# LC-Maintenance Plan: An Expert System for Strategic Maintenance Planning

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## 1.  INTRODUCTION

Recent changes in legislation have made housing associations (HAs) more financially responsible for all aspects of maintenance of their new housing stock. Because of the levels of funding within HAs and the need to provide accommodation at a "fair rent," the planning of maintenance, and the consequent planning of expenditure has never before been so vital. Moreover, most literature on maintenance, including government reports and research by professional bodies or academic institutions, identifies a need for improvement in decision making regarding building maintenance [1, 2].

The project has provided an expert system (ES) that assists maintenance and finance officers in strategic planning of maintenance. The system (called EMMY) is not a database for HAs building stock and their tenants, or a program that itemises maintenance jobs, handles invoices, and performs various accounting tasks. It is a strategic management tool

While there are many programs in existence that estimate the life-cycle costs of buildings or provide maintenance management, they all share two major problems:
* They require voluminous data input to describe each building.
* They function as "black boxes;" that is, data is put in and answers are given with little indication of how the answers were generated and what variables affected the results.

Storing all the relevant information in a database and selecting only that information required for the building under consideration is one method of reducing data input. In this way one can construct a model of the building from pre-packaged components, and calculations can then be performed using spreadsheets. This approach has the advantage of reducing data input and being relatively low cost [3]. Although there is a variety of computer software available to the industry, the technology with potentially the greatest benefits is still the least known and most rarely used - the ES [4]. ESs can directly address both of the problems outlined above:
* by reducing the need for data input,
* by explaining how it arrived at its results
* and by allowing users to explore different alternatives.

This paper first briefly describes the history of HAs and explains why they would benefit from this technology. The architecture of the EMMY system is described next, showing potential benefits of the system and paying particular attention to the advantages of EMMY over conventional software.

## 2.  THE POTENTIAL FOR ES IN HAS

HAs are non-profit making bodies providing housing and/or hostels at low rents. They are managed by committees of members with salaried officers to run their affairs. Until 1989 the primary method of obtaining moneys for maintenance was by a deductible allowance from rental incomes that was increased by "Major Repair Capital Grants" from the Housing Corporation.

The situation changed with the publication of the final circular of the Housing Corporation in Scotland [5]. This stated that all new submissions for development funds would be subjected to an annual provision to be laid aside for major repairs, replacements and renewals. This policy was subsequently implemented in England, whereby all major new schemes would require the establishment of sinking funds [6]. Consequently, for the first time HAs were forced to calculate the likely maintenance costs of buildings to estimate accurately the provisions for the sinking fund.

A study conducted at Salford University on the potential for ESs within HAs [7] identified strategic maintenance planning as joint highest priority with the formulation of alternative schemes at the briefing stage. Thus, the HAs themselves view strategic maintenance planning as essential in the future.

## 3. OVERVIEW OF THE MAINTENANCE ES

An initial design constraint upon EMMY (from Maintenance Expert or "M," "E") was that a person who was not a computer expert could consult with it. EMMY therefore employs a graphical user interface and is straightforward to operate. EMMY is implemented in the ES shell Kappa-PC® running under Microsoft Windows.

### 3.1. The building description module

EMMY is composed of three separate functional modules. The first of these modules is the Building Description Module. This contains the knowledge about buildings that is represented in two different forms:

- **Typical descriptions:** These represent descriptions of a typical example of a particular building. These can be altered by the user to account for local differences in building design or construction.
- **Description rule base:** These store knowledge about building design and materials that can be applied to any hypothetical building within certain limits.
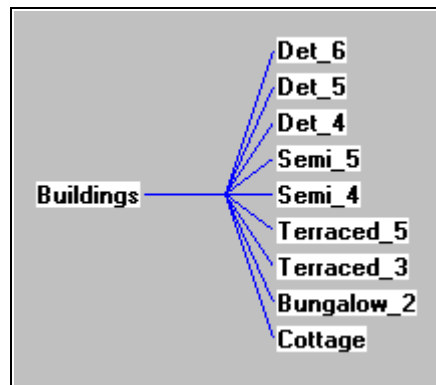


FIGURE 1. Building Templates

By providing both these forms of knowledge a user can either select a building from one of the typical buildings or construct a building from first principles. Figure 1 shows some of the building descriptions available to the user (the number after each house type refers to its number of occupants). The rule base is also used whenever the user changes a value of a typical building description. For example, the system knows that a pitched roof should not have an asphalt and gravel covering or that a six person house should not have twenty bedrooms.

### 3.2. The maintenance module

This contains a set of maintenance tasks that are only applicable under certain conditions; some of these tasks are shown in Figure 2. Hence, the task of repointing the brickwork would not apply if the building does not have brick walls. However, the task of replacing windows would apply to all buildings. In the latter instance, EMMY will then find out what type of windows the building has (e.g., hardwood), and from this it will calculate their life expectancy. This figure will consider the materials and various environmental factors (e.g., climate, pollution). From this information, an inspection, repair, and renewal plan can be prepared for the windows. This process can be repeated for all the elements in a building that require maintenance. This generates a complete maintenance profile for the life of the building, and for all the buildings within a housing scheme. EMMY can process up to 5000 buildings at once.
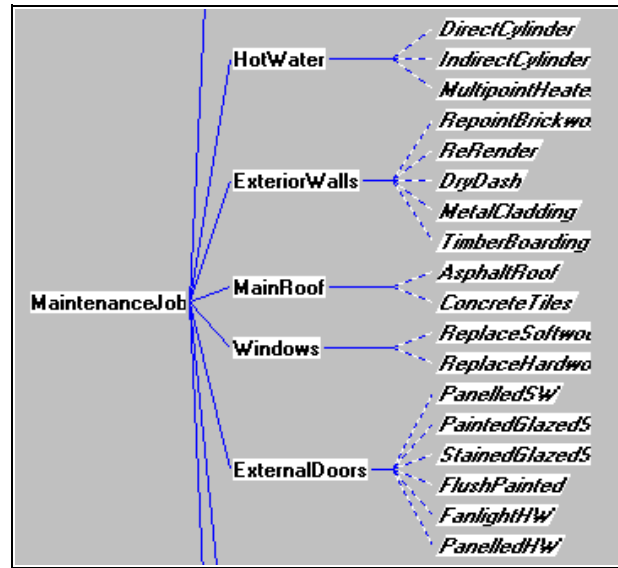
FIGURE 2. Some Maintenance Jobs

## 3.3. The calendar module

This takes each maintenance plan and displays it using a graphical summary for the entire projection that shows peaks and troughs in estimated expenditure (shown in Figure 3). Individual years within the projection period can then be examined in detail. The detailed annual analysis lists the maintenance jobs, their cost, and a textual description of the work entailed. At this level users can edit the predicted plans by moving jobs back or forward in time, and by adding and deleting work.

## 4. DIFFERENCES FROM CONVENTIONAL SOFTWARE

EMMY's knowledge about houses enables it to construct a detailed model of a dwelling from default knowledge and general rules. Just as most people when asked to visualise a three bedroom house will envisage similar, but not identical, houses, so can EMMY. To initiate a consultation with EMMY, a user chooses the closest building type to those they are considering. The user can then view all the assumptions made and if necessary make alterations. If they make alterations, EMMY's rule base ensures changes are propagated to all the elements they affect. This ability reduces the data input requirements dramatically since the users do not have to input every window, door, boiler, etc.
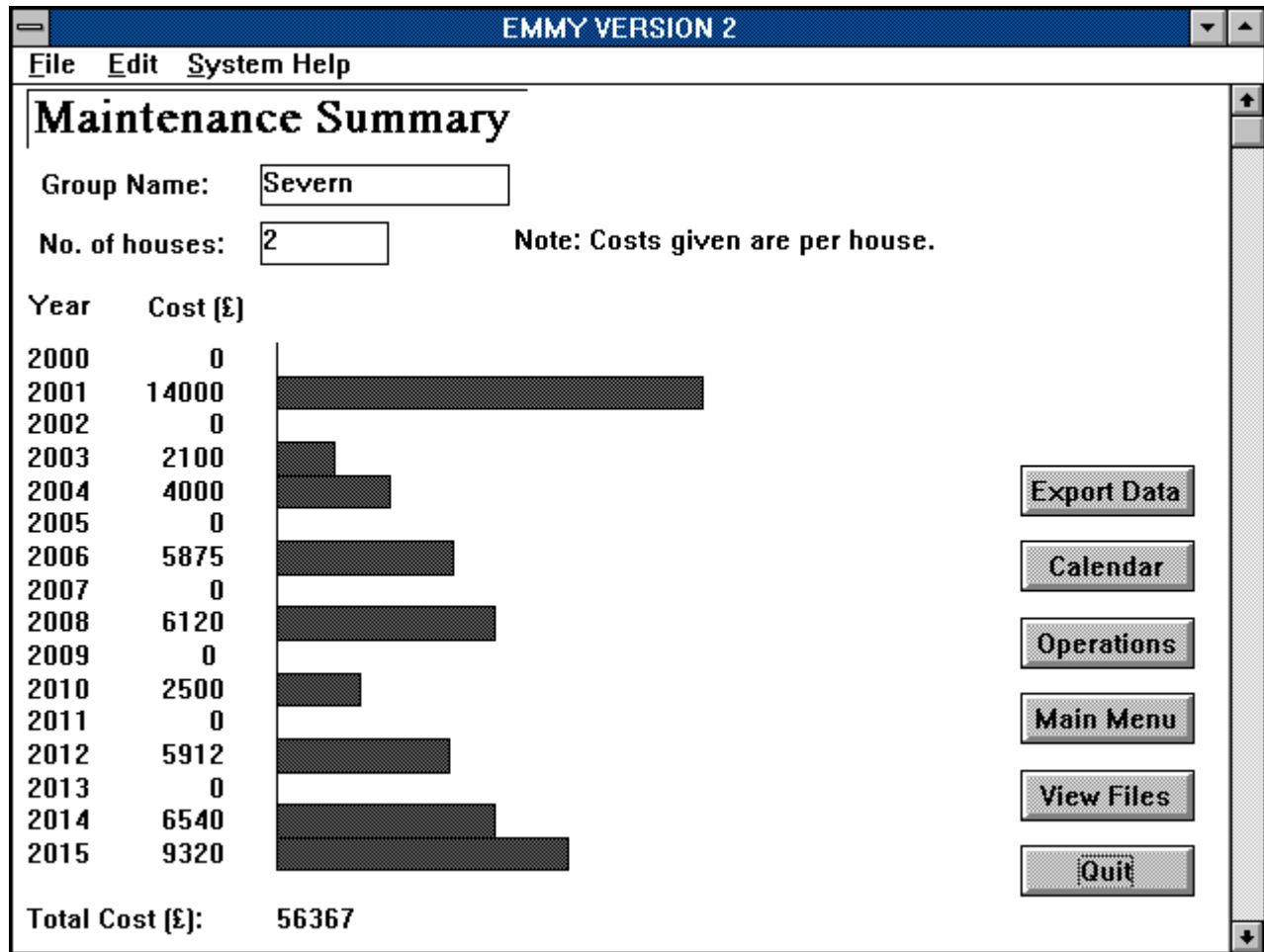
FIGURE 3. A Maintenance Summary Screen

This is of particular importance today. When a HA commissions a new scheme it possesses the architects' plans and the Bills of Quantity. From these it can determine the buildings' materials and their quantities without inspecting the properties. However, increasingly HAs are buying buildings from speculative private developers or are taking over local authority building stocks. In these instances the HAs have less detailed information about the design and the construction of their stock.

Fortunately, reasoning with uncertainty or incomplete knowledge [8] is a strength of ESs. Because EMMY will make a reasoned assumption where specific information is unavailable it could be used to assess the probable maintenance costs of buildings when the HA does not have detailed information.

## 5. POTENTIAL BENEFITS

Besides performing annual maintenance, it is vital that medium to long-term plans are made. The objective of this forward planning is to generate financial estimates for sinking funds. However, maintenance managers are often presented with a standardised plan rather than one tailored to their local needs. Users of computerised systems often rely blindly on the results without realising that the system has only been programmed with standard prices and statistical averages of life span. These programs cannot consider individual variables such as climate or quality [9]. However, EMMY enables strategic decisions regarding maintenance to be made with greater confidence, and therefore several advantages accrue:

- The system runs on comparatively low cost hardware (PCs) and is stand alone; (i.e., There is no requirement for it to link into any existing systems, although it can export it results in spreadsheet or database formats).
- The user will not need to be the HA's "computer expert" since the system is comparatively easy to use.
- A HA officer will not have to spend many hours entering data to obtain results.
- The methods by which results are obtained are accessible to the user. This increases confidence in the results.
- Information can be easily tailored to individual buildings and to local conditions and practices

- The user can ask "what if" to consider different alternatives.

Besides the benefits stated above, EMMY may also have a role in costing design alternatives with regard to maintenance. This approach overcomes the problems inherent in traditional cost modelling techniques that are inappropriate for realistic building design evaluation over the life cycle of a scheme [10].

Since users are not just provided with "the results," but are instead encouraged to explore various possibilities, they must take responsibility for the resulting decisions. EMMY is a management tool, not a decision maker.

## 6. CONCLUSIONS

EMMY has taken two man years to reach a "Usable" stage. This stage is defined by the ES development method the project has used. This method or "Client Centred Approach" (CCA) divides the development of an ES into seven stages [11 & 12]. EMMY is now undergoing testing by several HAs and building surveyors at their offices. A further period of work will then be required to bring the system to a "Saleable" state. Eventually EMMY will be linked to other ESs in development at Salford University. These systems budget the cost of residential schemes [13], and estimate project cash flows [14]. Once implemented they will provide a powerful set of tools enabling strategic decisions concerning many aspects of housing to be supported. This will be of particular benefit to the smaller HAs who may lack specific professional expertise and will ensure a more rapid spread of good practice throughout the sector.

The CCA provides useful milestones that enable the participants in the project who are not computer scientists to take an active role in assessing the progress of the project [12 & 13]. This addresses some of the problems associated with rapid prototyping [15], in particular, auditing the development process. The CCA is now the subject of a three year research project that aims to produce a working ES development method suitable for small and medium sized enterprises.

We believe that improving the flexibility of ESs once they are in use will crucially effect their acceptance in the construction industry and in other sectors. Towards this end, research building on the lessons of this and other development projects is in progress [11 & 12].

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