The Drones Are Coming!

Future Enterprise Architectures for Unmanned Aircraft Systems

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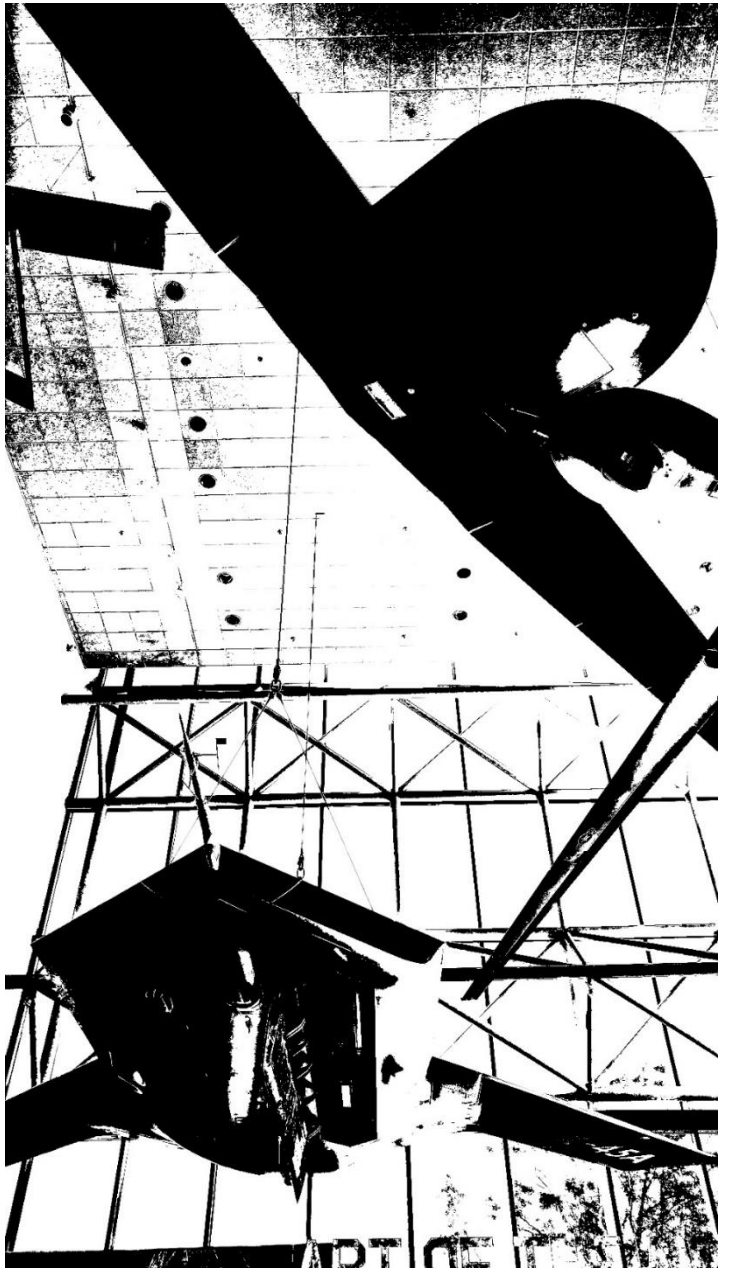


UAS – A Dream or a Nightmare?

Introduction

- Unmanned Aircraft Systems (UAS), *aka* Drones, are much in vogue.
- Near-daily reports of drones near commercial aircraft
- FAA reports nearly 300,000 drone registrations in December 2015
- Annual UAS sales are expected to reach millions in 2020s
- By 2030, there may be orders of magnitude more UAS flying in US National Airspace than manned aircraft
- How will this traffic be managed?
- What role will autonomy play in this evolution?
- This will transform global aviation

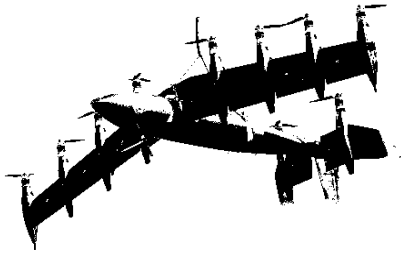
Air Traffic Enterprise Concerns

- How to assure safety?
- How to maintain traffic efficiency?
- How to manage much greater number of operations?
- How to assure security?
- How to provide agility for new types of operation?
- What should be the role of autonomy?
- How to achieve transition?

- What should be the Enterprise Architecture for the future Air Traffic Enterprise (ATE)?

What Types of UAS are we talking about?

- There will be as many different types of UAS, as there are missions:
  - Cargo transport
  - Infrastructure management
  - Communications infrastructure
  - Public Safety
  - Defense
  - Environmental Monitoring
  - + many we can't even conceive of
- Many of these missions can be achieved autonomously.

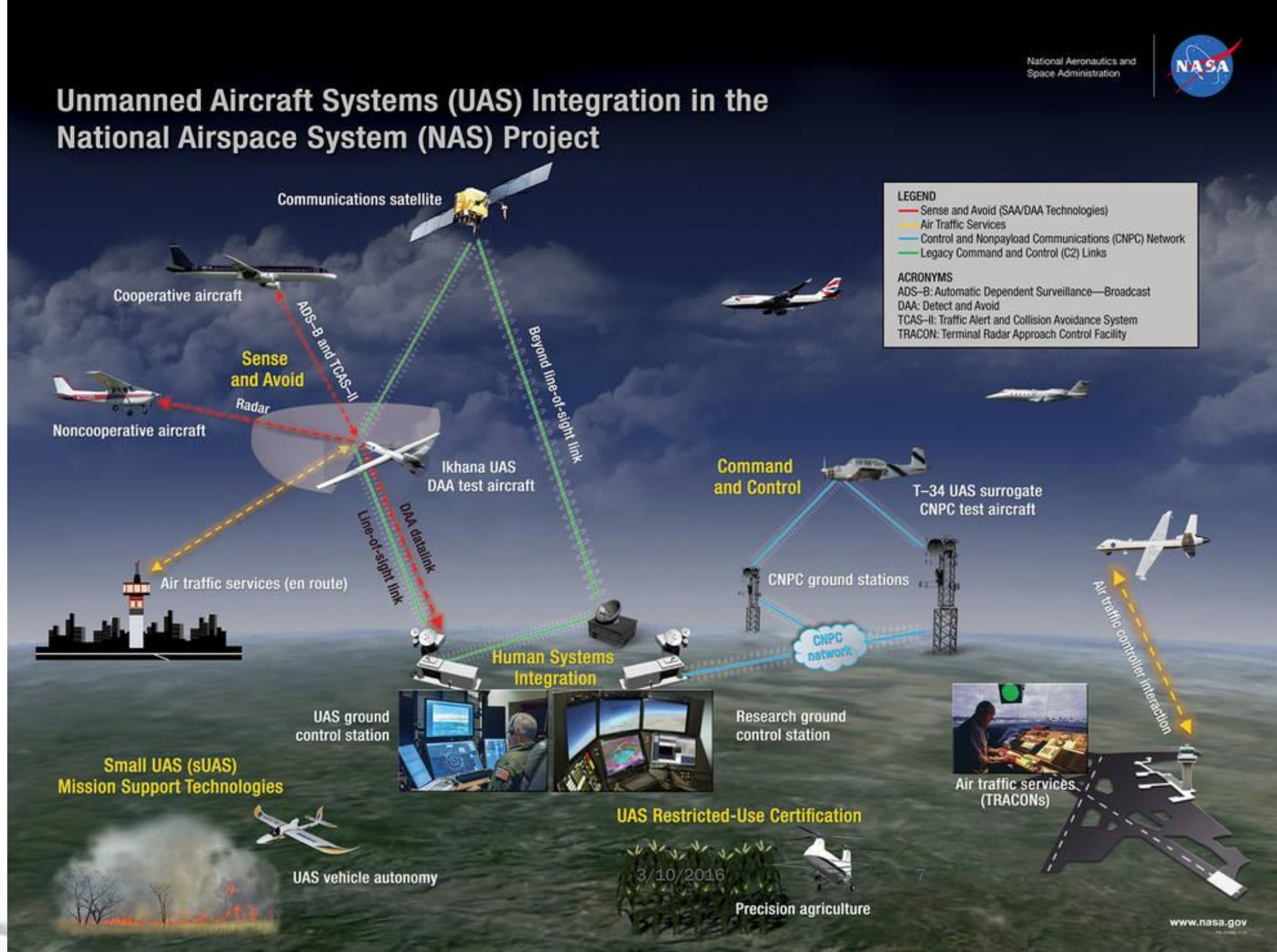


Photos: nasa.gov

UAS Autonomy

- Fully Autonomous: UAS operates without manual control over the full range of its mission. No manual override is possible.
- Fully Autonomous with override: UAS normally operates without manual command over the full range of its mission. Manual override is possible.
- Semi-Autonomous: the UAS normally operates without manual command over a significant portion of its mission. Manual control is routinely used (e.g., for take-off and landing).
- Manual with Limited Autonomy: the UAS normally operates under manual command, but is capable of limited autonomous action (e.g., conflict resolution response).
- Fully Manual: the UAS can only be operated under manual command. No autonomous action is possible.

NASA Vision



(nasa.gov)

Concern 1: Safety

- Providing safety is the primary concern of Air Traffic Management
- Challenge: Safety is an N^2 problem
  - Large increase in UAS traffic presents a major challenge for safety paradigm
- Current Multi-layered approach
  - Manage traffic load (centralized)
  - Maintain separation (centralized)
  - Resolve loss of separation (centralized)
  - Resolve conflict (“ACAS”) (localized)
- Need for UAS autonomous action

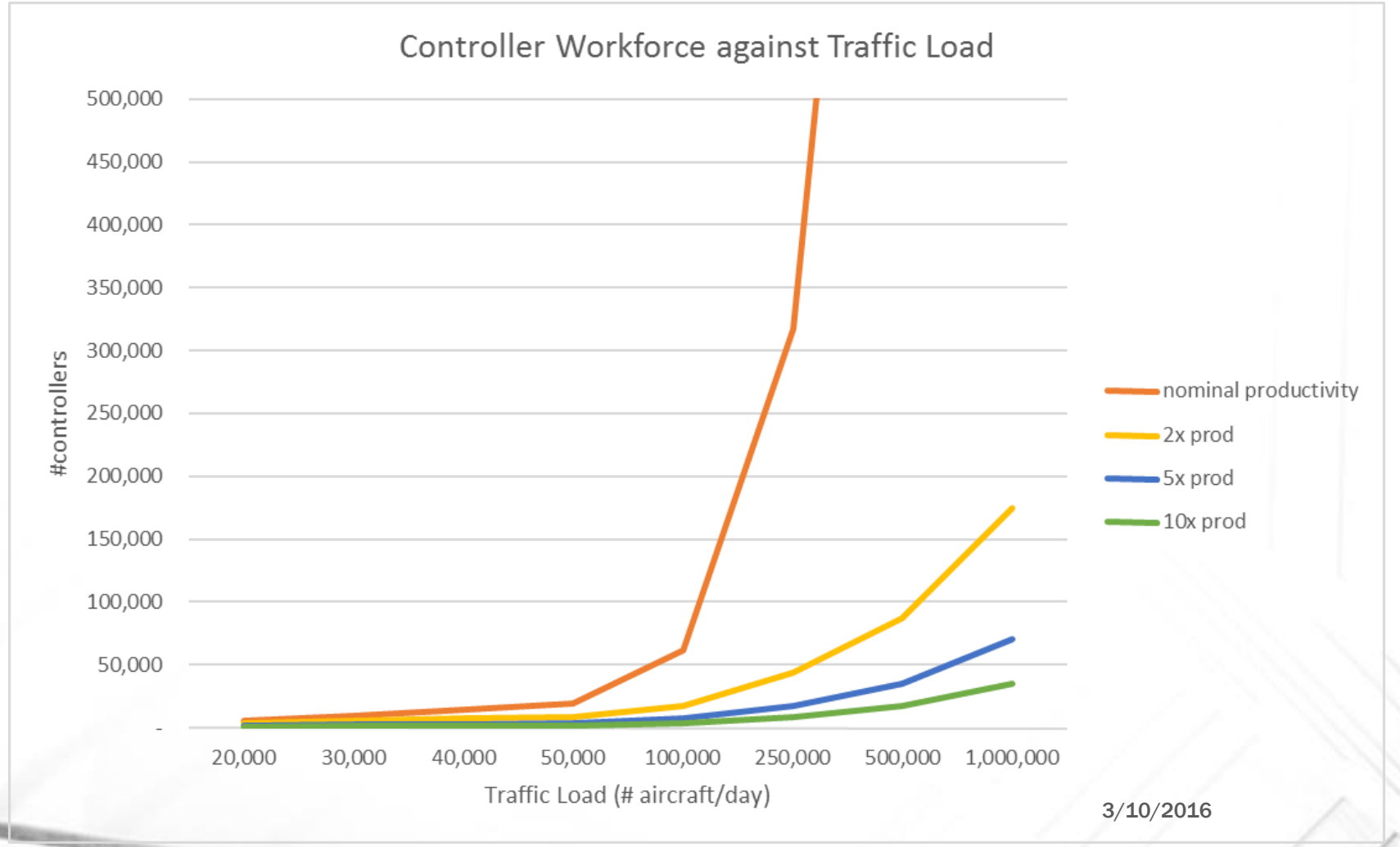
Concern 2: Maintain Traffic Efficiency

- Currently air traffic efficiency is achieved through a combination of the following:
  - Strategic Airspace Planning
  - Airspace Flow and Capacity Management
  - Tactical Traffic Management/Control
  - Dynamic responses
- Can these concepts be translated to large-scale UAS operations?

Concern 3: Manage Increased Number of Operations

- The current air traffic management system is human-centric
- The capacity of the Airspace is largely limited by the number of Air Traffic Controllers:
- There is a choice:
  - increase the number of controllers
  - Increase the efficiency of controllers
  - Introduce automated solutions (e.g., autonomy)

Impact of Traffic Load on Controller Workforce



Concern 4: Assure Security

- Physical and Cyber Security
- Issues:
  - Deliberate Airspace Intrusion
  - Communications vulnerabilities
  - Detection/Identification/Authentication
  - Security Response
- Challenge: No real current equivalent:
  - Human in the loop
  - Role for autonomy?

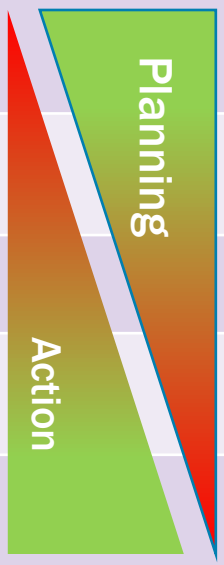
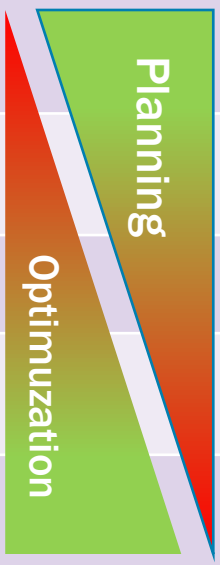
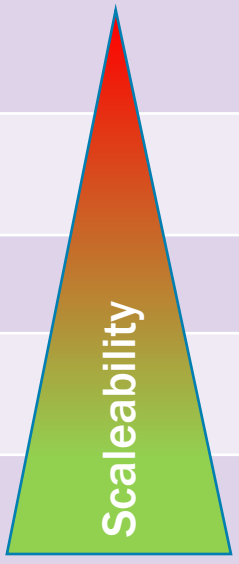
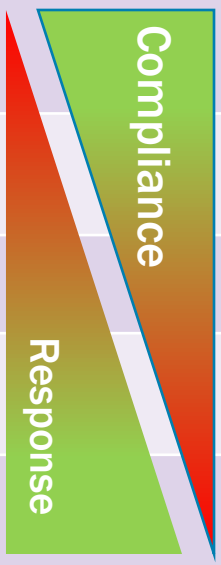
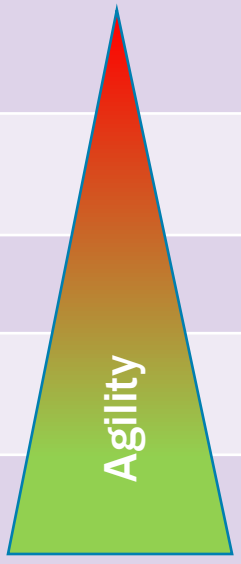
Concern 5: Provide Agility

- Traditional ATM is rigid and inflexible
- It takes many years (decades!) to introduce significant operational changes (with a centrally-managed process)
- UAS operations are likely
  - a) to be significantly different from current manned operations and
  - b) to evolve rapidly
- To be effective the future ATE needs to be able to respond quickly to such requirements

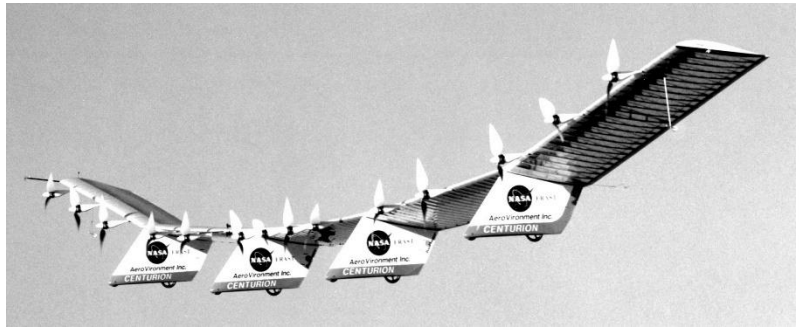
ATE Enterprise Architecture Options

Option	Description	Notes
Centralized	ATM performed centrally	*Classic Command & Control*
Partially Distributed	ATM performed at a limited number of distributed facilities	*Current FAA ARTCC/TRACON model*
Fully Distributed	ATM performed at a large number of distributed facilities	*Could be a federated approach*
Semi-Autonomous	UAS are under control of ATM facilities with limited autonomy	*E.g., for conflict avoidance*
Fully-Autonomous	UAS operate with full autonomy	*ATM is provided by strategic constraints on operations*

EA Option Assessment

EA Option	Safety	Efficiency	Capacity	Security	Agility
Centralized					
Partially Dist'd					
Fully Dist'd					
Semi-Autonomous					
Fully Autonomous					

Analysis



- The assessment shows the tension between
  - the benefits of centralized planning
  - the benefits of distributed execution
- This suggests that a hybrid approach may be optimal:
  - Centralized or Coordinated Planning
  - Distributed Execution, including autonomous action

Transition

- How will we get to this future architecture?
- It will take many years of incremental experimentation and operational trials
- A question of gaining increasing confidence in technology and operations
- Recommend starting locally and building out
- There will be setbacks…
- Will make NextGen look like a walk in the park
  - It actually requires transformation of the ATE to realize the vision
- Who's in charge…?

Other Considerations (not addressed)

- Environmental Impact:
  - Sustainability, Emissions, Noise
- Privacy
  - Operators
  - Third Parties
- Legal and Regulation
  - Legal Operating Framework
  - UAS Certification
  - UAS Registration
- Economic
  - Business Cases
  - Market Forces

FAA sUAS Registry	
Petitions Granted	Petitions Closed
3,306	399
As of 2/5/2016	

Conclusions

- A centralized solution alone will be incapable of providing the needed capacity and agility to support the future ATE.
- A distributed, federated public/private solution is required.
- Only local autonomy will enable the rapid response to assure safety
- However, consistent performance standards with certification will be needed to ensure compliance
- Security will be the most difficult objective to achieve

References

- NASA NAS Integration Fact Sheet, 2014: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-075-DFRC.html
- Autonomy Research for Civil Aviation, National Academies Press, 2014: http://www.nap.edu/catalog/18815/autonomy-research-for-civil-aviation-toward-a-new-era-of
- FAA UAS Roadmap, 2013: https://www.faa.gov/uas/legislative_programs/uas_roadmap/media/UAS_Roadmap_2013.pdf
- FAA Press Release on UAS Registration: https://www.faa.gov/news/press_releases/news_story.cfm?newsId=19914
- FAA Section 333 Exemptions: http://www.faa.gov/uas/legislative_programs/section_333/
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About the Author

- Steve Winter is an Enterprise Architect and Independent Aerospace Consultant, who has worked in the Aerospace Industry and Air Traffic Management for more than 30 years.
- He is also an Engineering Fellow at Raytheon Company in Boston, MA.
- He is the former Chief Technologist for NATS, the UK's Air Navigation Service Provider
- He is the author of numerous presentations and articles on aviation and enterprise architecture, as well as several articles examining the disappearance of Malaysian Flight 370 in 2014.