

## AGRIBUSINESS AND SPACE – NO LIMITS TO GROWTH

by

Oscar L. Montgomery\*  
Alabama A&M University  
Normal, Alabama 35762

and

Charles T. N. Paludan  
The University of Tennessee Space Institute  
Tullahoma, Tennessee 37388

### ABSTRACT

As with most other human endeavors related to resources, agriculture has continued to ride an exponential growth curve. Expanding population and increasing demand for better diets have required the growth, and technological innovations have provided the ability to utilize available arable land more efficiently. With several notable exceptions, the response to food needs has been met by individual and commercial interests: agribusiness. Commercial applications of research have provided much of the innovation.

The World Food Problem, once considered mankind's highest priority problem, is still with us. It has become increasingly evident, however, that the problem is not presently primarily related to a shortfall of total global production. If research-driven innovation declined prior to a reduction in global population growth rate, production would become the key issue. Currently, the food problem occurs in many regions due to war, political strife, unbalanced economic conditions, unanticipated weather shifts, and lack of education and adequate communications.

Agribusiness technology has become more space-related in recent years. Although crops forecasting and improvements in yield ("the green revolution") were developed prior to the space era, it would be unthinkable today to ignore the contributions of operational meteorological and communications satellites and experimental Earth observation satellites in agribusiness. Space-driven communications now permit national agribusiness database management networks, with a significant portion of the data being space-derived. In demonstration experiments, space communications have already been shown to improve those aspects of the food problem related to education and communications.

The higher cost of energy has already had some effect on agribusiness, and this factor will require further research and fine-tuning in the near future. Space-driven energy research is of direct concern to agribusiness. Energy cost tracking is now another factor in the agribusiness computer models in use.

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\*Paper presented by Oscar L. Montgomery.

## I. AGRICULTURAL ADVANCES

Agriculture is about 10,000 years old, yet the beneficial effect that it has had on mankind and civilization is several order of magnitude greater than the use of fire or other major pre-agriculture human innovations.

Agricultural production in the United States of America has been the greatest farming industry in the world. Since 1940 Agriculture has continued to increase exponentially at an annual percentage rate of 1.3. Past experience clearly demonstrates that U.S. Agriculture is a dynamic industry utilizing new technology in its production and processing, marketing and innovating product lines. The achievements in agribusiness are phenomenal. Plant breeding has brought us improved plant varieties such as the hybrid corn and dwarf wheat; improvements in photosynthetic efficiency, nitrogen fixation and use, multiple cropping systems, protoplasmic hybrids while adding emphasis to neglected but regionally imported crops. Soil research has brought improvement in the conservation, preservation and management of soils, thus leading to the expansion of crop average at a higher cost level, and better management of tropical soils as well as increased efficiency in the use of water and fertilizers. In animal research, the knowledge of nutritionally balanced diets for livestock and poultry increased productivity significantly. Research-based technology has led us to expand the use of chemistry in agriculture, leading to the development of families of agricultural chemicals that are making it possible for farmers to control insects and diseases and maintain soil fertility.

Agricultural research has resulted in developments in agriculture products which are in part satisfying the demands for improved human diets, particularly for our neighbors in developing countries.

People need both quantity (calories) and quality (proteins, vitamins, and minerals) in their daily food intake. During the decade between 1970 and 1980 world food production kept pace with population growth in some years but not in others. At the start of 1984, approximately 400 million people were starving. One out of every three people in the world today lives in a country that cannot produce enough food or afford to buy enough from another nation to feed itself. Nearly 70 percent of these people live in the four countries of India, Bangladesh, Pakistan, and Indonesia, with the rest in Africa and Latin America.

Agricultural research and education are probing new thresholds in areas such as genetic engineering and biotechnological innovations that touch on nearly every aspect of our food and fiber system. This kind of research moves us ever closer than the realization of the second green revolution.

Just as for all great industries, agriculture must accommodate changing conditions. In anticipation of these changes U.S. Agribusiness must build new developments into the basic structure of the agribusiness industry so as to retain its productive capacity and competitive position in the world market place.

## II. THE WORLD FOOD PROBLEM IN PERSPECTIVE

When the space program was still awaiting the first orbital missions dedicated to study of the Earth's resources — in the mid-1960's — one factor often quoted was the World Food Problem. Rarely was energy mentioned as a problem. One book of that period was even

entitled, Famine—1975! [1]. The President's Science Advisory Committee produced a 3-volume report of over a thousand pages in 1967: The World Food Problem [2]. One prominent author proposed an adaptation of the military battlefield policy of "triage", whereby food aid would be denied certain nations with "hopeless" famine conditions. The State Department's Agency for International Development titled its monthly publication War On Hunger (later renamed Agenda, and now Horizons). There is little question that hunger remains a major problem on a global basis, and although still argued by U.S. political figures, it remains a problem for certain groups even in this nation of monumental food surpluses.

The model suggested by the last comment is perhaps closer to the global reality than most politicians would be willing to admit. The model, represented quite well in this state and this region, is one of sufficient food supply, but of severe problems in distribution. Those who blame hunger on overpopulation should observe that the undernourished regions of this state are also those with declining populations and population densities.

Placing the blame on population has been popular since the publication of a treatise on population by Thomas Malthus in 1798. Malthus altered his views later, but the Neo-Malthusian view has revived the pessimism, especially in such studies as those sponsored by the Club of Rome (The Limits to Growth [3], and World Dynamics [4]) and the Carter administration (Global 2000 [5]). We do not wish to imply that overpopulation is not a problem, we applaud the efforts of medical science and groups such as Planned Parenthood whereby all newborn persons are lovingly welcomed and provided with adequate necessities. However, we do say that overpopulation is not usually the main cause of resource shortfall. We note that the hunger problems occur because of unbalanced economic conditions (in both Marxist and non-Marxist nations), political strife (especially war), locally unanticipated weather shifts, and lack of education and adequate communications. The Malthusian concept would become meaningless if the concepts of the High Frontier were actively pursued [6], but we agree with Kah, et al. [7], that even the colonization of space is not necessary to balance the resource budget. The balance has been achieved in many fortunate areas, and could be achieved everywhere, by the proper attention to advanced technology, especially that which is space-driven.

The Gompertz Curve, shown in Figure 1, is applicable for growth of populations, resource development, technological advance, and many other parameters. For population and technological advance, we are certainly on the cubic increase portion. As Herman Kahn said, forecasting is a matter of predicting where the curve will inflect [8, p. 56]. The doomsayers believe the population will not inflect until disaster by depletion of some resource strikes. Kahn believed that the U.S. bicentennial year, 1976, was at the midpoint of a 400 year cycle, so that the next 200 years would be devoted to assuring a comfortable life of plenty for all the world.

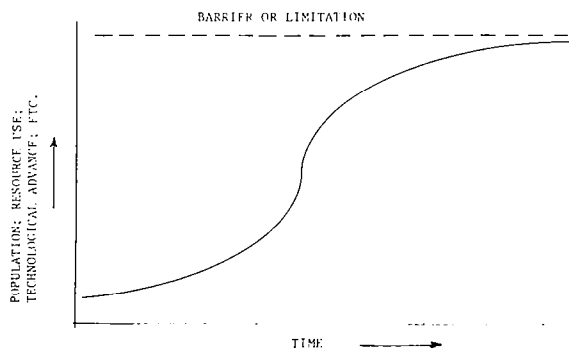


Figure 1. The Gompertz Curve.

Kahn's optimism was confirmed by Julian Simon in his book, The Ultimate Resource. The ultimate resource is the human mind, utilizing the technological ingenuity of mankind [9]. Simon, an economist, bases some of his optimism on commodity market trends. Simon and Kahn have collaborated on a rebuttal of Global 2000 called Global 2000 Revised [10].

The modern rebuttal to the Malthusism prophesy is the potential for agricultural technology for greater yields, that is, for growing more food on each acre of land under cultivation. The green revolution did not solve the problem of world food supply; rather it demonstrated an approach to a solution, a method. That method can only be successful only if it is continuously applied to crop improvement. The technological dependence of the agribusiness industry increases with increased demands for food and fibre.

Not only is the agribusiness industry dependent on advances in biotechnology, it is double dependent on advances in space technology.

Space technology must provide the agribusiness industry with the space laboratories in which to develop new crop strains new hybrids; improved information systems for world-wide management of agricultural production and distribution, and crop forecasting.

### III. DEPENDENCE ON TECHNOLOGICAL ADVANCE

The advance of agriculture has come from several technological advances. Increasing mechanization – improvements in the steel plow, the McCormick reaper (1834), and other later machines, steam, gasoline, diesel, and electric engines – made farming more efficient labor-wise, but was not necessary of the increase in food production, given the general labor surplus. There was the factor of release of land needed to feed draft animals, estimated to have been about 80 million acres (32 million hectares) in the U.S. in the peak year of 1919 when there were 21 million horses and mules [11, p. 33]. Production increase came from increases in yield per unit area. Both of these factors were difficult to achieve, once a certain point was reached, but both have proved to be positively affected by technology. We examine both.

Historically, as long as humanity had not yet expanded agriculture onto all arable and grazing land; i.e., all land with sufficient or suitable fertility, water, topography, texture, and climate; increased production was achieved by increasing farm area. In most regions of the world, this limit has been reached, although new plant varieties may permit further expansion onto marginal lands. Aridity is the most widespread limitation on crop production. Irrigation has been used to counter this, and can be expected to continue, especially as new tools assist in construction, new materials improve irrigation equipment (plastic pipe, etc.), and new inventions improve efficiency (center-pivot spray irrigation, trickle feeders). The major limit is the availability of fresh water. A technological advance in sea water desalinization or in transport of sea ice could be a future factor. Areas too cold may occasionally yield to new varieties, as in the examples of grain crops in Canada's Peace River Valley, and the USSR's virgin lands experiments. Wet tropics may accommodate more crops, if certain crops, such as rice, are encouraged; the main barriers are economic and political factors, plus the need to communicate with local and owners and farmers. Remote sensing and a comprehensive data network could go far in optimizing the use of arable and grazing land relative to shipments to areas of demand; i.e., a better balance of supply and demand.

Increase in yield per unit area can result from several technological advances. Supplemental irrigation is currently becoming more prevalent in the eastern U.S. as a yield-increasing technique. Natural and manufactured fertilizers improve yields for crops on lands with adequate water. Chemical and mechanical controls for insects, diseases, and weeds can increase yield, and

for this reason over 10,000 aircraft are used in the U.S. for "ag-air" applications of insecticides, herbicides, fertilizers, seed, and other materials. This billion dollar agribusiness has at least one computerized information service (operated by Econ, Inc., Princeton, NJ\*).

The most publicized yield-increasing technology is that of the "Green Revolution," for which Norman Borlaug, a plant pathologist, won the Nobel Prize for his work in developing high-yield wheat. To date, this has been primarily a result of careful breeding of hybrid varieties of certain important crops and livestock. Lurking on the technological horizon are the potentials of the new biotechnology and gene splicing. The latter technology is also potentially dangerous; a better task for an isolated and quarantined space laboratory cannot be imagined. The potential benefits of plant genetic engineering are worth some risk; think of the possibility of having non-legumes capable of fixing atmospheric nitrogen, even in hostile environments, for example. The new biotechnology has been called the Second Green Revolution, but it also involves livestock animals.

#### IV. SPACE RELATED AGRICULTURAL RESEARCH

##### A. Remote Sensing

The recent development in computer and space technologies and the subsequent marriage of the two gave birth to a new technology – remote sensing.

The recent development of satellites carrying earth-observational sensor systems has made available enormous quantities of photographic and other forms of data about the surface of the Earth, data which have a great potential for helping to solve many human problems: for relieving critical food shortages; for monitoring and controlling environmental pollution; for augmenting shrinking supplies of natural resources; and for planning the orderly growth of cities. In view of these needs, these satellite data are of great human value, provided they can be reduced to useful information both quickly and economically. Modern, high-speed digital computers are well suited to this data-reduction task, and the synthesis of computer technology with the new observations systems has already revolutionized our ability to obtain accurate and current information about the world we live in.

##### B. Computers, Networks, Software, Math Models

It would be unthinkable today to ignore the impact of computer technology on farm management practices. More than 65,000 farmers in this country are already using computers in every facet of farm management and production.

A recent article in a business newspaper [12] stated that 5% of all U.S. farmers now own computers, but this will rise to 45% by 1986. In a report released in March 1983, one market research firm predicted sales of 94,000 microcomputers to farmers by 1987, a value of \$428 million (including software). Any current issue of a farm magazine will contain several advertisements for computers and farm-oriented software. There is a computer magazine for farmers: AgriComp. Perhaps of even greater importance are the several database networks which can feed vital information into the farm computers or even dumb terminals. These include "Agritext," a service of Harris Electronic News in Hutchinson, Kansas; "Agnnet," run by the University of Nebraska; and "AgriStar," offered by AgriData Resources, Inc., of Milwaukee, Wisconsin, and actively marketed by Tandy Corporation's 5,000 Radio Shack stores, dealers, and computer

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centers. Agnet offers about 200 programs and information services such as crop reports and market prices. Agritext includes 24 hour-per-day agricultural news and other information, such as weather, commodity prices, and market trends. AgriStar is a full two-way communications system, with a comprehensive information service (worldwide agriculture-related weather, commodity prices, agricultural news), an electronic mails system, a catalog "yellow pages" and ordering system, in-depth crop and livestock analysis reports (including specific marketing recommendations), chart displays, several advisory services, an online farm management time-sharing software system which permits modeling, analysis, and forecasting, several commercial and noncommercial library services, and an encyclopedia [13].

These agribusiness database and communications networks are recent entries into the marketplace. Although the Purdue Larsys system has been online for many years, it has been intended for other research stations, not individual farms. AgriStar began service in 1982, but many of its features did not go online until mid-1983. Since this essential market tool was not available, agricultural data from land observation satellites could not be marketed to its most important customers. Instead, it trickled down through federal and state agriculture departments and the research-oriented universities. We recognize that all Earth resources satellite data to date has come from experimental, not operational, satellites. In fact, various technical problems have recently served to remind us that no one has yet made a commitment to provide uninterrupted data. This will soon change, as we have heard in earlier papers at this symposium. We predict that the U.S. agribusiness data base networks will become early and large retailers of satellite data. We also are confident that the global agricultural systems will not be far behind, especially in view of the expected further expansion of communications innovations, such as Intelsat's "Vista," announced in December. We note the beginnings, in 1982 of an international "World Center for Computers and Human Resources" in Paris [14].

### C. Global and Local Communication Improvements

Earlier in this symposium, we had a session on communications from the viewpoint of space commercialization. Now we wish to direct your attention to some of the effects this will have on agriculture and rural development.

We have mentioned the agribusiness data base and communications networks with respect to the inputs, outputs, and output devices (computers and dumb terminals). However, we have not yet discussed the essential linkage, because the U.S. and other developed nations have rather adequate telephone systems. The usual mode is to call a local or toll-free number (or have the computer do it) and use a direct or acoustically-coupled modem for digital data transfer (simplex or duplex). The legal and technical questions about misusing lines leased for voice communication seems to be on the back burner, at least for "personal" computer usage. It is recognized that the frequency response of the ordinary telephone circuit produces some limitations. Professional computer linkages usually consist of higher quality, higher lease cost, lines and microwave relays. A whole new industry, exemplified by Satellite Business Systems, Corp., McLean, VA (SBS), has begun to attack this problem. Their system, which includes direct transmission/reception via small-dish earth stations, is satellite-dependent. Another technological approach being implemented in several cities and along the U.S. East Coast is the optical fiber method. Recognition of the future need for improved linkage has led to certain steps toward the Integrated Services Digital Network (ISDN) by AT&T and GTE in the U.S., British Telecon, Nippon Telegraph and Telephone Public Corp., Thomson-CSF (France) and others, including Germany and Israel [15].

This still leaves a problem for remote rural areas, where an individual farmer or even farm village cannot afford the SBS-type linkage. There are several high-technology solutions suggested for the near future. One is the previously-mentioned good will gesture of Intelsat with their offering of low-cost Vista service to small isolated places by means of satellites and small earth stations. Another is the short-range radio linkage method. Two companies either already offer or propose to offer equipment for this: General Electric's "Personal Radio Communications System" (PRCS), which is intended for voice communications over a 3 to 5 mile range (more with extra repeaters); and Motorola's PCX (Trade Mark) portable digital two-way keyboard/display radio system. A satellite-based two-way digital communications/location/database system has been proposed by Gerard K. O'Neill [16]. It is called the Geostar Satellite System, and includes a pocket-sized keyboard/display, 3 satellites, and a computer center/earth station at Princeton, NJ. Finally, we are beginning to see the new cellular mobile telephone systems in Chicago, and will soon see them in other urban areas. Technologically, it should be possible to place the cellular transceivers in remote rural areas. Perhaps a combination of several of these technologies will prove to be the next step in agribusiness communications.

There have been a number of experimental demonstrations of one-way educational communications to remote areas. These include the ATS-6 television transmissions to remote villages in India. Both Canada and the USSR have operational satellite television transmissions to remote regions in their own nations. Both of these feature a large percentage of instructional material, such as news of agricultural situations and advancements.

Just as the "POT" (plain old telephone) can often substitute for more exotic communication devices, the mail and commercial delivery services can sometimes deliver documents adequately. This was, in fact, necessary for use of Control Data Corporation's (CDC) development-related data base system, DEVELOP. Originally in 1978, DEVELOP was intended to be a two-way online system, utilizing existing telephone linkages. However, poor quality connections, operator intervention, and electrical problems in developing nations forced CDC to operate it, in part, as a mail-in/mail-out search and information service [17].

#### D. Energy Research Related to Agriculture

American (U.S. and Canada) agricultural production is the highest in the world. It is generally acknowledged that this stems, in part, from the American farming practice of energy usage. For that reason, the high rise of fuel costs beginning in 1973 had a marked effect on farm profits and prices; and there was fear that the energy price trends would lead to lower American agricultural production and an eventual disaster in world food supply.

Fortunately, the multipronged approaches to the energy problem have paid off. The conservation approach has not only alleviated shortages, it has also reduced prices. In U.S. agriculture there was a 17 percent drop in energy use per unit of agricultural output from 1974 to 1980. In part, this was due to a shift from gasoline to diesel engines in farm equipment. The U.S. farm usage of the two fuels in 1974 was 3.7 billion gallons of gasoline and 2.6 billion gallons of diesel fuel. In 1980, the respective figures were 2.9 and 3.2, a reversal toward the more-efficient diesel engines. Total farm usage is down. Using figures for the total gallons of gasoline and diesel fuels, 1978 farm consumption was 6.8 billion, 1982 was 5.4 billion, and 1983 was estimated to be around 4.6 to 4.9 billion. Both fuels have also declined in dollar cost, although it must be admitted that electricity, LP gas, and natural gas prices were still climbing, in part due to deregulation [18].

The success of the energy conservation approach in the U.S. does not solve the long range agricultural energy problem, especially in energy-poor (non-OPEC) developing nations. Other prongs point toward cheaper and more abundant energy sources and alternate energy conversion and transmission techniques. First, the fossil fuels themselves may not be in short supply as the doomsayers predicted, given the market price adjustment which encouraged new exploration and new extraction methods. As we have heard earlier today from the Geosat Committee, orbital remote sensing makes important contributions to exploration. The space program has spurred development of solar-electric conversion and fuel cell technology. Ultimately, solar power is always waiting in the wings to save us if all other energy sources become too depleted. Combined with the "hydrogen economy," it or nuclear power could provide inexhaustible energy, just as it already does in the form of fossil fuels, photosynthesis of plants, and production of methyl alcohol.

Nuclear power research continues to progress, in spite of mostly-unjustified sensational no-sayers. Fusion research looks particularly promising for the next decade. Nuclear power can be delivered as electricity, or, if portable energy is required for vehicles, tractors, etc., hydrogen could be efficient transfer medium. Do we need to remind this audience where the techniques for use of hydrogen are being applied now?

Coal is quite abundant world-wide, and especially in the U.S. Unlike nuclear power, however, it is quite hazardous to health as presently used. Emphasis in research has concentrated on efficiency, pollution control, and exploitation with minimum ground disturbance. New techniques related to coal are magnetohydrodynamics and underground gassification.

We agree with Simon [9], Stine [8], and Kahn [19] that abundant cheap energy is a key factor in future human well-being, and that it is well justified to expect it. We expect space research to drive the technology for abundant energy commercialization.

## V. THE HOPEFUL FUTURE

At an October 1983 ceremony marking the 25th anniversary of NASA, President Reagan spoke of a "high road" for space policy. In the January 1984 State of the Union address, he added a detail, the space station. These policy decisions reflect an optimism and a reliance on the ability of technological innovation to overcome resource problems.

We have outlined an optimistic approach to the application of space technology for agricultural resources.

During an international symposium in 1955, Anthropologist Sol Tax read a poem composed by Kenneth Boulding [20]. It summarizes our feelings and is quoted here:



## A CONSERVATIONIST'S LAMENT

The world is finite, resources are scarce,  
Things are bad and will be worse.  
Coal is burned and gas exploded,  
Forests cut and soils eroded.  
Wells are dry and air's polluted,  
Dust is blowing, trees uprooted.  
Oil is going, ores depleted,  
Drains receive what is excreted.  
Land is sinking, seas are rising,  
Man is far too enterprising.  
Fire will rage with Man to fan it,  
Soon we'll have a plundered planet.  
People breed like fertile rabbits,  
People have disgusting habits.

Morale:

The evolutionary plan  
Went astray by evolving Man.

## THE TECHNOLOGIST'S REPLY

Man's potential is quite terrific,  
You can't go back to the Neolithic.  
The cream is there for us to skim it,  
Knowledge is power, and the sky's the limit.  
Every mouth has hands to feed it,  
Food is found when people need it.  
All we need is found in granite  
Once we have the men to plan it.  
Yeast and algae give us meat,  
Soil is almost obsolete.  
Men can grow to pastures greener  
Till all the earth is Pasadena.

Morale:

Man's a nuisance, Man's a crackpot,  
But only Man can hit the jackpot.

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