Real-Time Rate Distortion Optimization of Wireless Video with Horus

Ahmed Abdel-Hadi, Andreas Gerstlauer and Sriram Vishwanath

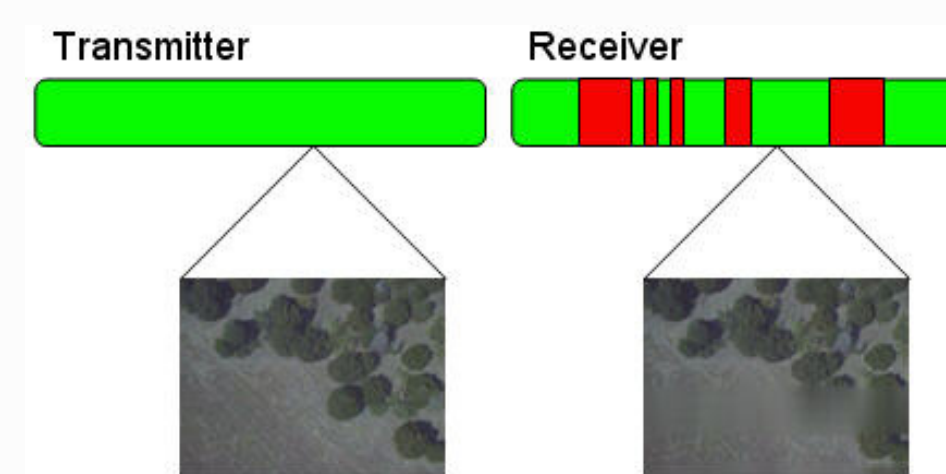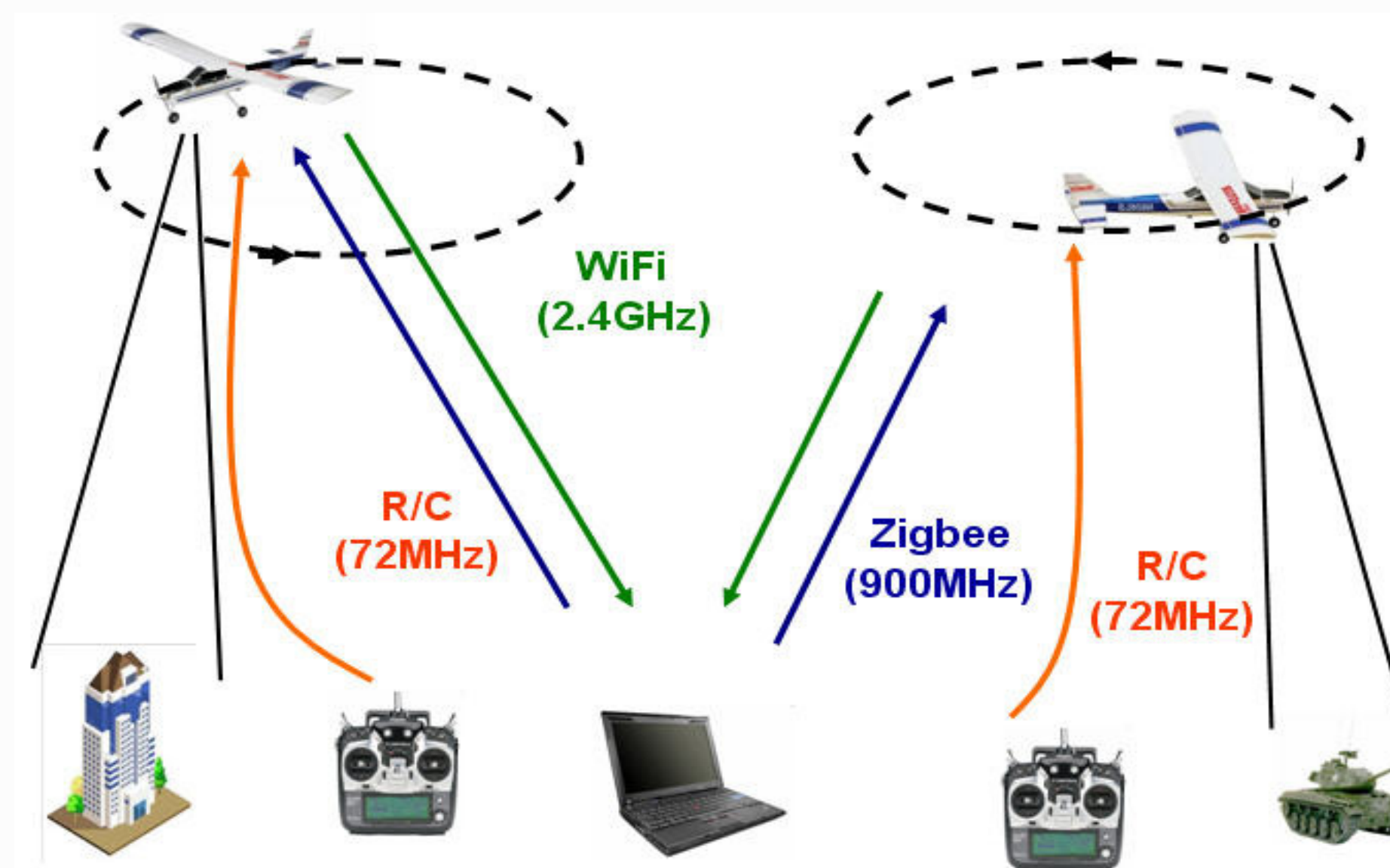Wireless Networking and Communications Group

WNCG

Real-Time Rate Distortion Optimization

- **General Overview:** Our primary goal is to transmit real-time (live) video with optimal visual video quality through the wireless network. We use Horus testbed to run our experiments.
- **Rate distortion optimization** problem aims to minimize distortion subject to rate constraints.
- **Rate** is determined by channel states using default IEEE 802.11 beacons.
- **Distortion** is a measure of the degradation in the video quality. It is measured using temporal and spatial distortion metrics.
- **Temporal distortion** metric is the ratio of the received video duration to the original video duration.
- **Spatial distortion** metric is the SSIM of sliced images from the received video w.r.t. the corresponding images sliced from original video.

- **Horus Applications:**
1) Aerial stereo photogrammetry
2) Visual target detection
3) Recording 3D live video signal

Transmitter   Receiver

Network Topologies

- **Unicast Topology**
- **Multiple Unicast Topology**
- **Multicast Topology**

UAV Path

Ground Station

Flight Path

A   B   C   D   C   B   A

Horus Testbed

WiFi
(2.4GHz)

R/C
(72MHz)

Zigbee
(900MHz)

R/C
(72MHz)

Experiments and Results

Experiment 1
1(a) all video frames
1(b) only i-frames
1(c) LCRDO-Beacon for MPEG2

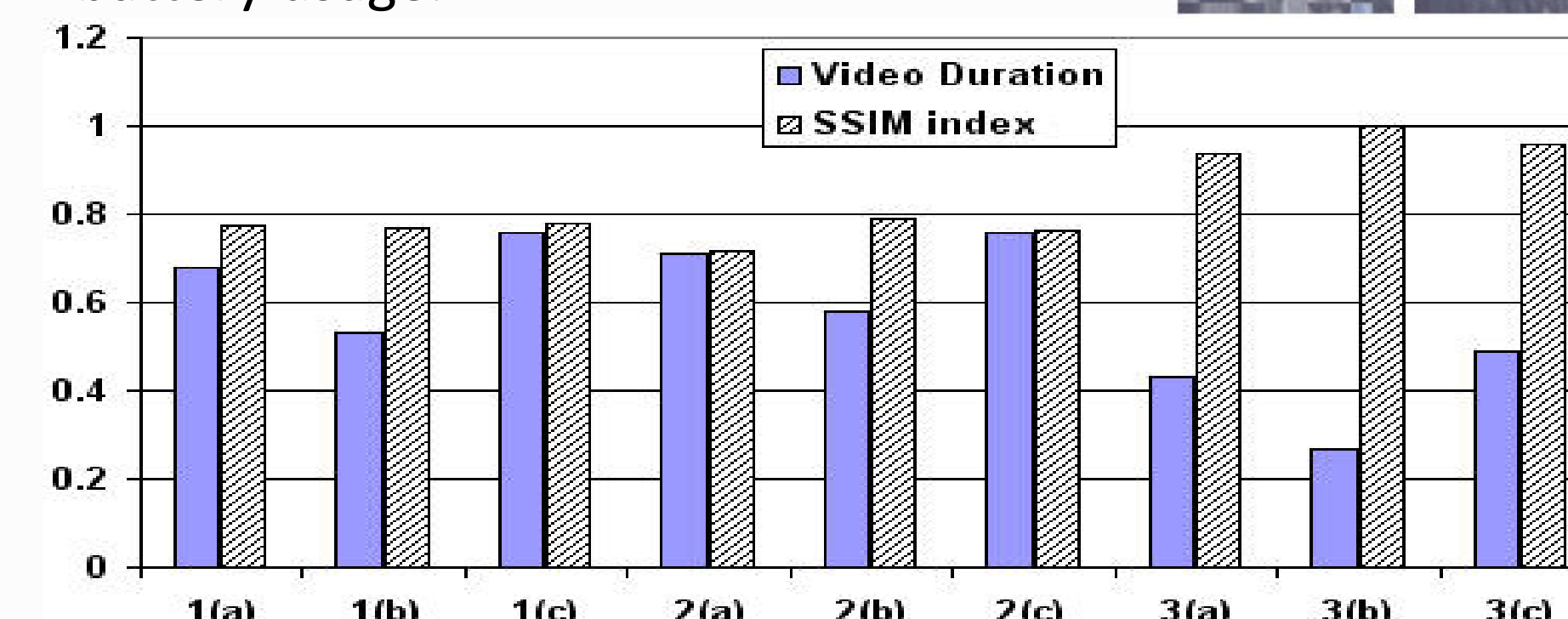**Experiment 2**
2(a) low bit-rate
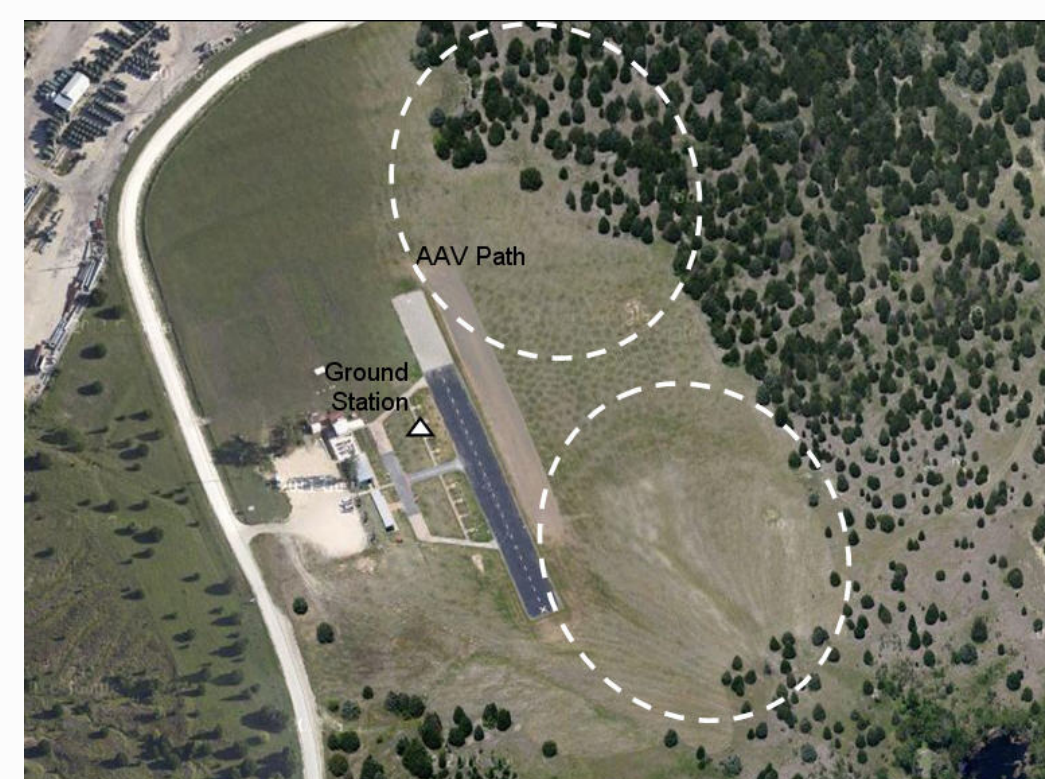2(b) high bit-rate
2(c) LCRDO-Adaptive for MPEG2

Experiment 3
3(a) low JPEG quality
3(b) high JPEG quality
3(c) LCRDO-Adaptive for MJPEG

- Temporal distortion is minimum for LCRDO algorithms.
- Spatial distortion is more dependent on the encoder compression (i.e. MPEG2 or MJPEG).
- Low complexity of LCRDO algorithms is suitable for portable devices with limited computational power and low battery usage.
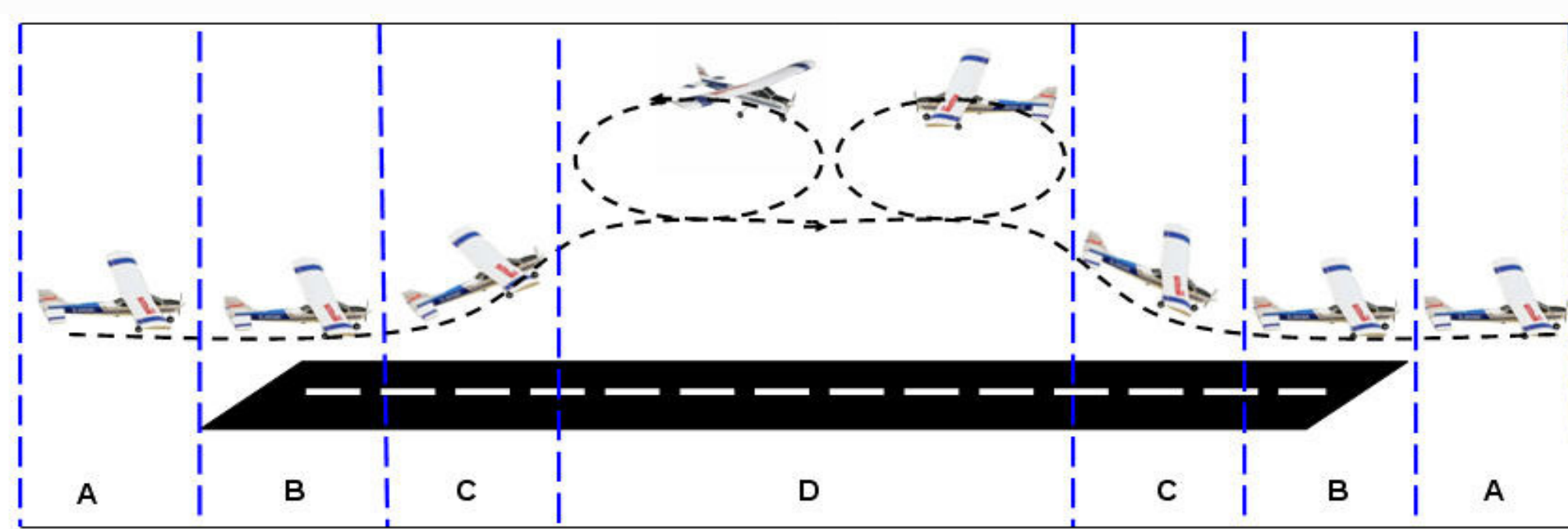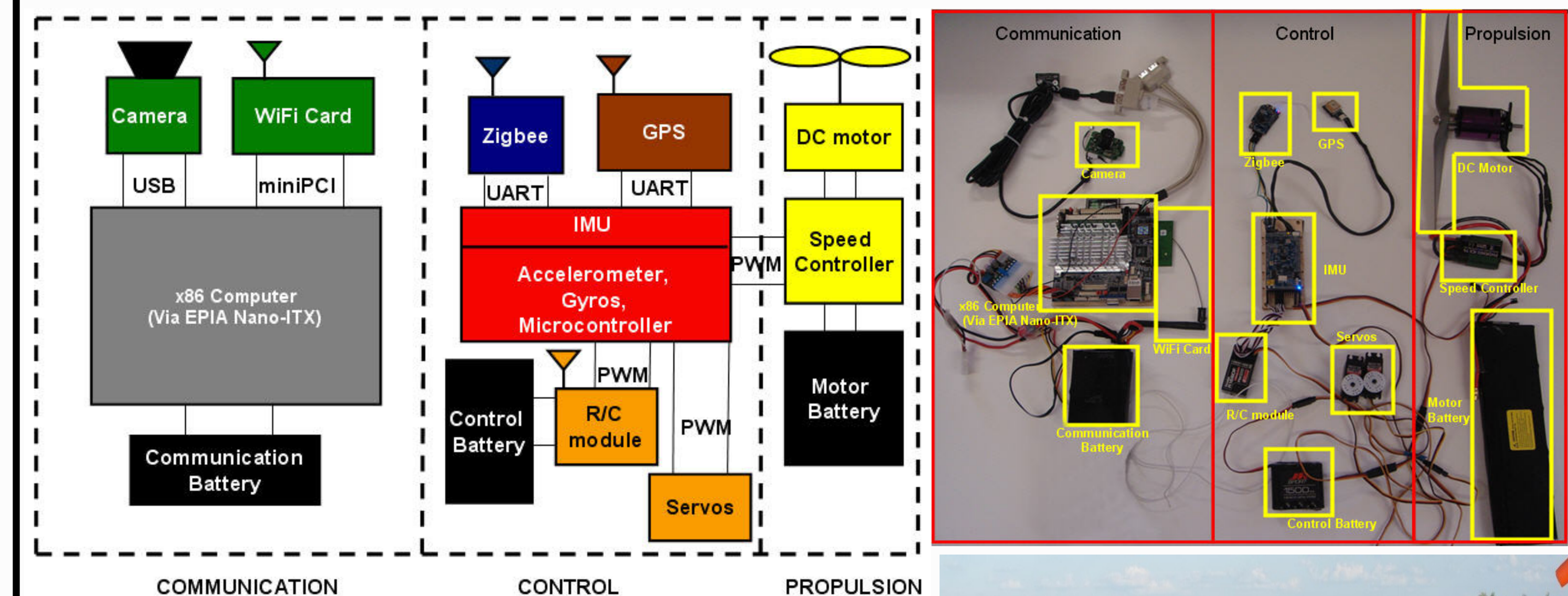
Horus Components Block Diagram & Hardware

COMMUNICATION   CONTROL   PROPULSION

Camera   WiFi Card   Zigbee   GPS   DC motor

USB   miniPCI   UART   UART

IMU

x86 Computer
(Via EPIA Nano-ITX)   Accelerometer, Gyros, Microcontroller   Speed Controller

PWM

PWM

Control Battery   R/C module   PWM   Motor Battery

Communication Battery   Servos

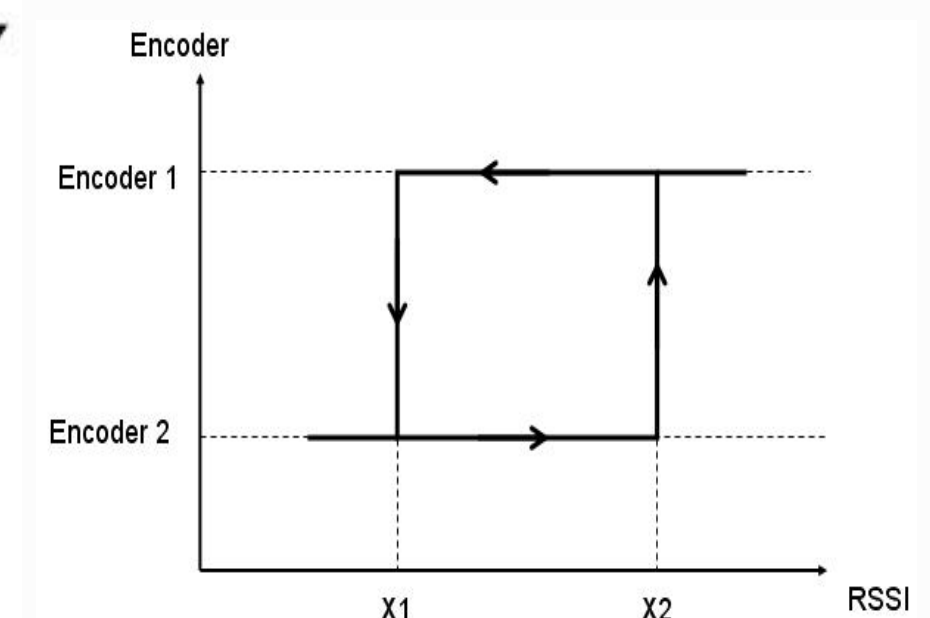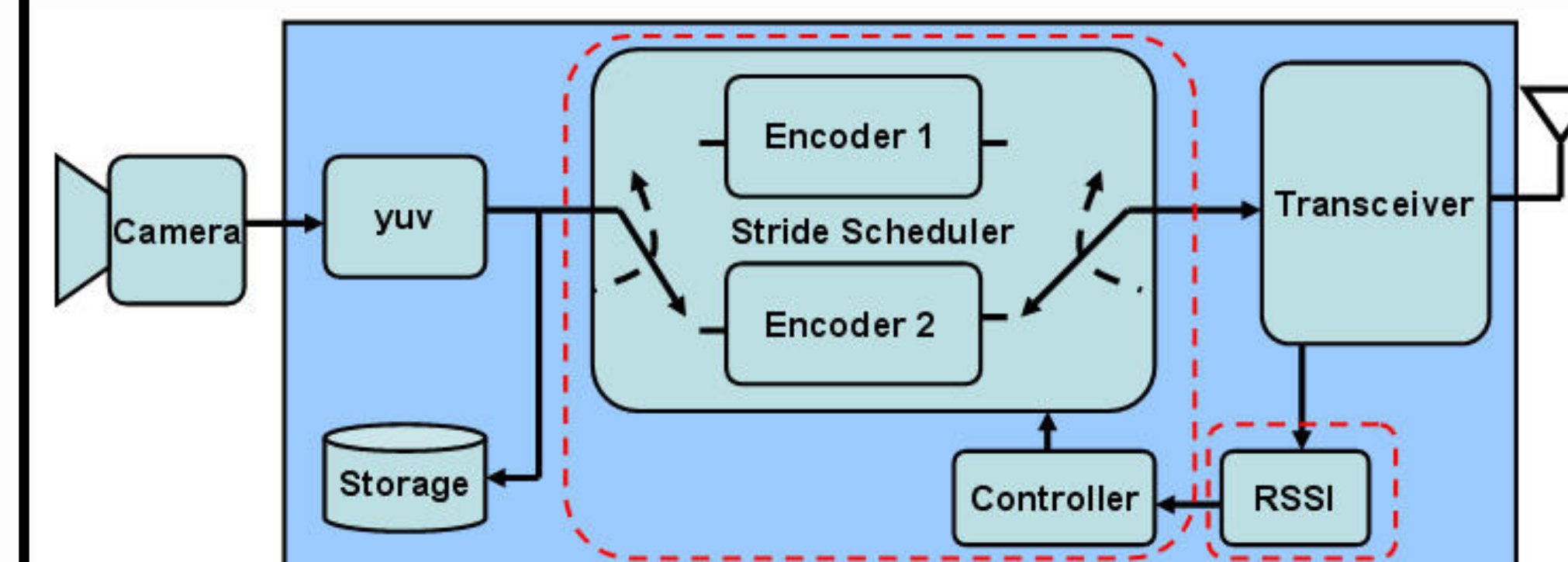Communication   Control   Propulsion

On board wireless transceivers:
- **WiFi (2.4GHz):** video transmission.
- **Zigbee (900MHz):** automatic flight control.
- **Radio(72MHz):** manual flight control.

LCRDO Algorithms

Camera   yuv   Encoder 1   Stride Scheduler   Encoder 2   Transceiver

Storage   Controller   RSSI
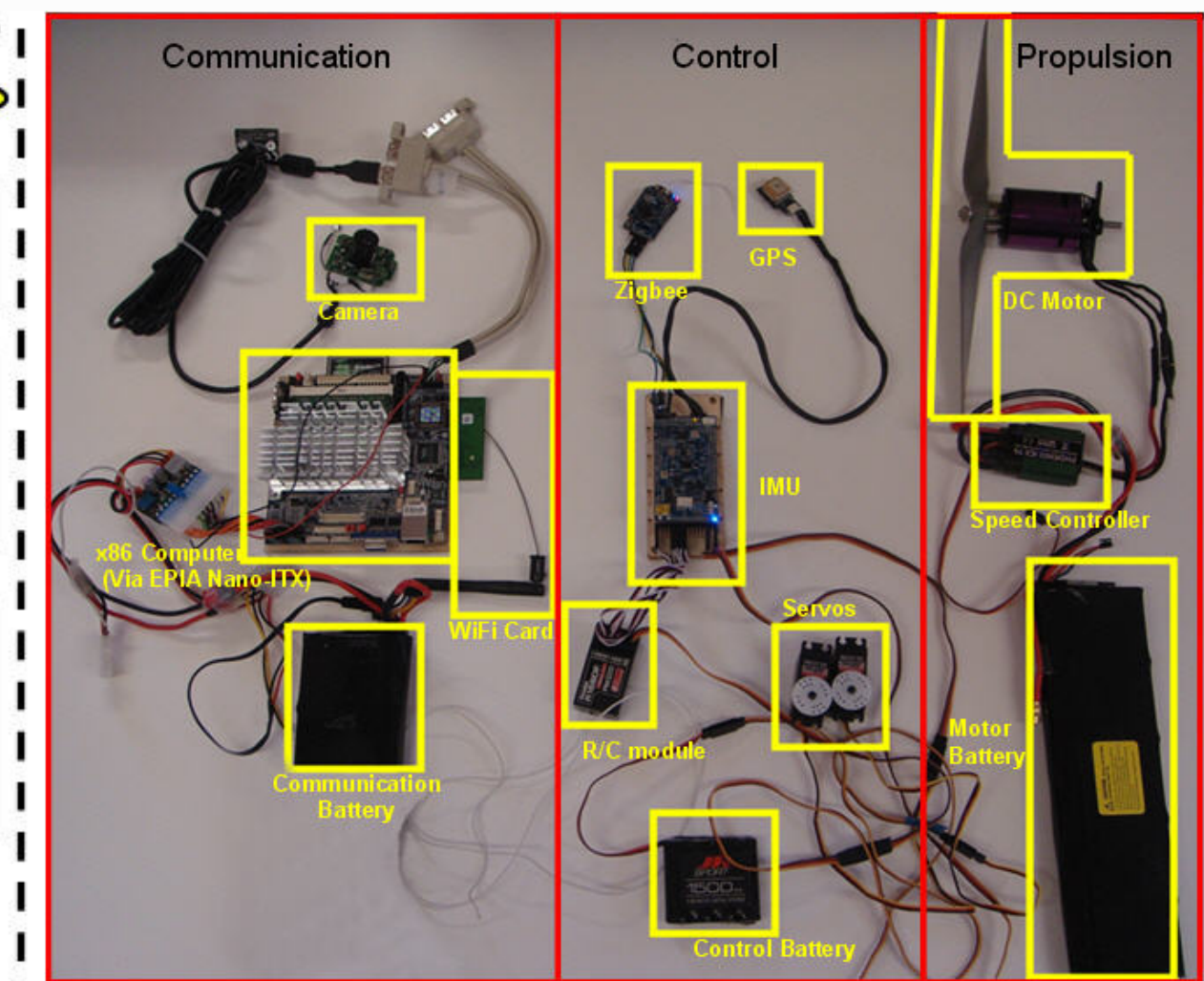
Encoder
Encoder 1
Encoder 2
X1   X2   RSSI

Low Complexity Rate Distortion Optimization (LCRDO) Algorithms main blocks:
- **Packet Estimator:** estimates channel state using IEEE 802.11 beacons.
- **Packet Selector:** Selects encoder based on feed from packet estimator and using hysteresis.

- **LCRDO-Beacon:** switches between sending all frames and only i-frames.
- **LCRDO-Adaptive:** switches between sending at low and high bit-rate.

Decoder   Display

Storage

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