Lecture 3:
Arrangement within a Physical Space

ENVD 5380 Human Factors/Ergonomics in Environmental Design
(ENVD 5311-001 Design & Ergonomics)
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References

• Sanders (1993), Ch. 14.
• Margaritis & Marmaras (2005). Supporting the design of office layout meeting ergonomics requirements, Applied Ergonomics (38)6, 781-790.
• Murata & Moriwaka (2007). Applicability of location compatibility to the arrangement of display and control in human vehicle systems: Comparison between young and older adults, Ergonomics (50)1, 99-111.

Arrangement of components

• Arranging components within physical space.
  – Examples
    • Controls and displays on a control panel
    • A telephone, pen holder, and books on a desk
    • Desks and equipment in an office
    • Offices, classrooms, and restrooms in a building
    • And building in an industrial park
  – The component is the lowest level entity being arranged in the space.
    • When arranging furniture in an office a desk is a component, but books on the desk are not.

Designers need to understand basic principles and methods for arranging components.

– To place each component in an optimum location for serving its purpose.
  • Optimum would be predicted on:
    – Human capabilities and characteristics
    – Sensory capabilities
    – Anthropometric
    – Biomechanical characteristics.
  – Not possible to place each component in its optimum location.
    • Example: So many office rooms can be close to the restrooms.
    • Must be determined by the design team, considering factors.
      • Depending on the circumstance
      • Concerned with the general location of components
      • Concerned with the specific arrangement of components.

Principles of arranging components

• Importance principle
  – Important components be placed in convenient locations.
• Frequency of use principle
  – Frequently used components be placed in convenient locations.
• Functional principle
  – The grouping of components according to their function that are functionally related in the system.
• Sequence of use principle
  – Sequences or patterns of relationship frequently occur in the operation of equipment or in performing some service or task.

Layout based on four principles

• The principle is applied only in circumstances
  – showing importance low and medium can be better or equal to high level arrangement.
Types of data for arranging

- Types of data for use in arranging components
  - Basic data about human beings
    - Anthropometric and biomechanical data
    - Sensory, cognitive, and psychomotor skills
  - Task analysis data
    - Work activities of people, tasks.
  - Environmental data
    - Any relevant environmental features of the situation
    - Illumination, noise, vibration, motion, heat, traffic, etc.

Design Arranging for who?

- How not to do it
  - We designed!
    - Example story, Sanders, p. 460-461 (Engineers’ design for the operators)
    - Not always followed in practice.

Gathering task data for arranging

- Gathering basic task data
  - For the existing system:
    - Use of film, observation, the use of eye movement recording, interview
  - For the New system:
    - need to be inferred from tentative drawings, plans, procedures, or concepts are available.

Task data for arranging

- Task data
  - The broad classes of task related information useful in arranging components are:
    - Information on the use of the components individually.
      - Example: Ranking 5 point scale, “seldom used” to “very frequently used”.
    - Example: Quantitative index of accessibility for use in locating controls
      - Composite index, control accessibility index
    - Information on the relationships between components as they are used.

Relationships between components

- Information dealing with relationships between components
  - Links = Relationships between components.
  - Types of links
    - Communication links
      - Visual (person to person)
      - Auditory, voice (person to person)
      - Auditory, non voice (equipment to person)
    - Touch
    - Control links
      - Control person to equipment
    - Movement links generally reflect sequential movements from one component to another.
      - Eye movements
      - Manual movements, foot movements, or both
      - Body movements

Summarizing link data

- Summarizing link data
  - Link data are often summarized in a link table.
  - The relationship of each component with any other one (e.g. each link) was rated by the following scale:
    - Example:
      - A: Absolutely essential for the activities to be located close together
      - E: Essential
      - I: Important
      - O: Ordinary
      - U: Link not exist
      - X: Undesirable to be placed together
      - Not effective for developing a picture of the problem at hand.
Graphic representation of link data

• Adjacency layout diagrams
  – Example:
    • Adjacency layout diagram of eye movements (links) between aircraft instruments during a specific maneuver.
    – It does not indicate the sequence in which the components are used.

• Spatial operational-sequence diagrams
  – SOS diagrams graphically depict the actual sequence of operation overlaid on a pictorial representation of the work place.

Graphic representation of link data

• Spatial operational-sequence diagrams
  – Example in nuclear power plant control room operator’s actions.

Layout meeting ergonomics

Ergonomic Office layout

• Office workplaces concern a growing percentage of the working population worldwide (Margaritis & Marmaras, 2005).
  – Office workers increased from 17% to over 50% of the workforce in USA.
• The ergonomic requirements concerning the design of computerized offices address four main elements of the work system (Margaritis & Marmaras, 2005):
  – The office equipment
    • comprising of requirements for the monitor/screen, the keyboard, the desk/work surface and the seat,
  – The environmental conditions
    • comprising of requirements for the work space, the lighting, the noise, the thermal environment and the static electricity.
  – The software
  – The work organization

• The following requirements are mainly dependent on the placement and the orientation of individual workstations (Margaritis & Marmaras, 2005):
  – There should be no annoying reflections or glare in the working area;
  – There should be appropriate lighting, conforming to the task’s needs;
  – The lighting should be uniform throughout the working person’s visual field;
  – There should be no annoying hot or cold draughts in the workplace;
  – The access to the workstation should be unobstructed and safe;
  – The work flow should be facilitated;
  – The cooperation (both between the personnel and between the personnel and the external persons) should be facilitated;
  – There should be conformance between the organizational structure and the placement of the workstations;
  – Privacy should be ensured, if required;
  – There should be ease of access to elements such as windows, cooling/heating devices, etc. for manipulation and maintenance purposes.
Ergonomic Office layout

  - They suggested a method and an information technology tool aiming to support the ergonomics layout design of individual workstations in a given space (building).
  - Method:
    - Methods included 6 stages to draw office layout meeting ergonomics needs.
    - Design 10 real office layouts
      - Using ErgoOffice 0.1
      - Not using ErgoOffice 0.1
    - Assess the effectiveness and usability of ErgoOffice 0.1 through cognitive walkthroughs by the four interior designers.

Ergonomic Office layout (6 stages)

- 1st stage: determination of space available:
  - To determine the space where no furniture should be placed, to ensure free passage by the doors
  - The four designers use the AutoCad 2000® and an electronic library containing the available furniture as tools.
  - A cognitive work analysis through systematic observation and a posteriori verbalization showed that the designers simplify the search for layout solutions by considering a small number of design requirements.
  - Consequently, they disregard the majority of the ergonomics requirements, and they produce layouts marginally meeting some of these requirements.

Ergonomic Office layout (6 stages)

- 2nd stage: design of workstation modules
  - To design workstation modules that meet the needs of workers.
  - Each module is composed of the appropriate elements for the working activities, desk, visitor’s seats, etc., delimiting the free space.
  - ErgoOffice 0.1 provides a library of about 600 different modules.
Ergonomic Office layout (6 stages)

• 3rd stage: placement of organizational units
  – To decide about the placement of the various organizational units (e.g. departments, working teams, etc.) within the various free spaces of the building.
  – Primary issues to be considered:
    • The shape of each space
    • The exploitable area of each space
    • The area required for each unit
    • The desired proximity between units
    • Eventual particular requirements of each unit
  – ErgoOffice 0.1 calculates automatically the exploitable area of each space
    - A exploitable = A total - A unexploitable
  - where no modules can be placed
    - A exploitable = A required

Ergonomic Office layout (6 stages)

– Proximity graphs (a graphical method for the relative placement of organizational units) were drawn to find out arrangements.
– The evaluation of alternative arrangements of organizational units using the following measure:
  $E_{\text{prox}} = \sum_{i=1}^{M} \sum_{j=1}^{M} \left( C_{ij} \cdot D_{ij} \right)$
  - where $M$ is the number of organizational units, $C$ is the proximity rate between two units, and $D$ is the relative distance between two units on the proximity graph.

Ergonomic Office layout (6 stages)

• 4th stage: placement of workstation modules
  – Following the ergonomic requirements
    • Place the workstations in a way that facilitates cooperation between co-workers. In other words, workers who cooperate closely should be placed near each other.
    • Place workstations at which external visitors will be received near the entrance doors.
    • Place as many workstations as possible near the windows. Windows may provide benefits in addition to variety in lighting and a view.
    • And more…
• 5th stage: orientation of workstation modules
• 6th stage: final adjustment and evaluation

Ergonomic Office Layout Results

• Results from the study (Margaritis & Marmaras, 2005)
  – They achieved by decomposing the layout design problem to a number of stages, during which only a limited number of variables and requirements are considered, as well as by converting the ergonomic requirements to functional design guidelines.
  – They found that given the complexity of workplace layout design is almost definitely encounter contradictions.
  – A recent layout philosophy is the “flexible office”, where the furniture and the equipment are designed to be easily movable in order to be able to modify the workstation arrangement, depending on the number of the people present in the office, as well as the running projects or work schemes themselves.
  – They proposed method shares common ideas with previous generic methods for office layout.
  – A systematic evaluation of 10 real office layouts designed using and not using ErgoOffice 0.1 showed that the former layouts meet much better the ergonomics requirements.
Discussion

• Interior Design and Arrangement
  – Designing and Decorating a room
    • The difference between designing a room and decorating a room is influenced by function and intent.
    • It is necessary to reach the final goal of a comfortable and functional space.
    • Interior designers are concerned with ergonomics, the relationships between humans and furniture and associated products.
    • There are interior designers who specialize in designs for special-needs populations, senior citizens, schools and other areas in which particular needs must be met.
    • The application of ergonomics is used in all aspects of interior design.
    • The interior decorator is less concerned with ergonomics and more concerned with aesthetic appeal of furnishings and the overall space.
    • Decorators may specialize in single elements of decor such as color application, furniture arrangement or fabric selection.
    • Interior decorators, however, usually are hired to redecorate an entire space, and so they must be well-versed in all the elements and principles of design.