

EECS159A/CSE181A

Broader Impacts

Outline

- Manufacturing process
- Impact in different contexts
 - Global:
 - Economic: manufacturability, market
 - Environmental: sustainability
 - Societal: acceptance

Electronics Manufacturing

- Electronics
 - PCB production
 - Component assembly
 - Firmware programming and Testing
- Housing & Packaging
 - Enclosure production
 - Enclosure assembly
 - Product packaging

PCB Production (1/2)

- Use layout tool to make a Gerber file
- Copper plate on laminate is coated with light(UV)-sensitive film
- Project UV over layout mask onto the resist => hardens the resist
- Chemical solution washes away the non-hardened resist and
- Another chemical solution washes away the copper not protected by hardened resist
- Another chemical removes the hardened resist

PCB Production (2/2)

- Oxide coating on copper
- Multiple layers are glued together...
- Drill holes
- Debur — remove debris from drilling or cutting
- Solder mask curing
- Legend
- Cutting
- Automatic Testing

Component Assembly

- Assume SMT (surface mount technology)
- Make (stainless steel) stencil with component outlines
- Load components in reels
- Machine applies solder paste (with stencil), coated with silk screen
- Machine places components (with stencil)
- Bake to melt solder, vaporize flux
- Automatic optical inspection (AOI)
- Optional: conformal coating

Firmware programming

- Programming here means “burning” ROM, “writing” to flash etc
- Could be done by component vendor before assembly
- Could be done by a flash programmer after assembly — but would need to leave programming header
- Flash Protection
 - write protection (lock pages to prevent writing)
 - read protection (prevent some from copying your image)

Automatic Test Equipment (ATE)

- PCB Testing after assembly
 - Automatic Optical Inspection (AOI) — testing solder defect
 - Automatic X-Ray Inspection (AXI) — for BGA, where contacts are not visible optically
- Functional testing
 - In-Circuit Test (ICT) checks circuit connectivity & function
 - JTAG Boundary Scan (IEEE 1149.1) — serially shift bits in/out of a chip (e.g., processor); also for firmware writing

Enclosure Production

- Mechanical design
- Production
 - Molding: injection, extrusion, compression, transfer
 - Subtractive: etching, drilling, milling, carving, texturing
 - Additive: 3D printing, SLA (stereolithography)
- Curing

Costs

- Non-recurring expense (NRE)
 - design, stencil, assembly setup, making mold
- Recurring expense
 - Bill of materials (BOM)
 - manufacturing, testing
 - Administrative, marketing, distribution
 - Maintenance, support costs
 - Royalty, licensing costs, cloud rental

Economy of Scale

- Component cost
 - MOQ (minimum order quantity)
 - lower unit price for larger quantity
- Amortize NRE over volume
 - type of mold: silicone (cheap, not durable) vs. metal casting (expensive, durable)
- Production cost
 - manual vs. automatic assembly, testing, ...

Distribution Costs

- Direct sale vs. distributor
 - sell on your own website? Ebay?
 - sell through some retail store? online store?
- Software distribution
 - on CD? USB stick? FTP download?
 - Downloadable app from the an app store?
(e.g., 30% commission)

Economic Impact

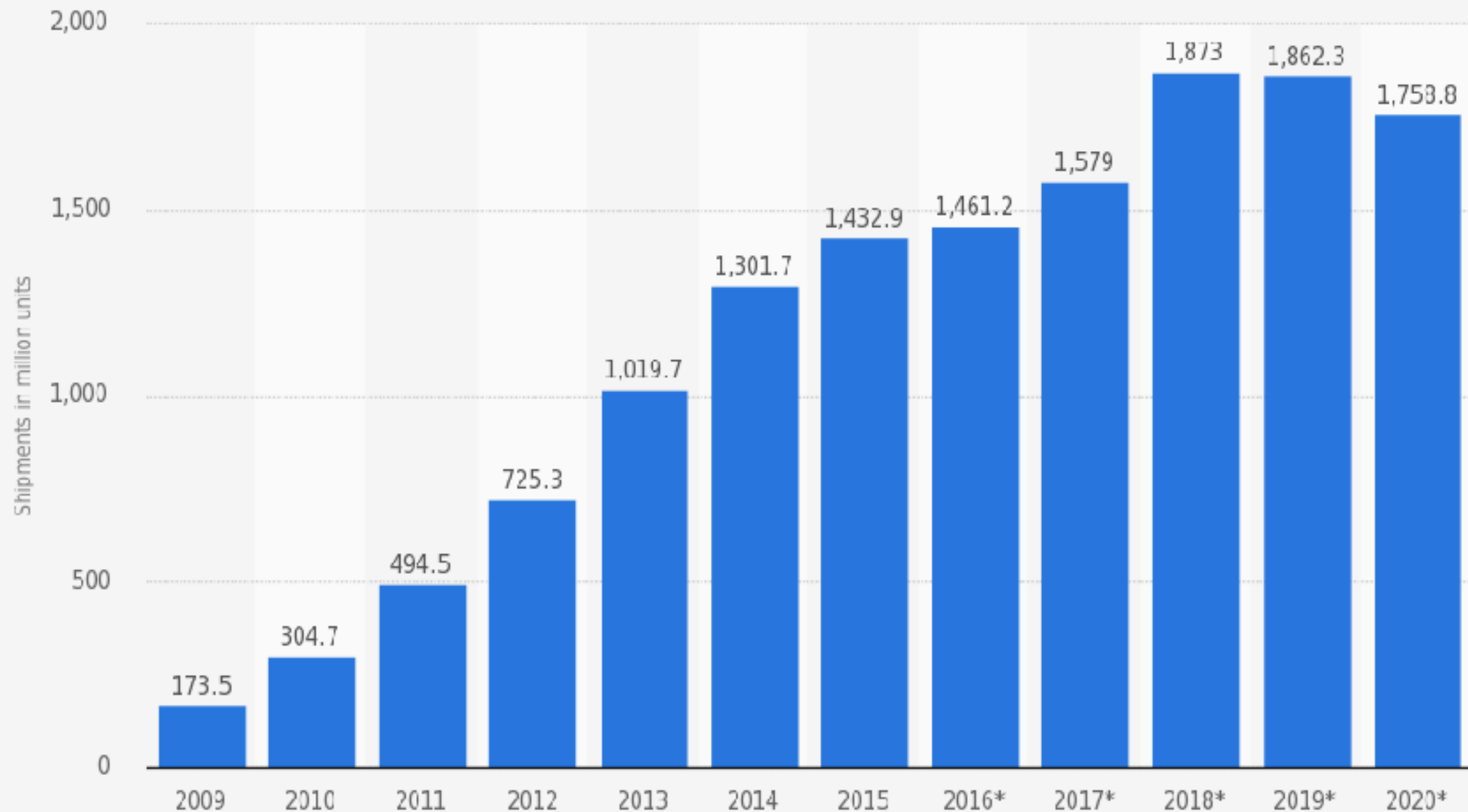
- Effect of producing and using a system on the economy of a region
 - Which other businesses do you depend on?
 - Do you create jobs? What kind? (design, manufacturing, ...)
 - Which industries may get negatively impacted?
- Types of impact
 - change in revenue, expenditure, profits, salary,
 - change in supply and demand on the market

Environmental Impact

- Impact on operating environment
 - wireless traffic?
 - available space in class room? fire hazard?
- Impact on the environment at large
 - ecosystems, global warming,
 - natural resources, sustainability

Case Study: Smartphones

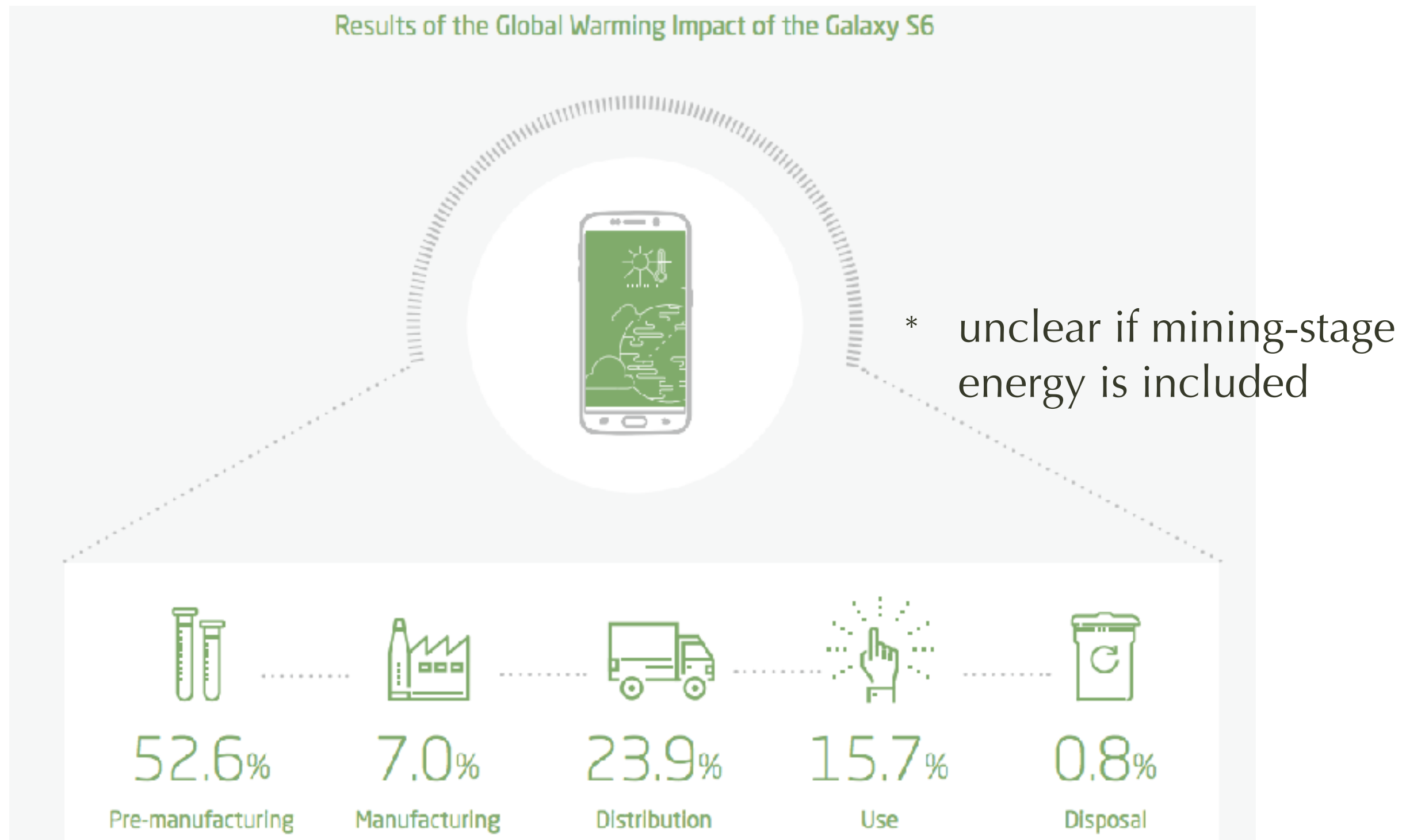
Global smartphone shipments forecast from 2010 to 2020 (in million units)*



Source:
IDC
© Statista 2016

Additional Information:
Worldwide; IDC; 2010 to 2016

Example: Samsung Sustainability Report



Sustainability

- The ability for the process to continue indefinitely on its own
 - socio-ecological, environmental, economic,
- Concepts
 - Scalability of system or process in space and time
 - Consumption vs resource availability

Resources & materials

- 15,000 components produced in different factories around the world.
- 165 pounds of raw materials to make one cellphone
- 16 out of 17 rare-earth elements
- 40 different minerals—including gold, tantalum, tin, and tungsten
- Copper has been in short supply recently
- 8 gallons of water to make one microchip

https://www.ieee.org/about/news/2013/22april_2013.html

<http://www.techradar.com/news/phone-and-communications/mobile-phones/our-smartphone-addiction-is-costing-the-earth-1299378/2>

What are rare-earth elements?

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ↓	I A	II A	III B	IV B	V B	VI B	VII B	VIII B	VIII B	VIII B	IB	IIB	III A	IV A	VA	VIA	VII A	VIII A
1	1 H Hydrogen 1.00794																	2 He Helium 4.002602
2	3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
3	11 Na Sodium 22.98976928	12 Mg Magnesium 24.305											13 Al Aluminum 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.9559	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.796
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.9063	42 Mo Molybdenum 95.96	43 Tc Technetium [98]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8662	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.293
6	55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.2217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
7	87 Fr Francium [223]	88 Ra Radium [226]	89-103 Actinoids	104 Rf Rutherfordium [261]	105 Db Dubnium [268]	106 Sg Seaborgium [271]	107 Bh Bohrium [272]	108 Hs Hassium [278]	109 Mt Meitnerium [276]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Uut Ununtrium [286]	114 Uuq Ununquadium [289]	115 Uup Ununpentium [288]	116 Uuh Ununhexium [293]	117 Uus Ununseptium [294]	118 Uuo Ununoctium [294]

Lanthanoids →	57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90768	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9253	66 Dy Dysprosium 162.5	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
Actinoids →	89 Ac Actinium [227]	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [262]	103 Lr Lawrencium [262]

“lanthanides”

Impact of PCB Production

- Chemicals
 - toxic metals, solvents, acids, photolithographic chemicals
 - reproductive toxicants, carcinogens
- Ways of exposure
 - as workers in PCB factories
 - as resident exposed to polluting PCB plant

RoHS: Restriction of Hazardous Substance in electronic equipment

- European Union directive
 - started in 2002
- RoHS1: 6 restricted materials (2006)
 - Lead (Pb), Cadmium (Cd), Mercury (Hg), Cr6+, PBB, PBDE
- RoHS2: added 4 more (2015)
 - DEHP, BBP, DBP, DIBP

Health and safety (of Attendance System)

- Health issues
 - shared fingerprinting sensor: sanitation?
 - harmful radiation or laser? skin irritation?
- Safety issues
 - Does it have glass? Does it shatter?
 - generates heat?
 - Is the device heavy? Is it a drop hazard?
 - tripping hazard of running long cords?

Societal Impact

- Society: Group of people
 - class, students at a university, workers, society at large
- Impacts
 - Culture of the group
 - Privacy of individuals in the group
 - Application beyond classrooms

Impact on Culture

- Culture
 - ideas, customs, social behavior of a group
- example group: class
 - how disruptive it is to the class?
 - Does it encourage or discourage attendance?
 - honesty of students?
 - habit of bringing ID card?

Impact on Privacy

- Accepted level of Privacy
 - don't care? highly protective?
- How much info can be extracted?
 - Does the Attendance System cause more privacy leak or strengthen privacy protection?
 - What do companies use the extracted info for?

Broader Impact on Society

- Applications beyond Attendance
 - As bus/train/subway tickets? Boarding pass?
 - amusement park admission?
- General ID for multiple purposes?
 - same ID for all different admissions?
 - how easy or difficult is it to forge ID?

Global Impact

- How does the production or use impact the rest of the world?
- Source and Production
 - worker condition (factory, mines)
 - regional conflicts
- Export restrictions

Worker Conditions

- Manufacturing conditions
 - Unclear if factory works have fair and safe working conditions
 - Unclear if factories treat hazardous wastes properly
- Rare-earth materials miners
 - require special possibly radioactive process
 - Unclear long term health effect on miners, some may be child workers

Regional Conflicts

- Source of materials typically mined in eastern Congo
 - Linked to a brutal conflict: Armed groups fight to control many of the mines
 - Profits from trading and smuggling minerals funds further violent activity that devastates the lives of civilians.
- Manufacturer disclosure
 - 79 out of 100 companies sourcing minerals from the Congo failed to report their supply chain adequately last year.
 - Unclear if Intel's well-publicized claims its microchips are conflict-free

Country-specific policies

- Country-specific policies
- Example: Google Map
 - not accessible in certain countries
 - => can't play Pokemon Go if can't access Gmap
- Export control laws
 - The Export Administration Regulations ("EAR") regulate exports of commercial items with potential military applications (so called "dual-use" items).

Ten Categories of Commerce Control List

- 0. Nuclear Materials, Facilities & Equipment and Miscellaneous
- 1. Materials, Chemicals, “Microorganisms” and Toxins
- 2. Materials Processing
- 3. **Electronics**
- 4. **Computers**
- 5. **Telecommunications and Information Security**
- 6. **Sensors and Lasers**
- 7. **Navigation and Avionics**
- 8. Marine
- 9. Propulsion Systems, Space Vehicles and Related Equipment

Summary

- Think about broader impact of your work
 - manufacturing process and use
 - impact on economy & environment
 - impact on society and the rest of the world
- How does this understanding influence your view on ethical responsibilities?
 - always keep professional responsibilities in decision process