Part 1: Design and Evaluation, Displays, and Controls

As the designer and the user are one and the same, this document will be written in 1st person

Topic

For this engineering exam I resolved to find a topic with which I had some personal experience to expedite the applicable domain learning curves. I considered many of the tools and processes with which I'm familiar, the jobs and the environments for/in which they come into use, seeking instantiations which related to the exercise prompts. Unfortunately (as far as this exam is concerned), the examples I could pull into clear memory were one-off experiences, from welding aluminum tubing to a cliff-side residence from atop a precarious ladder, to the hurried electronic and mechanical modification, transport, and assembly of large kinetic human-powered machines (to Sergey Brin's surprisingly intimate birthday party at his house), to the simplest operation of a splitting maul, prepping firewood to load into a pickup.

None of those operations really succumb to "workplace analysis", because they were either contingent on tight timelines and odd situations, or merely seasonal tasks without a sustained footprint in my mental landscape. Aside from jobs running dishwashers, waiting tables, and working at the rental car counter at the airport in my youth, my predominant encounter with repetitive and tedious workplace operations where I might be exposed to ergonomic stress and fatigue, is my daily work at the keyboard.

Seated computing is the source of all my personal workplace repetitive stress and fatigue. For 25 years I have worked as keyboard jockey, designing, programming, and running production work, with a variety of computer tools, but always long hours, at a desk, arms in one position, focusing on a nearby screen. Poor sustained seated postures have resulted in persistent shoulder and back injury.

A proper workstation designed to alleviate this strain would be well heralded by my aching frame. Furthermore, at my new residence, the family of two (my 5th grader and I), and sometimes three (when the mom visits), share an aged but cute house turned two-bedroom duplex, and my needs for a suitable office led me to commander a substantial swath of the kid's room—and this I want to repatriate for her.

The only viable solution is to find appropriate space in the main room. A traditional workstation setup would be less than desirable, as this room isn't that large, and serves multiple family functions from meals to evening social functions, and all the transitions between. My requirements are a slim minimal design, that includes transitional functionality, to minimize the obstruction.

In this vein, I have conceived a second functional group, that of *media* and *household dashboard,* to be described in later analysis. I have identified the best space in the main room that can serve as these functions for all the anticipated users. The station must accommodate these functions and their transitions, be aesthetic, well-integrated, and sensitive to episodic daily rhythms, as well as the circulation of the adjoining spaces. The height, if fixed, should serve all functions with minimal or no compromise, or should easily adjust, to allow for different modes of use, such as standing or sitting. Depth of the work surface may also be variable, as the workstation mode will facilitate computer input peripherals, while the media mode does not. The change in functional use could be facilitated by the transitional appearance of a stowable working surface when needed.

I introduce the "Workstation/Media Dashboard" or *WMD.*

Stages of HF in product Life Cycle

The product is a multi-functional utility furniture, for a limited and known user group, designed to accommodate specified equipment and purpose built for one location. As a secondary consideration, the product may be recoverable to be used in other locations, such as when the users leave the residence.

Front-end analysis asks chiefly *who are the users*, and for *what functions does the product serve*. Those functions shall be matched to specific tasks, to ensure the product accommodates user demands. Additionally, *environmental conditions* for the product and *user preferences and requirements* should be addressed.

The WMD serves me, my family, and guests, in a fixed indoor residential setting. The author of this report is both the designer and a user, and the principal user of the work surface functions that drive the primary design goals. The other common user in the household is a ten-year-old, who will interact with the product primarily through the secondary function as a media display. Examining Table 1 one might conclude that of the two classes of users, “Others” may be in contention with “Dad” for overlapping uses. Conflict resolution for these occasions is beyond the scope of this assignment, but there are well-known case-studies to refer to, wherein Dad-users tend to hold the tie-breaking vote (Nock, 1988)

The environment for the product is the multi-purpose room, which is the only entry point from the outdoors, via an ascending stairwell, and contains a dining area served by a bistro-height table with backed stools, and a living room with variety seating. The space measures about 12’ x 18’, and the installation occurs in the middle of the long wall. The room design is functional modern aesthetic, with a light touch of bohemian, which is germane to the user’s design preferences. Plans for prodigious leafy understory jungle plants are in the works.

The WMD serves two primary functions, 1) as a computer workstation for general computer work which may include casual web browsing and communications, up to intense document writing, coding, and visual design work. 2) The system must serve also as a multimedia entertainment and information display that will face evening recreational media roles, as well as the daily routine side of family operations as a dashboard organizer for tasks and rituals.

Table 2 demonstrates functional modes and associated tasks and users. As a functional workstation, tasks are system-centric, which is to say, active, and focused at the station, needing horizontal surface or surfaces to support conventional workstation needs. In the interest of simplicity and higher chance of success, options for ideal adjustments will be limited to those which can be situated inside the construction framework. The overall enclosure should be a fixed height and should afford comfortable operation from either a standing or a high seated (special ergonomic stool) position.

The media and dashboard functions are two modes supported by minimal sustained control input, ie, primarily passive, and at a distance. A caveat notes that media roles may include interactive sessions, such as those associated with gaming, but that function will be supported by dedicated accessories not related to the design needs of the WMD.

A dashboard mode provides detailed information display to the busy morning side of the household to include a clock with custom countdown alarms for multiple users, checklists, local and regional weather and news information, and schedules and reminders. The dashboard mode will also provide audio functions like internet radio. Both dashboard and media roles will make use of panel doors in the system cover to allow one or more screens to be extended for best viewing angles. See Fig 1 for proposed system overview.

Iterative design and testing. In a marketplace where a product will be sold in units of thousands or more, the product developers will iterate and evaluate the series of candidate releases for performance objectives. Some products are one-off, or bespoke, custom designs not likely to be repeated (but learned from, and therefore a process iterated in future projects).

However, like most custom utility furniture design projects, a creative, sometimes serendipitous, continuous iteration occurs between paper sketches, technical AutoCAD drawings, and a flip through the McMaster-Carr catalog. The WMD design process will inevitably be iterative, to include a variety of subsystem tests and prototypes. For instance, the WMD as conceived includes a form-fitting vertical cover that doubles as the worksurface when lowered. This is the most complex component of the design and will necessitate prototyping.

System Production. As a utility furniture installation into an active residential environment, efforts to minimize disruptions to the users will be appreciated. The installation site itself is relatively out of the way of daily routines, but the creep of tools and materials will inevitably be felt into the space. The components will be constructed offsite in external workshops and brought for assembly and fitting in phases. See Table 3 for optimistic timelines.

Implementation and evaluation. Since the designer and user are one and the same, the WMD will be under continuous evaluation, and subject to inevitable modification and upgrades. Perhaps the system will find a successful implementation that warrants further productization.

System operation and maintenance. Custom made utility furniture *on a budget* is frequently vulnerable to material or design failures and will need repairs. Hardware will be kept accessible to facilitate upgrade and maintenance.

System disposal. The materials will be non-toxic plywood using recoverable hardware.

Part 2: Anthropometry, Workspace Design, and Work Physiology

Anthropometry

The primary functions of the design are matched to known users, but the dominant functional mode, the workstation, will overrule other design decisions. If the design were meant to be exclusively a media or dashboard installation, invariably a different design path would be followed.

With the one primary user known in advance, exacting specifications can be set to achieve optimal performance. There are two critical heights to establish for the workstation, 1) display height, and 2) desktop height (for keyboard/mouse input). Many studies have been conducted on these primary ergonomic values, providing a mean sample to operate from, but beyond the quest for platonic perfection, a consistent message surfaces: some adjustability is essential. (Burns et al., 2017)

With regards to the first feature, display height, the user's eye height from floor should be known to calculate optimal mounting position for the displays. For the desktop height, the optimal settings are based on elbow height from floor. The user's overall height will be recorded for completeness. See Table 4 for measurements.

Research shows that optimal display height for either a standing or seated user is below the line of sight, up to 30 degrees below the horizontal, with a preference at 15 degrees. (Sommerich et al., 2001). The monitor shelf will be constructed to receive a dual screen mount

with adjustable armature allowing a range of movement to suit the user's best needs. See Fig 3 for a render of these proposed key placements.

Principles of Workspace Design

Wicken's workspace design principles address concerns of accessibility and optimization. Of the program needs, the WMD's workstation function mode has the most stringent requirements, as this is the only mode with persistent interaction. As established, the principal workstation user is known in advance, enabling a letter-perfect optimization to the user's anthropometry and preferences. Slight adjustments during use will be easily achieved by the monitor stands, adjustable keyboards, and the variable height standing/leaning stool slated for use in the implementation.

As a computer workstation goes, this design will not deviate greatly from established norms. The twin computer displays cover a wall area of 48" wide, and 18" tall, and comprise the only needed visual displays. The keyboard and mouse will comprise the primary input devices. The cabinet will contain potentially a few other minor control devices, HDMI output switches, routers, possibly lighting controls to be determined.

Seated vs Standing

One solution the designer is eager to try is a standing desk configuration with a leaning stool, such as the LeanRite chair (Fig 2), combined with a standing height workstation. Studies have shown mixed results for standing height computing, but overall indicate a variety of positions have positive results. (Lin et al., 2017) (Callaghan et al., 2015)

For establishing the ideal height for a standing workstation, the literature agrees that a height just about at or up to two inches lower than elbow height is ideal. (Commissaris et al., 2014)

Energy Costs and Expenditures

Fatigue and stress related to prolonged computer workstation use is well documented. Many health advisories suggest regular breaks and frequent position changes to relieve repetitive stress injuries. Some things are simply beyond the control of this project, but worth noting that near vision fatigue has been shown to decrease proportionally to distance from the screen. Wolfgang Jaschinski published a study in Optometry and Vision Science concluding that subjects chose a viewing distance of 63cm, roughly two feet, when working at a computer workstation (Jaschinski, 2002)

One might also wonder about the fatigue differential between seated and standing computer work, and for this a study confirmed that the difference in energy expenditure of tasks carried out in sitting compared to standing is negligible (Burns et al., 2017).

Thanks for reading.

See Figure 4, system stowed

Tables

Table 1

Front-end analysis—Use level and frequency by user, by function

User	Workstation	Media	Dashboard
Dad	Intensive, frequent	Occasional	Episodic, daily
Others	Rarely	Regularly	Episodic, daily

Table 2

Task analysis—function with tasks and configuration

Function	Task	Configuration
Workstation	Computing tasks	High-stool or standing, desk extension
Media	Screen viewing	Desk components stowed, soundbar positioned, one panel open, West screen extended
Media	Music control	Desk stowed, various panel and screen configs
Dashboard	Monitoring on-screen streams, interaction with a task app	Desk stowed, panels open, screens mirrored and extended

Table 3

System production—construction and installation timelines for the utility furniture

Component or Phase	Construction	Install
Wall-mount, base	2 hours	1 hour
Wall-mount, frame	4 hours	2 hours
Shelves	2 hours	1 hour
Wiring	-	1 hour
Screen and armature		2 hours
Soundbar adjustable frame	2 hours	1 hour
Desktop/Panel-lid	2 hours	1 hour
Finishing	-	1 hour

Table 4

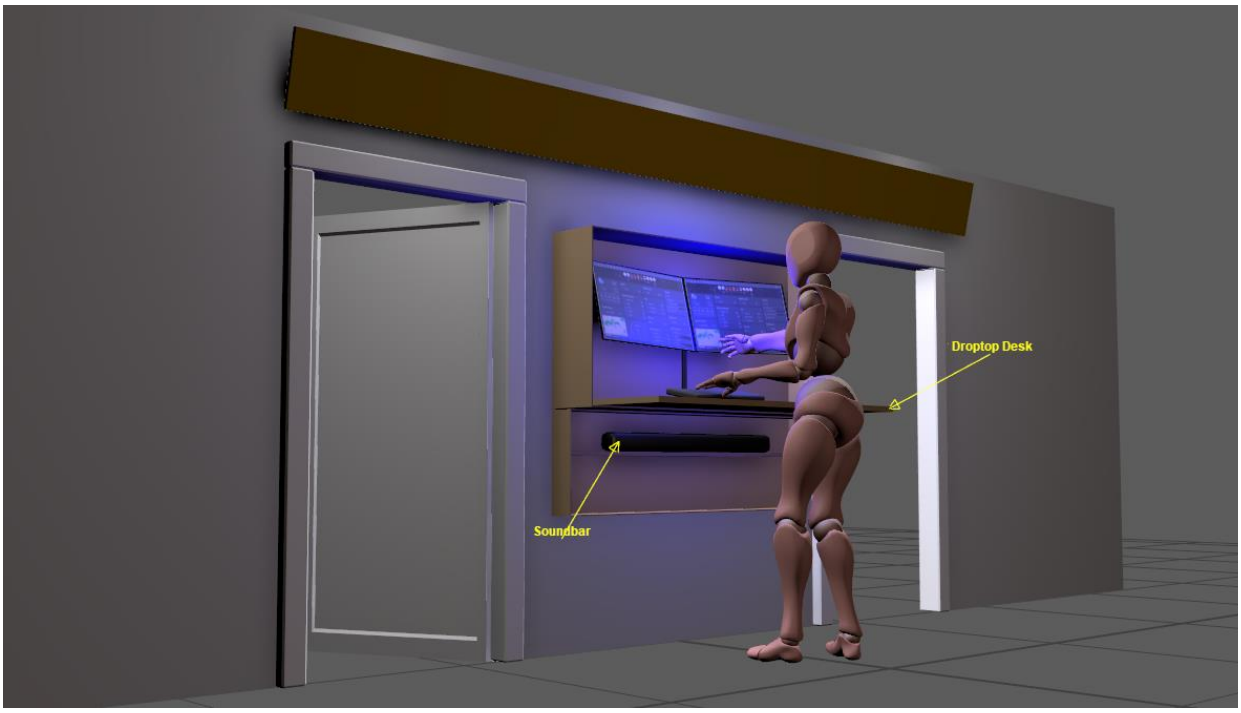
Anthropometric data—primary user measurements

Feature	Height
Overall Height	73.5”
Eye Height	69”
Elbow Height	44”

Figures

Figure 1

WMD system installation



Full resolution hyperlink

Figure 2

LeanRite chair positions

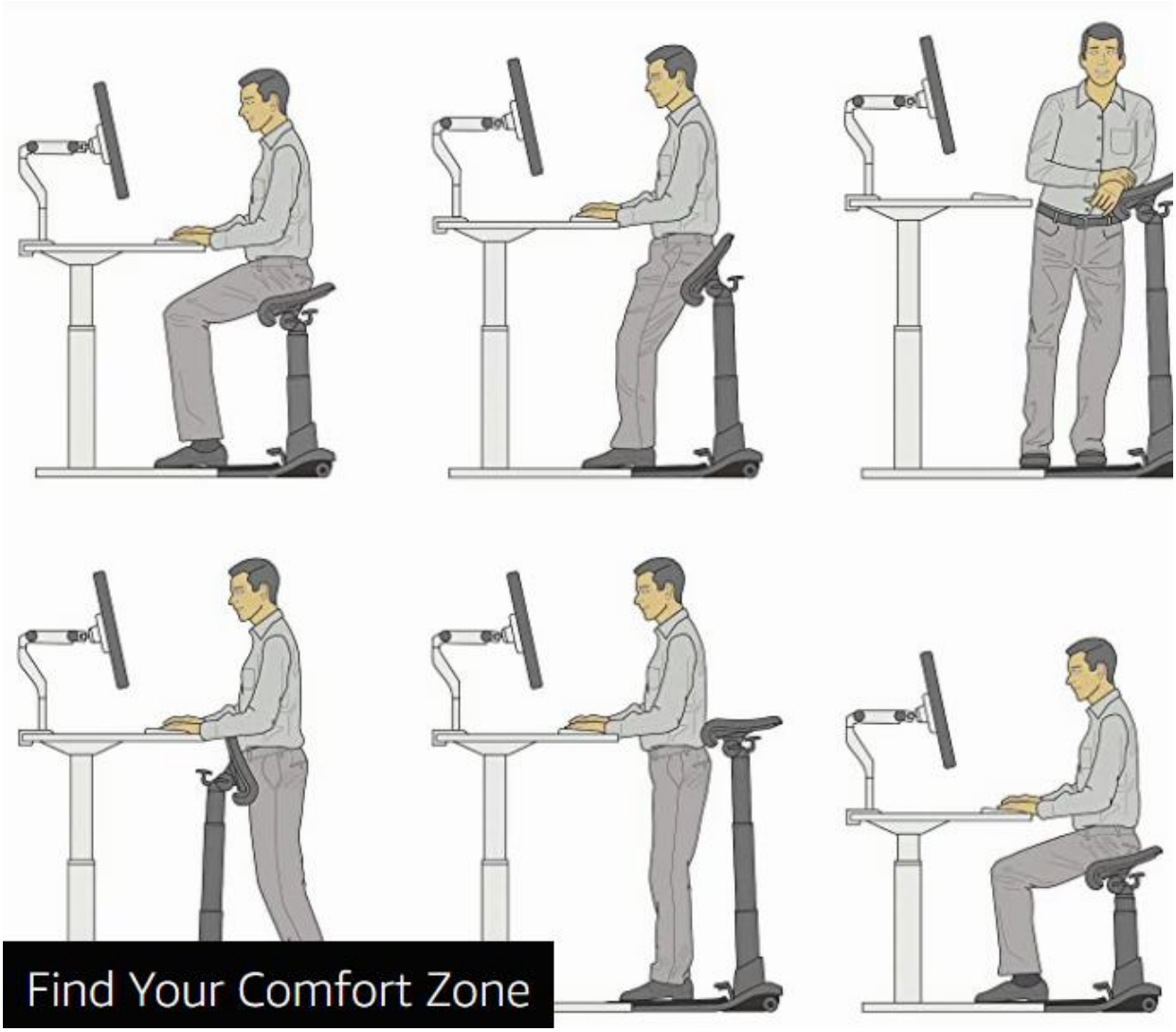


Figure 3

WMD key ergonomic placements

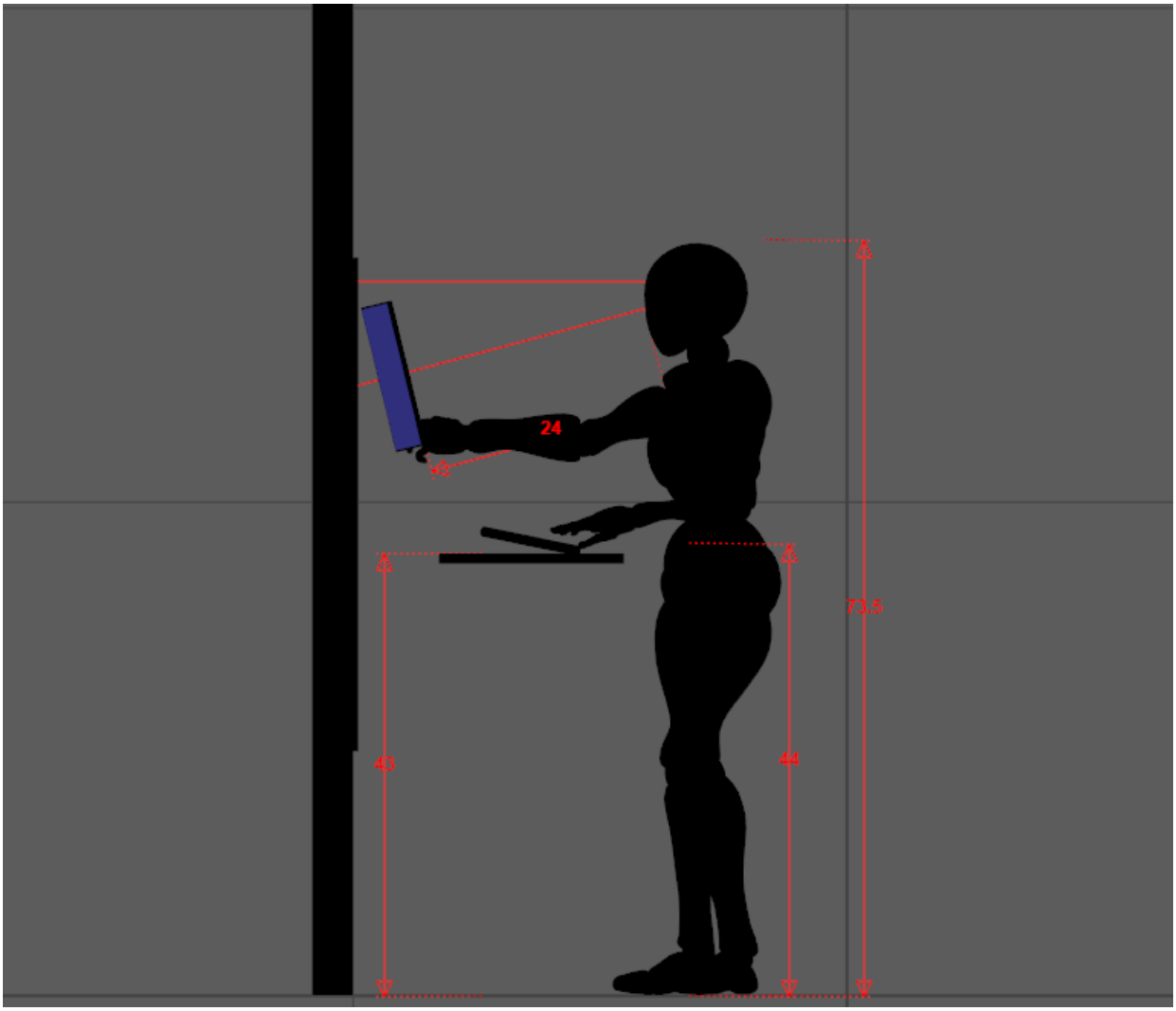


Figure 4

WMD—at home on the Palouse

Full resolution hyperlink

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