SPACE FLIGHT

Sputnik again orbited the earth on Thursday night, July 7, at SCIENCE BUZZ CAFÉ #xxx . It was launched by Robert Porter and kept in orbit by a NOVA rerun. But unlike the global news spread at the actual launch of Sputnik on October 4, 1957, the news accompanying this "relaunch" focused on the struggle between the three agendas that resulted in earth's first artificial satellite: Agenda #1 The development of ICBMs, Agenda #2 Safer ways of acquiring military intelligence, and Agenda #3 Extending scientific and engineering knowledge to enable humans to explore space and fly to the moon and stars. The relaunch news also named the principal characters who had roles in Sputnik history. Most important among these players were a weapons designer for the Wehrmacht and an American general who oversaw the defeat of the Wehrmacht::Wernher von Braun and Dwight Eisenhower. .

Wernher von Braun was an engineering genius who solved many of the technical problems of liquid fuel rockets. He and his team at Peenemünde. designed and built the V-2, the most advanced rocket of World War II.. used mainly to terrify those in the British Isles. Nonetheless, von Braun's personal motives were centered on agenda #3, the conquest of space. He said "My job is to make the rockets go up. Where they come down is not my department." However, he went along with the use of slave labor taken from concentration camps to make the rockets. With the defeat of the Third Reich in the spring of 1945, von Braun surrendered to the Americans. He and part of his Peenemunde team were brought to America to work on rockets for the U.S. military. Other members of the team were taken by the Soviets and used for the same purpose.

Dwight David Eisenhower was the president of the United States from 1953 to 1961. His military experience had convinced him that one of the most important <u>defensive</u> weapons was good intelligence. Soviet planes had shot down American spy planes that had penetrated Soviet air space,. a possible trigger for war. Eisenhower had the idea if we could get intelligence from above air space there would be less likelihood of sparking conflict. He felt that, like a nation's sovereignty over the seas was limited to a few miles off shore, a nation's sovereignty of the space overhead should be limited to air space. Above the atmosphere, like freedom of the seas, was to be freedom of space. The launch of Sputnik gave an opportunity to implement this policy. Eisenhower gave orders that Sputnik was to be ignored, not attacked. He felt if the first satellite had been American, and the Soviets had attacked it, the principal of freedom of space would be dead before born. But because the Soviets were first in space, Eisenhower's doctrine of freedom of space won.

When the "relaunch Sputnik" burned up in the atmosphere after one orbit, Robert Porter closed the meeting by reminding us of Eisenhower's views regarding Agenda #1:

> "Every gun that is made, warship launched, every rocket fired, signifies in the final sense a theft from those who hunger and are not fed, from those who are cold and not clothed. This world in arms is not spending money alone. It is spending the sweat of its laborers, the genius of its scientists, the hope of its children. This is not at all a way of life in any true sense. Under the cloud of war, humanity is hanging on a cross of iron."

THE EPIPHANY OF OCTOBER 4TH

Shortly after joining the RAND Corporation in June of 1957, I attended a conference of top Pentagon figures and CEOs of major defense corporations. The conference was principally about "Where do we go from here?". Among the presentations was a forecast made by a staff member of RAND. He said, "From my studies of Soviet thinking and planning I would like to make a prediction. On next October 4th, the 100th anniversary of Tsiolkovski's birth, the Soviets plan to put an object into orbit about the earth."

The response to this prediction by the top generals and CEOs was ridicule and scoffing. "They couldn't do anything like that for decades." Nonetheless, the following autumn on October 4, 1957, Sputnik began to orbit the earth. The response is now history.

It is customary to think that the "Atomic Age" began on July 16, 1945 when the first nuclear bomb was exploded near Alamogordo, New Mexico. And to think that the "Space Age" began with the launching of Sputnik. But perhaps the Space Age really began on July 16, 1969 with the launch of Apollo 11 and the landing of humans on the moon . "A small step for one man, but a giant step for all mankind".

But with this first landing on the moon, more than the space age was launched. Something happened to mankind's world view. Not only were astronauts caught up in an expanded vision as they looked back on that "fragile blue globe"called Earth, but people in all lands felt the power of the vision. It was not just Armstrong and Aldrin , not just NASA, not just the USA that did this: WE, all of us, did it. We humans have walked on the moon! Human identity suddenly burst beyond the traditional borders of nations, races, religions, ... We people of the earth have done this! There was a realization not only of what we could do, but of who we really were. We found a planet wide identity!

Decades later, this vision has not completely died, but the business-as-usual types have diverted space from a domain containing the challenges of mystery, discovery, and emergence to a domain for new weapon systems. As with former epiphanies–those moments when we glimpse who we are and sense our connections with the beyond, with the larger, with the higher– many do not grasp the meaning but can only focus on what might be accrued for power and profit through exploitation of new capabilities.

seconds direct view of the spectacle. Here we were suspended half way between heaven and earth and there was the amazing corona of the sun and adjacent were stars and planets that would not be visible again until another time of year. The whole universe was displayed above and beneath us. I had the strongest feeling that if I could just look at this spectacle long enough I could penetrate further into the truth than with all the data we could ever collect with our instruments. In that moment of deep darkness, I felt for the first time the oneness of all things, the earth, the sun, the stars, and we ourselves in the middle of it all. This was enlightenment. This was a glimpse of God.

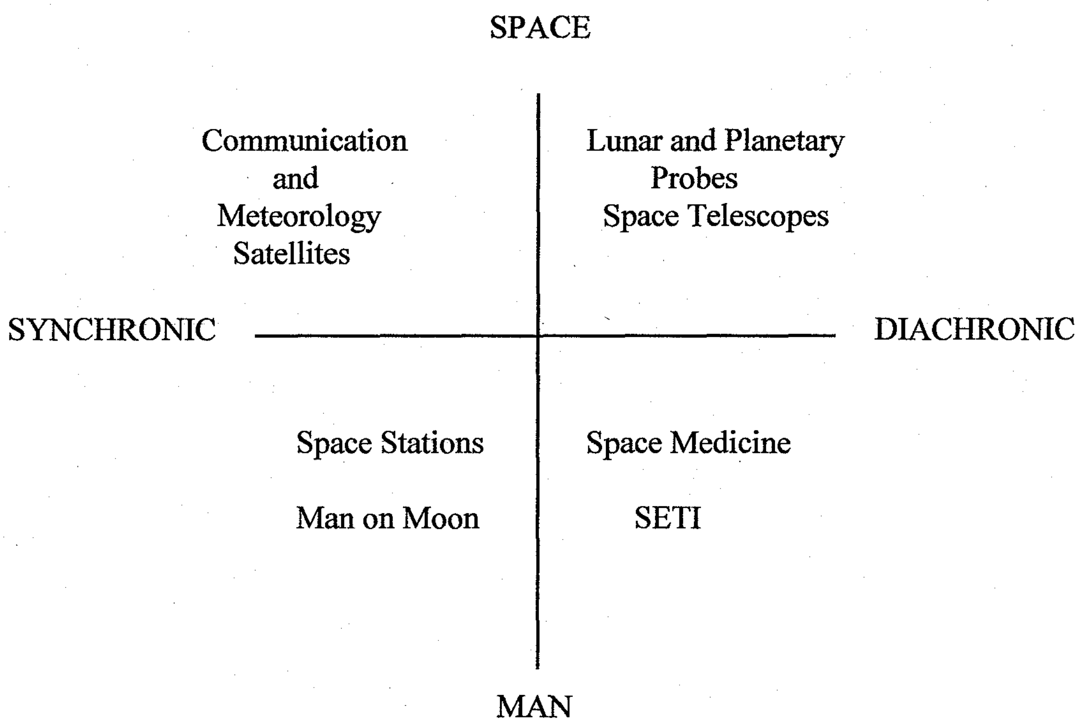
You know, today I can't remember what the purpose of our observations was. We collected and reduced our data, wrote and published the report and it sits on some shelves in some libraries. But that does not matter. The exploration began with a telescope, but the message was received with the heart. For me now darkness is not fearful nor depressing. It has become through the path of knowing a way to the mystic's 'cloud of unknowing'. And this is what the darkness of Advent can be.

I often think about the astronauts and their encounter with darkness.. In outer space all is black. But this is curious because space is filled with light. Light is everywhere and nowhere, and only when it strikes a bit of matter does it manifest itself. This gives us a different way to look at light and dark, perhaps closer to the way it was before God separated the light from the darkness to make day and night. It is only on the surface of the earth that light and dark are so separated. Elsewhere they are intimately intertwined. I think this is why it is said that 'to God light and dark are as one'. I feel the time has come for us to venture into the darkness knowing that in its depths we will find a light greater than any we have known.

SPACEAGE.WPD July 17, 2005

SOME NOTES ABOUT EXPLORING SPACE

The "official" beginning of the space age has been taken as the launching of Sputnik by the Russians on the 100th anniversary of the birth of K. E. Tsiolkovski, October 4, 1957. [1] This was followed in rapid succession by the launch of several earth orbiters by both the USSR and the USA. The first non-orbiter was the Soviet Mechta sent to the moon January 2, 1959. The first man in space was Yuri Gagarin, April 12, 1961. As the ability to penetrate space grew, the effort split into two modes and two objectives. The two modes were manned and unmanned exploration, The two objectives were knowledge, discover what was out there, and put our capabilities in space to practical uses. In the manned-exploration of space we hoped to learn not only about space but about ourselves. And perhaps eventually to learn how to ask some "non-earth" questions. In unmanned exploration we hoped to learn answers to many earth-based questions, but perhaps little else.



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[1]The first recorded attempt to launch something from earth into orbit was made by Fritz Zwicky and a group from CalTech at White Sands, New Mexico, on December 14, 1948 using a two stage V-2 / Wac Corporal rocket equipped with a shaped charge device. Whether the small particles fired by the shaped charge went into orbit is not known. No trails were photographed.

Leap.wpd July 19, 2009

By TOM WOLFE
Published: July 18, 2009

WELL, let's see now ... That was a small step for Neil Armstrong, a giant leap for mankind and a real knee in the groin for NASA.
The American space program, the greatest, grandest, most Promethean — O.K. if I add "godlike"? — quest in the history of the world, died in infancy at 10:56 p.m. New York time on July 20, 1969, the moment the foot of Apollo 11's Commander Armstrong touched the surface of the Moon.

It was no ordinary dead-and-be-done-with-it death. It was full-blown purgatory, purgatory being the holding pen for recently deceased but still restless souls awaiting judgment by a Higher Authority.

Like many another youngster at that time, or maybe retro-youngster in my case, I was fascinated by the astronauts after Apollo 11. I even dared to dream of writing a book about them someday. If anyone had told me in July 1969 that the sound of Neil Armstrong's small step plus mankind's big one was the shuffle of pallbearers at graveside, I would have averted my eyes and shaken my head in pity. Poor guy's bucket's got a hole in it.

Why, putting a man on the Moon was just the beginning, the prelude, the prologue! The Moon was nothing but a little satellite of Earth. The great adventure was going to be the exploration of the planets ... Mars first, then Venus, then Pluto. Jupiter, Mercury, Saturn, Neptune and Uranus? NASA would figure out their slots in the schedule in due course. In any case, we Americans wouldn't stop until we had explored the entire solar system. And after that ... the galaxies beyond.

NASA had long since been all set to send men to Mars, starting with manned fly-bys of the planet in 1975. Wernher von Braun, the German rocket scientist who had come over to our side in 1945, had been designing a manned Mars project from the moment he arrived. In 1952 he published his Mars Project as a series of graphic articles called "Man Will Conquer Space Soon" in Collier's magazine. It created a sensation. He was front and center in 1961 when NASA undertook Project Empire, which resulted in working plans for a manned Mars mission. Given the epic, the saga, the triumph of Project Apollo, Mars would naturally come next. All NASA and von Braun needed was the president's and Congress's blessings and the great adventure was a Go. Why would they so much as blink before saying the word?

Three months after the landing, however, in October 1969, I began to wonder ... I was in Florida, at Cape Kennedy, the space program's launching facility, aboard a NASA tour bus. The bus's Spielmeister was a tall-fair-and-handsome man in his late 30s ... and a real piece of lumber when it came to telling tourists on a tour bus what they were looking at. He was so bad, I couldn't resist striking up a conversation at the end of the tour.

Sure enough, it turned out he had not been put on Earth for this job. He was an engineer who until recently had been a NASA heat-shield specialist. A baffling wave of layoffs had begun, and his job was eliminated. It was so bad he was lucky to have gotten this stand-up Spielmeister gig on a tour bus. Neil Armstrong and his two crew mates, Buzz Aldrin and Mike Collins, were still on their triumphal world tour ... while back home, NASA's irreplaceable team of highly motivated space scientists — irreplaceable! — there were no others! ...anywhere! ... You couldn't just run an ad saying, "Help Wanted: Experienced heat-shield expert" ... the irreplaceable team was breaking up, scattering in nobody knows how many hopeless directions.

How could such a thing happen? In hindsight, the answer is obvious. NASA had neglected to recruit a corps of philosophers.
From the moment the Soviets launched Sputnik I into orbit around the Earth in 1957, everybody from Presidents Eisenhower, Kennedy and Johnson on down looked upon the so-called space race as just one thing: a military contest. At first there was alarm over the Soviets' seizure of the "strategic high ground" of space. They were already up there — right above us! They could now hurl thunderbolts down whenever and wherever they wanted. And what could we do about it? Nothing. Ka-boom! There goes Bangor ... Ka-boom! There goes Boston ... Ka-boom! There goes New York ... Baltimore ... Washington ... St. Louis ... Denver ... San Jose — blown away! — just like that.

Physicists were quick to point out that nobody would choose space as a place from which to attack Earth. The spacecraft, the missile, the Earth itself, plus the Earth's own rotation, would be traveling at wildly different speeds upon wildly different geometric planes. You would run into the notorious "three body problem" and then some. You'd have to be crazy. The target would be untouched and you would wind up on the floor in a fetal ball, twitching and gibbering. On the other hand, the rockets that had lifted the Soviets' five-ton manned ships into orbit were worth thinking about. They were clearly powerful enough to reach any place on Earth with nuclear warheads.
But that wasn't what was on President Kennedy's mind when he summoned NASA's administrator, James Webb, and Webb's deputy, Hugh Dryden, to the White House in April 1961. The president was in a terrible funk. He kept muttering: "If somebody can just tell me how to catch up. Let's find somebody — anybody ... There's nothing more important." He kept saying, "We've got to catch up." Catching up had become his obsession. He never so much as mentioned the rockets.

Dryden said that, frankly, there was no way we could catch up with the Soviets when it came to orbital flights. A better idea would be to announce a crash program on the scale of the Manhattan Project, which had produced the atomic bomb. Only the aim this time would be to put a man on the Moon within the next 10 years.
Barely a month later Kennedy made his famous oration before Congress: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth." He neglected to mention Dryden.

INTUITIVELY, not consciously, Kennedy had chosen another form of military contest, an oddly ancient and archaic one. It was called "single combat."

The best known of all single combats was David versus Goliath. Before opposing armies clashed in all-out combat, each would send forth its "champion," and the two would fight to the death, usually with swords. The victor would cut off the head of the loser and brandish it aloft by its hair.

The deadly duel didn't take the place of the all-out battle. It was regarded as a sign of which way the gods were leaning. The two armies then had it out on the battlefield ... unless one army fled in terror upon seeing its champion slaughtered. There you have the Philistines when Little David killed their giant, Goliath ... and cut his head off and brandished it aloft by its hair (1 Samuel 17:1-58). They were overcome by a mad desire to be somewhere else. (The Israelites pursued and destroyed them.)

More than two millenniums later, the mental atmosphere of the space race was precisely that. The details of single combat were different. Cosmonauts and astronauts didn't fight hand to hand and behead one another. Instead, each side's brave champions, including one woman (Valentina Tereshkova), risked their lives by sitting on top of rockets and having their comrades on the ground light the fuse and fire them into space like the human cannonballs of yore.

The Soviets rocketed off to an early lead. They were the first to put an object into orbit around the Earth (Sputnik), the first to put an animal into orbit (a dog), the first to put a man in orbit (Yuri Gagarin). No sooner had NASA put two astronauts (Gus Grissom and Alan Shepard) into 15-minute suborbital flights to the Bahamas — the Bahamas! — 15 minutes! — two miserable little mortar lobs! — then the Soviets put a second cosmonaut (Gherman Titov) into orbit. He stayed up there for 25 hours and went around the globe 17 times. Three times he flew directly over the United States. The gods had shown which way they were leaning, all right!

At this point, the mental atmospheres of the rocket-powered space race of the 1960s and the sword-clanking single combat of ancient days became so similar you had to ask: Does the human beast ever really change — or merely his artifacts? The Soviet cosmo-champions beat our astro-champions so handily, gloom spread like a gas. Every time you picked up a newspaper you saw headlines with the phrase, SPACE GAP ... SPACE GAP ... SPACE GAP ... The Soviets had produced a generation of scientific geniuses — while we slept, fat and self-satisfied! Educators began tearing curriculums apart as soon as Sputnik went up, introducing the New Math and stressing another latest thing, the Theory of Self-Esteem.

At last, in February 1962, NASA managed to get a man into Earth orbit, John Glenn. You had to have been alive at that time to comprehend the reaction of the nation, practically all of it. He was up for only five hours, compared to Titov's 25, but he was our ... Protector! Against all odds he had risked his very hide for ... us! — protected us from our mortal enemy! — struck back in the duel in the heavens! — showed the world that we Americans were born fighting and would never give up! John Glenn made us whole again!

> During his ticker-tape parade up Broadway, you have never heard such cheers or seen so many thousands of people crying. Big Irish cops, the classic New York breed, were out in the intersections in front of the world, sobbing, blubbering,

boo-hoo-ing, with tears streaming down their faces. John Glenn had protected all of us, cops, too. All tears have to do with protection ... but I promise not to lay that theory on you now. John Glenn, in 1962, was the last true national hero America has ever had.

There were three more Mercury flights, and then the Gemini series of two-man flights began. With Gemini, we dared to wonder if perhaps we weren't actually pulling closer to the Soviets in this greatest of all single combats. But we held our breath, fearful that the Soviets' anonymous Chief Designer would trump us again with some unimaginably spectacular feat.

Sure enough, the C.I.A. brought in sketchy reports that the Soviets were on the verge of a Moon shot.

NASA entered into the greatest crash program of all time, Apollo. It launched five lunar missions in one year, December 1968 to November 1969. With Apollo 11, we finally won the great race, landing a man on the Moon before the end of this decade and returning him safely to Earth.

Everybody, including Congress, was caught up in the adrenal rush of it all. But then, on the morning after, congressmen began to wonder about something that hadn't dawned on them since Kennedy's oration. What was this single combat stuff — they didn't use the actual term — really all about? It had been a battle for morale at home and image abroad. Fine, O.K., we won, but it had no tactical military meaning whatsoever. And it had cost a fortune, $150 billion or so. And this business of sending a man to Mars and whatnot? Just more of the same, when you got right down to it. How laudable ... how far-seeing ... but why don't we just do a Scarlett O'Hara and think about it tomorrow?

And that NASA budget! Now there was some prime pork you could really sink your teeth into! And they don't need it anymore! Game's over, NASA won, congratulations. Who couldn't use some of that juicy meat to make the people happy? It had an ambrosial aroma ... made you think of re-election ....

NASA's annual budget sank like a stone from $5 billion in the mid-1960s to $3 billion in the mid-1970s. It was at this point that NASA's lack of a philosopher corps became a real problem. The fact was, NASA had only one philosopher, Wernher von Braun. Toward the end of his life, von Braun knew he was dying of cancer and became very contemplative. I happened to hear him speak at a dinner in his honor in San Francisco. He raised the question of what the space program was really all about.

It's been a long time, but I remember him saying something like this: Here on Earth we live on a planet that is in orbit around the Sun. The Sun itself is a star that is on fire and will someday burn up, leaving our solar system uninhabitable. Therefore we must build a bridge to the stars, because as far as we know, we are the only sentient creatures in the entire universe. When do we start building that bridge to the stars? We begin as soon as we are able, and this is that time. We must not fail in this obligation we have to keep alive the only meaningful life we know of.

Unfortunately, NASA couldn't present as its spokesman and great philosopher a former high-ranking member of the Nazi Wehrmacht with a heavy German accent.

As a result, the space program has been killing time for 40 years with a series of orbital projects ... Skylab, the Apollo-Soyuz joint mission, the International Space Station and the space shuttle. These programs have required a courage and engineering brilliance comparable to the manned programs that preceded them. But their purpose has been mainly to keep the lights on at the Kennedy Space Center and Houston's Johnson Space Center — by removing manned flight from the heavens and bringing it very much down to earth. The shuttle program, for example, was actually supposed to appeal to the public by offering orbital tourist rides, only to end in the Challenger disaster, in which the first such passenger, Christa McAuliffe, a schoolteacher, perished.

Forty years! For 40 years, everybody at NASA has known that the only logical next step is a manned Mars mission, and every overture has been entertained only briefly by presidents and the Congress. They have so many more luscious and appealing projects that could make better use of the close to $10 billion annually the Mars program would require. There is another overture even at this moment, and it does not stand a chance in the teeth of Depression II.

"Why not send robots?" is a common refrain. And once more it is the late Wernher von Braun who comes up with the rejoinder. One of the things he most enjoyed saying was that there is no computerized explorer in the world with more than a tiny fraction of the power of a chemical analog computer known as the human brain, which is easily reproduced by unskilled labor.

What NASA needs now is the power of the Word. On Darwin's tongue, the Word created a revolutionary and now well-nigh universal conception of the nature of human beings, or, rather, human beasts. On Freud's tongue, the Word means that at this very moment there are probably several million orgasms occurring that would not have occurred had Freud never lived. Even the fact that he is proved to be a quack has not diminished the power of his Word.

July 20, 1969, was the moment NASA needed, more than anything else in this world, the Word. But that was something NASA's engineers had no specifications for. At this moment, that remains the only solution to recovering NASA's true destiny, which is, of course, to build that bridge to the stars.

МИР

Today, the space station MIR plunged fierily to earth. Bringing to an end the stage upon which many of mankind's "space firsts" were enacted. We see in MIR an avatar of Prometheus, bringing fire again to earth. But this time a new fire, a fire that will be as transforming of humanity as was Prometheus' first bringing of fire. What is this new fire? It does not burn on our hearths, it burns in our hearts. It releases our imaginations and challenges us to rise up and reach for what has always been in our dreams but beyond our grasp. To become who we really are, not a local overlord, but an aspirant to earning a voice in the councils of the cosmos. A long journey ahead, much to learn and much to unlearn, but the new fire will not let us turn back. The journey has begun.

ODE TO MIR

You have spent many a year in heaven in touch with the vast universe, and now in your fiery sacrifice you bring to Earth a portion of that experience. A portion that enriches and enables us as did Prometheus' first bringing of fire in ages past. Forces of arrogance and folly punished both Prometheus and us. But now, as did Prometheus, we too have become unbound, and soar high above Elbruz on our way to the stars.

POSTPISC. WP6 July 22, 1997

A POST-PISCEAN GLIMPSE

As we wind up the century, the millennium, and the age that began some 25 centuries ago, commonally called the Piscean Age, we wonder what the themes of the next age will be. Do we have any previews or glimpses of what the age now beginning will be like? If I were to make a guess, I would see as one highly likely, but definitely not assured, scenario something like the movie, Apollo 13. I see humanity united and identified with both the importance and the challenge of going beyond the Earth. And this not just from the technical challenge, but from its forcing us to graduate from ~~the cradle~~ our sand box and school yard mentality that has possessed us for millennia. For the venture into outer space is not only a physical journey, it is a symbolic journey of our leaving the cocoon in our spiritual evolution.

The venture into interplanetary space can serve as a ritual, a liturgy, that will also awaken and guide us in our venture into "inner space". Probes and space vehicles will be the candles and incense of our new litany. Already we have seen our hearts as well as our minds awaken as we find global identity with the astro-cosmonauts entering this new frontier for us. They carry each of us with them in spirit as they make their lonely dangerous way into the unknown

At this singular point in our journey we are briefly free of deterministic archetypes. There is a spectrum of choice before us. One choice is to stick with the familiar, repeat the scenarios of rivalry and conflict ingrained in us by our historic insufficiencies and inadequacies.* Another is to recognize our all but total blindness to a major sector of who we are and what we can become. A sector thus far recognized only poorly and partially by ~~some of our~~ most religions; and off limits to purely intellectual epistemologies.

But once before, if we look back millennia, there was a comparable time, when our ancient ancestors first walked to the shores of the sea, viewed it in wonderment, then began to venture forth on it, discovering both outer and inner realms of which they had never dreamt. We are their descendants and we cannot do otherwise than continue that Great Journey which they began.

* updating the mantra of the sixties, "Make love, not war" we might say, "Put poets, not weapons, into space"

THE ASTRONOMY OF SILENCE

Astronomy is the science in which we do not speak, only listen, listen to the starlight. It is true that we listen selectively, and that we understand only part of what we hear. But in having to remain silent we are not so likely to confuse our own voice with the voice of the cosmos. It is curious that with access to such purity, we nonetheless seek to extend our prejudices to encompass the whole universe by assuming that as it is here it is so everywhere and that as it is now it will always be.

Are we really ready to encounter the stars? Until we realize our identity with our parents, the Earth and the Sun, and know all the members of our family, we have not the wisdom to meet with any who may dwell beyond our home. Only when we come into oneness with all that live here, all that here support, all that endure in our midst, will we be able to hear and respond to the wondrous variety that inhabits the Cosmos.

It has been asked, Why have we not been contacted? Perhaps we are unprepared to know what lies beyond. Is it that we are not ready to receive, or is it that we have nothing to give? So long as we are intolerant and uncomfortable with local variety, we are not ready to encounter true variety. So long as we seek to render the world in our own image, we are not ready for coexistence with pluralities of images.

Only through the astronomy of silence, hearing what the starlight is seeking to tell us, will we reach the maturity for cosmic companionship.

THE EPISTEMOLOGY
of
SPACE EXPLORATION

Albert G. Wilson

Where we had thought to travel outward,
We shall come to the center of our own existence.
And where we had thought to be alone,
We shall be with all the world.

Joseph Campbell
[The Power of Myth p123]

BACKFRNT.WP5 VISRI EPIONTOLOGY 08/06/89

THE BACK FRONTIER

Crossing the frontier that lies within.

The exploration of the well known.

The re-examination of the obvious.

The search for what has already been found.

The gleaning of harvested fields.

The mining of well worked veins.

Examples:
- The Analemma
- Genesis, Chapter 1
- Kepler's Third Law

In his review of the book Hierarchical Structures, Whyte, Wilson, Wilson (Eds), In Main Currents of Modern Thought vol 27, No. 1., Sept-Oct 1970, Ervin Laszlo says:

> "I should like to emphasize a remarkable assertion by Gerard which could be the key word for the entire volume and for all others like it:
> 'Entitation is vastly more important than quantitation.' (p219) As he explains,
> 'A real breakthrough, scientifically at least, to me is when somebody has sufficient creative imagination-and courage to follow up, which may be even more important-to say, "Let us look at the universe in terms of some new kinds of entities, some new kinds of units; or, what really comes to the same thing, in some new way of combining units"; because combining units gives a new unit at the superordinate level.' (pp219-220) What this volume has tried to accomplish, it seems to me, is to look at various aspects of the universe in terms of some new kind of entity, and in terms of how such units combine into new units and relate to one another. Given the complexity of organization in all realms of nature, prolonged inquiry is bound to come up with concepts describing or explaining how the units, which the investigator had the imagination to discern and the courage to follow up. combine with one another and yield superordinate units which, in their holistic coordinate functioning, exercise constraints on the subunits which are not readily (or perhaps not at all) explicable on their own level."

EPISTSYS.WP5 DISK J Ø4/22/87

AN EPISTEMOLOGICAL SYSTEM

1 DESIGNATE or DELIMIT THE DATA AREA
The data area is the domain from which data is to be taken. For example, in astronomy, the basic data area is the sky itself. In archeology, say, the Mayan culture in Northern Yucatan.

2 SIGNIFICATE THE DATA AREA
Earmark special sub-areas for focus. For example, in astronomy, the nearby galaxies, M31, M32, NGC2Ø5; in archeology, tools and utinsels.

2.1 THE 'WHY' OF SIGNIFICATION
Signification is needed because of the limited band-pass of the human mind. It is generally impossible to operate with any data area in its entirety. Therefore we select or significate.

2.2 THE 'HOW' OF SIGNIFICATION
Signification is done on the basis of emphasis and focus on what has been selected with the denial or ignoring of what has not been selected.

2.3 THE BASES OF THE 'WHAT' IN SIGNIFICATION

2.3.1 SELECTION FROM INTEREST
Selection from interest is a priori selection. It may be done without any previous experience or knowledge of the data area. Interest involves the question of 'to whom'. Interest in general is a psychological and therefore an individual parameter.

2.3.1.1 THAT WHICH IS CHANGING
Especially at certain critical rates. e.g. Lava Lamps, the obverse of frog boiling.

2.3.1.2 PATTERNS
Regularities, simple or aesthetic patterns in space or time.

2.3.1.3 ANOMOLIES or THE DIFFERENT
This requires sufficient familiarity with the data area to recognize something as being unusual.

2.3.1.4 RECOGNITION
Even without previous experience in a data area, from time to time a piece of data may be significated on the basis of some sort of deja vu insight. This may through analogy or something more paranormal.

2.3.2 SELECTION FROM IMPORTANCE
Selection from importance is based or past experience with the data area and its relations to other areas. Importance is primarily a societal parameter, a matter of consensus among members of the social order.

2.3.2.1 RECOGNITION
Memory or knowledge of history is involved. A previously established pattern or archetype of importance is seen to be unfolding.

2.3.2.2 ATTITUDE and VALUE
Traditional attitudes or values, (whether valid or not), may be the
basis of selections

3 COLLECT DATA

4 ORGANIZE DATA

We may recognize structure or impose structure on our data. If our structures conform to more than their inputs, then we conclude they are 'real' or 'natural' and that we have organized correctly.

4.1 FOR ECONOMY

4.2 FOR PREDICTION

4.3 FOR MNEMONICS

5 DISPLAY DATA

6 DISSEMINATE DATA

7

ZEN AND THE ART
of
SPACE EXPLORATION

Albert G. Wilson

Lecture given at the Johnson Space Center
Houston, Texas
September 19, 1979

ZEN AND THE ART of SPACE EXPLORATION

A. G. Wilson

September 19, 1979

When I first proposed "Zen and the Art of Space Exploration" as a title for my remarks today, I was informed that it was not far enough out for this audience. It was explained that this is a really far out group which only touched base with earth from time to time. Nothing you could say would impress them as far out. This took me back somewhat. I had always prided myself on being among the fartherest-out, and felt that I could say I was farther-out than thou to almost anyone.

However, I must confess that it is becoming more and more difficult to maintain one's home base on the distant horizons of far-outedness. I first encountered this challenge some 25 years ago when I was consulting with one of the studios on some space flight science fiction films. They told me this was their last space picture and they were going to give up since reality had outstripped imagination. Anything that they came up with for a scenario was either old stuff or would be outdated by the time the film was completed.

Reality has indeed outstripped imagination. We do not imagine and design the future we want, we just respond as best we can to the sweeping tides of change created by our past investments. Our culture lacks the compass of guiding images to successfully navigate the future. Herman Kahn has gone even further and maintains that reality has outstripped experience and we all living in worlds of illusion where our social, economic and political models and icons have little to do with physical reality. We have not assimilated the new realities surrounding us and continue to think in ways that are increasingly losing validity.

Illusion brings us to the subject of Zen, a strategy to enable us to escape from illusion, which is predicated on the proposition that all is illusion. Miyamoto Musashi, the great 17th century samurai Kendo master said, "In strategy it is important to see distant things as if they were close and to take a distant view of close things." This audience is well practiced in the first part of Musashi's aphorism, but today I would like to venture some remarks applicable to the second part: To take a distant view of close things, is important to re-examine 'what every schoolboy knows as true'. Some of the most important advances in history have resulted from a purview of ideas everyone has accepted, for example, Einstein's re-examination of the basic Galilean concepts of relative motion.

Now every schoolboy knows what we mean by exploration, but let's take another look at it. We may start by trying to define 'exploration'. But this is not easy. Better to start by characterizing 'exploration'. The difference between definition and characterization is that the first is closed and complete, the second open and partial--an important discrimination to which we shall need to return to repeatedly. For example, in the exploration of space we may be asked 'what is life?'. We quickly realize that we cannot define life, we at best can only characterize it. Some characterizations of life are:

- Life is capable of local decrease in entropy.
- Life adheres to the principle of plenitude, i.e., replication, proliferation, environmental modification to its advantage.
- Life locally reduces deterministic causalism (exercises freedom)
- Life is capable of energy and information storage and transformation.
- etc.

Also we may be asked, 'what is intelligence?' Some characterizations are:

- Ability to read certain types of messages, to receive and decode certain types of signals, absorb certain levels of information.
- Ability to generate messages and signals with a certain level of informational content.
- Can make arrangements for modifying and freezing messages.
- Possession of certain self-referential capabilities.
- Ability to structure images.
- Can create and exercise options.
- etc.

Sometimes a 'trial definition' is used as a surrogate for a definition. The trial definition is composed of a subset of the list of characterizations.

SOME INFORMATIONAL ASPECTS
of
SPACE EXPLORATION

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Lecture given befor e the Sigma Xi Society
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Some Informational Aspects of Space Exploration

A. G. Wilson

The title of this talk has been announced as either Informal Aspects of Space Exploration, or Informational Aspects of Space Exploration, depending on what newssheet you read. This leaves me with a great deal of freedom - and I plan to take advantage of it. Actually, titles have very little to do with what is discussed in lectures anyway. They are only to serve as a lure. But I do not think you should have to listen to a lecture whose subject you do not know - so whatever the title, what I am actually going to talk about is the question of, "Can we design a self-organizing, automated, instrument-computer system to explore space?"

The first question is: Why? We already have an excellent self-organizing, automated, instrument-computer system for doing the job - a man. Why try to design something else? Pound for pound a man has greater capability to explore than any automated system -- however miniaturized -- assuming for the moment that you could design one. ~~This is certainly the case.~~ The only difficulty is we are not sure we can safely deliver a man to and return him from all of the alien environments we may wish to explore.

Since the problems of exploring space with man derive from a quite different set of obstacles than those of exploring space with automated systems, it would seem that if we are really intent on space exploration we are much more likely eventually to be successful if we have two avenues open to us. If one avenue leads to an insoluble problem, we have the other to fall back on.

If both prove impossible, then we have available a large set of combinations of man and automaton -- some of which may have a good probability of succeeding.

But before I go further into this matter, perhaps I should explain what is meant by space exploration. It is important that exploration be distinguished from research. Exploration is the process of proceeding into an unknown realm for the purpose of discovery. Scientific exploration is a systematic process of detecting all indigenous phenomena of whatever sort - with special emphasis on the hithertofore unknown, employing as little pre-prejudice as possible. Scientific research, on the other hand, is a systematic process of formulating hypotheses based on already known facts and checking them by expressly designed observations or experiments. Research employs, in this sense, maximum pre-prejudice.

Exploration seeks to add to existing knowledge by discovery of that whose existence is not predictable. It is a process of search. Research, on the other hand, seeks to add to existing knowledge by bridging out into the unknown through the hypothesis-observation-experiment process, utilizing a feedback loop to the existing body of knowledge in order to check for consistency and validity.

It is difficult to ~~decide which of~~ assess the division of effort between these processes ~~is the most~~ which would be most efficient ~~in the long run~~ for ~~adding to human~~ increasing scientific knowledge. On the one hand, we have the long experience of man which has been asking questions based upon existing knowledge (although most of the existing knowledge throughout human history has not been scientific knowledge, but rather authoritarian knowledge in some form or another) and, except in ~~recent years~~ the last two centuries, the types of questions based on the existing body of knowledge have not proven particularly fruitful for the extension of knowledge. It may be that now we have crossed through some sort of an "epistenological barrier" which means, we have at our command a sufficient body of knowledge to allow us to proceed in the ~~exploration~~ investigation of the unknown by asking the right questions. It certainly has taken many centuries for man to learn to ask the right questions. ~~Further,~~ It is claimed by some that, "Experience has shown that the scientific [or research] approach maximizes the rate of acquisition of new knowledge and minimizes the chance of error." [NAS SSB-1]

Standing against this argument is the idea that the research process of extending from the existing body of knowledge contains within itself limitations which in the long run -- except for occasional fortuitous discoveries -- tend to limit the recognition and treatment of phenomena to a small sub-set of the totality of phenomena which may exist in the universe.

Space offers the high probability of detecting new phenomena which cannot be readily linked to the known body of knowledge and therefore not best approached by the HOE process. Nonetheless, space exploration - whether manned or automated - will proceed along both paths - both the path of search and the path of research. Our initial problem of "Can we design a self-organizing automated-instrument-computer system to explore space," can now be phrased a little more precisely: To what extent can the research process be automated and to what extent can the search process be automated?

Let us approach this question by seeing whether we can resolve the research process into its constituent components. Let us employ a systems approach and determine what are the essential ingredients of a system whose function it is to acquire new scientific knowledge through the hypothesis-observation-experiment process. Such a system may appropriately be called an epistemological system. SLIDE 1 gives us a representation of a system of this type which is arbitrarily broken down in a way which is most useful for adaptation to space flight, as will be seen on a later slide. *It provides a convenient resolution into components without having to explain how each component works.*

The general purpose of this system is to observe the external world through a set of sensors and to modify the sensor data in appropriate ways to form a construct or map of the external world which can then be stored as part of the totality of knowledge.

In detail, how does this system work? First, the sensors, these may be either the ordinary human senses or their enhancements and extensions by means of instruments such as telescopes, radars, magnetometers, *etc.*, collect data ~~[illegible]~~. Each sensor has a built-in or "intrinsic" filter, which limits its range and resolving power. For example, the eye is limited ~~by~~ in spectral sensitivity to the range roughly from λ4000 to λ7000, *field of view 120°, resolving power 1'* -- we can think of this limitation as due to an intrinsic filter. The objects in the external world to be observed are selected by the filter control center through the "directivity" filter.(A) The sensor output data is selected by filter(B) according to what sense data is relevant or is believed relevant to the matter selected by the directivity filter. This system might be utterly oblivious to certain stimulations, not even recognizing they exist, even though they pass the intrinsic filter and A. Other stimulations with which it has established familiarity, it readily passes. Next, is the coder in which the filtered sensor data is correlated, paired, and converted into numerical data or verbal propositions. For example, if the sensor data were a photograph, the densities and positions of objects on the photograph would be measured and converted into numbers. The output of the coder is generally numerical data and filter C selects a certain sub-set of this data, held to be germane, to be fed to the data reduction computer. Usually what is attempted here is to find a correlation or some relationship among the data. If the results agree with some assumed hypothesis and therefore with existing knowledge - as checked by (D), we arrive at a scientific fact or law which is then added to our store of knowledge.

important

Ideally, All available scientific knowledge is ~~ideally~~ available to our data reduction computer. This knowledge not only consists of ~~such common~~ computer programs and compiler systems as used in machine numerical analysis, but also may consist of tables of numerical and factual data of all sorts which can be used to process new data.

From the knowledge storage block there is a feedback lead going to a hypothesis generator, which is a scientist - a man who is aware of what is stored in the knowledge block and who can generate new hypotheses and experiments -- these he sends to the filter control, which is in essence the process of designing an experiment which in turn directs the directivity filter in the selection of what to observe, the selectivity filters with regard to what data they should retain, and the reduction filters with regard to how to check the validity of results.

An epistemological system of this type will learn in the same way that an individual human learns, i.e. through the experience that certain types of hypotheses have greater payoffs. It learns that particular approaches, types of questions, particular settings of the filters are most fruitful. The four filters are then programmed or adjusted for these optimum payoffs and to avoid less successful ventures.

~~Let us look in more detail at Filter (A), the directivity filter - which is essentially concerned with the matter of what questions should we ask or what hypotheses should we form in operation of extending knowledge.~~ In this ~~simile~~ representation, we are thinking ~~of questions as filters with regard to directing our attention and selecting our data, i.e.,~~ the asking of a question or the posing of a problem is in effect ~~the~~ a setting of filters in the epistemological system - temporarily shutting out all other deliberations.

In space, for example, we ~~I~~ might ask questions concerning the compositions of the atmospheres of Mars and Venus, the strengths of the magnetic fields and radiation belts in the vicinity of Jupiter we can design for research if hypothesis generator is man

~~and Saturn, etc.~~

The questions asked are largely determined by the contents of body of available knowledge. The usual source of questions for our epistemological system are the ideas for experiments of qualified scientists who formulate their questions and experiments on the basis of their knowledge in their specialties. What is usually proposed by researchers falls into 3 classes: 1) from analogy, ~~e.g.~~ look for an aurora on Venus since one exists on the earth; 2) from feasibility, we have a magnetometer, let's take it into space and see what it tells us; and 3) from the structure of a scientific theory, Theory predicts wave regime circulation let us measure the turbulence patterns on Mars to see whether a Hadley (symmetric) circulation regime or a Rossby (wave) regime circulation exists.

From time to time in this process, something unexpected occurs which is in no way a direct consequence of the observation nor is derived from the existing body of knowledge, but is found - not as the result of a hypothesis - but due to an observation which may be quite fortuitous. The classical example is Becquerel's discovery of the shadows cast by a key on an unexposed photographic plate left in a drawer with a piece of pitchblend. This accidental association in the desk drawer of a physicist was the first step leading into the atomic age.

Except for sending a man, those planning the exploration of space are doing so through the research process in the conventional, orderly, hypothesis-observation-experiment process described by our epistemological model. They are primarily seeking the answers to specific questions, such as does the Martian atmospheric circulation

~~question~~ follow a Rossby pattern? But, on the side, are hoping that something new or interesting will turn up.

How may this <u>research</u> type of epistemological system be adapted to space? There are a great many ways. The simplest way, of course, is the method being used at the present in which no degree of self organization takes place. An observation based on a hypothesis is indicated and a sensor is designed to make this specific observation, ~~with~~ the result being telemetered back to earth. The second SLIDE shows us in block form the epistemological ~~xx~~ system of slide one as adapted for space research in this simplest way. Every component of the system remains on earth except the sensors whose directivity filters A are pre-set or may be tele-controlled and whose selectivity filters B are pre-set. If this system runs into an overload - as in the case of the counters which ~~xxxxxx~~ first detected the radiation belts, there is no adapt~~ivity~~ ability in sensitivity or range possible. ~~Adaptivity of this sort is the next degree of sophistication -- the Mark II system.~~

An epistemological system in space must include both hardware components and conceptual components:

HARDWARE COMPONENTS

Sensors, such as
- cameras
- ~~xxx~~ spectrographs
- magnetometers
- etc., etc.

Computers
- memory or
- data storage
- data processing

Telemetry devices

Power Supplies

CONCEPTUAL COMPONENTS

An epistemological approach
- hypothesis
- analogy
- or search

Component Arrangement
- all vehicular
- part earth, part vehicular
- multi-vehicular

Sophistication of Instruments
- fixed instruments
- post selection of sensitivity and range instruments

Vehicles

Protection sub-systems

Basing and Control Centers

post selection of Target instruments

Human simulation instrument systems

The remaining type of component in the epistemological system is of course man.

The various ways in which the components may be arranged and the places and levels where man would make his inputs and decisions lead to a large number of possibilities. It is because of this large number of possible alternate arrangements that it becomes necessary to make a systems analysis ~~study~~ to derive the optimum configuration for each mission. It must be borne in mind that there are several differences between the functioning of an epistemological system on earth in a laboratory adjacent to a library and computer and an epistemological system on a space craft. Timing and phasing pose severe modifications. Some other ~~of the~~ basic questions which arise are:

1) What components of the system should be located in the space-craft and what components should be left ~~located~~ on earth?

2) What components can be automated - where is man essential?

3) Will a hypothesizing-filter system such as the one in our epistemological system, which is specialized to terrestrial conditions (man is an example of such a system), be suitable for exploration of alien environments? If it is not effective, how may we redesign such a system to obtain optimum efficacy? (This means, if we are asking the wrong questions - making unfruitful hypotheses - how do we detect this and how do we learn the right questions to ask?) It is conceivable

that the important phenomena of a planet may lie completely outside the significance scope ~~detectability range~~ of the experiments which we have designed,

~~therefore, one answer might be to replace the hypothesizing system with one which provides for an automatic, systematic search for all phenomena down to a certain resolving power. Such a system would replace the hypothesizer for the initial operations in the exploration of space and then from the initial results, the hypothesizer would select the next important experiments to carry on the exploration.~~

By degrees of sophistication, we can visualize Mark I systems which measure specified targets in specific pre-set ranges and evolving to resolving power: ~~The type of system which carries an instrument to measure a radiation field - it measures the radiation field, telemeters the result, and that is all.~~ A Mark II ~~a~~ system which would, ~~say,~~ be able to make post selection of ranges and sensitivities according to the load encountered. An ~~The~~ instrument ~~xxxx~~ sent to measure the intensity of radiation, if it found the intensity outside its range would switch sensitivities and make an adaptive adjustment to the environment. A Mark III system might be still more sophsiticated - not only possessing the capability of selecting suitable sensitivities, but also post-selecting targets - objects to observe. For example, say we wish to take photographs of the planet Mars from a capsule descending toward the planet. We would like to know what is most useful to photograph in more detail on the basis of what already has been photographed. How to guide the capsule down in such a way as to photograph the most interesting phenomena is the question. Such an instrument system would have to select a succession of targets.

A Mark IV system might/could be capable of a systematic investigation to check certain types of hypotheses. For example, conduct according to pre-set criteria a test for semi-life, sub-life, or life phenomena, then concentrate on observing any object which passed the test. Finally, we can visualize systems which simulate human intelligence, systems which perform all of the operations in the epistemological research process including hypothesizing. Such a system would not telemeter back data - it would teletype back a printed paper ready for publication in the Astrophysical Journal.

So let us turn now from the possible ways in which automation of the research process might evolve to the question of what might be done in the way of automating the search process. This is the process of discovery and the one we feel man is absolutely essential to -- whereas we know an extensive amount of space research is clearly possible without man leaving the earth.

It is generally felt that, important as might be the answers to the specific scientific questions, explored through the research process, the most far reaching results of space exploration will be from the discovery of the entirely new and unexpected phenomena.

How may we best proceed systematically to go about the operation of discovery? First, how useful is the H-O-E or research process itself for discovery? Experiments derived by hypothesis are directed to a very specialized answer and consequently are not likely to reveal new phenomena as fast as some other approach. [N. R. Hanson, in Patterns of Discovery (Cambridge U.P. 1958) says, "The issue [in discovery] is not theory using but theory finding. Concern is not with the testing of hypotheses but with their discovery."] ~~Also~~, D. Gabor in "Astronomical Optics (p. 18) ... "if the research worker sets out to discover new things, this procedure [of ex hypothesi] is almost the opposite of reasonable. If one makes sure that one's observation system is most economical and efficient for observing things of a known kind, one has ipso facto almost made sure that anything new will slip through the net! If one wants to make new discoveries one must not specialise for known things; one must specialise for things which are outside the code." It thus seems the HEO (hypothesis-experiment-observation) or research method is one of the most inefficient methods which could be constructed for exploring the unknown.

Certainly it is possible that ~~Further,~~ questions arising from terrestrial experience may be absolutely defeating for exploring other planets. After all City slickers are not the best source of ideas on agriculture, nor military men on disarmament. The best source for the right questions to ask about Mars is from Martians, ~~experience on Mars.~~

Another way of saying this is that scientific space exploration must not be merely designed on the continuation of present theoretical structures despite our investment in them, but a balance must be found between hypothesis forming and testing based on present knowledge and theories, and basic search designed to look for new phenomena. This becomes all the more important when the domain of exploration is entirely new. Since the most cogent reason for space exploration is the discovering of the unknown, and ~~also since~~ if for the first time a systematic approach to the detection of unknown phenomena can be structured and not left to chance as in the past, inquiry should proceed on the basis of the totality of what is observable rather than be left entirely ~~on the~~ to schedule, basis of the known portions of knowledge.

One also suspects that it is likely to be much easier to design systems ~~to~~ for search and discovery than it is to design systems to hypothesize. How then does one program a systematic search for new phenomena - phenomena which may be totally unknown in terrestrial experience. How does one design a device to maximize serendipity?

If we are ~~stumped~~ perplexed on how systematically to pick up the new - we might proceed by attempting to design a net or sieve which will allow us to pick up the totality of certain classes of phenomena whose extensions exceed a given amount. Knowing the totality of phenomena, we may then reject the known and least interesting. If it is not apparent how best to catch a hitherto unknown species of fish, we can build a net and catch all fish down to a given size - throwing ones we are already acquainted with back - thus isolating the new ones. This may not be an efficient process, but it at least provides a methodology which may be used initially.

How then do we construct an "epistemological net"? Let us illustrate by considering photograph How do we go about ~~detecting~~ photographing all the phenomena on Mars bigger than say 10 centimeters in size. ~~Let us investigate the method by restricting ourselves first to phenomena which are photographically observable.~~ We first

~~describe our net and derive a measure of its fineness.~~ The detectable objects in a photograph of a planetary surface or atmosphere are those which emerge above the contrast and resolving power threshholds, and are contained in the light response, spectral, temporal, and angular ranges of the instrumental system. ~~Identification of what has been detected must be though comparison with familiar objects or events in terrestrial experience.~~

For purposes of an epistemological net, the process of direct photography may be considered to have five "dimensions." These are the two linear or angular dimensions of the region photographed, the brightness dimension (which is recorded as photographic density), the spectral dimension, and the temporal dimension. In each of these dimensions there are bounds which define the range and a threshold which sets the resolving power.

Although there is not complete symmetry in considering the parameters in this way, the viewpoint is useful in that it allows the construction of what we might call an "Instrument ~~Information~~ *Cognition* Space" whose extension is determined by the ranges, and which can be divided into information cells whose sizes are determined by the ~~several~~ resolving powers *of each parameter.*

It is evident that an Instrument Information Space will detect only phenomena of a certain class - missing those which are too large or too small *along the scale of any parameter* ~~or lie in some other spectral range~~. ¶ It is innteresting that certain subsidiary wave patterns in weather fronts had never been detected before TIROS took its photographs of the earth's atmosphere from space. These patterns were of such a scale that they slipped through the epistemological net determined by the distribution of surface meteorological observatories. The pattern of larger phenomena like cyclones could easily be ~~map~~ mapped from several stations. Smaller phenomena could be viewed in their entirety from one station - but in between was a phenomena of a size which was missed.

In this connection it is also informative to look at types of information spaces existing on earth which have been evolved by different creatures. We know something of these information spaces from the work that has been done by scientists working in the fields of learning theory.

An experiment conducted with frogs well illustrates these ideas. The visual information space of a frog is such that he sees only moving objects and of these only those in a limited size range - viz, something of the size of a fly or gnat. This function has evolved from the frog's dinner requirements. But he also detects large shadows, the shadows of birds of prey such as hawks, a function which has evolved from the frog's keeping-from-being-a-dinner requirement. Hence the information space of a frog is bi-modal; seeing moving objects smaller than a certain size and changes greater than a certain size, but omitting object detection which is inbetween these limits. A peculiarity of the thermal information space of the frog is the inability to recognize gradual changes. There is the case of the frog who was boiled to death because of the change of temperature of the water in which he swam was so gradual that he did not perceive it.

The parameters or dimensions of the instrument information space may be the quantities measured by any sensor we possess - thermal, x-ray, magnetic, or whatsoever. The instrument information space concept is useful as a measure of what portions of the natural world have been explored and what portions have not. The single I.I.S. can say nothing, however, concerning unknown parameters - like radio waves before Hertz. The discovery of new parameters constitutes a much more difficult type of search, requiring multiple I.I.Spaces.

By employing a set of instrument information spaces whose fields of view and resolving powers extend over a large range it should be possible to detect all phenomena in a specified size range. This type of information space which can act as a sieve for the discovery of all phenomena down to a knowable size we can call a detection information space. This detection information space must be spanned by a set of instrument information spaces, but the problem of designing set of instrument spaces optimally converging toward an unknown phenomenon is very complex.

Two types of detection spaces can be conceived. First, a space designed to act as a net to hunt for phenomena which are not even known to exist, the serendipity problem, and second an information space to sift for phenomena unknown except that their existence is suspected. (The search for the Yeti might be taken as an example of this type of search.)

In connection with the second type of detection problem, devices which give hints of anomalies without necessarily disclosing any properties or confirming the existence of a phenomenon may be quite useful, in providing economies.

One conceivable device is the application of the general (but not universally valid) principle that characteristic sizes, energies, and existence times of phenomena oft times have proportional orders of magnitude. For example, consider the following meteorological phenomena common in the earth's atmosphere: (A) Tornadoes, (B) Thunderstorms, (C) Hurricanes, and (D) Cyclones.

Figure 1 gives the relation between an order of magnitude size for each of these phenomena and a characteristic time. In the present case the characteristic time is taken as the interval between photographic exposures (say from Tiros) designed to adequately trace the evolution of the phenomenon.

The logarithmic relation is roughly linear. If, however, an afternoon thundercloud complex covering a large area appears unresolved to the camera, the characteristic size of the aggregate may be interpreted as 500 km (E) but the characteristic time would be the same as (B). The location of (E) on the plot would indicate that something anomalous was being observed - in this case an aggregate. This type of anomaly would suggest that the phenomenon (E) is one which should be observed with higher resolving power, indicating a possible fruitful direction in which to develop the detection information space, for converging on a new phenomenon.

We thus see that systematic searching for the unknown based on sieves or epistemological nets is possible and possible without the degree of sophistication that requires a man in space - but the process is wasteful of information - a great deal of redundancy being involved - and when one considers the space communication and telemetering problems over distances of the order of the mean distances of Mars and Venus, economy in information handling becomes an important consideration. ¶ Besides the rather uneconomical epistemological net, in what other ways may discovery be made systematic? There have been several proposals made concerning a strategy of exploration on which there is not adequate time in our present discussion to elaborate, but which in general depend on assuming that a phenomenon with certain properties exists and isolating it through a series of yes-no answered experiments - like the game of 20 questions. This is the natural extension of the research-hypothesis-observation-experiment method to the task of discovery. But this process is also uneconomical and being operationally kin to detecting the presence of a girl in a basket by plunging swords into it, is limited in the type of phenomenon which it is capable of isolating.

A more ~~xxxx~~ fruitful approach is to seek to isolate and describe the operations a human ~~being~~ performs in the process of detecting a new phenomenon. One approach to this is to ask what are the types of phenomena or patterns a man is most likely to notice. The basic human observational operation is the detection of differences ~~or~~ and identities. After a certain amount of basic observational experience is accumulated, an economy is effected through the establishment of a norm or reference datum and notice then is taken only of those events which depart by a minimum of a specified distance from this datum.

In the search for economies, frequently fine distinctions are ignored, which must later be brought to light. ~~The similar and the analogous are deliberately sought and lumped or classified in accordance with already established norms.~~ For example, on photographs of Mars are seen polar caps. These are familiar phenomena so we can assign them to familiar terrestrial categories, and whether warranted or not, tie them by analogy through theoretical or analytical treatments to the behavior patterns of similar phenomena on earth. ~~It gives us a great deal of confidence to proceed in this~~ manner and though we sometimes ~~end up flat on our faces,~~ But this method has proven to be both an economical and reliable way to proceed. It assumes the universality of certain physical laws. We do not ordinarily expect these laws to be refuted by new discoveries and are very surprised when they turn out to be limited. But The occasional departures from these known laws which we encounter lead us to the detection of phenomena which lie outside their kin.

Thus, one method of discovery is to assemble experience until what is typical can be established, then note what is atypical and focus our further attention on it.

Man also, ~~in way of the same process of economizing, though not the same as~~ in addition to searching for the typical, searches for the simple, the regular, the least complex.

And by contrast, man's attention is attracted to that which is most complex - that which changes most rapidly or shows the greatest discontinuities in the smallest region - in short, that which is the noisiest. (However, man may note noise in order to avoid it.)

Summarizing, Search is ~~the~~ conducted to determine ~~In searching for~~ the analogous, the anomalous, the regular, and the complex, ~~is man guided~~ Are these searches unified by any underlying general principle?

~~Before attempting~~ To explore this question ~~further~~, let us digress momentarily to review the concept of information. Although ~~There are three basic types of information,~~ For present purposes we wish to use the term, information, as it is most widely used - that is - in the sense of the communications engineer who defines information as the amount of modification which a message produces in a representation. (We shall stay away from mathematics today.) For example, if I believe that an invasion which is scheduled to be launched at the Bay of Pigs is to be supported by a general uprising of the population of Cuba and then a message comes through that no such uprising is taking place, the result is an extensive modification of the representation or the picture of the situation which I processed in advance. Such a message, therefore, is said to contain a great deal of information.

Another way of putting it: a message which is very unexpected contains a great deal of information, while a message which is expected contains little information. Thus, if I know that my wife's mother plans to visit us next week and I receive a message telling me she plans to stay two weeks instead of one, this message, although modifying my picture of the situation, does not contain very much information because ~~nothing very unexpected was communicated.~~ mother-in-laws are expected to overstay their visits.

Information can thus be described by assuming that the sender has a set of possible messages, which set is also known to the receiver. There is assigned to each message of the set a certain probability of occurrence. The receiver expects to receive the most probable message. A highly probable message contains very little modification in the receiver's representation or picture of the situation, hence little information.

Let us now return to man's tendency to mark the anomalous. This is nothing more than saying that man's attention is attracted by phenomena which are unexpected or which communicate to him a large amount of information. His interest is naturally drawn to the unusual - and hence he is structured automatically to discover new things.

Hence if we could devise an automaton which would seek out the regions of greatest information content, we could be designing a system which would take note of the same things that interest a man, and such a system could explore in a manner which would make discoveries in the same way a man discovers. Hence a process could be designed to scan an unknown region, the scan could be integrated and averaged to establish norms, then the region could be rescanned to note which portions of the unknown region depart most from the typical parts. The scan could be made with every sort of sensor - singly and multiply establishing typical correlations between parameters and isolating the anomalies or regions where the correlations fall down. This gives us a basic principle and a process upon which to design automated exploration. As the man said, the rest are just engineering details.

But this of course is not the case. When a communication channel is set up where the sender is Mother Nature herself, there cannot be a pre-arranged code. One cannot determine which of the messages, all of which are supposed to be known before hand, Mother Nature has intended to send us. There are dangers in stretching communication theory too far.

However, again I would like to quote Gabor:

"Though we ordinarily deal with communication theory, in which information is supposed to be pre-existent in some mind, the concept of information has wider technical applications than in the field of communication engineering. Science in general is a system of collecting and connecting information about nature, a part of which is not even statistically predictable. Communication theory, though largely independent in origin, thus fits logically into a larger physico-philosophical framework. "Information Theory" has already made much progress, and has made useful contact with formal logic and the mathematical theory of representation on the one hand, with epistemology on the other."

~~And~~ But here it supplies us with a tool to approach an otherwise intractable problem. It must be emphasized that information has nothing to do with meaning. Meaning is tied in with the relevancy or the relating to the existing body of knowledge. It is therefore possible that a message may contain a great deal of information but have no meaning. The most unexpected message contains by definition the greatest information, but a message may be received which is complete gibberish (even assuming no noise) completely unexpected - i.e. high information but meaningless.

As an illustration of this, I have a set of slides of aerial photos. This set of slides are all of terrestrial objects, however, those which contain a great deal of information because they are the very ~~most~~ atypical (terrestrial views) are sometimes not recognizable at all and hence, at least until they can be recognized, have no meaning.

Show Slides 3 - - 7

But meaning as well as information is a consideration in space exploration. That which proceeds from the existing body of scientific knowledge by the hypothesis-observation-experiment process will always have meaning because the manner in which it is to be organized into already known knowledge is known beforehand. This process is like looking for a missing piece of a jig-saw puzzle - its location, i.e. its meaning is known, but the color or pattern may be expected (low information) or unexpected (high information).

On the other hand a new discovery resulting from the exploration process may or may not have meaning according to whether it can be related to the existing body of knowledge -- that is to say -- if it does not fit into the jig-saw puzzle, it has no meaning, or if it fits, it has meaning -- that is, if it appears to be completely unrelated, no matter how large its information content, it has very little meaning. Later perhaps its meaning may emerge as it is related to existing knowledge. Thus meaning is measured by relevancy to existing knowledge, while information is measured by unexpectedness or complexity. The role of meaning leads us to what may be termed a "similarity threshold," on one side of which phenomena detected on other planets may be identified with familiar terrestrial phenomena or recognized as extrapolations of terrestrial phenomena, but on the other side of which their identification, and even their reality, becomes speculative. As more detailed knowledge of other planets is collected, the base of the familiar against which comparisons are made and meaning derived will be broadened. It is perhaps fortunate that the first planets to be explored, Mars and Venus, are quite similar to the earth allowing ready identification of many phenomena. The exploration of these planets should extend the base of the familiar and provide experience toward the formulation of a strategy of exploration which will create a more advantageous similarity threshold.

stet

Besides ~~a~~ meaning another difficulty in approaching an unknown or new phenomenon is that we are not aware of the large amount of pre-association information that we feed into its analysis. This is illustrated by comparing the results of looking at aerial ~~pix~~ photographs of the earth in which we supply much of the missing information and in looking at photographs of certain astronomical objects such as Mars, where we are unable to supply the association information and consequently see much less than in the photograph of a familiar object which may contain theoretically the same number of bits of information. And we tend to give "terracentric" interpretations because of the terrestrial pre-associative information we read in.

A second approach to the method of analyzing how the human being explores ~~and applying it~~ which may also be applied to the design of automated systems, is the approach which has been successfully employed by Simon, Newell, and others, in deriving programs for adapting computers ~~so they~~

to replicate certain types of human activity, such as playing chess, translating languages, or proving theorems in plane geometry. In a similar way computers might be taught ~~These devises could not only simulate, but might even extend~~ the ~~facility of the human being~~ to detect new phenomena.

So we may take as one of the most important by-products of the capability of space flight, the challenge to design ~~a~~ such an automaton.

Finally, we come to the very practical engineering aspects of the problem involving the parameters of storage capacities, rates of transmission, power limitations, bandwidth limitations, distances, and time, and optimization of these parameters in the problem of acquisition of knowledge.

This subject is summed very well by Lloyd Berkner in his address at the 1960 Symposium of the IRE, "Electronics out of this World." He states: "If one intercepts an occasional cosmic ray the instrument system can handle it very easily. However when one picks up a sample of rock and attempts to describe it in full scientific detail, that description can involve a great many bits of information. And, at great distances with limited power supply for transmission, such a description could take a life time." Hence, this is a situation in which the quality of the data must be maximized and the redundancy of information must be minimized to be transmitted back to earth. Given a fixed transmission distance, time of transmission of all relevant necessary data, and amount of weight for the collection of data, its reduction, synthesis, analysis, and transmission, leads to this basic problem: How does one allocate the weight among first, the experimental devices; second, the data reduction analysis and synthesis system and the transmitter coder and power supply to achieve an optimum flow of desired information about the object to be studied...For its size and weight, the most efficient computer we know is the human being, but the maintenance costs of the human computer in space inject a new factor into the efficiency computation.

Something of the order of one hundred tons in payload has been estimated for a man to do useful work on a planetary object. Therefore our problem is, given one hundred tons, what instrument system, computers, sensors, coders, transmitters can be designed to compete with the hundred tons of equipment necessary to support a man?

The Russians are also aware of the importance of this problem of developing instrument systems to replicate the activity of human intelligence. A quotation from a memorandum by C. L. Zakhartchenki, (In Space Science Board 102, p. 7, Aug. 6, 1959), "A development of an automatic device of the so-called self-organizing or perceptive type by the Institute of Automatics and Tele-mechanics is publicized. This device is presumably able to learn by experience, is capable of selective action under unspecified conditions and is designed for exploration of the lunar surface."

In summary, we must maximize the information obtained per watt of power; the information obtained per dollar expenditure. We must decide when hypothesis-derived experiments are best and when systematic search programs are best. We must decide what epistemological systems are possible - and for a given mission when, as a function of the engineering parameters, ~~we want man - a system of low accuracy and high flexibility, and when instrument-systems of low flexibility and high accuracy.~~ [which are systems]

Since we need the high flexibility systems first and there is a long delay before manned systems [the only available high flexibility systems] will be ready for space, the development of flexible decision-making instrument systems seems a matter of immediate concern. It is an aphorism of the scientific age that the future is determined by the questions we ask and the problems we undertake ~~to solve~~ [and the order in which they are ~~asked~~ approached.] -- I can only urge undertaking this problem now.

(A) Tornadoes: 1 min
(B) Thunder Storms: 10 min
(C) Hurricanes: 3 hours
(D) Cyclones: 1 day
(E) Thunder Storm Complex

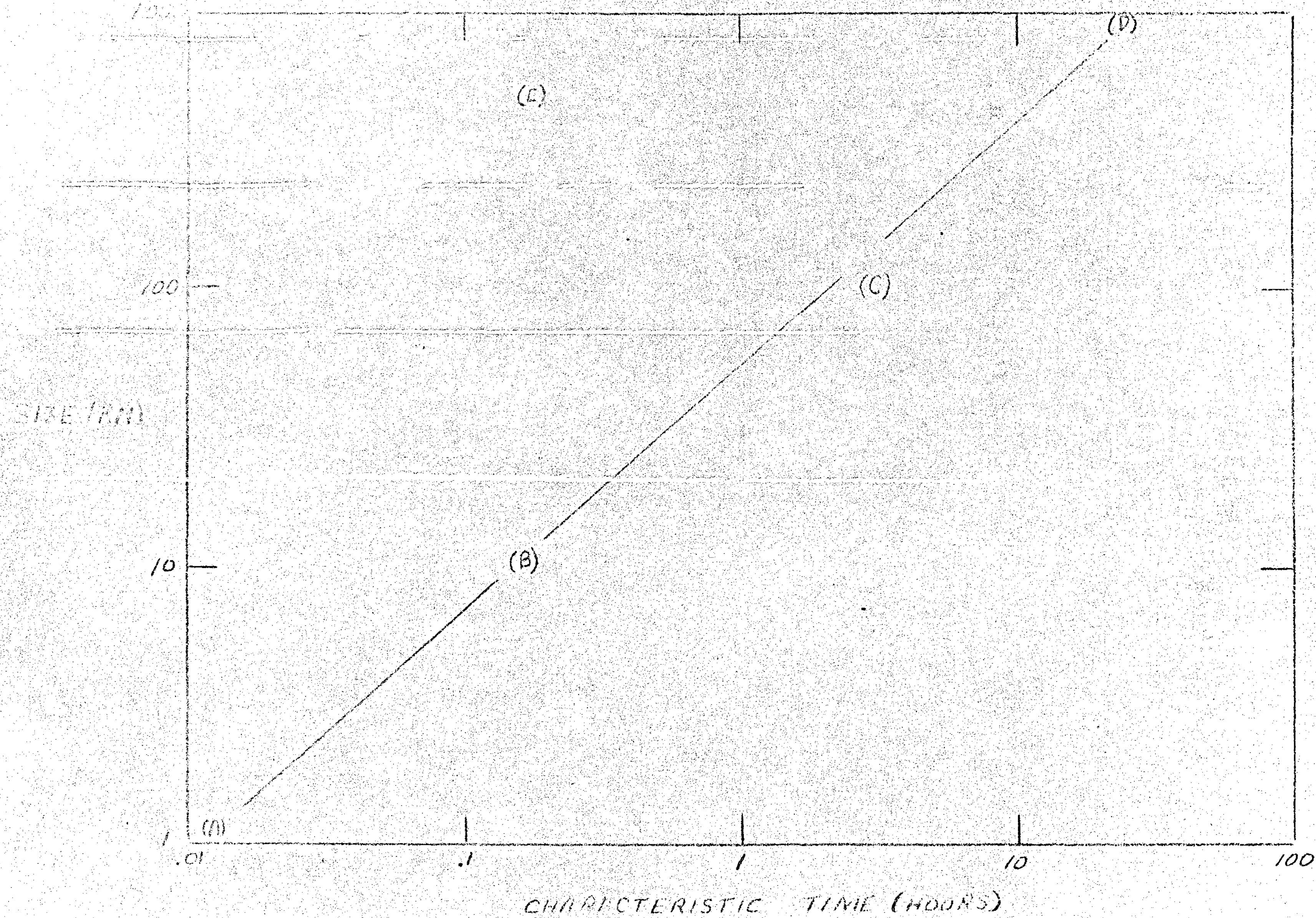

FIGURE 1

MARK I

EPISTEMOLOGICAL SYSTEM FOR SPACE EXPLORATION