Data and Model Integration for Real-time Forecasting

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Overview of Corps Water Management System and Model Integration Software (HEC–RTS) used in Real–time Forecasting and Watershed Management Decision Support

Discussion of Dniester River Basin’s existing data monitoring infrastructure and hydrologic and hydraulic modeling to support real–time forecasting
RTS: Real-Time Simulation

- Public Version of CWMS (Corps Water Management System) CAVI (Control and Visualization Interface)
- PC based (not client-server)
- Primarily model integration for real-time decision support
- No database or data acquisition and processing capabilities
- Connects to HEC-DSS and, in a later version, other databases through an API (i.e., you can hook it up to any database)
- Public version cannot access CWMS Oracle database (CWMS version can)

- HEC-RTS and the CWMS-CAVI are the same program, except HEC-RTS cannot access the CWMS Database.
CWMS Support to Water Management Mission

- Improves Real-Time Decision Support for Water Management for 700+ Multipurpose Reservoirs and Thousands of Miles of Levees

- Utilizes Standard Corporate Centrally Supported Hardware/Software

- Allows for Corporate Web-Based Information

- Migrates 40 Existing Unique Systems to One CWMS
CWMS Software Integrates the Processing from Data to Water Management Decisions

- Observed Data
- Data Processing
- Data Storage
- Modeling
- Servers
- Weather Forecast
- Public and Cooperators
HEC–RTS Configuration

*Laptop or Workstation
*RTS Model Files and Programs
*HEC-DSS Database Files

Database Server

Other Data Sources (USGS, etc.)
HEC Data Storage System (HEC–DSS)

- Designed to make it easy for users and application programs to retrieve and store data

- Stores time series data, curve data, spatial-oriented gridded data, and other types of data

- HEC–DSS is incorporated into most of HEC’s major computer programs
HEC-RTS Model Linking

- HEC–HMS computes forecasted flows from
  - Observed precipitation from NEXRAD and rain gages
  - Future precipitation forecasts and scenarios
  - Observed flow
- ResSim simulates reservoir operations and downstream flows from HEC–HMS flows.
- HEC–RAS computes stages and inundation areas from ResSim flows.
- FIA computes damages and impacts from HEC–RAS stages or ResSim flows.
- Inundation areas and depths computed by RAS Mapper
Model Integration

ResSim Model

HMS Model

RAS Model

Integrated Models
Modeling for Decision Support

- Hydrologic / hydraulic simulation models for short-term forecasts and event scenarios
- Discrete models developed outside and then linked together
- Spatially distributed models
- Typically use one week of observed data and evaluate results two weeks into the future
- Evaluate a variety of scenarios:
  - Future precipitation amounts and timing
  - Reservoir operations
  - Levee failures
Precipitation Analysis

- Precipitation processed on a grid basis.
- Observed data from NEXRAD or interpolated from gages.
- Future Precipitation Scenarios:
  - National Weather Service (NWS) Quantitative Precipitation Forecast (QPF)
  - Multiples of the QPF
  - Manual–entry or standard scenarios (What if?)
    - Timing
    - Location (watershed “zones”)
Gridded Runoff Analysis
Hydrologic Modeling (HEC-HMS)

- Computes runoff from observed data and future precipitation scenarios
- “Event-oriented” model
- ModClark model for rainfall/runoff transform from distributed data
  - Grid cell sizes are approximately 2 km x 2 km
  - Excess rainfall is lagged by grid cell translation times, routed through linear reservoirs, then combined at subbasin outlets.
- Soil moisture conditions calibrated prior to modeling runs
Reservoir Operations with HEC-ResSim

- Simulates operations through user-defined operating rules and scheduled releases
- Uses reservoir inflow and downstream local hydrographs computed by HEC-HMS
- Manually set release “overrides”
- Automatically generates downstream hydrographs for a “no reservoir” condition for project benefit analysis
River Hydraulics (HEC-RAS)

- Steady-flow or unsteady-flow analysis.
- Analyzes river hydraulics to compute water depth, velocity, & inundation boundaries
- Computes water surface profiles and stage hydrographs from HEC-HMS or HEC-ResSim hydrographs
- Channel friction adjusted through the HEC-RAS interface
- Inundation boundaries and depth maps are computed with HEC-RAS Mapper
Inundation Mapping

Delineates geographic extent of flooding using model results & topography
Economic / Impact Analysis (HEC-FIA)

- Computes agricultural and urban damages and project benefits by “impact area”
- Computes damages and benefits between different scenarios, and with and without project conditions
- “Action tables” provide a list and time of actions to take during an event, based on forecasted stages
Control and Visualization Interface (CAVI)

- Serves as the main interface to HEC–RTS
- Access and manipulate data and models:
  - View status of data feeds and gauge quality
  - Validate data
  - View hydro–meteorological conditions of the watershed
  - Plot, tabulate and edit data
  - Run models and view results
- CAVI organizing unit is called the “Watershed”, which contains data, models.
CAVI Modules ( Screens )

- Watershed Setup
- Data Acquisition
- Data Visualization
- Model Interface
Watershed Setup Module

- Load background maps.
- Build common “stream alignment”
- Build models that access the stream alignment.
- Identify common “nodes”.
- Add and configure time-series icons.
Data Acquisition Module

- View status of the data streams.
  - Status for each data stream represented by the color of a corresponding button on the control panel.
  - Last data stream status shown in the alert message line.

- View status and quality of data from individual gauges.
  - Quality color bar time-series icons reflect data quality at primary gauge locations.
  - Time window identified and set in the control panel.
  - Icons can be set to update automatically (e.g., every 5 minutes)

- Validate (edit) data from gauges.

- Identify usable observed data time window for modeling
Data Status Summary Report
Data Validation Editor

- Combined graphical / tabular editor.
- Used to accept / reject / estimate or enter gage data.
- Run in “ad hoc” mode, or list driven.
  - “ad hoc” by selecting time-series icons (shift – right mouse click), then press Validation button.
  - Pre-defined list.
- Filter list (selections) according to quality.
Data Visualization Module

- Viewing hydro-meteorological state of the watershed.
- Animation of precipitation from NexRad or interpolated gridded precipitation.
  - Combined “slider bar” and “Animation controls” allow user to play / fast forward / step through gridded precipitation time intervals
  - Placing the mouse over a grid cell shows the amount of rain for that cell for that hour.
- Thumbnail Plots for gage locations
Generating Full Plots and Tables from Thumbnail Time-Series Icons
Selecting a Time Series Icon to Export Data into MS Excel
Selecting a Time Series Icon to Display a Satellite Map or Webcam
Model Interface Module

- Evaluate “what if” alternatives:
  - What if there is more rain than forecasted?
  - How does reservoir operation affect downstream locations?
- Simulate reservoir operations.
- Forecast future flows and stages.
- Determine inundation areas and flood depths.
- Evaluate economic impacts.
Future Rain Input

- Main precipitation scenario selection

- Applies spatially uniform precipitation over basin

- Can specify an amount

- Can specify a temporal distribution
HEC–Ressim Reservoir Operations

- Evaluate reservoir release decisions and downstream flows
- Use release overrides as necessary
Stage Forecasting with HEC-RAS

- Manning’s N values adjusted for seasonal changes (e.g., vegetation)
- Model can be adjusted in real-time to account for changes in the waterway
- RAS Mapper is used to compute inundation depths, displayed by HEC-RTS
Generating Inundation Depths & Extents
Dniester River Discussion ...
Dniester River Real-time System

Data
- Real-time (hourly or sub-hourly time interval) data monitoring and transmittal
- Real-time database
- Data quality control, transformation, and dissemination

Models
- Meteorlogic forecasts
- Hydrologic forecasts
- Reservoir operations
- River stage forecasts
- Forecast Modeling Integration Framework

Data Exchange
Dniester River Basin

Flow Monitoring Stations
Dniester River Basin

- Irrigation Abstractions
- Water Abstractions