TALSIM-NG

(Talsim Next Generation)

River Basin Modelling
and
Water Resources Management

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SYDRO Consult GmbH
Mathildenplatz 8 • 64283 Darmstadt • Germany • Tel.: +49 6151 / 367367 • Fax: +49 6151 / 367348

INTRODUCTION

Water management is considered to be the sector with the highest number of mutual dependencies on other sectors. The fact that water resources interact with many physical and socio-economic components highlights the importance of a sound water management. In fact, water management affects not only the design of water infrastructure, but also even more importantly, operation and safety of water infrastructure. Consequently, effective water management is a crucial component for planning and design and essential during operation. Workable solutions for water management require in-depth knowledge of hydrology and all other operational-related issues. The identification of physical constraints arising from hydraulic structures, which may affect operation, is essential. In practice, operating rules must be based upon accurate and available data and require reliable monitoring by qualified water managers to ensure the highest standards. Additionally, multifaceted issues and objectives from different stakeholders need to be incorporated as key features to obtain wide acceptance and to achieve sustainable solutions.

Evaluating and optimizing water management usually starts with the analysis of crosscutting causal chains. The causal chains, or cause-effect analyses, yield all the components that are required to set up a comprehensive hydro-system. Subsequent the cause-effect analysis, a physically-based flow network with all hydrological and hydraulic elements such as sub-basins, point-sources of discharge, rivers, canals, pipes, weirs, wells, groundwater, consumers, irrigation, reservoirs, dams, etc. needs to be composed. In addition to the physical network, a logical network representing the structure of operational aspects must be established. At this point, it becomes obvious that the frame in which water management must be regarded extends the usual range of river basin models.

For this reason, SYDRO has developed a software package (TALSIM -NG) which combines hydrological modelling of river basins with operational features. This ensures that water management aspects are comprehensively addressed which incorporate realistic operation, the requirements of varying sectors, as well as multipurpose objectives. As such, decision-makers and stakeholders obtain well-balanced, transparent and sustainable results.

The software TALSIM-NG has been greatly extended since the first release in 1999. The software has been applied to all scales of river basins (< 10 km² and >> 50,000 km²) in Europe, Africa and Asia and comprises in its latest version:

- River basin model including precipitation-runoff components, flood routing, weirs, diversions, etc.
- Generic water management component with cross-sectoral options
- Time series management
- Non-linear atmosphere-vegetation-soil interface for calculating runoff, irrigation demands, groundwater recharge, actual evapotranspiration, etc.
- Reservoir operation
- Irrigation
- Water quality component
- Hydropower development
- Real-time operation mode with pre- and post-processing

APPLICATION OF TALSIM-NG

TALSIM -NG combines precipitation-runoff components, flow routing, water management and time series/simulation management as well as water quality components in one tool. Manifold water resources problems and in particular water management issues can be addressed and complex interactions can be incorporated and made visible. Thus, short-term or long-term effects of planned interventions, implementation of infrastructure, or operation of water infrastructure encompass the capability of the model. As TALSIM -NG includes all important aspects of hydrological modelling, complex river basins can be considered which constitutes a distinct advantage, e.g. in terms of the EU Water Framework Directive. The tool can also be linked to monitoring systems and allows users to operate the program in an operational mode. Two alternatives are possible: Application of the TALSIM -NG toolbox as a stand-alone product with a simple web-based interface or as model engine within the framework of FEWS (© Deltares).

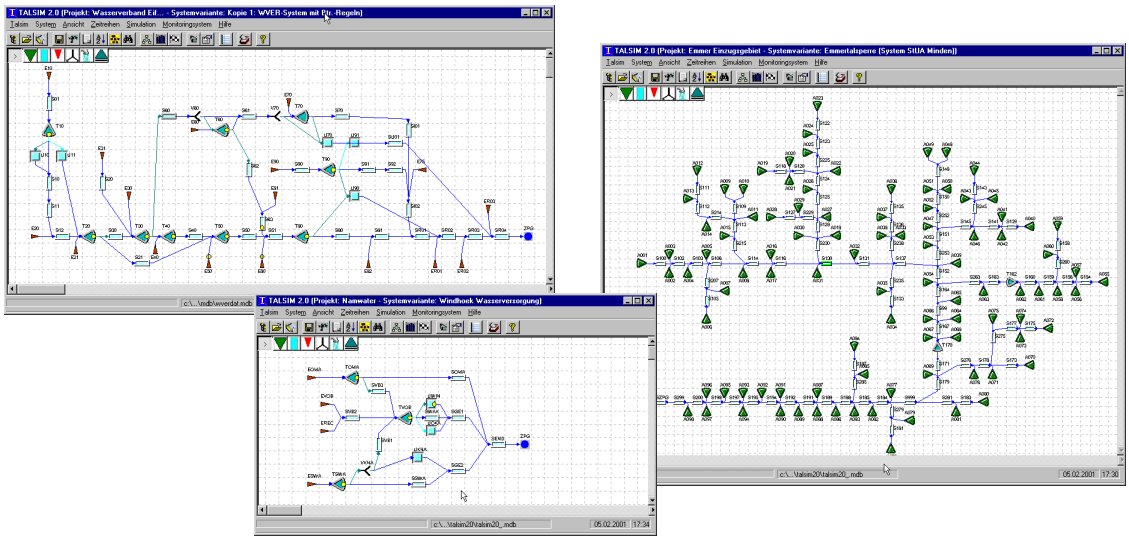
TALSIM-NG is based on generic software architecture. This enables the user to compose its systems by means of components in order to carry out:

- Precipitation-runoff modelling for flood control (short-term scenarios), drought situations (long-terms scenarios) or management scenarios
- River basin modelling with water management and operation
- Operation of dams, detention basins as single purpose or multipurpose reservoirs, as stand-alone reservoirs or within a reservoir system (water supply, flood control, low flow augmentation, hydro power generation, environmental flows, others)
- Design of water infrastructure
- Operational use in combination with a monitoring system
- Coupling of water quantity and quality
- Climate change studies

It is possible to run the model in Monte-Carlo Simulation mode, however, this requires the operational mode with pre- and post-processing.

HYDRO SYSTEMS
(FLOW NETWORK)

Modelling with TALSIM-NG requires the user to select the hydrological components according to the needs of the river basin. Each hydrological component represents parameters of the real-world objects and offers different methods for calculating flow. A hydro system is mapped out according to the water resources elements such as urban and rural areas, river reaches, dams, weirs, diversions, discharge points, water consumers (e.g. agriculture), irrigation, simplified groundwater aquifers and generic sinks and sources. Each of the elements are placed according to their location and linked to form a flow network. The set-up of the hydro systems is done graphically.



The elementary properties and methods are summarized below.

Hydrologic / hydraulic properties and methods:

Element	Most important input	Property / Method	Output
Natural / rural sub-basin 	- precipitation - temperature - evaporation - transpiration - irrigation	- soil properties / land use - runoff calculation - atmoshpere / soil / vegetation interface calculation - time of concentration - irrigation, efficiency - ...	- urban flow - surface flow - interflow - baseflow - total flow - actual evapotranspi-ration - …
Urban sub-basin 	-- precipitation - temperature - evaporation - transpiration	- Proportion of impermeable areas - runoff calculation - time of concentration - ...	- urban flow - surface flow - interflow - baseflow - total flow - actual evapotranspi-ration
Discharge point 	- time series - hourly /daily / weekly / monthly patterns	- Input into the System	- total flow
Water transport 	- inflow	- translation - retention	- flow - water level
Consumer 	- inflow	- consumption patterns - input from adjacent basins - sink / source terms	- inflow - sinks/sources - total flow
Weirs, diversions 	- inflow	- hydraulic calculation or - control rules	- two outflows
Dams / reservoir - reservoirs - detention basins - others 	- inflow optional: - precipitation - evaporation - percolation	- stage-volume curve - stage-water surfaced curve - stage-discharge curve of service and bottom outlets - control rules	- storage volume - water level - outflows

Aquifers with water abstraction can be modelled with simplifications by using generic storage elements.

The most important calculation options are:

Sub-basins (natural or urban):

Precipitation-runoff simulation by means of:

- runoff coefficient
- SCS-method with 21 days previous rain index
- Complex non-linear soil moisture calculation with hydrologic response units

Discharge points:

Reading of time series or patterns to be used in the hydro systems

- Time series (observed, synthetic, generated)
- hourly / daily / weekly / monthly patterns

Water Transport:

Calculating flow propagation by means of:

- Simple translation without retention
- Pipe with translation and flow retention
- Open channel with cross sections, calculation with extended approach of Kalinin-Miljukov
- Stage-discharge-cross section relations (e.g. from hydraulic calculations)

Weirs, diversions:

Hydraulic calculation with:

- Simple proportional diversion
- Diversion with a threshold
- Diversion according to inflow-dependent capacity curve
- Diversion according to control rules

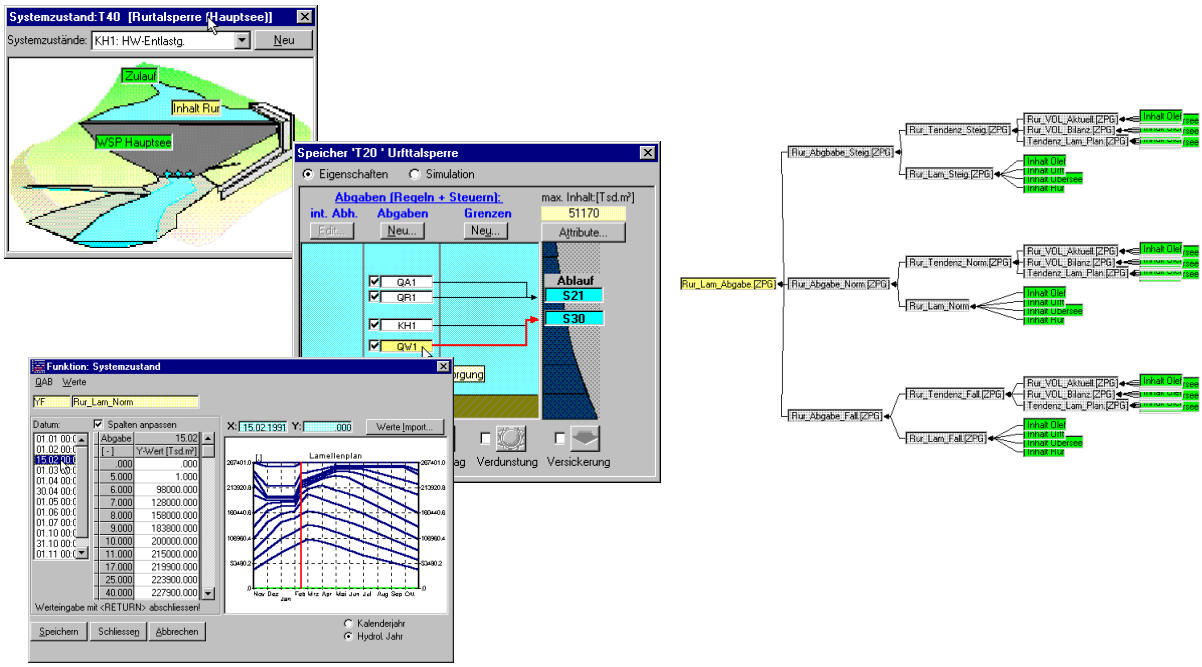
Dams / reservoirs:

- Non-linear calculation of lake retention
- Application of multifold rules like but not restricted to:
  - Rules depending of reservoir level
  - Zoning plans
  - Inflow depending rules
  - Hydro power generation
  - Free configuration of control rules using all system states or decision-trees of system states

OPERATION STRATEGIES
(CONTROL & RULES NETWORK)

Hydro systems are designed to meet certain objectives with regard to water supply, flood control, water quality goals, hydropower, environment and others. These goals are often achieved by implementing water infrastructures like canals, dams or others. The implementation is usually accompanied with facilities to operate the structures. Once these facilities are known and established in the model, all necessary elements are given to embark on targeted operation. This can be used in TALSIM-NG to model operation of water infrastructure or to run scenarios about water management. In contrast, it is also possible to use TALSIM-NG in a reverse way to derive the needs for water infrastructure and control facilities.

Operation of water infrastructure or water management requires rules. While setting-up a hydro system is a common feature in hydrological modeling, generic modeling of operation and management is a distinct advantage of TALSIM-NG. There are no restrictions in incorporating rules, cause-effect relationships and setting-up of decision trees as to consider water management options and assign them to water infrastructure elements.



TALSIM-NG offers simple storage-dependent or inflow-dependent rules, reservoir zoning or even complex, interlaced and/or nested decision trees. The individual composition of a flow network in combination with control & rules networks creates opportunities to integrate cross-sectoral topics ranging from water sector, urban development, agriculture and others.

WATER QUALITY

TALSIM-NG has been extended with the capability to model water quality components. In the current version substances can be considered by means of conservative modelling without interactions between substances or decomposition or decay respectively.

The option is an asset predominately aiming at salinization effects. Transport of substances follows the hydrologic / hydraulic calculation such that transport of load is directly linked with the water quantity. Concentrations are derived from load and volume respectively.

SIMULATION

Simulations can be performed in different ways. Long-term simulations are defined for a period of time requiring input variables as time series. All kind of parameters for input are possible whereas hydro-meteorological time series like precipitation and/or flow are required as drivers for a simulation run. Beyond that, water demand, population growth, crop patterns, or other imaginable variables are applicable within the generic control & rules network.

The following list presents different ways of simulation with time steps from 1 minute up to 1 month:

- Simulations based on historic/observed or synthetic (stochastically generated) time series. The time series must cover the simulation period
- Short-term simulations with design storms or design hydrographs
- Near real-time simulations in combination with monitoring system.
- Forecast based on weather forecasts.
- Tools in the TALSIM-NG package facilitate pre- and post-processing capabilities to prepare simulation logs, reports and pre-defined automated simulations.

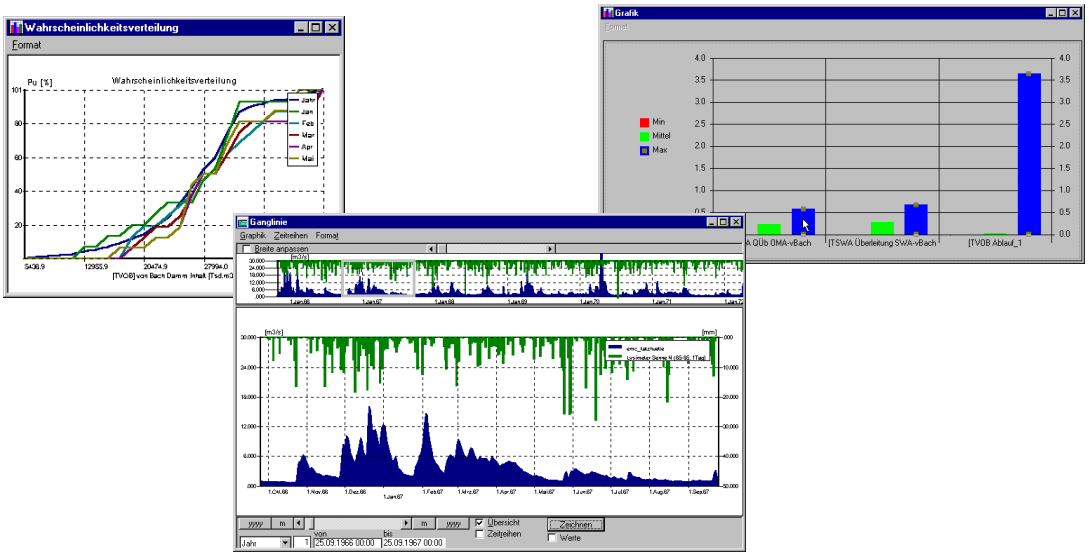
The tool box offers:

- Server based time series management tool
- Simulation manager including result management
- Long-term, continuous simulation or short-term simulation with design storms or design hydrographs
- Set-up and results for system states
- Calculation of balances and supply safeties

RESULTS WITH TALSIM-NG

Results provide the user with relevant and informative knowledge about the performance of the hydro system concerned. Questions need to be answered aiming at achieving of pre-defined goals or providing information about cause-effect relationships or simply hydrographs.

In TALSIM-NG all states can be illustrated as hydrographs or probability functions. Comparing results from different simulation runs is possible as well as copy-paste functions to export data to other tools like EXCEL. Thanks to the integrated simulation and time series management, the opportunities are very convenient.



The post-processing tool incorporates an own script language and can be configurated to almost all requirements which may arise during a water resources project.

CONTACT

Please contact:

SYDRO Consult GmbH

Consulting Engineers for Hydro Systems,
Water Resources Management and
Hydro-Informatics

Mathildenplatz 8

64283 Darmstadt

Tel: +49 6151-367367

Fax: +49 6151-367348

Email: info@sydro.de

Web: www.sydro.de
www.talsim.de