10.1 Electricity in nature

Electricity is not a human invention, and may be observed in several forms in nature, a prominent manifestation of which is lightning. Many interactions familiar at the macroscopic level, such as touch, friction and chemical bonding, are due to interactions between electric fields on the atomic scale. The Earth's magnetic field is thought to arise from a natural dynamo of circulating currents in the planet's core. Certain crystals, such as quartz, and even sugar, generate a potential difference across their faces when subjected to external pressure. This phenomenon is known as piezoelectricity, and was discovered in 1880. The prefix "piezo-" is derived from the Greek piezein (πιέζειν), which means to press or to squeeze. The effect is reciprocal, and when a piezoelectric material is subjected to an electric field, a small change in physical dimensions takes place.

Some organisms, such as sharks, are able to detect and respond to changes in surrounding electric fields, an ability known as electroreception, while the ability of an organism to internally generate an electric voltage is termed electrogenic (such an ability often serves as a predatory or defensive weapon). The biological order Gymnotiformes, of which the best known example is the electric eel, is able to stun its prey via high voltages generated from modified muscle cells called electrocytes. It is important to note here that all animals transmit information along their cell membranes with voltage pulses called 'action potentials'. Action potentials are also responsible for coordinating activities in certain plants.

10.2 Principles of electrical theory

The following principles form the foundation of electrical theory, and hence, are the basis of electricity.

1. All charged particles (i.e., charges) have an electric field. There are no magnetically charged particles (if they existed they'd be called "magnetic monopoles").
2. There are two ways of creating an electrical field: introduce an electrically charged particle, or introduce a time-varying magnetic field.
3. There are two ways of creating a magnetic field: move an electrically charged particle (i.e., an electrical current), or introduce a time-varying electric field.
4. Under static conditions (i.e., not changing with respect to time), either electric or magnetic fields can exist without the other. Technically, this is not entirely accurate in concern to magnetic fields, because the electric field is still present, it is just being cancelled out.
5. Under dynamic conditions (i.e., changing with time), neither an electric or magnetic field can exist without the other. If one field is time-changing, the other must be non-zero.
6. Electromagnetic energy refers to the synchronous presence of electric and magnetic fields.
7. Electrostatics is the study of static (unchanging) electric fields, electric charges, and the rules governing their interactions.
8. Magnetism is the study of static magnetic fields, magnets, and the rules for their interactions.
9. These two areas of study are tied together with electrodynamics, which is the study of changing electric and magnetic fields, and electromagnetic (EM) waves (of propagation radiating as "radiation").
10. Electrical science is the study of electrical effects. Electrical effects are caused by electric charges and by the electric and magnetic fields associated with charges.
11. The theory of electric circuits is a subset of the theory of electrodynamics, which is a subset of quantum theory.

INSIGHT: *There is no physical object called 'wave'. Wave is not what something is, but what something does. For instance, wave is what a flag does. There is no waving without the flag. Similarly, there is no physical object called vortex. Vortexing is what something does.*

10.3 Electric charge

The 'electric charge' is a property of some subatomic particles, which determines their electromagnetic interactions. Charge is the quantity of electricity responsible for electric phenomena. It is one of the fundamental physical quantities in electric circuit analysis. A quantity of charge that does not change with time is typically represented by Q. The instantaneous amount of charge, which is time dependent (changes over time), is commonly represented by Q(t). The concept of an "electric charge" adheres to the following principles:

1. The physical property of matter that causes it to experience a force when placed in an electromagnetic field is called an "electric charge", and it has historically been called a "charge of electricity".
2. Electric current is a "flow of charge", rather than "a flow of electricity."
3. Electrons are "charge carriers", rather than "particles of electricity."

CLARIFICATION: *The speed at which energy transfer occurs, or signals travel, down a conductor is the speed of the electromagnetic energy (light), not the speed of movement of the electrons.*

The decomposition of the physical environment to charge is as follows:

1. Matter - all forms of matter are composed of molecules.
2. Molecule - molecules are composed of atoms
3. Atom - atoms are composed of particles, of which there are three: protons, neutrons, and electrons.
   A. Relative position - the center of the atom is called the nucleus, which is surrounded by orbits.
   B. Protons within nucleus.
   C. Neutrons within nucleus.
   D. Electrons in orbit.
4. Charge - a property of particles determining electromagnetic interaction.
   A. Electrons maintain a negative polarity (-ve), a negative charge.
   B. Protons maintain a positive polarity (+ve), a positive charge.
   C. Neutrons do not have a polarity, are neutral.
5. Atomic charge determination
   A. An excess of electrons creates a negative charge.
   B. The absence of electrons creates a positive charge.
6. Charge field vector
   A. Positive charge outward
   B. Negative charge inward
7. Charge interaction/dynamics
   A. Different charges attract each other (void space).
   B. Same charges repel each other (create space).

In physics, 'charge', also known as electric charge, electrical charge, or electrostatic charge (dielectric), and symbolized 'q', is a characteristic of a unit of matter that expresses the extent to which it has "more (-ion) or fewer (+ion) electrons than protons". The basic unit of electric charge is the "coulomb".

- 1 coloumb = 6.25 x 10^{18} electrons

Electric charge, also called "the Quantity of Electricity," is a fundamental component of everyday matter. Objects are made of molecules and atoms, atoms are made of protons, neutrons, and electrons, and the protons and electrons are made in part out of electric charge. Electric charge is substance-like. If you have a quantity of charge, you cannot destroy it, you can only move it from place to place.

> **NOTE:** *Electric forces are what hold together atoms and molecules, solids and liquids. In collisions between objects, electric forces push things apart.*

Matter can carry charge. However, it is not the charge of matter that transports energy; it's the electromagnetic field that is linked to the charge. Charged particles are expressed as propagating electromagnetic excitations in the field. In a charged particle's rest frame (static charged), the magnetic components is not expressed, and only the time-like ones (the electric field and the energy, respectively) remain. Charge itself gives rise to a 'divergence' in the electric field. Current (moving charge) gives rise to a curl/spiral in the magnetic field. In other words, in its rest frame, a charged particle appears to generate an electric field only and no magnetic field at all. From a different frame of reference (in particular one in relative motion), we'll see the charge moving, thus a current which generates a magnetic field as well. Fundamentally, charge produces a field that acts on other charges.

> **NOTE:** *Materials can be listed in the order of those "most likely to lose electrons" (gaining positive charge) to "those most likely to gain electrons" (gaining negative charge). This is called the 'triboelectric series'.*

Note, it is possible to let charges pass through a vacuum with no resistance, but that is not a reason to call the vacuum a conductor [of charge]. Conducting is associated with influence of the conductor on the motion of the conducted - directing the motion - which a vacuum does not appear to have. The vacuum (space) allows charged matter to pass trough it. Electromagnetic waves propagates (at the speed of light) in vacuum.

10.4 Charge and electric circuits

Moving charges represent an electric current. During operation, although charges are transferred between different parts of an electric circuit, the total amount of charge does not change. Electrons or protons are neither created nor destroyed when an electric circuit is operating.

In a neutral state (zero charge), electrons will neither leave nor enter the neutrally charged body should it come in contact with other neutral bodies. If, however, any number of electrons is removed from the atoms of a body of matter, there will remain more protons than electrons and the whole body of matter will become electrically positive.

Should the positively charged body come in contact with another non-charged body, or having a negative charge, an electric current will flow between them. Electrons will leave the more negative body and enter the positive body. This electron flow will continue until both bodies have equal charges. When two bodies of matter have charges and are near one another, an electric force (F) is exerted between them. The existence of such force, where current does not flow, is referred to as 'static'.

The force of attraction or repulsion exerted between two charged bodies is directly proportional to the product of their charges (Q) and inversely proportional to the square of the distance (d) between them.

10.5 Conductors

Conductors allow for charge transfer through the free movement of electrons (or protons). Conductors guide the flow of electric charge, and hence, the flow of electromagnetic energy.

Three factors determine whether or not the atom is a "good" or "bad" conductor:

1. The number of electrons in the outer orbit.
2. The distance of the outer orbit from the nucleus of the atom.
3. The density of the atoms within the element.

Therein,

1. If the atom has only one orbit, maximum number of electrons on orbit is 2.
2. If the atom has more than one orbit, maximum number of electrons on outer orbit is 8.

The following are good conductors:

1. Gold, silver, copper have 1 electron on their outer orbit.
2. Mercury has 2 electrons in its outer orbit
3. Aluminum has 3 electrons in its outer orbit.
4. Carbon has 4 electrons in its outer orbit.

> **NOTE:** *The net electric charge of a conductor resides entirely on its surface. The mutual repulsion of like charges from Coulomb's Law states that the charges be as far apart as possible, hence on the surface of the conductor. The electric field inside the conductor is zero.*

10.6 Electric current

> **NOTE:** *Electron theory states that the subatomic particle that does the work in electronics is the electron, which happens to be negatively charged. There is a subatomic particle that flows the other way, from positive to negative: the Positron.*

An electric current is a flow of electric charge, which transfers electromagnetic energy through conductive space. The particles that carry the charge in an electric current are called 'charge carriers'. There are a variety of charge carriers:

1. In metallic solids, electric charge flows by means of electrons, from lower to higher electrical potential.
2. In electrolytic solutions, electric charge flows by means of ions.
3. In gases and plasmas, electric charge flows by means of ions and electrons.
4. In a vacuum, electric charge flows by means of ions and injected free electrons.

Electric current is measured in coulombs per second (amperes or amps; A or I).

- Amperage = amount of electrical current
- Amperage = Coulombs / Seconds
- 1 Ampere = 1 Coulomb / 1 Second
- 1 Ampere is equal to 1 Coulombs per second
- 1A = 1C / 1s
- A = C/s

> *1 Coulomb is approximately 6.241×10^{18} times the elementary charge (e or q). The elementary charge is the electric charge carried by a single proton, or equivalently, the magnitude of the electric charge carried by a single electron (-e or -q). This elementary charge is a fundamental physical constant.*

Current is rate of change in the electric field:

- current (I) = $\Delta q/\Delta t$
- wherein, q=charge

> **NOTE:** *Ampère's force law states that there is an attractive or repulsive force between two parallel wires carrying an electric current. This force is used in the formal definition of the ampere, which states that the ampere is the constant current that will produce an attractive force of 2×10^{-7} newtons per metre of length between two straight, parallel conductors of infinite length and negligible circular cross section placed one metre apart in a vacuum.*

Electric current is measured using an instrument called an **ammeter**.

> **NOTE:** *Humanity cannot [with present technology] directly observe the electrically-charged particles that produce current.*

The energy in electric circuits is not carried by individual electrons, it is carried by the circuit as a whole. Current is defined as the rate of flow of charges through a medium. Current is the flow of charges, stationary charges cannot give any current. Charge gives rise only to an electric field, while current produces both electric and magnetic fields. The energy flowing through an electric circuit as an electric current is contained in electrostatic and the magnetic fields produced by the electrons.

> **NOTE:** *In an electric current, the electron particles are the "medium", wherein energy is transferred electromagnetically.*

Electricity (electrical energy) is the flow of electrical charge, and all flows of electrical charge (electric current) transfer energy electromagnetically. In metals, the electrically charged particles are electrons. Electricity cannot flow through air, except in the form of electrically charged particles of air - as in a spark or lightning stroke.

> **NOTE:** *Some elements in a circuit can transfer ("convert") energy from one carrier ("form") to another. For example, a resistor transfers ("converts") electromagnetic energy traveling through a conductor (i.e., "electrical energy") to heat (i.e., "thermal energy"), this is known as the Joule effect. In other words, electric currents cause Joule heating.*

> **NOTE:** *The flow of charge (i.e., an electric current) causes friction, which is called resistance. Resistance quantifies how much current you get across something per volt applied. Namely, if you apply a voltage V across a wire and measure current I, the resistance R is defined by: R = V/I. Resistance therefore has units of V/A, which get another name, ohms.*

10.6.3.1 Current and the AC power grid

In an AC electric power grid, a certain amount of energy is lost because it vectors off into space. This is well understood: electrical energy is electromagnetic waves travelling everywhere, and unless the power lines are twisted or somehow shielded, they will act as 50-60Hz antennas. Waves of 60Hz electrical energy can spread outwards into space rather than follow the wires. The power lines can even receive extra 60Hz energy from space, from magnetic storms in Earth's magnetosphere. Electric energy is gained and lost to empty space while the charges of electricity just sit inside the wires and wiggle.

10.7 Current and electromagnetic fields

Any time current flows through a conductor, a magnetic and electric field are generated around the conductor. If that current is direct current (DC), then the resultant magnetic and magnetic fields will have a constant orientation/polarity (i.e., a constant electromagnetic field - DC magnetic field and DC electric field). If the current is alternating current (AC), then the electric and magnetic fields will vary in direction (polarity) and intensity with the alternation of the current (i.e., a varying electromagnetic field - AC magnetic field and AC electric field).

Any AC circuit propagates its signals using electromagnetic waves. The transmission of the signal between elements is done only by electromagnetic waves. But in a circuit, these waves are guided waves, the traces on a PCB or the wires of our circuit guide the waves along the desired path.

> **NOTE:** *An antenna is a transceiver/transformer of sorts. The antenna is a device that transforms guided electromagnetic waves into propagating electromagnetic waves (and vice-versa). So all it is doing is taking the guided wave that is sent to the antenna and providing it a means of going into open space.*

10.8 Electromagnetic fields

An **electromagnetic field (EMF** or **EM field)** refers to the field created by static (electric field) or moving (magnetic field) charges. Note that a constant electric or magnetic field filling a space is not a wave (i.e., not an electromagnetic wave). In physics, a field is a space together with a set of values for every point in the field, which generates a time-space coordinate system. An electromagnetic field is a set of values for electric and magnetic vector orientation and magnitude (strength), one for each point in space time. The components of the field depend on a reference point for the coordinate system (the observer), even though the field itself has a definite physical existence. Technically, a classical field is a function whose domain is space-time, and a wave is a configuration of the field that satisfies a [differential] wave equation. Note that a quantum field is more complicated. Note that the term 'field' is challenging to define because it is a fundamentally assumed/axiomatic form of existence in physics. Hence, it cannot be defined by saying what it is made of. Electric fields are measured in kilovolts per metre (kV/m) and magnetic fields are measured in milligauss (mG).

An electric field can be created by:

1. The presence of a changing magnetic field.
2. The presence of a charge[ed particle] (e.g., ion).

A magnetic field can be created by:

1. The presence of a changing electric field.
2. The presence of a dielectric charge[d particle] (e.g., permanent magnet).

10.8.1 Alternating current and electromagnetic fields

The electromagnetic fields produced by an alternating current can be categorized as follows:

1. *Near fields* allow for electromagnetic induction. The near-field is a reactive power field. Inductive coupling is the coupling of elements with near fields.
2. *Far fields* allow for electromagnetic radiation.

10.8.1 Alternating current and near field electromagnetic induction

In a coil of wire, AC produces fluctuating fields that can induce currents on another coil without any physical contact. This process is known as electromagnetic induction, and it uses near field electromagnetic reactance radiation (vs. far field propagating radiation).

The electric and magnetic fields produced for electromagnetic induction are not in a constant ratio of strengths to each other, and are not phase (i.e., there is a reactance). Electromagnetic induction is a particular form of the more general electromagnetic field (EM Field), which is produced by moving charges. If an AC current is fed through a piece of wire, the electromagnetic field that is produced is constantly growing and shrinking due to the constantly changing current in the wire. This growing and shrinking magnetic field can induce electrical current in another wire that is held close to the first wire. The current in the second wire will also be AC and in fact will look very similar to the current flowing in the first wire. One can generate a magnetic field by letting an alternating current flow through a wire or coil. That is what happens in the primary coil of a 'transformer'. The other way around, a change in a magnetic field will generate a current in a coil - that's what happens in the secondary coil. These properties of magnetic fields and current are called electromagnetic induction.

> **NOTE:** *The near field and far field are regions of the electromagnetic field around an object, such as a transmitting antenna, or the result of radiation scattering off an object. This difference between picking up a magnetic field and magnetic radiation is known as the difference between near and far field.*

In a general electromagnetic induction setup, the secondary coil exists inside one wavelength of the wave that is produced by alternating current on the first coil (i.e., in the near field). This means that the current in the secondary coil does not exist because of electromagnetic radiation (self-propagating EM fields), but because of electromagnetic induction (reactance EM fields). In an electromagnetic induction circuit, the electric and magnetic fields don't [re-]create each other and propagate outward.

10.8.2 Alternating current and far field electromagnetic radiation

Electromagnetic radiation (EMR) is a particular form of the more general electromagnetic field (EM Field), which is produced by moving charges. The electric and magnetic fields in EMR exist in a constant ratio of strengths to each other, and must also be in phase. In electromagnetic radiation, the magnetic field will create an electric field (just assume that), but further away from the conductor that began with making the electromagnetic field. The electric field will create a magnetic field, even further away, and so on. It just goes on and on, due to specific properties of the field. It can vary in frequency, from extremely low frequency all the way up to extremely high frequency.

Electromagnetic radiation (EM radiation or EMR or far field) is the radiant electromagnetic energy released by certain electromagnetic processes. Electromagnetic radiation is a transverse wave where an electric and magnetic field oscillate perpendicular to each other and in the direction of propagation. The energy of the wave is in the electric and magnetic fields. Electromagnetic radiation is associated with those EM waves that are free to propagate themselves ("radiate") without the continuing influence of the moving charges that produced them, because they have achieved sufficient distance from those charges. Thus, EMR is sometimes referred to as the **far field**; versus, the near field, which refers to EM fields near the charges and current that directly produced them, specifically, electromagnetic induction and electrostatic induction phenomena.

> **NOTE:** *In general, electromagnetic radiation from an antenna comes from alternating current flowing in a linear conductor.*

10.8.3 Direct current and electromagnetic fields

A direct current (DC) electromagnetic field refers to a constant or static DC electric or DC magnetic field emission, which has a frequency of 0 Hz. In a coil of wire, DC produces electromagnetism, and does not produce electromagnetic induction (near field) or electromagnetic radiation (far field). A DC magnetic field (constant polarity) cannot be used to induce current in any other conductor. Only a varying magnetic field can do that (to generate that you need varying current). You can use this unidirectional field in a way similar to how you can use permanent magnets. For example - closing and opening electromechanical relays. The only way to produce an electromagnetic field is to somehow change the current with time. So, even if the source of the current is constant (DC), then it is possible to produce an EM field by frequently changing the physical properties of conductor along its length, such as changing the cross-section of the conductor frequently along its length, or modifying the electrical parameters of the conductor frequently. The electric field of a direct current (DC electric field) is measured in are measured in Volts per meter (V/m). The magnetic field of a direct current (DC magnetic field) is measured in milliGauss mG with a DC gaussmeter.

10.9 Electromagnetic radiation

Electromagnetic radiation (in the shape/geometry of a wave) are produced by accelerating electrical charges. The current carrying charged particles in AC circuits are continuously accelerating (at a frequency) and always emit electromagnetic waves. These emissions may be limited to reduce energy losses with the use of shielding, twisting, and coaxial cables. An EM wave is present when there is an oscillation of charge (as in, an oscillator produces a periodic, oscillating electron signal, an AC signal).

In a DC circuit operating with a constant current, the electrical charges, usually electrons, only experience a brief initial acceleration when the circuit is energized, and negligible energy is radiated as electromagnetic waves. In other words, the DC hasn't been DC forever, there was a time when it turned on, and that put out a small electromagnetic click, but just for an instant. A DC wire puts out a steady magnetic field, not a propagating electromagnetic field. Direct current is also capable of producing a varying magnetic field (by turning it on and off at a certain frequency, for example), So, it may emit an electromagnetic wave, if it's varying in some way.

The electric and magnetic fields produced by direct current (DC) lines are referred to as static fields because their sources, voltage and current, do not alternate over time. Thus, DC fields are qualitatively different in nature than the alternating current (AC) electric and magnetic fields (often called EMF) produced by AC transmission lines. While AC EMF can cause the induction of currents or voltages in nearby objects, this does not occur with DC fields.

Stable AC produces a constant "vibration" in the conductor, while DC doesn't vibrate the conductor at all. If the electron flow in 60Hz AC power signal were converted to a sound, then it would sound like a low hum -- specifically, a 60 Hz hum, between a B and a Bb, right below the C two octaves below middle C. DC current sounds like a single click when it starts and another when it ends. This is because what we call sound consists of vibrations.

Electric and magnetic fields surround any electrical circuit, whether it carries AC or DC power, including appliances, electrical wiring and power lines. Both electric and magnetic fields diminish rapidly as the distance from the source increases. Electric and magnetic fields from DC transmission lines are commonly referred to as static fields because they do not alternate in direction. Static electric fields occur as a result of voltage. Static magnetic fields are created by a magnet or by the steady flow of electrical current (DC).

The fields associated with the operation of a DC line are static, which is the same as having a frequency of zero, and do not induce voltages or currents in nearby conducting materials in the environment. Note that in certain weather conditions, both AC and DC transmission lines may produce an electric field associated with electric charges in the air and not just those on the conductors.

An electric field applied to an electric circuit causes a flow of electric charge, which transports/moves electromagnetic energy and generates consequential heat as thermal energy due to resistance (friction). All charges have an electric field. When you accelerate a charge you also get a magnetic field. To get EM waves you need to accelerate the charges - like wiggling them back and forth or turn them in a circle for acceleration. Electrons accelerating in a conductor do emit EM waves out of the conductor - that is how radio transmitters work. A DC circuit does not emit significant EM waves while it transports/moves electrical energy from source to load.

In electronics and telecommunications engineering, a "transmitter" or "radio transmitter" is an electronic device which, with the aid of an antenna, produces EMR (as radio waves). The electronics of the transmitter device generate a radio frequency alternating current, which is applied to a part of the device known as an antenna. When excited by this alternating current, the antenna radiates EMR (as radio waves). The term transmitter is usually limited to equipment that generates radio waves for communication purposes, or radiolocation, such as radar and navigational transmitters. Generators of radio waves for heating or industrial purposes, such as microwave ovens or diathermy equipment, are not usually called transmitters even though they often have similar circuits.

The electromagnetic fields that we measure radiating from AC electric currents in the circuits in the walls of a building have a frequency of about 50 to 100 cycles per second. If we increase the frequency to 500 or 1000 kilocycles (1 kilocycles = 1000 cycles) per second, we are "on the air", for this is the frequency range which is used for radio broadcasts.

All accelerated charges radiate electromagnetic energy (i.e., electromagnetic radiation). So, everything that conducts alternating current acts as an antenna. However, in order to achieve efficient radiation the antenna must be designed appropriately. The antenna itself, when connected to a transmitter, is both the positive, 0, and negative pole at different times. This movement of charge creates a changing electric and magnetic field, which becomes an electromagnetic wave, capable of radiating energy from the antenna or aerial (see Maxwell equations and Hertz definition). As the [alternating] current from the transmitter approaches the end of the wire [antenna], but has no place to go, the charges pile up until they are pushed back in the other direction. By the time the charge is back at the transmitter, it's travelled λ/2 or experienced a 180° phase shift. The voltage at V1 has also changed by this point, and so the current is constructively adding to the new currents being produced by the transmitter, as an alternating current that form a sine wave. If it were not for some of this energy being "lost" as radiation, the energy in the antenna would grow without bound. The radiation of energy from the antenna is presently understood in the form of a set of equations named after a human being, "Maxwell's equations". Essentially, the equations state that the current in an antenna is associated with a magnetic field, and the voltage is associated with an electric field -- an antenna is an arrangement such that at some distance away from the antenna (the far field) these two fields are mutually perpendicular and in phase, and the output of their integration [in a medium] is a self-propagating EM [field] wave.

> **INSIGHT:** *An equation may be true, but not factual.*

The electric field is produced by stationary charges, and the magnetic field by moving charges (currents; or, permanent magnetic substance); these two concepts are often described as the sources of the field. The way in which charges and currents interact with the electromagnetic field is described by Maxwell's equations and the Lorentz force law. The alternating voltage from the transmitter is moving (accelerating) the [electron(ic)] charge backwards and forwards. Standing waves that impact the functioning of the antenna are the result of a miscalculated antenna, and they represent lost energy. The standing wave is the pattern you get (in voltage or current) when the power travelling to the antenna is superimposed on the power reflected back from the antenna due to mismatch of antenna and transmission line. Power is travelling in both directions at once and when you sum the instantaneous voltage at all points along the line you get a steady pattern of highs and lows. This is the "standing wave".

However, in transmission of charge through a wire, the wire is a poor "antennas" and doesn't radiate well. To make a functional antenna, power (i.e., the energy contained in voltages and currents) must be transferred effectively into electromagnetic radiation, where the energy is contained in the electric (E) and magnetic (H) fields [travelling away from an antenna].

A magnetic field, as the result of a moving charge, can also be thought of as the flow of water in a garden hose. As the amount of current flowing increases, the level of magnetic field increases. Magnetic fields are measured in milliGauss (mG). Electric fields are created around appliances and wires wherever a stationary charge, a "voltage", exists. Electric voltage can be thought of as the pressure of water in a garden hose – the higher the voltage, the stronger the electric field strength. Electric field strength is measured in volts per meter (V/m). The strength of an electric field decreases rapidly as you move away from the source. Electric fields can also be shielded by many objects, such as trees or the walls of a building.

Antenna absorbs radio waves and turns them into electrical signals. Antennas are sometimes called receivers. A transmitter an antenna setup that radiates radio waves (i.e., signals; electromagnetic radiation; invisible light). Electron oscillations on the antenna produce electromagnetic radiation in the form of radio waves. To make a good antenna you have to transfer power (the energy is contained in voltages and currents) into electromagnetic radiation (where the energy is contained in the electric field "E" and magnetic field "H") travelling away from the antenna. Antennas can emit radiation and can receive radiation.

The distance from one peak to the next is the wavelength, and the number of peaks passing through a fixed point per unit time is the wave frequency. Electromagnetic radiation is electromagnetic energy in motion. Electrodynamics is the physics of electromagnetic radiation, and electromagnetism is the physical phenomenon associated with the theory of electrodynamics. The electromagnetic field generated from currents and charges (i.e., "sources") is called electromagnetic radiation (EMR), since it radiates from the charges and currents in the source, and has no "feedback" effect on them, and is also not affected directly by them in the present time (rather, it is indirectly produced by a sequences of changes in fields radiating out from them in the past). EMR consists of the radiations in the electromagnetic spectrum, which has been split for government control and commercial application into a series of "bands", including radio waves, microwave, infrared, visible light, ultraviolet light, X-rays, and gamma rays.

10.10 EM radiation and EM waves

The following is a list of notes on EM radiation/waves

1. Radiation is the transfer of energy by way of electromagnetic waves. Waves are what something does, not what something is. Hence, what is waving?
2. Frequency: The frequency of the wave is the number of "crests" (and troughs) [of the wave] that pass a given measurement point within 1 second. In other words, it is the number of complete waves passing a given point in 1 second. And, it has the unit [measurement] of 'Hertz'.
3. Unit: Hertz - 1 wave or cycle, per 1 second, is call a 'hertz'.
4. Energy transfer: The higher the frequency (i.e., the higher the hertz as cycles per 1 second) the higher the amount of energy transferred. Gamma are the shortest (highest) energy "waves" in the current spectrum.
5. Compression and rarefaction: Wavelength is the distance between two consecutive compressions or rarefactions.
6. Note: In general, human vision can detect electromagnetic radiation waves (light) from ~400nm to ~700nm (the visible light region or band of the spectrum).
7. Objects appear to have color because em waves from 400-700nm interact with their molecules. Some wavelengths in the visible spectrum are reflected, and other wavelengths are absorbed. In the case of a green leaf, EM waves from 492-577nm a reflected (which the human eye interprets as green) and the rest of the wavelengths in the visible spectrum are absorbed. Seeing a leaf as green does not give enough information to determine how the leaf reflects UV, microwave, or IR. Everything emits, absorbs, or reflects electromagnetic radiation differently based on its composition. A spectral signature is a graph showing these interactions across a region of the EM spectrum. Characteristic patterns all for the identification of an object's

chemical composition, and determine such physical properties as temperature and density.

8. Sound waves are longitudinal waves - sound travels quickest through a solid.
9. EM waves have a transverse (right angle) and longitudinal (parallel) component.

10.11 Electromagnetic waves

> **NOTE:** *Electromagnetic waves are the geometry taken for the transfer of electromagnetic energy. Mechanical waves (longitudinal for sound and transverse for water) are the geometry taken for the transfer of mechanical energy. A wave is a compression and rarefaction of a medium. It is sometimes said that mechanical waves have a spatial medium (mass), whereas electromagnetic waves have a counterspatial medium (ether).*

Electromagnetic waves (EM Waves) are the oscillating electrical and magnetic fields, acting perpendicular to each other, and propagating through space. EM waves retain their total energy in accordance with the law of conservation of energy. The EM wave spreads out as it travels, which reduces both the field strength and the energy of any section of the EM wave. Total energy of the wave remains the same, however. The relationship between the electrical and magnetic fields at any given point in space is given by Maxwell's equations. An accelerated charge radiates electromagnetic energy in the form of electromagnetic waves. The speed at which energy or signals travel down a cable is actually the speed of the electromagnetic wave, not the movement of electrons. Electromagnetic wave propagation is fast and depends on the dielectric constant of the material. In a vacuum the wave travels at the speed of light and almost that fast in air. An electromagnetic wave is a certain configuration of the electromagnetic field. EM waves carry energy, momentum and angular momentum away from their source particle and can impart those quantities to matter with which they interact. It could also be said that an electromagnetic wave travels through fields and changes them. A field is not the same thing as a wave, but a changing field is experiencing a wave passing through it. And people shortcut this by speaking as if a changing field is a wave. When electric and magnetic fields fluctuate together they lead to formation of the propagating waves called electromagnetic waves. An electromagnetic wave is not constant - it oscillates with time. When an electric (or magnetic) field oscillates, it generates an oscillatory magnetic (electric) field. This oscillatory magnetic (electric) field then generates its own electric (magnetic) field, and back and forth they go until the EM energy in the field is absorbed by matter. This oscillatory electric-magnetic field is an electromagnetic wave. An EM wave can be traveling (e.g. radiation from an antenna) or it can be confined in what is called a standing wave (e.g. the radiation inside a microwave oven). It is the oscillation that makes it a wave. An electromagnetic wave is electromagnetic radiation, is electromagnetic energy in motion, which is described by wave theory. In other words, an EM wave is any EM field that obeys the differential equations governing waves. Technically all EM fields obey this equation, so the definition is usually restricted to fields which have a non-zero frequency component -- that is, fields that oscillate.

An electromagnetic radiation will travel forever, or until it contacts something, in accordance with Newton's first law -- just like any other object in motion.

Electromagnetic waves propagate in vacuum at a maximum speed of 299,792,458 meters per second . For a 12-gauge copper wire carrying a 10-ampere DC current, the speed of electric current (average electron drift velocity) is about 80 centimeters per hour or about 0.0002 meters per second. The speed of electric (electromagnetic) field propagation in copper wire is slower than in vacuum by a factor referred to as the velocity factor. The speed of electromagnetic waves propagate in vacuum is 299,792,458 meters per second. The velocity factor for a 12-gauge copper wire copper wire is about 0.951 (according to this source). Therefore, the speed of electricity in a 12-gauge copper wire is 299,792,458 meters per second x 0.951 or 285,102,627 meters per second. This is about 280,000,000 meters per second which is not very much different from the speed of electromagnetic waves (light) in vacuum.

10.12 Electrical circuits

Electrical circuits provide a means of guiding the transfer of electromagnetic energy (power) via charge carriers in the conductive conduit (i.e., the wire/circuit path).

Electrical circuits in which charges oscillate continuously (alternating currents) will continuously produce both:

1. EM energy through the wire/circuit path, and
2. EM energy that takes the vector path of the magnetic field.

> **DEFINITIONS: Reactance** *is the opposition of a circuit element to a change in current or voltage, due to that element's inductance or capacitance. A built-up electric field resists the change of voltage on the element, while a magnetic field resists the change of current. The electrical* **resistance** *of an electrical conductor is a measure of the difficulty to pass an electric current through that conductor. An ideal resistor has zero reactance, whereas ideal inductors and capacitors have zero resistance – that is, respond to current only by reactance. Note that The magnitude of the reactance of an inductor rises in proportion to a rise in frequency, while the magnitude of the reactance of a capacitor decreases in proportion to a rise in frequency (or increases in proportion to wavelength). As frequency goes up, inductive reactance goes up and capacitive reactance goes down.*

10.13 Voltage

A voltage (electromotive force) is required for charges to flow as an electric current. If the voltage difference between two points is zero, there can be no net current between the two points. In other words, charges will flow (as electrical current) through a conductor by applying a voltage across two separated points. The amount of current that flows when voltage is applied is known as amperage.

> **ANALOGY:** *If you have a garden hose and you are trying to push water through it (voltage), you can push as much as you want, but there is a limited amount of flow because the hose is a particular size. Increase the size [of the conduit] and you can increase the amount of flow (amperage).*

Voltage (a.k.a., electric potential difference, electric pressure, electric tension, or electromotive force) is the difference in electric potential energy between two points per unit electric charge. Therein, electrical potential energy is the energy that a charge has when it is at a certain location in an electric field. Each potential difference in a system describes the system's ability to do work. The voltage between two points is equal to the work done per unit of charge against a static electric field to move the test charge between two points and is measured in units of volts (joule per coulomb). A voltage may represent either a source of energy (electromotive force), or lost, used, or stored energy (potential drop). An electromotive force (EMF) is a force that causes electrons (electricity) to flow in a conductor. In a power system, voltage is a measure of the "strength" of an electrical supply.

> **NOTE:** *The higher the voltage, the stronger the electric field.*

Voltage is similar to pressure -- the presence of a potential difference (pressure gradient) drives the electric current, just as the pressure of a pump drives a flow of water. Hence, voltage could be called electrical pressure.

Voltage exists if charges are moving [through] a distance. It is sometimes said that a voltage may exist even when no current is flowing. For example, a disconnected battery has a voltage between its terminals, but because it is disconnected there is no current between the terminals. However, to determine the presence of voltage one must first establish a current; current is required to get/measure voltage. Thus, it is somewhat inaccurate to state that voltage drives the current. From this view, it could be said that a potential difference does not "drive" the current; instead, coulomb force and/or energy is what drives the current. Therein, coulomb force (on a charge) and/or energy can be directly calculated from the potential difference.

> **NOTE:** *Besides superconductors, which can maintain eddy currents flowing in rings with no externally supplied voltage, there can't be currents without voltages, because if there is a current there is a charge moving due to the presence of an electromotive force.*

Unless there is a difference in charge between two points, no field can be established, and hence there is no potential.

The electric charges will gather at the two poles. Positive charges at the cathode and negative charges at the anode. If the two electrodes are not connected by an external conductor they will not be able to leave the surface of the electrodes and they simply accumulate over there producing an open circuit voltage. As soon as the two electrodes are connected by a conductor the charges will flow by the forces of the electric field in the appropriate direction. If the connecting wire has no resistance or almost zero resistance then it will be a short circuit and a huge current will flow only limited by the internal resistance of the battery. If the electrodes are connected by a conductor through a resistance then the current will be limited according to the Ohm's law.

- current (I) = V / (R+r)
- where,
  - I is the current
  - V is the voltage between the electrodes
  - R is the external resistance
  - r is the internal resistance of the battery

In a battery, the electric field is maintained by the chemical reaction. When connected to a conductor, the charges move through the conductor since it is the path of least resistance.

> **ANALOGY:** *The flow of water through a pipe does depends principally on the pressure difference at the two ends. The flow of charge through a conductor does depends principally upon the charge (pressure) difference at the two ends. It is the pressure (voltage) difference between the two endpoints matters that is of principal significance.*

If electrical work can be done (i.e., there is electrical power), then there is a voltage -- voltage has units of J/C (joules per coulomb). Voltage is expressed and calculated as the difference in electrical energy between two points [in space] per unit electric charge. Voltage is electric [potential] energy per unit charge, measured in joules per coulomb (= volts).

- Voltage (V) = *energy* in joules (J) / *charge* in coulombs (C)
- Voltage (V) = joule (J) / coulomb (C)
- 1V = 1J/C
- Potential = the *ability* to do work.
- Electric potential is the <u>ability to do [electrical] work</u> per electric unit.

- similarly, the electric field is electric force per charge. E = f/q \ f=qE

Notes on voltage:

1. The word “drop” in the term ‘voltage drop’, comes from the analogy of current being the flow of water and each difference in height that makes the water flow is a drop, a voltage difference. So voltage drop is just a difference in voltage across a component that makes a current flow.
2. A “voltage difference” is the electric potential difference between two points on the circuit, and the current flows in a direction in which the potential difference can be minimized.
3. The second of Kirchhoff’s laws tell us that the sum of all the voltages in a circuit must be zero (so, in a simple circuit, the initial voltage from the battery minus all the voltage drops from all the resistors is zero).

11 Measurement constants and derived equations

WORKING GROUP CLARIFICATION: *Various units systems are encompassed in this section, ready for working group integration.*

Pressure is defined as force/area which is the same as momentum/area/time since F=dp/dt. Momentum flow would be the momentum passing through a unit area per unit time so it’s the same units.

- The physical units for heat are Watts (W), Joules/second (J/s) or calories/second (cal/s).
- Heat is measured in watts.
- Heat flow is designated by the symbol q (Watts/m^2).
- Electrical power is measured in watts.
- Power = work/time = J/s.
- Energy is in joules.
- Electrical power is watts.
- Heat is not energy, but power.

Energy (motion) transfers are denoted by:

- Q = Transfer by Heat (J)
- W = Transfer by Work (J)
- q = Specific Transfer by Heat (J/kg)
- w = Specific Transfer by Work (J/kg)
- J = Transfer by Heat per Second, or Power (J/s = Watts)
- W = Transfer by Work per Second, or Power (J/s = Watts)

Internal energies and enthalpies are denoted by:

- U = Internal Energy (J)
- u = Specific Internal Energy (J/kg)
- H = U + PV = Enthalpy (J/K)
- h = u + Pv = Specific Enthalpy (J/kg.K)
- $\dot{m}$ = mass flow rate (kg/s)

Single phase:

- Mechanically, power is calculated as leg pressure (Foot Pounds) times speed (Rotating Speed).
- Electrically, power is calculated as leg force (Voltage) times flow (Current).

Dual phase:

- Mechanically, power is calculated as leg pressure (Foot Pounds) times speed (Rotating Speed).
- Electrically, power is calculated as leg force (Voltage) times flow (Current).

Three phase:

- Mechanically, I’m not sure how to calculate the power.

- Electrically, power is calculated as cylinder force (Voltage) times flow (Current) times 1.732 (Square Root of 3).

For electric current:

- Coulomb = amount of electricity
- Coulomb = Ampere x Second
- 1 Coulomb = 1 Ampere • 1 Second
- 1C = 1A • 1s
- C = A • s

And,

- Coulomb = Farad x volt
- Coulomb = 1 Farad • 1 Volt
- 1C = 1F • 1V

11.1 Units of power

The unit of power is joules per second or J/s when work is measured in joules and time in seconds. The basic unit of power, 1 J/s is called a watt (W), named after James Watt who made important improvements to the steam engine. By definition, a watt is the consumption of one joule of energy per second. 1 W = 1 J/s

- Watts are units: units of power.
- A Watt is the unit of power.
- A Watt can be broken down further to the fundamental units of time, distance and mass.
- A Watt is 1 kg-m^2/s^3 in base SI units
- the power unit is 1 newton-metre/second, or 1 joule/second, this is 1 watt.
- A joule is a unit of work also known as force acting over a distance, i.e., F •d.
- Force is mass times acceleration, i.e., m•a.
- And acceleration is an exponential increase in distance over time, i.e., d/s^2.
- Watt = J/s = F•d/s = m•a•d/s = m•(d/s^2)•d/s = m • d^2 / s^3

- In metric that is kilogram•meter^2/second^3
- Or, generically, mass•distance^2/time^3 or ML^2/T^3
- A watt, as originally defined is volt²/ohm, the current dimensions are V²/R.
- If you use density-velocity-time, a watt = dv^5t^2.

Work Transfer:

- Work (J) = force (N) x distance (m)
- 1 Joule = 1 newton x 1 meter
- In units energy = joules (J)
- Work = joules (J)

Work is not a vector, but force and displacement are vectors.

- $W = {}^{+}F \times {}^{+}d$ - when force causes a displacement, work (energy) is positive (F x d = work)
- $W = {}^{+}F \times {}^{-}d$ - when force hinders a displacement, work (energy) is negative ($F \times {}^{-}d = {}^{-}$work).
- $W = {}^{+}F \times {}^{0}d$ - when force results in no displacement, there is no work (F x 0 = 0 work).

Secondly, work (W) is accomplished by a force (f) acting through a distance (d).

$W = \int f_i \cdot dx_i$ (i.e., Work = Force x Distance)

For a constant force; the work done formula as force x distance, only applies if you have a constant force:

$W = f_i \cdot \Delta x_i$

NOTE: *Mass is simply how much stuff there is in the object. No matter where you put an object in the universe without taking it apart or breaking it, the mass will always be the same. However, the weight changes. Weight is relative to the field in which the mass exists.*

11.2 Units of energy and power

In order to predict and account for "action", energy is a required quantification. In physics, action is an attribute of the dynamics of a physical/material system. Action is understood as a mathematical functional that takes the trajectory, also called path or history (memory), of the system as its argument and has a real number as its result. Generally, the action takes different values for different paths. Action has the dimensions of [energy]·[time\memory], and its SI unit is joule-second. This is the same unit as that of angular momentum.

Energy and power are measured in a variety of ways depending on the system (and scale) in which the measurement is occurring.

1. Energy determined to be contained in a system is called static form of energy (e.g. internal, kinetic, potential energies).
2. Dynamic forms of energy come from energy interactions, where energy crosses the system boundary during a process (e.g. heat transfer and work).

Electron volt (eV) is a unit of energy, not voltage. The amount of energy expressed when an electron is accelerated through a potential of 1 volt.

- e = charge on the electron = 1.6×10^{-19}C
- 1V = 1J/C
- eV = (1.6×10^{-19}C) x (1J/C) = 1.6×10^{-19} J

A measure of energy can be expressed/signified in the following ways (i.e., the direct release of energy is measured in units of):

- Electron-volt (eV) - A unit of energy equal to the work done on a charge ("electron") in moving it through a potential difference of one volt. An electron volt is defined as a unit of energy. An electron volt is the energy an electron gains when it is accelerated through a potential difference of one volt. Electron-volt scales: Nuclear energy scales are MeV; Chemical energy scales are eV.
- Joule or jule (J) = a unit of work (energy) equal to the work done when the point of application of a force of one Newton moves a distance of one meter, in the direction of the force. One joule is defined "mechanically" as the energy transferred to an object by the mechanical work of moving it a distance of 1 metre against a force of 1 newton (i.e., netwon-meter).
  - $1 J = 1 ((kg \cdot m^2) / s^2)$
- Watt-seconds or Watt-hour (KWh)
- Calorie
- Radiant energy units
- Heat units (e.g., British thermal units, BTUs)
- Electromagnetic energy units (SI electromagnetic units)
- Nuclear energy units
- Energy - The ability or potential to do work.
- Work - The transfer of energy from one carrier to another.
- No movement = no work.
- Power - The rate at which work is done and energy is transferred.

> **NOTE:** *A joule is a rather small amount of energy, roughly equal to the kinetic energy of a very gently tossed baseball, or to the gravitational energy that you give to a baseball when you lift it by 70 centimeters.*

The more Kilowatts used, the more energy that's being used up.

A kilowatt is 1,000 watts; one watt is the same as one Joule per second (J/s). Which is confusing, since J/s mentions a time frame (second) but it doesn't compare to kWh (which mentions hours, but isn't about time).

Watts cannot be converted to amps, because watts are power and amps are coulombs per second.

If you have at least two of the following, then the missing one can be calculated: amps, volts, watts.

- Watts = amps x volts
- Current = wattage / voltage
- Voltage = wattage / current

Amps are how many electrons flow past a certain point per second. It is equal to one coulomb of charge per second, or 6.24 x 10^18 electrons per second. Volts is a measure of how much force that each electron is under, which we call "potential". Power (watts) is volts times amps. A few electrons under a lot of potential can supply a lot of power, or a lot of electrons at a low potential can supply the same power.

11.3 Energy and work relationship

Energy is substance-like, and work is a transfer mode of that substance. However, energy and work are the same unit of measure although they are not necessarily measuring the same thing.

- Linear kinetics
  - Work = Δtotal mechanical energy
  - Assuming a rigid body that cannot store elastic energy:
  - $Fd = \Delta(.5mv^2 + mgh)$
  - $Fd = \Delta.5mv^2 + \Delta mgh$
- $F = ma$
  - $Work = m(.5v^2)$
- Angular kinetics
  - Work = Δenergy
  - $Fd = \Delta.5mv^2$
  - $\tau\Theta = \Delta.5I\omega^2$

A watt is a watt is a watt whether it's electrical or mechanical or chemical.

> **QUESTION:** *How much energy is the something (e.g., a bulb) using? That depends on time -- how long it is operating.*

11.4 Kinetic energy systems

- Energy = .5 mass (m) · velocity (v)^2

11.5 Potential energy

- Potential energy is often thought of as "stored" kinetic energy, meaning that bodies remain stationary in a potential field while held in place by some force, and upon change in this force (such as breaking the twig holding an apple, or breaking the bond between two atoms), potential energy is converted to kinetic form (the apple "falls" or the molecule "dissociates").
- Gravitational potential energy
  - Energy = mass (m) · gravity (g) · height (h)
- Units: Joules

Gravitational potential energy - energy contained in an object due to its vertical position above the plane of the Earth.

- Gravitational potential energy (PE) = m x g x h

- Where m=mass, g = gravitational constant $9.8m/s^2$, h=height
- g is known as the gravitational constant. It measures the strength of the Earth's gravitational pull on falling objects. Falling objects accelerate downwards at a rate of $9.8m/s^2$

Gravitational potential - potential energy per mass.

- PE/mass = (m x g x h) / m

Gravity analogy:

1. Two points in space at the same height\coordinate have zero potential difference.
2. 2. $\Delta\Phi := \Phi(x_2,t0) - \Phi(x_1,t0)$
    A. A falling rock - A 1 kilogram rock (unit mass) can transfer more gravitational potential energy to kinetic energy if it "falls" off the side of a 100 metre ledge than if it falls off a 10 metre ledge.
    B. A falling electron - Similarly, a 1 coulomb charge (unit charge) can transfers more energy if it "falls" through an electrical potential difference of 100 volts than if it falls through 10 volts.
    C. The rock "falls" through a gravitational potential difference and the coulomb "falls" through an electrical potential difference.

11.6 Total energy

Total energy, E. Energy can generally be divided into two groups:

1. Macroscopic: energy a system possesses as a whole with respect to some outside reference frame., such as kinetic energy (KE) and potential energy (PE).
2. Microscopic: energy related to the molecular structure of a system and the degree of the molecular activity, and they are independent of an outside reference frame. The sum of all forms of microscopic energy is called the internal energy, U, of the system.

The **internal energy** of a system is comprised of:

1. Sensible energy: the portion of internal energy associated with the kinetic energy of molecules (i.e. translational, rotational, and vibrational kinetic energies).
2. Latent energy: intermolecular forces between the molecules of a system.
3. Chemical (or bond) energy: internal energy associated with atomic bonds in a molecule. During combustion processes, atomic bonds are broken and new ones are formed, altering the internal energy of the system.
4. Nuclear energy: energy harnessed from the bonds within the nucleus of an atom.

Mechanical work is defined by the relation w = Fdx, where w = work is done, F is force, x is displacement, and the subscripts i and f denote the initial and final states respectively. Similarly, mechanical power is defined as P = Fdv where P is power delivered and v is velocity. Barring, special energy considerations (e.g. magnetic, chemical, surface-tension, etc ...), the total energy of a system can be expressed as:

- E = U + KE + PE

11.7 Internal energy

Internal Energy (E) measures the energy state of a system as it undergoes chemical and/or physical processes. Like other thermodynamic variables, internal energy exhibits two important properties:

1. It is a state function, and
2. it scales as an extensive.

Being a state function means that E has the following property:

- E = Ef - Ei

The relationship between the internal energy of a system and its heat and work exchange with the surroundings is:

- E = q + w

11.7.1 Energy

- Energy = force x distance
- Force = pressure x area
- Distance = volume / area
- Energy = pressure x volume (psig x cu-in = in-lbs)

11.7.2 Work

Mechanical work is:

- Work is scalar.
- Work is Joules.
- Mechanical work is force through a distance (displacement):
    - W is the work done, F is the force, d is the displacement, and · indicates the dot product.
    - Work (W) = Force (F) · distance (x)
    - $W = \int F \cdot x$
    - $W = F \times d \times \cos\Theta$
    - Units: Joules (do not use N.m)
    - Force (newton) = mass x acceleration
    - A force has both magnitude and direction, making it a vector quantity. It is measured in the

SI unit of newtons.

- The unit of power is the joule per second (J/s), known as the watt, named confusingly after James Watt.
- The mechanical shaft power P in Watts applied to a generator is given by:
  - $P = \omega T$
  - Wherein, ω is the speed in radians per second and T is the torque in Newton meters.
  - Therein,
  - Work = torque x revolutions

11.7.3 Mechanical energy

Mechanical energy is:

- Mechanical energy = Kinetic energy + Potential energy
- Mechanical energy = $1/2mv^2 + mgh$

11.7.4 Mechanical pressure

Mechanical pressure is:

- Pressure is defined as the normal force exerted by a fluid per unit area. Pressure can exist, even if no work is being done -- pressure has units of N/m^2 (Pascal as newtons per meter squared).
- The basic unit of mechanical pressure is the newton per square metre.
- Pressure (P) = force/area
- 1 Pa = $1N/m^2$

The pascal (symbol: Pa) is the SI derived unit of pressure used to quantify internal pressure, stress, Young's modulus and ultimate tensile strength. It is defined as one newton per square metre.

NOTE: *The flow of momentum is pressure.*

11.7.5 Mechanical power

- Mechanical power (P) is the quotient of mechanical work (A) by time (t).
- P = mechanical work (A) / time (t) = (F x s) / t
- The SI unit of measurement is watts (W).
- Rotational mechanical power is torque (T) and angular velocity (ω) (see Rotational speed).
- $P = T\omega$

11.7.6 Mechanical and fluid systems

In these systems, 'work' is another word for 'energy'. Work (W) = Force (F) · distance (x)

- Unit of force = Newton
- 1 Newton accelerates a mass of 1 kg. by 1 m/s2 (in case of no friction).
- A mass of 1kg on earth experiences a gravitational force of 9,8 Newton.
- Unit of work (energy) = Joule
- 1 Newton moves an object over 1 meter, the required amount of energy is 1 Joule.

NOTE: *Torque is force at a distance. Torque is a pseudovector (equivalent to a mathematical bivector in three dimension); energy is not. A pseudovector is distinguished it from a true polar vector. The units for torque are Newton-meters. Although this is algebraically the same units as Joules, Joules are generally not appropriate units for torque. Torque is usually given by rFsinθ, not just rF, unless the angle is always 90˚of course because sin90=1.*

11.8 Electrical systems

Energy is a quantity indicating the capacity to do work.

- Energy = Power x Time

Power is the rate at which work is done.

- Power = Energy / Time

Voltage exists if charges are moving [through] a distance. Voltage is electric [potential] energy per unit charge, measured in joules per coulomb (= volts).

- Voltage (V) = *energy* in joules (J) / *charge* in coulombs (C)
- Voltage (V) = joule (J) / coulomb (C)
- 1V = 1J/C
- Potential = the *ability* to do work.
- Electric potential is the <u>ability to do [electrical] work</u> per electric unit.
- Similarly, the electric field is electric force per charge. E = f/q \ f=qE

Electric potential energy - work required to move a charge.

- $F = (k\ 0_1 0_2)/d^2$

Electric potential - The electric potential Φ refers to a quantity with some numeric value. Expresses the effect of an electric field of source in terms of the location within the electric field.

- Φ = PE / q

Electric potential difference (ΔV) - the difference in electric potential (V) between the final and inital location when work is done upon a charge to change its PE.

- $\Delta V = V_B - V_A$ = work/charge = ΔPE/charge

The analog is:

- Volts (V) = Height or head (H)

- Charge (q) = mass m
- Current I = Δq/Δt = rate of mass flow Δm/Δt
- Power = VI = ghΔm/Δt
- Energy = VIdt = Vq = ghm // Energy is the time integral/sum of power.

11.8.1 Electrical work

Electrical work is:

- We = VI
- V = Voltage
- I = current
- We = VIΔt
- t = time
- Power = Energy/Time
- Energy = Power × Time
- Energy (J) = volts · charge in coulombs
- Power (w) = volts · amps
- The standard unit of electrical power is the Watt, which is defined as an [electric] current of one ampere, pushed by a voltage of one volt.
- Watt or kilowatt (watt/1000)
- Current (I) = charge in coulombs / time in seconds
- 1 W = 1J/s
- 1 kW = 1000 W = 1000 J/s
- 1 MW = 1,000,000 W = 1,000,000 J/s

Electric current is measured in coulombs per second (amperes or amps; A).

- 1 Ampere is equal to 1 Coulombs per second.

Current is rate of change in the electric field:

- current (I) = Δq/Δt
- wherein, q=charge

11.8.2 Volt

The volt is defined as the energy transfer per coulomb of charge as charges move between two points in a circuit.

- V = ΔW / ΔQ
- i.e. energy change per unit charge (so that 1 V = 1 J C-1)

11.8.3 Power

Power is equated in multiple ways:

- Power = energy / time (Units: Watts (J/s))
- Power = pressure x volume/time
- Power = Δwork / Δtime
- Power = (force x Δdistance) / Δtime
- Power = force x velocity
- Power = energy/time
- Power = work/time
- Power = (force x distance)/time
  - Distance/time = speed
- Power = force x (distance/time)
- Power = force x speed

11.8.4 Fluid power system

Power in fluid systems is equated in multiple ways:

- Force (F) = pressure (P) · area (A)
- Pressure (P) = Force (F) / area (A)
- Fluid pressure (P) = force (F) / unit area (A)
- Fluid flow rate (Q) = volume (V) / unit time (A)
- Fluid power = pressure (P) x flow rate (Q)

11.8.5 Fuel systems

Fuel systems create, store, and use fuel. A fuel is any material that can be made to chemically and/or atomically react with other substances so that it releases electromagnetics that produce thermal changes among materials and may thus be used for work.

In fuel systems, energy density is key. Energy density is the amount of energy stored in a given system or object, per unit [of object] volume.

Herein to understand fuel systems and energy density it is necessary to define,

1. 'Mass' is the counted atoms of matter (the quantity of atoms, elements, chemicals, substances).
2. 'Volume' is measured as a 3D coordinated area.
3. 'Energy' is measured as a of potential or actual electromagnetic [torque] transfer.

11.8.6 Battery systems

The formula for the power output (P) of a battery is:

- $P= VI - RI^2$
- P = V I − R I 2
- where,
  - V is the electromotive force in volts,
  - R is the resistance in ohms, and
  - I is the current in amperes.

11.8.7 Pressure system

- Energy = pressure · volume
- Pressure = Force/ area unit

11.9 Unit conversion factors

Data and measurements may be expressed in any units, usually chosen for convenience of size. But when this data is used in physical equations, it must be converted to the units required by the coherent system chosen.

Units must also be converted when translating from one coherent system to a different one.

Unit conversions begin with equations which relate sizes of units, for example: 1 meter = 3.28 feet. This equation states that the measurement "1 meter" is equal (equivalent to) the measurement "3.28 feet." To write simply 1=3 would be incorrect.

Equations relating measurements are manipulated by the ordinary rules of algebra, and the units are carried along according to the same rules. For example, if both sides of Eq. (3) are divided by 1 yard, the result is:

- 1 = 3 feet / 1 yard = 3 feet/yard
- 1 = 3 feet/yard

This last expression represents an identity relation for measurements. It is called a 'conversion factor'. In algebra it is often convenient to multiply an expression by another expression which is equal to one. When doing unit conversions, expressions may be multiplied by conversion factors, since they are physically equal to one.

Conversion factors for energy units:

- 1 kWh = 3,413 Btu
- 1 kWh = 3,600,000 joules
- 1 joule = 1 watt-second
- 1 joule = 1 Newton-meter
- 1 Btu = 1,055 joules
- 1 Therm = 100,000 Btu = 29.3 kWh
- 1 calorie = 4.184 joules
- 1 Btu = 252 calories

Conversion factors for power units:

- 1 watt = 1 joule/second
- 1 watt = 3.413 Btu/h
- 1 Btu/h = 0.2931 watt
- 1 kW = 1,000 watts
- 1 megawatt (MW) = 1,000,000 watts
- 1 kW = 3,413 Btu/h
- 1 ton of cooling = 12,000 Btu/h
- 1 horsepower (electric) = 746 watts

Guide for common fuels:

- Natural gas: 1,000 Btu/cu. ft.
- Propane: Between 91,333 Btu/gallon and 93,000 Btu/gallon
- Fuel oil: Between 138,700 Btu/gallon and 140,000 Btu/gallon
- Kerosene: Between 120,000 Btu/gallon and 135,000 Btu/gallon
- Gasoline: Between 114,000 Btu/gallon and 125,000 Btu/gallon
- Coal: 25,000,000 Btu/ton
- Seasoned dense hardwood firewood: Between 21 and 26 million Btu/cord
- Seasoned pine firewood: Between 14 and 16 million Btu/cord

Conversion factors used for measuring natural gas:

- 1 ccf ("centi- cubic feet") = 100 cubic feet
- 1 cubic foot of natural gas = 1,000 Btu = 0.01 Therm
- 1 Therm = 1 ccf of natural gas = 100,000 Btu = 29.3 kWh

Conversion factors for air pressure units:

- 1 atmosphere = 14.7 lb./sq. in. = 760 mm. of mercury = 406.78 in. of water = 101,325 Pascals
- 1 Pascal = 0.00401 in. of water
- 1 lb./sq. in. = 6,894.76 Pascals
- 1 lb./sq. ft. = 47.88 Pascals

> **NOTE:** *In the market, electrical energy is a measurable quantity that can be bought by the kilowatt-hour (KWh).*

> **NOTE:** *Energy density = electron-volt per cubic centimeter of space, or eV/cm^3*

> **NOTE:** *The basic quantity of electric charge is the electron. Conversely, electromagnetic waves have no charge.*

In the SI system of units, the joule (J) is a unit of energy, but the electron-volt (eV) is the traditional unit used in ion-solid interactions: 1 eV is defined as the kinetic energy gained by an electron accelerated through a potential difference of 1V. The electron-volt is a unit of energy. The definition of an electron volt is the kinetic energy a single electron acquires when moving through an electric potential of 1V. The charge on the electron is 1.602x10^{19} J. Commonly used multiples of the electron-volt are the kilo-electron-volt (10^3 eV) and the mega-electron-volt (10^6 eV).

Energy density units for problems involving thermodynamic analysis are typically in the form of joules per mole, where a mole (mol) represents Avogadro's number of particles or molecules: N_A = 6.02 x 10^{23} particles/mol.

Joule as a measure of energy. In particle physics, however, we use something more convenient called electron volt (eV) instead.

An electron-volt (eV) is the energy or work required to move an electron against a potential difference of one volt.

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Table 7. Measurement > Quantity > Length*: Spatial length accounting for function.*

Space Used	Surface area required m^2/person	Number of levels	Project area m^2	Estimated height,m	Volume m^3
Dwelling					
Assembly					
Recreation					
Entertainment					
Storage					
Transportation					
Park					
Waste and water treatment and recycling					
Electrical supply and distription					
Cultivational areas					
Mechanical subysystems					
Communications system					
...					

Table 8. Measurement > Quantity*: Quantities per area unit.*

Quantities	Per area	units	
Density of magnetic induction	Φ/A	per cm^2	
Density of dielectric induction	(Q)/A	per cm^2	
Density of electrification	(x)/A2	per cm^4	
Formula	**Type**	**Unit label**	**Description**
x/T = W	Work or energy	Joule	Quantity of electrification varied with respect to time. In time its quantity changes and that is called work or energy. Note that energy is a derivative and does not have a primary existence.
Φ/T = E	Electromotive force	Volt	Total quantity of magnetism varied with respect to time. A volt is the rate at which magnetism is produced or consumed in an electrical system.
x/T = I,	Magnetomotive force	Ampere	Total quantity of dielectrification (produce or consume a dielectric field) and vary that with respect to time.
Q/T^2=P	Power or activity	Watt	Quantity of electricity (the product of Φ•x=Q) and vary it to the time squared.
Φ/I = L	Magnetic inductance	Henry	Magnetism compared to how much current required to produce it.
x/E = C	Dielectric capacity	Farad	For every quantity of dielectric field there has to be a certain amount of electromotive force that gives rise that field.
E/I = Z	Impedance	OHM	
I/E = Y	Admittance	Siemens	
L/T = R	Resistance, Henry per second	OHM	
C/T = G	Conductance, Farad per second	Siemens	
L • C = T^2 ($time^2$)	$^2\sqrt{LC} = T = F^{-1}$	$Hertz^{-1}$	Time rate of energy exchanged from the magnetic and dielectric field as they constantly dump one into another

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Table 9. Measurement > **Electricity**: *Electricity and magnetism physical units.*

Physical Units: Electricity And Magnetism						
Quantity and Definition	Electro-static (esu)	emu/esu	Electromagnetic emu	MKS/emu	Rationalized MKS	esu/MKS
Charge (Q)	statcoulomb	1/c	abcoulomb	10	coulomb	c/10
Current I = Q/t	statampere	1/c	abampere	10	ampere	c/10
Potential V = W/Q	statvolt	c	abvolt	10^{-8}	volt	10^{8}/c2
Resistance R=V/I	statohm	c^{2}	abohm	10^{-9}	ohm	10^{9}/c2
Capacitance C = Q/V	statfarad	$1/c^{2}$	abfarad	10^{-9}	farad	10^{6}/c
Electric field strength E=F/Q=V/s	dyne/statcoulomb = statvolt/cm	$1/c^{2}$	abvolt/cm	10^{-6}	volt/meter	10^{6}/c
Magnetic flux	erg/ statampere	c	maxwell	10^{-8}	weber = volt x sec	10^{8}/c
Magnetic induction	dyne/ (statamp x cm)	c	gauss	10^{-4}	weber/meter2	10^{4}/c
Magnetic field intensity	statampere/cm	1/c	oersted	10^{3}/4pi	ampere/meter	12pi10^{7}
Inductance	stathenry = statohm x cm	c^{2}	abhenry	10^{-9}	henry	109/c^{2}

Table 10. Measurement > **Quantity** *Sub-conceptualizations (as a classification scheme) of the concept, 'quantity'.*

Sub-concepts [for the concept 'quantity']		Sub-conceptual application
length, l	radius, r	radius of a circle A, r_A or r(A)
	wavelength, lambda	wavelength of the sodium D radiation, λ_D or λ(D; Na)
energ, E	kinetic energy, T	kinetic energy of particle i in a given system, T_i
	heat, Q	heat of vaporization of sample i of water, Q_i
electric charge, Q		electric charge of the proton, e
electric resistance, R		electric resistance of resistor i in a given circuit, R_i
amount-of-substance concetration of entity B, c_B		amount-of-substance concentration of ethanol in wine sample i, c_i(C2H5OH)
number concentration of entity B, C_B		number concentration of erythrocytes in blood sample i, C(Erys; B_i)
Rockwell C hardness (150 kg load), HRC(150 kg)		Rockwell C hardness of steel sample i, HRC_i (150 kg)

Table 11. Measurement > **Units**: *Energy and power in base formula.*

Type	Symbol	Description	In Water	In Electrical Energy	Base Units
Energy	E	The ability to do work	Power=Current*Pressure (P=Q*H)	Power=Current*Voltage (P=I*V)	kg•m^2/s^3
Power	P	Rate at which work is done	Energy=Power*Time (E=P*t)	Energy=Power*Time (E=P*t)	kg•m^2/s^2

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Table 12. Measurement > Metrological: *Metrological units.*

	Units						
Descriptive Elements	Second (s)	Kilogram (kg)	Candela (C)	Kelvin (K)	Ampere (A)	Meter (m)	Mole (mol)
Measures	**Time**	**Mass**	**Luminous intensity**	**Temperature**	**Current**	**Length**	**Amount of substance**
Requires / Based Upon	Hyperfine-transition frequency of the caesium-133 atom (ΔVCs)	Planck's constant (h)	Luminous efficacy of monochromatic light of frequency 540 x 10^{12}Hz and a radiant intensity of 1/683 watts per steradian (Kcd)	Boltzmann's constant (k)	Charge on the electron (e)	Speed of light in a vacuum (c)	Avogadro's constant (N_A)
Definitions / Constant Used	Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133	One kilogram is Planck's constant divided by 6.626 070 15 x 10^{-34} $m^{-2}s$	Luminous intensity of a light source with frequency 540 x 10^{12} Hz and a radiant intensity of 1/683 watts per steradian	Equal to a change in thermal energy of 1.380 649 x 10^{-23} joules	Electric current corresponding to the flow of 1/(1.602 176 634 x 10^{-19}) elementary charges per second	Length of the path traveled by light in a vacuum in 1/299,792,458 seconds	Amount of substance of a system that contains 6.022 140 76 x 10^{23} specified elementary entities

Table 13. Measurement > Energy: *Common units of energy.*

Common Units Of Energy And Power	
Energy	Power
joule	joule/sec
calorie	calorie/min
Btu	Btu/hour
watt-hour	watt
kilowatt-hour	kilowatt
orange	orange/day

Table 14. Measurement > Motion: *Linear and rotational motion as speed and force.*

	Speed	Force
Linear motion	speed s	force f
Rotational motion	angular speed ω	twisting force τ

Table 15. Measurement > Units > Transfer: *Conserved quantities and rates of transfer.*

Conserved Quantity		Rate of Transfer	
Name	Units	Name	Units
energy	joules (J)	power	watts (W)
momentum		force	newtons(N)
angular momentum		torque	newton-meters

Table 16. Measurement > Units: *Linear and rotational work and power.*

System	Work	Power
Linear	W = F x d	P = W/t P = F x d/t = F x v
Rotational	W = T x Θ	P = W/t P = T x Θ = T x ω

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Table 17. Measurement > Units*: Generalized table of units of function.*

Description	Energy	Work	Force	Power	Pressure
Measured in units called			Force & torque are measured	Calculated	
Instrument of measurement is a			Dynamometer		Manometer
Has or does not have subcategories	Yes. Two primary forms (kinetic & potential). Multiple forms and types.	Manager...just joking.	Yes. Mechanical contact forces - normal, applied, friction, tension, spring, resisting. Electromagnetic force. Gravitational force. Nuclear force(s). Mechanical twisting force - torque. In mechanics, forces cause linear motion, torques cause rotational motion. Curved motion has centripetal and centrifugal force (and coriollis force).	Yes. Electric, mechanical, fluid, thermal.	No.
Formula(s)		Work = Force x Displacement	Force = Mass x Acceleration (Or) Force = dP/dt (change in momentum by time)	Power = work done/ time taken	
Definition	Measure of ability to do work. It doesn't mean work is being done, but that work can be done.	Change in energy via force. As a result of application of the force, if the configuration of the system changes, the measure of the same is the work done (force into displacement).	An influence that interacts to change the motion of an object. Cause of change in state of motion.	Rate of energy transfer by doing work. Power is the rate of doing work or expending energy. Rate of work done or the rate of energy release.	
Definition with respect to motion	Energy is the magnitude of stress, introduced in universal medium during work.	Work is the magnitude of distortions, introduced in universal medium about a 3D matter-body.	Force is matter-content times rate of change of work-done or rest mass times acceleration.	Power is temporal rate of work-done during acceleration.	
Value type	Scalar (given that work is scalar). Conserved.	Scalar (scalar but no direction)	Vector (direction) and magnitude	Since Energy and Time are both scalars, Power is a scalar also.	Scalar (magnitude and no direction)
Observable when?		When energy transfers.			
Linear motion		W = FΔ x or W = f x dx		P = Fv	
Rotational motion		W = tΔ0 or w = t x d0		P = tw	
Curved motion					

Figure 6. Measurement > Month Units*: All the months in the international fixed calendar system look like this.*

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

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Table 18. Measurement > Dimensionality*: Table shows electrical dimensions.*

Note here that there is disagreement over the naming of the electric field. Steinmetz eliminated the use of the term "electric field", and instead, called it the 'dielectric field'. The usage of the term 'magnetic field' is not in disagreement. In Steinmetz's electrical theory, electricity has to be the product of total magnetization times total dielectrification. If it is just one or the other it is not electricity. Hence, a charged capacitor with a total dielectrification and no total magnetization is not electricity. It is only when the energy of each is exchanged in a cyclic process that electricity is appears. In the days of Franklin, metals were called non-electrics because they destroyed the [di]electric field. Energy can be taken apart and put back together. Dimension - one of a group of properties whose number is necessary and sufficient to determine uniquely each element of a system of entities. The misuse of the word dimensions arrives when the term is defined as directional measurement or number of coordinates (i.e., 3 dimensional space). In reality, space is a single dimension (i.e., there exists, only the dimension of space). Space-time then is the relation of two distinct dimensions: the single dimension of space and the single dimension of time. For instance, velocity is expressed as the ratio of the dimension of space to the dimension of space (distance/time=velocity). Thus, velocity is expressed as a two dimensional relationship. Capacitance is a type of electrical energy storage in the form of field in an enclosed space. This space is typically bounded by two parallel metallic plates or two metallic foils on an intervening insulator or dielectric. A nearly infinite variety of more complex structures can exhibit capacity, as long as a difference in electric potential exists between various areas of the structure. The oscillating [tesla] coil represents one possibility as to a capacitor of more complex form, and will be presented here. All the lines magnetic force are closed upon themselves. All the lines of dielectric force terminate on conductors, but may form closed loops in electromagnetic radiation (EMR). Any line of force cannot just end in space. Inductance represents energy storage in space as a magnetic field. The lines of force orientate themselves in close loops surrounding the axis of current flow (magnetism scraping on the wire) that has given rise to them. The large the space between this current and its images or reflections, the more energy that can be stored in the resulting field. Inductance in electronics is electrical inertia. quantity dimensions vs. space and time as metrical dimensions.

Quantity in undivided form		
q	Total Electrification	Plank
Φ	Total Magnetization (outerspace aspect of dielectricity)	Weber
Ψ	Total dielectrification (innerspace aspect of dielectricity)	Coulomb
Basic relationship		
q/Ψ = Φ	Magnetic induction	Weber
Φ x Ψ = q	Magnetism and dielectricity are the two components of electricity	Plank
q/Φ = Ψ	Dielectric induction	Coulomb
Derivatives of quantity by space, A		
Φ/A =	Density of magnetic induction	per cm^2
Ψ/A =	Density of dielectric induction	per cm^2
q/A^2 =	Density of electrification	per cm^4
Derivatives of quantity by time, t		
q/t = W	Work or Energy *The quantity of electrification varied with respect to time. Energy does not have a primary existence. Energy is a derivative.*	Joule
Φ/t = E	Electromotive force *The quantity of magnetization (magnetic field) varied with respect to time. A 'volt' is the rate at which magnetism is produced or consumed in an electrical system.*	Volt
Ψ/t = I	Magnetomotive force *The quantity of dielectrification varied with respect to time (i.e., a dielectric field is either produced or consumed, and it is varied with respect to time.*	Ampere
q/t^2 = P	Power or/of Activity	Watt
Proportionality		
Φ/I = L	Magnetic inductance	Henry
Ψ/E = C	Dielectric capacity	Farad

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E/I = Z	Impedance	Ohm
I/E = Y	Admittance	Siemens
Density of decay		
L/T = R	Resistance - *The destruction of energy in an electrical system in Henrys per second.*	Ohm
C/T = G	Conductance - *The creation of energy in an electrical system in Farads per second.*	Siemens Mho
$LxC=t^2$	$^2\sqrt{LC} = t = F^{-1}$ *Frequency of oscillation (time rate between the two fields as they "dump" into one another.*	$Hertz^{-1}$

Table 20. Measurement > Units*: Fundamental (base) quantities, dimensions, and units.*

Dimension type	Name of physical quantity	Unit name	Symbol / Abbreviation
Temporal dimension	Time	Second, Month	s, month
Linear dimension	Length	Meter (Metre)	m
Matter dimension	Mass	Gram (Gramme)	g
Electric dimension	Electric current	Ampere (formerly known as Intensity)	A
Thermodynamic dimension	Temperature	Kelvin	K
Atomic mass dimension	Atom[ic amount of substance]	Mole	mol
Inductive illumination dimension	Illumination	Candela	cd

Table 19. Measurement > Units*: The expression of kinematical units in terms of units of energy.*

Quantity	Dimension		Conversions
	SI Units	Natural Units	
Mass	Kg	E	1 GeV = 1.8×10^{-27} kg
Length	M	1/E	1 GeV-1 = 0.197×10^{-15} m
Time	S	1/E	1 GeV-1= 6.58×10^{-25} s
Energy	Kg m^2/s^2	E	1 GeV = 1.6×10^{-10} Joules
Momentum	kg x m/s	E	1 GeV = 5.39×10^{-19} kg x m/s
Velocity	m/s	None	1 = 2.998×10^{8} m/s (c)
Angular momentum	kg x m^2/s	None	1 = 1.06×10^{-34} J x s (ħ)
Cross-section	m^2	1/E2	1 GeV^{-2} = 0.389 mb = 0.389×10^{-31} m2
Force	kg x m/s^2	E2	1 GeV2 = 8.19×10^{5} Newton
Charge	C-As	none	charge C=A x s none 1 = 5.28×10^{-19} Coulomb; e=0.303=1.6×10^{-19} C

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Table 21. **Measurement > Units***: The most common SI derived units.*

[name] Derivation (derived quantity)	[label] Unit Name	Unit Symbol	Expression in terms of SI base units
dynamic viscosity	pascal second	Pa s	m^{-1} kg s^{-1}
moment of force	newton metre	N m	m^2 kg s^{-2}
surface tension	newton per metre	N/m	kg s^{-2}
heat flux density, irradiance	watt per square metre	W/m^2	kg s^{-3}
heat capacity, entropy	joule per kelvin	J/K	m^2 kg s^{-2} K^{-1}
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg K)	m^2 s^{-2} K^{-1}
specific energy	joule per kilogram	J/kg	m^2 s^{-2}
thermal conductivity	watt per metre kelvin	W/(m K)	m kg s^{-3} K^{-1}
energy density	joule per cubic metre	J/m^3	m^{-1} kg s^{-2}
electric field strength	volt per metre	V/m	m kg s^{-3} A^{-1}
electric charge density	coulomb per cubic metre	C/m^3	m^{-3} s A
electric flux density	coulomb per square metre	C/m^2	m^{-2} s A
permittivity	farad per metre	F/m	m^{-3} kg^{-1} s^4 A^2
permeability	henry per metre	H/m	m kg s^{-2} A^{-2}
molar energy	joule per mole	J/mol	m^2 kg s^{-2} mol^{-1}
molar entropy, molar heat capacity	joule per mole kelvin	J/(mol K)	m^2 kg s^{-2} K^{-1} mol^{-1}
exposure (X and y rays)	coulomb per kilogram	C/kg	kg^{-1} s A
absorbed dose rate	gray per second	Gy/s	m^2 s^{-3}

Table 22. **Measurement > Units***: SI Derived Units (a.k.a., Metric Derived Units).*

[name] Derivation (derived quantity)	[label] Unit Name	Unit Symbol
Area	Square metre	m^2
Volume	Cubic meter	m^3
Speed, velocity	Meter per second	m/s
Acceleration	Metre per second squared	m/s^2
Wave number	1 per meter	m^{-1}
Density, mass density	Kilogram per cubic meter	kg/m^3
Specific volume	Cubic meter per kilogram	kg/m^3
Current density	Ampere per square meter	A/m^2
Magnetic field strength	Ampere per meter	A/m
Concentration (of amount of substance)	Mole per cubic meter	mol/m^3
Luminance	Candela per square meter	cd/m^2

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Table 23. Measurement > Units: *Examples of SI derived units formed by using the radian and sterdian.*

Quantity	Unit Name	Unit Symbol
angular velocity	radian per second	rad/s
angular acceleration	radian per second squared	rad/s^2
radiant intensity	watt per steradian	W/sr
radiance	watt per square metre steradian	$W\ m^{-2}\ sr^{-1}$

Table 24. Measurement > Units: *The seven defining constants of the new SI and the corresponding units they define.*

Defining constant	Symbol	Numerical value	Unit
Hyperfine splitting of caesium	Δν (133Cs)hfs	9,192,631,770	$Hz = s^{-1}$
Speed of light in vacuum	c	299,792,458	$Hz = s^{-1}$
Planck constant	h	$6.626070040 \times 10^{-34}$	$J\ s = kg\ m^2\ s^{-1}$
Elementary charge	e	$1.6021766208 \times 10^{-19}$	C = A s
Boltzmann constant	k	$1.38064852 \times 10^{-23}$	$J\ K^{-1} = kg\ m^2$ s−2 K^{-1}
Avogadro constant	N_A	$6.022140857 \times 10^{23}$	mol^{-1}
Luminous efficacy	K_{cd}	683	$cd\ sr\ W^{-1} = cd\ sr\ kg^{-1}\ m^{-2}\ s^3$
The numerical values are taken from the 2014 CODATA adjustment without the present associated uncertainties (not applicable to Δν(133Cs)hfs and c) and may slightly change by 2018.			

Table 25. Measurement > Units: *Physical units as mechanics.*

Physical units: Mechanics			
Quantity and Definition	Metric cgs	Metric MKS	English PFS
Time	Second	Second	Second
Length	Centimeter	Meter	Foot
Mass	Gram	Kilogram	Slug
Velocity v=d/t	centimeter/second	meter/second	foot/ second
Acceleration a = v/t	$centimeter/second^2$	$meter/second^2$	food/ $second^2$
Force F = ma	gm x cm/ sec^2 = dyne	kg x $meter/sec^2$ = newton	Pound
Energy (Work) W = fd	gm x cm2/ sec^2 = erg	kg x $meter^2$/ sec^2 = newton	foot x pound
Power P = W/t	erg/sec	joule/sec = watt	foot x pound/ second
Momentum P = mv	gm x sec = dyne x cm	kg x meter/ sec = N x s	slug x foot/ second
Torque G = Fr	dyne x cm	newton x meter	pound x foot
Frequency	1/sec = hertz	1/sec = hertz	1/sec = hertz

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Table 26. Measurement > Units*: SI derived units with special names.*

[name] Derivation (derived quantity)	[label] Unit name	Unit Symbol	Expression in terms of other units	Expression in terms of SI base units
plane angle[b]	radian	rad		$m \cdot m^{-1} = 1$
solid angle[b]	Steradian	Sr		$m^2 \cdot m^{-2} = 1$
frequency	Hertz	Hz		s^{-1}
force	newton	N		m kg s^{-2}
pressure, stress	Pascal	Pa	N/m^2	m-1 kg s^{-2}
energy, work quantity of heat	Joule	J	N m	m^2 kg s^{-2}
power, radiant flux	Watt	W	J/s	m2 kg s^{-3}
electric charge, quantity of electricity	Coulomb	C		s A
electric potential, potential difference, electromotive force	volt	V	W/A	m^2 kg s^{-3} A^{-1}
capacitance	farad	F	C/V	m^{-2} kg^{-1} s^4 A^2
electric resistance	ohm	Omega	V/A	m^2 kg s^{-3} A^{-2}
electric conductance	Siemens	S	A/V	m^{-2} kg^{-1} s^3 A^2
magnetic flux	Weber	Wb	V s	m^2 kg s^{-2} A^{-1}
magnetic flux density	Tesla	T	Wb/m2	kg s^{-2} A^{-1}
inductance	Henry	H	Wb/A	m^2 kg s^{-2} A^{-2}
Celsius temperature	Degree Celsius	*C		K
luminous flux	Lumen	Lm	Cd sr	cd $\cdot m^2 \cdot m^{-2}$ = cd
illuminance	Lux	Lx	Lm/m2	cd $\cdot m^2 \cdot m^{-4}$ = cd $\cdot m^{-2}$
activity (of radionuclide)	Becquerel	Bq		s^{-1}
absorbed dose specific energy imparted, kerma	Gray	GY	J/kg	m^2 s^{-2}
dose equivalent	Sievert	Sv	J/kg	m^2 s^{-2}

Table 27. Measurement > Units*: Table of common unit systems.*

[Fundamental] Units in system	[Fundamental] Dimensions of system	Common name of system
Foot-pound-second (FPS)	Length-mass-time	English “system”
Foot-slug-second (FSS)	Length-mass-time	English “system”
Centimeter-gram-second (CGS)	Length-mass-time	Mechanical system
Meter-kilogram-second (MKS)	Length-mass-time	Mechanical system
Meter-Kilogram-second-ampere-kelvin-candela-mole	Length-mass-time-current-temperature-illumiination-amount-of-substance	SI
Meter-Kilogram-second-ampere-kelvin-candela-mole	Length-mass-time-current-temperature-illumiination-amount-of-substance	SI

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Table 29. Measurement > Units: *SI Units.*

Base Quantity	Base Unit	Symbol [for dimension]	Current SI constants	New SI constants
time	second	s	hyperfine splitting in Cesium-133	same as current SI
length	metre	m	speed of light in vacuum, c	same as current SI
mass	kilogram	kg	mass of international prototype kilogram (IPK)	Planck's constant, h
electric current	Ampere	A	permeability of free space, permittivity of free space	charge of the electron, e
temperature	Kelvin	K	triple point of water, absolute zero	Boltzmann's constant, k
amount of substance	mole	mol	molar mass of Carbon-12	Avogadro constant N_A
luminous intensity	candela	cd	luminous efficacy of a 540 THz source	same as current SI

Table 28. Measurement > Units: *Distance as US and Metric units systems.*

United States System	Metric System
1 mile = 5280 feet	1 kilometer = 1000 meter
1 mile = 1760 yards	1 hectometer = 100 meter
1 rod = 5.5 yards	1 dekameter = 10 meters
1 yard = 3 feet	1 decimeter = 1/10 meter
1 foot = 12 inches	1 centimeter = 1/100 meter

Table 31. Measurement > Unit > Function > Temperature: *Temperatures in Celsius and Kelvin for important states.*

Name (description)	Celsius	Kelvin
Absolute zero	-273.15 C	0 K
Freezing point of water	0 C	273.15 K
Avg. body temperature	37 C	310.15 K
Boiling point	100 C	373.15 K

Table 30. Measurement > Units: *Derived units.*

Name of quantity	Formula	Derived units
Area	length x breadth	metre-square (m^2)
Volume	length x breadth x height	metre-cubed (m^3)
Speed	distance/time	metre per second ($m\ s^{-1}$)
Pressure	Force/Area	Newton per metre squared (Nm^{-2}) Pascal (Pa)

Table 32. Measurement > Number: *Table showing type of number and its decimal representation.*

Type of number	Decimal Representation
Integer	1.00000000000000000000
Non-repeating fraction	0.25000000000000000000
Repeating fraction	0.12312312312312312312
Irrational number	1.41421356237309504880

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Table 34. **Measurement > Dimensionality**: *Order of magnitude in (Dimension: Length; Unit Meter).*

Section	Range (m)		Unit	Examples objects
	≥			
Planck length	-	10^{-35}	ℓ	Quantum
Subatomic	-	10^{-15}	am(10^{-18})	Electron
Atomic and cellular	10^{-15}	10^{-12}	fm	Atomic nucleus, proton, neutron
	10^{-12}	10^{-9}	pm	Wavelength of gamma rays and x-rays, hydrogen atom
	10^{-9}	10^{-6}	nm	DNA helix, virus, wavelength of optical spectrum
Human scale	10^{-6}	10^{-3}	μm	Bacterium, fog water droplet, human hair diameter
	10^{-3}	1	mm	Mosquito, golf ball, domestic cat
	10^{0}	10^{3}	m	Human, automobile, whale, buildings
	10^{3}	10^{6}	km	Mount Everest, length of panama canal, trans-siberian railway, large asteroid
Astronomical	10^{6}	10^{9}	Mm	Moon, Earth, one light-second
	10^{9}	10^{12}	Gm	Sun, one light-minute, earth's orbit
	10^{12}	10^{15}	Tm	Orbits of outer plants, solar system
	10^{15}	10^{18}	Pm	One light-year, distance to Proxima Centauri
	10^{18}	10^{21}	Em	Galactic arm
	10^{21}	10^{24}	Zm	Milky way, distance to Andromeda Galaxy
	10^{24}		Ym	Huge-LQG, Hercules Corona Borealis Great Wall, visible universe

Table 33. **Measurement > Number**: *Number types.*

Name	Symbol	Meaning
Prime		Prime power factor
Composite		Whole subdivision of a count; for example, 6 is a composite number of 2 x 3
Natural	N	0, 1, 2, 3, 4, ... or 1, 2, 3, 4, ... N0 or N1 are sometimes used
Integer	Z	..., −5, −4, −3, −2, −1, 0, 1, 2, 3, 4, 5, ...
Rational, Ratio[nal], Fraction[able]	Q	>Where a and b are integers and b is not 0 >Perfect squares: √4, √9, √16, √25, √36, √49, √64, √81, √100,..., √256,..., √526, √1024,..., √4096,...)
Irrational, Irratio[nal], Non-fraction[able]	I	Decimal expression is: 1.non-terminal 2.non-repeating (no digit pattern to right of decimal)
Real	R	The limit of a convergent sequence of rational numbers
Complex	C	a + bi where a and b are real numbers and i is a formal square root of −1

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Table 35. Measurement > Statistics*: Measurement scale types.*

Level of measurement (in scale types)	Characteristics			
	Classification	Order	Equal intervals	True zero point
Nominal	Yes	No	No	No
Ordinal	Yes	Yes	No	No
Interval	Yes	Yes	Yes	No
Ratio	Yes	Yes	Yes	Yes

Table 36. Measurement > Statistics*: Measurement scale types.*

Incremental progress	Measure property	Mathematical operators	Advanced operations	Central tendency
Nominal	Classification, membership	=, !=	Grouping	Mode
Ordinal	Comparison, level	>, <	Sorting	Median
Interval	Difference, affinity	+, -	Yardstick	Mean, deviation
Ratio	Magnitude, amount	*, /	Ratio	Geometric mean, Coefficient of variation

Table 37. Measurement > Statistics*: Classification of scales.*

Classification of scales						
Scale	Operation	Examples	Location	Dispersion	Association	Test
Nominal	Equality	Numbering of objects	Mode			Chi-square
Ordinal	Greater or lesser	Hardness of minerals Street numbers Raw scores	Median	Percentiles	Rank-order correlation	Sign test Run test
Interval	Distance	Temperature: Celsius Position, Time	Arithmetic mean	Standard deviation	Product-moment correlation	t-test F-test
Ratio	Ratio	Numerosity (counts) Length, density Position, time Temperature: Kelvin Loudness: sones Brightness: brils	Geometric mean Harmonic mean	Percent variation		

Table 38. Measurement > Statistics*: Only the ratio scale meets the criteria for all four differentiating properties of a scale of measurement.*

Measurement scales	Indicates difference	Indicates direction of difference	Indicates amount of difference	Absolute zero
Nominal	X			
Ordinal	X	X		
Interval	X	X	X	
Ratio	X	X	X	X

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Table 39. Measurement > Statistics *Classification of measurement scales based on possible mathematical operations.*

Scale type	Description	Operations	Examples
Nominal	A renaming; can establish equivalence.	=	Colours (red, blue); Team members; Stellar spectral types (O,B,A,F,G,...)
Ordinal	Can establish order	= < >	Moh hardness; Rockwell hardness; Beaufort wind scale; Fahrenheit scales
Interval	Can establish meaningful differences	= < > + -	Date, time of day, year, latitude and longitude, centigrade temperature scale
Metric or ratio	Can establish meaningful ratios	= < > + - /	All SI scales (e.g., length, mass); frequency; thermodynamic temperature
Counting or natural	Counts of objects or events, an integer metric scale	= < > + - /	Apples, tires, birthdays

Table 40. Measurement > Statistics*: Measurement scale types*

Scale type	Level of information	Permissible statistics	Admissible scale transformation	Mathematical structure	Corresponding definition of measurement
Nominal (also denoted as categorical)	Equal/not equal	cell count, mode, contingency correlation, Chi-square	One to one (equality (=))	Standard set structure (unordered)	Assignment of numerals based on rules
Partial order	Order among some but not all categories	Cell count, mode, contingency correlation			
Ordinal	Order among all categories	Median, percentiles	Monotonic increasing (order(<))	Totally ordered set	
Interval	Equal intervals	Mean, standard deviation, correlation, regression, analysis of variance	Positive linear (affine)	Affine line	Measurement as quantification
Ratio	Meaningful zero	All statistics permitted for interval scales plus the following: geometric mean, harmonic mean, coefficient of variation, logarithms	Positive similarities (multiplication)	Field	
Absolute	Numerical count of entities in a given category	Mean, standard deviation, correlation, some forms of regression			

Table 41. Measurement > Statistics*: Scale types.*

Scale type	Characterization	Example (generic	Example (SE)
Nominal	Divides the set of objecvts into categories, with no particular ordering among them	Labeling, classification	Naming of programming language, name of defect type
Ordinal	Divides the set of entities into categories that are ordered	Preference, ranking, difficulty	Ranking of failures (as a measure of failure severity)
Interval	Comparing the differences between values is meaningful	Calendar time, temperature (Farenheit, Celcius)	Beginning and end date of activities (as measures of time distance)
Ratio	There is a meaningful "zero" value, and ratios between values are meaningful.	Length, weight, time intervals, absolute temperature (Kelvin)	Lines of code (as measure of attribute "program length/ size")
Absolute	There are no meaningful transformations of values other than identity	Object count	Count (as measure of attribute "number of lines of code")

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Table 42. Measurement > Numbers*: Number system scale.*

Number System Sub-name	Real world object	Binary (bi-nary)	Quinary (qui-nary)	Decimal	Sexadecimal a.k.a., hexadecimal (hex)	Base	Names for bases number systems
Base	Stones	two	five	ten	sixteen	2	binary
# of designators (symbols)	Sensation of a stone	2	5	10	16	3	ternary
Digits Increasing count (value), and therein, a base symbolic pattern of increasing orders of magnitude [of that count or value]	No stones	0	0	0	0	4	quaternary
	•	1 (2^0)	1 (5^0)	1 (10^0)	1 (16^0)	5	quinary
	• •	10 (2^1)	2	2	2	6	senary
	• • •	11	3	3	3	7	septenary
	• • • •	100 (2^2)	4	4	4	8	octonary
	• • • • •	101	10 (5^1)	5	5	9	nonary
	• • • • • •	110	11	6	6	10	decimal (denary)
	• • • • • • •	111	12	7	7	11	undenary
	• • • • • • • •	1000 (2^3)	13	8	8	12	duodecimal
	• • • • • • • • •	1001	14	9	9	13	tridecimal
	• • • • • • • • • •	1010	20 (5^2)	10 (10^1)	A	14	quattuordecimal
	• • • • • • • • • • •	1011	21	11	B	15	quindecimal
	• • • • • • • • • • • •	1100	22	12	C	16	sexadecimal
	• • • • • • • • • • • • •	1101	23	13	D	17	septendecimal
	• • • • • • • • • • • • • •	1110	24	14	E	18	octodecimal
	-	1111	30 (5^3)	15	F	19	nonadecimal
	-	10000 (2^4)	31	16	10 (16^1)	20	vigesimal

Table 43. Measurement > Language*: Counting in the English and Chinese languages.*

Written as a decimal (and fraction)	**Expression with placement (English). Note, the following words all mean the same thing: "decimal"; "point", and "and".**	**Expression without placement (Chinese)**
1.5 (1 5/10)	one decimal [point] five tenths	one decimal [point] five
3.2 (3 2/10)	three decimal two tenths	three decimal two
1.01 (1 1/100)	one point one hundredth	one decimal zero two
4.975 (4 975/1000)	four and nine hundred seventy-five thousandths	four decimal nine seven eight
5.0016 (5 16/10000)	five and sixteen ten thousandths	five decimal zero zero one six

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Table 44. Measurement > Language*: Linguistic efficiency comparison between numerical written expression in English language and Chinese language. The Chinese linguistic expression of numerals is more efficient Some researchers hypothesize that one possible reason some Asian cultures show proficiency in math at an early age ironically has nothing to do with math – it has to do with language. It is easier to learn to count in Chinese than it is in English because it requires learning fewer words.*

Numeral	"English" language		"Chinese" language	
1	one	Ten unique English words	one	Ten unique Chinese words
2	two		two	
3	three		three	
4	four		four	
5	five		five	
6	six		six	
7	seven		seven	
8	eight		eight	
9	nine		nine	
10	ten		ten	
11	eleven	Ten more unique words (total is 20 words)	ten one (or, one ten)	No more unique words (total is 10 words)
12	twelve		ten two	
13	thirteen		ten three	
14	fourteen		ten four	
15	fifteen		ten five	
16	sixteen		ten six	
17	seventeen		ten seven	
18	eighteen		ten eight	
19	nineteen		ten nine	
20	twenty		two ten	
21	twenty one	Eight more unique words (total is 28 words)	two ten one	One more unique word (total is 11 words)
30	thirty		three ten	
40	forty		four ten	
50	fifty		five ten	
60	sixty		six ten	
70	seventy		seven ten	
80	eighty		eight ten	
90	ninety		nine ten	
100	one hundred		one hundred	

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Table 45. Measurement > Metrology > Semiotics*: Measurement semiotics.*

Percept-ion	Symbols (digits/ letters)	De-notation (numeral/word, numerical signifier)	Con-notation (number/idea)
Mathematics	1 2 3 are digits	153/one hundred fifty three	Visual of a 153 amount
Linguistics	d o g are letters	dog	Visual of a dog
Issue[r]	Identifier	Length	Existent
Mathemat[ics]	123	153/one hundred fifty three	Visual of a 153 amount
Linguist[ics]	dog	dog	Visual of a dog

Table 46. Measurement > Metrology > Properties*: Tabular representation of the measurement of the properties of the objects of model set A. This is 'object oriented' measurement. A class of objects (A) are characterized by the combination of several properties in an object profile (M_1, M_2, m_n).*

Objects of the model set A	Properties			
	M1	M2	•••	mn
a	M_1(a)	M_2(a)		M_n(a)
b	M_1(b)	M_2(b)		M_n(b)
•	•	•		•
•	•	•		•
z	M_1(z)	M_2(z)		M_n(z)

Table 47. Measurement > Method*: Measuring objective and subjective quality-of-life [indicators] based on a focus and method for recording, and then using to predict future, measurement.*

		Intentional Focus of Measurement (is estimation; main criterion)	
		Objective as focused on external non-feelings	*Subjective as focused on feelings*
Method of Measurement (is estimation; subsidiary criterion)	*Objective as external measurement/ estimation*	Focus on external and estimated non-feelings; clearly OWB	-
	Subjective as using subject's self-report	Feelings and other self-reporting data can be objectively studied by externals	Clearly SWB

Land Accounting System

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Abstract

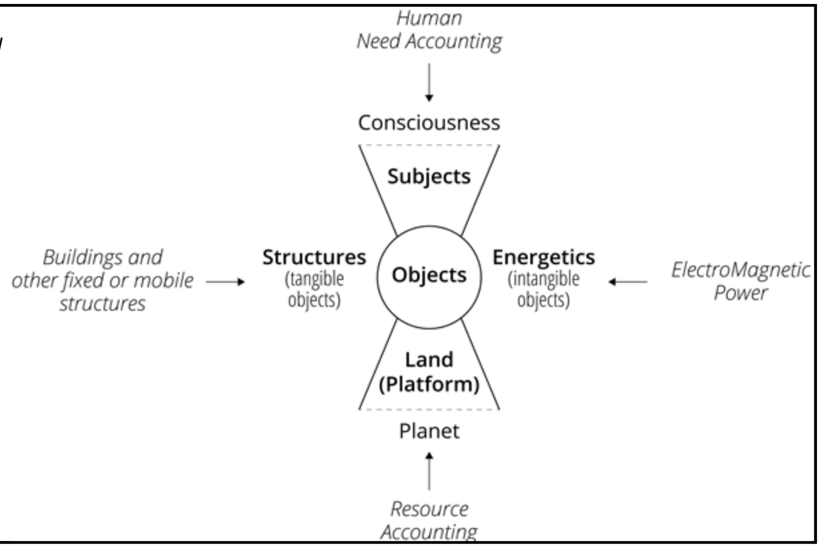
This article explores the fundamental aspect of land accounting, a critical process for any earth-based or oceanic engineering project. Land accounting encompasses a comprehensive assessment and survey of the land, ensuring that the environmental location is fully considered in the design, construction, and operation of habitat service systems. Recognizing land as a crucial element, this process involves a detailed land or site survey that accounts for various associated factors. The survey and subsequent zoning practices categorize land based on its usage, laying the groundwork for efficient and sustainable development.

The article delves into the contrasting perspectives on land within market and state contexts. In market economies, land is viewed as property, a commodity that can be bought, sold, and owned. This perception influences how land is valued, traded, and utilized, often prioritizing economic benefits over ecological considerations. Conversely, in the realm of state governance, land is regarded as territory or jurisdiction, emphasizing sovereignty, control, and administrative rights over environmental or communal values.

Through an examination of land accounting practices, the article argues for a holistic approach to land assessment and surveying. Such an approach not only acknowledges the economic and administrative aspects of land but also prioritizes the environmental and social impacts of its use. By integrating comprehensive land surveys and responsible zoning practices, societies can ensure that land management contributes to sustainable development, ecological preservation, and the well-being of communities. This article calls for a reevaluation of how land is accounted for, proposing a model that balances property rights with ecological stewardship and communal benefit.

Graphical Abstract

Figure 7. *Depiction of the account of material objects composed of four primary categories (structures, subjects, energetics, and land), of which land is a fundamental component. It is upon land (or, a "landed platform") that a set of useful services may be sustained.*



1 Introduction

Site analysis (a.k.a., site assessment) is a surveying and analytical process that gathers information from the environment to assess the suitability of a location for a particular purpose, taking into account a wide range of factors such as topography, geology, climate, infrastructure, and regulations (among other factors). Site analysis is necessary in every design processes where placement of objects in space is a consideration. Primarily, it involves the collection of data from various sources about a given spatial area. It involves the gathering of data from a site for use in site selection, engineered construction, and service operations.

Analytical terminology associated with a body of land (or water) includes:

1. Site analysis (a.k.a., site survey, land survey, land assessment, site inquiry, land inquiry, etc.).
   A. Topographaphical mapping - a detailed map of the surface features of land [contours]. Here, topology is the study of place, from topo-, combination form of Greek topos “place” + -logy “study of”.
   B. Natural systems analysis (a.k.a., geophysical/ geotechnical analysis).
   C. Human systems analysis (a.k.a., geopolitical, jurisdictional, financial, and social analysis).

PRIMARY: *For anything which is to be built, its design must account for its placement.*

A site analyses can provide data to analyse the difference (compare and contrast, strengths and weaknesses) between possible placement locations. For example, a developer would want to know whether the placement of a garden is on top of a former dumping ground. Or, the surface shape and undersurface makeup upon which a building is to be placed.

A site survey provides information that may be useful in decisions involving:

1. Site selection.
2. The design of the object to be placed.
3. The re-design of the spatial area into which the object is to be placed.

The typical phases/generic steps in site analysis are program investigation, site investigation and analysis, site evaluation, and report development.

1. **Program investigation:** The building program is investigated with respect to the selected or optional building footprints; area required for parking, circulation, open space, and other program elements; and any special constraints or requirements such as security, easements, preserving natural habitat, wetlands, and the like.
2. **Site inventory and analysis:** The physical, cultural, and regulatory characteristics of the site are initially explored. The site evaluation checklist identifies factors that may be considered. Some of these factors can be assessed by collecting and analyzing information; others are best addressed by walking the site and traversing its environs. A preliminary assessment of whether a location and site have the potential to accommodate the building program is made. Priority issues—those (such as environmental contamination) that may preempt further investigation—are identified. A site analysis plan is developed. When this has been approved by the client, consultants may be hired to further explore issues that require analysis beyond the capabilities of the core project team.
3. **Site evaluation:** At this point, thorough assessments are conducted when necessary to develop the site analysis plan. These may include physical testing of aspects of the site, its improvements, and adjoining properties.
4. **Report development:** The site analysis report normally includes property maps, geotechnical maps and findings, site analysis recommendations, and a clear statement of the impact of the findings and recommendations on the proposed building program.

NOTE: *Regulatory approvals normally required during or immediately following the site analysis phase include zoning, environmental impact, and utilities & transportation.*

1.1 Geographical information system

Geographic information system (GIS) refers to the process collecting and mapping data about a spatial-temporal location within an information system. A GIS process records spatio-temporal (space-time) location as the index variable for all information.

In other words, just as a relational database containing text or numbers can relate many different tables using common index variables, GIS can relate otherwise unrelated information by using location and time as the index variable. The contextualizing factor is the location and/or extent in space-time. Any variable that can be located spatially, and increasingly also temporally, can be referenced using a GIS.

Locations or extents in space–time may be recorded as dates/times of occurrence, and x, y, and z coordinates representing, longitude, latitude, and elevation, respectively. Earth-based spatial–temporal location and extent references should, ideally, be relatable to one another and ultimately to a “real” physical location or extent.

Some common GIS data about any given location on Earth might include topology with contour lines and elevations, soil and land mass composition, land use, wildlife, and even political districts. Any technology that can sense the real world can be used to collect GIS data. Some of the most common technologies referred to in the discussion of a GIS are the global positioning system, atomic clocks, remote sensing and imaging systems. Some commonly included models in a GIS are hydrological modeling, cartographic modeling.

2 Site survey and land assessment

A.k.a., Site analysis, land survey, land survey assessment, land assessment, land survey report, bio-geographic assessment, bio-region assessment, geographical region assessment, geo-political assessment, jurisdictional assessment.

This is a checklist of the factors that may be involved in the gathering of data about a “site”. A “site” is a spatial location of an area where something which is being designed and constructed may likely, or will, be placed). In our controlled habitat information is continuously collected, because the designed construction of our habitat service system is emergent.

> **NOTE:** *The site survey assessment as it presently exists here is oriented toward market-State conditions and does not represent a clean site survey as would be done in an environment without the market-State.*

Planning should, if possible, be undertaken before the land is acquired as this will enable the viability to be assessed before substantial investment has been made.

A site analysis (a.k.a., land survey assessment) may include the following analyses:

1. Site analysis (site survey).
2. Land survey (evaluation of land).
3. Satellite (remote-sensing) mapping.
4. Drone (aerial-sensing) mapping.
5. Cope survey (post occupancy evaluation).
6. Perimeter survey.
7. Climate analysis.
8. Geological analysis.
9. Geotechnical analysis (geotechnical survey).
10. Ground investigation.
11. Soils analysis (soil survey).
12. Water analysis.
13. Surroundings analysis (e.g., natural artifacts, neighbours, etc.).
14. Demographic analysis.
15. Psychological implications analysis (e.g., beauty, light, etc.).
16. Jurisdictional/political analysis.

> **NOTE:** *A complete site/land analysis includes jurisdictional/political analyses, because all land in the early 21st century is principally owned by State jurisdictions.*

The following should, if possible, be undertaken before the land is acquired (i.e., purchase), as this will enable the viability to be assessed before substantial investment has been made:

1. Geological assessment.
2. Soil and water assessment.
3. Keyline (water) site planning.
4. Regulatory assessment.

NOTE: *The following information is required when deciding where to locate a community habitat.*

2.1 Due diligence overview

Have "you" walked the perimeter of the land?
Yes / No

Have "you" completed a full physical survey of the land?
Yes / No

Have "you" completed a full legal survey of the land?
Yes / No

Have "you" seen all of the official records of the property?
Yes / No

2.2 Initial sale factors

Commercial factors that directly relate to land acquisition.

1. **Property specific data.**

    A. Link of listing:

    B. Address of listing:

    C. Contact name:

    D. Federal State jurisdiction:

    E. Sub-federal State jurisdiction:

    F. County/regional jurisdiction:

    G. Municipality jurisdiction:

    H. Regulatory bodies for jurisdiction:

    I. Zoning codes (zoning type):

    J. Building codes:

    K. Permitting codes:

    L. Coordinates (with property line):

    M. Size of land (with property line):

    N. Shape/dimensions of land (with property line):

    O. Type of land *(as percent rural, urban, sub-urban, etc.)*:

    P. Other local lands for sale in the area:

    Q. Size of surrounding lots and approximate price ranges:

    R. Sale price of last sold property (or, properties) in the area:

    S. Total price (all inclusive) of land (a.k.a., asking price of land):

    T. Size and currency price (price per area):

    U. Taxes on land when purchased:

    V. Taxes on house when built:

    W. Yearly taxes totals breakdown:

    X. Identification of reasons not to buy/use the land (examples include: running cost, utility difficulties and expense, access pain for guests, conflict, zoning limitations, etc.):

2.3 Initial ownership factors

Factors associated with ownership of the land.

2. **Ownership accountability.**

    A. Who currently owns the land:

        1. Name(s):

        2. Address(es):

    B. Who owns the surface minerals:

        1. Name(s):

        2. Address(es):

    C. Who owns the sub-surface minerals rights: Name(s):

1. Name(s):
2. Address(es):

D. Who owns the surface water rights:

1. Name(s):
2. Address(es):

E. Who owns the sub-surface water rights:

1. Name(s):
2. Address(es):

F. Is there a lien (and mortgage) on the land:

G. Will there be a land trust:

H. What/who is the land to be entrusted to:

I. Is the land represented on the blockchain in one or more smart contracts:

J. Who is accountable for taxes on the land:

K. Who is accountable for the state/status of the land:

L. Who will own the organizational property that owns the land:

M. List all contracts and agreements related to ownership and accountability with the land:

3. **Insurance accountability.**

A. Insurance on land:

1. Type of policy:
2. Name of policy:
3. Specific policy #:
4. Source of policy (and contact information):
5. Policy contract attachment:
6. Coverage of contract:
7. Names on contract:

B. Insurance of buildings (architecture):

1. Type of policy:
2. Name of policy:
3. Specific policy #:
4. Source of policy (and contact information):
5. Policy contract attachment:
6. Coverage of contract:
7. Names on contract:

C. Insurance on infrastructure:

1. Type of policy:
2. Name of policy:
3. Specific policy #:
4. Source of policy (and contact information):
5. Policy contract attachment:
6. Coverage of contract:
7. Names on contract:

D. Insurance on landed service:

1. Type of policy:
2. Name of policy:
3. Specific policy #:
4. Source of policy (and contact information):
5. Policy contract attachment:
6. Coverage of contract:
7. Names on contract:

E. Insurance on software:

1. Type of policy:
2. Name of policy:

3. Specific policy #:
4. Source of policy (and contact information):
5. Policy contract attachment:
6. Coverage of contract:
7. Names on contract:

4. **Site buildings list (area list).**
   A. How many units of architecture are on-site and what were their previous purposes:
   B. Location of each building/area on a topographic map:
   C. How many buildings/areas are in good condition:
   D. Expected cost for bringing building(s) back into good condition:
   E. How many buildings will be demolished:
   F. Expected cost for demolishing buildings:

5. **Condition of site.**
   A. Does the site need clean-up from human debris:
   B. Does the site need clean-up from architectural (built-environment) debris:
   C. Does the site need clean-up from significant vegetation:
   D. Is clean-up feasible; identify the cost:

2.4 Initial cost factors (initial financial factors)

Factors associated with ownership of the land.

6. **Start of financial costs.**
   A. Cost of property acquisition as purchase price:
   B. Cost of property acquisition as one time taxes:
   C. Legal fees of purchase:
   D. Total purchase price (A+B+C):
   E. Monthly tax cost after purchase:
   F. Yearly tax cost after purchase:
   G. Monthly cost of operation without humans present:
   H. Yearly cost of operation without humans present:
   I. Monthly cost of operation with humans present:
   J. Yearly cost of operation with humans present:
   K. Monthly cost of water:
   L. Monthly cost of fuel:
   M. Monthly cost of Internet communications:
   N. Monthly cost of electricity:
   O. Monthly cost of current worker(s):
   P. Monthly cost of farm operation (excluding workers):
   Q. Cost of removing criticality from unsafe critical infrastructure:
   R. Cost of annual State rental tax (a.k.a., home/land/property owner's tax):
   S. Expected cost of delivered cultivation system in operation:
   T. Expected cost of habitat-level infrastructural system:
   U. Expected cost of architectural dwelling systems:
   V. Expected cost of academic systems (bio-flow hacking and education):

2.5 Physical factors (geographical location factors)

Real-world material factors that influence the decision, and subsequent decisions.

2.5.1 Climate

7. **Solar orientation.**
    A. Sun site survey map (3D solar analysis):
    B. Sun angles:
    C. Days of sunlight:
    D. Cloud cover:
    E. Shading of (or from) adjacent structures, natural features, vegetation (where are shadows in the land, and from what structures):
    F. Sun direction on land throughout the day:
    G. Sun direction on land throughout the year:
8. **Altitude.**
    A. Average height above or below sea level:
    B. Lowest altitude:
    C. Highest altitude:
9. **Prevailing winds.**
    A. Direction:
    B. Maximum, minimum, and average velocities:
    C. Special forces (e.g., tornadoes, hurricanes, floods, flash floods, landslides):
    D. Wind direction on land throughout the day:
    E. Wind direction on land throughout the year:
    F. How will a changing climate affect winds:
10. **Temperature.**
    A. Ranges of variation:
    B. Maximums and minimums:
    C. How will a changing climate affect temperatures:
11. **Rain.**
    A. Ranges of variation:
    B. Maximums and minimums:
    C. Precipitation:
    D. Peak period totals:
    E. Annual and seasonal totals:
    F. How will a changing climate affect rainfall:
12. **Humidity (moisture).**
    A. Ranges of variation:
    B. Maximums and minimums:
    C. Peak period totals:
    D. Annual and seasonal totals:
    E. How will a changing climate affect humidity:
13. **Atmospheric pressure (barometric pressure).**
    A. Ranges of variation:
    B. Maximums and minimums:
    C. Peak period totals:
    D. Annual and seasonal totals:
    E. How will a changing climate affect atmospheric pressure:
14. **Storms.**
    A. Types and severity:
    B. Direction:
    C. Times of year:
    D. How will a changing climate affect storms:

2.5.2 Land topographic factors

Topography is the arrangement of the natural and artificial physical features of an area. The topographic factors are also called indirect factors as they influence the growth and development of organisms by bringing variations in climatic factors.

Land topography is a digital image of the three-dimensional structure of the Earth's surface.

15. **Topographic maps and aerial images (of terrain).**

    A. Satellite (remove-sensing) map and data:

        1. Orthophoto map:

    B. Drone (aerial-sensing) map and data:

        1. Orthophoto map and point map:

    C. Height-map (for simulation software):

    D. Contours and spot evaluations map (provides information on the rise and fall, and flow of the land):

        1. An orthophoto map (aerial photomaps) provide increased contour detail and a view of landscape objects (including landscape color map):

    E. Slopes; percentage, aspect, orientation:

    F. What percentage of the land is on hills and what degree of slope are the hills:

    G. Escarpments (typically unusable long and steep slopes):

    H. Erosion channels:

    I. Extent, location, and general configuration of rocks, ledges, outcrops, ridges, drainage lines, and other unique features:

    J. Visual characteristics:

    K. Potential problem areas during construction: situation, erosion, precipitation, etc.:

    L. Is it physically and financially feasible to improve the topographic characteristics of the land through earthworks:

16. **Analysis of physical features of landscape.**

    A. Unique remote-sensing maps (thermal, hydrological, etc.):

    A. Unique topography and artifacts:

17. **Existing access and circulation.**

    A. Human locomotion:

    B. Human easement:

    C. Vehicle locomotion:

    D. Vehicle easement:

18. **Vegetation.**

    A. Type:

    B. Specific names:

    C. Locations on land:

    D. Trophic (successional) map of plant organisms in area:

19. **Animal species.**

    A. Biospheric biodiversity level:

    B. Animal types and ranges map:

    C. Trophic (food) sphere map of animal organisms in area:

    D. Protected animal species:

    E. Legal code concerning hunting:

20. **Existing water and water bodies.**

    A. Water table elevation (water table level):

    B. Is the water table expected to rise/fall, and by how much, over the next 10-50 years:

    C. Does the site require mitigation measures to

    D. Location, size, depth, direction of flow of water under landscape:

E. Location, size, depth, direction of flow of water on landscape:

F. Water quality (clean, polluted, anaerobic conditions, etc.):

G. Flow and usability (seasonal, year-round):

H. Wetlands and other water-based ecological features:

I. Flood planes:

J. Variations (expected water levels, tides, wave action):

K. Coastal features:

21. **Drainage canals (rivers, streams, marshes, lakes, ponds, etc.).**

A. Natural and built:

B. Alignments and gradients:

C. Patterns and direction:

22. **Existing waterway easements.**

A. Surface:

B. Subsurface:

23. **Surface drainage.**

A. Patterns on and off the site (location of streams and washes):

B. Hydrological features (e.g., swales, berms, etc.):

C. Proximity to floodplains:

1. Maximum flood levels:

2. Frequent flood areas:

D. Local watershed areas, amount of runoff collected, and location of outfalls:

E. Swampy and concave areas of land without positive drainage and other obstacles that may interrupt or obstruct natural surface drainage:

F. Potential areas for impoundments, detention/retention ponds:

24. **Storm drainage (surface and subsurface).**

A. Source:

B. Quality:

25. **Unique physical site features.**

A. List:

2.5.3 Geotechnical factors

Geotechnical is a branch of civil engineering that deals with the earth materials engineering behavior.

26. **Land formation.**

A. What primary geological events/processes influenced the land forms of the area:

27. **Basic surface soil (e.g., sand, clay, silt, rock, shale, gravel, loam, limestone, etc.).**

A. Type of soil:

B. Depth of soil:

C. Fertility of soil:

D. pH of soil:

28. **Rock and soil type (character/formation and origin).**

A. Geologic formation process and parent material:

B. Inclination:

C. Bearing capacity:

D. Interference with construction and cultivation:

29. **Minerals.**

A. What are the minerals on the land's surface:

B. Where are the minerals/rocks on the land:

C. What are the minerals under the land's surface:

D. Where are the minerals under the land's surface:

30. **Bedrock.**

A. Depth to bedrock:

B. Bedrock classification:

C. Interference with constructions and cultivation:

31. **Seismic hazards and conditions (earthquakes).**

A. Type:

B. Frequency:

32. **Environmental water hazards and conditions (e.g., hurricanes, flash flooding, flooding, standing water mosquitoes, hail, etc.).**

A. Type:

B. Frequency:

33. **Environmental atmospheric hazards and conditions (e.g., tornadoes, strong winds, fires, lighting, etc.).**

A. Type:

B. Frequency:

2.5.4 Soil factors

Soil is the terrain surface material composed of minerals, living organisms, soil organic matter, gas, and water. A soil test must be conducted to determine the soil physics, soil chemistry, soil biology, and environmental soil sciences.

34. **Soil test to determine the composition of the soil.**

A. What is the mineral matter composition of the soil:

B. What is the organic matter composition of the soil:

C. What organisms are in the soil:

35. **Measured amount of top-soil.**

D. What is the depth of the top-soil where cultivation is expected:

36. **Is the soil polluted in any way (are there contaminants)?**

A. Type:

37. **What is the rock base underneath the soil?**

A. Type:

38. **How far deep is the rock base underneath the landscape?**

A. Meters:

39. **What is compaction (PSI) of the soil?**

A. PSI:

40. **What is the water retention and specific gravity of the soil?**

A. Water retention:

B. Specific gravity:

41. **What is the water retention of the landscape?**

A. Type:

2.6 Services location factors

Factors related to services in the local area. Assess the proximity to natural resources, water sources, and transportation routes.

2.6.1 Infrastructure factors (utilities and municipality factors)

Utilities and infrastructure are basic services that provide for the basic functioning of life and technical support of the habitat.

42. **Potable water.**

A. Source:

B. Quality test:

43. **Electricity.**

A. Source:

B. Quality:

C. Standby generator on property:

D. Transformer (onto property type):

E. Available amperage (cable and transformer capacity:

F. Network of electricity and Internet to and over property:

44. **Gas.**

A. Source:

B. Quality:

45. **Communications/data (Internet).**

A. Source:

B. Quality:

46. **Cellular communications of the "G"-type (cell phone, mobile phone signals, "my reception").**

A. Source:

B. Quality:

47. **Satellite communications of the "SATCOM"-type.**

A. Source:

B. Quality:

48. **Sanitary sewer service.**

A. Source (where does sewage go?):

B. Quality:

49. **Trash collection and disposal.**

A. Collection type/quality (where does trash go?):

B. Collection frequency:

C. Distance to landfill (where does garbage go?):

50. **Fire protection.**

A. Source:

B. Quality:

51. **Police/security protection.**

A. Source:

B. Quality:

52. **Mail.**

A. How do you get mail:

B. Quality of service:

2.6.2 Transportation factors

Transportation and distance related to the land.

53. **Access road (type of road to arrive on land).**

A. Type of access road:

B. Type of driveway road:

C. Access road state (quality):

D. Source of repair of road:

E. Easement of driveway road (does the driveway pass through other people's property):

F. Distance to main road:

G. Type of main road:

54. **Toll roads.**

A. Presence of toll roads near land:

B. Presence of toll roads to nearby cities:

C. Cost of toll roads:

55. **Distance to.**

A. Fire and police protection services:

B. Trash/refuse removal services:

C. Snow removal, including on-site storage:

D. Hospital (medical) services:

E. Small airport services:

F. Major airport services:

G. Major highway services (e.g., bus services, highway vehicles):

H. Major railway and bus services:

I. Next settlement (city, town, habitat, etc.):

56. **Transportation for construction and operation.**

A. How easy will it be to transport materials, tools, and personnel to the property?

B. What is the cost to transport materials, tools, and personnel to the property?

C. How far away from a major (or minor) road is the property?

D. How far away from a main airport is the property?

2.6.3 Accessibility and surrounding location factors

Environmental and population factors in the immediate surrounding environment.

57. **Local structures.**

A. Buildings nearby (number and type):

B. Proximity/distance to nearby buildings:

C. Conditions due to nearby buildings (e.g., shade, noise, pollution, aesthetic, etc.):

D. Cell towers (number and type):

E. Proximity/distance to nearby cell towers:

F. Electrical pylons nearby (number and type; ground return or non-ground return):

G. Proximity to airports:

H. Flight paths (air traffic patterns):

I. Proximity to rapid transportation stations:

J. Proximity to local transportation stations:

K. Satellite dishes:

L. Etc:

58. **Commercial entities.**

A. Business/shop types:

B. Distance to businesses and shops:

59. **Commercial services and the distance to them.**

A. Schools and churches:

B. Shopping centers:

C. Parks:

D. Municipal services:

E. Recreational facilities:

F. Banks:

G. Food services:

H. Health services:

I. Distance to highways:

J. Distance to main roads:

K. Distance to commercial outlets:

L. Distance to public transportation:

M. Ease of contractual work due to distance:

60. **Industrial entities.**

A. Industry types:

B. Distance to industrial locations:

61. **Shading and solar access.**

A. From trees:

B. From buildings:

C. From mountains:

62. **Views and vistas.**

A. View of land:

B. View of mountain:

C. View of air:

D. View of water:

63. **Nature preserves, wilderness, and national parks.**

A. What is the largest wilderness area in the region and how close is it:

B. How much of the land (location and percentage) must be dedicated as preserve by the law of the State:

C. Distance to nearest national park and size of national park:

D. Discuss the possibility of the State expanding the national park / nature preserve size in the future, thus expropriating owner's land:

64. **Who owns the land around the property?**

A. Name and contact details:

B. How much land around the property can be acquired as a buffer between the property and other property owners?

65. **What is being done with the land around the property?**

A. Type of usage:

B. Will the local land usage interfere with the habitat?

66. **Population and demographics of local people.**

A. Population size:

B. Age:

C. Education level:

D. Income level:

67. **Support of local people.**

A. Interests:

B. Socio-economic level:

C. Will to support:

2.7 Ecological location factors

Ecological factors are components of the environment that can influence the organisms directly or indirectly in natural (non-human) ways.

68. **Bio-region of the landscape.**

A. What is the name of the bio-region:

A. What plants are native to this landscape:

B. What plants are common to this bio-region:

C. What animals are native to this landscape:

D. What predators (that could harm livestock) are native to this landscape?

E. What animals are common to this bio-region:

69. **Ecological impact of settlement (ecological sustainability factors).**

A. What are the largest risks to the ecology from settlement of the area (evaluate the environmental impact of the settlement, including potential effects on ecosystems, air and water quality, and natural habitats):

1. Ecosystem (natural habitats) impact:

2. Air system impact:
3. Water system impact:
4. Soil system impact:

B. Discuss mitigation measures for risks:

1. Ecosystem (natural habitats) mitigation measures:
2. Air system mitigation measures:
3. Water system mitigation measures:
4. Soil system mitigation measures:

70. **Environmental regulations.**

A. Discuss any environmental regulations required for usage of the land:

1. Regulatory body/bodies:
2. Code(s):
3. Impact on land usage:

2.7.1 Pollution location factors

Factors related to pollution in the local area and at greater distance that could impact the location (pollution not from settlement).

> **NOTE:** *Mitigation measures are means to prevent, reduce or control adverse environmental effects of an activity.*

71. **Material pollution from land-base.**

A. Source(s):

B. Type(s):

C. Mitigation measures:

72. **Noise pollution from land-base (e.g., streets, emergency services, etc.).**

A. Source(s):

B. Type(s):

C. Mitigation measures:

73. **Material pollution from water-base.**

A. Source(s):

B. Type(s):

C. Mitigation measures:

74. **Noise pollution from water-base (e.g., boats, etc.).**

A. Source(s):

B. Type(s):

C. Mitigation measures:

75. **Material pollution from atmospheric-base.**

A. Source(s):

B. Type(s):

C. Mitigation measures:

76. **Noise pollution from atmospheric-base (e.g., aircraft, etc.).**

A. Source(s):

B. Type(s):

C. Mitigation measures:

77. **Noxious gas and odor pollution.**

A. Source(s):

B. Type(s):

C. Mitigation measures:

2.8 Site history and land use factors

Factors related to how the land was used previously.

78. **Buildable area.**

A. Square meters:

79. **Existing buildings.**

A. Type:

B. Location on site:

C. State/condition of existing buildings:

80. **Former site uses.**

A. Hazardous dumping:

B. Landfill:

C. Old foundations:

D. Archaeological grounds:

81. **History of existing structures.**

A. Historic worth:

B. Affiliations:

C. Outline:

D. Location:

E. Floor elevations:

F. Type:

G. Condition:

H. Use or service:

82. **Type of land ownership.**

A. Type:

83. **Function and pattern of land use: public domain, farm type, grazing, urbanized.**

A. Present:

B. Former:

84. **Adjacent (surrounding) land uses.**

A. Present:

B. Projected:

C. Probable effects on the development of this site:

2.9 Jurisdictional and regulatory factors (legal factors)

Factors related to the land existing within a specific jurisdiction, which likely includes various regulator factors and constraints.

2.9.1 Property relations and ownership factors

Factors related to property ownership.

85. **Analysis of legal property.**

A. Limits of property:

B. Easement:

C. Rights of way:

D. Deeds:

2.9.2 Taxes and fees

86. **Government taxes.**

A. Purchase tax price:

B. Yearly tax price:

87. **State taxes.**

A. Purchase tax price:

B. Yearly tax price:

88. **Municipality taxes.**

A. Purchase tax price:

B. Yearly tax price:

89. **Other tax implications:**

A. Identify:

90. **Jurisdictional-legal costs.**

A. Purchase legal price:

B. Yearly legal price:

91. **Submittal fees.**

A. Identify:

92. **Total land cost.**

A. Total purchase price (purchase of land including all taxation by governmental and legal fees):

B. Total yearly price (yearly rental from the government and legal fees):

C. Inflation rate (expected rise in costs over the next *x* number of years):

93. **Bureaucracy factors.**

A. Describe complexity of bureaucracy:

B. Describe relationship with politicians and bureaucrats:

2.9.3 Submittal factors

94. **Special submittals required for approval and/or hearings.**

A. Fees (financial costs):

B. Applications:

C. Drawings:

D. Color presentations:

E. Sample boards:

F. List of adjacent land owners:

G. Other:

2.9.4 Municipality future plans

95. **Current planning of the future municipality.**

A. Describe:

2.9.5 Zoning codes (including: municipality, city, town, village, etc.)

96. **Permitted uses.**

A. Type of site:

B. Type of adjacent:

A. What is permitted:

B. By variance:

C. By special use permits:

D. Accessory structures:

97. **Check zoning laws.**

A. Check deed about zoning laws, including for livestock:

B. Check county about zoning laws, including for livestock:

C. Check town for zoning laws, including for livestock:

D. Check local covenants, including for livestock:

98. **Building allowance.**

A. Is the building size allowed (including, maximum building coverage):

B. Is the building type allowed:

C. Is the building location allowed:

99. **Minimum site area requirements.**

A. List:

100. **Building height limits.**

A. Identify:

101. **Yard (setback) requirements.**

A. Identify:

102. **Lot coverage.**

A. Total area:

B. Floor area ration (FAR):

C. Percentage of coverage:

D. Open space requirements:

103. **Loading zone requirements.**

A. Identify:

104. **Parking layout restrictions.**

A. Identify:

105. **Off-street parking requirements.**

A. Identify:

106. **Landscaping requirements.**

A. Identify:

107. **Sign (signage) requirements .**

A. Identify:

108. **Zoning due diligence.**

A. Has zoning due diligence been completely done (list of all zoning codes at all legal levels):

109. **Right to roam laws present.**

A. Anyone has the right to walk through private land, and forceful action cannot be taken against them.

110. **Right to squatting laws present.**

A. Anyone has the right to come stay/live on the land, and forceful action cannot be taken against them:

2.9.6 Covenants codes

111. **Is the property under any covenants?**

A. If yes, where are those covenants filed? Note that someone may only be able to determine if a covenants exists by going to the county courthouse (or other jurisdictional headquarters) and checking?

B. If yes, what do those covenants say about what is allowed and what is not allowed?

C. If yes, how often is the covenants renewed and what is required for its renewal?

NOTE: *It doesn't take a lot of effort for a group of upset and angry neighbours to write a petition and create some sort of law to get property owners kicked off their property or stop someone from living a particular lifestyle (e.g., such as having livestock removed).*

2.9.7 Other contracts

112. **Private contracts, conditions, and restrictions (CC&Rs) that are associated with the land should be checked:**

A. Identify:

2.9.8 Subdivision, site plan review, and other local requirements and codes

113. **Lot requirements.**

A. Size:

B. Configuration:

C. Setbacks and coverage:

114. **Street requirements.**

A. Widths:

B. Geometry: grades, curves:

C. Curbs and curb cuts:

D. Road construction standards:

E. Placement of utilities:

F. Dead-end streets:

G. Intersection geometry:

H. Sidewalks:

I. Names:

115. **Drainage requirements.**

A. Removal of spring and surface water:

B. Stream courses:

C. Land subject to flooding:

D. Detention/retention ponds:

116. **Parks.**

A. Open space requirements:

B. Park and playground requirements:

C. Screening from adjacent uses:

2.9.9 Environmental regulations

117. **Water, sewer, recycling, solid waste disposal.**

A. Location:

118. **Clean air requirements.**

A. Identify:

119. **Soil conservation.**

A. Identify:

120. **Protected areas, wetlands, floodplains, coastal zones, wild and scenic areas.**

A. Identify:

121. **Protected plants on landscape.**

A. Identify:

122. **Fish and wildlife protection.**

A. Identify:

123. **Protection of archaeological resources.**

A. Identify:

2.9.10 Other codes and requirements

124. **Historic preservation and landmarks.**

A. Identify:

125. **Architectural (design) controls.**

A. Identify:

126. **Special district.**

A. Identify:

127. **Miscellaneous (e.g., mobile homes, billboards, noise).**

A. Identify:

128. **Site-related items in building codes.**

A. Building separation:

B. Parking and access for persons with disabilities:

C. Service and emergency vehicle access and parking:

2.10 Geopolitical and social factors (political factors)

Factors related to the government and related populations of people.

2.10.1 Governmental and political factors

129. **Type of State government.**

A. Identify:

130. **Stability of the State government.**

A. Identify:

131. **Type of local/municipal government.**

A. Identify:

132. **Stability of the municipal government.**

A. Identify:

133. **Political party in power currently.**

A. Identify:

134. **Political party probably in power in one year.**

A. Identify:

135. **Political party probably in power in five years.**

A. Identify:

136. **Involvement/inclusion of the local population in the local government.**

A. Identify:

137. **State influence over the local population.**

A. Identify:

138. **Corporate influence over the local population.**

A. Identify:

139. **Foreign influence over the local population.**

A. Identify:

2.10.2 Local population factors

140. **Culture, religion, and beliefs of local population.**

A. Identify:

141. **Average age of population.**

A. Identify:

142. **Education level of local population.**

A. Identify:

143. **Economic fulfillment and stability of local population.**

A. Identify:

144. **Felt well-being status of the local population.**

A. Identify:

145. **Average monthly and yearly income of local population.**

A. Identify:

146. **Number of vehicles per household for local population.**

A. Identify:

147. **Distance from site to local population.**

A. Identify:

148. **Are there nosy neighbours.**

A. Identify:

149. **Are the neighbours sticklers for following the rules.**

A. Identify:

150. **Are there any ongoing conflicts among locals.**

A. Identify:

151. **Interest of local population in you and your plans.**

A. Identify:

152. **Openness of local population to you and your plans.**

A. Identify:

153. **Disagreement of local population with your presence and your plans.**

A. Identify:

154. **Strategies for building positive relationships with the local population.**

A. Identify:

155. **Possible integration of locals into the plans.**

A. Identify:

2.10.3 Safety factors (security factors)

156. **Problems in the area.**

    A. Identify:

157. **Crime statistics in the nation.**

    A. Identify:

158. **Crime statistics in the local region.**

    A. Identify:

159. **State of criminal trafficking and gangs through the region.**

    A. Identify:

160. **War in the local region.**

    A. Identify:

161. **Terrorism in the local region.**

    A. Identify:

162. **Other potential security and safety concerns.**

    A. Identify:

163. **Disaster preparedness of local region.**

    A. Identify:

164. **Disaster preparedness of local population.**

    A. Identify:

2.10.4 Local market factors

165. **What goods and services are consumed in the local area:**

    A. Identify:

166. **What is the demand for consumed goods and services in the local area:**

    A. Identify:

167. **What economic opportunities are there to provide goods and services for the local/regional area (target markets):**

    A. Identify:

168. **What risks there in providing goods and services to the local/regional area:**

    A. Identify:

2.11 Housing factors (dwelling factors)

Factors related to human daily need fulfillment in the context of a dwelling (a.k.a., house).

2.11.1 Habitation housing factors

169. **Assessment existing buildings/housing on the land.**

    A. Number of existing architectural structures (a.k.a., buildings):

    B. State of existing buildings:

    C. Safety issues associated with building(s) and infrastructure:

    D. Immediately habitable:

    E. Immediate habitation restoration requirements (types and costs):

170. **Assessment of human habitation/dwelling need.**

    A. Who is going to live there:

    B. Who might be coming to temporarily live there:

    C. What is it being used for (permanent home, holiday house, etc.):

    D. What does it have now:

    E. What could it have 1 year from now:

    F. What could it have 5 years from now:

    G. What does a hotel room and hotel service have at a minimum that the current conditions don't provide:

H. Is it efficient in operation (low maintenance):

I. Is it user friendly:

J. Is it beautiful (aesthetic):

K. What if someone became injured or someone with a disability was visiting and special types of access are required:

2.11.2 Dwelling sleep area factors

171. **Assessment of sleep area (for sleep need).**

A. Bed(s):

B. Closet: long hanging, short hanging, drawer clothes (underware / swim suits) shoes, coats, hats:

C. Mirrors (short mirrors, long mirrors, space opening and light improvement mirrors):

D. Temperature of sleep area over year (over seasons):

E. Darkness of sleep area at night:

F. Laundry basket

G. Bedside side tables for reading light, books, Kleenex, clock, water glass:

H. Bedroom item storage:

I. Sheets, 2 sets each room:

J. Blankets:

K. Desk:

L. Trash can:

M. Book and toy storage area:

N. Safe for valuables:

2.11.3 Dwelling bathing area factors

172. **Assessment of bathing area (for bathroom and bathing need).**

A. Toilet:

B. Sink & cupboard:

C. Shower &/ bath:

D. Towel rails & hooks:

E. Storage for personal items:

F. Storage for toilet paper (where storing extra):

G. Storage for towels - where:

2.11.4 Kitchen area factors

173. **Assessment of kitchen/cooking area (for food need).**

A. Consider your minimal, then, people will want friends over:

B. Consider a cabinets (consider sizes; normal dinner plates need 12” top cupboard):

C. Consider hanging kitchenware:

D. Sink w/ grinder:

E. Sponge, location so as not to mold easily:

F. Sink presence, type, and size:

G. Faucets (1 faucet with hot & cold, 1 water filtered faucet, 1 soap dispenser, 1 grinder switch, countertop soap, etc):

H. Refrigerator:

I. Freezer:

J. Ice maker:

K. Dishwasher:

L. Kitchenware countertop drying rack:

M. Storage drying rack:

N. Stove (burner or electric):

O. Oven:

P. Microwave (built-in):

Q. Trash can:

R. Trash compactor:

S. Toaster:

T. Common appliances: Consider coffee maker, juicer, blender, griller, ice maker, kettle, etc.

U. Cutting board space:

V. Kitchen working space:

W. Counter top kitchen storage space (for commonly used items to be visible):

X. Space drying cloth:

Y. Hand towel, paper / cloth wipe towel:

Z. Paper towels:

AA. Additional elements here: Wine cooler, laundry washer and dryer, etc.

174. **Assessment of kitchen area tools (for food need).**

A. Dishes (places), glasses, utensils:

B. Jar openers:

C. Cooking pans, pots:

D. Utensils for cooking, splatter guard:

E. Serving dishes, platters:

F. Serving trays for pool & take outside:

G. Placemats, table cloths, napkins (cloth, paper):

H. Machines: Consider may not want all on counter.

I. Common Appliances: Coffee bean grinder, kettle, blender, mixing bowls and beater, juicer, cutting boards.

J. Hot plate and/or hot cabinet for keeping food warm/hot while waiting:

175. **Assessment of kitchen area food storage.**

A. Spices & oils: Consider light, temperature and humidity.

B. Teas, coffee, powders, pills:

C. Dry goods: flour, sugar, noodles, nuts, chips, (others don't eat like you):

D. Canned good: what and how much space needed:

E. Food and vegetables (cool storage):

F. Storage of: Consider dish soap, sink soap, cleaning products, wash cloths, swipers, sponges, etc.

G. Storage of bags from store:

H. Temporary unloading placement of bags filled with purchases (i.e., recently accessed and bagged items): Consider the space available for bag unloading as well as the distance needed to place the items in storage:

2.11.5 Cleaning of exterior architectural factors

176. **Assessment of architectural exterior for cleaning purposes.**

A. Architectural exterior type(s):

B. Method(s) by which exterior architecture is cleaned:

C. Location of equipment for cleaning of exterior architecture:

D. Requirement for usage of toxic/hazardous chemicals for cleaning of exterior architecture:

E. Storage requirements and location of toxic/hazardous chemicals for cleaning of exterior architecture:

2.11.6 Cleaning of interior factors

177. **Assessment of laundry (of fabrics) area.**

A. Is the laundering room in the building? Is the laundering room a separate building? If separate, how far are the buildings? If separate, how does the laundering get from the home to the laundering room, laundered, and then, returned:

B. Is hookup for appropriate water present:

C. Is hookup for drainage present:

D. Is hookup for atmospheric vent (for dryer) present:

E. Washer size, type, age distance, and orientation (to dryer another for ease of moving clothes from washer to dryer):

F. Dryer size, type, age distance, and orientation (to washer another for ease of moving clothes from washer to dryer:

G. Table for folding clothes and working with materials:

H. Sink presence, type, and size:

I. Faucets (1 faucet with hot & cold):

J. Hanging place for damp or wet clothes:

K. Iron board and iron if ironing is to be done:

L. Trash can (for lint and disposal of containers):

M. Storage of water, detergents, and other liquids and bottles:

N. Storage for batteries, flash light, maps (etc.):

O. Additional storage for tools and other items:

178. **Assessment of cleaning equipment/services.**

A. Upright vacuum cleaner:

B. Hand vacuum cleaner:

C. Broom and pickup:

D. Mop:

E. Steam cleaner:

F. Wash cloths:

179. **Automated floor vacuum cleaner (mop-vacuum cleaner).**

A. Is layout of building appropriate for an automated floor vacuum/mop cleaning system:

A. Sufficient clearance around house for automated cleaner to reach all areas:

B. Likelihood of automated cleaner causing damage to surfaces:

C. Home resting placement of automated cleaner:

2.11.7 Pool area factors

180. **Assessment of pool area.**

A. Ease of cleaning and maintenance:

B. Age of pool architecture:

C. Age of pool equipment:

D. Does the pool have an automated cleaning system:

E. How often is manual labor required to maintain the cleanliness of the pool:

F. Does the pool have an automatic fill/overflow system:

G. How often is manual labor required to maintain the water level of the pool:

H. Does the pool need to be drained/covered during specific seasons of the year:

I. Type of pool cleaning equipment (polls, brushes, etc.):

J. Location of storage of pool equipment:

K. Water filters and pump equipment (type, location, maintenance requirements):

L. Electrical equipment for poor operation (type, location, maintenance requirements):

M. Chemicals needed for pool, if any, for pool maintenance (type, location, usage and reacquisition requirements):

N. Brooms for pool maintenance (type, location, usage and maintenance requirements):

O. Hoses and machines for pool maintenance (type, location, usage and maintenance requirements):

P. Toilet nearby pool for users' usage:

Q. Shower exterior (and/or interior) nearby pool for users' usage:

R. Towel racks – inside / outside:

S. Pool toys/games storage:

2.11.8 Power and signals factors

181. **How many electrical circuits does the circuit breaker have.**

    A. Identify:

182. **What amperage are the circuits, and are there any special amperage circuits (as required).**

    A. Identify:

183. **How are cables routed through the building (via metal conduits, plastic conduits, staples, etc.).**

    A. Identify:

184. **How is the cell network reception throughout the building.**

    A. Identify:

185. **Considering WiFi placement in the building, how does the signal attenuate; how many routers (mesh/non-mesh and extenders) are required for optimal coverage.**

    A. Identify:

186. **Doorbell/intercom placement.**

    A. Doorbell/intercom exterior placement:

    B. Doorbell chime (and/or intercom) interior placement:

2.11.9 Other factors

187. **Assessment of other commonly needed equipment.**

    A. Emergency extinguisher(s):

        1. Presence:
        2. Type:
        3. Placement:

    B. Solar/battery powered emergency wall lights presence:

        1. Presence:
        2. Type:
        3. Placement:

    C. Office equipment:

        1. Presence:
        2. Type:
        3. Placement:

    D. Computing equipment:

        1. Presence:
        2. Type:
        3. Placement:

    E. Art and display equipment (consider objects of art, paintings of art, frames for images, televisions, projectors, etc.):

        1. Presence:

2. Type:

3. Placement:

F. Play and exercise equipment:

1. Presence:

2. Type:

3. Placement:

G. Storage of all other types of equipment:

1. Presence:

2. Type:

3. Placement:

2.12 Site continued operating resource tables

What is required to continue to operate the production and habitation services on-site:

188. **Habitat mineral materials usage (simplified).**

A. Mineral materials currently fixed into the site:

B. Mineral materials currently flowing through the site:

C. Mineral resources required for continued operation of the site:

D. Future planned table of materials and quantities (mineral requirements next 3, 5, and 10 year solutions):

189. **Habitat biological materials usage (simplified).**

A. Biological materials currently fixed into the site:

B. Biological materials currently flowing through the site:

C. Biological resources required for continued operation of the site:

D. Future planned table of materials and quantities (biologics requirements next 3, 5, and 10 year solutions):

190. **Habitat energy [power] usage (simplified).**

A. Table of materials, quantities, and consumption ratios to date (energy>power requirements for operation of the system to date):

B. Energy to power resources required for continued operation:

C. Future planned table of materials and quantities (power requirements next 3, 5, and 10 year solutions):

191. **Habitat computations required (simplified).**

A. Table of computations per time to date (computational requirements for operation of the system to date):

B. Computation resources required for continued operation:

C. Future planned table of computations next 3, 5, and 10 year solutions):

192. **Software for habitat design (simplified).**

A. Name(s) of design software:

B. Yearly cost(s) of design software:

C. Location of storage of design software:

D. Location and system (type) for executing running and using of software:

E. Computational requirements for design of the system:

F. Power requirements for design of the system:

193. **Software for habitat operations (simplified).**

G. Name(s) of operations software:

H. Yearly cost of operational software:

I. Location and system (type) for executing running and using of software:

J. Computational requirements for operation of the system:

K. Power requirements for operation of the system:

194. **Software for project coordination (simplified).**

L. Name(s) of operations software:

M. Yearly cost of operational software:

N. Location of storage of operations software:

1. Location and system (type) for executing running and using of software:

3 Cartographic survey and geographic information assessment

A.k.a., Mapping survey, geographical information system mapping, landscape mapping, geoinformatic mapping, spatial mapping, geospatial mapping, etc.

Cartography is the study and practice of making and using maps. Cartography graphically represents a geographical area, usually on a flat surface such as a map or chart. In concern to cartography, a geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map, such as streets, buildings, and vegetation. This enables people to more easily see, analyze, and understand patterns and relationships. A GIS can use any information that includes location (Read: a georeference). All site survey and land assessment information can be included in a GIS. GIS can also be used to display spatial relationships and linear networks (a.k.a., geometric networks; e.g., rivers, roads, transportation routes). Humanity now has visualization technology to model and simulate complex material environments consisting of a network of habitats in which resources move, are transformed and cycles for human fulfillment and ecological regeneration. Maps provide essential visual information to fully assess the material environment and to plan habitats.

Geospatial data refers to data about the material, spatially locatable environment. This is any information associated with a specific location in space. Geospatial data is an information requirement all humans have in common. Everyone survives and benefits from having detailed and accurate information about the world immediately around them. And globally, everyone benefits from having detailed and accurate information about the world at a global level.

> **NOTE:** *It is impossible to present the data in 2D exactly as it is observed (in 3D). However, through a simulation engine, it is possible to represent the material world exactly how it exactly how it is observed.*

GIS applications include both hardware and software systems. These applications may include cartographic data, photographic data, digital data, or data in spreadsheets. GIS technology allows all these different types of information, no matter their source or original format, to be overlaid on top of one another on a single map. GIS uses location as the categorical variable to relate data. Once all the desired data have been entered into a GIS system, they can be combined to produce a wide variety of individual maps, depending on which data layers are included.

The two major types of GIS file formats are:

1. Raster formats - are grids of cells or pixels. Raster formats are useful for storing GIS data that vary, such as elevation or satellite imagery.
2. Vector formats - are polygons that use points (called nodes) and lines. Vector formats are useful for storing GIS data with firm borders, such as habitat zones or streets.

Maps have standards for their composition:

1. **Cardinal points and intercardinal points (a.k.a., points of a compass):**
   A. The cardinal points that show planetary direction are: north, south, east, and west.
   B. The intercardinal points (a.k.a., ordinals) are: northwest (NW), southwest (SW), northeast (NE), southeast (SE). These intercardinal points are then subdivided by the following directional points: NNW, WNW, WSW, SSW, SSE, ESE, ENE, NNE.
2. **Coordinate system:** for global positioning using latitude, longitude, and time.
   A. Earth global positioning (GPS):
      1. Latitudes, including the equator.
      2. Longitudes, including the prime meridian.
      3. Timing, including seconds and minutes.
   B. Astronomical (celestial sky) positioning system:
      1. Right ascension - the total range of right ascension is 24 hrs = 360 deg / 15 deg/hr. The 15 deg/hr conversion factor arises from the rotation rate of the Earth.
      2. Declination - is analogous to latitude and is measured as north or south of the celestial equator.
3. **Grid:** A grid is a regular pattern of parallel lines intersecting at right angles and forming squares; it is used to identify precise positions. Topographic maps have two kinds of referencing systems:
   A. Universal transverse mercator (UTM) projection (easting/northing).
   B. Geographic: degrees and minutes (longitude/latitude).
4. **Scale:** Maps are made to scale. In each case, the scale represents the ratio of a distance on the map to the actual distance on the ground.
5. **Orientation:** Applies when a map is used in the real world. A map is "oriented to a user" when it is made to correspond to the ground features it represents. If someone knows his/her location and can also identify the position of a distant object, s/he can orient the map by turning it so it corresponds to the ground features.

Cartographic (spatial, georeferential) information visualization modes (each with accompanying set of tools); these are the ways to view geospatial data in map form:

1. **2D maps** - a map projected on a plain, or sheet of paper.
   A. GIS with 2D maps.
2. **3D maps (3D models)** - a map composed of an image projected on a 3D model (computer or physical).
   A. GIS with 3d maps.
3. **Simulation maps (3D + time)** - a map composed of an image projected on a 3D model inside of a simulation engine where interaction can be real-time and/or programmed; where there is time.
   B. GIS with simulation maps.

NOTE: *There is a lot of data that is a lot more intuitive and understandable when visualized in 2D (through graphs and 2D maps). Additionally, there is a lot of other data that is a lot more intuitive and understandable when visualized in 3D (virtual reality).*

The two primary and most important maps in visualizing terrain in 3D are:

1. **Terrain height map (a.k.a., land heightmap)** - shows variations in height over the terrain. When imported into a simulation engine this map will elevate or reduce areas on an original flat plain to produce an accurate 3D representation of relief. These maps (images) are grayscale with darker areas referring to lower elevations and whiter areas referring to higher elevations.
2. **Terrain color map (land color map)** - shows color of terrain (usually acquired through satellite or aerial photography. These maps (images) are color.

Primary cartographic maps include, but may not be limited to the following (note, a geographical map could include any of the following map types):

1. **Topographic map (a.k.a., topological, terrain map, terrain model, etc.)** - is a detailed and accurate illustration of man-made and natural features on the ground and geographical names. A topographic map portrays terrain features in a measurable way. Topographic maps always use of elevation contour lines to show the shape of the Earth's surface.
   A. **Relief map (a.k.a., topographic relief map)** - refers to the physical configuration of the Earth's surface, depicted on a topographic map by contour lines and spot heights. Relief is the term used to describe the shape of the land,

including the height and steepness. The main visualizations to show relief on topographic maps are spot heights, contour lines and patterns, layer coloring, and landform shading. Relief is the difference in elevation found in a region. To calculate relief, subtract the lowest elevation from the highest elevation on the map.)

1. **Contour lines (a.k.a., elevation lines, height change lines, contour map, isoline map)** - the lines on the map that represent elevation (a.k.a., contour levels). Contour lines are used to determine elevations and elevation changes. Contour/elevation lines are a level [elevation] line in the landscape. The closer together the lines are, the steeper the slope. Elevation lines on a map connect points of equal elevation above mean sea level; using contour lines, relief features can be profiled into a three-dimensional perspective. Note that "contour" lines are "elevation" lines; they mean the exact same thing. All points for a single line are at the same elevation. Additionally, water on the landscape is always level.
    i. **Contour interval (a.k.a., elevation interval)**- is the value between two consecutive contour lines. The elevation interval (a.k.a., height difference) between each contour line is always the same.
    ii. Characteristics of contour lines over a landscape:
        1. At the top of a hill, the contour lines make a complete circle.
        2. Some contour lines may loop, and others may not.
        3. Contour lines are closer together on a steeper slope and more farther apart on a gentle slope. On a steep slope, the amount of horizontal space between elevation changes is small, and thus they are closer together. On a gentle slope, the amount of horizontal elevation it takes to change elevation between two lines is broader.
        4. Contour lines bulge outward at the ridges.
2. **Hypsometric tints (contour map)** - the tints on the map, wherein each color represents a different range of elevation.

B. **3D topography maps (a.k.a., raised relief map, topographic simulation)** - is a topography map in 3D (Read: virtual or physical 3D). These maps show land and other features in 3D.

C. **The basic terrain units of relief are:**
    i. **Ridges (concave)** - a curved segment.
    ii. **Valleys (convex)** - a region between two adjacent ridges. Valleys are the space between two contiguous, adjacent ridges.
    iii. **Hilltop** - the highest part of top of the hill.
    iv. **Depression** - is a low point in the ground or a sinkhole.

2. **Optical imagery maps (a.k.a., photomaps, photogrammetry maps):**
    A. **Photogrammetry map (a.k.a., aerial photogrammetry map)** - combines multiple images captured by aerial photography to create a map an area. Generally provides a higher resolution than a satellite map.
    B. **Satellite map (a.k.a., satellite photogrammetry map)** - records images captured by satellite photography. Generally provides a lower resolution than a photogrammetry map.
3. **Landscape element maps:**
    A. **Rock map (a.k.a., mineral map)** - identifies large mineral deposits on or below the earth's surface.
    B. **Water map (a.k.a., hydrological map)** - identifies water sources, locations, flows, and possibly, processes happening to water. This map shows all aspects of the water on and through the landscape, and often has a dendritic pattern.
    C. **Vegetation map (a.k.a., plants map)** - identifies plants on or below the earth's surface.
    D. **Animal map** - identifies animals on or below the earth's surface.
    E. **Architecture map** - identifies architectural constructions on or below the earth's surface.
    F. **Infrastructure map** - identifies all infrastructure (e.g., conduits, fences, wires, etc.).
    G. **Paths map** - refers to paths (e.g., roads, railways, tunnels, etc.).
4. **Zone map (i.e., land use, areas, sectors, etc.)** - refers to land use as well as areas affected by environmental elements.
    A. Habitat zones in terms of land usage; such as, dwelling, recreation, production, cultivation, etc.
    B. Sectors in terms of environmental elements: sun, wind, smells, poisons, visual access, etc.
5. **Event map** - refers to events that occur to landscapes (e.g., storms, earthquakes, floods, human productions, human events, etc.).
6. **Territorial State border map (a.k.a., State territorial authority administration, territory map)** - refers to State borders.

A. **Solar site [survey] map** - shows the path of the sun during times of day and year.
7. **Climate map** - shows the change of climate over some time period, including wind, temperature, pressure, humidity, rainfall, cloud cover, days of sunlight, storms, etc.

Element cartographic maps (a.k.a., sector maps) include, but may not be limited to:

1. Thermal map - show temperature (and/or changes in temperature).
2. Climate and atmospheric maps - show wind, rain, humidity, and temperature.
3. Illumination map - show sources and distribution of illumination.
4. Noise map - show sources of noise and distribution of noise.
5. Pollution map - show pollution and distribution of pollution.
6. Sun map - show sun position and illumination from the sun throughout the year.
7. Electromagnetics map - show the EM volume.
8. Sensor map (e.g., cameras) - show position and coverage of sensor.

Metadata associated with location data may include:

1. Coordinate (a.k.a., location).
2. Time (a.k.a., daily rotation temporal record).
3. Date (a.k.a., solar rotation temporal record).
4. Altitude (a.k.a., elevation value).
5. Pressure (a.k.a., force value).
6. Percent (a.k.a., amount degree).
7. Direction (a.k.a., trending movement).
8. Intensity (a.k.a., relative output).
9. Density (a.k.a., concentration value).
10. Quantity (a.k.a., amount value).
11. Spread (a.k.a, distribution value).
12. Event (a.k.a., activity).
13. Etc.

Objects on maps will often be identified through the following data categories:

1. Object name.
2. Object dimensions (length, width, vertical).
3. Object volume.
4. Distance between objects.
5. Location of object over time.

There are different ways of representing data on maps. The following are different methods for the visual representation of mapping data (in all cases, the map's legend names the symbol and identifies units):

1. **Topographic maps** - are considered all-purpose maps for identifying natural and man-made features on a landscape. These maps are constructed from topographic surveys. These are the most common type of map used to survey and assess land and plan habitats.
2. **Firefly maps (a.k.a., glow maps)** - use glowing symbology with a dark desaturated backdrop. The strength of the glow (effect) relates to value (i.e., more glow and/or area equates to a larger value.
3. **Dot distribution maps (a.k.a., dot maps, dot density maps)** - use dot symbology to indicate value. More dots equates to a higher value. These maps depict a quantity for a given area by filling it in with small dots. Instead of larger symbols meaning “more” of something like in symbol maps, dot distribution maps shows “more” dots.
4. **Symbol maps**:
   A. **Proportional symbol map** - a larger symbol means “more” of something at a location.
   B. **Graduated symbol map** - is a map that scales the size of symbols proportionally to the quantity or value at that location.
5. **Vector direction maps** - displays symbols that are rotate (generally arrows) based on the angle/direction of flow in that location. If speed is to be depicted then the size of the arrows can be adjusted. Larger arrows depict faster flow.
6. **Distributive flow** maps - Distributive flow maps curl like "fingers" branching off to their destination depicting direction and movement. These "fingers" show routes of travel. These maps easily show how objects (e.g., liquids) or information travels from an origin to one or multiple destinations.
7. **Density-equalizing cartograms** - are traditional cartograms. Cartogram maps bulge the size of geographic areas from representative values. This distorts scale with each area remaining connected.
8. **Voronoi diagrams** - start with seed points that divide regions for each point. Each region shows the closest region for a point. So If you place a point in any region, then it’s the closest to that seed point.
9. **Choropleth maps** - vary the shading of each area based on its value. It’s one of the most common map types. They’re different from heat maps because they require a geographic boundary. We assume the entire boundary is homogeneous with its assigned shading.
10. **Surface maps** - take a set of known values and create a surface predicting the unknown ones in between. This map is common for rainfall, temperature, and elevation. They differ from choropleth maps because they’re not tied to a geographic boundary or region.

11. **Heat maps (point density)** - color-code using the density of points. Higher density often equates to red, medium to green, and low to blue.
12. **Isochrone maps** - reveal the geographic extent to which one can travel. If you start at a given point, it shades how far you can travel within an amount of time. It is a map that depicts the area accessible from a point within a certain time threshold.
13. **Dasymetric and choropleth maps** - are thematic mapping techniques. Dasymetric maps classify quantitative aerial data.
14. **Space-time cube maps** - where space-time cubes are slices of time stacked up in a three-dimensional space. Older time cubes are on the bottom. New slices of time are on top. These maps are ideal to show how values change in geographic space.
15. **Contour (isoline) maps** - have lines with constant values joining points of equal elevation. If contour lines are closely-spaced together, the terrain is steep. But if they are widely-spaced apart, it's a gradual incline.
16. **Data visualization maps** - visualize statistics on maps with bar graphs, pie charts, and line plots.
17. **Non-continugous cartograms** - resize features based on values and keep their shape intact. But features don't have to stay connected. Features scale up or down according to value. But the tradeoff is that you lose their precise placement.
18. **Dorling cartogram maps** - uses shapes like circles and rectangles to depict the area. By using shapes, it's easier to recognize patterns. These maps completely lose their geographic reference.
19. **Schematic maps** - depict engineered systems such as rail maps, traffic lights, and electric networks.
20. **Planimetric maps** - consist of manmade and natural features that are outlined (often with different colors representing different categories of object). The outlines depict areas and objects on a masterplan.
21. **Network flow maps** - show movement along a network (e.g., flight paths, transportation networks, communication systems, etc.).
22. **Coxcomb chart (a.k.a., polar area chart)** - includes pie charts with radial sectors that convey data.
23. **Hexagon binning** - a grid of hexagons cover the map and display data with color reference.
24. **Radial flow maps** - include lines that radiate from an origin. They radiate outwards to single or multiple destination nodes.

3.1 Mapping software

Cartographic and GIS mapping software include, but are not be limited to:

1. ArcGIS [arcgis.com] - mapping and analysis solution.
2. Agisoft Metashape [agisoft.com] - intelligent photogrammatry.
3. DroneDeploy [dronedeploy.com] - intelligent photogrammatry.
4. Google Earth Pro [google.com/earth/versions] - mapping and analysis solution.
5. Global mapper [bluemarblegeo.com/global-mapper] - mapping and analysis solution.
6. QGIS [qgis.org] - mapping and analysis solution.
7. Quick terrain modeler [appliedimagery.com] - mapping and analysis solution.

3.2 Terrain map sources

Terrain maps can be accessed (downloaded) from the following sites:

1. Bathymetric Data Viewer from the US National Centers for Environmental Information [ncei.noaa.gov/maps/bathymetry]
2. dwtkns tile map [dwtkns.com/srtm]
3. Global Eleveation Datasets [vterrain.org]
4. MapBox [mapbox.com]
5. NASA Earth Observatory Global Maps [earthobservatory.nasa.gov/global-map]
6. NASA WorldView [worldview.earthdata.nasa.gov]
7. Mapbox (OpenStreetMap) [heightmap.skydark.pl]
8. OpenTopography [portal.opentopography.org]
9. OpenStreetMap [openstreetmap.org]
10. US National Centers for Environmental Information [ngdc.noaa.gov/mgg/topo]
11. Switzerland Federal Office of Topography swisstopo [swisstopo.admin.ch]
12. Tangrams [tangrams.github.io/heightmapper]
13. Terrain.Party [terrain.party]
14. USGS [apps.nationalmap.gov/downloader]

4 Land surveying for construction

A.k.a., Construction survey, land surveying and mapping.

The land requires a survey, wherein a master plan drawing is aligned onto the terrain wherein physical markers are placed on the land to designate areas. The surveying process involves staking out (with physical stakes and positional references) the location of planned structures (e.g., buildings, fences, etc.) and modifications (e.g., earthworks). These reference points and markers will then guide the construction. These markers are usually staked out according to a suitable coordinate system selected for the project.

1. Survey existing conditions of the future work site, including topography, existing buildings and infrastructure, and underground infrastructure whenever possible (for example, measuring invert elevations and diameters of sewers at manholes).
2. Stake out lot corners (perimeters), stake limit of work and stake location of construction trailer (clear of all excavation and construction).
3. Stake out reference points and markers that will guide the construction of new structures.
4. Verify the location of structures during construction.
5. Provide horizontal control on multiple floors.
6. Conduct an As-Built survey: a survey conducted at the end of the construction project to verify that the work accounted for ("authorized") was completed to the specifications set on plans.

Surveying equipment include, but may not be limited to:

1. Levels.
2. Theodolites - used for accurate measurement of angular deviation, horizontal, vertical and slope distances.
3. Electronic distance measurement (EDM).
4. Total stations.
5. GPS surveying.
6. Physical staking.
7. Rope connected stakes.
8. Laser scanning.
9. GIS computation and visualization.

There are three primary types of land surveys herein, including:

1. **Land surveying (a.k.a., land database survey)** - is used to identify the physical quantities and qualities of the land, including present resources and cultural conditions. 'Site survey and land assessment' (3.0, earlier section) form must be filled in completely to have filled in a complete land survey form. There are no changes made by the surveyor to the physical land. Instead, the land surveying process involves filling in a database of separate inquiries about the current, past, and future possible state of the land. A database survey is completed by a research and discovery effort into the land.
2. **Site planning survey (a.k.a., plot plan or survey)** - is a plan of the entire property, drawn to scale, that shows the location and dimensions of all property lines, any existing and proposed structures, and any proposed exterior work. A site planning survey combines the elements of boundary and topographic surveys for site planning, and may even include succession (in possible terms of plants, animals, and structures). This type of survey is used to plan the whole design and development of a site before construction begins. It may be submitted to government officials for approval. Site plans are frequently required by the State for acquisition to State required permits that allow [for] development (construction) operations. In most States, anytime a structure or use is added to a property (such as fence, shed, parking, addition, house, farm, etc.) an accurate site plan is required to determine if the project meets all State zoning code requirements (and other legal codes and standards). A site plan survey is a combination of a 'boundary survey' and 'topographic survey':
   A. **A topographic survey** - is used to establish elevations and relief. A topographic survey is a land or aerial survey that gathers data about the elevation of points on a piece of land and presents them as contour lines on a plot. A topographical survey shows a 3D depiction of land on a 2D product with contour interval lines. Contour lines are useful because visualizes the various elevations on a plot of land. Topographic surveys are used to inform construction, erosion and other environmental issues, zoning issues, etc. The topographic survey provides the first layer of the site planning documentation.
   B. **A boundary survey (a.k.a., market-based property line, designating individually enforceable State ownership) -** is used to locate the corners and boundary lines of a parcel of land. This is someone's landed territory; first, landed by a State-government and then landed by individual or corporate citizens of that authority. This type of survey involves both record and field research, including any measurements and computations needed to set the boundary lines in accordance with applicable State laws. A boundary survey may also involve locating easement lines and

encroachments. Once surveyed, the boundary line should be physically staked. This survey identifies the lot dimensions in the physical and in an architectural orthographic top 2D view. A single line, or set of single lines designates the bounded location(s) on the topological terrain map.

C. **Construction surveying (a.k.a., site plan specification documentation, site construction survey)** - is used to stake out structures and specified functional areas located on the property, including walls, buildings, roads, and utilities. Staking provides construction personnel with directions for executing the decisions shown on the development master plans (i.e., in the site planning survey). A construction survey may also involve both horizontal and vertical grading in addition to an as-Built survey.

5 Surveying organizations and standards

The most well-known international surveying organization is:

- **International Federation of Surveyors (FIG)** [fig.net] - a federation of national member associations associated with surveying. FIG covers the whole range of professional categories within the global surveying field, including: surveying, cadastre, valuation, mapping, geomatics, geodesy, hydrography, geospatial, geo-information and quantity surveyors and provides an international forum for discussion and development aiming to promote professional practice and standards.

TABLES

Table 48. Land Accounting: *Hierarchical classification of geomorphological features (time and space scales are approximate).*

Hierarchical Classification Of Geomorphological Features			
Typical units		Spatial scale km^2	Time Scale Years
Continents		10^7	10^8-10^9
Physiographic provinces, mountain ranges		10^6	10^8
Medium and small scale units, domes, volcanoes, troughs		10^2-10^4	10^7-10^8
Erosional/depositional units:			
	Large scale, large valleys, deltas, beaches	10-10^2	10^6
	Medium scale, floodplains, alluvial fans, cirques, moraines	10^{-1}-10	10^5-40^6
	Small scale, offshore bars, sand dunes, terraces	10^{-2}	10^4-10^5
Geomorphic process units:			
	Large scale, hillslopes, channel reaches, small drainage basins	10^{-4}	10^3
	Medium scale, slope facets, pools, riffles	10^{-6}	10^2
	Small scale, sand ripples, sand grains, striations	10^{-8}	

Habitat Service System Accounting

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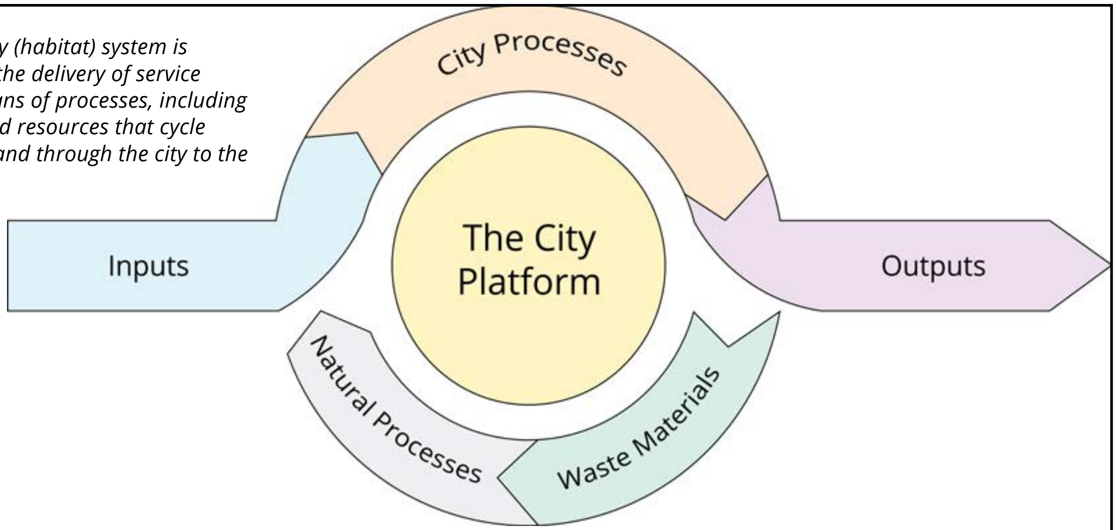
Abstract

The term 'habitat service system' is the technical name of a 'city'. Every habitat service system may be sub-divided into three primary systems, a life support system, a technology support system, and an exploratory support system. Each of these systems has a set of sub-systems that provide services to humanity. Cities are human habitats that localize services in a coordinated manner. A city (habitat) in a community-type society is an integrated, total living environmental service system. A habitat can be designed, engineered, operated, evaluated, simulated, and recorded. Cities in community are the result of viewing society first and foremost as an information system, from which cities are designed, developed, operated, and adapted. Habitat services distribute informational and spatial services and objects to a population. In this sense, a city (localized habitat) is a service bus that connects all interacting functional services in a local environment to one another. A network of habitat service systems (network of cities) may share information and spatial resources in order to optimize service globally. The three core services a habitat service system can offer are life support, technological support, and exploratory support. These three service systems (as well as a biospheric) service form the foundational function of any habitat service system. Each individually localized habitat service system (city) has these three functional service systems, which are engineered into operation through an intersystem [habitat service] team. Contributing team members have intersystem access. The whole population has access via cities to these three core human life functions throughout the community network of cities. Each core functional service (life, technological, and exploratory) has a set of functional sub-service access systems from which users in the community access those services (and service-objects therein).

Graphical Abstract

Figure 8. *A city (habitat) system is a platform for the delivery of service outputs by means of processes, including information and resources that cycle within the city and through the city to the larger ecology.*



1 Overview of a habitat service system

A.k.a., Overview of the city system and city system network, overview of the habitat service system network.

The technical term for a 'city' is a 'habitat service system' - a service system integrated into a larger ecological/ planetary habitat. The city is a central concept for human population-scale living. Every city is a continuous process of material creation, usage, and re-configuration. Herein, the rise of city networks and the movement of humanity into a predominantly engineered environment corresponds to a broader process of change during the "anthropocene" (the age of humans). In community, the habitat is the local service producer, producing for user access: contribution, life, technology, and exploratory services over all phases of life. An operational habitat system is a combination of people (with skills and knowledge), tools/equipment, controls, interconnecting means, and terminal elements by which resources are transferred and transformed to perform specific habitat [human need] functions, such as shelter, climate control, service water heating, lighting, etc. A habitat is landscape made up of individuals, families, neighborhoods (total habitats and regions), and an InterSystem team working group (Read: contribution service system) that configures physical resources into habitat support service platforms (known as cities/habitats). Within the definition of a habitat service system are three elements:

1. Personal residences (a home in which to live).
2. Local habitats (common daily life-radius; a complete life-phase service platform, habitat, in which to live).
3. Regional habitat networks (weekly and monthly life-radius; a regional habitat network in which to live).
4. A global habitat service system network (societal InterSystem and User Team; a global habitat support service system that ensures all live well).

TERMINOLOGY: *Habitation is the state or process of living in a particular place; a dwelling or city in which to live.*

In common discourse, the word "city" carries several characteristics, each portraying a different perspective on life in a materialized socio-economic system. The term, "city", is characterized differently depending upon societal perspective. From the perspective of population scale, people come together to form service hubs which are often given different names depending on the specific population size of the service hub. The population scale is generally something equivalent to: tribe [smallest population] hamlet > village > town > suburb > city > megacity (metropolis or megalopolis) [largest population]. In community, however, there is a global, unified habitat service system [network] in which there are many interconnected smaller habitat service systems known commonly as 'cities', each of which has been designed with a carrying capacity set by its [designed] configuration. To some extent, these other terms (e.g., village, town, etc.) for what is essentially a service system hub integrated into a habitat, divert attention from that fact. In other words, because of the language around how humanity is fulfilled, people don't generally think about a "village" or "city" in terms of what it actually is; which is, the materialization of socio-economic information into the material environment in the form of a habitat service system that exist to service human fulfillment requirements.

From a 21st century perspective on resource sustainability, a city is a place that requires that the majority of resources and goods come from outside of its boundary (i.e., it is, fundamentally, an unsustainable structure). Conversely, in community, the habitat service system must by definition be sustainable. It must be sustainable, because the term itself indicates the presence of a service system within a habitat, and for a habitat to sustain the population it must not overshoot carrying capacity. A habitat is a place where material needs are regeneratively fulfilled. If a habitat service system cannot sustain itself with local resources or sustainable access to the global network of resources, then it will assuredly begin to degrade and should not be considered a habitat service system. In community, the term 'habitat service system' is just another word for a "city", but the city is sustainable.

From the perspective of authority, a city is a governed area with a leader (or leadership) of some kind. Therein, a city as a space of government and authority, the territorialization of government through the structuring of social networks based upon power-over-others relationships. The city is a place where discipline and subordination is imposed. In contrast, in community, there is no authority who governs or otherwise leads everyone, or anyone. Instead, there is a common information model, an accountable decision process, and a contribution structure that facilitates participation in ones own life and the lives of all others. A city represents an individual's generalized life radius and the localization of services.

A city could be viewed as a piloted system, and equated with the modular nature of a space station. Cities could be designed like modular space stations, highly flexible and highly sustainable. A space station, like a habitat service system, has modular life (and other) support functions. Thus, in a more abstract sense, the core platform of a habitat service system could possibly be viewed as a "spacecraft bus", which is a major part of the structural subsystem of a spacecraft. It provides a place to attach components internally and externally, and to house modules. The bus also establishes the basic geometry of the spacecraft, and it provides the attachment points for appendages such as conduits (e.g., booms), communications elements (e.g., antennas), and sensors. Similarly, a city is a platform for the service fulfillment of humankind and its subsystems provide a variety of required functionality. However, a habitat service system is unlike a space station in that it integrates into a larger ecological environment, whereas a space station is designed to isolate its occupants for their protection. A city ought to connect and facilitate the adaptation of a life form to its environment. Also, it may provide protection, but if it isolates its users/ occupants from the larger habitat, then its users are likely to become disoriented from their highest potential trajectory in life. In reality, a service system (a city) must allow for the thoughtful flow energies with the larger ecological habitat if it is to flourish.

A city is where many people gather and live. A city is more than just an architectural expression -- it involves more service functions than just providing architecture for a population.

As a complex system, a city can express the following properties:

1. A city is a group of people and a number of permanent structures within a geographic area. In the market-State, said organization exists to facilitate social control and the trade of goods and services among residents and with the outside world. In community, said organization exists to facilitate so organized to facilitate human fulfillment.
2. A city is a center of, and for, human activity.
3. A city is a spatial pattern of human activities and their materializations at a certain point in time (note that this is often the definition for the term 'urban').
4. A city is an environment (space) configured through flows (exchanges, networks) of communication and the transport of matter and energy.
5. A city is an environment built for a social population.
6. A city is a network of people, information, and material flows designed to fulfill the requirements of a population. A city is a complex interconnection of people, information, and material flows. Therein, a city is a material system designed through the information system of a social population.
7. A 'city' is an information and spatial service system.
8. A city is an information and material processing system/platform that has been engineered for a social population.
9. A city is a socio-technically built environment that has been engineered to socio-technical specification standards. A city as a built information medium.
10. A city is the materialization of a population's socio-economic [information] system.
11. A city contains subsystems that provide structural and functional meaning, interconnected and enabled by networks of people, information, and material flow, as well as characterized by social, decisional, material, and lifestyle aspects.
12. A city is a habitat service system to fulfill human requirements.
13. A city is a multi-physic object, characterized by a dynamic interrelationship of energy, materials, information and human activities and behavior (Stepandic, 2019). In this sense, a city could be considered a "living" object of human, informational, and material interrelationship.
14. A city is an evolving, living system in complex interaction with its population, its artificially materialized environment and its natural physical environment.
15. A city is an environmentally controlled area.
16. A city is a living complex of geometrical and topological objects, limited in its material (artificial and natural) environment.
17. A city is sustained (operated) and lived in by its

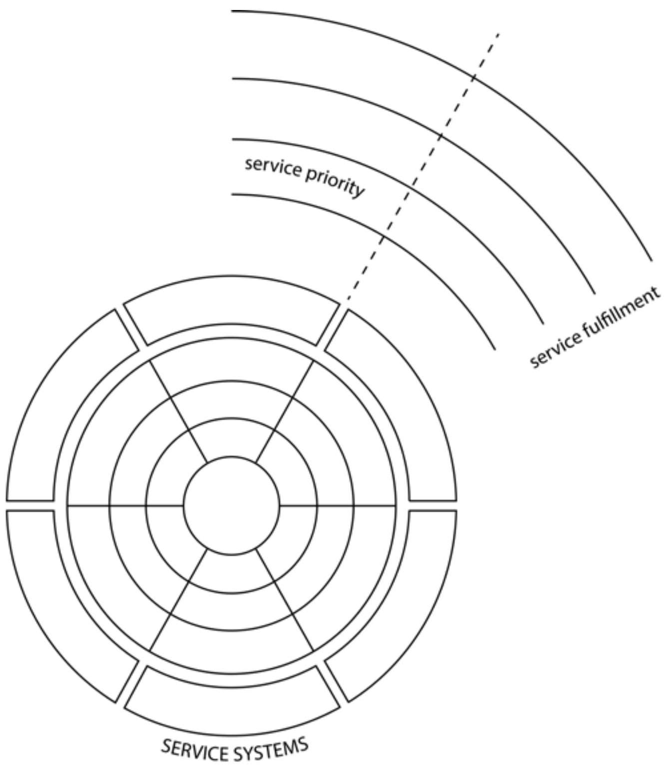


Figure 9. *Concept diagram depicting service systems with service priority (i.e., some services are prioritized) and service fulfillment (accountable degree of completion of service system demand).*

population, constrained by decisioning and physical laws.

18. Cities are hubs of people, supported by infrastructure. Cities are where people come together to experience the benefits of being together in close proximity - to access to services and opportunities.
19. A city is materially encoded intelligence (or, lack thereof).
20. A city is a place where people live and work and play together. A city is a live-work (or, live-work-play) environment.
21. A city is an environment that optimizes (or, should optimize) for the quality of life of the beings in that environment.
22. A city can make humans more productive. Humans become more productive in cities, in part, because they live closer together.

A city is a place where people live and work together under the same infrastructure:

1. City infrastructures are an enabler of collective living and working.
2. Infrastructures affect the “life” and behavior of a city.
3. Infrastructures are affected by the “life” and behaviors of a city.

A city is a place where people live within the same [type of] society:

1. A city is [the result of] a social system.
2. A city is [the result of] a decision system.
3. A city is [the result of] a material system.
4. A city is [the result of] a lifestyle system.

A city is a system with:

1. Feedback loops (inside and across sub-systems).
2. Complexity (interrelatedness).
3. Path dependency.
   A. Socio-systems.
   B. Technical-systems.

> **INSIGHT:** *In a city, people are likely to connect only if a city’s human-scale geometry creates shared spaces with the right complexity. In the controlled material environment that is the habitat of community (i.e., the Habitat Service System, the “city”), everything is analyzed and broken down for functional use by its users.*

In general, cities in the market-State are an organic mix of competing interests; where they are also highly planned, they are planned for market-State functions. Cities (habitats) in community, because they master-planned together for human need fulfillment, in a locally integrated manner, become an accountable community production technology as a single unit (in a distributed network of common heritage resources with local habitats). Habitats are centers of access to resources composed into socio-technical service support systems, including humans and sub-technology, the fundamental [material] technology being that of habitat [service system] design. Wherein, the fundamental [informational] technology is that of "artificially" intelligent information service-support system. In community, cities/habitats are community decision system determination. Habitats are delivered as master-plans that provide the conditions for access to resources composed into socio-technical service support systems, including humans and technology, that meet the common global needs of humanity. The fundamental socio-technical [service-support] system (a.k.a., the fundamental technology) is that of the habitat [service system] itself; its design, development, and operation. In the market-State, there is no one master-plan for the whole city, decided by the whole city in a unified planned and coordinated manner. In the market-State, there is the saying that "everyone has their own selfish plans". Conversely, in community, there is a unified information system, within which there is a decision system. That decision system produces local habitat master plans while accounting for habitat master plans globally; because, all master plans will be using common heritage resources. In community, there is a necessary accounting for common heritage resources as they pass through necessary habitat services localized to specific geo-located access radii. Here, there are protocols for access, and those protocols are formed from a set of societal standards, and formed into a resolving decision system that produces, in conjunction with humans, a best next version of the habitat (locally and globally).

1.1 The legal status of cities

Cities in a market-State are legal entities. The legal status of cities can vary depending on the specific local legal framework. In many jurisdictions cities are legally defined by their status of incorporation. City status is thought to be a natural progression to further raise the competing population’s economic profile. A city, like everything else in the market, is a product to be bought and sold. The most well-known city products are Paris, Beijing, Moscow, London, and New York.

In some cases, cities may be considered legal corporate entities with certain rights and privileges. This could allow them to enter into contracts, own property, and sue or be sued in court. However, it's important to remember that even in these cases, cities are still subject to the laws and regulations of the market-state they exist within. In other cases, cities may have a more limited legal status, and may not be considered true corporations. Cities are typically not corporations in the traditional sense; they lack some key characteristics of corporations, such as the ability to issue stock or operate for profit. However, some cities have established independent authorities or boards that function similarly to corporations. These entities may have their own budgets, governance structures, and the ability to enter into contracts.

As for how cities purchase goods and services, they typically follow a structured governance, budgeting, and procurement process. This process may involve soliciting bids from qualified vendors, evaluating proposals, and negotiating contracts. Cities also have access to various funding sources, such as taxes, grants, and bonds, to finance their operations. Typically, county governments reviews and approve the articles of incorporation for cities; wherein, if enough people in the county vote for establishing a new city government, then a new city is incorporated. The city then becomes run by a mayor and city council or some similar structure.

Hence, here are the typically legal characteristics of cities under market-State conditions:

1. **Subordinate to State law:** Regardless of their individual legal statuses, cities operate under the jurisdiction of the laws and regulations of the state or nation they are part of. They must adhere to higher-level legal frameworks even as they manage local affairs.
   A. **Legal entities:** Cities are generally recognized as legal entities, which means they can exercise certain legal powers. These can include entering contracts, owning property, and engaging in litigation (suing or being sued).
   B. **Autonomy and governance (sovereignty):** The degree of autonomy and governance powers afforded to a city can vary. In many market-States, cities are granted a certain level of self-governance, typically administered by elected officials such as a mayor and city council, which allows them to address local issues effectively.
2. **Incorporation:** The process of becoming a city often involves incorporation, a legal procedure that formalizes the city's status and delineates its governance structure. Incorporated cities are typically granted a charter that outlines their rights and responsibilities, and a set of Articles that outlines their standard of operation.
   A. **Corporate characteristics:** While cities may have some corporate-like features, they differ from traditional business corporations. They usually do not issue shares, have shareholders, or seek to generate profits. Instead, they provide and sell services.
3. **Procurement and funding:** Cities procure goods and services through a public procurement process, often involving competitive bidding. Their operations are funded through various means, including taxation, State or federal grants, and the issuance of municipal bonds.
4. **Establishment of new cities:** The creation of new cities usually follows a "democratic" process, including the creation of a charter and articles of incorporation, and a local election to gauge public support. If the vote is affirmative, the State or county government will review and approve the incorporation, establishing the city's legal framework for governance.

1.2 Types of cities

A.k.a., Cities in community and other types of society.

In any society, cities are the product of that societies societal information set. In other words, cities arise and are reconfigured based upon a given society's information system, whether that system is made explicit or not. Fundamentally, different types of societies Different underlying configurations of society (with different goals) are likely to create very different urban forms. types of material environments, and therein, different types of cities:

1. **Community cities (a.k.a., integrated city systems, total city systems, comprehensive urban systems, etc.)** - a total/integrated city system is a holistic and comprehensive approach to urban (habitat) planning and coordination where various components of a city's infrastructure, services, and systems are interconnected and optimized for efficient operation and improved quality of life for its residents.
2. **Market-State cities (a.k.a., market-city system, State-city system, smart city system, etc.**) - a market-State city is typically developed in an organic manner with private property, State property, and commerce as base elements of its design.

Fundamentally, specific organizations of cities play a key role in the systemic transition towards a more sustainable way of living.

1.2.1 Integrated total cities in comparison to organically developed market-State cities

A.k.a., Community versus market-State urban paradigms.

Urban development takes shape through two distinct approaches: the carefully planned and coordinated integrated city, and the organically evolved city that grows with the passage of time and under market-State conditions. Integrated cities are purposefully planned and designed to achieve specific goals, while organically developed cities evolve over time based on historical and local factors:

1. **Planning and design:**
   A. **Integrated city:** in an integrated city, planning and design are typically centralized by a comprehensive master plan. The layout, infrastructure, and land use are carefully designed and coordinated to achieve specific goals, such as sustainability, efficiency, and quality of life. Integrated community cities are primary planned by and for their local inhabitants. Additionally, integrated cities have master plans that are redone every several years leading to greater flexibility and customizability over time. In other words, integrated cities regularly update their master plans every few years, enhancing flexibility and adaptability as they evolve.
   B. **Market-State developed city:** in a market-State city, planning and design are typically guided by a local governmental-corporate plan and focused around private property, State property, and commerce. Market-state developed cities are often planned through collaboration between local government and corporate entities, with a strong emphasis on private property, State property, and commerce. Planning is often driven by economic interests and profit motives. Market-state cities prioritize economic growth and commerce as their primary focus, often with the goal of attracting businesses and generating profits.
   C. **Organically developed city:** organically developed cities grow over time without a centralized plan. Their layout often reflects historical growth patterns, resulting in a mix of land uses and infrastructure that may not be optimized for modern needs.
2. **Infrastructure:**
   A. **Integrated city:** infrastructure in integrated cities is usually well-coordinated, with optimized transportation networks, utilities, and services. It often incorporates smart technology for efficient coordination.
   B. **Market-State developed city:** infrastructure comes from financial by the local government and corporations, who naturally prioritize corporate interests and economic growth. Investments may lean towards commerce-related infrastructure, such as transportation networks that facilitate the movement of goods and services. Infrastructure investments will prioritize commerce-related infrastructure over public welfare. Public services will be influenced by corporate interests, with a focus on supporting businesses and economic development.
   C. **Organically developed city:** organically developed cities may have infrastructure that is patchy or outdated in some areas due to gradual expansion and a lack of central planning.
3. **Sustainability:**
   A. **Integrated city:** integrated cities often prioritize sustainability, natural beauty, green spaces, eco-friendly materials, and non-polluting power sources. Sustainability and environmental considerations are typically integrated into planning, with an emphasis on green spaces, eco-friendly practices, and reducing ecological impact.
   B. **Market-State developed city:** while sustainability efforts may exist, they are often driven by economic interests and may not be as comprehensive as in integrated cities. As is necessary in the market, profit is prioritized over sustainability, and as is necessary in the State, security is prioritized over freedom.
   C. **Organically developed city:** sustainability efforts in organically developed cities may be retrofitted rather than built into the original design, making them less comprehensive.
4. **Land use:**
   A. **Integrated city:** land use in integrated cities is carefully zoned to optimize community values and objectives (i.e., freedom, social justice, and efficiency).
   B. **Market-State developed city:** land use in market-State cities is carefully zoned to optimize market-State values and objectives (i.e., profit and coercion).
   C. **Organically developed city:** organically developed cities may have mixed land uses, with commercial, residential, and industrial areas intermingled due to historical growth patterns.
5. **Transportation:**
   A. **Integrated city:** integrated cities often have well-planned transportation systems that prioritize common transit, cycling, and walkable design. Transportation planning aims to serve the broader community's mobility needs and eliminate all possible congestion.
   B. **Market-State developed city:** market-State cities prioritize transportation infrastructure that facilitates commerce-related objectives. While public transit may exist, it may not receive the same level of emphasis as in integrated cities.

C. **Organically developed city:** organically developed cities may face challenges in terms of traffic congestion and limited public transportation options due to unplanned growth.

6. **Community and identity:**
   A. **Integrated city:** integrated cities may have a more cohesive and planned community identity, as efforts are made to create a unified urban experience.
   B. **Market-State developed city:** market-state cities prioritize a corporate, economic, and/or State identity, potentially leading to less community cohesion and a narrower focus on economic and/or State goals.
   C. **Organically developed city:** organically developed cities where there is a cohesion of identity are often peaceful and safe places with a focus on inclusivity; however, organically developed cities with a diversity of cultures typically have either high coercion to maintain peace, or low coercion, and thus, significantly less peace (more violence) due to serious disagreements in decisioning by people with differing cultural backgrounds.

1.2.2 Community-type cities

A.k.a., Community-cities, cities in community, community-based cities, community-type cities, integrated city systems, total city systems, etc.

Community-cities are humanity's primary habitat within the larger planetary ecology. These cities form a unified cooperative network for the sharing of information and resources to maximize global fulfillment of access. The term, 'community-city', is referential of the 'city' emerging as the material expression of a community-type society. Therein, 'community' is the term giving to the living system (i.e., society) as a whole, and the 'city' is its material expression. A community-city is a material ecosystem designed to facilitate the experience of a greater sense of connection and integration within each individual. Community-based cities are hubs for the sharing of access. Cities in community are complex socio-technical environments where access and services are available for free. Most cities in community are largely autonomous; however, some populations have chosen to live in low technologically developed cities where there is little application of autonomous systems. These low-tech city systems are often significantly reduced in population size and carry capacity compared to their high-tech alternatives. Effectively, community-type cities are integrated socio-technical service systems designed to fulfill the needs, wants and preferences of a population of human beings in a regenerative and emergent manner. Community cities are integrated habitat service access platforms with sufficiently complete ecosystems for soil restoration and materials cycling. A habitat is representational of a whole ecosystems.

A community-city is an integrated (total) socio-technological service system for providing material need fulfillment to a network of humans in a sustainable manner at pre-planned population scales. Therein, a city is the materialized reflection of socio-decisioning and lifestyle design. New (community-type) lifestyles require new material spaces, new habitats and updated cities.

1.2.2.1 Community-type city construction specifics

In community, cities can exist of at least the following types of constructed composition:

1. **By resource type:**
   A. Primarily, mineral-based construction.
   B. Primarily, bio-based construction.
   C. Mixed bio- and mineral-based construction.
2. **By density of human population:**
   A. Low, medium, high.
3. **By amount and inclusion of wild and/or cultivated landscape:**
   A. Rural (landscape around buildings is either high cultivation and/or high wild). *May or may not has the same infrastructural services as an urban environment.*
   B. Urban:
      1. In the market-State - there is little cultivation or wild land around buildings.
      2. In community - integrated city system include/integrate cultivation sectors into their service system for local and regional food production.

1.2.3 Market-State cities

A.k.a., Industrial cities, modern cities, early 21st century cities.

A State-city or city-State refers to a population center for social interaction within a territorial authority, the "jurisdiction" (i.e., a government body). State-based cities are governmental controlled environment (i.e., population-controlled environments). The population of a city-State is often called its "citizenry" -- the population are "citizens" of a particular jurisdiction. Here, a city is a center for national/local government. The state controls (or, restrains) the behavior of citizens in a city through laws and law enforcement (i.e., the monopolization of force/violence). Market-State cities are not complete eco-systems. All known cities to date are market-State cities.

A market-city or city-market refers to a city designed to accommodate the market. In the market, a city is a center for trade and financial investment. Market-based cities are designed around ownership and businesses. Individuals in a market-city are generally referred to as owners. A market-State city is necessarily divided up into plots of ownership, often, starting with that which is owned by the local governing authority. In fact, nearly all cities in early 21st century society are entirely owned by their local governing authority, which rents the land to secondary owners by means of taxation. Hence, market-cities are actually city governmental markets. Thus, a city is a conglomeration of people and buildings clustered together to serve as a center of politics, culture, and economics. Therein, a city is an environment in which people compete for resources.

> **TERMINOLOGY:** '*Urbanization' is the growth and diffusion of city landscapes and urban lifestyles.*

Cities within the market-State are developed around entirely different purposes than those developed for/in community. Early 21st century cities are a central hubs for competition, and the vast majority of them are designed primarily for automobile access. Modern cities are full of passive commercial attractions, and capital cities are full of embassies.

In the market-State, market demand is closely related to the size of any given economy, population, and income level of a city. Therein, different aspects of the market and State determine the spatial distribution, size, direction, and model of the production and circulation of goods and services within and between cities. (Ni, 2007)

Market-State cities in the early 21st century are generally designed along five business lines (*Systems of Cities*, 2009):

1. City management, governance, and finance.
2. Economic growth.
3. City planning, land, and housing.
4. Urban environment and climate change.
5. Handling urban poverty.

> *Note: These business items set out the objectives and benchmarks for financing and policy advice.*

The majority of data available on land and resource requirements to support a market-State city in the early 21st century is mostly irrelevant to the design of a city as a habitat service system in community. For example, the amount of food volume necessary to support the population is different since a community's service system accounts for nutritional density, which is something modern socio-economic service entities do not account for in their data. Further, there is no financial system in a community-city, which makes data tainted by financial bias somewhat useless.

> **NOTE:** *Market-State cities manage the poor instead of creating environments that don't produce poverty.*

In the early 21st century, some market-State cities are centuries old, having been built up and outwards for thousands of years. The lives of the current inhabitants of these cities are significantly shaped by centuries old structures and layouts that are creations of those with knowingly outdated understandings and value sets. In other words, the beliefs and values of those long dead are still affecting the day-to-day lives, behaviors and lifestyles, of city residents in the early 21st century.

Living systems survive, connect with their environment, and reproduce themselves. The biophysical facts of life then set up the conditions for individual survival and species survival. The city is just a natural and inevitable outcome of human behaviors that have resulted from human evolution. But, it has also become a life condition itself that directly impacts well-being. Cities in the early 21st century (and their suburbs) represent the structural encoding of a value orientation away from one of a resilient living system. To flourish, humanity must redesign its city habitats to more greatly encode and restore a life-fulfilling value set.

It would be far easier and would require less energy to build new, efficient cities than to attempt to update and solve the problems of the old ones. (*Circular cities*, 2020) The question then arises, what would be done with old cities in a global community-type society? Most of the old cities would be leveled and mined for their resources. They are too inefficient to maintain. Some of the cities would be set aside as museum cities. (*FAQ*, 2020)

> **INSIGHT:** *In making the city, we make the world more after our "hearts desire", but in making that city we also make our future selves.*

1.2.4 Smart cities

> *A.k.a., Smart urbanism, electronic government, electronic infrastructure, urban operating system.*

Smart cities are, generally, more technologically advanced cities in the market-State. A smart city is the conception of a city that uses technology to enhance governance, planning, management, and livability of a city by gathering and processing real-world, real-time data. Therein, city residents and visitors are claimed to live more easily (i.e., more conveniently) due to the integration of these "smart" technologies (i.e., sensors, computing, and automation systems). In terms of city management and service coordination, "smartness" also refers to applying information technologies to different stages of planning, designing, building, and operating cities. (Ronkko, 2018) There can be found more than 36 distinct definitions of the "smart city" concept in a current scientific literature. (Stepanek, 2019) A generalized definition of a "smart city" is a city that uses "electronic Internet of Things (IoT) sensors to collect data and then use insights gained from that data to manage assets, resources and services efficiently". (*Smart city*, 2020) The first attempts to define the concept were focused on the connectivity and features provided by information technology for managing various city functions (i.e., electronic government; e.g., smart meters). More recently, the usage of the term has widened in scope to include the outcome of a "smart city", such as sustainability, quality of life, and services to the citizens. (Ramaprasad, 2017) Of course, these outcomes are generally defined within the context of the market-State.

> **INSIGHT:** *A city could be viewed as a living organism that needs to fulfill specific goals for the city to preserve its existence. Note that this is of course a reification of the city, which could lead to misunderstanding. A city is not, in fact, a living thing; it is the humans (and other organisms) inside the city that are living and that which have need. In actuality, the city exists to fulfill a purpose beyond itself, for humanity.*

Ramaprasad et al., (2017) have proposed a Smart City ontology that attempts to connect early 21st century definitions and unify the concept of a "smart city". Ramaprasad et al. (2017) and Stapanek et al. (2019) consider the ontology a better way to organize smart city concepts than a single definition. This ontology defines the "smart city" concept as a function of two main parameters: smart and city. For each parameter, there is a function that explains the dimensions of the parameter. The concept Smart contains Structure, Function, Focus, and Semiotics. The City consists of Stakeholders and Outcomes. Each dimension from "smart" and "city" is sub-defined as a set of components (or classes).

For the "smart" dimension:

1. Structure includes: Architecture, Infrastructure, Systems, Services, Policies, Processes, and Personnel elements.
2. Function includes: Sense, Monitor, Process, Translate and Communicate.
3. Focus includes: Cultural, Economic, Demographic, Environmental, Political, Social, Technological and Infrastructural elements.
4. Semiotics includes: Data, Information, and Knowledge.

For the "city" dimension:

1. Stakeholders is constructed by: Citizens, Professionals, Communities, Institutions, Business, and Governments.
2. Outcomes include: Sustainability, Quality of Life, Equity, Livability, and Resilience.

The following glossary (Ramaprasad et al., 2017) is necessary to understand the whole definition:

1. Smart: Capable of sensing and responding through semiotics.
   A. Structure: The structure required to manage the semiotics.
      1. Architecture: The architecture to manage the semiotics.
      2. Infrastructure: The physical and virtual infrastructure to manage the semiotics.
      3. Systems: The computer, social, and paper based systems to manage semiotics.
      4. Services: The computer, social, and paper based services to manage the semiotics.
      5. Policies: The policies to manage the semiotics.
      6. Processes: The processes to manage the semiotics.
      7. People: The people responsible for managing the semiotics.
   B. Function: The functions required to manage the semiotics
      1. Sense: To sense the semiotic elements.
      2. Monitor: To monitor the semiotic elements.
      3. Process: To process the semiotic elements.
      4. Translate: To translate the semiotics into action/control.
      5. Communicate: To communicate the semiotic elements.
   C. Focus: The focus of intelligent sense and response (i.e., "smartness").
      1. Social: Social dynamics of the city.
      2. Economic: Economic dynamics of the city.
      3. Environmental: Environmental dynamics of the city.
      4. Technological: Technological dynamics of the city.
      5. Infrastructure: Infrastructure dynamics of the city.
   D. Semiotics: The iterative process of generating and applying intelligence.
      1. Data: The symbolic representation of sensations and measurements.
      2. Information: The relationship among data elements.
      3. Knowledge: The meaning of the relationships among the data elements.
2. City: A city capable of intelligent sense and response.
   A. Stakeholders: Those affecting and affected by the city.
      1. Citizens: Citizens of the city.
      2. Professionals: The professionals of the city.
      3. Communities: The communities of the city.
      4. Business: The businesses of the city.
      5. Governments: Federal, State, and Local governments.
   B. Outcomes: The desired outcomes of a city.
      1. Sustainability: Sustainability of the city.
      2. Quality of life: Quality of life of the stakeholders.
      3. Livability: The livability of the city.

4. Resilience: The ability of the city to recover.

Herein, the "smartness" of the environment affects the "city" in which people live. The expression between classes of the dimensions "smart" and "city" is:

> **Smart** *(Structure [+] Function [+] Focus [+] Semiotics) [by/from/to]* **City** *(Stakeholders [+] Outcomes)*

Therein, a "smart city" is compound function with two parts/dimensions:

> *Smart City = f (Smart + City)*

The "city" is a function of stakeholders and outcomes.

> *City = f (Stakeholders + Outcomes)*

The "smartness" of a city is a function of structure, function, focus (direction), and semiotics (information processes):

> *Smart = f (Structure + Function + Focus + Semiotics)*

Ramaprasad et al., (2017) define 'semiotics' as, the iterative process of generating and applying intelligence. Semiotics forms the core of the "smart" dimension, such that all other classes of this dimension refer to it. The direction of "smartness" is the "outcomes", which are of interest to the "stakeholders". The direction of "smartness" depends on the "structure" and "functions" of the systems for semiotics. The iterative "semiotics" process, involves data that are converted into information, information to knowledge, and the knowledge is then translated into smart actions. The "focus" of "semiotics" are the relevant possible sub-conceptions of the society and city. The semiotics of each focus will affect the corresponding smartness of the city, its stakeholders, and the corresponding outcomes. The "structure" and "functions" of a city's semiotics (i.e., data, information, knowledge) information system (or, management/coordination system) will determine its "smartness". Together, the four left dimension of "smart" are concatenated to form the "smartness" of a city. Taken together, there are 7*5*8*3*6*5 = 25,200 potential components of a Smart City encapsulated in the definition/ontology. A truly "smart city" is one that has realized a significant portion of these potential components.

Four concatenations are listed below as an example of the 25,200 possibilities:

1. Architecture to sense economic information by/from citizens for quality-of-life.
2. Systems to process environmental data for livability.
3. Policies to communicate technological knowledge [by professionals] for resilience.
4. Processes to translate political information to citizens for sustainability.

> **NOTE:** *This ontology and the following functions are bounded by the conditions and conceptions of a market-State society, and are not entirely representative of a "smart city" in a community-type society.*

Stapanek et al., (2019) note three additional papers that facilitate further explanation of the "smart city" ontology as a function. Babar and Arif (2017) propose a functional ontology with several layers. The first layer is an architecture for planning and decisioning. The second is data acquisition and aggregation, mainly using IoT components, and the last uses pre-processed data for taking decisions and communicating events to citizens:

> *f (f (architecture*
> *+ (monitor, process, translate, communicate)*
> *+ urban + data)*
> *+ f (citizens + quality-of-life))*

Uribe-Perez & Pous (2017) propose a communication architecture inspired by a human nervous system. The architecture is composed of:

1. A sensing layer containing a sensor network.
2. An access layer with "smart" gateways to process a low-level information and act consequently.
3. A data layer with sufficient (e.g., 3) types of databases to store data.
4. A platform layer to supervise and manage the city.
5. An application layer to provide services.

The ontological function is:

> *(f (architecture*
> *+ (sense, monitor, translate, communicate)*
> *+ urban*
> *+ (data, in formation))*
> *+ f (stakeholders + resilience))*

Chen et al., (2016) propose an automotive sensing platform used in the city to obtain data from different parts of the city by cars equipped with sensors. The ontological function is:

> *f (f (platform*
> *+ (monitor, process, communicate)*
> *+ data))*

1.2.4.1 A smart city ontology under community conditions

A glossary for a similar ontology to Ramaprasad et al., (2017), but applicable for community conditions would resemble (differences are underlined):

1. Smart: Capable of sensing and responding through semiotics.
   A. Structure: The structure required to coordinate

the semiotics.
1. Information technology: The software and hardware to coordinate the semiotics.
2. Projects (services): The projects (services) to coordinate the semiotics.
3. Teams: The teams responsible for coordinating the semiotics.
4. Processes: The processes to coordinate the semiotics.
5. Procedures: The procedures to coordinate the semiotics.

B. Function: The functions required to coordinate the semiotics
1. Sense: To sense the semiotic elements.
2. Monitor: To monitor the semiotic elements.
3. Process: To process the semiotic elements.
4. Translate: To translate the semiotics into action/control.
5. Communicate: To communicate the semiotic elements.

C. Focus: The focus of intelligent sense and response (i.e., “smartness”).
1. Resources: Resource dynamics of the city.
2. Access: Access dynamics of the city.
3. Social: Social dynamics of the society.
4. Decision: Decision dynamics of the society.
5. Lifestyle: Lifestyle dynamics of the society.
6. Life support: Human life dynamics (or, services) of the city.
7. Technological support: Technological dynamics (or, services) of the city.
8. Exploration support: Human exploration dynamics (or, services) of the city.

D. Semiotics: The iterative process of generating and applying intelligence.
1. Data: The symbolic representation of sensations and measurements.
2. Information: The relationship among data elements.
3. Knowledge: The meaning of the relationships among the data elements.

2. City: A city capable of intelligent sense and response.

A. Stakeholders: Those affecting and affected by the city.
1. Users: Users of the city.
2. Teams: The developers and operators of the city.

B. Outcomes: The desired outcomes of a city.
1. Values: Values of the society.
2. Fulfillment: Fulfillment of the stakeholders.
3. Flourishing: Flourishing of the stakeholders.
4. Quality of life (well-being): Quality of life of the stakeholders.
5. Flow: Flow of the stakeholders.

Four concatenations are listed below as an example of the 6,000 possibilities:

1. Information technology to sense life support information by/from users for quality-of-life. Sensors and surveys to sense the quality-of-life of the users of the city and make the data available to users.
2. Projects to process resource data for fulfillment. Projects to determine water pollution levels and warn users and teams when they exceed acceptable thresholds.
3. Procedures to communicate knowledge for flourishing. Procedures (e.g., notifications) to share knowledge about technological changes to the city with various teams.
4. Processes to translate decision information to teams for values encoding. Processes (e.g., optimization algorithms) to translate the social values of the users into decisions that may affect the sustainability of the city.

Using the same expression as Ramaprasad et al., (2017) between classes of the dimensions “smart” and “city”, there are 5*5*8*3*2*5 = 6,000 potential components of a “smart city” encapsulated in this definition/ontology. Note that this figure will be off due to the outcome measures not being completely elaborated. For instance, the values are not delineated herein. The market-State is a significantly more complex and convoluted environment than a community-type society, which is why there is such a significant difference between the Ramaprasad et al. (2017) combinatorial figure of 25,200 components and the 6,750 components of community.

1.2.4.2 Commercial smart city software solutions

There are an increasing number of software and hardware solutions designed to facilitate smart city development and operations, these include but are not limited to:

1. IBM: *Smarter City.*
   A. *Intelligent Operations Centre for Smarter Cities.*
2. Urbotica: *City Operating System.*
3. Microsoft: *CityNext.*
4. Rio de Janeiro: *Centro de Operações.*
5. Barcelona: *City OS.*

2 The city as a habitat service system

A.k.a., The city system, the city operation architecture, the ecological city system.

A habitat is the ecosystem we are dependent on, which we design in nature, and live in. An service support system ecology in the form of a habitat is required in order to sustain human life and optimize human living. A city is a habitat service system, and a habitat service system is the materialized aspect of society. The material elements of a society exists within the material, physical environment. The location(s) where humans live and operate within this environment is referred to as a 'habitat'. A habitat (which is Latin for "it inhabits") is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population 'habitat'. A habitat sustains a social population through the encoded recognition of a reciprocal interchange between that population and its material environmental reality. Fundamentally, a habitat service system coordinates the control and flow of material resources for human fulfillment. Effectively, cities/habitats are platforms for human material fulfilment and flourishing.

A material environment can be restructured into "intentional" service environments. In other words, out of a common material environment, humans may cooperatively create an intentional habitat to service their common needs. The intentional output of these services systems is: freely and openly accessible services, goods and technical productions (i.e., "products").

Each specific habitat service system (or "service platform") acts as an organizational resource for the structured flow of energy and information (resources) into systems that by their very structure generate a higher potential state of existence within a commonly known environment. The habitat service systems structurally organize common resources toward the fulfillment of individual needs. It could be said that the habitat service system is a platform for the transforming of energy and information into a state that has a higher potential to "support a purpose" and "fulfill a need" [in response].

Herein, operational processes constitute the core functions of these systems and they represent the primary "value stream" (i.e., the end-to-end system process which delivers a service or "product" to an person, subject, or entity). A value stream is composed of a sequence of activities (and tasks) required to design, produce, distribute, and maintain a specific service, with all relevant accompanying information, materials, and knowingly desired conditions (i.e., values).

The habitat service system model represents the functional model of a city. A community city is, in part, a physical space where people, resource, and technologies mix to provide services through contribution-based teams to meet the fulfillment needs (requirements) of the human population. Therein, functions can be defined as the abstracted behavior of a city. Functions are described in terms of the logical flow of information, energy, materials and signals. Functions and sub-functions can correspond to well-defined basic operations on well-defined flows leading to a taxonomy of functions (*as described below*). The functional structure (or, functional architecture) of a city is a form of a conceptual model of the functional domain. A conceptual model of the functional domain is a qualitative representation of the physical behavior of the informational and physical (spatial) structuring of a city as well as the [global] city network within which any city resides. Therein, the physical structure in interaction with a physical environment gives rise to a city's behavior. Behaviors are related to structural-physical descriptions of a city. Behaviors are derived from city functions and their interaction with a material environment. (Stepandic, 2019)

The habitat service system conceptualizes and models the city as a series of homogeneous (Read: alike) and sorted layers, structured around the set of domains representational of human life; that of life support, technology support, and exploratory support. Categorization and taxonomy are important here, as the resulting model seeks functional simplification. These layers are composed of relatively homogeneous, sorted and ordered components, the product of earlier phases of sorting and cataloguing of human life [without the market or State]. Each layer is configured and sorted according to a particular function, that of life, technology, and exploration. Each of its layers is an articulation of a specific logic.

Here, the habitat service system (Read: city) operates through connected classification and taxonomy, not only providing an order but, beyond that, establishing an ontology: categories, attributes and subcategories are created and, in doing so, they create their very object of intervention. Here, reality is thought of as an integrated organizational language and applied stack-a popular way of conceptualizing protocols, data formats and software amongst engineers-ensures that each layer [of the stack] handles the same base information simultaneously, but at different levels of abstraction. Extrapolating 'stack thinking' to the city means that, in a highly hierarchical fashion, different urban systems (such as health, transport, energy or waste) are modelled and understood in the same way (Read: are operationalized together). (Marvin, 2017: 95)

The city is, in essence, subject to a form of modularization and categorization according to a set of predefined [human and ecological] criteria that are then reflected in the realization of a global habitat software and hardware (hybrid) system. In order to integrate city organization, standardization, modularization and classification are fundamental processes. Therein, city planning analysis is the process of breaking down the city into a multiplicity of objects and components.

A service bus is a scheme used in computing, software, and spacecraft development to refer to a transferring interface between mutually interacting components. There are two core service buses to the city, one an information bus (with a particular focus on decisioning) and the other a material [service] bus. These buses represent the core, center or platform around which the wider ecosystem is organized. Within the total ecology of the city there is a form of interlayering of networks, interfaces and data integration that are assembled and operated together in a [decision] control system positioned within the layers of the city. Thus, the city may be viewed, decomposed, as a series of event rules, a set of semantic models, and a set of work-flows that are supported by indicators, directives, and alerts.

The information system of the city uses analytics (data analytics, predictive systems, modelling and simulation) that are based on a set of societal standards for habitat service systems. The analytics generated by habitat data are then related to a set of visualizations, such as dashboards for current operations and future possible operations (i.e., planning). Data integration and gateways for flow control occur along a information service bus and within the information system itself, which brings into existence a real-time, real-world visualization (Read: model) of the operation (or, potential operation) of the system. This visualization can be viewed from several core perspectives, including that of the support services themselves, the software therein, and the hardware therein. Such a holistic view of the habitat as an integrated information and spatial (Read: material) system, where everything is a data point, allows for flexibility, efficiency, and optimization of the planning and operation of the environment for all inhabitants.

Within the city (Read: habitat service system) network, there is the ability to access data globally, as well as the need for modularity, interoperability, and transferability across [service] systems and cities. An yet, each city within the network is also a customized package of sub-services (or, sub-customizations of service) depending upon the unique circumstances of individual cities. Local issues enter the global city information network in the form of data. Therein, by combining data sets, cities may be reconfigured in a multiplicity of ways. Therein, cities maintain a central processing system (or, central processing unit, CPU) as part of their information support service, which processes not only local city information, but distributed information pertaining to the global city network, which from an information viewpoint is known as, the societal information system. The societal information system works on comprehensive design solutions that may be applied to any city in the network. This process of disaggregation is made possible by reconfiguring the components of the city into data blocks that can later on be worked with, recombined or reprocessed. The city is viewed, like the society itself, as an information system (an assemblage of data), which may be disassembled into its constituent parts as defined by the categories of any human-based habitat service system, and then unproblematically re-assembled into new more desirable configurations and flows. Therein, [habitat service] operational processes can be analyzed as data packages and reconfigured in a variety of custom ways. (Marvin, 2017: 98-99) This technique is sometimes given the term 'digitalization'; and, the logical computation of a digital (information) system for a city/habitat is often called, 'habitat computational logic' (a.k.a., city computational logic). Whereupon, the total logic of said environment for a operating system for the global habitat (a.k.a., habitat operating system or city operating system. In a global, technologically developed community-type society, computational logics have become ubiquitous, pervading every aspect of life.

> **INSIGHT:** *A comprehensive habitat systems approach recognizes that the fabric of the natural world, from human biology to the Earthly biosphere, to the electromagnetically gravitational arrangement of the universe itself, is one huge synergistically connected system, fully interlinked. Human cells connect to form organs, organs connect to form bodies, and since bodies cannot live without the Earthly resources of food, air, water and shelter, organisms are intrinsically connected to the Earth in each moment of breath.*

2.1 Societal access platforms

A.k.a., Mapping habitat service systems.

All societal-based platforms must account for a material system. When producing anything, access to objects must be accounted for. Access is necessary and two dimensional concept. Firstly, there is access to a team or working group through a contribution-based structure, and then, there is access to goods and service (without force of trade). Access can be accounted for many types of surveys including demand surveys, resource surveys, contribution surveys, etc. In the market, access is considered through the cost of a sale. In the State, access is acquired through authority. Humans require access to objects and information, which are composed into services. In a market, access is controlled by price, and the concept itself is mixed with "rights" (given by authority) and "property" (purchased in the market). In a community-type society, access refers to demands and other issues for service that are accessible to users. Ultimately, the goal is to have access to that which optimally meets user requirements (human needs) given that which is available at the time of access. In a community-type society, access centers and integrated transportation systems distribute products. Services are integrated, often modularly, into the infrastructure of the environment in order to optimize efficiency and produce a higher quality experience of access [to services] by a user. With sufficient technical knowledge and ability it is possible to apply automation technologies to increase the efficiency by which access occurs. Automation technologies can free individuals for access to opportunities they might otherwise not have had. Automation technologies can also make access to services, such as medical and informational more safe, reliable, and faster.

2.2 The habitat system states

> **NOTE:** *In nature, a 'structure' is a responding service. And herein also, the habitat service system is structurally designed as responding services (i.e., a service that responds appropriately to human need).*

In systems thinking the state of a system is a complete description of the system in terms of its condition, its parameters, its dynamics, values and variables, at a particular moment in time. This domain represents the formalized, existent structure of the community (the one actually operating or previously operating).

The Real World Community information system maintains a record of every known state of every system in the habitat. This includes both a model of the natural world, and a 'state model' of each service system. For every current habitat state, there is a past state that may or may not have been recorded, and there is a future state depicted by the solution to some material (habitat) decision inquiry.

There are three possible types of state for which the information system must account:

1. The **current state** of each habitat system (*quantitative* and *qualitative*).
2. The **past states** of each system of the habitat are identified as elements of the habitat's history (*quantitative* and *qualitative*).
3. The **future planned, predicted, and simulated states** that identify potential states as well as the next selected incremental state (*probabilistic*).

The 'past' represents a record of former re-structured iterations of the environmental habitat. A 'past state' represents a model of the prior state-dynamics of information, energy and services in our total environment.

The 'current state' space represents the current re-structured iteration of our environmental habitat -- the current state dynamic of information, energy and services (Read: the responding flow of resources) in the our total environment.

Individuals in community naturally seek the iterative improvement of their service system's trajectory toward greater states of human fulfillment. In other words, in community, our intention is to cooperatively create progressively more informed and fulfilling states of our habitat.

> **NOTE:** *It is useful to know where we have been so that we can intelligently design where we are going. Further, it is useful to simulate where we are going so that our likelihood of a safe arrival is more certain.*

2.3 A unified information system

An information system is a fundamental element of a socio-technical society, because it interconnects four fundamental environments: the social and technical spaces as well as the digital (virtual) and material environments, and formalized through signals and language systems allows different actors to interact with coherency and precision. These connections are important in the production of useful projects, designs, possibilities, and simulations that are likely to generate a stable and predictable environment [for human fulfillment]. By viewing society as an information system, it is possible to formalize intentions, perceptions, and physical space in a useful and intelligent manner.

Through a unified information model it is possible to fully account for the material environment, in particular, composition and location. When composition is accounted for, then it is possible can compute various functions of the same materials. With a referential database of materials and functions it is possible to identify probable service configurations - exploring probabilistically the way in which material resources can be transformed into productive goods and services, and then back into their basic material constituents, following a sustainable cycle. Humanity can then design different material configurations of its environment and simulate their engineered experience for optimal resolution of the current habitat.

2.4 A service system

> *A.k.a., A productive contribution system, a production system, a socio-economic system, an access [contribution] system, production, etc.*

Everything which has been technically constructed into the habitat may be said to have been engineered and integrated into that which is most often referred to as a "habitat service system". Service needs become engineering requirements for a specific **states** and **resource positions** of the material system. In its base form, a service is a process of doing something for and with others -- for human fulfillment and with an Intersystem Team contributing through a Contribution Service System. The primary productions of this Contribution Service System are a Societal Specification Standard and an operating Habitat Service System(s) based on the societal standard. The Habitat Service System is the first societal=level produced [material] service system.

A society necessarily includes material platforms for service. Society is a socio-technical system that must account for service in order for fulfillment to have meaning. Service is an enabling element in society; it enables productive, organized, repeatable, and motivated effort. Service can be accounted for through user and habitat surveys. In the market, service is sold. In the State, service is duty. In a community-type society, services are accounted for, contributed to, and operationalized. Cities are localized service systems. Services are operated by contributors for users. All services require information and objects, and therein, sufficient information and objects to result in a continuation of the service and satisfied users.

A service system is a complex socio-technical system. A service system is a configuration of technology and organizational networks designed to transform resources into objects that are delivered as services [through contribution] that satisfy the needs and preferences of their users. Needs are essential, of which the top level material categories are:

1. **Life support needs** are provided by a life support system (safety).
2. **Technology support needs** are provided by a technology support system (infrastructure to produce and sustain service-objects).
3. **Exploratory support needs** are provided by an exploratory support system (discovery).

NOTE: *Societal service systems are socio-technical systems that have engineering requirements and performance requirements.*

Preferences (wants) are not essential and relate to the transformation of resources and environments that involve subjective preference. These are voted on, and votes are processed within a value inquiry processes which facilitates the design of the newly to be resolved habitat service system state.

The emphasis is placed on the co-operative characteristic of the act of service. Service is defined as the application of skills (knowledge and tools) to the benefit of others, suggesting that service is a agreement, commitment, and action between an individual (in the community) who is also a user (in the community) that has as a beneficial/useful result, thus meeting the Social System Standard value condition of 'Contribution'.

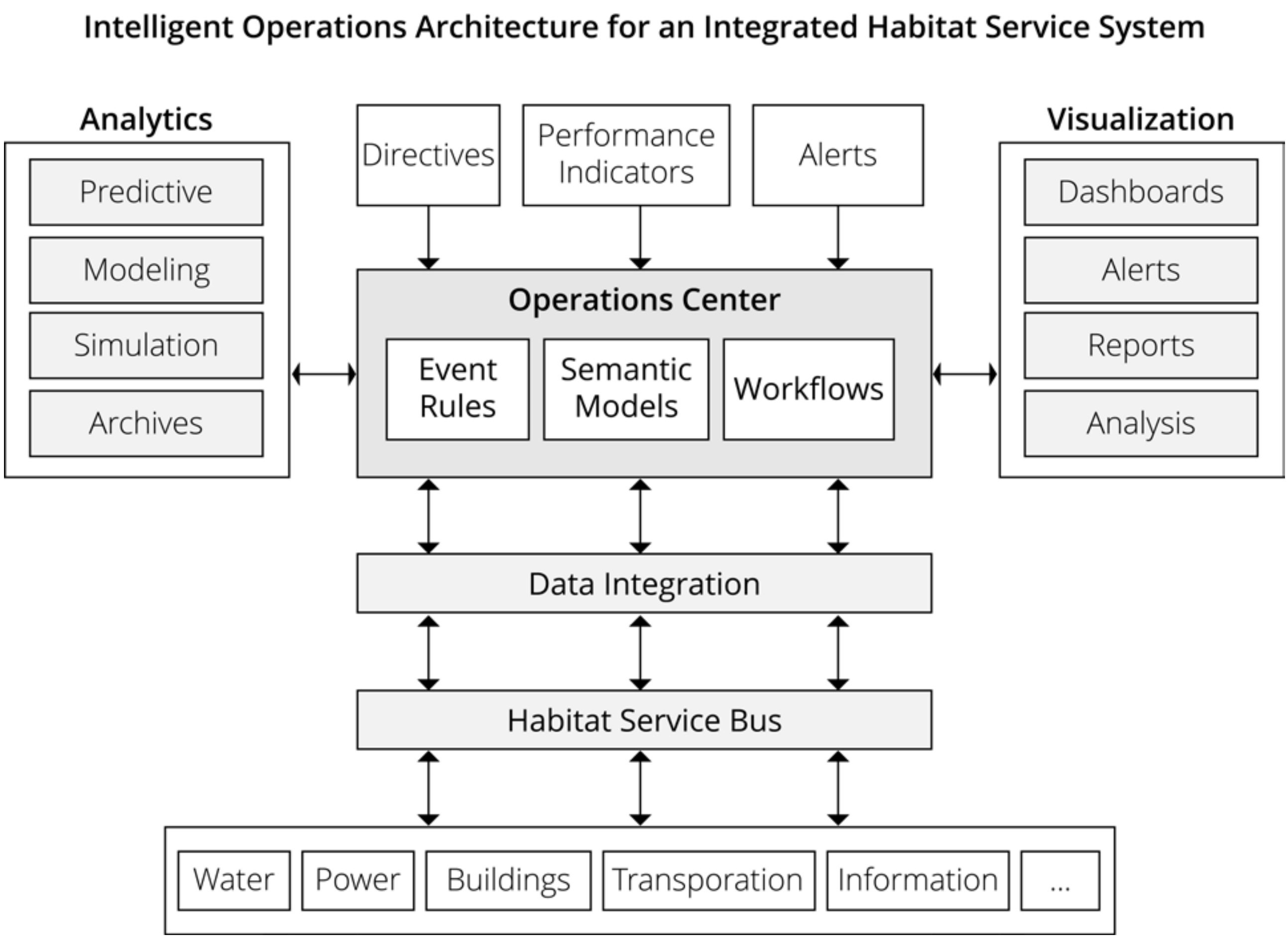


Figure 10. *Depiction of a city-level operating system for InterSystem Team Operations.*

NOTE: *A service system is more broadly labeled as a service. In other words a service system that serves a population is a service itself (i.e., it is recursive).*

In a task-based systems oriented sense, service involves at least two entities, one applying competence [at completing tasks/objectives] and another integrating the applied competences with other resources ("value-co-creation") and determining benefit. These interacting entities may be called, service systems (or, a service system). In other words, the idea of a service system involves two entities with the following inputs, processes, and outputs:

1. [Contributor] The serving entity, doing tasks with objectives, apply effort and resources. The serving entity accounts for requirements.
2. [User] The serviced entity, receiving the benefit of applied competence, and realizing a fulfillment benefit. The service entity accounts for needs.

A service system is thus a system of interacting and interdependent parts (people, and shared resources, technologies, organizations, and information) that is oriented to accept contributions by meeting the needs of the same population; by servicing fulfillment through human service contribution. A Habitat Service System's construction and operation requires an Intersystem (inter-/mulit-disciplinary) approach. Service interactions occur within environments. In a community-type society, the habitat is the location in which most service interactions occur. The habitat may be sub-divided into local habitat service systems (Local HSS).

Here, service is of actual social and material value to everyone. In order to be of actual social and material value, service is realized through the value condition of 'cooperation' (a stabilizing value in the Value System detailed in the Social System) within macro-decisioning and macro-coordination. In this sense, the material service system is an extension of a human contribution-based service system; because, the humans contribute so that habitat service fulfillment continues through socio-technical [habitat] service systems.

Broadly speaking, service is the application of resources, including individual human resources (competences, skills, and knowledge) and shared phsyical and informational resources, to operate systems and make changes to systems that have fulfillment (Read: beneficial) objectives (i.e., “value”) for another (system). Value is improvement in a system, or the fulfillment of an individual, as determined by a decision system or by the system’s ability to fit an environment.

Service systems are made up of resources included within activities. The two primary resource types/activities are:

1. **Operant resources** that perform actions on other resources.
   A. Operant resources can act on other resources (including other operant resources) to create change.
2. **Operand resources** that are operated on.

NOTE: *Without an operant resource there is no service system.*

Determining which resources are operand and which are operant depends on the position and orientation of the system deciding it. A physical tool, such as a "hydraulic press", is an operant resource for the service production system, because in this case it that creates tablets out of a powdered chemical. In this case, the tablet is an operant resource, because it is used to clean dishes in a dishwasher. Additionally, the "hydraulic press" may be the operand resource for a member of the InterSystem Team or an [automated] habitat service sub-system (e.g., factory production service robot). Operant resources act on operand resources from the resolution iof a deciding service system.

Note here that human contribution is an operant resource and individuals must act to apply operand resource through, at the very least, a proposal for contribution that is agreed upon and committed to, and which leads to the fulfillment of all. A service system is a configuration of resources, and so, it is also a type of resource itself. In fact, it may be an operand resource for another service system. For example, life support is part of the habitat service system. (Spohrer et al., 2008)

Note here that the ability to share the supply of (i.e., "pool") resources across a set of combined service systems is an essential component of community operation. A cooperative of using contributors agree to share common resources, commonly produced and used tools, and common information to meet a set of fulfillment objectives defined as service system requirements. Sharing is advantageous for the overall service system.

It is possible to decide the engineering of and evaluation of a service system; and, this process is generally called, "utility". A service system that doesn't have utility is not useful to its users.

The worldview of [common] service-dominant logic stands in sharp contrast to the worldview of the property-dominant logic of the early 21st century, as it holds service - the application of competences and resources for benefit of others - rather than property by means of competition (predation), to be the fundamental basis of economic operation. Within the service-oriented worldview, it is suggested the axiomatic material abstraction is the service system, which is a configuration of people, technologies, information, and other resources that interact to create mutual fulfillment. When this happens at the city level, within a habitat(s), it is reasonably labeled a, habitat service system. Herein, humans contribute, necessarily, to the existence and persistence of a [habitat] service system.

As a system, the habitat service system may be decomposed to a set of primary habitat service sub-systems, each of which meets a unique primary category need of the population (e.g., life, technology, exploratory). In this context, the organizational view of a service system is sometimes known as service system mapping (although it has many other names).

Note here that many systems can be viewed as service systems, including families, cities, and working groups, among many others.

2.5 Service system carrying capacity

NOTE: *Population problems have a horrible way of resolving themselves.*

Carrying capacity is a term that relates to the primary service systems in the habitat. Each service system has a capacity determined by its inputs, process, and outputs. The outputs of each service system are calculated to sufficiently fulfill the population, while providing a storage buffer for safety. For example, all cities will be designed with a buffer capacity for housing. Therein, something akin to 3-5% (*an estimate, accurate figures to be determined by decisioning*) of the dwelling will remain unoccupied. This allows for:

1. Expansion of the population,
2. Always available housing alternatives; and
3. Possible emergency housing in case of a disaster.

One might imagine 100% capacity as the most effective strategy for occupation of a locale, but in the context of survival in a larger ecology, a buffering strategy for occupation and usage of a service system is most efficient. Buffering means that there is a lessening or moderating of the impact of something. The buffering part of each service system provides access to resources and other materials in case of an unaccounted for demand or incident. When the precautionary principle is applied to habitat service functionality, then it means to have enough of something so that you have another one if the first one breaks or if more are immediately needed.

Businesses in the market prefer to operate their systems as close to full capacity (i.e., "peak capacity") as possible to maximize their revenues. In community, we design for service and ecological capacity, and we operate within that set capacity threshold with a buffer for risk. In community, there is no incentive to operate at peak capacity. Instead, service operations in community fluctuate directly with demand and participation - they are designed by the user, for the user.

It is also relevant to point out here that populations may actually begin migration within the city network, which may seasonally shift the population sizes of various community-cities.

Any service system may be reconfigured for a new function and capacity.

Allowing expansion sounds like a contradiction to total city design. We can duplicate cities, but to have them undergo expansion may be poor design and not even possible in a sustainable system.

In order to determine a structure's functional capacity, the following must be known (What is the functional capacity of a structure?):

1. What is the material composition of a structure?
2. What is its engineered configuration?
3. What is the functionality that it encodes?
4. What are the structure's interdependencies?
5. What is the affect of the structure on its environment?

3 City design in community

INSIGHT: *A community-city is a whole-expression of our humanity.*

Generally speaking, there are many factors to account for in city design. Sky, atmosphere, and orography generate variable meteorological conditions over a city (e.g., could covering shade, solar, wind, rain, etc.). Buildings and other standing objects/structures induce field dynamics in the environment, including but not limited to: masks, reflections, absorptions, re-emission, rainwater runoff, etc. Human activities produce issues, including but not limited to: heat, noise, waste, pollution, etc. And, human needs (and wants) produce requirements, including but not limited to: life support, technology support, and exploratory support.

Community cities employ the scientific method, prioritizes efficiency throughout appropriate design, have a cooperative versus competitive social structure, are high tech and highly automated, and are the result of a systems approach in managing its complexity. Such cities are a world benefiting platform for the sustainable advancement of humankind. Community cities are circular (generally), fully sustainable, appropriately functional, and access-oriented environments, built for those who are actively engaged in living their life to the fullest. In the 21st century, physics and computing are necessarily part of the whole infrastructure of densely populated (and sometimes even, low-density populated) habitat service systems, necessarily so.

Cities in community are entirely open source. The result of this openly sourced way of living is that there is the maximization of everyone's potential quality-of-life, and neither hoarding nor fighting over ownership. Community-based cities are operationalized to be continuously up-to-date with humanity's knowledge about how to live more optimally, while drawing upon humanity's inherent and individual strengths. Therein, individuals experience a space where knowledge is applied for the well-being and benefit of all. A lot of the work in these cities has been automated to free up time for individuals to pursue their passions and greater interests. Herein, automation and technology is intelligently integrated into an overall holistic socio-economic design, which primarily functions to optimize the quality-of-life of every individual.

It is possible to have a network of sustainable city systems where humanity has intelligently organized free access to that which is needed so that everyone may thrive; in contrast to an unstable living arrangement where individuals exchange artificial intangibles that everyone is coerced into acquiring and using for [at least] their mere survival, generating socio-economic inequality and the vast number of public health issues that are causal consequences therefrom.

Cities in community provide free access to all goods as services, as in nature, so that individuals don't become constrained (limited) by the abstract intangible known as "money", and hence, disconnected in their ability to accurately sense and appropriately respond to environmental signals. If people have access to the necessities of life they don't "steal", and "crime" (as it is known in early 21st century society) is rendered almost non-existent. The notion that things are "free" in community is something of a misnomer, because there is no money in community. In fact, community can only emerges in a world where everything has been coordinated to be accessible without the need for exchange (i.e., without 'trade').

It is possible to design cities where it is more enjoyable to walk or bike, than to drive, thanks to the intelligent and integrated layout of the physical environment. Among community, individuals walk through the majority of their beautifully planned daily life-space, wherein, they experience a living socio-economic system structured to coordinate decisions, and the flow of resources, for their fulfillment. Therein, individuals experience intentional design that supports a high quality-of-life for themselves and all others; it's an environment where technology and economy serve humanity and the ecology, not the other way around. It is an environment where human creations provide everyone with an abundance of access to life enriching opportunities, maintaining a support structure for living better lives - lives in alignment with the development of individuals' true potential. It is an environment that draws out the best in each individual; pulling out from them the energy of happiness, well-being, and deeply felt love and connection for one another and the universe. These cities are designed provides vast opportunities for outward exploration, as well as the space for humanity to go inward and experience states of universal being. Here, decisions and actions entangle one another in a direction commensurate to humanity's highest potential.

Community-based cities are designed so that there exists the values of efficiency and effectiveness in the fulfillment of human needs, wants, and preferences. Food, energy, transport, and production, for example, have efficiency as a core priority in their designs, which is a necessity for the sustainability of complex socio-technical systems. Material and service constructions are designed to meet human requirements in the best possible manner with the least usage of resources and effort. Conversely, in a monetary system, such designs are generally too expensive. The costs of trying to create a sustainable and efficient city inside a for-profit paradigm are simply too high, which is one of the many reasons there is not a single city optimized for human well-being in early 21st century society. There is very little that is sustainable in how cities in early 21st century society are designed, or the monetary and authority driven social values that have been adopted by their constituents.

Community-based cities are, in general, designed such that food cultivation and natural beauty are integrated into all appropriate and desirable spaces. As a city, community is a place in which all of the tasks (i.e., "jobs") are actually worth doing. Because of the encoding of the value of transparency, everyone in the city knows what needs to be done, and can contribute to the system's continuation and evolution in a coordinated and planned manner.

In community cities, individual's time is their own ad is not structured by coercive structures and authority figures. Here, opportunities for access, self-growth, and contribution are ever present. Individuals' contributions directly benefit everyone, as opposed to working for the direct benefit of someone else or some specifically competitive organization. All work (as effort applied toward the community's continuation and evolution) is relevant, and everyone "owns" their own time.

Due to the intelligently planned design of these cities there are no "prime locations" (as there are in market-State cities); instead, everyone has access to a prime location. Often, it is possible to walk around the living environment and freely pick a variety of flavorful and nutritionally dense foods without worrying about pollution and other toxic residues. These cities feel

> **QUESTION:** *How would it feel to live in a place constructed to express conditions of interest in your well-being as well as facilitate empathic concern for the well-being of others? It may feel like a city that has been designed openly, by all of us, and for all of our well-being.*

Neither the market nor the State has been encoded in a community-type city, and therefore, there is no revenue, no taxation, and no materialization of an environment focused around competition, ownership, and authority. Living in the early 21st century involves (and, for most people it requires) property ownership, and there are taxes and other fees that go along with that ownership. In order to have access, that sort of socio-economic arrangement necessitates either having a job to pay for things, or becoming a ward of someone else who pays for those things. Of course, cities in early 21st century society consequently look and feel very different than they do in community. In the market-State, cities are products and the people within them have little choice but to work for a boss, go on the dole, or starve. Oddly, there is a segment of this population that believes they have something they call "freedom of choice". What they actually have is the illusion of choice, because the options from which they can "choose" have already been decided upon by the structure of the system itself and the "decision makers" higher up in the socio-economic hierarchy or in the distant past; and, these pre-selected options are inescapable if survival is desired.

In community, there is no commerce, no economic trade or exchange of goods, no socio-economic classes or hierarchy, no politics, no bureaucracy, no police, no prisons, no trash, no poverty, no homelessness, and no congestion. When arriving in community from early 21st century society, there is a sense of relief that these things that have held humanity's potential down for so long are no longer present. And still, community creates a city where children and adults alike play outside safely at any hour. Therefore, community is an environment that notably lacks any and all advertising and marketing, in both the physical and digital space. There is no surveillance or misinformation, which are present almost everywhere in cities in the market-State. And yet, the city looks beautifully up kept, it is intelligently laid out, and as individuals move about they don't have to worry about walking on grass or other surfaces that have been sprayed with various killing substances, such as pesticides and herbicides. In community-based cities, no one has to wash industrial pollutants off of their food, or personally filter their water to remove pharmaceuticals, commercial by-products such as sodium fluoride, and other industrial contaminants.

> **INSIGHT:** *Among community, we have a saying, "Systems are what they produce, not what we wish them to produce."*

Individuals in early 21st century society have become habituated to the constant stimulus of commerce and advertising, which wears down (i.e., wears away) their sensitivities to their own needs and their environment. Cities in community are notably void of trash and other pollution. Over time, such pollution causes individuals to turn off from environmental stimuli. The continuously hostile environment of market-State cities causes people to not want to feel their sensory inputs. And, that is the weirdest thing to imagine, that you have to stop perceiving your environment to keep yourself sane. Of course, the light pollution in early 21st century society affects people's sleep, their circadian rhythms, and it prevents them from seeing the stars, which would otherwise provide them with a nightly connection to the larger universe.

In community, the living environment itself almost feels like a single self-regulating and self-healing organism. Community is similar (in this respect) to the human body, which wants to feel well and heal, but needs the correct inputs as well as minimal interference from that which is malignant. Community is a type of society run so efficiently and with organized care that it feels like it takes care of itself. All of those things that are essential for individuals to survive and thrive are integrated and engineered into a unified habitat service system, a city. A city that mirrors the operation of our natural world, which is itself a collection of integrated systems.

> **QUESTION:** *What would society look like if it inherited those properties of the universe that we see as it's incredible harmony and mathematics and self-organization? And, what would it look like if our intention for its creation was to be of benefit to the individual, of benefit to the social, and of benefit to the planet (and even, possibly, the very universe itself)?*

3.1 The integrated city system

A.k.a., Total city system, intelligent city system, unified city system, cooperative city system.

All city systems in community are integrated city systems. An integrated city system is, in part, in one in which the informational and physical systems of the city are accounted for together in the design and operation of the city. Additionally, integrated city systems account for the total system state of city in relation to its inhabitants and their requirements of the city. Information unification (i.e., looking at society and its cities as an information system first) allows for true cooperation among individual humans and the organization of an integrated living environment.

In order to create a life radius that fulfills humanity's real world needs and requirements, cities in community are designed in an integrated manner, and hence, they are often referred to as "integrated city systems" or "total city systems". An integrated city system (a.k.a. total city system) is a city in which every element operates together efficiently as a whole system. In other words, all aspects of the construction and functioning of a community-type city are well integrated. Instead of leaving city functions under the control of isolated organizations, individuals and obscured programs, cities in community integrate their control. All functional aspects of these cities, from food cultivation to sewage and energy production are processed together as one system (i.e., they are 'integrated'). Integrated city system are strategically planned and cooperatively operated socio-technical environments. In order to accomplish their functions, integrated city systems are data collection and product materialization platforms.

City systems in community are integrated living environments. Significantly, said city systems are [sustainably] integrated into the planetary biosphere/ ecology by means of a planned and bounded service area known as a habitat service system. Therein, these cities are integrated into the form of a human habitat through intelligent socio-decisioning and thoughtful material and lifestyle design. Community cities are based on individuals who play an active part in their design and operation.

An integrated city system is one in which:

1. The elements of the city are interconnected (informationally and spatially).
2. Access to all parts of the city exists through continuity of travel by various modes of transport.
3. The city layout exists by reason of function, demand, and optimization (i.e., function, effectiveness of fulfillment, and efficiency of fulfillment).

In community, ideas and designs are well thought-out and coherently integrated into a unified information system [model] before being encoded into decisioning and constructed into the environment, whereupon they are tested to ensure desired alignment. A total city system approach requires systematic design and overall planning to attain a high standard of living for all the occupants.

> **NOTE:** *A total city system is a city that accounts for the total (whole) environment.*

It important to address an issue here: the notion that intelligent core-systems planning, implies mass uniformity, is not accurate. Cities in community would be uniform only to the degree that they would require far less materials, save time and energy, and be flexible enough to allow for innovative changes (through modularity), while preserving the local ecology. Cities in community are planned so that they are capable of fulfilling the needs, wants and preferences of all community inhabitants. Through planning and testing we are able to produce a pleasant and desirable living space that removes urban sprawl and can effectively account for social, economic, and ecological problems. The integration of function is necessary for the optimization of our fulfillment, as well as an accountable solution-orientation to any problems that may arise.

Herein, information processing and automation systems are combined with sensors and human effort (where necessary and/or desired) to optimize the operating efficiency of the city. The use of up-to-date technological methods, including electronic feedback, digital information processing, and automation, is applied to the entire city system. The use of automation ensures that what we intend to happen, actually does happen, every time we want it to happen. Through the application of computing we are able to process trillions of bits of information per second, which is useful (though not absolutely essential) for the facilitation of complex multi-variate decisioning, and hence, the coordinated operation of these cities. Intelligent coordination keeps a city's services operating at peak efficiency and uptime, maintaining our materially desired fulfillment, and creating an optimized economy that avoids overruns and shortages. For example, the irrigation and fertilization of a primary food cultivation belt (within one of these cities) is programmatically controlled through an automated irrigation system involving environmental sensors, integrated circuitry, and various mechanical technologies. Hence, the emergence of a service system that frees humans from unnecessary labor, makes the most efficient use of resources (water in particular), while ensuring a sustained healthy landscape. Waste management, energy generation, and other services are managed by these "smart" (i.e., "cybernetic") methods. This integrated control is openly programmed by us, for us (as a community), and applied throughout these city systems for social and ecological concern.

Additionally, an integrated city system is also defined by the consolidation of as many functions as possible (or desired) into the least amount of material area. For example, most of the outer surfaces of buildings convert solar energy into electricity, and the surfaces are themselves fitted with automated cleansing systems.

Integration, not only within a city itself, but between cities provides innumerable benefits, including but not limited to:

1. Increased ability to identify problems.
2. Increased ability to aggregate information and identify useful/applicable information.
3. More informed responses.
4. One platform provides better coordination.
5. Better communication and cooperation.
6. Increased safety.

The total societal system may be delineated as follows:

1. One solar and planetary system.
2. One unified societal system design [specification standard].
3. Four societal information sub-systems (social, decision, material, lifestyle).
4. One global habitat service system (network of city systems, the economic global access system).
5. The local habitat service systems (individual, integrated city systems).

In general, a city/habitat may be integrated in terms of its:

1. View on common heritage resources (decisioning) via socio-technical standards.
2. Computation for production, operations and exploration..
3. Infrastructural and habitat fulfillment operations for life-user service.
4. Production (light production and heavy production) for habitat service production.

3.1.1 The cybernetic city

A.k.a., The cybernated city, the computationally integrated city, the diagrammatic city, the smart city, the computational city, the intelligent city, the automated city, the computed city, the city operating system, the urban operating system, the city information system, the city central processing system, cyber-physical-social systems (CPSS).

Cybernetics is an interdisciplinary science for exploring digital, mechanical, or biological regulatory systems. (Wiener, 1948) Most simply, cybernetics is the study of systems that steer in an uncertain environment using feedback. Navigational paths need to be corrected [via the integration of feedback] continuously as the system proceeds in the uncertain environment. Cybernetic economy essentially refers to steering the economy with direct feedback using computers and economic calculation. Market economies adapt through local interactions by undershooting targets and overshooting constraints; whereas a cybernetic economy uses a series of feedback loops, calculation, and planning to operate the economic platform. Classical cybernetics has evolved, since its instantiation in the 1940s into second (or, third) order cybernetics-the cybernetics of observing (includes the observer, rather than only being observed) systems, which also concerns the principles of learning and communication. (Ross, 1957; Glanville, 2007) In line with the original meaning of the word, “to steer, navigate, or control”, cybernetics can be applied to the design and operation of any complex system, including cities. (Ronnko, 2018)

> **NOTE:** *The central element(s) in cybernetics is control, which implies feedback, decisioning, and communication, which all involve the transmission of information.*

At the core of a cybernetic city (a.k.a., smart city) is a software control (i.e., cybernetic) center in which planning and operations occur. Since the science of cybernetics focuses on the information and communication involved in the process of feedback and decisioning, a cybernetic city is one in which the latest information and technology is utilized to maximize the fulfillment of the inhabitants. (Lasker, 1981) At the core of cybernetic city operations are clear, real-time situational information for monitoring, analyzing, understanding, planning, and operating smart cities.

> **NOTE:** *The idea of a cybernetic city and the emerging conception/ontology of a smart city are highly related, except that the cybernetic view is more systems- and community-based, whereas the notion of a smart city is more based in the market-State ideology.*

A cybernetic city is a cyber-physical-social system. Common cyber-related terms to understand this complex relationship include, but are not limited to:

1. **Cyber-social systems (CSS)** - social systems with embedded digital structures and devices to facilitate human scale endeavours. Cyber-social systems are a collection of technologies for coordinating and controlling interconnected social and computational capabilities. CSS is the merger of cyber (electric/electronic) systems with social structures.
2. **Cyber-physical system (CPS)** - is a system featuring a combination of computational and physical elements, all of which are capable of interacting, reflecting and influencing each other. Cyber-physical systems are a collection of technologies for coordinating and controlling interconnected physical and computational capabilities. CPS is the merger of cyber (electric/electronic) systems with physical things. (Trappey et al., 2016) For example, mechatronic systems, which combine the disciplines of mechanical, control

and electrical engineering. CPS systems include automated systems that sense and control physical phenomena through sensors, processors, and actuators.

   A. **Human-in-the-loop (HiTL) CPS** - CPS systems that involve control loops with human goal-oriented interaction.

3. **Cyber-physical-social systems (CPSS)** - the integration of cyber space, physical space, and social space.

Fundamentally, cybernetics is the science of self-regulating systems, which (1) exist in living matter and its relationship to its environment, (2) as the interaction among living things, (3) in machines, and (4) in the interaction between living things and machines. In the context of cybernetics, self-regulation includes processes that maintain organisms or organizations as viable entities and that enable machines to perform selection and control operations. (Lasker, 1981) A city system that is systematically involved in the production, organization, distribution, and use of knowledge and information, which constitutes a self-regulating city system.

Amstutz (1968: 21) states that a city could be made more response to its populations needs via a threefold strategy:

1. Structuring the environment into categories and subcategories. For example, identifying the core services of the habitat (e.g., life, technology, and exploratory).
2. Developing clear objectives and criteria for evaluation. For example, what is flourishing, fulfillment, and quality of life, and how are they measured.
3. Using computers to 'synthesize and maintain a representation of the total environment'.

Amstutz's approach rests on the delegation of control ("authority") to computer systems. If city functions were pre-programmed, then city planners and operators would be able to approach city problems with '"increased effectiveness due to the availability of more meaningful data and an increased (model based) understanding of [the] environment" (Amstutz, 1968: 21).

INSIGHT: *Intelligent systems evolve through feedback phenomena. Feedback is an essential action in the generation of a sustainable city environment, for both the efficient use of resources and the integration of effective functionality.*

Computer science, systems science, and simulation are early sources of inspiration for viewing the city as an operating platform for humanity. Since the 1950s and Norbert Wiener's laying out the principles of cybernetics, the city has increasingly come to be viewed as a communications system. (Meier, 1962; Webber, 1964; Light, 2003) The city is a space of data flows and environmental modelling is traceable to the digital computation work of Forrester (1961; 1969). Forrester thought of cities from a scientific perspective (as in, the 'science of cities'; Batty, 2013; see Townsend, 2015 for a critique), and saw the city as a complex (yet arguably linear) system of interacting parts experiencing growth, equilibrium and stagnation; a system easily modelled through calculated flows and an account of conditions in the surrounding environment. Batty et al., (2011) state that, "One of the key differences between theories of cities developed a half century or more ago and the emerging science of cities and societies in the early 21st century revolves around the idea that the focus should no longer be on location, but on interactions and connections, on networks and the concomitant processes that define flows between places and spaces." The understanding that computer applications, system dynamics and digital modelling are mechanisms to solve societal, and particularly, city problems was espoused by a generation of planners and technologists, one of the most notable being Jacque Fresco who envisioned architectural structures (and even, whole city systems) optimized for and by computer aided environments. (Fresco, 2007)

An cybernetic city system establishes a diagrammatic form of relationship with the city. Diagrammatic modeling and simulation occurs for information structures and dynamics as well as spatial structures and dynamics. Informational diagrammatic control involves the visualization of information to easily identify functions and simplify decision selection. In effect, a unified city operating system establishes a diagrammatic form of relationship with the city. (Marvin, 2017: 92) Fundamentally, cities can be visualized, diagrammed, and all aspects can be simulated. Therein, coordination and control of the [cybernetic] city is given over to computational logic-- involving the coordination of information and material flows through information systems and technologies, and their interface with the material world.

INSIGHT: *The conception of a cybernetic city carries with it the possibility of information-system-based planning and cybernetic coordination. Cities can be known, planned and controlled in large part through data processes and algorithms.*

In a cybernetic city functions that are kept separate and loosely coupled (e.g. waste collection, transport provision, energy services, security and emergency response) are planned and operated in an integrated relationship. Therein, there is a single, unified information system that accounts for software and hardware systems that interoperate and are interconnected.

NOTE: *In the industrial environment, enterprise* *resource planning (ERP) systems have been used extensively to coordinate the flow of resources in order to streamline internal operations, linking finance, procurement, payroll and human resources in cities. ERP systems effectively render internal resources relations predictable and controllable. The use of ERP implies a functional understanding of the organization, wherein the division of operations into functions and sub-functions is crucial for the appropriate functioning of the whole. In an ERP system, organizational operations are detailed as a breakdown of components into sites (locations), agents (subjects), functions, and relationships. Note that there are also resource planning systems for various sub-industrial functions, including, for example, manufacturing resource planning (MRP).*

Technology embodies routines and procedures that generate particular forms of perception and cognition, both shaping behaviour due to the processes of functional simplification and reification by which a prescriptive order is formed (Kallinikos, 2011:7). Kallinikos explores different techniques of coding with a particular focus on object-oriented programming. Object-oriented programming is a structured form of software coding, organized by structures and procedures, that divides reality into objects, which are further divided into sub-objects. Each object has attributes, and by recombining attributes the relationships between objects can be reconfigured. This computational logic renders reality as a set of integrated information, and thus, usable in the real world.

Through an emphasis on modularity, along with pre-determined structural features and intrinsic qualities, information technology packages and knowledge are constituted as both specialized and transferable--from or organization to organization or city to city (Voutsina et al., 2007).

A cybernetic city, as a system of systems, operates through techniques of classification, resulting in the provision of a system for organization and, in this way, a framing for an objective reality. This classification process involves the development of typologies, the establishment of system hierarchies and a mapping of connections between these components. Such direct identifying and explication of interconnectedness renders the entire system of internal relations predictable and controllable. Classification also has an ontological function, by determining components and establishing a set of relationships, thus creating entities with definable boundaries (e.g., service inputs, processes, and outputs). The integrated visualization of a city as a system of systems necessarily involves the development of a detailed map for organizational action and control. (Marvin, 2017: 93-94)

Current hardware and software technologies allow for city-scale operating systems. The idea of the city as an operating system has been discussed in the literature. First, it has been used as a 'metaphor' in which cities are seen as interchangeable with computer systems. (Marvin, 2017) Therein, the city is viewed as an information [processing] system based on the acquisition, storage, processing, and retrieval of information and materiality – an operating system. Through these information technology systems, locations and actions are capable of being sensed in real-time, wherein the operating system aggregates and processes data leading to decisions and actions at a distance. (Marvin, 2017). The resulting 'real-time city' operates through sensor networks, computing frameworks, and automated hardware that aggregate data streams into services and products (i.e., fulfillment) for their users (Townsend, 2000; 2015). Further, Easterling (2014: 5) examines how a combination of infrastructure space, sensors and software are may be designed to use information to "determine how objects and content are organized and circulated [in] an operating system for shaping the city". Easterling (2014:6) describes an operating system as a platform, both updated over time and unfolding in time to handle new circumstances and situations, which uses software 'protocols, routines, schedules and choices' to encode relationships between buildings or managing logistics of infrastructures. This later view describes the operating system as a platform for city control. Thus, it is possible to view, understand, and operate a city through an examination of the hardware and software systems that coordinate and control its behavior.

The software components of these systems include, but are not limited to:

- Databases, predictive systems, analytics, modelling and simulation.

The hardware components of these systems include, but are not limited to:

- Computers, sensors, control rooms) assembled into purpose-built platforms for functional and spatial integration.

NOTE: *In practice, these software and hardware systems form a hybrid of techniques, tools, and software systems.*

Responsive city design and operation is not just about the convergence of different technologies, it is also about the convergence of semantic structures (perceived environment and life world) and syntactic structures (services and infrastructures) over time. Thus, cybernetic cities can be viewed from four primary dimensions:

1. **The conceptual cities (1D-cities)** - for example, the conception of a city
2. **Bi-dimensional cities (2D-cities)** - for example, GIS overlay data.
3. **Three-dimensional cities (3D-Cities)** - for example, 3D mesh models of a city's objects.

4. **Dynamic, spatio-temporal cities (4D-Cities)** - for example, a simulation of the city with mesh models and GIS data over time.

Cybernetic modules for a city system are likely to include at least three principle elements (Costa, 2019):

1. **Instrumentation** - the ability of systems to measure information by means of sensing tools. Instrumentation is the first movement of action against entropy. Examples are locative media (LBM), georeferencing (GIS) and remote sensing. Herein, environmental, energy, and social sensors serve as parameters.
2. **Analytics** - informatics to perceive and interpret acquired information in accordance with a set logic. When a system acts upon information within the information environment to produce more useful information. In city design, parametric methods include: BIM (Building Information Modeling), SIM (System Information Modelling) methodologies, and performance management (PM).
3. **Actuators** - when a systems acts physically within the spatial environment.

NOTE: *Instrumentation and control systems are used to automate processes. Items to be included in the design and analysis of these systems are: reliability of control of critical processes, safety of personnel, and suitability of instruments and control devices in the environment in which they are installed.*

Cybernated habitat data collection sources (terminology) and assessments include, but are not limited to.

1. **Environmental monitoring networks** - Networks that provide data [sources] on environmental variables. For example, weather data, air quality, user health data, etc.
2. **Fixed and mobile sensory arrays** - arrays of sensors, such as those attached to the interior or exterior of buildings, or airbone platforms.
3. **Real-time sensors** - sensors that collect and transmit data to be processed in real-time.
4. **Recorded sensors** - sensors that collect and store data to be processed at a later time.
5. **Distributed sensory networks** - sensors to monitor and collect data on physical phenomena, physical conditions, and physical systems.
6. **Biomonitoring (biological monitoring)** - the assessment of an ecosystem base on organisms living in it. The lives in the ecosystem.
7. **Data contributed by city inhabitants (crowd sensed, social)** - city inhabitants articulate issues and other data.
8. **Global positioning system (GPS) -** data from a satellite-based global positioning system.
9. **User profiles** - the current, check-in, or modification of user profiles.
10. **Habitat assessments** - the assessment of an ecosystem based on its physical characteristics. The physical characteristics of an ecosystem.

The four characteristics of city-level data for a cybernated system (i.e., "big data") are (Santana et al., 2017):

1. **Volume -** coming from many data sources distributed across the city.
2. **Variety -** data is collected from different sources, and have structured, semi-structured, or unstructured formats, such as video records, relational databases, and raw texts, respectively. This is important for cities, because city data is collected from multiple sources.
3. **Velocity -** data processing must be fast and, in some cases, real-time, or it may be useless.
4. **Veracity -** because of the large amount of data collected, and the use of multiple data sources, it is important to ensure data quality, because errors in the data or the usage of unreliable sources can compromise its analysis. In cities, incorrect GPS readings, malfunctioning sensors, and malicious users can be sources of poor data.

3.2 *Cybernetic city automated operations control system components*

NOTE: *City planning may be otherwise viewed as the pre-programming of habitat [city] functions.*

A cybernetic operational control system for a highly automated city would necessary involve:

1. A project coordination system, including but not limited to:
   A. A tasking system with tasking flow automation.
   B. A documentation system with document flow automation.
2. A unified information database.
3. A unified information coordination system (a.k.a., information management system, IM; e.g., BIM).
4. Continuous system design and development software.
5. Models development to control devices and facilities (e.g., buildings).
6. Software and hardware (hybrid) systems to organize, coordinate, and control operations.

The conception of an operational information model of a cybernetic city control system requires solutions to the following tasks. In other words, the following tasks must be solved for the functional conception of an operational information model of a cybernetic city (Kuzina, 2019):

1. **Task 1:** The identification of alternative technical systems that implement the goals and objectives (i.e., a probabilistic decision system).
   A. **Input information:** Tasks and criteria, general requirements for the technical complex (product), the composition of the complex and the requirements for subsystems, the approximate terms of use, the data of scientific and technical information.
   B. **Output:** Principles of design solutions, the required technology and materials, the required solutions and scientific and technical problems, the tree of alternative versions of the technical complex with an assessment of the existing state of availability for each of the options and an assessment of the probability of creating a technical complex to given estimated time
2. **Task 2:** Full assessment of alternative solutions and selection of the solution according to the objectives criterion.
   A. **Input information:**
      1. Product characteristics (for each alternative): static characteristics (e.g., product design specifications, weight, geometric dimensions), dynamic characteristics of the product in different operating modes.
      2. Characteristics of the product life cycle: the required volume of production works for the solution; a calendar date of completion of research, development, production and operation; the duration of the stages of development and production (standards of the times); the economic parameters for life-cycle stages of complex (cost standards).
      3. Criteria and models of the target effect/outcome.
      4. Model and objectives criteria.
   B. **Output information:** Evaluation of the objectives criterion for each alternative solution; comparative characteristics of alternative solutions for different parameters; reasoning/justification of the proposed solution.

NOTE: *For this purpose it is necessary to create specialized software that can provide decision support for each task level.*

The composition of a system-wide mathematical and software automated control system operation of the object is divided into 4 subsystems (Kuzina, 2019):

1. **Message/signals analysis system** - determination of incoming information processing modes and providing necessary dialogue between users and technical means. The mode of such messages processing should be determined by the system on particular features of messages. There are five modules (or, blocks) for this system:
   A. **Module coordinator (dispatcher module; 1)** - designed to ensure the joint operation (co-operation) of all units of the message analysis system in accordance with the type of message, the configuration of the system in accordance with the allocated resources, and the implementation of communication with other systems involving mathematical support.
   B. **Modules of (2) syntactic and (3) semantic task analysis** — the allocation of individual sentences of messages, checking the correctness of their construction, their distribution, in order of importance, the formation of the summary rules of their analysis, the definition of input and output parameters of the message, the formation of signals in the block dialogue about anomalies identified during the syntactic and semantic analysis.
   C. **Module of the works list (4)** - intended for determination of the message processing possibility (transition - from input parameters of the message to output), determination of optimum ways of processing, creation of the list and sequence of works with their necessary description and formation of output arrays structure with their description, formation of signals in the module of dialogue about reception of the message in processing or about impossibility of its processing.
   D. **Module of dialogue with the user (5)** - provides formation and delivery to the user of signals about acceptance of the message in processing or impossibility of its processing, about the anomalies revealed during the syntactic and semantic analyses, the analysis of additional (secondary) messages of the user, addressing them in other modules of system and formation of the corresponding signals to the user about implementation of its additional messages.
2. **Information support system for task solving** - The system is designed to organize the storage of information and provide the necessary information to solve all calculation and information problems. The information support system includes 7 modules. Additional modules can be included in the system, such as standard procedures, placement optimization modules, information

security, and statistics collection.

A. **Module coordinator (1)** - to ensure the joint operation of all the modules of the system.
B. **Module of information requests analysis (2)** - performs the functions of perception, semantic analysis of the request, determining the optimal way of its processing.
C. **Modules of (3) formation, (4) updating and (5) maintenance of information arrays** (fields) - ensure the compilation of information record structures, the establishment of semantic (associative) links, the compilation of addresses, the location of records, the organization of new data or changes to existing records, the elimination of obsolete records.
D. **Module of information retrieval (6)** - provides the determination of the location addresses necessary for solving a specific task of information, the selection of information from the corresponding information files, the organization of the primary grouping of information in accordance with the requirements of a specific information request.
E. **Module of response arrays formation (7)** - determine the form of the response array, which is necessary for solving a specific task, selecting and arranging information in the necessary order, selected and grouped by the search unit, including standard library procedures into operation, which are not explicitly in the main information arrays.

3. **Organization system for task solving** - direct control of a projects (or, programs) set of work including mathematical support at the solution of information and settlement tasks. To perform its necessary functions (*see below*), there are 5 modules:
   A. **Module coordinator (1)** - to ensure the joint operation of all the modules of the system for solving problems, setting the system to work in the mode corresponding to the allocated resources, and communication with other parts of the system involving mathematical support.
   B. **Module for planning (2)** - provides the definition of the resources required to solve the problem and the formation of the corresponding application, the planning work on the solution of tasks when selected.
   C. **Module for task library maintenance (3)** - maintains a library catalogue searches and a call to the required programs, should maintain and update the library and directory.
   D. **Module for control (4)** - ensures the development of the plan of computational work, timely connection to the necessary programs, the formation of appeals to the exchange unit in the case of joint work of several programs.
   E. **Module for exchange (5)** - organizes the joint work of several programs, processing of additional instructions received in the course of solving problems, monitoring the use of allocated resources and the time of return of free resources.
4. **Automatic project coordination/management system** - designed for registration and accounting of all appeals to the system, differentiation of access to information and tasks. To perform its functions (*see below*) the system has 6 modules:
   A. **Module coordinator (1)** - provides for the joint functioning of all the modules of the system in all modes: applications for inputting, outputting information and solving problems from individual external subscribers, technical personnel of the facility, other automated objects of the system, other tasks solved in the system, etc.
   B. **Module of message registration (2)** - registers messages.
   C. **Module of checking request authentication (3)** - authentication of a request based on unique characteristics of calls (names or numbers of subscribers, various digital, light codes, especially voices, etc.) identifies subscribers and checks their right to Enter, output information and solve problems.
   D. **Module of newly formed information classification (4)** - classification (establishment) block of the newly formed information column automatically, based on a meaningful analysis, determines the right (security classification) of different subscribers to use information, which is a synthesis of individual messages or the result of solving problems.
   E. **Module of accessing information organization (5)** - prohibits or allows access to information and tasks without the permitting commands of the authentication checker unit, and organize access to information and tasks with appropriate permissions.
   F. **Module of registration and information delivery (6)** - registers the delivery of information.

In concern to the information support system of a city, to reduce the volume of operations for the preparation and input of information into the system, eliminating unnecessary duplication of work and information, reducing the required amount of memory and unification of mathematical support, it is necessary to create a single array (fields) of information to solve all problems of automated control systems. According to the efficiency of use and physical storage of information single arrays (fields) can be divided into levels (Kuzina, 2019):

1. Permanent information.
2. Operational information required to solve a set of tasks of one stage of management.
3. Current, information needed to solve a specific problem.

The objectives of an information support system include (Kuzina, 2019):

1. Reception, placement and storage of information.
2. Search on information fields and selection of information necessary for solving specific tasks.
3. Processing of selected information, editing and formation of response information.
4. Arrays (fields) in the form necessary for solving specific tasks.

The following requirements are necessary in order to solve problems associated with the necessity for operational information (Kuzina, 2019):

1. Ensuring efficient and optimal use of data, information and all types of resources.
2. Automation of production processes, decisioning processes in the event of deviations from the planned indicators (or, pre-planned flows).
3. Complex systems formation for interaction of production and socio-technical processes.
4. Ensuring information interaction between people and between people-and-machines as a means of communication and information transfer.
5. Development of a learning system, system of knowledge accumulation and information coordination within the society.
6. Predictive analysis of scientific and technological development, forecasting of engineering systems.
7. Risk assessment and calculation of the probable consequences of adverse circumstances.

In concern to the organization system for task solving, the system should provide the following functions (Kuzina, 2019):

1. Specific planning of computational work required to solve task problems.
2. Determination of the necessary system resources to solve a problem.
3. Timely inclusion in the work of some programs of special mathematical support.
4. Monitoring the progress of the task and its logging.
5. Processing and maintenance of additional instructions received in the course of solving a problem.
6. Definition of capabilities and management of parallel solution of several tasks.
7. Modify the plan of solving the problem and the redistribution of computational efforts in the case of changing the allocated resources.

The operation of the automatic project coordination system should provide the following functions (Kuzina, 2019):

1. Identification of the subscriber who has applied to the system for input, output of information or solution of this or that task;
2. Check the rights of the subscriber to input, the output of this information, and that the solution of a particular problem;
3. The permit input, output information and the solution of the problem or a signal of disloyalty of circulation;
4. Definition of the classification of the newly generated information (the solution of task or generalization of individual messages) on the right of secrecy;
5. Registration of all requests for input, output information, problem solving with indication of subscribers, time entered or issued information.

The requirements of a software system for the operation of the prior detailed automated control system, which can take an effective final decision, include (Kuzina, 2019):

1. Database containing data of statistics reports, goals and requirements of the users of projects.
2. Software modules for collecting information, importing data into the repository by both automated and manual input that depend on the required information and its source, modules for calculating performance indicators and comparing options.
3. Analytical subsystem of standards, infrastructural elements, suppliers of materials, equipment, etc.
4. A planning subsystem for predicting the results of selected solutions, based on the calculations of local problems, which performs calculations in the form of comparison.
5. A means of visualization of the obtained multi-factor parametric models. Means of display of initial data at the stage of information input, results of changes of the main criteria depending on the chosen decision for each parameter, results in General on object. Generation of reports in various formats.
6. An administrative subsystem is necessary to

ensure information security (taking into account the differentiation of access rights to information, the order of use of data libraries), to work with database servers.

In addition, the usage of an information system for coordinating the operation of buildings and their infrastructure will allow (Kuzina, 2019):

1. Improve the efficiency of design, construction, operation on the basis of predicting the behavior of the building system and its infrastructure.
2. To organize rational management of the project implementation by increasing the level of operation planning at the initial stages of design and increase efficiency in the implementation of tasks.
3. Build a predictable financing system for the facility throughout the life cycle of the building, simulate changes in infrastructure projects.
4. Reduce time for preparation and execution of works, labor costs for operations on search and processing of data for decision-making.
5. Provide the proper level of security in operation of life support systems in smart city.

Additional requirements for the implementation of a cybernetic city system include, but are not limited to:

1. A universal coding system (or, universal code) for the unique identification of all recorded knowledge and information. The designation of an information system designed to provide global access to all knowledge and information. All material identified by this code can be located by the use of a multi-category index. These categories include, but may not be limited to: (1) subject terms and phrases, (2) proper names, (3) geographic names and places, areas, or segments, (4) type of material, and (5) level of material. (Lasker, 1981)
2. The software for all habitat service systems.
   A. An information system to account for all planning and operational activities at any given time.
      1. Systems to collect, analyze, model, optimize, and visualize operations of city systems.
      2. The software architecture to monitor, process, translate/control, and communicate city and human data.
      3. Information software to acquire and understand environmental data for livability.
      4. Information software (decisioning) to determine optimal materializations from knowledge for resilience.
      5. Information software processes (communication) to translate information to users for sustainability.
3. The hardware for all habitat service systems.
   A. The hardware architecture to monitor, process, translate/control, and communicate city and human data. For example, sensors to sense economic information from users; sensors to sense environmental and ecological information; hardware Systems to computationally process data.

3.3 Computational and mathematical modeling for cities

Data acquisition and 3D modeling has enabled the dynamic modeling of physical phenomena, objects, and human behavior, including the simulation of complex environments and problems. Computational models can be applied to almost every aspect of city design, decisioning, and operation. Therein, computational models require relevant data and are used to produce indicators for decision support by each subsystem of a habitat service system. Additionally, computational models and their associated software are necessary for optimization, improved design and decisioning. (Stjepandic, 2019)

Computational modeling is fundamentally related to mathematical modeling. A mathematical mode of a the human domain is a formal representation of individuals' attributes and/or desired requirements of a design. For instance, the definition of values and their encoding (transformation) into decisioning is significant for design. Mathematical modeling allows for precision, which can be used to achieve traceability, robustness, certainty, and better rapport with reality. Further, a mathematical model of the functional domains of a habitat service system would represent those functions formally. A formal representation of functions is a prerequisite for representing functions in computers. A mathematical model of the behaviors represents formally the behavior of the physical model. Wherein, the mathematical model of the physical domain is a formal representation of physical variables, design principles and physical principles of the design of a city. (Stjepandic, 2019)

> **INSIGHT:** *We must operate within the carrying capacity of the city as we do similarly within the limits of the earth itself.*

3.4 Evolution and appropriate habitat design

There exist three general evolutionarily-oriented principles for habitat [re-]design:

1. **Constant habitat features:** If there was some habitat feature that was constant during all of a species evolution, then it must be accounted for in the habitat's design. In general, continuous habitat

features are, in fact, the core habitat functions of life, technology, and exploratory support. Take shelter for example, humanity has never known life any other way. If shelter is altered significantly, or it isn't there at all, then the organism will start to face some very serious issues, such as insect predation, climactic extremes, fire, etc.

2. **Cyclical habitat features:** Some habitat features are cyclical, like night and day. In the case of a cyclically variable habitat feature it is possible to modify the feature with a degree of deviation and to the extent that the organism is adapted to it changing. But, the presence of the feature gets completely out of cycle, out of sync, or becomes monotonous on one side or the other, then the organism is likely to experience dis-ease - this is seen on submarines and with shift-work (where shift workers experience high rates of cancer).
3. **Variable habitat features:** If a species evolved for much of its evolutionary history with a variable habitat feature [within some bounds], it is probably adapted to that feature remaining varied. So if there is a temperature with a dynamic fluctuation through the seasons, or through the days/nights, or maybe the surfaces that the organism moves on varies, and things become too monotonous, then the organism is likely to start experiencing dis-regulation. Variation can be healthy and present adaptive advantages. For example, the night environment is colder than the day environment, which facilitates sleep onset and a lack of waking during the night. Walking on varied surfaces with the full articulation of the foot is supportive of optimized human body physiology.

The human body is dysfunctional in certain environments. It is not adapted to certain environmental structures, and it maladaptive to others. And, without knowledge and a realization of the environmental territory into which one is entering, or being conditioned, an individual could kill oneself or cause serious harm to the continued optimal functioning of its organism if it doesn't account for its principle redesign (qualified by a hermetic stress response to prevent fragility).

> **INSIGHT**: *In the natural world, adaptive structures are the result of conscious self-organization.*

3.5 City surface mediums

On Earth, there are presently two surface mediums for city construction:

1. Land-based cities - cities positioned on land.
2. Ocean-based cities - cities positioned on bodies of water.

A global network of cities in the sea can easily accommodate many millions of people and relieve the land based population pressures. On the ocean, ships could act as integrated manufacturing platforms producing products as they travel.

There may eventually be off-plant city surface mediums for the locating of habitats:

1. Space habitats.
2. Other solar planetary habitats.

3.6 City layouts

> *A.k.a., City structuring, city pathway structuring, city top-view layout.*

There are three primary types of city structure:

> **NOTE:** *The following descriptions attempt to be societal-type agnostic.*

1. **Radio centric cities (a.k.a. circular city)**: Radiates outward from a common center. Inner and outer ring roads are linked by radiating roads. A direct line of travel for centrally directed flows. A radio-centric city does not have to be a circular city; a square or other shape can also be laid out as a radio centric city. Moscow, for example, is a radio-centric city, with the center of all rings being Moscow Kremlin and Red Square.
   A. Street paths in an integrated circular city system have:
      1. Intersections that meet a complex of intersecting angles.
      2. Circulars (i.e., circular pathways, curved continuous lines) are continuous curvature lines. Lines in other layouts of city are broken by angles, and therefore, not continuous. A user of transportation in a circular city system may travel around a particular circular (ring) indefinitely, continuously.
      3. Going straight down from A to B is straight (or, curved continuous and straight).
      4. Going diagonal from A to C uses straight and curved continuous lines.
2. **Circular block cities**: Composed of a tiling pattern of circular city blocks.
   A. Street paths in a circular compacted grid city system have:
      1. Intersections that meet with curved lines, with lines that intersect at 90° and with lines that intersect with blended angle alignment.
      2. Has straight lines and curved lines.
      3. Has no continuous lines.

4. Going straight down from A to B is via a straight line.
5. Going diagonal from A to C requires traveling a zig-zagging curved line. Traveling zig-zagging curved line is more efficient than streets with a square or hexagonal compacted grid. Circular curves require less pathway [material] per land area, because they better approximate a circle over a square or hexagon.

3. **Square block cities (a.k.a., gridiron city, rectilinear city)**: A tiling pattern of rectilinear blocks. Composed of straight streets crossing at right angles to create many regular city blocks. This form is typical of cities built after the industrial revolution. This structure requires many flow hierarchies because of the many 4-way intersections. The square block grid is potentially monotonous and lacks the continuous of curvature more akin to the radial shape of nature. This layout allows for flexible grid expansion by the continuous adding of blocks over the landscape. Square blocks are typically compacted.
   A. Street paths in a square compacted grid city system:
      1. Intersections meet at 90°.
      2. Has straight lines, has no curved lines (straight lines are the most efficient path).
      3. Going down from A to B is straight.
      4. Going diagonal from A to C is least efficient with multiple perpendicular turns.
4. **Hexagon block cities:** A tiling pattern of hexagon blocks, which may either be compacted, or with triangular shaped separations in between octagonal block nodes. This layout allows for flexible grid expansion by the continuous adding of blocks over the landscape.
   A. Street paths in a hexagon compacted grid city system have:
      1. Intersections meet at 120° (which, increases visibility over 90° blocks).
      2. Has no continuous lines, has no curved lines.
      3. Going straight down from A to B is not straight and requires zig-zagging.
      4. Going diagonal from A to C is not straight and requires zig-zagging.
      5. Going diagonal from A to C is more efficient than streets with a square compacted grid. Hexagons require less pathway [material] per land area, because they better approximate a circle over a square.
   B. Street paths in a hexagon-triangle grid city (i.e., non-compacted hexagon grid city) system have:
      1. Intersections meet at 60° and 120°.
      2. Has no continuous lines, and has no curved lines.
      3. Going straight down from A to B is not straight, and uses two straights lines at 120° to each other or four straight lines off 120° to each other.
      4. Going diagonal from A to C is not straight and uses two straights lines off by 120° to each other.
      5. Triangular separations require less pathway [material] per land area, because they are the smallest structural shape.
5. **Cellular block cities:** A tiling pattern of cellular-like blocks, typically, with nature areas within the center of each cellular block. Cellular blocks are typically compacted.
   A. Street paths in a cellular compacted grid city system:
      1. Intersections meet at multiple angles.
      2. Has no straight lines, has angled lines, has no continuous lines.
      3. Going down from A to B is not straight and uses many angled lines.
      4. Going down from A to B is not straight and uses many angled lines.
6. **Linear cities**: A city expanded along a linear transport system. This type of layout is very sensitive to transportation blockages. Dubai and Navi Mumbai are examples of linear urban-spread cities, and the prototype Line city in Saudi Arabia, is an example of a pure linear city (without sprawl).

The most well-known models of city land growth include:

1. **Concentric model (a.k.a., concentric zone model, Burgess model)** - city grows radially outward from a single point. Ideally, different land uses are distributed via concentric rings around the city center.
2. **Sector model (a.k.a., sector zone model)** - city grows sector by sector.
3. **Multi nuclei model** - city grows from several independent points rather than from a central area. Little to no planning; almost completely ad hoc.

In the market-State, rectilinear cities have several advantages and disadvantages given those conditions (Levinson, 2020):

1. Advantages include, but are not limited to:
   A. Maximizes the use of space for square/rectangular buildings.
   B. Simplifies real estate by making market-State surveying easier.

    C. Is embedded in existing property rights, effectively making the property rights structure [nearly] impossible to change.
2. Disadvantages include, but are not limited to:
    A. Is among the least efficient way to connect places from a transportation perspective.
    B. Reduces opportunities for nature, interesting spaces, architecture, etc.
    C. Wastes developable space by overbuilding roads.

The market-State urban population-dimension hierarchy generally scales in the following manner:

1. **Hamlet** - may only include a few dozen people and offer limited services. These are clustered around an urban center and may only consist of basic need services.
2. **Villages** - larger than hamlets and offer more services.
3. **Towns** - more urban with a defined boundary, but smaller than a city in terms of population and area.
4. **Cities** - densely populated areas that may include tens of thousands of people.
5. **Metropolis** - large cities and their suburbs.
6. **Megalopolis** (conurbation) - where several metropolitan areas are linked together to form a huge urban area.

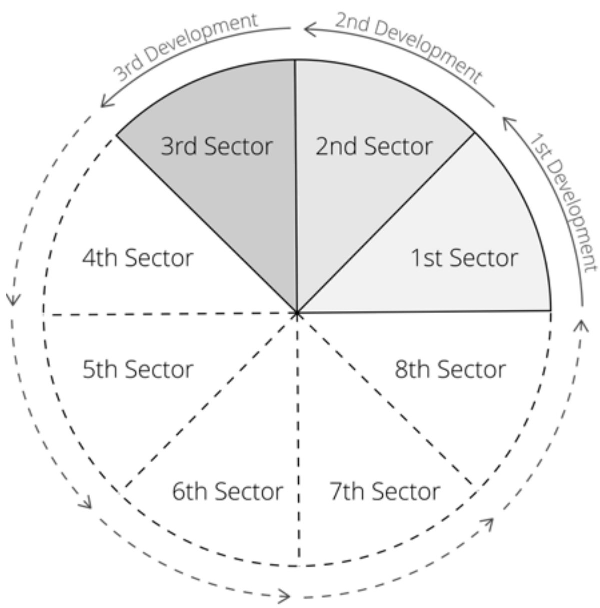
In concern to sustainability, the key design issues in city structuring include, but are not limited to (Marshall, 2005):

1. The need to create layouts that minimise the demand for energy and materials.
2. The need to create layouts that eliminate the automobile, while facilitating walkability and utilizing mass rapid transport.
3. The need to use environmentally friendly modes of transport, especially walking and cycling (which may also bring health benefits).
4. The need to space service locations appropriate to demand.

The divisioning of districts/zones in a city occur based upon (includes, but is not limited to):

1. **Demand** (i.e., # of people; mass and volume of demanded objects)
2. **Service type** (e.g., business, residential, recreational, etc.)
3. **Access type** (e.g., personal, commons, system)
4. **Location and proximity** (of people to goods and services)
5. **Socio-economic class** (market only; e.g., high-income class, middle-income class, lower-income class, poverty class)

It is relevant to note here that many of the ongoing early 21st century theories around city design and



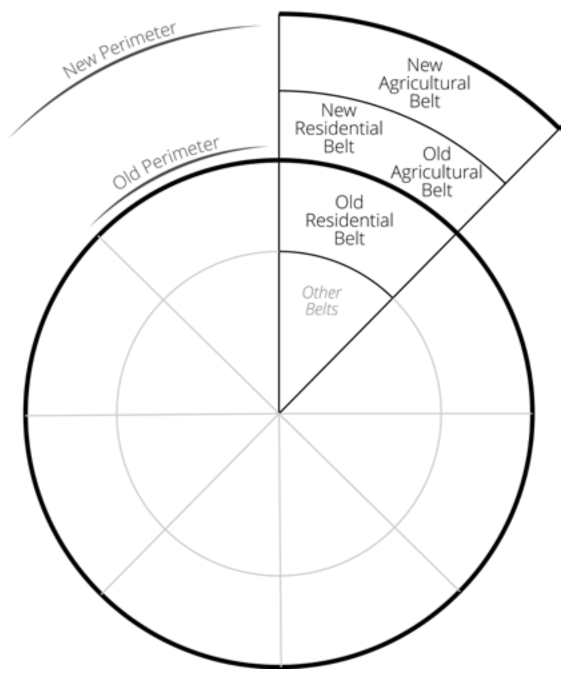


Figure 11. *Figure on left shows city expansion going sector by sector over time. Figure on right shows sector-ring by sector-ring over time.*

development are marred by presumptions based on outdated understandings, poor quality data on humans' real-world requirements, and dis-unified modeling. Central place theory, for example, is a market-State geographical model of the spatial distribution of cities across a landscape that sought to explain the number, size and location of human settlements in a residential system, and was developed in 1933. (Ben-Joseph, 2000; Pumain, 2004) The theory was created by the German geographer Walter Christaller, who asserted that settlements simply functioned as 'central places' providing services to surrounding areas. (Goodall, 1987; *Central place theory*, 2019)

The sub-conceptions of central place theory are [out-dated and market-focused]:

1. **Central places** - urban centers that provide services to their surrounding rural people (hinterland).
2. **Threshold** - the minimum number of people needed to support a particular function's existence in a central place. Including, the minimum number of resources and tasks required to maintain a particular function's existence in the city. The more unique and special an economic function, the higher the threshold.
3. **Range of good or service** - the maximum distance a person is willing to travel to obtain a good or service. And, the maximum distance at which a good or service may be accessed. How far is a consumer willing to travel? Central place theory assumes consumers will not be willing to travel as far for lower central place functions. What if the consumers may no longer need to travel because the transportation system now delivers?
4. **Spatial competition** - central places compete with each other for customers. Central place theory assumes central paces will be located farther away from each other, because consumers are more likely and willing to travel a longer distance to obtain higher central place functions.

3.6.1 Comparing city layouts

At the most simple level, cities may be compared in the following ways:

1. Land use (a.k.a., city services, including nature and roadways).
2. Fixed master planning (i.e., integrated/unified development) or sprawled master planning (i.e., organic development, sprawling).
3. Top-view street grid layout:
   A. Circular fixed (sectors within a circle).
   B. Blocks (of cells, circles, hexagons, squares, etc.).
4. Buildings (a.k.a., massing; types and arrangement of architecture).

> **NOTE:** *The same massing of buildings, but organized in a different composition, can result in a tremendous increase or reduction of road (and road infrastructure).*

The three general land usage variables to account for when comparing city layouts are (by percentage of total area, 100%):

1. Built area - what percentage of the total area (100%) is built area?
2. Road area - what percentage of the total area (100%) is road area?
3. Nature area (greenscapes) - what percentage of the total area (100%) is nature area?

In concern to a comprehensive understanding of city services (i.e., land use), it is then necessary to account for each of the services within the habitat service by area:

1. Life:
   A. Architecture: What percentage of the total area (100%) is part of the architectural service?
   B. Water: What percentage is part of the water service?
   C. Power: What percentage is part of the power service?
   D. Etc.
2. Technology:
   A. Computation: What percentage is part of the computation service?
   B. Communications: What percentage is part of the communications service?
   C. Transportation and distribution: What percentage is part of the transportation service?
   D. Etc.
3. Exploration:
   A. Education: What percentage is part of the education service?
   B. Technology development: What percentage is part of the technological development service?
   C. Consciousness exploration: What percentage is part of the technological development service?
   D. Etc.
4. Market (market only):
   A. Commerce and finance: What percentage is part of commercial services?
   B. Etc.
5. State (State only):
   A. Defense: What percentage is part of defensive services?
   B. Politics: What percentage is part of political services?
   C. Etc.