# AN OUTLOOK FOR THE TWENTY FIRST CENTURY AS TO LAUNCH OPERATIONS, FACILITIES AND SYSTEMS

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Predicting the future, has many of the same hazards as translating from one language to another or trying to interpret the ambiguities within a given language. It is in the language of Damon Runyon "A mugs game, in which no self respecting shyster should be caught". I have not managed my affairs well or I would not be here. Let me plead the lamest of excuses, I am a substitute for a speaker who could not attend because of schedule conflicts.

Let me illustrate some of the problems in prediction. A teacher asked a student "How many seconds are there in a year?" The interrogator expected an answer in the millions and was puzzled when the student responded "12". He asked how the answer was derived and the student responded promptly: the second of January, the second of February; etc. The answer was "correct"; in one family of expectations, and out of order in another.

I live in the south of Texas, where the general rule is that it is sufficient to send only one ranger, if there is only one riot. Apart from "braggadocio" as to the prowess of rangers; this was a way of dealing with the vagaries of translated and delayed messages. A good illustration is the case of the ranger who was in "hot pursuit" of a young m
an who robbed a bank in Pharr, a few miles north of the border.

In due course the Ranger apprehended the young man, a few miles across the border and found himself, in the situation that he could only speak and understand English and his captive, only Spanish. He did the reasonable thing and recruited one the local men as an interpreter.

Since the "pursuit, had been hot" the young man admitted that, he had in fact, been the robber who held up the bank. The Ranger asked his name and he responded; "Jose".

The Ranger asked "Where did you hide the gold ?" and Jose did not answer. The Ranger pulled out his Colt 45 and pointed it at Jose's head and said to the interpreter "Repeat the question?". The interpreter repeated the question and Jose very softly said "I hid it in the village water well"; which the interpreter repeated to the Ranger as "Jose says he is not afraid to die!".

I tell these stories to emphasize how strongly our expectations of what will happen are influenced by our beliefs about what should happen. The stories are not "right or wrong". They reflect our prejudice about what "ought to prevail" rather than a realistic assessment as to what could, in fact, prevail.

I'll risk a few more philosophical thoughts before I give you what you came to hear. The space business is like the more important things in life: children, love and beauty; they have clearly identified costs but not so crisply identified benefits. That is important to consider because only communication satellites are economic space ventures. In the next century perhaps materials processing will be economic; it has both its believers and its sceptics. If there is a space enterprise of the scale required for the Space Exploration Initiative advocated by President Bush, then Solar Power Satellites could be economically competitive.

All the other space enterprises are undertaken by governments for some form of social good. Many are for national defense. In a sense, all space programs could be said to be motivated by the need for national security, and the belief that to be secure one must be a participant in the exploration of this new frontier.

In this context then let me outline what I see as the Outlook for the Twenty First Century.

The beginning of the next centuries activities will use the systems that have been described in the last three days of this meeting. The currently operational systems have been described here as have those that are in development and will be available by the turn of the century. Further, the perspective in the near term, is that no major new program initiative provides an order of magnitude change in requirement and no new technology development provides a real "breakthrough" opportunity.

One or two decades into the next century, the scenario could be dramatically different. The commitment to the Lunar Base and the Exploration of Mars will come, and when it does it will significantly alter the context of all space enterprises. There is also under way a major revolution in materials technology as evidenced by the work in high temperature superconductivity, metal matrix composites and exotic alloys. Many of these changes will be small but the accumulation and aggregation of these changes will have profound effects, when one assesses them after twenty or forty years. That will be even more true of the analytic tools such as computational fluid dynamics, probabilstic risk assessment, and finite element analysis as computational power continues to grow and is augmented by graphic expression and artificial intelligence "assistants" to human designers.

The launch systems with which we will enter the new century are well known to all of you.

In Europe the principal launch vehicle will be the Ariane family, the Ariane 4 and its variants in use now and the Ariane V which is in development. Hermes may be available at the turn of the century but probably a bit later. Kourou is the only launch site planned, and the infrastructure there becomes more elaborate and sophisticated as the launch rate and traffic warrant.

There does not appear to be a European entry in the small launch vehicle class unless one considers the joint venture between the Italians and LTV of the United States in upgrades for the Scout launch vehicle. It could be operated from San Marco as well as from the US sites at Wallops Island and Vandenberg.

In Japan, the NASDA H-1 is the current applications launch system but it will be augmented by the H-II vehicle toward the end of this century. These are both capable systems and the only issues they face are the environmental restrictions which limit their launch season from the Tanegashima complex because of conflicts with the fishing fleets. HOPE is an unmanned reusable system that could be a precursor to a manned system.

The ISAS uses a solid rocket motor system for its scientific probes, the M-3S-II, launched from Kagoshima. While only launched once a year, it has proven capable and reliable.

In the United States a number of programs are in progress. The Titan IV flight rate has been reduced from 10 per year to six but the operation extended to the west coast as well as the current operations from the east coast. The consequence has been a significant increase in cost per flight.

A number of Titan II retired ballistic missiles are being refurbished as space launch vehicles and will be used from Vandenberg Air Force Base to launch weather and other high inclination paylaods.

Delta II has made its upgrades in both the core stages and in the boosters, substantially enhancing its throw weight. It is not clear that it has reached the limits of its growth; a new cryogenic second stage could make it competitive with many other vehicles.

Automated Operations

As we have discussed here the last three days, the activities associated with the launch of a vehicle and its spacecraft from any of our existing facilities is a manpower intensive activity. So too is the management of our more complex facilities on orbit, particularly manned spacecraft.

The developments in artificial intelligence, data base management, data archiving and retrieval and automated operations provide great opportunities to use new technology in ways that can significantly reduce the cost and complexity of space operations while improving reliability and safety. It will take some time for these innovations to become accepted and trusted.

Let me take a different turn and propose that there are some issues that are unique and specific to the new century.

Management of the space environment is going to be one of the major issues. In space their are no "healing" forces and the duration of the consequences of many of todays decisions is measured in hundreds if not thousands of years. Some of the issues we need to begin to give serious consideration are:

Low Earth Orbit (LEO)

Small Satellites and Dense Constellations
End of Life Disposal
Critical Density`

It is quite likely that there will be a revitalization of the small satellite, small launch vehicle component of space operations activities. It will increase the cost per pound but reduce the cost per launch and increase the entrance availability to those who can muster something on the order of 20 Million $, as opposed to a minimum of 50 to 80 M $ for more conventional space launch vehicles. It should be noted that the cost per pound for such systems may be four to ten times the cost per pound of larger vehicles. Such a development could exacerbate the issues of critical density in low earth orbit and accelerate the need for end of life disposal of spacecraft and stages at the end of useful function.

In the high inclination orbits that seek sunsynchronous conditions there is also a high spatial density over the polar region and an increased risk of collision between spacecraft seeking those conditions. This is also the region that has experienced the highest incidence of inadvertent upper stage explosions. As a consequence of the spatial density over the poles, the inadvertent explosions and the relatively long life of the sunsynchronous orbits, 700 years or greater, this region is approaching a critical density ie. even if no more spacecraft or rocket bodies are left in this orbit there will be collisions among those objects already there .

Proliferation of "small sats" into this already critical region could create serious long term problems. Alternatively, timely imposition and acceptance of controls could maintain all the desirable operational attributes of these orbits for the indefinite future. The essential control is that all future participants who place objects into space will remove them at the end of their useful life. It is not an insignificant cost, but it can be minimal if addressed at the beginning of each project.

Geosynchronous orbit represents a different class of problem. Orbit lifetime is essentially indefinite and there are strongly preferred longitude locations. Since this is the one class of space systems that is strongly driven by economic imperatives the decision system is different than that for other orbital regimes. The economics both in orbital mechanics and in communications cash flow are critical to the operators of the systems and to the users. To date operators have "boosted" systems for operator convenience not for long term environmental control. In the future environmental control considerations will have to prevail. Reboost of spacecraft will not be for a few 10's of kilometers but for a few hundred; the issue will not be the convince of operation over the next ten years but the 1,000 year control of the environment.

Launch sites and their effect on the regions downrange are increasingly becoming an issue. The US has had the advantage of always launching over a large body of water, the Caribbean in the east and the Pacific in the West. Japan has used coastal launch sites, as has India; and the Ariane group selected Kourou for its favorable low latitude and downrange characteristics even though it was a substantial distance from the rest of their operations.

The USSR is experiencing increasing complaint from the down range regions of Kazackstan as to the consequences of launch vehicle overflights during the last thirty years. Similar complaints are being heard in other regions of the USSR as the freedom to complain develops.

The Peoples Republic of China has a problem similar to that of the USSR in that they have most of their launch sites are in the west of China and launch trajectory is over many of their population areas. They are sensitive to the environmental issue and the hazard to their peoples and will modify their practices as they feel that national security permits. In the meantime they have implemented a very good range safety system to minimize the hazard.

In every industry there comes a time to consider standardization. The objectives are straightforward. Standards facilitate complementary operations and data exchange, provide an environment for joint and coordinated operations and facilitate other cooperative products and operations. The time for the inilizatiaion of some standards is now.

Reliability

Launch vehicle performance has improved by a factor of 4-5 in mass to orbit for a given price in the last twenty years.

Launch vehicle reliability; ie. expectation that the payload will in fact get to orbit has improved by a factor less than 2.

An order of magnitude improvement in the reliability of launch vehicle success reduces total program cost more than an order of magnitude reduction in the cost of launch services or the cost of a pound mass to orbit.

If there is any single message in the assessment of the present launch capability and what the future requires, it is that there must be a significant change in reliability. Standards that were acceptable for ballistic missiles are and will not be acceptable for future space launch vehicles. Achievement of significantly higher levels of reliability is the challenge for the new century.