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Quantifying Consequences Through Scales

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Introduction

- Why needed? Risk communication tool
- Classification
- Impact, significance, importance, hazard
- Media effects (FAQ)
- Regulation

Scales

- Flare scale
- Richter or Mercalli-Sieberg scale
- NOAA scale
- Torino (Palermo) scale
- Rio scale
- San Marino scale

Natural phenomena

- **Intensity of flares**
- Depends on the area of solar flares (in millionth part of the solar disk):
- Subflare, 1 2 3 4
- Additional index: B = bright
- F = faint
- N = normal

Natural phenomena

- **Intensity of earthquakes**

- Richter scale
  From 1 to 9 impact on the surface
- Mercalli-Sieberg scale
  From I to XII surface effects

NOAA Scale

Characterizing the terrestrial impact of solar weather

- The US NOAA has developed a scale to measure the hazard solar events will have on humans, on spacecraft and on ground systems. The index rates solar radiation storms, geomagnetic storms and radio blackouts on a scale of 1 to 5 with 5 representing the worst storms..

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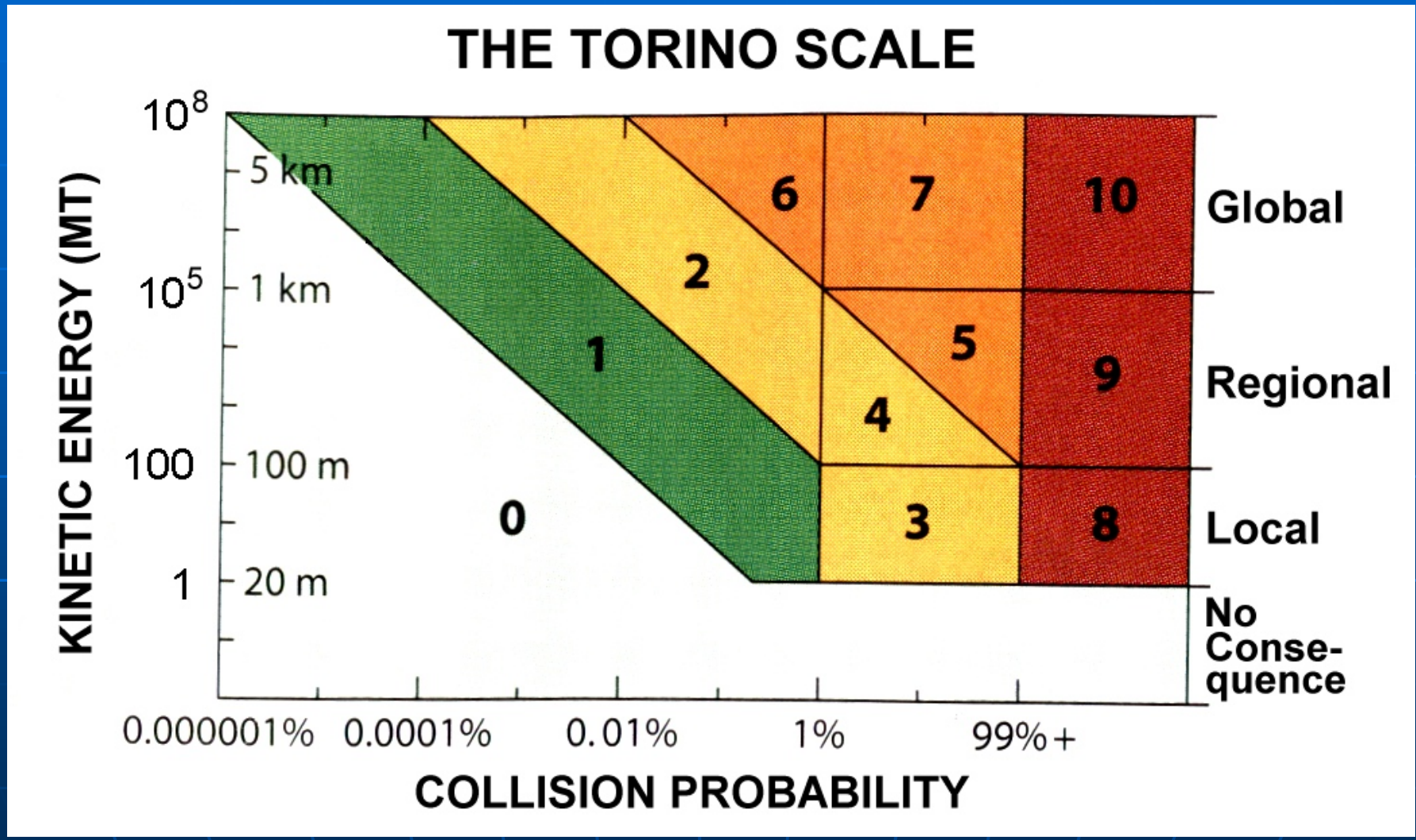
Possible effects:

Category	Biological	Satellite operations	Other systems
S-5 Extreme	High radiation hazard for spacewalking astronauts; high-altitude airplane passengers at far polar latitudes get radiation exposure equivalent to a chest X-ray	Total loss of some satellites; permanent damage to solar panels; loss of control; serious noise in image data; star trackers unable to locate sources.	No high-frequency communication possible in polar regions; position errors make navigation operations extremely difficult.
S-4 Severe	Radiation hazard for spacewalking astronauts	Memory device problems; noise in imaging systems; interference with star trackers cause orientation problems; degradation of solar panels.	Blackout of high-frequency communication throughout the polar caps; increased navigation errors over several days.
S-3 Strong	Radiation hazard avoidance required for spacewalking astronauts	Noise in imaging systems; permanent damage to exposed components and detectors; decrease of current generated by	Degraded high-frequency radio throughout the polar caps; some navigation position errors.

The Torino Scale

Asteroid impact

- It is a linear combination of the *size* (kinetic energy) of an asteroid or comet on a near-Earth trajectory and its *collision probability* to assess the risk it represents for the Earth
- Palermo scale


THE TORINO SCALE
KINETIC ENERGY (MT)
10^8
10^5
100
1
5 km
1 km
100 m
20 m
0
1
2
3
4
5
6
7
8
9
10
Global
Regional
Local
No Conse-quence
0.000001%
0.0001%
0.01%
1%
99%+
COLLISION PROBABILITY

The Torino Scale (2)

Assessing asteroid and comet impact hazard predictions in the 21st century

0 Events having no likely consequences	The likelihood of a collision is zero, or well below the chance that a random object of the same size will strike the Earth within the next few decades. This designation also applies to any small object that, in the event of a collision, is unlikely to reach the Earth's surface intact.
1 Events meriting careful monitoring	The chance of collision is extremely unlikely, about the same as a random object of the same size striking the Earth within the next few decades.
2 Events meriting concern	A somewhat close, but not unusual encounter, Collision is very unlikely.
3 Events meriting concern.	A close encounter, with 1% or greater chance of a collision capable of causing localized destruction.

The Rio Scale

ETI discovery

- An ordinal scale between zero and ten, proposed to quantify the impact (or importance) of any public announcement regarding evidence of extraterrestrial intelligence.
- Calculates the level of *probable consequences* weighted by the assessed *credibility* of the claim

Rio Scale (2)

Characterizing the level of significance of any claimed discovery of ETI

Q 1	*Class of Phenomenon*	Q 2	**Discovery**	Q 3	**Distance**
1	Traces of astroengineering, or any indication of technological activity by an extant or extinct civilization at any distance, or an ET artifact (trash) the purpose of which is unknown	1	From archival data; *a posteriori* discovery without possibility of verification	1	Extragalactic
2	Leakage radiation, without possible interpretation, or an ET artifact the purpose of which is understandable	2	Non-SETI/SETA observation; transient phenomenon that is reliable but never repeated	2	Within the Galaxy
3	Omnidirectional beacon designed to draw attention, or an ET artifact with a message of general character	3	SETI/SETA observation; transient phenomenon that has been verified but never repeated	3	Within a distance which allows communication (at light speed) within a human lifetime
4	Earth-specific beacon to draw our attention,	4	Non-SETI/SETA observation; steady	4	Within the solar system

Rio Scale (3)

$RS = Q \times \delta$ $\qquad$ $Q = Q_1 + Q_2 + Q_3$

δ	**Credibility**
0	Obviously fake or fraudulent
1/6	Very uncertain, but worthy of verification effort
2/6	Possible, but should be verified before taken seriously
3/6	Very probable, with verification already carried out
4/6	Absolutely reliable, without any doubt

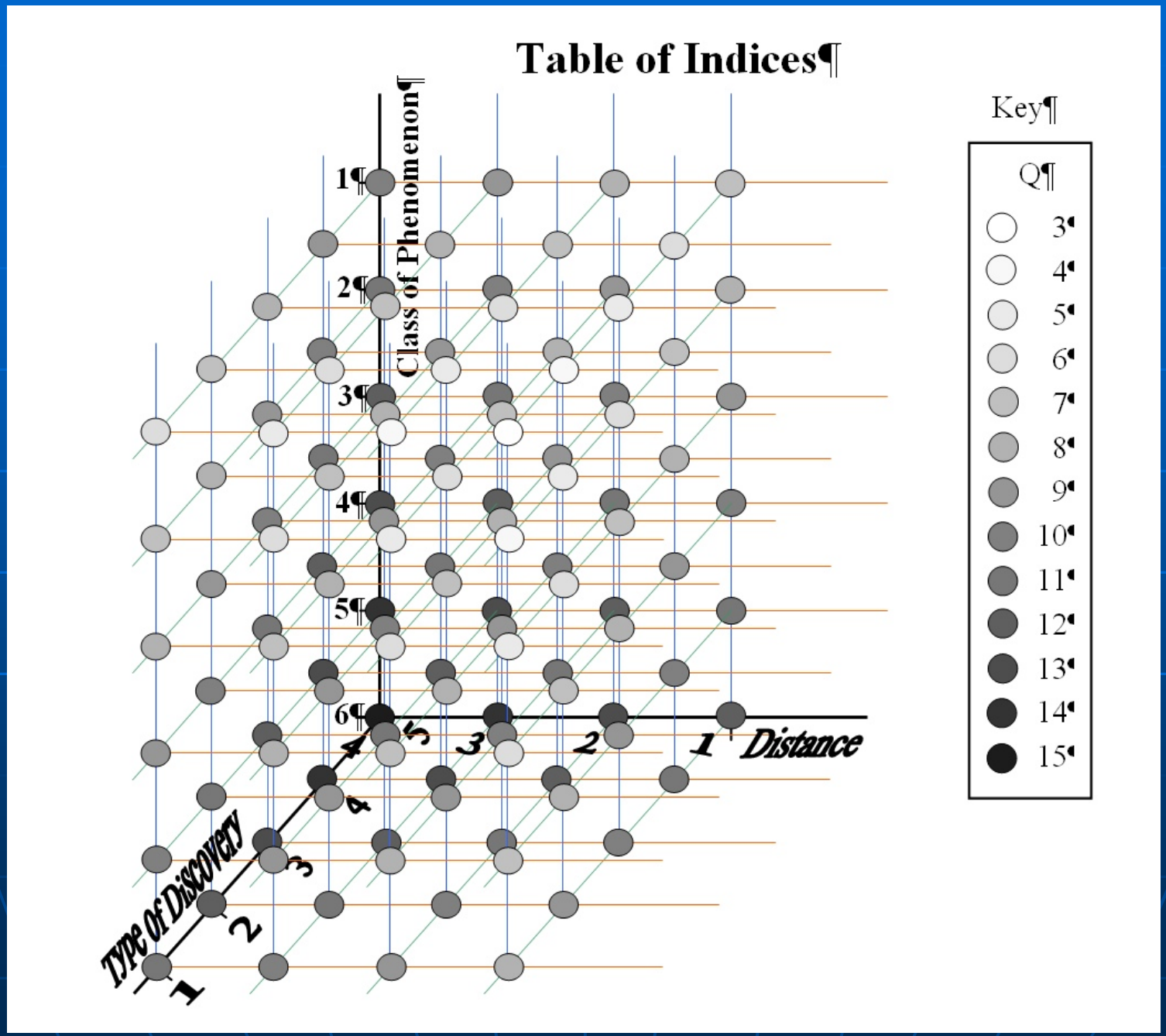


Table of Indices¶
Class of Phenomenon¶
1¶
2¶
3¶
4¶
5¶
6¶
Distance
Type of Discovery
Key¶
Q¶
3¶
4¶
5¶
6¶
7¶
8¶
9¶
10¶
11¶
12¶
13¶
14¶
15¶

Transmission from Earth

- A debate within the SETI community
- Arguments against a transmission
- Arguments for an active SETI program, or transmission of messages or reply to any ET signal
- Legal regulation of such activities and its limits

The San Marino Scale

Transmission or active SETI

- The possibility of a potential hazard connected with any transmission towards the sky (and towards ETI) assessed by a combination of the *intensity* and of the *character* of the transmission.
- The scale is the sum of two arbitrary indices (I and C) and expands from 1 to 10

San Marino Scale (2)

Assessing potential hazard from active or aimed transmission from Earth

The *San Marino Index (SMI)* is the sum of the *I (intensity)* and the *C (character)* indices and extends from 1 to 10.

I (intensity of the transmission)

Current average level of the terrestrial noise background intensity 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

San Marino Scale (3)

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, e.g. Yevpatoria	2
Special signal in a preselected direction at a preselected time in order to draw the attention of ET astronomers, e.g. Lemarchand's suggestion	3
Continuous omnidirectional, broadband transmission of a message to ETI	4
Reply to an extraterrestrial signal or message (if they are not aware of us yet!)	5

SMI = I + C

Conclusions

- Every time we want to assess the potential risk of a phenomenon (or activity), which depends on several parameters, a transformation into a linear scale is useful and necessary
- Thanks for suggestions and assistance (from Paul Shuch in particular)