Futurology
for Developers

@markrendle



My First Server

- Tandon 286
- 2MB RAM
- 150MB HDD
- 8 programmers



https://www.bartvandenakker.nl/computer-collection/tandon-28612/



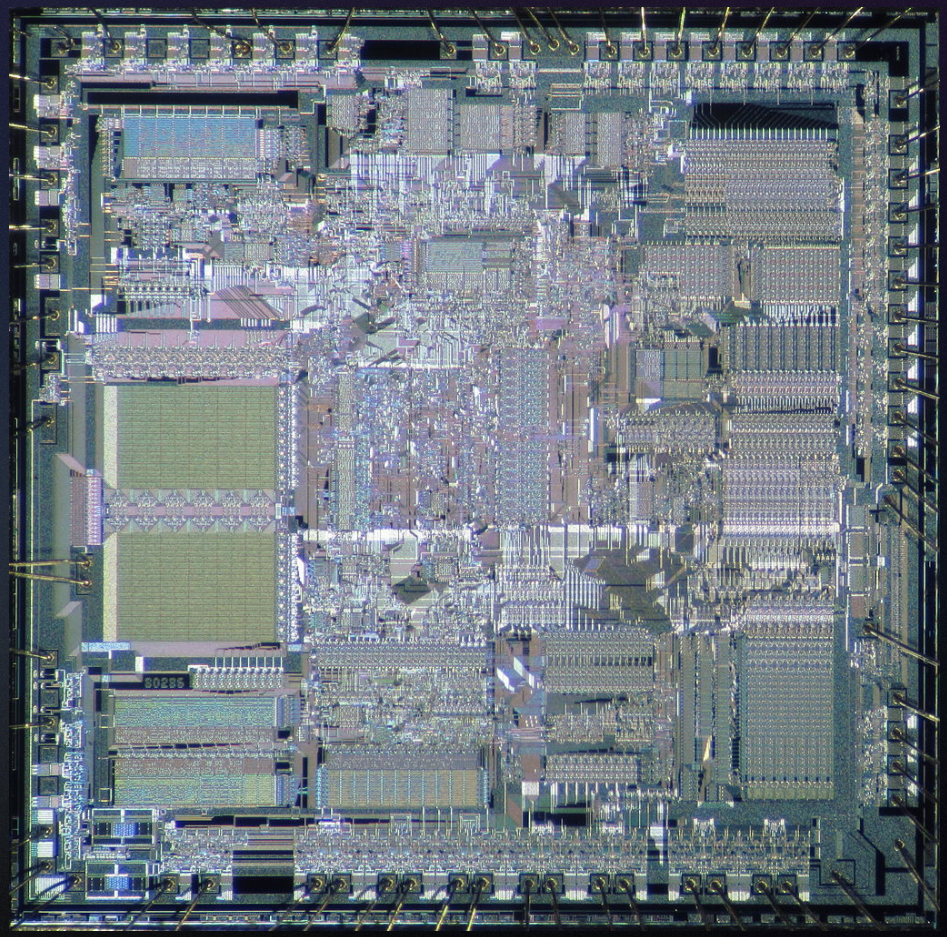
Intel 80286



Konstantin Lanzet

Intel 80286

- 8MHz
- 1 Core
- 134,000 transistors
- 1.5 µm (1500nm)
- 16-bit
- 16MB RAM
- 1.6 MIPS
- 0 FLOPS



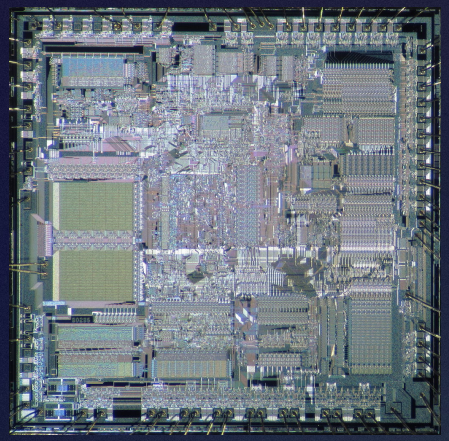
Pauli Rautakorpi

“The number of transistors in a dense integrated circuit doubles about every two years”

Gordon Moore, CEO of Intel, 1965

Moore's Law





Intel 80286

8MHz

1 core

134,000 transistors

1.5 µm (1500nm)

16-bit

16MB RAM

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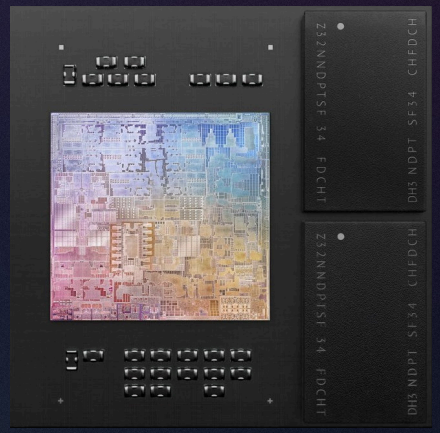


Apple M1

3GHz

32 cores

16,000,000,000 transistors

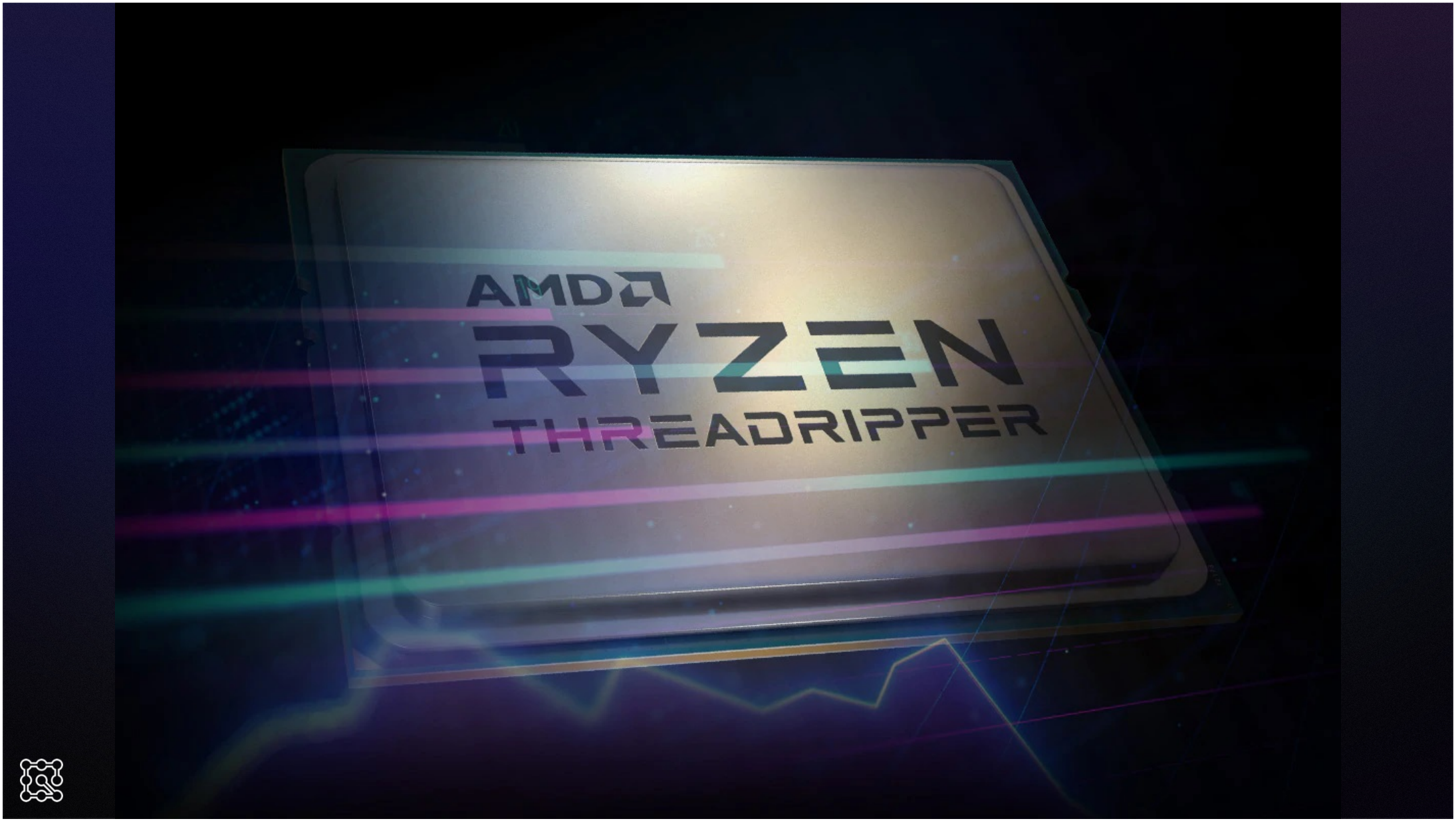
5nm

64-bit

16GB RAM

MIPS?

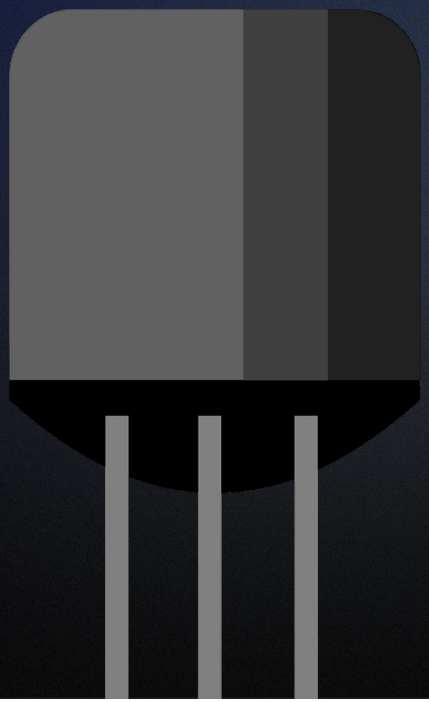
Many, many TeraFLOPS


AMD
RYZEN
THREADRIPPER

1.5µm vs 5nm

1989

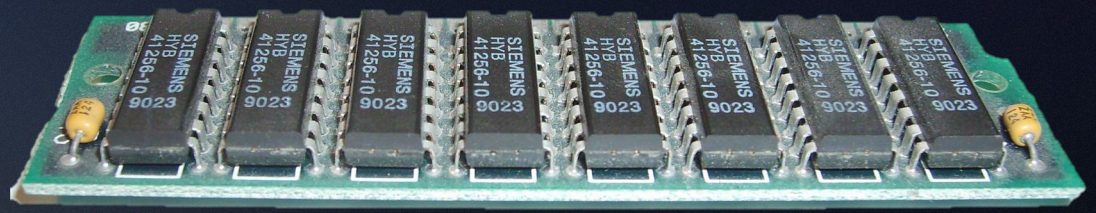
2020



It's there

2MB DRAM SIMM

- 22MHz
- 8-bit data width
- 177MBps



32GB DDR4-2666 SO-DIMM

- 333.33MHz
- 64-bit data width
- 21.3 GBps

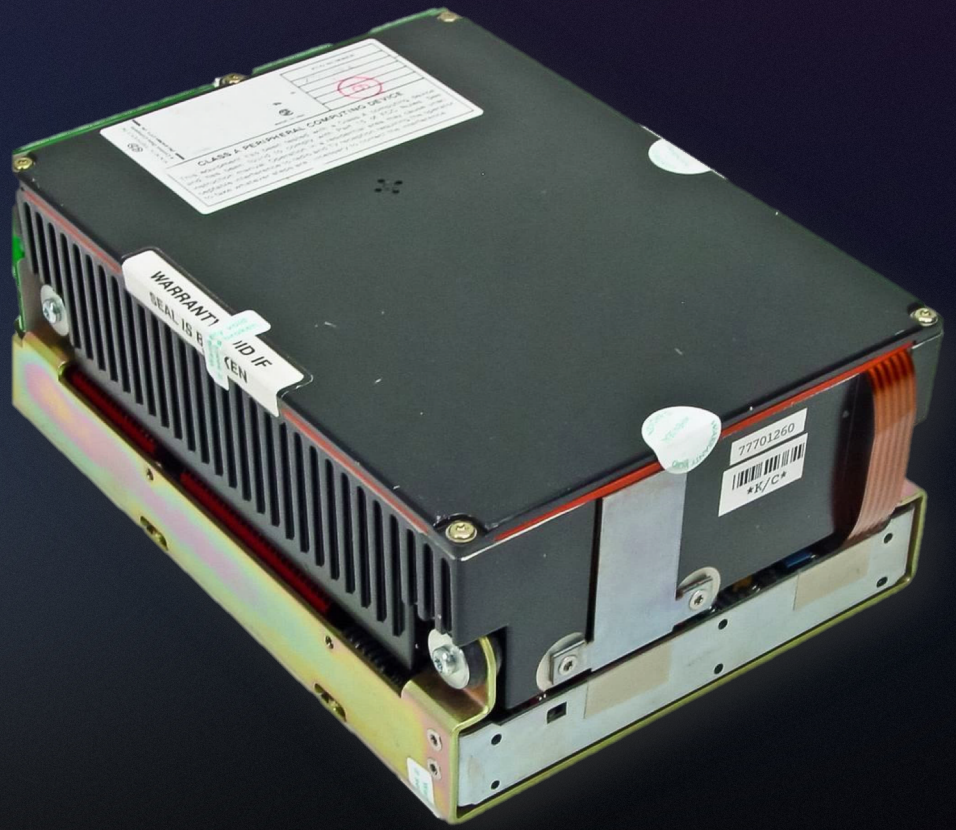


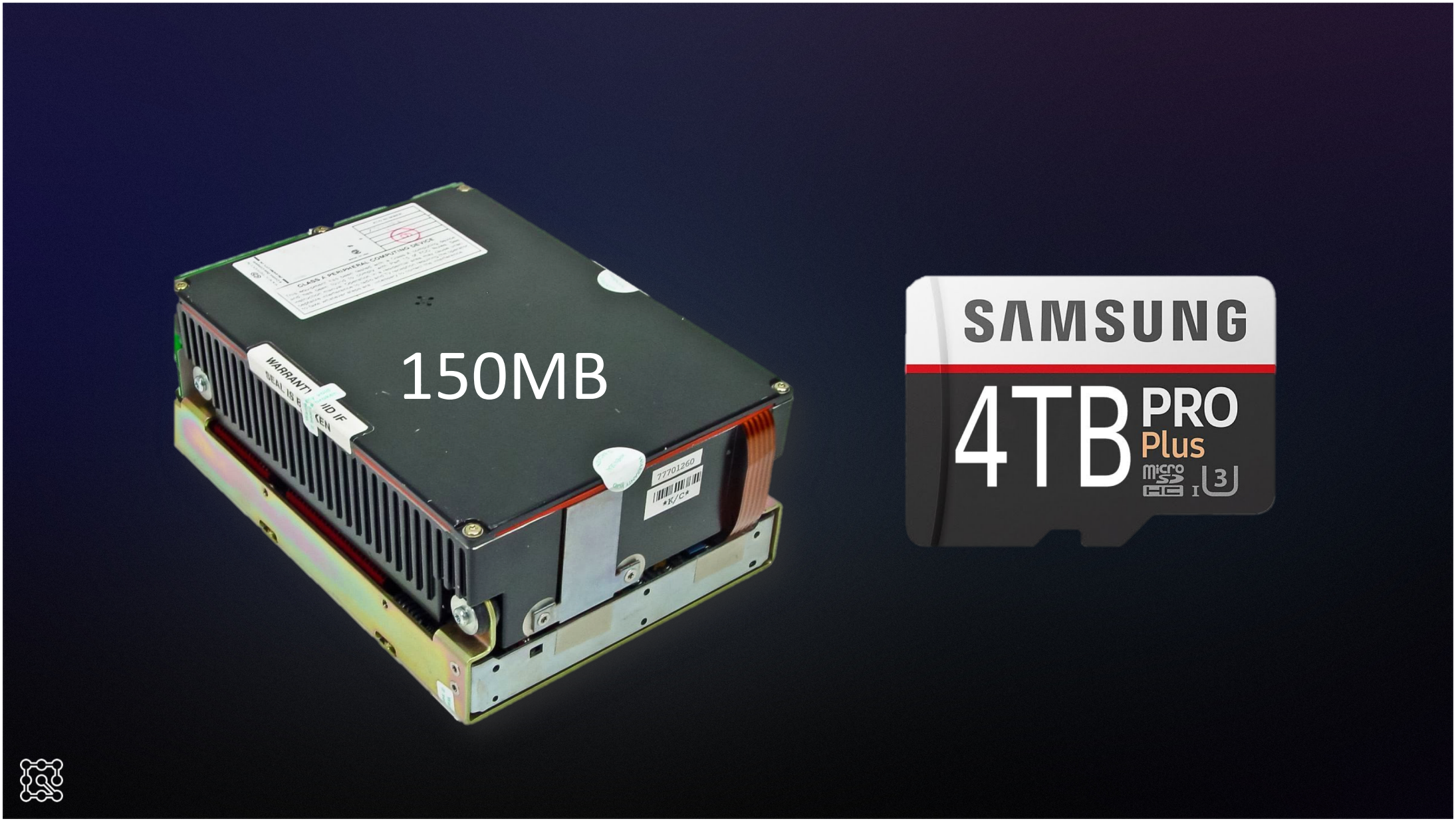
150MB 5.25" SCSI

"Full height"

£2,000






150MB
SAMSUNG
4TB
PRO
Plus

Wyse 50

- 80 x 24 characters
- 2 colour
- RS-232 interface
- Teletype protocol



Compaq Portable SLT/286 1903

- 1-core 12MHz 16-bit CPU
- Monochrome LCD screen
- 640KB RAM
- 40MB HDD
- 3 hours on battery
- 6.4kg
- £6000



http://www.computinghistory.org.uk/det/2223/Compaq-Portable-slt-286-1903/



Lenovo ThinkPad X1 Extreme

- 6-core 4.6Ghz 64-bit CPU + GPU
- 4K touchscreen
- 64GB RAM
- 2TB SSD
- 15 hours on battery
- 1.8kg
- £2500



Printer

- 24-pin Dot Matrix
- Monochrome
- Huge
- Expensive
- Noisy



These just didn't exist in 1989

New Things











Apple MessagePad (1993)

- 336x240 LCD
- Monochrome
- 640KB RAM
- 4MB Flash memory
- 640g



Apple iPhone XS (2018)

- 2436x1125 OLED
- All the colours
- 4GB RAM
- 512GB Flash memory
- 177g



Progress

Faster

Smaller

Lighter

Preciser

Powerfuller

Connecteder



(My New Hobby)

Extrapolation



Moore's Law to 2049

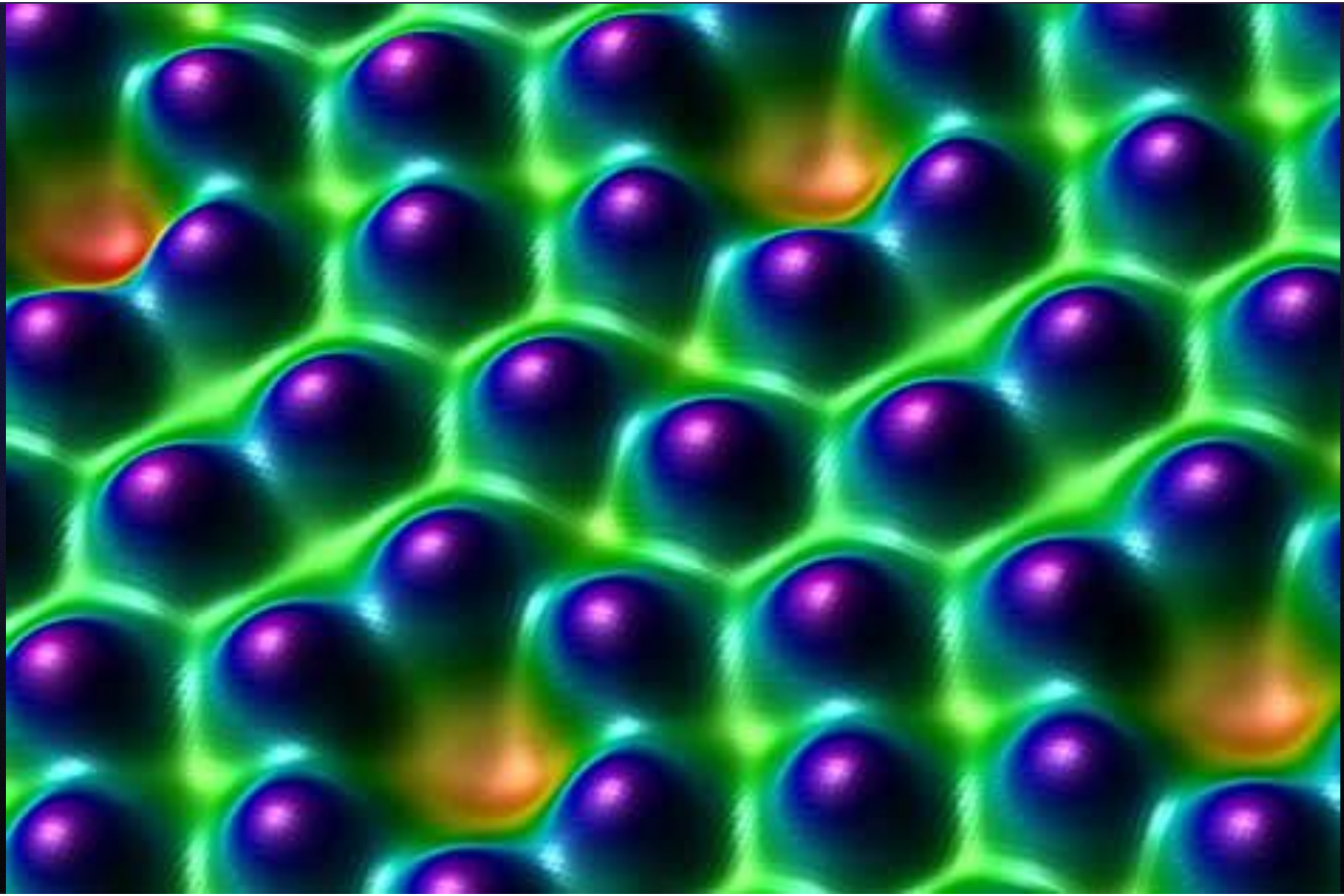
328 trillion transistors?



Process nodes

- 2020: 5nm
- 2022: 3nm
- ????: 1.4nm?






Processor possibilities
Silicon-Germanium
Graphene / Carbon nanotubes
Photonic
Organic
Quantum

“In a 64-bit quantum computer, each 64-bit register can hold 18,446,744,073,709,551,616 different values at the same time.”

https://www.techradar.com/uk/news/computing-components/processors/beyond-silicon-the-future-of-the-cpu-147829/2




Smaller, faster, cheaper, everywhere
Current trends

A Non-Exhaustive List of Things Connected to the Wi-Fi in My House

8 computers
8 phones and tablets
2 Xboxes
1 PlayStation
2 Nintendo Switches
The TV
3 SkyQ boxes
2 FireTVs
2 wristwatches
6 Amazon Echo devices
3 Books
So many lightbulbs
The doorbell
The washing machine
A printer
A camera



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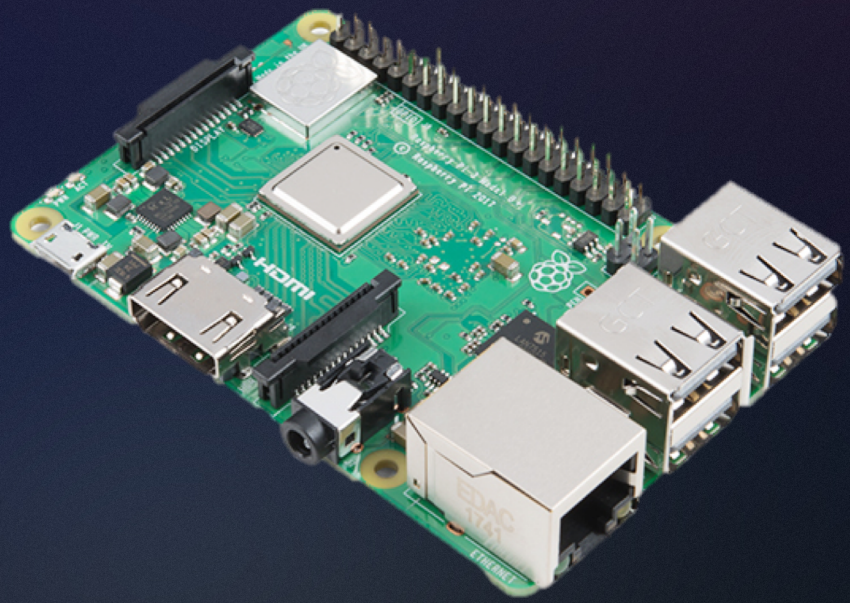


Raspberry Pi 4 B

ARM Cortex-A72 1.5GHz CPU, ^4GB RAM

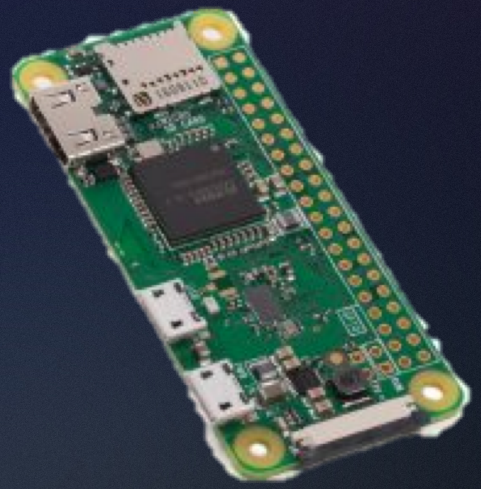
Raspberry Pi Foundation, 2019



ASUS Tinker Board

ARM Cortex-A17 1.8GHz CPU, 2GB RAM

ASUS, 2017

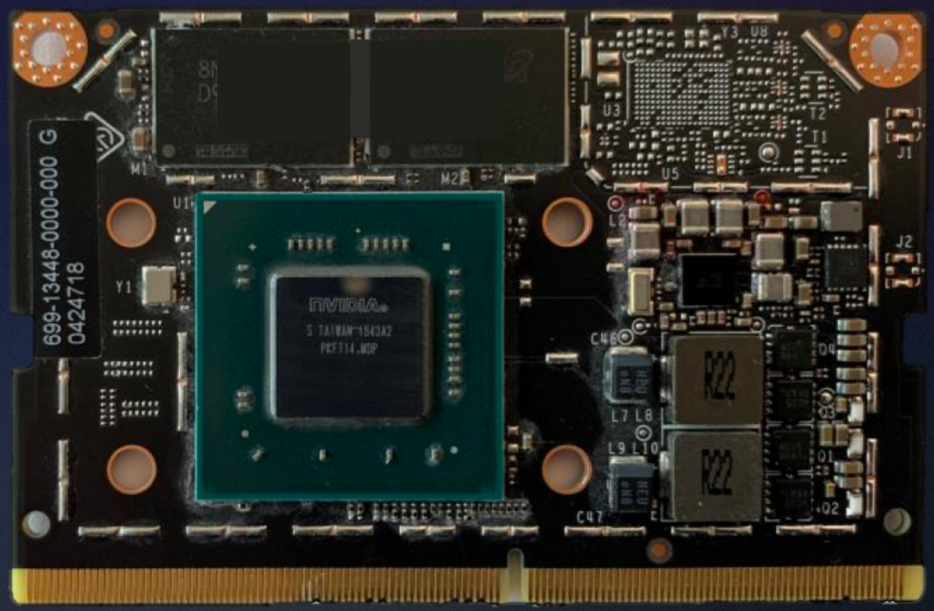


Raspberry Pi Zero W

ARM11 1GHz CPU, 512MB RAM

Raspberry Pi Foundation, 2017





Nvidia Jetson Nano

4xARM57 1.4GHz CPU, 4GB RAM, 128 Core Maxwell 472GFLOPs GPU

Nvidia, 2019

HummingBoard

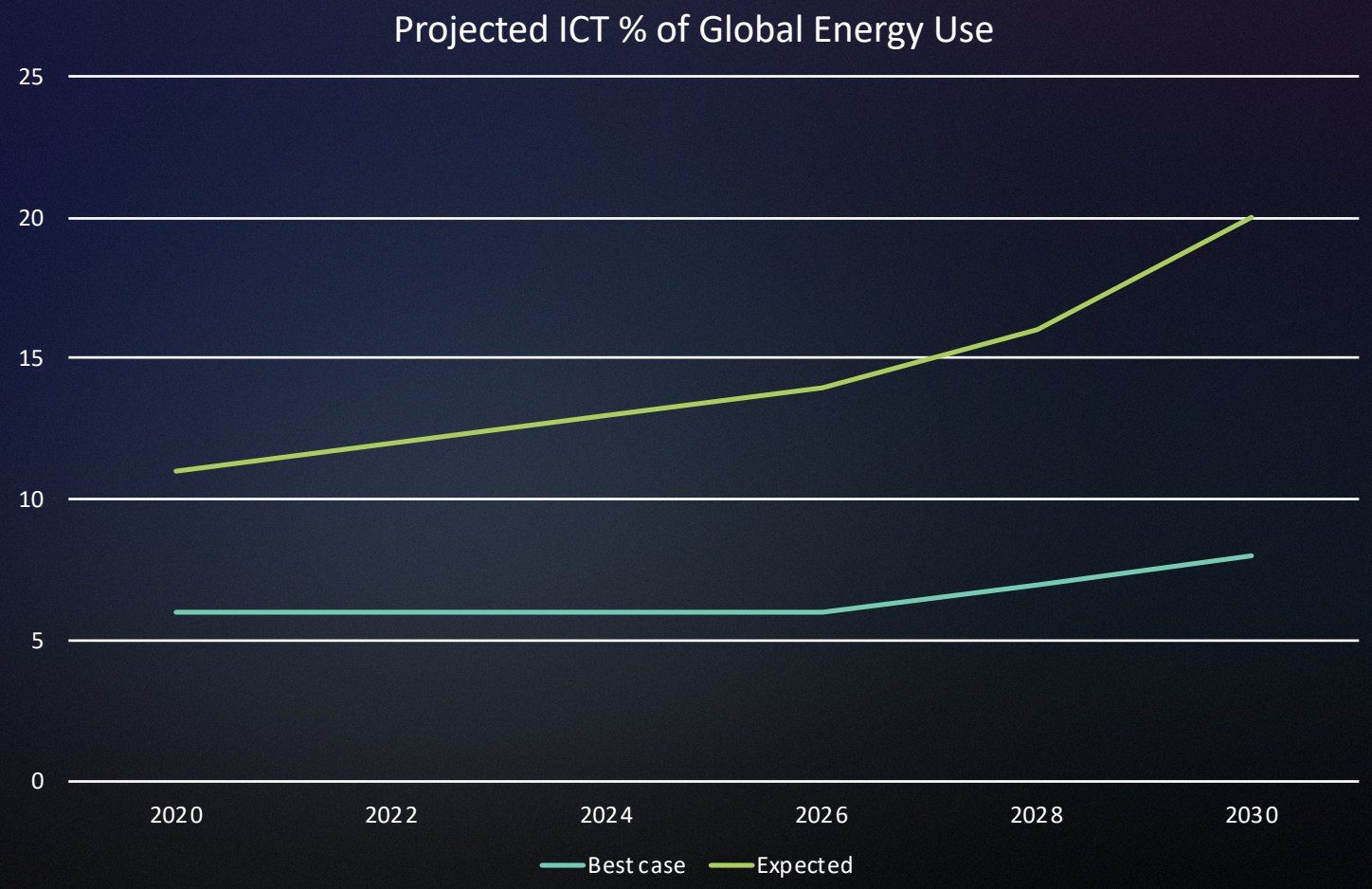
Orange Pi

Banana Pi

Odroid

(Arduino)




Projected ICT % of Global Energy Use
25
20
15
10
5
0
2020
2022
2024
2026
2028
2030
Best case
Expected

Arm hosting

Scaleway

Mythic Beasts (hosted Raspberry Pi)

Packet

AWS a1 instances



Getting Started

.NET 5.0 ARM64 and ARM32

github.com/dotnet/CoreRT

jsandler18.github.io - Build an OS for Raspberry Pi

Follow Alexandre Mutel on twitter.com/xoofx

System.Device.Gpio (.NET Core 3.0)

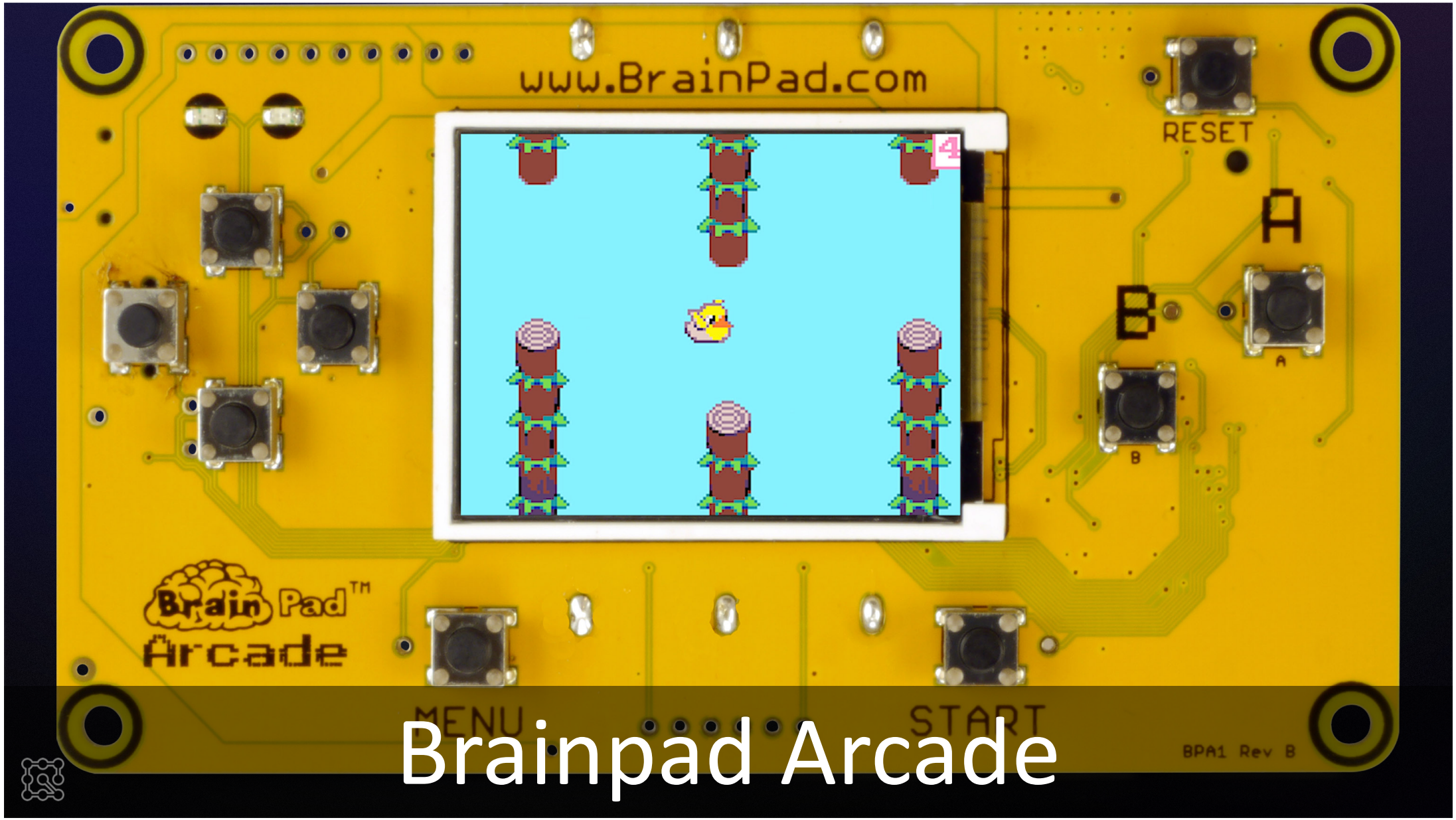
unosquare.github.io/raspberryio



If you’ve got kids

MakeCode Arcade





Brainpad Arcade



Adafruit Pygamer



Adafruit Pybadge


KittenBot Meowbit

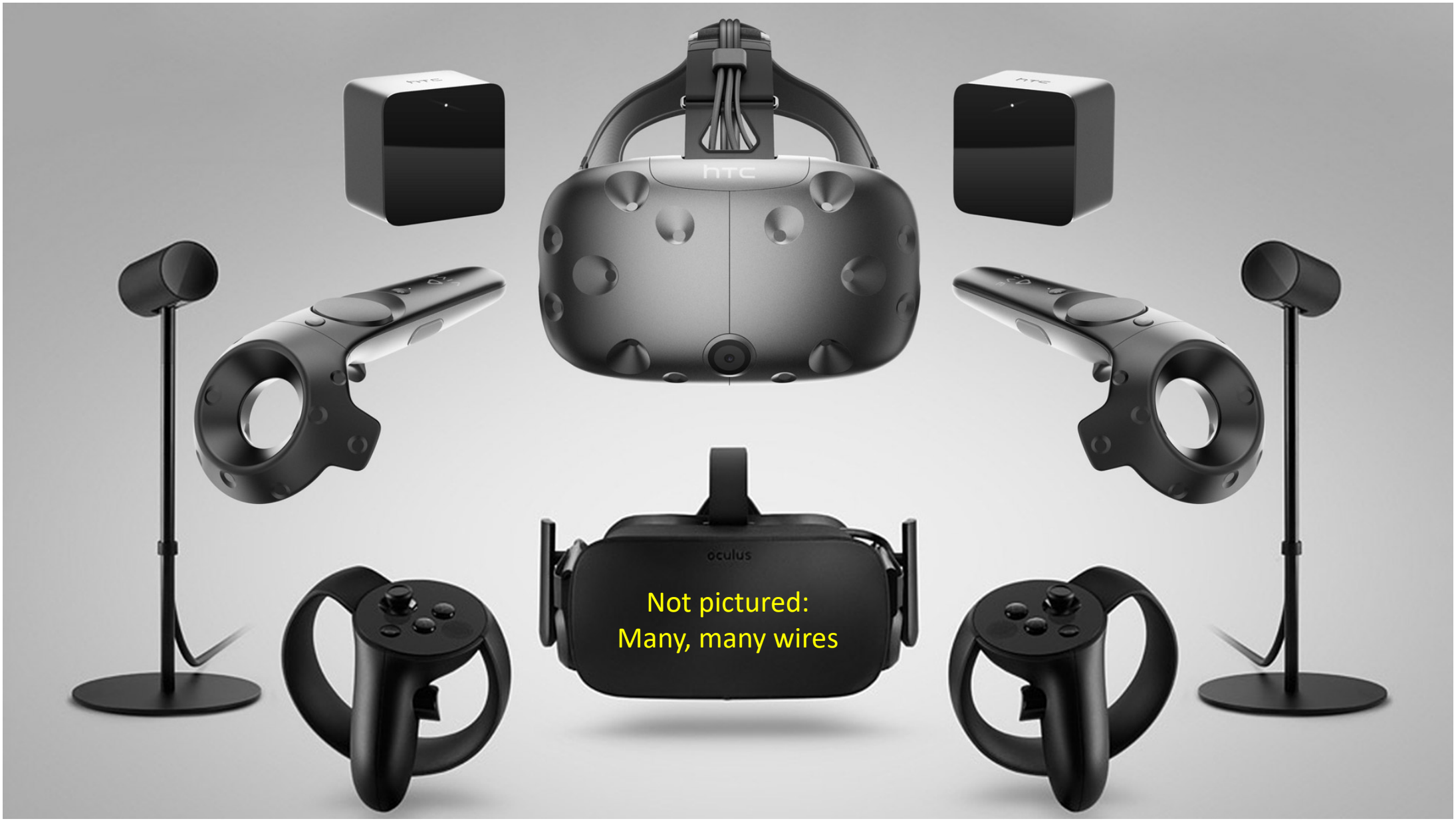
Modern Primitive Technology




User Interface
Photo by Giu Vicente on Unsplash


The Sunday Globe
GAMES UNVEILS THE OASIS
HAVE YOU WASHED YOUR HANDS?


- FIRST CASES BUILD -
2025

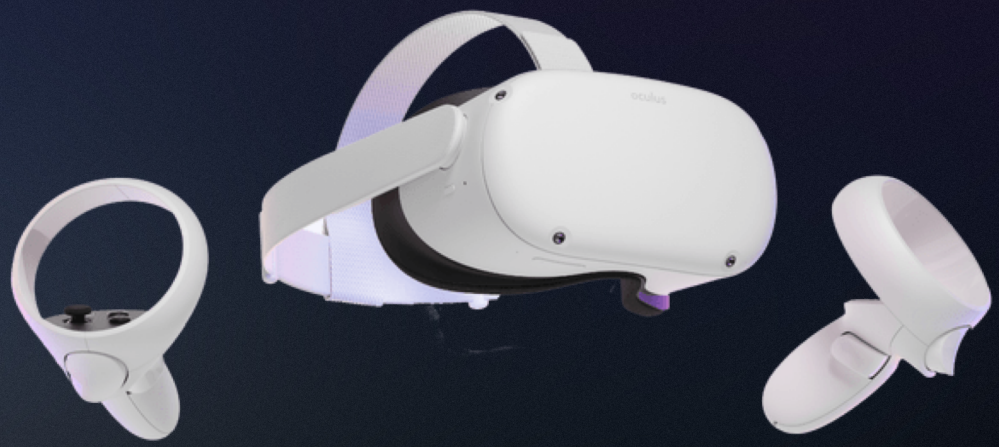

htc
htc
htc
oculus
Not pictured:
Many, many wires


GEFORCE GTX
GEFORCE GTX

Oculus Quest 2

- Snapdragon XR2 CPU
- 6 Degrees of Freedom
- 1832 x 1920 per eye
- 95° Field of View
- Inside-Out tracking
- Touch controllers

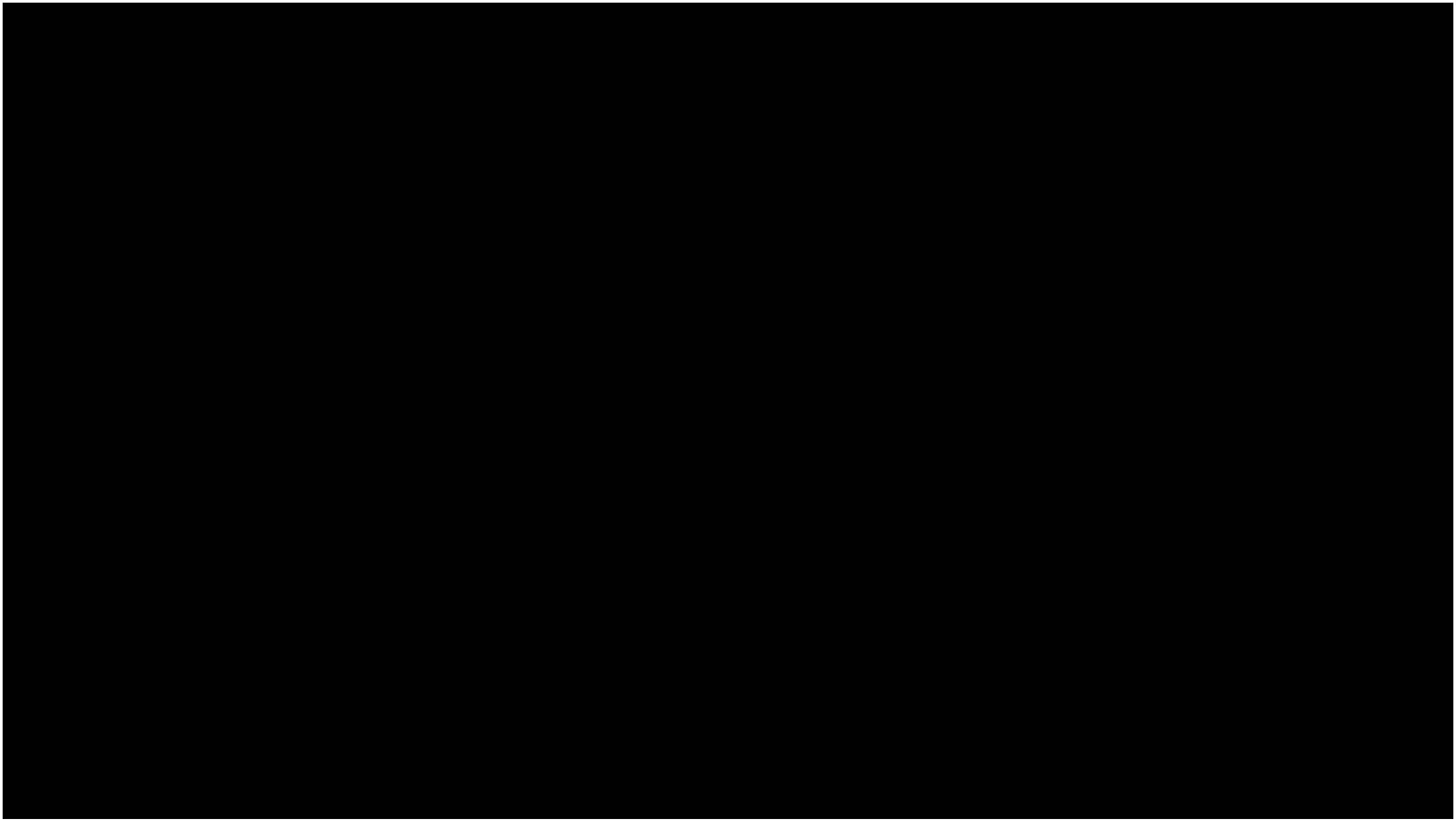
"Xbox One performance"



Beat Saber VR

Example





Beat Games

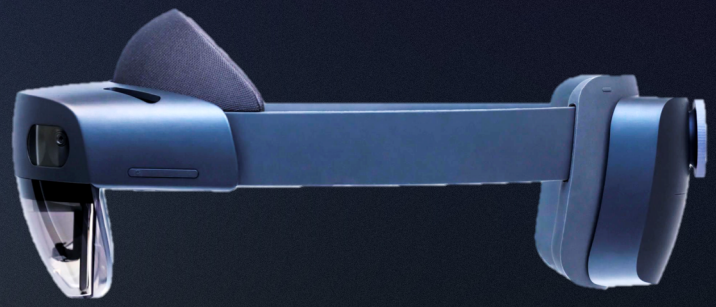
Beat Saber

PS4, Oculus, Vive



Microsoft HoloLens 2

- Snapdragon 850 CPU
- Microsoft HPU 2.0
- Custom AI processor
- 70° Field of View
- Available now



Magic Leap

- NVIDIA CPU + GPU
- 8GB RAM
- Waveguide
- 40° Field of View
- Bluetooth & WiFi



Cheddar for Magic Leap

Example





Cheddar

Cheddar Live News

Magic Leap




Cool headgear, bro

1993



13 years

2006



By Rafael Fernandez - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=63395591

2018

2031?



13 years




nreal
www.nreal.ai


Cheddar
cheddar
EXCHANGE


Proshot Sport Li-Po
LEAP
MOTION

Required Skills

3D graphics and modelling

Spatial design

New interaction models



Getting Started

Unity3D:	unity3d.com
Asset Store:	assetstore.unity.com
Engine Kits:	moremountains.com
Unity In Action:	Manning Press
YouTube	try searching "Brackeys"
Code tutorials:	catlikecoding.com



Getting Started Web Version

A-FRAME: aframe.io

WebXR: immersive-web.github.io/webxr



Minecraft Earth

AR on smartphones





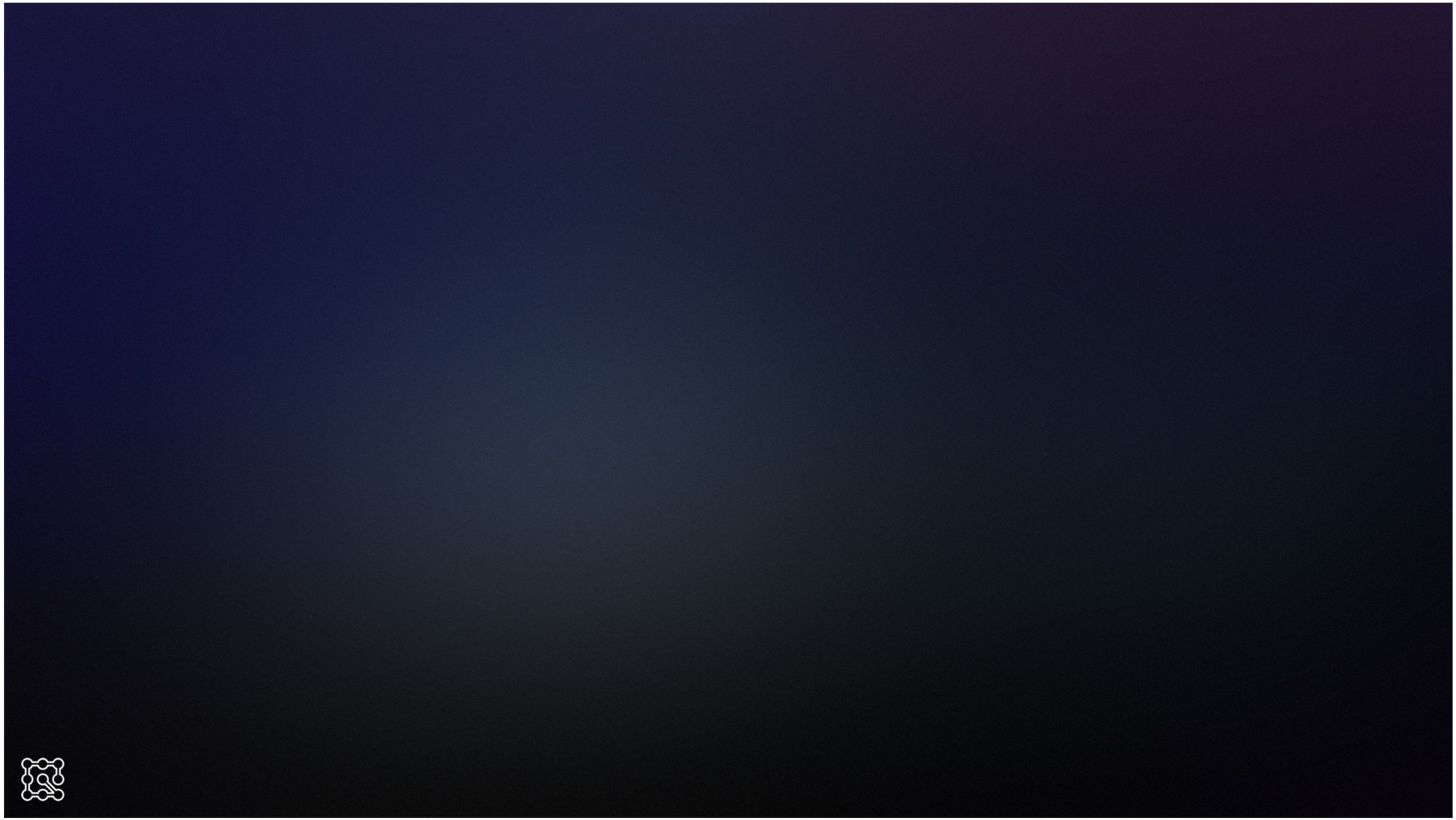
Minecraft Earth

AR on smartphones



Recommended Reading






Manufacturing

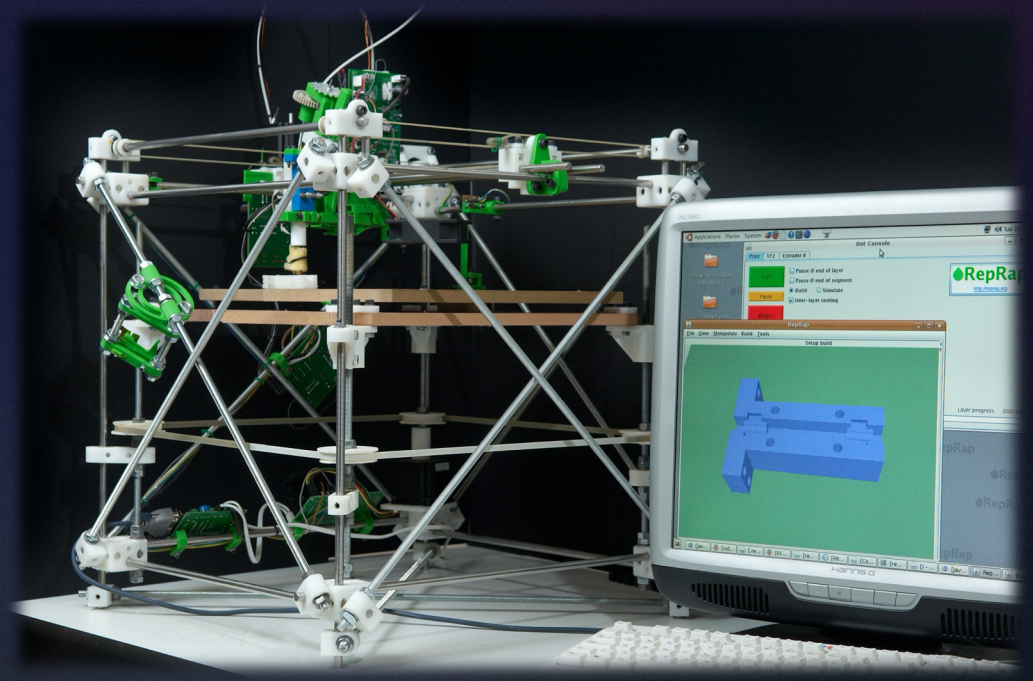


$100,000

3D Systems SLA

Stereolithographic Apparatus

1992



Darwin

"Rep Rap" v1

University of Bath, 2007

1-24 of over 1,000 results for **Business, Industry & Science : 3D Printing & Scanning : 3D Printers : "3d printer"**

Sort by Featured

Show results for

- Any Category
- Business, Industry & Science
- 3D Printing & Scanning
- **3D Printers**

Refine by

Delivery Option

- ☐ prime

Delivery Day

- ☐ Get It Today

Brand

- ☐ Flashforge
- ☐ GEEETECH
- ☐ XYZ Printing
- ☐ Wanhao
- ☐ Monoprice
- ☐ TRONXY
- ☐ JGAURORA
- ☐ Cubify
- ☐ ANYCUBIC
- ☐ HICTOP
- ☐ Aleph Objects Inc.
- ☐ AA+inks
- ☐ win-tinten
- ☐ CoLiDo
- ☐ GIANTARM

See more

Global Store

- ☐ global store

Avg. Customer Review

- ★★★★☆ & Up
- ★★★☆☆ & Up
- ★★☆☆☆ & Up
- ★☆☆☆☆ & Up

New Arrivals

Last 30 days
Last 90 days

Price

Under £15
£15 - £50
£50 - £100
£100 - £200

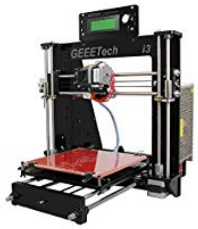
Ad feedback

Showing the results in **Business, Industry & Science**. Show instead the results in All Departments.

Amazon's Choice



Comgrow Creality Ender 3 3D Printer Aluminum DIY with Resume Print 220 * 220 * 250mm
by Comgrow
£196.96 prime
FREE Delivery by **Friday, Jan 25**
More buying choices
£193.02 (4 used & new offers)
★★★★☆ 83



Geeetech Acrylic Prusa I3 Pro B Unassembled 3D printer DIY Kit high quality excellent CNC.
by GEEETECH
£165.00 prime
FREE Delivery by **Friday, Jan 25**
More buying choices
£159.00 (2 new offers)
★★★★½ 190



ANYCUBIC i3 Mega 3D Printer Full Metal with Patented Heated Bed and 3.5 inch Touch Screen Large Print Size UK Plug, Works with
by ANYCUBIC
£289.99 prime
FREE Delivery by **Friday, Jan 25**
More buying choices
£269.69 (7 used & new offers)
Promotion Available and 6 more promotions
Save £15.00 with voucher
★★★★½ 88



Flashforge 3D Printer Finder Single Extruder Printer
by FLASHFORGE
£320.00
Only 1 left in stock - order soon.
Eligible for FREE Delivery
★★★★½ 112

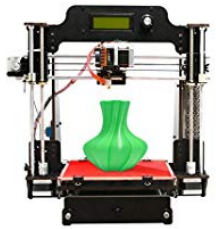


More options available

BIBO 3D Printer Sturdy Frame Dual Extruder Laser Engraving WIFI Touch Screen Cut Printing Time In Half Filament Detect
by BIBO
£648.99 prime
FREE Delivery by **Tomorrow, Jan 24**
More buying choices
£603.56 (2 used offers)
★★★★½ 19



ANYCUBIC MEGA-S 3D Printer Printing Size 210 x 210 x 205mm With UltraBase Heated Build Plate UK Plug, 3.5" Touch Screen + Free
by ANYCUBIC
£319.99 prime
FREE Delivery by **Tomorrow, Jan 24**
More buying choices
£278.99 (2 used offers)
Promotion Available and 8 more promotions
★★★★★ 7



More options available

Geeetech 3D Printer desktop 3D printer DIY Kit
by GEEETECH
£179.00
More buying choices
£84.44 (1 used offer)



ANYCUBIC Photon 3D Printer, LCD Masking Technology with UK Plug (Upgrade Yellow Model)
by ANYCUBIC
£399.99 prime
FREE Delivery by **Friday, Jan 25**
Promotion Available and 9 more promotions



More options available

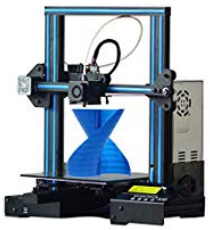
Monoprice Select Mini 3D Printer V2
by Monoprice
£195.22 prime
Some colours are Prime eligible
More buying choices



Monoprice Mini Delta 3D Printer With (110 x 110 x 120 mm) Heated Build Plate, Auto Calibration, Fully Assembled for
by Monoprice
£142.99 prime
FREE Delivery by **Friday, Jan 25**
More buying choices
£132.98 (4 used offers)



Monoprice Maker Select Plus 3D Printer With Large Heated (200 X 200 X 180 mm) Build Plate, LCD Touchscreen Display + Free
by Monoprice
£214.00 ~~£399.99~~ prime
FREE Delivery by **Tomorrow, Jan 24**
★★★★☆ 18



GEEETECH A10 3D Printer Aluminum Prusa I3 Half Assembled DIY Kit with Print Size 220×220×260mm,OPEN SOURCE
by GEEETECH
£186.00 prime
FREE Delivery by **Friday, Jan 25**
More buying choices
£175.42 (1 used offer)

https://smile.amazon.co.uk/BIBO-Extruder-Engraving-Printing-Demountable/dp/B01LNADH8M/ref=sr_1_9?s=industrial&ie=UTF8&qid=1548257765&sr=1-9&keywords=3d+printer



da Vinci Jr.

Fully-assembled. Has WiFi

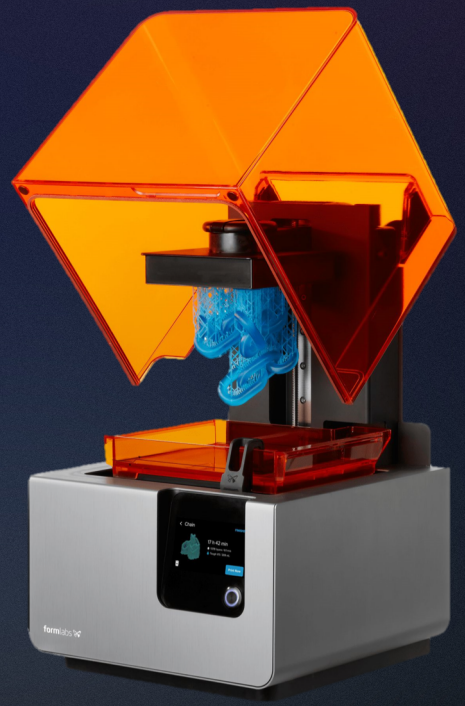
XYZ Printing, 2015



da Vinci Color

Full-color Printing

XYZ Printing, 2017



Form 2

Pro-consumer SLA

FormLabs, 2015










formlabs.com/store/uk/form-2

1989



20 years

2009



HP Photosmart A626

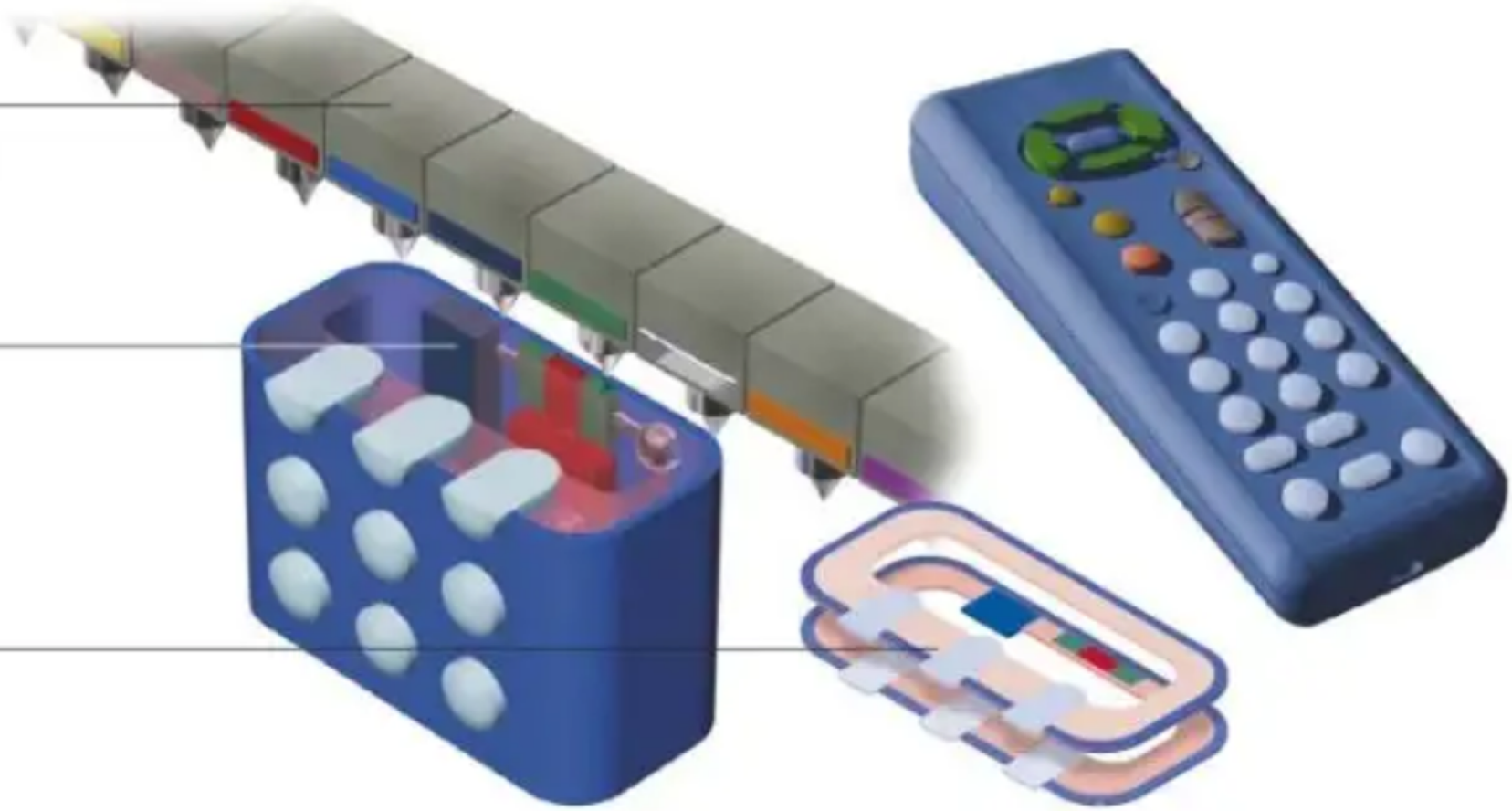
Near future

Gadgets



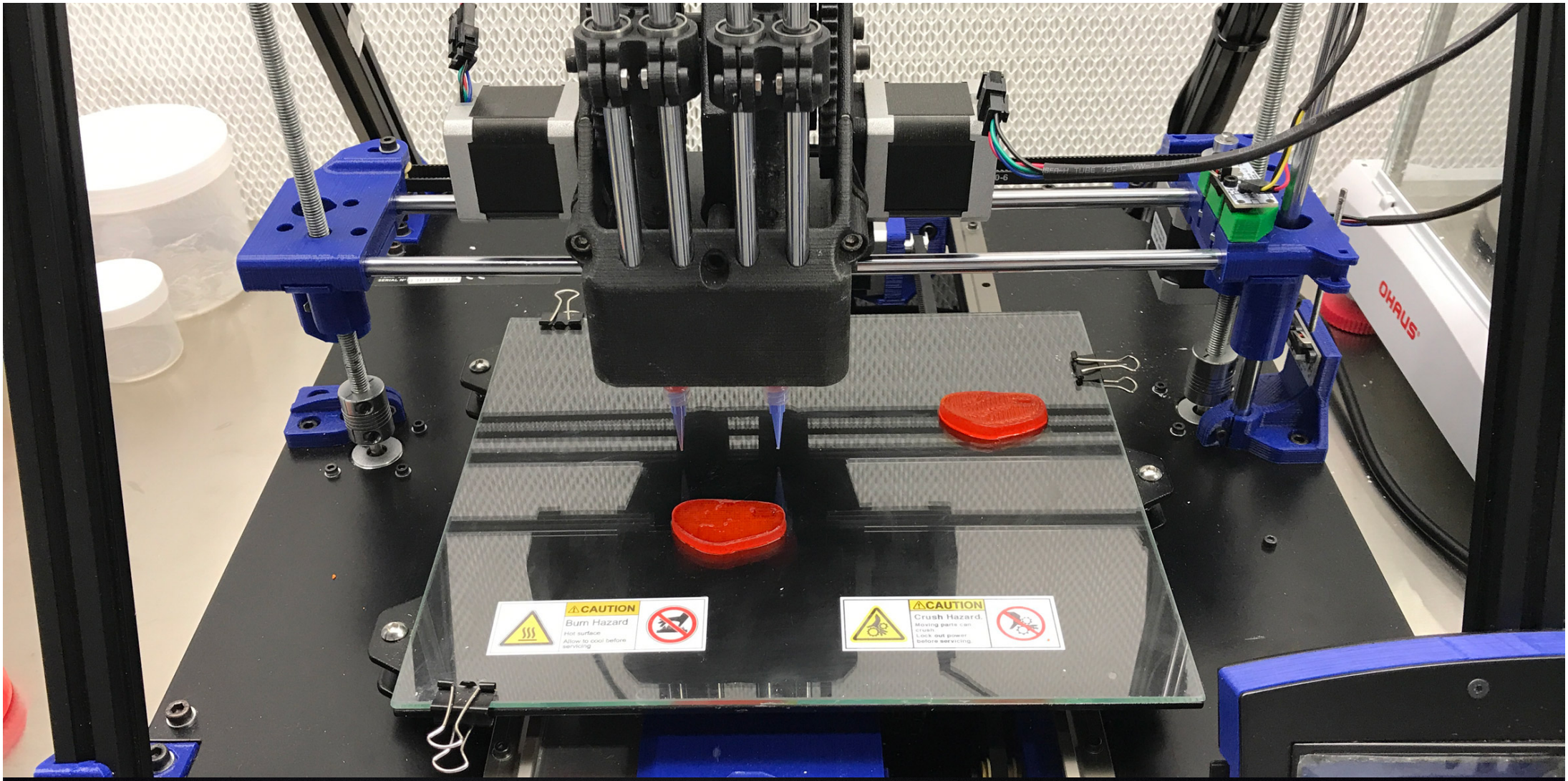
THE 3D GADGET PRINTER

How to print a remote control all in one go



Near future

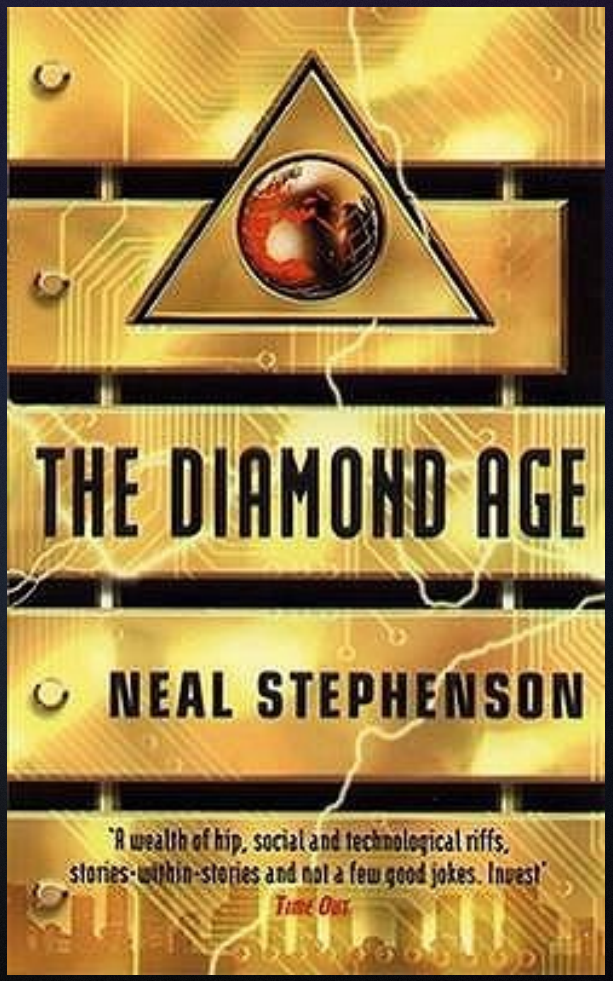
Food

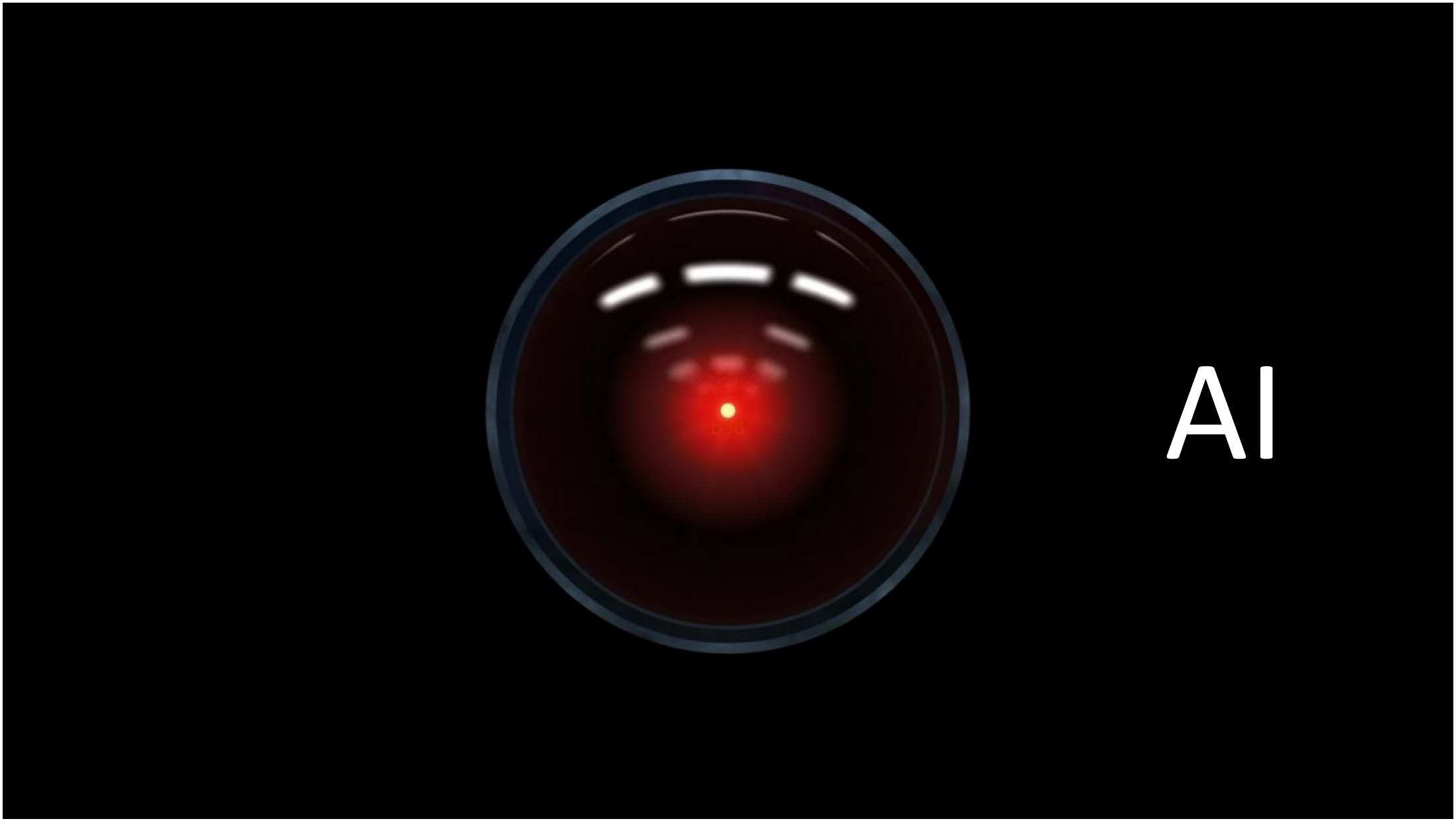


https://www.dezeen.com/2018/11/30/novameat-3d-printed-meat-free-steak/


Far future
Tea, Earl Grey, hot

Recommended Reading




AI

History



1950

The Turing Test



1956

McCarthy & Minsky



1973

The Lighthill Report



1980s

Expert systems



1997

Deep Blue vs Kasparov



2002

Roomba


iRobot
Roomba
Robotic FloorVac
S
M
L
Select Room Size to Start / Stop

2005

Boston Dynamics



2011

Watson plays Jeopardy



2011

Siri



2014

Alexa



2014

Driverless cars



2016

Google Assistant



2016

AlphaGo



2017

AlphaZero



Present



“John Carmack stepping down as CTO of Oculus to work on AI”

https://www.theverge.com/2019/11/13/20963899/john-carmack-stepping-down-cto-of-oculus-work-on-ai



Neural Processing Units

NVIDIA Tensor Cores

Apple A14X NPU

Snapdragon 865

HoloLens 2 HPU

FPGAs



AI as a Service

Microsoft Cognitive Services

Google Cloud AI

AWS AI, ML, etc.

IBM Watson



SDKs

ML.NET

OpenCV

Keras

TensorFlow

Mycroft



Getting Started

dot.net/ml

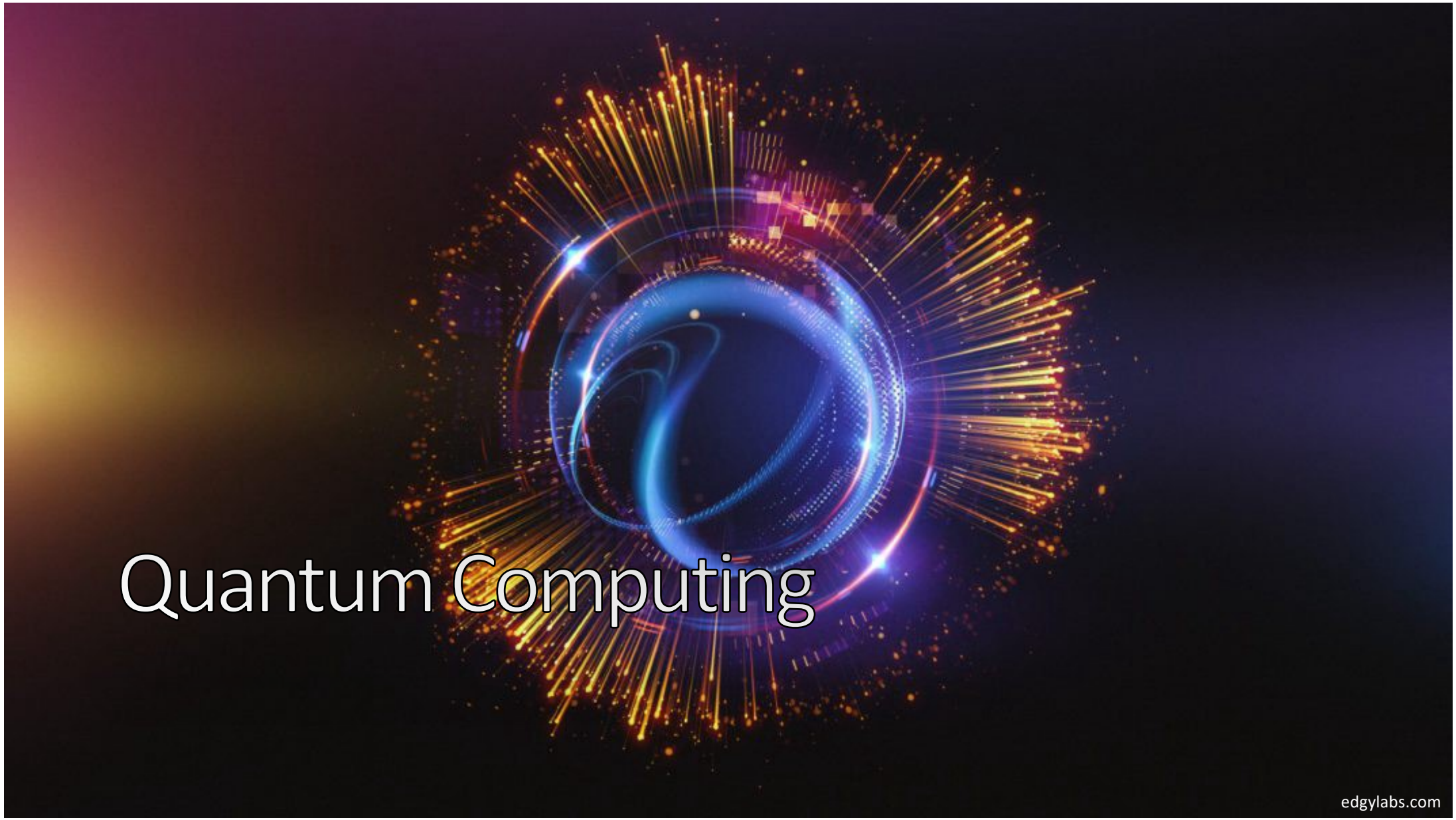
github.com/dotnet/machinelearning-samples

.NET 5.0



Future



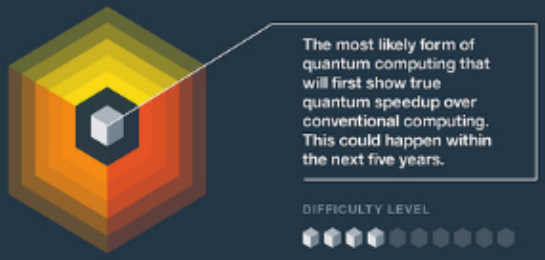

Quantum Computing
edgylabs.com

The three known types of quantum computing and their applications, generality, and computational power.



A very specialized form of quantum computing with unproven advantages over other specialized forms of conventional computing.

DIFFICULTY LEVEL



The most likely form of quantum computing that will first show true quantum speedup over conventional computing. This could happen within the next five years.

DIFFICULTY LEVEL



The true grand challenge in quantum computing. It offers the potential to be exponentially faster than traditional computers for a number of important applications for science and businesses.

DIFFICULTY LEVEL

Quantum Annealer

The quantum annealer is least powerful and most restrictive form of quantum computers. It is the easiest to build, yet can only perform one specific function. The consensus of the scientific community is that a quantum annealer has no known advantages over conventional computing.

APPLICATION
Optimization Problems

GENERALITY
Restrictive

COMPUTATIONAL POWER
Same as traditional computers

Analog Quantum

The analog quantum computer will be able to simulate complex quantum interactions that are intractable for any known conventional machine, or combinations of these machines. It is conjectured that the analog quantum computer will contain somewhere between 50 to 100 qubits.

APPLICATIONS
Quantum Chemistry
Material Science
Optimization Problems
Sampling
Quantum Dynamics

GENERALITY
Partial

COMPUTATIONAL POWER
High

Universal Quantum

The universal quantum computer is the most powerful, the most general, and the hardest to build, posing a number of difficult technical challenges. Current estimates indicate that this machine will comprise more than 100,000 physical qubits.

APPLICATIONS
Secure computing
Machine Learning
Cryptography
Quantum Chemistry
Material Science
Optimization Problems
Sampling
Quantum Dynamics
Searching

GENERALITY
Complete with known speed up

COMPUTATIONAL POWER
Very High

IBM **Research**

Infographic by **Carl De Torres for IBM Research**

Getting Started

Q#

Microsoft Quantum Development Kit

www.microsoft.com/en-us/quantum/development-kit

IBM Quantum Experience

quantumexperience.ng.bluemix.net/qx/editor

Computing With Quantum Cats - John Gribbin / Black Swan



Nanotech



Current Nanotech Research

Nanomaterials
Carbon nanotubes, nanoparticles, quantum dots, medicine

Bottom-up
DNA/RNA, molecular self-assembly

Top-down
EUV lithography, solid-state systems, focused ion beams

Functional
Anisotropic superparamagnetic materials, molecules with electronic properties, molecular motors

Biomimetics
Copying nature, biomineralization, biomolecules

Speculative
Single-molecule manipulation, nanorobotics, productive nanosystems, programmable matter



en.wikipedia.org/wiki/Nanotechnology

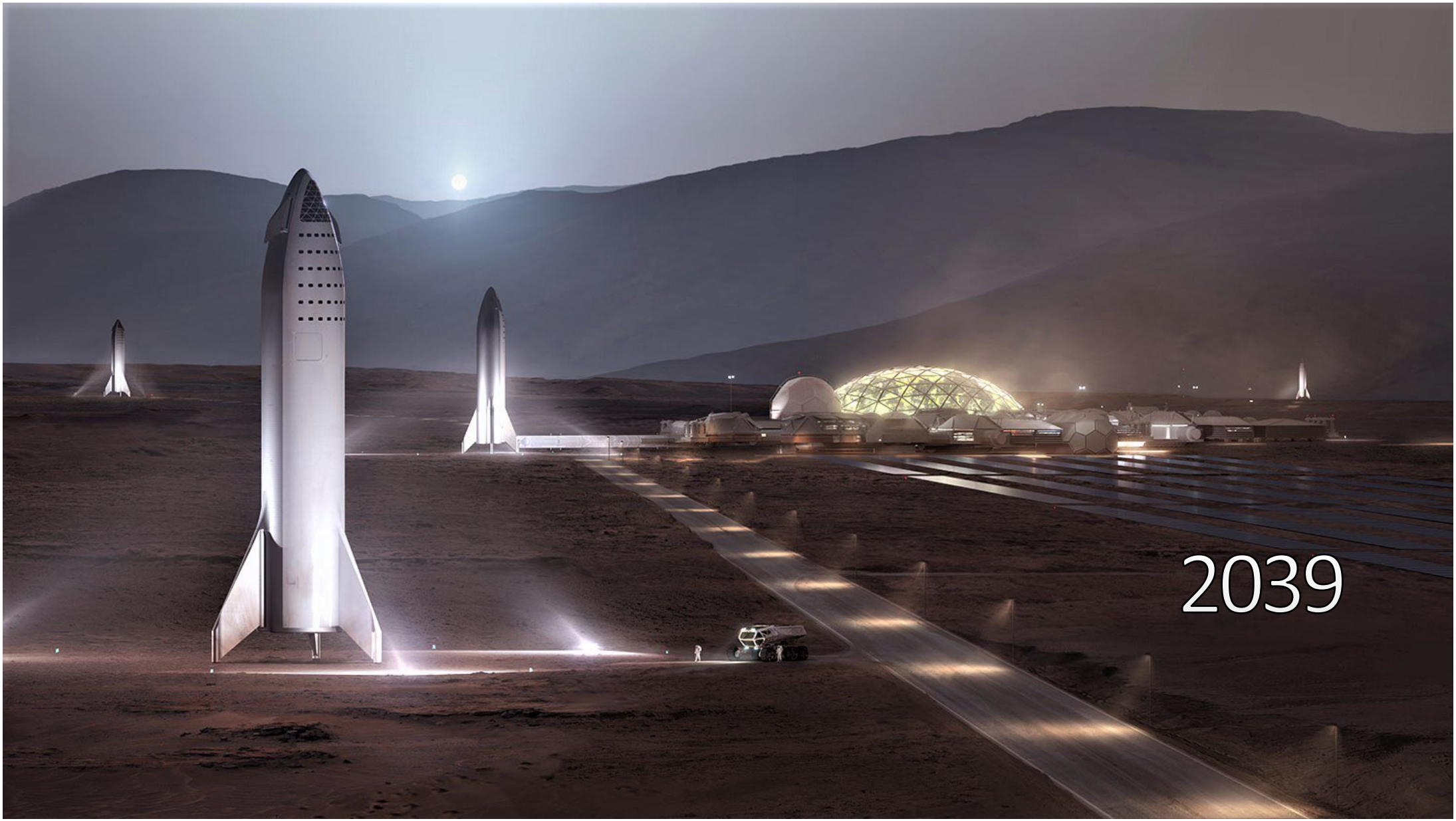
Getting Started

- Bachelor's degree
- Master's degree
- PhD
- Research position at a good university






2029


2039



conatusnews.com/transhumanism-engineering-utopia

futurology4.dev

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