AIP STUDY OF MULTI-INSTITUTIONAL COLLABORATIONS: FINAL REPORT

HIGHLIGHTS AND PROJECT RECOMMENDATIONS

Joan Warnow-Blewett

Joel Genuth

Spencer R. Weart

AIP

Center for History of Physics • American Institute of Physics

One Physics Ellipse • College Park, MD 20740-3843

Tel: 301/209-3165 • Fax: 301/209-0882 • E-mail: chp@aip.org

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INTRODUCTION

The American Institute of Physics Study of Multi-Institutional Collaborations was launched in 1989 and completed this year. The study was initiated by the AIP Center for History of Physics because of the increasing importance of large-scale research projects and the many unknowns and complexities of documenting them. This is the first systematic examination of the organizational structures and functions of multi-institutional collaborations. We covered research projects involving three or more institutions in physics and related fields: high-energy physics (Phase I), space science and geophysics (Phase II), and ground-based astronomy, heavy-ion and nuclear physics, materials science, and medical physics (Phase III). For each discipline under study we had a Working Group of historians, archivists, sociologists, and—most important of all—distinguished scientists and science administrators. Our last Working Group reviewed and updated the contents of our final report.

Throughout the AIP Study, our field work consisted on the one hand of structured interviews with over 450 scientists who participated in nearly 60 collaborations selected to serve as our case studies, and on the other hand, of site visits to numerous archival and records management programs. The interviews provided data on organizational patterns, records creation and use, and the likely locations of valuable documentation. The archival site visits—to academia, federal science agencies, the National Archives, and elsewhere—provided data on existing records policies and practices and the likelihood of collaborations being documented under current conditions. Reports published at the end of each phase of the study are available on request from the AIP Center; summary reports are on the Center's Web site.

The AIP Study concludes with the publication of its final report covering all phases of the study and including, as far as possible, recent trends. The report has two constituent parts: *Documenting Multi-Institutional Collaborations,* the full report, and *Highlights and Project Recommendations,* which is the report in hand.

It is important to note that these* Highlights *consist of a selection of excerpts from the full report rather than a summary of it.

Highlights follows the organization in three parts of the full report; the excerpts for each section typically focus on one discipline in order to illustrate the varied coverage and the in-depth work of the AIP Study. Part A, Findings, has two sections: Historical-Sociological Findings and Archival Findings. Our excerpts in the former are taken from the fields of ground-based astronomy and space science; in the latter, the excerpts illustrate archival findings in each field covered by the AIP Study. Part B, Appraisal of Records Created, consists of three sections. In Section One, Typology, our excerpts focus on the discipline of particle and nuclear physics; Section Two, Functional Analysis, concentrates on geophysics; and excerpts in Section Three, Appraisal Guidelines, are devoted to materials science. In Part C, Current Archival Practices and Project Recommendations, the section on Current Archival Practices provides highlights from the study's findings in various sectors including academia, corporations, and federal agencies. Because of its central importance, the Project Recommendations section is reprinted in full. We refer throughout these *Highlights* to the relevant sections of *Documenting Multi-Institutional Collaborations*, and encourage readers to turn to that report for more complete information.

Archivists and records managers may wonder why they must take on “yet another responsibility.” A different perspective would be that scientific activities are simply being shared differently than in the past—fewer scientists are doing individual or small projects and more and more of them are participating in collaborative projects.

It may be difficult for scientists—even those who direct collaborative work—to recognize the importance of saving documentary source materials. It may seem that their personal recollections and those of their colleagues are sufficient. This is unfortunate from the standpoint of present needs. From the standpoint of the future it is disastrous, for even the imperfect personal recollections will die with the scientists, and later generations will never know how some of the important scientific work of our times was done.

The long-term AIP Study of Multi-Institutional Collaborations was funded by the AIP and by public and private foundations, including the National Science Foundation, the Andrew W. Mellon Foundation, the National Historical Publications and Records Commission, and the Department of Energy. Joan Warnow-Blewett and Spencer R. Weart served as project director and associate project director throughout the AIP Study. The staff position of project historian was held by Frederick Nebeker during Phase I and Joel Genuth throughout Phases II and III. In the position of project archivist: Lynn Maloney served during Phase I, Janet Linde overlapped with Maloney on Phase I and with Anthony Capitos on Phase II, and Capitos continued as project archivist during Phase III until April 1997, after which time Genuth assisted Warnow-Blewett with these responsibilities. Major consultants to the AIP Study included historians Peter Galison, John Krige, Frederick Nebeker, Naomi Oreskes, and Robert Smith; archivists Deborah Cozort Day and Roxanne Nilan; and sociologists Wesley Shrum, Ivan Chompalov, and, for Phases I and II, Lynne Zucker. We also want to acknowledge the support of research assistants, notably Martha Keyes. R. Joseph Anderson, now assistant director of the AIP Center, helped out with the work and—most importantly—provided an objective perspective on our draft documents. Martha Keyes and Kiera Robinson (Phase II), and Holly Russo (Phase III and Final Report) were responsible for publication layout and production of reports; each was assisted by Rachel Carter.

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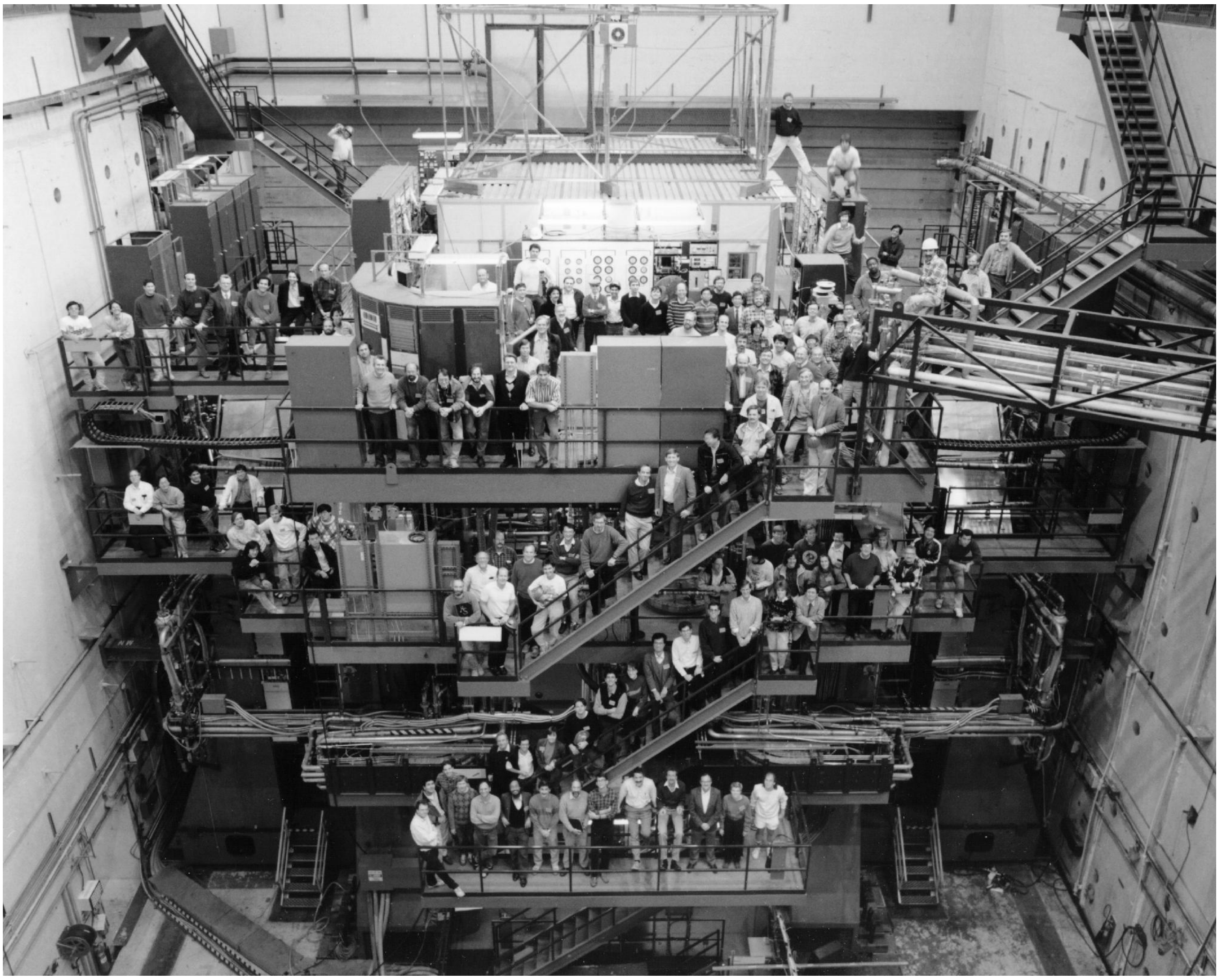

Photograph of the SLAC Large Detector, known locally as the ‘ants on the detector’ photograph. It illustrates the sizes of large detectors and collaborations in high-energy physics in the mid-1990s. Photo courtesy of Harvey Lynch.

HISTORICAL-SOCIOLOGICAL FINDINGS
by Joel Genuth

The three phases of the AIP Study of Multi-Institutional Collaborations were organized around the investigation of scientific disciplines. Our expectation was that while multi-institutional projects in all fields would have similar roots in researchers' desire for more resources, nevertheless researchers in each specialty would have particular traditions and needs that would shape the character of their collaborations. We searched for a characteristic pattern within each specialty; we rarely found one. Instead, we found significant variations in collaborations within each field. Subsequent analysis of a database covering all three phases of the AIP Study bore out the conclusion that discipline-specific styles of multi-institutional collaborations do not exist (see Part B, Section One: Topology).

We found that styles of collaborating are related to aspects, such as project formation or organization and management, that are (more or less) common in all the disciplines we covered. For example, in every field we studied, the scope of collaboration involvement in data management was central to its style. Some collaborations enabled individual or groups of researchers to acquire data and then imposed few if any requirements on what the researchers did with the data. Some collaborations determined when and where their members acquired data—and thus what data their members could collect—but then imposed few if any requirements on how their members processed, analyzed, or interpreted the data they had acquired. Some collaborations controlled data acquisition and then insisted that their members share data streams and at least discuss interpretive issues that involved multiple data sets. Some collaborations required that their members reach consensus on the interpretation of data streams acquired by the collaboration prior to any dissemination of findings outside the collaboration. Finally, some collaborations did not acquire data but obtained and processed data that were individually and independently acquired.

In general, the broader a collaboration's scope and the more it collectivized the interpretation and presentation of results, the more participatory its internal governance. Because the collaboration, in these cases, controlled the factors that most influence the development of scientific careers, individual researchers and their employing institutions insisted on equal participation in collaboration affairs. The narrower a collaboration's scope and the more it limited itself to the design and construction of instrumentation, the more likely it was to grant decision-making power to individual researchers or institutions. We found that the more participatory collaborations tended to centralize their management of records more than the formal or hierarchical collaborations. Participatory self-governance was a collaboration's response to its members' interdependence in all phases of scientific work, and members required a centralized information pool in order to assess and discuss each other's contributions to their shared work. Because formal or hierarchical collaborations tended to have more restricted scopes, their members were more prone to have records that were unique to their use of the collaboration's resources.

In this *Highlights* report, our general introduction is followed by excerpts from our findings in the fields of ground-based astronomy (observatory builders) and space science.

I. *INTRODUCTION*

The stories of collaborations in the contemporary physical sciences constitute a fascinating tapestry of patterned diversity. Within each scientific specialty covered by the AIP Study, the researchers' quest for effective, feasible, and soul-satisfying organizational frameworks for querying nature has produced variations on classic themes. A full and definitive accounting of such frameworks was beyond the scope of the AIP Study, whose primary objective has been to generate empirically informed recommendations for how to document multi-institutional collaborations. However, for our program of interviews with participants in selected collaborations—we interviewed over 450 participants in nearly 60 collaborations to create the empirical foundation for our recommendations—we liberally interpreted our mandate in order to provide the materials for a first comparative assessment of the narratives of collaborations. Within each of the areas of physical research, we attempted to cover a range of characteristics in the collaborations we selected for investigation. We designed the interviews to obtain insights into processes that must be understood to begin imagining a documentation strategy and framing a historical investigation:

- How did the collaboration form and who made it form;
- Who provided the collaboration with funding and what obligations did the collaboration owe to its patron(s);
- How was the collaboration organized and managed and who took responsibility for the collaboration's administrative needs;
- How did the collaboration structure communication among its individual and institutional members;
- How did the collaboration divide labor and what was the role of the participating institutions in the collaboration;
- Who determined the timing, placement, and content of dissemination of scientific results stemming from the collaboration's activities;
- What were the opportunities, challenges, and obstacles to international participation in a collaboration; and
- What significance did the collaboration have for the course of scientific research and the careers of its individual participants?

The interviews thus provided at least skeletal information on the origins, organization, and legacy of each collaboration. The historical and sociological analyses of this information not only serves the cause of identifying those collaborators who were most likely to have records that document significant developments, but also can help archivists, administrators, and policy analysts to assess how collaborations generate and use records, why collaborations organize themselves in the ways they do, and why they seem more or less successful in the eyes of their participants.

There is, of course, no best way to run a multi-institutional collaboration; there is not even a best way to run a collaboration in most of the individual areas covered in the AIP Study. However, there are styles of collaborating that are appropriate to particular conditions or purposes that recur throughout the areas and the individual cases. The more intimately inter-dependent participants in a collaboration are, the more participatory and democratic a collaboration tends to be; particle physics collaborations, in which instrumentation components made by individual teams must all work well together to create meaningful data, most frequently practice this style. At the other extreme, collaborations create fewer and less intense inter-dependencies among scientists when their purpose is to develop and maintain research facilities that members of participating institutions compete to use. Such collaborations sharply distinguish "engineering" from "science," strive to make their facilities' engineering serviceable to many scientific interests, and employ elaborate organizational structures to insure their divisions of labor are suitable and that all the claimants on the facilities receive a fair hearing. The geophysics collaborations that "import techniques" and the ground-based astronomy collaborations that build observatories often practice this style. In-between these extremes are various shades of gray. The variations in how collaborations are managed, in the roles of participating institutions, and in the dependencies of the participating scientists underpin the archival analysis that follows this section.

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III. *GROUND-BASED ASTRONOMY: OBSERVATORY BUILDERS*

A. *Introduction*

Only universities were charter members of all of the four collaborations we investigated, all of these collaborations have allowed only universities to be full institutional members, and in only one of our cases did the collaboration invent a less-than-full-member category in order to accommodate other scientific institutions. In all cases, the bulk of the funding for the collaboration came from university endowments and private sources. Government funding was an important supplement to the private funding in all but one case but securing government funding was not a pre-requisite to formalizing a collaboration and initiating work. All the projects were ongoing at the time of interviewing; AIP interviewed a total of 15 participants.

Our sample did not include any collaborations that involved national optical or radio observatories or that was managed by the Association of Universities for Research in Astronomy (AURA), which manages many of the national observatories. Our findings would likely have been different had such collaborations been included.

B. *Project Formation*

Aging, university-owned facilities and frustrations with the quantity and flexibility of the time to be won by competing for the use of national observatories have stimulated astronomers and engineers in university astronomy departments to consider the creation of new or re-capitalized observatories. Would-be instigators with promising ideas for a new observatory performed preliminary design studies (sometimes with "seed" funding and sometimes on departmental time) and convinced their departmental colleagues to be supportive. Collaborations became necessary when the department lost confidence in its ability to raise, on its own, sufficient funds to implement the instigators' ideas. The purpose of collaborating, in all cases, was to find enough monetary contributions to build the observatory.

Observatory-instigators used the scientific capabilities of national observatories as the context in which to argue for their plans. The collaborations we studied had all succeeded in identifying an appealing combination of features that partially distinguished them from national observatories and partially emulated national observatories. Lower estimated construction costs were the most common and obvious way for collaborations to distinguish themselves in an appealing way from national observatories, but lower costs were neither necessary nor sufficient to forming an observatory-building collaboration. In one case, a collaboration raised funds comparable to the construction costs of a national observatory on the promise of building an observatory that outperformed national observatories employing the same basic techniques. In the three cases in which the collaborations raised significantly less money than needed for a national observatory, they did not simply build lesser versions of national observatories but focused resources so as to match or outperform some of the capabilities of the national observatories. One collaboration accepted having less across-the-board observing power, but developed remote-user capabilities that enabled astronomers to carry out a wide range of schedules. (For example, one astronomer, to good effect, observed the same quasar for twenty minutes every other night for months on end. The astronomer could not have carried out such a program at a national observatory and discharged his other responsibilities). Another collaboration accepted having less angular observing range than has been typical, but sought at least to match the observing power of the world's best telescopes within its observing range. Another built a smaller-than-national observatory that covered a frequency range for which there was no dedicated national observatory.

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C. *Organization and Management*

Historically, astronomy has long been a "big science" in the sense of needing expensive facilities and engineering services, but its facility-builders have worked on a single-institution basis, and facility-users, even when they have cooperated across institutional lines, have had little need to formalize their organization. Recently, however, the facilities that have seemed worth building cost more than any single institution could raise. Thus, university astronomers have struggled with the trade-off between centralizing project management and maintaining their individual institutions' prerogatives and traditions.

On a broad level, all the observatory-building collaborations adopted similar organizational structures. All four vested ultimate intra-collaboration authority in a Board of Directors comprised of representatives from the member institutions. In one case, each member had a representative; in the rest, representation reflected the relative sizes of the members' contributions. The Boards met (face-to-face or by conference call) at least twice a year and as often as six times a year.

In all four projects, one individual was most responsible for the physical construction of the observatories. In two cases, the individual was an engineer and formally designated the "project manager." In one case, the individual was an astronomer and formally designated the "observatory director." In the last case, the leading scientist geographically closest to the observatory site was most responsible for construction, and he held the title "project director." In three of the cases, the collaboration organized advisory committees of scientists from the member institutions to deliberate on trade-offs between enlarging scientific capabilities and assuming engineering and financial burdens in the development of the observatory, to decide on broad specifications for additional scientific instruments for collaboration-wide use, and to plan a series of commissioning measurements to test the observatory's capabilities and shake down its component parts. In the fourth case, meetings of the Board of Directors came to include more individual participants and effectively served as a forum for general discussion of the collaboration's plans and prospects. Finally, in three cases the Board of Directors occasionally commissioned external panels to perform design reviews of major observatory components.

Within this common structure of Board of Directors, principal administrator, intra-collaboration advisory committees, and external design-review panels, these collaborations varied mostly by the degree to which they chose to professionalize the development and construction of their observatories. Two of the collaborations were strongly professional, meaning the collaboration empowered a trained project manager to get the observatory built by contracting out for services to private corporations. One of the collaborations preferred self-management, meaning the participating scientists managed collaboration resources and relied more on university staffs and students than external contractors to design and build the observatory. Finally, one of the collaborations fell between these two extremes.

The professionally managed collaborations empowered their formally designated project managers to build an autonomous organization to carry out the development, construction, and integration of the major observatory components. The project managers operated mostly by contracting out for services. The activities of scientists at the member institutions were restricted to development and construction of scientific instruments that were peripheral to the observatory's systems engineering, to advising the project manager on the specifications for the contracts to be let, and (when relevant) to building technologically novel components. Conflicts between scientists and project management were common over the degree of technical and financial risk to assume in the interest of achieving the highest possible scientific performance. Such conflicts were noticeably more intense in the memories of participants in a project in which scientists were building a technologically novel component that was organic to the observatory's systems engineering. While both scientists and project management had equivalent administrative access to the Board of Directors for settlement of disputes, the burden of proof, as a rule, lay with the scientists. The Boards for these projects considered building observatories that embodied the scientists' original insights to be a sufficient challenge for project management, and they protected managers from pressures to continue pushing the state-of-the-art.

The moderately professionalized observatory-building collaboration, like the highly professionalized ones, operated mostly by contracting out for services, with an individual designated to keep the contractors centrally coordinated. However, in this instance, the Board selected a scientist from one of the member institutions to be observatory director and the coordinator of the contractors without giving the director or his member institution the authority to hire the contractors. Instead, the contracting was spread across all the member institutions. When the collaboration succumbed to the temptation of accepting sizable technical risk (though at no additional cost) to achieve greater scientific capabilities than originally planned, and the contractor developing the technically risky component ran into difficulties, the collaboration as a whole suffered. As word of the problems of one contractor spread through the collaboration, the observatory director, given his lack of hiring and firing authority over the contractors, did not have the clout to keep the rest of the contractors from letting their schedules slip. The collaboration came to view this organization as inadequate, and in pursuing a second major project, it has added a project manager, who reports to the observatory director, to track and evaluate the progress of contractors.

The self-managed collaboration went beyond the moderately professional collaboration by not only letting the member institutions be the administrators of observatory development and construction but also by doing much of the work in-house. The division of institutional labor was part of the formal agreement that formed the collaboration. Initially, this collaboration was going to have an engineer serve as project manager, but the individual resigned early in the collaboration's life, and the Board of Directors decided not to hire a replacement. No single entity filled the vacuum in inter-institutional coordination. The Board itself used its meetings to identify collaboration-wide tasks and to assign sub-groups to carry out the needed work. An Executive Committee, consisting of one scientist from each institution, held conference calls every two weeks to assess development. And the scientist whose institution was responsible for the bulk of the hardware development was designated "project director" and his institution oversaw activity at the observatory site. With money tight (and in the absence of professional project management to negotiate the best value for the needed design and construction services) the collaboration came to operate on a cash-conserving, build-it-yourself basis.[1] Graduate students and postdocs were heavily relied on to perform labor that could have been done by construction workers.

None of the collaborations we studied centralized project management to the point that its Board of Directors, comprised of representatives of each member institution, became a figurehead body. In all our cases, the Board of Directors was a vibrant, decision-making body.[2]

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H. *Communication Patterns*

All of these collaborations strongly centralized communication concerning observatory design and construction in the office of the project manager (or his equivalent in the less professionally managed collaborations). Information from SWGs, instrument builders, and contractors flowed to the project manager, who kept the Governing Board and scientists at member institutions

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[1]There are multiple possible reasons for this collaboration's relatively paltry use of external services. The project director's institution had a tradition of building in-house, and the instrumentation did not represent such a technical challenge as to require employing professional services.

[2]In selecting case studies, we considered AURA-managed national observatories to be single institutions and thus outside the scope of our study, and we focused on collaborations among universities as the most significant challenge for documentation research. Our finding would certainly have been different had our sample included collaborations that involved AURA-managed observatories with other observatories. AURA appoints a "project director" with the power to make decisions when the engineering and scientific leaders of a project clash. Boards of directors, when they exist, serve to set broad goals and to hold the project director accountable but not as vehicles by which the institutions that contribute financially to the project resolve intra-project disputes.

apprized of progress and developments. When collaboration members disputed a project manager's decisions, they directly communicated their concerns to members of the Governing Board.

Communication concerning observatory use for scientific research was strongly decentralized. Time allocation committees of member institutions usually did not inform each other of the proposals they received, and scientists who could benefit from coordinating their observations had to learn about each other and make arrangements on their own. The self-managed collaboration came closest to centralizing some communication concerning observatory use. Its Governing Board has considered trying to coordinate the efforts of several scientists in order to implement large observing projects that no individual scientist could readily carry out.

I. *Social and Scientific Significance*

Only one of these collaborations finished building its observatory on time and on budget, and it was one that had professionalized development and construction. The others either suffered from amateurism in their cost estimates or outright considered a slower pace of construction less evil than creating a powerful organization that could build an observatory punctually by spending money quickly and efficiently. All of the collaborations succeeded (or apparently will) in building their observatories, though the ones that overran construction schedules have had problems operating as well as was initially specified, because too many of the principal individuals in the development of individual components had become too busy with new work (taken on during the construction delays) to participate in observatory integration and shake-down. The observatories all have been or will be used for a wide variety of studies. The common contribution to astronomy of three of the observatories has been to show that part of a national observatory's capabilities can be built on a several-university budget; the fourth stands for the ability of several universities to build a general-purpose observatory around a technologically novel and challenging component when private philanthropists are willing to donate $100 million.

Observatory-building projects, in the opinion of nearly all interviewees, are for tenured professors who are uninterested in moving, because these projects absorbed scientists' time without generating scientific accomplishments needed for building a career in astronomy. Scientists in the more professionalized collaborations were prone to complain about the power and personality of the project manager, while scientists in the more self-managed collaborations were prone to complain about the quantity and pace of the work. However, such conflicts were not project-threatening, and none of the interviewees mentioned the possibility of empowering an individual to balance scientific and engineering interests. The interviewees implicitly understood that both professional management and self-management have their virtues, both come at a price, and there can be no fundamental mid-stream change in organizational approach to managing observatory development.

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VIII. *SPACE SCIENCE*

A. *Introduction*

For space science, AIP interviewed approximately 100 participants in six multi-institutional projects that were all launched between 1975 and 1985. (In the terminology of the field, "project" refers to the effort to launch, operate, and analyze data from spacecraft; we will use "project" in the space scientists' sense in this section.) These figures include the projects and interviews undertaken in our parallel study of the European Space Agency (ESA). AIP staff and consultants consciously tried to cover a range of features in the selection of projects to investigate: projects managed by different space flight centers, projects whose participating scientists came from a variety of institutions, international and nationally organized projects, astrophysical and planetary science projects, and smaller and larger projects. In our choice of interviewees, the AIP staff sought to cover all the types of people who might be vital to the documentation of scientific work, from administrators at funding agencies to graduate students at university departments. However, the perspective of flight-center scientists and engineers is strongest, because they turned out to be the best sources of documentation of space science projects during the period we studied.

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C. *Organization and Management*

NASA has imposed a formal structure on space science projects. Program managers at NASA Headquarters, engineers by training, have overseen project managers, also engineers by training, at NASA space flight centers. Project managers have overseen the design, construction and integration of spacecraft, including their payloads of scientific instruments. The PIs, scientists by training, have designed and built scientific instruments. A project scientist, typically an employee of the space flight center, has advised the project manager on spacecraft engineering options that could affect the project's scientific capabilities and has kept the other PIs informed of spacecraft engineering developments. To discuss and resolve collective scientific concerns, the project scientist has led meetings of a "Science Working Group" (SWG) of PIs and select members of their teams. The project scientist has also reported to a program scientist at NASA Headquarters, who has been able to bring scientists' concerns to the program manager at Headquarters or their mutual superiors.

These arrangements have attempted to manage an intrinsic tension in the concept of space science projects: which is the more difficult and significant challenge—sending and operating equipment in space, or satisfying criteria of scientific value? All space projects have had common problems of design and operations, and project managers are expert in building apparatus that will function in space. However, science projects, whether pursued in space, the natural earth environment, or the laboratory, have been valuable only if they yielded new or improved data. By providing scientists with their own line of communication to higher authorities, NASA has reminded project managers that they must serve as well as manage the PIs. Projects vary in how they cope with this tension.

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1. *The Scope of the Science Working Groups*

Science Working Groups in our sample varied in how much business they handled. Scientists appear to have been torn between limiting the scope of the SWG, and thus maximizing their autonomy from each other, and expanding the scope of the SWG, and thus maximizing their unity in dealing with project engineers and outside scientists.

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Most commonly, the SWG restricted itself to dealing with collective issues that were engineered into the project's initial design, such as problems of interference between scientific instruments or the protocol for coordinating the operations of the instruments. At the other extreme, the SWGs for the two projects that originated outside flight centers felt the need to expand their scope in order to secure or maximize the project's scientific values. These two projects suffered through more conflicts than the others we studied, because the SWGs wanted responsibilities that the project or program manager considered their province.

Even the projects with expanded SWGs kept significant areas of science activity in the control of their projects' experiment teams and outside the SWGs' jurisdictions. Experiment (i.e., instrument) builders almost always cared principally about the spacecraft's capabilities and their individual interfaces to it rather than the capabilities and designs of other experiments. Individual teams decided when, where, and what to publish. When scientists within a project reached different conclusions about the same topic, they almost always disseminated their views individually without attempting to reach an intra-project consensus.

2. *The Scope of Flight Center Officials*

In every project, the flight center project manager was responsible for the project's money and schedule and was usually the most powerful individual in the project *during its design and construction*. In most cases project managers imposed their flight center's customs on the project. Most issues were resolved in communiques between PIs (or their engineers) and the project manager (or a staff member the project manager assigned to track science payloads). Even when the PIs resented the flight center's culture or the project manager's style, they usually accommodated each other.

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During mission design and construction, the needs of the project manager consistently determined the scope of the project scientist's work. When the SWG dealt with collective science issues without requesting additional resources, the project manager needed the project scientist's guidance on when engineering expediency might upset the scientists' planning. When the SWG incubated conflicting ambitions that the spacecraft could not handle, the project manager needed the project scientist to adjudicate conflicts among the scientists and mediate between the scientists and project management.

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After the launch, project scientists administered project funds for data analyses and fielded proposals from members of science teams pursuing longer-term research on their data sets. Once funding for the project ceased, science teams had to obtain funding for analyses in the general competition for NASA program grants.

3. *Coordination Among Flight Centers*

The cases we studied included three international, multi-flight center projects: two multi-spacecraft projects in which one spacecraft was built at each flight center, and one single-spacecraft project in which the flight centers each built part of the spacecraft. The multi-spacecraft projects were consciously organized to minimize inter-flight center engineering interfaces, to maximize the project managers' individual and collective latitude, and to leave coordination of the project's greater-than-national capabilities to post-launch operations—the province of the SWG, which operated as an international body in both these projects.

In the case of a single spacecraft that had systems built by multiple flight centers, the project staffs communicated heavily to discover and solve the integration problems before the scheduled launch, but the nations still had their own SWGs, which operated autonomously. Each flight center's SWG had designated blocks of time in which it could specify how the spacecraft should be operated.

4. *The Scope of NASA Headquarters Officials*

Once Headquarters had selected a flight center, selected the PIs, and initiated the flow of money for a project, its officials lost most but not all ability to exert daily influence over a project. Whether they continued to be active in a project depended on the project's budget and the intensity of conflict between scientists and project management. When a project was unusually expensive, or when conflict within the project was sufficiently intense, Headquarters officials were influential. Even when not interested in exercising influence, program managers often collected excellent records, because project managers were careful to report thoroughly and to invite program managers to important meetings. To do otherwise was to risk exciting a program manager's suspicions that a project harbored hidden problems. Program scientists only became significant when participating scientists and project managers could not resolve their conflicts.

D. *Activities of Experiment Teams*

"Experiment" in the terminology of space science has referred to the design, construction and operation of an instrument plus processing and interpreting the signals the instrument returns. For purposes of design and construction, an instrument was often broken down into self-contained "boxes," whose mechanical interfaces were cleanly and simply specified at the start of the project and whose digital interfaces could be worked out over the course of construction. The head of a team usually has the title "principal investigator" (PI), and that is how we will use that term.[3] Other team members with independent standing as scientists usually held the title "co-investigator." The significance of that title, as will be seen, has varied.

"Scientists interested in carving out a niche for themselves in space experimentation must "space qualify" an instrument by demonstrating that it can survive the rigors of launch and operate in the harsh environment of space. Experimentalists have routinely employed two strategies to meet these difficult challenges. First, they consciously looked for laboratory instruments they thought could be adapted for use in space without compromising too severely on the instruments' scientifically valuable features. Second, they have relied on components that have proven their

[3]In projects that formed outside the space flight centers, PI referred to the overall project instigator and leader, and another term, like principal scientist, was used for the scientists in charge of building particular instruments.

reliability in commercial or military use[4] and rarely attempted to develop and use technical novelties unless an industrial firm was interested in taking up the novelty's manufacture. Once experimentalists have space qualified an instrument, they usually have not even considered diversifying into a new area of instrumentation because of the competition they would face from established specialists.

Experiment teams have usually had a center-periphery structure. At the center has been a small number of institutions overseeing hardware development and basic data-processing software. On the periphery are scientists, often from other institutions, providing additional expertise in the science analysis of the data. In this manner, work on the many technical problems of space-based instrumentation have been efficiently centralized without wasting data on experimentalists unaware of all the ways the data could be used.

"Co-investigators" has been the common term both for scientists who contribute to an instrument while working at a different institution from the PI and for scientists who increase a team's scientific breadth. When co-investigators contributed to instrument design and construction, the PI had to decide on the allocation of the experiment's spacecraft resources among the instrument's components and was responsible for keeping the several parts compatible. Co-investigators who were included to increase scientific breadth never influenced the technical development of an experiment; they were chiefly of symbolic importance, demonstrating the existence of outsiders' confidence in the scientific value of a proposed experiment.

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H. *Communication Patterns*

The space science projects we studied always structured formal communication in a hub-and-spoke fashion. However, the office at the hub varied and the importance of the hub in comparison to the spokes shifted with stages of the project. Consequently it is difficult to cast trustworthy and meaningful generalizations.

The most important communication hubs during the conceptualization of space science projects have been the NASA and ESA space flight centers. However, other institutions in both the United States (Johns Hopkins Applied Physics Laboratory, American Science & Engineering) and Europe (Rutherford Appleton Laboratory, Max Planck Institute for Extra-terrestrial Physics) have also successfully functioned as hubs for conceptualization. (More recently, the "Working Groups" that advise "discipline scientists" at NASA Headquarters have become pro-active in the design of science projects.) The "spokes" in this initial stage have been experimentalists with hopes of tailoring a project to fit their instrumentation expertise.

Once a project was conceived, a "discipline scientist" or "division chief" at agency headquarters became the hub for project communication. Project instigators fed information to their agency advocate. Spokes consisted in this stage of members of the agency's advisory panels (and in the

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[4]The military context in which the parts and materials of space instrumentation originated has not noticeably hindered space scientists. They have used them successfully without needing to know their internal workings or the manufacturing processes used in their fabrication.

United States, the National Academy's Space Studies Board) that compared the virtues of projects vying for funding.

When headquarters secured funding for a project, it declared a project manager and a project scientist at a space flight center to be the communications hubs. The project manager received and passed on the information the PIs needed to build instruments that were technically compatible with each other and the spacecraft. The project scientist received and passed on the information the PIs needed to develop their data acquisition strategies. In the event of an irreconcilable conflict, each had a contact at agency headquarters. The project manager was the more important hub during design and construction; the project scientist became more important after launch.

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I. *Social Significance*

Space science collaborations have been high-risk, high-reward ventures for their participating scientists. When projects have succeeded, participants obtained unprecedented data. When they have failed—and failure can easily be due to factors beyond scientists' control—participants have still had to continue to compete for career rewards with disciplinary peers obtaining data in safer fashion. Increasing participants' nervousness has been their impression that the number of flight opportunities has been decreasing and the time spent in their design and construction has been increasing. Instrument designers on university faculties feel most threatened, because long, risky undertakings are not well suited to graduate students. By contrast, university scientists without direct responsibility for instrumentation have happily prospered when they have been able to learn enough about an instrument to use its data with imaginative sophistication.

As economists have long noted, failure must be tolerable for people to accept risks. The challenge for space science communities will be to keep failure from becoming intolerable for scientists. If flight opportunities for experimentalists are few, then there must be career rewards for those who successfully provide desirable space instrumentation for projects that fail. If professional productivity is judged by the quantity and quality of papers published in journals of astronomy and planetary science, then there must be enough flight opportunities for experimentalists to recoup from project failures. Recent NASA policy has favored more frequent launchings of smaller scientific projects.

ARCHIVAL FINDINGS
by Joan Warnow-Blewett

In our full report, *Documenting Multi-Institutional Collaborations*, this section includes archival findings from all the fields studied by the AIP followed by some findings on the impact of the Web and other electronic records and a passage about other findings of archival interest. These *Highlights* contains excerpts from the archival findings from each field and closes with an excerpt from the subsection, Other Findings of Archival Interest.

I. *INTRODUCTION*

This report is based on a number of sources: (1) archival analysis of over 450 interviews on the nearly 60 selected cases for the disciplines included in the AIP Study; (2) the patterns uncovered through the historical-sociological analysis of these interviews; (3) discussions with archivists at the home institutions of interviewees; (4) site visits to discuss record-keeping with administrators and records officers (especially at federal funding agencies) involved with our disciplines; (5) discussions with National Archives and Records Administration appraisal archivists for the federal agencies; and (6) the AIP Center's general knowledge of archival institutions in various settings.

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II. *FIELDS STUDIED BY THE AIP*

A. *Geophysics*

The best locations to find the records of geophysics projects, according to the interview subjects, are the Science Management Offices (SMOs) and the consortium headquarters; they are, for example, the most likely locations for collaboration-wide mailings. SMOs provide the likely locations for records of project administrators, Science Working Groups (SWGs) and executive committees. Similarly, consortium headquarters have the records of the project's chief scientists (director, president, etc.), its standing committees (and, perhaps, subcommittees), and its Executive Committee. Other key players at consortium headquarters are staff scientists or engineers who work with each scientific party. For example, for the Ocean Drilling Program, one of the staff scientists assists the co-chief scientists with the planning and ship-board administration. Because of these responsibilities, records of the staff scientists would provide valuable documentation. However, at SMOs and consortium headquarters, there were typically no formal record-keeping requirements imposed by the collaboration. In certain geophysics or oceanography projects, the ships' logs provide a central record of a project, and perhaps even metadata concerning the conditions under which data were collected. These logs are often considered to be institutional records; their value in documenting projects is sometimes overlooked.

Because projects in geophysics have a longer, more political, prefunding period—our investigations located additional categories of records at policy-making bodies. These records were at the National Academy of Sciences in the United States and, at the international level, the International Council of Scientific Unions (ICSU) and the World Meteorological Organization (WMO).

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Geophysics projects—like others in the field sciences—generate electronic data of long-term usefulness for scientific research. In addition, samples taken in field research (such as cylinders of sediment and rock) are often preserved for future research. Although our study did not focus on the final disposition of the data created by these projects, we know there are many electronic data centers for these disciplines. The largest holder of geoscience data in the United States is the National Oceanic and Atmospheric Administration (NOAA) with a number of facilities across the country (e.g., the National Geophysical Data Center in Boulder). In the cases we studied, it may not always have been mandatory for individual investigators to deposit their data into a data archives. By and large the trend is for more stringent requirements. We are aware that some electronic data are found by archivists in the records of individual scientists; when this happens, archivists should notify the appropriate data center.

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B. *Ground-Based Astronomy: Observatory Builders*

We found that the patterns of organization and management of all telescope-building collaborations are quite similar. All four collaborations included in our case studies vested authority in a Board of Directors, and made one individual most responsible for the physical construction, usually with the title of project manager but occasionally another title. In most cases they organized Science Advisory/Science Steering Committees of scientists from the member institutions to develop scientific instruments and advise the project manager on the trade-offs between scientific capabilities and engineering and financial burdens. In the building collaborations in which national observatories were members, management has been unified, giving decision-making power to a project manager when the scientific and engineering leaders clash and lessening the authority of the Board of Directors as representatives of member institutions. Virtually all of the individuals holding these positions are on university faculties where archival repositories are available.

Despite these similarities, the difficulties of documenting the work of telescope-building collaborations are distinctive among the disciplines covered by the long-term AIP Study, and this is true for the building of both academic and national observatories.

In the case of academic observatories, funding is mostly from non-federal sources—private university endowments, state university allocations, and private foundations; support from federal funding agencies exists in some cases, but has been limited in its scope, e.g., to support site development. Private funding usually means less stringent records requirements. Collaboration proposal files, progress reports, correspondence with grant officers, and other related records may never have been created or—when they have—may be more difficult to find in university administrative files or in records of private foundations. When considering which university should be most responsible for saving records of an observatory's design, construction, and operation, we look to the university with which the observatory was affiliated; in most cases this will also be the university that has the largest membership on the collaboration's Board of Directors (reflecting the size of its obligation).

Documenting the building of national observatories is complicated by the records policies of the National Science Foundation (NSF)—the agency that supports the building and maintenance of the national observatories in the U.S.[5] Unlike the Department of Energy's contract laboratories, the NSF's contract laboratories and observatories do not create federal records; accordingly, these national observatories are not required by law to maintain records management programs or secure records of archival value. While at least some national observatories retain records, we are not aware that any of them have archival programs. To make matters worse, national observatories are not affiliated with universities or other organizations with archival programs and thus lack natural repositories.

C. *Ground-Based Astronomy: Users of Observatories*

If it is difficult to document the building of observatories, it seems virtually impossible to document collaborations of observatory users—at least radio telescope users.[6] The reason is straightforward. They leave a scanty paper trail (except for observational data) because:

- They neither design nor build the instrumentation they use;
- They require little or no dedicated funding; and
- They require only minimal organizational structures.

The best documentation of a given collaboration is to be found in the lead scientist's proposal for use of a participating observatory's telescope and his/her collaboration-wide correspondence. For minimal documentation, then, we need radio observatories to have policies to preserve their proposal and evaluation records. For a richer record, we are dependent upon lead scientists to save their papers and their employing institutions to accession them for their archives.

It is highly unlikely that the scientific data of VLBI (very long-base interferometry) collaborations will be useful for future research. As we learned, the data streams from each of the participating observatories had first to be successfully correlated. Although these correlated data are preserved following NASA regulations, considerable processing is required before correlated data can be the basis for scientific interpretation; further, our interview subjects agreed that this processing required too much familiarity with the original observing conditions and instrumentation for anyone who had not been involved with the data acquisition.

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[5] The AIP Study's four case studies of telescope-building collaborations did not include any collaborations involving national optical or radio telescopes. As a result, our archival analysis of this category of collaborative building is based on previous experience of the AIP Center, the AIP Study's site visits, and input from the Working Group rather than the usual combination of these elements and oral history interviews conducted by the AIP Study.

[6] The AIP Study's four case studies of telescope-using collaborations did not include any collaborations conducting sky surveys or, indeed, any collaborations of optical telescope users. Accordingly, our archival analysis of collaborative research in the uses of optical telescopes and in conducting sky surveys is severely limited; it is based solely on the previous experience of the AIP Center and input from the Working Group, rather than the usual combination of these elements and oral history interviews conducted by the AIP Study.

D. *Materials Science*

Our historical analysis of collaborations in materials science makes distinctions between those that make use of accelerators for synchrotron radiation and reactor facilities at DOE National Laboratories and those that do not. Our archival analysis is strikingly different for these two categories.

Collaborations that do not use national laboratory facilities present documentation challenges whether managed by universities or corporations. In two of three instances of university-managed collaborations, the collaborations made final funding decisions on institutional members' research; all three cases lacked a physical location beyond their offices at the fiscally accountable university. In a field with strong participation of corporate organizations, it is not surprising that our case studies included an instance in which the collaboration was managed by a corporate member which no longer exists because it was merged into another corporation. Such mergers confront corporate historians and archivists with questions concerning successful transfers of records; we can only urge corporations in such situations to be responsible for adequate transfer of archival records.

As usual, support by federal science agencies generates some core documentation. However, a cautionary note is in order. NSF centers (the Science and Technology Centers and the Materials Research Science and Engineering Centers) have emerged in recent decades on university campuses; most, if not all, of the centers make the final decisions on which researchers at member institutions get funded. This delegation of some authority from NSF to its centers diminishes the detail of documentation at NSF Headquarters; thus, it is important for university archives to take responsibility for securing their NSF centers' records of long-term value.

The characteristics of those collaborations that did make use of accelerators or reactors at DOE National Laboratories (half of our case studies) are quite different from those materials science collaborations that did not. For one thing, they had some attributes similar to those we were familiar with from other studies involving DOE National Laboratories: they were all required to submit both technical and managerial plans to the Facility Advisory Committees (our generic term for a variety of titles) of the laboratory facility, and they all had a liaison with the DOE Laboratory facility (whether called spokesperson, staff director, or an untitled member who played the role). These characteristics assure preservation on the part of the DOE National Laboratories of some core records and help us locate documentation for significant collaborations. On the other hand, we found that the collaborations rented space for offices at the synchrotron laboratories, these offices are freestanding and impermanent, and the collaborations do not create federal records unless the DOE laboratory is a formal member of the collaboration. We also found that each institutional member of a collaboration raised its own funds; typically academic institutions go to NSF and corporate members use internal funds.

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E. *Medical Physics*

It is virtually impossible for us to assess with any certainty the archival situation in the area of medical physics. The reasons are several. The AIP Study experienced difficulties in persuading individuals in the discipline to participate fully (or at all) in our interview program and found that even the more eminent leaders of the community were not at all familiar with questions of documenting their discipline for historical and social science studies. Also, the AIP Center has had little experience in documenting the research activities of medical schools or other medical research centers, in saving papers of individual practitioners,[7] or in dealing with the key funding agency—the National Institutes of Health (or its constituent parts, such as the National Cancer Institute).[8] Consequently, our appraisal guidelines and our project recommendations to funding agencies and research institutions in the field are—for the most part—merely suggestive.

F. *Particle and Nuclear Physics*

1. *Introduction*

The initial phase of our long-term study of multi-institutional collaborations was devoted to high-energy physics. During our third, and last, phase of the project we examined briefly the area of heavy-ion physics. We found the characteristics of the disciplines to be so much the same that (with the agreement of the Working Group) we have combined our findings as collaborations in particle physics. Moreover, we have been told that our findings conform to those in nuclear physics experiments. Thus, this disciplinary category is now titled, particle and nuclear physics.

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It is interesting to note that in the brief period between the time our high-energy physics projects were conducted and those we studied of heavy-ion physics were conducted, there were some management changes. In addition to the numerous well-known roles from high-energy physics, we found management structures in heavy-ion physics more familiar to us from collaborations in other disciplines—in one a project engineer and in the other a project manager—as well as a technical committee and a board made up of representatives from member institutions. These structures may indicate emerging complexities in the various areas of particle and nuclear physics collaborations that archivists should be on the lookout for.

2. *Archival Analysis*

The main locations of records appear to be in the hands of spokespersons; at the laboratories; and, to a lesser extent, with group leaders. We focus here on records with spokespersons and at the laboratories.

a. *Spokespersons*

Spokespersons, in nearly all of the cases we studied, had the most complete documentation. We found that the larger the collaboration, the more likely the spokesperson was to have kept the

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[7]The AIP Member Society most relevant to medical physics is the American Association of Physicists in Medicine which joined the AIP in 1973—a fairly recent affiliation compared to other AIP Member Societies. This, combined with the fact that the Association does not represent the full scope of medicine-related disciplines included in our selected case studies, may account for the fact that most practitioners we encountered during the course of the AIP Study lacked knowledge of the documentary concerns, responsibilities, and services of the AIP Center.

[8]Our ignorance about the NIH presents a major obstacle to our advocacy for effective preservation activities; e.g., we learned from our Working Group that the proposal process—so valuable in providing core documentation of collaboration plans and progress—varies among the institutes of the NIH.

proposal and related materials. In addition, most spokespersons have some unique materials, e.g., correspondence with laboratory administration.

With larger numbers of people and institutional members, the role of spokesperson has come to encompass managerial tasks. There is, for example, ample evidence that intra-collaboration mailings correlate with the larger, more recent collaborations; responsibility for such mailings falls largely on spokespersons. In the best cases we've seen, their "archives" were well-organized and covered all aspects of the collaboration's work, including minutes of collaboration meetings (technical reports from group leaders and others on their assignments for detector development and data analysis, etc.), technical memoranda, and other intra-collaboration mailings. In other cases, spokespersons appeared to have kept many of these files but they were literally in piles all over their offices and may be difficult to extract from other, unrelated materials. Conversely, collaborations with fewer than 30 people and four or five groups, as was common in the 1970s, communicated more by telephone and in less formal meetings, resulting in far thinner documentation.

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b. *Accelerator Laboratories*

The AIP Center was aware from its earlier study of DOE National Laboratories that these laboratories were the best source of documentation on the activities of their Physics Advisory Committees. (There are variations on the title of these committees; we refer to them generically here as PACs.) Site visits during the current project established that the laboratories still retain a full set of PAC records, including proposals from collaborations for experimental work and accelerator beamtime and minutes of the PAC's decision-making process.

The AIP Study of Multi-Institutional Collaborations provided evidence for other significant documentation of collaborations at the laboratories. During the 1980s, more detailed agreements emerged covering the responsibilities of both the laboratory and each of the institutional members of a collaboration. These responsibilities range from detector development and construction to provision of computer facilities and financial commitments. The most detailed of these agreements today are called Memoranda of Understanding.

There has been a very significant shift of responsibilities from individual investigators and universities to the laboratories. Recently, the laboratories have been exercising tighter control over experiments—at least the larger, more expensive ones. For one thing, major funding for large detectors is now likely to come directly to the laboratories from DOE and NSF, rather than to the institutional groups. In addition, there are increasing and widespread demands for accountability on the part of DOE in such areas as fiscal matters and health and safety. In some cases, the need for tighter control on the part of the laboratories may be reflected in the spokesperson being a laboratory staffer; in other cases, the spokesperson may be required to remain on site during the entire construction period of the experiment. Finally, there was evidence of yet another shift from academic laboratories to accelerator facilities—for fabrication of detector components; in addition, as detectors become bigger and more complex, laboratories tend to have more permanent staff in order to maintain detector components. Overall, the trend is for the laboratories to be the location for many technical records.

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G. *Space Science*

In the field of large space science collaborations in the United States, NASA provides virtually all of the funding and much of the technical and managerial expertise through its space flight centers. Space science projects have formal record-keeping requirements related to the organizational structure NASA imposes on its projects. Also, since participating scientists create individual instruments which have to be integrated into a single spacecraft, considerable formally documented interaction between flight centers and the experiment teams takes place. The situation is very similar for the European Space Agency (ESA) and its flight center. For these reasons, substantial documentation is virtually always created by space science projects. The creation of records does not, of course, equate with saving those records. Outside of NASA, creating and saving records is largely based on the personal inclinations of participants.

The bureaucratic structure imposed by NASA—especially at the flight centers—means that certain offices are held responsible for specific aspects of NASA projects and are expected to create specific categories of records. Because of this, records are created almost regardless of the circumstances of the particular instrument-building team (such as number of member institutions and geographical distribution). At the NASA Headquarters level, however, more documentation is generated for joint projects with space agencies abroad, and for missions funded from budget lines that attract annual congressional scrutiny.

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The best documentation for information concerning scientific aspects of the mission, according to the scientists who responded to our questionnaires, are the records of the Science Working Group. These materials are normally located with the project scientist, who chairs this group of principal investigators.

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Finally, our investigations located a small number of categories of records (about 10) that, taken as a whole, provide adequate documentation for all multi-institutional collaborative research in space science. For any one project these records are located at several settings. The main locations of records in the United States are at the National Academy of Sciences in its Space Studies Board records (previously the Space Science Board);[9] in the hands of discipline scientists, program scientists, and program managers at NASA Headquarters, project scientists and project managers at NASA flight centers, and PIs of project experiments (instruments). At ESA the important policy groups to document are the Science Programme Committee and the Space Science Advisory Committee and its two working groups: the Astronomy Working Group and the Solar System Working Group. Additional records are those of the European Space Science Committee of the European Science Foundation; it synthesizes, promotes, and coordinates advice

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[9]Projects in space science, like those in geophysics, have a long, more political, prefunding period; the National Academy's Space Studies Board has been the most important policy-making body for space science in the U.S.

on European Space science and policy from the space science community in Europe. Finally, funding agencies of the several nations involved in each mission independently pass judgement on proposals to build experiments for ESA projects.

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H. *Computer-Mediated Collaborations*

In the third and last phase of the long-term study, the AIP determined that it should deliberately examine a new category of collaborations that might well become more dominant in future collaborative research. The principal characteristic our three case studies in this category have in common is the central role of computer science and technology—hence the name for this group, Computer-Mediated Collaborations. In this area, the AIP sought to learn of the relative health of these new kinds of projects: would they continue and thrive over the near future? We also needed to obtain a clearer picture of the ways, if any, the focus on computer science and computer techniques would affect a collaboration's organizational structure and the records the collaboration generated, as well as which records should be preserved.

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Would these new computer-mediated collaborations prosper in the near future? From our site visits to NSF and DOE and the meeting of our Working Group, the resounding, general answer must be yes. For one thing, the NSF STCs [Science and Technology Centers] appear to be thriving and we can believe some of them will be devoted to research in computer science and technology. The Grand Challenge is no longer a formal NSF program unto itself, but it seems reasonably clear that such projects will be considered under the Knowledge and Distributed Intelligence (KDI) program under development at NSF. Collaboratory-style projects will also fall within the KDI at NSF and continue receiving support at DOE under its Mathematical Division, which—under various names—has been the organization within DOE for high-end computing. It is important to note that collaboratory techniques are now implemented by projects in a wide range of disciplines from electronics to research in AIDS.[10]

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IV. *OTHER FINDINGS OF ARCHIVAL INTEREST*

B. *Trends in Multi-Institutional Collaborations*

We close with one more striking change. Collaborations in one field may take on characteristics of those in another field. The point was made clear to us at the last meeting of the AIP Study referred to earlier. The subject was the role of the builders and the users of detectors/instruments in the fields of particle physics and ground-based astronomy. A decade or more ago, most particle detectors were built and used by the same, single collaboration and most telescopes were built by a collaboration (and then maintained by the facility) for other scientists to use. The

[10]For an example of a recent overview, see "Internet-Based 'Collaboratories' Help Scientists Work Together," *The Chronicle of Higher Education*, Vol. XLV, No. 27 (March 12, 1999), p. A22. Just this year the following report appeared on the Web, "Report of the Expert Meeting on Virtual Laboratories," organized by the International Institute of Theoretical and Applied Physics, Ames, Iowa with the support of UNESCO. It explores the use of the collaboratory far beyond science and technology. (Web site: http://www.iitap.iastate.edu/reports/vl)

current situations are quite different because of the increasing sophistication of the instruments/detectors and the need for more sophisticated processing of much larger amounts of data. New multi-purpose detectors in particle physics have practical lifetimes that may equal those of the accelerators; this means the detectors are used by more than one collaboration and that maintenance has shifted to new permanent, technical staff at the accelerator facility; thus, detectors are moving toward the model of astronomy in terms of builders and users of instrumentation. Meanwhile, in the case of ground-based astronomy, the instruments—the equivalent of particle detectors—are increasing in cost faster than the telescopes; the huge increases in costs for instruments and data processing have inspired ground-based astronomers to begin looking into management practices in particle physics collaborations.

HIGHLIGHTS AND PROJECT RECOMMENDATIONS

PART B: APPRAISAL OF RECORDS CREATED

In the AIP Study, our extensive fieldwork is followed by the other phase of macroappraisal projects: analytical studies to develop documentation aids for archivists, records officers, and others responsible for the records of multi-institutional collaborations. In this part of our report, we offer aids to records appraisal through three approaches: a typology of multi-institutional collaborations, functional analysis of records creation, and appraisal guidelines.

Those responsible for records should recognize the value of these analytical essays. They are reality-based, derived as they are directly from our extensive fieldwork with participants of collaborations, and the period under study is almost current. As a matter of fact, we can characterize our macroappraisal work as a historical-sociological study of organizational trends of multi-institutional collaboration and their archival implications.

TYPOLOGY OF MULTI-INSTITUTIONAL COLLABORATIONS
by Joel Genuth

One of the most fascinating products of the AIP Study's program of interviews is the classification scheme or typology developed by the project historian and sociologists for the organization and management of collaborations. The area of organization and management is the aspect of collaborations most closely connected to the generation and accumulation of records.

The basis for the typology is "cluster analysis"—a statistical technique that groups objects on the basis of how closely they resemble each other across a range of variables. The project team performed cluster analysis on the organization-and-management variables for the 46 collaborations for which we had complete information. They found variables that were sufficiently inter-related to justify reducing them to four factors:

- formalization (which combines presence of written contracts, presence of an administrative leader, division of administrative and scientific authority, self-evaluation of the project, and outside formal evaluation);
- hierarchy (which combines levels of authority, system of rules and regulations, style of decision-making, and degree to which leadership subgroups made decisions);
- presence of scientific leadership; and
- style of division of labor.

The result of the cluster analysis is that collaborations can be reasonably divided into four organizational types. With one notable exception, organizational types are *not field specific*—meaning that the particular disciplinary specialty of a collaboration (e.g., materials science or geophysics) is not a clue to its organizational type. The exception is particle physics.

The first organizational type is comprised of collaborations with a high degree of formalization, high degree of hierarchy, high scientific leadership, and specialized division of labor. We designate this type "**highly structured**." The second and third types differ from the first in that they are comprised of collaborations that are either less formal or less hierarchical than the highly structured. They are distinguished from each other by their needs for scientific leadership and by their method of dividing labor. The second type—"**semi-structured with no scientific leader**"—never has a designated scientific leader and usually has a specialized division of labor; the third type—"**semi-structured unspecialized**"—usually has a designated scientific leader and always has an unspecialized division of labor. The collaborations in the fourth type register the lowest amounts of formalization and hierarchy, while still possessing scientific leadership and a specialized division of labor. We designate them "**low-structured**."

We focus on this last type in the *Highlights*.

The **low-structured** type of collaboration is, as the label suggests, the absence of the classic features associated with Weberian bureaucracy. The membership of this type is dominated by particle physics collaborations. Among all the specialties in physical research we covered, particle physics alone has a distinct style of collaboration. Occasionally, particle physics collaborations fall outside the main category for particle physics and occasionally collaborations in other specialties most closely resemble a typical particle physics collaboration, but it seems justified to speak of “particle physics exceptionalism.”

Particle physics collaborations are exceptional in their combination of two characteristics. First, the participants find that their collaborations are highly egalitarian. Compared to what we heard from collaborators in other disciplines, particle physics collaborators describe decision-making as participatory and consensual, define their organizational structure through verbally shared understandings rather than formal contracts, and institute fewer levels of internal authority. At the same time, in contrast to collaborations that did not publish scientific findings collectively, the scope of particle physics collaborations encompasses nearly all the activities needed to produce scientific knowledge, including those activities most sensitive to building a scientific career. The collaborations always collectivize the data streams from the individual detector components built by the participating organizations, they frequently track who within the collaboration is addressing particular topics with the data, and they routinely regulate external communication of results to the scientific community.

Particle physics collaborations minimize the powers that collaboration managers can exercise in order to make their members comfortable with the large breadth of activities that the collaboration as a whole regulates. In all other research specialties we examined, participants in collaborations were more autonomous than particle physicists in the generation and dissemination of scientific results; and the participants (more or less happily) allowed collaboration managers to exercise discretionary powers to secure what the collaboration as a whole needed.

The prevalence of high-breadth, egalitarian collaborations in particle physics is due to: (1) the dispersal of particle physicists among many universities, (2) the specialty’s centralized institutional politics, and (3) competitive pressures. Because particle physicists in the United States and Europe are dispersed among many universities and because they crave integrated, multi-component detectors, they need to be in high-breadth collaborations in order to conduct publishable research. Because collaborations must submit proposals to central authorities for access to an accelerator, participants are behooved to commit to an organizational structure that convinces the accelerator laboratory’s administration that they are properly organized to produce what they promise. With respect for internal structure thus secured before any commitment of resources to the collaboration is made, collaboration administrators have not required formalized powers to maintain order and could afford to grant broad rights of participation to all members of the collaboration, from graduate students to senior faculty. Such Athenian-style democracy has produced publications rather than cacophony because competition for discoveries—and for career-advancing recognition—limit the collective tolerance for intra-collaboration dissent.

FUNCTIONAL ANALYSIS OF RECORDS CREATION
by Joan Warnow-Blewett with the help of Anthony Capitos

The key functions of all scientific activities can be summarized as establishing research priorities, administration of research, including development of instrumentation, the research and development itself, and dissemination. We list the key functions of multi-institutional collaborations below and illustrate the process of functional analysis by providing a brief analysis of the functions along with the categories of records created through these activities. Details on these categories of records are provided in the Appraisal Guidelines section of our full report.

Our *Highlights* excerpts have been drawn from the field of geophysics.

I. *ESTABLISHING RESEARCH PRIORITIES*

A. *National/Multi-National/Discipline Priorities*

Geophysics

Establishing broad research priorities in geophysics and oceanography, as in space science, is done on a discipline level. When global phenomena seem important, priorities are worked out not only in national but in multi-national disciplinary organizations. This function of establishing research priorities is carried out in many different arenas. In the United States, the National Academy of Sciences' advisory boards, such as the Ocean Studies Board, the Polar Research Board, and the Board on Atmospheric Science, are sites for the scientific community to voice their opinions concerning broad program ideas. On an international scale, organizations like the International Council of Scientific Unions (ICSU) and the World Meteorological Organization (WMO), along with programs like the International Geophysical Year, have helped to set goals in the fields of geophysics and oceanography. In ICSU, priorities for broad areas to pursue typically rise up through one or more of the international unions for scientific disciplines (e.g., the International Union of Geodesy and Geophysics), its interdisciplinary bodies (e.g., the Scientific Committee on Oceanic Research), or its joint programs (e.g., the World Climate Research Programme). Through interaction with these groups and institutions, the scientific community promotes ideas for large multi-institutional collaborations.
Documentation: National Academy of Sciences' Ocean Studies Board, Polar Research Board, and Board on Atmospheric Science; International Council for Scientific Unions (its unions, interdisciplinary bodies, and joint programs), and the World Meteorological Organization.

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B. *Individual Project Research Priorities*

Geophysics

The more specific hypothesizing and defining of priorities takes place as programs or projects are focused and shaped by the scientific community. In the cases we studied, we found two different approaches by research scientists: obtaining funding for formal workshops (usually employed by "technique-aggregating" projects) and informal gatherings (usually employed by "technique-importing" projects).[11]

In the formal workshop approach, instigators for projects obtain support from funding agencies to hold workshops for interested research scientists which define the scope and methodology of the project, select members of an Executive Committee and an institutional base to serve as the project's Science Management Office, along with a principal investigator (PI) to administer it, and initiate a set of proposals for submission to a funding agency.

For the international projects we studied, ICSU and WMO have been particularly influential in setting up workshops and symposia, which typically generate a number of workshop panels. If project proposals receive the blessing of ICSU and WMO, workshop panel members and other interested scientists submit proposals to their national funding agencies and ICSU's members—the national academies—feel pressured to provide support.

In the less formal approach, the process of establishing priorities for specific projects can be initiated wherever key research scientists get together. Meetings of the American Geophysical Union or review panels of funding agencies are examples. Some, but not all, consortia need funding to set themselves up and prepare proposals. In the technique-importing projects we studied, funding agency personnel played an important role in defining the terms of consortia formation and, in some cases, later project research activities.

Whether the approach is formal or informal, scientists involved in the instigation of geophysics and oceanography projects should take care in documenting these initial meetings and workshops. <u>Documentation</u>: Minutes and other records of workshops and initial meetings of consortia, proposals to funding agencies, correspondence of program managers at funding agencies, professional papers of scientists.

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II. *ADMINISTRATION OF R & D*

A. *Support/Funding*

Geophysics

In the geophysics cases we studied, domestic funding was provided by various agencies (and often more than one). The process involves submission of proposals to discipline program managers at funding agencies, peer and panel reviews at the program level and—for larger projects—review at the highest policy level, such as the National Science Board of the NSF. To be more specific, technique-aggregating projects submit a package of proposals to one or more funding agencies where a set of individual proposals (and, thereby, principal investigators) are selected. For the most part the technique-importing projects we studied were supported by block grants from funding agencies to the consortia which, in turn, selected proposals for using the imported

[11]Technique-aggregating projects aggregate geophysical techniques to study, e.g., a global phenomenon. Technique-importing projects import, for academic research, established techniques from industrial research or other scientific fields. These geophysics projects are described in more detail in Part A, Section One: Historical-Sociological Findings, in our full report, *Documenting Multi-Institutional Collaborations.*

techniques; however, in two of these cases, would-be individual users had to submit proposals for approval by the funding agency.

Finally, we note that consortia are funded, in part, by institutional members.
Documentation: Consortia standing committees and subcommittees, program managers and proposal files at funding agencies, and professional files of principal investigators. Additional documentation, at higher levels not dealt with by our study, will be found in the records of university administrators, records of the Office of Management and Budget, and records of the U.S. Congress.

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B. *Staffing*

Geophysics

Staffing of geophysics and oceanography projects is most visible in records of workshops and consortia and the subsequent funding process. Workshops and consortia select committees and science administrators; proposals, as a minimum, identify principal investigators and, often, prospective team members. Decisions to fund proposals are made at various levels of funding agencies or by committees of consortia. Additional information on staffing of projects would be in the records of chief administrators, staff scientists, and papers of principal investigators.
Documentation: Workshop and consortia records, Science Working Groups and consortia committees, funding agencies, chief administrators, and professional files of principal investigators.

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C. *Organization and Management*

Geophysics

In technique-importing projects there would normally be a consortium responsible for appointing standing committees (or more than one, or one with subcommittees responsible for separate aspects of the project). These advised or directed project executives. A consortium in these projects proceeded in one of two ways: (1) it created an arena in which institutions could participate as equals even when one among them was made responsible for administration, or (2) it created a new independent, freestanding entity in which the involved institutions could vest responsibilities that they did not want any extant member institution to dominate. The technique-importing projects have needed to operate far longer—in order to apply the technique to many objects of curiosity—than the technique-aggregating projects. They have, therefore, adopted a more secure institutional base and more formal chain of command. Project executives include an Executive Committee and a chief administrator. Another key position at some project headquarters is that of staff scientist.
Documentation: Consortia headquarters records, records of federal funding agencies, and professional files of principal investigators.

Technique-aggregating projects united multiple, independent principal investigators who formed a Science Working Group (SWG) that, in turn, selected members for an Executive Committee. In these projects, there would typically be a modest Science Management Office run from an institution and under the direction of one of the principal investigators with grant funds to spend on coordinating logistics for the principal investigators.

Technique-aggregating projects, as compared with technique-importing projects, usually have a more *ad hoc*, informal institutional base in order to maximize self-governance. The SWGs for these projects are critical in managing what is intrinsically collective to the design of the projects, such as the allocation of space and the track of oceanographic research vessels, the distribution of core samples, a common data processing algorithm for combining data streams from several individual instruments, and protocols for comparing data sets obtained by deploying several techniques at the same site. That was usually the limit of power allotted to a project's Science Working Group, although—for example—the Executive Committee of the working group might be called on at times to add a judgement of project relevance to the proposals to funding agencies. The rest was left to the discretion of individual principal investigators.

The Science Management Office (SMO), under the direction of its principal investigator, is responsible for the logistics of technique-aggregating projects. The office provides technical infra-structure and gets people and their equipment to the site where they can take their data. While this was challenging in all cases, it was particularly so for ship-based oceanographic projects as compared to land- and space-based geophysics projects. SMOs have also been responsible for creating centralized data management systems to facilitate exchanges of data streams and to maintain project-wide data bases. They have also organized post-field-work workshops for intra-project exchanges of preliminary findings, which—among other things—often inspired joint data analyses efforts.
<u>Documentation</u>: Science Management Office's principal investigator files including records of the Science Working Group and its Executive Committee.

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III. *RESEARCH AND DEVELOPMENT*

A. *Instrumentation*

Geophysics

Research and development of instrumentation for academic geophysics mostly takes place in geophysical research institutes, which maintain engineering staffs to service the facilities they provide their research staffs. University departments of geophysics or geology usually do not have the research-and-development laboratories and machine shops to support design and construction of instrumentation. However, the body of instrumentation available for academic geophysical research is supplemented by the efforts of commercial interests (e.g., oil exploration companies) and governmental functions (e.g. detection of nuclear weapons tests) to develop instrumentation that university geophysicists may parasitically use or adapt for their purposes.
<u>Documentation</u>: Records of consortium Executive Committees as well as other standing committees (and subcommittees where they exist). Records of project Science Working Groups, administrators of the Science Management Offices, and other principal investigators.

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B. *Gathering and Analyzing Data*

Geophysics

While preliminary plans for gathering and analyzing data were spelled out in proposals, the more detailed plans were developed by individual principal investigators and consortium administrators of technique-importing projects and by Science Working Groups (made up of all principal investigators) and Science Management Office administrators of technique-aggregating projects. Virtually all principal investigator teams kept logbooks on the data-gathering techniques they employed (instruments, locations, and so forth) that would provide the metadata necessary for data analysis. The data gathered by the cases studied by the AIP included electronic data, cores (of ice, of sediment) and water samples.

Documentation: Consortium administrators, including staff scientists; Science Management Office (Science Working Groups and administrators), professional files of principal investigators, and databanks.

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IV. *COMMUNICATING AND DISSEMINATING RESULTS*

Geophysics

In most cases, collaborations in geophysics and oceanography required that each team produce an article that would be published with the others as a set—often as a special issue of a science journal. However, collaborations did not control the content or author lists of publications. Instead, it is the principal investigator of each experiment who is in control of the team's data and publications. Members of other teams must obtain permission of the principal investigator to use the data; in such cases, it is traditional that the principal investigator would be asked to review the draft publication and be listed as an author. If a member of their own team prepares an article for publication, it is customary for principal investigators to review the article and be listed as an author. The inclusion of other members of the team as authors varies from case to case. Arrangements for making oral presentations are typically even more informal, although principal investigators would usually be aware of their team members' plans.

Documentation: Chief administrators at consortia and Science Management Offices, professional papers of principal investigators and other team members, and press releases and other public affairs materials.

APPRAISAL GUIDELINES

by Joan Warnow-Blewett with the help of Anthony Capitos and Lynn Maloney

The scope of these guidelines is records created by multi-institutional groups that participate in collaborative research projects. Also, for the fields of geophysics and space science, we have included records of groups that set national and international policy. Outside the scope of these guidelines are the records created by other activities at the government laboratories, universities, and other institutions involved, and by other activities of individual scientists. We recommend different appraisal guidelines for these materials.

Finally, these guidelines reflect two of the purposes of the AIP Study: (1) to identify a small set of core records that should be permanently preserved for all collaborations in a given disciplinary field and (2) to distinguish the wider array of documentation that should be preserved for selected experiments—those that are of major scientific significance and, if possible, some that are of special value because they can serve as typical or representative of a period or category of experiment—and that, therefore, will be of high interest to future historians, sociologists, and other users. Hereafter, these selected experiments will be referred to as "significant." Action mechanisms for identifying these experiments are included in our Project Recommendations.

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Although our focus in this appraisal section is the field of materials science, we open it with an important excerpt from our General Appraisal Guidelines that applies to all the scientific disciplines covered in the AIP Study:

PAPERS OF INDIVIDUAL SCIENTISTS

To document significant collaborations (as well as careers of distinguished scientists), archivists and records officers should place the highest value on the papers of PIs and other leaders of multi-institutional collaborations. Papers of these scientific leaders are prime locations for documentation of a number of topics, including details of staffing, plans for data gathering and analysis, and use of the data by collaboration members. The papers will typically contain proposals, personal notebooks, and correspondence with other collaboration leaders and with funding agencies. In cases where the scientific leader was also an instigator of the collaboration, the files may provide especially unique documentation of the initial thinking and early plans of the project. When individual scientists have been leaders of significant collaborations or have regularly played a leading role in important research, the records of their participation should be saved (whether or not the full range of papers documenting their careers merits archival preservation).

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III. FIELDS STUDIED BY AIP

D. ***Materials Science***

1. ***Core Records to be Saved for All Collaborations***

a. *NSF Cooperative Agreement Jackets for Centers*

It is important to distinguish between grants for NSF research projects and cooperative agreements for NSF centers—Science and Technology Centers (STCs) and, in this case, Materials Research Science and Engineering Centers (MRSECs). Grants provide funds for best effort and contracts specify deliverables with awards and punishments; contracts now have largely been replaced by the more flexible cooperative agreements. Among other things, cooperative agreements allow NSF to get involved in administration and become partners with its centers. Jackets for NSF center cooperative agreements contain somewhat different documentation. In addition to proposals, referee reports, minutes of panel meetings, and progress and final reports, the jackets include NSF site visit reports, and (we recommend that they include) valuable preproposals. On the negative side, since most, if not all MRSECs and STCs make the final decisions on which researchers at member institutions get funded, the NSF jackets lack funding details (e.g. individual proposals) of the research of MRSEC and STC collaborations. Overall, future historians and other users will find documentation of the initial plans and ambitions of a center, how the center had to modify its plans to suit NSF, and community reactions to the center's plans and accomplishments. For further details, see General Appraisal Guidelines in our full report. Locations: Records of MRSECS are in possession of NSF's Division of Materials Science; records of STCs are in NSF's Office of Science and Technology Infrastructure.

b. *DARPA (Defense Advanced Research Projects Administration) Proposal Files*
Proposals, referee reports, MOUs/Intellectual Property Agreements, and progress and final reports. The proposals document the plans and ambitions of the collaborations and the level of information the participants were willing to share about their individual capabilities prior to the negotiation of an intellectual property agreement. The MOUs/Intellectual Property Agreements document the terms on which the corporations could jointly participate and could individually share information with the participating universities; successful negotiation of the MOUs was a prerequisite to the start of funding from DARPA. Files should also contain projected schedules of deliverables and reimbursements that provide the basis for intra-collaboration milestones. For details, see General Appraisal Guidelines. Location: In the possession of the relevant DARPA program officer.

c. *NSF Grant Award Jackets*
In most materials science collaborations using facilities at national laboratories, each institutional member raises its own funds, with corporate members using internal funds and academic institutions going to NSF. In at least some cases, member institutions apply jointly to NSF. Award jackets include proposals documenting the plans and ambitions of the collaboration, referee reports, minutes of panel meetings, and progress and final reports. For details, see General Appraisal Guidelines. Location: In possession of NSF's Division of Materials Science program officer.

d. *Proposals to Corporate Management*
Corporate researchers proposing to build and share a beamline at a DOE National Laboratory have to convince their corporate management to underwrite a share of the construction costs. These records are the functional equivalent of a proposal, albeit less formal than what university scientists submit to a federal funding agency. Likely locations: In the records of individual researchers or—where they exist—in the archives of the corporation.

e. *Records of Executive (Program) Committees of MRSECs and STCs*
In both the MRSECs and STCs, scientists or groups of scientists desiring funding have to submit an annual proposal (which, among other things, is supposed to justify the interdisciplinary and

multi-institutional aspects of their work that make them acceptable for this sort of funding). A collection of such proposals comes to the Executive (Program) Committee for evaluation. That evaluation sets the scientific agenda. The records of this review process (proposals, reviews, and award decisions, etc.) would provide a definitive record of the scientific evolution of the MRSEC or STC project as well as insight into the management criteria imposed. A sampling, at least, of these files (every three or five years) should be preserved. Likely locations: In records of the MRSEC or STC or the academic officer it reports to (e.g., the vice-president or associate provost for research).

f. *Records of Facility Advisory Committees (FACs) at DOE National Laboratories*
The materials science collaborations using facilities at DOE National Laboratories in our case studies used two synchrotron radiation facilities and one breeder reactor facility. Use of these research facilities is governed by a Facility Advisory Committee (FAC); this is our generic term to cover several titles used by the laboratories. E.g., Argonne's Advanced Photon Source (APS) has two relevant FACs: (1) the APS Program Evaluation Board, a scientific peer advisory board that evaluates proposals to form research teams to gain research access to the APS and reviews subsequent scientific performance; it formally advises laboratory management on the scientific appropriateness of proposed research and the likelihood of success and (2) the APS Management Plan Review Committee, a staff committee that reviews management plans of collaborations and advises APS management on the collaboration's readiness to sign a formal Memoranda of Understanding (MOU) and begin construction and subsequently operate beamlines at the APS. In general, FAC records include proposals, letters of intent, and conceptual design reports submitted by the collaboration to apply for space to develop a beamline and end stations. The records will not include proposals for money, since each member institution is responsible for its own funding, but researchers will find MOUs between the collaboration and the DOE facility covering obligations of the collaboration and the facility to each other. The files may also provide justification for FAC actions and recommendations. Interviewees indicate that these are the best, perhaps the only, collective statements of collaboration goals and strategies. The records of the FAC for the breeder reactor are also important for the impact of safety concerns and regulations. Location: At the relevant research facility at the DOE National Laboratories.

g. *Memoranda of Understanding between Member Institutions*
Sometimes referred to as joint agreements, these legal documents lay out the powers of the collaboration's Board of Governors, the obligations of the member organizations, and their privileges to use the finished beamline. They include terms on which staff scientists will work with the corporations on proprietary research. Likely locations: In the records of the Facility Advisory Committee for the relevant DOE National Laboratory facility and in the archival records of collaboration member institutions.

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2. ***Records to Be Saved for Significant Collaborations***
We have previously stated the importance of identifying and securing a wider array of documentation for a selection of highly significant multi-institutional collaborations. Because of their scientific importance, extensive records of such collaborations will be

needed by science administrators and policy-makers as well as future historians, sociologists, and other users.

For this *Highlights* report, we do not include records descriptions but merely list the series titles of records to be saved for significant collaborations in the discipline of materials science. They are: (a) Records of Executive Board (or Governing Board, Program Committee, or Technical Representatives Committee); (b) Records of External Advisory Committees; (c) Records of Annual Meetings of the Collaboration; (d) Records of Spokespersons/Staff Directors; and (e) Newsletters and Sector Descriptions. For details, see the full report, *Documenting Multi-Institutional Collaborations.*

HIGHLIGHTS AND PROJECT RECOMMENDATIONS

PART C: CURRENT ARCHIVAL PRACTICES AND PROJECT RECOMMENDATIONS

In Parts A and B, we covered the initial phases of the documentation strategy research employed by the AIP Study: the findings of our field research and our analyses of the data collected through that research.

In Part C we introduce another stage of documentation strategy research—a stage that is particularly suited to a discipline history center like the AIP Center—in which we address policy and programmatic issues. The purposes of this stage are two-fold: (1) to pinpoint records of long-term value that are at risk under current procedures, and (2) to develop recommendations for policies and procedures to safeguard records that will be needed by research administrators, historians and other scholars. For the AIP, this stage is critical. We conduct the first stages to learn how to document an area. With that knowledge in hand, we assess the ability of archival and record-keeping programs to secure the important records; then we issue formal policy recommendations to institutions that have control over the records.

When we compare the scope of the records needed to document collaborations against our assessment of current archival policies and practices, the urgency of our project recommendations is abundantly clear.

SECTION ONE: CURRENT ARCHIVAL PRACTICES

SECTION TWO: PROJECT RECOMMENDATIONS

CURRENT ARCHIVAL PRACTICES
by Joan Warnow-Blewett and R. Joseph Anderson

Our excerpts in this section illustrate the AIP Study's findings in the various sectors including academia, corporations, and federal agencies.

I. *INTRODUCTION*

Archival policies and practices differ widely in the USA. The differences can be seen most clearly in terms of the sectors of our society in which the institutions operate. We have organized this section of our report accordingly.

The AIP's knowledge of archival programs has accumulated since its history program was initiated in the early 1960s. Those experiences—trying to save one scientist's papers at one repository—bore little resemblance to our present goal of documenting multi-institutional collaborations. Now, we might need to save the records of one collaboration at several repositories—repositories that probably would be in different sectors (academic, government and/or government-contract, and, perhaps, corporate institutions).

In the spring and summer of 1997, the AIP History Center conducted surveys of archives at leading research universities and at corporations with strong R&D programs to assess their ability and willingness to identify and preserve the records of historically important multi-institutional collaborations and the papers of key collaboration members. We also wished to improve our overall knowledge of these archives; that knowledge was based on a variety of sources, including interviews with archivists, published sources, site visits, correspondence regarding preservation of papers, and other contacts. Our contacts with corporations have been far less frequent than with universities.

The AIP also needed to broaden its understanding of the ways federal science agencies operate—in particular, how well their records management programs protected their historically valuable records. After years of site visits and interim reports on records programs at these agencies (and at the National Archives, the repository for agency records), the AIP assembled the first-ever meeting of science agency records officers and representatives of the National Archives and Records Administration (NARA). The meeting achieved its goal of updating and clarifying our knowledge of current programs at the agencies and at NARA.

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II. *ACADEMIC ARCHIVES*

B. *AIP Survey of Academic Archives*

The repositories that we surveyed generally are at the top of the academic tree. They are located at major research institutions whose programs in the physical sciences represent the best and most prosperous of American academe, and their faculty include many of the leaders in the multi-institutional collaborations that we have studied.[12] We sent the academic survey to 42 repositories and received a total of 37 returns for a response rate of 88%.

The academic questionnaire contains 12 questions and seeks two kinds of information. First, we asked respondents to describe their program; questions included the size of the staff and the collection, whether there had been staff expansion or reduction in the past five years, expansion space for the collection, the nature of records management, and policies on electronic records and collecting personal papers of faculty and staff. Second, we asked whether they would accept collaboration-related records of faculty who were key participants in multi-institutional collaborations and the records of the collaboration itself if it was headquartered on their campus.

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The findings from the academic survey are mixed, but the results seem generally positive. The range of programs is very wide in terms of staff and collection size. A little over a third of respondents reported fewer than five staff—almost certainly fewer people than needed to adequately document a major research institution—but nearly a quarter said that they had 15 or more staff, which seems large by university archives standards. At a minimum we were able to identify an archivist or similar staff member at all the institutions in our target group, and the question about staff additions/reductions during the period 1992-1997 reveal a fluctuating pattern of loss and gain rather than the sharp declines that we had heard about anecdotally during this era of government and academic downsizing. Overall, in fact, respondents reported a few more staff additions (41%) than staff reductions (39%).

More significant for our study of multi-institutional collaborations, 82% of respondents said that they would accept the collaboration-related papers of their faculty who were key participants in highly ranked collaborations, and 78% said that they would accept the administrative records of a highly significant collaboration if it was headquartered at their university. An important reality check here is that the AIP Center's International Catalog of Sources for History of Physics and Allied Sciences (ICOS) contains entries for the records of only three multi-institutional collaborations already in academic archives. In light of this, the strongly positive responses to these two questions should probably be interpreted as evidence of willingness to preserve records of collaborations rather than of active efforts to identify and accession them. However, the responses offer the hope that if a third party like the AIP History Center is able to rank collaborations and help identify valuable papers and records, most of the archives in this sample may be willing to provide a home for those related to their university (because of a major role by faculty or the site of an administrative office).

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III. *FEDERAL AGENCIES*

Each federal agency is required by law to have a set of records schedules that determines how long records will be retained and when records of long-term value are to be transferred to the

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[12] We surveyed repositories at research universities that rank in the top quartile in one or more of five physics-related fields (physics, astronomy, astrophysics, oceanography, geophysics) in *Research-Doctorate Programs in the United States.* Washington, D.C.: National Academy Press, 1995

National Archives and Records Administration (NARA). These schedules must be approved both by senior management at the agency and by NARA.

It is not enough to review the records schedules from federal agencies; a review of the records management program which will implement the schedules is equally important. When discussing records programs with agency records officers, their description of the programs and the proper use of the records retention schedules may differ from the actual implementation by agency employees. Our findings show that, in general, federal agencies and their laboratories (or contract laboratories) do not document their research and development activities well.

We have learned that it is the responsibility of the agencies to see that their records schedules are maintained and properly applied. For example, agencies must update their records schedule manuals as new records series are identified (via inventorying or other means) and they must schedule new program records within a year. NARA has oversight responsibilities. It also has authority to conduct evaluations of agency records management programs; however, for reasons of efficiency, most of NARA's efforts in this area are shifting to a new initiative called a Target Assistance Program. TAP is an agency-initiated nationwide collaborative program customized to help agencies work on their records problems.

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During the long-term AIP Study we analyzed the current practices at the Department of Energy, National Aeronautics and Space Administration, the National Institutes of Health, the National Oceanic and Atmospheric Administration, the National Science Foundation, and the United States Geological Survey. Our findings, described in *Documenting Multi-Institutional Collaborations*, are based on our decade-long fieldwork and on discussions with records officers of science agencies and the National Archives at a meeting in 1999 at AIP. All of the agency records officers—with the possible exception of DOE—were well aware that they are critically understaffed and short of funds, and that their scientists and administrators are largely unaware of their programs.

IV. *CORPORATE ARCHIVES*

A. *General Findings*

Over the decades, the AIP Center has had minimal experience with corporate archives and what experience we have had has not been encouraging. We have found that few research corporations have archival programs and, where these programs exist, they have focused on administrative records and those that provide protection of their patent rights. It has been a major exception to the rule to find corporate archives that would accession the professional papers of their distinguished scientific staff. In addition, the records of many corporate archives have not been made easily accessible to historians and other external researchers.

Corporations did not play a primary role in the multi-institutional collaborations we studied. In fact, with the exceptions of materials science and medical physics, corporations were not among the member institutions of our selected case studies. There were, however, indications—at least in high-energy physics and materials science—that the presence of corporate institutional members was growing. In high-energy physics, we are aware that corporations have been full members of collaborations (in cases more recent than the period we covered). In the field of materials science, there are at least two, relatively recent catalysts that have boosted the presence of corporate members: (1) synchrotron radiation facilities are attractive to many corporate researchers and (2) the introduction of NSF's Materials Research Scientific and Engineering Centers (MRSECs) has fostered collaborative links between academia and the corporate world. Finally, in the area of medical physics, we have just learned that the NIH expects multi-institutional collaborations to have a higher profile in its research programs in the near future; this should mean increased participation by corporations. We believe that collaborations are becoming more important in scientific research. It seems equally evident that corporations are becoming more important to collaborations.

For these reasons (and because the AIP Center is considering a future research project to understand how we might do a better job of documenting physics in industry) a survey of corporate archives was conducted.

As a whole the academic survey (section II.B., above) presents a picture of varying but generally active efforts to document America's leading research universities. Predictably, the corporate survey presents a very different picture, and one that is both less optimistic and less clear. At the same time the corporate survey shows some interesting patterns. We contacted the American companies that employ the most physicists, and we used a list developed by AIP's Division of Education and Employment Statistics of the 37 companies that employed approximately half of all U.S. physicists in industry in 1994.[13]

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In summary we found that eight (22%) of the 37 U.S. enterprises, who employed approximately half of all physicists in industry in 1994, had professional in-house archives and another three (8%) preserve at least some records by sending them to independent non-profit archives. A large proportion of the eight in-house archives said that they would accept staff records from important collaborations and half said that they would take in records of important collaborations. However, these responses shouldn't be interpreted as evidence that the archives at top science industries, when they exist, are documenting R&D. We have visited or had lengthy phone contacts with four of the eight archives in our sample, and two of these are currently preserving records almost exclusively of business operations. And the small size of most of the archives that we identified makes it unlikely that they can go much beyond saving top administrative records.

Overall, the corporate survey reinforces the findings of a conference on business records convened by the Hagley Museum and Library and the Minnesota Historical Society in 1996, that American corporate life is not well documented and that this is as true among major science corporations as for other areas of the corporate world. The results do not bode well for

[13]AIP Division of Education and Employment Statistics, "The Corporations Employing the Largest Number of Ph.D. Physicists in the Private Sector, 1996." We should note that the corporate sector represents about one-third of the working physicists in the USA.

documenting this increasingly large sector of physics and allied sciences or of preserving industry's contributions to major multi-institutional collaborations.

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V. *OTHER FINDINGS OF INTEREST*

We have encountered two types of freestanding institutions during the long-term AIP Study of Multi-Institutional Collaborations: NSF National Observatories and geophysics institutes. We refer to them as freestanding because they have no affiliation with a university or other large institution and, as a result, have no natural link to a repository for their records.

The NSF National Observatories have some characteristics in common with the DOE National Laboratories. Both DOE's and NSF's facilities are internationally top-ranking institutions making major contributions to contemporary science and, although operating under contract, they can be considered to be "permanent" organizations. There are, however, two significant differences: while the DOE laboratories create federal records and have come to terms with the responsibilities of securing their records of historical value, the NSF National Observatories do not create federal records and—as younger organizations—they are just beginning to worry about coping with their old records. As already mentioned, the NSF observatories lack affiliations with archival institutions. We do not know of any that have initiated archival programs or made formal arrangements for their records to be transferred to an established repository. Until one of these choices is made, the records of these research facilities will be in danger.

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VI. *SOME CONCLUSIONS*

There are inconsistencies and problems in archives and records management efforts at various universities, government agencies, corporations, and other research institutions. These challenges are compounded when one tries to document collaborative research efforts across institutions. Many archives and records management programs are well-intentioned but desperately underfunded and overwhelmed with work. Many research institutions—including all the national observatories and most corporate laboratories—lack archival programs altogether. Indeed, it is not at all clear that the nation's archival and records management programs are capable of doing an adequate job of documenting multi-institutional collaborations.

The problems of corporate archives are particularly difficult to resolve, as illustrated by our corporate survey. It is obvious that corporate archives and records management programs cannot survive unless they serve the parent institution, and many are just barely surviving. There is little room for preserving records of multi-institutional collaborations—a task few in the corporations would consider essential to their missions. Nevertheless, in our recommendations, we ask corporate research laboratories to meet a modest standard: those corporations that lack archival programs should initiate them and all corporations should consider documenting their role in multi-institutional collaborations to be part of their responsibilities.

Most of all, we are concerned about archival and records management programs in the academic and federal sectors, where our fieldwork shows the tasks of documenting collaborative research in the physical sciences will impose its greatest burdens. Additional resources—critical in both cases—would help resolve the problems. In our Project Recommendations we ask federal funding agencies to provide a very modest increase in overhead rates to academic institutions—an increase that would be targeted for the support of academic archives. We also ask these federal agencies to recognize that, with the exception of the Department of Energy, their own agency records programs lack the resources to meet even the legally required standards of securing adequate documentation of their programs and activities. Without professional records programs, agencies cannot meet training goals or enjoy the efficiencies of proper records-keeping—to say nothing of halting the loss of records needed for administrators and future historians.

PROJECT RECOMMENDATIONS

by Joan Warnow-Blewett, with the help of Spencer R. Weart

All chapters of our report—whether they be findings, analyses, or assessments—lead to our project recommendations. We have provided ample evidence that changes in records programs at research institutions and federal agencies must be made to secure an adequate record of multi-institutional collaborations and their contributions to science and our society.

It may be difficult for scientists—even those who direct collaborative work—to recognize the importance of saving documentary source materials. It may seem to them that their personal recollections and those of their colleagues are sufficient. This is unfortunate from the standpoint of present needs. From the standpoint of the future it is disastrous, for even the imperfect personal recollections will die with the scientists, and later generations will never know how some of the important scientific work of our times was done.

Archivists and records managers may wonder why they must take on what might be seen as "yet another responsibility." A different perspective would be that scientific activities are simply being shared differently than in the past—fewer scientists are doing individual or small projects and more and more of them are participating in collaborative projects. We expect it will become quite natural to archivists and records managers working in the scientific arena to find that collaborative research projects have become integral to the major institutional policies, programs, and activities that they are committed to document. Nevertheless, we are well aware that archivists and records officers—particularly in academia and federal agencies, where responsibility for collaboration records is highest—are overwhelmed by workloads and inadequate budgets. Our recommendations #3.a. and #3.b. address this issue.

The project recommendations that follow are aimed at preserving only a small fraction of the records created by multi-institutional collaborations. As shown in our appraisal guidelines, records of archival value will consist of a small set of core records plus, in a few cases, a wider range of records for very significant collaborations. Our experience indicates that records of this quality will be of interest to future historians and other scholars. Multi-institutional collaborations have a diversity of characteristics that contribute to their potential interest to scholars. For example, collaborations may be not only multi-institutional but multi-disciplinary and multi-sectored as well. In addition, these multi-institutional collaborations must be seen in the context of the national and other major research facilities they use. Whether on their own or in the context of the research facilities, multi-institutional collaborations are an integral part of the "Big Science" characterized by large federally-funded budgets and national and even international planning and policy making. For these reasons, multi-institutional research collaborations are of potential interest to a wide variety of scholars. Securing adequate documentation of multi-institutional research collaborations is critical for future historical studies. It is also vital for current management of technical innovation and for science policy needs of federal agencies and others who want to understand such basic issues as the effectiveness of team structures.

The following recommendations are directed to the actions needed to document collaborative research in physics and allied sciences, particularly in those fields studied by the AIP Study of

Multi-Institutional Collaborations during its three phases, namely: high-energy physics (Phase I), space science and geophysics (Phase II), and ground-based astronomy (divided into observatory builders and observatory users), heavy-ion and nuclear physics, materials science, and medical physics and an area we named computer-mediated collaborations (Phase III). They are justified in more detail in the reports issued at the end of each phase of the long-term study of collaborations.[14] Many of the documents referred to are currently on paper, but our recommendations also apply to information in electronic format.

The AIP Center has encountered a wide range of complexities facing the documentation of experiments in modern physics and allied fields. On the most basic level, good records-keeping may be acknowledged by all as necessary while the experimental process is alive but, when the project is over, records can easily be neglected, forgotten, or destroyed. As a result, the most important recommendation (Recommendation #14.b.) urges a new approach to securing the documentation for future collaboration projects. We suggest that, once a project has been approved by a research laboratory (observatory, NSF center, etc.), the collaboration be required to designate a member to be responsible for its collaboration-wide records. In addition—where historical significance warrants—individuals should be named to be responsible for group (or team) level documentation of innovative components or techniques. This information should be incorporated into any contractual agreement with the collaboration. Use of this simple mechanism would assist archivists by assuring that records will be available for appraisal and by providing information on their location.

Multi-institutional collaborations are virtually all funded by federal science agencies and much of the research and development is carried out at agency facilities. Most of our recommendations are addressed to these agencies, as well as the National Archives and Records Administration (NARA), because successful documentation relies heavily on the effectiveness of their records management programs.

The recommendations are grouped in the following order:
<u>Recommendations—Policies and Procedures</u>
1. General
2. National Archives and Records Administration
3. Federal Science Agencies
4. Specific Federal Science Agencies
5. Other Institutional Settings

[14]The AIP project recommendations issued at the end of each of the three phases are available on the AIP Center's web site (http://www.aip.org/history/); sets of printed reports for each phase are available upon request to the AIP Center.

Recommendations—What to Save:[15]
1. Policy and Planning Records
2. Core Records by Scientific Discipline
3. Significant Collaborations

Recommendations—How to Save

RECOMMENDATIONS—POLICY AND PROCEDURES

CATEGORY ONE—GENERAL

Recommendation #1: Professional files of key scientific faculty/staff members should be permanently preserved by their institutional archives.

Explanation:
Virtually all of our recommendations are focused on securing records of collaborations; accordingly, we must make clear at the outset the importance of preserving papers of individual scientists.

For some decades now, it has been traditional—especially in English-speaking countries—for professional files of academic scientists to be permanently preserved in their institutional archives. Those papers most frequently sought are of individuals who have made major contributions to science or science policy on a national or international level or to their university.

There are two principal targets for this recommendation. First, university archives in all countries should have policies to permanently secure files documenting the professional careers of their distinguished scientists. Second, similar policies are sorely lacking at virtually all research laboratories and other nonacademic institutions; they should be initiated and supported by directors of laboratories, whether they be in the corporate or government sector.

CATEGORY TWO—NATIONAL ARCHIVES AND RECORDS ADMINISTRATION

Recommendation #2:

a. *The National Archives and Records Administration (NARA) should solicit increased input from subject matter experts so that it can make more informed decisions on records appraisal;*
b. *NARA should work with agencies to monitor and promote agency records management practices to insure that legal regulatory responsibilities are met, including the identification and maintenance of records of permanent value;*
c. *NARA should identify and promote best practices for records management programs that agencies should utilize, including the development of R&D records criteria. The R&D records schedule of the DOE (Department of Energy) could serve as a model for other scientific agencies;* and,
d. *NARA should consider, on a case by case basis, accessioning non-federal records essential to documenting federal support of science.*

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[15] The records to be saved for high-energy physics, heavy-ion physics, and nuclear physics will be found under particle and nuclear physics (Recommendations #12.f. and #13.f.).

Explanation:

2.a. ***NARA should solicit increased input from subject matter experts so that it can make more informed decisions on records appraisal***.

Although the National Archives has responsibility for the final appraisal of federal records, we are heartened that it has become increasingly aware of the importance of obtaining input from subject matter experts when appraising records of science and technology. Our particular concern is for the policy and planning records as well as the R&D records themselves. In these cases, it is urgent that the appraisal process be initiated with those who best understand the value of the documentation—the onsite records creator-scientists. Specifically, NARA should seek out subject matter specialists for the review of R&D records schedules of scientific agencies; it should also encourage records officers at science agencies to include subject matter specialists in the assessment of the importance of particular research projects; other opportunities for including subject matter specialists should be pursued.

2.b. ***NARA should work with agencies to monitor and promote agency records management practices to insure that legal regulatory responsibilities are met, including the identification and maintenance of records of permanent value.***

NARA holds to its traditional position of discouraging the placement of professional archivists at external agencies. In its experience, the placement of an agency archivist equates directly to the assembly of an institutional archives rather than conformance to the legal requirement to transfer federal records to the National Archives. For this reason, when these recommendations discuss federal records we refer to "records advocates" (i.e., someone who can argue on behalf of the historical value of records) rather than "archivists."

Accountability should be the cornerstone of a records management program. While we propose some ways to improve existing agency records schedules (see, e.g., our Recommendation #2.c., below), the most serious problems we see are the failures to implement records programs by the agencies themselves. All too often, those responsible for records programs are ill-informed about their own institution and its science and technology, and passive about gathering records and about suggesting to NARA the additions or adjustments to their records schedules needed to protect valuable records series. Typically, scientists, administrators, and other staff at the agencies are uninformed about record-keeping programs. Consequently, it is critical that NARA work with agencies to monitor and promote agency records management practices. They should see to it that the responsibility for records management has been clearly assigned and defined and that staff are appropriately trained and experienced.

Records officers must be grounded in records management principles and should be expected to serve as "records advocates." Competencies for records advocates would include skills in dealing with non-current records and archival, historical, or records management training and experience. The National Archives has seen that records advocates have been effective at such scientific settings as some of the accelerator laboratories of the Department of Energy; these have offered the National Archives a far better selection of records. The selection is better because a proactive program is in place to review records at the place where they are created—consulting those who created them—for the purpose of providing adequate documentation of the entire facility. The records advocates we have worked with most closely have been professional archivists, but trained historians or records managers skilled in dealing with noncurrent records could work equally well as part of a records management team. Records advocates should be expected to be knowledgeable about the scientific institution and the research programs it carries out. They should argue for the historical value of records in the context of agency records schedules and help NARA understand the unique records creation process at each of the science agencies. For all these reasons, we recommend that records advocates (e.g., trained archivists, historians, or records managers skilled in noncurrent records) should be made part of the records management programs—both at agency headquarters and at the key facilities and laboratories.

2.c. ***NARA should identify and promote best practices for records management programs that agencies should utilize, including the development of R&D records criteria. The R&D records schedule of the DOE (Department of Energy) could serve as a model for other scientific agencies.***

As part of a program to monitor records management practices at federal science agencies, NARA should consider conducting a survey of science agencies about their basic records management practices to determine the kinds of infrastructure now in place. This—along with our suggestions for implementation and for training and use of "records advocates" in Recommendation #2.b., above—should help NARA identify Best Practices for agencies records management programs. A set of Best Practices is sorely needed and should be widely promulgated through the World Wide Web, other publication vehicles, and discussions at sessions of professional meetings of records managers.

For science agencies, it is critical that NARA develop Best Practices for developing criteria for the appraisal of R&D records, including procedures for ranking the importance of specific scientific research projects. Since NARA rescinded the part of its General Records Schedule covering research and development records, it became necessary for each science agency to schedule these records according to the unique practices of their individual agencies. A number of federal science agencies have already done so. Among these, DOE (Department of Energy), NASA (National Aeronautics and Space Administration), NIST (National Institute of Standards and Technology), and NOAA (National Oceanic and Atmospheric Administration) have gone further to include sets of criteria that help their agencies identify significant R&D records. We believe all federal science agencies should include such sets of criteria in their records schedules. The schedules of the DOE, NIST, and NOAA could serve as models.

The new DOE Research and Development Records Retention Schedule, approved in August 1998 by NARA, is by far the best schedule we have studied. We are particularly impressed with its guidelines for procedures to rank scientific research projects as "significant," "important," and "other" and to involve the science records creators in this ranking. We also want to point out the importance placed on the proper evaluation of scientific policy and planning records in the DOE records schedule.

Our main purpose in this recommendation is to ask NARA to include the development of criteria for the appraisal of R&D records in its Best Practices. In addition, because National Archives appraisal archivists play a key role in developing agency records schedules, we ask NARA to urge them to encourage their assigned science agencies to have sets of criteria that provide effective procedures for identifying significant research and development records for permanent retention.

This may require additional resources for the National Archives' Life Cycle Management Division.

2.d. ***NARA should consider, on a case by case basis, accessioning non-federal records essential to documenting federal support of science.***
Many important federally-funded research organizations do not legally produce federal records, yet some of the records they produce provide valuable evidence of the government's support of science. Accordingly, we ask NARA to consider—on a case by case basis—serving as a repository of last resort for selected records of organizations not formally affiliated with the federal government that have no appropriate repository for their records. Prime examples are contractor institutions that oversee FFRDCs (Federally Funded Research and Development Centers) and free-standing research institutions.

See also Recommendation #6.b. to academic archives and #8 to NSF National Observatories.

CATEGORY THREE—FEDERAL SCIENCE AGENCIES

***Recommendation* #3:**

a. *Federal agencies responsible for negotiating overhead rates to universities should support a marginal increase to provide the modest additional support academic archives need to document collaborative and other federally funded research. The OMB should specifically include archives costs as allowable costs;*
b. *Federal science agencies should recognize the needs and benefits of providing adequate support for their agency records management program;*
c. *Federal science agencies should employ records advocates as part of their records management staff;*
d. *Federal science agencies' records management programs should increase educational programs within the agency in order to stress the importance and benefits of records management and the criteria for saving scientific records;*
e. *Federal science agencies should save records documenting interagency funding of collaborative research projects*;
f. *Federal science agencies whose research centers/laboratories are operated under contract should permanently secure their headquarters' records relating to the contractor organizations*;
g. *Federal science agencies should permanently secure proposals and other documentation related to major research facilities at their centers/laboratories and other sites*; and
h. *Federal science agencies should save controversial—albeit unsuccessful—collaborative research proposals in addition to successful ones.*

<u>Explanation</u>:
The two most important of these recommendations are #3.a. and #3.b. If science agencies adopted only these two recommendations, success in documenting significant scientific research in general, and multi-institutional collaborations in particular, would undergo a spectacular increase. For further information, see Academic Archives and Federal Agencies in Current Archival Practices, Part C, Section One [of the full report, *Documenting Multi-Institutional Collaborations*].

3.a. ***Federal agencies responsible for negotiating overhead rates to universities should support a marginal increase to provide the modest additional support academic archives need to document collaborative and other federally funded research. The OMB should specifically include archives costs as allowable costs.***

By now, readers [of the full report, *Documenting Multi-Institutional Collaborations*,] are aware that—in addition to the federal science agencies—it is the academic sector that must bear the burden of documenting multi-institutional collaborations. Over the decades federal science agencies have supported PIs (principal investigators) and research groups in academia far more than in any other sector. Each grant (or contract or cooperative agreement) has included overhead to support costs incurred by the university. No one seems to have considered the costs accrued by archives at these universities for preserving the records of significant scientific research made possible by federal funds.

Two stipulations of the OMB apply to the establishment of overhead rates: (1) universities will negotiate their overhead rates (known as facilities and administration [F&A] rates) from the Department of Health and Human Services (HHS)or the Department of Defense's Office of Naval Research (DOD) and (2) information on funding shall be derived from relevant data gathered by the National Science Foundation (NSF). Further, the principles for determining the appropriateness of costs that can be included in an F&A rate agreement are found in OMB Circular A-21, "Cost Principles for Educational Institutions." One of these allowable costs is library costs.

The fact that library costs are allowable by the OMB is unlikely to provide adequate coverage for costs for archives which, for one thing, may or may not be included within the library organizational structure. The relevant agencies (HHS, DOD, and NSF) should recognize the need for the support of academic archives and realize that an extremely modest increase in overhead rates (dedicated to support of the university archives) would make it possible for academic archives to secure the records that will be needed by science policy makers and administrators, by historians and other scholars, and the public at large. The OMB should be urged by universities and the relevant agencies to add costs of archives to its list of costs that can be included appropriately in an F&A rate agreement.

3.b. ***Federal science agencies should recognize the needs and benefits of providing adequate support for their agency records management program***.

At our October 1999 meeting with current agency records officers and staff of the National Archives, AIP project staff were taken aback by the meager resources made available to in-house records management programs. We ask federal science agencies to recognize that, with the exception of the Department of Energy, their own agency records management programs lack the resources to meet even the legally required standards of securing adequate documentation of their programs and activities. Without professional records management programs, agencies cannot meet training goals or enjoy the efficiencies of proper records-keeping—to say nothing of halting the loss of records needed for administrators and future historians. With appropriate levels of support, agency records management programs can efficiently carry out the remainder of our recommendations.

3.c. ***Federal science agencies should employ records advocates as part of their records management staff***.
Each science agency should examine the effectiveness of its existing records management program and seriously consider the benefits of adding records advocates—e.g., trained archivists, historians, or records managers skilled in noncurrent records—to its staff, both at headquarters and at major laboratories, flight centers, etc. that carry out national scientific programs. Such advocates should be expected to work proactively with scientists and administrators to become knowledgeable about their organization and the science and technology it is dedicated to.

See Recommendation #2.b. for additional arguments.

3.d. ***Federal science agencies' records management programs should increase educational programs within the agency in order to stress the importance and benefits of records management and the criteria for saving scientific records***.
During our interviews with agency scientists and administrators, it became clear that many individuals creating important science policy records or scientific research records were unaware of the records-keeping program of their agency. This was the case in varying degrees at each of the agencies involved in our selected projects throughout our long-term study: DOD (Department of Defense), DOE (Department of Energy), NASA (National Aeronautics and Space Administration), NIH (National Institutes of Health), NOAA (National Oceanic and Atmospheric Administration), NSF (National Science Foundation), and USGS (United States Geological Survey). We also found that some records management staff were not as knowledgeable as they should be about their program. Education programs need to target both records creators and records managers. Records managers should be able to work with the scientists to assist them in following records retention policies to document their projects; this joint effort would greatly increase the survival of significant records. Agency records management staff should take advantage of workshops offered by the National Archives. They should, in turn, be expected to offer workshops for their agency employees, both at headquarters and in the field. One very effective means is to hold periodic workshops for secretaries and other files administrators (including those responsible for maintaining central files) so that they understand agency records schedules and are knowledgeable about identifying which records should be destroyed, which saved, and how and why.

3.e. ***Federal science agencies should save records documenting interagency funding of collaborative research projects***.
Individual federal agencies are usually the sole funder of collaborative research projects. In the instances where their funding responsibilities are shared with other agencies, the agency that takes the lead role should preserve on a permanent basis its records of interagency meetings, correspondence, agreements, and so forth.

3.f. ***Federal science agencies whose research centers/laboratories are operated under contract should permanently secure their headquarters' records relating to the contractor organizations***.
In some important instances federal agencies (notably DOE and NSF) do not operate their research centers/sites directly but rather through contracting organizations. Some contractors are universities, corporations, or other longstanding institutions; other contractors are set up for the very purpose of operating FFRDCs (Federally Funded Research and Development Centers). Examples of the latter

category are AUI (Associated Universities, Inc.), AURA (Association of Universities for Research in Astronomy, Inc.), and URA (University Research Association, Inc.). The role exercised by these contractor organizations over the research directions and policies of their centers/laboratories is considerable and, therefore, the importance of documenting their activities is clear. Records at the relevant agency headquarters would include correspondence between the agency and contractor, minutes of contractor board meetings, annual fiscal and progress reports, and copies of committee reports—with names like Users Committee and Visiting Committee—of the centers/laboratories under contract.

3.g. ***Federal science agencies should permanently secure proposals and other documentation related to major research facilities at their centers/laboratories and other sites***.
When laboratories request support for new, large research facilities (such as accelerators, particle "factories," telescopes, reactors, and supercomputers) and for other major instrumentation, federal agencies should permanently secure the proposals (whether accepted or rejected) along with relevant correspondence. Files for successful facility proposals should also include financial and narrative progress reports, final reports, records of agency site visits, correspondence with site officials, and any other materials that provide valuable documentation.

N.B.: This recommendation pertains to proposals from centers/laboratories/observatories for building major research facilities; recommendation #3.h. pertains to proposals for experimental research projects.

3.h. ***Federal science agencies should save controversial—albeit unsuccessful—collaborative research proposals in addition to successful ones***.
Federal funding agencies are currently required to save records on successful research proposals (contracts, cooperative agreements). We recommend that—for multi-institutional research collaborations—the agencies also preserve the records for the (relatively few) unsuccessful proposals that stimulate significant debates or controversies. The files typically would include proposals, referee reports, minutes of panel meetings, and—in some cases—records of agency site visits.

N.B.: This recommendation pertains to proposals for collaborative research projects; recommendation #3.g. pertains to proposals from laboratories for building major research facilities.

CATEGORY FOUR—SPECIFIC AGENCIES

Department of Energy (DOE)

Recommendation #4: DOE should be commended for its new R&D records schedule; it should make certain the implementation of the schedule is fully supported.

<u>Explanation</u>:
The DOE and its records management staff, as well as the NARA liaison archivist, deserve congratulations on the development of its excellent, new records retention schedule for research and development records—no modest task. We now ask DOE to provide the fiscal and moral support needed for the implementation of this important schedule.

We believe that the DOE's new R&D records schedule supports these AIP Project Recommendations as well as our Appraisal Guidelines (see Part B, Section Three). We ask that the DOE records officer contact us to discuss any discrepancies.

See also, Recommendation #2.c. to NARA and #3.b. and 3.d. to Federal Agencies, above.

National Aeronautics and Space Administration (NASA)
***Recommendation* #5: *NASA needs to upgrade coverage and to clarify some confusing generalities in its records schedules*.**
Explanation:
NASA's recent records schedules are a great improvement. We note, however, that some generalities are confusing and, more important, some categories of records needed to document collaborative research in space science are not covered.

The NASA records schedules are written in a very general manner in order for the manual to be applicable to both NASA Headquarters and its flight centers. Only records of the upper level management offices at headquarters are specified with the mid-level headquarters scientists being fit into other functional locations. For example, the term "program" and the term "project" are interchangeable in these schedules, even though in NASA parlance program scientist and program manager are headquarter positions and project scientists and project managers are at flight centers.

NASA's records schedules do not provide for retention of some records deemed valuable by the AIP Study. Important examples are the records of the advisory groups of discipline scientists at NASA Headquarters (where ideas for most NASA projects are initiated) and records of the Science Working Group for projects at flight centers which provide the most important documentation of the scientific aspects of the mission.

National Science Foundation (NSF)
***Recommendation* #6: *The NSF should include archival arrangements in the requirements for cooperative agreements to support its research facilities and its centers, as well as other management offices of collaborations*.**
Explanation:
These NSF-supported research facilities (e.g., National Observatories) and centers (both its Materials Research Science and Engineering Centers [MRSECs] and its Science and Technology Centers [STCs]) do not create federal records. Neither do science management/consortium headquarters offices or freestanding research institutions set up to administer NSF-funded collaborations. Special arrangements should be made to permanently secure the essential documentation of their research programs. Specifically, NSF should fund fully the archival programs at its national facilities and provide fiscal and moral support for proper maintenance of records at its centers and at the collaboration offices and freestanding research institutions it funds.

NSF Facilities. The NSF supports—through contractor organizations—some of the most important laboratories (e.g., Scripps Institution of Oceanography) and observatories (e.g., National Radio Astronomical Observatory) in the country. Because of their long-standing importance and because they lack affiliations with established archival repositories, we are especially concerned about the NSF National Observatories. To our knowledge these observatories lack strong records management programs. The NSF should provide the fiscal support for them to initiate archival programs to permanently secure at least their most important documentation.

NSF Centers. MRSECs and STCs are relatively new and rapidly growing phenomena at academic settings. NSF funds its centers for a period of years to function as multi-institutional collaborations and foster research in particular areas of materials science or science and technology. Although the centers are at academic settings, academic archivists will need to be persuaded to consider the documentation of NSF centers to be part of their responsibility. The fact that the NSF centers are impermanent institutions presents another danger to the records.

Science Management/Consortium Headquarters Offices Within Academic Settings. In NSF-funded collaborations that have no connection with any NSF center, one principal investigator applies for a grant enabling the collaboration to set up an office for administering the project. For the most part, these offices are within a department of a college or university; when this is the case, the most appropriate repository for the project's core records would be that institution's archives.

Freestanding Research Institutions. In some other cases, NSF grants to collaborations result in the setting up of freestanding institutions to administer their research programs. Records of such institutions have no appropriate repository. They are far more likely to find an adequate repository if they are maintained in orderly condition with adequate finding aids to facilitate research.

NSF should stipulate appropriate arrangements for records in its cooperative agreements/ contracts. A very small fraction of the amount awarded to the facilities, offices, and freestanding institutions would pay for the proper organization of records permitting greater efficiencies of operations as well as the archival maintenance or orderly transfer of records. Special NSF funding may not be required to secure the small set of core archival records of NSF centers.

See also Recommendations #7.b. to Academic Institutions and #8 to Nonacademic Research Laboratories, below.

CATEGORY FIVE—OTHER INSTITUTIONAL SETTINGS

Academic Institutions

***Recommendation* #7:**

a. *Professional files of collaboration principal investigators and other key academic scientists should be retained by their home institutions according to their individual careers; and,*
b. *Academic archives should enlarge as necessary the scope of collecting policies in order to accession non-federal records of NSF centers as well as science management offices and consortium headquarters offices within their institutions.*
c. *Universities with strong science programs should request modest increases in their overhead rates to support their archives.*

Explanation:

7.a. ***Professional files of collaboration principal investigators and other key academic scientists should be retained by their home institutions according to their individual careers***.
The professional papers of PIs (principal investigators) are a prime location for information concerning the development of an experiment or an experiment team. A substantial fraction of the principal investigators in the collaborations we studied are employed by academia. The papers of those who have regularly led or participated in important collaborative research are well worth saving. In other cases, collaboration-related records kept by a faculty member should be accessioned (whether or not the balance of the individual's papers are), especially if the collaboration was deemed significant.

N.B.: This is a rewording of Recommendation #1, above. Our point here is to emphasize the essential role academic archives play in documenting collaborative research by preserving the papers of individual scientists who played leadership roles in the projects.

7.b. ***Academic archives should enlarge as necessary the scope of collecting policies in order to accession non-federal records of NSF centers as well as science management offices and consortium headquarters offices within their institutions***.
The NSF centers (both its Materials Research Science and Engineering Centers and its Science and Technology Centers) are funded for a period of years; although renewals are possible, they are not permanent. The NSF centers are organized to function as multi-institutional collaborations; most, if not all, make the final decisions on which researchers at member institutions get funded. We also found, in our study of geophysics, that science management offices and consortium headquarters offices last the lifetimes of the collaborative projects, which may be quite short. Most of these offices are NSF-funded and, as such, do not produce federal records.

The academic institutions within which they operate should hold themselves responsible for accessioning core records of the centers or management offices. If such arrangements are not possible, the records should be offered as a gift to the Archivist of the United States and the National Archives and Records Administration.

See also Recommendation #2.d. to NARA and #6 to NSF, above.

7.c. ***Universities with strong science programs should request modest increases in their overhead rates to support their archives.***
Universities with strong science programs should request modest increases in their overhead rates to support their archives. It has been noted more than once in our report that the academic sector must bear a major share of the burden of documenting multi-institutional collaborations. Additional support for university archives is essential to document significant collaborative and other federally funded research. Academic archivists should bring these facts to the attention of their universities when it is time to renew contracts for overhead rates.

Universities negotiate overhead rates with specific federal agencies, but OMB guidelines must be followed. Currently library costs are allowable by the OMB but archives costs are not mentioned.

Universities should urge the OMB to add costs of archives to its list of costs that can be included appropriately in an overhead rate agreement.

For details, see Recommendation #3.a. to Federal Science Agencies, above.

Nonacademic Research Laboratories

Recommendation #8: Nonacademic research laboratories (government, FFRDCs, corporate, and free-standing institutions) lacking programs to identify and permanently secure records of historical value should initiate them

Explanation:

The nonacademic laboratories in our study have included all major categories of research laboratories, primarily those in the U.S., but also some major laboratories abroad. Almost without exception, these laboratories—however important their contributions to postwar science may be—lack programs to protect their valuable records. All too many even lack records management programs (the exception here are government laboratories and FFRDCs that produce federal records and are required to have records management programs).

Our experience shows it is possible to permanently preserve an adequate record of scientific research where laboratories have records advocates (i.e. archivists, historians, or records managers trained in noncurrent records) and impossible where laboratories lack them. Records advocates are needed to work with scientists to identify and permanently secure those records of interest to future scientist-administrators, historians, and other users. From our experience it seems clear that the chief responsibility for initiating these programs lies with the individual laboratory directors. Once programs are in place, records advocates develop relationships of trust and provide an array of invaluable services to laboratory staff and management. The records they preserve provide the best means to achieve the all-important institutional memory.

For laboratories in the U.S. that create federal records (government laboratories and those of the DOE), our concern is for appropriate historical evaluation of files on site so that records that provide essential evidence of long-term value will be offered to the National Archives. In other countries, some laboratories are required to transfer permanent records to state or national repositories.

Free-Standing Institutions

***Recommendation #9: Freestanding but temporary American research institutions should offer historically valuable records to an appropriate repository at the end of a project*.**

Explanation:

In our study of geophysics we found a few cases where, rather than setting up consortium headquarters offices in academic settings, entirely new and freestanding—but temporary—institutions were created to manage a collaborative project. Although these institutions are federally funded, their records are not federal in ownership. Selected records of these consortia should be offered to an appropriate repository such as a participating university or state historical society.

See also Recommendations #2.d. to NARA, #6 to NSF, and #8 to Nonacademic Research Laboratories, above.

National Science Foundation Facilities

***Recommendation* #10: *The NSF National Laboratories and Observatories that lack archival programs should initiate them*.**

Explanation:

As already stated, these NSF facilities consist of some of the most important laboratories and observatories in the country, if not the world. There is no doubt that future historians and other scholars will need to draw on their historically valuable records.

NSF National Laboratories and Observatories that lack them should initiate archival programs. (We recommend that NSF provide the fiscal support.) They should consider maintaining their collections of records on site. Where this is not feasible, the records of archival value may be offered to a nearby university or state historical society; they may also be offered to the National Archives because they provide important evidence of federal support of science.

See also Recommendations #2.d. to NARA and #6 to NSF.

RECOMMENDATIONS—WHAT TO SAVE

CATEGORY ONE—POLICY AND PLANNING RECORDS

Recommendation* #11: *Records of policy and planning boards in the U.S. and elsewhere relating to multi-institutional collaborations should be saved at appropriate repositories.

Explanation:

Every scientific discipline has international and national boards (unions, committees, etc.) that set priorities for research areas and guide support for major efforts; a good number of these decisions lead to the initiation and, at times, the oversight of multi-institutional and/or multi-national, collaborations. Other policy bodies operate within scientific agencies and often have more impact on specific collaboration projects. Records of these policy groups are of great value to a wide variety of scholars and scientist-administrators.

Among the disciplines covered by the AIP Study, we found policy-making bodies that have had a direct influence on collaborations in the fields of geophysics and space science. Records of policy-making bodies effecting collaborative research in these fields are listed here. For descriptions of these records, see the Appraisal Guidelines, Part B, Section Three.

POLICY AND PLANNING RECORDS

a. ***Geophysics and Oceanography***: Records of the National Academy of Sciences' Ocean Studies Board, Polar Research Board, and Board on Atmospheric Science; also, records of the International Council for Scientific Unions and records of the World Meteorological Organization.

b. ***Space Science***: Records of the National Academy of Sciences' Space Studies Board and, at NASA Headquarters, minutes and other records of various working groups from the Management Operations Working Groups up to its Advisory Council. In Europe, records of ESA's Space Science Advisory Committee, its Science Programme Committee, and its working groups. The records of the European Space Science Committee of the European Science Foundation are also of potential value.

CATEGORY TWO—CORE RECORDS BY SCIENTIFIC DISCIPLINE

***Recommendation #12: A core set of records should be saved at appropriate repositories to document multi-institutional collaborations*.**

Explanation:

There is a short list of records that, taken together, provide adequate documentation of most collaborative projects in a given discipline. Core records for collaborations in the disciplinary fields studied during the long-term AIP Study are listed here. For descriptions of these records, see the Appraisal Guidelines, Part B, Section Three.

CORE RECORDS

a. ***Geophysics and Oceanography***

There have been relatively few large, multi-institutional collaborations during our period of study and these should be considered to be significant. Additional records should be saved for all large collaborations over and above the core records described here (see Recommendation #13, below).

Core records to be saved for all collaborations: proposal files of federal funding agencies.

b. ***Ground-Based Astronomy—Observatory Builders***[16]

Each observatory-building collaboration is considered to be significant: few are built in any one decade and each is essentially unique. Additional records should be saved for all collaborations over and above the core records described here (see Recommendation #13, below).

Core records for observatory-building collaborations: NSF grant award jackets and/or NSF cooperative agreement jackets for research facilities; documents of incorporation.

c. ***Ground-Based Astronomy—Observatory Users***[17]

Core records for observatory-using collaborations: proposals and related records in Time Allocation Committee files of radio and national optical observatories and, where relevant, records of observatory consortium chairpersons.

d. ***Materials Science***

Core records for materials science collaborations: proposals to federal funding agencies and/or to corporate management; where relevant, records of Executive (Program) Committees of NSF MRSECs and STCs; Memoranda of Understanding; and—for those using DOE accelerator facilities—records of Facility Advisory Committees at DOE National Laboratories.

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[16]The AIP Study's four case studies of telescope-building collaborations did not include any collaborations involving national optical or radio telescopes. As a result, our recommendations in this category are based on previous experience of the AIP Center and input from our Working Group.

[17]The AIP Study's four case studies of telescope-using collaborations did not include any collaborations conducting sky surveys or, indeed, any collaborations of optical telescope users. Accordingly, our recommendations in this category are based solely on the previous experience of the AIP Center and input from our Working Group.

e. ***Medical Physics***
Core records for medical physics collaborations: proposal jackets at private foundations and/or federal funding agencies and—for those using DOE accelerator facilities—records of DOE Facility Advisory Committees.

f. ***Particle and Nuclear Physics***
Core records for particle and nuclear physics collaborations: proposal files at DOE or NSF; at accelerator laboratories—records of laboratory directors responsible for areas of particle and nuclear physics as well as records of Physics Advisory Committees documenting the process of proposals for access to beamtime on accelerators and including contracts between the laboratory and the collaboration.

g. ***Space Science***
In the field of space science, all large projects/missions are considered significant. Additional records should be saved for large projects/missions over and above the core records described here (see Recommendation #13, below).

Core records for space science collaborations: records of the relevant discipline/program scientist and program manager, along with their respective advisory groups, at NASA Headquarters. Records of their counterparts at ESA Headquarters. (Also, at NASA, core documentation for development of instruments used in space science projects/missions is provided by grant proposal files of discipline scientists.)

CATEGORY THREE—SIGNIFICANT COLLABORATIONS

Recommendation #13: Fuller documentation should be saved for significant collaborations.

Explanation:
A wider array of substantial documentation should be preserved for highly important collaborations to meet the needs of scientist/administrators as well as historians and other scholars. The early identification of current experiments of outstanding significance should initiate actions to secure fuller documentation for subsequent appraisal (see Recommendation #14.b., below). This documentation would include those categories of records specified in the appraisal guidelines prepared by the AIP Study and other records found to contain valuable evidence of the collaboration's organizational structure and research process. Records to be saved for significant collaborations in the disciplinary fields studied during the long-term AIP Study are listed here. They are described in detail in the Appraisal Guidelines, Part B, Section Three.

N.B.: We make note that, for the largest and most controversial multi-institutional collaborations, significant documentation will also be found at higher administrative levels, such as offices of presidents and provosts of universities, top administrators at agencies and laboratories, and other key policy boards. We do not address recommendations to offices at such higher levels on the assumption that their records are already secured.

RECORDS TO BE SAVED FOR SIGNIFICANT COLLABORATIONS

a. ***Geophysics and Oceanography***
Additional records to be kept for all large collaborations: records of the consortium headquarters office or the project's science management office as follows. The consortium headquarters office records, including records of standing committees, records of the consortium's administrative head, and records of consortium staff scientists. The science management office records, including records of the SMO administrator and records of the Science Working Group. Also—specifically for oceanographic projects—ships' logs should be retained.

b. ***Ground-Based Astronomy—Observatory Builders***[18]
Additional records to be kept for all observatory-building collaborations: Board of Directors' minutes of meetings; records of project manager; records of Science Advisory/Science Steering Committees; records of Design Review Panels; records of Science Project Team; contracts and associated records; and technical reports.

c. ***Ground-Based Astronomy—Observatory Users*** [19]
Additional records to be kept for significant collaborations: papers of first authors of VLBI (Very Long Baseline Interferometry) collaborations and, where relevant, records of observatory consortium secretaries.

d. ***Materials Science***
Additional records to be kept for significant collaborations: records of Executive Board (or Governing Board, Program Committee, or Technical Representatives Committee); records of External Advisory Committees; records of annual meetings of the collaborations; records of spokespersons/staff directors; and newsletters and sector descriptions.

e. ***Medical Physics***
Additional records to be kept for significant collaborations: minutes of collaboration meetings; records of group leaders for statistical analysis; and protocols and samples of data collaboration forms.

f. ***Particle and Nuclear Physics***
Additional records to be kept for significant collaborations: records of spokespersons, including intra-collaboration mailings; records of group leaders, including—in selected cases—proposal submitted as PI (principal investigator); records of project managers and project engineers; Intra-Collaboration Technical Committee records; Accelerator/Research Division files on experiments; and selected technical records (e.g., logbooks and blueprints and specifications).

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[18]See footnote 6.

[19]See footnote 7.

g. ***Space Science***
Additional records to be kept for all large projects/missions are at NASA flight centers: records of project managers; records of project scientists, along with the Science Working Groups; also, records of instrument managers, where the position exists.

Additional records for space science in Europe would include records at ESTEC (ESA's flight center): records of the project managers and project scientists, along with the Science Working Groups; also, the records of payload specialists.

RECOMMENDATIONS—HOW TO SAVE

***Recommendation* #14**:
a. *Scientists and others should take special care to identify past collaborations that have made significant contributions; and*
b. *Research laboratories and other centers should set up a mechanism to secure records of future significant experiments.*
Explanation:
14.a. ***Scientists and others should take special care to identify past collaborations that have made significant contributions***.
Future scholars, as well as science administrators and policy makers, will need considerably more documentation in order to study in more detail those multi-institutional scientific collaborations that can be considered most significant in their contributions to advances in scientific knowledge, including theory and experimental techniques.

There exist general guidelines for identifying significant research projects. The best we have found thus far are in the 1998 DOE Research and Development Records Retention Schedule.[20] Other parameters for identifying significant projects can obviously be made to meet the needs of particular research laboratories, say in the corporate sector, or by disciplines outside those covered by DOE research.

Our first concern must be the identification of past collaborative research projects, since the documentation becomes endangered as soon as the project has ended and scientists turn their attention to other matters. The participation of all knowledgeable parties is needed:
(1) **Individual scientists** could bring the contributions of a research project they consider to be significant to the attention of their research director, institutional archivist, etc.;
(2) **Academic departments or research laboratories** could set up an *ad hoc* history committee from time to time to identify their most significant research projects and bring them to the attention of their provost, archival program, etc.;
(3) **Policy and planning bodies**, such as DOE's High Energy Physics Advisory Panel, could compile lists of most significant research collaborations and broadcast them to their disciplines; and

[20]See the Department of Energy's Web site (http://www-it.hr.doe.gov/records/) for this schedule; of particular interest is the Introduction which includes a review of the guidelines and an R&D evaluation checklist. See also Recommendation #2.c. to the National Archives, above.

(4) **History committees of AIP Member Societies** could either compile lists or survey their members for nominations and then broadcast the lists to their members.

The AIP Center for History of Physics will also contribute to the identification of recent significant research collaborations by working proactively with Boards of the National Academy of Sciences and other policy and planning bodies.

14.b. ***Research laboratories and other research centers should set up a mechanism to secure records of future significant experiments***.
The scientists and research directors—at laboratories/observatories and other research centers/sites—are best informed to identify those experiments/projects that are likely to be considered significant by future judgements. We are aware that efforts to document events from earlier decades will be frustrated by frailties of records-keeping practices. Therefore, we urge the laboratories themselves to identify as early as possible experiments/projects of potential significance. While doing so, the research directors should bear in mind the recent emergence of subcontractors for major research and development collaborations and identify experiments/ projects in which significant subcontracts should be documented—either by the laboratory, the subcontractor, or a combination of both.

Laboratories and other research centers can easily reduce the complexity of locating the additional records needed to document the more significant experiments by setting up a mechanism to identify and secure records during or prior to their creation. Once a proposal for an experiment/project is approved, the relevant administrator at the research site should require a collaboration to include in their next write-up a statement as to: (1) which individual collaboration member should be responsible for collaboration-wide records and (2) which, if any, records on the team level should be retained on a long-term basis because of scientific significance.[21] A collaboration's chief scientist knows at the outset when a particular component of the instrument or technique is revolutionary or innovative; appropriate identification and assignment of records responsibilities for these should be included. When assigning responsibility for collaboration-wide records to an individual, the chief scientist should select a collaboration member at a permanent institution; in many cases, this will be an academic institution or the research site itself. A collaboration's statement about records-keeping responsibilities should be incorporated in its MOU (Memorandum of Understanding) or other contractual agreement with the research center.

The purpose of this recommendation is to secure the records that may be needed to document significant experiments. Later, when an experiment has been identified as significant, archivists will be in an excellent position to contact the individuals assigned responsibility for the records and make arrangements to permanently preserve those of enduring value.

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[21]Ideally, the relevant administrator would be located at a national laboratory, flight center, or other central research site where the project was conducted. In some cases—e.g., NSF centers and Deep Sea Drilling Programs—it would be the site where the project was approved for funding. Unfortunately, fields like VLBI (Very Long Baseline Interferometry) observations and medical physics lack a central site and the most relevant administrator would be the program officer at the funding agency.

The laboratories and research directors should also consider employing technologies on behalf of collaborations that would assist in the capture, retention, and access to valuable evidence. For example, the research sites could offer to retain certain files, such as collaboration e-mail, Web sites, and other relevant electronic records, on their computer systems.

***Recommendation* #15: *Institutional archives should share information on their relevant holdings with each other and with AIP/RLIN*.**

Explanation:

Knowledge of institutional records and professional papers of individuals is essential to foster use by historians and other scholars. For example, papers documenting a particular experiment/project are likely to be physically located in various repositories; shared catalogs will bring them together intellectually for the user. Archivists should include sufficient facts—such as laboratory name and experiment/project number or title—to identify the collaboration documented in their collections when they prepare inventories, scope and content notes (or any other descriptions), and indexes.

One means for archivists to broadcast information on their holdings is to send descriptions of collections or records series to the AIP where they will be added to the International Catalog of Sources for History of Physics and Allied Sciences, maintained by the AIP Center for History of Physics. In cases where the archives itself does not report its holdings to the American database RLIN-AMC (the Research Libraries Information Network-Archives and Manuscript Control) of the Research Libraries Group, the AIP can provide this service.

THE ROLE OF THE AIP CENTER

The AIP Center can play a facilitating role in a number of these recommendations. It can work with laboratories and other research institutes by: (1) providing advice to those that decide to establish or upgrade archival programs, (2) aiding in the process of identifying significant experiments, and (3) assisting laboratory advisory committees in such areas as identifying appropriate repositories for papers and records documenting significant experiments. The AIP Center will continue its work with corporate, academic, and other institutional archivists to preserve significant papers and records and to provide advice on records appraisal. In addition to its International Catalog of Sources (http://www.aip.org/history/icos.htm), the Center offers, upon request, such cataloging tools as topical indexing terms and authorized names of thousands of individuals and institutions.

AIP Center for History of Physics
One Physics Ellipse
College Park, MD 20740
phone: (301) 209-3165; Facsimile: (301) 209-0882
e-mail: chp@aip.org; Web site: http://www.aip.org/history/

AIP STUDY OF MULTI-INSTITUTIONAL COLLABORATIONS
WORKING GROUP FOR THE FINAL REPORT

SCIENTISTS

Geophysics
Dr. John Knauss, Dir. Emeritus
National Oceanographic & Atmospheric Administration
and
Graduate School of Oceanography
University of Rhode Island

Ground-Based Astronomy
Dr. Goetz K. Oertel
President
Association of Universities for Research in Astronomy

High-Energy Physics
Dr. Stanley G. Wojcicki
Stanford Linear Accelerator Center

Materials Science
Dr. Ulrich Strom, Program Dir.
NSF Materials Research Science & Engineering Centers

Medical Physics
Dr. John Watson, Deputy Dir.
National Heart, Lung, & Blood Institute
National Institutes of Health

Space Astronomy
Dr. Robert E. Williams
Director Emeritus
Space Telescope Science Institute
and
Department of Physics & Astronomy
Johns Hopkins University

Space Science
Dr. Joseph K. Alexander
Director
Space Studies Board
National Research Council

HISTORIANS AND SOCIOLOGISTS

History: High-Energy Physics
Prof. Peter Galison, Chair
Department of the History of Science
Harvard University

History: CERN & ESA
Dr. John Krige
Director
Center for History of Science & Technology, Paris

History: Geophysics
Prof. Naomi Oreskes
Department of History
University of California at San Diego

History: Space Science
Prof. Robert Smith
Department of History & Classics
University of Alberta

Sociology of Science
Prof. Wesley Shrum
Department of Sociology
Louisiana State University

ARCHIVISTS & RECORDS MANAGERS

Academic
Prof. William J. Maher
University Archivist
University of Illinois

Ms. Helen W. Samuels
Office of the Provost
Massachusetts Institute of Technology

Corporate
Ms. Elizabeth W. Adkins
Manager of Archives Services
Ford Motor Company Archives

DOE National Laboratories
Ms. Victoria Davis, Budget Officer
Particle Physics Division
Fermi National Accelerator Laboratory

Federal Science Agencies
Ms. Mary Ann Wallace
Supervisory Management Analyst
Department of Energy

Government Records
Ms. Marie B. Allen, Dir.
Life Cycle Management Division
National Archives

Mr. Larry Baume, Supervisor
Life Cycle Management Division
National Archives

Dr. Terry Cook
National Archives of Canada

Dr. Sharon Thibodeau
National Archives

NSF Facilities
Ms. Deborah Cozort Day
Archivist
Scripps Institution of Oceanography

AIP PROJECT STAFF

Ms. Joan Warnow-Blewett
AIP Study Project Director
and
Archivist Emeritus, AIP Center

Dr. Spencer R. Weart
Chair, AIP Study Working Group
and
Director, AIP Center

Dr. Joel Genuth
Project Historian, AIP Study

Dr. Ivan Chompalov
Project Sociologist, AIP Study

Mr. R. Joseph Anderson
Assistant Director, AIP Center