

# ASPARI IS FOR PAVING

## NETWORK TO PROFESSIONALISE THE PAVING INDUSTRY

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### ASPARI

ASPARi is short for Asphalt Paving Research & innovation. It is a cooperative network of eleven contractors that work together with the CM&E-department in research projects and technology development to improve the performance of the industry. The ASPARi Founder Members pave together about 8 million tonnes Hot Mix Asphalt annually (adding up to about one billion euro's). As a network, they represent about 85 per cent of the Dutch



FIG. 1 Contractors within the ASPARi-network

road paving industry. ASPARi is also connected with key role players in the road construction industry: the national roads authorities, training schools, research institutes and international partners. The ASPARi Founders agreed to bundle the on-going activities to pave the way forward to a high professionalised asphalt construction industry. As a primary goal, ASPARi focuses on innovation and performance in the asphalt paving process. The issues around more professional approaches to asphalt paving became relevant and pressing due to changes in the business environment. Road agencies now require longer guarantee periods where contractors also are responsible for the maintenance of a road. Meanwhile the availability of the road is more and more under pressure. Consequently, the asphalt

team is under pressure to construct the pavement in less time (nights and weekends) and in less space (constructing only one lane).

Key in the ASPARi approach is:

- With SMART technologies (as GPS, thermography, imaging, pervasive networks) we make processes explicit at an operational level (so bottom-up approach), and with that: we create transparency of the process and the operational choices;
- With analyses and visualisations we help in sense making for individuals, teams and organisations;
- Create insights into the paving process and give feedback to operators to reduce variability and enhance control in the paving process and continuously advance productivity;
- Working from tacit knowledge to explicit knowledge, because operators have to verbalize their reasoning and operational choices during feedback sessions;
- Move from an experience based practice (single loop individual learning) to a method based practice (double loop team/organizational learning);
- Improve product quality for the clients and reduce risks for the paving companies.
- The research contributes to professionalism, visibility and recognition for the infrastructure industry.
- The ASPARi founders hold a strong conviction that changes in the industry can only happen [a] when research and

### The ASPARi approach

- using new SMART technologies
- create deeper insight into the paving process and provide feedback to operators and teams
- reduce variability, improve process control, continuously advance productivity
- reduce risks for the paving companies and improve product quality and value for the clients

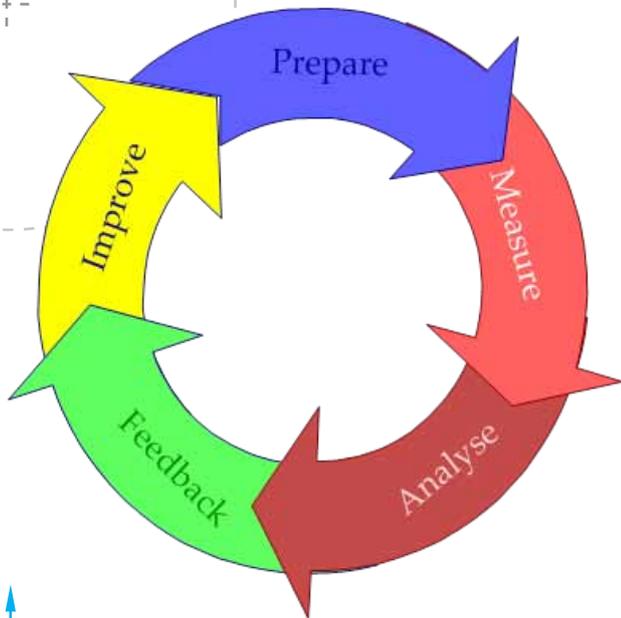


FIG. 2 The process quality improvement cycle (PQi)

technology development are driven by practice, [b] when it is guided by scientific rigor, and [c] when it involves the people working in practice in an action research methodology. Giving feedback, training and education of operators are vital in the process towards continuous learning and improvement.

## MEASUREMENT FRAMEWORK

To support its mission, the ASPARi-network developed a Process Quality improvement (PQi) framework towards the process of continuous improvement and learning in the asphalt paving process. It is a method-based approach for improving the process quality by monitoring and analysing the paving process and making operational behaviour explicit. The explicit data is made available to asphalt teams so that they can reflect on their own work, discuss and analyse the results, and propose improvements to their working methods and operational strategies. The PQi methodology combines elements of reflection theory, elements of process improvement, quality control and feedback systems. The typical PQi cycle shown in figure 2 consists of:

- Phase 1: Preparation and definition – check construction site design, undertake a site calibration, record site conditions and hold a preparatory meeting with the asphalt team;
- Phase 2: Data collection – temperature profiling, monitoring all asphalt machine movements, monitor weather conditions, nuclear density profiling and recording all noteworthy events;
- Phase 3: Data analysis – analyse all data and prepare visualisations and animations;
- Phase 4: Feedback session – discuss all results, visualisations and animations with the HMA team, laboratory technicians

### Direct results PQi-framework

- A 4D animation of the entire paving process
- Asphalt temperature and density during the process
- The paver's operational characteristics
- Compaction behaviour and number of roller passes
- Variability in results and working methods of the team
- Vulnerable areas and issues of the pavement
- Recommendations for process improvement

### Indirect results PQi-framework

- A georeferenced dossier for future failure analysis
- Increased awareness of quality for the asphalt team
- Improved communication within and with the asphalt team
- More insights into the differences between asphalt teams
- Identification of "best practices" in the process
- Quality improvement and the limitation of risks

and others directly involved in the project.

- Phase 5: Improve – Appoint improvements for working methods and future projects.

## TECHNOLOGIES AND SENSORS

Within this measurement framework we make use of different technologies and sensors (such as GPS, laser and infrared temperature sensors) to make the working methods of the asphalt team explicit and show the variability within these methods and the results (the quality of the pavement).

The movements of the paver and rollers are monitored and documented using high-end differential GPS equipment with a local base station. Based on these measurements we can analyse the strategies of the different rollers and the consistency of these strategies. Also, the continuity of the logistic process (trucks) and paving process (paver) can be analysed by the speed of the paver. At every project we also place a weather station to monitor the most important project conditions, such as the wind speed, sun radiation and the ambient temperature.

The temperature of the asphalt mixture is monitored by a laserlinescanner, thermocouples connected to a datalogger and an infrared camera. The laserlinescanner is mounted behind the screed of the paver and continuously measures the surface temperature of the asphalt. Thus, this device measures the surface temperature of the asphalt mixture at the whole construction site. Additionally, at certain fixed positions we measure both the surface temperature and the in-asphalt temperature of the asphalt mixture. The surface temperature we measure with an infrared camera and the in-asphalt temperature we measure with thermocouples. Based on the measurements at these fixed positions, we can determine the relationship between



FIG. 3 GPS equipment and weather station at the construction site

the surface and in-asphalt temperature. Consequently, with this relationship we can predict the in-asphalt temperature at the whole construction site based on the measurements with the laserlinescanner.

### VISUALIZATION OF THE PAVING PROCESS

It is hard to underestimate the role of feedback sessions within the PQi-cycle. These sessions are oriented to analyse events during the construction process and the corresponding consequences. Nevertheless, without a carefully prepared user-oriented visualization it is hard to increase understanding of the paving process. For example, if a relatively cold place within the asphalt mixture was noticed, it is difficult to localize the place on a site. The geo-referenced location can assist in that. For this purpose the corresponding streams of data should be processed and combined, with enough level of detail, but avoiding an overload of information from another side.

Within ASPARi we developed and continuously use different types of visualization, including information about the temperature of the asphalt mixture and positioning data of the paving equipment. Keeping the ideal paving process in mind, where the temperature of the laydown mixture is the same at any point of the road, it is possible to control deviations using temperature graphs (see



FIG. 4 Roller with GPS Equipment on the roof

figure 6). Although continuous temperature visualization helps to identify differences, it is hard to relate a particular area on the road with this temperature information. Therefore, its position data should be introduced for the quality monitoring (like the GPS-referencing mentioned before). To support it we developed a position based temperature contour plot where GPS readings are combined with the temperature information. With information of the initial temperature distribution in an asphalt layer and the documented cooling processed we can estimate in-asphalt temperature at any moment after paving was done. In addition, the graph represents temperature homogeneity of the deployed mixture and can be used for examining efficiency of new technologies to form a temperature-homogeneous asphalt mix. For example, we examined efficiency of using a 'shuttle

FIG. 5 Laserlinescanner behind the paver





FIG. 6 Asphaltting

buggy' - a machine that transport the asphalt mixture between the asphalt trucks and a paver. With continuous remixing of the asphalt, this machine can assist in building an asphalt layer without large deviations in the temperature.

After spreading the asphalt mixture, roller operators are in charge for homogeneous compaction of the asphalt layer. This is a highly individual process, where every operator relies on the personal experience and 'feeling' about the proper further movements. On the higher level, paving teams often have their own style, when different machines have different roles in the compaction process, varying in according to the sequence of the position of the roller influence the decision, when to should start and stop rolling within a particular area.

To analyse asphaltting activities on the team level we reconstruct the process in the form of animation. Thus, it is possible to locate the machinery in every particular moment and their

FIG.7 Asphalt temperature behind the paver



previous movements. During the feedback sessions this type of visualization is useful to show what happened during construction and identify possibilities for improvement on an individual and group level.

With the available tools and methods to visualize and analyse activities on a construction site, we also plan to use these techniques to improve training of asphaltting professionals, as well as in the initial education of the operators. Awareness of the group behaviour and vital role of every operator in the team along with the representation of the temperature of the asphalt mixture during the process might help in identifying best practices and exploring the tacit knowledge of asphalt operators and teams. In the foreseen future, we plan to use virtual reality approaches to deliver such knowledge in an easy understandable form.

## RESEARCH PROJECTS WITHIN ASPARI

Within the ASPARI-network, it is almost always possible to

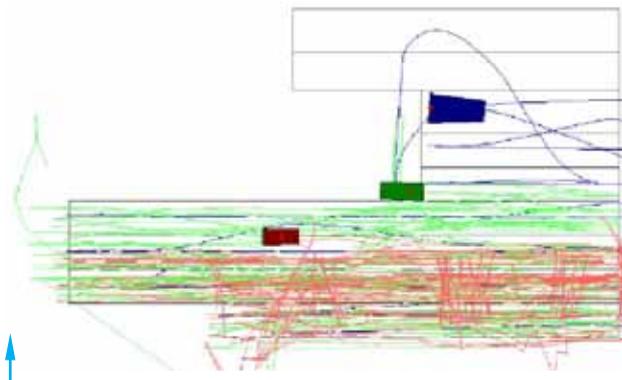


FIG. 8 Positions of the machinery at a certain time

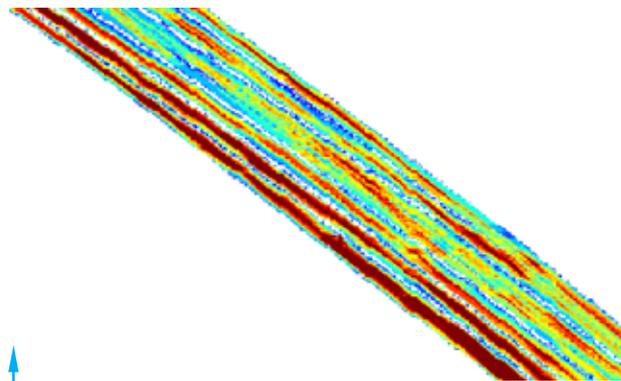


FIG. 9 Technical visualization of the number of roller passes at a stretch of asphalt

arrange MSc or BSc projects. Furthermore we are searching for student assistants to help us in data-processing and data-visualizations. There are already some pre-defined projects, but own initiative will also be appreciated.

Examples of possible projects are:

- Find ways to evaluate model and improve the planning and logistics of asphalt road construction. If trucks arrive on site too late then the paving process comes to a stop. Such stops are weak spots in road's quality. Some clients now give penalties to the contractor for each Stop-Go event. To prevent penalties: how can and should the logistics be altered to support a more smooth paving process?
- More and more the paving happens in confined space and time. That requires development of new process design, working methods and even technologies. The same goes for al new types of road constructions as roundabouts and safe junctions. MSc and BSc project can contribute in these developments.
- Compare the results of the PQi-measurements from projects of different contractors. Do the working methods from one contractor differ from the other contractor? And what are the effects of different operational strategies on the final quality of the asphalt pavement?
- Conduct lab-experiments in order to find (causal) relationships between different operational strategies of the asphalt team on the final quality of the asphalt pavement. What is the effect of the use of different roller types and does the sequence of roller passes matter? Does it matter if the asphalt temperature cools down very fast or very slow and what can roller operators do about it?
- Find methods and visualizations to show the in-asphalt temperature of the whole stretch of asphalt to operators of the asphalt team. Do operators want to see numbers, figures or colour bars? What kind of colour-combinations should be used to make it understandable for operators? How is it possible to provide operators with important information in real-time?
- Develop methods to automatize the data processing and data visualization. Currently, much of the processing is done manually and, is quite work intensive. This hinders us currently to timely provide feedback to operators. To support us in this next phase, we are looking for interested students with a background in signal processing and experience in the Matlab and JAVA programming languages.
- Interviewing the paving professionals about their expectations of the proposed technologies. For example, before introducing Virtual Reality visualization for analysis and training purposes, we want to know the expectations and suggestions of the managers, paving and education professionals. In this way, your communication and analytical skills are valuable for the further development education and training of the machine operators. ■

FIG. 10 Measuring in-asphalt temperature and density



**More information**  
 To see more about the ASPARi approach and projects: [www.aspari.nl](http://www.aspari.nl). To get in contact with the researchers, you can e-mail Frank Bijleveld ([f.r.bijleveld@utwente.nl](mailto:f.r.bijleveld@utwente.nl)) or prof. André Dorée ([a.g.doree@utwente.nl](mailto:a.g.doree@utwente.nl)).

**CONTACT**