

# HIGHWAY RESEARCH

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## HIGHWAY RESEARCH IN PROGRESS

### A Geographical Study

by

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### FOREWORD

A year and a half ago, the Highway Research Board received this analysis of research as reported in our "Highway Research in Progress" and the IRF reports of research abroad. This analysis was mislaid and has just now come to light. Although it was made of research work that was underway two years ago, we still think that it has considerable value in pointing to distributions that still exist today, in pointing to ambiguities and discrepancies in descriptions of research and in calling our attention to some of the shortcomings of any information system, admittedly including our own. We should point out that some of the problems described have been cleared up in our system by now.

A very important reason for distributing this analysis is to call attention to the need for considerable study of information files such as HRIS. We are nearly finished with the software that will make possible computer analyses of the HRIS files. Tables such as those prepared by Messrs. Ferval and Bellis can now be made by the computer. More advanced versions of the computer programs will make many other analyses possible. Examples are cross-tabulation of the file according to research agencies and specific keywords, or cross-tabulation between two classification schemes that are based on different sets of index terms.

W. N. Carey, Jr.

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# HIGHWAY RESEARCH IN PROGRESS - 1969

## A Geographical Study

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## HIGHWAY RESEARCH IN PROGRESS

### A Geographical Study

#### INTRODUCTION

The review which is the subject of this report grew out of an urge to see and grasp the forest concealed within the numerous trees in the three stout volumes of "Highway Research in Progress - January 1969." It is a valuable mass of research, but it does not bring out clearly just who does it and in what way the many participants are involved. Because of the very size of the operation and its extreme complexity, also because a high degree of freedom is required for fruitfulness in research, rigidity of organization of Highway Research was out of the question; a certain looseness appeared natural. But even a cursory inspection of the books produced the impression of an underlying cohesion, a combination of common, though diversified, trends, grown out of the nature of the multiple problem and the achievable means for dealing with it. What then are the patterns which give form to these trends? Last but not least, how do the various participants rate in doing their share of the prodigious effort?

The Highway Research in Progress obviously had not been conceived for any other purpose than to supply a collection of summaries of all the highway research projects that were known and current at the end of 1968, so as to equip all and any researchers with the most up-to-date bibliography possible, a purpose that the books have most excellently achieved. Nonetheless, we thought at first sight that it ought to be simple to gather the answers to our questions with the help of the source index and the geographical index, put together in Volume III. Soon, however, our practical task appeared enormous as it grew unavoidably into a kind of manual compilation, which is not done anymore these days, but by a computer; furthermore, a closer look revealed the many voids, duplications and inconsistencies that were unavoidable in a collection of data voluntarily reported by hundreds of independent sources, in a show of very uneven discipline and care, often due to fluid situations. You just cannot freeze literally thousands of more-or-less live projects (involving tens of thousands of individuals) and "photograph" them all at one chosen moment, without many shadowy edges appearing blurred.

The gathering of abstracts and related designations so painstakingly achieved by the Highway Research Board in the three tomes had necessarily been helped by its own computer; this admirable gadget could not produce any other material but that which had been programmed into it; this material in turn could not be any better than the very uneven information supplied by hundreds of "sources." As some joker recently put it, "to err is human, but to really foul things up requires a computer." It is a truism to say that the machine can juggle around the products of human thought but cannot think itself. To quote another wit, "man is a slow, sloppy and brilliant thinker - the machine is fast, accurate and stupid."

So we set ourselves to the inevitable task, with all due respect for the huge achievement of the HRIS and its associates, but with the obstinacy which alone could produce the additional insight we wanted. We made full use of the indexes, but had to develop their data from the ground up, and organize them selectively with the help of multiple cross-checkings which no computer could have done for us.

## METHOD

In order to get at the trees for the purpose of deriving the structure of the forest, we had to tackle them in groups smaller than the overall forest. This meant that our approach to the chosen objective had to be of a geographical nature; the first most natural subdivision was the U. S. on the one side, the rest of the world on the other; digging still deeper, the U.S. was divided into its components, the States; the world later on was analyzed by countries.

Within each state of the Union, and each country of the Outside World, the entities involved in the highway research activities were studied by major categories, of which the most essential is the "Highway Department," followed closely by the "Educational Institutions." It was found that the remaining entities could be conveniently covered under the two headings of "other local government" and "private."

Now another distinction appears, clearly characterized and reported by HRIS: any entity whose activity has a bearing on a given research project is either a "doer" or a "payer," respectively called "research agency" (code number 43) and "sponsor" (code number 45) in the Highway Research in Progress; occasionally one and the same entity assumes both roles in relation to a given project.

As our study progressed, we found that in many states - especially the most active ones - appreciable numbers of entities, while they happened to reside in a given state, actually worked for federal or national organizations; it would therefore distort the comparative picture of the states' activities if we included the entities which happened to be "in them but not of them." The most typical example is any one of many consultants residing in a state, working on a specific project for the United States Department of Defense in Washington, D. C.; another example is any one of several large federal research establishments scattered throughout the nation; a third type of example is the one of a number of central offices or laboratories belonging to specific industries grouped into associations of a cooperative character, located necessarily in some state or another, but active in the interests of some nationwide industry; a fourth and flagrant example is the large number of agencies located in Maryland and Virginia (in these instances suburbs of the Nation's Capital) but actually working nationally or for the "51st State," the District of Columbia. Hence our fundamental distinction between LOCAL projects and NATIONAL projects: in the course of the analysis of each state's activity, we set aside the projects that are of a national character and put them together on a separate list of national road research activities. They amount to approximately one-fifth of the total number of projects.

Care had to be taken in all this exceedingly complex picture to bring out a clear-cut view of the true activities throughout the nation through an unflinching effort to remain both realistic and fair. One major difficulty in this respect was the often confusing intermingling of the responsibilities of "doing" and those of "paying," of performing and/or sponsoring. It soon appeared that clarity could be most constructively achieved by focusing the whole of our analysis on the primary function of "doing," the one of financing being relegated to a secondary position. Fortunately, the data on "doing" were found to be mostly clear-cut, while those on "paying" were frequently missing or confused. This is why the basic statistics extricated from our step by step scrutiny and subsequent groupings are all based on "researches done" at a certain location, i.e., in a given state, or in the "national" realm as explained above.

Since the raw material under discussion amounts to thousands of separate projects, a reproduction of the details of each of them in this report would make its use unmanageable. We have, of course, very fat folders full of lists of projects "fished out" of the mass and grouped as we have explained, with detail notes of their intricate classifications and the difficult elimination of duplications. We have derived from these lists detailed summaries of both doings and sponsorings (including the all-permeating action of the Bureau of Public Roads) for each of the 50 states, plus the D.C.; plus also the national list, Puerto Rico, and a small but necessarily distinct international list covering 9 projects, done in this country for use in and by foreign countries or organizations of an international character.

Derived from all those lists and summaries, a set of tables was prepared, bringing out the basic findings and arranged in an effort to make the picture meaningful and suggestive to the reader. To fully discuss here the details of each and every state would soon become unnecessarily ponderous, because of the many repetitions of little significance; we will therefore limit our local comments to a small number of typical situations, and of brief descriptions of representative spot-findings.

After the nationwide survey of highway research in the United States, we shall present a similar one on the nations outside of the U.S., as far as data have been available to us. Whereas our domestic study has been based on the contents of the United States Highway Research Board's "Highway Research in Progress, January 1969," in three volumes (two of abstracts, plus one of indexes), our foreign study has been founded on the almost (but not entirely) parallel publication by the International Road Federation in Paris and Washington, whose one big volume is called IRF-1968. Our tables covering the latter field of operations have been designed on the same characteristics as the tables covering the U.S., making a direct comparison easy and very interesting indeed.

There are several differences between those two most worthy efforts which, we hope, are only the beginnings of more uniform and more precise presentations of happenings in our field. The IRF has no figures on costs of research, but goes into systematic details on the status of all reports with short tables of these for each country. The Highway Research in Progress has tried to gather data on expenditures but with so little success that a study of that fundamental aspect of the picture in the U.S. has proved to be impossible at this stage of the process; equally the Highway Research in Progress's information on the status of each report still is so sketchy and uneven that we had to leave out entirely any such distinction between the stateside projects. We have preserved, however, this distinction for the foreign field; because of the vagueness of some countries' information and the need to avoid an irrational inflation of national pictures through the inclusion of very old material, our foreign tables will include only studies given by the IRF as "active" or "future," in other words, the "live" material.

The exposé of our work finally leads to the definition of the essential unit of measurement which traditionally should have been mentioned at the beginning, but would not have been easy to understand: as we cannot measure the effort of the researchers in terms of money spent or time given to the task (for lack of clear and complete data), and since the relative qualities of the numerous projects and/or achievements of the agencies cannot be measured by any known instrument, our only possible criterion remains the number of research projects which, therefore, is the basis of this study.

U N I T E D    S T A T E S

GENERAL FINDINGS

First a word about the final totals. We may be accused of "jumping the gun," but feel that for the reader it is important to know at the beginning what order of magnitude we are faced with.

There are really three sets of figures. It has already been mentioned that the Highway Research in Progress and International Road Federation reports, although basically parallel, are not identical. For our own purposes, we have tried to clarify the picture and make it more meaningful by "weeding out" both, thus ending up with figures on our own.

The latest annual report of the Highway Research Board mentions a total of "about 5700." We have counted the abstracts in the two big volumes of Highway Research in Progress-1969, and found 5675, of which 2833 originated in the United States and the balance of 2842 abroad. The International Road Federation-1968 quotes a total of 5075 (as against 3534 in 1967); this is for all the reporting countries outside of the U.S. The apparent inconsistency between those widely differing totals of closely allied organizations arises from the fact that the International Road Federation's coverage of the world picture (outside of the U.S.) was much broader than the Highway Research in Progress's; the latter missed many reports and several countries.

When all is said and done, our own analysis falsely seems to produce a larger overall total than the other two, in spite of our careful weeding. Our total for the U.S. is 2896 (plus 11 for Puerto Rico and the few international items, raising the sum to 2907). For the outside operations we boiled down the IRF's 5075 to 3181 by eliminating the non-alive items. Our global figure for U.S. and abroad amounts to 6088 research projects actually listed as done in 1968. If we accepted the original figures of the two reporting organizations, we ought to add up 2833 for the U.S. and 5075 for overseas, giving a global amount of 7908 items. We believe that our number of 6088 is both realistic and fair.

Another general outcome of this analysis is the average ratings for the geographical units involved: the states of the Union and the countries abroad. In the next chapter the genesis of those ratings will be explained in relation to our states; the same method will be applied in the chapter on the foreign field. Let us show in advance the overall rating averages in a short, comparative tabulation by numbers of research projects.

<u>Averages:</u>	<u>Per 1 Million Population</u>	<u>Per 1000 Sq. Miles</u>	<u>Per 1000 Road Miles</u>	<u>Overall Rating</u>
for 51 States	15.06	6.83	1.07	22.96
for 39 Countries	3.96	0.89	1.36	6.21
for New Jersey	8.32	7.52	1.77	17.61

The much denser coverage in this country, as opposed to the foreign, is clearly apparent; even New Jersey by itself exceeds the outer countries, with the exception of the rating related to population - because of our exceptionally heavy concentration of people.

The structure of the effort and production in this country is summarized in Table I; it has also been transposed on the first map, from which an impression can be obtained of the regional values. The details by states and the prevailing trends will be discussed in the following chapter. Our most eloquent language in all this will be the figures; we shall let the tables speak, giving the reader the pleasure of discovery.

This is the place, however, for a few remarks on the all-permeating involvement of the Bureau of Public Roads, whose vitalizing influence has appeared on every step of our inquiry. Our count shows that, besides 86 projects they are doing and paying themselves, they sponsor close to 1200, more precisely 1194 based on the Highway Research in Progress listings. In the 50 states, the District of Columbia and Puerto Rico, they supported the local highway department on between 13 and 100% of the number of their research projects. To be more exact, only 5 states were sponsored below 50% of the numbers of their projects; 21 states got 100%; the remaining 26 states were granted between 50 and 100% coverage of their production.

As far as we were able to see, grants to educational entities were much fewer; doubtless for the reason that the moneys went to the highway who then sponsored the college or university. Grants to others were exceedingly rare. A number of other organizations (governmental and semi-governmental, among them AASHO) readily supply their help on worthwhile undertakings. We do not have sufficient information to estimate the dollar amounts involved. The strictly centralized countries beyond our borders might take a look at our most productive democratic methods, where each state of this federated country has to fend for itself with a fair amount of freedom, knowing, however, that the good uncle in the District of Columbia is not far away.

The most striking feature (besides the systematic stimulus by the Bureau of Public Roads) is the multiple character of the involvement of numerous people and organizations of a great variety of characteristics and functions. It reflects the first-rank importance that transportation in general and the automobile in particular have attained in the economy of the country and the American way of life.

Due to the magnitude of the necessary expenditures and to the need for standards and controls, the role of the various governmental entities, federal and local, has been and no doubt will continue to be prominent. The technical and scientific characters of the problems naturally brought the educational institutions into the picture, with the laboratories and scientific staffs. Private search organizations acting as consultants on specific projects brought their varied competencies to bear, swelling the numbers of the participants to such an extent that very few, if any, useful minds and energies seem to be left on the outside. At the same time, the immense number and variety of the musicians clearly point to the need for conductors and of a well-defined harmony.

A particularly interesting aspect in this "concert of participants" is the division of labor between the highway departments and the educational institutions in the

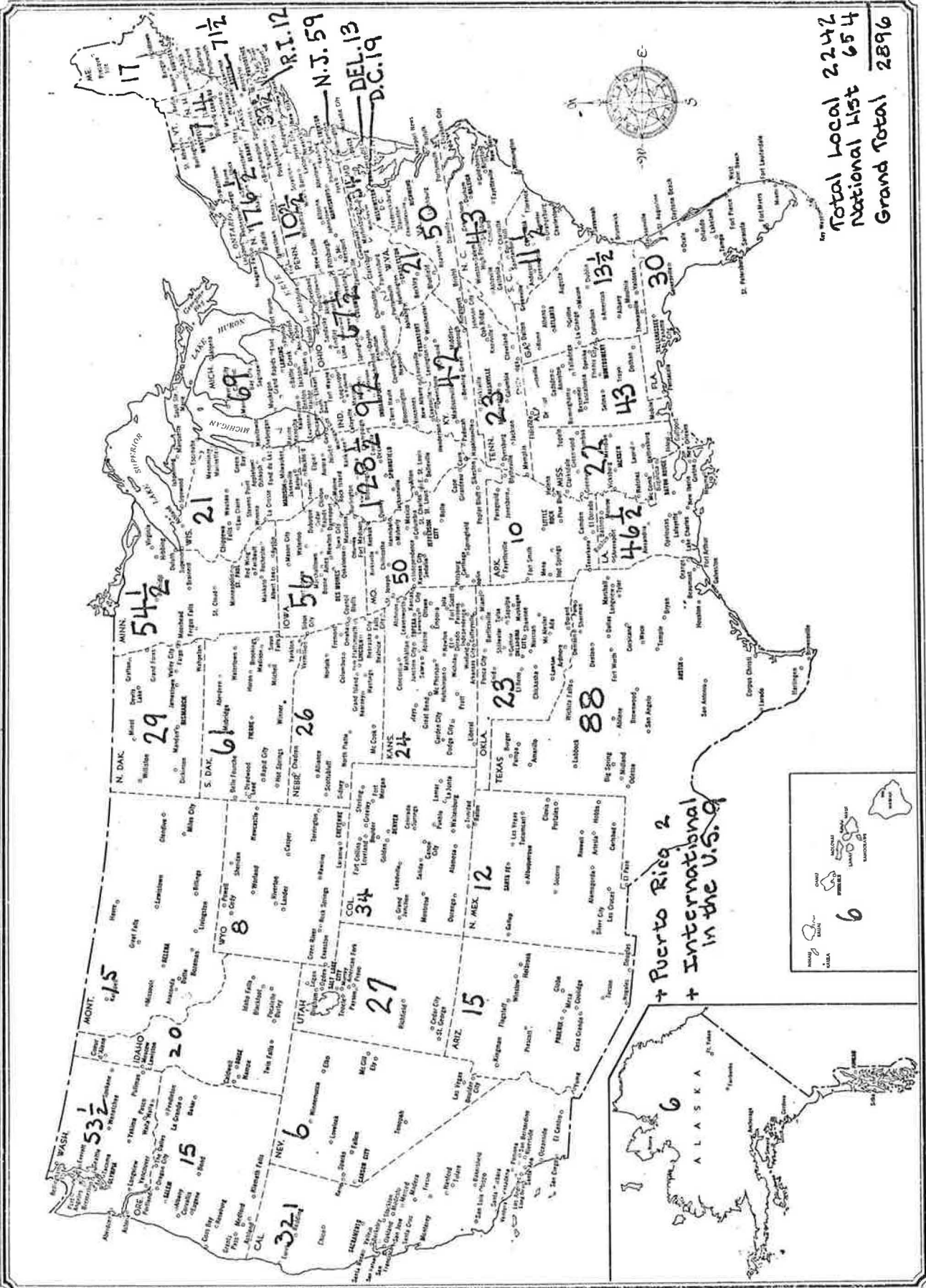
TABLE I

## NUMBERS OF LOCAL RESEARCH PROJECTS

U. S. by States - Jan. 1969 - HRP CODE 43

A.	California	321.0	D.	District of Columbia	19.0
	New York	176.5		Maine	17.0
	Illinois	128.5		Arizona	15.0
	Pennsylvania	<u>102.5</u>		Montana	15.0
		728.5		Oregon	15.0
				Delaware	13.0
B.	Indiana	92.0		Georgia	12.5
	Texas	88.0		Rhode Island	12.0
	Massachusetts	71.5		New Mexico	12.0
	Michigan	69.0		South Carolina	11.5
	Ohio	67.5		Arkansas	10.0
	South Dakota	61.0		Wyoming	8.0
	New Jersey	59.0		Vermont	7.0
	Iowa	56.0		Alaska	6.0
	Minnesota	54.5		Nevada	6.0
	Washington (State)	53.5		Hawaii	6.0
	Missouri	50.0		New Hampshire	<u>4.0</u>
	Virginia	<u>50.0</u>			189.0
		772.0			
C.	Louisiana	46.5		Total Local Items	2242.0
	Alabama	43.0		National List	<u>654.0</u>
	North Carolina	43.0		Grand Total U.S.	<u>2896.0</u>
	Kentucky	42.0			
	Connecticut	38.0		Puerto Rico	2
	Colorado	34.0			
	Maryland	34.0		International in U.S.	<u>9</u>
	Florida	30.0			2907.0
	North Dakota	29.0			
	Utah	27.0			
	Mississippi	26.0			
	Nebraska	26.0			
	Kansas	24.0			
	Tennessee	23.0			
	Oklahoma	23.0			
	West Virginia	21.0			
	Wisconsin	21.0			
	Idaho	<u>20.0</u>			
		550.5			





Total Local 2,242  
 National List 654  
 Grand Total 2,896

+ Puerto Rico 2  
 + International in the U.S. 6

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various states. In the several tables that will follow, the great diversity of solutions in this respect will clearly appear. Some states seem to make it a policy to develop their own research departments, thinking with much justification that the people who have to do the designing, the construction and the maintenance, ought to know best what is needed. Others again go to the opposite extreme, having decided that the colleges and universities have the equipment in apparatus and in specialized men, together with an eager youth that wants to put its enthusiasm to real use. Between those two extremes are innumerable intermediate solutions, of which perhaps the most interesting is the one of the alliances between a college and a highway department, as is done, for example - with outstanding success - by Texas and Virginia, in slightly different setups. In a number of states, some university or college has organized a separate transportation research department or institute, with the informal, but steady, support of the local highway department. It seems that in many instances the state's highway department sponsors the local state university, in preference to any private available institution.

#### COMMENTS ON THE STATES

The performances of our 51 units (including the District of Columbia) vary greatly, not only in absolute dimension but also in relation to their separate characteristics. A glance at Table II will show how unevenly the three most determinant factors, population, area and road mileage, differ in no apparent relationship to each other. So does the activity in highway research, as expressed by the number of projects carried out in each state. Geography, climate, resources, history, the character of the people and the impact of its neighbors, all have subtle influences whose combined effect seems to escape precise analysis.

It was impossible, nonetheless, to resist the temptation of getting closer to the apparent picture, by relating the number of projects to the three essential factors. This we did in Table III, where each state receives a triple rating in the form of the numbers of projects per one million of population, per 1000 square miles of territory, and per 1000 miles of roadways. The separate "weights" of the three characteristics visibly distort the positions of most of the states, thereby revealing their direct influence, as well as the particular stresses under which each state is laboring.

A cool judge will say that the merit of a state's performance resides in its overcoming of local handicaps; at the same time he will have to admit that, since this is a human operation, abnormally high handicaps in one direction or other, must be accepted as a valid excuse for not ranking with the most productive. Such an attempt at fairness leads naturally to a combination of the three figures into one overall rating in the form of a summation.

Table IV lines up the states under this overall criterion. It brings out, as we might have expected, the natural advantage of the highly concentrated unit, of which the federal district is the most outstanding example. It also epitomizes the significance of another figure: the national average. The District of Columbia is the only unit whose number of projects exceeds the national mean for each of the three fundamental characteristics (and this, mind you, refers only to the "local" projects; numerous ones that have a national significance have been switched to our "national" list).

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U.S. HIGHWAY RESEARCH IN PROGRESS

TABLE II

States	No. of Projects Jan. 1969 (Code 43)	Population(1000) est. mid 1968	Area sq. miles 1960	Road mileage 1967
Alabama	43.0	3,558	51,609	77,850
Alaska	6.0	274	586,400	6,582
Arizona	15.0	1,663	113,909	40,843
Arkansas	10.0	1,986	53,104	79,211
CALifornia	321.0	19,300	158,693	162,809
Colorado	34.0	2,043	104,247	81,228
Connecticut	38.0	2,963	5,009	17,980
Delaware	13.0	534	2,057	4,826
Dist. of Columbia	19.0	809	69	-1,083
Florida	30.0	6,151	58,560	82,898
Georgia	12.5	4,568	58,876	97,524
Hawaii	6.0	780	6,424	3,401
Idaho	20.0	703	83,557	53,484
Illinois	128.5	10,991	56,400	128,479
Indiana	92.0	5,061	36,291	90,878
Iowa	56.0	2,774	56,290	112,409
Kansas	24.0	2,293	82,264	133,232
Kentucky	42.0	3,220	40,395	70,225
Louisiana	46.5	3,726	48,523	51,759
Maine	17.0	976	33,215	21,267
Maryland	34.0	3,754	10,577	25,585
Massachusetts	71.5	5,469	8,257	27,544
Michigan	69.0	8,739	58,216	113,895
Minnesota	54.5	3,647	84,068	126,879
Mississippi	26.0	2,344	47,716	65,525
Missouri	50.0	4,625	69,686	114,285
Montana	15.0	693	147,138	75,747
Nebraska	26.0	1,439	77,227	103,374
Nevada	6.0	449	110,540	46,798
New Hampshire	4.0	702	9,304	14,613
New Jersey	59.0	7,093	7,836	33,183
New Mexico	12.0	1,006	121,666	66,350
New York	176.5	18,078	49,576	102,292
North Carolina	43.0	5,122	52,712	84,219
North Dakota	29.0	627	70,665	107,163
Ohio	67.5	10,588	41,222	108,049
Oklahoma	23.0	2,520	69,919	106,955
Oregon	15.0	2,008	96,981	88,329
Pennsylvania	102.5	11,728	45,333	113,166
Rhode Island	12.0	914	1,214	4,883
South Carolina	11.5	2,664	31,055	58,766
South Dakota	61.0	656	77,047	83,941
Tennessee	23.0	3,975	42,244	77,182
Texas	88.0	10,977	267,339	237,769
Utah	27.0	1,034	84,916	38,684
Vermont	7.0	425	9,609	14,109
Virginia	50.0	4,595	40,815	59,781
Washington	53.5	3,276	68,192	72,424
West Virginia	21.0	1,802	24,181	35,700
Wisconsin	21.0	4,221	56,154	101,295
Wyoming	8.0	315	97,914	78,461

NUMBERS OF ROAD RESEARCH PROJECTS IN THE U.S.

HRP - JANUARY 1969 (CODE 43)

Table III

TOTALS 1968	COUNTRIES	PER 1 MILLION POPULATION	PER 1000 SQ. MILES	PER 1000 ROAD MILES
A. 321.0	California	16.63	2.02	1.97
176.5	New York	9.76	3.56	1.72
128.5	Illinois	11.69	2.27	1.00
102.5	Pennsylvania	8.82	2.28	0.91
B. 92.0	Indiana	18.18	2.53	1.01
88.0	Texas	8.02	0.32	0.37
71.5	Massachusetts	13.07	8.65	2.59
69.0	Michigan	7.89	1.18	0.60
67.5	Ohio	6.37	1.63	0.62
61.0	South Dakota	93.84	0.79	0.72
59.0	New Jersey	8.32	7.52	1.77
56.0	Iowa	20.21	0.99	0.49
54.5	Minnesota	14.93	0.64	0.42
53.5	Washington (State)	16.31	0.78	0.73
50.0	Missouri	10.82	0.71	0.43
50.0	Virginia	10.89	1.22	0.83
C. 46.5	Louisiana	12.50	0.95	0.89
43.0	Alabama	11.94	0.81	0.55
43.0	North Carolina	8.39	0.81	0.51
42.0	Kentucky	13.04	1.03	0.59
38.0	Connecticut	13.34	7.88	7.19
34.0	Colorado	16.66	0.32	0.41
34.0	Maryland	9.06	3.21	1.32
30.0	Florida	4.87	0.51	0.36
29.0	North Dakota	46.03	0.41	0.27
27.0	Utah	26.21	0.31	0.69
26.0	Mississippi	9.40	0.46	0.33
26.0	Nebraska	18.05	0.33	0.25
24.0	Kansas	10.48	0.29	0.18

Continued

## NUMBERS OF ROAD RESEARCH PROJECTS IN THE U.S.

HRP - JANUARY 1969 (CODE 43)

Table III

TOTALS 1968	COUNTRIES	PER 1 MILLION POPULATION	PER 1000 SQ. MILES	PER 1000 ROAD MILES
C.	Tennessee	5.79	0.54	0.29
	Oklahoma	9.12	0.32	0.21
	West Virginia	11.66	0.86	0.58
	Wisconsin	4.97	0.37	0.20
	Idaho	28.57	0.23	0.27
D.	District of Columbia	23.45	271.42	17.59
	Maine	17.52	0.51	0.79
	Arizona	9.03	0.13	0.36
	Montana	21.73	0.10	0.19
	Oregon	7.50	0.15	0.16
	Delaware	24.52	6.31	2.69
	Georgia	2.95	0.22	0.13
	Rhode Island	13.18	9.91	2.45
	New Mexico	12.00	0.09	0.18
	South Carolina	4.32	0.37	0.19
	Arkansas	5.05	0.18	0.12
	Wyoming	9.40	0.46	0.33
	Vermont	16.66	0.72	0.49
	Alaska	22.22	0.01	0.91
	Nevada	13.33	0.05	0.12
	Hawaii	7.69	0.93	1.76
	New Hampshire	5.71	0.43	0.27
TOTAL\$	Average	15.06	6.83	1.07

OVERALL RATING OF THE STATES IN THE U.S.

District of Columbia	232.46
South Dakota	95.35
North Dakota	46.71
Delaware	33.54
Idaho	29.07
Connecticut	28.41
Utah	27.21
Rhode Island	25.54
Massachusetts	24.31
Alaska	23.14
AVERAGE	22.96
Montana	22.02
Indiana	21.72
Iowa	21.69
California	20.62
Maine	18.82
Nebraska	18.63
Vermont	17.87
Washington State	17.82
New Jersey	17.61
Colorado	17.39
Minnesota	15.99
New York	15.04
Illinois	14.96
Kentucky	14.66
Louisiana	14.04
Maryland	13.59
Nevada	13.52
Alabama	13.30
West Virginia	13.10
Virginia	12.94
New Mexico	12.27
Pennsylvania	12.10
Missouri	11.96
Kansas	10.95
Hawaii	10.38
Mississippi	10.19
Wyoming	10.19
North Carolina	9.71
Michigan	9.67
Oklahoma	9.65
Arizona	9.52
Texas	8.71
Ohio	8.62
Oregon	7.81
Tennessee	6.62
New Hampshire	6.41
Florida	5.74
Wisconsin	5.54
Arkansas	5.35
South Carolina	4.88
Georgia	3.30

It happens that the 10 front-runners on this list are also those whose overall rating is above the national average for this rating. Quite significantly, several of these winners are among the smallest states in the nation; Delaware for example, rises above its minute dimensions with only a comparatively small number of projects; the evenness of its performance almost makes it equal the feat of the District of Columbia, which ranks above the national average on each of the three separate counts.

The two Dakotas offer an interesting comparison, because of their closeness in location, combined with similar areas and populations. A closer look at the figures indicates that, although its road network is one quarter larger, the North has produced only one half as many projects as the South; the rating of the North is still among the best, but the one of the South is second only to the District of Columbia in all the United States. Is this a case for judging local progress in terms of "researchmindedness?"

In Table V the research projects accomplished in the 51 units have been broken down into the four main categories of agencies, namely the local "highway department" (uniformly named this way regardless of the varying local designations); the "other local (or closely regional) government" agencies; the universities, colleges and related or similar agencies which we call "educational institutions;" finally the quite varied agencies whose non-official character puts them in the category we call "private." This last sector excludes even the privately-owned educational organizations, but includes all the other remaining ones, whether non-profit or else business entities, consultants, researchers, industries, such as industrial research associations, foundations, et al.

On the same table we have inserted, for the researchers' convenience, the number of Bureau of Public Roads sponsorships, the number of agencies of all kinds, and finally the often large number of projects of a national character which we kept out of our statewide, strictly "localized," listing. A word of caution is here in order: the numbers of agencies cannot be added up in the end, because many of them necessarily overlap beyond the borders of the separate states. This number of active (code 43) agencies, when viewed separately for each state, reveals the size of the overall base of its operations and the tempo of its activities; Illinois, Pennsylvania and, of course California, are good examples. It also has, when in the large numbers, the inconvenience of much scattering, therefore of cohesion difficulties.

The National list, whose meaning was explained in the Introduction, is of considerable weight (over 1/5) in the overall picture. It comprises, of course, no Highway Department as such, since all of these are strictly local; the federal Bureau of Public Roads takes here its legitimate place, but limited to the projects which it actually does-and-sponsors, all in one operation; its sponsoring impact is visible in the first column at the left. At the risk of being repetitious, let us underline once more that the figures used in this study are basically the various counts of "research agencies," that is, the "doers" which the HRIS lists under the code number 43 (the suffix in the 10-digit classifications of the projects); the sponsoring code number is 45.

Table V

## LOCAL COUNT OF RESEARCH PROJECTS BY STATES

IN ALPHABETICAL ORDER (CODE 43)

STATES	1 (CODE 45) BPR	2 HWY. DEPT.	3 OTHER LOCAL GOVERNMENTS	4 EDUCATIONAL	5 PRIVATE	(2 to 5) TOTAL (43)	AGENCIES (43)	ITEMS SWITCHED TO NATIONAL
Alabama	29.0	6.0	5.0	30.0	2.0	43.0	7.0	2.0
Alaska	5.0	3.5	2.5	--	--	6.0	3.0	--
Arizona	9.0	3.0	5.0	4.0	3.0	15.0	8.0	--
Arkansas	9.0	3.0	--	7.0	--	10.0	3.0	--
California	191.0	142.0	25.0	136.5	17.5	321.0	33.0	62.0
Colorado	17.0	11.0	--	22.5	0.5	34.0	5.0	65.0
Connecticut	28.0	32.5	1.0	--	4.5	38.0	7.0	15.0
Delaware	5.0	10.0	2.0	--	1.0	13.0	4.0	--
D.C. (Local)	8.0	10.0	5.0	2.5	1.5	19.0	10.0	--
Florida	18.0	20.5	0.5	8.5	0.5	30.0	6.0	--
Georgia	10.0	4.5	0.5	7.0	0.5	12.5	6.0	--
Hawaii	1.0	3.0	2.0	1.0	--	6.0	3.0	1.0
Idaho	4.0	13.0	2.0	5.0	--	20.0	4.0	--
Illinois	55.0	26.0	10.0	88.0	4.5	128.5	18.0	54.0
Indiana	36.0	11.0	19.5	61.5	--	92.0	8.0	2.0
Iowa	8.0	22.0	3.0	28.5	2.5	56.0	7.0	1.0
Kansas	15.0	13.5	1.5	9.0	--	24.0	4.0	--
Kentucky	28.0	28.5	0.5	11.0	2.0	42.0	4.0	--
Louisiana	46.0	26.0	2.0	18.0	0.5	46.5	6.0	--
Maine	12.0	12.5	3.0	1.5	--	17.0	4.0	--
Maryland	30.0	19.5	0.5	7.5	6.5	34.0	10.0	43.0
Massachusetts	19.0	12.0	2.0	49.5	8.0	71.5	18.0	16.0
Michigan	28.0	35.0	4.0	24.0	6.0	69.0	10.0	6.0
Minnesota	20.0	35.5	3.0	14.5	1.5	54.5	6.0	1.0
Mississippi	26.0	7.5	3.0	15.5	--	26.0	4.0	9.0
Missouri	26.0	23.0	1.0	14.5	11.5	50.0	9.0	5.0
Montana	10.0	4.0	1.0	10.0	--	15.0	5.0	--
Nebraska	12.0	21.5	--	4.5	--	26.0	2.0	--
Nevada	2.0	2.0	--	4.0	--	6.0	2.0	--
New Hampshire	1.0	1.0	3.0	--	--	4.0	3.0	19.0
New Jersey	13.0	33.0	6.0	20.0	--	59.0	11.0	3.0
New Mexico	6.0	7.0	1.0	4.0	0.0	12.0	3.0	1.0
New York	79.0	56.5	24.0	81.0	15.0	176.5	26.0	34.0

14

Continued



Continued

Table V

LOCAL COUNT OF RESEARCH PROJECTS BY STATES

IN ALPHABETICAL ORDER (CODE 43)

STATES	1 (CODE 45) BPR	2 HWY. DEPT.	3 OTHER LOCAL GOVERNMENTS	4 EDUCATIONAL	5 PRIVATE	(2 to 5) TOTAL 43	AGENCIES (43)	ITEMS SWITCHED TO NATIONAL
North Carolina	35.0	5.0	0.5	34.5	3.0	43.0	6.0	2.0
North Dakota	11.0	18.0	1.0	9.0	1.0	29.0	4.0	--
Ohio	58.0	24.0	3.0	36.5	4.0	67.5	13.0	13.0
Oklahoma	17.0	14.0	5.0	4.0	--	23.0	5.0	1.0
Oregon	5.0	4.5	0.5	10.0	--	15.0	4.0	--
Pennsylvania	38.0	22.0	4.0	55.5	21.0	102.5	24.0	16.0
Rhode Island	7.0	3.0	2.0	7.0	0.0	12.0	5.0	1.0
South Carolina	6.0	2.0	2.0	7.0	0.5	11.5	6.0	--
South Dakota	39.0	30.0	2.0	29.0	--	61.0	5.0	1.0
Tennessee	2.0	--	17.0	6.0	--	23.0	8.0	--
Texas	63.0	3.0	2.0	78.0	5.0	88.0	10.0	23.0
Utah	17.0	19.0	--	8.0	--	27.0	3.0	2.0
Vermont	4.0	3.0	1.0	3.0	--	7.0	3.0	--
Virginia	30.0	2.0	36.0	11.0	1.0	50.0	6.0	20.0
Washington(State)	17.0	8.0	25.0	20.0	0.5	53.5	7.0	4.0
West Virginia	9.0	2.0	1.0	18.0	--	21.0	3.0	--
Wisconsin	6.0	6.0	2.0	13.0	0.0	21.0	5.0	--
Wyoming	7.0	4.0	2.0	2.0	--	8.0	4.0	1.0
<b>Total Local</b>	<b>1177.0</b>	<b>828.5</b>	<b>244.5</b>	<b>1042.0</b>	<b>125.0</b>	<b>2242.0</b>		
<b>State Mean</b>	<b>24.0</b>	<b>17.0</b>	<b>5.0</b>	<b>21.0</b>	<b>3.0</b>	<b>46.0</b>		
<b>Puerto Rico</b>	<b>2.0</b>	<b>2.0</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>2.0</b>	<b>1.0</b>	<b>--</b>
<b>National List</b>	<b>--</b>	<b>BPR Self 86.0</b>	<b>259.0</b>	<b>68.0</b>	<b>166.0</b>	<b>579.0</b>		
<b>Overall Total</b>	<b>--</b>	<b>916.5</b>	<b>503.5</b>	<b>1110.0</b>	<b>291.0</b>	<b>2821.0</b>		

Among the 269 items (again code 43 only) in the "government" column (which, for the national list, is of course non-local), practically all are Federal Departments, with their numerous subdivisions and appendices. The biggest one is Defense, with some 90 items, followed closely by Interior with over 80 (mostly Reclamation); Bureau of Agriculture, close to 30 (mostly soils); Commerce, about 50 (essentially Bureau of Standards); the balance going to HEW, Transportation (outside of the Bureau of Public Roads) and minor entities, including five by the Highway Research Board itself, which we put in this category for the sake of simplification. We "localized" most of the Geological Survey items, because of their necessarily local nature.

The 68 national items under "educational" are so few because they only include work done for the National Defense and business associations of a clearly national character.

The "private" sector is subdivided into three almost equal categories: The consultants (with non-industrial research agencies and laboratories), the industries (including their associations and other businesses for profit), and finally the non-profit institutes, councils, foundations and societies.

An odd phenomenon is the International list, whose small contents could not be put in any other place. It covers nine projects only, done (and partly sponsored) in this country by diverse agencies, for the account of two international associations and a half-dozen foreign governments. We have left them out of our count.

Back on the local scene, U.S.A., it is as difficult to appraise the performance of a local highway department as it is to measure the one of a whole state. In the local case, some highway departments choose to sponsor research rather than doing it themselves, shying away from the notion that those who plan, design and build the roads must know best. Some states do both the doing and the paying, the most dynamic ones handling both methods on a large scale. Of this maximum approach California, by far the biggest of them all, is the prototype. In the next-ranking state, New York, appears already the vigorous prominence of the educational, but without any weakening of the highway department. In a tight group come next Michigan, Minnesota and New Jersey, our own state being the fifth in the line, ahead of Connecticut and South Dakota.

A big state, huddling around a huge metropolis, naturally has severe traffic problems; when the big city extends its tentacles far out, there are suburban, satellite and regional problems of transportation that generate researches in association with neighboring communities. These make up the majority of the column "other local government" in our table. California, Indiana, Illinois and New York are in this position. Virginia's Highway Research Council, since it is distinct from the highway department, appears in this column. Tennessee has a peculiar situation with its TVA Authority, which does two-thirds of the local road research; so has Washington State, where the local Motor Vehicles Bureau does half of all the highway research in the state — three times as much as as the local highway department.

The educational sector, as the table shows, is as active, in terms of code-43 projects, as all the local governments (including the highway departments) put together. This is of course because local governments have asked for their assistance and have

instructed them about it; they have scientific equipment and personnel, they relieve the highway departments of much expenditure and worry. At the same time this kind of work helps to build up the technical departments of the higher schools, making it all an association for mutual benefit.

The importance of the colleges and universities in highway research has become so important, that in New York and Ohio it does half again as much work as the quite active highway departments; in Colorado, Mississippi, Pennsylvania (nine agencies) and Wisconsin (and in many smaller states), their effort doubles the highway's; in Washington State it is two-and-one-half times, in Illinois three-and-one-half, in Massachusetts four (by eight agencies), Alabama five, Indiana five-and-one-half, North Carolina seven, West Virginia nine times the local highway departments production. The case of Texas is special, because an association in a specialized institute permits the highway department to remain in the background. A similar situation exists in the very effective, though somewhat different, set-up adopted by Virginia with its Highway Research Council. Some universities, such as Purdue and Cornell (Aeronautical Lab.) are outstanding whereas in other states, such as Connecticut and Delaware, the educational sector seems surprisingly inactive in our field.

There are more "private" agencies on the national list than on the local ones, because so many consultants and similar organizations work for national, non-local purposes, at the behest of the Federal Government. They happen to conglomerate by preference in such states as California, Pennsylvania, New York and Missouri, where they also do work on local projects. This includes industrial groups and non-profit institutions, as mentioned already in the discussion of the national list.

The characteristics of the local operation in our own State of New Jersey are described below.

#### THE STATE OF NEW JERSEY

The total of separate items listed by HRIS under code number 43 for the State of New Jersey and relevant to this study is 59. The New Jersey Department of Transportation is involved in 33 of these, including one by the Division of Traffic Engineering. Of these 33 research projects, the Division of Research and Evaluation did 31 all by itself and sponsored one each done by Rutgers University and Stevens Institute.

Altogether four educational institutions established in the state have done substantial road research, mostly outside of any intervention of the N.J.D.T. Rutgers did eight projects with its own funds and six more, for which they obtained or expect financing from third parties: two from the National Science Foundation, one each from the U.S. Interior Department, the U.S. Agriculture Department, the N.J.D.T. (mentioned above), and one from a group of six miscellaneous sponsors. Stevens' six projects were all financed by third parties: two by the National Bureau of Standards, two by the U.S. Housing and Urban Development Department, one by the U.S. Health, Education and Welfare Department, and the last one by the New Jersey Department of Transportation (quoted above). The College of Engineering of Newark

reported one, sponsored by the U.S. Health, Education and Welfare Department. Finally, Princeton participated in a small way, with six others, in the financing of one of the Rutgers' jobs (see above).

In the "other governmental" sector, the townships and cities of Woodbridge, New Brunswick and Jersey City, the New Jersey Departments of Health and of Education, and three regional groupings were responsible for or participated in seven other items.

In the "private" sector, Products Research Corporation of Gloucester, New Jersey, sponsored one project performed by the highway department of the neighboring State of Delaware.

As we have seen in the comparative discussion of the activities in the various states of the Union, some of them like to farm out all or most of the required work of research; others prefer to concentrate on direct operations by their highway departments. Some of the most effective ones belong to the latter group, including New Jersey: although this state is not among the largest, its Department of Transportation is the fifth in the country among the self-doing ones, by number of research projects.

The high activity of the state was supported by a large group of sponsors lead by the Bureau of Public Roads, which largely financed 13 of the projects of the New Jersey Department of Transportation, including the one executed by Rutgers University. Besides the Bureau of Public Roads, other sections of the U. S. Department of Transportation assumed a share of this statewide effort (outside of the projects of the New Jersey Department of Transportation), as did the U.S. Departments of Agriculture, Interior, Health, Education and Welfare, Housing and Urban Development, the National Bureau of Standards and the National Science Foundation. Several neighboring or regional organizations also took part, the whole group of outside sponsors covering some or most of the expenditure of 15 projects.

The positions and performances of the several states of the Union have been compared in our several tables. The figures concerning New Jersey are repeated hereafter, as a conclusion to the foregoing description of the highway research activities within the state:

		<u>Rank of New Jersey</u>
Number of research projects, as reported in the HRIP - January, 1969 report (code 43)	59	the 11th state
Population (1968 estimate)	7.0 million	the 8th state
Area (1960 figure)	7.836 sq. mi.	the 46th state
Road mileage (all types, as of December 1968)	33,183 miles	the 39th state

Number of research projects:		<u>Rank of New Jersey</u>
per million of population	8.32	the 40th state
per 1000 sq. mi. of area	7.52	the 5th state
per 1000 miles of roads	1.77	the 7th state

The concluding page of our annual report for the fiscal year 1967/68 contained some essential facts on the special position of New Jersey in the Road-and-Traffic picture of the U. S. It is reprinted at the end of this chapter.

The subjects of the projects done or sponsored by the New Jersey Department of Transportation have been classified and summarized in Table VI. It indicates a dual preoccupation with the problems of materials and those of traffic, altogether covering a broad field of highway research.

It may be of interest to also define briefly the subjects chosen by the two educational agencies of outstanding activity in our domain in this state. Rutgers specialized in materials, particularly soils and connected themes:

stress vs. loading in soils  
 soil stabilization by additives  
 shale in engineering

suburban hydrology  
 drainage performance

frost action, general  
 frost action in soils  
 pressure vs. temperature in freezing

The State University did not handle any traffic on land, but several more subjects related to design and construction:

behavior of PCC  
 internal friction in PCC  
 cracking in PCC

turfgrasses  
 economic benefits from scenic enhancement (for New Jersey Department  
 of Transportation)

aircraft in suburban transportation (for a regional group of six sponsors)

Stevens concentrated on vehicles:

auto stability  
 stability of trailers  
 skid tester-trailer (for New Jersey Department of Transportation)  
 tire performance  
 tire use

All the other projects, done by many others outside of the New Jersey Department of Transportation, concerned traffic and related, but widely scattered, subjects.

Table VI

Highway Research in Progress - January 1969 (HRIS)

New Jersey Department of Transportation

Division of Research &amp; Evaluation

Number of Projects by HRIS Technical Subjects

Subject	Area	Group	43/45	45	Total	BPR	%
Transportation Economics	15	A		*1	1	1	6
Urban Community Values	82	"	1		1		
Highway Safety	51	B	4		4	1	43
Road user Characteristics	52	C	1		1		
Traffic control & operations	53	"	6		7	3	
Traffic measurements	55	"	3		3	2	
Highway Design	22	D	1		1	1	
Pavement Design	25	"	1		1		
Pavement Performance	26	"	8	**1	9	3	
Highway Drainage	23	E	1		1		
Bridge Design	27	"	2		2		51
Construction	33	G	1		1	1	
Materials, general	34	"	1		1	1	
Maintenance, general	40	"	2		2		

\* Done by Rutgers University (Beautification Benefits) (BPR)

\*\* Done by Stevens Institute (Skid Truck &amp; Trailer) (Not BPR)

BPR Sponsored by U.S. Bureau of Public Roads

43/45 Self-conducted &amp; self-sponsored

45 Self-sponsored but conducted outside

WHAT YOU DON'T KNOW ABOUT US WOULD FILL A POSTER

N E W J E R S E Y

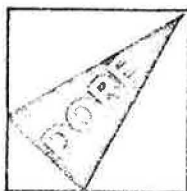
IS THE MOST DENSELY POPULATED STATE IN THE COUNTRY.

IT HAS . . . THE MOST DENSELY POPULATED MUNICIPALITY IN THE COUNTRY  
. . . THE MOST TRAFFIC PER MILE OF ROAD  
. . . THE HIGHEST MOTOR VEHICLE REGISTRATION PER AREA  
. . . THE LARGEST ROAD MILEAGE PER AREA.

IT ALSO HAS . . . THE SMALLEST TOTAL ROAD MILEAGE PER PERSON  
. . . THE SMALLEST AMOUNT OF FEDERAL FUNDS PER PERSON.

IT IS LOGICAL, THEREFORE, TO EXPECT MANY PROBLEMS TO APPEAR  
IN N E W J E R S E Y FIRST - IN THEIR MOST ACUTE FORM.

THIS MAKES RESEARCH A NECESSITY



## O U T S I D E W O R L D

BEYOND THE HORIZON: INTERPRETATION OF THE OVERALL PICTURE

The grand total here reviewed is less than half of mankind, in terms of population. Neither HRIS nor IRF were able to report with accuracy on any of the communist countries (excepting Poland, covered by IRF); and, naturally, the numerous underdeveloped or under-organized countries are not mentioned at all. But from the standpoint of road mileage of automobile roads and mechanized traffic and road research, we can safely assume that the data which we used include the vast majority of what matters.

As we already indicated, the reports of the HRIS and the IRF are closely parallel, but not entirely identical. The IRF was able to include in its book a number of new projects that the computerized operation of HRIS could not catch in time, and IRF obtained information from Poland and India which did not reach HRIS at the same time. IRF derives most of its data from the International Road Research Documentation (IRRD), a mostly European cooperative organization under the auspices of the OECD, whose membership of 14 countries is essentially based on the Common Market (less Italy), flanked by three Scandinavian nations in the north and two Iberian ones in the south, plus three marginal ones: Eire, Austria and Switzerland.

Our work on the big book of the IRF, after we had already spent much time on the three books of the HRIP (HRIS), confirmed our finding that nowhere is the real operational basis of highway research as complete and clear-cut as it ought to be. The detailed explanations given by IRF illustrate the enormous difficulties encountered in assembling an accurate picture in such a variegated field of human activity. Of 39 reviewed countries only eleven furnished completely balanced data, in spite of the complexity of their arrangements; even in the superbly organized U. K., such a balance was not achieved. Five countries did not send in their revised programs (Bolivia, Denmark, Greece, Israel, Nigeria) and the Netherlands updated only part of theirs.

The active projects put out by the 39 foreign countries have been grouped in Table VII, similar to Table III in the chapter on the U. S.; we have also plotted them on a map of the world. In Table VII, the total per country are lined up, this time by order of magnitude, in three classes: the nations with over 100 items, those with more than 20, and the smaller ones. In order to bring out the relative significance of the 39 performances we have again developed their ratings in relation to population, to area and to mileage of roads. In each of these three columns, the champions are underlined; some of them are as surprising as some of the states of the U. S. At the bottom of the table's second page we have inserted our overall rating, i.e., the sum total of the three detail ratings, again by order of magnitude, grouped around the general average. A comparison of the positions of the several countries with the averages in the four ratings, reveals that five countries only are above those averages on all four counts: The United Kingdom, Japan, West Germany, Switzerland and Lebanon.



Table VII

## NUMBERS OF ACTIVE (IRF) ROAD RESEARCH PROJECTS OUTSIDE OF THE U.S.

TOTALS 1968	COUNTRIES	PER 1 MILLION POPULATION	PER 1000SQ. MI.	PER 1000 ROAD MILES
A. 489	United Kingdom	8.94	5.20	2.26
402	Japan	4.06	<u>2.81</u>	4.37
328	Germany (w)	5.49	3.42	3.35
294	Canada	14.70	0.12	0.66
265	France	5.34	1.24	0.54
260	Australia	2.22	0.88	0.49
160	India	0.33	0.13	0.29
B. 98	Sweden	12.56	0.57	1.63
88	Spain	2.75	0.45	1.06
78	South Africa	4.26	0.17	2.44
77	Switzerland	12.83	4.81	7.00
60	New Zealand	<u>22.22</u>	0.58	<u>1.03</u>
51	Denmark	(10.63)	(3.19)	(1.34)
45	Italy	0.85	0.39	0.27
41	Finland	0.87	0.32	0.95
39	Argentina	1.71	0.04	0.11
39	Mexico	0.88	0.05	1.08
39	Poland	1.23	0.32	0.20
34	Pakistan	0.32	0.09	0.48
32	Ireland (Eire)	11.03	1.19	0.60
32	Venezuela	3.48	0.09	1.78
30	(Netherlands)	(2.40)	(1.88)	(1.03)
26	Brazil	0.31	0.01	0.08
25	Norway	6.58	0.20	0.61
C. 19	Turkey	0.58	0.06	1.19
16	Ceylon	1.39	0.64	1.45
15	Nigeria	(0.26)	(0.04)	(0.30)
15	Peru	(1.17)	(0.03)	(0.56)
14	Lebanon	5.83	3.50	7.00
12	Chile	1.30	0.04	<u>0.34</u>
11	Greece	(1.28)	(0.22)	(0.46)
11	Thailand	0.35	0.06	1.83

Continued

Continued

Table VI I

NUMBERS OF ACTIVE (IRF) ROAD RESEARCH PROJECTS OUTSIDE OF THE U.S.

TOTALS 1968	COUNTRIES	PER 1 MILLION POPULATION	PER 1000 SQ. MILES.	PER 1000 ROAD MILES	
C. 10	Portugal	1.09	0.28	0.56	
9	Israel	(3.46)	(1.13)	(4.50)	
5	Austria	0.68	0.16	0.25	
5	Belgium	0.53	0.42	0.71	
3	Colombia	0.16	0.01	0.12	
2	Bolivia	(0.49)	(0.01)	(0.20)	
2	Philippines	0.06	0.02	0.06	
3181	Average Coefficients of 39 Countries	3.96	0.89	1.36	
<u>OVERALL RATING</u>					
Switzerland	24.64	South Africa	6.87	Poland	1.75
New Zealand	23.83	AVERAGE	6.21	Chile	1.68
United Kingdom	16.40	Venezuela	5.35	Belgium	1.66
Canada	15.48	Netherlands	5.31	Italy	1.51
Lebanon	15.33	Spain	4.26	Turkey	1.30
Denmark	15.16	Australia	3.59	Austria	1.09
Sweden	14.76	Ceylon	3.48	Pakistan	0.89
Ireland	12.82	Thailand	2.24	India	0.75
W. Germany	12.26	Finland	2.14	Bolivia	0.70
Japan	11.24	Mexico	2.01	Nigeria	0.60
Israel	9.90	Greece	1.96	Brazil	0.40
Norway	7.39	Portugal	1.93	Colombia	0.29
France	7.12	Argentina	1.86	Philippines	0.14
		Peru	1.76		



It is interesting to line up the achievements (numbers of research projects) of some of the main international groupings of nations, as a reflection on progress related to the general picture of power and influence:

<u>The Common Market</u>	<u>EFTA</u>	<u>British Commonwealth</u>	
Germany (W)	328	U. K.	489
France	265	Sweden	98
Italy	45	Switzerland	77
Benelux	<u>35</u>	Denmark	51
	673	Norway	25
		Portugal	10
		Austria	<u>5</u>
			755
		U. K.	489
		inner members:	
		Canada	294
		Australia	260
		New Zealand	<u>60</u>
			614
		outer members:	
		India	160
		South Africa	78
		Pakistan	34
		Ceylon	<u>16</u>
			<u>288</u>
			1391

The overall international activity in highway research clearly exceeds the one in the U.S. especially when we consider that in our international count we have included only the active projects; we have not been able to do this for the stateside operations. This is not surprising, since the total populations, areas and road-mileages are bigger than ours. While in many respects we are ahead of the others, their work is clearly worth observing, be it only for the different approach they bring to problems similar to our own. For one thing there is a subtle difference in the manners of thinking: the Europeans are more theoretically inclined, we are closer to practicality; one might say that they are more truly scientific, we are really more technical; they proceed more naturally from abstract calculations, we function more instinctively out of experiments. A combination of the two cannot help being highly fruitful. This is one reason among several why our looking beyond the horizon can be inspiring and productive.

In all this we cannot forget our most outstanding advantage, the one being a true UNION. Although we are a federation of 50 partly self-governing countries, our cohesion gives us levers of action and achievement the others cannot even dream of. The nations listed in this study are all totally separate, in real isolation despite their many contacts; each one of them has to solve its own problems with the means available at home. Technically, their cooperation fortunately is growing, but they do not have our magic BPR. Their achievements have considerable merit.

In Table VIII the figures on the U.S. confront those of the foreign field. They all give complete totals, excepting the last line: for the U.S., the averages per state could not include the items that were specially classified as "the national list;" if we did spread that list evenly among the states, the state average would rise from 46 to to 55.3 items, which compares with 81.5 abroad. However, as was

Table VII I

## COUNT OF RESEARCH PROJECTS BY COUNTRIES

IN ALPHABETICAL ORDER - BASED ON IRF - 1968

COUNTRIES	HWY. DEPT.	OTHER GOVERNMENTS	EDUCATIONAL	PRIVATE	TOTAL	NUMBER OF AGENCIES
Argentina	22	--	13	4	39	11
Australia	125	21	113	1	260	39
Austria	--	--	5	--	5	1
Belgium	--	5	--	--	5	1
Bolivia *	--	--	2	--	2	2
Brazil	15	1	10	--	26	20
Canada	59	71	126	38	294	50
Ceylon	6	7	--	3	16	5
Chile	8	--	4	--	12	3
Colombia	1	1	1	--	3	3
Denmark *	17	0	13	21	51	4
Finland	20	11	10	--	41	6
France	165	35	14	51	265	25
Germany (W)	34	30	207	57	328	105
Greece *	2	4	4	1	11	5
India	99	42	19	--	160	16
Ireland (Eire)	--	21	11	--	32	8
Israel *	--	--	9	--	9	2
Italy	3	7	33	2	45	18
Japan	13	180	195	14	402	37
Lebanon	4	--	9	1	14	3
Mexico	11	1	26	1	39	8
Netherlands **	--	--	14	16	30	6
New Zealand	38	8	13	1	60	13
Nigeria *	8	1	4	2	15	5
Norway	19	1	--	5	25	6
Pakistan	25	1	8	--	34	11
Peru	4	--	11	--	15	5
Phillipines	2	--	--	--	2	1
Poland	34	--	5	--	39	5
Portugal	--	10	--	--	10	2
South Africa	38	20	18	2	78	19
Spain	56	32	--	--	88	7
Sweden	61	13	19	5	98	21
Switzerland	--	13	39	25	77	32
Thailand	6	2	3	--	11	4
Turkey	14	--	5	--	19	3
United Kingdom	141	61	144	143	489	106
Venezuela	8	1	23	--	32	8

CONTINUED

Table VII I

CONTINUED

COUNT OF RESEARCH PROJECTS BY COUNTRIES  
IN ALPHABETICAL ORDER - BASED ON IRF - 1968

COUNTRIES	HWY. DEPT.	OTHER GOVERNMENTS	EDUCATIONAL	PRIVATE	TOTAL	NUMBER OF AGENCIES
Totals: Foreign	1058	600	1130	393	3181	626
U.S.	916.5	503.5	1110	291	2821	
Percent: Foreign	33.3	18.9	35.5	12.3	100	100
U.S.	32.5	17.8	39.3	10.4	100	
Average Totals =						
39 Foreign Countries	27.2	15.4	28.9	10.0	81.5	46 ***
51 U.S. States	17	5.	21	3	46	

\*Report not updated.

\*\*Updating incomplete.

\*\*\*Total average per State is 51.3 when "National" list is evenly apportioned.

mentioned before, the non-active items could not be eliminated in the U.S. count, which therefore put us in a position of special advantage. For the foreign countries, the IRF listed a gross of slightly over 5000 items; we used only the 3181 active-and-future ones.

There is a striking similarity in proportions between the two lists, those of the U.S. and the rest of the world, indicating beyond any doubt that some general laws work uniformly all over the map. There is even — curiously enough — one giant in each team: both California and the United Kingdom do between 11 and 15 percent of the research of their almost-half of the work of the world. We might add that, in our impression, the British Road Research Laboratory is probably, at the present time, the foremost institution of this kind around the globe.

The number of agencies is a significant figure: the more advanced an area is the greater will be the number of participants in the research effort. Yet, some countries are more centralized than others, even in the higher statistical brackets; some also make a better use of their educational institutions for constructive purposes. It is to be remembered that in most foreign countries road research is overwhelmingly financed or backed by public funds; besides the fact that the nations cannot even out that effort between neighbors or associates as we do between the states, they control and subsidize their schools often more directly, using various budgets for more flexible financing, as is the case over here.

It will not do to add up the total number of agencies in the U.S., because the different theatres interpenetrate directly and the agencies, therefore, frequently overlap. For the other countries we were able to develop a total; just as an impression, it seems proportionately larger than ours. A special difficulty arose from the fact that five countries did not update their reports to the IRF and one other filed incomplete data. In order not to forego the possibility of calculating the totals, the averages and the ratings for the global picture, we had to decide to use the complete figures for those six locations, disregarding the probable inclusion of outdated items; this will probably not appreciably change the conclusions. One further trouble came from the different organizational habits of many overseas countries: they handle materials and geometrics in what can be called a highway department, while traffic and safety problems are in the hands of separate departments; we have tried as much as possible to add up the two activities under the heading of Highway Department, for easier comparison with the U. S.

COMMENTS ON THE COUNTRIES

The tables contain the essential characteristics; our remarks, therefore, can be few and brief.

- Argentina - While most of the research was done by provincial governments and the cement industry, the national government has increased its effort.
- Australia - Considerable growth of interest in research; the active projects have tripled; mostly state financing, work done by Research Board and universities; the largest of these has a Highway & Traffic Research Institute.
- Austria - Example of misleading statistics: 36 projects are listed, of which only five are active; these done by the state university; the cement industry also used to cooperate.
- Belgium - They have an active road research laboratory with which we have corresponded; we were therefore surprised upon discovering that only five items were active; the cement industry used to help.
- Brazil - One of the biggest developing countries, therefore, with the biggest resources for the future and the biggest problems for the present; 26 projects only active, out of 72 listed; provincial governments (states) do much of the work; we recently had visitors from the largest, i.e., Sao Paulo. They have serious climatic difficulties.
- Canada - Very much alive; 73 percent of the 405 projects listed are active or future, a quarter were recently started.
- Finland - Quite active recently, with a growing turnover of projects.
- France - Highly centralized, although many-branched, government organization, with streamlined controls; we have been in touch with their very active and well-organized Road Research Laboratory, whose highly competent staff produces exceedingly well done series of bulletins, probably the best in this field to date; overwhelming emphasis on geometrics and materials, because most of the traffic problems are handled by other agencies.
- Germany (W) - Less than one-fourth handled by government; 14 universities involved; many items handled by individuals and private groups, and private institutions.
- India - Significantly nothing done in the private sector of this "special brand of democratic socialism;" as is well known, their big trouble is the insufficiency of financial means to solve huge-size problems; therefore, operations are overwhelmingly governmental. Heavy rains, black cotton soils, are among the physical obstacles, not to mention the outsize human ones; highway research is highly appreciated, but mostly out of reach.



- Italy - From bibliographical material and quotations we know them to be up-to-date, and often original in their thinking, but from the evidence of this survey the official activity does not appear great; strong tendency to decentralize the research work to scholarly labs.
- Japan - The economical and technical miracle-nation of this generation (outside of the U.S.) is second only to the U.K.; also 22 percent larger than the third nation, Germany; scattering among 11 governmental agencies, 16 universities.
- Mexico - The number of projects has doubled since the 1966 report.
- Netherlands - Unfortunately, report material is not complete; they are quality people; I remember from extensive driving in pre-war Europe that the Amsterdam-the Hague freeway at that time appeared to be the finest in existence anywhere; those people are probably the most tenacious and experienced "re-makers of the land."
- New Zealand - Considerable growth of road research.
- Pakistan - Forty-five percent of the active projects concerned planning and economics, revealing the state of evolution of this new country.
- Poland - This is the first IRF survey of this country which, after crippling war damage, has made a remarkable recovery.
- Spain - Total centralization in four government departments is not surprising; but altogether considerable upsurge of research activity, superbly eclectic, sophisticated and up-to-date, with no signs of backwardness.
- Sweden - Moderate growth, but fairly high activity for their size; good impression of what looks like a fine Road Research Institute.
- Switzerland - Also relatively fair activity, closely related to their specific problems (tunnels, snow, etc.).
- United Kingdom - Their Road Research Laboratory at Harmondsworth is probably the model institution of this kind today; all by themselves they still listed 128 active projects at the end of 1968, not counting 13 more in other divisions of their Ministry of Transport; excellently balanced activity in all sectors, with high degrees of participation.

SUBJECT AREAS

For an easy glance at the current classifications of research subjects, we are reproducing on the next page the table of Areas and Area-Groups prepared by the HRIS. It is our Table IX. In another endeavor of simplification, we are condensing these areas still further into "Administrative," "Safety and Traffic," and "Structures and Materials;" these super-groups cover respectively the HRIS groups A, B & C; D through H.

The subject has been basically treated by the NCHRP in Report 55 by Tallamy & Smith, whose main objective was the systematic development of highway research programs. Table 8 of that report lines up, in percentage figures, two desirable distributions of research efforts which, again for the sake of simplicity, we are rearranging under the HRIS groupings reduced to our super-groups:

## Distribution in Percent

	HRB - 1959	HRIS - 1965	
A	29	14	administrative & planning
B & C	17	19	safety & traffic
D through H	54	67	structures & materials

Actual recent performances are summarized in the four tables that follow. Table X is the result of our own count of the technical areas of the projects included in the two volumes of the HRIP-1969, picking out the domestic projects only. Table XI is a reproduction of the summary of subject areas prepared by the IRF in their monumental 1968 report. Table XII is a count we made of the 86 projects done by the Bureau of Public Roads itself during that same period. Table XIII is a duplication of the operations of NJDT's own Division of Research & Evaluation in the chapter on New Jersey. (Table VI, Page 20.)

	<u>U. S.</u> <u>HRIP-1969/IRF-1968</u>	<u>Foreign</u> <u>IRF 1968</u>	<u>BPR's own</u> <u>HRIP-1969</u>	<u>NJDT's own</u> <u>1968/69</u>
A	17	9.5	7	3.1
B & C	20	23.6	28	43.7
D through H	63	66.9	75	53.2

Table IX

5. HRIS Current Awareness Service Subject Area Groups

Subject Area Group		Subject Areas
Group Letter	Area Number	Name
A	11	Transportation Administration
	12	Personnel Management
	13	Land Acquisition
	14	Transportation Finance
	15	Transportation Economics
	70	Legal Studies
	81	Urban Transportation Administration
	82	Urban Community Values
	83	Urban Land Use
	84	Urban Transportation Systems
B	90	Highway Research, General
	51	Highway Safety
C	52	Road User Characteristics
	53	Traffic Control and Operations
	54	Traffic Flow
	55	Traffic Measurements
D	21	Photogrammetry
	22	Highway Design
	24	Roadside Development
	25	Pavement Design
	26	Pavement Performance
E	23	Highway Drainage
	27	Bridge Design
F	31	Bituminous Materials & Mixes
	32	Cement and Concrete
G	33	Construction
	34	General Materials
	35	Mineral Aggregates
	40	Maintenance, General
	41	Construction & Maintenance Equipment
H	61	Exploration-Classification, Soils
	62	Foundations, Soils
	63	Mechanics, Earth Mass
	64	Soil Science

Table X

HIGHWAY RESEARCH IN PROGRESS - JANUARY 1969

NUMBERS OF PROJECTS IN THE U.S.  
BY GROUPS OF TECHNICAL SUBJECT AREAS (HRIS)

GROUPS	SUBJECT AREAS	NUMBER OF PROJECTS	%
A. Transportation Administration, Economics and urban problems	11, 12, 13, 14, 15, 70, 81, 82, 83, 84, and 90	400	17
B. Highway Safety	51	306	
C. Traffic and Road User Characteristics	52, 53, 54, and 55	399	20
D. Highway and Pavement Design and Performance	21, 22, 24, 25, and 26	320	
E. Drainage and Structures	23 and 27	362	
F. Bituminous and Concrete Materials	31 and 32	271	63
G. Construction and Maintenance	33, 34, 35, 40 and 41	374	
H. Soils and Foundations	61, 62, 63 and 64	401	
Totals		2833	100

35  
 Table XI  
 General Areas of Research  
 1968 Inventory

Country	Number of Projects by Areas of Research (Active and Inactive)								Total
	A Trans- portation adminis- tration, economics and urban problems	B Highway safety	C Traffic and road user charac- teristics	D Highway and pave- ment de- sign and perform- ance	E Drainage and struc- tures	F Bitumin- ous and concrete materials	G Construc- tion and mainten- ance	H Soils and foundations	
Argentina	3	-	4	9	2	28	15	20	81
Australia	45	28	58	48	37	31	44	58	349
Austria	4	8	9	4	-	-	4	7	36
Belgium	-	4	8	11	-	12	1	6	42
Bolivia	2	-	-	-	-	-	-	-	2
Brazil	2	-	2	11	7	16	8	26	72
Canada	22	14	46	60	43	56	75	89	405
Ceylon	3	-	1	2	2	4	5	3	20
Chile	5	-	-	2	7	19	7	10	50
Colombia	10	-	-	4	1	3	2	17	37
Denmark	5	4	5	9	-	23	4	1	51
Finland	11	14	19	11	3	7	13	18	96
France	19	21	66	35	21	111	74	114	461
Germany	39	22	112	108	29	88	71	32	501
Greece	2	-	1	1	-	4	-	3	11
India	16	7	5	15	23	52	11	66	195
Ireland	7	8	9	10	6	1	5	16	62
Israel	-	3	3	3	-	-	-	-	9
Italy	16	8	34	13	14	11	10	20	126
Japan	38	12	80	52	126	51	48	106	513
Lebanon	2	-	5	-	4	2	3	12	28
Luxembourg	-	-	-	-	-	-	-	-	-
Mexico	7	1	4	6	21	4	8	20	71
Netherlands	-	10	21	6	-	-	3	2	42
N. Zealand	7	9	19	13	12	6	15	8	89
Nigeria	5	-	1	-	3	1	1	4	15
Norway	26	5	8	7	1	-	8	10	65
Pakistan	14	-	4	3	13	3	11	8	56
Peru	-	-	-	2	-	5	2	6	15
Philippines	1	-	-	2	-	5	1	2	11
Poland	5	10	3	9	8	8	6	1	50
Portugal	4	-	-	8	5	6	1	7	31
S. Africa	13	12	19	21	9	13	12	37	136
Spain	15	18	24	23	14	34	12	21	161
Sweden	19	12	84	23	7	12	13	12	182
Switzerland	11	7	13	27	18	3	8	12	99
Thailand	7	1	1	1	6	-	5	6	27
Turkey	-	-	2	3	1	14	1	12	33
U. Kingdom	86	90	195	47	118	91	94	70	791
Venezuela	10	1	6	4	7	16	7	3	54
TOTAL	481	329	871	613	568	740	608	865	5,075
PERCENT	9.5	6.5	17.1	12.0	11.2	14.7	12.0	17.0	100.0
	9.5		23.6			66.9			

Table XIII

## Highway Research in Progress - January 1969 (HRIS)

New Jersey Department of Transportation

Division of Research &amp; Evaluation

Number of Projects by HRIS Technical Subjects

Subject	Area	Group	43/45	45	Total	BPR	%
Transportation Economics	15	A		*1	1	1	6
Urban Community Values	82	"	1		1		
Highway Safety	51	B	4		4	1	43
Road user Characteristics	52	C	1		1		
Traffic control & operations	53	"	6		7	3	
Traffic measurements	55	"	3		3	2	
Highway Design	22	D	1		1	1	
Pavement Design	25	"	1		1		
Pavement Performance	26	"	8	**1	9	3	
Highway Drainage	23	E	1		1		
Bridge Design	27	"	2		2		51
Construction	33	G	1		1	1	
Materials, general	34	"	1		1	1	
Maintenance, general	40	"	2		2		

\* Done by Rutgers University (Beautification Benefits) (BPR)

\*\* Done by Stevens Institute (Skid Truck &amp; Trailer) (Not BPR)

BPR Sponsored by U.S. Bureau of Public Roads

43/45 Self-conducted &amp; self-sponsored

45 Self-sponsored but conducted outside

For details on trends around the world, Table XI (by IRF) is recommended study. It will be noticed that it covers all the listed projects, over 5000 in number, many of which go very far back; our own analysis eliminated all but the active ones, retaining 62 percent. We have not tried to boil down the IRF table in similar fashion.

In comparison with the initial intentions of the HRB (1959), the first sector (administrative and planning), has been gradually whittled down, so much so that a reaction is to be expected. Brand-new countries cannot get under way without systematic planning, and the fully developed nations, like our own, will need more planning just to keep the effervescent activities in rational shape.

On the other two branches, which will always be the bulk of the work, the IRF says: "In general, where highways are still in an early stage as a means of transportation, research is concerned more with soils, materials and design; in countries where highways have been developed over a longer period of time, there is a greater emphasis on users of the highway and highway safety."

Actual average experience does not seem to confirm this very logical view of the IRF. True, there has been a surge of emphasis on safety and traffic, but of a slight size. It may be that in this country the enormous problems of design and construction arising from the Interstate Program have spearheaded a counter-offensive of soils and bridges, design and construction. But, here again, a reaction is to be expected when the Interstate System is completed, and danger continues growing with the ever-heavier traffic.

In the meantime, our own State of New Jersey can boast a good balance of emphasis between the two main areas of research, with perhaps the perspective of an increased activity in research for planning. New aspects of old problems and their endless refinements with the changing circumstances cannot be forgotten, just as throughout the country and all over the world the localized researches reflect the local preoccupations, derived from varied climates and resources.

Ireland, for example, studies the drainage of peatlands; India black-cotton soils and bamboo-soil; Japan aseismatic characteristics of structures and volcanic landslides; Brazil the influence of mica on soil characteristics; Mexico, seismic regionalization; Australia, the loss of water during compaction in arid areas; Nigeria, specifications for concrete in tropical climates; Canada, the unfrozen water content in soils, at temperatures below freezing, and the behavior of structures erected on permafrost... The list has no end, and the more the researcher digs, the more he uncovers additional problems. No wonder that there are so few research reports and papers that are final and conclusive.

#### SUGGESTIONS FOR THE HRIS

As we indicated at the outset, the raw material from which this analysis was derived is essentially a compilation of abstracts of separate research reports, arranged by the HRIS in such a way that complete bibliographies on technical subjects can be assembled with all possible ease and precision. In this respect the HRIP-January 1969 is a tool of invaluable importance.

On the other hand, the use we have made of it in this study has shown that the HRIP collection was not conceived for a statistical analysis of highway research operations. But the broad awareness which this kind of study provides also goes to show that it would be very useful to re-arrange future collections of the HRIP series (beginning perhaps with the one to be brought out in January 1971) in such a way that statistical studies could become easier as well as more precise.

We are fully aware of the monstrosity of the task already confronting the HRIS and of its meritorious achievement to date, but we firmly believe that a further effort should be made to develop the necessary improvements. As a wise man said long ago: "All things great are done with time, not in the instant," but we also have confidence in the unlimited possibilities of the nation that set foot on the moon and builds 40,000 miles of national superhighways in less than a generation.

Of course, the imperfections scattered throughout the three volumes of HRIP-January 1969 indicate that the first and most important thing to do is to gradually improve the reporting by the thousands of researchers involved. It goes without saying that, since this is a human and very complicated undertaking, 100 percent correctness cannot be expected; the absolute here is not even necessary, but something of the order of 90 percent precision and up-to-dateness should be quite possible, given a little time and persistence, so as to avoid distortions and over-simplifications.

At the same time our work has shown in all frankness that the identification-data that were assembled were not checked and put down with all the necessary care and the fullest usefulness and practicality for the user in mind. In complex situations, computerization produces truly meaningful pictures only when it is highly refined, if it is not to mislead by over-simplification. Hence, the need for much more sophisticated and painstaking programming and especially careful preparation of various codes and indexes, the keys to statistical studies.

As NCHRP Report 55 has indicated, a further expansion of the planning process, in the perspective of the National BPR Program of 1965, would be highly advantageous to all concerned. Our suggestions are akin to this view, with the purpose in mind to broaden the base of awareness of management by a more complete dissemination of the actual ramifications of the highway research process.