A Hardware Wonk's Guide to Buying the Best 3D and BIM Workstations, 2013 Editions

Matt Stachoni

Senior AEC / BIM Applications Technical Specialist, *CADapult LTD*

matt@stachoni.com
matts@cadapult.net
Twitter: @MattStachoni

Class Summary

At the end of this class, you should be able to:

- Explain the specific technical demands of applications in the Autodesk Building Design Suite
- Understand the current state of the art in processors, memory, storage, and graphics hardware
- Know the trends that will drive hardware considerations in the near future
- Identify the sweet spots are in today's graphics workstation hardware
- Answer the question, "Should I buy _____?"

Obligatory Disclaimer Slide

I do not officially endorse nor am I sponsored by any of the companies or products that I talk about in class.

No one sends me things to review or pays me to say nice things about them.

However, if you want to send me things to “evaluate” and pay me to say nice things about you and your product, I will.

Session Outline

- Market Analysis of Industry Trends
- Application Demands in the Building Design Suite
- Current and Future Hardware Trends
- Processors
- Memory
- Storage
- Graphics
- Buy or Build?
- Example Builds
- Laptops and Mobile Workstations

Survey

How many of you…

- Have the Building Design Suite Standard? Premium? Ultimate?
- Are using Revit? 3ds Max? Navisworks? Showcase?
- Want (or need) to move to the Revit platform soon?
- Create renderings and animations in any of these applications?
- Are running hardware more than a year old?
- Probably need new hardware, but aren't sure of what to get?
- Are hardware geeks at heart?

Market Analysis of Industry Trends

Industry Pressures and Trends

Industry moving from CAD to BIM at a record rate

Designers > General Contractors > Subcontractors > Owners

New hardware capabilities allow for heavier problem solving

Parallel problem solving → BIM, rendering & ray tracing

Distributed problem solving → render farms, cloud analysis

More people using higher-end software

Using > 1 large application at a time (3ds Max/ Photoshop/Revit)

Increasing number of background Windows services (AV, etc.)

More multithreaded applications

The Cloud

What is it?

What does it do?

How does it work?

How much does it cost?

Affect on hardware purchasing considerations today?

How will it affect hardware configurations in the future?

Pricing Compression

Each year = new hardware iterations

New CPUs, graphics cards, storage options

Push out the old / repurpose for new life

Typically equal or even lower in price

Commodity pricing: 500GB is $75, 2TB is $93

Application Demands on Hardware

Building Design Suite Application Demands

	CPU Speed / Multithreading	System Ram - Amount / Speed	Graphics Card GPU Capabilities	Graphics Card Memory Size	Hard Drive Speed
Revit	**10 / 9**	**10 / 7**	**7**	**5**	**10**
3ds Max Design	**10 / 10**	**9 / 7**	**7 / 5 /10 (Nitrous / mr / iRay)**	**6 / 10 (mr / iRay)**	**10**
Navisworks Simulate Navisworks Manage	**8 / 7**	**7 / 6**	**7**	**5**	**8**
Showcase	**9 / 8**	**7 / 6**	**9**	**5**	**9**
Sketchbook Designer	**4 / 4**	**5 / 5**	**4**	**4**	**4**
AutoCAD (2D & 3D)	**6 / 6**	**5 / 5**	**5**	**5**	**6**
AutoCAD Architecture AutoCAD MEP	**8 / 8**	**7 / 5**	**8**	**7**	**8**
ReCap Studio / Pro	**10 / 10**	**9 / 5**	**8**	**7**	**8**

Note: Any score of 5 or below can be handled by almost any machine you buy today.

Application Demands – Revit Stresses

Revit stresses every major subsystem in a workstation:

- CPU, RAM, Video Card, Mass Storage, Networking
- Revit is a desktop-based Database Management System

DBMS Applications stress hardware differently than other apps

- Typically like large CPU L1, L2, L3 caches
- Typically consume a lot of system memory

Revit is a Parametric Change Engine

- Changes propagate through the model and need to be verified
- No computational shortcuts to be had

Revit Stresses the CPU:

Revit is all about creating and maintaining ***Relationships:***

- Between Hosted and Hosting Geometry
- Cleanup of Wall Joins
- Maintaining Constraints (Dimensional, Alignment, Equality)
- Between Solids and Voids
- Parametric families / nested families / linked parameters / formulas
- Host and Linked Models – Copy / Monitor, Coordination Review

Maintaining these relationships is computationally ***expensive***

- Typically require the fastest CPU(s) available
- Multithreading abilities in wall joins, rendering engine, family regeneration

Revit Specific CPU Considerations:

Review Autodesk's ***Revit Model Performance Technical Note***

http://images.autodesk.com/adsk/files/autodesk_revit_2014_model_performance_technical_note.pdf

Parametric Change Engine scales well with CPU capabilities

Database behavior favors CPUs with large L1/L2/L3 caches

Revit is *somewhat* multithreaded (and getting better):

- Rendering uses a separate, multithreaded process (fbxooprender4.exe)
- Hidden-line removal
- Wall join cleanup
- Printing
- Family generation in Views (since 2012)
- Perspective silhouette generation (since 2012)

Revit Stresses the Graphics Card

Views are live reports of the project database:

- Always remain in sync with the underlying data
- Regenerations are very common and often jarring to the user
- View properties are modified quite often
- Layered approach of Object Styles > V/G Overrides > Filters

Each View has its own display properties

- Visual Styles, Eye Candy, Shadows, Transparency, Overlay
- Wireframe : Very fast but not often used
- Hidden Line: Most common
- Shaded: Very effective but are slower
- Realistic: Would be nice to be able to use 100% of the time

Revit Stresses RAM, Storage, Network

RAM Considerations

Typically consumes 20x the model size on disk in memory

100MB model = 2GB of RAM required; Small models = 650MB of RAM

Storage System Considerations

Long application load times

Very large single files → 100MB+ to 1GB

Uses local files for Workshared Projects

Network Considerations

Saving / Synchronizing to Central

Copying down new Local Files daily

Working with remote offices demands fast WAN connectivity

Application Demands – 3ds Max Design

Polygons - Interacting with millions of vertices, edges, faces, and elements on screen at any time;

Materials - Physical properties, bitmaps, reaction to incoming light energy, surface mapping on polygonal surfaces, and procedural mappings;

Lighting - Physical and non-physical lighting models, calculating direct and indirect illumination, shadows and reflections;

Rendering **- Combining polygons, materials, lighting, and environment together to produce photorealistic imagery; ray tracing with Global Illumination and Final Gather under the mental ray rendering engine; post-rendering effects**

Application Demands – 3ds Max Design

Processor:

Rendering with the mental ray rendering engine is *wholly** CPU bound

System Memory:

Rendering requires lots of RAM

Video card:

Demands high speed wireframe, hidden line rendering in the viewport

Anti-aliasing (no jaggies) require more GPU oomph

Nitrous viewport technology adds eye candy with real time shadows, materials

Moving towards Real Time viewports, minimizing need for renderings

iRay rendering engine supports GPU-based rendering *on Nvidia graphics only*

Application Demands - Navisworks

Much lighter on system resources than either Revit or 3ds Max

Import CAD/Revit models → Lightweight “cache” geometry files

Handles large “supermodels” with ease (e.g., entire city models)

Clash Detective and TimeLiner relatively lightweight

Any machine built for Revit / 3ds Max will handle Navisworks

Uses DirectX for viewport rendering

New in 2014: NVIDIA mental ray® for rendering (multithreaded)

Application Demands - Showcase

Gaming engine applied to AEC visualization and design review

Uses DirectX for all viewport operations

Stresses the video card more than anything else

Hardware applied lighting and shading, real time ray tracing

Typically considered slow compared to other applications

Application Demands – Autodesk ReCap

Process Point Clouds = billions of points

Crop, measure, annotate point clouds

Process raw clouds into .RCS files and .RCP projects

RCS/RCP can be linked into Revit, Navisworks, AutoCAD

Hardware Stresses in this order:

- Video card
- CPU
- Hard disk (massive 20GB+ files)

Current and Future Trends

Hardware Trends in 2013

Intel Haswell CPU = new microarchitecture on 22nm process

Nvidia “Big Kepler” GK110 GPU (K6000, GTX Titan and 780Ti, Tesla)

Multiple GPUs in one box (Note: do not confuse w/SLI or Crossfire)

Integrated Graphics Processors (IGPs) are better but still stink

SSD prices stay the same (1$ / GB); much more popular

Mechanical HD prices stabilize to pre-2011 flood prices

AMD is still dead to us (both on CPU / GPU)

Windows 8.1 is here *and works well*

Intel's "Tick-Tock" Development Model

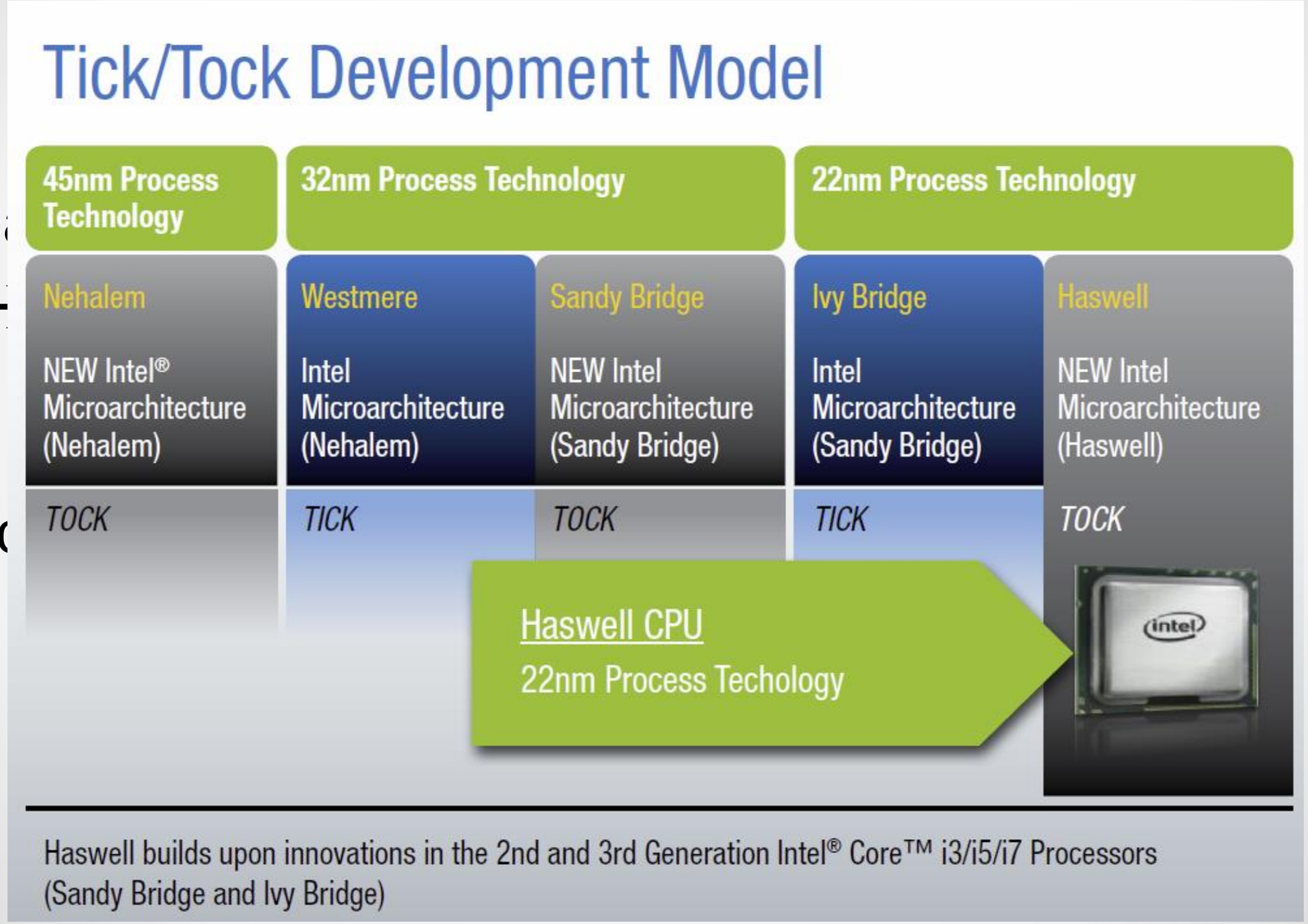
Tick:

Same ba

(32nm -

Tock:

New Mic



Hardware Trends for 2014

Intel Broadwell die shrink to 14nm (a “Tick”)

Intel Haswell-E – “Extreme” Haswell (8-core)

DDR4 Memory

Nvidia Maxwell architecture / G-Sync on selected monitors

SATA Express using PCI Express lanes

Higher resolution 4K monitors

Windows 8 → More tablets & ultraportables

Processors

Multi Core meets Main Street

Every CPU today is of a multicore design

Intel strategy:

- 4 cores mainstream, 6 cores for “extreme”, eventually to 8 cores
- Use Hyper-threading to get 8 / 12 thread execution cores
- Push for highest performance with the lowest power consumption

AMD strategy:

- No HT available → 4 / 6 / 8 actual physical cores on single CPUs
- Higher clock rates 3.5GHz -> 4.0 GHz stock
- Targets Intel Core i3 & i5 level performance; cannot touch Core i7

Hyper-threading Explained

Cache misses, aka the “Price check at the supermarket” problem:

- Modern CPU pipeline wants to always execute threads per clock cycle
- Uses L1, L2, L3 on-die memory caches to re-read data
- A “cache miss” means having to go back to slow main memory for data
- Thread execution stops until it gets back
- Many cache misses can stifle CPU performance

Hyper-threading:

- The OS can schedule another thread to jump in line with a cache miss
- Keeps the pipeline stuffed with executions per each clock cycle
- Side effect: The OS sees 2x as many cores; quad cores now look like 8

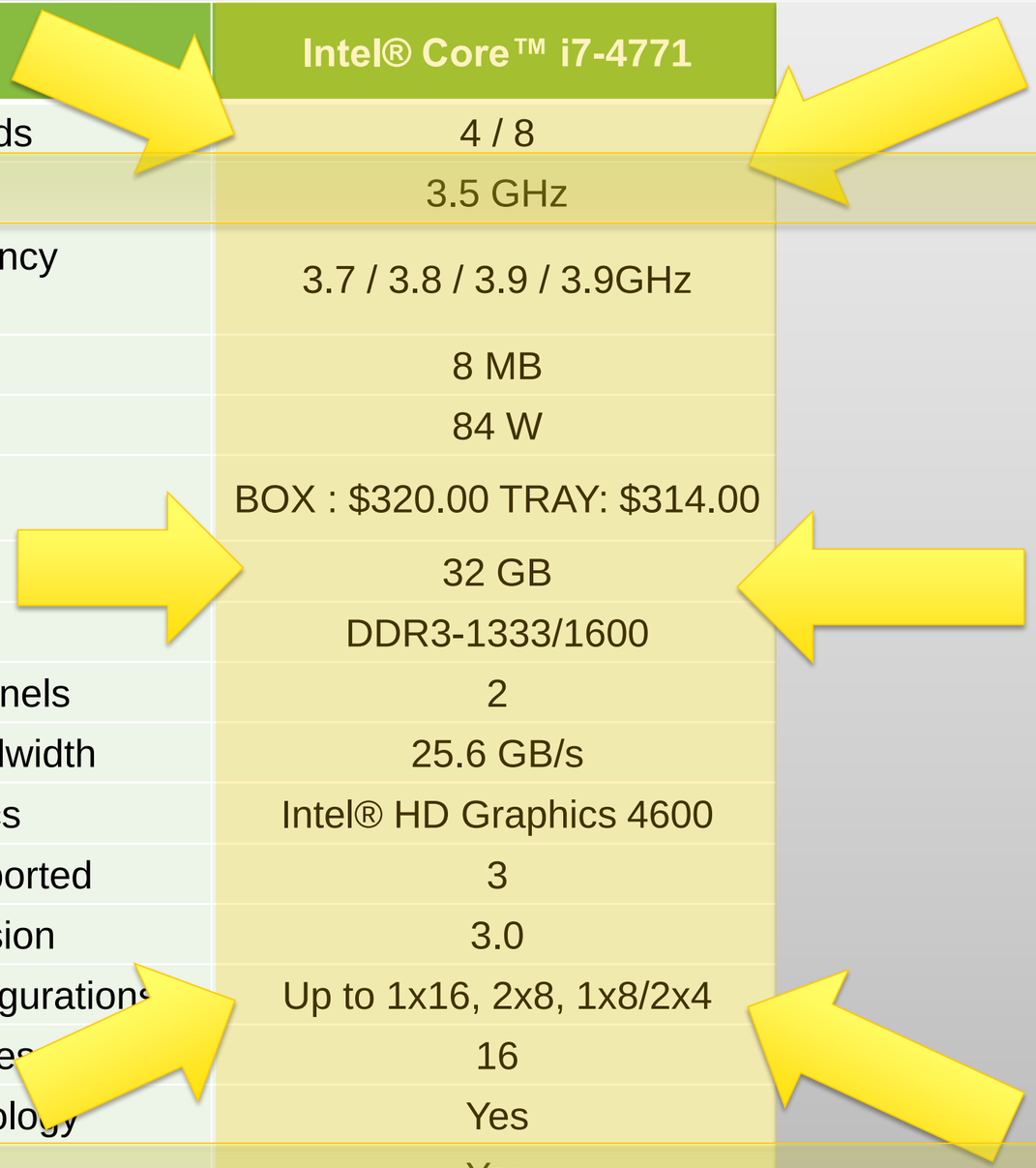
Intel Haswell Microarchitecture

Features:

- Approximately 8% better vector processing performance
- Up to 6% faster single-threading performance
- 6% faster multithreaded performance
- Eight execution ports per core, up from 6 in IB
- 20% faster IGP (Intel HD 4000 Graphics)
- Runs hotter than IB; harder to overclock
- TSX: Faster (potentially) multithreaded code; App. specific
  - Future potential benefits to the BDS user

Intel's Haswell Core i7 Processor Lineup

	Intel® Core™ i7-4771
# of Cores / Threads	4 / 8
Clock Speed	3.5 GHz
Max Turbo Frequency (4C/3C/2C/1C)	3.7 / 3.8 / 3.9 / 3.9GHz
Cache	8 MB
Max TDP	84 W
Price	BOX : $320.00 TRAY: $314.00
Max Memory Size	32 GB
Memory Types	DDR3-1333/1600
# of Memory Channels	2
Max Memory Bandwidth	25.6 GB/s
Processor Graphics	Intel® HD Graphics 4600
# of Displays Supported	3
PCI Express Revision	3.0
PCI Express Configuration	Up to 1x16, 2x8, 1x8/2x4
Max # of PCI Expres	16
Intel® vPro Technology	Yes
Intel® TSX-NI	Yes



Intel Z87 Chipset

Item	7 Series	8 Series
I/O Port Flexibility	No	Yes
Total USB Ports (Includes USB 2 and USB3 Ports)	14 USB Ports	14 USB Ports
USB 3.0 Capable Ports	Up to 4	Up to 6
xHCI Ports	4 USB3 Ports	All USB Ports controlled by xHCI
PCI Express	Up to 8 PCIe 2.0 (5GT/s)	Up to 8 PCIe 2.0 (5GT/s)
Total SATA Ports (Includes 3 Gb/s and 6Gb/s Ports)	6 SATA	6 SATA
SATA 6 Gb/s Capable Ports	Up to 2	Up to 6
Legacy PCI	Legacy PCI on Q/B SKU	Legacy PCI removed from all SKUs
Digital Display I/F	DP, HDMI (w/ integ. LS), Wireless Display	Digital display moved to processor
Analog Display I/F	VGA	VGA
SPI	Dual Read	SFDP, Quad Read

Ivy Bridge-E

“Extreme” version of Ivy Bridge (22nm)

Basis for E5-1xxx Xeons

Models: i7-4930K, i7-4960X

True 6 core design (12 threads total)

Quad-channel memory controller (RAM installed in 4s)

More expensive platform than Haswell desktop (i7-47xx)

Sometimes faster, sometimes slower than i7-4771

Always faster in rendering or CPU intensive tasks

Ivy Bridge-E, Sandy Bridge-E, & Haswell Compared

	Intel® Core™ i7-3930K	Intel® Core™ i7-3970X	Intel® Core™ i7-4930K	Intel® Core™ i7-4960X	Intel® Core™ i7-4771
Code Name	Sandy Bridge E	Sandy Bridge E	Ivy Bridge E	Ivy Bridge E	Haswell
Launch Date	Q4'11	Q4'12	Q3'13	Q3'13	Q3'13
# of Cores / Threads	6 / 12	6 / 12	6 / 12	6 / 12	4 / 8
Clock Speed / Max Turbo Frequency	3.2GHz / 3.8GHz	3.5GHz / 4GHz	3.4GHz / 3.9GHz	3.6GHz / 4GHz	3.5GHz / 3.9GHz
Cache	12 MB	15 MB	12 MB	15 MB	8 MB
Instruction Set Extensions	SSE4.2, AVX, AES	SSE4.2, AVX, AES	SSE4.2, AVX, AES	SSE4.2, AVX, AES	SSE 4.1 / 4.2, AVX 2.0
Lithography	32 nm	32 nm	22 nm	22 nm	22 nm
Max TDP	130 W	150 W	130 W	130 W	84 W
Recommended Customer Price	BOX : $594 TRAY: $583	BOX : $1059 TRAY: $999	BOX : $594 TRAY: $583	BOX : $1059 TRAY: $999	BOX : $320 TRAY: $314
Max Memory Size	64 GB	64 GB	64 GB	64 GB	32 GB
Memory Types	DDR3-1066 / 1333 / 1600	DDR3-1066 / 1333 / 1600	DDR3-1333 / 1600 / 1866	DDR3-1333 / 1600 / 1866	DDR3-1333 / 1600
# of Memory Channels	4	4	4	4	2
Max Memory Bandwidth	51.2 GB/s	51.2 GB/s	59.7 GB/s	59.7 GB/s	25.6 GB/s
PCI Express Revision	2.0	2.0	3.0	3.0	3.0
Max # of PCI Express Lanes	40	40	40	40	16
Sockets Supported	FCLGA2011	FCLGA2011	FCLGA2011	FCLGA2011	FCLGA1150
Intel® vPro Technology	No	No	No	No	Yes
Intel® TSX-NI	No	No	No	No	Yes
Processor Graphics	None	None	None	None	Intel® HD Graphics 4600

Xeon Processors

Designed for servers and “serious” workstations

Built on same Haswell / Ivy Bridge-E microarchitecture (no IGP)

Various clock speeds 2.0GHz – 3.8GHz

Support for ECC Memory (slower, more $$)

Dual-CPU configurations in higher–end E5-2xxx models

More L3 Cache (12MB – 20MB)

Quad-channel memory controller in E5 Series

3 Series to choose from:

- E3-12xx v3 : Single CPU configuration, Haswell based
- E5-16xx v2 : Single CPU configuration, Ivy Bridge-E based
- E5-26xx v2 : Dual CPU configuration, Ivy Bridge-E based

Xeon E3-12xx v3 Series

	Intel® Xeon® E3-1230 v3	Intel® Xeon® E3-1240 v3	Intel® Xeon® E3-1270 v3	Intel® Xeon® E3-1280 v3
Code Name	Haswell	Haswell	Haswell	Haswell
Launch Date	Q2'13	Q2'13	Q2'13	Q2'13
# of Cores	4	4	4	4
# of Threads	8	8	8	8
Clock Speed	3.3 GHz	3.4 GHz	3.5 GHz	3.6 GHz
Max Turbo Frequency	3.7 GHz	3.8 GHz	3.9 GHz	4 GHz
Cache	8 MB	8 MB	8 MB	8 MB
Instruction Set Extensions	SSE4.1/4.2, AVX 2.0	SSE4.1/4.2, AVX 2.0	SSE4.1/4.2, AVX 2.0	SSE4.1/4.2, AVX 2.0
Lithography	22 nm	22 nm	22 nm	22 nm
Max TDP	80 W	80 W	80 W	82 W
Recommended Price	BOX: $250 TRAY: $240	BOX: $273 TRAY: $362	BOX: $339 TRAY: $328	TRAY: $612
$ / 100MHz	$7.58	$8.03	$9.69	$17

Xeon E5-16xx Series

Model Name	Launch Date	Cores / Threads	Clock / Turbo Speed	Cache	Max RAM	Price (Box/Tray)
Xeon E5-1620	Q1‘12	4 / 8	3.6 / 3.8 GHz	10MB	375 GB	N/A / $294
Xeon E5-1650	Q1‘12	6 / 12	3.2 / 3.8 GHz	12MB	256 GB	N/A / $583
Xeon E5-1660	Q1‘12	6 / 12	3.3 / 3.9 GHz	15MB	256 GB	$1080 / $1083

Xeon E5-26xx Series

Model Name	Launch Date	Cores / Threads	Clock / Turbo Speed	Cache	Max RAM	Price (Box/Tray)
Xeon E5-2643	Q1‘12	4 / 8	3.3 / 3.5 GHz	10MB	384 GB	N/A / $885
Xeon E5-2667	Q1‘12	6 / 12	2.9 / 3.5 GHz	15MB	384 GB	N/A / $1552
Xeon E5-2670	Q1‘12	8 / 16	2.6 / 3.3 GHz	20MB	384 GB	$1556 / $1552
Xeon E5-2680	Q1‘12	8 / 16	2.7 / 3.5 GHz	20MB	384 GB	$1727 / $1723
Xeon E5-2690	Q1‘12	8 / 16	2.6 / 3.8 GHz	20MB	384 GB	$2061 / $2057
Xeon E5-2687W	Q1‘12	8 / 16	3.1 / 3.8 GHz	20MB	384 GB	$1885 / $1890

Motherboards and Memory

Choosing the Right Motherboard

CPU choice determines platform; platform may determine CPU:

- i7-4771 → LGA1150 Platform w/Z87 Chipset & 4 DIMMs ($100 - $225)
- I7-4930K → LGA2011 Platform w/X89 Chipset & 8 DIMMs ($280 - $400)

Feature Sets:

- PCIe 3.0 slots + PCIe 2.0 Slots (multi-GPU support);
- Plenty of USB 3.0 headers for front panel ports;
- Wi-Fi onboard, 2 Gigabit ports, HDMI, eSATA, 8-channel audio
- UEFI replaces older BIOS = more low level features (e.g., 2TB+ boot disk)
- Easy overclocking: fine voltage control, easy reset from bad overclocks
- For the kiddies: Bling, heat pipes, day-glo PCI slots, etc.

System Memory

RAM is CHEAP and plentiful

Best bet: Purchase machine with 16GB or 32GB minimum

Do not overpay for RAM upgrades from Dell / HP / XYZ-Corp.

8GB sticks are the only ones to buy today (2x8GB / 3x8GB / 4x8GB)

Ensure your RAM configuration matches the CPU memory controller

Buy all RAM at one time from one place

Tip: Check the numbers on the chips if you have system instability

Different binnings may not be fully compatible with each other

Storage

Storage Considerations

BDS Stresses:

Long program load times

Revit 300MB central models / Creating new Local Files daily

Mechanical Disk Solutions:

Hard disks: 7,200, 10,000 and 15,000 RPM (Good / Fast / Cheap for storage)

RAID 0 provides solid benefits (YMMV). Note need for backups with RAID 0!

OR: Use multiple separate HDs

Windows will multithread I/O between HDs on difference channels / SATA ports

Store page file on 2nd HD; move it before adding any additional data to drive

Set page file size so min = max

Solid State Drives (SSDs)

$1 GB; ~ $200 for 250GB

MUST HAVE FOR ALL MACHINES (easy upgrade)

Use for the OS and Apps (store add'l data on mech. HD)

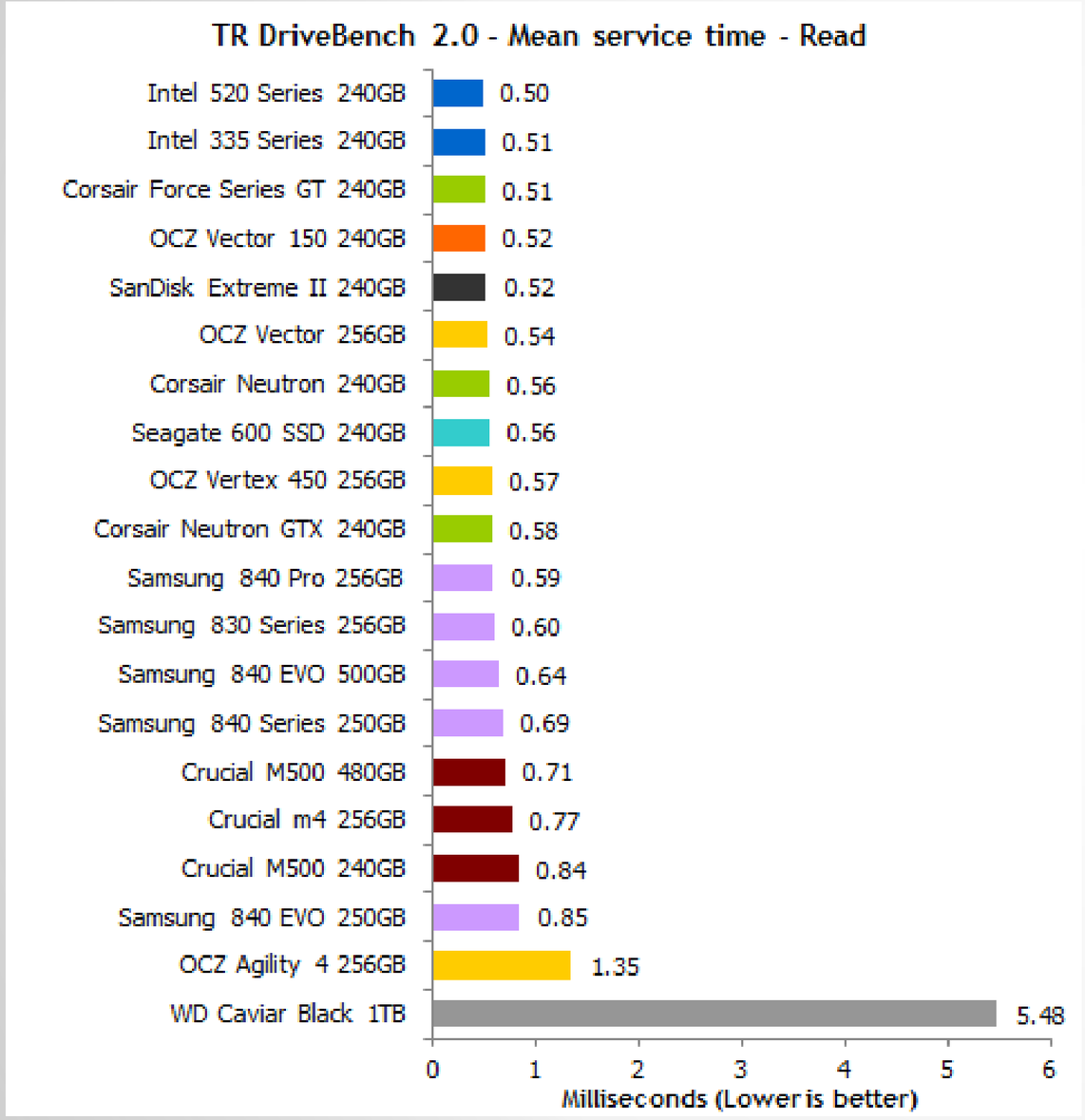
Performance varies *wildly* between units – research

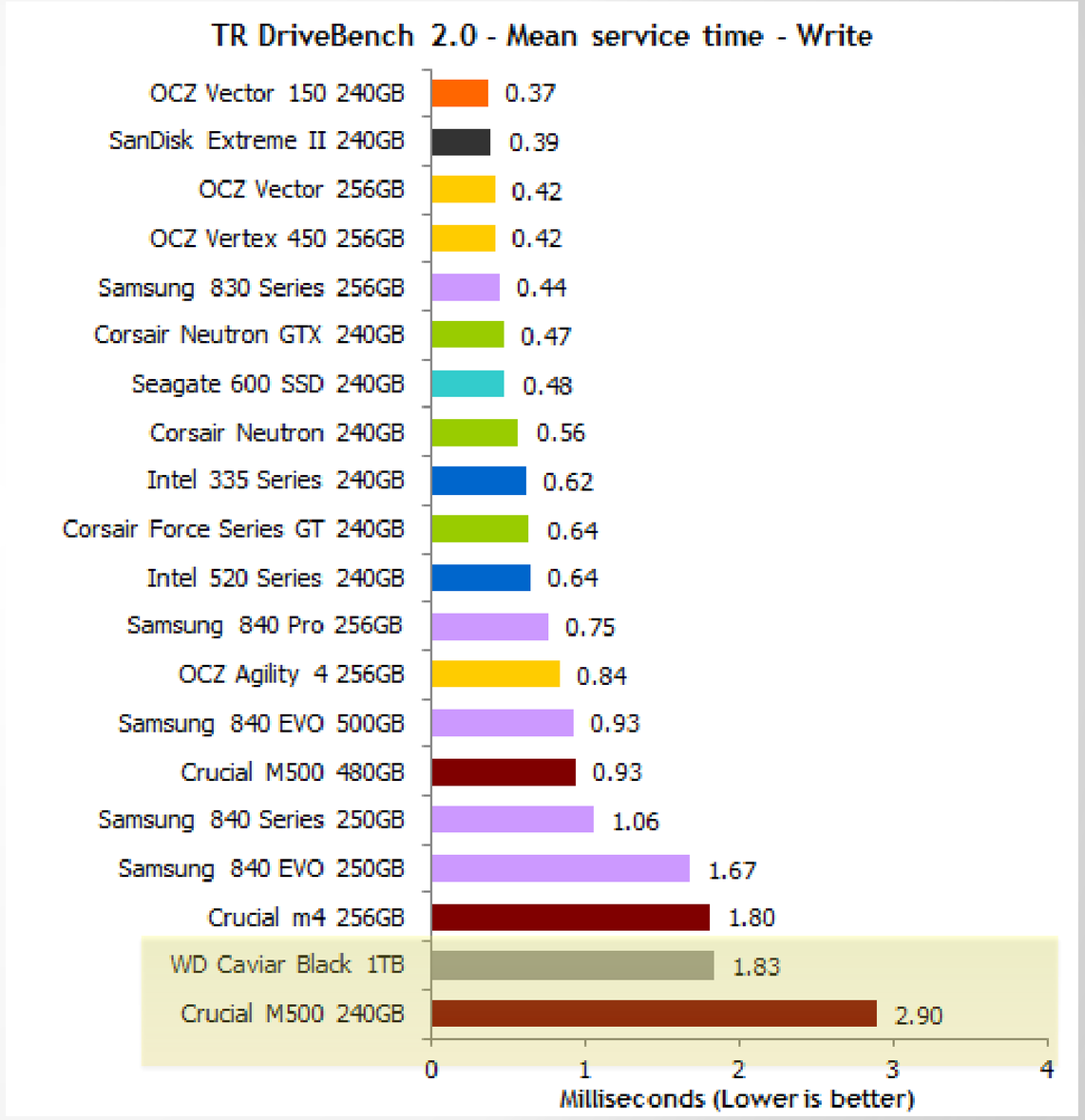
Research individual units carefully

Watch out for cheap SSDs:

Cheap controller / cheap NAND chips

Solid State Drive Benchmarks





Graphics

What Graphics Cards Actually Do

Take 3D vector geometry from the CPU and converts it into pixels by a process through the graphics **pipeline**

Pipeline:

- Reads vertex data from CPU / memory
  - Applies per-vertex lighting and shading
    - Discards unseen geometry
      - Projection Transformation (Perspective)
        - Viewport Transformation
          - Scan Conversion and Rasterization
            - Output to monitor
              - Repeat 60x / sec

Graphics Explained: Direct3D, DirectX, Shader Models

Direct3D is the 3D API portion of DirectX, which is a whole set of APIs that covers handling multimedia on the Windows platform

Direct3D was originally used for developing games for Windows and Xbox, now migrating to CAD/CAM engineering applications

Replaced OpenGL as the graphics API of choice for all Autodesk apps

DirectX version is “somewhat” Windows version specific:

- DirectX 9 = Windows XP (XP will not run later DX versions)
- DirectX 10 = Windows Vista (can also run DX 11)
- DirectX 11 = Windows 7
- DirectX 11.1 = Windows 8

Rendering Engines in Autodesk Applications

mental ray™

- Developed by NVIDIA; licensed to Autodesk
- Autodesk gets SDK, writes the front end
- Included in 3ds Max Design and Revit
- Fully featured, photorealistic realistic renderer
- Supports Global Illumination, Final Gather, Caustics, etc.
- Very complex – many dials / knobs / variables to understand
- Supported by Backburner network rendering in 3ds Max / Design
- Supports Distributed Bucket Rendering (DBR)
- Almost 100% CPU bound; does not leverage graphics card***

Rendering Engines in Autodesk Applications

iRay™

- Developed by Nvidia specifically *for Nvidia GPUs and CUDA technology*
- Physically based ray tracing renderer - Excellent photorealistic results
- Simplified interface – “Pushbutton” renders possible
- Requires physically correct lighting and materials
- Iterative renderer: Start rendering and stop when it looks good enough
- Time based: Set the time for each rendering beforehand
- Supported by Backburner (render farm)
- Does not support Distributed Bucket Rendering (DBR)
- Can use Nvidia graphics cards and/or CPU for rendering
- GPU on average 12x speed of fastest CPU for rendering
- Note: Scene must entirely fit into GPU onboard memory for it to render **

Nvidia's Kepler Architecture

Kepler design focus = maximize Power per Watt

Replaced Fermi architecture (GTX 500 series, Quadro)

Shrink the process, realign CUDA core technology

Initial offering = GK104 = "midrange" part

2014: GK110 = Big Kepler

GK104 = Optimized for gaming

GK110 = Professional graphics GPU for compute

Kepler was released after 3ds Max 2013. **iRay does NOT work with Kepler GPUs before 3ds Max Design 2013 Update #6**

What about AMD / Ati?

VERY good gaming cards; On part with GTX 77x series in games

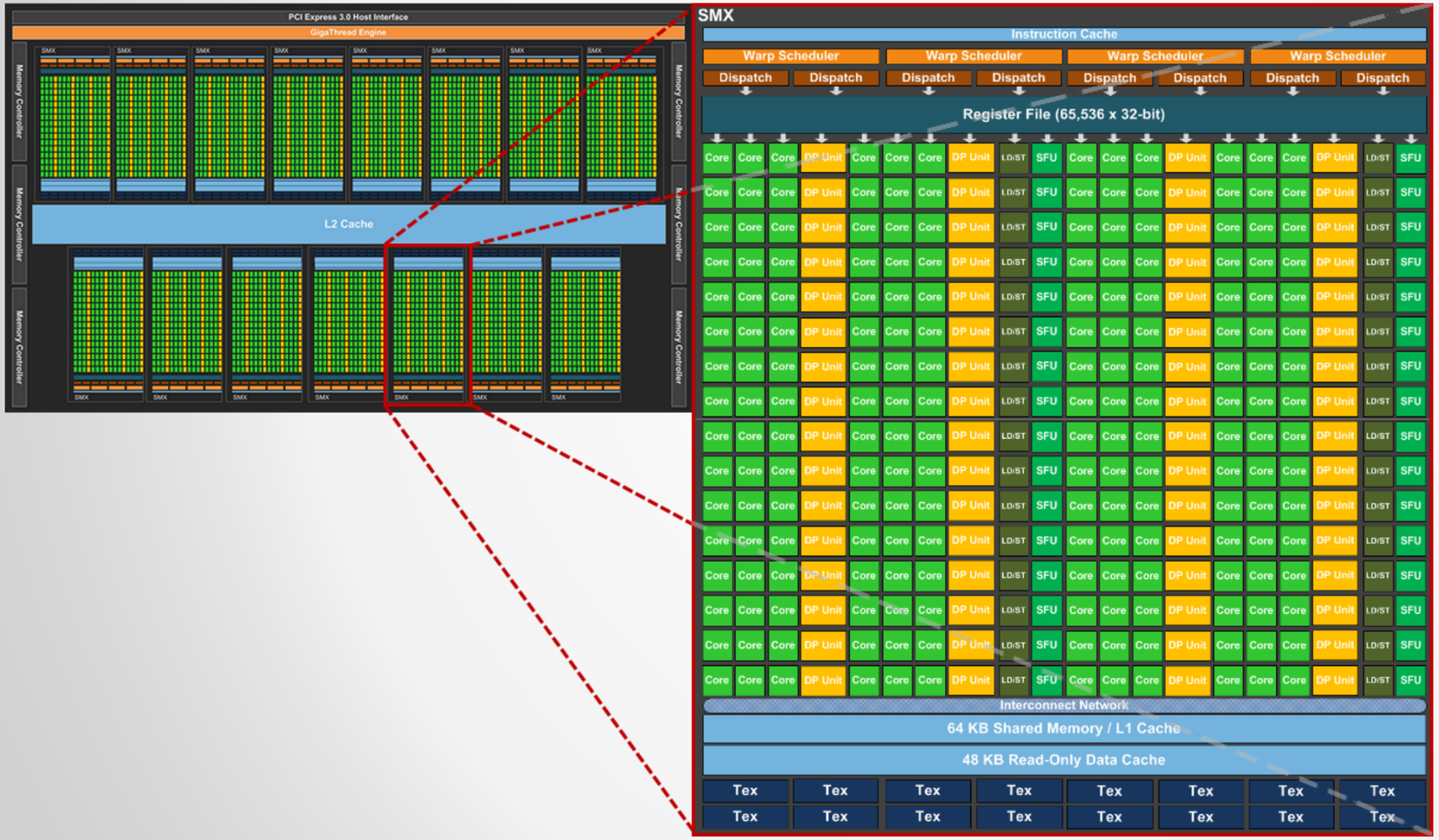
Expect ATI gaming cards to perform the same as Nvidia GeForce cards in mainstream Autodesk BDS applications

As always, watch for issues typical with gaming cards, e.g., tearing in Inventor, wonky dialog boxes in Navisworks, etc.

Exception: iRay rendering **must** use Nvidia hardware

Nvidia Graphics Solutions

GK110 Architecture built on 15 Streaming Multiprocessor (SMX) Units



Each SMX Unit =
192 single-precision CUDA cores
64 double-precision units
32 special function units (SFU)
32 load/store units (LD/ST).

Different GPU models disable one or more SMX units

Big Kepler = All 15 SMX Units

Nvidia Graphics Solutions

Current Nvidia “Big Kepler” (GK110) offerings:

NVIDIA Quadro K6000 = $5,000.00 / 12GB / 2,880 Cores

GeForce GTX Titan = $1,000 / 6GB / 2688 Cores (one SMX disabled)

GeForce GTX 780 Ti = $700 / 3GB / 2880 Cores

GeForce GTX 780 = $525 / 3GB / 2304 Cores

Nvidia Graphics Solutions

Current Nvidia workstation-class cards:

Quadro = Older Fermi generation workstation class cards (obsolete)

Quadro K2000 → GK107, 384 CUDA cores, 3GB, $430

Quadro K4000 → GK106, 769 CUDA cores, 3G, $800

Quadro K5000 → GK104, 1536 CUDA cores, 4GB, $1,800

Quadro K6000 → GK110, 2880 CUDA cores, 12GB, $5,000

Designed for *good, solid* performance in Autodesk professional apps

Solid drivers certified for Autodesk apps; better mfr. process & Nvidia warranty

Not as powerful as Tesla (dedicated card for compute)

NVIDIA Maximum = Quadro + Tesla combination (1 for compute, 1 for Windows)

2013 Workstation Graphics Cards Benchmarked in Professional Applications

Data Source: http://www.tomshardware.com/charts/workstation-graphics-2013/benchmarks,146.html

MFR	Model	Core GPU	Nvidia CUDA Cores	Price	$ per CUDA Core	RAM	AutoCAD 2D Summary (Score)	% of Top Score	AutoCAD 3D Summary (Score)	% of Top Score	Inventor (Score)	% of Top Score	iRay CUDA (Sec)	X Slower than Fastest Card
Nvidia	Quadro K5000	GK104 (Kepler)	1536	$1,800.00	$1.17	4GB GDDR5 ECC	429	95.33	1275	87.09	19	40.43	435	1.93
Nvidia	Quadro K4000	GK106 (Kepler)	768	$800.00	$1.04	3GB GDDR5	450	100	1158	79.1	17	36.17	604	2.68
Nvidia	Quadro K2000	GK107 (Kepler)	384	$430.00	$1.12	3GB GDDR5	439	97.56	1015	69.33	15	31.91	816	3.63
AMD	FirePro W9000	Tahiti XT (HD7970)		$3,400.00		6GB GDDR5 ECC	442	98.22	1209	82.58	29	61.7		
AMD	FirePro W8000	Tahiti Pro (HD 7950)		$1,400.00		4GB GDDR5 ECC	428	95.11	1182	80.74	27	57.45		
AMD	FirePro W7000	Pitcairn XT (HD 7870)		$650.00		4GB GDDR5	436	96.89	1124	76.78	25	53.19		
AMD	FirePro W5000	Pitcairn LE (HD 7800)		$410.00		2GB GDDR5	434	96.44	1007	68.78	23	48.94		
Nvidia	Quadro 6000	GF100 (Fermi)	448	$3,650.00	$8.15	6GB GDDR5 ECC	448	99.56	1170	79.92	16	34.04	379	1.68
Nvidia	Quadro 5000	GF100 (Fermi)	352	$1,500.00	$4.26	2.5GB GDDR5 ECC	448	99.56	1088	74.32	14	29.79	473	2.1
Nvidia	Quadro 4000	GF100 (Fermi)	256	$720.00	$2.81	2GB GDDR5	444	98.67	1015	69.33	11	23.4	584	2.6
Nvidia	Quadro 2000	GF106 (Fermi)	192	$390.00	$2.03	1GB GDDR5	433	96.22	944	64.48	8	17.02	769	3.42
AMD	FirePro V7900	Cayman Pro GL		$630.00		2GB GDDR5	440	97.78	952	65.03	18	38.3		
AMD	FirePro V5900	Caman LE GL		$413.00		2GB GDDR5	439	97.56	730	49.86	9	19.15		
AMD	FirePro V4900	Turks (HD 7500)		$150.00		1GB GDDR5	428	95.11	863	58.95	8	17.02		
AMD	FirePro V3900	Turks (HD 7500)		$110.00		1GB GDDR3	437	97.11	858	58.61	7	14.89		
Nvidia	GeForce Titan	GK110 (Kepler)	2880	$1,000.00	$0.35	6GB GDDR5	442	98.22	1412	96.45	29	61.7	225	1
Nvidia	GTX 780 Ti	GK110 (Kepler)	2880	$730.00	$0.25	3GB GDDR5	441	98	1464	100	34	72.34	225	1
Nvidia	GTX 780	GK104 (Kepler)	2304	$530.00	$0.23	3GB GDDR5	442	98.22	1411	96.38	29	61.7	278	1.24
Nvidia	GTX 770	GK104 (Kepler)	1536	$330.00	$0.21	2GB GDDR5	437	97.11	1444	98.63	28	59.57	340	1.51
Nvidia	GTX 760	GK104 (Kepler)	1152	$260.00	$0.23	2GB GDDR5	438	97.33	1446	98.77	22	46.81	487	2.16
Nvidia	GTX 690	(2) GK104 (Kepler)	3072	$1,000.00	$0.33	4GB GDDR5	443	98.44	1449	98.98	42	89.36	345	1.53
Nvidia	GTX 680	GK104 (Kepler)	1536	$390.00	$0.25	2GB GDDR5	447	99.33	1376	93.99	28	59.57	343	1.52
AMD	Radeon HD 7990	Malta		$580.00		6GB GDDR5	440	97.78	868	59.29	47	100		
AMD	Radeon HD 7970 GE	Tahiti XT2		$390.00		3GB GDDR5	437	97.11	1019	69.6	32	68.09		
AMD	Radeon HD 7870	Pitcairn XT		$170.00		2GB GDDR5	448	99.56	1005	68.65	24	51.06		
Nvidia	GTX 580	GF110 (Fermi)	512	N/A		1.5GB GDDR5	447	99.33	1258	85.93	21	44.68	275	1.22
AMD	R9 290X	Hawaii XT		$560.00		4GB GDDR5	448	99.56	1205	82.31	40	85.11		
AMD	R9 290	Hawaii PRO		$400.00		4GB GDDR5	443	98.44	1034	70.63	36	76.6		
AMD	R9 280X	Tahiti XTL		$300.00		3GB GDDR5	448	99.56	1083	73.98	31	65.96		
AMD	R9 270X	Curacao XT		$210.00		2GB GDDR5	441	98	872	59.56	25	53.19		
AMD	R7 260X	Bonaire XTX		$150.00		2GB GDDR5	449	99.78	954	65.16	18	38.3		
AMD	R7 250	Oland XT		$91.00		1GB GDDR5	440	97.78	692	47.27	16	34.04		
AMD	R7 240	Oland PRO		$80.00		2GB GDDR3	443	98.44	638	43.58	9	19.15		

Gaming vs. Workstation Cards for BDS

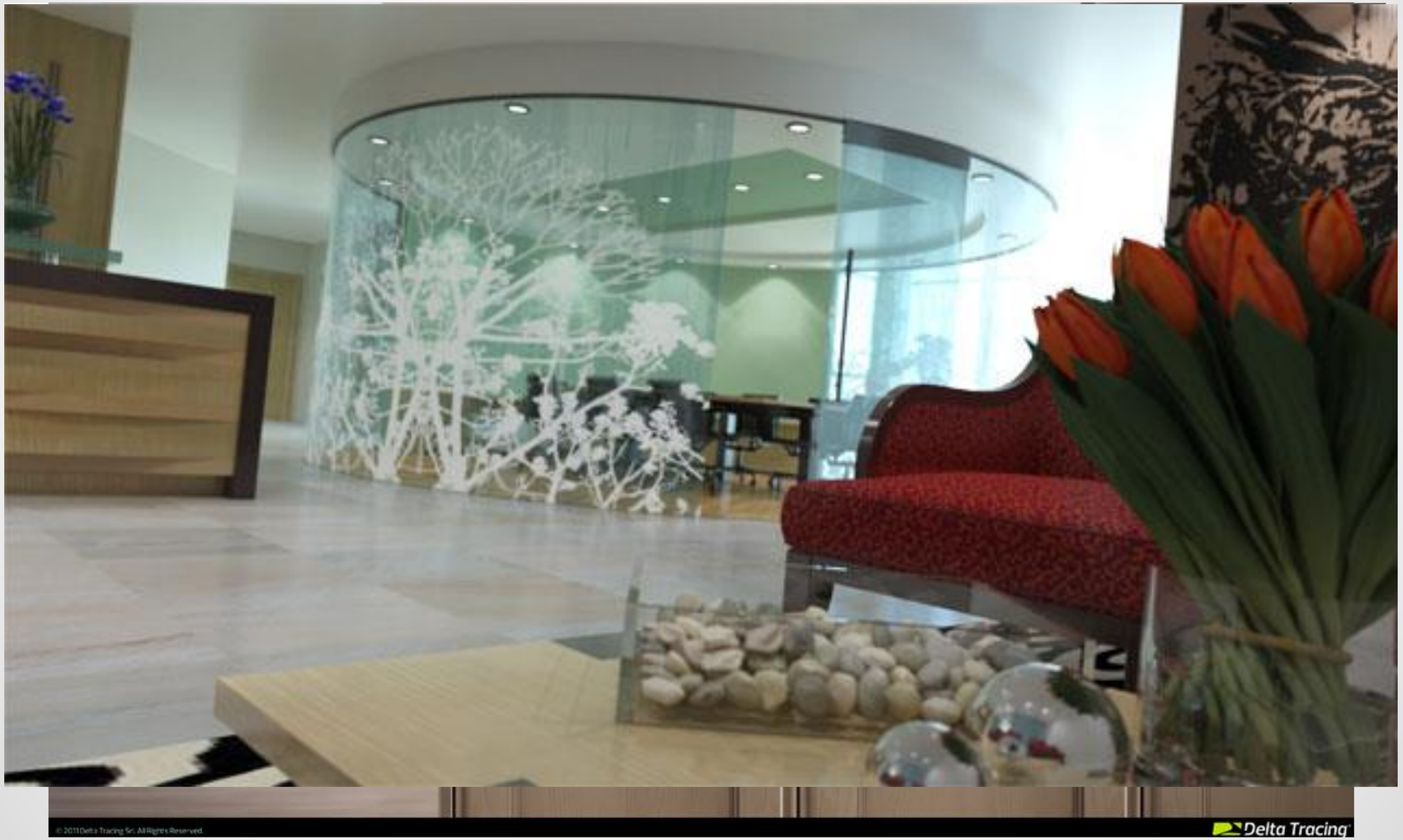
Gaming Cards

- Most Autodesk apps don’t take advantage of graphics card power
- Autodesk apps built for DirectX 9, not OpenGL
- Render performance in iRay = CUDA core dependent = GTX 7xx
- Cheap! If it doesn’t work, sell it on eBay or CL

Workstation cards

- Typically more stable drivers (certified by Autodesk)
- Possibly smoother viewport performance in all visual style modes (varies)
- Unlocked firmware features like hardware anti-aliasing, Z-buffering, etc.

3ds Max's iRay – A Game Changer



Peripherals

Monitors, Keyboards, Mice

Monitors:

- IPS panels in 24” 27” 30” (e.g. Dell U2410, U2713HM, U3011)
- Look for HDMI and DisplayPorts. DVI ports are on the way out.
- Extras: USB ports, card readers (nice but optional)

Mice:

- Wireless
- Programmable buttons
- Ergonomic

Keyboards:

- Cherry MX switches (varying feel, weights, etc.)
- Wireless, multimedia keys, programmable F keys, solid feel, backlighting

Buy or Build?

Build It!

Often done for SOHO operations

Looking for specific parts not available from a vendor

Hoping to save money

Enjoy a challenge

Buy It!

Corporate IT standards on workstation components

Corporate relationships with vendors

Often get preferred pricing

Warranties and level of technical support

System Build 2013 – Mainstream BIM Workstation

Entry Level BIM Workstation: Dell T1700 Precision Workstation, Mini Tower		
Component	Item	Price
Processor	4th Generation Intel Core i7-4770 @ 3.4GHz	$2,150.00
Memory	16GB (2x8GB) 1600MHz DDR3 Non-ECC	
Graphics	Integrated Graphics Processor on CPU	
Storage	256GB 2.5" Solid State Drive (model unknown)	
	1TB 3.5” 7200 RPM Hard Drive (model unknown)	
	16x DVD+/-RW SATA (model unknown)	
Power supply	365W 90% Efficient Power Supply	
Keyboard	Dell KB-522 Wired Business USB Multimedia Keyboard	
OS	Windows 8 Professional, 64-bit	
Warranty	3 Year ProSupport + 3 Year NBD Limited Onsite Service after Remote Diagnosis	
Mouse	Logitech MX Performance Mouse	$87.00
Monitor	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
Dell Subtotal		$3,536.98
	Additional items purchased separately from NewEgg.com	
Video Card	EVGA GeForce GTX 780 w/3GB	$499.99
Newegg Subtotal		$499.99
System Total		**$4,036.97**

System Build 2013 – Mainstream BIY BIM Workstation

Entry Level BIM Workstation: Newegg		
Component	Item	Price
Case	Corsair Obsidian 750D	$159.99
Processor	4th Generation Intel Core i7-4770 @ 3.4GHz	$319.99
Motherboard	ASUS Z87 Pro LGA 1150 Motherboard	$199.99
Memory	Kingston HyperX Black 16GB (2x8GB) DDR3-1600 Non-ECC	$129.99
Graphics	EVGA GeForce GTX 780 w/3GB	$499.99
Storage	Samsung 840 Pro 256GB 2.5" Solid State Drive	$229.00
	Seagate Barracuda 1TB 3.5” 7200 RPM 6GB/s Hard Drive	$69.99
	ASUS 24x DVD +/-RW SATA DVD Burner	$16.99
Power supply	Corsair AX Series AX 860 860W 80+ Platinum PSU	$169.99
Mouse	Logitech MX Performance Mouse	$99.99
Keyboard	Corsair Vengeance K95 w/Cherry MX Red switches	$149.99
OS	Windows 8.1 Professional, 64-bit, OEM	$99.99
Monitor	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
System Total		$3,446.86

System Build 2013 – Ivy Bridge-E BIY BIM Workstation

Ivy Bridge-E Workstation from Newegg.com		
Component	Item	Price
Case	Corsair Obsidian 750D	$159.99
Processor	Intel Core i7-4930K Ivy Bridge-E 3.4GHz LGA 2011 6-Core CPU	$579.99
CPU Cooler	Corsair Hydro Series H75 Closed Water Loop CPU Cooler	$84.99
Motherboard	ASUS Rampage IV Extreme Edition LGA 2011 Intel X79 Extended ATX	$429.99
Memory	Kingston HyperX Black 32GB (4x8GB) DDR3-1600 Non-ECC	$259.98
Graphics	EVGA GeForce GTX 780 Ti w/3GB	$729.99
Storage	Samsung 840 Pro 256GB 2.5" Solid State Drive	$229.99
	Seagate Barracuda 1TB 3.5” 7200 RPM 6GB/s Hard Drive	$69.99
	ASUS 24x DVD +/-RW SATA DVD Burner	$16.99
Power supply	Corsair AX Series AX 860 860W 80+ Platinum PSU	$169.99
Mouse	Logitech MX Performance Mouse	$99.99
Keyboard	Corsair Vengeance K95 w/Cherry MX Red switches	$149.99
OS	Windows 8.1 Professional, 64-bit, OEM	$99.99
Monitor	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
System Total		$4,381.84

System Build 2013 – High End Corp. BIM Workstation

Component	Item	Price
Processor	Intel® Xeon® Processor E5-1650 v2 (Six Core HT, 3.5 GHz, 12 MB)	$3,485.00
Memory	32GB (4x8GB) DDR3-1866 ECC RAM	
Graphics	Not Included	
Storage	256GB 2.5" Solid State Drive (model unknown)	
	1TB 3.5” 7200 RPM Hard Drive (model unknown)	
	16x Half Height DVD+/-RW SATA (model unknown)	
Power supply / Chassis	Dell Precision T3610 685W TPM Chassis	
Mouse	Logitech MX Performance Mouse	$87.00
Keyboard	Dell KB-522 Wired Business USB Multimedia Keyboard	
OS	Windows 8.1 Professional, 64-bit	
Warranty	3 Year Basic Hardware Service with 3 Year NBD Onsite Service after Remote Diagnosis	
Monitor	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
Subtotal		$4,871.98
From Newegg.com		
Video Card	EVGA GeForce GTX 780 Ti w/3GB	$729.99
Subtotal		$729.99
System Total		$5,601.97

System Build 2013 – Hybrid Dell + Newegg Combo

Component	Item	Price
Processor	Intel® Xeon® Processor E5-1650 v2 (Six Core HT, 3.5 GHz Turbo, 12 MB)	$1,950.00
Memory	4GB (2x2GB) 1600MHz DDR3 Non-ECC	
Graphics	Not Included	
Storage	1TB 3.5” 7200 RPM Hard Drive (model unknown)	
	16x Half Height DVD+/-RW SATA (model unknown)	
Power supply / Chassis	Dell Precision T3610 685W TPM Chassis	
Mouse	Logitech MX Performance Mouse	$87.00
Keyboard	Dell KB-522 Wired Business Multimedia USB Keyboard Black	
OS	Windows 8.1 Professional, 64-bit	
Warranty	3 Year Basic Hardware Service with 3 Year NBD Onsite Service after Remote Diagnosis	
Monitor	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
	Dell UltraSharp U2713HM 27-inch Widescreen Flat Panel	$649.99
Subtotal		$3,336.98
From Newegg.com		
Video Card	EVGA GeForce GTX 780 Ti w/3GB	$729.99
Memory	Crucial 32GB (4x8GB) 240-Pin DDR3-1866 ECC	$435.56
Storage	Samsung 840 Pro 256GB 2.5" Solid State Drive	$229.99
Subtotal		$1,395.54
System Total		$4,732.52

Mobile Workstations

Ivy Bridge Mobile CPUs

	Core™ i5-4200M	Core™ i7-4600M	Core™ i7-4700MQ	Core™ i7-4800MQ	Core™ i7-4900MQ	Core™ i7-4930MX Extreme Edition
Code Name	Haswell	Haswell	Haswell	Haswell	Haswell	Haswell
# Cores / Threads	2 / 4	2 / 4	4 / 8	4 / 8	4 / 8	4 / 8
Clock Speed / Turbo	2.5 GHz / 3.1 GHz	2.9 GHz / 3.6 GHz	2.4 GHz / 3.4 GHz	2.7 GHz / 3.7 GHz	2.8 GHz / 3.8 GHz	3 GHz / 3.9 GHz
Cache	3 MB	4 MB	6 MB	6 MB	8 MB	8 MB
Lithography	22nm	22nm	22nm	22nm	22nm	22nm
Max TDP	37 W	37 W	47 W	47 W	47 W	57 W
Recommended Price (Box / Tray)	N/A TRAY: $225.00	N/A N/A	N/A TRAY: $378.00	BOX : $380.00 TRAY: $378.00	BOX : $570.00 TRAY: $568.00	N/A TRAY: $1096.00
Max Memory	32 GB	32 GB	32 GB	32 GB	32 GB	32 GB
Memory Types	DDR3L-1333 / 1600	DDR3L-1333 / 1600	DDR3L-1333 / 1600	DDR3L-1333 / 1600	DDR3L-1333 / 1600	DDR3L-1333 / 1600
# Memory Channels	2	2	2	2	2	2
Memory Bandwidth	25.6 GB/s	25.6 GB/s	25.6 GB/s	25.6 GB/s	25.6 GB/s	25.6 GB/s
Integrated GPU	Intel® HD Graphics 4600	Intel® HD Graphics 4600	Intel® HD Graphics 4600	Intel® HD Graphics 4600	Intel® HD Graphics 4600	Intel® HD Graphics 4600
PCIe / Lanes	3.0 / 16	3.0 / 16	3.0 / 16	3.0 / 16	3.0 / 16	3.0 / 16
Temp.	100°C	100°C	100°C	100°C	100°C	100°C
Intel® vPro Technology	No	Yes	No	Yes	Yes	Yes
Intel® TSX-NI	Yes	Yes	Yes	Yes	Yes	Yes

Buying a Mobile Workstation

Decide on screen size / portability needs first: 15” or 17”? Weight?

Screen resolution: 1900x1080+ is ideal for Revit / 3ds Max

Installable RAM: Look for 4 DIMM slots for a total of 32GB

Storage: 256GB SSD as C:\, 500GB HD as D:\

- Replace the optical drive with a drive caddy

Video: Ensure it has strong graphics.

- Quadro K1000M and K2000M are solid in all Autodesk apps

Case aesthetics: Where are the ports?

Keyboard – Backlit? Separate numeric pad? Multimedia keys?

Opt for better connectivity options – 802.11n WiGIG, Bluetooth

Docking Station – Get one if available

Thank You!

Please fill out your evaluation forms online after class!

Please see me if you need the answers