Project	IEEE P802.16 Broadband Wireless Access Working Group
Title	TDD Frequency Re-Use for BWA
Date Submitted	20 June 1999
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Re:	Call for contributions on coexistence, posted on the IEEE 802.16-web site, June 1999. Specifically, this contribution demonstrates that TDD systems can be deployed successfully in both symmetric and asymmetric configurations and achieve the required grade of service required for BWA applications.
Abstract	It has been stated that TDD will experience interference limitations when deployed in a point to multipoint configuration. While internal LMDS/LMCS frequency re-use issues have been identified to not be specifically studied within the framework of 802.16, this contribution will demonstrate these negative statements to be incorrect. This contribution will demonstrate that suitable re-use methodologies can be developed that meet acceptable interference objectives and do not require synchronization.
Purpose	To demonstrate to the 802.16 standards committee that TDD will meet acceptable interference criteria, perhaps even superior to FDD.
Notice	This document has been prepared to assist the IEEE P802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16. However, Wavtrace consider the re-use methodology concepts to be unique and proprietary. Patent filings are currently in progress.

TDD FREQUENCY RE-USE FOR BWA

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OBJECTIVES

- **To Develop Repeatable Frequency Re-Use Plans**
- **To Constrain Interference to Within Controlled Limits**
- **To Facilitate Dynamic Asymmetric TDD Operation**
- **To Estimate Interference Grade of Service (GOS) Performance**

SYSTEM ASSUMPTIONS

- **Asynchronous Transmission Between Cells**
- **Asynchronous Transmission Between Cell Sectors**
- **LOS Primary Path Transmission**
- **LOS Interference Paths**
- **Arbitrary Interference Blockage**

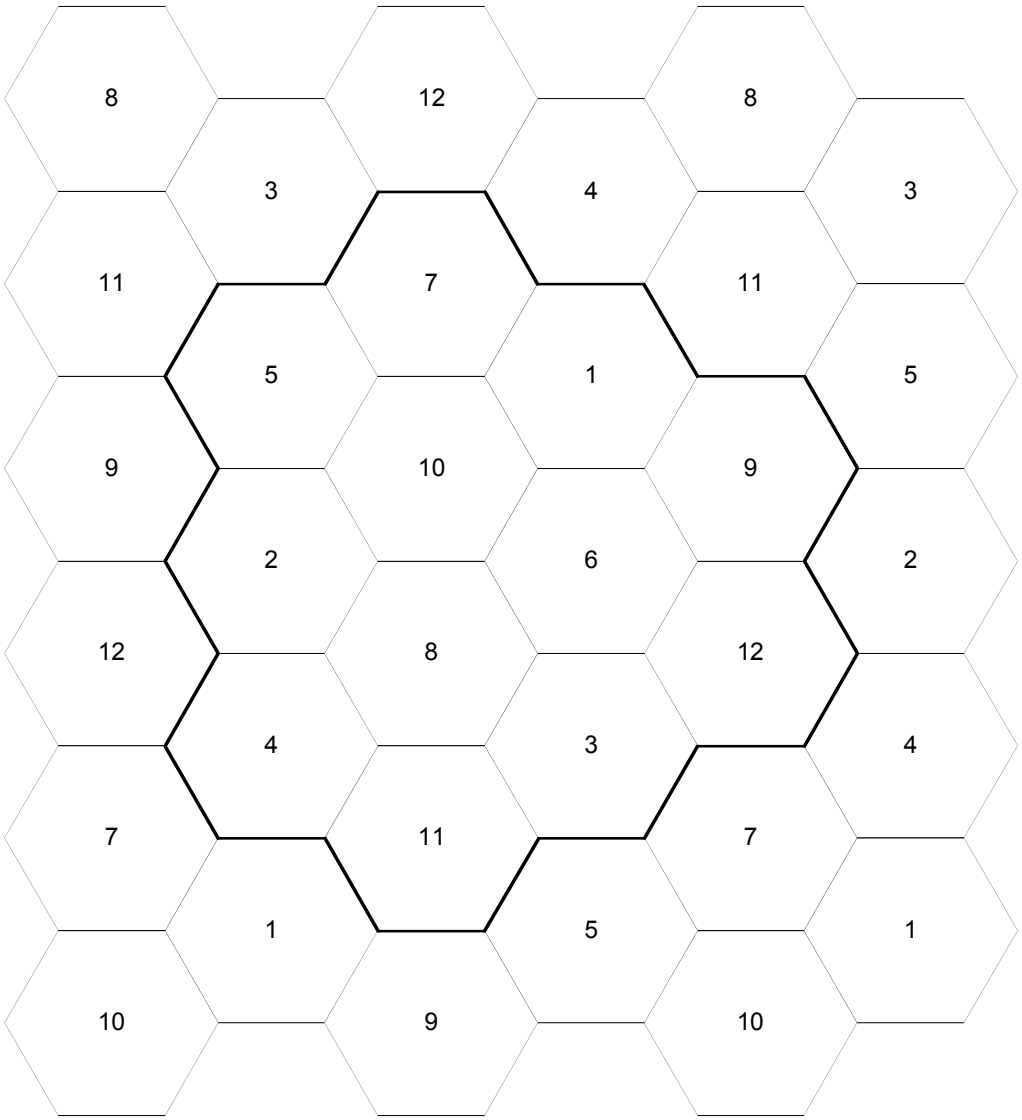
CLUSTER DESIGN METHODOLOGY

- **Tessellating Re-Use Plans**
- **Borrow From the Mathematical Theory of Geometry**
  - **Coxeter, Introduction to Geometry, Wiley, 1989**
- **Sector Rotation to Minimize Interference Exposures**
- **Utilize both V-Pol and H-Pol**
- **Signal Balance:**
  - **Employ Inbound Power Control**
  - **No Outbound Power Control**

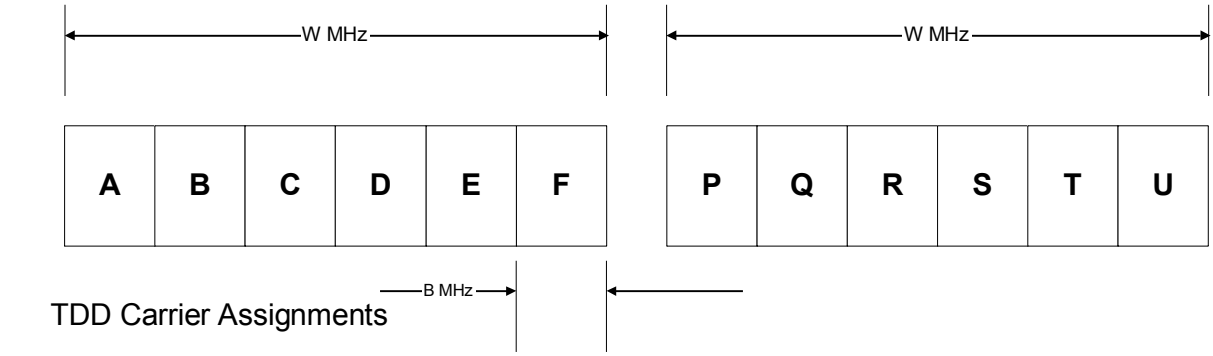
EXAMPLE: N=12, 30 DEGREE SECTORS

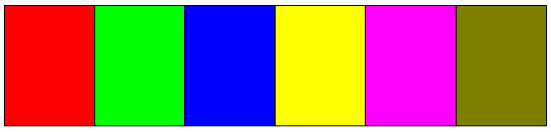
- **Total Number of Carriers=12 (Only 6 FDD Paired Carriers)**
- **12 TDD Carriers ← 2 Pol = 24 Degrees of Freedom**
- **Sector Repeat at 180 Degrees**
- **Sector Assignments Per Cell = 180/30 = 6**
- **Distinct Cell Types = 24/6 = 4**
- **Rotated Cell Type Repeat = 12/4 = 3**

- **No Same Frequency-Cross Pol Sector Assignments Within a Cell**
- **No 1'st Adjacent Flanking Carriers Within a Cell**
- **2'nd Adjacent Flanking Carriers at Least 2 Sectors Removed (60 Degrees)**
- **Significant Rain Fade Correlation on Major Interference Paths**



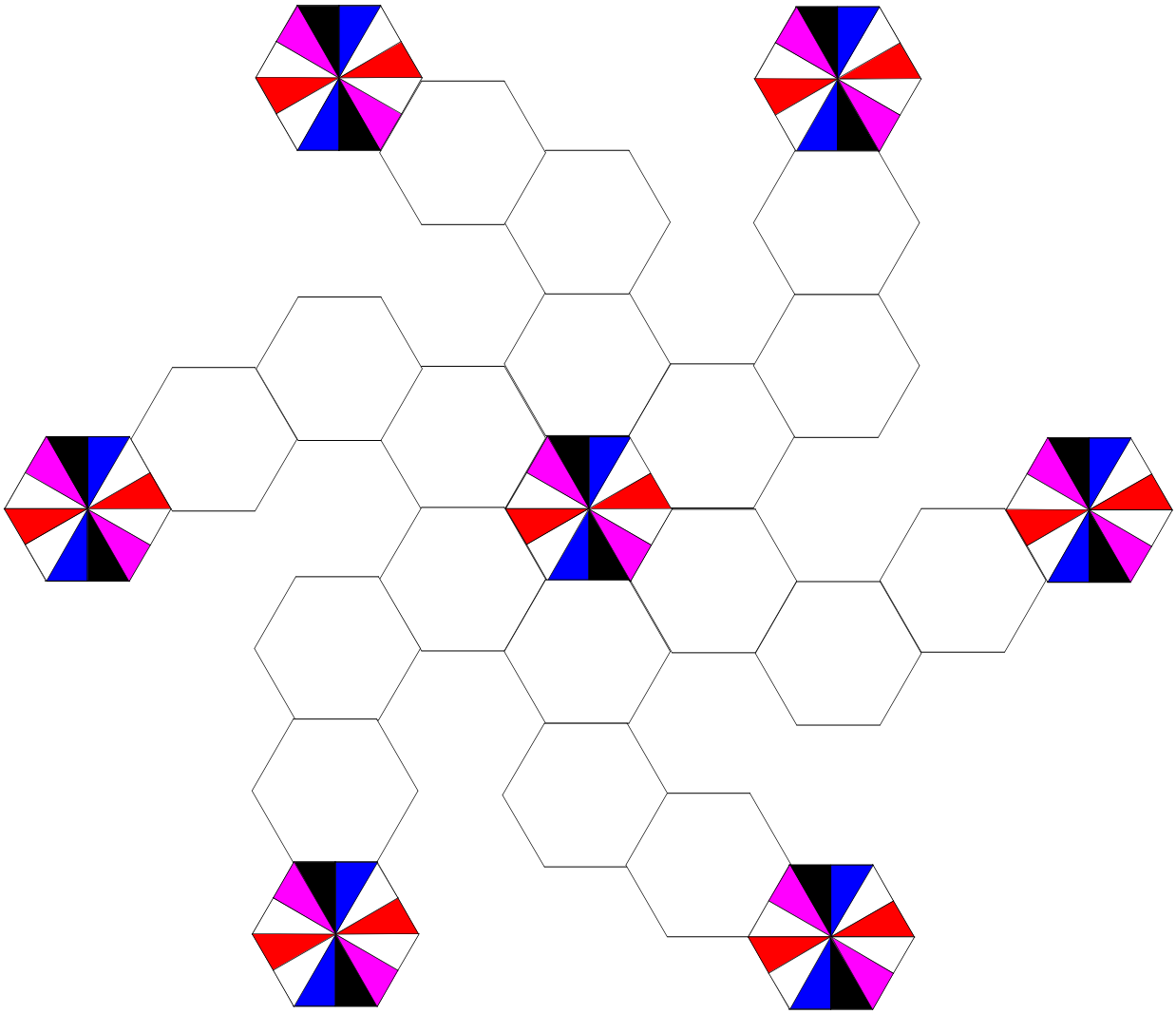
N=12 Frequency Re-Use Plan



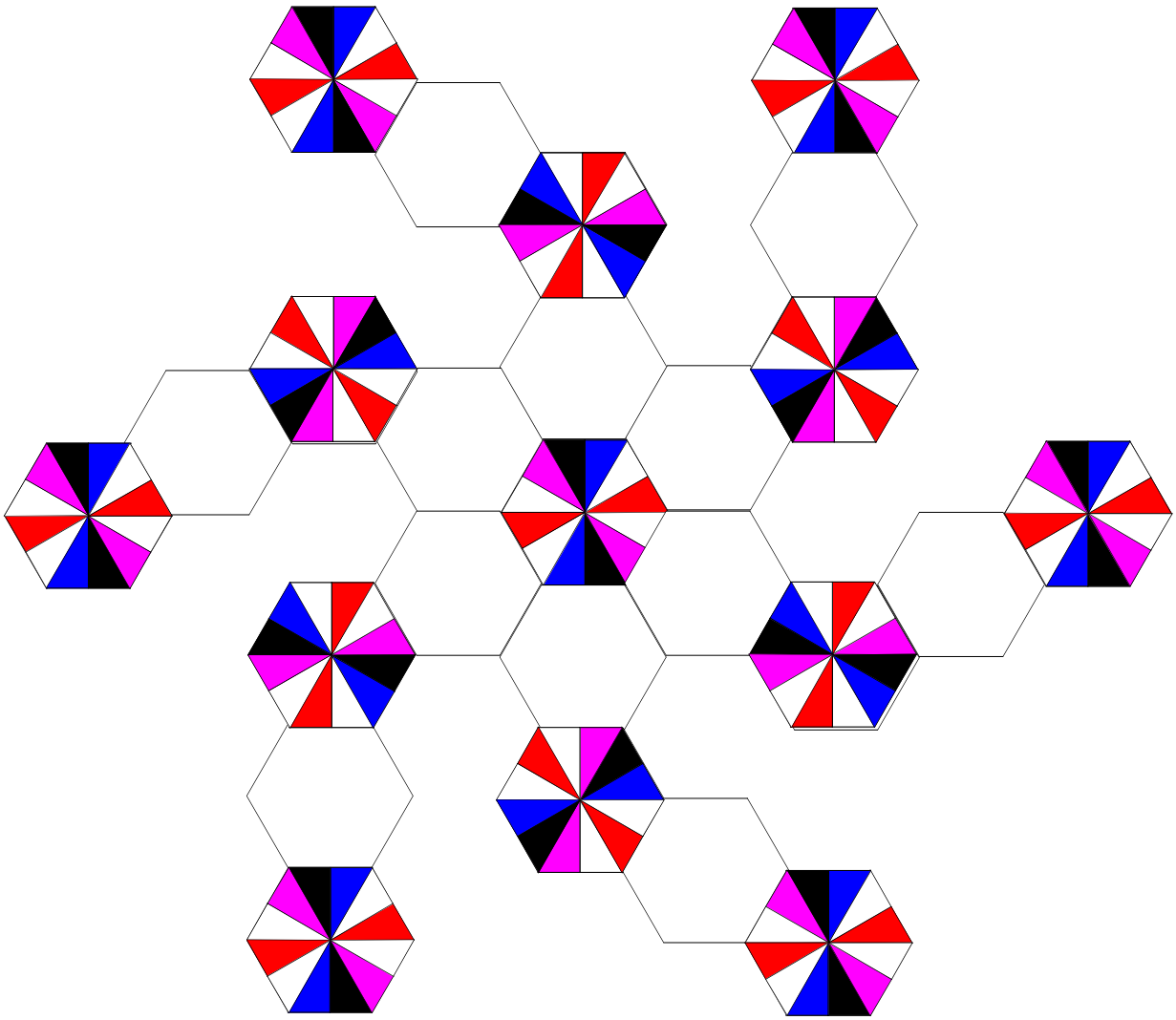


Cell Type 1

Reference Polarization (H/V) and Frequency Assignments for 30 degree Sectors



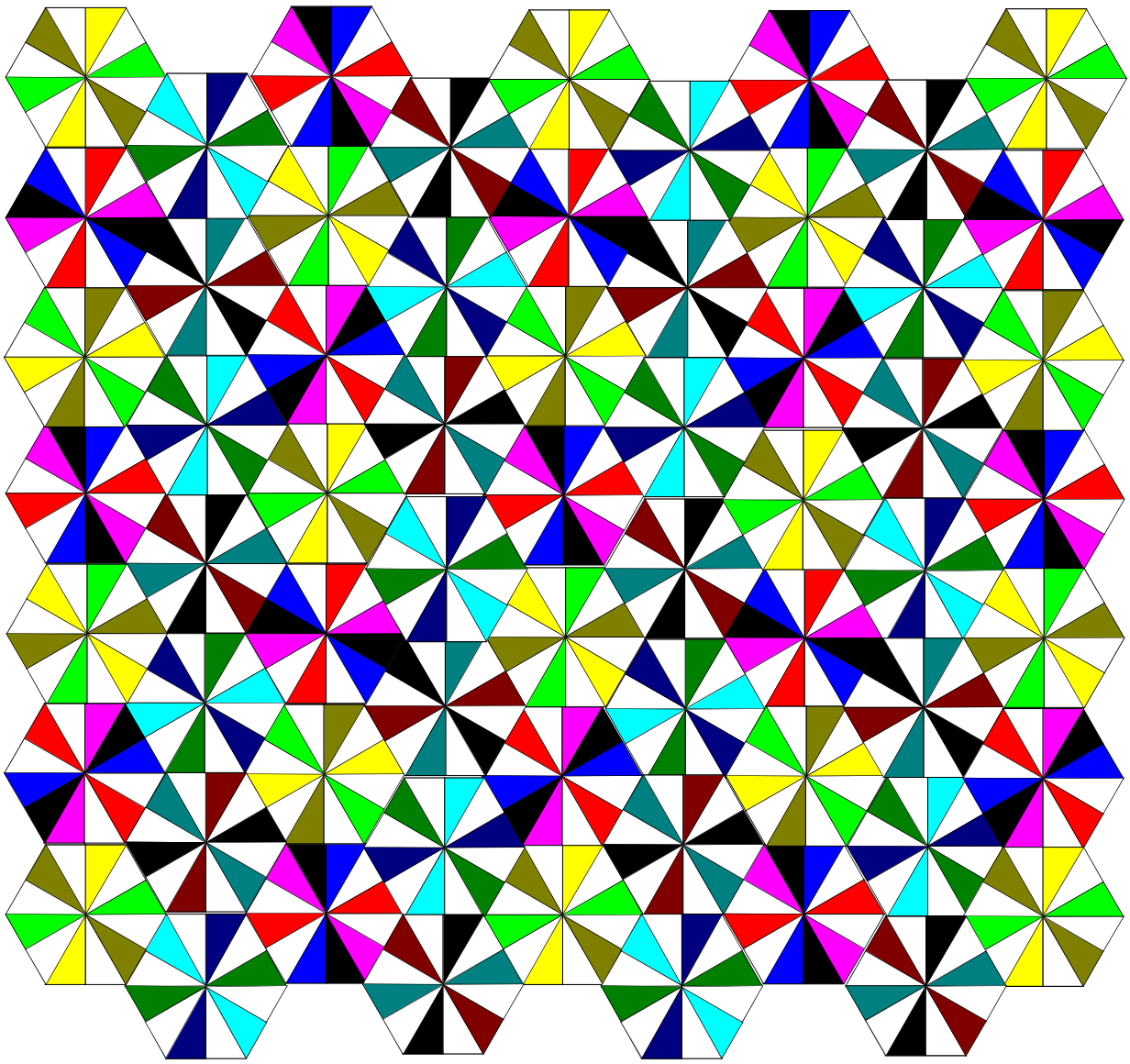
Nearest Neighbor Repeat Pattern



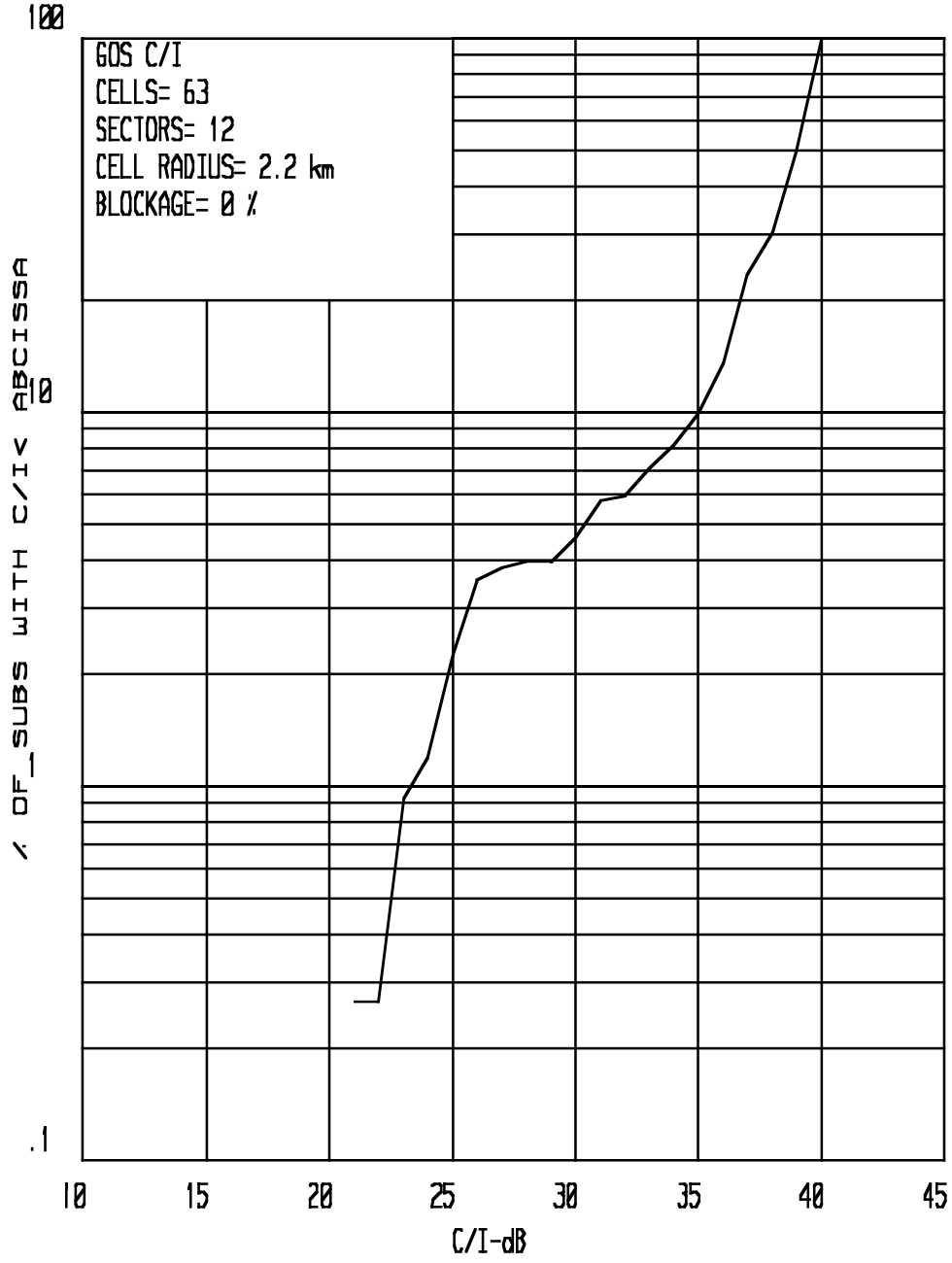
Nearest Neighbor and 60 Degree Sub-Cluster Assignments for Cell Type 1

GRADE OF SERVICE SIMULATION

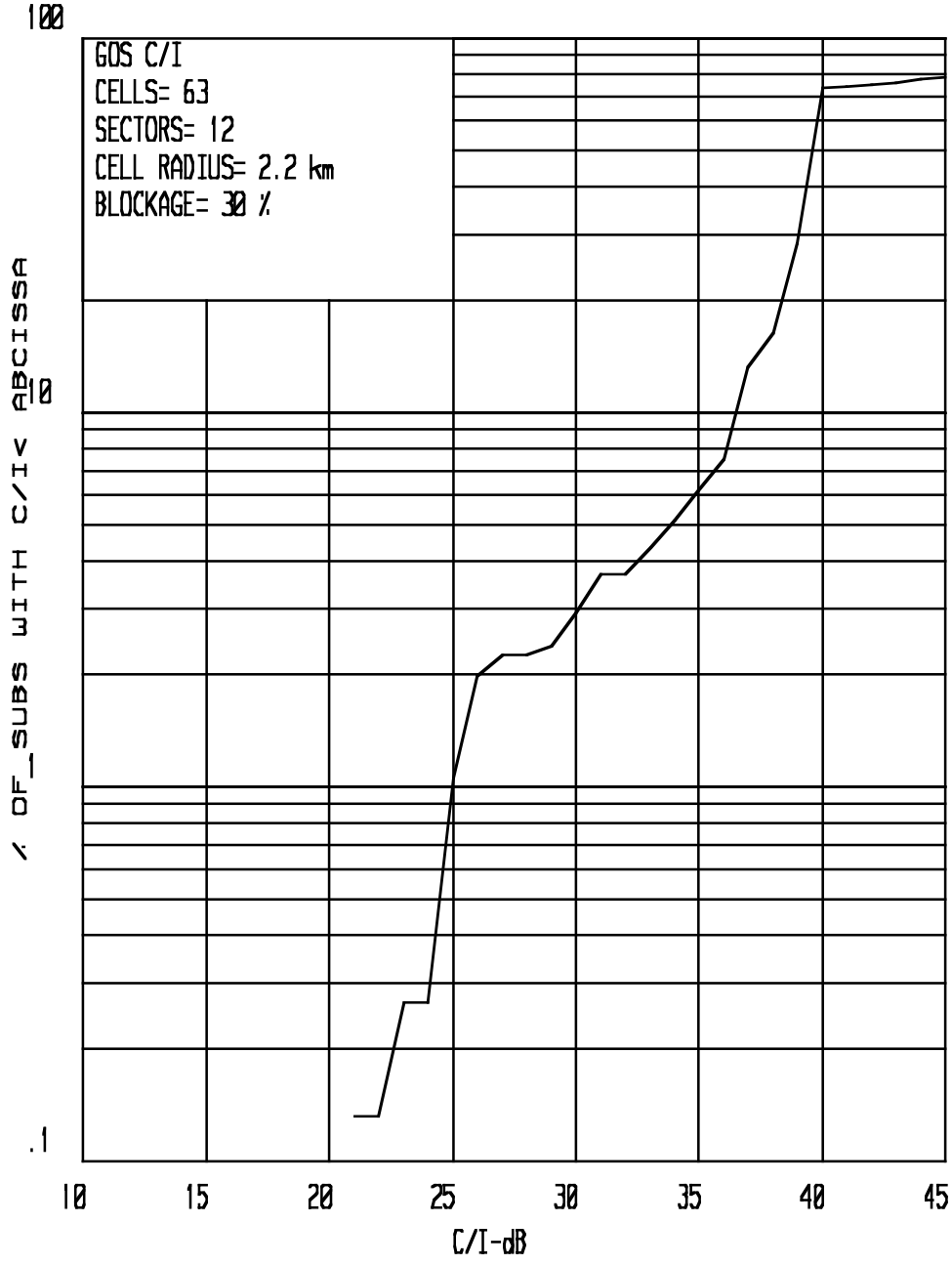
- **Randomly Locate a Subscriber on the Edge of a Sector**
- **Sequentially Assign Interference Source to All Sectors of all Cells**
- **Randomly Assign an Interference Source to be Outbound or Inbound**
- **Compute Interference from Each Vector Referenced to:**
  - **Distance**
  - **Antenna Gains**
  - **Power Control**
  - **Antenna Angular Discrimination**
  - **Antenna XPD**
  - **Co – Adjacent Channel Interference Levels**
  - **Blockage**
  - **Rain Correlation**
- **Compute Composite Interference Level**
  - **63 Cells←12 Sectors –1=755 Interference Vectors**
- **Repeat by Sequentially Reassigning Victim Subscriber to all Sectors of all Cells**
  - **63 Cells←12 Sectors=756 Interference Estimates**
- **Sort Data and Compute GOS**



GOS Simulation Grid



GOS for Randomly Located Interference and Victim Subscribers at Blockage=0%


GOS C/I
CELLS= 63
SECTORS= 12
CELL RADIUS= 2.2 km
BLOCKAGE= 30 %
100
10
.1
% OF_SUBS WITH C/I< ABCISSA
10
15
20
25
30
35
40
45
C/I-dB

SUMMARY

- **TDD PROVIDES TWICE THE NUMBER OF FREQUENCY ASSIGNMENTS AS FDD**
- **TDD EFFECTIVLY UTILIZES THESE ADDITIONAL FREQUENCIES TO DEVELOP REPEATABLE FREQUENCY RE-USE PLANS**
- **TDD ASYNCHRONOUS OPERATION IS NOT AN ISSUE WHEN PROPER RE-USE DESIGN IS EMPLOYED**
- **ASYMMETRIC TDD OPERATION DOES NOT WASTE BANDWIDTH AS MAY FDD**
- **A TDD FREQUENCY RE-USE AND GOS EXAMPLE CONFIRMS TDD PERFORMANCE TO BE WITHIN CONTROLLED INTERFERENCE LIMITS**
- **NO FREQUENCY RE-USE OR GOS EXAMPLES FOR FDD HAVE BEEN PRESENTED THAT SUGGEST THAT FDD CAN EVEN WORK WITH ITSELF LET ALONE COEXIST WITH TDD**
- **NEGATIVE CONTRIBUTION COMMENTS RELATIVE TO TDD HAVE BEEN DEMONSTRATED TO BE OPINIONATED AND INCORRECT**