Overview

The purpose of this site survey is to provide AP placement based on predictive RF behavior and Wireless LAN (WLAN) performance for the facility. The recommendations from this survey will be provided as follows:

(a) AP placement
(b) Other Wireless Considerations

Installer NEED TO KNOW

The following items are required "NEED TO KNOW" details are for all installers, specifically:

- **Line of Sight Rule**
- **Proper Antenna Angle Photo**
- **Proper Forward Area at Elevation Photo**

Line of Sight Rule

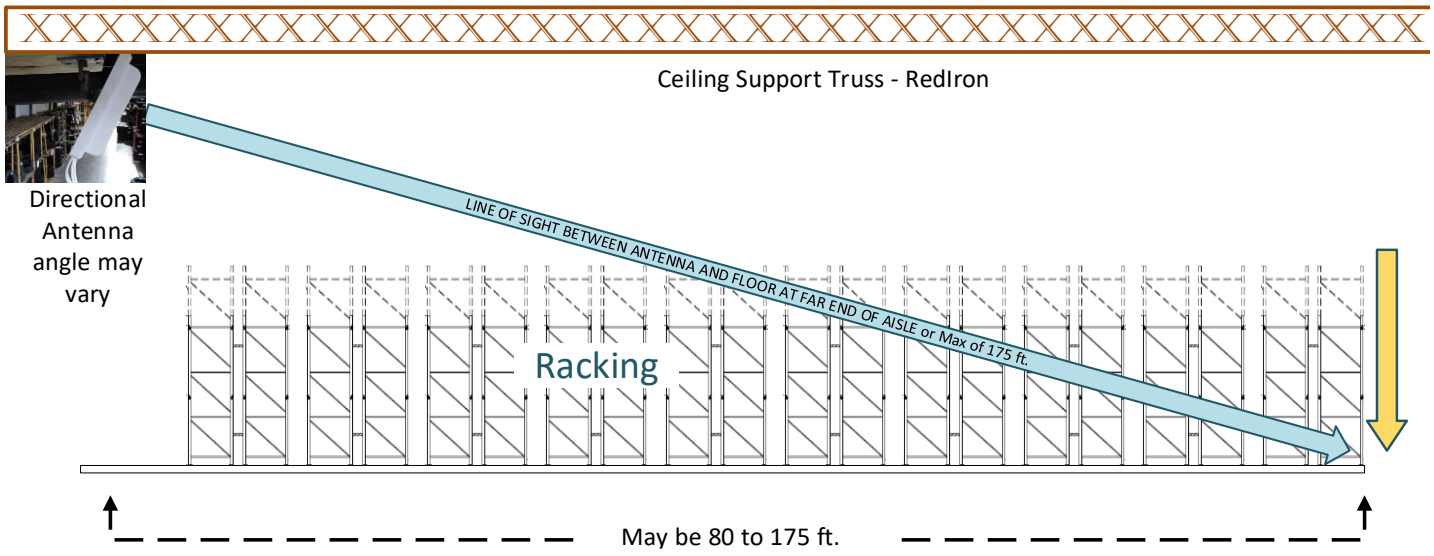


Figure 1: Line of Sight Rule

Installers should always keep the **Line of Sight Rule** in mind when determining proper antenna placement. There should be no pipes, HVAC units or ductwork, light fixtures, support trusses or any other structures in the **Line of Sight** between the antenna and potential location of client devices. This includes **Line of Sight** servicing lifts operating at the highest racking elevation.

To document proper **Line of Sight** installers should include photos that show the area directly forward of the directional antenna AT EVELVATION of the antenna in addition to photos taken from down the aisle.

In addition, installers should provide photos AT ELEVATION of the antenna clearly showing everything in the immediate area around the antenna including immediately to the right, left and behind the antenna.

Installer NEED TO KNOW *continued*

Photos for Directional Antenna Angle

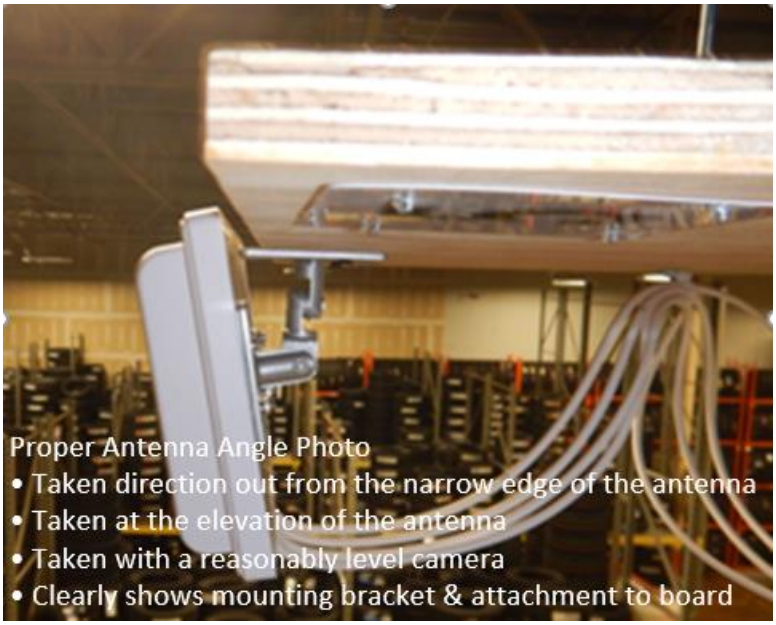


Figure 2: Proper Antenna Angle Photo

Sample Photo clearly showing area just forward of antenna taken at elevation from behind shown below

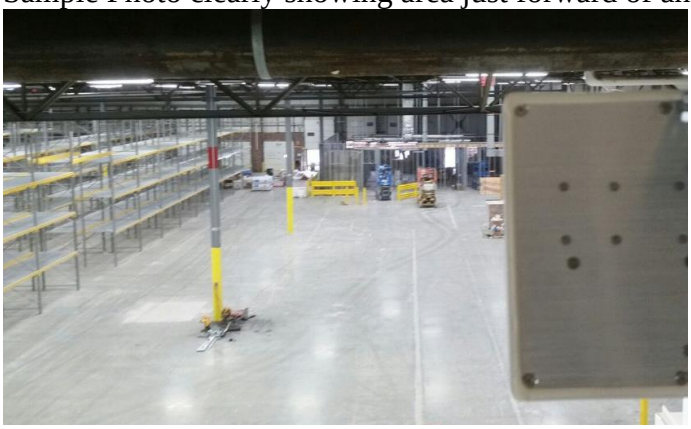


Figure 3: Proper Forward Area at Elevation Photo

Proper method for lowering antenna using all-thread rod. Note that cable management illustrated is <u>not correct</u>.

Figure 4: All-thread method

There are numerous other considerations for installers detailed in the Installer Instructions below.

AP Placement

Physical Placement of the APs

See AP placement below shown with designation for both directional and downfacing directional antennas. Red arrows are used to signify directional antenna orientation and downfacing antenna orientation is designated by rectangular symbols.

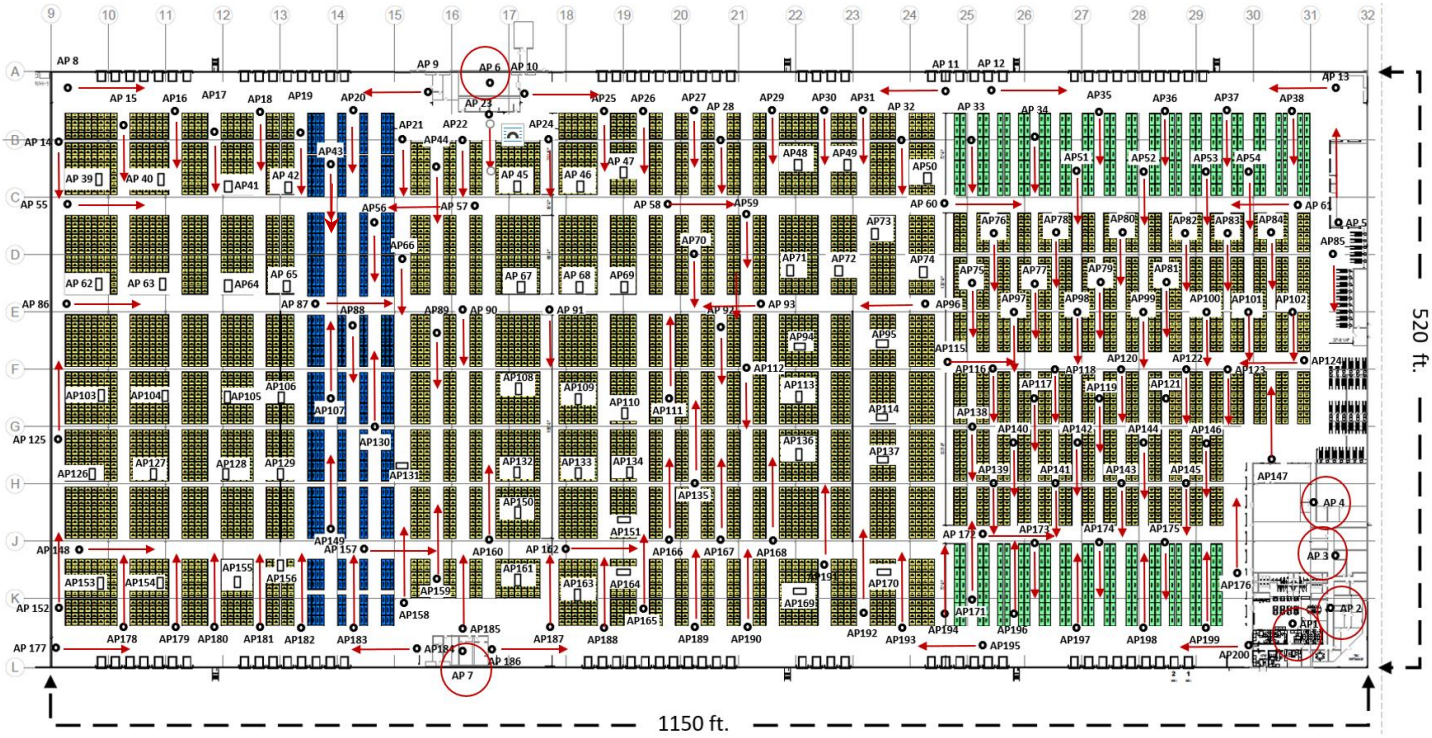


Figure 5: AP Placement

Note: No outdoor AG area at this facility

Antenna Model Detail

AP	Antenna Model
AP-1	Cisco 2802i Internal Antenna
AP-2	Cisco 2802i Internal Antenna
AP-3	Cisco 2802i Internal Antenna
AP-4	Cisco 2802i Internal Antenna
AP-5	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-6	Cisco 2802i Internal Antenna
AP-7	Cisco 2802i Internal Antenna
AP-8	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-9	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-10	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-11	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-12	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-13	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-14	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-15	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-16	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-17	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-18	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-19	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-20	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-21	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-22	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-23	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-24	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-25	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-26	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-27	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-28	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-29	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-30	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-31	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-32	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-33	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-34	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-35	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-36	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-37	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-38	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-39	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down

Table 1: Antennas

Antenna Model Detail *continued*

AP	Antenna Model
AP-40	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-41	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-42	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-43	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-44	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-45	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-46	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-47	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-48	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-49	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-50	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-51	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-52	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-53	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-54	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-55	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-56	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-57	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-58	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-59	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-60	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-61	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-62	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-63	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-64	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-65	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-66	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-67	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-68	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-69	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-70	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-71	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-72	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-73	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-74	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-75	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-76	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz

Table 2: Antennas

Antenna Model Detail *continued*

AP	Antenna Model
AP-77	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-78	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-79	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-80	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-81	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-82	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-83	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-84	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-85	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-86	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-87	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-88	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-89	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-90	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-91	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-92	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-93	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-94	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-95	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-96	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-97	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-98	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-99	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-100	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-101	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-102	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-103	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-104	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-105	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-106	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-107	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-108	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-109	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-110	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-111	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-112	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-113	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down

Table 3: Antennas

Antenna Model Detail *continued*

AP	Antenna Model
AP-114	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-115	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-116	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-117	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-118	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-119	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-120	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-121	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-122	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-123	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-124	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-125	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-126	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-127	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-128	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-129	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-130	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-131	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-132	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-133	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-134	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-135	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-136	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-137	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-138	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-139	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-140	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-141	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-142	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-143	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-144	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-145	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-146	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-147	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-148	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-149	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-150	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down

Table 4: Antennas

Antenna Model Detail *continued*

AP	Antenna Model
AP-151	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-152	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-153	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-154	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-155	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-156	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-157	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-158	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-159	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-160	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-161	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-162	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-163	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-164	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-165	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-166	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-167	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-168	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-169	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-170	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down
AP-171	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-172	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-173	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-174	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-175	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-176	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-177	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-178	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-179	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-180	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-181	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-182	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-183	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-184	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-185	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-186	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-187	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-188	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-189	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz

Table 5: Antennas

Antenna Model Detail *continued*

AP	Antenna Model
AP-190	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-191	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-192	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-193	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-194	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-195	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
AP-196	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-197	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-198	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-199	TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
AP-200	TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam

Table 6: Antennas

BOM

(6) Cisco 2802i Internal Antenna
(74) TerraWave 503910 / M6060060P1D43602V 2.5/5GHz
(66) TerraWave 2.4/5 GHz 6 dBi 349502 / M6060060MP1D43602 Narrow Beam
(0) TerraWave 515086 / M6060060P23602 2.5/5GHz 6 dBi High Density
(54) TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down

Installer Instructions

The TerraWave 2.4/5 GHz 6 dBi quad patch (MIMO) antenna M6060060P1D43602V & M6060060MP1D43602 ship with a dual adjustable articulating mount show below in figure 14. Additional consideration for indoor & outdoor applications are detailed below.

Indoor Application

The following recommendations apply to the indoor antenna mounts.

- Maximum antenna mount height is 32 ft. Preferred antenna mount height is 28 ft. except for the TerraWave 503910 / M6060060P1D43602V 2.5/5GHz Facing Down. The down-facing antenna provides more coverage with higher install height so install the down-facing antennas at the maximum height practical.
- Do not install antennas next to light fixtures or HVAC in warehouse or office.
- Avoid mounting antennas directly behind light fixtures or other equipment.
- Avoid mounting antennas near any large flat metal surface.
- Avoid mounting antennas near sprinkler pipes or other piping.
- Do not install antennas inline or very near to support pillars
- Install directional antennas just under the elevation of the BOTTOM of any nearby light fixtures, trusses or pipes.
- Mount all office as shown in figure 5. Keep away from lighting and HVAC venting.
- Mount directional antennas for APs 8-9-10-11-12-13-177-184-186-195-200 centered between the nearby rack edge and respective outside wall
- Mount directional antennas for APs 8-9-10-13-23-61-177-185-186-200 on the wall if practical.
- Center all directional antennas within the aisle while maintaining distance from lighting.
- Mount all downfacing antennas to board with mounting bracket provided. Do not mount antenna directly on board unless there is no metal (red iron) directly behind entire area where antenna is mounted
- Make certain to orient all downfacing antennas as shown in figure 5.
- Angle all directional antennas down by one notch. See figure 2 Proper Antenna Angle Photo on page 2.

Please remember if in doubt, call before moving forward with antenna installations

Heat Maps

Below is the heat map with the signal strength key. The least signal predicted is -65 dBi in a few very small area and the vast majority of the site is predicted for signal strength in the high -5X dBi range or better.

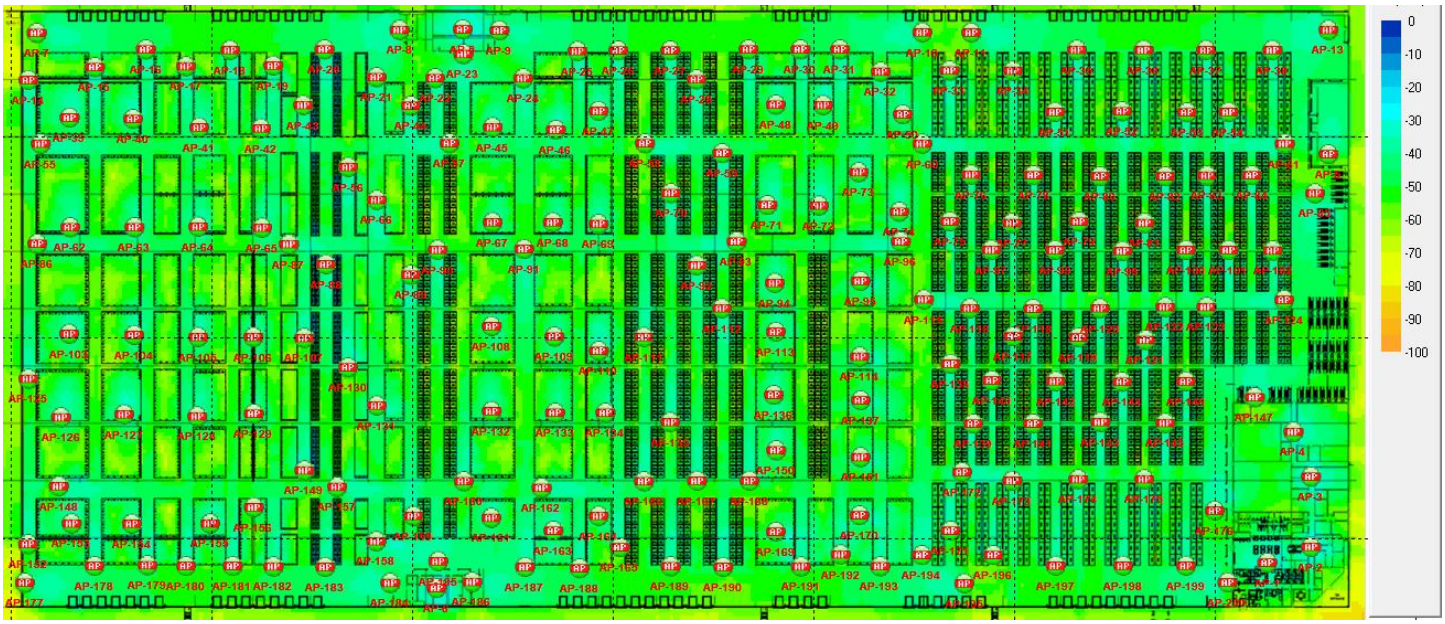


Figure 6: 5 GHz heat map

PHY Data Down Rate

The PHY Data Down rate for 5 GHz is shown to be 289 Mbps across the facility. This PHY rate is the same for both 2.4 & 5 GHz ranges and a channel width of 20 MHz is used.

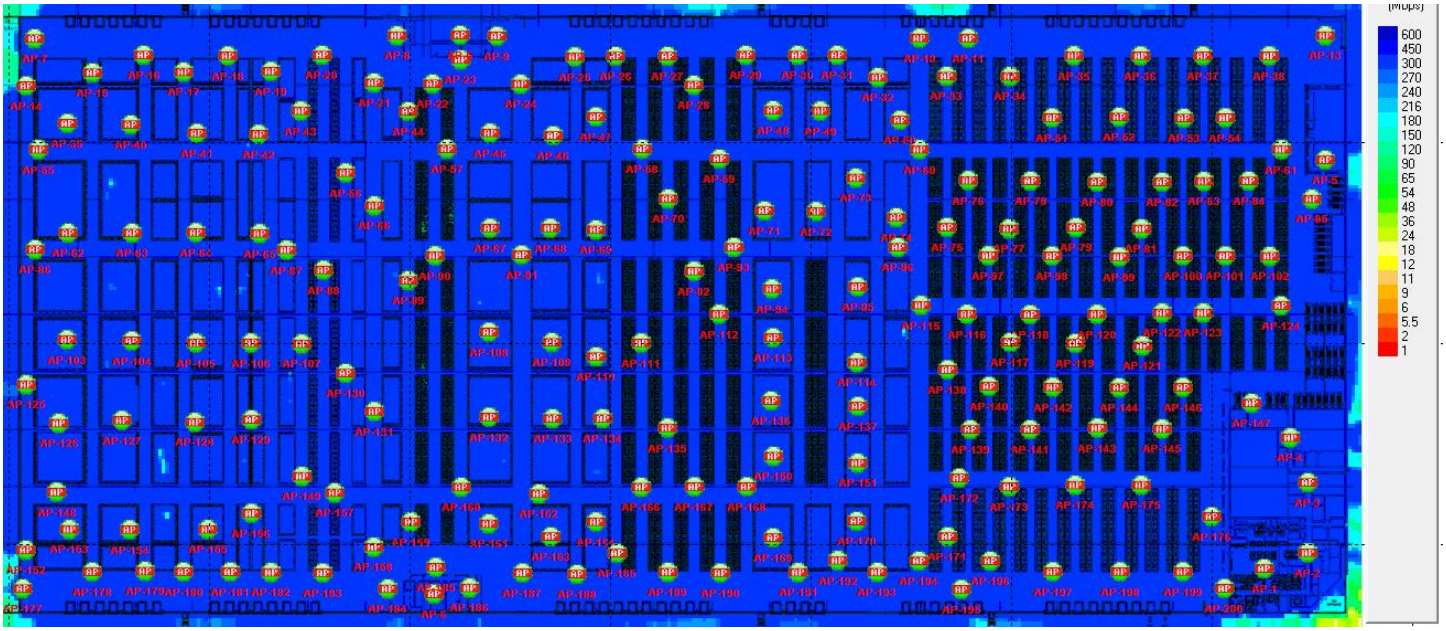


Figure 7: 5 GHz PHY

Heat Maps *continued*

Throughput

Overall throughput in the 5 GHz range is likely a more true predictor of performance as opposed to the above PHY. The throughput rate predicted is 171 Mbps across the facility. Throughput for 2.4 GHz range is exactly the same.

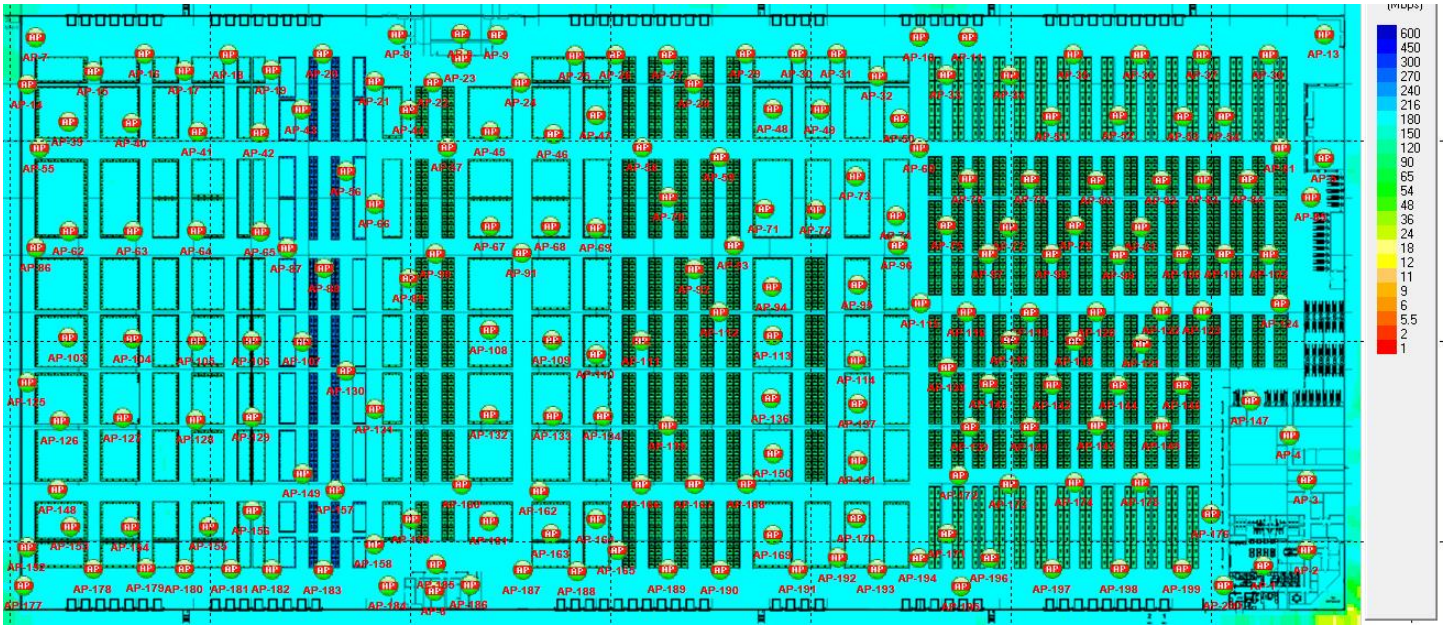


Figure 8: 5 GHz Throughput

Note that the MCS Index for 5 GHz was 31 and MCS Index for 2.4 GHz was 31 across the facility.

Additional Mounting Detail

Survey Approach

This predictive survey is conducted with simulated dBi losses that vary as there are different wall and structure compositions expected to influence RF patterns. These losses are based on real-world observations. Also outside concrete walls, metal doors and office drywall walls are simulated. The heat maps above show the expected coverage based on 50 mWatts of power with each AP with the recommended antennas specified in table 1 mounted at a height of 32 ft.

Heat Map Color Key & Acceptable Signal Strength Range

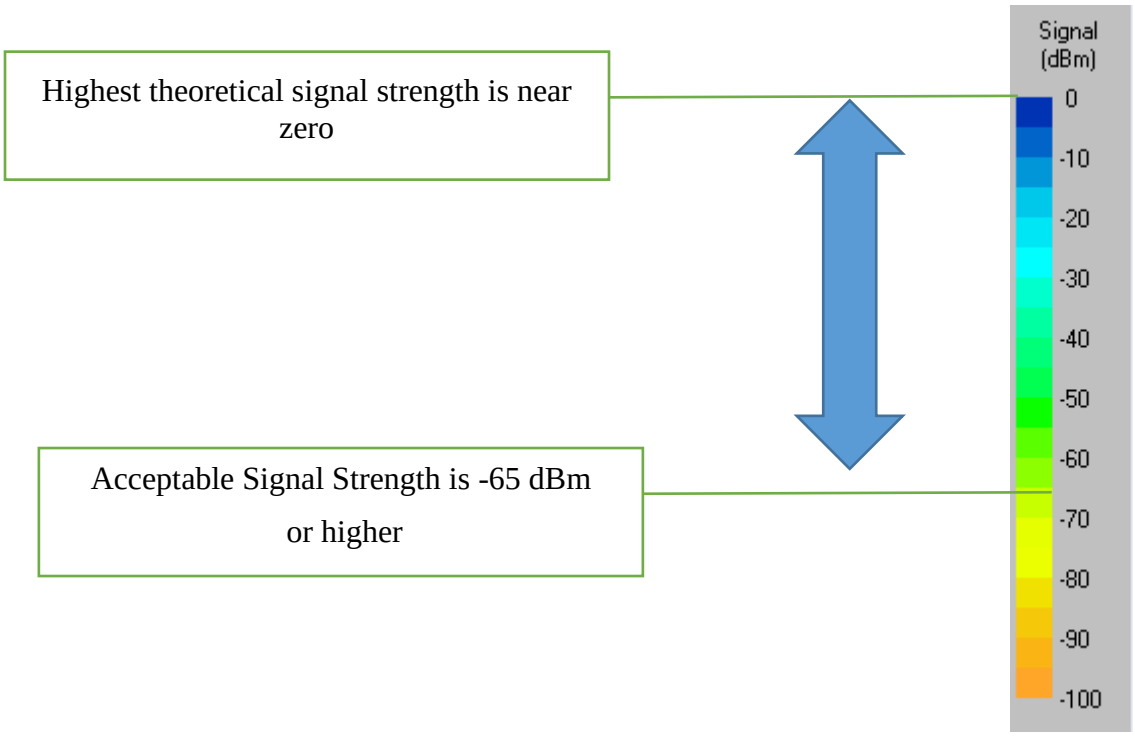


Figure 9: Signal strength color reference

"Heat Map" colors for signal strength can be easy to read.
Generally, the darker, the better on these reports
Yellow and orange areas indicate signals are too weak
Light green-yellowish is one the edge of acceptable (-62 to -65 dBi)

Special Consideration

This design incorporates extensive use of the downfacing directional antennas in place of the omnidirectional antennas widely deployed prior to the Grand Prairie TX design. Site switching to the downfacing antenna implementation no on-site wireless surveys have been conducted therefore the exact behavior and real-world radiation patterns are not known. The custom radiation pattern for the downfacing directional antennas employed in all designs was created in AirMagnet by working directly with the antenna equipment manufacturer engineers and is a best effort attempt to predict coverage. However, a much better understanding of the actual radiation patterns and behaviors will only be known after an on-site wireless survey can be conducted.

Figure 10: Cisco AIR-2802E shown with dipole antennas

Survey AP: Cisco 2802e Key Features

- 802.11ac Wave 2 with 4x4 multiuser multiple-input multiple-output (MU-MIMO) technology supporting three spatial streams. MU-MIMO enables access points to split spatial streams between client devices to maximize throughput.
- Best-in-class RF architecture, which provides high-performance coverage for a high density of client devices, giving the end user a seamless wireless experience. HDX includes features such as custom hardware in 802.11ac Wave 2 radios, Cisco CleanAir®, ClientLink 4.0, cross-access point noise reduction, and an optimized client roaming experience.
- MIMO equalization capabilities, which optimize uplink performance and reliability by reducing the impact of signal fade.
- IMPORTANT NOTE: Smart antenna connector can be utilized when running the flexible radio as either a second 5-GHz serving radio or Wireless Security Monitoring radio

Cisco Aironet 2800 Series Access Points Data Sheet
http://www.cisco.com/c/en/us/products/collateral/wireless/aironet-2800-series-access-points/datasheet-c78-736497.html

Predictive Survey Equipment: HP EliteBook xw8770

Specifications
Intel Core i7-3610QM 2.30 GHz
16 GB RAM
Windows 10 64-bit v1802
Proxim 8494 / Oranco 802.11a/b/g/n USB Wireless Adapter / MAC 0020.ABCA.6022
Netgear A6210 802.11ac USB WiFi Adapter / MAC A004.6010.FAB7

Survey Software
Netscout AirMagnet Survey 9.2.2 Build 36951

Antennas Recommended *continued*

TerraWave's 2.4/5 GHz 6 dBi quad patch multiple-input and multiple-output (MIMO) (M6060060P1D43602V) Indoor / Outdoor antenna to be used in indoors for warehouse.

Specifications		
Model	M6060060P1D43602V	
Frequency Range	2400~2500	5150~5850
Bandwidth	100 MHz	700 MHz
Gain	6 dBi	6dBi
Horizontal Beamwidth	105	125
Vertical Beamwidth	60	70
VSWR	≤2.0	≤2.0
Isolation	≥20dB	
Nominal Impedance	50 Ohm	
Polarization	Vertical	
Maximum Input Power	20 W	
Lightning Protection	N/A	
Connector Type	4x RPTNC Plug	
Cable Length	36"	
Dimensions	10" x 5.6" x 1.4"	
Weight	1.2 lbs	
Operating Temperature	-40°F to 158°F	
Wind Load	60 mph	

Table 7: Indoor / Outdoor antenna specifications & radiation patterns

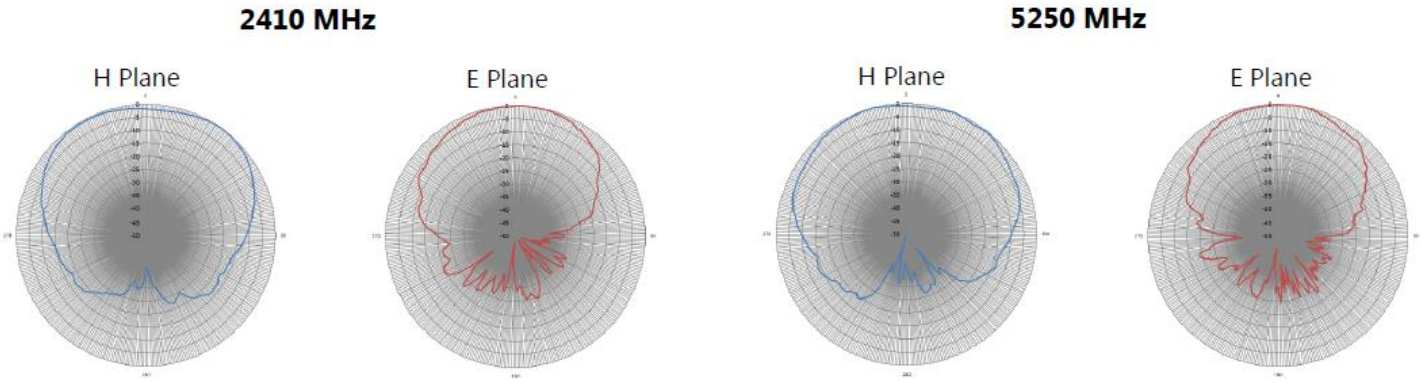


Figure 11: Directional antenna radiation patterns

Note: H-Plane patterns above are relevant for this report only.

Antennas Recommended *continued*

Ventev's TerraWave 2.4/5 GHz 6 dBi High Density Multiple-Input and Multiple-Output (MIMO) directional Wi-Fi antenna (349502 / M6060060MP1D43602) is designed to operate with Cisco's latest 802.11ac Waves I & II WLAN access points.

Specifications		
Model	M6060060MP1D43602	
Frequency Range	2400 ~ 2500 MHz	5150 ~ 5850 MHz
Gain	6 dBi	
Vertical Beamwidth	80°±20°	45°±20°
Horizontal Beamwidth	80°±20°	45°±20°
VSWR	≤ 2.0	≤ 2.5
Front-to-back ratio	≥18	
Polarization	Vertical	
Max Power	100 Watts	
Connector	RPTNC Plug	
Pigtail Length	36" (w/ Connector)	
Dimensions	9.2" x 9.0" x 1.1"	
Weight	2.65 lbs	
Operating Temperature Range	-40°F to +140°F	
Rated Wind Velocity	134.2 mph	
Mount Style	Wall or Mast/Pole	

Table 8: Indoor / Outdoor antenna specifications & radiation patterns

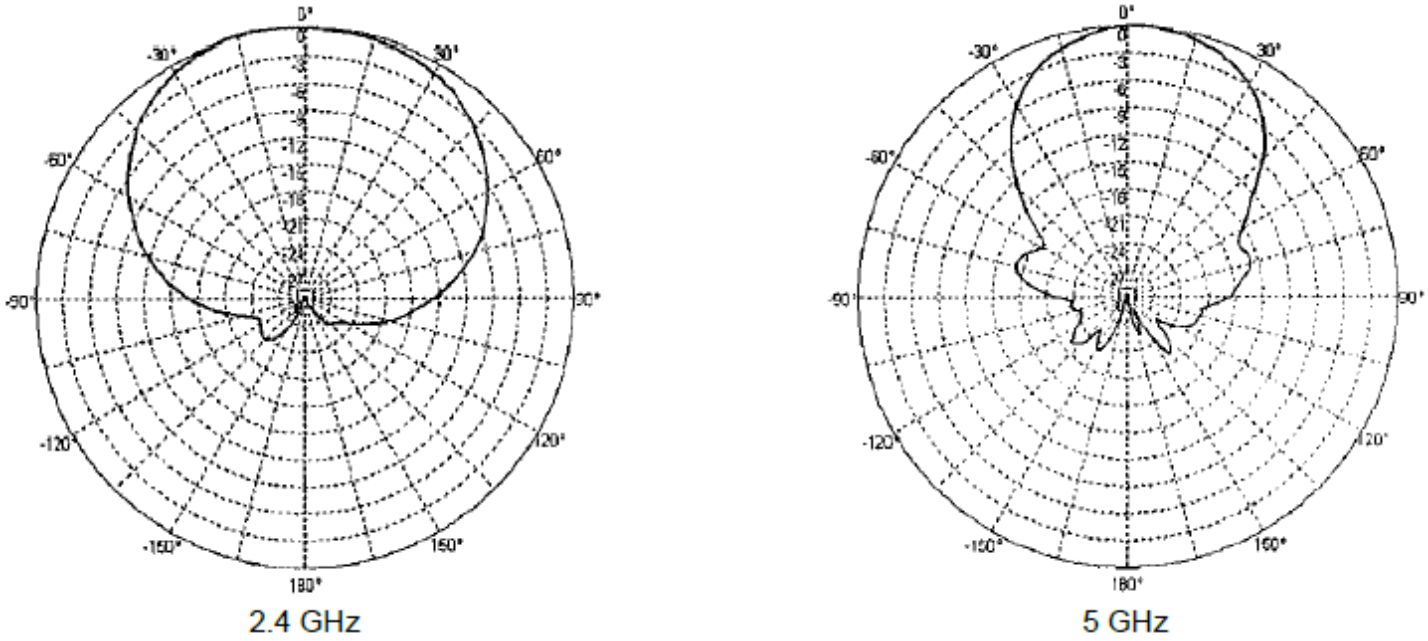


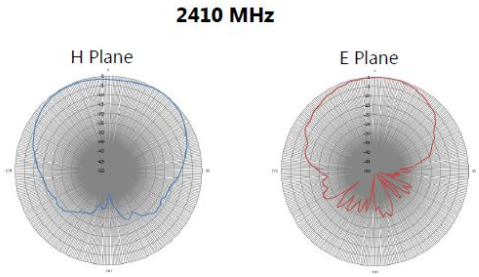
Figure 12: AG Outdoor Directional antenna radiation patterns

Antennas Recommended *continued*

TerraWave's 2.4/5 GHz 6 dBi quad patch multiple-input and multiple-output (MIMO) (M6060060P1D43602V) Indoor / Outdoor antenna to be used in indoors for warehouse.

Specifications		
Model	M6060060P1D43602V	
Frequency Range	2400~2500	5150~5850
Bandwidth	100 MHz	700 MHz
Gain	6 dBi	6dBi
Horizontal Beamwidth	105	125
Vertical Beamwidth	60	70
VSWR	≤2.0	≤2.0
Isolation	≥20dB	
Nominal Impedance	50 Ohm	
Polarization	Vertical	
Maximum Input Power	20 W	
Lightning Protection	N/A	
Connector Type	4x RPTNC Plug	
Cable Length	36"	
Dimensions	10" x 5.6" x 1.4"	
Weight	1.2 lbs	
Operating Temperature	-40°F to 158°F	
Wind Load	60 mph	

Table 9: Indoor / Outdoor antenna specifications & radiation patterns



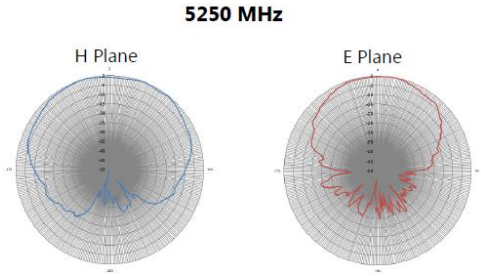


Figure 13: Directional antenna radiation patterns

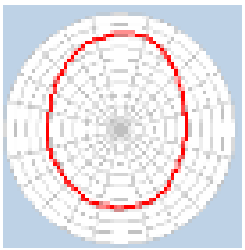


Figure 17: 503910 Facing Down Pattern

Antennas Recommended *continued*

Ventev's TerraWave 2.4/5 GHz 6 dBi High Density Multiple-Input and Multiple-Output (MIMO) directional Wi-Fi antenna (515086 / M6060060P23602) is designed to operate with Cisco's latest 802.11ac Waves I & II WLAN access points. This antenna is ideal for high-density venues such as lecture halls, stadiums and convention centers.

NOT USED IN THIS DEPLOYMENT

Specifications		
SKU	515086	
Model	M6060060P23602NB	
Frequency Range	2400 ~ 2500 MHz	5150 ~ 5850 MHz
Bandwidth	100 MHz	700 MHz
Gain	6 dBi	6 dBi
Horizontal Beamwidth	55° ± 10°	35° ± 10°
Vertical Beamwidth	55° ± 10°	35° ± 10°
Impedance	50 Ohms	
Polarization	Vertical	
VSWR	≤ 2	≤ 2.5
Maximum Power	20 Watts	
Connector	4 x RPTNC Plug	
Pigtail Length	36"	
Dimensions	10.3"x10.3"x1.4"	
Weight	2.31 lbs.	
Mounting	Mast Mounting	

Table 14: Indoor / Outdoor antenna specifications

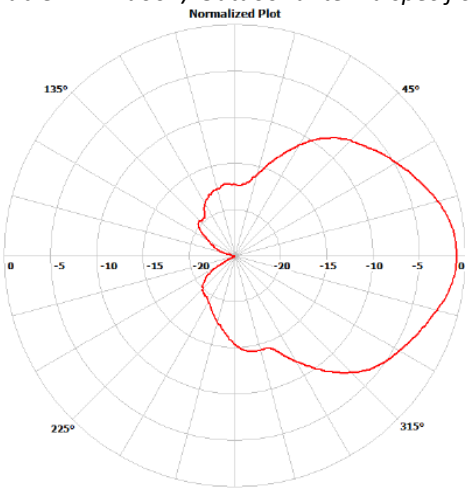


Figure 17: 2.4 GHz radiation pattern

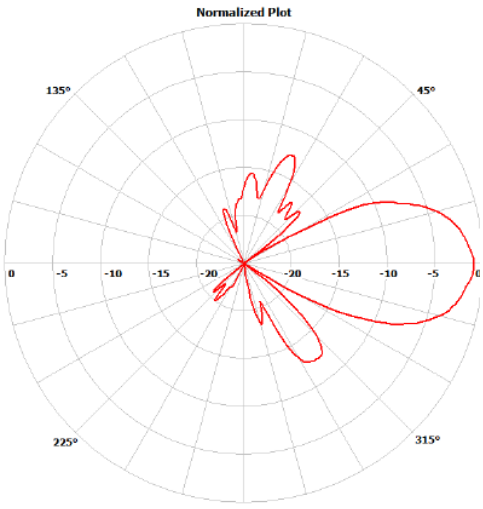


Figure 18: 5 GHz radiation pattern

Site Picture

Figure 15

Site Picture

 The TerraWave patch antenna (M6060060P1D43602V & M6060060MP1D43620) mounting bracket is fully articulating and shown below.

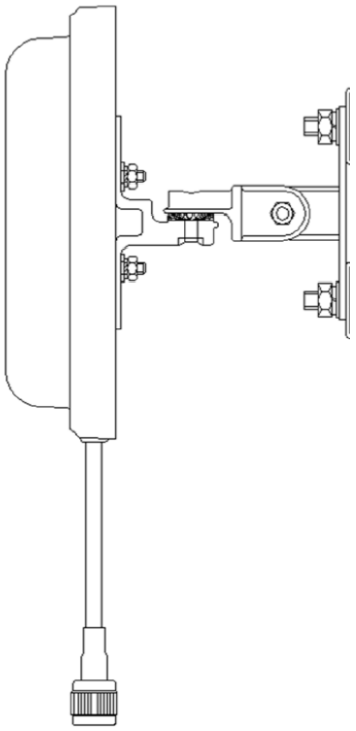


Figure 16: Panel antenna articulating mounting bracket

Down-Facing Antenna Mounting

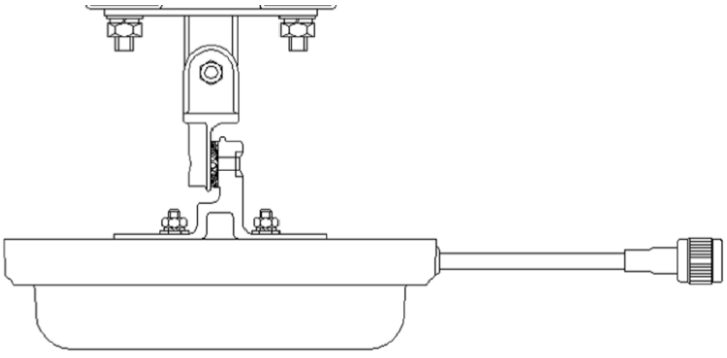


Figure 17: Down-facing Antenna

Directional Patch Antenna Mounting Instructions

Mounting hardware shipping from Tessco

You can mount this antenna outdoors. If you mount the antenna outdoors, you may need to provide the mounting hardware. For outdoor installations, follow the instructions printed on the back of the antenna.

The antenna should be mounted clear of any obstructions to the sides of the radiating elements. Generally, the higher an antenna is above the floor, the better it performs. If possible, find a mounting place directly above your wireless device to ensure the lead-in cable can be as short as possible.

Antennas transmit and receive radio signals which are susceptible to RF obstructions and common sources of interference that can reduce throughput and range of the device to which they are connected. Follow these guidelines to ensure the best possible performance:

- Install the antenna vertically and mount it with the cables pointing towards the ground.
- Keep the antenna away from metal obstructions such as heating and air-conditioning ducts, large ceiling trusses, building superstructures, and major power cabling runs. If necessary, use a rigid conduit to lower the antenna away from these obstructions.
- The density of the materials used in a building's construction determines the number of walls the signal can pass through and still maintain adequate signal strength. Consider the following before choosing the location for your antenna:
  - Signals penetrate paper and vinyl walls with little change to signal strength.
  - Signals penetrate only one or two solid and pre-cast concrete walls without degrading signal strength.
  - Signals penetrate three or four concrete and wood block walls without degrading signal strength.
  - Signals penetrate five or six walls constructed of drywall or wood without degrading signal strength.
  - Signals will likely reflect off a thick metal wall and may not penetrate it at all.
- Signals will likely reflect off a chain link fence or wire mesh spaced between 1 and 1 1/2 in. (2.5 and 3.8 cm). The fence acts as a harmonic reflector that blocks the signal.
- Install the antenna away from microwave ovens and 2-GHz cordless phones. These products can cause signal interference because they operate in the same frequency range as the device to which your antenna is connected.

Tools and Equipment Required

A mounting installation kit is shipped with the antenna and consists of the following hardware:

- Four #8 x 1¼ screws
- Four #8 plastic anchors
- Four end caps
- You may need the following tools and equipment, which are not provided.
- A Phillips screwdriver
- A drill
- A #29 (0.136-in. (s.45 mm)) drill bit (for drywall installation, other surfaces may require a different size).
- A pencil
- A small mallet or hammer

Directional Patch Antenna Mounting Instructions *continued*

Mounting on a Vertical Surface

Four mounting screws are provided to mount the antenna. To ensure a safe, reliable, and long-standing installation, you must use all four screws to mount the antenna.

Follow these steps to mount your antenna on a vertical surface. This procedure describes mounting the antenna on a drywall surface. If you are mounting the antenna on any other type of surface, your procedure may vary slightly.

Step 1 Determine the location where you will mount the antenna.
Step 2 Use the antenna as a template to mark the location of the four mounting holes.
Step 3 Use a drill and #29 drill bit to drill four holes at the locations you marked in Step 2.
Step 4 Start a plastic anchor into each hole.
Step 5 Use a mallet or small hammer to seat the anchors into the wall.
Step 6 Align the antenna's mounting holes with the anchors.

Mounting on a Vertical Surface *continued*

Step 7 Start a #8 x 1¼ screw into each antenna mounting hole.
Step 8 Use a Phillips screwdriver to secure the antenna to the wall. Do not overtighten.
Step 9 Install the end caps into the antenna mounting holes.
Step 10 Remove the yellow outdoor installation warning label from the antenna random.

An orientation arrow is printed on the back of the antenna that indicates the proper orientation for the antenna for outdoor installations. You must install the antenna so the arrow points up to prevent any water intrusion and to provide a drain for any moisture that may accumulate inside the antenna.

Safety Precautions

Translated versions of the following safety warnings are provided in the *Safety Warnings for Cisco Aironet Antennas,* which is available at http://www.cisco.com.

Warning Installation of this antenna near power lines is dangerous. For your safety, follow the installation directions.

Each year hundreds of people are killed or injured when attempting to install an antenna. In many of these cases, the victim was aware of the danger of electrocution but did not take adequate steps to avoid the hazard. For your safety, and to help you achieve a good installation, please read and follow these safety precautions. **They may save your life!**

1. If you are installing an antenna for the first time, for your own safety as well as others, seek professional assistance. Your Cisco sales representative can explain which mounting method to use for the size and type antenna you are about to install.
2. Select your installation site with safety as well as performance in mind. Remember: electric power lines and phone lines look alike. For your safety, assume that any overhead line can kill you.
3. Call your electric power company. Tell them your plans and ask them to come look at your proposed installation. This is a small inconvenience considering your life is at stake.
4. Plan your installation carefully and completely before you begin. Successful raising of a mast or tower is largely a matter of coordination. Each person should be assigned a specific task, and should know what to do and when to do it. One person should be in charge of the operation to issue instructions and watch for signs of trouble.
5. When installing your antenna, remember:
    a. **Do not** use a metal ladder.
    b. **Do not** work on a wet or windy day.
6. **Do** dress properly—shoes with rubber soles and heels, rubber gloves, long sleeved shirt or jacket.
7. If the assembly starts to drop, get away from it and let it fall. Remember, the antenna, mast, cable, and metal guy wires are all excellent conductors of electrical current. Even the slightest touch of any of these parts to a power line completes an electrical path through the antenna and the installer: **You!**
8. If any part of the antenna system should come in contact with a power line, **don't touch it or try to remove it yourself. Call your local power company**. They will remove it safely.
9. If an accident occurs with the power lines, call for qualified emergency help immediately.

About the author of this report

Expertise

- Cisco Wireless
- Cisco CUCM & Unity
- Cisco ASA & FirePower
- Cisco DVPN
- Cisco Nexus & Catalyst
- CCIE Skill Level on staff

Limited Warranty

The results contained in this Site Survey Report ("Report") are warranted, for a period not to exceed 1 year from and reflect the actual data collected during the surveys with the goal of providing recommendations needed to achieve one hundred percent (100%) RF coverage for the designated indoor areas. Author will furnish additional assistance for WLC configuration and WLAN performance optimization or troubleshooting at the normal fee. Changes after the date of this Report to the facility's structure, or parameters within the facility, may create the need for an additional Site Survey or AP/antenna placement adjustment. Additional surveys or adjustments on the site may incur an additional fee. Changes include but are not limited to structural changes, addition or removal of storage racks, addition or removal of equipment and any significant changes to inventory material types, item densities and the addition of any RF emitting device(s) that might cause interference.

Disclaimer

IN NO EVENT SHALL HORIZON ELECTRONICS OR SWC,LLC BE LIABLE FOR ANY INDIRECT, INCIDENTAL SPECIAL, CONSEQUENTIAL OR ASSOCIATIVE CONSEQUENTIAL DAMAGES WHATSOEVER, INCLUDING WITHOUT LIMITATION, DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION, OR OTHER PECUNIARY LOSS, RESULTING FROM DEFECTIVE MATERIALS OR IMPROPERLY INSTALLED OR SERVICED SYSTEMS. THIS LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, WHICH MIGHT OTHERWISE ARISE WITH RESPECT TO THE SERVICES PROVIDED.