Before we can climb out from the Chinese control of rare earths and battery materials – we must understand our past.

Technology is the engineering of science, and manufacturing engineering is the scaling up of engineering to enable the efficient and economical mass production of finished goods.

The scientific development of the rare earth permanent magnet and of the lithium-ion battery both occurred primarily in the United States in the greatest period of consumer technology development in American history; from 1945 until the end of the twentieth century.

Until the moon landing in 1969 the US Department of Defense (DoD), from the beginning of World War II, and NASA, from 1961-69, was the majority funding entities for both science and technology. Since then private corporations have provided the majority of funding for consumer product development.

The current awakening of government to a critical materials' supply crisis as a security issue has highlighted the failure of American manufacturing to pay any attention to the dangers of just-in-time supply chains, made fashionable beginning in the 1980s as a technique to free up the capital required by inventories of raw materials and semi-finished goods. For the capital-intensive OEM automotive, aerospace, and allied industries this was a "no brainer."

Overlooked completely at that time was the end of corporate subsidies for and thus the demise of stand-alone in-house education in specialty manufacturing engineering (now called

“automotive engineering in the OEM automotive industry). The General Motors Institute, GMI, in Flint, Michigan, for example, was a company-owned engineering college the students of which were typically GM employees in what is now called work-study programs. This ensured **continuity** as older engineers both taught and worked alongside the “students” in any one of the many parts plants and assembly plants in Flint and nearby Saginaw, Michigan, where foundries and the world’s largest steering gear manufacturing operations operated.

One of GM’s parts operations in Indiana was called the Magnequench Division; it was the world’s largest manufacturer of rare earth permanent magnets.

GM and Ford were heavily invested in science. The General Motors Technical Center and the Ford Scientific Laboratory were outstanding, but the managers of the corporations were losing focus on the long term and entering the long decline in their fortunes due to just-in-time outsourcing and the emphasis on share price, not corporate citizenship, aka, “financialization.”

Hugely expensive attempts at automation in the late 1970s and early 1980s had convinced American OEM automotive that it wasn’t going to work, so instead of profit growth through technological productivity increases the managers turned to cheap overseas labor. At first American engineers were sent to organize and manage operations in “developing” countries like China. It was assumed, as a matter of faith, that the Chinese in particular would never learn how to develop “native” industries to compete with American ones in producing goods for the American home market. Poorly made Japanese cars were just then the source of much derision in Detroit’s toniest suburbs. Korean cars were non-existent.

In the last 20 years of the twentieth century, the American Big Three car makers disassembled their vertically integrated operations, their in-house engineering continuity “colleges”,

and any long-term planning they might have looked at in favor of just-in-time outsourcing and management by the metric of share price only.

As I recall rare earth permanent magnets were first studied by the Russians in the late 1960s, by the 1970s both Japan's Sumitomo and General Motors had developed and begun manufacturing and using samarium cobalt types. In the late 1970s, cobalt pricing spiked (take note of this well those who look for big increases in rare earth, lithium, and cobalt prices as a supply or demand driver!) and this caused General Motors to switch over to neodymium iron boron magnets for its miniaturization of electric motors needs. The capacity for the production of the separated rare earths needed soon overwhelmed the then Molycorp's mine and separation capacity (7,000 tpa), and it (Molycorp) sought to outsource. The Chinese, eager for investment, and jobs, and having the large accessible deposits (as byproducts of mining the iron ore, magnetite) of light rare earths in the Bayan Obo region of Inner Mongolia, where health, safety, and the environment were of no interest soon became the biggest miners and separators of light rare earths using the chloride based solvent extraction technology proved out and gifted to them for that purpose by Molycorp.

Most commentators say that, after the above transfer of technology, the rest is history. But that means overlooking something. The Chinese did not just take over a technology and keep it static. They did at first, but soon, it was noticed by their leader, Deng Xiaoping, and soon thereafter the state underwrote a massive rare earth use and production research and development program while such programs in the west withered and died.

Rare earth mining and separating in North America ceased in 1998, the manufacture of rare earth metals, alloys, and magnets in North America ceased shortly thereafter, and the large-scale company set up originally by Sumitomo and GM for

that purpose, Magnequench, which had dominated the production of rare earth permanent magnets for many years, was, after many years during which it was unable to compete with Chinese rivals, ultimately sold to a Canadian concern that moved it to China in 2004.

It is not possible to ignore the fact that competence erosion in the extraction, separation, making of metals and alloys from, and making magnets based on rare earths did not occur as these technologies left North America. It is also foolish to not consider China's massive intellectual property developments in all of those rare earth sourcing, refining, and in the development of and manufacturing of rare earth enabled product technologies can be just ignored by those who think that throwing money and university research at a problem can miraculously overcome a generation of neglect and a criminal discontinuity of engineering skills.

Whether or not the US can re-create a total domestic rare earth enabled products supply chain will depend on whether or not the management of such attempts has enough perspective to find engineers, still alive who created the rare earth refining, metal and alloy making, and permanent magnet industry and entice them to train a new generation. I personally think we can still do this and be globally competitive, but I am skeptical of financiers who know nothing of how technologies are commercialized.

And until there is a focus for this work in the form of a commitment by, for example, the US DoD to take or pay for enough tonnage of rare earth permanent magnets and to pay for the tooling to produce the more than 500 different specifications of rare earth permanent magnets used in weapons systems, nothing will happen.

European manufacturers of products using rare earth permanent magnets still have a small domestic supply chain that has maintained continuity for 45 years. But Europe has no rare

earth mines. America has such a mine, and North America has many such deposits in development. America also has the only licensed and capable processor of purchased monazite in the Western World. That project is up and running. It will deliver the first multi-ton lot of radiation-free mixed rare earth carbonate to a European customer next month. That customer will separate the rare earths and deliver the magnet ones to a British company that will turn the delivered oxides into metals and alloys, which in turn will go to a German company to be made into magnets for a German OEM automotive company’s EV powertrains.

The question now is will the US government wake up to the fact that it must use Title 7 of the Defense Production Act to assemble an industrial panel to address this issue.

The Chinese are watching intently.