

Dimensions of Development

Mike Treder

Executive Director, The Center for Responsible Nanotechnology

The development of molecular manufacturing—an advanced form of nanotechnology—will be a hinge point in history. Like the invention of the printing press, steam engines, and computers, molecular manufacturing (MM) will transform business, industry, social structures, and the balance of world power. The question is not if, but when.

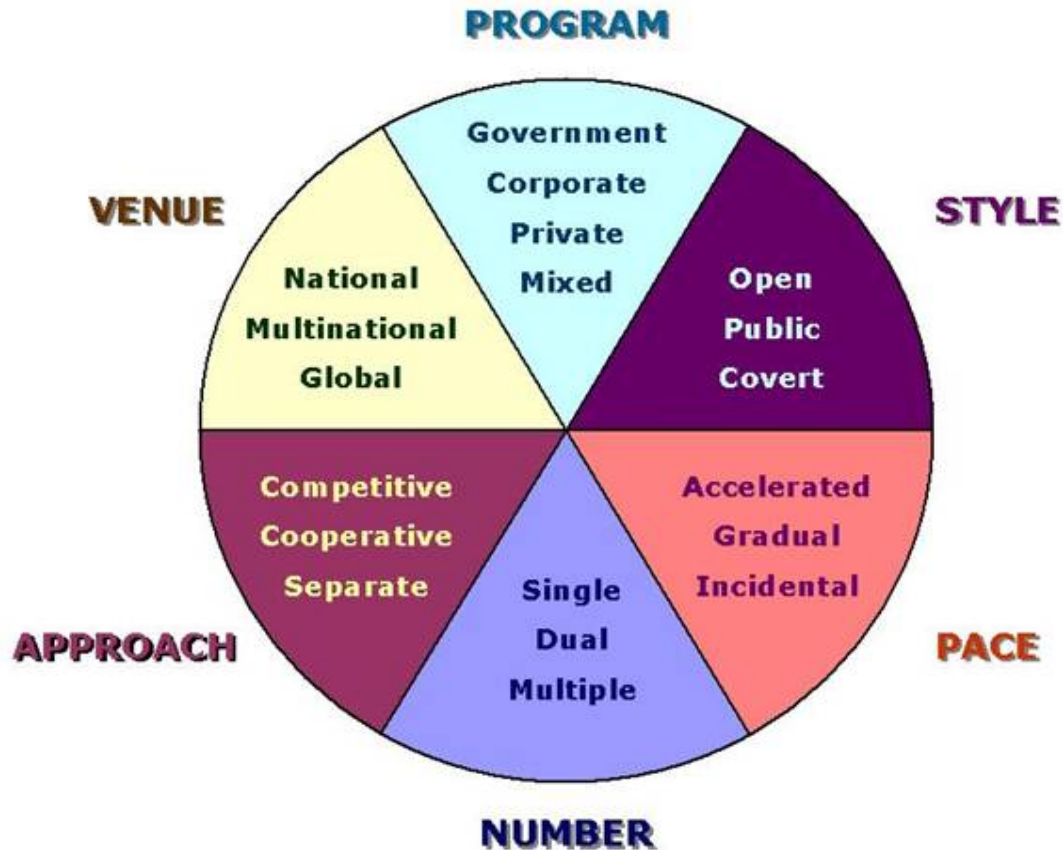
Powerful new products made quickly, cheaply, and cleanly, with atomic precision, will impact all of us. People on every continent, in every country, and of every language will be affected. Whether those impacts will be largely beneficial or terribly damaging is unknown.

There are many factors that will determine how soon and how safely MM is integrated into society, including where, how openly, and how rapidly it is developed. Because nanotech manufacturing could be so disruptive and destabilizing, it is essential that we learn as much as possible about those factors and others. The more we know, the better we may be able to guide and manage this revolutionary transformation.

Although it is not yet certain how quickly progress will occur from today's nanoscale technologies to a robust molecular manufacturing capability, recent developments suggest it could be sooner than many expect. Because we can construct plausible scenarios in which MM arrives within the next ten years, or possibly even less, it is urgent that we study and understand these contingencies and the factors that will influence them.

At least [six different dimensions](#) have been identified by the Center for Responsible Nanotechnology (a nonprofit research group co-founded by the author) along which molecular manufacturing may be developed. Within each dimension, several possible *directions* are shown.

DIMENSIONS	Directions
NUMBER:	<i>Single, Dual, or Multiple</i>
STYLE:	<i>Open, Public, or Covert</i>
VENUE:	<i>National, Multinational, or Global</i>
APPROACH:	<i>Competitive, Cooperative, or Separate</i>
PROGRAM:	<i>Government, Corporate, Private, or Mixed</i>
PACE:	<i>Accelerated, Gradual, or Incidental</i>



With three or four *directions* within each dimension, the number of possible permutations is in the high hundreds. This means that policy and strategy planning must take into account an enormous range of variables and potential outcomes.

A few of the more likely combinations include:

- Nations racing to be first, for military advantage/security -- *Multiple, Covert, National, Competitive, Government, Accelerated*
- Nations/corporations share costs, expecting it to take a long time -- *Multiple, Public, Multinational, Cooperative, Mixed, Gradual*
- Corporations race to be first, for commercial advantage -- *Multiple, Covert, Global, Competitive, Corporate, Accelerated*
- Hackers organize to develop nanotech tools -- *Multiple, Open, Global, Cooperative, Private, Gradual*
- An unexpected break-through by one corporation drives development -- *Single, Covert, Multinational, Separate, Corporate, Incidental*

Making effective policy for the safe and responsible use of advanced nanotechnology will require a deep and comprehensive understanding of all six dimensions of development—and all the different directions within those dimensions. Solutions that appear to work in one area might contradict solutions in other areas. To be effective, a

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coordinated and integrated strategy of multiple complimentary policies must be designed and implemented. Clearly, this will be a daunting challenge.

Until molecular manufacturing is fully developed, there may be little apparent incentive for policy creation. But the late stages of development could occur very rapidly, and the inherent ease of proliferation after development will likely spread the disruptive effects much faster than existing policy can handle. The issues involved are highly complex, include multiple factors, and may take years to sort through.

For all these reasons—the power of the technology, the scope of its impact, the uncertainty of how soon it will arrive, and the difficulty of policy creation—serious studies aimed at answering these questions should begin immediately.

Future articles will elaborate on several of the contingences raised in this overview.

This essay is original and was specifically prepared for publication at Future Brief. A brief biography of Mike Treder can be found at our main [Commentary](#) page. Recent essays written by Mr. Treder can be found at the [Center for Responsible Nanotechnology](#). He receives e-mail at mtreder@crnano.org. Other websites are welcome to link to this essay, with proper credit given to Future Brief and Mr. Treder. This page will remain posted on the Internet indefinitely at this web address to provide a stable page for those linking to it.

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