Made in Britain: Not made to measure.

Ronnie Cohen

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Foreword

Every country needs a system of weights and measures that everybody understands and uses. This is necessary for consumer protection, designing buildings, specifying engineering components, prescribing medicines, signposting distances, fixing speed limits, and forecasting the weather. In all these instances, clarity and precision are essential. Just as clarity of verbal communication requires that everybody understands and uses the same language, so communication about dimensions and quantities requires that everybody uses the same units of measurement.

What nobody needs is two systems – with some people using one system but other people using a different system – with all the attendant problems of incomprehension, conversion errors, accidents and additional costs that result. Yet this situation, which the UK Metric Association has described as "a very British mess", is exactly what we have to put up with in the UK. Amazingly – and to their discredit – no British Government in recent years has been prepared to do anything to sort it out.

Indeed, the mess has existed for so long now that many British people are so accustomed to it that they do not realise that it is a mess. Even committed supporters of full adoption of the International System of Units (to give the metric system its proper title) have become so accustomed to the obstinate refusal of the Government to face up to the problem that we have almost begun to tire of making the case.

It was refreshing therefore to come across Ronnie Cohen's cogently argued tract. He brings together much of the material and arguments that many of us have been making for years (decades), but he brings to the argument the freshness and impatience of a young man and makes an overwhelming case for finally clearing up the "mess".

I hope the booklet will be widely read – especially by those who are in a position to influence events.

Robin Paice
Chairman, UK Metric Association

Introduction

The intention of the booklet title, “Made in Britain: Not made to measure”, is to emphasise that the situation of the UK in the middle of two competing, incompatible measurement systems (i.e. the imperial and metric systems) that our political leaders have created is uniquely British and is not fit for purpose in the modern age.

The phrase “Made in Britain” conveys the fact that although the UK is not the only country that faces a measurement muddle, its situation differs from other countries. Although the US has also had problems with metrication, its situation is different. For instance, the US is behind the UK in package labelling but ahead in its use of metric units on its roads.

The phrase “made to measure” is normally used in the sense that something is tailor-made to meet the unique, specific requirements of a particular person or organisation. The way the UK uses measurements is illogical and not fit for purpose. It fits poorly with other countries, including the rest of Europe. The use of two systems has led to numerous anomalies and problems. These will be described in more detail later in this booklet. For more details, read on.

This booklet is aimed at a British audience though it contains a lot of general information about the problems of running a dual measurement system and a lot of useful information about the metric and imperial systems.

Central Role of Measurement in Daily Life

The use of measurements is everywhere, both seen and unseen. It is used to describe the dimensions of buildings and furniture, manufacture and sale of products, nutrition information, sport, medical dosage, our weight and height, sale of packaged and loose food products, road signs, energy consumption, mobile phone usage, transport and many other applications of everyday aspects of modern life. “Each year in the UK, £622 billion worth of goods and utilities are sold on the basis of the measurement of their quantity.” (Source: National Measurement Office, http://www.bis.gov.uk/nmo/) Measurement is a fundamental part of our lives and used all around us. Everything that is manufactured involves measurement and many measurements are frequently needed to manufacture a single product. Think about it. Look at any object around you and think about the measurements used to make it. Whenever we refer to distance, weight, dimensions, area, volume, speed, time or temperature, measurement is involved.

Why Measurement Matters

As the Measurement Matters publication by the National Measurement Office states, "Measurement underpins the welfare of a modern society and touches almost every part of daily life:
• Ensuring the safety and effectiveness of healthcare diagnostics and treatments
• Measuring the composition, energy value and quantity of gas piped to our homes, or of fuel in our vehicles
• Ensuring safe operation of aircraft in flight
• Ensuring consistency of international time standards so we can communicate reliably and navigate accurately throughout the world
• Quantifying emissions of greenhouse gases to understand and mitigate climate change
• Ensuring the security and sustainability of our food supply
• Ensuring fairness between buyers and sellers in markets where goods are sold by weight or volume"
(Source: http://www.bis.gov.uk/assets/bispartners/nmo/docs/nms/measurement-matters.pdf)

The need for accurate measurement is important for the development of new products where quantity, quality, dimensions and performance need to be measured accurately. In precision engineering, a very high standard of accuracy in measurement is critical for manufacturing components. The production of a typical car uses a very large number of individual components. Thousands of individual measurements are used in making cars, including all their components.

Multinational trade requires a common system of measurement standards supported by measurement regulations to ensure that trade is open, fair and honest. Multinational co-operation on joint projects requires common standards of measurement to ensure that tools and parts from different countries are compatible. For example, NASA switched to the metric system in 2007 for this reason. Before the switch, NASA used a version of imperial and the other space agencies that NASA works with used the metric system.

If measurements are inaccurate, manufacturers could find that their components do not fit, chefs could ruin their recipes, patients could be harmed and consumers could be cheated. These are just some of the consequences of inaccurate measurements. The consequences of inaccurate measurements could be serious. Here are two examples of serious consequences that can result from inaccurate measurements.

NASA once lost the Mars Climate Orbiter space shuttle because of a mix-up between imperial and metric measurements. It crashed into Mars because of a misunderstanding between NASA and a contractor that led to a catastrophic and expensive measurement error.

An Air Canada aircraft once ran out of fuel in mid-flight because of a miscalculation in the amount of fuel that was needed for the aircraft and had to make an emergency landing. This aviation incident could have had serious consequences such as serious injuries or even loss of life.

The Measurement Matters publication expresses the need for measurement in one simple sentence, saying that "Measurement provides structure, removes chaos, reduces waste, ensures open and fair markets, supports precision where required and saves lives, money and time." (Source: http://www.bis.gov.uk/assets/bispartners/nmo/docs/nms/measurement-matters.pdf)

Quest for Honest Measurements since Ancient Times

The quest for honesty in weights and measures and the problems of cheating by giving short measures were recognised several thousand years ago in biblical times. This is reflected in verses about weights and measures in the King James bible, as shown by the following passages:

“Just balances, just weights, a just ephah, and a just hin, shall ye have” (Leviticus 19:36)
“Thou shalt not have in thy bag divers weights, a great and a small. Thou shalt not have in thine house divers measures, a great and a small. But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have.” (Deuteronomy 25:13-15)

To prevent cheating by traders, countries regulate the use of weights and measures by specifying which ones are legal for trade, defining their quantities, ensuring that traders use common measurement standards to sell their products and regulating the use of weighing and measuring equipment.

Measurement Facts: Did you know that....?

- Did you know that the UK bans its own official and primary measurement system from most of its own road signs? Despite the fact that the metric system is the UK's official and primary measurement system, the Traffic Signs Regulations and General Directions (TSRGD) legislation explicitly bans the use of metres and kilometres for speed and distance signs. The TSRGD states that only imperial units may be used for speed and distance signs.
- Did you know that roadwork signs must be displayed at intervals in multiples of 100 metres (e.g. 100 metres, 200 metres, 400 metres) but that those signs must display intervals by using the same number of yards (e.g. 100 yards, 200 yards, 400 yards)?
- Did you know that the Highway Code uses measurement units for stopping distances and visibility that are not authorised for use on distance signs on British roads?
- Did you know that it has been illegal to sell anything in the UK by the stone since 1985? Apart from its use to express body weight, it is a completely redundant unit.
- Did you know that pounds and ounces have not been legal for trade since 1 January 2000 and can only be used as supplementary indications (i.e. they can only be used alongside but not instead of metric units)? This is the law despite the widespread flouting of the law by market traders and lack of enforcement. As the National Measurement Office states, “The only imperial units permitted to be used for trade are the pint for draught beer, cider, and bottled milk and the troy ounce for precious metals. However, imperial units may continue to be used alongside metric in dual labelling and consumers can continue to request imperial quantities.” (Source: http://www.bis.gov.uk/nmo/regulation/weights-and-measures-legislation/metrication)
- Did you know that many US measurement units differ in size from UK measurement units with the same name?
- Did you know that the products that the UK imports from Asia are made entirely to metric specifications even though some of them are described in imperial units (e.g. computer monitors, televisions)?
- Did you know that beer and cider in cans and bottles must be sold in metric units but draught beer and cider must be sold in imperial units?
- Did you know that milk sold in plastic bottles and cartons must be sold in metric units but milk sold in returnable glass bottles may be sold in imperial units?
- Did you know that the troy ounce is restricted to the sale of precious metals and that it is a different weight to the avoirdupois ounce sometimes shown on kitchen and market scales?

In the following sections, this booklet explains the British imperial and metric measurement systems followed by a section about the measurements used in the UK today. After that, there is a brief history of the British metrication programme followed by sections that explain what is wrong with using two measurement systems and the problems, inconsistencies and anomalies that are a consequence of using two incompatible, competing measurement systems.

Description of the British Imperial System

Introduction to the British Imperial System

The British imperial system of weight and measures was created by the 1824 Weights and Measures Act. When the act was passed, older measurements were outlawed. As its name suggests, the British imperial system was developed for trade with British colonies within the British Empire. In 1959, the US, which uses its own version of the imperial system called the US Customary System, and the Commonwealth of Nations, which includes the UK, agreed on common definitions for all the imperial measurements still in use. These were all defined in terms of the metric system.

The following tables show the measurements that make up the British imperial system. Some of these units are now rarely or no longer used. Only part of the British imperial system is still in use.

Units of Length

General	Maritime	Gunter's Survey
1000 mil = 1 inch 12 inches = 1 foot 3 feet = 1 yard 5.5 yards = 1 rod * 4 rods = 1 chain 10 chains = 1 furlong 8 furlongs = 1 mile 3 miles = 1 league	6.08 feet = 1 fathom 100 fathoms = 1 cable 10 cables = 1 nautical mile	7.92 inches = 1 link 25 links = 1 rod * 4 rods = 1 chain 10 chains = 1 furlong 8 furlongs = 1 mile

* The rod is also known by the unit names, “pole” and “perch”.

Units of Area

144 square inches = 1 square foot
9 square feet = 1 square yard
30.25 square yards = 1 rod x 1 rod = 5.5 yards x 5.5 yards = 1 square rod
40 square rods = 1 furlong x 1 rod = 220 yards x 5.5 yards = 1210 square yards = 1 rood
4 roods = 1 furlong x 1 chain = 220 yards x 22 yards = 4840 square yards = 1 acre
640 acres = 1 square mile

Units of Volume

The term, “apothecary”, was used historically for someone who makes, provides and/or sells drugs and medicine. It now means a pharmacist. As its name suggests, the apothecary system was used historically for medical recipes. In the imperial system, there were apothecary systems for volume and mass. Both were abolished a long time ago and replaced by the metric system.

General	Apothecary
5 fluid ounces = 1 gill 4 gills = 1 pint 2 pints = 1 quart 4 quarts = 1 gallon 2 gallons = 1 peck 4 pecks = 1 bushel * 2 bushels = 1 strike/raser 4 strikes/rasers (8 bushels) = 1 quarter 5 quarters = 1 load/wey 2 loads/weys = 1 last 1728 cubic inches = 1 cubic foot 46 656 cubic inches = 27 cubic feet = 1 cubic yard **	20 minims = 1 fluid scruple 3 fluid scruples = 1 fluid dram 8 fluid drams = 1 fluid ounce 20 fluid ounces = 1 pint 8 pints = 1 gallon
For some commodities, such as coal, the following additional volume measurements were used: 3 bushels = 1 sack/bag 12 sacks/bags = 1 chaldron/chauldron/chalder	

* 1 bushel = approx. 1.284 cubic feet
** 1 cubic yard = approx. 21 bushels

Units of Mass

The term, “avoirdupois”, literally means “goods of weight”. As its name suggests, the avoirdupois system is the imperial system used for the general sale of goods by weight. The troy system was named after a region in France and its use is restricted to trade in precious metals.

Avoirdupois	Troy	Apothecary
7000 grains * = 1 pound 16 drams = 1 ounce 16 ounces = 1 pound 14 pounds = 1 stone 2 stone = 1 quarter 4 quarters = 1 hundredweight 20 hundredweights = 1 ton	5760 grains * = 1 pound 24 grains = 1 pennyweight 20 pennyweights = 1 ounce 12 ounces = 1 pound	5760 grains * = 1 pound 20 grains = 1 scruple 3 scruples = 1 dram 8 drams = 1 ounce 12 ounces = 1 pound

* The grain is the same weight in the avoirdupois, troy and apothecary systems.

Commodity Measurements

Ale, Beer and Porter (1688-1803)	Ale, Beer and Porter (After 1803)	Wine, Spirits, Cider, Vinegar, Oil and Honey (After 1824)
8.5 gallons = 1 firkin 2 firkins = 1 kilderkin 2 kilderkins = 1 barrel 1.5 barrels = 1 hogshead 2 barrels = 1 puncheon 2 hogsheads = 1 butt 3 puncheons = 1 tun	4.5 gallons = 1 pin 2 pins = 1 firkin 2 firkins = 1 kilderkin 2 kilderkins = 1 barrel 1.5 barrels = 1 hogshead 2 barrels = 1 puncheon 2 hogsheads = 1 butt 3 puncheons = 1 tun	18 gallons = 1 rundlet 31.5 gallons = 1 barrel 42 gallons = 1 tierce 2 barrels = 1 hogshead 2 tierces = 1 puncheon 2 hogsheads or 3 tierces = 1 pipe/butt 2 pipes or 3 puncheons = 1 tun

Different measurements were used for **imported wine and spirits** from other parts of the world. Here are a few of them:

- 1 pipe of Madeira = 92 gallons
- 1 pipe of Sherry = 108 gallons
- 1 pipe of Port = 115 gallons
- 1 hogshead of Hock, Rhine and Moselle = 30 gallons
- 1 hogshead of Claret = 46 gallons
- 1 hogshead of Brandy = 57 gallons

Source for Commodity Measurements:
http://www.nottingham.ac.uk/manuscriptsandspecialcollections/researchguidance/weightsandmeasures/introduction.aspx

Other Imperial Measurements

Name	Unit of What?	Relationship to Other Units
inch of water	Pressure	
hand	Length	1 hand = 4 inches
cental	Mass	1 cental = 1 short hundredweight = 100 avoirdupois pounds
pound-force	Force	
ton-force	Force	1 ton-force = 2240 pound-force
cran	Volume	1 cran = 10403.23 cubic inches = approx. 6.02 cubic feet
horsepower	Power	
degree Fahrenheit	Temperature	
foot pound-force	Energy	
British thermal unit	Energy	1 BTU = approx. 778.169 foot pound-force
therm	Energy	1 therm = 100 000 British thermal units
foot candle	Illuminance	
knot *	Speed	

* The UK definition of the imperial knot.

Source: http://www.legislation.gov.uk/uksi/1995/1804/schedule/made
(The Units of Measurement Regulations 1995 - No. 1804 SCHEDULE)

Possible Imperial Measurements of Some Physical Quantities

These are some of the possible imperial units for measuring the following physical quantities:

Length: mil, hand, inch, foot, yard, rod, pole, perch, chain, furlong, mile, league, fathom, cable, nautical mile, link
Area: square mil, square hand, square inch, square foot, square yard, square rod, square pole, square perch, square chain, square furlong, square mile, square league, square fathom, square cable, square nautical mile, square link, rood, acre
Volume: cubic mil, cubic hand, cubic inch, cubic foot, cubic yard, cubic rod, cubic pole, cubic perch, cubic chain, cubic furlong, cubic mile, cubic league, cubic fathom, cubic cable, cubic nautical mile, cubic link, minim, fluid scruple, fluid dram, fluid ounces, gill, pint, quart, gallon, peck, bushel, strike, raser, quarter, load, wey, last, sack, bag, chaldron, chauldron, chalder, firkin, kilderkin, barrel, hogshead, puncheon, butt, tun, pin, rundlet, tierce, pipe, cran
Mass: grain, avoirdupois dram, avoirdupois ounce, avoirdupois pound, stone, quarter, short hundredweight, long hundredweight, short ton, long ton, pennyweight, troy ounce, troy pound, scruple, apothecary dram, apothecary ounce, apothecary pound, cental
Force: pound-force, ton-force
Pressure: pounds per square mil, pounds per square inch, pounds per square hand, pounds per square foot, pounds per square yard, pounds per square rod, pounds per square chain, pounds per square furlong, pounds per square mile, pounds per square league, pounds per square fathom, pounds per square cable, pounds per square nautical mile, pounds per square link, tons per square

mil, tons per square inch, tons per square hand, tons per square foot, tons per square yard, tons per square rod, tons per square chain, tons per square furlong, tons per square mile, tons per square league, tons per square fathom, tons per square cable, tons per square nautical mile, tons per square link, inch of water
Energy: mil-pound, inch-pound, hand-pound, foot-pound, yard-pound, rod-pound, chain-pound, furlong-pound, mile-pound, league-pound, fathom-pound, cable-pound, nautical mile-pound, link-pound, mil-ton, inch-ton, hand-ton, foot-ton, yard-ton, rod-ton, chain-ton, furlong-ton, mile-ton, league-ton, fathom-ton, cable-ton, nautical mile-ton, link-ton, foot-poundal, barrel of oil equivalent, British thermal unit, therm, thermie, cubic inch of atmosphere, cubic foot of atmosphere, cubic yard of atmosphere, cubic foot of natural gas, imperial gallon atmosphere, US gallon atmosphere, foot-grains, horsepower hours, ton of oil equivalent, ton of coal equivalent, ton of TNT equivalent
Power: horsepower, mil-pound per second, inch-pound per second, hand-pound per second, foot-pound per second, yard-pound per second, rod-pound per second, chain-pound per second, furlong-pound per second, mile-pound per second, league-pound per second, fathom-pound per second, cable-pound per second, nautical mile-pound per second, link-pound per second, mil-ton per second, inch-ton per second, hand-ton per second, foot-ton per second, yard-ton per second, rod-ton per second, chain-ton per second, furlong-ton per second, mile-ton per second, league-ton per second, fathom-ton per second, cable-ton per second, nautical mile-ton per second, link-ton per second
Luminous intensity: candlepower
Amount of substance: pound mole

No Imperial Units for Certain Physical Phenomena

There are no imperial units defined for:

- Frequency
- Electricity
- Capacitance
- Magnetism
- Inductance
- Radiation
- Catalytic activity

Description of the Modern Metric System

Introduction to the Modern Metric System

The modern metric system is called the International System of Units (or SI, its French-based abbreviation for *Système International d'Unités*). It has been developed internationally with co-operation from many countries, including the UK and is a world standard. It is the only measurement system that is recognised and accepted in all countries. The International Bureau of Weights and Measures (also known as BIPM, its French-based abbreviation for *Bureau International des Poids et Mesures*) is the international body that is responsible for the maintenance and development of the metric system.

SI consists of 7 base units, 22 derived units with special names and symbols and countless derived units without special names. There are also metric units that are not part of SI but are approved for use with SI because they are compatible with it (e.g. hectare, litre, tonne, etc.). These units are always used with zero or one of the SI prefixes. Combinations of prefixes are not permitted. Multiples and submultiples of these units are expressed with the use of common prefixes, which always have the same meaning, no matter which units they are used with. There are common symbols for each one of these prefixes and these are case-sensitive (e.g. “mm” means millimetre or one-thousandth of a metre whereas “Mm” means megametre or one million metres).

SI Prefixes

The full list of SI prefixes is shown in descending order in the following table with the commonly used ones in the UK shown in bold text. The common range of multiples and submultiples is highlighted in yellow. The prefixes outside the highlighted range are used in specialist fields. The written value in the Value in Words column uses the short scale of numbers (the scale where one billion is used to express one thousand million, the system of numbers commonly used in the UK). Prefixes are used to express the amount of the base unit (e.g. “kilogram” means one thousand grams, “millimetre” means one-thousandth of a metre). No prefix is used to express the quantity of the base unit itself (e.g. “watt” means one watt).

Prefix	Symbol	1000^n Value	10^n Value	Decimal Value	Value in Words
yotta	Y	1000^{8}	10^{24}	1 000 000 000 000 000 000 000 000	Septillion
zetta	Z	1000^{7}	10^{21}	1 000 000 000 000 000 000 000	Sextillion
exa	E	1000^{6}	10^{18}	1 000 000 000 000 000 000	Quintillion
peta	P	1000^{5}	10^{15}	1 000 000 000 000 000	Quadrillion
tera	T	1000^{4}	10^{12}	1 000 000 000 000	Trillion
giga	G	1000^{3}	10^{9}	1 000 000 000	Billion
mega	M	1000^{2}	10^{6}	1 000 000	Million
kilo	k	1000^{1}	10^{3}	1 000	Thousand
hecto	h	$1000^{2/3}$	10^{2}	100	Hundred
deca *	da	$1000^{1/3}$	10^{1}	10	Ten
(none)	(none)	1000^{0}	10^{0}	1	One
deci	d	$1000^{-1/3}$	10^{-1}	0.1	Tenth
centi	c	$1000^{-2/3}$	10^{-2}	0.01	Hundredth
milli	m	1000^{-1}	10^{-3}	0.001	Thousandth
micro	µ	1000^{-2}	10^{-6}	0.000 001	Millionth
nano	n	1000^{-3}	10^{-9}	0.000 000 001	Billionth
pico	p	1000^{-4}	10^{-12}	0.000 000 000 001	Trillionth
femto	f	1000^{-5}	10^{-15}	0.000 000 000 000 001	Quadrillionth
atto	a	1000^{-6}	10^{-18}	0.000 000 000 000 000 001	Quintillionth
zepto	z	1000^{-7}	10^{-21}	0.000 000 000 000 000 000 001	Sextillionth
yocto	y	1000^{-8}	10^{-24}	0.000 000 000 000 000 000 000 001	Septillionth

* NOTE: The prefix “deca” is officially used in the UK and in most English-speaking countries and by the BIPM. In the US, the prefix “deka” is the official spelling for this prefix.

SI Base Units

The 7 base units in SI are used for measuring specific physical quantities. All other metric units, whether they are part of SI or approved for use with SI (i.e. SI and non-SI metric units) are derived from these 7 base units. The official definitions of these base units are the ones that have been agreed internationally and are part of the current SI standard that is published by BIPM.

Name	Symbol	Unit of What?	Official Definition
metre *	m	Length	The metre is the length of the path travelled by light in vacuum during a time interval of $^{1}/_{299\,792\,458}$ of a second.
kilogram **	kg	Mass	The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.
second	s	Time	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.
ampere	A	Electric Current	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.
kelvin	K	Thermodynamic Temperature	The kelvin, unit of thermodynamic temperature, is the fraction $^{1}/_{273.16}$ of the thermodynamic temperature of the triple point of water.
mole	mol	Amount of Substance	The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is “mol”. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.
candela	cd	Luminous Intensity	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $^{1}/_{683}$ watt per steradian.

* NOTE 1: The spelling “metre” for this SI base unit is officially used in the UK and in most English-speaking countries and by the BIPM. In the US, “meter” is the official spelling for this unit.
** NOTE 2: For historical reasons, the kilogram is the only base unit that contains a prefix. In the case of the kilogram, the system of prefixes apply to the gram, which contains no prefix. The kilogram contains the prefix “kilo” and is therefore 1000 grams.

SI Derived Units

These are the 22 derived units in SI that have special names and symbols. The last column shows how these units are derived from the base units. There are countless other SI derived units without special names (e.g. square metre (m²), metre per second (m/s), newton metre (Nm)).

Name	Symbol	Derived Quantity	Relation to other SI Derived Units	Relation to other SI Base Units
radian	rad	plane angle	1	m/m
steradian	sr	solid angle	1	m^2/m^2
hertz	Hz	frequency		s^{-1}
newton	N	force		m kg s^{-2}
pascal	Pa	pressure, stress	N/m^2	m^{-1} kg s^{-2}
joule	J	energy, work, amount of heat	N m	m^2 kg s^{-2}
watt	W	power, radiant flux	J/s	m^2 kg s^{-3}
coulomb	C	electric charge, amount of electricity		s A
volt	V	electric potential difference, electromotive force	V/A	m^2 kg s^{-3} A^{-1}
farad	F	capacitance	C/V	m^{-2} kg^{-1} s^4 A^2
ohm	Ω	electric resistance	V/A	m^2 kg s^{-3} A^{-2}
siemens	S	electric conductance	A/V	m^{-2} kg^{-1} s^3 A^2
weber	Wb	magnetic flux	V s	m^2 kg s^{-2} A^{-1}
tesla	T	magnetic flux density	Wb/m^2	kg s^{-2} A^{-1}
henry	H	inductance	Wb/A	m^2 kg s^{-2} A^{-2}
degree Celsius	°C	Celsius temperature		K
lumen	lm	luminous flux	cd sr	cd
lux	lx	illuminance	lm/m^2	m^{-2} cd
becquerel	Bq	activity referred to a radionuclide		s^{-1}
gray	Gy	absorbed dose, specific energy (imparted), kerma	J/kg	m^2 s^{-2}
sievert	Sv	dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent	J/kg	m^2 s^{-2}
katal	kat	catalytic activity		s^{-1} mol

Non-SI Approved Units

The following table contains non-SI units that are officially accepted for use with SI.

Name	Symbol	Quantity	Value in SI Units
minute	min	time	1 min = 60 s
hour	h	time	1 h = 60 min = 3600 s
day	d	time	1 d = 24 h = 86 400 s
degree	°	plane angle	$1^{\circ} = (\pi/180)$ rad
minute	′	plane angle	$1' = (1/60)^{\circ} = (\pi/ 10\,800)$ rad
second	″	plane angle	$1'' = (1/60)' = (\pi/ 648\,000)$ rad
hectare	ha	area	1 ha = 1 hm^2 = 10^4 m^2
litre *	L, l	volume	1 L = 1 l = 1 dm^3 = 10^3 cm^3 = 10^{-3} m^3
tonne *	t	mass	1 t = 10^3 kg
electronvolt	eV	energy	1 eV = 1.602 176 53 (14) × 10^{-19} J
dalton	Da	mass	1 Da = 1.660 538 86 (28) × 10^{-27} kg
unified atomic mass unit	u	mass	1 u = 1 Da
astronomical unit	ua	length	1 ua = 1.495 978 706 91 (6) × 10^{11} m
bar	bar	pressure	1 bar = 0.1 MPa = 100 kPa = 10^5 Pa
millimetre of mercury	mmHg	pressure	1 mmHg ≈ 133.322 Pa
ångström	Å	length	1 Å = 0.1 nm = 100 pm = 10^{-10} m
nautical mile	M	length	1 M = 1852 m
barn	b	area	1 b = 100 fm^2 = $(10^{-12}$ cm$)^2$ = 10^{-28} m^2
knot	kn **	speed	1 kn = (1852/3600) m/s
neper	Np	logarithmic ratio quantities	*** See footnote.
bel	B	logarithmic ratio quantities	*** See footnote.
decibel	dB	logarithmic ratio quantities	*** See footnote.

* NOTE: The spellings “litre” and “tonne” for these non-SI approved units are officially used in the UK and in most English-speaking countries and by the BIPM. In the US, “liter” and “ton” are the official spellings for these units. As the US spelling “ton” can also represent US tons, it is often preceded by the word “metric” in the US to indicate that it refers to the tonne (or “metric ton” in the US).

** The knot is defined as one nautical mile per hour. There is no internationally agreed symbol, but the symbol kn is commonly used.

*** The numerical values of the neper, bel, and decibel (and hence the relation of the bel and the decibel to the neper) are rarely required. They depend on the way in which the logarithmic quantities are defined.

Weights and Measures used in the UK Today

This section does not attempt to give an exhaustive guide to every measurement unit that is used in the UK because there would be too many to list but provides you with the commonly used units and a few other units that are used for specific purposes.

The official and primary system of measurement in the UK is the modern metric system. However, the use of imperial units is still widespread in the UK. They are widely used in product descriptions, pubs, supplementary indications on some commercial products, marketing, the media, road signs and in everyday conversation.

These are the measurement units in common use in the UK today:

- Metric units of distance or length: millimetre, centimetre, metre, kilometre.
- Imperial units of distance or length: inch, foot, yard, mile.
- Metric units of area: square millimetre, square centimetre, square metre, square kilometre, hectare.
- Imperial units of area: square inch, square foot, square yard, square mile, acre.
- Metric units of volume: cubic millimetre, cubic centimetre, cubic metre, millilitre, centilitre, litre.
- Imperial units of volume: cubic inch, cubic foot, cubic yard, fluid ounce, pint.
- Metric units of mass: microgram, milligram, gram, kilogram, tonne.
- Imperial units of mass: ounce, pound.
- Metric units of temperature: degrees Celsius.
- Imperial units of temperature: degrees Fahrenheit.

In addition to the common measurements, other measurements are still used for specific purposes in the UK, such as:

- Furlongs in horse racing
- Stones for measuring body weight
- Troy ounces for trade in precious metals
- Nautical mile and knot for sea and air traffic

History of the British Metrication Programme

Aims and Objectives

In 1965, the UK started its metrication programme and planned to complete it within 10 years. By the end of the programme, the UK was supposed to become a fully metric country and to leave behind the British imperial system. This programme was started in response to pressure from British industry that could see the obvious advantages in trade, commerce and international co-operation of using the same measurement system as the rest of the world. The rest of the Commonwealth followed the UK's lead and moved to the metric system.

Problems and Issues with the Metrication Programme

Unfortunately, the UK adopted the voluntary and gradual approach to metrication. This included a plan to convert the UK's road signs, which was subsequently abandoned and never re-instated. The metrication programme concentrated on British industry and largely ignored the public. It was soon realised that metrication could not be confined to industry. There were issues related to metrication such as the need for workers who could work with metric units and how far metrication should go. For these reasons, the UK Metrication Board was set up in 1969 and chaired by the scientist, Dr Ritchie Calder, to plan the metric changeover for the whole of the British economy. Metrication progress varied across different sectors and was rapid in some and slow in others. Construction started the move to the metric system in 1969 and education started it in 1974. At that time, British manufacturing faced a number of problems, including industrial strife, poor quality, lack of capital, obsolete plant, and outdated products. Given the scale of the problems that manufacturers faced, metrication was seen as a low priority compared to their more immediate problems.

Conversion of the Transport and Retail Sectors

In 1970, the Transport minister and the Transport Department made clear that it will not be changing its road signs to use metric units. This stance has been maintained by successive Transport ministers and the Transport Department ever since. This was an important development at the time. Today, British roads are almost exclusively imperial and is the one major sector that has not yet converted to the metric system. In 1978, the government considered converting the retail sector to the metric system but that was postponed and there was a general election the following year. In 1979, a new government was elected. The new government abandoned the conversion of the retail sector and abolished the UK Metrication Board in 1980.

Political Opposition to Metrication

In the early years of the programme, there was a failure to make the changes in legislation that were necessary to ensure that goods and services were sold using the metric system. By the time of the development of the European Single Market in the 1990's, the European Union issued directives to the EU member states, including the UK, and that included Units of Measurement directives. The European Single Market, like any common market, requires a common system of weights and measures. This is essential for consumer protection and honesty in the use of weights and measures. Given that all countries in the EU except the UK and Ireland used the metric system during that period, it was a no-brainer to standardise on the metric system. Ireland completed its transition to the metric system 5 years ago with the conversion of its road speed signs, leaving the UK totally isolated in Europe in its continued use of the imperial system.

This booklet expresses no judgement or opinion about the EU, the euro, the European Single Market and other aspects of the EU, which is an entirely separate issue from metrication. However, any common market needs a common system of weights and measures. Unfortunately, opposition to metrication has become politicised and tangled with the European controversy. The metrication legislation in response to the European directives was exploited by many eurosceptics and their supporters among the right-wing eurosceptic national newspapers for political advantage. They promoted the 'Big Lie' that the EU was imposing metrication on the UK. For many eurosceptics, opposition to metrication has become an article of faith.

In fact, the metrication programme started several years before the UK joined what was then the European Economic Community, the forerunner of the European Union, in 1973. The decision to go metric was supported by British industry and taken by British leaders acting in the British national interest. The EU Units of Measurement directives were drawn up with the agreement of British ministers and included several derogations (i.e. exemptions in certain areas). These derogations were extended several times. A few years ago, all these derogations except the use of the acre for land registration were extended indefinitely. The derogation for using acres was ended. By that time, the use of the acre had fallen into disuse in the UK and Ireland so the derogation for acres was redundant. The UK Land Registry stopped using acres in 1995 and has been using hectares exclusively for land registration ever since. This proves that the EU could not care less about the UK's continued use of imperial measurements as long as they do not interfere with cross-border trade. None of the derogations interfere with cross-border trade.

As a consequence of the politicised, strident, vocal and organised opposition to further metrication and the general anti-metric environment, the metrication programme has stalled and the UK has got stuck between two competing, incompatible measurement systems.

Politicians have buried their heads in the sand over metrication and pretend that the problems of two systems do not exist. There is now nobody in politics or government who is willing to publicly express a pro-metric view. It has become a taboo subject and no politician wants to touch it with a bargepole. The desire expressed by the Magna Carta, that there should be one measure has been abandoned for now.

What is Wrong with Two Measurement Systems?

The use two measurement systems is full of problems and anomalies that would not have arisen if the UK only used one measurement system. The muddled and disorganised way that British political leaders have run the metrication programme has created many inconsistencies in the use of measurements. If you want to know more about them, read on. These will be explained in the next section.

Potential for Error

When you consider that many measurements are used to build power stations and other buildings and in many manufactured products, it would be crazy to use two measurement systems for their design. The scope for error would be huge and in safety-critical systems, it would just take one error to cause a disaster. Think about the huge number of measurements that would be required to build a space shuttle. The loss of the NASA Mars Climate Orbiter space shuttle was caused by the confusion between the use of metric and imperial units by a NASA contractor and only took one mistake to cause the space shuttle to crash into Mars. NASA learnt the hard way about the folly of using two measurement systems for their work. NASA moved to the metric system in 2007 to enable them to work with other space agencies, which all use metric units, and now uses the metric system most of the time. As Dr Metric correctly observes, “Surely, if anything is going to be standardised in the world, it should be the units we use for measurement. It's crazy to use one set for some aspects of our life and a completely different set for other aspects. The potential for error in translating from one set to another is enormous...” (Source: Dr Metric website, http://www.drmetric.net/counterarguments.html)

Historical Recognition for the Need for One Measurement System

About 800 years ago, a famous document called the Magna Carta was issued in 1215. That document recognised the need for one, and only one, system of weights and measures. Here is the relevant quote from that document, "Let there be one measure of wine throughout our whole realm; and one measure of ale; and one measure of corn, to wit, “the London quarter”; and one width of cloth (whether dyed, or russet, or “halberget”), to wit, two ells within the selvedges; of weights also let it be as of measures.". That document recognised that one system of weights and measures is enough and no country needs two systems. Before the Act of Union, England and Scotland had their own separate standards for weights and measures. In the Act of Union between Scotland and England in 1707, there was an agreement to use the weights and measures of England as the common standard for the whole union. The weights and measures of Scotland were discarded and not used in the new Union. For many countries, the metric system is their only measurement system.

Untidy Dual Labels and Road Signs

Sometimes, dual units are used for some consumer products and road signs. On road signs, that makes them look untidy and cluttered. For consumer products, the continued albeit voluntary use of imperial units as supplementary indications is a messy compromise to make up for the refusal of the US to adopt the modern metric system known as SI. It would have been a lot better to persuade the US to allow metric-only labelling, as proposed by the National Institute of Standards and Technology, an agency of the US Department of Commerce. Metric-only labelling would look neater and smarter.

Dual labelling is especially wasteful, inefficient and costly. The use of dual units to express the same quantity always looks like a messy compromise. After all, how many measurement systems do you need to express the height of a bridge or the weight of a chocolate bar? You would think that one would be enough in all cases but two are often used.

On its website, the National Measurement Office, an Executive Agency of the Department for Business, Innovation and Skills, states that “Having a single consistent set of units of measurement in use for trade reduces costs for business and enables consumers to make price and quantity comparisons more easily.”. That quote appears as the first sentence on the NMO Metrication web page at http://www.bis.gov.uk/nmo/regulation/weights-and-measures-legislation/metrication.

Inconsistent and Illogical Measurement Rules

For some purposes such as building regulations, only the metric system can be used. For some purposes such as serving draught beer and cider, only the imperial system can be used. For some purposes such as the sale of many packaged goods, you must use the metric system but you can use the imperial system as well if you want to. For some purposes such as the display of measurement units on height and width restriction and warning signs on British roads, you must use the imperial system but you can use the metric system as well if you want to. Hence, imperial units appear on a few products but most products show none and metric units appear on some height and width warning and restriction signs but not on others. Can you see any logic in these incoherent, disorganised sets of rules? How many measurement systems do you need to express weight, volume or dimensions? Presumably one is enough but two systems are often used.

Odd Use of Measurement Units by the DfT

The Department for Transport tells road contractors to substitute yards for metres in some places. In road regulations, road contractors must put up signs that show roadworks ahead at intervals of 100 metres but put up signs that display multiples of 100 yards despite the fact that a yard is officially defined as 0.9144 metres. The DfT also uses the symbol “m” for both metres and miles. On some road signs, as many as four different units are used when one would be enough (e.g. road signs that show the distance to a hazard ahead in yards and the height or width restriction on the same signs show the dimensions in metres, feet and inches. Just using metres for them all in this case would be sufficient.). For some road signs, such as weight restriction signs, only the metric system can be used. For all distance and speed signs, only the imperial system can be used. For restriction and warning signs, the imperial system must be used but the metric system can be used as well. A metric-only triangular warning sign is permitted as long as it is accompanied by an imperial-only triangular warning sign above it or to the left of it. For dual restriction signs, the metric unit must appear above the imperial unit.

Apparently both imperial and metric units can be used in the Highway Code in any combination and style. In the Highway Code, there are places where only metric units are used, other places where metric units are used followed by imperial units in brackets, other places where imperial units are used followed by metric units in brackets and other places where only imperial units are used. Interestingly, no conversions are used anywhere in the Traffic Signs section of the Highway Code for non-dual signs. It is notable that the Highway Code uses metres in several places without any imperial conversion and wherever imperial conversions of metres are used, they are given in feet, never in yards. That includes the extensive use of metres for distance despite the fact that only yards and miles may be used for distance signs on British roads.

Odd Use of Measurement Units in the Media

Sometimes, imperial and metric units are used in the same reports in newspapers and magazines and in weather forecasts, often in the same sentence. Across the media, there is a lack of consistency in the use of measurement units. Some media groups follow certain standards but others such as the BBC leave it to the discretion of individual journalists. Some use imperial only, some use metric only and others use both. Where both are used, the metric is sometimes quoted first with the imperial equivalent in brackets and the imperial is sometimes quoted first with the metric equivalent in brackets. When temperatures are low or moderate, the Celsius scale is used but when temperatures are high, the Fahrenheit scale is often used to make the figures look dramatic. Press reports about petrol prices often quote prices per gallon despite the fact that fuel has not been sold by the gallon since the 1980's and bears no relation to what readers see at petrol stations.

Use and Abuse of Fluid Ounces

When fluid ounces are used as supplementary indications on product labels, sometimes the US fluid ounce of 29.57 millilitres is used for the conversion and sometimes the UK fluid ounce of 28.41 millilitres is used for the conversion. Thus we have two definitions of fluid ounces in current use in the UK at the same time. In some cases, manufacturers use figures for fluid ounces that are completely wrong by both definitions, even when rounding errors are taken into account.

Not Good Enough

Is this ideal or even good enough? The way that measurements are used in the UK is illogical and shames us all. We are in this situation because we started a metrication programme in 1965 and got stuck in the middle. As opposition to metrication became politicised and exploited by eurosceptics and their supporters for their own political ends, the metrication programme has stalled and has become a taboo issue that no politician wants to address for fear of losing votes. Politicians have buried their heads in the sand as far as metrication is concerned and now ignore the problem. The metrication programme was supposed to have been completed within 10 years but it is now almost half a century since it was started and there is now no end in sight. What a mess!

British Measurement Anomalies: How does it affect us?

Patriotic Argument Fallacy

The way that measurements are used in the UK has created numerous anomalies and this affects us all. Opponents of metrication either want to maintain the status quo or go backwards (i.e. reverse metrication). They often claim that they are preserving British identity, heritage and culture, and that it is patriotic to save the mile and the pint for Britain. They could say the same thing about the sixpence and the farthing but nobody is seriously suggesting that the UK should go back to using pre-decimal currency to preserve British traditions. As long as we have this kind of mindset in the UK, especially among politicians, there will be little prospect of making more progress toward the Magna Carta ideal of one system of weights and measures used in the whole country.

The claim that keeping imperial units preserves British identity, heritage and culture is odd when you consider the fact that almost all imperial measurement units used in the UK have foreign origins and many were imposed on us by foreign invaders such as the Romans. Many of the imperial units that are used in the UK are not unique to the UK but were used in other European countries as well before they moved to the metric system (e.g. inches, pounds and ounces, etc.).

The claim that keeping imperial units in the UK is patriotic implies that it helps us or benefits us somehow. In the developed world, the only two countries that are holding out for the continued use of the old measurements are the UK and the US. If they gain advantages from using the old measurements, other developed countries cannot see what they are. In fact, some Commonwealth countries (e.g. Australia, South Africa) and the Republic of Ireland have completed the transition to the metric system and permanently abandoned the imperial system. They will not be going back to that system.

Two Measurement Systems: Whom does it help?

In order to examine how it affects us, let us ask whom the continued use of two measurement systems helps? Whom does it benefit? What advantages do we get from it?

Q. Does it help schoolchildren?

A. No.

Schoolchildren mainly learn the metric system at school. Apart from a few imperial equivalents, the metric system has been taught exclusively since 1974. The ability to measure and do calculations relating to length, weight, area and volume are fundamental to a good maths and science education. British schoolchildren are at a disadvantage compared to their counterparts in all other European countries because the measurements that they learn in school bears no relation to what they see when they step outside the school gates. There general imperial environment and common use of imperial by British adults in everyday conversation and the media undermines what they learn at school and hence their maths and science education. If you judge the use and status of the metric system by what you see, you would find it hard to believe that the metric system is the official and primary measurement system in the UK and virtually everything that is built and manufactured exclusively in metric units. The continued use of imperial units adds to their confusion, perceived lack of relevance of a metric education and complexity in calculations. Some just give up as a result. For more information about the damaging education effects of using imperial units in the UK, go to the Dr Metric website at http://www.drmetric.net/, which is run by the highly experienced teacher Alan Young.

Q. Does it help drivers?

A. No.

The measurement for fuel efficiency for cars is often given in miles per gallon despite the fact that petrol is no longer sold in gallons and has been sold by the litre since the 1980's. This limits the usefulness of this measure. If you want to use this measure to work out how much fuel you need to buy to drive a certain distance, you would have no chance if you do not know how any litres are in a gallon. Even if you knew how many litres are in a gallon, you would still need to do some awkward calculations to work out the answer and would probably need to use a calculator. The miles per gallon figure is even useless to American drivers for use in the US where petrol is still sold by the gallon because the US uses the US liquid gallon, which is much smaller than the British imperial gallon used in the miles per gallon figure. The fuel efficiency measure of litres per 100 km is also limited because road distances are displayed in yards and miles on British road signs so it is awkward to use.

Width and height restrictions are given in feet and inches, occasionally with their metric equivalent, but vehicle dimensions in vehicle manufacturers' handbooks are given in metres, making it hard to judge whether your vehicle will fit under a bridge or tunnel.

Visibility and stopping distances are given in metres and feet in the highway code but neither of these measurement units are authorised for displaying distances on British road signs. That makes it difficult to use information on the road signs to judge stopping distances correctly.

The dual-unit speedometers used in cars sold in the UK are more cluttered and harder to read than the single-unit kilometres per hour speedometers used in cars elsewhere in Europe.

Foreign drivers who drive cars that were registered abroad will not have speedometers and odometers that use miles and the fact that the UK uses miles is unhelpful to them as the units they see on their dashboard differs from the units they see on British road signs.

Q. Does it help consumers?

A. No.

Loose fruit and vegetables sold by weight are sold by the kilogram by the supermarkets and by the pound by market traders, normally with no metric equivalent in defiance of the law. As long as fruit and vegetables are sold exclusively by different measurement units in supermarkets and by market stalls, direct price comparisons are impossible. Also, the use of imperial units in the descriptions of some products whereas others are described in metric units also hinders simple, fair comparisons between similar products. In some cases, the conversion factors between some imperial and metric units (e.g. British thermal units (BTU) and watts) are obscure. Even when they are known, the conversion factors are often awkward to use without a calculator.

Q. Does it help tourists?

A. No.

The official and non-official use of British imperial units is limited to the UK, the US and a handful of Commonwealth countries. In other countries, the British imperial system is not used and often unknown. Many tourists who come from those other countries will not be familiar with British imperial units. For them, the imperial units used on signs and in leaflets and brochures are meaningless and unhelpful.

Q. Does it help the emergency services?

A. No.

The road marking system used on motorways is entirely metric and little-known to the majority of drivers, probably because it is metric. So we have the metric system used on the roads for professionals and the imperial system for general road users. The fact that road signs for drivers are almost exclusively imperial limits the usefulness of the road marking system by the emergency services for locating stranded drivers. If all road signs were metric, the road marking system would be much more useful to both drivers and the emergency services as they would be part of an integrated common system and make it a lot easier to deliver help to drivers who need it.

Q. Does it help builders and DIY enthusiasts?

A. No.

The dual-unit measuring tapes commonly used by builders and DIY enthusiasts have the metric units along the bottom edge of the tape, making it awkward to measure in metric units accurately and increasing the scope for error. Also, turning the tape upside-down and measuring from right to left is awkward. It is hard to find metric-only measuring tapes. This is an important issue as measurements are used extensively in the building trade. Building materials in the building trade are often given common descriptions in inches and fractions of an inch (normally eighths and sixteenths of an inch), despite the fact that they are manufactured in metric units and all building regulations are in metric.

Q. Does it help businesses, house buyers and tenants?

A. No.

The residential property market works almost exclusively in imperial units and commonly gives dimensions in feet and area in square feet. The commercial property market often advertises office space in square feet. However, the fixtures and fittings, including carpets and furniture, for these

buildings are sold in metric units. That makes it awkward to plan the contents of rooms and their renovation. The calculations to order the right quantities and buy furniture in the right dimensions will require conversions between imperial and metric units.

Q. Does it help farmers?

A. No.

Land area is often given in acres, especially land for sale, but official land registration and any business relating to Common Agricultural Policy with the government and the European Union is administered in hectares. See Ian Pigott's article, “Time to ditch the language of the past” in Farmers Weekly Interactive for more details about the pervasive use of imperial units in British farming, http://www.fwi.co.uk/Articles/08/04/2011/126279/Time-to-ditch-the-language-of-the-past.htm. According to that article, the farming industry tends to select units of measurements depending on emphasis and often mixes imperial and metric units, depending on which sounds better. Agronomists, GPS soil analysts and machinery manufacturers also do this. This is not helpful to anyone.

Q. Does it help chefs?

A. No.

The different units used to sell fruit and vegetables in supermarkets and market stalls in unhelpful and makes it harder to ensure that chefs order the right quantities. Also, it is harder to read dual-unit kitchen scales than single-unit kitchen scales. The former are widely available whereas the latter are hard to find. This is a consequence of the continued use of two measurement systems.

Q. Does it help dieters?

A. No.

The Body Mass Index (BMI) is based on a person's weight and height in metric units. The BMI is calculated as weight in kilograms divided by height in metres squared (i.e. $kg / (m^2)$). If dieters measure their height in feet and inches and their weight in pounds and ounces, it is more complex to calculate their BMI from these imperial measurements and more steps are required. Nutrition information on food products is given in quantities per 100 grams. If they measure their food consumption in pounds and ounces, they need to perform extra calculations.

Q. Does it help holidaymakers?

A. No.

Holiday brochures often give temperatures in degrees Fahrenheit but weather reports use degrees Celsius. When holidaymakers drive to other European countries, they are forced to adjust to seeing metric units on road signs, which never appear on British distance or speed signs, something they would be used to or familiar with. The UK is the only European country to use imperial units on its road signs. All other European countries use metric units on their road signs.

Q. Does it help drinkers?

A. No.

The fact that draught beer and cider are sold by the imperial pint (a legal requirement) makes it harder to calculate the number of alcohol units that are being consumed. Drivers need to know to ensure that they do not go over the legal limit. All drinkers need to know how much they are drinking to ensure that they remain within their recommended daily limits to avoid harming their health. The fact that some drinks are sold in metric quantities and others are sold in imperial quantities makes it harder to add up the total amount of alcohol consumed, especially when drinkers consume draught and bottled beer and cider.

An alcohol unit is defined as 10 mL of pure alcohol in the UK, the amount of alcohol the average adult can process within an hour. Drinkaware, an independent UK-wide charity, publishes recommended recommended daily limits on the number of alcohol units (2-3 units a day for women or 3-4 units for men) that drinkers may safely consume without harming their health (Source: http://www.drinkaware.co.uk/). Alcohol units are calculated by using metric units and the formula for calculating them is Alcohol By Volume multiplied by the number of millilitres divided by 1000 (i.e. (ABV x mL) / 1000).

Q. Does it help car buyers?

A. No.

British regulations force car manufacturers to install speedometers that display miles per hour on the outer dial and kilometres per hour on the inner dial and odometers that display the number of miles travelled. These differ from the regulations of other European countries that require car manufacturers to install speedometers that only display kilometres per hour and odometers that only display the number of kilometres travelled. This forces them to a use separate production line for making cars for the British market and increases their costs. Do you think that car manufacturers do that for free? Who pays those increased costs? You do, of course. No wonder cars in the UK cost a lot more than they do elsewhere in Europe. Obviously, another reason for that is the fact that we drive on the left whereas other Europeans drive on the right. Nevertheless, the use of miles in the UK and the regulations that force them to install components that use miles still increases their costs.

Q. Does it help road contractors?

A. No.

All parts of the road network, including road signs, are built entirely using metric units. However, when road contractors are need to install road signs, they need to convert from metric to imperial units. Confusingly, when they put up distance road signs that lead to roadworks, they must place them at 100 metre intervals and put signs up in multiples of 100 yards. So in some road regulations, distances in metres need to be converted into yards and in other road regulations, yards are used as a substitute for metres. What is even more confusing is that signs that are used as part of the road marking system used by the emergency services to locate stranded drivers must be in metric units. All this increases the scope for error and mistakes will occasionally happen.

Q. Does it help manufacturers and exporters?

A. No.

Manufacturers and exporters need workers who are familiar with metric units as products are manufactured to metric specifications and exported to metric countries. However, maths and science education in metric units is undermined daily by the general imperial environment. Education in metric units bears no relations to the visible use of imperial units used in society. That means that schoolchildren cannot apply what they have learnt in school to what they see daily in the UK.

Another problem for manufacturers is that they need to make dual-unit measuring and weighing instruments for the British market and metric-unit measurement instruments for foreign markets. That forces them to use separate production lines and increases their costs.

The failure to fully adopt the metric system while many other countries moved to the metric system is a symptom of the UK's failure to adapt to the modern world. This presented threats as well as new

opportunities. A consequence of that is the steep decline in British manufacturing over the last few decades. Now, a substantial proportion of the products sold in the UK are made entirely in metric units in Asia, especially China.

Q. Does it help professionals?

A. No.

If the imperial system is used for professional jobs, civil engineers would be working in feet and inches, land surveyors would be working in links and chains and sailors and maritime engineers would be working in cables and fathoms. There is no co-ordination between all these imperial systems and that prevents these professionals from understanding each other's work.

Q. Does it help workers?

A. No.

Wherever measurements are used in health and safety legislation, they are entirely metric. However, when government and the media communicate with the general public, they normally use imperial units. This undermines workers' understanding of rules that are designed to protect them.

Q. Does it help newspaper readers and television and radio audiences?

A. No.

The non-specialist media communicates with the public mostly in imperial units. This gives them the misleading impression that we live in an imperial world. This is not the case. It undermines their understanding of the fact that the metric system is the primary and official measurement in the UK and that public administration, virtually all manufacturing and construction is done in metric units. Despite the fact that many of the units we see being used are imperial, most of the unseen use of measurement is metric. As the National Measurement Office, states, the UK is “substantially metric”. (Source: National Measurement Office, http://www.bis.gov.uk/nmo/regulation/weights-and-measures-legislation/metrication)

Q. Does it help walkers?

A. No.

Despite the fact that the Ordnance Survey uses a kilometre-based grid, many commercial maps use both imperial and metric units and distance signs on British roads are in imperial. Some British signposts use metric units whereas others use imperial. This is unhelpful when comparing information with Ordnance Survey maps and finding out where you are. This could be a safety issue in times of poor visibility. For the sake of outdoor safety, walkers need to know where they are so that they can avoid hazardous conditions and nasty accidents.

Q. Does it help international travellers?

A. No.

Some of the points made about the way that walkers are affected by the use of two measurement systems also applies to travellers. When travellers go abroad, they have to adjust to the use of metric units but when they travel around the UK, they have to adjust to imperial. It is inconvenient for international travellers that the UK is the only country in Europe that uses imperial units on its roads and on signposts in other places. For many foreign travellers coming to the UK, the imperial signs are meaningless. Switching between different measurement systems every time you enter or leave the UK is a nuisance.

Q. Does it help advertisers?

A. No.

Advertisers constantly face a dilemma over whether they should use metric or imperial units in their advertisements. They have to consider what their target audience will understand better and and which units will be more effective in their message to consumers.

Q. Does it help retailers?

A. No.

There is greater scope for error in the use of dual pricing for products, though dual pricing is voluntary. Some retailers may be disadvantaged by the dubious practices of rival retailers that freely metric or imperial units or even both to make prices look cheaper or price reductions look bigger than they really are. It is essential that there is a single, consistent set of units used for advertising, marketing and product descriptions to ensure that the market is free and fair for all retailers. The legal loophole that allows some unscrupulous retailers to engage in dubious practices over the use of measurements is bad for the rest of the retail market. As the National Measurement Office correctly states, “Having a single consistent set of units of measurement in use for trade reduces costs for business and enables consumers to make price and quantity comparisons more easily.” (Source: http://www.bis.gov.uk/nmo/regulation/weights-and-measures-legislation/metrication)

Q. Does it help other Europeans?

A. No.

The UK is totally isolated in Europe in its use of imperial units. All other European countries, including those outside the EU, use metric units. When other Europeans come to the UK, they are forced to adjust to the UK's widespread use of imperial units. For many European tourists visiting the UK, imperial units are meaningless. If the UK only used metric units, it would be unnecessary for them to learn and use another measurement system. Also, the need to constantly convert between imperial and metric would be unnecessary.

Q. Does it help Americans?

A. No.

Like us, the Americans also use a version of imperial units. They use their own adaptation of the British imperial system called the US customary system. Although the US customary system and British imperial system have many features in common (e.g. identical units of length), there are many differences between them. There are units that are used on one system but not the other (e.g. British use of stones and fluid scruples, which do not exist in the US customary system) and many units with the same names in both systems represent different quantities. The ton, gallon and pint are all a lot smaller in the US customary system than they are in the British imperial system. All volume measurements are different in both systems. Americans in the UK would need to learn all those differences to ensure that they use the correct quantities. Unlike the imperial system, the metric system is exactly the same all over the world because it is a world standard.

Q. Does it help Commonwealth citizens?

A. No.

All the major Commonwealth countries have already switched to the metric system and, with the partial exception of Canada, the UK is the only major Commonwealth country that has not yet completed the transition to the metric system. Those other Commonwealth countries completed it by 1980 so a whole generation of citizens has grown up on those countries who are only familiar with metric units. It is inconvenient that when they come here, they are forced to get used to an unfamiliar measurement system.

Metrication Opposition: Not for Your Benefit

As you can clearly see from all the previous arguments, the opponents of metrication are not doing you any favours by blocking further progress towards full metrication. Their campaign against the metric system is not for your benefit. Many eurosceptics see metrication as an EU plot and opposition to metrication as a battle against the EU. They and their supporters in the press oppose metrication and resist any further moves toward the metric system for their own political ends.

Judge the Metric System on its Own Merits

The EU and metrication are separate issues. The case for metrication should be judged on its own merits without the distraction of the European issue. There are more countries outside the EU than in the EU that use the metric system as their only measurement system. That includes most Commonwealth countries, including Australia, New Zealand and South Africa.

Need to Standardise on One System. Which One?

From all the arguments presented so far, we can see all the problems and anomalies that arise from using two measurement systems (i.e. dual-use of imperial and metric). The obvious solution is to use only one system. If we need to choose between the imperial and metric measurement systems, we ought to ask ourselves which system is better. We should be using the best available system of weights and measures.

Can we go back to Exclusive Use of Imperial?

Let us examine whether the UK can abandon the metric system and go back to using imperial exclusively. If we want to answer this hypothesis, we need to examine the imperial system and what it can and cannot measure. There are certain things that the imperial system cannot measure, such as electricity, magnetism and radiation. If only imperial is used, how will we charge for electricity? We cannot do so by using imperial units because there are no imperial units for electricity. Another problem with imperial units is that they cover a limited range of quantities. So the imperial system is no good for measuring the properties of atoms, blood cells or the structures of DNA. Nor is it any good for covering large distances across the universe, measuring the mass of other planets or the power output of the sun. Thus the use of the metric system for such tasks is unavoidable.

Factors to Consider for Standardisation

Another major factor to consider is the fact that the metric system is a world standard and is recognised and accepted all over the world whereas the British imperial system is confined to a few Commonwealth countries and the US that have not completed their transition to the metric system. The US has its own version of the imperial system and is officially called the US customary system. Their system is incompatible with the British imperial system. Despite the general imperial environment in the UK, there is now so much use of metric units behind the scenes in government administration, construction and manufacturing and the UK is substantially metric. The UK needs the metric system for international trade and co-operation to meet international specifications and the legal requirements and standards of other countries. For these purposes, the metric system is indispensable. So much progress has already been made in metrication and it is now indispensable for inward investment, manufacturing, exports and joint multi-national defence co-operation and projects with other countries. It would be madness to go backwards. Clearly, attempting to abandon the metric system and reverse all progress made since the start of the Metrication Programme in 1965 would be disastrous. Nobody is seriously arguing that the UK can revert to exclusive use of imperial units. Therefore, the only option is to proceed toward full metrication and abandon the imperial system.

Advantages of Metric over Imperial

The metric system is suitable for all purposes whereas the imperial system is not. The metric system can meet all our needs whereas the imperial system cannot. The metric system is a world standard whereas imperial units often differ between countries. The metric system is recognised and accepted in all countries whereas the imperial system is not. The metric system is supported and maintained by international organisations (e.g. BIPM, CGPM, etc.) to meet present and future needs whereas the imperial system is not. For all these reasons, the only sensible solution is to complete the transition to the metric system and abolish the remaining imperial units still in official use for all economic, health, safety and administrative purposes.

Full Metrication and the Anti-Metric Lobby

It is clear that many anti-metric websites dispute the need for full metrication. They argue why we should continue to use imperial measurements and resist all further steps to the full adoption of the metric system. In the next few sections, this booklet will explain the problems with the imperial system and why the metric system is better. Anti-metric campaigners have nothing positive to offer to address the problems of using two measurement systems. They are either happy with the status quo or campaigning to reverse some aspects of the metrication programme. All anti-metric campaigners fit into one of these two categories.

Problems with the Imperial System and their Metric Solutions

Too Many Names

The imperial system has a ridiculously large number of names for its units, some of which are highly obscure. Do you know anything about imperial units called minims, scruples, hogsheads, rods and chains? Do not worry if you do not know them. They are quite obscure and rarely used these days. It is not just the number of different names for different units that is a problem. There are several distinct names to differentiate several types of a unit such as the imperial ton (e.g. short ton, long ton, assay ton, water ton, etc.).

By contrast, SI, the modern metric system, contains just 7 base units and 22 derived units with special names and symbols. As well as the SI units, there are some compatible non-SI units (e.g. hectares, litres, tonnes, etc.) that are approved for use with SI. Some of these units are commonly used by the general population and others are mainly used in specialist fields. As well as these units, you just need to learn a system of prefixes that are used with these units. Only a subset of all the SI prefixes are commonly used. These are the ones you need to know.

Too Many Multiples

Look at the number of multiples that are used in the imperial system: 2, 3, 4, 5, 5.5, 6.08, 7.92, 8, 10, 12, 14, 16, 20, 22, 24, 25, 100. These multiples are the common multiples that are recognised in familiar relationships between imperial units and do not account for all the multiples in all possible relationships between imperial units (e.g. cubic inches in a gallon, yards in a furlong, etc.). So this is not a comprehensive list. In the imperial system, there is a need to learn where all these multiples are used and not just these multiples but the squares and cubes of these multiples. You would need to learn by heart how different imperial units relate to one another because there are no common rules or system to help you with that. Every time you learn a new system within the imperial system (e.g. troy system, imperial units of volume, etc.), you would need to learn a new set of multiples and how the various units within that system relate to one another.

Instead of multiples, SI uses a system of prefixes. All of them are based on tens and powers of ten. For SI prefixes of one-thousandth and a thousand, there are prefixes for one-thousandth (milli-), one-hundredth (centi-), one-tenth (deci-), ten (deca-), hundred (hecto-) and thousand (kilo-). Beyond this range for both smaller and larger quantities, all other prefixes are based on multiplying or dividing the base unit by 1000 (itself a power of ten, 10^3) or powers of 1000. The ones in common use, which you need to know, are one-millionth (micro-), one-thousandth (milli-), thousand (kilo-), million (mega-) and billion (giga-). That is all you need to know to use any part of the metric system. The same system is of prefixes is used for the entire metric system. The same system of SI prefixes is used for metres (unit of length/distance), grams (unit of mass, commonly used for weight), hertz (unit of frequency, commonly used for computer processor speeds), watts (unit of power), litres (unit of volume) and many other metric units.

Unpredictable Relationships

There is no logical sequence of multiples in the imperial system. The sequence of multiples appears to be random, unpredictable and illogical without any kind of order. Again take a look at sequence of multiples in the different systems that make up the imperial system. These were shown in the imperial tables earlier in this booklet.

These are the sequences of multiples used in the British imperial system:

Type of Units	Sequence of Multiples
Units of Length (General)	1000, 12, 3, 5.5, 4, 10, 8, 3
Units of Length (Maritime)	6.08, 100, 10
Units of Length (Gunter's Survey)	7.92, 25, 4, 10, 8
Units of Volume (General)	5, 4, 2, 4, 2, 4, 8, 5, 2
Units of Volume (Apothecary)	20, 3, 8, 20, 8
Units of Mass (Avoirdupois)	16, 16, 14, 2, 4, 20
Units of Mass (Troy)	24, 20, 12
Units of Mass (Apothecary)	20, 3, 8, 12

It is hard to find any pattern or logic in any of the number sequences shown above. The various number sequences also have no logical relationships with one another.

Unlike the imperial system, consistency is at the core of SI. The same set of SI prefixes are used with all parts of the metric system and they have exactly the same relationship to the base unit, no matter which unit they are used with.

Awkward Relationship of Grain with Other Avoirdupois Units

Did you notice something about the number sequences above? When you multiply the numbers in the sequence in the troy and apothecary systems, the result is 5760, exactly the number of grains in a pound in both systems. However, the grain has an awkward relationship with the other units in the avoirdupois system. In the avoirdupois system, there are 7000 grains in a pound, 437.5 grains in an ounce and 27.34375 grains in a dram. It is not clear how it relates to any of the smaller units in that system. There is no obvious way in which the grain fits in with the rest of that system. The grain would be needed for measuring very small quantities.

In the imperial system, the apothecary system is only used for drug and medical recipes, the troy system is only used for precious metals and the avoirdupois system is used for everything else. At the heart of the biggest system of the 3 systems (i.e. the avoirdupois system) for mass, there is an awkward relationship between the grain and the other units of that system.

There is no such problem with SI. The system of SI prefixes avoids this kind of problem. The multiples and submultiples within the metric system are all whole numbers and are only based on powers of 10.

Dual Use of Ounce and Quarter

Confusingly, the ounce has a dual role as a measure of mass and a measure of volume. For dry measures, the ounce is only used as a unit of mass. For liquid measures, the ounce is used as a unit of volume and is called a fluid ounce. So the meaning of an ounce depends on what is being measured. For measuring solid volumes, fluid ounces cannot be used and another measure of volume must be used such as cubic inches or cubic feet.

A similar problem exists with the quarter. The quarter is used as a unit of mass that contains 2 stones and as a unit of volume that contains 8 bushels. When this term is used in the imperial system, you need to work out whether it refers to mass or volume based on the context wherever it is used. In the imperial system, the quarter represents both definitions.

No such problem exists in SI. The 7 base units and 22 derived units with special names and symbols measure one, and only one, physical quantity (e.g. metre for unit of length, kilogram for unit of mass, etc.). Each one of them was created for a specific purpose and none of them is used in the same way that ounces and quarters are used.

Changing Quantities Over Time

The quantities of many ancient imperial units have been changed so many times that we have lost the original values. This causes us problems when we want to make historical comparisons. When using historical records that refer to ancient imperial units such as miles, we would need to know which definition is being used.

For example, Parliament changed the definition of a mile in 1592 from 5000 feet to 5280 feet to make it exactly 8 furlongs. The 1824 Weights and Measures Act changed the definition of the hundredweight from 100 to 112 pounds and the ton from 2000 to 2240 pounds to make them multiples of 14, the number of pounds in a stone, so that there are whole numbers of stones in these larger units. The US did not adopt these changes and retained the old quantities of the hundredweight and ton.

By contrast, the quantities of the SI base units, the fundamental parts of SI which form the basis of the rest of the system, have never been changed. The quantities have remained the same since the creation of the metric system but have been redefined with greater and greater accuracy.

Different Definitions in Different Countries

Many imperial measurements with the same names represent different quantities in different countries. This can clearly be seen by comparing the differences between the British imperial system and the US customary system.

In the avoirdupois system, the quantities of units in both the US customary system and the British imperial system are identical up to 1 avoirdupois pound. Above that quantity, the two differ. The quantities in the British imperial system were redefined in 1824. That was influenced by the existence of the stone in the British version of the avoirdupois system, which does not exist in the US customary system. In the British system, the number of pounds in the larger units were changed to multiples of 14, the number of pounds in a stone, to ensure that these larger units consisted of a whole number of stones. As the US was already independent at the time, they did not adopt the reforms that were taking place in the UK.

The quarter, hundredweight and ton represent different quantities in the British and American versions of the avoirdupois system, as shown in the following table:

Unit Name	US Definition	UK Definition
Quarter	25 pounds	28 pounds
Hundredweight	100 pounds	112 pounds
Ton	2000 pounds	2240 pounds

If clarification is needed about which hundredweight or ton is being used, the short hundredweight and short ton are the terms used for the US versions of these units and the long hundredweight and long ton are the terms used for the UK versions of these units.

All volume measurements are different between the two systems. The following table shows the differences between both systems. All values are approximate. In the British imperial system, dry and liquid measures are the same. For certain units, US dry measures are not given because those units are not used for dry measures.

Unit Names	UK Imperial Measure	US Dry Measure	US Liquid Measure
minim	0.05919 mL		0.06161 mL
fluid scruple	1.184 mL		n/a *
fluid dram	3.55 mL		3.697 mL
fluid ounce	28.41 mL		29.57 mL
gill	142 mL		118 mL
pint	568 mL	551 mL	473 mL
quart	1.1365 L	1.101 L	946 mL
gallon	4.546 L	4.404 L	3.785 L
peck	9.092 L	8.81 L	7.57 L
bushel	36.368 L	35.239 L	30.283 L

* The fluid scruple does not exist in the US customary system.

As well as the problems of units that represent different quantities, some of the units in the US customary system have different relationships to other units compared to the British imperial system. In the US customary system, there are 16 fluid ounces in a pint and 128 fluid ounces in a gallon. In the British imperial system, there are 20 fluid ounces in a pint and 160 fluid ounces in a gallon.

Different definitions for these imperial units causes ambiguity wherever these unit names are used. There is always the problem of knowing which definition is meant. Unlike the imperial system, SI is a world standard and all the metric units are the same all over the world. In the development of the imperial system, the British and the Americans went their own way. The Americans do not measure like we do, literally. So if you are thinking about using the imperial quantities in an American recipe with British measuring equipment, watch out!!! All their volume measurements are different to ours, in some cases significantly different. So if you use fluid ounces, quarts and pints in a US recipe book and measure those quantities with British measuring equipment, you could easily forget to convert them and ruin your recipes.

By contrast, the development of SI has been a truly international effort and is governed by the International Bureau of Weights and Measures, which is known by its French abbreviation, BIPM. The BIPM, in their own words, is responsible for ensuring "the world-wide uniformity of measurements and their traceability to the International System of Units (SI)."

"It does this with the authority of the Convention of the Metre, a diplomatic treaty between fifty-five nations, and it operates through a series of Consultative Committees, whose members are the national metrology laboratories of the signatory States, and through its own laboratory work.

The BIPM carries out measurement-related research. It takes part in, and organizes, international comparisons of national measurement standards, and it carries out calibrations for Member States." (Source: BIPM Home Page, http://www.bipm.org/en/home/)

Different Definitions based on Purpose and System

Some imperial units represent different quantities depending on which system you are using. For an example of this, take the familiar pounds and ounces that are widely used. In the avoirdupois system, there are 16 ounces in a pound. In the troy and apothecary systems, there are 12 ounces in a pound. The troy and apothecary ounce weigh 31.103 grams but the avoirdupois ounce weighs 28.35 grams. The troy and apothecary pound weigh 373.242 grams but the avoirdupois pound weighs 453.59237 grams exactly. The inconsistent weights of pounds and ounces in these different systems hinders direct comparisons between the weights of precious metals, ingredients used in medical recipes and the weights of everything else, where the avoirdupois system is used. As well as the inconsistency between these various systems, here is another fact about the use of ounces that adds to the complexity. A fluid ounce is always different to the ounce in these various systems, no matter where you are, and refers to volume, not weight.

At sea and in aviation, the word "mile" means a different length compared to the mile used on land. Miles that refer to the distance travelled by sea or by air are called nautical miles but miles that refer to the distance travelled on land are called statute miles. In the imperial system, a nautical mile is equal to 1853.184 metres, approximately 15% longer than the statute mile of 1609.344 metres. Thus it is awkward to compare distances travelled by different modes of transport as different definitions of miles are used. It is also awkward to calculate the total distance travelled on a journey when part of the journey was on land and part of it was at sea or by air. To add to the confusion over the use of

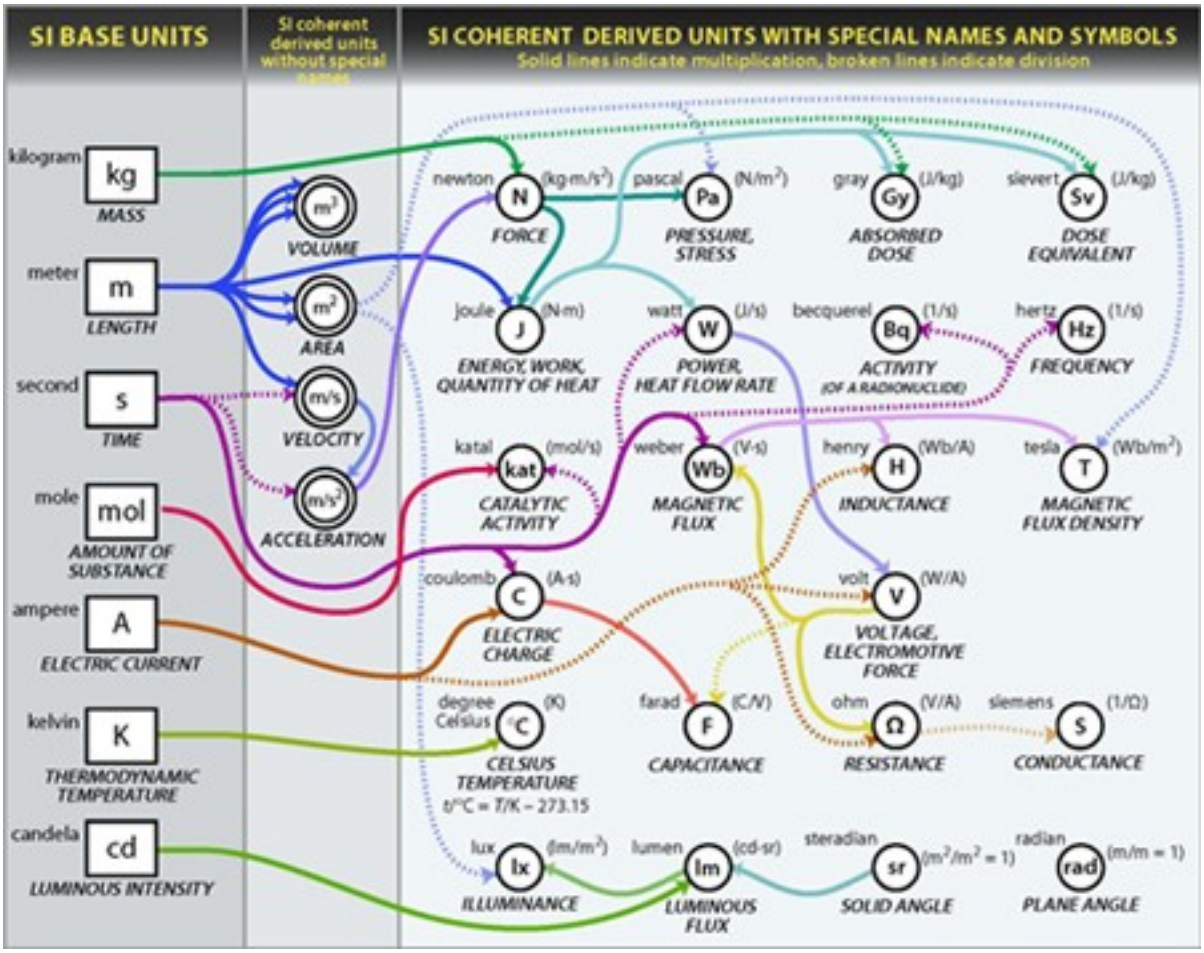
miles, the US also has a survey mile of 1609.3472 metres for mapping and surveying purposes, about 3.2 millimetres longer than the statute mile, and had an imperial nautical mile of 1853.249 metres and other nations had different lengths for nautical miles until the nautical mile was standardised worldwide to be exactly 1852 metres. Whenever the word “mile” is used, there is always the problem of knowing which definition you mean and has to be inferred from its context.

Unlike imperial units, metric units always represent the same quantity, no matter where they are used, when they are used or what they are used for. Each metric unit has one, and only one definition at any given time. No metric unit represents more than one quantity. This clarity and transparency makes it possible to define existing imperial units still in use in terms of the metric system.

Imperial System is a System Only in Name

The imperial system is not really a single system but a collection of separate systems that were developed independently for unrelated purposes. For instance, there is no obvious relationship between pints and cubic inches although they are both measures of volume. There is no obvious connections between the imperial systems for length, mass and volume. Even within these systems, there are 3 separate systems for length. These are general, maritime and Gunter's survey systems of length. Some units appear in one system that do not appear in the other and there is an awkward relationship between the different units in these different systems of length. This can be seen when you consider that the basis of the maritime system is based on the fathom, which is equal to 6.08 feet, and the basis of the Gunter's survey system is based on the link, which is 7.92 inches.

Unlike the imperial system, SI was developed as an integrated, coherent system of units. This can clearly be seen by looking the interrelationships between the different units in the following diagram:



(Source: NIST, http://www.nist.gov/index.html, http://www.nist.gov/pml/wmd/metric/si-units.cfm and http://physics.nist.gov/cuu/Units/SIdiagram.html)

Imperial Systems contain Units of Different Origins

The British version of the avoirdupois system is an example of the problem caused by units of different origins and the need to redefine other units to make them fit. The avoirdupois system comes from France and the British and American versions of that system are derived from the French version. The following table shows the original French version of the avoirdupois system and the British and American adaptation of that system.

Unit Name		Number of Avoirdupois Pounds per Unit		
French	**English**	**French Version**	**US Version**	**UK Version**
drachme	dram	$^1/_{256}$	$^1/_{256}$	$^1/_{256}$
once	ounce	$^1/_{16}$	$^1/_{16}$	$^1/_{16}$
livre	pound	1	1	1
n/a	stone	n/a	n/a	14
n/a	quarter	n/a	25	28
quintal	hundredweight	100	100	112
tonne	ton	2000	2000	2240

As you can see from the table above, the quarter did not exist in the original French avoirdupois system but appears in the British and American adaptation of that system. The stone only appears in the British version of the avoirdupois system. The stone is a traditional British unit of weight that was used for a variety of different commodities and was not part of the original French avoirdupois system. Before the stone was standardised as a weight of 14 avoirdupois pounds in 1824, the number of pounds in a stone varied depending on what commodity was being weighed, by geographical region and over time. The quarter, hundredweight and ton were redefined to make them a whole number of stones.

Another example of an imperial system that contains units of different origins is the imperial units of length. While the inch, foot and mile are of Roman origin, the yard, rod, chain and furlong are of Anglo-Saxon origin. The mile was originally defined by the Romans as the length of 1000 paces of a Roman legion where each pace consisted of two steps. This was roughly 5000 feet. Before Parliament fixed the length of a mile as exactly 8 furlongs in 1592, there were several different definitions of a mile in use.

By contrast, SI uses a system of base units and sets of prefixes to define the multiples and submultiples for units. These SI prefixes are used throughout the metric system and this avoids the problems of disparate, unrelated units cobbled together in a single system. Inevitably, the imperial system sometimes produced combinations of units that did not always contain whole numbers of other units and this often led to the redefinition of other units. This problem does not exist in the metric system because it was planned and developed internationally from the start as a truly integrated, coherent system.

Too Many Ways to measure the Same Physical Quantity

In the imperial system, there is a bewildering number of ways to measure the same physical quantity. This hinders direct comparisons for the same physical phenomena and many of the conversion factors between these measurements are obscure. For example, descriptions of heaters sometimes use British thermal units (BTU), descriptions of cars and air conditioners use horsepower and descriptions of light bulbs use watts. It is hard to compare their power consumption when different units are used for measuring the same thing. By contrast, the metric system only uses watts for measuring power consumption. When they are all expressed in watts, comparisons between their rates of power consumption are clear and transparent and it is easy to work out how much power they use and how much they cost to run.

For the imperial system, the Metric 4 Us website identified 14 ways to measure length, 16 ways to measure area, 27 ways to measure volume including dry and liquid measures (or 25 ways to measure volume excluding differences between dry and liquid measures, which do not exist in the British imperial system), 13 ways to measure mass, 2 ways to measure force, 32 ways to measure pressure, 29 ways to measure energy and 29 ways to measure power. (Source: http://www.metric4us.com/why.html) The number of conversion factors to convert between the various ways to measure the same physical quantity is enormous.

Metrication Matters listed an astonishing 93 ways to measure energy and 8556 conversion factors between them. It also listed 74 non-metric ways of measuring length and this is not even a comprehensive list as there are many other non-metric units of length. (Source: http://metricationmatters.com/why_metrication.html)

By contrast, there is only one SI unit for measuring each physical quantity and this unit is combined with none or one of the SI prefixes. These are the SI units for measuring each of the following physical quantities:

- **Length** – metre
- **Area** – square metre (derived units: are = 1 square decametre, hectare = 1 square hectometre = 100 ares)
- **Volume** – cubic metre (derived unit: litre = 1 cubic decimetre)
- **Mass** – gram (derived unit: tonne = 1000 kilogram = 1 megagram)
- **Force** – newton
- **Pressure** – pascal
- **Energy** – joule
- **Power** – watt
- **Temperature** – kelvin (derived unit: degree Celsius = kelvin – 273.15)

So when you need to use a metric unit for a particular purpose, you know exactly which one to use. Using the same units for the same physical quantity enables you to make direct comparisons effortlessly.

Limited Range of the Imperial System

In all the systems that make up the British imperial system, the range of units is limited. This means that you either end up using astronomical numbers to measure the very large or very tiny fractions or decimals that are extremely close to zero for measuring the very small. That makes the imperial system unsuitable for such purposes.

The smallest imperial length is the mil, which is one-thousandth of an inch, or 25.4 micrometres ($25.4 * 10^{-6}$ metres). The largest imperial length is the league, a length of 3 statute miles, or 4828.032 metres ($4.828032 * 10^{3}$ metres). In the metric system, the smallest length is the yoctometre (10^{-24} metres) and the biggest length is the yottametre (10^{24} metres). The yoctometre is small enough to measure the smallest particles in the universe and the yottametre is big enough to measure extremely large distances across the universe. For these purposes, the imperial system is no good because you will end up using astronomical numbers or ridiculously tiny numbers. The range of imperial units does not reach far enough to use numbers of a reasonable size that we can comprehend at either end of the scale.

The smallest imperial volume in general use is the fluid ounce, which is 28.4130625 mL and the smallest imperial volume in the whole British imperial system is the minim, a unit in the apothecary system, which is 59.2 microlitres. The largest imperial volume in the imperial system is called the last (yes, "last", this is not a typing error), which is 2909.4976 litres. If we assume that we are using litres for volume rather than a variant of square metres, the the smallest volume in the metric system is the yoctolitre (10^{-24} litres) and the biggest volume is the yottalitre (10^{24} litres). Remember that the litre is exactly the volume of a cubic decimetre.

The smallest unit of mass in the avoirdupois, troy and apothecary systems, which are all part of the British imperial system, is the grain. This unit is the same in all 3 systems and is equivalent to 64.79891 milligrams. The largest imperial unit in the troy and apothecary systems is the troy pound and the apothecary pound respectively and both are equivalent to 373.2417216 grams. In the British version of the avoirdupois system, the largest imperial unit is the ton, which is equivalent to 1016.0469088 kg. In the metric system, the smallest unit of mass is the yoctogram (10^{-24} grams) and the biggest unit of mass is the yottagram (10^{24} grams). This is far bigger by astronomical proportions than the biggest unit of mass the imperial system.

Whether you are working with lengths, volumes, mass or any of the other physical quantities in the metric system, the very large range of SI prefixes from yocto- (10^{-24}) to yotta- (10^{24}) can be used with metric units and covers every conceivable human activity and there is always one that is sufficiently large or small for your tasks. This range is far greater than anything found in the imperial system. Nothing in the imperial system comes close to this range. The range of the imperial system is very limited at both ends of the scale. Another advantage of the design of the metric system is its scalability. If the range is found to be insufficient sometime in the future, the set of SI prefixes can always be extended at both ends of the scale.

Awkward Calculations with Multiple Imperial Units

When you use two or more imperial units together, it is awkward to do calculations with them. To prove this point, try to do the following calculations:

1. Person A weighs 14 st 2 lb, Person B weighs 12 st 8 lb and Person C weighs 13 st 1 lb. What is their average weight?
2. What is the area of a room whose length is 14 ft 7 in and whose width is 11 ft 9 in?
3. What is a mile divided by 3 in furlongs, chains, yards, feet and inches?
4. How many 4 and $^{3}/_{16}$ inch pieces of wood can you cut from a 6 foot plank of wood?

The first thing that you will need to know is the conversion factors between the various imperial units. Then you will need to convert all the different units used in any of these calculations into a single unit. Then you will need to do the usual addition, subtraction, multiplication and division,

depending on what you need to calculate, to get the result. Then you will need to convert the result into the different imperial units to get the answer. Why should such simple problems in the given examples be so complicated to work out? Why should something so simple require so many steps?

Let us look at the given examples in the equivalent metric units and see how we work them out:

1. Person A weighs 89.8 kg, Person B weighs 79.8 kg and Person C weighs 83 kg. What is their average weight?
2. What is the area of a room whose length is 4.45 m and whose width is 3.58 m?
3. What is 1609 metres divided by 3 in metres, centimetres and millimetres?
4. How many 10.6 cm pieces of wood can you cut from a 1.83 m plank of wood?

For all these metric calculations, you just need to get a calculator and do the usual addition, subtraction, multiplication and division to get the result.

For Question 1, you just need to add up the weights of all three people then divide the result by 3.
For Question 2, you just need to multiply the length by the width to get the result.
For Question 3, you need to divide 1609 by 3. That gives you 536.333 metres to 3 decimal places. To express that in metres, centimetres and millimetres, take the integer part of the number to express the number of metres, take the first two digits after the decimal point to express the number of centimetres and take the third digit after the decimal point to express the number of millimetres. That gives you 536 m, 33 cm and 3 mm.
For Question 4, move the decimal point two places to the right to get the number of centimetres, which gives you 183 cm, then divide that figure by 10.6 to get your answer.

As you can see, calculations with metric units are much simpler than calculations with imperial units. Also, the metric system fits well with the decimal number system that we use every day because the entire metric system is based on powers of 10. This can clearly be seen in the calculations for Questions 3 and 4.

Use of Imperial Often Requires Fractions

Take a look at any dual ruler or measuring tape. Typically, one side will show centimetres divided into ten units, which represent millimetres, and the other side will show inches divided by a particular number of units. On the imperial side, the inches are normally divided into eighths or sixteenths. It is frequently necessary to work with eighths or sixteenths when using inches because there is no smaller convenient unit to use for DIY or building work in the imperial system.

When you need to perform calculations with these fractions, calculators will not be any use to you because calculators work with decimals, not fractions. Before you do any calculations with your calculator, you will need to convert the fractions into decimals first. Trying to do mental calculations with fractions is awkward. In addition to the problems with fractions, the use of fractions with different denominators (e.g. some figures with eighths and others with sixteenths) makes life harder and obscures clear comparisons with fractions of different sizes.

It is possible to use fractions with the metric system but it is normally unnecessary because the millimetre is normally a sufficiently small unit for building and construction and DIY jobs around the house. If you need greater precision for engineering projects, there are smaller metric units available. For such tasks, the metric system offers far greater precision than you will ever need. Another advantage of the metric system is that to convert between any multiples or submultiples of the metre, you only need to move the decimal point a certain number of places to the right or to the

left.

Anyone who does precision work with inches (not common these days), decimalises the inch and uses the mil unit, thousandths of an inch, for their work. Construction and building work in the UK is predominantly metric. British building regulations require the use of the metric system. By dividing the inch into a thousand units, the imperial system has borrowed the idea from the metric system. Unfortunately, the smaller mil unit is too small to be seen by the naked eye on rulers and measuring tapes so imperial users of these measuring instruments are forced to use fractions of an inch for their work because the inch does not offer enough precision.

Lack of Integration between Imperial Systems

The British imperial system is only a system in name. It cannot really be described as a system in any meaningful sense because it contains a collection of unrelated systems that developed independently for unrelated purposes.

In the metric system, there are only 7 base units and all other units in that system are derived from those 7 base units. Thus there is a clear relationship between the litre and the metre. The litre is a non-SI unit that is approved for use with SI. The litre is officially defined as one cubic decimetre exactly. A litre of pure water at a particular temperature weighs exactly one kilogram. Similar, the hectare, another non-SI unit approved for use with SI, is a special name for a square hectometre. Another way of expressing the area of a hectare is a 100 metre by 100 metre square or 10 000 square metres.

Let us try to look for similar relationships in the imperial system. What do we find? The British imperial pint is roughly 34.7 cubic inches. An acre is an area of 4840 square yards or 43 560 square feet, which is equivalent to a rectangle whose length is one furlong and whose width is one chain (i.e. 220 yards x 22 yards). There is a similar problem with the rood. The rood is an area of 1210 square yards or 10 890 square feet, which is equivalent to a rectangle whose length is one furlong and whose width is one rod (i.e. 220 yards x 5.5 yards). With such awkward relationships between the pint and acre and the imperial units of length, it is clear that the pint and acre developed independently from the imperial units of length, some of which are of Roman origin and others of Anglo-Saxon origin. No wonder they have such awkward conversion factors.

In the imperial system, there is no common base units from which all other units are derived, unlike the metric system. Even within the 3 imperial systems for mass (avoirdupois, troy and apothecary), there are awkward relationships between the units in different systems. The pounds and ounces in the troy and apothecary systems have an awkward relationship to the pounds and ounces in the avoirdupois system. They represent different weights and have different relationships within these systems (i.e. 16 oz = 1 lb in the avoirdupois system, 12 oz = 1 lb in the troy and apothecary systems). In the various imperial systems of length, we find an awkward relationship between the foot and the fathom (6.08 feet = 1 fathom) and the inch and the link (7.92 inches = 1 link).

There is no obvious relationship between the imperial systems of length, volume and mass. Another problem is that there are 3 systems for mass, 3 for length and several for volume when the old commodity measures for alcoholic drinks are included. When you compare the imperial systems for length or the imperial systems for volume or the imperial systems for mass, you find that there are units in one system that do not exist in the other. These are comparisons between systems that measure the same physical quantity. Even where there are units with the same names in systems that measure the same physical quantity, they do not always represent the same quantities or have the

same relationships. For example, compare avoirdupois pounds and ounces with troy/apothecary pounds and ounces. They represent different quantities and there are different relationships between these units.

These points only cover the problems within the British imperial system and do not cover the awkward differences between the British imperial system and the US customary system (the American version of the imperial system), making large parts of these systems incompatible with each other.

Need to Learn Each Imperial System Separately

Learning one of the systems that make up the British imperial system will not help you when you need to learn another one as each system needs to be learned separately. For example, you cannot know how the troy and apothecary systems work by learning the avoirdupois system. Those other systems need to be learned separately. Nor will learning the avoirdupois system provide with the knowledge to use any of the imperial systems for length, area or volume.

To learn how the entire metric system works, you just need to learn the system of SI prefixes and how they are used with metric units. Once you learn that, you can apply that to the metre, the litre, the gram, the joule and the watt and to other metric units that make up the metric system. For each new system, you just need to know the name of the base unit. Unlike the imperial system, there is no need to learn new names, new multiples or conversion factors. There is a consistent relationship between the base units and the SI prefixes, no matter which unit you are using, and there are no conversion factors between them.

Need to Know Conversion Factors to do Imperial Calculations

Frequently, it is necessary to use two or more imperial units to express a given quantity. In order to do calculations with quantities that contain more than one imperial unit, you need to know the conversion factor. You might not just need to know the conversion factor between one imperial unit and next smallest or the next biggest unit. You might also need to know the conversion factors between any two conversion factors in the same system (e.g. pounds in a ton, yards in a chain, feet in a furlong, ounces in a stone, etc.) if you have quantity that uses that combination of units, which is possible in the imperial system. You either have to know the conversion factors or work out the conversion factor from the conversion factors of the intermediate units.

Now compare that to the metric system. You can identify a metric unit itself when there is no prefix affixed to a metric unit. When there is a prefix affixed to a metric unit, that prefix always has the same meaning throughout the metric system. As each prefix is known and means the same thing throughout the metric system, it is easy to work out how many millimetres there are in a centimetre or how many megahertz there are in one gigahertz, for instance.

No Way of Knowing Relationships between Units by their Names

Take a look at the names of any imperial units you can think of. Their names give you no information about their relationships with other imperial units. You either know how many of imperial unit X are in imperial unit Y or you don't. What is worse is the fact that the relationships can be different depending on which system you are using or even which country you are in.

For example, there are 16 ounces in a pound in the avoirdupois system and 12 ounces in a pound in the troy and apothecary systems. A pint contains 20 fluid ounces in the British imperial system and only 16 in the US customary system. A gallon contains 160 fluid ounces in the British imperial system and only 128 in the US customary system. What makes this situation worse is the fact the the units themselves represent different quantities in these different systems.

Now compare that with the metric system. If a unit name contains no prefix, then this represents the unit itself (e.g. the term “metre” represents one metre). If a unit name contains a prefix, that prefix always means the same thing, no matter where it is used in the metric system (e.g. centi- always means one-hundredth and kilo- always means a thousand. Thus centimetre means one-hundredth of a metre and kilogram means one thousand grams).

Lack of International Standards and Symbols

The imperial system lacks international standards. Unlike the metric system there is no international body to co-ordinate the development of the imperial system, which stopped evolving about 200 years ago. The British and Americans use imperial systems that contain English units as their common basis but they both went their own way in its development and now have their own versions of the imperial system. Though they have many features in common such as identical units of length, many parts of their systems are different such as volume measures and different quantities of avoirdupois units that are bigger than the avoirdupois pound. The 1824 Weights and Measures Act standardised British weights and measures and unified dry and liquid measurements. As its name suggests, the British imperial system was developed for trade with countries that were part of the British Empire. The 1824 Act ensured that there was a standard set of weights and measures for use throughout the British Empire. By that time, the American colonies were already independent and did not adopt the reforms that were taking place in the UK and stuck to the older measures and developed some measures that were unique to the American customary system such as the US pint and US gallon.

Unlike the metric system, there are no international language-independent symbols for imperial units. For example, the symbol for the metre is “m”, which is internationally recognised and is independent of language. By contrast, there is no symbol for the yard and various English abbreviations are often used for the yard. As road signs in Wales must be bilingual by law, wherever the word “yards” is used on a Welsh road sign, the Welsh word for yards, “llath”, must also be used. Other abbreviations for imperial units such as “in” for inch, “ft” for feet are language-specific (i.e. specific to English) and so are “cwt” for hundredweight. In that abbreviation, the “c” stands for “centum”, the Latin word for a hundred.

Before 1959, the UK, the US and Commonwealth countries had slightly different measurements for various imperial units such as the yard. In 1959, the US and the Commonwealth of Nations agreed to standardise all imperial measurements and fixed their values in terms of the metric system. For example, the international yard is now exactly 0.9144 metres and the international avoirdupois pound is exactly 0.45359237 kilograms (or 453.59237 grams).

No Imperial Units for Electricity, Magnetism or Radiation

It is not surprising that the imperial system does not cover electricity, magnetism or radiation as it stopped evolving about 200 years ago. Although the definitions of the imperial units have been modified slightly since then, the fundamental structure of the imperial system stopped evolving

since the 1824 Weights and Measures Act. Even the most ardent opponents of the metric system and defenders of the imperial system are forced to use the metric system for electricity, magnetism or radiation because there are no imperial equivalents for them. The imperial system has no equivalent units for the volt, ampere and ohm. Watts are used for measuring electricity consumption and are used for products like light bulbs. For that, there is no imperial equivalent.

Too Many Systems

As long ago as 1862, the Select Committee On Weights And Measures published a report that identified no fewer than 10 different measurement systems in use at the time. The report stated that most of these were established by law. Remember that the British imperial system was introduced in 1824 by the Weights and Measures Act that was passed at the time. The use of so many different systems was a problem of the British imperial system (and still is). This booklet has described 8 different systems within the British imperial system, three for length, two for volume and three for mass. That Committee seriously considered a switch to the metric system as that system addressed the problems with the myriad measurement systems in use. As long ago as 1215, the Magna Carta document declared that there should be one weight and one measure throughout the realm.

The report identified and listed the following different systems in use at the time:

1. Grains, computed decimally, used for scientific purposes.
2. Troy weight.
3. Troy ounce, with decimal multiples and divisions, called bullion weights.
4. Bankers' weights, to weigh 10, 20, 30, 50, 100 and 200 sovereigns.
5. Apothecaries weight.
6. Diamond weights and pearl weights, including carats.
7. Avoirdupois weight.
8. Weights for hay and straw.
9. Wool weight, using as factors, 2, 3, 7, 13, and their multiples.
10. Coal weights, decimal.

That did not include the numerous anomalies with the measurement system at the time. The problems with multiple measurement systems were identified as far back as 1862 but the imperial system fails to address this problem as it is not really a proper system in the true sense but a collection of unrelated systems that were developed for unrelated purposes. The defenders of the imperial system fail to acknowledge this problem.

By contrast, the metric system is a proper, coherent, integrated system that is suitable for all purposes and contains one unit for each physical quantity.

Ambiguous Names

The name of a particular imperial unit can mean so many different quantities. For example, a gallon can mean a British imperial gallon (4.546 litres), a US dry gallon (4.404 litres), a US liquid gallon (3.785 litres) or any of the obsolete gallons that have ever existed. Have you noticed why it is possible to give the metric equivalent in litres for comparison? It is possible to express these quantities in litres because the definition of a litre is clear and unambiguous. It is defined as the volume of a cubic decimetre. No metric unit ever has more than one definition at any one time. Each unit in the metric system only contains one definition. The fundamental base units of the metric system have contained the same quantities ever since the metric system was invented. They

have just been defined with greater and greater accuracy. For these reasons, it is possible to fix the values of all old and new measurements in terms of the metric system. All old and new measurements still in use are now defined in terms of the metric system. All metric units represent the same quantity worldwide unlike imperial units, which often represent different quantities in the US and UK. Also, some imperial units represent different quantities, depending on which system is being used (e.g. pounds and ounces in the avoirdupois system contain different quantities compared to pounds and ounces in the troy and apothecary systems). In some cases, an imperial unit represents a different quantity based on where it is used. For example, a mile can mean a Roman mile of 1000 paces by a Roman legion, the international statute mile of 1609.344 metres, a US survey mile of 1609.3472 metres, a nautical mile used at sea and in aviation or any one of the historical miles used in various countries in Europe. Multiple definitions for imperial units with the same name hinders honesty and transparency and can lead to inefficiency, waste, confusion and increased costs.

Particular Units exist in Some Systems but not in Others

In the imperial system, there are units that exist in some systems but not in others for measuring the same physical quantity. Take another look at the following table for the imperial systems of length that was shown earlier in this booklet:

General	Maritime	Gunter's Survey
1000 mil= 1 inch 12 inches = 1 foot 3 feet = 1 yard 5.5 yards = 1 rod * 4 rods = 1 chain 10 chains = 1 furlong 8 furlongs = 1 mile 3 miles = 1 league	6.08 feet = 1 fathom 100 fathoms = 1 cable 10 cables = 1 nautical mile	7.92 inches = 1 link 25 links = 1 rod * 4 rods = 1 chain 10 chains = 1 furlong 8 furlongs = 1 mile

* The rod is also known by the unit names, “pole” and “perch”.

As you can see, there are units that are used in one system that are not used in the other systems. Despite the fact that all these units measure the same physical quantity, this is common throughout the imperial system. It also hinders direct and clear comparisons between the units in the different systems in the table. Now don't say that you do not need to convert between units. If that were true, conversion tables would not exist as there would be no need for them.

The same can be said for the imperial systems for volume and mass. To some extent, this is also true for the different versions of parts of the imperial system between the UK and the US. For example, the stone and the fluid scruple do not exist in the US customary system. This all just makes the imperial system needlessly complicated.

Compare this situation with SI. In SI, there is only one unit for measuring each physical quantity and that unit is used with the same standard set of SI prefixes that is used throughout the metric system.

Limited Use of Certain Units

Some imperial systems are maintained for only very limited purposes. For example, the troy system is kept for the sole purpose of measuring precious metals. The only part of the troy system that is still used is the troy ounce for metal prices. The troy system is used for measuring mass, like the kilogram. Why should we keep a whole system for such a limited purpose? It means that everyone who wants to buy or sell precious metals (i.e. gold, jewellery, etc.) needs to learn this system. The kilogram and its related multiples and submultiples can be used for precious metals as the metric system is suitable for all purposes.

Similarly, the stone is only used for body weight. Apart from its use for measuring body weight, it is a completely redundant unit. Whenever stones are used, you almost always have to use pounds because measuring weight to the nearest stone for this purpose is too inaccurate and is no good. As mentioned before, using multiple imperial units together makes it hard to use in calculations. Again, it would be better to use the kilogram for this task and avoid the need to learn to use another system for such a limited purpose. Another disadvantage of using stones is that it does not exist in the US customary system and Americans weigh themselves only in pounds, never in stones.

If the metric system were used for measuring body weight and precious metals, only one system would be necessary. Only the kilogram and related units would need to be used, which are already used for a wide range of measurements. Thus we could eliminate the troy and avoirdupois systems. Instead of using three systems for measuring mass (and weight), we could just use one. That would make all our lives easier.

Similarly, British imperial gallons are often used to express fuel efficiency in the miles per gallon measure. There is already the official litres per 100 km fuel efficiency measure. If only that measure were used, we could forget about gallons and their conversion factors. Given that petrol is only sold in litres in the UK, if you do not know how many litres there are in a gallon, you cannot use the fuel efficiency measure to work out how much petrol you need to buy to drive a certain distance. Many British drivers may think that they understand imperial gallons. How many of them will know how many cubic inches or cubic feet there are in an imperial gallon?

Descriptions of cars often include the horsepower measure and descriptions of heaters often include British thermal units. For these descriptions, the watt can be used instead. This unit is already used for electricity. If we eliminated horsepower and British thermal units, this means that we can forget about them. Wouldn't it be much easier to use one system that offers clear and transparent comparisons between products rather than the three that we use now? How many British people know the conversion factors between British thermal units, horsepower and watts?

We make our lives needlessly complicated by keeping so many systems for such limited purposes when the metric system can be used for all purposes and meet all our needs. As a consequence, we either end up being ignorant about the measurements that we use and that undermines maths and science education where measurement skills are essential or we end up wasting so much time learning obsolete measurement systems that offer the UK no advantage but waste our time and money when these same scarce resources can be used more productively for learning other things. In the last few decades, there has been a world-wide move to the metric system. In the long term, imperial measurements are doomed. We do ourselves no favours by trying to hold on to them for as long as possible.

Permanent Divisions with US in Imperial Measurements

The British imperial system was created by the 1824 Weights and Measures Act. As its name suggests, it was developed for trade within the British Empire. However, the creation of the British imperial system created permanent divisions with the US in imperial measurements and they have never been the same since. Since 1824, there has been a long ton and a short ton, a long hundredweight and a short hundredweight and all volume measurements were never the same again. The long designation for the ton and the hundredweight refer to the British quantities of these units whereas the short designation for the ton and hundredweight refer to the American quantities of these units. Some imperial units with the same names in the US are substantially different in size compared to the British versions. For example, the US ton, hundredweight, gallon and pint are substantially smaller than the British versions. To make matters more complicated, the Americans maintained separate dry and liquid measures whereas the British unified them in 1824.

Where there have been slight differences in definitions between imperial units (e.g. avoirdupois pound, yard and related units of length), it was possible to standardise them and fix them in terms of the metric system. That was done in 1959 by agreement between the US and the Commonwealth of Nations. However, there are fundamental differences between the British imperial system and the US customary system. These will remain. There is no hope of uniting these two systems. The only time when the US and the UK will be using the same set of measurements for everything is when both countries complete their transition to the metric system, which is the same worldwide.

Defenders of the imperial system often argue that we should continue to use imperial because the US is the most powerful nation on earth and uses the imperial system. They ignore the fact that the US customary system, the American version of the imperial system, is incompatible with the British imperial system, metric usage in the US is on the rise, the metric system is officially the preferred measurement system for US trade and commerce, the Americans have got a Metric Program run by NIST to encourage greater use of SI in government and in business and British imperial measurements are no use in American dual labelling requirements where they differ from US customary units. The UK has been moving to the metric system but progress has stalled. The US is trying to move to the metric system and at least they are making progress, even though it is slow progress. Some anti-metric campaigners are blocking further moves toward the metric system in the UK while pointing to US use of imperial measures. However, if the Metrication Programme is stalled for too long in the UK, there is a chance that the US could complete metrication before the UK.

Unlike the imperial systems in use in the US and the UK, the metric system is exactly the same in all countries. That means that the metric system is also the same in both the US and the UK.

Imperial works badly with Decimals

The relationship between most imperial units is not based on powers of 10. Thus the imperial system does not work well with decimals. Working with decimals in the imperial system often involves using a single unit and ignoring other units within the same system or just decimalising the smallest unit when a combination of units is used.

Take the imperial measurements of body weight and height as examples of the poor relationship between imperial and the decimal number system. When people give their weight in stones and pounds and their height in feet and inches, they normally give you their weight rounded off to the nearest whole pound and their height to the nearest inch. Thus imperial body weight and height are

normally expressed with two whole numbers in both cases and the use of decimals is ignored. The relationship between stones and pounds and between feet and inches does not fit with the decimal system. In either case, switching between the use of decimals and the imperial units would require conversions in both directions.

In the metric system, a figure such as 1.854 metres can easily be converted into 1 metre, 85 centimetres and 4 millimetres. Here, you can clearly see that the same digits are being used by breaking down the figure of 1.854 into three figures: 1.0, 0.85 and 0.004 then converting the last two figures by simply moving the decimal point two places to convert from metres to centimetres and three places to convert from metres to millimetres. Thus, it is clear from this example and from many others that the metric system works very well with the decimal number system that we use every day. The reason why the metric system fits so well with the decimal number system is that the entire metric system is based on powers of 10 and the decimal number system is a base 10 system. Both use 10 as their base.

Multiple Units are often needed to express Measurements

Whenever body weight or height is expressed in imperial units, two units are normally used. For weight, the units used for children and adults are stones and pounds and the units used for babies are pounds and ounces. For height, feet and inches are used. For giving information about people's weight and height, the information may be useful until you try to use these imperial measurements for doing calculations. Before you can use them in a calculator, you need to convert them into single decimal figures. That would pose a dilemma about which imperial unit to use for the conversion.

When body weight or height is expressed in metric units, only one figure is needed. Kilograms are used for weight and metres are normally used for height. These figures can be used straight away in calculations. They are instantly ready to use in calculators.

Lack of Scalability

The design of the imperial system makes it hard to extend it on either end of the scale without increasing its complexity. Even if new multiples and submultiples were based on powers of 10, they fit poorly with the rest of the imperial system. Decimalising parts of the imperial system does not solve its problems. For example, the use of the mil, which is one-thousandth of an inch, is an idea borrowed from the metric system but that does not make it any easier to use imperial units of length as you still have the same problems with myriad multiples as well as the multiples of 10, 100 and 1000. You will still need to work with all kinds of multiples that exist in the imperial system. Any extension to the imperial system cannot solve its lack of consistency and random sequence of multiples.

In the metric system, you can start with the smallest submultiple and consistently multiply that by 1000 repeatedly until you end up with the biggest multiple. Apart from the quantity that represents the base unit, there is an SI prefix that represents a submultiple or multiple at each stage. For example, let us use the example of the metre to prove this point and start with the smallest submultiple of the metre and multiply that by 1000 at each stage until we reach the biggest multiple. We get the following result:

1 yoctometre, 1 zeptometre, 1 attometre, 1 femtometre, 1 picometre, 1 nanometre, 1 micrometre, 1 millimetre, 1 metre, 1 kilometre, 1 megametre, 1 gigametre, 1 terametre, 1 petametre, 1 exametre, 1

zettametre, 1 yottametre

As you can see, consistency is at the heart of the metric system and if there is any future need to extend it at either end of the scale, we can predict that new multiples and submultiples of 1000 will be used to maintain its consistency. The relationship between each quantity in the sequence above and its adjacent quantities is based on multiplying and dividing by 1000. There is nothing like this in any part of the imperial system.

Proof of the scalability of the metric system can be seen by the past extension of the system of SI prefixes to meet new demands for greater precision in measurement. At the twelfth General Conference on Weights and Measures (*Conférence Générale des Poids et Mesures*, CGPM) in 1964, the femto (10^{-15}) and atto (10^{-18}) prefixes were added. At the fifteenth CGPM in 1975, the peta (10^{15}) and exa (10^{18}) prefixes were added. At the nineteenth CGPM in 1991, the zetta (10^{21}), zepto (10^{-21}), yotta (10^{24}) and yocto (10^{-24}) prefixes were added.

Long Time to Learn and Burden of Memorisation

For imperial lengths, there are units called the mil, inch, link, hand, foot, yard, fathom, rod, chain, furlong, cable, mile and league.

For imperial volumes, there are units called minims, fluid drams, teaspoons, tablespoons, cubic inches, fluid ounces, gills, cups, pints, quarts, gallons, pecks, cubic feet, bushels, cubic yards and cubic feet. That does not include all the commodity measures of volume for alcoholic drinks.

For imperial mass, there are units called grains, apothecary scruples, pennyweights, drams, apothecary drams, ounces, apothecary ounces, apothecary pounds, avoirdupois pounds, short hundredweights, long hundredweights, short tons and long tons.

None of these lists is comprehensive. There are others that can be added for imperial units for length, volume and mass. The list of imperial volumes does not even take into account all the different UK and US definitions of units that share the same name or the separate US dry and liquid measures that share the same name. The relationships between these units are awkward and combinations of these different units often have conversion factors that are peculiar and hard to remember. For users of the imperial system, there will be occasions when conversions are needed otherwise conversion tables would not exist. It takes time to learn all these different units and how they relate to one another. Just look at any conversion tables that show all combinations of units between the same physical quantity to see how complex the imperial system is.

Not only does it take time to learn all the different units and their conversion factors, it also takes time to learn how to perform calculations with them.

Compare that with SI, which contains only one unit for each physical quantity and uses a standard set of SI prefixes. These prefixes that can be used with many different units within the metric system instead of all kinds of conversion factors that must all be learned separately. Once you learn how the set of SI prefixes works with metric units, that can be used throughout the metric system because the prefixes are the same no matter where they are used in that system.

Accuracy of Imperial Units depends on the Metric System

Did you know that all imperial units still in use have been defined in terms of the metric system since 1959? In 1959, the US and the Commonwealth of Nations agreed on common definitions for all the imperial units still in use at the time and all these definitions were based on the metric system. For example, the yard was fixed at 0.9144 metres exactly and the avoirdupois pound was fixed at 0.45359237 kilograms exactly.

Since then, this means that the accuracy of the imperial system depends on the accuracy of the metric system. Defenders of the imperial system may argue that imperial measurements are now just as accurate as metric measurements. The argument that the imperial system is accurate because the metric system is accurate hardly inspires confidence in the imperial system.

Anti-metric campaigners who condemn the metric system and defend the imperial system conveniently ignore the fact that the system that they support is defined by the one that they condemn. SI is now the standard by which all other measurements, old and new, are defined.

Confusion from Too Many Non-Metric Systems with the Same Units

The UK is not the only European country that has used pounds and ounces. Nor is it the only one that has used feet and inches. These measurements were widely used in many European countries before they moved to the metric system. Despite their use of these measurement units and their use of the same unit names, these units differed in quantity from one country to another. So whenever the unit names, “pound”, “ounce”, “foot” or “inch”, are mentioned, they can mean so many possible quantities, given the number of historical definitions they have.

Obviously, these are not the only imperial units that were used in other European countries but they are being used here to prove the point that the existence of so many definitions for these units causes confusion and ambiguity. If someone uses a recipe from the distant past, say one that is 300 years old, and came across these units, there would be a problem knowing which definition was meant. Even within the UK, if you found an historical recipe from the eighteenth century, there would be difficulty in knowing which quantity was meant by “ounce” or “pound” as weights were only standardised in the nineteenth century with the passing of the 1824 Weights and Measures Act that introduced the British imperial system. The 1862 Report from the Select Committee on Weights and Measures mentioned that, “If you buy an ounce or pound of anything, you must inquire if it belongs to Dutch, troy, or avoirdupois weight.” and that does not take into account all the different national definitions of pounds and ounces.

Imperial weights differed between countries. In some cases, they differed within countries. Where they represented different quantities in different periods in history, the most recent pre-metric value is used in the table. The first table shows the differences in the quantities of a pound and an ounce across Europe. Part of the first table was left blank either because the relevant unit was not used in that country or because of lack of information. The second table shows the differences in the lengths of the foot and inch (or their equivalents) across Europe.

Historical Mass Measurements in Europe				
Country	**Pound**		**Ounce**	
	Local Name	**Quantity**	**Local Name**	**Quantity**
Denmark	pund	499.75 g	unse	30 g
France	livre	489.5 g	once	30.59 g
Ireland			unga	28 g
Malta			uqija	26.46 g
Netherlands	pond	470 to 494 g	ons	30 g
Norway	pund	498.4 g		
Portugal	libra	459 g	onça	28.6875 g
Spain	libra	460 g	onza	28.75 g
Sweden	skålpund	425.07 g		

Sources: Wikipedia (see bibliography for details of Wikipedia sources) and http://www.rabbel.nl/Olddumes.html

Historical Length Measurements in Europe				
Country	**Foot**		**Inch ***	
	Local Name	**Quantity**	**Local Name**	**Quantity**
Denmark	fod	31.385 cm	tomme	2.6154 cm
Finland	jalka	29.69 cm	tuuma	2.474 cm
France	pied	32.48 cm	pouce	2.707 cm
Germany	Fuß	23.51 to 40.83 cm	Zoll	$^1/_{12}$, $^1/_{11}$ or $^1/_{10}$ foot
Ireland	troighid	25 cm	ordlach	2.1 cm
Malta	xiber	26.19 cm	pulzier	2.183 cm
Netherlands	voet	27.19 to 30.14 cm	duim	2.575 to 2.6162 cm
Norway	fot	31.374 cm	tomme	2.61 cm
Portugal	pé	33 cm	polegada	2.75 cm
Spain	pie	27.86 cm	pulgada	2.322 cm
Sweden	fot	29.685 cm	tum	2.96 cm
Turkey	ayak / kadem	37.887 cm	parmak **	3.157 cm

Sources: Wikipedia (see bibliography for details of Wikipedia sources) and http://www.rabbel.nl/Olddumes.html

* In many countries, the equivalent unit for the inch is called a “thumb” in the local language.
** “parmak” is the Turkish word for finger. This is the Turkish equivalent of the inch.

Compare these values for pounds and ounces with the value used in the UK today for the avoirdupois pound (approximately 453.6 grams) and avoirdupois ounce (approximately 28.35

grams). Also, compare these values for feet and inches with the value used in the UK today for the foot (exactly 30.48 cm) and inch (exactly 2.54 cm). None of the other countries in either table used the same definition of the pound, ounce, foot or inch that we use in the UK today. Each country in these tables had unique versions of non-metric systems for length and mass. The one thing that all countries that use the British versions of these measurement units have in common is that they are all former British colonies. None of the British units is compatible with the same units which were once used in those other European countries. If you use these unit names in conversations with other Europeans, they might think of these units in terms of their historical definitions in their own country. Why would you expect them to assume that they refer to the British measurements?

The metric system was developed in response to the problems of all these non-metric systems. One of the main problems with them was the differences in quantities between different places, different systems and different periods. Contrary to popular media and public perception, pounds and ounces are not British nor are feet and inches. In fact, they are Roman. Both the words for “inch” and “ounce” come from the Latin word “uncia”, which means one-twelfth part. This reflects their role in the Roman system of weights and measures where there were 12 ounces in a Roman pound and 12 inches in a foot. The abbreviation commonly seen for pounds for pricing fruit and vegetables, “lb”, comes from the Latin word for pound, “libra”.

Ever since the development of the metric system from the late eighteenth century, all the SI base units have represented the same quantities. Changes in their definition did not alter those quantities but defined them more accurately. These units are the same all over the world, regardless of what is being measured. Nobody could be in any doubt what quantities you are talking about when you use grams and kilograms, millimetres, centimetres and metres.

The UK is now totally isolated in the whole of Europe in holding out for the continued use of the old measurements. The rest of Europe have abandoned the old measurements and is now fully metric. The only other country that used the old measurements was the Republic of Ireland. The Republic of Ireland completed its transition to the metric system when it completed the conversion of all its road signs in January 2005. We have done this to ourselves and we do ourselves no favours by wasting resources on the operation of a dual measurement system and continuing to use an inferior measurement system for no obvious reason.

Doomed Legacy System – No Future

The imperial system stopped evolving around 200 years. In its fundamental structure, it has been the same since the 1824 Weights and Measures Act. The international agreement between the US and the Commonwealth of Nations in 1959 to standardise imperial measurements such as the pound and the yard consolidated its status as a legacy system.

As it stopped evolving so long ago, it lacks measurement units for modern phenomena such as electricity, magnetism and radiation. The range of units has barely changed since 1824, which makes it incapable of measuring the extremely large or the extremely small.

Long ago, it was used for trade between Commonwealth countries. Now, all major Commonwealth countries except the UK and Canada have completed their transition to the metric system. Its use in international trade, which is now predominantly metric, is now limited. The British imperial system was developed to ensure a common system of weights and measures within the British Empire. That raison d'etre has disappeared long ago. Even the US, the only developed country that has not officially adopted the metric system, is trying to move to the metric system. Hence, NIST runs the

US Metric Program to encourage American businesses and government agencies to use SI.

It is not even useful for trade with the US because they do not measure like we do. For instance, their ton, gallon and pint are all smaller than ours. If imperial units were used in Anglo-American trade, which versions of these units would be the standard for trade or would both be used? Neither the UK nor the US can be expected to use imperial units in trade that they do not legally recognise. Clearly, any attempt to use both versions in trade with the US would cause confusion, misunderstanding and mistakes.

The imperial system is now mainly confined to domestic use. It is used for road signs, the sale of draught beer and cider and bottled milk, trade in precious metals and supplementary indications on product labels. Its use is also accepted in limited areas by international agreement, such as the use of feet for altitude in aviation. In the long term, the imperial system is doomed. Given the worldwide move to the metric system, its demise is only a matter of time.

The metric system continues to evolve and is governed by international organisations. Its continued development is a truly international effort. The metric system is capable of meeting our present and future measurement needs. The metric system is designed to meet the world's ever-increasing demands for more precise measurements. Six of the seven SI base units are now defined by constants of nature and it is only a matter of time before the kilogram, the only remaining base unit defined by a physical artefact, is redefined by a constant of nature. Scientists are currently working on a redefinition of the kilogram.

Lack of International Support and Recognition

In many countries, not only is the imperial system not recognised, it is also unknown. The imperial system is now confined to the US, the UK and a few Commonwealth countries. There are no international bodies to set international standards and develop the imperial system, which stopped evolving about 200 years ago. This was a problem from the beginning. Hence, the US and the UK use English units as the basis of their imperial measurement systems and went their own separate ways in developing their own standards. That is why many unit names used within the US Customary System and the British imperial system represent different quantities. That is also why many US unit names often represent different quantities for dry and liquid measures whereas there is no distinction between dry and liquid measures in the British imperial system.

From the beginning, the development of the metric system was a truly international effort. No single nation was responsible for its complete development. The development of a decimal-based measurement system started over 200 years before its adoption in France. The following time-line from the first proposal to the development of the modern metric system, officially called the International System of Units (*Système International d'Unités* or SI), shows the international contributions to its development.

Year	Event
1215	Magna Carta requires "one measure" of wine, corn and cloth throughout the realm; and similarly for weights.
1585	Simon Stevin of Flanders (now Belgium) published a book called “De Thiende” (The Tenth) in which decimals were introduced in Europe.
1668	Bishop John Wilkins of England published a paper called “Essay towards a Real Character

	and a Philosophical Language", which included a proposal for a decimal measurement system.
1670	Gabriel Mouton of France suggested that a new measurement system could be based on natural phenomena. He repeated many of the suggestions that John Wilkins made two years earlier.
1740	César-François Cassini de Thury of France undertook a geometrical survey of the whole of France to determine the size of the earth. The distance from the pole to the equator was the basis of the original definition of the metre in the metric system.
1780	James Watt of Scotland suggested that a decimal system should be the basis for a new measurement system.
1790	Thomas Jefferson of the US submitted a report called "Plan for Establishing Uniformity in the Coinage, Weights, and Measures of the United States" to the US House of Representatives. That report suggested a decimal currency for the US and a decimal measurement system based on the foot.
1790	Marie Jean Antoine Nicolas de Caritat Condorcet of France asked Charles Maurice de Talleyrand-Perigord to propose a new decimal-based measurement system to the French National Assembly. Condorcet proposed a system that was based on a length from nature with decimal submultiples. All measures in that system, including area, volume and weight, would be based on the unit of length. The French National Assembly adopted the proposal but, assuming that the new metric system would be fully international, agreement was sought from many other countries.
1790	French National Assembly sends delegates to the UK, Spain and the US to propose cooperation in units of measurement. Cooperation is rejected by the UK.
1791	Jean Charles de Borda, Chairman of the French Commission of Weights and Measures, resolved the pendulum problem by proposing that the new standard length be $^{1}/_{10\,000\,000}$ of the distance from the pole to the equator of the Earth. This, despite some resistance, became the first standard for the metre.
1792 / 1798	Delambre and Méchain measured the length of the meridian between Dunquerque in France and Barcelona in Spain so that they could accurately estimate the distance from the equator to the North Pole.
1793	Borda, Lagrange, and Laplace computed a provisional value for the metre based on the survey carried out by Cassini de Thury in 1740. The metric system was passed into law by the French National Assembly and a metre bar together with a kilogram mass were dispatched to the USA expecting that the USA would adopt the new measures. Congress hesitated because the standards were provisional, and the UK and Germany became hostile to the metric system because of the changed definition of the metre.
1795	Republic of France adopts French Academy of Sciences recommendation for a decimal Metric System.
1798	An International Commission began work with the goal of replacing the provisional values with more precise standards.
1799	The platinum standards for the metre and kilogram were defined for decimal Metric System. These were deposited in the *Archives de la République* in Paris, France.
1799	Based on the data collected by Delambre and Méchain, an International Commission produced a platinum bar that became the official definition of the metre. After more than 200 years of development (from 1585 to 1799), 22 June 1799 became the legal beginning

	of the decimal metric system. On 10 December 1799, the metric system was officially adopted in France.
1832	Johann Carl Friedrich Gauss of Germany enthusiastically promoted the use of the metric system for the physical sciences. He made absolute measurements of the Earth's magnetic field by using the three metric mechanical units millimetre, gram, and second for, respectively, the quantities length, mass, and time. He and Weber later extended these measurements to include electrical phenomena.
1874	The British Association for the Advancement of Science (BAAS) developed the CGS system, a version of the metric system that contained the centimetre, gram and second as base units and a set of derived units based on these base units. This was used with a set of prefixes ranging from micro to mega to express submultiples and multiples of these units.
1880s	The size of the base units in the CGS system were found to be inconvenient for electricity and magnetism. For this reason, the BAAS and the International Electrical Congress approved the use of a mutually coherent set of practical units, including the ohm for electrical resistance, the volt for electromotive force, and the ampere for electric current.
1875	The Metre Convention was signed on 20 May 1875. This international treaty created the BIPM and established the CGPM and the CIPM. They started to work on new international prototypes for the metre and the kilogram.
1889	The international prototypes for the metre and the kilogram were approved at the first CGPM. That conference established the astronomical second as the unit of time and established the MKS system, with the metre, kilogram and second as the base units. This was similar to the earlier CGS system.
1901	Giovanni Giorgi of Italy showed that it was possible to add a fourth base unit to the MKS system to form a coherent set of 4 base units. That unit would represent a physical quantity of an electrical nature.
1921	At the sixth CGPM in 1921, the scope of the BIPM was extended to other fields of physics.
1927	At the seventh CGPM in 1927, the Consultative Committee for Electricity (CCE) was created.
1939	After the Giorgi proposal was discussed by several international organisations, the CCE recommended the adoption of the MKSA system, where the metre, kilogram, second, and ampere would be the base units.
1946	At the CIPM of 1946, the MKSA system as approved.
1948	The BIPM started an international inquiry into extending the base units of the metric system.
1954	At the tenth CGPM, the introduction of the ampere, the kelvin and the candela as new base units for electric current, thermodynamic temperature and luminous intensity respectively was approved.
1960	At the eleventh CGPM, a new name and abbreviation was agreed for the metric system. In English, it was called the International System of Units. In French, it was called *Système International d'Unités*. The international abbreviation for this system is SI, which is derived from its French name. This CGPM also approved the adoption of a series of prefix names and prefix symbols to form the names and symbols of the decimal multiples and submultiples of SI units, ranging from 10^{12} to 10^{-12}.

1964	At the twelfth CGPM, the addition of the femto (10^{-15}) and atto (10^{-18}) prefixes was approved.
1971	At the fourteenth CGPM in 1971, the mole was added as a new base unit for amount of substance. This made a total of 7 base units and completed the current version of SI as we know it today.
1975	At the fifteenth CGPM, the addition of the peta (10^{15}) and exa (10^{18}) prefixes was approved.
1991	At the nineteenth CGPM, the addition of the zetta (10^{21}), zepto (10^{-21}), yotta (10^{24}) and yocto (10^{-24}) prefixes was approved.

Sources: UKMA Website (http://www.ukma.org.uk/), Metrication Matters Website (http://www.metricationmatters.com/), Wikipedia (various pages), BIPM

The metric system is now supported by three international organisations. These are the General Conference on Weights and Measures (*Conférence Générale des Poids et Mesures* or CGPM), the International Committee for Weights and Measures (*Comité International des Poids et Mesures* or CIPM) and the International Bureau of Weights and Measures (*Bureau International des Poids et Mesures* or BIPM). The SI continues to evolve to meet the world's ever-increasing requirements for measurement. It is the only measurement system that is recognised and accepted in all countries.

Imperial Dilemmas over Use of Units

Given that there is only one unit for each physical quantity, it is obvious which unit you would choose to measure something in SI. For example, if you wanted to measure pressure, you would choose the pascal. For force, you would use the newton. For energy, you would use the joule. For power, you would use the watt. If you used the imperial system for measuring these phenomena, which unit would you use? In the imperial system, there is a bewildering number of choices for measuring them. The choice is hardly obvious and all present conversion problems and compatibility with the work of others who are using different imperial measurements for measuring the same physical quantity.

Misleading Names

If you want to know the quantities of some imperial units, looking up their names in a dictionary is worse than useless because some of them have misleading names. They have lost their original meaning.

Despite the fact that the unit name, ounce, is derived from the Latin, “uncia”, which means one-twelfth part, it does not represent one-twelfth of a unit in various systems. In the avoirdupois system, it is one-sixteenth of a pound. In the imperial system, a fluid ounce is one-fifth of a gill or one-twentieth of a pint. In the US customary system, a fluid ounce is a quarter of a gill or one-sixteenth of a pint.

A mile was originally defined as the length of 1000 paces by a Roman legion. This is not the modern definition of any currently used unit that bears the name “mile”. Despite the fact that the word “mile” is derived from the Latin word, there is no recognised unit that is one-thousandth of any version of the “mile” in current use. The international mile contains 1760 yards and the nautical mile contains exactly 1852 metres.

A hundredweight contains 112 pounds in the British imperial system, despite its name. The name made sense when it was equal to 100 pounds before it was redefined by the 1824 Weights and Measures Act.

The metric system does not have this problem with the names of measurement units. Unlike the imperial system, the entire metric system was planned from the start and thus avoids the kinds of problems with imperial unit names that are a consequence of numerous changes to their quantities in history.

Strange and Obscure Conversion Factors

There are some strange conversion factors in the imperial system. Some of these conversion factors are not even whole numbers. For example, there are 5.5 yards in a rod, 16.5 feet in a rod, 2.714 fathoms in a rod, 6.08 feet in a fathom and 7.92 inches in a link. These are just a few examples of strange conversion factors for lengths.

Other conversion factors are frequently obscure. For example, conversion factors between horsepower and British thermal units are not well-known. Among the many pre-metric energy units that were still in use in 2007, how many of us are likely to know the conversion factors between the atomic energy unit, barrel oil equivalent, foot-pound force, foot-poundal and inch pound force? Most of us would need to look them up in conversion tables. (Source: Metrication Matters, http://metricationmatters.com/why_metrication.html)

The metric system avoids this problem by using only one unit for each physical quantity in combination with zero or one of the SI prefixes. This eliminates the need for conversions as there are no conversion factors.

Use of Imperial Units undermines Education in Metric Units

The continued use of imperial units undermines school children's education in metric units because they have little opportunity to practise what they have learnt at school. When they step outside the school gates, they are confronted with the predominant use of imperial units that they know little about. As a result, they do not see the relevance of what they learn at school and this wastes their education. This is a serious matter because the ability to calculate measurements (i.e. length, weight, area, volume, etc.) is the foundation of maths and science education. As Alan Young, who runs the Dr Metric website and has been a mathematics teacher for three decades, has told Metric Views, "Without the opportunity to practice measurement using only one system of measurements, children find it difficult to see the relevance of the sums they are required to calculate and are consequently not improving their skills as children elsewhere in the world are. Like most things mathematical, this is accumulative.". (Source: Metric Views website, http://metricviews.org.uk/2010/05/kids-dont-count/)

School children learn to use metric at school but when they come home, they often find their parents using imperial for expressing their own height and weight, for cookery recipes and in everyday conversation. That eliminates many opportunities to practise and reinforce what they have learnt in school. School children in other European countries do not face these problems because they only use the metric system.

According to the Summary Fact-sheet published by Alan Young on the Dr Metric website, the

continued use of imperial units has the following damaging educational effects (Source: Dr Metric Website, http://www.drmetric.net/, http://www.drmetric.com/):

- British school children do not understand that our world is almost exclusively designed and built using metric units.
- They do not see the relevance of what they learn about the metric system at school.
- They are confused when imperial and metric units are used in the same report, even in the same sentence, in the media.
- They have to use dual scales outside schools, which is hard and confusing to read. (Metric-only measuring equipment is not widely available and is hard to find.)
- They have to convert from metric to imperial and vice-versa.
- Their science education is undermined when the media suddenly switches to degrees Fahrenheit for hot temperatures.
- They cannot compare their height and weight with those of their parents when they use metric and their parents use imperial.
- They often move to secondary school without a good foundation in measurement skills or numeracy.
- They often see mathematics as irrelevant and boring and give up the subject.

The elimination of all the remaining imperial units that are still in use would get rid of all these problems. Unlike school children in the rest of Europe and in most of the developed world, these are educational problems that British school children have to face every day.

Unhelpful for British Tourists Abroad

In many other countries, the British imperial units are unknown. In such places, British tourists cannot expect others to be familiar with feet and inches or stones and pounds, the units that are frequently used in the UK for expressing height and weight respectively. If others need to know this information in an emergency, it could be a problem. Even the US does not use stones. Americans express their weight only in pounds, never in stones. The stone does not exist in the US customary system. The simple solution to this problem is to use the metric system, which is recognised world-wide.

Bad for the UK's Image Abroad

The UK is now the only country in Europe that uses old pre-metric measurements on its roads. All other European countries use the metric system for their road signs. This is bad for the UK's image abroad where perceptions matter when we try to promote the UK to potential tourists. British road signs are almost exclusively imperial. The continued use of miles, yards, feet and inches on British road signs when all other countries in Europe use metres and kilometres on their road signs makes us look like a bunch of eccentrics. Let us ask ourselves this question: What do other Europeans think of the UK's position as the only European country that uses non-metric road signs?

In the field of measurement, we are still living in the imperial past. This is because of our reluctance to end the measurement mess and complete the transition to the metric system. As Lord Kinnock states in the Foreword to the UKMA publication, Metric Signs Ahead, “Our road signs are perhaps the most obvious example and they contradict the image - and the reality – of our country as a modern, multicultural, dynamic place where the past is valued and respected and the future is approached with creativity and confidence.”. The removal of imperial units and their replacement with metric units will solve the image problem.

Wide Margins of Error For Body Measurements

We commonly weigh themselves in stones and pounds. We tend to round off our weight to the nearest pound. Given that there are just over 450 grams in a pound, that produces a wide margin of error of almost a quarter of a kilogram. It would awkward to use ounces in addition to stones and pounds. A decimal value for pounds would also be hard to calculate on an imperial scale as pounds are divided into 16 ounces and would probably not show that much detail on a non-electronic scale. When body weights are expressed in kilograms, they can be conveniently rounded off to tenths of a kilogram and would be more accurate. The maximum margin of error in that case would be 50 grams.

Given that an inch is equal to 2.54 cm, height expressed in feet and inches is rounded off to the nearest inch and produces a margin of error of approximately one and a quarter centimetres. When height is expressed in metres to two decimal places, the margin of error is reduced to a maximum of half a centimetre.

Complex Relationships between Biggest and Smallest Units

In the imperial system, it is awkward to calculate the relationship between the biggest and smallest units. For example, let us try to calculate the number of inches in a mile. If we do not know the answer, we would need to know all the intermediate units between the inch and the mile and their relationships to one another. There are 12 inches in a foot, 3 feet in a yard, 22 yards in a chain, 10 chains in a furlong and 8 furlongs in a mile. So the number of inches in a mile is equal to: 12 x 3 x 22 x 10 x 8 = 63 360. This is hardly easy or convenient to remember.

Now let us try to calculate the number of millimetres in a kilometre. In order to do that, we know from the prefixes that the number millimetres in a metre is 1000 and the number of metres in a kilometre is 1000. So the answer is 1000 x 1000 = one million. Now that is easy to calculate and remember. It is a round number. It would be just as easy to calculate the number of micrometres in a megametre. To find the relationships between them and the metre, we look at the prefixes, which always mean the same thing. The number of micrometres in a metre is 1 000 000 and the number of metres in a megametre is 1 000 000. So the answer is 1 000 000 x 1 000 000 = one trillion. This was no harder to calculate as this calculation is also based on powers of 10. In the imperial system, the equation would be harder and is likely to produce a result that is even more difficult to remember.

No Co-ordination between the Different Systems

In the imperial system, there are maritime lengths used at sea, Gunter's survey lengths used for surveying purposes and lengths that are used for surveying purposes. There is no co-ordination between these different systems of length. Nor is there any co-ordination between the units of volume in the apothecary system, the measurement of various types of commodities and the general volume measurements. Nor is there is any co-ordination between the units of mass in the apothecary, troy and avoirdupois systems.

By contrast, the metric system has only one unit for each physical quantity. The unit of length is the metre. The unit of volume is the cubic metre. The litre is a special name for the volume of a cubic decimetre. It is easy to see that it is derived from the metre. The unit of mass is the kilogram. All these units are used with zero or one of the SI prefixes in the metric system.

Imperial Measurements had to be standardised in Metric Terms

Before 1959, the United States and Commonwealth countries had slightly different definitions of the inch, foot, pound and other measurements. That caused problems with incompatible equipment between the US and UK during the Second World War. Their manufacture was based on slightly different definitions of the inch. Imperial measurements were not standardised between the US and Commonwealth countries until 1959 when they agreed on common definitions for the remaining imperial measurements still in use. They were all redefined in terms of the metric system.

However, there are still US survey measures and international measures still in use. For historical use of these imperial measurements, it would still be necessary to look up their older definitions. That does not include all the different historical measurements with the same name in the rest of Europe.

Unlike the imperial system, the metric system is a world standard and all metric measurements are exactly the same all over the world.

Unintuitive Measurements for Physical Quantities

For the common imperial measurement of pressure, pounds per square inch is often used. For pressure, this term implies the measurement of "weight per area", which is not an intuitive way to express pressure. The metric system uses the pascal, which is a derived unit for newton per square metre, which expresses pressure as the intuitive "force per area".

For energy, the foot-pound force or simply foot-pound is commonly used. This implies distance-weight as an expression of energy. The metric system uses the joule, which is equal to 1 newton metre. This is defined as the energy used or work done in applying a force of one newton through a distance of one metre. The metric system expresses energy as force-distance, again using force instead of weight. This is a lot more logical.

For power, the common imperial measurement of foot-pound per second expresses power as distance-weight per second. The metric system uses the watt, which is equal to one joule per second. This expresses power as energy per second, a more logical way of expressing power.

Resistance to Change

The Anti-Metric Environment

There is a lot of resistance to metrication in the UK. There are several British anti-metric advocacy groups, including the British Weights and Measures Association, the Metric Martyrs, Active Resistance to Metrication and the Facebook group called the "Campaign for Imperial Measurements" whereas the UK Metric Association is apparently the sole pro-metric advocacy group in the UK. In addition to opposition from anti-metric groups, there is also a lot of opposition from the general public, the UK Independence Party, a large number of eurosceptics and others in the main political parties, the Department for Transport, many politicians, most eurosceptics and all right-wing eurosceptic national newspapers. It is hard to find a single politician or national newspaper prepared to express a pro-metric view.

Motives for Resistance to Metrication

The motives for resistance to metrication include resistance to change, fear of the unknown, misplaced notions of British tradition and culture, short-term costs, disruption and euroscepticism. Let us deal with each of these problems and show how they can be overcome.

What is Wrong with the Objectives of Anti-Metric Groups?

The BWMA and the Metric Martyrs want freedom for traders and customers to trade in measurement units that both parties find most convenient. This has never been allowed in 1000 years of weights and measures legislation. If it were allowed, there would be chaos in the market place and consumers would find it hard, if not impossible, to compare prices and quantities. The National Measurement Office, an executive agency of the Department for Business, Innovation and Skills, states that "Having a single consistent set of units of measurement in use for trade reduces costs for business and enables consumers to make price and quantity comparisons more easily." (Source: NMO Website, http://www.bis.gov.uk/nmo/Regulation/weights-and-measures-legislation/metrication) Since medieval times, the Crown has asserted the right to regulate weights and measures. This can clearly be seen in the Magna Carta, which calls for one system of weights and measures throughout the country. The Magna Carta was issued in 1215, almost 800 years ago. Despite the fact that the UK decided to go metric in 1965, several years before joining the EU, or European Economic Community as it was called at the time, the objective of one system of weights and measures has been abandoned for now. Traders are not permitted to trade in measurement units that are not legal for trade in the UK. For example, carpets cannot be sold by the cubit or the yard, even if traders and their customers agree to use these units for trade. As the House of Commons Committee of Public Accounts states in a report, "To maintain the confidence of consumers and businesses in weights and measures the Government regulates the units and standards of measurement for trade; the design and use of weighing and measuring equipment; the provision of quantity information; and the sale of goods by quantity." (Source: Department of Trade and Industry: Regulation of weights and measures - Thirty-eighth Report of Session 2002–03, http://www.publications.parliament.uk/pa/cm200203/cmselect/cmpubacc/581/581.pdf)

Right of Governments to regulate Weights and Measures

The right of the Crown to regulate the use of weights and measures and the rejection of freedom for traders to trade in measurement units of their choice have been proven in court. In a case between Steve Thoburn and Sunderland City Council, the council won. John Dove, Julian Harman, Colin Hunt and Janet Devers, the other so-called metric martyrs, were also taken to court and convicted for similar offences. These offences include the failure to display metric signage and the use of illegal, non-approved weighing equipment. Contrary to media reports and the Metric Martyrs website, they were not convicted of selling in imperial measures but for failing to use metric units. Imperial measures may still be used as supplementary indications alongside but not instead of metric units. They could have done that legally. The BWMA, Metric Martyrs and their supporters continue to campaign against their conviction and want a posthumous pardon for Steve Thoburn, who has died since the court case. They will not get their way because these traders broke the law at the time they committed the offences, even if the law were changed. The government has made it clear that citizens are expected to obey the law as it is at the time and there would be no grounds for overturning the traders' convictions or granting Thoburn a pardon, even if the law were changed.

Measurement Freedom led to Market Failure

Traders' freedom of choice in measurement units led to a market failure in the 1970's when there was a voluntary retail initiative to convert stores to the use of metric units. That ended in a fiasco in 1977 when one major retailer of carpets discovered that it could gain a huge advantage over its rivals by going back to selling by the square yard. Subsequently, their rivals reverted to imperial units and sold carpets by the square yard. According to Jim Humble, the last director of the UK Metrication Board, “The product which brought all voluntary retail initiatives to a full stop was the experience of the floor covering and carpet retailers. Their 1975 change to sales by the square metre started well, but in 1977 one of the major High Street retailers found enormous commercial advantage in reverting to sales by the square yard. Consumers could not be persuaded to believe that goods costing, for example, £10 per square yard or £12 per square metre were virtually priced the same. Consumers bought, in very significant volume, the apparently cheaper priced imperial version. Metrication of carpet sales entered into full scale reverse and the Chambers of Trade and retail associations pressed for firm Government leadership, i.e. compulsory cut-off.” (Source: UKMA Website, http://www.ukma.org.uk/articles/jhumble) This example shows why the use of measurement units must be regulated and traders must not be allowed to choose any measurement units they like. This is essential for consumer protection. Freedom of choice in measurements would lead to chaos in the marketplace, make it hard, if not impossible, for consumers to compare prices and quantities and would be a charter for rogue traders to rip off their customers at every opportunity. If traders had such freedom, rogue traders would give you the smallest quantity that they could get away with.

Consensus for Cut-Off Date for Imperial Units

After the failure of the voluntary retail initiative, many retail trade, industry, engineering, consumer, trade union, elderly person, sporting and educational organisations and the vast majority of politicians realised that metrication could not be a voluntary process and there had to be a cut-off date for imperial units. An Order was made by the Department of Trade in 1978 but was not put to Parliament for a vote, despite the level of support in favour of it. There was a lack of political leadership on this issue. After the 1979 election, there was a change of government and the Order was abandoned. The stage was set for another 20 years of dithering on the metrication of the retail trade. That was not completed until 1 January 2000. From that date, loose goods sold by weight had to be priced in metric units.

Tendency to use the Smallest Units

Isn't it odd that we had no problems with replacing British imperial gallons with litres for the sale of fuel yet there is a lot of resistance by small shops and market traders to replacing pounds with kilograms? This is possibly caused by the fact that prices look cheaper when using smaller units. Litres are smaller than gallons so it was adopted rapidly without any problems. Kilograms are larger than pounds hence the resistance with their adoption by small shops and market traders. Ironically, anti-metric groups often complain that manufacturers downsize their products when they switch to metric without any price reduction but do not admit that this trick would not be possible if the UK used only one measurement system. This is only possible because of the existence of a dual-measurement system, which they support. They are quiet or supportive when this happens in the opposite direction. In May 2011, several newspapers reported that ASDA was returning to pounds and ounces for the first time in 16 years, which they praised (Sources: http://www.thesun.co.uk/sol/homepage/news/money/3603564/Punnets-make-pounds-at-Asda.html, http://www.express.co.uk/posts/view/249651, http://www.dailymail.co.uk/news/article-1392266/Supermarket-puts-1lb-punnet-strawberries-shelves.html). That was despite the fact that ASDA downsized its punnets of strawberries from 500 grams to 454 grams without any price reduction. The result was that we got about 10% less for our money. Perversely, this was presented as a victory for us.

Precedent of Decimalisation

The current problems with the transition to the metric system can be dealt with and we have an important precedent for dealing with these problems. About 40 years ago, the UK threw out its Roman-style non-decimal currency and replaced it with a decimal currency. The UK decided to decimalise its currency at the same time when it decided go metric in 1965. It took several years before decimalisation actually happened in 1971. There was no notion in this plan that old coins such as the shilling should be preserved for the sake of tradition or culture. Obviously, there were short term costs and disruption but we just got on with it.

This is the design of the pre-decimal currency system used before 1971 (Sources: http://www.simetric.co.uk/si_imperial.htm, http://en.wikipedia.org/wiki/£sd):

2 farthings = 1 halfpenny *
4 farthings = 1 penny *
3 pennies = 1 threepenny bit
4 pennies = 1 groat
6 pennies = 1 sixpenny piece
12 pennies = 1 shilling
24 pennies = 2 shillings = 1 florin
30 pennies = 2 shillings and 6 pennies = 1 half crown
60 pennies = 5 shillings = 1 crown
120 pennies = 10 shillings = 1 ten 'bob' note
240 pennies = 20 shillings = 1 pound
252 pennies = 21 shillings = 1 guinea

* This submultiple lasted until 1960.

So a complex currency that consisted of farthings (before 1960), pennies, pounds, groats, shillings, florins, crowns and guineas was replaced by a simple currency of only pounds and pence where 1 pound consists of 100 pence (100p = £1). Decimalisation was a great British success that led to a permanent change for the better and made life much easier for us all. Metric units are used worldwide for the same reason that decimal currencies are used worldwide: simplicity and ease of use.

Temporary Problems

As we can clearly see from decimalisation, the problems of resistance to change, fear of the unknown and short-term costs and disruption are temporary, short-term problems. It leads to unpopularity in the short-term but popular support for decimalisation could only be expected after the change. This is also true about metrication. If the arguments about short-term costs and possible price increases were used to prevent decimalisation, we would still be using a Roman-style pre-decimal currency and would not have got the benefits of the change to a decimal currency.

Metrication in Other Countries

Other countries have completed metrication, including South Africa, Australia, New Zealand and the Republic of Ireland. They have moved to the metric system permanently and abandoned the imperial system for good. There has been a worldwide move to the metric system in the last few decades. In the postwar period, the markets for imperial goods have been declining and the imperial system is doomed in the long term. Holding out for the continued use of the imperial system in the UK and the US is untenable in the long term. The process of decimalisation proves that the UK is not a museum. The fact that the pre-decimal currency was very old was not a good reason for keeping it.

Anti-Metrication and Euroscepticism

Since the introduction of laws and Statutory Instruments that implement EU Units of Measurement directives, metrication has become associated with euroscepticism. Metrication is not a European issue and started several years before the UK joined the EU in response to pressure from British industry. In fact, most Commonwealth countries and all European countries are completely metric. The metric system is not only a European standard, it is a world standard. We can and should separate metrication from EU issues. Politicians now need to start a debate about the metric and imperial systems on their own merits and ignore the European issues in that debate, as this booklet has tried to do.

The UK is the only country in the EU that is holding out for the use of the old measurements. This does not damage the EU nor does it damage the interests of other EU members. It is only self-defeating for us to resist the worldwide move to the metric system and reject the full adoption of the metric system in the UK. By doing so, we only cause problems for ourselves.

Like decimalisation, politicians can only expect metrication to be popular after its completion, not during the transition period. There will be opposition, resistance and unpopularity as long as we fail to complete metrication. In countries that have completed metrication, the change has been permanent and there has been no desire to go back to the old measurements. Examples include South Africa, Australia, New Zealand and the Republic of Ireland.

Today, we use the metric system on a daily basis and take it for granted. Did you know that the metric system had to be imposed in France where it was first implemented? If the French had not imposed it, there would probably be no metric system in use today. That system replaced the enormous number of different measurements that existed in France at the time with a single, common measurement system. In 1795, France was the first country to introduce the metric system but it was not welcomed by the French public. There was so much hostility and resistance to it that Napoleon allowed *mesures usuelles* (French for customary measurements) to be used again in 1812, but the traditional measures were redefined and based on the metric system. For example, the *livre* (French for pound) was redefined as exactly 500 grams. Napoleon's successor abolished *mesures usuelles* in 1837. The abolition took effect in 1840 and the French have been using the metric system as their only measurement system ever since.

Nostalgia for Imperial Measurements

Nothing Special about Imperial Units

It seems that there is a lot of emotional attachment to imperial measurements, including pounds and ounces, pints, miles, yards, feet and inches. Do you think that there is something special about any of these imperial measurements? Are you nostalgic about them? Well, you may be disappointed to learn that they are all arbitrary. Contrary to what you might read in the British press, there is nothing special about them. There have been all kinds of measurements used in the past in other parts of the world, including different definitions of pounds and ounces, miles, feet and inches in other European countries. The Americans still have liquid and dry pints, which are both different from the British imperial pint. There were slightly different definitions of the yard used in different parts of the Commonwealth before it was standardised as exactly 0.9144 metres. Why should you or anyone else believe that the British (or English) weights and measures are more special than any of these other definitions of these imperial units or other units of measurement? The following images show various quantities for volumes, weights and lengths. Call them whatever you like but it does not change the fact that there is nothing special about these quantities.

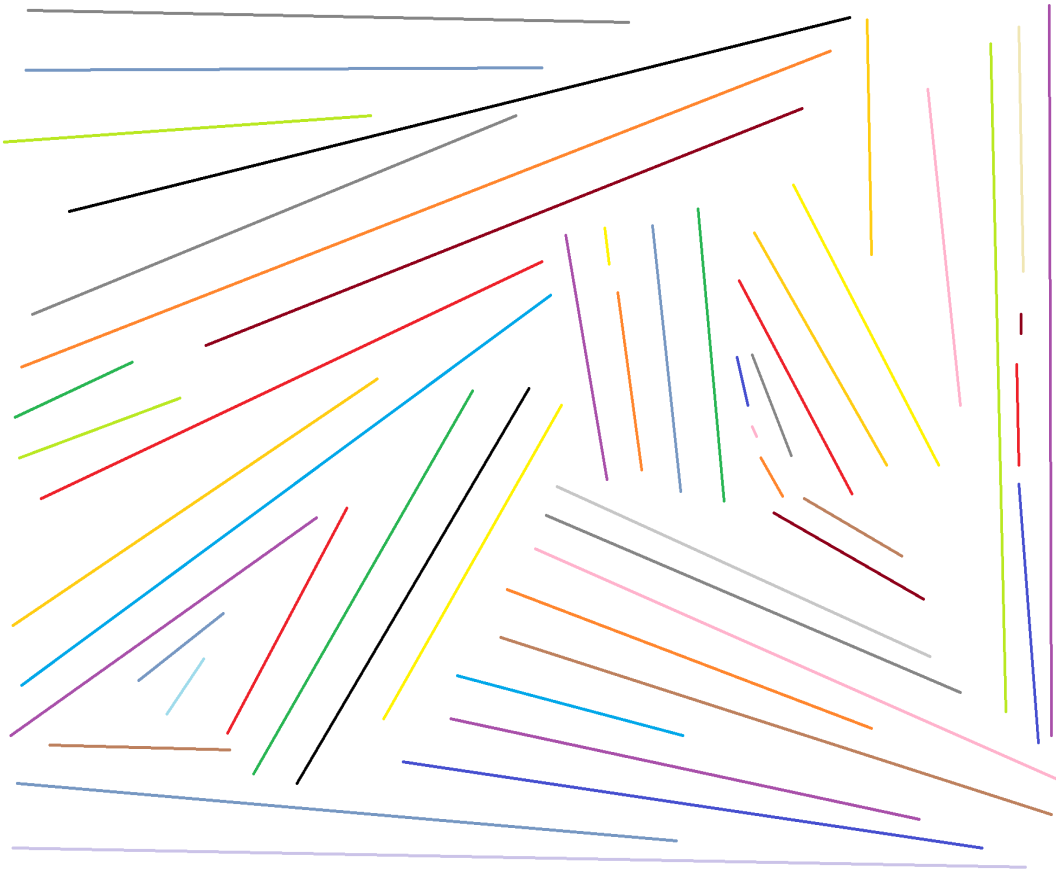
Arbitrary Volume Measurements

Look at the glasses in the image above and think about the volumes that each one of them can hold. Ask yourself one question: what is so special about the volume that a particular glass can hold? You can ask yourself the same question about any of these glasses. Now ask yourself the same question about the imperial pint. That volume is not more special than any other size of drink.

Arbitrary Mass Measurements

Look at the products in the image above and ask yourself what is special about any of their weights. Several British newspapers published articles in the past about the prosecution of the so-called "metric martyrs" for selling exclusively in pounds and ounces in defiance of the law. They insist that they should have a right to do so. This is wrong as that would imply that all measurement units should be legal for trade. If that were the case, rogue traders would give their customers the smallest quantities that they could get away with. For this reason, the Crown has regulated the use of weights and measures since medieval times. There are many measurements used elsewhere in the world that cannot be used for trade in the UK. What is more special about one pound of apples than 450 grams or 500 grams of apples? If a trader served you 500 grams rather than one pound or 450 grams, would you even notice the difference? What is more special about one pound in the British imperial system than all the different pounds used elsewhere in Europe several hundred years ago?

Arbitrary Length Measurements



Look at the lines in the image above and ask yourself what is special about the particular lengths of those lines. Like all those lengths, the lengths of the inch, foot, yard and mile are all arbitrary. It does not matter whether a particular length is based on the size of the earth or the size of your hand, it is still arbitrary. The fact that it has been given a name and used for hundreds of years does not change the fact that it is arbitrary. All measurements were once defined somewhere by someone in history and imperial units are no exception. All measurement systems and units are created by people. They do not just appear spontaneously out of nowhere with no human input.

British newspapers and anti-metric campaigners have argued that we should continue to use them because they are British, they are old and traditional and that they are part of British identity, heritage and culture. In fact, most of the measurement units in the British imperial system have foreign origins. If we accept all the other arguments about tradition, age, identity, heritage and culture, we would still be using all kinds of obsolete units (e.g. minims, scruples, firkins, hogsheads, etc.) that were used in the UK a long time ago and there would never be any improvement in the quality of our system of weights and measures.

Summary of Advantages of the Metric System

Unlike the imperial system, the metric system is:

- a world standard
- suitable for all purposes
- a proper, coherent system
- a truly decimal-based system
- universal
- consistent
- simple to learn and use
- supported and legal in all countries
- maintained by international organisations
- fundamental to all measurements, both old and new
- able to measure the extremely small and large
- a system that can meet all of our needs
- a system that only uses powers of 10
- a system with common prefixes
- a system with common symbols for prefixes and units
- a system with common international symbols
- a system with logical links between related measurements
- a system that was fully planned since its creation
- a system with base units that were always the same size
- a system where all units have one definition at any time
- a system with only one unit for each physical quantity
- a system that is the same all over the world
- a system that uses prefixes instead of multiples and submultiples
- a system where prefixes always mean the same thing wherever they are used
- a system where prefixes always have the same relationships with all units
- a system that enables quick and easy calculations
- a scalable system that can adapt to ever-increasing global measurement needs

Conclusion

Since the UK started the metrication programme in 1965, a lot of progress has been made. Unfortunately, we started it and got stuck in the middle between two systems. Since opposition to metrication has become politicised, no politician wants to do anything to complete metrication for fear of becoming unpopular and losing votes. The imperial system is an obsolete, inferior, complex, inconsistent and messy system that stopped evolving about 200 years ago and is inadequate for our needs. For instance, the imperial system cannot be used for measuring electricity consumption, radiation doses, the chemical compounds in a bottle of mineral water, the wavelengths of light, the mass of blood cells or the width of the transistors on computer chips. These are only a few examples of essential measurements that the imperial system is unsuitable for. By contrast, the metric system is suitable for all purposes and can meet all of our needs.

Despite all the shortcomings of the imperial system, there are many who defend it, especially eurosceptics who see it as resistance to the EU. Given that the EU has allowed some imperial units to be used for specific purposes indefinitely that do not affect cross-border trade, it shows that the EU could not care less that the UK continues to use imperial units for internal use or how much longer the UK continues to use them. After extending the deadline for the continued use of imperial units several times, the EU eventually decided that the UK could use them forever more if it wanted to and has effectively withdrawn from the politically sensitive issue of weights and measures. This does not affect the EU or other member states within the EU but it does all of us a disservice by depriving us of the full benefits of the best available system of weights and measures, namely the metric system.

As a nation, we have no qualms about getting rid of old measurements. By the time that the UK started its metrication programme in 1965, the commodity measurements for measuring various alcoholic drinks and a few other commodities were already obsolete. So we had no more rundlets, tierces, firkins, kilderkins, hogsheads, puncheons, pipes, butts and tuns. By the time of the 1976 Weights and Measures Act, a whole range of other measurements ceased to be legal for trade. These included the entire apothecaries system, all troy measures except the troy ounce, pecks, bushels, strikes, rasers, chaldrons, rods, poles and perches. The 1985 Weights and Measures Act banned the use of the furlong, chain, square mile, rood, square inch, cubic yard, cubic foot, cubic inch, ton, hundredweight, cental, quarter, stone, dram and grain for trade. In 1995, the hectare replaced the acre for new land registration. In that year, a whole range of imperial units, including the inch, foot, yard, mile, square foot, square yard, acre, fluid ounce, gill, pint, quart and gallon, could no longer be used for trade except as supplementary indications. An exception was made for avoirdupois pounds and ounces for the sale of loose goods up to 1 January 2000. After that date, these units could only be used as supplementary indications. On that date, the use of the therm for gas supply and fathom for marine navigation was abolished. On 1 January 2010, the exemption for using the acre for land registration was abolished. The acre is no longer used officially in the UK.

Only six imperial units remain in official use. These are the mile, yard, foot, inch, pint and troy ounce for specific purposes. These units are still in official use for the following purposes:

- The mile, yard, foot and inch are used for road traffic signs, distance and speed measurement.
- The pint is used for draught beer and cider and for milk in returnable containers.
- The troy ounce is used for transactions in precious metals.

All other imperial units have ceased to be legal for economic, health, safety or administrative purposes. However, there is still widespread use of imperial units in marketing, advertising and product descriptions. There are many small shopkeepers and market traders who display prices in imperial units without their metric equivalent in defiance of the law. The government, organisations and the non-specialist media predominantly use imperial units for communication with the general public. Several imperial units are still used officially for the purposes described in the previous paragraph.

Only a small part of the imperial system remains in use. While a lot of progress has been made with metrication, there is still some way to go toward full metrication. Achieving full metrication means that the metric system will become our only measurement system for all purposes and the rest of the imperial system will be abolished. Only by full metrication will we solve all the problems of running a dual measurement system and realise the Magna Carta ideal of a single measurement system throughout the UK. So let's finish the job that we started in 1965. Let's get rid of the remaining imperial units still in use and fully adopt the metric system for all official, trade, legal, contractual and other purposes in the UK as soon as practicable.

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