CES 2020 Notes

By Richard Helfrich

This paper is an assembly of notes collected after visiting CES 2020 along with related input from other sources. These notes cover some exhibits in selected CES sections.

These notes make no attempt to cover all of CES or all exhibitors in any one sector or technology.

These notes are limited to a modest number of companies that may or may not be representative of their technological areas or sectors.

These notes contain input received from exhibitors that who may not have complete knowledge or who are overly optimistic. There may be a few opinions but an attempt was made to limit opinions. Others may have different views that could be polar opposites

Overly optimistic views of exhibitors were evaluated for realism based on basic physics, biochemical reality, and mathematical models. Exhibits were evaluated from the viewpoint of a science and engineering perspective for technological realism as well as from a venture investor perspective for economic viability.

CES 2020 was too extensive for any one person to have time to visit more than a few percent of exhibits. Increases in the number of attendees resulting in denser crowding further increases the time to move between exhibits.

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The contents of this document are the personal opinions of the author and are not warranted to be complete or accurate, but an attempt has been made to achieve 'reasonable commercial correctness'. These notes are provided as background materials for further investigation and verification by each reader. The author assumes no responsibility for errors or omissions and the reader is responsible to verify data presented.

Photos included were taken with the author's mobile phone camera and may not present products with their ideal rendering found on a company's website.

Other product images were collected from a company's promotional materials.

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FOOTNOTES AND ENDNOTES

Footnotes on each page are identified by roman numeric superscripts in text and used to provide detail that may be useful to understanding terms and descriptions that are specialized for certain products or technological areas.

Endnotes at the very end of this document are identified by lower-case alpha superscripts in text and may be helpful as background in areas that are less-widely covered in publications other than technological journals.

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Richard Helfrich Notes for CES 2020

Table of Contents

Products covered in this document that may someday provide high value to millions of people are noted with the star symbol at left. Whether these products will ever reach the mass market is not known and may not be know for over a year or longer. Whether each product has any possible chance of success is left for each reader to decide.

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Notes Covering Selected Sections and Exhibits at CES 2020

INTRODUCTION

- CES 2020 set new records for attendees and exhibitors, but some emerging companies from CES 2019 did not return in 2020. Booth space is expensive, and prices are rising which may cause many emerging companies to spend their marketing budgets elsewhere.
- CES was extremely crowded making it hard to navigate smaller aisles in both the Convention Center and the Sands Expo.
- Is CES following in the footsteps of COMDEX during its final years as prices rose and crowding became severe?
- This document covers selected categories with a focus on physical products that have a defensible market advantage. There is no attempt to cover all categories of products and services at CES so many areas are glossed over or skipped entirely.

SUMMARY

- There were many new devices; most were clever concepts, but many lacked a cost-benefit value proposition for the end consumer.
- **Hyperbole is the "new normal".** Hype from exhibitors has expanded with a vengeance with new rounds of excessive claims especially for (a) 5G wireless, (b) artificial intelligence (AI) and/or (c) virtual reality (VR) /augmented reality (AR).
- Nearly all companies claimed their products included artificial intelligence (AI) by redefining AI to fit their company's capabilities.
- Many new and returning companies outside the Virtual Reality (VR) and/or Augmented Reality (AR) product sectors used as part of the marketing.
- Apps and software startups abounded again; many seeking early stage venture investors. Given the extremely low rate of success[a], for apps and software startups, investors could do better at a casino poker table using only modest skills. Most large companies have created apps for both new and existing products. A few provide modest benefits, while most of those apps appear to only offer benefits for their internal marketing/promo departments to grab customers' data.
- Mobile devices and equipment performance improved over the prior year. Improvements were achieved by (a) advances in semiconductors that reduced power consumption and/or (b) improvements in electric motor efficiency based on better motor design and/or (c) improvements in rare-earth magnets.
- Improvements in battery energy density for the most part resulted from mechanical improvements such as lighter housings.
- The energy density of Lithium Ion individual cells has not improved much in the last 12 months.
- CES was extremely crowded making it hard to navigate smaller side aisles in the Convention Center and the Sands Expo.

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BEST PRODUCTS

Selections of best products at CES in this document are based on discussions with staff at a limited portion of CES booths – probably less than 150 out of over 4,400. Due to crowds at some booths, it was only feasible discuss products with company personnel at a few dozen booths. In general, discussions were held with the most knowledgeable person at a booth such as executives (CSO, CTO, CFO or Chief Engineer). Exhibitors were skipped when a suitably knowledgeable person was not available; or where the staff could not (a) explain their products, (b) define what type of customer needed their product(s) AND (c) explain their value proposition. Some input was collected from competing companies. Competitors were not reluctant to point out shortcomings.

> *Deciding which products to select as best is* ***based upon their potential to provide important quality-of-life improvements to millions of people over the next two decades.*** *Products that are not likely to be used for a least 10 years were not considered. Some categories lacked any product that would be in widespread use for 10 years or would provide sufficient benefits for quality-of-life. .*
> *Best products selected are noted in their category and marked as noted with a gold star outlined in green.* 

SELECTED CATEGORIES AT CES 2020

There were too many exhibitors offering similar products in some categories. Many exhibitors promoted products at CES 2020 that were markedly different from any others at CES; BUT lacked differentiation from products being sold by companies that did not exhibit at CES.

This report focuses on product areas that are more likely to have some viable market advantage. In some cases, the advantage may be superior performance while others may not be superior but have exclusive access to the best distribution channels. Others may have leading manufacturing capabilities not available to their competitors. A few have a technological advantage with innovations developed internally or acquired that are trade secrets. In rare cases a company may have a global patent portfolio[1] along with very deep pockets to enforce that intellectual property worldwide.

[1] In most sectors of technology, a “global patent portfolio” requires issued patents in the “countries that matter”. Depending on the particular technology, the number of countries that matter may be as low as 12 or as large as 22.

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CONNECTED EVERYTHING

- NO LIMITS = NO PRIVACY

There were few devices at CES 2020 that were not "connected devices". While data connections may seem valuable, there are many devices that provide little or no benefit from connecting to the web to perform their functions. One side effect of any connection is the potential for security break-ins by hackers/thieves. Security experts indicate that there is no level of encryption that can make communication totally safe. Those experts also opine that once any device on a network is hacked, it may, and frequently does allow access to other devices on the network.

Bluetooth

Bluetooth and other low-power wireless standard are being included in more and more small devices that run on batteries. Bluetooth 5 performance is limited to areas without obstructions such as walls. Bluetooth 5 enables (a) longer range, (b) higher bandwidth and (c) multiple devices to connect to a single host. Each application must make tradeoffs between data rates and range. To allow greater data rates and/or range, Bluetooth 5 uses Hamming Codes (invented over 70 years ago at Bell Labs by Richard Hamming) for error detection and correction.

WiFi

WiFi is going into many devices that need more frequent and/or higher bandwidth data connections than Bluetooth.

5G Wireless (5th Generation Wireless) – and then 6G

5G was overhyped at CES 2020 as well as in mass media advertising as the "ultimate solution" for high-speed communications. Eventually there will be some high-speed 5G[2] (using "5G high-band") in very limited locations. High-speed 5G will eventually be implemented in markets that have sufficient users willing to pay premium prices for high-speed video to enable telecom companies to recover investments for base stations and backhaul data links[b]. Costs for 5G are very high[c] due to (a) shorter range, (b) much greater power for 5G basestations as well as (c) much greater power consumption for 5G phones[3].

In an effort to bring 5G devices to market faster, the standards committee was pushed to make several poor decisions about basic modulation and other aspects. Now that there is hardware being sold using this standard, it may be too late to change those

[2] High-speed 5G is possible using the spectrum the FCC authorized in the "high-bands" https://venturebeat.com/2019/12/10/the-definitive-guide-to-5g-low-mid-and-high-band-speeds/ .

[3] Standards committees selected a global modulation standard for 5G (Orthogonal Frequency Division Multiplexing known as OFDM) that is similar to the 4G system that designers and operators understand from working on 4G. According to experts, OFDM was a mistake that is not likely to be corrected due to investments by telecoms in this standard. https://spectrum.ieee.org/telecom/wireless/5gs-waveform-is-a-battery-vampire

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basic functions now built into the semiconductors used in base stations and mobile devices.

WILL 5G BE ECLIPSED BY 6G?

Meanwhile, the international wireless standards committees are advancing 6G wireless standards and semiconductor companies are working on solving the challenges for 6G. 6G wireless will enable somewhat faster data rates than 5G as well as more users per area and more users per base station which is especially important in city centers. 6G wireless committees are working on both achieving better performance with 6G as well as fixing the shortcomings of 5G driven by the push for rapid market introduction.

Given the progress on 6G, time will tell if 5G is a short-term solution.

SPORTS AND WEARABLES

There were so many similar sports devices and wearables that it did not make sense to waste time visiting multiple exhibits with nearly identical devices and capabilities.

There were many “new devices and apps” but not very much in terms of innovation. There was one device that was somewhat innovative, partly because it combines more functions into one wearable; but equally so because it actually looks like a dressy watch.

Withings Watches

Withings offers a range of watches for tracking activities that have features similar to most other brands. These sports watches look like high-end watches from Europe with a standard analog dial and no numbers on the screen, just a mark for each hour along with a window that displays the measurements by the sensor(s).

The devices displayed at CES had various combinations of functions added to the normal sports monitoring capabilities.

One model added blood oxygen monitoring (SpO2) that would detect sleep apnea. Others offered capabilities similar to specialized models from other brands.

MEDICAL DEVICES EQUIPMENT AND DIAGNOSTICS

Personal medical devices are the one area of CES that has the potential to provide the greatest benefits to mankind. Real medical devices are highly regulated, so it takes much longer to transition from prototypes to government-approved commercial production and sales. Traditional shortcuts (known as 510(k) which enables devices to be approved that do better than ones already being sold continues. However, the FDA has placed tight restrictions on when the 510(k) approach can be used and

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increased some documentation and post sales data collection requirements, depending on the type of device.

MEDICAL EQUIPMENT, DEVICES AND DIAGNOSTICS

Bringing anything really innovative that serves a serious healthcare purpose is challenging. There are many complex issues to overcome that are very expensive for medical equipment, devices and diagnostics and extremely expensive for drugs. A major cost factor is the time between inventions and commercial sales that can take a year for simple improvements to well over 10 years for a new drug. Research and development to create the prototype or pick a drug candidate may only entail 1% of the total cost[4].

Medical Equipment

CES has a limited number of exhibits demonstrating real medical equipment each year but it is an important area where great breakthroughs can occasionally be found.

While breakthroughs are rare, each year there are worthwhile product improvements. CES 2020 did not have any medical equipment breakthroughs but did have one product improvement that fits the worthwhile classification.

Magnetic Resonance Imaging (MRI) provides a great diagnostic tool for doctors[d]. MRI is starting to be tested to provide 3D real-time guidance for surgeons while performing brain surgery.

The holy grail for MRI is a portable device that can be used at small medical facilities without special electrical power, shielded rooms and, someday, inside an ambulance.

Hyperfine Portable MRI – somewhat portable at 1400 pounds since it is on wheels.

The magnet is 0.064 Tesla, so Hyperfine claims it will not erase a credit card if you walk close to the system (a 5-Tesla MRI will erase a credit card at over 30-foot range).

[4] The first challenge is the US Food and Drug Administration (FDA) or its equivalent (such as CE in Europe) that regulates new medical innovations and determines the type and scale of clinical trials. Manufacturing ramp-up to the quality needed, along with detailed documentation, is another hurdle that is essential to minimize product liability and future litigation. Smaller companies that excel at R&D tend to lack some of the necessary skills.
Next a company must determine how a new product will receive payment such as Medicare (controlled by CMS) and insurance which generally follows CMS guidance on coverage by insurance. In recent times some new products avoid the CMS and instead require the consumer to pay directly without any insurance coverage.

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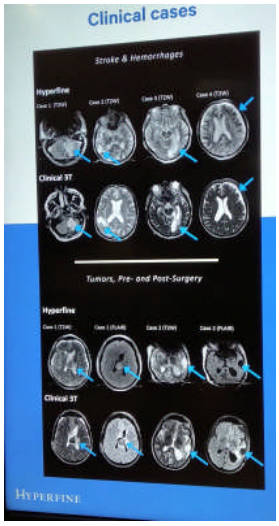

Most MRIs contain very powerful magnets and various models have 1-Tesla, 1.5-Tesla, 3-Tesla, 5-Tesla and a few 7 to 8-Tesla magnets) These are large machines that are limited to use in hospitals that build specially magnetically shielded rooms. Each machine uses a lot of electricity and requires cryogenic cooling. Prices for recent machines range from about $5M to $50M fully installed, started and calibrated.

MRIs can detect and identify strokes with greater accuracy than most other modalities. It is critical to identify the type of stroke within a few hours so the correct treatment can be started. Using a pharmaceutical for the wrong type of stroke can quickly cause death.

If a stroke is treated within about 3 or so hours after it happens, brain damage can be minimal. However, there are two types of major strokes: Ischemic (blockage - treated with tissue plasminogen activator -tPA) and a hemorrhagic (bleeding – treated with blood coagulators and/or surgery). Using the correct drugs can minimize brain damage – as well as saving on the order of $100 billion per year in long-term treatment of stroke victims.

Medical Devices and Health Monitoring Devices

MEDICAL DEVICES

Medical devices can be external or implanted inside the human body. CES typically has a few exhibitors with serious external devices and sometimes has an implanted device or so. Implanted devices require years of testing and validation for the FDA before approval for sale. Many attendees may not consider implanted medical devices as “consumer products” since they must be prescribed and installed by an MD, although the end user is a consumer.

CES 2020 had both external and implanted devices. The following are samples of devices that have potential to improve the quality of life for millions of people.

There were a moderate number of innovative medical devices – all of which require FDA Clinical Trials.

HEALTH MONITORING DEVICES

There were numerous health monitoring devices, but most were simple devices that tracked functions such as sleep status and duration that do not require FDA clinical trials mainly due to negligible safety issues.

Some devices may not fall into normal categories controlled by the FDA but may require FDA clinical trials when used as part of a system that includes a medical device.

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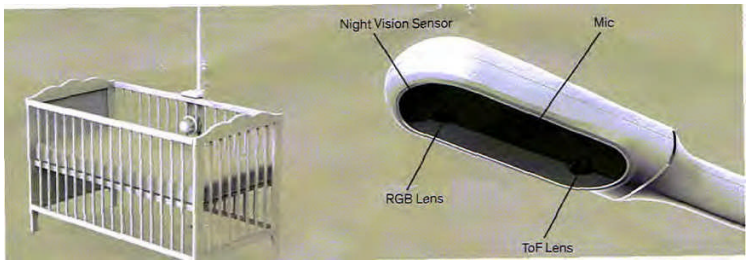
BrainCo

BrainCo is a medical device company that was incubated at Harvard and uses brainwaves to intuit the user's desired commands. BrainCo claims to use machine learning and neuroscience along with games to train each user on how and what to think to produce desired control signals. Each person's brainwaves may be sufficiently different, so games enable training the system to interpret the resulting brainwaves and use that interpretation to control a medical device.

One initial medical device application is to control a prosthetic hand with brainwaves to simplify the links to the person with the hand. Brainwaves could replace connections to nerves that require surgery. The FocusFIT headband device and machine learning system is in FDA clinical trials and is projected to sell for about $13K. The FocusFIT headband could be useful in many areas outside medical devices so there could be value for other non-medical system control. Pricing, volume and safety issues may be a factor in most applications outside medical.

Analog Devices/Arrow



Baby monitor to detect and warn of impending Sudden-Infant-Death Syndrome. This is innovative due to its use of an inexpensive technology that enable a small product with useful benefits. The prototype at CES had a flexible arm with a simple clip that attached to a crib and monitored breathing of an infant with zero contact. The device uses near-infrared time-of-flight technology and specialized signal processing to detect breathing motions. It combines a WiFi camera into the device for full monitoring functions. It seems that this same technology could be applied to other monitoring devices for heath as well as general robots.

Abbott is mainly known as a pharmaceutical company providing both small molecule drugs and large molecule biologics for therapeutic purposes. That side of Abbott spends a billion dollars or more over ten to fourteen years to develop and prove the value of each new therapeutic agent before it can be sold.

Abbott promoted medical devices and diagnostic product areas that did not include therapeutic agents (small molecule drugs and biologic agents used to treat or prevent disease) at CES 2020.

Abbott Neurostimulation Implants for Pain Relief

There have been several external devices that provide local or limited relief from minor to moderate pain (i.e. Quell) and other neuromuscular disorders (such as tremors) with electrical stimulation. For patients with more severe chronic pain, stimulation is

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required in the spinal cord, while other patients need electrical stimulation inside the brain.

Abbott Dorsal Root Ganglion Stimulation

Existing therapeutic agents have limited impact on severe chronic pain over long periods of time. Most doctors prescribe drugs that frequently include opioids. New regulations increase the steps and paperwork demanded of doctors for opioid prescriptions, whether those prescriptions are critically needed or not. Given the undesirable effects of opioids, a solution without addictive drugs has been sought for years. Abbott is showing success in clinical trials using a small device implanted in the torso and connected to electrodes that stimulate ganglion in the spinal cord. This device may provide relief to many patients while avoiding drugs.

Abbott Directional Deep Brain Stimulation

Relief from severe tremors for Parkinson's disease using drugs has demonstrated limited results. As tremors become severe, the option for patients is removal of a small portion of the brain which has benefits for a while along with some side effects. This new device can be used in patients that have not had that portion of the brain removed. A small electronic device with its 5-year battery is implanted in the torso. Wires connect under the skin to the skull and then via a 1-cm hole in the skull to electrodes placed in the small area of the brain that was formerly removed from Parkinson's patients. This implant procedure does not remove any portion of the brain so is not considered major brain surgery.

During an implant procedure, each patient undergoes testing to determine the ideal spot within that small target region of the brain for that one patient. Due to the electrode placement evaluation during surgery, the procedure may not be inexpensive.

DIMEDI Co.,Ltd Zeroveno Deep Vein Thrombosis (DVT) Prevention System

Dimedi is a Korean company that started in processing medical images. Zeroveno is an external therapeutic device that performs a mechanical message on the calf of a leg to prevent DVT. The device is attached to the calf via a Velcro sleeve that wraps around the calf. The mechanical motion is achieved via axial rotation. The internal battery is projected to provide 20 hours of operation between charges.

Medical Diagnostics

Medical diagnostic testing is advancing at a phenomenal rate driven by rapid advances in diagnostic equipment and measuring numerous molecules and genetics in blood.[e]

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Abbott covered a new diagnostic test at CES 2020 that is showing better results than the best equipment at major hospitals. This test is still in FDA clinical trials.

Abbott Blood Test for Traumatic Brain Injury

Recent understanding of brain functions has determined that there are many more traumatic brain injury cases than previously known[5]. Abbott claims that a diagnostic blood test can find the cases detected by CT scans as well as most cases missed by CT scans.

VEHICLES

The crowds around most vehicle exhibits were too dense to enter the inner portions and have a discussion with a knowledgeable person.

> *NOTE: Drones, including fixed wing, tiltrotor and small quadracopters, are covered in a separate category*

There were several vehicles that looked flashy and promised performance well beyond anything available in dealers at this time. Overall, there were no vehicles that were both (a) innovative and (b) likely to reach the market within a decade.

Terrestrial Vehicles

Many all-electric vehicles were displayed at CES and some were available for demonstration rides across from the convention center – with a very long lines to take a ride. Most vehicle exhibitors did not offer rides, but many did have prototypes or non-functioning demonstration units inside the main Convention Center.

Driverless Shuttles –

Driverless Shuttles (Category 5 with no steering wheel or brake) were a popular category of vehicle exhibited at CES this year. These vehicles are the most likely fully-autonomous vehicles to enter service in the near future. It is likely that initial operation will be municipal vehicles on fixed routes where ridership does not justify a large bus on frequent intervals. Initial locations may include airport

[5] It was believed that brain injury was not severe unless there were a hard impact such as those received by soldiers nearby an explosion or a boxer receiving an exceptionally hard hit. Now we understand that there are many more serious injuries such as numerous moderate impacts as helmets collide in a football game. Typically, testing for traumatic brain injury entails a hospital visit for a CT scan. Data shows that CT scans have a high false negative failure rate, meaning they miss a case where there is an injury that will manifest itself in the future. Abbot indicates this blood test will be able to detect which of the patients that show no indication of brain injury in a CT scan have a serious brain injury that requires treatment.

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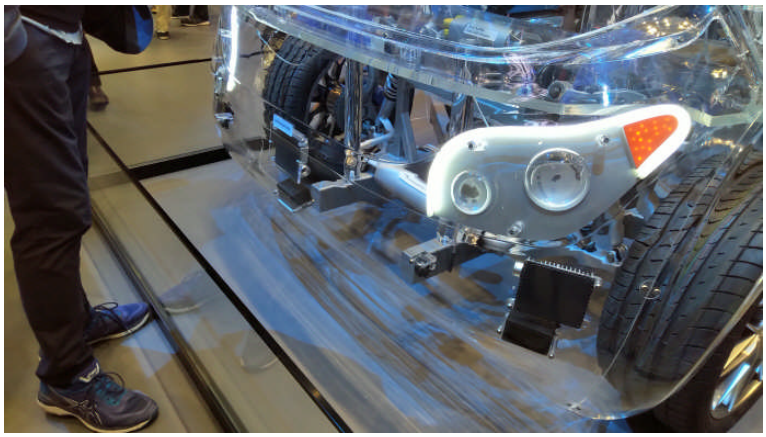
shuttles to remote parking or in central city areas where very frequent (5-minute wait maximum) service is important to many potential riders.



There were a variety of driverless shuttle entries from several companies. Some were a vehicle's passenger compartment while others displayed a chassis that could have several different bodies attached for various end uses. Companies promoting shuttle vehicles emphasized the use of most types of sensors and some included redundant sensors. Product liability issues and insurance requirements may be driving manufacturers of Level 5 and possibly Level 4 self-driving to add the maximum suites of sensors practical on every vehicle.

These shuttle vehicles could easily be modified to become Category 4 "mostly-self-driving" delivery vans or airport shuttles with a "safety driver" who can take over in emergencies.

Typical configurations of a fully autonomous demo shuttle vehicle had 4 to 10 seats as well as floor space that could accommodate added people standing or for luggage. The interiors of concept vehicles at CES bore a strong resemblance to some monorails used at airports.

Electric Pickup Trucks, SUVs and Delivery Vans

There were a few vehicle manufacturing companies at CES 2020 that are not standard auto manufacturers. Most are focused on utility vehicles. Many claimed to use one base platform containing electric motors, transaxles, suspensions, steering and control-power electronics to serve different customer sectors. Various bodies could be mounted on the base platform to produce pickups, SUVs, vans or shuttles.

<u>Rivian's R1-*T* Electric pickup truck or 8-passenger SUV-*S* or Delivery Van -*V*</u>

Rivian is focused on practical vehicles with Level 3+ assisted driving.

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Rivian is one of several emerging companies that has designed a "basic chassis" that is nearly flat which Rivian calls their "Skateboard". It is about 18 feet long.

The skateboard base can accommodate a pickup truck body, an SUV body or a delivery van body.

- Rivian battery up to 180 KwHr for 400+ mile range. Battery is sealed so it will not be damaged if it is submerged.
- Accelerate 0 to 60 mph in under 3 seconds and can tow 11,000 pounds with 750 hp that self-adjusts torque to each of 4 wheels.
- The suspension can be electronically adjusted up and down. Ground clearance can be set very low (under 4 inches) to allow easy access. Ground clearance can be set very high (over 14 inches) for off-road driving.
- Production near the end of 2020 for volume delivery early 2021 under $70K
- Manufacturing is in an Illinois plant south of Chicago.

NOTE: Amazon made a $700 million investment into Rivian[6] and ordered 100,000 of Rivian's all-electric delivery vans.

Electric Automobiles

This year most major auto companies promoted Level 4 or Level 3. No manufacturer would provide an official forecast when Level 5 (no steering wheel or brake) would be sold in the mass market. Some hinted that Level 5 was possible within a year – but all indicated that fully-autonomous all-road (freeways, highways and smaller local roads) vehicles depended on passing new laws allowing driverless vehicles as well as limiting manufacturer/operator liability.

BMW - A BMW "concept car" was focused on super luxury with comfort. The interior uses so-called green materials. They demonstrated a self-driving version as well as Level 4 versions.

Other brands of sedans – most other luxury auto companies at CES (Mercedes, Audi, etc.) presented vehicles in the super-luxury category similar to BMW.

Toyota and other mid-market brands had demo or concept vehicles with many electro-mechanical features similar to BMW but did not include the high-end interior materials and detailed design functionality.

Fisker - Fisker was founded around 2009[7]; Fisker is the name of the company founder who has had a long history designing vehicles at other companies. Fisker as a company has tried to enter the electric-vehicle market in the past, but their early products failed.

[6] Amazon Invests in Rivian https://www.nytimes.com/2019/02/15/business/rivian-amazon.html

[7] At one time Fisker was working on an electric vehicle that used a supercapacitor and no battery. The company that made one small-scale supercapacitor for Fisker could not make a full-scale version and could not even duplicate the small-scale supercapacitor.

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Fisker's newest vehicle has many similarities to the Tesla Model 3 while promising a lower price point before any tax credits. Fisker has not sold electric vehicles in the US, which allows Fisker to qualify for the Federal tax credit on all-electric vehicles until Fisker sells 200,000 units. The lower price point along with the tax credit will provide a very large price advantage over Tesla.

The staff at the Fisker booth were not very knowledgeable except for a manager. The key features of Fisker's vehicle are:

- The name Ocean was selected because this vehicle makes extensive use of plastic materials recovered from ocean waste.
- All-electric with 250+ range on base model and up to 400+ mile range using 80-KwHr battery pack option.
- Claims to be ALL vegan – no leather – seats are made from recovered plastics from the ocean.
- Customers can lease/rent for $379/mo.; or purchase for $37.5K base price.
- Deliveries to start at the end of 2021.
- The platform can be built as an SUV or sedan.

Agricultural Vehicles

Deere had the largest vehicle at CES 2020 which was a tractor connected to a very large sprayer boom (120-feet across) at the rear. This farm vehicle claims to incorporate AI and can provide various farming functions.

CES does not normally attract a farming management crowd. Deere may be attempting to appeal to investors.

Flying Vehicles for People Transportation

Many people dream about transportation options around crowded urban areas that are not restricted to fixed infrastructure such as roads or expensive underground or elevated routes. The advantages of operating in three dimensions opens up nearly unlimited fast transport, regardless of the traffic density as long as collisions are prevented.

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These solutions exist already in the form of helicopters that provide a viable solution to the portion of the population that can afford those services. As a former business user in urban environments, the benefits are exceptional; but the cost per ride is also exceptional relative to ridesharing or even limousine services.

Preventing collisions of a modest number of helicopters in a small area has been achieved. How can it work if there are 100,000 flying Ubers over Manhattan, NY along with a similar number of delivery drones in that same airspace?

Despite those challenges, new flying concept vehicles show up at CES.

Hyundai/Uber Electric Flying Taxi – The concept vehicle at CES was a tilt-rotor design. This flying taxi was innovative but not likely to be available before 2030, if ever – despite any claims by Hyundai.

The concept demo at CES had 5 seats including a pilot and 200 mph speed using the Uber Elevate brand.

- These vehicles are planned as all-electric vertical-take-off-and-landing (eVTOL) aircraft that use electric motors and batteries.
- The vehicle is projected to carry 4 paying passengers that have no more than 40 pounds of luggage each.
- Range will be a severe limitation given energy required to carry that payload at high speed compared to the energy density (especially KwHr per Kg) of batteries. Profitable helicopter shuttle services are in the air as much as 10 hours per day with minimal time for each stop at heliports[f].

Having flown helicopters to travel to-and-from airports in Los Angeles and New York on business trips, the range and luggage limitations of Uber Elevate may not be acceptable to many customers.

Electric Flying Taxi by Toyota

Toyota is also developing a flying taxi similar to the one by Hyundai – but did not have any prototypes or demonstrations at CES other than a person at the Toyota exhibit booth that presented ideas and made claims. It is likely that Toyota will have the same limitations as Hyundai due to issues involving *basic laws of physics and math*.

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Notes Covering Selected Sections and Exhibits at CES 2020

TELEVISIONS AND DISPLAYS

CES is the leading location for TV manufacturers to introduce new models and to evaluate consumer/dealer response to future TV/display concepts. Nearly all TV manufacturers from around the world displayed new and potential upcoming products. New products typically have high price tags, some over $10,000, or much more. The high-end products target commercial establishments.

Crowds at many TV exhibits were too dense to connect with booth personnel that had technological knowledge of the inner workings of the products. Most TV makers appear to be targeting similar products for the next few years.

TV manufacturers at CES 2020 changed their focus from CES 2019 by little or no mention of:

- 3D TVs
- Curved TVs

All TV makers at CES 2020 demonstrated 8K TVs **and all brands of 8K TVs produced spectacular video**, even bargain brands such as TCL – but all were wired to a very high-bandwidth 8K video source. Every tiny blemish on an actor's face was discernable.

> *All TV makers at CES 2020 claimed that their 8K TV could upconvert a 4K video stream to nearly 8K quality without pixilation, low frame rates or blurring. None would promise that upconverting would work as well if the 4K video source was compressed video that is common via most sources (satellite, cable, or most Internet streaming).*

Conclusions based upon a limited sample of TV makers along with information from telecom companies and video services are:

A. New televisions with 8K resolution were overly promoted. All major TV manufacturers were demonstrating their new 8K displays.
B. Picture quality and clarity on every TV brand of 8K was spectacular from video sources filmed in 8K and wired to the TV display.
C. There are few, if any, 8K programs available for purchase on media. No content is yet available on cable or satellite – 8K cable or satellite channels require nearly 4 times the bandwidth. Cable or satellite companies could not offer many 8K channels.

Based on the above, some likely projects are:

- It may take years for 8K to become mainstream.
- Many consumers have not yet upgraded all their TVs to 4K.
- Prices for 8K TVs in 2020 are too high for 95% of consumers.

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- Consumers are likely to only receive 8K content-on-demand over high-speed Internet only.
- ISPs are likely to advise and warn consumers to purchase 30+ Mbps Internet for each simultaneous video stream. Price that service above low-end cable or satellite TV subscriptions.
- One critical issue for 8K TV is the bandwidth needed to send sufficient bits per second from a server to a home while minimizing pixilation, jumping and blurring.
- It is not clear how consumers will get 8K content – except via fast wired Internet connections. Blu-ray disks lack capacity for a full-length movie. Even double layer (DL) Blu-ray disks may not provide space for a full movie.
- Existing satellite services and coax-cable services have limited 4K content due to bandwidth needed per channel (about 4x the bandwidth of HD).
- 8K video requires about 4x the bandwidth of 4K video to avoid pixilation and video artifacts.
- Some telecoms anticipate using very-high band (over 95 GHz) 5G wireless to deliver 8K video. Due to very-short range limits for very-high band 5G, telecoms will likely require 5G basestations on every telephone pole . Each 5G basestations can reach subscribers within 100 meters.

The critical issue for 8K is "how many consumers will pay a high premium for sufficient bandwidth to receive 8K".

Samsung 292-inch MicroLED

Samsung took the global lead in ultra-large screens with their 292-inch (**24-foot** diagonal) "Wall MicroLED" and offered smaller versions as well. The 24-foot TV is sufficiently large to replace a movie screen at a small theater in a movie multiplex – or in homes of some billionaires.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence is a label that is being thrown around.

> *Most exhibitors of any product at CES 2020 claimed their products contain AI.*

Crowds at exhibits for companies offering AI as their product were too dense to connect with knowledgeable booth personnel. The following items are based on information from staff that had limited technological knowledge that were manning a few booths.

Unfortunately, to gain attention from reporters in the non-technological media, it is now essential that a product contain artificial intelligence (AI).

> *It was a challenge to find any exhibitor that did NOT claim their products contained AI*).

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A few exhibitors could demonstrate expert systems functionality whereby the system used an analysis approach that has been known for decades as a "Decision Tree" *Most products claiming there was "AI Inside" lacked any sign of intelligence, real or artificial.*

Those AI claims appear to be, at best, marketing hype, making those companies appear to lack real intelligence - or expect consumers and the press to be really dumb.

There were few companies offering AI or AI inside that could explain their function, operation and types of algorithms used.

> *Algorithms may become and frequently are the core value of a company. Companies guard their algorithmic equations; generally, via trade secrets[8]. Some companies indicate their coders are segmented and only work on small sectors of their algorithmic systems so very few individuals know their complete algorithms.*

Konami Gaming – **RAPID facial recognition** of nearly everyone with high probability of accurate conclusions. Konami claims their system can achieve exceptional accuracy in almost all lighting conditions as long as there is sufficient image resolution. Their system will also warn their users when the probability of a facial match is lower and specify the probability of a match. This is an extremely challenging analysis problem that many people claim will require quantum computers at a scale that are not likely over the next decade.

> *Achieving a match of a particular face within a global database of billions of faces in a very short time without those distant future quantum computers requires algorithms that others have not been able to develop.*

Konami offers rapid facial recognition for companies and government agencies that can be *used for both beneficial and/or nefarious purposes*. Konami hinted that they have both:

(a) the ability to achieve high-probability facial matching; and
(b) assembled a database of facial data that includes many (maybe most?) people in developed countries.

[8] Trade secrets tend to provide better protection than patents for many types of intellectual property other than "Composition of Matter" patents that cover the atomic structure of a molecule such as a drug or a plastic. Trade secrets have been a staple of US Intellectual Property for many decades and were further expanded in 2016. . https://en.wikipedia.org/wiki/Defend_Trade_Secrets_Act

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How will consumers and governments respond to privacy issues?
Could data sources for facial analysis include one or more of the following (1) social networks (i.e. Facebook, etc.), (2) government agencies (passport agencies, police departments, state motor vehicle licensing departments, state professional licensing boards), and/or (3) employers?

Facial recognition can provide benefits to consumers such as recognizing people in lines at hotels, airports, motor vehicle departments, etc. Those data systems could identify people waiting in line and access whatever stored information is needed to speed-up processing and documentation.

That same rapid facial recognition can be used by governments or large corporations to track everyone's movements without their permission. *This type of AI is likely to collide with privacy issues, lawsuits and strict limitations in some countries over the next decade until an international uniform system is finalized with exceptional security and privacy*.

PHONES - TABLETS - LAPTOPS

Foldable devices or exceptional camera functions were hot items.

Intel offered a full-size foldable PC. The entire device folds to the size of a 12.5-inch laptop, but the screen unfolds to 17-inches. The demo was a working prototype, but Intel intends to license the technology and not manufacture or sell the PC itself. The Intel screen is NOT bent to a small radius. The hinge mechanism leaves a gap between the two halves. Intel takes advantage of that gap to add a physical keyboard that makes this laptop almost like a large screen desktop.

Samsung offered a Galaxy **Foldable** Phone that drew a very dense crowd, so it was not practical to get close. This may eventually become a very popular device when it can provide the full capabilities of both a phone and a tablet. Millions of workers that travel frequently would benefit from having just one smaller and lighter device.

TCL is starting to make phones under its own brand at much lower prices than big brands with similar features and capabilities.

TCL has been making phones sold under the Alcatel and Blackberry brands (most recently the Blackberry Key2). The product manager at the booth indicated that TCL had planned to make a Blackberry Key3 as recently as the end of 2018, but that the Key3 is not on their current roadmap. [DISCLOSURE: I was planning to buy a Key3].

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TCL demonstrated some new phone products under their TCL brand name at CES. Two products were aimed as direct competitors to major brands such as Samsung at price point that were less than their competitors. Some devices were priced in the range of 50% of their competitors.

TCL 10 Pro mid-priced (~ $500) phone with high-end features similar to $1,000 Samsung models.

TCL 5G Foldable phone to be sold later in 2020 opens to a 7.2-inch screen. This phone will cover wireless 5G low-bands but not the high bit-rate upper bands. This phone will fold to the size of a phone that fits in a suit pocket and offer the screen size of a very large phone. It is not sufficiently large to replace a tablet; generally, customers such a traveling businesspeople want a 10-inch tablet screen.

PHONE CAMERA FUNCTIONS AND CAPABILITIES

Many phone makers have 3 or 4 rear-facing camera chips and lenses on their phones. Their claim is that these combinations of cameras provide superior focusing for images with nearby and distant objects as well as capabilities closer to optical zoon without loss of resolution when using digital zoon. Many claimed exceptional video motion improvements with multiple lenses. Others claimed improved low-light performance and glare reduction.

There were some that had additional claims and hinted that future phones may have "more than 4 camera chips and lenses".

None of the exhibitors visited spoke about 3D functionality that was covered at CES 2019 and CES 2018. That corresponds to the elimination of 3D on most new TVs.

CATEGORIES THAT WERE MINIMALLY COVERED

There were several categories at CES 2020 which were visited briefly, mainly due to time constraints. Several of these categories appeared to have modest product improvements since CES 2019, but no breakthroughs and did not justify expending time given time constraints.

DRONES

New FAA rules will usher in widespread use of drones for delivery of small and light packages but will make it more expensive and challenging for non-commercial drones.

There were many small quadracopters again this year. Most appeared to contain similar batteries to those in prior years. Some claimed longer flight times and/or greater payload. The driver for performance improvements were designs using lighter materials and/or more efficient motors using new designs and better rare-earth magnets. The

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energy density of the internal lithium-ion battery cells did not improve much. One staffer at an exhibit indicated a desire for batteries with more than 20 times the energy density by weight as the best existing batteries.

Consumer Drones

Flying quadracopters of various sizes were plentiful at CES 2020. Most can be classified as toys. Under the newly passed FAA drone regulations, drones over 8.8 ounces must carry an identification transmitter that can be tracked at a long distance so collisions with airliners, private airplanes, helicopters and commercial drones can be absolutely prevented air traffic control.

Commercial Drones

– FAA has issued rules that will go into effect over the next few years. Now that the rules are finalized[9], commercial applications with profit potential will enter the market. Flying delivery drones will be entering service in the next year or so for items that have a combination of factors: (a) low total weight, (b) justify the higher cost of drone delivery, (c) are sufficiently close to a warehouse, and (d) can avoid restricted airspace between the warehouse and the delivery point of the end consumer. Airspace can be restricted: (1) by the FAA when there are aircraft carrying people in the area, (2) by governments when there are noise sensitive recreation areas or schools in the area, or by local privacy ordinances. Many of these issues are likely to undergo years of court litigation before national standards are final.

ROBOTS

There are 3 basic categories of robots

1. Industrial
2. Commercial
3. Consumer

[9] The FAA has created rules for legally operating all types of drones that are designed to prevent interference with commercial airliners, business/private airplanes and helicopters. These rules will be phased in over time but ultimately will apply to all remotely and autonomous flying vehicles. The major requirement is virtually each and every drone over 8.8 ounces must have an operating identification system on board whenever it is off the ground. https://www.geekwire.com/2019/faa-draft-rules-drones-remote-id/ FAA offers an exception for hobbyists that operate drones in existing areas for flying model aircraft.

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INDUSTRIAL ROBOTS

The use of industrial robots in warehouses, factories of all types and transportation continues to grow rapidly. These categories are rarely demonstrated at CES. There was a robot at the Omron exhibit booth with a fully functional pick-and-place robot that assembled circuit boards. This pick-and-place robot capability has been in place for a few decades. Much more advanced functions are already in large factories that can afford extremely expensive capital investments[10].

Industrial robots combine manual dexterity with accurate sensing that enables a robot to perform tasks correctly. Recent advances in motion control are demonstrating the dexterity needed for most applications. In some applications, sensing remains a challenge. The use of multiple types of sensors, such as suites used on self-driving automobiles (visible and IR cameras, LiDAR, ultrasound, etc.), may provide sensor solutions for robots.

These applications will provide improvements in manufacturing productivity that all companies and most governments seek. These robots will replace some blue-collar jobs and few white-collar jobs.

COMMERCIAL ROBOTS

Robots are just beginning to fill roles at restaurants, hotels and other commercial establishments. Now that these service industries are 80% of developed economies, these robots can create major improvements in global productivity. These robots will replace very large numbers of unskilled jobs as well as white-collar jobs. Nearly all studies indicate that there will be a greater number of new types of jobs crated than jobs that are eliminated. Governments must find solutions that enable displaced workers and displaced companies.

[10] Solar cell as solar panel production lines have been implementing robots. The newest solar production lines in China are reported to have achieved 100% automation that required capital on the order of US $1billion. Saving labor costs in China cannot justify that capital investment but eliminating production errors easily justifies full automation due to unavoidable human errors without automation that result in scrapped products.

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Notes Covering Selected Sections and Exhibits at CES 2020

CONSUMER ROBOTS

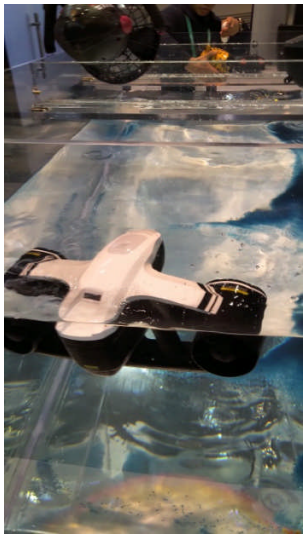
Robots for end-user consumer use have a bright long-term future. Existing robots (except for extremely expensive prototypes) have not been able to achieve either the physical dexterity or real-world understanding of a small child.

Many large companies are working on high-value robots that can provide end-user consumer services:

a. in countries with aging populations, especially with higher percentages over age 65,
b. shortages of young people able and willing to provide home services and home health care and
c. older populations with substantial wealth. (i.e. Japan and parts of Europe).

Robots were abundant at CES, but none could provide functions in a consumer's home that justify their prices or likely leasing payments per month. Examples of functions that would provide higher value are general cleaning similar to a maid service, cooking a complete meal with no human assistance or providing butler services.

UNUSUAL ROBOTS



Dancing robots were demonstrated at CES 2020. They entertained crowds, but it was easy to become bored watching robots dance. What is their value?

Submersible Robots were a new category at CES 2020. There were prototypes (about 2-feet to 3-feet long) in a large tank that could navigate on their own or be guided by remote control. A suitable camera could be attached. The booth staff would not comment on whether a robot hand could be attached to enable robots to catch lobsters.

Emotional support robots that could provide value similar to existing support animals (but without the need for care and feeding) were present at CES 2020. One exhibit demonstrated *Jennie the Tombot* which looks realistic and will wag its tail and move its head when petted. Booth staff claimed that Jennie has demonstrated comfort to patients such as people with Alzheimer's.

Picnic, a pizza making robot for homes, was exhibited at CES 202. This is basically a simple appliance with very limited use. Can consumers justify the space and cost of a limited-use robot in their home?

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Delta Airlines It is unusual for a passenger airline company to exhibit at CES. Delta Airlines is making that leap for luggage handling with an exoskeleton device made by Sarcos. Delta's Guardian XO exoskeleton enables employees to lift heavy luggage or cargo without injury. The exoskeleton amplifies a worker's strength by 20 times or greater. This robotic assistance device for workers could provide value for airline workers as well as delivery and warehouse workers. Initially, Sarcos will lease these exoskeletons for about $100K per year.

This type of device could shorten the turnaround time at an airport gate for every passenger flight which is a very high value function for passenger airline and cargo airline services. Equally important this type of device could substantially reduce airline worker injuries that result in worker compensation insurance claims and litigation.

FOOD AND BEVERAGE

CES has become a leading place where suppliers demonstrate potential future products. Some products are about to enter mass production and exhibitors are using CES as a promotional platform for global coverage.

Other products are early conceptual units that may or may not ever be sold, but exhibitors are looking for feedback from consumers around the world and how people from various cultures view their product and what features are important.

For both product introductions and for gathering consumer feedback, CES can be highly efficient and cost-effective.

There were several food and beverage entities sprinkled around CES along with appliances and gadgets that are used to transport, store, process, prepare, cook or serve food. Most included internet connections.

By far the most popular exhibit in this category was Impossible Foods that offered samples of their new meatless pork product. There were many times more visitors to the Impossible Foods exhibit than all other food and beverage and related appliance exhibits combined.

Impossible Foods introduced "Impossible Pork" in the form of sausages. Impossible Foods was handing out samples to an overly "impossible crowd", making it impossible to get to samples. Pork sausage should be an easy item to copy because the taste of real sausage is dominated by non-meat flavorings consisting of various herbs, spices and vegetables (i.e. onion and/or garlic).

The selling point for Impossible Pork was that pseudo-pork is (a) vegetarian, as well as (b) "green" because it uses less water, less grain and less space to produce than growing pigs.

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Notes Covering Selected Sections and Exhibits at CES 2020

VIRTUAL REALITY (VR) AND AUGMENTED REALITY (AR)

This document does not intend to provide detailed coverage of any VR or AR.

Crowds at exhibits for companies offering VR or AR as their main product were dense with few knowledgeable booth personnel. The following items are based on information from staff that had limited technological knowledge or could explain the limitations of their competitors.

There were booths companies that had VR/AR products and most attracted big crowds. There was not much value in most of their products, most of which were 3D games. Some of those games included 3D motion simulators such as flying on a sled. Some attendees had to quit a demonstration as motion sickness set in.

VR and AR are now considered essential by companies that want to sell to millennials. It does not matter if there is any need or advantage provided by VR or AR. Any company that can afford to gin up some VR or AR or hire someone to do it, offered VR/AR.

There were useful implanted medical devices that were explained using AR, but the quality was insufficient to achieve the desired results. It is likely that 3D holograms projected at a distance would be a far better solution than VR/AR.

APPLIANCES

This document does not intend to provide detailed coverage of appliances.

CES has become a leading place where appliance makers demonstrate potential future devices. It can take much more time to evaluate a complex appliance, so very few exhibits in this category were covered and only one (a repeat from CES 2019 with some added model variations) appeared worthwhile.

Appliances in the food and beverage category were generally similar to those at CES 2019.

- Refrigerators that monitor inventory and order food returned this year.
- Cooking appliances that would identify some foods or read bar codes on some frozen food would automatically cook those products.

HOME BARTENDER MACHINES

- How many consumers want to make and serve several types of mixed alcoholic drinks at home and also want to avoid reading a recipe book and mixing ingredients?

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- Are there people who are willing to buy and use a home appliance that can only make a limited selection of mixed alcoholic drink at a higher price than making drinks from a few ingredients?

Apparently, some entrepreneurs believe there are such consumers and there are sufficient numbers of those consumers to make a profit.

Keurig is adding an automated home bartender to its product line under a new brand called "Drinkworks".
This home bartender machine priced around $300 makes mixed drinks using capsules similar to coffee pods that include the alcoholic content. Pods sell for about $4 each for a single size drink. Drinkworks will even make fizzy drinks.

Bartesian[11] is a competitor to Drinkworks and exhibited at CES. Unlike Drinkworks Bartesian capsules do not include alcohol and required users to provide alcohol. Their alcohol-fee capsules were priced around $2.50. This approach allows customers to buy the quality of alcoholic products of their choosing and simplifies the sale of capsules by avoiding the issue of underage purchases of on-line alcoholic capsules. However, the Bartesian approach would require the customer to stock a number of different types of alcohols (whiskey, tequila, vodka, gin, scotch, etc.).

VOICE CONTROL APPLIANCES

There were some non-food appliances spotted while walking aisles at CES 2020. Most appeared similar or identical to those from last year.

This year nearly all offered voice control via Amazon or Google speakers or via mobile phones, and some specified they could connect to any voice control device.

APPLIANCES WITH USEFUL FUNCTIONS

There were some appliances with useful functions at CES 2019 such as a clothing closet that deodorized and removed wrinkles using steam and/or ozone priced around $2,000. It would save many trips to the dry cleaners with suits, sports coats and slacks and was "green" since it used no chemicals and eliminated driving to a

[11] Bartesian demonstrated their machine at CES https://bartesian.com/

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dry-cleaning establishment. That device may have been at CES 2020 but was not easily found.

Toto returned with their self-cleaning toilets that can be retrofitted into a normal toilet location with a slightly longer front-to-back size – but they also require 120 VAC power. These appliances could be useful to a large number of people[12] that are unable to clean their toilet such as elderly or people with dexterity issues (i.e. arthritis) or strength limitations. The price of US $10,000 will limit the market. A price of $2,000 may enable a much greater volume.

OTHER MOBILE AND PORTABLE DEVICES AND ELECTRONICS

There were too many types of portable devices and electronics to cover at CES 2020.

One that attracted crowds of spectators was FasTeesH.

FasTeesH offers Y-Brush that could brush all your teeth in two steps of 5 seconds each. The Y-Brush is a tray-shaped brush that covers all your upper teeth and claims to do a complete brushing in 10 seconds. It takes 5 seconds for the top teeth and then you flip it over and do that 5 second brushing on the bottom teeth. It uses the same ultrasonic technology as the Philips Ultrasound toothbrushes.

NOTE: Some dentists advise their patients to avoid ultrasonic toothbrushes. Ultrasonic toothbrushes have demonstrated far superior cleaning than any other toothbrushing device. However, ultrasonic cleaning also removes a small amount of the tooth's enamel with each use. Over time, ultrasonic cleaning will remove all tooth enamel and require covering teeth with the same polymer material used in mercury-free tooth fillings, or a very expensive tooth replacement with titanium implants.

CATAGORIES NOT COVERED

There were many other categories of products at CES 2020, but those categories were NOT covered at all.

[12] These toilets clean themselves and are chemical free, which is a benefit to water recycling systems used in many cities. These toilets are highly automated in that they are normally closed but the lids open when a user approaches the toilet. After use the toilet flushes, then closes and seals itself to perform a cleaning cycle. Toto had demonstration devices that had a clear lid to allow watching the cleaning cycle. A hidden door in the rim opens and a wand extends to the center of the rim. The wand then shoots out a pressurized stream of "ionized water" to clean all parts of the bowl and rim. When completed the toilet returns to its normal operating state.

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ENDNOTES

[a] Success for startups is determined and defined by sophisticated institutional investors into venture capital (VC) funds. Those investors into VC funds are called Limited Partners (LPs). The vast majority of all funding into VC funds comes from LPs that are pension funds, trusts and endowments.
LPs that invest into "Early Stage VC funds" demand a high risk premium due to the lower success rate of Early Stage investing. Success is typically determined by a risk-free rate-of-return return (interest rate of 10-year US Treasury Bills), plus a premium that combines a rate for the risk of capital loss plus lack of liquidity, plus opportunity cost.
Success as calculated for the above factors by LPs investing into Early Stage VC funds in 2020 is an IRR of about 13%. It has been as high as 20% in the 1980s and 1990s according to the National Venture Capital Association. Early Stage VC funds have a low success rate and about 80% of their investments lose all their capital. Winning investments by Early Stage VC funds must therefore achieve about Five-Times the average success rate to make up for the 4 out of 5 investments that lose everything. In 2020 that means 65% IRR (13% fund average time 5).

[b] According the global engineering society's recent publication (Institute of Electrical and Electronic Engineers – IEEE www.ieee.org) actual high-speed 5G requires (a) much more power than 4G, especially in each base station; (b) has much lesser range than 4G due to limited propagation of most 5G bands (35 GHz to 150 GHz) that have potential for higher data rates; and (c) 5G bands that offer high-speed data cannot penetrate walls or even tree leaves.

[c] According to knowledgeable analysts, building high-speed nationwide 5G basestations and backhaul links is so expensive that it may never be completed. Some analysts calculate it will take over $100 billion for each nationwide wireless carrier.
While some telecoms claim they offer 5G basestations, so far nearly all of those basestations are in the 600 MHz band. That band has limited bandwidth capacity so it cannot be high speed. The high-speed bands for 5G are at 35 GHz and above. There are no phones out for those high-speed 5G bands.

[d] Magnetic Resonance Imaging (MRI) uses magnets and radio waves that cause each type of molecule to produce a unique radio frequency signature. By collecting the signatures from the moleclues and performing extensive real-time signal processing, an MRI produces a 3D image of the interior of the human body that can identify and precisely locate a wide range of injuries and diseases. The stronger the magnetic field of the MRI machine, the better quality it can produce images and detect smaller objects such as injuries to small blood vessels or the earliest stages of cancers.

One key feature of an MRI machine is the "bore diameter" (donut hole) into which people are placed horizontally to scan. The price tags, sizes and power consumption of MRI machines as escalated as the bore diameter has increased to accommodate people with larger and larger girth.

The benefits of MRI have been demonstrated for decades with large machines that have powerful ultra-uniform magnets that can image very small features in a short amount of time. By using larger magnets, machines have been able to achieve high-resolution and faster patient throughput.

Magnet strength typically ranges from 1.5 Tesla to 8 Tesla that can interfere with other equipment and damage digital storage media such as the strips on credit cards or data on magnetic hard disks. Each MRI machine requires a special room to shield that magnetic field along with large amounts of electricity and cryogenic systems. These machines carry a price tag from $1M to over $20M each plus the cost of building a special magnetically-shielded room that can support the MRI which weighs several tons. These issues have limited the availability of MRIs to larger population areas that can afford them.

Nearly all these groups have tried to invent MRI machines that have a large bore, high-resolution and short imaging times. So far no low-cost MRI has been developed.

Companies building MRI machines and many university research teams have been working to develop small MRI machines with reduced price tags. There have been many different approaches and large numbers of patents. There have been a few attempts to develop MRI devices that can be carried by one person.

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[e] Some diagnostics are based on mapping of groups of genetic single nucleotide polymorphisms of DNA or RNA that identify each person's likely disposition to a particular disease and their likely reactions to particular therapeutic agents. While DNA and RNA are important; how they impact health changes over time.
A newer field called proteomics is in its infancy and more complex but produces definitive results beyond DNA/RNA. Proteomics is the analysis of particular groups and ratios of proteins at the time of testing. Proteins and their ratios can be the definitive answer to the state of health and disease at the time of testing. Those protein ratios vary within a person from time to time. There are many millions of proteins in every person so it may be decades before there is complete knowledge. Advances in testing and comparing proteins from a large base of patients is starting to achieve valuable insights. Proteomics measures proteins at a particular point in time that will someday positively determine detailed heath information and identify the precise treatment needed for a particular patient.
[f] To achieve similar performance and range to existing helicopters would require about 15 times as much energy density (KwHr/Kg) in the battery cells. As a former customer of airport helicopter shuttles, helicopters can only achieve sufficient customer volume at a price point that requires a helicopter to fly many round trips per day with only a few minutes of gate time at each end for unloading and loading passengers and sometimes a crew change.

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