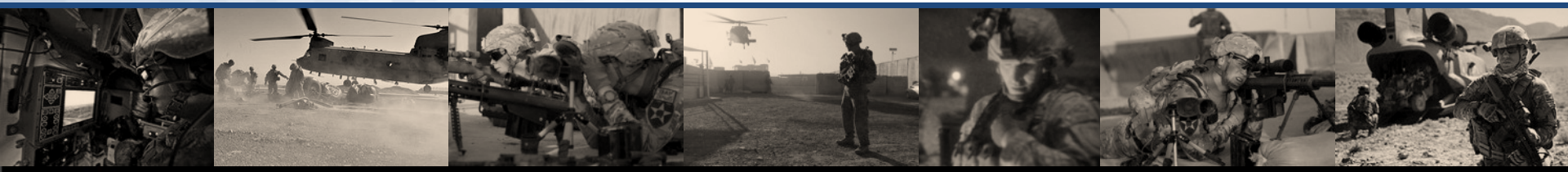
Technology Wargaming Overview

Federal Foresight Community of Interest



BLUF

- Enables Army Science & Technology (S&T) to identify game-changing technology that could impact Army capabilities in the far future(2035-2040), executed in the Office of the Deputy Assistant Secretary of the Army for Research and Technology (ODASA R&T).
- Ensure comprehensive technology reconnaissance by crowdsourcing technology concepts from underutilized non-DoD traditional organizations and entities. Mitigate cognitive bias within the Army/Army S&T. Leverage creative abilities from a diverse audience
- Analyze crowdsourced capabilities to inform Army S&T Program Objective Memorandum (POM) and create a “here to there” narrative illustrating basic S&T investments now for Army capabilities in 2035-2040

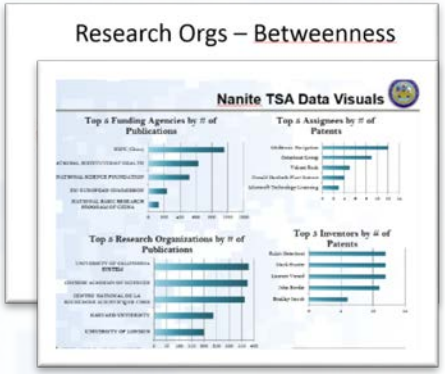
Technology Wargaming Overview

- Crowdsource future capabilities from the Army S&T enterprise, academia, and non-traditional DoD thinkers
  - Mitigates risk of cognitive bias's within the Department of the Army by leveraging the creativity and insight of non-traditional DoD individuals and organizations
  - Executed through in-person and online ideation exercises
- Analyze potential technologies using bibliographic-based data analytics(universities, personnel, countries performing the research)
- Through SME review create a functional decomposition of a potential capability
- Assign probabilities and perform Monte Carlo Simulation to create a here-to-there narrative for how basic science advances will produce an Army capability through a Technology Sequence Analysis (TSA)
- Provide broad future S&T context in Annual Trends Report

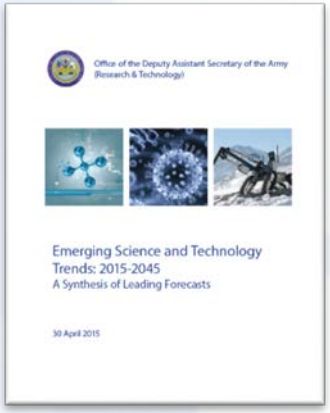
"…The elite amateurs were on average about 30% more accurate than the experts with access to classified information…the full pool of amateurs also outperformed the experts. The most careful, curious, open-minded, persistent and self-critical…did the best."[1]

Crowdsourcing

SME-Informed Bibliometric Search



S&T Trends Report

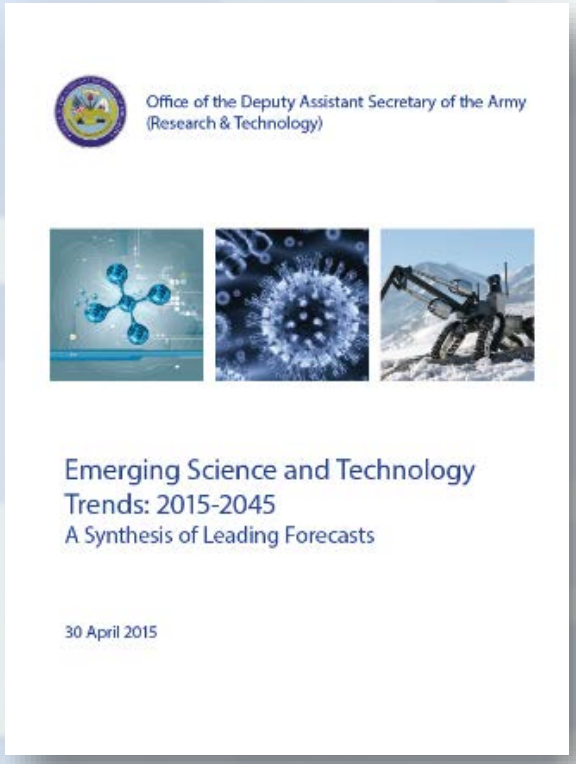


Deep Dive Analysis

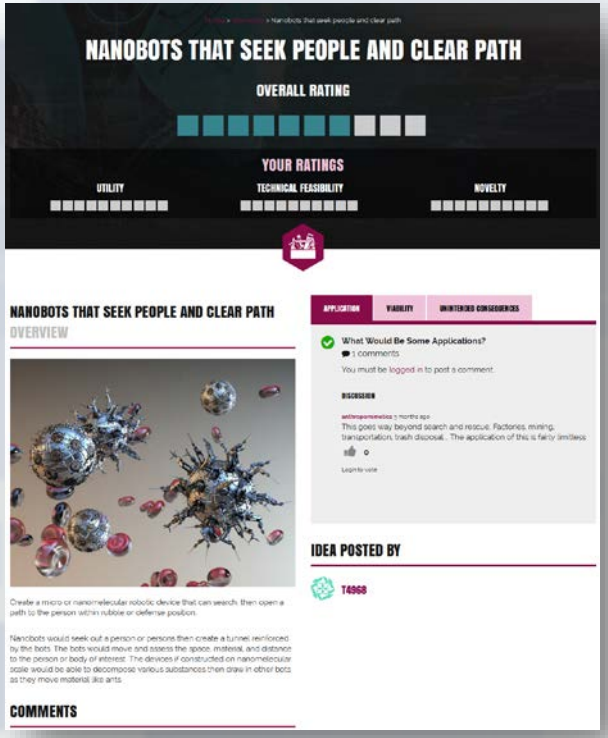
[1] Zweig, J. (2015, September 25). The Trick to Making Better Forecasts. Retrieved November 20, 2015, from http://www.wsj.com/articles/the-trick-to-making-better-forecasts-1443235983

Execution

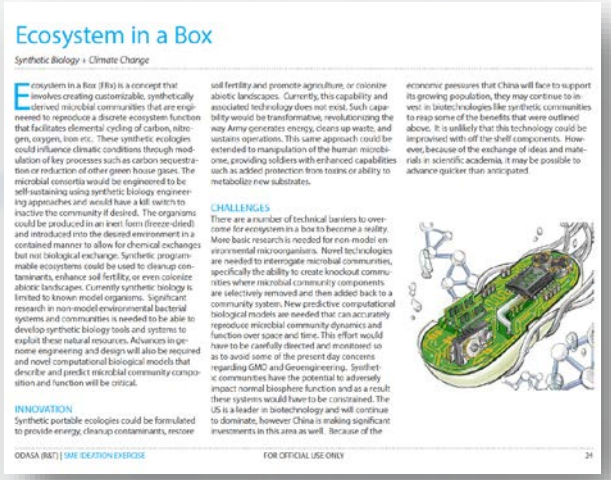
Broad meta-analysis of S&T trends



Web-based crowdsourcing events



SME ideation exercises



Trends Report

- Background
  - Integrates 14 S&T Forecasts by government agencies in the US and UK, industry leaders, international institutions, and think tanks
  - Covered trends over the 2015-2045 time frame
- Key Takeaways
  - Data revealed 20 common emerging S&T trends and 3 cross-cutting non-S&T Trends
    - 14 “core” S&T trends with potential for significant impact for Army operations
    - 6 additional trends with potential for moderate impact for Army operations
    - 3 non trends: tensions over privacy, impacts of climate change, rise of China as technological rival

S&T Themes

- Autonomous Systems
- 3D and 4D Printing
- Analytics
- Human Augmentation
- Mobile and Cloud Computing
- Future Medicine
- Cyber
- Energy
- Changing Nature of Work
- Internet of Things
- Food and Water Technology
- Quantum Computing
- Social Technologies
- Directed Energy
- Education
- Materials
- Synthetic Biology
- Interface
- Transportation and Logistics

Example Card

Food and Water Technology

Over the next 30 years, access to food and water will become a crucial driver of global tension and technological innovation. Population growth and climate change are putting pressure on food production and fresh water supplies. Drought is already affecting access to drinking and irrigation water in many parts of the world, causing ripple effects across many unstable regions. Roughly 25% of current farmland is already degraded from overfarming, drought, and air/water pollution. Under optimistic forecasts, prices for staple grains could rise by 30% over the coming decades. Food and water, long taken for granted in the developed world, will become a major priority for innovation, and could become a major flashpoint for conflict.

36% Concurrence

4% Share

ENABLING S&T

Transgenic Crops
Splicing genes from one plant species into the DNA of another species can provide crops with new traits such as drought tolerance, the ability to fix nitrogen from the air, and pest/disease resistance.

Precision Agriculture
Technologies like robotic automation and micro-irrigation, which improves water delivery to crops by 32-95% will make farming more resource efficient and productive.

Water Technology
In addition to improved desalination technology, development is underway on filtration systems that can produce potable water from greywater sources.

Alternative Food Sources
Closed-system hydroponics, vertical urban farms, and other new technologies are enabling crops to be grown without access to arable land.

SIGNALS

"BoniRob" is a lightweight agricultural robot being developed by German firm Amazone. BoniRob is capable of working in swarms to complete common farming tasks such as weeding and fertilizer application.

Scientists at Kansas State University are working on a heat-tolerant strain of wheat that could increase yields in hot regions by up to 35%

A UK-based team of engineers has developed a low-cost, portable desalination technology powered by renewable energy. The Desolanator used solar energy to desalinate up to 15 liters of water per day. Each unit costs around $450 and is designed to operate for up to 20 years.

Today, the world's poor get by on 5-10 liters of water per day, while members of the global middle and upper class use 50-150 liters daily.

IMPACT

Social
Food and water are essential to human life, and disruptions to these vital resources could prompt erosions of trust in civil governments, rioting, and hoarding.

Political
Resource management is likely to become an important focus for domestic and international politics.

Economic
Food and water shortages could worsen economic instability and exacerbate class divisions.

Environmental
Genetically modified organisms (GMOs) have the potential to boost agricultural yields. However, the environmental impact of GMOs is uncertain.

Defense
Food and water crises represent dangerous flashpoints for conflict. Some of the world's poorest regions are the most vulnerable to food and water shortages. Food and water infrastructure could become a critical target for future adversaries.

Without mitigation, by 2045 or sooner, around 3.9 billion people – over 40% of the world's population – are likely to be experiencing water stress.

UK Ministry of Defense (MoD2013)

In the future, geopolitical tensions over access to strategic water resources could become more systemically impactful, and water shortage coupled with poverty and societal instability could weaken intra-state cohesion.

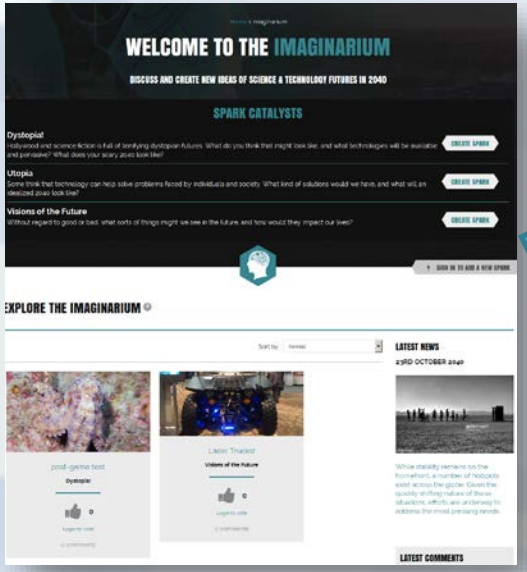
World Economic Forum (WEF)

Transgenic technologies—which enable the transfer of genes from one plant species to another to produce a plant with new or improved traits—hold the most promise for achieving food security in the next 15-20 years.

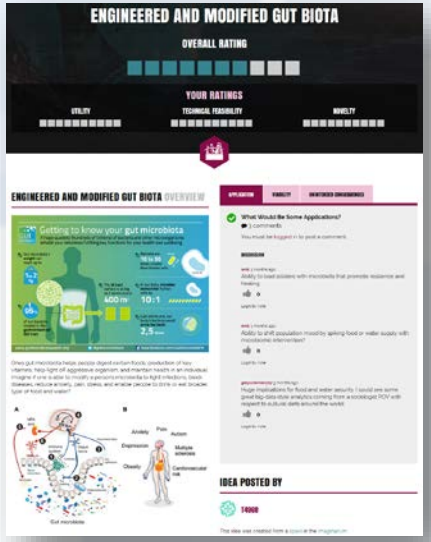
National Intelligence Council (GT2030)

Online Ideation Exercises

- Crowdsource future capabilities from the Army S&T enterprise, academia, and non-traditional DoD communities
  - Mitigates risk of cognitive bias's within the Department of the Army by leveraging the creativity and insight of non-traditional DoD individuals and organizations
  - Executed through in-person and online ideation exercises



Imaginarium



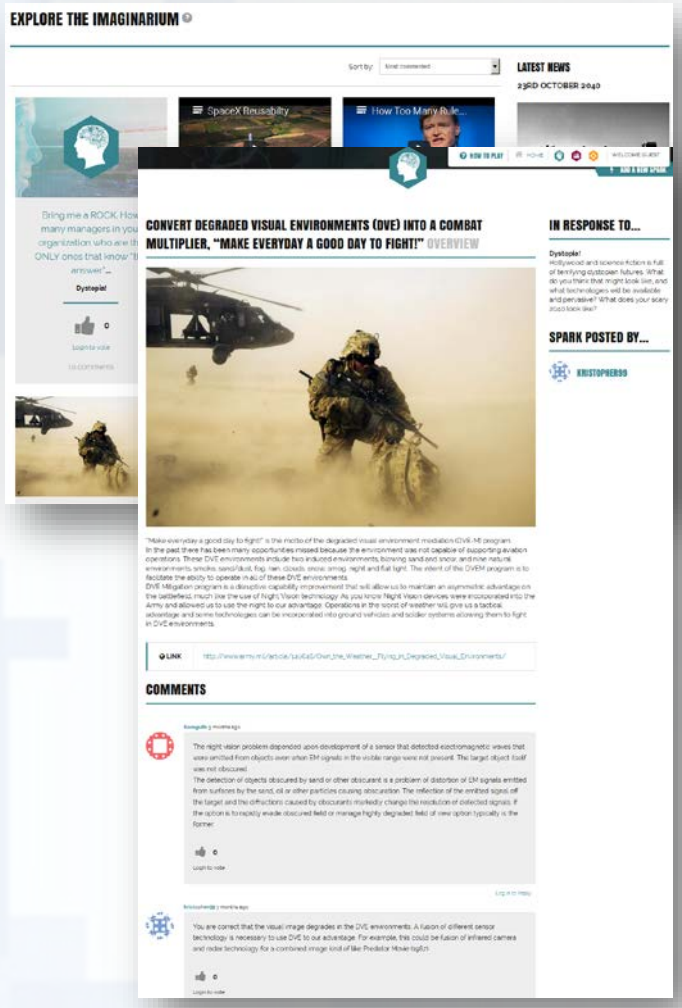
Workshop

Battlespace

Imaginarium

Purpose

- Place to offer quick ideas about future trends, technologies or capabilities
- Minimum of title and short description; images, links, or video encouraged
- Meant to be light, quick, and easy to read (e.g., Pinterest)



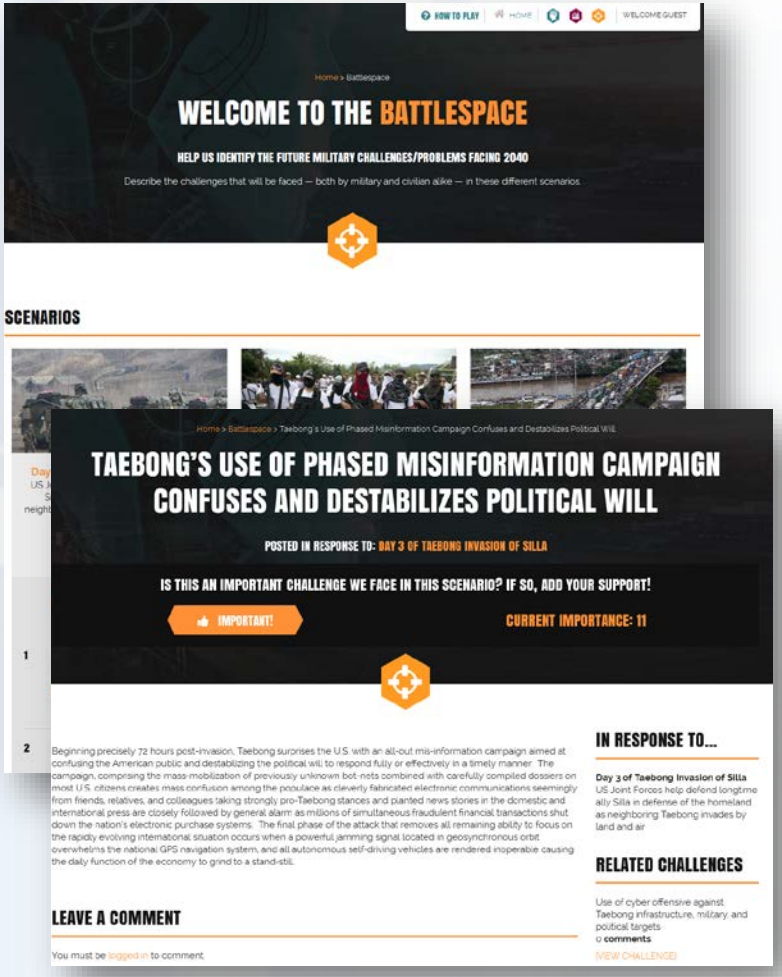
Results

- 43 Sparks submitted and covered a wide variety of topics
- 83 comments submitted on those 43 sparks

Battlespace

Purpose

- Lists scenario-based news stories in style of an online news outlet (e.g., BBC, CNN)
- Three fictional but realistic scenarios:
  - Narcowarfare in South America
  - Ground war in Asia
  - Environmental disaster in Africa
- Players apply workshop ideas against the scenario
- Players fill in what they see as difficult challenges. Updates can be tagged as "important"



Results

- 28 total challenges
- Top rated challenge "…Use of Phased Misinformation Campaihn Confuses and Destabilizes Political Will"

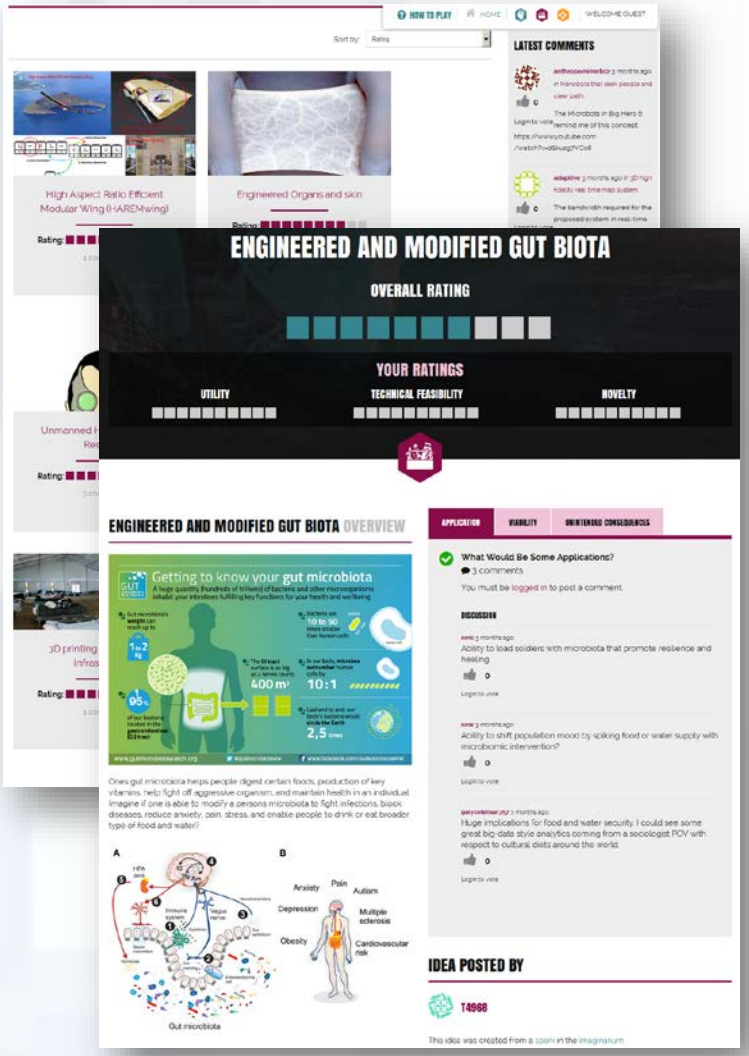
Workshop

Purpose

- Intended focus area for participants to debate/vet/discuss potential Army capabilities
- Ratings used to get quick numerical sense of participants Comments in free form or based on Application/Viability/Unintended Consequences
- Ideas promoted from sparks or submitted direct to workshop

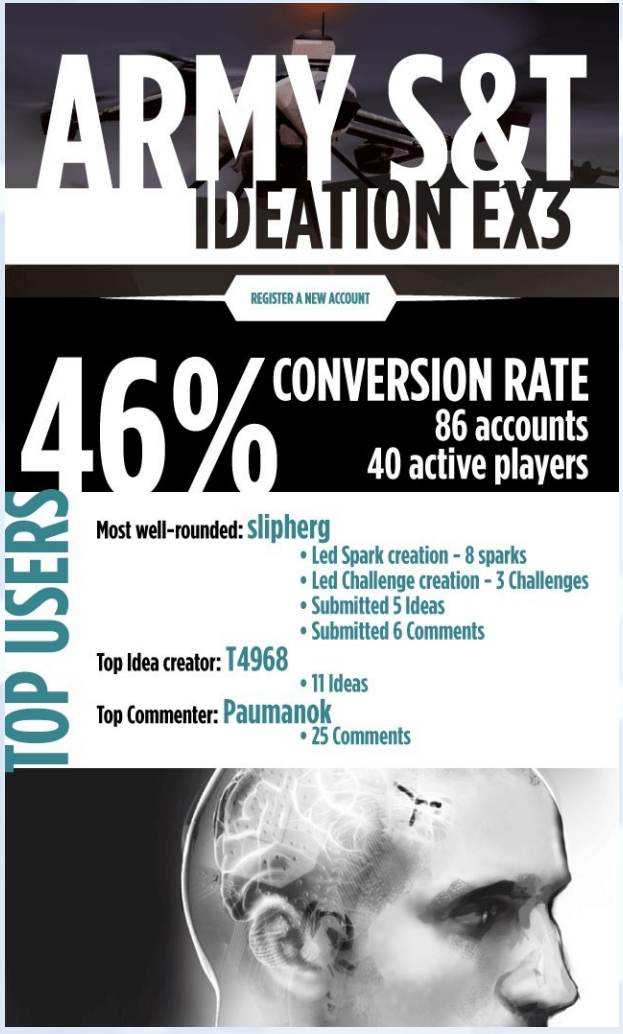
Results

- 31 ideas and 28 Workshop Challenge Questions answered



Technology Wargaming Ex4 Infographic

EX3 Infograph sent to participants



EX3 Concept Art from crowdsourced ideas

EX3 Concept Art from crowdsourced ideas

SME Driven Ideation

- Play by email ideation using engineers and scientists from the Army's research and development community
- Each SME provided 5 S&T trends and 5 socio-political trends and asked to generate a new idea for a technology combing two or more trends
- Intended to induce new ideas using constrained inputs to think beyond cognitive biases and produce creative ideas

Green Death: Entomological Warfare

Energy + Sustainable Cities + Demographic Patterns + Global Inequality + Constrained Budgets + Climate Change

Over the next 30 years urban footprints grow and the majority of the world's population will live in urbanized areas. Transportation of resources will become increasingly difficult and costly, exacerbated by the depletion of natural resources. Cities will become increasingly sustainable with large dependence on engineered plants/vegetation that will be specialized to "indigenous" zones. Plants will be critical to sustained air quality, food, water as well fuel. Industry will drive innovation and resistance to natural pests will be a common, with advancements towards increasing efficiency of growth and performance. Our understanding of plant genetics will continue to advance. Similarly, synthetic biology will advance to create highly specialized insects that can target and feed on plants and vegetation. The more engineered plants are, the more costly, creating a stratum that correlates with trends in global inequality that could be exploited to further exacerbate political and social tensions through targeted entomological warfare leading to civil unrest.

S&T advances in systems and synthetic biology in botany and entomology are required to deliver/prevent species/variant targeting; advances in crop engineering are needed to provide broad-spectrum protection and reactive plant systems which can convert to toxic-insecticide secreting systems upon attack.

INNOVATION

This technology would prevent adversary overmatch through: protection against next generation biowarfare. In the event of offensive capabilities, one would have a unique advantage over adversaries not possessing this protection. This capability could be used to further exacerbate political and social tensions through targeted entomological warfare leading to civil unrest.

CHALLENGES

Potential adversaries could hav same technology. It could be p engineer and propagate resista however, if highly specialized t environment, this may not have lenges to social/ethics of genet safety are clearly a concern if n properly.

ODASA (R&T) | SME IDEATION EXERCISE FOR OFFICIAL USE ONLY 23

Accurate 90-Day Micro-Weather Forecast

Internet of Things + Mobile & Cloud Computing + Individual Empowerment + Climate Change

By 2045, mobile devices will be a staple across the globe, will be laden with sensors, and will have a compute capacity similar to that of today's supercomputers. Army mobile communication will be in lock-step with commercial capabilities (i.e. will overcome its current 15 year technology gap) and will use a transparent rather than trusted supply chain to ensure the technology is affordable and can be rapidly updated. Mobile device sensors will be used to collect weather data and will publish that information to a tactical cloud computing capability. The tactical cloud will have reach back to large supercomputers in CONUS, which will provide 90 day 99% accurate micro-weather forecasts at a resolution of 0.01 square kilometers in 10 minute increments; the tactical cloud, 30 day forecasts in 30 minute increments; the off-line mobile device, 10 day forecasts in 1 hour increments. In off-line mode, the latter will produce forecasts based on the last information downloaded from the tactical cloud and a history of observations gathered by the mobile device itself.

The Army will have worked with mobile device providers over the previous 10 years to provide a (purposefully) less accurate and more near-team forecast capability at a lower resolution, (similar to the military's approach for GPS technology) using non-military local cloud services and mobile devices. Private mobile users will (either through volunteering or by default) push local weather information to provide instantaneous weather data. (Most would consider this data to be innocuous information.) Computing within the mobile device will be able to discern the nature of the observation (e.g., whether the device is indoors or outside, in shade or in direct sunlight; where the device is located via GPS) in order to tag the data appropriately for assimilation with information reported by all participating private mobile devices to a local cloud computing capability.

In exchange for posting tagged data, this local cloud capability will distribute 10-day weather forecasts to the participating mobile devices. These forecasts will be 99% accurate to one square kilometer of resolution in one-hour increments. Businesses which greatly depend on the fore-knowledge of weather (e.g. hotels, airlines, cruise ships) will be able to buy an enhanced service – a 30-day weather forecast accurate to one square kilometer in 30-minute increments. The private mobile device data collected by participating private local clouds will be forwarded to the Army

ODASA (R&T) | SME IDEATION EXERCISE FOR OFFICIAL USE ONLY 33

City Scrape

Analytics + Mass Urbanization

City Scrape is a collection of sensors and analytics that enable a real time view of living entities at a city-level scale. Data collected includes position and simple biometrics for each entity that enable tracking individuals through complex multi-story building structures, and over large areas. City Scrape tracks millions of entities using a combination of overhead and localized sensors combining technologies (that do not exist today but imagine combining GMTI, ground penetrating radar, and radiation imaging; or radio signals/nuclear sensors, and inert materials in water/air that accumulate in living organisms like mercury in fish) giving a 3D image with bio signs that can be logged over time to characterize the behavior and location of individuals. This data is used to identify threats and potential collateral damage in a location and empowers soldiers to more safely control challenging urban situations, and act decisively.

INNOVATION

As population increases and people move into larger mega-cities the density of people provide an environment where radicals and enemy forces will be entrenched in close proximity with large numbers of noncombatants in locations where traditional kinetic attacks are infeasible without significant collateral damage. This will place an increased emphasis on boots-on-the-ground and door-to-door operations, which place our troops in significant risk in environments where the adversary has a significant advantage. The ability to monitor situations at stand-off distances and only engage with extreme precision and high confidence attacks.

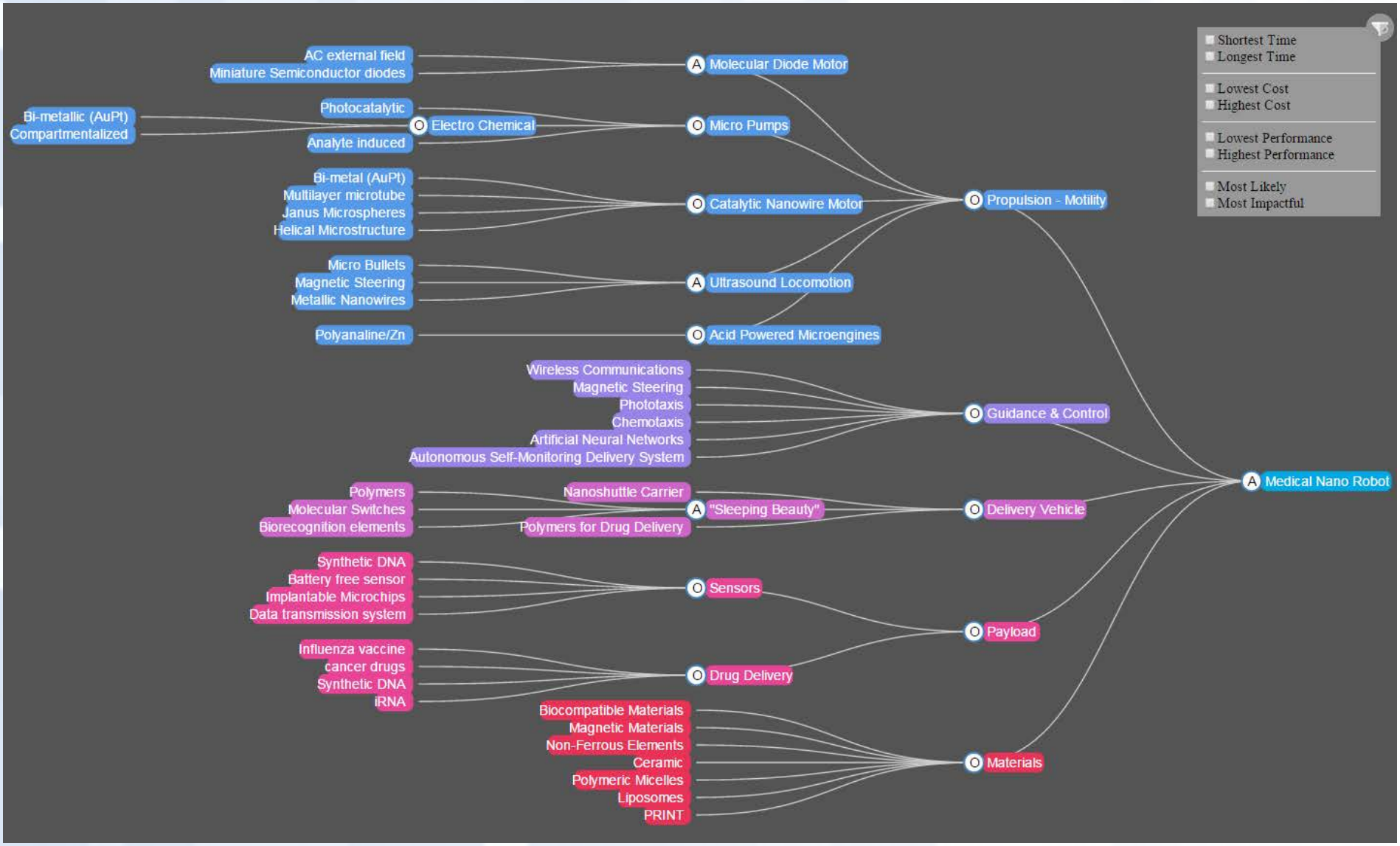
CHALLENGES

The ability to view entities through buildings on a large scale does not currently exist. If it did exist, it would be a significant tactical advantage, but would require likely a major investment in infrastructure to be put in place making it more difficult for adversaries to implement. Small-scale implementations might be possible. Techniques for avoiding detection, manipulating data, and faking biometrics would be likely threats to success.

ODASA (R&T) | SME IDEATION EXERCISE FOR OFFICIAL USE ONLY 17

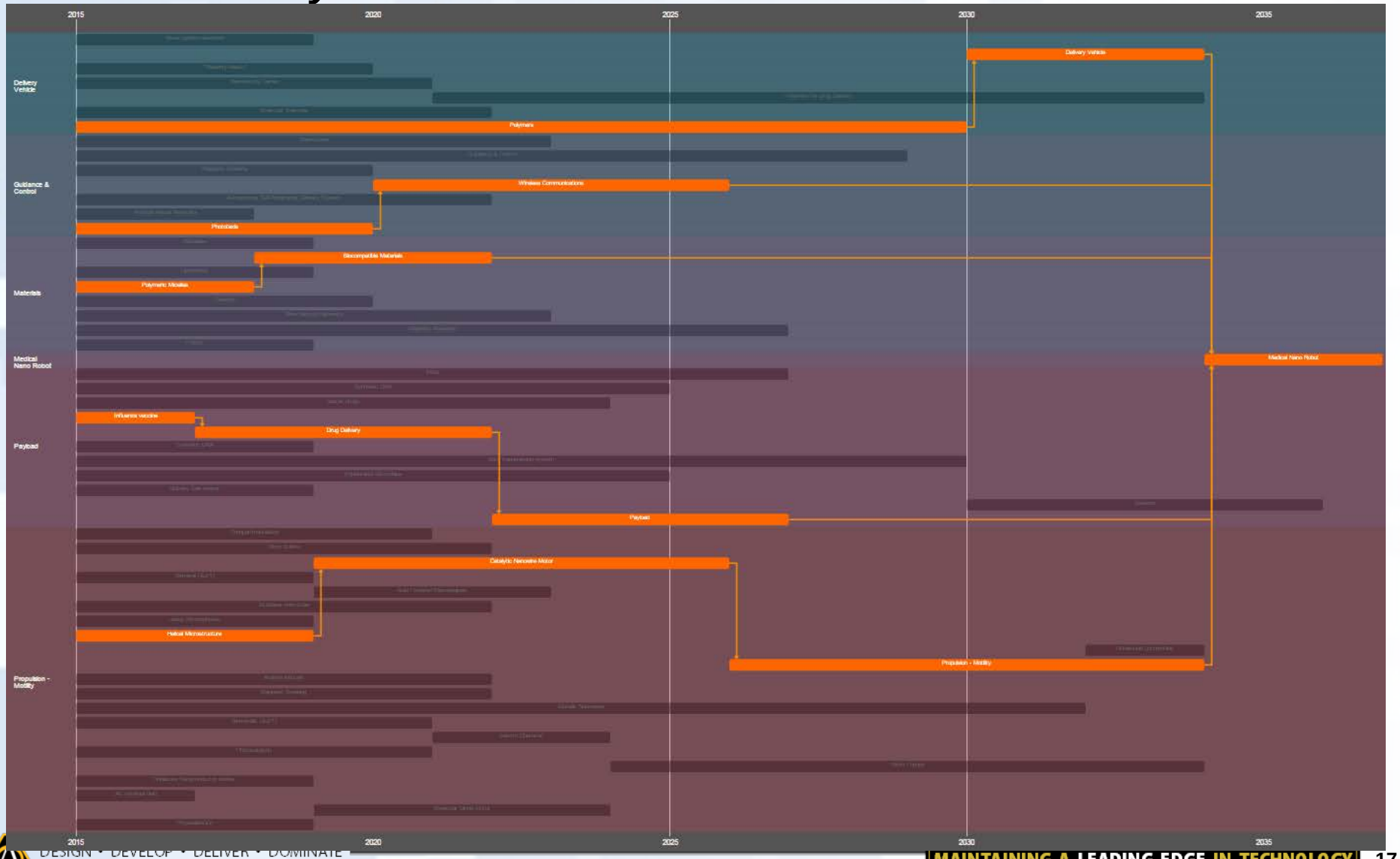
Backup

Medical Nanites TSA System View



Medical Nanites TSA Timeline View

- Most Likely Path - 2038



Nanite TSA Research Data

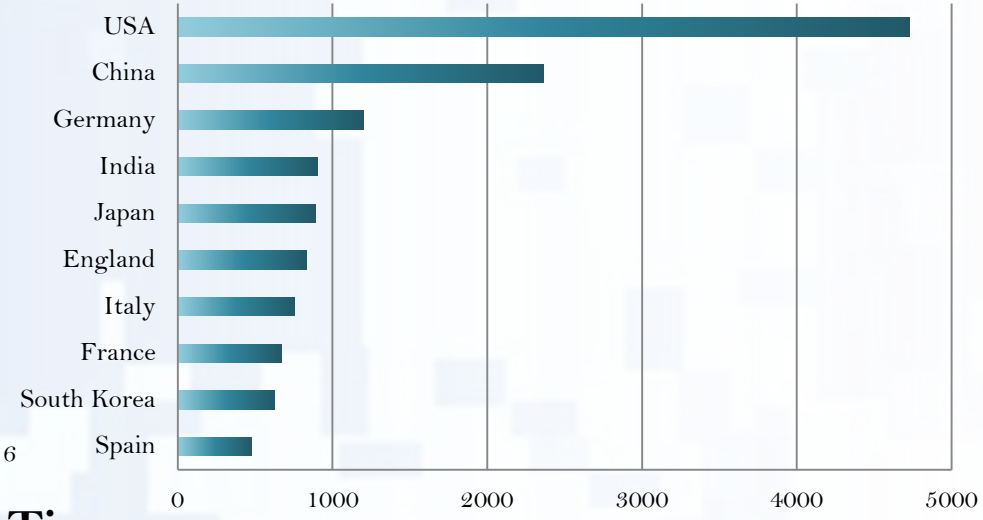
Name	Position	Affiliation	Background
Dr. Mark Davis	Prof. Chemical Engineering	Cal. Tech	Nanoparticle therapeutics; nanomedicines
Dr. Andrew Ellington	Prof. Biochemistry	Univ. of Texas	Molecular Biosciences; DNA research
Dr. Shana Kelley	Prof. Chemistry	Univ. of Toronto	Electrochemical nucleic acids; Microchips; Ex vivo clinical diagnostics
Dr. Yamuna Krishnan	Prof. Chemistry	Univ. of Chicago	Synthetic DNA devices; DNA nanomachines
Dr. Sylvain Martel	Assoc. Prof. Computer Engineering	Montreal Polytechnique	Remote microsurgery; nanorobotics; drug delivery to combat cancer
Dr. Ayusman Sen	Prof., Chemistry	Penn St. Univ.	Nano and micro pumps and motors; Chemical catalysts as motors
Dr. Alexander Stengh	Asst. Prof. Neurology	Northwestern Univ.	Geneticist; investigating novel brain cancer treatments; iRNA research
Dr. Bill Tang	Biomedical Engineering Dept.	Univ. California, Irvine	Remote in vivo diagnostics; micro-implantable devices
Dr. Orlin Velev	Prof. Chemical and Biomolecular Engineering	North Carolina State Univ.	Innovative colloidal materials; Nanostructures wth electrical and photonic functionality
Dr. Szu Wang	Prof. Materials	Univ. California, Irvine	Fabrication of functional nanostructures; development of novel polymers
Dr. Albert Yee	Prof. Chemical Engeineering and Material Science	Univ. California, Irvine	Materials science - polymers and nanotechnology

- Preliminary Publication/Patent Research:
  - Search term: ((nanite* OR nanorobot* or nano*) AND medic*)
  - 16162 publications, 36 patents

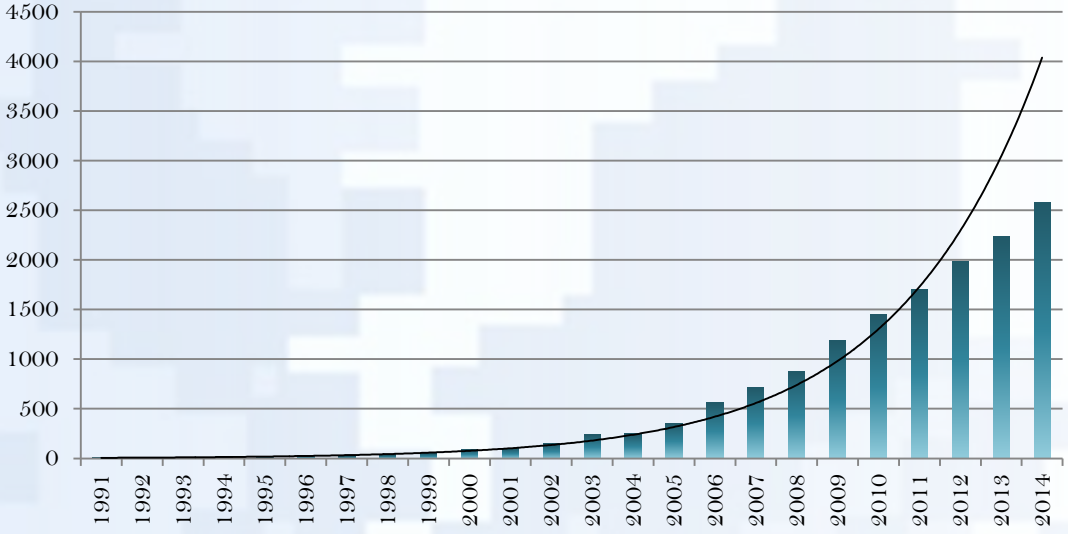
Nanite TSA Data Visuals

Patents Over Time

Top Research Countries By # of Publications

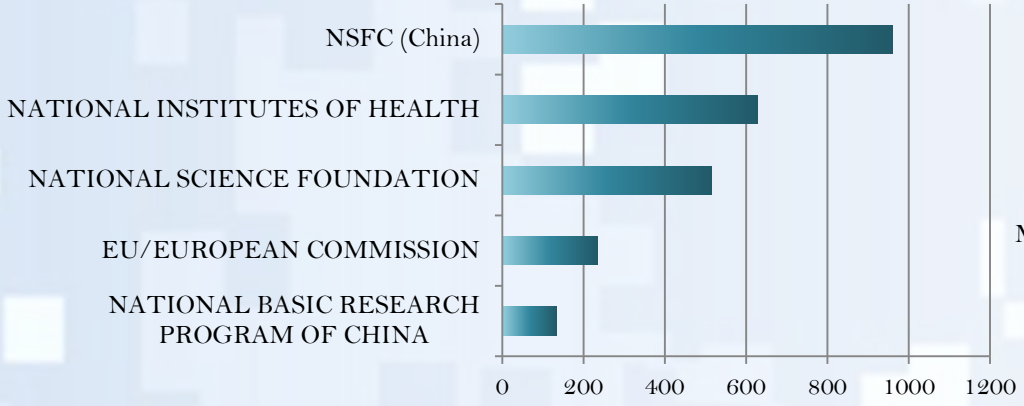


Publications Over Time

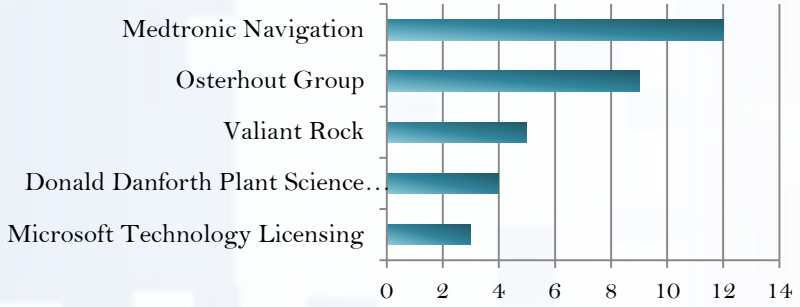


Nanite TSA Data Visuals

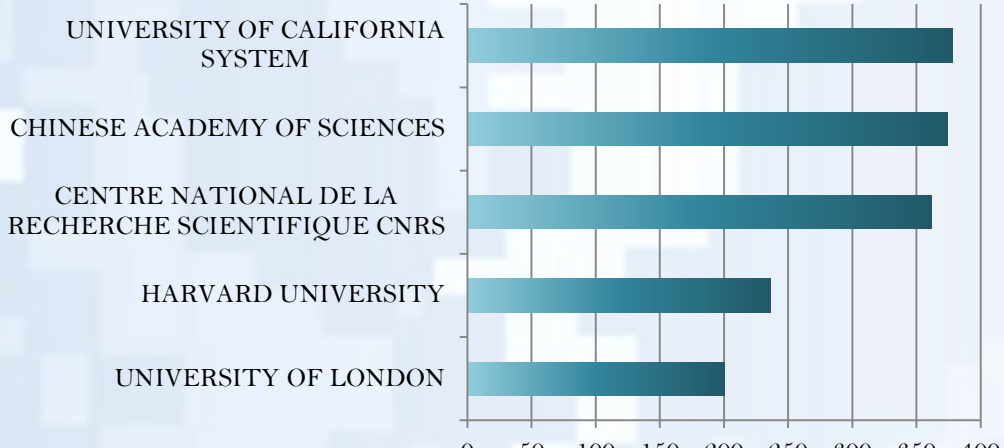
Top 5 Funding Agencies by # of Publications



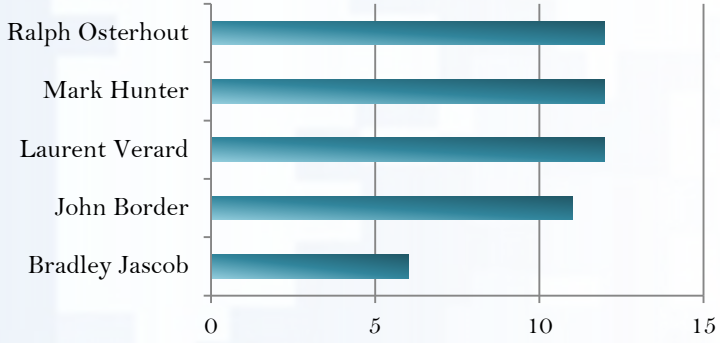
Top 5 Assignees by # of Patents



Top 5 Research Organizations by # of Publications

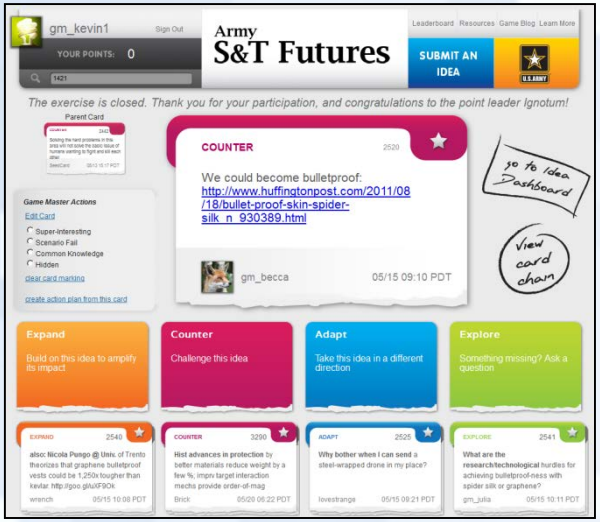


Top 5 Inventors by # of Patents

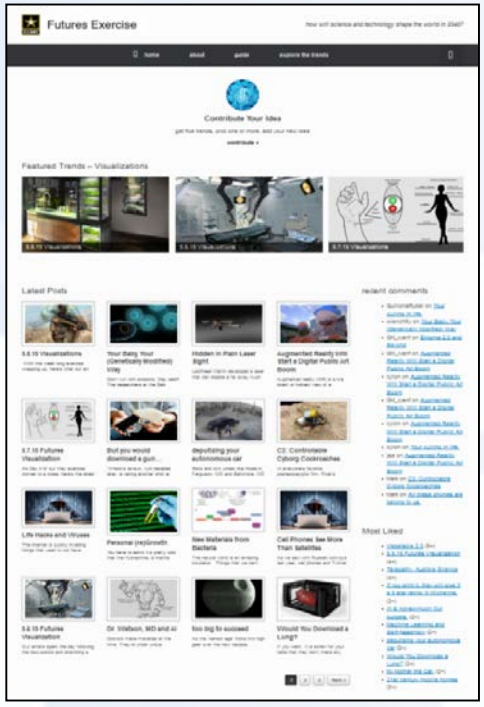


Crowdsourcing/Ideation Platform

<u>Purpose:</u> Provide an intuitive platform for engagement of "non-traditional" technical, tactical, and creative communities not normally involved in the Army S&T planning process



2014 - MMOWGLI



2015v1.0 – Blog Style

2015v2.0 – Ideo Style

Video

Link to Background Video

https://vimeo.com/126458402

Link to site

http://futures.armyscitech.com