Things to know about using fiber-optic cables to provide broadband internet connectivity:

1. While **Cable TV** and **Landline** telephone cables transmit data using electrical pulses over copper wires, fiber-optic cables transmit data using pulses of light over clear optical fiber strands. At each end of a fiber-optic connection, electrical transceivers covert pulses of light into pulses of electricity and vice versa. This allows data to be distributed to the end users via wired Ethernet connections or via Wi-Fi.
2. Traditional fiber optic connections required two fiber strands – one strand to transmit data and another to receive data. It is more common today to use single strand connections – with one wavelength (color) of light used to send data and a different wavelength of light used to receive data over the single fiber strand.
3. There are also technologies that allow a single fiber strand to transmit dozens of independent data communications by using dozens of different wavelengths of light. Those systems work by finely tuning the wavelengths of light transmitted on each "channel" and are relatively expensive. Coarse Wave Division Multiplex (CWDM) and Dense Wave Division Multiplex (DWDM) systems are primarily used for very long-distance transmissions, where it is often more cost effective to add expensive multi-channel electronics to an existing fiber strand than it is to install hundreds or thousands of miles of additional fiber cable. We will probably not be talking about CWDM or DWDM systems as part of a Champaign County Broadband solution.
4. The clear optical core of a single strand of single mode optical fiber is very thin – some 5-10 microns thick. For comparison, a typical sheet of paper is 25 microns thick, and a typical human hair is 75 microns thick.
5. The clear optical core of each strand of fiber in a "standard" fiber cable is surrounded by multiple coatings that both protect the core as well as keep the light being transmitted over multiple strands from interfering with each other. Those coatings come in 12 standard colors, which allow them to be identified.
6. In a standard fiber cable, each group of 12 strands is encased in a small tube that itself is one of those 12 colors. A fiber cable that has 144 strands, is comprised of 12 different colored tubes that each contain 12 different colored fiber strands. Larger fiber cables have additional schemes for identifying more than 12 tubes, but the colors of the strands in each tube remain those same basic 12 colors. When deploying and splicing fiber, a technician can say he is using the red strand in the yellow tube, and a second technician, possibly miles away will be able to identify the exact strand being used.
7. Fiber strands are spliced to each other with fusion splicers that align the strands to be spliced using microscope level magnification and then melt the two strands to each other, hopefully in a way the minimizes the loss of light. Even the best splicing loses some light, so the fewer splices on a long fiber run the better.
8. In main facilities, fiber strands are terminated into a patch panel that resembles an old -time telephone central office. Connections between different cables and between various equipment can be made by using fiber patch cables that fit into special plugs and can be reconfigured at will without the need for any splicing. Again, there is light loss with every patch panel connection, so keeping the ends of a patch cable clean is important.

Things to know about designing fiber networks

9. Broadband service over fiber is not like water or electricity service. Just because there is a live fiber cable in your front yard, unless somebody has planned to provide service to you over that cable and built the supporting infrastructure accordingly, it is unlikely that you can just “tap” into that cable to get broadband access.
10. You can put a simple T-connector on a water line to provide water to an additional location that an initial design did not anticipate. You can also easily splice an additional AC power outlet into an existing electrical line with minimal equipment or planning. If you think you may want to use a fiber cable to someday serve 32 customers along its path, you need to plan for the fiber strands, manholes, splice cases and slack loops for that purpose well before anything gets built. If there is any possibility that the number of possible customers along that path may grow, you also need to allocate extra strands and infrastructure to support that future growth.
11. A fiber broadband connection is typically a point-to-point connection. There needs to be electronics at one end of the fiber strand at the network core that are dedicated to a specific end user, and the end user needs to have complimentary electronics at the other end of the fiber strand to “talk” to the core electronics.
12. There is a fiber technology that allows the simple and easy addition of future customers over existing strands of fiber. Passive Optical Networking (PON) uses a prism-like splitter to divide the signal coming over a single fiber strand into as many as 64 customer locations. The beauty of PON technology is that there is no need for any powered devices anywhere on the network – other than at the network core and at a customer site, which could be as much as 25-30 miles from the core.
13. The current incarnation of PON technology is called GPON for Gigabit PON. A single Gigabit capable connection is typically shared with up to 32 possible locations, but rarely do all 32 locations become customers. Fiber-based broadband service providers are usually happy if they have 12-16 active customers connected to a 32-port splitter. In the design phase they need to allow for a PON port for every possible customer as well as some ports for unknown future growth. Today, having 16 or fewer customers share a 1 Gigabit core connection usually provides a satisfactory experience for all users.
14. There are also 10G PON and 40G PON systems on the market and will become more widespread soon. For now, they are relatively expensive, but the prices may come down by the time Champaign County looks to deliver PON-based services. As the demands for bandwidth increase in future decades and the bandwidth that PON can deliver increases, only the electronics will need to be updated. All the fiber cables, conduits, manholes and PON splitters remain the same if the PON network is migrated to 10, 40 or even 100 Gigabits. The goal is to only bury backbone fiber cables once, and PON technology allows for future upgrades without future construction.
15. As the ARPA funding is perhaps a once in a lifetime opportunity for the County, it would make sense to build a fiber backbone as future-proof as we know how to and can afford. There are several ways to future-proof a fiber plant.

16. The traditional way is to install a very large fiber cable. A 288-strand fiber cable is just a little larger than a 144-strand fiber cable, but it still fits in a "standard" 2-inch conduit. It is also a more expensive than a 144-strand cable, but certainly not twice as expensive. The labor and materials to install the conduit would be the same for either.
17. Where the costs do significantly rise with a larger count fiber cable is for the splice cases and the manholes to hold the larger splice cases. At every location where a fiber strand on a ring cable needs to be used, there needs to be a splice case and a manhole to store that splice case. Just to build a 210-mile fiber backbone in Champaign County could require more than a thousand manholes and hundreds of splice cases.
18. There will also be locations where one 2–3-mile section of fiber cable needs to be butt-spliced to another. With proper planning and engineering, those cable splice points can be located where a fiber access splice needs to be located anyway. The detailed fiber engineering is an important and significant cost in deploying a fiber network.
19. There is also a newer fiber technology called micro duct, where a single fiber duct is pre-divided into 7-12 smaller ducts, which allow specialized fiber cables to be pulled into one of the micro-ducts with no impact on any existing fiber cables in other micro-ducts. It is often very difficult, if not impossible, to pull a second fiber cable into a standard duct that already has another cable in it – especially over long distances and even if in theory there is enough room for the second fiber cable. Micro ducts solve that problem.
20. Fiber cables designed for micro-ducts have far less protective coating on the strands and the outside of the cables. That allows them to have a far smaller diameter and fit in the micro duct.
21. When designing for micro duct, several of the available micro ducts can be utilized to meet today's needs, while the remainder can be used in the future for whatever reason more fiber strands are needed. Extra manholes with slack loops need to be designed into the system for potentially splicing those future cables, but a well-designed system should have a lot of slack loops anyway to deal with possible repairs. Our consultant will provide a more thorough discussion of micro-ducts and the tradeoffs of deploying them.
22. The bottom line is that we don't know what we don't know about the future broadband and telecommunications needs of any specific area of Champaign County. The wisest use of our limited resources will build a fiber system that allows for growth, but one that does not allocate too much money for unknown future growth. This project will probably happen in stages over many years. If we build a good foundation with a backbone network now, the next stage will be easier and less expensive to deploy, making it more likely to happen.