Air Transportation Infrastructure Concept for the 21st Century

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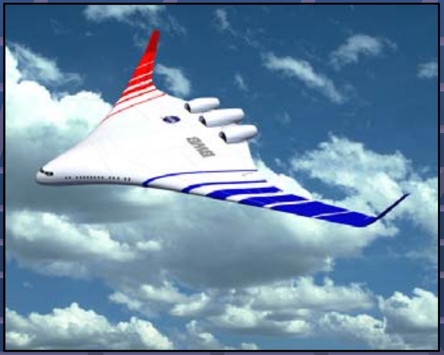
This paper represent the views of the author ……. and ….

…. is not an official position of FAA or the JPDO

Imagine in 2025 …



- Taking a business trip leaving my office in Washington DC to visit Boeing in Seattle
  - Booking my travel just minutes before leaving
  - Checking luggage at the L’Enfant Metro travel kiosk
  - Intermodal security checking unobtrusively as I board the Metro
  - Stepping off the Metro near the boarding gate for my flight to Seattle
  - Participating in an interactive video-conference from my seat
  - Departing and arriving on time, even though traffic is 5 times today’s
  - Arriving in Seattle, my luggage already in the trunk of my Avis car
  - Driving to Boeing in time for an afternoon meeting

Imagine in 2025 …

- Taking a family trip from my home in Manassas to our daughter’s home in Rochester New York
  - Driving our fractional ownership car to Manassas airport
  - Hopping into our fractional ownership airplane, which I, a non-pilot, will operate
  - Selecting the most scenic route and avoiding weather
  - Engaging the flight management system/autopilot
    - Which taxis, takes-off and flies the plane to Rochester, lands and taxis to our awaiting fractional ownership car
  - Departing and arriving on time in spite of 500,000 other automated aircraft operating in the NAS at the same time
  - Driving to our daughter’s home for the weekend

Air Transportation System Infrastructure

- All systems, people and procedures needed to operate the air transportation system, including.
  - Communications, navigation and surveillance (CNS)
  - Air Traffic Management (ATM) systems
  - Airports/heliports systems and aircraft ground services
  - Aircraft systems and operators
  - Aviation security systems
  - Passenger, luggage and cargo handling systems
  - In-flight services

What we know about ….
….. 2025 and beyond

- Nothing for sure.
- Any point design based on what we know today would most likely be wrong,
- But ….. we can be smart about preparing for the future we would want,

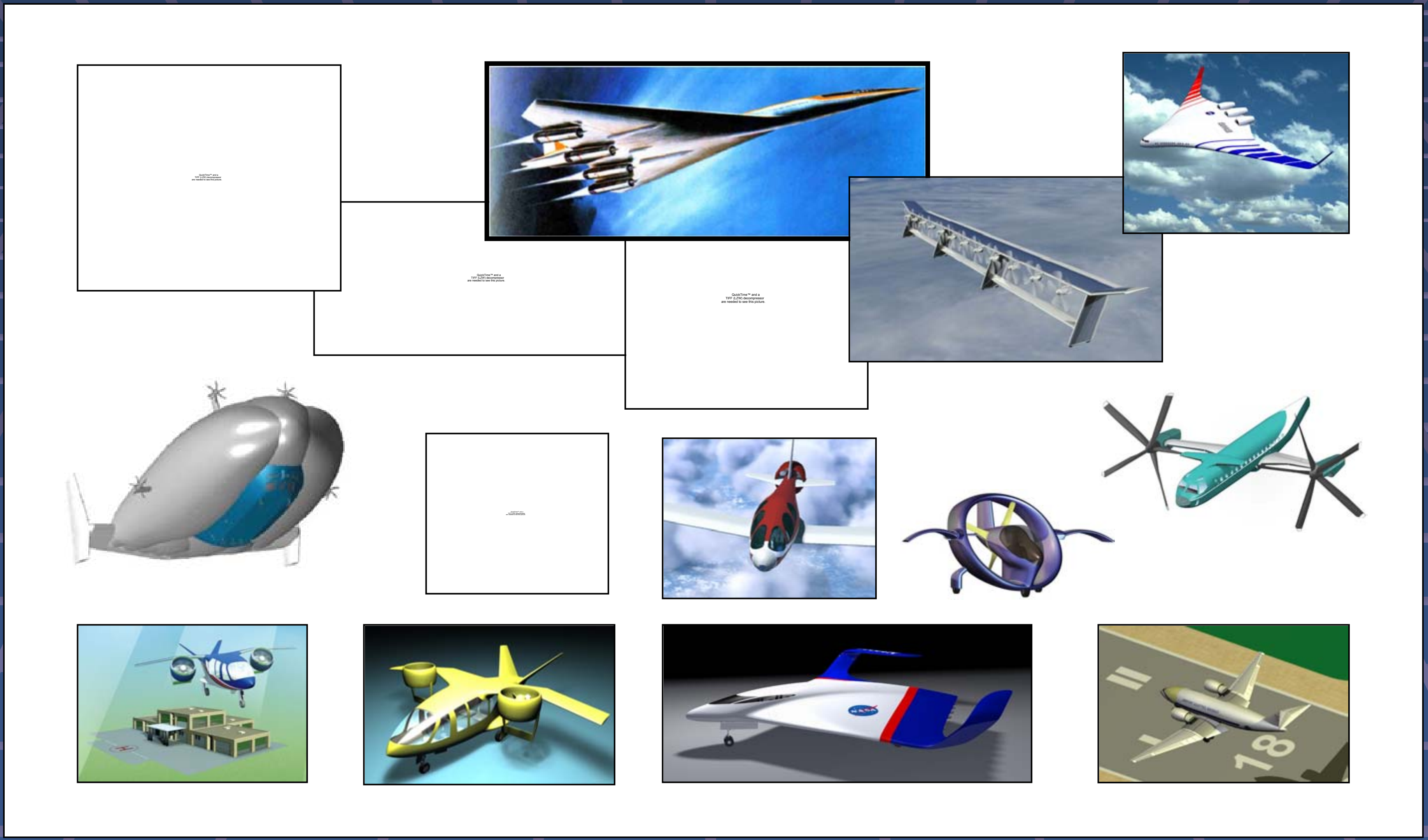
  …and we need to start preparing now.

- Infrastructure will take decades to change.

Infrastructure Preparation

- R&D should investigate infrastructures to support, even stimulate, the most optimistic desired futures.
- Define infrastructure that is robust, adaptable and scaleable from the minimum to the most optimistic futures.
- Evolve the infrastructure only to the degree actually needed at any point in time.

Possible Future Aircraft



My Optimistic Future

- Business travel
  - Business jets fly from origin to destination
    - Including international supersonic business jets
  - Commercial transport business travel growing in spite of extensive use of video-conferencing
    - Extensive inflight wireless office options
- Cargo
  - Express cargo demand continue to increase
    - Growing demand for same-day air delivery
  - Just-in-time manufacturing and commerce moves cargo from trucks, trains and ships to air
  - Dedicated cargo aircraft increasing, including UAVs

My Optimistic Future (continued)

- Special civil operations
  - Medical emergency and law enforcement
    - Helicopters take-off, land and operate anywhere in IFR conditions
  - Civil UAVs
    - Surveillance, remote sensing, communications, cargo, etc.
    - Take-off, land and operate anywhere in IFR conditions
  - Forest fighting
    - Operate close to fires/terrain under heavy smoke & IFR conditions
  - Off-shore oil platforms logistics
    - Operate in sever weather and IFR conditions
  - Space transportation
    - Frequent launch and landings at multiple sites within the NAS

My Optimistic Future (continued)

- Personal, leisure and recreational travel
  - More people retire early with adequate discretionary income travel by air as much as they want
    - Southwest-type Airline fly 1,200 passenger transports to increasing number of national and international destinations
  - Affluent population commute to work by air
    - Take-off and land close to home and office
  - Personal air vehicles used for routine personal travel
    - Fully automated from take-off, en route and landing
    - Possibly roadable air vehicles “flying car”
  - Increasing numbers and types of recreational and sport aircraft

Infrastructure Supports

- Fully automatic aircraft operations - VFR & IFR
  - Take-off, en route, landing and ground operations
  - All airports, heliports and other desired location
- Automated air traffic management
  - National and international to varying degrees
  - Capable of handling millions of aircraft
  - Allow autonomous aircraft operations
- Automatic airport/heliport operations - VFR & IFR
  - Adaptive/programmable runways, taxiways & gates, ground traffic management, and aircraft servicing
- Non-intrusive aviation security
  - All aircraft, passengers, luggage, cargo and all origins
  - Full-time surveillance and positive ID of all aircraft

Infrastructure Supports

- Automated passenger, luggage & cargo processing
  - Seamless across transportation modes
  - Luggage may take different route than passenger
- Ubiquitous in-flight information services
  - Business/entertainment information any time, any place
- Efficient and seamless inter-modal operations
  - Multiple options for door-to-door transportation with common infrastructure seamless to customers
- <u>All functions robust</u>
  - Flexible, adaptable to change and tolerant to human and system errors

Operational Factors

- Required
  - Full operational capability available 24/7
  - Full service available essentially everywhere desired
    - Scaleable to local needs
  - Global interoperability
- Desired
  - Minimum suite of avionics <u>required </u>to operate within NAS affordable to anyone who wants to fly
  - Costly portions of the infrastructure also supports non-aviation applications to broaden user-fee base

Architecture Characteristics

- Communication
  - Multiple independent networks
    - System-wide safety-critical net - multiply redundant
    - Mission-critical net - duplex and/or backup capability
    - Capacity-enhancing net - simplex
    - Business and entertainment net - comparable to existing commercial nets, but available to any aircraft
- Space positioning
  - Multiple independent systems
    - Satellite, terrestrial and airborne assets
    - Integrated design for multi-fail operational capability with no loss in functionality, I.e., “fly-by-wire” design philosophy
- Surveillance
  - Dependent for system monitoring
  - Independent for monitoring non-cooperative aircraft

Architecture (Continued)

- ATM information, processing and procedures
  - Operational concept and airspace management that help enable automated ATM
  - Safety-critical information from safety-critical communication network(s)
  - Sensing and processing systems are safety-critical
    - Provide full service under all but extremely rear circumstances, e.g., one lose of full automatic service in 10 years
- Aircraft avionics (aircraft operating in controlled airspace)
  - Flight control systems support fully automatic flight from take-off to automatic landing and ground operations
  - Flight management systems provide automatic flight from brake release to take-off through landing and taxing to parking location

Integrated System Design

- Integrated design approach to space positioning and data communications
  - Multiple fail-operational reliability
  - Consider all space, terrestrial, and aircraft assets
    - Future upgrades to GPS and Galileo, and other potential space-based and ground-based augmentation system
    - Existing and potential future ground-based space positioning system
    - On-board inertial and aircraft-to-aircraft distance measuring instrument
    - Satellite, airborne and ground-based data communications
  - Use adaptive optimal estimation and failure detection logic to derive position, velocity and time (state vector) for all aircraft
    - Include estimates of system “health” and state vector accuracy
    - Redundancy management accomplished through this mechanism

Integrated System Design

- Provide state vectors derived from the same source to aircraft and automated ATM systems
  - Aircraft in close proximity to other objects require more accuracy than ATM
  - Terminal area and ground operations require more accuracy than en route ATM
- Design-in highly secure information security protection
- Certify at the functional capability level rather than individual components
  - Aircraft and ATM: certify availability of all information and processing needed for fully automatic operations under multiple failures
  - Potential cost savings

Transition

- Ground rules
  - Implementation must be evolutionary without service interruptions
  - Each step in transition must be *viable* in all dimensions
    - Technical, operational, business case, political, cultural, etc.
  - Transition towards "optimistic future infrastructure" will only go as far as National and Global needs and policies support

- Assumptions
  - ATM systems, airports, aviation security systems and aircraft avionics will continue to be upgraded as technology advances, whether based on this proposed infrastructure or some other

Transition (continued)

- Approach
  - Develop evolutionary transition paths for each major function
    - System infrastructure elements - space positioning, communications, ATM automation, aircraft systems, security, etc.
    - Procedures and policy changes
    - Workforce - human/automation roles and training
    - R&D plan and major decision points
    - Alternative business models
  - Develop business case for each stage of transition
    - Transition towards the optimistic future infrastructure will only progress as far as the business case justifies
  - Use business case to gain stakeholder acceptance/support

Business Case

- Sufficiently attractive business case must be established to justify capital investment and stimulate growth
  - User costs must be sufficiently low to gain acceptance
  - Consider various levels of user base
    - Assume optimistic future opportunities for aircraft usage
    - Analyze with and without non-aviation users
  - Consider high-volume commercial production avionics
    - Low certification costs via functional certification

- Consider alternative business models for infrastructure
  - Government provided fee-for-service
  - Commercial fee-for-service
    - Private investment capital - repaid from user fees
  - Public-private international partnerships

Concluding Comments

- R&D for 2025 air transportation system should <u>investigate</u> alternatives for the most optimistic future
- An integrated system design approach should be taken for the infrastructure, considering space, ground and airborne assets
- Transition from today to the 2025 system must be viable in all dimensions - scalable to National/Global needs
- Business case should include the broadest user-base and consider new business models