Utility Tunnels – Proven Sustainability Above and Below Ground

Axel Laistner, Hermann Laistner

(Dipl.-Ing. Dr. techn. Axel Laistner, axel laistner consulting UG(hb), Rosenstr. 6 – 73466 Lauchheim, axel.laistner@laistnerconsult.de)
(Dipl.-Ing(FH) Dipl.-Ing.(FH) Hermann Laistner, Hardtsteige 29 – 73466 Lauchheim)

1 ABSTRACT

Utility tunnels have been elements of urban supply systems for almost two centuries now. However, their use and implementation is still less determined by urban planning and urban needs – and more by the qualities, preconceptions and determination of the urban managers in question. During the 1990s in the course of the German reunification process the fluidity of the urban management situation created opportunities for new approaches to this old technology.

In conjunction with landmark urban development projects on the path to urben sustainability, utility tunnels were used as one of the many instruments and approaches to achieve sustainable developments. Now – almost 20 years later we can look at these developments and the utility tunnels and have a first discussion on their sustainability success.

At present a new relevance developes in regard of this technology. The current urban development schemes in China, India and many other places of the world are of such scale, that questions of doing it right while doing it timely are of prime significance. At the same time, we are facing a situation, in which – within the coming 40 years – the whole energy supply and distribution system of the world – including China and India – will need to be 100% restructured and reworked. We need a whole new quality of system flexibility and reaction capacity in urban engineering to achieve the path to urban sustainability.

Taking proven experience in sustainable urban development and engineering, what are and will be the taskings and quality expectations to urban design and development in the coming years and decades? System changes will require mental, philosophical and educational changes in human minds – also those of the developers, planners, architects, and engineers. So what do we need to learn, and how do we teach it fast and to many of us in a short time?

2 HOW DID WE COME BY THE IDEA TO BUILD UTILITY TUNNELS?

In the 1980s, when considering the known damages, especially in the community pipeline networks transporting water and sewage, in a context of soil & aquifer protection, the technical and engineer community in Germany began to think about how to design better controlable systems. Ideas developed, like absolutely straight line house connections, or double pipes with leak detection systems.

Hermann Laistner injected into this discussion a rectangular infrastructure culvert (utility tunnel), large enough to be easily walked in. From this utility tunnel property and building connections could be constructed in a controllable way, while the main pipes and cables would be inside mounted and accessible. In the early and mid 1980s, these were rather theoretical thought constructs.

2.1 Research Focus "Ecological Development Concepts"

Working within the experimental research on urban development, such ideas however, could be injected for further consideration and detailing of concept. In the state capital of rhineland-palatia, the City of Mainz , the city planning authority – thematically lead by Dipl.-Ing. Jürgen Hoffmann – had applied for, and had been awarded, a federal research demonstration project on the development of an ecological business and industrial park. Hermann Laistner and his company IfEU, having worked succesfully in this research field before, and bringing both an understanding of the research process and the practical every day experience of urban development and supply system engineering into such projects, were selected to be the lead expert researchers for and together with the various offices of the City of Mainz.

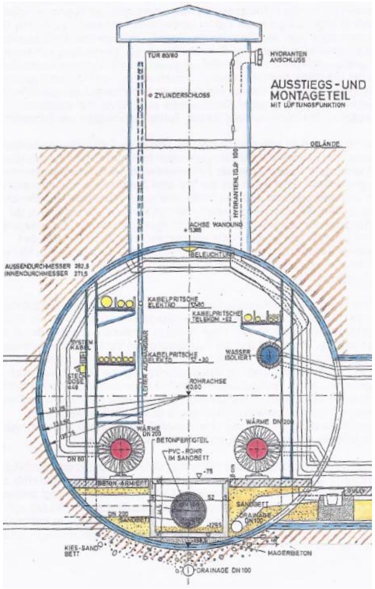

Fig. 1: Sustainable underground system development for urban development area = the utility tunnel picture excerpt from research final report[1] Abb. 17

The urban development tasking was started by an encompassing ecological evaluation study. It was intended to develop a purposfully structured occupation mixed area. A tram-way was to be a high quality public transport connection for the area. State roads were to be the vehicle access routes. In developing the key idea of orienting the developments along wide green corridors, with an explicite focus on empowering pedestrian traffic and their easy connection between public transport and work place. In this context the idea of an utility tunnel was first incorporated by us into a development project and injected into its discussion process.

2.2 The German Reunification

It was 1989 when we had these discussions and did the concept development of a utility tunnel for the City of Mainz. And then the German reunification came and all of a sudden totally new urban development taskings were to be tackled. Through our research we had, after the opening of East Germany, developed contacts to the "Bauakademie Leipzig", because they had written for the GDR (East Germany) the standards on utility tunnels – and nothing comparable was available within the West German standards.

At the time the main development tasking was to create business areas fast, to begin to satisfy the expectations of a better economic and supply situation after the long time of "managing dearth" during the final two decades of the socialist regime. Among the available development areas, in discussion and under review, were the huge refill areas of the lean-coal strip mines. After visiting such an area "Espenhain" next to Borna, we considered the special problems of the large differential ground settlements, that were to be expected in such an uneven industrial refill situation. The idea was to implement utility tunnels with a certain hull flexibility. So we came to look at the long proven corrugated steel culverts instead of the originally envisioned (traditional) concrete culverts. Requests on information regarding as yet undeveloped or unusual production elements of such steel culverts (e.g. bends, manholes, side-penetrations, e.g.) produced an intensive interest within one of the producers – the Austrian Voest-Alpine Krems Finaltechnik corporation.

In the meantime we were contracted to be the development planners and engineers for one specific such new business development in the small village of Wachau directly bordering on the City of Leipzig to the south. The situation there was driven by the need to inject at least a minimum of mandated urban planning into a situation already dominated by a large shopping center construction investor in the north-east corner of the area. Time was of the essence. All over the larger area and many parts of the eastern states of Germany, communities used their new found freedom of communal decission making and planning. Whereever one looked there were growing large billboards advertising business developments in the green fields next to the

[1] For more information and the literature references to this research project: "Modellvorhaben Mainz – Ökologischer Wirtschaftspark Mainz-Süd" please see the paper "Sustainable Urban Development in Germany in the 1990s – a situation report after 20 years" in these proceedings by the same authors

settlements. It was clear, that for the just developing small business and industrial structure in the changing society, there would be very shortly an over-availability of zoned business areas.

We used the many experiences gained in the 1970s and 1980s in urban development projects, development research, and a practised unterstanding of the community political process involved, to help Wachau to a speedy process and solution for the community development. We especially used all the readily developed ideas from the Mainz project. The overall situations were comparable. Close proximity to a city, just outside the city development, with tram-way access to the area, and outside but bounding state road connections.

When coming to the design and then the tendering process of the development construction works for the area, we had presented to the by then just founded PPP business park development company, the concept of using utility tunnels. As this was a known technology, used in most large urban developments of the GDR, this was a readily understood and agreed to concept. However, we did open up the tender to enable bidder proposals for the use of other tunnel materials then the well known concrete culverts. We defined the necessary cross sections and the intended inside installations, but left the material choice to the bidders. At the time, the steel culvert came in with the lowest price – and was selected. In the perpetual see-saw of cement and steel prices worldwide – steel was cheaper at the time.

2.3 The Learning Curve – Execution Problems

Even though the idea of the utility tunnel was nothing unusual in eastern Germany, there was significant concern, that the transition staff of West-German public servants (Wessies), which had been transfered into the East German civil authorities, would project their own rather limited expereince in this field, and reinstate all the problems that had limited the use of utility tunnels to universities, airports and private industry in the West. Individualized and legally protected compentences for supply and utility companies, public suppliers, and a resulting highly differentiated authority structure – with a seperate office for everything – had in the West effectively stifled most atempts to create combined public systems. And the utility tunnel very definitely is a combined services system.

So one of our first steps was to ask the TÜV Rheinland – Divission for Nuclear and Chemical Plants for a safety analysis of the utility tunnel we were designing. The result came in as expected – very positive, and disqualifying all the fake arguments against utility tunnels – while at the same time enhancing our understanding on the special considerations that needed to be given to this technology.

The easy part of engineering and planning work was to incorporate the utility tunnel into the community area zoning plan (Bebauungsplan) and have it politically decided upon by the council. It was a bit more difficult, and a learning process, to design and construct our first utility tunnel. For example – putting the utility tunnel system on a sloped grading to accomodate the function of the integrated gravity sewer and its connection to the Leipzig sewage system – was easy. Then however, coordinating the utility tunnel slopes with the surface profiling of the development area, so that the open surface drainage ditches and their road crossing culverts could be kept consistently safely above the utility tunnels, already became more difficult. Being under time pressure to achieve early marketability of the area was very helpful in the decission making process on this and other issues. Solutions had to be found and compromises could be reached easier.

2.4 Government Subsidies & Initial Discoveries on Utility Tunnel Economics

The decisison to build the utility tunnel system was made easier by the situation of a special canon of federal subsedies and special conditions for the development of business areas in East Germany at the time. Normally e.g. sewers would not be subsedised, the utility tunnel however, as a combined system, could be subsidised with 30% of construction costs including systems at the time. This subsidy more than balanced the expected higher investment costs.

Then we discovered an unplaned economic effect. Steel culverts can be built with a progress of up to 25 m per day completed tunnel hull. And immediatly after – later with – the backfill the internal systems installation started. Due to the fast backfill and closing of the surface, the road construction could progress with only a few days delay behind the hull construction. A fundamental difference in development process exists to the buried pipe and cable system. There road construction usually is delayed by weeks or months to commence only after completion of most or all pipes and cables underground.

Property in the development area was consequently almost immediatly markteable. And buildings were already going up while we were still equipping the utility tunnel with the systems. This created an immediate and unexpected market advantage. Hleped by the fast approval process of the urban zoning process, by the state authorities (Regierungspräsidium Leipzig), and the decoupling of above and underground construction development, this area was the only one in the larger area of souther East Germany, that was able to sell accessible plots already during the summer of 1991. By enabling the investors and enterpreneurs to enact their own developments earlier, their acceptance of some accompanying unusual conditions of the business park, such as mandatory permanent green areas on their business property, and membership in an operations cooperative for the upkeep of the business park area, were a much easier sell than expected.

2.5 So What?

Why have such "anecdotal" story telling in a reviewed paper? Isn't that what you're asking yourself right now as reader? Because it illustrates and highlights an important and very dissatisfying state of affaires in urban supply and engineering of utility systems as a whole – not only regarding utility tunnels.

We're worldwide hide bound and turf cracy when it comes to the fictional independence of our supply systems owners and operators, and our authority and decission perogatives.

Why? Very often for reasons driven by the legal system and its developmen history in our countries. Among other reasons however not for a small part also, because academic education is dropping the ball! We all learn or teach intensively the ins and outs of our technical systems, don't we. Yes we do – the electrical engineer for the cables, the mechanical engineer for pipes and plant installations and their operation, the civil engineer about how to construct these under and above ground, and the architect and urban planner how to shape cities, environments and buildings to human needs and functionalities.

- And that's the point – WE'RE STOVE-PIPING OURSELVES ! -

And we're happily projecting this mental self-limitation onto generation after generation of young academics. We've so much dropped the ball on academic interdisciplinary training and team functionality, that it needed the totally destabilized administrative situation of the first few years of German reunification, to re-inject a combined services system into the public sphere again. And when the administrative system stabilized again – that came to an early end again.

AND THAT'S THE STARTING POINT FOR UTILITY TUNNELS IN OUR REALITY!

3 UTILITY TUNNELS – WHERE THEY COME FROM – WHERE THEY'RE GOING

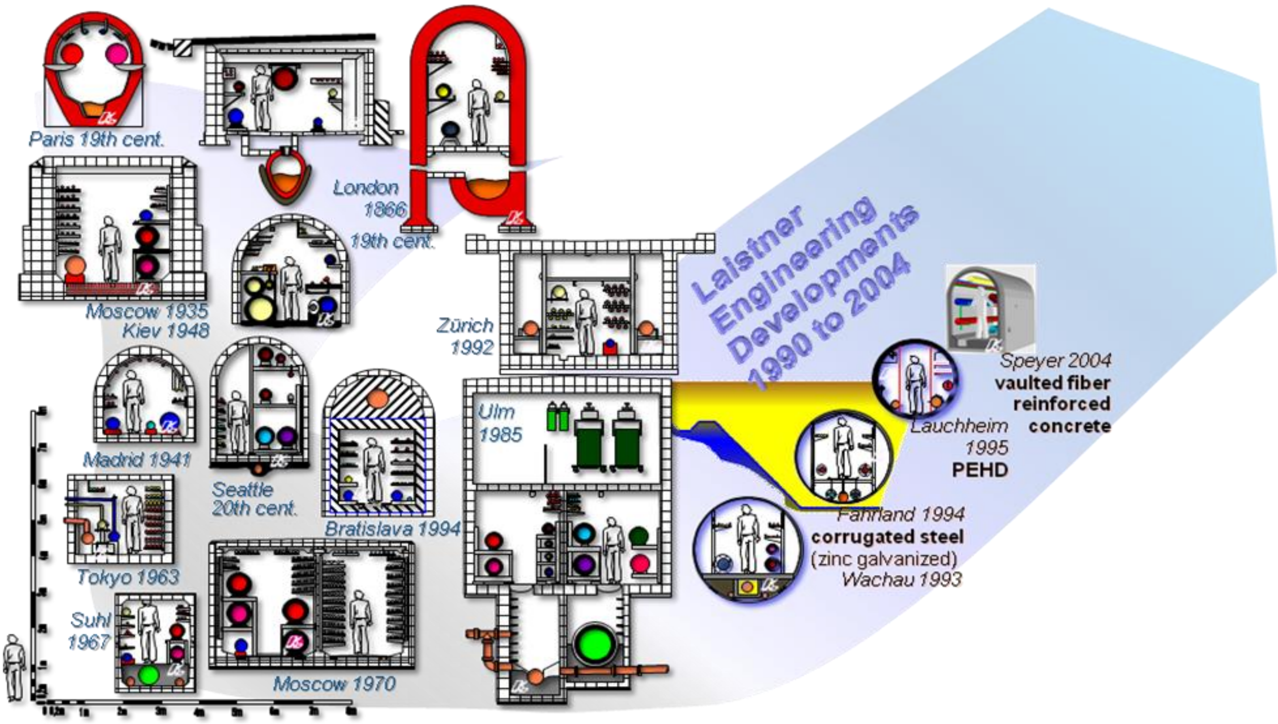

Fig. 2: Utility Tunnels since 1866 – worldwide and developing – pictures Axel Laistner 1994 to 2012 – use of fibre concrete was developed together with and first implemented by Carl Dupré GmbH & Co KG

As you can see above, there are many more utility tunnels than you probably thought. These depicted here are with the exception of Seattle and Ulm all public space utility tunnels. The latter two are university system utility tunnels. When we started into this field as described above – we teamed with the Prof. Knoflacher, at the Institute for Transport Planning and Transport Technology (IVV) of the TU Wien and the VOEST ALPINE KREMS FINALTECHNIK and jointly financed and conducted a privately funded research project into the technology. This produced 1 doctoral thesis and 5 diploma dissertations and a variety of publications from 1992 to 1997. From 1995 until 1997 and thanks to Prof. Jodl we even had a targeted graduate level course on the subject of utility tunnels offered at the Institute for Construction Operations and Construction Economics (IBB) of the TU Wien for civil engineering, architecture and mechanical engineering students. Together with Prof. Stein of the IKB of the Ruhr-Uni Bochum and the GSTT, working groups on the subject of utility tunnels were established in Germany and internationally within the ISTT.

Our intention was to produce a large enough critical education and knowledge base to enable this technology to finally become the accepted state of the art in urban engineering. Now 15 years on – we're again entering a phase of renewed interest in utility tunnels.[2] A little earlier than the historic cycle of 20 to 25 years hiatus and dormancy until the next engineering generation discovers this technology, which we had discovered in our research back all the way to the late 1800s. So we were at best only partially successful in our efforts.

Between 1991 and 2008 we were ourselves involved in designing, or instigating, and supporting the development of 10 utility tunnel systems or system modifications, 7 of which were built, and 4 of which pioniered new forms of hull materials or enlarged their field of suitable implementation. We've been responsiblly involved for the design of ~31 km of utility tunnels and constructed ~ 13.5 km to date. We've gathered experience with utility tunnels in ground water and in earthquakes – and not just as design parameters – but having to deal with the real thing happening. We'd in each situation designed for such known hazards, and the tunnels performed well. And we encountered unknown, or at least unexpected hazards, mostly originating from human thoughfulness and thoughlessness both. We've seen utility tunnels float in their construction ditches, and suffer from water incursion because the outside drainage protection system had been forgotten and needed to be rediscovered. With all this experience through 20 years we can unequivocally state:

There is no more effective, efficient, economic, safe, supply secure, environmental and sustainable urban supply and support systems technology than the Utility Tunnel !

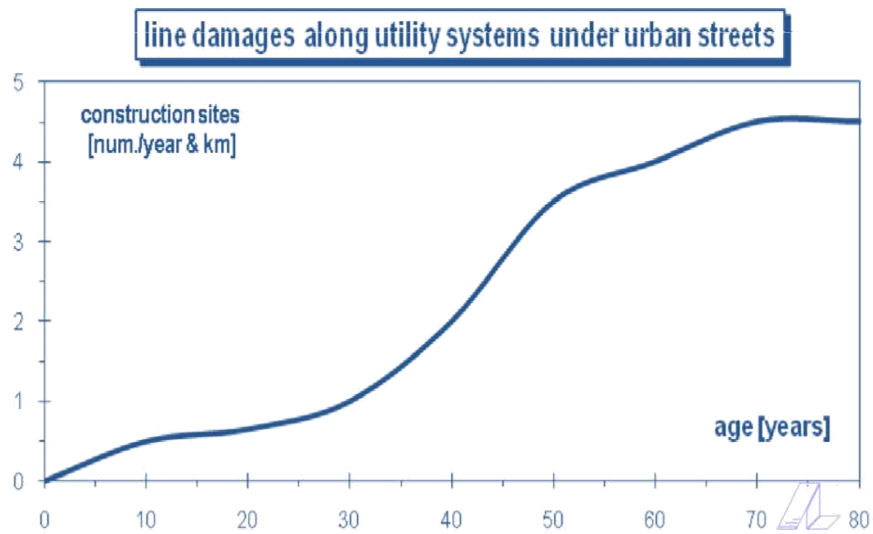

Fig. 3: Utility Faults per m Public Road – Age Dependency Axel Laistner 1995/2012

[2] in 2011/2012 we conducted visits to our utility tunnels for delegations from China, Sweden, Finland, Austria and were invited to present on the system in India

ISBN: 978-3-9503110-2-0 (CD-ROM); ISBN: 978-3-9503110-3-7 (Print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI

3.1 Utility Tunnel Economics

3.1.1 Let's talk Reality about the Urban Underground

Our urban supply systems leak like sieves! Even a quick look into the literature makes this clear, and the constant sight of urban undergound construction is known to all of us. In 1994/95 we analyzed, with the help of the City of Wien, Austria their construction site database in the public road spaces. We present these results here again – as their impact is so grave, that it needs to be restated again and again.

Our societies spend immense sums of public money (a scarce commodity when lately we listened to the news) on pipes and cables under ground – and doesn't even know it. It's so well hidden in the scattered budgets and responsibilities, that on the whole not even the supply company itself has any idea what their reality of system maintenance by daily construction costs them per running meter of system line.

The reality check of this rare data[3] sends a clear message. Any private industry manager would call them crazy – not knowing the costs of operation of what in fact is their main method of product delivery to their paying clients – but such is the way we've structured our western urban engineering economy. Well as long as the client = the end-user of water, power, IT, etc. is willing to pay – it's an easy job, isn't it? It could be funny – if it wasn't so sad, and so bad for our urban societies.

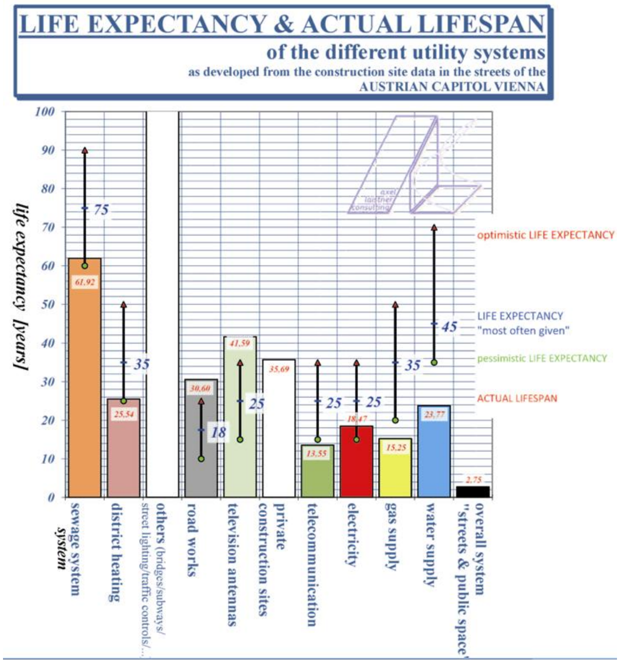

Fig. 4: Utility Systems real LIFETIME EXPECTANCY per m Pipe/Cableway Axel Laistner 1995/2012

We compiled the data and projected onto it assumed maintenance construction costs (fault repair, system enhancement etc.) and combined them with the real statistical life expectancies of the underground buried pipes and cables. Result was a system comparison between conventional construction and the utility tunnels for 7 Reference Projects using real construction costs from 5 projects (3 Utility Tunnels and 2 Conventional Constructions). In the end, we came up with a realistic economic picture of the comparative operational running maintenance cost per year and technical system and "m" Utility Tunnel as homogenizing unit.

The Utility Tunnel beats conventional construction hands down on operating costs. In many cases, even if the responsible utility tunnel owner would put aside a reconstruction and rehabilitation fund for the future. At present we're in the process of verifying the UT numbers for the three constructed systems as best as possible. Early indications of the returning information is, that the UT operational costs are even lower than estimated in 1995.

[3] most cities and towns – and most utility companies and supply system operators, have no clue about their real line costs – as the operate by strictly segregating larger construction sites as investment into their development divisions with a project based system monitored site by site, and their smaller maintenance by construction into their operational divisions, usually equipped to execute all measures with fixed rate contractors.

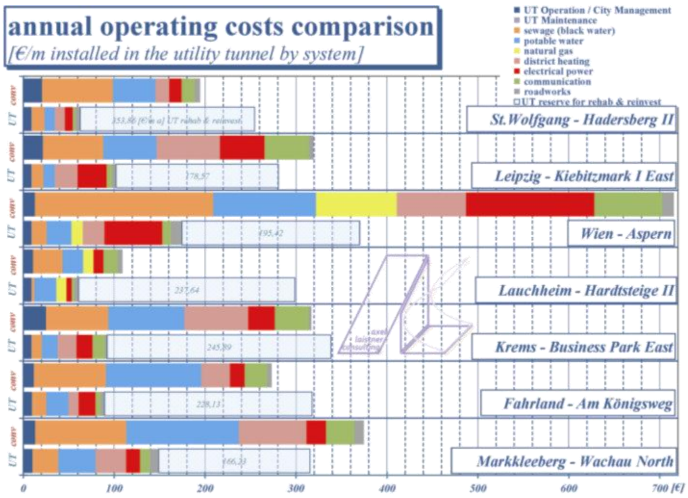

Fig. 5: Utility Systems with/without UT. Real Operational Cost Comparison, projected onto the base unit of 1 m Utility Tunnel – Axel Laistner 1995/2012

This comparison, by the way, is totally without economic costs of the normal conventional product losses (e.g. water leaks, sewage spills, cable-way resistance heat, etc.) all of which are much lower or non existent in a utility tunnel, as well as any discounting of the significantly longer road and surface stability over utility tunnels.

UTs beat buried pipes and cables operationally any day

3.1.2 Let's talk Cost of Urban Development

That might be so, you're maybe thinking at this time, but THE INVESTMENT COSTS of the utility tunnel will take care of that. So lets look at these investment costs, but in total, and with proper consideration of timelines of credit and repayment by the public investor, developing an urban area.

The first glance already shows, that the utility tunnel actually is only a small part of the developement costs. Even First-Prototype projects like Wachau have a fighting chance with the utility tunnel investment being recovered by the faster pay back of financing costs through the earlier marketing start of the property sales. Other considerations also come to the fore. Where it is difficult to built a utility tunnel (e.g.in a river flood plain like in Krems), this is equally so for the normal burried systems, and their extra protection and function requirements.

Where the utility system demand however is too low (e.g. in Lauchheim or St. Wolfgang, rural housing with only 25/65 individual buildings only) utility tunnels do significantly raise the property development costs to such an extent, that this cannot be compensated. So there is a lower limit of supply volumen and urban density that is needed or should be there in future projection, for a utility tunnel to be the implementation method of choice. Or to say it in another way. Because it needs to be large enough to be walked in, it is too large if only 25 to 65 single family homes in a spacious rural development are to be supplied and connected.

In our successful public utility tunnel projects (Wachau, Fahrland, Lauchheim,[4] Speyer), even including the utility tunnel investment costs, the development cost on the sales price of the developed property was identical to a conventional construction development. This was validated by other nearby conventional developments at the time.

Again, these costs depict single point in time development investment only. The do not consider that while the pipes and cables within a utility tunnel might last with a little maintenance for a verified 100+ years in some cases (e.g. London), while the pipes and cables in the ground will face major and/or point rehabilitation much, much earlier than that. The more congested the area the shorter the buried system lifetime.

[4] At Lauchheim – the worldwide first "High Density Polyethylene Hull" Utility Tunnel – the producer of the hull pipe sponsored the project as a demonstration prototype – accepting as payment the avoided conventional pipe construction costs of the city as calculated and expected from the original design conventional development design.

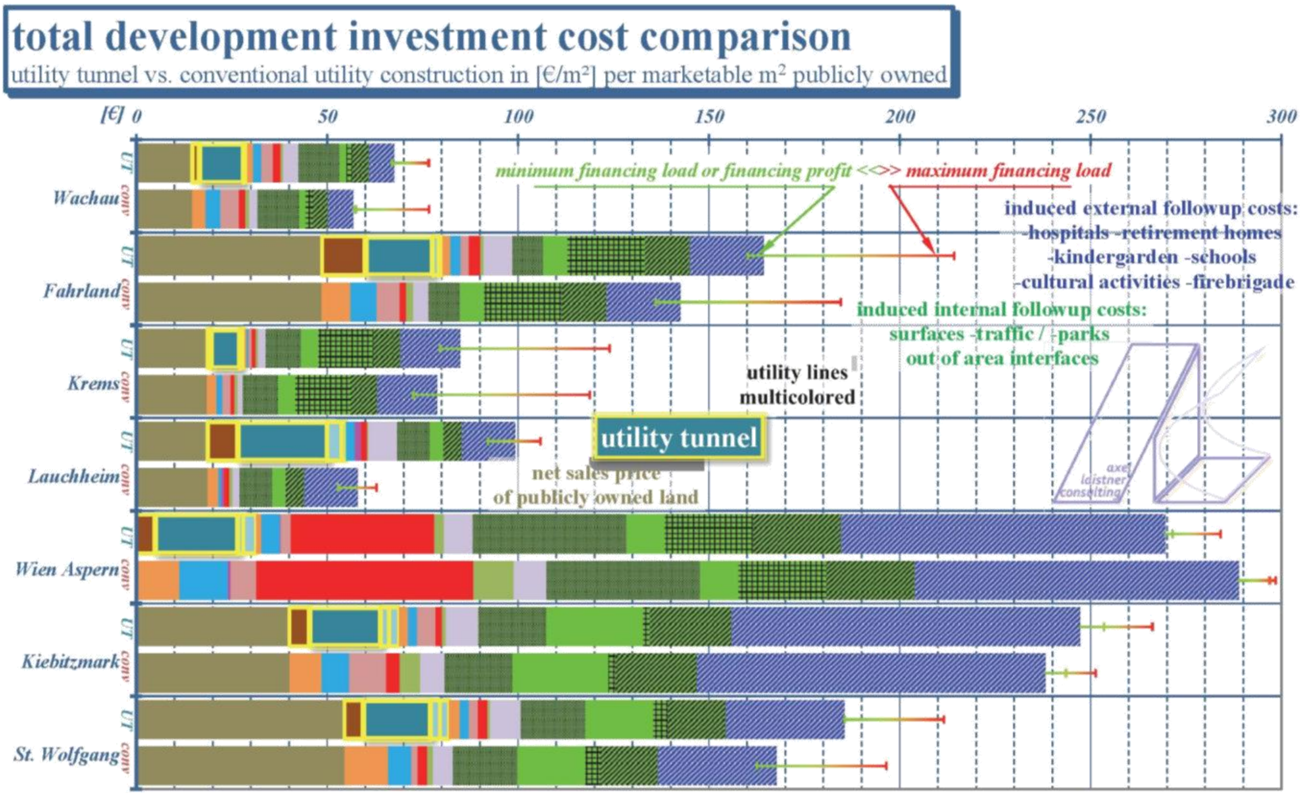

Fig. 6: Total Urban Development Costs: Comparison: Utility Systems with/without UT per m² marketable developed property Axel Laistner 1995/2012

Therefore also the effect on longevity of road surfaces is again NOT included in this depiction. With a utility tunnel road and surface conditions are truly only traffic and climate dependent, and can be extended by up to a factor of 2 in low load cases and 1.5 in high load cases. As the bearing layers of the surface are never interrupted, the total surface structure endurance and life expectancy is finally that, which is always calculated in the pavement design methods, as the surface is once built and then remains intact on an uninterrupted homogenous base.

Site inspections in Wachau, Fahrland and Lauchheim conducted in February 2012 have consistently shown, that even after 20 years most surfaces still look pristine, even like newly built. In Wachau due to an implementation of salt for snow clearing during the first years, the asphalt top-layer shows some degradation. However, even with the heavy loads of truck traffic in a business park – the road structure is still ok. No developing depressions as indication of bas instability, below frost damage, or developing water pipe leaks and breaks, or the like anywhere.

Taking these lifetime and system quality effects also into account, the utility tunnel beats conventional construction everywhere except in the budget sheets of one year only public budget calculations. These procedurally discount any future cost saving or producing effect of any technology, and therefore depict a significantly if not wholly wrong, but very prevalent, picture of the costs of urban development and the associated systems.

As currently in Germany communities are so cash strapped that a federal change of law is under consideration, allowing a community to bill property owners also for any future road and system rehabilitation works – this easy but shortsighted perception of cost might come under political pressure fast.

3.1.3 Let's talk Cooperation

Utility tunnels are unifying, combining systems. They therefore require poeple and institutions to cooperate, which they usually do in some form anyway, but not, maybe, so focused and in such an all encompassing group, of all technical supply system operators and engineers in an area.

A utility tunnel also is a plant facility – however, it is NOT a working place, and it classifies as an equivalent of a large storm drainage culvert in the German administrative system (only in Brandenburg is a building permit needed). But it needs – a little – but continuous maintenance (meaning – a well operated and upkept utility tunnel needs a technical inspection walk through -every 3 to 6 months – and after all pipe and cable modification works). So foresight and consideration should be given who in the urban supply company structure takes on this operations job and why.

utility tunnels in the legal network

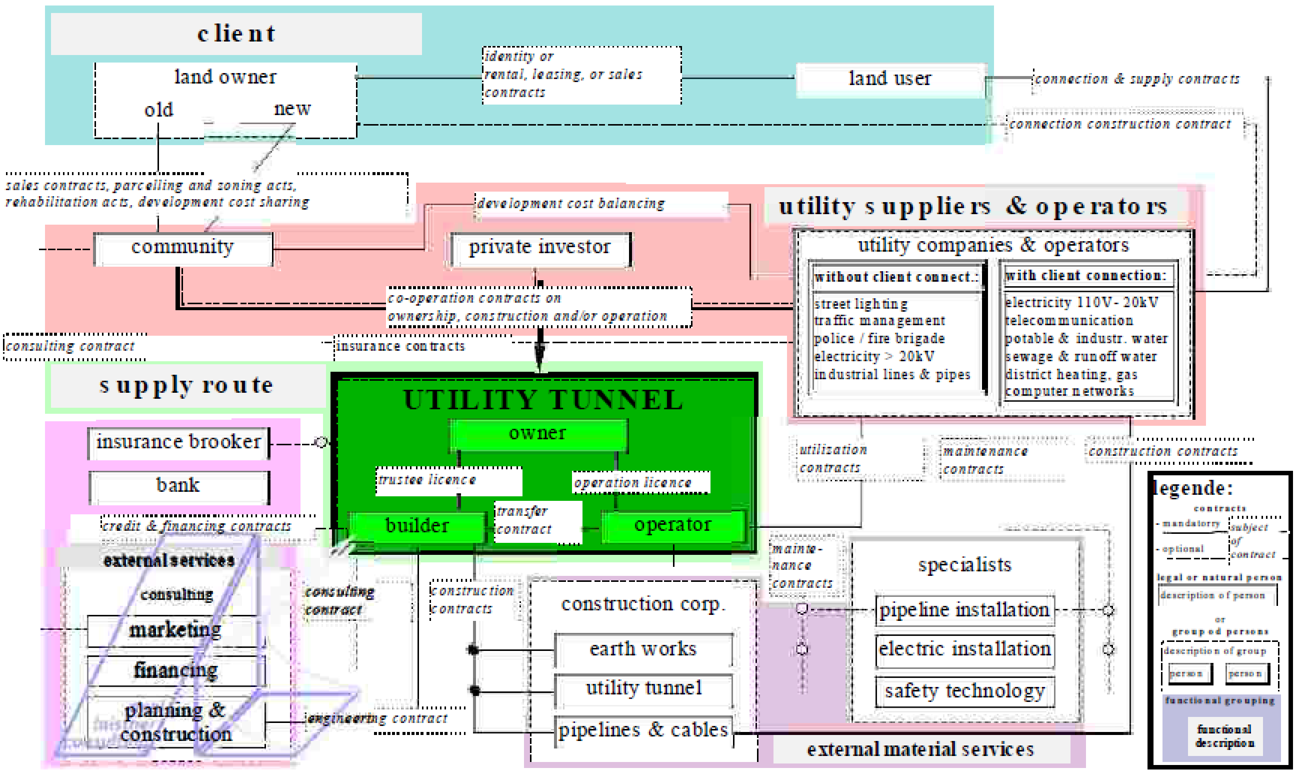

Fig. 7: Utility Tunnel in the network of Urban Legality – Axel Laistner 1995/2012

The Wachau solution – while it is a splendid example how PPP should work to enable and empower the public sector in the long term – is not necessarily the prefered one. Where there are other entities around, like city works corporations, power and transportation companies, why not have them do the job. They operate power plants and other equipment, and very well understand what needs maintenance and how much.

What a utility tunnel in a development fosters, is a sustained joint cooperation of all parties, also later during operation. A significant benefit in a future that requires all of us to find more cost effective, and longer lasting solutions. In our experience of between us almost 65 years as engineers – we believe from our own experience, that more often than not, the synergy is discovered in the cross trade cooperation.

4 CONCLUSION

Utility tunnels, those designed and build with our help and those discovered in our research, all have proven an unexpected longevity. Many even survived the city bombing of the second world are. If a single urban supply system technology can lay any claim at all to sustainability on a long-term time perspective – it's the utility tunnel.

Utility tunnels are the second hull around the transported media, they can have very benefitial side effects. One is absolute and easy leak and fault detection – another can be electro-magnetic-shock-shielding of cables against lightning or weapons impact – or the better power transmission due to lower cable temperatures.

After working in this field for 20 years, we know of 2 cable joint explosion, 2 water main breaks and 1 fire, in all the many utility tunnels around the world we know of (~ 35 UT systems). For sure, there must have been more faults, but this short list of faults is, what one city engineer of conventional systems, has in every small village on a half-yearly basis continuously! So again – no comparison here! Not even close.

However, utility tunnels are almost completely absent from our academic curricula and training, and from our technical standardization structure. The latter might be a boone – as it allows engineering knowledge, and sensibility to risks, to dominate utility tunnel design and operations. Simply following a cook-book recipy is out. The academic situation however is a shame. If at all this subject is touched within in the education of a young civil engineer or architect or planner, in maybe one lecture, of one course on principle technical systems for urban supply, at some universities.

This technology is not rocket science, but requires the understanding and cooperation of almost all engineering and architectural professions, and the inclusion of public and private administrators and managment. This is exactly what is meant when we all call for more team skills. That the teams by and large don't form by themselves in public development, is an indictment of the education of our city planners and engineers, as well as the administration structure of cities and their public works divisions overall.

Wherever – even in the public sector – there is a coherence of responsibilty (e.g. at universities, hospitals, or airports, or within private factory grounds) the utility tunnel is the technology of choice. It doesn't even need to be talked about – naturally it's expected to be part of any large development or modification project of such facilities.

We wonder why, or shouldn't we ?




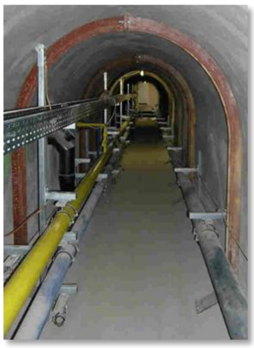

Fig. 8 Steel Culvert Construction. Fig. 9 PEHD outfitted. Fig. 10 Steel Culvert outfitted. Fig. 11 Fibre Concrete outfitted. Pictures Axel Laistner and Hermann Laistner 1993 to 2004 – use of fibre concrete was developed together with and implemented by Carl Dupré GmbH & Co KG

5 REFERENCES

5.1 Publications

LAISTNER, Hermann, "Nachhaltige Erschließung der Zukunft mit Leitungsgängen – Hemmnisse und Lösungen", Rohrleitungen in Neuen Energieversorgungs-Konzepten, iro Schriftenreihe aus dem Institut für Rohrleitungsbau Oldenburg, Band 37 Seiten 197 bis 200, Tagungsband zum 26. Oldenburger Rohrleitungsforum, Oldenburg, 2012

LAISTNER, Axel, LAISTNER, Hermann, "Utility Tunnels – potential in urban development – history & Operation – economics – construction", Presentation to the City Government of New Delhi India, organized by UMTC Urban Mass transit Company Ltd. New Delhi, April 2011

LAISTNER, Axel, "Utility Tunnel – Wachau & Utility Tunnels – what are they in Fact", Trenchless Laying and Repairing of Pipes in Germany 1997, GSTT German Society for Trenchless Technology, Bertelsmann/Gütersloh, 1997

LAISTNER, Axel "Utility Tunnels long-term investment or short-term expense? The new economic feasibility of an old idea", INFRA’96 Les Infrastructures Urbaines, Montreal, 15th International NO-DIG’97, Taipei, 5th International Conference on Pipeline Construction, Hamburg 1996, 1997

LAISTNER, Axel, "Kommunale Erschließungsplanung – Der Infrastrukturkanal in Bau und Betrieb" – University Graduate Level Course – Diploma of Engineering Programs – Civil/Mechanical/Architectural Engineering, Vorlesungs¬unterlagen zur Veranstaltung am Institut für Baubetrieb und Bauwirtschaft TU Wien, Wien, 1995 to 1997

LAISTNER, Axel, "Einsatz begehbarer Leitungsgänge/Infrastrukturkanäle in der öffentlichen Ver- und Entsorgung", Doktorarbeit an der Technischen Universität Wien, Fakultät für Bauingenieurwesen, Wien, Juni 1996

LAISTNER, Axel, "Sicherheitsmanagement und Planung bei Leitungsgängen", Sicherheit+Management, GIT Verlag, Darmstadt, 1996

LAISTNER, Axel, LAISTNER, Hermann, "Infrastrukturkanäle – Neue Wege in der kommunalen Versorgungstechnik", Der Gemeinderat 1/1996, Eppinger Verlag, Schwäbisch Hall, 1996

LAISTNER, Axel, LAISTNER, Hermann, "Der moderne Infrastrukturkanal – Die Alternative der kommunalen Wirtschaft", Die Gemeinde 6/1996, Baden-Württembergischer Gemeindetag, Stuttgart, 1996

STOBRAWE, Herbert, "Evaluation der korrosiven Alterungsprozesse von erdverlegten feuerverzinkten Wellstahlrohren"- Diplomarbeit an der FH Coburg – Maschinenbau Studienschwerpunkt Umwelttechnik – mit betreut durch LAISTNER, Axel, Coburg/Lauchheim, 1995

LAISTNER, Axel, "Modern Urban Utility Tunnels", NoDig International, Nov. 95. pages 15 to 17, London, 1995, ISSN 0960-4405

ROHOWETZ, Hans, "Untersuchung der verkehrsbelastenden Auswirkungen von Baustellen auf Grund von Ver- und Entsorgungssystemen in der Stadt Wien" Diplomarbeit an der TU Wien – Institut für Verkehrsplanung und Verkehrstechnik – betreut durch LAISTNER, Axel, Wien/Lauchheim, 1995

LAISTNER, Axel, "Strom und Gas störungsfrei nebeneinander – Leitungsgang Lauchheim mit ausgefeilter Sicherheitstechnik", Zeitung für Kommunalwirtschaft 6/95 page 23, München, 1995

LAISTNER, Axel, "Begehbar und mit Mehrfachfunktion – Leitungsgänge verkürzen Erschließungszeit – Versuche mit Kunststoffrohren in Lauchheim", Zeitung für Kommunalwirtschaft 5/95 page 32, München, 1995

AVUNDUK, Remzi, "Die Erfassung und Dokumentation der bisher entwickelten technischen Detaillösungen der Konstruktionselemente beim Infrastrukturkanal", Diplomarbeit an der TU Wien – Institut für Verkehrsplanung und Verkehrstechnik – betreut durch LAISTNER, Axel, Wien/Lauchheim, 1995

GLASER, Marion, "Erfassung und technische Dokumentation von Wellstahlrohren im Einsatz bei Infrastrukturkanälen mit kreisförmigem Querschnitt" Diplomarbeit an der TU Wien – Institut für Verkehrsplanung und Verkehrstechnik – betreut durch LAISTNER, Axel, Wien/Lauchheim, 1994

WILLIMAYER, Gerhard, "Transportsysteme in Infrastrukturkanälen" Diplomarbeit an der TU Wien – Institut für Verkehrsplanung und Verkehrstechnik – betreut durch LAISTNER, Axel, Wien/Lauchheim, 1994

LAISTNER, Axel, "Neue Technologien beim leitungsgebundenen Güter- und Informationstransport", Vortrag an der Hochschultagung der Universität Dortmund Fakultät Raumplanung – FG Verkehrswesen und Verkehrsplanung, Münster, 1994

LAISTNER, Axel, "Planung von Infrastrukturkanälen – Kreuzungsbauwerke", Vortrag zum Kongress "Internationale Leitungsbautage 1994", Hamburg, GSTT, Hamburg, 1994

LAISTNER, Hermann: „Der moderne Infrastrukturkanal" in: Das Ingenieurblatt für Baden-Württemberg, Stuttgart, 14.04.1993

LAISTNER, Hermann, "Begehbare Leitungsgänge – Finanzierung und Herstellung eines Infrastrukturkanals", Tunnel 1/92, Köln, 1992

5.2 Utility Tunnel projects designed, constructed or significantly impacted on

LAISTNER, Axel, "SKYLINK Development", Vienna Intl. Airport, Wien-Schwechat, Austria, 2004 to 2008 – idea giver and interface coordinator between SKYLINK and airside apron systems, as consultant to Werner Consult ZT, Wien.

LAISTNER, Axel, "New Terminal Building and airside/landside facilities/Detailed Design" Airport of Makedonia, Thessaloniki, Greece, 2002/2003 – lead designer & project manager of all outside and underground systems as consultant to Doxiadis Associates, Athens

LAISTNER, Axel, "New Athens International Airport", AIA Eleftherios Venizelos, Spata, Greece, 1996 to 1999 – employee to HOCHTIEF AG responsible also for the final design and outfitting coordination of the utility tunnel system

LAISTNER, Axel, "ISK St. Wolfgang (Realisierungsstudie)/Alternative-Vorplanung", Gemeinde St. Wolfgang, Bayern, Deutschland, 1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, "ISK Kiebitzmark (Realisierungsstudie)/Entwurfsplanung", Stadt Leipzig, Sachsen, Deutschland, im Rahmen der Erschliessungsplanung des Baugebiets Kiebitzmark als Erschliessungsvariante, 1994/1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, "ISK Aspern (Realisierungsstudie)/Alternative-Vorplanung", Stadt Wien, Österreich, im Rahmen des Forschungsprojektes ISK an der TU Wien, 1993 bis 1996 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, LAISTNER, Hermann, SCHOLZ, Roland, KRAUSE, ANTBACKA, (POET mbH Lauchheim, VAU GmbH München, KWH Pipe Vaasa) "ISK Lauchheim Hardtsteige II", Stadt Lauchheim, Baden-Württemberg, Deutschland, im Rahmen der Erschliessungsplanung des Baugebiets Hardtsteige II als Erschliessungsvariante und Prototype System einer PEHD Hülle, 1994/1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, (POET mbH Lauchheim, ZT Retter Krems, VAKF Krems), "ISK Krems (Realisierungsstudie)/Alternative-Entwurfsplanung", Stadt Krems, Österreich, im Rahmen des Forschungsprojektes ISK an der TU Wien und des Erschließungsprojekts "Gewerbepark Krems Ost" als Alternative Planung, 1993 bis 1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, LAISTNER, Hermann, SOLLER, Ulrich, SCHOLZ, Roland, KOTSCHATE, Peter, ERTL, (POET mbH Lauchheim/Fahrland, IfEU mbH Fahrland, PfE GmbH Berlin, VAKF Krems), "ISK Fahrland Am Königsweg", Stadt Potsdam (vorm. Gemeinde Fahrland), Brandenburg, Deutschland, im Rahmen der Erschliessungsplanung des Baugebiets Am Königsweg als Erschliessungssystem, 1992/1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

LAISTNER, Axel, LAISTNER, Hermann, SOLLER, Ulrich, SCHOLZ, Roland, KOTSCHATE, Peter, ERTL, (POET mbH Lauchheim/Fahrland, IfEU mbH Lauchheim, PfE GmbH Berlin, VAKF Krems), "ISK Wachau", Stadt Markkleeberg (vorm. Gemeinde Wachau), Sachsen, Deutschland, im Rahmen der Erschliessungsplanung des Baugebiets Gewerbepark Wachau Nord als Erschliessungssystem, 1992/1995 – employee to POET mbH responsible for utility tunnel research and utility tunnel design/construction oversight

5.3 Standards on Utility Tunnels, existing and obsolete (East German)

5.3.1 Schweizer Eidgenossenschaft – Normen und Richtlinien

Schweizerischer Ingenieur- und Architektenverein (SIA), Verlegung von unterirdischen Leitungen, SIA 205, Zürich, 1984

5.3.2 Bauakademie der DDR, Institut für Ingenieur- und Tiefbau

Komplexrichtlinie Sammelkanäle

Schriftenreihe der Bauforschung: Reihe Ingenieur- und Tiefbau; Sonderheft 1, Leipzig. Berlin, 1976
Komplexrichtlinie Sammelkanäle – Korrosionsschutz, Bauforschung – Baupraxis; Heft 25, Leipzig, Berlin, 1978
Komplexrichtlinie Sammelkanäle – Fernwärmeleitungen, Strangvorschubtechnologie, Bauforschung – Baupraxis; Heft S/12, Leipzig, Berlin, 1981
Komplexrichtlinie Sammelkanäle – Bautechnischer Brandschutz, Vorschrift 159/84, Leipzig, Berlin, 1984
Druckrohrleitungen der Wasserversorgung aus Gusseisen mit Kugelgraphit in Leitungsgängen und Sammelkanälen, Bauforschung – Baupraxis; Heft 178, Leipzig, Berlin, 1986
Gebäudedurchführung von Wasserversorgungs- und Abwasserleitungen mit Öffentlichkeitscharakter, Bauforschung – Baupraxis; Heft 193, Leipzig, Berlin, 1986
Informationsblatt zur Komplexrichtlinie Sammelkanäle, Leipzig, Berlin, 1988
Gebäudedurchführung von Versorgungsleitungen – Allgemeine Grundsätze, Bauforschung – Baupraxis; Heft S/38, Leipzig, Berlin, 1989
Gebäudedurchführung von Versorgungsleitungen – Kabel/Wärmeleitungen, Bauforschung – Baupraxis; Heft S/41; Leipzig, Berlin, 1990
Verlegen von Rohrleitungen und Kabeln der Stadttechnik in Kellergeschossen von Alt- und Neubauten, Prospekt, Berlin, 1988