Challenges for Digitalization of the Asphalt Paving process in the Netherlands – a position paper

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Abstract

Ten of the largest contractors in the Netherlands and researchers of the University of Twente, have since 2007, been working together to find ways to reduce variability in the asphalt construction process and in so doing, improve the overall quality of constructed asphalt layers. Given experiences in the Netherlands, this short position paper briefly describes the challenges Dutch construction companies face regarding digitalization of asphalt supply chains and in particular, the uptake of new technologies in asphalt construction processes. In addition to highlighting today's main challenges for digitalization of the Dutch pavement construction industry, a plea is made for machine and sensor manufacturers to work closely with contractors to develop more appropriate data management solutions, and amongst others, address issues of data standardization and uniformity. Lastly, we describe a future vision in which asphalt paving and its quality is addressed from (1) an appropriate digitalization perspective and (2) a life-cycle approach to data and the value thereof.

1. Background

The Asphalt Paving Research and innovation network (ASPARi) was founded in 2007. It is a cooperation between the University of Twente and 10 of the largest Dutch contractors, responsible for around 80 percent of the Dutch paving market. In this alliance the focus has always been on the improvement of the quality of the final product by mitigating variances in process parameters, reducing risks and giving feedback to the asphalt crew. Closing the gap between technology and operator skills is key in this, combined with a scientific view. Compared to asphalt materials and asphalt production there still appears to be a lack of science in the asphalt paving process.

In the current world market, we are at a crossroad regarding digitalization. Digitalization leaps forward while the construction sector's own level of digitalization remains low. Despite taking a few small steps, this has still not led to a data-driven way of working which is one of the aspirations of our network. More than 100 ASPARi monitored projects has taught us valuable lessons, which have been translated into the operator-centered approach vision of today as described by Miller et al (2015) – The Asphalt Construction Site of the Future – a Dutch perspective. Presently, several questions arise: How far along are we on this route or have we taken a different direction or shortcut? How are we proceeding in this low-tech environment where measurements and data become indispensable lifecycle information of the pavement construction?

2. Last decade

Paving construction started with little to no registration and documentation systems a decade ago. Together with machine manufacturers, researchers at the University of Twente and the ASPARi contractors, several systems have been developed, tested or studied. As a result, several systems have found their way to the Dutch paving market These systems all help in the collection of data and slowly transform the market from an implicit knowledge approach to that of a data-driven approach. Aspects of these systems are very promising for the future. For instance, cloud solutions for centralizing data storage from several sources including asphalt plants, equipment and various sensors. Examples include the following:

- WITOS: closely integrated in the machinery (rollers, pavers and milling machines) of the Wirtgen Group
- Völkl: independent cloud platform for practically all connected machines from different manufactures and quickly able to export valuable reports, GIS-layers and analysis.
- BPO: independent platform as well, strongly focused on the real-time adjustment and optimization of the (logistic elements of the) paving process.
- Trimble: independent platform connected to other construction site solutions (VisionLink) and strong in positioning (as well as 3D-guidance)
- Q-Point (formerly known as HiQ);
- BOMAP: easy to use platform for roller operators of BOMAG rollers and others.
- Pavelink: cloud-based solution from Topcon that interconnects the paving business

In general, Intelligent Compaction (IC), fleet logistics and several software systems all appear to be heading in the right direction and have the potential to transform the asphalt industry (see Table 1).

	Company	Solution name	Solution domain	Solution features
Road construction systems	Ammann	GPS-based compaction (ACEpro and ACEforce)	Compaction	Records compaction results
	Atlas Copco-Dynapac	Continuous Compaction Control (CCC) Compaction meter (Dynalyzer)	Compaction	Records compaction results. Determines stiffness ofthe compacted material
	Bomag	Bomag compaction management and positioning BCM 05	Compaction	Records compaction results
	Caterpillar	Compaction Control Technologies	Paving and Compaction	Provides integrated guidance and automatic gradecontrol with real-time pass count and temperature mapping
	HAMM	HAMM Compaction Quality (HCQ)	Compaction	Measures the stiffness of the soil or asphalt pavement during the dynamic compaction process, current asphalt temperature

	Leica	Leica PaveSmart 3D system	Paving	Constructs precise as-designed 3D surfaces
	Moba	PAVE-IR	Paving	Measures the material surface temperature to detect thermal segregation
	Sakai	Compaction Information System 2 (CIS2)	Compaction	Counts number of roller passes, determines roller speed. Controls and adjusts vibration frequency and amplitude. Determines paving surface temperature
	Topcon	Sitelink3D, C-53 intelligent compaction	Compaction	Records compaction results. Measures paving surface temperature. Provides accurate pass counts
	Trimble	Trimble Compaction Control System (CCS900)	Compaction	Provides display and mapping of compaction measurements in real-time
	Trimble	ROADWORKS	Paving	Paving Control System to accurately control the paver screed based on a 3D design
	Volvo	Compact Assist for Asphalt with Density Direct	Compaction	Records compaction results, pass mapping, temperature mapping, real-time density calculation over the full mat surface
	Vögele	RoadScan	Paving	Records paving results, captures the base temperature before paving, records the wind strength and direction, ambient temperature, air pressure and humidity
	Völkel	Völkel Compaction Control (VCC)	Compaction	Records compaction results, controls and adjusts vibration frequency and amplitude, controls roller speed
Logistics	BPO Voltz logistics	BPO ASPHALT		Controls number of trucks, amount of mixture delivered to site
	Thunderbuild	APEX / ALIX		Controls number of trucks, amount of mixture delivered to site
Software Application	Ammann a.o.	Q-POINT	Construction process	Plan, control and document the entire construction process
	SIMPAVE	Interactive Simulations for Planning Pavement Construction	Simulations for paving and compaction	Provides path planning for hauling, roller motion paths, paver motion. Simulates wind, temperaturerush hour, accidents. Provides plant output, truck capacity, paver capacity, roller sizes
	VETA	VETA – Intelligent Construction software	Paving and Compaction	Map-based software for visualizing and analyzing geospatial data
	Vögele	WITOS PAVING/DOCU	Construction process	Plan, control and document the entire construction process

Table 1: Selection of road construction systems, logistics and software applications [Source: Makarov et al (2020)]

Equally important to these futureproof features is the fact that the market is moving and is progressing quicker and quicker. As systems become more intelligent, technologies can improve usefulness, efficiency and provide more possibilities for process improvement and quality. For example, ASPARi has been working on combining real-time asphalt cooling rate measurements and compaction data to create priority mapping (digital guidance) for the most optimal compaction strategy based on mixture type.

3. Contracts and clients

At the same time as the digital evolution in the paving sector, clients in The Netherlands are changing contract types, contract conditions and the contract management system. The approach is changing from an empirical prescription-based system to performance and system-based quality assurance, where the final product as a whole is approved or rejected. In the performance-based contracts, each individual element is supervised by the client, whereas the performance and system-based contract management provides an incentive for the contractors to verify the process and deliver satisfactory results from that process. Quality control by the contractor is now shifting towards process control. These same contracts bind the contractor to a warranty period of 5-10 years, making the incentive more attractive to achieve the highest quality possible.

Road authorities are also moving rapidly in this contract-changing market. It is their intention to include digitalization more and more in construction. Road authorities are more obligated to develop and improve asset management and therefore need access to accurate data of the road construction process and material properties. To achieve this, they need to be able to read and process the as-built information provided by the contractor in their own data and management systems. Soon, additional demands will be specified in contracts to enforce their data needs/demands. With no data standardization or uniformity in both data exchange as well as data types and files, the contractors can simply not fulfill this task without incurring enormous costs, until standardization and uniformity has been accomplished.

4. Current status

The scenario envisaged by Miller et al. (2015) represents what currently happens at the construction site. Several (near) real-time process control systems are available and in use both for paving and compaction. Systems which are currently connected to one another have low interoperability or integration, which leads to ad-hoc and company specific interfaces or connections, with little to no room for flexibility. This results in high efforts for almost a prototype-like system rather than a business-model worthy ICT system. Also, operability is not specifically designated to the skills and needs of roller- and paver operators who are not IT-specialists. Additional data input has to be done by hand and therefore distract operators from doing their job, which is paving and rolling. Output and screens are difficult to interpret and needs lots of background knowledge. It seems that the systems are not designed for operators but rather, for data scientists or management assistants.

Furthermore, the available systems are mostly closed systems, often also manufacturer specific. Companies with mixed fleets can therefore use the system partially or only with company specific alterations and connections. Open or interoperable systems, mainly aimed at operators, could provide a better outcome for the mixed fleet companies and significantly aid in the paving process itself.

It is also apparent that many manufacturers aim to provide a ‘total-solution’ system for the complete process from planning to the as-built documents for handover to the road authorities.

In the Netherlands, most companies already have several programs in use that support part(s) of the asphalt construction process. The need and desire for a complete cultural and digital change to a single new system, which has been built for international standards, does not fulfill the demand for the Dutch contractors. The differences even within the Netherlands are rather large for the same process. Changing this ‘overnight’, when digitalization already has been a challenge for the last decade is simply not a realistic vision for the Dutch market. However, a lifecycle approach on data and digitalization (independent of the application) is necessary from the contractors’ point of view.

In summary, today’s main challenges for digitalization of the Dutch pavement construction industry include:

- Development of a standard ontology
- Achieving high interoperability of systems
- Improving GPS range, accuracy and fallback solutions
- Improving real-time feed
- Developing appropriate Jobsite communication solutions
- Developing universal plug & play and, display facilities integrated in paving equipment.

Contractors cannot do this alone, nor can road authorities or machine and equipment manufacturers do it alone. It obviously requires a sound, joint approach.

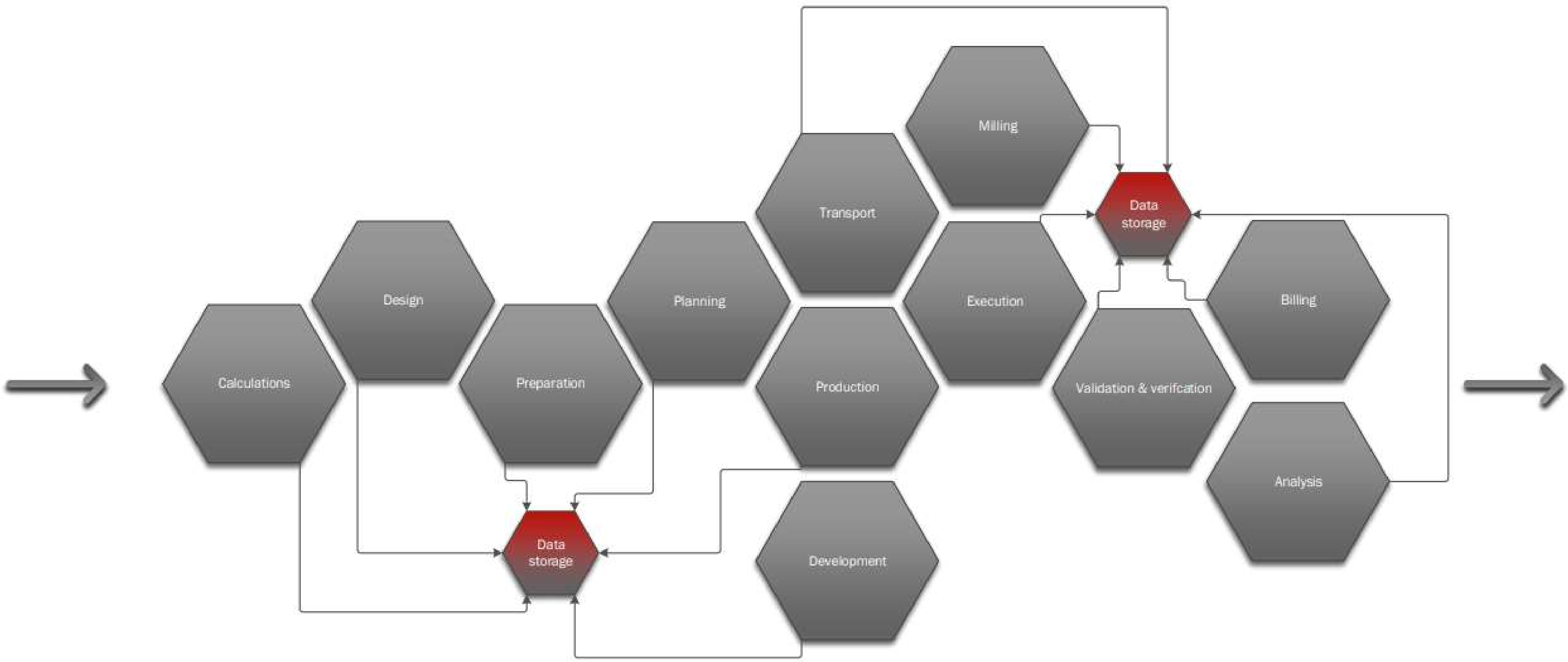

Figure 1- Typical segments that can be found in a standard asphalt paving process [1]

[1] The figure above shows the different segments (represented by a hexagon) that can be found in a standard asphalt paving process. Within the standard operations these segments fit together as a whole. All these segments require support in terms of digitalization and data transfer to other segments in order to reduce errors and increase efficiency. Desired IT solutions or applications can be tailored or focused for each of the segments. However, it is a necessity that despite the unique solutions per segment they also perfectly fit together and their interfaces are standardized (like the hexagons) in order to create a seamless process as a whole. Moreover, it provides exchangeability and introduction of (novel) solutions per segment without disrupting the entire process.

5. *Future vision*

We envision a market where manufacturers adopt the research done by ASPARi and other researchers and will use the information gathered to optimize proof of concepts developed. The available ICT-products on the market for assisting the paving process will (partially) be open systems. The systems in their core are therefore not manufacturer specific and work inter-operably with other systems. Data will come first, and machines and applications will come second. The final data products are standardized data files, which later can be used for analysis or the visualization/projection of data in geospatial applications e.g., GIS software. To develop such systems requires an ontology suitable for the complex asphalt paving process. To prevent rework, when developing a novel system, one is advised to focus on a limited scope of the paving process. "One size fits all" (in terms of a total-solution package) does not work, because of already well-established business operations, organizational growth or very different company cultures. This picking-and-packing principle does require system integration and an open system approach, to be able to serve contractors with mixed fleets.

It is probable that the availability of skilled human resource will be limited in 20 years' time. Where in current practices the experienced operator functions mostly on experience and implicit knowledge, the new operator will have to rely on the digital support system(s). Hence, in the coming years, developers should aim for support systems rather than registration systems only. Support systems should provide answers to: where should the roller operator compact first, depending on the temperature behind the screed, weather circumstances, mixture type and layer thickness? The system must be able to train the operator to eventually be autonomous [Makarov et al, 2019] When training the operators, feedback from previous jobsites is essential. Most registration systems can only process the "now" but, cannot replay a previous jobsite. Also, current systems tend to distract an operator from his or her primary tasks: e.g., an operator ticking-off truck loads reduces the attention for asphalt construction tasks needed to create better quality. In addition, systems that require high levels of manual input to work at all, are rather 'backward' given current levels of technology development. Current outputs and screens can be quite difficult to understand, and a comprehensive manual analysis must be done, before an output is understandable and explainable. This is counter-intuitive and counterproductive and needs to change. Given the likelihood of limited human resources, paving quality must be assured in the future. Digitalization in the form of valuable, tailored support systems will be key therein.

In summary, all market stakeholders have put considerable effort into the digitalization and optimization of the asphalt construction process by using ICT-solutions. During these last years the solutions differ significantly from one another in terms of data formats, interoperability, integration, and other aspects, making it difficult to combine all the different systems to fit contractors' primary processes. Often the application or system has become leading rather than the data itself. When integrating these systems, ad-hoc solutions for transferring data cost a lot of time and money only to connect to one or two company specific systems. However, when using a standardized ontology, communication protocols and data file types, the integration of systems changes from high to low effort and real interoperability for a growing number of systems used can be achieved. An example is the current usage of GIS systems. Only a very limited number of systems have an automated export function to be able to create a GIS-layer, which visualizes data rather quickly and easily with a less comprehensive analysis. Also, (real-time) ICT systems are needed to support the operators more instead of complicating their work. For this, the focus must switch from office-orientated development to the jobsite.

The dependency on ICT is growing, despite all these bumps in the road along the way. To further enhance asphalt paving and its quality, one of the main future goals is to enhance current and future systems, considering the perceived flaws mentioned above. If this can be achieved within a reasonable amount of time, enormous progress can be made. Importantly, a life-cycle approach to data and the value thereof, can be accomplished independent of the system being used.

6. References

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