DESIGN GUIDELINE 273524
CELLULAR PHONE SIGNAL REINFORCEMENT SYSTEM (CPSRS)

Scope

This guideline defines the requirements and standards for design of building-wide Cell Phone Signal Reinforcement System (CPSRS). CPSRS shall provide signal reinforcement for wireless voice and data telecommunication service providers. The guideline covers basic requirements for system design, specifications, bidding and testing.

Related Sections

U-M Design Guideline Sections:
5.4 DG – Telecommunications Rooms
6.3 DG 260513 – Medium, Low and Control Voltage Cables
6.3 DG 260526 – Grounding and Bonding for Electrical
6.3 DG 260533 – Electrical Materials and Methods
6.3 DG 272000 – Voice and Data Communications
6.3 DG 273523 Emergency Responder Radio Coverage

U-M Master Specification Sections:
7.1 MS 017823 – Operations and Maintenance Manuals
7.3 MS 260513 – Medium, Low and Control Voltage Cables
7.3 MS 260526 – Grounding and Bonding for Electrical
7.3 MS 260533 – Electrical Materials and Methods
7.3 MS 272000 – Voice and Data Communications

Reference Documents:
- Federal Communications Commission Regulations
- IFC, "International Fire Code"
- MBC, "Michigan Building Code"

Definitions:
RF = Radio Frequency
BE = Building Entrance
UPS = Uninterruptible Power Source
DAS = Distributed Antenna System
CPSRS = Cell Phone Signal Reinforcement System
IP = Internet Protocol
FCC = Federal Communication Commission
SISO = Single input, single output
MIMO = Multiple input, multiple output

Design Requirements

The installation of a Cell Phone Signal Reinforcement System (CPSRS) is not code required. Review with Design Manager if system shall be included in project. In early design/ programming phase a cost per square foot can be carried as a placeholder for budgetary purposes. Coordinate with UM ITS for space requirements for necessary system carrier racks. The system shall include an infrastructure network served by head end components including but not limited to the following:

- a neutral host DAS
- vendor-neutral active RF components served by an IP-based headend
- multi-carrier small cells, or similar technologies common to CPSRS installations.

CPSRS

When approved, provide CPSRS in new buildings and in major renovations to support RF-based telecommunication applications. The system shall be a 4-carrier neutral host system with inputs from wireless carrier head ends located in the School of Education (SoE) or in other on-campus head end locations. U-M will deliver signal or IP traffic from the carrier head end equipment to the building entrance room (BE) via U-M fiber optic cable.

Wireless carriers to be accommodated:

- AT&T
- Verizon
- T-Mobile (future)
- Fourth Carrier – U-M private network or other facilities-based provider (future)

The system shall accommodate a frequency range of 617-4200 MHz, and may optionally support other frequency ranges as approved by U-M ITS. All carriers/frequencies that are turned up must be approved by U-M ITS in writing prior to going on air. The system shall support LTE and 5G NR standards. LAA, CBRS GAA, 5G NR-U, and any other unlicensed transmissions shall not be initiated on these systems without a written master contract amendment with U-M and express approval of U-M ITS. SISO, interleaved MIMO, or MIMO design configuration and sector count shall be coordinated with carriers and U-M ITS based on building density/occupancy and carrier KPI requirements. The DAS shall pass all carrier RF performance requirements and be modified as appropriate during commissioning to attain carrier acceptance.

DAS frequency configuration shall be coordinated in advance with U-M ITS and carriers during the construction phase, subject to modification as technology changes during the construction phase. Bidder shall provide U-M with a proposed configuration table for review that matches latest best practice at the time of bid e.g.

Frequency	Technology	Target RSRP	SISO/MIMO	Sector Count
2100 MHz (AWS)	LTE	>-90 dBm	2x2 MIMO	1
850 MHz (SMR)	5G NR/LTE	>-90 dBm	2x2 MIMO	1
2500 MHz (EBS)	5G NR/LTE	>-90 dBm	2x2 MIMO	1
3500 MHz (CBRS)	5G NR/LTE	>-90 dBm	2x2 MIMO	1
3700 MHz (C Band)	5G NR/LTE	>-90 dBm	2x2 MIMO	1
1900 MHz (PCS)	LTE	>-90 dBm	2x2 MIMO	1

Millimeter wave equipment is permitted as applicable, if neutral host capability is provided in the DAS design for additional mmWave deployments.

The system shall have expansion capability with features and space for additional RF modules or the equivalent expansion capability in IP-based systems.

Donor antennas shall not be used as signal sources for CPSRS without U-M ITS approval.

System design shall include signal amplification on every floor of the building. Infrastructure (equipment space, electrical power and cable pathways) shall be installed throughout the building.

Provide spare capacity to install amplification later on floors that pass pre-installation testing but may drop below the required percent coverage or signal strength when construction and furniture move-in are completed.

The design shall include RF Safety Evaluation Minimum Permissible Exposure (MPE) evaluations for DAS and any donor antennas proposed as part of the project design to demonstrate compliance with FCC MPE limits in 47 CFR1.1310. These evaluations shall be submitted to U-M EHS for review and approval. Safety evaluations shall identify accessible areas or zones where RF can exceed FCC member of public MPE and describe mitigation measures that will be used to prevent exposures of individuals to RF levels above the member of public MPE. For equipment to be installed that is suitable for unlicensed use under 47 CFR Part 15 supply the manufacturer's FCC-required certification of MPE compliance (e.g. 47 CFR 15.212, 15.247, 15.319, 15.407) upon request by UM.

All components shall be low passive intermodulation (PIM) rated.

DAS shall be registered under the most current applicable rulings of the FCC. The system shall comply with all applicable interference standards.

All equipment shall be Underwriters' Laboratories (UL) listed and labeled in accordance with applicable NEMA and ANSI standards.

CPSRS shall not be combined with the following radio systems:

- Medical telemetry systems
- ERRC Emergency Responder Radio Coverage

CPSRS systems can share space and vertical riser shafts with a separate ERRC. In this case, systems shall be maintained completely separate within the same shaft and racks.

CPSRS shall be designed to maintain full system operation during a normal power outage. It shall transfer to and from a UPS without interruption. Size UPS to provide emergency power to head end and node equipment for a length of time determined by the Design Manager in coordination with the user group. Consider connecting the UPS to a generator-backed emergency power circuit if available.

- UPS batteries shall be of the sealed maintenance-free type.
- UPS specification shall be coordinated with U-M ITS Infrastructure to be monitorable by ITS systems.
- Provide battery ventilation in accordance with applicable codes.

Locate CPSRS head end equipment in the telecommunications Building Equipment (BE) room whenever possible. Locate node equipment in Telecommunications Rooms (TRs). See Design Guideline DG 5.4. Coordinate with U-M ITS Infrastructure for space within telecommunication rooms.

The system shall be capable of internal monitoring and status reporting via an Ethernet network and Simple Network Management Protocol, or similar standardized streaming telemetry protocol. System status shall report to carriers and U-M ITS Infrastructure.

Provide drawings showing the general system architecture, equipment locations and routings. Provide a performance-based, non-proprietary, specification. The detailed technical design of the CPSRS shall be by the selected and qualified firm's professional (Contractor).

Passive Infrastructure Network

Passive infrastructure network shall be a combination of coax cables and directional couplers designed in such a manner to distribute signals with equalized losses to each antenna node.

DAS node antennas shall be Low PIM rated to reduce signal mixing and creation of harmonics.

Review antenna styles and mounting locations with Design Manager for aesthetic concerns and coordinated approval with the U-M Radio Shop.

Use above ceiling antennas in corridors and common areas. In other areas use low profile, flush-mount types installed on the underside of ceilings. Node location shall comply with all application RF exposure guidelines.

Antennas shall be securely attached independently from the work of other trades. Antennas and cables shall not impede access to the service side of existing equipment.

Antennas shall have an identifying label or address number visible from the traffic path location.

Rooftop donor antennas must comply with FCC MPE safety requirements Antennas shall have an electrical disconnect designed to accept a lockout device to control RF exceeding the MPE for public exposure. The antenna shall preferably have a local disconnect and/or signage to readily identify the disconnect location.

Install conduit for routing cabling through inaccessible ceilings, finished spaces with open ceilings and unfinished spaces below 10'-0.

Riser and feeder cables shall be plenum rated and shall be installed in UL listed raceways or support methods.

Cables shall be installed hidden from view except in open ceiling areas.

Methods of installation shall be per NEC and cable manufacturers requirements.

Specification Requirements

Architect/Engineer of Record shall provide performance-based specifications. Require final and complete design, specifications and drawings be provided by the Contractor and submitted as part of the shop drawing process.

Performance-based specifications shall include the following:
- Performance specifications for major components.
- Scope and quantity of spare parts required.
- The design shall include RF Safety Evaluation Minimum Permissible Exposure calculations.

Performance-based specifications shall include the following requirements:
- Equipment shall be FCC certified.
- Contractor shall be FCC licensed as required by code.
- Contractor shall submit detailed shop drawings for approval.
- Components shall be industry standard and readily available to U-M.
- Head end and node equipment shall be securely attached to racks or backboards.
- Components shall be labeled with unique part or address numbers which correspond to numbers shown on the Contractor drawings.
- Head end room door shall be labeled to identify the presence of head end equipment.

- Furnishing factory-authorized service representatives to supervise the field assembly, connection of components, commissioning and testing of their respective systems.
- Coordinate signal review and confirmation with service providers and U-M.
- Required separation distances between CPSRS equipment and other mechanical, electrical and telecommunications equipment.
- Required separation distances between CPSRS antennas and antennas of other radio systems.
- Riser cables and cables for individual antenna feeders shall be installed in a neat and workman like manner. Each cable shall be individually supported.
- Contractor to submit a detailed work plan including narrative setting forth in sufficient detail how the Contractor will provide the scope of services.
- Contractor to attend progress meetings as required by the Construction Manager to maintain a thorough understanding of the project schedule and associated coordination issues
  Utilizing iBwave Model Generation software, the Contractor shall perform a predictive RF propagation survey in native and AutoCAD formats and submit results to UM Design Manager and ITS Infrastructure.

Shop drawing submittals shall include the following:

- Proof of Contractor's qualifications.
- FCC registration number.
- Detail design package
- Testing and commissioning procedures.

Contractor's detailed design package shall include the following:

- Table of contents.
- Description of project.
- Project team contact information.
- One-line wiring diagrams.
- Building floor plan drawings with equipment layouts.
- Enlarged plans depicting layout of head end equipment, UPS and battery storage units.
- Rack diagrams showing the CPSRS head end equipment, fiber patch panels, cable cross connect schedules and any other associated equipment installed on the head end equipment racks.
- Bill of Materials broken down into active and passive component categories.
- Data sheets for each piece of equipment with model numbers.

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Specify the following to support operation and maintenance activities:

- Four paper copies of operation and maintenance manuals.
- An electronic file storage device (USB drive, SD card, etc.) containing the final system software including the master program generic to the system, the software associated with each programmable piece of equipment, and the software licenses and passwords required by the Plant Radio Shop to perform programming changes.
- A minimum of 8 hours of Owner training on operation and maintenance.
- One year of customer service from the date of acceptance by U-M.
- A parts and labor warranty for 1 year from date of acceptance by U-M.
- The first code-required annual operational test at the end of 1 year.

Testing Requirements

Testing shall include the carrier networks comprising the CPSR system.

The Contractor shall perform pre-installation testing for percent coverage and signal strength . Testing shall not be performed until after the building is fully enclosed (roof, exterior skin, doors and windows are installed), and interior ceilings and walls are in place.

- Measure the percent coverage and signal strength in both the critical and general areas on each floor. Measure the signal strength receivable within the building and the signal strength received when transmitting from within the building.

- The Contractor shall perform acceptance testing for percent coverage and signal strength. Testing shall be performed after furniture move-in. Testing shall be scheduled and performed with UM ITS. Demonstrate full compliance with specification requirements.

During system testing the Contractor shall involve System Operators, commercial carriers and University Staff to ensure compliance with their standards and FCC regulations.

Provide testing report including testing results, any modifications required, floor plans and attendance sign in sheet.

Test results shall indicate date, time and weather conditions at the time of the testing.