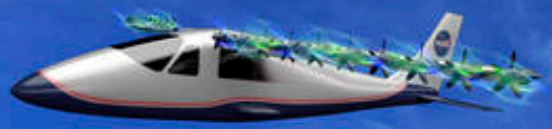
National Aeronautics and Space Administration

Future of Flight:

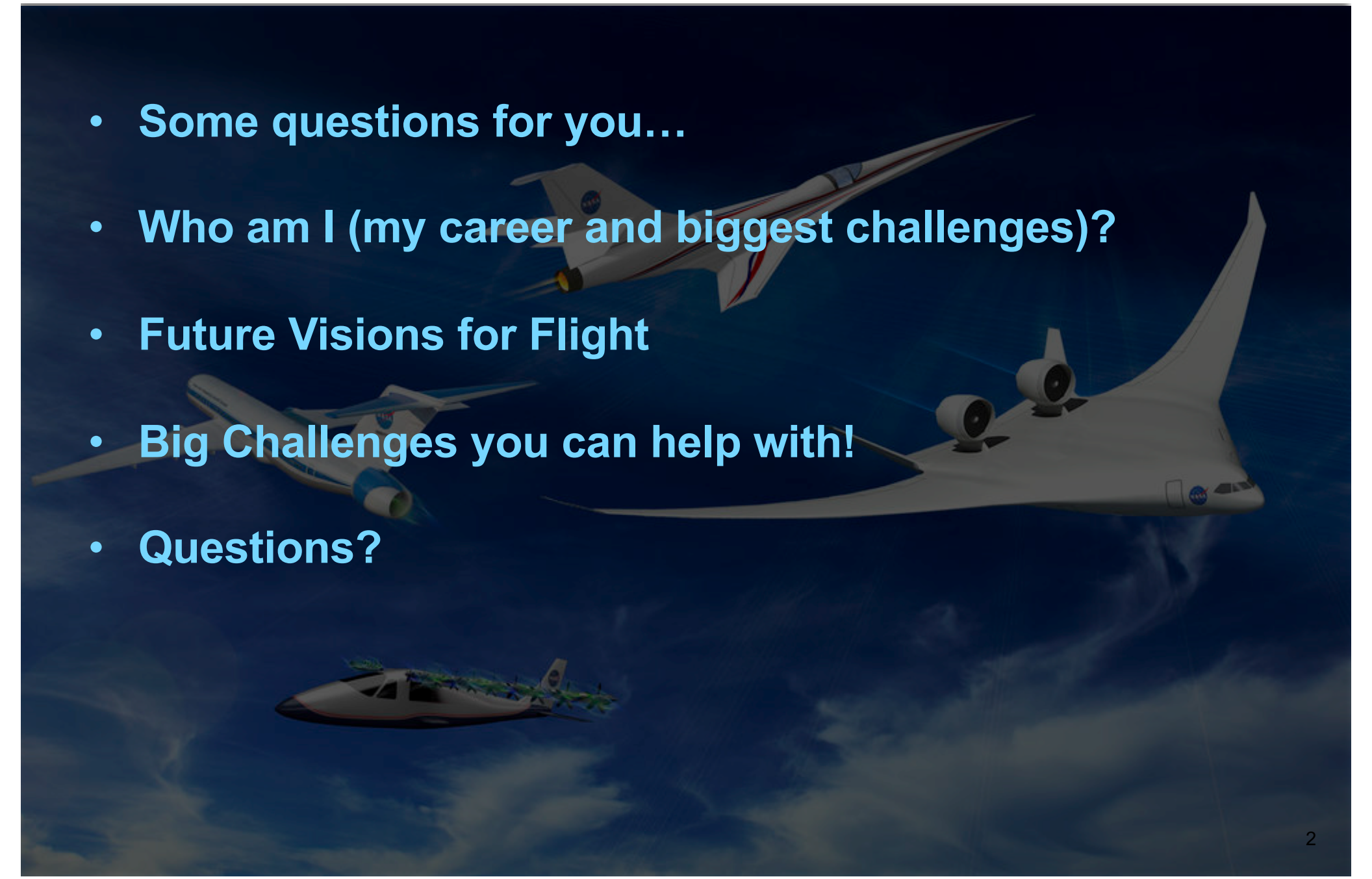


Flying Cars to X-Planes

Discussion at:
Santa Clara High School
May 23, 2019

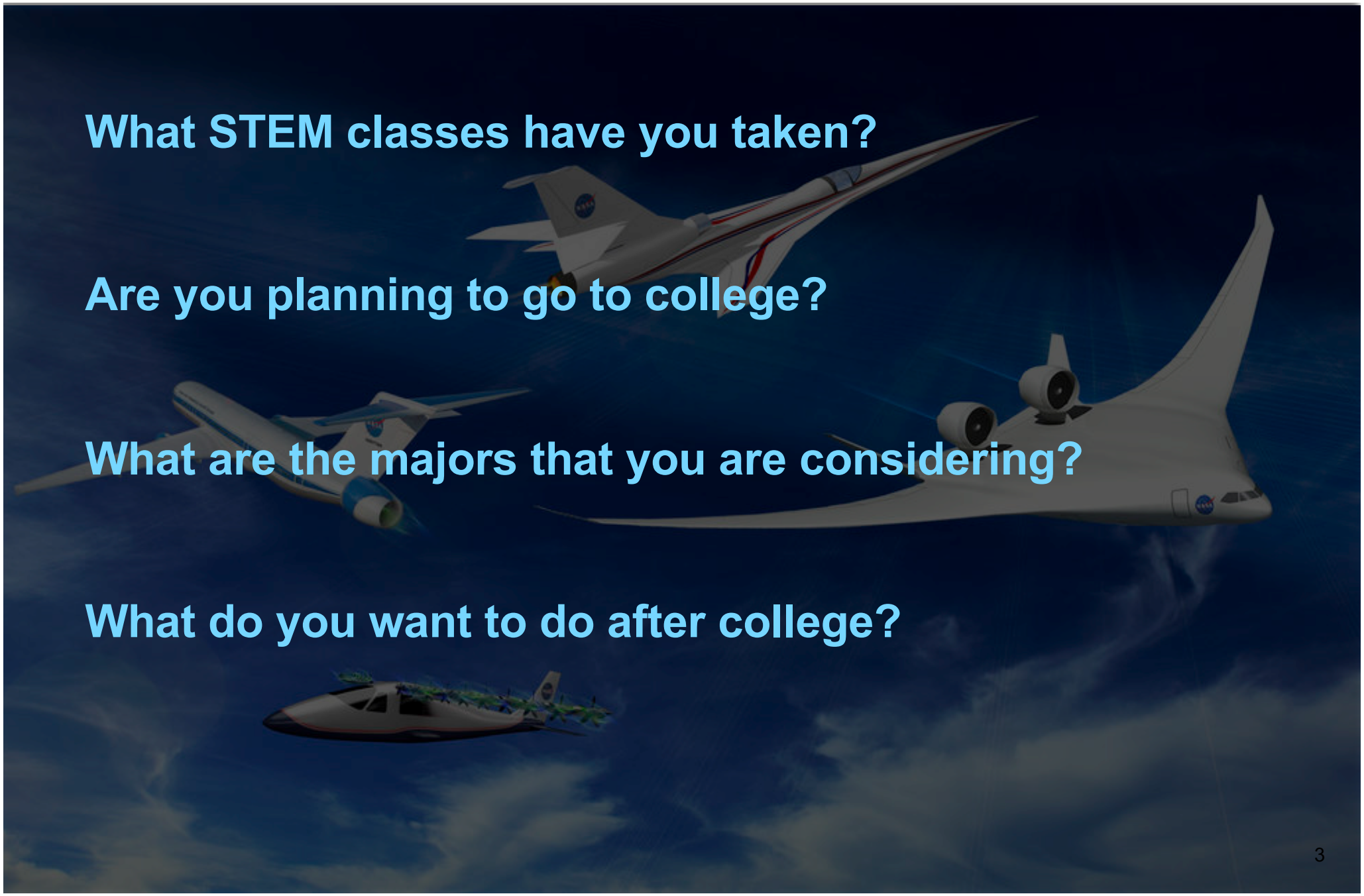
Moderator:
Dr. William (Bill) R. Van Dalsem
NASA Ames Research Center

Proposed Discussion…



- Some questions for you…
- Who am I (my career and biggest challenges)?
- Future Visions for Flight
- Big Challenges you can help with!
- Questions?

Some questions for you…



What STEM classes have you taken?

Are you planning to go to college?

What are the majors that you are considering?

What do you want to do after college?

My Career…

College Education: (Mechanical & Aerospace Engineering)

- Bachelor of Science (B.S.), University of California, Santa Barbara
- Masters of Science (M.S.), Stanford University
- Doctor of Philosophy (Ph.D.), Stanford University

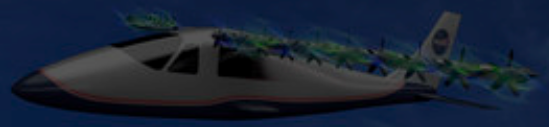
NASA Experience:

- Worked at NASA for about 38 years
- Many different jobs:
  - Research Scientist (computational physics)
  - Project Manager (~$200M/year)
  - Currently Deputy of the Aeronautics Directorate (~600 people)
- Worked on:
  - Human spacecraft (Space Shuttle, ISS)
  - Robotic spacecraft (looking for new Earths, going to the Moon)
  - Aircraft (airliners, cargo, helicopters, fighters, and unmanned aerial vehicles)

My Biggest Challenges…

College (Bachelors) Expenses:

- From my summer jobs, I decided I really wanted to go to college…
- But, my family could not afford to send me to college.
- I worked hard in High School and applied for many scholarships.
- I received a University of California Regent Scholarship.
- At college (UCSB), I had to watch my finances very carefully, as had just barely enough income to make ends meet, no savings, and my family couldn't help me if I got in financial trouble.



My Biggest Challenges…

College (Masters & Ph.D.) Work Load:

- I completed by Masters and Ph.D. while working at NASA.
- Typically worked full-time and took ~3 graduate classes, which meant I typically worked/studied ~70 hours a week for about 5 years.

Career – Need Continually Learn New Disciplines:

- In college, I was trained as a mechanical & aerospace engineer.
- At work, I have had to learn computer science, management (project & people), system engineering, electrical engineering, and many more new skills and how to apply these to ground-based, aircraft, and spacecraft systems.

Future of Flight

NASA Aeronautics is enabling fundamental changes in how we use flight:

Future of Flight

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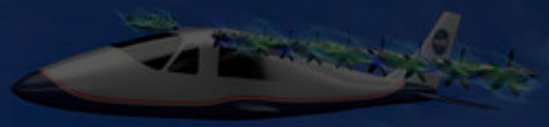
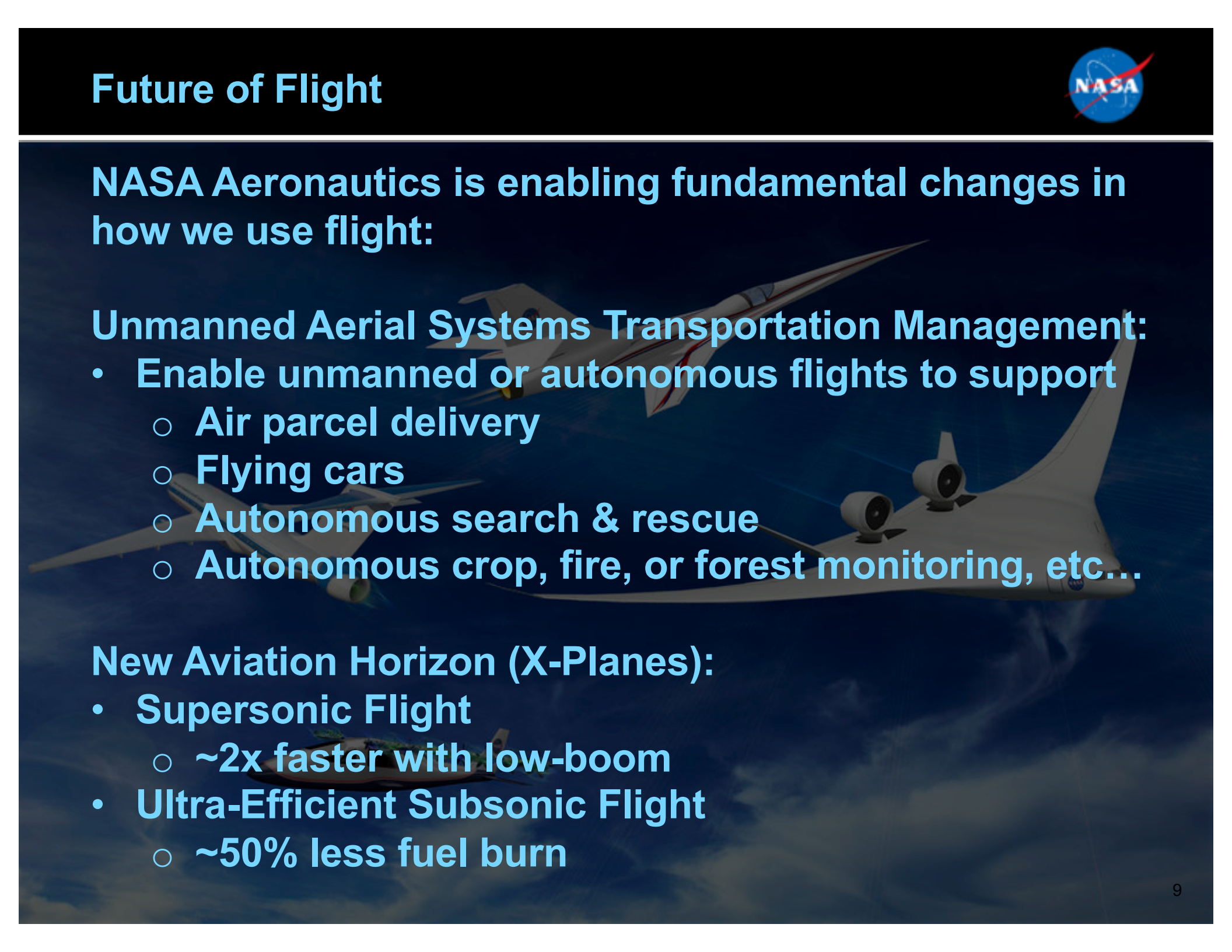
Unmanned Aerial Systems Transportation Management:

- **Enable unmanned or autonomous flights to support**
  - **Air parcel delivery**
  - **Flying cars**
  - **Autonomous search & rescue**
  - **Autonomous crop, fire, or forest monitoring, etc…**



Future of Flight



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Unmanned Aerial Systems Transportation Management:

- Enable unmanned or autonomous flights to support
  - Air parcel delivery
  - Flying cars
  - Autonomous search & rescue
  - Autonomous crop, fire, or forest monitoring, etc…

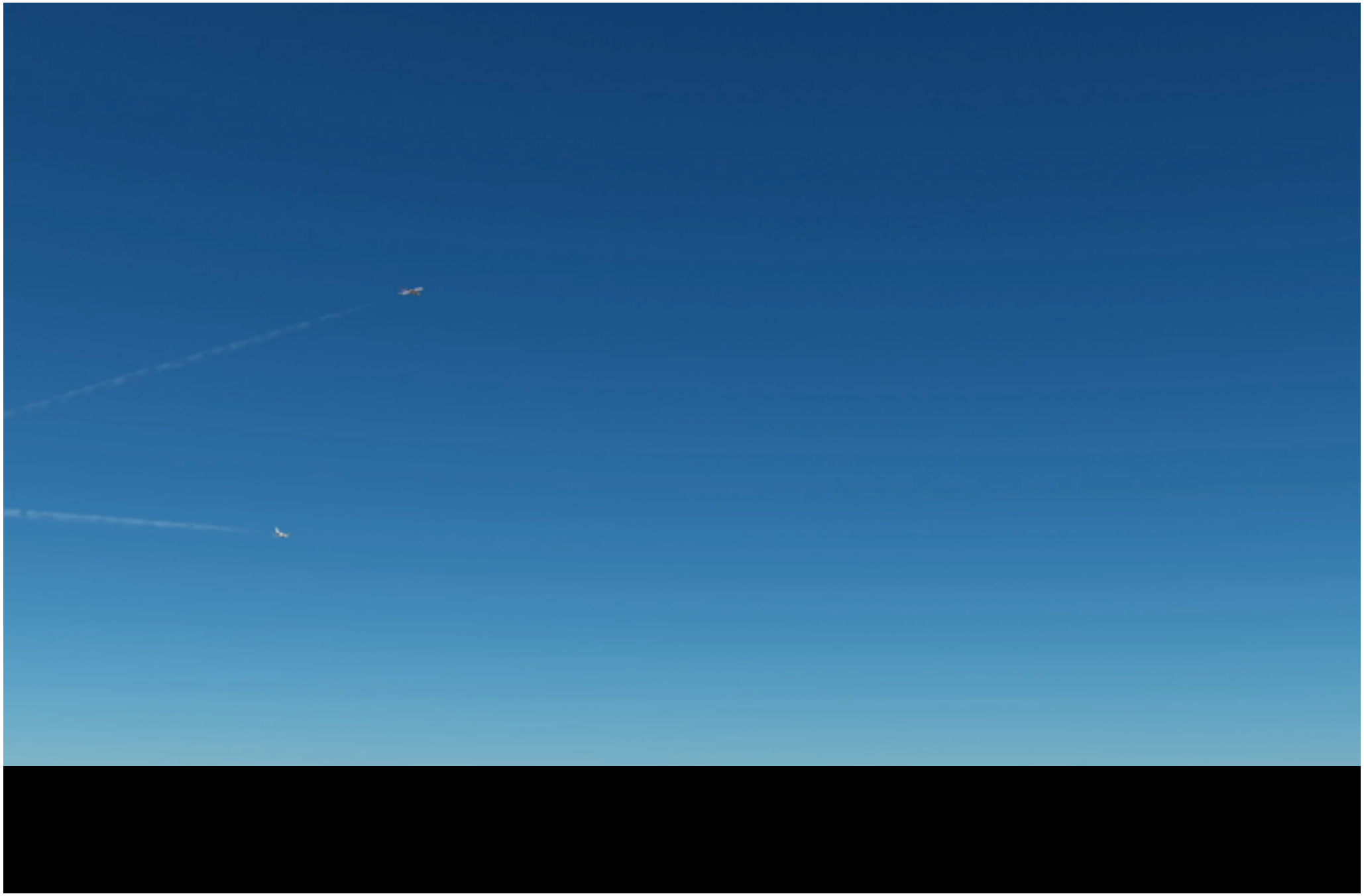
New Aviation Horizon (X-Planes):

- Supersonic Flight
  - ~2x faster with low-boom
- Ultra-Efficient Subsonic Flight
  - ~50% less fuel burn

Future of Flight: Air Parcel Delivery

Future of Flight: Flying Cars

Future of Flight: Unmanned Traffic Management



Future of Flight: New Aviation Horizons (X-Planes)

Big Challenges you can help with!

- Aircraft Designs (V/STOL)
- Artificial Intelligence
- Batteries
- Cloud Architectures
- Composite Materials
- Cyber-Security
- Engineering Tools for Aerodynamics & Acoustics
- High-Performance Embedded Computers
- Human-Machine Interfaces
- Vehicle Health Management
- Reliable Software
- Quantum Computing
- Sensor (Detect Aircraft / Obstacles)
- Vehicle Health Management
- Virtual Engineering Teams

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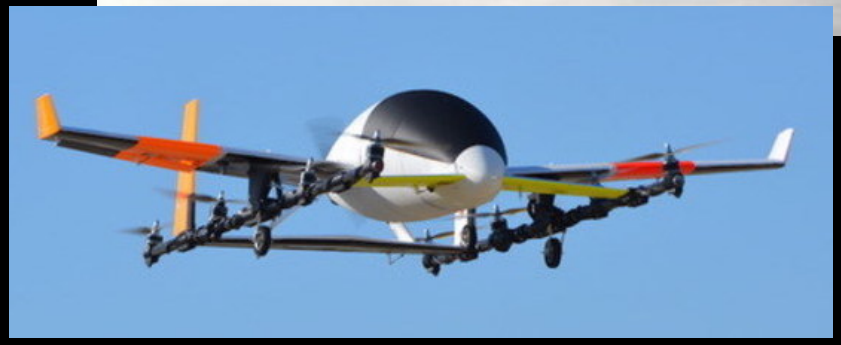
Aircraft Designs (V/STOL)

How take-off/land vertically, be quiet and efficient?



- Rotors or jets?
- Wings?
- Tail sitter?
- Tilting Wings or Rotors?
- Ducts?
- Electric, Hybrid, or Gas Propulsion?

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Engineering Tools for Aerodynamics & Acoustics

Fluid Flow (Navier-Stokes) Equations

$$\frac{\partial W}{\partial t} + \frac{\partial (F_i - F_i^v)}{\partial x_i} = 0$$

$$W = \begin{pmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ \rho H - p \end{pmatrix} \quad F_i = \begin{pmatrix} \rho u_i \\ \rho u_i u_1 + p\delta_{i1} \\ \rho u_i u_2 + p\delta_{i2} \\ \rho u_i u_3 + p\delta_{i3} \\ \rho u_i H \end{pmatrix} \quad F_i^v = \begin{pmatrix} 0 \\ \tau_{i1} \\ \tau_{i2} \\ \tau_{i3} \\ u_1\tau_{i1} + u_2\tau_{i2} + u_3\tau_{i3} - \kappa \partial T / \partial x_i \end{pmatrix}$$

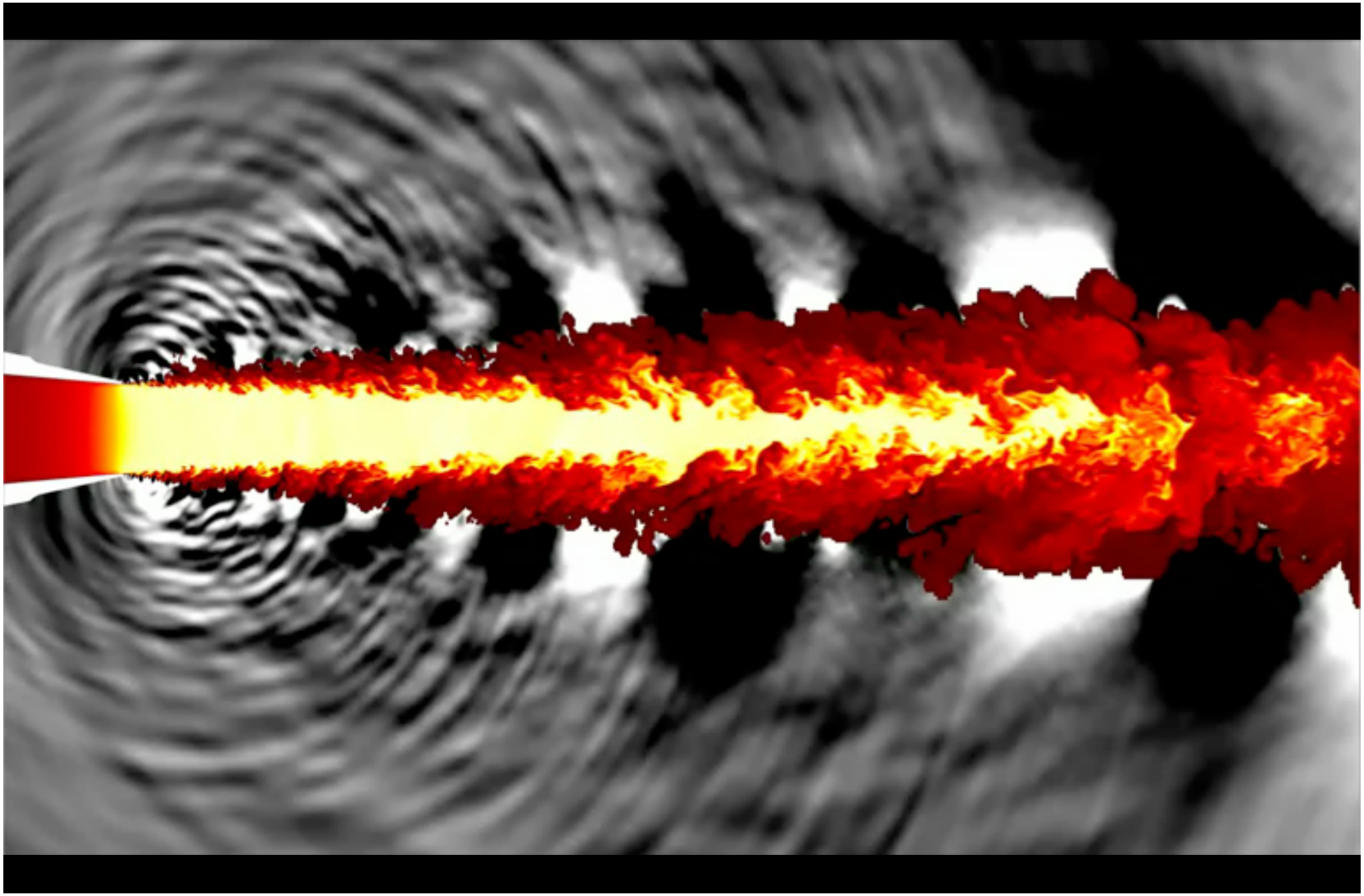
$$H = h + \frac{u_i u_i}{2} \qquad \tau_{ij} = \mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \frac{2}{3}\mu\frac{\partial u_k}{\partial x_k}$$

$$\rho \equiv \rho(p,T)$$

$$h \equiv h(p,T)$$

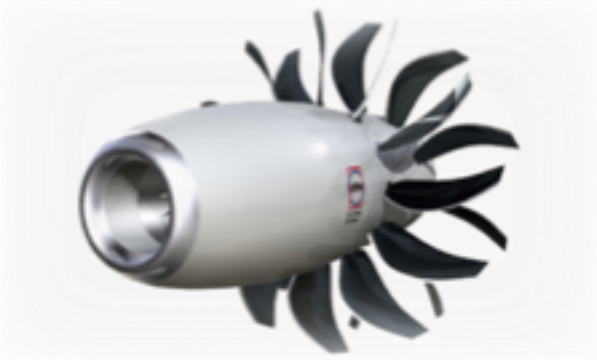
Engineering Tools for Aerodynamics & Acoustics

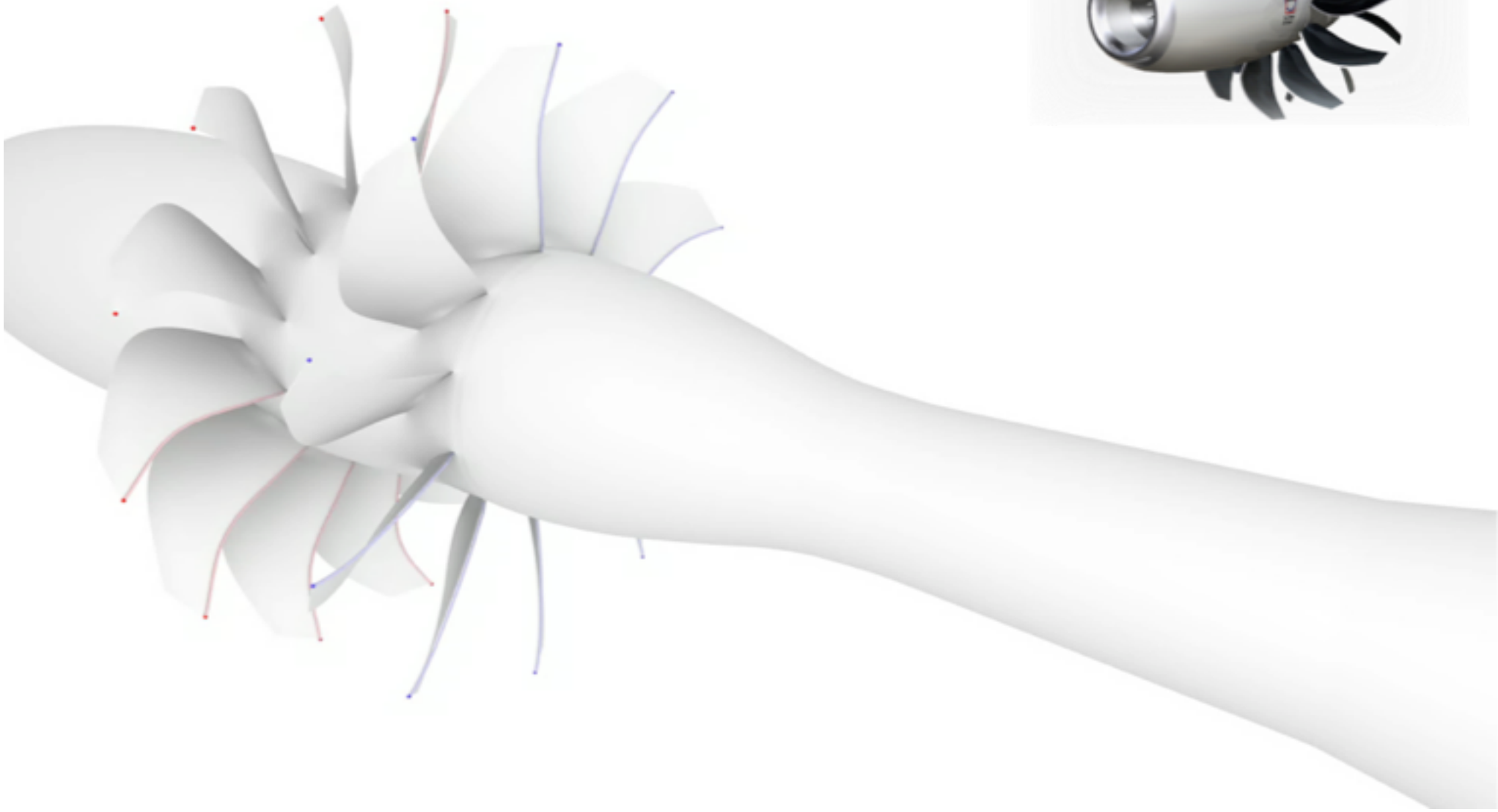
Jet Noise Prediction for Airport Noise Reduction



Engineering Tools for Aerodynamics & Acoustics

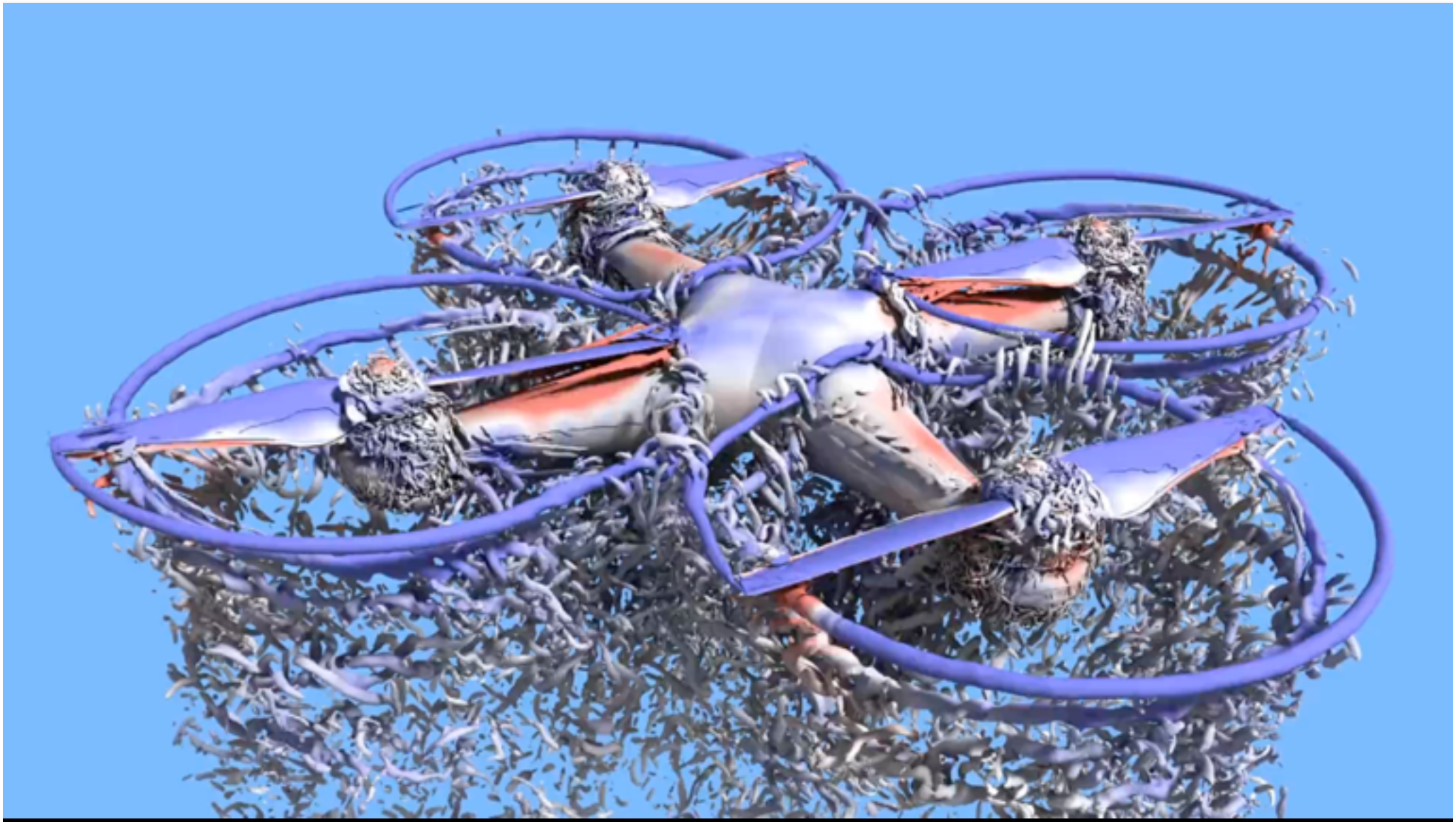
Open Rotors for Green Aviation

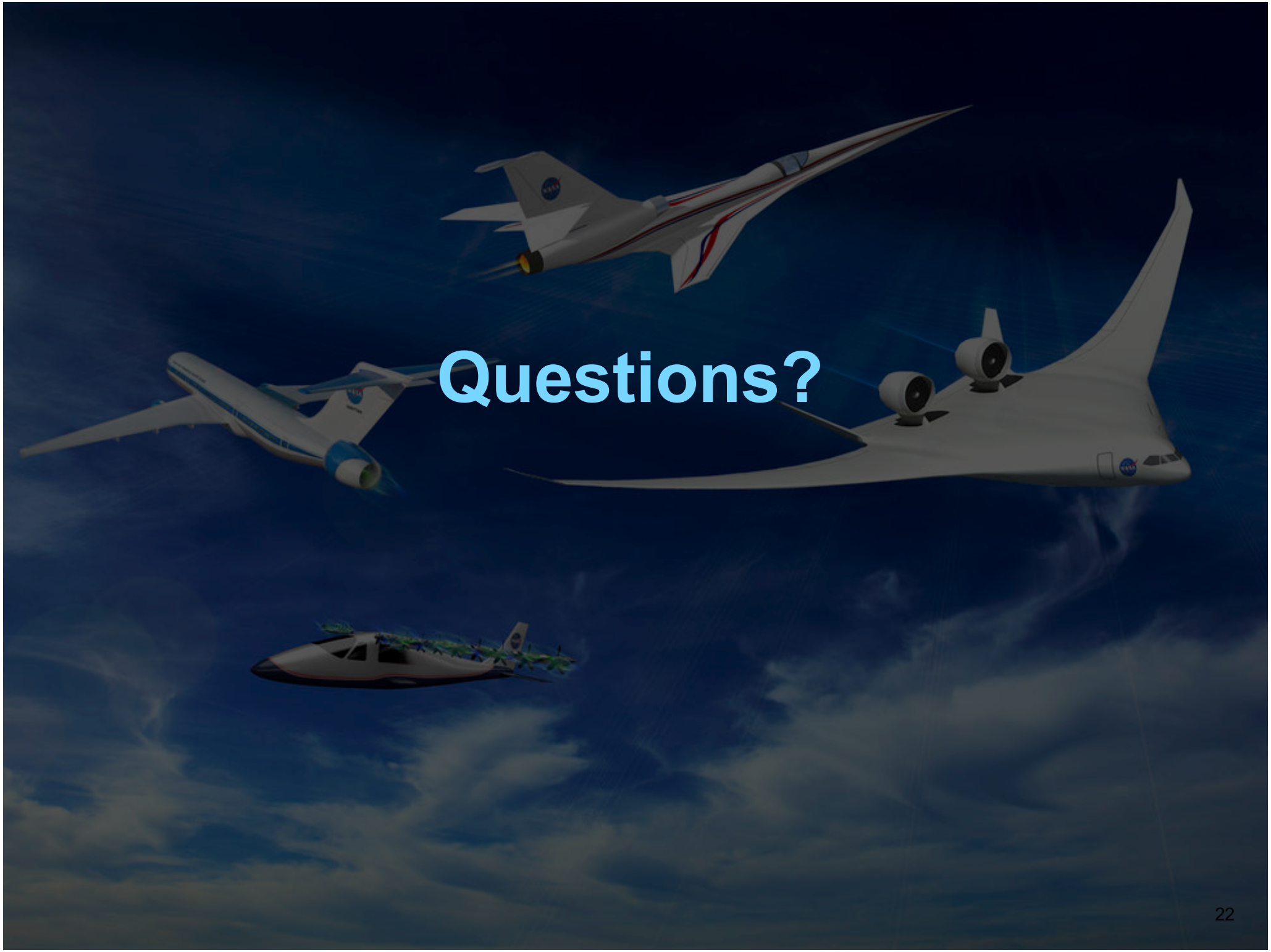




Engineering Tools for Aerodynamics & Acoustics

QuadCopter Performance & Noise Simulations




Questions?