

XVS for the LBFD

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Low Boom Flight Demonstrator (LBFD)



- 1/3 Scale single-pilot demonstrator
- No forward facing windows
- XVS technology required
- First flight: 4Q/2020 (If approved by OMB, NASA HQ)

High-Level System Requirements

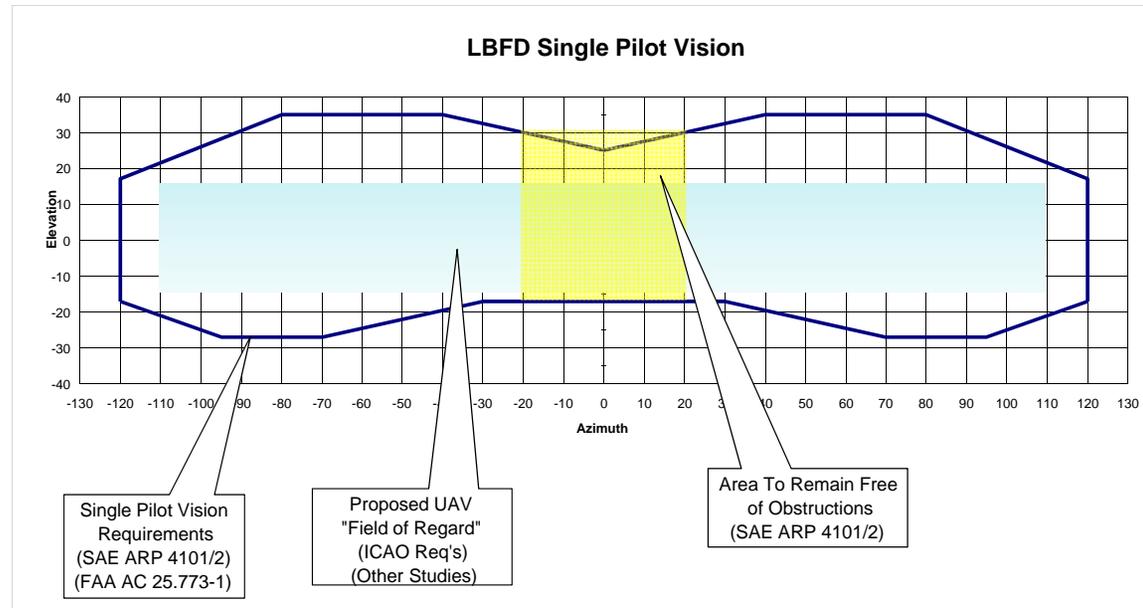


Overall System Objective: Use a combination of sensor, computing, and display technologies to provide an equivalent level of safety and performance as provided by the forward-facing windows in standard aircraft.

Forward-facing Window Functionality:

- Aircraft take-off and departure
- Land aircraft and taxi safely
- See-to-Follow
- See-and-Avoid

Forward-Facing Visibility



High-Level System Requirements (cont.)



Forward-Facing Acuity

Requirements:

- 20/20 Snellen acuity requires a minimum of 60 pixels/degree (ppd). More than adequate for taxi, departure, and landing.
Rationale: 20/20 letter ("E") -> 2 arc min per cycle -> 2 pixels per cycle -> 60 arc min per degree -> 60 pixels per degree (ppd)
- See-and-Avoid detection requires a minimum 72 ppd
Rationale: Detection time of 12.5 seconds (AC90-48C) at closure rate 578 knots (true) with 3 cycles needed for recognition of a small (C-172) size aircraft.
- See-to-Follow recognition requires 69 – 140 ppd
Rationale: Small (C-172) sized aircraft at 3-miles. Large (B-757) sized aircraft at 5-miles.

High-Level System Requirements (cont.)



Forward-Facing Acuity: Other Factors

- **Sensor Performance**
 - Resolution
 - Field-of-View
 - Sensitivity
 - Noise
 - Output/Input Transformation
- **Scene Content**
 - Target Characteristics
 - Background Characteristics
 - Lighting
 - Motion
 - Clutter
- **Display / Monitor**
 - Resolution
 - Luminance
 - Contrast
 - Distance from DERP
 - Window Glare
 - Is a top window needed?
 - Glare shield might be required.
- **Atmospheric Transmittance**
 - Haze
 - Fog
 - Rain
 - Dust
 - Clouds
 - Etc.

Background: HSR XVS Legacy



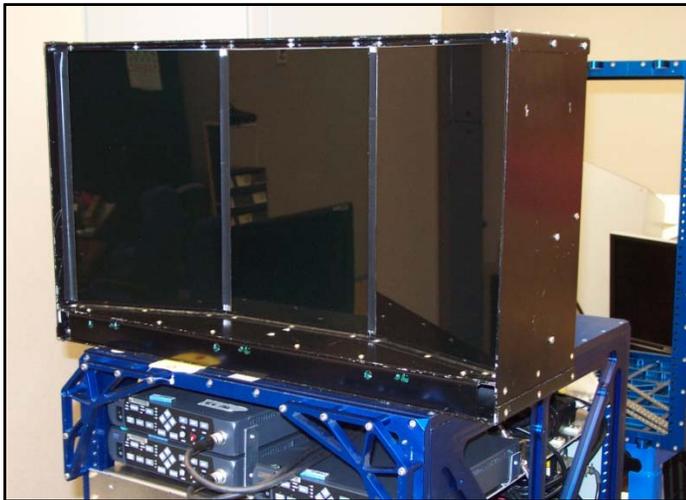
Circa 1998



- Big and Heavy
- Mechanically Complicated
- Power Hungry



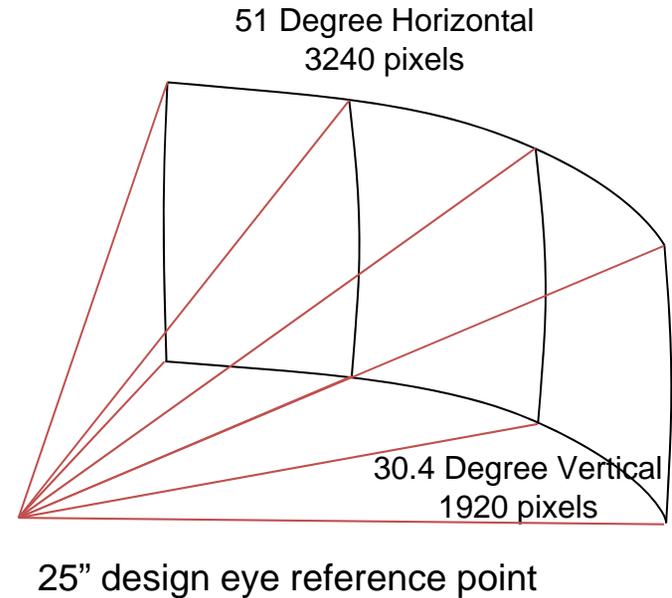
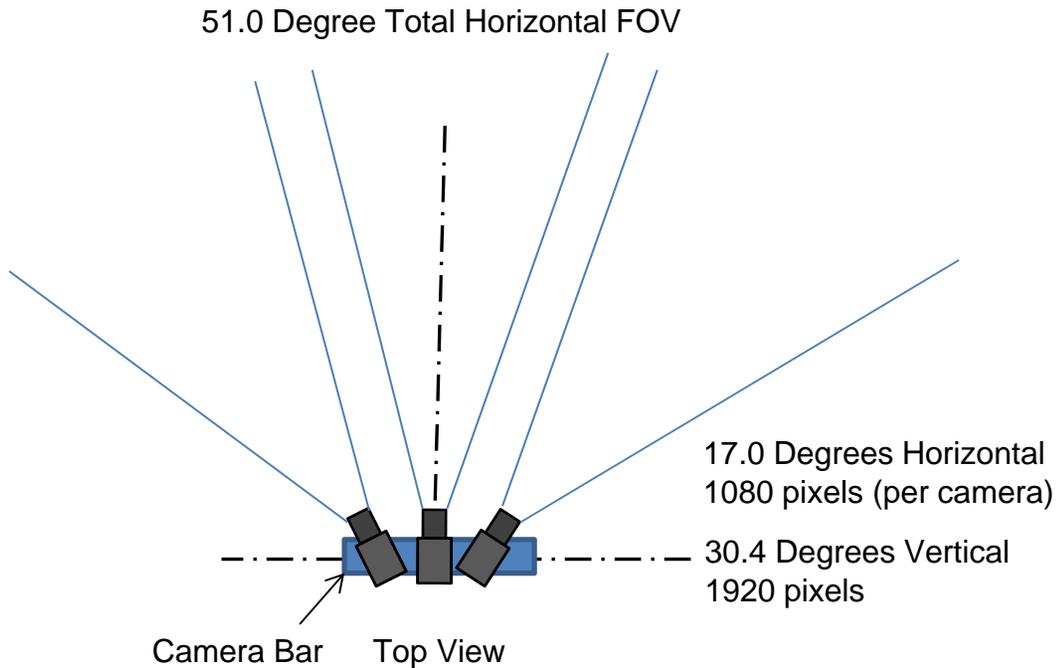
Background: 2012 Flight Test



- Small and Light
- Mechanically Uncomplicated
- High Performance



Background: 2012 Flight Test (cont.)



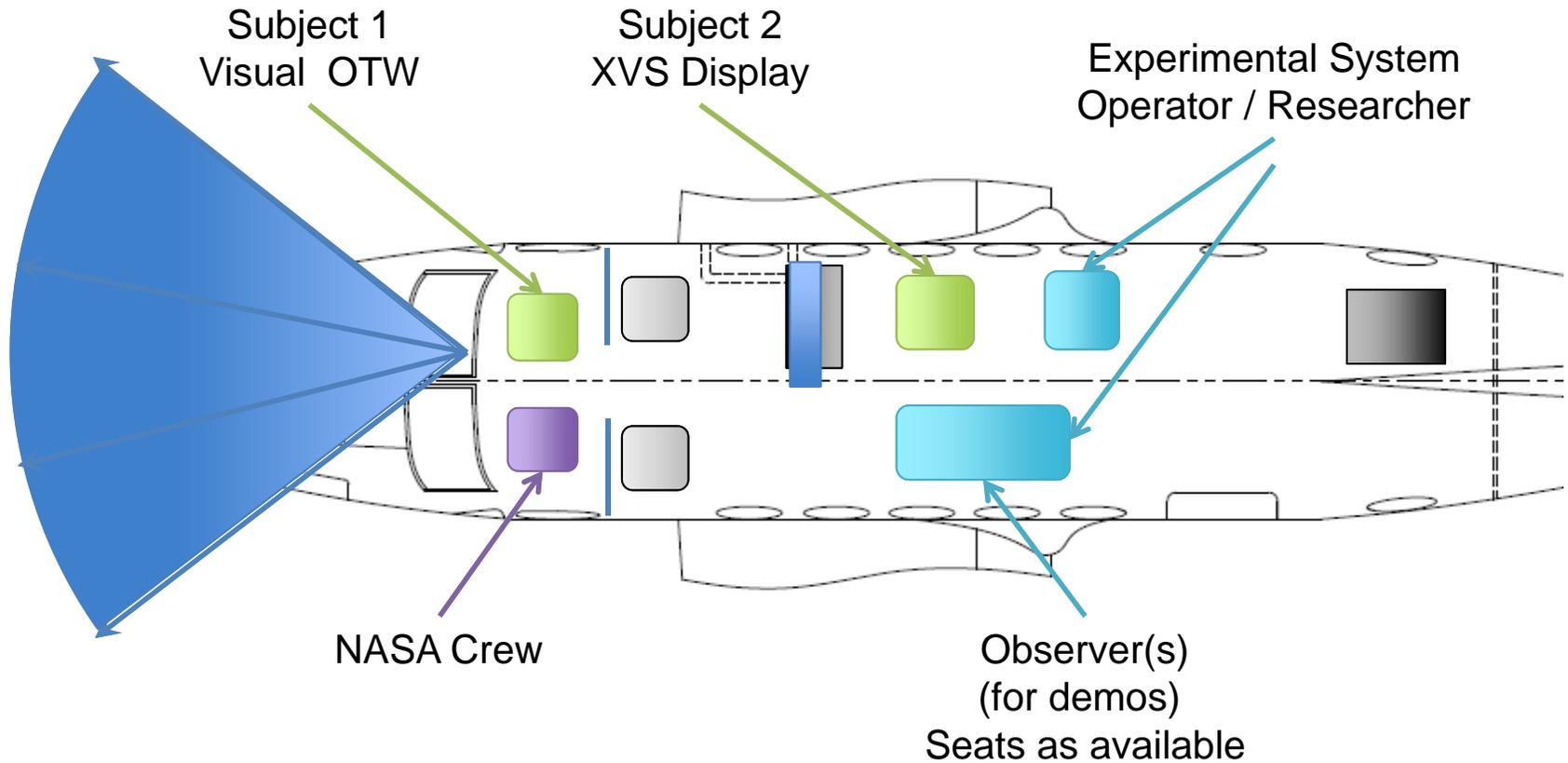
- **Camera Assembly**

- Cameras mounted in portrait orientation
- Aligned to maximize horizontal FOV
- Zero image overlap with 63 ppd

- **Monitor Assembly**

- 3 – HD LCD laptop monitors in portrait
- Configured to match camera angles

Background: 2012 Flight Test (cont.)



- One NASA Crew (Pilot)
- Two Research Subjects (1 Visual Out-The-Window, 1 XVS)
- Two Researchers

Background: 2012 Flight Test (cont.)



Cockpit – Glare Shield

HD Cameras (3)



Cabin – Racks

Triple LCD Display



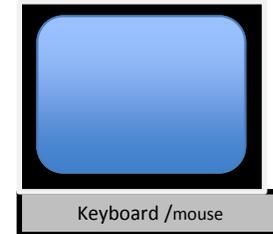
Recorders (3)

Image Mixers (3)

Display Computer

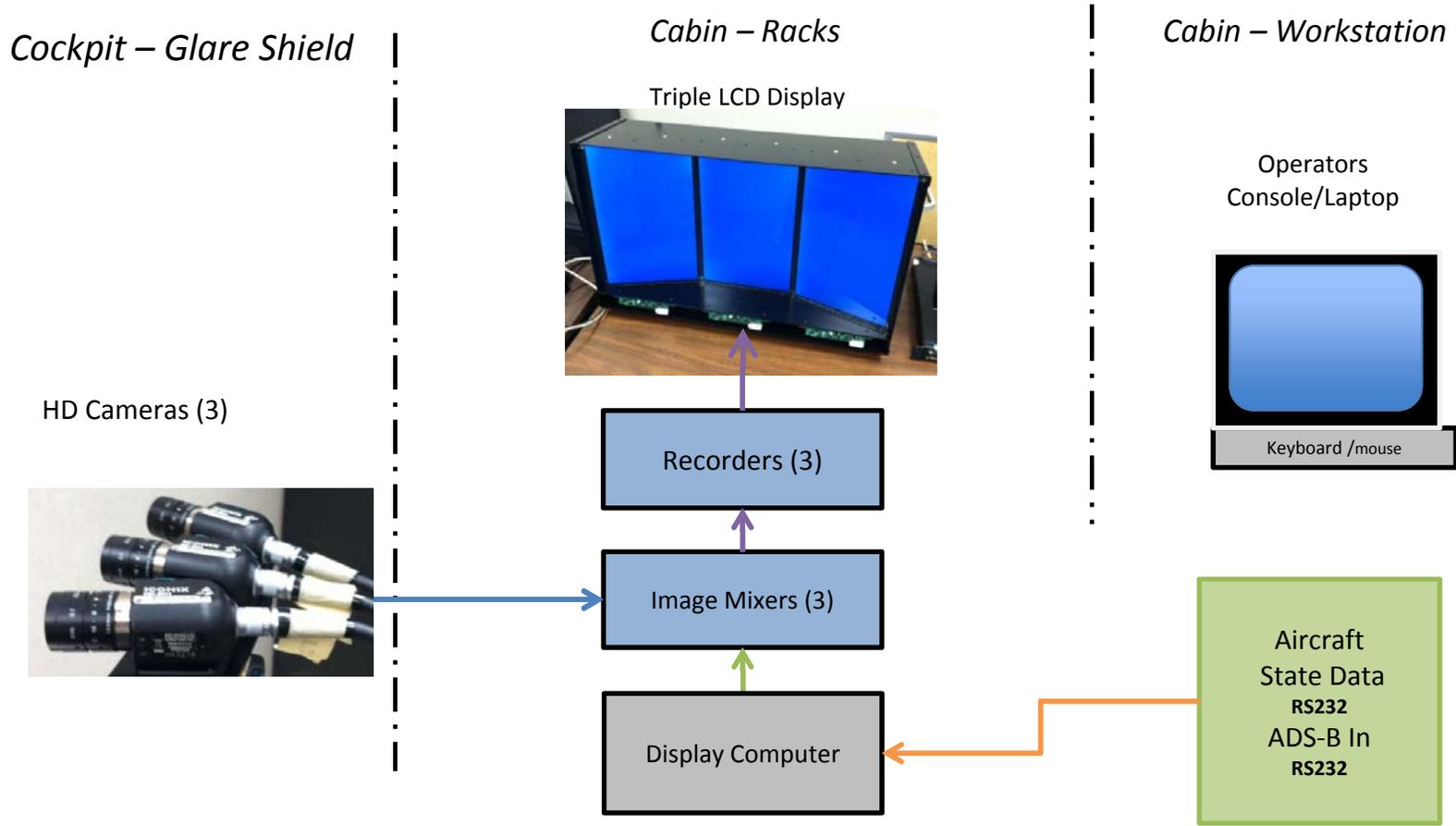
Cabin – Workstation

Operators Console/Laptop



Aircraft State Data
RS232
ADS-B In
RS232

Simplified Block Diagram

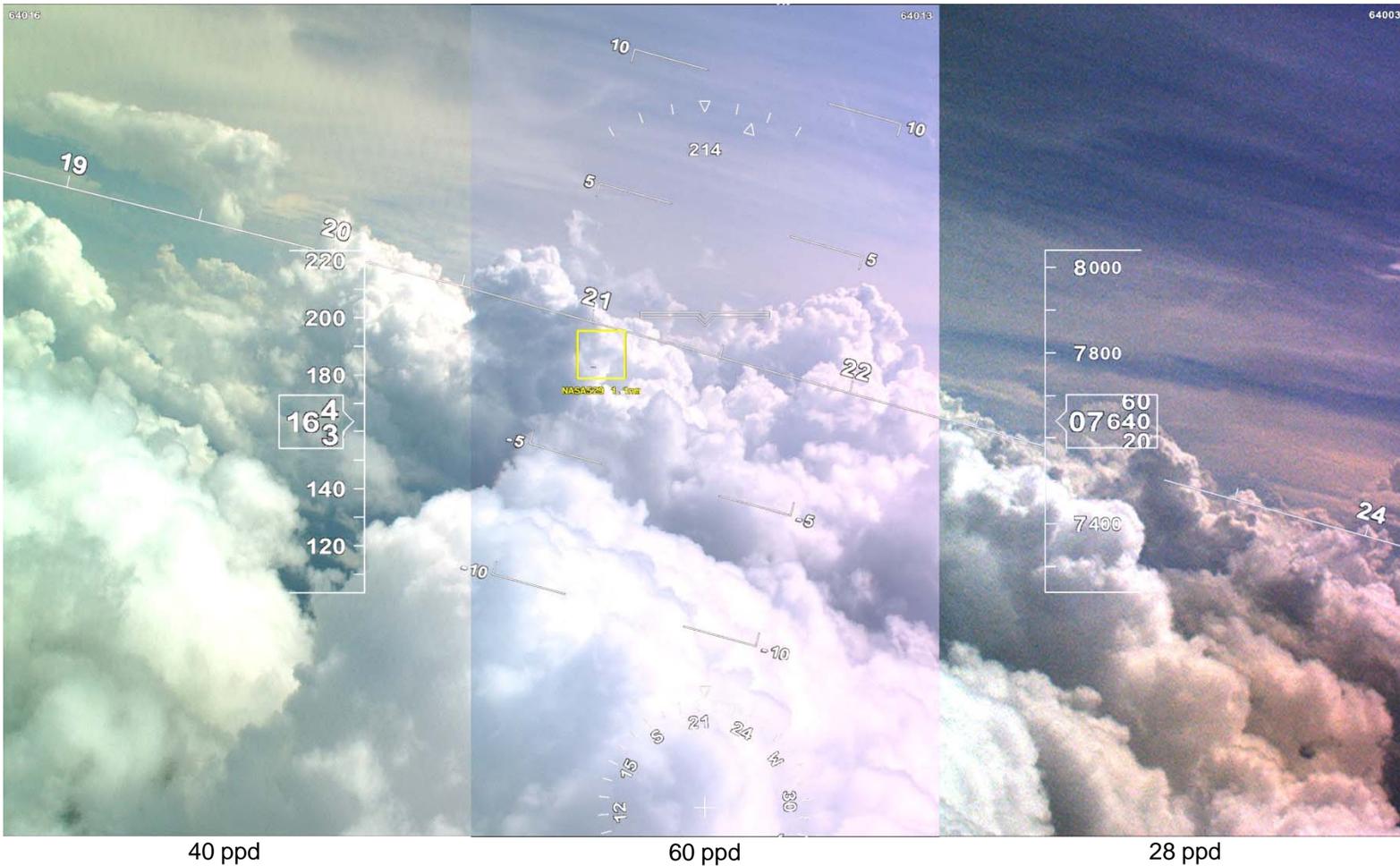


Background: 2012 Flight Test (cont.)



XVS Display Installed in Aircraft

Background: 2012 Flight Test Snapshots



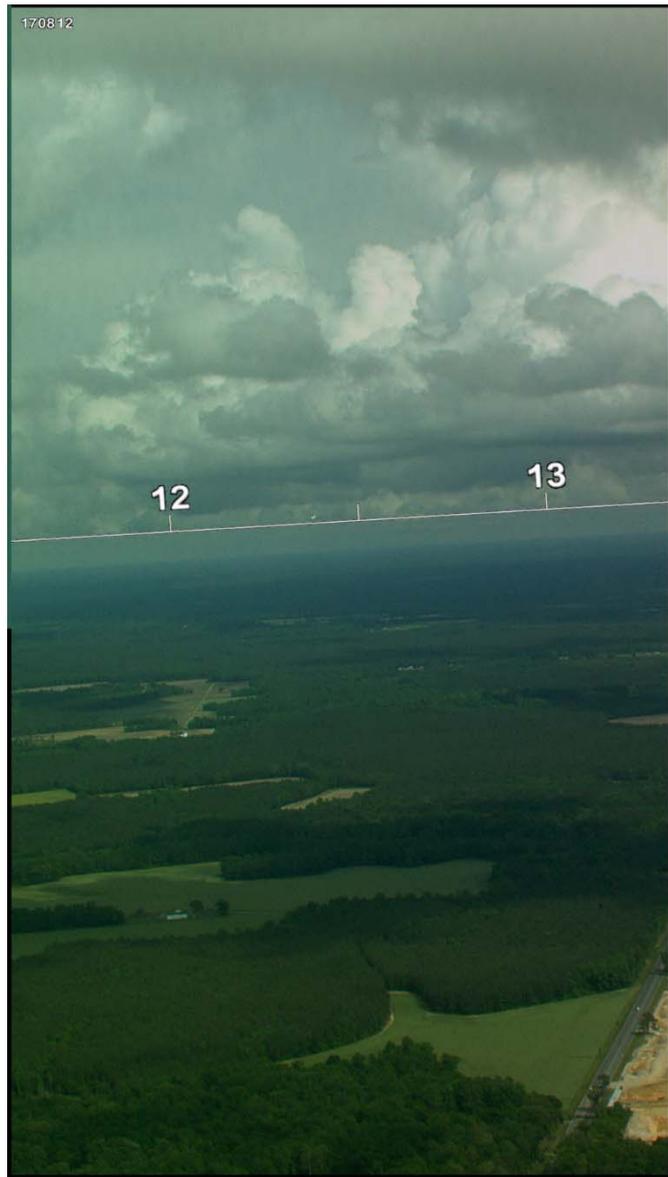
XVS Camera/Symbology Images
Cameras set to different resolutions for comparison

Background: 2012 Flight Test Snapshots

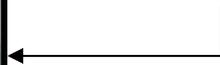


Traffic : B-200 11 O'Clock 1mile

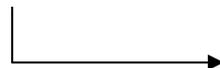
Background: 2012 Flight Test Snapshots



B-200
Co-altitude
head-on at
1.5 nm



B-200
Climbing out
of ground
clutter at
1.0 nm



System Description: 2015 Components



- Emergent HS-12000
- 4K UHD Resolution
- 84 fps max frame rate
- 350 grams
- 176mm x 50mm x 50mm



- NEC 24" UHD – EA244UHD-BK
- 4K UHD Resolution
- 60 fps
- LED Backlit LCD Panel
- 22.0" x 13.2" x 2.8"

System Description: 2015 Components (cont.)

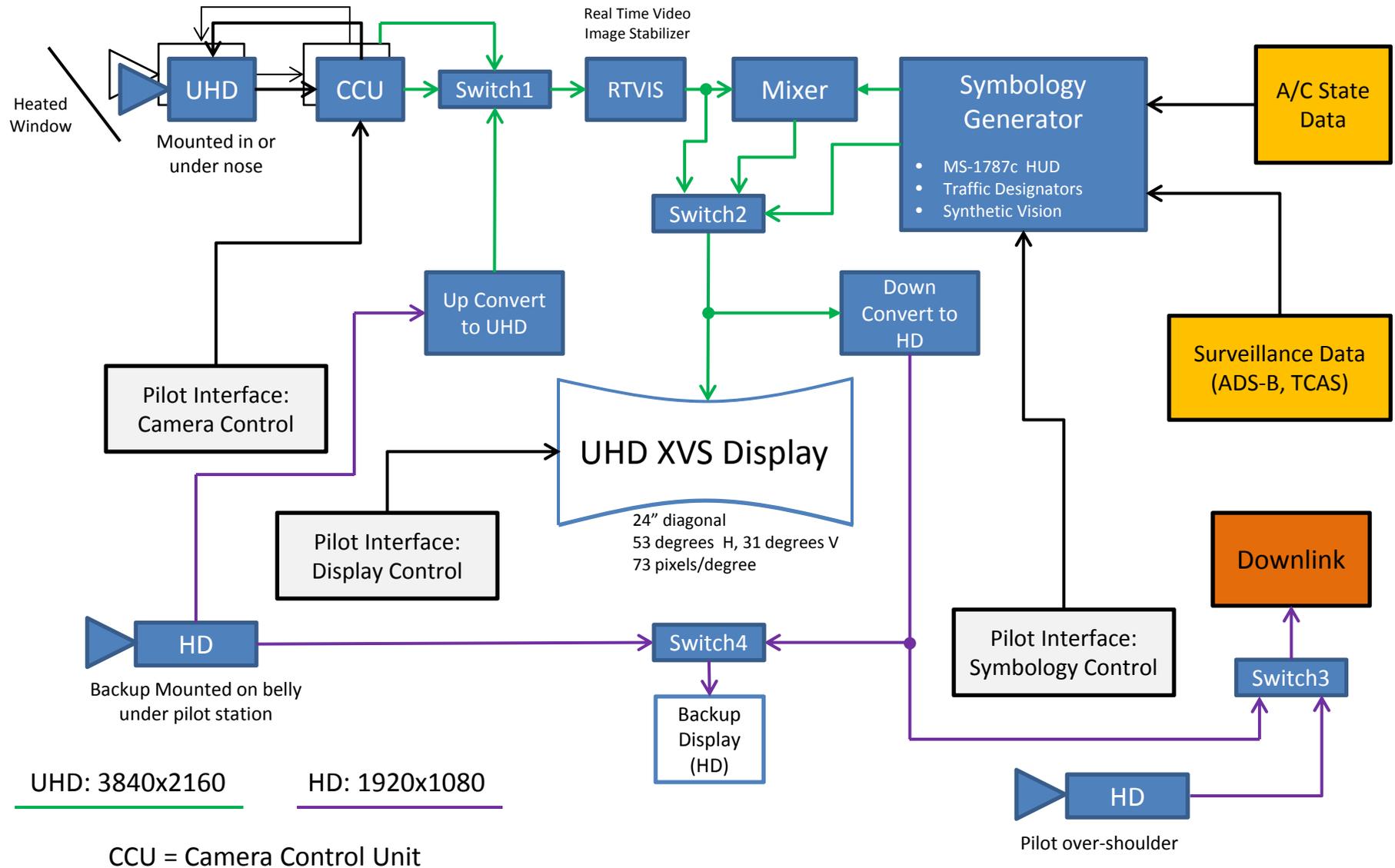


- EmbeddedLine EL1082
- Intel® Core™ i7-3610QE (4 × 2.3 GHz)
- 8GB Ram
- 250GB Hard Drive
- 260 x 200 x 89 mm

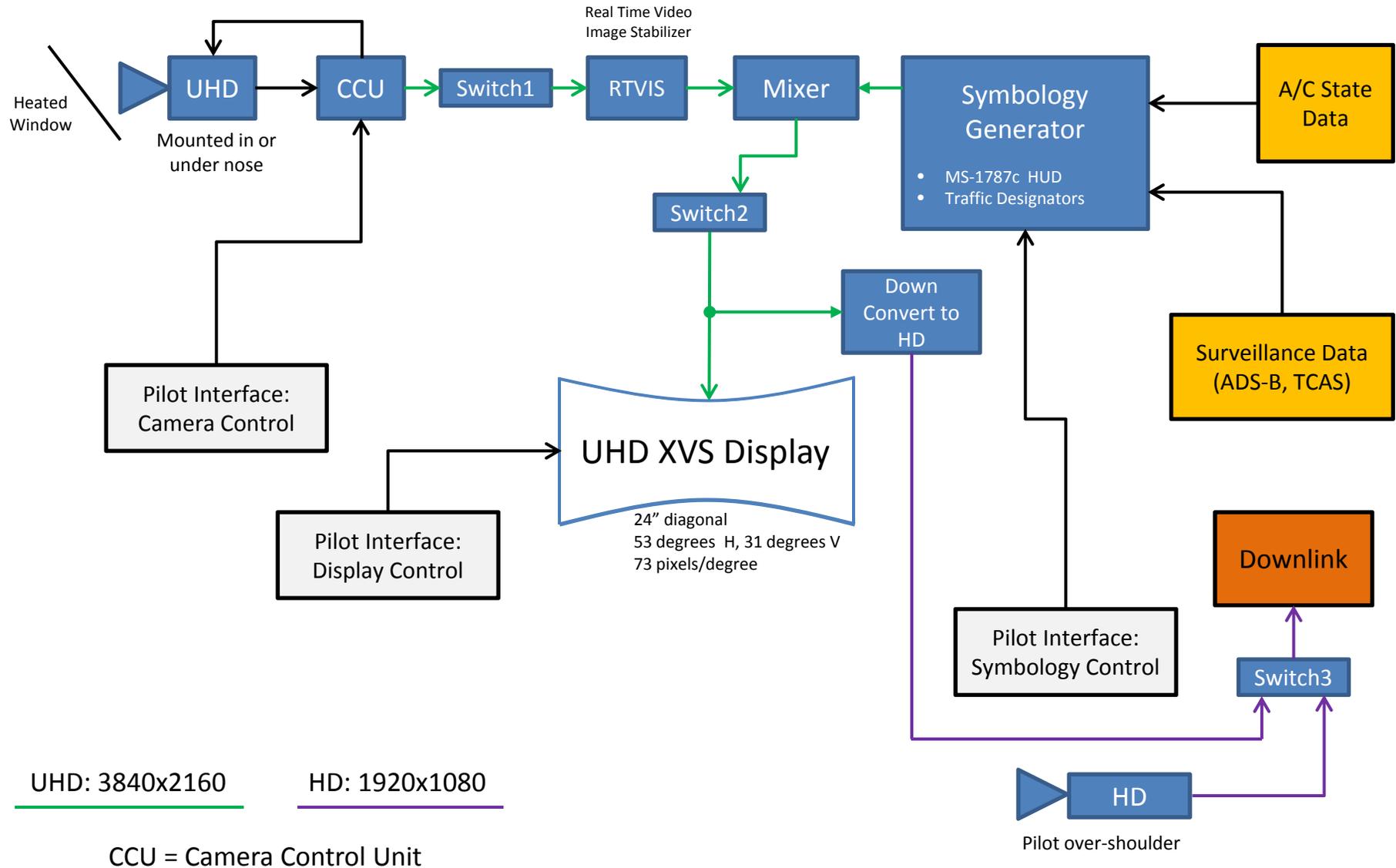


- RGB Spectrum SuperView 4K Multiviewer/Mixer
- 4K UHD Resolution
- 60 fps
- 17" x 18" x 3.5"
- Candidate for custom hardware development

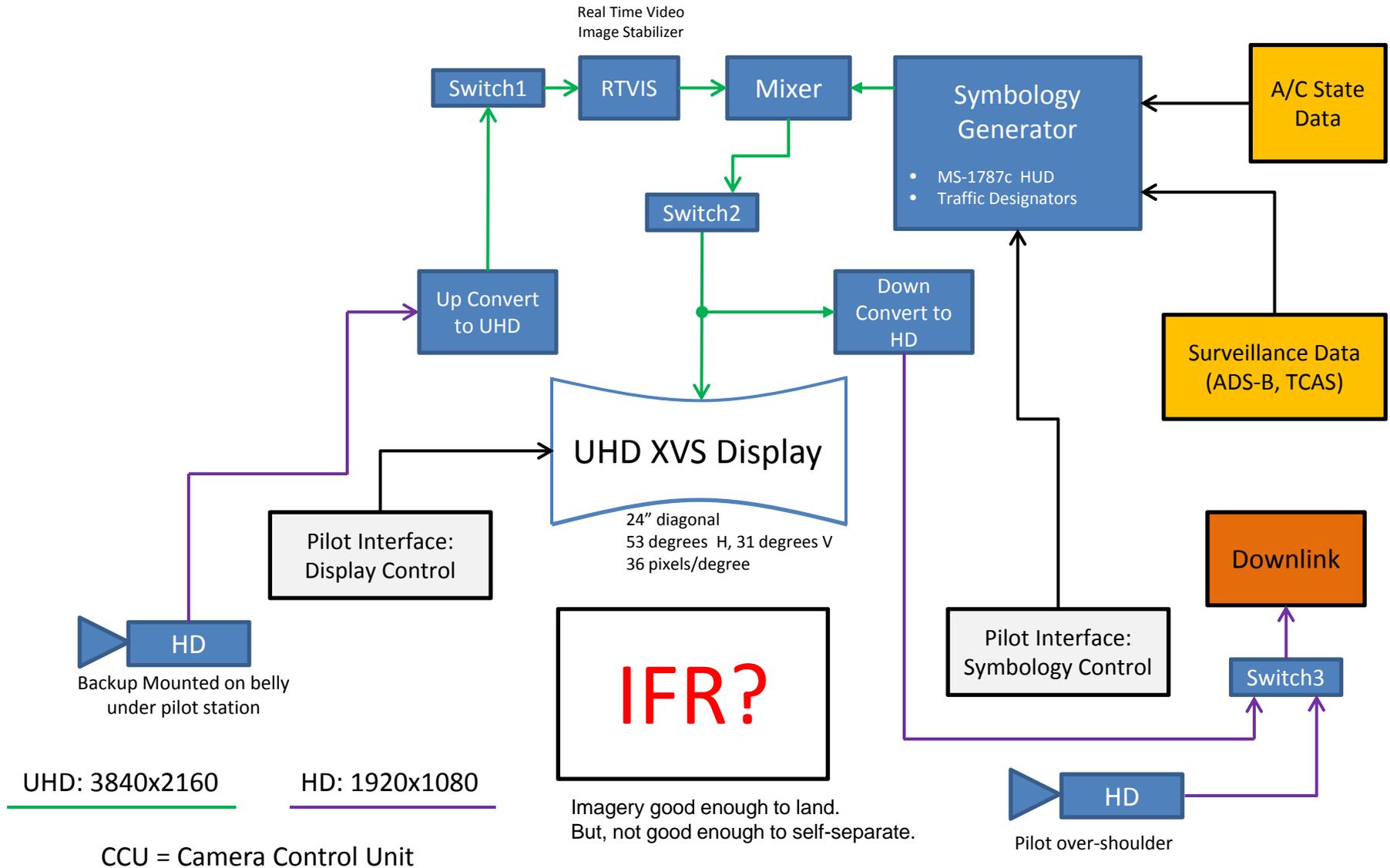
System Description: Block Diagram



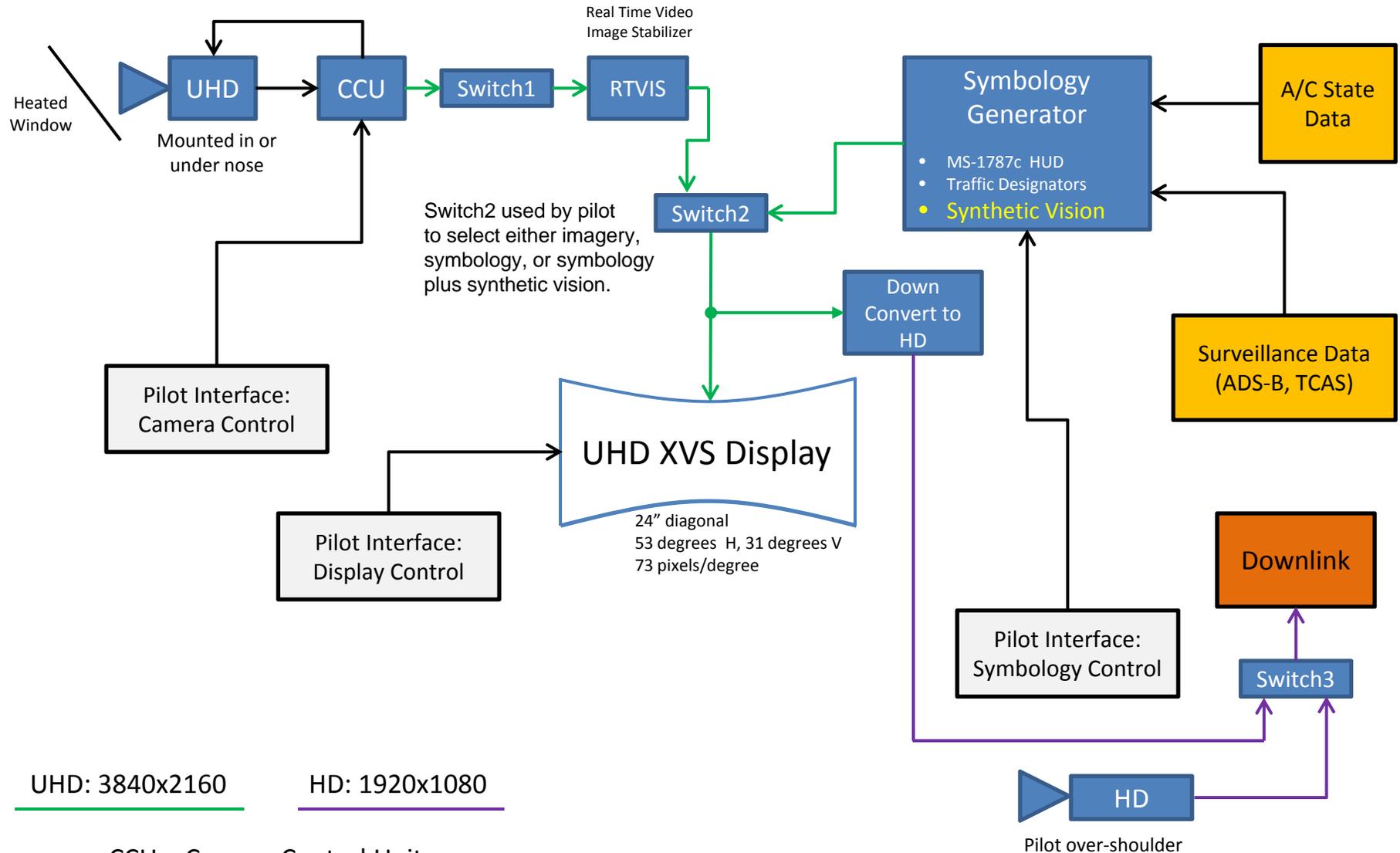
System Description: Nominal Operation



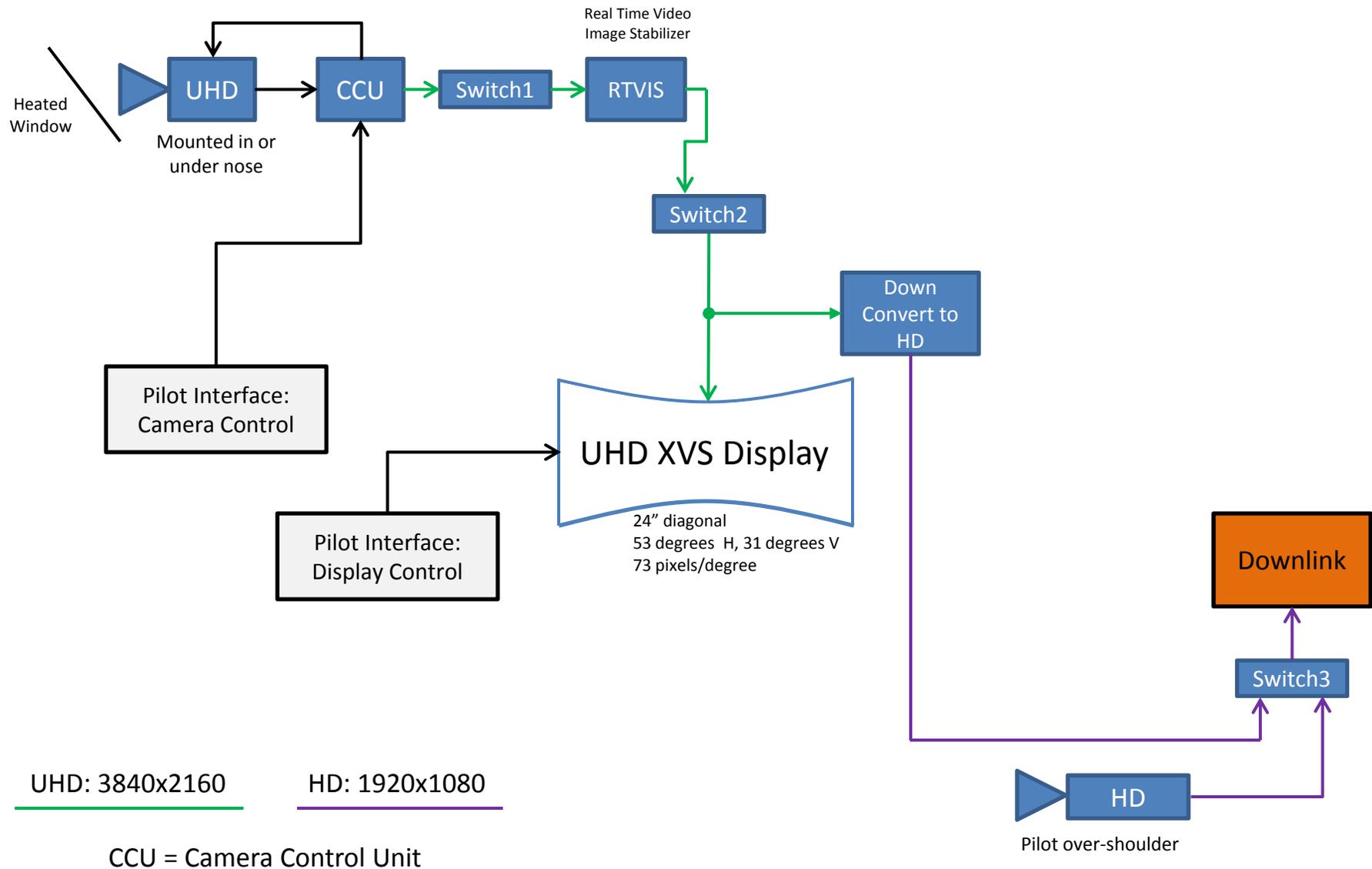
System Description: Primary Cameras Fail



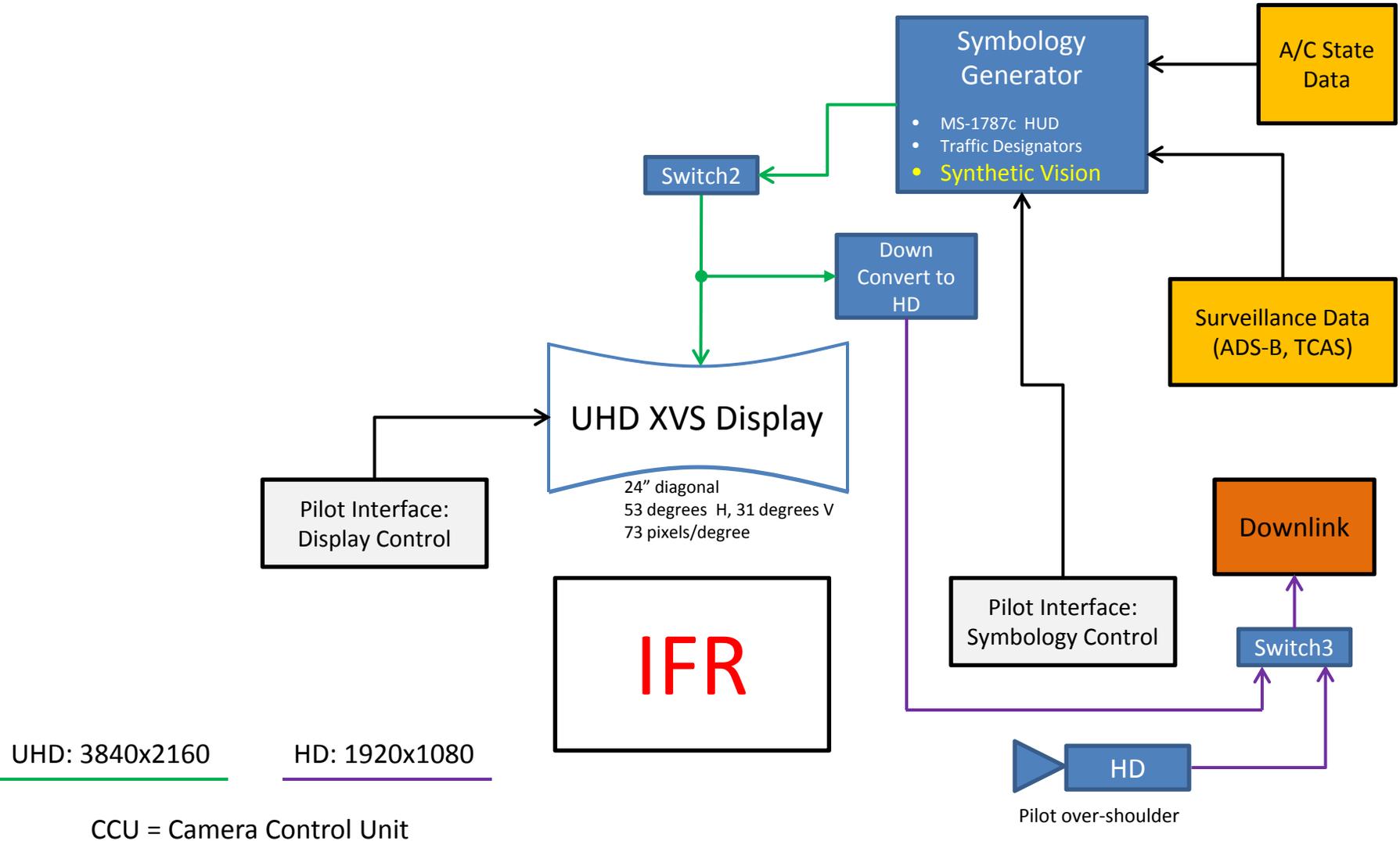
System Description: Mixer Fail



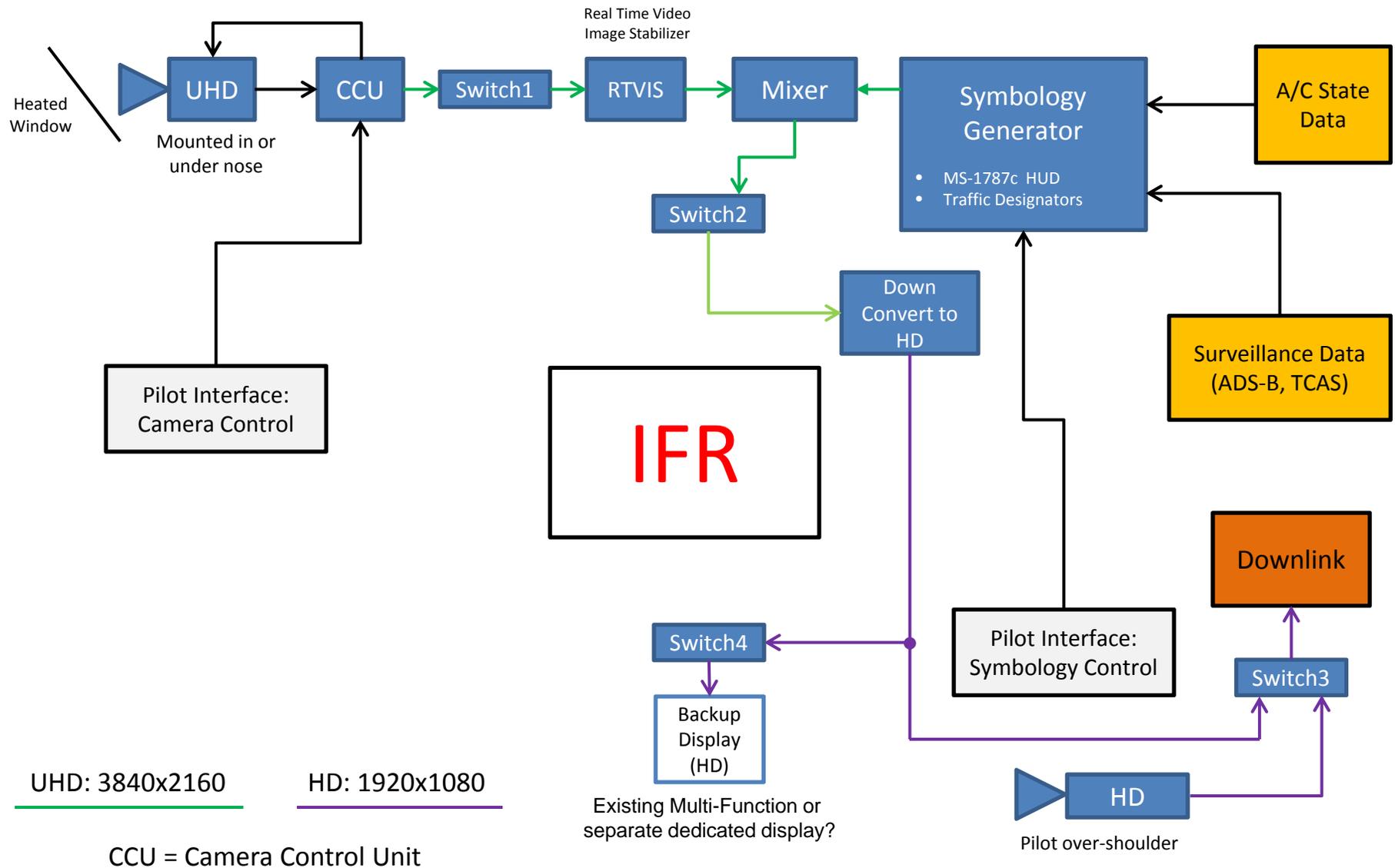
System Description: Symbol Generator Fail



System Description: All Cameras Fail



System Description: XVS Display Fail



System Description: Night Operation

