Recent Climate Change Activity at AIAA: Forum 360s at SciTech Forum 2020

- **Forum 360: The Next Challenge for Aerospace: Global Climate Change**
  - This session will explore the challenges and opportunities that global climate change represents for the aerospace community. We will frame the key science, economics and policy issues and discuss how aerospace engineers can shape the future by developing technologies that can measure and analyze environmental impact, as well technologies that will successfully mitigate aviation's impact on the environment.
  - https://www.aiaa.org/detail/session/forum-360-session-thu-am
- Forum 360: Achieving Sustainable Aviation
  - Not that long ago, "Green Aviation" and minimizing the environmental impact of aviation was an aspirational goal, but today it is a goal for survival. The global aviation community has been proactively collaborating to set industry-wide goals and targets to reduce aircraft emissions, but will it be enough to sustain the industry as new entrants and worldwide demand drive exponential growth? Many think it is not enough and that the industry needs need to be much more aggressive. This panel will take a systems-thinking approach across the aircraft lifecycle to focus on compressing the design cycle, optimizing operations, maximizing energy savings, and accelerating the development and commercialization of new and promising technologies.
  - https://www.aiaa.org/detail/session/forum-360-session-mon-am

Recent Climate Change Activity at AIAA

- Online Short Course on Sustainable Aviation
  - Instructed by Dr. Marty Bradley
  - 7 October and 9 October (2 Lectures, 4 Hours)
  - Wednesday and Friday at 1300-1500 Eastern Time (sessions will be recorded and available for replay; course notes will be available for download)
  - All students will receive an AIAA Certificate of Completion at the end of the course
  - Non-Member Price: $299 USD, AIAA Member Price: $199 USD, AIAA Student Member Price: $99 USD
  - In this (short) short course, participants learn about the history and current developments in sustainable aviation. Participants will learn the about the various topics related to sustainable aviation that include noise, alternative fuels (biofuels, synthetic fuels, methane, alcohols, and hydrogen), and lifecycle environmental impact and analysis. The possible advantages and challenges of each type of alternative fuel will be discussed. Electric aircraft will also be discussed, but to a limited extent. (For detailed instruction on electric and hybrid electric propulsion and aircraft, other AIAA courses are available)
  - https://www.aiaa.org/events-learning/courses-workshops/detail/sustainable-aviation---online-short-course-(starts-7-oct-2020)

Recent Climate Change Activity at AIAA

- On-Site Course on Sustainable Aviation
  - Topics:
    - Air Transportation and Environment
    - Green Aircraft and Engine Technologies for Reducing the Fuel Burn & Noise
    - Alternative Aviation Fuels (Biofuels) & Materials
    - Operational Improvements (NextGen ATM, Air-to-Air Refueling, Formation Flying, Tailored Arrivals)
    - Integrated Analysis Tools to Model the Economic & Environmental Impact of Aviation
    - Sustainable Green Airports
  - Instructed by Dr. Ramesh K. Agarwal
  - Your organization can realize substantial savings by bringing an AIAA short course to your workplace. On-site delivery is perfect for training 10 or more employees in a specific topic. Many of our courses are available for on-site presentation.
  - https://www.aiaa.org/events-learning/courses-workshops/detail/sustainable-green-aviation

Recent Climate Change Activity at AIAA

- Green Engineering Integration Committee
  - The purpose of the Green Engineering Integration Committee (GEIC) is to promote a holistic, systems approach to improved energy efficiency, sustainability, renewable energy and 'cradle-to-grave' design. GEIC serves as the AIAA focal point for all "green" aerospace-related programs and technologies and works synergistically with the appropriate technical committees to assure that the AIAA membership is adequately informed about all aspects of this critical aerospace activity.
  - Nomination period is open until 11.15.2020
  - Contact Info: Kurt Papathakis, NASA Armstrong Flight Research Center kurt.v.papathakis@nasa.gov
- In-progress: Liquid Rocket Engines: Emerging Technologies in Liquid Propulsion - Online Short Course (20 Hours, Starts 15 Sept 2020)
  - https://www.aiaa.org/events-learning/courses-workshops/detail/liquid-rocket-engines-emerging-technologies-in-liquid-propulsion

Climate Change Topics at Recent AIAA Conferences

- AIAA Propulsion and Energy Forum
  - https://www.aiaa.org/propulsionenergy/registration
  - It was from 24–26 August 2020 but can access all online material until 31 October 2020
  - Program: https://www.aiaa.org/propulsionenergy/program
  - Technical Program: https://aiaa-mpe20.abstractcentral.com/itin.jsp
  - Examples:
    - EERE-01: Renewable and Bio-Inspired Technologies
    - HR-02: Green Propulsion Systems: Design and Application
- SciTech Forum 2021
- ASCEND 2020
  - 16-18 November 2020 https://www.ascend.events/experience/rates-virtual/
  - https://www.ascend.events/experience/program/
  - Example: 11/17: 132 PANEL-31 Space-Enabled Solutions Towards Addressing Global Climate Change 4:00 PM - 6:00 PM

SKAI Overview

- SKAI is an Alaka'i Technologies Corporation
- Founded in 2006 by Steve Hanvey (CEO) and Brian Morrison (CTO)
- Headquartered in Hopkinton, MA
- Founders were both a part of the Advanced General Aviation Transport Experiments or (AGATE)
  - public-private partnership launched in 1994 as a collaboration between NASA, FAA and the aviation industry focusing on replacing short distance transportation
- Idea for SKAI first developed in 2012
- Worked on vehicle patent from 2012-2018
- Starting building prototype in May 2018
- Unveiled non-flying vehicle, SKAI, on May 29, 2019
- Goal is to have first aircraft available early 2021

Sources: https://www.skai.co/vehicle
https://www.businesswire.com/news/home/20190529005834/en/Alaka'i-Technologies-Launches-World's-First-Hydrogen-Powered-Air-Mobility-System
https://www.bizjournals.com/boston/inno/stories/profiles/2019/05/30/this-mass-startup-exits-stealth-with-its-electric.html

SKAI Vehicle

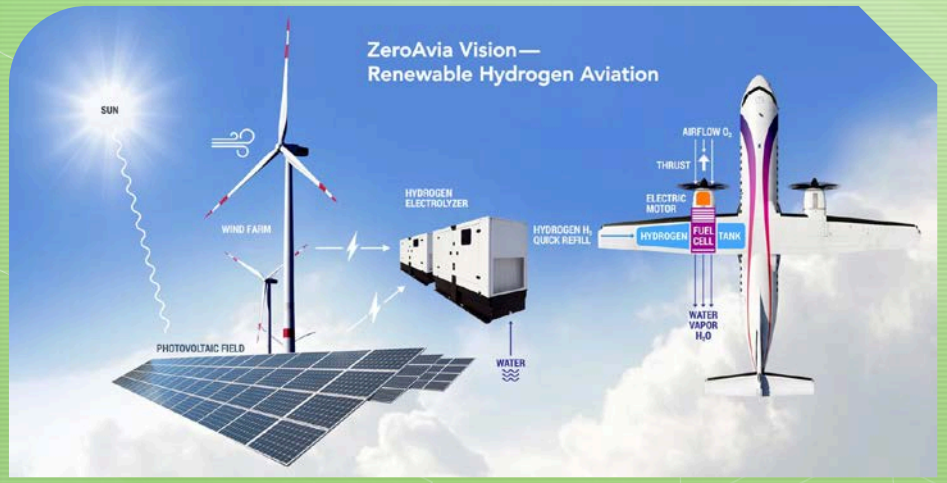
- Co-designed by Designworks, a design innovation studio for the BMW Group
- Powered by 3 hydrogen fuel cells
- Range: Up to 2 Hours, ~150 Miles
- Speed: 85-115 MPH
- Six rotor propulsion system
- Seats up to five passengers (1 pilot + 4 passengers)
- Piloted, ground-piloted and fully autonomous flight

Image: https://apnews.com/article/1fbec291498646d5889516f54cf12889

Image: https://evtol.news/alakai-technologies-skai/

Current state-of-the-art and recent breakthroughs

H2 Fuel Cells



Recent Aviation Efforts

Boeing Phantom Eye

- UAV (liquid hydrogen powered)
- Continuous operation up to 4 days

CHEETA

- NASA-funded program and collaboration between UW-Madison, UIUC, CMU
- Cryogenic fuel cell system

Airbus ZeroE Commercial Airliners

- Turbo fan
- Turboprop
- Blended-wing body

2010 — **2016** — **2019** — **2020** — **2035**

HY-4 (University of Ulm)

- first passenger fuel cell aircraft (four-seater)
- Hybrid fuel cell + battery

ZeroAvia Hyflyer

- First commercial-scale electric flight in the UK
- Piper M-Class 6-seater retrofitted w/ propulsion tech

Independent Study by Fuel Cells and Hydrogen Joint Undertaking (FCH), Clean Sky 2, EU

Innovation Roadmap for H2 Fuel Cells:			
Objective	**Goal**	**Target**	**Where we are today**
Lightweight and safe LH2 Tanks	Decrease weight of LH2 tanks for efficiency	- 35% gravimetric index for short-range - 38%+ for long-range	15-20% gravimetric index (for tank with less than one ton of LH2)
On-board LH2 distribution components	Ensure Kerosene-level safety and reliability	Safe, certified distribution architecture	Pilots exist, no designs for commercial aircraft standards yet
High-power, optimized fuel cell system	Enable use of fuel-cell propulsion over H2 combustion	- 1.7 kW/kg for regional aircraft - 2 kW/kg for short-range	0.75 kW/kg power density on system level
Commuter Prototype	Proof of H2 aircraft concept	First standardization of (L)H2 certification	First H2 demonstrators exist
Regional / Short-Range Prototype	Evaluate feasibility and economics of H2-powered aviation	Regional and SR prototype in TRL6 and ready for certification	N/A

https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

Exhibit 3

Comparison of new technology and sustainable aviation fuels and new technologies

Comparison vs. kerosene	Biofuels	Synfuels	Battery-electric	Hydrogen
Commuter <19 PAX	No limitation of range	No limitation of range	Maximum ranges up to 500-1,000 km due to lower battery density	No limitation of range
Regional 20-80 PAX				
Short-range 81-165 PAX				
Medium-range 166-250 PAX			Not applicable	Revolutionary aircraft designs as efficient option for ranges above 10,000 km
Long-range >250 PAX				
Main advantage ✓	Drop-in fuel – no change to aircraft or infrastructure	Drop-in fuel – no change to aircraft or infrastructure	No climate impact in flight	High reduction potential of climate impact
Main disadvantage ✗	Limited reduction of non-CO_2 effects	Limited reduction of non-CO_2 effects	Change to infrastructure due to fast charging or battery exchange systems	Change to infrastructure

https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

Exhibit 4

Comparison of climate impact from H_2 propulsion and synfuel

Compared to kerosene-powered aircraft, timeframe until 2100

Ongoing scientific debate about **full climate** impact, in particular:

- Contrail/cirrus formation
- Aggregate measure

Total climate impact could be 2 to 4 times compared to CO_2 emissions alone

	Change of in-flight emissions and emission related effects[1]				**Climate impact reduction potential[4]**
	Direct CO_2	NO_x	Water vapor[2]	Contrails, cirrus	
Synfuel	-0% / -100% (Net)[3]	-0%	-0%	-10-40%	-30-60%[3]
Hydrogen turbine	-100%	-50-80%	+150%	-30-50%	-50-75%
Hydrogen fuel cell	-100%	-100%	+150%	-60-80%	-75-90%

1. Assuming decarbonized production and transportation of fuels in 2050
2. 10 times lower climate impact than from CO_2 emissions
3. Net CO_2 neutral if produced with CO_2 captured from the air
4. Measured in CO_2 equivalent compared to full climate impact of kerosene-powered aviation

https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

Sources

- https://www.boeing.com/defense/phantom-eye/
- https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html
- http://hy4.org/
- https://newatlas.com/nasa-cheeta-funding-aircraft-fuel-cell/59725/
- https://www.flyingmag.com/story/aircraft/zeroavia-hyflyer-first-uk-flight/
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