AFRL

SUGGESTED STRATEGY FOR PILOT UNEXPLAINED PHYSIOLOGICAL EVENT INVESTIGATION

OXYGEN STANDARDIZATION COORDINATING GROUP MEETING
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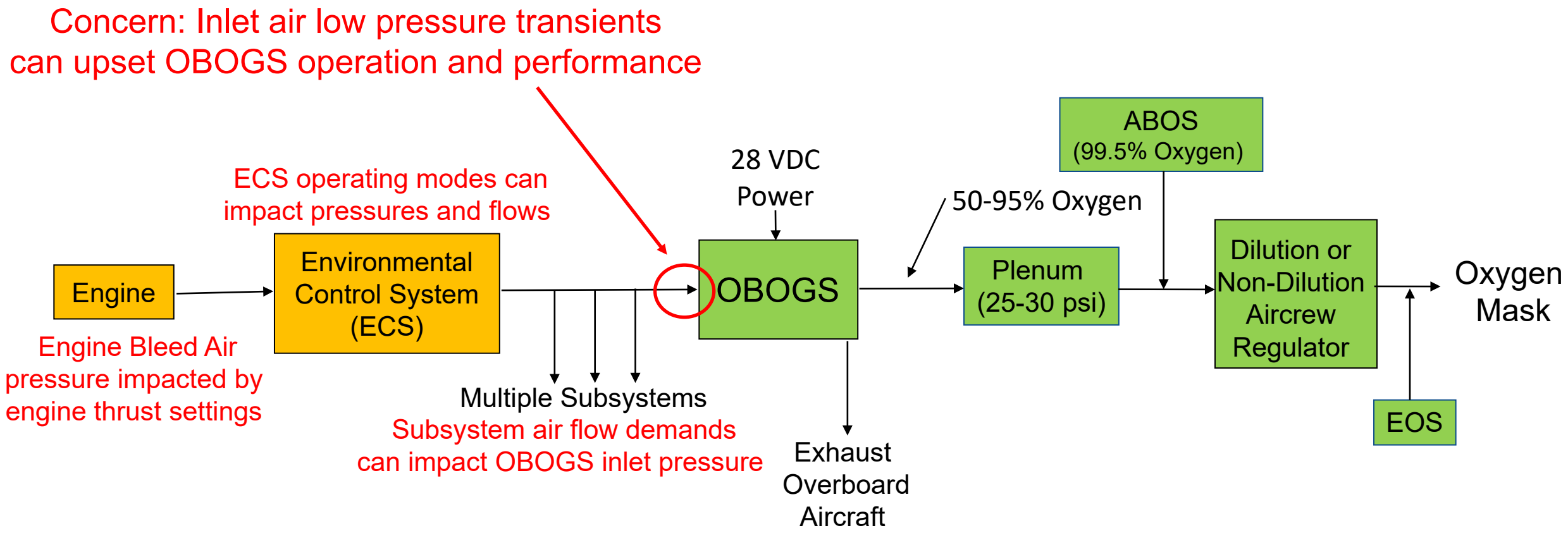
Overview

- BLUF: Suggest pilot UPE investigation includes operational flights with minimal sensors -- goal is to collect critical life support system data during pilot UPE
- Introduction
- New Strategy
- Sensors – 711 HPW OBOGS Pressure Monitor (OPM) and Eaton Respiratory Sensor Block (RSB)
- Est. Schedule
- Est. UPE Occurrences
- Est. Cost
- Conclusions

Typical OBOGS Integration



ABOS = Automatic Backup Oxygen System
EOS = Emergency Oxygen System

New Strategy

- Most critical parameter for OBOGS and life support system performance is OBOGS inlet air pressure
  - Fighter OBOGS typically need 1 to 4 pounds air/minute at minimum pressure of 25-30 psig
  - ECS air supply low pressure transients (even for short periods, several seconds) can cause OBOGS performance issues, such as, degraded oxygen and restricted breathing flow
- Past UPE investigations using lab studies and limited flight testing haven't been successful in discovering causal factor -- concern current investigation approach will not resolve pilot UPE problem
  - Lab studies are valuable to provide in-sight but can't exactly duplicate the highly variable in-flight operating conditions and therefore are not viewed as conclusive
  - Past limited flight testing (~40-60 sorties) with significant aircraft modification (multitude of sensors and data acquisition system) on one or two aircraft was costly and resulted in limited flying hours – UPEs didn't occur

New Strategy (cont.)

- Data shows ECS low pressure transients can occur at any altitude (even on the ground) – their occurrence tends to be unpredictable and generally ECS experts can't explain why they occur
  - ECS low pressure transients observed on multiple USAF aircraft
  - U.S. Navy observed ECS pressure issues on aircraft
  - Netherlands noted ECS low pressure transients on F-16 test aircraft
  - Lab unmanned research data have shown effects of inlet air low pressure transients on research OBOGS – degraded oxygen% and restricted breathing gas flow
  - Lab human testing of aircraft life support system has not observed UPEs because testing uses stable and within specification OBOGS inlet air pressures

New Strategy (cont.)

- Objective: To capture life support system (LSS) data during pilot UPE
  - Currently, we get limited or no LSS data after pilot UPE – generally get several sentences
  - Data gap has hindered progress on this issue
- Plan to add sensors at LSS inlet and outlet – one at OBOGS air inlet and one pilot mounted
- Critical parameters recorded:
  - OBOGS Pressure Monitor:
    - OBOGS Inlet Air Pressure (pounds/square inch gauge referenced to aircraft pressure altitude)
    - OBOGS Vent or Exhaust Pressure (pounds/square inch absolute)
  - Respiratory Sensor Block:
    - Pilot Oxygen% prior to oxygen mask
    - Pilot Breathing Gas Flow in ambient liters/minute
    - Mask Cavity Pressure in mm Hg gauge referenced to cabin pressure
    - Cabin Pressure

New Strategy (cont.)

- Modify ~25 aircraft (one squadron) of the same type at one base with OPM and RSB
- Aircraft modifications would be executed by TBD (most likely aircraft prime, SPO, and 711 HPW)
- Aircraft will fly normal operational sorties
- Sensor data downloaded if UPE occurs – plan to do periodic sensor inspections and data checks

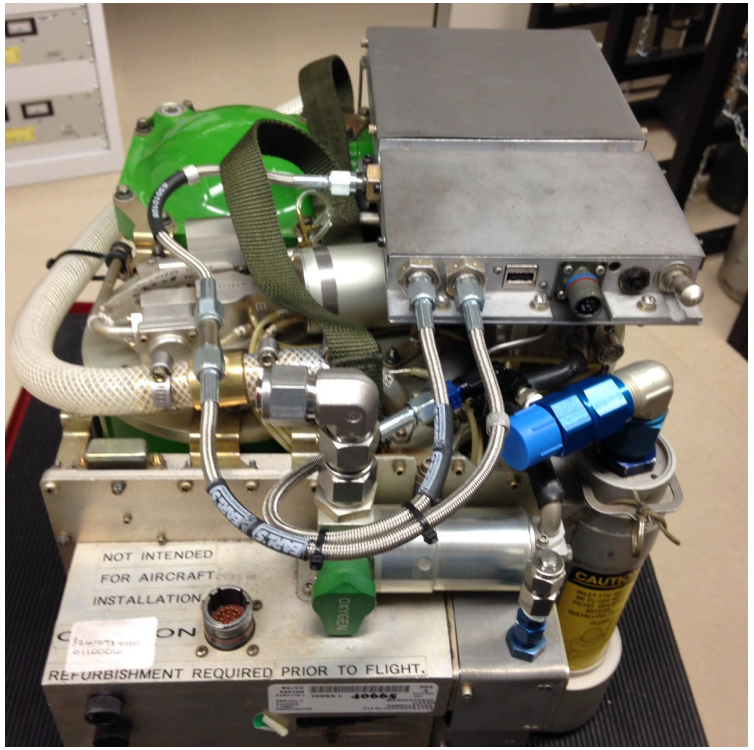
OBOGS Pressure Monitor (OPM)

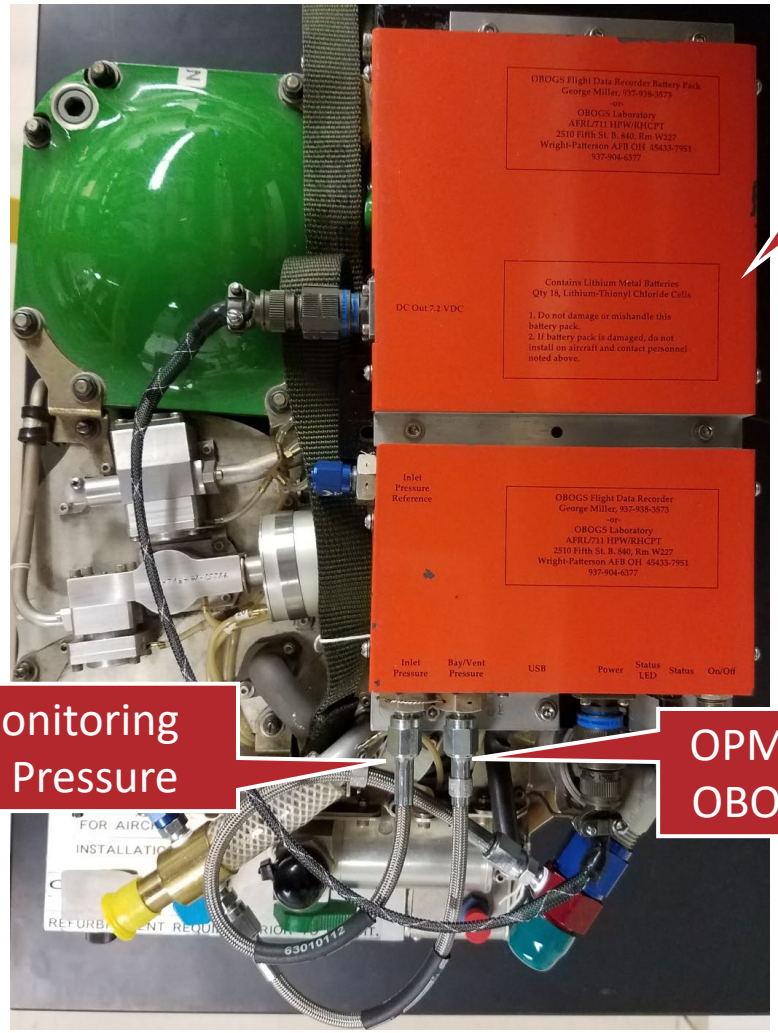
- Device measures and records OBOGS inlet air pressure and vent pressure
- Device “wakes-up” from “sleep mode” when air pressure is applied to OBOGS
- Plan limited flight qualification testing -- altitude-ok, EMI-ok, temperature, vibration, humidity, and acceleration
- Mounted to OBOGS or installed in OBOGS bay
- Collects data at 20Hz and overwrites data after 23 operational hours
- No aircraft wiring changes – device powered by long duration battery pack

OBOGS Pressure Monitor

OBOGS Pressure Monitor (OPM)

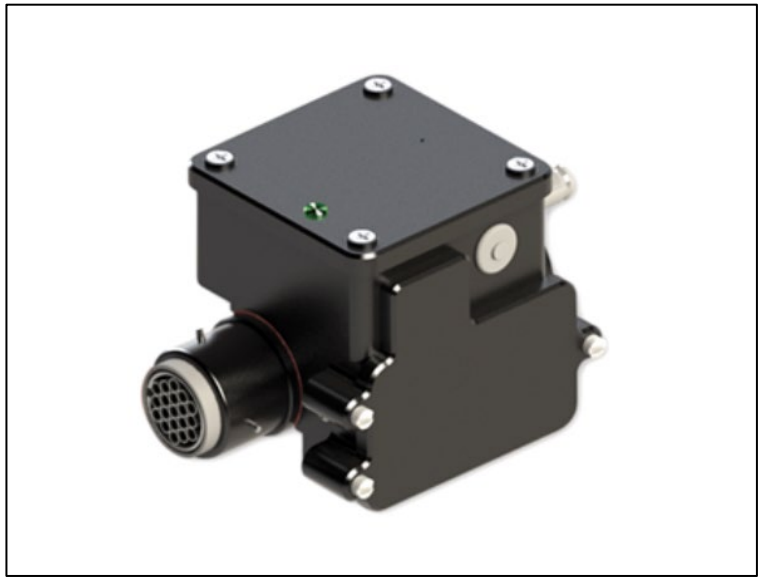
- Example installation on F-15E OBOGS
- Worked with F-15 SPO to devise installation approach and SPO conducted fit test





Eaton Respiratory Sensor Block (RSB)

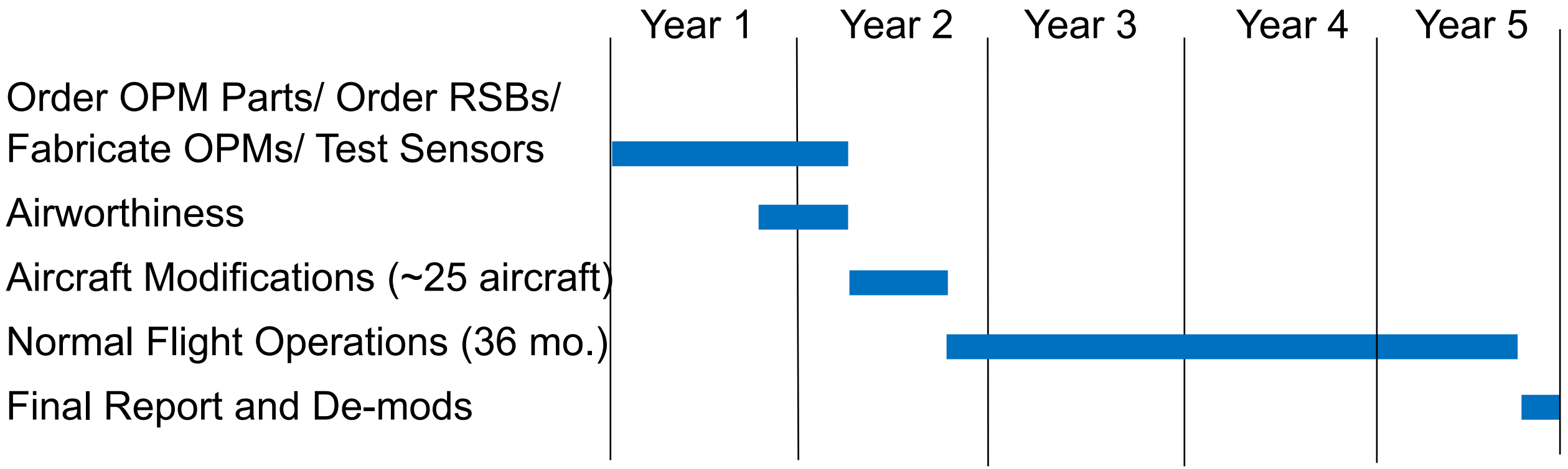
- Pilot mounted device – installs between ITB and oxygen mask hose
- Similar to Eaton Inhalation Sensor Block (ISB) -- RSB has mask pressure sensor
- Key parameters:
  - Pilot Oxygen%
  - Pilot Breathing Gas Flow in ambient liters/minute
  - Mask Cavity Pressure in mm Hg gauge
  - Cabin pressure



Eaton Inhalation Sensor Block*
(predecessor to Eaton RSB)

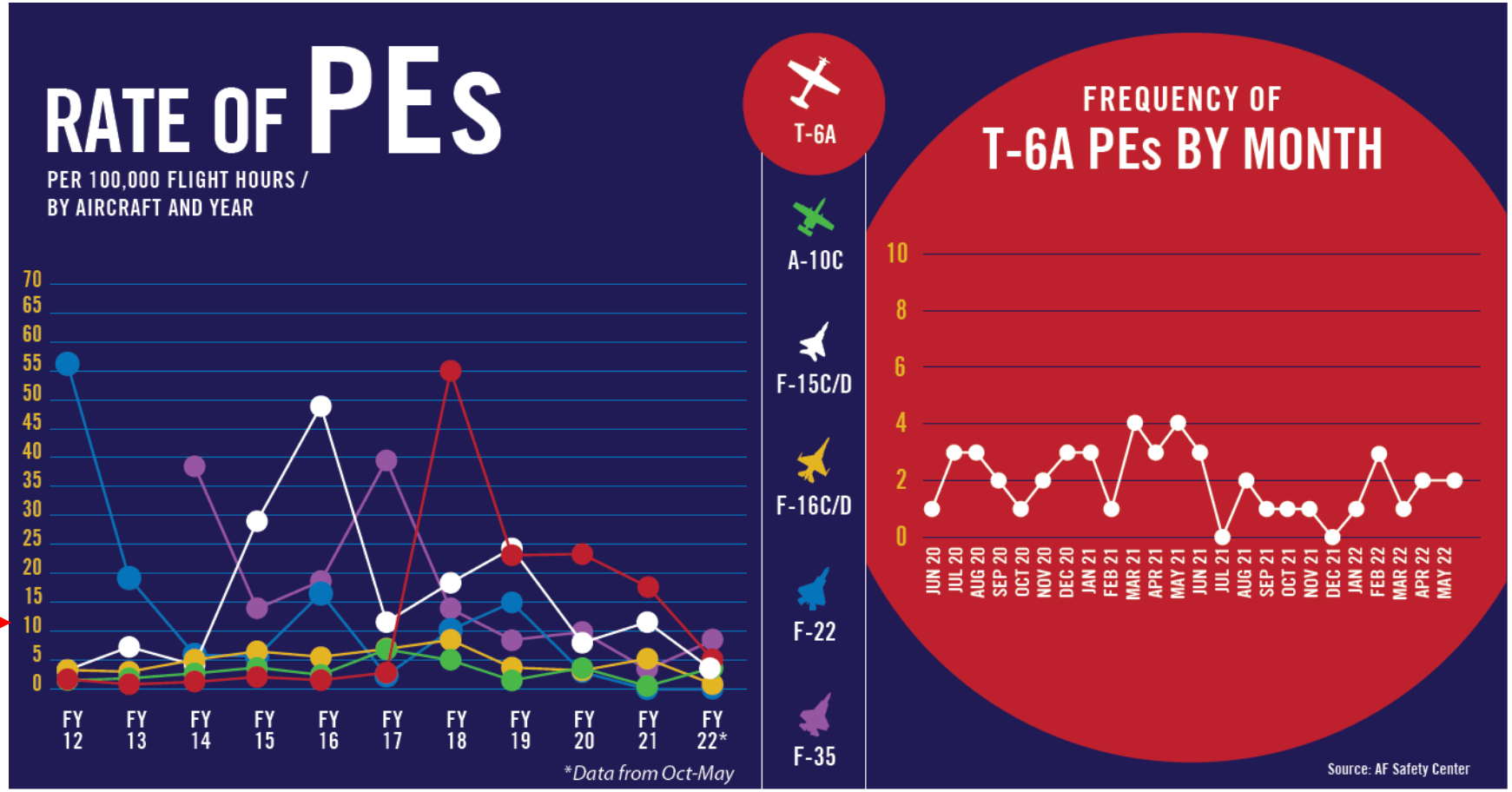
*** Source:**
https://www.eaton.com/us/en-us/catalog/life-support-systems/vigiloxtm-pilot-breathing-sensors.html

Estimated Schedule



Estimate of UPE Occurrences (Specific aircraft is TBD.)

Assumed an UPE Rate of 10 UPEs/100000 flight hours



Estimate of UPE Occurrences

- Assumed UPE Rate = 10 UPEs/100000 Flight Hours
- Assumed Flight Hours Per UPE: 10000 Flight Hours
- Assume 25 aircraft, 36 months of flying, each aircraft flies 3 sorties/week, and each sortie is 1.5 hours: 16200 Flight Hours
- Estimated Number of UPE Occurrences = 16200 Flight Hours/10000 Flight Hours/UPE = ~2 UPEs

Estimated Cost

Item	Total ($K)
Hardware (sensors, etc.)	1700
Personnel Man-hours	1100
Aircraft Modifications ($50K/aircraft + eng. design drawings)	1800
Travel	300
Total	4900

Summary

- When UPEs occur we get no or very limited/insufficient data to investigate event – this data gap has slowed progress in understanding causal factor
- Proposed effort minimizes number of aircraft, number of sensors, and cost yet has reasonable probability for capturing critical data during UPE
- Existing evidence points to aircraft ECS low pressure transients could be causal for UPEs
- UPE issue has persisted for ~15 years
  - UPE rates tend to fluctuate but UPEs continue with moderate improvement
  - When PEs occur on LOX aircraft they are generally explainable -- we find LSS equipment issue
  - OBOGS equipped aircraft tend to have UPEs but LSS equipment generally checks good
  - Concern is pilot UPEs likely to continue until we identify causal factor

Questions?