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# CPS Challenges in NextGen Aviation

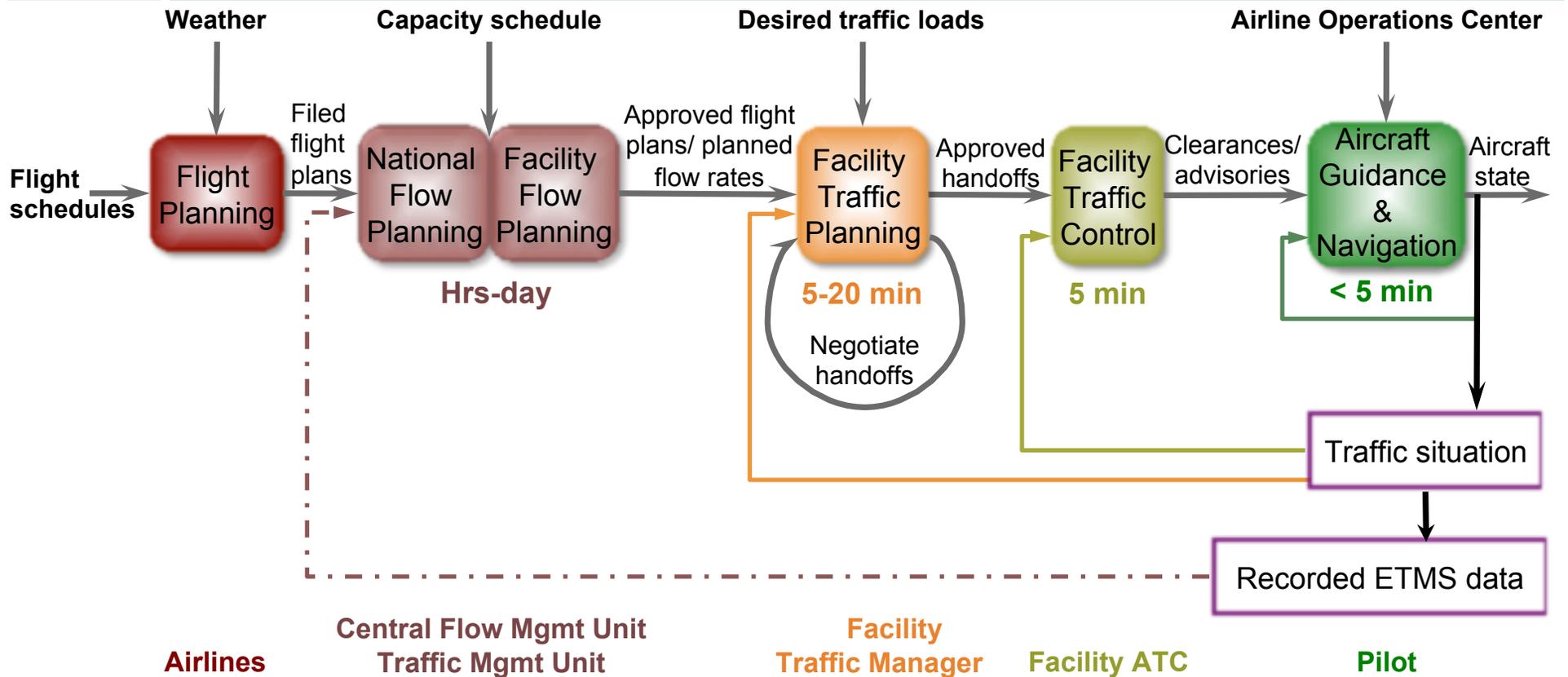
Hamsa Balakrishnan, Massachusetts Institute of Technology  
Claire Tomlin, University of California at Berkeley

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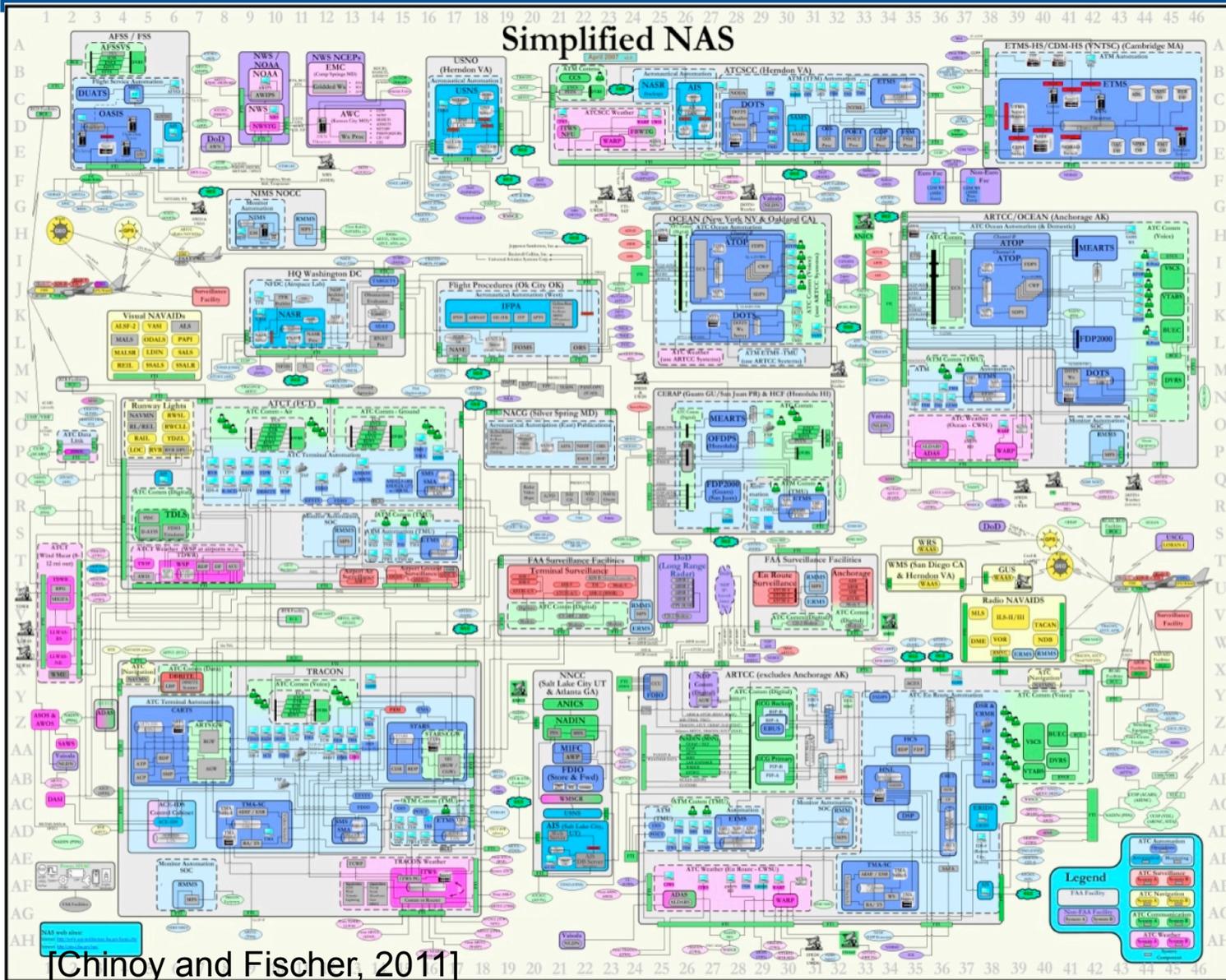
# Context for Modernization

- Current operations
  - Surveillance using ground-based radar systems
  - Primarily “procedural” approach to air traffic control
  - Manual handoffs between controllers with little prior coordination
  - Radio communications between pilots and controllers
- NextGen operational concepts
  - Automatic Dependent Surveillance – Broadcast (ADS-B)
  - Increased potential for optimization and control algorithms
    - Increased availability of state information (onboard and ground)
    - Datalink capabilities
- **Potential to enhance capacity, efficiency and safety; decrease environmental impacts**

# Today's Air Traffic Management System: Functional Architecture



# “Simplified Model of the National Aispace System”



# Key Challenges

- Identifying, assessing and mitigating risks
- Managing uncertainties
- Human-automation integration

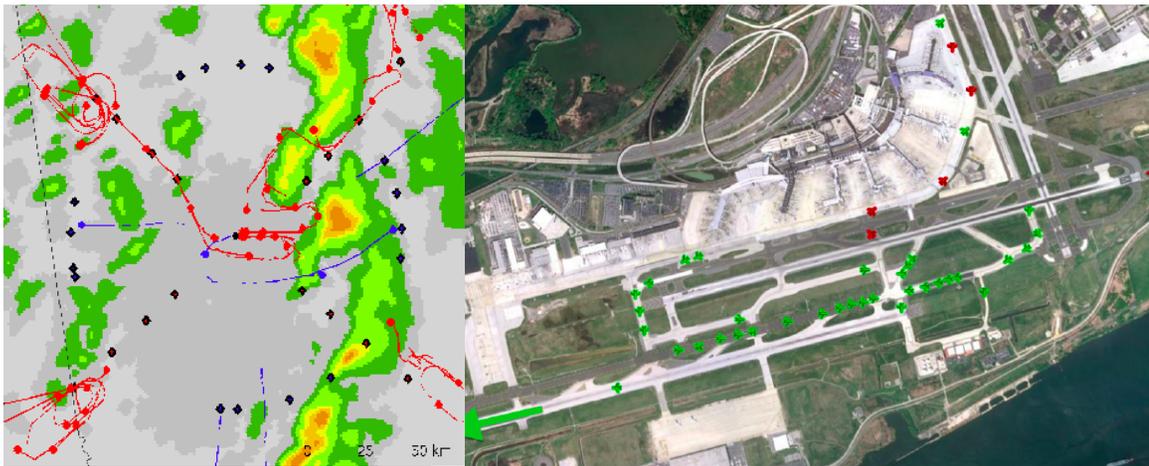
# Identifying, Assessing and Mitigating Risks

- Technology transition
  - Interactions with legacy systems
  - Mixed-equipage scenarios
- Security
  - GPS jamming/spoofing
  - Threat detection and mitigation
- Incentives for participation
  - Programmatic risks: Cancellations, time/cost overruns
  - Cost vs. potential benefit of collaboration (“Equipage paradox”)
  - Risks associated with information-sharing

Program	Status
Advanced Automation System	Cancelled
Microwave Landing System	Cancelled
Controller Pilot Data Link Communications	Cancelled
Advanced Tech & Oceanic Procedures	~10 yr delay
Standard Terminal Automation Replacement System	~7 yr delay
En Route Automation Modernization	~3 yr delay

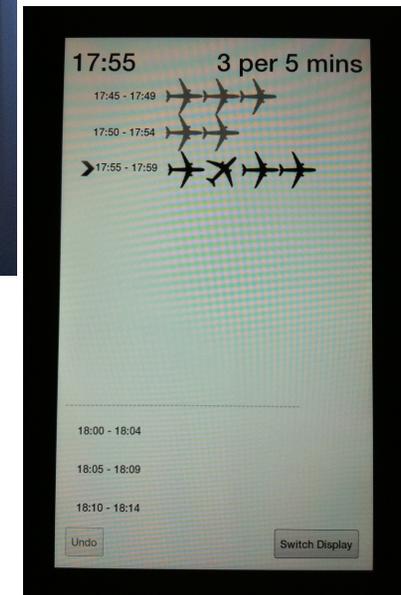
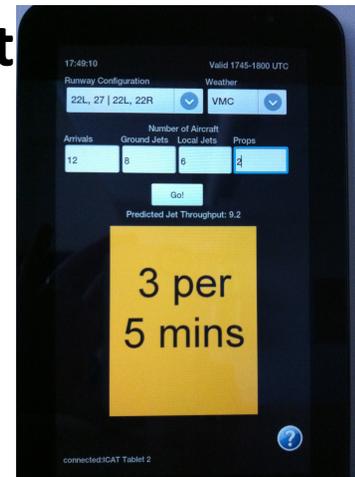
# Managing Uncertainty

- Modeling of capacity- and demand-side uncertainties
- Prediction and reduction of delays and their propagation
- Large-scale stochastic/robust optimization and control algorithms
- Resilience through multi-modality?



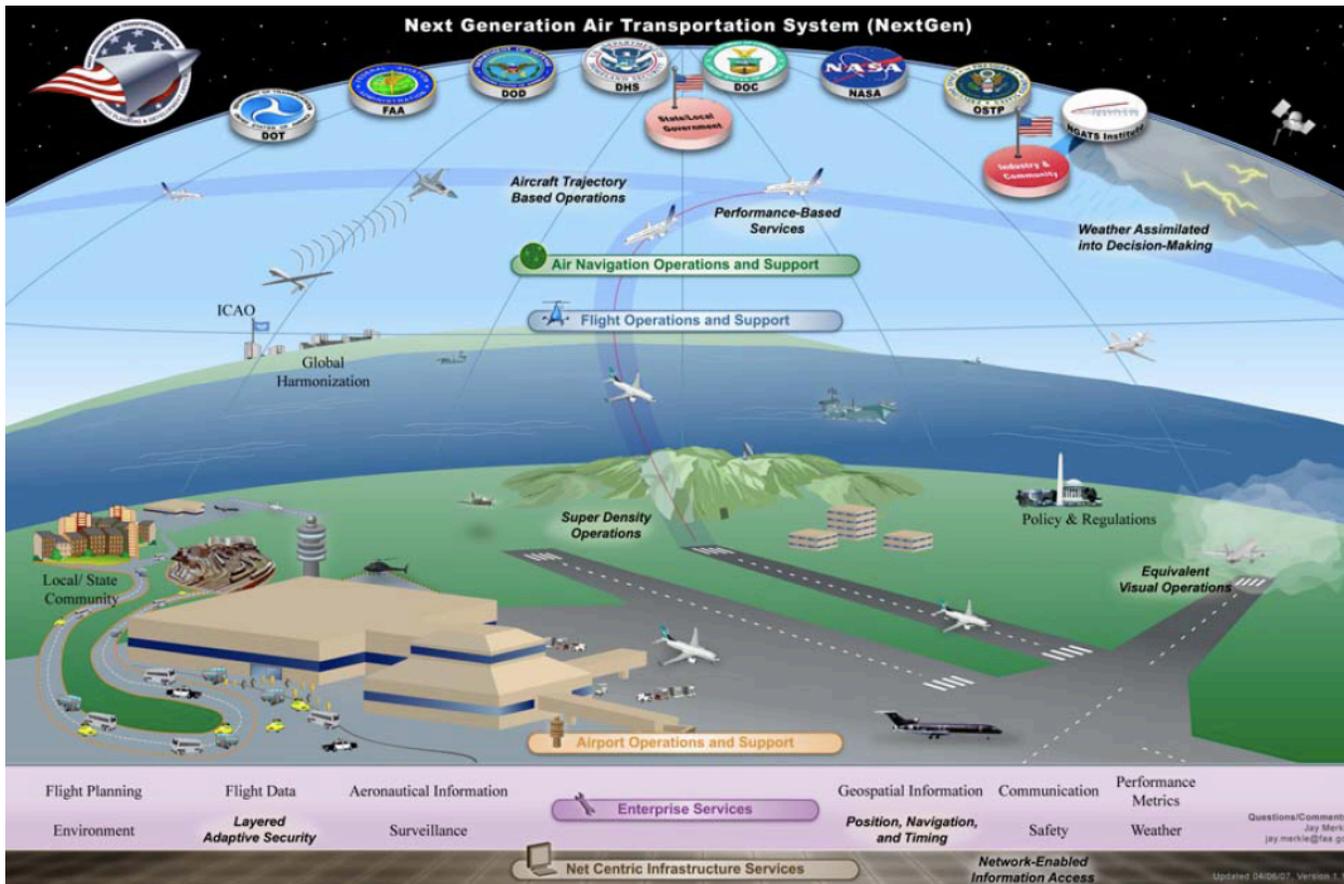
# Human-Automation Integration

- Human-in-the-loop CPS (aka *h*-CPS)
- **Situation awareness**, while important, **does not equal decision-support**
- Performance tracking
  - Development of metrics
  - Feedback to operators
- Graceful degradation
- Multi-stakeholder tradeoffs and interactions
- Increase in **autonomy**
- Data-driven modeling and simulation; learning-based control



# Summary

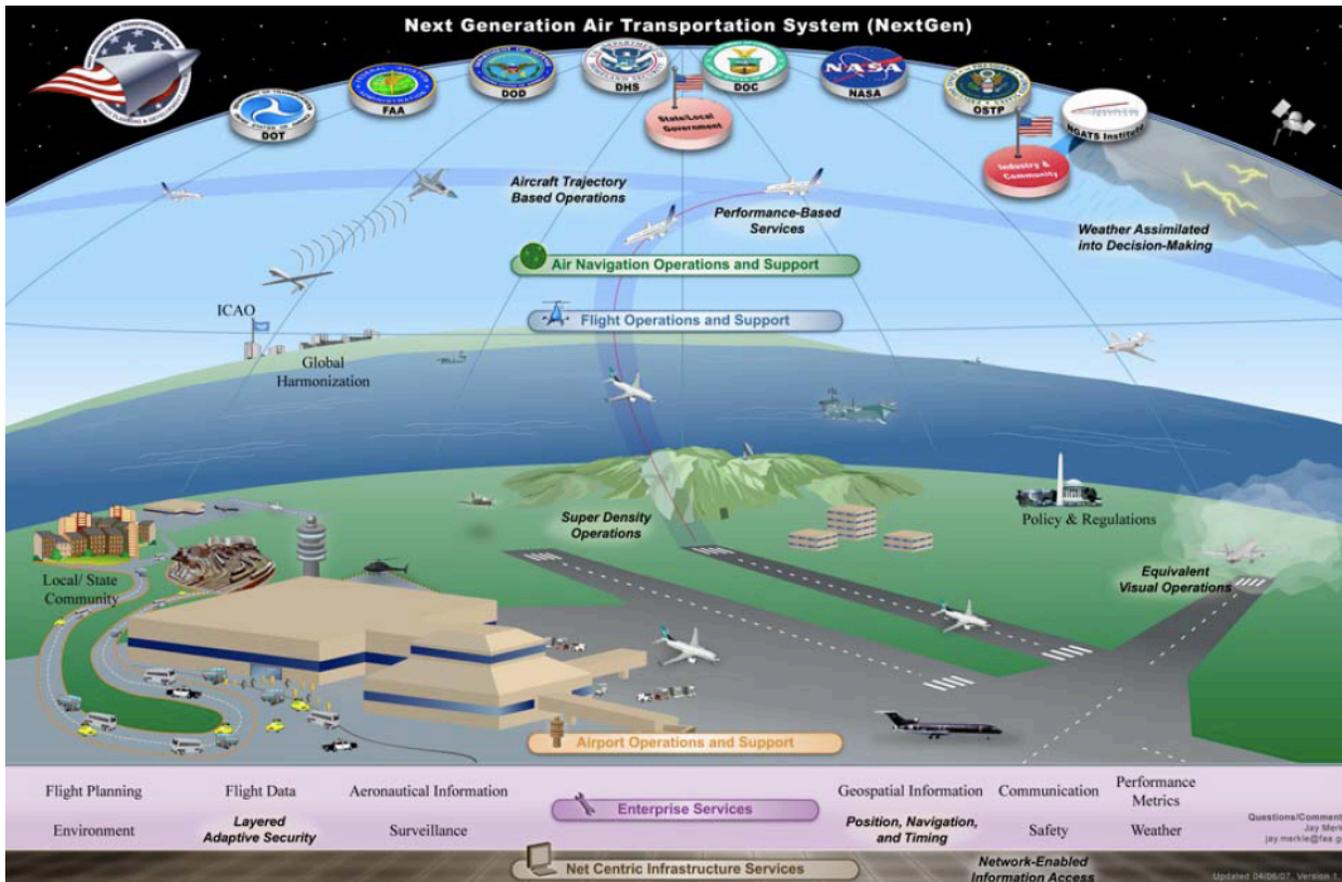
- NextGen technologies present a range of opportunities...



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# Summary

- NextGen technologies present a range of opportunities...  
...while also raising important CPS challenges



Identifying, assessing and mitigating **RISK**

Robustness and resilience under **UNCERTAINTY**

Effective **HUMAN-AUTOMATION INTEGRATION**

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