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The Danger of Massive Malinvestment

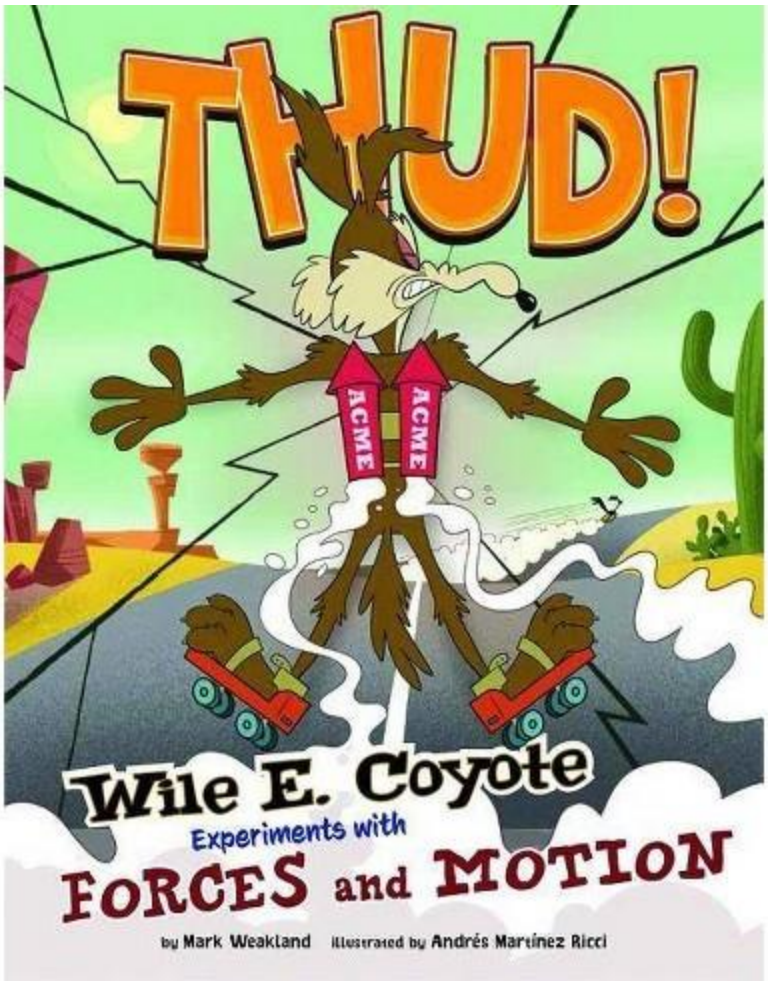
Over the last year, digital infrastructure asset acquisition ***values skyrocketed***:

- KKR acquired CyrusOne: ***$15 billion***
- Digital Bridge acquired Switch: ***$11 billion***
- American Tower acquired CoreSite: ***$10 billion***
- Blackstone acquired QTS: ***$10 billion***

Private financing transactions inclusive, more than ***$50 billion*** of capital directed by "smart money" has flowed into the space in the last year. And this does not even count ***tens of billions in internal capital expenditures*** by largest digital infrastructure-enabled companies in the world: ***Apple, Baidu, Meta, Netflix, Microsoft, Google, and Tencent***. Everyone's climbed aboard the current model rocket. Clearly, the "good" deals and the "good" projects have strong strategic rationale. But some appear to be running around building with a cookie-cutter architecture or simply chasing returns, without a clear view of the road ahead. ***What could go wrong?***

"If you're not in the right classification, you're basically ***stealing funding and opportunities*** *from other people. This is not the NFL.* ***There's only so much money to go around****." - Jessica Long*

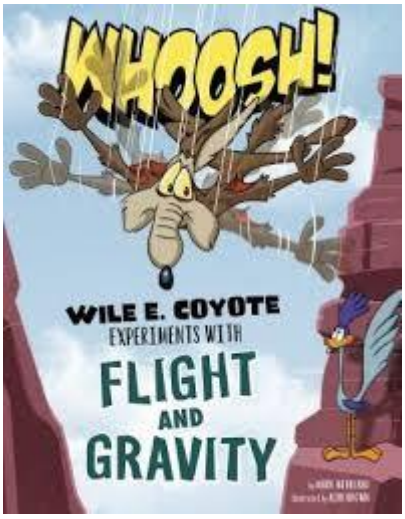
As in sport, so it is in the investment marketplace. There are well-known, and well-funded sectors. There are also less well-known, and underappreciated sectors, within every industry. The innovative and inventive souls striving to overcome challenges must simply work harder and demonstrate more grit. And exercise patience, which is generally no innovator's virtue.



Inertia will cause princely investors to continue pouring money into building up entire cavalries of knights in shiny current cash flow, long after they have been unhorsed by a newer, more efficient technology generation.

In the digital infrastructure space, it's not just capital that is now scarce. Driven by high compound annual growth rates in new facilities construction, and the [allegedly] monopolistic profit margins of the largest players funding large portions of that growth, the materials that go into these "critical facilities" are now scarce, as well. Why are they "critical"? Without them, you wouldn't be reading this article on LinkedIn. Or going on a Zoom/Teams/GoToMeeting tomorrow morning. Or ***spending 44 DAYS this year on your smartphone***, if you're an average American. Because all of that technology, and indeed the ***modern global economy***, requires digital infrastructure to function. ***Digital transformation accelerates every day, making the situation more acute.*** Add

COVID and supply chain challenges on top, and the path forward gets really steep, really fast. Impact on cost: Do you see inflation, anyone?



"Economics is like gravity. You can defy it, but not for very long" - Nicholas Economides

Inertia: A Destructive Force (or, When A Little Better is No Longer Enough)

An executive at a well-known firm servicing the critical facilities construction industry related this short story: An engineer, proud of his profound impact on the hundreds of terawatts power consumed by data center servers, showed off a new box. [*Background: The thermal conductivity of steel is measured at approximately 45 W/(mK), which is extremely low compared aluminum, which exhibits a thermal conductivity value of 235 W/(mK)].* The new box was aluminum, moving heat out of the box more efficiently than a steel box. ***The engineer calculated the marginal improvement in power consumption on the whole data center by using the new box: 1.5%.*** Power cost reduction of 1.5% is great, right?

Not when the base technology selection was wrong in the first place. Says who? Says physics.

On the question of insulation, air is a far better insulator than either water or ice. In fact, it is the standard to which all other insulating materials is compared. So, the question deserves to be asked, ***"Why in God's name did we build the global digital economy on an architecture that uses an insulator to transfer heat?"*** [Please see metal conductivity story above] The most frequent

answer we get, is the worst one: ***"Because we've always done it that way".***

It's Not Complicated (even though some folks want it to be)

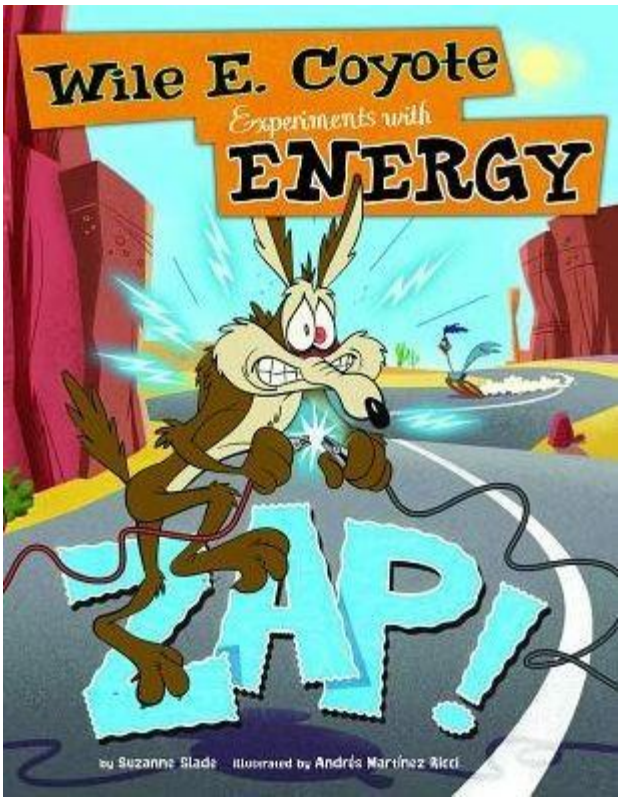
Let's switch the cooling medium to liquid, because it has capacity to transfer heat up to 4 times higher than the capacity of air of the same mass. And data center cooling loop water is 784 times denser than air. We don't want a 1.5% improvement; we want a 95% improvement. Fine. That's done. Now what?

The Current Asset Base Has Massive Embedded Problems, All Expensive to Fix

Higher efficiency has its own unintended consequences. We can now run our digital infrastructure in liquid at 100 kilowatts per rack, instead of 10 kilowatts per rack. Great benefit, yes? The footprint reduces by 85% to 97%, saving a lot of space. But now we've created several big problems:

Too much space. What do we do with all the extra space? The space that's already built? I just invested in a REIT, and I judge it by rent per square foot. ***You just wrecked my business model, and my key profitability metric?*** Yes, we did. Maybe fix it up and rent it out as office space, or makes some nice rooms and put them on Airbnb? We don't know. Please take out your frustration on the real culprits, Physics and Economics, OK?

Insufficient power distribution. The old power density was 100-200 watts per square foot. That was fine. Let's pretend the engineers figured out how to plug this new stuff into our building's existing cooling system (they did not, but let's pretend). Our engineers did all the calculations. The server vendor's engineers did all the calculations.



We plugged in the new gear, then turned on the power. All of the breakers popped. What's going on?

My bus bar is drawing 2,000 amps. I need to deliver 1,000 watts per square foot. Not 100. Oops. We must rip out all of the power distribution out of our building to the panel and start over. Very expensive.

Cooling, but the wrong size pipes. Sure, we have cold water available. But now the pipes don't fit. What to do? Rip out all of the plumbing all the way to the chiller and start over. Very expensive.

Wait, did someone say there's a megadrought on? Yes, but only the worst one in 1,200 years (/sarc). Now I can't run my cooling towers? My adiabatic coolers? No worries, I implemented direct air cooling with a sophisticated "hot aisle containment system". Which is great, except Hoover Dam just quit producing power, and now the lights are out. What's going on around here?

Let's just call one of the chip makers and order some new chips.

Upgrade! Great idea. These chips are super-fast. And much more powerful than the previous generation. But, there's a problem: The CPU socket power has blown through 400 watts and the GPU socket power I need for full self-driving, artificial intelligence and machine learning just went through 800 watts. Can't we go back to air? No, you can't. Air cooling even leaving half the slots blank no longer works above 350 watts. ***Sorry, you just need next-generation, liquid-cooled, fit-for-purpose, digital infrastructure*.**