

## THE RIO SCALE APPLIED TO FICTIONAL SETI DETECTIONS

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Almar and Tarter [1], and Almar [2] have proposed a scale for quantifying the probability of claimed detections of extraterrestrial presence, either via signals or via direct physical evidence. The proposed Rio Scale was developed by borrowing from the more widely known Torino scale used by scientists studying the potential consequences of predicted impacts by near-Earth objects, and is intended to give the media and the public some indication from the science community of how seriously to regard such claims of detected ETI. In order to provide an illustrative set of examples, the authors have applied the criteria of the Rio Scale to a set of selected fictional extraterrestrial “encounters” from the cinema, as well as to some non-fiction “claims.” It is the authors’ hope that these examples will both clarify and enhance the usefulness of this important metric.

### INTRODUCTION

While no confirmed detection of an extraterrestrial signal has yet been received, there have been cases in which a cosmic signal was legitimately suspected of being of artificial origin. These include the Ohio State “Wow” signal of 1977 [3], the Project Phoenix Soho signal of 1997, and the EQ Peg hoax of 1998 [4]. The first and last of these were – and to some extent, still are – the subject of media inquiry. Because of the routine presence of extraterrestrials in the popular media – particularly film, television, and printed fiction – the public has been conditioned to expect their imminent detection (or revelation of their presence on Earth). The degree to which the public is vulnerable to claims regarding extraterrestrials can be gauged from polls showing that the majority of Americans believe that evidence for their existence is being secreted from them by their own government – 71% according to a 2001 Gallup poll [5].

This is a special problem for SETI researchers, insofar as (1) their work is based on a strictly scientific approach to detecting alien existence, one that relies on careful verification and multiple detection, (2) the fact that funding – which in the United States is entirely private – is dependent upon this conservative approach, and (3) the enormous popularity of the University of California, Berkeley’s SETI screen saver, [SETI@home](#), which has involved approximately four million people in the search, and conditioned them to be prepared for a detection at any time.

In other words, the public has many reasons to find a claimed SETI detection believable. They cannot, however, easily judge how credible such claims may be, as evidenced by the attention paid to the EQ Peg hoax. Indeed, even SETI scientists themselves were unsure how to treat this claim, and radio telescope time was invested by Australian and American researchers in verification attempts.

Given the widespread interest and optimism in SETI, we can expect that there will be future claims of detection from both within and without the (small) SETI research community. In the interests of better assessment of such announcements, Almar and Tarter [1,2] have proposed a scale that can be used by the media to convey to the public both the credibility and potential impact of claimed detections. The so-called Rio Scale would rate claims on a scale of 0 to 10, with 10 being most credible and representing the greatest societal impact. Rio Scale ranking would be set by an as-yet undetermined collaborative or representative body of active SETI scientists.

The (revised) Rio Scale consists of two terms multiplied together to produce a ranking. The first term (designated  $Q$ ) is comprised of the sum of three indices that determine the importance, or consequence, of the detection. The second term (designated  $\alpha$ ) is a fraction that can take any of five discrete values between zero and  $2/3$ , and gives the estimated credibility of the claimed detection. The terms of the revised Rio Scale are listed in Table 1.

**Table 1. Components of the revised Rio Scale**

Level of Importance  $Q$

$Q_1$	Class of Phenomenon	$Q_2$	Discovery Type	$Q_3$	Distance
1	Traces of astroengineering at any distance, or any indication of technological activity by extant or extinct civilization	1	From archival data; <i>a posteriori</i> discovery without possibility of verification	1	Extragalactic
2	Leakage radiation, without possible interpretation	2	Non-SETI/SETA observation; transient phenomenon that is reliable but never repeated	2	Within the Galaxy
3	Omnidirectional beacon designed to draw attention	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	4	Non-SETI/SETA	4	Within the solar system

	draw our attention		observation; steady phenomenon verifiable by repeated observation or investigation		
5	Omnidirectional message with decipherable information	5	Same as 4, but result of SETI/SETA observation		
6	Earth-specific message or physical encounter				

### Credibility ä

ä	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

This scale, like its inspiration the Torino scale for classifying the threat from asteroids [6], can only be of significant benefit to the extent that it's both known and understood by the media that would use it. To this end, we have endeavored to apply the Rio Scale to a series of existing SETI "detections," mostly from the world of fiction. Since these occurrences already exist in the public consciousness, application of the Scale to these examples can serve to establish its nature and use.

### SELECTED RIO SCALE SCENARIOS

We offer below our grading of SETI "detections" from selected films and novels.

#### *Signal Detection – Films*

1. "Contact" (1997). In the movie version of Carl Sagan's 1983 novel, the protagonist is engaged in a targeted search of stellar systems using the Very Large Array (VLA). Her initial detection of a signal modulated at audio frequencies is made using headphones. Confirmation (using a "follow-up detection device" reminiscent of that used for the SETI Institute's Project Phoenix) follows within minutes. The resolving power of the VLA permits a quick check that the source – coincident with the nearby star Vega – is moving at the sidereal rate through the sky, and is therefore not an aircraft or satellite. The next major confirmation gambit is to check the source with other radio telescopes. The Australians quickly confirm Vega as the source

direction, and within days other observatories, world-wide, have weighed in on the side of an extraterrestrial detection. The signal is discovered to include a transponded version of a 1936 television broadcast, indicating that the transmission is intended for Earth. There is never any doubt about the extraterrestrial nature of the signal, although its origin from Vega could be considered uncertain until the imbedded TV signal is found. Not surprisingly given Sagan's authorship, "Contact" presents the most realistic scenario of what an actual radio detection would be like. Our Rio Scale categorization is as follows:

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Immediately following Detection	3 - 6	5	1 - 4	1/2	4 - 8
After confirmation by other telescopes	3 - 6	5	1 - 4	2/3	6 - 10
After transponded TV Broadcast discovered	6	5	3	2/3	9

2. "The Arrival" (1996). In this film, a pair of SETI scientists (including protagonist Zane Zaminsky) scanning the skies for artificial radio signals get bored with normal protocol, and elect to tune to a lower frequency. Unexpectedly, a 42 second signal comes in (clearly extraterrestrial), which the scientists record and bring to their boss. In a surprise move, the boss fires Zaminsky and destroys the recording. The dismayed Zaminsky then cobbles together a replacement scope using backyard satellite antennas (in a Y-formation that mimics the VLA) and hobby-grade radio parts. He finds that there is communication between the extraterrestrial source and Earth, and the aliens are already afoot in the land, causing global warming as they re-shape our climate to fit their colonization plans. There are, consequently, three Rio Scale regimes as this film unfolds:

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Immediately following detection	3 - 6	3	1 - 4	2/3	5 - 9
Two-way communication recognized	6	5	3	2/3	9
Presence of aliens on Earth recognized	6	5	4	2/3	10

3. "Independence Day" (1996). A SETI Institute listening post (suggestively, but erroneously set in New Mexico) picks up a signal, announced by a flashing red light and suspicious modulation heard with a pair of earphones. Unlike many films, there are actually a few follow-up checks made to determine whether this is truly ET on the line, or merely "another... Russian spy job." These consist of a quick call to air controllers to rule out our own rockets, and then a few "computer confirmations" that the signal is both unidentified and coming from something near enough to have a measurable trajectory. This all takes but a few minutes, after which the

source of the signal is determined to be incoming spacecraft no farther than the moon! The aliens are soon camped out above major cities, eager to join battle.

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Immediately following detection	3 - 6	5	1 - 4	1/2	4 - 8
Moments later, after confirmation	6	5	4	2/3	10

***Signal Detection – Books***

1. “The Listeners” (1972, James E. Gunn, Arrow Books, London). It’s 2027, 67 years since Project Ozma, and many in the government and among the public are discouraged about SETI’s prospects. A project at the Arecibo telescope is still listening, but in fact discovery comes from careful analysis of conventional astronomical data collected by another instrument: the Big Ear, a five-mile diameter antenna network in orbit a thousand miles above Earth’s surface. Music and voices are teased out of these data, leading to the analysis of more data. Eventually, it’s realized that the “message” consists of fragments of terrestrial radio broadcasts from the 1930s, coming from the direction of the double-star Capella. This fixes the distance (45 light-years), as well as the fact that the broadcast is intended for Earthlings. It also foreshadows “Contact,” written a decade later, since the scientists soon find a message buried within the retransmitted earthly broadcast – a simple, one-bit pictogram showing the Capellans. A reply is sent, and ninety years later, the transmitter at Capella is heard to respond, giving bad news about Capellan society.

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Discovery of music and voices in astronomical data	5 - 6	4	1 - 4	1/2	5 - 7
After repeated observations fix the transmission direction as that of Capella, and the “message” is learned to be earthly transmissions from the 1930s	5 - 6	4	3	2/3	8 - 9

2. “The Sparrow” (1997, Mary D. Russell, Fawcett Columbine, New York). It’s the year 2019, and SETI is still an occasional endeavor at the Arecibo radio telescope. The telescope’s Japanese owners make some time available for a targeted SETI search when the antenna is not engaged in other observations. The SETI experiment uses a 14 million channel receiver (a surprising regression in capability) and now focuses its attention on extrasolar planets, rather than stars (this hardly makes sense, as the Arecibo beam is too large to make the distinction.) In the wee hours of a summer morning, a researcher pulls off his headphones to sit “back in his chair, sweating and sucking air, sure now, but hardly able to believe what he alone in all his world knew.” The signal has been found. Only three hours later, a confirming observation from Goldstone and eventually other telescopes pinpoints the source of the transmission (which turns out to be alien music) as a world in orbit around Alpha Centauri, a mere 4 light-years distant.

The public eventually loses interest, and subsequent messages get little media attention. It's worthy of note that Alpha Centauri, at  $-62$  degrees declination, cannot be observed with the Arecibo instrument, although that obvious bit of poetic license has not influenced the Rio Scale evaluations below.

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Discovery	5- 6	5	3	1/3	4-5
Three hours later, after confirmation by Goldstone	5- 6	5	3	2/3	9

3. “The Coming” (2001, Joe Haldeman, Ace Books, New York). It's the year 2054, and astronomer Aurora Bell has deciphered a disconcerting message from space: “We're coming.” No telescope is specified as the source of the message, but there is little doubt that the signal originates from extraterrestrials who are a mere one-tenth light-year away, inbound to Earth. Three months later, they arrive – humanoid in appearance and speech, and primed to extricate humanity from its decadent, destructive self. They are the second coming of Christ. But the public, egged on by the media, grow suspicious, and eventually come to believe the extraterrestrial visit is a hoax.

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
Discovery	6	5	3	2/3	9
After arrival of the aliens	6	5	4	2/3	10

### *Artifact Detection (SETA) – Films*

1. “Sphere” (1998). When a cable laying ship finds a massive, undersea artifact in the Pacific, the American government quickly summons a feisty team of scientists to investigate. The kilometer-long craft, with obvious high-tech festoonery, is partially buried under nearly 10 meters of slow-growing coral, which the scientists realize means that it crashed nearly three centuries ago. Consequently, it can be nothing other than a wayward extraterrestrial craft, “the biggest scientific discovery since Copernicus,” intones the astrophysicist (betraying a reassuring familiarity with SETI literature). However, what was initially a virtually certain alien artifact is later discovered to be an American space ship from the future, returned to Earth and the past via a black hole. At this point, the Rio Scale drops to zero (this is the artifact equivalent of terrestrial interference). Shortly thereafter, a bizarre looking sphere is found on board, possessing abilities that seem like magic to us, and assumed to be of extraterrestrial origin (although in theory, it might have been a future development by humankind.)

<b>When</b>	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>ä</b>	<b>Rio Scale</b>
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When discovery of undersea craft, buried for centuries, is first made	1	4	4	2/3	6
After evidence aboard the craft prove it to be of American origin	1	4	4	0	0
Discovery of the on-board sphere with highly advanced capabilities	1	4	4	1/2	4

2. “2001: A Space Odyssey” (1968). The Americans are keeping a big secret at their Clavius moon base. Most outsiders suspect that a virulent epidemic has broken out there, but the truth is more outlandish: a 5-meter high, gray slab has been dug out of the lunar regolith. From the geological evidence, the discoverers have determined that the slab was deliberately buried four million years earlier. What is the slab? The Americans consider that it might be a tomb, a shrine, or even a spare part. “The only thing about it that we are sure of, is that it is the first direct evidence of intelligent life beyond the Earth. Four million years ago, something, presumably from the stars, must have swept through the solar system and left this behind.” Shortly after the utterance of this dramatic statement, the slab makes a shrieking noise (always a trick on airless worlds), and points the earthlings in the direction of Jupiter. “2001” is the classic artifact scenario.

When	Q1	Q2	Q3	ä	Rio Scale
Discovery	1	4	4	2/3	6

3. “Stargate” (1994). A large, circular cover stone, sporting conventional hieroglyphs as well as cryptic markings, is found near the great Gizah pyramids in 1928. Beneath it a ring that also sports these strange markings is unearthed, made of “a mineral unlike any other.” The artifacts somehow make their way into the possession of the U.S. military, and seventy years later, an unlikely young scholar finally succeeds in decoding the cryptic markings. They are stellar constellations, describing a location in another galaxy. When the ring artifact is suitably hooked up to some hi-tech, smoke-blowing machinery, it functions as a wormhole-style portal (“stargate”) to this distant locale.

When	Q1	Q2	Q3	ä	Rio Scale
Following 1928 discovery	1	4	4	1/6	2
Seven decades later, when stellar constellations are recognized	1	4	1	2/3	4

*Non-fiction Claims*

1. “Face on Mars.” This is based on the resemblance to a human face of an approximately 2 km size feature in Mars’ Cydonia region, as seen in photos made by the 1976 Viking orbiter. More recent, high-resolution photos of this feature have been made by the Mars Global Surveyor, showing an obviously natural geological formation. Despite this, there remains a body of people who think the feature is artificial.

When	Q1	Q2	Q3	ä	Rio Scale
Following 1976 discovery in Viking orbiter data	1	4	4	1/6	2
After 2001 Mars Global Surveyor high-resolution imagery.	1	4	4	0	0

2. “EQ Peg hoax,” 1998. This was a complex hoax in which a Web site claimed that a SETI-type signal from the star system EQ Pegasi had been found by a British amateur using a 10 meter antenna. This information was originally communicated to the SETI League, via hacking into their in-house bulletin board. Members of the SETI League failed to confirm the signal, but shortly thereafter a BBC on-line news report gave the claim some credibility. The Web site soon announced that other amateurs had also found the signal. This eventually led to additional observations with radio telescopes in Australia and the United States, none of which could confirm the discovery. Eventually, the weight of evidence (including clearly “doctored” signal plots) removed all doubt that this was merely an elaborate prank.

When	Q1	Q2	Q3	ä	Rio Scale
After SETI League notification and lack of confirmation by League members	2 - 6	3	2	1/6	1 - 2
After BBC story, and claims of other amateur confirmations	2 - 6	5	2	1/3	3 - 4
Following Australian and U.S. observations and additional Web site anomalies	2 - 6	3	2	0	0

## EVALUATION

In applying the proposed Rio Scale to a range of popular fiction, as well as to two purportedly valid claims of extraterrestrial presence, we find that the Scale has served us well in several areas:

- It can be applied to all of the scenarios considered; in other words, it is complete.
- What are intuitively scenarios of less societal impact do, indeed, score lower on the scale. This is true even in those cases when lack of specific information (for example,

“is the signal deliberately targeted to us or not?”) is missing. In other words, the scale is not susceptible to wild variation due to small input changes; it is robust.

- On the other hand, and to its credit, when new data of consequence are introduced (particularly for the credibility index  $\bar{\alpha}$ ), the resulting Rio Scale values change qualitatively.

There are other conclusions to be drawn from this small survey that suggest possible modifications to the Rio Scale:

- Indices  $Q_1$  and  $Q_3$  may be difficult to quantify early in the discovery. How is one to know if a signal is omnidirectional or beamed our way, unless we find understandable modulation that gives unambiguous target information (such as embedded terrestrial TV or radio – e.g., “Contact,” “The Listeners”)? How can we be certain of the distance to the transmitter if, for example, we are receiving the signal using telescopes such as Arecibo that have beamwidths of several arcminutes? Observations with arrays ameliorate this difficulty, of course, but these might not be the discovery instrument.
- As has been noted before [2], the Scale gives low weight to artifacts ( $Q_1 = 1$ ). In the three examples of artifact discovery considered here, two take place on Earth (“Sphere,” “Stargate”) and one on the moon (“2001”). Despite the fact that all three were of major importance, none ranked higher than 6 during discovery (although “Stargate” postulates eventual physical contact with extraterrestrials by travel to their world, which would simultaneously both raise the index ( $Q_1 = 6$ ) and lower it ( $Q_3 = 1$ , since the alien world is extragalactic.) This latter situation – discovery followed by travel to another world – is also depicted in “Contact.” We haven’t considered a Rio Scale ranking for these scenarios, as it’s not intended to apply to interstellar visits by us.
- In the directly relevant cases of the EQ Peg hoax and the Face on Mars, the Rio Scale gave low rankings. To be candid, this is largely a consequence of the small  $\bar{\alpha}$  values attributed to these instances, and this might be criticized by those who are inclined to believe in such claims. But the Rio Scale is intended to be an index based on the scientific opinion of a group of experts, not on popular vote.

Finally, although it is hoped that this exercise will serve to both demonstrate the usefulness of the Rio Scale, and will aid in its recognition and application by the media, there is no doubt that using detection scenarios from fiction gives the Scale a less than thorough workout. There is an incomplete intersection of the Scale and Hollywood. The former is intended to apply to signals and, to some degree, artifacts. The latter is primarily concerned with visits – sometimes ours (the 1979 film “Alien” is a good example), but most often theirs. In the case of visitation *a la* Hollywood, there is often little need for a gauge of credibility. When the aliens cover our cities with menacing slabs in “Independence Day,” they quickly eliminate all concern about a hoax or a misinterpreted bit of evidence.

Ambiguity about whether evidence for aliens exists or not is almost never the subject of Hollywood films (but note the exceptional 2001 film, “K-pax”). Even less so is the idea of a hoaxed signal. Hollywood’s stories seldom benefit from the sort of ambiguity that is the target of the Rio Scale. But if ambiguity were truly rare, the Rio Scale would be unnecessary. In the real world, things are not always what they seem, and this is both a justification and an encouragement to fashion tools that will help clarify a purported detection of extraterrestrial intelligence.

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