

Artificial Intelligence models for the sewage water system in the province Limburg, The Netherlands

Pre-Commercial Procurement (PCP)

Market consultation document (including annexes)

Waterschapsbedrijf Limburg ("Contracting entity")
Postbus 1315
6040 KH Roermond
Maria Theresialaan 99
6043 CX Roermond

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List of Acronyms

EAFIP – European Assistance for Innovation Procurement
CRK – Central Control Room
CCR – Central Control Room
IPR – Intellectual Property Rights
OECD – Organisation for Economic Cooperation and Development
OMC – Open Market Consultation

PA – Process Automation / Industrial automation
PCP – Pre-Commercial Procurement
TED – Tenders Electronic Daily
WBL – Wetenschapsbedrijf Limburg
WL – Waterschap Limburg
WML – Waterleiding Maatschappij Limburg N.V.

List of Definitions

Artificial Intelligence – Theory and development of computer systems that can perform tasks that normally require human intelligence.

Big data – Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations.

Cybersecurity - Activities undertaken to protect IT and data against unauthorized access and other cyber threats, to maintain awareness of cyber threats, to detect anomalies and incidents that adversely affect IT and data, and to the impact of reducing, responding to and repairing incidents.

IoT – Internet of Things is a network of Internet connected objects/devices able to collect and exchange data.

Machine learning – A subset of artificial intelligence that consists of the scientific study of algorithms and statistical models that computer systems use in order to perform a specific task effectively without using explicit instructions, relying on patterns and inference instead.

Maintenance - Maintenance means not only corrective and preventive maintenance, but also adaptive and perfective maintenance where necessary, whereby components of the relevant ICT infrastructure must be replaced by means of purchase.

PCP – Pre-Commercial Procurement (PCP) is a specific approach to procure R&D services that involves competitive development in phases, risk-benefit sharing under market conditions, and where there is a clear separation between the PCP and the deployment of commercial volumes of end-products (potential follow-up PPI).¹

Sensor - A sensor is an artificial version of what is called a sense in biology. It is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics.

Security - Security of critical infrastructure, including penetration tests, Security by design and dealing with and responding to incidents.

Value Engineering – Value Engineering (VE) means an analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply, directed at improving performance, reliability, quality, safety, and life cycle costs.

¹ See eafip Toolkit, at www.eafip.eu

WAUTER – Water Automation concept of WBL

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1. Introduction

This document describes the objectives and the rules applicable to the Open Market Consultation (OMC) of WBL. The OMC aims to inform market operators regarding the upcoming procurement of research and development (R&D) services for the development of artificial intelligence models for the sewage system in the province Limburg, The Netherlands (see sections 2 and 3 below). This OMC is performed under Dutch law.

The OMC also aims to understand the operators' capabilities to satisfy the procurers' needs and to obtain market parties' input on the viability of the procurement plans and conditions as described in this document and annexes.

The timetable for the OMC is as follows:

12 September 2019	Publication of pre-announcement and making available market consultation documents & list of questions (through the EU Survey).
20 September 2019	Possible publication of updated version of the EUSurvey.
27 September 2019, not later than 15:00 CET	Registration for the meeting in Roermond
4 October 2019, 14:00 – 16:00 CET	Physical meeting for explanation and possible questions. Date: 4th of October 2019 Time: 14:00 – 16:00 CET Location: Congrescentrum Het Forum, Elmpsterweg 50, 6042 KL Roermond, The Netherlands Info: http://forumroermond.nl/
12 October 2019, not later than 17:00 CET	Deadline to receive answers to the questions in the EU Survey
31 Oktober 2019	Publication of market consultation report.
1st November 2019	Closure of market consultation.

WBL is entitled to adjust the time schedule. WBL is and remains entitled to terminate the OMC for its own reasons at any time. In such a case, WBL will make the termination known as such through a publication on TED and TenderNed.

The OMC starts on the date of its publication in the EU's Official Journal (TED) and ends on 1st of November 2019, unless terminated earlier. The market consultation is organised in the form of a meeting and an online questionnaire. The meeting will take place on the 4th of October 2019, in Roermond, the Netherlands. Interested parties can register for participation via the email address wblpcp@wbl.nl by 20th of September 2019.

All interested operators are invited to take part in this OMC, regardless of their geographical location, size or governance structure. Participation in the OMC is voluntary and non-binding and, moreover, is done for own account and risk. A market party cannot charge any costs to the procurers for participation in the OMC or for (re)-use of its information in the context of a future procurement procedure.

In case the information provided in this document and annexes needs further clarification, market parties may ask questions during the meeting in Roermond or via the following email address: wblpcp@wbl.nl

Any market operator who desires to supply additional confidential information that is not revealed during the OMC meeting, may send such information (clearly marked as confidential) at the following email address: wblpcp@wbl.nl before the end date of the market consultation (1st of November 2019).

Market parties are requested to fill out the questionnaire available at <https://ec.europa.eu/eusurvey/runner/WBLBigDataPCP2019>. The questionnaire should be filled out before 12th of October 2019. The responses to the questionnaire should not contain any confidential information. As the questionnaire is intended to explore the market 'as-is', there can be no wrong or right answers. The answers provided will be used as input for our procurement strategy and conditions.

After processing the questions and responses of all suppliers, we will communicate the results widely. In this context we will treat all information provided by operators as commercially sensitive and we will therefore not communicate any supplier specific details. Only the general findings will be summarised and communicated. The resulting anonymised report (excluding the confidential information) will be published on 1st of November 2019 via TenderNed and TED.

All communication (before, during and after the OMC) will be carried out in English. However, for the subsequent procurement, the interface of a final solution should be made available in Dutch language. In connection with this requirement, several documents which are made available in the annexes are in Dutch language.

Participation in this OMC is not a condition for submitting a tender in the subsequent procurement. Also, the provided input in this OMC will not be used to evaluate future proposals.

By carrying out this market consultation, the procurers do not commit to subsequently deploying a procurement procedure. Moreover, in case this OMC will be followed by a procurement procedure, the public procurers reserve the right to change any elements that define the desired solution. No rights can be derived from any statements made by the procurers during the OMC.

The following annexes are attached to this document:

- ICT-Group N.V. - Adviesrapport innovatie bedrijfsvoering afvalwatertransportstelsel
- ICT-Group N.V. - Rapportage workshops MOMS
- Witteveen+Bos - Onderzoek slimme besturing transportsysteem
- Witteveen+Bos – Set prestatie indicatoren transportsysteem
- RHDHV – Basisdocument Aquasuite FLOW pilot Venray
- RHDHV/WBL – Aquasuite Flow op ATS Venray
- Brightcape – Big Data Innovation Vision Waterschapsbedrijf Limburg
- Geographical map transport system Venray

The annexes form an integral and inseparable part of this OMC document. In the event of any conflict between the provisions of this document and the provisions in the appendices, the provisions in this document prevail.

Please note that the questionnaire (EU Survey) is explicitly qualified as an annex to this market consultation document and is not a standalone document, but is part of a set of documents. For the sake of readability, the choice has been made to have the questions asked in this document come back within the framework of the EU Survey (<https://ec.europa.eu/eusurvey/runner/WBLBigDataPCP2019>); in this way the context of the questions can be better explained.

Please note that photos will be taken during the meeting. If you do not want to be photographed, you must make this known in advance through your registration.

2. Background to the OMC

2.1 Organisational changes

Waterschapsbedrijf Limburg (WBL) has 17 sewage treatment plants and approximately 150 pumping stations in ownership and management. In the past, each purification system had its own process automation. It often consisted of different equipment that was not geared to one another and was partly outdated. It was inefficient, ineffective and unnecessarily expensive. Together with Waterleiding Maatschappij Limburg N.V. (WML), WBL has developed the WAUTER concept (water automation) in the recent past. With this central process automation project, the management of the installations of WBL is standardized and automated. A highlight in the automation process was the official commissioning of the Central Control Room. This has been phased in and fully operational since mid-2016.

An important task of WBL is the management of (own) pipelines for the transportation of waste water. Currently there is little insight into the correct functioning of these systems, as WBL can only react to fault notifications, rather than anticipating and taking proactive action. Active management of pipelines is needed for WBL to have more control over its operations. For this, it is necessary that the performance of the pipelines is continuously monitored so that deviations can be predicted and maintenance can be anticipated.

In recent years, a growing number of municipalities in Limburg are transferring their waste water transportation services to WBL. Within a few years, thousands of pumping stations will be managed by WBL. The pumping stations of these municipalities are currently not linked to WAUTER, since this would overload the central control room (CCR) with systems for monitoring and alarming. Monitoring of the pumping stations is currently being done manually. Given the increasing size and complexity of the systems, it is not a realistic option to continue doing these analyses manually. In order to achieve efficiency in the maintenance of these pumping stations, WBL has recently launched a procurement for an improvement of WAUTER.

The procurement approach also took into consideration the cooperation agreement signed between WBL and WML in May 2018 (hereinafter: MOU - Memorandum of Understanding -). This MoU foresees a close cooperation aiming to save costs, improve quality and reduce vulnerability / become more robust in favour of the customer / Limburg society.

This MOU is in line with, among other things, the agreements in the 'Administrative

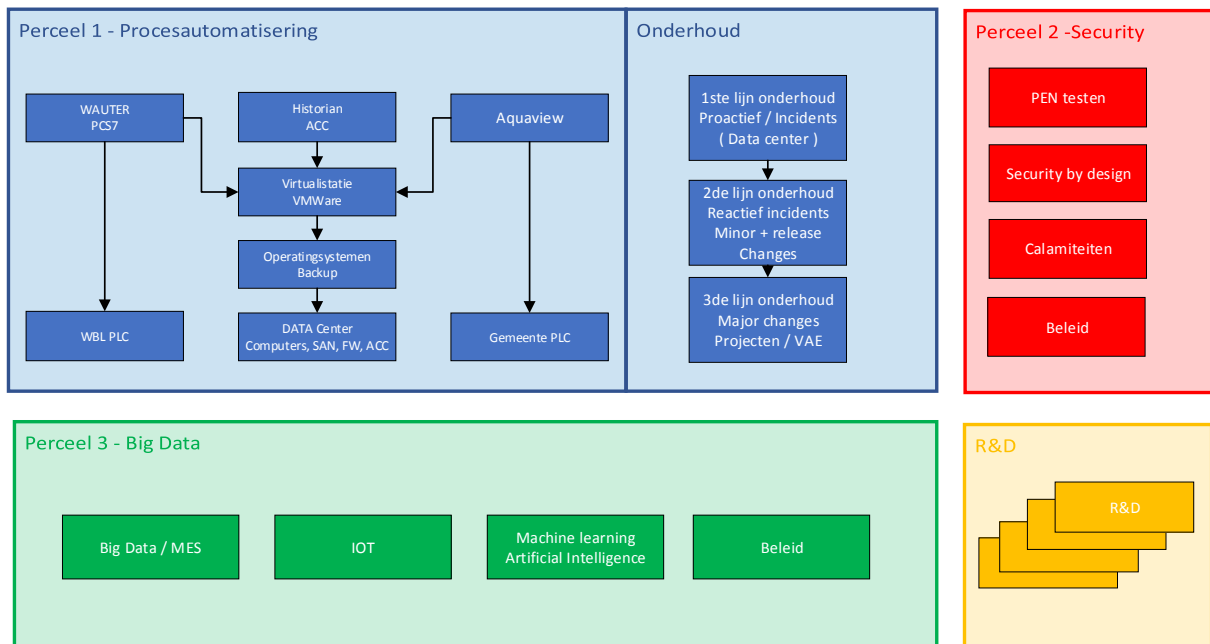
Agreement on Water' ('Bestuursakkoord Water' 2011) and with the vision documents 'Mission Vision and Objectives 2014-2018' (WML, 2013), 'Valuable growth' ('Waardevol Groeien', Waterpanels Limburg, 2015), 'Vision on cooperation in the water cycle' ('Visie op samenwerking in de watercyclus' WML, 2016) and the 'Vision on the future of water purification and water chain 2030' ('Toekomstvisie waterzuiveren en waterketen 2030' Water Board Limburg, 2017).

One of the areas of cooperation identified in the MOU concerns computerization and automation, in particular cooperation in the field of PA management, known as WAUTER. It has been agreed in a generic sense that the management of the PA can be taken over by WML as a result of the collaboration. It was therefore crucial that WBL during the current procurement ensures alignment, standardization of PA systems, network and information security and work processes of WML. As WML is mandated by the Law on cyber Security Data Processing and Reporting Obligation and the Decision on Cyber Security Reporting Obligation, WBL needs to take into account during the current procurement that the same high level of security of the PA is ensured. In this way an effective and efficient transfer of management will be guaranteed, so that the agreements in the MOU can be implemented. In concrete terms, this means that although WBL is not formally qualified as a supplier of vital infrastructure, WBL will voluntarily commit itself to the consequences arising from the Law on Cyber Security Data Processing and Reporting Obligation and the Decision on Cyber Security Reporting Obligation Decree.

2.2 Procurement Process Automation, Security and Big Data²

On this background, WBL decided to divide the procurement of process automation and standardisation of PA systems, network and information security, and improvement of work processes into three lots:

- Lot 1: Process Automation;
- Lot 2: Security;
- Lot 3: Big data.



Lot 1: Process Automation - consists of services of maintaining (preventive, corrective, adaptive and perfective) and managing the process automation.

Lot 2: Security - consists of conducting penetration tests, advising on Security by design and dealing with and responding to incidents. Security risk management covers the full range of activities undertaken to protect IT and data against unauthorized access and other cyber threats, to maintain awareness of cyber threats, to detect anomalies and incidents that adversely affect IT and data, and to the impact of reducing, responding to and repairing incidents.

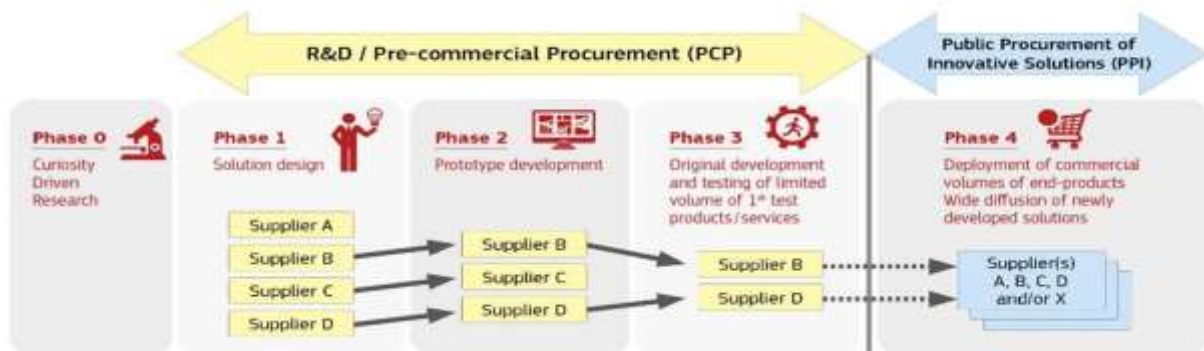
Lot 3: Big Data - consists of services related to the collection and processing of Big data. WBL is aiming to have a Big Data platform that is capable to save data collected by sensors placed in its infrastructure, continuously and in real-time. Additionally, the quality of the data must be monitored and the structure of the

² Tenderned kenmerk 212151

data must be improved easily and quickly, thus increasing its value. The aim is to be able to collect data, enrich data, store data on premise or in the cloud, analyse data and convert data into information with a set of selected tools to optimise water management. WBL will select a partner with knowledge and experience in the field of IOT, Data Analytics, Artificial Intelligence and deep knowledge about the transportation of waste water and waste water treatment plants.

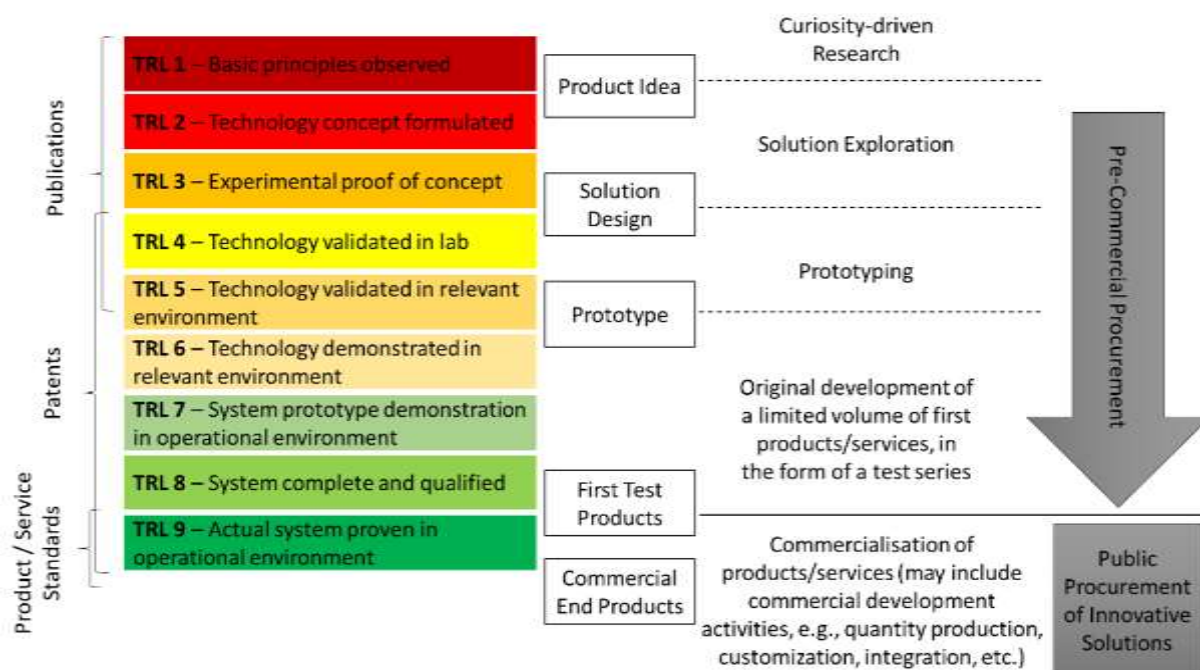
2.3 PCP in general

The Pre-Commercial Procurement (PCP) approach consists of competitive phases of solution design, prototype and piloting.



"Pre-commercial procurement: driving innovation to ensure sustainable high quality public services in Europe", COM(2007) 799 final

In essence, the PCP concerns a tender of R&D services at level TRL = 5 up to and including TRL = 8, (Technology Readiness Level) with a lead time of about 2 years.



In sum, the aim of the PCP procedure is to:

- Pull a radical breakthrough from the market to identify innovative Big data solutions for the water chain prediction, efficiency improvement and costs

reduction;

- Force a radical breakthrough to solve the above mentioned issue. The PCP methodology will allow for the sharing of risks and benefits between governments and vendors to attract innovative proposals from technology vendors and includes the three stages of R&D, resulting in a minimum of two developed (in competition) and field-tested solutions to the identified need.

3. Pre-Commercial Procurement of Artificial Intelligence models for the sewage water system

3.1 Objectives of the PCP

This OMC focuses specifically on the PCP of Artificial Intelligence models for the sewage water of Limburg (in relation with IOT, Big Data and Data Analytics), that WBL intends to launch outside the scope of the procurement described in paragraph 2.2 above. WBL aims to challenge the market through the planned PCP, to develop innovative solutions/algorithms to continuously analyse measured values and to convert these into intelligent signals that tell whether and what has changed in the system. Because of the many different types of sensors in the field, WBL has a large amount of data to process in real time. The quality of the data must be monitored and the structure of the data must be able to be changed easily and quickly, thus increasing the value of (Big) data for WBL. This will allow for more efficient planning of inspection and maintenance rounds and eventually lead to efficiency gains and cost reduction.

For example, the following questions should in the future be answered by the IOT / Big Data / Data Analytics / Artificial Intelligence solution:

- is the system currently working well enough (current effectiveness)?
- will the system work well enough in the near future (future effectiveness)?
- can the performance of the system be improved / optimized (efficiency)?
- are there imminent leakage incidents that should be prevented?
- is it possible to predict maintenance?
- how can weather forecasts be integrated?

WBL has already conducted a pilot in Venray, where regular pipe breaks take place. The pilot showed that functioning of pumping stations and pipelines can be monitored effectively. The software tested during the pilot, was able to respond quickly and adequately to a pipeline leakage.

In this regard, knowledge and experience are needed in the field of IOT, Data Analytics, Artificial Intelligence and deep knowledge about the transportation of waste water and waste water treatment plants.

In addition, the market parties selected to compete in the PCP will be requested to supply the application layer during the prototype phase that is necessary for the analysis and processing of Big data. The interfaces of such solutions should be made available in Dutch language.

3.2 PCP approach

The Pre-Commercial Procurement (PCP) artificial intelligence models for the sewage system in the province Limburg, The Netherlands is divided into 3 phases:

Phase 1

- **Solution Design for lot 3**

Delivering the specifications for lot 3 (described in 2.2).

The functional specifications how to collect data, enrich data, store data on premise or in the cloud, analyse data and convert data into information with a set of standard tools to optimise water management.

All functional specifications will be input for the procurement of lot 3.

- **Solution Design for common situation**

- o **Prototype the transport system Venray in detail**

- o **Roll out the full transport system of WBL**

The design should be useable for the full transport system in the province Limburg in The Netherlands. That means the existing of 149 WBL pumping stations.

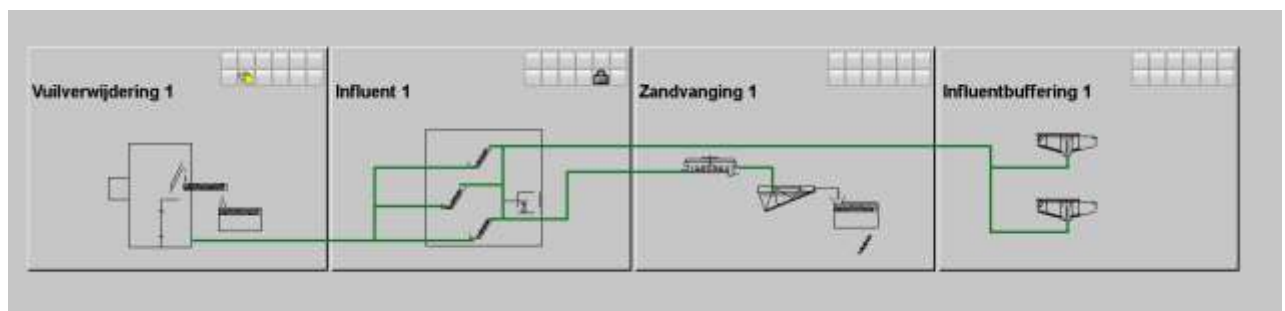
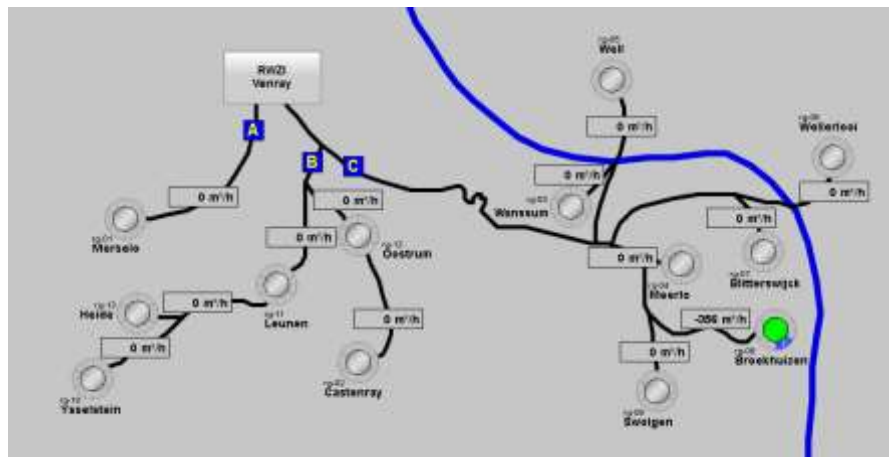
- **Solution design for the future**

- o How to integrate thousands of small pumping stations of municipalities.
 - o possibilities to integrate administrative data from administrative systems in the future

Phase 2 Prototype Development and Training³

Developing the machine learning model and train it with existing historical data.
The size of the prototype is the transport system (pumping stations combined with gravity / freefall) of the sewage plant Venray.

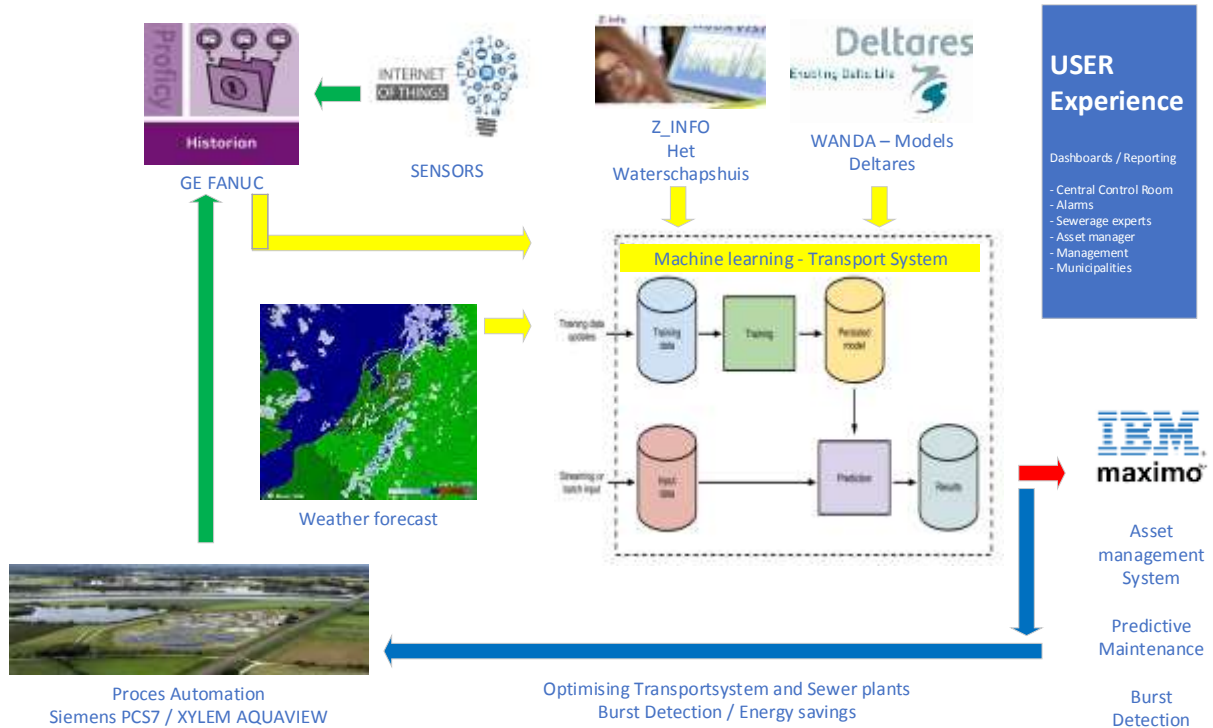
SIZE PROTOTYPE - PCP - VENRAY



A geographical map of the transport system is included in annexes.

³ Training in the sense of machine learning.

PROTOTYPE -PCP - TRAINING



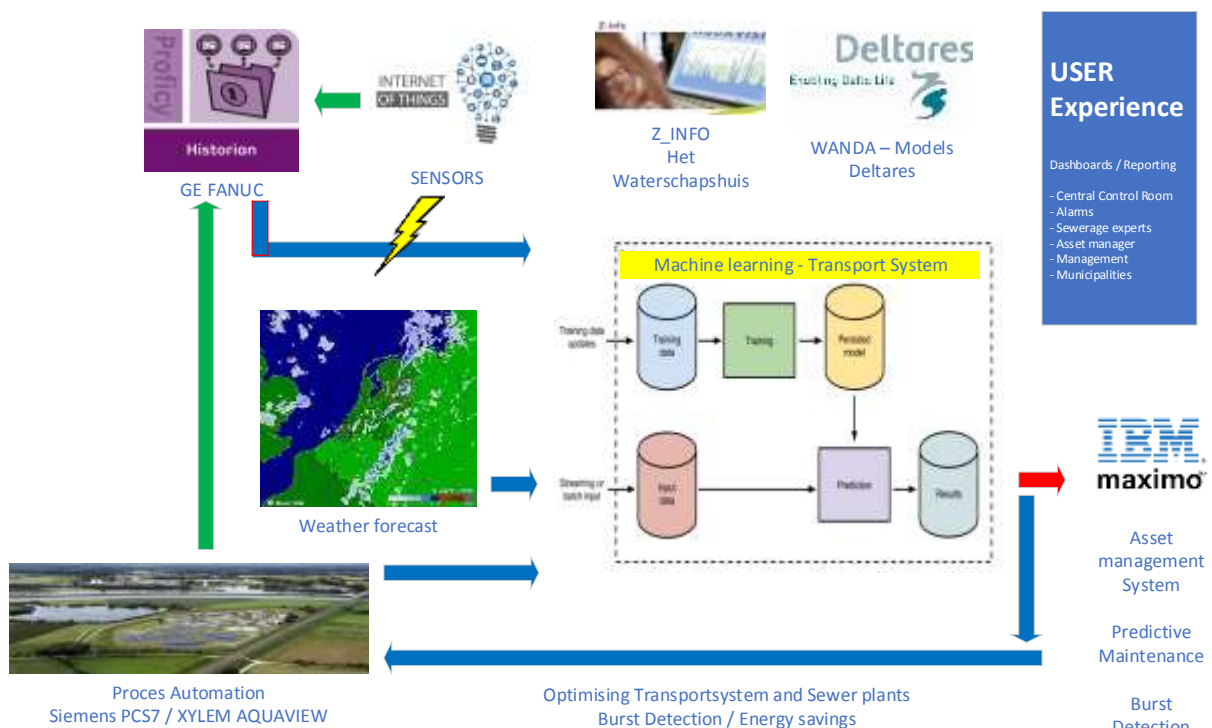
Phase 3 Prototype Streaming

Test de developed model on streaming data.

The system should:

- optimise the transport system / sewer plant
- trigger the asset management system for maintenance

PROTOTYPE -PCP - STREAMING



During Phases 2 and 3 of the PCP, the competing suppliers are required to collaborate with those suppliers related to Lot 1 and Lot 2 described in point 2.2.

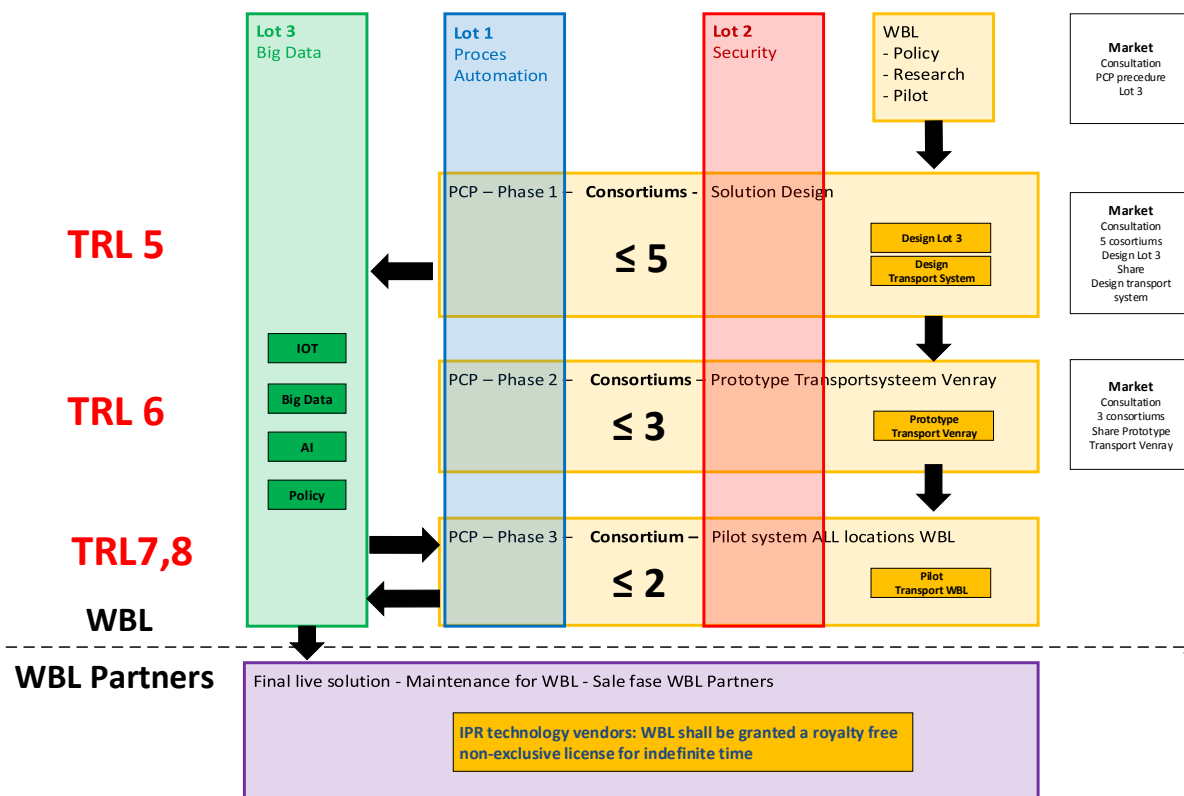
WBL will receive from the Big Data PCP suppliers a royalty free non-exclusive license to use the developed technology for indefinite time. FRAND⁴ agreements will be concluded between two technology vendors (phase 3 PCP) and the three different suppliers of [Lots 1, 2 and 3 – if applicable -]. FRAND licensing aims to compensate the innovative companies through patent royalties so they can re-

⁴ Fair, reasonable and non-discriminatory agreements (FRAND).

invest in next generation technologies, while allowing fair access to their technologies based on trust. The FRAND requirement facilitates wide use of standard essential patents (SEPs).

3.3 Implementation of Final PCP Solution in Lot 3

The best prototype will be implemented in the services in Lot 3 that has been awarded during the procurement mentioned before (see point 2.2).

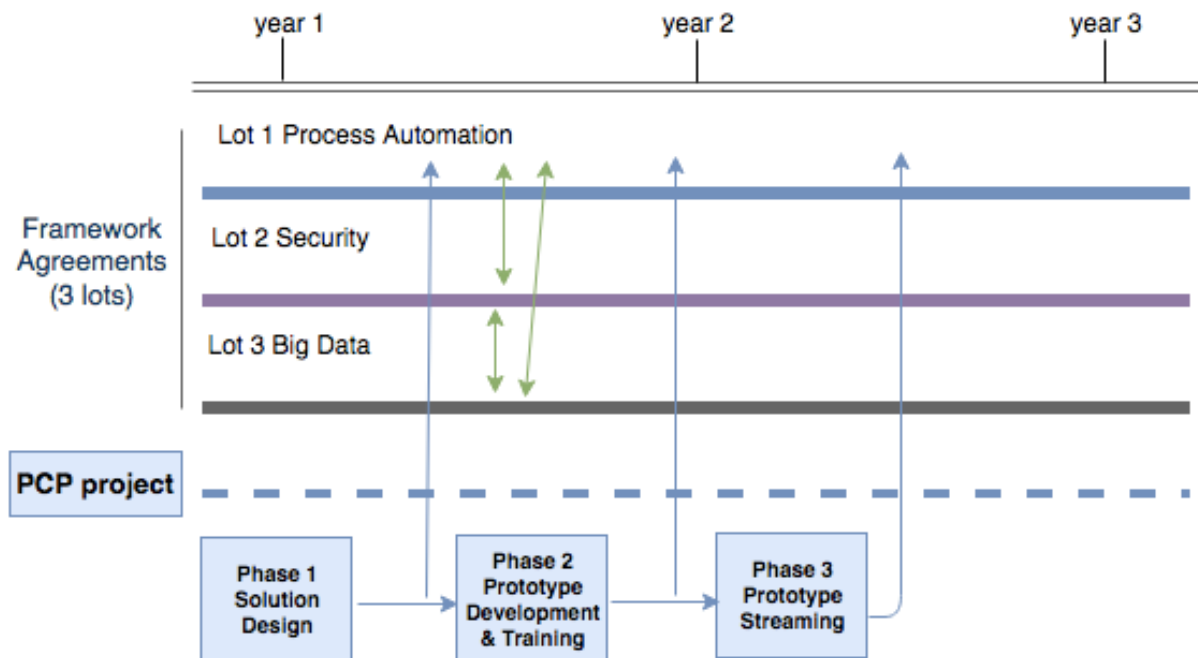


Through the use of Value engineering⁵, the supplier of Lot 3 is mandated by contract to introduce one of the solutions that has been developed during the Big Data PCP. Similarly, the Big Data PCP suppliers will be required to cooperate with the suppliers of Lot 1, 2 and 3 in the integration and implementation of the innovative solution. It is expected that the benefits of this integration can be recovered in about 2-3 years.

The suppliers of Lot 1, 2 and 3 are free to compete in the PCP of artificial intelligence models for the sewage system in the province Limburg, The Netherlands. Alternatively, they are allowed to offer at the end of the Big Data PCP alternative innovative solutions than those developed during the Big Data PCP. WBL will evaluate at that stage which of the innovative solutions would be implemented.

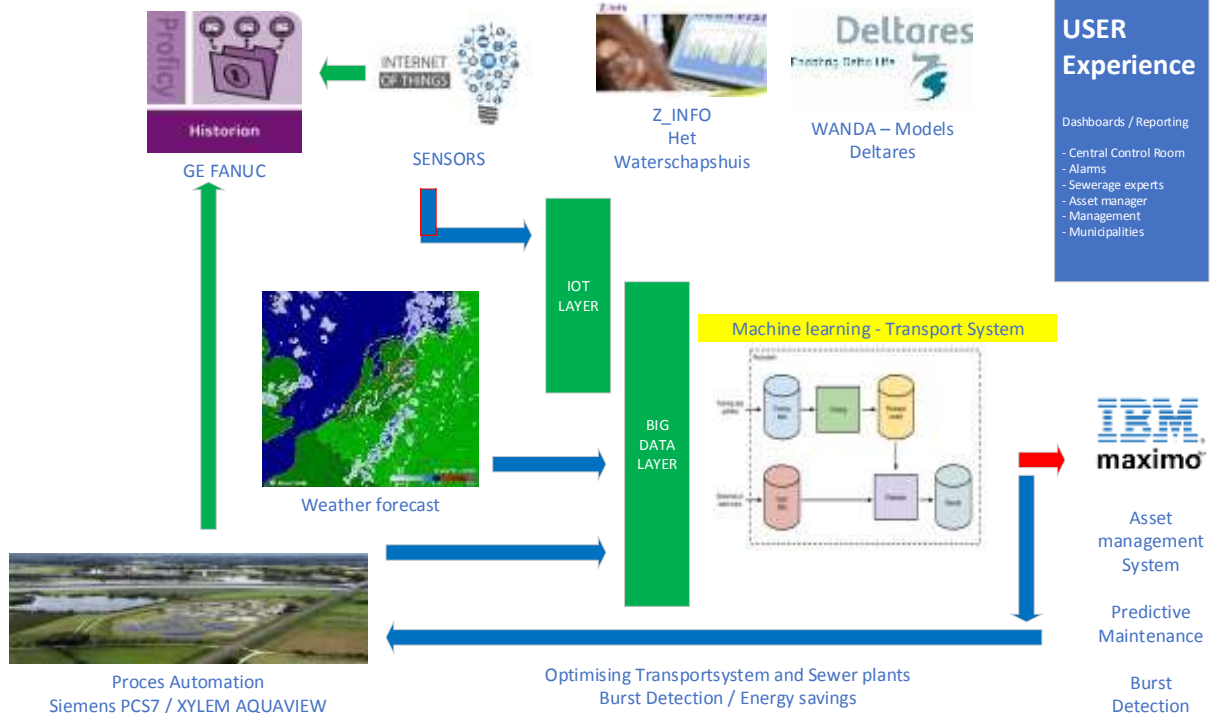
⁵ A VE clause in the framework agreements requires the suppliers of Lot 1, 2 and 3 to provide for improvements during the term of the contracts.

The results achieved throughout each of the 3 PCP phases (see point 3.2) could also inform (progressively) the implementation of Lots 1, 2 and 3 with the purpose to capture potential innovative solutions in due time.



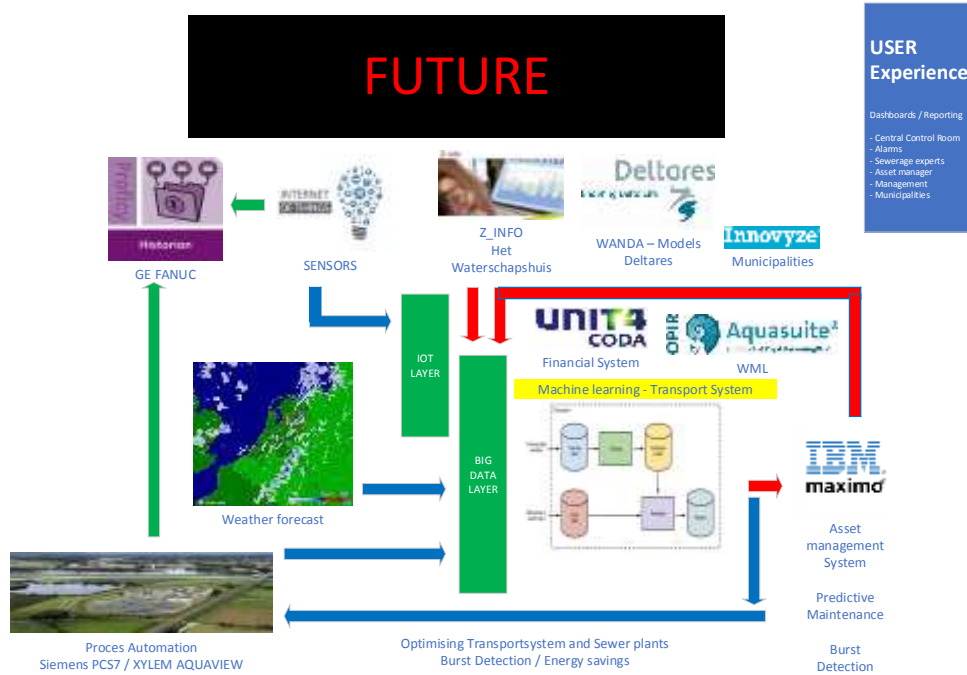
- a) Cooperation of suppliers to implement results adding value for WBL using value engineering methodologies.
- b) Value Engineering proposals by suppliers of Lot 1, 2 and 3 can integrate their own innovative solution(s) and/or the solution(s) developed during the Big Data PCP throughout the implementation of the framework agreements.

FINAL SOLUTION LOT3 – PCP



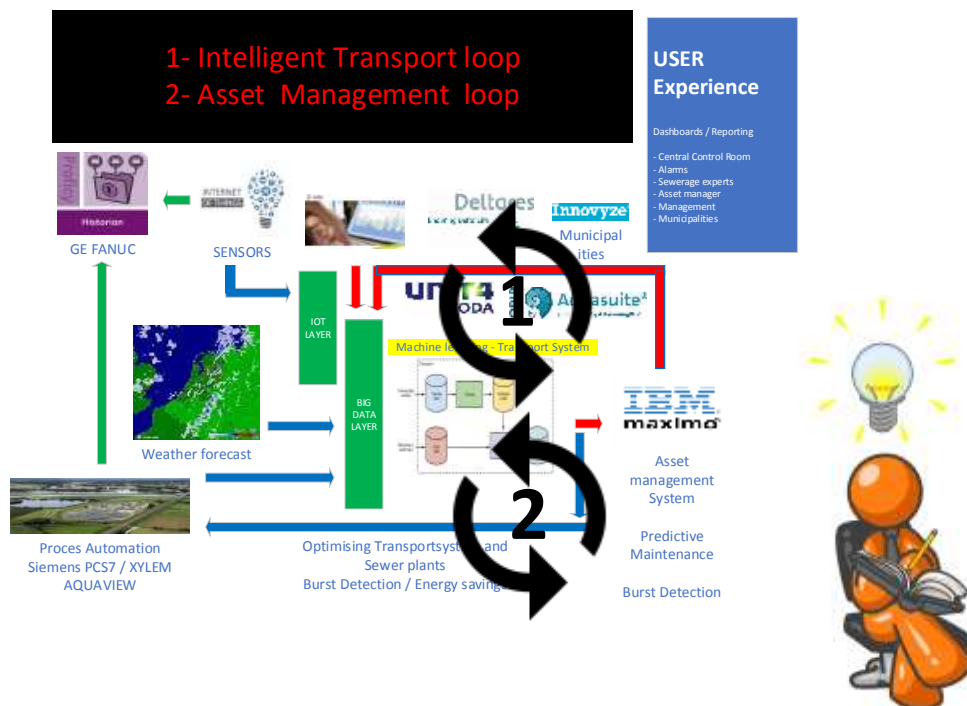
Future developments

The resulting solutions will be further developed for their future integration within the administrative portfolio of WBL and the integration of the industrial automation of WML, WL and the municipalities.



The aim is to implement the PDCA cycles for a:

- Intelligent transport system;
- Asset Management.



3.4 Planning of the Big Data PCP

The Big Data PCP will start at the end of 2019, and it is currently anticipated that the completion of the PCP process will take place in 2020/2021, whereby two competing technology vendors will be able to have working prototypes in real-life environments.

The results of the Big Data PCP will be deployed subsequently during the implementation of the services in Lot 3 that has been awarded during the procurement mentioned in section 2 above.

Questions:

1	Do you have any suggestions regarding the scope of the envisaged PCP that would lower the budget for the delivery of the use of Big data solutions in the water chain?
2	What would you consider an appropriate budget for delivering the services detailed in the market consultation document and related annexes. Please elaborate.
3	Do you have knowledge of any suitable technology for Big data solutions/analysis (e.g. prediction models) in the field of water management? Please elaborate.
4	Do you have knowledge of any suitable methodology/approach to estimate the impact of Big data solutions in the water chain? Please elaborate.
5	Can you suggest a classification for potential technologies (e.g. value stream design, etc.) ?
6	Can you describe your approach to developing and testing technologies for Big data solutions in the water chain?
7	Do you foresee any barriers to use of existent solutions in different settings? If yes, please elaborate.
8	Do you foresee any barriers to implement Big data solutions in the water chain automation, maintenance and security? If yes, please elaborate.
9	Can you offer relevant functionalities that have not been described in the Market Consultation Document ? If yes, please elaborate.
10	Are there any inadvertencies in the requirements as described in the Market Consultation document ? If yes, please elaborate.
11	Can you provide any other recommendations regarding the Big data PCP for the development of innovative solutions for the water chain automation, maintenance and security?

4. Prior art analysis and outcome of preliminary market consultation

In 2018, an analysis of prior art in the form of protected intellectual property (patents and literature) and technical consensus (standards) was performed. The prior art analysis was performed with the aim to gain insights into the available technology and methodologies regarding Big data solutions for the water chain automation, maintenance and security, to identify the active and innovative market players and to inform the tender documentation in the follow-up procurement.

Based on keywords derived from internal project documents and project partners, it revealed 170 potentially relevant patents with unique technical content, 19 relevant scientific articles and 72 relevant standards (see table 2 below).

Regarding Big Data solutions, there appears to be room for European suppliers to innovate, and incentives for them to do so, given that there are almost no relevant patents with coverage in a Dutch or European wide innovation procurement (1.2% of total)³² and no patents with global coverage. There are no patents belonging to a patent family (i.e., receiving coverage at more than one patent office), and the patents are relatively dispersed among a number of suppliers (the company with the highest number of relevant patents has 5 of the 170, or only 3%). The vast majority of patents are held in China, and by Chinese companies. Compared with patents in Phase 2: Security, patents for Big Data had much higher Technical Relevance (TR) scores (18 patents with a TR > 3), indicating that there are a number of patents for which certain attention must be given as they are more technically relevant to other solutions in the area. These patents are held in China, Japan, and the US, and therefore while they do not block similar innovation in the Netherlands or the EU, they may have technical characteristics which can benefit suppliers developing new solutions while having a low risk of being infringed.

Literature for Big Data is primarily on methods and models for water treatment systems, including foci on chemical analysis, prediction, and monitoring. This is often based on statistical analysis, and offers early-stage research that may be of interest to WBL in defining the solution space or supplier requirements. Standards for Big Data have been set by industry consortia (e.g., NEMA National Electrical Manufacturers Association) and standards-setting organizations (ASTM, NEN and DIN, among others). Topics range from increasing energy efficiency, to automatic sampling, to field bus systems and control / automation. The 2003 European

standard was harmonized by countries including by NEN, DIN (Germany), PN (Poland), and SN (Slovakia), entitled: "Wastewater treatment plants - Part 12: Control and automation". International standards cover information systems connections in local area networks (ISO).

Table 2: summary of findings of the prior art analysis

Document Type	Item	Results
Patents	Total	170
	Jurisdictions Patents held in jurisdictions relevant to a European-wide project: EU/WO (% of total)	2 (1.2% of total)
	Top 10 Patent Applicants (by TR)	• Beijing Tsinghua With Scale Planning Design And Research Institute Co. Ltd. • Bridgestone Corp. • Hu Xiao-en • Li Jian-guo • University Sichuan • Xu Qiu-tao • Xing Xiao-jun • Guangzhou Chime-long Water Supply Equipment Co. Ltd. • Zhengzhou Water Industry Science And Technology Development Co. Ltd. • Ceng Chen-lin
	Suggested codes for choosing Common Procurement Vocabulary (CPV)	73100000-3 Research and experimental development services 73110000-6 Research services

Document Type	Item	Results
Literature	Number of articles found	19
Standards	Number of relevant standards	73
	Standard-Essential Patents (SEPs)	No

	Represented Standards-Setting Organizations (SSOs) with related standards	• GOST R (Federal Agency on Technical Regulating and Metrology, Russia) • Finnish Standards Association • DWA (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.) • Verein Deutscher Ingenieure • ASI (Austrian Standards Institute/Österreichisches Normungsinstitut) • Verband Deutscher Maschinen- und Anlagenbau e. V. • DIN • CEN • DVGW (Deutscher Verein des Gas- und Wasserfaches e. V. - Technischwissenschaftlicher Verein) • ASTM (American Society for Testing and Materials) • FGSV (Forschungsgesellschaft
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Subsequent to the Prior Art analysis, a market consultation was organized in 2018. The market consultation of 2018 had the purpose to collect input from market parties on the procurement of the 3 Lots (Process automation, Security and Big Data Storage). In the context of this market consultation, preliminary input has been received on the technological possibilities and approach to the Big Data analysis, which forms the subject-matter of the PCP.

Hereafter, we present an anonymized summary of the most relevant input received from the market regarding the Big Data storage and analysis.

As Big Data is a rather new area in the IT field, the pace of technology development is quite high. Thus, still few standards have arisen in this area, and that is confirmed by most of the companies in the market consultation. That is particularly true for the Big Data analysis, that would seem the most challenging to standardize, since is mostly driven by the final users' specific requirements and needs (e.g. predictive maintenance).

A point that should be emphasized when looking at potential standards and solutions for Big Data is to make a clear distinction between *data storage* and *big data storage*. The former is not new in the IT industry, and there are indeed plenty of solutions available in the market for corporate needs. It follows that there are many standards related to it. The second is the new frontier of data and just few standards seem to be available.

Some market parties argued to have created their own platform to collect and

analyze sensor data, although a patent has not been pursued.

Based on recurrent comments, it would seem that any kind of Big Data initiative (especially from a data analysis perspective), before even considering potential corporate solutions, would require a structured and efficient planning. This preliminary phase can be tackled through various standard methodologies, which may be considered particularly in the PCP.

Several market parties proposed to have a reference **Hybrid Data Management** for grounding and validating the decisions based on the Big Data. This system is a standardized approach on how to manage and take decisions in complex data environment. Moreover, it would serve as a preliminary exercise to choose the most suitable Big Data solutions.

Market parties also requested clarification from WBL on the following aspects:

- Functional requirements, including purpose and intent per functional component
- The components to support software and service selection processes that are required for setting up a platform.
- Strategic design principles that serve as guidelines for the market party in defining detailed design and implementation
- Determine usage patterns - the merging of similar use cases and applications - and relate them to the organizational value and priority. This way a clear roadmap can be determined for execution of projects on the platform.
- Define key conditions for data flow patterns early, for example which data sources need to be included - so that timely measures are taken to determine the availability and the input of data
- Non-functional aspects of components – e.g. whether and which cloud strategy should be used applied - to ensure optimal deployment in terms of cost efficiency and business value
- To gain insight into which expertise and knowledge capacities are required and how these are being invested for the realization and operation of the platform.

The reference architecture therefore does not have technology or standards as a starting point, but is the guiding principle and demands future stability and modularity.

In other words, when a technology no longer satisfies the wishes of WBL, it can be

phased out, without the reference architecture and the platform suffering from it. This gives stability and control, whereby initiatives from PCP can also be fitted.

A similar approach for the design and implementation of solutions based on big data analytics could be based on the **Cross-Industry Process for Data Mining (CRISP-DM)**. The CRISP-DM is not a standard per se, rather a structure to plan a data mining project, based on a number of data mining phases. In market parties' view the CRISP model is the most used standard approach for Big Data planning.

The following steps are hereby relevant:

- 1) *Business Understanding - building a good understanding of the business needs, definition of the research area and concrete research questions.*
- 2) *Data Understanding - building a good understanding of available data, including analysis of relevance and usability for the research question.*
- 3) *Data Modelling - structuring, cleaning and enriching relevant data for optimal application in an analytical model.*
- 4) *Analytics Modelling - applying analytical models to the prepared data in such a way that insights are obtained that help to answer the research question.*
- 5) *Analytics Deployment - answering the research question through visualization and presentation of the obtained insights, including in some cases operationalizing the analytical model in a continuous improvement process.*

The market parties have suggested open source solutions for the big data storage (such as *Apache Hadoop*).

Market parties have also shared their views on technological developments in this field:

- *The making of analytical models often takes place in the languages R and Python, to a lesser extent we encounter Matlab.*
- *For the good management and reuse of analytical models in larger organizations, development environments such as Rapid-Miner and R-Studio are widely used.*
- *Most commercial suppliers of reporting and visualization products now offer good opportunities for integration and visualization of analytical models in a managed and secure environment.*

As said, Big Data is a fast-developing sector and at least from the point of Big Data Analysis the current market trend is varied and difficult to define. Still, there are new trends that suppliers are confident to see implemented in the near future (if

not already) such as **Artificial Intelligence** and **Machine learning**.

Finally, one market party pointed out that *“real-time processing, decision models and machine learning require rapid switching that the infrastructure and data sources of WBL need to support these functionalities. In addition, the question is which intermediate tools you will use to convert data and make the calculations”*.

Questions:

12	Can you indicate whether the listed patents and standards in the prior art analysis are relevant ?
13	Can you name additional relevant standards and patents? Are you aware of other relevant rights or trade secrets ? If so, please provide reference to the relevant patent registration and details, as well as a general description of any relevant rights or trade secrets.
14	Do you own any relevant IPR to the objectives of Waterschapsbedrijf Limburg?
15	Are you aware of any patents that may constitute a barrier to your delivering a solution in the envisaged PCP procurement?
16	Can you suggest a more suitable list of developments in the field?
17	Do you commercialize Big data solutions for the water chain automation, maintenance and security? If yes, please elaborate.