Model Integration with GIS, CIS and SCADA at the Greater Cincinnati Water Works

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Overview / Agenda

- **Physical Facilities**
  - GIS: Integrate for maintenance
  - Facility Schematics
  - Pump Curves
  - Tank Geometry

- **Demand Data (Allocated AAD)**
  - CIS (Billing data): Integrate for maintenance
  - Non-revenue water

- **Operational Data**
  - SCADA: Integrate for operational evaluations
  - Valve status (open/closed) and settings
Greater Cincinnati Water Works (GCWW) System Profile

- GCWW provides about 136 million gallons a day through 3,000 miles of water main
- 235,000 residential and commercial accounts
- Serves over 1,000,000 people
- GIS contains 200,000 pipes as of Jan. 1, 2008
- One of the largest All-Pipes hydraulic model ever constructed
- Selected H2OMAP Software by MWHSoft to perform hydraulic modeling
Geographical Information System (GIS)

- Source of Distribution System Records
- ESRI Arc Map Geometric Network
- Mains, Valves, Fittings, Hydrants
- Pump Station and Storage Tank schematics only. Size and Capacity information in other records.
- Additions & Corrections during model construction need to be added to GIS
GIS Data

- Data contained in GIS Database
  - Installation Date
  - Rehabilitation Date (Clean & Line)
  - Abandonment Date
  - Size
  - Material Type
GIS Issues

- **Discretation**
  - Current GIS allows for complex edges
  - GCWW GIS created with much detail
  - Branches complex
  - Valves and Fire Hydrants break pipe lengths

- **Connectivity**
  - Critical
Establishing GIS Network Connectivity

- Evaluate network connectivity in GIS prior to model development
- Topology rules:
  - Fittings at endpoint of main
  - Hydrants at endpoint of main
  - Mains must not overlap
  - Mains must not self-overlap
  - Pumps at endpoint of main
  - Valves must be at endpoint of main
  - Water Storage units (reservoir/tank) must be at endpoint of main
- Over 300 topology errors existed
- Built “Geometric Network” in GIS to maintain connectivity
Network Connectivity/Topology

- No duplicate database records (duplicate features with identical IDs & attributes)
- No orphan nodes
- No duplicate nodes
- Pipes must not overlap other pipes
- Pipes must not self-overlap
- Pipes must not self-intersect
- Pipes must be split at intersections or (exceptions allowed)
- Pipe endpoints must be covered by nodes
### “Points and Lines” GIS vs. Hydraulic Model

<table>
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<tr>
<th>GIS Database</th>
<th>Features</th>
<th>Feature Type</th>
<th>Hydraulic Model (H2OMAP)</th>
<th>Features</th>
<th>Feature Type</th>
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Relating GIS with Hydraulic Model in H2OMAP

- Asset ID’s are the key for 1:1 relationship with GIS
- Representing Pumps and Valves in H2OMAP
Constructing the Model in H2OMAP

- Exported pipes from GIS to H2OMAP software
- Exported facility data (pump stations, control valves, tank facilities) to H2OMAP
- Hydraulic Model QC
  - Orphaned nodes & pipes
  - Nodes in close proximity
  - Parallel pipes
  - Diameter discrepancy
  - Network trace
Facility Model Development

- Developed from GIS data
- Schematic drawings used to verify facility network
- SCADA data used to refine operational information
- Provided documentation of additions, subtractions, and/or modification of facility elements to client
GIS & Model Issues

- To include hydrants or not
  - No. of hydrant segments = 62,000 pipes *
  - No. of pipe segments = 200,000 *

- Model Performance vs. One-to-One
  - Model Execution Time vs Maintenance
  - Trim “spurs”
  - Combine small pipe segments with others
  - Auto skeletonization

(* GIS status as of Jan 2008)
GIS & Model Issues

- GIS IDs generally not descriptive
- MODEL IDs need to be descriptive enough to help calibration of model

WARNING: Negative pressures at demand node(s) at 7:00:00 hrs.
WARNING: FCV 6519.1 open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009221A open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009417 open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009867B open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009858A open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009965 open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009974E open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009948A open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV EQ009948A open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV UNKVF1 open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV UNKVF2 open but cannot deliver flow at 7:00:00 hrs.
WARNING: FCV UNKVF3 open but cannot deliver flow at 7:00:00 hrs.
WARNING: Pump EQ000015 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ000022 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ001017 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ009436 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ009439 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ009440 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump EQ009443 closed due to its inability to deliver head at 7:00:00 hrs.
WARNING: Pump EQ009444 closed due to its inability to deliver head at 7:00:00 hrs.
WARNING: Pump UNKPU8 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: Pump UNKPU9 open but exceeds maximum flow at 7:00:00 hrs.
WARNING: System unbalanced at 7:00:00 hrs. EXECUTION HALTED.

** Error: hydraulic simulation failed **
Customer Information System (CIS)

- Billing System Characteristics
  - Premise Code for one property
  - Each meter has one service
  - Multiple Services may be linked to one Premise
  - Numerous usage type codes (single-family residential, commercial, school, etc.)

- Allocation of Sales from CIS
  - Multiple CIS usage types combined into two consolidated usage types (residential, ICI)
  - Consumption summed for each Premise by usage type
Demand Allocation

 Allocation of year 2007 annual average day use
  – Domestic use from CIS:
    • residential and ICI metered usage
  – Wholesale customers:
    • metered but special handling required
  – Unmetered water:
    • apparent losses, real losses, unmetered uses

 Various demand conditions created using demand manager and peaking factors
Linking Metered Sales to Model

- CIS contains premise number for all accounts
- Premises are mapped in GIS
- Tap location in GIS allows for accurate allocation
- Use spatial link in GIS
Consumption from these four premises was summarized by Branch Number and assigned to Branch 260546. Total consumption = 0.000985 mgd.
Demand Issues

- Unmapped Premises and Branches caused minor losses in demand allocation
- Domestic Water Demands only
- Monthly vs Quarterly Readings
  - Annualized data only
- Must include Water Loss in demand calculation to match actual AAD water use in system (consumption)
SCADA

- Source of operation data with 10 year storage
- Flow, Pressure, Pump Status, Valve Opening, Storage Water Level, Water Quality Monitor Values
- Desire ability to import operational conditions to calibrate or to balance model to specific conditions
SCADA System

- Each signal has specific SCADA Tag ID
  - SCADA Identifier is descriptive on Tag function
  - SCADA Identifier is longer than model ID allows
  - GIS Identifier vs SCADA Identifier

- Multiple signals for single equipment
  - Pump: on time, off time, speed
  - Valve: open status, close status, transition or percentage
  - Flow meter
SCADA Link

- Add field in Model for SCADA Tag ID
- Maintain Cross Index Table of IDs Among GIS, Model and SCADA (spreadsheet application)
- Operation data from SCADA imported into spreadsheet application with Model IDs for import to model
  - Alternative suggestion: Consider using this spreadsheet to help provide more descriptive ID names at key facilities for error messages.
Model Maintenance

- How are changes made in GIS
  - Abandon original pipe, valve, hydrant, etc
  - Install new pipe, valve, hydrant
- Demands
  - Infrastructure replaced
  - New infrastructure
- Upgrade to GIS, CIS, or SCADA Systems can affect integration
- Platform of Modeling Software
  - GIS, CAD or stand alone
  - Manual vs Automatic process
Maintenance Issues

- How often?
- Recalibrate?
- Effort required vs. improved accuracies
Model Update Steps

- **Update piping network: GIS and Hydraulic Model tools**
  - Flag in GIS all pipes not used in previous model construction(s)
  - Flag in GIS all abandoned mains
  - Assignment and/or modification of C-values

- **Update facilities**
  - New or modified facilities
  - Update pump performance tests
  - Changes to control valve settings

- **Update AAD allocation**
Summary

- Integration allows for more accurate model
  - Pipe Network, Demands
- Integration allows for future flexibility
  - Operational Conditions
  - Maintenance
- Integration requires balancing of needs
Contact Information

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