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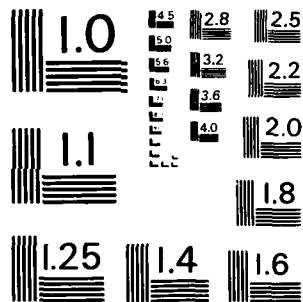
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**THE DESIGN AND DEVELOPMENT
OF MILITARY CLOTHING PART 4:**

A COMPUTER MODEL OF MEN'S TROUSERS BASED ON CRAMS DATA

by

DR M. G. KING.

JULY 1983

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THE DESIGN & DEVELOPMENT OF MILITARY CLOTHING

PART 4: A COMPUTER MODEL OF
MEN'S TROUSERS BASED ON CRAMS DATA

BY

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ABSTRACT

From the results of an anatomical survey of the men in the Australian Army, those measurements related to men's trousers were analysed. From computer modelling of the figures it was shown that:

- a. The current issue men's trousers provide a good fit for only 23% of the population.
- b. There were two main reasons for the low level of fit:
 - (1) a number of sizes in great demand were missing from the size roll;
 - (2) the trousers are too loose in the seat area.
- c. That computer models indicate that alternative trouser specifications should provide a better fit for a greater proportion of the population without raising the number of stock sizes.

Introduction

1. The CRAMS survey conducted in 1980 (KING and O'LEARY, 1983) provided basic data on the size and shape of male ARA personnel. The survey was intended to provide information on which to base the size rolls and tariffs for male uniforms. To assist in the design of size rolls for uniform items, the measurements of 21341 men have been assembled in a computer data bank.
2. From the results of the questionnaire relating to the male uniform, it was indicated that the general style of the trousers defined by Australian Army Specification (AS) 5363 was acceptable to members of the Army. It was therefore decided to develop a size roll for dress trousers based on the style parameters of the current men's wool/polyester trouser, AS 5363.

Aim

3. The aim of this report is to:
 - a. consider the size distribution of the men in the Australian Army, and compare this distribution with size roll of the trousers in AS 5363; and

- b. suggest, where necessary, changes to the size roll or to the shape of the trousers in order to achieve a better percentage of satisfactory fit.

4. This report will describe the results of four computer experiments related to the design of a size roll for men's trousers.

- a. The first experiment was an analysis of the current size roll to estimate the number of men satisfactorily fitted by AS 5363 trousers.
- b. The second experiment was a more detailed analysis of a problem area - the seat of the trousers.
- c. The third and fourth experiments were the assessment of two solutions to the problem of designing a size roll to fit the maximum number of men.

EXPERIMENT 1: Does the current size roll fit?

5. The CRAMS data included measurements for waist, seat circumference, and inside leg length. These are the values which are used to describe the size of a pair of trousers. For the Wool/Polyester trousers, only two of these measurements are used for each size. These are:

- a. trouser waist circumference which has a range of 14 sizes, from 72.5 cm to 105 cm in increment of 2.5 cm; and
- b. inside leg seam length which has seven sizes; 71, 72, 75, 77, 79, 82 and 85 cm.

Of the possible 98 sizes defined by these two dimensions, only 47 are listed in the schedule of measurements contained within AS 5363.

Goodness of Fit

6. There is no definition of "goodness of fit" given in the schedule of measurements, however in an earlier issue of this specification (issue 11) specific guidance for "made to measure" garments can be interpreted as indicating the fit which would be expected of the trousers; it is suggested that the finished seat of the trousers should have an "allowance" of 6.5 cm over a 100 cm seat of wearer, where "allowance" is trouser seat minus man's seat. This allowance should be varied by 0.65 cm for a change of 5 cm in the wearer's seat over or under 100 cm. These instructions can be represented by the expression:

$$A = 6.5 + \frac{(MSEAT - 100)}{5} \times 0.64 \quad (1)$$

where A is the allowance in cm and MSEAT is the man's seat circumference, in cm.

7. Advice from tailors in QA Div led to the adoption of a working definition of "fit": that the range of the allowance should be between the value calculated by equation (1) to not more than 6 cm greater than this allowance. Thus a trouser measurement of 106.5 cm was accepted as a 'good fit' for men with actual seat measurements between 94 and 100 cm. Using this as a basis six categories of fit were defined, based upon 6 cm increments in allowance. These six categories are listed in Table 1.

8. The Seat: Waist Relationship. The schedule of measurements gives not only waist and in-seam measurements, but also the finished seat measurement of the trousers. This finished seat measurement bears a constant relationship to the waist measurement:

$$TSEAT = TWAIST + 23 \qquad (2)$$

where TSEAT is finished trouser seat, in cm, and
TWAIST is finished trouser waist, in cm.

9. Comparison of Men with Garments. In a computer analysis of the CRAMS data, each man represented was assigned to one cell in the table of waist by in-seam. This means that each man was assigned a pair of trousers by the computer based upon his waist and inside leg measurement. For each man the actual allowance (trouser seat minus man's seat) was calculated and compared with the ranges in Table 1. The numbers of men in each category are listed in Table 2.

10. Approximately 40% of the men are in the "good fit" category. A further 40% are in the "loose fit" category, that is the trousers are one size too large in the seat.

11. The analysis for "goodness of fit" in Table 2 was based upon the assumption that all the 98 sizes (7 leg and 14 waist) were available. In fact, only 47 of the sizes are available as stock sizes. These 47 sizes provide a "good fit" for only 24% of the men. The estimated demand for each size is given in Annex A.

Discussion of Experiment 1

12. Using the information relating to goodness of fit which is given in current Australian Army Specifications the computer was programmed to estimate the demand for 98 trouser sizes. This gave an estimate of the percentage of men who can be fitted by the currently available size range. The computer also estimated the number of men who cannot be fitted because the seat in the current trousers would be ill-fitting.

13. The greatest single reason for men not being fitted by the trousers was because the seat would be too loose. There are few seats that are too tight. This computer prediction is supported by any inspection of men parading in the current wool/polyester trousers. It should be remembered that this observable test of the computer prediction is to some extent clouded by the fact that many of the trousers on parade have been altered to try to improve the fit of the seat.

Table 1

The six categories of 'goodness of fit' of trousers

<u>Category</u>	<u>Minimum Allowance</u>	<u>Maximum Allowance</u>
too tight	trouser seat is smaller than man's seat	
tight fit	A - 6	A
good fit	A	A + 6
loose fit	A + 6	A + 12
very loose fit	A + 12	A + 18
very loose indeed	A + 18 and above	

(Where A is the allowance calculated from equation (1))

Table 2

Distribution of men according to the fit of trousers

<u>Category</u>	<u>Number</u>	<u>% of Sample</u>
too tight	191	0.9
tight fit	1417	6.6
good fit	8520	39.9
loose fit	8652	40.5
very loose fit	2246	10.5
very loose indeed	<u>315</u>	<u>1.5</u>
Total	<u>21341</u>	<u>99.9</u>

14. Whilst it is easy to be critical of the current trouser style, it should be noted that the result of having stock trousers with seats that are too baggy is that in any rapid mobilization nearly all men could be given a pair of stock trousers which can be worn without further modification. For a peace-time Army the relative lack of urgency could enable the Q-store personnel to make a decision to alter, to tailor-make, or to give ill-fitting trousers. This decision could be based upon a number of practical factors which might include the rank of the wearer.

15. The information in Table 2 suggests that about 40% of the men could be fitted if all 98 sizes were offered. However only 47 sizes are currently stocked. The table in Annex A shows the estimated demand for all 98 sizes. From this table it can be seen that the current policy which has led to the selection of certain sizes and the omission of other sizes is frequently wrong. A number of the sizes which are stocked are very low demand items: for example, waist 102.5 cm, inseam 77 cm is demanded by 0.1% of the men. On the other hand, many sizes which are not stocked have quite significant demands: for example waist 77.5 cm, inseam 72 cm, 2.3% of the men.

16. The information in the table at Annex A can be used to provide a number of changes to the present stocking system. For example, there are 36 sizes with an estimated demand of 1.0% or greater. These 36 sizes would provide a fit for 29.2% of the men. Therefore by simply providing the sizes which are in great demand, more men could be fitted with a smaller size range without further modification to the present trouser pattern.

17. The information in Table 2 shows that while 40% of the men could be fitted from the complete set of 98 sizes based on the current trouser style, another 40% would find that the trousers would be one size too large in the seat. This is the 'loose fit' category. This finding leads to the suggestion that perhaps it is necessary to provide two seat sizes for each waist/inleg combination. Clearly this proposition would have the effect of doubling the number of sizes stocked, and such a decision would be best implemented together with a rationalization of the stocking policy (para 16). The implications of stocking two sizes of seat for each waist/inleg will be considered in Experiment 3 of this report.

Conclusions to Experiment 1

18. This experiment was designed to provide a computer-based estimate to the question "does the current size roll fit?". The short answer is that only 23% of the men could receive a good fitting pair of trousers over the counter selecting from the present 47 sizes.

19. The reason for the poor degree of fit from AS 5363 is two-fold:

- a. the trousers are too loose in the seat for a large proportion of the men in the Army; and
- b. many unwanted sizes are currently stocked and a number of sizes in high demand are not stocked.

Recommendations from Experiment 1

20. The conclusions from Experiment 1 are based upon a computer modelling of the trouser demand and supply situation. As with all mathematical models, some practical factors may have been ignored. The first recommendation based upon a mathematical model must therefore be that the predictions be assessed in practice.

21. The prediction that certain sizes are in very low demand should be checked against usage rates.

22. The prediction that in a large proportion of the cases the trouser seat would be too loose should be verified by tailoring personnel, preferably at a "point of demand" such as at a Central Clothing Store servicing a major population.

23. The suggestion that different styles of trouser might provide a better fit for more men should be first developed by further computer modelling, and finally verified in practice.

24. These recommendations are similar to those contained in a more ambitious trial proposal made in March 1981 (Reference Notes 1 and 2). However only the suggestion for further computer modelling has been proceeded with to date (May 1983).

EXPERIMENT 2: What is wrong with the seat?

25. The results of Experiment 1 indicated that in many cases the current design of trousers provided a seat which was too loose. This experiment was designed to investigate the relationship between men's seat measurements and other measurements which are used to select the size of trousers. In particular, the present experiment is intended to show whether or not the current trousers are designed around the shape of Australian Army men.

26. Several abbreviations will be used in this paper. These abbreviations are:

- a. MSEAT = man's seat measurement in cm, from CRAMS data;
- b. TSEAT = the trouser seat measurement, in cm.
- c. TWAIST = the trouser waist measurement, in cm;
- d. MWAIST = man's waist measurement, in cm, from CRAMS data.

Method and Results

27. The specification for the current men's wool/polyester trousers gives all of the critical dimensions of the trousers. Since it is the fit of the seat which is under question, the relationship between seat and waist was given closer attention. Over the entire size range, the trouser seat (TSEAT) is consistently 23 cm larger than the trouser waist (TWAIST). This can be represented by the simple formula:

$$\text{TSEAT} - \text{TWAIST} = 23 \quad (2)$$

28. Equation (1) gives the preferred difference between a man's seat (MSEAT) and the trouser seat (TSEAT), that is, the allowance "A". If we combine equation (1) (relating MSEAT and TSEAT) with equation (2) (relating TSEAT with TWAIST) we can calculate a relationship between TWAIST and MWAIST. In the case where the trousers are a "perfect fit" at the waist, then TWAIST equals MWAIST. For this case, the new equation would give the assumption of waist/seat relationship which forms the basis of the trouser style in AS 5363. This equation is developed below:

Since $TSEAT = MSEAT + A$

then from equation (1) we get:

$$TSEAT = MSEAT + 6.5 + \frac{MSEAT-100}{5} \times 0.64 \quad (3)$$

$$\text{but } TSEAT = TWAIST + 23 \quad (2)$$

and for the case when $MWAIST = TWAIST$,

$$TSEAT = MWAIST + 23 \quad (4)$$

substituting (4) in (3) we get:

$$MWAIST + 23 = MSEAT + 6.5 + \frac{MSEAT-100}{5} \times 0.64$$

$$MSEAT = MWAIST \times .89 + 26.0 \quad (5)$$

29. Equation (5) is the equation to the "shape of an average man", derived by a manipulation of the rules published in the specification for trousers in AS 5363. Put another way, the current Wool/Polyester trousers are designed for men who can be described, on average, by equation 5.

30. The CRAMS data enables the shape of the average man to be calculated directly, from the 21341 sets of waist and seat measurements. The seat/waist measurements based upon the CRAMS data bank are presented in Figure 1.

31. Superimposed on the scattergram in Figure 1 are two lines. These lines represent:

- a. the shape of men assumed by the specification for the current trousers Wool/Polyester, marked "WOOL/POLYESTER"; and
- b. the line which best fits the CRAMS data - this line is marked "CRAMS".

The equation to the CRAMS line is:

$$\text{MSEAT} = \text{MWAIST} \times 0.591 + 46.8 \quad (6)$$

Discussion of Experiment 2

32. This experiment was designed to investigate the reason for the predicted poor fit of the trousers in AS 5363. A scattergram of waist versus seat was created and this was compared with the assumptions underlying the trousers in question.

33. In Figure 2, most of the points of the scattergram lie below the "WOOL/POLYESTER" line. This indicates that most men's seats are rather smaller than the assumed size, based on these trousers. This analysis explains the reason for the computer prediction of a large number of loosely fitting trouser seats.

Conclusions to Experiment 2

34. The results of this experiment indicated that the assumptions underlying the design of men's trousers in AS 5363 are not compatible with the CRAMS data. Calculations based entirely on the rules given in AS 5363 suggest that the trousers were designed for men whose seats are much larger than the CRAMS measurements values. For larger waist sizes, the discrepancy between the trousers and the actual men becomes increasingly serious.

Recommendations from Experiment 2

35. This experiment indicated the need for a closer examination of the tailoring assumptions involved in the design of the seat/waist sizes of all Army dress trousers.

36. In particular, it is recommended that further computer modelling should be used to produce a proposed design of trousers which is based upon actual men, rather than upon incorrect assumptions or invalid conventions.

EXPERIMENT 3: A better pair of trousers, Solution A

37. The scattergram of waist/seat is shown in Figure 1. From this figure it can be seen that the seat generally increases as the waist increases. However it is also clear that for any particular waist size, there will be a considerable range of seat sizes.

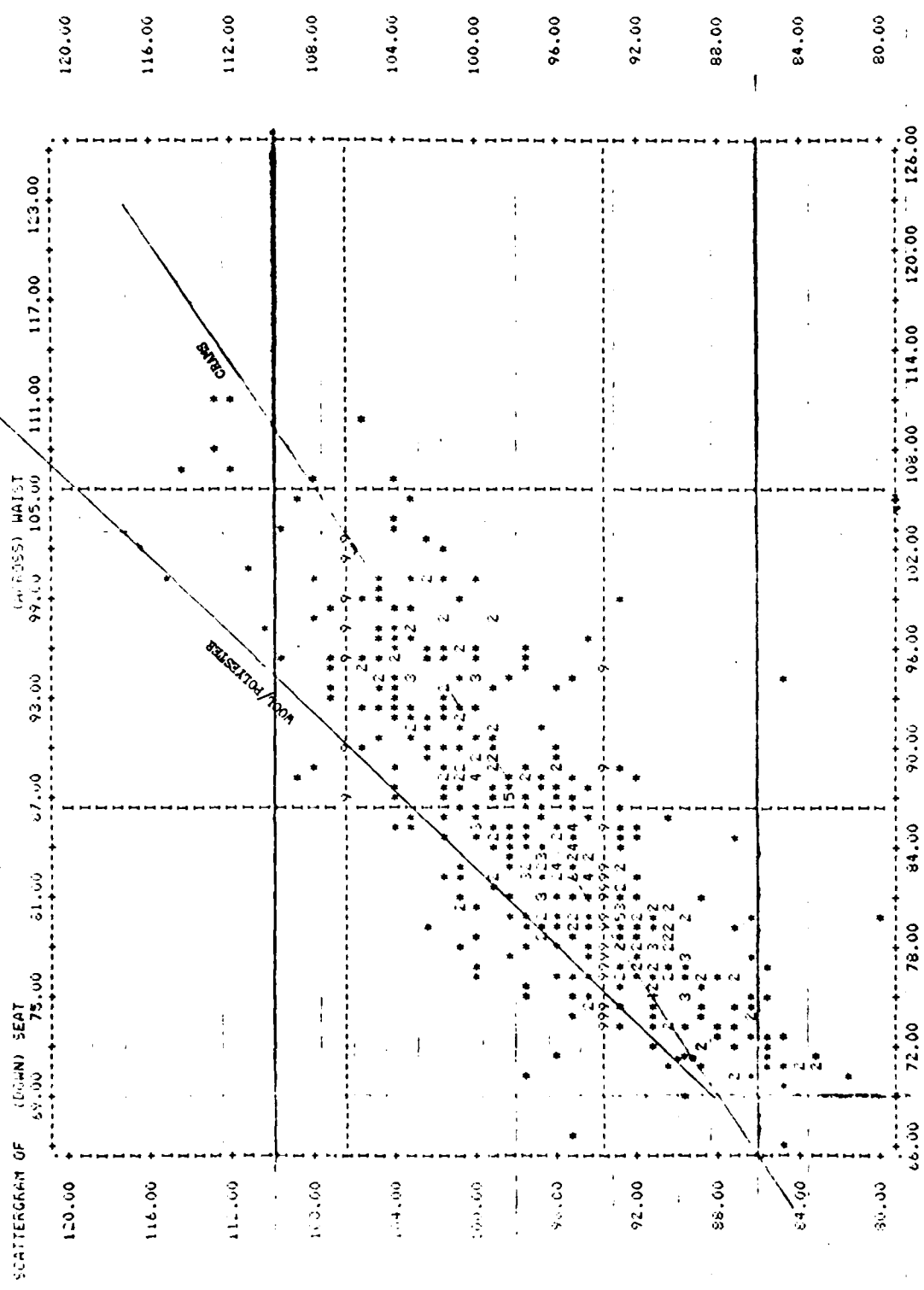
38. The fact that for any given waist size, men's seat measurements will have a considerable range leads to the conclusion that there will be a range in the "allowance" (the amount of loose material in the seat of the trousers) even when men are fitted correctly by the waist measurement.

39. The expected range in allowance can be calculated from the CRAMS data, and this calculation is shown in Annex B. The results show that a range of 13.2 cm in allowance is required to cater for 95% of the men of any given waist size.

40. It has been suggested (see para 7) that a satisfactory range of the allowance should be 6 cm. The evidence that the actual range is a little more than twice this value would lead to two predictions:

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FIGURE 1
SCATTERGRAM OF SEAT WITH WAIST



- a. no single range of trousers with a fixed seat value for each waist size can be expected to fit more than half the population; and
- b. that a "double range" of trousers, with two seat sizes for each waist size should fit approximately 75% of the population.

41. The aim of this experiment was to derive the specifications of a trouser range which could be expected to provide a satisfactory level of fit for a majority of the population.

Methods and Results

42. To design a pair of trousers for a man, it is necessary to have four measurements. These are waist, inside leg, seat, and outside leg. The position of the trousers on the man's waist will be determined by the difference between the outside leg measurement and the inside leg. This difference is termed the RISE.

43. Designing trousers for the ready to wear market, it is possible to decide in advance which waist sizes, and which inside leg sizes will be offered. The RISE can also be decided upon by convention. If the trousers are to provide a satisfactory fit then the most likely value of the seat must be predicted for each waist size. Annex C details the calculations involved in predicting the best estimate of trouser seat for each waist size. The formula, based upon CRAMS data and tailors' rules is:

$$TSEAT = 0.67 \times TWAIST + 46. \quad (10)$$

44. Equation (1) gives the average value of TSEAT for each value of TWAIST. Approximately one half of the population will actually find the trouser seats too tight, and approximately one half of the population would find that the equation has produced trousers that are too loose.

45. Within the group for whom the trousers would be too loose, the trousers would generally be no more than 6 cm too loose, and this is within the tolerance which this paper has suggested is acceptable. Therefore a range of trousers made to the limits suggested by equation (6) should fit nearly half the population. This range of trousers has been termed the "slim" fit.

46. A second range of trousers with seats 6 cm greater than those for the Slim Fit would fit most of the population whose seats are relatively large compared with their waist. This range has been termed Regular.

47. A complete range of waist and inside leg sizes would fit approximately 90% of the population, as is indicated in Table 3. However to approach this goal a large number of stock sizes would be necessary since this approach requires two sizes for every waist/inleg combination.

Table 3

Percentage of population fitted by
two sizes of seat, Regular and Slim

<u>Fit</u>	<u>Population</u>	<u>%</u>
Too tight	1224	5.7
Good Regular fit	9798	45.8
Good Slim fit	9535	44.6
Too loose	832	3.9

48. From para (11) it should be remembered that the current size range has 7 leg sizes. One method of reducing the total number of stock sizes of trousers is to provide garments with unfinished legs, and to finish these at the point of issue. Using this proposal of unfinished legs, it was suggested by tailoring staff that to retain the style of the garment it would still be necessary to have more than one leg length. The computer modelling procedure was therefore based upon the concept of unfinished legs, but with three leg lengths, at 8 cm increments. This provided a good compromise between the demands for good tailoring and the goal of reducing the number of stock sizes.

49. The tables included in Annex C illustrate the demand for each of 42 sizes of trousers: 7 waist sizes, 2 seat sizes, and 3 (unfinished) leg sizes. The computer prediction is that these 42 sizes would fit 85% of the population, after the legs were finished.

Discussion of Experiment 3

50. The present experiment investigated the possibility of offering two ranges of seat sizes in trousers to overcome the difficulty of fitting trousers in the seat dimension. The necessary increase in the number of stock sizes was off-set by the proposition that all trousers should be unfinished in the legs, and that this finishing should be done at the point of issue.

51. The proposed solution is predicted to be accompanied by a fitting rate of 85% for 42 sizes. This compares well with the present fitting rate of 23% with 47 sizes.

52. Two doubts about the proposal have been raised, and the usefulness of the scheme should be evaluated in the light of these reservations.

53. The cost of finishing the legs. At the time of the investigation (1981) it was estimated that if outside contractors were used to finish the trousers, approximately \$5.00 would be added to the cost of the garments. The preferred solution would be to provide each issue point with the required machines for finishing trouser legs, and to use Service personnel trained in the task. Costing of this proposal is beyond the scope of the present report.

54. The accuracy of the fittings. A possible problem with the approach of finishing trouser legs at the point of issue is the concern tailoring staff expressed about the possibility that a large number of inaccurately fitted leg lengths would result. The tailoring staff suggested that it is difficult to instruct the wearer to position the trousers in his "normal" position on the waist while staff are measuring leg length. It is much easier, and more likely to result in correct fit, to provide the customer with several different pairs of finished trousers. He can then walk about and decide on a more informed basis which leg length is correct for him.

Conclusions to Experiment 3

55. Computer predictions indicate that the solution proposed (unfinished leg lengths, and a double range of seat sizes) should provide trousers which fit the majority of the population without further alteration.

56. The cost of implementing the leg finishing scheme at the point of issue may be a disadvantage. The possibility that some trousers would be finished to the wrong length is another issue which has been raised.

Recommendations from Experiment 3

57. Three investigations are necessary before a decision on the present proposal can be reached. These are:

- a. a fitting trial of trousers made to the specifications in Annex C to test the computer prediction of better fitting seats;
- b. a fitting trial to assess the ability of relevant staff in the task of measuring and finishing trouser legs;

- c. a study of the costs involved in the implementation of the unfinished leg proposal.

58. It is recommended that these three investigations be completed before further studies are undertaken on the trouser problem.

59. As an alternative to Para 58, if significant delays in the trialling procedures are anticipated, it is recommended that, alternative computer modelling be continued to allow the development of other theoretical solutions to the trouser problem.

EXPERIMENT 4: A better pair of trousers, Solution B

60. In the previous solution (Solution A) the problem with trousers was approached by designing a "double" seat range. That is, two seat sizes were offered for each waist. This was because there is a wide range of actual seat measurements found in men for any given waist measurement.

61. The present experiment took what at first seemed to be an illogical approach to the problem. Rather than attempting to cater for the admittedly wide variation in seat measurements, this solution seeks to fit the men by:

- a. designing for each waist size a single seat size such that the maximum number of men will be fitted;
- b. predicting the number of alterations which can be made to the trousers to ensure a fit without recourse to made-to-measure.

62. The underlying approach to the solution under consideration in this experiment is similar to that presently used in clothing stores. The major difference is that the basic trouser is designed to fit a greater number of men without modification.

Methods and Results

63. Discussions with tailoring staff at the Central Clothing Store, Melbourne indicated that tailoring conventions would allow certain levels of alterations to be made without destroying the "lines" of the trousers. These limits were as follows:

- a. a 6 cm range in allowance is permissible;
- b. trouser seat can be taken in by up to 5 cm;
- c. if seat is too tight, then take the next (waist) size and take in waist by 5 cm; and
- d. if MWAIST is within 1 cm of upper boundary for the waist size, and seat is too tight, take the next (waist) size and no alterations will be required. This represents a "borderline" case where a man could take either of two waist sizes, so allow the seat size to dictate the choice.
- e. for each waist size, the trouser seat should be midway between the "SLIM" and "REGULAR" trousers of Annex C.

Table 4

<u>Class of Fit</u>	<u>Percentage</u>
too loose	0.9
take in TSEAT <5cm	12.1
good fit	61.1
next size ok	5.3
next size, reduce waist	12.8
man's seat is too big	5.7
TOTAL	98

64. Table 4 gives the breakdown of the computer predictions for a range of trousers designed around the given fitting rules. It can be seen that if the trousers are created to minimize the number of alterations, then approximately 66% of the men can be fitted without further alterations.

65. For a range of trousers with 5 cm increments in waist, and 2.5 cm increments in leg it is predicted that 43 sizes would be required. Using these 43 sizes, 66% of the population would be fitted without further alteration, and a further 25% would be fitted with an alteration.

Discussion of Experiment 4

66. The solution offered in this experiment seeks to optimize the balance between maximum number of men fitted, minimum number of sizes stocked and minimum number of alterations.

67. The solution appears to offer greater promise than the "double seat" range suggested in Experiment 3. For the double seat solution, an excessive number of trouser sizes needed to be stocked, or (using the chosen method of compromise) all trousers would need to be "altered" by having the leg length taken up to correct length.

Recommendations from Experiment 4

68. The solution presented in this experiment was proposed in August 1981. Despite the apparent attractiveness of the solution, no action has been taken to promote it as a viable solution to the trouser problem.

69. It is recommended that the vital implications of this solution should be trialled in the following stages:

- a. trousers should be designed around the seat/waist relationships which underly this solution (and it should be noted that the correct seat/waist relationship is vital to the success of this model);
- b. a fitting trial of the predictions of this model should be undertaken with experienced tailors/fitters (for example from a Central Clothing Store) making judgements as to which category each man/trouser combination falls into; and
- c. further work should then proceed, if the predictions of this model are sustained by the practical trial.

REFERENCES:

- A. King M.G. and O'Leary R.P. The Design and Development of Military Clothing. Part 3: The 1981 Survey of Clothing Related Anatomical Measurements on Australian Males. Department of Defence. AR-003-168. 1983.
- B. LOG(C) 471-1-1 dated 30 Mar 81.
- C. Army Office. A309-20-45(1) dated 21 Apr 81.

COMPUTED DISTRIBUTION OF DEMAND FOR EACH SIZE FOR 98 SIZES OF MEN'S DRESS TROUSERS

ANNEX A

This table shows the 47 sizes currently offered by AS 5363, and 51 additional sizes which are not currently stocked. The numbers in parentheses show the computed demand for the sizes which are not stocked.

The numbers in each cell are: total
&
percentage

In Seam cm	71	72	75	77	79	82	85
Finished Waist cm							
72.5	71 .8	(73) (.9)	113 1.3	91 1.1	72 .8	(38) (.4)	(10) (.1)
75	109 1.3	(132) (1.5)	156 1.8	153 1.8	(107) (1.3)	57 .7	(29) (.3)
77.5	139 1.6	(200) (2.3)	320 3.8	274 3.2	191 2.2	(71) (.8)	(38) (.4)
80	(127) (1.5)	(206) (2.4)	286 3.4	278 3.3	(298) (2.3)	112 1.3	(52) (.6)
82.5	(143) (1.7)	(208) (2.4)	306 3.6	285 3.3	199 2.3	(127) (1.5)	(50) (.6)
85	(116) (1.4)	140 1.6	198 2.3	236 2.8	142 1.7	106 1.2	(27) (.3)
87.5	(77) .5	152 1.8	(168) (2.0)	178 2.1	120 1.4	61 .7	37 .4
90	(61) (.7)	75 .9	97 1.1	119 1.4	78 .9	54 .6	(15) (.2)

In Seam cm	71	72	75	77	79	82	85
Finished Waist cm							
97.5	(30) (.4)	(49) (.6)	(70) (.8)	70 .8	62 .7	(26) (.3)	13 .2
95	(19) (.2)	37 .4	31 .4	42 .5	33 .4	17 .2	(3) (0)
92.5	(6) (.1)	12 .1	26 .3	24 .3	(14) (.2)	(14) (.2)	8 .1
100	(5) (.1)	8 .1	(16) (.2)	7 .1	(15) (.2)	7 .1	(4) (.0)
102.5	(4) (.0)	(4) (.1)	(6) (.1)	5 .1	(7) (.1)	(6) (.1)	(0) (0)
105	(0) (0)	3 0	(2) (0)	(3) (0)	(3) (0)	(2) (0)	(1) (0)

SUMMARY OF RESULTS IN ANNEX A

Total fitted by the current 47 sizes
 Total fitted by the 51 sizes not offered
 Total falling outside the range of the 98 sizes
 Total not fitted by the 98 sizes because of ill-fitting seat

23.8%
 13.6%
 2.5%
 60.0%

ANNEX B

Calculation of 95% range in seat allowance range

For two correlated variables, (x and y) the residual standard deviation $SD_x \text{ resid}$ in X, after removing the variance explained by Y is given by:

$$SD_x \text{ resid} = ((SD_x)^2 * (1 - r_{xy}^2))^{\frac{1}{2}}$$

where r_{xy} is the correlation between x and y.

For waist and seat

	Mean	sd	r
Waist	84.48	8.531	.8420
Seat	96.66	6.233	

thus

$$\begin{aligned} SD \text{ seat resid} &= (6.233^2 * (1 - .842^2))^{\frac{1}{2}} \\ &= 3.36 \text{ cm} \end{aligned}$$

Now, 95% of the population will lie in the range (mean \pm 1.96 x SD), that is, the 95% confidence interval.

Thus for any given waist size, 95% of the population will have a range of seat size predicted by:

$$\begin{aligned} \text{range} &= \pm 1.96 * 3.36 \\ &= \pm 6.58 \text{ cm} \\ \text{thus range} &= 13.2 \text{ cm.} \end{aligned}$$

ANNEX C

THE SEAT/WAIST RATIO FOR TROUSERS

From made to measure rules

$$A = 6.5 + \frac{(MSEAT - 100)}{5} * 0.64 \quad (1)$$

$$TSEAT = MSEAT + A$$

$$TSEAT = MSEAT + 6.5 + \frac{(MSEAT - 100)}{5} * .13 \quad (7)$$

$$= 6.5 + MSEAT + .13 MSEAT - 13$$

$$TSEAT = 1.13 MSEAT - 6.5 \quad (8)$$

From CRAMS Data

$$MSEAT = (MWAIST * .591 + 46.8) \quad (6)$$

and combined with (8)

$$TSEAT = 1.13 (MWAIST * 0.591 + 46.8) - 6.5 \quad (9)$$

$$= 0.668 MWAIST + 46.4$$

Thus for the case where MWAIST = TWAIST,

$$\text{TSEAT} = 0.67 * \text{TWAIST} + 46. \quad (10)$$

Equation (10) is a prediction of the most probable TSEAT demanded for trousers where MWAIST = TWAIST.

Equation (10) predicts the "average" trouser seat measurement. This equation will generate the TSEAT value for approximately one half of the population, that is, the group whose seat is between "average" and average minus 6cm. These trousers are termed "slim". The other half would find these trousers too tight, and so a second series of seat sizes were generated using the formula.

$$\text{TSEAT} = 0.67 * \text{TWAIST} + 52 \quad (11)$$

This range is termed "Regular".

Practical Applications of Results

Whilst the underlying relationships are based upon valid measurements, the calculations for seat allowance are based upon interpretations of tailoring norms. It is therefore possible that in practice a constant factor would need to be included in equations (10) and (11). A practical trial of the trousers defined in Tables C-1 and C-2 would answer this question.

TABLE C - 1

DISTRIBUTION OF SIZES : "SLIM" FIT

WAIST SIZE		10	12	14	16	18	20	22
"TOO FIT" (cm)		70	75	80	85	90	95	100
FINISHED WAIST (cm)		72.5	77.5	82.5	87.5	92.5	97.5	102.5
FINISHED SEAT (cm)		95	98	101	105	108	111	115
IN SEAM (DISTRIBUTION)	65 + CM	159	534	683	564	488	340	157
		1.7%	5.6%	7.2%	5.9%	5.1%	3.6%	1.6%
	73 + CM	301	1012	1338	1132	770	520	261
		3.2%	10.6%	14.0%	11.9%	8.1%	5.5%	2.7%
81 + CM		40	142	234	179	118	60	37
		.4%	1.5%	2.5%	1.9%	1.2%	.6%	.4%

TOTAL FITTED: 9078
42.5%

TABLE C - 2

DISTRIBUTION OF SIZES : "REGULAR" FIT

WAIST SIZE		10	12	14	16	18	20	22
"TOO FIT" (cm)		70	75	80	85	90	95	100
FINISHED WAIST (cm)		72.5	77.5	82.5	87.5	92.5	97.5	102.5
IN SEAM (DISTRIBUTION)	FINISHED SEAT (cm)	101	104	107	111	114	117	121
	65 + CM	87	262	448	491	359	227	106
	73 + CM	0.9%	2.7%	4.6%	5.0%	3.7%	2.3%	1.1%
	81 + CM	261	940	1579	1361	937	613	274
		2.7%	9.6%	16.1%	13.9%	9.6%	6.3%	2.8%
		71	234	429	309	209	116	55
		.7%	2.4%	4.4%	3.2%	2.1%	1.2%	.6%

TOTAL FITTED: 9368
43.8%

END

DATE
FILMED

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