International Journal of Astrobiology 14 (4): 577–587 (2015)
doi:10.1017/S1473550415000075

Unknown caller: can we effectively manage the announcement of discovery of extraterrestrial life?

Gordon M. Gartrelle

PhD Candidate, University of North Dakota, John D. Odegard School of Aerospace Studies, Department of Space Studies
e-mail: gmgartr@gmail.com

Abstract: The definitive discovery of another form of life from beyond Earth will answer one of our most fundamental questions: Are we alone in the Universe? This announcement will be the most significant in history. It will have impact on every facet of our lives and affect everyone on Earth. Ensuring the announcement is handled properly represents an opportunity to unify government, industrial, and scientific resources to work together on a global scale issue. The purpose of the present paper is to understand whether we have the overall strategy, management structures and process disciplines in place on a global scale to handle an announcement of this magnitude. The research methodology included review and analysis of peer-reviewed work on the topic, publications from appropriate scientific and policy organizations, and public statements from several acknowledged experts in the field of astrobiology and extraterrestrial communications. The 1996 case of the announcement of possible life from Martian meteorite ALH84001 was also analysed. The findings of the paper are multiple deficiencies exist in the ability to manage this problem globally in an integrated fashion across borders, institutional boundaries, and through the media. High-level recommendations are offered to address major identified gaps.

Received 8 December 2014, accepted 14 January 2015, first published online 18 March 2015

Key words: Astrobiology, announcement, protocols, exoplanets, extraterrestrial life, SETI, risk communication

Introduction

The day extraterrestrial life is definitively discovered will be momentous. It will remain locked in the memory of everyone old enough to comprehend the discovery, but how will it be remembered? Will the announcement of the discovery of extraterrestrial life inspire public understanding, cooperation, and support? Will it help to unify our home planet? Or will the announcement result in widespread confusion, panic, chaos or further conflict? The answers to these questions hinge on our ability to effectively deliver the announcement on a global scale. This will require preparation and organization at a global level across multiple institutions and cultures.

The purpose of the paper is to understand what is in place to handle an announcement of this magnitude. The paper examines whether current plans are sufficient to handle a global announcement of extraterrestrial life. The paper defines criteria of effectiveness and applies these criteria towards answering the research question. It will also identify gaps or weaknesses of current plans and present high level recommendations to address any items identified.

Research methodology

The methodology consisted primarily of review and critical analysis of peer reviewed journal articles on the topic. Papers concerned with the process, policy, legal, social, media, risks and other impacts of a definitive discovery of life beyond Earth were analysed. Publications from recognized groups such as the SETI Institute, NASA Astrobiology Institute, European Space Agency, Société Française d'Exobiologie, Secure World Foundation, Association of Space Explorers and United Kingdom Centre for Astrobiology were considered. The author also reviewed sources concerned with defining and constraining the effectiveness of a formal communications process. A past example of an announcement of extraterrestrial life, the ALH84001 announcement of 1996, was evaluated to understand the potential impacts or pitfalls resulting from public release of information of this magnitude. Finally selected interviews with leading experts on the topic such as Dr Frank Drake, Dr Seth Shostak, Dr Chris McKay, Dr David McKay and Dr Jill Tarter were reviewed to add background context to the research.

Literature review

The modern search for extraterrestrial life: a brief history

The search for life beyond Earth has been in the hearts and minds of humans since the beginning of recorded history. With the advent of the space age came the ability to search for life on other worlds *in situ* with robotic spacecraft. The Martian exploration of Mariner 9 in 1972 opened the door to the debate about the possible existence of liquid water on the surface of Mars in the past or beneath the surface during the present (Dick 2006; Baker 2014). Subsequent missions confirmed Mars' aqueous past and current subsurface water ice (Head *et al.* 1999; Lunine *et al.* 2003; Squyres *et al.* 2004; Dohm *et al.* 2007; Carrozzo *et al.* 2009; Williams *et al.* 2013). If water was or is present on Mars, could life have started there? The twin Viking landers were the first robotic missions to land on Mars and directly search for life (Klein 1978, 1996; Klein & DeVincenzi 1995). Although the initial results of the experiment were inconclusive, some scientists suggest based on subsequent discoveries from other missions, Viking may have located soil containing organics (Klein 1978; Cockell 2013).

There are three main current approaches to searching for extraterrestrial life; astrobiological searches for extant or past life in the Solar System through robotic missions; scanning stars with a variety of techniques to search for Earth-like exoplanets; and scanning stars with radio antennas to find a signal originating from a technically advanced civilization. The Solar System has three primary astrobiology targets; Mars, Europa and Enceladus; containing energy, liquid water, organics and chemical exchange, all essential to forming life as we know it (McKay 2011). A fourth target is Saturn's moon Titan which has energy, organics, chemical exchange and liquid methane (McKay 2011; Griffith *et al*. 2012). The life forms we might find within our Solar System are likely to be very small extremophile microorganisms or microfossils (Gross 2014). Terrestrial extremophile microorganisms are known to live or have lived in environments consistent with Mars or deep space (Corliss *et al.* 1979; Corliss *et al.* 1981; Brack 2000; Westall *et al.* 2011; Gross 2014). A plethora of international missions with advanced instrumentation are being proposed or planned to explore these targets to directly search for life (Konstantinidis *et al.*; Mitri *et al.*; Westall *et al.* 2000; Wu *et al.* 2010; de Vera *et al.* 2012; Schulze-Makuch *et al.* 2012; Sims *et al.* 2012; Grossman 2013; Sephton *et al.* 2013). If we find evidence of a *second genesis* of life within our Solar System, then it will mean life is likely abundant throughout the Universe (Brack 2000; McKay 2011).

The first planet outside the Solar System was discovered in 1991 using the Arecibo radio telescope in Puerto Rico (Wolszczan 2012). Advancements in techniques and instrumentation have resulted in the discovery of close to three thousand exoplanets, with some containing Earth-like properties (Léger *et al.* 2011; Fressin *et al.* 2012; Gautier *et al*. 2012; Quarles *et al*. 2012; Dressing & Charbonneau 2013; Petigura *et al.* 2013). Exoplanet research appears to yield evidence almost every star has multiple planets, thus increasing the possibility of life (Barker 2011; Brown 2011; Fraknoi 2012).

The first attempts to use radio to search for life off the Earth were made in by Guglielmo Marconi and Nikola Tesla at the beginning of the 20th century (Drake 1993). The modern search for extraterrestrial intelligence (SETI) through radio astronomy was conceived in the late 1950s (Cocconi & Morrison 1959) and actually implemented by Frank Drake in 1960 with Project Ozma (Drake 1979). Ongoing progress in SETI has included the opening of the SETI Institute in the mid-1980s, a NASA-funded project in 1992, Project Phoenix in 1995, and the recent opening of the privately funded Allen Telescope Array (Drake 1993; Trottier 2013). Continuing advancements in digital technology, reduced technology costs and applications such as SETI Live will continue to increase the number of stars which can be examined (Shostak 2011, 2012; Trottier 2013).

Existing detection and discovery protocols for extraterrestrial life

The SETI community engaged in a 2-year work effort beginning in 1985 to develop a set of principles to apply to SETI programmes and the communication of detection of an intelligent signal from another civilization. This resulted in a set of papers presented at the 37th and 38th meetings of the International Astronautical Federation and published as a group in the 21st volume of Acta Astronautica in 1990. The SETI community agreed to a nine point declaration of principles regarding the activities following a successful detection (Michaud 1992). The principles outline a process where a scientist will verify the signal, share information openly with other scientists and the UN, seek agreement to protect the appropriate radio frequencies and agree not to respond to the signal until 'appropriate international consultations have taken place' (Michaud 1992). Billingham (1993) and Michaud (1998) both advocated an addendum to the principles to drive additional consensus regarding a potential reply to a detected signal and the inclusion of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) as the sponsoring authority for a reply. Tarter (1998) argued for an amendment to the principles to mandate an immediate automatic reply to a verified extraterrestrial signal in the form of a repeating acknowledgement the signal was received. The acknowledgement would be specifically encoded in such a way as to label it as coming from the responsible authority on the Earth (Tarter 1998). This would prevent unauthorized replies, from fringe groups or a single nation, from being perceived as Earth's official reply.

There have been other attempts to add context to the principles over the years. Boyce (1990) recommended the first step after a detection is made is to verify the signal by sharing the information with other scientists in the SETI community. This would best be accomplished using the International Astronomical Telegram Bureau, a network of connected astronomical observatories, laboratories and universities (Boyce 1990). This would allow other scientists the opportunity to analyse and confirm the prospective signal (Boyce 1990). The recommendation is now part of the current version of the principles (Trottier 2013). The second step would be to provide accurate information to the media in support of public communication of the announcement (Boyce 1990). Almar (1995) suggested extraterrestrial messages should be classified into one of four categories according to the character and information content of the message.

In 2000, Shostak & Oliver (2000) proposed the development of an internet portal for use by the SETI community as an information repository in the event of a detection. A successful detection would not be a secret for long and would most likely be first reported by the least responsible segment of the media

(Shostak & Oliver 2000). The web portal would make information about a detection available on a real-time basis to local SETI scientists who would handle local media requests (Shostak & Oliver 2000).

The SETI response policy and the role of the SETI Post Detection Committee (PDC) were summarized in 2004 (Norris 2004). This included discussion of roles and responsibilities before, during, and after a detection, including extraction of a potential message within the signal (Norris 2004). Almar & Tarter (2011) introduced the Rio Scale, a three-dimensional algorithm, designed to characterize the significance of a detected signal, and suggested the scale should be universally adopted by the SETI community for use in verifying actual detection scenarios. Modelled after the Torino scale for potential near-Earth asteroid impacts (Binzel 1997), the Rio scale assesses the class of phenomenon (signal), the type of discovery, and the distance travelled to arrive at a level of significance ranging from 0 (no significance) to 15 (extraordinary significance). The London Scale (Almár 2011) is similar to the Rio scale except it is designed to classify the discovery of extraterrestrial life by classifying the type of life discovered, the nature of discovery evidence, the method of discovery, the distance to the discovered life form, and a credibility factor. Race & Randolph (2002) developed a set of suggested principles concerned with the discovery of non-intelligent life. The principles are aimed at preserving and protecting the life form (Race & Randolph 2002). They are modelled after the SETI guidelines and include the specific principles regarding interactions with and follow-up missions to the discovery site (Race & Randolph 2002). Almár & Race (2011) formally advocate the adoption of the Rio Scale and London Scale for astrobiological discoveries of new life forms.

Policy implications of a discovery

A number of policy-related issues frame the question of how the detection or discovery of life beyond Earth will be managed. The detection of a remote signal from extraterrestrial intelligence presents distinctly different policy decisions than the detection of a signal or extraterrestrial artefacts within the Solar System (Michaud 1998). In a scenario involving a remote signal there is more time available to analyse the incoming signal and determine the next course of action (Michaud 1998). Baxter & Elliott (2012) argue for specific differentiated post-detection policies for received signals, discovery of extraterrestrial artefacts and direct contact with another intelligent civilization. Michaud (2003) believes there are ten categories of policy decisions connected to first contact with extraterrestrial intelligence. Four of these: information release and access to the signal; managing political reactions; who speaks for Earth; and who decides are directly connected to the detection of a signal, announcement to the public and handling the public reaction to the announcement (Michaud 2003).

Several researchers (Cocca 1998; Lyall 1998; Michaud 1998; Tarter 1998; Lee 2006; Barker 2011; Vakoch 2011; Baxter & Elliott 2012) argue the current SETI post-detection policy is largely unenforceable from within and outside the SETI community and some advocate the involvement of sovereign governments as well as UNCOPUOS in constructing more effective SETI post-detection policies. Cocca (1998) suggests a legal framework be in place pre-detection to govern activities and ensure all scientists and institutions adhere to stated policies. Lyall (1998) believes a post-detection protocol could be useful with full governmental participation on an international scale, but that a communications or reply policy would be difficult to legally enforce. Sterns (2000) and Tarter (2000) agree government concerns about national security, panic or some other perceived threat from an extraterrestrial civilization may impose restrictions on the free dissemination of information or data about a detection.

False signals or hoaxes

The most notable false announcement of the discovery extraterrestrial life was Orson Welles' broadcast of H.G. Wells' War of the Worlds in 1938, which caused multiple reports of public panic in the Northeastern USA (Socolow 2008). In 1977, researchers at Ohio State University reported the detection of the 'Wow' signal, a strong narrow band emission near the 21 cm hydrogen line (Gray & Ellingsen 2002). The 'Wow' signal, believed to be from an advanced extraterrestrial civilization, could not be reproduced by the discovering scientists or multiple other research teams since the initial discovery (Gray & Ellingsen 2002). Project Phoenix strongly suspected an actual detection in 1997 (Shostak 1997). Prior to verification, a New York Times reporter learned of the suspected signal and called the Project Phoenix leadership team to confirm it (Shostak 1997). The signal ultimately turned out to be a transmission from the European SOHO solar satellite (Shostak 1997). A prankster from the UK in 2002 attempted to perpetuate a hoax by claiming discovery of a signal from the star EQ Pegasi and communicating the claim to the SETI league (Shostak & Almár 2002). The SETI league worked to verify the claim for several hours before discovering it was a hoax (Shostak & Almár 2002). The Rio Scale has been applied to fictional detections from books or movies as well as the EQ Pegasi hoax and is proven to be a useful tool in early classification of detection claims.

ALH84001: a case study

The announcement of microfossils from Martian meteorite ALH84001 is the only case of a government sponsored announcement of the discovery of extraterrestrial life (McKay *et al.* 1996; Sawyer 2006). Prior to the initial announcement from President Bill Clinton, the information was inadvertently leaked to the media and the government had to scramble to gain control of the story (Sawyer 2006; Rothschild 2009). Sterns (2000) reports although the ALH84001 story was huge, there were no reports of public panic after the announcement. Garber (1999) and Sawyer (2006) agree the ALH84001 announcement captured the imagination of the public and catalysed additional funding from NASA for future robotic missions to Mars to search for life. Shostak (1997) suggests the ALH84001 case presents model lessons going forward for future SETI discoveries and the role of the media.

https://doi.org/10.1017/S1473550415000075 Published online by Cambridge University Press

Risks posed by mishandling the announcement of a discovery of extraterrestrial life

Public understanding of the facts related to the discovery of extraterrestrial life must be balanced with a fair presentation of the risk associated with discovery (Ropeik 2012). Michaud (1998) argues policy makers could use the announcement to buttress a political agenda by overplaying or underplaying the announcement. Shostak (1997) suggests potential leaks of the announcement of discovery to the most irresponsible elements of the media would result in publicity for fringe groups and UFO aficionados. Korbitz (2013) intimates scientists should be cautious in ensuring the announcement of extraterrestrial life presents an accurate discussion of any potential danger to humanity. Failure to do so could subject scientists to unfounded political attacks or ridicule (Korbitz 2013). Harrison (2011) advocates broad coordination between political institutions, administrative agencies, the military, the intelligence community, scientists, religion and others is required as the announcement is taking place. This coordination is necessary in order to manage the myriad potential social and cultural reactions to the announcement (Harrison 2011).

Evaluating effective communications processes

Evaluation of potential effectiveness of the announcement process related to a discovery of extraterrestrial life requires the definition of what constitutes a *communications process* and understanding how the process can be measured to determine *effectiveness*. Meng (2012) believes organizational leadership is the critical starting point for any communications process. If the leader is dynamic, visionary, collaborative, ethical, open in relationships, a capable strategic decision maker and has communication knowledge management capability the organization will be well positioned to construct an effective communications process (Meng 2012). Shaping the message involves understanding, on a global level, the media environment and how communications are conducted (Eyre & Littleton 2012). Communications of social change, such as an extraterrestrial announcement, require the ability to manage in an interconnected world of people, groups, narratives and emotions that are not contained within national borders (Eyre & Littleton 2012). Lanard (2005a) implies trust, transparency, candor and involving the public are aspirational goals for critical public announcements. Trust of the communicating official or agency by the public is an obvious requirement, but it is just as important that the official or agency have trust in the public to receive the message and act on it appropriately (Lanard 2005a; Berthelot 2012). Frewer (2004) suggests that if public risk is an element of an announcement, it needs to be included as part of a clear message and include uncertainties as well as the nature and extent of disagreements between experts.

Several examples of strategic communications process templates from large organizations that could produce announcements analogous in scale to a SETI announcement were examined to understand their objectives and makeup. These include the US Environmental Protection Agency (Jackson 2010), the UN World Health Organization (Hyer & Covello 2005) and the International Atomic Energy Agency (Berthelot 2012). Each of these documents provides detail on structure, guidance and vision on communications strategies and management of major announcements from an organizational perspective.

The World Health Organization (WHO) policy provides an additional element by including a closed loop evaluation process for communications to promote continuous improvement (Hyer & Covello 2005) and a coaching model for evaluating a communications process for the delivery of a specific message (Lanard 2005b). High-level evaluation of communications should focus on the purpose, scope and maturity of a campaign using a qualitative evaluation of effectiveness (Dorfman *et al.* 2002). A different qualitative evaluation methodology is focused evaluating on five elements of a basic communications strategy, including objective setting; research and planning; outputs; outtakes; and results (Michaelson *et al.* 2012). The organization's level of connection to the audience, quality of global leadership engagement, unique creativity or innovation and ability to set the agenda are advanced elements of communications strategy an evaluation seeks to assess (Michaelson *et al.* 2012).

Potential NEO impact response efforts: an analogue model?

A closely connected example of global policy and communications plan linkage within the space industry is found in current efforts to provide a global defence and response strategy for a potential impact of a near-Earth object (NEO). An NEO impact scenario has several striking similarities to the potential discovery of life. They are both global events with broad social implications across the entire planet that will not discriminate at national borders and, worst case, may result in long term negative effects on a planetary scale. Extensive governmental action may need to be quickly mobilized to deal with both situations and may require broad international cooperation. Finally, communication of these events will need to be global, real-time, use multiple media forms, be clear and be credible to ensure the entire population understands the issue, the risk and the next steps.

The global NEO community of scientists, engineers and academics, has successfully linked governments, space agencies, as well as the United Nations in a common effort to deal with a potential impact. This includes endorsement of the NEO threat by UNCOPUOS leading to an approved UN resolution authorizing an international response to an NEO threat (General Assembly Resolution 68/75: International cooperation in the peaceful uses of outer space 2013). One of the additional results of this effort was the creation of a framework for an 'effective' global communications plan for NEO response sponsored jointly by the Secure World Foundation and the Association of Space Explorers (Williamson *et al.* 2012). The NEO response effort and supporting documents should serve as comparative guidance for evaluating the announcement process for a discovery of extraterrestrial life because of the broad acceptance of the NEO response team by the international community as well as the similarity of factors related to the NEO problem those related to the discovery of extraterrestrial life.

Analysis and discussion

Discovery scenarios

Five different plausible scenarios exist for the discovery of extraterrestrial life. Each scenario presents a unique combination of risk to Earth, potential for social or societal change, and requirement for significant actions by global institutions in response to a discovery. Each scenario also presents a different level of potential activity between humanity and the newly discovered life form. The announcement of a discovery of life for each scenario will kick off a chain of downstream events that will differ by scenario. This makes the requirements, nature, tone, and characteristics of the initial discovery announcement different for each scenario. The next section will discuss each scenario in detail, include the announcement implications and categorize them to determine the criticality of the announcement of each scenario.

Discovery of extraterrestrial life in the Solar System

The discovery of extraterrestrial life in the Solar System will most likely come from robotic missions engaging in astrobiological searches on Mars or the moons of either Jupiter or Saturn where liquid water, or in the case of Titan, liquid methane exists. The life forms may be microbial or possibly higher order life forms. They could be extant or fossilized remains of extinct life forms. They could originate from the same tree of life as terrestrial life (Eukaryote, Bacteria and Archaea) or represent a second genesis of life within our Solar System.

If we discover life in the Solar System, there will be likely little interaction between humanity and the new life form because the new life form, if extant, is likely to be non-intelligent. Obviously no interaction would be possible with a fossilized specimen. Our interactions will be confined to examination of the physiology, behaviour and habitat of the life form. Risk to Earth will be close to zero unless a sample is returned to the Earth. In that case, planetary protection protocol would be engaged to minimize the risk prior to a sample arriving on the planet. The social or societal change resulting from this discovery will also be limited. Although there will be extensive interest globally and ongoing discussion, the daily routine of life on Earth does not change as a result of this type of discovery. Religious, biological and philosophical conventions will undergo some level of change. In the case of a second genesis, there will be general agreement that if two distinct families of life could form in our Solar System, then life is probably plentiful throughout the Universe. This may initiate downstream discussion and additional activities. Governments are not required to mobilize resources as a result of this type of announcement, although it would be hoped they would divert additional resources to space efforts and the search for life outside the Solar System.

Discovery of extraterrestrial artefacts in the Solar System

There is no current effort underway to search for extraterrestrial artefacts in the Solar System. A discovery of this type would be a low-probability random event and would more than likely occur in the outer reaches of the Solar System (Haqq-Misra & Kopparapu 2012). An alien artefact could take the form of a marker or monument intentionally left behind by ancient visitors or it could be a probe, analogous to the Voyager spacecraft, sent from another world that randomly found its way here after many years of travelling through deep space.

A discovery of this type provides immediate confirmation of the existence of another intelligent spacefaring species. Although the artefact may contain a translatable message detailing the location of its origin, there will probably be no real-time interaction between humanity and the new species. Risk to the Earth is again probably low. It may not be possible to bring the artefact back to the Earth due to its size, location, speed of travel or security concerns. In this scenario, more social and societal change would be expected. We would know we are not alone as an intelligent species. Religious, academic, and philosophical foundations would undergo significant discussion leading to change, but day to day life on the Earth would not change. Governments may be forward thinking enough to the point where they could begin to plan for the potential of another visit by the extraterrestrials. If we are able determine the artefact's point of origin, there may be a groundswell to send a message back to the new species, telling them who we are, and we have found the artefact.

Discovery of a 'Living Exoplanet'

Success in discovering exoplanets has occurred at a rapid pace due to amazing advancements in technique and technology over the past two decades. We currently look for Earth-like worlds, containing liquid water on the surface, within the habitable zone of a star. However, finding a living exoplanet, an Earth-like planet with an existing industrialized civilization, is beyond our current capabilities. This scenario is akin to looking through a telescope at a remote desert island from a ship many miles off the coast to try to see smoke from native cooking fires. We cannot detect the presence of greenhouse gas in the atmosphere of an exoplanet and determine whether the gasses are produced as a result of industrialization. We also cannot detect electromagnetic signals from local exoplanet radio broadcasts, the presence of satellites or local satellite transmissions from interstellar distances.

We could confidently assume sometime in the future the technological advancements necessary to find living exoplanets will be developed. If this is the first discovery of extraterrestrial life, it will have some unique implications. We will know another intelligent civilization exists, and if the star is close enough to our Solar System, the civilization could have existed during human existence on the Earth or still be in existence at time of discovery. If the distances are close enough, communication would be possible, but unless the other species has interstellar travel capability, further interaction will not be possible. The risk to the Earth in this case would be almost zero. Social and societal changes would occur on a slightly higher level than in the artefact scenario, particularly if the extraterrestrial civilization was still in existence. Day-to-day life on the Earth, after the initial excitement of the announcement, would quickly return to normal. There is no required public call-to-action resulting from this announcement. If we determined the extraterrestrial civilization was still active, Earth governments would likely begin to work together to develop a communications plan to reach out to the extraterrestrials and begin a dialogue.

Discovery of a SETI signal

Receipt of a SETI signal is indicative of an intelligent species capable of transmitting an intentional signal of their existence strong enough to reach the Earth. The signal may be targeted for us because we were detected, or may be a general hailing type signal. In either case, the existence of extraterrestrial intelligent life will be confirmed. Receipt of an intentional signal is our first interaction with the extraterrestrials. If we decide to respond, we will have more interactions. The overall risk to the Earth would be moderate in this case because we do not know what interaction with this species would ultimately mean. Will they visit? Are they friendly? What are their moral principles? Do they have diseases for which we do not have anti-bodies? Could they send an electromagnetic virus signal through interstellar space and disable our computer and communications networks? These are some of the questions which will require extensive study after a message is received.

Social and societal order would surely change as a result of questions or concerns related to these issues. Day-to-day life would also change as the global discussion begins regarding how to respond, what will be said, and who will say it. This will be a planet-wide discussion across all media forms. Governments, the UN and other institutions will be actively mobilized to participate in the development of a planetary strategy to construct a response. It is certain there will be fringe groups or rogue governments who will not agree with the majority consensus on constructing a message, its content, or the extent to which their views are represented. This may led to heightened international tensions or conflict and will have to be carefully managed.

Discovery of incoming spaceships

Most people are familiar with this scenario which has been popularized in numerous books, television shows, and movies. Inhabited spaceships are detected inside the Solar System on a trajectory towards the Earth. Although this scenario is highly unlikely, it cannot be completely discounted in this analysis for several reasons. In this scenario, an immediate global announcement and response will be required. If ships are incoming, interaction with these extraterrestrials is a certainty whether we want it or not. The risk to Earth will be extremely high because we will not know their intentions and if their intentions are not peaceful, we may have no way to defend ourselves. Even if they are peaceful, the risk of an unknown pandemic from the visitors still exists. Social order and day-to-day life could be disrupted or disintegrate entirely due to widespread fear, chaos, hoarding and panic. Immediate, massive, coordinated and extensive mobilization will be required from governments and other global institutions to maintain local order, organize a global reception committee, and develop a contingency planetary defence strategy.

Announcement implications

Each of the above scenarios generates a different type of discovery announcement to the global public. A summary of characteristics as described above for each scenario plus the main characteristics of the associated discovery announcement is found in Fig. 1. An announcement of the discovery of extraterrestrial life may have several different objectives including providing information, increasing awareness, encouraging action, building consensus, changing behaviour, promoting community participation, resolving conflict or asking for input (Jackson 2010). These objectives are not mutually exclusive.

The future announcement of a definitive discovery of another life form in the Solar System from astrobiological searches would, as in the ALH84001 case, spark a broad global discussion about our place in the Universe and may serve, in some sense, as a unifying force for humanity. The tone of this announcement would be upbeat, positive and informational. There is no public call to action required or emergency mobilization. There is no time sensitivity to this announcement. The case of discovery of an extraterrestrial artefact leads to an announcement similar in structure and tone to the announcement of non-intelligent extraterrestrials. Global mobilization or public response is not required. The announcement tone remains positive and educational with perhaps increased social or spiritual inspiration from the knowledge of existence of another intelligent species.

The discovery of intelligent extraterrestrials in the cases of a living exoplanet, SETI signal or incoming spaceships raises the intensity, tone, public call-to-action, societal implications and time sensitivity of the resulting discovery announcement. In the case of discovery of a living exoplanet, the issues of extraterrestrial intelligence, multiple intelligent civilizations in the Universe and our response policy become part of the announcement. Follow-on discussion and debate about a potential response will be widely scrutinized and debated. The SETI signal case raises the issues of extraterrestrial intent and our reaction to their intent to the forefront of the announcement. Why the signal was sent, the 'real' intentions of the extraterrestrials, how we respond, when we should respond, do we prepare a planetary expedition or a planetary defence are all fair topics for the initial and follow-on announcements. There will likely be a public call-to-action to remain calm and possibly for suggestions on responding.

The discovery of incoming spaceships would elicit the most strident announcement in tone and intensity. This would be similar to warning announcements about severe storms or other pending natural disasters but would take place on a global level. There would be strong direction from authorities to the public, law enforcement, the military, the scientific community and other groups. Information would be time-sensitive

Discovery Scenario	Potential for Interaction	Potential Risk to Earth	Potential for Social/Societal Change	Global Instutional Action	Announcement Type
Astrobiology	None	Almost None	Low	Almost None	Educational
Artifact	Almost None	Almost None	Low	Almost None	Educational/Inpsirational
Living Exoplanet	Low	None	Med	Low-Med	Includes Profound Debate
SETI Signal	Med-High	Low-Med	Med-High	High	Triggers Intense Debate
Incoming Spaceships	Very High	Very High	Very High	Very High	Strong Public Directives

Fig. 1. Characteristics of extraterrestrial life discovery scenarios.

as the arrival of the extraterrestrials would be imminent. There would be a series of ongoing real-time updates as the time of encounter drew closer. The highest level of authority would be the visible face to the public in this type of announcement.

Evaluation of current announcement protocols for extraterrestrial life

Overview

There are two current announcement protocols for the discovery of extraterrestrial life. Race & Randolph (2002) developed a suggested set of protocols for the discovery on non-intelligent extraterrestrial life. Discovery of intelligent life is governed by the SETI 'Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence' (Tarter & Michaud 1986, 1987). The two documents are similar in several ways. First, they both call for multiple means of scientific verification of the discovery prior to informing public officials and subsequently conducting a public announcement. Open access to data and research methods is also a feature of both protocols. Restraint of follow-up is also evident in both sets of guidelines. The SETI guidelines specify no response will occur 'until appropriate international consultations have taken place' (Tarter & Michaud 1986, 1987). Race & Randolph (2002) state with respect to the discovery of non-intelligent life that 'No further missions or activities prior to international consultation'. The main difference between the two protocols is found in the first principle of the protocol for discovery of non-intelligent life which states, 'If evidence of extraterrestrial life is found, do no harm. Avoid intrusive action until full consultation can be made', and 'protect and preserve the ET life form' (Race & Randolph 2002). In the event of a signal detection, the SETI Principles seek to 'protect the appropriate frequencies by exercising the extraordinary procedures established within the World Administrative Radio Council of the International Telecommunications Union' (Tarter & Michaud 1986, 1987).

There is general agreement among the scientific community about the validity of these protocols and the need to use them in the event of a discovery. Outside this community there is no formal recognition of either set of principles and thus no assurance they would be utilized in the event of a discovery. Unlike the NEO case, neither the SETI protocol nor the protocol for non-intelligent life is recognized by UNCOPUOS or any other government authority. This severely limits their practical application and potential effectiveness in the event of an actual discovery.

The ALH84001 case is the only historical test case of any of the scenarios for the discovery of extraterrestrial life. In this case, the NASA team performed multiple verifications and included several members who served as 'devil's advocates' and were commissioned to try to disprove the main findings (Sawyer 2006). The team informed United States government officials, up to and including the President, prior to announcing their findings. Intentionally or unintentionally, this team followed the discovery protocols almost verbatim with full governmental cooperation and delivered a credible global announcement. Positive public reaction to the announcement led to increased legislative support for expansion of robotic exploration of the Solar System resulting in increased funding for missions (Sawyer 2006; Rothschild 2009). The announcement also led to a spirited ongoing scientific debate about the actual existence of microfossils within ALH84001 that remains unresolved (Sawyer 2006; Rothschild 2009).

Evaluation criteria

There are several criteria that can be applied to the two protocols for the announcement of discovery of extraterrestrial life to make a subjective judgment regarding their overall effectiveness, areas of strength and areas needing improvement. The first set of criteria is related to the *personality* of announcement protocols and encompasses the variables of leadership, shaping the message, ability to manage in an interconnected world, trust and risk communications. The second set of criteria is centred the protocol's *foundational principles* and applies to how the protocol is intended to operate. This set of criteria includes the announcement process, how the announcement is organized and managed, and how collaboration and cooperation is encouraged throughout the process.

Leadership

Although neither of the protocols names an actual leader for the discovery announcement, both protocols display adequate leadership principles. Each protocol positions the actual discoverer(s) of extraterrestrial life as the primary global face of the initial announcement. Each protocol calls for the establishment of an additional set of communicators from the scientific community to provide support for the announcement by serving as the primary local face of the announcement within their respective countries. These policies allow for the discoverer(s) to get deserved global credit and recognition. It also provides a

https://doi.org/10.1017/S1473550415000075 Published online by Cambridge University Press

network of local experts who can deliver information about the announcement in the local language. It also relieves the discoverer(s) of the burden of having to respond to media requests in every country. The SETI protocol discusses how the network is staffed, set up, and activated through the International Astronautical Union and other groups. One could envision the global announcement being supplemented in the USA by credible, media savvy scientists such as Dr Seth Shostak from the SETI Institute, NASA's Dr Christopher McKay or Dr Lynn Rothschild, Dr Neil deGrasse Tyson from the American Museum of Natural History, Dr Laura Danly of Griffith Observatory and many others. They would provide enormous credibility for the announcement and capably engage the public.

Shaping the message

The processes of ensuring independent verification of the discovery and alerting national as well as global leadership prior to an announcement are precursor elements of shaping the message. However, neither protocol addresses this area head on. Strategic communications of social change involve sustained engagement of the public through the media over the long term (Eyre & Littleton 2012). It also involves managing beyond the 24 h news cycle to shape effective narratives which construct realities for the audience (Eyre & Littleton 2012). Telling an effective story about the discovery is essential to driving public support for engaging and funding follow-on efforts related to the search for life. The NEO protocols also contain several elements of message shaping similar to the protocols concerning the discovery of extraterrestrial life. These are found in the area of educating and informing policy makers. The NEO protocols go further by calling for identification of key entities relevant to public safety at a region level and engagement of these organizations about the threat of NEO's prior to an incident. This should drive additional support and cooperation from authority figures in the event of an actual incident.

Ability to manage in an interconnected world

Both protocols require updating in this area. The SETI Principles were authored in 1990 and the principles for discovery of non-intelligent life were authored in 2002. In the intervening years the level of global connectivity has grown exponentially requiring the use of multiple media forms by communicators to reach widest possible audience. The NEO protocol calls for the use of a wide variety of 'tools' to communicate with the public to drive awareness and desired actions, if any (Williamson *et al.* 2012). None of the protocols mention the use of social media in any context. Given the many widely publicized difficulties with managing real-time content and response through social media, this many not necessarily be a deficiency. Despite its potential pitfalls, social media is a trusted source of information by a significant segment of the public and must become an integral part of an announcement process.

Trust

Both discovery protocols are built on apparent ethical frameworks and convey adequate levels of trust the announcement will be delivered fully and truthfully to the public. This is evident in the policy of open access to data and methods related to discovery for the scientific community and in the declaration an open, prompt announcement of the discovery will be made to the public. Supporting documents to the protocols recognize the risk of leaks cannot be eliminated, necessitating an announcement be delivered as soon as the findings of a discovery are verified. This ensures the first analysis of the announcement is provided by the more responsible segments of the media and helps to increase overall public trust in the delivered content. The discovery protocols also contain provisions for follow-up activities to ensure ongoing analysis and revision of the initial discovery findings.

Unlike the discovery protocols, the NEO protocol actually mentions 'trust' and 'transparency' as key principles. One additional element of the NEO protocol, not found in either discovery protocol, is the need for the communications leadership team to 'deal directly with misinformation and conspiracy theories in an upfront manner' (Williamson *et al.* 2012). This serves to provide an additional level of trust within the announcement process.

Risk communication

As previously discussed, risk is present at some level in four of the five different discovery scenarios, but neither the SETI protocol nor the non-intelligent life discovery protocol addresses risk. Given the massive global impact of a discovery announcement the element of risk communication must be a foundational part of the announcement protocol because it is the public perception of risk, rather than the actual risk, that becomes the reality requiring action (Frewer 2004). Frank and open discussion of potential risk at the time of announcement will have the effect of improving the public level of trust with the announcement team. It will also serve to blunt efforts of those who may try to raise untruthful concerns or profit from false public perceptions of risk. The NEO protocol contains a major section on risk communications which call for active participation with risk communication experts prior to an announcement (Williamson *et al.* 2012). Different levels of risk for an NEO threat (general, a few years advance notice, imminent) are identified (Williamson *et al.* 2012).

Announcement process

There are several major factors used to determine, at a high level, the effectiveness of an announcement process. A process must be written in a manner which is well understood, conveys how the process works, who is responsible for the overall process and each individual component of the process. There must be evidence the process has been agreed to by all stakeholders. The process should be current and reflect current world conditions. There should also be analogues which will provide useful comparison to an announcement of this scale.

Both discovery protocols are well written, easy to understand and provide credibility that, if followed, will result in the announcement of discovery of extraterrestrial life being truthfully and openly delivered. The protocols provide a high level flow which adequately conveys how the process works. Other than providing responsibilities for the discoverer(s), neither protocol describes individual responsibilities for major portions of the process. There is no evidence of agreement by outside stakeholders to either discovery protocol. The SETI protocol is 24 years old and the non-intelligent discovery protocol is 12 years old. By comparison the NEO protocol, published in 2012, is well written, and contains significant outside stakeholder agreement through the UN. The NEO protocol does not provide a flow of activities or names but it does list responsible groups within the NEO team (Williamson *et al.* 2012). The ALH84001 case is a very useful analogue for determining the effectiveness of the discovery process. Examples outside the space industry of major events which can be used as communications analogues include the communication performance during the 2011 Fukushima nuclear disaster resulting from a large tsunami, the Christmas 2004 tsunami in Southeast Asia, the response to Hurricane Katrina or the attacks of 9/11/2001 (Williamson *et al.* 2012).

Organization and management

Evaluation of organizational and management structure of the discovery protocols is constrained through examination of several factors. Neither process declares who is in charge of a discovery announcement or provides a management structure. The sponsoring authority for each protocol is the scientific community. The steps necessary to ensure validation of discoveries are well defined and prescribed in each process. The Rio and London Scale addendums to the SETI protocol serve as adequate filters to deal with false signals or hoax attempts (Shostak & Almár 2002; Almár 2011; Almár & Tarter 2011).

The NEO protocol outlines the responsibilities of three groups: the Informational Analysis and Warning Network (IAWN) responsible for communications of a hazard; the Mission Planning and Operations Group (MPOG) responsible for organizing a response mission; and the Intergovernmental Mission Authorization and Oversight Group (MAOG) responsible for authorizing responsive action in the event of an NEO hazard. Authority for the NEO principle emanates from the UN and from the responsible agencies of spacefaring nations (Williamson *et al.* 2012).

Collaboration and cooperation

Both discovery protocols advocate collaboration and cooperation, with the SETI protocol providing more specific detail about the collaborating groups. The SETI protocol calls for collaboration at the international level to determine how to respond to a received signal. Both protocols generally mention working with the UN and other responsible government entities as part of their announcement process. The NEO protocol calls for active engagement and education of government officials and other stakeholders, assigning this responsibility to the IAWN. The high-level working relationship with UNCOPUOS is also described.

Results

Overall evaluation of the research finds there is an adequate process in place to handle the low-risk scenarios of extraterrestrial discovery; the discovery of non-intelligent life and the discovery of an artefact. This is due primarily to the lack of human interaction with the extraterrestrial life form, the low-risk presented to the Earth by these types of discoveries, the limited need for global mobilization or public response, and the prior experience gained from the ALH84001 announcement and other analogue situations. Although there are several notable but addressable gaps, announcements of low-risk discoveries of extraterrestrial life can be adequately delivered and managed.

Announcement of higher risk discovery scenarios are more problematic. Several major gaps exist in this area including, most importantly, the lack of support or endorsement from the UN or national governments. Focused planning groups, covering key components of the discovery announcement, are not identified. Should a situation arise where there is a high risk to Earth, or interaction with the extraterrestrial life form is imminent, we could find ourselves scrambling to assemble a credible announcement and organized response. This may make obtaining the desired action required from the public or institutions difficult. Finally, the use of two separate sets of guiding principles for the discovery of intelligent and non-intelligent life is confusing and requires duplicate management effort.

Recommendations

Prominent members of the scientific community believe the discovery of extraterrestrial life will occur within the next decade or two. If this is true, the date of discovery will be the most famous date in human history. The words and images from that day will be indelibly imprinted in the minds of the entire planet and the historical record forever. The efforts, up to this point, of the scientific community to prepare us for this announcement have been considerate and commendable. With some additional coordinated effort we can be fully prepared to deliver the announcement of the discovery of extraterrestrial life and handle any foreseeable scenario.

Five major recommendations result from the research. First, there needs to be a single protocol for the discovery of extraterrestrial life to cover all scenarios. This will help unify the scientific community over a single set of guidelines covering all possible scenarios. The guidelines can be written to account for differences between the various scenarios of extraterrestrial discovery. Second, the scientific community must gain acceptance from national governments and the UN for the single protocol. This will provide authority for handling and announcing the discovery of extraterrestrial life. It will also position resources and appropriate action by governments if needed. Adoption of a single protocol by the scientific community for the discovery of extraterrestrial life will streamline the effort of obtaining endorsement from UNCOPUOS and national governments.

Third, the guidelines need to formally identify who leads the announcement process, including a basic organizational framework for handling a discovery event. Groups tasked to handle communications planning, response planning and an emergency action group should be created and chartered. The announcement process needs to be outlined, documented and formally tested. This will ensure the process will work when it is used in a real situation.

Fourth, the protocols must reflect contemporary elements of communication strategy, including the need to shape messages by educating stakeholders as well as the public prior to announcement, utilization of current media outlets and social media, implementation of strategies to deal with misinformation, hoaxes, and fringe groups, and full inclusion of current risk communication principles as part of the overall announcement process. Finally, the scientific community must develop additional efforts to promote collaboration and cooperation from outside the scientific community in the development and operation of the announcement protocol for the discovery of extraterrestrial life. Support must be garnered prior to an event to ensure it is in place when it is actually needed. This will add authoritative strength to the protocol and may result in additional support as well as funding for the overall effort to search for extraterrestrial life.

References

Almár, I. (1995). The consequences of discovery: different scenarios. *ASP Conf. Series* **74**, 499–504.

Almár, I. (2011). SETI and astrobiology: the Rio Scale and the London Scale. *Acta Astron*. **69**, 899–904.

Almár, I. & Race, M.S. (2011). Discovery of extra-terrestrial life: assessment by scales of its importance and associated risks. *Phil. Trans. R. Soc.: Math. Phys. Eng. Sci*. **369**, 679–692.

Almár, I. & Tarter, J. (2011). The discovery of ETI as a high-consequence, low-probability event. *Acta Astron*. **68**, 358–361.

Baker, V.R. (2014). Planetary geomorphology: some historical/analytical perspectives. *Geomorphology*.

Barker, T. (2011). Seth Shostak on SETI. In ed. University, S.

Baxter, S. & Elliott, J. (2012). A SETI metapolicy: new directions towards comprehensive policies concerning the detection of extraterrestrial intelligence. *Acta Astron*. **78**, 31–36.

Berthelot, L. (2012). *Communication with the Public in a Nuclear or Radiological Emergency*. International Atomic Energy Agency, Vienna, AT.

Billingham, J. (1993). SETI post-detection protocols: what do you do after detecting a signal? *ASP Conf. Ser*. **47**, 417–424.

Binzel, R.P. (1997). A near-earth object hazard index. In *Annals of the New York Academy of Sciences*, ed. Remo, J. I. New Yok, NY, Blackwell Publishing, pp 545–551.

Boyce, P.B. (1990). The first two steps after the signal arrives: verify and tell the world. *Acta Astron*. **21**, 85–88.

Brack, A. (2000). The exobiology exploration of Mars: a survey of the European approaches. *Planet. Space Sci*. **48**, 1023–1026.

Brown, A. (2011). First contact – Marc Kaufman, Jill Tarter, Frank Drake, Seth Shostak. In *SETI Talks*, ed. Institute, S.

Carrozzo, F.G., Bellucci, G., Altieri, F., D'aversa, E. & Bibring, J.P. (2009). Mapping of water frost and ice at low latitudes on Mars. *Icarus* **203**, 406–420.

Cocca, A.A. (1998). Legal science as catalyzer of SETI science, engineering and operations. *Acta Astron*. **42**, 671–675.

Cocconi, G. & Morrison, P. (1959). Searching for interstellar communications. *Nature* **184**, 844–846.

Cockell, C. (2013). Life beyond the Earth: Christopher McKay. In *UK Astrobiology Conference*, ed. Astrobiology, U.C.F.

Corliss, J.B., Baross, J. & Hoffman, S.E. (1981). An hypothesis concerning the relationship between submarine hot springs and the origin of life on Earth. *Oceanol. Acta*, Supplement, 59–69.

Corliss, J.B., Dymond, J., Gordon, L.I., Edmond, J.M., Von Herzen, R.P., Ballard, R.D. & Van Andel, T.H. (1979). Submarine thermal sprirngs on the Galápagos rift. *Science* **203**(4385), 1073–1083.

De Vera, J.-P., Boettger, U., Noetzel, R.D.L.T., Sánchez, F.J., Grunow, D., Schmitz, N. & Spohn, T. (2012). Supporting Mars exploration: BIOMEX in low Earth orbit and further astrobiological studies on the Moon using Raman and PanCam technology. *Planet. Space Sci*. **74**, 103–110.

Dick, S.J. (2006). NASA and the search for life in the universe. *Endeavour* **30**, 71–75.

Dohm, J.M., Barlow, N.G., Anderson, R.C., Williams, J.-P., Miyamoto, H., Ferris, J.C. & Hare, T.M. (2007). Possible ancient giant basin and related water enrichment in the Arabia Terra province, Mars. *Icarus* **190**, 74–92.

Dorfman, L., Ervice, J. & Woodruff, K. (2002). Voices for change: a taxonomy for public communications campaigns and their evaluation challenges. In ed. Center, C.C.M. Berkeley Media Studies Group, Berkeley, CA, pp 1–40.

Drake, F. (1979). A reminiscence of Project Ozma. *Cosmic Search* **1**, 10–20.

Drake, F. (1993). A brief history of SETI. *ASP Conf. Ser*. **47**, 11–17.

Dressing, C.D. & Charbonneau, D. (2013). The occurrence rate of small planets around small stars. *Astrophys. J*. **767**, 1–20.

Eyre, D.P. & Littleton, J.R. (2012). Shaping the zeitgeist: influencing social processes as the center of gravity for strategic communications in the twenty-first century. *Public Relat. Rev*. **38**, 179–187.

Fraknoi, A. (2012). An interview with Frank Drake. In *SetiCon*, ed. Institute, S.

Fressin, F., Torres, G., Rowe, J.F., Charbonneau, D., Rogers, L.A., Ballard, S. & Uddin, K. (2012). Two Earth-sized planets orbiting Kepler-20. *Nature* **482**, 195–198.

Frewer, L. (2004). The public and effective risk communication. *Toxicol. Lett*. **149**, 391–397.

Garber, S.J. (1999). Searching for good science: the cancellation of the NASA SETI program. *J. Br. Interplanet. Soc*. **52**, 3–12.

Gautier, T.N. *et al*. (2012). Kepler-20: a sun-like star with three sub-Neptune exoplanets and two Earth-size candidates. *Astrophys. J*. **749**, 1–19.

General Assembly Resolution 68/75 (2013). *International cooperation in the peaceful uses of outer space*. A/RES/68/75. (16 December 2013), available from undocs.org/A/68/75

Gray, R.H. & Ellingsen, S. (2002). A search for periodic emmissions at the WOW locale. *Astrophys. J*. **578**, 977–971.

Griffith, C.A. *et al*. (2012). Possible tropical lakes on Titan from observations of dark terrain. *Nature* **486**, 237–239.

Gross, M. (2014). The past and future habitability of planet Mars. *Curr. Biol*. **24**, R175–R178.

Grossman, L. (2013). NASA urged to seek live Martians with 2020 rover. *New Scientist* **219**, 9.

Haqq-Misra, J. & Kopparapu, R.K. (2012). On the likelihood of non-terrestrial artifacts in the Solar System. *Acta Astron*. **72**, 15–20.

Harrison, A.A. (2011). Fear, pandemonium, equanimity and delight: human responses to extra-terrestrial life. *Phil. Trans. R. Soc. A, Math. Phys. Eng. Sci*. **369**, 656–668.

Head Iii, J.W., Hiesinger, H., Ivanov, M.A., Kreslavsky, M.A., Pratt, S. & Thomson, B.J. (1999). Possible ancient oceans on Mars: evidence from Mars Orbiter Laser Altimeter data. *Science* **286**, 2134–2137.

Hyer, R.N. & Covello, V.T. (2005). *Effective Media Communication during Public Health Emergencies*. World Health Organization, Geneva, CH.

Jackson, L.P. (2010). Communication strategies. In ed. Agency, E.P., Environmental Protection Agency, Washington, DC. 1–7.

Klein, H.P. (1978). The Viking biological experiments on Mars. *Icarus* **34**, 666–674.

Klein, H.P. (1996). On the search for extant life on Mars. *Icarus* **120**, 431–436.

Klein, H.P. & Devincenzi, D.L. (1995). Exobiological exploration of Mars. *Adv. Space Res.* **15**, 151–156.

Konstantinidis, K., Martinez, C.F., Dachwald, B., Ohndorf, A., Dykta, P., Bowitz, P. & Förstner, R. (2015) A lander mission to probe subglacial water on Saturn's moon Enceladus for life. *Acta Astronautica*. **106**, 63–89.

Korbitz, A. (2014). Toward understanding the active SETI debate: insights from risk communication and perception. *Acta Astron*. **105**, 517–520.

Lanard, J. (2005a). Talking to the public about a pandemic: some applications of the WHO outbreak guidelines. *Yale J. BIology Med*. **78**, 369–376.

Lanard, J. (2005b). *WHO Outbreak Communications Guidelines: Evaluation and Coaching*. World Health Organization, Geneva, CH.

Lee, R.J. (2006). Rules for first contact: Legal and policy issues arising from establishing and maintaining communications with extraterrestrials. In *57th Int. Astronautical Congress* IAF, Valencia Spain, 1712–1717.

Léger, A., Grasset, O., Fegley, B., Codron, F., Albarede, A.F., Barge, P. & Sotin, C. (2011). The extreme physical properties of the CoRoT-7b super-Earth. *Icarus* **213**, 1–11.

Lunine, J.I., Chambers, J., Morbidelli, A. & Leshin, L.A. (2003). The origin of water on Mars. *Icarus* **165**, 1–8.

Lyall, F. (1998). Legal aspects of SETI – present and future arrangements. *Acta Astron*. **42**, 661–665.

Mckay, C.P. (2011). The search for life in our Solar System and the implications for science and society. *Phil. Trans. R. Soc., Math. Phys. Eng. Sci*. **369**, 594–606.

Mckay, D.S., Gibson, E.K., Thomas-Keprta, K.L., Vali, H., Romanek, C.S., Clemett, S.J. & Zare, R.N. (1996). Search for past life on Mars: possible relic biogenic activity in Martian meteorite ALH84001. *Science* **273**, 924–930.

Meng, J. (2012). Strategic leadership in public relations: an integrated conceptual framework. *Public Relat. Rev*. **38**, 336–338.

Michaelson, D., Wright, D.K. & Stacks, D.W. (2012). Evaluating efficacy in public relations/corporate communication programming: towards establishing standards of campaign performance. *Public Relat. J*., **6**, 1–25.

Michaud, M.a.G. (1992). An international agreement concerning the detection of extraterrestrial intelligence. *Acta Astron*. **26**, 291–294.

Michaud, M.a.G. (1998). Policy issues in communicating with ETI. *Space Policy* **14**, 173–178.

Michaud, M.a.G. (2003). Ten decisions that could shake the world. *Space Policy* **19**, 131–136.

Mitri, G., Coustenis, A., Fanchini, G., Hayes, A.G., Iess, L. & Khurana, K. & Tosi, F. (2014). The exploration of Titan with an orbiter and a lake probe. *Planet. Space Sci*. **104**, 78–92.

Norris, R.P. (2004). How to respond to a SETI detection. In *Bioastronomy 2002: Life among the stars*, ed. Norris, R.P. & Stootman, F.H. Astronomical Society of the Pacific, San Francisco, CA, 1–6.

Petigura, E.A., Howard, A.W. & Marcy, G.W. (2013). Prevalence of Earth-size planets orbiting Sun-like stars. *Proc. Natl. Acad. Sci*. **110**, 19273–19278.

Quarles, B., Musielak, Z.E. & Cuntz, M. (2012). Habitability of earth-type planets and moons in the Kepler-16 system. *Astrophys. J*. **750**, 1–5.

Race, M.S. & Randolph, R.O. (2002). The need for operating guidelines and a decision making framework applicable to the discovery of non-intelligent extraterrestrial life. *Adv. Space Res*. **30**, 1583–1591.

Ropeik, D. (2012). The perception gap: recognizing and managing the risks that arise when we get risk wrong. *Food Chem. Toxicol*. **50**, 1222–1225.

Rothschild, L.J. (2009). ALH84001 and other Martian meteorites. *Stanford Astrobiol. Course*.

Sawyer, K. (2006). *The Rock from Mars: A Detective Story on Two Planets*. Random House, New York, NY.

Schulze-Makuch, D., Head, J.N., Houtkooper, J.M., Knoblauch, M., Furfaro, R., Fink, W. & Andersen, D. (2012). The biological oxidant and life detection (BOLD) mission: a proposal for a mission to Mars. *Planet. Space Sci*. **67**, 57–69.

Sephton, M.A., Court, R.W., Lewis, J.M., Wright, M.C. & Gordon, P.R. (2013). Selecting samples for Mars sample return: triage by pyrolysis–FTIR. *Planet. Space Sci*. **78**, 45–51.

Shostak, S. (1997). Media reaction to a SETI success. *Acta Astron*. **41**, 623–627.

Shostak, S. (2011). Efficiency in SETI. *Acta Astron*. **68**, 347–350.

Shostak, S. (2012). Prolog to the section on the search for life: SETI. In *Proc. of the IEEE*, 100.

Shostak, S. & Almár, I. (2002). The Rio scale applied to fictional "SETI detections". In *53rd Int. Astronautical Congress Preprints*. IAF, Houston, TX.

Shostak, S. & Oliver, C.A. (2000). Immediate reaction plan: a strategy for dealing with a SETI detection. *N. Era Bioastron*. **213**, 635–640.

Sims, M.R., Cullen, D.C., Rix, C.S., Buckley, A., Derveni, M., Evans, D. & Holm, N. (2012). Development status of the life marker chip instrument for ExoMars. *Planet. Space Sci*. **72**, 129–137.

Socolow, M.J. (2008). The hyped panic over 'War of the Worlds'. *Chronicle Higher Educ*. **55**.

Squyres, S.W., Grotzinger, J.P., Arvidson, R.E., Bell, J.F., Calvin, W., Christensen, P.R. & Soderblom, L.A. (2004). *In situ* evidence for an ancient aqueous environment at Meridiani Planum, Mars. *Science* **306**, 1709–1714.

Sterns, P.M. (2000). SETI and space law: jurisprudential and philosophical considerations for humankind in relation to extraterrestrial life. *Acta Astron*. **46**, 759–763.

Tarter, D.E. (1998). Reply policy and signal type: assumptions drawn from minimal source information. *Acta Astron*. **42**, 685–689.

Tarter, D.E. (2000). Security considerations in signal detection. *Acta Astron*. **46**, 725–728.

Tarter, J. & Michaud, M.A. (1986). SETI Post detection protocol. In *37th Congress of the Int. Astronautical Federation*, Innsbruck, Austria.

Tarter, J. & Michaud, M.A. (1987). SETI Post detection protocol. In *38th Congress of the Int. Astronautical Federation*, Brighton, UK.

Trottier, J. (2013). Hunting extraterrestrials: interview with SETI icon Jill Tarter. In *Think Again TV: The Star Spot*, ed. Canada, C.F.I.

Vakoch, D.A. (2011). Responsibility, capability, and active SETI: policy, law, ethics, and communication with extraterrestrial intelligence. *Acta Astron*. **68**, 512–519.

Westall, F., Brack, A., Hofmann, B., Horneck, G., Kurat, G., Maxwell, J. & Vassaux, D. (2000). An ESA study for the search for life on Mars. *Planet. Space Sci*. **48**, 181–202.

Westall, F., Foucher, F., Cavalazzi, B., De Vries, S.T., Nijman, W., Pearson, V. & Anne, S. (2011). Volcaniclastic habitats for early life on Earth and Mars: a case study from $\approx$ 3.5 Ga-old rocks from the Pilbara, Australia. *Planet. Space Sci*. **59**, 1093–1106.

Williams, R.M.E., Grotzinger, J.P., Dietrich, W.E., Gupta, S., Sumner, D. Y., Wiens, R.C. & Team, M.S. (2013). Martian fluvial conglomerates at Gale Crater. *Science* **340**, 1068–1072.

Williamson, R., David, L. & Schweickart, R. (2012). Crafting an effective communications plan for an international response to a threatening near-Earth object. In *25th Symp. on Space Policy, Regulations, and Economics*. Naples, Italy: 63rd Astronautical Congress.

Wolszczan, A. (2012). Discovery of pulsar planets. *N. Astron. Rev*. **56**, 2–8.

Wu, J., Zhu, G.-W., Zhao, H., Wang, C., Li, L., Sun, Y.-Q. & Huang, C.-L. (2010). Scientific objectives of China–Russia Joint Mars Exploration Program YH-1. *Chin. Astron. Astrophys*. **34**, 163–173.