Results of the UKIRT Reactive Scheduling Experiment

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ABSTRACT

I present some conclusions from the UKIRT reactive scheduling experiment. This shows that, provided adequate back-up time is available, it is possible to manipulate the schedule of a 4m class telescope to increase significantly the likelihood that a few chosen programmes can be completed and that such a scheme can double the success rate of those programmes. Also, despite the personal inconvenience, observers are willing to be flexible when offered a second chance to take up observing time lost to bad weather.

Keywords: Weather, flexible scheduling.

1. INTRODUCTION.

The United Kingdom Infrared Telescope (UKIRT) is a 3.8m telescope dedicated to observations in the infrared and is located on the summit of Mauna Kea on the Big Island of Hawaii. It is at this writing the premier such telescope available to the UK community on a regular basis. In 1996 I pointed out (Davies 1996) that, based on a review of 200 observer reports, only one-third of UKIRT's users were blessed with clear weather throughout their full allocation of telescope time and that a fraction (approximately 10%) obtained no data at all. As a consequence science, judged important and timely by the peer review process, was being lost due to the random effects of weather on a six-month-long telescope schedule fixed months in advance. In an attempt to increase the number of the most highly rated projects that could be completed in a single semester, a scheme was proposed to minimise, as much as possible, the effects of weather and technical problems on these proposals. The objective was, in effect, to take these proposals out of the "weather lottery" which gives all projects, irrespective of their perceived scientific merit, an equal chance of being completed.

2. THE PRINCIPLE OF REACTIVE SCHEDULING.

The stated objective of reactive scheduling was to "adjust the UKIRT schedule in near real time to maximise the likelihood that projects, identified by peer review as being of high priority, are completed in a single semester." This was to have been achieved by modification of the UKIRT schedule on an approximately monthly basis to react to what actually happened during the time allocated highly rated or "starred" proposals and to extend or reschedule these runs in order to compensate the observers for time lost to bad weather. A precise definition of time lost is difficult to reach since some conditions, eg cirrus cloud or bad seeing, may not preclude observing but may none the less prevent the scientific objectives of a particular observing run being met. However, such subtleties are difficult to measure objectively and for the purpose of the experiment "bad" weather was considered that in which the telescope could not be used at all.

The intention was that during the preparation of the six month schedule empty slots would be built into the schedule and these would be used for rescheduling the starred runs as required. Since UKIRT operates on the basis that observations are mostly made by visiting observers, the timing of such weather recovery slots is quite critical. Either they must be close enough to the original run that the affected observers can extend their visit to Hawaii by a few days in order to re-attempt their observations almost immediately, or they must be sufficiently distant to allow time for the observers to return to their home institution (usually in the UK), arrange new travel and then make another trip to Hawaii at reasonable cost and minimum inconvenience. In addition, the scheduling process must allow for the possibility of a period of good weather which would allow the starred proposals to be completed without the need to use any reactive recovery time so that unallocated nights would begin to appear in the schedule. The intention was that these empty slots would be filled by promoting new projects from a pool of proposals which narrowly failed to get selected (or in fact would have been selected had the number of available nights not been

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reduced to allow the back-up slots to be inserted) at the bi-annual allocation committee meeting. In this case a period between the starred run and the recovery slot would be needed for the promoted observers to organise travel to the Hawaii. Although one lunation would be best, especially for optical telescopes for which lunar phase is a demanding scheduling requirement, a period of six to eight weeks between the original run and the recovery slot was felt to be optimum for replanning travel while retaining sufficient RA coverage that targets available for the original run would still be accessible in the rescheduled slot.

It was also assumed that if a starred proposal lost only a small fraction of time, less than a night for instance, or if only a small extra allocation was available after the starred proposals had been re-scheduled, observations could be executed by staff scientists using observing scripts supplied by the affected Principal Investigator.

3. THE PERCEIVED WEAKNESSES.

In discussions about implementing such a scheme a number of potential objections were raised. These included:

- Many observers, for example senior staff in Universities, have numerous commitments outside observing (eg lecture courses, committee meetings etc) throughout the year and so would not, in practice, be able to alter their personal schedule at a few weeks notice in order to make a second observing trip.
- At certain times of year, notably Christmas and New Year, affordable tickets to Hawaii are difficult to obtain at short notice.
- The need for a night of acclimatisation prior to observing at the summit of Mauna Kea makes it impractical to have people on standby to observe at notice of less than 24 hours. Thus a decision to extend or terminate a starred run must be made before the final night of the run has actually taken place.
- In order to build recovery time into the schedule fewer proposals can be accepted as there is less time available to allocate. With UKIRT typically oversubscribed by a factor of 3 – 4 this was felt to risk alienating those proposers who might otherwise have been awarded time as the lowest ranked, but still successful, proposals.

4. RESULTS IN 1996 AND 1997.

The experiment ran from February 1996 to January 1998, Semesters 96A,B and 97A,B in the UKIRT calender. This period was a busy time as it marked a major phase of engineering on the dome and telescope as part of a project intended to dramatically improve the image quality delivered by UKIRT. This work required substantial blocks of time to be set aside for engineering work and temporarily reduced the number of nights available for the UK scientific community. In consequence the time allocation committee felt that further reducing the number of projects to which they could award time in order to build recovery slots into the schedule would not be acceptable and little or no such time was set aside. It was however agreed that any potential observing time released by changes in the engineering schedule should be used for rescheduling of existing proposals rather than for previously unscheduled ones..

This compromise was not an optimum solution since the dates of the engineering time were set by completely different criteria than the need to provide suitable back-up slots for selected projects. This meant that it was not possible to have back-up nights appended to specific observing runs to allow them to be extended if necessary; only complete rescheduling of runs was possible and then only over limited RA ranges. Also, since it was not apparent at the beginning of each semester whether or not any recovery time would be available, it was not realistic to prepare a list of back-up proposals nor to expect the observers for the starred proposals to prepare detailed recovery plans which might never be implemented. However, in several of the semesters, alterations to the engineering programme did result in the release of several, ranging from three to six, nights for normal observing and so some reactive rescheduling was possible. In one semester no extra time became available and so no attempt was made to reschedule the starred proposals.

In total during the experiment six projects which lost significant amounts of time (more than 50 % of the original allocation) were rescheduled, in one case twice after the rescheduled run was also weathered out. In six cases out of the seven the second set of observations were carried out by a member of the original proposal team, the remaining run was carried out by UKIRT staff in a service mode. In most cases the original primary observer did not return for the rescheduled run due to pressure of other commitments but instead a student or collaborator carried out the rescheduled observing programme. This usually involved a second dedicated trip to Hawaii, but one project was supported by extending a visit required for a run on another telescope. This confirmed the expectation that 4m telescope time is considered so valuable that despite their heavy workload, astronomers will find a way to take advantage of any time which is offered to them.

The experiment also highlighted the difficulty of dealing with projects which are affected by weather or technical problems which are not severe enough to declare the run totally lost. For instance one such project was predicated on taking observations with high spatial resolution but a period of bad seeing prevailed during the run and this objective could not be met. In another case instrumental problems degraded the primary instrument and the observers felt that it was not appropriate to continue with their main programme. However in neither case was it possible for the observing programme to be switched to another programme unaffected by the circumstances because either no such programme had been identified in advance or because the observers preferred to continue with a back-up project of their own rather than execute someone else's project. These sorts of circumstances present the reactive scheduler with a dilemma since on the one hand the primary project has not been completed and so rescheduling is called for, but on the other the observers have had their allocation of clear time and can only be rescheduled at the the cost of a project that might otherwise have been promoted from a backup queue.

5. DID THE EXPERIMENT ACHIEVE ITS GOALS?

The ultimate objective of reactive scheduling was to increase the amount of high quality science being done at UKIRT, however quantitative measures of success of any observing programme are difficult to define in terms of scientific output over short timescales, if at all. Qualitatively the following comments from the PI's of four proposals which were most affected by weather and which were subsequently rescheduled can be noted.

"I would say we got everything that we hoped for out of three scheduled UKIRT nights. The process is excellent and stops good projects dying through bad weather on one trip."

"I was extremely pleased with the reactive scheduling. We lost some time to weather, and we had all our time given back. Consequently we finished the project. I have a student working on the data, and we'll be publishing forthwith."

"It meant getting some crucial data 12 months earlier than we would have been able to, had it not been for the nights having been rescheduled"

"...otherwise it would have been at least another year until we could have attempted to finish this important project"

Of course such enthusiasm is to be expected from observers who have been fortunate to have been treated in this way. It is obvious that some other observers whose projects were starred but who could not be rescheduled, or who required good seeing and did not get it even though their nights were clear by the working definitions of the experiment, were not so happy with the outcome.

Quantitatively it is possible to examine the number of nights which were starred for possible rescheduling, to determine the fraction of those nights which were clear as originally scheduled and to compare this with the number of clear nights actually achieved after one or more rescheduling attempts. This has been done for the four semesters in question and the results are shown in Table 1.

TABLE I.

Success rate of starred UKIRT proposals.

Semester	Starred Nights	Original Nights lost	No of Nights Rescheduled	Initial Success Rate %	Success Rate after Rescheduling %	Note
96A	15	8.5	4	43	83	
96B	12	4.5	0	62	62	No time available
97A	6	4.5	3	25	75	
97B	7	4.5	5	35	100	

Table 1 shows that the rescheduling more than doubled the success rate, defined here as the number of nights clear compared with the number of nights allocated, of the starred proposals. As such the experiment should be considered successful in its basic of goal of providing clear observing time to specific projects. Whether this will be translated into higher quality scientific output remains to be seen. What can be said is that three of the four most highly rated UKIRT proposals of semesters 97A and 97B would have been lost to weather and/or technical problems but for the reactive scheduling programme. In the event, these three projects eventually received their full allocation of clear telescope time and it behoves the observers to take advantage of this by reducing and publishing their data in a timely manner. The fourth project was also affected, although more subtly, by weather and bad seeing but in this case could not be compensated.

6. CONCLUSIONS.

Provided sufficient flexibility is built into the schedule at an early date, reactive rescheduling of runs can be achieved without undue strain on either the telescope support staff or the observers. However, unless time allocation committees are willing to set aside recovery time at the expense of denying lower graded proposals an entry into the "weather lottery" the existence of such a programme will raise expectations which cannot be met.

When offered an opportunity to re-attempt an aborted run, most observing teams can find a means of supporting the run even at short notice.

To ensure and to demonstrate fairness there is a need to have a peer reviewed pool of back-up observations and to insist that the reactively scheduled observers fall back on this pool if they cannot complete their primary programme.

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6.2. References.

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