The objectives of the EINSTEIN project was to formulate and integrate a number of state-of-the-art building control strategies to test their effect on improving the performance of buildings beyond traditional control approaches typically employed.

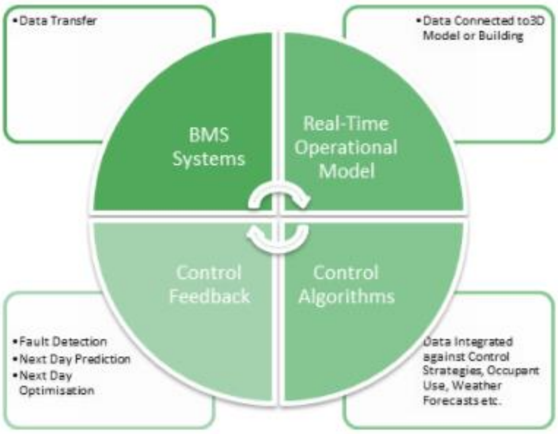
The three control strategies developed in the project relate to:

1. Fault Detection and Diagnosis (FDD)
2. Building Performance Prediction
3. Building Performance Optimisation

While Fault Detection and Diagnosis are generally the first step in "correcting" issues in a building, the second and third algorithm form part of what is described as a Model Predictive Control (MPC) solution, which essentially predicts and dynamically optimises the building performance beyond typical rule-based state-of-the-art control.

To implement an MPC control strategy a Reduced Order Model (ROM), which is representative of the building's key performance parameters, needs to be incorporated. The ROM is developed and used in conjunction with the algorithms in real-time to continuously predict and optimise the dynamic performance of the building and its systems to meet a set of objectives and constraints. These objectives and constraints can be multi-faceted, such as minimise energy cost while maintaining comfort based on the predicted performance of the building over the next number of hours. In this way, the MPC approach is predictive and pro-active in managing the building's performance, as opposed to re-active control found in current building control practices, such as proportional control.

The key objectives of the EINSTEIN project was to research, develop and test FDD and MPC algorithms to determine any benefit over traditional control strategies. The algorithms developed in the project are tested on both data acquired from real buildings for FDD, and on Advanced Calibrated Models (ACMs) based on existing buildings for MPC (ACMs are full dynamic building simulation models developed in IES's IESVE building simulation software, which are calibrated to ensure the models accurately effect the real performance of the building they represent).




EINSTEIN developments were tested and refined during the project for a range of demo sites, which included:

- MPC climate control tested for a residential building in Dublin, Ireland
- E-MPC for a residential building located in Findhorn, Scotland
- E-MPC for a commercial office building in Dublin, Ireland
- MPC and E-MPC for a block of 16 apartment buildings in Louth, Ireland
- An open loop system ID demo for fault detection in a room in TCD, Dublin
- Signal based fault detection for heating equipment for a typical two zone residential building

- Rule-based fault detection testing on real data from a University room based in Galway Ireland

All of the tests carried out resulted in improved performance of the buildings in terms of energy consumption and/or cost, while critically maintaining user comfort. Tested on both residential and commercial buildings the E-MPC and FDD algorithms show promise as practical solutions to improve the performance of buildings across the EU building stock. Testing of the MPC algorithms on the models developed resulted in demonstrated energy savings in the range of 15-17%, with energy cost savings associated with E-MPC algorithms ranging from 35-40%. Although difficult to associate a definite energy and cost saving with the FDD algorithms implementation, all of the tests successfully resulted in the automated identification of faults which in itself leads to the avoidance of energy and cost waste, as and likely reduce the possibility of user discomfort due to mechanical faults.

Considering that buildings consume almost 40% of energy in the EU, better management of operational buildings will positively affect society both socially and economically through the reduction in energy production required, reduced requirements on the grid infrastructure to meet this demand and the minimisation of operational energy costs, all while maintaining/improving user comfort. The successful prototyping of the algorithms developed in EINSTEIN opens up new and real opportunities to advance beyond classical building control approaches by deploying solutions that are “Smarter”. The key benefits of the demonstrated EINSTEIN approach are that it:

- Addresses the complexity of modern buildings in terms of the systems and dynamics involved, as well as external factors such as weather;
- Takes advantage of the current technical evolution and progression in meters/sensors and smart devices to provide more building and user data at lower costs
- Aim’s to connect into existing building control infrastructure to reduce the cost and effort of installation of the solution
- Results in better and more efficient building management on a continuous basis, and greater flexibility for control through Building Management Systems (BMS)

You can find out more information about the EINSTEIN project and its results at www.einstein-iapp.eu or contact Catherine Conaghan (catherine.conaghan@iesve.com)