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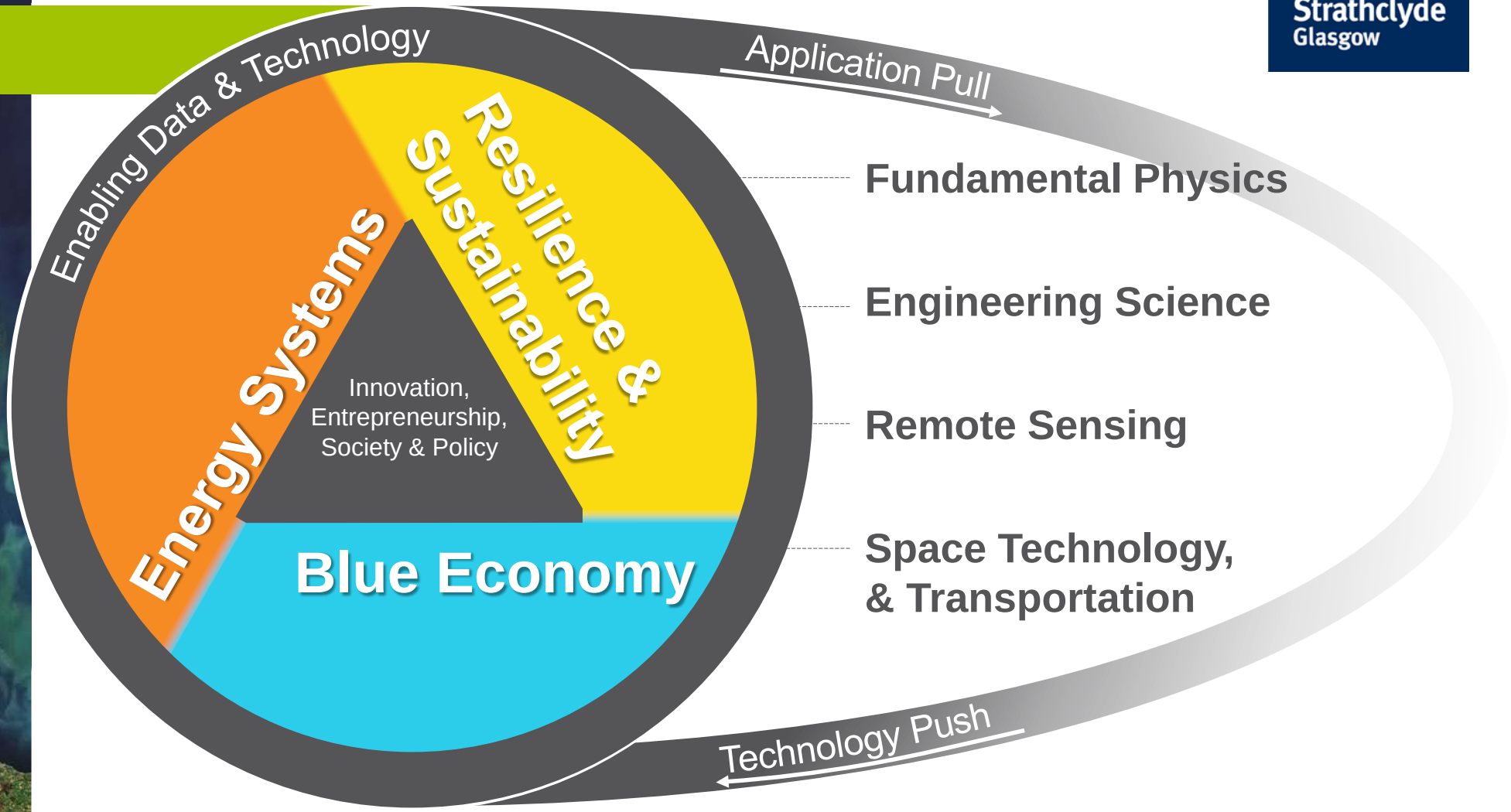
Bringing Space Down to Earth as a Service Utility

Eur Ing Dr Malcolm Macdonald

Image Credit: hitc.com

SoXSA



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Scottish Centre of Excellence in Satellite Applications // Ionad de Sàr-mhathas ann an Goireasan Saideal na h-Alba

delivery partners

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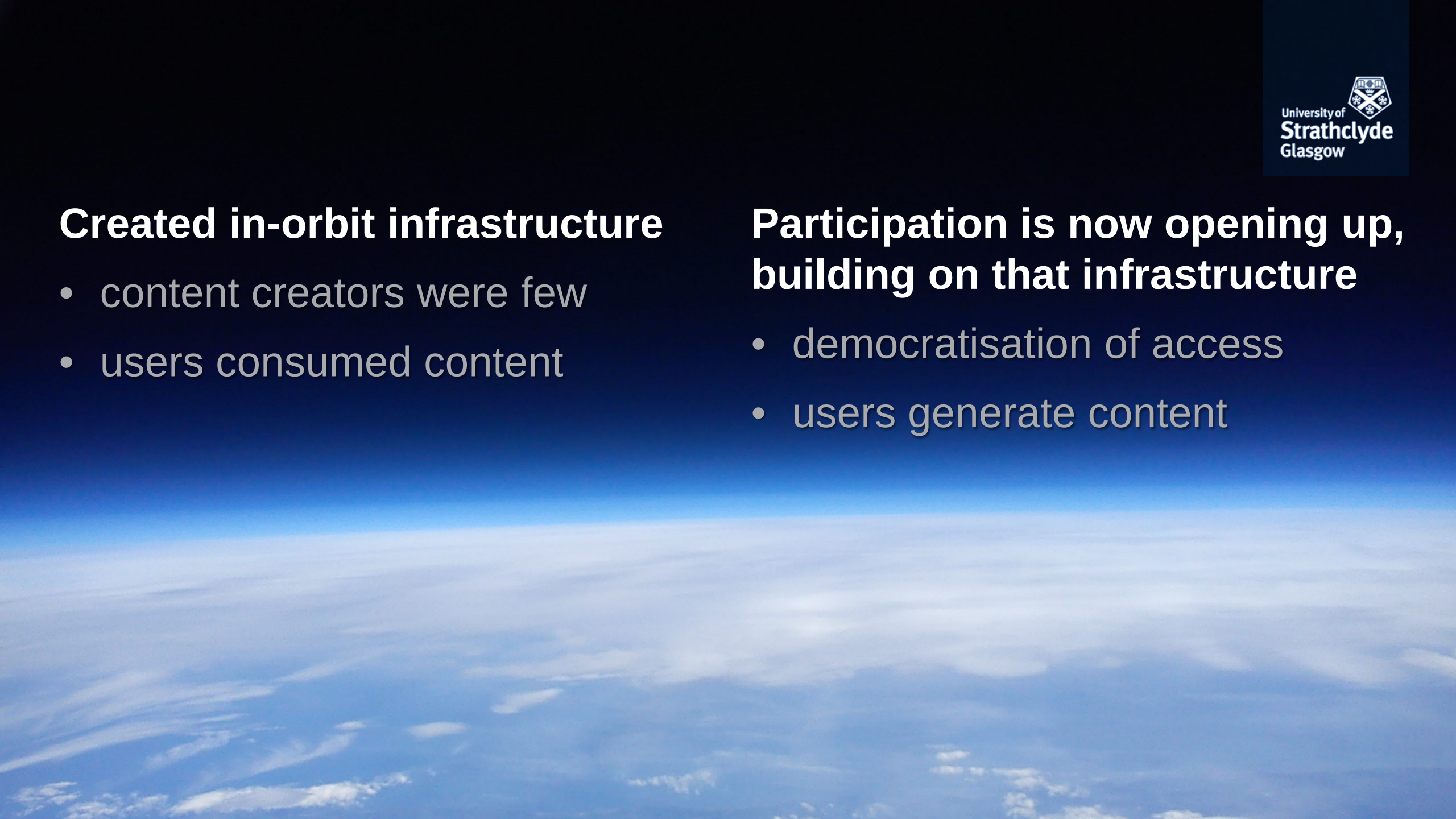


Created in-orbit infrastructure

- content creators were few
- users consumed content

Participation is now opening up, building on that infrastructure

- democratisation of access
- users generate content

Low cost, responsive space missions

- Spacecraft become interdependent & specialised
- Capabilities enhanced & augmented as required

In-Orbit Utilities

Procure services or rent hardware while in orbit

- Navigation

In-Orbit Utilities

Procure services or rent hardware while in orbit

- Navigation
  - Orbit determination & attitude determination
  - Timing signal

In-Orbit Utilities

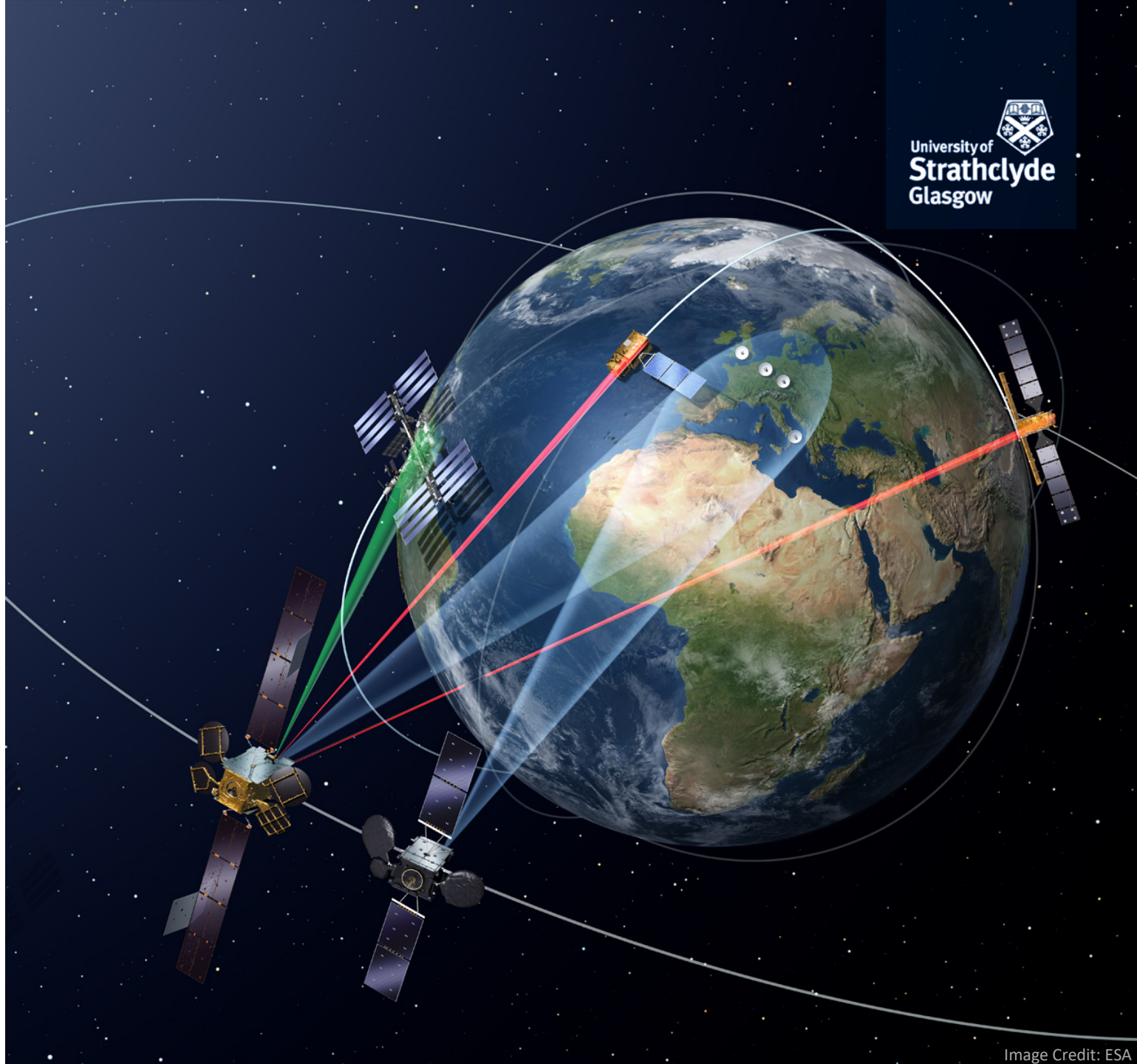
Procure services or rent hardware while in orbit

- Communications

In-Orbit Utilities

Procure services or rent hardware while in orbit

- Communications
  - Limited visibility to ground stations
  - Continuous communication



Underpinning this future is networked systems

– Including, swarming, constellations, & federated satellites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Nature is fallible

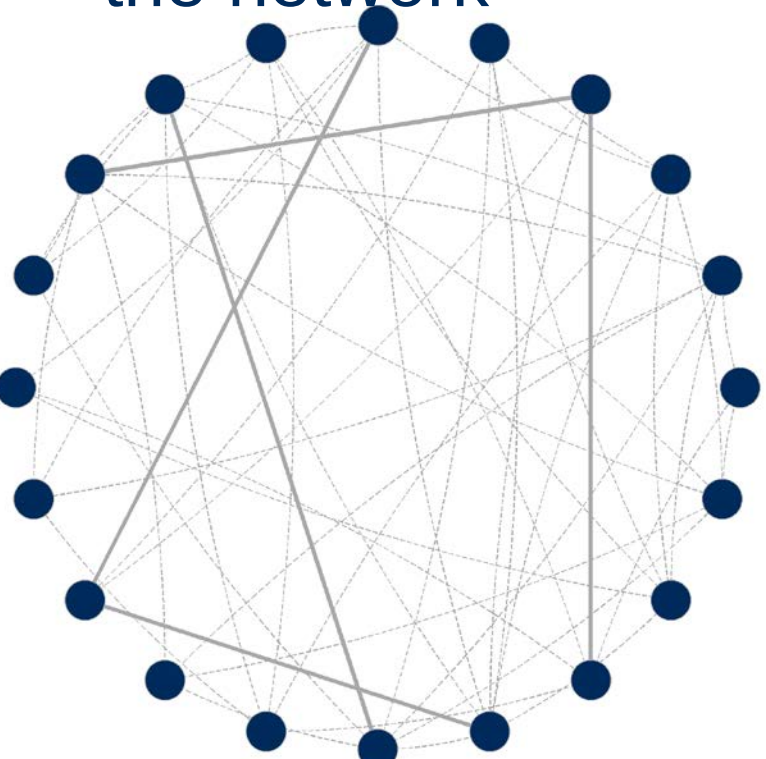
Engineering requires a robust, repeatable, verifiable and scalable behaviour

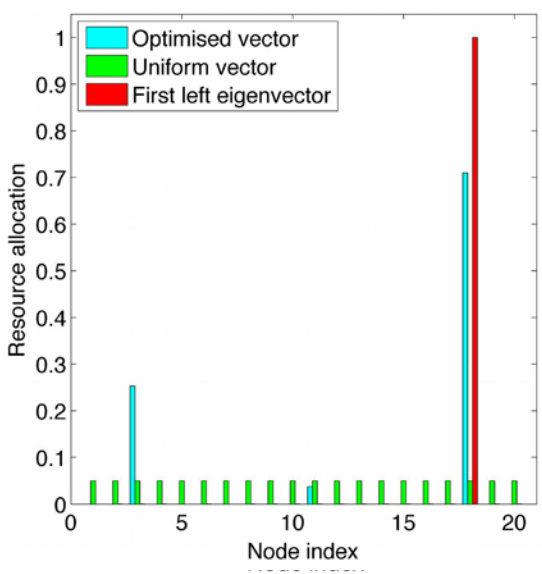
Ant Death Spiral, or Ant Mill

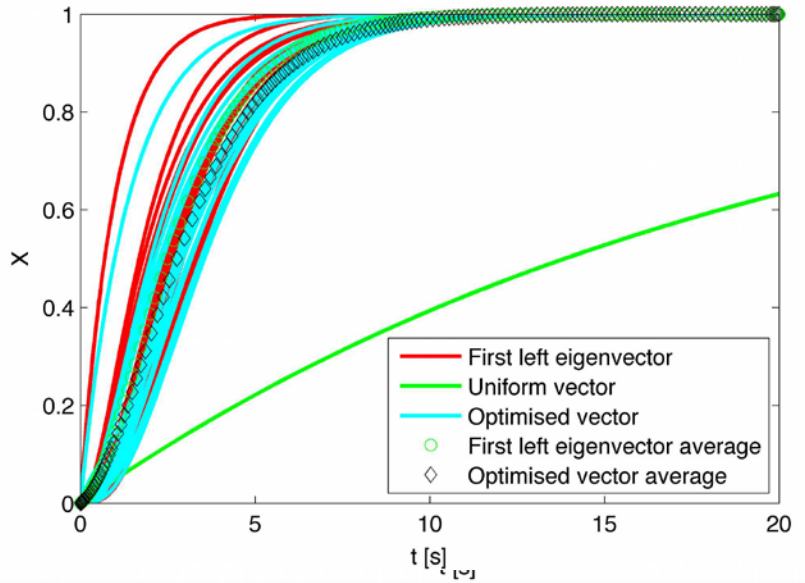
Army ants, which are blind, become detached from colony and begin to follow each others pheromone trail; strength of pheromone trail draws in other nearby ants. *Similar phenomena have been noted in processionary caterpillars and fish*.

Rapid Manoeuvring

Reaction to external stimuli analytically optimised by allocating resources within the network







Random network

For a simple 1D swarm, the time to transition to a commanded state is shown for an all-to-all communication network (green), an analytically defined control matrix (red) and a numerically optimised control matrix (cyan)

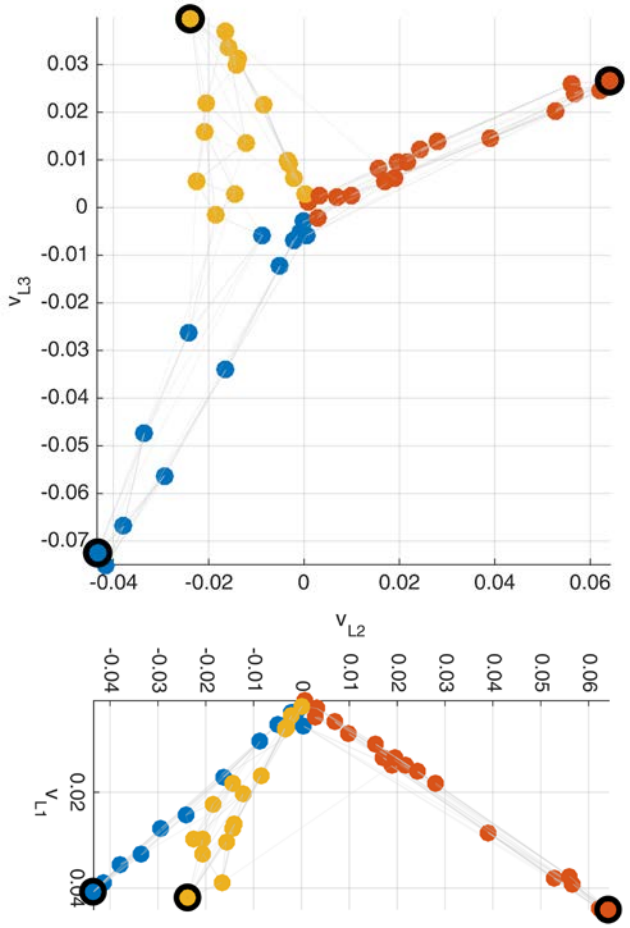
Allows engineered swarms to rapidly manoeuvre in similar fashion to flock of birds

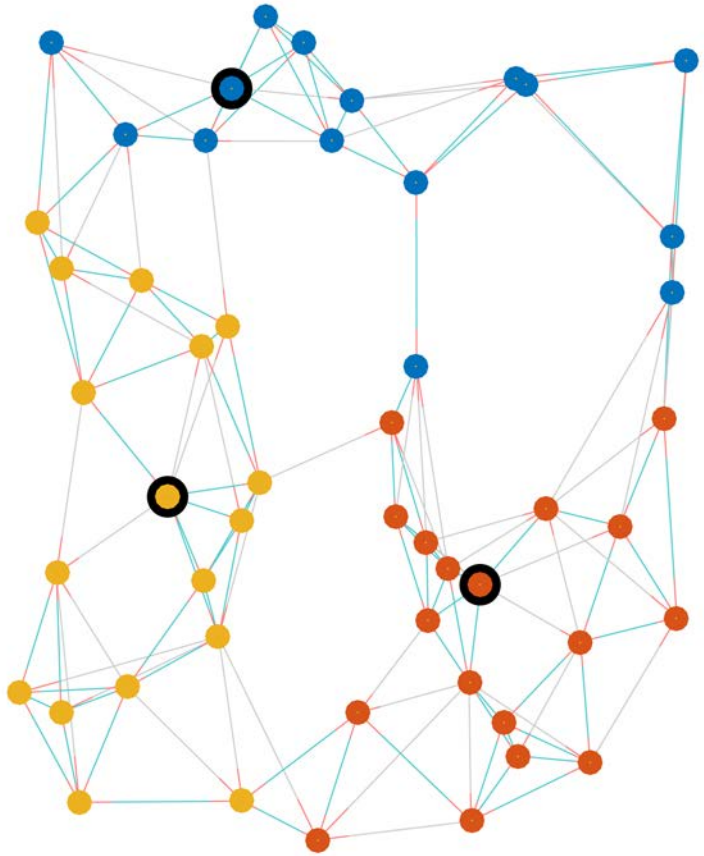
- Such rapid manoeuvres cannot currently be fully explained in nature

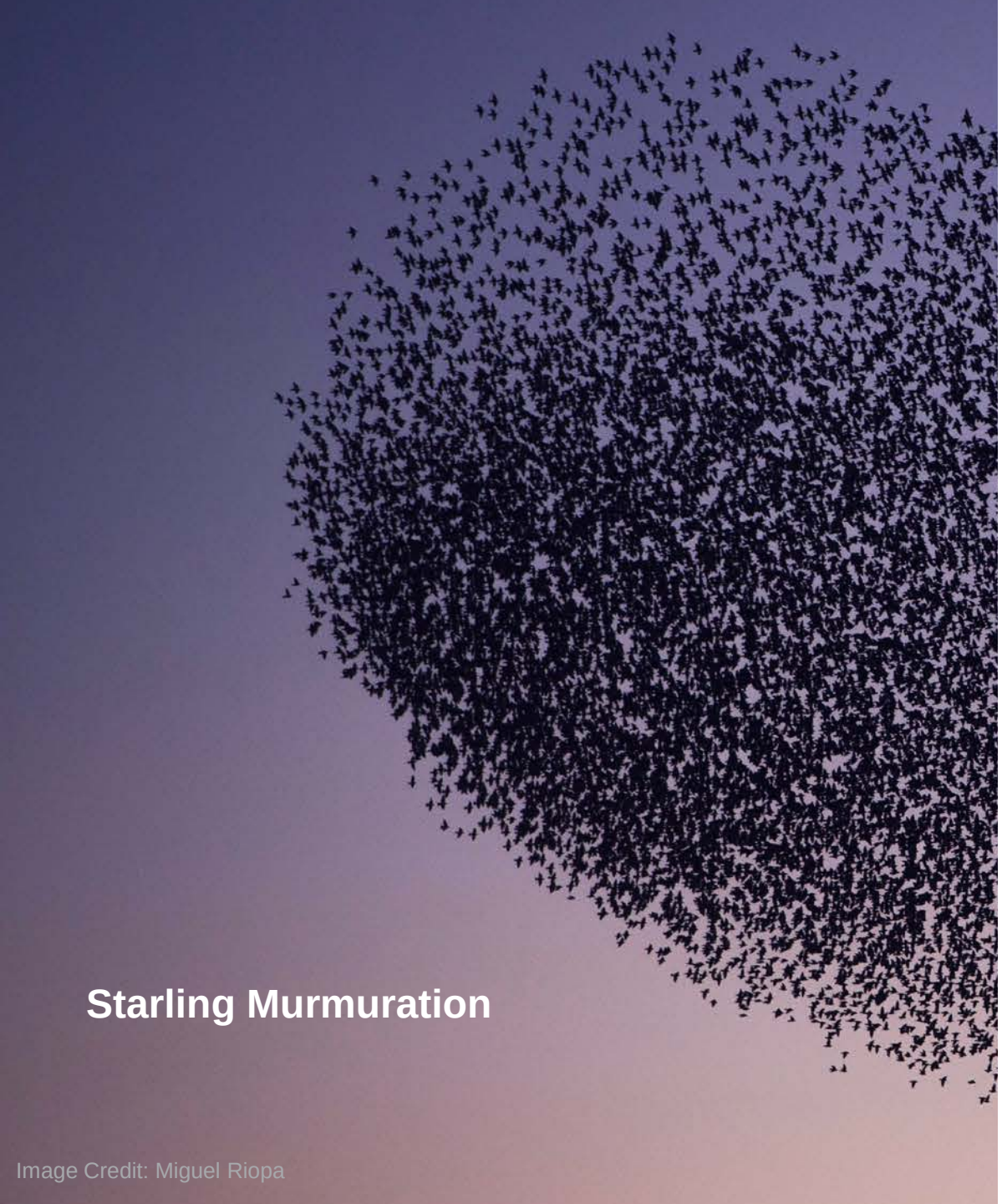
Leader Selection

Identification of communities within the network

- Greater than order of magnitude reduction in computational effort compared to a genetic algorithm

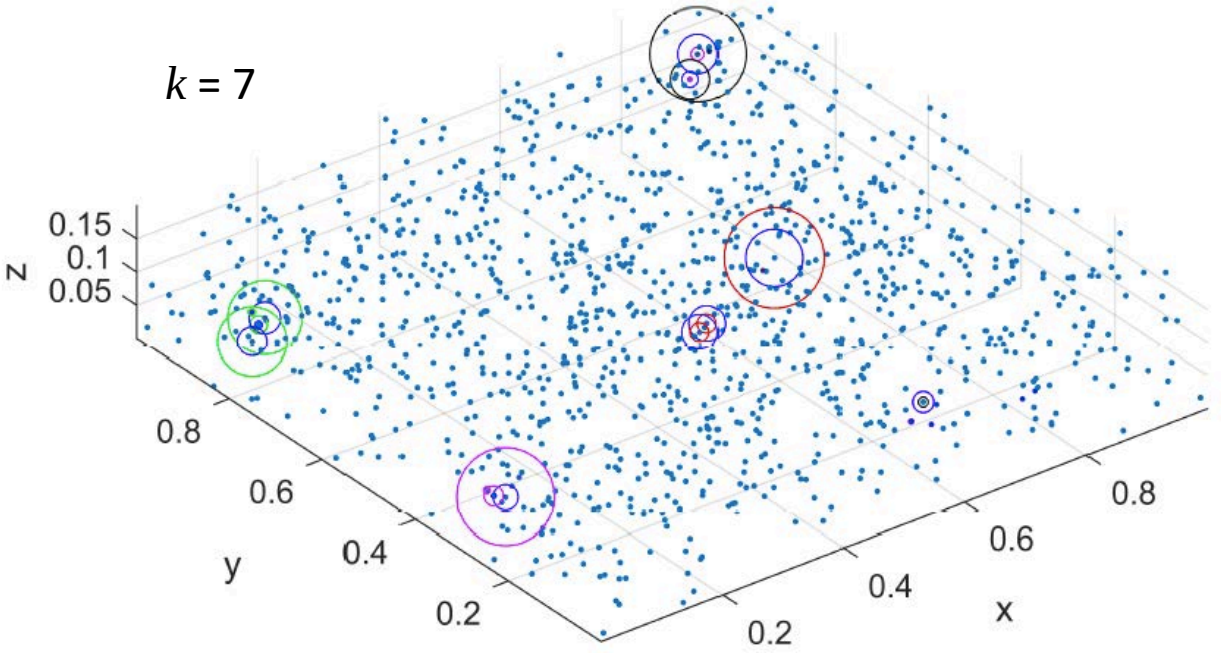






Starling Murmuration

Image Credit: Miguel Riopa



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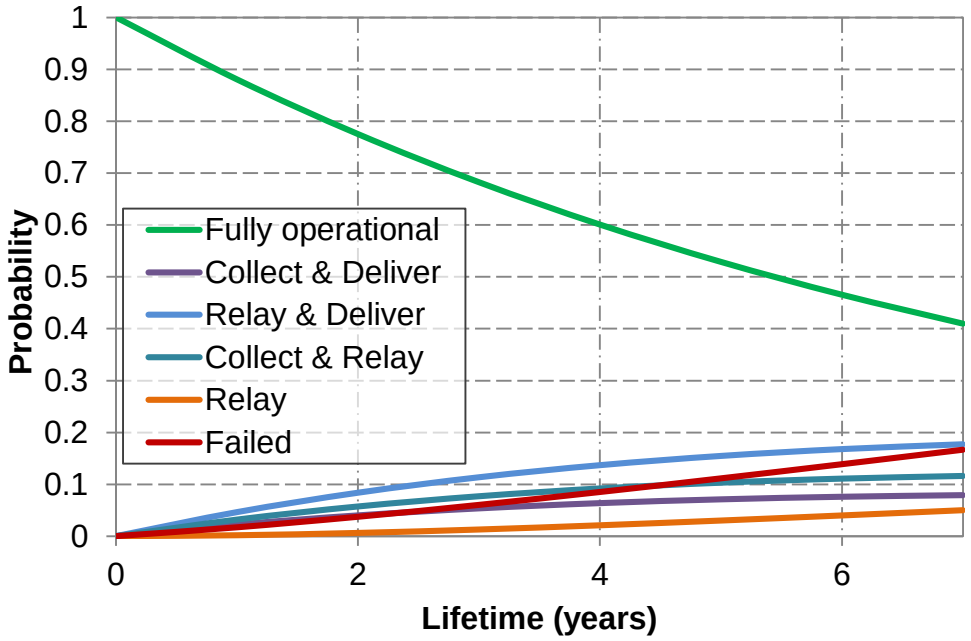
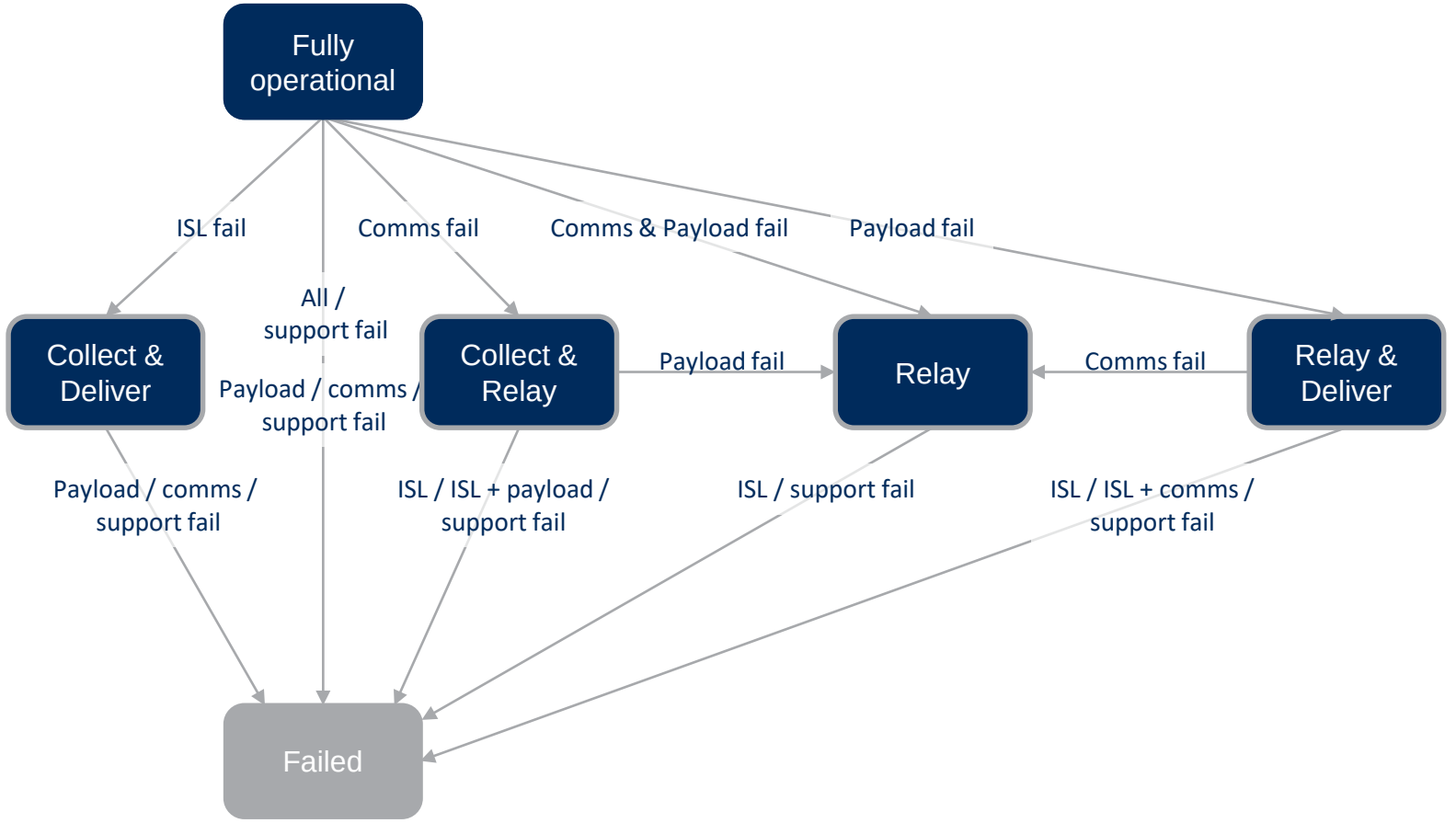
Challenging conventional ideas & developing new concepts

Image Credit: NASA

Resilience of Networked System

Markov chain approach to show value of inter-satellite connections and resilience to failure



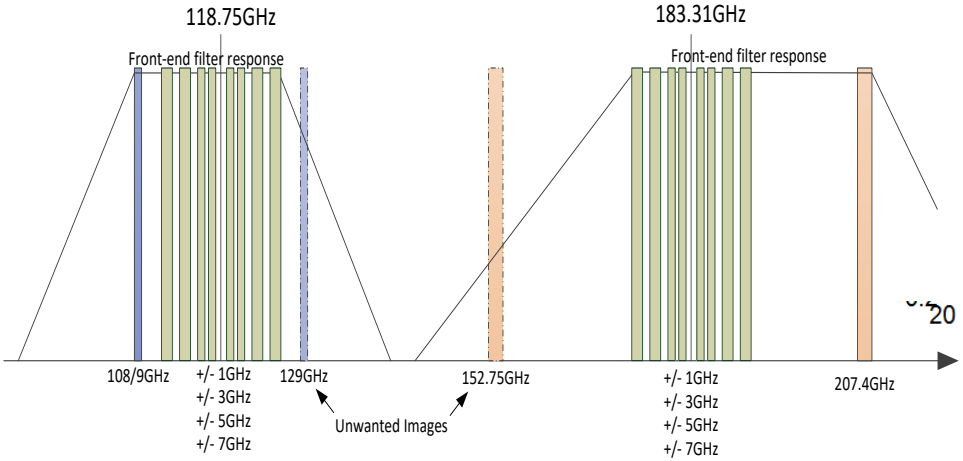


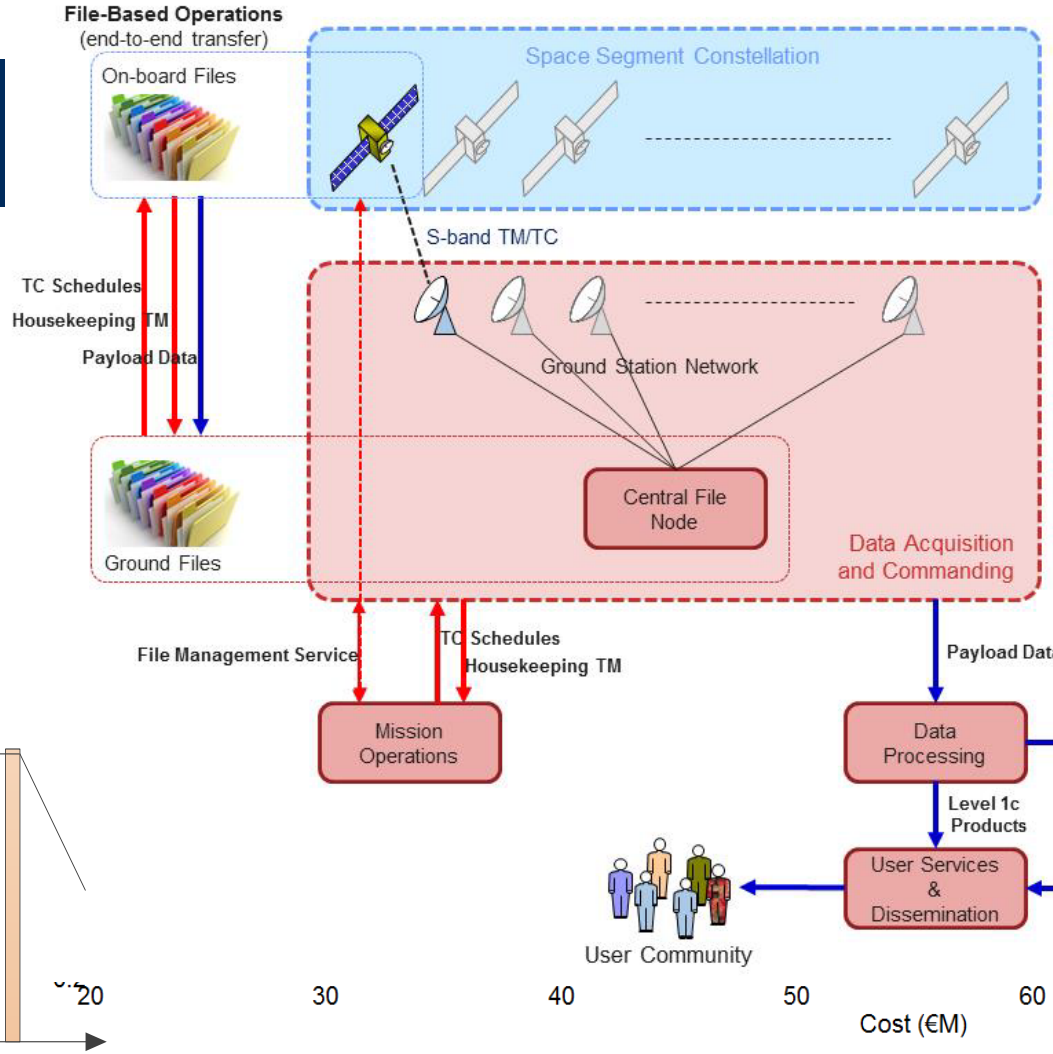
Remote Passive MW Sensing with Cooperative NanoSats

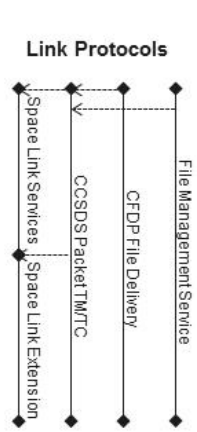
Rapid repeat global coverage

- Spatial resolution of 10km – 20km
- Average hourly revisit time at 40° latitude
- Data latency to user <1 hour on average

Instrument concept through to mission & system design, and concepts of operations







Resource Considerate Routing

Novel routing algorithms at the network layer

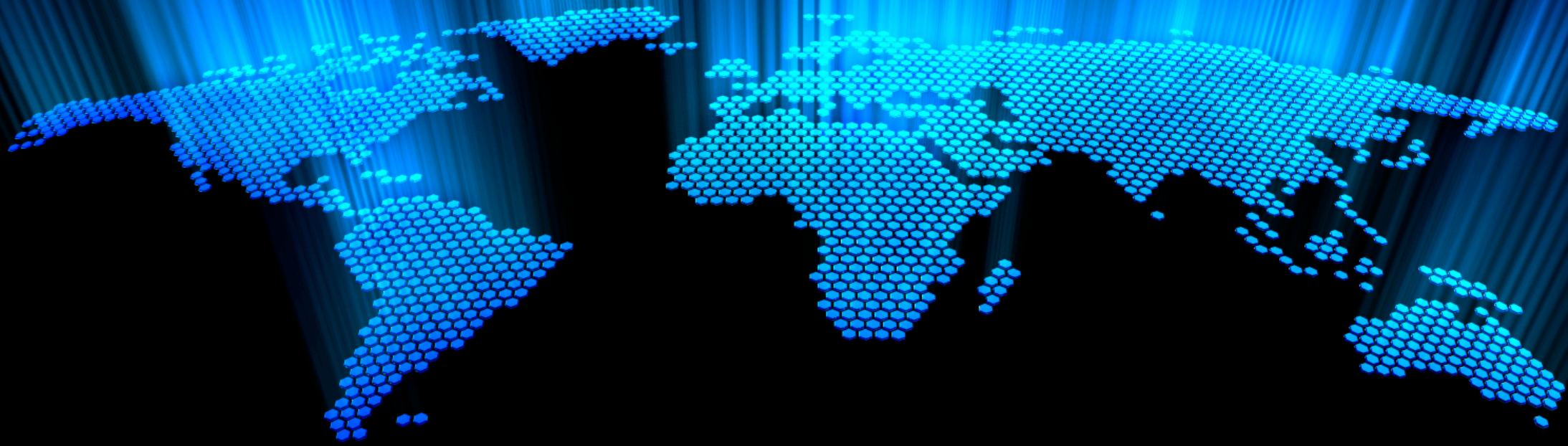
- Consideration of network bottlenecks to route around congestion

Cost savings through ground/space network reduction and/or performance enhancement

Agile Constellations

Developing agile and reactive space segments

- Reconfigure and react to demand & opportunity



Missions Laboratory

Space will be seamless from orbit to ground

Terrestrial concept of service utilities expands into orbit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