Defense One

Emerging Tech in Defense

SEPTEMBER 2019 EBOOK

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Foreword

"It's becoming easier than ever before in history to invent, to test, to model, and to unlock clues in nature, thanks in part, to breakthroughs in the spread and flow of information. That's leading to a new phase of optimism in areas of research and exploration beyond the digital — areas like design, flight, and directed energy.

This ebook explores how the U.S. military is looking to make rapid technological progress in areas such as autonomous flight, hypersonics, nature-aided design, ubiquitous sensing and new forms of directed energy. The general aim is to achieve unique competitive advantage over China and Russia.

The work is moving along more quickly in some areas, like hypersonics, than in others, like neutral-particle beams. Emerging technology is a field of unknowns by definition, after all. But technology has brought humanity to the point where concepts and plans that were once dismissable as too ambitious are now within practical reach. U.S. defense officials, such as Undersecretary of Research and Development Michael Griffin, now say that refusing to engage on big ideas represents a greater risk to the future security environment than making the attempt and coming short. As technology has become cheaper and more powerful, the United States no longer has ownership over innovation, a fact of which the Pentagon is keenly aware.

Patrick Tucker
Technology Editor
Defense One

US Air Force Wants Wargames that Simulate Lasers, Electromagnetic Weapons

The sims are meant to teach airmen about these new weapons and help the Air Force develop new tactics and procedures.

By Aaron Boyd

📷 A drone damaged by a laser during a 2017 test by U.S. Army's Space and Missile Defense Command and Army Forces Strategic Command Technical Center. | ARMY / MONICA K. GUTHRIE

Directed energy weapons—i.e., lasers and high-powered electro-magnetic weapons—are fast becoming a reality for troops and the Air Force wants its airmen to be prepared.

The Air Force Research Lab issued a request for information Friday seeking a vendor that can provide wargame modeling and simulations that include how energy weapons are being used today and how they will be used in the near future.

"The purpose of these [military utility] studies is to determine if and how well AFRL/RD and industry technologies can help address warfighter needs and gaps including complementing current fielded technologies and those under development by others," the notice states.

The Air Force has been working on laser weapons systems, or LaWS, and high powered electro-magnetics, HPEM, for some time, with plans to deploy the technologies on planes by 2020.

Earlier this year, AFRL officials said they successfully shot down "several" missiles using a ground-based laser system. Researchers are working on a smaller, lighter version of the tech—part of a program called the Self-Protect High

Energy Laser Demonstrator, or SHiELD—will be mounted on planes for aerial protection as soon as next year.

Through the simulations and wargames, the Air Force hopes to educate airmen on what to expect, as well as learn more from them about how the military should be adjusting to fight with and against these weapons.

"Distributed wargames provide a method of working with warfighters to develop tactics, techniques and procedures—TTPs—and concept of employment—CONEMP—to utilize these AFRL/RD and industry technologies to meet the warfighter needs and gaps," according to the RFI.

The training program will focus on five areas:

▸ **Modeling**: Develop models that run at accelerated speeds while maintaining real-world conditions and results. The models should use artificial intelligence and machine learning to improve over time.

▸ **Simulation**: Using those models, the vendor will develop simulations for airmen to train on, including scenarios that enable users to mix and match tools, techniques and resources to different effects.

▸ **Analysis**: Analytic tools should collect data and return results on trainee performance, as well

as the fidelity of the models and simulations to real-world situations and physics.

▸ **Studies**: Participate in studies to further research into directed energy weapons. Those studies will look to "identify what questions need to be answered, what modules are required, what simulations need to be run for specific missions and what analyses need to be performed to answer study questions."

▸ **Wargames**: All this culminates in "distributed wargames" that will be used to determine whether emerging technologies are ready to be transitioned to the battlefield. The contractor will be expected to "facilitate and participate in" these events, as well as manage the upkeeping and development of the platform.

Vendors able to meet these requirements should submit capability statements to AFRL by mail by Aug. 19. All responses should be unclassified and any proprietary information should be marked as such.

The solicitation notes that the final deliverables on the contract "may contain Military Critical Technology List information whose export is restricted....Therefore, only offerors who are certified by the Defense Logistics Information Services may submit statements of capability." **D**

The Pentagon Is Turning to Nature to Solve Its Most Complex Problems

DARPA is exploring ways to harness chemical reactions, biological processes and other natural phenomena to build a more efficient computer.

By Jack Corrigan

Modern computers aren't powerful enough to handle the Pentagon's most complex models and simulations, so the department is looking to nature for a new solution.

On Aug. 1, the Defense Advanced Research Projects Agency kicked off a research initiative that looks to harness the computational power of living cells, chemical bonds and other natural processes to develop more efficient computers. Participants in the program, called Nature as Computer or NAC, will rapidly explore a wide array of computational processes found in the natural world and prototype systems that can mimic them in a lab.

In the years ahead, the most promising projects could spin off into their own full-fledged DARPA programs, with the potential transforming aviation, robotics, nanomaterials and an untold number of other fields, according to NAC Program Manager Jiangying Zhou.

"We're trying to learn from the mechanisms nature is using and then engineer materials to mimic that process," Zhou said in a conversation with Nextgov. "A lot of those [computational] feasibilities are already established by the research community. NAC is pushing us to go one step further, saying, 'OK, now all these are possible. Can they be used to solve really hard problems?'" The NAC program seeks to address the same fundamental challenge that's fueling the government's quantum computing research: the silicon-based, binary computers that exist today aren't equipped to solve the complex problems the U.S. faces today. Using classical computers to simulate nuclear detonations, model air turbulence or predict other intricate physical processes
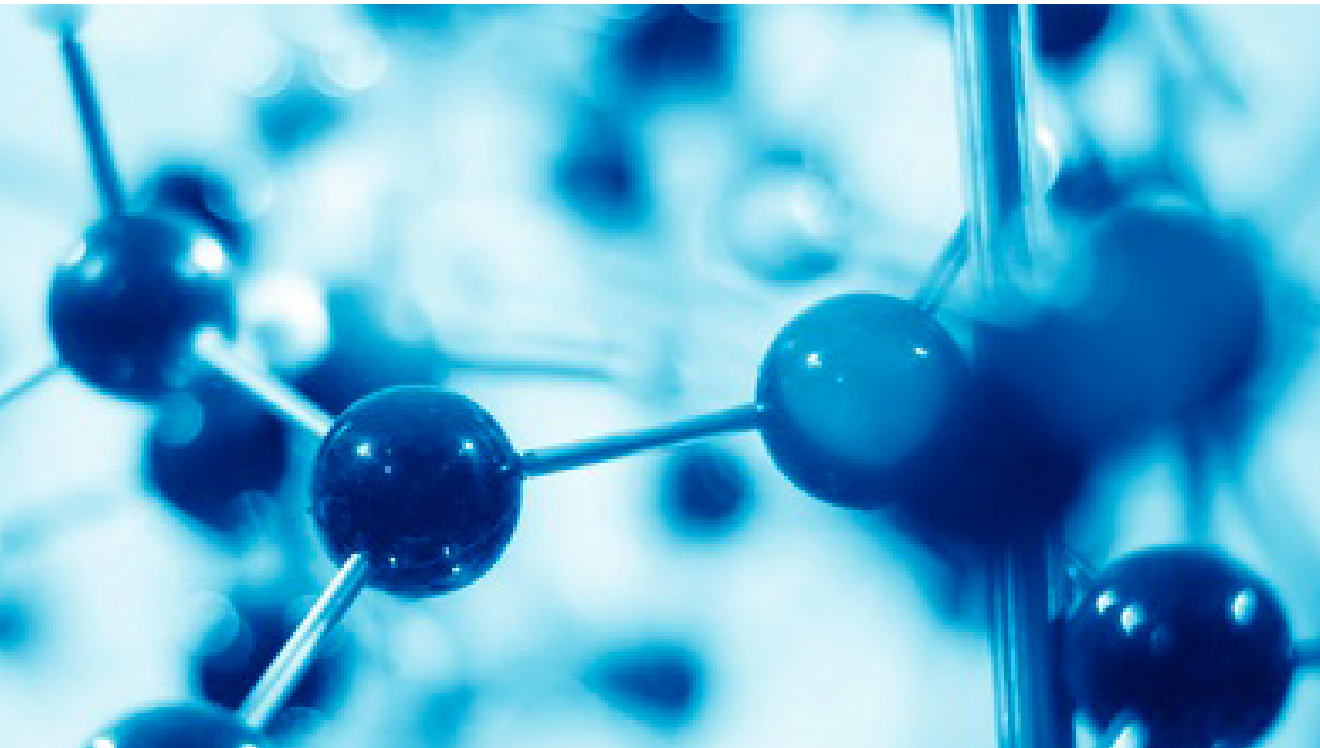
consumes a significant amount of time, money and hardware, which even the Pentagon can't always afford.

"Without a change in computing technology, the level of power consumption, fault tolerance, and cost necessary for large-scale multiphysics modeling may be enormous and impractical," DARPA officials wrote in the NAC solicitation. While quantum technology offers one solution, research has also shown natural processes could help solve these problems with a fraction of the resources.

Take protein folding, the process by which proteins built by living cells contort themselves into the three-dimensional structures that let them function properly. Protein folding is "exponentially complex" for scientists to model on a computer, but in the real world, the entire process is completed in a matter of milliseconds, Zhou said.

Researchers still don't fully understand the mechanisms at play in protein folding, "but one of the insights from the current scientific understanding is nature seems to be seeking a different computing strategy," she said. And instead of using a separate piece of hardware to complete the computation, like a server or mainframe, the process occurs within the protein itself.

"It doesn't need to be plugged into a power outlet … but if you're running the same algorithm on the computer … it consumes a huge amount of power," Zhou said. "That's where the efficiency is coming from."

By learning how to harness this process, she said the Pentagon could potentially build airplane wings that automatically adjust their shape for different conditions or so-called "soft robots" that can adapt to their environment through decentralized intelligence, much like an octopus.

Besides protein folding, there are numerous other natural processes that could potentially yield the same sort of efficiency; researchers have found light waves, chemical reactions, and certain composite materials all have properties that humans could potentially co-opt to solve computationally complex problems.

Under NAC, participants will select a natural computational process they wish to exploit and complete a proof-of-concept demonstration by the end of the 18-month program. DARPA will offer each team up to $1 million in funding.

The program is hosted under DARPA's Disruptioneering initiative, which offers small bursts of funding for high-risk, high-reward research efforts. The agency adopted a similar model to support its more ambitious artificial intelligence projects.

If NAC results in a prototype or idea that proves to be "at least theoretically feasible," DARPA intends to launch a bigger, better-funded program explore it further, Zhou said.

Teams interested in participating in NAC must submit their proposals by Sept. 3. **D**

A Small Texas City Will Become the Country's 'Hypersonics Research Capital'

The Army Futures Command will test missiles and autonomous vehicles some 100 miles east of Austin.

By Patrick Tucker

The U.S. Army Futures Command may be in Texas to take advantage of Austin's tech-startup scene, but the Lone Star State has at least one other feature that meshes well with research into hypersonic missiles, lasers, and autonomous weapons: lots of room.

On Thursday, Texas A&M University announced that it will build a $130 million testing range, lab, and proving ground for the Futures Command on a 2,000-acre campus near the small city of Bryan, about 100 miles east of Austin. The facility will include a kilometer-long testing tunnel for hypersonic missiles, weapons that fly at five times the speed of sound.

"Texas A&M will be the hypersonics research capital of the country with the planned construction of a 'ballistic aero-optics and materials' [or BAM] facility," Katherine Banks, Vice Chancellor and Dean of Engineering at Texas A&M, told a meeting of the university's board of regents on Thursday. "BAM will consist of an above-ground tunnel that is one kilometer long and two meters in diameter with integrated sensors. It will be used for hypersonic and directed energy research."

Currently, the Pentagon does much of its hypersonics testing at NASA's Ames, Ca., facility, home of the world's largest wind tunnel: at 80 feet by 120 feet. Military

> **[The ballistic aero-optics and materials facility] will consist of an above-ground tunnel that is one kilometer long and two meters in diameter with integrated sensors.**
>
> **Katherine Banks**
> **Vice Chancellor and Dean of Engineering, Texas A&M**

leaders have pointed out that China has built more test ranges for hypersonics than the United States. That's contributed to a research and development gap in missile development. "If you look at some of our peer competitors, China being one, the number of facilities that they've built to do hypersonics...surpasses the number we have in this country. It's quickly surpassing it by two or three times. It is very clear that China has made this one of their national priorities. We need to do the same," DARPA director Steven Walker told reporters in March 2018.

The new facility will also have what the university is calling an "Innovation Proving Ground" for testing autonomous vehicles. "The systems involved are highly complex with networks and sensors using innovative operating approaches. Because of the integrated instrumentation and land area, a test-site like this is unique," said Banks.

The Texas legislature kicked in $50 million to help develop the facility. Texas A&M will spend $80 million, including a $50 million building with labs, an office for the Army Futures Command, and an accelerator space; and $30 million for infrastructure improvements. **D**

Air Force Tests Contraption That Can Turn Any Plane Into a Robot Plane

Scientists say new ROBOpilot completed a two-hour test flight, essentially turning a manned plane into a drone.

By Patrick Tucker

📷 **ROBOpilot First Flight | AIR FORCE RESEARCH LAB**

Air Force scientists have announced that they had tested a robot kit that can turn virtually any plane into a self-piloting drone, through a program called ROBOpilot.

Why is that important? For starters, planes and drones are expensive. The drone shot down over Iran last month cost $220 million. For years the military has rushed to fund fabulous, exquisite drones of all shapes and sizes. Some, like the $15 million MQ-9 Reaper from General Atomics, are cheaper than manned military aircraft. But the big ones are more expensive than many types of civilian sport aircraft.

"Imagine being able to rapidly and affordably convert a general aviation aircraft, like a Cessna or Piper, into an unmanned aerial vehicle, having it fly a mission autonomously, and then returning it back to its original manned configuration," said Dr. Alok Das, senior scientist with the Air Force Research Lab's, or AFRL's, Center for Rapid Innovation, in a statement. "All of this is achieved without making permanent modifications to the aircraft." AFRL has partnered with DZYNE Technologies to produce the kit.

The system interacts with flight controls just like a human pilot, pushing all the correct buttons, flipping the switches, manipulating the yoke and throttle and watching the gages. "At the same time, the system uses sensors, like GPS and an Inertial Measurement Unit [essentially a way for a machine to locate itself in space without GPS] for situational awareness and information gathering. A computer analyzes these details to make decisions on how to best control the flight," AFRL said in a statement. Once the flight is done, the kit can be pulled out and the plane reconverted to one requiring a human pilot.

On August 9, the system completed a two-hour test flight at Utah's Dugway Proving Ground.

In theory, the same or a similar technology could be applied to expensive fighter aircraft. And the military has said that the next, sixth-generation fighter will be optionally manned. But the military has expressed reservations about allowing autonomous software to undertake lethal actions, so don't expect to see ROBOpilot doing combat missions anytime soon. **D**

DHS Seeks Standards for 'Smart City' Sensors, Starting in St. Louis

Public-safety IoT devices promise to help cities dispatch and direct first-responders and other municipal agencies — if the devices can talk to each other.

By Brandi Vincent

The Homeland Security Department's Science and Technology Directorate is kicking off a pilot program that will test the integration of smart city technologies in St. Louis, Missouri, the agency announced Wednesday.

Working in collaboration with the city and the Open Geospatial Consortium, agency insiders will use the pilot to research, design and assess Homeland Security's Smart City Interoperability Reference Architecture, or SCIRA.

"There's tremendous pressure on cities, right now," Norman Speicher, a program manager working in the weeds of the project told Nextgov. "Many municipalities, I do hear that they are being pressured and that there's this expectation that they know what 'smart cities' means—and it really means many things to many people."

As more cities turn to next-generation technologies to support public safety, the department recognized a need to ensure that the new smart tech is interoperable with city departments and other jurisdictions and that city officials understand its potential, implications,

and requirements. SCIRA aims to assess standards as they develop in the realm of public safety and support the development of an open architecture for interoperable internet of things sensors.

Through its findings, the program seeks to offer cities open methods for incorporating IoT sensors into their services while also ensuring that appropriate standards are being met.

During the pilot set to take place at a technology innovation center in downtown St. Louis called T-REX, Homeland Security will test how SCIRA works as a framework to integrate commercial proprietary IoT sensors and other devices for public safety applications at the community level. It will essentially integrate and test existing technologies' impact on daily operations. Insiders will evaluate the technologies' performance and capability to boost public safety through a series of events such as flash flooding, vulnerable population outreach and building fire scenarios.

"Smart cities can augment the information that cities have at their disposal and allow them

St. Louis skyline | ANETA WABERSKA / SHUTTERSTOCK

to be more efficient," Speicher said.

Speaking from St. Louis where he's attending kick-off events, Speicher said the comprehensive project will rollout as a series of activities. This week, a variety of city, federal and OGC stakeholders are meeting to learn about and discuss various scenarios and how the technology provides augmenting capabilities. In October they'll meet again to hone in on what execution will really look like and the final event will culminate into a blend of table-top exercises and operational elements of a sort of real-world scenario that demonstrates how city insiders can leverage the tech.

"This is a way to get them to think creatively and operationally that this is the tech that exists out there and ultimately what they are looking to do is use that to continue to think about what would be their priority in terms of procurement and what would have the most immediate operational impact and benefits," he said. "So it's really to further their vision and discussion to what a smart city means to St. Louis."

Speicher said the city will need to pull in elements of their existing infrastructure to be realistic and garner the most effective insights from the project. St. Louis' chief technology officer, who serves as Homeland Security's main point of contact, likely plans to leverage some small sample of the city's cameras as an example. They are also going to deploy flood sensors from another Homeland Security project.

"We realize that the timeline won't allow for a complete integration [of the tech], but certainly enough to collect meaningful information and understand the scale and scope of what a procurement and subsequent implementation might look like," he said.

With that in mind, he said stakeholders involved are already making careful considerations around privacy and security.

"I'm sensitive to it," Speicher said. "I don't know the scale or scope at this point in time but I don't see it as being fundamentally different than our other experiments in the sense of ensuring that we can evaluate the tech without any exposure or concerns with privacy-related data."

He added that the collaboration is already proving to be "a great alignment of the stars."

On top of the city's initial enthusiasm and opportunistic timeline, when considering the collaboration Homeland Security also valued St. Louis' desire to have the smart city research ultimately inform their future acquisitions.

"If we have a significant impact in informing St. Louis in their procurement decisions and their acquisition decisions, I think that's definitely the ultimate goal," he said. "We would logically then look to replicate this for other cities." **D**

Pentagon Shelves Neutral Particle Beam Research

One of the U.S. military's most ambitious space-based projects has crashed back to Earth.

By Patrick Tucker

Defense officials are taking a step back from one of its most ambitious research goals: launching a massive neutral-particle-beam generator, essentially a ray gun, into space to fry the electronics of enemy missiles. The funds will go instead toward more fundamental research aimed at making lasers more powerful, according to Michael Griffin, defense undersecretary for research and engineering.

It marks a return to Earth for one of the biggest ideas that the Department has broached in recent years. Griffin first publicly floated the idea of a neutral particle beam in space in March 2018, while highlighting potential directed-energy weapons beyond high-powered lasers.

"High-powered microwave approaches can affect an electronics kill. The same with the neutral particle beam systems we explored briefly in the 1990s," he said.

In March, Defense and military officials announced their intention to test a neutral particle beam in space in 2023, and requested $34 million to develop it in the 2020 budget.

$34M

Budgeted cost of developing a neutral particle beam by 2023

Congressional Democrats weren't pleased. In May, the House Appropriations Committee stripped the beam's funding from their version of the defense authorization bill.

Kingston Reif, who leads disarmament and threat reduction policy at the Arms Control Association, summed up the view of the project's detractors. "Congress made it clear it wouldn't fund the project, so the writing was on the wall. But this begs the question of why Griffin included $34 million for the gambit in the FY 2020 budget request — and $380 million over the next five years — in the first place. Space-based interceptors, whether kinetic or non-kinetic, would be costly and massively destabilizing. The

costs and risks vastly outweigh any potential benefits," Reif told Defense One in an email.

On Wednesday, Griffin acknowledged the hard truth. "We are deferring work on neutral particle beams, indefinitely," he said at the Defense News conference in Virginia. "It's just not near-term enough."

But Griffin added that the Pentagon is still pursuing directed energy research in lasers and microwave energy, aiming eventually to deploy them on combat aircraft, with ground units, and aboard satellites.

"My own opinion is we need to get systems built and put onto platforms so we can see what they do how they do it," he said, meaning how the weapons interact with their platform(s) and environment. "We need to understand the lethality of those systems, things like beam control. We need to know how to scale them up in practical ways. If you have 250 kilowatts of, say, laser, and you are operating at best at 50-percent efficiency, you have to figure out what to do with the other kilowatts of heat.
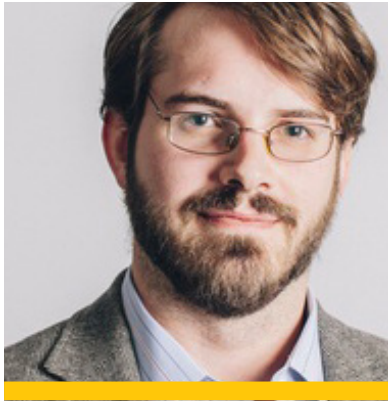
"So there are a lot of practical problems with real-world weapons systems," he said. "We are spending money on it." **D**

An artist's rendering of a neutral particle beam. | IMXPIX IMAGES
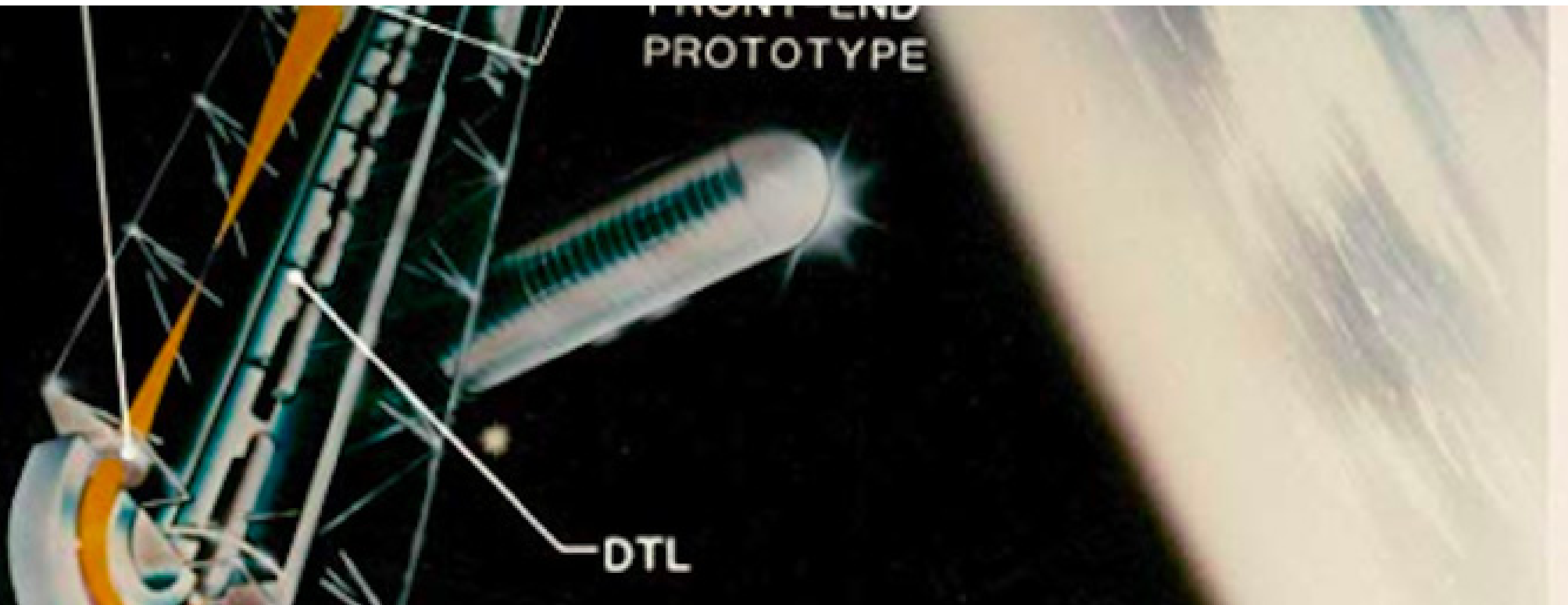
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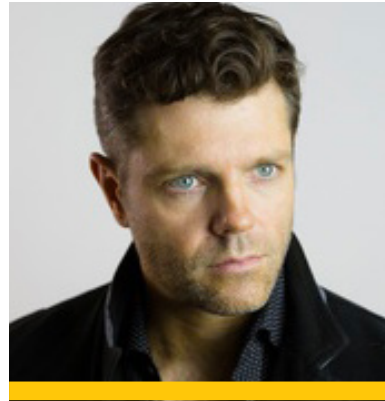
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