Goal of the document

This paper serves as an implementation guideline, a collection of caveats and lessons learned on the topic of demand responsive transportation (DRT). As an example, LVB describes its process of scaling up a first DRT pilot (“Flexa”) towards an immanent part of the Leipzig Public Transport (PT) network. This process is not finished yet and remaining tasks are clarified. Of course, the ultimate automated driving perspective is the long-term prospect and insights from LVBs automated driving project ABSOLUT influence upscaling pathways.

- Scope

These guidelines and lessons learned are deduced from Leipzig, Germany and its suburbia, a typical mid-sized European City of more than 600,000 inhabitants embedded in the dynamic metropolitan area Mitteldeutschland of 2,300,000 inhabitants. Generally, Leipzig has a sound public transport offer and good preconditions for cycling. However, high car ownership and usage are predominant in the peripheral areas where DRT is aimed to be part of the sustainable mix of transport alternatives to decrease CO2 emission and air pollution.

The potential target groups of this paper are decision makers and transport planners in municipal administration, transport companies and politics.

- Local process overview

1. Vision: Together with the LVB departments for transport planning, research and development, and operations, a vision for the DRT product “Flexa” was developed. Details of this vision are continuously adapted to new findings.
2. Requirements Analysis: To turn the vision into reality, the requirements for the software used, the product design and the operation were determined together with all relevant departments, as well as with customers and drivers.
3. Identifying the major challenge: The substitution of line-based services was identified as a major and particularly challenging goal. Offering a DRT system instead of a scheduled service poses special challenges for the flexible service of Flexa in terms of reliability and plannability, especially since it does not operate according to a timetable like other on-demand services.
4. Testing the substitution of line-based services by Flexa: For the purpose of testing the substitution of scheduled services, two new pilot areas were planned and prepared. In one of these areas, the currently operating bus line will be completely replaced by Flexa, while in another area the operating bus line will be limited to the core area. The launch is planned for November 2022.
5. Preparing the new pilot areas: On the way to the opening of the new test areas, many questions had to be answered. These were, in particular, the creation of new service concepts, the first-time application for new permits following an amendment to the German



Passenger Transportation Act (PBefG), the participation of citizens in the affected areas, and the expansion of the software used.

6. Retrospective: Finally, the retrospective of the implemented steps, as well as the generated results is foreseen. This is already being done in the form of this report and the storage of knowledge within the company, as well as in the future with the implementation of the new pilot areas mentioned.

2. Planning and policy framework

- Background

The planning of local public transport has different actors and levels in Leipzig and the region. Local rail passenger transport is organized by the local special-purpose association “Zweckverband für den Nahverkehrsraum Leipzig” (ZVNL). The responsible authority for road-based local public transport is the city of Leipzig. The city has entrusted LVB with the planning, implementation and ongoing further development of public transport within the framework of the city's concepts. The “Mitteldeutscher Verkehrsverbund” is responsible for tariffs and for creating a unified access to public transport in the region by setting standards and ensuring communication between all operating transport companies.

- Legal framework overview

Currently, the DRT service “Flexa” is regulated as a so-called “Gelegenheitsverkehr” under a special permit, as the German Passenger Transportation Act (PBefG) did not explicitly consider DRT systems until mid-2021. The responsibility for “Gelegenheitsverkehre” in Saxony lies with the city of Leipzig. This is currently the licensing authority. Within the framework of an amendment to the PBefG, the so-called “Linienbedarfsverkehr” will be included in the PBefG with the new paragraph §44. The Flexa service of the LVB is to be assigned to this new paragraph. The responsibility for permissions thus changes from the local authority to federal state authorities. The responsible licensing authority is then the Saxonian “Landesamt für Straßenbau und Verkehr” (LaSuV). The Flexa service is currently being examined there. The new license under §44 PBefG is expected in the end of 2022.

Since this is a completely new paragraph and a new type of traffic, a close exchange with the authorities was and is necessary.

- Planning/policy context (local, regional, national)

There are several mobility concepts in the city and the region, in which the transport planning, and also the Flexa offer are embedded:

- Integrated urban development concept (INSEK): Future strategy for the development of Leipzig for the next 10 to 15 years. It brings together all the issues that are important for



Leipzig's urban development. Interdisciplinary work within the city administration is just as important as the involvement of all stakeholders in the city's society.

- Urban Development Plan - Traffic and Public Space (STEP Verkehr und öffentlicher Raum): Establishment of goals in the field of mobility and public space, decided by the City Council.
- Local transport plan (NVP): The definition of standards for the public transport services in general, the design of an integrated transport network and the financing of transport services in Leipzig.
- Sustainability scenario - mobility strategy 2030: The focus is on promoting sustainable, clean, and inclusive mobility. Leipzig is to be sustainably developed for all road users.

- Related initiatives

In the context of the DRT service Flexa, other projects in the Leipzig region are worth mentioning.

The LVB project ABSOLUT deals with self-driving vehicles for passenger transport and seeks for highly automated driving of vehicles at high speeds suitable for public transport. The follow-up project of ABSOLUT is planned to merge results from ABSOLUT and Flexa more tightly. The projects are already being coordinated with each other. A long-term goal is to provide a DRT service with autonomous shuttles.

In the region around Leipzig, there are other DRT services operated by other transport companies. To improve the customer experience, access to the various DRT services in the region is to be standardized. In particular, by including them in various mobility apps.

A reform of LVB's ALITA product is also on the agenda. This is a scheduled line-based DRT service for bus lines with low demand during off-peak hours. The long-term goal here is to convert the predominantly telephone-based service into a digital service and to market all variants of DRT uniformly.

3. Key results and findings

- (as applicable in each FUA) results, analysis and conclusions from conducted study, participation process, workshops, tests, etc. or key results from related initiatives that should be highlighted

Previous main findings from lessons learned brochure

The LVB's project setup focussing on the two nowadays different topics of DRT and automated vehicles in the two different projects Flexa and ABSOLUT is a good approach. Contributing to the automated vehicle market is crucial, since today main manufacturers focus on the private car rather than public transport suitable vehicles. Contrary, learning things around the DRT service immanent to automated vehicles should not wait until the breakeven of autonomous vehicles. A shift towards sustainable modes of transport is needed now. Hence Flexa operates already today and LVB together with Leipzig citizens identify challenges and requirements very early in the market.



The central finding of the ABSOLUT project is, on the development toward highly automated vehicles, public transport operators could be the prime integrators of such fleets. They have local knowledge to prepare and identify operational fields. They are on site and can resolve conflicts physically. They operate control rooms already today. And most important via tele-operated driving they can benefit from incremental improvements in technology reducing the number of human interventions increasing the number of tele-operated vehicles per tele-operator. They can reduce costs even before the breakthrough of real autonomous driving.

However, the challenge from pursuing goals towards a shared goal from different sides is the synchronization and regular exchange between both paths. Since both parts are more and more merging this synchronization will become more and more crucial. We will account for that with regular meetings and an organizational overlap between both paths.

Eventually, we emphasize that additional resources are necessary for the development and implementation of DRT structures and vehicle automation. This might appear contradictory to the involved terms of automation, algorithms and artificial intelligence. However, the implementation, operation, maintenance and further development requires knowledge and trained staff. Eventually this could be a positive perspective for parts of the existing personnel affected by vehicle automation.

Two successful results from lessons learned

Among various other aspects, we had four learnings on DRT during Dynaxibility4CE.

In general, stakeholder engagement is crucial for a projects success. In particular, for the political mandate it was necessary to engage with the administration, with the public and with representatives on the neighbourhood and city level. During stakeholder analysis we learned about another citizen engagement initiated from the City Planning Department. This process matched our spatial and temporal scope for engagement. We actively contributed our topics and questions generating a win-win situation for both initiatives. The city planning department was professionally engaged in such processes and sought for exchange on the long-term local neighbourhood developmental concept (5 years+). We could provide with the DRT pilot something tightly content wise related (traffic) but with a short-term realisation scope (1 year). This triggered interest and encouraged the strategic discussion for the long-term questions. The DRT engagement benefitted from the established engagement format and the coordination between city of Leipzig and transport company.

Beyond the local political mandate, a license for the operation of transport service is mandatory. A lot of exchange on vision and details in operation was necessary with the licensing authority to satisfy the requirements originating from classical line-based transport services. In Germany in 2021, the law on transport services was renewed and received a concrete article for PT-based DRT services. This involved a change of the responsible licensing authority. Exchange with others DRT providers and transport companies supported us to suggest lean and appropriate recommendations for the licensing procedure.

DRT in Leipzig is called Flexa. This term attributes flexibility to the product. Currently, driving service and drivers are operated by a subcontractor to provide LVB with experience and flexibility during our learning process with this new form of mobility. During contracting, it is essential to actually preserve this flexibility during operation. Initially, the service schedule including the number of vehicles per hour of the day was set and fixed. Procurement rules prohibited an adjustment of the service schedule to the actual demand post-award. This would have been crucial for services and vehicles that need to match closely to be attractive and economic at the same time. With the new procurement, this was



improved and flexibility possibilities on different time scales were introduced. This will facilitate a fine balancing of PT offer and demand even during lifetime of the contract. For further reading on first insights on DRT procurement, we recommend „Hinweise zur Ausschreibung von Linienbedarfsverkehren“, VDV-Mitteilung 10016, 12/2021.

Previously, DRT services were mostly used to save costs at times and on routes with low demand. Flexa, like many modern DRT systems in public transport, focuses on better connectivity and high quality. This makes the product only in rare cases a tool to save costs. In particular, it can be used to close gaps in the network, improve connectivity quality, and attract new customer groups to sustainable mobility. To keep costs in check, however, integrated traffic planning that coordinates line-based services and DRT services, and software that makes this possible are helpful. Necessary software components are in particular a mechanism to avoid parallel traffic, as well as a combined routing of line-based services and DRT.

4. Action Plan towards CCAM/MaaS/UVAR in XX

Operational processes

In a joint workshop with LVB's operations control department, several key tasks were identified for implementing Flexa in regular operations:

- **Traffic disruption management:** Traffic disruptions such as road works must be identified, evaluated in terms of their impact on the DRT system, and taken into account in the system. The difficulty here is that for DRT systems, the entire road network can be affected, in contrast to regular traffic, where only the predefined route is relevant.
- **Approval process of virtual stops:** new processes in regular operations need to be created to apply for new and manage existing approvals for DRT services and stops.
- **Organization of driving operations:** Fixed structures for the organization of driving operations need to be established. Currently, service provision takes place through contracting by tender. The preparation and execution of tenders has so far been the responsibility of the project team. In the future, these are to be managed by the regular structure. The implementation of a service provider management system is also necessary.

Digital customer experience

- **Integration in mobility apps:** During pilot phase the Flexa system has its own standalone app to inform and book trips. Aiming for simplicity this need for additional apps needs to be overcome. The Flexa system will be connected to regional mobility apps. The first priority here is integration into LVB's "LeipzigMOVE" mobility platform.
- **In long-term the integration in other mobility apps should follow.** However, this a central point among such DRT systems. We advise a sector driven standardization process aiming for a



open API to facilitate booking of such upcoming services across local PT ecosystems. Other mobility apps are to follow.

- **Improving the algorithm:** To improve the quality of the routes and the speed of the Flexa system, the pooling algorithm will be revised, optimized, and provided with new functions. In particular, the link with scheduled transport is to be improved.
- **Merger of Flexa and ALITA:** ALITA is a scheduled line-based DRT service for bus lines with low demand during off-peak hours. The long-term goal here is to convert the predominantly telephone-based service into a digital service and to market all variants of DRT uniformly.

Capacity management

- **Automation of vehicle deployment planning:** To always find an optimal balance between supply and demand, it is planned to predict vehicle requirements on the basis of various parameters such as past demand, weather and major events. On this basis, an optimal vehicle deployment plan will also be created automatically.
- **The ad hoc consultation of further capacities:** To be able to react to unexpected short-term peaks in demand, a possibility is to be created, both technically and procedurally, to automatically assign individual travel orders to local passenger transport companies, especially cabs.
- **Continuous optimization of the service concept:** To always be able to offer the optimal mix of public transport modes for each area, concepts for the combination of line-based transport and DRT service are continuously being developed and optimized. These may include the replacement or restructuring of line-based services, but also the reintroduction of line-based services in the event that an attractive DRT service has increased demand for public transport. To achieve these goals, new planning and modelling methods are used. With the extension of the previously used planning software PTV Visum by a DRT module, DRT finds its way into the integrated transport planning of LVB. Furthermore, new approaches to traffic modelling are being tested. Together with the city of Leipzig and the Technical University of Berlin, a city-wide traffic model is being created using the software MatSIM, which also takes DRT systems into account.



5. Conclusions and recommendations for innovative low-carbon mobility planning In FUA

The LVB's project setup focussing on the two nowadays different topics of DRT and automated vehicles in the two different projects Flexa and ABSOLUT is a good approach. Contributing to the automated vehicle market is crucial, since today OEMs focus on the private car rather than public transport suitable vehicles. Contrary, learning things around the DRT service immanent to automated vehicles should not wait until the breakeven of autonomous vehicles. A shift towards sustainable modes of transport is needed now. Hence Flexa operates already today and LVB together with Leipzig citizens identify challenges and requirements very early in the market.

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Among various other aspects, we had three learnings on DRT during Dynaxibility4CE:

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6. Dissemination and exploitation plans

The evolution of DRT in Leipzig was accelerated with the Dynaxibility4CE project. The results and insights of Dynaxibility4CE prepared for the next steps of the Flexa development, both for the next implementations that Leipzig citizens can experience and funding applications that have now a sound strategic background.

The scenario development resulted in a concrete vision for the role of DRT with implications across all time scales. On the long term, i.e. by the end of the decade we foresee cost leverage effects by the roll-out of automated vehicles. Midterm we see an upscaling of the current pilot phase with integrated PT network reform Netz24 at all applicable peripheral areas in Leipzig. Short-term we will launch two new pilot that seek to prove our concept around the (partial) substitution of bus services. These new pilots have been mainly prepared during Dynaxibility4CE and will be launched in November 2022. The Planning for Netz24 will base on the findings of these pilots and thorough evaluation in 2023. The results of Dynaxibility4CE can be experienced by Leipzig citizens by the end this year.

From this scenario process particular further demands for our DRT service have been identified. We plan to apply for different public funds to leverage these investments in software and service. The strategic process resulted in sound background to justify such application and increase the probability to succeed in such proposals.



In particular the highly-automated vehicle project ABSOLUT is foreseen to proceed to the next level within a consecutive project. The goal of this project could be the remote-operation of highly automated vehicles. This would be a crucial step towards cost efficiency of these attractive services.

References (if applicable, images or maps to be provided as annex)

- www.l.de/flexa
- www.absolut-project.com
- https://www.isv.uni-stuttgart.de/vuv/publikationen/downloads/MEGAFON_Abschlussbericht_V028_20161212.pdf
MEGAFON-Study on the Impact of autonomous fleets in different business cases on traffic volume in cities 12/2016
- „Hinweise zur Ausschreibung von Linienbedarfsverkehren“, VDV-Mitteilung 10016, 12/2021



Annex

New Pilot: Flexa Leutzsch (Neighborhood service)

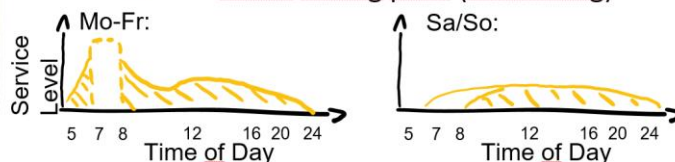


- Bus 67: Lowest passenger numbers of all Leipzig Lines
- Still school peak
- Missing Link to S-Bahn & regional busses

Aim: Full substitution of bus

Flexa Vehicle operate in two modi:

- Fully flexible DRT mode
- Line mode during peak (Platooning)



6 | May 17th 2022 | Flexa – DRT in Leipzig



Figure 3: Flexa Leutzsch: One of the two new Flexa pilots prepared during Dynaxibility4CE planned for full implementation by end of November 2022. Buses are substituted completely. During the early school peak free area operation of the two DRT vehicles is interrupted for a line based operation by the same vehicles.

New Pilot: Flexa Southwest (typical Suburban)

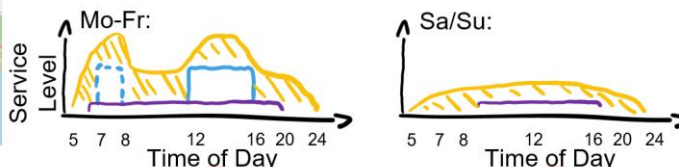


- Heavy School Peak, Low Residual Demand
- Long Distance Walking
- Incomprehensible Bus Service

Flexa: simple, straightened bus line 63 during School Peak

Remote village: Pure OD Traffic

- Flexa On Demand
- Bus 63 Circle
- Bus 63 Circle + Knautnaundorf
- TaktBus 120



10 | May 17th 2022 | Flexa – DRT in Leipzig



Figure 4: Flexa Southwest: One of the two new Flexa pilots prepared during Dynaxibility4CE planned for full implementation by end of November 2022. The bus operates only in the morning and afternoon at a constant frequency of three services per hour. All other areas or served in DRT mode by two other vehicles. Remote areas featuring narrow roads see attractive PT for the first time in close distance.