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TRL 4

LIFE SCIENCES

## Drug delivery and targeting including personalised treatments using molecular recognition

Designer gene therapy; embryonic treatment of hereditary diseases. Use of nucleotide polymorphism to tailor individual requirements to pharmacological treatments.



TRL 3 LIFE SCIENCES

## Computational drug design and testing

Modelling and mathematics to develop working models of complex biological processes for the identification of disease and prediction of DNA interactions. Nascent fields such as biosimulation, pharmacogenomics are expected to mature first and will give rise to fully predictive biomedicine for development of tailored treatments, including addiction. “Laptop labs” will allow the simulation of bio-processes in the early design of drugs



TRL 4 LIFE SCIENCES

## Medical nanostructures for drug delivery

Metal (gold) covered non-conducting nanoshells are injected into cancerous tissue. Nanoshells have been injected with a specific antibody specific to that type of cancer so that the shells bind to cancer only. Once light of specific frequency is shone, nanoshells emit heat and kill the cancer.



A microscopic image showing numerous green fluorescent cells, likely bacteria or yeast, against a dark background. The cells are of various sizes and are brightly lit, showing internal structures.

TRL 6

LIFE SCIENCES

# Nanobiology

Application of nanotech to treat disease and detect changes on nano-level (better drug delivery and vaccine development, advanced nano-sensing of CB threats, sensing of biological signatures)



TRL 5

LIFE SCIENCES

## Genetic modification of biological organisms

Control of pests, disease and improvements in food production. Stem-cell therapies to supplant pharmacological approaches.



TRL 3

LIFE SCIENCES

## Water purification using nanotechnologies

Use of nanoscale porous membranes to improve the efficiency and reduce the size and energy consumption of desalinisation plants. Nano-ceramic sponges can remove industrial contaminants; biofilters can remove bacteria viruses and prions. Nanoscale purification, disinfection and measurement are expected to standardise wastewater treatment that is more efficient, effective and small.



TRL 2

LIFE SCIENCES

## Advanced biometrics

DNA pattern recognition. Behavioural and passive biometrics. Facilitated by detection and characterisation of traces of DNA from as little as a single molecule, complex sensory networks and computational models.

Ubiquitous sensing and embedded biometric algorithms. Speech and language recognition. Intelligent information processing based on aural language comprehension, biological characteristics.

A scanning electron micrograph (SEM) showing a dense, tangled network of thin, elongated nanowires. The wires are light gray against a dark background, creating a complex web-like pattern.

TRL 4

LIFE SCIENCES

## DNA microarrays, rapid bioassays and nanowire sensors

Enable optoelectronic and chemical detection of DNA for testing against viruses, toxins, drug interactions – could replace current microarrays. Correlation of DNA interactions with physical processes



TRL 3

LIFE SCIENCES

## Biological process identification and modelling

Use of RNA interference techniques to rapidly link DNA functions to biochemical processes (2012-2019). Development of mathematical models of complex biological systems (2050).



TRL 5

LIFE SCIENCES

## Environmental models and complex simulations

Application of complexity theory to modelling biological systems and environmental processes. Design of efficient operations and urban planning. Accurate climate and weather modelling. Predictive and accurate models of anthropogenic climate effects.



TRL 3

LIFE SCIENCES

## Neurochemical behavioural markers and mapping of high-order brain functions

Development of cognitive sensors for brain-machine interfaces and human mental performance augmentation. Integration of massive analytics to understand neural computations, learning and pattern recognition





TRL 4

LIFE SCIENCES

## Embedded health monitoring sensors

Remotely accessible, embedded sensors for individual performance and health monitoring. Instantaneous delivery of treatments in emergency situations to combat pathogens and adverse biological symptoms. Highly selective miniaturised sensors for chemical and biological threats.



TRL 5

LIFE SCIENCES

## Widespread sensor networks

Miniaturised, self-powered, processing-enabled sensors that are ubiquitous globally. Enabling massive data gathering and analysis about living organisms and infrastructure. Aided by growth in embedded sensors and computational devices in personal goods.



TRL 4 LIFE SCIENCES

## Accurate prediction and modification of human behaviour and intent

Modelling of human cognition based on biological processing. Application of statistical methods to behaviour modelling and prediction of behaviour. Reasoning under great uncertainty. Use of applied sociology across multiple scientific disciplines. Combination of neuroscience and psychiatry for brain imaging and high-level functional mapping.



TRL 7 LIFE SCIENCES

## Artificial implants for improvements or recovery of biological functions, including brain-machine interfaces

Controlling/mimicking high-order biological functions through synthetic means. **Artificial** extensions of human capabilities, including brain repair (2020-2030). Long lasting, bio-compatible cochlear, optoelectronic implants for better sensing performance. Brain-machine interfaces.



TRL 4

LIFE SCIENCES

## Pharmaceutical or biological human performance modification

Use of drugs for increased cognition, performance, reduced sleep. Pharmaceutical improvements to intelligence, memory, endurance (2030-2060). Behaviour modification. DNA modification for offspring selection based on performance characteristics (2030-2060). Understanding and treating brain conditions.

A photograph of a bio-engineered human ear, which is pinkish-white and has a realistic, curled shape. It is resting on a transparent, circular, nanopatterned scaffold inside a clear petri dish. The background is dark, and the lighting highlights the texture of the tissue and the structure of the scaffold.

TRL 4

LIFE SCIENCES

## Restoration/regeneration of human body parts

Skin, tissue and organ growth on nanopatterned scaffolds. Bio-engineered tissue and organs grown in-vivo.



TRL 8

LIFE SCIENCES

## Integrated machine control

Wearable computers for device control.  
Hands-free interfaces and input devices  
(voice recognition, gestures, optical sensing)  
for rapid communication of intent to  
autonomous systems.



TRL 8

LIFE SCIENCES

## Immersive optical interfaces

Contextual, flexible and interactive displays augmenting human visual perceptions to provide a fully seamless simulation or entertainment experience and extending visual capacity.





TRL 7

LIFE SCIENCES

## Bio-mechanical robotic integration and biomimetic devices

Introduction of biomimetic implants and biologically inspired mechanical concepts.  
Remote control of insects in flight.  
Development of bioelectronic devices.  
Application of biomimetic robotics.  
Autonomous decision making on robotic platforms. Intelligence [sic] service robots.



TRL 6

LIFE SCIENCES

## Bio-factories and biological substrates

Large scale manufacturing of synthetic biochemicals. New discoveries of reproducible biological processes and molecules. Mass application of **artificial** photosynthesis to organic solar cells (**artificial** leaves). DNA modification of animals and plants to produce new materials (spider silk spinning from goat milk). Use of silk worms to spin spider silk.

A photograph of a plant, possibly a tobacco plant, with its leaves and stems glowing with a bright green fluorescence. The plant is set against a dark, almost black background, which makes the glowing parts stand out. The leaves are large and have a distinct vein pattern, some of which are covered in the green glow. The stem is also visible and glows. The overall image has a high-contrast, scientific feel.

TRL 4

LIFE SCIENCES

## Synthetic biological engineering

Manufacture and application of synthetic chemicals such as bioactive peptides to target specific cellular receptors and affect human behaviour. Developments in genomics and proteomics to create synthetic organisms engineered to achieve specific tasks.



TRL 6

MATERIALS AND MANUFACTURING

# Nanomaterials and structures

Application of nanotechnology to embed multifunctional characteristics into materials.





TRL 4

MATERIALS AND MANUFACTURING

## Metal-organic compounds

Structural self-assembly. Safe hydrogen storage. CO<sub>2</sub> capture. Mass manufacture of organic electronics.



TRL 5

MATERIALS AND MANUFACTURING

## Biomedical materials

In-situ cellular and organ self-repair. Tissue engineering and regenerative medical applications.



TRL 7

MATERIALS AND MANUFACTURING

## Specialised, high-performance coatings

Multi-functional coatings that improve existing material strength, endurance, reduce friction, lower RF signatures and increase resistance to environmental hazards.



TRL 5

MATERIALS AND MANUFACTURING

## De-icing composites

Composite materials that actively remove ice crystals or impede their growth.



A hand is holding a glowing green cylindrical device, possibly a microchip or a small electronic component, in a laboratory setting. The background is blurred, showing various pieces of equipment and wiring. The device is emitting a bright green light, and the hand is positioned in the foreground, holding it gently.

TRL 4

MATERIALS AND MANUFACTURING

## Electronic materials

Specifically programmed materials with embedded functional elements. Combined photonic and electronic effects. Large band gap semiconductors that operate at high frequencies.



TRL 7

MATERIALS AND MANUFACTURING

## Smart fabrics

Fabrics embedded with electronics, power sources and optoelectronics. Protective clothing, bioactive textiles that remove toxins, electronic textiles capable of remote sensing, adaptive textiles incorporating actuators, reactive textile that respond and change shape to external stimuli such as impacts.


A microscopic image of a translucent, yellowish material with a visible vertical crack. The material has a wavy, organic shape. The background is dark and out of focus.

TRL 4

MATERIALS AND MANUFACTURING

## Self-healing materials

Routine self-repair and maintenance performed automatically and in flight.

A solid, bright blue horizontal bar spanning the width of the slide at the bottom.



TRL 3

MATERIALS AND MANUFACTURING

## Room temperature ferromagnets and superconductors

Use of new materials for high density data storage, new computing architectures such as memristors and quantum computing and high-energy applications



TRL 4

MATERIALS AND MANUFACTURING

## Carbon nanotube

Portable and inexpensive water purification using CNT membranes and filters. Use of CNTs to create new composites that are stronger and lighter – CNRPs. These may be used to create efficient morphing wings, radiation resistive space hardware, impact resistance; space elevator. More immediate applications will be to lighten vehicles where performance is secondary to cost. Integrated sensor ability using nanotubes. Nanotubes...

A scanning electron micrograph showing a dense, tangled network of nanowires. The wires are thin, elongated, and appear to be interconnected, forming a complex mesh-like structure. The background is dark, and the wires are light gray, creating a high-contrast image.

TRL 4

MATERIALS AND MANUFACTURING

## Nanowires

Extremely low resistivity and vast increases in electronics' efficiency. Used in the replacement of copper wires and as heat sinks as they have great thermal conductivity. Can be used in miniaturising spacecraft. May exhibit superconductivity near room temperature. Improvements in greater battery energy densities compared with Li-ion devices.



TRL 2

MATERIALS AND MANUFACTURING

## Quantum materials

Materials with tailored quantum effects for use in quantum computers, high-temperature superconductivity or lasers. Macro-quantum effects of photonic material, new principles for quantum manipulation, characterising and measuring.

A close-up photograph of a person's hand holding a pair of glasses. The hand is positioned with the thumb and index finger gripping the top of the frame, while the other fingers are curled underneath. The glasses have a thin, dark frame and clear lenses. The background is a soft, out-of-focus grey. The overall image has a clean, professional aesthetic with a light blue gradient at the bottom.

TRL 6

MATERIALS AND MANUFACTURING

## Reactive materials and structures

Shape-adaptive materials that react to electric currents, kinetic forces. Shapememory materials that can be programmed to take on certain configurations in specific environmental conditions. Reactive nano-armour composites for battlefield use. Impact resistant rheo-fluidic systems.





TRL 4

MATERIALS AND MANUFACTURING

## Next generation low observable materials

Adaptive camouflage in the visible and microwave regions. RF absorbing metamaterials with reduced EO/IR visibility.

A microscopic view of a silicon photonic device. The device features a complex arrangement of gold-colored metal contacts and a central yellowish component, possibly a waveguide or resonator. It is mounted on a green printed circuit board (PCB) with various electronic components and a circular blue feature. The background is a blurred blue and green.

TRL 4

MATERIALS AND MANUFACTURING

## Silicon photonics

Optical processing on future computing platforms for massive decreases in heat dissipation and increases in processing speed.



TRL 4 MATERIALS AND MANUFACTURING

## DNA fabrication techniques and nanomolecular manufacturing

Application of molecular self-assembly and programming using DNA information on a macroscopic scale.

A close-up photograph of a 3D printer's extruder head, which is silver and yellow, positioned above a partially completed blue printed part. The background is blurred, showing a person's hands working on a surface. The text 'CAUTION' is visible on the printer's head.

TRL 6

MATERIALS AND MANUFACTURING

## On-demand manufacturing

Development of 3D printers with multifunctional materials to produce complex designs for the end user. Low complexity, low-energy manufacturing. Decreased reliance on mass production and factories.



TRL 3

MATERIALS AND MANUFACTURING

## Programmable manufacturing

Nano-brick self-assembly into functional electronic, mechanical, optical or biological structures. Creation of quantum nanostructures for use in brain repair or quantum computing. Manufacturing technology using advanced information technology and service robotics.

The background of the slide is a dark blue-green gradient. On the left, a dark rectangular block has the equation  $\hat{H}\Psi = E\Psi$  inscribed on it. To the right, several glowing green mathematical formulas are visible, including  $E_{\text{total}} = E_{\text{kin}} + E_{\text{pot}}$ ,  $\Psi$ ,  $\Psi = \sum c_i \phi_i$ , and  $\Psi(r) = E\Psi(r)$ .

TRL 2

MATERIALS AND MANUFACTURING

## Quantum chemistry

High fidelity chemistry models used in the prediction of reaction rates, energy flows and chemical pathways to maximise reaction efficiencies and reduce waste by products.

A close-up photograph of vibrant green tea leaves. Sunlight filters through the foliage from the upper right, creating a warm, golden glow and soft shadows. The leaves are sharp in the foreground and gradually blur into the background.

TRL 4

MATERIALS AND MANUFACTURING

## Green chemistry and manufacturing

Use of biomass and low toxicity chemicals in manufacturing. Development of new chemical reactions and process simulations to support efficient manufacturing.



TRL 5

MATERIALS AND MANUFACTURING

## Extreme manufacturing

MEMS, NEMS for precision manufacturing;  
extremely powerful functions for operations in  
extreme environments.



A person is standing in a server room, working on a laptop. The room is filled with rows of server racks, which are illuminated with blue and yellow lights. The person is wearing a dark blue shirt with white stripes on the sleeves and is holding a red cup. The server racks are filled with various components, including cables and lights.

TRL 6

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Massive analytics

Vast databases that may include personal, genetic and biometric information will require supercomputer-like processing power on demand to complete smart contextual searches. Algorithms and computational models could be developed to complete sophisticated pattern matches, track logistics and engage in market trading. Autonomous systems may be supported by similar massive analytics to make real-time decisions under...



TRL 5

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Semantic web

Machine readable context will allow accurate human-machine coupling and data sharing in time-sensitive applications.



TRL 4 COMPUTING AND ARTIFICIAL INTELLIGENCE

## Miniaturised high-density data storage

MRAM and spintronic applications to new computing architectures providing high data densities in miniaturised packages. Possible transistor replacements for miniaturised and more powerful computing architectures. Applications to neuromorphic computer systems and pattern recognition.

A hand is holding a transparent sphere. The sphere reflects a cityscape with a prominent rainbow arching over it. The background is a clear blue sky with some clouds. The hand is positioned at the bottom, with fingers visible.

TRL 5

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Computational sociology and prediction of mass behaviour

Application of social network modelling and novel cognitive models to estimate human behaviour and intent autonomously



TRL 4

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

# Bioinformatics

Data gathering and process identification in complex biological environments using a combination of nanosensors, massive analytics and autonomous reasoning.

A photograph of a weather station in a field. The station consists of several tall poles with various sensors and instruments attached. The background shows a clear sky and some distant trees.

TRL 5 | COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Accurate weather forecasting

Interdisciplinary interaction between complex atmospheric models, sensor networks and new computing architectures with massive processing power will enable accurate decision-level predictions.



TRL 3

COMPUTING AND **ARTIFICIAL** INTELLIGENCE

## Quantum computing

Will enable massively parallel computations for quantum cryptography, pattern recognition, autonomy and simulations. Quantum informatics, correlated electronics, quantum communication, confined small-scale quantum system and **artificial** photonic crystal for future IT development.



TRL 4

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## DNA computing

Biochemical nanocomputers based on biochemical interactions of protein chains. Will provide very large improvements in computational power and will be self sustaining and have the potential for self-repair. Could be integrated with biological organisms for direct interactions with cellular chemistry and autonomous biological regulation.



The background of the slide features a dark blue, almost black, field filled with glowing blue circuit patterns. Scattered across this field are several padlocks, some of which are open and others closed. The padlocks have a metallic, textured appearance with a glowing blue keyhole. The overall aesthetic is high-tech and digital.

TRL 4

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Ad-hoc networks

High-flexibility, attack free [sic] data networks and ad hoc intelligent system. Network polymorphism.



TRL 5 COMPUTING AND ARTIFICIAL INTELLIGENCE

## Artificial Intelligence and autonomous, intelligent processing

Gearing human intensive functions through processing-enabled devices. Robotic decision making based around autonomous reasoning and learning. Use of distributed sensing to be aware of environments. Trusted autonomy that can be validated.



TRL 8

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Software agents

Self organising and evolving software. Intelligent agents and bots. Automated software generation based on signal data recognition and autonomous learning within complex environments.

A close-up, grayscale image of a robotic hand with white and gray segments, positioned over a dark laptop keyboard. The hand is in a typing position, with fingers slightly curved over the keys. The background is blurred, showing more of the keyboard and the laptop's surface.

TRL 6

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Cyberspace UAV

Software agent that is adaptive and flexible while under cyber threats. Monitors and conducts ISR on the cyber environment. Repairs friendly nodes affected by malicious cyber operations

A woman with dark hair tied back, wearing a dark top, is seen from the side, looking at a large digital display. The display is divided into several sections. On the left, it shows a 3D wireframe of a building structure. On the right, there are two main panels. The top panel is a design board with various colored sticky notes containing text like 'modern', 'abstract', 'carbon finish', 'geometric', 'metal', 'organic', 'Post modern', 'welcoming', 'circular', 'Sleek', 'angular', and 'mix eras'. The bottom panel is titled 'Floor finishes' and shows images of wood and stone textures with sticky notes like 'Chestnut', 'distressed', 'Oak stain', 'oak', and 'Apple'.

TRL 6

COMPUTING AND **ARTIFICIAL INTELLIGENCE**

## Immersive collaboration tools

Self-organising networks for information management and flow. Community computing grids for efficient resource allocation and parallel computing. Peer production networks for rapid problem solving. Social mobile computing that supports collaboration and problem-solving in ad-hoc situations.



TRL 8

COMPUTING AND ARTIFICIAL INTELLIGENCE

## Virtual synthetic environments and adaptive training

Cultural, social and combat training. Virtual surgery. Quantitative simulations of social interactions. Data mining of social interactions such as online social networks or MMOG to quantify relationships and establish predictive models. Continuous, adaptive training.



TRL 5

COMMUNICATIONS AND SENSING

## Pervasive, undetectable sensor networks

Real-time data mining and health monitoring using NEMS or MEMS based sensors. Embedded combat ID. Smart-dust sensors that are completely undetectable and persistent.

A person's hand is pointing at a thermal image of a human figure displayed on a screen. The thermal image shows a person's silhouette with internal organs highlighted in red and yellow, indicating heat. The background is a blurred image of a person in a blue uniform.

TRL 6

COMMUNICATIONS AND SENSING

## Hyperspectral and terahertz sensors

Stand-off detection of substances such as explosives and chemical agents. Improved imaging systems for vision through surfaces such as water, walls and vehicles.

Multispectral sensor swarms.





TRL 4

COMMUNICATIONS AND SENSING

## On-chip BWA identification

Immediate recognition of toxic biological agents using nanosensors or DNA sensing techniques.



TRL 4

COMMUNICATIONS AND SENSING

## Stand-off laser detection of explosives

Ranged detection using a plasma pulse to evaporate small amounts of substance. Line of sight effects only.

The background of the top section is a dark blue gradient. It features several faint, concentric circles in a light blue or teal color, suggesting a radar or sonar scan. A prominent red line, possibly representing a trajectory or a specific radar beam, curves across the right side of the image. The overall aesthetic is technical and futuristic.

TRL 4

COMMUNICATIONS AND SENSING

## Miniaturised radar for UAV and personal applications

Use of NEMS/MEMS and high density energy storage to create a light-weight, portable radar system.

A network of interconnected metallic spheres, resembling a molecular or sensor network, set against a teal background. The spheres are connected by thin, metallic lines, forming a complex, web-like structure. The lighting creates highlights and shadows on the spheres, giving them a three-dimensional appearance.

TRL 5

COMMUNICATIONS AND SENSING

## Autonomous and self organising sensor networks

Processing enabled sensors that autonomously track their environment and can optimise placement for maximum data collection and interpretation.

A close-up photograph of a person's arm wearing a smartwatch. The watch has a dark, rectangular face and a light-colored, possibly fabric or leather, strap. The person is wearing a white t-shirt with a grey horizontal band across the chest. The background is blurred, showing a light-colored wall and a wooden surface.

TRL 5

COMMUNICATIONS AND SENSING

## Highly portable or wearable inertial and position, motion and acceleration devices

Chip-scale (micro and nano) atomic clocks for accurate timing in GPS-denied environments. Cold atom interferometric devices for acceleration measurements Highly portable or wearable inertial and position, motion and acceleration devices

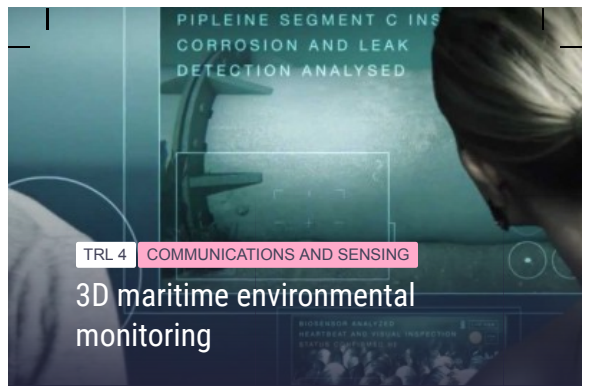


TRL 5

COMMUNICATIONS AND SENSING

## Hyperprecision munition

Use of autonomous munitions and networked sensors to provide real-time accurate ISR.

A person's profile is visible on the right, looking at a large digital screen. The screen displays a teal-colored interface with various data elements. At the top, the text 'PIPELINE SEGMENT C INS CORROSION AND LEAK DETECTION ANALYSED' is shown in a light blue, monospace font. Below this, there's a rectangular area with a grid and a central crosshair. In the bottom right corner of the screen, another text box reads 'BIOSENSOR ANALYZED HEARTBEAT AND VISUAL INSPECTION STATUS CONFIRMED BY'. The overall aesthetic is high-tech and futuristic.

PIPELINE SEGMENT C INS  
CORROSION AND LEAK  
DETECTION ANALYSED

TRL 4

COMMUNICATIONS AND SENSING

## 3D maritime environmental monitoring

Synchronised monitoring from space, offshore stations, water surface, and inwater. Research will be focused on remote marine sensing technology, acoustic probe technology, buoy technology, shore-based long-range radar technology, and marine information processing and application technology.

A deep-sea environment with a hydrothermal vent (black smoker) in the center. A submersible or ROV is visible in the upper right, emitting a bright blue light beam that illuminates the scene. The water is dark blue with some suspended particles.

TRL 4

COMMUNICATIONS AND SENSING

## Deep sea sensing

Ocean floor-based multi-parameter fast sounding technology, gas hydrates mining, deep-sea sample collection and communications.





TRL 4

COMMUNICATIONS AND SENSING

## Secure wireless links

Development of highly secure wireless, RF data links and encryption protocols for cloud computing applications and ubiquitous equipment-sensor links. Protocols will utilise polymorphic networks and may be highly frequency-agile and adaptive in order to be as resilient to cyber attacks as possible. Automated vulnerability assessments and reactions will allow such systems to maintain operational efficiency under ongoing cyber...

The background image shows a satellite in space, illuminated by a bright light source, possibly the sun. A beam of light, representing a laser communication, is shown traveling from the satellite towards a ground station on Earth. The ground station is depicted as a large, circular structure with a central lens or mirror. The overall scene is set against a dark, starry background, suggesting a space-based communication system.

TRL 5

COMMUNICATIONS AND SENSING

## Laser communications

Application of quantum key distribution to encrypt high bandwidth laser communications and provide full-spectrum access to communication channels in congested environments.



TRL 6

COMMUNICATIONS AND SENSING

## Persistent near-space communication relays

HALE airships with advanced thermal and meta-materials. Self monitoring and autonomy will further ensure survivability.



TRL 4

ENERGY

## Short-range laser defence

Destruction of air threats using MW-class, precision laser weapon. It can sense and track multiple targets and instantaneously engage it.



TRL 2 ENERGY

## Femtolaser

Self focusing, high power laser



TRL 3

ENERGY

## Space-based lasers

Two concepts: ground based laser with mirrored space relays or a space-based solid-state laser.



TRL 4 ENERGY

## Future airborne laser

Aircraft mounted nuclear-powered laser on board a manned platform with extremely long endurance (crew-limited).



TRL 4

ENERGY

## Tactical airborne laser

Use of solid-state and fibre laser systems to provide 300kW power and autonomous self defence against missile or aircraft threats. Possible tactical strike use.



A photograph of a military vehicle, possibly an M1 Abrams tank, equipped with electronic warfare equipment. A person in a blue shirt and jeans is standing on a blue ladder, working on a large, tan-colored electronic control unit mounted on the vehicle. A large, dark, parabolic antenna is visible on the left side of the vehicle. The vehicle is parked on a dirt surface under a blue sky with scattered clouds.

TRL 6

ENERGY

## Microwave and RF DEW

Delivery of electronic attack using directed energy to disrupt electronic components and personnel. Microwave beams will cause painful sensations with no lasting damage. RF attacks will damage electronics.



TRL 4 ENERGY

## High-density/high-efficiency energy storage technology

Hydrogen fuel cell development and use of CNT structures to ensure safe hydrogen capture and storage. Synthetic development of specialised high energy materials. Large scale applications of super-capacitors. Efficient rechargeable cell materials and supercapacitors.



TRL 4

ENERGY

## Controlled fusion power

New confinement, simulation and material could produce an operational reactor by 2030 and commercialisation no earlier than 2040. Research into large superconducting magnets, microwave heating, beam injection heating, materials, high-temperature plasma physics and non-Tokamak approaches to fusion



TRL 5

ENERGY

## Biofuels and synfuels

Production of fuels from biomass generated in shallow sea/desert conditions. Produces petrochemical feedstock in a closed CO<sub>2</sub> cycle (carbon neutral). Replacement of petrochemical sources with synthetic alternatives that are mass produced and not oil-dependant. Use of tactical biorefineries to convert waste and garbage into energy.

A photograph of a laboratory microreactor. It features a central grid of approximately 15 vertical, parallel glass or plastic tubes. To the left and right of this grid are two cylindrical ports with flanges, likely for fluid input and output. The device is mounted on a dark surface. In the bottom left corner, there is a white box containing the text 'TRL 5' and an orange box containing the text 'ENERGY'. Below these boxes, the word 'Microreactors' is written in a large, white, sans-serif font.

TRL 5

ENERGY

## Microreactors

Nanoengineered molecular reactors harnessing biochemical reactions inside living organisms or as part of a synthetic bio-machine. Very efficient, invisible and portable.



TRL 3 ENERGY

## Next-generation nuclear reactors

Fourth generation nuclear energy systems with increased efficiency. Fast neutron reactor technology (breeder).



TRL 4

VEHICLES

## Hypersonic air-breathing engines

Propulsion technology and materials that can withstand the extreme temperatures of hypersonic flight will take another 20 years to develop. Automatic diagnostic and prognostic systems will allow reusable combined rocket/scramjet platforms for low cost orbital insertion. Inward turning inlets and dual flow paths will provide high volumetric efficiencies. Hypersonic transatmospheric aircraft to deal with heat issue as above Mach 10.



TRL 4

VEHICLES

## Next generation high-efficiency turbine engines

Alternate fuels, serpentine nozzles, health monitoring, MEMS flow control and nanomaterials will be used to deliver efficient embedded turbine engines for future aircraft configurations





TRL 4 VEHICLES

## Dual mode propulsion (supersonic/hypersonic)

Dual mode propulsion  
(supersonic/hypersonic) stand-off missile with  
optical terrain following, advanced EW and  
jam-resistant PNT systems.



TRL 5

VEHICLES

## Supersonic/hypersonic bomber

Operational readiness of a new bomber platform is not likely until 2037 or beyond. Low observables in a supersonic configuration are the likely future requirements.



TRL 3

VEHICLES

## Hypersonic aircraft

Trans-atmospheric vehicle with global radius. Allows rapid, reusable access to space and orbital payload insertion. May have combined-cycle propulsion (rocket/scramjet) with vertical takeoff



TRL 3

VEHICLES

## HALE airships

Long endurance, large lift capacity, faster than equivalent seafaring transport options, large sensors. Requires high-altitude, radiation hardened materials. Lightweight solar panels and high density energy storage technologies. Multifunctional sensor structures. Has onboard health monitoring and potential self healing capabilities. Microwave power beaming for propulsion.

A white X-45 hybrid wing-body aircraft is shown in flight against a clear blue sky. The aircraft has a unique, blended wing-body design with a large, curved leading edge and a high, swept-back wing. Two engines are mounted on the upper surface of the wing. The NASA logo is visible on the side of the fuselage.

TRL 4

VEHICLES

## Hybrid wing-body aircraft

Highly unstable dynamically and requires fully automatic actuation and autonomous control under a variety of environmental conditions.

A close-up photograph of a small, rectangular, blue and gold MEMS device being held between two fingers. The device has a blue central area and gold-colored ends with small black square features. The background is a soft, out-of-focus grey.

TRL 3

VEHICLES

## MEMS flow control

Micro flow control to eliminate control surfaces and reduce drag by 80%.  
Application to lifting surfaces and propulsion systems. Observability reduced

A photograph showing several drones in flight against a twilight sky. The drones are silhouetted against the lighter, hazy background of the sky. They are arranged in a loose, non-linear pattern, suggesting a swarm. The sky has soft, horizontal bands of color, indicating the time is either dawn or dusk.

TRL 6

VEHICLES

## Autonomous swarming vehicles

Miniaturised, autonomous agents with a shared sensory network capable of swarming and re-organising in response to external conditions or operator intent.



TRL 5

VEHICLES

## Fractionated, survivable, remotely piloted system

Modular, composable platform that has autonomy in takeoff and landing. Has basic swarming elements for collaborative organisation. Low observable and expendable.



The image shows a Wingman UAS, a small, dark-colored unmanned aircraft, flying in formation with a larger, grey and blue manned fighter jet. The aircraft are positioned against a backdrop of a bright, cloudy sky. The Wingman UAS is seen from a side-on perspective, showing its wings and tail. The manned jet is slightly ahead and to the right, showing its cockpit and canopy. The overall scene suggests a military or defense application of the UAS technology.

TRL 5

VEHICLES

## Wingman UAS

UAS accompanies a manned aircraft to conduct ISR, air interdiction, IADS attacks, offensive counter air, C2 of micro-UAS and provides additional weapons payload to the main aircraft. The wingman UAS can also be a transport or refuelling platform. Has embedded electronic EW (jamming) capability, self repair and diagnosis systems.



TRL 6

VEHICLES

## Automated highways and vehicles for increased capacity and safety

Congestion and safety improvements in dense urban infrastructure. Management and autonomous, intelligent coordination of traffic flows both within and without the vehicle. Requires a persistent sensor network for complete traffic monitoring.

A detailed image of a Mars rover, likely a Curiosity rover, on the surface of Mars. The rover is a six-wheeled vehicle with a complex mast and camera system. It is positioned on a rocky, reddish-brown terrain with rolling hills in the background under a hazy, orange sky. The rover's solar panels are partially visible.

TRL 8

VEHICLES

## Unmanned space exploration

Unmanned space exploration will continue to far outnumber human space exploration with autonomous and sensor systems advanced as a result.



TRL 2

SPACE

## Persistent SSA

Allows birth to death detection, tracking, advanced collision warning. Requires massive data fusion across sensor platforms. Use of a Space Based Surveillance system for detection and tracking including identification of payload using EO/IR sensors.

A detailed image of a satellite in space. The satellite has a complex structure with various instruments and a large solar panel array extending from it. It is positioned above the Earth's horizon, which shows a blue and white atmosphere. A bright star with a lens flare is visible in the upper right corner of the image.

TRL 3

SPACE

## Orbital Conjunction Prediction

Predictions of environmental interactions on spacecraft and their orbits. Monitors space weather, sensors fusion (SSA), satellite drag models. Will provide enough confidence in predictions to manoeuvre space assets out of harms way, if needed.

The image shows a satellite in orbit above Earth's surface. The satellite has a cylindrical body with several blue rods protruding from it. A bright orange sphere, representing a target, is visible on the ground. A trail of smoke or fire is seen where the rods are striking the target. The background shows the Earth's surface with blue oceans and brown landmasses.

TRL 3

SPACE

## Hypervelocity rod bundles for kinetic bombardmen

Tungsten rods delivered de-orbited from an orbital satellite platform striking global targets at orbital speeds.

A sleek, black, air-breathing rocket is shown in a steep climb against the backdrop of Earth's blue and white clouds. The rocket has a long, slender body with a pointed nose and a small, dark, rectangular sensor or antenna protruding from its side. The Earth's horizon is visible at the top of the frame, with a thin layer of white clouds separating the dark blue of the sky from the lighter blue of the planet's surface.

TRL 3

SPACE

## Reusable Air breathing Access-to-Space Launch

Vertical takeoff space launch using rocket first stage and air breathing rocketscramjet second stage. Requires advanced thermal materials, automation, onboard health monitoring systems.



TRL 4

SPACE

## Rapidly Composable Small Satellites

Modular components for fast insertion.  
Includes automatic recomposition should systems fail, communications via secure links.  
Cooperative control, guidance, on-orbit self-assembly. Attitude control, orbital manoeuvre, communications, ISR, weapons modules.





TRL 4 SPACE

## Fractionated/Distributed Space Systems

Provides redundancy, survivability and system upgradeability. Fractionation will involve system elements that cooperate and communicate via secure, jamresistant links (laser). Such systems are easily added to/repared by adding or substituting small satellites.