

Use of Carpet Plots to represent functions of two variables

ESDU Copyright material. For current status contact ESDU.

Endorsed by
The Royal Aeronautical Society

ESDU DATA ITEMS

Data Items provide validated information in engineering design and analysis for use by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and are invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Performance Committee. This Committee first met in 1946 and now has the following membership:

Chairman	
Mr G J R Skillen	– Independent
Vice-Chairman	
Mr K J Balkwill	– Independent
Members	
Mr P V Aidala*	– Northrop Grumman ESID, Bethpage, New York, USA
Dr J D Avery	– QinetiQ, Boscombe Down
Mr M Broad	– Independent, UK
Mr N J Herniman	– Airbus Industrie, Toulouse, France
Mr R G Humpston	– Rolls-Royce plc, Aero Division, Derby
Mr D Law	– Civil Aviation Authority, Safety Regulation Group, Gatwick
Mr R J Orlowski*	– Boeing Commercial Airplane Company, Seattle, Washington, USA
Dr P Render	– University of Loughborough
Mr P P Renze*	– Independent, USA
Mr D N Sinton	– Independent
Mr G E Smith	– Independent
Mr A Stanbrook	– Independent
Mr R Storey	– BAE SYSTEMS, Brough
Prof. E Torenbeek*	– Delft University of Technology, The Netherlands
Mr S Tsach*	– Israel Aircraft Industries, Jerusalem, Israel
Mr C J Turner*	– Boeing Commercial Airplane Company, Seattle, Washington, USA
Mr M Wilson	– GAMTA Ltd, Aylesbury, UK

* Corresponding Member.

The construction and subsequent development of the Data Item was carried out under contract to ESDU by a Member of the Performance Committee

Mr G.E. Smith.

The person with overall responsibility for the work in this subject area is Mr D.J. Mitchell, Engineering Director.

USE OF CARPET PLOTS TO REPRESENT FUNCTIONS OF TWO VARIABLES**CONTENTS**

	Page
1. NOTATION	1
2. INTRODUCTION	1
3. CONVENTIONAL TWIN 2-DIMENSIONAL PLOTS	1
4. CARPET PLOTS	2
4.1 Interpolation Within Carpet Plots	3
4.2 Construction of Carpet Plot from Data Presented in Graphical Form	3
4.3 Use of Single Composite Independent Variable, “V”	5
5. EXAMPLES OF CARPET PLOTS	6
6. LATTICE PLOTS	11
6.1 Interpolation of Point in Lattice	11
6.2 Interpolation of Complete Carpet Within Lattice	12
6.3 References	12

USE OF CARPET PLOTS TO REPRESENT FUNCTIONS OF TWO VARIABLES

1. NOTATION

K_w, K_x, K_z, K_0	constants defining composite variable V
V	composite variable defined in Equations (4.1) and (6.1)
w, x, z	independent variables
y	dependent variable

2. INTRODUCTION

The “carpet” plot is a form of graph which illustrates the behaviour of a function of two independent variables. It is widely used in aeronautical work but the only formal treatments are in References 1 and 2. Unlike the conventional type of graph, which shows the variation of a function with one of the independent variables while the other is held at a series of fixed values, the carpet plot shows how the function varies with both variables together. This feature facilitates interpolation of the function for intermediate values of both independent variables.

Section 3 illustrates the problems that can arise with conventional twin 2-dimensional plots while **Section 4** shows how these are overcome by use of carpet plots. **Section 5** provides further examples of carpet plots to illustrate the various forms they may take. **Section 6** extends the concept of the carpet to the “lattice” plot which can represent the behaviour of a function of three independent variables. Examples of lattices are given to show how they are constructed and how interpolation is carried out.

3. CONVENTIONAL TWIN 2-DIMENSIONAL PLOTS

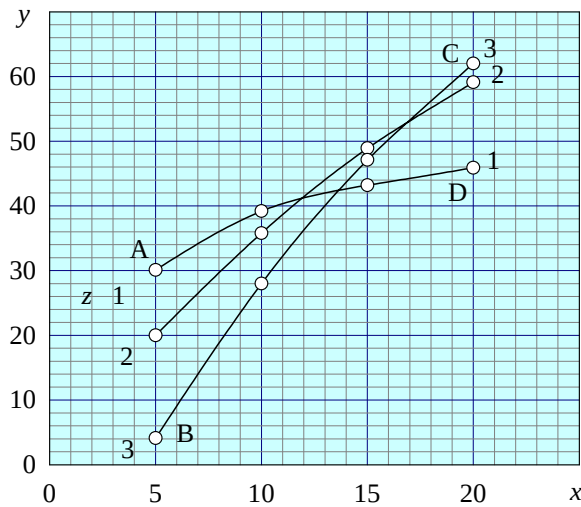
A function y of a single variable x is represented graphically in two dimensions by plotting values of y against x and drawing through those points a single smooth curve which can be used to interpolate for values of y lying between them.

If y is a function of two independent variables, x and z , a similar procedure is adopted. A typical set of data is shown in Table 3.1 and is plotted in Sketch 3.1 (a). Values of y corresponding to one of the fixed values of z , and intermediate values of x , are interpolated from the appropriate z -curve in the usual manner. However it is difficult in this case to interpolate curves of y against x for intermediate values of z because the plotted z -curves are unevenly spaced and cross each other. This problem is overcome by replotting the data as a series of curves of y against z for fixed values of x , as shown in Sketch 3.1 (b). However, even using Sketches 3.1 (a) and (b) in conjunction, it is difficult to interpolate values of y for intermediate values of both x and z together.

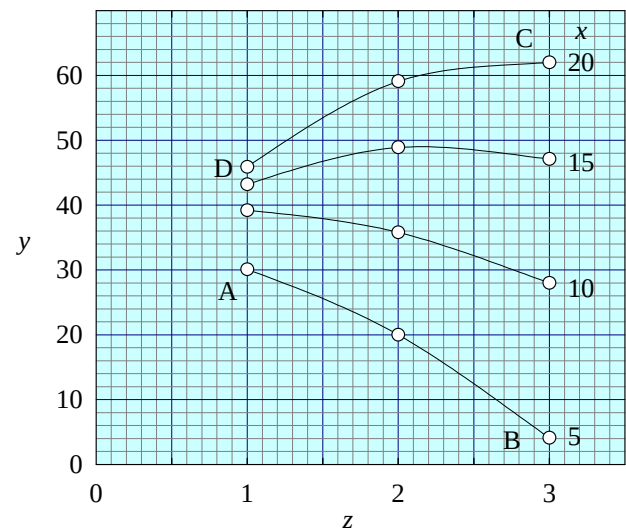
TABLE 3.1 Data for Sketches 3.1, 4.1 and 4.2

x	5	10	15	20	5	10	15	20	5	10	15	20
z	1	1	1	1	2	2	2	2	3	3	3	3
y	30.1	39.2	43.2	45.9	20.0	35.8	48.9	59.1	4.1	28.0	47.1	62.0

Issued November 2003, 14 pages



(a) y as a Function of x



(b) y as a Function of z

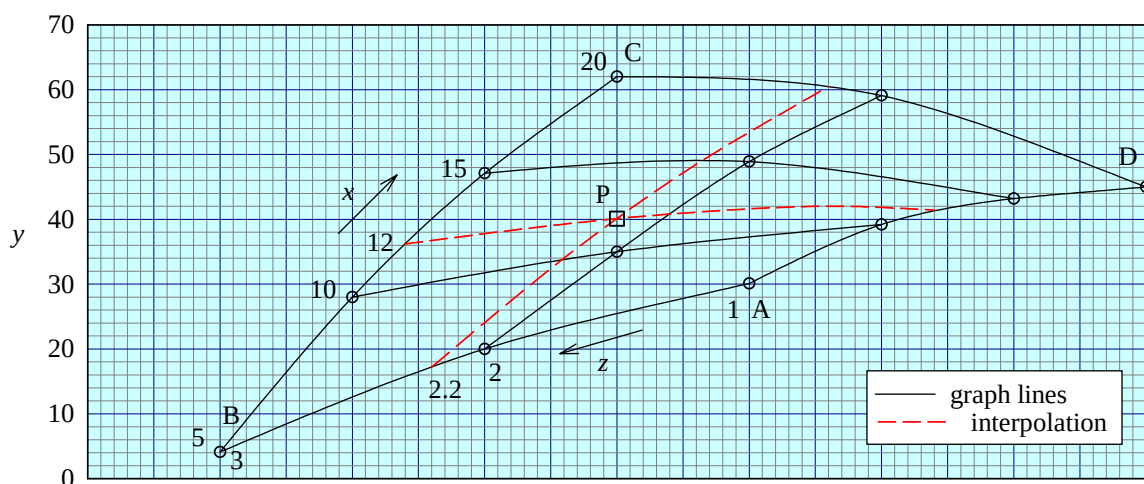
Sketch 3.1 Conventional twin 2-dimensional plots of data from Table 3.1

4. CARPET PLOTS

Sketch 4.1 shows an alternative method of plotting the data from Table 3.1. The curve AD of y against x for $z = 1$ is plotted as in Sketch 3.1 (a), but using a moveable x -scale whose origin is positioned 50 small divisions of the graph to the right of the y -axis. The curve of y against x for $z = 2$ is plotted with the origin of the x -scale moved 20 divisions to the left. Similarly, the curve BC of y against x for $z = 3$ is plotted with the origin of the x -scale moved a further 20 divisions to the left. The values of x are marked at the end of each curve, but do not appear on the graph abscissa.

Curves are now drawn through points having the same values of x on each of the three curves along which z is constant (z -curves). These form curves of constant x (x -curves). The x -curves in Sketch 4.1 are similar to those in Sketch 3.1(b) but are plotted in the opposite direction and stretched out over twice the horizontal distance. This is a consequence of displacing successive z -curves 20 divisions to the left.

The x -curves and z -curves in Sketch 4.1 give an impression of a curved surface, hence “carpet” plot.



Sketch 4.1 Carpet plot of data from Table 3.1

ESDU Copyright material. For current status contact ESDU.



Sing

4.1

4.2

In some cases data are not available in numerical form but are presented as a graph in which y is plotted against x for various values of z . A carpet plot can be derived directly from this by a graphical construction, as illustrated in Sketches 4.3 and 4.4