RF SYSTEM DESIGN FOR CABLE TV
A NEW APPROACH

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ABSTRACT

The high demand for cable TV systems with more channel capacity and two-way communications has caused increased congestion in the CARS frequency band, and a need for new microwave system planning techniques.

Compucon has developed a new computer program which can quickly scan a computerized data base and identify available channels in designated directions. This paper discusses how this new system planning technique may be applied in the early planning stage to select a feasible cable system configuration.

In addition, ideas are presented to combine earth station and CARS band planning to help design an integrated system for program reception and distribution.

Cable TV systems are experiencing unprecedented demands for more channel capacity, more capability, and more flexibility from communities both large and small. The demand for cable systems has caused increased congestion in the CARS frequency bands and has created a need for more sophisticated microwave system planning techniques. The expanded requirements for cable systems have forced the development of new system configurations to more effectively utilize the allocated frequency spectrum.

Most cable systems can be categorized by three design configurations (Refer to Figures 1, 2, and 3). The star system design is the most common with the principle flow of traffic from the hub to the individual headends. A headend can be a repeater location to other outlying headends. An application of this design is the "Master Headend" concept being planned and implemented for many large metropolitan areas. The two transmitter site system design allows double channel capacity over the star design but greatly increases the intra-system frequency interference considerations. The solution to these considerations involve more complex antenna systems and antenna cross-polarization. The colocated dual transmitter system design has the same capacity as the previous system and similar considerations. The tradeoffs between the two designs are the number of hubs and the number of headends. In all three system designs, the upstream channels to the hub must be separated by frequency from the channels downstream. A different frequency band may be used for upstream channels depending on the channel application; an example is the 12 GHz private microwave band for local government use.

A general review of the CARS system planning cycle will point out the need for a preliminary CARS band frequency analysis (Refer to Figure 4). After a cable company has responded with an interest in providing a system proposal, the local market analysis study begins. The technical feasibility study follows and evaluates whether the system should be FM or AML, approximate antenna sizes, tower heights, approximate hub and headend locations, need for a receive-only (TVRO) earth station or microwave interconnect, system capacity, and system capability. This step in the cycle is where a preliminary frequency analysis would assist in determining frequency availability, site selection, antenna sizes, and the probability for a TVRO earth station clearance. After the market analysis and technical feasibility studies prove to be viable, a full proposal is submitted followed hopefully by a franchise award. Now the implementation steps occur with final site selection, detailed frequency analysis and system engineering, construction permit and license, system installation and distribution of programming.

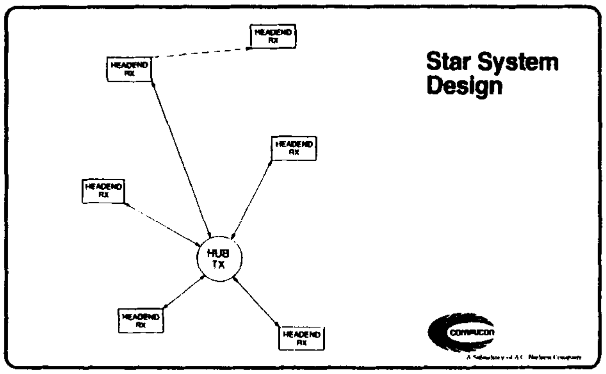

FIGURE 1

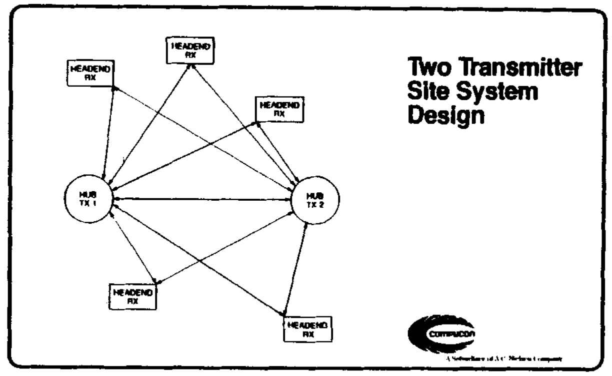

FIGURE 2

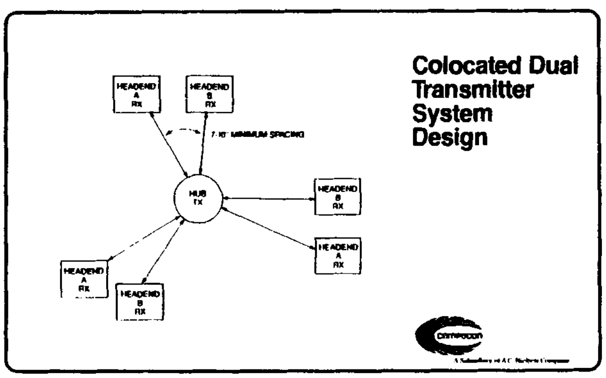

FIGURE 3

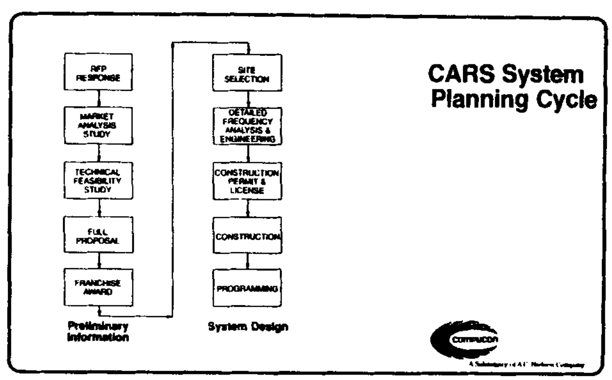

FIGURE 4

Performance of a preliminary analysis requires a computer system which can access an extensive terrestrial database of all existing and planned CARS systems as well as antenna, equipment, and interference criteria databases (Refer to Figure 5).

The computer program design concept is based on a central hub site transmitting in 10 radials to potential receiver locations equidistant from the hub (Refer to Figure 6). The half-duplex analysis will evaluate interference resulting from the hub transmitter into outside receivers and interference into each potential headend from outside sources. The full duplex analysis will also consider interference from each headend location into outside receivers and interference into the hub receive antennas.

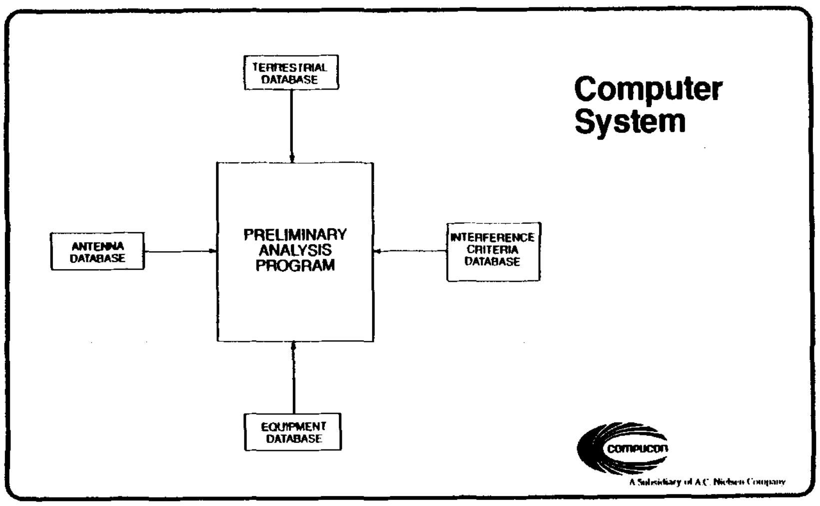

FIGURE 5

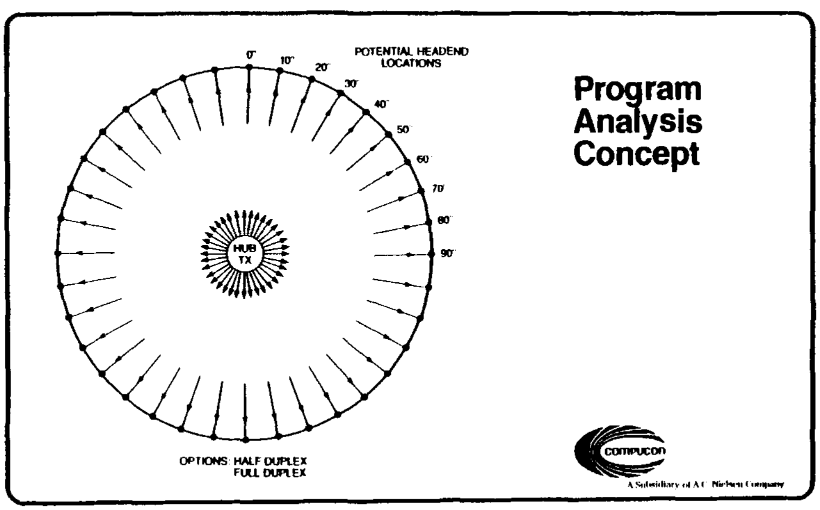

FIGURE 6

All of the program input parameters and options are listed on the report data sheet (Refer to Figure 7). The minimum required input information is the site name, latitude, and longitude. The remaining items: antenna, transmit power, margin, coordination distance, colocate distance, receiver distance, azimuth step size, half or full duplex, and modulation type are variable, but will also default to the values listed when different values are not supplied. The program can be used in all configurations mentioned and would be applied to each hub transmit site.

The Preliminary Frequency Availability Report provides a summary of the clear frequencies from and into the hub and headends (Refer to Figure 8). The interference is evaluated at each listed azimuth and the program prints the number of clear frequencies in each group of the CARS band at each end of each azimuth path. Both polarizations are evaluated with the total combined number of clear frequencies printed. An evaluation of the computer printout provides information in making the following decisions: optimum locations for headend sites, maximum channel capacity based on interference, choice of frequency groups, recommended antenna sizes and types, and the probability of the hub site being the best location.

If not all of the factors have given the required results, then the variables can be changed and the program rerun. The major items to change would be the choice of antennas, transmit power, receiver distance, and hub location.

CARS / STL

04/21/82

COMPUCON
DALLAS, TEXAS

PRELIMINARY FREQUENCY AVAILABILITY REPORT

HUB NAME : SAMPLE SITE, IL

CUSTOMER : HUGHES

SYSTEM PARAMETERS

1.	HUB NAME		: SAMPLE SITE, IL
2.	LATITUDE	(DMS) :	39 - 00 - 00
3.	LONGITUDE	(DMS) :	89 - 00 - 00
4.	ANTENNAS		
	FCC CODE		: A03222
	MANUFACTURER		: ANDREW
	MODEL		: P6 - 1220
5.	MAXIMUM TRANSMIT POWER	(DBM) :	30.0
6.	MARGIN	(DB) :	10
7.	MAXIMUM COORDINATION DISTANCE	(MI) :	125.0
8.	CO-LOCATE DISTANCE	(MI) .	0.1
9.	NOMINAL HEADEND DISTANCE	(MI) :	10.0
10.	AZIMUTH STEP SIZE	(DG) :	10.0
11.	HALF OR FULL DUPLEX		: FD
12.	MODULATION TYPE		: AM

FIGURE 7

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PRELIMINARY FREQUENCY AVAILABILITY REPORT

HUB NAME: SAMPLE SITE, IL

MODULATION: A M

HUB TO HEAD END AZIMUTH (DEG)	-- TRANSMITTING AT HUB RECEIVING AT HEAD END --- CHANNELS (TX)/(RX) - C -	- D -	- E -	- F -	SUMMARY KEY	-- TRANSMITTING AT HEAD END RECEIVING AT HUB --- CHANNELS (TX)/(RX) - C -	- D -	- E -	- F -	SUMMARY KEY
0.0	29/32	29/30	29/28	22/22	***	29/30	26/30	27/38	19/28	***
10.0	31/31	33/29	30/42	23/32	****	42/29	39/30	28/30	19/22	****
20.0	2/42	2/42	32/42	25/32	****	37/31	36/31	29/32	20/22	****
30.0	19/42	21/42	31/42	25/32	****	30/29	29/26	3/31	2/23	***
40.0	14/42	14/42	42/ 7	28/ 5	**	42/42	42/39	2/42	2/29	*****
50.0	42/33	41/33	29/ 2	21/ 2	****	42/42	41/41	5/42	3/31	*****
60.0	32/31	32/28	31/30	20/22	****	31/42	31/39	3/27	3/22	****
70.0	42/29	42/27	27/30	18/22	***	42/42	42/40	4/27	4/20	*****
80.0	42/42	39/39	42/30	32/22	*****	42/42	41/39	4/42	3/31	*****
90.0	35/42	33/40	42/30	28/23	****	42/33	41/33	42/32	32/25	****
100.0	28/27	26/29	42/27	32/20	***	42/13	42/11	30/42	24/30	****
110.0	42/42	42/39	42/42	32/32	*****	42/26	41/25	42/42	30/32	*****
120.0	42/30	41/27	32/42	26/32	****	31/ 6	32/ 8	30/30	23/24	****
130.0	42/28	40/25	42/27	31/18	***	4/16	2/13	42/35	32/26	****
140.0	30/38	32/40	42/42	32/31	*****	3/ 6	2/ 7	30/30	20/21	****
150.0	42/31	42/28	32/42	24/32	****	3/ 2	2/ 2	42/ 6	32/ 3	*
160.0	42/42	41/42	33/38	22/26	*****	6/ 7	8/ 4	29/ 8	21/ 4	*
170.0	27/42	24/39	28/31	23/22	***	42/ 3	40/ 2	31/ 8	29/ 5	*
180.0	42/42	42/42	42/27	28/22	*****	36/42	35/42	42/27	32/19	****
190.0	32/32	29/34	28/28	19/21	****	42/31	39/29	28/42	20/31	****
200.0	42/27	42/24	30/39	25/27	****	42/32	42/29	42/42	32/31	*****

FIGURE 8

One of the major sources of programming for a cable TV system is a receive-only earth station. During the technical feasibility stage, it would be advantageous to know if a TVRO could be co-located at the desired hub site. A separate preliminary TVRO analysis can be performed to provide that information (Refer to Figures 9, 10, and 11). After supplying the site name, company name, and coordinates, the program will calculate the potential interference into the earth station, and print out each source of interference and a figure of merit analysis summary. The figure of merit will state the estimated percent probability of successful placement of the earth station.

In conclusion, the preliminary analyses that were described can be an economical design tool to be used in the planning of a cable system. They provide technical insight at a low cost, provide an integrated design package, are easy to perform and analyze, are flexible to an application, and can save money in a system design by selecting the right equipment configuration early in the planning cycle. The programs have a limited capability and were not designed to replace the full detailed analyses that are required. The ancillary services to CARS and TVRO planning, detailed frequency analysis, earth station coordination, FCC applications, field services, and interference alert protection, are available through Compucon.

***** C O M P U C O N , I N C *****

EARTH STATION POINTING AZIMUTHS AND ELEVATION ANGLES

MULESHOE
34-15- 0 N LATITUDE
102-45- 0 W LONGITUDE

POINTING AZIMUTHS IN DEGREES FROM TRUE NORTH AND ELEVATION ANGLES ABOVE HORIZONTAL FOR ACCESSING SATELLITES IN THE GEOSTATIONARY ORBIT BETWEEN 70.0 DEGREES WEST LONGITUDE AND 145.0 DEGREES WEST LONGITUDE. NAMES INDICATE 4/6 GHZ SATELLITES PRESENTLY IN ORBIT.

GEOSTATIONARY SATELLITE NAME	POSITION	EARTH STAT. POINTING AZIM.	ELEV.	GEOSTATIONARY SATELLITE NAME	POSITION	EARTH STAT. POINTING AZIM.	ELEV.
	70.0	131.2	37.1		108.0	189.3	49.8
	71.0	132.4	37.8	ANIK B-1	109.0	191.0	49.6
	72.0	133.4	38.5		110.0	192.7	49.4
	73.0	134.6	39.1		111.0	194.4	49.3
	74.0	135.7	39.8		112.0	196.1	48.9
	75.0	137.0	40.4		113.0	197.8	48.7
	76.0	138.2	41.1	ANIK A-3	114.0	199.5	48.4
	77.0	139.5	41.6		115.0	201.0	48.1
	78.0	140.7	42.2		116.0	202.6	47.7
	79.0	142.0	42.8		117.0	204.3	47.4
	80.0	143.3	43.4		118.0	205.8	47.0
	81.0	144.7	43.9	SATCOM F2	119.0	207.3	46.6
	82.0	146.1	44.4		120.0	208.9	46.1
	83.0	147.5	44.9		121.0	210.3	45.7
	84.0	148.9	45.4		122.0	211.8	45.2
	85.0	150.4	45.9	WESTAR II	123.0	213.2	44.7
	86.0	151.9	46.3		124.0	214.6	44.2
COMSTAR C	87.0	153.4	46.7		125.0	215.9	43.6
	88.0	155.0	47.2		126.0	217.3	43.1
	89.0	156.5	47.5		127.0	218.6	42.5
	90.0	158.1	47.9	COMSTAR A	128.0	219.9	41.9
WESTAR III	91.0	159.8	48.3		129.0	221.2	41.3
	92.0	161.4	48.6		130.0	222.5	40.7
	93.0	163.0	48.8		131.0	223.6	40.1
	94.0	164.8	49.1		132.0	224.8	39.5
COMSTAR B	95.0	166.4	49.4		133.0	226.0	38.8
	96.0	168.2	49.5		134.0	227.1	38.1
	97.0	169.9	49.7	SATCOM F1	135.0	228.2	37.5
	98.0	171.6	49.8		136.0	229.3	36.8
WESTAR I	99.0	173.4	49.9		137.0	230.4	36.1
	100.0	175.1	50.1		138.0	231.4	35.4
	101.0	176.9	50.2		139.0	232.5	34.6
	102.0	178.7	50.2		140.0	233.4	33.9
	103.0	180.4	50.2		141.0	234.4	33.2
ANIK A-1	104.0	182.2	50.2		142.0	235.4	32.5
	105.0	184.0	50.1		143.0	236.3	31.7
	106.0	185.7	50.1		144.0	237.2	31.0
	107.0	187.5	49.9		145.0	238.2	30.2

FIGURE 9

**** C O M P U C O N , I N C ****
02/05/82
FIGURE OF MERIT ANALYSIS FOR A RECEIVE-ONLY EARTH STATION SITE

SITE : MULESHOE
LOCATION : 34-15- 0 N
102-45- 0 W
COMPANY : MULESHOE CABLE TV

ANTENNA TYPE : F.C.C.
32-25 LOG(THETA)
SATELLITE ARC : 70.0 TO 145.0
AZIMUTH RANGE OF SATELLITE ARC : 131.2 TO 238.2

INTERFERENCE CRITERIA

-137.0 DBW/1.0 MHZ SHORT TERM
-147.0 DBW/1.0 MHZ LONG TERM

DISTRIBUTION OF POTENTIAL INTERFERING TRANSMITTERS

LEVELS ARE BASED ON FREE SPACE LOSS

X = WITHIN SATELLITE ARC
* = OUTSIDE SATELLITE ARC

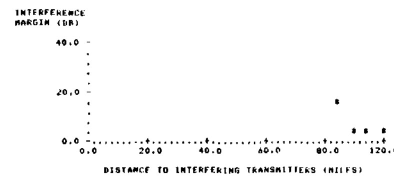

FIGURE OF MERIT

ESTIMATED PROBABILITY OF SUCCESSFUL EARTH STATION PLACEMENT = 96.1 %

CONFLICT CODE AND CAT. CODE = 4000000 1
STATUS : CLEAR SITE

FIGURE 10

***** C O M P U C O N , I N C *****

SUMMARY OF MICROWAVE INTERFERENCE FOR EARTH STATION PLACEMENT

SITE NAME: MULESHOE
TEXAS

COORDINATES: 34-15- 0 N LATITUDE
102-45- 0 W LONGITUDE

ELEVATION: 0 FEET AMSL
CENTERLINE: 0 FEET AGL

E.S. ANTENNA PATTERN USED: F.C.C. 32-25 LOG(THETA)

INTERFERENCE CRITERIA: -137.0 DBW/1MHZ@0.01% -147.0 DBW/1MHZ@20.0%

DATE OF THIS RUN: 02/05/82
SATELLITE ARC: 70.0 TO 145.0

SATELLITE TRANSPONDERS AFFECTED BY EXISTING AND PROPOSED MICROWAVE CHANNEL USAGE ON PATHS CREATING INTERFERENCE INTO THE PROPOSED EARTH STATION (BASE ON LINE-OF-SIGHT). ASTERISK INDICATES EFFECT OF OPERATING TERRESTRIAL MICROWAVE CHANNEL; PLUS SIGN INDICATES EFFECT OF FUTURE TERRESTRIAL CHANNEL ADDITION.

TRANSPONDER NUMBER (12 TRANSPONDER SATELLITE)
1 2 3 4 5 6 7 8 9 10 11 12
TRANSPONDER NUMBER (24 TRANSPONDER SATELLITE)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
SATELLITE CENTER CHANNEL FREQUENCIES (MHZ)
3720 3740 3760 3780 3800 3820 3840 3860 3880 3900 3920 3940 3960 3980 4000 4020 4040 4060 4080 4100 4120 4140 4160 4180

FREQUENCY RANGE 3700 TO 4200 MHZ

TRANSMITTER (RECEIVER)	PATH STATUS	ELEVATION-CENTERLINE (CARRIERS)	TRANSPONDERS	EARTH STATION TO TRANSMITTER DISTANCE	AZIMUTH	EXCEEDS OBJECTIVE TIME FCT SHORT	LONG
ADY R (VEGA RS .TX)	.TX OP	3910'- 58' ATTNW	+ + + + + + + + + + + + + + + + + *	85.8 MI	35.6	1.4	14.4
PALODURO (WAYSIDE .TX)	.TX OP	3311'- 83' ATTNW	* * * * * * * * * * * * * * * * * *	96.8 MI	61.3	0.0	1.7
BORDER R (AMARILLO JCT .TX)	.TX OP	3433'- 95' ATTNW	* * * * * * * * * * * * * * * * *	107.8 MI	35.5	0.0	2.7
CARDENAS (TAIBAN .NM)	.NM OP	5302'-308 ATTN	+ + + + + + + + + + + + + + + + + *	119.9 MI	229.0	0.0	1.6

FIGURE 11