USD(R&E)

The Importance to DoD of AI and Autonomy in Maintaining a Technological Advantage in Space

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Principal Director for Space Technology

- Established in R&E by Congress in FY2021 NDAA, along with other Principal Directors (PDs), for 14 Critical Technology Areas (CTAs)
  - 10 CTAs fall under OUSD(R&E)/OASD(CT)
- Functional role:
  - Serve as CTO for specific CTA to USD(R&E), and thus, to SecDef
  - Senior OUSD(R&E) official for CTA
- ***To ensure the US/DoD has the technological advantage to deter, and, if necessary, win any future conflict in Space***

PD Space** is the **Senior Space Official in OUSD(R&E)** and **Space CTO** for the **Department of Defense

Intra- and Inter-Domain Capabilities

Space-based Earth-focused capabilities (S2G)

- Strategic deterrence
- Missile Warning/Missile Tracking
- ISR
- Communications
- PNT
- OPIR

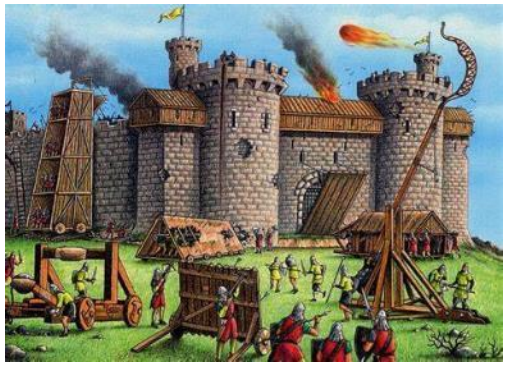
Space-based Space-focused capabilities (S2S)

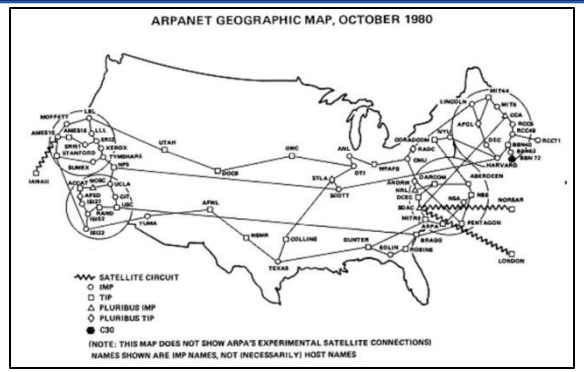
- Space control
- SDA/SSA/Space Traffic Management
- Communications
- PNT

Earth-based Space-focused capabilities (G2S)

- SDA/SSA/Space Traffic Management
- PNT
- Space Control
- Communications

Ability of Systems to Adapt to Stress





Fragile → Brittle → Resilient → Anti-Fragile

- *Not designed/intended for a hostile/stressing environment*
- *Breaks (i.e., goes out of mission) easily if it encounters stressing conditions*
- *Example: most research, commercial satellites*

- *"Hardened" for stressing/hostile environment*
- *Expensive, capability based on small number of components*
- *Hard to break, but once broken, capabilities are quickly lost*
- *Example: previous generations of defense and national security satellites*

- *System capabilities designed to "take a punch" and keep operating*
- *Individual systems inexpensive; based on large number of systems*
- *Capability is maintained despite losses of individual components*
- *Individual components may not be super-hardened, but numerous and easily/quickly reconstitutable*
- *Example: Starlink, next generation of defense and national security satellites ("pLEO")*

- *Performance/capabilities improve under stress*
- *Example: biological evolution via natural selection such as resistance in bacteria/viruses*
- ***Is there a way to implement "Anti-Fragility" for space systems?***

Modified from Nassim Taleb (Author of The Black Swan)

Time →

Key Enabling Technologies for Space Resiliency

Capability	Launch capacity expansion/reduced cost to orbit	Improved maneuver engine technologies	AI/ML (e.g., H-O-T-L Autonomy)	Enhanced s/c components (e.g., microelectronics)	Enhanced sensors
Rapid reconstitution	✓	✓	✓	✓	
Inter-orbital-regime maneuver		✓	✓		✓
Orbital Diversity	✓	✓		✓	
On-orbit refueling/repair	✓	✓	✓		✓
S/C hardening (radiation, DE, EW, cyber)			✓	✓	✓
Proliferation	✓	✓	✓	✓	✓
Enhanced SDA/BA			✓		✓
On-orbit local maneuverability			✓		✓
Ground-based cyber hardening			✓		
Radiation remediation		✓	✓	✓	✓

Importance of Autonomy on Resiliency of Future Space Systems

- Autonomous ground and space systems Improved sensors, significantly reduced latencies, enhanced maneuver systems
  - "Swarm"-type operations; i.e., multiple elements cooperating, multiple systems working together, etc.
  - Able to sense battlespace and take action to preserve/protect/defend self, others
  - Potential to operate orders-of-magnitude faster than H-I-L systems
  - *Begin to approach "anti-fragile" system?*

- Implications of autonomous systems
  - E.g., use-it-or-lose-it, first mover advantage
  - Ethics issues->policy issues

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- Questions?

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