Desktop Build

Working Backwards Story

As Josh - a Senior SDE at Amazon - once said to me, we are *Masters of the Machine*. I do not yet feel as though I am such a master as of today but I am confident that the design and assembly of my personal desktop computer will bring me substantially closer. In addition to being an educational experience, this new tool which I am building will need to be designed such that I can quickly and effectively use it to develop future projects which I have planned. These include but are not limited to; circuit board design, 3D modeling, video editing, and educational games. I plan to keep this desktop with me for the next thirty years so it will need to be durable enough to survive multiple relocations. This desktop will also be the new home for all my personal data, including but not limited to; photos and documents. The budget for this desktop is in the range of 1000$ to 1500$. It is a right of passage as a Computer Engineer to have designed and built your own desktop and I am excited to embark on this quest now.

Specifications from Working Backwards Story

System Requirements for Desired Programs

The first approach to derive the computer specifications was to list and evaluate the suggested specifications for the software I wanted to run. In this chart I selected a single software application to represent each of the following categories, respectively; Circuit Design, 3D Modeling, Gaming, and Video Editing. Low and behold, I find out that the software pages which vend these applications provided extremely vague system requirements. For instance listing a CPU by core count or general identifier (think Intel i7 or i5) can span a significant range of benchmarking scores. I think these values will be good to sanity check our solution against in the end but not as a primary method to create our system requirements.

Software to Run	RAM (GB)	Drive Space (GB)	CPU (cores)	Gaphics Card (Toms Hardware)
Altium Recommended Specifications	16	10	4	20.8% (percent of 1080p Ultra)
Autodesk Inventor System Requirements	32	40	4	22.0% (percent of 1080p Ultra)
Fortnight System Requirements	30	26	6	66.8% (percent of 1080p Ultra)
DaVinci Resolve	16	2	4	62.5% (percent of 1080p Ultra)

System Recommendations from PC Part Picker by Build

PC Part Picker creates a design guide for different classes of home desktops. These classes range in cost as follows;

Budget	Entry Level	Modest	Great	Excellent	Enthusiast	Magnificent	Glorious
$450	$600	$720	$1,100	$1,300	$1,530	$1,800	$3,200

Since my budget is between $1000 and $1500 the Great, Excellent, and Enthusiast builds are of interest. PC part picker provides example builds for its build types for both AMD and Intel. The following table shows the high-level part breakdown for the three AMD builds of interest (please see the *Discourse on AMD and Intel* section below to understand the rationale for AMD).

	Great		Excellent		Enthusiast	
CPU	Ryzen 5 7600	$ 178.99	Ryzen 5 7600X	$ 194.00	Ryzen 5 7600X	$ 194.00
RAM	2x16GB kit of DDR5 RAM	$ 81.99	2x16GB DDR5 RAM	$ 81.99	2x16GB DDR5 RAM	$ 81.99
Storage	1TB SSD	$ 89.97	2TB SSD	$ 89.97	2TB SSD	$ 89.97
Motherboard	B550 chipsets	$ 99.99	B650 chipsets	$ 99.99	B650 chipsets	$ 129.99
Graphics	AMD Radeon RX 7800 XT	$ 439.99	NVIDIA GeForce RTX 4070 SUPER (12 GB)	$ 574.99	NVIDIA GeForce RTX 4070 SUPER (16 GB)	$ 739.99
Case	Mid Tower	$ 36.90	Mid Tower	$ 89.99	Mid Tower	$ 59.99
Cooling	Mountable Air Cooled	$ 74.97	Mountable Air Cooled	$ 39.90	Mountable Air Cooled	$ 35.90
Power	80+ Bronze certified or above	$ 49.99	80+ Gold certified	$ 75.97	80+ Gold certified	$ 75.95
PriceTotal		$ 1,052.79		$ 1,246.80		$ 1,407.78

This guide published by pc part picker provides a good reference against which to check the cost and performance of our final build; however, does not address the specific needs of this particular build. The core components and features are discussed in the following section through the lens of our working backwards story.

Design Decisions and Rationale

Air Cooling vs Water Cooling

Air cooling is the old reliable way to keep your cpu and graphics card from overheating. Bolt down enough fans to create a small tornado in the room and watch everything stay around room temperature; wallah. This tried and true method is reliable, takes no maintenance, and importantly will not fry your system if it fails. On the flip side, the sleeker modern alternative is to water cool your system. Typically this is done by running a fluid through both your cpu and your graphics card to a radiator on the side of your case and blowing air through the radiator. This is supposedly more efficient than air cooling, quieter, and, I will admit, looks a hell of a lot cooler.

That said, this specific build will need to be semi portable to make relocations easier and may even be subject to some functional time on the road. The dynamic environment which this build will find itself in exposes it to many failure scenarios and I do not want to burn a grand; however, the air cooled cpu's look ridiculous to me so we will compromise and go with a water cooled cpu and an air cooled graphics card.

CPU Selection

Out of the different AMD cpus available the Ryzen product line is the one designed for desktop computers. The Ryzen processors follow the following naming convention: *Ryzen x gzzz*. Where *x* indicates its performance tier being one either 3, 5, 7, or 9 (where higher numbers indicate higher performance), and *gzzz* indicating its feature set. The feature set includes but is not limited to clock speeds, core count, and power consumption. Notably, the *g* indicates the generation of the chip. If Ryzen were to hypothetically launch a new cpu tomorrow they would name it Ryzen 7 (10)*zzz* indicating that it is a 10th generation processor in the performance tier 7 with feature set *zzz*. Armed with this information lets look at what PC part picker recommended we use for the excellent desktop build: Ryzen 5 7600X. This is a 7th generation chip which was produced late 2022 early 2023 and is of performance tier 5.

Graphics Card Selection

Graphics cards require certain motherboard slots and power supply wattage. Graphics cards have a soft requirement to roughly match the CPU performance. Financially it would be a bad idea to pair a budget CPU like a 3-series Ryzen processor with a high end graphics card like the NVIDIA RTX 4090.

A core feature of this build is to enable me to work on a variety of different projects. The implied intent behind these projects is that they will bolster my professional career. One big industry trend in computer engineering is the rise of Cuda as a language with which to control GPUs. Cuda is the proprietary language for NVIDIA graphics cards, cards which have swept the market over the last few years and will presumably continue to dominate in the immediate future.

This professional advancement coupled with BennieBoo's comment about how one can "only play ray tracing games with an NVIDIA graphics card" has solidified my decision to go with this brand.

The nvidia graphics cards are broken into two main categories: RTX and GTX. The newer RTX supports ray tracing technology whereas the older GTX does not. These both reside in NVIDIA's GeForce family, designed for desktop computers. The first number after GeForce RTX is the series it is from, higher numbers indicate a newer series. The common ones on PC part picker as of today are the 3-series and the 4-series. The RTX 4-series super is the one which is recommended to buy for my build by pc part picker.

It is interesting, if there are so few GPU producers (AMD / Nvidia) why are there so many brands flooding the market which I have never heard of? The GPU chips are sold to add-in-board (AIB) partners who package the chips.

Motherboard Selection

In the working backwards story I alluded to the personal projects which this build would enable. I cannot visualize all personal projects which this build *might* play a role in so it is best to err on the side of caution. I do know that I would like to have a 3D printer and some networking equipment so at a minimum I would want to have an ethernet port, a USB-C ports, two USB-A ports, and at least one HDMI and DVI port. As far as networking is concerned I also expect to have a wifi chip and bluetooth transceiver.

Chipsets, chipsets, chipsets ! AMD motherboards follow a pretty simple naming conventions: one letter followed by four numbers. The letter (X -> B -> A) describes the feature set with X being high end and A being low end. The first number (and really the only number that matters) tells us which series processor the motherboard is compatible with.

One key feature I want in the motherboard is that it breaks out the ports in a rectangular interface which will be flush to my case. This coupled with the hard requirement that it must be a microATX board and compatible with AM5 sockets still leaves a handful of options on Amazon. Analysis of these options indicates that the cheaper versions of these boards selectively omit certain components or features. This includes but is not limited to wifi cards, 2.5G ethernet (vs. 1G ethernet), PCIe headers, or RAM slots. Since my use case is not particularly well defined I will err on the side of caution and spend a little more to acquire all the features I need / may need.

Case Selection

There are two main decisions to make when selecting the case; material and size. The case selected will need to be durable enough to undergo multiple relocations and at its extreme, use while on the road. This will expose the unit to regular vibrations, compressive loads, as well as dust and debris. The best material for this build will be an all metal case with mesh grating for airflow (there needs to be some way to cool this powerhouse of a graphics card)! As for the size it should be portable enough to not make moving it a health risk, yet big enough to allow for adequate airflow. The two case options I am considering is ATX Micro and Mid Tower. The critical metrics to take into account when considering an ATX Micro case will be the graphics card length and radiator support sizes.

Discourse on AMD vs Intel (& Apple)

Intel and AMD are the two powerhouses in commercially available desktop CPUs. Unlike Apple's M-series CPU chips which are ARM based and cannot be easily integrated into other ecosystems, Intel and AMD both offer x86 CPUs adaptable for most personal systems*. This market dynamic

results in the common core question; AMD or Intel? Since this topic is as surface level to computer engineers as what colors to make the Kuiper Customer Terminal LEDs, everyone and their mom feels like they have the right to declare their opinion. This overwhelming volume of biased information has frankly made me not give a shit. I am sure they both have their pros and cons, features which I might regrettably discover later, but I will base this decision on my intuition. Intuition which has been shaped by multiple hours of *Tech Linked* videos on youtube proclaiming Intel's latest line(s) of chips consistently underperforming their past generations. I am not in the market for a budget desktop and AMD has always had some mythical appeal. Decision final.

*Technically AMDs CPUs run a *Zen* architecture but under the hood this is really an x86 architecture.

Design Complete

Well, after consuming a high volume of specs and comparing a seemingly endless number of parts the build is complete. The final selection is as follows.

	Part	Cost
CPU	AMD Ryzen 5 7600X	$ 194.00
RAM	DDR5 RAM 32GB (16GBx2)	$ 83.99
Storage	SSD 2TB PCIe NVMe Gen 4	$ 119.99
Motherboard	B650M AORUS Elite AX	$ 179.99
Graphics	GeForce RTX 4070 Ti Super 16G	$ 739.99
Case	ASUS A21 Micro-ATX Case	$ 39.99
Cooling CPU	AIO 360 mm	$ 71.99
Cooling STD	Fan Kit (120x3 mm)	$ 19.99
Power	Corsair RM750e (full modular)	$ 99.99
PriceTotal		$ 1,549.92

Ultimately, we are over budget by $49.92 but I feel good about this because I would rather err on the side of caution regarding components I am on the fence about. Of these, the power supply which is recommended by the graphics card manufacturer to be at LEAST 700w, I have decided to go with 750w to be on the safe side. Additionally, I included an additional 3x120mm fan kit which was not even listed in the PC Part Picker guides because I would like to have this setup to have adequate airflow (especially since I am ripping a beast of a graphics card). The other item I did go over budget on is the motherboard. There is a host of i/o which is hardware specific and I do not know which of these will be necessary for my personal projects so I did decide to go with a more spec'e out motherboard than was recommended by pc part picker. I look forward to putting all these pieces together!