Design and Prototype of Auto-Track Long-Range Free-Space Optical Communication

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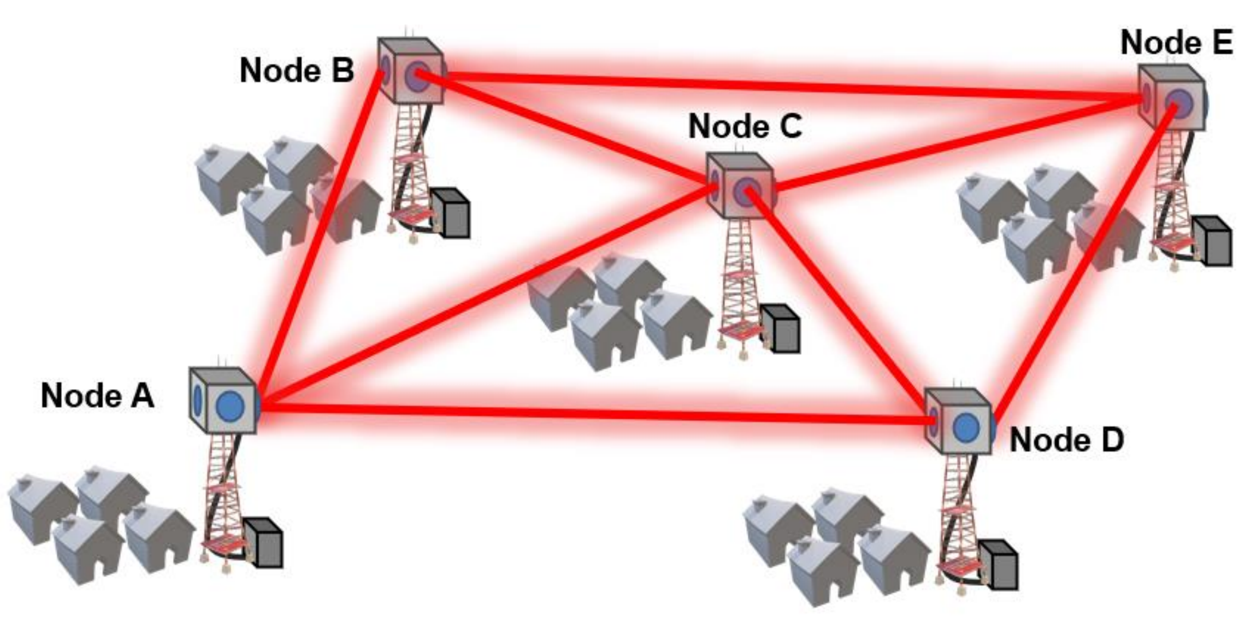
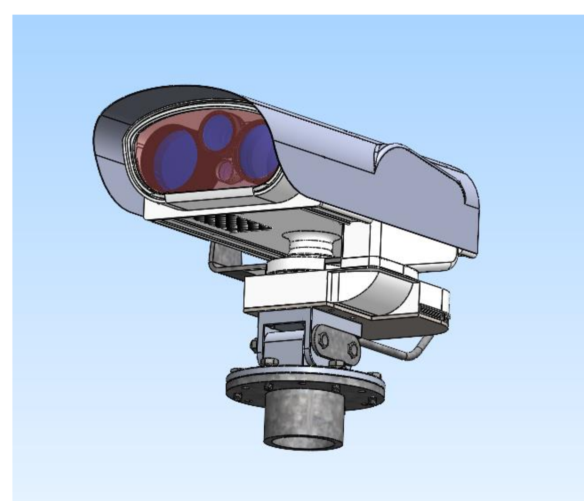
Introduction

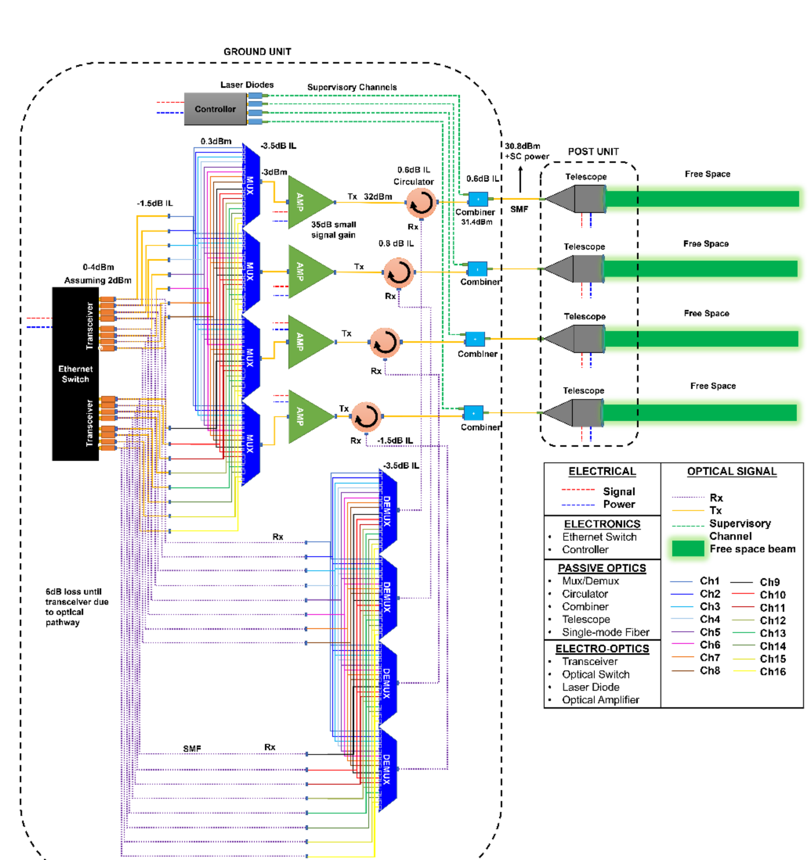


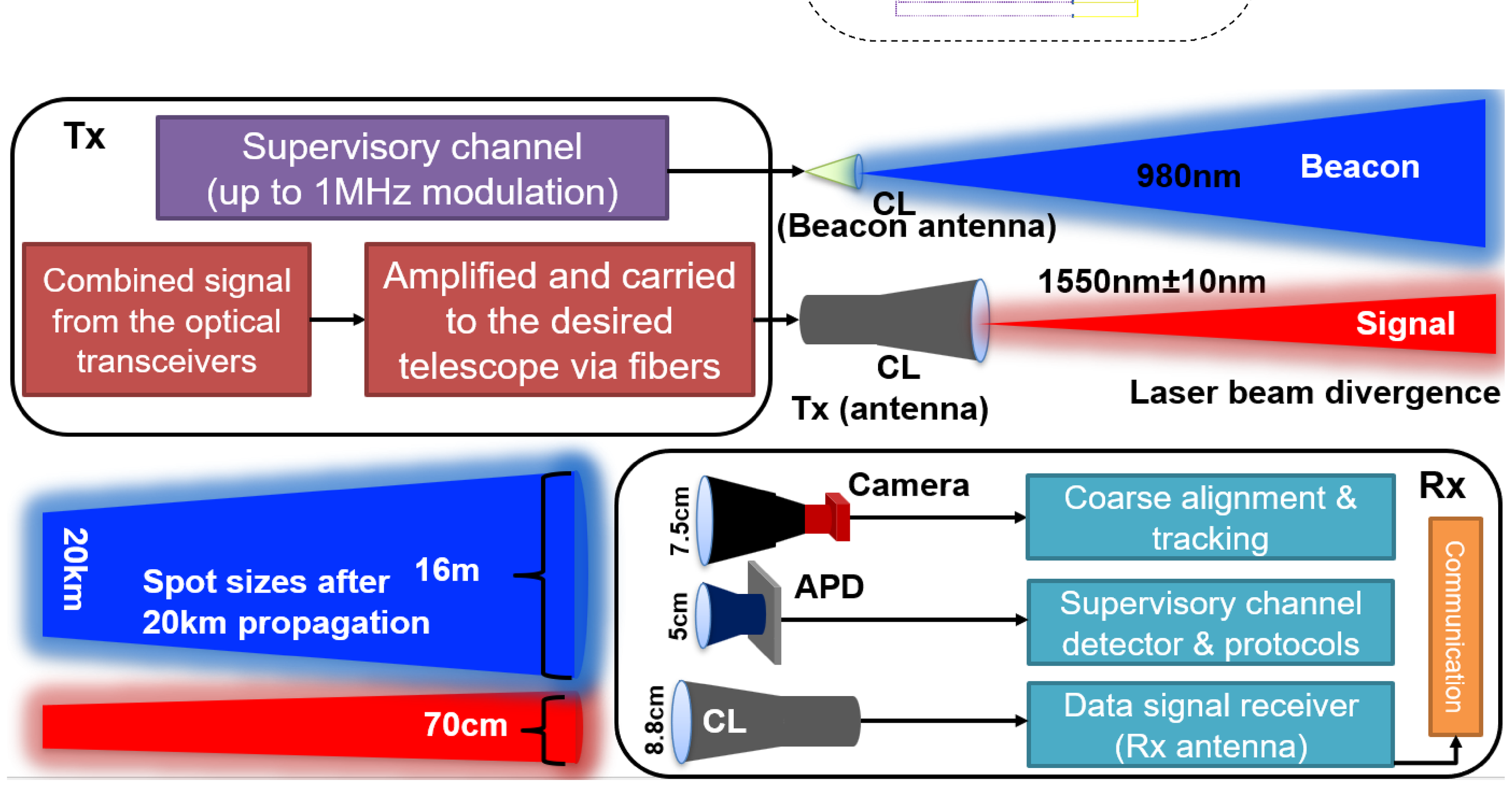


- We design an FSO communication telescope unit that operates at C-band with multiple channels in ITU grid to realize a data transfer with 100Gb/s using an optical collimator (CL) with 35µrad divergence angle for ARA Network supported by the NSF PAWR program and to be deployed in rural Iowa State.
- The link connection is established by 3 level monitoring system, an ultra fine resolution stepper motor and a custom control algorithm.
  - Coarse alignment is performed by a 980nm beacon light and Si APD followed by a lens with a field of view +/-6degrees.
  - Fine alignment is achieved by a monochromatic CMOS camera that gives +/- 1.73mdeg/pixel angle of arrival resolution.
  - Ultra-fine alignment is achieved by power monitor at the receiver.
  - Two stepper motors provide pan and tilt with 13.3µdeg per micro step resolution.
  - Automatic control system utilized the APD, camera and power monitor data to precise line of sight communications.
- Transceivers are standard SFP+ modules with 10GB/s data rates followed by wavelength multiplexers, an optical amplifier and a circulator.
- Data rates are programmable through the edge switches.

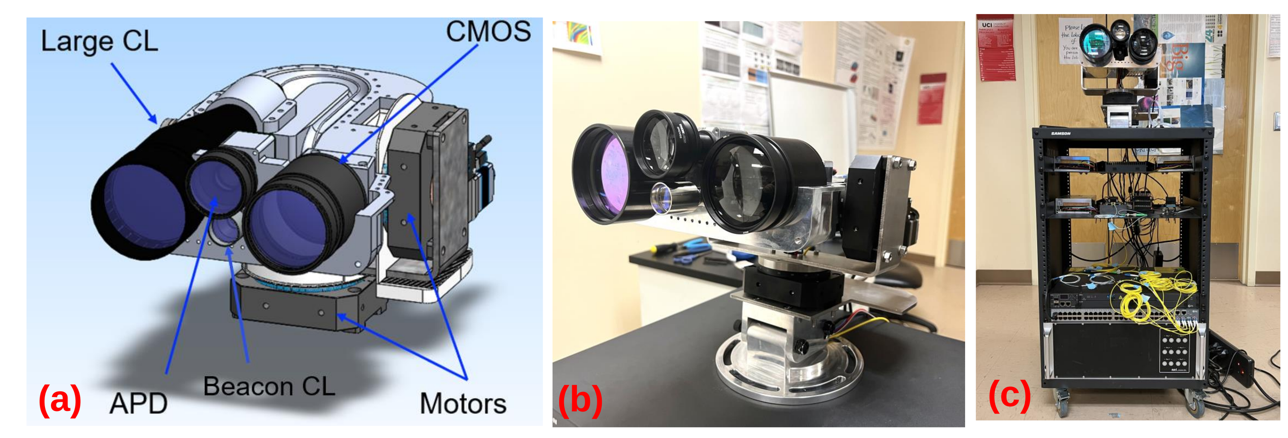
Network Architecture

- The signal branch has a CL with 88mm aperture and 35µrad beam divergence that results in a ~70cm diameter spot size at the receiver unit at 20km.
- The gain saturation of the EDFA is 33dBm. Minimum resolvable power by the transceiver is -23dBm yielding a 50dB margin for losses.





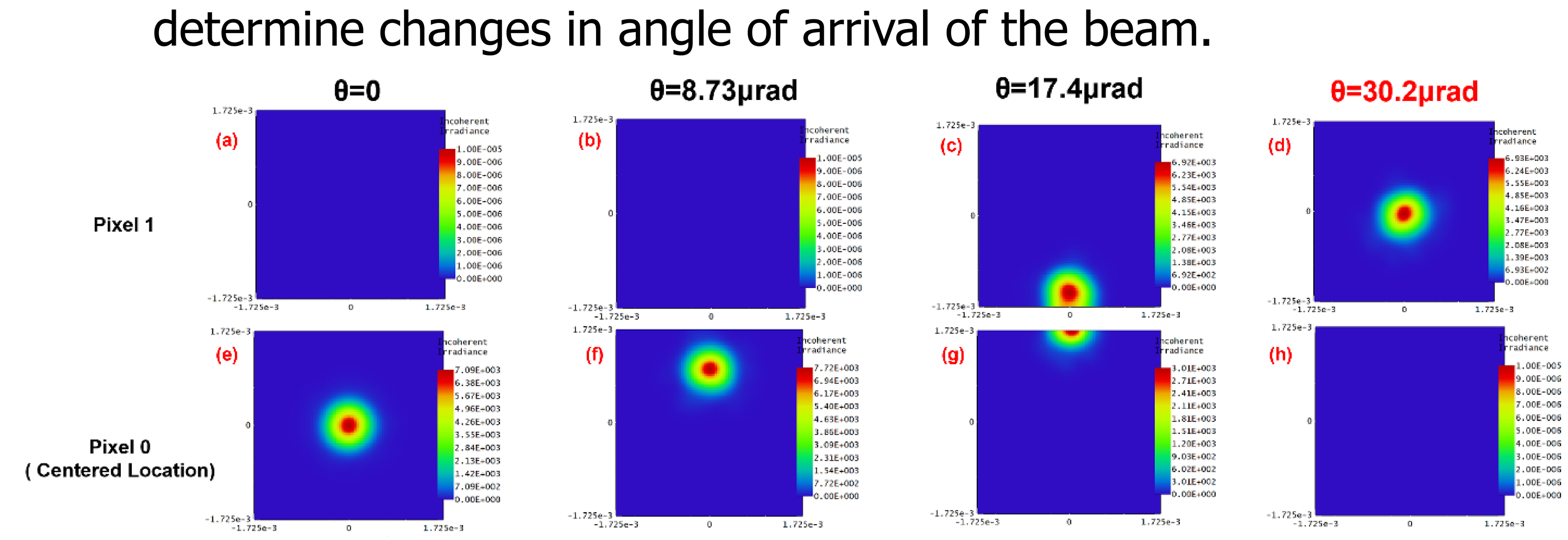
Beacon System Demonstration



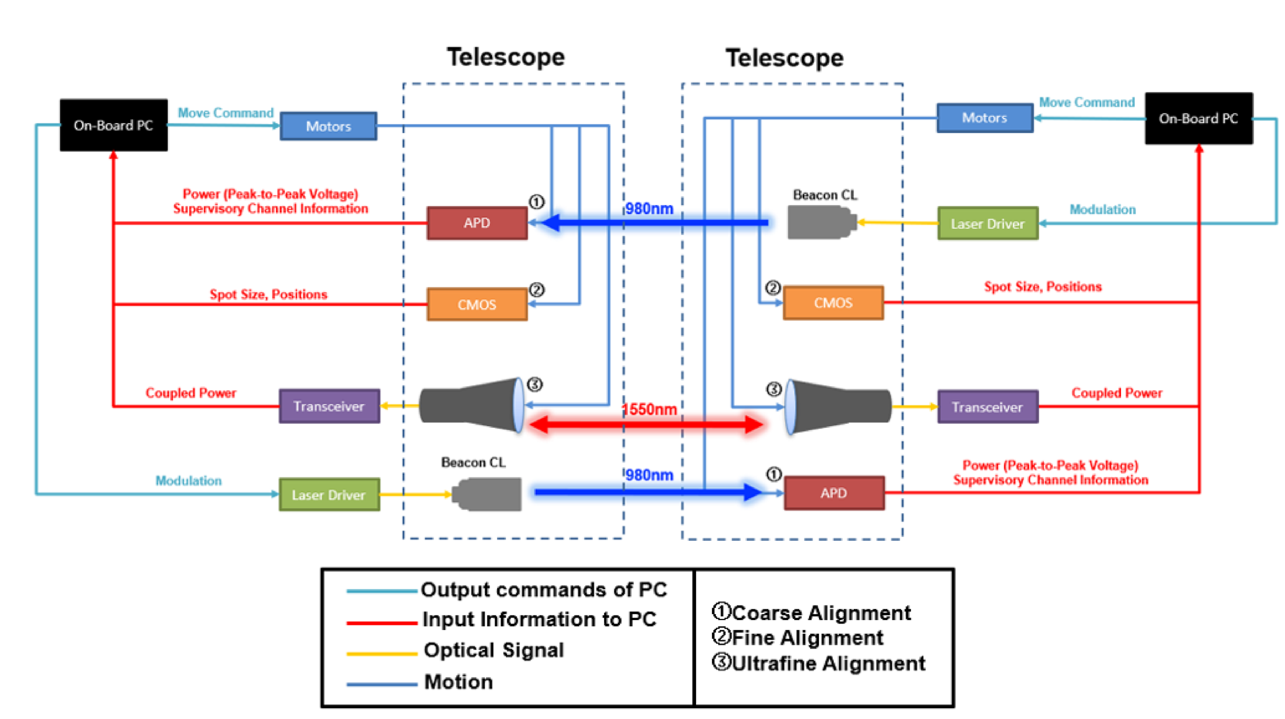
- A direct modulated 980nm beacon laser is used for system alignment and to exchange protocol commands between two nodes at <1MHz data rates.
- The beam divergence of the beacon laser is 0.8mrad to obtain a 16m diameter spot size at the receiver end.
- The coarse alignment: 100mm^2 Si free-space APD + a 50mm double-convex lens.
- The fine alignment: a 28mm^2 CMOS (3.45µm by 3.45µm pixel size) + a 75mm aspherical lens.

Fine Alignment by CMOS Camera

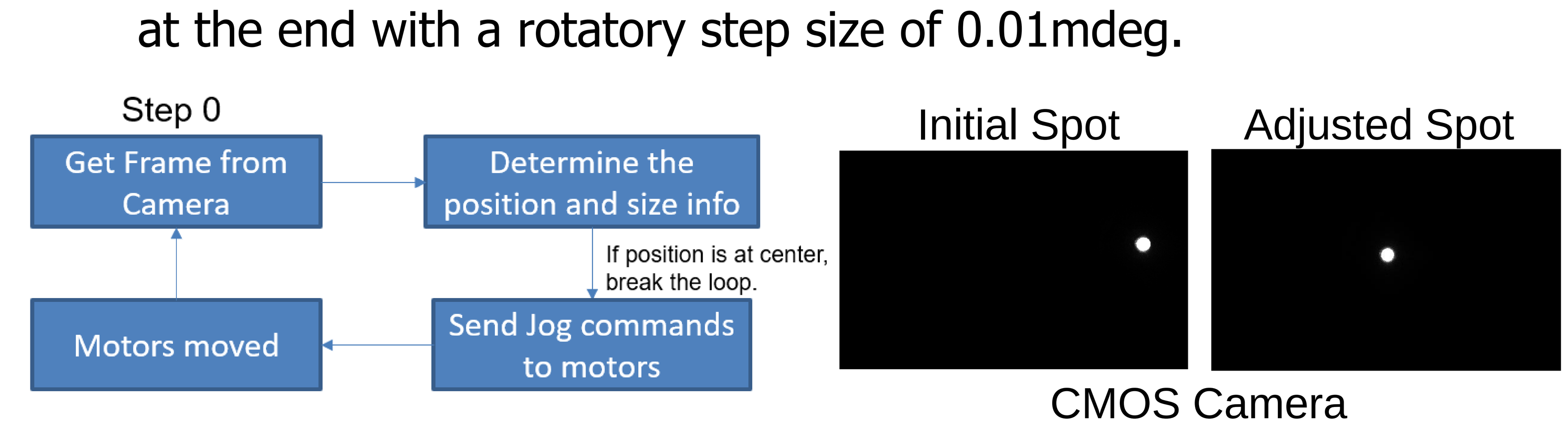
- We use CMOS camera to monitor angle of arrival.
- For 20 km distance 30.2urad change in the angle of arrival leads to one px walk off, as shown in the figure below.
- Control algorithm actively monitor the pixel variations and determine changes in angle of arrival of the beam.



Control Algorithms



- We demonstrate the feedback loop using spot size and position of the CMOS camera.
- The referred figure shows that the spot is aligned to the center at the end with a rotatory step size of 0.01mdeg.



Acknowledgements

This work was supported by the NSF under grant number PAWR-5582469.