



Introduction to Draft Resolution C

On the extension of the range of
SI prefixes

17 November 2022

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Head of Metrology

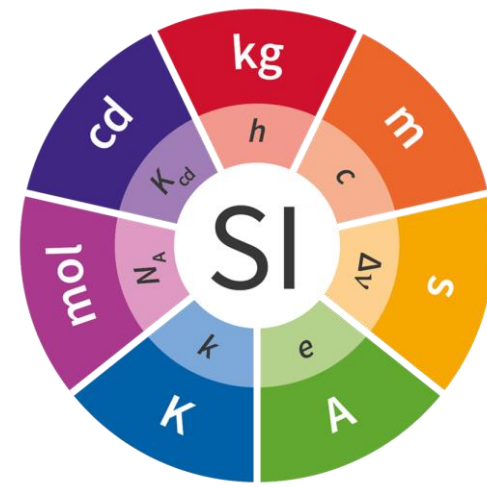
National Physical Laboratory

A decorative graphic on the right side of the slide, consisting of multiple overlapping, concentric arcs in various colors (red, orange, yellow, green, blue, purple, magenta) that create a sense of motion and depth.

Working together to
promote and advance
the global comparability
of measurements

The International System of Units (SI)

- The SI is an essential part of modern society



Defining constants ($h, c, N_A...$)



SI base units (m, s, mol...)



SI derived units (m/s, m^3 , N, W...)



SI prefixes (M, k, μ , n...)

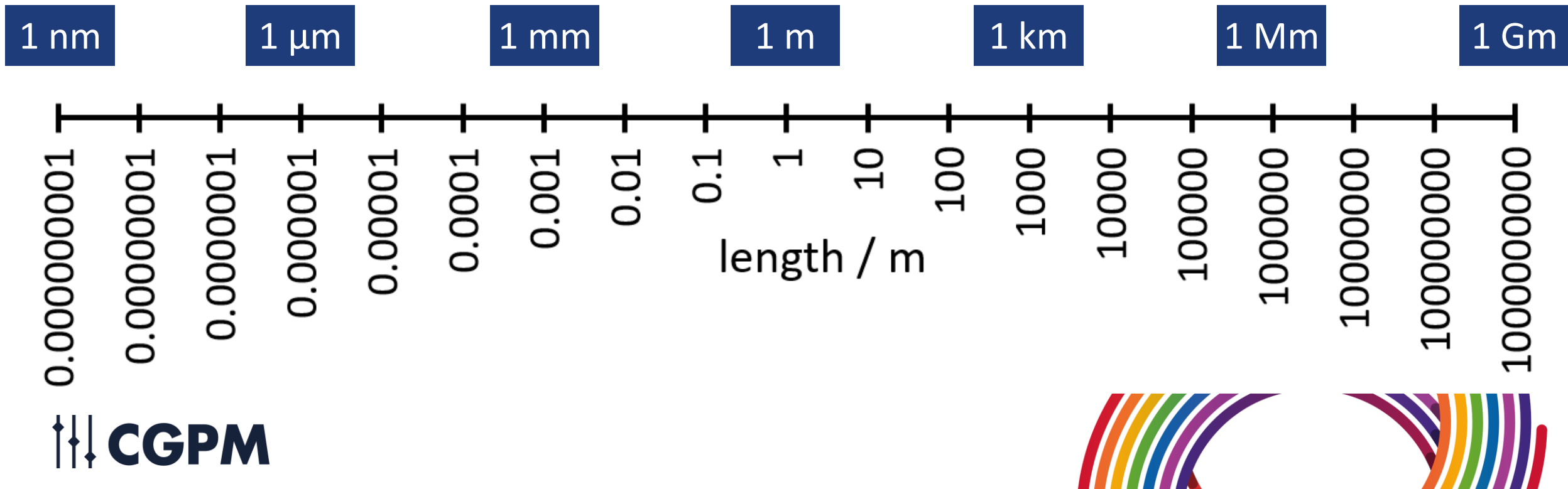


SI prefixes in everyday life



The complete set of SI units

- Includes the multiples and sub-multiples formed using SI prefixes
- SI prefixes allow use of SI units across a range of quantity sizes
- Fundamental for effective communication across disciplines



'Human scale' numerical values

Ensures numerical value of the quantity remains on the 'human scale' between 1 and 100, making them easier to comprehend & communicate

"Amount fraction of sulfur hexafluoride in the atmosphere"

Decimal notation

0.000000000011 mol/mol

Hard to comprehend

Scientific notation

1.1×10^{-11} mol/mol

Easier to comprehend

SI Prefix notation

11 pmol/mol

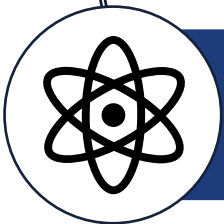
Easiest to comprehend



Prefixes evolve in response to stakeholder need



Increase usage in communities where current range is not sufficient



Progress in science and technology requires an expanded range

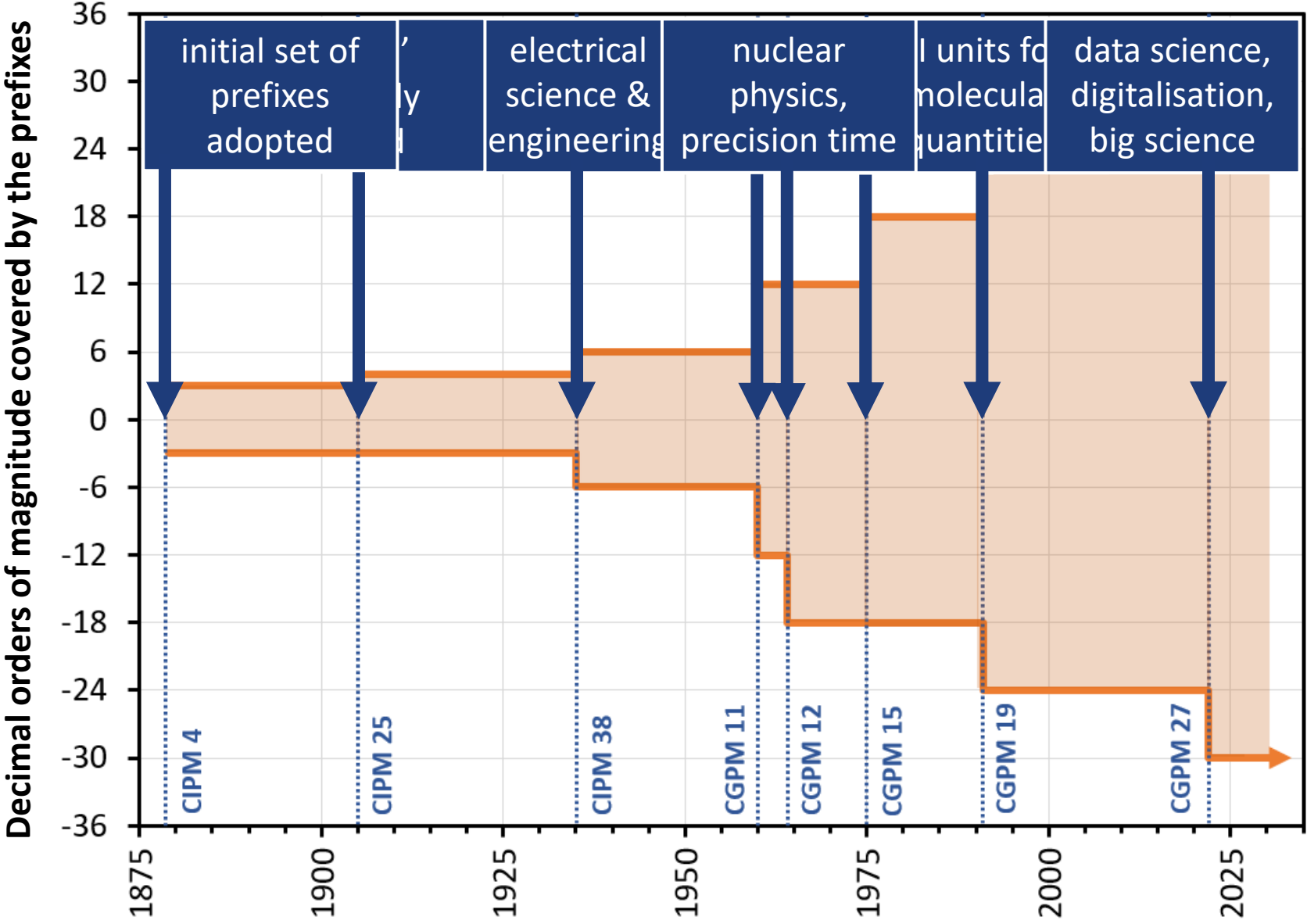


Ensuring unofficial names do not become adopted *de facto*

The SI must respond otherwise non-SI solutions will appear



SI Prefixes over time



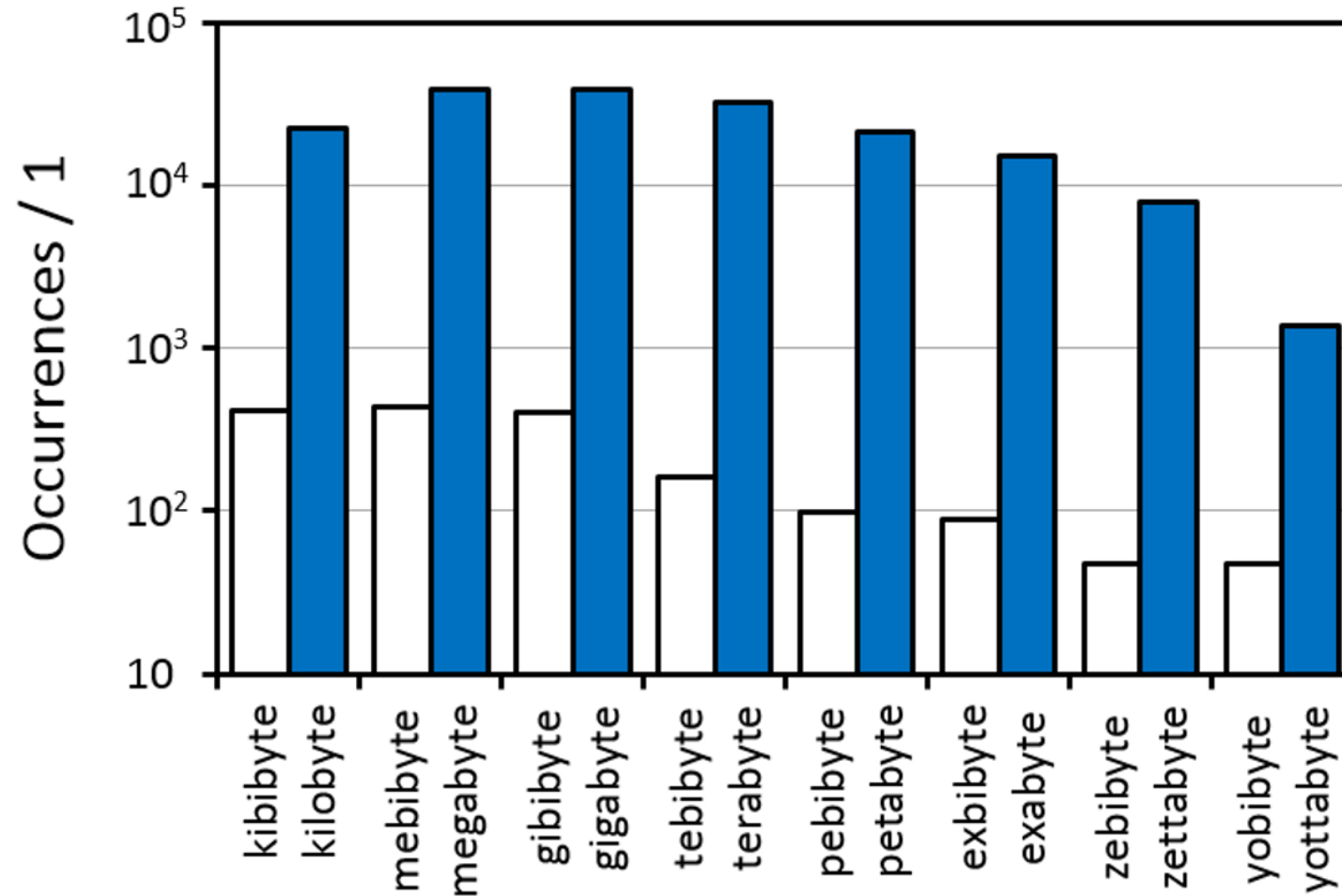
The SI needs to respond to rapid increases in:

- Size of data sets used in science & technology
- Detail with which the universe can be studied



SI decimal prefixes are preferred in data science...

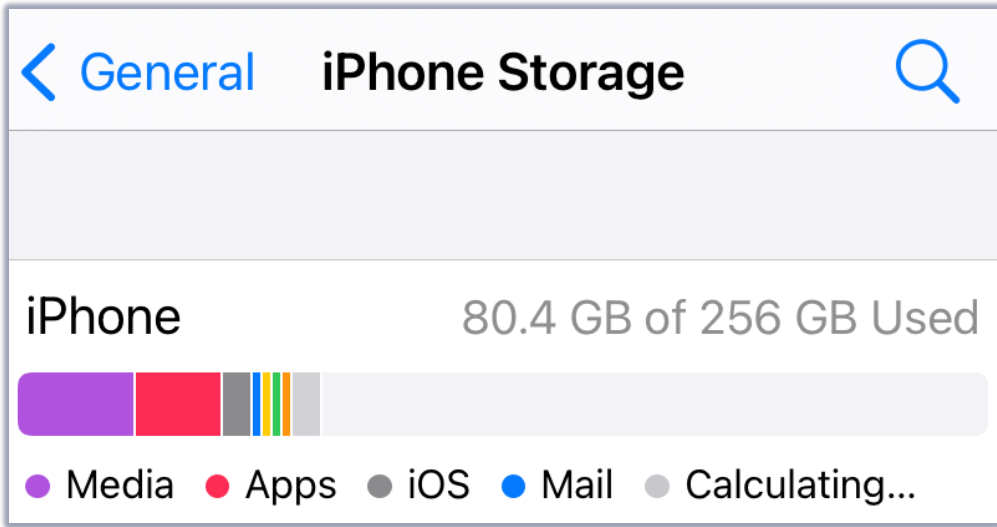
Prevalence in the scientific literature (1992-2017)



Binary prefixes
are standardized
in IEC 80000-13



...and in everyday life



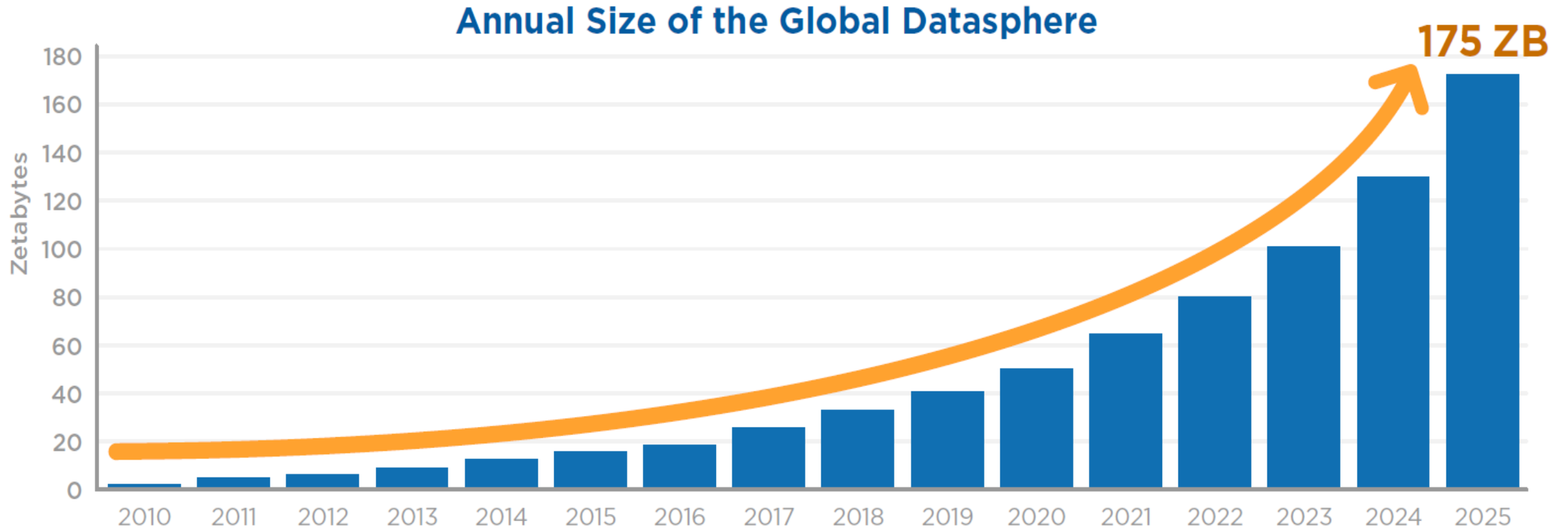
Today (5)

Convocation-EN .pdf	31/10/2022 08:46	Adobe Acrobat ...	199 KB
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Special-Procedure-EN .pdf	31/10/2022 08:46	Adobe Acrobat ...	109 KB
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CGPM-2022-Letter-from-CIPM-President...	31/10/2022 08:47	Adobe Acrobat ...	174 KB



Requirements of data science and digital storage

Acceleration expected from digitalisation, quantum computing, IoT, 6G

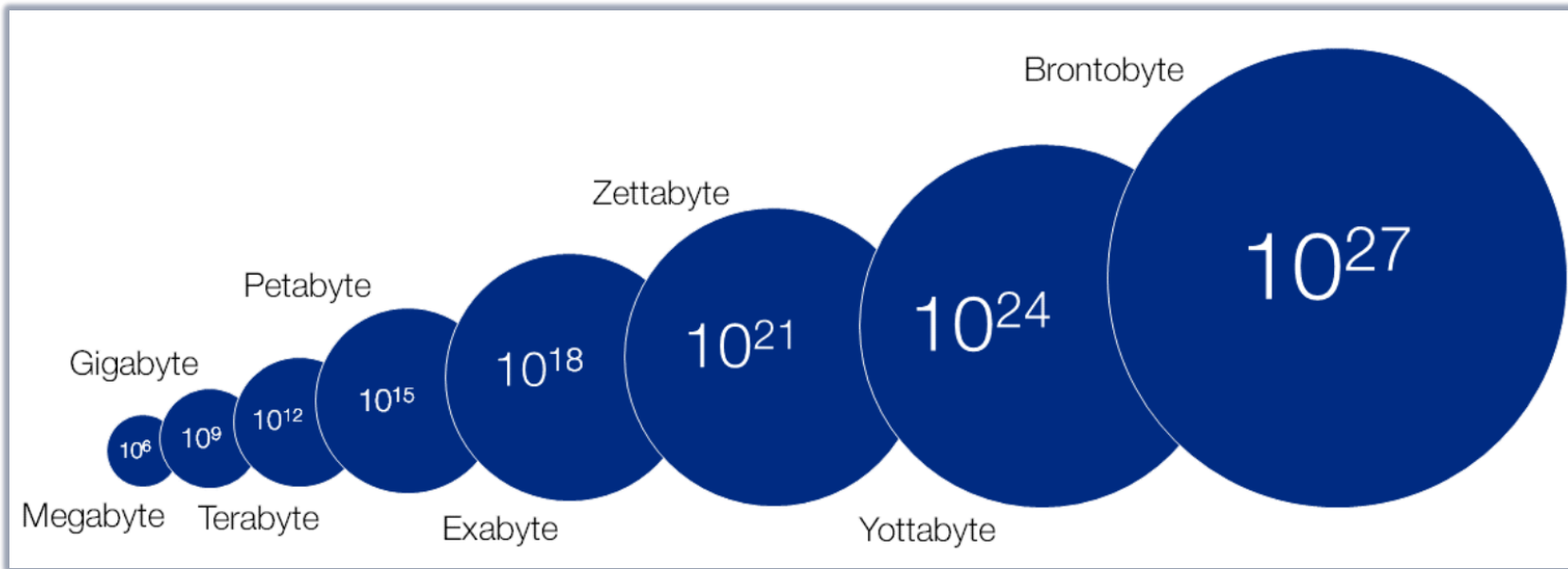


Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018



What is bigger than a yottabyte?

ukhsa.blog.gov.uk



Need for an expanded range of prefixes

Danger of unofficial names being adopted

Official SI prefixes must be provided instead

google.com

Google 1000 yottabytes in hellabytes

About 18,400 results (0.48 seconds)

Digital Storage

1000 Yottabyte = 1 Hellabyte

Listen now

Kilobyte to Brontobyte: Naming the Monster Numbers

How the names of digital storage files evolved.

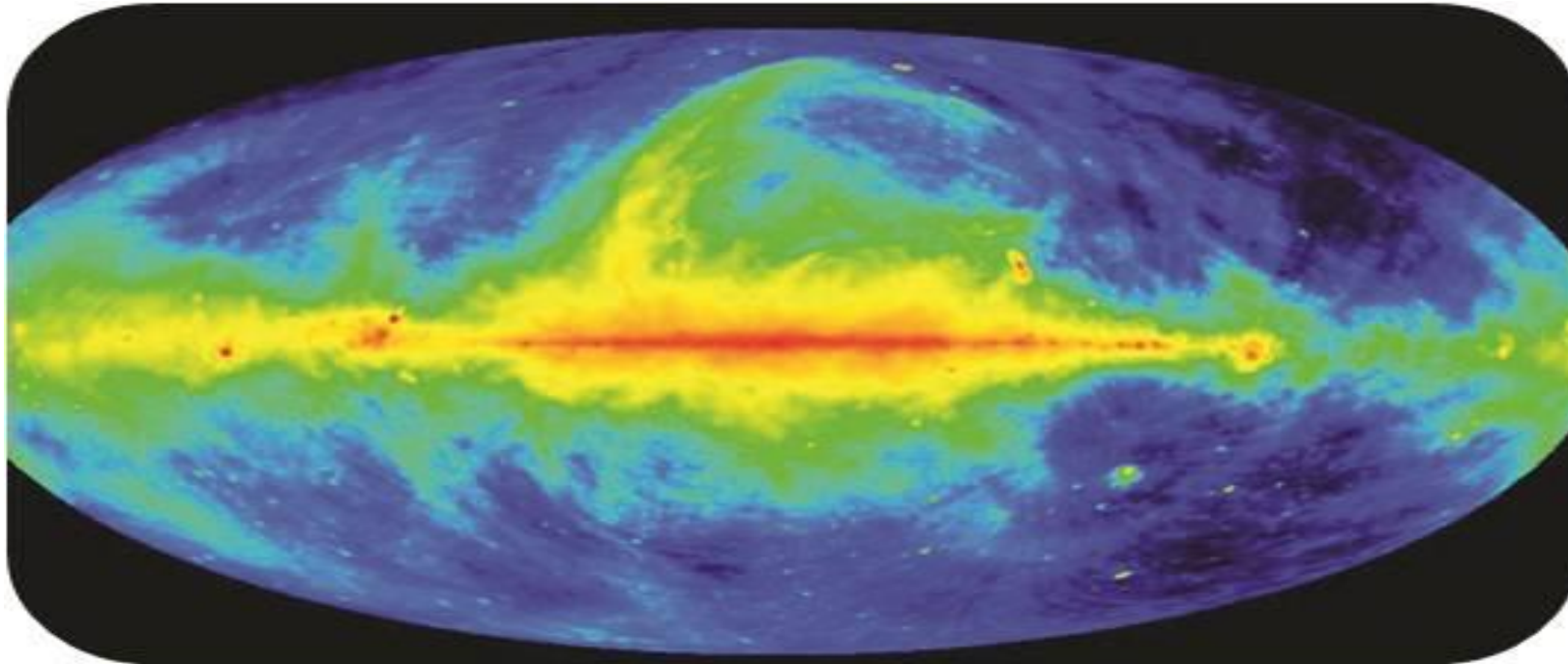
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Symmetrical extension to sub-multiples

- Technical areas such as particle physics and astronomy would benefit
- The jansky (Jy) is a non-SI unit of spectral flux density used in radio astronomy
- State-of-the-art targets sources below $100 \mu\text{Jy} = 10^{-30} \text{ W m}^{-2} \text{ Hz}^{-1}$



The sky seen at a radio frequency of 408 MHz (G. Haslam/MPIfR)



New SI prefixes – following recent precedent

Symbols

only 'r' and 'q'
available: used
in reverse order
alphabetically

Symbols

capitals for
multiples; lower
case for sub-
multiples

Names

multiples
end in 'a';
sub-multiples
end in 'o'

Names

loosely based on
Greek for 9 and
Greek & Latin
for 10

Multiplying factor

10^{27}

10^{-27}

10^{30}

10^{-30}

Name

ronna

ronto

quetta

quecto

Symbol

R

r

Q

q



24 SI prefixes covering 60 orders of magnitude

Name	Symbol	Factor	Name	Symbol	Factor
quetta	Q	10^{30}	quecto	q	10^{-30}
ronna	R	10^{27}	ronto	r	10^{-27}
yotta	Y	10^{24}	yocto	y	10^{-24}
zetta	Z	10^{21}	zepto	z	10^{-21}
exa	E	10^{18}	atto	a	10^{-18}
peta	P	10^{15}	femto	f	10^{-15}
tera	T	10^{12}	pico	p	10^{-12}
giga	G	10^9	nano	n	10^{-9}
mega	M	10^6	micro	μ	10^{-6}
kilo	k	10^3	milli	m	10^{-3}
hecto	h	10^2	centi	c	10^{-2}
deca	da	10^1	deci	d	10^{-1}



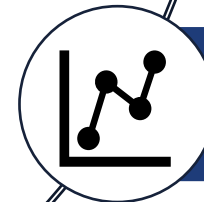
Useful, timely, low risk addition to the SI



Essential for areas with a pressing need



Remains optional, but useful, for wider use



Promotes effective, unified communication in science





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On the extension of the range of SI prefixes

The General Conference on Weights and Measures (CGPM), at its 27th meeting,

recalling that decisions were made at previous meetings when it was considered timely to extend the range of SI prefixes including Resolution 12 (paragraph 3) adopted by the CGPM at its 11th meeting (1960), Resolution 8 adopted by the CGPM at its 12th meeting (1964), Resolution 10 adopted by the CGPM at its 15th meeting (1975), and Resolution 4 adopted by the CGPM at its 19th meeting (1991),

considering

- the essential role of the International System of Units (SI) in providing confidence in the accuracy and global comparability of measurements needed for international trade, manufacturing, human health and safety, protection of the environment, global climate studies and scientific research,
- the benefits of encouraging the use of SI units by providing new SI prefixes for scientific communities that depend on measurements that are not covered by the current range,
- the needs of data science in the near future to express quantities of digital information expressed using orders of magnitude in excess of 10^{24} ,
- the importance of timely action to prevent unofficial prefix names being *de facto* adopted in other communities,

decides to add to the list of SI prefixes to be used for multiples and submultiples of units the following prefixes:

Multiplying factor	Name	Symbol
10^{27}	ronna	R
10^{-27}	ronto	r
10^{30}	quetta	Q
10^{-30}	quecto	q