

## Priority-Based Marginal Resource Allocation Using Competitive Subsystems

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### ABSTRACT

In the design of Arkansas' Emergency Medical Services System, extensive application and integration of several aspects of systems theory have been employed. This paper focuses particularly upon the application of systems theory to the design and operation of the management subsystem. Of particular interest is the use of function analysis as a basis for: a) subsystem definition and structure, b) differentiated management authority, c) program budgeting employing a competitive priority-based marginal resource allocation technique, and d) performance contracting.

The Department of Health, Education and Welfare has recently funded five experimental projects to develop Emergency Medical Services (EMS) Systems. Only two of the five projects are for statewide systems: Arkansas and Illinois. Four of the five project areas were already noted for being highly developed in some aspect of emergency medical service delivery. Arkansas, on the other hand, had recently scored zero on a scale of 100 in a Department of Transportation EMS evaluation. In contrast, Illinois had scored a 90 on the same scale.

The \$3.4 million contract for developing Arkansas' EMS System went to Arkansas Health Systems Foundation (AHSF), a private, nonprofit, management consultant firm based in Little Rock. To the firm, the embryonic status of Arkansas' EMS System seemed to present not only special problems, but challenging opportunities as well.

The biggest and most obvious problem was that \$3.4 million was not enough to design and implement an entire statewide EMS System. Yet the Federal contract under which the firm was operating called for the design of a

complete EMS System, the implementation of all aspects of that system in at least one region of the state, selected implementation of high priority system components in the rest of the state, and a plan for phased implementation of the complete system statewide using other sources of funds.

To a systems analyst, the logical starting place was a definitive operational definition of an EMS System. An extensive literature search turned up no such definition. Site visits to the most advanced EMS Systems in the nation merely offered further evidence that there was no agreed upon system definition. For example, the EMS System in Jacksonville, Florida, consisted mainly of a network of centrally dispatched firehouse-based ambulance services of extremely high quality, while the EMS System in Illinois was made up of a network of highly coordinated hospital trauma facilities with some emphasis upon the use of emergency air transportation.

Having found no acceptable system definition, the design team decided to employ a systems definition based upon functional outputs. This meant that we would first define with precision what it was we wanted our EMS System to do (i.e., specific services definition) and we would then build a system based upon those outputs. The reliable delivery of those outputs (or services) would furnish the basis for system and subsystem evaluation and further system refinements.

The subtle but extremely powerful impact of using a functional output systems definition was not apparent to most observers in the beginning. However, the distinction between this technique and conventional planning and programming practices has proved to be radical.

While functional output systems design is common in industry, it is practically nonexistent in governmental planning and management. For example, when an aircraft manufacturer designs the nose wheel for a new airplane, the first step taken is the definition of the "functional outputs" of that component. Once the engineers know with precision what it is they want that nose wheel to do: for example, maximum force of impact, maximum speed of impact, angle(s) of impact, etc., they then design a nose wheel assembly to meet those performance specifications, iterating that design as necessary to interface with other components. This is not the procedure that is normally employed in designing delivery systems for health, social, or psychological services. Instead, institutional and organizational configurations serve as the basis of design, and the resultant "functional output capability" is seldom defined and rarely evaluated.

Systems theorists have never really resolved the problem of how to define a system. Silvern, using a traditional approach, defines a system as "the structure or organization of an orderly whole, clearly showing the interrelations of the parts to each other and to the whole itself [1]." This is clearly not an "output-oriented" systems definition.

Laszlo has discussed Weiner's work on system "purpose," saying that, "it is

now possible to describe systems in terms of ends and goals [2].” The distinction between these two views is critical. There exists a choice. One can define a system by naming selected parts and describing their interrelationships. A problem with defining a system as a set of organized, interrelated components or subsystems is that such a definition leaves no place for analysis of disorganized systems. In other words, if a system isn’t a good system (i.e., highly organized), it isn’t a system at all.

The output-oriented definition offers an alternative which (from a management point of view) is highly persuasive. Rather than defining a system by naming interrelated parts, one can first define specific system outputs, then define the system as “those entities and their interrelationships (or lack of interrelationships) which significantly influence, either positively or negatively, the defined outputs.” This latter approach has been employed in the analysis and design of the Arkansas EMS System.

EMS System outputs (services) were first defined with considerable specificity. The EMS System was then defined as “all entities and their interrelationships (or lack of interrelationships) which significantly influence, either positively or negatively, the reliable delivery of defined emergency medical services.”

In this context, the key word in defining system boundaries is “significantly.” For example, when the state legislature is in session and is either acting or failing to act on an issue which may significantly influence the delivery of one or more emergency medical services, then the state legislature is, at that time, a component of the EMS System. System boundaries, therefore, fluctuate with actual behavioral conditions. Under the more traditional definition, system boundaries would remain fairly constant, and systems analysts and engineers would refer to such entities as the legislature and other important sources of influence as the system’s “environment.” The distinction between an entity of powerful influence which is inside the system and one which is outside the system, is then arbitrary.

This writer is currently of the opinion that the general systems principles which are applicable to systems defined one way are different from those which are applicable to systems defined another way. It is further proposed that the output-oriented definition, using fluid system boundaries, is most appropriate from a management point of view, since outputs are the primary concern of management.

Not only that, today’s rate of technological change alters methods of achieving outputs much more rapidly than it alters the outputs themselves. For example, the innovation of remote monitoring of cardiac output via telemetry has allowed paramedical personnel in some states to administer cardiotropic drugs to heart attack victims. In this instance, the output (or service) did not change, but the boundaries of the system delivering that output shifted greatly. Thus, an output-oriented systems definition should, if

properly designed, offer greater adaptability in the face of rapid technological change.

The extremely definitive functional output definition which serves as the core of the Arkansas EMS System is broken into five "functional categories." Those categories are:

1. Detection and Reporting
2. Command and Control
3. Mobile Medical Services
4. Nonmobile Medical Services
5. Evaluation Services.

Detailed definition was carried out for every service (functional output) under all five categories. Those five functional categories then became the program categories which serve as the basis for an output-oriented program budget totaling \$3.4 million. All money expended, all subcontractual arrangements, all subsystems design and definition, all evaluation, and all management decision-making has subsequently focused upon defined system outputs. No money is spent which cannot be related to a positive change in system output.

A "complete EMS System" is, therefore, defined as a system which reliably delivers the complete range of emergency medical services (outputs) within prescribed service standards. As noted earlier, the \$3.4 million dollars was not enough to implement a complete system statewide. Therefore, implementation of incomplete systems in various areas of the state was planned and budgeted on the basis of locally-determined service (output) priorities. To accomplish this, a competitive priority-based allocation technique was utilized.

### **The Management Subsystem**

In designing the management subsystem for the EMS System, problems of size, complexity, and diversity had to be addressed. Geographically and demographically, Arkansas is highly differentiated. The EMS System must serve approximately two million people in 75 counties spread over 53,000 square miles. The state is divided into eight economic development districts, some poor and others in poverty, one highly urban and the rest very rural, some extremely mountainous and others flat, some with racial difficulties (black-owned ambulances serving blacks, white-owned ambulances serving whites) and some without; and to further complicate things, each district was at a different stage of EMS capability. All this diversity, complexity, and size, indicated the need for selectively decentralized management. To accomplish this, district health planning agencies were contracted to perform initial planning tasks and to create in each district an incorporated nonprofit management body called a District EMS Council. Political, provider, and consumer representation was mandatory for all District EMS Councils.

The aim of decentralization was to differentiate management authority in a manner which would allow decisions which could best be made at the district level to be made at that level, while decisions which would affect the entire state would be retained at the state level. Another extremely important consideration in the design of the management subsystem was Arkansas' commitment to creating an EMS System with the flexibility to use both private and publicly owned hospital and ambulance services. Up until now, the best ambulance operations in the nation (e.g., Jacksonville, Florida, and San Diego, California) have been socialized systems—that is, they are owned and operated by a governmental body. With over 100 public and private ambulance operations throughout Arkansas, and with at least that many emergency hospital facilities, selective decentralization of management authority was the only practical solution short of socializing the entire system.

Several kinds of authority have been vested in the District EMS Councils, but for the purposes of this paper, the authority I shall discuss is the authority to approve the total EMS plan for the district, and to set district priorities. In keeping with the program budgeting technique being used, each district planned, budgeted, and arranged in priority order program objectives specifically aimed at making measurable improvements in one or more of the defined system outputs (services).

Because of contractual obligation, Arkansas Health Systems Foundation's own Board of Directors retained state-level management authority. However, early in the design phase, the Board of Directors voted to strictly honor the order of priorities set by district management.

When initial planning was complete, it was clear that to implement the entire EMS System statewide would cost in excess of \$6 million. Having only \$3.4 million to spend, the Board of Directors could obviously not fund all district program objectives. This problem of marginal resource allocation was resolved by allowing district management to plan and budget using the program objective format, with each district setting its own priorities. State-level management then strictly honored the order of the district priorities, basing resource allocations on quality of planning and design, local commitment, and demonstrated need. The funded (purchased) program objectives from each district were then formulated into a performance contract between the Arkansas Health Systems Foundation and the District EMS Council.

This use of selectively decentralized management authority helped to overcome a budgeting problem that is peculiar to priority-based marginal resource allocation. In formulating an incremental priority-based plan, the order of priorities must be set before budget can be finalized on each priority item. For example, one of the districts had as its highest priority the provision of basic emergency medical technician training to all 98 ambulance attendants in the district at a cost of approximately \$9,000. That same district's second

priority was to provide the emergency-related equipment (excluding ambulance and communications equipment) that these attendants would have been trained to use if the first priority were funded. This second priority was budgeted at approximately \$11,000. That district's third priority was to create fully operational Class II ambulance service units at five locations in the district at a cost of approximately \$95,000.

The stated cost of achieving each of those priorities is accurate only if the order of the priorities is preserved. For one thing, priority number two would make no sense at all if priority number one had not been funded. And, if priorities one and two were not funded, the cost of priority number three would be approximately 30 per cent higher than projected, since the cost of basic training and basic equipment would have to be added. This example merely points out the fact that the order of priorities must be fixed before budget projections can be finalized.

This was not, however, the only reason for adopting a selectively decentralized management subsystem. The needs of each district are unique, and it would be an impossible task for top-level management to become familiar enough with all local complexities to be able to rationally set priorities within every district. State-level management has not retained authority *over* district-level management, but rather state and district management groups retain different kinds of authority.

### Allocation Process

On March 17, 1973, the Arkansas Health Systems Foundation Board of Directors met to finalize 12 programmatic/budgetary decisions totaling \$3.4 million. The 12 decisions that had to be made were as follows:

1. To finalize the total program content and budget for the Western Arkansas District. (This was the district which was singled out for implementation of a complete EMS System capable of reliably delivering all defined system outputs within prescribed performance standards.)
2. To finalize the design and budget for the statewide EMS communications subsystem. (While district management retained the authority to decide where in the district communications equipment would be placed, and in what quantities, state-level management retained the authority to determine overall communications subsystem configuration. This was necessary to insure communications compatibility among the districts. The state communications subsystem budget, therefore, included the costs of all antenna towers, repeaters, teletype systems, and all other items necessary to providing the statewide communications "skeleton." District budgets included the cost of any radios, both mobile and nonmobile, to be used in

the district. This division of authority has insured the development of a statewide communications subsystem which will be compatible with any EMS System changes in the foreseeable future.)

3. To finalize the state-level training program and budget. (To insure uniform quality and economic delivery of training services, state-level management retained the authority to develop a statewide training program. It was left to the districts, however, to plan and budget for the coordination of training schedules in each district, to decide the number of persons to be trained as well as the level of training to be delivered, and to pay any student stipends and transportation costs. This meant that state management would provide and pay for costs of instruction, while district management would provide and pay for student expenses. This was a natural delineation of authority since the training needs of a district are totally contingent upon the district's order of priorities. It should be noted that the Arkansas State Department of Health has contributed substantial resources to this training effort.)
4. To finalize the Category I Nonmobile Services Program and budget. (This is a state-level management responsibility because the Category I Program exists to render several kinds of technical and consultative services to hospitals throughout the state.)
5. To finalize the State Command and Control Center program and budget. (District Command and Control Centers fall under district management control, while the State Command and Control Center falls under state management control. It is interesting to note that in some districts the provision of central command and control services was a high priority, while in other districts that service was a very low priority.)
- 6.-12. To finalize allocations to district management in the other seven districts. (This excludes Western Arkansas, the only district with a complete EMS System.)

The purpose of listing the programmatic and budgetary decisions that had to be made at the state level is to indicate the extremely detailed complexity of the system design. The problem is similar to tasks faced by city councils, county governments, and state legislatures. Another similarity is that the EMS System is just one of several projects for which the AHSF Board of Directors is responsible.

The problem of making intelligent and informed programmatic and budgetary decisions on a project of this complexity was greatly simplified by the systems work which had been done in the beginning, and by the rather strict adherence to specially adapted program budgeting and management by objectives techniques. But probably the biggest advantage was gained by the use of numerous task forces acting as advisory groups on each of the decisions

which were to be made. The basic philosophy underlying the use of these advisory groups was that the quality of a decision is heavily dependent upon the number and kind of alternatives that are considered. An example of how this philosophy was put into effect can be seen in the activities of the subcommittee responsible for the communications subsystem design:

The AHSF Board of Directors, working with the state Comprehensive Health Planning Agency, selected a number of individuals for this task force based upon their expertise and experience in this particular area of decision-making. At least one AHSF Board member sat on each of the advisory subcommittees. To provide the communications subcommittee with enough information to make quality recommendations, the University of Arkansas was contracted to develop four alternative communications subsystem designs, each within a different specified budget range.

At first, a more traditional approach was considered. This approach was to first decide how much money would be spent on a communications subsystem, and then a contract would be let to design the best possible communications subsystem that could be built with that amount of money. If that had been done, the advisory group and the AHSF Board of Directors would then have had only one plan (one alternative) to consider. It would not be possible, using such a method, to weigh the relative advantages and disadvantages of various communications designs and costs against similar alternatives in other categories of expense, such as Command and Control or training.

In the work of every advisory subcommittee, care was taken to insure that a number of specific alternatives were considered. The task of the advisory groups was to offer the AHSF Board of Directors specific recommendations regarding the advantages and disadvantages of each of the alternatives and the relative costs involved.

### **District Allocations**

The largest advisory group was set up to make recommendations regarding allocations to the seven district-level management groups. All aspects of medical expertise and health management expertise were represented on this advisory group.

Considerable discussion had gone on for some time among AHSF staff members, the AHSF Board of Directors, and interested parties around the state, regarding the methods that should be employed in finalizing marginal resource allocation to the seven districts. A number of fairly traditional models were considered ranging from allocation by population distribution, number of counties, number of accidents, and various need indicators. The answer came in the middle of a fairly heated discussion between an AHSF Board member and a district planner. The planner had said the money should



go where the greatest need is. The Board member replied, "No, the money should go where the apparent ability to meet the need is."

At a March 10, 1973, meeting of this advisory group, representatives from each of the seven districts were allowed to present their total plans, starting with a description of need, followed by an explanation of the total district EMS plan for meeting the stated needs and, finally, a budget explanation and justification.

Then, each district representative was asked to present and defend his district's priority delineation in a manner which would describe how the district would go about building its EMS System gradually, in the event only partial funding were immediately available.

Each advisory group member individually rated the district plans based on three criteria:

1. Did the plan indicate a strong understanding of local needs and present a clear description of the district's present EMS capabilities?
2. Did the plan offer a clear description of how the district's EMS capabilities would be improved if the total plan were implemented?
3. Did the plan offer a clear and reasonable explanation of costs?

In addition to rating the plans, each advisory group member individually rated the districts' presentation of priorities using the following criteria:

1. Did the district's description of priorities offer a clear presentation of the manner in which the district's EMS System would be built if resource availability forced the district to build the system gradually, in predetermined stages of development?
2. Did the district's priorities relate logically to the district's expressed needs?
3. Did the district's priorities build logically, offering practical service capability at any stage of development?
4. Were the district's cost increments (as attached to specific priorities) clear and reasonable?

Each advisory group member was presented with the full text of each district's priority description, as well as with a single sheet listing in columns by district all program objectives (including costs) for all districts *in the order set by district management*. Each objective was referenced by page number to the full text of priorities provided by each district representative. These sheets were called "Ranking Sheets," and each advisory group member was asked to individually rank all objectives *without inverting priorities within a district*. The instructions that went with these ranking sheets were as follows: "Number the objectives from 1 to 79 (there was a total of 79 objectives) in

the order that you as an individual would fund these objectives if you had limited funds; provided, however, that you may not number an objective unless the objective above has already been numbered or unless the objective in question is at the top of a column." In this manner we were able to preserve the order of district priorities set by district management, while still allowing districts to compete. The results of these individual recommendations were then compiled statistically in a manner which reflected a true consensus of the group opinion. Staff recommendations were performed in the same manner, but compiled separately.

By statistically compiling the individual evaluations and recommendations, rather than having the entire advisory group vote on all possible combinations of priorities, all minority opinions were preserved and reflected in the resulting statistical compilation.

One week later, the results of all advisory group efforts were made available to the AHSF Board of Directors. The Board initially accepted all advisory group recommendations, then readjusted these recommendations on a programmatic basis using secondary recommendations with considerable staff input in order to balance the budget. Because of the budgeting technique being used, and because of the priority recommendations which had been generated, this budgetary trade-off process was done programmatically, and with the benefit of secondary alternative recommendations.

For district management groups, the final programmatic allocation, *using each district's own objectives and priorities*, then became the basis for a performance contract between the District EMS Council and AHSF. (The Federal government does, however, retain the right to disallow any district plan. At this writing, the outcome of that option has not been determined.)

## Conclusions

While a number of innovations were employed in this design effort, the one that was most difficult to accept and, at the same time, the most successful, was the decision to use a competitive priority-based allocation procedure. Virtually none of the individuals involved had ever before participated in such a process.

Several of the district planners had advocated simply dividing the money by seven, giving each district an equal share regardless of the quality of planning. Planners from a more highly populated district suggested allocating the funds on a per capita basis. One district planner compiled a rather elaborate allocation formula based upon population, size of the district, number of accidents per year, and so forth. Everything except quality of planning was included in this allocation suggestion. When presented with this allocation formula as an alternative to the competitive procedure, the AHSF Board of Directors flatly rejected the more traditional approach. (It was

interesting to note that the two districts which scored highest on the competitive evaluation would have received the least amount of money if the more traditional, though very complex, allocation formula had been adopted.)

Readers will be interested to know that the makeup of the AHSF Board of Directors includes the administrators of some of the largest hospitals in Arkansas, the director of the largest agency of state government, the director of the state health planning agency, the director of Arkansas' Regional Medical Program, numerous medical doctors, and other persons holding positions of responsibility in established institutions. So while the AHSF Board of Directors, which was responsible for implementing these innovations, is not a governmental body, its makeup seems to indicate that similar innovations in management decision-making, programming, and budgeting are not out of the question for state or municipal government, or for other established institutions.

### **Implications for State and Municipal Government**

Focusing upon state government as an example, I will briefly draw a picture of how state and municipal governments might operate in the future using widespread application of program budgeting, management by objectives, competitive priority-based resource allocation, performance contracting, and institutional configurations designed and continuously redesigned to conform with predetermined functional output delineations.

At the core is the application of output-oriented systems and subsystems definition. Presently, institutional configuration forms the basis for program planning. In the model being suggested, program planning would form the basis for institutional configuration. For example, the budgets normally presented to state legislatures are divided into categories based on institutional configurations. There is a health department budget, a welfare department budget, a department of mental retardation budget, etc., because those agencies exist. There is not, on the other hand, a budget for health services. Medicare and Medicaid funding requests normally appear in a welfare department budget. Funding requests for nutritional services, which could be considered preventive health services, normally appear in agricultural extension budgets. Anyone familiar with state government could offer endless examples. The point is, the health department budget is not the health program budget. And there is no health program budget. These practices make the institution of genuine management by objectives in state government practically impossible.

If state government were to first define its outputs, and then budget programmatically, state legislatures could perform budgetary trade-offs and cutbacks on a pure programmatic basis. A budgetary cutback would be synonymous with a reduction in some specific service capability. Put another

way, a reduction in budget would have a known corresponding reduction in organizational output.

The task of planning would alter drastically in this context. Besides performing continuous output analysis and needs assessment, planners would also have to assist in setting priority order, and in budgeting output objectives. Such procedures would force zero-based budgeting, and would offer legislators definitive programmatic alternatives from which to select.

With this type of hybrid program planning and budgeting technique as the basis for legislative decision-making, the relationship between a legislature and the executive branch of state government would amount to a performance contract. The governor and his staff would, in effect, be attempting to sell to the legislature, budgeted programmatic objectives geared to organizational output. The performance of such objectives would be easily evaluatable, offering the press something a good deal more important to report on than a line-item breakdown. A governor who could not deliver the objectives he had sold to his legislature would have a difficult time securing funds in the next legislative session, or in getting reelected, for that matter.

The ultimate result of such a system of decision-making would probably be a drastic reduction in the size of state government, and a similarly drastic shift in the role of the executive branch. State government would very likely begin to turn legislative appropriations into performance contracts with local governments, private industry, and newly developing private, nonprofit service corporations. The primary role of the executive branch of state government would, in this context, be planning, evaluation, and contracts management.

In effect, the executive branch would do the planning, performing extensive needs assessments and developing numerous alternative programmatic ways of meeting those needs. Then the executive branch, working with the legislative branch, would arrange these outputs in priority order. Executive branch planners and managers would then budget each program objective in accordance with the order of priority which has been set, compiling a total budget far in excess of anticipated expenditures. Much of this budgeting effort would very likely be done via requests for proposals (rfp's) sent to appropriate public and private organizations.

The legislature would then select from among the output objectives which had been developed. This selection would constitute the budgeting process, and the final result would be the State Plan. The executive branch, consisting largely of well-paid planners, managers, and legal advisors, would then turn this State Plan into performance contracts with appropriate institutions and organizations, only a few of which are likely to be institutions of state government. The role of evaluation would become extremely important, since evaluation would serve as the basis for contract monitoring.

Using somewhat similar management control and reinforcement techniques,

the Jim Walters Corporation effectively manages an \$800 million per year business using a central office staff of less than 50 people, including secretaries [3]. (The average yearly bonus in Jim Walters Corporation exceeds \$4000.) I can well imagine that it will be some time before state and municipal governments exhibit significant movement in the direction of advanced management systems. However, I'm convinced that this is the direction of the future and, if it's not, it should be.

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