Space Science Strategy

1990–2026 A.D.

The headline to a recent news article read "NASA Focuses on Station, Faces Growing Budget Crisis" [*Covault,* 1989], which I thought summarized NASA's present and probable future succinctly. The article was unusual: it not only discussed NASA's budget options through 2000, a long time by the normal standards of these discussions, but it also pointed out that "major design decisions over the next two years will be critical to constructing a [space] station that will endure 30 years."

Imagine trying to think 30-40 years ahead in the space program to a time in the middle 2020s when the station will presumably cease to endure! As I will try to show, however, it is crucial for those of us in the space program to think ahead for those 30-40 years if we are going to interpret correctly the events already beginning to shape the program for those years and which must soon begin to have a dramatic effect on its viability.

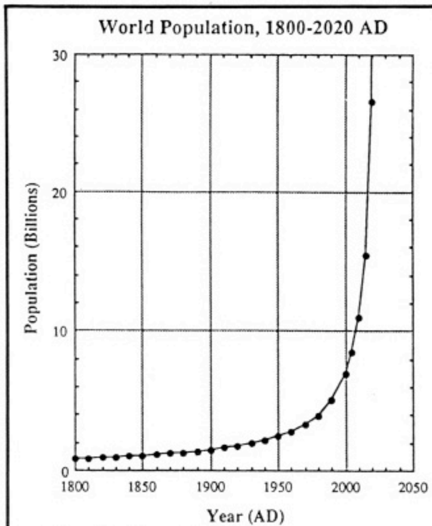
About three decades ago *von Foerster et al.* [1960] published a somewhat tongue-in-cheek article, "Doomsday: Friday, 13 November, A.D. 2026." The authors proposed the following equation as a good fit to estimates of past world population and a prediction of how population was going to grow:

$$N = \frac{1.79 \times 10^{11}}{(2026.87 - t)^{0.99}}$$

N is the world population, t is time in years from 0 A.D., and the empirical constant 2026.87 turns out to be the time in years when N goes to infinity. The date corresponding to 2026.87 is Friday, November 13, 2026 A.D.

The graph shows the variation of N graphically. We are now, in 1989, in the middle of a transition in which the relatively slow population growth, measured in billions of people, characteristic of our past is changing to a stage of much more rapid growth, with the increase of population becoming quite extraordinary over the next three decades. This is, of course, the well-known population explosion, but it is here quantified and made explicit by the equation and the graph. In most discussions the population explosion is something that will happen in the future. The graph shows that the explosion is now underway and that it will reach its conclusion, or some kind of conclusion, within the lifetimes of many readers of this letter.

There were criticisms of the growth predicted by the equation as soon as the article was published. The authors discussed and generally dismissed them in three further short communications [*von Foerster et al.,* 1961*a*, 1961*b*, 1962; see also *Robertson et al.,* 1961; *Hutton,* 1961; *Howland,* 1961; *Shinbrot,* 1961; *Coale,* 1961; and *Dorn,* 1962].



Graph of world population plotted against year for the time interval 1800-2020 A.D. according to the equation of *von Foerster et al.* [1960]. Population numbers are shown every 10 years up to 2000 A.D. and every 5 years thereafter. Current estimates of world population are slightly higher than the 1989 population implied by the data used for the graph.

We are now in a much better position to judge the validity of the equation because we have almost 30 years more data. It is significant that world population figures not only have conformed with those predicted by the equation through 1975 [*Serrin,* 1975] but that the equation today predicts a population of 4.9 billion for epoch 1989.0, which is in close agreement with the 5.2 billion currently estimated. It is also predicted that the population will grow to 6.3 billion by 2000, which is close to the 6.9.billion predicted by the equation.

Thus, although the population growth curve appears extreme, it satisfies two old-fashioned scientific criteria: First, it agrees with earlier data, namely population estimates for the years before the equation was published. Second, it has provided reasonably accurate predictions since then. It is also consistent with current estimates of population through 2000, after which the population predicted by the equation begins to exceed substantially the current estimates. Current estimates always involve assumptions about declining birth rates that, in retrospect, have always been too optimistic.

As we all surely know, world population can never go to infinity, so I have shown growth only through 2020 in the graph. It is likely that limitations to population growth will begin to exert themselves well before that time. However, the large and unprecedented increases over the next three decades will have an extraordinary influence on every aspect of our lives.

The coming population explosion has serious implications for space science. Over the next ten years alone another one billion people will be added to the world, equivalent to adding the present population of China, the world's most populous country. Although the natural rate of population growth in the U.S. is relatively moderate, as in most developed countries, there will be increasing pressure on U.S. population from "reunification of families" (the goal of present U.S. immigration policy), large numbers of refugees and asylum seekers, and unidentified millions streaming across our borders.

Depletion of resources in the U.S. will move to a new high, just as it will globally. Prices of oil, wood, food and water, those once relatively inexpensive staples of the U.S. way of life, will rise to keep supply and demand in balance.

In this context it will become increasingly difficult to obtain money for any science that does not provide some immediate and preferably highly visible form of support for our burgeoning population and for its standard of living. Administrations and Congresses, facing extraordinary interest charges on the national debt due to the chronic and apparently uncontrollable deficit, will refer increasingly to "budget realities" as they struggle to apportion whatever discretionary funds are available between projects involving science and those designed to relieve the homeless, the starving, and the poverty-striken. It seems likely that in the longer term the only strong support we can expect for space science in general and the Space Station in particular will come from their "Mission to Planet Earth" capability [*Ride,* 1987].

Although the goal of Mission to Planet Earth is to "use the perspective afforded from space to study and characterize our home planet on global scale," it is only a short step to using the characterizations of our planet to explore for new resources and manage present resources. California, one of the fastest growing states, is in its third year of drought, despite average rainfall this year; the U.S. as a whole is overdrawing its easily available water supplies. Observations from space that could help characterize water supplies in California and the U.S. and thus help in allocating water resources should be relatively immune from congressional budget cuts. Also immune should be observations and measurements with a potential for reducing the depletion of our oil reserves, enhancing food supplies and monitoring the continuing degradation of our environment.

These monitoring activities, and others I have not detailed, could bring enough overall support for space science to provide a base for more exploratory activites in space. Certainly, if they bring support for the Space Station, there is a chance for the two other bold initiatives for manned exploration described in the Ride report and favored by the present administration [*Lemonick,* 1989; *Bush,* 1989]: the establishment of an outpost on the Moon, and a program to send astronauts to land on Mars.

More support will surely be forthcoming if the initiatives are internationalized by making them joint efforts with the Soviet Union, Europe and Japan, each of which has independently developed great capability in space. In the long run, however, all the other nations with a capability in space will also be adversely affected by the rapid growth of the world's population, decline of resources, and resulting political instability. To my thinking, time is short for bold initiatives in space exploration, and we may have to live with the fact that there will be no more great steps for mankind.

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