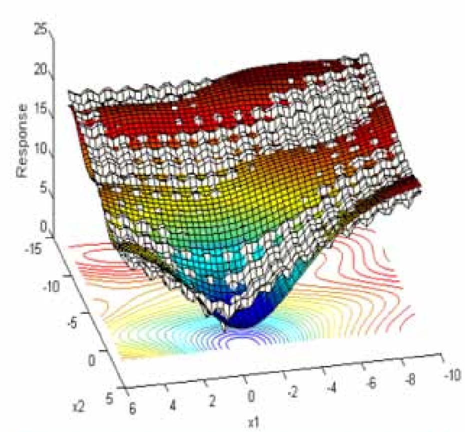
Executive publishable summary

The design of self – diagnostic structures usually requires several physical tests in order to evaluate the performance of an SHM system and the structure itself. The SENCES project focused on the development of a software tool called OSAS platform that will use validated analysis tools instead of expensive physical tests. With this platform, the designer will be able to model a self – diagnostic structure and perform diagnostics and prognostics using simulated data coming from Multilevel Structural Analysis. Moreover, the platform will have the ability to perform design optimisation and to select the best SHM system properties.

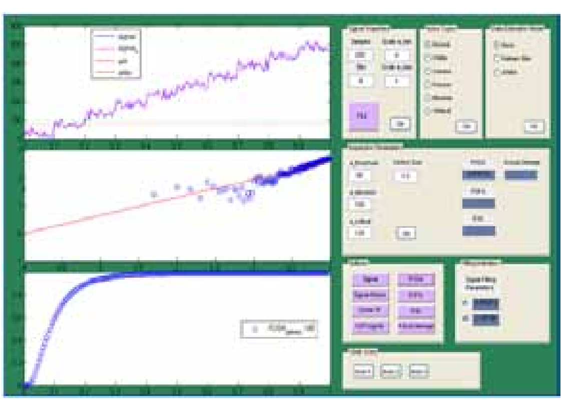
In the course of realising the OASAS platform the following activities have been carried out:

1. Approximation techniques have been developed to build computationally inexpensive surrogate models (or meta-models) to replace expensive-to-run multilevel analysis code. The developed meta-models will be used to produce valuable information to perform Diagnostics and Prognostics. Two meta-models are going to be generated for the multilevel analysis model. A global and a local meta-model. These surrogate models use sampled information from high–fidelity analysis codes in order to generate faster and lower–fidelity approximations. Sampled information is determined by the use of Design of Experiments (DoE), which create a set of points that the analysis response will be computed. A Permutation Genetic Algorithm (PermGA) method has been developed in order to generate a high – quality DoE. In order to build reliable surrogates, a Kriging predictor has been combined with a typical Response Surface Method (RSM). The developed Matlab code is developed in a Graphical User Interface environment and has three main procedures: Design of Experiments, Kriging Approximation and Adaptive LHD (for inherited DoE).



Kriging Approximation (coloured surface) of 2-D Ackley function (white surface) using 20 points.

2. A Diagnostic theory and tool has been developed to detect and identify damage using simulated signal information and could be used to assess and optimise the reliability of SHM system. The model takes into account the signal characteristics and uncertainties (e.g. signal noise, signal threshold, etc.) and determines the detected damage parameters (type, size and location). It also takes into account the quantification of the uncertainty coming from the signal. Further to the original expectations, the theory has been complemented with the capability of determining the actual damage size characteristics using the results of the detected state as well as with updating schemes of the damage state when additional monitoring data becomes available,



based on Bayesian statistics. Thus, it is able to represent the "true" damage state and its characteristics as a function of time/cycles.

3. A comprehensive and detailed Prognostic theoretical tool has been developed to compute the structural behaviour over time. Initially, the **Probability of detecting a life – limiting damage** is computed using updated information (multiple monitoring events) coming from different SHM systems with different attributes (mixed mode procedures). The next step is to compute the **Probability of structural failure due to a non – detected damage** for the above cases (multiple – mixed mode). The third step is to calculate the **Probability of not detecting a life-limiting damage with a specified rate of occurrence**. In the end the synthesis of the above is generalized in order to compute the **Probability of Failure for various damage types in different subcomponents (or zones) of the**