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Document History

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0. Preamble

This Chapter is intended to provide a brief overview of UKPMS processing and is aimed at those who require an appreciation of how UKPMS processes data and how to interpret the results produced. It also provides an introduction to this Volume of the User Manual, *UKPMS Processing*, and directs the reader to other Chapters for more detailed information.

1. Introducing this volume

This Volume of the UKPMS User Manual is concerned with how UKPMS processes data. It is divided into a number of Chapters, each of which deals with a different aspect of processing:

- **Overview of UKPMS Processing**

This provides a simplified overview of UKPMS processing for those who require a general understanding of what results are produced and how they are obtained.

- **Details of UKPMS Processing**

This Chapter provides more detailed information about UKPMS processing. It is intended as a reference guide for those who need to know in depth how the processing logic operates.

- **Treatment Definitions**

This Chapter provides definitions of the treatments suggested by UKPMS, and is intended for those who need to interpret and use the results from UKPMS.

- **Rules & Parameters**

This Chapter provides the rationale for the Rules & Parameters. It explains how they control the processing and gives the reasoning behind the values in the current default Rule Set.

- **Best Value Performance Indicators**

This Chapter explains how the Best Value Performance Indicators are calculated from UKPMS data.

This Volume does not include information about the UKPMS network, or about the data collected for UKPMS; these topics are covered in Volume 1 *UKPMS Fundamentals*, Volume 2 *Visual Data Collection for UKPMS* and Volume 3 *Machine Data Collection for UKPMS* of the UKPMS User Manual.

2. What are the aims of UKPMS processing?

The aim of UKPMS processing is to use the network, inventory and condition data available to produce an analysis of the condition of the network, the treatments suggested and an indicative budget for the work required. The processing logic does not aim to provide detailed schemes of work, or detailed costings; these are not possible without more detailed information or a site visit by the engineer. Instead the results from UKPMS provide a preliminary indication of areas for investigation and allow the engineer to focus on those parts of the network most in need of attention.

3. What does UKPMS processing produce?

UKPMS processing splits the network up into defect lengths, and then reports the condition, treatment and ranking for each of these defect lengths. Each of these concepts – defect length, condition, treatment, ranking – is now explained in turn. A further, more detailed account of how these are produced by UKPMS is given below in Section 5 *How is UKPMS data processed?*

3.1 Defect Length

The UKPMS network is divided into sections, and within each section there may be several features (e.g. carriageway, footway etc) and several XSPs (cross sectional positions). XSP is the term used in UKPMS to denote transverse position (e.g. Lane 1, Lane 2 for carriageway, or left, right for footway). See Volume 1 Chapter 4 *Network* for more details about the UKPMS network and the definitions of section, feature and XSP.

During UKPMS processing each XSP of each feature of each section is considered separately, and is further divided into defect lengths. The start chainage and end chainage for each defect length may be controlled by the user or may be derived automatically during processing if desired.

Figure 1.1 below depicts some defect lengths on a 2-lane carriageway with a left and right footway and a right cycletrack.

Figure 1.1 – Example defect lengths

The defect lengths are indicated by the shaded parts of the diagram. This example section has four defect lengths as listed in the table below:

Section	Feature	XSP	Start	End
A123/999	CW	CL1	40	180
A123/999	CW	CR1	20	100
A123/999	FW	L	0	40
A123/999	CT	R	80	140

Table 1.1 Example Defect Lengths

Note that defect lengths do not necessarily cover all of the section; in general defect lengths are only produced where there are some defects present. So for this example, the right footway has either not been assessed or has no defects recorded.

3.2 Condition Index

UKPMS can process condition data from many different sources, both visual and machine-based. The defects recorded are combined together, using the Rules & Parameters and UKPMS processing algorithms, to form condition indices. A condition index (CI) is a measure of the condition of a particular aspect of the defect length. So, for example the Edge CI provides information about the condition of the edge of the carriageway, and it is calculated from defects which measure the deterioration of the edge. Other condition indices include Structural, Wearing Course, Surface Properties and Overall.

Certain condition indices only apply to particular types of pavement; for example the Reflective Cracking CI is only calculated for Leanmix and Covered Concrete pavements.

3.3 Treatment

The condition indices are used, together with other information about the defect length (e.g. pavement and hierarchy), to provide a suggested treatment for the defect length. The treatments are governed by the Rules & Parameters, which determine which treatment is suggested for a particular combination of condition indices. In some situations multiple treatments may be suggested, for example edge works in conjunction with surface treatment.

In addition to suggesting a treatment, UKPMS also calculates the quantity of treatment required and the cost (based on a table of unit costs for each treatment). These quantities and costs are necessarily broad-brush, since they are based on typical unit costs for that treatment, rather than the particular circumstances pertinent to the site in question. The unit costs are supplied by the user of the UKPMS system, and will therefore differ from one authority to another.

3.4 Condition Ranking

Ranking is the process used by UKPMS to determine the relative importance of defect lengths requiring treatment and is used during the Budget process to determine which defect lengths should receive funding. Condition ranking is the method used to provide an objective 'worst first' list.

4. What data is required for UKPMS processing?

UKPMS processing uses the following three types of data:

- **Network**

The network data provides the default carriageway and footway hierarchies, which are used if no feature hierarchies[1] are recorded in the inventory. The network data also provides the 'step level' and 'off-carriageway tied' indicators which are used in the selection of treatments. The 'step level' is set if there are reasons to prevent treatments which would raise the carriageway and the 'off-carriageway tied' indicates that associated off-carriageway works are required if the treatment raises the carriageway. (For more details see Chapter 2 *Details of UKPMS Processing*). If inventory data is not available then the 'road type' is used in conjunction with the road hierarchy to provide a default feature width.

- **Inventory**

[1]Volume 1 Chapter 4 *Network* explains about feature hierarchies in more detail. In brief, each carriageway, kerb or footway is assigned to a hierarchy depending on its importance. In the current Rule Set (RP6.01) cycletracks and verges do not have hierarchies defined.

Inventory data is generally optional for UKPMS processing. It provides dimensions (via chainages and widths) for each feature of the section, plus a feature hierarchy and construction type.

The feature hierarchy is used during the selection of treatments and condition ranking.

The construction type is used to 'refine' the pavement type recorded for the condition data. For example, if a defect has been recorded with a pavement type of 'Bituminous surface, unknown construction', and the inventory construction type at that location is 'Covered concrete' then the defect will be processed as a covered concrete defect.

The dimensions of the feature are used to determine the treatment quantities, and hence the treatment costs. They are also used when processing certain types of data (such as defect area) in order to calculate the percentage defectiveness. If inventory is not available then the default feature width is used to provide the feature area.

There are two circumstances when inventory is essential for processing:

- When processing footway data for BVPI 187 then footway dimensions and hierarchies are essential.
- When processing data containing defects for joints, then an inventory for the joints is essential.

- **Condition**

UKPMS can process data from a number of different sources. The main types of survey in current use are:

- Coarse Visual Inspection (CVI)
- Detailed Visual Inspection (DVI)
- SCRIM
- GripTester
- SCANNER/TTS
- Machine measured rutting (CRUT & DRUT)

However, there is also the capability to process Deflectograph data (sometimes used for scheme specific situations) and HRM data (rarely used in practice).

Each of these types of survey measures a defect at a location (section/feature/XSP/chainage). The user can select which surveys to process, and then UKPMS will combine together the information from all the different types of survey to provide condition indices, treatments and rankings. More information is given below in *How is UKPMS data processed?* and in detail in Chapter 2 *Details of UKPMS Processing.*

5. How is UKPMS data processed?

UKPMS processes data in a series of stages. These are outlined below, and then expanded in Chapter 2 *Details of UKPMS Processing*.

The function within UKPMS used to process data is referred to as the 'Automatic Pass'. All accredited systems must provide an Automatic Pass, and they are tested to ensure that each system produces the same results over a set of test runs. (See Volume 1 Chapter 2 *Beginner's Guide to UKPMS* for more details of the accreditation process).

UKPMS can store many sets of processed results, in different Automatic Passes. Each is distinguished by an Automatic Pass identifier which is set up when that particular Automatic Pass is first run. This allows the results of different Automatic Passes (perhaps using different data) to be compared with each other.

The Automatic Pass in UKPMS has been designed to offer flexibility (in what data is processed and how it is processed) and consistency (via the accreditation process).

The stages of the Automatic Pass are depicted below in Figure 1.2, and then each stage is described in more detail in turn.

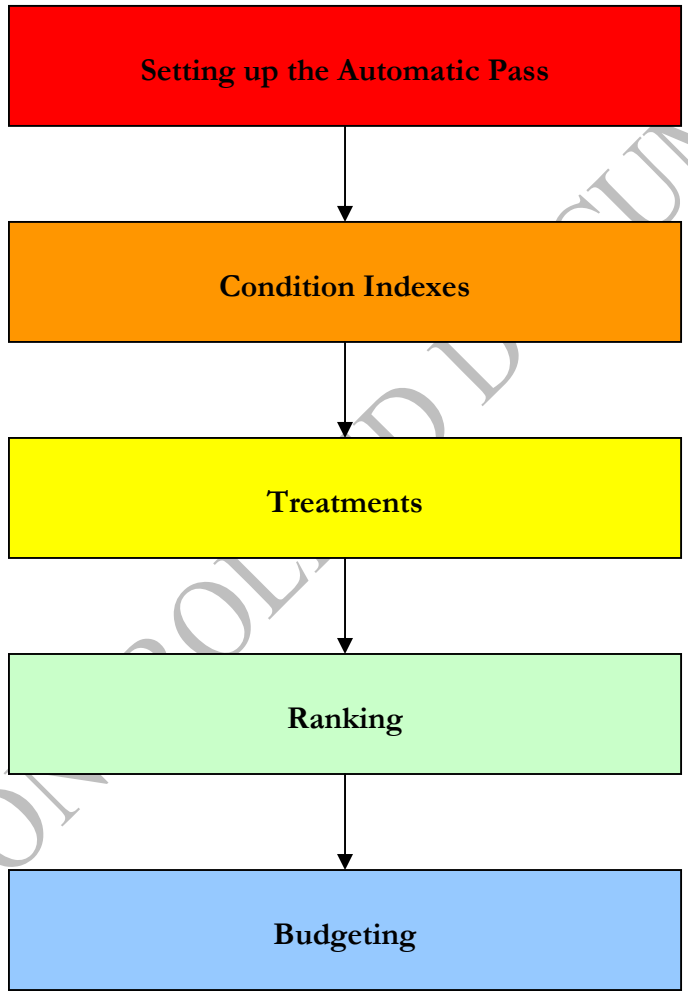

Figure 1.2 – Automatic Pass Stages

5.1 Setting up the Automatic Pass

There are two aspects to setting up an Automatic Pass; deciding **what** data to process and deciding **how** to process it. Each of these will be considered in turn:

5.1.1 Data Selection

In choosing the data to select for the Automatic Pass there are two main considerations:

- What part of the network should be processed?
- What condition data to include?

The way in which the part of the network for processing is determined will vary between UKPMS systems but in essence this is a choice of which sections to include. This may be achieved by selecting particular sections directly, or by selecting the type of section to be processed (e.g. the principal network).

The condition data to include is determined in a variety of ways: choosing particular types of survey e.g. CVI; choosing particular surveys, normally by the reference number for that survey; setting dates, so that only data collected within the given dates is included; setting a precedence switch to choose which type of visual data to process when both CVI and DVI are present.

5.1.2 Processing parameters

The processing parameters determine how the Automatic Pass processes the selected data.

The first choice is to check the Rule Set to be used for the Automatic Pass. Each Rule Set will process the data differently, and for BVPI purposes the use of a particular Rule Set is prescribed (e.g. the 2005/06 BVPI results must be produced using RP6.01).

The second choice is of the parameters which control how the defect lengths are formed. There are three options:

- **Fixed interval**

The defect lengths will be formed for a selected fixed length, normally chosen to provide a suitable treatment length.

- **Pre-defined interval**

The defect lengths are defined (by chainage) within particular sections prior to running the Automatic Pass. This option may be useful to establish the

condition indices and rankings for a particular scheme and compare these with those for other schemes.

- **Variable interval**

The defect lengths are formed automatically during processing based on the condition; adjacent parts of a section in similar condition will form a single defect length.

The final choice when setting up an Automatic Pass is to select a Budget to be used during the budget allocation stage of the Automatic Pass.

5.2 Condition Indices

There are four key steps which together create the defect lengths and calculate the condition indices. These steps are described briefly below and a more detailed explanation is given in Chapter 2 *Details of UKPMS processing*.

5.2.1 Chopping to form Rating Lengths

In this step each section included in the Automatic Pass is chopped into small temporary subsections referred to as Rating Lengths. These rating lengths are produced so that the defectiveness and other attributes (e.g. feature hierarchy) are constant.

The rating lengths are formed separately for each feature and XSP within the section.

Figure 1.3 below shows some example CVI condition data for a bituminous carriageway, and shows how this would be chopped to form rating lengths.

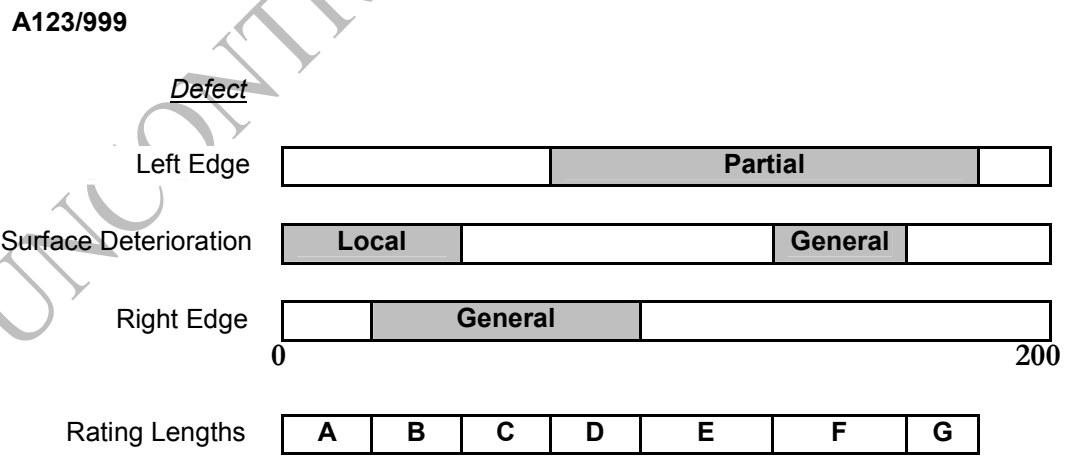

Figure 1.3 – Rating Lengths

Rating Length	Start	End	Defects		
			Left Edge	Surface Det'n	Right Edge
A	0	20		L	
B	20	40		L	G
C	40	60			G
D	60	80	P		G
E	80	120	P		
F	120	160	P	G	
G	160	180	P		

Table 1.2 Rating Lengths

5.2.2 Calculating Defect Ratings

Once the rating lengths have been established then each defect present on a rating length is assigned a rating value. The defect ratings are obtained from look up tables or curves in the Rules & Parameters. For CVI defects there is a different rating for each extent code. For other defects the rating is obtained from a rating curve which relates the defectiveness to a rating value.

The ratings for the defects used in Figure 1.3, based on RP6.01, are:

Defect	Local	Partial	General
Edge (Left or Right)	40	70	90
Surface Det'n	10	40	70

Table 1.3 Defect Ratings

The purpose of the ratings is to place all of the different measures of defectiveness from different defects and surveys onto a common scale so that they can subsequently be combined together to form condition indices.

The rated defects for the example from Figure 1.3 are:

Rating Length	Start	End	Defects		
			Left Edge	Surface Det'n	Right Edge
A	0	20		10	
B	20	40		10	90
C	40	60			90
D	60	80	70		90
E	80	120	70		
F	120	160	70	70	
G	160	180	70		

Table 1.4 Rated defects

5.2.3 Calculating Condition Indices

The rated defects are combined together to provide condition indices for each rating length.

For footways, cycletracks, verges and kerbs only one condition index is calculated, the Overall CI, whereas for carriageways a number of condition indices are calculated depending on the pavement type (bituminous, covered concrete etc).

This process is governed by the Rule & Parameters, which determine which defects contribute to which condition index, and the precise way in which they are combined together. Note that defects from a number of different types of survey can be combined together when calculating the condition index.

The condition indices calculated at this step for the example in Figure 1.3 are given in the table below:

Rating Length	Start	End	Condition Index	
			Edge	Surface Properties
A	0	20	0	10
B	20	40	90	10
C	40	60	90	0
D	60	80	90	0
E	80	120	70	0
F	120	160	70	70
G	160	180	70	0

Table 1.5 Condition Indices

The other possible condition indices for bituminous pavements (Structural, Wearing Course and additional SCANNER CIs) are all zero for this example.

5.2.4 Merging to form Defect Lengths

The final stage in the calculation of condition indices is to merge the rating lengths to form defect lengths. This process is controlled by the parameters set up at the start of the Automatic Pass.

If the Automatic Pass has been set up to use a **fixed interval** merge, then a defect length is formed for the fixed interval. The condition indices for the defect length are calculated from the length weighted average of all the rating lengths which lie within the defect length. For the example used above (Figure 1.3) with a fixed interval of 100m, the defect lengths are:

Start	End	Condition Index	
		Edge	Surface Properties
0	100	68	4
100	200	56	28

Table 1.6 Fixed interval condition indices

If the **pre-defined interval** merge has been used with the defect length chainages set to 60 and 180 then the following defect lengths will be formed:

Start	End	Condition Index	
		Edge	Surface Properties
0	60	60	7
60	180	73	23

Table 1.7 Pre-defined interval condition indices

If the **variable interval** merge has been used (with the default parameter settings) then the following defect lengths will be formed for this example:

Start	End	Condition Index	
		Edge	Surface Properties
0	20	0	3
20	120	79	3
120	160	79	70
160	180	70	0

Table 1.8 Variable interval condition indices

Once the defect lengths have been merged, then the Overall CI is calculated for defect lengths on carriageways. The Overall CI is obtained by combining together the other condition indices for the defect length, and once again the Rules & Parameters determine exactly how this is done. For the example above, the relevant rules specify that since the only non-zero condition indices are the Edge CI and the Surface Properties CI, the Overall CI is set to whichever is the higher of these two.

At the end of this stage of the Automatic Pass, defect lengths have been formed and condition indices have been calculated for each of these.

5.3 Treatments

There are three aspects to the treatment selection stage of UKPMS processing.

5.3.1 Treatment Selection

The first is to determine what treatment if any to suggest. The Rules & Parameters compare the condition index values for the defect length with intervention levels in order to determine the most appropriate treatment. These intervention levels vary depending on the feature hierarchy for the defect length. Other factors are also taken into account: whether the defect length has a step level set (which would prevent the carriageway being raised); whether the off-carriageway is tied to the carriageway (which leads to a requirement for associated works if the suggested treatment raises the carriageway); or whether there is SCRIM or GripTester failure.

An example defect length and treatment is given in the table below:

Condition Index		Hierarchy	Treatment
Edge	**Surface Properties**		
79	70	3a	Edge Reconstruct part depth PLUS Surface Treatment

Table 1.9 Example Treatment

This example assumes that there is no step level, the off-carriageway is not tied, and there is no functional failure. This combination of treatments is selected because the Edge CI lies at or above the intervention level of 70 and the Surface Properties CI lies at or above the intervention level of 40.

5.3.2 Treatment Quantity

All treatments unit costs are expressed as a cost per metre or a cost per square metre. In the former case the quantity calculated is the length of treatment required, and in the latter case the area of treatment required. The quantities are obtained from the inventory if available. If inventory data is not available then the default feature widths (which are based on road hierarchy and road type) are used instead to allow an area to be calculated.

5.3.3 Treatment Cost

The estimated cost of the treatment is simply the quantity of treatment multiplied by the unit cost. Unit costs are set up by the user of the UKPMS system, and can be set up to differentiate between treatments on different feature hierarchies.

5.4 Ranking

Once condition indices have been calculated and a treatment selected, the next stage is to determine the ranking for the defect length. Again this process is controlled by the Rule & Parameters.

If there is no suggested treatment (because the defect length is considered to be at an acceptable standard) then the ranking is zero. The condition ranking for each defect length with a suggested treatment is determined from the treatment, the Overall CI and the feature hierarchy.

For example, the condition ranking curve shown in Figure 1.4 is for the surface improvement treatment for road hierarchy 4a. If the defect length has an Overall CI of 70, the ranking will be 50. (This illustration is based on RP6.01).

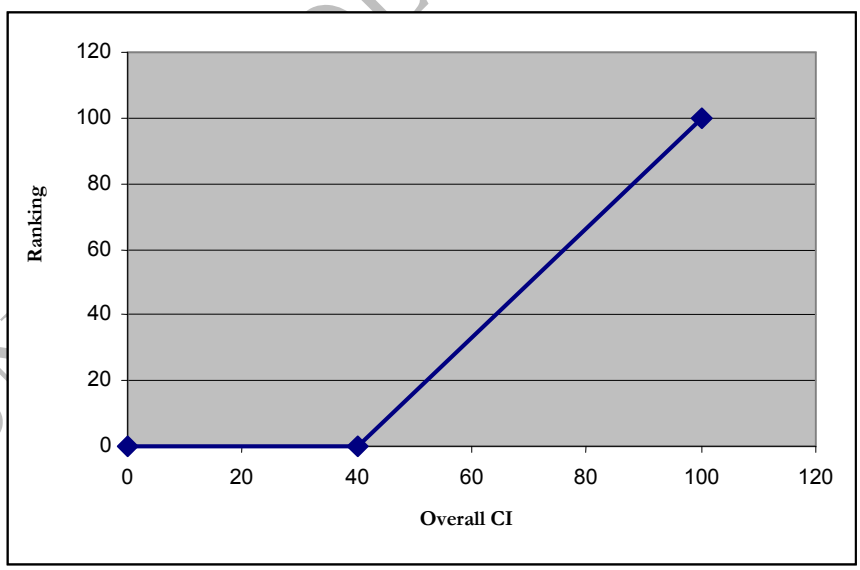

Figure 1.4 – Condition Ranking Curve for Surface Improvement Treatment, Road Hierarchy 4a

Note that condition rankings lie within the range 0 to 100, and the higher the ranking the worse the condition of the defect length.

If a defect length requires multiple treatments then the ranking is taken to be the highest obtained from any of the treatments.

5.5 Budgeting

The budget allocation stage uses the budget selected when the Automatic Pass was set up.

Each UKPMS Budget is made up of a number of budget headings, and each of these budget headings has a definition and a monetary limit. So for example, the UKPMS system might contain a budget called '2005 Budget' which has three budget headings; 'Edge works', 'Surface improvements' and 'Resurfacing'. The definitions for each of these budget headings would be set up to assign defect lengths according to treatment.

During the budgeting process the defect lengths are assigned to one of these budget headings, or to the 'Unassigned' heading. The budget heading is then 'top-sliced' to fund any defect lengths which require treatment for SCRIM or GripTester failure. After this, all remaining defect lengths are sorted into descending ranking order within each budget heading, and then designated as 'funded' or 'not funded' depending on whether the cumulative treatment costs exceed the limit for that budget heading.