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A Review Paper on Space Exploration

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Abstract: This paper outlines why space exploration is carried out. There is a summary of method of how missions are selected and their success rate is determined. The kinds of risks associated with Space exploration and what should be done in order to obtain maximum information. The innovation that is being worked upon in order to make human travelling in space more effective and steps being carried out to makespace exploration, a fieldwith morepossibilities thanit is inthe recent times.

***Keywords**: Probabilities, methodology, bio-signature, exploration.*

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I. INTRODUCTION

The exploration ofspaceis notsomething that has been carried out aftertechnology took overthe world.It has been the subject of curiosityforvarious individuals since the inception oftime.It is averydebatable topicwhetherthereis a need to look out for bodies in spacewhilewe arenot even able to discovereverythingon ourplanet. But the curiosityof human beings never fails to takeover thehuman actions. Also, with thedepletion of resources being the most focused environmental issue in the recent times, theremaycome atime where the resources on earth arecompletely exhausted and the most influential raceof the planet earth mayhaveto look for resources on the extra-terrestrial planetsor consider movingto one.For this to be possible, humans areexploringother planets, stars,galaxies.Howthese milestones, with goal ofknowingmore about theplaceoutside earth, is reached.

II. MISSION TECHNIQUES

Whiledecidingwhich spacemission to be carried out, theprobabilities ofsuccess of the mission is determined. This is doneby consideringfourcomponents of the mission that havethe maximum influence on the success of themission.These probabilities are: 1.*J*and*J*~arethe propositionsthat thejourneyrequired is, or is not, completed successfully. 2.*S* and *S* ~arethe propositions that we can successfully, or unsuccessfully, acquirea single sampleat thedesignated sample site. 3. *L*and*L*~arethe propositions that the sampledoes, or doesnot, contain the target bio signature. 4.*T*and *T*~ arethe propositions that wehave, or do not have, apositivetest resultforthetarget bio signature.

2.1Defining missionoutcomes (dependent probabilities)

There aresixpossible outcomes to the scientificmission and foreach outcome we cancalculate theprobabilityof it occurring. Themission outcomes can be thought of as dependentprobabilities and arelisted in Table1.

Table 1
Mission outcomes (dependent probabilities) and their definitions.

#	Dependent probabilities	Definition
DP1	P(~J|I)	This is the probability that the journey is not completed successfully. The outcome is that no sample arrives at the point of measurement. When calculating this probability we are allowed to use whatever background knowledge (I) that we have
DP2	P(~S,J|I)	This is the probability that we have a successful journey but do not obtain a sample. Again we can use background knowledge when we calculate this probability
DP3	P(T,L,S,J|I)	This is the probability for our preferred outcome. Namely, a positive test result on a sample that contains the target biosignature, which has happened after a successful journey and sample collection step
DP4	P(~T,L,S,J|I)	This is the probability for an outcome we would prefer to avoid. We successfully acquire a sample containing the target biosignature, but the test returns a negative result following some sort of failure in the physical test or the analysis
DP5	P(T,~L,S,J|I)	This is the probability for another outcome that we would wish to avoid. We get a positive test result from a sample that does not contain the target biosignature
DP6	P(~T,~L,S,J|I)	This is the probability of a negative test result from a sample that does not contain the target biosignature. This outcome is one we would prefer not to experience, but as a true result is better than the outcomes that involve testing errors

Table 2
Mission steps (independent probabilities) and their definitions.

#	Independent probabilities	Definition
IP1	P(J|I)	This is the probability of successfully completing the necessary journey
IP2	P(S|J,I)	This is the probability of successfully obtaining a sample when we assume that the journey is completed successfully; we can also use our background knowledge for this probability
IP3	P(L|S,J,I)	This is the probability that the sample contains the target biosignature when we assume that the journey is completed successfully and that a sample was successfully obtained
IP4	P(T|L,S,J,I)	This is the probability that we obtain a true positive result; there is also a related probability of getting false negative result
IP5	P(T|~L,S,J,I)	This is the probability of getting a false positive result; there is also a related probability of getting a true negative result

2.2. Defining missionsteps (independent probabilities)

Thesixdependent probabilities above cover allpossibilities and so must sum to one. From this requirement weknow that we can haveat most five independent pieces of information and the remaining probabilityis simplythesum of thefive independent probabilitiessubtracted from atotal of one. Notethatchangingthe values of*P(JI)*|or *P(SJ,I)*|will necessarilychangeallofthe other probabilities. So wenow introducefive independent probabilities(Table2).

Thedependent and independent probabilities can appearverysimilar, but aremathematicallydifferent. To appreciate the differenceonemustnote theposition of thevertical line in the two probabilities. We assumethat wehavesome background

knowledge*I*(), but that *T*, *L*, *S* and *J*are unknown and wewish toknow the probabilitythat*T*and *L*, and *S* and *J*occur simultaneously.

III. JOURNEY PROBABILITY ESTIMATIONMETHODOLOGIES

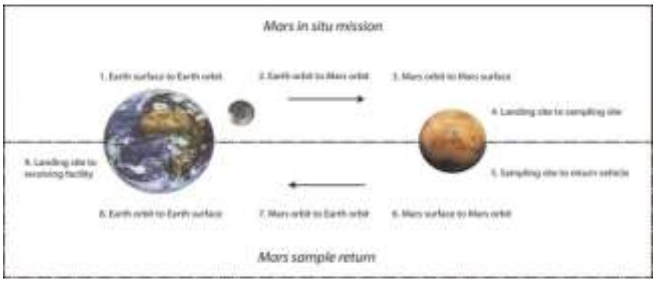
Oncethe mission is into thephasewhereit has successfullybeen found capable of being carried out, theprimarysteps that willbe carried out in the mission.In this section we consider howto estimatethe independent probabilitiesforacase involvingasinglesample, asinglesample tooland onetarget rock type.

Theprobabilitythat a journeycan be completed successfullywilldepend on where westart, where wewant to get to and how wetransition between the two. Anyjourney, e.g. between the points A andB, can bebroken down into a series of steps. Therewillbean intermediatepoint, e.g. C, and the first stepwillbe$A \rightarrow C$and the second step willbe $C \rightarrow B$. This process can beiterated sothat anyjourney can bebroken down intomanyshort steps. Theprobabilityof completingajourneyis the product of theprobabilityof completingeach step. Thenumberof steps that ajourneyis broken into is amatterof convenience. What is important is the abilityto assignameaningful probability to complete the chosen steps.It is possible that astep, e.g. $C \rightarrow$B,can be completed in two, ormore, ways. Theparticular way chosen willdepend on information that is not currentlyavailable.What matters at this stageof theanalysisis that we can estimate$P(C \rightarrow B)$ using some appropriate methodology. Perhaps themostrelevant exampleof two different journeytypes is provided bycomparingin situ and sample return missions to Mars (Fig. 1).In situ missions relyon analyseson ornear the surfaceof Mars to achievetheirobjectives. Samplereturn missions select samples on Mars but relyon extensive analyses in Earth laboratories to meet mission goals. To date, onlyin situ Mars missions have taken place. Substantial planningis taking placefor Mars Sample Return and statistical approaches canform part of ongoingpreparation activities.In situ and samplereturn missions present different engineeringchallenges.Whilesome features are common to both mission types, samplereturnalso requires sample storage, departurefromMars, transport to Earth and recoveryin a fashion that maintains sample integrity.Mission designs for Mars SampleReturn involve the collection and temporarystorage (caching) ofmaterial on thesurfaceof Mars, beforeits recoverybyaseparate mission.If cachingis involved, the journeycan be complexbecauseasample mustbeobtained at one site and then trans-ported to a suitablestorage

An exampleof thesteps for ajourneyto gather samples from theMartian surface maycontain: 1.Earth surfaceto Earth orbit; 2. Earth orbitto Mars orbit;3. Mars orbit to Mars surfacelanding site; 4. landingsiteto sample collection site. For in situ measurements thesefoursteps wouldconstitute the complete journey. For asamplereturn missionwewould havea lengthyand more complexlist of stages to the journey, which might be: 1.Earth surfacetoEarth orbit; 2.Earth orbitto Mars orbit; 3. Mars orbitto Mars surface landingsite; 4.Landingsiteto sample collection site; 5. Transfer ofsampleto return vehicle at samplecollection site; 6. Sample collection site to Mars orbit;

7.Mars orbitto Earth orbit; 8. Earth orbit to Earth landingsite; 9. Earth landingsite to samplereceivingfacility. The probabilityforthejourneyelement ofa samplereturn mission willbethe probabilityof thetwo separate journeys.

When estimatingif wecan obtain asample at a location with a specifictoolthereare two issues to consider: does thetool operateas designed, anddoes the target



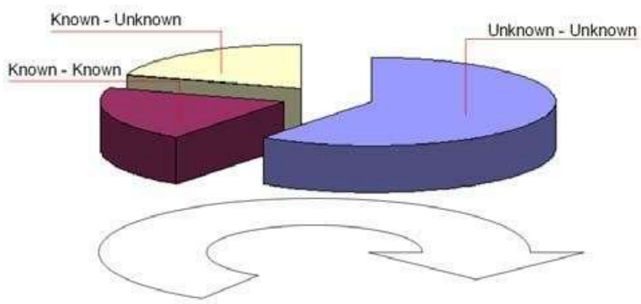
rockexistat thelocation. Therefórethe probabilitythat wecan obtain asample at aspecified site isgiven by

P(*SlJ,I*)=*P*(tool worksas designed) x P(rock type exists at samplelocation) Different tools willhavedifferent probabilities ofworking as designed dueto the complexityof their operation. A scoop willbemorelikelyto operateas designed than arockabrasion toolor corer which in turn is morelikelyto operate successfully when compared to a more complexdrill. Theprobabilitythat a rock typeexists will depend on the ensembleof rock types that might be present.If weassumethat the target bio signature is contained in therock and not in unconsolidated regolith then *P*(target rock present) =[P(rock) + P(mixture)]/[P(rock) +P(mixture) + P(regolith)]

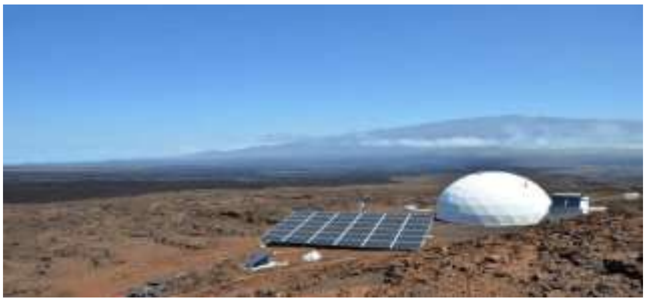
For example, foralocation that is judged to haveaprobabilityof 1/3 that it is regolith covered, aprobabilityof 1/3 that it is suitable target rockand aprobabilityof 1/3 that it is amixture, then P(target rock present)=2/3.

IV.INFORMATION GATHERING

Ineverymission wecandistinguish risk in threepossible ways: a) known-known --weknow therisk and haveretired it, b) known-unknown --weknow that thereis a risk and the risk is modelled and c) unknown-unknown --wedon't even know thereisarisk. Exploration is about diving in theunknown-unknown.



Divinginto unknown-unknown can be donein two ways, eitherbyactually cominginto contact with the unknown identityor through asimulation. Simulation beingspoken of,means creatingartificial conditions to imitate the real conditions in order to accomplish an objective. Mars beingthemostdiscussed futuresubstitute for human habitation, HI- SEAS(HawaiiSpaceExploration Analog and Simulation) aNASA funded space simulation, is aseries ofspacesimulation studyingthe effects of isolation and confinement on human beings.

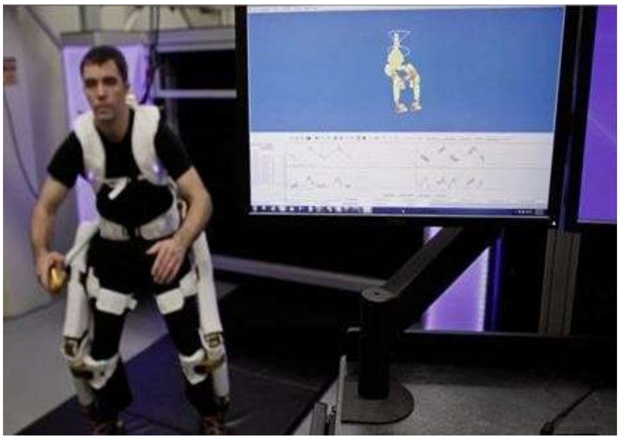


The HI-SEAS habitat

Therehavebeen four missionscarried out under HI-SEAS, thefourth one beingthe longest, lastingup to 366 dayswhile the formermissionsweren'teven foraperiod of half ofayear. TheHI-SEASsitehas Mars-likegeologywhichallows crews to perform high-fidelitygeological field work and add to therealism of the mission simulationas various countries arelooking forward to amanned mission to mars in recentyears. There werevolunteers living inthehabitat, selected from various fields to be able to observetheexperiencefrom allpossible angles.HI-SEASoffered not onlyphysical isolation and geological similarity. Theyhavedevelopedarobust system of high-latencycommunication between Crew and Mission Support that imposes aMars-like20-minute delayon messagereception eachway. Communication is solelyasynchronous (i.e. no real-time conversations), using email and posts to the mission project site hosted byBasecamp. HI-SEASoffers an environment where communication latencyand other mission parameters can bevariedaccordingto studyrequirements. Thehabitat consisted of largesonar panels forgeneratingpower forthe entireday, while some power was stored in batteries forthe night. The also had afood and water containment whichwas scarcely supplied to the habitants, just like the situationcould be whenhuman actuallygo to mars for theinitial times. Theyhad to begiven psychological and physical trainingfor themission. Theyhad some restrictions. Theycouldn't go out of the habitat and breathe air liketheywereon earth. Theyhad to wear spacesuits andgo outside. The experiencessuggested that it is reallydifficulttowalkin that kind ofa terrain andwearingtheheavyspacesuit madeitjustharder. Thevolunteers carried out researches provided bythe higher authorities as wellas their personal researches.

V.INNOVATIONAND IMPROVEMENT

The challengeof spaceexploration drives a continuing effort to design ever more capable,reliable,and efficient systems requiringthe utmostingenuity. Space exploration missions usethe unique capabilities ofhumans (e.g. on the spot decision-making,cognitive adaptability, versatility)and robots (e.g. precision, sensoryaccuracy, reliabilityand expendability) to achieveambitious exploration goals. Maximizingthe productivityof thesemissions by demanding an effectivepartnership between humansandmachines drives progress in human health care,robotics, automation, and otherdomains. Space exploration thus supportsinnovation and economicprosperitybystimulating advances in science and technology,as wellas motivatingthe global scientific andtechnological workforce, thus enlargingthe sphereof human economicactivity.



Exoskeletonto help paraplegics walk, derivedfrom space robotic systems

Overcomingthe challenges of workingin spacehas led to manytechnologicaland scientific advances that haveprovided benefits to societyon Earth in areas includinghealth and medicine, transportation, publicsafety,consumer goods, energyandenvironment, information technology,and industrial productivity.

Thewider listof technological benefits encompasses improved solarpanels, implantable heart monitors, light-based anti-cancer therapy, cordless tools, light- weight high-temperaturealloys used in jet engineturbines, camerasfoundin today's cellphones, compact water-purification systems,globalsearch-and-rescuesystems and biomedical technologies. Scientific research founded on datafrom spaceis also leadingto discoveries with benefits forlifeon Earth. Ongoingresearch in the space environment of theISS– in areas such as human physiology,plant biology, materialsscience, andfundamental physics – continues toyield insights that benefit society.Forexample, studies ofthe human body'sresponse to extended periods in the microgravityenvironment of theISS are improvingour understandingof the aging process.Fundamental scientificstudies of the Martian environment,its evolution and current staterepresent important benchmarks of terrestrialplanetary evolution, and hence, provide amodel that some scientists believewill aid our growingunderstandingof climate change processes on Earth.

Global Technical WorkforceDevelopment

Investment in the Apollo Moon exploration programmein the 1960s correlates with the levelof technical education laterattained bystudents (Figure 3), suggestingthat the programme's high publicprofile and dramatic achievements had awidespread influenceon the level of US technical education.

A 2009 surveyfound thatfiftypercent of the internationallyrenowned scientists who published in theprestigious journal *Nature* duringthe previous threeyears had been inspired byApollo to become scientists;89 percent of therespondents also agreed that human spaceflight inspires youngergenerations to studyscience.One of thelessons from Apollo is that havinga visible space exploration programmeis important in encouragingyoungpeopleto pursuescience, technology, engineering, and mathematics (STEM) fields. Such a programmewillalso send amessageto students that theyhavethepossibilityof long-termexcitingcareers in science and technology.

Today, manyspace exploration missions include components designed to stimulate youngpeople's interest in STEM. More than 2 million teachers and 43 million students from 49 countries have participated in student experiments and activities associated withtheInternational SpaceStation (ISS).In some cases, scientists enlisted thehelp of students to conduct their investigations aboard the ISS, and in othercases students designed space experiments themselves. For example, aprogrammeinvitingstudents to design scientific experiments for implementation on theISShas attracted the interest of tens of thousands ofyoung people.

The earlyspaceactivities have undoubtedlyenlarged our economic sphere, which now extendsinto space, includingthe low Earth orbit up to geostationarydistances.Recentlyprivate initiatives havebeen launched to extend the economicsphereeven further, extendingto theMoon, asteroids, and even Mars. This relies on space exploration, which drives thedevelopment ofnew technologies and capabilities (e.g. heavy lift launchers, human androbotic servicing, and autonomous space operations).Bydevelopingreliable space exploration systems thatincorporate human decision-making,troubleshooting, and flexibility, possibilities are created for enhancingtheeconomicdevelopment of spacedriven byprivate sector investments (e.g. new means to servicein-space infrastructureforapplications and science purposescan be envisaged). Furthermore, bydeepeningour understandingofhow humans and machines function in space, and developingtechnologies for space exploration, publiclyfunded space exploration has lowered therisks and costs associated with accessing and workingin space. Asaresultprivateinvestment is increasingin space-basedendeavours such as spacetransportation systems, Earth-orbitinghabitats, spacetourism and even planetaryminingtechnologies to eventuallyharvest precious materials thought to bepresent in asteroids. Investment inspace-based endeavours is becomingsufficientlyattractiveto private entrepreneurs, so that humankind maybe readyto"incorporate thesolarsystem in our economicsphere".

VI. CONCLUSION

With the amountof exposurebeing given to thestudents interestedin thefield and the amountof effort shown bythe governments of various countries willbe verymuch crucial in determiningthe extent of human reach inthe space. There arepeoplefrom all over theworld taking space exploration astep forward by lookingat theskywith their telescopes and theirscientificthirst for information.The limit of the extent ofexploration is totally dependent of the scientificprogress of the earthasawhole. However, with the advancements beingmadein science, morescopeofdevelopingnew methods of exploration and moreinnovative methods of travellingin spacebyimprovingthe suit or theimprovingthe spaceshuttlesjustto name afew, the humanreach will be increasingwith everytime period.

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