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Metrication Leaders Guide

This resource book will help make your inevitable upgrade to the metric system easy, smooth, cheap, and fast.

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Make your upgrade to the metric system easy, smooth, cheap, and fast.

Deciding on a metrication program confirms that you are a metrication leader – not a follower. You have the courage to stand aside from the crowd, decide what you think is best for yourself and for others, and you are prepared to differ from other people in your class, your work group, your company, or your industry.

As a metrication leader, you will soon discover three things:

1 Metrication is technically a simple process.

2 Metrication doesn't take long if you pursue a planned and timed program.

3 Metrication can provoke deeply felt anti-metrication emotions in people who have had no measurement experience with metric measures, or people who have difficulty with change.

The first two encourage confidence – it's simple and it won't take long – but the third factor can give you an intense feeling of isolation when you first begin your metrication program. You feel you are learning a new language (you are – a new measuring language), while people around you not only refuse to learn this language, but will do what they can to prevent you from growing and from making progressive developments in your life.

The purpose of this book is to give you some supporting arguments to use in your metrication process. At Metrication matters we see the metric system as something so obviously superior to everything that went before it, the only question is: **What took so long?**

Some people consider that there are only four universal methods of written communication. The four methods that cross all language barriers, listed in the order they were developed, are:

- Music notation;
- Mathematical signs and symbols;
- Symbols for chemical elements; and
- The modern metric system, now known as the International System of Units (SI).

These four methods can be understood wherever you are in the world and whatever language you use to speak and to write. It doesn't even matter if you write with an alphabet or you use pictograms; you can still understand these four international methods of communication.

Since the introduction of the modern *decimal metric system* of measurement there has been a gradual, and unstoppable, move toward this worldwide measurement system that can be applied to all occupations, is simple enough to be used by everyone, and that can be used anywhere, and at any time.

One of the founders of the metric system (with a glorious name), Marie Jean Antoine Nicolas de Caritat, Marquis de Condorcet, 1743/1794, put this extremely simply when he said that the metric system was:

'A tous les temps; a tous les peuples'

('For all time; for all people')

And now — a successful metrication story

Metrication in a day

The fastest, simplest, and cheapest metrication process that I ever had anything to do with, or even heard about, occurred when about 200 plumbers and their assistants completed their whole metrication process in a single day.

How was this achieved?

This successful metric transition was achieved with 10 carefully planned steps:

1. All of the plumbers from the same company were invited to a public hall for a '*Metric information and training day*'. Prior to this day, they were informed that their company and their industry had decided to '*Go metric*'.
2. Their invitation included a request to bring along all their company-owned rulers and tapes so they could do some practical measuring exercises during the day.
3. At the registration desk, the old rulers and tapes were exchanged for brand new high quality rulers and tapes marked in millimetres. The plumbers were also given a booklet summarising the day's activities and a simple robust calculator.
4. The plumbers then attended a presentation by a professional speaker that outlined the reasons why the company (and their industry, and the nation) had decided to 'Go metric'. Part of this presentation was training in how to '***Learn the metric system in a minute***' (see next section).
5. After the first presentation, the plumbers were directed to a courtyard for morning tea.
6. Before tea or coffee was served, their old feet-and-inches tapes and rulers were ceremoniously wheeled, in labelled 200 litre drums, into the centre of the courtyard. Flame accelerant was poured on to them and the old rulers and tapes were burned to total destruction. This dramatic demonstration made it absolutely clear that the object of the day's training was to change wholly to metric units and to do it now.
7. The next session, back in the hall, included a practical session about human body measurements, useful in on-the-job estimations that plumbers do every day. Using millimetres only, they measured fingernail widths, finger widths and lengths, hand widths, hand spans, cubits (elbow to finger tip), arm lengths, and they happily discussed some others that we need not mention here.
8. Back outside, after a barbecue lunch, the next session was planned to make larger length and mass estimations. For this they measured (again in millimetres only) their foot lengths and the length of their normal pace, before they used pre-marked lengths of 5 metres, 10 metres, 20 metres, and 50 metres to establish a stretched pace of 1000 millimetres. Facilities were also provided to measure their height and body mass and to calculate their body mass index.
9. The next formal presentation in the hall focussed on water with concepts such as:
   - 1 litre of water has a mass of 1 kilogram
   - 1 cubic metre of water has a mass of 1 tonne
   - 1 millimetre of rain on 1 square metre of roof will add 1 litre of water to a rain water tank
   - 1 millimetre of rain on 1 hectare of land will provide 10 000 litres of water to soils or dams
10. For the final session, several stations had been set up in a room adjacent to the hall. Here the plumbers were asked for '*your best guess*'. They then actually measured normal structures such as doors and windows. Helpers, people who had received pre-training in both the procedures to be followed at this session and the principles behind the chosen processes, were available to answer the plumbers' questions.

Why did this metrication process work?

This metrication plan had a number of features that ensured its success:

- This program used the well-established experience of metrication transitions elsewhere that held:

  'The optimum change is a quick change'.

- It was based on dramatically and immediately stopping the use of old pre-metric measures, and the immediate use of metric-only practices. There was no going back. Burning the old pre-metric rulers and tapes made it clear to all the plumbers that management was unequivocally committed to the metrication process and was prepared to spend money to achieve this goal.

- The plumbers were introduced to the metrication policy of all of the building trades in Australia. The Australian Building and Construction Advisory Committee policy was:

  *The metric units for linear measurement in building and construction will be the metre (m) and the millimetre (mm), with the kilometre (km) being used where required. This will apply to all sectors of the industry, and the centimetre (cm) shall not be used. **

- With these words the Australian Building and Construction Advisory Committee effectively banished centimetres from the building trades in Australia, with the result that metric conversion in these trades was smooth, rapid, and complete. They made it clear that the centimetre should generally not be used, and in particular:

  *... the centimetre should not be used in any calculation and it should never be written down. **

  **Standards Association of Australia 'Metric Handbook, Metric Conversion in Building and Construction' 1972*

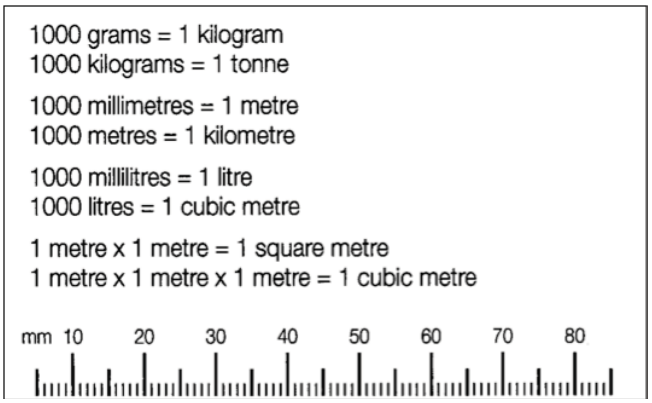
- The simplicity of the metric system was demonstrated using industry standard millimetre rulers and tapes, kilogram scales and degree Celsius thermometers to make real measurements. Here is a description of some of the stations that had been set up around the hall and the types of measurements:

  - Some stations were for measuring short lengths, with a range of plumbing tools, books, pencils, and various pieces of A-series papers from A4 to A1 showing the standard paper sizes used for building designs. These were all marked and measured in millimetres.
  - Some stations were for measuring longer lengths. These had instructions for guessing the heights and widths of doors and windows, and the lengths and widths of the floor of the hall with a view to calculating the roof area in square metres to quote for work such as alterations, repairs, and replacements.
  - Some stations were for measuring small amounts of mass. There were kitchen scales for measuring grocery items such as sugar and flour, various fruits and vegetables, and more plumbing tools. These were measured in grams.
  - Some stations were for measuring large amounts of mass. There were bathroom scales that went to 150 kilograms and workshop scales up to 500 kilograms. Safe lifting posters using only metric units were also displayed.
  - Some stations were for measuring volume. There were graduated metric measuring cylinders, calibrated jugs and cups, and a variety of teaspoons and tablespoons with a variety of unmarked flasks and containers filled with various amounts of free-pouring sand or water. These were measured in millilitres.
  - One station was for measuring temperatures from below freezing in a deep freeze, to drinking water from a refrigerator, to cold and hot water from sink tap outlets, to boiling water. These were measured in degrees Celsius only.
  - Some stations had a range of building plans, on A-series papers, showing various plumbing designs; these included designs for a single toilet, house plans, and multi-level buildings with all dimensions in millimetres. The plumbers had to estimate the materials needed for each job.
  - They calculated the volume of a circular rainwater tank in cubic metres and litres using the π button on their new calculators.

- The metric system was made personal by measuring their own body dimensions as a basis for making good on-the-job estimations.

- The process did not in any way use conversions. The message was loud and clear — old to new conversions (and worse from new to old) were simply not needed in the building construction industry. It followed that metric conversions did not need to be considered or discussed.
- All of the company plumbers were involved. There was no chance that any individual could be isolated by the metrication process, or for a metric elite to develop within the company. Special arrangements were made for the three plumbers who could not attend on the day.
- There was no dithering. A clear and definite decision was made to use millimetres for all measurements. Using only millimetres and metres means that decimal fractions are rarely required. Also, many people have observed that if people are given two choices during a metrication transition, dithering will occur; some will plump for one of the choices and others will settle on the other. This not only can lead to long-term disputes and confusion, it also dramatically slows the whole metrication process. The units chosen were on the back of a business card like this:

- No attempt was made to completely describe the metric system — the program only covered what was necessary for the everyday needs of working plumbers and their assistants.



- The program was complete. There was no thought of learning about temperature this week, volume next week, and length the week after that. The interrelationships within the metric system, such as a litre of water has a mass of a kilogram and a millimetre of rain on a square metre of roof would put a litre of water into a rainwater tank, were clear to all of the plumbers
- All irrelevant knowledge such as the history and politics of the metric system was simply left out of this program.
- The process recognised that resistance to metric change is often fear of the unknown; it countered this by making the metric system known through practical hands-on activities.

Note: It is not strictly true that the whole of the metric transition was 'completed' in a day. The plumbers reported that they '*changed their mind to metric*' on that day and then consolidated their metric knowledge on the job over the next two weeks. Surveys of participants a month later showed that they, personally, saw their metric transition as complete by then. The plumbers and their unqualified labourers were comfortably using millimetres for all of their work. They reported that critical factors in their success were using only millimetres so they didn't have to mix measurements or to use any fractions or decimals at all. They particularly liked avoiding the confusion that comes from using centimetres.

Learn the metric system in a minute

Hi, my name is Pat Naughtin and I am confident that you can learn enough about the metric system — in less than a minute — to design and build a house or a multi-storey office block, bake a cake, or set out a new garden. This may sound impossible, but I know from extensive experience that you can do this if you follow these steps:

1 Look at the front of my business card. Notice that I am a highly qualified and experienced metrication specialist who has helped thousands of people to learn enough of the metric system for almost all practical activities in their lives. I tell you this, not to brag, but to assure you that thousands of people have done this exercise before you.

2 Now look at the back of the business card.

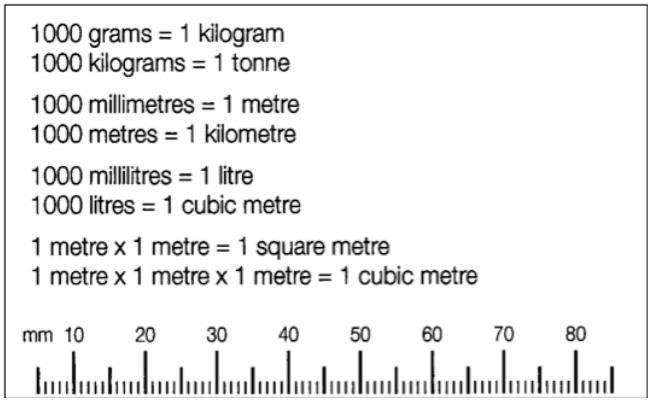
3 Find how many millimetres there are in a metre.

4 Repeat aloud: 'There are 1000 millimetres (mm) in a metre (m)'.

5 Find metres and kilometres, and repeat aloud: 'There are 1000 metres in a kilometre (km)'.

6 Next find grams, kilograms, and tonnes, and remember that: 'There are 1000 grams (g) in a kilogram (kg)' and 'There are 1000 kilograms in a tonne (t)'.

7 Finally, see that: 'There are 1000 millilitres (mL) in a litre (L)' and 'There are 1000 litres in a cubic metre (m^3)'.



8 When you are satisfied with steps 2 to 7, fold or cover this page so that you can't see the business card, and complete this test:

Metric system assessment test

1 How many grams are there in a kilogram? ———

2 How many millilitres are there in a litre? ———

3 How many kilograms are there in a tonne? ———

4 How many millimetres are there in a metre? ———

5 How many metres are there in a kilometre? ———

6 How many litres are there in a cubic metre? ———

That's it — Congratulations!

I know you got all 1000 answers right!

Questions and answers about 'Learn the metric system in a minute'

When I successfully demonstrate this method to '***Learn the metric system in a minute***' to live audiences, they realise how fast a metrication upgrade can be. Some then ask questions such as:

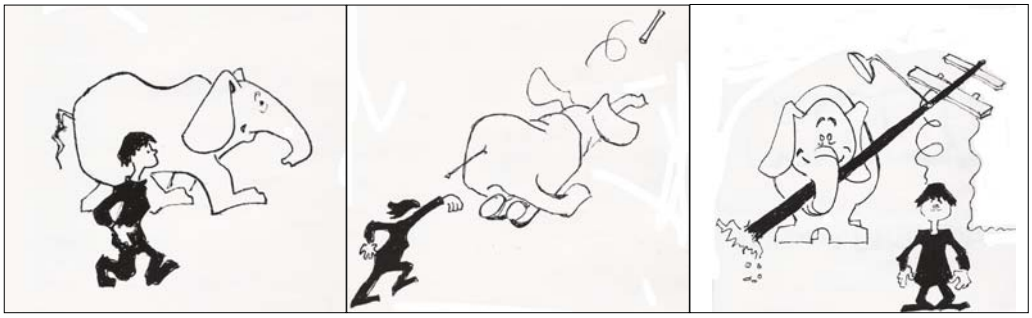
Why does this teaching method work?

'***Learn the metric system in a minute***' works because it includes several benefits. They are:

- It only includes the metric measuring units that people use every day.
- For more than 95 % of daily measuring, people only use the 11 units on the business card. I have included a summary of the complete metric system as an appendix, but it is most likely you will not need to refer to it.
- The choice of metric prefixes means that all measurements and calculations can be done in whole numbers with simple calculators.
- There is no reason to use decimal fractions or to move decimal points.
- There are no common or vulgar fractions.
- There are no conversions. No conversions from old to new; and no conversions within the metric system such as from decimetres to centimetres.

Why do you cut down the metric system to this really small size?

Because the direct practical experience of millions of people in the world every day is that they only choose to use a small number of metric units. The 11 units on the back of my business card probably cover more than 95 % of all the measuring done in the world each day. The metric system is able to measure anything in the Universe from the smallest thing to the size of the Universe itself but for most people only 11 units is enough for most things. You don't need it all every day.



Can I do all the things that I want to do in my life with just these few units?

Almost! You will find that using units from outside these 10 is quite rare. However, it is not too difficult to adjust if you have to. Consider these questions: 'How many joules are there in a kilojoule?' and 'How many milliwatts are there in a watt?' See, no trouble!

Does anyone in the world actually use this reduced metric system?

Yes, in Australian occupations, about 85 % of workers use only 11 units. In the whole world, all auto workers and almost all building and construction workers use this reduced metric system.

What are the advantages of using a reduced metric system?

Overall simplicity that leads directly to ease of use with fewer mistakes and reduced costs.

How does 'Metrication in a minute' fit with metrication policies?

Consider this building and construction policy from Australia:

> *The metric units for linear measurement in building and construction will be the metre (m) and the millimetre (mm), with the kilometre (km) being used where required. This will apply to all sectors of the industry, and the centimetre (cm) shall not be used. ... the centimetre should not be used in any calculation and it should never be written down.*
>
> Standards Association of Australia 'Metric Handbook, Metric Conversion in Building and Construction 1972'

Become familiar with the metric system in an hour

When you have done all of these activities, you will have developed a set of measuring references and a metric mindset and it is likely that you will never go back to using old pre-metric measures ever again.

You will need:

- 1 ruler with millimetre markings (without inches and without centimetres). A 300 millimetre ruler will do but the longer the better, with the best being a metre long.
- 1 tape measure with millimetre markings (without inches and without centimetres). Length doesn't matter but 10 metres is good.
- 1 kitchen scale that can measure in grams (without ounces and without pounds).
- 1 bathroom scale that can measure in kilograms (without pounds and without stones).
- A thermometer that can measure in degrees Celsius (without Fahrenheit degrees).
- Some standard metric measuring jugs, cups and spoons (without pints and ounces).
- A simple calculator.

Your measurements (my measurements are in brackets):

Use the ruler to measure:

Across your little finger nail (10 mm)

Across your hand (100 mm) (my wife's = 80 mm)

Your handspan from thumb to little finger (250 mm with a stretch)

Your cubit from elbow to longest finger (500 mm)

Your height (1830 mm)

Your shoe length (340 mm)

Your shoe width (120 mm)

Your foot length with socks (305 mm)

Your foot width with socks (115 mm)

Use the tape to measure:

Your largest room (5 m x 10 m)

The length of your house (20 m)

A bedroom (4 m x 3 m)

Mark out 10 metres then step out to calculate:

Your average pace (750 mm) and your longest – stretched – pace (1000 mm = 1 metre)

Step out 10 metres then check with the tape.

Use the bathroom scales to measure:

Your body mass (122 kg)

Your maximum body mass for good health can be calculated by taking the 1 and the decimal point from your height (for me 1.83 - 1. = 83) so I should not be more than 83 kilograms!

Use kitchen scales, jugs and cups:

Establish that a teaspoon has a capacity of 5 mL

Establish that a tablespoon has a capacity of 20 mL (15 mL in the UK and the USA)

Find the mass of an empty cup (say 350 g)

Find the volume of a cup (250 mL)

Establish that 250 mL of water is 250 g

Establish that 1 L of water has a mass of 1 kg

Measure the temperature of the water from the hot tap (60 °C)

Measure the temperature of the water from the cold tap (15 °C)

Measure the air temperature outside (14 °C)

Measure the air temperature inside (20 °)

Learn this rhyme:

Forty *is hot,* ***Twenty*** *is nice,*

Ten *is cool,* ***Minus*** *is ice.*

Decision making for metrication leaders

Consider two kinds of decision-making skills.

1 We make quick **short-term intuitive** decisions that are good enough for the present circumstances, when we are under stress of any kind, especially stress due to lack of time. The chief advantage is speed; you can make decisions that are – good enough – quite quickly.

2 We also make **long-term rational** decisions that require careful research, deep thought, and strategic planning. In deciding to adopt the metric system for your business, you will need long-term rational and strategic decision-making to develop your metrication policies and to write your policy documents. On the other hand, your staff will need to regularly make **short-term intuitive** decisions to put your policies into action.

For this reason it is a good idea to consider where and how you will use each of these decision-making methods. You can decide how they might be used appropriately or avoided when necessary, and how you will use them during and after your metrication upgrade. To begin your thinking about these two decision-making methods, think about the following situations as you decide whether **short-term intuitive** decisions or **long-term rational** decisions are the most appropriate for each circumstance by ticking the boxes.

Task	Short-term intuitive decision	Long-term rational decision
Agreeing to go to a party		
Buying a cheap guitar because it is *on special*		
Buying a new home		
Choosing your life partner		
Deciding what to wear today		
Deciding about your children's education		
Evaluating job opportunities		
Selecting a meal when dining out		
Selecting the next book you will read		
Selecting the next car you will buy		

You would probably use your short-term intuitive decision making skills for some of these situations – but hopefully not all of them!

As a metrication leader it is important that you understand how people use these two decision-making methods, so I will describe them in a little more detail before I recommend what to do about them.

Short-term intuitive decision-making

Often people are unable to move quickly and easily to the use of the metric system because of the mindsets that they hold. We hold mindsets because they have proved to be so useful to us in our past.

Sometimes making intuitive decisions is referred to as using: common sense, gut feeling, inner voice, instinct, or using your sixth sense.

Studies of fire fighters and military personnel show that leaders in these fields often make intuitive decisions based on the mindsets that they have developed from their own experiences, and stories they know about the experiences of other people.

However, in this scientific age the idea that we make decisions according to what our '*gut*' tells us is hard to justify. Our feelings are supposed to be mastered, and we are supposed to carefully collect facts and

figures and then to make rational decisions based on our research. But we all hold firm convictions that for many, perhaps most, decisions and even complex ones, all the data in the world can't beat a lifetime's worth of experience that provides our gut feelings, instincts, and intuitions.

Some organisations actively promote intuitive decision-making skills. For example, in the USA the Marine Corps follows a procedure developed by Colonel John R. Boyd, who demonstrated in 1989 that a person in the midst of conflict continuously moves through a decision-making pattern that he termed the *Observe-Orient-Decide-Act (OODA) Loop*. Colonel Boyd pointed out that the decision maker who moves through the OODA cycle the fastest gains a decisive advantage by disrupting the opponent's ability to react. He wrote:

> *Since these intuitive skills result from experience, we must include repetitive decision-making drills and exercises in all of our formal ... training programs of our operational units. Finally, our commanders must foster a climate within their units that is supportive of intuitive skill development.*

We especially use the mindsets we have acquired when we need to make fast – good enough – decisions to meet particular stressful situations. Often these decisions are regarded as *intuitive*, but the reality is that we use a particular technique to arrive at these *intuitive* decisions. The OODA loop is one such process; there are other analyses from other experts (Google "intuitive decision making"). As an example, this is from http://www.decision-making-confidence.com/decision-making-models.html

> *Psychologist Dr Gary Klein has been studying decision making for many years and he suggests that people actually use an intuitive approach 90% of the time. His recognition primed decision-making model describes that in any situation there are cues or hints that allow people to recognise patterns. Obviously the more experience somebody has, the more patterns they will be able to recognise. Based on the pattern, the person chooses a particular course of action. They mentally rehearse it and if they think it will work, they do it.*
>
> *If they don't think it will work, they choose another, and mentally rehearse that. As soon as they find one that they think will work, they do it. Again past experience and learning plays a big part here. There is no actual comparison of choices, but rather a cycling through choices until an appropriate one is found.*
>
> *Obviously people become better with this over time as they have more experiences and learn more patterns. But can this be taught?*
>
> *I believe so.*

Long-term rational decision-making

But even with extensive training in intuitive decision-making, this is probably not the best model for a corporate decision to '***Go metric***' with a metrication upgrade. A long-term rational decision-making process is preferable for this.

A long-term rational decision-making process is essentially a step-by-step procedure. It has many advantages that make it the best tool to use for a decision like the metrication of a business. Your long-term rational decision-making model will involve steps such as these:

1. Defining the current situation and the planned situation carefully.
2. Asking questions aimed at defining the decision(s) to be made.
3. Identifying the important criteria for the process and for the result.
4. Researching possible sources of information and collecting facts, including learning from the experience of others who have been through a similar process.
5. Considering and evaluating all of the data you have collected.
6. Considering and listing all possible solutions.
7. Calculating the consequences of each possible solution.

8 Comparing the possible solutions to the initial criteria.

9 Choosing the best option.

10 Setting SMAART goals (see below) and then putting your plan into operation.

Examples of metrication decisions from the past

Have you have ever found yourself saying:

It seemed like a good idea at the time!

If you have then you probably used the short-term decision-making process.

We are all used to making short-term intuitive decisions in our daily life whenever rational reasoning is difficult to apply. However, intuitive decision-making is not always the best method to use. Here are some examples of policy decisions – some intuitive – some planned.

Policy decision	Example	Result	Comments
Use millimetres.	A 1909 meeting in Paris decided photographic film would be measured in millimetres.	Metric transition completed within the year by most companies including Kodak in the USA.	Little cost and much material saving for film companies since 1909.
Use centimetres.	Photographic paper began to be measured in centimetres in about 1916.	Metric transition still in progress in 2009 with 13 sizes – some centimetre and some inch.	Additional cost a little more than 3 % of all turnover for 93 years so far.
Use whole numbers of millimetres.	Australian building industry changed to metric using millimetres without fractions in 1974.	Successful metric upgrade completed in 1975.	Savings to industry estimated at 10 % of turnover every year from 1975.
Use mixed numbers such as: 2 metres, 34 centimetres, and 5 millimetres.	Builders in France, Italy, other European nations, and some parts of Canada use mixed numbers.	Metric transition is still ongoing; numbers with two decimal markers, such as 2.34.5, are on building drawings.	Costs of training new employees have been extremely high for each year since 1795 (more than 200 years ago).
Use whole numbers of millilitres.	Wine and spirits bottlers in the USA changed all sizes to millilitres.	All bottles and containers changed within a year or two.	The companies saved 0.9 % of all contents with little or no complaint from the public.
Use whole numbers of litres.	Soft drink and fresh juice packers in the USA changed most sizes to one and two litres.	Metric transition completed without fuss within a short time.	Savings were made in production techniques – new easy-to-fill shapes were designed.
Hide metric units with old names as Napoleon did with '*Mesures usuelles*'	Since 1959 the UK and the USA have used metric inches, metric feet, and metric miles.	The public are still unaware that the UK and the USA are almost totally metric nations.	The political fights are about the existence of the words pints and miles and not their meaning.
Encourage metric conversion	Schools in the USA waste 10 % of each year's education budget practising conversions.	Every child in the USA takes an extra year to learn what other world children learn.	About 70 % of USA industry uses metric units. Training new staff at work to use the metric system is common.

Recommendations on how to make metrication decisions

Don't underestimate the difficulty of helping people escape from their old pre-metric mindsets. It will be hard, but it's a necessary consideration if you are to help people to succeed.

As mindsets have developed in one of three ways, this gives us a clue about how you might overcome the mindsets of the people involved in your metrication upgrade. Recall that the three factors in developing a mindset are:

1. Personal experiences
2. Learning from others
3. Remembering stories in the form of rules, principles, and moral stories in the form of fables, myths, and legends

Your task as a metrication leader is to provide the circumstances through which people can upgrade their old pre-metric everyday examples and rules of thumb to everyday metric examples and metric rules of thumb. To do this you will provide:

1 Personal experiences

As soon as you can, have participants experience metric measurement directly. Use direct measurements. Try for as many as possible from as large a range as you can. Use little stuff – teaspoons – and big stuff – buckets, baths, and rainwater tanks. You are developing new mindsets – so don't use conversions – ever. Try always for whole numbers so you don't have to enter debates and discussions about fractions of any kind.

2 Learning from others

Choose consultants with wide metrication experience.

3 Remembering stories in the form of rules, principles, and moral stories in the form of fables, myths, and legends

Use successful case studies from similar industries to your own. Gather stories of successful metrication upgrades and distribute them widely through newsletters and posters.

Support for this activity

1 Personal experiences

Use these sections from above:

- Metrication in a day
- Learn the metric system in a minute
- Become familiar with the metric system in an hour

2 Learning from others

To help you with this, I have collected some *metrication approximations, reference points*, *everyday metric examples*, and *metric rules of thumb* that you can use as part of your metrication training programs. These are listed as an appendix below (search for the words: *reference points*).

3 Remembering stories in the form of rules, principles, and moral stories in the form of fables, myths, and legends

Read through the *Arguments and responses* section (below) and choose from the 136 examples the stories that best suit your business. Also use examples from the *Metric pays off* web page at http://lamar.colostate.edu/~hillger/pays-off.html

What is metrication?

Metrication is the process of upgrading from any of the many and various old pre-metric measurement methods to the modern metric system, (formally known as The International System of Units or by the abbreviation SI). At its best, the metrication process of upgrading to the full use of the metric system is done smoothly, quickly, and economically.

The metric system is quite simple in concept, easy to learn, and easy to use. However the metrication process can be relatively complex because of personal forces related to mindset issues and social forces related to peer pressures. Metrication upgrades that work address these issues directly with careful planning and thoughtful applications of those plans. To do this you need metrication leaders.

Metrication is a process. It is a process like learning to play golf or learning to play a musical instrument. It takes a little time to master the metrication basics (less than an hour for most adults), but you can then take the rest of your life to explore all of the possibilities and subtleties of metrication.

Metrication is definitely not 'metric conversion', which for most people, is an unnecessary diversion that distracts them from your true metrication process.

Metrication is inevitable

The metrication process began when France made the '*decimal metric system*' legal in the 1790s. Metrication then spread rapidly to all other nations in the world. Gradually, through the 1800s, the metric system replaced all of the numerous old historical weighing and measuring methods. By 1900, almost all nations had passed laws that accepted the metric system for use in trade, and during the late 1800s this usually translated into widespread use of the metric system by the public.

The metric system is now used by all of the world's people in all nations. The philosopher, Condorcet, proved to be correct when, in 1791, he described the original metric system as:

For all time; for all people.

The USA has legally allowed metric measuring units since 1866, and the UK since 1873. Liberia and Myanmar are the only nations that have not yet passed specific metric laws, but the metric system is used in both of those countries every day.

Only in France, Japan, the United Kingdom, and the United States of America has there been any significant opposition to metrication, the main objections being based on history, tradition, aesthetics, economic conjecture, and a personal distaste for ideas regarded as new or foreign.

In France and Japan the opposition faded as soon as people regularly used the metric system. This left only two nations, the UK and the USA, with citizens who have difficulty accepting the reality of worldwide metrication.

For example, while the world automotive industry 'went metric' in the 1970s, the anti-metric lobbyists in the UK and the USA in the 21st century still insist that the all-metric cars, whether made in the UK and the USA or imported, have mph (miles per hour) written on their speedometer, ml (mile) written on their odometers; and psi (pounds per square inch) written on their tyres.

While the anti-metric people protest, the rest of us simply:

> *Get over it; get with it; and get on with it!*

Opposition to the metric system sometimes leads to quite odd results. In the USA, since the Mendenhall Order in 1893, all old measures such as yards and pounds have been legally and officially defined by the USA in terms of the metric system. The USA yard was defined as: 1 yard = 3600/3937 metre, or 1 inch = 25.400 050 8 millimetres. In the same year, 1893, the Congress of the USA defeated a measure to adopt the metric system. As suggested by Mark Twain (Samuel Langhorne Clemens 1835/1910):

> *Denial ain't just a river in Egypt.*

What is a metrication leader?

Your interest in the metric system is all you need to become a successful metrication leader. Use the ***Metrication Leaders Guide*** to take you quickly through your own process of upgrading to the metric system. As you use the ***Metrication Leaders Guide*** you will also develop many leadership skills that are transferable to other parts of your life and career. These include developing your ability to help others, and building your business by decreasing costs and increasing sales.

You will soon face these issues:

- How you learn about the International System of Units (SI).
- How you use the International System of Units (SI).
- How much you need to know about the International System of Units (SI).
- How much you need to understand about the International System of Units (SI).
- Why do some people resist change to the International System of Units (SI)?
- How do you overcome this resistance?

At the end of your own metrication process, you will find that the metrication change is forever. Wherever and whenever a change to SI has been made, the change is permanent. No one ever goes back to old pre-metric measures willingly. The superiority of the International System of Units (SI) compared to all of the old methods in the world becomes obvious to anyone who has used SI, and it doesn't matter whether the change was made voluntarily or compulsorily.

You will learn how to:

- Develop your metrication leadership
- Plan your metrication campaigns
- Save money for your business
- Develop more efficient work practices
- Develop your change management skills
- Refine your planning techniques
- Polish your presentation performance

How to develop as a metrication leader.

To help you through your metrication process, you need genuine facts and knowledge, and sound arguments. I hope that you will find both in the ***Metrication Leaders Guide***.

To continue your development as a metrication leader we suggest that you:

1. Click here to subscribe to the http://www.metricationmatters.com/newsletter

Your free subscription to the ***Metrication matters newsletter*** will provide you with a monthly newsletter keeping you up-to-date with worldwide progress on metrication matters. This will help you to build the skills you need to become a professional, well-respected metrication leader.

Metrication matters can support your development because we offer specialist expert support to anyone who wants to continue to develop as a metrication leader. We know that you are a metrication leader in your own company, in your own industry, or in your own community. Most of our resources are free. ***Metrication matters*** offers you:

- Specialised resources and courses designed to develop your metrication skills, talents, and attitudes that will help you achieve your metrication goals,
- Expert metric system knowledge from many crafts, trades, and professions,

- Specialist knowledge of the metric system from all around the world, and
- Understanding of metrication methods such as metric conversion.

2 Do the Metrication Basics e-course

When you click here and sign up for the Metrication basics e-course (at http://www.MetricationMatters.com/MetricationBasics.html), you will also receive a **free** copy of the quick guide **10 ways to promote metrication**.

There is nothing a company or any other organisation does that is not involved with measurement. If you understand how a business or an industry measures, you will also understand how the whole industry works.

The more that companies trade internationally, the more opportunities there are for metrication leaders. Get in now and find your niche in the growing metrication industry

At the core of every industry is measurement. When businesses buy, process, or sell they use measurements. Every business needs people who understand measurement in all operations. Every business needs metrication leaders. As a metrication leader, you will grow to understand all aspects of your company's business, leaving you well placed to accept management roles and positions.

There are hundreds of metrication leaders working in all types of industries, knowing that much of the enjoyment in their jobs is due to the fact that they enjoy knowing about all aspects of their business, and they enjoy the continuous learning about their industry and the world. They also enjoy their status because they are known as the 'metrication leader' and many others come to them to benefit from their knowledge.

One of your roles as a metrication leader is to be open about your interest in fair and honest metric measurements. You need to be a role model for others to follow. Most people find it much easier to make a change in their lives if they can see that there is someone to follow.

Why shouldn't you be a metric system role model as a metrication leader for your community?

What is metric? What is SI? And how do I spell metre?

About now, I need to explain two technical matters:

1 I sometimes refer to the modern metric system using its internationally agreed initials, SI (pronounced 'ess eye'). This is because SI is the officially recognised abbreviation for the International System of Units (SI) from its French name, Le **S**ystème **I**nternational d'Unités. If you want to know more about the International System of Units (SI) you can download a free copy of the official 88 page brochure from http://www.bipm.org/utils/common/pdf/si_brochure_8_en.pdf

2 My spelling of the word, metre, may seem a little odd to some people.

- I use the spellings metre and litre as they are used in the SI brochure. That is, I use metre if the unit and the subject are related in any way to the metric system (such as in micrometre, millimetre, metre, and kilometre).
- I use meter when I refer to any device that measures something (such as gas meter, parking meter, speedometer, and voltmeter) or to a particular kind of measurement (such as diameter and perimeter). I might use an odometer to measure a perimeter, but I would choose to do so in millimetres, metres, or kilometres. If you need to discuss spelling with any of your colleagues, you might find the article at: http://www.metricationmatters.com/docs/Spelling_metre_or_meter.pdf useful to provide you with arguments for you to support your choice of spelling.

Approaches to metrication

The common processes that governments use in upgrading from traditional measurement methods to the metric system are:

- Direct metrication
- Phased metrication
- Metric conversion
- Hidden metrication
- Ignore it and it will go away

Direct metrication

Direct metrication is rapid, smooth, and economical. Direct metrication was used by India in the early 1960s. The Indian approach was to simultaneously outlaw the use of all old pre-metric measurements, to rewrite and to reissue all government publications and laws, and to change education curricula to metric. India's metrication upgrade lasted from 1960 April 1, when metric became legal, to 1962 April 1, when all the old pre-metric measures systems were banned for use in trade. The Indian model was extremely successful and it was also successfully copied by several other nations. Direct metrication was used by the Australian construction industry to 'go metric' in a single year, and direct metrication was successfully used by the world automotive industry to 'go metric' in the 1970s.

Phased metrication

Phased metrication is slow, painful, and expensive. Phased metrication involves passing laws that permit the use of metric units in parallel with old measures. This is then followed, on a parliamentary and political timescale, by slowly banning all of the old pre-metric measures. I will use 3 phased metric examples in the order that they 'went metric': the USA, the UK, and Japan.

USA

The USA has been using a phased metrication policy since President Andrew Johnson signed the Kassen Act (1866 July 28). This Act declared it lawful throughout the USA to '*employ the weights and measures of the metric system*'. The USA is still going through its process of phased metrication in 2009 — more than 140 years later — and still counting.

UK

The United Kingdom permitted the use of the metric system in 1873, but little progress was made until pro-metric laws were passed whenever UK politicians saw a chance to do so (the major Weights and Measures Acts in the UK were in 1963, 1976, and 1985).

However, with huge political efforts, anti-metric lobbyists in the UK have been able to gain exceptions in three areas: miles, yards, feet and inches for road signs; pints for beer and milk delivered to doorsteps and beer sold in pubs; and troy ounces for gold and silver. All other measurements in the UK are now fully metric.

Japan

Japan chose phased metrication and their changeover was painfully slow, with bitter political and personal disputes, and expensive.

Japan ratified the Convention du Mètre in 1886, and began their phased approach in 1891 but little happened. The government then decided, in 1909, to adopt the units of the British inch-pound system. Japan then had three legally approved measuring methods: traditional units based on the 'shaku' and the 'kan', metric units, and the British inch-ounce measures.

In 1924, the Japanese government decided to adopt the metric system within ten years, but their law also allowed the continued use of other methods as transitional measures. The metrication process was so

slow (probably due to dithering between the three measurement methods) that it was relatively easy to create considerable public opposition to the metric system.

Japanese metrication experienced a further setback when the country was occupied, in the late 1940s, by military forces from the USA. Japan then experienced a de facto measuring conversion to the customary units of the USA — the Japanese then had four different methods of measurement.

The cultural power of the USA is still felt around the world as a result of the measuring language used in film, television, radio, and sports commentaries. When reporters imported from the USA to comment on (say) tennis players from that country, they choose to use feet, inches, and miles per hour. These commentators seem quite unaware that more than 96 % of the world population prefer to use metric measuring units. Japanese phased metrication is still continuing into the 21st century with sake bottles and tatami mats as examples of holdouts.

Metric conversion

Metric conversion is one of the ways that you can upgrade to the modern metric system — ***eventually***.

I say ***eventually*** because the **metric conversion** process is slow — painfully slow.

Many people who have chosen the **metric conversion** path have found through bitter experience that upgrading to the metric system using **metric conversion** can be really slow, very difficult, and extremely costly. Whether your **metric conversion** to the modern metric system is aimed at yourself, your work group, your company, or your nation, you will also find that **metric conversion** is one of the slowest possible paths.

Let me repeat a line from the great American journalist, H. L. Mencken, who could have been talking about the difficulties of metric conversion when he wrote:

> ***...for every complex problem there is a solution that is clear, simple and wrong.***

Metric conversion is so slow that it may never succeed; so bitter that it divides families, industries, institutions, and nations; and so expensive that most nations probably cannot afford it. For example, I estimate that non-metrication in the USA costs over a trillion dollars a year. This is more than twice the annual cost of all military expenditure in the USA. See: '*Costs of non-metrication*' at http://www.metricationmatters.com/articles

Metric conversion sounds like it is moving toward the adoption of the metric system when the reverse is nearer to the truth. When people are told that (say) a room is 6 metres long, they ask, 'What's that in feet?' If they are told that there was 15 millimetres of rain during the night, they ask, 'What's that in inches?' Almost all references to metric conversion tables are to change metric units back into old pre-metric measures.

Metric conversion is almost always an attempt to retain the names of old pre-metric measures; to keep the old names the old measures are sometimes redefined using metric units. This has the effect of keeping alive many multiple methods of measurement alongside the metric system. This is usually referred to — erroneously — as dual measurement but it almost always is much more complex than dual measurement. Remember that before the introduction of metric units there never was a system for measuring at all. There were thousands of random un-coordinated

As an example of the complexity of 'dual' measurements consider the conversion from inches to millimetres in the English speaking nations. In 1958, there were several definitions of the word 'inch'. The UK used the Imperial inch and the Enfield inch; the USA used the customary inch and the survey inch based on the 1893 survey foot; the Canadian inch differed from all four of these, and the Cape inch in South Africa had yet another value. Because of the complexity of all the old pre-metric 'inches', the inch was officially redefined in English-speaking nations as exactly 25.4 millimetres (1959 January 1). As metrication specialists say:

> ***Don't duel with dual!***

Metric conversion is often simply about retaining old measuring words in an attempt to keep the old words alive with little thought to the meanings of the words. The old measuring words can then remain in use for many years. When Napoleon supported the introduction of a 500 gram livre in 1812, this had the effect of increasing the number of different French livres from 12 to 13. The obfuscation of measurement words that is inherent in metric conversion might keep the realisation of the truth of metrication away from public attention for many hundreds, perhaps thousands, of years. Remember the cubit is still around in some texts.

To understand why metric conversion is so difficult and so slow, you need to know that **metric conversion** actually involves three quite separate and distinct learning pathways. One of these — learning about the metric system — is quite simple but the other two can be enormously complicated and correspondingly slow.

We won't fully explore why metric conversion is so slow here, but you can study the reasons for this at http://www.metricationmatters.com/metric_conversion.html

Hidden metric

Hidden metrication takes place when a company works internally and then communicates all measurements to their customers and to the public in old pre-metric measures. Some people choose to use the metric system to gain its positive benefits and then hide their use of the metric system from other people.

For example, when I visited the Kennecott copper mine in Utah, they had a tyre from one of their Caterpillar dump trucks outside the visitor's centre. It was 4 metres in diameter and I checked this with its imprinted dimension of 4.00 that was moulded into the rubber on the tyre. However, on the ground in front of this metric tyre was a sign that read, '13 ft 1-1/2 in'. The company was using a 4 metre tyre but labelling it with old pre-metric measures presumably because they didn't want the public who visited their 'Public Information Centre' that they were using metric.

I was so intrigued with this deceit that I then traced through the whole copper mining process from mine to market:

1. The ore is torn from the mine face using explosives that are calculated in metric units.
2. The ore is loaded with loaders that were designed and built in metric units.
3. Dump trucks, designed and built by Caterpillar in the USA in metric units using metric fasteners such as metric bolts and metric screws, carry the ore out of the pit.
4. The ore is crushed to specific sizes specified in fractions of millimetres or more likely micrometres.
5. The separation of the ore from the minerals is done in flotation tanks under the supervision of trained chemical engineers who calculate the processes and the yields in metric units.
6. The mineral, in this case mostly pure copper, is then formed into bundles of cathodes of 5000 lb. so that the customers of the Kennecott Mine will not know that they are buying from a metric company.

I think of this process as '*Dumbing down at the door*', where companies operate as metric companies internally, and then do whatever they can to hide what they are doing from their clients and the public.

Think of Ford and GM who buy all of their parts on the world market using metric units, design and build vehicles using the metric system, then tell their customers about mph, mpg, and psi, simply because of the anti-metric efforts of two government lobbyists – often a long time in the past. I cannot understand why people choose to use hidden metric. Their motivation is a mystery, but I suspect that it has something to do with how people perceive their acceptance by the rest of their community. They may think, '*Will I become a social outcast if I describe a length in millimetres?*'

If you are interested in the various ways that others have approached metrication you will find their approaches at http://www.metricationmatters.com/docs/ApproachesToMetrication.pdf where I write:

> *I have been closely involved with many successful, smooth, and rapid metrication transitions. I have also observed inefficient, bitter, and painfully slow attempts at metric conversions. Based on these experiences, my overall belief is that metrication is inevitable in all nations, in all industries, in all nations, and that it can be achieved quickly, smoothly, and economically.*

Ignore it and it will go away

This is the approach taken by Republican Lyn Nofziger and his long-time political rival Democrat Frank Mankiewicz when they colluded to defeat the metrication of the USA during the Reagan presidency. These two men seemed to be quite unaware that metrication is inevitable. The inevitability of the metric system arises because the metric system possesses simplicity, honesty, openness, international acceptance, and the ability to save time and money every where it is used.

In a Washington Post remembrance of the late Reagan Press Secretary and leading Republican Lyn Nofziger, long-time political rival Democrat Frank Mankiewicz claims that the two of them had worked secretly together to kill the metric system in the United States. Mankiewicz wrote in the Washington Post (http://www.washingtonpost.com/wp-dyn/content/article/2006/03/28/AR2006032802142.html)

> *... during that first year of Reagan's presidency, I sent Lyn another copy of a column I had written a few years before, attacking and satirizing the attempt by some organized do-gooders to inflict the metric system on Americans, a view of mine Lyn had enthusiastically endorsed. So, in 1981, when I reminded him that a commission actually existed to further the adoption of the metric system and the damage we both felt this could wreak on our country, Lyn went to work with material provided by each of us. He was able, he told me, to prevail on the president to dissolve the commission and make sure that, at least in the Reagan presidency, there would be no further effort to sell metric.*
>
> *It was a signal victory, but one which we recognized would have to be shared only between the two of us, lest public opinion once again began to head toward metrification.*

France — a special case

Following the failure of phased metrication in France, some French people, led by Napoleon, then chose metric conversion. As an example, they simply took an old word, 'livre' and redefined it as 500 grams (in 1789, there were 12 different livres in France varying from about 344 grams to 519 grams). A similar approach was taken in China with a 500 gram 'jin'; in Denmark with a 500 gram 'pund'; and the Netherlands redefined the 'pond' as 500 grams and the 'ons' as 100 grams.

France was a special case because they initially tried phased metrication and when it failed they successfully used direct metrication for most things and metric conversion for some others (you can still hear Parisians ask for 'une livre' of fruit). They passed metric laws in the 1790s and these were universally ignored in favour of the old '*mesures usuelles*'. This failure was corrected when the French government finally passed laws favouring direct metrication. The metric system was reinstated as the only legal measurement system in France from 1840 January 1. French people who did not use metric units were threatened with large fines and severe penalties but few, if any, were charged.

Metrication business planning

Metrication, at it's best, is seen as an opportunity – an opportunity to improve all aspects of your business.

In 1992, the government of the USA decided to make the metric system the preferred system of weights and measures by passing this law:

> *... to require that each Federal agency, by a date certain and to the extent economically feasible by the end of the fiscal year 1992, use the metric system of measurement in its procurements, grants, and other business-related activities ...*

This law is now having far reaching implications for the business community – and for the whole society – in the USA and elsewhere in the world. The law is having an effect on product-oriented as well as service-oriented businesses and it has led to many new opportunities for business growth.

For example, businesses that upgrade to the metric system are then able to obtain the benefits of improved competitiveness and market access, as well as savings from standardisation.

Businesses are discovering that metrication is a necessary change if they wish to retain their government contracts, and businesses that choose to resist metrication will not be able to compete in metric markets.

Metrication need not be complicated; it can be quite simple. However, it needs careful planning to make your upgrade to the metric system as cost-effective and as efficient as possible.

Many other people and companies have done this before you – so learn as much as you can from their successes and failures – you don't have to do metrication for your business all by yourself.

There are a number of steps you can take to simplify the process. As you proceed through each of the steps in your metrication upgrade process for your business, keep asking:

> *Can we use this opportunity to reduce costs, improve our processes, increase our markets, and increase our profits?*

Naturally, you will decide on the emphasis you will give to each of these steps (and also consider other steps that you might add). You might use the following steps as a guide for the metrication upgrade of your business:

1. **Prepare yourself to be a metrication leader**
2. **Goal setting – first thoughts**
3. **Preliminary investigations**
4. **Buying analysis**
5. **Processing analysis**
6. **Marketing analysis**
7. **Planning**
8. **Policy writing**
9. **Goal setting – again**
10. **Now do it**

Prepare yourself to be a metrication leader

Personnel: Metrication leader alone.

Here is a 10 step orientation for a new metrication leader

Step 1

Walk around your business or your department and speak to everyone – from the General Manager and CEO to the janitor – to ask about the measurements they use and which of these are most important to their work. Think about how past practices will become to new practices.

Step 2

Find the most successful metrication policies from industries that are similar to your own from all around the world. Learn from them and copy from them shamelessly. My experience is that experienced metrication leaders are more than willing to help you. Approach them and ask.

Step 3

Begin to write notes that will form your own metrication policy, keeping thoughts like these in your mind:

1. Choose metric system units that will almost always give you whole numbers to work with.
2. Use the metric system prefixes to use whole numbers without fractions wherever you can.
3. Choose a larger and smaller unit range using the thousands prefixes from the SI prefixes.
4. Specifically plan to state which metric prefixes will not be used by your business, e.g. centi, deci, deca, and hecto are not used in most businesses.

Step 4

Find reference examples that are appropriate to your industry. In the paper industry examples might include paper dimensions in millimetres (A4 = 210 x 297); in the health industry examples might include baby birth mass in grams, and walking speeds in metres per minute (a brisk walk = 100 m/min). These references are really important as they give a '*feel*' for the size of things that allows them to know 'instinctively' when something is going wrong.

Step 5

Prepare to run a marketing educational campaign that includes:

1. Posters on notice boards
2. Place tips and tricks for the metrication process in your internal newsletters.
3. Articles showing successes and savings made by using simpler metric system measurements.

Step 6

Walk around again to plan for the effectiveness of your education and marketing campaign. You need to be sure that about 85 % of your staff members are ready for the next stage. The figure of 85 % is chosen because this will ensure that your culture has permanently changed from old pre-metric units to metric units.

Step 7

Allow enough time for the extremely important training processes. Your training should be sufficiently effective that your staff will believe that completing the metrication upgrade is inevitable.

Step 8

Plan to organise special days for each phase of your metrication process (say T-Day for temperatures, V-Day for volumes, k-Day for kilograms, and L-Day for lengths). Begin to look for venues and find the names of potential speakers and consultants.

Step 9

Plan that after a settling period, you will seek out and destroy any old measuring practices. Look for old double-sided rulers and tapes – burn them or bury them. Look for conversion charts on the backs of doors and inside desk drawers – remove them, as these are mostly kept to preserve a 'feel' for the old numbers that people have got used to. Work with these people as you repeat Step 4 to find the best examples of ready references and rules of thumb for your industry.

Step 10

Plan to have a party; better still plan to have lots of parties. Plan for special celebrations to announce that your metrication process has begun extremely well. Ask staff to be especially careful about importing bad measuring practices from clients, suppliers or from new staff. Give awards to those who have actively contributed to the metrication process.

Goal setting

Personnel: Metrication leader alone – for now – more thinkers required later.

Don't do this now but keep it in your mind as you go through the process of developing your metrication business plan. This might help:

To set effective goals that work, you could use what I call **SMAART** goals. **SMAART** is an acronym that stands for:

Specific, **M**easurable, **A**ctionable, **A**ttributable, **R**ealistic, and **T**imed.

SMAART goals give you a starting point for your goal setting. In an article at http://www.metricationmatters.com/docs/SettingSMAARTmetricationGoals.pdf I use metrication activities as examples of SMAART goal setting.

SMAART metrication goal setting makes sure that you have a positive direction in your metrication activities.

Setting SMAART goals is so easy that you'd be crazy not to set aside the small amount of time needed to sort out your plan of metrication action. SMAART Goals will help you make your metrication successful.

Preliminary investigations

Personnel: Metrication leader reporting to small management committee.

Your preliminary investigations allow you to discover the range of things that will be necessary for you to consider and plan for during your metrication upgrade.

Questions you should ask are:

- What is your current position on measurement?
  - Do you have a measurement policy?
  - Are you in full control of all of your measurements when you:
    - Buy from your suppliers?
    - Process internally?
    - Sell to your clients?
  - Do you need to be in control or do you trust people who are outside your business?
- Where do you look for the best advice on how to upgrade to the metric system?
- Should you use one or other of the old metric systems? Or, should you go all out for the International System of Units (SI)?
- Are there metrication consultants who can advise you on the best way to proceed with your upgrade to the metric system?

- Can you learn from others who have successfully upgraded to the metric system already?
- Can you learn from others who have failed to upgrade to the metric system? Where did they go wrong? And can you avoid their errors?
- Has anyone in your industry written a metrication policy that works? Would it work for you? Can you adapt or devise a metrication policy that will give us a simple, smooth, and economical transition to the metric system?
- When will you start to develop your metric system capabilities?
- When will you apply your metric system capabilities?
- How quickly can you develop your metric system capabilities?
- How quickly can you apply your metric system capabilities? Can you do it in a day?
- What other steps might be involved in your metrication process? Parties? Awards?

Buying analysis

Personnel: Metrication leader with small management committee.

Questions you should ask are:

- Have you used an overall purchasing policy, or did you simply rely on your suppliers to measure accurately, precisely, and honestly?
- What are your suppliers' measurement abilities? Will you need to reconsider your suppliers when you upgrade to the metric system?
- What effects will metrication have on your inventory? Can you reduce the numbers of items you carry by rationalising what you need? For example, did you know that the engineer, Ferdinand Porsche reduced the number of bolt sizes in his first Volkswagen car from over thirty different sizes to only three when he chose to be all-metric in about 1932?
- What effects will metrication have on your logistics? How will you need to change your supply timetables?
- How much can you buy from outside in an economical way? Can you outsource some of your current production? Or do you need to bring some of your current outsourcing back in-house?
- Have you identified supply sources that are committed to the metric system?
- Do you have your purchasing specifications written in metric system units?
- Do you need to make provision for dual inventory facilities?
- Have you scheduled lead-time requirements for phasing in metric system purchasing?

Processing Analysis

Personnel: Metrication leader with small management committee.

- Do you have an internal measuring policy for all of your measuring?
- Do you comprehend why experienced metrication experts advise to keep old methods separate from new metric projects? Can you understand the old machinist's observation: '*Only a fool duels with dual!*'
- Can you isolate old pre-metric jobs from new projects that can be fully metric in future?
- Can you decide to make all new products fully metric from this point onwards without any change to the old ones? Remember: '*Don't duel with dual!*'
- Can you find out how the Otis Elevator Company '*went metric*'? Even though they had elevators to maintain that were more than 120 year old, they were able at the same time to develop all-metric new projects (this information from Stan Jakuba, West Hartford, Connecticut).

- Do you have a goal to maintain your heritage work as you progress to all-metric projects?
- Would the Red/Blue and Gold/Green system work for you? This is where you label job cards, drawings, and parts for each job so that everyone knows whether to work in old pre-metric measures or to work in modern metric units. As everyone works on only one job at a time, there is no need for anyone to do conversions of any kind.
  - For old equipment you use old tools and old parts on old machinery
    - Red is for old equipment repairs
    - Blue is for new parts for old equipment
  - For metric equipment you use metric tools and metric parts on new machinery
    - Green is for metric equipment repairs
    - Gold is for new metric parts or new metric equipment
- If you manufacture very little, is it possible to outsource the lot?
- Can you refine the operations of your test activities, or can you transfer these to independent test agencies or even suppliers' test facilities.
- Do you understand the difference between metrication and metric conversion?
- What is required to add, replace or modify tools and service equipment?
- Do you have excessive pre-metric equipment that you can sell? This could be: tools and service equipment or inspection and test equipment.
- Do you need to make changes in your paperwork? For example, do you need to change: your service order forms, your test reports, your storeroom parts or tools checkout forms?
- Do you need to consider your performance and testing specifications?
- What is required to add, replace or modify inspection and test equipment?
- Have you planned to maintain, store and handle dual inventories?
- Have you planned to reduce and to phase-out old pre-metric items from production?
- How will you revise service order forms and other job related documents?
- Can you project future costs for developing your metric system servicing capabilities?
- Have you considered how the savings from working in metric system units will affect your budget?
- Are there any non-cost considerations that you could evaluate in your processing activities?
- Don't forget – as you consider each of the above items don't forget to ask: *Can we rationalise this process to improve cost efficiency and increase profitability*?

Marketing Analysis

Personnel: Metrication leader with small management committee.

- What are the trends in sales of your products now that you can supply in metric system units?
  - What information can you find from
    - Sales literature?
    - Suppliers?
    - Competitors?
    - Trade associations?
- How will you identify new market areas (both domestic and foreign now that you can trade with the whole world)?

- Do you have to make any changes in your sales paperwork?
- How can you check metric products sales trends?
- What potential is there for new markets that prefer and require metric system product specification?
- What potential is there for new markets that require and prefer service work to be done using the metric system?
- How will you provide continuing metric market research?
- How do you determine if your market is saturated with small businesses offering metric system services for any of your products and services?
- Can you project the potential for new metric system business?
- Are you in a position to review projected sales revenues based on new metric system business?
- How will you keep your customers informed about your new metric orientation? How will you inform them of your metrication successes and of your overall metrication progress?

Planning

Personnel: Metrication leader reporting to small management committee with participation from all sections of the business.

Begin your planning by assuming that everyone in the business will be involved and fully informed. Assume that this involvement will go from the Chairman of the Board, via the CEO, to the janitor in the workshops and the gardener. Identify the main groups in your company. This alphabetical list from a textile business might get you started:

Accountants	Knitters	Sales and marketing
Art and advertising	Laboratory	Security
Building maintenance	Laundry	Spinners
Janitor and cleaning	Library	Storeroom/Inward goods
Despatch	Machine shop	Testing
Grounds and gardening	Maintenance	Top-makers
Human resources/personnel	Management	Weavers
Kitchen and canteen	Office staff	Workshop

As you consider each of the groups from this list, you might ask questions like these:

- How will this group be specifically involved in the metrication upgrade?
- Who, from this group, will be their metrication leader(s)?
- Can any members from this group contribute to the metrication in other departments?
- Does anyone in this group have specific metrication skills?
- Does anyone in this group have public speaking or other communication skills that might be useful for your metrication upgrade?
- Does anyone from this group have specific personnel training planning skills?
- What training do members of this group need?
- Who could best provide this training for this group?
- How can you best keep this group informed of the overall metrication successes and progress from the whole of your business?

Metrication training

Personnel: Metrication leader, everyone in the business, and probably metrication consultants.

Your first assumption, when it comes to training, is that everyone will be involved. You will need to consider appropriate training for the CEO and for the janitor. Here are some questions that you might ask:

- How will you notify each employee about training opportunities?
- How will you select which level of training is appropriate to which staff member?
- Do you know how to conduct a training needs identification survey?
- What types of training do you need?
- Who will prepare the training materials?
- What is the timetable for training?
- How will you schedule metrication training to be the least disruptive to normal business operations?
- Can you use this opportunity to gain formal recognition of this training for at least some of your staff? Can your staff gain a saleable new metrication qualification? Is there a technical college nearby who will do this for us?
- Can you find suitable metrication consultants, speakers, and presenters?
- Can you use your training to specifically reduce costs and increase profits? See http://www.metricationmatters.com/docs/PageBordersInchesORmillimetres.pdf for an example of one way to do this.
- Do you need to schedule things like printing of training materials?
- Do you need to book rooms and other spaces fro training?
- Do you have issues with heritage products or services, like the Otis Elevator Company? If so, then you will have to train some people to be bilingual with respect to measurement. This is harder than training people to use the metric system by itself because the bilingual measurement people have to know three things: the old measures and the metric system units equally well, and how not to do any conversions – that's right – NO conversions at all. The hard part is to educate these people to split their thoughts so they might need two sets of tools, one metric and one with old tools. They then select the right toolbox for their current job. I heard of one manufacturing company who labelled each job as a red job or a green job using colored cards to mark them. The red was for heritage work, and the green was for all-metric work. Workers were then able to switch comfortably from working in metric on metric jobs and in old pre-metric measures on heritage jobs without anyone having to do any conversions at all. They were able to switch mentally from old documentation (in inches and ounces) to the new metric units several times a day for as many years as might be needed. Workers somehow got a feel for reference values in both systems.

Policy writing

Personnel: Metrication leader and the metrication management committee reporting to senior management.

Typically, companies establish a metrication policy and then the CEO signs this off. The CEO's participation is seen as essential to give credibility to your metrication upgrade.

The CEO's statement should say that from a certain date and time all newly designed products from the company will be designed, made, and sold using the modern metric system.

The CEO should also sign a carefully worded policy statement. This does not need to be long, but it is necessary so that everyone is reading the same policy statement when they need to make metric

decisions about their work. If this policy statement is not written, and not made public, then the practice is for everyone in the business to form his or her own metric policy.

Consider these examples:

Australian Building and Construction Advisory Committee policy:

The metric units for linear measurement in building and construction will be the metre (m) and the millimetre (mm), with the kilometre (km) being used where required. This will apply to all sectors of the industry, and the centimetre (cm) shall not be used. ... the centimetre should not be used in any calculation and it should never be written down.

Standards Association of Australia 'Metric Handbook, Metric Conversion in Building and Construction 1972

General Hospital Policy

To avoid errors that arise from decimals and other fractions, at the General Hospital we record and discuss the mass of all of our babies and small children in whole numbers of grams. For all children below 20 kilograms we record their body mass in grams within a precision of 5 grams. The unit for children is grams; kilograms will not be used. Above 20 kilograms, the body mass of all patients – children and adults – will be weighed, recorded, and discussed in whole kilograms without fractions of any kind – no decimal fractions and no common or vulgar fractions.

Goal setting – again

Personnel: Metrication leader, the metrication management committee, and senior management reporting to the board of directors.

Now is the time to get serious about you goal and objective setting. Read about the SMAART goals formula at http://www.metricationmatters.com/docs/SettingSMAARTmetricationGoals.pdf because you are now in a good position to apply it to your business.

You probably will want to do this in bite-size pieces before you consider the whole business.

Department by department goals

- What are the goals for each department of the business? Who from each department will help you formulate these?

Whole business goals

- What metric system units will you use in your business? Which metric system units will you choose NOT to use in your business?
- What is your metrication policy? Can you write this down so that everyone – management, employees, customers, and suppliers – knows exactly where you are going?
- What is the timetable for your metrication program? Do you have the resources (including the courage) to do it in a single day?
- What are your estimates for the costs of the metrication program? What will you spend on meetings, consultants, speakers, and trainers? What do you estimate to be the money value of the immediate benefits to your business?

Now do it

Personnel: Everyone in the business from the chairman of the board to the janitors.

After working through the steps described above, you should now have a comprehensive, detailed metrication plan. So you are now ready to put your metrication plan into operation. Here are some thoughts for you to consider:

- Training is essential for everyone from management to casual staff.
- Don't skimp on training – if in doubt be excessive – you will not regret being thorough. Remember, you only need to do this once.

- Don't miss informal opportunities for training:
  - Place some – kilogram only –bathroom scales in a communal area such as a lunchroom.
  - Place a two metre height scale on a wall near the scales.
  - Have – millimetre only – tapes and rulers freely available to all staff.
  - Consider printing your company logo on – millimetre only – rulers and tapes as gifts for staff to take home.
  - Consider printing your company logo on – degree Celsius only – thermometers as gifts for staff to take home.
  - Consider placing – degree Celsius only – thermometers immediately inside and outside a frequently used entrance door.

A predominant key to achieving success with your metrication plan to get the metric system established in practice is reporting. Report everything to everybody.

- Publish your plans so the whole process is transparent to everyone.
- Hold meetings – lots of meetings:
  - For all participants
  - For metrication leaders
  - For management to maintain their vision of the metrication benefits to your business.
  - For awards and ceremonies to mark metrication successes.

The usual way to begin is to schedule a meeting where management makes it absolutely clear that it is completely committed to your metrication program. You probably see the problem immediately. You have to make sure that this management commitment is really committed – and that it will be committed for the long term. Instead of the general meeting, start with management training to make sure of their resolve.

Too many metrication programs have failed because management made grand decisions then went to water as soon as they perceived any opposition to the metrication program – Napoleon Bonaparte springs immediately to mind because he moved away from the metric system as soon as he detected opposition from the aristocracy and the merchants who were about to lose from honest measures. Napoleon reintroduced *mesures usuelles*, which delayed the introduction of the metric system in France by almost 50 years.

Now that management is involved and committed, employee motivation and support can be generated by outlining the importance of metrication to the future of the company and to job security.

Make sure that you keep all management and employees informed about the progress of the metrication process. Keep it positive by reporting all successes – even the smallest.

Remember that metrication is personal to all of the people involved. All individual employees are vital keys to the success of your metrication upgrade, so as you report your successes use the names of the people who apply extra effort. Keep these reports as personal as you can by identifying individuals in the metrication process. This will help to alleviate any remaining fears of others and it will make your metrication transition smoother.

Finally

Two essential points:

1. Don't get so involved with implementation that you forget to check with your original goals and plans. It is important that you keep a continuous check on how closely the metrication process follows what you actually planned. One way to do this is to always have the metrication plan as an agenda item whenever your metrication task leaders meet.

2 Have a plan to keep monitoring metrication in your company into the future. There will be forces that seem to be trying to degrade your metrication program. Usually this is not deliberate but it will happen anyway.

Let me give you an example from the marketing area.

> *In marketing a company identity, someone is appointed – and informally labelled – as 'Logo Cop'. It is this person's job to make sure that the logo of the company is always consistent when it is presented to the public – the colours don't change; the right type face and size is used for the company name etc. It is surprising how often individuals casually change the company identity by being 'creative' with the company logo.*

This will also happen with your metrication policy after the concentrated efforts of your metrication upgrade. People will get slack. They will do this in all innocence but in time it can make the time, trouble, and expense of your metrication upgrade much weakened. Consider these instances:

- Jargon words such as micron instead of the correct micrometre; calorie or Calorie instead of kilojoule; mils instead of milligrams, millilitres, or millimetres; and far too many more.
- Words from older 19th century metric systems such as ergs of energy rather than the modern joule for energy.
- Acceptance of things like the default margins in word processor packages. The 1 inch top and bottom and 1 1/4 inch sides in a Microsoft Word package can increase you business paper costs by more than 20 % for example. See http://www.metricationmatters.com/docs/PageBordersInchesORmillimetres.pdf
- Acceptance of old pre-metric measures from your suppliers; say '*If you can't supply us with metric – I'm sure we can soon find someone who can*'.
- Beware of new employees – remember that schools are not effective teachers of an appropriate metric system for businesses. It is best to assume that new people to your business who come directly from schools, colleges, and universities know nothing about the metric system that businesses use – you will need to train them all. They won't know, for example, that most business units like millimetres and grams are used as whole numbers to avoid the use of fractions.
- Like the 'Logo Cop', your business will probably always need to have an informally named, 'Metric Cop' to guard the effectiveness of your metrication process.

Appendices

By now, you have enough information to carry out a successful metrication upgrade.

What follows is background information and support material for you to use, as and when you need it.

Who invented the metric system?

The answer to this question comes in four parts. The metric system's three separate parts were invented at three different times and in three different places. Then they were all put together at a fourth time. This is easily seen when we give the metric system its first full name. In 1790, it was called the:

decimal metric system

Let's work backwards through these three parts.

system

An English bishop called John Wilkins invented the *system* part of the *decimal metric system* when he published a book with a plan for a *'universal* measure' in 1668. To be more exact, he published his plan for what became the decimal metric system on Monday, 1668 April 13.

Bishop John Wilkins was, among other things: Warden of Wadham College, Oxford; Master of Trinity College, Cambridge; married to Oliver Cromwell's sister; writer of the first book in English on secret codes; writer of one of the first science fiction books about a trip to the Moon; and one of the chief founders of the Royal Society, still one of the world's most important science academies.

metric

The word, *metre*, and its adjective *metric*, probably derived from a translation of Wilkins words, '*universal measure*', into the Latin words, '*metro cattolico*', by Tito Livio Burattini in 1675. Burattini was born in Italy but he spent most of his life in Poland where he worked as an architect. He had previously travelled to study the building methods used in ancient Egypt.

decimal

The decimal part is the oldest of the three. Decimal numbers have been used on and off since ancient times in many parts of the world but they never became well established anywhere. The first person to recognise the full importance of decimal numbers, and how they could be used to simplify calculations, was Simon Stevin, from Brugge in Flanders, which is now called Belgium.

Simon Stevin was an engineer, a surveyor, and an accountant. As he was working out a set of tables for working out the amount of interest that banks should charge for lending money, he realised that decimal numbers made all of these money calculations much easier to do, and then he also realised that decimal numbers could also make all of the calculations in all of the other areas of life much easier as well. Simon Stevin believed that the use of decimals could rid the world of the cumbersome common, or vulgar, fractions with all of their various calculating difficulties. Simon Stevin published his decimal ideas in a book called, '*Disme: the art of tenths*' in 1585, and this book influenced John Wilkins who read a 1608 English translation of Stevin's book before he decided on decimal numbers for his system of '*universal measure*' in 1668.

The first time that the three parts of the metric system came together, they were written like this:

decimal système metrique

It was written like this because the people who were trying to develop the idea for a legal '*universal measure*', in the 1780s, usually wrote or spoke to each other in the French language.

Charles Maurice de Talleyrand-Périgord, (usually known simply as Talleyrand) and Jean-Antoine Nicolas de Caritat, Marquis de Condorcet (usually known simply as Condorcet) in France; Sir John Riggs-Miller, in England; Benjamin Franklin and Thomas Jefferson from the USA met together or corresponded on a proposal for '*universal measures*'. Condorcet and Jefferson were particularly close friends. It seems likely that Franklin and Jefferson promoted their strong support for decimal measurement and for decimal currency during the 1780s. Benjamin Franklin was the USA Ambassador to France from 1776 to 1784 and Thomas Jefferson served in this position from 1784 till 1789.

Essentially, Talleyrand, Condorcet, Riggs-Miller, Franklin, and Jefferson were proposing that their three nations should cooperate to equalise their weights and measures, by the joint introduction of a '*decimal système metrique*' (*decimal metric system*).

In the 1780s, they had all realised that the money and measuring methods were a mess in all three nations. For example, in the USA, various currencies were in use that came from the various nations who had an interest in the USA. There were such things as Pounds from the UK, Guilders from the Netherlands, Pieces of Eight and Reals from Spain, and this mess had been recognised by Thomas Jefferson as early as 1782 when he suggested the use of a decimal currency for the USA and achieved agreement among the states on this, in principle, by 1785.

Decimal currency became a reality when George Washington and Thomas Jefferson combined forces politically, to pass the USA Congress Mint Act in 1792. The world's first decimal currency, with one dollar consisting of 100 cents, was introduced smoothly and successfully to the USA. However, by then, Jefferson's decimal currency system had been already well established in the thirteen states of the USA by the daily use of Benjamin Franklin's independently minted, '*Fugio Cent*' since 1787. The ready acceptance of decimal currency in the USA had a major influence on the measurement leaders in France as they developed the decimal metric system to become the legal French measuring system.

I doubt that we would now have a universal metric system – at all – without the influence of Benjamin Franklin. Thomas Jefferson, and George Washington from the USA.

SI and the law

All nations have now chosen 'The International System of Units (SI)' as their legal measuring standard, promoting fairness and honesty in international commerce.

It has always been necessary for governments to pass laws to prevent people from cheating each other. There has never been freedom of choice in the use of measuring units for use in trade. Here is an example from the USA:

> *The primary objective of the Office of Weights and Measures is to achieve equity between buyers and sellers in the marketplace; to prevent deception and fraud. (USA Office of Weights and Measures)*

In most nations, responsibility for 'fixing the weights and measures' is simply incorporated into the nation's constitution. Sometimes it is done through legislation, but it is never done by referendum. No nation has ever chosen to use a referendum to choose their methods of measurement. Another way of looking at this is used in the Q and A section of the Metrication matters newsletter:

Question (from a reader in the UK):

> *The metric system is wrong because we have never had a referendum on its use. We should be consulted about our measuring methods. Why don't we have a referendum to decide on whether or not we use the metric system?*

Answer:

> *What you say is simply not true. A perfectly democratic vote is taking place every day in the UK and in all other nations in the world. Whenever someone in the UK chooses to buy 500 grams of butter or a 2 litre bottle of soft drink, they are freely and democratically voting for metric units. Whenever someone in the USA chooses to drive, or ride in, an all-metric car, they are voting for the safety and efficiency of metric units.*

Nations regard the right to establish measuring standards as a fundamental right of any national government. It is not a task that has ever been left to the states within the nation, to local civil authorities, or to individuals. For example, in the USA (Article 1, Section 8) of the United States Constitution provides, in part, that the Congress:

> *... shall have power ... To coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures; ...*

Measurement methods are so important to all nations, that responsibility for 'honest weights and measures' after incorporation into a nation's constitution or legislature, is then delegated to groups of measurement experts who devise appropriate measurement methods for their nation. Every advanced nation has a body of measurement experts whose job is to 'fix the weights and measures' so that they are fair to everyone.

Some of the measuring laws have been quite severe. In 1816, an English Law defined a number of measuring standards and then added that:

> *... it ought to be penal for any person to have in his possession any Measure or Weight that is not agreeable to the aforesaid standards.*

This meant that not only shopkeepers and traders, but also anybody could go to jail if they did not use the legal measuring standards.

Although there has never been a referendum on metric measures, it is also true that no other method of measures have ever been introduced after a referendum. Opponents of metrication sometimes suggest that there should be a referendum before metric measures are introduced; they say that compulsory metrication is undemocratic. However they always fail to mention that no measurement method, anywhere in the world, has ever been the result of a democratic voting process – there never was a referendum to introduce any of all the different inches, shekels, feet, pounds, ephahs, hins, miles, ounces, or gallons.

In the case of the International System of Units (SI), the legislation is an international treaty known as the 'Treaty of the Metre', and this is supported by each nation's legislation. For example, the USA was one of the first 17 nations to sign up to the 'Treaty of the metre', in 1875. The UK signed in 1883. Australia signed in 1947.

All nations now use the 'International System of Units (SI)' as the basis of their own national measurement methods. They simply adopt SI as part of their national legislation. Every nation in the world has laws that permit the use of the International System of Units (SI). Almost all of them go further and make the use of SI compulsory. However, the worldwide adoption of SI has little to do with coercion. Whenever people have used SI for some time, they have come to realise that it is simple to use; it is practical; and it is international.

Using SI, all people can achieve the main goal of any measurement method, which is to provide conditions so that people can trade – fairly and honestly – with each other.

> *'The concept of measurement is one of the most sophisticated products of the human mind; without it there would be no science, no industry, no commerce. Isaac Asimov (1920/1992)*

History of the metric system

Some metrication leaders are tempted to thoroughly explore, and then communicate, a more complete history of the metric system throughout history. This is a fascinating study but it is not very relevant to you as a metrication leader.

Metrication leaders need to concentrate on those things that get results — and that get results fast.

If you need to find historical facts and figures to illustrate your presentations and training sessions you will find many of them at http://www.metricationmatters.com/docs/MetricationTimeline.pdf where I have wasted much time on the task of collecting the history of the metric system into a '*Metrication timeline*'.

Universal acceptance of the metric system

The International System of Units (SI) is universally accepted because:

- SI is honest; it is fair to all concerned. The metre or kilogram that you use is the same for everybody else in the world. Compare this with the UK gallon, quart, and pint and the USA gallon, quart, and pint.
- SI is consistent with the decimal numbers we all use. SI is called a coherent system, which means that SI symbols can be used algebraically just like numbers. There are no illogical inconsistencies and there is no need for any conversion factors.
- SI diminishes or completely eliminates measuring confusion. For example, SI uses (easier to use) decimal fractions – there are no vulgar fractions. SI uses standard prefixes to change from smaller to larger units and by careful choice of SI prefixes you can even eliminate decimal fractions from your work leaving you with no fractions at all. SI does not have to use long rows of zeroes to give place value; SI prefixes can almost eliminate them.
- SI calculations can be easily checked with a calculator. By eliminating fractions, calculations, and conversion errors, you can significantly reduce or eliminate many costs.
- SI is based on international standards, not on features that are peculiar to a particular nation. This ensures global uniformity in the adoption of SI. There are no international differences; SI is a world standard fully maintained by international treaty. SI uses various internationally approved conventions that govern the use of terms and symbols.
- SI is more logical than any previous methods of measurement. There are only seven base units in SI and 21 'units with special names'. All other units are derived from these 28 units. Compare this with the many hundreds, or thousands, of old units you know now.
- SI uses the seven base units and the 21 units with special names to form all of the derived units that are needed by all of the world's people in all the world's occupations. SI is the same in all nations and for all trades and professions.
- SI has only one unit for each physical quantity. No conversions are necessary but SI Prefixes may be applied to any SI Unit to generate smaller (submultiples) or larger (multiples) of any particular SI unit.
- SI units can provides additional information; for example, the number of molecules of each compound present in a biological fluid is reported by using the mole.
- SI is SImple– remember SImple starts with SI.

Resistance to metrication

Whenever metrication, the change to the modern, simpler ways of the International System of Units (SI), has been suggested, there is always deeply felt resistance from some sectors of the community. But these conservative forces have yet to permanently reintroduce the old ways anywhere in the world. On the other hand, the bakers, butchers, building workers, engineers, manufacturers, and scientists who have upgraded to the metric system have never – repeat never – volunteered to reconvert to the old inefficient measures.

It doesn't take long to 'change your mind to metric'. It probably takes about an hour, yet many people in nations that have recently metricated have never done so. People become very attached to the units of measure they use – sometimes unreasonably so – but more importantly it takes a conscious decision (and about an hour of effort) to change to the metric system. If you know someone who is deeply opposed to metric measures, then it is most likely that this person has not – yet – spent an hour acquainting themselves with simple metric measures.

We could think of the people who oppose metrication like those who, in their time, argued against:

- the adoption of the Gregorian Calendar;
- the introduction of compulsory schooling;
- the introduction of motor vehicles;
- the introduction of television;
- the end of State executions; and
- the introduction of decimal currency.

All of these were considered controversial in their day, but people quickly adapted to them, realised that the new practices were better, and never looked back. For example, when was the last time you heard someone demand that we return to '*pounds, shillings, and pence (£/s/d)*' or for '*Reals divided into pieces of eight*'?

The people who changed to metric units quickly and easily, often did so as a requirement of their employment, and they made the change quickly and easily. People who don't do much measuring, because they don't need measuring skills for their work, are often the most opposed to metric measures. It's odd really that the greatest opposition often comes from the people with the least need to understand, or to have anything to do with, measuring methods. It's interesting to compare metrication with decimal money conversion; because nobody could avoid the decimal currency conversion, they simply:

Got over it, got with it, and then got on with it!

In the UK, anti-metric people try to blame metrication on the European Union (EU) but British industry chose to go metric before the entry of Britain into the EU. British industry simply recognised the benefits of SI, and took full advantage of them.

Anti-metric campaigners in the UK call themselves '*metric martyrs*'. They campaign to take measures in the UK back to old, unchecked, scales and bowls to sell fruit and vegetables. To my knowledge there has never been a standard bowl and I have no doubt that the traders intend to choose the size of their own bowl. I doubt that they would simply fill any bowl that a customer brought to their market stall. The use of old unapproved scales and a self-selected bowl effectively shifts control of measurement definitions from the government to individual traders, with the legal effect of taking measurement law to some time before Magna Carta, when anyone could decide the size(s) of the containers they use to buy and sell.

I was amused when the 'Metric Martyrs' chose a trader called Janet Devers to be one of their martyrs. Presumably she chose her own size of bowl and (with an illegal set of scales) her own standard for weight. I think of these as Devers weights and Devers measures and I can't get this line out of my head whenever I think of her name:

> *Devers weights and Devers measures, both of them alike are an abomination to the Lord.*

This is a paraphrase from the Christian bible that reads:

> *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. Diverse weights and diverse measures, both of them alike are an abomination to the Lord. (Deuteronomy 25:13-14)*

The possibilities for cheating when trading are not new; early books of the Christian Bible treat measurement almost as a running theme. See: Leviticus 19:35-36, Micah 6:11, Isaiah 5:10, Ezekiel 45, and Amos 8:5.

Anti-metric people in the UK have also formed a vandalism wing called Active Resistance to Metrication (ARM), who have taken to lawlessness to promote support for their old ideas. Members of ARM look for metric signs, such as road safety signs, which they then vandalise or destroy. ARM members perform criminal acts to try to stop metrication!

The rest of us know better.

Personally, I have never met any serious resistance to a metrication program once training began. Any mild initial resistance simply disappeared as soon as people started to become familiar with the metric system. This was especially true when real '*hands-on*' experience was a significant part of the training process. Resistance simply evaporated well before training was completed.

Emotional responses

However, you need to recognise that metrication can be, emotionally, a very mixed experience. Metrication all around the world has brought outstanding benefits at surprisingly little cost, but it has also produced personal trauma for some of the people involved. If this personal trauma is not handled well – or not even considered as part of the metrication process – it can leave the long-lasting scars that any poorly introduced process can produce.

The feelings that people experience as they approach their own metrication process can predominate over rational thoughts. Because these emotions are not rational does not reduce their importance. If you are a metrication leader, you should at least be aware of how others might be feeling about metrication. Also be aware that the negative responses to the metrication program arise from emotions.

When you (and your team) first face metrication you will need to consider questions like this from individuals who are part of the process of metrication:

- *In what way will my workplace change as a result of metrication?*
- *How will metrication change my relationships with my colleagues at work?*
- *How will I learn to use metric measures?*
- *How do I find a good metrication trainer?*
- *How bad will the changes be?*
- *What are the possible complications?*
- *Will I lose control of my job, or of my group?*
- *Will the others still accept me if I cant learn this new stuff?*
- *With the training, will I be able to keep up with the others?*
- *Will anyone find out about the stuff that I don't know (that I might have been covering up for years)?*
- *Will anyone find out that I am afraid of how I will handle the change?*

When you look at these questions you can see that most of these emotional fears are really about how others see us and on how they treat us.

Remember, it is the emotionally based fears and questions that can endure long after the process of metrication is declared at an end. It is not the technical features of metrication that will hurt you in the long run; it is the emotionalism in the process of metrication that causes the continuing trauma.

Deeply felt anti-metrication emotions invariably arise from fear of the unknown, in people who have had no measurement experience with the metric system at all. So the solution to resistance is simple. *In which ever measurement system people were reared, they are used to making unspoken comparisons – they can mentally visualise their height, weight, thumb width or whatever with their past experiences. This unspoken, and mostly unconscious, visualisation is an important part of the hands-on training you will provide when you* provide direct hands-on experience with metric measuring and especially metric estimation, to help people form their own metric mindset and to build common metric reference examples for themselves.

Positive attitude

A major key to handling the emotions involved in a metrication process is to be positive about the metrication process at all times. As we all know, one of the major keys to adopting change of any kind is to maintain a positive attitude during the process of change.

Remember that metrication will soon become part of you – as normal as your ability to count in tens, hundreds, and thousands. Metrication is not a disease but a positive addition to your capabilities that you will carry with you – and use constructively – for the rest of your life.

Whingeing, whining, and denigrating the process and its promoters will only delay metrication and make us, personally, miserable while we do it.

As **Victor Frankl,** author of Man's Search for Meaning, put it so succinctly:

> *When we can no longer change a situation, we are challenged to change ourselves.*

The more positive you are and the more willing you are to be open to change, then the better your resilience and coping skills will be. People with a positive attitude are the ones who easily cope with metrication. We all know that a positive attitude is a good thing, and in times of dramatic change such as metrication, it can be the best skill you can have.

If you focus on the negative aspects of the emotionally based questions, your life will be a misery right through the process of metrication. But, if you can think positively, metrication will be a delightful (and short) experience for you. You might like to consider the words of Napoleon Hill who said:

> *Every adversity, every failure, and every heartbreak carries with it the seed of an equivalent or greater benefit.*

One of the techniques that works, using this idea, is to find and list benefits you will soon have from metrication. Consider your personal benefits, your group benefits, your company benefits, your national benefits, and the world benefits. Whenever I give keynote speeches or run training seminars, I ask people to write their thoughts under the two headings below. These comments are from people in companies that have experienced successful metrication upgrades.

Metrication matters because it makes ...	**After successful metrication there is ...**
◊ our business more profitable, ◊ our calculations simpler, ◊ our contracts simpler and more reliable, ◊ our costs less, ◊ our dealings with others more open and honest, ◊ our export income greater, ◊ our imported goods cheaper, ◊ our international dealings friendlier, ◊ our legal expenses lower, ◊ our learning easier, ◊ our lives safer and more secure, ◊ our schools and colleges more effective, ◊ our training more effective, and ◊ our work more efficient.	◊ Better morale ◊ Getting it right first time ◊ Greater accuracy ◊ Greater customer happiness ◊ Less customer unhappiness ◊ Less cheating ◊ Fewer mistakes with less staying back to fix things not done right first time around ◊ Less repeating things ◊ More happiness ◊ More harmony ◊ More honesty ◊ More pleasant working atmosphere ◊ More togetherness because we all feel better valued ◊ People feeling valued because of less niggling over errors ◊ Shorter meetings (because there's no squabbling about conversions!

Metrication approximations and reference points

Most length measurements in industries all around the world are in millimetres – only.

This happened because millimetres work and work well because when you use millimetres you can design, measure, and build using whole numbers only.

Most of the items you use daily were designed and built using millimetres only.

This fact is often hidden from you. For example, buildings, cars, computers, roads, sewing machines, tractors, and trucks are mostly designed and constructed using millimetres (or metres and kilometres if required).

These are usually rounded sensibly; you don't say 503 mm when 500 mm is good enough for the current job.

Millimetres are chosen because when you use millimetres you never have to use fractions at all. That's right, common or vulgar fractions and even decimal fractions are rarely used when you only use millimetres. If you follow this example you might never need to use fractions or decimals ever again.

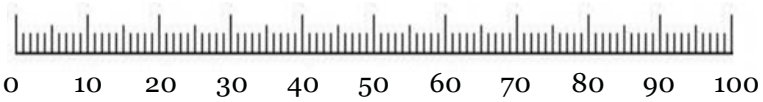
To help you develop your mindset in millimetres start here by using one of these rulers to measure — **in millimetres only** — the widths and lengths of your fingers, thumbs, and the widths of your hands.

Fill in the right hand column of this table.

Your measurement	**millimetres**
Measure the width of the nail on your little finger. Mine is about 10 millimetres wide.	mm
Measure the widths of each of your other three fingers. Mine are all about 20 millimetres wide.	mm
Look at the width of your fist across the knuckles. Mine is about 100 millimetres wide.	mm
Measure your hand span. Mine is about 240 mm when I stretch.	mm

Remember these and you can estimate short lengths quite readily using your own 'handy' references.

By the way, I have provided two rulers so you can use whichever is most convenient and you might like to copy one or both of these to use in your own training programs.



Everyday metric examples, and metric rules of thumb

To help you begin this process, here is a list of the metric examples that I use on most days. These are followed by some rules of thumb that I also use relatively frequently.

Some of these I created and some I obtained from others. Some of these are exact and some are more approximate, but they can all be useful guides to decision-making for future action.

Everyday metric examples, and metric rules of thumb are important because once you know some of these you are then in a position to readily make intuitive metric decisions and be confident that you have made the right decision. By using these, you can soon develop your own new metric *mindsets* and then you will be in a position to help others. The sooner you develop your metric *mindsets* then the sooner you will make intuitive metric decisions with confidence.

Most people make intuitive decisions preferably to well-researched and considered scientific or technical decisions; as Psychologist Dr Gary Klein says '*people actually use an intuitive approach 90% of the time*'.

Common metric examples

Here are some of the everyday metric examples and metric '*Rules of thumb*' that I have collected. Some of these use ordinary metric units from the 11 units on my business card. I have included some others simply because they might be interesting to you. I also wanted to show that the metric system can be used to measure anything in the Universe from the thickness of your hair (at about 60 micrometres) to the size of the Universe (at about 250 yottametres).

Human sizes

1.65 m is the average height of a woman in Australia, the UK, or the USA.

1.75 m is the average height of a man in Australia, the UK, or the USA.

65 kg is the average mass of a healthy woman.

75 kg is the average mass of a healthy man.

100 kg is the mass of a large man.

1 m is the height above the ground of an average man's waist.

1 m is the waist measurement (circumference) of a slightly above average man.

40 W is the power rating of a typical human heart.

1 km is 10 minutes of brisk walking as most of us can walk at about 100 m/min.

Babies

3500 g is the average mass of a newborn baby; babies range from small babies of about 2500 g, to large babies of about 4500 g.

500 mm is the average length of a newborn baby.

My own measurements – for you to compare your own

1 metre is the distance from my right fingertip to my left ear when my right arm is fully stretched.

1 metre is the distance from elbow to elbow when I place the tips of my two longest fingers together.

10 mm is the width of my little finger nail. Yours might vary but one of your fingernails will be close to 10 mm; remember which one. This is a very *handy* measurement.

100 mm is the length of my little finger.

100 mm is the width of my palm.

20 mm is the width of my longest finger.

240 mm is my hand span

25 mm is the width of my thumb

50 µm to 150 µm is the range of diameters of human hair.

262.5 kg is the world record for weight lifting (don't try this at home!)

300 J the approximate energy I need to do one push up.

330 mm is the length of my foot

95 mm is the width of my foot

Temperatures

– 18 °C Home freezer temperature.

0 °C Water freezes/thaws.

4 °C Home refrigerator temperature.

37 °C Human body temperature.

45 °C Limit up to which skin contact is not painful.

15 °C Cool, but no jacket needed.

20 °C Comfortable room temperature.

58 °C Highest temperature ever measured on Earth (Libya).

60 °C Typical home hot tap water temperature.

100 °C Water boils.

Cooking

These are examples from our home in Geelong, Australia.

1 L – standard cardboard milk carton

1 kg is the mass of a 1 L carton of milk.

2 L is a large milk carton

1 kg is our usual bag of spaghetti and sometimes 500 g or 2kg.

1 mL is the volume of a sugar cube.

1 N is the weight of a small apple.

1 kg is the mass of 10 medium size apples.

100 g is the mass of one medium apple.

5 5 kg or 10 kg is the mass a bag of flour.

100 g is the mass of meat in an average sandwich.

125 g is the mass of a medium size banana.

1 litre of water, or milk, or soft drink, or fresh juice has an approximate mass of 1 kg.

1 mL is the volume of one large drop of water.

1 kg is the mass of a 1 L carton of milk.

2 L is a large milk carton with a mass of about 2 kg.

2 mm is the thickness of a matchstick.

300 mL is the capacity of a small carton of milk or cream.

600 mL a medium carton of milk.

600 mm is the width of a normal stove.

700 mm is the width of a common refrigerator.

900 mm is the usual kitchen bench height.

750 ml is the capacity of a bottle of wine.

5 mL is the capacity of one level teaspoon.

Sewing

8 mm is the diameter of shirt buttons.

20 μm is the average diameter of a wool fibre.

3 mm is the diameter of common knitting needles.

4 mm is the diameter of common coloured beads for threading.

In the garage and the garden

1 tonne (1000 kg) is the mass of an average mid-size car.

4 m is the length of an average car.

2 mg is the approximate mass of a 'typical' raindrop but there is a wide variation.

4 mJ is the average kinetic energy of a 'typical' raindrop

4 m is the length of an average car

5 m is the typical height of a bridge, such as a pedestrian, train, or road overpass, over a road.

6 mm is a common diameter of bicycle bolts.

7 mm is the width of a common screwdriver blade.

7 kJ is the chemical energy stored in typical 'flashlight' battery.

10 mm is typical size for a wrench, spanner, or socket used on a VW car.

13 mm is the size of the other wrench, spanner, or socket used on a VW car.

100 m or 0.1 km is the unit of a car's odometer (these days some can be calibrated to give 0.01 which means they click over every 10 metres).

300 mm is a typical size of a shifting spanner or crescent wrench.

355 mm is a common diameter of a car wheel and the tyre is made to suit.

700 mm is the diameter of racing bicycle tyre.

2 mg is the approximate mass of a 'typical' raindrop but there is a wide variation.

4 mJ is the average kinetic energy of a 'typical' raindrop.

Home office

1 mm is a common diameter of a pen tip.

1 g is the mass of three paper clips.

1 mm is the thickness of a CD.

5 mm is the width of a common graphics trim.

5 g is the mass of a piece of A4 paper where the paper is specified as 80 g/m^2.

10 g is the mass of a piece of A3 paper where the paper is specified as 80 g/m^2.

20 g is the mass of a piece of A2 paper where the paper is specified as 80 g/m^2.

40 g is the mass of a piece of A1 paper where the paper is specified as 80 g/m^2.

80 g is the mass of a piece of A0 paper where the paper is specified as 80 g/m^2.

12 mm is the is the width of a common paper staple.

20 mm used as an all-around page margin will save a little more than 20 % of your paper costs.

210 mm x 297 mm is the width and length of a standard sheet of A4 printer paper.

450 mm is the width of a common computer keyboard.

Lounge

100 mm is the width of a cassette tape case.

120 mm is the diameter of a CD audio disk.

120 mm is the diameter of a DVD disk.

120 mm is the diameter of a CD-ROM disk.

250 mm is the diameter of old 78 records.

300 mm is the vinyl LP.

250 g is the mass of a 400 page paperback novel.

200 W is the typical heat loss of a human sitting quietly in a lounge room.

Shopping

1 mm is the thickness of an Australian 5 cent coin.

1 mm is the thickness of a USA 10 cent dime.

3 g is the approximate mass of an Australian 5 cent coin (2.83 g).

9 g is the exact mass of an Australian dollar coin.

20 mm is the diameter between an Australian 5 cent coin (19.41 mm) and a 2 dollar coin (20.5 mm).

25 mm is the exact diameter of an Australian dollar coin.

30 mm is the approximate distance across the flats of an Australian 50 cent coin (31.51 mm.

15 g is the approximate mass of an Australian 50 cent coin.

Around the house

1 m is the height of a door handle in the USA.

2 m is the approximate height of a standard internal door (2050 mm).

2050 mm is the height of normal door.

800 mm is the width of a standard door.

1300 mm is the common doorknob height in Australia.

Living things

4 kg is the mass of an average household cat.

50 kg is the mass of an average Great Dane.

500 kg is the mass of an average large cow.

800 kg is the mass of an average giraffe.

5 t is the approximate mass of an average elephant.

200 t is the mass of an average blue whale.

8800 m is the height of Mount Everest.

40 L is about the size of a small aquarium.

10 m is the average height of an average full-grown street shade tree.

Geology and astronomy

40 Mm (40 000km) is the circumference of the Earth.

150 000 000 km is the Distance from the Earth to the Sun.

385 Mm is the Distance from the Earth to the Moon.

6 500 km is the length of the river Nile.

Odds and ends

50 mm is the Length of an AA battery.

8 mm, 16 mm, and 35 mm is the width of common film sizes.

7000 tonnes is the mass of the Eiffel Tower in Paris

Please find some of your own examples and send them to:
pat.naughtin@metricationmatters.com

Rules of thumb

Rules of thumb are guides that fall somewhere between a scientific or mathematical formula and a shot in the dark. The expression, *rule of thumb*, has been recorded since 1692 and it probably wasn't new even then. It meant then what it means now; a method or procedure that comes from practice or experience, often – but not necessarily – without any formal basis.

Rules of thumb are very useful for any measurements, and they are especially useful as you go through your upgrade to the full use of the metric system for making short-term intuitive decisions.

Rules of thumb are usually designed to be easy to remember, and to be shared by passing them along to others. Rules of thumb are a kind of tool that helps to identify a problem or to give guidance in forming a solution to any given situation. However, having said all of this, I appreciate that 'rules of thumb' are often crude, so professionals have to make calculations that are more complex. But rules of thumb are especially useful as you go through your upgrade to the full use of the metric system.

Aerobic Fitness: The amount of oxygen you use is a measure of your aerobic fitness. To estimate your aerobic fitness, multiply the number of kilometres you can run in twelve minutes by 20. If you can run 2 kilometres in 12 minutes, your rate of oxygen use is 2 x 20 millilitres per minute for each kilogram of your body mass, or 40 (mL/min)/kg, which is regarded as a good basic fitness level. Cross-country skiers perform well on this test with the highest recorded values for oxygen use up to the low nineties (90 (mL/min)/kg).

Air Conditioning in rooms: In cooling a room, increasing the temperature by 1°C will save you about 5 % of your cooling bill.

Air Conditioning in cars: You can check the efficiency of your car's air conditioner by noting the maximum temperature difference it can produce. It should be able to produce a difference of about 15 °C between the outside and inside temperatures.

Air masses: The air masses, the highs and lows, you see on your weather map travel at about 50 kilometres per hour or 1200 kilometres per day. They are slower in summer and faster in winter.

Air pressure: Air pressure decreases as you go higher into the atmosphere. The pressure drops consistently, by about 12 pascals per metre, until you get to a height of about 8500 metres.

Anchoring your boat: Allow 10 m of anchor line for each metre of depth you expect. If the water is 3 m deep, you will need 30 m of anchor line.

Apple cider: Thirty litres of apples will make about 10 litres of cider.

Aquarium heating: If you want to heat an aquarium allow one watt per litre (1 W/L) of water to heat a tropical fish tank.

Baby animals: Keep baby animals at 35 °C until their eyes open. After that lower the temperature by 3 ˚C a week until you get to room temperature. At 20 ˚C this will take five weeks.

Babies: An average baby is 3500 grams at birth; small babies are about 2500 grams; and big babies are about 4500 grams. Whatever its size the baby should double its birth weight in six months; for example, a 3500 gram baby should be about 7000 grams at 6 months. Babies are about 500 millimetres long when they are born and they grow at about 1 mm every two days, or about 15 millimetres in a month.

Barbecue temperature: Place your hand where you intend to put the food. If you can hold your hand there for more than five seconds the fire is too slow; one or two seconds is too hot; somewhere between three and four seconds is best. Use the back of your hand when testing the heat of a flame, not your palm — if (when) you burn yourself it won't be so inconvenient.

Beer: To make a 25 litre batch of beer with 4% alcohol use a total sugar content of 2 kilograms. Roughly half of the sugar will become carbon dioxide gas and the other half will become alcohol; the sugar, $C_6H_{12}O_2$ by the action of yeast produces C_2H_5OH, the alcohol + carbon dioxide, CO_2 + water, H_2O.

Bees: A beehive can produce 50 kilograms per year of honey.

Blood volume: You can find out how much blood you have by multiplying your body mass in kilograms by 0.08. This will give your blood volume in litres. For example, if you are 60 kilograms then you have about 5 litres of blood (60 x 0.08 = 4.8 L).

Blood: Your heart pumps about 100 millilitres of blood into your blood vessels with each beat. At 70 beats per minute you pump 7000 millilitres per min. 7000 mL/min is equal to 7 L/min, 420 L/h, or about 10 000 litres per day (10 kL/day).

Body mass: Anyone, man or woman, who is 1.5 m tall, probably has a mass of close to 50 kilograms. For women who are taller than this add 8 kilograms for each 0.1 m height increase, or subtract 8 kilograms if you are shorter. For men add or subtract 10 kilograms. Examples are: a woman 1.5 m tall = 50 kg and a man 1.5 m tall = 50 kg; a woman 1.6 tall = 58 kg and a man 1.6 m tall = 60 kg; and finally a woman 1.75 tall = 70 kg and a man 1.75 tall = 75 kg

> You can easily estimate your 'correct' body mass by subtracting 1 metre from your height. For example, if you are 1.75 metres tall, a good body mass for you would be less than 75 kilograms; if you are 1.95 metres tall then your body mass should be less than 95 kilograms. However, this rule does not work so well for women. For women use this rule and then subtract 5 kilograms. For example, if you are 1.75 metres tall, a good body mass for you would be 70 kilograms; if you are 1.95 metres tall then your body mass should be 90 kilograms.

Breath: Assume the temperature is below 7 °C if you can see your breath.

Brick volume: A brick has a volume of about two litres. If you put a brick into an old style toilet cistern, you will save 2 litres of water every time you flush your toilet. A lighter alternative is to completely fill a 2 litre plastic drink bottle with water and to place this in your cistern.

Burning matches: A kilojoule (kJ) of energy is approximately the amount of heat energy produced by completely burning a wooden kitchen match.

Bushwalking: To work out the distance you can walk, allow 4 kilometres per hour without a pack, and reduce this to 2 kilometres per hour if you have a heavy pack. Without a pack, a fit walker should be able to easily walk 30 kilometres in a day, or about 15 kilometres if you carry a pack that is about a quarter of

your body mass. In hilly country allow 20 minutes per kilometre (3 km/h) plus 10 minutes for each 100 m rise in altitude.

Bushwalking – catering: If you're travelling to an area with no fresh water, allow 5 litres per day for drinking and washing, 1 kilogram of food per person, and try for at least three changes of menu to avoid boredom.

Camels: A good camel should easily be able to travel 100 kilometres in a day.

Cars: A small car such as a Mini or a Volkswagen Beetle has a mass of about 1000 kilogram, or 1 tonne.

Cassette tapes: A case for a cassette tape is exactly 100 millimetres wide.

Cheese: To order the cheese for a wine and cheese party allow 100 grams of cheese per head or 1 kilogram for every 10 people.

Chemical reactions: You can expect a doubling of the rate of a chemical reaction with each 10 °C rise in temperature. This also works for biological reactions, such as yeast, within the enzyme's viability limits.

Chicken breast: You will get 500 grams of boneless skinless chicken breast from a kilogram of skinned breast on the bone.

Chimneys: A chimney needs to be at least 1200 millimetres above a flat roof or 600 mm higher than anything within three metres of it on a sloped roof. The area of the fireplace opening should be equal to or slightly less than 10 times the cross sectional area of the flue.

Coffee making: Multiply by 100 to work out your coffee needs. A kilogram of ground coffee can make 100 cups of coffee. If you are filling cups to 200 millilitre cups, 1 kilogram of coffee will make 20 litres.

Concrete: It will take a full day for one person to mix and pour two cubic metres of concrete. If you are inexperienced you may be only able to make and pour one cubic metre (1 m^3).

> The stones that you use to make your concrete (often called aggregate) should be no larger than one-quarter of the thickness of your finished work. For example, if you are pouring a path 100 millimetres thick, the largest stones should not be larger than 25 millimetres.

Cottage cheese: Ten litres of milk will make a kilogram of cottage cheese.

Cows: Multiply by three to estimate a cow's water requirements. A cow needs about three litres of water for every litre of milk she produces.

Cups: I cheat with cups. Although a cup measures 250 millilitres, I sometimes think of it as 240 millilitres. Let me explain; when I use a measuring cup to pour four cups into a jug, it reaches the one litre mark; so, if I want 2 litres, I count out eight cups and if I want 1.5 litres of chopped fruit, I count out 6 cups. When I need less than a cup, it is easier for me to think of the cup as 240 millilitres as it is easier to divide 240 millilitres (rather than 250 mL) and the adjustment makes little difference to recipes. With this method: 1 cup = 240 mL, 3/4 cup = 180 mL, 2/3 cup = 160 mL, 1/2 cup = 120 mL, 1/3 cup = 80 mL and 1/4 cup = 60 mL.

Diamonds: A diamond will have only half of its rough mass after it has been cut and polished. A 400 milligrams stone can be cut and polished to a 200 mg stone.

Drums – 20 litres: Twenty litre motor oil drums were designed so that 10 of these smaller drums could be filled from a standard 200 litre drum. The German army in WW II used a 20 litre rectangular container for fuel. It was so practical that the Allied forces, who called it the 'jerry can', soon copied it.

Drums – 200 litre: When the 200 litre drum was first used in Australia it was measured and found to contain 43.993 849 imperial gallons; it has been called a "forty-four" ever since. (In the USA the same 200 litre drum was measured and found to contain 52.834 435 gallons (USA); in that nation, it has been called a 55 gallon drum ever since). The design of the 200 litre drum (200 L) seems to have had two principle criteria: the design had to be related to the International Volume Standard, the cubic metre (m^3), and it had to be liftable by (usually two) humans. A standard 200 litre drum holds 200 litres of liquid and has an air space of about 8 litres.

Drying Herbs: Since it takes about a kilogram of fresh herbs to make 250 grams of dried herbs multiply or divide by four to change from one to the other when you are adapting a recipe.

Ears: If your ears pop in an elevator or a plane you are probably travelling vertically faster than 7 metres per second.

Eggs: The shell of an egg takes up about 10 % of its mass; the yolk takes about 30 %; and the white takes up the remaining 60 % of the egg's total mass. A smallish egg, with a mass of 50 grams, will have 5 grams of shell, 15 g of yolk and 30 g of white.

> **Storage:** Eggs stored with their pointy end downwards will stay fresher for longer. If an egg sinks in a glass of water, it is very fresh; if it rests on one end, it is less fresh; and if it floats, it is bad. Toss it out immediately.

Energy: You can estimate that people at a party are emitting about 250 W of heat energy; that is a 1000 W or 1 kW for every four people. Ten people will raise the temperature of a medium size room by 1 °C per hour.

> At rest your body runs on about the same amount of energy as a 100 W light bulb. Like the 100 W light bulb, you use 100 joule of energy per second; 6 000 J per minute (6 kJ/min); 360 kJ/h; or 8 640 kJ/d. Of your power rating of 100 W: 25 W goes to muscles including 8 W to your heart, 25 W goes to your liver and spleen, 20 W goes to your brain, and 30 W is for all other organs and for digestion
>
> **Saving:** in energy terms, it pays to turn off your car's engine if you expect to be idling for more than one minute.

Estimating size: If you hold a pencil (7 millimetres diameter) vertically at arms length (700 millimetres), it will cover a distance of 10 m wide 1000 m (1 km) away. This ratio (100:1) also holds for other items; a match 2 millimetres wide will cover a little less than 3 m wide at a distance of 1 kilometre.

Estimating the horizon: To estimate the distance you can see to the horizon you need to carry out a two step procedure. First estimate the height of your eye above the ground or the sea in metres. Take the square root of this height and multiply it by 3.57. This will give you the distance you can see to the horizon estimated in kilometres. I remember this (for a height of 1 m) by recalling the first four odd numbers 1-3-5-7. If I am observing from one metre above the ground then the horizon is 3.57 kilometres away; if I am observing from four metres above the ground then the horizon is 7.14 kilometres away ($\sqrt{4}$ m = 2 m and then 2 m x 3.57 = 7.14 km say 7 km).

Exercise – swimming: Swimming 250 m is the same as running 1 000 m (1 km) and swimming one kilometre uses about the same energy as running four kilometres or cycling ten kilometres, The fastest swimmers can swim at 8.4 kilometres per hour.

> Those who wish to reduce their body mass can expect to use four joules of energy for each kilogram of their body mass for each kilometre that they run or jog. For example, if a 75 kilogram person jogged for 5 kilometres they would use 1500 joules of energy (4 x 75 x 5 = 1500 J). This can be thought of as 1.5 kilojoules. A brisk walk has a similar effect.

Experiments: In many situations, experiments are best planned in lots of three. Your first attempt allows you to identify procedural problems; your second try allows you to clean these up; and the third attempt begins to show what you really can achieve.

Fan belts: As a rule, a fan belt is adjusted properly if it can flex between 10 millimetres and 20 millimetres in the middle of its longest span. If you try to adjust it and the bolts are rusty, these can be loosened if a few drops of kerosene or turpentine are allowed to seep around the threads.

Fashionable ties: The width of neckties varies with fashion but the average of a standard-shape tie is about 90 millimetres. If you choose ties that are 90 millimetres wide, you will always be not far away, even close, to the current trend.

Fingers and thumbs: One of your fingernails will measure 10 millimetres across. If you remember which one it is a convenient measure for small item such as bolts and button holes. Across your thumbnail (usually about 20 millimetres) is also a handy (sic) measure.

Fire fighting: Use an extinguisher on the base of a flame from a distance of less than 3 metres. If you cannot get closer than about 3 m, the fire is probably too big for a hand-held extinguisher.

Fish – size: The usual size of a single serve of fish is between 100 grams and 120 grams. To put this into perspective, the world's smallest fish is the dwarf goby (6 millimetres long), and the world's largest fish is the whale shark; it has a mass of 20 tonnes and it can be more than 12 metres long.

Flies: if you are more than a metre away from a housefly, it cannot see you.

Flying a kite: when you can barely feel the wind on your face, it is blowing between 6 kilometres per hour and 10 kilometres per hour. When the trees are in constant motion the wind speed is about 20 kilometres per hour and is near the upper limit for kite flying. If the wind is lifting loose paper or dust off the ground keep your kite inside.

Foot: Measuring the length of your own feet, in millimetres, can give you a very convenient measure if you work out how many of *your* feet there are in a metre. Most of my shoes are about 330 millimetres so I assume that three of my shoe lengths measure about a metre. My wife's shoes are about 250 millimetres, so she needs four of her shoe lengths for a metre.

Freelance: We work about forty hours a week for about fifty weeks; that is 2000 hours. Many professionals and freelance operators set their hourly rate by dividing their estimated annual income by one thousand. This covers the fact that free-lance people expect to put in one un-billable hour for every billable hour they do. Another approach is to decide what you think you can get away with charging, and then double it. Professionals reckon that their final expenses usually exceed their original estimate by a factor of two.

Freezers: When buying a refrigerator freezer you can estimate your needs by allowing 200 litres for two people plus 20 litres for each additional member of your family.

> You can overload the chilling capacity of your freezer. When adding unfrozen food, do not put in more than 1 kilogram for each 20 litre of freezer capacity. If you have a 100 litre freezer, do not try to freeze more than 5 kilograms at a time.

Gardening: A good gardener can efficiently work up to one hectare of land, and if the land is suitable, the gardener can produce all the vegetables needed for 100 people.

Grapes: One tonne (1000 kg) of grapes makes about 500 litres of wine.

Graves: A human grave is 2.2 m long, 1 m wide, and 2.3 mm deep to make it 1.8 m deep to the top of the coffin. If you intend to bury more than one person in the same grave, add 600 millimetres of extra depth for each body.

Greenhouse: To store heat overnight in a greenhouse you can use containers of water. A good start is one cubic metre of water for each square metre of glass. Five 200 litre drums are an inexpensive way of storing a cubic metre of water.

Heartbeats: Your heart pumps about 100 millilitres of blood into your blood vessels every time it beats. That is about 7 litres per minute when you are resting or 10 litres per minute when you are walking briskly.

Height: Your child's adult height will be twice their height at 22 months. For example, if your child is 850 millimetres tall at 22 months, they will grow to about 1.7 m.

> **In photographs:** The apparent height of the image of your subject (as seen in your view-finder) will double if you double the focal length of your lens. For example, a 100 millimetres lens will appear to double the image height that you saw with a 50 millimetres lens.

Herb Gardens: When you are planning a herb garden, allow five plants for each square metre. This is the space the herb plants will need when they are fully grown.

Honeyeaters: To feed honeyeaters, such as the wattlebirds and the New Holland honeyeaters we have in our garden, mix one part sugar with four parts water. If you put some red colouring on the feeder the birds will be attracted to it – you don't need food colouring in the sugar and water mixture.

Horses drinking: A horse will drink between 50 litres and 60 litres on a hot day, if it is exercising. A friend observed his horse drinking after exercise on a warm day for three hours. The horse swallowed 30 gulps of water and dropped the water level in a trough by 40 millimetres. My friend, (armed with a calculator and her considerable knowledge of algebra) calculated that the horse drank about 7 litres of water in one minute – that is nearly 250 millilitres per gulp. Another horse was observed gulping, without letup, 60 swallows, which amounted to about 15 litres of water in one drinking session.

Hot Air Ballooning: To judge your flying time, allow 10 kilograms of propane for each hour of flying time.

Human DNA: Each living cell in the human body has two kilometres of deoxyribonucleic acid (DNA), the material that contains our genetic material.

Human Power: Working hard a human can use three hundred joules of energy in a second. This is equivalent to a power rating of 300 watts.

Ice cubes: Ice cubes vary in size from about 10 millilitres to about 30 mL so you need to take a little care when you are freeze juice or egg whites in an ice cube tray. For example, if you had a recipe that used more yolks than whites, and you froze the extra whites in an ice cube tray, make sure that the ice cube tray holds about 30 mL so that each egg cube will be roughly equal to the white of one egg.

Indoor plants: For each square metre of growing area you need at least 200 W of lights.

Kitchen planning: Kitchen designers allow about one square metre of shelf space for glassware and china, the same again (1 m^2) for pots, casseroles and other cooking equipment. They also allow half a square metre (0.5 m^2) for each member of the household for general storage. This is a starting point only, as individuals vary greatly in the way they cook.

Ladders: Your ladder should be 1 m away from a wall for every 4 m of height you intend to climb.

Lifting: You can lift for a short time twice your body mass (say 160 kg). You can lift and carry, for a short distance, a mass equal to your body mass (say 80 kg). You can carry a quarter of your body mass relatively comfortably (say 20 kg). Reduce your loads and remember to lift using the back safety rules. If you carry a pack that is about a quarter of your body mass (say 20 kg), you could expect to walk about 15 kilometres in a day.

Lighting instrument displays: Engineers who work with human-readable displays use the candela per square meter (cd/m^2). The candela per square meter (cd/m^2) is used to specify the brightness of a display. This works whether it is a direct display or a backlit display. For example, a 150 candela per square meter (150 cd/m^2) display will be readable in normal room light, but it will be washed out in direct sunlight; a 600 candela per square meter (600 cd/m^2) display will be readable in sunlight, but it will be too bright for viewing in a darkened room.

Lightning: If the hair on your arm and head start to stand on end, the lightning is going to strike near you. Squat down with your feet as close together as possible. If you are wearing shoes, they may help a tiny bit. If you have trouble with your sense of balance, drop to your knees and lean forward. Put your hands on top of your knees to avoid ground current that can occur if the lightning strikes within 50 metres.

> Lightning travels through the Earth's atmosphere at about 100 000 m/s, which is 100 kilometres per second or 6000 km/h. Note that the '*Speed of Lightning*' is not the same as the '*Speed of Light*'.
>
> **Lightning and thunder:** Sound travels at about 340 metres per second or roughly 1 kilometre in 3 seconds. When you see lightning, start counting 'one second, two seconds, three seconds, four seconds' etc; stop counting when you hear the thunder. Divide the seconds by three to find out how far you are from the storm. For example, if the sound of the thunder takes six seconds to reach you the storm is 2 km away. Repeat this procedure to see if the storm is moving toward you or away from you.

Litres and kilograms: In 1795, the litre was defined so that a litre of water should have a mass of one kilogram. From this it follows that: one millilitre of water has a mass of one gram; one litre of water has a mass of one kilogram; one cubic metre of water has a mass of one tonne.

Loading and unloading: If there is an odd number of items let your partner load the first one. If there is an even number, let your partner load the first two.

Mammals: An average adult woman has a mass of about 65 kilograms and adult men average about 75 kilograms. To compare humans with other mammals, the world's largest mammal is the blue whale; a blue whale can be 30 metres long and have a mass of 150 000 kilograms or 150 tonnes. The world's smallest mammal is Savi's Pigmy Shrew; it can be as short as 35 millimetres and have a mass of 1200 milligrams.

Marching: A marching pace is 750 millimetres from heel to heel. Since there are 120 paces per minute in strict march time, you can estimate the distance you march by multiplying these together (750 paces x 120 mm = 90 000 millimetres per minute). You will march 90 m/min or 5 400 m/h – that is 5.4 km/h.

Margarine: One kilogram of margarine will spread up to eight kilograms of bread. Divide the mass of the bread by eight to buy the margarine.

Meeting room: Allow about three square metres (3 m^2) of space per person for a good-sized meeting room. If you go below 2.5 m^2 people will feel cramped.

Molten metal: Castings of molten metal shrink in all directions as they cool to ambient temperature. Iron shrinks by about 5 millimetres per metre and aluminium shrinks by about 10 millimetres per metre.

Moon measuring: Today, the moon will rise about 50 minutes later than it did yesterday.

> The moon covers about half a degree of sky. You can measure this with your little finger nail (about 10 millimetres) at arm's length (about 700 millimetres); your little fingernail will just cover the face of the Moon.
>
> Your little fingernail (10 mm) will cover the face of the Moon or the Sun when your hand is held at arms length (700 mm). The angle that your little fingernail makes at your eye is about 0.8 degrees. The angle that the Moon or the Sun makes at your eye varies from about 0.5 degrees to about 0.55 degrees.

Nuts: A kilogram of nuts in the shell will give you about 500 grams when shelled.

Office design: A comfortable office provides about 20 m^2 per person. Designers of offices allow 25 m^2 for senior managers, 20 m^2 for middle managers, and 15 m^2 for clerical workers.

Orange juice: A single orange should produce about half a cup of juice, that is, 125 millilitres. It normally takes about eight oranges for a litre of juice (four cups).

Painting: On average it takes one hour to paint 100 square metres plus an hour for each window or door. In each hour, you will use about 7 litres of paint and cover a little over 100 m^2.

> **With a roller:** It takes about four 'dips' of a roller to cover one square metre of wall or ceiling. Count the 'dips'. About 60 'dips' will use one litre of paint and cover about 15 m^2.

Parking: If you are estimating the size for a car park, allow 30 m^2 per car. This will allow enough for the 15 m^2 needed for each car (2.5 m x 6 m) plus enough for the driveways.

Planting Seeds: If you have lost the packet, plant seeds at twice their width – plant a 2 millimetre wide seed at a depth of 4 millimetres.

Posts: Generally 20% of a post should be in the ground. A 3 m post should be 600 millimetres in the ground and 2.4 m above ground.

Pottery: To calculate the amount of clay for a casserole use: 500 grams per person, 1000 grams for a two-person pot, or 2 kilograms for a four-person casserole.

Pressure in the atmosphere: If the entire atmosphere of the Earth was all at standard atmospheric pressure (~ 100 kPa), and did not become less dense with altitude, then our atmosphere would be about

8 kilometres deep. In its natural state, the Earth's atmosphere is regarded as about 100 kilometres deep. You can think about the thickness of the Earth's atmosphere as being as thick as the eggshell of a hen's egg – if they were on the same scale!

Pressure in the sea: The pressure at the surface of the ocean is about 100 kilopascals; this is due to the pressure of the air. The pressure increases by 1000 times as you near the deepest points in the oceans, where the pressure is about 100 megapascals.

Public address: Use one watt (W) of amplification per person for an indoor audience and 1.5 W for an outdoor audience.

Radius of the Earth: The circumference of the Earth is about 40 000 kilometres, so its diameter is about 12 734 kilometres and its radius is about 6 400 kilometres. I remember the radius of the Earth by writing 12 — then leave a space before I write 34 — I add the 3 and 4 to make 7 and then I write this in the middle to get 12 734 kilometres. I know this sounds rather silly – but it works for me.

Reading: Reading is easy for most people if the letters are 5 millimetres high at a distance of 500 millimetres. From this we get a ratio of 1:100, and this will work on any scale. If you are planning a billboard 40 m from a country road then the letters should be 400 millimetres high (40 m ÷ 100 = 40 000 mm ÷ 100 = 400 mm). Similarly, if you are designing a conference poster to be read from 2 m the letters should be a minimum of 20 millimetres high (2 000 mm ÷ 100 = 20 mm).

Rice: The approximate measure per serve is ¼ cup, which will swell when cooked to ¾ of a cup. Some people use a handful as a quarter of a cup or a single serve. You can test your own hand size by using a measuring cup and taking an average of (say) five handfuls.

Rising air: Air cools as it rises by about 1°C every 100 metres. Sinking air warms at the same rate. By the way, the expression *hot air rises* is an illusion of sorts; hot air won't rise unless there is some cold air being pulled down by gravity to drive the hot air upwards. It's the cold air that causes the air movement.

Scuba diving: The average scuba tank holds enough air to dive for forty-five minutes at a depth of 10m.

> To attain an appropriate buoyancy you calculate 10% of your body mass and attach this much mass to your belt, for example if you are 60 kilograms you will need an extra 6 kilograms.

Sea Level: Allow one metre for the average line of the seawater to move inland with a rise in the sea water level of 100 millimetres. This was a remote piece of geomorphologic esoterica until we began to understand global warming.

Sharks: White pointer sharks can detect blood in water from up to one kilometre away.

Shearing a sheep: A kilogram of wool will make one sweater for an average human and a fine-wool merino sheep yields about 4 kilograms of cleaned wool each year.

Shelter belt: A row of trees or shrubs will protect the ground behind it from the wind for a distance of twenty times the height of the trees. For example, a dense row of trees 10 metres tall will protect the ground for 200 metres downwind of the trees.

Shoes for kids: Primary school kids will wear out the tops of the shoes before they wear out the bottoms. In any case, the child will probably outgrow the shoes before they wear out. At peak growth, children's feet can grow at about 1 millimetre every 10 days or 10 millimetres every 100 days. Shoe sizes represent the lengths of barleycorns; a shoe size of one barleycorn is about 8.5 millimetres so expect the child's shoes to fit for about 85 days.

Shower: A five minute shower can use up to 100 litres of water. A water saving showerhead can reduce the amount of water you use by 75 per cent – that is from 100 litres to 25 litres.

> **Cubicle:** A large shower cubicle occupies a volume of about two cubic metres; the more usual size is nearer to 1800 litres (1.8 m^3).

Skin: The largest organ of your body is your skin. To estimate the mass of your skin divide your body mass by 16. For example if your body mass is 64 kilograms then the mass of your skin is about 4 kilograms.

Skylights: for adequate light, you need 15 % of the floor area in a kitchen or bathroom, 10 % in a bedroom, and 5 % in a hall.

Sleeping like a baby: Babies, generally, will sleep through the night once they are five kilograms or ten weeks old - whichever comes first.

Snails: Cans for preserving foods were invented in Napoleon's time. His armies carried canned snails as emergency rations. One thousand snails (one kilosnail?) were allowed for each soldier per week.

Snow: One hundred millimetres of fresh snow is very roughly equivalent to about 10 millimetres of rain.

Solar energy: In a year the Earth intercepts about 4 yottajoules of energy (4 YJ) from the Sun.

> Each square metre of window facing directly into the sun can collect up to 1000 watts per square metre of energy – for free. This is the same amount of energy you use in a 1000 W electric heater. This means that if you can organise such a window with the sun shining on it directly it would heat the area just as efficiently as the radiator.

Sparks: Sparks produced electrically will jump a gap of 1 millimetre for each 1000 volts.

Speed: A sailfish is the fastest fish in the world; it can travel at 109 kilometres per hour. You can compare this with the top speed of a human sprinter: 43 km/h, a cheetah: 113 km/h, or a spine-tailed swift: 171 km/h.

Stairs: The optimum configuration for stairs is a riser height of 175 millimetres and a tread width of 275 millimetres. If you have to change these values, try to keep the total the same, that is keep the sum of the riser and the tread at 450 millimetres.

Supermarkets: Limiting the size to about 2000 m^2 can help prevent communication problems between staff in supermarkets.

Survival: You can live up to: three seconds without blood; three minutes without air; three days without water; and three weeks without food.

Swimming pool: –A large swimming pool has a volume of about 400 m^3.

Table seating: Your guests will be comfortable at the dining table if you allow 750 millimetres for each place setting.

Tanks: A circular container with a height of 100 millimetres and a diameter of 113 millimetres will hold a litre. If you increase these figures by a factor of 10, that is, make the height 1 m and the diameter 1130 millimetres then the volume will be 1 cubic metre (m^3), that means that it will hold 1000 litres.

Temperature: In a mine, as you travel into the Earth's crust, you can calculate the rising temperature by adding 3°C for every 100 metres you descend. As you rise above the ground the temperature drops by 0.6 °C to 0.7 °C for every 100 meters that you rise.

The Rule of Twice: For many people this approximation works. Measure the distance around your wrist; twice around your wrist is the same as around your neck; twice around your neck gives your waist measurement – and if this is more than a metre you probably need to do something about it.

Transport by animal: A pack-camel can travel at about 4 kilometres per hour (a pace is about a metre and it moves at about 70 paces per minute), and a travel-camel can travel at about 6 kilometres per hour (its paces are longer and there are more of them). A horse can travel at about 5 kilometres per hour for an hour but this drops to about 4 kilometres per hour if you travel 10 hours in the day. For comparison, humans can walk at about 100 metres per minute or 6 kilometres per hour.

Trees: A large tree has an evaporative cooling capacity of about ten kilowatts (10 kW). This can be compared to a single room size air conditioner with an energy input of about 1000 watts (1 kW) with a cooling capacity of a little more than 2000 watts (2 kW).

> If you multiply the diameter of the trunk by 10, you will know the radius of the tree's roots. This is normally about the drip line of the tree. For example, a tree with a 200 millimetres trunk will have a drip line at about 2 metres (200 mm x 10 = 2000 mm = 2 m).

To fertilise trees supply 20 grams of complete fertiliser for each millimetres of trunk diameter. For example, a tree with a 40 millimetres trunk will need 800 grams of fertiliser.

Trout Ponds: For a healthy trout pond, multiply the surface area in hectares to give the mass of trout (in kilograms) produced in a year.

Universe estimations

- The average distance from the Earth to the Sun is about 150 000 000 000 m or 150 gigametres (150 Gm). The Earth travels at an average speed of about 30 km/s around the Sun.
- Light travels through space at 300 Mm/s or 300 000 000 m/s. The light from the Sun takes about 500 seconds (8 minutes and 20 seconds) to reach the Earth's surface.
- In a year, the Earth intercepts about 4 yottajoules of solar energy (4 YJ) from the Sun.
- Shooting stars are travelling between 40 km/s and 60 km/s when they strike the top of our atmosphere and burn up to form a quick streak of light.
- The average distance from the Earth to the Moon is about 380 000 000 m or 380 megametres (380 Mm) and the Moon travels at about 1 km/s around the Earth.
- From the Earth to the next nearest star (after the Sun), is about 40 petametres (40 Pm). The next nearest star can refer to either Proxima Centauri or Alpha Centauri, depending on their relative positions in their orbits around each other.
- From the Earth to the nearest galaxy, M 31 in Andromeda, is about 20 zettametres (20 Zm)
- From the Earth to the furthest, normal, galaxies is about 40 yottametres (40 Ym).
- From the Earth to the furthest objects detected in our observable Universe (quasi-stellar objects or quasars) is a little more than 100 yottametres (100 Ym).
- As the distance from Earth to the furthest Quasars that have been studied is about 100 yottametres, this means that the diameter of our observable Universe is about twice this value or 250 yottametres (250 Ym).

Washing machines: 5 kg to 6 kg front load washing machines use about 60 litres of water per load, while top load machines use about 110 litres.

Water: A 10 litre bucket of water has a mass of 10 kilogram; a 200 litre drum of water has a mass of 200 kilograms; and a cubic metre (1000 L) of water has a mass of 1000 kilograms or 1 tonne.

If you are travelling where there is no fresh water, you should provide 5 litres per day per person for drinking and washing.

Whales: You can guess the mass of a whale by allowing five tonnes for each metre of the whales length.

Wine glasses: When wine is served in 125 millilitre glasses there are six glasses in a 750 millilitre bottle of wine or eight glasses in a 1 litre bottle.

Wine production: One tonne of grapes makes about 500 litres of wine.

Worms: A useful start to a worm farm is to use 10 000 worms per square metre (about 2.5 kg/m^2).

Plan your worm farm to be up to 150 millimetres deep and to have a capacity of 15 litres for each member of your household.

A worm can eat its own body mass in food each day. A kilogram of worms (between 3000 and 4000 individual worms) will eat about one kilogram of food scraps every day.

Earthworms travelling to new food sources have been tracked for distances of up to one kilometre.

Native earthworms of south-eastern Australia can grow to 2500 millimetres long and 30 millimetres thick.

Please find some of your own examples and send them to:
pat.naughtin@metricationmatters.com

Measurement practice stations

Set up places for measurements that are only metric. Absolutely avoid any opportunities for anyone to choose the *'metric conversion*' path (*Don't duel with dual!*). Here are some ideas:

Temperature sensing

Place two degree Celsius only thermometers just inside and just outside a popular door. On a nearby notice board place this poem:

degrees Celsius (°C):

Zero is freezing, 10 is not,

20 is pleasing, 30 is hot,

40 frying, 50 dying.

You can download a formatted copy of this poem from:
http://www.metricationmatters.com/docs/degreesCelsiusPoster.pdf

How heavy?

Place various items on or near a '*Heft table*' with a range of items all marked in grams or kilograms (but not both).

Examples might include:

- kilogram bag of flour
- 2 kilogram bag of oatmeal
- 2 kilogram bag of wheat
- 2 litre drink bottle labelled as 2 kilograms
- 1 kilogram bag of flour
- 1 kilogram bag of oatmeal
- 1 kilogram bag of wheat
- A set of bathroom scales.
- A set of scales with appropriate metric weights.
- An electronic set of scales up to 5 kilograms.
- Barbells of 1 kg, 2 kg, 5 kg, 10 kg, 15 kg, 20 kg, and 50 kg.
- Some mystery bags and suitcases that can be used to make guesstimates that can be checked on (say) the electronic or the bathroom scales.

You will also need several sets of scales for checking the mass of these various objects. Kitchen scales and bathroom scales will do if you cannot arrange to have highly accurate commercial scales or laboratory scales. Just make sure that the scales are all marked in metric mass measures only.

How much?

For this you need a range of jugs, saucepans, buckets, basins, and anything else that will hold sand or water. Free running sand is good because you don't get water everywhere, but you will need water to show that:

1 millilitre of water has a mass of 1 gram

1 litre of water has a mass of 1 kilogram

How long, how wide, and how high?

Small Measures

Measure in millimetres the length, width, and thickness of your:

Little finger

Little finger nail

Long finger

Long finger nail

Thumb

Thumb nail

Hand palm

Hand span

Medium Measures

Measure in millimetres the length, width, and thickness of your:

Foot

Cubit (elbow to long finger)

Pace

Stretched pace

Body span

Elbow to elbow

Shoulder to shoulder

Your height

Your waist

A metre up from the floor

How High?

Measure in millimetres the length, width, and thickness of a:

Chair

Table

Bench

Door

Window

Ceiling

Map skills

Use the maps in an Atlas to develop metric map reading skills by answering questions like:

- How wide is the UK?
- How wide is the USA?
- Which is wider, the USA or Australia?
- How far is it from New York to New Orleans?
- How far is it from Geelong to Cairns?

Walking challenge

Use paving paint to mark out several metric pacing paths along a well-used walking path (say from a car park to a work place). Try 5 metres, 10 metres, and 20 metres so people can pace out these distances as they go to and from work. Have one 5 metre path marked at every metre so people can try stepping out in metres.

Accurately measure, and post in a prominent position, various lunchtime walks of (say) 1 kilometre, 2 kilometres, and 3 kilometres with a challenge to walk these in 10 minutes, 20 minutes, or 30 minutes (walking at 100 metres per minute is a brisk walking pace). As an example, my Post Office box is 1300 metres from my home office so I try for 13 minutes there and 13 minutes back.

If you have done this exercise well, you should now have acquired portable skills that will allow you to make reasonable estimates (sometimes called '*guesstimations*') within about 10 per cent without any measuring instruments. Obviously, you will become more skilful the more you practice these skills.

Body Mass Index (BMI)

Fix a two metre ruler or tape marked in millimetres to a wall where people congregate (a lunchroom perhaps) and have a bathroom scale that will measure in kilograms (only) to 150 kilograms. Place a sheet on a nearby table showing how to calculate Body Mass Index (BMI) together with a calculator. The sheet could contain this information:

Adolphe Quetelet (1796-1874), a Belgian statistician, developed a formula to find if people were overweight or obese. Known initially as the '*Quetelet Index*' it is now called the Body Mass Index or by its initials, BMI. The Quetelet formula is still used as an international measure of obesity.

To calculate your own Body Mass Index (BMI) you need two personal measurements:

- Your body mass in kilograms, _____ kilograms

and

- Your height in metres. _____ . _____ metres

The BMI formula can look a bit daunting:

BMI (kg/m²)= weight in kilograms ÷ (height in meters)²

But your Body Mass Index calculation is quite straightforward in a normal calculator. In this example we are using a height of 1.65 metres and body mass of 75 kilograms. You proceed like this:

1 Enter your body mass in kilograms (say 75 kg)

2 Touch the ÷ button

3 Enter your height in metres (say 1.65 m)

4 Touch the ÷ button (doing this twice organises the square metres automatically)

5 Enter your height in metres again (1.65 m), and

6 Touch the = button (In our example the BMI is 27.5 so it is in the overweight group below)

7 Your Body Mass Index (BMI) is now on the screen and you can interpret it from this USA Department of Health & Human Services BMI Weight Status Categories table.

BMI	Your BMI Status
Below 18.5	Underweight
18.5 -24.9	Normal
25 - 29.9	Overweight
30 & Above	Obese

Other countries use slightly different tables.

An easier way – for men

You estimate your best body mass by subtracting 1 metre from your height. If you are 1.75 metres, your body mass should be less than 75 kilograms; if you are 1.95 metres, then less than 95 kg is your goal.

An easier way – for women

This easier rule does not quite work so well for women. For women use the men's rule and then subtract 5 kg. If you are 1.75 metres tall, a good body mass for you would be 70 kilograms; if you are 1.95 metres tall then your body mass should be less than 90 kilograms.

What holds metrication back?

There are several issues holding back metrication. The main issue is the approach that you choose for your metrication process. You can choose from direct metrication, phased metrication, metric conversion, or hidden metric and the repercussions of each of these decisions are described above.

However, there are also some other issues that will affect your metrication transition whichever process you choose. The main restraining forces involve:

- Conjecturing
- Dithering
- Centimetres
- Power games
- Habitual cheating

Conjecturing

Beware of conjecture! Often intelligent and forceful people who have little or no experience of the metrication process will decide on metrication policies and practices simply based on conjecture.

The classic conjecture is to assume that metric conversion will move you toward full use of the metric system. This is wrong; in fact it is so badly wrong that it will delay progress for many decades, perhaps even hundreds of years.

The great American journalist, H. L. Mencken, could have been talking about this conjecture about metric conversion when he wrote:

> ***…for every complex problem there is a solution that is clear, simple and wrong.***

Metric conversion is an example of a conjecture that looks as if it might work. It doesn't, and it has been shown to fail on numerous occasions. To avoid conjecture, find experienced metrication people who know what works and what doesn't.

Another example is expressed in the often-shouted line:

> *'But can't they see – all they have to do is move the decimal point.*

The metric system can – and occasionally does – use decimal fractions but it is not necessary to do this. The metric system has a superbly powerful system of prefixes that allow you to use whole number almost all the time. You can use the properties of the metric system to rid your business of fractions altogether.

Be especially careful of conjectures about the metrication process in government departments. Bureaucrats are inclined to write their ill-founded conjectures into legislation and regulation that then mean extra – totally unnecessary – work for the business community.

Dithering

Dithering occurs when you have to choose between two or more different measures that seem to be equally good choices. Dithering is important enough to be considered as you go through the process of planning for your metrication, because dithering can delay your metrication process remarkably.

As an example, think about the competition between the officially recognised metric unit for food energy, kilojoule, and some of the other common measuring words such as, calories, Calories, gram calories, kilocalories, or kilogram calories.

There has been only one official metric unit for measuring food energy since 1889 — kilojoules. For example, a slice of bread contains about 250 kilojoules of food energy and a sweet biscuit has about 500 kilojoules of food energy. The kilojoule had been accepted as the sole unit for energy internationally since 1889.

However in 1918, 29 years after the establishment of the kilojoule as an international standard unit for measuring the energy in food, Dr Lulu Hunt Peters popularised an alternative word, 'calorie', to describe

food energy in the USA. However, she avoided the concept of food energy by writing, '*... hereafter you are going to eat calories of food. Instead of saying one slice of bread, or a piece of pie, you will say 100 calories of bread, 350 calories of pie*.' Food energy and measuring have been muddled ever since then.

As a child, Lulu Hunt Peters was aware of her problem with body mass when she wrote, '*... that there is genuine mental suffering in being an obese child*.' As an adult, she reached a body mass of 100 kilograms.

Dr Hunt Peters defined a calorie as the amount of heat needed to heat 4 pounds of water by 1 degree Fahrenheit. She based her definition on the German research into dog digestion done by W. O. Atwater who was investigating the best way to use dog droppings for tanning leather.

Many attempts were made later to define the word, calorie, in metric terms. But this only led to more confusion as different groups devised different definitions. This is why we have calories, Calories, gram calories, kilocalories, kilogram calories, and perhaps 20 or 30 other varieties. Like other old pre-metric measures there are now far too many different calories (or Calories or kilocalories) and these have many different names and varying values.

The existence of these seemingly good choices (kilojoule accurate, the others popular) means that the debate between them will continue for many generations, with nutritionists and dieticians dithering between them. To a measurement specialist there is only one choice, the kilojoule, but I suspect that women's and diet magazines will continue dithering. You can avoid dithering by adopting a definite measurement policy.

As another example, the Australian building construction industry conducted a smooth, rapid, and profitable metric transition using a definite measurement policy that you saw earlier. I repeat it here:

'The Australian Building and Construction Advisory Committee policy is:

> *The metric units for linear measurement in building and construction will be the metre (m) and the millimetre (mm), with the kilometre (km) being used where required. This will apply to all sectors of the industry, and the centimetre (cm) shall not be used.'* *

With these words the Australian Building and Construction Advisory Committee effectively banished centimetres from the building trades in Australia and there was never any chance of individual workers or companies dithering over whether to use centimetres or millimetres for individual tasks or on individual jobs. They also made it clear that the centimetre should generally not be used, and in particular:

> *'... the centimetre should not be used in any calculation and it should never be written down.'* *

*Standards Association of Australia 'Metric Handbook, Metric Conversion in Building and Construction 1972

The result of this policy was a smooth, rapid, complete, and profitable metric upgrade without any dithering.

Among many other advantages, this policy also had the immediate effect of removing all references to fractions from building sites. Most other trades, crafts, and professions in Australia followed the example of the building industry's successful metrication upgrade. About 84 % of trades and crafts and professions now routinely use millimetres — and avoid centimetres.

Another – high risk – example of dithering is with the reporting of the body mass of newborn babies. Their baby mass is determined at birth in grams so that small gains or losses can be readily seen when weighed subsequently. Medical staff often then gives the baby's mass to the parents as grams **and kilograms** leaving the parents dithering between the two. Their reaction is to ask, '*What's that in pounds and ounces?*' This can have the effect that the life of the baby is less secure if it becomes ill, as parents and medical staff try to retrace the conversion steps that might have occurred. A far better approach is to decide, as a policy issue, only to use grams for the birth mass and the subsequent mass of babies and to help grandparents, parents, sisters, cousins, and aunts how to convert the pounds and ounces of their earlier babies to grams, so they can make comparisons.

Measurement policies don't have to be complicated – but they do have to exist.

centimetres

Another example of dithering between two measures is in the case of centimetres and inches. When people choose centimetres as their small unit for measuring lengths they usually also bring the full range of skills acquired using the old pre-metric inch.

For example, since inches are divided by fractions, then so is the centimetre. The world computer industry chose this approach when they set the defaults for word processors; when you set the defaults to centimetres they are automatically sub-divided into halves and quarters of centimetres despite the fact that one of the reasons for upgrading to the metric system in the 1790s was to get rid of fractions.

People opposed to the metric system sometimes protest about the absence of thirds, which they formerly needed for finding thirds of a shilling, thirds of a foot, or thirds of a yard. It takes them some time to realise that thirds are rarely necessary in a decimal system. They are simply trying to transport their old skills to the metric units.

The textile industry uses quarter centimetres, quarter metres, thirds of metres, half centimetres, and half metres together with other measures divided by decimal fractions. For textile workers who have trouble with fractions, having both common or vulgar fractions and decimal fractions makes their lives doubly difficult at the very least.

Most trades and crafts (about 84 % in Australia) choose to use millimetres as their small length measure, and by doing so they rid themselves of all fractions, both common or vulgar fractions, as well as decimal fractions. Fractions are simply extremely rarely, if ever, used.

It is sometimes difficult to judge the success of metrication efforts when some succeed easily and quickly, while others fail slowly amid great cost and difficulty. One reason for the differences becomes clearer when you ask: '*Did they choose centimetres or millimetres for their metrication process?*' Metrication with millimetres typically takes less than a year; using centimetres can typically take at least 100 years.

Power games

Some people who are highly skilled at arithmetic, especially mental arithmetic, encourage conversions between old pre-metric measures and modern metric units because it gives them an opportunity to show off their arithmetic skills, and they can belittle inexperienced students. This is a too-common practice among older engineers, scientists, mathematicians, and teachers.

Sadly, I have observed several professors who have chosen this path. Probably, the best approach to handling these people is to wait for them to retire or die, and to try and isolate them from students before that happy event.

Habitual cheating

In some industries cheating is so endemic, and it has been practised for so long, that many participants in the industry seem to be unaware that they are habitual cheats. Here are several examples. Unfortunately, there are others.

Shoe industry

Shoes have been sold according to 'size numbers' since at least the 1300s. A size number was originally the length of a barleycorn, '*chosen from the middle of the ear, full and round*'. But no specification was made as to where the measuring by barleycorns should begin. As a result, most of us can tell a story (or several stories) about shoes we bought as the 'right size' but that proved within a few days not to fit properly and then they had to be thrown out or given to charity. Probably between 10 % and 20 % of all shoes suffer this fate – a direct profit to the shoemaker.

Beer makers

Beer makers sell in containers that measure to the glass brim when everyone knows that beer is best with a 'head' of froth. This increases beer sales by about 10 % overall at the expense of beer drinkers.

Women's clothing

Many items of women's clothing are sold by size numbers. In this case, there are often no underlying measurements at all. A size 16 this season might become a size 12 next season according to the whimsy of the fashion sales team. Many women have wardrobes containing unused garments bought from these unscrupulous marketers.

Men's clothing

Makers of men's clothing have discovered the opportunities afforded by dithering between centimetres and inches. They design and make their garments in inches and then sell to the public in size numbers based on 'nominal centimetres'.

Oil industry

The oil industry tells us the price of oil in 'dollars per barrel' each day. They do not buy oil in barrels; they do not sell oil in barrels; they simply calculate a theoretical oil price based on a theoretical oil barrel of unspecified size –an oil barrel that never existed — to report to the public. Today's oil price was reportedly close to $55 per barrel (probably about 35 cents per litre) and today I had to pay 109.9 cents per litre at the service station, where I served myself.

But not everyone thinks like this!

Relevant thoughts from famous thinkers

You might find these thoughts useful if you need to write articles for newsletters, or prepare speeches, about the metrication process:

The metric system is: 'A tous les temps; a tous les peuples' ('For all time; for all people)

The Marquis de Condorcet (1743/1794)

Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has.

Margaret Mead (1901/1978)

The concept of measurement is one of the most sophisticated products of the human mind; without it there would be no science, no industry, no commerce.

Isaac Asimov (1920/1992)

The primary objective of the Office of Weights and Measures is to achieve equity between buyers and sellers in the marketplace; to prevent deception and fraud.

USA Office of Weights and Measures

Everything should be as simple as possible — but not simpler.

Albert Einstein (1879-1955)

You must be the change you wish to see in the world.

Mahatma Ghandi (1869/1948)

All the difficulties in the metric system are in translating from one system to the other, but the moment you use the metric system alone there is no difficulty.

Dr Alexander Graham Bell (1847/1922)

Metrication is SUCCESSFUL

(possible format for a metrication presentation)

Metrication is SUCCESSFUL because it is:

Simple

The modern metric system, formally known as the International System of Units (SI), is the simplest and easiest-to-use system of measurement ever devised.

Unique

The metric system is unique. Never before, has there been a method of measurement that has all the positive benefits as SI. In fact the metric system is the only system of measurement ever devised. All previous measuring methods were just a hodge-podge of randomly generated local measures.

Coherent

The metric system uses the same decimal nature as our number system, and it uses the same mathematical rules and symbols that we use for the mathematic of numbers.

Capable

The metric system is capable of measuring anything in any trade, profession, or other human activity. The metric system has no limitations. For example, you might measure the distance from here to the door in metres, the distance from between your home and your work in kilometres, the width of your little finger nail in millimetres, the diameter of the hairs on your head in micrometres, and the size of one of your cells in nanometres. Why stop there? With the SI prefixes, there is more than enough flexibility to measure from the size of sub-atomic particles – the diameter of an electron is about 6 femtometres – to the size of the whole Universe – the diameter of the Universe, as observed by the world's best telescopes, is about 250 yottametres.

Equitable

The key argument for using the metric system is that it is fair to all concerned. This has been a demand placed on all measuring methods from the beginning of recorded history.

For example, in the King James version of the Bible there is the instruction:

> *'Just balances, just weights, a just ephah, and a just hin, shall ye have ... ' (Leviticus 19:36).*

As the book of Leviticus is one of the earlier books of the Bible, we can assume that these demands for honest weights and measures have been around for thousands of years.

The Koran (written between 610 and 632) says:

> *'Woe to those who give short weight! Who when they measure against others take full measure; but when they measure to them or weigh to them, diminish!" (Koran Sura 83)*

Supported

The metric system, as the International System of Units (SI) is supported by international treaties and by national legislation. There are no international differences; SI is a world standard fully maintained by the 'TREATY OF THE METRE'. SI is a legal method of measuring in every nation in the world.

System.

The metric system is a system of units. SI was designed and planned with each unit as part of the whole plan. This is why it is called the 'International System of Units'. SI is a system that ensures that quantities and units are uniform in concept and style. SI is a system that reduces or eliminates measuring confusion.

Fundamental

SI is now fundamental to all measurements, both old and new. All old measures, even in the USA, are now defined with SI units as their basis. For example:

- 1 USA inch = 25.4 millimetres (exactly)
- 1 USA pound = 453.592 37 grams (exactly)

The inch and the pound have no other definitions except in terms of metric system units. The metric system is now the sole system used as the basis of international trade.

Unique

There has never been a measuring system like SI – never in the history of the world. Because SI was designed with each unit as part of a whole plan there is only one unit for each physical quantity. SI uses quantities and units that are uniform in style so conversions are not necessary.

Legal

Legislation in every nation in the world supports the metric system. SI is often the sole measurement method recognised by governments. International agreements legally support the metric system so that contracts written in SI are valid across borders.

Let me spell it out for you:

Metrication is

S - U - C - C - E - S - S - F - U - L

Black and Decker

With drawings and files being easily transferred from one facility to another, a line of DeWalt power drills was developed, consisting of housings designed in the USA, motors designed in Italy, and switches designed in Germany. The streamlining of the design efforts and data transfer enabled Black & Decker to leverage the strengths of various designers, improve overall quality, and promote a modularity of design that enables manufacturing flexibility. The resulting line of DeWalt tools has been marketed worldwide and was an incredible success.

Caterpillar Tractor

The benefits of metric conversion at Caterpillar included elimination of redesign in overseas plants; reduction in the number of sizes, resulting in fewer and larger steel orders, as well are reduced steel inventory; improved design selection resulting from a more logical sequence of sizes; and cost reductions of between $900,000 and $1,000,000 a year!

Kodak

A corporate policy was put into place requiring all new products, processes, and systems to be metric. Bob Burkowski, Corporate Metrication Leader, noted, *We are incorporating the use of metric units into our training processes, our operations, and our product design and manufacturing. SI, the international system of metric measurement, is a key ingredient in obtaining six sigma quality worldwide.*'

More metrication success stories at: http://lamar.colostate.edu/~hillger/pays-off.html

Summary of the metric system

This is included for reference. You do not need to memorise all of this but it is useful to know the overall structure of the metric system.

Seven base units form the basis of the whole metric system. Other units are derived from these seven in such a way that there is only one unit for each quantity. This eliminates any need for conversion factors. Using the metric system prefixes can also make it possible to avoid any references to fractions.

The modern metric system is called the International System of Units (SI) and it is formed from 7 base units.

Base units

Quantity name	Base unit	Original definition*	Modern definition**
length	**metre (m)**	1/40 000 000 of Earth's polar circumference	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.
mass	**kilogram (kg)**	mass of a litre of pure water	The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.
time	**second (s)**	1/86 400 of a mean solar day in the year 1900	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.
electric current	**ampere (A)**	coulomb per second	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 m apart in vacuum, would produce between these conductors a force equal to 2 x 10−7 newton per metre of length.
thermodynamic temperature	**kelvin (K)**	Celsius degrees above absolute zero	The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.
amount of substance	**mole (mol)**	the number of atomic mass units in twelve grams of carbon	1. 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. 2. 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.
luminous intensity	**candela (cd)**	brightness of a standard candle	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

* These original definitions might help you get a feel for the size of the unit.

** Go to http://www.bipm.org/en/si/base_units/ for the most recent definitions.

Derived units

In the International System of Units (SI) derived units are expressed in terms of the seven base units. These are coherent in that they require no conversion factors within the SI and there is only one unit for

each physical quantity. Here are some commonly used examples — there are as many of these as are required to measure all things in the Universe.

Name of quantity	SI symbol	Unit name	SI symbol
area	A	square metre	m^2
volume	V	cubic metre	m^3
speed, velocity	v	metre per second	m/s
acceleration	a	metre per second squared	m/s^2
density, mass density	ρ	kilogram per cubic metre	kg/m^3
surface density	ρA	kilogram per square metre	kg/m^2
specific volume	v	cubic metre per kilogram	m^3/kg
amount concentration	c	mole per cubic metre	mol/m^3
luminance	L_v	candela per square metre	cd/m^2

The radian and steradian are special names for the number one that may be used to convey information about the quantity concerned. In practice the symbols rad and sr are used where appropriate, but the symbol for the derived unit one is generally omitted in specifying the values of dimensionless quantities.

Some of the derived units are used so often that they are given special names. The special names and symbols are simply a compact form for the expression of combinations of base units that are used frequently. SI prefixes can be used with any of the special names and symbols, but when this is done the resulting unit will no longer be coherent.

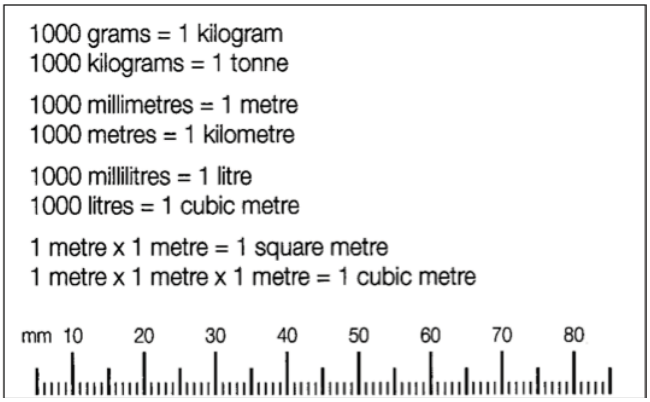
The degree Celsius is the special name for the kelvin used to express Celsius temperatures. The degree Celsius and the kelvin are equal in size, so that the numerical value of a temperature difference or temperature interval is the same when expressed in either degrees Celsius or in kelvins.

In the International System of Units (SI), there are:

- 7 SI base units and
- 22 SI derived units with special names.
- 22 SI units in total.

In the whole of the International System of Units (SI) there are only 29 unit names to learn to know the whole system.

Most people do not need to know the whole metric system. Most people and most activities can be successfully done using only the SI units that will fit on the back of a business card like this:



Derived units with special names

There are 22 derived units with special names approved for use within the International System of Units (SI). Here is the complete list

Derived quantity	Name	Symbol
plane angle	radian	rad
solid angle	steradian	sr
frequency	hertz	Hz
force	newton	N
pressure, stress	pascal	Pa N/m2
energy, work, amount of heat	joule	J
power, radiant flux	watt	W
electric charge, amount of electricity	coulomb	C
electric potential difference, electromotive force	volt	V
capacitance	farad	F
electric resistance	ohm	Ω
electric conductance	siemens	S
magnetic flux	weber	Wb
magnetic flux density	tesla	T
inductance	henry	H
Celsius temperature	degree Celsius	°C
luminous flux	lumen	lm
illuminance	lux	lx
activity referred to a radionuclide	becquerel	Bq
absorbed dose, specific energy (imparted), kerma	gray	Gy
dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent	sievert	Sv
catalytic activity	katal	kat

The metric system prefixes

Using the metric system prefixes can also make it possible to avoid any references to fractions. You can do all your measuring work in whole numbers without decimal fractions and without common or vulgar fractions. There are 20 prefixes in the metric system. Here is the complete list:

SI prefix list

prefix	Symbol		Used for measuring
yotta	**Y**	**10^{24}**	The size of the whole Universe ≈ 250 Ym
zetta	**Z**	**10^{21}**	The distances to galaxies
exa	**E**	**10^{18}**	The distance to the farthest stars
peta	**P**	**10^{15}**	The distance to the nearest stars
tera	**T**	**10^{12}**	Distances between the Sun and the planets
giga	**G**	**10^{9}**	Diameters of large stars – Betelgeuse ≈ 500 Gm
mega	**M**	**10^{6}**	Diameters of small stars – Sun ≈ 1392 Mm
kilo	**k**	**10^{3}**	Distances between cities – Geelong to Sydney ≈ 1090 km
hecto	h	10^{2}	Rarely used except for square hectometres (hectares ha or hm^2)
deca	da	10^{1}	Rarely used
deci	d	10^{-1}	Rarely used
centi	c	10^{-2}	Rarely, if ever, used in industry but common in schools
milli	**m**	**10^{-3}**	Width of your little fingernail ≈ 10 mm
micro	**µ**	**10^{-6}**	Typical diameter of a bacteria
nano	**n**	**10^{-9}**	Width of a virus – flu virus 50 nm to 120 nm
pico	**p**	**10^{-12}**	Typical diameter of atoms ≈ 300 pm
femto	**f**	**10^{-15}**	Sub-atomic particles – protons ≈ 1 fm
atto	**a**	**10^{-18}**	Size of a quark ≈ 1 am
zepto	**z**	**10^{-21}**	Size of a preon ≈ 1 zm
yocto	**y**	**10^{-24}**	Size of an astronomical black hole ?

From the BIPM Brochure (8th Edition):

> *The complete set of SI units, including both the coherent set and the multiples and submultiples of these units formed by combining them with the SI prefixes, are designated as the* ***complete set of SI units****, or simply* ***the SI units****, or the* ***units of the SI****.*

Although the prefixes: hecto, deca, deci, and centi are legitimate parts of SI, they are used much less frequently than the others because they have proved to be more difficult to use and consequently they slow down metrication programs — dramatically. See the article, *centimetres or millimetres – which will you choose? See* http://www.metricationmatters.com/docs/centimetresORmillimetres.pdf for the text.

Arguments and responses

As a metrication leader, you will meet all sorts of resistance to change. Some of the resisters will have developed their own arguments supporting why they should never upgrade to the metric system. This next — rather long — section will provide you with responses to most of these arguments.

To compile this list I surfed the internet to find as many anti-metrication views as I could. I found a lot, but many of them were very, very repetitive. Almost all of them were from the UK and the USA. I kept collecting until the repetitions became too boring.

At that point, I had collected 136 negative views about the metric system. I then grouped them into some sort of order so that I could find them easily, and wrote a response for each one. The original arguments are as I found them except for a little light editing when the writers had obviously let their emotions take over from their spelling, grammar, and courtesy skills. I also tried to reduce repetition, but I know I didn't get them all, so there is still a little repetition.

I make no apology for the length of this document – I was thorough. This list is idiosyncratic to me. I have had direct experience farming beef cattle, cereals, dairy, poultry, sheep, and wool. I have also worked in home building, industrial construction, recycling, science education, and scientific research. Indirectly, I have worked with ballet dancers, bricklayers, carpenters, electoral counters, forensic scientists, furniture makers, mechanical engineers, opera singers, piano makers, police, plumbers, prisoners and prison officers, spinners, teachers, top-makers, weavers, and welders.

One observation that I made from my various experiences is that the change to metric goes much smoother and faster if you choose millimetres as your small unit and avoid the use of centimetres altogether. I don't fully know why this is so, although I suspect that it is direct result of eliminating fractions from calculations. However, having carefully observed metrication in many industries and having carefully considered this question for many years, I am convinced that metrication programs that choose millimetres go much more smoothly – and rapidly – than those that choose centimetres.

I am indebted to the generosity of members of the UK Metric Association and the U.S. Metric Association for their thoughts on some of these responses.

136 arguments against SI

The 138 arguments that I collected are grouped under these nine headings:

- There are better ways than metric (41 arguments)
- Other people use old measures – so old measures are OK (37 arguments)
- It's too hard to change (17 arguments)
- It is old - therefore it is good (10 arguments)
- Metric is foreign (9 arguments)
- There's nothing wrong with the old methods (8 arguments)
- We should have freedom of choice in measurement (7 arguments)
- Old measures are natural (5 arguments)
- I don't want to change my mind (2 arguments)

There are better ways than metric (41 arguments)

Argument: Any method of measurement is OK. We don't need new measures. **Response:** This is an interesting observation because the old ways are not a 'single method of measurement' – they are a random collection of all the methods of measurement ever used by anyone in the world. Our major religious documents refer to cubits, ephahs, and hins; our clocks refer to ancient Babylonian hours and minutes; and our shoe sizes are measured in barleycorns. One of the main goals of metrication is to simplify the measures we use for our daily life. A key part of that simplification is to reduce the number

of measuring units from the many hundreds of thousands of old units to the twenty-nine units of the International System of Units that is universally known by the symbol SI.

Argument: It is an advantage for children to learn two sets of measurements. **Response:** This argument contradicts the truth – it is a major disadvantage for children to have to learn more than one set of measurements, and it is a major waste of their time. Learning the old measures takes schools about an hour each day, for about 200 days in a school year, and for anything up to twelve years of schooling. At the end of this process, very few people claim to be competent and confident in using old measures. On the other hand, educational research, in the USA, suggests that teaching of measurement can be reduced by about 90 % when only the metric system is taught in schools.

Argument: We should use both measurements. We should use be able to use dual methods at the same time. **Response:** Valerie Antoine, Executive Director of the U.S. Metric Association says, '*We can't afford to use two measurement systems. U.S. companies that export, have to keep two sets of records, one for domestic products and one for exported products. It costs more for them to manufacture goods, therefore it costs American people more to buy them.*'

Argument: Now that we have calculators, we don't need to change to metric to save time in calculations. **Response:** Unfortunately, calculators are not very good for handling fractions other than decimals. Calculators are almost all designed to handle decimal numbers easily. This suits the metric system because, in SI, all factors between multiples are either 10, 100 or 1000. In fact, for many people, and for many purposes, such as in building and engineering, their only multiple is 1000.

Argument: On the farm, we are used to a range of units. Some examples are: inches, links, feet, yards, rods, chains, furlongs, and miles. **Response:** This is not a complete list of old farm measures – there are hundreds, maybe thousands of other old units that have been used on farms. SI, with only 29 units, replaces all of these old measures. For example, measuring lengths on a farm can all be done using only three SI units – millimetres, metres, and kilometres all related by one multiple – 1000. Who would prefer to use the old mismatched collection of Babylonian, Egyptian, French, Greek, Roman, and Syrian measurements with strange multiples such as: 3, 5 1/2, 7.92, 12, 15 1/2, 22, 40, 72, 80, 1760, and 2240?

Argument: At sea, we like to use a range of units, such as fathoms, feet, inches, leagues, nautical miles, and yards? **Response:** In SI, all of these are replaced with millimetres, metres, and kilometres – only three units – simpler is safer.

Argument: As mechanical engineers, we already enjoy the advantages of decimal numbers because we regularly use decimal inches. **Response:** And civil engineers use decimal feet, land surveyors use decimal chains by having 100 links in their chains, and car and truck drivers use decimal miles. However, like many old methods of measurement, there is no coordination between these different decimal methods. There is no system that allows a mechanical engineer to readily understand the work of a civil engineer, a land surveyor, or a driver and vice versa. The metric system, on the other hand, is well adapted to this. A mechanical engineer, working in millimetres and metres, can readily comprehend the metres and kilometres used by a civil engineer.

Argument: Metrication is a scam to benefit other countries that think that conformity is a good thing – it's not. **Response:** Conformity in standards, technology, and measurement saves all manufacturers millions of dollars every day because traders anywhere in the world can trust the measurements made by other people anywhere else in the world. In addition, people from SI nations have no need for training to cope with overseas developments and technology; only people from the USA have to face these issues, and these additional costs.

Argument: SI is changing all the time. **Response:** True, it's getting better all the time. For example, since 1790, the definition of the metre, the key unit of the metric system, has been changed several times. At no time has the length of the metre changed, but its definitions has got better each time so that modern measurements can be confidently undertaken. The original metre was good enough for land measures in the late 18th century, but these days with viruses and bacteria measured to fractions of a nanometre we need the precision that we can achieve by defining the metre in terms of the speed of light. However, to repeat the main point of this response, the changes in the definition of the metre has never resulted in a change in the length of the metre.

Argument: Any methods would be OK. Units of measurement are only as good as those who use them. **Response:** Any system of measurement is essentially a common tool that we have all agreed to use. Its effectiveness depends on the ease of use of the tool, and on the ability of users to employ that tool. By having a tool that is easy to use, you reduce the amount of energy needed to use it effectively and you increase the productivity of all of the tool's users. By using SI as our measuring tool we all gain in accuracy and precision as we reduce costs.

Argument: SI is scientific and not suitable for everyday living. **Response:** Do you regard drinking Coca-Cola that comes in litres and millilitres as a scientific activity? Do you regard driving your metric car as scientific; all cars have been designed and built using metric units, only, since the mid 1970s? There are about 7000 million people in the world and 96 % of them use the metric system for everything they buy, sell, or measure every day – and very few of them are scientists. The other 4 % of people live in the USA.

Argument: The English System is based on one of the most basic measurement notions, that of halving and doubling. There are 16 ounces to a pound, which means that if you cut your quarter-pounder in half and then in half again, you have an ounce. Similarly, half of a quart is a pint, half of that a cup and if you halve that three more times, you have a fluid ounce. Half of that is a tablespoonful. Double a quart twice and you get a gallon. **Response:** This is a nice thought and about three thousand years – so far – has been spent trying to implement it. The net result is that in the world, we now have several different ounces, several different pints, several different quarts, several different cups, several different teaspoons, several different tablespoons, several different quarts, and several different gallons. I wish you well if you decide to promote a new halving and doubling method.

Argument: The Fahrenheit temperature scale is better than Celsius because its got more degrees on it. This makes it more accurate. **Response:** It is a curious thing that human sensitivity to temperature is about one degree Celsius; humans cannot detect differences smaller than this. Of course, because a degree Celsius is a metric measure, and therefore decimal, you could simply use tenths of degrees, or even millidegrees Celsius, if you require more precision.

Argument: I am used to the old measures; I know what 68 °F feels like. **Response:** And you know what 20 °C feels like too – because they're the same.

Argument: The public are not smart enough to handle metric measures. **Response:** Every day, in every way, 96 % of the world's people use the metric system. Only the people of the USA have not yet (openly) chosen the simplicity and ease of using the metric system.

Argument: The Imperial System is more practical because its units developed from use – rather than by Committee. **Response:** Although mathematicians, scientists, and technicians designed the decimal nature and the logical coherence of the metric system, the measures that they chose were based on practical human-scale measures. For example: your little fingernail is about 10 mm wide; and your hand is about 100 mm wide.

Argument: Let's go back to the 'imperial' weights and measures, i.e. the good old-fashioned pounds, pints, inches, ounces, and feet. **Response:** They may be old-fashioned, but are they good? Do you really support measuring methods that are uncoordinated, difficult to use, and prone to errors?

Argument: The USA, quite rightly, should never have anything to do with the metric system. **Response:** the USA has been deeply involved with the development of the metric system for a very long time. The decimal nature of the metric system is largely due to the activities of Benjamin Franklin and Thomas Jefferson when they were in France in the 1780s. The USA is a signatory of the Metric Convention of 1875 and it is a member state of the International Bureau of Weights and Measures, set up under that convention?

Argument: The metric system is just a rip-off. Metric units are very close to the old inch-foot-pound units: a metre is really just a long yard, a litre is about the same as a quart, and so are a tonne and a ton. **Response:** What you say is true. In all methods of measurement, there are sizes that are convenient for humans to handle, but it doesn't matter how you measure them. SI was designed to have many values similar to the old ones to make it more convenient to use and more acceptable to the conservatives as it was adopted in each nation.

Argument: The metric system is not a coherent stable whole (it has internal contradictions and it is in flux) and the US does not use the 'Imperial System'. **Response:** There are many more internal contradictions and fluxions with old measures than there are with SI. Until the foot was defined by metric measures, for example, its length was in a constant state of variation. Compare this with the metre that has been a consistent length since 1799.

Argument: The metric system is too complicated. It uses the speed of light just to define a metre – who can understand that – everybody could understand what a foot is. **Response:** The second part of this argument is simply untrue. Very few people know that a foot was defined as 304.8 millimetres in 1959; and even less know that a foot was defined (in the USA) as (36/39.37)/3 metres in 1893. The first part of the argument is also untrue; because the speed of light is the standard for the metre, any competent laboratory anywhere in the world can check the length of the metre. Where in the world is the world standard foot?

Argument: The feet, inches and miles – used by the USA – are good enough that they could be used as the world standard. **Response:** The USA does not have a standard foot, a standard inch, or a standard mile, because all units in the USA are defined in terms of metric standards; a foot is defined as 304.8 millimetres exactly, an inch is defined as 25.4 millimetres exactly, and a yard is defined as 914.4 millimetres exactly. There is no such thing as a 'Standard Yard' or a 'Standard Pound' in the USA anymore. The Mendenhall Order superseded the old definitions in 1893, when they were replaced by metric definitions. Currently, all measurement in the USA (such as feet, inches, yards and pounds) totally depends on the modern metric system; the USA is currently using a second-hand metric system.

Argument: The metric system is too rigid; there aren't enough units to be able to choose the best unit for the job you are doing. **Response:** SI uses only one unit, the metre, to measure from the diameter of an electron, at about 6 femtometres, to the diameter of the known Universe, at about 250 yottametres; both of these are measured in metres with prefixes being chosen to suit the different sizes. Old measures have trouble measuring these extreme sizes in any understandable way without changing the names and definitions of the units.

Argument: The metric system seems to always come back to the old values. Look how often they use 300 mm - why not say a foot? What about 30 mL; why not use an ounce? In buildings, they use 1200 mm all the time; what's wrong with four feet? Metric measures are constantly shifting toward the old units. **Response:** The pyramids were built using a 'Royal Cubit' of close to 600 millimetres. If you place two of these together, you get a building module of 1200 millimetres. Builders throughout history have chosen to build with 'building modules' that were convenient enough to handle but not so small that they required too much measuring, cutting, or fixing. In the olden days, you could get a two foot wallboard, a three foot wallboard, a four foot wallboard, a four foot six inch wallboard; and all of these came in multiple lengths; this range of sizes led to increased costs. A wallboard of 2400 mm by 1200 mm has the additional advantage of having its length to width in the ratio of 2:1, which means that sheets can be fitted together in several efficient ways to cover many different areas. A 2400 mm by 1200 mm sheet is about as big as one person can handle so it has become a very common size in building all around the world, and it has been a convenient size for a long time, however it was measured.

Argument: The metric system violates the natural human requirement of subdivision into 3, 4, 6, 8, ... parts. The metric system is also inadequate for the subdivision of the circle, for the 24 hours in the day, the 12 months in the year, and the 32 points of the compass. All these requirements are met by changing the number base from 10 to 12; we need a duodecimal system rather than a decimal system. **Response:** Using duodecimal measures, based on twelves, would come at the expense of not having a measurement system that matched the numbers we use for counting and calculating things. You are advocating that we have measures based on twelves and twelfths, while at the same time we count in tens and tenths. I think that thousands of years experience, since Babylonian times, have shown that having multiple number systems at the same time leads to multiple confusion, with its associated corruption. However, having said that, we still have the remnants of many duodecimal methods that have been tried over the years; most of them failed. The fact that there are 12 inches in a foot is a notable example, and this is a remnant of a Roman attempt at using a duodecimal measuring method, 2000 years ago. The word 'inch' comes from the Latin word 'uncia' and this simply meant 'a twelfth'. Coincidentally, the Latin word 'uncia' also gave us the word 'ounce' because there were 12 'uncia' in a 'libra' in ancient Rome.

Argument: The old imperial measurements worked very well. They were easy to imagine but they were sometimes difficult to use in calculations. This didn't really matter because few people did many calculations. **Response:** Few people did many calculations with old measures because the calculations were often too difficult. Now, with SI, calculations are easy and even easier if you use your calculator. SI is demonstrably easier to use in day-to-day commercial and technical calculations because all SI measurements are automatically expressed in terms of a single multiple in decimal form. To test this idea try figuring how many 5 ½ ounces bottles of perfume you can get from a nine-gallon container, and then calculate how many 150 millilitre bottles you could get from a 40 litre container.

Argument: The USA has already set world standards like the 55 gallon oil or chemical drum that is used everywhere in the world. **Response:** This drum was designed to hold 200 litres of oil or chemical with a small air space above the level of the liquid. Of interest is the fact that the 200 litre drum became 55 gallons in the USA and 44 gallons in the UK because of the different gallons used by these two nations.

Argument: The old ways of measuring are not bad. Proponents of SI should not attack them. Just because the metric system is better does not mean that USA measures are bad. I'm tired of the constant diatribe against the old methods. **Response:** Think about the Model T Ford or an IBM 286; these weren't bad either. However, the old ways of measuring are bad in that they are inefficient, complicated, and expensive. Some of the old ways were so bad that most people could not use them. They were riddled with tricks and devices that favored traders over members of the public. In many cases, the old methods were, and still are, deliberately designed and used to defraud the public.

Argument: The old ways were not inefficient. **Response:** Every individual, every group, every company, and every nation that has ever changed to metric measures for long enough to get used to them, has always remained with metric; none of them have ever gone back to the old ways permanently. The most notable example of this was when France reverted to old measures. Following numerous protests about the new system of measurement the French government of Napoleon decided to go back to the old ways and reintroduced 'mesures usuelles' such as the aune, the boisseau, the livre, and the toise. This led to total confusion in measurement in France and eventually led to demonstrations, riots, and even deaths. The confusion lasted for about a generation. The metric system was reinstated as the sole means of measurement, in 1840, and its position in France has never been threatened again.

Argument: Only learning multiples of 10, and nothing else, would dumb down the school system because kids would learn less mathematics. **Response:** Fractions will still be part of the school arithmetic curriculum. There is nothing at all, in any part of the metric system, against the teaching of fractions. They are just not used as often in measuring as previously. People will still think and talk about things such as half a litre of drink or a quarter kilogram of bacon. However, experience with children has shown that once they learn multiples of 10, they readily master metric measurements. In all other countries, other than the USA, learning metric measures actually helps kids learn the rest of the mathematics curriculum.

Argument: The whole metric system, which seems to be rational on paper, is irrational in practice. For example, the gram was first defined as a cubic centimetre of water. This was too small, so they switched to a kilogram and defined that, not as 1000 grams of water, but in terms of a platinum cylinder kept in a suburb of Paris. Am I supposed to go to Paris whenever I want a kilogram of cheese? **Response:** Definitions of units are necessary to give a system of measuring units the legal authority to maintain its integrity all over the world and through time. The original designers of the metric system had a motto, 'A tous les peuples; a tous les temps' and this translates as, 'For all people; for all time'. You don't need to go to Paris (although it might be rather pleasant to do so) when you want a kilogram of cheese because your government has a copy of the standard kilogram and your government makes further copies for the use of your local weights and measures inspectors. When you buy your kilogram of cheese the amount you get is directly traceable all the way back to the standard kilogram in Paris. Even if you order a pound of cheese, the amount you get can be traced back to the international standard kilogram in Paris. There are no international standards, anywhere in the world, for the pound, the ounce, the, hundredweight, and the ton, other than the kilogram in Paris. By the way, have you had trouble with the definition of a yard in the past – did you toddle off to London every time you wanted a yard of fabric?

Argument: There are more natural number choices rather than 10. Twenty and twelve are better choices. **Response:** Many different numbers have been chosen as bases for measuring methods in the

past. Twenty has been used, as has twelve, both with limited success. A notable example was English currency. Before they 'went decimal', they divided pounds into 20 shillings, the shillings into 12 pence, and the pennies into 4 farthings. They used twenty, twelve, and four as the basis of different parts of their money system. Now that the change to decimal currency has been made there is no demand for them to go back to these old methods. Other factors have also been tried; we still have remnants of an old method from Babylon, in Iran, that gives us 60 seconds in a minute, sixty minutes in an hour and twenty-four hours in a day.

Argument: Today, the metre is defined as the length of the path travelled by light in a vacuum in 1/299,792,458th of a second. Isn't that a handy rule of thumb when buying a string of sausage? **Response:** I've never thought to order a metre of sausages before, thank you for the idea. I suggest that you buy your sausages by the kilogram and leave the precision offered by a definition based on the speed of light to scientists and technicians such as surveyors. They need the extra precision for their work – you don't for your kilogram of sausages. When you next make a length measurement with (say) a metre stick, you will have the full assurance that you are not being cheated because you know that the measuring authorities have calibrated your metre stick, to an appropriate level, down to the last 1/299,792,458-th of a second. By the way, have you had trouble with this definition of a yard before? Remember that the yard is defined as a fraction (0.914 4) of the metre so the yard, too, is defined in terms of the length of the path travelled by light in a vacuum in 1/299,792,458th of a second.

Argument: We can understand the old ways better than metric. **Response:** Would you rather use minims, fluid drams, ounces, pints, quarts, gallons, bushels, hogsheads, US ounces, US dry pints, US dry quarts, US dry barrels, cranberry barrels, petrol barrels, wine gallons, ale gallons, etcetera, and so on, and so forth? Alternatively, could you rather use litres – with millilitres and kilolitres? Hardly anyone, including measurement specialists called metrologists, ever understood all of the old ways of measuring – they were far too complicated. As an example, think of a common rural problem. How big does a rainwater tank need to be to hold a year's supply of water from a roof? In metric, this is easy; each millimetre of rain on each square metre of roof causes a litre of water to flow into the tank. Using old measures, this calculation is so difficult that few ever attempted it; it involved conversions of fractions of inches of rainfall into feet to find the number of cubic feet of water that could be converted into gallons.

Argument: We know we are getting good value when we shop using the old measures. **Response:** Most of the shopping we do is done by a simple visual examination. We choose the package the same size as the last one we bought. We trust the government regulators and inspectors to make sure that the amount of goods placed in each package meets the legal standards. If we can't see the package, we ask for one that's about 'Yay' big. In fact, it is quite rare for any actual measurement to take place during a purchase for your normal requirements.

Argument: Metric measurements aren't easy to calculate just because they're based on multiples of 10. One-third of a kilometre, for example, can be rounded to 333.333 meters, but that's not precise. A third of a mile, however, is exactly 1,760 feet. **Response:** It is rarely necessary to divide kilometres into three. However, if you have to divide a kilometre into thirds, you simply choose your level of precision by adding more threes; for example 333.333 is accurate to the nearest millimetre. On the other hand: what is 1/3 gallon? What is 1/3 pound or 1/3 ounce avoirdupois? What is 1/3 chain or 1/3 furlong? What is the logic and precision of the widespread practice of dividing old units in decimals? What is the meaning of 5.6 miles, 3.7 ft, 5.8 gallons, etc.? I know very well that 5.62 km is equal to 5620 metres, but it is much more difficult to understand that 5.62 miles is 5 miles, 48 chains, 13 yards, 0 feet, and 7 13/64 inches.

Argument: We should have a rich and diverse choice of measurement **Response:** We have had a rich and diverse range of measurements available to us and all it did was cause inefficiency and confusion. Don't forget that our measurement methods underpin almost everything that we do. From the time we rise each morning to the time we go to bed, a range of measurements governs most of the moves we make. We need measurements to be as simple as possible so that they do not impinge too much onto the more enjoyable activities in our lives.

Argument: Why do we have to use a base-10 system? Why can't we use a base-12 system? Tens only divide into twos and fives, but twelves divide into twos, threes, fours, and sixes. **Response:** It is true that twelves give a better range of factors for stacking – so we should use a base-12 system for that – stacking. However, because we use a decimal number system, a decimal number is better for anything

that requires calculations, and for this it is better to use a base-10 system. After each attempt at using other number bases, the decimal system returned and it became the most widely adopted. From time to time, some people will try to resurrect these old number systems. Curiously, everyone who does this always starts with the decimal numbers as the basis for their 'new' methods.

Argument: With metric, things have to be done in tens; we can't get a dozen eggs any more! **Response:** To say that 'things have to be done in tens' is nonsense. Eggs pack well in dozens that are 6 x 2, and bottles of wine pack well in dozens that are 4 x 3; and tennis balls work OK in threes. However, tens are best when you have calculations to do. Measurements often need to be added, subtracted, multiplied, or divided, so tens are always best for this purpose.

Argument: You have to be clever with numbers to be able to use the metric system. In the old days, everyone could understand feet and inches. **Response:** Very few people could say that they were experts on the old methods of measurement – the old ways were too complex and too variable. Many people with a little training can and do claim to be expert users of the metric system. This could be one of the sticking points in a metrication program; people don't want to learn another complicated method like the old one they had to learn in the past, and they don't yet have enough experience to know the simplicity of SI.

Argument: As a day-by-day, visit-the-timber-yard, ordinary sort of bloke, I do seriously prefer inches, feet and yards to mms, cms and ms. These old measurements remind me of thumbs and feet and paces. They relate to the familiar. I have a mental picture of what they are, and so, still, do many other people I encounter. That scarcely makes us Luddites! **Response:** Measure yourself – your thumb is 25 millimetres wide; your foot is 300 millimetres long; your pace is 750 millimetres; your thumb nail is 0.5 millimetres thick; your little finger nail is 10 millimetres wide; and it is a metre from the ground to your hip. As you become familiar with metric measures, your tasks will become easier and easier. You might then describe yourself as 'a day-by-day, visit-the-timber-yard, metric sort of bloke'. Good luck!

Other people use old measures – so old measures are OK (37 arguments)

Argument: All the sports are reported in feet and pounds. **Response:** In a single country such as the USA, sports can be reported in old measures, but SI makes the sports news, sports travel arrangements, and sporting exchanges understandable between all nations. For example, to describe the Olympic Games the metric system is the only way to communicate the sports results with the 96 % of the world population who use SI as their daily measurement language. Athletes know that they have to operate with SI units when it comes to international competition, so they learn how to do this early in their competitive career.

Argument: Babies are measured in pounds and ounces. Have a look at the Birth Notices in the local paper. **Response:** The newborn baby's mass is measured in grams. The medical staff then carefully records the baby's mass in grams in case the child becomes ill; they know that they will have to calculate medicines in micrograms or milligrams per gram to treat the baby. Having done the things that are necessary for the health and safety of the baby, the medical staff then dumb down the baby's mass into pounds and ounces so that the new mother can compare the 'weight' of her baby with the remembered 'weights' of the babies of her mother, her grandmother, her aunts, and her sisters. Sadly, by doing this, these collective mothers are putting the lives of babies at risk of treatment errors if the baby becomes ill.

Argument: Computers have their screens in inches. **Response:** For years the television industry has lied about the size of the screen available to viewers using arguments about the internal size of the cathode ray tube (CRT) versus the size of the viewing screen that we actually see. For example, a (so-called) 21 inch screen has a viewable screen of about 19¼ inches. As early computers used television screens, this fraudulent practice came to the computer industry along with the screens. If you are about to buy a computer screen, and you are told the screen size in inches, it is best to assume that this is a lie and measure the screen yourself, preferably in millimetres.

Argument: Computer printers all work in inches. **Response:** Computer printers are completely designed and built in SI units: they run on volts; their current is in amperes; the resistors are in ohms; their width, length, and height are in millimetres; and then they translate one of the metric measures to dpi to confuse the lucky punter. In your case the subterfuge worked.

Argument: More than 25 years after Americans were told their country would adopt the international measuring standard, the USA remain one of three nations – the others are Liberia and Myanmar – that doesn't use the decimal-based metric system of weights and measures. **Response:** Liberia and Myanmar conduct trade with the nations around them on a daily basis. These neighbouring nations are all metric countries. Liberia and Myanmar are going metric from the grass roots level and metric usage has advanced greatly. It is no longer true to say that Liberia and Myanmar are not metric. The USA will now be the last nation in the world to openly accept metrication. People from the USA often use a statement like this to give support to the idea that the USA is not alone in their measuring practices. Usually they include two – curiously almost always two – of the following: Burma, Liberia, Libya, Myanmar, and Yemen.

Argument: It's been 25 years since America was supposed to begin converting to the metric system – and more than a century since President Andrew Johnson encouraged us to adopt it – and we're not much closer now than we were then. It must be too hard for Americans to learn. **Response:** Every other nation in the world has successfully accepted the modern metric system. Sometimes it has taken them a long time to change, like the UK, and sometimes they have been able to change quickly, like Australia. It is hard to believe that the metric system is too hard for Americans to learn, since every person in every other nation has already done so.

Argument: Football is still in feet. **Response**: It is amusing to watch football in the USA where the measure of ten yards is a crucial part of the game. From time to time two measurers run on to the ground with two upright sticks tied together by a piece of cord. They believe and most of the football fans believe that the piece of cord is ten yards long, but I know that the yard in the USA is defined in terms of the metre, so the cord is exactly 9.144 metres long – exactly – not a millimetre more and not a millimetre less.

Argument: French and German plumbers use inches. **Response:** What you say is partly true. A small number of French and German plumbers still use old words to refer to pipes, but this has no relationship to reality. They sometimes refer to a 13 mm pipe as a 'demi pouce', which means half of an old French inch. Other French plumbers refer to this pipe size as a 'treize', which means a 'thirteen' (millimetres). The inches used by the plumbers are called 'nominal inches' and these can vary in size from place to place. The pipes were designed, made, and sold in metric sizes; the French plumbers might use the word 'pouce' but there has been no 'pouce' sized pipes in France for almost two hundred years. Neither the French nor the German plumbers are using real (international standard) inches. I suggest you actually measure some of their pipes; you will soon find yourself in the world of 'virtual' inch sizes where reality is regularly suspended – for the sake of a good story.

Argument: People's heights are still in feet. **Response:** Heights are guessed more often than they are measured, so we need to have a measurement method that suits our inclination to guess a person's height. It takes a while for people to develop their metric height guessing skills. To do this you need to guess in metres. If you walk into a room where there are several men, look at their heights with the idea of picking the person whose height is in the middle of the range. This is the man of average height, and if the group is of a normal range of heights – you're not at a basketball party – then the person you chose would be close to 1.75 metres tall. Guess heights that end in zeroes or fives. Don't try to get any more precise than this; you can't guess heights like 1.73 m or 1.74 m so don't try. Now look at the women, Pick a woman of average height and she will be close to 1.65 metres. You can guess the heights of all the others by comparing them with your two average people.

Argument: I was in Germany last year and I could buy apples in Pfund. Even the Germans haven't changed fully to metric. **Response:** When Germany changed to metric measures (in 1872) they changed the measurement but not the name of their unit for mass. The Pfund was changed from all of its old pre-metric measurements to 500 grams exactly; so modern Germans use an old name for a modern measure. Curiously, at a different level, it seems clear, from experience around the world that metrication takes very little time; but for word patterns to change, it takes much longer. For example, we are still singing about a 'bushel and a peck' some hundreds of years after most of us stopped using either of these measures.

Argument: European countries haven't totally abandoned old measurements; they still use hours and minutes with hours that are 60 minutes in length, not 100 minutes. **Response:** The idea of 60 minutes

in an hour originated 3000 years ago in the city of Babylon, which is a part of modern Iran. This statement says nothing at all about the nature of the metric system.

Argument: In the UK, we have been free to use the metric system for over a century – there are still very few takers. Most people haven't changed to metric yet. **Response:** This argument simply refers to the fact that anti-metric folk are a noisy lot and pro-metric folk are quieter. All UK manufacturing is done with metric measures and hundreds of thousands of metric measures are made every day, but at the end of the day, drinkers can still buy a pint of beer in a pub. Being able to use one old unit, out of the thousands they have used during the day, gives some people the illusion that nothing has changed. People who hold this view are wrong.

Argument: My customers don't understand the old measurements and that is good for me; I can tell them what I like, and they'll believe me. **Response:** Sadly, I suspect that this has been the motivating force for the introduction and continuing use of many old measuring units. Unfortunately, many traders know this and they use it shamelessly. For a trader the perfect trading practice is to buy using simple, supported, SI units, and then to sell using whatever units that the trader makes up by themselves, or with the assistance of other traders in the same industry. Examples are buying diamonds by the gram and then selling them by the carat, or buying oil by the kilogram and then reporting its price, to the uninformed public, by the barrel.

Argument: My staff is too old and they won't go along with the change to metric. My staff is too young; they will not be able to handle the change to metric. Old weights and measures are preferred. Most people, in all age groups, prefer the old weights and measures. **Response:** I simply don't believe you – show us your facts. Most very old and very young people in the world are quite comfortable using SI. Remember that 96 % of the world's people, of all ages, use SI as their measurement language. The experience of nations all around the world who have been through the metrication process is that age has nothing to do with metrication. More important is openness to new ideas and an attitude that embraces new things. If you believe that your staff is too old, think about my mother-in-law – at 97 she had no trouble buying 250 grams of cheese, or knowing that 40 °C was a very hot day – you must have really old staff. If your staff is too young, do your self, and your staff, a favor and buy a training program. SI is so simple that this is an easy solution, and you will find that it is quick, and it can be inexpensive.

Argument: Nobody wants SI. **Response:** Overall this statement is not true. Currently, about 96 % of the world's people now prefer to use the metric system as their primary measuring method. So many people realise the advantages of SI that they are readily adopting it wherever they can. However, several people have tried to use the change to metric measures to promote other political campaigns. For example, the United Kingdom Independence Party (UKIP) used the so-called metric martyrs to gain publicity for their anti-Europe campaign. Overall, the noise and publicity given to anti-metric people is out of proportion to their numbers. Over time everyone who has used the metric system accepts it as the best available and then gets on with their lives.

Argument: Old measures are the 'industry standard'. **Response:** This is not true. The standard for all measures, everywhere in the world, is SI, the modern metric system. Even in the nations where they use (say) inches and pounds, these are all based on metric 'standards'. In the USA, for example, an inch is defined as 25.4 millimetres and a yard is defined as 9.144 metres.

Argument: We do things that are familiar to our customers, readers, bosses, clients, etc. They do not understand the metric system and complain every time we use metric units. **Response:** Some people always complain when they confronted with change – any change at all. Often when this happens they thrash about looking for reasons why they don't want change. They are not necessarily opposed to metric measures because they know little about them; the simple fact is that they don't like to change their minds. As an example, I once had a friend who vigorously claimed that he didn't like modern music. Every time anything that sounded vaguely modern came on the radio and TV, he immediately turned it off. How could he know whether or not he liked modern music –he had never heard any! I suspect that many people react the same way to metric units – they turn off their minds using the theory that if they ignore it, it will go away. If you are a team leader or a group manager, expect the moans and groans. Remember that it is one of your fundamental roles, as a manager, to manage change. You could look at metrication as a chance to hone your management skills.

Argument: Our national identity (in the USA) is defined by our difference to others, that's why we cling on to the old measures. **Response:** SI simplifies communication between nations because every nation in the world uses SI units. This means that nations can seek real differences between them rather than using the artificial prop of measurement, which in the end has little significance as a point of difference between nations. In any case, it is a poor sense of national identity that can be threatened by the adoption of an international system of measurement. Metres and grams will not dim the colors of 'Old Glory', and they will not diminish the grandeur of Times Square.

Argument: People like the old ways better. **Response:** Ignorance is always a strong motivator to retain old ways. People who know both old measures and the metric system – and therefore have the ability and knowledge to make a rational choice – always favor the metric system. It's a reasonable guess that anyone who uses the argument, 'People like the old ways better', is ignorant of even basic metric measures. It's a puzzle why people would want to use grains, drams, ounces, pounds, stones, hundredweights, tons, troy ounces, troy pounds, long tons, short tons, long hundredweights, short hundredweights, and many hundreds of others, instead of simply replacing all of these with grams, and kilograms.

Argument: People won't change to metric voluntarily. **Response:** People constantly change to metric voluntarily. Almost the entire world population – 96 % or 6700 million people out of 7000 million – choose to use metric measures every day of their lives.

Argument: Politicians actively support and include references in speeches to the old measurements. **Response:** Any group of politicians includes some who are conservative and some who are progressive. Perhaps you have chosen to quote the conservative politicians.

Argument: The majority of consumers do not understand metric measurement. Moreover, consumers are not demanding that their food products be packaged and labelled using the metric system. **Response:** It might be fairer to say that the majority of consumers do not use or understand any measurement methods at all. They buy packages that are 'Yay big' or 'So big' (with lots of hand gestures) without reference to measurement information at all. This observation fits well with the experience of metrication in England where people were quite comfortable with metric packaging and protests didn't arise (and then from only a very small minority) until consumers actually had to say measurements like, 'Could I have a kilogram of bananas, please?'

Argument: The measurement issue will never be decided in a government office. It will be settled at the checkout counter, in grocery stores and kitchens, on the desks of editors and drafters, on shop floors, and on highways. **Response:** This is true. The measurement issue has already been decided '*at the checkout counter, in grocery stores and kitchens, on the desks of editors and drafters, on shop floors, and on highways*', and this has already happened all around the world. The decision was made in all of these places that metric measures were simpler and easier to use, so the metric system has become the dominant measuring system for 96 % of the world's population – so far.

Argument: The metric system is becoming more unpopular in Britain. **Response:** Some politicians and some news media have successfully used the metric system as a symbol of the European Union's (*Brussels Bullies*) efforts to standardise British Weights and Measures (*trample British culture and sovereignty under a foreign yoke*). These people have quite deliberately used the metric system debate to support their rampant nationalism. The fact that the official name for the modern metric system is Système International d'Unités (SI) (International System of Units (SI)) doesn't help when marketing to those citizens of England, who are proudly, and loudly, anti-French. It's sad that this nationalistic attitude is depriving some English people of the benefits of using the metric system.

Argument: The metric system is breaking USA ties with British culture, and moving us toward European culture. **Response:** These ties were accidentally broken, in 1834, when Parliament House in London burnt down, destroying the English measuring standards for the pound and the yard. From then, the UK and the USA chose to use different measurement methods. After the introduction of SI into the UK and the eventual acceptance of SI in the USA, it will be the first time, since 1834, that the UK and the USA, once again, have a common measuring language.

Argument: From what I see on television and read in the papers, the metric system is becoming more unpopular in Britain. **Response:** The media will support anything that promotes controversy. They will

promote any cause if they believe they can get people to feel strongly about. The issue doesn't matter – emotional content is all-important. The media in England, like the media in the rest of the world, loves conflict, so they have chosen to give loads of publicity to a small group of traders who are refusing to obey the UK measurement laws. There is, in England, a small group who will oppose metrication till they die; then they will be buried in a 1.8 metre grave. Remember, too, that many of the old measures were especially designed to confuse people when they were shopping. That's one of the reasons why we have two different ounces of weight (Troy and avoirdupois), two different ounces of mass (Troy and avoirdupois), various fluid ounces, and all of the other ozs that come in UK and USA flavours.

Argument: I have asked several media outlets, print, radio, and TV, why they haven't changed to metric. They said that they couldn't change until the public had substantially changed to metric. **Response:** This is just a circular argument that many journalists use to avoid a discussion about their numeracy. Although there are many exceptions, journalists are generally employed because of their literacy skills, and not because of their numeracy skills or mathematical knowledge. Many journalists are not only functionally innumerate, many actually fear having anything to do with numbers. News items from one SI nations can be readily understood in all other SI nations. This is not necessarily true for news items originating from the USA or going to the USA. News has to be translated for the USA – some say '*dumbed down*' – and this is always accompanied by conversion and rounding problems with the possibility of significant errors.

Argument: Metrication is just putting new labels on existing measurements. Thirty-five millimetre film, for example, looks like it was invented as 1-3/8 inch, and then relabelled by manufacturers to make it a global standard. **Response:** Worldwide, the photographic industry has had totally metric products since the Kodak company, in the USA, made a decision to produce B&W 16 mm black and white film for amateurs in 1910 and their 16 mm color movie film, for professionals, in 1929; other film makers followed Kodak's lead. The photographic industry was one of the first industries in the USA to change to metric. The similarity of size between 35 mm and 1-3/8 inch is just a coincidence.

Argument: I have asked several companies, from the USA, why they don't use metric measurements on their web sites. They always reply, '*The web site is intended for our local audience in the USA*'. When I ask why non-SI units are used on the same company's Australian or Canadian web sites, I get the reply '*We include it as a courtesy to our international (i.e. from the USA) visitors*'. **Response:** Do you get the sense of going around in circles? This is just a circular argument that is used quite commonly in metric discussions to hide the real argument. '*I don't want to change my mind*'.

Argument: The metric system is for scientists and engineers, and not for us ordinary people. **Response:** The metric system was originally designed to help prevent traders from taking advantage of ordinary people in the marketplace. In fact, the motto of the metric system has always been: '***For all time'; for all people***'. The world's scientific community uses SI units, not because they want to be different to everyone else, but because they know that it is easy to exchange scientific information and technology between different disciplines as well as globally if they use the International System of Units (SI). This means that scientific and technical journals never have any need to do conversions from old units into SI. It also means that every school child in the world, who learns about SI at school, can understand scientific and technological reports and textbooks.

Argument: The press support the old measures: miles, ounces, gallons, and tons. **Response:** When you use old units you have to be cautious because old measures can have many different values. A mile can be 'nautical', 'statute', or 'survey', and these have different lengths. Ounces in the USA are not the same as the English ounces; and dry ounces are not the same as fluid ounces or troy ounces. And as for gallons and tons, there are at least two quite different definitions of a gallon (UK and USA) and there are 14 different definitions of tons that are used, in the USA, to measure mass, force, power, volume, or one or other of three different kinds of energy; with the metric system, the rest of the world uses only a single litre and a single tonne.

Argument: The printing trade still uses old measures such as: ems, ens, points, lines, and inches. **Response:** Are those inches international inches, French inches, or computer type inches? Ems and ens are sixths and twelfths of one or other of those inches. Remember that the size of a computer point is not the same as the size of a printer's point, so take extreme care if you have to use points. If you are not using SI in the printing trade, you have little in the way of standards to support you in international

trade. Sanity will prevail as soon as printers realise the ease of laying out printing work using millimetres for paper sizes and micrometres for print sizes.

Argument: The USA, with the world's largest economy, uses English feet and inches, pounds and ounces, and intends to continue doing so. Why shouldn't England continue to use them too? **Response:** It is not true that the USA uses English measures, even though many units have the same names. The UK and USA measuring units have different values and this has caused considerable difficulty in trade between England and the USA. This is one of the main reasons that both nations have decided to change to metric; for the first time since 1834, both nations will be using the same measures.

Argument: We can still trade internationally with old weights and measures. **Response:** International trade and commerce are much simpler with SI mainly because SI units mean exactly the same thing in every nation in the world. Imports and exports don't have to be repriced, repackaged, or overprinted for sale in other SI nations. Most new technologies incorporate SI so they can be readily traded in all nations of the world. Except for goods from the USA, it is unnecessary to live with the irritations of the endless conversion associated with old units of measure. Only goods from the USA have to have their packaging repriced, repackaged, or overprinted. In all of the world's nations (except the USA) all old packaging designations are virtually meaningless.

Argument: I know that the NY Stock Exchange and NASDAQ have used fractions of dollars until very recently. They avoided decimal money. **Response:** The USA changed to decimal currency in 1793, one year after the opening of the New York Stock Exchange (NYSE). Because the NYSE opened before the introduction of decimal money, they decided to trade in Spanish Pesos that could be divided into eight parts, known as 'pieces-of-eight'. After 1793, the NYSE traded in dollars but continued to divide them into eighths in the tradition of the old 'pieces-of-eight' The NYSE continued this practice for 208 years, until 2001.

Argument: We can't work in metric because we talk inches and pounds all the time in our normal life. **Response:** This is a curiosity brought about by the forces that operate during the process of metrication. The technical aspects are quite simple, and if done properly change fairly easily and rapidly. However, the social factors involved in a metric transition can be much more difficult to overcome. It is not unusual to find engineers, who work in metric units all day, discussing the heights of themselves, their children, and their favourite football players, in feet and inches. This simply reflects the advantages that are gained by doing engineering calculations in metric units as opposed to guessing someone's height; for one there are considerable financial and efficiency advantages, and for the other there are few benefits. However, it is a mistake to claim that because there are areas where the benefits of metrication are less than in others that we should not make the metric transition in any of them. In some areas, there are simply no old measuring units; for example, the understanding of electricity would simply not be possible using old units — there aren't any – all electrical units are metric units.

Argument: We just have to work in metric - the head office ordered it, but there are plenty of people in my office who would go back and work with the old inches and feet; they reckon it's more natural. **Response:** This sounds like an argument where the metrication process was poorly done. Insufficient time was allowed for mindsets to change or the education component was unsatisfactory. In any case, get over it; get with it; and then get on with it. When the management of your company is looking for SI literate supervisors – don't be found chatting at the water cooler hankering after the old days – they've gone forever.

It's too hard to change (17 arguments)

Argument: All of our old recipe books would become redundant. **Response:** Textbooks, teaching aids, and all other educational equipment written in SI units are useful in all nations of the world, whereas, textbooks, teaching aids, and other educational equipment from the USA are useless anywhere else in the world because they are written using old pre-metric measuring words. When the USA changes to metric measures they will be able to export their textbooks, teaching aids, and other educational equipment to other countries.

Argument: All our recipe books, formula books, and production guides are written in the old measures. It would be too expensive to change them. **Response:** Have you considered the cost of the calculation

time and the cost of errors using the old methods compared to the simplicity of SI? Have you considered that metrication might be an excellent opportunity for you to revise your '*recipe books, formula books, and production guides*'? It may be that a review and a revision of your measuring procedures are long overdue.

Argument: Halves, quarters, and eighths are better than decimal because all you have to do is halve things. **Response:** There was an old medieval English 'doubling' system for measuring volumes. It never worked in practice, but remnants of it are still with us. It started with the idea that 2 mouthfuls were equal to a jigger or a mouthful was half a jigger. Next, two jiggers made a jack, or a jigger was half a jack. The whole series went like this: mouthful, jigger, jack, gill, cup, pint, quart, pottle, gallon, peck, pail, bushel, strike, barrel, hogshead, butt, and finally tun. Unfortunately traders corrupted it from the start by making odd sized containers, rather than doubling each measure, so the measures never worked as a system. It is possible that the nursery rhyme 'Jack and Jill (Gill) went up the hill' was a reference to the use of these units for collecting excise taxes on alcoholic wines and spirits. If the founders of SI had decided on doubling numbers, we could have bought our two litre milk containers by the 'pottle'.

Argument: It is too expensive to change to metric. **Response:** It is too expensive not to change to metric. During metrication in Australia many companies estimated that converting to SI would involve them in considerable expense; after metrication they were surprised to find they had actually saved money. This was largely due to the reduction of the number of sizes of wire, nuts and bolts, etc. that they had to stock; and these savings continue forever.

Argument: It will take too long a time before we become conversant in metric. We don't have this time because we have our work to do. **Response:** All you have to do is to decide that you – that's you personally – will change to metric. That decision might take you about 3 milliseconds and after that, everything is easy. What you are really saying is that it might take you a long time to prepare yourself to make this decision and it might take you a long time to convince your associates that you have made the right decision.

Argument: It will take too long a time before we become conversant in metric. **Response:** It takes about an hour to begin to develop your metric mindset if you spend one single hour measuring the things you use every day. A good place to start is to measure your hands and feet. Here are my measurements to give you a starting guide. My little fingernail is 10 mm wide; my fist across the knuckles is 100 mm wide. My hand span is 250 mm and the length of my cubit (elbow to tip of long finger) is 500 mm. My foot (in socks) is 320 mm long and 125 mm wide, and this means that my metric shoe size (called Mondopoint) is 320/125.

Argument: Metric units aren't easy for the average person to guesstimate. **Response:** All guesstimates are based on experience. The more experience you have the better your guesses. This is true for all measures, whether old-style or SI. As good guesstimates come from experience, you need to develop your metric experience to be a good metric guesstimator. To begin this development draw a square metre on the floor and leave it there for a few days (or even weeks) until you get used to the idea of its size. Mark out a length of 10 metres where you can step it out and practice pacing with a one metre pace, or a half metre pace if it's more comfortable (When I did this, I marked the ten metres on a path between the car park and my office and practised every day.) Keep practising until you are confident of your ability to estimate in metres and square metres. For smaller measures, look at my measurements in the previous response – measure yourself the same way.

Argument: We think that changing to metric would be too difficult. **Response:** Then you would be the first in the world to find this to be true. Not only have people who have metricated found it easy, but also they have always refused to return to the old ways once they have changed. This is true for individuals, for groups, for companies, and for nations.

Argument: We think that changing would be too expensive. Our entire inventory is in old units and the transition to totally new stock would take a very long time and would be too expensive. **Response:** During metrication in Australia, many companies were hesitant and – before the event – they projected that metrication would be very costly. One company detailed its metrication costs at $550 000. However, after the event of metrication many of these companies realised that metrication had not been a cost but a benefit to them. In the case of the company that estimated its costs at $550 000, it recouped these costs

in less than three years and the savings it achieved, in 1973, through metrication, are a continuing benefit today. The savings were largely due to the reduction of the number of sizes of spare parts such as wire, nuts and bolts that they had to stock. These companies now view metrication as a rare opportunity for modem industry to totally revise products and adopt newer and more effective procedures. Australian examples of this type of process improvement included the standardisation of the location of screw holes on hinges that reduced the number of standard hinge sizes from 153 to 11 to suit the same applications as before. Another Australian example was the reduction of the number of steel sections, to rationalise the sizes of oil drums, from 55 to 11. You could use the opportunity provided by metrication to rethink your inventory position. If you are holding stock in inventory for too long it's probably about time you had a review anyway.

Argument: All our tools are in old units. We would have to buy a new set of metric tools. **Response:** You are going to buy a new set of tools anyway, to replace them as they wear. Make sure you aren't stuck with the expense of two sets of tools. Make the decision to change to metric as quickly and as cleanly as you can. Experience in all countries has proved that repairs and maintenance of equipment, such as cars, videos, and cameras, is simpler with SI. This is because it is easier to design and fit parts in metric units. There is a cost of retooling during the metrication process, but good companies have used metrication as an opportunity to retool and to align themselves with the best world practices.

Argument: Aircraft heights are in feet. **Response:** The height of an aircraft is based on air pressure measured in pascals, an SI unit. This is then converted into height in metres by computer. Some pilots then change this so they can report to the passengers in feet. Personally, I would prefer the pilot to be concentrating on flying the aircraft, rather than doing these completely pointless calculations.

Argument: Some things should not change for safety reasons. For example, aircraft should continue to fly in nautical miles and feet. The aviation industry seems quite happy using feet and nautical miles. **Response:** From a practical point of view, aeroplane manufacturers know that – sooner or later – they are going to use metric units – so they have already done so – and then hidden them. Planes built in the last 10 years or so have electronic flight instrument displays that are built to operate according to ICAO (metric) rules. This practice also fits in with the fact that more and more planes are relying on the satellite based Global Positioning System (GPS) to find out where they are. The GPS, too, was designed and operates in metric units. However, with the push of a button, all of the displays in the cockpit can have conversion factors applied, and have the electronic displays seem to revert to old pre-metric measuring words. The altitude that was determined in metres and given in metres now appears in feet. The speed that was calculated in kilometres per hour and given in km/h now appears in knots. The height that was determined in metres and given in metres now appears as feet. And payloads and fuel loads that were determined in kilograms now appear in pounds. All the original metric measures are hidden by electronic displays. I sometimes wonder what would happen if someone bumped the button that changes all the readings from the ICAO settings to the old USA values.

> *Pilot: 'Hey what are these mountain goats doing way up here in the clouds?'*
>
> *Co-pilot: 'In flight school I learned that these kinds of clouds are called 'cumulo-granite.'*

Loud crashing sounds then silence!

Argument: The brain easily accommodates repeated halving (and doubling), which is another way of saying 'powers of two', but powers of ten are anything but natural. **Response:** Of all the possible numbering systems most have been tried by humans, somewhere and at some time. For example, the Babylonians tried sixties, the Romans tried twelves, and twenties were used in English money. After all these experiments, all of these nations (Iran, Italy and the UK) have now decided that tens are the most practical for money and for all measurement. Powers of two were tried in the doubling and halving measures in mediaeval times but, clearly, they did not have proven staying power.

Argument: What will happen in our schools, when our kids have to learn both the old ways and the new system? **Response:** School students should never have to '*learn both the old ways and the new system*'. School administrators should simply make a decision to change to the metric system immediately and have nothing more to do with old measures. SI is demonstrably easier to learn and to remember. Estimates made by sociologists, in the USA, estimate that the use of SI can shorten measurement education in a twelve year life at school by, at least, one full school year. All over the world, SI has been

the basis for very significant improvements in the techniques of teaching physics, engineering, and all of the other sciences.

Argument: American children have the advantage of learning two methods of measurement – US customary measures as well as the metric system. **Response:** What you say is incorrect. A key disadvantage to the children of the USA is having to learn the metric system as well as all of the other old pre-metric methods of measurement. Children in all other parts of the world study only the units of the International System of units. All of the teachers, language, science, and social studies, use only metric units every day. The children and their teachers use these units in their daily lives as well as in their school studies.

Argument: We should use dual measurements. This gives us the greatest variety and choice. **Response:** Variety and choice in measurement lead to inefficiency and increased cost. Some people argue that it would be better not to change, at all, until you are ready to change to metric completely. SI is very much the best choice, the old ways are a long way back as second best, and dual measurements are a long, long last.

It is old - therefore it is good (10 arguments)

Argument: Inches, pounds, and yards are part of our heritage and as such, they should be retained forever. **Response:** As words, they probably will be retained forever. We will still '*inch forward*', love someone '*a bushel and a peck*', seek a '*pound of flesh*', and '*do the hard yards*', but these old units will never be supported, as measuring units, by international agreements for international trade. Already, 96 % of the world's people use SI daily and even in the USA, the last nation on Earth to avoid the metric system, inches, pounds, and yards are defined using metric measures.

Argument: Calculating in the old units works well. **Response:** Which of these would you rather do?

- Add 1 yd 2 ft 3 1/2 in to 3 yds. 1 ft 8 3/4 inches
    - or add 1.613 metres to 3.270 metres;
- Subtract 2 yds. 1 ft 8 3/4 inches from 3 yds 2 ft 3 1/2 in
    - or subtract 2.270 metres from 3.613 metres;
- Multiply 1 yd 2 ft 3 1/2 in by 3 yds. 1 ft 8 3/4 inches
    - or multiply 1.613 metres by 3.270 metres;
- Divide 3 yds. 1 ft 8 3/4 inches by 1 yd 2 ft 3 1/2 in
    - or divide 3.270 metres by 1.613 metres.

Anybody who ever actually goes to the trouble of calculating these eight problems, will never willingly choose the old methods for calculations ever again. And they can use their calculators for the metric calculations, but they have to use pen and paper for the old ones.

Argument: Metric is a sterile evolutionary dead-end. The leading-edge work in fundamental physics has abandoned metric and is using so-called 'natural units'. **Response:** Scientists love jargon, so they regularly create words and even languages that will give the impression that they are different (and therefore special) people. A part of this special language building is to create words and then use them as jargon to exclude others from their exclusive group. My favorite is the word 'barn' that is used by the cognoscenti, in place of a square femtometre. I suspect that some nuclear physicists were ribbing each other about the size of a nuclear target they could hit. When one of them said, '*You couldn't hit the side of a barn*', this simply became the jargon for square femtometre (Ho ho, nudge nudge, wink wink!). With only a little knowledge of SI prefixes we can all get some understanding of a square femtometre, but you have to become part of the 'in group' of nuclear physicists before you will understand the full meaning of a 'barn'. There is a place for seeking such things as '*natural units*' but don't ever forget that the drive among specialists to create jargon is incredibly strong – don't get confused between these two competing forces. Jim Frysinger, a Physics teacher from Tennessee, puts it like this: *Engineers will be third to last to metricate, physicists second to last, and astronomers dead last.*

Argument: Old measures require greater numeracy than metric, but this is a skill to be encouraged! It is part of our culture and history and should not be replaced by a soulless alternative. **Response:** It is not true that '*Old measures require greater numeracy than metric*'. This perception arises because old measures require greater memory skills – you have to try to remember all the names of the old units, all of the old conversion factors between them, and which ones are appropriate in the present circumstances. The level of numeracy is probably about the same, with an advantage for the decimal metric measures because it consistently uses decimal fractions if it uses fractions at all.

Argument: Old measures arose when they were needed in history and they are the best measures because they were chosen from experience. **Response:** Because old measures arose randomly throughout history, they have never had any coordination into any sort of system – even though some attempts were made to make old measures systematic – it never worked. On the other hand, the metric system was designed so that metric units are all logically related to each other. This was refined even further when the metric system was formed into the International System of Units (SI), in 1960.

Argument: The old units are part of our heritage. Our weights and measures have been used for centuries in our literature, from Shakespeare to Roald Dahl. Their loss would further weaken understanding and appreciation of this inheritance. **Response:** In literature, measures are used more for their connotations as words, rather than as rigidly precise units of measure. In '*Measure for measure*', Shakespeare was talking more about getting even rather than thinking of precise measures; and he used the expression '*a pound of flesh*' figuratively rather than precisely in '*The Merchant of Venice*'. We will always use these old unit words in the ways that the writers intended.

Argument: The proliferation of apparently unrelated units of measurement in our system is anathema to the tidy minded. However, if it is so bad, why has it survived all these centuries? **Response:** It hasn't survived in any way as a 'system' – it has been constantly changing and altering to suit the political and commercial realities of the times. There have been regular wars and revolutions over unjust and unfair measures. Until the metric system was developed, there had never been a universal system of units that everyone in the world could rely on.

Argument: This 'Think Metric' program failed miserably, because it stressed simply conversion, with no practical application. Feet and inches, gallons and pints, pounds and ounces are better. They are more practical than metric units for easy division into useful fractions. **Response:** What you are saying is based on your mindset. Because you have more experience with the hodgepodge of old units, and less with the modern metric units, you are making an unfair comparison and basing your decisions about measurement based on your unequal knowledge and experience.

Argument: Metrication has had the same effect as mandating a language change from English to Esperanto. **Response:** Four methods of written communication are recognised everywhere in the world. These four successful methods can be understood wherever you are in the world and whatever language you speak and write. It doesn't even matter if you write with an alphabet or use pictograms; you will still be able to understand these four international methods. The four methods that cross all language barriers are: the way of writing notes for music; the set of mathematical signs and symbols; the symbols for chemical elements, and the International System of Units (SI). Esperanto is not one of these four so it should not be compared with them.

Argument: It's still 200 miles from San Antonio to Houston, not 321.8 kilometres; a hot summer day is 100 degrees Fahrenheit, not 37.777 degrees Celsius; and San Antonio Spurs basketball player, David Robinson, is seven feet tall, not 2.1336 metres. **Response:** Is the distance between San Antonio and Houston exactly 200 miles, or would saying '320 kilometres or even 300 km' be accurate enough; is 37.777 degrees Celsius, another too exaggeratedly accurate conversions from 100 degrees Fahrenheit, or could you say 38 degrees Celsius or even 40 degrees Celsius; and does Mr. Robinson really measure exactly 7 feet? Maybe he is 6' 10 2/3" and that would make him 2.1 m tall. Competent users of metric measures use rounded values; just as users of old measures use rounded values with old units. You're not cheating again – are you?

Metric is foreign (9 arguments)

Argument: Metric is not 'American' or 'English'; it's foreign. **Response:** The metric system is as 'American' or 'English' as it is 'European'; it is the global international language of measurement. Paradoxically, the United States was almost the first country to adopt the metric system when Thomas Jefferson (1743/1826) and John Quincy Adams (1767/1848) recommended conversion to the metric system for the USA to replace the existing Imperial system sometime before 1784. The USA now has the distinction of being the first nation to consider the metric system and the last nation in the world to openly accept it. It was the British Association for the Advancement of Science who reformed and improved the metric system in the second half of the 19th century. Examples of SI units named for scientists and technicians from the UK and the USA are: farad, gray, henry, joule, kelvin, newton, siemens, tesla, and watt.

Argument: Compulsory metrication is undemocratic. The introduction of metric is unauthorised by any democratic process. There has not been a referendum on metric measures. **Response:** It is true that metrication has never been introduced anywhere in the world following a plebiscite; it is also true that no other method of measures have ever been introduced after a referendum – there was no referendum to introduce inches, feet, pounds, and gallons. Nations use either legislation or constitutional powers to provide for 'honest weights and measures'. This power is then delegated to groups of measurement experts who devise appropriate methods for each nation. In the case of the International System of Units (SI), the legislation is an international treaty known as the 'Treaty of the Metre', and this is supported by each nation's legislation. The USA was one of the first 17 nations to sign up to the 'Treaty of the metre', in 1875.

Argument: The edict making metric units compulsory for pre-packaged goods, and those sold by length, was rubber-stamped by the UK Parliament without proper consultation or debate, against the public's wishes. **Response:** You put a highly emotive argument. Measurement legislation and regulation have always been subject to debate, as they are far too important to everyone not to be fully and vigorously discussed. However following these discussions, appropriate legislation and regulations must be written and enforced. If measurement becomes the subject of random decisions by many individuals, there would be no trustworthy system in place, as there would be too many disputes. Applying this notion to all of government, there would be anarchy – no nation could be governed at all.

Argument: I posted a message on an email discussion site, advocating that weather be given in metric units. The answers given included: '*Move to Europe*'. '*What are you, boy, one of them foreign national subversives?*' '*This is the US of A, we don't need no stinkin' metrics*'. '*We like using feet, gallons, and cubic inches, not this quiche-eating 'metric' stuff*' and '*People who believe in the metric system are commos*'. **Response:** These rather sad remarks make a telling point. People can feel very strongly about the old pre-metric measuring words they use. The minority view expressed by these people intuitively recognises that measuring units affect everything that we do, all the time, wherever we are. Measurement is extremely important to us all, and we need to consider the strong emotional responses that they engender whenever we plan a metrication program.

Argument: Metric measurement is un-American and socialist. **Response:** Thousands of young men and women get trained to use the metric system in military training in the USA and for overseas military operations. These military personnel often get posted overseas where they see ordinary people using metric measures every day. Are you saying that you think that the army, navy, and air force of the USA are un-American and socialist?

Argument: Metric is for third world countries. **Response:** It is true that third world countries gained enormously when they metricated. It is also true that developed first world countries benefit even more than third world countries, mostly because they have more industries based on science and technology that benefit directly from the metrication change. However, the biggest winner from metrication will be the USA when that nation finally figures out how to make their metrication change.

Argument: Metric is not 'American' or 'English'; it's foreign. **Response:** It is true that metric is not 'American' or 'English'; it is fully international and universal. Children in all nations (including the USA) are taught SI units in mathematics and science at school and university. People from SI countries have no trouble travelling in other SI countries. They don't have to have special measurement training to

travel in any other SI nations. For most people in the world, they already have a working knowledge of SI, so they don't feel that they need to learn about old measurements. Only if people travel to the USA do they have to learn an old pre-metric measurement language.

Argument: Metric is not American, we use good old-fashioned measures. **Response:** People all around the world know that if you buy equipment from the USA, you also need special tools and special trade training for your staff. Manuals and instructions related to USA equipment require conversion by highly skilled tradesmen or staff at technical colleges or your employees have to be retrained to use them. Craft books from the USA have little application because they do not relate to measurements and materials anywhere else in the world. It is costing the USA an enormous amount of money to remain isolated – in measurement terms – from the rest of the world. See the article at http://www.metricationmatters.com/docs/CostOfNonMetrication.pdf

Argument: We don't export anything at our company so we don't have to change. The metric system is foreign – it's un-American. Metric is for foreigners. **Response:** This idea of maintaining social and measurement isolation from the rest of the world means that the USA has less access to all of any good ideas that arise from the rest of the world. With SI, there is greater international standardisation and interchangeability of qualified and trained people, machines, equipment, and spare parts. Every company in the USA, that adopts SI, will benefit from the change and you are competing with them even if you don't export anything. After you change to SI, you will then be able to expand your markets globally. SI stands for Système Internationale d'Unités – the International System of Units – so once you adopt SI, you become part of the global market.

There's nothing wrong with the old methods (8 arguments)

Argument: Learning fractions at school was good enough for me - so it's good enough for my kids - it'll do 'em good. Metric doesn't have any fractions. What will we do when we want a half, or a third, or a quarter? **Response:** You'll still use a half, a third, or a quarter in appropriate circumstances. As examples, consider a half litre of paint; a quarter kilogram of bacon; or cutting a 2400 mm x 1200 mm sheet of plywood into quarters, thirds, or sixths, to make some shelving. Kids will still learn about fractions at school. You, and the kids, will continue to divide a pie into halves, thirds, or quarters, but, in future, you will not use fractions so often when you are measuring. I would have thought that any parent, who cares for their children, will want them to learn to measure as quickly, as easily, and as painlessly as possible, and for this vulgar fractions are not the way to go.

Argument: Old measures are part of our culture, history, and heritage, and as such, they should be retained forever. **Response:** Bedpans and night soil carriers are part of our heritage too, but fortunately, we have realised that sewerage systems are better. '*Royal cubits*' and '*a just ephah, and a just hin*' are also part of our culture, history, and heritage. We will continue to use all of these to enrich our language, just as we will continue to do the '*hard yards*' as we '*inch forward*'. However, these words will be used less and less as measuring units as SI units replace them.

Argument: SI means that everything will be decimal – eights in a boat race will have to be extended to tens; and Beethoven will have to be resurrected to write another symphony. **Response:** This is nonsense, of course, some things are best done in tens (all calculations); some are best done in twelves (dozens of eggs); and some are best done in sixteens (pages in books). In future we will still choose the best number for each job, but we will probably choose tens when we need to do any calculations to make the decimal arithmetic easier.

Argument: I don't see what all the fuss is about. It doesn't take a rocket scientist to understand the USA and English methods of measurement. 12 inches = 1 foot, 3 feet = 1 yard, 5280 feet = 1 mile. **Response:** Rocket scientists don't have a good reputation when it comes to old measurements. Perhaps you haven't heard of the demise of NASA's Mars Climate Orbiter. The loss of the Mars Climate Orbiter, at a cost of 125 megadollars (M$), is an excellent example of what can happen when you use dual measurements.

Argument: SI means we won't get 12 oysters in a dozen any more – we'll only get 10. **Response:** When SI was introduced into Australia, a few restaurateurs tried to promote the idea that oysters now came in 'metric dozens' of ten oysters, rather than the traditional twelve. These traders were quickly recognised

as the rogues they were, and the practice is never likely to become widespread. Hang out for your two extra oysters – if you ordered a dozen, you ordered twelve oysters.

Argument: The old ways are more intuitive than metric. **Response:** This argument is really saying, '*I am familiar with old units, but I am not yet familiar with metric units*'. For most people, it takes less than an hour to become competent in using metric measures. It only takes this short time because SI is truly intuitive in that the decimal numbers used by SI are the same as the decimal numbers we use every day for all of our calculations.

Argument: These old measurements remind me of thumbs and feet and paces. They relate to the familiar. I have a mental picture of what they are. **Response:** Your thumb is about 25 mm wide; your feet are about 300 mm long; and your pace is about 750 mm. It is very easy to develop familiar mental pictures with metric units. You could also look at your little finger nail – it is about 10 millimetres wide; and look at your fist – it is about 100 millimetres across the knuckles.

Argument: We'll get ripped off in the shops because of metric downsizing. **Response:** In ancient Rome the emperor, Diocletian, wrote a long edict in an attempt to prevent traders corrupting the Roman weights and measures – he failed. Traders continue to attempt to change measurements to suit themselves, and they don't mind if they do this in libras, unciae, and scruples; livre and troy ounces; pounds and inches; they will even try to devise cheating methods using centimetres and millilitres. Of these, the hardest to cheat is the modern metric system, because the SI units are very tightly controlled, in exactly the same way, in every nation in the world.

We should have freedom of choice in measurement (7 arguments)

Argument: International bureaucrats want to build a 'one size fits all' world where it is easier for them to regulate more and more aspects of our lives. **Response:** It is true to say that there are bureaucrats who believe in improving communication between nations. These people recognise that SI is a major tool to help achieve this goal, as SI is the world's largest single language of measurement.

Argument: Old measurements are more flexible. There is a wider choice of units and a wider choice of conversion factors. **Response:** This is a flexibility that has to be earned by extensive – and expensive – training, and this training that is not portable from one industry to another. For example, if you become a jewellery expert, who understands carats of gemstones and Troy ounces of precious metals, this does not help you cook your evening meal, and if you use a recipe book you need to know if it's American or English – so I wish you joy with your curry. There has never been any evidence that a large choice of measuring units makes measurement simpler, more open, or more honest. In fact, the available evidence contradicts this idea. There have been many units invented with the express goal of deceiving the public. In modern times the barrel for oil and the carat for diamonds are specifically not designed to make transactions clear to all concerned.

Argument: We should have freedom to measure any way we like. We should end compulsory metrication. Defend your freedom to use British weights and measures. Beware, that we do not lose an ancient freedom. **Response:** Every government that has ever existed soon realises that units of measure are so important, and affect our lives in so many ways, that they cannot be left to the citizens to decide units of measure for themselves. Not since 1324, have British people had the freedom to use any measures they like. Since then, measures have been regulated continuously, not only in England, but also in every other nation in the world. It only takes one unscrupulous trader who uses a smaller pound than others to affect all traders who then have to cheat to compete. All governments, eventually, have made one set of measuring units compulsory, and all the nations of the world, including the USA, have chosen to use SI units as the basis of their measuring systems.

Argument: We should be free to choose our measurements; we should be given freedom of choice. A citizen should be able to choose what units they choose to use and governments should not be able to stop them. We need active public support to get the Government to end compulsion, and to give us the freedom to measure how we like. **Response:** This is the classical position of any trader – but only when they are selling. When they buy, they want the government to legally support a proper measurement system.

Argument: Is it a crime to be British? From the end of 1999, it has been illegal to sell fruit, vegetables, etc., priced by the pound. It is a criminal offence to use our own pounds and feet for trade in our own country. **Response:** I take it you are referring to the avoirdupois pound from France and the Roman foot from Italy and not the metric system that was invented in Oxford, Cambridge, and London. Governments have always preserved their right to define the weights and measures that can be used by their people so that they can reduce the number of measurement frauds and disputes. In the UK this power was given to the government in the Magna Carta in 1215.

Argument: We already have decimal currency. Why do we want everything else to be decimal? What's wrong with variety? **Response:** SI is much easier to use because it has one, and only one, unit to measure each physical quantity. Every known physical quantity has its own unique unit in SI. For example, the metre is used to measure the physical quantity of length. For shorter or longer lengths the unit metre can be modified by prefixes; millimetre means one thousandth of a metre and kilometre means one thousand metres. Compare this to the variety that is possible with old measures. A length could be measured with: air miles, angstrom units, astronomical units, cables, chains, computer picas, computer points, drill numbers, European shoe sizes, fathoms, fermis, furlongs, gauge numbers, geometrical paces, hands, inches, international feet, international miles, light minutes, light seconds, light years, links, microinches, mils, military paces, nautical miles, parsecs, poles, perches, printers' picas, printers' points, rods, screw numbers, shotgun gauges, UK shoe sizes, US shoe sizes, US survey feet, US survey miles, standard plate gauges, vinyl gauges, wire gauges, and yards.

Argument: We can handle metric; but that doesn't mean we want to ditch the old measures. We could use both measurement methods together at the same time with old measures for some things and SI for others. We do things in metric some of the time. We are flexible here; we can use both methods - the old as well as the new. **Response:** Have you stopped to calculate the costs of a dual system? Your costing should include the time taken for all of the conversions, plus the extra printing costs for control charts etc., plus any costs of errors that you might sometimes make when you are doing this highly pointless task. The worst possible result of a metrication program would be to produce a company, or a nation, with two parallel measurement methods in operation. This is the most costly result as it means that you have multiple constant conversion calculations with their attendant errors and accidents. The loss of the Mars Climate Orbiter, at a cost of 340 M$ USD, is a good example of the use of dual measurements.

Old measures are natural (5 arguments)

Argument: The old measures are natural. A woman wears size five shoes, size twelve dresses, size six gloves, and size thirty-two hats, and she knows all these sizes and she can remember them easily. **Response:** It is true that we can remember some of these strange old numbers, but most of us have no idea what any of them mean. Traders can – and do – change the values of the sizes as often as they like. Have a look through your shoes, clothing, and hats – how many do you have that were bought for your size number but you haven't worn because they don't fit. Using the old size numbers, it is highly likely that you are being ripped off – regularly. With equivalent metric sizes, this woman's clothing could go like this. Her 'Mondopoint' shoe size (the length of her foot rounded up to the next 5 mm) is 240 mm. Dress sizes vary widely from maker to maker but a mid-range 'Size 12' would give her a bust of 850 mm, a waist of 650 mm, and hips of 900 mm. Her glove size is 150 millimetres. If this woman's hat size is really 32, she either has an extremely large head or her hat keeps falling off – hat sizes range from very small hats of 500 mm to very large hats of 650 mm – medium size is 575 mm (an old hat size of 32 is probably equivalent to 815 mm).

Argument: The old system is natural: my thumb is an inch across; my hand is four inches wide; my foot is about a foot long; and when I pace each step is about a yard and it's about a yard from my nose to the tips of my fingers. The old measures were designed to a natural human scale. **Response:** The metric system is natural. My thumb is 25 millimetres across. My hand is 100 millimetres wide. My foot is about 300 mm long and when I use a long pace each step is about a metre. It's about a metre from my left ear to the tips of my fingers on my outstretched right hand, and it is about a metre from the floor to the point of my hipbone. Obviously, the new metric measures were designed to a natural human scale. Actually, as you and I have both shown, we can choose any measures we like to prove that any measuring method is 'natural' and 'designed on a human scale'. In these examples, you chose simple examples that would support your argument. You cheated – and so did I.

Argument: The old system may be less rational, but it is more human. The inch was first defined in 1150 by King David I of Scotland as the width of a man's thumb at the base of the nail. Edward I of England redefined the inch in the 13th century to equal three grains of dry and round barley laid end to end. The inspiration for the foot's definition should be obvious. The mile comes from the Latin, 'mille passus', which means a thousand steps. **Response:** This argument is a good demonstration to show that all of the old ways of measuring were completely uncoordinated; the sources of these measures stretches across many nations and across many thousands of years. There never was an old 'system', and there has never been any possibility of coordinating all these old measures. On the other hand, the metric system was closely coordinated ever since it was first developed. SI is a simple, coherent, system of units, it is an all embracing, conceptually accurate system of units in which the unique unit of every known physical quantity can be derived from only seven base units and the meaning and definition of each physical quantity is explicitly expressed in its unique SI unit symbol. Before the development of SI, there never had been any coordinated system of measuring units.

Argument: We have a feel for acres – hectares just don't make sense. **Response:** I doubt that you have a feel for acres – quickly now – if an acre was laid out in the shape of a square how long are its sides? Congratulations, if you guessed that the sides would be about 69 yards 1 foot 8 71/128ths inches. After a few minutes of examining a hectare in the shape of a square, you would realise that each side was exactly 100 metres, and you could easily measure one side of a hectare using the odometer's decimal numbers on the trip meter of your car.

Argument: When you convert to metric you get strange numbers - for example, 4 inches comes out at 101.6 millimetres - and that's a lot harder number to say and to deal with than 4 inches. **Response:** When you convert from metric you get strange numbers - for example, 100 millimetres comes out at approximately 3 1919/2048ths inches - and that's a lot harder number to say and to deal with than 100 millimetres. Actually, you can choose examples to demonstrate the superiority of either old measures or the metric system. In these examples you cheated – and so did I.

I don't want to change my mind (2 arguments)

Argument: We simply don't want to change. SI is unfamiliar to me and the old measures are familiar to me. **Response:** This is a typical response from someone who is unaware of how much they use metric measures already. They are unaware that they use metric medicines, drive metric cars, eat metric food, and even use metric pounds and metric inches. People who make this statement are either profoundly ignorant of their surroundings or they are 'in denial'.

Argument: In the USA, we have always done it this way. We don't object to metric - we just don't want the USA to change. **Response:** It is not true for people in the USA to say, 'We have always done it this way'. The USA has been changing to the metric system since the 1780s. There are many in the USA who do not know about, or care to admit to, the widespread use of SI in the USA. Currently, it is estimated that more than 60 % of industry in the USA uses the metric system internally and more than 90 % use SI units for imports and exports. The change to SI is happening all around you, and if you want to stay in business, you will be forced to catch up to your competitors.

An open challenge

However, I challenge you to go for a single day without using the metric system. You could use the article, *Don't use metric*; to get your thinking started. You will find this article at: http://www.metricationmatters.com/docs/DontUseMetric.pdf if you still want advice on how to avoid the metric system.

If you accept this challenge, beware of *hidden metric* where old pre-metric measures are now defined in metric units. For example in the USA, the two different inches, the two different feet, the two different yards, the two different furlongs, and the two different miles have been defined in metric units since 1893 for one of them and since 1959 for the other. The same is true in the UK except that they use the 1959 inch alongside the 1824 Imperial inch, the 1845 Imperial inch, the Enfield inch and all of the feet, yards, furlong, and miles based on these old pre-metric inches. Also beware of the different pints, pounds, and gallons (with UK and USA definitions).

Resources, references and acknowledgements

Resources

If you are seeking a customised programme to train your internal metrication team on the expert techniques needed to design and deliver a metrication program that gets results for you company go to http://www.MetricationMatters.com/speaking.html

To find out about Pat Naughtin, the founder and CEO of Metrication matters go to: http://www.MetricationMatters.com/pat_naughtin.html

You can enrol now in the **Metrication Basics** course and start learning how to be a metrication leader today. Don't put it off any longer. Being a metrication leader might be the key to your career development that you've been looking for.

How Metrication matters resources differ from others?

There are other courses on the metric system and metric conversion, but we think that the Metrication matters approach is unique in that it focuses on the process of metrication. But don't take our word for it. Read testimonials from people who have experienced our Metrication matters services at http://www.MetricationMatters.com/speaking.html

References and acknowledgements

The material in this e-book comes from many places; the main sources are:

Bureau International de Poids et Mesures (BIPM)

For the best information about SI, go to the International Office of Weights and Measures (Bureau International de Poids et Mesures, BIPM) at **www.bipm.fr** where you can freely download the latest edition of 'The International System of Units (SI)', the main reference for all information about SI; measurement experts refer to this brochure as the 'Metric Bible'.

National Institute of Standards and Technology (NIST)

Another good source of information is the National Institute of Standards and Technology (NIST) at **http://www.nist.gov/index.html where** you can also download documents that are very useful as authoritative sources. NIST's 'Guide for the Use of the International System of Units (SI) (SP 811)' from http://physics.nist.gov/Pubs/SP811 and the The International System of Units suitable for the USA http://physics.nist.gov/Pubs/SP330/contents.html

Sources of Power: How People Make Decisions by Gary Klein

See: http://www.amazon.com/Sources-Power-People-Make-Decisions/dp/0262611465

UK Metric Association (UKMA) *and the*

U.S. Metric Association (USMA)

I have received much generosity and support from many friends and acquaintances who are members of the UK Metric Association (UKMA) at http://www.metric.org.uk and the U.S. Metric Association (USMA) at http://lamar.colostate.edu/~hillger

I have found the USMA metric discussion mail list (accessible from http://lamar.colostate.edu/~hillger/listserv to be a great source of reliable information.

The, Metric Views at http://www.metricviews.org.uk are also very reliable.

You will find many friendly pro-metric people through the UKMA and the USMA who are able and happy to provide you with generous personal support for your own metrication efforts.

Metrication consultants and trainers

Metric methods – James R. Frysinger

James Frysinger is certified by the U.S. Metric Association as a Lifetime Certified Advanced Metrication Specialist (LCAMS), experienced in:

- nuclear engineering, chemistry, and physics
- teaching at high school and college levels
- teaching on the job in military environments
- consulting on metrication of documentation, production, training, and management procedures.

He is a member of these professional organizations:

- American Association for the Advancement of Science (AAAS)
- IEEE/ASTM Committee for Maintaining IEEE/ASTM SI 10, "American National Standard for Use of the International System of Units (SI): The Modern Metric System", Vice Chair
- Institute of Electrical and Electronics Engineers, Inc. (IEEE) – Senior Member of the IEEE
- The Institute of Electrical and Electronics Engineers Standards Association. (IEEE SA) and a member of Standards Coordinating Committee 14 (SCC14), Chair
- National Conference on Weights and Measures (NCWM)
- The American Welding Society (AWS) A-1 Committee on Metric Practice, maintaining AWS A1.1:2001: "Metric Practice Guide for the Welding Industry", an American National Standard
- The Greater Van Buren County/Spencer Chamber of Commerce
- U.S. Metric Association, Inc. (USMA) – awarded lifetime certification, elected Fellow of the USMA

* U.S. Technical Advisory Group to IEC Technical Committee 25 and ISO Technical Committee 12, sponsored by NIST and registered with the American National Standards Institute.

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S I Jakub Associates

S I Jakub Associates (SJIA) is an independent company, based in West Hartford CT, dedicated to providing training and consulting in the changeover to metric, global practices.

SIJA have served over one hundred organizations, both in the U.S. and abroad, from Government and Fortune 500 companies to small machine shops, training employees, developing strategies for the changeover, searching for metric product suppliers, writing standard manuals, and providing expertise through the transition period.

Having worked with a broad range of organizations, Stan has the knowledge to be an effective lecturer and leader to scientists and engineers, as well as workmen and clerical employees. He has delivered thousands of seminars and speeches, and has developed a multitude of courses for groups of laymen and professionals in machine design, road and building construction, printing, etc.

Training is provided in-house and it covers, in addition to the metric units, pertinent ISO, DIN, ANSI, EN, etc. standards. Consulting covers strategy for metrication, update of design and drafting manuals, harmonization of engineering practices and hardware among sister companies globally, interpretation of foreign design practices, reviewing specifications and advertising literature for use abroad.

Contact: http://metric1.org/sijakub or email Stan Jakuba at jakuba@snet.net

S I JAKUB ASSOCIATES, 43 Westbrook Road , West Hartford CT 06107 (860 521-7924)

Good luck and best wishes for your metrication program. If we can help you with your metrication program, please contact: pat.naughtin@metricationmatters.com

Metric system consultant, writer, and speaker, Pat Naughtin, has helped thousands of people and hundreds of companies upgrade to the modern metric system smoothly, quickly, and so economically that they now save thousands each year when buying, processing, or selling for their businesses. Pat provides services and resources for many different trades, crafts, and professions for commercial, industrial and government metrication leaders in Asia, Europe, and in the USA. Pat's clients include the Australian Government, Google, NASA, NIST, and the metric associations of Canada, the UK, and the USA.

Pat specialises in the modern metric system based on the International System of Units (SI), but he is mostly concerned with the processes that people use for themselves, their groups, their businesses, their industries, and their nations as they go about their inevitable metrication process. See http://www.metricationmatters.com/ for more metrication information, contact Pat at pat.naughtin@metricationmatters.com or subscribe to the free 'Metrication matters' newsletter at http://www.metricationmatters.com/newsletter/

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