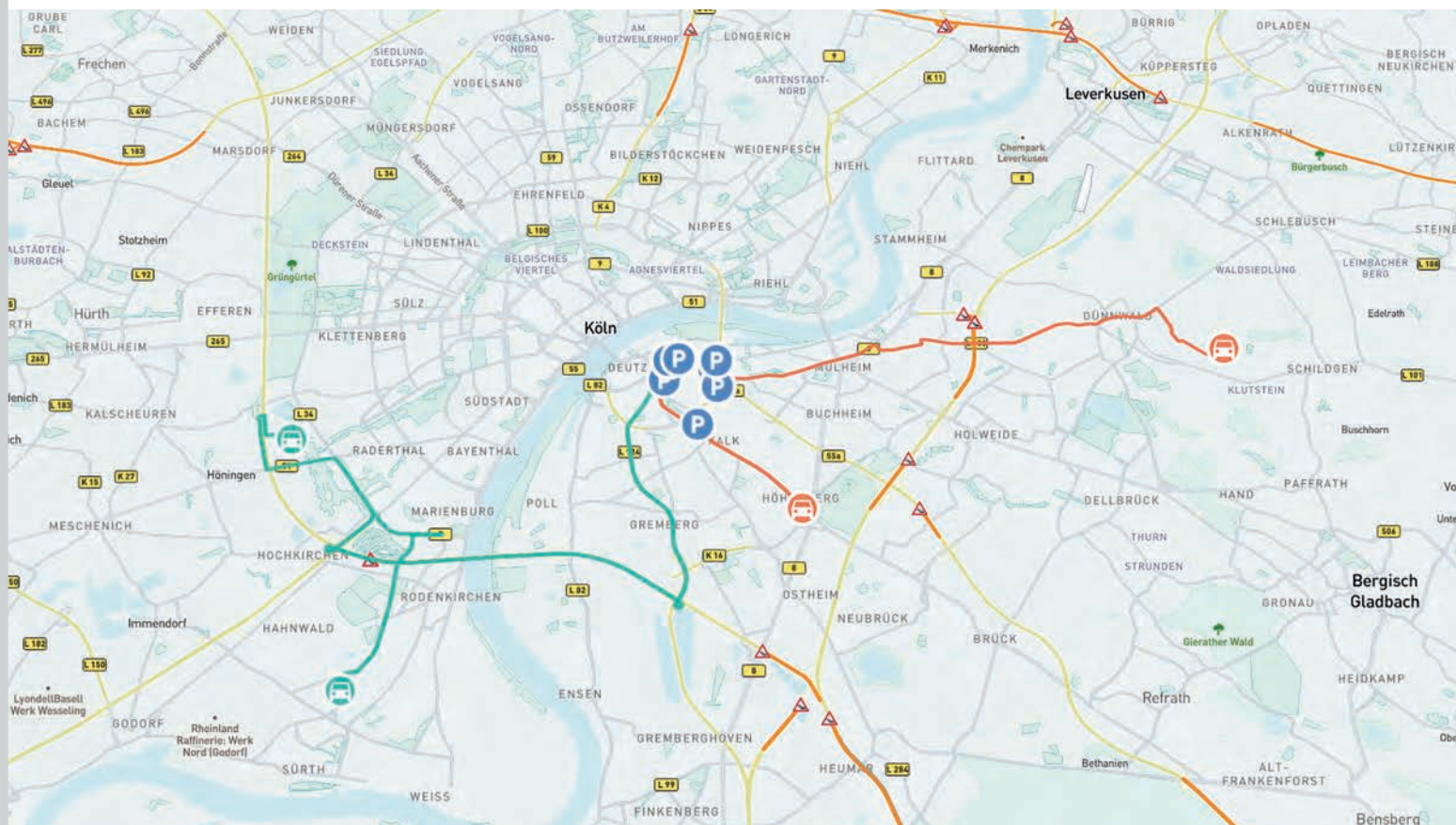


graphmasters

collaborative routing



NUNAV Navigation



NUNAV Bus



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Reliable and sustainable Mobility

*"The world wide traffic congestion is a \$267 billion problem worth solving."
Roland Berger Strategy Consultants 2013.*

The world of Graphmasters is in professional routing services. With our award winning routing engine NUNAV, – Microsoft Imagine Cup finalist, Australia 2012,– we provide drivers with intelligence during their entire journey. Meanwhile Graphmasters is a steadily growing company with more than 50 employees and locations in Bern, Cambridge, Hanover and Wien.

Our “collaborative routing” algorithms leverage the power of distributed cloud-computing and allow for unparalleled traffic flow efficiencies on any street network. This brings us closer to “No more traffic jams”. We empower traffic management agencies to take control over their streets on a strategic level and combine it with their existing physical road infrastructure.

By doing so, traffic management becomes a customer journey for a cities citizens, an event visitor or a roads user right down to the turn-by-turn instructions in their infotainment system or their smartphones. The C-ITS platform NUNAV orchestrates traffic independently and based on rules defined by public authorities and allows its user base to get in the best possible way to their destination.



Alexander Meister
Profession: Customer success
smart mobility
alexander.meister@graphmasters.net





Your venue journey

Philip gets in the car.

Today he enjoys a concert in Hamburg.

Full of anticipation, he holds his event ticket in his hands.



2

With his smartphone, he scans a NUNAV QR code that is printed on his event ticket. This opens the free, anonymous and ad-free NUNAV navigation app and displays the venues screen with useful information.

3

Philip presses „navigate“. The NUNAV Navigation App on his smartphone works as the GPS for Philip. But NUNAV works different compared to conventional GPS-Systems. First, it provides Philip with the best possible route. And it does more: NUNAV Navigation will guide Philip not to the approximate place of the concert but to the exact, defined parking slot. This makes the journey for Philip way more relaxed and gives public authorities and venue organisers the opportunity to manage traffic - especially during large scale public events.



4

Hamburg

Philip's QR-Code gives him permission to use the VIP-parking area and clears his access right to his designated parking slot.

He arrives relaxed and exactly in time at his venue location.

Let the concert begin!



Don't get stuck in traffic jams

Collaborative routing can orchestrate a free slot on the road for every car owner in real-time.

Regardless of the drive train concept: Collaborative routing can orchestrate a free slot on the road for every car owner in real time within milliseconds.

The pressure on fleets to become more sustainable and efficient is growing and the automotive industry is striving to do exactly that. But is that enough to be prepared for the future? A lot can be achieved with the important and necessary further development of electromobility and drive trains and their systems, but they don't change one important thing: in the end, there is still a vehicle on the road that takes the space of another vehicle - no matter if it is an electric vehicle, one with some sort of combustion engine or with a different drive train. At the end, all road users compete for a space on the supposedly best route. This leads to traffic jams, loss of production and productivity and delayed deliveries, with an estimated damage of EUR 100 billion only in Germany.

Selfish Navigation – unnecessary source of many traffic jams

Unfortunately, conventional in-car navigation systems do not enhance that situation. All navigation systems in the market - even the really big ones that are using lots of data - treat each driver individually and guide him or her through the traffic network selfishly (see page 8: "Background: Professional Accuracy"). If a traffic jam occurs, the system reacts: Everyone is given an alternative route. Unfortunately, everyone is given a similar

route and rather quickly the next traffic jam is born. The result of this selfish navigation is the same as driving without any navigation system - it just feels more digital!

Of course there are measures with which drivers try to eliminate or at least mitigate the traffic chaos. Some people have three or more navigational systems running in parallel. Their in-car navigation system, one from their operating platform and one apparent alternative like Waze. But hardly any of these systems looks at traffic as a whole. In the road ecosystem, every road user is in the same boat: a parcel delivery driver influences rush hour traffic just as much as a truck driver, a commuter or a trade fair visitor.

Collaborative Routing – the real alternative to the selfish systems

Once you see these connections, it is time to do things differently. The NUNAV technology is based on the idea of collaborative routing. Every road user guided by NUNAV Navigation is part of an intelligent swarm. The system distributes their users not only to one street and then to the next one once the first one is full like a selfish system would do. NUNAV distributes every user from the beginning - one could even say altruistic - on the entire road network. That way it can occur that users starting from the same destination at the same time might be guided through three different routes to their goal.



Additionally NUNAV Navigation considers emerging measures that influence traffic in real time. Today, cities or municipalities put up road signs with delivery restrictions. Traffic-free cities are one of the hot topics of today's discussions. Tomorrow, they might require access protocols or put up physical barriers. Already, electric vehicles use bus or taxi lanes and soon they might have longer access permissions to city centre's. Either way, the digital transformation of our everyday mobility modes breaks its way.

Big Concert show: the idea of collaborative Routing

In traffic management, NUNAV is already the go-to-solution to metropolitan traffic challenges. During the concerts of Andreas Gabalier (Volkspark-Arena) and Udo Lindenberg (Barclaycard-Arena) in 2019 in Hamburg an astonishing 17 percent of all vehicles arrived with the NUNAV navigation app. The leading local newspaper titled: "Thanks to anti-traffic-jam app? Traffic chaos avoided during double concert." There are many more of these examples e.g. from Hanover or Cologne that show: the idea of collaborative routing works and it is a solution obvious and easy to implement for a world of fluent traffic.

info

Saving 700.000 km - every week!

When using our NUNAV technology in fleets, such as those of Hermes or the Austrian Post do already, Graphmasters serves post service providers as well as the general public. Drivers reach their destination faster and on-time, drive fewer kilometres and save CO2 by consuming less fuel and energy. At the same time, all road users benefit, because the delivery vehicles contributes less to the formation of traffic jams thanks to „Collaborative Routing“. With the use of the NUNAV technology only in Germany 700.000 km are saved - every week!

Professional accuracy

Citizens need to be mobile. Mobile in the sense of getting from A to B.

Be it on the road, with public transport or with shared mobility services.

To be mobile, estimated times of arrival matter a great deal to Graphmasters. They are the guarantee, that NUNAV users get in time to their desired destination. Being on time says a lot about our road network. It provides everyone with an indication of how good or bad traffic flow is within a streets network. It gives us an indication, how well construction side management on our roads are planned and how good deviations are described. It also tells a great deal about Graphmasters traffic model accuracy.

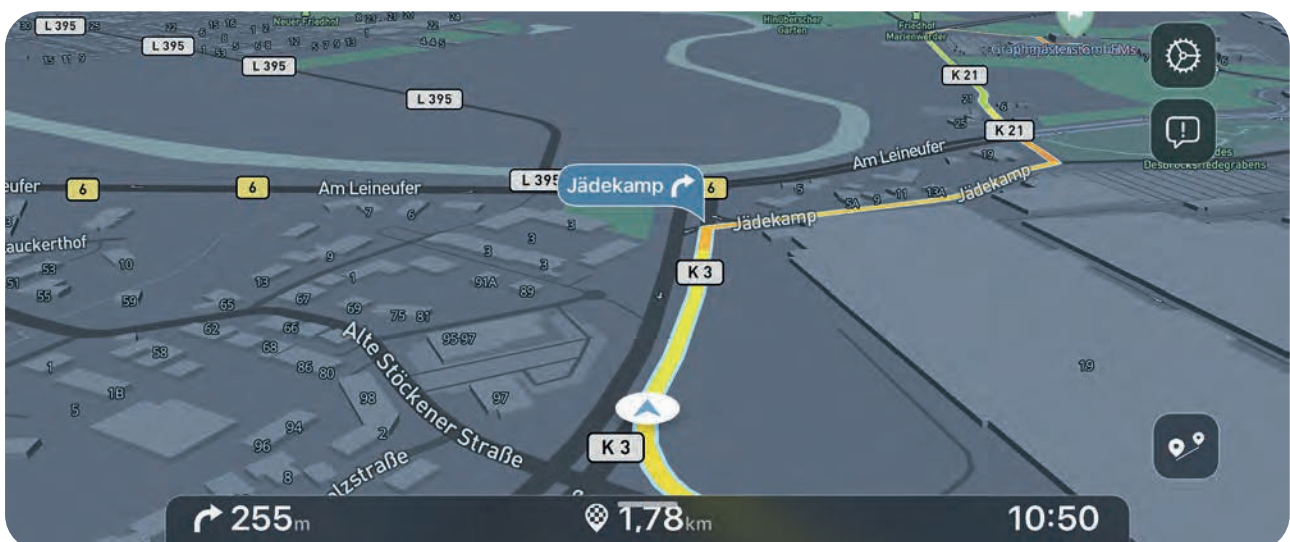
One of the most common problems why traffic jams occur, does not come from road side management. It is not coming from rush hours - many people want to go from A to B during the same timeslot, mostly for work. Most traffic jam problems trickle down to "selfish routing".

Selfish routing and broadcasting the same traffic remedies to us all over and over again leads to traffic jams. Traffic jams on

a main road, traffic jams on a deviation road, traffic jams back on the main road. Actually, conciliating traffic is a bigger and bigger problem nowadays. When users commute the shortest route available, they do not take into account the traffic congestion they cause for others. And selfish routing is reactive and creates more traffic on a given road until a traffic jam is detected. Then deviation information is broadcasted to all and everything starts all over again.

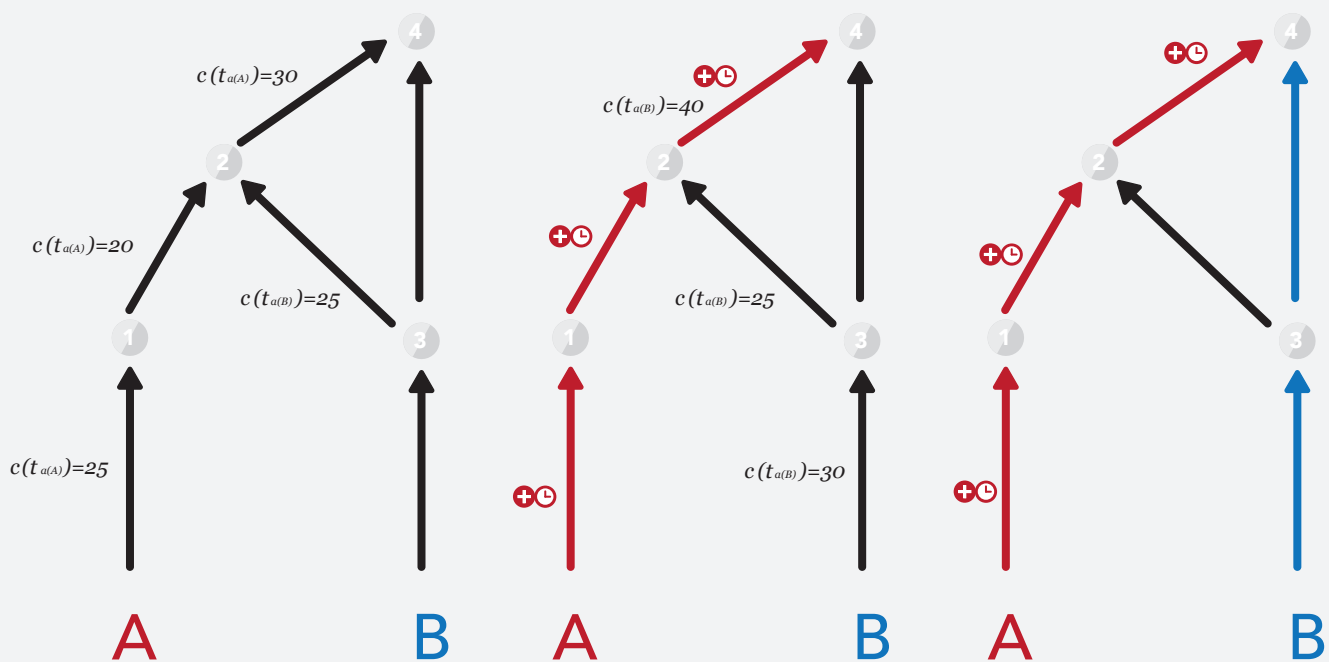
"We might enter the new beautiful age of electric mobility now. But it is of no help if you're sitting in your brand new modern, emission-free electric car stuck in an old fashioned traffic jam."

- Sebastian Heise, COO of Graphmasters



Collaborative Routing

In a collaborative routing system, routing decisions are not only made on traffic conditions but on the overall demand of participants. They implicitly share route planning and a computer creates the ideal route in relation to everyone else.



$c(t_x)$ cost at time x
 $a(B)$ time when vehicle B arrives
 $a(A)$ time when vehicle A arrives

+- reservation for vehicle A for a time range
+- reservation for vehicle B for a time range

By predicting traffic costs into the future for any given road segment and junction for any vehicle class over a users total travel time, NUNAV orchestrates road users in an optimal way into a road network. NUNAV does not shift all road users of road A onto road B, but rather selects individual users for road A or B based on an array of information leading to better roads with lower traffic pressure for everyone.

It's instant, it's in real time, it's predictive and it puts everyone in a better position. And it hands control back to the road authorities when using the NUNAV C-ITS platform. Another effect: the capacity of the existing road network grows exponentially without expensive investments into road infrastructure that often goes along with tough public participation procedures.

"NUNAV Technology opens up the possibility for public authorities to directly control traffic down to the single car with a minimum of investments into infrastructure."

- Alexander Meister, Graphmasters

A Traffic Management paradigm

A world in which technology and experience work hand in hand is readily available and gives the power back to public authorities to control traffic.

By integrating existing intelligent transport systems (ITS) in our C-ITS Platform NUNAV, we bring along the best of all worlds. The NUNAV C-ITS platform provides traffic management operators with an unique overview of their traffic status. Build upon our [fiware*](#) expertise, different sources can be integrated and provide a holistic overview, ranging from automatic incident detection to integrating camera views of particular spots on a map.

User roles define the granularity of information at display for operators or supervisions. Our readily deployable software-as-a-service platform provides an holistic overview of a cities, a districts or a states options in terms of traffic management.

And every time, a routing engine is used in one of your projects, our [Rest-APIs**](#) can make sure you are in control of your traffic flow. With our digital routing services, every road user can receive their individual routing strategy. Event visitor receive up-to date information and logistics companies can plan with their delivery routes with respect to delivery hours in inner-city restrictions. Hereby individual needs and public interest's are melted into one service.

*see page 13 for more information on fiware and fiware-ready
W** (Rest-API) Representational state transfer (Rest-) Application Programming Interface (API) und dient der Machine to Machine (M2M) Kommunikation

Who actually decides on your routes?





ZONE

frei für:

- Lieferverkehr** von 7-13 h
- Bewohner,**
Firmenangehörige und
Grundstückseigentümer von 18-9 h
- Radfahrer** von 18-13 h
- Taxen** von 18-13 h

Let road users navigate with your experience

Turn by turn - Traffic Management - C-ITS - Strategy Editor



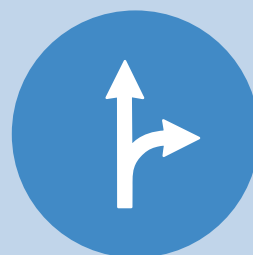
Traffic information

Deciding which route to take to get to a destination can be a fastidious job. This is especially true for people who need to be on time because their job requires it. Logistics companies for example, post & parcel operators are another perfect example. Every time, a traffic information is broadcasted their drivers might need to adapt their routes because their clients have come to expect punctual deliveries. There are many specialised tools, which broadcast traffic information to a broader audience. Radio stations or Traffic Message Channels are the recipients/transmitters of such information. But computers in autonomous driving cars have other needs of traffic information than humans behind a steering wheel. **No matter the medium, no matter the recipient, Graphmasters reads and writes traffic information the way our clients need them most.**



Road Works, incidents, day-to-day management

Road works or incidents are important information to maintain traffic flow. Their day-to-day management has direct implications on a road users usage. And with the emergence of autonomous driving cars or on-demand mobility services a much more granular precision is needed. Gone are the days where humans simply listen to traffic broadcasts, infotainment systems display traffic message channel (TMC) or traffic and travel information service (TIC). **NUNAV offers it all: It's on demand, it's real-time, it's predictive and it's lane and vehicle specific.**



Turn-by-turn

Building upon our NUNAV technology, Graphmasters provides specialised apps and infotainment integrations to OEMs that integrate turn-by-turn instructions. These easy to see turn-by-turn indications let you know when the next turn is coming and where you need to go next. Turn-by-turn instructions are built upon our real-time data traffic model and integrate future traffic conditions into their instructions. It's never been easier to get around.



Free App Download

These apps integrate all the good things we have come to expect from a turn-by-turn navigation software. They combine traffic information, road capacities and update themselves every 15 seconds with the best possible way to get to a user's destinations. It's real time, its predictive artificial intelligence and our system gets smarter with every daily commute. NUNAV combines technology and the best advice a traffic management agency can give you.



NUNAV Navigation

Available at Apple App-Store
and Google Playstore



Strategy Editor

At Graphmasters, we have extensive experience in reaching drivers with strategic routing options. Public authorities like traffic managements operators can virtually select roads for particular road users and direct them accordingly. This greatly enhances the usage of a cities street network by selecting usage according to:

purpose, vehicle class ,date / time ,streets ,venue strategy traffic strategy.

Depending on a users management rights, operators can manage entire venues or only individual parts of it.



Parking access & departure strategies

NUNAV can combine any defined array of parkings based on a users role, their time frame or any other restriction. Weather it's a single event or multiple events simultaneously, NUNAV enhances the customer experience and reduces parking search traffic to zero. You can integrate existing parking infrastructure or create ad hoc parking spaces as the on-side situation requires it. Define your strategy in advance, manage it during the event and analyse it afterwards.



NUNAV & public transport

Combine individual mobility with public mobility by simply integrating official park & ride parking's or by creating new park & ride parking's e.g. at locations that are unused during the weekend. NUNAV users will be informed about your events parking strategy and navigated to the nearest park & ride parking before continuing their journey with public transport. Connections are seamlessly and the system is easy to deploy and fully reliable. It opens up to a new level in your customer journey and makes your parking strategy easier to implement for all stakeholders. The digital park-guidance system in NUNAV allows a seamless implementation.



Fiware-ready

FIWARE is a curated framework of open source platform components to accelerate the development of smart solutions. The NUNAV Traffic Management & Strategy Editor as well as the entire Graphmaster's NUNAV platform is fiware-ready. We can incorpore and visualize data from a wide range of different sources.





Interview

“Everyone will get their space on the road”

with Sebastian Heise, COO of Graphmasters

Especially in places where things get extremely tight - in the literal sense of the word - during that last mile, the ability to intelligently organise traffic flows offers relief. Sebastian Heise, COO and founder of the Hanover based company Graphmasters, explains how technology and data linking can become the solution to all traffic jam problems.

Sebastian, what is your preferred inner-city and rural means of transportation?

S. Heise: I live in a small village outside of the city. If you don't have a car there, you're really stuck. For Graphmasters, though, I am on the road a lot and visit quite a few metropolitan areas. In each one of them, the ability to get somewhere varies depending on the various means of transportation offered. Whether I use the train, take a cab or simply walk ultimately depends on the time pressure, the weather and the options offered in that particular city.

Traffic volume globally and in Germany is continuously increasing. Mobility is a critical topic to focus on when discussing how we want to live our lives in the future. In your opinion, what will Traffic 2030 look like?

S. Heise: I expect to see an increasingly mobile society. Mobility will become easier and increasingly less expensive. Stationary workplaces will be a thing of the past. We will all be travelling more, be on the road more. Especially where younger people are concerned, I expect they will become mobile

at an earlier age and the older generation will remain mobile for longer. The need for customised transport will, in my opinion, most likely increase rather than decrease. So, the winning ticket for the future will be to find a way to smoothly dovetail the various mobility options.

What are the challenges when it comes to intelligently managing traffic flows?

S. Heise: It is becoming more and more important for capacity planning when using the road. What I mean is that traffic should be effectively organised both with respect to time and space. The problems we're dealing with today are basically the effects of having too many people wanting to use the same roadways at the same time. It's been said that 90 percent of the vehicles are only using 10 percent of the roads. A large portion of the road network is not being properly utilised whilst there are a lot of complaints about traffic jams. This is exactly where the technology of Graphmasters comes into play. We work directly with traffic control centres in Germany. The spatial distribution of traffic is quickly noticeable, especially during major events. For example we helped the 70,000 Eminem concert-

goers to get to and from Hanover. They could easily install the NUNAV app free of charge and were rest assured that they would easily find their way around. This has as well happened for the 200,000 visitors to the HAJ Marathon, where we were able to show road closures for the inner city area to the exact minute. In Dresden, the navigation app directs you to park and ride car parks outside of town and shows you how many free parking spaces car parks have. The increased ability to link into the infrastructure systems has particular created new potential opportunities: system-wide linking into these systems has decreased waiting time at traffic lights by half.

How does the NUNAV technology that Graphmasters developed differ from any other navigation software?

S. Heise: With traditional systems such as Google, you can see that all vehicles are always directed to use the same routes. But that is exactly how traffic jams are created! Moreover, this google traffic jam itself is measured by its own participants, which means someone and with him his google-Maps-App is always stuck in traffic. Our route calculator keeps track of how often roads have already been assigned to other traffic participants; everyone is given their space on the road. Based on the number of vehicles on a section of road, we can calculate the driving speed that can be achieved. This is why NUNAV also recommends routes that you yourself would never have thought of.

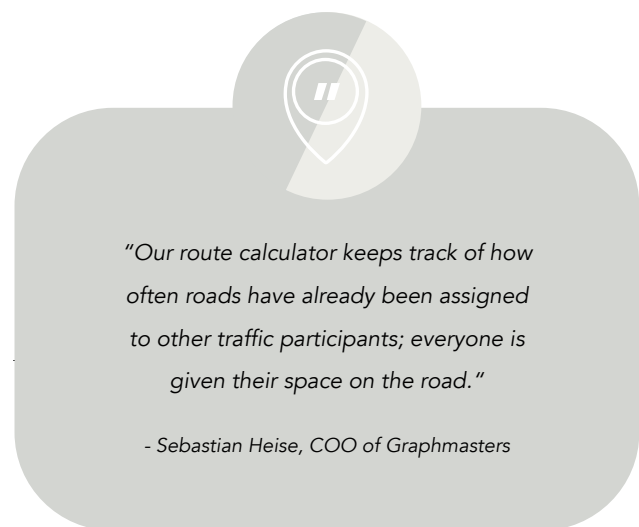
What data points and information does your platform make use of to manage traffic more efficiently?

S. Heise: We look at as many data sources as possible. Graphmasters adds stationary sensors onto roads using GPS measurements from mobile devices. We also use information issued by the press from various sources about road closures. While navigating using NUNAV, we continuously compare how the originally estimated speed matches the actual speed. This helps to continuously improve NUNAV through use.

What special features are there when developing routing software for parcel delivery?

S. Heise: For parcel delivery, the travel times over short distances must be very precise. An average route is typically only 0.72551 minutes. However, couriers make hundreds of these short routes a day. If your work is careless in this regard,

you simply underestimate huge deviations which can add up throughout the day. Travel times are often underestimated – yet in fact, every second counts! I would think everyone is familiar with road signs showing weight and size restrictions for vehicles. However, people tend to overlook the many challenges facing delivery traffic. NUNAV Courier is now making it possible to plan scheduling and dispatch based on real-time traffic volumes so that legal requirements are always observed. Yet, all of this only works if route planning can be smoothly integrated into existing business processes and still be flexible enough to respond to all unforeseen things, which are ultimately part of this task.



The NUNAV technology is also being used for traffic management in cities and at major events such as the Hanover Trade Fair and concerts. What overlaps are there with such projects and the requirements of the parcel industry?

S. Heise: Simply stated: Everyone meets up again on the road. Most of the time, traffic groups are viewed individually as trade fair traffic, football fans, commuter traffic, lorries and parcel couriers. What is mostly ignored is that everyone is using the same roads. The trade fair visitor and the commuter have similar destinations. In the end, we should all be pursuing the goal of saving time and energy. At street level, NUNAV assists in combining all of these relationships. Couriers help to measure the roads in inner city areas. Links with infrastructure facilities also allows the precision necessary for professional applications. For the first time ever, this technology provides real tools to traffic management centres and urban traffic planners which can be used to manage and plan traffic.



C-ITS ready

real time

pure Autobahn
emotion

collaborative
routing

over the
air updates

Implement your traffic strategy with Graphmasters

Readily deployable, routing as a platform and free citizens apps - implementing traffic strategies is readily available

The project team at Graphmasters brings with it extensive experience in balancing traffic ideally in any given infrastructure for public or private entities. The team has already managed numerous events larger than 25.000 vehicles. The deployed technology NUNAV can orchestrate vehicles as a swarm and feed them with individual routing information based on roles, vehicle class or at least ten other requirements. Navigation apps for passenger-, light- and heavy duty vehicles are available to the public for free.

Traffic advisors can use a strategy editor to define global traffic strategies. These traffic scenarios can be planned for in advance and activated when necessary at any given time. Ad hoc traffic strategies can be added, or existing traffic strategies can be modified whenever necessary by any group member. A user and group role concept defines what can be edited, changed or seen by any member.

Operators work according to their user roles and can access it from anywhere. Traffic information can be feed with a multi-channel approach. All incoming issues should reach an 80 to 90 percent automation degree as to their location based classification. An unlimited number of workflows can be integrated for any given issue according to the issues status. Automatic incident detection based on a streets classification and any combination of global, regional, local or a combination of streets settings is mandatory. The herein issue classification

can be pushed to or broadcasted to different data marketplaces. Traditional traffic information center (TIC) messages are displayed, too.

The deployed solution works on premise or in a data centre. It is to operate redundantly and in a micro-service architecture paired with continuous deployment practises and a staging development environment. Our Service Level Agreements guarantee a 7/7, 365/365 with an 99.99 percent uptime and 3rd level support via the Graphmasters project team. Security layers can be introduced by government agencies and secure classified information as such.



info

"We are able to guide NUNAV users to the precise location were we want them to go to. This relives traffic congestion and significantly increases traffic flow for all."

**Statement: Verkehrsmanagementzentrale
Niedersachsen/ Region Hannover**





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