2.0 Signal Space ($\underset{\sim}{S}$).

$(\underset{\sim}{S}) = (S_1, \ldots \underset{\text{signal vector}}{S_i} \ldots S_n)$ $\qquad S_i = [a_{i1}\ a_{i2}\ \cdot\ a_{ik}]$

2.1 Bit Signal Space

Considering the signal space Ω for a business data transmission code such as the Transcewa Code or 4-out-of-8 code (see p 2-2), leads to the subdivision of the signal space by bit and by characters. For example, the letter "A" is represented as:

$$S_A = S_A(t) = \underset{\text{bit signal}}{S(t)} \underset{\text{coding}}{\begin{bmatrix} a_{A1} \\ a_{A2} \\ a_{A4} \\ a_{A7} \\ a_{AR} \\ a_{AR_1} \\ A_{AD} \\ a_{AX} \end{bmatrix}} = S(t) \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 1 \\ 1 \end{bmatrix} \qquad (2.1)$$

The "bit signal" may be of numerous forms:

$$S^c(t) = \cos \frac{2\pi t}{T} \quad \text{for} \quad 0 \leq t \leq T \qquad (2.2)$$

$$S^{hc}(t) = \cos \frac{\pi t}{T} \quad \text{for} \quad 0 \leq t \leq T \qquad (2.3)$$

$$S^s(t) = \sin \frac{2\pi t}{T} \quad \text{for} \quad 0 \leq t \leq T \qquad (2.4)$$

Note that the extension of Fig 1-1 to the transmission line case requires a modification of "$\otimes$" to account for the delay characteristics.

		HOLLERITH PUNCHED CARD CODE 2-N	TRANSCVR CODE XOA 7421	RAMAC 305 OX124RC	EDPM 702 & 705* 124BAHC	650 MAGNETIC DRUM O-PH ALPHABETIC 05	01234	TWO NUMERALS 05	01234	DECIMAL EQUIVALENT	TAPE CODE FOR 650 CARDATYPE FO 124.8COR	
1	1	-1	XXXOOXOX	OOXOOOO	XOOOOOX	OX	OOOOX	XO	OXOOO	91	XOO.OOOO	1
2	2	-2	XXXOOOXO	OOOXOOO	OXOOOOX	OX	OOOOX	XO	OOXOO	92	OXO.OOXO	2
3	3	-3	OOXXOOXX	OOXXOOX	XXOOOOO	OX	OOOOX	XO	OOOXO	93	XXO.OOOO	3
4	4	-4	XXXOOXOO	OOOOXOO	OOXOOOX	OX	OOOOX	XO	OOOOX	94	OOX.OOOO	4
5	5	-5	OOXXOXOX	OOXOXOX	XOXOOOO	OX	OOOOX	OX	XOOOO	95	XOX.OOXO	5
6	6	-6	OOXXOXXO	OOOXXOX	OXXOOOO	OX	OOOOX	OX	OXOOO	96	OXX.OXOO	6
7	7	-7	XXXOXOOO	OOXXOOO	XXXOOOX	OX	OOOOX	OX	OOXOO	97	XXX.OOOO	7
8	8	-8	OOXXXOOX	OOOOOXO	OOOXOOX	OX	OOOOX	OX	OOOXO	98	OOO.XOOO	8
9	9	-9	OOXXXOXO	OOXOOXX	XOOXOOO	OX	OOOOX	OX	OOOOX	99	XOO.XOOO	9
10	0	-0	OXXOXXOO	XOOOOOO	OXOXOOO	OX	OOOOX	XO	XOOOO	90	OOO.OOXO	0
11	A	12-1	XXOXOOOX	XXXOOOO	XOOOXXX	OX	OXOOO	XO	OXXOO	61	XOO.OOXX	A
12	B	12-2	XXOXOOXO	XXOXOOO	OXOOXXX	OX	OXOOO	XO	OOXOO	62	OXO.OOXX	B
13	C	12-3	XXOOOOXX	XXXXOOX	XXOOXXO	OX	OXOOO	XO	OOOXO	63	XXO.OOXX	C
14	D	12-4	XXOXOXOO	XXOOXOO	OOXOXXX	OX	OXOOO	XO	OOOOX	64	OOX.OOXX	D
15	E	12-5	XXOOOXOX	XXXOXOX	XOXOXXO	OX	OXOOO	OX	XOOOO	65	XOX.OOXX	E
16	F	12-6	XXOOOXXO	XXOXXOX	OXXOXXO	OX	OXOOO	OX	OXOOO	66	OXX.OOXX	F
17	G	12-7	XXOXXOOO	XXXXXOO	XXXOXXX	OX	OXOOO	OX	OOXOO	67	XXX.OOXX	G
18	H	12-8	XXOOXOOX	XXOOOXO	OOOXXXX	OX	OXOOO	OX	OOOXO	68	OOO.XOXX	H
19	I	12-9	XXOOXOXO	XXXOOXX	XOOXXXO	OX	OXOOO	OX	OOOOX	69	XOO.XOXX	I
20	J	11-1	XOXXOOOX	OXXOOOX	XOOOXXO	OX	OOXOO	XO	OXOOO	71	XOO.OXOX	J
21	K	11-2	XOXXOOXO	OXOXOOX	OXOOXXO	OX	OOXOO	XO	OOXOO	72	OXO.OXOX	K
22	L	11-3	XOXOOOXX	OXXXOOO	XXOOXXX	OX	OOXOO	XO	OOOXO	73	XXO.OXOX	L
23	M	11-4	XOXXOXOO	OXOOXOX	OOXOXXO	OX	OOXOO	XO	OOOOX	74	OOX.OXOX	M
24	N	11-5	XOXOOXOX	OXXOXOO	XOXOOXX	OX	OOXOO	OX	XOOOO	75	XOX.OXOX	N
25	O	11-6	XOXOOXXO	OXOXXOO	OXXOOXX	OX	OOXOO	OX	OXOOO	76	OXX.OXOX	O
26	P	11-7	XOXXXOOO	OXXXXOX	XXXOOXO	OX	OOXOO	OX	OOXOO	77	XXX.OXOX	P
27	Q	11-8	XOXOXOOX	OXOOOXX	OOOXOXO	OX	OOXOO	OX	OOOXO	78	OOO.XXOX	Q
28	R	11-9	XOXOXOXO	OXXOOXO	XOOXOXX	OX	OOXOO	OX	OOOOX	79	XOO.XXOX	R
29	S	0-2	OXXXOOXO	XOOXOOX	OXOOXOO	OX	OOOXO	XO	OOXOO	82	OXO.OXXO	S
30	T	0-3	OXXOOOXX	XOXXOOO	XXOOXOX	OX	OOOXO	XO	OOOXO	83	XXO.OXXO	T
31	U	0-4	OXXXOXOO	XOOXXOX	OOXOXOO	OX	OOOXO	XO	OOOOX	84	OOX.OXXO	U
32	V	0-5	OXXOOXOX	XOXOXOO	XOXOXOX	OX	OOOXO	OX	XOOOO	85	XOX.OXXO	V
33	W	0-6	OXXOOXXO	XOOXXOO	OXXOXOX	OX	OOOXO	OX	OXOOO	86	OXX.OXXO	W
34	X	0-7	OXXXXOOO	XOXXXOX	XXXOXOO	OX	OOOXO	OX	OOXOO	87	XXX.OXXO	X
35	Y	0-8	OXXOXOOX	XOOOOXX	OOOXXOO	OX	OOOXO	OX	OOOXO	88	OOO.XXXO	Y
36	Z	0-9	OXXOXOXO	XOXOOXO	XOOXXOX	OX	OOOXO	OX	OOOOX	89	XOO.XXXO	Z
37	/	0-1	OXXXOOOX	XOXOOOX	XOOOXOO	XO	OOOXO	XO	XOOXO	31	XOO.OXXO	/
38	#	3-8	OXXOXOXX	OOXXOXO	XXOXOOX	XO	OOOOX	OX	OOOXO	48	XXO.XOOO	#
39	.	12-3-8	OOXOXOXX	XXXOOXO	XXOXXXX	XO	OXOOO	OX	OOOXO	18	XXO.XOXX	.
40	$	11-3-8	XOOOXOXX	OXXXOXX	XXOXOXO	XO	OOXOO	OX	OOOXO	28	XXO.XXOX	$
41	,	0-3-8	OXOOXOXX	XOXXOXX	XXOXXOO	XO	OOOXO	OX	OOOXO	38	XXO.XXXO	,
42	@	4-8	OOOXXXOX	XOOOXXX	OOXXXOO	XO	OOOOX	OX	OOOOX	44	OOX.XXOO	@
43	¤	12-4-8	OOXOXXOX	XXOOXXX	OOXXXXO	XO	OXOOO	OX	OOOOX	19	OOX.XOXX	¤
44	*	11-4-8	XOOOXXOX	OXOOXXO	OOXXOXX	XO	OOXOO	OX	OOOOX	27	OOX.XXOX	*
45	%	0-4-8	OXOOXXOX	XOOXXXO	OOXXXOX	XO	OOOXO	OX	OOOOX	39	OOX.XXXO	%
46	-	11	XOXOXXOO	OXOOOOO	OOOOOXX	XO	OOXOO	XO	XOOOO	10	OOO.OXOX	-
47	&	12	XXOOXXOO	XXOOXOX	OOOOXXO	XO	OXOOO	XO	XOOOO	20	OOO.OOXX	&
48	SPACE		OOXOXXOO	OOXOOOX	OOOOXOX	XO	XOOOO	XO	XOOOO	00	OOO.OOOO	SP
49	12-0	12-0	OXOOXXXO									
50	11-0	11-0	XXXXOOOO									
51	EOT		OOXOXXXO									
52	TEL		OOOXXXXO									
53	EOC START		XOOOXXXO									
54	RESTART		OOOOXXXX									
55	PLUS ZERO											
56	MINUS ZERO											
57	RECORD MARK											
58	TAPE MARK											
59	AC & OR MK											
60	GROUP MK											

TEL ROUTE IS THE
SAME AS RAMAC CODE
WITH PHYSICAL POSITION
OF CHANNELS SHIFT

702/705 * PUNCH		PRINT 702	705
12-0	OXOXXXO	&	&
11-0	OXOXOXX	-	-
0-2-8	OXOXXOX	‡	BLANK
	XXXXOOO	NP	
	OXOOXOO		
12-5-8	XXXXXXO*		■

UNUSED	UNUSED	UNUSED	UNUSED		XXX.XXXX	TF
OOOXOXXX	OOOXOXX	XOXXOOX	1-18 INCLUSIVE	UNUSED	OXO.XXOO	FI1
OOXOOXXX	OOXOXXO	OXXXOOX	21-27 INCLUSIVE		OXO.XOOX	FI2
OXOOOXXX	OOOXXXO	XOXXXXX	32-37 INCLUSIVE		OXO.XOXO	FI3
OXOXOOXX	OOXXXXX	OXXXXXX	40-47 INCLUSIVE	1-18 INC	XOX.XXXO	FI4
OXOXOOXX	OXOXOXO		50-60 INCLUSIVE	21-27 INC	XOX.XOXX	FI5
OXOXOXXO	OXXOXXX	XOXXOXO	70	32-37 INC	XOX.XXXX	FI6
OXOXXOOX	OXOXXXX	OXXXOXO	80-81	40-47 INC	XXX.XOOO	FI7
OXOXXXOO	OXXXXXO	XXXXOXX		50-60 INC	OOX.OOXX	EL
OXOXXXOO	XOOXOXO	XOXXXOO		70	OXX.XXXO	SKIP
XOOOOXXX	XOXOXXX	OXXXXOO		80-81	XXX.XXOO	CAN
XOOXOOXX	XOOXXXX	XXXXXXO			XXX.XOOX	FOR
XOOXOXOX	XOXXXXO				OXO.XXXX	FS1
XOOXOXXO	XXOXOXX				OXX.XOXX	SP2
XOOXXOOX	XXXOXXO	FUTURE			OXX.XXOX	=
XOOXXOXO	XXOXXXO	XXXXXXO			OXX.XOOO	FS1
XOOXXXOO	XXXXXXX				XXX.XOXO	FS2

REFERENCE 22-6206-0 702 22-6173-1 DRUM 22-6060-1
705-22-6627-2 TAPE 22-6265-0
22-6705-0
THE MANUALS
TABULATE THIS IN
CPA 8421 ORDER

22-6172-0

SAN JOSE
6-5-56

CORRECTION 8-24-56
27 Q
28 R

The probability density function has two components: (1) bit probability and (2) character probability. The bit probabilities for the 4-out-of-8 code are:

$$\sigma(a_{ij} = 1) = 0.5$$
$$\sigma(a_{ij} = 0) = 0.5$$

2.2 <u>Character Space</u> Ω

Using the 4-out-of-8 code as an example, the probability distribution functions are:

Alphabetic $\sigma_A'(s_i)$ where $\sum_{i=1}^{26} \sigma_A'(s_i) = 1.0$

determined from tables of usage of English letters in writing.

Numeric: $\sigma_N'(s_j)$ where $\sum_{j=0}^{9} \sigma_N'(s_j) = 1.0$

Unless facts show some weighting exist, assume equal probability for each numeric

or $\sigma_N'(s_j) = 0.1$

Control Code. $\sigma_c'(S_h)$ where $\sum_{h=1}^{18} \sigma_c'(S_h) = 1.0$
(also special symbols)

As a first approximation the proportion of useage of special symbols + control code symbols can be estimated from present transceiver operations.

Unused (Reserve) Symbols:

$\sigma_u'(S_\ell)$ where $\sum_{\ell=1}^{16} \sigma_u'(S_\ell) = 1.0$

where the probabilities of use of classes of symbols are defined as follows:

α_A = Probability of alphabetic symbol occuring

α_N = " " numeric " "

α_C = " " control code or special symbol occuring

α_U = " " unused or reserve symbol occuring

Then the character probabilities are related by:

$$\alpha_A \sum_{i=1}^{26} \sigma_A'(S_i) + \alpha_N \sum_{j=0}^{9} \sigma_N'(S_j) + \alpha_C \sum_{h=1}^{18} \sigma_c'(S_h) + \alpha_U \sum_{\ell=1}^{16} \sigma_u'(S_\ell) = 1.0$$

Alternatively let $\sigma_m = (\alpha_A \sigma_A'(S_1), \alpha_A \sigma_A'(S_2), \ldots \alpha_U \sigma_u'(S_{16}))$

then $\sum_{m=1}^{70} \sigma_m = 1.0$

Question: Can these signal probability function be profitably put in matrix form?

Ref: TK 3226 K73
Kazuo Kondo ed. Memoirs of the unifying study of the basic problems in engineering sciences by means of geometry v. 1.
Tokyo (1955)

TK 3226 L36
P. Le Corbeiller Matrix Analysis of Electric Networks Harvard (1950)

TK 3226 K8
Gabriel Kron. Tensor Analysis of Networks Wiley (1939)
Chap IX - Compound Tensors.

TK 2000 K75
Gabriel Kron Equivalent Circuits of Electrical Machinery Wiley (1951)

AD-63074 Bendix Aviation Corp.
Information

p68 §4.3 The Information Channel as a Matrix
Noiseless channel.

$$\widehat{CH} = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ & & \cdot & & \\ 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$$

p70

$$\vec{P} \cdot \widehat{CH} = \vec{Q}$$

$$\left[\tfrac{1}{2}\ \tfrac{1}{4}\ \tfrac{1}{4}\ \tfrac{1}{8}\right] \cdot \begin{bmatrix} 0 & \frac{1}{2} & \frac{1}{2} & 0 \\ \frac{1}{4} & \frac{1}{4} & 0 & \frac{1}{2} \\ 0 & 0 & \frac{1}{2} & \frac{1}{2} \\ \frac{3}{4} & \frac{1}{4} & 0 & 0 \end{bmatrix} = \left[\tfrac{5}{32}\ \tfrac{11}{32}\ \tfrac{10}{32}\ \tfrac{6}{32}\right]$$

5-29-57

Question: Can a three dimensional probability matrix be developed? I.E. can the bit probabilities and character coding be introduced in the third dimension?

JBW