2019 UTSR Final Presentation

SOUTHWEST RESEARCH INSTITUTE®

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What is the UTSR Program?

- U.S. Department of Energy
  - Advanced Turbine Program
    - University Turbine System Research
      - ***Gas Turbine Industrial Fellowship***

- Takes "student researchers from the university to industrial gas turbine design and manufacturing environments"

- 10-12 weeks at one of the sponsor companies
  - FlexEnergy
  - Siemens Energy, Inc.
  - Solar Turbines, Inc.
  - Southwest Research Institute
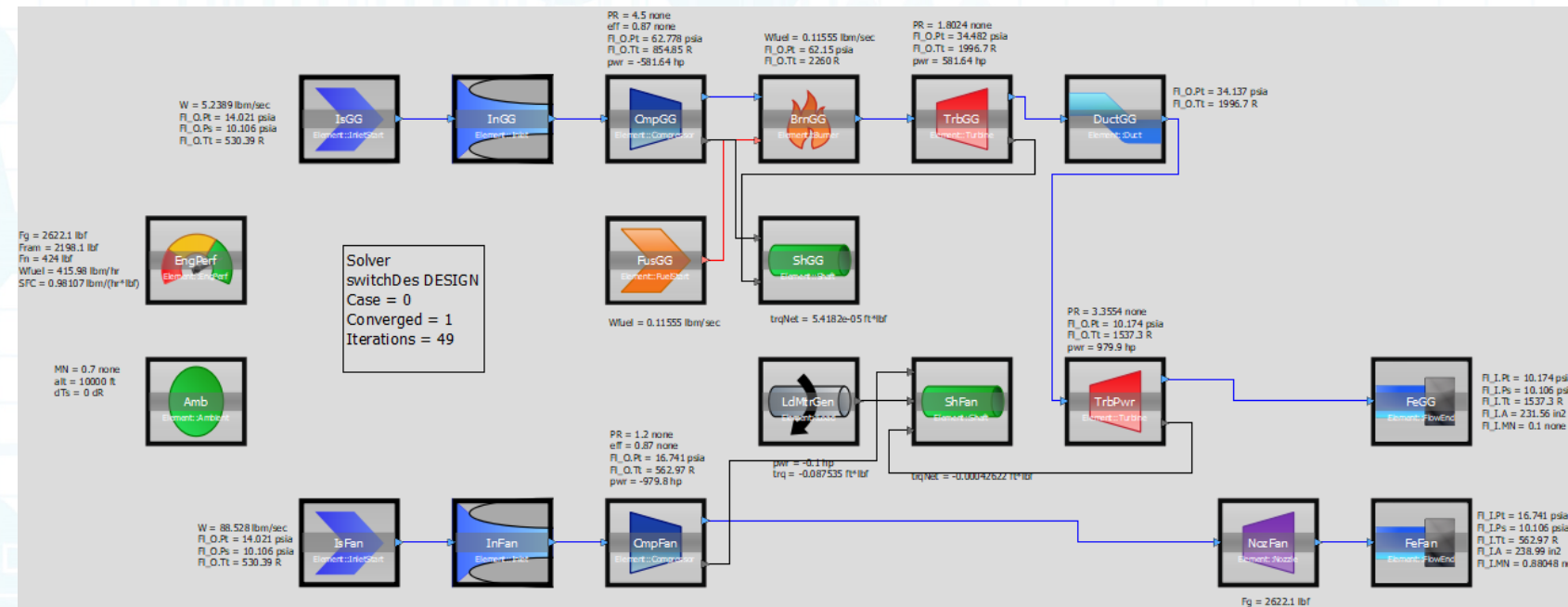 - Gas Technology Institute
  - General Electric

Projects Overview

- Variable Cycle Quiet (VCQ) Hybrid UAV

- PoC: Laser PIV system

- Drag test rig

- Titan T62 instrumentation

- NPSS unit conversion

VCQ Hybrid UAV

May 20 - August 2

VCQ= Variable Cycle Quiet

- Integrated design
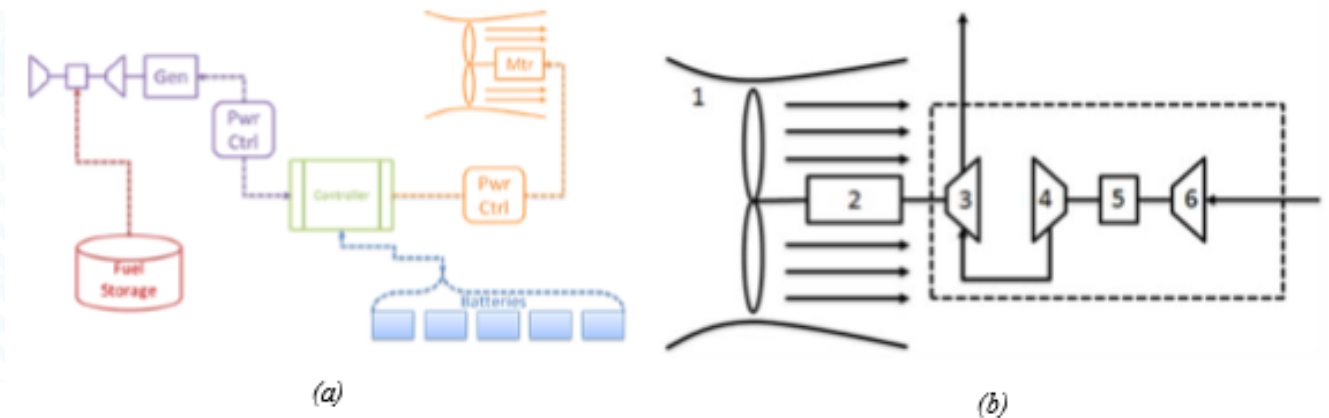
- Quiet loiter

- Up to 66% reduction in size

Figure 1(a). Hybrid System Concept and (b) Variable Cycle Quiet Concept

Project Objectives

1. Determine viability of hybrid UAV

2. Modify VCQ model to be modular

3. ISR mission analysis

    – Document for future use

- *Use the IDE & provide feedback*
- *Document any improvements or unexpected behavior*

How big? Why?

Category	Mini	Tactical	Strategic
Altitude	Low	Low to medium	Medium to high
Endurance	Short (about an hour)	Medium (up to several hours)	Long (ranges from hours to days)
Range	Close-range	Limited to line-of-sight (approximately 300 kilometers or less) (about 186 miles)	Long range
Example	Raven	Shadow	Global Hawk

Sources: CIA (information); DOD (photos).
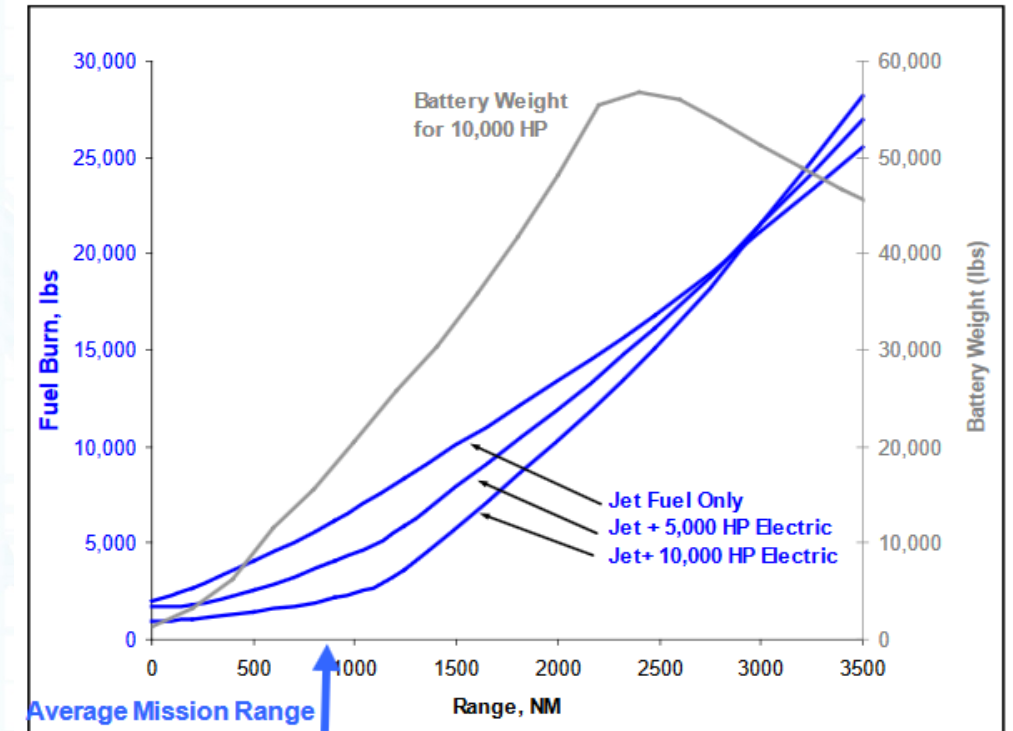

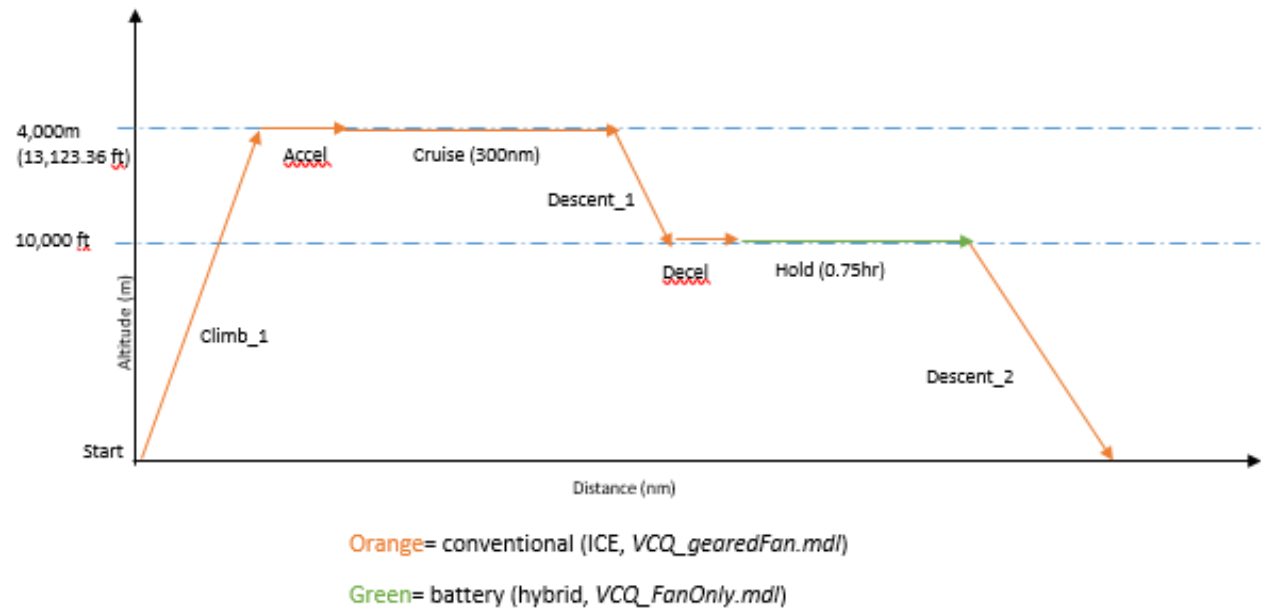Figure 2.3 – **Hybrid Electric Tube and Wing Sizing Results**

The bird in question

High endurance, glider UAV (scaled Predator)

- Wing area= 170 ft^2
- MTOW= 3000lb
- *Take off thrust= 1000lbf*
- 600lb payload

- 300nm cruise
- L/D ratio= 30
- Aspect ratio= 25
- Max speed= 125kts

Modifications and Analysis

4,000m
(13,123.36 ft)

10,000 ft

Altitude (m)

Start

Climb_1

Accel

Cruise (300nm)

Descent_1

Decel

Hold (0.75hr)

Descent_2

Distance (nm)

Orange= conventional (ICE, *VCQ_gearedFan.mdl*)

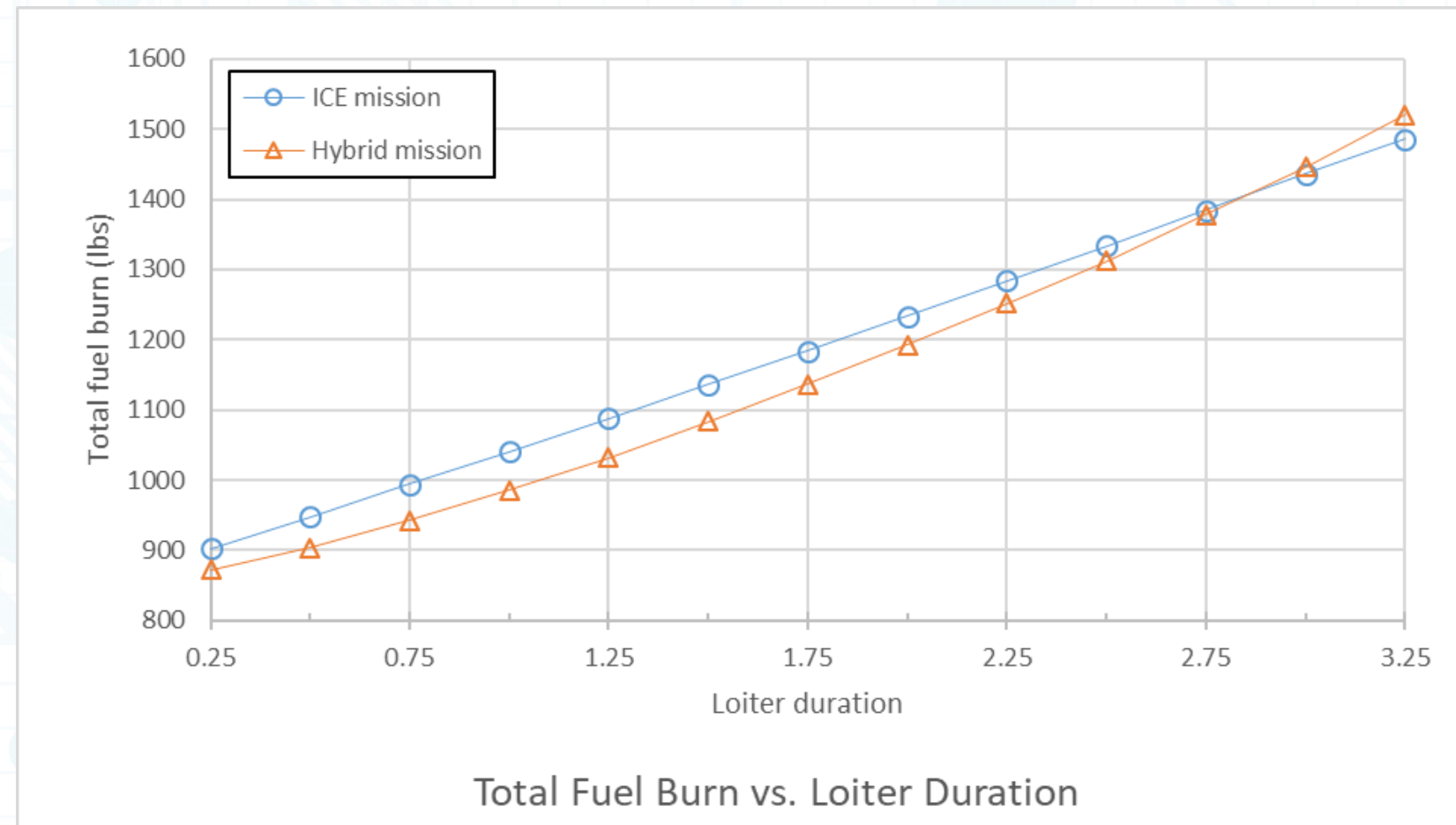Green= battery (hybrid, *VCQ_FanOnly.mdl*)

- Placement in Assemblies

- Airframe modifications (weights, drag polar, payload)

- Switching engines

Choose hybrid for <2.75hr loiter

- Under-fueled/over-fueled handling

- Battery calculations

- Sensitivity analysis

Fuel cell replacement?
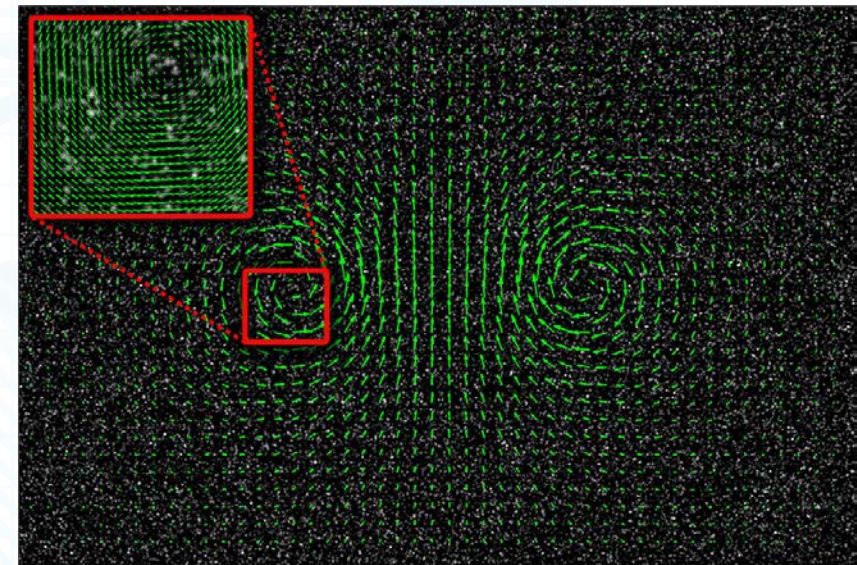
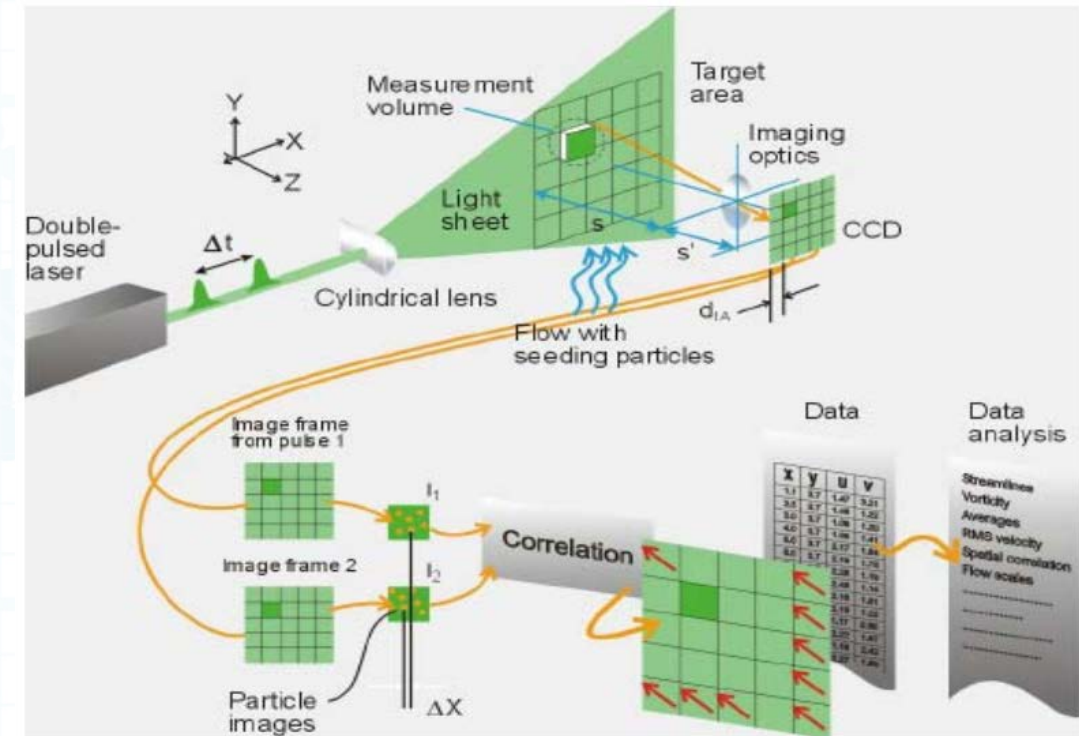

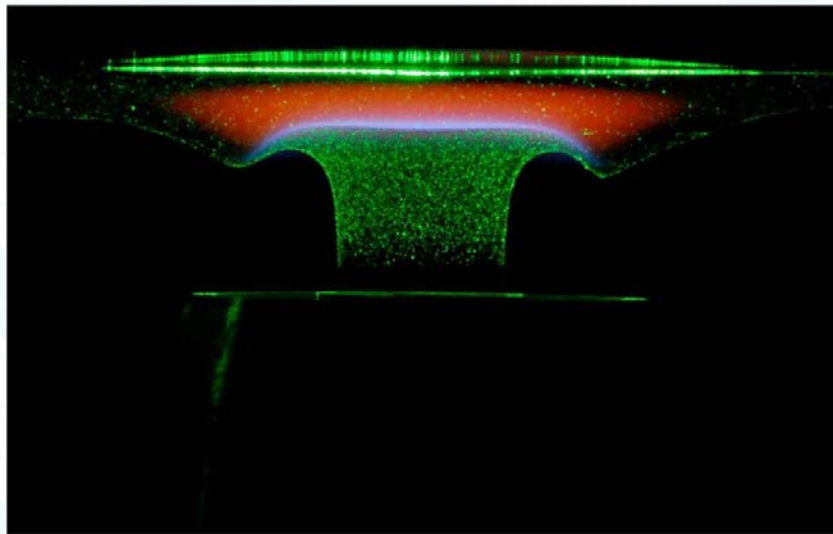Total Fuel Burn vs. Loiter Duration

Proof of Concept: Laser PIV

May 24 - August 2

What is PIV?

- Laser illuminates particles

- Camera captures image(s)

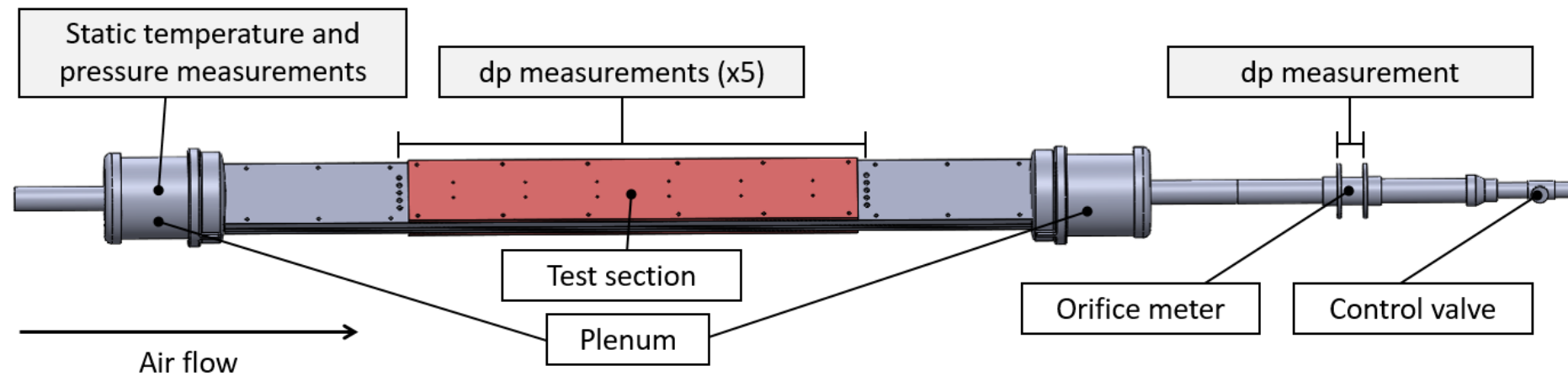- Software calculates velocity

DIY PIV: Possibility & Cost

- Optics ($275)
- Camera ($420)
- +Misc, total=
  $1,600 vs $80,000+
- OpenPIV and PIVlab

- SOP write up
- Blown fuses

Drag Test Rig

May 27 - August 2

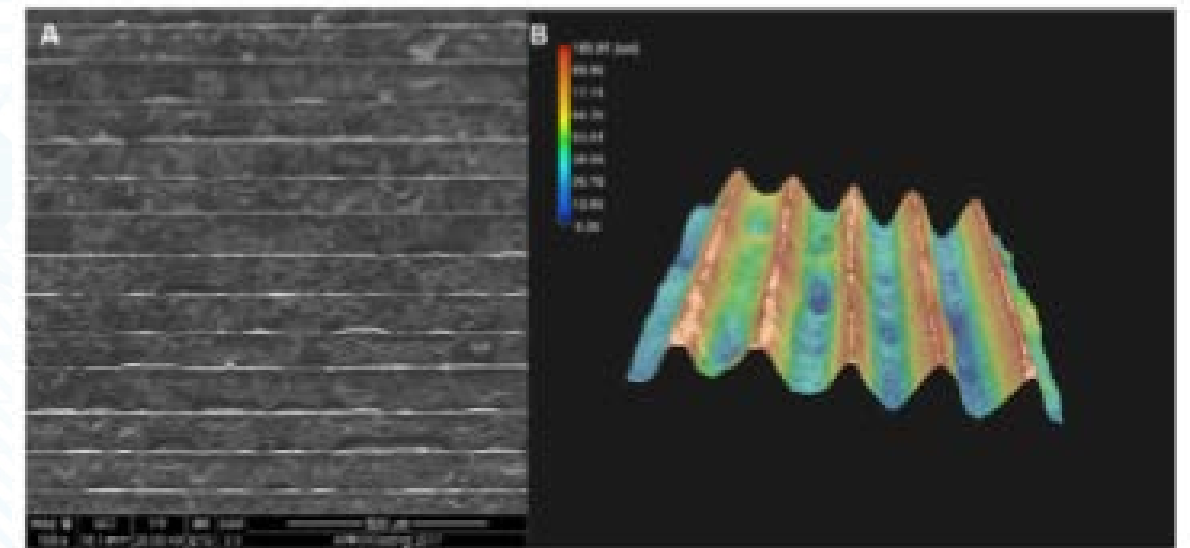# Rebuild rig and get new data

Static temperature and pressure measurements

dp measurements (x5)

dp measurement

Test section

Plenum

Orifice meter

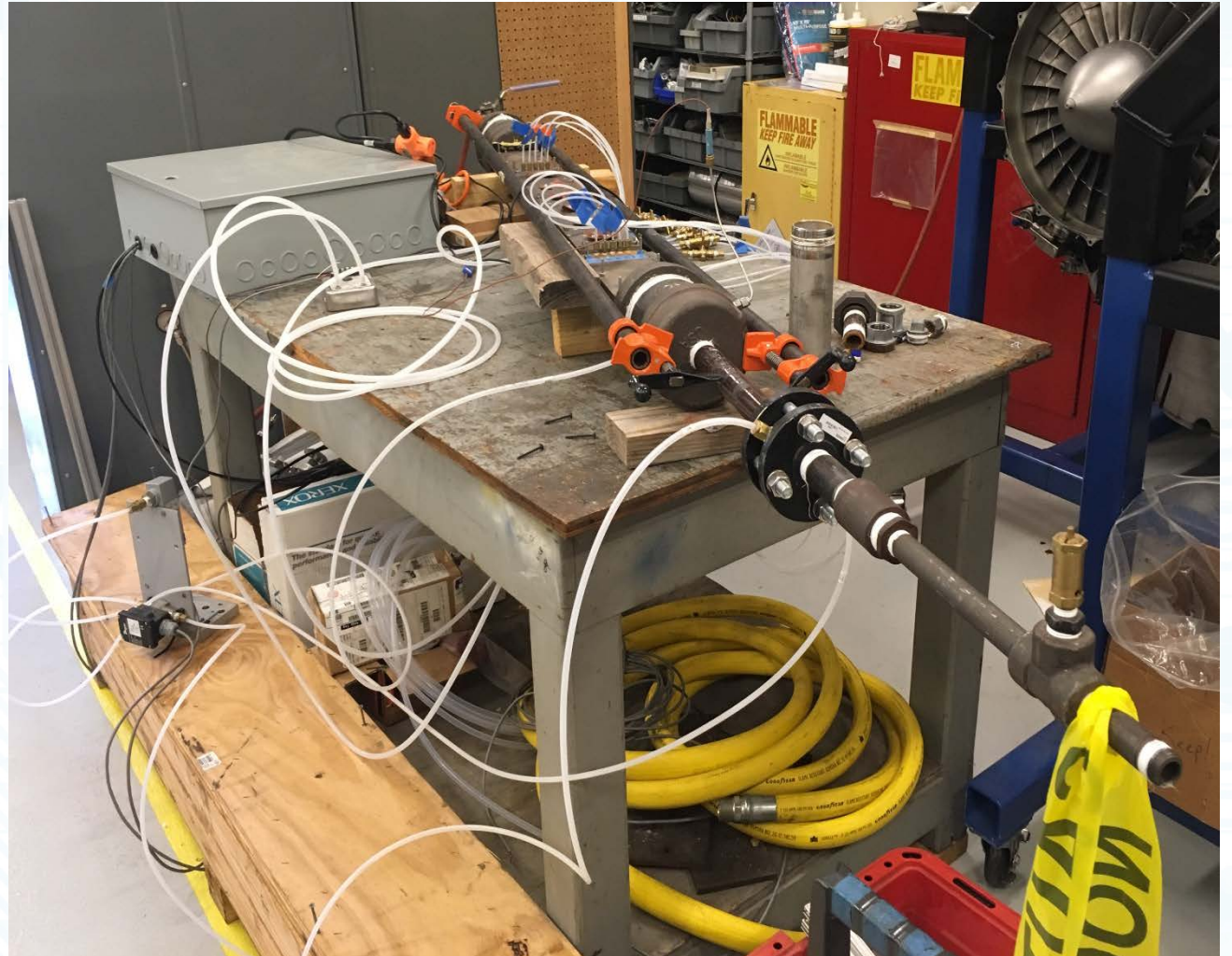Control valve

Air flow

Riblets

- Reduce drag
- Susceptible to environmental particulates

Project Status

- Instrumentation delay

- Compressor down

- *Collected data (to be analyzed):*
  - *Smooth plates*
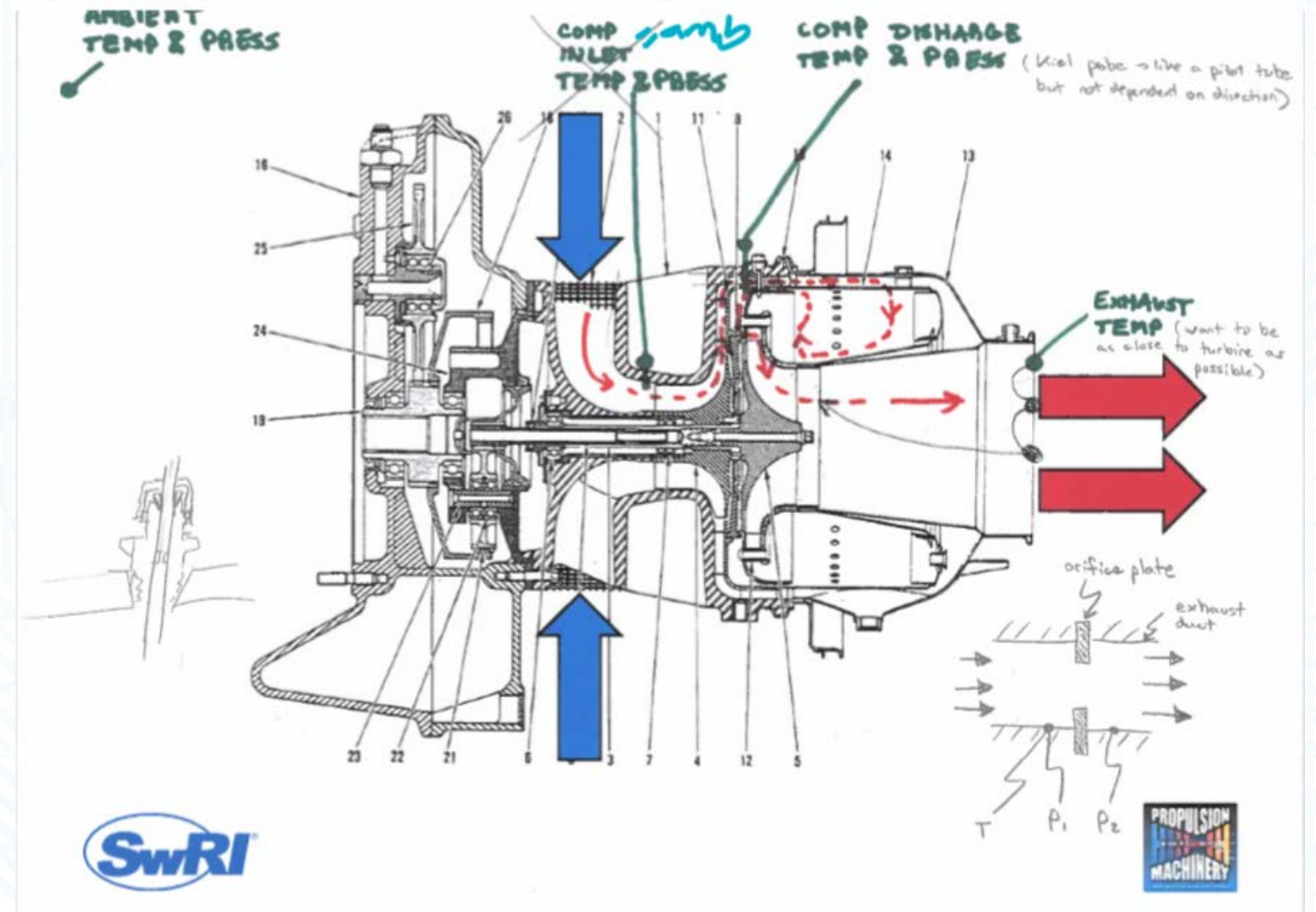 - *Riblets*

Titan T62 Instrumentation

July 1 - August 2

MECHANICAL ENGINEERING

swri.org

Project Objectives

1. Obtain baseline data

2. Attach generator and run with load

3. Document information re: engine operation

MECHANICAL ENGINEERING

swri.org

Safety Modifications

- After running stock

- Extended wires

- Attached generator

- "Custom" wrench
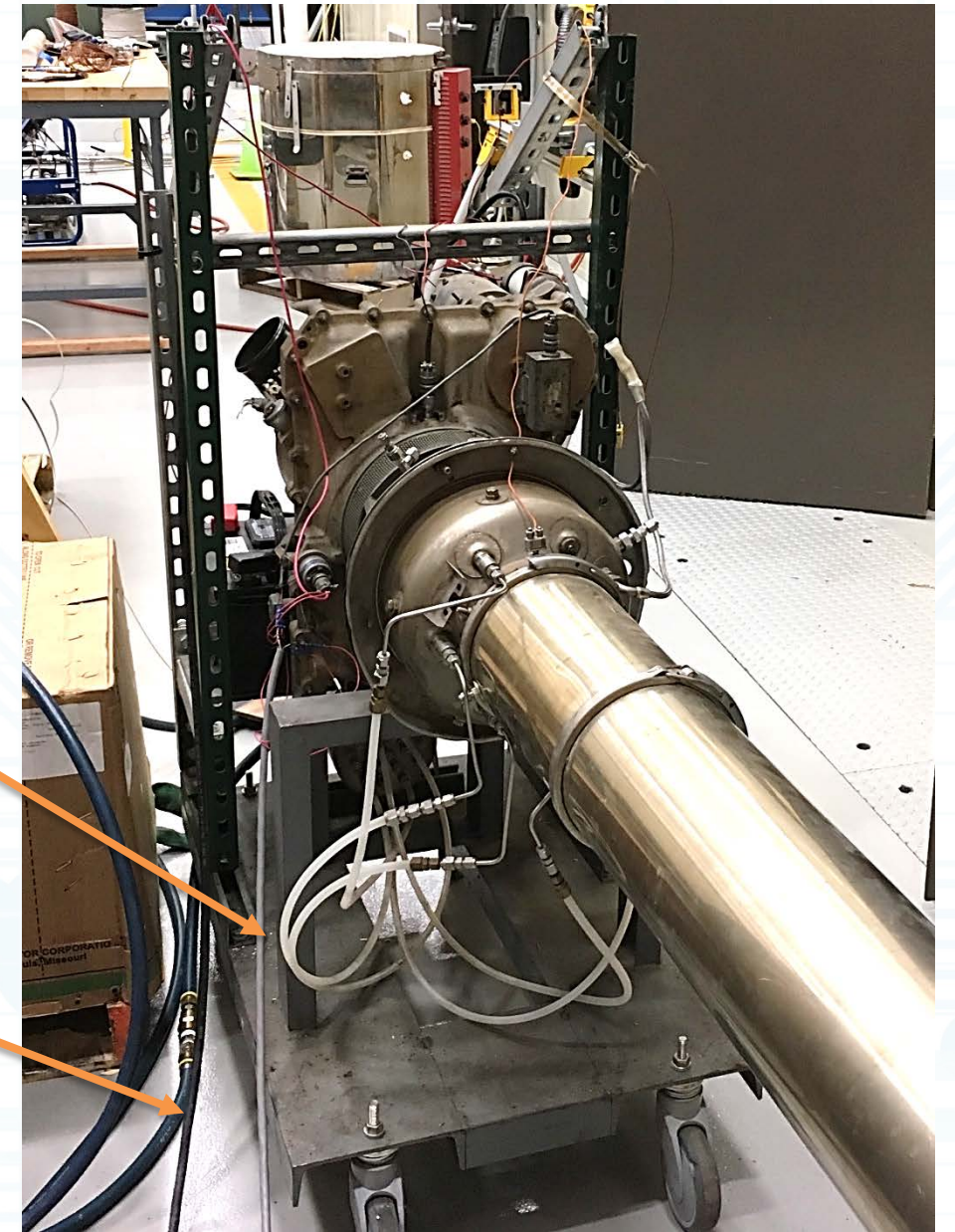
Project Status

- Need regulator for generator

- Configured instrumentation ports

- Documented safety and operating procedures

NPSS Unit Conversion

July 16 - July 23

Convert one of the CDM files to SI units

- Model files have two ways of conversion

```
real ChxDes_SI = 1135.65;    // 1 "Btu/(sec*in2*R)" = 2.94361e+06 "W/(m2*K)"
ChxDes_SI.units= "W/(m2*K)";     //so 1135.65 W/(m2*K) = .0003858 Btu/(sec*in2*R)
ChxDes=convertUnits("CmpH.S_Qhx.ChxDes_SI","Btu/(sec*in2*R)");
```

```
alt_in= 10668 "m";
```

- Summary block required manual conversion

```
vars = {"Amb.MN","Amb.alt*0.3048", //ft to m
```

- PageViewer block is a simple @units

```
compAttr = {"W:????.??=W[kg/sec]@kg/sec",
```

Also wrote a file explaining how & when to use each

Acknowledgements

I would like to thank SwRI for choosing me for the 2019 UTSR Fellowship and investing in my education. I am very grateful for the introduction to a variety of research topics- something I appreciate as I am in the process of picking an area for my Master's thesis.

Throughout the fellowship, I felt like a valued member of the team and had the support of the entire group. I would especially like to extend my gratitude to **Grant Musgrove**, **David Ransom** and **Tim Allison** for integrating me into their sections. Also to **Jacob Delimont**, **Charles Krouse**, **Owen Pryor**, **Ellen Smith**, **Shane Coogan**, and **Dorothea Martinez** for providing their assistance and guidance throughout the fellowship.

References

VCQ Images

1. *Mechanical Design Options for Variable Cycle Quiet Power and Propulsion for Unmanned Aircraft Application*
    David Ransom, Grant Musgrove
    2019 JANAF paper

2. *Agencies Could Improve Information Sharing and End-Use Monitoring on Unmanned Aerial Vehicle Exports*
    GAO-12-536: Published: Jul 30, 2012. Publicly Released: Sep 12, 2012.

3. *Subsonic Ultra Green Aircraft Research: Phase II – Volume II – Hybrid Electric Design Exploration*
    Marty K. Bradley, Christopher K. Droney. Boeing Research and Technology, Huntington Beach, California

4. *TigerShark*. MicroUAV. 2019 from: microuav.com/AirVehicle/TigerShark#TigerShark_Technical

5. *An MQ-1 Predator, armed with AGM-114 Hellfire missiles, piloted by Lt. Col. Scott Miller on a combat mission over southern Afghanistan*
    U.S. Air Force Photo / Lt. Col. Leslie Pratt

Riblets Image

1. *Conformal Anti-Icing Coatings for Aircraft Components*
    Carol A. Ellis-Terrell, Vicky Poenitzsch, Ronghua Wei, Kent Coulter, and Michael Miller
    2018 AIAA Aerospace Sciences Meeting. January

PIV Images

1. *Image of a stagnation flame with flow seeded with 1 micron Al2O3 particles, illuminated by green light (wavelength 532 nm) for particle image velocimetry*
    Photo by Sean Salusbury for the Alternative Fuels Lab, McGill University (2008).

2. *Particle Image Velocimetry: Fundamentals and Its Applications*. 2011, *Particle Image Velocimetry: Fundamentals and Its Applications*.
    Jahanmiri, Mohsen.

Questions?