

## December 2020 Entry (on orders of magnitude)

“A range of magnitude extending from some value to ten times that value.” – Merriam-Webster online dictionary at “[Order of Magnitude](#),” November 8, 2020.

“An order-of-magnitude difference between two values is a factor of 10. For example, the mass of the planet Saturn is 95 times that of Earth, so Saturn is two orders of magnitude more massive than Earth. Order-of-magnitude differences are called decades when measured on a logarithmic scale.” – from Wikipedia article, “[Order of Magnitude](#),” November 8, 2020.

So why did [place counting](#) (or positional notation) systems triumph? Because I do not have a maths brain, I had to figure out my own elegant answer to that puzzle. To someone educated from youth in a mainstream place counting system, 40 is  $4 \times 10$ ; it's easy to see, just place a 0 after the number being multiplied when multiplying by 10. Anyone would instantly see that, and think you are dumb if you do not.

But what is IV times X in the Roman Numeral [tally counting](#) (or [unary numeral](#)) system? It is XL. And that might mean ‘Xtra large’ (as in headache) because there is nothing intuitive about  $IV \times X = XL$ . I am sure that they had a system, or that one was retroactively constructed but it's not obvious even to most of the mathematically-talented brains of our time, for example, John Davidson wrote (see full quote [1 Beginnings](#), p. 33):

“Try long division, for example, using Roman numerals.”

Thus I asked on p. 23 of [1 Beginnings](#) how the Romans would have had the concept of Orders of Magnitude? This is a general example that might be given to apply to many of the things discussed in GGDM, for example, the Uber Alles discussion in [2 Eras](#), where we could not even have a concept of things that will be obvious to a ‘technologically advanced future,’ in fact, it is argued that even the invention of zero as a numeric operator in math was necessary for computer technology, e.g., in the popular Stargate SG-1 episode “[Serpent's Venom](#)” (2000):

*Dr. Daniel Jackson:* These are Tobin numbers. This is 1, this is 2, this is 3...

*Major Samantha Carter:* Wait, wait! What about zero?

*Dr. Daniel Jackson:* What?

*Major Samantha Carter:* Zero. Why didn't you say zero?

*Dr. Daniel Jackson:* Uh... because there's no zero in the Phoenician numerical system.

*Jacob Carter/Selmak:* What if the Tobins added it?

*Major Samantha Carter:* He's right! Inventing technology with this level of sophistication would require a zero.

*Dr. Daniel Jackson:* Why?

*Major Samantha Carter:* Just trust me. It's a math thing.

I remember that I once had an argument with a white-haired typing and word

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processing instructor who said that [Roman Numerals](#) were silly and useless and we should stop using them. I was young then and I don't think I phrased my argument correctly; in my current state, I would say yes, Roman Numerals are useless from a mathematical view (other than history) because no one does math with Roman Numerals now, but they still retain a function in documents, for example, to distinguish levels of an outline.

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(orders of magnitude in GGDM Eras)

“The number zero is something we all take for granted, yet its conceptual origin has eluded archaeologists and historians. An updated analysis of an ancient Indian manuscript is shedding new light on this longstanding mystery, showing that the symbol that would eventually evolve into the number zero emerged at least 500 years earlier than previously thought. Carbon dating of the Bakhshali manuscript, a sole surviving copy of a mathematical text, has pushed back the time of origin to between 224 to 383 AD, rather than the 9th and 12th centuries as previous research had suggested. The Bakhshali manuscript is littered with a symbol for zero, as conveyed by a solid black dot, making it the oldest known example of the symbol that would later evolve into a number in its own right...

The concept of zero seems intuitive, but that's because we're already familiar with it. There's a big conceptual leap between saying 'there are no apples on this tree' to saying 'this tree has zero apples on it.' Historically, the concept of requiring a placeholder to denote 'nothing' emerged in several different ancient cultures, including ancient Mayans and Babylonian societies....” – George Dvorsky, [“Origin of Zero Symbol is Centuries Older than Previously Thought,”](#) Gizmodo, September 14, 2017.

In the Magnitude of Eras discussion in [2 Combat](#), p. 952, I assert that the progression of Eras in warships (and colony defenses) is not just slight linear progression, but orders of magnitude. This is not borne out strictly, however, by the increasing chances to hit in terms of base chance to hit and Era Differential Shifts described in [3 Combat](#), p. 978; that is, a 2nd Era Warship does not have ten times the chance to hit as a 1st Era Warship and a 3rd Era Warship does not have ten times the chance to hit as a 2nd Era Warship. At best, with Era Differential Shifts, a 3rd Era warship has nine times the chance to hit a 1st Era Warship as a 1st Era Warship has to hit a 3rd Era Warship; and thus the difference from 1st Era to 3rd Era is as close as the game comes to a literal order of magnitude difference between warships of different Eras.

- An order of magnitude is the difference between a dime and dollar.
- An order of magnitude is the difference between a century and a millennia.
- An order of magnitude is the difference between a kilobyte, megabyte, gigabyte and terabyte.
- An order of magnitude is the difference between the bomb that hit Heroshima and a megaton thermonuclear bomb (in the 1983 movie Threads, England was hit with 210

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megatons).

A system could be constructed that literally demonstrates an order of magnitude difference to hit between Eras, but that might, for example mean a 1st Era warship would have only a 1% chance to hit another 1st Era Warship and no chance to hit anything else; a 1% chance to hit would cause combats to drag out for dozens of rounds just to get a hit and that's not good for game design purposes. The base chance of a 2nd Era Warship would then be 10% against other 2nd Era Warships and 100% against 1st Era Warships and no chance against 3rd Era Warships, and 3rd Era Warships' base chance to hit anything would be 100% (there might be other ways to do it, but you get the idea). Generally then, a literal order of magnitude difference in chances to hit in combat would not be fun either in real life or gaming. Such a system has never existed in any game I have seen or played and rarely is reflected even in real word combat outside the naval realm.

Instead, the order of magnitude difference between Eras in warships (and even Defense Bases) depends in large part on other concurrent technological developments, and even non-technological abilities such as a Combat College and Doctrinal Templates (see [4 Colleges](#)) and industrial base:

“Hannibal had in mind an astonishingly bold plan which aimed to profit from the very numerical advantage of the enemy. First throwing out a screen of light troops to conceal his dispositions, he drew up a line of battle which could have been conceived only by a genius or a fool. The unique feature was a convex centre, composed of 25,000 Gallic and Iberian foot and bending outward toward the 70,000 legionaries of the Roman centre. The units at the apex were heaviest, the sides being built up in echelon and linked to the Libyan infantry of the wings.” – [Lynn Montross, War Through the Ages](#) (3rd Ed. 1960), p. 60.

Players fill in the gaps by improving ship speed (see [2 Stardrive](#)), logistics (i.e. Operational Flight Limitations and Operational Supply Limitations, see [3 Movement](#), pp. 855-856), adding Enhancement technologies, and so forth, with the industrial base to support them. Thus the apparent difference in orders of magnitude between Era warships (and fighters and colony defense bases) is not strictly in the percentage chance to hit in combat, but also in strategic ability and this is reflected in the real world in “what if” comparisons, for example, a WWII Pacific Ocean theatre U.S. Navy carrier group vs. the British or German fleet from the Battle of Jutland, or more popularly, the question of whether the U.S.S. Nimitz in the 1980 film [The Final Countdown](#) could have smashed the entire [Imperial Japanese Navy](#) task force set to [attack Pearl Harbor in December 1941](#). The analysis must take into account the differences in speed, propulsion systems, fuel logistics, radar and sonar detection, targeting systems, missiles vs. old naval guns, etc.

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(non-technological orders of magnitude)

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"We have maintained the most complex society humanity has ever known, and we have maintained it up to this point.... I have argued that technological innovation and other kinds of innovation evolve like any other aspect of complexity. The investments in research and development grow increasingly complex and reach diminishing returns."  
– [Joseph Tainter](#), podcast interview (transcript) on [PeakProsperity.com](#), by Adam Taggert, June 25, 2017.

Order-of-magnitude progression of warships (and colony defenses) or even just starships is, of course, just the tip of the sword so to speak in a potentially militant [space opera science fiction](#) simulation game. To be fully [grokked](#), the scope must be expanded to the entirety of civilization, both technological and non-technological, e.g., the same sort of comparisons could be made in industry, medicine, communications and data, time keeping and time and spatial sense (see discussion in Just Don't Call Me Late for Dinner, [3 Reformation](#), p. 1403) , government structures and so forth of different eras (or of humans of different ages) and this is the reason that [Uber Alles](#) have two parts, one technological and one non-technological. Order-of-magnitude progression goes to the core of whatever macro-sort of argument exists in GGDM's model of civilizations.

Whether order-of-magnitude differences between any two things in successive Eras is achieved in-game is up to the players; not only what they do in the game, but also overall agreed upon preferences and guidelines, some players may want to run with it to the point of endangering the coherent sanity of the game and others may prefer low-tech grind. In a mixed crowd, the likely result will be somewhere in the middle (with the Concierge as the gatekeeper); however, I did note in [1 Patents](#), p. 728, due to cost and time considerations, each position will have a limited number of opportunities to introduce something new to the game (most of the early Patents are pre-established Existential Patents for the game's early interstellar setting), "so go for something crazy."

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(the "natural experiments" called history)

["Albuquerque divided his forces in two groups, a smaller one under the command of Dom João de Lima and a larger one which he commanded personally. The landing commenced at 2 am. While the Portuguese fleet bombarded enemy positions on shore, the infantry rowed their boats onto the beaches on either side of the city's bridge. They immediately came under artillery fire from the Malayan stockades, though it was largely ineffective. ...](#)

[Protected by steel helmets and breastplates, and with the \*fidalgos\* clad in full plate armour in the lead, the Portuguese charged the Malayan defensive positions, shattering any resistance almost immediately. With the stockades overcome, the squadron of Albuquerque pushed the defenders back to the main street and proceeded towards the bridge, where they faced stiff resistance and an attack from the rear. ...](#)

[\[A day later\] Unable to oppose the Portuguese any further, the Sultan gathered his royal](#)

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treasure and what remained of his forces and finally retreated into the jungle.” – from Wikipedia article, [“Capture of Malacca \(1511\).”](#)

Though I talk in GGDM about how the [Incans](#) and [Aztecs](#) were overwhelmed and defeated, those are not isolated cases, but rather, the most famous cases that readers will (most likely) readily know, especially in North America. They are not isolated, but rather, repeated phenomenon around the world in the 16th to 19th Centuries, and thus require explanation and exploration.

Another illustrative example I stumbled up on recently was the [Portuguese storming of Malacca in 1511](#); the one thing not present in that example is [smallpox](#) or any sort of European-borne plague. There were divisions in Malacca that the Europeans exploited (mainly for information gathering and to keep other elements out of the fight), but in the end, it was still about 1,000 Europeans attacking a city defended by 10,000 native troops. The Europeans did have an effective naval bombardment, but unlike the Aztecs and Incas, the defenders also had muskets and cannon, so that’s a wash, though the European weapons were superior. When a couple of hundred pike-armed Europeans attacked the fortifications near the shoreline, the defenders fled after a few minutes of fighting. So once again, once you have washed everything out, it comes down to the same insane non-technological magnitude problem of a ‘few’ Europeans defeating ‘masses’ (even if only 4,000 of the defenders of Malacca were combat-fit troops) of native defenders in their own fortified place.

And like the Aztecs and Incas, you can’t say much for the leadership of Malacca, the [Sultan](#) actually betrayed the Portuguese at the behest of local merchant organizations who wanted to keep the Portuguese competition out of their market, and thus created the pretext for the war that the Portuguese wanted anyway. And the Sultan was ineffective in commanding the defense and fled the capital to wage ultimately futile [guerrilla warfare](#).

Unlike the Spanish [Conquistadors](#)’ pure lust for gold, slaves (the [Spanish Encomienda](#) system) and governor’s titles, the early 16th Century Portuguese program in the Indian Ocean five hundred years ago was a clear-eyed attempt to both dominate markets and cut Islamic expansion and trade monopolies (à la [Jean-Baptiste Colbert](#), [discussed in 2 Commerce](#), pp. 1195-1197):

“On 8 August, the Governor held a council with his captains in which he invoked the necessity to secure the city in order to sever the flow of spices towards Cairo and Mecca through Calicut and to prevent Islam from taking hold. ...

[Later] Some of the information suggests adaptations had already been made based on Portuguese maps plundered from the *feitoria* in 1509. With such knowledge, the Portuguese learned the path to the fabled ‘Spice Islands,’ and in November, Albuquerque organized an expedition of three *naus* and 120 men to reach them, under the command of António de Abreu, who had previously been in the command of the junk. He was the first European to sail into the Pacific Ocean.” – from Wikipedia article,

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“Capture of Malacca (1511).”

“The Portuguese conquest of Goa occurred when the governor of Portuguese India Afonso de Albuquerque captured the city in 1510. Goa was not among the cities Albuquerque had received orders to conquer: he had only been ordered by the Portuguese king to capture Hormuz, Aden, and Malacca. ... Unlike Almeida, Albuquerque realized that the Portuguese could take a more active role breaking Muslim supremacy in the Indian Ocean trade by taking control of three strategic chokepoints – Aden, Hormuz, and Malacca. Albuquerque also understood the necessity of establishing a base of operations in lands directly controlled by the Portuguese crown and not just in territory granted by allied rulers such as Cochin and Cannanore.” – from Wikipedia article, “Portuguese Conquest of Goa.”

By Charles W. Phillips