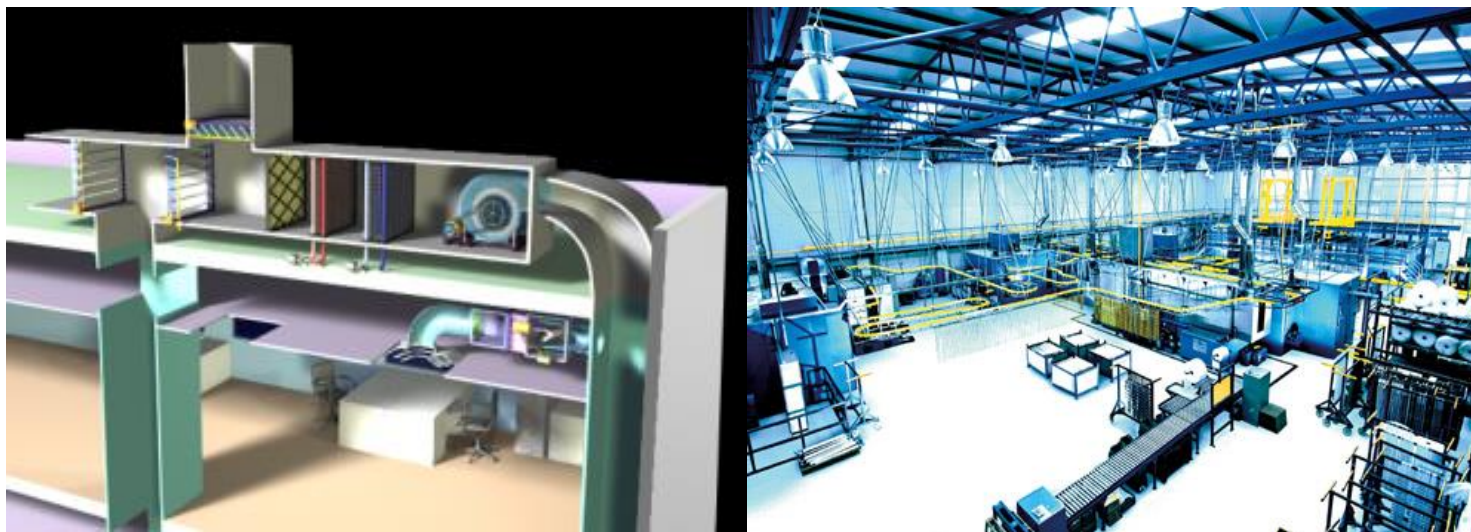


RESULTS FROM TESTING OF A “CLOUD BASED” AUTOMATED FAULT DETECTION AND DIAGNOSIS TOOL FOR AHU’S

ETFA SEP 11TH 2013, CAGLIARI

Ken Bruton, Daniel Coakley, Peter O'Donovan, Marcus M. Keane
& D. T. J. O'Sullivan





Agenda

- What is i2e2?
- Why does industry need this work?
- Why HVAC?
- An automated solution.....
- AFDD techniques
- Early Results

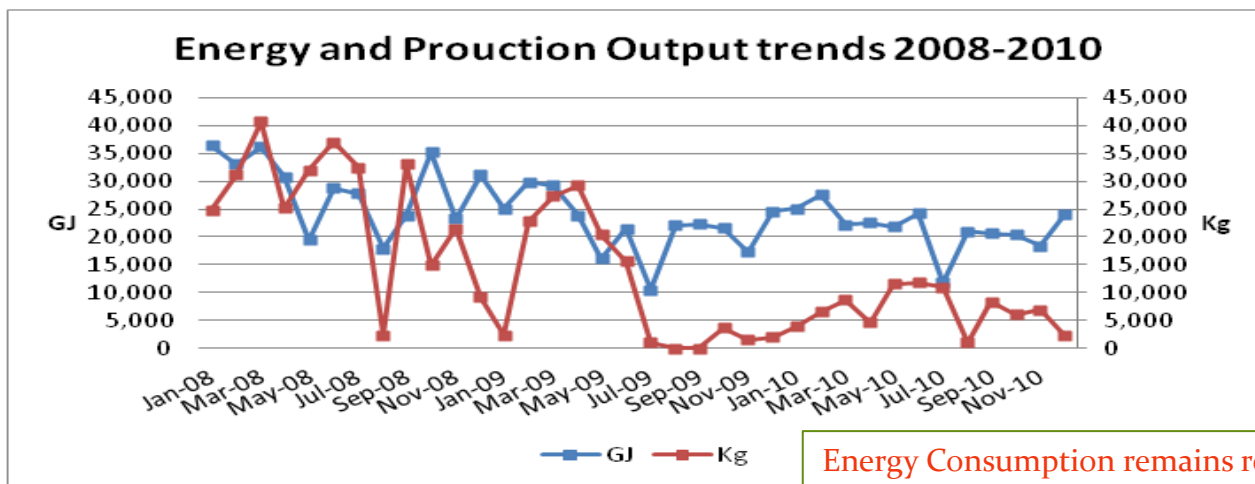


What is i2e2?

- i2e2 is an industry/academic collaboration under the Irish government's Technology Centre initiative
- Focus on research with a direct impact on industry
- UCC's task, in collaboration with NUIG, is to provide Appropriate Working Environments
- i2e2 companies provide access to their operations



Why does industry need this research work?



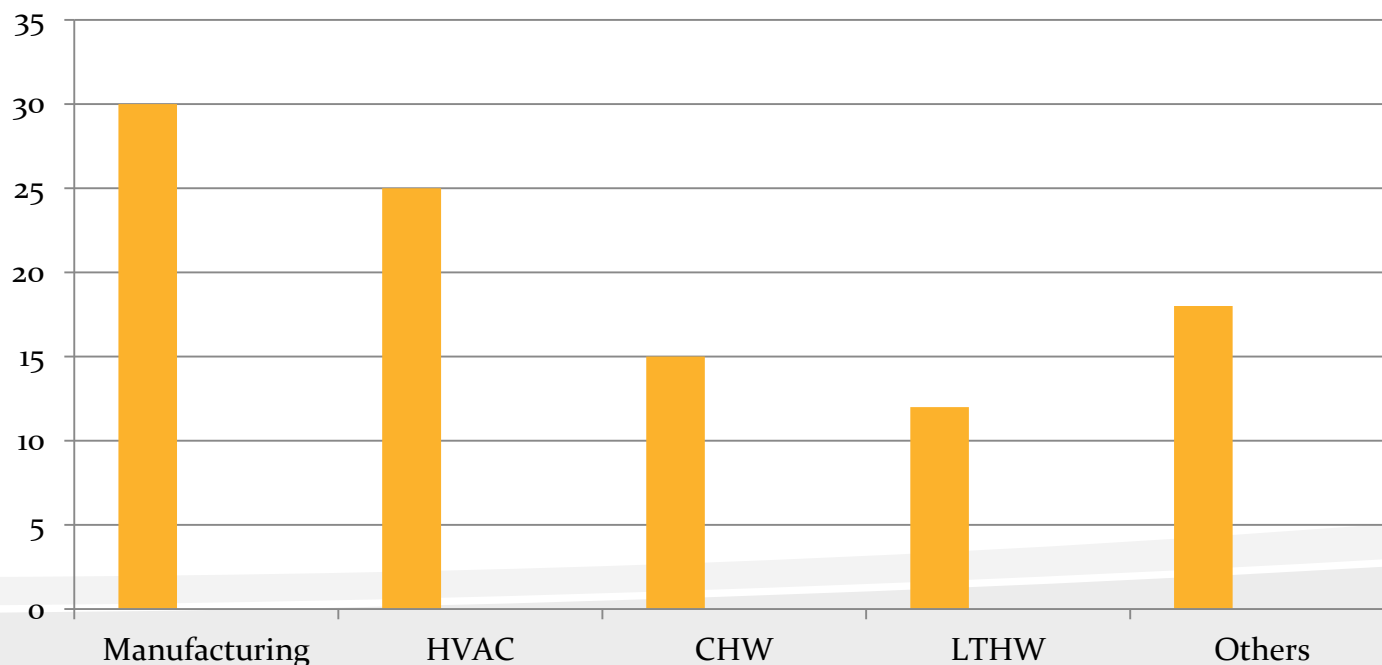
Energy Consumption remains relatively constant though production volume has decreased significantly



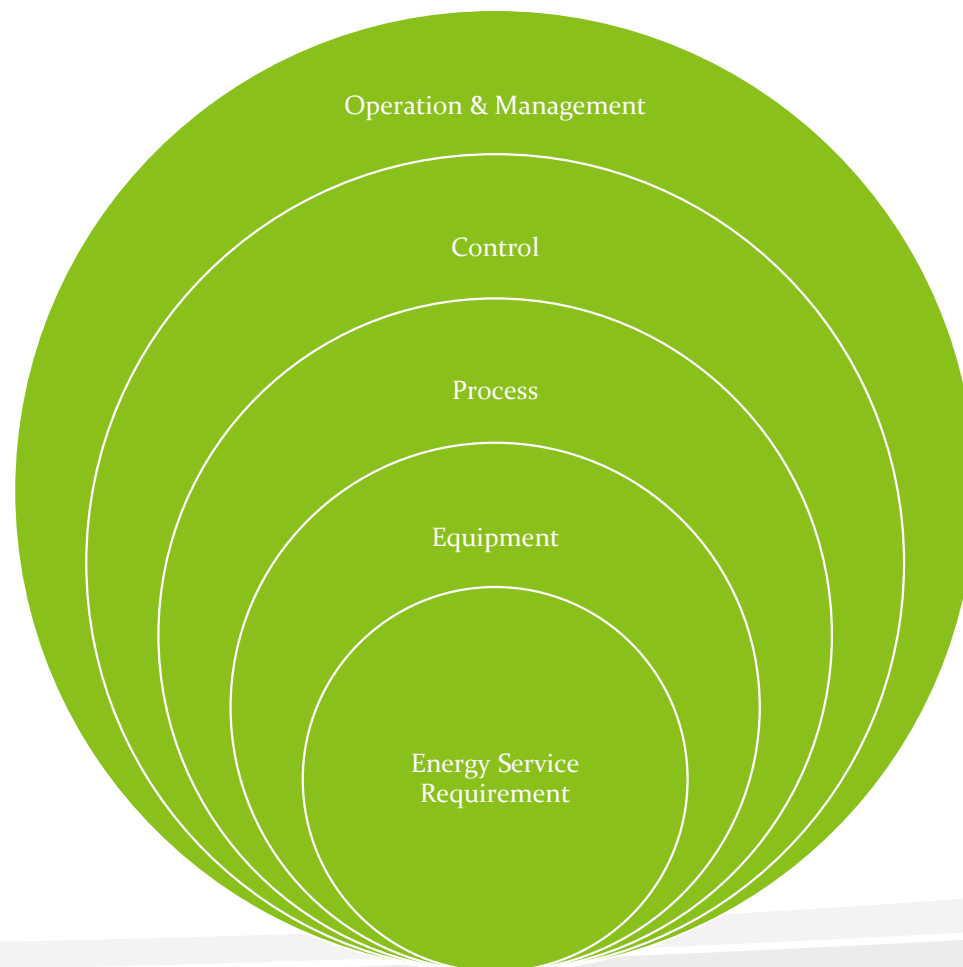
- Focus on production output in lieu of efficiency
- Difficult to track efficiency due to islands of information
- Competition from lower cost economies for investment

Why Focus on HVAC Systems?

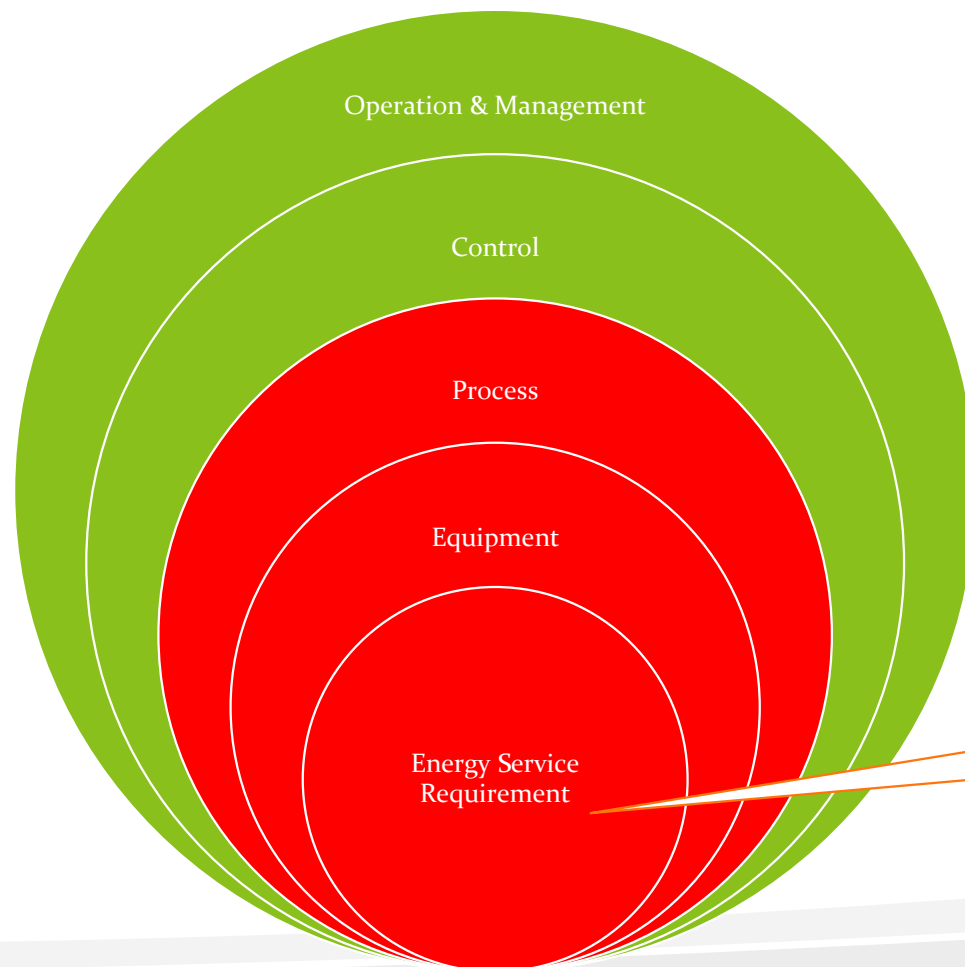
- Typically greater than 20% of an industrial site's energy consumption
- HVAC systems get less efficient over time
- 20-30% energy savings are achievable by re-commissioning HVAC



How can AFDD help save HVAC Energy?



How can AFDD help save HVAC Energy?

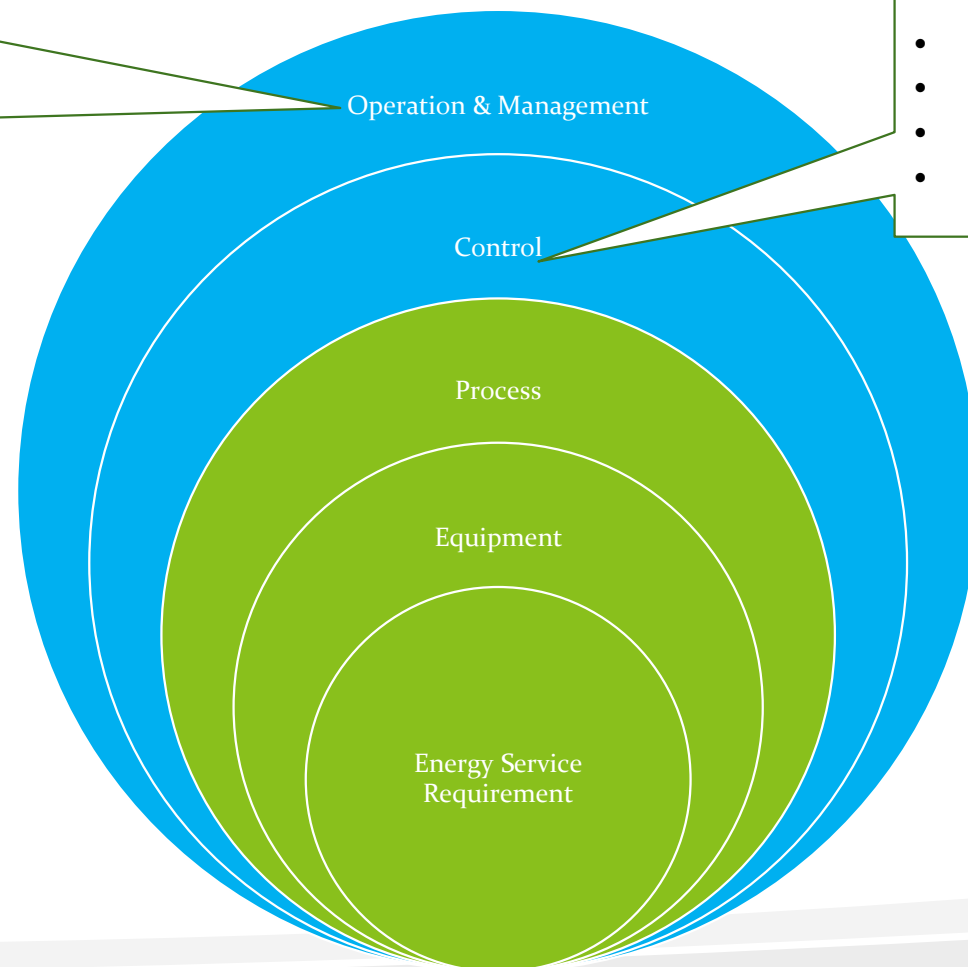


Air Change Reduction



How can AFDD help save HVAC Energy?

- Simultaneous heating & cooling
- Set point adjustments
- Manual operation
- Sub optimal performance of equipment



- Inefficient control strategies
- Poor loop tuning
- Free cooling
- Incorporation of Deadbands



Why an automated tool?

20 to 1
Knowledge
Complexity





AFDD tool requirements

Prioritisation

Minimal False positives/negatives

Rapid Setup

Use existing instrumentation

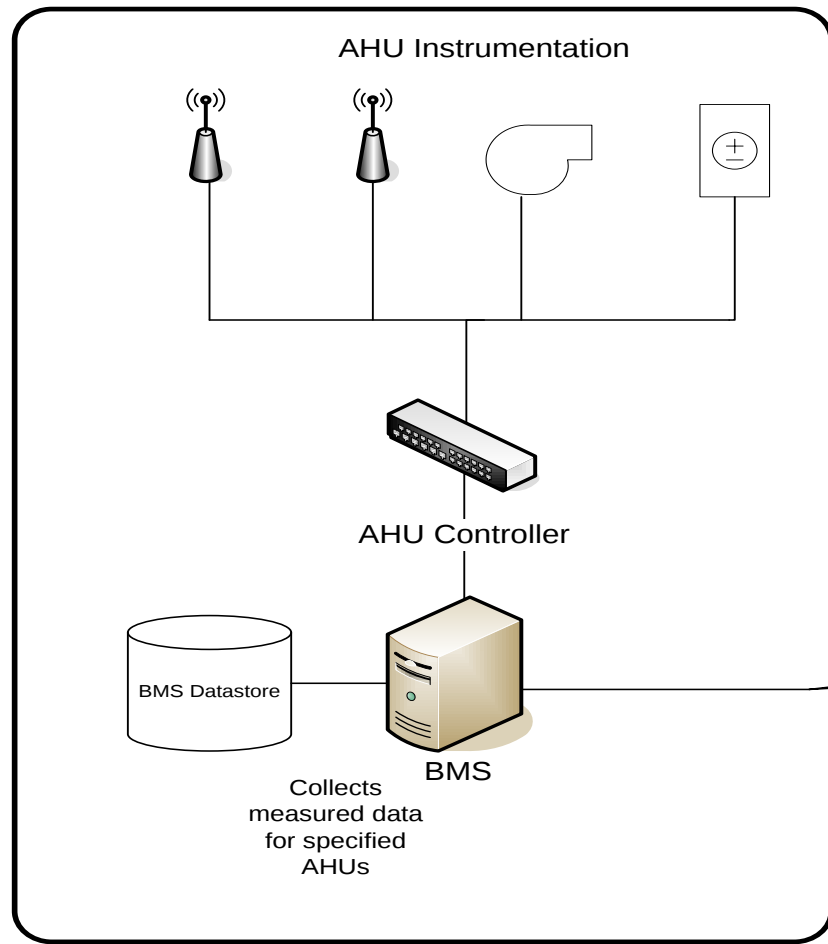
No sensor/instrument dependencies

BMS Flexibility

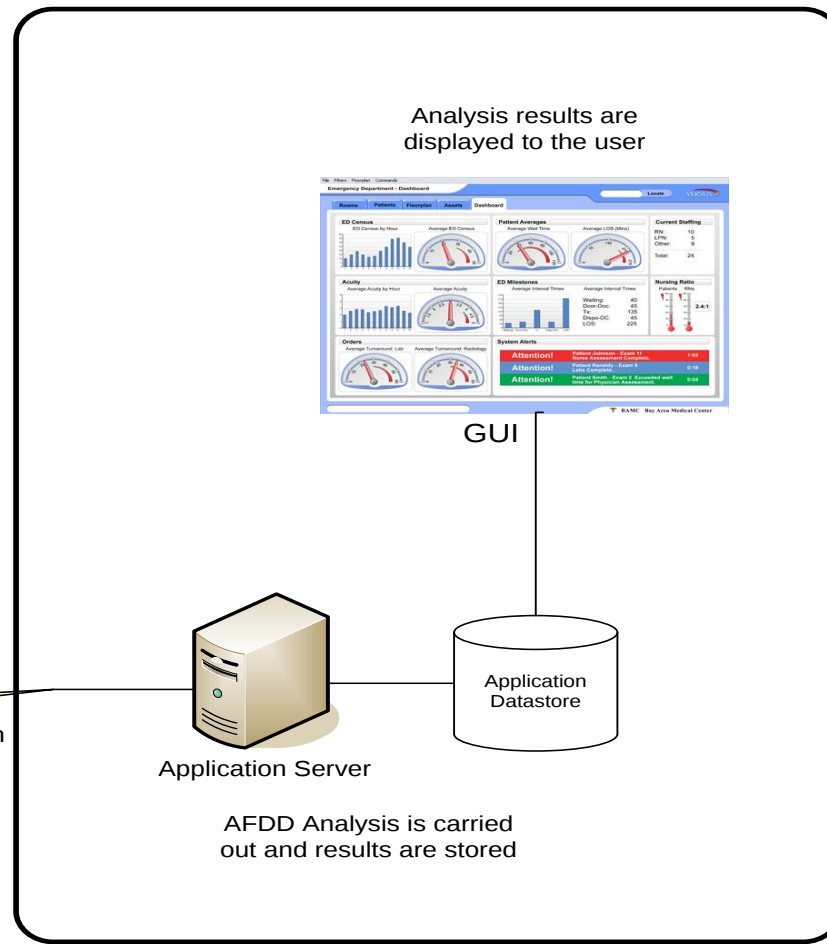
OBJECTIVE

AFDD tool requirements

LOCAL CONFIGURATION



REMOTE CONFIGURATION

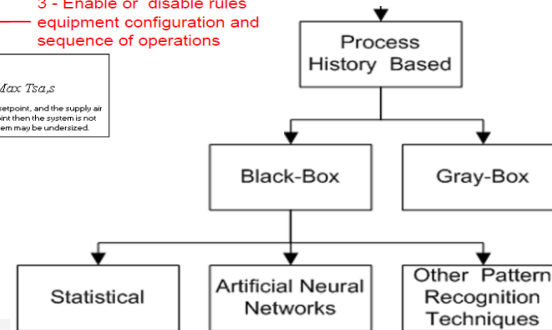
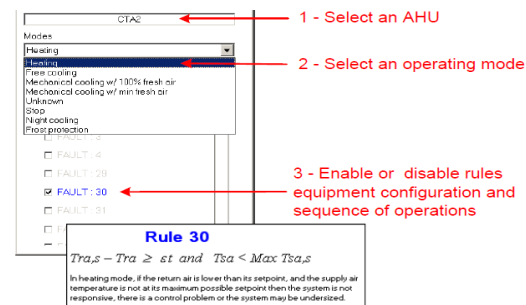
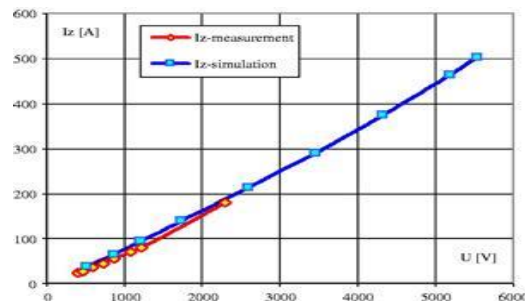
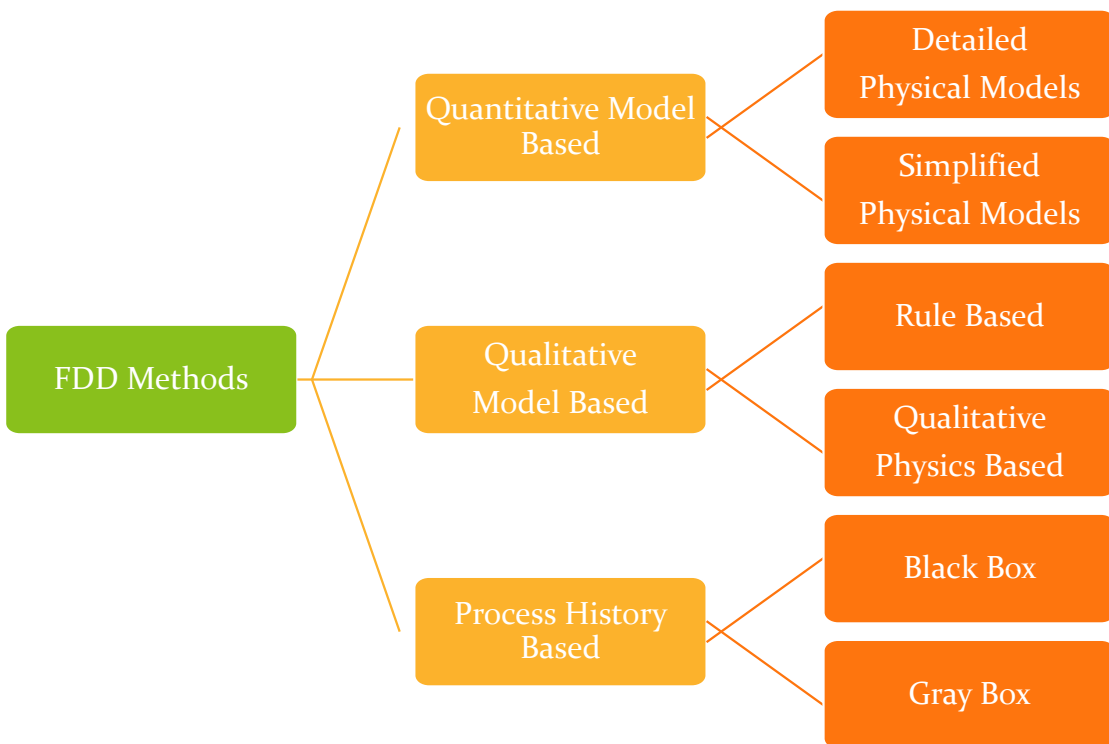


HTTPS Communication

OBJECTIVE

FDD Techniques

- FDD automates the process of detecting and diagnosing faults



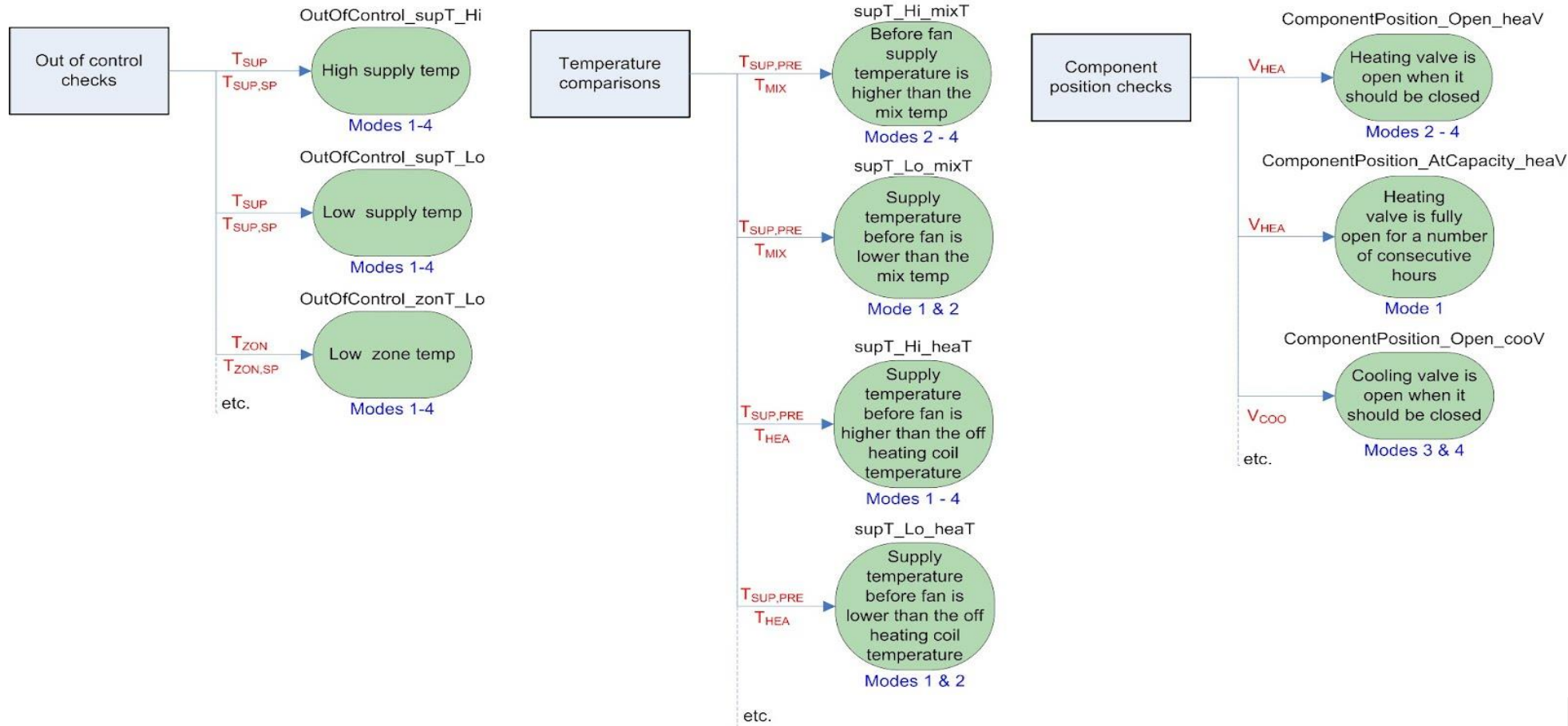
- A rule based FDD tool can be developed and implemented in industry relatively quickly utilising existing equipment

The Business Layer

- Business layer expanded on existing knowledge based rule sets by;
 - Applicable fresh air & recirculation AHU's as well as return air units
 - Detecting issues when the AHU is off
 - Calculating virtualised readings
 - Improved error threshold calculation
- A server side application performs the mode checks, calculates the virtual values, applies the business layer rules, and stores the results in the database



The Business Layer



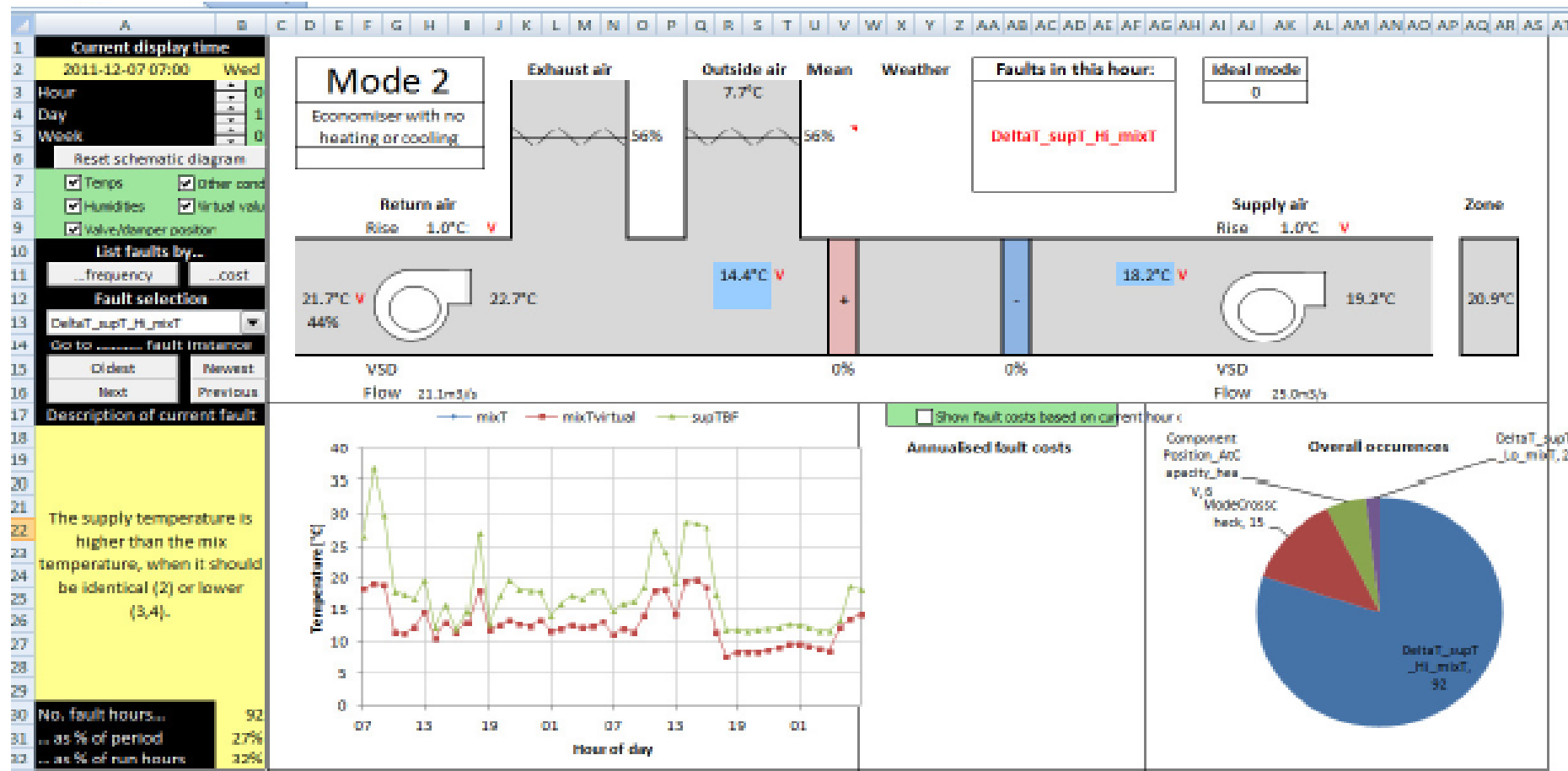
Design of Test Study

- > 100 AHU's available on 4 industrial and commercial sites
- AHU's were selected with
 - Different component and sensor layouts
 - Varying levels of instrumentation



Site	No. AHUs	Type	Design airflow [m ³ /s]	Type of zone(s) supplied	Operating hours per annum	BMS Software	Frequency of logged data
1	2	Constant volume	14	Office & canteen	8760	Trend	15 minutes
2	4	Constant volume	20	Production area	8760	Tridium	15 minutes
3	9	Variable Volume	13	Manufacturing Floor	6240	Cylon	15 minutes
4	3	Variable Volume	8	Commercial office space	6240	Schneider	15 minutes

AFDD tool in Alpha testing



AFDD tool in Alpha testing

Current display time
2011-12-07 07:00 Wed

Hour: 0
Day: 1
Week: 0

Reset schematic diagram

☒ Temps ☒ Other cond
☒ Humidities ☒ Virtual valv
☒ Valve/damper position

List faults by...
...frequency ...cost

Fault selection
DeltaT_supT_MixT
Go to ... Fault Instance

Oldest Next Newest Previous

Description of current fault

The supply temperature is higher than the mix temperature, when it should be identical (2) or lower (3,4).

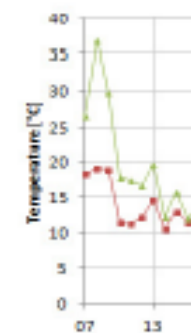
No. fault hours... 92
... as % of period 27%
... as % of run hours 32%

Mode 2
Economiser with no heating or cooling

Return air
Rise 1.0°C

21.7°C V
44%

VSD
Flow 21.1m³



ENGINEER'S REPORT & DAYWORKS SHEET

ACE
CONTROL SYSTEMS LTD.

Ballincollig, Co. Cork
Phone [021] 4873 005

Nasa Road, Dublin 24
Phone [01] 4036 202

REPORT NO. 31779

SITE	DEPUT		
CUSTOMER	ALIGHTY		
SITE CONTACT	DAVE COTAREL		
ENGINEER	TOM DEASY		
PROJECT NO.	MOSS	P.M.	VC

SURVEY ON OPERATIONS OF CONTROLS ON PRODUCTION FLOOR
AHU'S 6, 4, 8, 9

• CHECKED ALL C.H.W + L.P.H.W VALVES FOR SIGN'S OF PASSING
• ALL TEMPERATURE SENSORS CHECKED CORRECTLY CALIBRATED
AND ADJUSTED WHERE REQUIRED
• CHECKED CORRECT OPERATION OF FRESH, RECIRC AND EXHAUST DAMPERS
• ALL ASSOCIATED FIELD EQUIPMENT (IE V.S.D'S, ACTUATOR) CHECKED

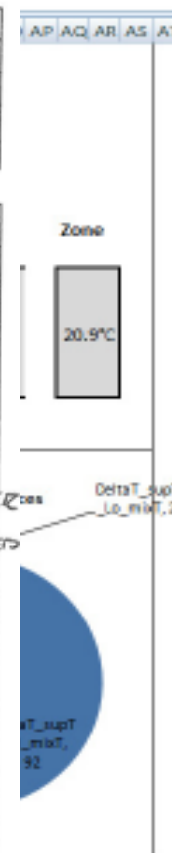
FOUND FOLLOWING ISSUE'S

AHU 6 (A) CHECKED ~~ON~~ ~~DIFFUSER~~ ON LEGS FOUND 3 AIR
DIFFUSER ON LEG 3 NOT OPERATING.

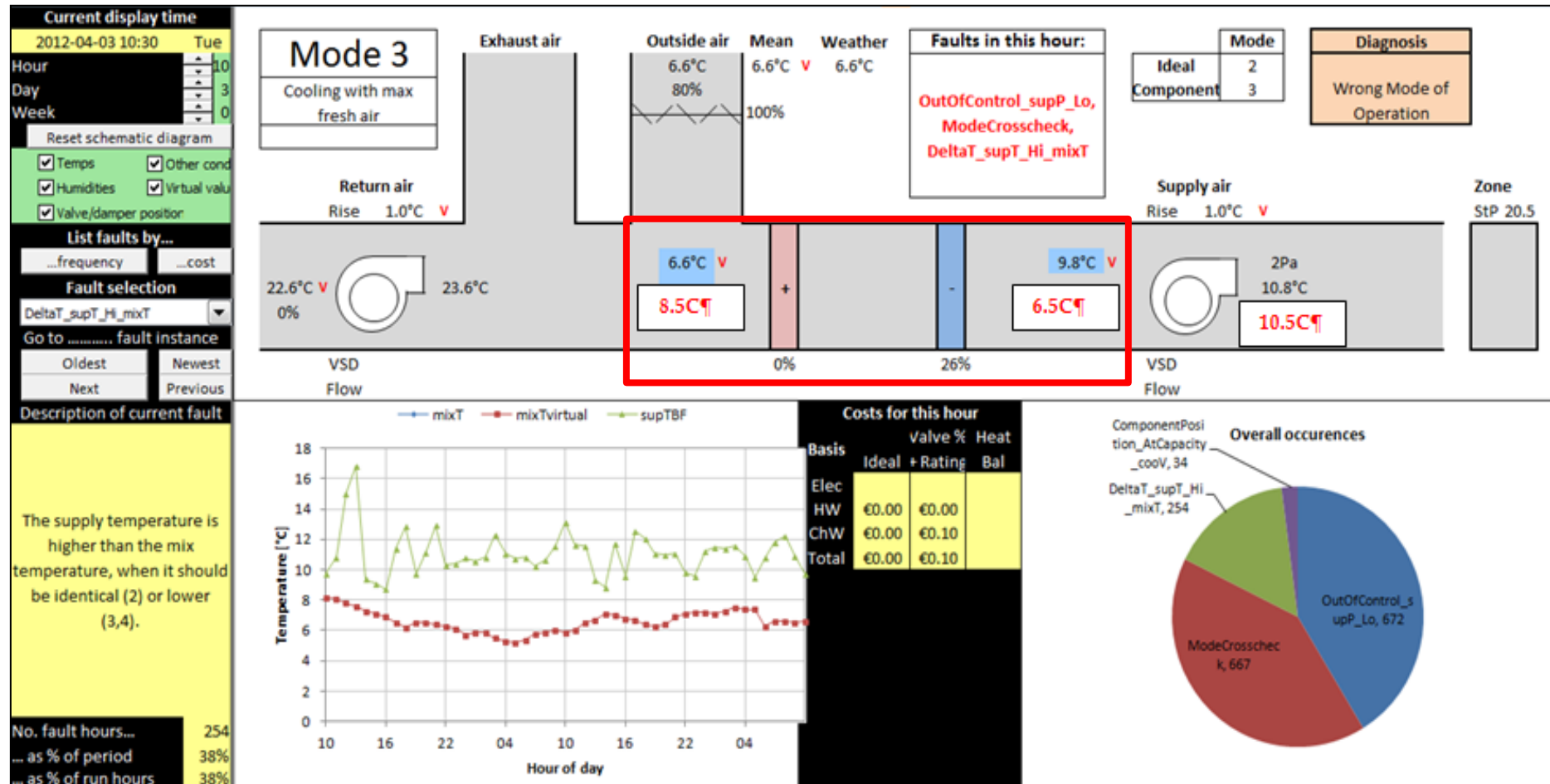
AHU 4 (A) RETURN MOTOR FAULTY RECOMMEND REPLACING AS THIS IS
EFFECTING OPERATION OF SYSTEM'S DAMPER'S AND IS CAUSING
AREA TO OVERHEAT (B) ~~FRESH AIR DAMPER ACTUATOR ON UPPER~~
~~DAMPER FAULTY~~

AHU 8 (A) RECIRC DAMPER NOT SEALING CORRECTLY LOUVERS ~~DAMAGED~~
(B) COOLING VALVE SLIGHTLY PASSING CLADDING AROUND VALVE TO
BE REMOVED TO DETERMINE WHAT SIZE VALVE.

AHU 9 (A) RECIRC DAMPER NOT SEALING CORRECTLY LOUVERS DAMAGED



AFDD tool in Alpha testing

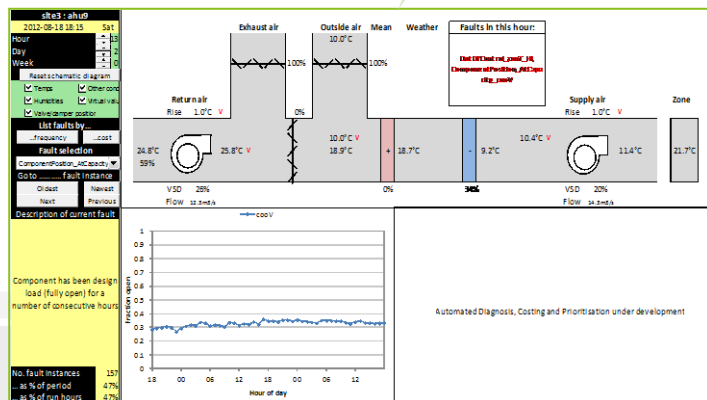
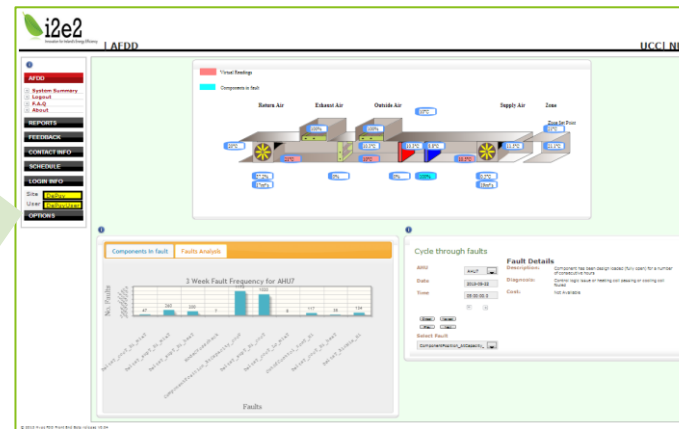


Alpha to Beta Testing

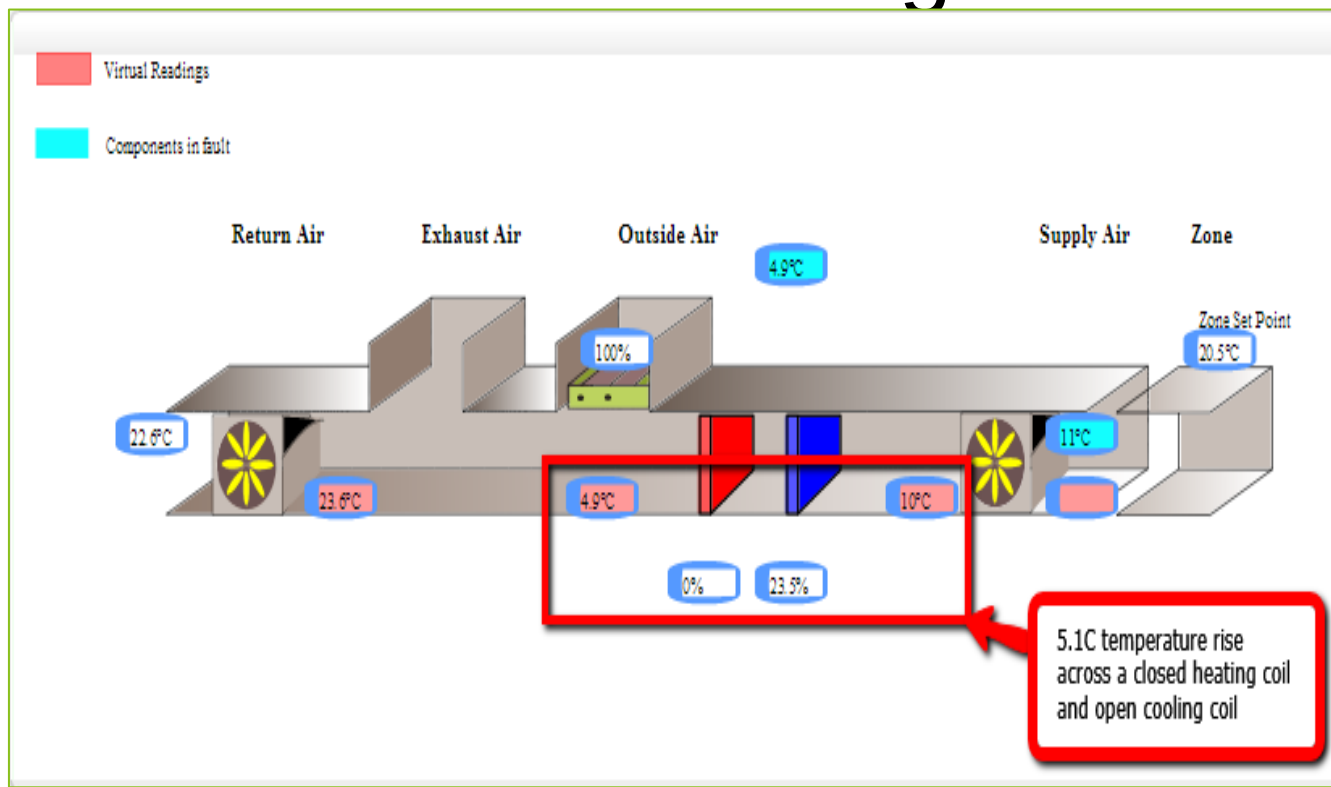
Browser based
GUI

Development of
web based
configuration
tool

Secure HTTPS
communication



AFDD tool in Beta testing



April 2012

November
2012

February 2013

March 2013

AFDD tool in Beta testing



April 2012



November
2012

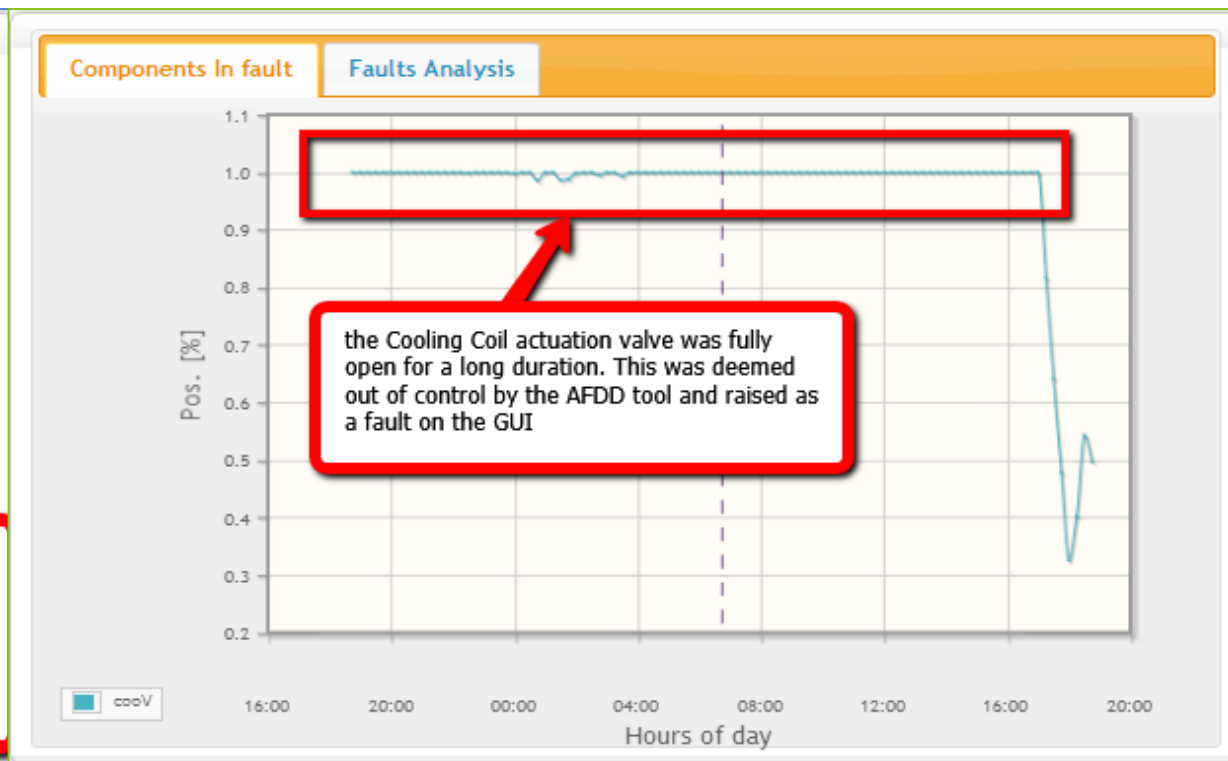
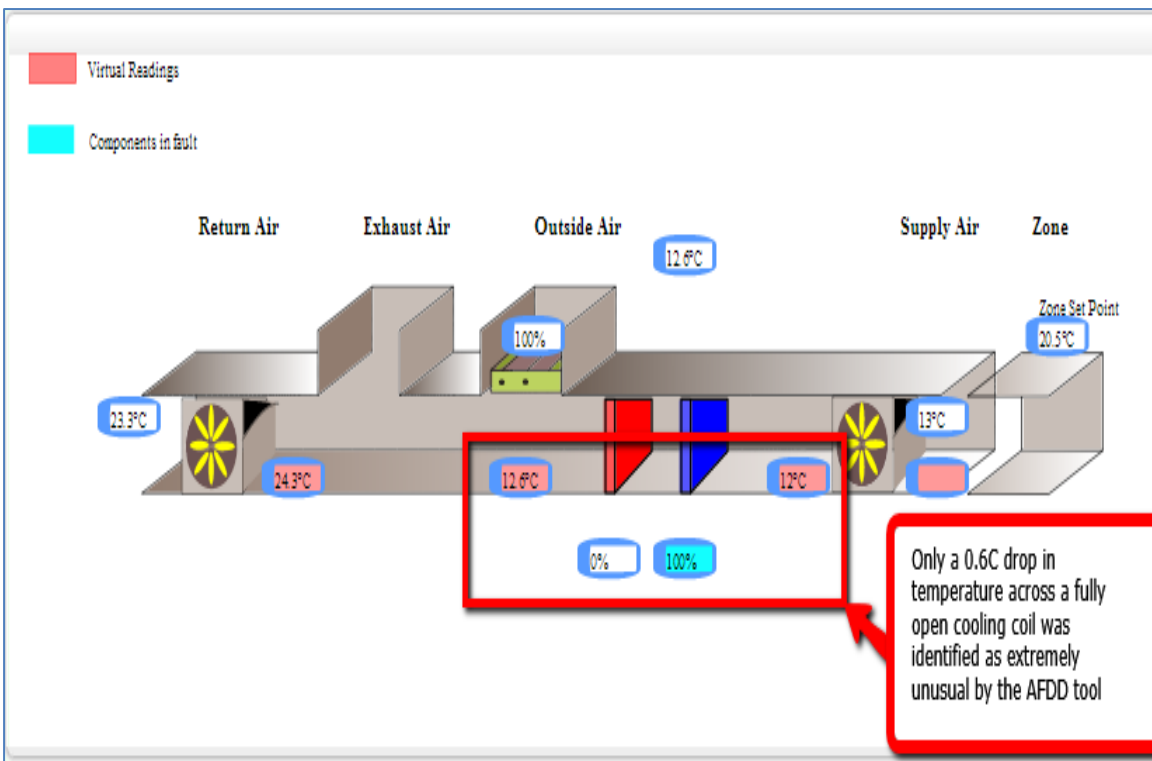


February 2013



March 2013

AFDD tool in Beta testing



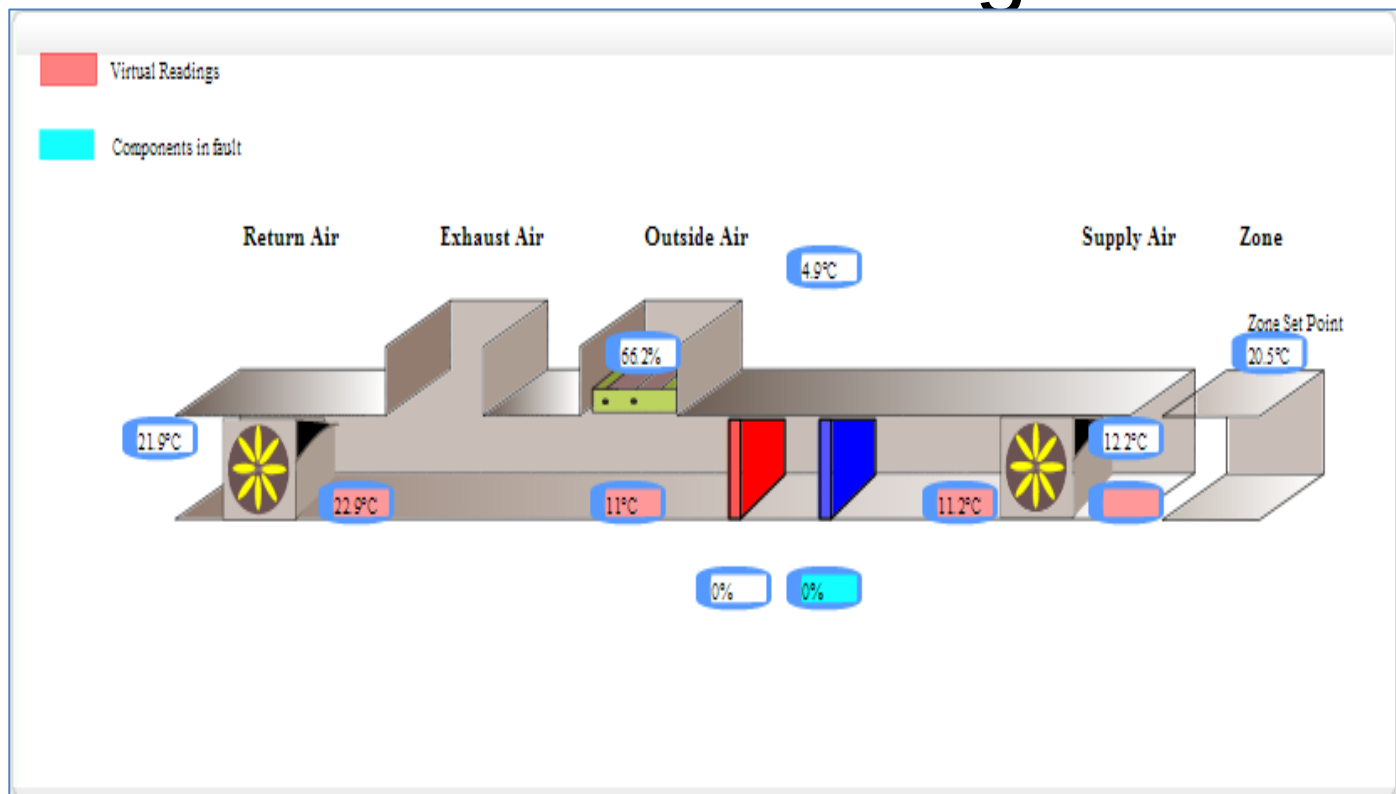
April 2012

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AFDD tool in Beta testing



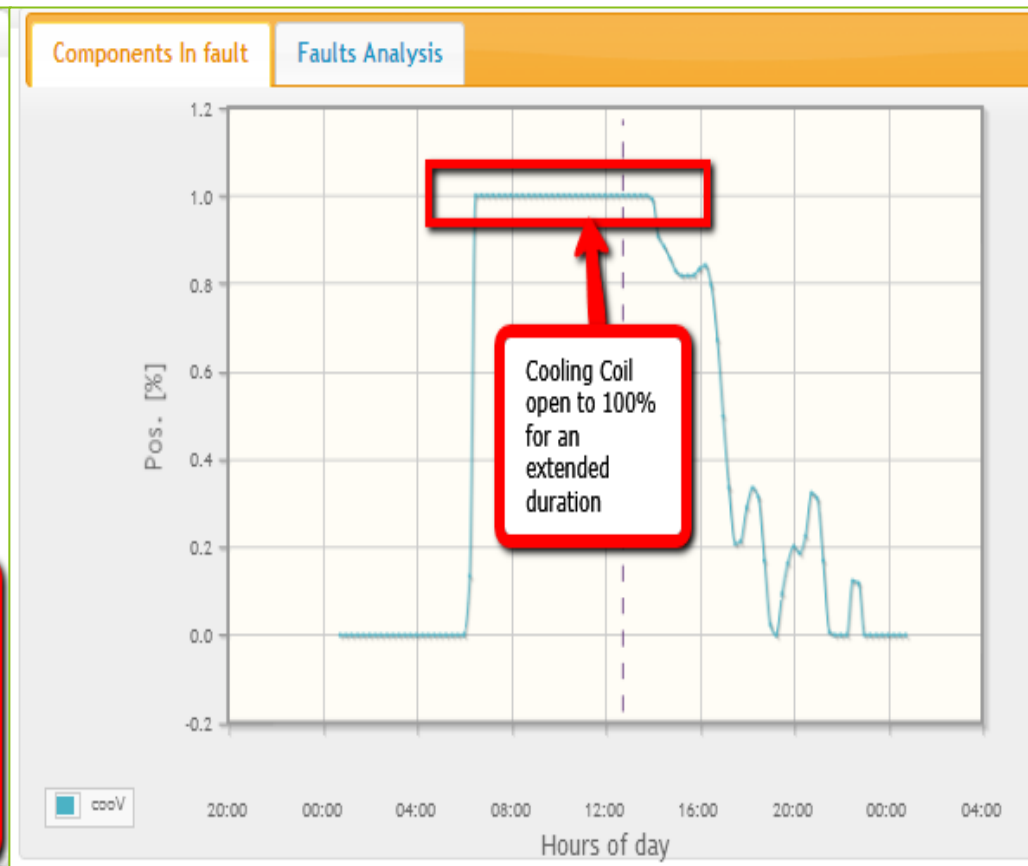
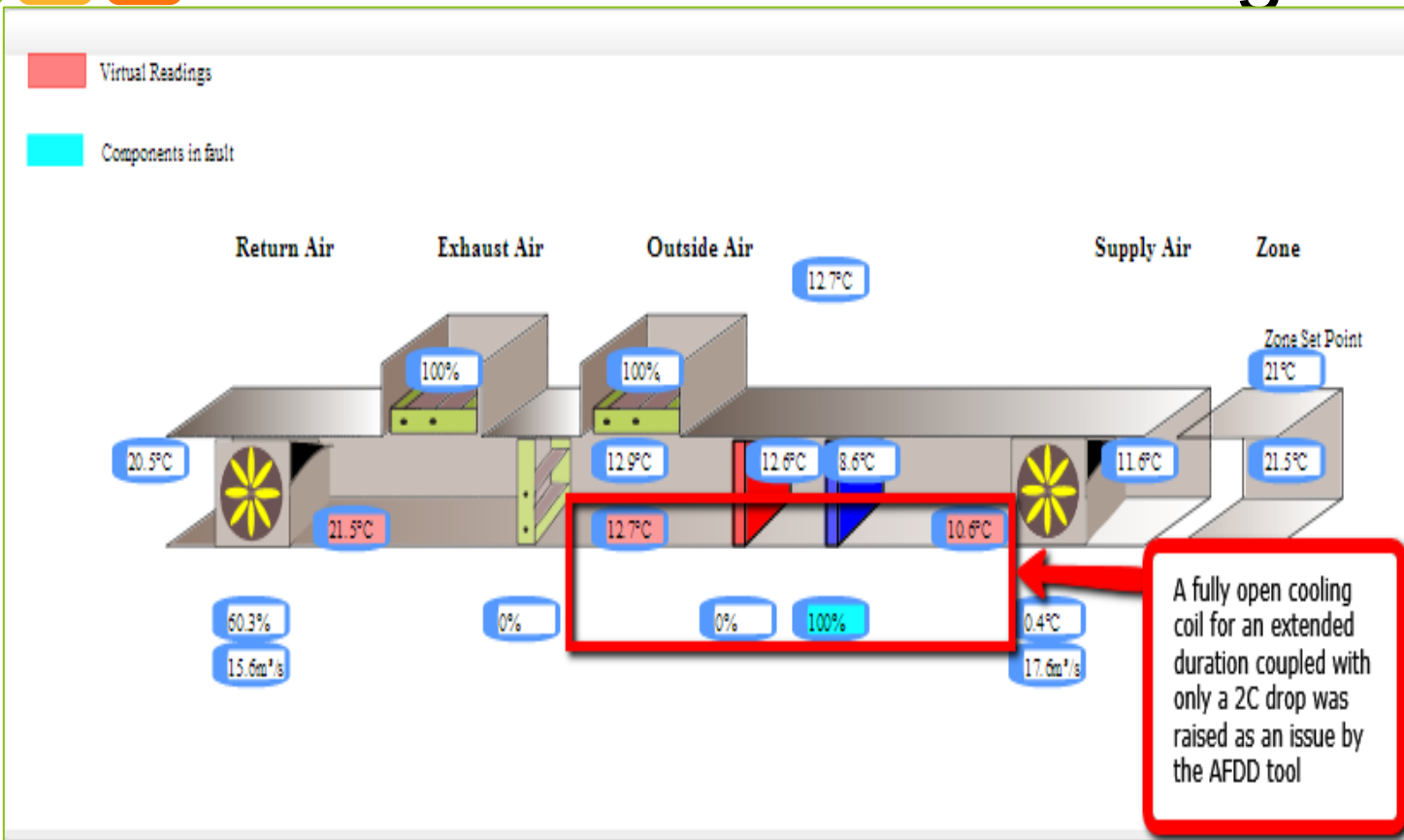
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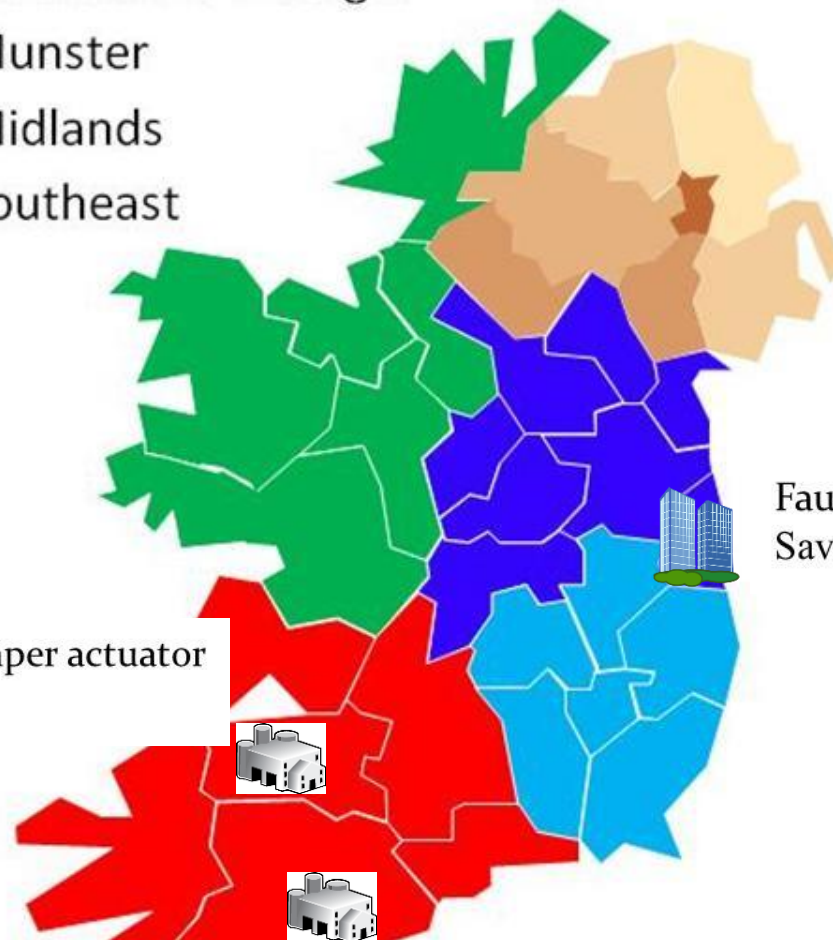


Requirements Versus Developments

Rationale	Requirement(s)	Framework/Tool Developed
Data Access Layer Flexibility	Compatibility with any BMS type or age	A generic data access tool was developed
Business Layer Flexibility	Compatible with various combinations of sensors and components	Calculation of virtual values coupled with “rule libraries”
Reliability	Low number of false positives/negatives	A error threshold applied to each rule based on rule makeup
Usability	User friendly graphical user interface (GUI)	A browser based GUI was developed
Fault Priority	Quantification and prioritisation of the diagnosed faults	Each fault is prioritised in terms of cost and frequency of occurrence
Scalability	Rapid setup time per AHU	A web based site configuration tool was developed
Low Cost	Ability to use existing measurements	First principal techniques and engineering computation utilised to calculate readings where none are present

Results

-  Connacht & Donegal
-  Munster
-  Midlands
-  Southeast



Faults: Passing heating coil, stuck damper actuator
Savings: €74,000

Faults: Passing coils, design issues
Savings: €26,000

Faults: Damaged dampers, high supply temperature, passing cooling coil
Savings: €53,000



Next Steps

- Extend the data access platform
- Minimise design data required
- Expand the business layer to incorporate humidity control AFDD
- Expand the prioritisation methodology
- Improve diagnostic capabilities
- Link to planned maintenance systems





If we knew what it was we were doing, it
would not be called research, would it?

Albert Einstein

Ken Bruton

i2e2 Researcher

Department of Civil & Environmental Engineering,

University College Cork

k.bruton@ucc.ie