5 Years Later

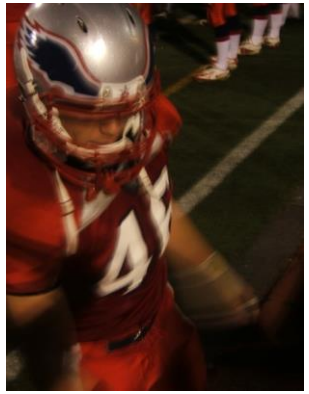
Shades of Blue

Andrew Tsoi

Lockheed Martin Space Systems Company
University of Colorado Boulder (M.S. 2014)
Heritage High School (Class of 2008)

A LITTLE ABOUT ME

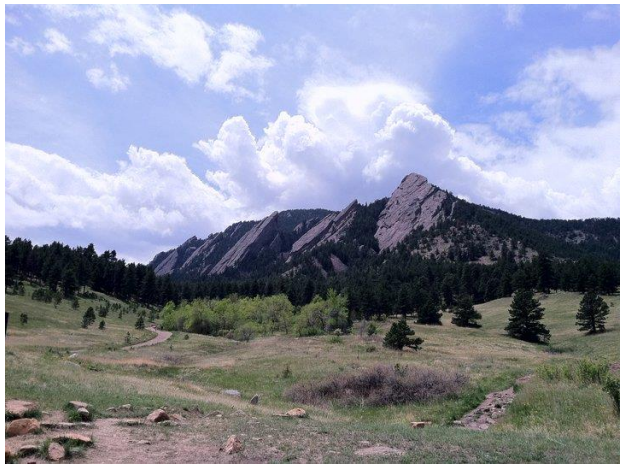
- Born June 11th 1990 in Englewood CO
- K-12 (Littleton Public Schools)
  - Runyon Elementary
  - Powell Middle School
  - Heritage High School
- Clubs and Activities
  - Littleton Rotary/Interact Club
  - Destination Imagination
  - Club Inline Hockey
  - Varsity Lacrosse
  - Yearbook (Sports Editor)
  - National Honor Society



MR. WARREN

- Math teacher at Heritage H.S.
  - Advanced Algebra and Calculus
- Key Lessons
  - “Use your imagination”
  - “Be creative”
  - “Think outside the box”
- I chose to major in aerospace engineering my senior year

THE LAST FIVE YEARS

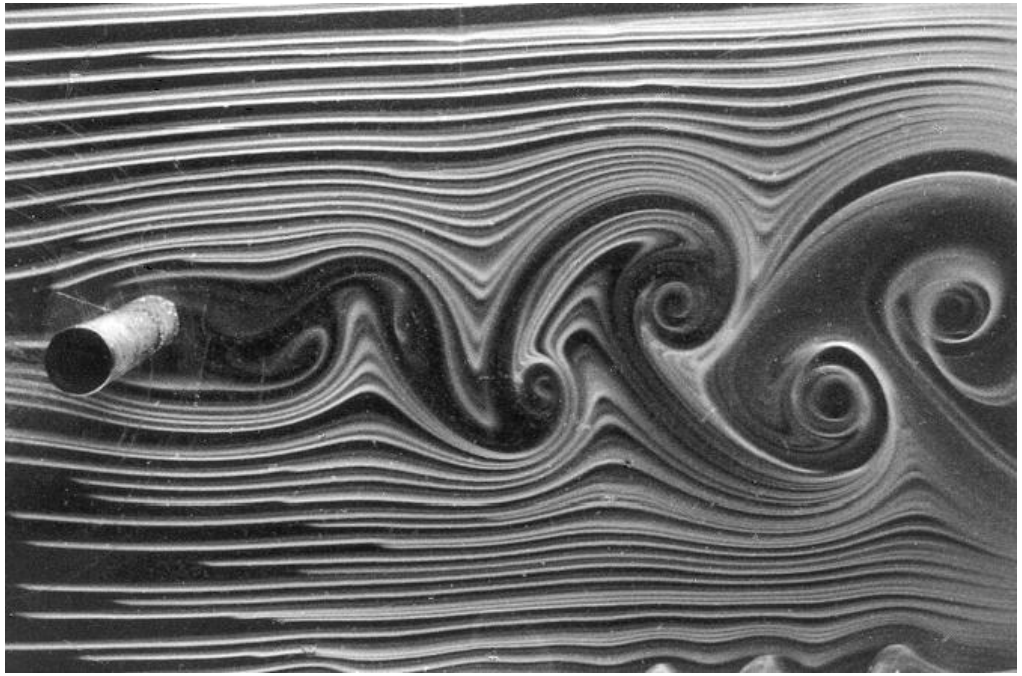


- University of Colorado at Boulder
- **Bachelors** in **Aerospace Engineering** Sciences (ASEN) in May 2013
- **Masters** in **ASEN/Structures** and Materials in May 2014

- **Clubs and Activities**
  - Student Leadership Council
  - Student Success Center
  - Men's Club Lacrosse
  - Zeta Beta Tau Fraternity

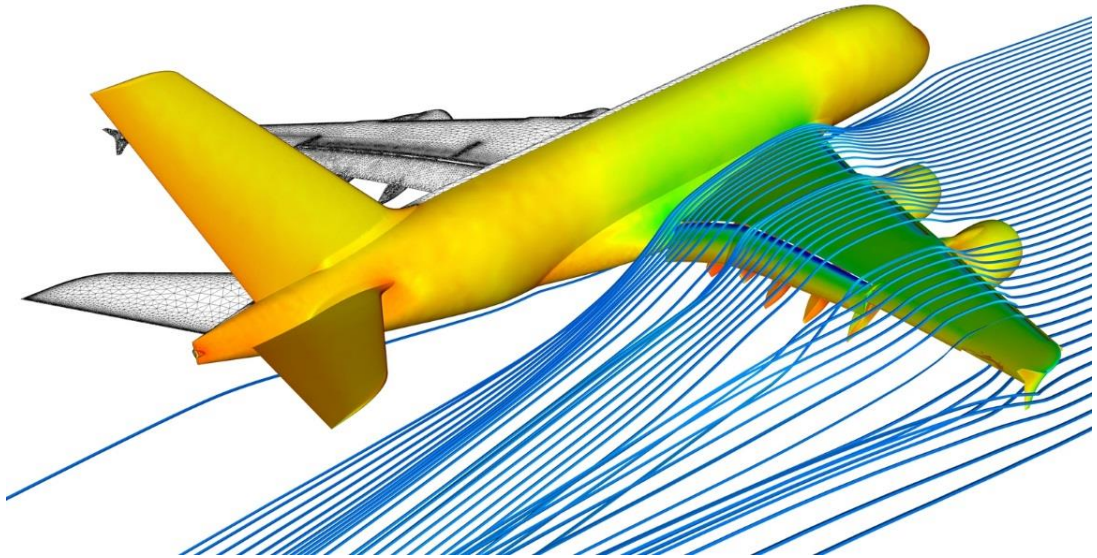
WHAT IS ENGINEERING?

SCIENCE IS THE **WHAT/WHY**



Karman vortex sheet: repeating swirling vortices caused by unsteady separation of flow of a fluid around blunt bodies.

ENGINEERING IS THE **HOW**



Boundary layer injection: injecting fluid into the airstream to create turbulence such that more lift is generated along the wing. More lift means less fuel. Less fuel means more efficient airplanes.

AEROSPACE ENGINEERING IS A BROAD FIELD

AERONAUTICS

- Aircraft technologies
- Military and civilian applications
- Aerodynamic sciences

ASTRODYNAMICS

- Spacecraft technologies
- Ballistics and celestial mechanics
- General relativity

LAUNCH VEHICLES

- Space Shuttle
- Space Launch System/Orion
- 100+ others

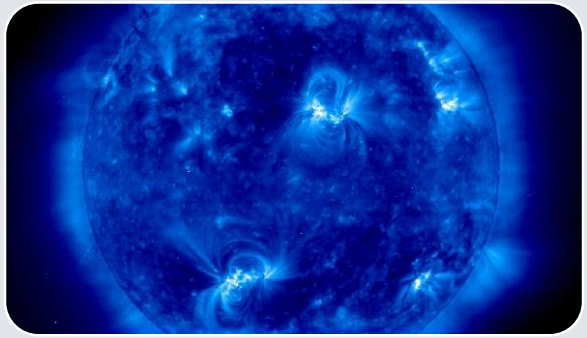
AEROSPACE ENGINEERING IS A BROAD FIELD

BIOASTRONAUTICS

- Human spaceflight
- Biological, behavioral and medical space sciences
- Design of payloads, space habitat, and life support systems

ROBOTICS

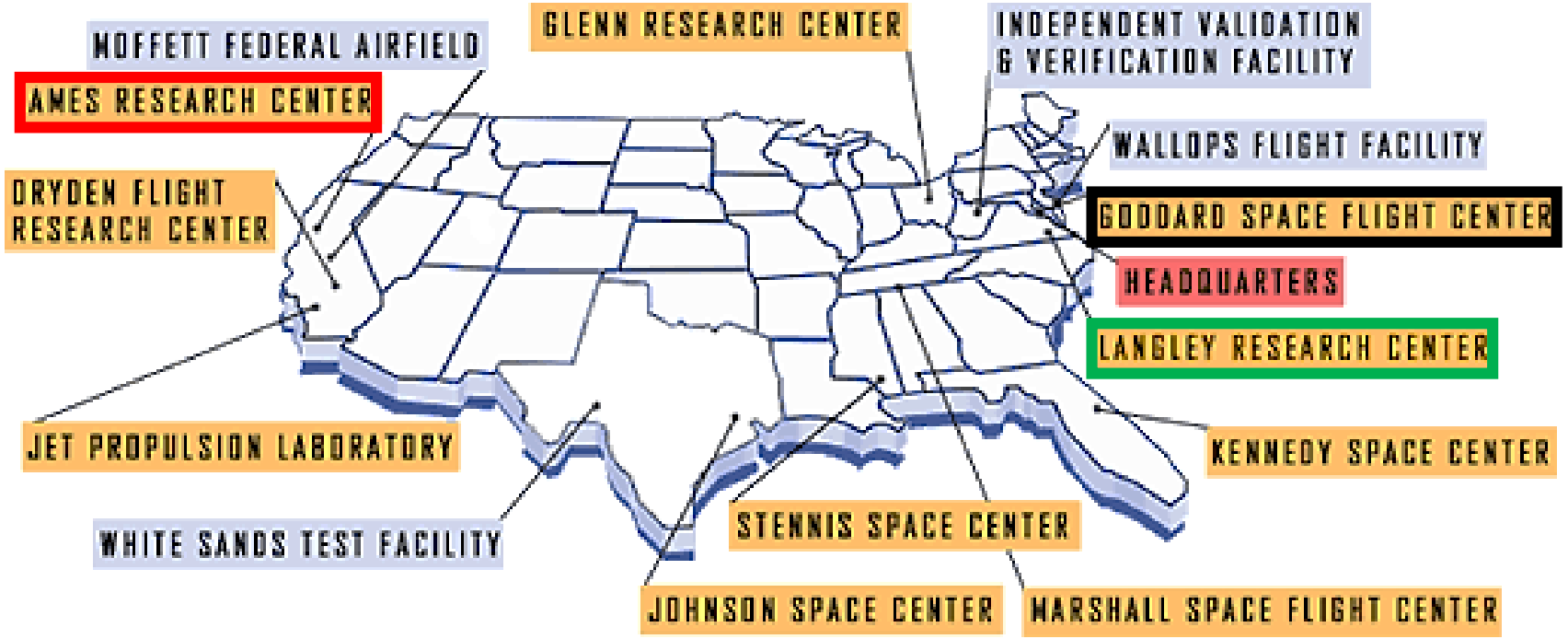
- Planetary exploration (Mars Science Laboratory - Curiosity)
- Autonomous vehicles
- Communication (GPS)



SPACE PHYSICS

- Heliophysics (sun)
- Earth atmosphere (weather)
- Galactic science

10 NASA FIELD CENTERS TO DO THE JOB



LANGLEY

GODDARD

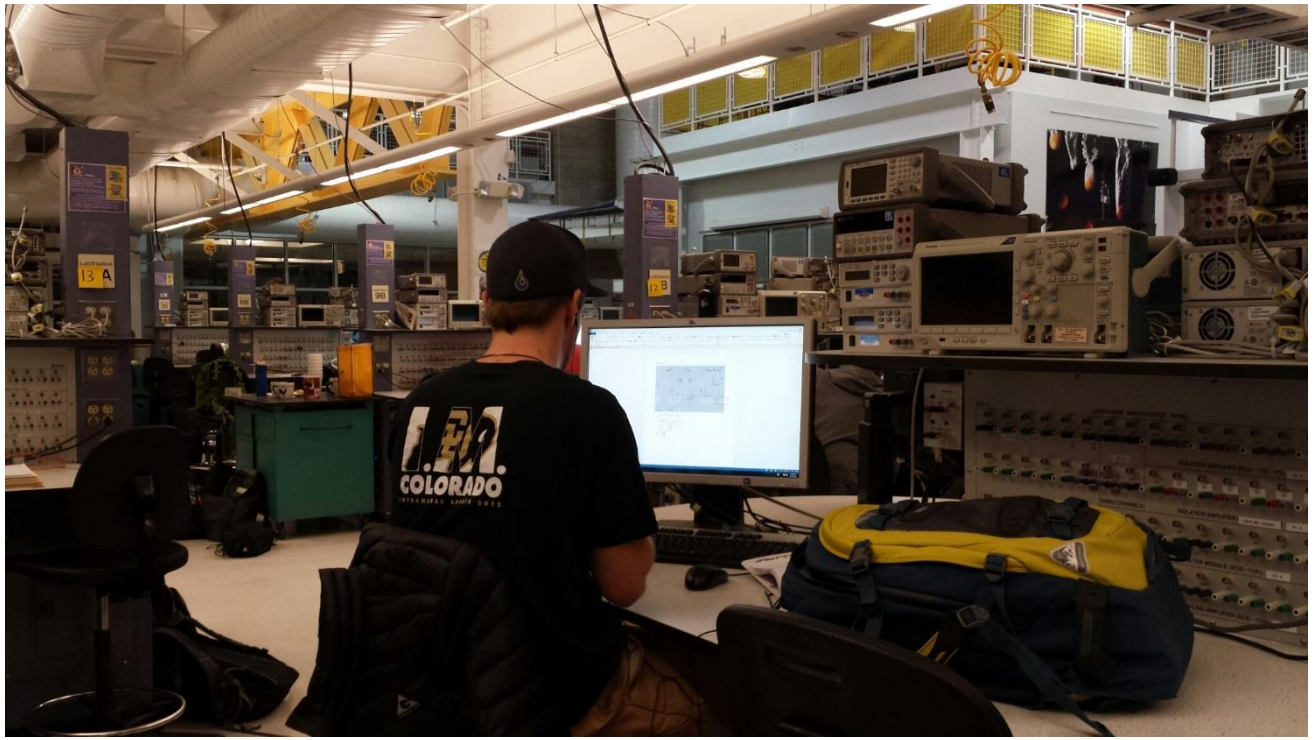
AMES

THE CALL THAT CHANGED MY LIFE

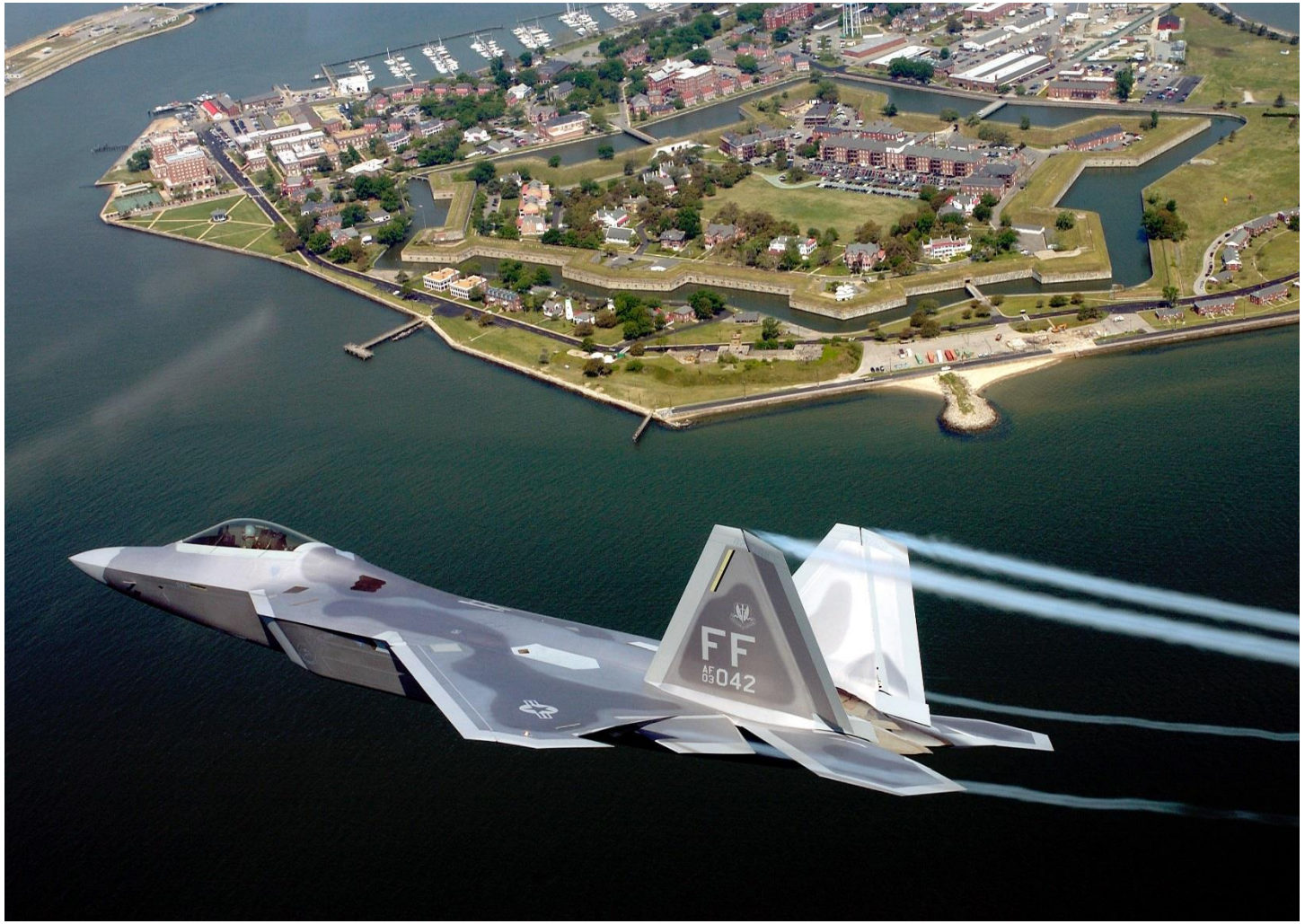
On Tuesday September 9th 2010, I was accepted into the NASA/USRP program.

I would get the opportunity to take an entire year off of school to work at NASA.

I was sitting at my lab station (right) when I got the call. Within a week, I withdrew my from my classes and was on an airplane to NASA Langley!



NASA LANGLEY RESEARCH CENTER



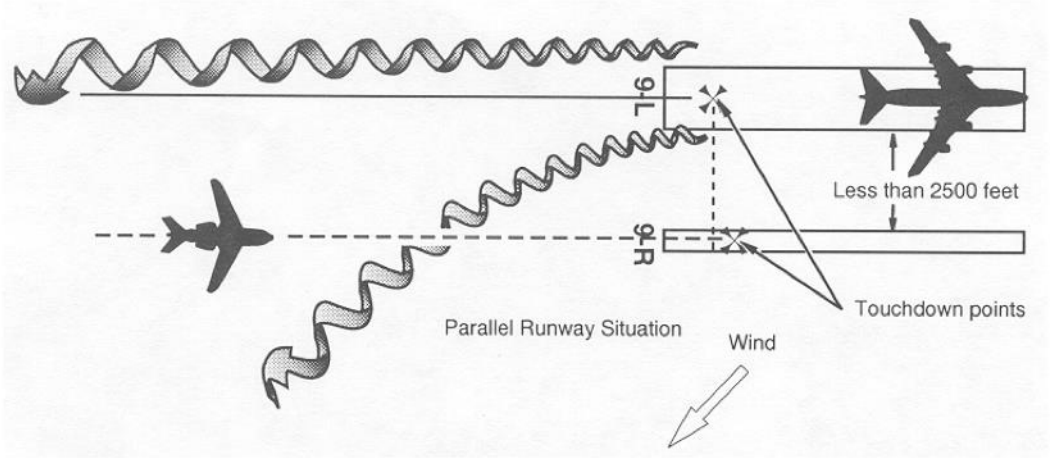
LANGLEY: MY FIRST ASSIGNMENT

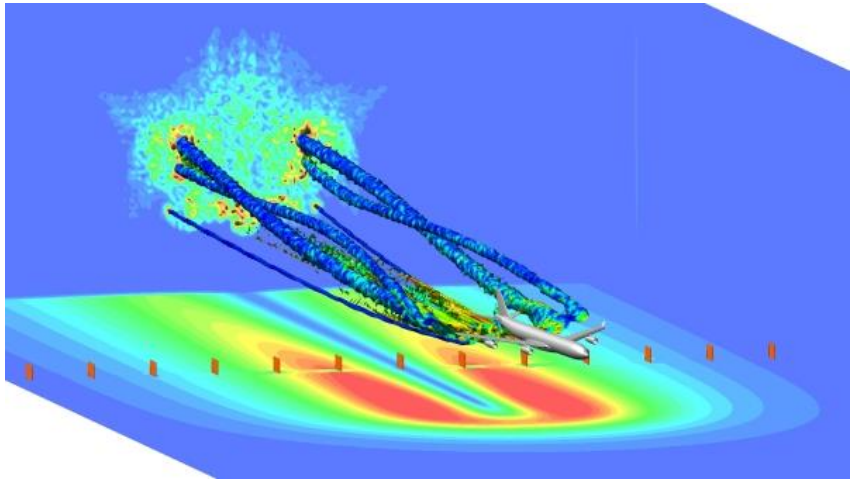
› I studied wake turbulence (white tails)

http://www.youtube.com/watch?v=__pyxPb6gMc

WAKE TURBULENCE: WHAT DID I DO?

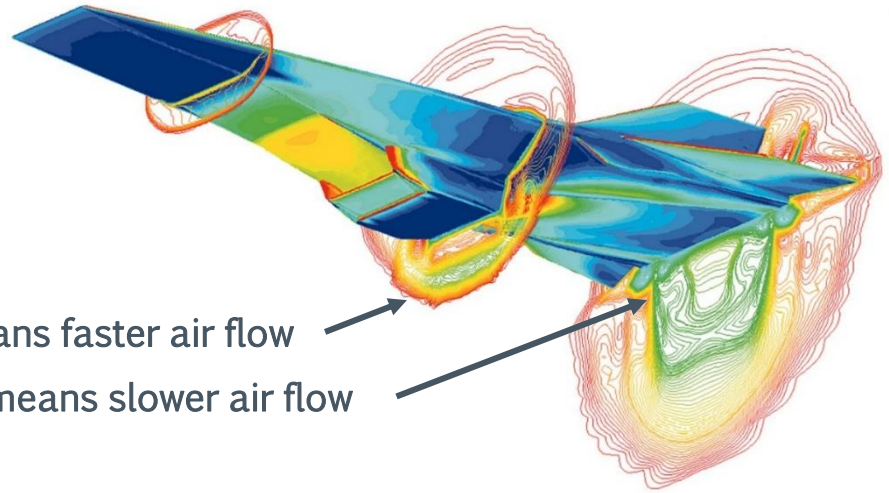
- Computer models (and lots of it!)
  - Trying to re-create real-life phenomenon with computer models so we can predict and improve existing airplane and airport designs!
  - How far back does the trailing aircraft have to be to avoid wake turbulence?

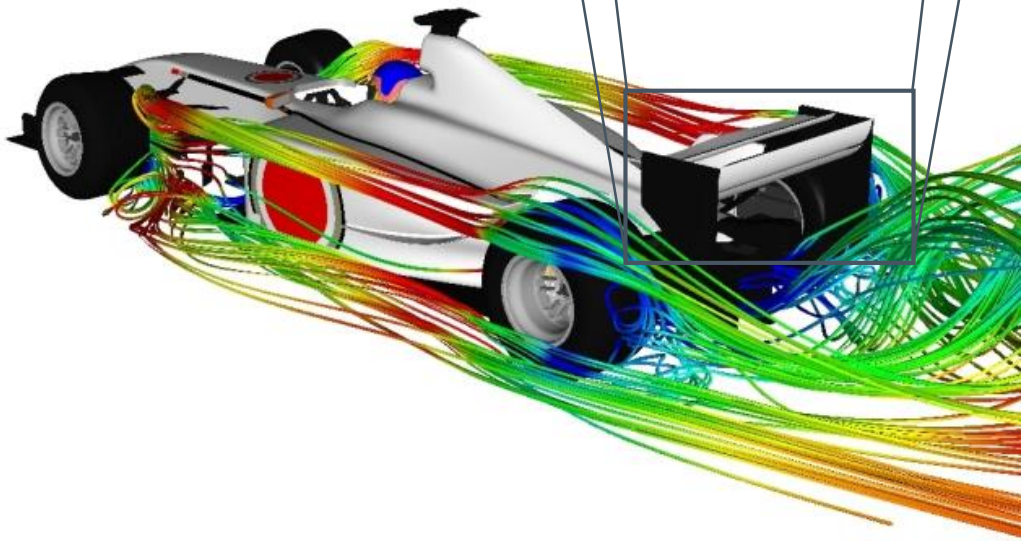




COMPUTATIONAL FLUID DYNAMICS

- Using calculus to predict fluid behavior around a body
  - NASA X-43: unmanned hypersonic aircraft
  - Formula One: effectiveness of rear spoilers
- Allows engineers to predict performance before even building

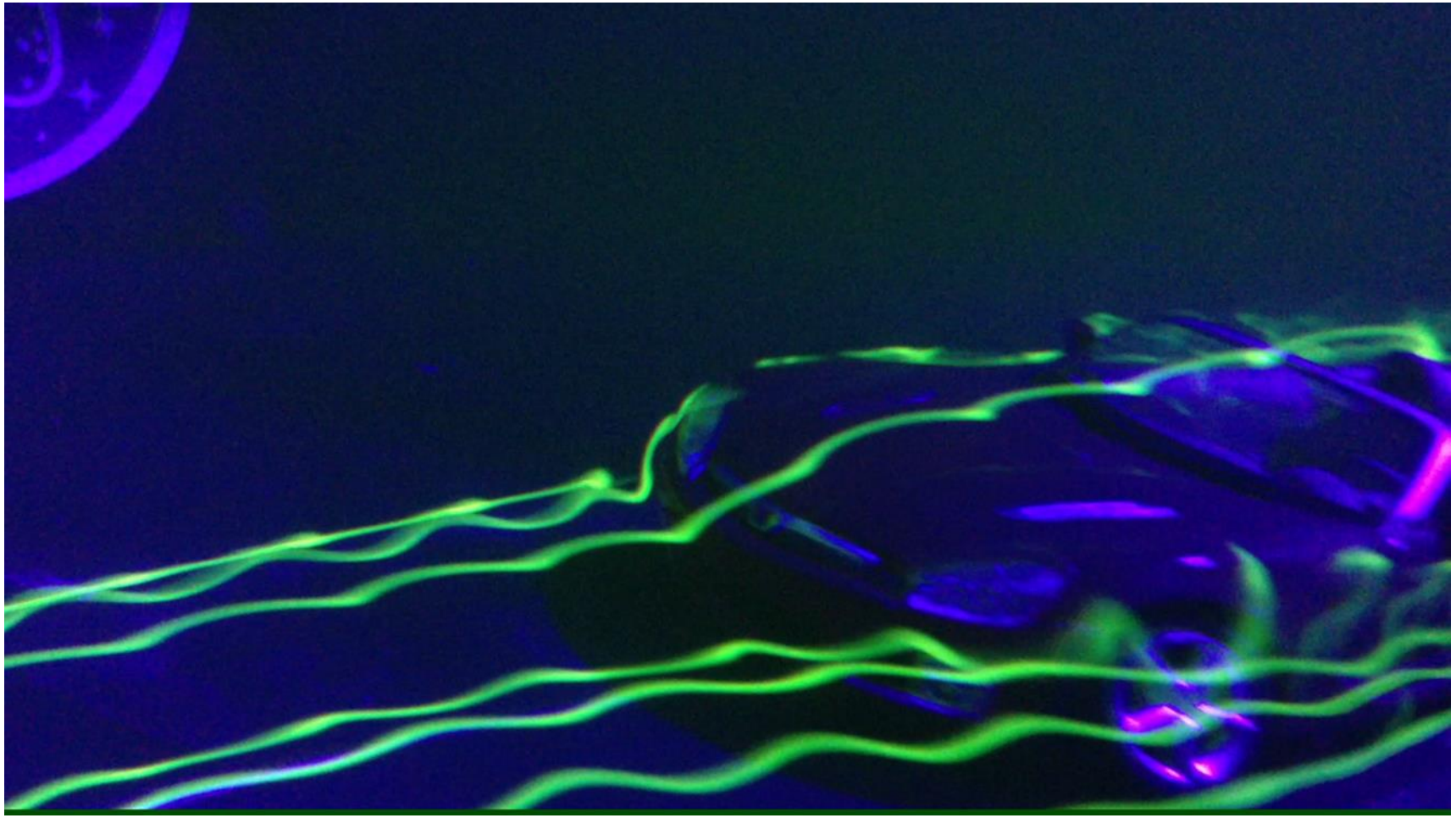




Red means faster air flow

Green/Blue means slower air flow

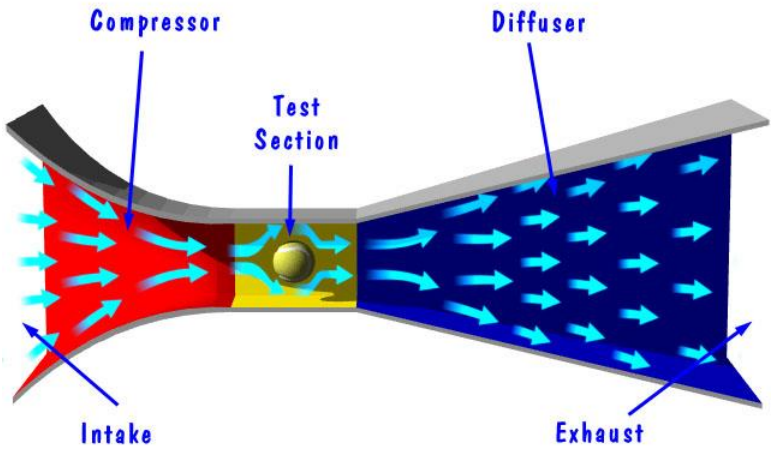
EXPERIMENTAL VALIDATION



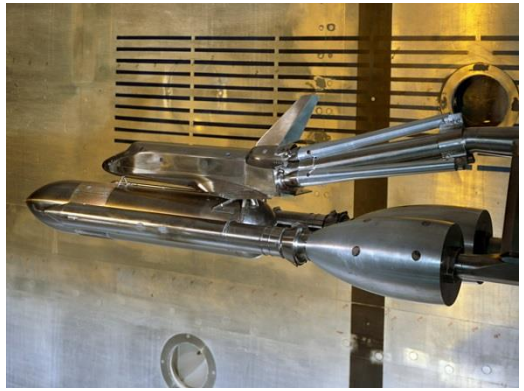
SUMMER ASSIGNMENT: NATIONAL TRANSONIC FACILITY WIND TUNNEL

WHAT IS A WIND TUNNEL?

- A closed or open tunnel where air is blown or pulled around a small test vehicle using fans



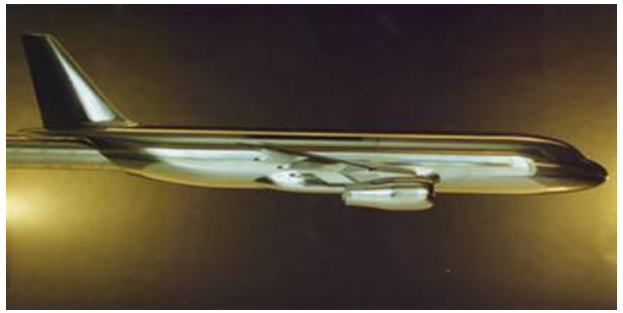
NATIONAL TRANSONIC FACILITY

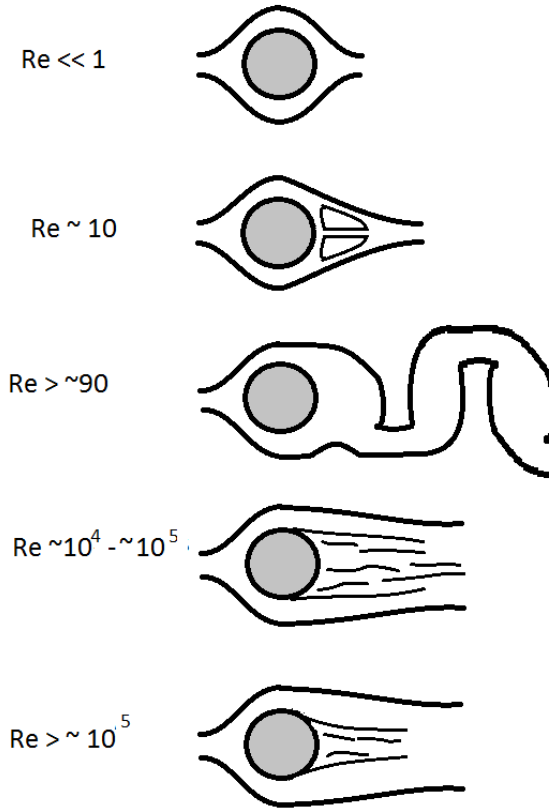


NATIONAL TRANSONIC FACILITY WIND TUNNEL: WHY IS IT IMPORTANT?

NTF CAN MATCH REYNOLDS NUMBERS FOR IDEAL FLIGHT CONDITIONS

- When wind-tunnel tests are performed at sea-level, the air is more dense than the ideal cruising altitude the airplane will actually fly at
- Therefore, the Reynolds number must be changed to meet ideal flight conditions

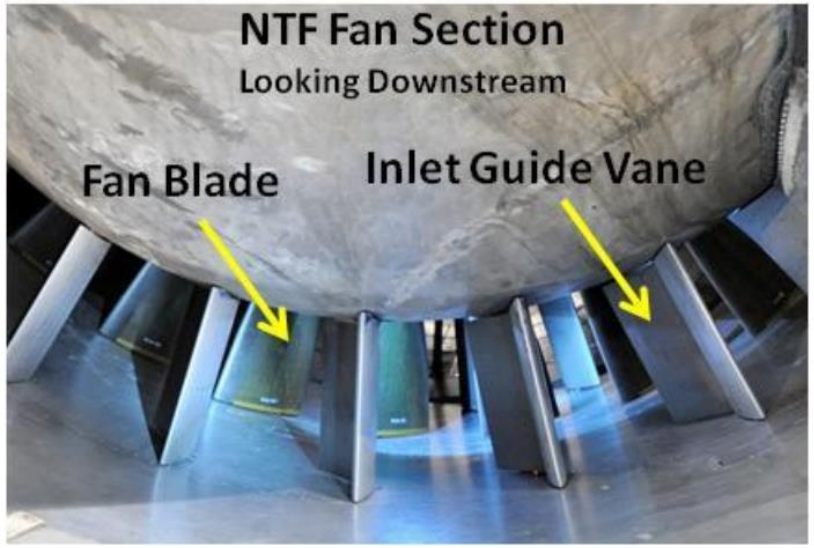


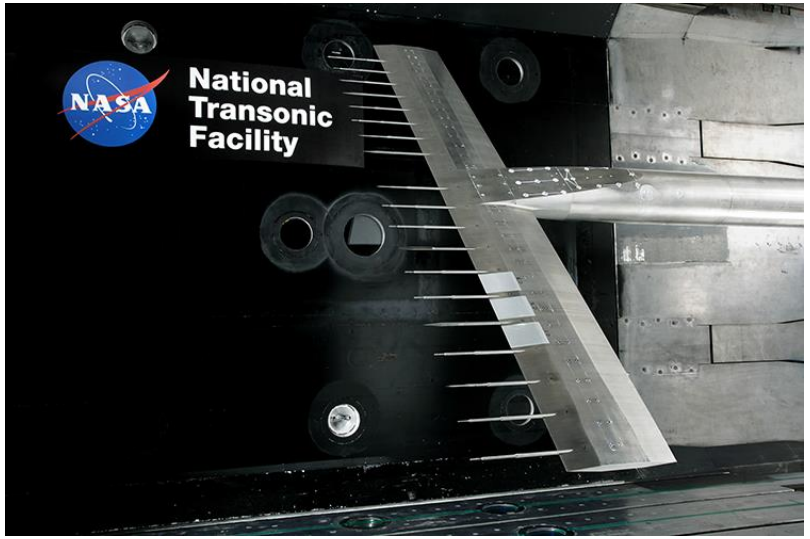


SO HOW DO WE CHANGE THE REYNOLDS NUMBER?

THE ANSWER: CHEMISTRY

- We inject cryogenic nitrogen (liquid N2) into the wind-tunnel to cool down the fuel
- Temperatures can go as low as - 250^{0}F (colder than the surface of Jupiter!)
- Sensor rake is used to measure temperature, pressure, velocity (crucial to understand turbulence in the test section)



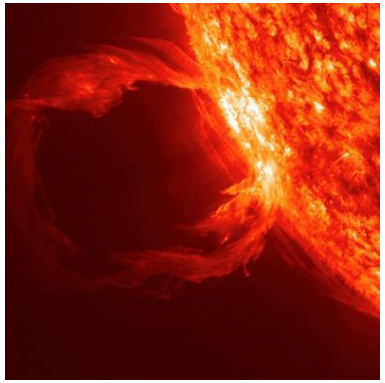


NEXT SUMMER: NASA GODDARD

- Came back to CU-Boulder for junior year (2011)
- Went to Greenbelt MD in May 2012
- Intern at Mechanical Systems Branch (Code 542)

NASA GODDARD SPACE FLIGHT CENTER

- Greenbelt, MD (25 minutes from Washington DC)
- Spaceflight Research Laboratory
  - Spacecraft (SC) tracking and data acquisition
  - Earth science data information systems (NOAA)
  - Also manages construction of SC systems
- Space and Atmospheric Sciences (science)
  - Solar system and universe observatory



THE JAMES WEBB SPACE TELESCOPE

The JWST, NASA's successor to the Hubble Space Telescope, will capture infrared light from the first galaxies. Too large to fit into a rocket fairing, it will unfold in orbit and cool to cryogenic temperatures.

Backplane

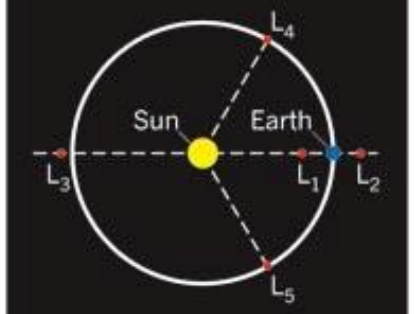
Once the mirror has unfolded, the JWST's 'spine' will hold it still and support the telescope's cameras and spectrographs.

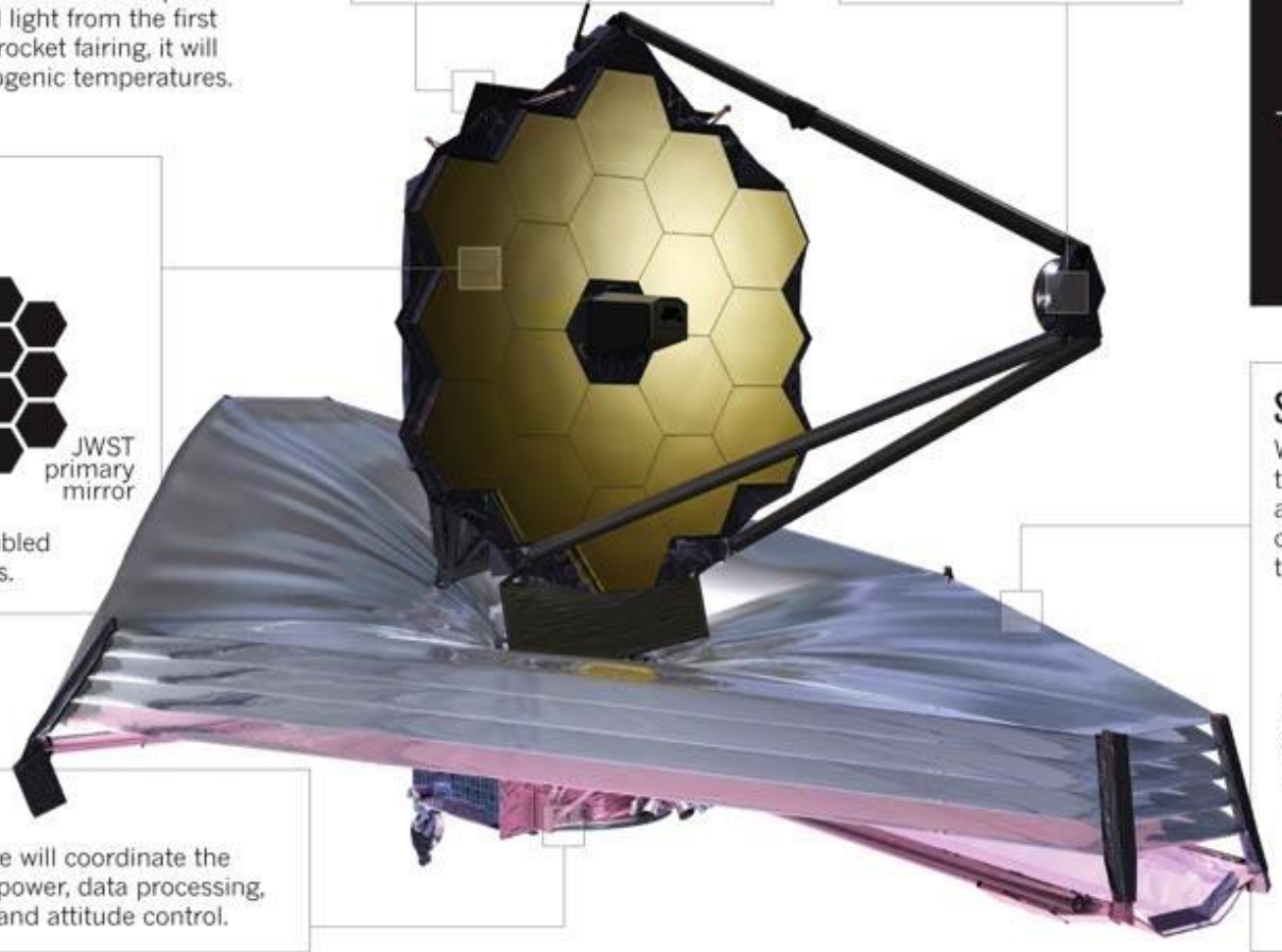
Secondary mirror

Light will bounce off the primary mirror into the smaller one, then to the instruments.

LAGRANGIAN POINTS

There are five places where the balance of gravitational forces allows a spacecraft to be stationary relative to the Sun and Earth. The JWST will operate opposite the Sun at the point designated L_2.



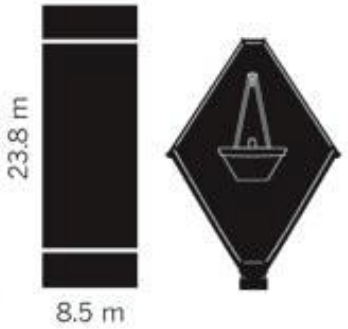


Primary mirror

The primary mirror is assembled from 18 hexagonal segments.

Sunshield

When deployed in space, the sunshield (right) will be about the size of a tennis court (left). It will protect the telescope from solar heat.



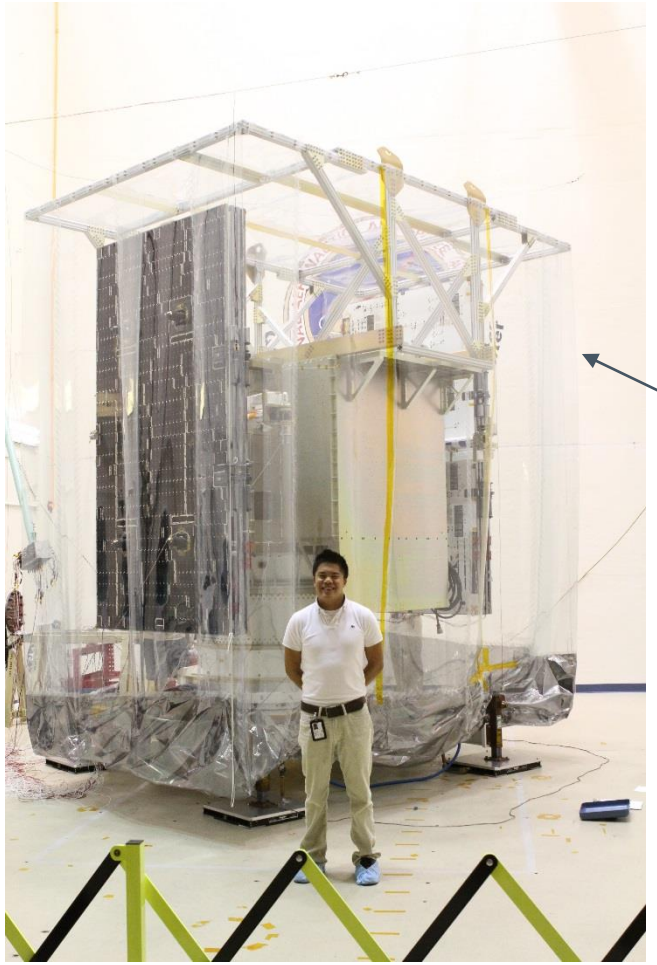
Spacecraft bus

The JWST's command centre will coordinate the mission's communications, power, data processing, propulsion, thermal control and attitude control.

VIBRO-ACOUSTIC ANALYSIS ON JWST

- Biggest risk for JWST is breaking during launch
- JWST's launch vehicle is called the Ariane 5
  - It's freaking loud (170 dB)
  - Death of hearing tissue at 180 dB
- The sound field of the rocket engine can create lots of problems:
  - Rocket fairing noise transmission
  - Satellite structural/bus failures
  - Satellite instrument failures
- My job: **Build a better understanding of the structural properties of the satellite.**

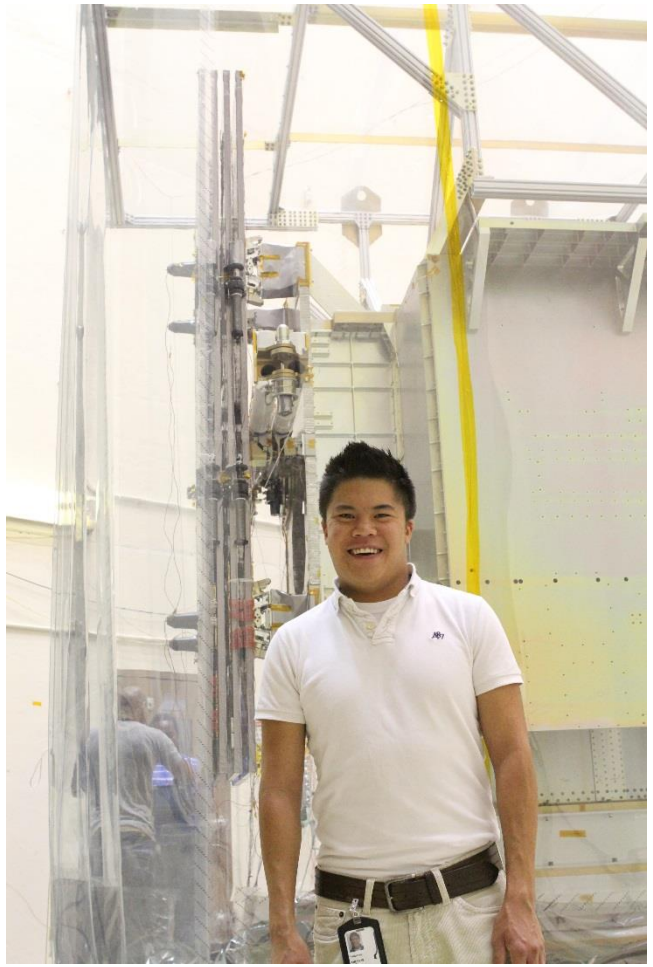
ACOUSTIC TESTING (~170 dB!)



Sound is an acoustic wave. Air pressure can carry debris.

Engineers protect the satellite by putting a “tent” over the satellite to prevent dust from damaging the satellite during testing

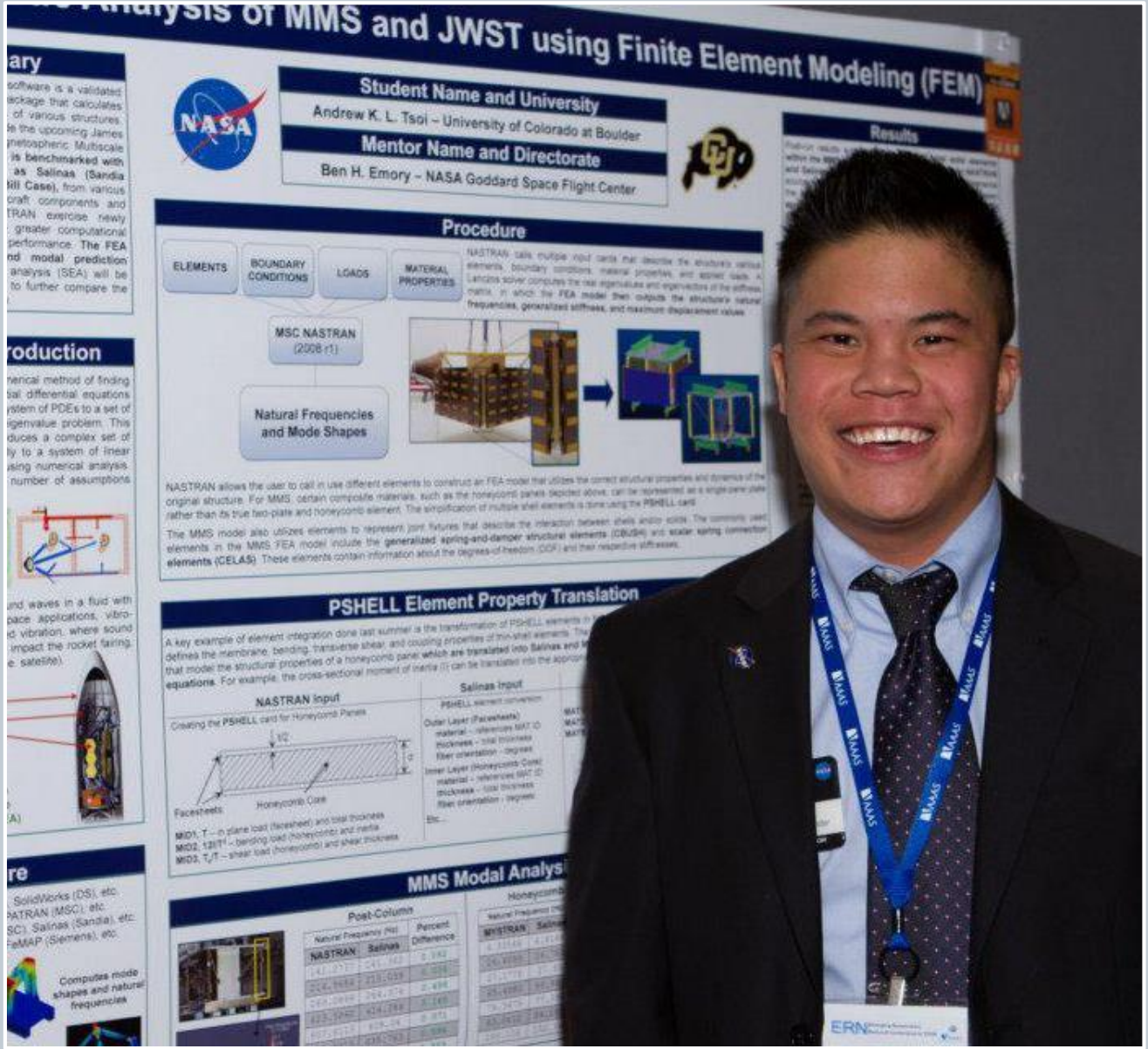
Because the tent can “dampen” the sound, they have to crank the sound even louder. Crank it up!



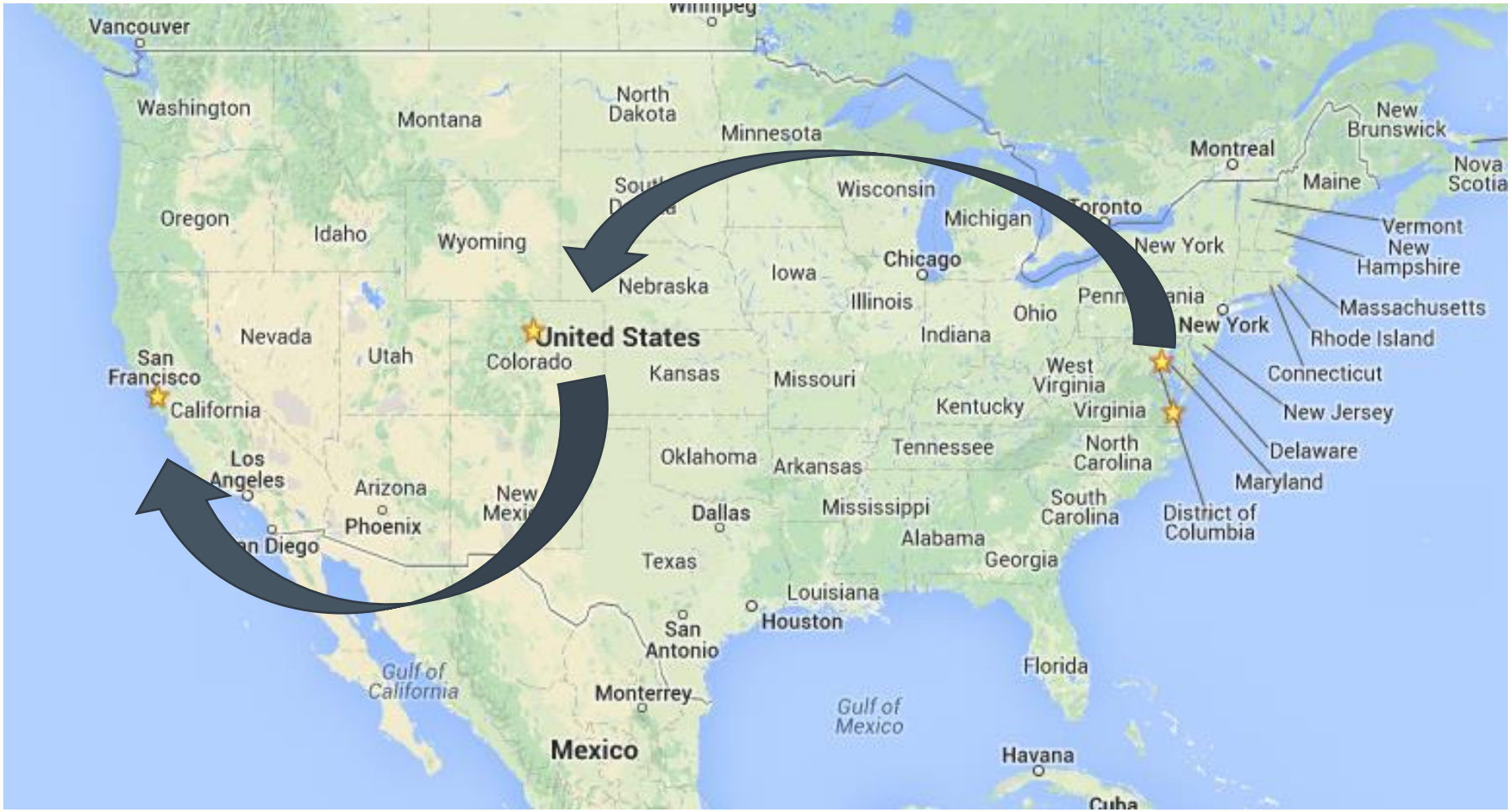
ERN CONFERENCE IN STEM 2013

I had the privilege to present my work at a conference in Washington DC

There, I got meet Leland Melvin (NFL astronaut), Sylvester Gates (physicist) on string theory



LAST SUMMER: NASA AMES

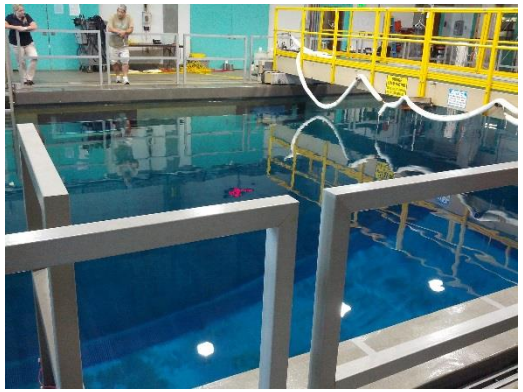


NASA ACADEMY

- Premiere leadership development and training program for students
- Wore a tie almost everyday and interacted with NASA management (the guys calling the shots)
- Still worked on a individual project and a group project

INDUSTRY TOURS AROUND THE AREA

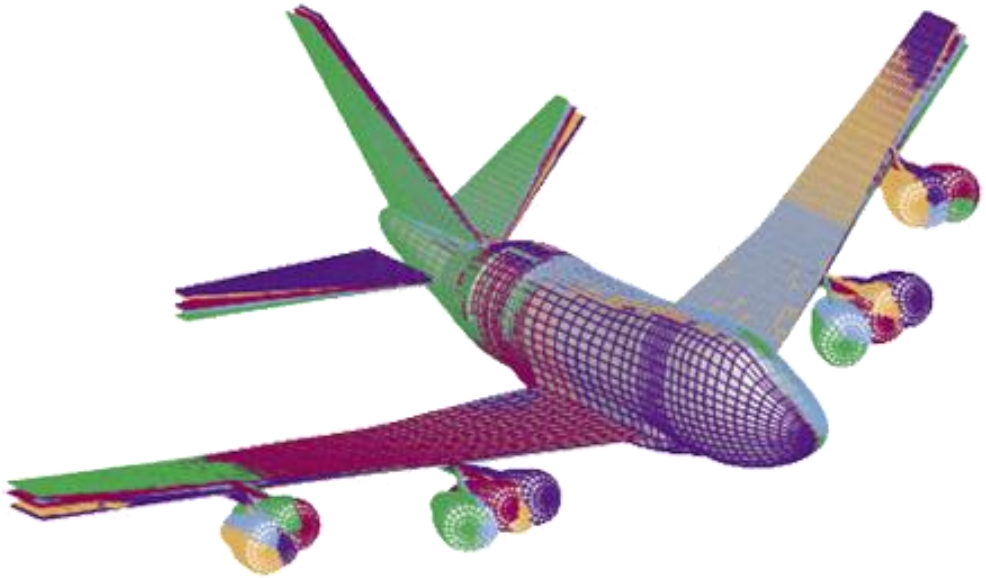
› Company tours to:
  - SpaceX (LA) and Tesla
  - Google
  - Lockheed Martin
  - Boeing Space Systems
  - Monterey Bar Research Institute and Aquarium
  - Lick Observatory
  - Jet Propulsion Laboratory
  - Skybox Imaging
  - Digital Solid State Propulsion
  - Space Systems Loral



NASA AMES RESPONSIBILITIES

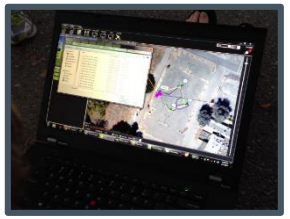
INDIVIDUAL RESEARCH: **AEROELASTIC MODELING**

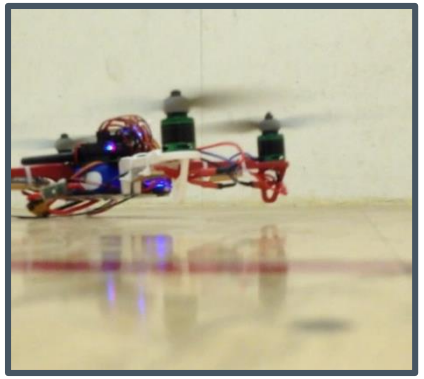
- Computer models used to predict wing vibration due to turbulence



GROUP PROJECT: **ROTORCRAFT APPLICATIONS**

- Used autonomous quadcopters to demonstrate feasibility of public transportation using quadcopter vehicles





FINAL PRESENTATION

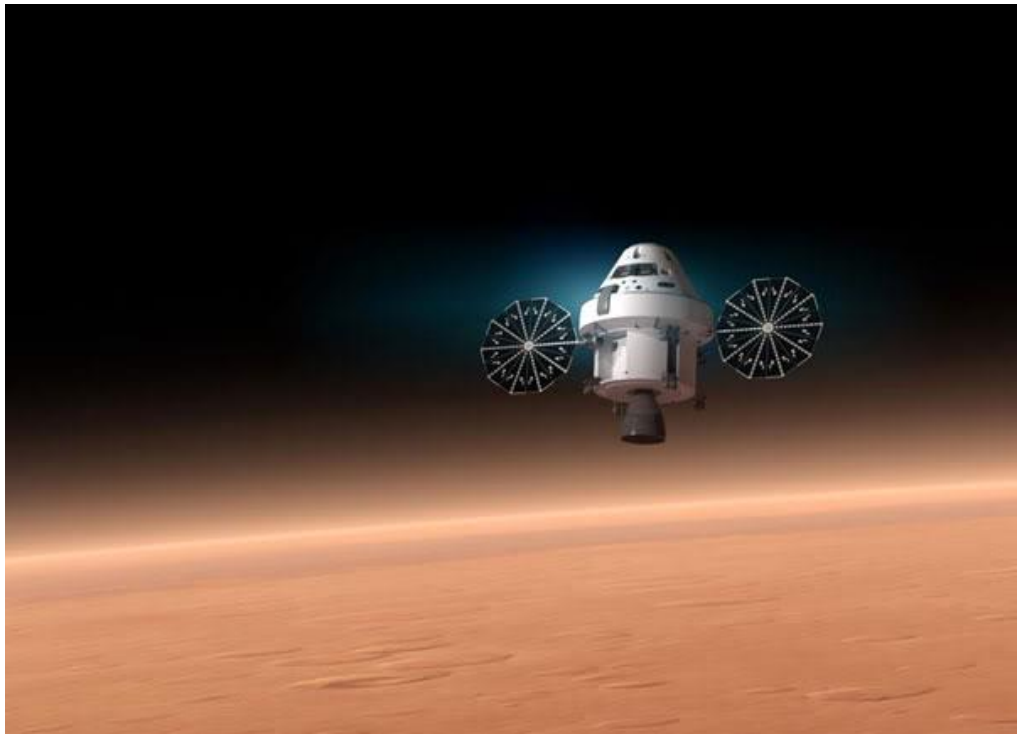
We gave our final presentation to Code Aeronautics on our second to last day in August

It extremely nerve-racking. Among the audience, included the center director, code-A chief engineer, and more (big named guys).

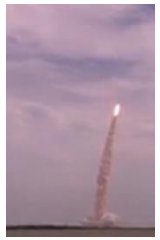
It was different being the expert in the room.

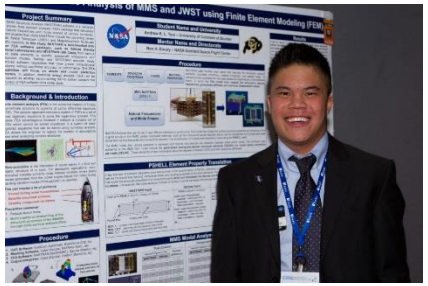
NOW: LOCKHEED MARTIN - ORION

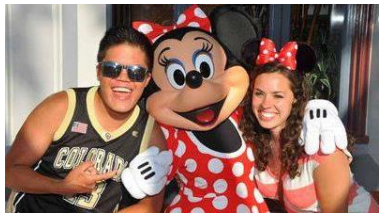
- Flight Software Engineering
- Fault Management: deals with detection, isolation, and recovery (FDIR) of malfunctions onboard the vehicle
- Systems Engineering: requires broad understand of various subsystems of the spacecraft (propulsion, power, communication, etc.)

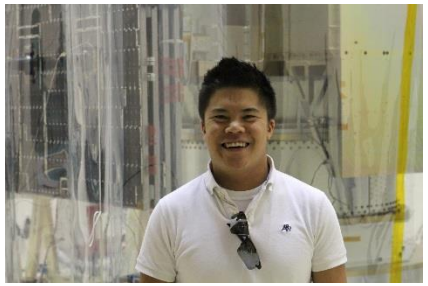


POST REFLECTION AND COMMENTS





LESSONS LEARNED

- Don’t be afraid of difficult challenges – face them!
- You don’t need to be smart to be an aerospace engineer, you just need HARD WORK.
- Strive to better than you were yesterday, but don’t compare yourself with the people around you. Only you can be the judge of yourself.
- Work hard, but have fun doing it.
- Be proud of what you do.

THANK YOU

- **Andrew Tsoi**
  Orion Flight Software Engineer
  Lockheed Martin Space Systems

  University of Colorado Boulder
  ASEN, AESys: BS/MS 2014

  NASA Student Ambassador
  Cohort IV: LaRC, GSFC, ARC

GET INSPIRED

- Neil deGrasse Tyson
  - http://www.youtube.com/watch?v=9D05ej8u-gU
- CU Engineering
  - http://www.youtube.com/watch?v=Q7Y6iH5Oank
  - https://www.youtube.com/watch?v=0FJhWTa4S9E
- A380 Flutter Tests
  - http://www.youtube.com/watch?v=ImSuZjvkATw