
GU@5 MHz Solution Deep Dive

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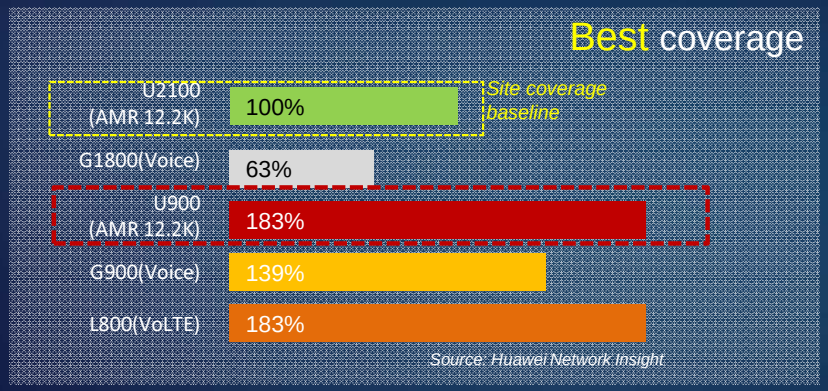
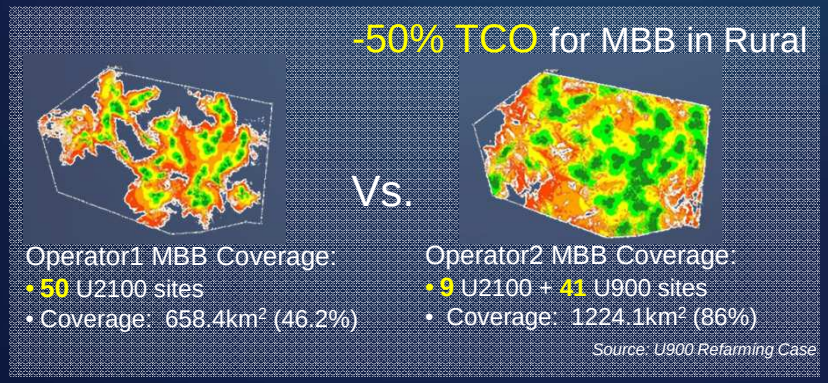
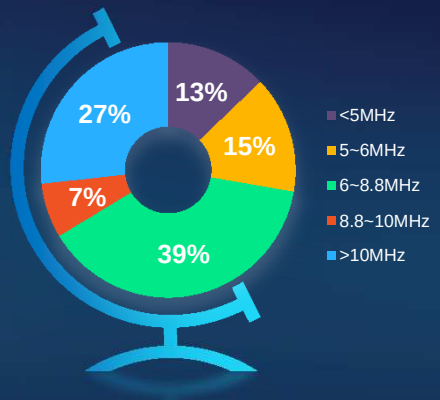
Lack of Low Band Spectrum Blocks MBB Spreading in EM

U900/850 Bridging Digital Divide at Low Costs





But U900 Spectrum is Expensive and Rare



15% global operators only have 5-6MHz spectrum in 900MHz band, cannot deploy GU900

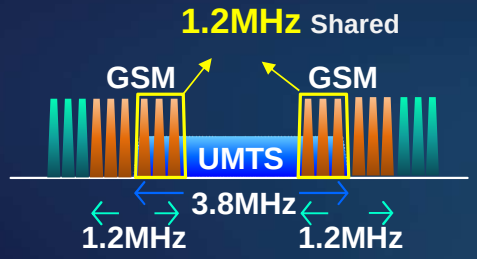
900MHz auction in India 2016 failed due to high price (98M USD/MHz for 1 state)

Jasmine (Thailand operator) won in 900MHz auction but failed to pay

True (Thailand operator) quit 900MHz re-auction due to high price

GU@5MHz, Break Spectrum Limitation in Different Scenarios

Phase1

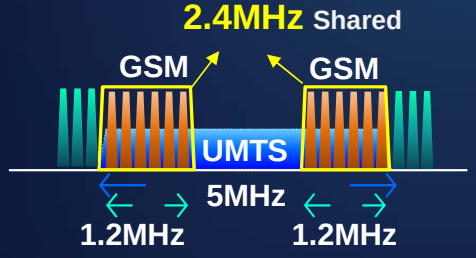


G111

U1 60%~85% Vs U5MHz

24% Sharing

Phase2



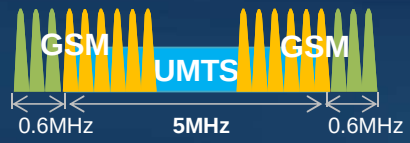
G222

U1 60%~100% Vs U5MHz

48% Sharing

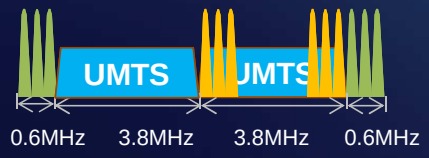
1. **5~6MHz**
   Make U900 possible
   G S222 + 1U @5MHz

2. **6.2~8.6MHz**
   More GSM Capacity with U900 deploying
   G S333 + 1U @ 6.2MHz



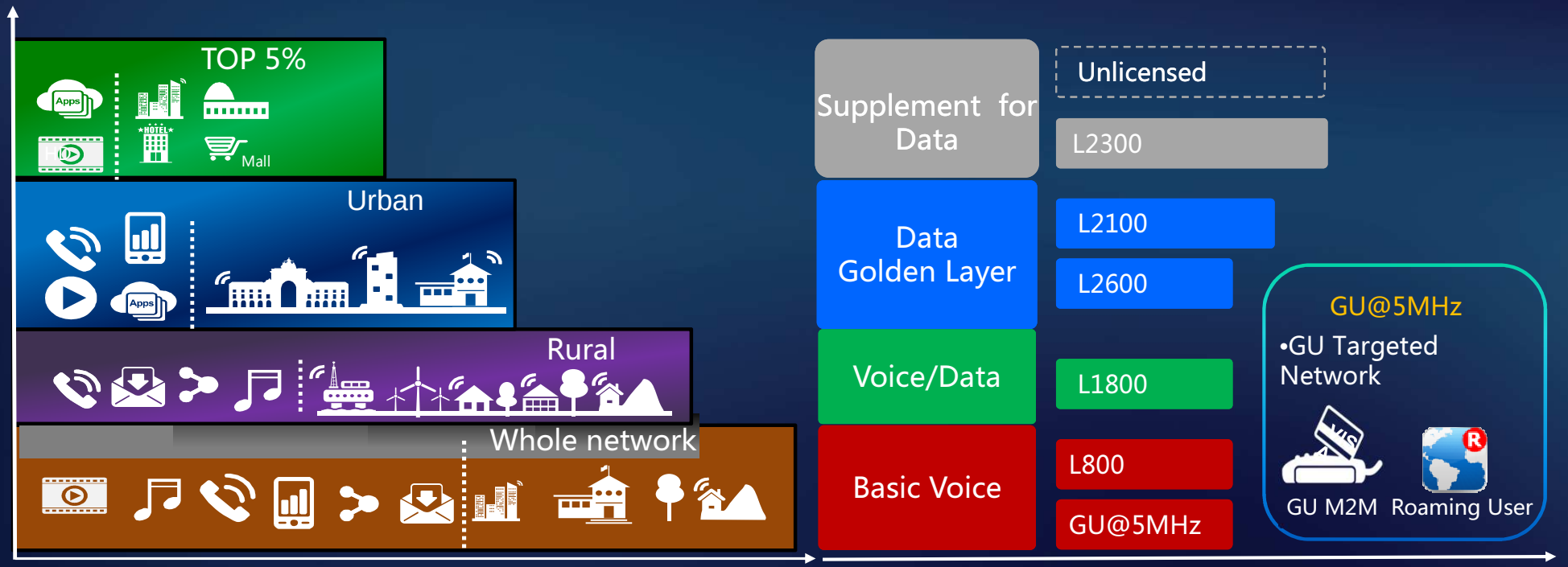
3. **≥8MHz**
   Enable GUL900 tri-mode GUL900@8MHz

4. **≥8.8MHz**
   Enable U900 Dual-Carrier
   GSM S222 + 2U @ 8.8MHz



Future: 5MHz Build GU Targeted Network

Insight of Future Oriented-Target Network

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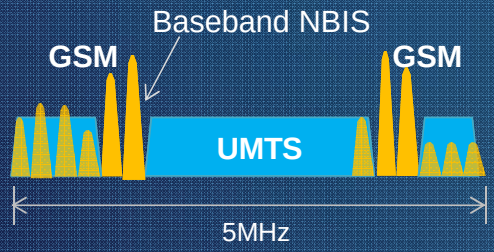
1 Background
2 Solution Introduction
3 Impact Analysis
4 Activation Guide

GU@5MHz Solution Key Technologies

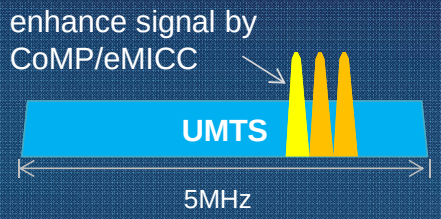
Direction A

Eliminate Interference from 2G UE to 3G NodeB

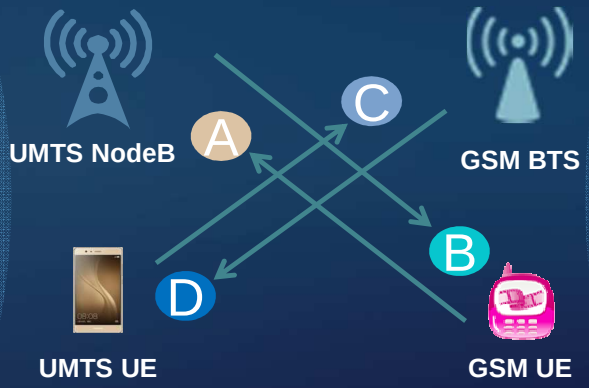


Direction C

Eliminate Interference from 3G UE to 2G BTS

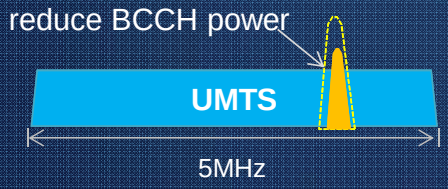


Eliminate Interference from 4 Directions



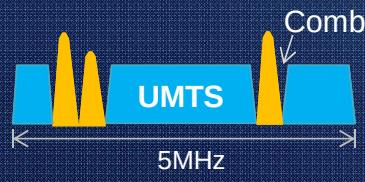
Direction D

Eliminate Interference from 2G BTS to 3G UE



Direction B

Eliminate Interference from 3G NodeB to 2G UE

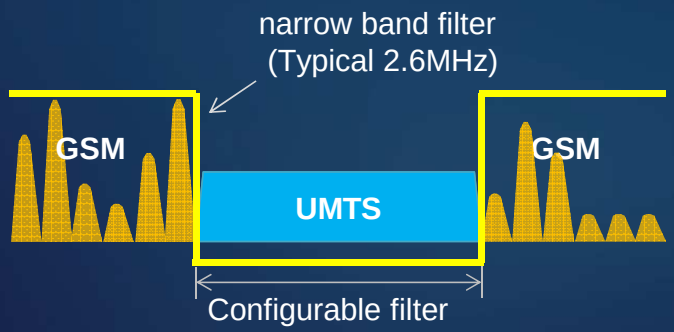


3G Capacity Vs. U900 5.0M
60%~85% (PH1)
60%~100% (PH2)

2G Stable KPI
Vs. Normal BCCH 4*3 frequency reuse
(Refarming impact not considered)

3G UL Advanced Filter Reduce Interference (Direction A: 2G UE->3G NodeB)

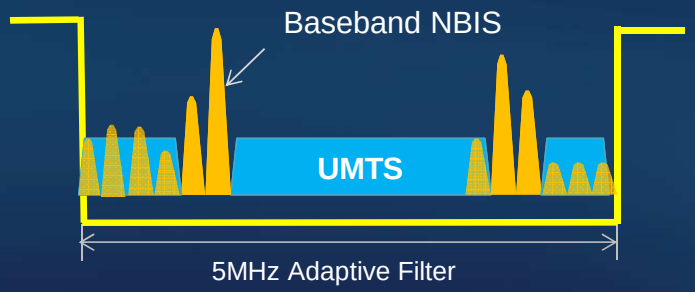
PH1: Uplink Super Narrow Band Filter



- Eliminate GSM signal out of the narrow band filter
- Negative Impact to UMTS UL Capacity

WRFD-19120901 Uplink Super Narrowband Filter

PH2: Uplink Adaptive Band-pass Filter

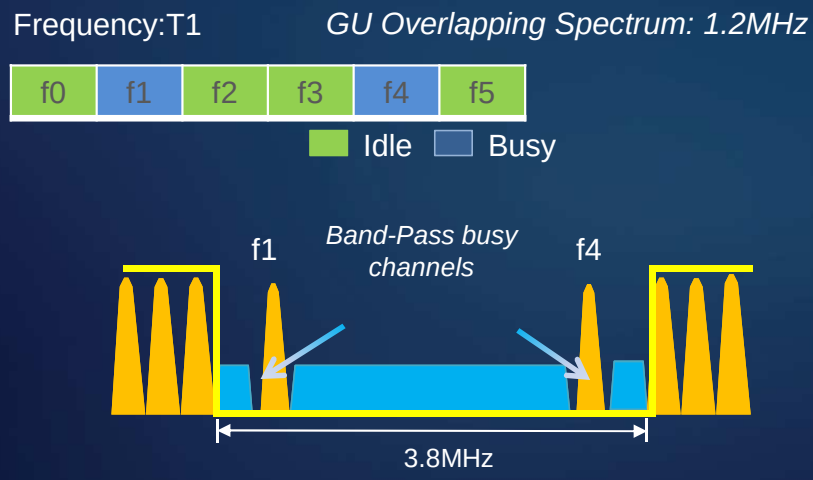


- Dynamically filter Strong GSM interference.
- Small GSM interference have less impact after receiver processing .
- Reduce the impact to UMTS UL Capacity

WRFD-200201 GU@5 MHz Phase 2

3G DL Advanced Filter Reduce Interference (Direction B: 3G NodeB -> 2G UE)

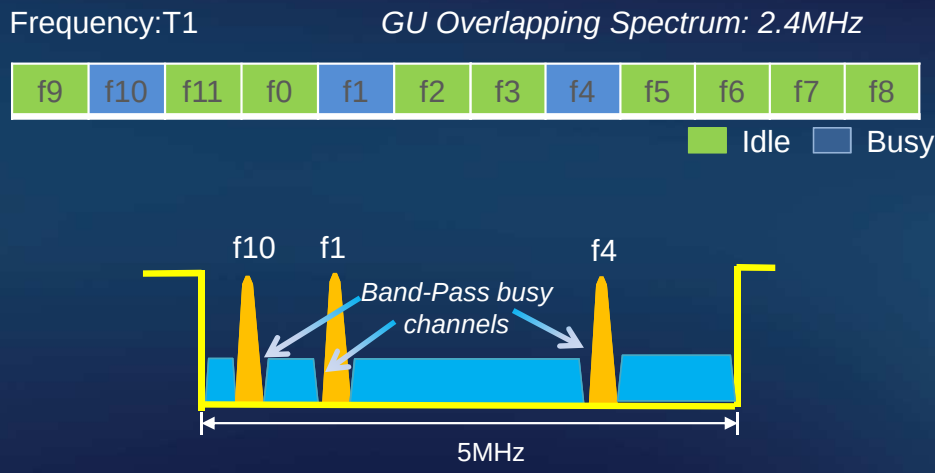
PH1: DL Adaptive Band-Pass Filter (3.8MHz)



- Band-pass busy channel in 3.8MHz
- Negative Impact to UMTS DL Capacity

WRFD-19120902 Downlink Adaptive Band-Pass Filter

PH2: DL Adaptive Band-Pass Filter (5MHz)

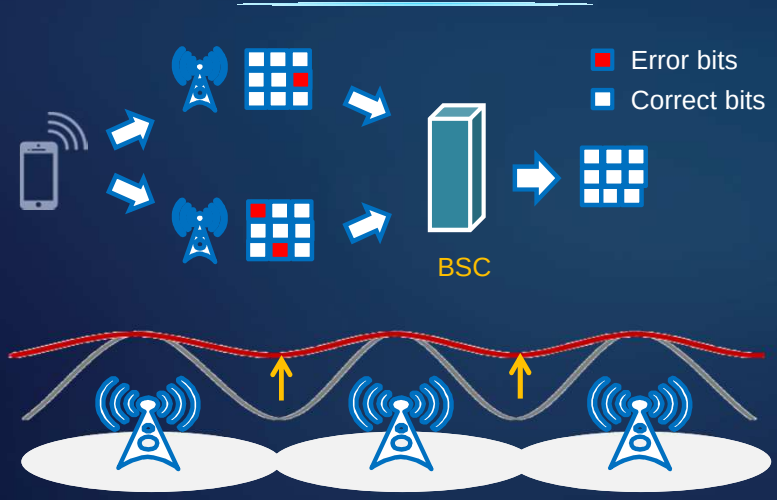


- Band-pass busy channel in 5MHz
- Reduce Impact to UMTS DL Capacity

WRFD-200201 GU@5 MHz Phase 2

2G Anti-interference Solutions (Direction C: 3G UE->2G BTS)

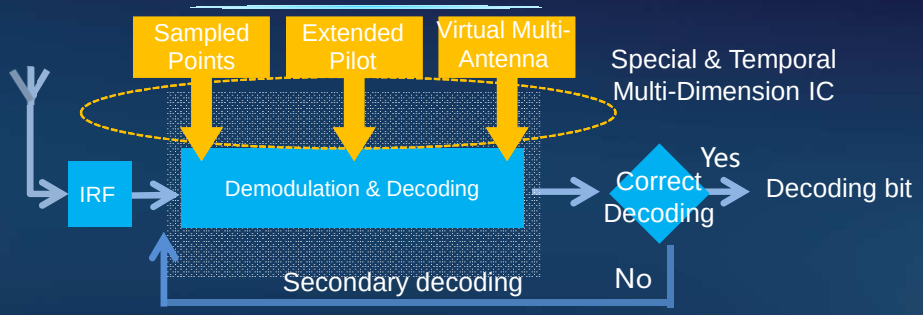
Uplink CoMP: Improve Voice Quality

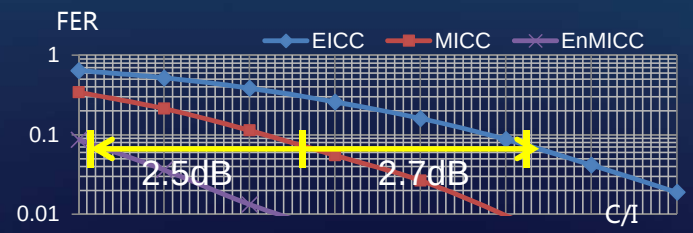


- MOS of cell edge users improved by **0.1~0.2**.
- LQI Improved by **5~20%**.

GBFD-191201 Uplink CoMP (Joint RX)

MICC: Improve by +4-4.8dB vs. EICC





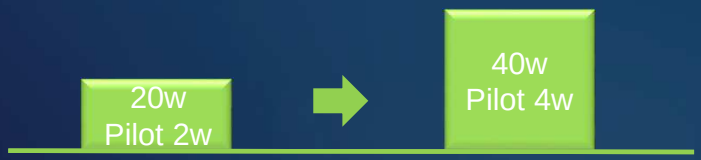
- LQI improved by **15%~40%**

GBFD-160202 MICC

2G Intelligent Power Control to Reduce Interference (Direction D: 2G BTS->3G UE)

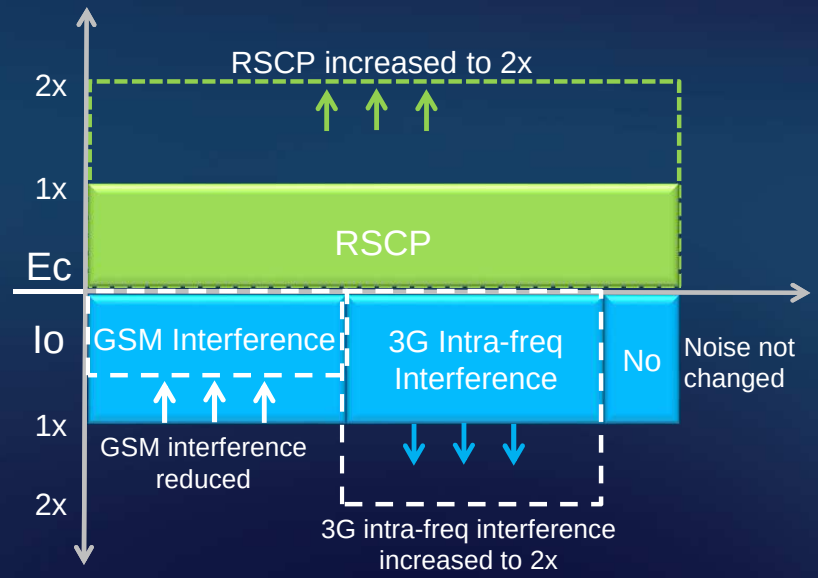
Increase UMTS Output Power and Decrease GSM Signal Strength

UMTS Output Power from 20w to 40w



Reduce Downlink Power of GSM BCCH TRX

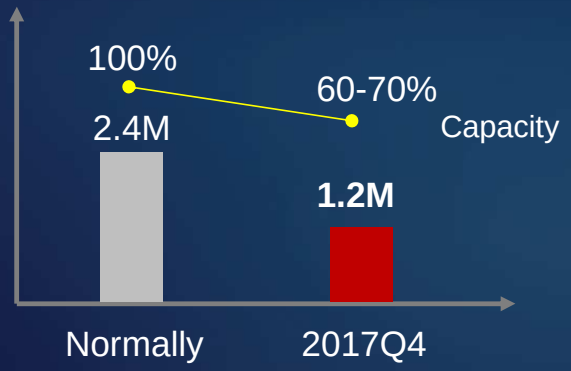
UMTS Downlink Ec/Io Improved



GBFD-181204 Intelligent BCCH Interference Suppression (IBIS)

S111@1.2MHz Squeeze GSM for More UMTS Capacity

S111@ Spectrum Bandwidth(MHz)



- Frequency reuse pattern 4*3 -> **2*3**
- GSM KPIs stable vs. S111@2.4MHz
- Spectrum Saved by **50%**

Interfer. Staggered

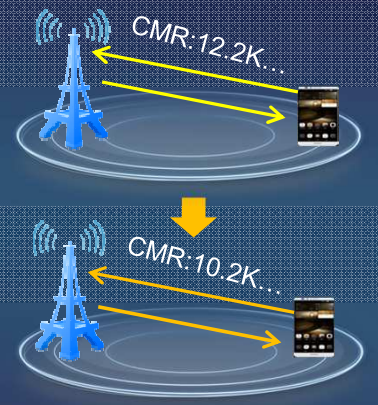
	TS0	TS1	TS2	TS3	TS4	TS5	TS6	TS7
Cell A	BCCH /SD	H	H	H	L	M	M	M
Cell B	L	M	M	M	BCC H/S D	H	H	H
	TS4	TS5	TS6	TS7	TS0	TS1	TS2	TS3

TS cross assignment

- Cross assignment based on TS No. and Priority
- Interference Reduction with IBIS feature

GBFD-200201 1.2 MHz Networking for BCCH TRXs

Interfer. Reduction



- Reduce power of highest speech rate coding users
- 40ms fast power control VS 480ms traditional one

GBFD-200202 User-Level Precise Power Control

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CloudAIR License Dependency

Spectrum Sharing SW Pkg

	RAT	Feature ID	Feature Name	Remark
SRAN 12.1	GSM	GBFD-191205	GU@5MHz Joint Scheduling	
	UMTS	WRFD-191209	GU@5 MHz Phase 1	For V6 RF Module
		WRFD-191211	Customized GU@5 MHz Solution (UBBPd) Phase 1	For V2/V3 RF Module
SRAN 13.0	GSM	GBFD-200201	1.2 MHz Networking for BCCH TRXs	
	UMTS	WRFD-200201	GU@5 MHz Phase 2	For V6 RF Module
		WRFD-200203	Customized GU@5 MHz Solution (UBBPd) Phase 2	For V2/V3 RF Module

Spectrum Sharing RTU

RTU Description	Unit	Configuration Principal
RF Spectrum Sharing License (GSM)	per Band per RRU	Required for 3000 Series RF module, Configure one for GSM and UMTS respectively per band per RRU
RF Spectrum Sharing License (UMTS)	per Band per RRU	
Spectrum Sharing License for 5000 Series RF Module(GSM)	per Band per RRU	Required for 5000 Series RF module, Configure one for GSM and UMTS respectively per band per RRU
Spectrum Sharing License for 5000 Series RF Module (UMTS)	per Band per RRU	

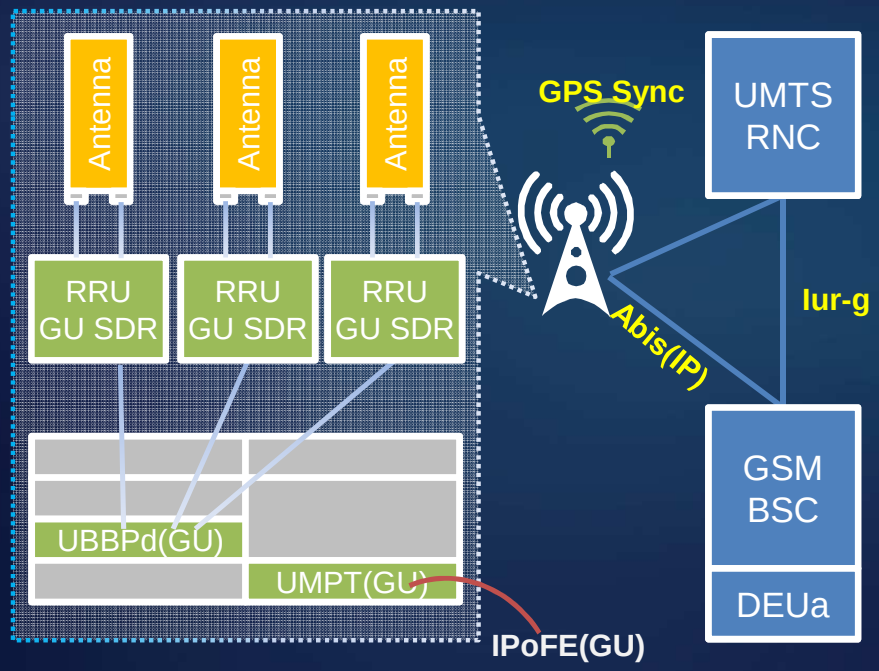
Software Dependency

	RAT	Feature ID	Feature Name	Remark
Mandatory Features	UMTS	Power License	NodeB Hardware License	40W power License per U Cell
	GSM	GBFD-160202	MICC	
		GBFD-191201	Uplink CoMP (Joint RX)	For GSM KPI enhancement
		GBFD-181204	Intelligent BCCH Interference Suppression (IBIS)	Required for BCCH <2.4MHz
		GBFD-118601	Abis over IP	1 of 2 required for Abis IP transmission
		GBFD-118611	Abis IP over E1/T1	
		GBFD-510401	BTS GPS Synchronization	1 of 3 required for time synchronization
		GBFD-118620	Clock over IP support 1588V2	
		GBFD-118201	Soft-Synchronized Network	
	GSM (GU5M PH2)	GBFD-200202	User-level Precise Power Control	
		GBFD-510502	Handover Re-establishment	

	RAT	Feature ID	Feature Name
Recommended Features	UMTS	WRFD-150206	Turbo IC
		WRFD-010210	Control Channel Parallel Interference Cancellation (CCPIC)
		WRFD-140202	Control Channel Parallel Interference Cancellation (Phase 2)
		WRFD-160201	Control Channel Parallel Interference Cancellation (Phase 3)
		WRFD-010691	HSUPA UL Interference Cancellation
		WRFD-140222	Adaptive Adjustment of HSUPA Small Target Retransmissions
		WRFD-010712	Adaptive Configuration of Traffic Channel Power offset for HSUPA
		WRFD-160202	Flexible Power Control for Uplink Low Data Rate Transmission
		WRFD-171203	Uplink Control Channel OLPC
		WRFD-140215	Dynamic Configuration of HSDPA CQI Feedback Period
		WRFD-020138	HSUPA Coverage Enhancement at UE Power Limitation
		WRFD-171204	DPCH Power Control Based on Radio Quality
		WRFD-181207	DPCH TPC Power Adjustment
		WRFD-151205	Uplink CoMP (Joint Reception)
		WRFD-140201	AMR Voice Quality Improvement Based on PLVA
		WRFD-150230	DPCH Pilot Power Adjustment
	GSM	GBFD-111609	Enhanced BCCH Power Consumption Optimization
		GBFD-117602	Active Power Control
		GBFD-117601	HUAWEI II Power Control Algorithm

- Recommended feature used for UMTS capacity enhancement, contributing relative 10%~20% capacity gain

Hardware Dependency



Network Requirement

RNC&BSC

- Iur-g interface
- DEUa(BSC6900)/EGPUb(BSC6910) (Optional)

BTS&NodeB

- (Common Solution) V6 and later RF modules, UBBPd/e baseband board
- (Customized Solution) V2/V3 Modules, UBBPd baseband board
- UMPT / GTMUb/c
- Abis IP Transmission if GU co-UMPT
- GU SDR

Others

- Time Synchronization: GPS or 1588v2 or **Soft-sync**
- GU share antenna & co-site at the ratio of 1:1
- The ratio of G & U Max power 1:2

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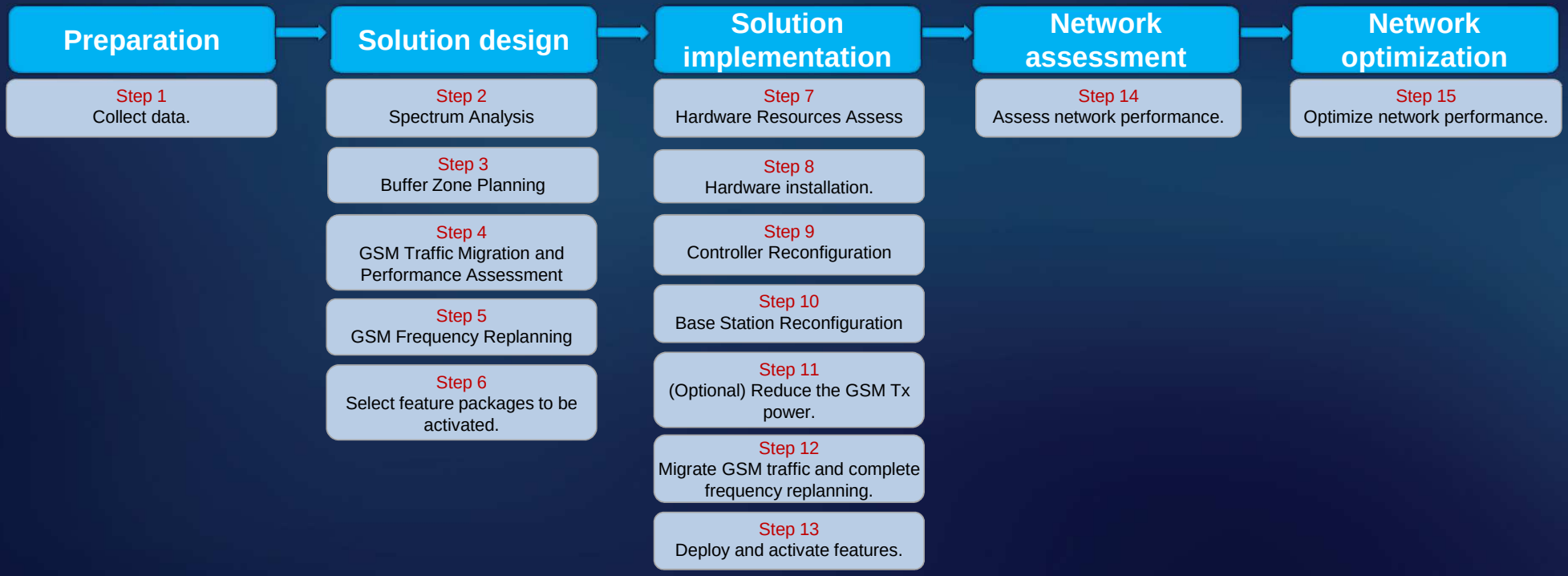
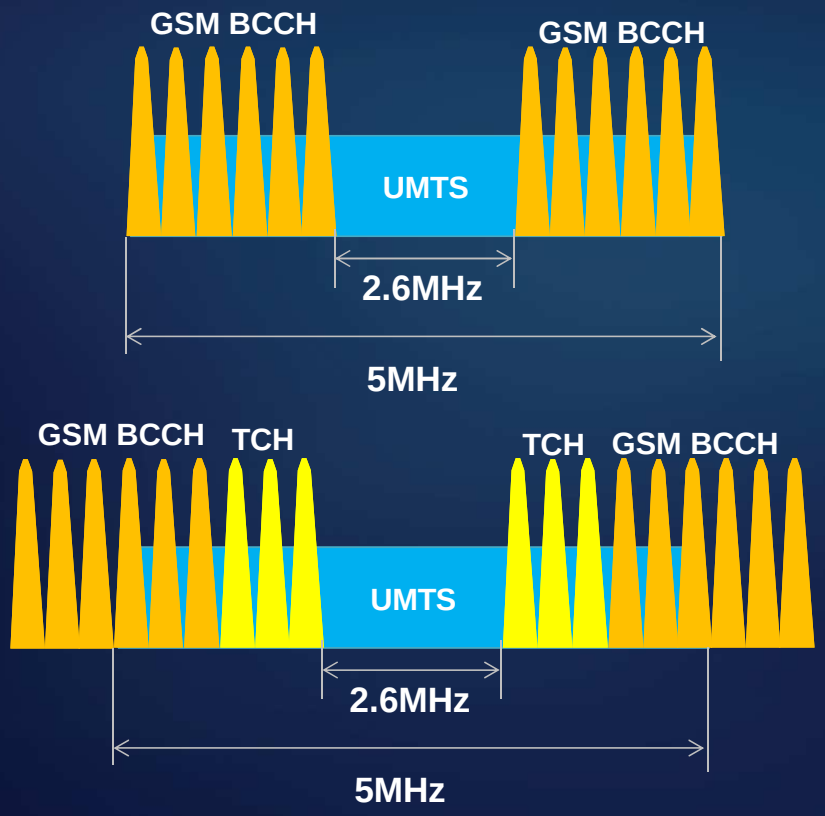
Delivery Process

The delivery process of the GU@5 MHz solution includes **preparation, solution design, solution implementation, network assessment, and network optimization**. The following figure outlines such delivery process.



Solution Design: Spectrum Analysis

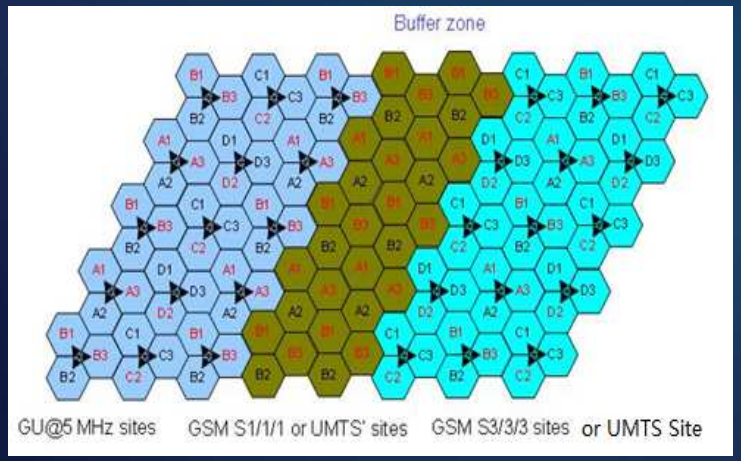
Typical spectrum scenarios



- The GU@5 MHz solution supports frequency bands 850 MHz, 900 MHz, and 1900 MHz.
- GSM and UMTS frequency allocation principles:
  - Preferentially allocate the center spectrum to the UMTS cell, and keep GSM frequencies spaced away from the UMTS center frequency.
  - Plan a maximum of 12 GSM frequencies spaced less than 2.5 MHz from the UMTS center frequency and a maximum of 6 GSM frequencies spaced less than 1.9 MHz from the UMTS center frequency.
  - The BCCH frequency reuse is recommended to be not lower than 4 x 3 and the TCH frequency reuse not lower than 2 x 3 to reduce the number of GSM frequencies spaced less than 1.9 MHz from the UMTS center frequency.
  - Allocate TCH frequencies (if any) spaced less than 1.9 MHz from the UMTS center frequency as possible to reduce GSM interference on UMTS performance.

Solution Design: Buffer Zone Planning

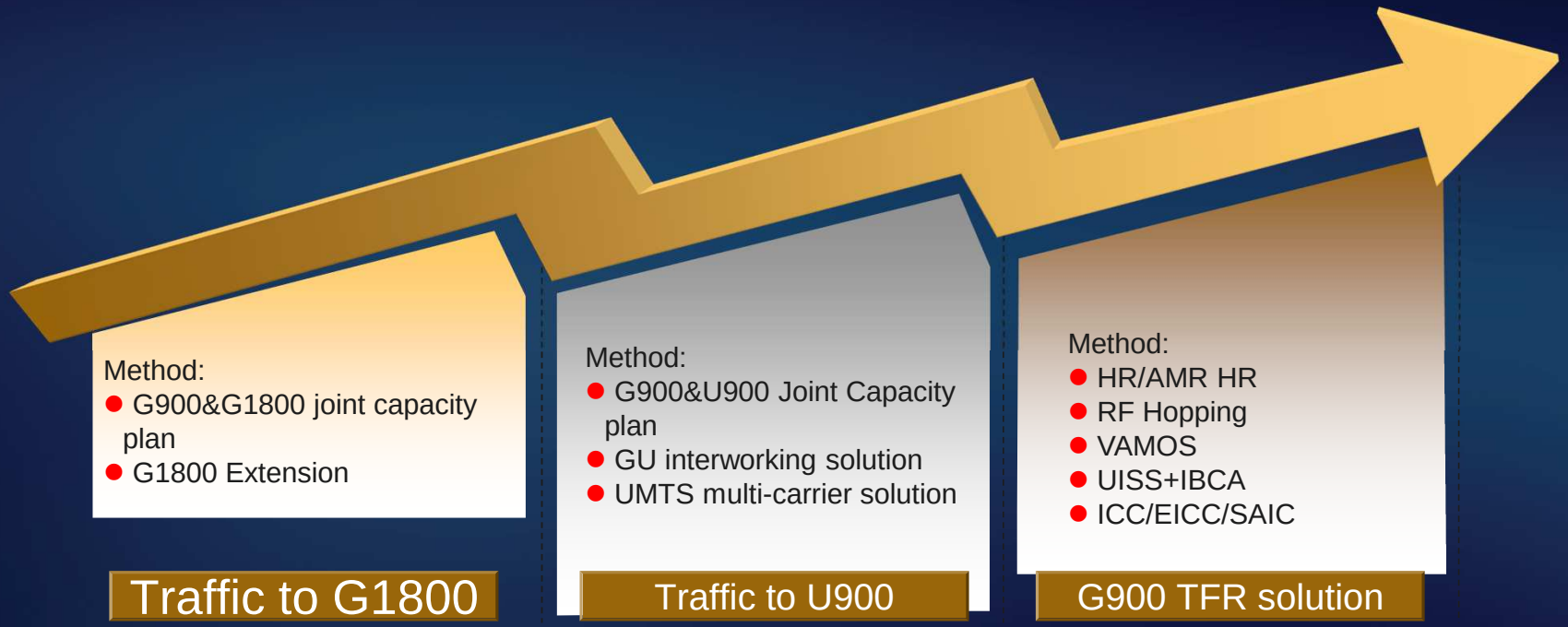
GU frequency refarming allows UMTS and GSM networks to operate on the same frequency band. Meanwhile, co-channel interference between the UMTS and GSM networks cannot be totally eliminated by the filter. To minimize such interference, an intra-frequency buffer zone is introduced between the GU900 area and not-yet-refarmed area.



The GU@5 MHz uses the same buffer zone planning method as the GU refarming solution.

- As shown in the figure, blocks at the left part indicate GU@5 MHz areas.
- Blocks in the middle part indicate buffer zones, where only GSM S1/1/1 sites or sites using the UMTS' dedicated spectrum are allowed.
  - UMTS' refers to UMTS carriers in GU@5 MHz scenarios.
  - GSM S1/1/1 sites are deployed in the buffer zone if the GU@5 MHz network is reconstructed from a G900 network.
  - UMTS' sites are deployed in the buffer zone if the GU@5 MHz network is reconstructed from a U900 network.
- The GSM S3/3/3 cells can use frequencies used by the GU@5 MHz cells because the pass loss between them can mitigate co-channel interference.
- If hardware of buffer zone area are ready, we can use GU 0 Bufferzone feature, so buffer zone area can deploy GU5MHz sites.

Solution Design: GSM Traffic Migration and Performance Assessment

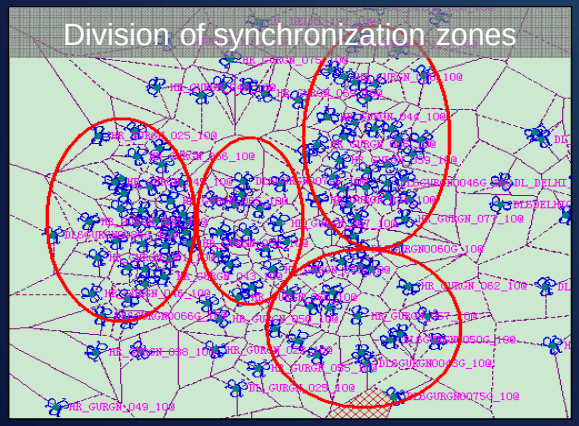


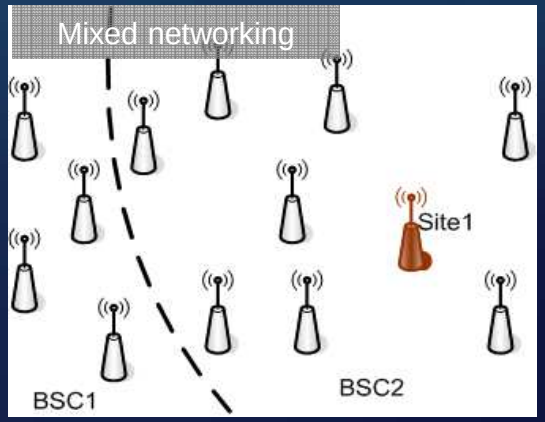
Refarming will reduce the G900 frequency, in order to guarantee the G900 network quality, traffic must be transferred from G900 to other band. There are three methods, traffic to G1800, traffic to U900, G900 TFR feature.

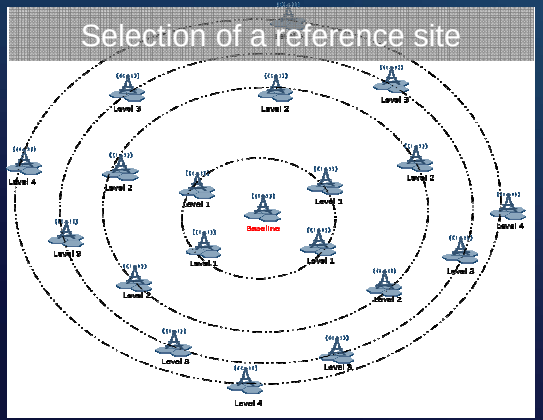
Solution Design: Soft Synchronization Planning

Using the planned frame number and offset, synchronization is performed for BTSs to reduce the number of GPS receivers. The site selection method for a soft synchronized network is as follows:

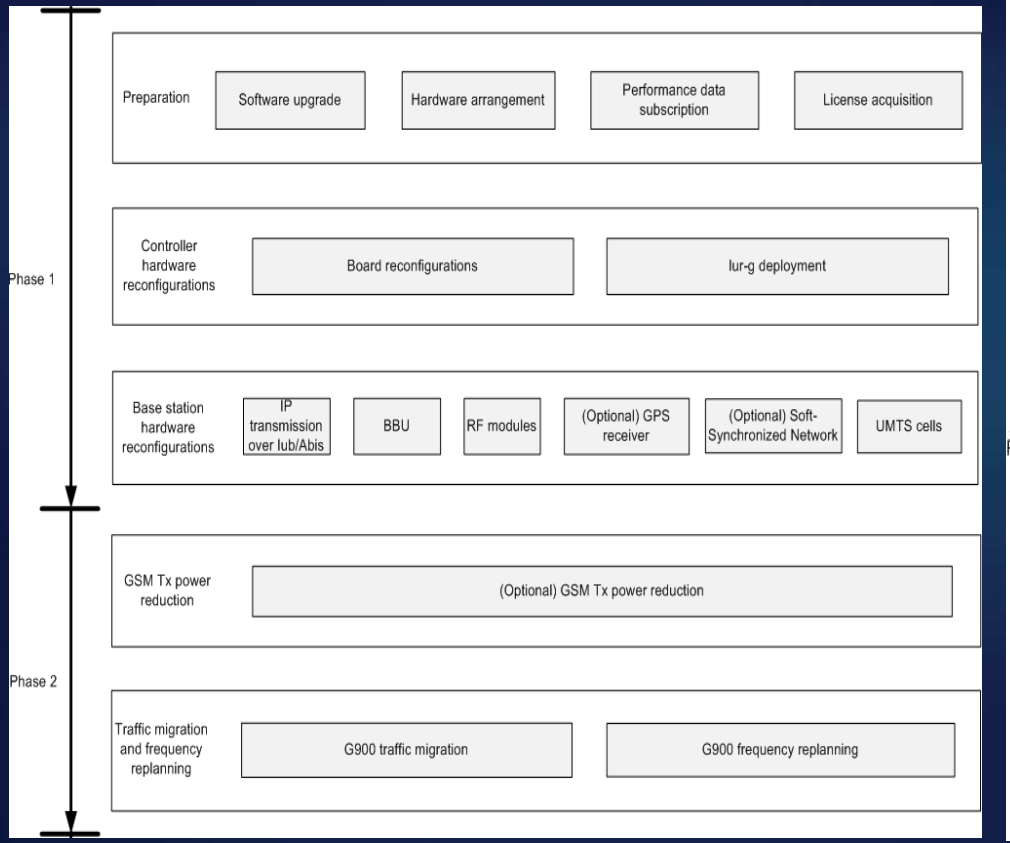
1. **Divide synchronization zones.** Based on the topology (displayed using MapInfo, U-net, or Nastar), the area including 20 to 25 BTSs under contiguous coverage managed by the same BSC serves as a synchronization zone.
2. **If a zone contains a base station served by another BSC,** rehome this base station or install a GPS receiver specific for this base station.
3. **Select a reference site.** Select the site in the center of the synchronization zone as the reference site and install a GPS receiver on the site. A maximum of four levels is recommended for the sites within a synchronization zone.

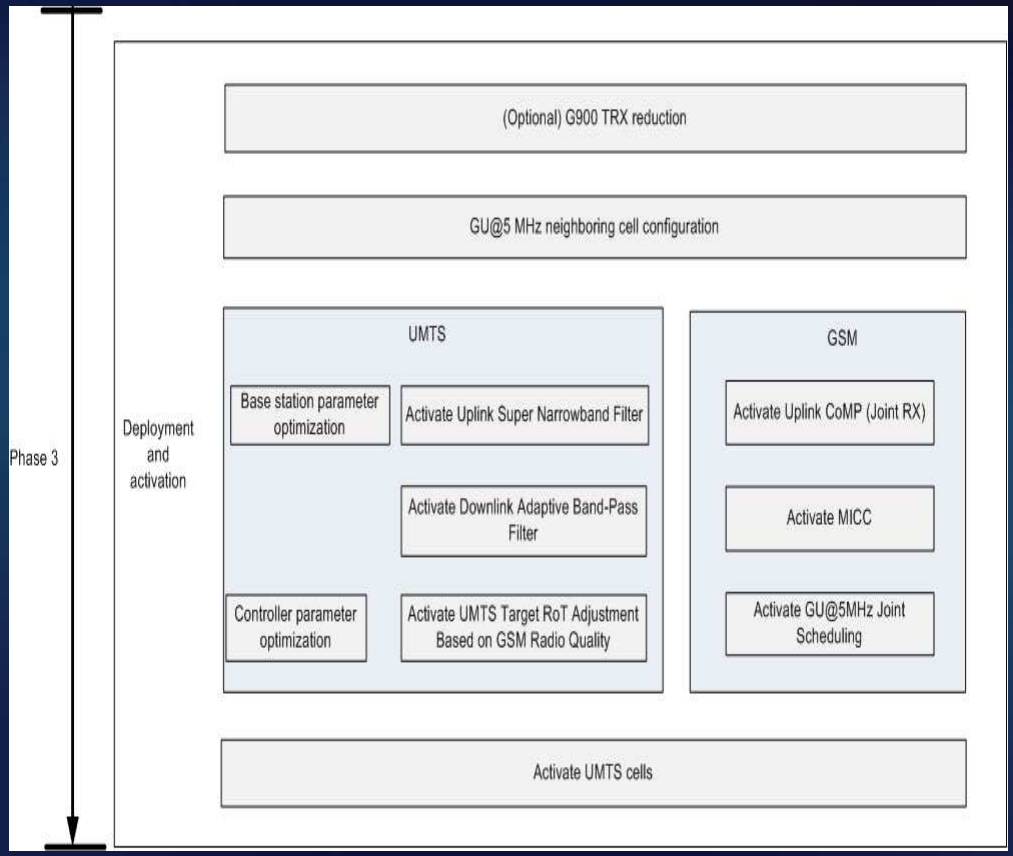






Solution Implementation: Process Overview





Solution Implementation: Hardware Resources Assess

The assessment of base station hardware resources involves the planning and assessment of **RF modules, BBU, clock synchronization, and transmission**.

RF module planning

- Check whether the RF module supports GU@5 MHz.
- Determine the GSM baseband equipment policy based on the model of the RF module.
- Check whether carrier specifications of the RF modules meet requirements for deploying GU@5 MHz.
- Check whether the power specifications of the RF modules meet the requirement.
- Check whether the GSM and UMTS networks share the antenna system.

BBU planning

- Check whether GSM/UMTS co-MPT (UMPT board sharing) is used.
- Check whether sufficient UBBPd boards have been configured.
- Check whether the UBBPd board is configured in slot 2 or slot 3 of a BBU3900 and the UBBPd board is connected to an RRU through the CPRI cable.
- Check whether auxiliary facilities such as the fans and power supply meet requirements for heat dissipation and power after reconstruction.

Clock planning

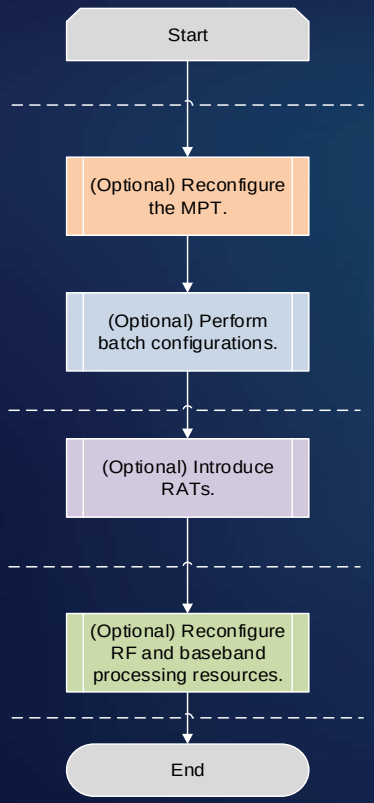
- Select the clock source based on customer requirements and determine the number of GPS receivers and the network reconstruction solution.

Transmission bandwidth planning

- Assess the transmission bandwidth over the Abis interface and expand the capacity.
- Assess the transmission bandwidth over the Iub interface and expand the capacity.

Solution Implementation: Base Station Reconfiguration

Generally, using the CME can facilitate reconfigurations. The process is detailed as follows. For details, see *GU@5 MHz Solution Deployment Guide (Based on the Standalone CME).*



Step 1: Reconfigure the MPT and perform batch configurations.

- Co-MPT reconstruction:

1. For co-MPT base stations, skip this step.
2. Co-MPT reconstruction enables device and transmission configurations of legacy sites to be inherited to the greatest extent.

- Batch configuration

1. In some scenarios, devices or transmission resources need to be reconfigured (such as subrack or route reconfiguration). You can reconfigure them in batches before or after co-MPT reconstruction.
2. Skip this step if no adjustment is needed.

Step 2: Introduce RATs.

1. If the reconfigured site supports GU or GUL, skip this step.
2. If the reconfigured site only supports GL, introduce the UMTS mode.
3. If the reconfigured site only supports UL, introduce the GSM mode.

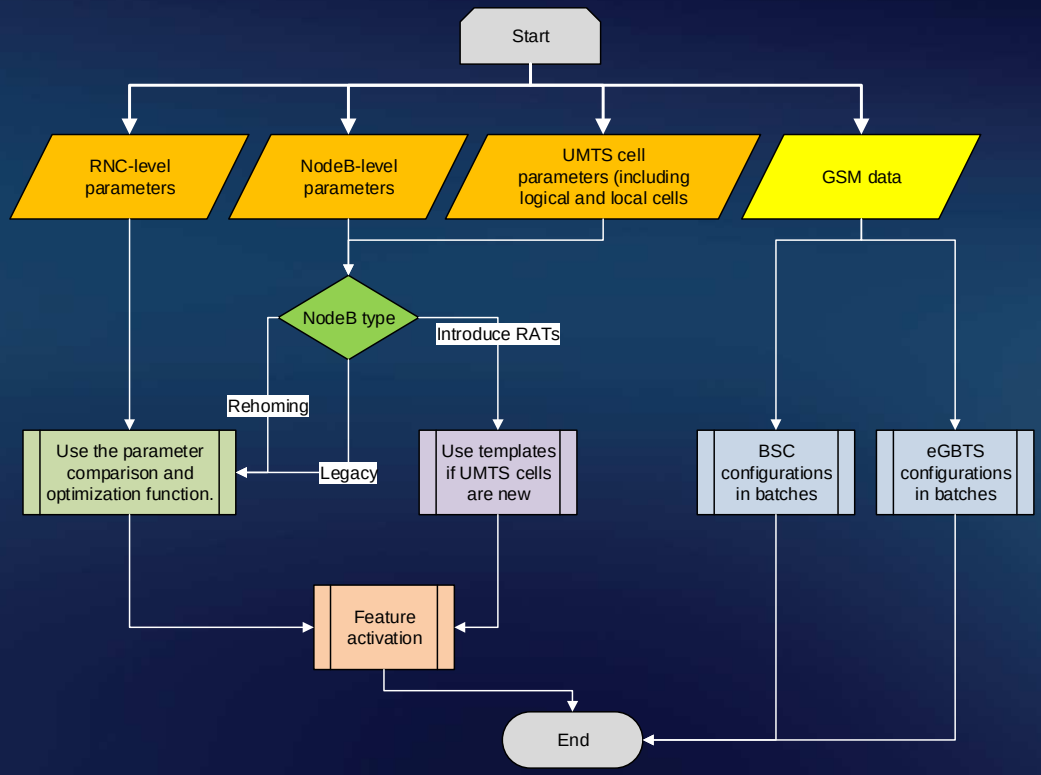
Step 3: Reconfigure RF and baseband processing resources.

1. Add U900 cells and related RF and baseband processing resources based on the plan of the Network Planning Department.
2. Skip this step if U900 cells have been configured.

Solution implementation: Deployment and Activation

GU@5 MHz deployment and activation mainly involve reducing G900 TRX configurations, configuring related optimization parameters on the UMTS network, and activating target features. The process is detailed as follows. For more details, see *GU@5 MHz Solution Deployment Guide (Based on the Standalone CME).*

1. GSM TRX reduction: using the frequency replanning function on the CME.
2. UMTS feature and optimization parameter configuration: feature parameters include RNC-level parameters, global parameters, and cell-level parameters. These features and parameters can be configured by the following three methods:
   - Using Radio templates and cell templates if UMTS cells are new.
   - Using the parameter comparison and optimization function if UMTS cells have been configured.
   - Using the batch configuration function to activate UMTS features.
3. GSM feature activation: using the batch configuration function on the CME.
4. UMTS cell activation: manually execute MML commands to activate GU@5 MHz cells.



Network Assessment: Acceptance Guidelines

The actual network performance may vary with field situations. The following part provides the guidelines.

Acceptance Scenario	U900 Acceptance Guidelines	G900 Acceptance Guidelines
Evolution from G900 to GU@5 MHz networks	U900 networks are newly deployed, which are accepted only by absolute value instead of relative value. Acceptance items: • U900 network-level KPIs • Uplink and downlink throughput (drive tests) • CS service MOS (only when demanded by the customer)	For legacy G900 networks: The KPI review committee checks KPIs before and after the solution deployment (with reconfigurations considered), and then provides acceptance results. Acceptance item: • G900 network-level KPIs
Evolution from U900 to GU@5 MHz networks	For legacy U900 networks, the KPI review committee provides acceptance results with solution impacts considered. Acceptance items: • U900 network-level KPIs • Uplink and downlink throughput (drive tests) • CS service MOS (only when demanded by the customer) • UMTS coverage (only when demanded by the customer)	• For G900 networks with TRXs added ➢ Deploying G900 networks: acceptance is performed based on baseline KPIs. ➢ Adding TRXs on legacy networks: The KPI review committee checks KPIs before and after the solution deployment (with reconfigurations considered) and then provides acceptance results. • For G900 networks with TRXs and carriers reduced for LTE network deployment: The KPI review committee checks KPIs before and after the solution deployment (with reconfigurations considered) and then provides acceptance results.

Detailed indicators are beyond the scope of this document and are specified by GSM and UMTS KPI review committee. The GU@5 MHz performance specifications are provided by comparing:

- UMTS' networks against 5-MHz U900 networks (UMTS' refers to UMTS carriers in GU@5 MHz scenarios)
- GSM networks against G900 S1/1/1@2.4 MHz networks

The KPI review committee provides acceptance standards for the uplink and downlink throughput in drive tests under some limitations (such as power load and code utilization) based on the networking. Acceptance on the average throughput in drive tests must be performed at cluster level.

Network Optimization

GU@5 MHz is a special refarming solution. Differing from common refarming solutions, GU@5 MHz enables GSM and UMTS cells share a spectrum. In this case, the GSM and UMTS signals interfere each other both on the downlink and uplink, affecting the capacity and KPIs.

The guidelines provided in this slide aim to troubleshoot the following issues after GU@5 MHz deployment:

- GSM KPIs deteriorate.
- Complaints about the GSM network increase.
- The KPIs of the UMTS network (U900) do not meet the standards.
- Complaints about the U900 network increase.

For details, see *GU@5 MHz Solution Delivery Guide*.

No.	Standard Action	Symptom	RAT	Occasion	Purpose
1	Checking KPIs	KPI problems	G/U	During implementation	**Check whether the KPI bidding commitment is too high to achieve and estimate network risks.**
2	Checking for known issues	None	G/U	During implementation	**Check whether the current version has known issues affecting GU@5 MHz implementation.**
3	Checking key parameters	None	G/U	After implementation	**Check the configuration of GU@5 MHz key parameters.** **Check prerequisite features and functional parameters.**
4	Checking GU frequency solutions	GSM KPI problems	GSM	After implementation	**Check whether the GU frequency solutions are proper.**
5	Checking GU power	UMTS capacity problems	G/U	After implementation	**Check whether the GU power ratio is proper and whether it is consistent with the solution design.**
6	Checking capacity and traffic migration	UMTS capacity problems, single-frequency congestion	G/U	After implementation	**Check based on the capacity test results and the KPI commitment.** **Check the result of traffic migration.** **Check the traffic migration design scheme.**
7	Check for interference	U900 interference	UMTS	After implementation	**Identify GSM network interference caused by GU@5 MHz, external interference, and eliminate GU intermodulation interference.**
8	Checking the antenna solution	U900 pilot pollution and interference	UMTS	During implementation	**Identify sites where deploying the co-antenna solution is improper and perform antenna optimization.** **Evaluate the performance of the co-antenna solution after refarming and provide description of the impact on network.**
9	Checking U900 performance	U900 KPI problems	UMTS	After implementation	**Identify U900 KPI problems and perform relevant optimization.**
10	**Checking G900 performance**	**G900 KPI problems**	**GSM**	**After implementation**	**Identify G900 KPI problems and perform relevant optimization.**

Thank you