
The San Marino Scale:
Independence of Terms
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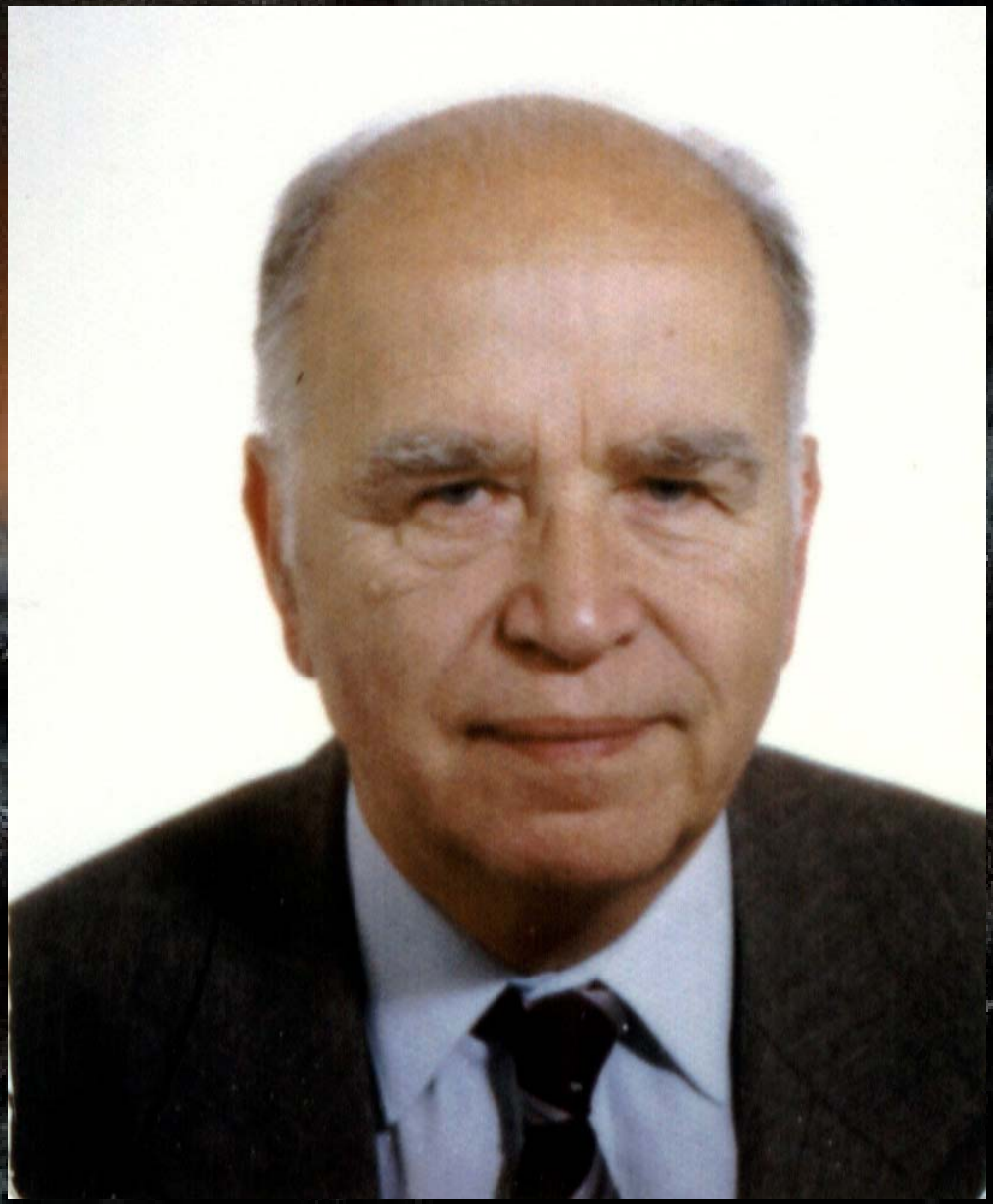
The San Marino Scale!

- **Integer**
- **Ordinal**
- **Categorical**

Value	Potential Hazard
10	Extraordinary
9	Outstanding
8	Far-reaching
7	High
6	Noteworthy
5	Intermediate
4	Moderate
3	Minor
2	Low
1	Insignificant

The San Marino Scale!



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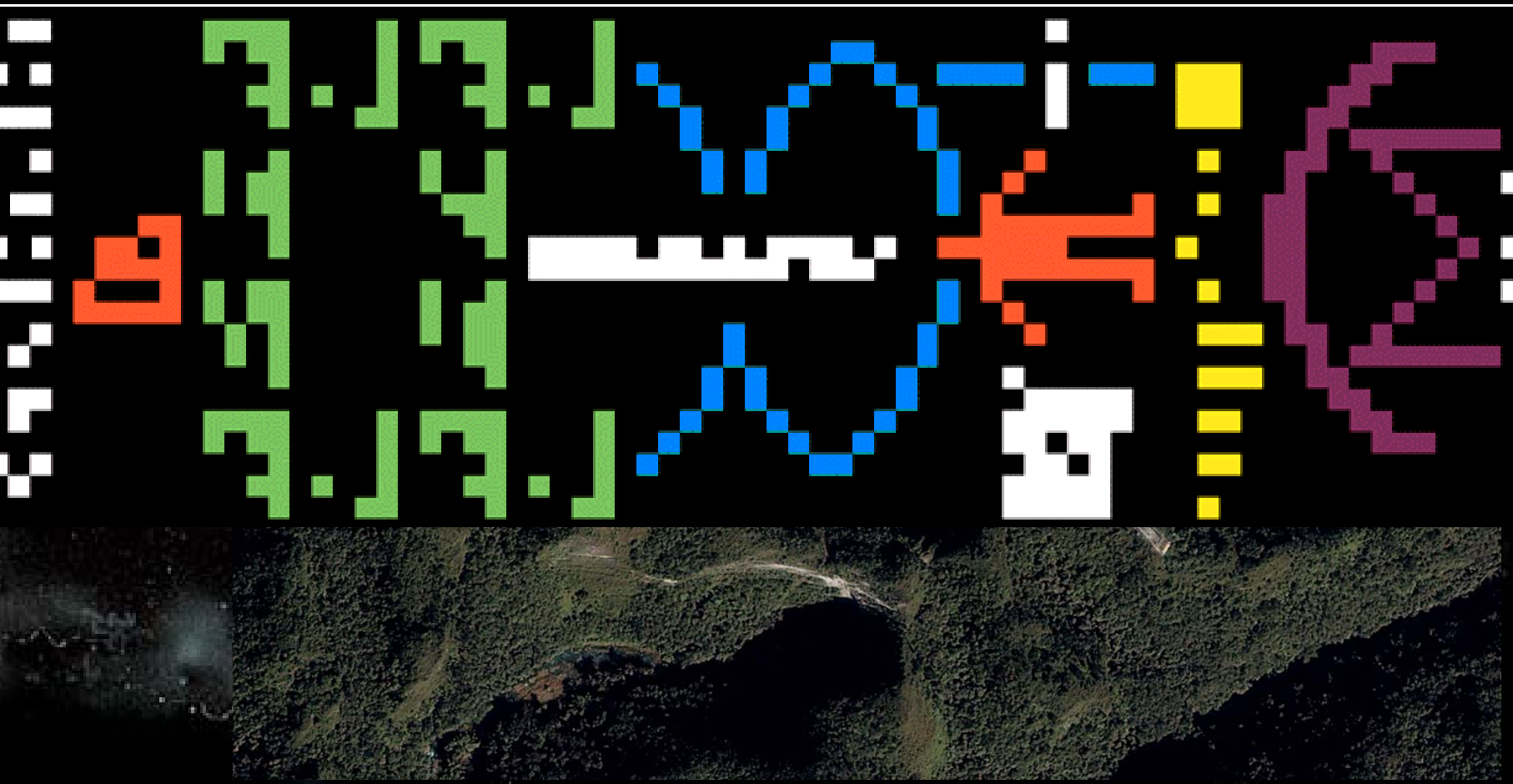
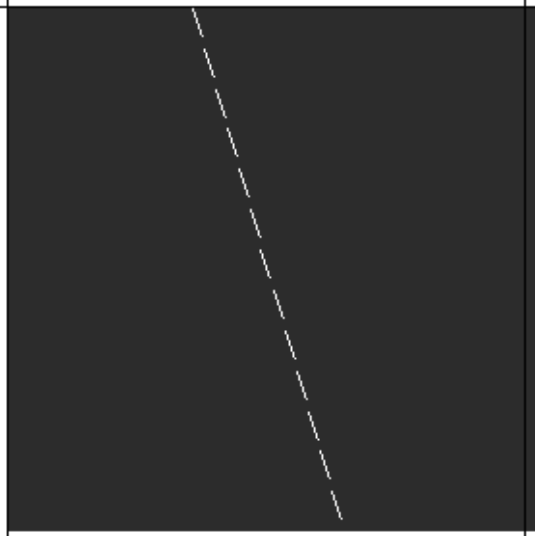
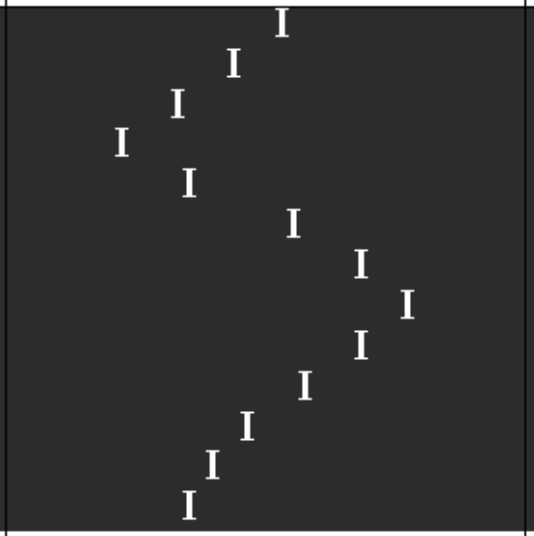
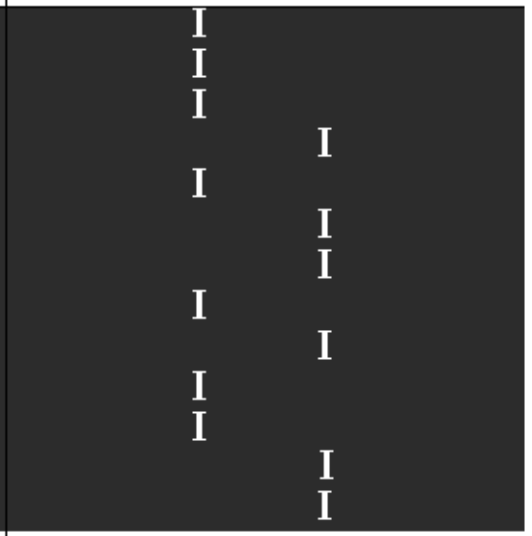


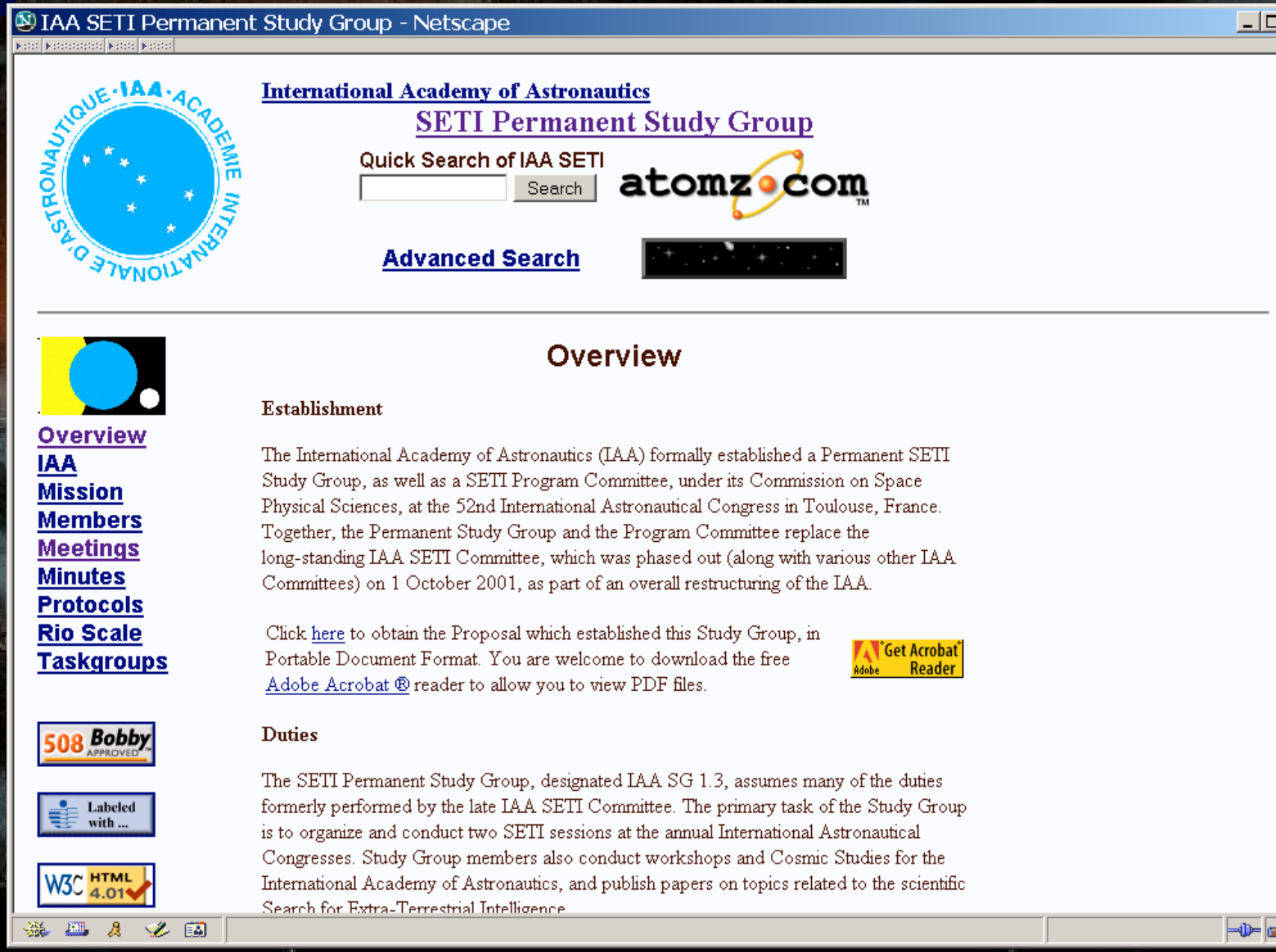
The San Marino Scale:

Spectral Structure of Interstellar Radio Messages

Three Types of Single-valued Frequency Functions:

Type	1. Constant	2. Continuous Function	3. Discrete Function
Author	Radio Engineer	Artist	Scientist
Sonogram			
Name	Language of Nature	Language of Emotions	Language of Logic
Decoding	Astrophysical	By Art Jury	Linguistic

The San Marino Scale!



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The San Marino Scale:

I: intensity of the transmission

Average solar flux density in the frequency band of the transmission (I_o)	0
10 I_o	1
100 I_o	2
1000 I_o	3
10 000 I_o	4
≥100 000 I_o	5

I is the Common Logarithm of the Intensity Ratio

(think: "*Bels over Background*")

The San Marino Scale:

C: character of the transmission

A beacon without any message, e.g. planetary radar	1
Message with the intention to reach ETI – at arbitrary directions for minutes or hours,	2
Special signal in a preselected direction at a preselected time in order to draw the attention of ET astronomers	3
Continuous, broadband transmission of a message to ETI	4
Reply to an extraterrestrial signal or message (if they are not aware of us yet!)	5

C is a numerical value assigned to a Categorical Designato

The San Marino Scale:

$$SMI \equiv I + C$$

The additive model assumes the two terms are independent random variables

The San Marino Scale!

But...

- Signal character depends on information content
- which influences bandwidth
- which determines SNR
- which changes the Intensity term

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Testing six transmitters

- CommSat uplink
- UHF Broadcast TV
- Ham Radio Moonbounce
- NASA Goldstone DSN
- Evpatoria Planetary Radar
- Arecibo Planetary Radar

The San Marino Scale:

against four modulation modes

- CW carrier
- Narrowband voice
- Mid-bandwidth video
- Broadband digital data

The San Marino Scale:

We get a sample of 24 different transmissions

(6 x 4 = 24)

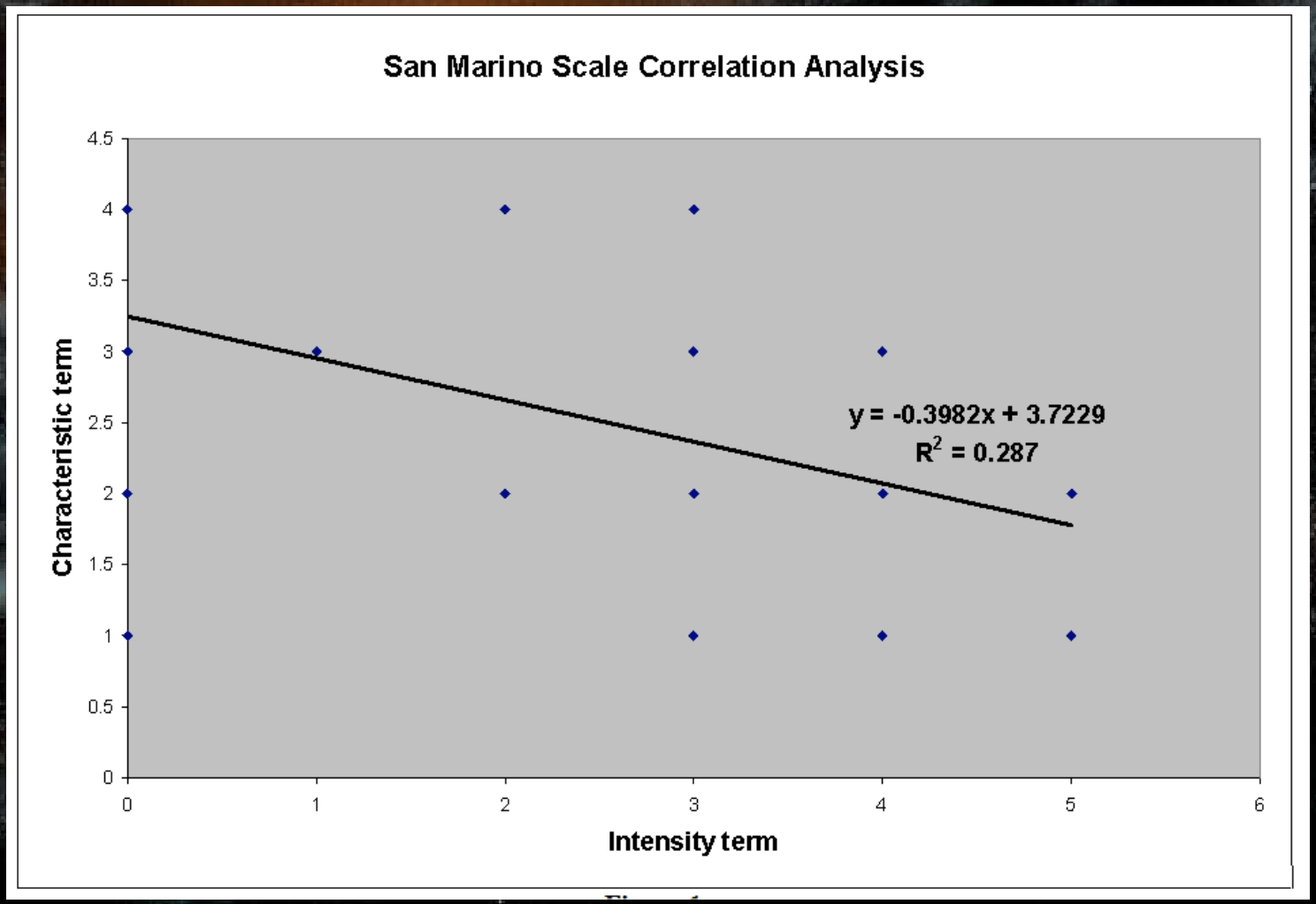
To evaluate for independence of I and C

The San Marino Scale:

Transmitter	Modulation	I	C	SMI
CommSat	CW	0	1	1
CommSat	voice	0	2	2
CommSat	video	0	3	3
CommSat	data	0	4	4
UHF TV	CW	4	1	5
UHF TV	voice	3	2	5
UHF TV	video	1	3	4
UHF TV	data	0	4	4
23 cm EME	CW	3	1	4
23 cm EME	voice	2	2	4
23 cm EME	video	1	3	4
23 cm EME	data	0	4	4
Goldstone DSN	CW	5	1	6
Goldstone DSN	voice	4	2	6
Goldstone DSN	video	4	3	7
Goldstone DSN	data	3	4	7
Evpatoria Radar	CW	5	1	6
Evpatoria Radar	voice	4	2	6
Evpatoria Radar	video	3	3	6
Evpatoria Radar	data	2	4	6
Arecibo Radar	CW	5	1	6
Arecibo Radar	voice	5	2	7
Arecibo Radar	video	4	3	7
Arecibo Radar	data	3	4	7

The San Marino Scale:

Are I and C Independent?



The San Marino Scale:

For interdependent terms, a better choice would be a log-linear model.

$$\ln\left(e_{ic}\right)=\mu+\alpha_i+\beta_c+\gamma_{ic},$$
$$i=0,1,\ldots,5,\quad c=1,2,\ldots,5 \quad (1)$$

Where $\ln(e_{ij})$ is the naperian log of the expected frequencies of the **I** and **C** cell combinations, μ is the overall mean of the log of the expected frequencies, α, β, and γ are the parameters to be estimated for **I** , **C**, and **I×C** , respectively, and i and j are the category levels for **I** and **C**.

The San Marino Scale:

Is sample size adequate?

$$n = \frac{\chi^2_{2(30);0.025}}{4d} = \frac{59.34}{(4)(0.3177)} = 46.69 \approx 47.$$

(for 95% confidence level)

But, our *n* is only 24.

CONCLUSIONS

- San Marino Scale is valid, but flawed
- I and C terms are interdependent
- Log-Linear Model is a better choice
- Sample size is too small for significance
- Not recommending changes at this time
- Need more data

The San Marino Scale!

International Academy of Astronautics

SETI Permanent Study Group

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San Marino Scale Calculator

Rev. 0.1, proposed March 2005

Instructions:

Use the boxes below to describe the active SETI transmission you wish to analyze. Select one option in each of the two boxes. The potential hazard associated with the event, estimated on a scale of one (insignificant) to ten (extraordinary), is displayed at the bottom of the page.

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