

Changes to ARMER Conceptual Plan (February 2008)

Prepared by Mn/DOT Office of Electronic Communication

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1.0 Summary of Proposed Changes

The following summary is intended to give a quick overview of the plan changes being proposed. Details of these proposed changes are outlined in the remainder of the document.

RF Coverage/Sites

Coverage criteria

From 95 % Mobile Statewide to 95% Mobile County by County

Sites counts

Phase 4 changes from 69 to 66

Phase 5 changes from 62 to 81

Phase 6 changes from 54 to 78

Total 456 changes from 185 to 225

Phase 3 adds 7 additional sites

MSO's

of MSO's

Conceptual plan had 6 MSO's, recommendation is to stay at 6 MSO's

Location of MSO's

Area served by each MSO

MSO Inter-zone link configuration

Connectivity

Change from Loop protection to Trunk and Spurs with path diverse routing for critical sites. (Same as approved for Phase 3, detailed work still in process)

2.0 Summary of adopted conceptual plan for Phases 4, 5 and 6:

2.01 RF System (coverage/site locations)

Phase 4: 69 sites

Phase 5: 62 sites

Phase 6: 54 sites

2.02 Master Switching Offices (MSO) – Zone Controller

The conceptual plan called for the addition of one zone controller per phase with a final total of six zone controllers. Conceptual plan was for phase 3 to have an additional controller in Rochester, phase 4 adds a controller in Duluth, phase 5 adds a controller in Detroit Lakes and phase 6 adds a controller in Virginia.

2.03 Connectivity

The conceptual plan called for all sites to be interconnected by digital microwave configured in loop topologies with loop protection equipment.

2.04 Implementation Plan

The adopted conceptual plan called for an implementation by geographical phases.

2.05 Frequency Plan

2.06 Interop

This is directly from the conceptual plan:

A system plan will be needed to establish detail requirements for providing an interoperational system (Interop) that will facilitate communications between non-participating entities and those who choose to join the 800 MHz system.

A couple of options are under consideration at the time of this writing. It should be noted that these are offered as topics for discussion.

- *Use the existing Minnesota State Patrol VHF radio equipment that exists today. While some of this equipment is somewhat old in terms of electronics, it may serve as a temporary link between entities of dissimilar radio systems. Since the Patrol system and most equipment used by public safety agencies in the state are already programmed with the State Mutual Aid channels (MINSEF, MIMS and the Fire Mutual Aid frequencies) it may be the least expensive route to pursue.*
- *Use the existing county sheriff's radio system and equipment. However, this option would require all counties within the district being upgraded to participate in the shared statewide trunked system. It is unlikely that all counties will convert to the new system during the initial implementation phase, which would leave major gaps in the Interop system.*
- *Use a combination of the previously described options.*

This plan has provided some cost figures to provide for interoperability between the old and the new. Best estimates indicate that the cost to implement the Interop System statewide would be approximately \$3.3 million.

Estimates and details of how the Interop issue can be satisfied will be better addressed once funding has been approved and meetings begin with local units of government to determine their interest in participating on the Trunked System as well as their requirements.

For Phase 4, 5 and 6 the plan included \$ 3,500,000 for Interop equipment. Basically it planned for \$14,000 per site to purchase VHF repeaters.

2.07 Cost Estimates

Original estimates from Conceptual plan:

Phase 4 – This phase covers the Duluth and Brainerd State Patrol districts. The two districts cover 12.5 counties (half of St. Louis Co.)

	Numbers	Costs
Counties Involved	12.5	-
New Towers: Includes Land, Shelters, Generators, Site Prep Work	39	\$13,472,000
Existing Towers	27	\$ 0.00
Modifications	3	\$ 498,000
800 Fixed Equipment	5 chnl stations	\$10,669,200
Interop Eqp/Control	69 sites / 1 Zone Cont	\$ 4,966,000
Microwave Eqp	Loop, High cap, Hot Stand-by	\$13,065,000
Engineering	Trunk & Microwave	\$6,500,000
TOTALS		\$49,170,200

Phase 5 – This phase encompasses three Patrol districts – Mankato, Marshall, and Detroit Lakes. This phase will include 31 counties.

	Numbers	Costs
Counties Involved	31	-
New Towers: Includes Land, Shelters, Generators, Site Prep Work	40	\$13,920,000
Existing Towers	15	\$ 0.00
Modifications	7	\$ 689,000
800 Fixed Equipment	5 chnl stations	\$ 9,727,800
Interop Eqp/Control	62 sites / 1 Zone Cont	\$ 4,868,000
Microwave Eqp	Loop, High cap, Hot Stand-by	\$15,640,000
Engineering	Trunk & Microwave	\$6,500,000
TOTALS		\$51,344,800

Phase 6 –This phase covers the Virginia and Thief River Falls Patrol districts. These two districts include 11.5 counties.

	Numbers	Costs
Counties Involved	11.5	-
New Towers: Includes Land,Shelters,Generators, Site Prep Work	32	\$11,136,000
Existing Towers	15	\$ 0.00
Modifications	7	\$ 1,220,000
800 Fixed Equipment	5 chnl stations	\$ 8,315,700
Interop Eqp/Control	54 sites / 1 Zone Cont	\$ 4,756,000
Microwave Eqp	Loop, High cap, Hot Stand-by	\$12,200,000
Engineering	Trunk & Microwave	\$6,500,000
TOTALS		\$44,127,700

3.0 Details of Proposed Plan Changes for Phases 4, 5 and 6.

Since the approval of funding for Phase 4, 5 and 6 Mn/DOT has been looking at what it will take to implement these phases. This work has been based on the following assumptions:

- Seamless system operation through out different ARMER phases.
- Make use of existing Mn/DOT sites where possible.
- Make use of existing Mn/DOT digital microwave where available and capacity exists.
- Implement the voice RF coverage within phase 4,5 and 6 with the allocated \$186 million.
- Make use of internal Mn/DOT staff where possible to keep costs in line.

3.01 RF System (Coverage/Site locations/Channel Capacity)

The RF system design from the ARMER conceptual plan was 95 % mobile coverage statewide. In 2007 the Statewide Radio Board adopted a coverage design requirement of 95 mobile converge on a county by county bases. The new target RF coverage level is 33 dbu, 95% of area, 95% of time over 95 % of each County.

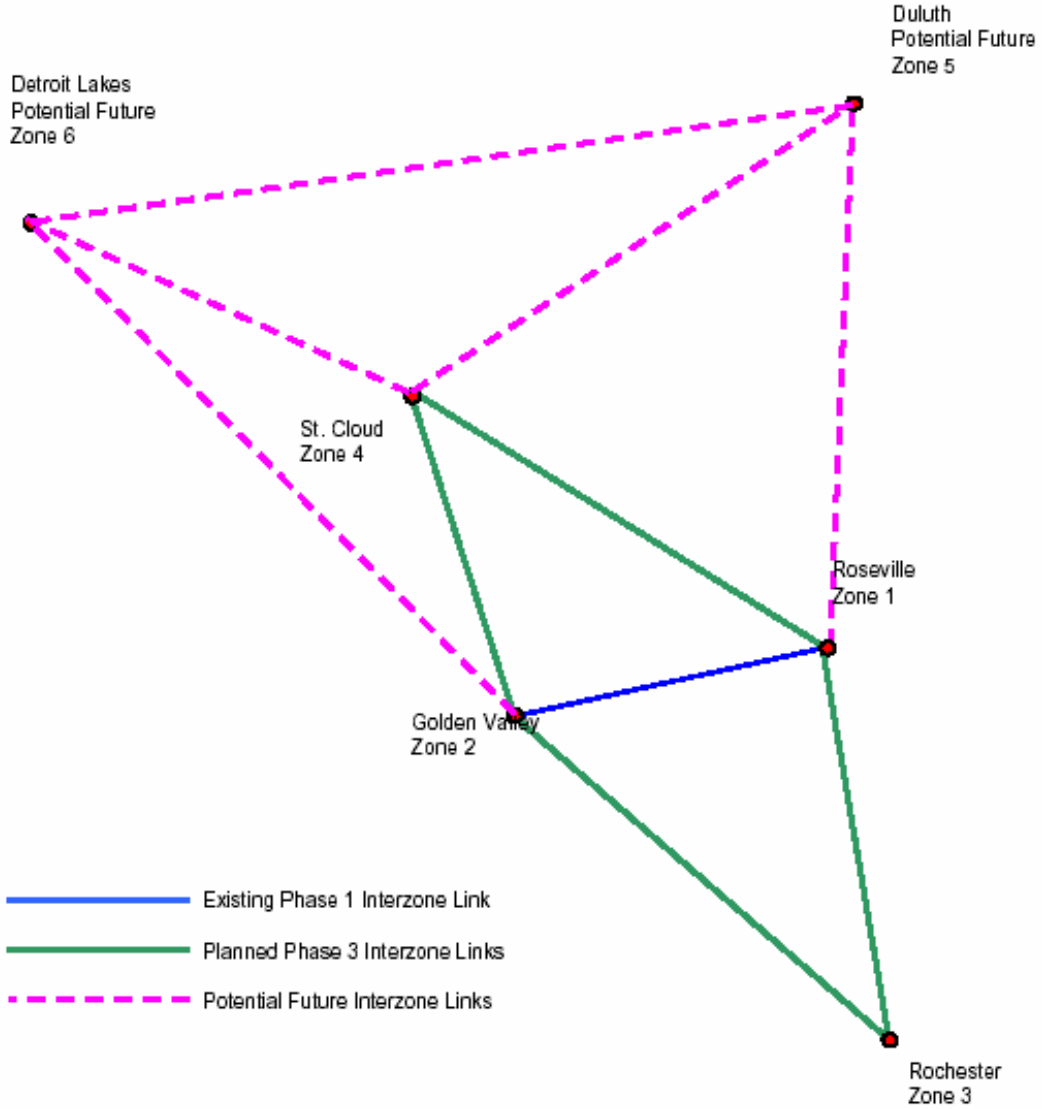
See Appendix A for more detail on the coverage prediction methods used and for County maps showing the predicted coverage in Phases 4, 5 and 6.

Based upon the above changes the following tables are a listing of sites for phase 4, 5 and 6.

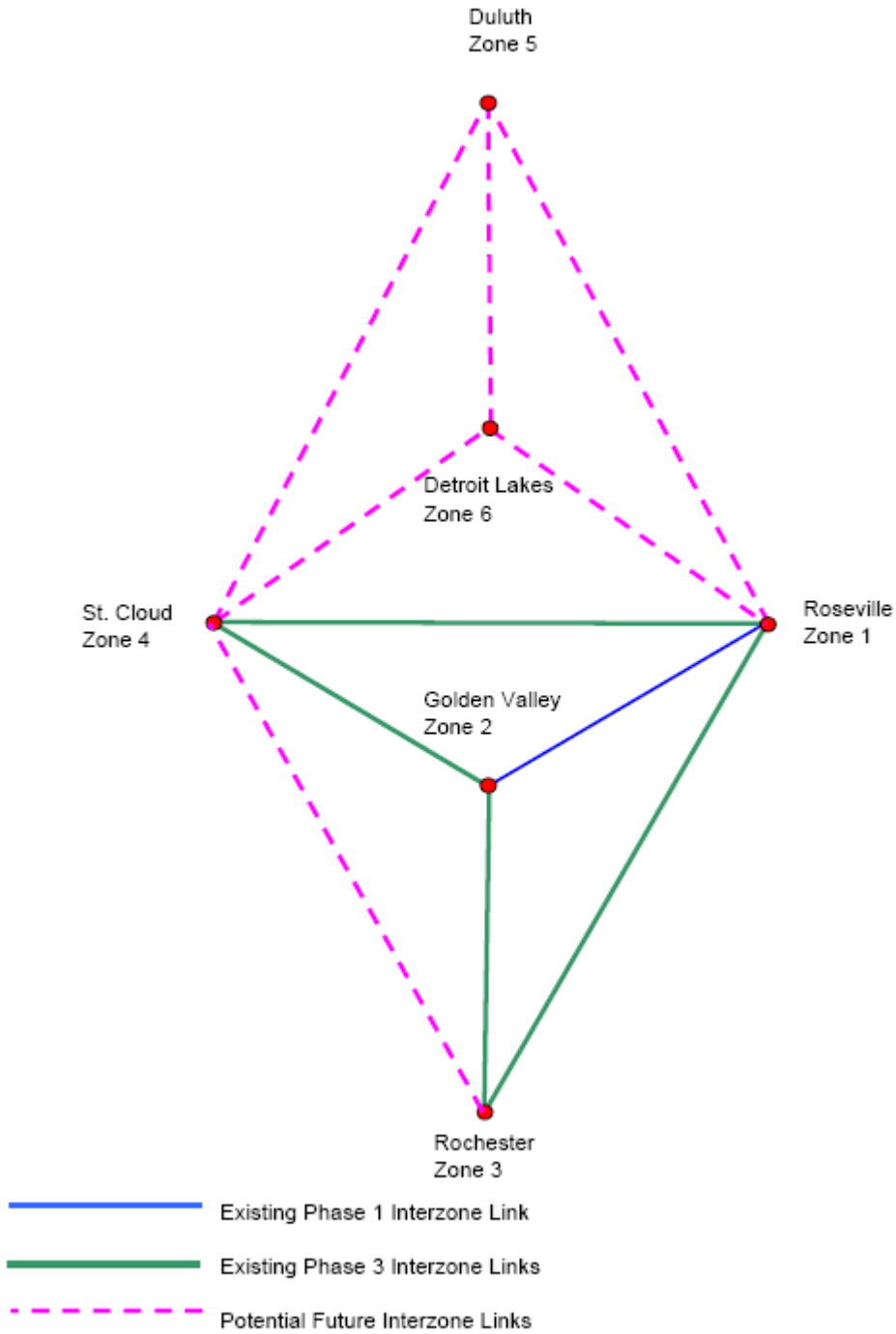
3.02 Master Switching Office (MSO) - Zone Controllers

Inter Zone Links:

Previously proposed Inter-zone link plan:



New proposal for Inter-zone links:



3.03 Connectivity

Microwave Radio Links

The sites in the ARMER System will be interconnected by microwave radio links. The links will be configured as shown in the maps on the following pages. The microwave connections will be 4DS3, 3DS3, 28T1 or 8T1 radios as show in the microwave maps. All radios will be configured as hot standby protected. See Appendix B for preliminary specifications for the ARMER Phase 3 microwave equipment purchase.

The basic microwave configuration will be in loop configurations with spurs to the end sites. Loop switch protection will not be used in the Phase 3 ARMER microwave plan; instead a method of diverse route protection will be employed for critical infrastructure protection. The diverse route protection will be based on the following guidelines:

Inter-zone Links	Required diverse routing by different microwave routes or by microwave and fiber as a alternate route.
Prime Site Controller to MSO links	Required diverse routing by different microwave routes or by microwave and fiber as a backup route.
Prime site controller to remote site links	To be determined on a site by site bases and connectivity available.
ISR site to MSO links	These sites will be bundled together, 3 or 4 sites into a single T1 that is diverse route protected.
Console to MSO links	Not protected by diverse routing. Dispatch centers should all plan on control station for backup in the event of a loss of console connectivity. The dispatch centers could also add diverse routing at their expense by provide the alternate microwave, fiber or phone line connections. All dispatch centers should also have radio control stations for backup purposes.
Conventional RF and interop equipment	Not protected by diverse routing.
Site monitoring links to MSO	Provided by a single redundant T1 system wide.

T1 assignments and T1 channel plans

The T1 assignments and Channel plans will be developed as part of the DDR and installation process. See Appendix C for the preliminary T1 plan. The actual T1 assignments will be determine as the system is installed. The T1 assignments will be changed as required for system additions and changes.

The plans are to assign a T1 from each radio site to the MSO and provide site interconnection at a DACS located at the MSO.

Diverse T1 routing and protection switching will be installed on the ISR sites and Simulcast PSC sites.

Since the microwave will be replacing or making use of existing Mn/DOT microwave the Mn/DOT, Patrol and DNR legacy VHF and the Patrol MDC system equipment will need to be put onto the digital microwave. This payload will be incorporated into the T1 assignments and channels plans as the build out progresses. The Mn/DOT, Patrol and DNR legacy equipment will not make use of diverse routing unless the channels are packed into a T1 that is diverse routed for the ARMER System.

Fiber routes

Fiber connections are being investigated to connect the MSO for redundant Interzone Links and for redundant paths connecting the DAC's together.

Future RF network

The design of the microwave makes use of 3DS3 microwave as the primary links. The plan is to use 1-DS3 as a network to connect the RF sites. We are working with Motorola on the concept of connecting the sites by a network and eliminating the need for T1 type connectivity for the RF sites or console locations. This concept is not currently published on Motorola's roadmap but indications are that it is possible and will likely be added to the roadmap in the future.

Site alarming

For site alarm monitoring Mn/DOT is developing an in house system. The new system is called the Site Monitoring and Alarm Reporting Tool (SMART) System. The SMART System is being designed as an "open" and cost conscience multi-user platform providing access and configuration to all agencies while maintaining some degree of separation. The network backbone of the SMART System will utilize a small portion of bandwidth between adjacent microwave towers eliminating the need for messy cross-connects and providing separation from the 800MHz network. The database utilized by the SMART system is an enterprise grade database licensed under the GNU License meaning it is a free distribution reducing the need for costly licensing fees. During the design of the SMART system emphasis is being put on providing support for 3rd party equipment vendors, ease of use and configuration, multi-agency access and configuration, redundant routing, intelligent notification and paging, open client access methods, and above all user and administrator friendliness.

3.05 Frequency plan

The frequency plan for Phase 456 makes use of 800 MHz and 700 MHz channels.

We are also looking at the 700 MHz assignments to determine how we can make use of these channels. We are working with Motorola through the DDR process for Phase 3 to see how the 700 channels can be implemented. We hope to have at least one 700 Channel installed on one or two site so that we can evaluate the operation as part of the Phase 3 build.

All sites in the system will be capable of handling the 800 MHz only radios that are on the system.

The following criteria will be used for the use of 700 MHz channels at the ARMER sites:

- Any available 800 MHz channels will be used before 700 MHz channels are added.
- The control channel and any backup control channels will be 800 MHz channels.
- A minimum of 60% of the voice channels beyond the primary control channel will be 800 MHz with any 700 MHz channels added on top of these.
- The ARMER System interop talkgroups and public safety main dispatch talkgroups will be tagged in the system and allowed only on 800 MHz channels. This is to insure all radios on the system are capable of scanning and operating on these talkgroups.

Mn/DOT has also recommended that the ARMER System standards be reviewed and updated as required to incorporate the above criteria.

At sites adjoining the metro area we will be installing 700/800 MHz capable antennas and tower top amps.

4.0 Additional proposed changes to Phase 3

Appendix A

Coverage Predication Maps (Phases 4, 5 and 6)

Coverage prediction method used for determine Phase 4, 5 and 6 coverage. This is the same method that was used and outlined in the Phase 3 conceptual plan change submitted by Mn/DOT, approved by the Statewide Radio Board Operations and Technical Committee and subsequently approved by the Statewide Radio Board.

The target RF coverage is:

Target coverage level of 33 dbu 95% of area, 95% of time, 95 % of County by County.

95% of area is defined such that in any given 3”X3” square under study the square is considered to have a level of 33 dbu if 95% of the area in the square is greater than 33 dbu.

95% of Time is defined such that due to atmospheric variations the field level in the area under study will exceed the indicated level no less than 95% of the Time.

The coverage predictions for the 800 MHz RF System were generated as follows:

- Radiosoft comstudy Verion 2.2.8.8 version
- 3” terrain database
- 70 watts ERP
- 850 Mhz
- 4/3 Earth Curvature
- Longley Rice 1.2.1
- 95% Time (This account for weather effects)
- 95% Area (This accounts for Raleigh fading)
- 20 db miscellaneous loss (this accounts for environmental loss, foliage loss and Raleigh fading)

- Bullington
- 4/3 earth curve
- 30 db miscellaneous loss

These study parameters are based on field measurements done by the Office of Electronic Communications in the Virginia area, and in the Rochester area. The Virginia study was conducted using an 800 MHz base station with antennas mounted at the top of the 300’ midway tower. The Rochester study was conducted using a 800 MHz base station with antennas mounted at the top of the 300’ Viola tower.

A communication test set with field strength mapping software was used to record the field strength in the area of study. This is the same setup that was used to measure s field levels in the Metro system

The results of the study were compared with the predictions from different models and a model was selected and parameters adjusted to best match the field readings.

Target coverage level

- 15 dbu radio sensitivity
- 9db margin
- 9 db Raleigh fading
- 33 dbu Target level

Typical coverage targets

- Mobile 30 dbu
- Portable on the belt 40 dbu
- Light in building add 6 db loss
- Heavy in building add 12 db loss

We expect that this should provide reasonable coverage to a portable in a vertical position at head level.

Site spacing

- Site spacing of no more than 18 miles for simulcast sites.
- Site spacing of less than 20 miles for microwave is preferred.
- Site spacing of up to 23 miles with space diversity microwave.
- Microwave path clearance to surrounding sites for heavy route criteria.

Appendix B

Connectivity Maps

Appendix C

Previously Approved Changes to the Conceptual Plan Changes in Phase 3

- Site changes
 - Add site at Buffalo.
 - Add site at Terrace.
 - Add site at Nodine.
 - Change Big Stone to Schumacher and Correl.
 - Add two additional sites in Houston County.
 - Add site at Cannon Falls, Hader moved to Zumbrota.
 - Remove site in Warsaw.
 - Move Hoffman from Phase 5 to Phase 3.
 - Move Lincoln from Phase 4 to Phase 3.
- Reconfigure Phase 3 Simulcast configuration/locations.
 - Move St Cloud site to a simulcast subsystem.
 - Change Enfield-Kimball to Enfield-Zimmerman- Buffalo
 - Change Faribault-Lonsdale-Warsaw-Hader to Cannon Falls-Zumbrota-Red Wing, with Faribault and Lonsdale become multicast sites, Warsaw site removed.
 - Change Winona-Alma-Troy-Wilson-Elba to Oakwood-Bear Valley-Lake City. Troy, Wilson, Winona and Elba become multicast sites.
 - Change Viola-Pleasant Grove-New Have-Rock Dell-Oakwood-Bear Valley to Viola-Pleasant Grove-New Haven-Rock Dell. Oakwood and Bear Valley moved to simulcast group covering Wabasha County.
 - Change the Holdingford site from an ISR stand-alone site to a simulcast site that will be part of the St Cloud sub-system. Increase St Cloud simulcast to 9 channels.
- Increase channel capacity at sites adjoining metro area to 6 channels.
- Add 700 Channels to frequency planning.
- Move future Phase MSO Zone controller to Phase III and locate it in St Cloud.
- Change microwave from Full Loop protection at each site to a Topology of Trunk and Spur with redundant route for protection of critical equipment.

SE Minnesota Sites	Site Type	Comments	Antenna System	RF Channel Count
Lonsdale	ISR		700/800	6
Faribault*	ISR		700/800	6
Cannon Falls	Simulcast 1		700/800	6
Zumbrota	Simulcast 1		700/800	6
Red Wing	Simulcast 1		700/800	6
Lake City*	Simulcast 2		700/800	6
Oakwood*	Simulcast 2		700/800	6
Bear Valley*	Simulcast 2		700/800	6
Owatonna	ISR		800	5
Washoja*	ISR		800	5
New Haven	Simulcast 3	In Service	800	11
Viola	Simulcast 3	In Service	800	11
Rock Dell	Simulcast 3	In Service	800	11
Pleasant Grove	Simulcast 3	In Service	800	11
Mayo Bldging	Simulcast 3	In Service (Olmstead County added site)	800	11
Alma	ISR		700/800	6
Elba*	ISR		800	5
Troy*	ISR		800	5
Rollingstone*	ISR		800	5
Wilson	ISR		800	5
Nodine*	ISR		800	5
Dresback	ISR		800	5
Albert Lea*	ISR		800	5
Geneva	ISR		800	5
Oakland Woods	ISR		800	5
Hayfield	ISR		800	5
Elkton	ISR		800	5
Wykoff*	ISR		800	5
Amherst*	ISR		800	5
Spring Grove*	ISR		800	5
Money Creek*	ISR		800	5
Caledonia*	ISR		800	5
Reno*	ISR		800	5
Rochester	MSO			0

34 sites

* Site purchase/lease work still in progress so actual site name may change, but the site will be in this general area.

CM Minnesota Sites	Site Type	Comments	Antenna Type	RF Channel Count
Zimmerman	Simulcast 4		700/800	6
Enfield	Simulcast 4		700/800	6
Buffalo*	Simulcast 4		700/800	6
St Cloud	Simulcast 5/ MSO	RF in service	800	8
Blue Wing	Simulcast 5	In Service (St Cloud added site)	800	9
Calvary Hill	Simulcast 5	In Service (St Cloud added site)	800	9
Holdingsford *	Simulcast 5		800	9
Kimball	ISR		700/800	6
Eden Valley*	ISR		800	5
New London	ISR		800	5
Litchfield*	ISR		800	5
Willmar*	ISR		800	5
Terrace	ISR		800	5
Benson	ISR		800	5
Holloway*	ISR		800	5
Morris	ISR		800	5
Chokio*	ISR		800	5
Schumacher	ISR		800	5
Correl	ISR		800	5
Gilman	ISR		700/800	6
Freeport	ISR		800	5
West Union	ISR		800	5
Long Prairie	ISR		800	5
Lincoln	ISR		800	5
Glenwood	ISR		800	5
Hoffman	ISR		800	5
Herman	ISR		800	5
Wheaton	ISR		800	5
Browns Valley	ISR		800	5

29 sites

* Site purchase/lease work still in progress so actual site name may change, but the site will be in this general area.

Site changes (Six additional sites)

St Cloud coverage to come from 28 sites. This is 6 more sites than the conceptual plan. 4 of the sites were additions for coverage and 2 of the site came from the St Cloud addition ahead of the state build. 22 of the sites will be ISR-standalone sites. The remaining 6 sites will be configured in 2 simulcast subsystems.

- Add site at Buffalo.

Site need to improve coverage in Wright County. The original plan had much of the coverage for regional users in the Wright County area coming from the Metro Regional/Henn West and Norwood subsystems. After further review it was decided that this would put too much outstate traffic on Metro resources and cause a lot of unnecessary inter-zone traffic.

- Add site at Terrace.

This site was added to improve coverage and to complete microwave paths.

- Move Hoffman from Phase 5 to Phase 3.

This is an existing Mn/DOT tower and the site is moved to this phase for coverage improvements to phase 3 and to complete the microwave paths.

- Move Lincoln from Phase 4 to Phase 3.

This is an existing Mn/DOT tower and the site is moved to this phase for coverage improvements to phase 3.

33 sites will cover the Rochester area. This is 4 more sites than the conceptual plan. 3 were additions for coverage and 1 site was added by the Olmstead County addition ahead of the State build. There were 22 of the sites will be ISR-standalone sites. The remaining 11 site will be configured into 3-simulcast subsystems.

- Add site at Nodine.

Site added to complete microwave path from Wilson to Dresback. This site will also add to coverage in the area.

- Add two additional sites in Houston County.

Sites were added to improve coverage in area. Due to the terrain in this part of Minnesota these sites are needed to get the required coverage.

- Add site at Cannon Falls, Hader moved to Zumbrota.

Existing sites built by Mn/DOT ahead of the ARMER program for DOT required microwave connection from Metro to Rochester. Original plans had a single site at Hader. This would have required the microwave paths to be greater than 20 miles. The Hader move to Zumbrota and adding Cannon Falls shortened the microwave path while also providing an additional site for RF coverage improvements.

- Remove site in Warsaw.

A review of the coverage from Faribault tower and site west of Rice County showed site not needed in Warsaw area.

Reconfigure Phase 3 Simulcast configuration/locations.

- Move St Cloud site to a simulcast subsystem.

The conceptual plan called for a single site in St Cloud for the state level coverage. Since Homeland Security money was available St Cloud built ahead of the State a 3-site simulcast subsystem was built. The plans are to now share this subsystem and its operating cost and we will add additional channels for regional users.

- Change Enfield-Kimball to Enfield-Zimmerman- Buffalo

The other simulcast subsystem planned was moved from the Kimball-Enfield sites to the Zimmerman, Enfield and Buffalo sites. This was driven by frequency availability and also the site spacing between Kimball and Enfield is close to 20 miles. Motorola recommends that simulcast sites be closer than 18 miles. Also a new site is planned in Buffalo due to coverage and roaming concerns.

- Change Faribault-Lonsdale-Warsaw-Hader to Cannon Falls-Zumbrota-Red Wing, with Faribault and Lonsdale become multicast sites, Warsaw site removed.

This change is recommended after reviewing site spacing and frequency availability. The change from a single site at Hader to the Cannon Falls/Zumbrota sites also lends itself to a logical simulcast system with Red Wing to cover Goodhue County.

- Change Winona-Alma-Troy-Wilson-Elba to Oakwood-Bear Valley-Lake City. Troy, Wilson, Winona and Elba become multicast sites.

After doing a detailed review of the sites in this area this change is recommended due to frequency availability and site spacing.

- Change Viola-Pleasant Grove-New Have-Rock Dell-Oakwood-Bear Valley to Viola-Pleasant Grove-New Haven-Rock Dell. Oakwood and Bear Valley moved to simulcast group covering Wabasha County.

After doing a detailed review of the sites in this area this change is recommended due to frequency availability and site spacing.

- Increase channel capacity at sites adjoining metro area to 6 channels.

From traffic/loading history in the metro we recommend that the sites adjoining the metro area be increased from 5 to 6 channels.

- Add 700 Channels to frequency planning.

700 MHz channels will be added to the frequency plan for Phase 3. Mn/DOT recommends that all sites in the system be capable of handling the 800 MHz only radios that are on the system.

The following criteria will be used for the use of 700 MHz channels at the ARMER sites:

- Any available 800 MHz channels will be used before 700 MHz channels are added.
- The control channel and any backup control channels will be 800 MHz channels.
- A minimum of 60% of the voice channels beyond the primary control channel will be 800 MHz with any 700 MHz channels added on top of these.
- The ARMER System interop talkgroups and public safety main dispatch talkgroups will be tagged in the system and allowed only on 800 MHz channels. This is to insure all radios on the system are capable of scanning and operating on these talkgroups.

We recommend that the ARMER System standards be reviewed and updated as required to incorporate the above criteria.

At sites adjoining the metro area we will be installing 700/800 MHz capable antennas and tower top amps. These are the sites that would most like require use of 700 channels.

Master Switching Office (MSO) – Zone Controller

In reviewing the conceptual plan, one zone controller was planned to cover two different geographically separated regions. The zone controller was planned to be located in Rochester. It would appear that not a lot of thought went into this part of the conceptual plan. We looked at the plan to tie all sites in St. Cloud to Rochester and determined that the microwave costs to do these links would approach the cost of an additional zone controller.

There are 26 sites plus the dispatch centers in the St Cloud area that need to be routed to the zone controller. Even if you pack the sites together to minimize the number of T1s we still need at least a 28T1 path from St Cloud to Rochester. A minimum of 10 hops of microwave would be needed to accomplish this. At \$300,000 per hop we are approaching \$3,000,000 just for this interconnection. The same problem exists if you were to move the ZC to St Cloud. We also looked at putting the zone controller half way between and locating it in the Metro. The same problem exists since now all Rochester and St Cloud sites need to be linked back to the metro.

The Statewide Radio Board has approved the addition of Zone 4 in Phase III.

Connectivity

In reviewing the conceptual microwave and T1 plans we determined that the loop protected microwave consumed T1's at a high rate. This drives the need for higher capacity microwave. The higher capacity microwave also requires tower spacing to be reduced to keep the paths reliable.

We are recommending a system of 3DS3 hot standby Microwave Trunks and Spurs, see attached maps. This plan would include the addition of links at various points to close the microwave paths into various loop topologies but without loop protection switching. Instead of loop protection we recommend that critical links be T1 diverse route protected.

The following will be the guideline for determining which T1s are diverse routed:

Interzone Links	Required diverse routing by different microwave routes or by microwave and fiber as a alternate route.
Prime Site Controller to MSO links	Required diverse routing by different microwave routes or by microwave and fiber as a backup route.
Prime site controller to remote site links	To be determined on a site by site bases and connectivity available.
ISR site to MSO links	These sites will be bundled together, 3 or 4 sites into a single T1 that is diverse route protected.
Console to MSO links	Not protected by diverse routing. Dispatch centers should all plan on control station for backup in the event of a loss of console connectivity. The dispatch centers could also add diverse routing at their expense by provide the alternate microwave, fiber or phone line connections. All dispatch center should also have radio control stations for backup purposes.
Conventional RF and interop equipment	Not protected by diverse routing.
Site monitoring links to MSO	Provided by a single redundant T1 system wide.

The 3DS3 microwave will also provide the connectivity in the future when the microwave could partition a DS3 as a network and configure the network to provide a level of loop protection. See the attached network configuration proposal. We have met with Motorola and they are reviewing this proposal and we plan to continue discussing this. They have indicated it is possible but not in the immediate future it would likely be added to the roadmap for a future release.

The Lonsdale site connectivity will be through the metro by reconfiguring the south metro loop. This is required due to the height restrictions at Empire not allowing a path back to Shakopee.

We are investigating the cost of fiber links between St Cloud - Metro and Rochester - Metro. The intent of these links is to provide an alternate protection path for the interzone links. If these fiber paths cannot be achieved then an alternate routes microwave will be used for the interzone links.

Some microwave paths in Phase III may need to be upgraded, rerouted or reconfigured when the system is expanded into neighboring phases.

Interop (VHF to 800 MHz)

No work has been done in this area since the former interop committee chaired by Col. Beers was meeting.

Meetings with the State Patrol and the local entities will need to be held to determine the interoperability requirements for equipment and procedures. We recommend that Tom Cherney the DPS Interoperability Coordinator lead this task.

We are holding \$1.0 million of the Phase III implementation money for the purpose of Interop.

Cost Estimates

Since not all equipment has been bid for Phase III implementation the following are estimates of Phase III costs. We are still working to fine tune these but wanted to get something down to show magnitude for planning purposes.

	Numbers	Costs
Counties involved	23	-
New Towers: Includes Land, Shelters, Generators, Site Prep Work		\$12,100,000
Existing Towers	28	\$ 0.0
Modifications	12	\$ 2,840,000
800 Fixed Equipment	Mix of 6 ch and 5 ch stations/ 2 zone controllers	\$15,150,000
Interop/Control	52 sites	\$ 1,000,000
Microwave Eqp	3DS3 Trunk and Spur	\$ 14,500,000
	Hot Stand-By	\$ 260,000
	Fiber connections	
Engineering	Trunk & Microwave	Performed by Mn/DOT staff
TOTALS		\$45,850,000

Appendix D

ARMER Frequency Plan

Appendix E

Phase 456 Implementation Plan