RUNNING THE TRAINS ON TIME

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ABSTRACT:

Early in 1983 Metrail made a major effort to improve the timeliness of Melbourne's suburban rail service. The project was a visible success. The paper describes the background to the project, some of the principles used in attacking the problem and some successful applications of the principles in practice. General conclusions are drawn which may be applicable to other systems.

1. GENERAL BACKGROUND

Reliable on-time running of trains is a major objective, perhaps the most important objective, of Melbourne's suburban rail system. Much management and staff effort is devoted to its achievement and performance has risen year by year up to 1983. The best month was August 1983 when over 90% of all trains arrived on time.

Performance fell at the end of 1983 and again at the start of 1984 partly because of industrial problems but more importantly during introduction of new signalling technology. The change meant that many of the functions of signalmen and train controllers were moved to a central control room and direct observation of train movements was replaced by monitoring their progress on computer-driven displays. The dislocation to long-established work patterns was considerable and several weeks elapsed before the system operators became familiar with the new environment, whereupon performance began to climb once again.

Performance stabilised in about March 1984, with only about 80% of trains arriving on time. This unsatisfactory level plus the absence of signs of further improvement triggered management action to set up an "On Time Running Project". The remit of the project team was to discover the cause or causes of the problem and instigate remedial action.

2. FORMATION OF THE TEAM

The On Time Running Project team was established outside of line management, with a charter to examine issues - in any part of the organisation - that impacted on the reliability of the Metropolitan Train System. The team reported directly to the Chief General Manager of Metrail. Its prescriptions were to be formulated as remedial projects and handed over to line management for execution.

The team included three full time members with managerial or professional experience, plus clerical and secretarial support.

The members of the team were chosen to have the widest possible spread of relevant backgrounds. The team leader was an electrical engineer with experience of planning the overall operation of the railway. The second member was a mechanical engineer with experience of design and maintenance of rolling stock. He was particularly familiar with the operation of the train maintenance facility. The third team member was a senior foreman, with experience in industrial relations.

None of the members had worked in line management in the operating arm of the railway, but all understood existing methods of railway operation, service requirements and the demands that these impose on engineering and maintenance facilities. The team also had access to inputs from PA Consultants who provided an independent view and experience of practices in other transport organisations.

The first action was to set up a "war room" where all significant work by the team took place. As team members generated data or reached conclusions, the resulting charts, action plans, project outlines and strategies were posted on the war room walls and pin boards for all to see. This war room approach was successful in:

- Maximising communication between team members.
- Encouraging group dynamics within the team.
- Generating the atmosphere for developing new ways of looking at traditional problems.

Unfortunately the war room was seldom visited by line management, who worked in separate buildings. Consequently the beneficial effects of exposure to the information-rich environment in the war room were confined to the team and their immediate contacts.

3. INITIAL VIEWS OF THE PROBLEM

An initial survey by the team indicated that, as a result of the poor performance early in 1984, twenty or so projects aimed at improving rolling stock and track reliability were already in progress and others offering apparent benefit had been suggested. It was clear to the team that there would be a strong temptation to set many more projects in motion than line Management could follow through effectively. The result would be that although many projects were started, each would be overtaken in mid stream by its successors and few would ever be finished. In order to avoid this trap the team decided to look for ways to prioritise projects and ration the number undertaken.

Many of the problems reportedly due to equipment failure contained an industrial component. For example existing work practices meant that a failed traction motor could result in a train delay, even though the vehicle in question was designed to operate satisfactorily with one or two motors out of action. If the project team could emphasise the importance of the organisation's commitment to on-time running then morale might improve to the point where some of these restrictive practices could be relaxed. The result would be a dramatic lift in performance without large expenditures on additional maintenance.

Very early in the project the team decided that in order to satisfy to brief it would be necessary to:

- Establish an understanding of the problem based on objective quantitative data.

- Set up a methodology for determining the relative merits of particular projects.

- Select for implementation a manageable number of projects likely to give the most benefits quickly.

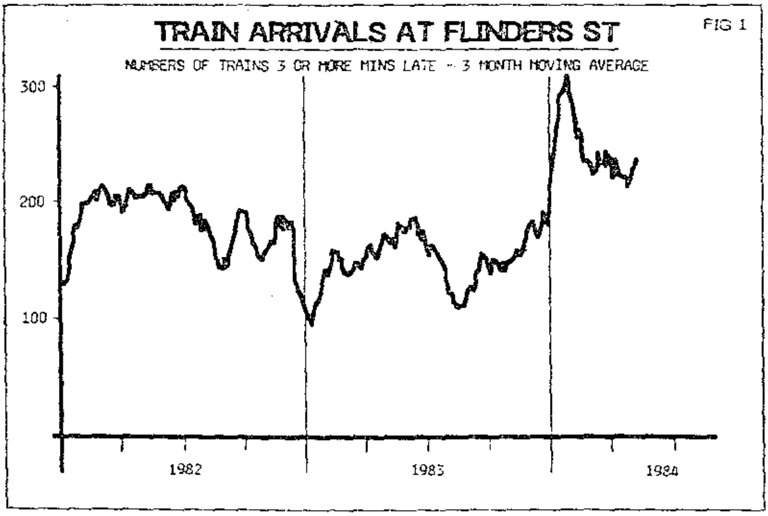
- Set up project management mechanisms to make the selected projects happen quickly.

- Create interest in on-time running and reverse some of the adverse impact of previous industrial action.

4. REVIEW OF HISTORICAL DATA

The team's first task was to assemble the available information relating to performance and delays. A great deal of potentially pertinent data existed dealing with individual instances, but as little of it was in machine-readable form, useful summaries were hard to obtain. The most relevant pieces of information were:

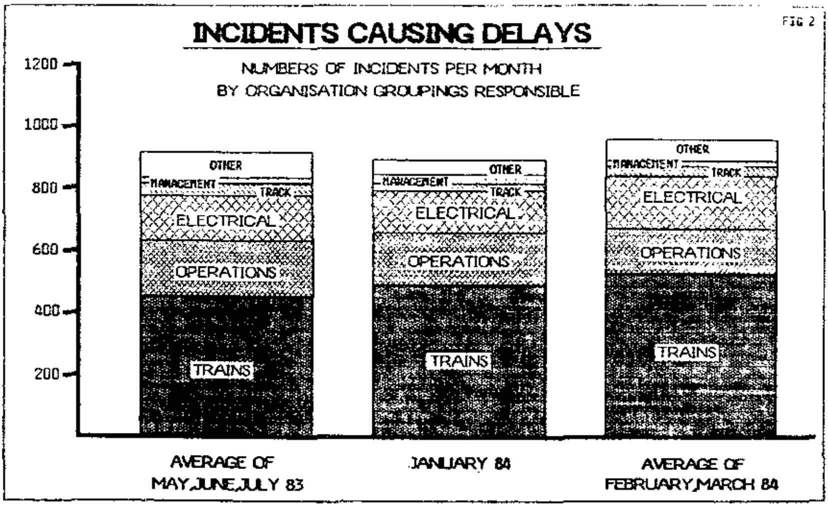
- A history of the timeliness of train arrivals at Flinders Street Station (fig 1). Flinders Street is the central station in Melbourne and due to the radial nature of the rail network, arrivals at Flinders Street account for roughly half of all train arrivals.



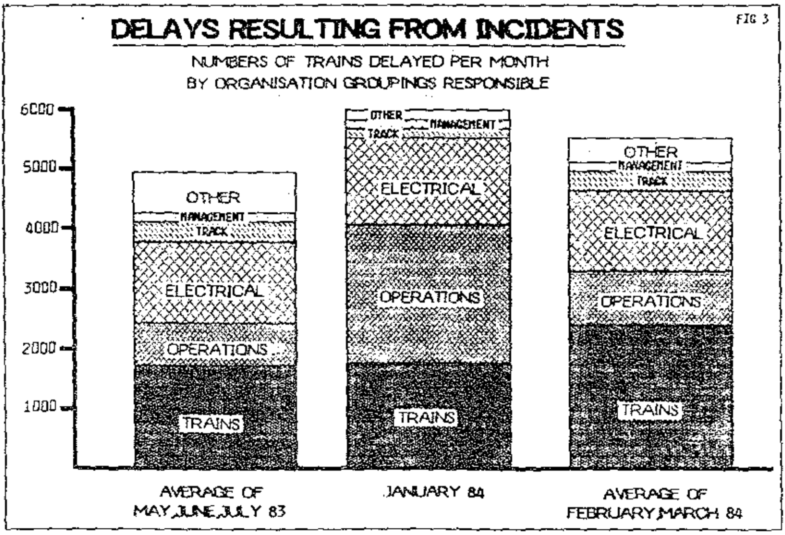
- A monthly history of incidents resulting in delays to trains analysed by 139 incident types. The individual incident types were grouped into categories corresponding to the major organisational groupings within Metrail.

- Fig 2 shows for each of these organisational groupings the numbers of incidents causing delays before, during and after the transition in signalling methods.

FIG 2



- A monthly history of trains delayed or cancelled as a result of the above incidents. Fig 3 shows the numbers of train delays and cancellations attributed to the incidents in fig 2.



deterioration in 1984 compared to 1983, but the histories of incidents and related delays showed only modest increases. Further investigation indicated that:

- The number of delay-causing incidents had increased by only 5 - 10%.

- While the delays attributed to these incidents had risen by about 15%, the major change was an increase in the number of delays and cancellations attributed to general system congestion rather than to specific incidents.

A more rigorous view of cause and effect might have associated many of the "general congestion" delays with particular incidents. However in an interrelated network such as Metrail's such attributions tend to be speculative, particularly during periods of above-average problems.

The team formed the view that on-time performance was affected by factors other than the simple number of delay-causing incidents. These would include in particular the mix of incident types and the likelihood that clusters of incidents could result in overall congestion.

5. DIAGNOSIS

5.1 The "Vital Few" - a Fallacy?

Of the 139 classified incident types the "vital few" accounted for about 50% of all incidents and a slightly smaller percentage of all related delays. Finding solutions to the top ten problems seemed to offer a major improvement in performance and the team accordingly pursued this possibility with enthusiasm.

FIG 4

THE TOP TEN CAUSES OF INCIDENTS

CAUSE	INCIDENTS		DELAYS	
	PERCENT OF TOTAL	CUMULATIVE PERCENT	PERCENT OF TOTAL	CUMULATIVE PERCENT
BRAKES	9.3	9.3	8.7	8.7
MOTORS	5.7	15.0	4.7	13.4
TRACK CIRCUITS	5.6	20.6	6.2	19.5
TRIPS	5.5	26.0	3.9	23.4
DRIVER	5.4	31.4	4.3	27.8
SIGNAL FAILURE	3.6	35.0	5.6	33.4
COMPARTMENT DOOR	3.5	38.6	2.6	36.0
POINTS FALIURE	3.3	41.9	3.9	39.8
PANTOGRAPH	3.3	45.2	2.7	42.6
GUARD	3.1	48.3	2.1	44.7

On further investigation each of the top ten incident types turned out to be the sum of a series of related but discrete faults. For instance, the commonest incident type: "Brakes" consisted of 13 separate faults. Each major incident type could be similarly decomposed, so that the top ten incident types quickly became over 100 different faults.

The effect of a project aimed at eliminating one particular fault type was calculated as follows:

- Train maintenance problems account for 42% of train delays.

- Brakes are the commonest Train Maintenance problem, accounting for 9% of train maintenance delays.

- Hitachi Drivers Brake Valve is the commonest of these, accounting for 9% of brake problems.

- It follows that elimination of Hitachi Drivers Brake Valve problems would improve matters by 9% of 9% of 42% or 0.34% overall.

Fixes to other individual faults are likely to have consequences of similar or smaller magnitude. Thus a hundred or more of such single-fault projects would be needed to make substantial reductions in numbers of incidents.

The conclusions drawn by the team from this analysis were:

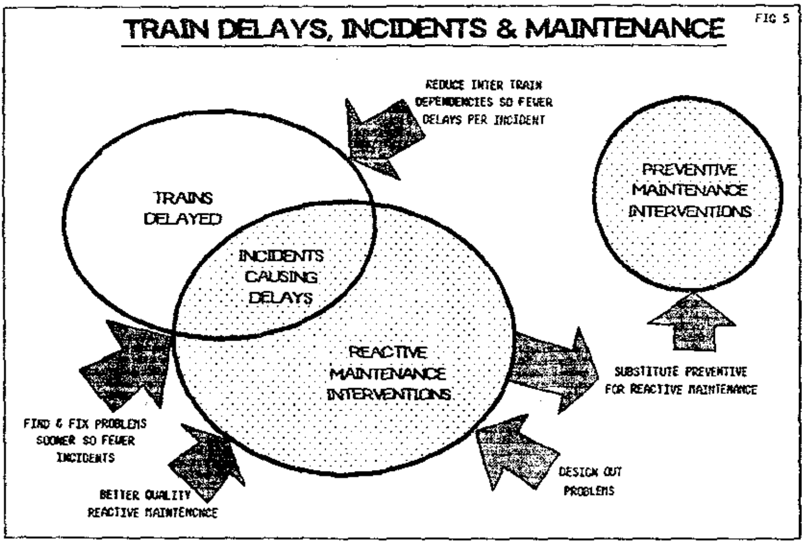
- While elimination of individual faults is worthwhile, each such fix has a relatively small impact on the whole.
- This approach will only be manageable if projects can be implemented and completed quickly so that not more than a handful are under way at one time.

5.2 Attack Strategies

Following these results from the "vital few" approach, the team looked for other ways of attacking the problem.

A team review meeting led to preparation of the bubble diagram shown in fig 5 which makes the following points:

- Train maintenance interventions are of two kinds, remedial and preventive.
- Most problems and remedial interventions occur without delaying trains.
- Any instance where this does not happen and a train is delayed is an "incident".
- The majority of trains delayed have not themselves suffered an incident; they are delayed because of their relationship to other trains which have.



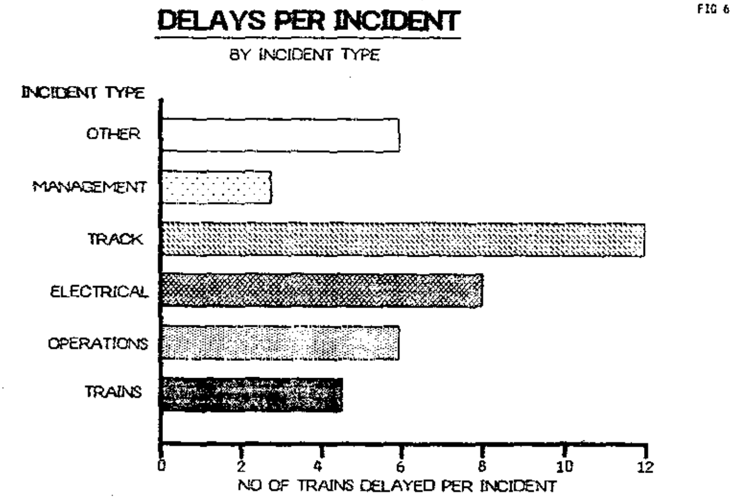
This analysis suggested a number of possible "attack strategies" by which delays might be reduced:

- Improved reliability of equipment, leading to a smaller total number of remedial interventions and hence fewer incidents. Ways to achieve this might include:
  - Higher quality of remedial maintenance so problems stay "fixed" longer. (The "conventional" previous approach)
  - More preventive maintenance, reducing the need for remedial maintenance.
  - Design improvements eliminating certain maintenance needs altogether.
- Earlier problem detection and improved responsiveness of remedial interventions so that faults were detected and fixed before trains were delayed. Ways to do so included:
  - Relocation of maintenance points
  - Reorganisation of communication links.
  - Improved mobility of maintenance resources.
- Operational rearrangements to loosen the inter-relationships between trains so that a single incident would result in fewer train delays. These could include:
  - Changes to timetables
  - Changes to path and platform utilisation
  - Changes to train and crew rostering.

5.3 Project Prioritisation

The analysis of historical incident data showed that some incident types caused many more train delays than others (fig 6). Certain faults which regularly caused large numbers of delays per fault were obvious candidates for remedial projects in the track and signalling area.

FIG 6



Discussions with the engineering branches concerned regarding the frequency of various types of interventions revealed another factor not shown by the data: some fault types seldom resulted in an incident while others always resulted in delays. Fault types in the latter category were early candidates for remedial projects in several engineering areas.

The attack strategies outlined in the previous section also suggested possibilities for remedial projects in the areas of organisation, management and operations.

The major constraint on implementation of these projects (apart from funding) was the availability of management resource to oversee effective implementation. The team believed that each management area could cope with 3 - 5 projects at any one time. There were effectively 5 management areas: operations; rolling stock; signals; track and electrical. Thus the target number of active projects was limited to about 15.

The expected payoff from a project was the reduction in numbers of delays expected to result. A project selection criterion was tentatively formulated as:

- Potential delay reduction.
- Divided by project duration.

In actual practice the team used the concepts subjectively and the projects tended to select themselves:

- A number of short projects were mooted, undertaken and finished in less than 4 weeks each.
- Several projects were evaluated and shelved, to be re-activated once the higher-priority ones are complete.
- A small number of long projects were started and are still being actively pursued.
- Several potentially important and long projects were examined and shelved on the grounds of excessive industrial, technical or organisational difficulty.

6. EXAMPLES OF REMEDIAL PROJECTS

6.1 Preventive Maintenance of Brake Trips

Brake trip apparatus on Victorian trains has proved over the years to be particularly troublesome equipment. The existing design is difficult to maintain, and as it relates directly to the braking system, failures have an immediate impact on the operability of the trains. An engineering assessment prior to the project had indicated that the correct long term solution was a full redesign but this approach would not improve performance in the immediate future. Preventive maintenance was the only one of the possible attack strategy which could be applied specifically to brake system components to improve performance in the short term. Additional manpower was placed in train stabling areas specifically to inspect, adjust and report on trip apparatus. Arrangements were made for unit exchange of latching cables, the component identified as the major contributor to failure.

6.2 Consequence Reduction

Metrail's present operating practices lay down that, a train cannot start a journey with a defective brake trip. Thus a train which has arrived at Flinders Street with a reported brake trip problem is likely to be immobilised there until repaired. A review of the various attack strategies suggests the possibility of reducing the consequence of the delay by operating strategies such as:

- Remove the cause of the delay at the Flinders Street Station by running the train to a siding or other area away from the intense traffic before attending to the fault.

- Direct the train to a less frequently used platform to minimise the number of following trains delayed while the train is attended to.

- Seek agreement with the Drivers to relax some traditional restrictions on operating methods such that the train could remain in running for a limited period before being attended by the equipment examiners.

- Develop operating strategies to enable the train to be repaired at Flinders Street in the platform of its timetabled destination, but divert other train services to operate around the obstruction.

6.3 Faster Repair

Brake trip problems are only one of a class of rolling stock running faults whose correction has traditionally been undertaken at Flinders Street Station. The procedure is for a driver detecting a fault on his train to transmit a Train Defect Message to the Central Operations Control Room from where it is relayed through the maintenance arm of the organisation to an equipment examiner stationed at Flinders St. On arrival of the train the equipment examiner diagnoses and usually corrects the problem.

The team looked at ways to shorten the communication links between driver and train repairer with a view to:

- Giving the repairer more time to prepare the appropriate remedial tools and spare parts.

- Stationing the repair resources at the right place so that diagnosis and repair could start immediately on arrival of the train.

6.4 Selective Maintenance of Signals

The various lines in the rail system carry different densities of rail patrons; and hence signalling failures at different locations have different consequences. The team discovered that signal maintenance personnel were not necessarily aware of these differences and consequently maintenance effort was not being optimally deployed. The solution was to establish a senior experienced signal supervisor in a review position to address the issue. Commencing with the Burnley group of lines, the area of highest traffic density, each and every signal failure was investigated. A full inspection of the signal systems on these lines was undertaken, and variations in maintenance standards set up on a rational basis. The exercise resulted in far higher reliability on the Burnley lines and a clearer understanding amongst all personnel as to the most likely items to cause delays to trains. The approach has been extended system wide.

6.5 Rational Maintenance Working Hours

Railways have long tailored the hours that maintenance support workers are on duty to the hours of train operations. However, the team found that there were significant periods prior to or during peak hours when signal maintenance staff were not on duty. Early morning signalling failures which could not be quickly remedied because maintenance staff were not available were causing disruption to the whole morning peak period. The necessary remedial action was to re-roster maintenance staff. Staff are now on duty at all major interlocking signal boxes during peak periods to respond quickly to failures which may arise. A lower degree of coverage is provided during other hours of train operation.

This exercise vindicated the team's decision not to dismiss a particular issue because it had been obviously considered previously. Changes in maintenance staff hours of duty and operational requirements since the previous major review resulted in less-than-ideal arrangements being accepted prior to the the present project.

6.6 Flood Damage

Difficulties of communication were highlighted when both Signalling Maintenance and Track Maintenance staff were asked to identify locations subject to track flooding. Civil staff noted problem areas where drainage was insufficient as far as Civil Engineering aspects were concerned. The Signalling Maintenance staff on the other hand indentified a different set of locations where water periodically damaged signalling apparatus. The team arranged for communication between the two groups and as a result all problem locations were addressed prior to heavy spring rains and the problem areas removed.

6.7 Track Problems

The analysis of historic data showed, to the surprise of some experienced railway people, that the highest single cause of problems was track circuit failures. This finding was verified by examining the records of signal failures. It was also discovered that these failures are due primarily to discontinuities in track feed cables or rail joining cables, and are directly related to track condition. These problems are simple and relatively easily rectified while the more complex and difficult to fix signal relay failures are less significant from the viewpoint of train delays. As a result of the team's analysis, additional low-skill staff were recruited for a period to assist in rectifying the high risk areas and a significant improvement in reliability recorded.

6.8 Operations - The "Black Hole" at Jolimont Yard

Management of trains in the immediate areas around Flinders Street is difficult due to the concentration of traffic to and from all lines in the radial MetRail system. Interruptions or delays at Flinders Street usually mean that approaching trains have to be held in the rail yards pending clearance of the problem. Yard delays have been referred to as the "black hole" effect.

The team set about calibrating the problem by recording the numbers and circumstances of trains delayed. Among the outcomes of the exercise:

- The discovery that movements from platforms to the stabling sidings were being made without full regard to their effect on the subsequent timetable.

- Alterations to timetables to ensure the most suitable routes and times are chosen for stabling movements.

- The remedial actions previously referred to for reducing consequences when trains fail at Flinders Street.

6.9 Communications

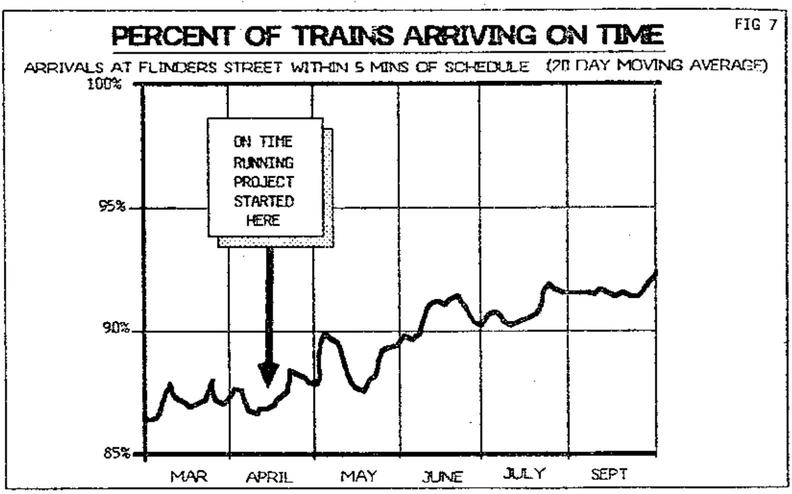
One way to minimise the impact of a train failure is to quickly substitute a fresh train for the disabled one. Speed of communication is extremely important when making such substitutions. The people who need to be advised include: Passengers, Platform Staff, Crews on both trains, Signalling Staff, Yard Staff, and of course, Operations Control. At present this is an extensive network of personnel who relate to each other in very formal and traditional ways. The team drew up a communication network which showed that a weakness of traditional arrangements was the number of serial links from the initiator of the communications to the final person involved. At the time of preparation of this paper, a more streamlined and direct network is being developed in consultation with the employees.

6.10 Wheel Slip

Running times for MetRail trains are based on performance of the wooden bodied and earlier steel bodied trains, and while more modern rolling-stock can perform faster, intermingling of the various classes of trains requires that all schedules be drawn up to the slower standard. Schedules do not allow for poor performance under adverse weather conditions. Experienced drivers can (through manual control of acceleration and intimate knowledge of the braking systems) operate trains to maintain timetabled running times even in the wet. On the newest class of train the driver cannot manually control acceleration, and as a result these trains lose time during wet periods, in spite of their theoretical superiority to the rest of the fleet. The team recommended modifications to the control circuits to return the necessary measure of manual control to Drivers.

7. WHAT HAPPENED

The On Time Running Project created within Metrail a group of individuals who specifically looked at performance improvement in new ways. It also formed a focal group for all employees to relate to and underlined management's commitment to performance. Within six weeks of its formation, on-time running (as measured by train arrivals at Flinders Street) had risen to a record level for that particular period of the year. It was obviously too early to claim (apart from some Hawthorn effect) that this was a result of the project group. The improvements have however subsequently been maintained and extended (fig 7) and there are grounds for believing that the On-Time Running Project has made a significant contribution.



By far the biggest gain from the organisational point of view was a clearer identification of those areas within the railway responsible for the various percentages of train delays. Individual managers had previously reacted to problems by feel rather than on the basis of numerical analysis. The development of measurement methods has allowed senior management to review the performance of the various areas of the organisation and some considerable structural improvements have resulted.

8. CONCLUSION

The traditional approaches to improving train running performance - management exhortation and increased engineering effort - can and do have an effect. The Victorian project revealed some additional weapons which may have application in other rail system. They are summarised in the following prescriptions:

- Look at the numbers of trains delayed by various incident types.
- Concentrate first on types which delay many trains per incident.
- Concentrate on problems which have a high probability of delaying trains.
- Use the "vital few" approach - but keep small the number of projects in course at one time
- Look for ways to reduce train delayed per incident by building capacity margins into the system.
- Look for ways to find and fix problems before trains are delayed.
- Seek out alternative attack strategies to generate novel problem solutions.
- Do not avoid areas just because people say they have been looked at before.