SIMONE as a key support for operating transmission system of Plinacro

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Abstract

The paper describes briefly the circumstances, technical solution, practical experience and future directions of SIMONE gas pipeline simulation software use in Plinacro.

Plinacro role, responsibilities, plans and pipeline system

Plinacro is a state owned company which is the owner and operator of the natural gas transmission system in the Republic of Croatia. It operates about 2085 km of the main and regional gas pipelines. Around 60% of the transported gas is being produced on the domestic gas fields both onshore and in the northern part of the Adriatic sea, and the remaining 40% come through the Republic of Slovenia from Russia, which is at the moment the only import supply route. On the gas transmission system of Plinacro there are two important and a few smaller entries of natural gas from national production in the northern part of the Republic of Croatia, entry of gas from national production from offshore gas fields in the northern part of the Adriatic sea, one import supply route through Slovenia and an underground gas storage. From the transmission system, gas is being delivered through 151 offtake stations, which includes 245 measuring lines.

The transmission system itself consists mainly of two parts. At the first place it is the old gas transmission system with 1659 km of the gas pipelines of nominal pressure 50 bar with some smaller local sections with lower working pressure (4-20 bar). The largest part of that system is being maintained in terms of working pressure in the range of 30-45 bar, in order to provide gas reception at the entry points and the maintenance of the minimum pressure of gas submission at the exit points, including the underground gas storage. Gas pipeline network has structure of a few closed loops which significantly increases safety of gas transmission and makes execution of works on gas pipeline maintenance easier.

Intensive construction during the last few years resulted in a new gas transmission system consisting of 426 km of gas pipelines of nominal pressure 75 bar, which in the first place provides direct transport of the gas from the domestic offshore fields to the inner parts of the Republic of Croatia, but also gas transmission to the new consumers in the southern parts, which did not have such possibility prior to the construction of the new gas pipelines. Plan of the further development of high pressure transmission system includes expansion of the gas pipeline network to the areas in the Republic of Croatia which were not covered so far, as well as interconnection with the neighboring countries. Transmission system of Plinacro has not been using compressor stations, so far. Also, all performed transport of about 3 bcm/y is for domestic market, which means there is no transit, because there is only one boundary point with Slovenia.

Technological conditions for management of transmission system are such that the flow rates at all entry points, in normal conditions, are mostly stable with no significant changes. Supply of households occupies a big part of the gas market (percentage) that results in larger increase of gas consumption during heating season, which is being compensated by usage of the only underground gas storage. Existing storage was designed for the purpose of seasonal system balancing, which results in problems with balancing of transmission system at extreme daily oscillations during the heating season. Gas storage is not Plinacro´s property, but its mode of operation has been directly controlled by the National Dispatching Centre.

Gas market in the Republic of Croatia is not open yet. There is still monopoly of one company that both produces gas and imports all gas for the market. On the other hand, buyers are 37 local distribution companies and 38 direct consumers in the category of industry and electric power production. Position of Plinacro as a transporter is such that it has been executing services upon only one contract on gas transmission with the only large gas supplier, despite the fact that basic legal frames, which formally enable gas buyers to chose another supplier as well as independent supply and contracting of transport for own purposes, already exist. In such situation there is no developed regulation system of delivered nomination for all transmission capacities or account of imbalance like on developed, open markets. Plinacro balances transmission system by independent defining of mode of operation of underground storage; in special circumstances direct arrangements are made with the only user of the contract on transmission.

Transmission system has been managed from the National Dispatching Centre, located at Plinacro´s headquarters in Zagreb. Modern SCADA system, constructed in 2006, controls all key points of the transmission system in real time, which includes about 98% of incoming and approximately 90% of outgoing amounts of gas. DC is connected to the remote facilities by its own telecommunication system, partly by usage of radio-connection and partly by newly-constructed fiber optic system. SIMONE was put into operation that same year, as a part of the gas transmission control and management system. It has been used for real-time simulations and off-line estimates in the process of planning of new gas pipelines as well as drawing up planes for transmission system management for the works on maintenance of the existing transmission system. One of the key parameters for stipulation of mode of operation of the underground storage is packing rate as a result of estimation made by SIMONE state reconstruction module.

As it was already mentioned in the text, basic legal frames which enable access of the third party to the infrastructural services on the gas market, already exist. Process of the preparation of other legal acts on the lower level, which shall define regulations and reciprocal relations among the subjects on the gas market, is being underway. Passage of these regulations and regulation of the natural gas market, which should happen in the near future, and opening of the new supply routes for gas import should result in real opening of the market; that is , arrival of competition in supply of gas market. As TSO, Plinacro has to be capable to respond to the requirements of the larger number of consumers of transmission services as well as to provide transparent and non-discriminatory approach that includes complex way of elaboration of the request for the access to the transmission system, nomination system of usage of contracted capacities, allocation and process of withdrawal, reporting as well as transmission system management in compliance with new regulation of balancing. Plinacro has already started a few new projects, purpose of which is to install information-communication solutions that will enable execution of all requests that the company will face due to the opening of gas market. Construction of the system for remote reading and supervision of all fiscal measuring points at transmission system (telereading) is being underway. The most demanding and the most complex project is project of construction of gas transmission management system GTMS, which shall be integrated with the existing informational system in one functional unit. SIMONE package of programs, along with necessary adjustments for the purpose of integration and data exchange shall be significant segment of GTMS system for assessment of the requests for usage of transport capacities and assessment of transport nominations.

Figure 1: Map of existing Plinacro system with future extensions

SIMONE installations in Plinacro

As mentioned in the first part, SIMONE online system was delivered in 2006 to Plinacro by Končar-KET as main contractor (integrator) and SIMONE Research Group as subcontractor (simulation software vendor).

SIMONE online is integrated with ABB SCADA system via bi-directional interface and uses the dedicated interface to UDW database for forecasted/scheduled boundary flows. The online simulation system is equipped with the following functions:

- State reconstruction, consuming SCADA readings (pressures, flows, valve positions) and manual entries for non-metered data.
- Look-ahead simulation, consuming forecasted consumptions and scheduled flows (supplies, gas storage) and manual entries. Manual entries can contain timely information about control activities scheduled for near future.
- Leak detection and localization (uses the same input like state reconstruction).
- Support for on-request simulation:
  - Save the automated look-ahead simulation for quick what-if analysis starting from current state of network.
  - Access to forecasted load data for creating simulation scenarios interactively.
- Pig tracking (manual entries are used for pig launching commands).

The computational kernel uses all standard features (quality tracking, heat dynamics…). One full foreground license and 5 viewer licenses are installed on the online system.

Simone online is installed in standby support configuration with backup standalone computer with possibility to make manual switchover. For Plinacro project, the monitoring of status of both computers via ABBClient interface was developed by SIMONE Research Group and Končar-KET. This monitoring solution shows the information about health/performance of the computers, leak cycle status from the primary computer and in case of need triggers an appropriate alarm in standard SCADA visualization environment.

The main role of the online simulation system is to improve monitoring of the pipeline network for dispatching personnel, enlarging the set of directly metered values by calculated results. The most important figures, namely network balance trends, are exported from SIMONE cyclic functions (state reconstruction + look-ahead simulation) back to SCADA in order to be easily accessible for network operators within their native working environment. In parallel, the SIMONE user interface is available for more detailed insight or system administration.

The balance figures – linepack, or volume-averaged mean network pressure (traditional quantity the personnel is familiar with), and packing rate – are the main routinely used results provided by the state reconstruction. The practical experience showed remarkable stability of the state reconstruction; thanks to number of pressure readings the linepack is always captured very reliably. Depending on manual entry of unmetered consumptions and their matching with current situation the overall mass correction of the real-time model can vary; in case of good matching the mean value of overall mass correction is usually well below 5% of total system load.

Look-ahead simulation is used primarily as an early-warning indicator that can warn dispatching personnel about the need to re-schedule control activities in short time horizon (next 24 hours), if the network behavior is about to move outside of operational margins.

See the attached Figure 2÷ Figure 4 for quick illustration of the real-time system performance. As the field technology is expanding, the mapping of SCADA measurements is under continuous development. Also, the real life makes sometimes things turbulent (e.g. outlying measurements due to temporarily dead signals) and the real-time model is in fact often the first place when experienced user can discover such issues.

Interactive what-if simulation enables detailed possibility to prepare and test network control activities by expert user. From user point of view, crucial factor for seamless use of network simulation tools is easy access to data about network load and supply – this is currently accomplished using the data preparation possibilities on the online foreground workplace.

Leak detection is based on the processing of state reconstruction results analyzing the sudden change of mass correction signal of the state estimator. Traditional balance method was not usable as not all delivery stations are equipped with flow meters transmitted online. The feasibility study indicated that the approach used can detect leak induced by ~30 mm equivalent rupture diameter with a limited possibility to localize the leak to node/milepost within area; the real performance confirmed this assumption (filling empty new pipeline section, see Figure 5 ÷ Figure 7 for illustration of this test). Certain network areas with small amount of pressure measurements and manually substituted offtakes are prone to false alarms (experienced analysis of results can however sort them out easily).

SIMONE offline installations (originally one, enlarged to current count of 2 offline licenses) equipped with all standard features (quality tracking, heat dynamics, compressor stations, capacity calculation tool) are used for planning purposes, namely capacity verification, network extension design and operation scheduling (maintenance works, pigging regimes etc.).

Technically interesting issue, particular for Plinacro pipeline system, is the star-like arrangement of control valves in crossings, allowing bi-directional flow of gas in the control valve and acting as pressure & flow limiters in its primary direction (Figure 8). Solution prepared in SIMONE kernel admits easy use of such topology for all scenario types including steady-state simulation.

As mentioned above, the highly transient behavior of Plinacro pipeline network is determined by relatively flat supply rate versus consumptions modulated by typical daily curves - all major supplies are delivering more or less constant flow (out of Plinacro control) and scheduling the storage operation remains the main “degree of freedom” for operational network control. Therefore, computational analysis including transient simulation is useful if not inevitable decision-supporting tool in all aspect of network operation and ensuring its reliability. The main benefit is speed-up of sound engineering analysis, especially for complex cases, of course requiring experienced use of the simulation tools.

The role of computational analysis is expected to increase when Plinacro faces the need to react quickly on capacity and nomination handling requests. The key factor for users is to ensure quick and easy access to input data for SIMONE scenarios by integrating the appropriate interfaces for surrounding information systems.

Future plans for SIMONE system in Plinacro are linked with two major running projects:

- GTMS project supporting the activities of TSO in fully opened market – there are new integrated workplaces for validating of nominations and verification of capacity requests planned
- The increase of safety and security of operations – redundant installation on online system including oncoming integration with remote backup control centre.

Besides these major development projects, all parties (vendor, integrator and user) formed a dedicated team that is involved in maintenance and continuous improvements of the running integrated solution as well as in taking care about education and discussions of working issues. This “human element” is the most important factor for running any complex software system successfully, in this case SIMONE in Plinacro.

Acknowledgments

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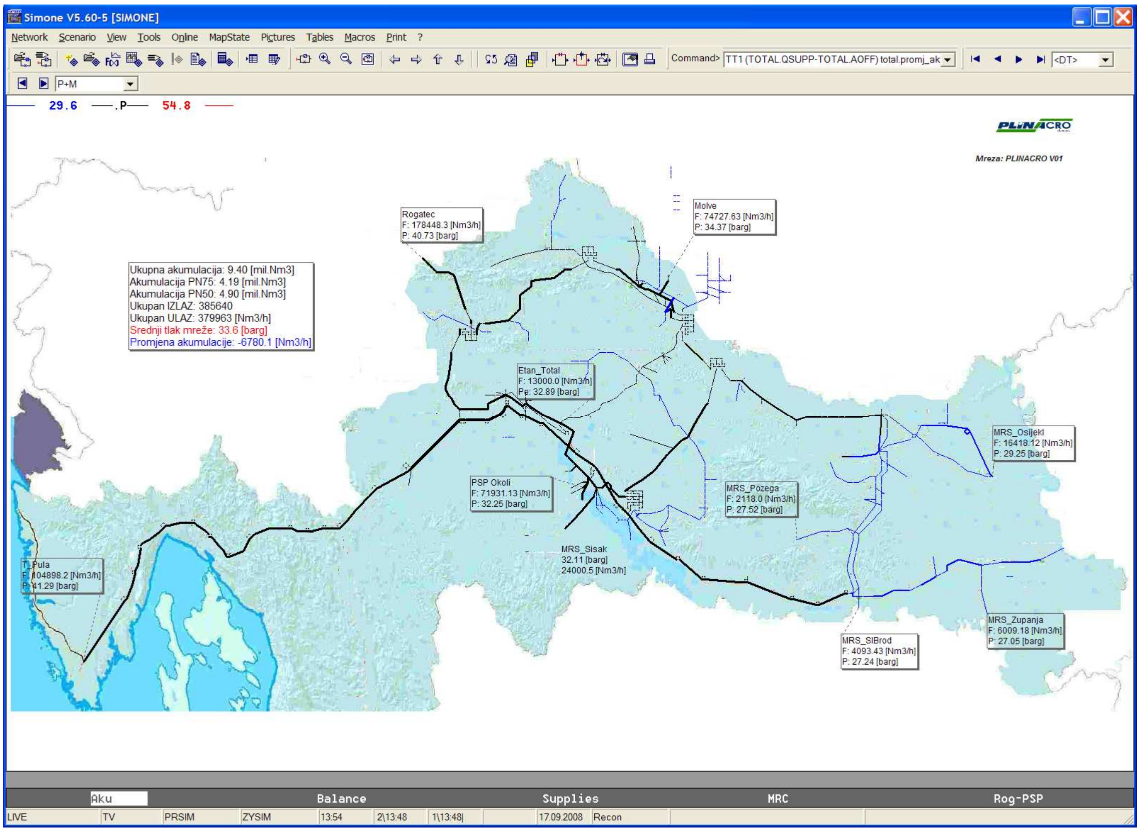

Figure 2: Current network model of Plinacro pipeline system in SIMONE

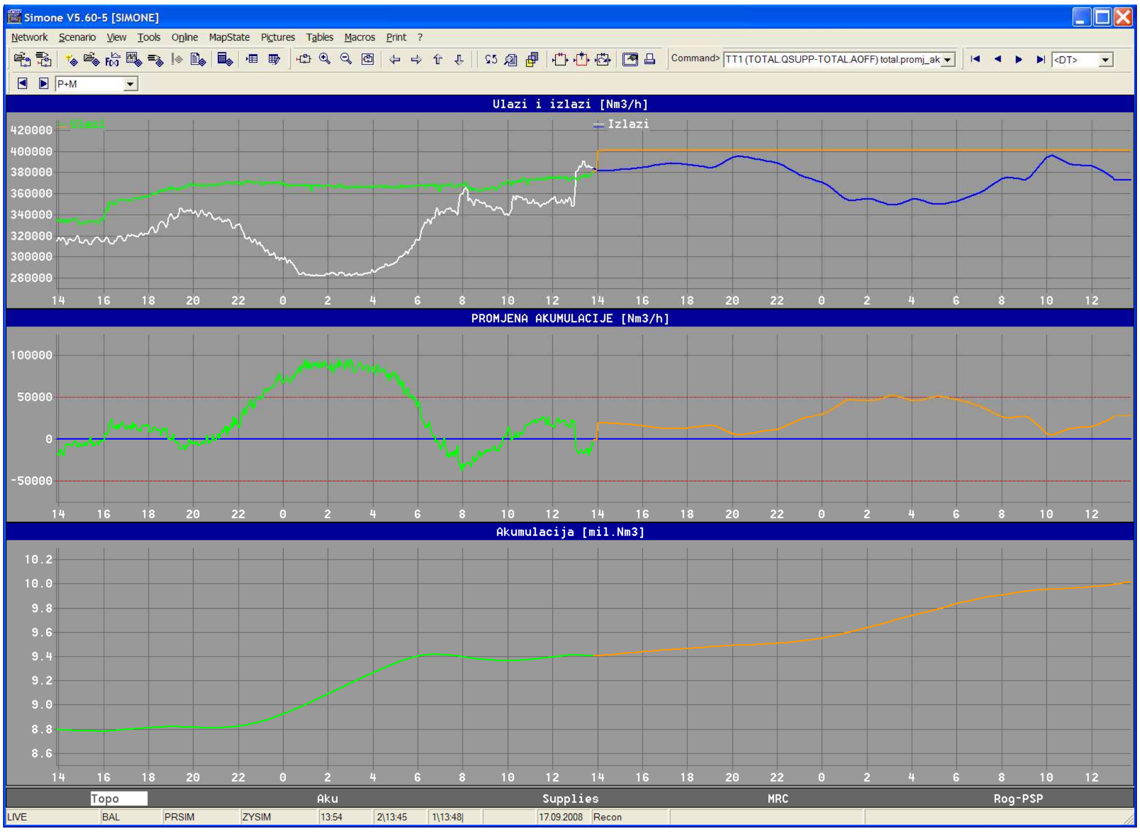

Figure 3: Example of network balance (total supply/offtake), packing rate and linepack trends; state reconstruction and look-ahead simulation shown concatenated

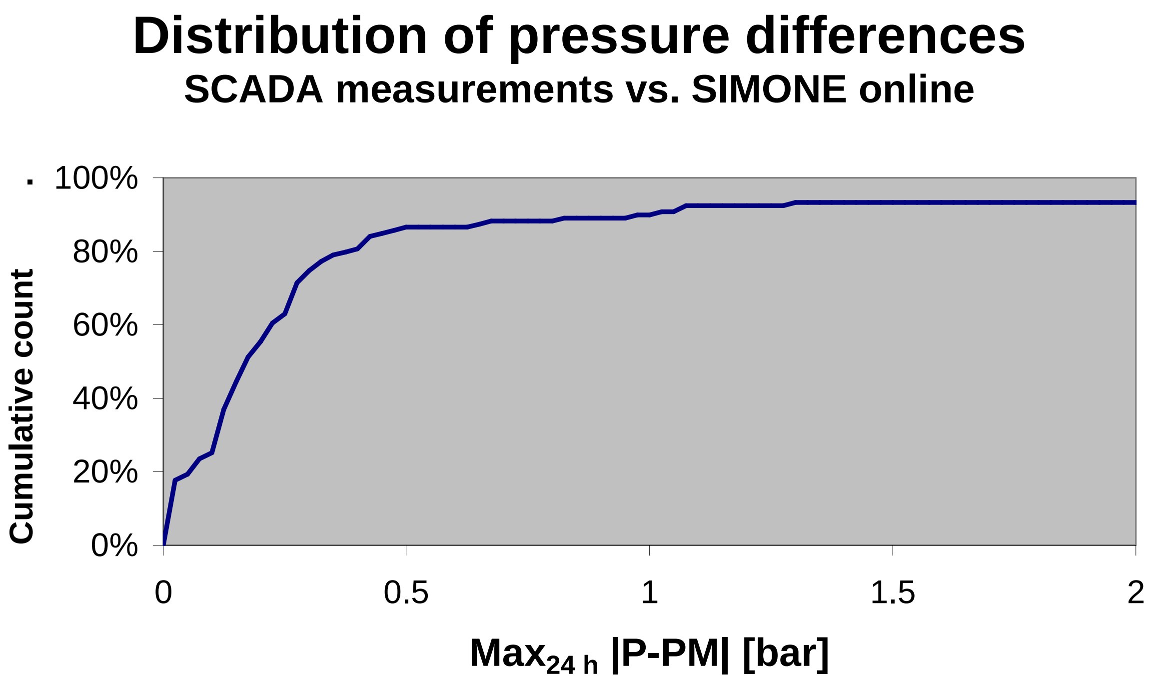

Figure 4: Example of state reconstruction performance on a sample day in terms of matching calculated and metered pressures (including outliers – temporarily dead signals etc.)

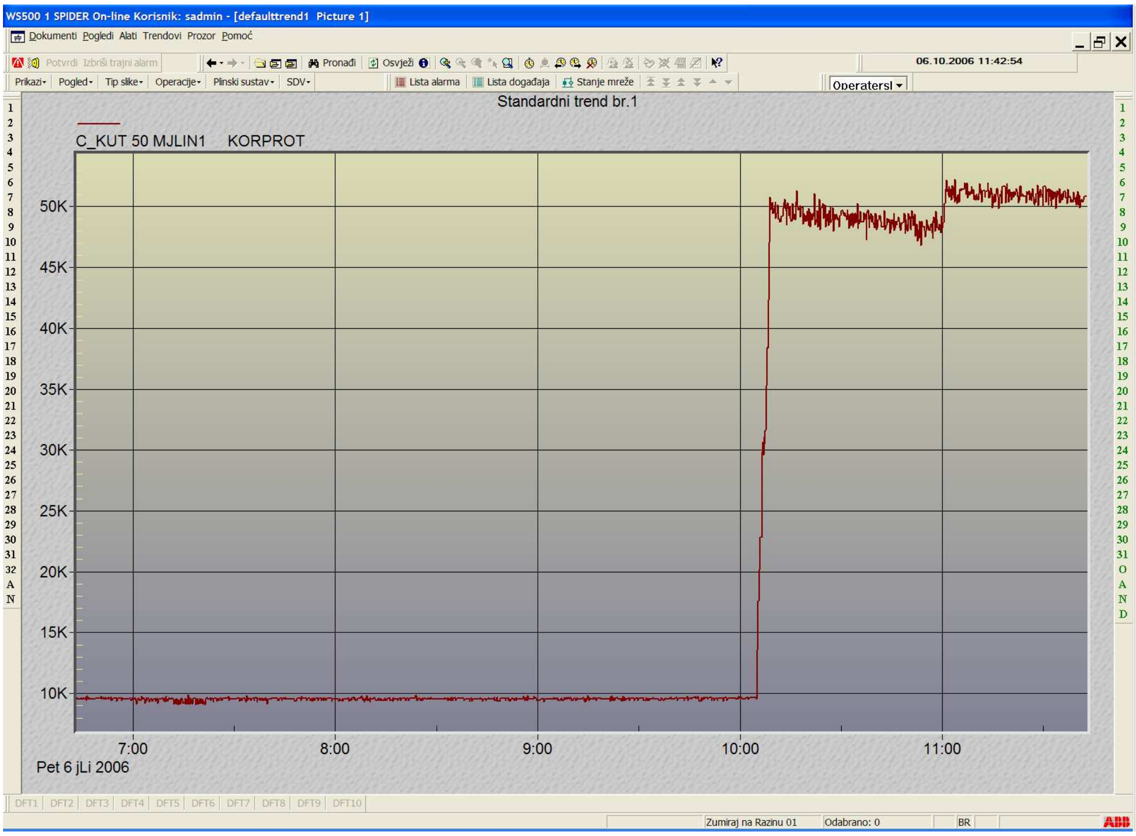

Figure 5: Test "leak" – flow metering when filling new pipeline section (not known to the real-time network)

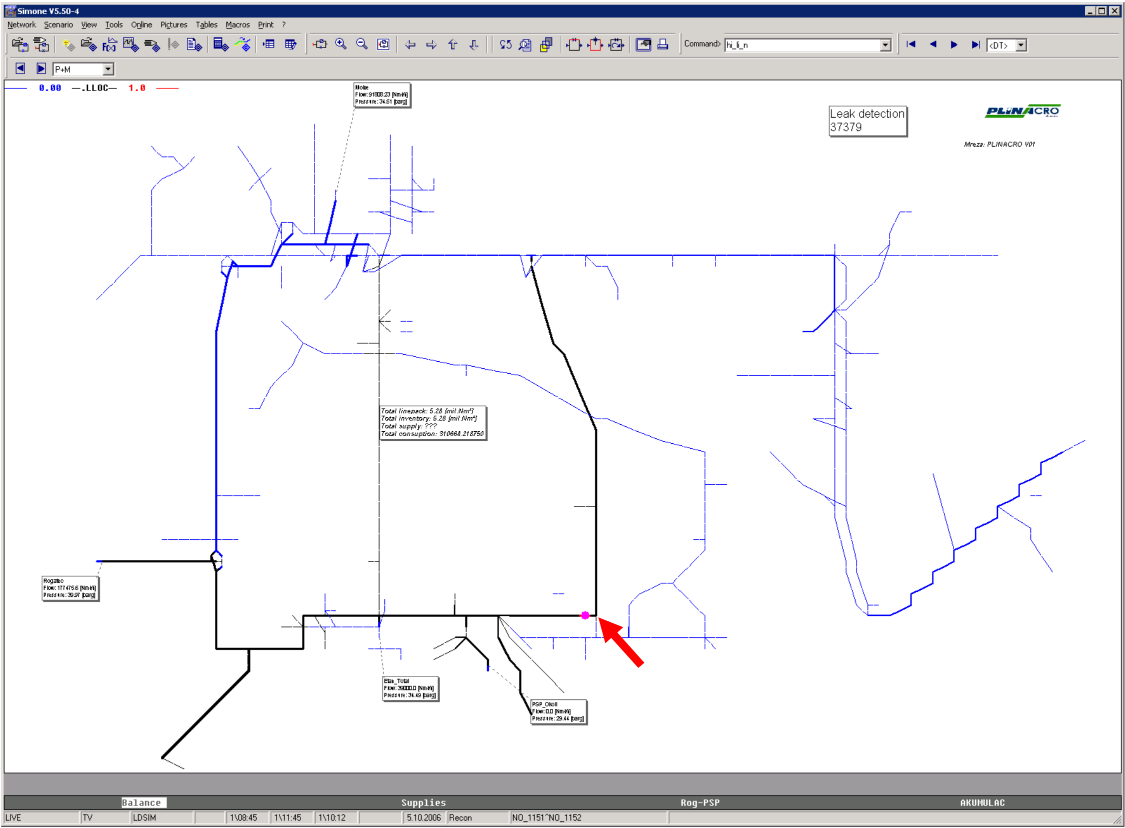

Figure 6: First detection and localization of the test leak from Figure 5 to network node (~6 min after start); red arrow shows true location

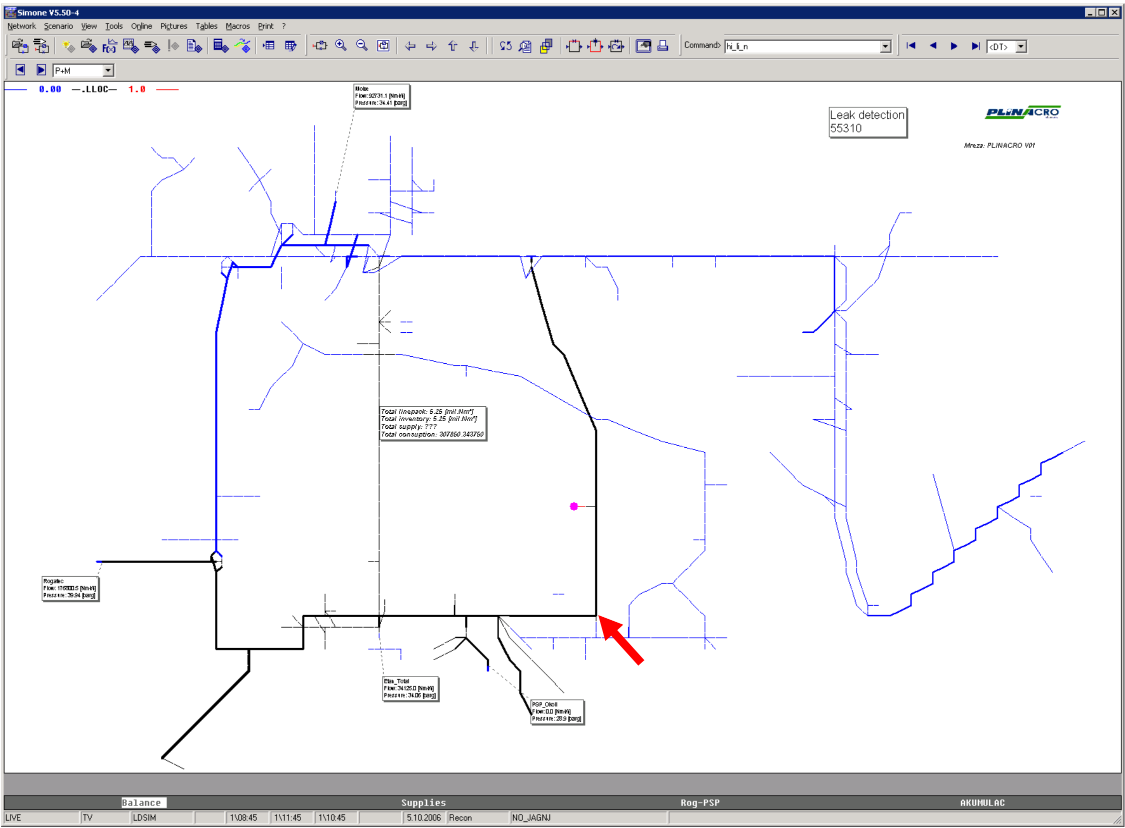

Figure 7: Final location shown ~45 min in after start of the leak test

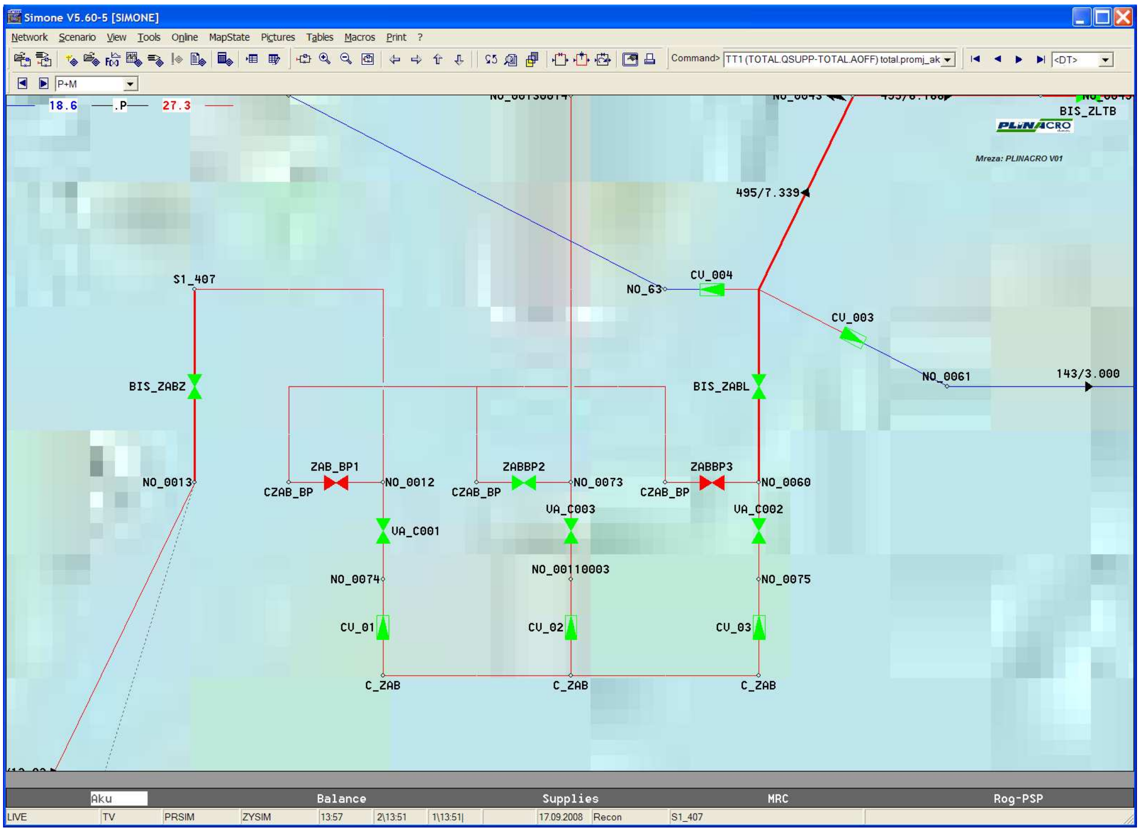

Figure 8: SIMONE network model topology for the star-like configuration of control valves