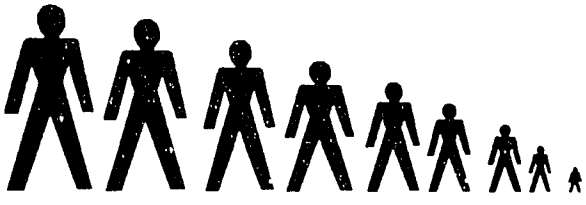
-PN-ABR-921 ISN 89169

ACEC

RESEARCH & MANAGEMENT FOUNDATION

Engineering at AID

Less Is Not More



DRAFT

A NONPROFIT FOUNDATION ESTABLISHED BY THE AMERICAN CONSULTING ENGINEERS COUNCIL

Preface

Engineering plays an important role in many of the projects funded by the Agency for International Development (AID). The more successful programs and projects have had the benefit of sound technical judgment and guidance from engineers within AID. Where this guidance was weak, projects have often failed to achieve their objectives. This hurts U.S. prestige and does little to support growth and self sufficiency in developing countries. What is the optimal engineering input into the future AID programs? What is the needed capability?

In November 1989 at the request of the Agency for International Development, under the direction of the Coordinating Group for Improving Agency Operations and Efficiency, the ACEC Research & Management Foundation undertook a study of AID's engineering capabilities. The foundation, which is the public-service arm of the American Consulting Engineering Council (ACEC), was asked to examine these capabilities and to make recommendations for their development over the next decade.

The study was based on interviews with present and former AID employees, advice from members of the ACEC International Engineering Committee, and Congressional and AID documents.

Contents

Changes in AID's Mission 1
Unrecognized Engineering Needs 3
Engineering in AID Today 5
Inadequate Engineering Oversight 7
Engineering Requirements 9
Engineering Workload 11
Number of AID Engineers Needed 13
Engineering Recruitment and Advancement 15
Recommendations 18

Changes in AID's Mission

Loss of Needed Engineering Oversight

Following World War II, the United States took the lead in international economic assistance. From AID's inception, capital projects—infrastructure—played a major role in the U.S. foreign aid program. Infrastructure had been an important precondition to economic growth in the renewal of war-torn Europe and Japan in the 1940s and 1950s. AID applied this lesson to less-developed countries (LDCs) as well.

Throughout the 1950s and into the 1960s, AID (and its predecessor agencies) successfully completed many engineering projects. Thousands of engineers and technicians from developing countries were trained in the United States and returned to become the managerial and technical core upon which their countries have come to rely. In developing countries such individuals are a precious resource.

It became increasingly evident, however, that attaining sustained economic growth was no easy task. What had been seen as negligible factors were in fact seriously compromising the usefulness of many AID initiatives. These factors included price policy (subsidization of poorly performing organizations and inadequate attention to making operations self-sustaining); lack of career patterns, incentives, and opportunities in LDC institutions to retain needed personnel; poor choices of technology; and inadequate preparation of recipients to manage and operate completed projects—e.g., power plants, water treatment and wastewater plants, road systems.

Thus Congress in the 1970s turned away from industrialization and high-tech infrastructure—which were also seen as benefiting the urban rich at the expense of the rural and urban poor—toward efforts to improve agriculture, the backbone of most LDCs. Today, AID's mission also includes basic human needs (BHNs), the provision of primary health care, food production, and educational systems.

Currently, aside from the very large AID programs—primarily in Egypt and Pakistan—capital projects have become rare

Administrator IDI
Agricultural Division Officer (2)
Agricultural Economist
Agricultural Engineer
AID Representative
Associate Mission Director (2)
Budget/Accounting Analyst
Civil Engineer (2)
Deputy Director Program Operation
Deputy Mission Director (3)
Director Energy Office
Director Housing/Urban Development
Division Coordinating Officer
Division Officer Agriculture
Engineering Officer (2)
Engineering Officer Eltrl/Eltrs
Engineering Officer Environmental (2)
Engineering Officer HYD/WRS (2)
Engineering Officer Transportation
Environmental Engineer
Health Science Specialist
Housing Guaranty Specialist
Housing Urban Development Officer
Industrial Engineer
Inspector
International Trade Specialist
Mission Director
Officer Food for Peace Program
Physical Science Administrator
Physical Scientist (2)
Private Enterprise Officer
Program Analyst
Program Officer (2)
Project Development Officer (9)
Project Supervisor Division Office
Regional Director
Science Technology Officer
Special Projects Officer (2)
Supervising Contract Specialist
Supervising Engineering Officer (13)
Supervising Inspector
Supervisor Agricultural Division Office (2)
Supervisor Executive Office (2)
Supervisor General Development Office (2)
Supervisor General Division Office
Supervisor General Project Office
Supervisor International Trade
Supervisor Private Enterprise Office
Supervisor Project Development Office (3)
Supervisor Regional Division Office
Supervisor Sanitary Engineer
Supervisor Special Projects
Supervisory Agricultural Development Officer

Table I. Where the engineers are in AID. Positions held by AID employees with engineering degrees.

components of the AID program. While most countries continue to require a variety of infrastructure assistance, financing of these projects has passed to other organizations, e.g., the multilateral development banks, bilateral assistance and capital transfer (lending and grant) programs of Japan, Germany, France, Canada, and increasingly, the European Economic Community.

AID's shift away from infrastructure has had numerous benefits for the United States and the countries that AID serves. However, the baby was thrown out with the bath water. The AID engineering staff was equated with capital projects. As the shift occurred, AID's engineering staff shrank and was downgraded in AID's management structure.

As this attrition took place, some engineers moved to other backstop codes and today occupy senior roles in the field and Washington (Table 1). However, as managers they are not in a position to provide engineering advice or project inspection or oversight. For the most part, they also cannot serve as mentors, since they and the engineering component is spread so thin. This relationship, which is as important in engineering as in other fields, provides an important degree of continuity. It is not happening in AID. Thus, new talent does not enjoy a primary, needed relationship.

The graying of the agency has also reduced AID's engineering resources through retirement. While some retirees have been rehired on personnel service contracts at the mission level, this approach does little to restore or build capacity within the AID organization.

The balance of policy and execution is always delicate, as is central (engineering) versus decentralized. What is optimal depends on the total organizational structure, e.g. matrix versus departmental. Since organizations are usually a mix of these structures, management must strike the balance. Too much either way impedes the other. However, as important as engineering is as an input, there is no designated high-level input of this resource into AID policy. Further, AID engineering contacts with the private sector have been reduced to informal contacts only. No mechanism exists for formal liaison with the major professional constituency organizations.

Unrecognized Engineering Needs

Engineering Serves Basic Human Needs

Engineering remains a significant if unrecognized element of many AID projects. The full extent of AID's engineering responsibilities can be disguised by the names of AID's program categories. Consider:

- "Agriculture" and "rural development" for the most part mean irrigation projects, farming systems, and decentralized host government assistance (similar to the county farm agent in the United States), all of which require a variety of buildings and transportation development. Civil and construction engineers as well as hydrologists and agricultural engineers are needed for projects, technical assistance, and institution building.

- "Health," "population control," "AIDS and disease prevention and control" efforts, and "child survival" depend on improved health delivery measures such as potable water and better sanitation facilities. Civil, mechanical, electrical, water resource, and sanitary engineers are needed for facilities planning and design, and, more important, for training local people how to operate and maintain facilities.

- "Education and human resource development" implies increased literacy and other programs that need facilities and equipment for people and for communications, e.g., microwave telephone/TV towers and stations. Structural, civil, and electronics engineers are needed to develop concepts, analyze designs, and monitor construction as well as provide technical assistance for building ongoing capability to establish and operate educational institutions.

- "Environmental and energy" projects require specialized engineering resources. Toxic and hazardous waste cleanup technologies, solid waste disposal, and the like are purviews of chemical, mechanical, civil, and electrical engineers as well as hydrologists, chemists, biologists, and related disciplines. Resource allocation and selection of

technologies is of prime importance. Project management—increasingly an "engineering" service—is critical and often means the difference between success and failure.

- "PL 480, Title II," primarily the transfer of surplus American agriculture goods to over 100 countries, requires transfer facilities, equipment, logistical planning, and other engineering support. Observers of U.S. food aid in emergency situations have commented on the inability to deliver food to points of need because of inadequate road systems and logistical arrangements.

From this listing it can be seen that projects with significant engineering components are spread among many AID programs. In any organization as big and geographically dispersed as AID, the cross communication among programs, regions, and countries is less than optimal. Thus, projects that may have similar engineering needs—e.g., irrigation—do not benefit from engineering expertise applied in different countries. These many locations and smaller-sized projects make it difficult for the few engineers remaining on AID's staff to provide needed engineering review or to ensure that available engineering advice is heeded.

AID engineers are also required by the Foreign Assistance Act to protect U.S. interests in large-scale projects when working with other international agencies. In addition, AID engineers are needed to work with U.S. agencies such as the Tennessee Valley Authority, Bonneville Power Authority, the Bureau of Reclamation, and others who provide managers and technical assistance to AID. Use of AID's limited engineering staff for this work further reduces needed monitoring of U.S. foreign assistance.

Access and Feeder Roads
Agricultural Infrastructure Development
Agricultural Marketing Development
American University of Les Cayes
Amman-Na'ur-Dead Sea Road
Basic Rural Health
Boys Town - Jerusalem, Israel
Cuttington University College
Emergency Rehabilitation
Farming Systems Research
Hospital St. Croix, Leogane, Haiti
Housing and Urban Development
Industrial Production - Gypsum
Kimbanguist Hospital Assistance
Kordofan Rainfed Agriculture
O.M.V.S. Groundwater Monitoring Project
On-Farm Water Management
Potable Water and Environmental Sanitation
Rural Health Support
Secondary Roads Development
Shaba Refugee Water Supply
Small Rrual Water Systems
South Pacific Commission Multi-Project Support
Strengthening Health Planning Capacity
The American British Cowdray Hospital
Xavier High School

Table II. A sample of the 312 1989 AID projects containing an engineering component.

Engineering Requirements In AID Today

AID's direct-hire engineering staff is required to certify the soundness of major AID-financed engineering projects. More broadly, the many AID projects with technical components demand engineering oversight to reduce potential waste, fraud, and abuse in AID's far-flung assistance activities.

One indication of the magnitude of engineering in AID's work is the size of the AID contracts with engineering firms to design AID projects. AID's report of contracts in effect for FY 1987 shows 25 engineering design contracts totaling over $131 million. This amount of design activity in turn multiplies many times over in terms of the value of the constructed projects being designed.

A more comprehensive picture of AID's engineering component emerges from a review of the broad sweep of AID's projects. We searched the Development Information System database at the AID Center for Development Information and Evaluation using the keywords "construction" and "engineering." Roughly 15 percent—$1.37 billion—of the current AID budget goes to projects that have significant engineering components (see Figure 1).

The number of current AID projects—over 300—containing engineering components has grown from a little over 200 since 1981. During the same period, however, AID engineering positions decreased 53 percent (Figure 2). Today, fewer than 50 engineers backstop all AID projects. The lack of sufficient in-house engineering expertise to review AID projects has impaired their effectiveness. Diminished engineering expertise has in turn resulted in a misperception that engineering expertise is necessary only on capital projects. As a result, new project management concepts, techniques, and the like cannot be presented in an AID-sensitive context.

Roughly 13 percent of AID's projects have significant engineering requirements. These projects account for 15 percent of AID's budget.

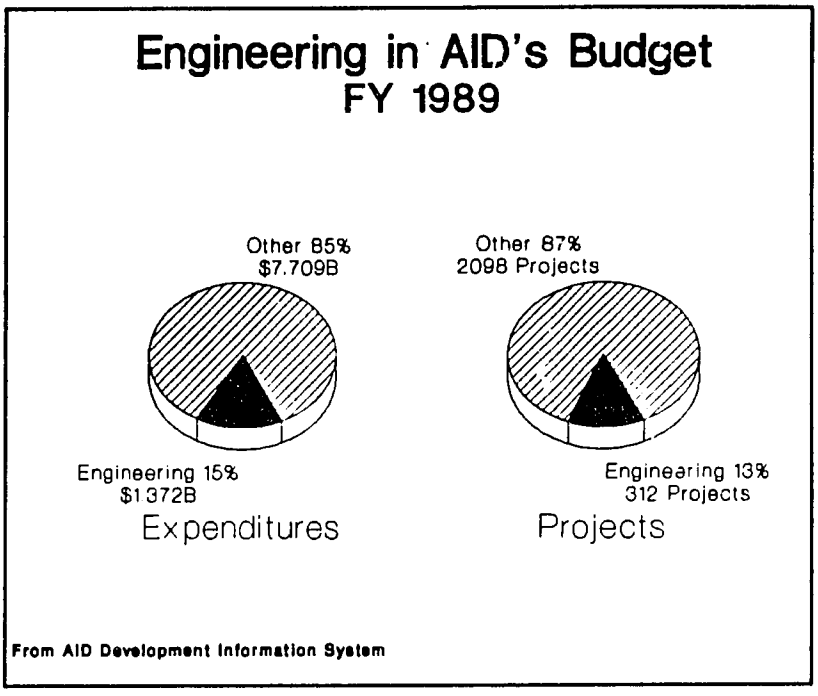


Figure 1. Fifteen percent of AID's budget goes to projects that have significant engineering components.

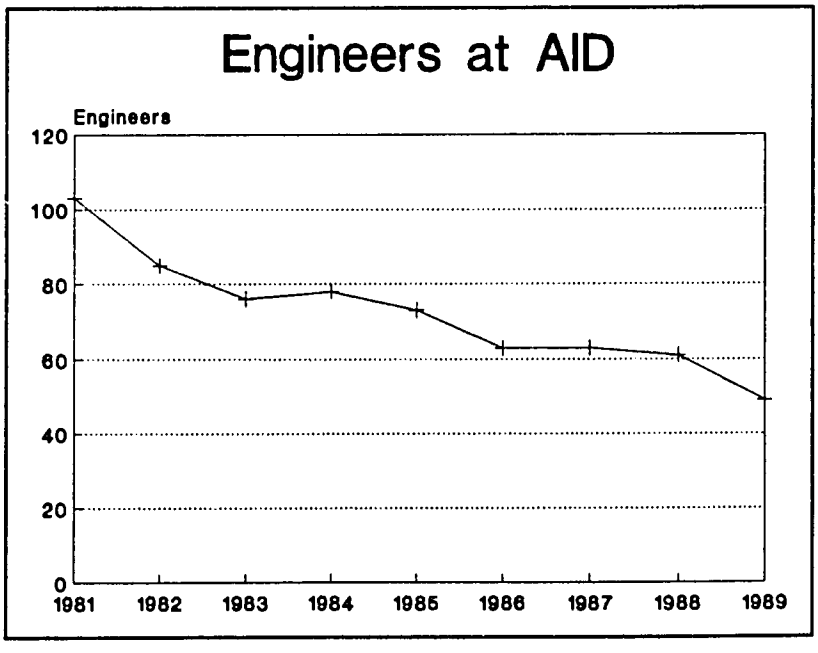


Figure 2. The number of AID engineers has dropped 53 percent since 1981—while projects have doubled.

Inadequate Engineering Oversight

When engineering advice and review is neglected, AID projects suffer. This can happen because a mission project manager may not recognize the symptoms of a project in trouble, may be misinformed by the contractor, or may not take the advice of an AID engineer. A few examples[1] make the point:

- A North Africa irrigation project, considered a rural development activity but with many interdisciplinary aspects, did not have any engineering input. Inadequate planning for floods and peak rains and other factors led to failure. This is a common AID project type that needs engineering input.

- In one South American project, funds were allocated in the absence of a feasibility study, thus masking a basic problem: Power resources were inadequate for the plant's size, causing it to be downscaled and fall behind schedule, disappointing expectations created by AID.

- In Africa a road project was established with many parameters decided for other than engineering reasons. Sited by an engineering firm with limited country experience, the cost was underestimated. With only sporadic review because of a lack of AID engineering resources, the project went beyond budget. Assignment of a non-highway engineer to the project delayed implementation. A scaled-down project was completed years behind schedule.

- An agriculture project in Africa cost escalated 400 percent from the original estimate. The first estimate was made without an engineer, the second by a an inexperienced engineering firm. Pressure to obligate resulted in drawings being issued without an AID internal engineering review. Pressures to meet unrealistic deadlines, unfamiliarity with required procedures, and a shortage of engineering project managers led to the problem. The contractors completed

the project with inadequate reinforcing steel and low-cement concrete that have led to building failures.

- The design of a desalinization plant off the coast of Africa was contracted without any AID technical involvement. Later the AID/Washington engineering staff identified shortcomings in the design. The design was approved without resolving the objections. Major cost overruns resulted.

- A dry dock was designed and built in the United States for an African country. After arriving on site, no AID engineer was available to supervise installation and to resolve bureaucratic and technical problems. Problems with ballast pumps and electrical supply caused the facility to sink. Two years later it was refloated into place, but a channel access is lacking for boats needing the service. Absence of adequate AID engineering resources caused delays and ultimate failure of the project.

- The lack of qualified water resource engineers on AID staff reduced the effectiveness of U.S. programs to be implemented in the U.N. International Drinking Water and Sanitation Decade.

Clearly there are substantial costs from not providing substantial engineering oversight. Can AID afford to continue to compromise its objectives by not having adequate in-house engineering resources?

A mission manager may not recognize the symptoms of a project in trouble, may be misinformed by the contractor, or may not take the advice of an AID engineer.

Engineering Requirements

Staff Needs for the 1990s

AID asked us to project a range of AID engineering requirements over the next 10 years. We used the funds for U.S. Foreign Assistance over the past decade (in constant 1989 dollars) as the basis for projections.[2] To create the projected levels of expenditure, we manipulated foreign aid for the past decade along three trend lines—low, status quo, and high.[3]

AID's spending pattern over the past decade offers some peaks and valleys on which best- and worst-case spending can be encompassed, as shown in Figure 3. A trend line using data points from the 1977-1989 period is projected until 2000. This generates the status quo scenario. The underlying assumption is that aid during this period reflects the upturns and downturns that reflect an average world situation. By taking the peak, which reflects increased aid during times of turmoil, we can generate an upper envelope boundary. Likewise the

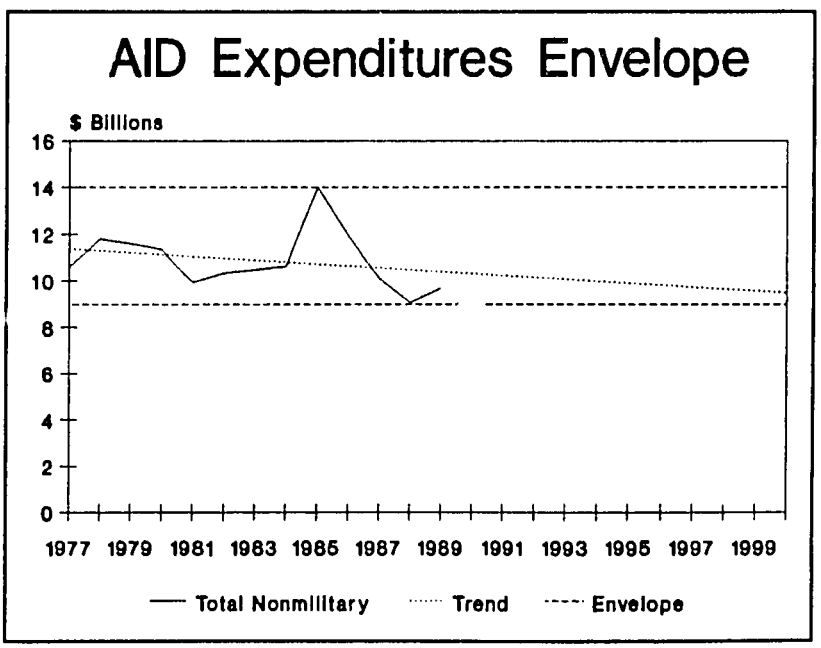


Figure 3. Recent AID outlays offer a basis for projecting future outlays.

valley generates a lower envelope boundary. Barring truly cataclysmic events, it is likely that the amount of U.S. aid will lie somewhere in this envelope.

- *Status quo.* This is an extension of the aid programs with all components included. In 2000, this level would be slightly over $9 billion.

- *Upper Envelope Boundary.* This was generated by projecting along the peak year (1985), in which economic supplemental aid was high. The rationale is that such an outer boundary would result if the United States were involved in solving regional conflicts as characterized by the solution that the Camp David Peace Accords brought about in 1979, or in providing economic supplementals to deal with emergency and short-term problems such as provisions for famine-stricken countries. The upper envelope boundary is $14 billion.

- *Lower Envelope Boundary.* The lower envelope boundary was arrived at by projecting along the trough value in 1988. In 1989 the requested appropriation is again trending upward. The lower envelope boundary is some $9 billion.

Engineering Workload

Figure 4 shows the *diminishing* engineering staff's *increasing* responsibilities on the basis of project funding for the 1981-1989 period. It is based on the current overall budget/engineering work ratio—namely, that 15 percent of AID project funding has and will continue to involve engineering.[4] This figure indicates that AID engineers' responsibilities have doubled since 1981.

Figure 5 shows engineering staff's responsibilities in terms of number of projects for the 1981-1988 period. Here again, the number of projects per engineering staff member has increased steadily. Note that the effort required for an increased number of projects does not track dollar amounts; each project, even small ones, requires a certain level of documentation, oversight, travel, etc. This highlights the seriousness of the situation at AID, where staff engineers have dropped 53 percent since 1981.

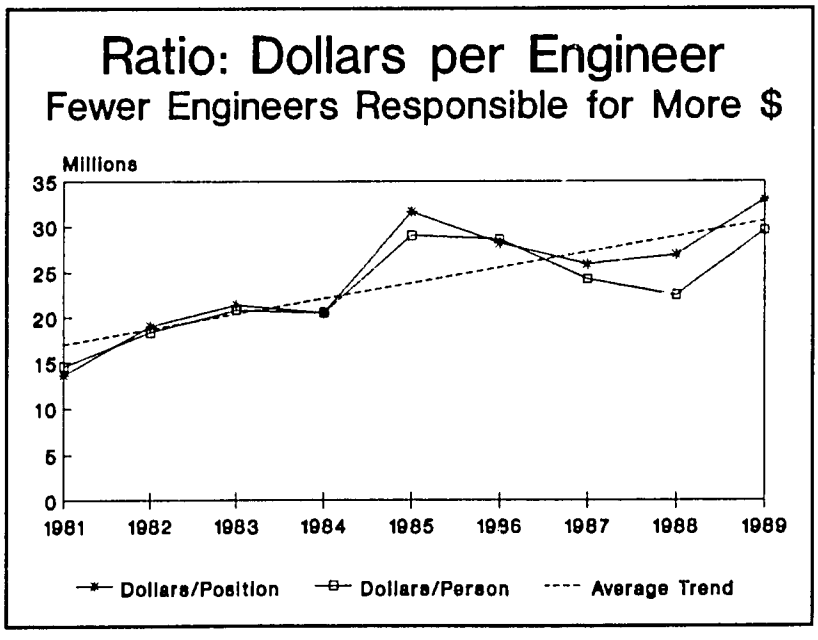


Figure 4. AID engineers are responsible for twice the dollars they were in 1981.

AID as a whole has dropped 17 percent in the same time period (see Figure 6). Non-direct hires increased by 320 percent. Fewer AID employees are overseeing the work of contractors. The span of oversight can be spread too thin. In the case of engineering, this has occurred.

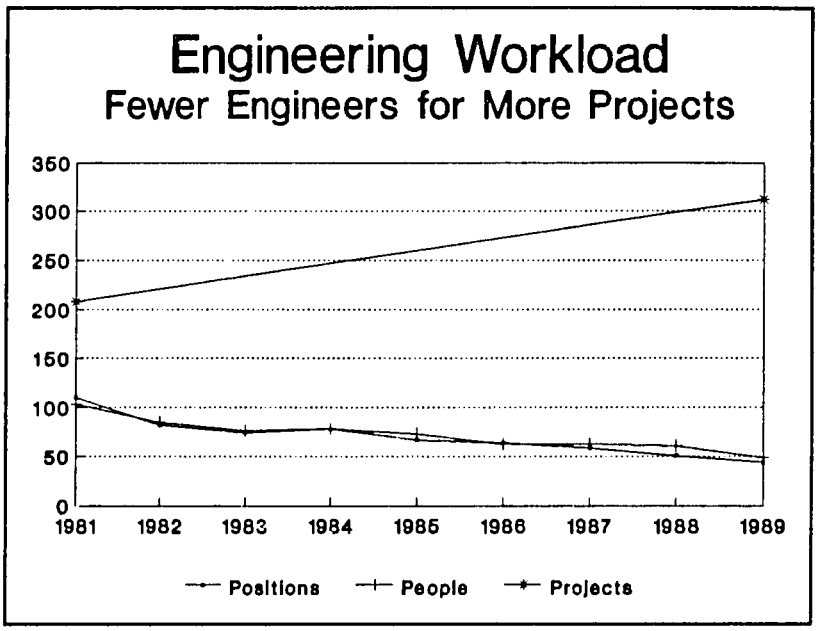


Figure 5. Projects per engineer have risen steadily since 1981.

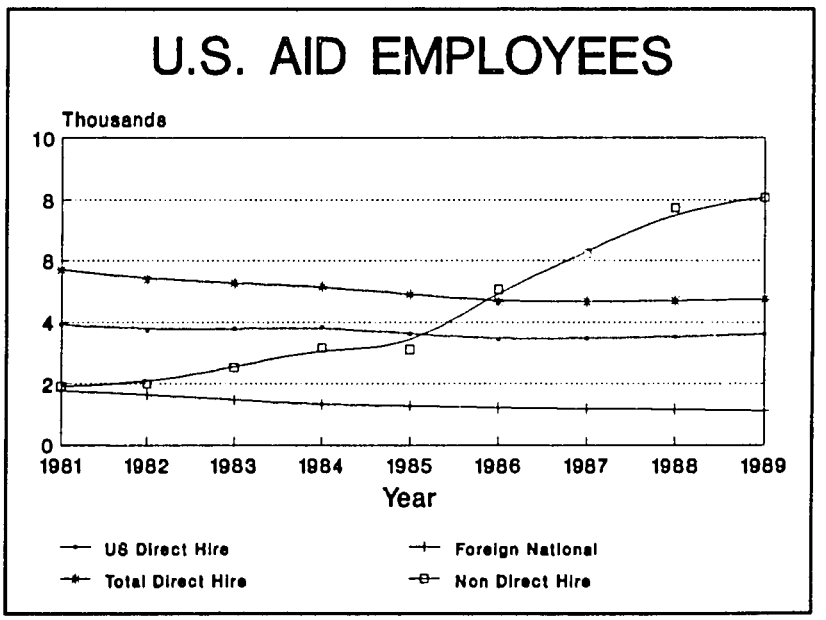


Figure 6. AID employees have dropped 17 percent since 1981, while non-direct hires have increased 320 percent.

Number of AID Engineers Needed

We assume that each engineer could usefully control $15 million in projects with engineering components and could oversee two to three projects, depending on size. We make these assumptions based on AID's ability to successfully manage engineering projects in 1982, before the sharp downtrend began.

We also assume that approximately 15 percent—the current amount—of future years' AID budgets will contain projects requiring engineering resources.

With these assumptions, we can project high-low ranges of engineering personnel needed for the previously developed AID budget envelope.

AID's direct engineering requirement could range as high as 139 and as low as 90 people over the next decade. At the present level, approximately 94 engineers would be required compared to the 43 now in place.[5]

Scenarios	Seasoned Staff	Field Staff	**Total Staff**
High trend	84	55	139
Present trend	32	62	94
Low trend	35	55	90

Table III. Mix of Engineering Talent 1990-2000.

Table III shows one set of possible mixes of field/Washington engineers based on the following rationale. AID needs engineering resources in three areas:

- *Policy Direction.* Not only a substantial portion of the AID budget but also the success of programs is affected by access to engineering judgment. An important role for a few senior engineers is in working with and reviewing policy.

- *AID/Washington.* Central engineering and within bureaus must provide the overview and senior engineering judgment to keep field projects on course. A small central engineering staff is needed to provide cross-bureau communication and to marshall resources needed in the field. This central core would know what is active, how to redirect effort as needed, etc. The policy direction staff should be in close communication with this group and the bureaus.

- *Field Engineering.* While some missions require an engineering staff because of their large number of projects, others do not. Some field engineers could be assigned to a block of countries. This must be closely monitored because some projects will require intense attention simultaneously, potentially overloading the system and causing project failures or delays.

An important role for a few senior engineers is in working with and reviewing policy.

The present-trend scenario in Table III is based on a mix of senior engineers who are not only specialists within a discipline but also have extensive AID field experience and of less-experienced new hires who while working in the field would have ties to the senior engineers, not only in the field but in Washington.

Both the high- and low-trend scenarios reflect fewer field engineers to senior engineers. In the case of the high trend, AID would want as much experience and judgment to be applied to projects as possible. The low-trend scenario reflects the realities of the world, namely, that when AID activity is low it would be more difficult to attract project engineers because of competition with private industry.

Engineering Recruitment and Advancement

The composition of AID's engineering staff by discipline currently favors civil engineers. This reflects, to a degree, a past concentration on infrastructure projects, as well as irrigation and other hydrological projects. It is important to have engineers in house who have degrees (and field experience) in the major disciplines required by the project—e.g., an electrical engineer is not qualified to administer a road project.

AID must decide on discipline selection and resource deployment based on data more extensive than possible within the scope of this review. As a guide, a 1983 AID survey[6] identified the needed discipline mix as shown in Figure 7. A comparison with projects from 1984 and 1989 reveals a similar project mix. We assume that the 1983 mix is still within the range of actual needs.

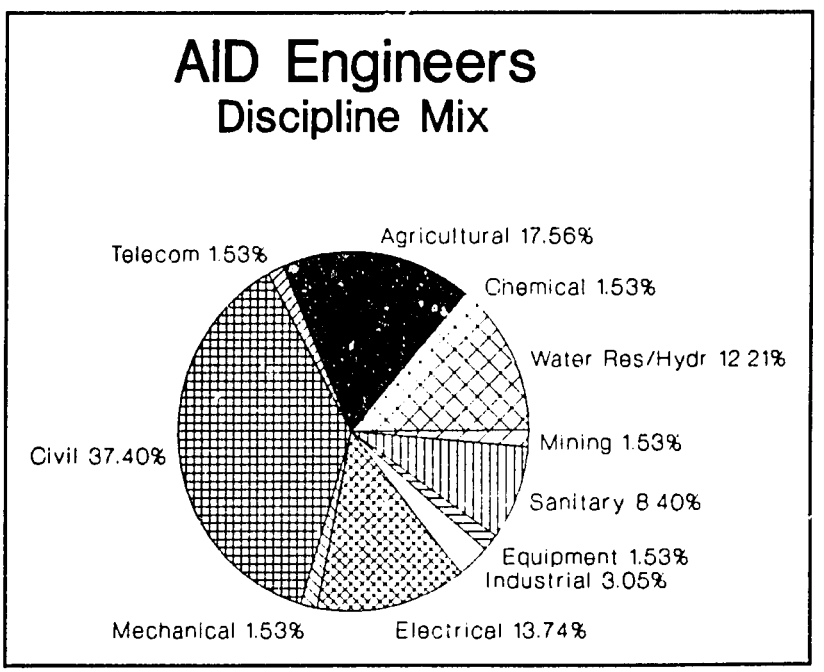


Figure 7. Discipline mix recommended for AID engineers in 1983.

Engineering Disciplines Needed in the Next Decade	Lower	Present	Upper
Civil	34	36	52
Agricultural	16	17	25
Electrical	13	13	19
Hydrologist	11	12	17
Sanitary	8	8	12
Industrial	3	3	4
Telecommunications	1	1	2
Chemical	1	1	2
Mining	1	1	2
Equipment	1	1	2
Mechanical	1	1	2

Table IV. Future discipline mix based on percentages in Figure 7.

Table IV lists the engineering discipline mix needed for the three levels of AID budgets, based on the percentages shown in Figure 7.

The numbers in Table IV will of course need to be adjusted to meet emerging priorities, e.g., a greater emphasis on environmental quality and resource management, greater reliance on telecommunications for public education.

Looking at AID engineers, including those who are now in non-engineering AID positions, it appears that they come from a diverse mix of U.S. universities. This is positive, representing the mixing of many academic viewpoints and geographical experiences. Recruitment should continue this pattern, but with an emphasis on recruiting needed disciplines, not just bodies.

The U.S. college-age population is declining, and more of those seeking degrees are women. They do not enroll in large numbers in engineering. Another phenomenon is the increasing difficulty of recruiting engineers into government positions where the pay and benefits have traditionally trailed the private sector. A hiring policy is needed that early on identifies potential employees and grooms them for AID. AID should take advantage of internships and recruits from private volunteer organizations.

AID's one-ladder promotion method drains talent unnecessarily. A second ladder would encourage especially talented individuals to stay within their discipline.

Advancement within AID for engineers, like many private businesses, is via management. While crossover is to be expected, this one-ladder promotion method drains talent unnecessarily. A second ladder would encourage especially talented individuals to stay within their discipline.

Professionals seeking postgraduate degrees more often do so in fields such as management rather than pursuing advanced degrees in their initial field because promotion in American companies is more through management than research. Recruiting those with multiple degrees does not produce immediate benefits. In AID as in any sector, engineers must have experience to match education before they are truly valuable. The trends above point to a more limited supply of talent in the next decade and the need to "season" and retain engineers within AID.

Developing countries present a special opportunity for the advancement of U.S. objectives through engineering. In many countries U.S. engineering has enjoyed a long relationship with the country's leading development ministries. Where the U.S. is displaced from this relationship, however gradually, a shift also begins in terms of frequency of U.S. contacts with decision-makers, especially the technically trained elite, who, more in developing countries than in the United States, are likely to decide the direction of their nations' futures. AID, by strengthening its engineering capacity, can reverse this trend and strengthen U.S. interests abroad.

Recommendations

(To be written after review by the ACEC International Engineering Committee)

1. *Status and Functions of AID Engineers,* an internal AID report on engineering by Louis A. Cohen, S&T/EN, 8 February 1983.

2. AID's *U.S. Overseas Loans and Grants* were used for funding through 1988. Data from the House Task Force of the House Foreign Affairs Committee were used for 1989 and 1990.

3. Forecast based on trends can be wrong as the world turns. See "The Trouble with Forecasts" by Alan Woods in *Development and the National Interest*, 1989. Washington, D.C. U.S. Government Printing Office. p. 99.

4. AID's *U.S. Overseas Loans and Grants* were used for funding through 1988. Data from the House Task Force of the House Foreign Affairs Committee were used for 1989.

5. These figures were derived by taking 15 percent of the total AID budgets at the year 2000 for the status quo and upper and lower boundaries and dividing the results by $15 million.

6. *Status and Functions of AID Engineers,* an internal AID report on engineering by Louis A. Cohen, S&T/EN, 8 February 1983.