Smart City Monitor: Digital Transformation ICT

Novel ICT platform that enables unified AI-driven digital transformation assisting organisations, administrations and utility providers in smart sustainable management and governance for continuous improvement of Quality of Life in urban communities

The Smart City Monitor (SCM) is a cutting-edge high level application running at Pharos Navigator® ICT platform (PharosN). It helps communities and utility providers to deal with increasing complexity, accelerated change and diverse linkages to smart everything supporting improving of quality of life, efficiency of resource use, holistic performance transparency, new jobs, business models, learning, lifestyle and operations.

SCM represents real time operation of large scale urban cyber-physical systems (CPS) existing in the interlinked physical and virtual worlds. It introduces and realises novel abstract concepts of Intelligent Sustainable Systems which are able to learn, understand and control their sustainable behaviour in real time. The innovation offers principally new level of automated assistance to smart management and operators of complex urban systems in many application areas fostering the holistic efficiency, big data analytics, prediction and prescription, testing and evaluation of smart urban innovations, its demonstration to the stakeholders.

The essence of the novel technology

1. Digital transformation of multiple big data streams from divers urban data sources into customised information services, big data analytics and controls assisting in smart management and efficient optimised operation of complex real world systems
2. AI-driven calculation of ongoing status of each system object and process as well as the sustainability status of the whole big system based on statuses of sub-objects and indicators enabling holistic view into the current system status as answer to the question "**How are you, my Big System?**" (i.e. the city as a whole, its particular district, street, campus, shopping center, buildings, hospitals, parks, etc)
3. Rich set of interactive tools to let in-depth analysis of causes, impacts, optional controls and scenarios
4. Implementation of custom user UX requirements to for analytics and controls accordingly to roles of specific stakeholder groups and mobile devices used (dashboards, interactive reports, widgets, predictive and prescriptive and control wizards, mobile apps)
5. Adaptation and customisation of the operational prototypes in use cases and pilots, its testing, evaluation and demonstration to the stakeholders
6. Providing high level tools for the development of customised application models of the large scale target urban CPS including multiple object-themes such as Energy, Water, Waste, Transportation, Economy, Environment, etc as defined in the relevant standards (ISO 37120, etc). The model implementation in the platform does not require programming supporting definition of relevant structure of objects, its properties and optional states, indicators representing specific processes, its targets, constants, big data elements that store data received from the both worlds in the system database, the definitions of individual linkages to all connected sensors, video cameras, actuators, automated systems, databases, pictures and illustrations, user interactions UX, etc.) The tools let municipalities, utility operators and businesses customize and upgrade their urban transformation systems to accommodate ongoing change and address new use cases and eliminate non-productive data processing and analytics in daily reporting.
7. Incorporating the requirements by necessary international quality standards into the model (e.g. ISO 37xxx, ISO 50001, ISO 14000, ISO 9001 and others) enabling compliance management and monitoring and performance assessment in real time for corrective actions and improvements.
8. Implementing and updating of custom key performance indicators (KPIs) presenting performance and analytic properties of each system object in the urban CPS model. The Editor of Indicators as one of the main model builder tools allows defining necessary indicator formulas having their arguments directly linked to various data streams from the physical and virtual processes as well as to other optional indicators. The editor provides users with many options to define various KPI properties including automatic definition of process patterns, consolidation, replication, targets, optional states, selection of machine learning methods, etc.
9. Linking of the urban CPS application model to all necessary data sources over existing connectivity networks including IoT, sensors, smart meters, automated systems, robotics, drones, vehicles, ships, etc. and databases and spreadsheets as well as actuators. The communications are implemented at the high level http protocols available in optional cable, LAN, WAN, Wi-Fi, Lora, 4/5G cellular and other networks such as mqtt, coap, RESTful, OPC UA and others. The linking to the industrial and building automation systems such as Bachnet, ModBus, KNX, etc is supported by additional gateways.

10. Running the CPS model on PharosN platform linked to external automated systems and various mathematical, optimisation, scheduling and simulation models by extended PharosN APIs.
11. Implementation of the CPS model in the distributed multi-engine PharosN system enabling real time individual processing of each big data stream applying AI-driven methods.

The application areas

The SCM applications assist in Smart Governance and Management of cities and utility services for communities, including Energy, Water, Waste, Transportation, Air and Environment Quality and other utilities and public services, Management of Smart Connected Assets e.g. shopping centers and campuses, manufacturing and public service enterprises, hospitals, universities and schools. It effectively supports various activities related to Quality and Environment, online Education and eLearning, Experimentation and Innovations in smart green technologies.

The new technology implementation began in Europe in several mid-size cities (Greece, Latvia, Moldova, Portugal, Romania, Spain) in 2017 and increasingly applied to several novel urban developments in 2018.

The urban infrastructure as CPS is presented by Open Metropolitan Assets Model (OMAM). Its initial content was realised in full compliance with definitions of ISO 37120 standard "Sustainable development of communities — Indicators for city services and quality of life" presenting theme-objects **Economy, Education, Energy, Environment, Finance, Fire and Emergency Response, Governance, Health, Recreation, Safety, Shelter, Solid Waste, Telecommunications and Innovation, Urban Planning, Transportation, Wastewater, Water and Sanitation with 102** indicators and 60 data sources presented in MS Excel files.

The OMAM is open to further customisation and upgrading to reflect actual local city infrastructure and objects, processes, topology, technologies, data sources and controls. In particular the model can provide focus into specific application areas such as Energy, Waste, Water, Transportation, Safety and Security, Leisure, Tourism, etc.

The ongoing sustainability status of each object in the urban CPS model is calculated in real time. It may include large number of various city objects such as energy, waste and water, environment, transportation, economy, buildings, vehicles, telecommunication, health, education, food and leisure, resilience, etc.

The default object statuses are "Excellent" in green, "Optimal" in blue, "Deficient" in red colour while the names are customizable. The rules for the automatic object state calculation are custom defined for each object. The system supports multiple use cases providing automatic data collection from large number of information sources and transforming into comprehensive holistic vision of ongoing processes. It includes wide range of applications from simple measurements of city pollution, city noise, traffic congestion in diverse locations, etc to comprehensive evaluation of current or predictable statuses and performance of different community objects delivering services to citizens. SCM provides city stakeholders with web and mobile applications having various interactive widgets, presentation of objects on City Maps and dashboard monitor, interactive reports and personalized events as well as various advanced high level analytic tools. The resulting digital transformation reveals information about the sustainability status of a city and its urban objects, and each urban process KPI in real time.

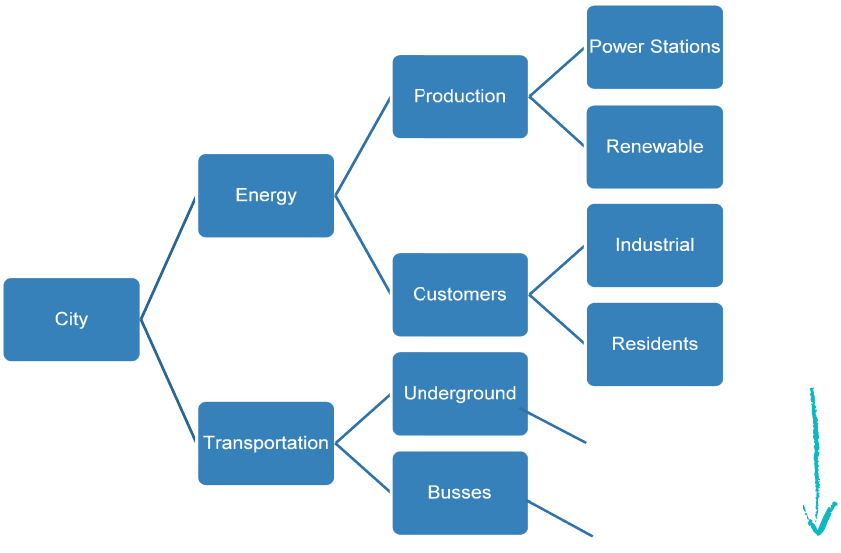

Figure 1. The structure of Open Metropolitan Assets Model (OMAM) by ISO 37120

SCM assists citizens and community management in continuous improvement of quality of life, supporting introduction of innovations and ways of urban life, offering transparency and simple holistic presentation of complex processes and events, awareness and practical instruments for sustainable development in the city municipalities and communities. It facilitates compliance to the relevant international standards that address economic growth and efficiency, ecological and infrastructural construction, environmental protection, social and welfare progress. The municipalities obtain own control and transparency over community processes presenting local businesses and services, cultural places, public and private service providers, life of citizens and relevant events. The core of such control is ownership and copyrights of communities and utility providers for their own OMAM models that can accommodate local content, its change and serve as community knowledge base as well as the digital transformation engine for all its stakeholders.

Using existing data sources: The SCM automatically imports diverse data from multiple **electronic data sources in real time**. It includes various city databases or spreadsheet files (e.g. MS Excel) prepared by municipality staff or relevant

departments or service providers. It allows significantly decrease non-productive work in preparation of reports and monitoring of processes. SCM can be linked to existing city automation and information systems automatically collecting large amount of data e.g. daily attendance in schools and universities, resource consumptions, health statistics, etc.

Linking to sensors and IoT: The SCM supports OMAM linking to different types of sensors and IoT providing specific measurement data over existing connectivity networks that exist in particular urban area (e.g. CO2, NOx, radiation, sound level, transportation, number of passengers/visitors, amount of waste by categories, energy/water supply-demand, costs, etc). It transforms relevant data streams from actual sensor/meter networks into real time values of quality of life KPIs and public services and ongoing statuses of urban processes and objects. The city planners are supported by city growth scenarios that combine evidence data and future estimations of new smart city services and planning new city objects.

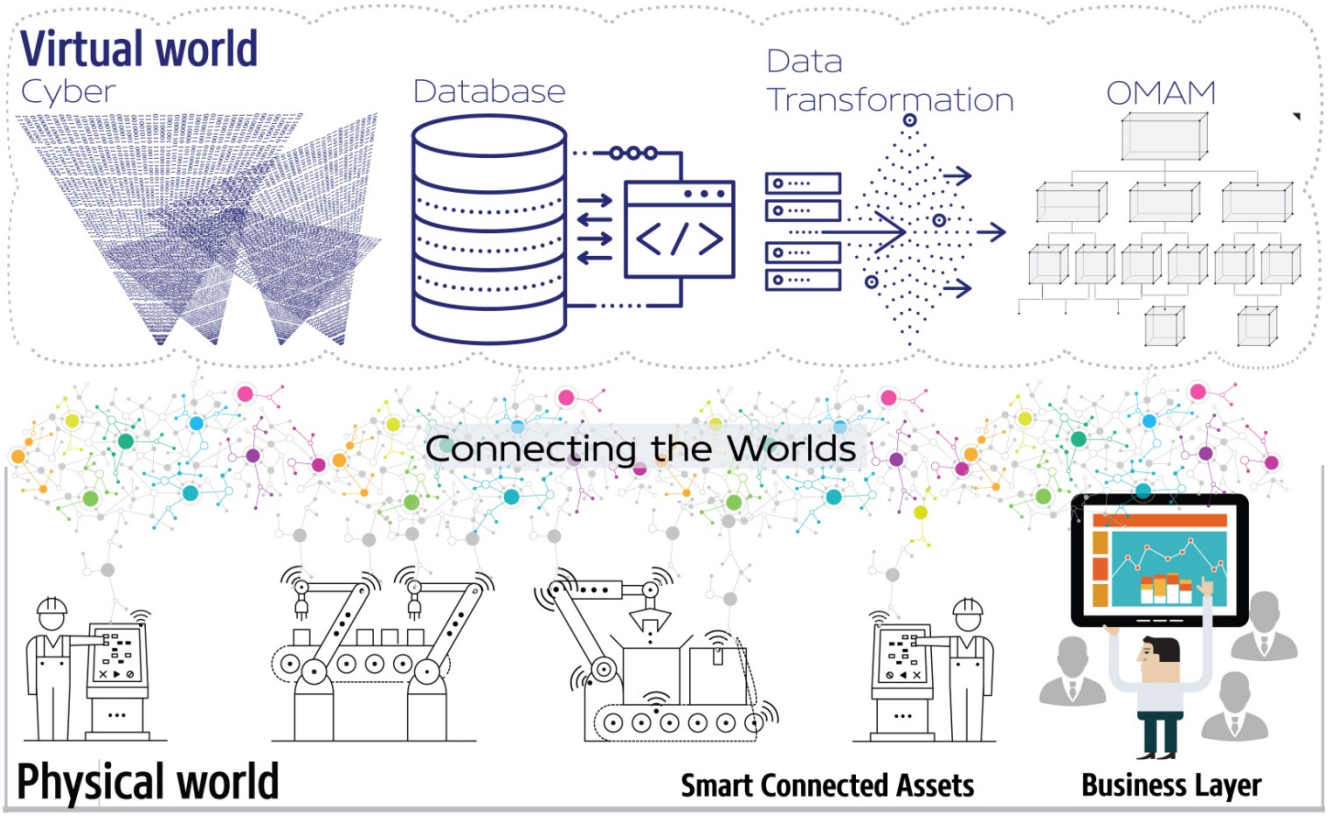

Figure 2 Generic city infrastructure as complex cyber-physical system existing in physical and virtual worlds

Engines location: SCM engines can be set on cloud servers in European Union or on-premises in relevant organisations. Each engine can serve large number stakeholders providing interactive dashboards, widgets and reports presenting the city objects, its statuses and KPIs on City Map, information and performance analytics.

The open source components: SCM is the backend software running OMAM as large scale application linked with multiple data sources and automated and information systems via Internet using secure protocols (https, RESTful, CoAP, MQTT, OPC, etc). It is implemented in C++ and JavaScript using only **open source components** such as Linux, docker containers, postgresql, apache, QT5, poco, C++ and JavaScript libraries, security standards (https, websockets ISO/IEC 18033-3. As the result the communities can have SCM services at decreased costs.

Smart City Monitor links: additional information and online demo http://smartcity.pharosnavigator.com, use cases at http://asidees.org, the international applications Internet search "UNIDO Pharos".

Support for Smart City projects: The SCM is available for **city councils and urban utility providers** as contractual service. The implementation includes the following stages: (1) The project preparation, (2) Training of local personnel, (3) OMAM build-up and support for business applications and optional ISO 37120 certification.

Legal: SCM is available as a service for customers such as city administrations, utility providers and local businesses and includes support and upgrading. **The customer has own copyright for locally developed OMAM** after the project. Data access and its authorisation are administered by the customer.

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