Prioritized Technology Challenges Breakout Session

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3rd Annual TVF Workshop

Hartford, CT

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2017

- Prop/fan and wing aero interaction research
- Study alternatives to DEP that meet noise, emissions, perf. requirements
- Simulate or test various flight scenarios
- Cyber security
- Demonstrating min acceptable handling qualities and pilot/vehicle interface
- Demonstrate almost zero-zero recovery capability
- Rapid recharge for all-electric
- Helicopters that apply electric power for backup, e.g. OEI, divert power from APU to propulsion, etc.
- Digital Twin & RMS & Health management, sensors, connectivity, analytics, “big data”

2018

- Disk loading vs. ground environment
- DEP integrated VMS (FCC, FADEC, electric power control), 2018-2021
- Affordable fly-by-wire to lead to autonomous flight demo
- “Pilot’s associate” standards; precursor to full autonomy, e.g. automated IFR procedures
- Aero-propulsive control: Flight path control; FDAL A, B, C
- DEP information bus to avoid EMI; fiber-optic WDM, TFCH
- Safety process FMEA, redundancy management, “# of 9’s”
- Dependable flight components, 2018-2022 leading to demo
- Sense and avoid tech demo
- Basing technology (TO/LDG ops, maint. & support), 2018-2021
- Integrated flight/propulsion control to enable full autonomy
- Benchmark system (within 2 years) for best SOTA all-electric onboard network

2019

- DEP fireproof and fire detection/protection
- Solar electric standards and demo (2018-2021)
- SVO integrated with autopilot for loss of control avoidance
- Avionics and communication/network interoperability (standards)
- Modular articulating propulsors for efficient hover, transition, and high forward flight speed (2018-2020)
- Search and rescue demo
- Demo for wildfire
- Demo for agriculture
- Fuel-cell based air vehicle
- Low inertia motors over 80 kW; $1/20^{th}$ of current inertia
- Manufacturing system demo (2018-2023)
- Ultra-low noise VTOL aircraft demo (2018-2022)

2020

- Low-cost obstacle avoidance systems for huge increase in # of vehicles (2017-2025)
- VTOL ATM demo, low density (1 heliport/sq. mile), 10 min sequencing, outside UTM and NAS, human supervisor, use sUAS for demo, 2020
- Electric grid (increased power required for charging vehicles) and charging infrastructure
- Ultra-quiet propellers/rotors
- Standardized interchangeable “power cells” (2020-2021)
- Operation w/out ground infrastructure (w/in 3 years)
- Structural batteries
- 400 Wh/kg battery specific energy
- Integrated VTOL with hybrid electric demo
- Discrete hybrid VTOL/CTOL platform (2019-2025)

2021

- Low-cost electric propulsion pilot trainer (or training?)
- Anti-ice, de-ice systems w/out hot bleed air and limited electric power
- Ice protection for DEP systems (low and variable speed props and fans)
- 5 MW propulsive electric motor

2022

- Vehicle-to-vehicle interlink with GA, airlines, drones
- Synthetic vision systems
- Acoustics stage N, N+1, N+2 (2017-2024)
- Transition dynamics and control standardization
- Infrastructure energy replenishment solution (recharge, batt. swap, other)
- Dynamic datalink methods based on traffic density (low density, high power ADS-B; high density, WiFi mesh network; spectrum conservation)

2023

- Fully-automated control flight systems demo

2024

- VTOL ATM demo, high density (>10 heliports/sq. mile), 1 minute sequencing, integrated with UTM and NAS, complete automation
- 800 Wh/kg battery specific energy

2026

- 1200 Wh/kg battery specific energy

Comments by Audience During Briefing

- Battery specific energy targets are not likely realistic and the aerospace industry will likely have little control of battery technology evolution
- Replace “battery” specific energy with “energy storage” specific energy
- Integration aspects, e.g. thermal management, that lead to increased empty weight, should be part of the R&D. For example, many forget about the controller/inverter weight during design.
- “Reference architectures” (typical motor, controller, bus topologies) might be valuable as an investment and as a basis of standards, but they may also be obsolete quickly because technology continues to evolve.