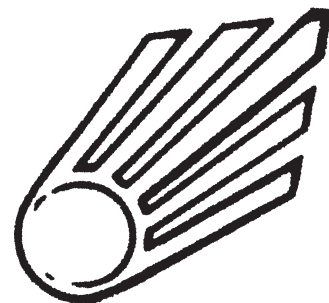


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# SHOUTING IN THE JUNGLE: THE SETI TRANSMISSION DEBATE

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The prudence of transmitting deliberate messages from Earth into interstellar space remains controversial. Reasoned risk-benefit analysis is needed, to inform policy recommendations by such bodies as the International Academy of Astronautics SETI Permanent Study Group. As a first step, at the 2005 International Astronautical Congress in Fukuoka, we discussed the San Marino Scale, a new analytical tool for assessing transmission risk. That Scale was updated, and a revised version presented at the 2006 IAC in Valencia. We are now in a position to recommend specific improvements to the scale we proposed for quantifying terrestrial transmissions. Our intent is to make this tool better reflect the detectability and potential impact of recent and proposed messages beamed from Earth. We believe the changes proposed herein strengthen the San Marino Scale as an analytical tool, and bring us closer to its eventual adoption.

**Keywords:** San Marino Scale, SETI, METI

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## 1. INTRODUCTION: FIFTY YEARS OF SOLITUDE

Modern SETI science traces its roots to a brief paper by Cocconi and Morrison [1], published in the journal *Nature* in 1959, suggesting that Earth's radio telescopes had advanced to the point where they were in a position reasonably to detect likely radio emissions from nearby, technologically advanced extraterrestrial civilizations. At the exact time that article was in press, Drake [2] was laying the groundwork to perform, from NRAO Green Bank WV, the very investigation that Cocconi and Morrison were proposing. The two authors, and the lone investigator, had no knowledge of one another, but had arrived independently at the same basic experimental design, suggesting that the search now known as SETI was an idea whose time had come.

In the intervening years, hundreds of searches, of ever increasing complexity and continually improving sensitivity, have been conducted by dozens of institutions worldwide [3]. All have, to date, achieved identical results: not *one single* radio emission of clear and irrefutable intelligent extraterrestrial origin has yet been detected. After nearly fifty years of solitude, SETI proponents ask, might it not be time to break our radio silence, and make some noise from planet Earth?

## 2. RISK-BENEFIT ANALYSIS

Transmission from Earth is not wholly without risk. In spirited debates within the SETI Permanent Study Group of the International Academy of Astronautics, participants are neatly divided into two distinct camps: those who believe predation is a possibility in the cosmos, and those who envision benevolent extraterrestrials.

Lacking a confirmed interstellar contact, we cannot at this time intelligently take sides in this debate. But, no matter what positive motives we might ascribe to our cosmic companions, no matter

how altruistic we may believe our neighbours to be, or no matter how unlikely we may consider it that we would encounter malevolent extraterrestrials, even the most ardent proponents of transmission from Earth, and other forms of Active SETI, must honestly concede that the probability of negative consequences from terrestrial transmission is non-zero.

In its advisory capacity to such policy-making bodies as the United Nations Committee for the Peaceful Uses of Outer Space (COPUOS), the IAA SETI Permanent Study Group (SPSG) has for years been grappling with the issue of establishing international transmission protocols. One vocal subset of the SPSG has urged a total moratorium on transmission, stating emphatically that intelligent species refrain from shouting in the jungle. American physicist and science fiction author David Brin evokes the Fermi Paradox when he writes, "If advanced aliens are being strangely quiet, should *we* start yelling? Maybe they know something we don't know. As Yossarian said, in *Catch 22* — if that's what everyone else is doing, I'd be an idiot to do any different" [4].

Brin's suggestion prompted a humorous response from Alexander L. Zaitsev of the Russian Academy of Sciences, a vocal proponent and practitioner of Active SETI: perhaps the SETI acronym actually stands for Search for Extra-Terrestrial Idiots [5].

Though Zaitsev's comments were intended to be tongue-in-cheek, it can be argued that, if we truly believe that transmissions doom a civilization to annihilation, then the whole SETI enterprise is futile, as the intelligent extraterrestrials whose signals we seek will either know better than to transmit, or will by now be extinct. Others ask: if we ourselves are not willing to rustle the bushes, how can we in good conscience expect our cosmic companions to reciprocate?

Numerous rational and emotional arguments continue to be put forth, both for and against transmission from Earth. But, until a rigorous risk-benefit analysis can be performed, neither proponents nor opponents of Active SETI are likely to convince each other of the wisdom of their respective positions. We do not suggest that we have here performed such a rigorous analysis. However, until we have quantified one specific aspect, the exposure to which Earth is subjected by a given transmission, historical or hypothetical, planned or past, we cannot take the next necessary steps in further assessing risk and benefit. Hence, we have introduced the San Marino Scale, as an attempt to quantify exposure, a critical aspect of transmission risk.

### 3. PROPOSING AN ORDINAL QUANTIFICATION TOOL

While SETI, the Search for Extra-Terrestrial Intelligence, is a widely accepted science, the reciprocal activity of Active SETI (sometimes called METI, Messaging to Extra-Terrestrial Intelligence) remains a controversial area, receiving much discussion and debate within the SETI community. The authors of this paper have, for the past two years, been developing the San Marino Scale [6,7,8], a numerical tool to give such discussions a modest analytical basis. Named for the tiny but lovely European Republic in which it was first introduced [9], the San Marino Scale seeks to quantify one aspect of transmission risk: the exposure presented by a given transmission from Earth.

The San Marino Scale recognizes that not all transmissions can be considered equal, but that the potential impact of a given transmission is related to its strength or intensity (which is clearly parametric), as well as its character, a function of duration and information content (which we concede is categorical, thus somewhat more difficult to quantify). We believe we have come up with a means for expressing the combination of these factors on an ordinal, integer scale. We emphasize that the San Marino Scale remains a work in progress, having received beneficial feedback and suggestions from the attendees at various conferences at which it has been discussed over the past two years. We now endeavour to update the San Marino Scale previously introduced, based upon both that feedback and subsequent email discussions among members of the IAA SETI Permanent Study Group.

### 4. THE PARAMETRIC TERM ‘I’

In its first iteration, signal intensity, the parametric (quantifiable) term of the San Marino Scale (referred to by the literal ‘I’) was referenced to the Earth’s microwave footprint, as follows:

*“I is a logarithmic measure to the base 10 of signal strength or intensity, relative to the Earth’s background radiation intensity...”*

We now suggest that for all practical purposes, it is the Sun’s background radiation intensity, rather than Earth’s, which probably limits detectability of our planet’s microwave signals. We deem it unlikely that a distant SETI antenna will enable ETI to separate terrestrial microwave radiation from the natural microwave emissions emanating from our nearest star.

Consider a transmission from Earth to even the nearest stellar neighbour. For convenience in computation, let us set the transmission distance at 1 parsec (pc) [it is actually a little

greater than this]. The pc is defined as the distance at which an object displays a parallax of 1 second of arc across a baseline of 1 astronomical unit (which is, of course, the radius of the Earth’s orbit). By symmetry, the Earth, as viewed from that star, will thus appear to be separated from the sun by an angular distance of not more than one arc sec.

1 arc second equates to just under  $5 \times 10^{-6}$  radians. Thus, to resolve over interstellar distances a signal from Earth, independent of radiation from our Sun, a receive antenna must have a beamwidth of less than  $5 \times 10^{-6}$  radians.

For a single parabolic antenna, the receiver’s 3 dB beamwidth, in radians, equals roughly wavelength divided by diameter [with the two measured in like units]. Given a terrestrial microwave signal at, say, the neutral hydrogen line (wavelength equal to 21 cm), the required receive antenna diameter to achieve a beamwidth of 5 micro-radians would be about 45 km. Thus, to distinctly resolve Earth and Sun over interstellar distances at 21 cm, it would take a single parabolic reflector at least 45 km in diameter, or a properly phased array of smaller antennas with equivalent capture area — in other words, the equivalent of more than 2,000 Square Kilometre Arrays, all working in concert.

In an excellent article dealing with the likelihood of ETI detecting terrestrial television broadcasts, Scheffer [10] considers two hypothetical receive antennas, a “small” one of 30 km diameter, and a “large” one spanning 1,000 km. He computes, for the former, a range of 280 LY for detection of terrestrial UHF TV carriers. However, in his calculations Scheffer assumes an extraterrestrial receiver whose sensitivity is limited only by the 2.7 Kelvin cosmic microwave background. As we have just shown, a 30 km aperture is insufficient to eliminate solar radiation from its beamwidth; thus, antenna noise temperature will significantly exceed the cosmic microwave background, and detection range will be correspondingly reduced. This underscores our assertion that the Sun is the limiting factor in practical detection of Earth’s microwave leakage emissions.

What of the “large” antenna Scheffer suggests? Clearly, a 1000 km aperture could easily resolve the Earth and the Sun. Such an array could, perhaps, be built on a moon, or in outer space. Accurately aiming and steering such an array would represent a daunting engineering challenge. However, it is true that, in the case of an array with a capture area of a million SKAs, over interstellar distances, the Sun’s noise is no longer a limiting factor.

Only, Earth has yet to build a *single* SKA, much less a million such instruments. We will certainly not here attempt to limit the technological capacity of an advanced extraterrestrial civilization. We concede that interferometric techniques can indeed be used to null out the glare of a star, when attempting to image individual planets. These techniques, which have been demonstrated in both the radio and the optical spectrum, show promise at popular microwave SETI frequencies, though wavelengths (and hence antenna size) are five or six orders of magnitude greater than they would be for optical telescopes. Space-based VLBI techniques [11] are a demonstrated possibility. They are unlikely to prove particularly useful in the search phase, however, being more practical once the presence and location of a target planet (in this case, Earth) are already known to, or at least suspected by, the extraterrestrial astronomers.

For SETI, it makes sense to employ antenna beamwidths sufficient to encompass an entire solar system. In addition, the design and construction of even Scheffer’s proposed “small” array are, to say the least, daunting. And, as the distance to the neighbouring star increases, the angular separation between Sun and Earth becomes vanishingly small. We thus conclude that, in the case of ETI’s own SETI programs, it is unlikely that any signal will be detected from Earth, absent a dominant solar background radiation component.

It is true that at certain times, in certain directions, and at certain frequencies, the microwave emissions from Earth caused by our technology can exceed those of the Sun by a million-fold or more. However, these terrestrial emissions are highly intermittent, exceedingly directional, and scattered across the spectrum. We are inclined to classify such powerful emissions as inadvertent METI signals. The Sun’s microwave flux, on the other hand, is almost constant and isotropic. Thus, we suggest, the backdrop against which terrestrial signals must be evaluated is not Earth’s modest 290 K thermal profile, nor even the average intensity of artificial terrestrial microwave emissions, but more properly the interference generated by a 5780 K thermal black body: our own Sun.

SETI 2020, the SETI Institute’s planning document for activities into the early 21<sup>st</sup> Century [12], discusses several different powerful transmissions from Earth, in terms of the degree to which each “outshines the Sun.” This would seem to validate our assertion that solar radiation represents a reasonable background against which to evaluate transmissions from Earth.

Given these considerations, we now propose to modify our definition of the parametric term ‘I’, as follows:

*“I is a logarithmic measure to the base 10 of signal strength or intensity, relative to the Sun’s background radiation intensity, measured in the same frequency range as the terrestrial transmission in question, and over a bandwidth equivalent to the total modulation bandwidth of the transmitted signal, or the detection bandwidth of the receiver intercepting it.”*

Table 1 shows a modification of Table 1 in [6], reflecting this change.

## 5. THE CATEGORICAL TERM ‘C’

Electromagnetic emissions from Earth, or anywhere else, can be highly directional (beamed or targeted), omnidirectional, or somewhere in between, as a function of transmit antenna gain. In categorizing the character of a transmission, the term ‘C’, as originally introduced, differentiated between directional and

omnidirectional signals. We now believe that distinction to be superfluous, in that directionality is already encompassed in the ‘I’ term.

The intensity term ‘I’ is derived from the effective isotropic radiated power (EIRP) of the transmission in question. EIRP is in turn a product of transmitter power and antenna gain. But antenna gain and directionality are inexorably linked. That is, a high gain antenna achieves its gain by focusing photons; high directionality inevitably results. Similarly, an omnidirectional antenna will, by definition, exhibit low gain; it responds equally poorly in all directions. Thus, the directional character of a transmission has already been encompassed in quantifying its intensity.

To include directional characteristics in the determination of the categorical term ‘C’ will, in effect, give them double weighting. Thus, we now recommend that all references to directionality be omitted from the ‘C’ term, while retaining considerations of intentionality and information content.

Table 2 shows a modification of Table 2 in [6], reflecting this change.

## 6. MIXING UNITS

At the Fukuoka meeting, interesting questions were raised from the audience about the validity of deriving a quantitative criterion measure by summing parametric and non-parametric terms. It was noted that, while the Intensity term was clearly quantifiable, the contributions to detectability (and hence impact) of a signal’s nature clearly were not.

While we concede that there is no analytical basis for quantifying the potential impact of a signal based upon the characteristics listed in Table 2, we maintain that the considerations listed are, at the very least, ordinal. That is, a radar beacon lacking message content will clearly reveal to our interstellar neighbours less about our civilization than would a sustained message transmission. Similarly, the other categories for the ‘C’ term are ranked in terms of increasing information content, duration, detectability, or societal impact. Thus, we maintain that the rankings implied in the ‘C’ term are ordinally significant, as is ‘Q’ in the earlier Rio Scale [13], of which the San Marino Scale is a descendant. If not truly quantifiable, ‘C’ still has ordinal meaning in the context of the overall San Marino Scale (which, after all, is itself subjective, ordinal, and non-parametric).

## 7. STRUCTURE

“How would you rate the risk of that transmission, on a scale of one to ten?” This is the very kind of question which we would

**TABLE 1: Revised I Term.**

Intensity of Transmission	Value of I
$\geq 100,000 * I_{sol}$	5
$\sim 10,000 * I_{sol}$	4
$\sim 1,000 * I_{sol}$	3
$\sim 100 * I_{sol}$	2
$\sim 10 * I_{sol}$	1
Solar flux intensity at the frequency of the transmission, over detection bandwidth consistent with the signal ( $\sim I_{sol}$ )	0

**TABLE 2:** Revised C Term.

Character of Transmission	Value of C
Reply to an extraterrestrial signal or message (if they are not yet aware of us!)	5
Continuous, broadband transmission of a message to ETI	4
Special signal targeting a specific star or stars, at a preselected time, in order to draw attention of ET astronomers	3
Sustained, untargeted message with the intention to reach ETI	2
A beacon without any message (e.g., planetary radar)	1

expect the media, the would-be regulators, and in fact the general public to ask, whenever transmission from Earth is discussed. The San Marino Scale seeks to reduce all discussion to that simplistic level. Despite the minor changes suggested above, the San Marino Index remains structured as originally proposed, and is mathematically defined as:

$$\text{SMI} = \text{I} + \text{C}$$

Where:

**SMI** is the numeric San Marino Index, on an integer scale of 1 to 10,

**I** is a logarithmic measure to the base 10 of signal strength or intensity, now relative to the Sun's radiation intensity (think "Bels over background"), with a maximum value of 5,

**C** still represents the characteristics of the transmission, with regard to information content, intentions, and duration (but no longer directionality).

The overall San Marino Index remains a qualitative tool for assessing exposure, an essential component of relative transmission risk.

## 8. POLICY IMPLICATIONS

While there are those within the scientific community who consider any and all transmissions from Earth so potentially hazardous as to be worthy of total prohibition, others suggest that the benefits outweigh the risks, and that no restrictions whatever ought to be imposed on Active SETI. We suggest that blanket policy decisions in either direction are ill-advised. The San Marino Scale underscores our assertion that not all transmissions can be considered equal. We respectfully suggest that transmissions weighing in at the bottom of the San Marino Scale (say, with scores of 1 or 2) are probably insignificant, and can justifiably be ignored by policy makers and regulators. We concede that transmissions at the top of the scale (say, rating a 9 or 10) hold so much potential for detection that some form of regulation, or at least a temporary moratorium, might indeed be justifiable. In between, we believe, planned transmissions from Earth need to be evaluated on a case by case basis, with the San Marino Scale used as one of the determinants in evaluating transmission policy.

## 9. CONSIDERING TIME CAPSULES

METI (Messaging to ETI) includes not only electromagnetic emissions, but also such artifacts as the plaques on the Pioneer probes and the records on the Voyager interplanetary space-

craft. They are en route to possible alien civilizations. There are similar plaques on some long-living satellites as well (e.g. LAGEOS) which can be considered as messages to future generations of humankind. Who knows who will discover these physical messages: our descendants, or representatives of ETI?

It is only a small logical step from such messages to existing "time capsules" here on Earth, intended as messages to future generations. An early example (circa 1940) is the "Crypt of Civilization" at Oglethorpe University, Atlanta, GA, USA [14].

It is the authors' opinion that such time capsules face problems in some respects similar to the case of active SETI or METI: who decides what the message should contain, who is responsible, what kind of time capsule should be considered a serious message, and what only a joke of an amateur? We therefore suggest that something akin to the San Marino Scale could well be applied to quantifying the potential impact of such "Messages to the Future".

## 10. CONCLUSION

The proposed San Marino Scale remains a work in progress. It has still not been adopted by any regulatory or advisory body. Doubtless, future changes will be proposed, and some adopted, before this tool is ready for prime time. In the interim, we believe that a strong need exists for quantification of transmissions from Earth, be they planned, past, performed, or proposed. We feel the two changes to the proposed scale outlined herein (i.e., referencing intensity to solar radiation, and eliminating directionality as a consideration for the categorical term) strengthen the San Marino Scale as an analytical tool, and bring us closer to its eventual adoption.

With no knowledge whatever of the SETI enterprise, let alone the feasibility or risks of transmission from Earth, the poet Emily Dickenson, more than a century ago, unwittingly framed the transmission debate. While the first line of her poem suggests that we can attract signals from our neighbours by sending ones of our own, the last lines would seem to be a dire reminder that, once sent, a transmission can never be recalled:

We send the Wave to find the Wave —  
 An Errand so divine,  
 The Messenger enamored too,  
 Forgetting to return,  
 We make the wise distinction still,  
 Soever made in vain,  
 The sagest time to dam the sea  
 Is when the sea is gone.

Emily Dickinson, (circa 1884)

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## APPENDIX: A SAN MARINO SCALE CALCULATOR

For anybody wishing to try their hand at evaluating various transmissions from Earth, we have implemented a San Marino Scale Calculator on the website of the IAA SETI Permanent Study Group. This calculator can be located at

<http://iaaseti.org>

clicking on Protocols from the Main Menu at left, and then following the links.

Alternatively, the San Marino Scale calculator may be accessed at:

<http://www.setileague.org/iaaseti/smicalc.htm>

The structure of the JavaScript calculator makes its use

quite intuitive. Radio buttons enable the user to quickly enter the particulars of any transmission (hypothetical or actual) being analysed. The calculator software then computes the resulting San Marino Scale value for the event under study. Members of the scientific community and the media are invited to use this tool for estimating San Marino index values during analysis of candidate transmissions from Earth, and to assign San Marino Scale values in quantifying their estimates of the potential hazard associated with any active SETI project.

**Webmaster's Disclaimer:** The San Marino Scale Calculator on the IAA SETI Permanent Study Group website requires a JavaScript-enabled browser. Your browser must be set to "allow active content." Some browser security settings block active content, and thus will inhibit this calculator's performance.

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