Transport morphology and organizational development as catalyst of transport efficiency

Olof Moen
Department of Human and Economic Geography, University of Gothenburg, Sweden

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Abstract
Current research in freight transport deals largely with models and routing algorithms, but questions are conspicuously absent regarding organizational development and change in business models. The application of modern IT tools within the transport industry has provided new opportunities to streamline and control transported goods. This paper explores the similarities between urban morphological studies and transport planning, where the introduction of geographic information technology has enabled research methodologies as well as has promoted transport efficiency. The concept of transport morphology is based on a tripartite division: transport infrastructure, vehicle development, and transport management, and is derived from urban morphology. A case study of the Swedish meatpacking industry compares manual dispatching with digital planning based on route optimization, used to increase transport efficiency. The methodology simulates a gradual removal of constraints that change the physical outcome of driving routes. The result is primarily a product of manipulation of data and software parameter settings and not relying solely on software algorithms to solve the problem. A simulation in which pickups can be performed any day of the week, resulted in a 24-percent reduction in mileage, but applying the results to achieve greater transport efficiency in the current Swedish transportation infrastructure requires a new legal agreement and business model.
Introduction

The overall objective of operators in the transport sector is to increase transport efficiency. For this to happen fundamental parameters, such as transport infrastructure, vehicle technology, and transport management, have to change. Furthermore, focus in the first decade of the 21st century has shifted in favor of environmental issues from strict economic reasons. It manifests itself as an emerging paradigm shift of the power over the transport chain, where the transport buyer demands more insight and control previously reserved for the transporter. The question arises how transportation of goods as a phenomena can be studied from a social science perspective, with new parameters added to an already complex situation. Based on the existing transport infrastructure, with the vehicle as a medium and transport management as final outcome, can transport morphology be introduced as a concept with a clear spatial dimension.

The term “morphology” is used in geography to express variances in spatial objects or phenomena by visualizing their development over time. This implies that a methodological approach, the mapping of a morphological sequence of events, depends on level of resolution and a distinct chorological link to cartography. Fundamental to morphological analysis is access to relevant information. A chorological approach has been revitalized and developed with geographic information technology as a strong driving force. Rapidly increased computing power has also improved opportunities for modeling and statistical analysis of the real world. “Morphology,” in its rudimentary interpretation, refers to physical and cultural landforms. An image of the earth's surface at a specific space and time where the phenomena (or object) under study is visualized and preferably illustrated in cartographic form. Pursuant to a chorological approach, morphology can describe phenomena such as movements of persons or goods.

Innovation in the transport sector requires changes in behavior of individuals and organizations; in short, all stakeholders that take part in a specific transport flow of goods. Dispatching and manual planning, will be replaced by computer operators working interactively with digital information at all stages and with full transparency between parties. At the same time, with digital planning comes the need for organizational development and improved skills among employees, where the easy part is to define and implement new IT-tools, the challenge is to get the organization to adopt it. Sweden in the 2010s has formulated a broad approach with academia, government, and in the transport sector to create new business models to reduce freight transport carbon emissions, ultimately, accepting the new approach becomes a political
decision (Moen, 2013). Transport morphology presumes that movement of goods relates to urban form, which defines what a specific flow of transport can produce over a specified period. Production in this regard is expressed in different units of transportation measurements, such as ton-kilometer, Vehicle Kilometers of Travel (VKT), vehicle fill rate or in terms of supply chain management, punctuality and predefined time windows for delivery. These factors set constraints on the amount of goods being moved within a given transport system, where the constructed environment indicates the morphological framework in which to operate. The morphological connection between urban form and a transport flow can be measured and visualized by goods transported in an intelligent street network between nodes of suppliers and recipients. Early stages of “modern” morphological research noted a particular need for the linkage between urban morphology and transportation with planning as common denominator. Urban areas are dependent on good accessibility, which requires transportation planning as an integral part of the overall urban planning (Herbert, 1976). Nevertheless, unlike public transport governed by municipalities, planning initiatives based on R&D within urban freight have been neglected, not the least in Sweden (Lindholm 2012). Government authorities in Sweden have left planning and control of freight transport to the market. It stands in sharp contrast to how public transport issues have been handled with detailed time table control and procurement with regulation of vehicle type and fuel.

There are more methodological similarities between urban morphology and transport planning than the relationship first suggests. Work routines have mainly been carried out manually in morphological research based on analog cartographic material, as well as transport planning by a dispatcher. In both cases, geographical information technology has been introduced as a platform to develop and streamline research methods and, respectively, planning. With a constant increase of freight transport there is a greater need for a more holistic approach in the study of transport management. The interaction between regulation and voluntary action by stakeholders leading to transport pattern changes, will be measured over time and visualized as cartographic imageries. This paper starts with a presentation of morphology as a research field within geography. The theory of urban morphology will be used as a theoretical starting point for methodological development of transport morphology. Similarities in methodology between urban morphology and transport planning will be highlighted, where geographical information technology and route
optimization, will be discussed in subsequent order. A case study examining the Swedish meat supply industry and in particular transport to slaughter, will be used to demonstrate how transport morphology impedes transport efficiency, and finally, some concluding remarks. The discussion in the introduction is based on research in Sweden, and the same approach is used throughout the paper. This is due to the emergence of national transport systems, developed primarily by national stakeholders through business models, laws and regulations specific to the country in question. Nevertheless, what is presented can be seen generically in terms of methodology and approach to establish a concept of transport morphology. Planning, managing and scheduling freight transport is a complex process, which is part of a supply chain and includes a number of activities and decisions related to transport management. The paper is a first attempt to describe an interdisciplinary methodology for transport planning and vehicle routing R&D. The method is similar to research work in urban morphology, and is hereafter referred to as “transport morphology.”

**Morphology of landscapes**

Morphology as a scientific concept in the field of geography, originated in natural sciences at the end of the 19th century. However, Carl Sauer’s 1925 epochal essay “Morphology of Landscapes” moved the research topic toward social scientific and cultural studies. Sauer defined the link between the natural and cultural landscape and saw the geographer’s task as being to discover the areal connection between phenomena. Morphology is, in this sense, the study of structure and form with an inductive approach. As described by Sauer, “The cultural landscape (is) fashioned from a natural landscape by a culture group. Culture is the agent, the natural area is the medium, the cultural landscape the result” (ibid., p. 343). The morphological outcome is expressed as a process of change, where any social phenomena or function that was significant in the 20th century fits a morphological framework, where transportation surely belongs. There was a Swedish connection where Sten de Geer’s early research based on chorological population maps with supplementary descriptions of population dispersal patterns, made a significant impression on Sauer (de Geer, 1922; Buttimer, 1983, p. 83). This is particularly evident in the conclusion in the landscape study which is stated by Sauer to be substantially in agreement with Sten de Geer’s article “On the Definition, Method, and Classification of Geography,” a chorological approach to geography (de Geer, 1923). Attribute data was related to
objects in maps, where the analysis was not based on calculations but from categorizing and visualizing patterns in a specific landscape, physical or cultural. The two strands of thought met in the study “The towns of Mälardalen: A study in urban morphology” by John Leighly, at the time a Berkley graduate student supervised by de Geer in Stockholm (Leighly, 1928). The morphological approach demonstrated the need for research of the cultural landscape and continuous human activity that affect land use and induced movements of humans and goods. At a later stage urban geographer Lennart Ameén, developed a line of thought with distinct morphological features. Améen (1964) advocated that a substantial part of the social structure could be understood and explained, based on knowledge of existing ownership and where owners had exercised power to make land use decisions. Landownership and land policies have been used in inter-disciplinary fashion in Sweden to give understanding and an explanation to the process behind urban growth in different periods of time, labelled as the “social-morphological” approach (Abarkan 2009).

However, another Swedish human geographer Torsten Hägerstrand stated in a tribute to Carl Sauer, that the “Berkley school” departed from the landscape approach with the insight that the concept, the visual (urban) landscape, merely constituted a starting point for analysis (Hägerstrand, 1984). In using geographical information technology, chronological aspects of morphology can be expanded, where large amounts of attribute data can be processed and hence, increase the explanatory value significantly. Therefore, one can detect shortcomings to the statement of Hägerstrand, who himself was a pioneer of the methodological and technical framework of Geographic Information Systems (GIS). What is questionable is whether Hägerstrand, realized that the methodology could be used for more social-morphological analyses, and not just chorological studies.

In an article from 1955 clearly ahead of its time, "Statistical primary data, air photographs and computers, a combination project", Hägerstrand pinpointed that there must be a reference between the geographical denominator (aerial photo) and the phenomena being studied (census data), in order to increase efficiency within public administration (Hägerstrand, 1955). The study described a digital map with coordinates with a reference to attribute data in a register that comprise the basis of a geographical information system. It was an inaugural work that can be claimed to be the first work in GIS ever produced (Ottoson and Rystedt, 1992). Hägerstrand, coming from the post-war “new geography”, clearly was influenced by models
such as Central place theory (Christaller, 1933). Hägerstrand himself modeled innovation-diffusion as a spatial process in human geography (Hägerstrand, 1953). His position was that GIS would solve what at the time seemed to be the unsolvable problem of creating socio-economic data with geographic references in a register for use in public administration. He explained clearly his ideas on computers in geography, as a future tool for applied geography (Hägerstrand, 1967). In the same time frame as the formation of the famous Laboratory for Computer Graphics at Harvard University, did Sweden in 1969 start to build a Land Bank system of census data and geo-referenced address information, based on computer cartography and Hägerstrand’s ground-breaking work (Nordbeck and Rystedt, 1971).

The theme of urban morphology
The development of a concept of morphology stems from German regional geography, which in the latter half of the 1900s was channeled towards urban studies with a British nucleus. Urban morphology within the English-speaking world become an accepted idea among scholars from different disciplines, such as geographers, historians, archaeologists, architects and planners, where the study of the urban landscape is based on three principles: form, resolution, and time (Whitehand, 1987). It should be noted that the three principles are interrelated. The urban form is the core of the analysis. The resolution of the study and the historical setting, are parameters for analyzing the urban landscape.

The father of urban morphology M.R.G. Conzen, created a morphological framework based on stringent applications with terminological precision (Whitehand, 2001). Conzen’s work in his inaugural study emanated from Alnwick, a market town in northern England, characterized as an urban landscape with a tripartite division: first, the town plan with its streets, plots, and block plans of buildings; second, the material of buildings; and third, the land use and building utilization (Conzen, 1960). The division of the urban landscape into different principles and elements is primarily for pedagogic reasons, when method and analysis are discussed from a theoretical standpoint. All three components are present in a morphological study, but the focus lies on one of them.

The theme of urban morphology is purely geographic in nature and answers the question how different parts of the manmade urban environment have been configured into a fabric of buildings, streets, green areas, and commercial land use. Ultimately, the morphology has been
laid out in a town plan that reflects the land use and utilization of buildings. The method is based on visual representation by means of minute cartographic studies that distinguish between different morphological periods. In generic terms, a morphogenic landscape can be applied to urban forms or transport flows. In a spatial perspective, there is an area available for transportation inserted between buildings and designated land use with a strong dynamic component of land utilization. Streets and highways are the lifeblood of movement patterns and control the roadmap of those who depend on accessibility; pedestrians, cars, public transport, and trucks moving goods.

Charles Colby’s distinction between two diametric groups of forces, the centripetal and centrifugal, was an early morphological research effort. It forms the basis for structural differences in land use between the central business area and the periphery (Colby, 1933). The centripetal forces focus on the city center’s attractive location with optimal accessibility. A modern example of a centrifugal force, is the development of warehouses, terminals and freight consolidation centers that move further away from the catchment areas they are intended to serve, which has been defined in geographical terms as logistics sprawl (Dablanc, 2011).

However, the dynamic component in urban morphology has just been noted as “innovation adoption” pushing an uninterrupted outward growth of building cycles with distinct boundary zones as fringe belts, which together constitute the morphological frame (Whitehand, 1994). Transport innovations have a strong relation to corresponding changes in urban morphology, where the prevailing trend in the transport system has had an indisputable impact on urban form during the 20th century. The impact of cars and trucks gave rise to an expansion of the urban environment along larger highways with commuter development to suburban housing. But in general, transport innovations have shorter life cycles compared with the duration of urban form over time (Giannopoulos and Curdes 1992). The expansion of the urban area might falter in the 21st century, due to an awareness of the negative effect of air pollution and global warming factors. That will ultimately have an impact on urban morphology, resulting in densification of built-up areas, a situation that has occurred in developing countries through an ongoing urbanization process (Zhou et al., 2013).

In the same generic way that urban landscapes can be divided into tripartite divisions, transport landscapes can be divided into three parts: transport infrastructure, vehicle technology, and transport management.
(1) Transport infrastructure. Streets, highways, depots, buildings of suppliers and recipients of goods; the objects and phenomena that make up the transport system.

(2) Vehicle technology. The vehicle industry goes through stages of innovation that affect the development of vehicle types, engine construction, and fuel sources, where mode of transport affects urban form.

(3) Transport management. Centripetal and centrifugal forces, interrelated in distance and time in a transport network, are derived from business models and transport planning decisions that have a positive or negative effect on transport efficiency.

In this paper the discussion will be confined to the third part, transport management. It does not mean that other two are irrelevant, but in this case, they are constants, while transport management will vary because of changes to manual dispatching and digital planning.

**Geographical information technology as an agent of change**

Studies in urban morphology have been characterized by manual analysis of cartographic material, a time-consuming task. Manual intervention also reflects methodology and research approach, with an aim to visualize and explain how cities are built and why. Nevertheless, over the past two decades the academic domain has been boosted by geographical information technology. Researchers have been able to build geographic databases that, together with help of different GIS functions, combine data in more sophisticated analyses. The new opportunity within urban morphology has allowed linking attribute data to point, line, and polygon features stored in digital maps, with the ability to classify and structure text-based information and perform analyses on a larger geographical scale than previously possible. The researcher can relate physical space to the socio-economic factors that influence actual building forms and land use patterns; for example, census data such as income and ethnicity (Moudon, 1997).

In the 1990s, the developments were similar in research carried out in urban morphology to the development of applications in “GIS in Business” (Grimshaw, 1994). An example was analyses of a company’s internal sales data, overlaid with socio-economic (external) data within a defined geographical area, which can be related to or constitute key performance indicators (KPIs). The same KPIs could then be used in strategic analysis to find similar conditions when establishing new outlets in other geographic markets. Site selection was manual work using a graphical (GIS) interface and combining internal data with external data. The trade magazine “Business
Geographics” explored business cases using GIS software with site selection as one of the flagship applications (Castle, 1998).

One problem that slowed down development initially was substandard GIS database handling and the integration of attribute data related to customers, products, and socio-economic variables. The geography as a third dimension with points, lines and polygons was the obstacle. It had to be integrated with attribute data in traditional relational databases with rows and columns. In addition, transport planning, previously handled manually by a dispatcher, must be performed by computer scientists lacking knowledge of operations. The same problem existed in urban morphology, where the scientists had to learn new technical practices, with the natural reaction of resistance to change and to stay with hands-on analysis (Koster, 1998).

This is symptomatic of information technology applied to social science problems. The problem lies not in the technical solution but in the data itself. The operator behind the IT-tool is constantly required to make judgments and decisions when data is missing or incompatible, thus creating GIS software solutions that are erroneous or incomplete. On the other hand, manual routines in the planning process inevitably lead to sub-optimized solutions. In the end, it is about brain capacity and human limitations where too many parameters and too much information make it impossible for the researcher, analyst or dispatcher, as an individual, to solve the tasks by hand.

The application of modern IT-tools has given new possibilities to make planning more efficient and to control the flow of transported goods. One tool used in transport planning is vehicle routing software, but algorithms do not solely determine the outcome of operational work. On the contrary, planning is done by the operator interacting with the computer through its interface. In terms of commercial products, this is referred to as route optimization and the result of these routes and tours increases transport efficiency by minimizing VKT. At the same time, digital planning is expected to provide increased services in the supply chain, through transparency in the information flow and in the ability to track goods and provide improved delivery precision to the end-customer.

Route optimization has generated substantial research in mathematical modeling and Operational Research (OR), to develop algorithms aimed at streamlining the transport of goods. But in general, these tools lacks research that examines adaptation and behavioral changes required by stakeholders within organizations (Browne and Goodchild 2013). On one hand, route
optimization can be described from the perspective of the complexity of the scheduling process with its many constraints and parameters related to distribution centers, fleet composition, vehicles, load capacity, time windows, customers, road network, regulations, etc. On the other hand, route optimization can be described from the standpoint regarding organizational development and change in business models, with demands for behavioral changes among stakeholders and for information transparency that digital planning provides.

In the last two decades of the 20th century, there were R&D objectives to integrate geographical data, algorithms, and customer data into a single application. However, the goal was not achieved due to lack of technology, such as street network databases, graphical interfaces, and overall low computational capability (Gayialis and Tatsiopoulos, 2004). At the turn of the millennium, the R&D focus was to evaluate and integrate system solutions for different industries in which the three components--GIS, OR, ERP (Enterprise Resource Planning)--were carefully analyzed from the customer's perspective and customarily followed by a costly pilot. The three systems were more or less developed independently of each other. Integration efforts resulted in specific proprietary solutions that did not benefit from economies of scale.

When OR was married with GIS to produce route optimization, finding user-friendly interfaces in business operations was an obstacle. The situation changed in the 2000s when commercial software for route optimization with an open interface to ERP-systems and nationwide street networks, became available, allowing information to be moved freely. The general trend in GIS, which gradually has been accepted as mainstream is defined as Location Based Services (LBS). A coherent and well-understood terminology, or semantic interoperability, has been developed in LBS where different technologies and human practices are globally spread and adopted on an individual basis (Jiang and Yaio, 2006). What has happened is that conventional GIS concepts disappear when the technology moves mainstream, where the evolution of GIS reflects the shift of computing platforms from mainframe, to desktop, to internet, to mobile devices and to “the cloud.”

The same movement to the mainstream applies to digital transport planning. The technical platform adapted to a business model where different stakeholders perceive the message of interoperability and the requirement of digital information in all stages of a supply chain. Meanwhile, extensive research has continued in the algorithm family called Vehicle Routing Problem (VRP), with both theoretical modeling and commercial applications. VRP-algorithms
are available in a multitude of variations with extensions of more rudimentary solutions with regard to capacity and time windows, to more advanced VRPs with multiple depots, multiple use of vehicles, pickups and deliveries in the same route, dynamic planning and many more (Golden et al., 2010).

However, there are few studies of applications, methods and analyses before and after the implementation of vehicle routing. The important question is how the algorithms are bundled into an interface for commercial use, and the experience of the operator when digital planning replace manual dispatching. A prerequisite is that the operator acquires detailed knowledge of features and parameter settings of the software, together with good understanding of the attribute data and local knowledge of the street network. There are two opposite forces, the movement of the vehicle in a street network and the delivery requirements of the recipients of goods.

In a simulation will the conditions applied by the operator to a street network (named geography) delineate delivery addresses, thus having a limiting effect on transport efficiency. On the other hand, delineation allows the operator to “help” the system and fulfill the conditions set by the recipient (named constraints). The latter can be done by manually moving delivery addresses from one driving route to another (a practice known as “swapping”) or changing the conditions in a new simulation with a new result. In this case, the operator performs an interactive task by repeating simulations with new parameter settings to achieve the optimization potential instead of letting the algorithms perform the planning autonomously. The crucial part is the operator’s understanding and knowledge of the data being the primary component of interactive work.

**Case study: the Swedish meatpacking industry**

A methodological framework for transport morphology using digital-based operation planning was initially applied to veterinary research (Moen, 2008). The method integrated theory with a case study of the Swedish meatpacking industry. Transport to slaughter was chosen because of the abundance of data and the ability to construct a situation analysis with defined vehicles, arrival times, and number of animals transported. In general, the meatpacking industry in Sweden and Europe have been the subject of investigations aimed at creating a coherent regulatory environment within the EU, where in particular animal welfare and transport to slaughter has been focused areas (Gavinelli et al., 2008).

An interdisciplinary project brought together logisticians and veterinarians, with the overall aim
of studying the relationship between transport efficiency and animal welfare (Algers et al., 2006). The project’s intention was to reduce the industry’s environmental impact, but also decrease animal stress hormones. Extensive research has shown that transportation, loading-unloading, space allowance, and duration of journey, are all stress factors affecting animal welfare and meat quality (Pinheiro et al., 2007). When digital transport planning was introduced in the case study, animal pickup became an integral part of the slaughterhouse supply chain. The route optimized “just-in time” arrivals of animals, secured feeding the slaughterhouse production line during butchers working hours. The number of animals in overnight holding pens was significantly reduced as well as total travel time, thus contributing to an overall increase in animal welfare.

The meatpacking industry in Sweden is confined to specialized vehicles, where the transporter takes care of planning and contact with producers. In the contemporary business model reports the producer to the slaughterhouse the animals to be retrieved. Based on incoming orders get the transporter consignment notes, which forms the basis for manual transport planning performed by the transport firm. Finally, the transporter specifies to the slaughterhouse what animals will be picked up and on which day. With route optimization, transport planning will be completely reversed. The transporter receives information on the time, date and number of animals to be picked up; the sequence of pickups for each route; and the time when unloading will take place at the slaughterhouse.

To move from one business model to another is gradual. In the R&D-work five simulations were carried out. The situation analysis was the first. Changing business models fundamentally changes transport planning and consequently the relationship between stakeholders in any given flow of transport. The major constraint encountered was the time window for planning, which was not used fully in the planning process. The transporter only planned the next day’s pickup, while Swedish regulations provide a much broader time window. From the date that producers reports that livestock is ready for slaughter, the pickup should take place within one week for pigs and three weeks for cattle. The case study is based on transport of pigs to a slaughterhouse in Southern Sweden during a 2-week period with 25 vehicles in the situation analysis (Moen et al., 2008).
The slaughterhouse catchment area is shown in Figure 1, in the densely populated province of Skåne. WinRoute, a commercial software package with VRP-algorithms, was used for simulation (Routing International, 2009). The simulation methodology comprises a gradual removal of constraints. In this way, it is iterative work in morphological spirit, which shows that it is not only the algorithms that determine the “net effect”. It is primarily dependent on the management decisions that specify the parameter settings used by the operator for each simulation. The parameter settings “geography” and “constraints” constitute generic functionality in commercial route optimization software, based on VRP-algorithms, where different vendors may have different names in their package.

The optimization is carried out either in terms of minimizing distance (geography) or conditions set by the recipients (constraints), an approach that implies that the operator has choices and needs to work interactively with different software parameter settings. Priorities might inhibit transport efficiency, for example, when the algorithms must ensure that the vehicle will be at a pickup address at a pre-defined time (constraint), when it might have been better to choose another option choosing the next pickup address with regard to overall optimization and to minimize the total VKT (geography). The ultimate alternative would be to drop all constraints.
completely and let the algorithms loose and allow them to independently choose the most optimal routes throughout the geographic area to minimize mileage and avoid idle time between pickups or deliveries.

Human interaction manipulates the software to loosen/remove (spatial) constraints using parameter settings that change the physical outcome of transport planning. It provides different (visual) patterns of driving routes through numerous simulations, eventually reaching optimal level and increasing transport efficiency in a given street network/transport flow. Coming back to the tripartite division of transport morphology, transport infrastructure and vehicle type will be set as constants. Transport management through route optimization will reproduce map images, “transport morphology”, of the same transport flow with different results in transport efficiency. The human interaction with VRP-type algorithms in a commercial software package is essential and with significant similarities to analyses conducted with GIS within the theme of urban morphology.

Figure 2 Summary of results of five simulations in transport to slaughter. (Moen et al., 2008)
In route optimization with commercial software, restrictions such as agreements, laws, or customary procedures that govern planning are called “business rules”. They set the framework for the business model used. Figure 2 shows the result of five simulations, each of which is an interactive iteration performed by the operator before the optimization potential is reached. The result is primarily a product of manipulation of data and parameter settings of the software, and by no means relying on the software algorithms alone to solve the problem. The iterative process contains the situation analysis (Simulation 1) and three simulations (Simulations 2 to 4) where constraints gradually dissolve as defined in the legal agreement. In the final simulation (Simulation 5) the time window for planning is set to the maximum with a weekly time window, which includes 5 days’ worth of pickup addresses. This enables the algorithms to geographically cluster producers to minimize “deadhead driving” (VKT), a sure centripetal force in morphological terms.

Simulation 1 is an exact reconstruction of all driving routes that were downloaded from GPS logs during 2 weeks of measurements, a total of 50,902 kilometers divided among 25 vehicles included in the study. Thus, Simulation 1 represents the situation analysis in which the restrictions consisted of; (1) “Limited use of vehicles” in which each vehicle is designated for the current assignment that each transporter provides; (2) “Fixed pickup/vehicle” in which every pickup address is linked to a specific vehicle; (3) “Fixed sequence” in which driving sequence for each route is determined by each transporter; and (4) “One day time window” which is strictly used for planning route pickups.

The difference between Simulation 1 and 2 is that the system freely selects sequencing in Simulation 2, resulting in a 4-percent reduction in VKT. In Simulation 3, there is no pickup address tied to a specific vehicle. Instead the system freely chooses the vehicle that will handle the first pickup, resulting in a significant 12-percent increase in VKT efficiency, compared to the situation analysis. In Simulation 4, restrictions on the fleet are removed with the only requirement being that incoming commissions be picked up on the same given day, a 1-day time window, with a saving of 16 percent. Finally, in Simulation 5, the time window is opened up where pickups can be performed any day of the week, resulting in a 24-percent reduction of VKT. However, Simulation 2-5 would require a new business model between producers, transporters and slaughterhouse (Moen et al., 2009).
Conclusion
The transport system occupies significant geographic area with its streets, intersections, highways, parking lots, terminals, etc., and provides a framework for other land use. At the same time, there are clear morphological changes over time with a centrifugal force of transport related land use towards the city's periphery. But there is an equal centripetal force involving the expansion of transport land use in nodes of peripheral locations; for instance, parking areas for consumer shopping, freight consolidation centers and warehouses for industrial use. The tripartite division (transport infrastructure, vehicle development, transport management) derived from urban morphology, sets the framework of transport morphology. What connects urban morphology to freight transport and transport morphology as a new concept, are changes in planning and business models, which have direct impact on the utilization of the transport infrastructure and, hence, transport efficiency and related issues of carbon emissions and accessibility in urban areas. The centripetal force has been used in urban morphology as concept opposite to a centrifugal force, where morphology as qualitative approach responds to the quantitative gradient analysis of how the built environment and urban functions change in a systematic way due to increased distance from the city center.

The need for organizational development to achieve transport efficiency, can be determined by a transport morphological analysis with regard to transport management. Digital technologies will continue to accelerate, as shown by the constant development of algorithms for vehicle routing. However, at the same time, innovations in information and communications technology, requires parallel innovation in business models, organizational processes structures, education and skills (Brynjolfsson and McAfee 2012). In short, organizational innovations are lagging, not the least in the transport sector. Ultimately, those who embrace the new technology will be the one who benefit most. Without structural changes and organizational development there will be no gains in transport efficiency. That is what this paper and the study of transport morphology, aims to highlight.

Freight transport, imaged through spatial modeling, takes place at different aggregation levels; as separate distribution routes, in hub-spoke networks, intermodal transport or channeled through a freight consolidation center. It is possible to visualize a flow of transport in a digital map based on route optimization, or a graphical model that schematically shows the relationship between catchment area and VKT. The case study presented in this paper presumed that the infrastructure
and vehicles were held constant, but that changes in software parameter settings changed the outcome of transport planning. However, it could just as well be that transport management was held constant and changes in different infrastructure scenarios were tried out.

When changes occur in the power over transport planning, from transporters to transport buyers, it changes the relationship between stakeholders, which at an aggregate level will alter the design of the transport infrastructure. The emphasis in the transport flow will be displaced from existing infrastructure, to facilities determined by the transport buyer. The facility infrastructure will be located in new nodes, and often non-zone nodes for transport operations, requiring new entrances, exits and heavy traffic routed through residential areas, which adversely affects traffic safety, accessibility, noise and CO₂-emissions. Another significant impact, a centrifugal force through logistics sprawl will increase feeder distance to the catchment area to be served, with less pickups or deliveries per route, which ultimately will reduce the fill rate and goods transported to and from that particular area.

When vehicle routing is used as a planning device there will be a spatial centrifugal (unifying) force where constraints are loosened up or removed, as shown in Figure 2. It means, in turn, that addresses will be geographically concentrated into clusters to reduce vehicle mileage. This geographic concentration will lead to changes in transport morphology, from a situation characterized by manual dispatching, with a transport imprint in the urban landscape with relatively more VKT in a less dense pattern of recipients. The centripetal force in a transport morphological context, will seek to increase access to urban functions impeded by freight transport. To sum up, digital planning produces a completely different transport landscape compared to manual dispatching, where the two business models represents two separate flows over the same transport workload, which can be described as two separate transport morphologies.
References

AMÈEN, L. (1964) Stadsbebyggelse och domänstruktur, svensk stadsutveckling i relation till ägoförhållanden och administrativa gränser, Meddelande från Lunds universitets geografiska institution, 46, CWK Gleerup, Lund


Examples, 130-141, Swedish University of Agricultural Sciences, Skara


MOEN, O., ALGERS, B., MOBACK, D., PETERSSON, K., WIBERG, S. (2008) Scan: Transporteffektivisering av slaktdjurtransporter, Swedish University of Agricultural Sciences, Department of Animal Hygiene, 12, Skara


