Center for Responsible Nanotechnology

SCENARIO #4: Presidential Commission

Presidential Commission on Molecular Manufacturing

Analysis: Origins of the Present Crisis

Executive Summary
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The present struggle over dominance in the arena of nanomanufacturing technologies does not derive from a single cause.

The Commission found that the widely-held view (encouraged by administration leaks) that the crisis arose due to misbehavior on the part of non-governmental research groups (both corporate and academic) does not in fact explain the origins of the present situation; neither does the analysis, more prevalent in academic circles, that the nanotechnology strategies of the current generation of Russian leadership triggered the crisis. The position held by the opposition party, that the crisis derives from a series of policy missteps on the part of the current and previous administrations, is equally insufficient.

Alone, each of these explanations is incomplete. Together, however, they form the skeleton of a useful analysis of our current dilemma, and in doing so, suggest useful directions for how to resolve the crisis.

First Driver: Non-Governmental Innovation

Most observers cite the 2007 public release of the open-source Nanoengineer 1.0 software from by NanoRex as the initial catalyst for the "bottom-up" nanotechnology movement. While Nanoengineer 1.0 certainly was influential, MIT's Susan Cheng makes a persuasive argument that the 2008 version of TinyOS, the open source software behind the communication protocol for smart dust, was actually of greater importance. Dr. Cheng notes, correctly in this Commission's view, that software enabling the coordination of a multitude of dispersed components solved a harder problem than did software enabling easy product design.

This is not to say that Nanoengineer was irrelevant. The 2008 partnership between the American Association for the Advancement of Science (AAAS) and Nanorex, funded in part by the US federal government, put copies of Nanoengineer into thousands of schools and student computers nationwide. Many of today's leading nanomanufacturing specialists cite the appearance of Nanoengineer in the schools as a primary cause for entering the field. By the end of that year, documentaries in multiple languages about the use of Nanoengineer and the potential for molecular manufacturing had appeared on leading Internet video sites; at some universities, discussion of the potential for nanomanufacturing eclipsed the debates about the disputed presidential election of that year.

In 2009, the burgeoning public awareness of the potential for nanotechnology became a major topic of public debate, with the announcement by Sir Richard Branson of funding for three nanotechnology and molecular manufacturing-related X-Prizes. The three had distinct purposes: the first focused on the space race (through the development of so-called "diamondoid" spacecraft materials); the second focused on the potential for exponential manufacturing; the last focused on enabling tool development.

The new public awareness of nanotechnology's potential, along with the growing excitement among younger generations for nano-related training, helped to trigger the explosion of home fabrication technologies in the early part of this decade. In 2010, the HP ThingJet became the first general-use fabrication system available for under $1,000; this was followed by numerous competing products, quickly flooding the market. Although these home fabbing devices were by no means molecular manufacturing systems, they relied on similar design philosophies. This similarity was underscored late in 2010 when updated versions of Nanoengineer appeared online, allowing the nano design software to be used with most home fabbers.

Two social drivers proved to be key influences over the deployment and use of fabrication (and, eventually, proto-nanomanufacturing) systems.

The first was a generational schism. Many of the initial fabbing enthusiasts came from the worlds of online gaming, virtual communities, and "DIY" artisans -- three cohorts with strong Gen-X and Millennial participation. The norms and expectations of these groups, especially with regards to intellectual property and collaboration, alienated many in the traditional productive industries (and their political allies). As a result, the use of fabrication and digital manufacturing technologies took on a strong "underground" character.

The second driver emerged directly from this "underground:" conflicts over intellectual property and economic losses. The period of 2011 through 2015 saw repeated legal disputes over design copyrights and "product cloning," as well as ongoing attempts to legislate restrictions on the ability of fabber-users to compete in the market against established manufacturers. As the music and movie industries discovered in the previous decade, this sort of legal and legislative activity only emboldened those who sought to use the technologies for socially-disruptive purposes, and few if any of the resulting restrictions proved to be viable.

These drivers directly influenced the manner that Zyvex chose to announce and distribute its breakthrough nanomanufacturing technologies in 2015. By ignoring incumbent producers and focusing its marketing and educational efforts on fabber-using communities, Zyvex virtually guaranteed that the first generation of proto-nanomanufacturing systems would have a wide array of innovative and powerful applications. Over the subsequent four years, however, this strategy served as a roadblock for the acceptance of Zyvex's systems in many corporate (and, it must be acknowledged, governmental) environments -- even as the Zyvex design has continued to advance.

Second Driver: Russia

From as early as 2007, Russia has made it clear that it will aggressively engage in the development of nanomanufacturing technologies, with military uses at the top of the list of desired applications. Although this was an official policy, the Russian oligarchs quickly came to be players in the technology race. In 2008, Abramovich channeled several tens of millions of dollars to the Russian government specifically to support nanotech development for military, security, and intelligence purposes. His stated goals of developing molecular manufacturing for commercial purposes masked his real interests. When Putin left office later that year, handing off power to a hand-chosen successor, Russian billionaires less friendly to Putin saw an opportunity to step into the nanotechnology arena, as well, starting with Berezovksy, then in exile.

By early 2009, China enters the picture as a research ally with Russia. This cooperation with Russia, primarily concerning military applications of nanomanufacturing, remained a secret for several years, even while China publicly built ties with commercial nanotechnology firms in the US and Japan. The most visible of these ties was the relationship China built with Nanorex, delivering their innovative open source

Nanoengineer software to schools in China at the secondary public-school level (modeled on the partnership Nanorex had signed with the AAAS).

At the same time, the Chinese government complained about commercial ties between US nanomaterials corporations and high-tech firms in Taiwan. Taiwan had been known as a primary manufacturing center for American computer products, and many US observers believed that it was a likely future leader in nanomanufacturing, as well. (Such analysis bore fruit in 2015, when a still-unnamed Taiwanese billionaire launched a major private initiative for IT-related nanomanufacturing, relying in part on Zyvex designs.) In isolation, these complaints were typical diplomatic maneuvering, but in combination with the China-Russia nano-partnership, analysts at the Department of Defense saw signs of a multi-prong effort to slow US nano research.

It's clear that Putin's 2012 return to office, talking openly of the military implications of advanced nanotechnologies, had a quantifiable impact on that year's election. Republican candidates across the nation saw a 5-10% increase in support, largely on the basis of established positions on the potential military impact of nanotechnology. Given that Putin scaled back the nano-rhetoric shortly after the election, some observers thought that he was consciously trying to push voters towards the Republicans (Putin is known for having found Democratic politicians too inflexible on human rights issues.)

The deployment of the Russian Swarm Surveillance Network in 2013 quieted that analysis, however. The SSN proved a useful tool for monitoring the Chechen border; the US Department of Defense claims in unclassified documents that the SSN increased the capture rate of Chechen guerillas by 500%. Although the Swarm Surveillance Network is most accurately considered "microtech," not nanotech, the manufacturing and control systems needed for its development gave Russia an apparent advantage in the nanomanufacturing race.

This is why the July 2015 briefing from the CIA on Russian nanotech proved so controversial. All of the post-Iraq War quality of intelligence measures signaled that this report was the best intelligence the CIA could offer at the time, yet the report's conclusions -- that the Russian nanotech initiative is greatly underachieving, and is primarily a Russian propaganda effort -- ran counter to both the conventional wisdom and the assessment from the Pentagon.

It remains unclear whether the leak of this report, in late 2016, was intended to undermine the support of the Republicans (who had maintained a strong military posture vis-a-vis the Russian nano-weapons claims) or to undercut the legitimacy of the CIA, seen by many observers as having become overly-cautious in the post-Iraq era.

Subsequent events seem to have borne out the legitimacy of the CIA report, as Russia has yet to demonstrate any significant advances beyond the SSN, and classified reports suggest that Russia has seen numerous fatalities resulting from nano-research accidents. China's recent (2018) overt moves to distance themselves from the Russian program support that argument. Nonetheless, the ability of Russia to make a major leap ahead in proto-nanotechnological military systems, at a time when the US remained mired in debate about just how much to cut from the federal nanotech initiative, colored the perception of security analysts for the remainder of the decade.

Third Driver: Policy Mistakes

It's abundantly clear that major policy mistakes, from both of the leading political parties, have contributed to the crisis in which we now find ourselves. In many respects, this was the key element — without these mistakes, the other drivers may not have proven so problematic.

First, and foremost, was the lack of serious thought or analysis given to the issues surrounding the advent of molecular manufacturing in the decade leading up to the breakthrough. Nanomanufacturing did not come as a surprise; numerous small non-governmental organizations, futurists and novelists had described the likely effects of the development of this technology. Political leaders simply chose not to listen, even ignoring the advice from the federal nanotechnology initiative.

When nanotechnology did show up on the political agenda, it almost invariably appeared as a health and environmental threat. Although some on this commission feel that a risk-sensitive posture was appropriate for a nanomaterials-focused policy, the application of regulations about dumb nanoparticles to the technologies of nanomanufacturing was simply wrong.

For example, the prominence of anti-nanotechnology activists (such as the ETC Group) in high-level policy debates around the application of nano-engineering to the fight against global warming arguably slowed the federal government's willingness to underwrite such research (and despite the strong anti-global warming stance taken by the newly-elected president).

The public awareness and excitement about nanotechnology brought on by Richard Branson's X-Prizes (and the growth of home fabrication technologies) forced the federal government to pay more attention to the subject. The administration added funding for civil society groups to consider the environmental issues surrounding nanotechnology as well as increased funding for basic research and development to the 2010 federal budget. Nanotechnology-related funding increased gradually over the next three years, although in nearly every case with explicit ties to environmental uses. This program did have important results: today's widespread availability of inexpensive, ultra-efficient photovoltaic materials can be directly traced back to this set of programs.

The 2009-2011 oil crisis, brought on by insurgent attacks on Iran's oil infrastructure, crippled both the Iranian economy and the global trade network. The oil shock had numerous immediate effects, including a higher profile for former Venezuelan strong man Hugo Chavez, a greater push for non-fossil fuel-based transportation, and a severe loss of support for the administration (and the Democratic party as a whole). Despite U.S. denials, the broad global consensus was that the insurgent attacks were paid for or perpetrated directly by the United States. In reality, [REDACTED]. Regardless, the major cuts to the federal budget necessitated by the oil shock led the president to call on private industry and institutions to lead the way in innovating new solutions to spiraling energy and trade crises.

Google co-founder Sergei Brin was among the first to answer this call, offering full funding for the Nanofactory Collaboration, a research group led by nanotechnology pioneer Robert Freitas. The Nanofactory Collaboration swiftly filed numerous key patents, promising to make them freely available to other groups working on public nanotechnology solutions. The early successes of the Nanofactory Collaboration, along with the utility of nanotech-based antiviral techniques in the 2010 H5N1 outbreak, seemed to solidify public support for greater nanotechnology development.

This support proved short-lived. In February of 2012, a major study released in JAMA demonstrated that nanoparticles released during the Avian Flu anti-viral deployment were responsible for 5,200 excess deaths in the United States in less than a year, and projected another 50,000 deaths from lingering effects over the subsequent decade. Although later research showed that the deaths were due to a combination of rare sensitivities and careless use by contractors, the US public, no longer enthusiastic about nano-solutions, pressured the US Environmental Protection Agency to add strong new regulations to nanotechnology research and production.

One of the industries hit by the new regulations was the nano-solar field, as the administration chose not even to try to exempt energy and manufacturing nanotechnologies from the new regulations. EPA scientists later linked the recalls and restrictions to an increase in CO_2 emissions in the US in 2013. While a majority of environmental scientists emphasized the global warming importance of nanotechnology over the perceived risks of nanomaterials, the vocal minority of activists held sway over public opinion, and were soon joined by mainstream religious groups and healthcare workers, all supported financially by traditional industrial and energy concerns.

From 2012 through 2017, U.S. government support for innovative nanotechnology research was essentially dead. Small programs continued to receive funding through DARPA and NASA, but after the University of Arizona fiasco in 2014, the surviving projects opted to maintain "below the radar" budget levels for the time being. While this did still allow for critical research, the Commission is unanimous that this five-year interruption of government-funded development was the critical factor magnifying other nano-related problems.

Although the new administration, coming to power in early 2017, eventually reversed the decision to stop major support for nano-research, the Commission feels that it is necessary to point out that it did so only after overwhelming evidence that the United States had fallen behind emerged, and that the initial changes to nano-policy were haphazard and ill-thought-through. (Administration representatives on the Commission voted against including this statement.)

2017 proved a pivotal year in nano-research, for two widely-recognized reasons. The first was the leak of Zyvex nano-assembly system specifications by the "NKVD" hacker team out of Belorussia. Although the Zyvex designs were incomplete — and Zyvex was still two years from being able to release anything significant — this leak made clear just how far non-governmental researchers had advanced towards the development of nanotechnologies. The subsequent revelation that the NKVD hacking group had been funded by Russia underlined the importance of the technology.

The second was the re-formation of the Nanofactory Collaboration. Although the NC had been cleared of liability in the nanoparticle disaster, public antagonism regarding the organization and research had led the major investors to suspend funding. By 2017, the public fear of nanotechnology had subsided enough that Brin, along with Richard Branson and Bill Gates, felt able to restart funding. As the NC participants had generally continued with low-level research during this time period, the Collaboration was able to move quickly towards the development of a nanomanufacturing system competitive with the Zyvex design.

The Commission applauds the administration for the announcement of the "NanoManhattan Project" in the 2018 State of the Union Address, but cautions against relying too heavily on hype and marketing. NanoManhattan has yet to receive full funding, and may not get fully underway until 2020.

By that time, it may be too late. After the end of the Commission hearings, members received word that the Nanofactory Collaboration has a major announcement scheduled for next month. The word "nanofactory" figured prominently in these messages.

By the CRN Scenario Working Group (see INTRODUCTION)