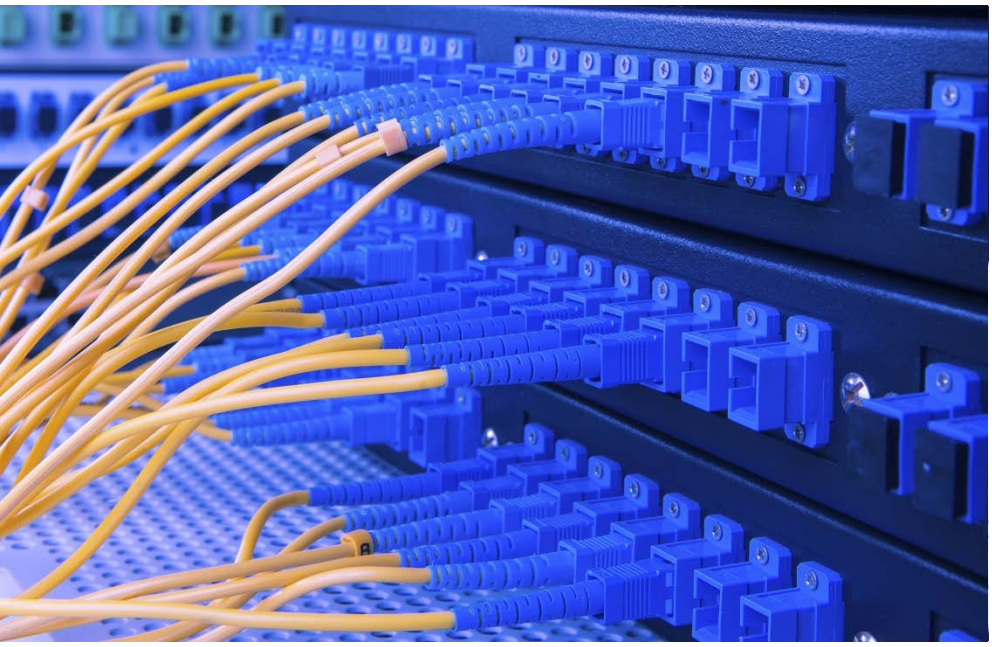
CHR Solutions



Engineering Consulting Services Guide ~ 2017

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Engineering Services

Are you looking for a company that will provide you with more than just a short-term solution? CHR collaborates with our clients to provide long-term solutions and will partner with you every step of the way. CHR is ideally positioned to help you with all of your network design and build needs. Our engineers and consultants have the technical knowledge and industry expertise to help you minimize risk, manage technology implementation and determine the most cost effective approach delivering a solid Return on Investment to you and your shareholders.

Knowledge and expertise of Current and Emerging Technologies is our business. Our experienced engineering staff explores with your team how applying current and emerging technologies can help replace revenues that are eroding under pressure from competition and line loss. CHR understands that traditional telecommunications goes beyond simply providing Voice, Data and Video Services.

The integration of networks with people and machines is producing ever-evolving applications and devices. The Internet of Things has the possibility to be the most disruptive as well as provide the most opportunity over the next few years, and the telecommunications network will tie all these pieces together. Let CHR assist with your long-term integrated network planning to connect to all of the available devices, applications and content to provide a quality customer experience by connecting the customer where they live.

CHR's innovative Engineering Design price models demonstrate a competitive advantage, offering flexible Outside Plant and FTTx Design pricing. CHR provides both Time and Expense and Unit-based pricing options removing the guesswork from engineering costs. Depending on scope, unit prices may be defined by the passing, foot or pole. As a result, each unit has a fixed price ensuring you are paying for production not just time. CHR's Scope of Work defines these fixed-price units for easy customer reference.

Whether you are building for the future or implementing new services, with CHR you benefit from our expertise and careful planning. CHR can help you deliver broadband services through the "**Planning**", "**Designing**" and "**Building**" of fiber and other network initiatives that will allow you to gain new customers and add additional revenue through a variety of broadband applications.

At CHR, our experience is your advantage.

Professional Engineering, Field Services & Technology Expertise

CHR is experienced in applying current and emerging technologies to replace revenues that are eroding under pressure from competition. Our engineers are continually researching new and emerging technologies to ensure our clients have the information required to make informed decisions. CHR will help you leverage and improve your existing infrastructure to support new services and sources of revenue.

Professional Engineering and Field Services

- Network Planning & Design
- PE certifications in most states
- Plans & Specifications Preparation
- Complete Project Management
- Outside Plant Engineering
- Grounding Audits
- CAD/GIS Services
- RUS/Co-Bank Loans and Grant Applications
- Wireless Engineering
- Construction Management
- Network Evolution Plans & ETC Filing (FCC form 481)

FTTx

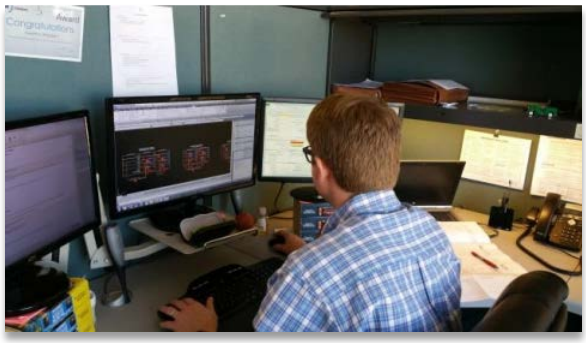
- Active Ethernet
- GPON and RFOG
- Aerial and Buried
- Splitter Placement
- Service Integration
- Copper Migration
- Product Recommendations
- OSP Layout and Design
- OSP Staking Services
- OSP Inspection Services
- Residential & Commercial (including multi-dwelling) design and deployment

Data and Voice

- Transport Networks and DWDM
- TDM to IP Migration
- Network Design and Implementation
- Network Integration
- MPLS, VPLS and VLANs
- Carrier Grade Softswitch Migration
- Voice over IP (VoIP)

Network Evolution Planning

A Service Provider's infrastructure and systems must have the flexibility and agility to support future subscriber needs and planned services. Our engineering experts spend time with your team building a five-year strategic plan, resulting in a written document outlining a proactive strategy for network design, a schedule for amending the plan over time and a list of solutions capable of kick starting and supporting the five-year plan.



Approach

Using a **services first** approach, CHR defines which network elements, systems, processes and data models are necessary to fulfill future service needs. In this deep-dive phase, CHR team considers all aspects of infrastructure including:

- Inter-carrier Exchange Networks
- PSTN Networks and the migration to an all IP Network
- Voice Switching (TDM and VoIP) and Transport Systems
- Access Networks: Fiber-to-the-Home, Fiber-in-the-Loop, Hybrid Fiber
- Wireless as a complementary service or to extend reach

Broadband Baseline and Bandwidth Planning

CHR, in conjunction with the client company, determines the broadband baseline capabilities for all exchanges and develops a "bandwidth timeline" based on minimum bandwidth requirements for towns, rural and special case areas over a 5-year time period. Bandwidth predictions, both upstream and downstream, are based on services such as tiers of broadband, Over the Top applications, IPTV, Smart Home or other services in your product portfolio.

Analysis

Proactive analysis of all components of the inter/intra-service provider environment helps to reduce surprises and the costs associated with them, resulting in:

- Efficient maintenance operations
- Eliminating unexpected budget spikes
- Improved management of customer expenditure dollars
- Predictions of future capital requirements for better budget planning
- Anticipation of emergency situations that could potentially impact customer experience

Network Evolution Planning

Network Evolution Planning provides you with a clear strategy for going from where you are today to where you want to be in the future. The Network Evolution Plan may consider the following technologies to deliver broadband depending on the bandwidth desired, risk sensitivity, customer demand, density, topology and cost per subscriber:

- Wi-Fi/Wi-Max/4G LTE
- EPON/GPON
- Active Ethernet
- Bonded/Vector xDSL

CHR's Network Evolution Plan deliverable is a strategic planning tool used to define the services you want while managing the cost to deliver those services.

Support

Once the five-year plan is in place, CHR's Network Planning Service team works to establish a schedule for revalidating assumptions according to scheduled events, such as annual planning meetings, or changes in business or market goals.

ETC Filing (FCC form 481)

CHR works with our partners to offer a comprehensive Engineering & Financial FCC Form 481 annual report filing service based on the Network Evolution Plan. FCC Form 481 is a mandatory filing for ETCs (Eligible Telecommunication Carriers) that receive high-cost support from the government.

CHR leverages our regulatory partners to handle all aspects of your initial ETC filing or annual progress report to the FCC. We can also customize this service to your individual requirements by performing just the engineering. Let us know what you need.

Outside Plant Engineering and Field Services

CHR provides comprehensive Outside Plant (OSP) engineering services. CHR can lead you through a step-by-step process, from the initial Outside Plant design to staking, public ROW procurement, contract and construction management, turn-up, testing and final acceptance. CHR's extensive experience in utility construction influences designs resulting in an end product that "builds easier" thus keeping overall cost down. CHR is dedicated to deliver a seamless, digital "paperless" OSP engineering process creating a more efficient implementation. Whether you are seeking engineering engagement for a small project or a large turn-key engineering project, CHR is dedicated to your success by delivering accurate, timely, and cost effective OSP engineering services.

Outside Plant Design

CHR evaluates your existing plant and makes recommendations on the latest technology.

- FTTH Active Ethernet Designs – P2P
- FTTP PON Designs (GPON/NGPON) – P2MP
- FTTN (CSA xDSL)Designs
- Centralized or Distributed Fiber Network Architectures
- Detailed Cost Analysis Between Design Alternatives
- Detailed Buried, Underground, and Aerial Infrastructure Designs
- Digitized "Paperless" Design Process, Utilizing GIS Land Base, GIS/GPS Tools

CHR's OSP Design Standards document Client-specific designs in order to ensure design and cost decisions are followed from the initial design through implementation phases.

Field Staking

We will stake the project area and create detailed plans and specifications using state of the art computer technology and graphics.

- CHR Engineers are familiar and proficient with several third party digital staking solutions
- Detailed Buried, Underground and Aerial Staking and Cable Mapping
- Use of USDA Rural Utilities Service (RUS), CHR and/or Service Provider Recommended Construction Specifications, and Standards
- Digitized "Paperless" Field Staking Services used with the Development of GIS Land Base and GPS Assisted Field Staking Systems

Public Right of Way (ROW) Acquisition and Environmental Analysis

CHR will work with you to secure the rights-of-way and verify the easement requirements for the entire project.

- State, County, and Railroad ROW Permitting
- Public Permitting Management (through Construction to Completion)
- Cultural Resources Study and Approval
- Natural Resource Management and Approval
- Stormwater Pollution Prevention Plans (SWPPP)

OSP Contract/Plans and Specifications

CHR will manage the bid process by evaluating the bids, checking the references and performance bonds of the responders and providing recommendations for the acceptance of the bid.

- RUS 515 and/or CHR 515 OSP Contracts
- Detailed Construction Plans and Specifications
- Contract Administration and Management Services
- Detailed Standards References (RUS, NEC, NESC, Federal, State and Local)
- Detailed Construction Guide Drawings, Fiber Assignment Schematics, Construction Sheets
- Management of the Competitive Bid Process, Bid Analysis & Recommendation After Bid Award

Construction and Site Management

CHR provides construction coordination, planning and monitoring of progress. Construction Inspection can be provided for assurance of construction quality.

- Resident Engineers and Inspectors with Extensive Construction Knowledge and Experience
- Standardized Construction Management and Documentation Processes and Procedures
- Software Based Construction Unit “As-Built” Inventory Process and Digitized As-Built Maps
- Dedicated Contract Administration Staff Assigned to a Project throughout the Implementation, including Monthly Invoice Reconciliation and Contract Budget Tracking
- Final As-Built Inventory, Reconciliation and Contract Closeout Services

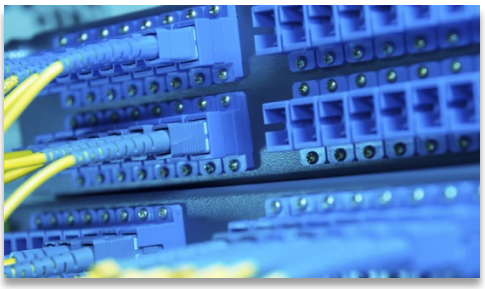
Final Acceptance Testing

CHR will thoroughly review the contractor’s detailed copper and fiber testing results and perform our own complete acceptance testing. We will complete the final inspection at every location to ensure the project equipment is professionally and correctly installed.

- Fiber Cable Continuity Testing – Verification of Fiber Assignments, continuity by Light Source/Power Meter; OTDR Test Results review/analysis
- Copper Cable – “Megger” Testing, Continuity, pair assignment verification
- Cable location – Ability to conduct “Spot Checks” as requested, for random verification of cable depth for Adherence to Contract Specifications

Fiber to the Home and Business

Implementation of the right FTTx architecture ensures you will have enough bandwidth for your residential and business customers in the future, eliminating the need to rebuild your distribution network. Solutions range from Passive Optical Networks (PONs), Active Ethernet and Metro Ethernet networks, to a hybrid network, in order to support 100Mbps, 1Gbps or higher.



Fiber to the Premise (Home and Business)

CHR engineers are experts in deploying FTTx, including Active Ethernet and Passive Optical Network (PON) designs, Radio Frequency (RF) over Glass, and outside plant construction implementation. In planning and designing a successful Fiber-to-the-Business (FTTB) or Fiber-to-the-Home (FTTH) deployment, integration success depends on the quality of the engineering process. CHR begins with a thorough understanding of the client's requirements and an assessment of the project scope to identify critical information necessary for high-quality engineering results.

CHR's design team is recognized as industry experts in providing engineering services. With extensive experience in design and detail engineering for OSP and FTTx networks.

Our service provider clients' benefit from CHR's FTTx and OSP network knowledge, and the understanding of multiple FTTx active and passive component vendors' equipment. CHR engineers collaborate with clients to outline the project scope and design requirements, resulting in a comprehensive integrated solution that reduces risks and delivers exceptional results.

Design Engineering

CHR FTTx design engineering services provide practical designs for FTTx networks and infrastructure featuring multi-vendor, multi-technology solutions. With extensive FTTx, OSP and Central Office experience, CHR delivers superior engineering designs.

CHR Design Engineers provide:

- FTTx Design Assumptions
- FTTx Migration Development
- Plans for FTTx Network Growth
- FTTx Capacity Planning Designs
- RFP Management for Electronics Vendor Selection
- Fiber Efficiency
- CO Infrastructure Designs
- OSP and Passive Optical Network Design
- Inside Plant Fiber Distribution Frame Planning

Detail Engineering

CHR's experienced detail engineers can provide drawings for customer records and specifications for installation teams. CHR Detail Engineers deliver:

- Site Surveys
- Installation Specifications
- Floor Plans and Equipment Drawings
- Assignment Records and Database Updates

Equipment and Optical Design

The CHR Equipment Engineering Design Team will conduct a detailed analysis of the existing network and create a cost effective design based on requirements and future needs with consideration for all network components, including Outside Plant and Central Office Facilities for FTTx applications and services.

Equipment Recommendation and Contract/Plans and Specifications

CHR consultants are knowledgeable on many platforms and have cultivated relationships with key product vendors who supply routing, switching, access, transport, wireless and other equipment to the service provider market segment. Whether you just need an expert recommendation for the right gear, based on an expert analysis of your requirements, or assistance with procurement, CHR delivers.

CHR can assist you with Equipment Contracts and Plans & Specifications and will manage the bid process by evaluating the bids, checking the references and performance bonds of the responders, technical reviews and providing recommendations for the acceptance of the bid.

- Detailed Plans and Specifications
- Contract Administration and Management Services
- Management of the Competitive Bid Process, Bid Analysis, and Recommendation

FTTx and OSP Design

The CHR Engineering Design Team will conduct a detailed analysis of the existing network and create a cost effective design based on requirements and future needs with consideration for all network components, including Outside Plant and Central Office Facilities for FTTx applications and services. Alternate plans will also be studied and cost analysis performed to determine the most prudent course of action.

The OSP Design group is involved with fiber-optic cable systems in FTTx (Active Ethernet and PON) designs for direct buried, aerial and duct bank installation. Services include:

- OSP Review for Optimum Utilization of Existing Infrastructure Plant
- Area Coverage Survey (ACS) Maps Detailing the Location of all service locations (residential, business, future growth), potential Fiber Distribution Cabinets, Access Terminals

- OSP Designs for Centralized and Distributed fiber distribution Models
- Cable Schematics with Cabinet Placement and Access Terminal Designs
- Mapping and Design for Primary Feeder and Secondary Distribution Cable Plant
- Test Inspections to Verify Compliance with FTTx PON Specifications and Architectural Design Components

Field Verification

The CHR Engineering Design Team can conduct an Area Coverage Survey (ACS) to locate existing establishments and potential growth areas on existing and new Map/Plat systems. Field Verifications of existing plant and subscribers for new FTTx systems can also be performed.

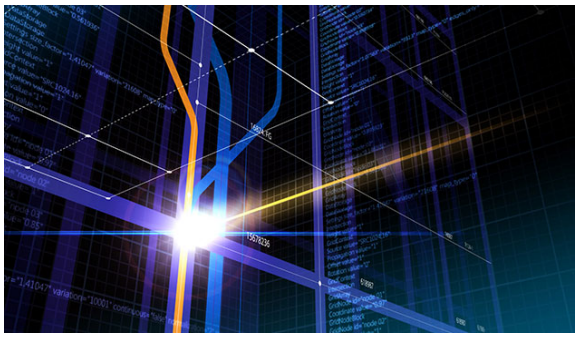
Staking and Permitting

CHR Engineering Design Team provides clients exact Construction Drawings for Aerial, Buried and Underground facilities, compliant with National Electric Safety Code (NESC) and local building and electrical requirements. Based upon the FTTx Design, the CHR Engineering Design Team performs permitting for all state, local and federal authorities.

Construction Monitoring/Quality Control

The CHR Engineering Design Team provides construction coordination, planning and monitoring of progress. Construction Inspection can be provided for assurance of construction quality. Post Construction services includes acceptance testing of all cables, cabinets, and access points, along with an inventory of facilities placed to verify contractor billing and assure accurate property records. Acceptance testing includes certification of all plant and hardware associated with the FTTx design.

GIS/CAD Services



Accurate and up-to-date mapping is crucial to nearly every element of your business. Everything from network maintenance, emergency response, budget forecasting and company valuation require these records be accurate in order to keep your company on course.

Relying on single point dependencies and perishable paper records creates vulnerabilities for your customer, community and company. CHR' GIS/CAD Services take the guess work out of geospatial management and ensure your business is on the right path.

No matter what format or condition your maps are currently in, from paper to newer electronic formats, CHR's GIS/CAD team can update into the latest standard format and make sure they match your plant. We also offer an option for turnkey management of all plant and operational CAD records in our cloud based system. Our technical resources, proven processes and systems help assure business continuity, improve operational efficiencies and reduce reporting errors through real-time geo-referenced intelligence.

CHR provides the following GIS/CAD Services:

- Aerial Imagery and GPS
- Data Files Hosted on CHR Servers
- Data Imports (FEMA, Soils, DFW, FCC)
- Report, Query and Analysis Capabilities
- Facilities Management System Integration
- Data Exports to "One-Call-Dig-Tess" and Google Earth
- Data Extraction and Normalization from Paper to CAD
- Graphical Object Assignment (Routes, Pedestals, CSA#)
- Ongoing System Updates and Support of Geographical Data
- Advisory Support and Recommendation for Network Improvements
- Land-Base and Coordinate Creation (Lat/Lon, Roads, Hydrology, Landmarks, ROW)
- Linking of Billing system to CAD maps
- Creation of maps for Marketing
- Ability to access and work in customer proprietary systems
- AutoCAD and MapInfo product support
- AutoCAD training (Intermediate to Advanced)
- Innovative Elations CAD support
- AutoDesk Design Review support
- Geocoding of customer addresses
- OASIS FM support

Managed GIS/CAD

In addition to performing the above mentioned GIS/CAD services on an as-needed basis, CHR offers a fully managed GIS/CAD service for those that prefer this be handled in a turnkey fashion in order to maintain and keep all their mapping records up-to-date without fulltime staffing towards that effort.

Grounding Audits

Proper central office grounding and bonding provides the best protection against incoming surges that have the potential to disrupt service and damage expensive network equipment.

CHR technical experts will:

- Inspect central office locations for compliance with RUS' 1751f-810 grounding bulletin
- Perform an in-depth, onsite review of the existing grounding configuration and test the ground field resistivity
- Provide a detailed report, based upon RUS documentation, with recommendations for correcting any violations noted during the ground audit
- Reports include photos of the violations to clearly show corrective actions to be taken

Client staff are encouraged to participate during the visit so informal training can be provided in a real world environment.

In addition to performing the Ground Audit, CHR can help address any grounding issues by providing field technicians to assist with corrective actions, making CHR's Grounding Audits a true turnkey service.

Technology Assistance with Loan and Grant Applications

Since 1984, CHR consultants have prepared or overseen the preparation of over150 loan applications on behalf of our clients, securing more than $1.0 billion dollars in loans and grants from the government and many lending institutions. Our engineers are highly experienced in all technology aspects needed to secure financing, Long Range System Planning and System Design and Cost Analysis.

Options

Usually, the easiest and most convenient way to finance an upgrade is via the use of general funds. However, general funds alone are usually not sufficient to allow for the complete implementation of these new technologies. At this point, the next question usually is “What other options do we have?” You have several options available:

1. **Rural Utilities Service (RUS) - Traditional**
   The Rural Utilities Service (RUS) makes loans to furnish and improve communications service in rural areas. Loans made or guaranteed by RUS will be made in conformance with the Rural Electrification Act of 1936. RUS provides borrowers specialized and technical accounting, engineering and other managerial assistance in the construction and operation of their facilities when necessary. The various types of RUS loans include RUS Hardship Loans, RUS Concurrent Loans and FFB Guaranteed Loans.

2. **Rural Utilities Service – Broadband**
   The Rural Broadband Access Loan and Loan Guarantee Program is designed to provide loans for funding, on a technology neutral basis, the costs of construction, improvement and acquisition of facilities and equipment to provide broadband services to eligible rural communities. The goal of the program is to ensure that rural consumers enjoy the same quality and range of communications services that are available in urban and suburban communities. Whether you are trying to secure a Direct Cost-of-Money Loan, Private Loan Guarantee, or Direct 4 Percent Loan – CHR can help.

3. **Rural Telephone Finance Cooperative**
   The Rural Telephone Finance Cooperative (RTFC) provides various types of short and long term financing to complete the necessary upgrading that you as a borrower may be looking for. Payment schedules and interest rates will vary based on the amount borrowed and longevity of the payback period.

4. **Connect America Fund**
   The FCC is planning to move forward with the solicitation of proposals for the deployment of high-speed broadband networks in unserved rural areas utilizing the Connect America Fund (CAF). In addition to price, a sound understanding of complex federal processes and

procedures is needed to be successful. The FCC requires recipients to comply with existing and new rules to secure funding.

5. Commercial Lenders
   Other lending institutions provide various short/long term loans. Qualifications and interest rates vary from one institute to another (Commercial Banks, Trust Companies, Mortgage Companies, Insurance Companies, and Institutional Investors).

Application Process

CHR's engineering team can work with your organization and regulatory/financial partners to deliver the engineering, technology selection, budgets and project plans to complete an application for any of the above mentioned grant and/or loan programs. Our team has extensive experience working with federal organizations such as RUS and the FCC to successfully acquire grants and loans for rural carriers to fund Network Upgrades, BSS/OSS software and other network related projects. CHR can assist with these areas covering the major requirements generally outlined in the process:

- Executive Summary/Justification
- Technical Feasibility
- Census block maps
- Project Schedule
- Project Budget

Wireless Engineering and Project Services

CHR Solutions' wireless engineering team works with you to complete a comprehensive technology assessment that extends far beyond the basic technology issues. We make design recommendations based on your requirements in terms of time to market, features, budget and return on investment.

CHR Solutions optimizes your wireless operations: project planning and specifications, equipment negotiations and review of vendor proposals, complete project coordination, acceptance testing, onsite training and cutover assistance.

Wireless Engineering Services Include

- Complete Network and RF System Architecture, Design and Implementation
- Capacity Planning and Forecasting
- Network Design and System Objectives
- RF Coverage and Performance Models
- 4G/LTE build-outs
- Licensing and Frequency Coordination Support
- Base Stations, DACS, Switch, Backhaul and Billing System Integration
- Field Support Engineering Services
- Microwave Radio Design (Licensed or Unlicensed)
- Drive Test Management and Annual System Verification
- Mobile Switching Office and Cell Site Power and Battery Systems
- Data and Internet Access Systems
- Long Range Planning Support
- Spectrum Evaluation and Interference Management
- Manage and Negotiate Contour Extensions
- Construction Management Services
- Transport/Backhaul and IP Design
- Problem Isolation and Repair

Experience

CHR wireless engineers and wireless project specialists have extensive experience preparing wireless designs, performing propagation studies, inspections, analyzing problems and managing wireless implementations. They have handled everything from community WiFi deployments to regional and nationwide wireless design and 4G/LTE build-outs. For 4G LTE, Cellular, PCS, Wireless Local Loop, MMDS, LMDS, Point to Point Microwave, Unlicensed Bands, Wireless Internet, Switching Centers (Voice and Data) and Broadband Wireless technologies – CHR is your one stop shop.

Additional CHR Offerings

Billing and Customer Relationship Management

CHR's billing and CRM solution, Omnia360™, is a complete 'out-of-the-box', pre-integrated customer relationship management and billing solution. Available as a fully-hosted cloud-based solution, managed service or on-site license subscription, this next generation solution empowers service providers with a client-centric model for service differentiation and rapid deployment of new services.

Inventory Management

Whether your challenges are in the physical, logical, or virtual network layers, CHR Inventory Management Software helps you to take control of your network inventory assets and expenses.

Managed NOC and IT Services

Improve your business while reducing operational costs and managing risk. Leverage CHR's 24/7 managed IT Network and Data services to deliver the resources and experience you can depend on!

Cybersecurity

As organizations continue to trend towards always connected, concerns for network security arise. Building the best defense possible and constant vigilance are required to reduce vulnerability. CHR Solutions provides services that can help protect against Cyber Attacks.

Network Assessments

CHR's Network Assessment Service provides a third-party objective review of your organization's data, voice, video and wireless environments. We explore every aspect of your Network as a necessary component of maintaining a healthy network infrastructure.

IP Network Implementation and Network Architecture Services

Today's IP networks move data, telephony, video, cellular backhaul and anything else that will fit in a packet. All these services are critical for keeping your customers satisfied, and with your IP network being the foundation to your organization's services, CHR understands how important it is to understand and manage the flow of every service from the first mile access through to the network core and beyond.

Systems Integration

Voice Switching changes are complex and even the best implementation of the wrong technology platform can waste both time and money. CHR can help you determine the best switching solutions and implement them the right way to deliver the highest value and best solution for you and your subscribers. We take into consideration maintenance, upgrades, migrations, settlement impacts and other operational costs.

Contact a CHR Solutions representative at 713.351.5111 or info@chrsolutions.com to explore options to ensure your company has the best opportunity to take advantage of these programs.