# A Reorganization of the Technical Management of NRAO

## Recommendations of the NRAO Observatory Technical Council (OTC).

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### 1. Introduction

The Director of NRAO asked the Observatory Technical Council (OTC) to recommend changes to the technical management of NRAO that would improve the technical efficiency of the observatory, and allow the organization to become more responsive to application of new technology to Radio Astronomy. This report presents a consensus of the views of the council. Most of the discussion took place via email, with some input from NRAO employees not on the council, and also some outside advice from Hein Hvatum (who was responsible for technical management of the observatory until about 1984) and Sandy Weinreb (who was responsible for the CDL until about 1988). During this period note was also taken of somewhat parallel discussion taking place in the Observatory Computing Council (OCC).

The **Membership of the OTC** during this investigation was Barry Clark, Larry D'Addario, Darrel Emerson (Chair), Rick Fisher, Brian Glendenning, Tony Kerr, Lee King, Peter Napier, John Payne, Dick Sramek, Dick Thompson and John Webber.

### 2. Technical management at NRAO in 2003.

The technical management at NRAO at the beginning of 2003 is essentially site-based. A simplified organizational chart is shown in **Figure 1.** Each telescope site has its own technical divisions, reporting to the local site director. In this context, the new projects at NRAO (e.g. ALMA and the EVLA) are treated as sites, with their own technical groups, budgets and technical management. The Central Development Lab (CDL) supports all NRAO sites and NRAO projects. New initiatives, for example for innovative instrumentation for existing telescopes, come mainly from the individual telescope sites, and are funded either from individual telescope operations budgets, or the corresponding *Research Equipment* budget for the site. The CDL has tried to pursue longer term research projects as well as providing support to existing telescopes, but all projects, either for telescope support or for longer term instrumentation research, have been severely hampered by inadequate *Research Equipment* budgets.

Communication between different NRAO sites or projects has been very poor for the last several years. This has led to some duplication of effort, with very little advantage being taken at one site of developments at other sites.

Within NRAO, funding has separated budgets for *people* from budgets for *equipment or materials.* In general each site has a fixed ceiling of number of employees, and has not been permitted to exchange salaries for, for example, test equipment purchases. This is one reason that approximately 75% of the current NRAO annual expenditure is spent on people; a more healthy fraction might be only 60%. This relationship between accounting of salaries and of hardware leads to inefficiencies; in some cases, engineers have been forced to build test and other equipment that may already be readily available commercially. This is inefficient in use of skilled engineer resources as well as in use of limited budgets. The true cost of equipment construction is underestimated, since salaries are normally omitted from the cost estimates.

Given this background, it is appropriate to look at NRAO's management of its technical resources, to see if there is a more effective way of using limited resources.

## 3. The balance between *support* and *research & development*

Throughout the observatory, most engineers engaged in research and development roles also have some responsibility for telescope support. This is both good and bad: it keeps development engineers in touch with operational needs, and avoids creating a 2-class engineer society; most instrumentation for NRAO's telescope is of a one-off type, and so in one sense may never stop being a research and development project. Unfortunately, since day-to-day operational crises invariably take precedence over the more lengthy research or development activities, this often seriously delays the new projects.

## 4. Other compromises

Any new management structure has to balance a number of factors:

- the relationship between and relative priority of new research and development, versus operation and maintenance of existing equipment and facilities
- if a revised structure introduces additional layers of management, and requires more managers, then the gain in efficiency of the new structure needs to be balanced against the overhead
- a balance is required between the autonomy of individual telescope sites, with the needs to support the telescope and its observers in the best possible way, and the centralized control that will encourage communication, share resources, and avoid duplication of effort in the observatory.

## 5. Computing

One point discussed by the OTC was whether computing should be included in the same management structure as the other technical disciplines, or whether it should remain a separate division. Broadly, there are 2 different areas of computing: off-line data processing, and real time process control. Arguably the latter, at least, should be included within general technical management.

The OTC membership is split on this issue. Some believe that, on balance, both real time and off-line computing should remain in a separate Computing Division. This is based partly on the fear that it will prove impossible to hire a technical leader for the Observatory who has sufficient depth of knowledge in both electronics and computing, in view of the increasing complexity and specialization that both fields have undergone in recent years. This is countered by the fact that nearly every electronics development project now has an important computational element, with either an embedded processor or a need for external computer control or both. One of our greatest difficulties has been inadequate coordination between hardware and software efforts, and putting them under a single management would improve this.

## 6. Possible Structures

Here we discuss three possible new management structures.

Whatever scheme is adopted, the personalities of the heads of divisions are key factors. Good communications among these key people is essential. Without it, almost any management structure is likely to fail. With it, almost any scheme can be made to work.

Clearly these are not the only possible management schemes.

### 6.1 Central Control

One possible reorganization shown in **Figure 2.** In this option, each operating site would have a local Head of Technical Services (HTS), to whom all engineers and technicians at that site report. These site-specific managers report to the NRAO-wide Head of Technical Services. The local technical manager handles day-to-day work assignments, and the NRAO-wide HTS handles assignment of projects, tracking project-level progress, and allocation of budgets. The site directors provide feedback to both the local and the NRAO-wide technical leaders, about the operational needs of the telescopes, including problems faced by users. There must be a clear understanding between each site director and his own local HTS about the handling of telescope emergencies – e.g. the local HTS maintains an on-call list of engineers and technicians available to the local operations managers. Note that the local HTS does not report to the site director. Hopefully the local HTS and site directors will always be able to come to reasonable agreement about priorities, but in case of problems a site director can appeal to the NRAO Director. This scheme is close to the NRAO organization as it existed until about 1988.

The Project Managers for the major NRAO Projects (e.g. ALMA, EVLA, GBT-PTCS), who are responsible for keeping the Projects on budget and on schedule, would negotiate with the Technical Services Division to obtain the resources that each project requires. This might involve a top-level agreement in principle with the NRAO-wide HTS, then more detailed agreements with the local HTSs at the sites where the technical work is actually done. The Project Managers may sometimes need their own technical managers (Electronics, Antennas, Computing etc.) to make sure that NRAO's Technical Services division is delivering what was promised. This scheme introduces one extra layer of management, which introduces its own inefficiency; more study may be required to confirm or ensure that the gains inherent in the scheme do justify this overhead. For the major projects, this scheme has the disadvantage that the Project Manager no longer has direct control over the resources for which he is responsible; in this scheme, the demands on the HTS, to manage resources efficiently in all major projects, are probably unreasonable. It also does little to deal with the problem of engineer-to-engineer communication across sites, placing the burden of such coordination on the NRAO-wide HTS, who must be cognizant of details at every site.

### 6.2 Central Coordination

**Figure 3** is a variation on Figure 2 in which the role of the technical leader is now **advisory** to the local technical managers – the title Coordinator of Technical Services (CTS) might be more appropriate. The local technical managers report to the local site director or project manager, as now. This has the advantage **at the site level** of a more direct management path compared to that depicted in Figure 2, and has the advantage that there will now be some coordination among sites, instigated and encouraged by the HTS. The disadvantage is that the technical direction **from the observatory CTS** is only advisory, rather than mandatory. However, given the right people, this could work very efficiently and would be a marked improvement on the situation today. It should be noted that, if necessary, there is still a strong command path from the CTS to the Site Directors or Project Managers, via recommendations from the CTS to the NRAO Director.

In this plan, the Coordinator of Technical Services would be responsible for less of the day-to-day management chores than would be the case for the HTS of Figure 2.

### 6.3 Central Resource Allocation with Goal-based Direction

In this option there are separate, well-defined roles for the HTS and for the head of each operational unit (site) or project. This is depicted generically in **Figure 4**, and it is applied more specifically to the current configuration of the NRAO in **Figure 5**. It may be regarded as intermediate between the Central Command and Central Coordination schemes. It is the largest departure from the present structure.

Here all technical services at each major location are organized into divisions according to technical discipline, such as electronics, structural/mechanical, and computing, much as we have already. Each division is headed by a knowledgeable manager who resides at the same location. Each technical staff member is considered to belong to a division and

has the division head as his supervisor. The major change is that the division heads now report to the Observatory-wide HTS, rather than to a site director or project manager. Nevertheless, each division head, and through him each technical staff member, also takes direction from the site directors and project managers, as further explained below.

Site directors (SDs) and project managers (PMs) (including major projects like EVLA as well as smaller projects) make demands on the technical staff because they have tasks that must be accomplished. In this arrangement, they do it in two stages: First, a request for resources for each task is made to the HTS. The HTS, in consultation with the appropriate division head, assigns one or more staff members to the task. He has the flexibility, where appropriate, to assign people from any site and to form teams that span sites. The HTS also establishes a budget for the task, including both materials and labor, and decides how it should be funded. There are several funding options, including the operations budget for a particular telescope, the separate funding of a large project, and the "research equipment" funds of the Observatory. In some cases, the HTS may also have to ensure the availability of special laboratory facilities or test equipment. The second stage, once all necessary resources have been allocated, is to provide detailed technical direction and to monitor progress. The SD/PM or his designee is responsible for this during the course of the task. Formally, this is done through the division head, but in practice the SD/PM should normally be able to communicate directly with the staff members involved. Some tasks, like telescope support, continue indefinitely. The HTS and the division heads can later re-allocate resources, if necessary. Assignments can be changed and people can be hired or fired, as long as agreed upon tasks are accomplished. It is up to the HTS to establish and maintain priorities for the Observatory as a whole; occasionally this may require diverting resources from a task or project, thus slowing its progress or canceling it entirely, because something more important must be done. The HTS has the authority to do this. If conflicts arise, those involved can appeal to the Director.

Many important projects do not involve the development of a whole new telescope, but are nevertheless big enough to require some management. The major projects can be considered to be broken into tasks, each of which is like a smaller project. For each task, there is always a technical leader. Thus, although each staff member reports to his division head and through him to the HTS, and these are the people who decide his job assignment and evaluate his performance, he also receives direction from someone else, according to his current assignment. The HTS should know who is providing this technical leadership for each task, and should maintain good communication with that person. Sometimes a division head or the HTS will be the technical leader of a task, in which case he fills both management roles. For a small task involving only a few people at the same site, one of them can serve as leader with no additional management. Depending on the circumstances, the technical leader of a task might report to a SD or to the PM of a large project, or he might be a member of the scientific staff or report to such a scientist. We should be able to be very flexible in this regard.

If the needs of a task imply that new staff should be hired, the HTS is automatically involved. In some cases, he may delegate the details to a division head or someone else,

but he should always be closely involved in the recruiting of senior staff and in the promoting of existing staff into senior positions. He needs to consult with the Human Resources and Business divisions in doing this.

## 7. Recommendations

### 7.1 Leadership

Our strongest recommendation is that the Observatory create a new position called "Head of Technical Services" (HTS) reporting to the Director and having Observatory-wide jurisdiction over technical work, including both advanced development and support of existing instruments. We regard it as critically important that this position be filled by someone with broad and deep knowledge of many of the areas of technology that are important to radio astronomy, because it should be his/her responsibility to provide leadership in the selection of the projects and of the in-house facilities and expertise that will be most effective in helping the NRAO to carry out its mission and to remain a center of excellence within the astronomical community. The HTS must therefore have good personal knowledge of the present state of appropriate technologies, and also be able to make good judgments about future technologies and trends. Whereas these technologies are broad and varied, deep expertise in all of them is not likely to reside in one person. Therefore the HTS must have close access to advisors who are truely expert in each significant area.

### 7.2 Management Structure

Hiring a good HTS is not sufficient to ensure that the NRAO is an efficient center of technical excellence. So our second recommendation is that there be changes in the organizational structure. We believe that various structures can be made to work if we have good people in the key positions, and the OTC members are not experts in the design of management structures. Our recommendations are based on knowledge of what has worked in the past at the Observatory.

Regardless of the details, there is a strong consensus that the new structure should cover the whole range of technical work from pure research (projects with a wide range of applications) to development (new things with specific purposes, usually dedicated to one telescope) to maintenance (keeping the existing things working). Most engineers should spread their time across this spectrum and not be confined at one end or the other. This spreading of experience and responsibility will benefit operations and research alike.

A small majority of the OTC recommends that the Central Coordination scheme depicted in Figure 3 be implemented. This is least disruptive to the existing structure, so that it could be put in place immediately upon appointment of the HTS, allowing us to benefit from the improved coordination that the HTS should provide. The effectiveness will depend strongly on the skills of the HTS, since he/she has little direct authority and must

influence what is done by persuasive arguments, or by following the indirect management path through the Observatory Director.

The structure may be allowed to evolve. Eventually, a structure closer to that of Figure 4 might be reached. That is, the HTS would be given more authority in the allocation of resources, and thereby the ability to set priorities and make choices about which new technologies will be pursued. This will give the greater efficiency improvement that comes from the ability to assign tasks to the most appropriate persons or groups, regardless of site, and to form inter-site teams. Some of the OTC consider that a scheme like Figure 4 might be adopted right away, but others prefer a more conservative, evolutionary approach. The details may depend on who is appointed as HTS, and that person should be involved in setting up the structure.

### 7.3 Budgetary Authority

Our third major recommendation is that the HTS be given control of a significant budget for technical development. This should include all of the NRAO's development funds other than those that are part of a project with its own separate funding from NSF or another agency. Staff members, including site directors and scientists, should be able to propose projects that use these funds. The full cost of proposed projects should be accounted for, including both personnel and materials, in setting priorities. The total budget should not be partitioned in advance into personnel and materials, but rather the HTS should be free to set the ratio as required. Further discussion of budgeting issues is given in Section 8, below.

### 7.4 Additional Suggestions

**(1)** The HTS should have available to him/her advisors who are experts in a wide range of technologies. To some extent the OTC fills this role, but the HTS should also be allowed to appoint one or more full-time staff persons to this role if necessary. Such persons would be free of management responsibilities and able to concentrate on the details of technical issues.

**(2)** The observatory should revise some of its budget allocation policies, giving greater freedom to site directors and others to convert salary funds into equipment funds (but not *vice versa*). Managers should be encouraged to reduce the number of employees in their division, but in return would be permitted to keep the money thus saved, to be invested in test equipment and other technological aids.

**(3)** As soon as resources can be made available, the observatory should invite proposals for technical research projects. Such projects might be funded by NRAO for from 1 to 3 years, with the expectation of some significantly new technical capability for existing NRAO telescopes, or for radio astronomy in general.

## 8. Research Equipment funding

Whatever management scheme is adopted, it is essential that the funds allocated to technical research projects, currently known as *Research Equipment* funding, be substantially increased. Given that the total NRAO operations budget is limited, and that the NRAO manpower budget accounts for some 75% of the total NRAO budget, it should be investigated whether some fraction of the manpower budget could be diverted to Research Equipment.

In today's management organization within the NRAO, each site has a ceiling of number of employees, in addition to operations and materials budgets. The site director does not in general have the freedom to transfer funds between salaries and equipment. If it is decided at a given site that some particular position is no longer required, the site director does not automatically have the right to convert the salary money that might be saved into materials or equipment. This policy has a tendency to encourage all sites to maintain their maximum quota of employees, even if all positions are not strictly necessary. This policy should be reversed; those responsible for staffing should be given an inducement to reduce their number of employees, and be allowed to keep all funds so saved, to be used on test equipment, or other hardware or projects. This does not imply freedom to convert M&S funds into positions.

A related proposal is that observatory-wide funding should be made available for a limited number of major technical research projects. Part of the RE resources should be competed for by active staff members in the form of proposals that would be ranked, perhaps by the OTC. The length of these proposals should be limited to one page.

One additional suggestion considered by the OTC is that staff should be encouraged to seek funding outside the NRAO operations budget for research and development activities which might attract money from, for example, NASA. Our conclusion is that this may be a useful short term strategy to help over a temporary budget crisis, but there is a danger of this becoming damaging to NRAO if we come to rely on such funding as a normal way of life.

## 9. Conclusions

Currently, there is almost no technical coordination between NRAO sites and projects. This leads to inevitable inefficiencies – some sites may already have solved technical problems facing other sites, and there is some unnecessary duplication of effort. It may be feasible to share certain expensive pieces of equipment between sites, but today that is rarely done. Almost any level of coordination would bring about a dramatic improvement.

The recommendation of a majority of the OTC is that the Central Coordination scheme depicted in Figure 3 be implemented, for the reasons outlined in Section 7.2. Some of the OTC prefer a less conservative approach, such as is shown in Figures 2, 4 or 5. The new HTS should be involved in planning any future evolution beyond the structure adopted from Figure 3.

## Figure 1. NRAO today

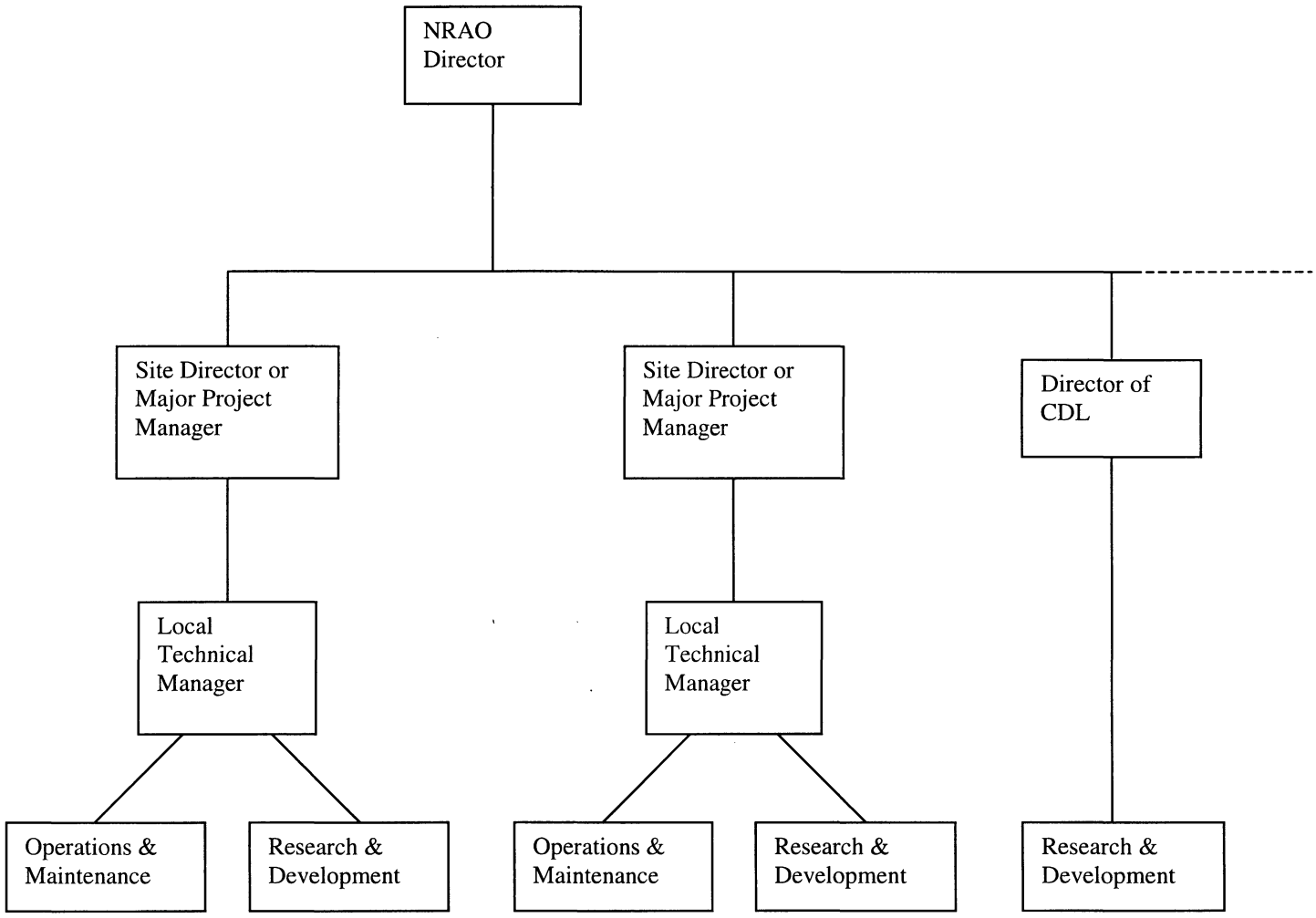



**Figure 1** shows the existing NRAO technical management structure. R & D projects relevant to a particular site are carried out either at that site, or at the CDL. The CDL is also responsible for longer-term technological R & D projects. The site manager is responsible for ensuring appropriate sharing of resources between Operations & Maintenance, and Research & Development.

## Figure 2. Central Command

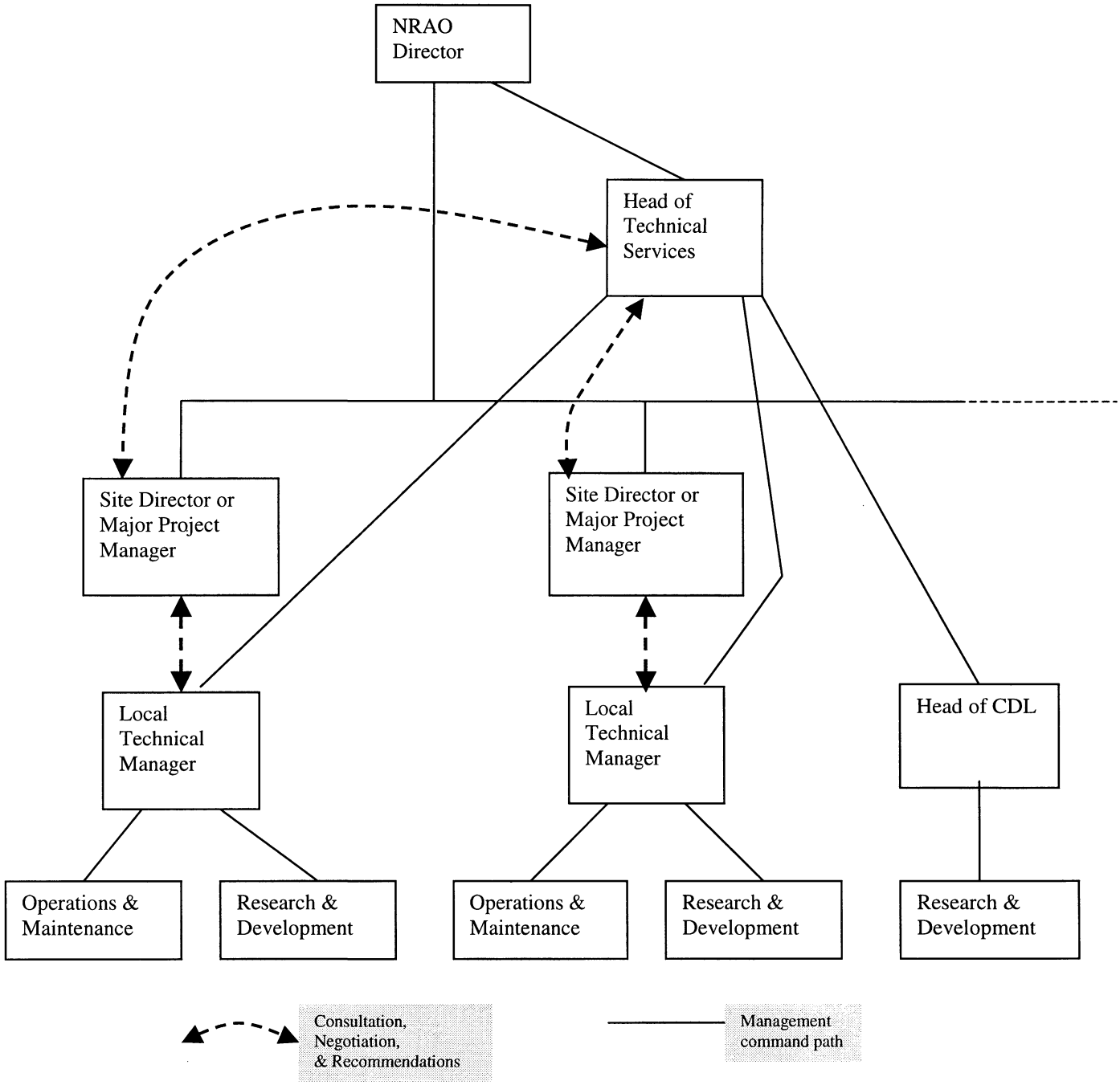



**Figure 2** shows a possible reorganization of NRAO technical management. All technical divisions, both at the CDL and at telescopes sites, report directly to the observatory-wide Head of Technical Services. Local site directors no longer have direct authority over the technical groups at their site. Adequate safeguards are essential, so that resources are always available at the telescope to solve technical emergencies. What R & D projects are carried out at the remote sites, versus the central location, is decided by the Head of Technical Services.

# Figure 3. Central Coordination

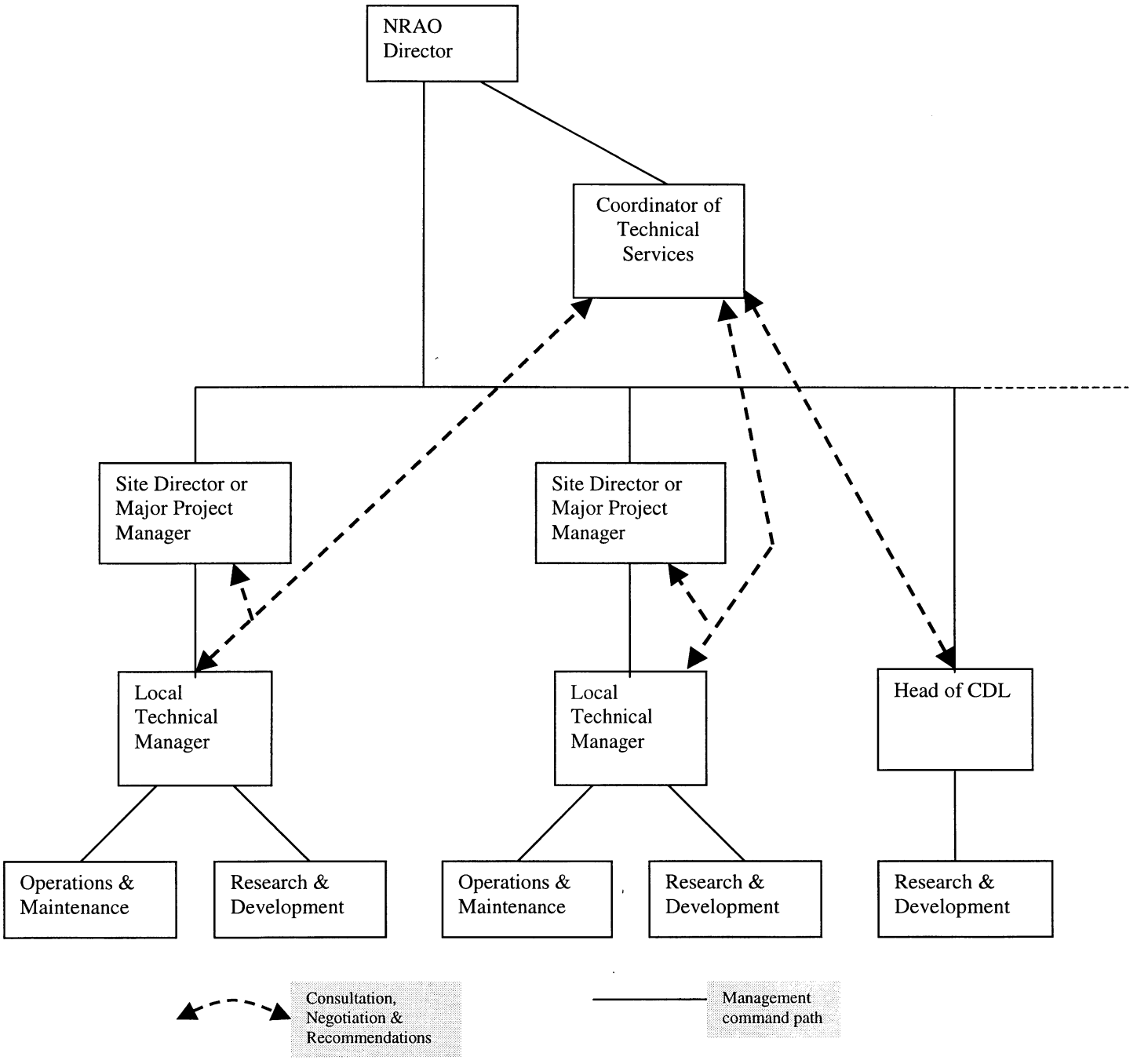
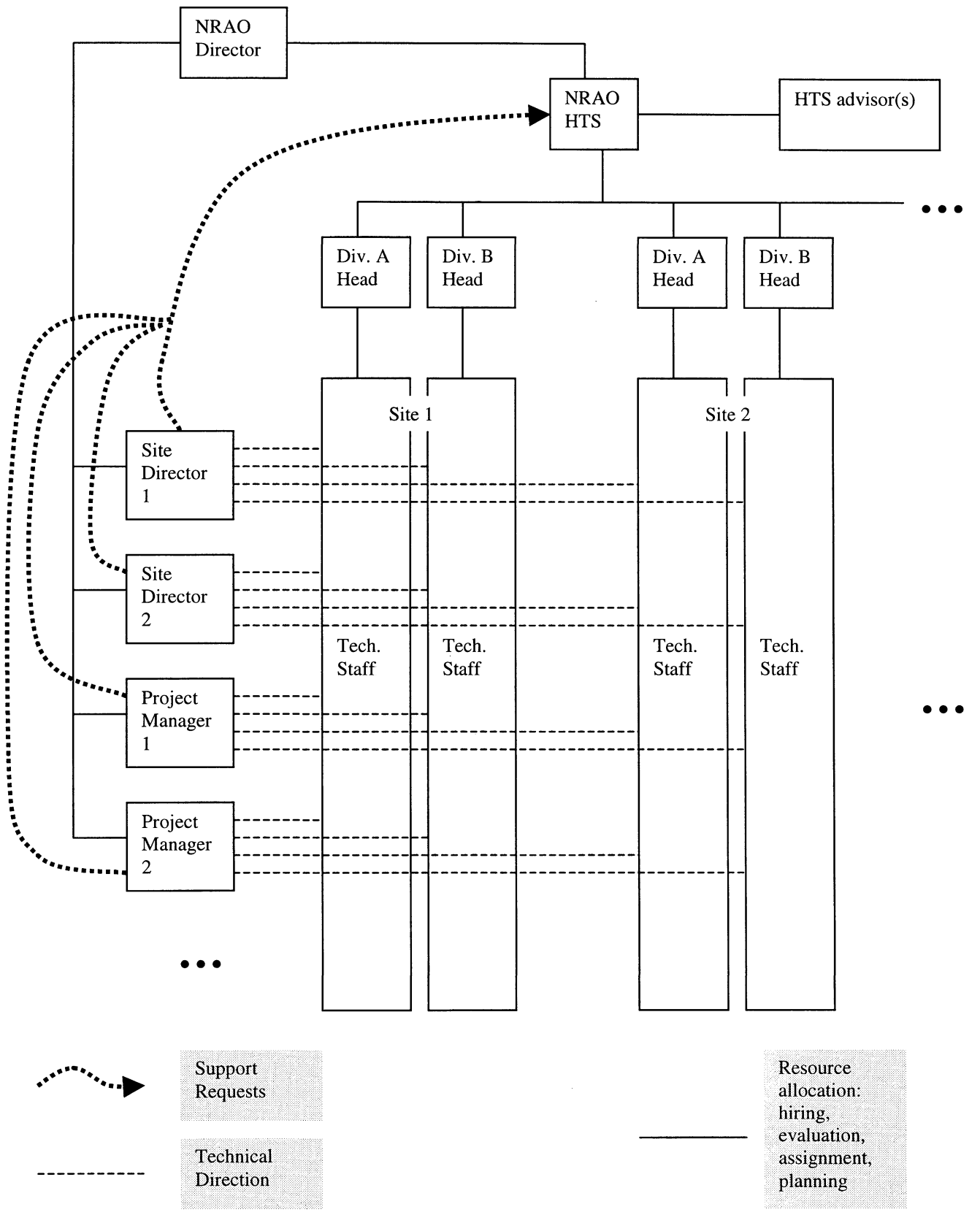
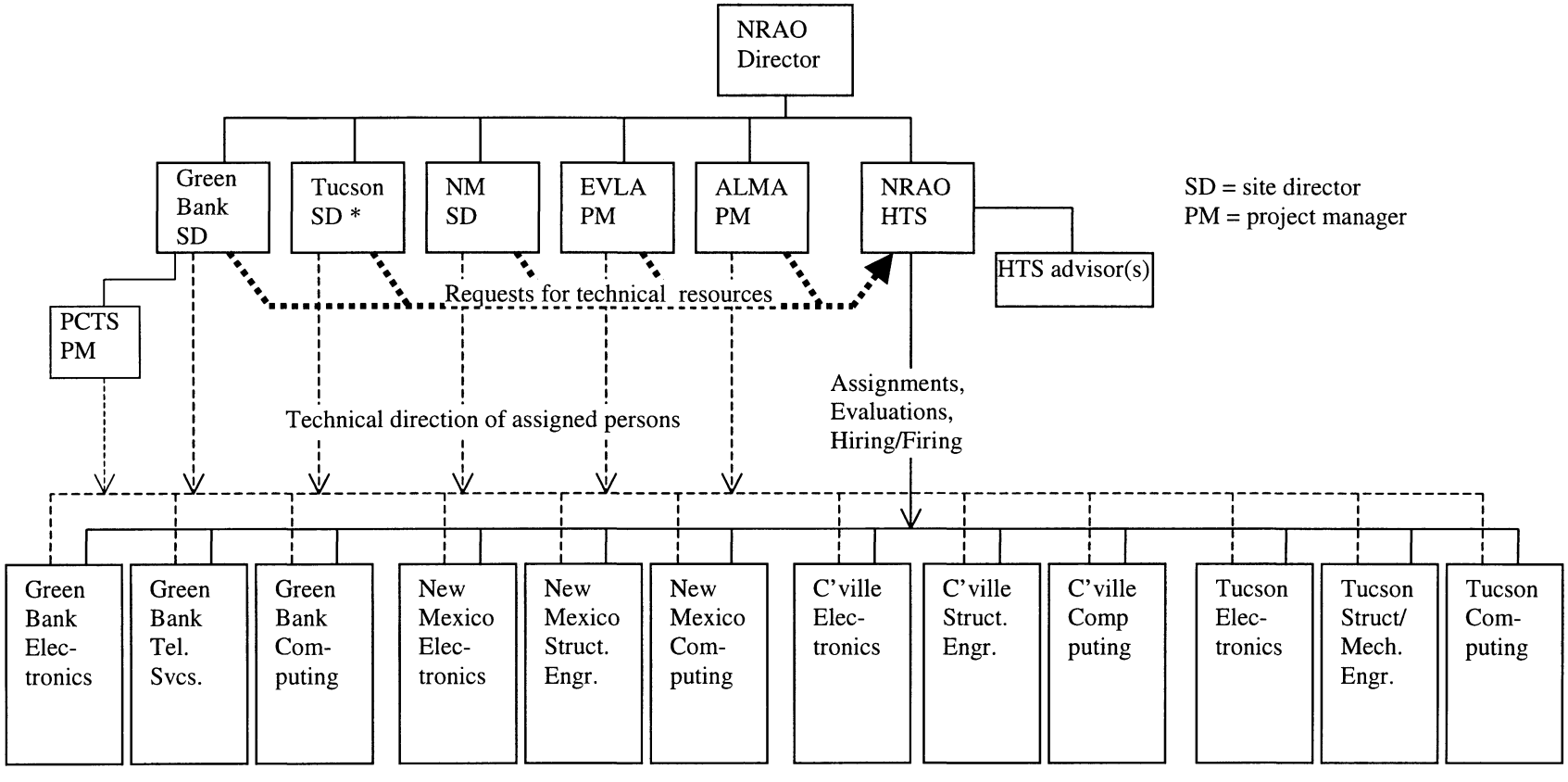



**Figure 3** Another possible reorganization of NRAO technical management. All technical divisions still report to their respective division head or site director. The HTS plays a strong advisory role, although the local site directors still have direct authority over the technical groups at their site. Which R & D projects are carried out at the remote sites, versus the central location, is decided by the Head of Technical Services in collaboration with the site directors.

# Figure 4: Central Resource Allocation (generic view)



# Figure 5: Central Resource Allocation (applied to NRAO in 2003)




Technical Divisions: each has a Division Head and technical staff members

* Under present circumstances, Tucson SD could be same person as ALMA PM, or could report to ALMA PM.