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**Mapping the Multi-layered Additive Manufacturing (AM) community: Understanding the Future Landscape and Implications for National Security**

**Introduction**

Emerging technology is moving faster than government planning and policy development can track. Emerging technology is not just evolving rapidly, but much of it is evolving outside the control – or even the understanding – of the national security community. Though most research on emerging technology focuses on the (sometimes alarming) physical characteristics of innovations, the communities behind innovation remains understudied. Understanding these drivers, creators, diffusers, and users of technology will be key to successfully navigating the future environment of strategic tech.

Additive manufacturing (AM), and its implications for national security, is of particular concern. First, it has already been identified as a potential threat to counter-proliferation efforts. By reducing observable industrial footprint of proliferation efforts, facilitating intangible technology transfer, and reducing the necessary level of skill of users, it significantly lowers barriers to entry for weapons of mass destruction (WMD) production by nefarious actors. Secondly, the adoption of licit AM within the US and allied countries will undoubtedly impact their manufacturing bases. By empowering some firms and sectors, and hollowing out others, the landscape of industry – as well as its relationship to the state’s national security apparatus – will have significant consequences for planners.

We seek to remedy this emerging lacuna in our understanding of the AM thought communities. First, we seek to understand the most immediate level of impact – patents. These are AM ideas that are easiest to code and closest to impact the national security space. Second, we seek to map the academic community that is refining and vetting the upcoming generation of AM techniques: the basic research that will result in tomorrow’s patents and applications. Third – and most ambitious – is to map the “primordial ooze” of AM thinking. This includes the online maker/hacker/hobbyist communities that are producing and proliferating the most far-reaching, notional, and sometimes fantastical ideas about AM. Many of these ideas will come to naught, but a handful may be game-changers.

These layers of analysis are explained more fully below. The scope of the work will be to build, map, and analyze these networks with the intent of providing insight into how AM may shape national security today, tomorrow, and into the future.

**Layer 1: patent applications (US-centric)**

Rapid developments in the *application* of AM technology are largely driven by the private sector, as individuals and corporations turn theoretical insights into marketable products. Using data from the US Patent and Trademark Office (USPTO), we will build a network of AM-related patent applications cross-referenced at both the individual and corporate level. This will let us map innovation and collaboration both by individuals (who often transition between companies) and through larger-scale joint corporate efforts.

The advantage of using patent applications and published research is that there is a high incentive to ‘self-report’ these data. Innovators in both the academic and private sectors want to protect their intellectual property and get credit for their innovations. This means that research publications and patent applications are likely to be a near-comprehensive data set, which is advantageous for our efforts.

**Layer 2: academic research (global scope)**

The academic community is responsible for many of the major *theoretic* breakthroughs in AM. We will map this layer of the AM community by building a database of (co)-authorship of academic research articles. Repositories of published research such as JSTOR will allow us to map the established network of AM knowledge and collaboration. We can also draw on stores of more cutting-edge theoretical work, using repositories of working papers such as ArXiv. The resulting network will provide information on “who is doing what, with whom” in the academic sphere. These data will allow us to map the emergence of the academic AM community over time, as well as the research trajectories of individuals and working groups in the AM field.

**Layer 3: social communities (English-language scope)**

Many of the day-to-day practitioners in AM are unlikely to either publish academic research or apply for original patents. Instead, these individuals apply existing knowledge in innovative ways, adapting AM technology for often-unforeseen purposes. We will map this community in two steps. First, we will map the individual sub-networks that constitute AM-related online forums – communities dedicated to aiding and connecting users of AM technology. This will let us identify important ‘nodes’ in these forum networks: individuals who are highly active or hold positions of authority in the forum. Second, we will attempt to map broader cross-forum networks by identifying users who are members of more than one forum. This allows us to identify ‘bridging’ individuals who can easily transfer ideas and information between different forum communities.