The SAS Head Office

– spatial configuration and interaction patterns

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Interaction is identified as a key office activity, making the most of the knowledge and expertise invested in individuals. This paper describes the investigation of the head office of the Scandinavian Airlines System (SAS) in Stockholm, a building specifically designed to promote interaction. Space Syntax techniques were used to analyse the interior layout, whilst direct observations provided data on interaction levels and locations. The building was found to be strongly interactive, but not in the ways envisaged by its designer or the occupying organisation. The results from the study are compared with an international sample of buildings. General relationships and design principles are described.

THE OFFICE AS A BUILDING TYPE has two main functions. It is both a place of individual work (which, with modern technology could be carried out elsewhere) and crucially, a place of interpersonal face to face interaction. Interaction is a key office activity since it provides a mechanism for the exchange of information, knowledge and ideas. It is a means of making use of the resources and expertise invested in employees and plays a integral part in organisational decision making and innovative processes. Research has identified interaction as being related to the quality of solutions produced (Allen, 1977) and employees' satisfaction with their jobs and environment (Brill, 1984). The widespread use of information technology (IT) has been seen as increasing rather than decreasing the importance of interaction. IT equipment has not provided a substitute for face to face communication. If anything, it has isolated employees, who now interface more with machines rather than each other. However IT has caused a shift in the composition of organisations, with fewer rule governed and procedure based clerical jobs, and more open ended, innovation based professional, managerial and technical jobs, which have been found to be interaction intensive.

Interaction has been used as the underlying basis of office planning. Early layouts were based on minimising travel distances between clerks sitting in open plan spaces. The Quickborner Team who created the concept of bürolandschaft (or 'office landscaping') proposed that layout should directly reflect the existing pattern of interaction. Groups and individuals with strong links were to be located in close physical proximity to each other, those with weak links would be placed further apart. This idea,

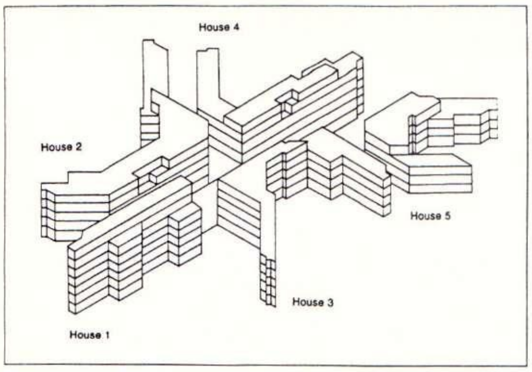


Figure 1. Axonometric of the head office of the Scandinavian Airlines System.

that the layout should reflect the pattern of interaction has proved to be pervasive, and has been used as the basis of subsequent layout types from Action Office to contemporary mixed cellular and furniture system configurations, and has become enshrined in computer aided facilities management (CAFM) software.

However, research has not adequately investigated the relationships between spatial configuration and interaction patterns (Grajewski, 1992a, 1992b). Although bürolandschaft configurations were designed specifically to foster interaction, early research concentrated on ascertaining inhabitants' attitudes towards their environment and layout but largely ignored interaction patterns. Similarly the protagonists of automatic generation procedures assumed that interaction was related to physical proximity, and aimed to produce methods by which optimum layouts could be derived from communication surveys, but with little success. The few researchers who did attempt to investigate interaction produced contradictory results. For example both Duffy (1974a, 1974b, 1974c) and Farbstein (1975) concluded that layouts had little functional effect but had strong symbolic connotations. In contrast Allen (1977) found the quantity of interaction was related to metric proximity and to more open plans. Similarly Symes (1980) found that a shift from predominantly cellular building to predominantly open plan caused a shift from written to verbal communication. Both apparently confirmed bürolandschaft expectations. However the BOSTI studies (Brill, 1984) found that ease of communication (but not quantity) was related to the degree of enclosure, with more enclosure making interaction easier.

A likely reason for these inconclusive results seems to be a lack of analytical tools able to capture the full complexity and subtlety of office layouts. The research was focussed mainly on the small scale of the individual's workplace, which was described in terms of the amount and quality of furniture, screens and walls, and their positions. The larger scale configuration was dealt with only in rudimentary terms describing distance between workplaces.

This paper describes some of the results of an extensive research programme funded by the British Science and Engineering Research Council (SERC) which aimed to tackle these problems by the application of 'Space Syntax' methods to the description of the interior configurations of buildings (Hillier, Grajewski & Peponis, 1987, Hillier & Grajewski 1990, Grajewski, 1992b). It concentrates on describing the investigation of the head office of the Scandinavian Airlines System (SAS), a building specifically designed to be interactive and to promote communication between its various inhabitants.

The building

During the 1970's and 80's the head office operation of SAS was accommodated in some thirty different locations scattered throughout the greater Stockholm area. In 1982 a decision was taken to design a new head office to be located at Frösundavik, on the northern edge of Stockholm. The client's brief for the new premises went beyond providing accommodation within a single building complex, to specifying a building which would actively work to encourage and promote interaction between its inhabitants. The rationale for pursuing these aims was a corporate philosophy which saw interaction as a positive element in exchanging ideas, information and problem solving, thereby helping to promote a more effective and creative organisation (SAS, 1988). A limited design competition for the new premises was announced in 1984, with Niels Torp being declared the winner. The building new designed and completed by late 1987.

On moving to the new building each employee was presented with a booklet entitled *Togetherness* (SAS, 1988) explaining in detail the design objectives and the way in which the management envisaged the new complex would be used. In the section "Good ideas spring from impromptu meetings" Jan Carlson, the President and Chief Executive Officer explained how

> "good ideas are rarely created when you're sitting at your desk feeling alone and tense, but during creative encounters between human beings. The new office has been planned to foster that kind of communication ... There are many opportunities to meet - in multipurpose lounges adjoining individual offices, in restaurants and cafes, in the recreation facilities, in the conference unit. Our "main street" is almost like a street scene in a small town where people can gather to relax and socialise... Growth results from encounters and dialogue. Sitting at your desk does not necessarily mean being productive. Meeting a colleague from another department is not the same as shirking your duties". (op. cit. p. 4–5.)

Further sections explained how "...in this office you can indeed leave your desk from time to time. In fact it's considered a good thing that you do. There are twice as many meeting places as there are employees" (op. cit. p. 6) and "...a lot of effort has gone into creating an environment that is full of life..making the daily working life as stimulating as possible". (op. cit. p. 8.)

The new complex provided office accommodation for staff responsible for the strategic operation of the airline and some of its subsidiary businesses. The accommodation was arranged in five distinct 'houses' of office accommodation located along a central glazed 'street', which had shops, restaurants, conference rooms and recreational facilities situated on its lowest levels

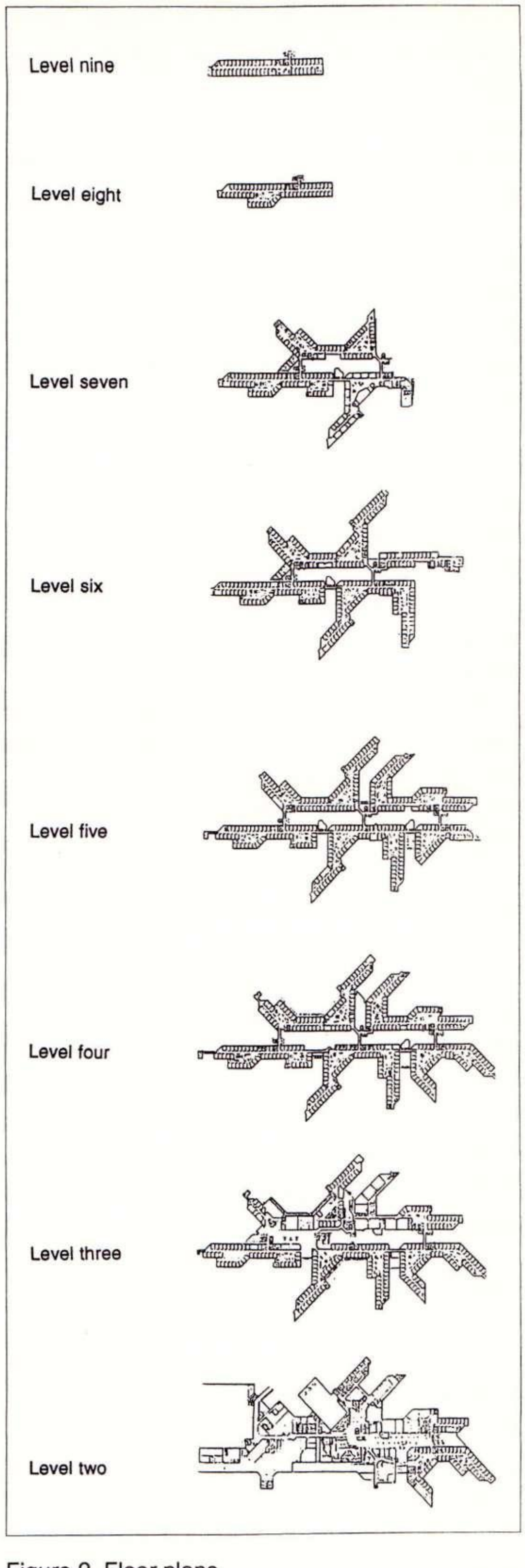


Figure 2. Floor plans.

(*figures 1 and 2*). The overall profile of the building sloped from the west down to the east, such that house 1 had nine floor levels, the adjacent house 3 had seven levels, and house 5 had only five levels. On the opposite side of the street, house 2 had seven floor levels, and house 4 had six levels. There was some office accommodation on levels two and three, but the first full office floor was located on level four. This had a number of design features which were duplicated (in some cases in a modified form) on all of the office floors above. The central area constituted a void over the street spaces below, which was bridged at three locations. At each bridge there was a pair of lifts and a staircase to other floors. Each house was a physically separate entity, linked to the others by means of more bridges. Meeting rooms shaped like pianos were located between houses 1 and 3, and between houses 3 and 5.

The spaces within the houses were linked by means of circulation corridors located centrally. The perimeter of each house was lined by individual enclosed rooms, with the central areas taken up by common lounges called a 'multirooms'. Except for the most senior staff, all employees regardless of status or task were allocated rooms an identical 3 x 4 m in size. These had a window to the 'outside' (either the outdoors or to the internal street) and a fully glazed wall to the circulation corridor or multiroom. The multirooms were intended to be used as shared rooms for local meetings, and contained common facilities such as photocopiers, printers, and computer terminals as well as meeting tables, armchairs and sofas.

The building features which were therefore specifically designed to encourage interaction were of thee types: the internal 'street' and the various shops, eating places and recreational facilities located along it; the 'multirooms' intended for more local meetings; and meeting rooms and meeting spaces. The architect adopted a uniform approach to the way in which these elements were assembled into a whole building, where staff were allocated identical rooms, and which had similar relationships with the circulation corridors. There were, however, differences in the overall form of the building. On the south side of the building there were three houses of accommodation, whilst on the north side there were only two. The houses on the south side had a single long corridor passing directly through all three, whilst the two houses on the north had a complicated bridge connection. Lastly, the number of floors in each of the houses varied, with those at the west end of the complex being higher than those at the east end.

Space Syntax analysis of configuration

The Space Syntax analysis was based on an axial map of the interior of the building, taking into account the detailed position of furniture (not shown on the plans due to the small scale). The map represented all of the building spaces except the plant rooms and underground car park. The measure of integration was computed at two levels: first, 'whole building integration' (termed RA1(1)) which took into account all of the spaces within the building as a single entity; and second 'local integration' (termed RA1(2)) computing integration for the spaces within each house, on each floor as individual isolated entities.

Figure 3 shows the axial maps shaded to show the distribution of whole building integration. The 10% most integrated lines are shown in bold black line, whilst the 50% most segregated lines are shown in dotted line. The figure shows that the there was a concentration of integration on level five, approximately mid way up in the complex, with a progressive reduction in integration levels on floors above and below floor five, such that levels three, eight and nine were the least integrated. Within individual floors there was a bias of integration towards houses 1, 3 and 5 on the south side of the building, with the spaces of house 4 being consistently most segregated. Furthermore, within individual houses the offices spaces located along the dead end 'branch' corridors were the least integrated. The most integrated individual spaces for the whole

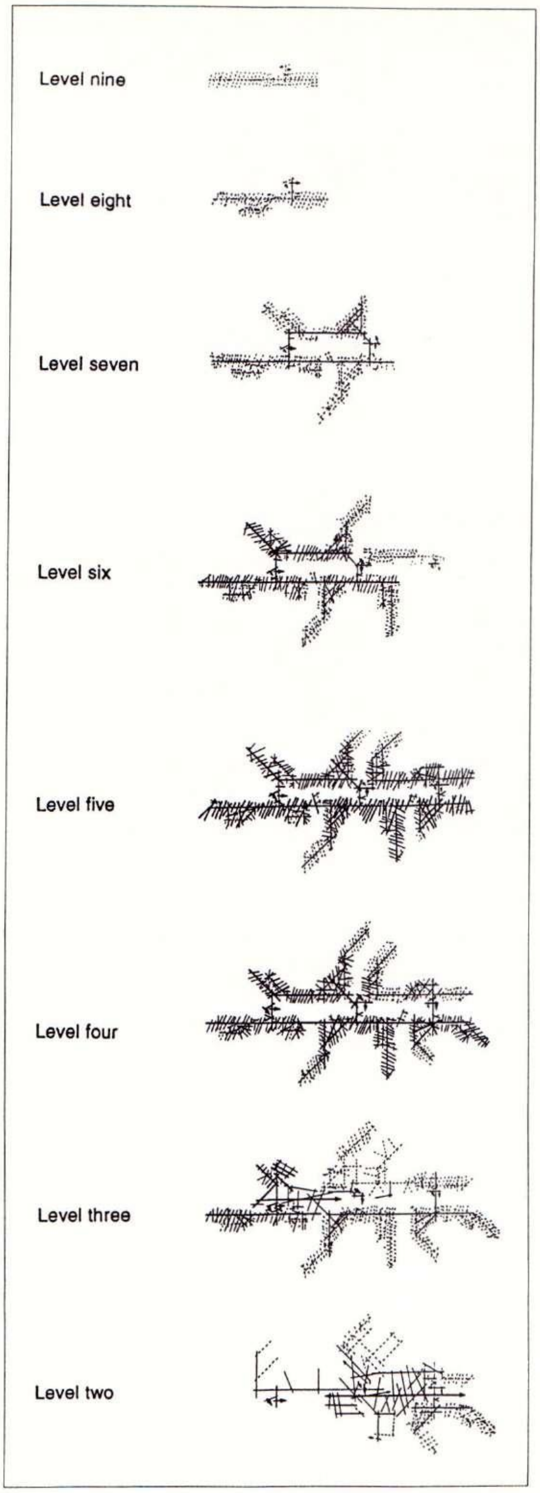
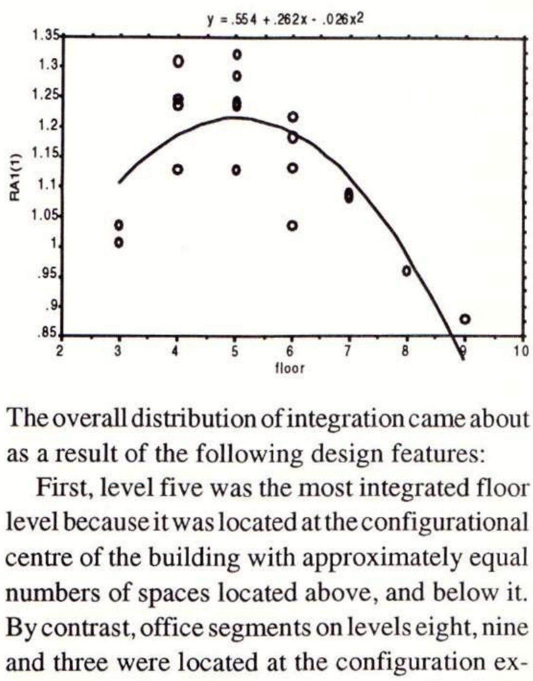


Figure 3. Axial map shaded to show the distribution of whole building integration. The 10% most integrated lines are shown in bold black line, whilst the 50% most segregated lines are shown in dotted line.

complex occurred in the west staircase and lift. The overall distribution of integration is shown graphically below. In the figure each point represents a single office segment per floor within a house, the vertical scale measures its level of integration, and the horizontal scale, its floor level within the building. The figure clearly identifies how integration levels peak on level five, and shows the relative segregation of office segments on both the lower and upper floors.



The overall distribution of integration came about as a result of the following design features:

First, level five was the most integrated floor level because it was located at the configurational centre of the building with approximately equal numbers of spaces located above, and below it. By contrast, office segments on levels eight, nine and three were located at the configuration extremes of the building, with the bulk of the building's spaces being located either above, or below these segments.

Second, the bias of integration towards the segments located at the west end of the complex was the result of the overall form of the building, where house 1 and house 2 had the greatest number of levels (and therefore office spaces) whilst the houses towards the east of the complex declined in height. The west staircase and lift, located above the reception, therefore connected the greatest number of levels together, and as a consequence formed the most integrated individual spaces within the complex. Office segments and other spaces at the west end of the building had increased integration values as a consequence of their configurational proximity to this key element of vertical circulation.

Third, the imbalance in integration within individual floors, with houses on the south side of the complex (1, 3 and 5) being more integrated than those on the north side (2 and 4) was a consequence of two design features – the long internal corridor on the south side, and an overall asymmetric distribution of houses. The long corridor linking the segments within houses 1, 3 and 5 created a single direct connection which was directly linked to the majority of individual rooms within these segments. Effectively, it provided a means of access both between the segments, and between individual rooms which would require very few changes in direction. In contrast the passage between the segments of houses 2 and 4 missed out the direct link between the two houses. The junction where they met had a strongly articulated bridge connection, thereby making any journey considerably more torturous. House 4 was the least integrated on each floor, since it did not have the benefit of the connection to the west staircase and lift of house 2. The asymmetric distribution of houses, with three on the south side (1, 3 and 5) and only two on the north side (2 and 4) meant there were considerably more rooms on the south side, than on the north side. Since integration measures the relationship between each line and all other spaces, the south side effectively had more spatial 'weight' than the north side. The main corridor on the south side had more spaces either directly connected, or within a radius of a few axial changes of direction, than the broken up corridors on the north side. This further reinforced the prominence of the south corridor, and diminished the importance of spaces within the north segments.

Last, the concentration of segregated spaces along the branch corridors occurred because of the articulation of the building form. Bending the branch corridors through 45 degrees introduced an additional changes of direction further removing office rooms from the main circulation corridors.

Figure 4 shows the axial maps shaded to show the distribution of integration for each of the building segments computed in isolation. For convenience, the integration maps of all segments on a single floor are shown on the same diagram, but the corridor and bridge links are broken to indicate that each segment is being considered on its own.

All of the segments had a similar distribution of local integration. The line representing the central east west corridor was the most integrated as a result of its central location in each of the segments, forming the only means of access from one end of the segment to the other. The lines representing the multiroom spaces and corridor spaces directly connecting to the central corridor were the next most integrated, within the 10% range. The values of the branch corridors reflected their spatial distance from the central corridor. As a result of a 45 degree turn these were in the middle integration range. The integration values of office rooms was similarly reflective of their depth from the central corridor. Those which were directly connected to it, or the integrated multiroom spaces, were generally in the middle range, but rooms located along the branch corridors were in the 50% most segregated range.

The segments located within houses 1 and 4 had the highest integration values, whilst the remaining segments located within houses 2, 3 and 5 had lower values. This was a reflection of the extent to which the internal configuration of the segments was articulated. The segments within house one was the smallest on all floor levels, and did not possess any branch corridors. This meant that it had the simplest configuration where most of the office rooms connected either directly to the central corridor line, or to a multiroom space. Conversely the segments located within houses 2, 3 and 5 had either one, or more generally, two branch corridors. Each corridor introduced additional articulation into the local configuration of the segment. The majority of office rooms in these segments were located along the branch corridors and were therefore

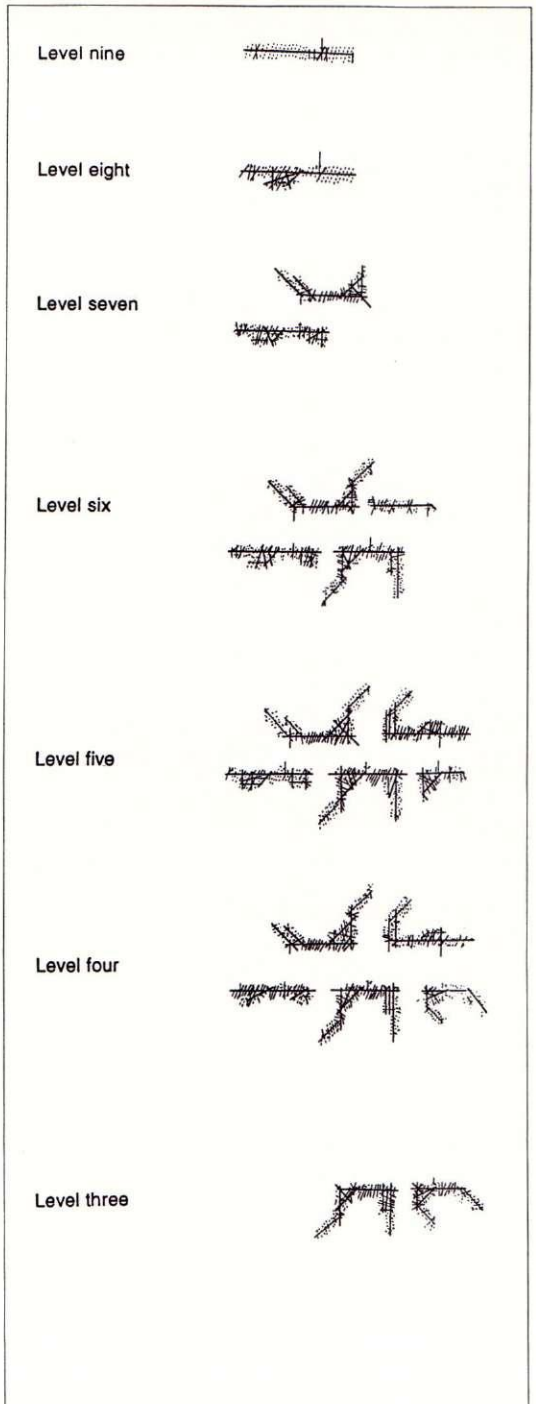


Figure 4. Axial maps shaded to show the distribution of integration for each of the (observed) building segments computed in isolation. The 10% most integrated lines are shown in bold black line, whilst the 50% most segregated lines are shown in dotted line.

between two or three steps removed from the integrated east west corridor.

Therefore, the design presented a picture of apparent formal sameness at the level of individual rooms, but the integration structure of the whole building showed strong variations, with building segments on floor level five being the most integrated, but segments at the top and bottom of the building being segregated. Furthermore, within individual floors there was a strong variation with the segments on the south side of the building, in particular house 1 being integrated, but house 4 on the north side being segregated. The mean integration levels of the segments taken in isolation also varied depending on the degree of articulation introduced by the branch corridors.

Interaction patterns

Data on how the building was used by its inhabitants and the locations which were interaction intensive or non-intensive was obtained by means of direct observations. The method used involved a researcher walking a set route designed to include most of the office and circulation spaces within the building. Copies of the building plans were used to record the exact location and activity of office personnel at the moment they were passed by the researcher.

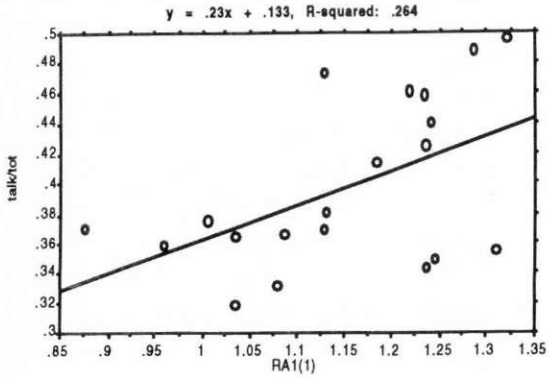
For all observed spaces throughout the building a total of 3 081 instances (where one instance equals a single person observed on one occasion) of interaction were recorded over the fifteen observation rounds. In terms of the spaces designed specifically for interaction, there were 172 talking people on both levels of the street, and an additional 95 in the cafe area, giving a total of 262 in total. However as a proportion of the total number of recorded interactions in the whole building, this represented only 9%. Of the 36 observed multirooms one had no observed interaction at all (level five house 1, east end), 18 multirooms had between one and ten instances of interaction, 10 multirooms had between ten and twenty instances of interaction, and 7 multirooms had over twenty instances. The total number of recorded instances of interaction for all multirooms was 411 representing 13% of all interaction. The meeting spaces located within the houses did no better, with a total of 195 recorded instances or 6% of all interaction. The meeting rooms located between houses accounted for a further 144 instances or 5%. Circulation corridors and bridges had 88 instances of interaction or 3% of the total. Therefore spaces which were designed specifically with interaction in mind were poorly used. The bulk of interaction (1976 instances or 64% of the total) occurred within the confines of individual offices.

Overall, interaction represented 37% of all observed activities within the building (talk/tot). *Table A* gives the breakdown of interaction for each of the building segments:

Floor level	House 1	2	3	4	5
3	–	–	37%	–	38%
4	36%	46%	34%	37%	35%
5	50%	44%	43%	47%	49%
6	46%	41%	38%	32%	–
7	37%	33%	–	–	–
8	36%	–	–	–	–
9	37%	–	–	–	–

Table A. The level of all interaction, expressed as a percentage of the total observed activities within each segment (talk/tot).

There was a tendency for segments which had high levels of whole building integration RA1(1) to have more interaction. The scattergram below shows the relationship between whole building integration and talking as a percentage of all observed activities, where each point represents



a single building segment. The correlation is r = .514 prob .0206. The three points in the lower right hand corner represent integrated segments which had a low level of interaction. These were adjacent segments within houses 1, 3 and 5 all on level four. Excluding these, the correlation was even stronger at r = .784 prob .0002.

Appraisal of the SAS building

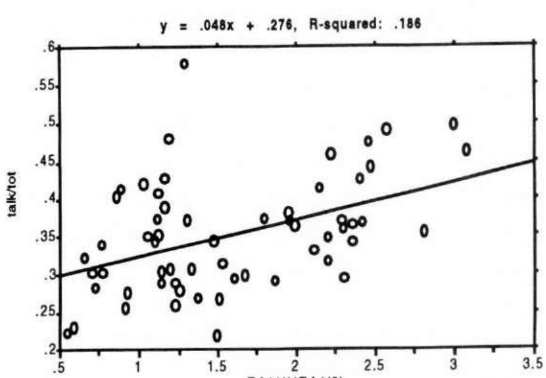
When SAS commissioned its new head office a specific requirement was that the building design should encourage interaction between its inhabitants. The observations of how the inhabitants used the building indicated that the features designed especially for interaction (the street, multirooms, meeting places) were used only at a low density, with bulk of interaction took place within the confines of individual rooms. This is not to say that the building structure did not affect the pattern and level of interaction. On the contrary, a strong relationship existed between the levels of integration and observed interaction, which occurred in spite of different divisions and tasks being assigned to the various segments. The inhabitants of more integrated segments spent a greater proportion of their time interacting, whilst the inhabitants of segregated segments spent less of their time interacting.

Therefore it would seem that the SAS complex did not work as the architect or management intended, but that it did have a strong effect on interaction patterns. The features designed overtly for interaction, such as the street which was intended to be the 'heart' of the building, were underused. However, it was the less intuitively obvious (especially in a building where each office segment had the same appearance) characteristics of the whole building integration which had a very marked effect on the levels of interaction. This distribution of integration was the result of a number of key design features. In particular this included the decision to increase the amount of office accommodation, and the numbers of floors towards the west end of the building, the decision to have more houses of accommodation on the south side, and the introduction of a complex linking connection between houses on the north side of the complex, where the south side of the building had a continuous straight corridor linking the thee houses.

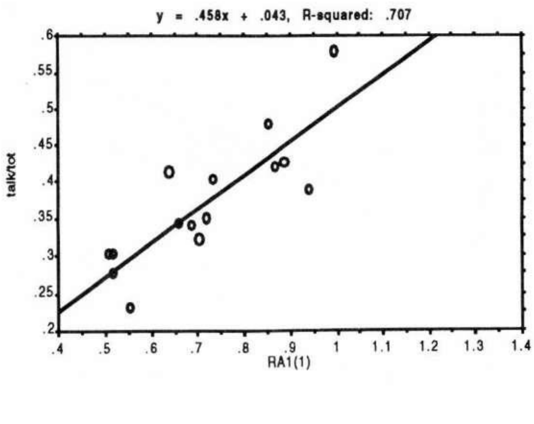
General relationships

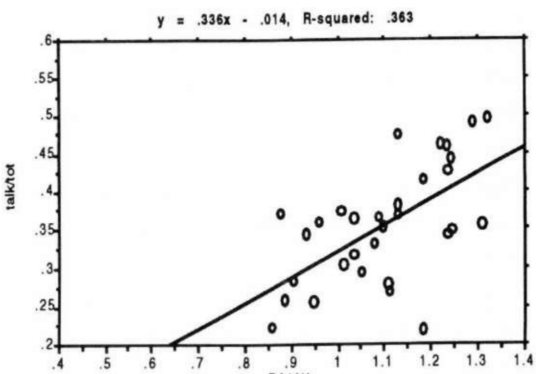
The research programme which investigated the SAS building also encompassed six other buildings from the United Kingdom and the United States. These had a wide variety of interior layouts, from bürolandschaft, to furniture systems and cellular configurations. Organisational activities varied from multi-disciplinary design, to computer companies and included a Local Authority. Relationships between measures of integration and observed interaction were found in most, but not all of the buildings taken individually. For the sample of all building segments a number of relationships were apparent (each segment was a building floor, or like the SAS 'houses' an identifiable part of a floor).

For all 59 of the segments were considered together the correlation between observed interaction and whole building integration was weak, although significant at r = .3 prob .020. The correlation with local integration was slightly stronger at r = .377 prob .0032. However, the strongest correlation was apparent for the level of 'combined' integration. This was the product of whole building integration multiplied by local integration (RA1(1) x RA1(2)) and measured the extent to which a segment was both integrated in the building and integrated in itself. The correlation was r = .431 prob .0007, as shown in the scattergram below.

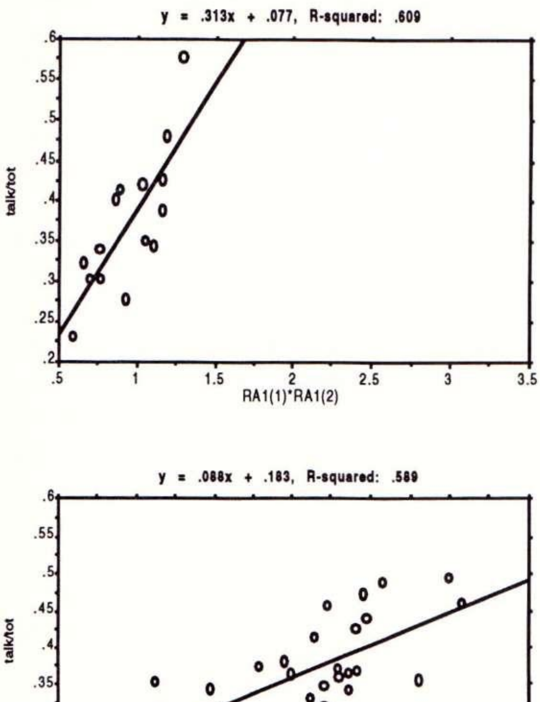


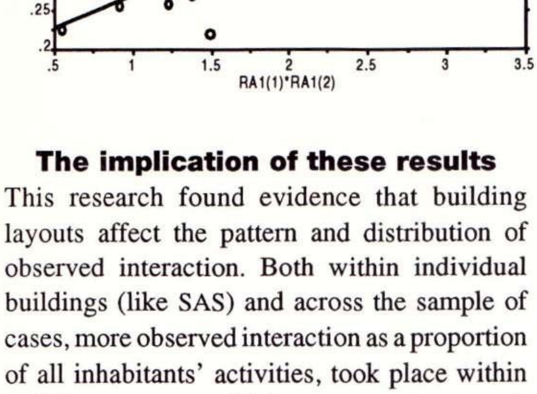
However, an examination of the sample revealed a number of distinguishing features. First, for individual buildings, the Local Authority stood out as the only case in which interaction did not have any relationship with integration parameters. When this case was excluded, there was a slight improvement in the above correlations. Secondly, excluding the Local Authority, the sample was being split between three high density buildings with between 3.8 and 6 observed people per 100 m^2 of office area and three low density buildings which had under two observed people per 100 m^2 of area. When the sample was broken down by density considerably stronger correlations were apparent for each sub sample. The two scattergrams below show the relationships of whole building integration with interaction, drawn to the same scale. The upper scattergram is for the high density sample (r = .841 prob .0001) whilst the lower scattergram is for the low density sample, including SAS (r = .602 prob .0003):





Strong correlations were also obtained with the levels of combined integration, shown below. Again, the upper scattergram shows the relationship for the high density sub sample (r = .78 prob .0006), whilst the lower scattergram shows the relationship for the low density sub sample (r = .767 prob .0001):





The implication of these results

This research found evidence that building layouts affect the pattern and distribution of observed interaction. Both within individual buildings (like SAS) and across the sample of cases, more observed interaction as a proportion of all inhabitants' activities, took place within building segments which were more integrated. These results would seem to have the following implications:

First, previous research has produced contradictory findings, with some studies suggesting that more interaction took place in spaces with greater enclosure, and others suggesting the opposite. This study suggests that both cellular and variations on bürolandschaft and furniture system themes can be either integrated or segregated, either interactive or non interactive. The classification of a layout into one of these types does not necessarily describe either its spatial characteristics or its use pattern. For example, SAS was a completely cellular but interactive building. This appeared to be the product of a comparatively simple and unarticulated layout, with resulting high degree of both whole building and local integration. However, other cellular (and also open plan) building in the sample had strongly broken up and articulated layouts, with low levels of integration and interaction. This method of analysing building layouts therefore offers the possibility of a tool able to predict the likely use and interaction patterns of unbuilt designs or changes to existing layouts, regardless of their levels of enclosure.

These results do not rule out the possibility that the ease of interaction, its relative confidentiality, or privacy might still be related to the enclosure of the workstation. Common sense, supported by the findings of the BOSTI study (Brill, 1984) suggest that more enclosure will ensure greater privacy and confidentiality. The results of this study suggest that it is possible to design offices with high levels of enclosure, which will maintain both high levels of interaction and allow for the privacy of conversations, if desired. That is, the two are not mutually incompatible, and the cellular office (as demonstrated by SAS) would seem to offer the possibility of both. The existence of full height walls together with a door which can be open or closed seems to provide a means by which occupants can gain control over their environment, whereas furniture systems and open plans will always be subject to some level of uncontrolled intrusion, in the form of noise, and a lack of control over the ability to overhear conversations.

Lastly, these results indicate that office buildings seem to have 'natural use patterns' where the spatial configuration of a building has a consistent effect on the distribution and levels of interaction. Moreover, this would seem to transcend both the location of specific activities within individual buildings, and different types of organisational activity and culture, as demonstrated by the ability to plot different segments and different buildings on the same scattergram axis.

However, there is one caveat to these findings. The relationships were found to hold for organisations where the majority of organisational departments and groups were interlinked. That is, the members of different departments, located within different segments, had to communicate with each other in order for the organisation to function. It was noticeable that the relationships were not reproduced in the Local Authority building whose departments (such as 'Housing' or 'Education') worked largely independent of each other, and did not have to communicate with each other in order to carry out their tasks.

In terms of the implications for design practice, the research found that three key design features were responsible for the level and distribution of whole building integration:

First, the degree of axial articulation accounted for the overall level of integration of each building. The less complex the configuration, and the greater the area covered per axial line, the more integrated was the configuration. This was related to the size of the building, and the area assigned to each employee. In the sample larger buildings, with a low density of occupation were more integrated. It should be possible for small buildings to have high levels of whole building integration, however, it is likely that a general space planning principle applies here. That is, larger buildings, almost by definition, are likely to be less broken up physically. They are likely to have fewer constraints imposed by the form and dimensions of the building shell, and are likely to have longer, uninterrupted circulation runs (although, obviously, this will not be true in all buildings). Space standards are not automatically associated with building size, but a similar general principle might apply. That is, where there a low density of occupation it seems to be easier to design and manage a layout which is not articulated. In densely occupied buildings, each employee would still seem to require a minimum amount of furniture. However, the greater density at which this is packed into the available space would seem to make it difficult not to create articulations and chicanes, particularly at the level of the workstation.

Second, the location of a segment in the overall building configuration was responsible for its relative level of integration in the building. The most integrated building segments were located towards the centre of each building, and had an approximately equal 'weight' of spaces located on either side of the segment (such as the middle level five in the SAS building). The least integrated segments and lines were located towards the periphery of each building, with the bulk of spaces being to one side of the segment (levels three, eight and nine in the SAS building). This suggests, that the way to minimise extremes of segregation, and to create a more even distribution of integration, is to have buildings where the segments are as centralised as possible. That is, buildings should have few, rather than many floors, and should consist of a single building envelope rather than a number of separate buildings forming an overall complex.

Third, other things being equal, the way in which an office segment was linked to the rest of the building complex was responsible for its particular level of integration. Direct linkages with few axial lines required to represent them and hence few actual changes of direction required to traverse them, resulted in more integrated segments. Indirect and complex connections, represented by several axial lines and hence comparatively more changes of direction, resulted in less integrated segments. If it is unavoidable that a complex should consist of several buildings, the connections between these should be as simple as possible (like the long corridors on the south side of the SAS complex), and should avoid torturous linkages (like those connecting houses 2 and 4).

Last, the key design feature responsible for the levels of local integration were the nature of the connections within the segment. Integrated segment layouts had a simple circulation system with few complications or changes of direction (in extreme, consisting of a single straight corridor like that of level nine in the SAS building). The links between individual workstations and the circulation were similarly simple, and in extreme, consisted of a direct one step, one change of direction link.

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