# ORBITAL OPERATIONS STUDIES

Natural Resources Research Institute
in association with the
National Aeronautics and Space Administration

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Information Circular No. 68

# ENVIRONMENTAL ASPECTS OF THE UNITS PROBLEM

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This Information Circular is one of a series concerned with a newly conceived and formulated "Geospheric System" of defining and identifying "Geounits" for coordinating human activities with respect to the characteristic nature of our Earth-centered or Geospheric environment. Its initial publication in this form is intended to provide a timely input into current considerations of the advisability of "converting to the metric system" in the United States — and to serve as a preprint of whatever other forms of publication might prove to be desirable to bring the promising potentialities of this development to the attention of those who might well utilize it.

The concepts presented here have been developed during the last several years with partial support from Grant No. ~~Ns0658~~ NGR-51-001-001 of the National Aeronautics and Space Administration, Wyoming's Institutional Grant from the Office of Water Resources Research, Contract No. 14-06-D-6002 of the Bureau of Reclamation, and Contract No. E-12-70(N) of the Environmental Science Services Administration; and with the valued encouragement of especially William J. Healy, Gerald L. Barger and P. V. H. Weems and his ad hoc committee of the Institute of Navigation.

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February 1971

ABSTRACT

The metric system of units is seen herein to have evolved into the International System of Units more to provide for precise quantitative comparisons of the physical qualities of different things than to interrelate the several different kinds of physical qualities of particular one unit-things.

In contrast, the customary units of angle and time and the nautical mile are seen to have evolved to provide for identifying and coordinating particular one space-time positions in and of our Earthly environment with nominal numbers of ideally defined "unified" units of their several different kinds of physical qualities.

The so-called "English" units are similarly seen to have evolved primarily to identify particular one unit-things in familiarly useful relationship to everyone's own personal measures of things – to happen to be more conveniently related to widely useful subdivisions of the Earth than the metric units – and therefore might now very well evolve into an integrally-related part of a newly conceived Geospheric System of Units for coordinating human activities with respect to characteristic features of our Earth-centered or Geospheric environment.

# E N V I R O N M E N T A L   A S P E C T S
# O F   T H E
# U N I T S   P R O B L E M

We in the United States are currently faced with two closely related problems. On the one hand, Public Law 90-472 was approved on August 9, 1968: "To authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States." On the other hand, it is becoming increasingly necessary to coordinate all human activities throughout the world in closer coordination with their Earthly environment. Hopefully the following discussion will help to lead to a viable solution of both of these important problems.

It is apparently often assumed that an increased usage of the basically Earth-related metric system would help solve such environmental problems. For example, its meter unit of length was originally defined to be exactly one 10,000,000th of the length of a quadrant of the Earth from the Equator to the North Pole. In contrast, the customary foot in use today was originally defined to be one third of the length of a brass bar called the British Imperial Yard, which in turn was established in 1592 as being the length of Queen Elizabeth's "ruling arm".

On second sight, however, the metric system is seen to be less usefully Earth-related than other units can well be. For example, the nautical mile instead of the kilometer has come to be used by sea, air and space navigators throughout the world to coordinate their horizontal positions with respect to minutes of arc on the surface of the Earth and in conveniently useful relationship to the apparent positions and motions of the stars. Evidently Thomas Jefferson foresaw this development when he proposed in 1784 that Congress adopt such a "geographical mile" instead of either the kilometer or the English mile that was finally used to subdivide the public lands into sections and townships.

A lack of suitability of the metric system for most everyday and environmental purposes becomes especially clear by considering units of time and angle. It does not, for example, include any of the non-decimal multiples of its basic second unit of time such as the minute, hour, day and year – with which human activities and natural phenomena are coordinated throughout the world with respect to the life-giving rays from the Sun. Neither does it include non-decimal multiples of its radian unit of angle such as the degree, minute and second – with which horizontal latitude and longitude positions on the surface of the Earth are coordinated with each other and with the angular positions of the Sun and stars throughout the world.

It is even of life and death importance to everyone who flys that aircraft altimeters indicate numbers of either feet or meters of the non-metric "pressure-altitude" measure of atmospheric pressures. If the metric system's millibar unit of pressure were to be used, for example, it would be practically impossible for pilots to relate their flight altitudes to the numbers of feet or meters in terms of which the heights of solid terrain are charted. In fact, numbers of feet rather than meters have been adopted to coordinate the altitudes of aircraft with respect to each other and the surface of the Earth even in most otherwise "metric" countries.

Significantly in this latter regard, Queen Elizabeth's foot happens to be more usefully related to the size of the Earth than the meter – since the current international nautical mile of exactly 1,852 meters happens to contain about 6,078 feet. Corresponding numbers of feet and nautical miles contained in vertical and horizontal distances thus happen to be interrelated by the approximate conversion factor of 6,000 with sufficient precision for most purposes. In contrast, multiplications or divisions by a comparably precise approximate conversion factor such as 1,850 would be required to interrelate corresponding numbers of meters and nautical miles.

This turn of events is especially ironic since the meter was originally defined in terms of the characteristic size of the Earth — largely in spite of the fact that it thereby no longer provided for the age-old utility of personally-related units such as the foot. Such personally-related units are part of the so-called English (or in England the Imperial) System only insofar as it was in England that they were first precisely defined to initiate the modern unit-of-measure point of view. From an obverse utility point of view, they can much better be considered to be a part of a Personal System of Units that had its origins in the dim reaches of the earliest civilizations.

Specifically, the earliest known Egyptian units of length comprised a binary or successive-doubling system that was usefully related to everyone's own

| | |
|---|---|
| | finger or digit, |
| 2-digit | half-hand, |
| 2-half-hand | hand, |
| 2-hand | span, |
| 2-span | cubit, from elbow to fingertips, |
| 2-cubit | yard, from chin to fingertips or stride, |
| 2-yard | pace, or double-arm and man-height fathom, and, for longer distances |
| 1000-pace | mile (of ten 100-pace stades or 200-yard racing-distances in stadiums). |

The evolution of these units into the Swedish tum or English inch of 72 printer's points and the 12-inch or third-of-a-yard foot is evidently attributable to the same kind of subdivisibility by 3 as well as by 2 that has been provided by the factors of 24, 60 and 360 among the day, hour, minute and second units of time and the circle, degree, minute and second units of angle.

The so-called English units of volumetric capacity are also outgrowths of an ancient Egyptian binary system that started with the personally important "mouthful" or tablespoon. Two such tablespoons made a jigger or one-ounce "handful", two of which made a "double handful" jack or jackpot, and successive doublings of which were the original English jill, cup, pint or jug, quart, pottle, gallon, pail, peck, bushel, strike, coomb, cask, barrel, hogshead, pipe and tun.

Some of these units of capacity have since been abandoned or modified for a variety of reasons – among which one of the most interesting and informative is reflected in the nursery rhyme:

"Jack and Jill went up the hill,
to fetch a pail of water.
Jack fell down and broke his crown,
and Jill came tumbling after."

This rhyme refers to the imposition of a tax by Charles I on all jackpot sales of goods and – to gain more revenue – a reduction in the size of the jack that broke the crown's assurance of the value of both the jack and jill, which in turn led to the refusal of the common people to use them.

The historic saying that "a pint's a pound the world around" evidently also preceded a similar correspondence between a liter and a kilogram of water. Indeed, the common practice of manipulating units of measure to gain trading advantage might well have degraded an earlier correspondence between the volume of a 3-inch cube and a pint in essentially the same way that the volume of a tenth-of-a-meter cube corresponds to a liter. For example, a 3-inch cube of a King whose ruling arm was only about three quarters of an inch longer than Queen Elizabeth's yard might well have been equal to the volume of the current U.S. pint; or his cubic foot unit of volume could have been equivalent to the volume of one 8-gallon bushel.

The Role of the Metric System

The units of the metric system are thus clearly not sufficient to coordinate the space-time positions and scale-sizes of things with respect to characteristic features of either the Earth or its human inhabitants. Rather, it is evidently necessary to gain an understanding of why an increased usage of the metric units is being advocated so strongly in spite of such obvious vitally-important shortcomings.

As might be expected, this lack of understanding is attributable to a lack of recognition of two very different connotations of the word "unit". On the one hand, most scientists and engineers usually think of it as referring to queries concerning "how many units of measure?" have been observed or computed to be contained in a particular physical quantity. Others, on the other hand, more commonly think of it as referring to queries concerning "which one unit-thing?" — particular ones of which are identified with nominal or "naming" numbers of suitably selected and identified units of measure.

For example, the second unit of time is utilized to respond to the "how many?" kind of query with the cardinal kind of numbers — such as $2.98 \times 10^{-5}$ seconds or 29.8 microseconds for a quantity such as the travel-time of a radar pulse. On the other hand, particular "one-second" unit-periods of time are identified with the very different ordinal or "which one?" kinds of naming-numbers — such as "the 5th second of the 10th minute of the 20th hour of the 18th day of the 4th month of the 1775th year A.D."

Many of the cardinal-numbering or "how many?" kinds of needs can thus well be served by one and only one basic unit of measure for any one kind of physical quality. For example, the computation that a measured time interval of 0.0864 megaseconds contains 24.0 of another interval such as 3.60 kiloseconds would have been more convenient if both of those measurements had been expressed at the outset as being the cardinal numbers $8.64 \times 10^4$ and $3.60 \times 10^3$ of the single second unit measure of time. For other purposes, however, it is clearly much more useful to identify such unit-intervals of time as being some particular day and hour of a particular month and year.

The metric system is thereby seen to have evolved almost entirely to serve a generalized "how many?" rather than the "which one?" kind of needs for units. This became especially clear when the International System of Units was officially adopted in 1960 and recommended by the members of the Eleventh General (International) Conference on Weights and Measures "for all scientific, technical, practical and teaching purposes." The outstanding characteristic of this "Systeme International d'Unites" is that it consists of one and only one of its officially abbreviated "SI Units" for each of the different kinds of physical qualities listed in Table 1 — but any one of which can of itself identify only one of the infinite variety of different nominal scale-sizes of particular one unit-things.

The metric system of units thus now essentially consists of those decimal multiples or sub-multiples of the SI Units that can be formed and identified with the symbol and naming prefixes listed in Table 1. Even those decimally interrelated units are clearly not sufficient in and of themselves, however, to serve all needs to identify particular "which one" unit-things. Rather, these symbol and naming prefixes evidently provide a very conveniently useful way to identify whichever such decimal multiples or sub-multiples of the SI (OR ANY OTHER!) Units might well serve some particular useful purpose.

Each of the SI Units thus evidently serves primarily as a "medium of exchange" for each particular kind of physical quality such as the length, volume, mass, weight, etc. of things — in very much the same way that the dollar serves as the basic medium of exchange of their "worth". In both cases, the quantitative relationships among any one such quality of different unit-things are most universally comparable when they are expressed as cardinal numbers of a single SI or single dollar unit of exchange. Particular scale-of-ten digits of these cardinal numbers are then conveniently identifiable in terms of subsidiary denominations such as the monetary cent or "centidollar", dime or "decidollar", kilobuck or "kilodollar" and megabuck or "megadollar".

In neither case, however, are such decimally-related denominations sufficient to serve all needs even for units of exchange – as clearly exemplified by the need for other monetary denominations such as the nickel, quarter and half-dollar; the two, five, twenty and fifty dollar bills; or even the eighth-of-a-dollar bits or points in terms of which most stock transactions are conducted. In much the same way, the useful effectiveness of graph paper critically depends upon being able to specify that its unit-squares represent whatever other units might best serve to depict a particular physical relationship. Especially, the nominal scale-sizes of actual unit-things clearly cannot be restricted to only those of the metric units any more usefully than the cost of all unit-things could be restricted to only one cent, one dime, one dollar or only decimal multiples of a dollar.

The SI and metric units could thus much more characteristically be called "units of exchange" than even "units of measure". For example, the minute hands and hour hands of clocks are obviously much more directly useful than decasecond, hectosecond or kilosecond hands would be for a vast majority of coordinative purposes. Similarly, measurements of horizontal distances with aircraft radars can much more usefully be expressed at the outset as numbers of nautical miles instead of kilometers – or especially instead of the numbers of microseconds of radar pulse travel-times with which such distances are actually measured.

The metric system thus evidently evolved into that medium of exchange whereby all other more specifically useful units can be unambiguously interrelated by virtue of defining them to be particular numbers of the basic SI reference units. This definitive role of the metric system was esentially established in the United States in 1893 when the "Mendenhall Order" of the then Superintendent of Weights and Measures made it mandatory to so-define all legal units of measure in terms of the metric units — much as the inch was redefined in 1959 to be exactly equivalent to 2.54 centimeters of the metric system; or hence since 1960 to be exactly 0.0254 of the basic SI meter reference unit for all such units of length.

The units of the metric system have thereby also essentially become those units in terms of which generalized scientific knowledge concerning the quantitative relationships among all scale-sizes of all kinds of things throughout the universe are customarily expressed. In addition, the derived SI Units have been defined so that they very usefully eliminate numerical conversion factors other than UNITY from — but only from! — those particular idealized relationships that have been selected to so-define them. For example, the selection of the radian as the basic SI reference unit of angle has eliminated the incommensurate conversion factor of $\pi$ in those largely theoretical computations that are associated with the differentiation and integration of trigonometric functions. However, any restriction to the use of only the metric units of angle would thereby introduce the extremely inconvenient conversion factor of $\pi$ into much more commonly useful relationships such as between the angular positions of the Sun and times of the day.

The scientific utility of the metric units is thus seen to be essentially a necessary quantitative means toward extremely generalized, and hence more qualitative than specifically applicable quantitative, ends. Such generalized scientific knowledge is ultimately useful, in turn, almost solely insofar as it serves to establish ideally generalized "constant" quantitative relationships among the characteristic physical qualities of widely important classes of specific one unit-things — or hence largely insofar as it provides for utilizing such "physical constants" to define and interrelate whatever other units of measure can better serve specific end-use purposes.

The Geospheric Queen of Length

Of specific interest here, the International System of Units evidently serves especially well as a generalized Earth-related means of defining whatever other more specifically useful units might be found to select, establish and interrelate the nominal unit-sizes, amounts and space-time positions of manufactured goods, structures, real estate, ships, aircraft and spacecraft in optimum coordinative relationship:

> To each other;
>
> To characteristic features of their natural environment and the natural resources of the Earth-centered or "Geospheric" region of the universe;
>
> To each of its inhabitant's own personal measures of such unit-things; as well as
>
> To any and all other units that might be found and so-defined to be whatever other particular numbers of the SI units of exchange can better serve other specific end-use purposes.

In this regard, the qualitative relationships between the age-old Personally-related units of length and anyone's and everyone's own thumbwidth, foot, reach, stride or height is evidently much more important than the precise quantitative way in which they happen to have been defined. Throughout most of recorded history, for example, they were logically defined in terms of the highest dispute-settling authority: namely a ruler replica of the ruling arm of the ruling Pharaoh, King or Queen. It was not until 1592 that the Imperial Yard replica of Queen Elizabeth's ruling arm was designated in England as being the basic reference unit of length from that time on — in almost exactly the same definitive sense that the International Prototype Meter replica of the 10,000,000th part of the Earth's "ruling quadrant" was adopted by the International Metric Commission in 1889. In the meantime many attempts have been made to define units of length in terms of more widely available and precise things than a prototype bar-standard — such as especially the much maligned "three barleycorn inch" for which it took until 1960 to adopt a suitable successor in the "1,650,763.73 Kr86 wavelength meter".

It is also significant in this regard that the basic motivation for the establishment of the metric system by the French Academy of Science in the late 1700's was to provide a common medium of exchange to replace the proliferation of unrelated units of weights and measures that had been established with respect to the ruling arm of some King, Queen, Duke or Duchess of each independent country and locality. It would have been virtually impossible at that time in history to have deified any particular King or Queen — or especially England's Queen Elizabeth! — by adopting her imperial ruling arm as the supreme ruler of all things in all countries. Rather it was clearly desirable at that time to forego the Personally-related qualities of units such as the inch, foot and yard to obtain the Earth-related characteristics of the meter.

Now, however, the evolution of the nautical mile and the world-wide aeronautical usage of numbers of feet of altitude has essentially demonstrated the possibility of evolving toward the use of units that are BOTH Earth-related and Personally related. Toward this end, a "Geospheric Queen of Length" is hereby figuratively nominated for international election to succeed Queen Elizabeth's nearly 380-year term of office. The primary qualification of this apolitical Queen is that her nominal finger-tip-to-finger-tip reach, by virtue of being something less than one thumbwidth longer than Queen Elizabeth's, would be as typically representative as any one such single measure can practicably be of the length of BOTH of:

- The double-arm reach, two-stride pace and "fathom" height of each of the world-wide electorate that she would ideally represent; as well as
- One-thousandth of one angular-minute of each of the great-circle arcs on the surface of the Earth-centered or Geospheric portion of the universe that she would rule.

In addition, this Geospheric Queen would be ideally proportioned in the extremely useful figurative sense that 32 of her half-geoounce mouthfuls or her geopint would be equal to the volume of a cube with sides of exactly 3 of her geoinch thumbwidths — or of exactly 1/4 of her geofoot counterpart of 1 centisecond of great-circle arc. That geopint would also contain exactly 1 geopound of Ideal Water, the heft of which would be one of her geopound-force units of weight when subjected to an ideally defined "1 gee" unit of the Earth's gravitational attractions throughout the ideally conceived Biospheric portion of her Earth-centered Geospheric realm.

## The Geospheric System of Units

Specifically, this ideally defined Geospheric Queen could well rule her ideally conceived Earth-centered realm by subdividing its overall circumferential extent into successively smaller unit-intervals such as

| | | | |
|---|---|---|---|
| 1 | circle-like, | "circile" | or C-scale interval, |
| 360 | degree-like, | "dile" | or D-scale intervals, |
| 60(360) | minute-like, | "mile" | or M-scale intervals, |
| 60(60)(360) | second-like, | "sile" | or S-scale intervals, |
| 100(60)(60)(360) | foot-like, | "file" | or F-scale intervals and |
| 12(100)(60)(60)(360) | thumb-like, | "thile" | or T-scale intervals. |

These unit-subdivisions can then well serve as the "Principal Scale Sizes" of a Geospheric System of Units such as specified in the Appendix, any one such particular "U-scale" size of particular qualitative "Q-kinds" of which are explicitly identified with symbols such as its

| | | |
|---|---|---|
| U'$\alpha$ units of angle | U'$L^2$ units of area | U'F units of force |
| U't units of time | U'$L^3$ units of volume | U'E units of energy |
| U'L units of length | U'M units of mass | U'p units of pressure. |

The desired coordination of space-time positions throughout the Geosphere is then provided for in this Geospheric System by defining the overall "circile" or C-scale size of its "geounits" of:

Angle, $C'\alpha$, to be exactly equal to 1 circle of the Earth's angular circumference and the apparent solar day of 1 circle of its angular rotation with respect to the life-giving rays from the Sun;

Time, C't, to be exactly equal to the mean solar day of exactly 24(60)(60) or 86,400 SI seconds; and

Length, C'L, to be an ideally conceived circumference of the Earth's Biospheric land or water surface of exactly 40,000,000 SI meters.

A single "UNIFIED" U-scale symbol is thereby provided for identifying corresponding pairs of customary units of angle and time such as the

C-scale or "circile-scale" exact geounit counterparts of the day unit of solar angles, $C'\alpha$, and day unit of time, C't,

D15-scale or "fifteen-dile-scale" exact counterparts of the 15-degree unit of solar angles, $D15'\alpha$, and 1-hour unit of time, D15't,

D-scale or "dile-scale" exact counterparts of the 1-degree unit of solar angles, $D'\alpha$, and 4-minute unit of time, D't,

D/4 scale or "quarter-dile-scale" exact counterparts of the 1/4 degree unit of solar angles, $D/4'\alpha$, and 1-minute unit of time, D/4't,

M-scale or "mile-scale" exact counterparts of the 1-minute unit of solar angles, $M'\alpha$, and 4-second unit of time, M't, and so forth down to the

S-scale or "sile-scale" exact counterparts of the 1-second unit of solar angles, $S'\alpha$, and 1/15-second unit of time, S't, or 4-cycles of 60 cycle per second electrical clocks.

These same U-scale symbols thereby also provide for identifying U'L geounits of length that are UNIFIED in the extremely useful sense that they are each as typically representative as any one such unit of length can practicably be of BOTH of:

The corresponding U-scaled unit of angular measure of great-circle arcs anywhere and everywhere in the Earth's Biosphere; as well as

Integral numbers of each of its inhabitant's own personal measure of things – such as the

D-scale or dile unified D'L counterpart of
1 degree of arc, D'$\alpha$, and
60,000 double-stride paces;

M-scale or (geo)mile unified M'L counterpart of
1 minute of arc, M'$\alpha$, and
1,000 double-strice paces or 6,000 feet;

S-scale, sile or geochain unified S'L counterpart of
1 second of arc, S'$\alpha$, and 100 feet;

F6-scale, six-file or geofathom unified F6'L counterpart of
1 milliminute of arc, mM'$\alpha$ or F6'$\alpha$;

F3-scale, three-file or geoyard unified F3'L counterpart of
3 centiseconds of arc, cS3'$\alpha$ or F3'$\alpha$;

F-scale, file or geofoot unified F'L counterpart of
1 centisecond of arc, cS'$\alpha$ or F'$\alpha$; or

T-scale, thile or geoinch unified T'L counterpart of
1/12 centisecond of arc, cS/12'$\alpha$ or T'$\alpha$.

The nominal scale-sizes and amounts of manufactured goods, structures and real estate can thereby also well be coordinated with their space-time positions in their Geospheric environment by expressing them in terms of ideally conceived cubical amounts of water – any particular UNIFIED U-scale amount of which has a nominal:

- Lineal dimension of one U'L geounit of length;
- Cross-sectional area of one U'$L^2$ geounit of area;
- Volume of one U'$L^3$ geounit of volume;
- Mass of one U'M geounit of mass of 1 U'$L^3$ of Ideal Water with 1 geounit of density '$\rho$ (of exactly 1000 SI kilograms per cubic meter); and
- Weight of one U'F geounit of the force associated with a "1 gee" geounit of gravitational acceleration 'g (of exactly 10/1.0206 SI meters per second squared) acting upon 1 U'M geounit of mass anywhere and everywhere in the Earth's ideally conceived Biosphere.

For example, unit-amounts of the Earth's life-giving waters can thereby be identified interchangeably for all qualitative and most quantitative purposes as being particular UNIFIED U-scaled amounts of water such as:

1 "sile, S, of water" — whose nominally cubical
Lineal dimensions are 1 sile or 1 S'L geounits of length,
Area is 1 sile or 1 $S'L^2$ geounits of area,
Volume is 1 sile or 1 $S'L^3$ geounits of volume,
Mass is 1 sile or 1 S'M geounits of mass, and
Weight is 1 sile or 1 S'F geounits of force;

1 "file, F, of water" — whose nominally cubical
Lineal dimensions are 1 file (of length), F'L or 1 geofoot,
Area is 1 file (squared of area), $F'L^2$ or 1 square geofoot,
Volume is 1 file (cubed of volume), $F'L^3$ or 1 cubic geofoot,
Mass is 1 file (of mass), F'M and
Weight is 1 file (of force), F'F;

1 "half-file, F/2, of water" — whose nominally cubical
Lineal dimensions are 1 half-file (of length), F/2'L
or 1/2 geofoot,
Area is 1 half-file (squared of area), $F/2'L^2$
or 1/4 square geofoot,
Volume is 1 half-file (cubed of volume), $F/2'L^3$,
1/8 cubic geofoot or 1 geogallon,
Mass is 1 half-file (of mass), F/2'M and
Weight is 1 half-file (of force), F/2'F; and

1 "quarter-file, F/4, of water" or
1 "three-thile, T3, of water" — whose nominally cubical
Lineal dimensions are 1 three-thile (of length), T3'L
or 3 geoinches,
Area is 1 three-file (squared of area), $T3'L^2$
or 9 square geoinches,
Volume is 1 three-thile (cubed of volume), $T3'L^3$,
27 cubic geoinches or 1 geopint,
Mass is 1 three-thile (of mass), T3'M
or 1 geopound, and
Weight is 1 three-thile (of force) T3'F
or 1 geopound-force.

It is even also usefully possible to define a similar nearly-equivalent geounit counterpart of the acre-foot unit of volume with which larger scale unit-amounts of water are customarily related to unit land areas. For such purposes a "geoacre" could well be defined to be 100x12 geopaces or 600x72 geofeet instead of the traditional 10x1 Gunther chains or 660x66 English feet. The resulting 43,200 square geofeet of area would be only about 1 part in 60 larger than the 43,560 square-foot area of an English acre, and the geoacre-foot unit of volume of water would be very nearly 1.03 times or only 3 percent larger than the traditional acre-foot. A major advantage of these acre-like geounits is that a flow rate of 1 file of volume or 1 cubic geofoot and nominally 1 file of mass (or hence 8 geogallons and 64 geopounds of Ideal Water) per second is exactly equivalent to a flow rate of 2 such geoacre-feet per day.

The water-related geounits provide especially for coordinating the vertical positions of things throughout the oceanic or Hydrospheric portion of the Geosphere. For this increasingly important purpose, the following three different kinds of vertical coordinates of "horizontal" surfaces are involved and can well be conceived to coincide in an Ideal Hydrosphere — each of which can well be identified with the same nominal UNIFIED numbers of any particular U-scaled geounits of:

Geometric depth, U'L;

Constant-pressure levels, U'p
- the $U'F/U'L^2$ geounits of which are exactly equivalent to the increment of pressure exerted by 1 U'L depth of Ideal Water when subjected to the 1 gee ideal geounit of gravitational acceleration; and

Constant potential-energy levels, U'E
- the U'E geounits of which are exactly equivalent to the work required to move 1 U'L geounit of distance against 1 U'F geounit of force,
- or hence the work required to lift 1 U'M unit of mass (or 1 $U'L^3$ unit-volume of Ideal Water) 1 U'L unit of depth against the 1 gee unit of gravitational acceleration.

A special Earth-related R-scale or "radile" scale-size of geounits such that

1 radile (of length), $R'L = 1/2\pi\ C'L = 40{,}000{,}000/2\pi$ SI meters and
1 radile (of angle), $R'\alpha = 1/2\pi\ C'\alpha = 1$ SI radian

similarly provides for coordinating the vertical positions of things such as satellites throughout the outer airless but full-of-fiery-energy "Pyrospheric" region of the Geosphere. This Pyrospheric portion of the Geosphere can well be considered to extend to the limits of the Earth-centered gravitational field at very nearly 1/100 of the Astronomical Unit distance to the Sun, at almost 4 times the distance to the Moon, and at a radius of very nearly 235 times this nominal 1 radile radius of the Biosphere.

A special set of geounits of the Julian or "stellar" kinds of time also provides for coordinating the horizontal positions of things throughout the Geosphere with respect to the apparent angular positions of the stars — each U-scaled geounit U*t of which is defined to be exactly equal to 365.25/366.25 times smaller than the corresponding U't units of mean solar time. These units are thereby defined to be as nearly equivalent as any one such U-scaled unit can practicably be of the slightly variable periods during which the Earth rotates a corresponding U-scaled unit of angle with respect to BOTH of the:

Vernal Equinox
- with respect to which the angular positions of the stars and times of the year are coordinated in astronomical and navigational practice throughout the world,
- and with respect to which the sidereal day period of 1 circle C'$\alpha$ of rotation was equal to about 1+0.0000213 of the C*t or stellar days during 1960; and the

Inertial Space of the so-called "fixed stars"
- with respect to which the period of rotation of the Earth was about 1-0.0000173 of the C*t geounits of such Julian time in 1960.

The Geospheric System of geounits also potentially provides for the vital coordination of the vertical positions of aircraft with respect to unified identifications of particular ones of the Atmosphere's several different

constant geometric elevation,
constant pressure,
constant potential-energy,
constant density and
constant temperature

kinds of horizontal and quasi-horizontal surfaces. Specifically in this regard, the development of aviation is attributable in large part to a parallel evolution of the ideally generalized concept of these several different unified kinds of "altitude":

- o Which are ideally conceived to coincide in a mathematically defined Standard Atmosphere;
- o Particular ones of each of which are identified with the geometric altitude at which any particular pressure, potential energy, density or temperature occurs in that Standard Atmosphere;
- o Each of which is thereby identified with numbers that correspond as closely as practicable with the geometric elevation above mean sea level at which any one such quality of the atmosphere is likely to occur at any and all horizontal positions or times;
- o Which thereby provide for vitally simplified computations and depictions of the basic pressure-height, temperature and wind-flow states of the atmosphere for any and all constant-pressure flight levels in terms of the highly informative residual
  - D-value or so-called "Altimeter Correction" differences between geometric-elevation and pressure-altitude and the
  - S-value or "Specific Temperature Anomaly" differences between actual and ideal temperatures

  at any and all particular positions and times in and of the atmosphere; and
- o Which are currently evaluated in the aeronautical practices of even the "metric" countries of the world with numbers of Queen Elizabeth's feet of each of these several unified kinds of "altitude".

Indeed, the Geospheric System was originally conceived to provide for the utilization of such unified altitude coordinates in meteorological as well as aeronautical practice throughout the world. The basic problem in this regard has been the lack of suitability of numbers of either <u>meters</u> or Queen Elizabeth's <u>feet</u> for selecting and identifying those particular constant-pressure meteorological mapping levels for which observations of the basic pressure-height state of the atmosphere need to be reported from throughout the world. Now, however, such mandatory reporting and charting levels can well be established at uniform 1 <u>geomile</u> or 6,000 <u>geofeet</u> intervals of pressure-altitude — or hence at the

1013.25, 810, 641, 503, 388, 296, 223, 167, 125, 93 and 70 <u>millibar</u> levels instead of the current arbitrarily selected round numbers but otherwise very inconvenient numbers

1000, 850, 700, 500, 400, 300, 250, 200, 150, 100 and 70 of the metric system's millibar and hectonewton per square meter pressure-units of exchange.

This particular 1 geomile mapping interval provides a good example of the basic utility of the sexagesimal ratio of 60 between the S, M and D scale-sizes of geounits; a basic characteristic of which is that a group of 60 unit-things is the smallest group that can be subdivided into each of the most frequently useful 1, 2, 3, 4, 5 or 6 sub-groups of whole units. Consequently mapping levels at intervals of 1 of the M-scale and hence 60 of the 100-geofoot S-scale or sile geounits of pressure-altitude would provide for interpolating to whichever of each of the particular 1st, 2nd, 3rd and so forth of whichever particular one of the intermediate

| | | |
|---|---|---|
| M or S60 | M/5 or S12 | M/15 or S4 |
| M/2 or S30 | M/6 or S10 | M/20 or S3 |
| M/3 or S20 | M/10 or S6 | M/30 or S2 |
| M/4 or S15 | M/12 or S5 | M/60 or S |

scale-sized intervals such as between nominal flight levels might best serve some specific purpose – and to do so in fully coordinated ordinal-number relationship to whatever other such nominal intermediate levels might be so-selected and identified by someone else for some other specific purpose.

It is thereby also seen that the evolution and survival of the 360-degree subdivisions of a circle of angle is undoubtedly attributable in large part to the extremely wide range of choice that it provides for so-selecting and identifying nominal intermediate scale-sizes of particular "which one" unit-things. It especially provides for subdividing the circle into the extremely subdivisible 60-degree sextile angles of equilateral triangles and of the arcs of circles that are subtended by the 1-radius chords of inscribed hexagons – as well as the characteristic 90-degree quadrants or right angles of squares and cubes. This highly subdivisble sextile scale-size of such basic geometric C/6 scale-sizes of unit-things can well be explicitly identified in the

Geospheric System as being the "X-scale" geounits of angle, length and/or time.

In much the same way, the evolutionary survival of the 24-hour denominative subdivisions of a day is undoubtedly attributable to the useful convenience it provides for identifying the 1st, 2nd, 3rd, etc. of whichever ones of the

| | |
|---|---|
| 24 one-hour | 4 six-hour |
| 12 two-hour | 3 eight-hour |
| 8 three-hour | 2 twelve-hour or |
| 6 four-hour | 1 twenty-four-hour |

nominal periods of work shifts, class periods, observational periods and so forth might well be selected and established for any one specific purpose in fully ordered coordinative relationship to all other so-selected and numbered unit-periods. The 60-part minute and second denominators of this particular "hourly" or C/24 scale-sized unit of time can well continue to be identified with the customary symbols h, m and s whenever, for example, the symbol m is known by the context of its use not to represent the meter unit of length. They can also well be systematically identified in the Geospheric System as being the

Hr or horile,
Hm or homile and
Hs or hosile

scale-sizes of units of either the customary

Mean solar units of time: Hr't, Hm't and Hs't; or the

Julian or "stellar" units of time: Hr*t, Hm*t and Hs*t;

whenever it might be useful to explicitly relate them to the corresponding Hr, Hm and Hs unified geounit scale-sizes of angles or horizontal distances.

The ratio of 12 between the F or file and T or thile principal geounit scale-sizes similarly continues to provide the same kind of subdivisibility whereby a dozen package of unit-things such as donuts can be evenly distributed among families of one, two, three, four, six or twelve. It especially provides for establishing nominal inch sizes of building materials such as the one by twelve, two by six, four by four, twelve by two and so forth nominal lumber sizes – the numbering order of which identifies their use as a plank or joist in highly selectable ordinal-number coordination with nominal foot sizes of structures, furnishings and so-called "yard-goods".

Rates of precipitation expressed as numbers of geoinches per hour are thereby also usefully equivalent to numbers of geofeet per half day; each of which is also equivalent to nominal numbers of corresponding T-scale or F-scale geounits of volume, mass and weight flow of water per $T'L^2$ or $F'L^2$ geounits of horizontal area per hour or per half-day. Especially the characteristically Earth-related knot or (geo)mile per hour unit of velocity is also exactly equivalent to 1 sile per minute; and the reference speed of 60 knots (of about the common speed-limit of 70 statute-miles per hour) is equivalent to whichever of the

1 C/15d or 1 fifteenth-circle per day,
1 D/h or 1 dile per hour,
1 M/m or 1 mile per minute,
1 S/s or 1 sile per second, or
1 F/cs or 1 file per centisecond

geounits of either linear or angular velocity might be most usefully related to a particular scale-size of phenomena or time-interval of particular interest.

## The Future Evolution of Units

It would thus evidently be much more advantageous to evolve toward the utilization of such geounits than toward greater everyday usage of the metric units. This in no way degrades the importance of a wider understanding and appreciation of the basic definitive and generalized scientific roles of the International System's basic SI reference units of exchange. Rather, they are evidently useful primarily insofar as they ultimately provide for finding, defining and utilizing other more specifically useful units such as those of the Geospheric System.

It is especially important in this regard to recognize that the oft-quoted and commonly presumed computational advantage of the decimally-interrelated units of the metric system pertains almost only to the most generalized kinds of idealized scientific relationships. For example, the particular number 9,192,631,770 of oscillations of the primary standard Cs133 kind of "atomic clock" has essentially been selected to define the SI second unit of time so that it is as nearly equivalent to previous definitions of the second as possible. As close a quantitative correspondence as possible has thereby essentially been maintained with all previously established time-related kinds of scientific data — all different kinds of which can most readily be intercompared if they are expressed in terms of at most the metric system's decimal multiples or submultiples of this single SI second unit of time.

From either a more specific astronomical or Sun-related end-use point of view, however, this particular definition of the SI second has essentially made it to be as typically representative as any one such unit of time can practicably be of one 24(60)(60) or 86,400th part of the somewhat variable periods of one circle of angular rotation of the Earth with respect to the life-giving rays from the Sun. The basic utility of doing so has been to provide for the use of a single idealized "constant" conversion factor of $2\pi/86{,}400$ between the SI radian measures of the Sun's angular positions and the SI second measures of corresponding periods of time. This single "physical constant" can well be used in the vast majority of instances that it is not necessary to suffer the inconvenience of having to take into account those small differences that invariably pertain to any specific day of any specific year.

But then it is also seen to be extremely useful, in basic definitive principle, to introduce some "new" non-metric units such as the $2\pi$-radian circle of angle and 86,400-second day of time — and to relate them explicitly to the angular positions of the Sun by calling them the "apparent solar day" unit of solar angles and the "mean solar day" unit of time. The basic computational utility of doing so is essentially to replace the idealized metric conversion factor of $2\pi/86{,}400$ by the exactly equivalent and extremely simplified conversion factor of UNITY. Even more importantly, it thereby becomes possible to utilize the same ordinal-numbers of days, months and years to identify particular ones of either or both of these two different kinds of "days"; and especially to refer to either or both of them as merely being a "day" in the vast majority of instances that it is neither significant nor desirable to distinguish between them.

In addition, such a "UNIFICATION" of these two different kinds of days greatly simplifies precise cardinal-number computations of the quantitative relationships between specific solar angles and periods of time. For example, the time-periods of the angular circles of specific apparent solar days were observed to vary in 1930 between extremes of about

86,428.6 seconds or 1+.000331 days of time on Jan. 1,
86,382.0 seconds or 1-.000208 days of time on Apr. 1,
86,411.8 seconds or 1+.000136 days of time on July 1, and
86,381.6 seconds or 1-.000470 days of time on October 1.

Consequently, direct computations of corresponding numbers of the metric system's radian and second units of solar angles and time on Jan. 1, 1930 would involve multiplying or dividing by the number $2\pi/86{,}428.6$. In contrast, equally precise computations with the conversion factors of 1+.000331 or its inverse of 1-.000331 can be obtained with a first-order conversion factor of UNITY between numbers of these two kinds of days, and with second-order "residual" adjustments when — but needfully only when! — they are significant and required. Those small additive · subtractive residual adjustments can readily be computed, in turn, by multiplying by a three-significant figure residual such as ±0.000331 from the first-order UNITY conversion factor instead of six significant-figure evaluations of either $2\pi/86{,}428.6$ or $86{,}428.6/2\pi$!

The extreme quantitative and qualitative utility of such ideally unified units of different qualitative kinds is thereby seen to be an outstanding characteristic of both of the International and Geospheric Systems of Units. For example, the way in which the SI meter and kilogram Base Units of length and mass have been defined has essentially so-unified the centigrade angular and kilometer linear units of horizontal distances, as well as the cubic decimeter or liter volumetric and kilogram mass measures of unit-amounts of water. All of the Derived SI Units have also been so-unified with respect to those particular idealized kinds of physical relationships that have been selected to define them in terms of the six SI Base Units and two Supplementary Units and proportionality factors of and only of UNITY. The explicit recognition of the basic principle of such "unification" has especially been utilized in the Geospheric System to provide the added utility of identifying each of the different Earth- and water-related qualities of particular one unit-things and space-time positions in and of the Geosphere with a common unified scale-size symbol and name — and to provide for explicitly distinguishing between them when but only when it is necessary or desirable to do so.

These unified geounits could thus well be utilized at the outset to coordinate nominal unit-amounts and space-time positions of the Earth's vital waters in oceanographic and hydrologic practice — and especially to coordinate the vertical positions in and of the atmosphere with geounit numbers of the several unified kinds of "altitude" in world-wide meteorological practice. The full meteorological advantage of utilizing such altitude coordinates and their non-redundant D-value and S-value residuals depends only upon the adoption of a very slightly modified definition of the Standard Atmosphere in terms of more usefully convenient round geounit values of its idealized defining constants. For example, a standard tropospheric lapse rate of exactly 2°C per 1000-geofeet or 12°C per geomile could very usefully be substituted for the current 6.5°C per kilometer or 2.000617•••°C per 1000-geofeet up to a standard tropopause level of exactly 6 geomiles instead of the current 11 kilometers or 5.94 geomiles of pressure-altitude.

The highly desirable consolidation of meteorological and aeronautical practices throughout the world could then well await the time that flyers have become thoroughly familiar with the meteorological usage of such geounits. It would only be necessary in rare instances during this transition period to take into explicit account differences such as only about 300 feet between a charting level of 4 geomiles or 240 siles of pressure-altitude and the current 240 hundred-foot flight-level. The very nearly 1 part in 80 difference between corresponding numbers of geofeet and the current English feet of their residual D-values could readily be accounted for when necessary, but could usually be neglected within the limits of accuracy of the basic use of such charts for geostrophic wind determinations. The ultimate transition to the aeronautical usage of geounits could even be accomplished by readjusting — rather than remanufacturing — most pressure altimeters; and the qualitative feel that pilots throughout the world have acquired for numbers of Queen Elizabeth's feet would be directly transferable to numbers of the Geospheric Queen's geofeet.

In much the same way, the increasing world-wide needs to coordinate hydrologic and hydrometeorological surveys of our natural water resources could well be served at the outset by the basic geounit coordinates of space-time positions and unit-amounts of water. Such geounit designations of unit-amounts of water could then well evolve into the use of nominal geounit scale-sizes of pipe lines, tanks, cans, bottles, glasses, or even "one mouthful" tablespoons. This evolution would be especially trouble-free in English-speaking countries since the differences between the geounits and their current customary counterparts would be virtually negligible for most everyday purposes. Specifically, the English foot and inch are only about 1 part in 80 smaller than the geofoot and geoinch; the U.S. pint and gallon are only about 1 part in 60 larger than the geopint and geogallon; and the avoirdupois pound is only about 1 part in 80 smaller than the geopound.

The use of nominal geounit scale-sizes of such water containers, and hence ultimately of all other kinds of manufactured goods, might thereby also very well evolve throughout the world. Significantly in this regard, the precise cardinal-number measures of the dimensions or other physical qualities of any one such actual unit-thing can never correspond exactly to its nominal ordinally-numbered scale-size. Consequently nominal geounit scale-sizes of things such as screws, bolts, gears and bearings could well be utilized throughout the world to coordinate them with nominal Earth-related, Personally-related and highly selectable ordinal-number geounit scale-sizes of structures and machines – and their precise cardinal-number dimensions could well be specified as they are now in terms of either centimeters or English inches until such time as it might become advantageous to convert to the use of geounit tapes, rulers, scales, micrometers or gauge-blocks for use with any one particular class of manufactured goods, vehicles or structures.

Toward this end, the formulation of the Geospheric System has greatly simplified the unavoidable conversions among numbers of its geounits and of the International System's units of exchange among all other such more specifically useful units. For example, the definition that the geomile is exactly one 360(60)th part of the 40,000,000-meter circile makes $2 \cdot 3^3$ or 54 geomiles exactly equivalent to 100 kilometers. The inconvenient prime-number factor of 463 has thereby essentially been eliminated from the current definition of the 1,852 or $2^2 \cdot 463$ meter nautical mile, which in turn is only 1.00008 times larger than the readily calculable inverse number $10^6/2 \cdot 3^3$ or 1,851.851•••of SI meters in 1 geomile.

The use of defining ratios such as $12=2^2 \cdot 3$, $24=2^3 \cdot 3$, $60=2^2 \cdot 3 \cdot 5$ and $360=2^3 \cdot 3^2 \cdot 5$ among the other principal geounits has similarly eliminated inconveniently large prime-numbers in the conversion factors to and from numbers of any and all of the metric units of time, length, area, volume and mass. Specifically, the prime-number factor of 127 in the current $2 \cdot 127/10^2$ or 2.54-centimeter definition of an inch has thereby been eliminated from all of the highly selectable 2, 3 and 5 geounit multiples of the geoinch of exactly $10^2/2^4 \cdot 3^5$ or 1/38.88 SI meters. The current U.S. pint of $231/8(0.0254)^3$ cubic meters and avoirdupois pound of exactly 0.45359237 kilograms is thereby essentially replaced by the 3-geoinch cubed geopint of exactly $10^6/6^{12}$ cubic meters and its unified geopound of exactly $10^9/6^{12}$ kilograms.

The defining number $10^5/2 \cdot 3^6 \cdot 7$ or 10/1.0206 meters per second squared for the 1 "geogee" unit of acceleration similarly contains as few large prime-number factors as possible — consistent with its also being near the center of the range of variation of the acceleration of gravity throughout the Biosphere. The current theoretical Standard Acceleration of Gravity of 9.80665 or $5 \cdot 7 \cdot 28019/10^5$ meters per second squared for sea level and $45^{\circ}$ of latitude can thereby well be compared to measured and other theoretical values there and elsewhere by expressing it as the number 1.000867 of this permanently useful one geogee reference unit of acceleration. This particular defining number especially provides for usefully convenient, exactly defined, small prime-number equalities such as among

$3^2 \cdot 7/2 \cdot 10$, 63/20 or 3.15 (geo)gees,
1 geofoot per second per centisecond,
1 sile per second squared,
1 (geo)mile per minute per second and
1 dile per hour per second;

or among

$3 \cdot 7/2^2$, 21/4 or 5.25 centigees,
1 geomile per minute squared,
1 geomile per hour per second and
1 knot per second;

as well as for the extremely useful approximate unifying conversion factor of UNITY among geounit numbers of the mass and weight of anything anywhere in the Biospheric portion of the Geosphere.

In basic scientific principle, the Geospheric System of Units has thereby essentially been formulated in terms of a simply and usefully conceived Ideal Geosphere as summarized in the Appendix. In particular, the ideally generalized single values of the yearly revolution, daily rotation, circumferential size and gravitational acceleration of this Ideal Geosphere have been defined to be as representative of any and all specific days or positions in the Biosphere as possible — consistent with their also being as conveniently interconvertible unifying numbers as practicable of each of:

- Everyone's own personal measures of things,
- The International System's basic SI units of exchange; and
- The highly-selectable nominal unified scale-sizes of unit-things that have been provided throughout the ages with ordinal numbers of the customary time and angle unit-subdivisions of the overall Geosphere.

Consequently this Ideal Geosphere could now well be utilized by anyone who wishes to do so as a systematically-simplified, highly-subdivisible, easily-remembered and personally-related model of the basic physical qualities of the Earth and its vital waters. Especially, for example, the personally-related scale-sizes of geounits could thereby well be utilized as conveniently simplified first-order approximations of the relationships between the customary English unit sizes and amounts of goods and either or both of the International units of exchange and the angular subdivisions of the Earth. But then anyone who does so will have essentially adopted the Geospheric System of Units the moment that he first considers the English units to be inconvenient approximations of their geounit counterparts rather than vice-versa!

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Table I

THE INTERNATIONAL SYSTEM OF "SI" UNITS
(As of 1966)

BASE UNITS

| | | |
|---|---|---|
| Length | meter, m | 1,650,763.73 Kr86 wavelengths |
| Time | second, s | 9,192,631,770 Cs133 periods |
| Mass | kilogram, kg | International Prototype Kilogram |
| Temperature | kelvin, K | Makes triple point of water 273.16 |
| Electric Current | ampere, A | Produces $2 \times 10^{-7}$ newtons of force per meter between wires 1 meter apart |
| Luminous Intensity | candela, cd | Of 1/600,000 square meters of a cavity at the freezing temperature of platinum. |

SUPPLEMENTARY UNITS

| | | |
|---|---|---|
| Plane Angle | radian, rad | $1/2\pi$ circle |
| Solid Angle | steradian, sr | $1/4\pi$ sphere |

DERIVED UNITS

| | | | | | |
|---|---|---|---|---|---|
| Area | $m^2$ | | Velocity | | m/s |
| Volume | $m^3$ | | Angular Velocity | | rad/s |
| Frequency | $s^{-1}$ | hertz,Hz | Acceleration | | $m/s^2$ |
| Density | $kg/m^3$ | | Angular Acceleration | | $rad/s^2$ |
| Force | $kg{\cdot}m/s^2$ | newton,N | Entropy | | J/K |
| Pressure | $N/m^2$ | | Specific Heat | | J/kg•K |
| Kinematic Viscosity | $m^2/s$ | | Thermal Conductivity | | W/m•K |
| Dynamic Viscosity | $N{\cdot}s/m^2$ | | Radiant Intensity | | W/sr |
| Work, Energy, Heat | N•m | joule,J | | | |
| Power | J/s | watt,W | | | |
| Electric Charge | A•s | coulomb,C | Lineal Frequency | | $m^{-1}$ |
| Potential, Voltage | W/A | volt,V | Radioactive Activity | | $s^{-1}$ |
| Field Strength | V/m | | | | |
| Resistance | V/A | ohm,Ω | | | |
| Capacity | A•s/V | farad,F | | | |
| Magnetic Flux | V•s | weber,Wb | Luminous Flux | cd•sr | lumen,lm |
| Inductance | V•s/A | henry,H | Luminance | $cd/m^2$ | |
| Density | $Wb/m^2$ | tesla,T | Illumination | $lm/m^2$ | lux,lx |
| Field Strength | A/m | | | | |
| Magnetomotive Force | A | | | | |

SCALING FACTOR PREFIXES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| deca- | da- | $10^1$ | deci- | d- | $10^{-1}$ | femto- | f- | $10^{-15}$ |
| hecto- | h- | $10^2$ | centi- | c- | $10^{-2}$ | atto- | a- | $10^{-18}$ |
| kilo- | k- | $10^3$ | milli- | m- | $10^{-3}$ | | | |
| mega- | M- | $10^6$ | micro- | μ- | $10^{-6}$ | | | |
| giga- | G- | $10^9$ | nano- | n- | $10^{-9}$ | | | |
| terra- | T- | $10^{12}$ | pico- | p- | $10^{-12}$ | | | |

# THE GEOSPHERIC SYSTEM OF UNITS

A useful system of identifying particular one unit-things and their space-time positions in and of the Earth-centered or Geospheric region of the universe

With unified naming-numbers of each of several of their physical qualities in simply defined quantitative relation to the SI reference units of the International System of Units, and

In nominal integral ordinal-number relation to characteristic features of the Earth, its vital waters and each of its inhabitant's own personal measure of things.

As Proposed in May, 1971

by

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# GEOUNIT SYMBOLS AND NAMES

Nominal geounit sizes and amounts and geounit intervals of the space-time positions of particular one unit-things are identified and coordinated in the Geospheric System with symbols and names such as

T3 for the "three-T" or "three-thile" multiples or
T/3 for the "third-T" or "third-thile" submultiples

## of their PRINCIPAL DENOMINATIVE U-SCALE SIZES, namely their

| | | | |
|---|---|---|---|
| **T,** | thumb-like | or "thile" | 1/12 parts of their |
| **F,** | foot-like | or "file" | 1/100 parts of their |
| **S,** | second-like | or "sile" | 1/60 parts of their |
| **M,** | minute-like | or "mile" | 1/60 parts of their |
| **D,** | degree-like | or "dile" | 1/360 parts of their nominal |
| **C,** | circle-like | or "circile" | lineal scale-sizes; |

## or of SUPPLEMENTARY U-SCALE SIZES such as their

| | | | |
|---|---|---|---|
| **R,** | radius-like | or "radile" | $= C/2\pi$ |
| **X,** | sextile-like | or "sextile" | $= C/6$ |
| **Hr,** | hour-like | or "horile" | $= C/24$ |
| **Hm,** | hourly-minute-like | or "homile" | $= C/24(60)$ |
| **Hs,** | hourly-second-like | or "hosile" | $= C/24(60)(60)$ or |
| **m,** | meter-like | or "metrile" | $= C/40{,}000{,}000$ |

## nominal linear scale-sizes.

Corresponding unified geounits of each of their Q-kinds of physical qualities are explicity identified when, but needfully only when, necessary with symbols like U'Q for any one such U-scaled

| | | | | |
|---|---|---|---|---|
| **U'α** units of angle, of which | 1 C'α | = 1 circle | | |
| **U't** units of time, of which | 1 C't | = 1 day | = 86,400 | SI Seconds |
| **U'L** units of length, of which | 1 C'L | = 1 circile | = 40,000,000 | SI meters |
| | 1 D'L | = 1 dile | $= 10^6/9$ | " |
| 1 "geomile" = | 1 M'L | = 1 mile | $= 10^5/54$ | " |
| | 1 S'L | = 1 sile | $= 10^4/324$ | " |
| 1 "geofoot" = | 1 F'L | = 1 file | $= 10^2/324$ | " |
| 1 "geoinch" = | 1 T'L | = 1 thile | = 1/38.88 | " |

## in terms of which the nominal U-scaled

| | |
|---|---|
| **U'L²** unit of area | is the area of an Ideal Square with sides 1 U'L long, |
| **U'L³** unit of volume | is the volume of an Ideal Cube with sides 1 U'L long. |
| **U'M** unit of mass | is the mass of 1 U'L³ unit-volume of Ideal Water with a defined unit-density, $^1\rho$, of exactly 1000 SI kilograms per cubic meter, |
| **U'F** unit of force | is the weight of 1 U'M unit-mass subject to 1 "gee" of gravitational acceleration, $^1g$, of $10^5/2{\cdot}3^6{\cdot}7$ SI meters per second per second, |
| **U'E** unit of energy | is the work of moving 1 U'L unit-distance against 1 U'F unit-force and |
| **U'p** unit of pressure | is that of 1 U'F unit-force per 1 U'L² unit-area, or the increment of pressure exerted by 1 U'L unit-depth of Ideal Water subject to the Ideal 1 gee Unit of Gravitational Acceleration. |

# IDEAL GEOSPHERE

A simply and usefully conceived, imaginary counterpart of the Earth-centered region of the universe that is defined

To rotate one circle of angle, $C'\alpha$, with respect to the Sun in 1 mean solar day, $C't$ = 86,400 SI seconds,

To revolve one circle of angle around the Sun in 1 Julian year of 365.25 mean solar days, $C't$
and 366.25 stellar days, $C^{*}t$

and to consist of its concentric, spherically symmetric

IDEAL solid LITHOSPHERE;

IDEAL liquid HYDROSPHERE with an Ideal Density of 1 $^{1}\rho$ = 1000 SI kg/m$^3$
in which like numbers of length-units of Geometric-Depth, Pressure-Depth and Energy-Depth coincide;

IDEAL intermixed BIOSPHERE of infinitesimal thickness with a
Circumference of 1 circle, $C'L = 4 \cdot 10^7$ SI meters,
Radius of 1 radile, $R'L = C'L/2\pi$, and
Acceleration of Gravity, $^{1}g = 10^5/2 \cdot 3^6 \cdot 7$ or 10/1.0206 SI m/s$^2$,

The inhabitants of which have an

| | | |
|---|---|---|
| Ideal Height or Two-Stride Pace of | 1 F6'L = | 100/54 SI meters, |
| Yard-Reach or Stride of | 1 F3'L = | 100/108 SI meters, |
| Foot-Length of 1 geofoot or | 1 F'L = | 100/324 SI meters, |
| Thumb-Width of 1 geoinch or | 1 T'L = | 1/38.88 SI meters, and |
| Half-Ounce Mouthful of 1/32 of 3 geoinches cubed or of | 1 geopint = | $10^6/6^{12}$ SI m$^3$ and |
| | 1 geopound = | $10^9/6^{12}$ SI kilograms, |

A geoacre of which contains 12x100 geopaces or $10^6/3^5$ SI m$^2$;

IDEAL gaseous ATMOSPHERE in which like numbers of length-units of Geometric-, Pressure-, Density- and Energy-Altitude coincide

in hydrostatic equilibrium in an Ideal Gas with (tentatively) a
Zero-Altitude Pressure, $p_0 = 2 \cdot 3^4 \cdot 5^4$ or 101,250 SI N/m$^2$
Density, $\rho_0 = 5^2 \cdot 7^2/10^3$ or 1.225 SI kg/m$^3$
Temperature, $T_0$ = 15°C = $2^5 \cdot 3^2$ or 288
"Absolute Atmospheric Degrees, °A",

| | | | |
|---|---|---|---|
| Lapse Rate of | −12°C per geomile | | up to 6 geomiles, |
| Temperature of | −57°C, $6^3$ °A | or 216°A | up to 15 geomiles, |
| Lapse Rate of | + 6°C per geomile | | up to 24 geomiles, |
| Temperature of | − 3°C, $3^3 \cdot 10$°A | or 270°A | up to 30 geomiles, |
| Lapse Rate of | − 6°C per geomile | | up to 45 geomiles, |
| Temperature of | −93°C, $2 \cdot 3^2 \cdot 10$°A | or 180°A | up to 48 geomiles, |

and an inverse radius-squared decrease of gravitational acceleration from 1 $^{1}g$ at the Zero-Altitude Biospheric Radius of 1 radile; and

IDEAL energetic PYROSPHERE (or that airless but full of fiery energy region) with a nominal lower transition boundary at 48 geomiles and that extends to the limit of Earth-centered gravity at 235 radiles, almost 4 times the distance to the Moon and very nearly 1/100 of the Astronomical Unit-distance to the Sun.

## CUSTOMARY COUNTERPARTS OF THE GEOUNITS

$$\frac{1\ \text{circle}}{1\ \text{C'}\alpha} = \frac{1\ \text{degree, }^\circ}{1\ \text{D'}\alpha} = \frac{1\ \text{minute, '}}{1\ \text{M'}\alpha} = \frac{1\ \text{second, ''}}{1\ \text{S'}\alpha} = \frac{1\ \text{radian}}{1\ \text{R'}\alpha} = 1$$

or, for hour-angles, $\dfrac{1\ \text{hour, h}}{1\ \text{Hr'}\alpha} = \dfrac{1\ \text{minute, m}}{1\ \text{Hm'}\alpha} = \dfrac{1\ \text{second, s}}{1\ \text{Hs'}\alpha} = 1$

$$\frac{1\ \text{day, d}}{1\ \text{C't}} = \frac{1\ \text{hour, h}}{1\ \text{Hr't}} = \frac{1\ \text{minute, m}}{1\ \text{Hm't}} = \frac{1\ \text{second, s}}{1\ \text{Hs't}} = 1 \text{ of Mean Solar Time}$$

$$\frac{1\ \text{Inertial Period of Rotation}}{1\ \text{C*t stellar day}} \doteq 1-0.0000173 \text{ in } 1960$$

$$\frac{1\ \text{day, d}}{1\ \text{C*t}} = \frac{1\ \text{hour, h}}{1\ \text{Hr*t}} = \frac{1\ \text{minute, m}}{1\ \text{Hm*t}} = \frac{1\ \text{second, s}}{1\ \text{Hs*t}} \text{ of Sidereal Time}$$

$$= \frac{1\ \text{degee, }^\circ}{1\ \text{D*t}} = \frac{1\ \text{minute, '}}{1\text{M*t}} = \frac{1\ \text{second, ''}}{1\ \text{S*t}} \doteq 1+0.0000213 \text{ in } 1960$$

Hayford 1909 Equatorial Radius of 6,378,388 m = 1+0.001915 R'L
and Polar Radius of 6,356,912 m = 1−0.001458 R'L

$$\frac{1\ \text{International Nautical Mile}}{1\ \text{M'L geomile}} = \frac{1.852\ \text{km}}{100/54\ \text{km}} = 1.00008$$

$$\frac{1\ \text{inch}}{1\ \text{T'L}} = \frac{1\ \text{foot}}{1\ \text{F'L}} = \frac{1\ \text{yard}}{1\ \text{F3'L}} = \frac{1\ \text{fathom or pace}}{1\ \text{F6'L}} = \frac{1\ \text{chain}}{1\ \text{S'L}} \text{ (of 1959 statute)}$$

$$= \frac{0.0254\ \text{m}}{1/38.88\ \text{m}} = 0.987552 = 1-1/80+52/10^6$$

$$\frac{1\ \text{U.S. (1959) pint}}{1\ \text{F/4'L}^3 \text{ or T3'L}^3} = \frac{1\ \text{U.S. gallon}}{1\ \text{F/2'L}^3 \text{ or T6'L}^3} = \frac{231/(0.0254)^3\ \text{m}^3}{8(10^2/6^4)^3\ \text{m}^3} \doteq 1+1/60$$

$$\frac{1\ \text{avoirdupois pound}}{1\ \text{F/4'M or T3'M}} = \frac{0.45359237\ \text{kg}}{(10^3/6^4)^3\ \text{kg}} \doteq 1-1/80$$

$$\frac{1\ \text{acre of 660x66 feet}}{1\ \text{geoacre of 600x72 F'L}} = \frac{43{,}560\ (0.3048)^3\ \text{m}^3}{43{,}200\ (100/324)^3\ \text{m}^3} \doteq \frac{1}{1.03}$$

$$\frac{\text{Standard Sea Level and 45° Latitude } g_0}{\text{Geounit of Acceleration, } {}^1\text{g}} = \frac{9.80665\ \text{m/s}^2}{10/1.0206\ \text{m/s}^2} = 1.000866699$$

1 S'L/Hs't² or 100 geofeet per second squared = 63/20 $^1$g
1 M'L/Hm't² or 1 (geo)knot per second = 21/400 $^1$g

$$\frac{\text{Standard Sea Level Pressure}}{\text{Zero-Altitude Pressure, } p_0} = \frac{760\ \text{mm Hg at } 9.80665\ \text{m/s}^2 \text{ or } 101{,}325\ \text{N/m}^2}{760.096\ \text{mm Hg at } 10/1.0206\ \text{m/s}^2 \text{ or } 101{,}250\ \text{N/m}^2}$$

$$= 1.000\ 740\ 740\cdots$$

$$\frac{400\ \text{T'p or } 100/3\ \text{F'p}}{\text{Zero-Altitude Pressure, } p_0} = \frac{1}{1.004\ 42348}$$

$$\frac{\text{ICAO Gas Constant}}{\text{Geo-Gas Constant}} = \frac{(101{,}325\ \text{N/m}^2)/(1.225\ \text{kg/m}^2)\ (288.15°\text{K})}{(101{,}250\ \text{N/m}^2)/(1.225\ \text{kg/m}^2)\ (288°\text{A})} \doteq 1.000230$$

$$\frac{\text{Zero-Altitude Effective Virial Temperature}}{\text{Zero-Altitude Absolute Geounit Temperature}} = \frac{288.15\ (1-A^{aa}p/R-\cdots)\ °\text{K}}{(15+273)\ °\text{A}}$$

$$\doteq \frac{288.03\ °\text{K}}{288\ °\text{A}}$$