Future Highways Research Group

AI & Highways

Midlands Highways Alliance (MHA+)

ADEPT / Proving Research Partnership

The world is changing fast…

Future Highways Research Group

“There has been more technological advancement and cultural change in the last 100 years than in all previous human history combined”.

“The Anthropocene”, World Economic Forum, 2021

Our World In Data

Technological Change

Max Roser, Hannah Ritchie and Edouard Mathieu

https://ourworldindata.org/technological-change

OXFORD MARTIN SCHOOL

UNIVERSITY OF OXFORD

Future Highways Research Group

Decision Equipped.

proving

ADEPT

Association of Directors of Environment, Economy, Planning & Transport

Highways

PART OF TRANSPORT NETWORK

AI: A Brief Introduction

Future Highways Research Group

What is intelligence?

…and what would we recognise as intelligence in machines.

- **Human intelligence is a complex mental ability that allows us to learn, reason, solve problems, adapt to new situations, and through semiosis, understand and use language. It encompasses a wide range of cognitive skills, including:**
  - Learning and forming concepts,
  - Applying logic and reasoning (critical thinking),
  - Recognizing patterns and predicting outcomes,
  - Planning and problem-solving,
  - Creativity and innovation,
  - Moral and ethical assessments (beyond reactive religious, ideological and legal frameworks),
  - Decision-makin1g, and,
  - Self-awareness.

Processing Power
Technology vs Biology

Future Highways Research Group

Comparable?
Getting there.

HP Frontier Supercomputer
12 quadrillion transistors, 8.3 million cores.
96 miles of cable. 700 Petabytes (PB) storage.
1,140 petaFLOPS* at 22.7MW
62.68 gigaFLOPS/watt (@3.8MHz)
70 years, 3 months (3,665 weeks) from TRADIC to HP Frontier
Performance doubling every 18 months.

Biological Neuromorphic Processor
86 billion neurons†, 100 trillion dynamic synaptic connections. 850,000km of axons and dendrites. 2.5 Petabytes (PB) storage.
14 petaFLOPS* at 15 watts
933.33 gigaFLOPS/watt (@ 7.5Hz)
61 MY to evolve (3,172,000,000 weeks)
Modern human capabilities appear to have remained constant over the last 75,000 years.

*1 petaFLOP/s = 1,000,000,000,000,000 floating operations per second.
† Each neuron represent approximately 10,000 transistors (brain = 2 quadrillion transistors).

Technology Impact (AI Headlines, July 2023)

AI Highlights (see Appendix A for citations)

Future Highways Research Group

- **Moore's Law shows no sign of slowing.**
  - Compute power will double every two years, and prices will continue to fall.
  - A top-of-the-range processor in 2020 is 30% of the speed of the 2023 equivalent (SD 888 vs SD 8 Gen 3).
  - A flagship smartphone in 2024 contains more compute power than all computers in the City of London in 1990 combined.
- **66% of computers now include Neural Processing Units (NPUs).**
  - This will rise to 85% by 2025.
- **ChatGPT has become the fastest-growing consumer software application in history.**
  - Gaining over 100 million users and contributing to the growth of OpenAI's current valuation of $80 billion.
- **AI will accelerate technological development by 1,600% by ~~2028~~. (it has already occurred in 2024).**
  - In medicine, computing, energy technology, genetics, product design, efficient consumer response, robotics.
- **An AI "singularity" event will see AI take over AI development by ~~2027~~ (it has already occurred in 2024).**
- **AI will become more important and, critically, more trusted in all human activities by 2045 (?).**
  - Including, *inter alia*, replacing drivers, lawyers, doctors and surgeons, hardware and software engineers.
  - Excludes sports and entertainment.
- **AI controlled drones will increasingly replace many prescriptive and repetitive manual jobs.**
- **Strong (general) AI will "most probably" (now certainly) be achieved in our lifetimes.**
  - With a predicted ~~2035~~ to ~~2040~~ timeframe (revised to occur by 2031).

Types of AI

Future Highways Research Group

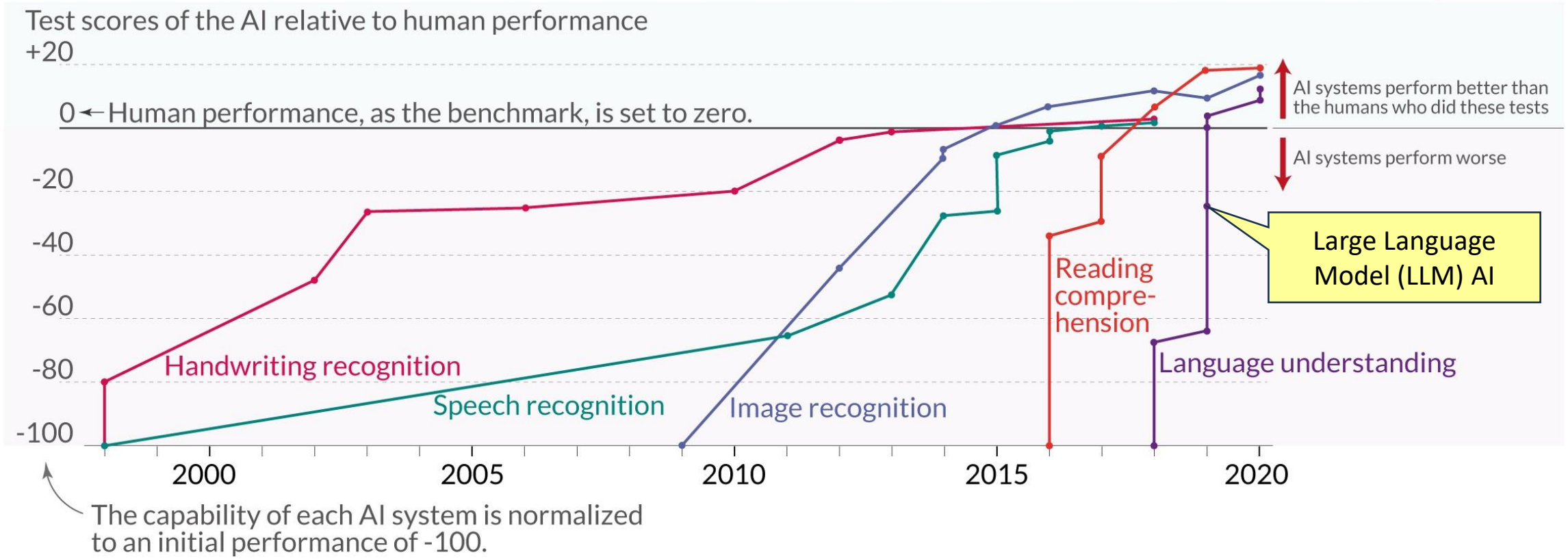
- **Narrow AI (now)**
  - This type of AI performs specific tasks and doesn't learn beyond that. Image recognition, natural language processors, and image generators are forms of narrow artificial intelligence. Apple Siri, Google Assistant, and Alexa are forms of narrow AI. They can understand and respond to voice commands, but they can't give you accurate medical diagnoses.
- **Reactive machines (now)**
  - These machines can only react to stimuli. They don't build memories that they can retrieve in the future like limited memory AI machines, but they're useful parts of digital life. Spam filters and recommender systems that note your behaviour and suggest what you should watch next or what you might like to buy are reactive machines.
- **Limited memory AI (now)**
  - Limited memory AI can store knowledge, learn from it, and perform new tasks based on that learning. This type of AI is useful for making predictions, and is used to forecast future trends in everything from finance to the weather. This is the most common type of AI in use today, appearing in chatbots and self-driving cars.
- **Theory of mind AI (2026)**
  - This type of AI is able to understand complex and unique challenges and provide appropriate responses to human emotions, facial expressions and gestures. There are a range of demonstrators for this technology, including, ChatGPT 5, Gemini, Sophia and Kismet. ChatGPT's theory of mind ability has evolved rapidly in the last couple of years and the latest iteration delivered results comparable to that of a 9-year-old human.
- **Self-aware AI (2029)**
  - The final type of AI is self-aware. This will be when machines are not only aware of the emotions and mental states of others, but also their own. When self-aware AI is achieved, we would have AI that has human-level consciousness combined with exponentially higher intelligence - with "needs", "purposes", "curiosities", and possibly "emotions". It will be the first time modern humans have shared the planet with another truly sentient intelligence.

Is AI ready for traditional sectors' disruption?

Future Highways Research Group

Language and image recognition capabilities of AI systems have improved rapidly

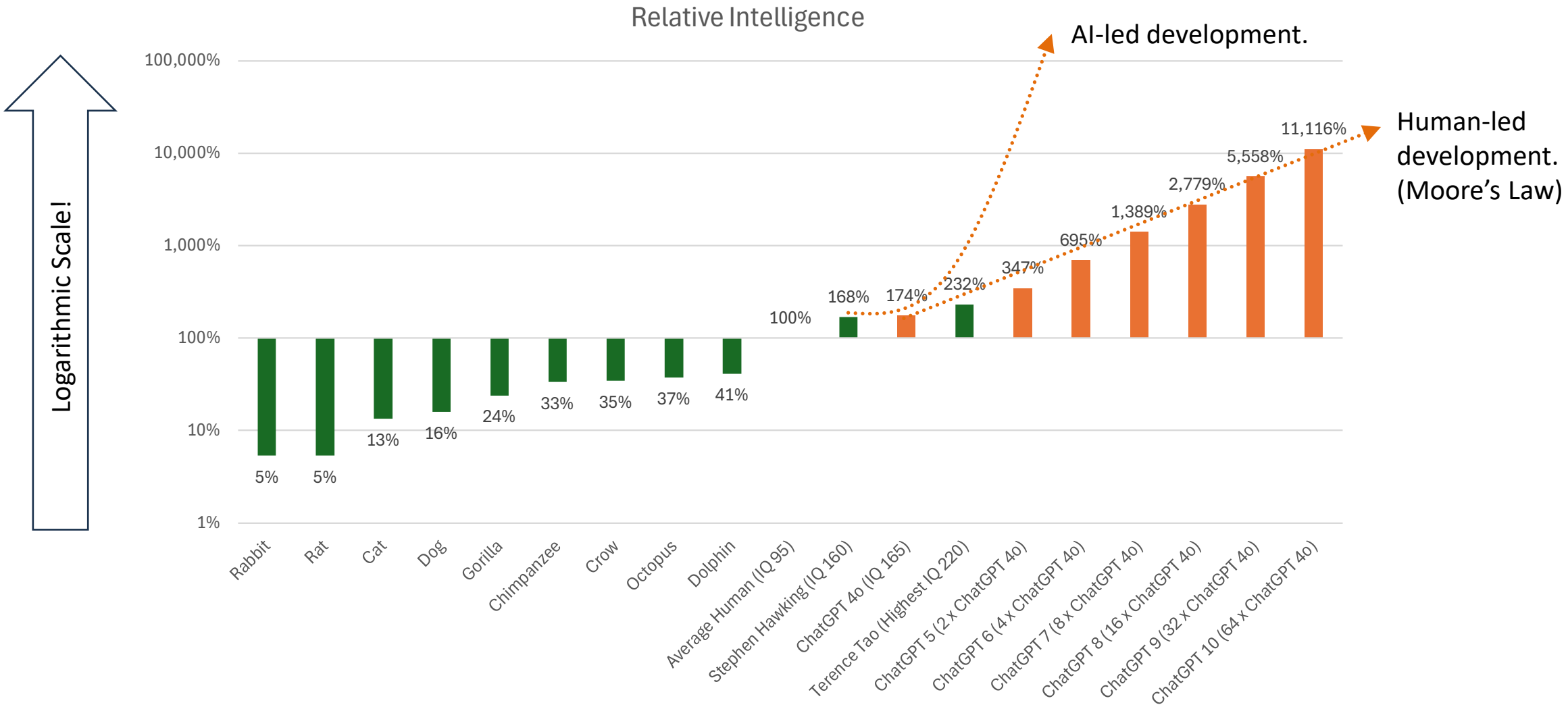
Our World in Data



Data source: Kiela et al. (2021) – Dynabench: Rethinking Benchmarking in NLP
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Intelligence Comparison

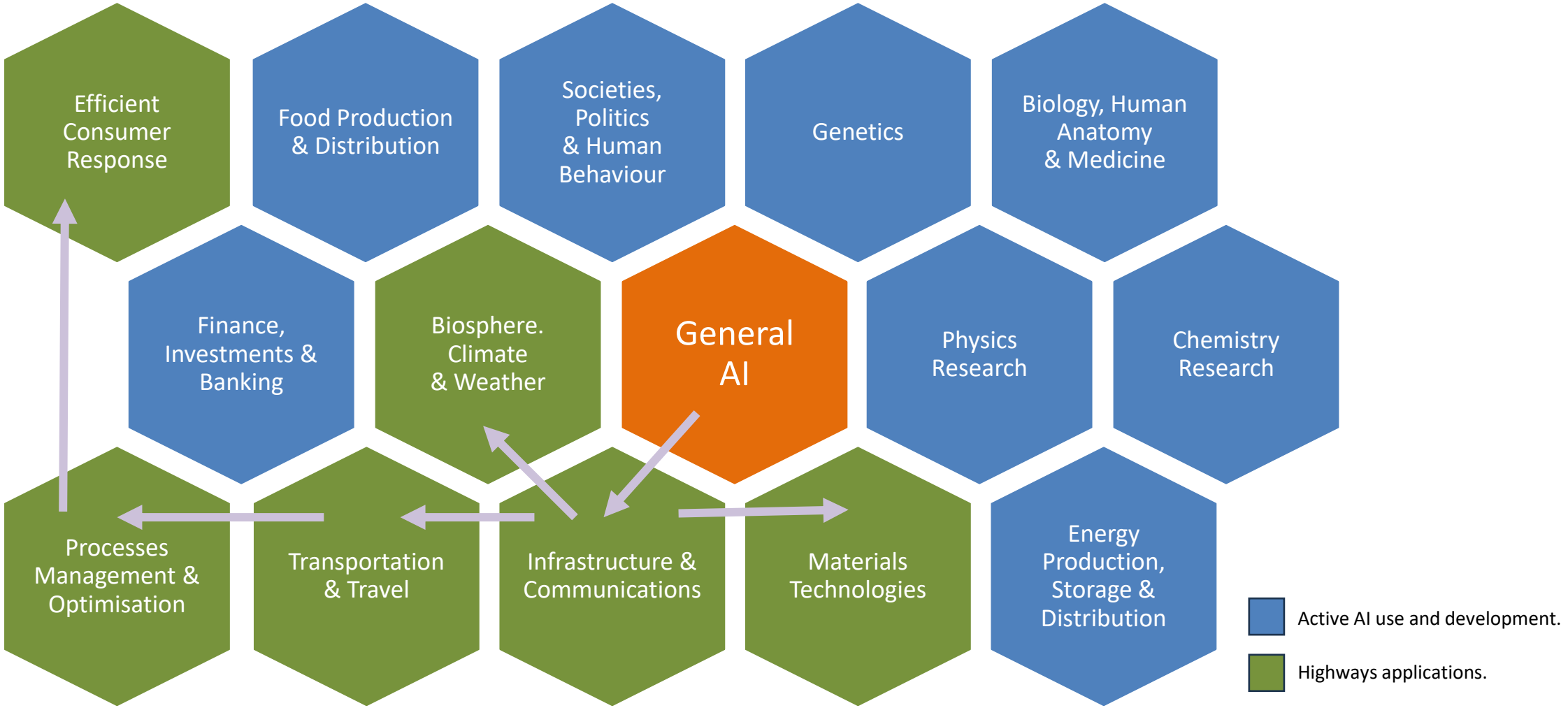
Future Highways Research Group



Brave New Worlds

Where is AI being used?

Future Highways Research Group



Technological & Societal Challenges

Should we be worried?

Future Highways Research Group

"This is our Oppenheimer moment. AI is more important than all other human challenges; including climate change. It may lead to a Utopia or, more likely, a catastrophic collapse of the global economy, or even a third world war. We just don't know"... "We have made a big mistake letting this technology connect to the internet. It now knows everything we know"… "AI has no comprehension of morality or ethics, and it can be employed by anyone."

Mo Gawdat, Ex-Vice President, Google AI X Division, 2023

"Humans are vulnerable to degeneracy through our dependence on robots. We rely on and trust robots; more than friends, more than family. Human intelligence springs from adversity and necessity. With no real challenges, people have lost the spirit, intelligence, and physical fitness of humanity at its peak. The human predilection for indolence robbed us of ambition and purpose."

Isaac Asimov, I, Robot, 1953

"Why study? If your job can be done by an AI, it will be. You can't outcompete AI. It works 24/7/365 for peanuts, never complains, and knows more than you do. Good luck with your CV in that marketplace."

Bill Gates, AI Futures, Q&A Session, 2024

Future Highways Research Group

Decision Equipped.

proving

ADEPT

Association of Directors of Environment, Economy, Planning & Transport

Highways

PART OF TRANSPORT NETWORK

AI: So what?

Future Highways Research Group

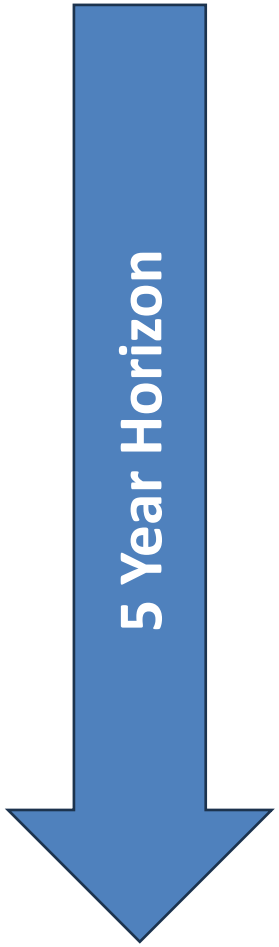
Highways Service Impact Analysis
Sector Readiness for Disruptive Technologies

Future Highways Research Group

- **Mature providers and supply chains.**
- **Mature, static (potentially stagnant) processes.**
- **Aging workforce, reducing capability and capacity in the sector.**
  - Declining tacit knowledge and experience.
- **Many efficiency challenges.**
- **Many funding challenges.**
- **Many emerging challenges.**
  - Including climate change, energy sourcing, etc…
- **Significant political profile.**

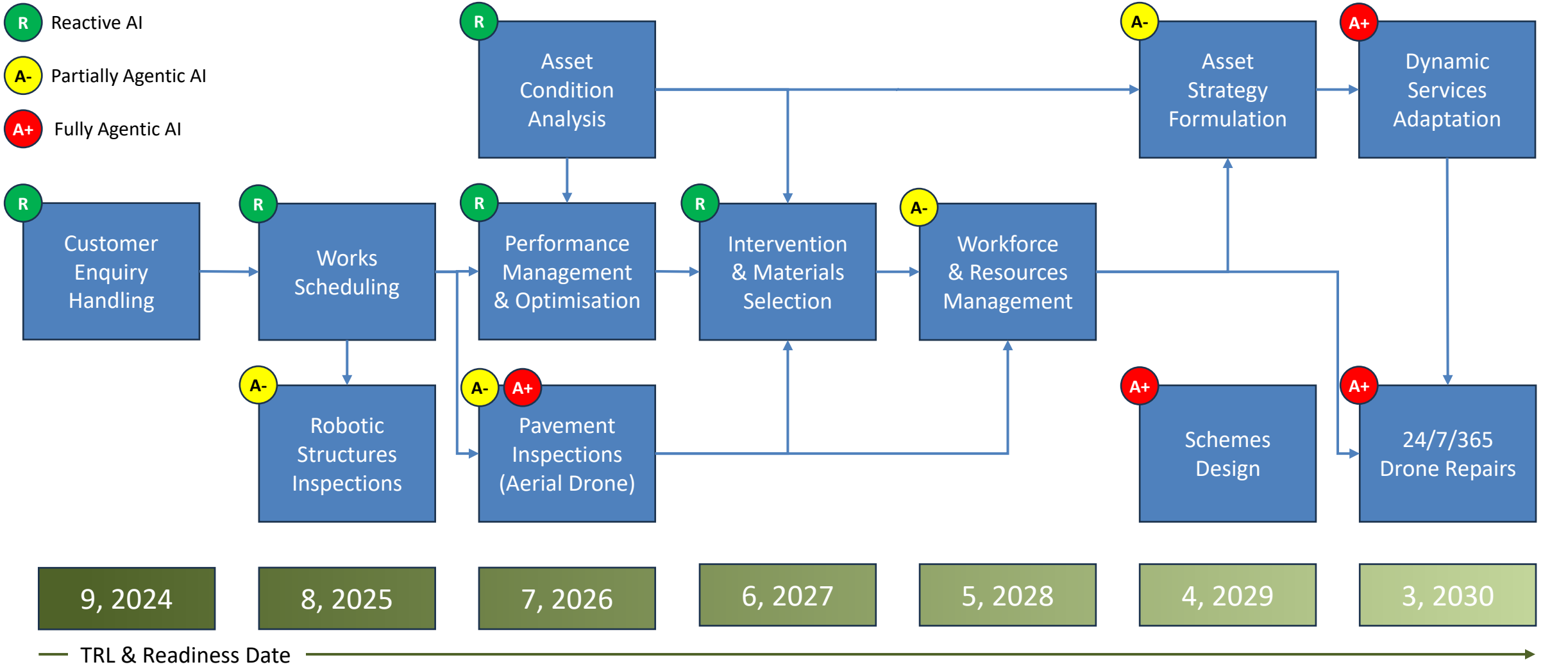
AI Technology Readiness Levels (TRL)

Future Highways Research Group



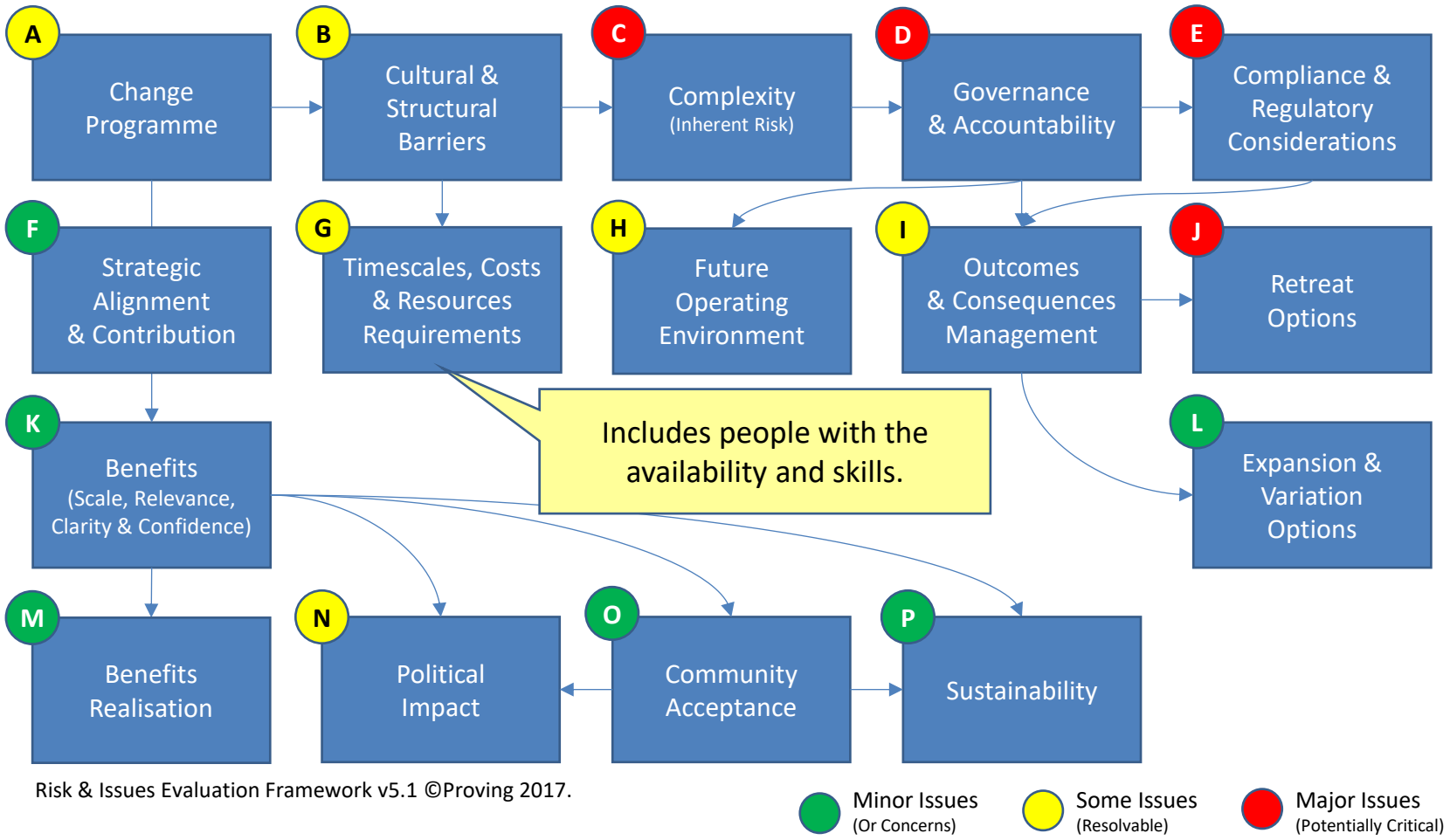
TRL	Description
3	Experimental proof of concept.
4	Technology validated in lab.
5	Technology validated in relevant environment.
6	Technology demonstrated in relevant environment.
7	System prototype demonstration in operational environment.
8	System complete and qualified.
9	Actual system proven in operational environment.

AI/Robotics TRL Timeline



Risk Assessment: Telephone Enquiry Handling

Initial Risks RAG Report



Future Highways Research Group

Decision Equipped.

proving

ADEPT

Association of Directors of Environment, Economy, Planning & Transport

Highways

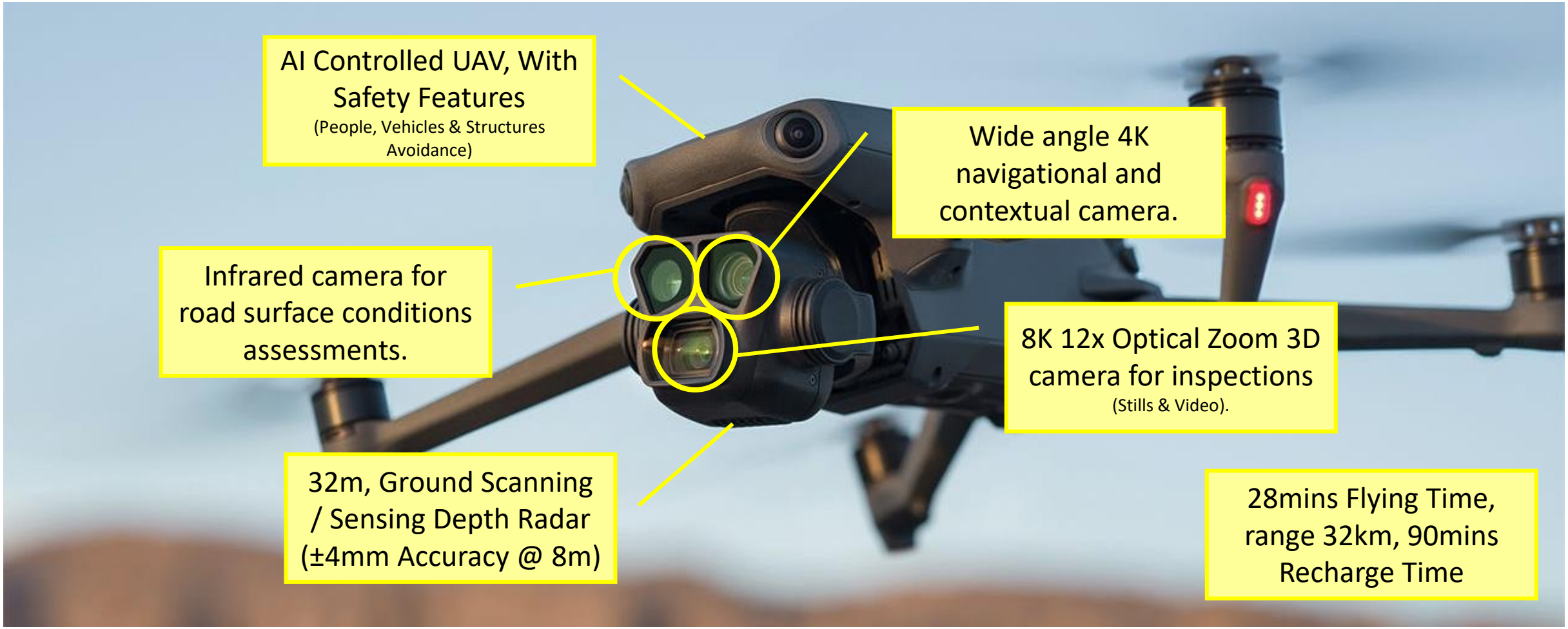
PART OF TRANSPORT NETWORK

AI: Aerial Highways Inspections

Future Highways Research Group

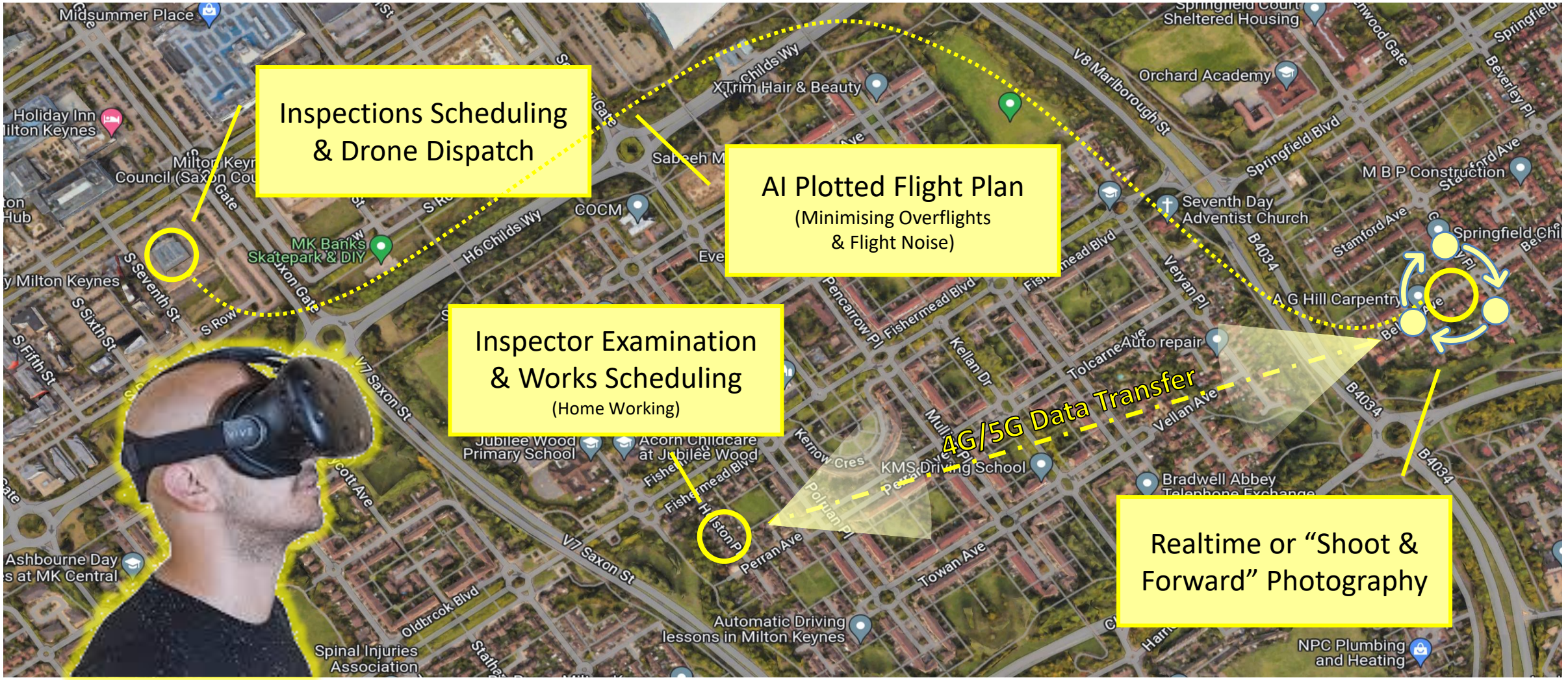
AI Piloted Drone: Highways Inspections

Future Highways Research Group



Future Inspections Process

Future Highways Research Group



Technology Constraints

- **Requires legislative change.**
  - Out-of-sight, AI piloted UAVs.
- **Limited to daylight hours.**
  - 9 hours in winter months.
  - 15 hours in the summer months.
- **Weather condition constraints.**
  - Windspeeds below 15m per second (or 34 mph).
  - Light rain or sleet (ice buildup on rotas a significant risk in snow).
  - Visibility of greater than 50m.
- **Requires a drone management and maintenance team.**
  - Battery management.
  - Drone maintenance and flight safety assurance.
  - Drone recovery and diagnostics.
- **“We don’t lose many drones to avionics failures, but we do to gunfire.” (Chicago Dept Works).**
  - Probably less of an issue in the UK.

Future Highways Research Group

Decision Equipped.

proving

ADEPT

Association of Directors of Environment, Economy, Planning & Transport

Highways

PART OF TRANSPORT NETWORK

Open Discussion: What are your views?

Future Highways Research Group

Future Highways Research Group

Decision Equipped.

proving

ADEPT

Association of Directors of Environment, Economy, Planning & Transport

Highways

PART OF TRANSPORT NETWORK

End of Document

Future Highway Research Group