SimulAIIt: Water Demand Forecasting & Bounce back
Intelligent Software Development (ISD)

“Predict a better future”
Data Analytics & Decision Process

Observe
Descriptive Analytics

Business Questions:
What happened?
Why did it happen?
What is happening?
Why is it happening?

Solutions:
Data mining & forensics
Real-time analytics & mining
Market segmentation
Reporting & dashboards
Ah-hoc database queries

Predict
Predictive Analytics

Business Questions:
What is likely to happen?

Solutions:
Simulation
Statistics & linear regression
Predictive data-mining

Influence
Prescriptive Analytics

Business Questions:
What should I do about it?

Solutions:
Simulation
Optimisation

Simulate mass-consumers, their behaviour and choices, their changing trends, and strategies & factors that influence them

ISD’s SimulAIt micro-simulation platform

* Based on Gartner’s model of analytics

“Predict a better future”
Factors that impact water demand

- Population trends and dynamics
  - Population growth & demographic change – e.g. household structure and size
  - Change in household allotment/garden size – e.g. getting smaller

- Products or appliances used
  - Uptake and penetration
  - Efficiency and consumption (water, energy, carbon) – e.g. becoming more efficient

- Consumer behaviour
  - Consumers usage of appliances – range of possible and rational behaviours
  - Frequency and duration of use, per household or per person
  - Interdependencies: seasonal factors, demographic factors (e.g. age & bath use)

- Behaviour change & maintenance from influences (strategies and policies)
  - Factors: social, economic, environmental, political
  - Water conservation: restrictions (gardens, cars, pools), rebates, retrofit
  - Price: discretionary and non-discretionary
  - Marketing & media on the water situation – e.g. drought & water levels
  - Different consumers respond differently within range of behaviours – e.g. income level, preferences for different demographics, duration persisting with behaviour, etc.

SimulAIIt considers all these factors

"Predict a better future"
Current limitations

Spreadsheets
- a 2D tool (rows and columns) to tackle an multi-dimensional problem
- Limited scalability

“Econometric Only” models
- Limited in addressing these non-linear, dynamic, human-centric problems
- Limited detail, unrealistic assumptions about decision making, …

Statistics, data mining, and mathematical models
- Observes and forecasts what people do, no insight into “why” they do it
- Inability to effectively represent complex consumer behaviour, and the impact individual behaviour has on aggregated results
- Single purpose (forecasting) – difficult to address other business problems
- Past demand may not be a good predictor of the future

“Predict a better future”
What is SimulAIIt?

Business tool to help you accurately **predict** and explore options to **influence** mass-consumer behaviour and decision making

- Simulates populations of all sizes with regional breakdown
- Model reactions and behaviours of individual consumers to new strategies, policies, products, prices and competitive strategies
- Handles different types of data to incorporate many consumer decision making factors
  - Qualitative and quantitative data
  - Social, economic, environmental and political data
- Incorporates different technologies from Defence
  - AI & Micro-Economics, Agent-Based Modelling, Human Cognition Reasoning Engine, Dynamic Multi-Dimensional Database, Micro-simulation

“Predict a better future”
Accurate Validated Models

- Water forecast with different restrictions, prices, marketing and media (2010)
- **Accurate**: proven approach, demonstrated over 95% accuracy
  - Model not built on past demand data – demand data used to validate the model
  - Accuracy due to greater representation of a broad range of consumer factors
- **Decision support**: can assess different options and strategies through what-if scenarios to improve future outcomes

"Predict a better future"
Energy Forecasting: Non-Res, 30mins

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>99.0%</td>
<td>99.2%</td>
<td>97.9%</td>
<td>98.8%</td>
<td>98.0%</td>
<td>95.0%</td>
<td>98.5%</td>
<td>99.6%</td>
<td>97.0%</td>
<td>99.6%</td>
<td>98.7%</td>
<td>96.5%</td>
<td>85.0%</td>
</tr>
<tr>
<td>2009</td>
<td>99.8%</td>
<td>96.7%</td>
<td>99.3%</td>
<td>99.3%</td>
<td>99.0%</td>
<td>98.9%</td>
<td>98.4%</td>
<td>98.8%</td>
<td>95.1%</td>
<td>97.3%</td>
<td>93.1%</td>
<td>98.6%</td>
<td>98.3%</td>
</tr>
<tr>
<td>2010</td>
<td>98.3%</td>
<td>91.9%</td>
<td>97.9%</td>
<td>97.1%</td>
<td>97.6%</td>
<td>98.6%</td>
<td>98.1%</td>
<td>99.1%</td>
<td>97.1%</td>
<td>87.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Predict a better future”
Benefits: more than just accuracy…

Multi-purpose forecasting and decision support tool

- Address a broad range of strategic business and policy problems through what-if scenarios
  - More consumer/human decision making variables to analyse and test
- Isolate and understand significance of strategies
  - Better define relationships between strategies & decision variables
  - Forecast the impact of new strategies or disruptive events
- Test & optimise strategies and return on investment (ROI)
  - Evaluate past and future strategies, support business cases
  - Testing consumer “influences” enables greater control over future outcomes/forecasts

“Predict a better future”
SimulAIt Overview

**INPUTS**

**SCENARIO CONFIGURATION**
- Strategies & Policy
- Trends
- Assumptions

**RULES & PARAMETERS CONFIGURATION**
- Market research
- Survey data
- Econometric data
- Data mining outputs
- Engineering data
- Environmental data
- Sales data
- Domain knowledge
- ...

**SCENARIO EXECUTION**

**PARAMETERS & CONFIGURATION**
- Jun 21
- Jul 43
- Aug 65
- 82
- 87

**MODELS**

**BEHAVIORAL RULES & LOGIC**

**CENSUS & POPULATION DYNAMICS**

**OUTPUTS**

"Predict a better future"
Water Forecasting Model

SimulAIt is used to create a detailed simulation of your water customers

- Simulated how consumers use water and make decisions in the garden, kitchen, bathroom, laundry, etc.
  - What products they use, how they use the products, how this changes over time
- Simulate how consumers’ decisions are influenced by different policies and communication signals, such as media communications

"Predict a better future"
Customers

Awards

“Predict a better future”
Objective

- Blind validation: Used 4 yrs of demand data to calibrate outdoor water use and then forecast next 6 years of demand without access to actual demand data
- Separate models created for YVW, CWW and SEW
- Forecast bounce-back in demand from easing restrictions & price increases
- Flexibility to investigate customer water use behaviours and uptake of efficient appliances
Key outcomes and benefits

- Blind validation provides greater confidence in the model and forecasts
  - Minimizes risk and enables optimisation of strategies
  - Potential use in pricing submissions to regulators
  - Ability to investigate bounce-back in demand
- Share a consistent and accurate model: for the wholesaler and retailers

"Predict a better future"
CHW/DSE – Bounce-back

Objective

- Evaluate past strategies, and forecast bounce-back in demand from easing restrictions
- Pricing impact on consumption
- Impact of product uptake on revenue
- Business case to regulators
- Demographic analysis

Key outcomes and benefits

- Informed capital expenditure, corporate plans, restriction setting
- Rigorous business case to industry regulators
- Isolated and quantified the effectiveness of past & future strategies (campaign analysis)
- Inform & increase ROI on future strategies

“Predict a better future”
## Project Aquarius

<table>
<thead>
<tr>
<th>SAVINGS</th>
<th>Water</th>
<th>Energy</th>
<th>Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>199.2 ML/2.34yrs; 85.2 ML/yr</td>
<td>4.3 GWh/2.34yrs; 1.8 GWh/yr</td>
<td>1664 tonnes/2.34yrs; 711 tonnes/yr</td>
</tr>
<tr>
<td><strong>Per HH</strong></td>
<td>37.4 KL/yr</td>
<td>815 KWh/yr</td>
<td>0.32 tonnes/yr</td>
</tr>
<tr>
<td><strong>$</strong></td>
<td>$52.36/yr</td>
<td>$58.72/yr</td>
<td></td>
</tr>
</tbody>
</table>

---

**Average Monthly Household Water Consumption**

- Simulated Benchmark
- Without Project Aquarius

"Predict a better future"
## Other influences

<table>
<thead>
<tr>
<th>SAVINGS</th>
<th>Water</th>
<th>Energy</th>
<th>Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>1.9 GL/3yrs</td>
<td>39 GWh/3yrs; 12.9 GWh/yr</td>
<td>16,706 tonnes/3yrs; 5,900 tonnes/yr</td>
</tr>
<tr>
<td><strong>Per HH</strong></td>
<td>15.1 KL/yr</td>
<td>973 KWh/yr</td>
<td>0.14 tonnes/yr</td>
</tr>
<tr>
<td><strong>$</strong></td>
<td>$21.14/yr</td>
<td>$23.35/yr</td>
<td></td>
</tr>
</tbody>
</table>

### Average Monthly Household Water Consumption

- **Simulated Benchmark**
- **No Other Influences**

*“Predict a better future”*
Results – future forecasts

Comparison of scenarios (KL/HH/yr)

"Predict a better future"
**Bounce back components**

- Theoretical maximum bounce back
  - Natural decrease in demand from uptake of efficient appliances and population dynamics
- Behaviour maintenance/change
  - Test different levels of behaviour maintenance (sensitivity analysis)

---

**Graph: Reduction in demand from behaviour change**

- Baseline
- Past demand
- No influence
- Baseline - greater behavioural maintenance

---

"Predict a better future"
Price rises

- Forecasts show that two 10% price increases from 2013 results in a 1.5 kL (0.9%) reduction in household water consumption per annum.
- Economic analysis shows a 6.3 kL (4.2%) drop in water consumption.
- SimuAIIt results show the current high level of behaviour change in the Ballarat community provides little opportunity to reduce water consumption from price rises.

"Predict a better future"
SimulAIt Online

- Access SimulAIt via your web browser
  - includes hosting, maintenance and support

- You can:
  - Access your validated model online
  - Add many users
  - Create multiple scenarios – test assumptions and what-if analysis
  - Share scenarios (models), results, notes and descriptions
  - Refresh data and configure assumptions, parameters, etc...
  - Run simulations
  - Download results – disaggregated via region, and time or appliance

- Benefits
  - On-demand access to your models
  - Control, Visibility, Ease of Use
  - Facilitates collaboration: share scenarios and results
  - Maximise ROI: execute many scenarios when required
  - Hosted solution: no installation of software or hardware required to run large scale simulations

“Predict a better future”
Questions?

“Predict a better future”
Technology theory – ants...

Ant behavioural rules:
(1) Pick up food

“Predict a better future”
SimuLAIt Technology

- Consumer behaviour can be described by rules which are driven by a consumer's demographic characteristics, situation, and preferences
- Agent-based modelling provides a practical bottom-up approach to model mass-consumer behaviour where you start with the consumer
- Agents represent consumers and their prescribed rules to simulate decisions and behaviours of different consumers
- Millions of consumers can be simulated using SimuLAIt, allowing you to predict and explore options to influence mass-consumer behaviour
SimulAIt is used to create a detailed simulation of your water customers

- Simulated how consumers use water and make decisions in the garden, kitchen, bathroom, laundry, etc.
  - What products they use, how they use the products, how this changes over time
- Simulate how consumers’ decisions are influenced by different policies and communication signals, such as media communications

"Predict a better future"
SimulAIt Simulation

“Predict a better future”
QWC

Objective

- Inform future water conservation measures to maintain demand in order to delay billions of dollars in infrastructure costs
- Evaluate past water conservation and demand management measures

Key outcomes and benefits

- Informed future water conservation options/programs to increase the likelihood that strategic objectives and financial savings are met
- Quantified water, energy, carbon and financial savings from past programs and policies

“Predict a better future”
SimulAIte Online (SOL)

“Predict a better future”
Self Service – SimulAIt Online

- SimulAIt Online (SOL)
  - Web portal into SimulAIt

- Package includes
  - License, maintenance, and support
  - Hosting

- Clients can:-
  - Create multiple scenarios
  - Refresh data and configure the assumptions, parameters, etc...
  - View the results

"Predict a better future"
SimulAIt Technical Overview

"Predict a better future"
Benefits of SOL

- Control, Visibility, Ease of Use
- Facilitates collaboration
  - Share models
- Timeliness
  - Ability to respond quickly, rapid turn around
- Maximise ROI
  - Execute many scenarios when required
- Minimise cost of ownership/operating
  - Hosted solution
  - No infrastructure required
  - No IT support required
- Scalability
  - Cost-effective capacity on demand hosting

“Predict a better future”
Main SOL screen

- Scenario menu items
- Session messages
- Admin menu items
- Model type
- Scenario groups
- Scenarios
- Active scenario
- Working pane
- User & logout
- Session message log

Predict a better future
Client admin – user information

```
<table>
<thead>
<tr>
<th>Login ID</th>
<th>Last Name</th>
<th>Other Names</th>
<th>Email</th>
<th>Phone</th>
<th>Mobile Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:wsmith@chw.com.au">wsmith@chw.com.au</a></td>
<td>Smith</td>
<td>William</td>
<td><a href="mailto:wsmith@chw.com.au">wsmith@chw.com.au</a></td>
<td>03 90001234</td>
<td>0412999999</td>
</tr>
<tr>
<td>pablo</td>
<td>Dhanwyanti</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lsd</td>
<td>Demo</td>
<td>ISO</td>
<td><a href="mailto:lsddemo@example.com">lsddemo@example.com</a></td>
<td>1224</td>
<td>1224</td>
</tr>
</tbody>
</table>
```

Add new user

Active users: user details

“Predict a better future”
Scenario: Edit scenario

“Predict a better future”
Scenario: About - Notes

“Predict a better future”
Scenario: Configuration

- Config input type
- Parameters tree: hierarchical to reduce complexity
- Slide to increase working pane
- Time explicit parameter values (cells)
- Scroll cells through time
- Time associated with parameter values
Run scenario – SimulAIt!

Start simulating the scenario

Set the scenario start and end times

Region tree

Selected regions

Save the selected regions for the scenario

Predict a better future
Scenario: Results

Range of results to download:

- Water, energy, carbon, revenue, etc.
- Monthly, yearly
- Disaggregated into different regions, appliances

“Predict a better future”
Outputs: Monthly Demand

Water consumption trends over time with graphs showing water consumption per household and per person.
## Outputs: Yearly Demand

### Water Consumption - Yearly

<table>
<thead>
<tr>
<th>Date</th>
<th>Total (Ml.)</th>
<th>HL/Household</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 09</td>
<td>104.59</td>
<td>10.21</td>
<td>15.37</td>
</tr>
<tr>
<td>Mar 09</td>
<td>209.29</td>
<td>18.31</td>
<td>23.45</td>
</tr>
<tr>
<td>May 09</td>
<td>314.86</td>
<td>26.42</td>
<td>31.59</td>
</tr>
<tr>
<td>Jun 09</td>
<td>417.94</td>
<td>34.53</td>
<td>40.74</td>
</tr>
<tr>
<td>Jul 09</td>
<td>521.02</td>
<td>42.64</td>
<td>48.84</td>
</tr>
<tr>
<td>Aug 09</td>
<td>622.22</td>
<td>50.75</td>
<td>57.93</td>
</tr>
<tr>
<td>Sep 09</td>
<td>721.42</td>
<td>58.85</td>
<td>66.03</td>
</tr>
<tr>
<td>Oct 09</td>
<td>820.62</td>
<td>66.96</td>
<td>74.13</td>
</tr>
<tr>
<td>Nov 09</td>
<td>920.82</td>
<td>75.06</td>
<td>82.22</td>
</tr>
<tr>
<td>Dec 09</td>
<td>1020.22</td>
<td>83.17</td>
<td>90.32</td>
</tr>
</tbody>
</table>

### Water Consumption per Household

- **Date**
  - Jan 09: 10.21 ML
  - Mar 09: 18.31 ML
  - May 09: 26.42 ML
  - Jun 09: 34.53 ML
  - Jul 09: 42.64 ML
  - Aug 09: 50.75 ML
  - Sep 09: 58.85 ML
  - Oct 09: 66.96 ML
  - Nov 09: 75.06 ML
  - Dec 09: 83.17 ML

### Water Consumption per Person

- **Date**
  - Jan 09: 15.37 L
  - Mar 09: 23.45 L
  - May 09: 31.59 L
  - Jun 09: 39.74 L
  - Jul 09: 47.84 L
  - Aug 09: 55.93 L
  - Sep 09: 63.12 L
  - Oct 09: 71.22 L
  - Nov 09: 79.32 L
  - Dec 09: 87.42 L

### Total Water Consumption

- **Date**
  - Jan 09: 10.21 ML
  - Mar 09: 18.31 ML
  - May 09: 26.42 ML
  - Jun 09: 34.53 ML
  - Jul 09: 42.64 ML
  - Aug 09: 50.75 ML
  - Sep 09: 58.85 ML
  - Oct 09: 66.96 ML
  - Nov 09: 75.06 ML
  - Dec 09: 83.17 ML

---

**Scenario Information**

- **Account**: XYZ Company
- **Username**: User1
- **Scenario name**: Baseline
- **Date created**: 16/03/2023
- **Scenario ID**: 1234567890

---

**Total Water Consumption**

- **Date**
  - Jan 09: 10.21 ML
  - Mar 09: 18.31 ML
  - May 09: 26.42 ML
  - Jun 09: 34.53 ML
  - Jul 09: 42.64 ML
  - Aug 09: 50.75 ML
  - Sep 09: 58.85 ML
  - Oct 09: 66.96 ML
  - Nov 09: 75.06 ML
  - Dec 09: 83.17 ML

---

**Summary**

- **Water consumption**
- **Households**
- **Persons**
- **Scenario information**
- **Other**
Outputs: Household Usage

"Predict a better future"
Outputs: Revenue, Water Bills

“Predict a better future”
Outputs: Rebate uptake/efficiency

"Predict a better future"
Technology

“Predict a better future”
Traditional approaches: Stats

Linear regression

- Uses historical data and selected variables
- Algorithm estimates the level of impact of variables on the forecasts
- The model extrapolates historical data to produce forecasts

Limitations for a complex human-centric environment

- A top down approach where aggregated variables are used to create the model, without considering how individual consumer behaviours affect the forecasts
- Unable to incorporate dynamic & non-linear human decision making factors
- The past is not always a good predictor of the future
- Unable to test new strategies or disruptive events not seen in the past
- Limited ability to validate models, as historical data is used in the models

Typically single-purpose: forecasting

- Unable to address a range of business or policy questions

“Predict a better future”
SimulAIt behavioural model

Usage of products

Influences → Behaviours (change) → Decision for Usage → Usage → Water Consumption

Composition/acquisition of products

Decision for Change → Behaviours (change) → Influences

Model: Influence → Behaviours → Decisions → Water Consumption

“Predict a better future”
Influence-Behaviour model

“Predict a better future”
SimulAIt Execution

Simulation execution

Δ Time

Situation (Change) → Usage Behaviours → Use Items & Products

Social & Population Dynamics → Physical & Environ. → Economic & Political

Decision for Change → Composition of Items & products

Water Consumption
Energy
Carbon
Waste

“Predict a better future”
## Energy Forecasting: Non-Res, 30mins

### Energy load forecasting accuracy

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>99.0%</td>
<td>99.2%</td>
<td>97.9%</td>
<td>98.8%</td>
<td>98.0%</td>
<td>95.0%</td>
<td>98.5%</td>
<td>99.6%</td>
<td>97.0%</td>
<td>99.6%</td>
<td>98.7%</td>
<td>96.5%</td>
<td>85.0%</td>
</tr>
<tr>
<td>2009</td>
<td>99.8%</td>
<td>96.7%</td>
<td>99.3%</td>
<td>99.3%</td>
<td>99.0%</td>
<td>98.9%</td>
<td>98.4%</td>
<td>98.8%</td>
<td>95.1%</td>
<td>97.3%</td>
<td>93.1%</td>
<td>98.6%</td>
<td>98.3%</td>
</tr>
<tr>
<td>2010</td>
<td>98.3%</td>
<td>91.9%</td>
<td>97.9%</td>
<td>97.1%</td>
<td>97.6%</td>
<td>98.6%</td>
<td>98.1%</td>
<td>99.1%</td>
<td>97.1%</td>
<td>87.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The non-res model

“Predict a better future”
Why do this?

Raw data with no/little context/understanding provides little value

- The past may not be a predictor of the future – e.g. water and energy
- If you don’t know what is contributing to the peaks and troughs, how can you:
  - Accurately forecast what will happen next week/month/year
  - Understand the impact on forecasts with changing factors or disruptive events (prices, uptake of efficient appliances, business expansion/growth, etc…)

Simulation and SimulAIIt provides a methodology and tool that can drill down into data, add context, represent complicating factors, and deal with the problem’s complexity

- Data + Context + SimulAIIt → Accurate and functional forecasting model

“Predict a better future”
The process

Input

Demand data

Context & other data
- Type of business
- Weather & building efficiency
- Public holidays
- Prices
- Daylight hours
- Business hours, breaks, ...
- Etc...

SimulAIt

Appliances and equipment

Behaviours/usage

Output

Scenarios

Forecasts

“Predict a better future”
SimulAIIt Features

- Scalable simulation engine
  - 2 million households, > 4.5 million consumers

- Handles multiple data sources
  - Consider all factors than impact on consumer decision making

- Extensible
  - Scriptable architecture caters for complex environments

- Supports the creation and rapid turn-around of multiple scenarios and very large simulations
  - Comparisons, what if analysis
  - Ability to refresh/update data sources

- Provides visibility
  - Assumptions and parameters that drive the business rules and logic

“Predict a better future”
Intelligent Software Development Pty Ltd

Innovation House
Mawson Lakes Boulevard
Technology Park, Mawson Lakes
South Australia, 5095

Phone: +61 8 8343 8455
Fax: +61 8 8260 8100
info@intelligentsoftware.com.au
www.intelligentsoftware.com.au

"Predict a better future"