REPORT OF THE REVIEW PANEL TO THE JCMT BOARD

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1. Executive Summary

The James Clerk Maxwell Telescope has been the world's premier submillimetre observatory for much of the past decade. The observatory's success has been largely based on the performance of the Submillimetre Common User Bolometer Array, SCUBA, comprising twin arrays simultaneously operating at 850 and 450 microns. Other instrumentation has also played a significant scientific role.

The JCMT is currently entering a new era in which an entirely new set of instruments is about to replace previously operating equipment. Three new observing modes are anticipated. HARP-B will introduce a 4 x 4 element heterodyne spectroscopy array for rapid spectroscopic mapping at 850 μm. eSMA, a JCMT extension to the Submillimeter Array, will permit improved high-spatial resolution interferometric mapping. Finally, SCUBA-2 will provide a unique facility, unmatched for the foreseeable future for high-speed, wide-field submillimetre mapping to revolutionize our understanding of the submillimetre sky.

The Review Panel has no doubt that the future of the JCMT is closely tied to the success of SCUBA-2. This dependency, however, will require vigilance to assure that the focus of the observatory clearly rests on this highest priority operating mode, which represents an advance in instrumental capabilities at least as great as that of its predecessor, SCUBA. Each of SCUBA-2's twin arrays comprises more than 5000 transition edge bolometer pixels -- a two-order-of-magnitude increase in complexity over SCUBA. Moreover, this type of bolometer has, to our knowledge, never been tested on a telescope to date. Every effort will, therefore, have to be made to make this technology a success. In particular, adequate staffing levels to assure a smooth installation and commissioning of SCUBA-2 are vital. Every effort should be made to continue operations of this instrument on the JCMT for at least three years beyond expiration of the current memorandum of understanding between the UK, Canada and the Netherlands in 2009.

The rapidly approaching expiration of the present agreement is a cause of major uncertainty for the affected astronomical communities, the observatory, and its staff. It is important for the funding agencies supporting the JCMT to decide as soon as possible whether to extend the existing agreement, and if so, to determine which of the current partners will wish to participate and whether or not any new partners should or could be found.

We list a set of recommendations at the end of this report.

2. Introduction

The James Clerk Maxwell Telescope (JCMT) has a 15 metre aperture, which makes it the world's largest single-dish telescope dedicated to astronomical observations at submillimetre wavelengths. It is operated as a partnership between the UK, Canada and the Netherlands which, respectively contribute 55, 25 and 20% to its operations. A tripartite JCMT Board oversees the observatory's activities. Observing time is allocated by an international time allocating committee supported by three national time allocating groups. The observatory saw first light in 1987 and has been operational ever since. The current memorandum of understanding between the three partner countries terminates in May 2009. The Review Panel has been asked to examine the potential of the JCMT for operating beyond 2009.

In this report, we review three periods in the operation of the JCMT. These are defined by two major events – the commissioning of SCUBA2/HARPB/eSMA in 2006-7, and the ending of the tri-national agreement in 2009. We deal with each period, prior-to-2006, 2006-2009 and post-2009, separately. In responding to the terms of reference reproduced in Appendix A, we focus on the challenge to assure the JCMT's continuing world leadership in submillimetre astronomy in the years beyond 2009.

Our approach has been based in part on helpful background information for which we thank the JCMT Director, Prof. Gary Davis and the observatory's staff. Some of the Review Panel members also met with PPARC and NWO officials, and had face to face meetings with interested astronomers in the UK and the Netherlands. Factual information about competing submillimeter observatories was obtained from a variety of sources. Most importantly, we also made use of responses to surveys circulated to UK, Dutch and Canadian astronomers. The results of these surveys are summarized in Appendix B.

3. The JCMT prior to 2006

3.1 Scientific Highlights

Submillimetre observations conducted with the Submillimetre Common User Bolometer Array, SCUBA, at the James Clerk Maxwell Telescope burst on the astronomical scene in the late 1990s and, without exaggeration, provided the field with an entirely new set of eyes through which to view the Universe. The figures speak for themselves. To date there are around 1,400 refereed papers which are either directly based on SCUBA science or interpret SCUBA-based observations. These have had over 26,500 citations – a striking indication of the influence of this instrument on a wide range of observational and theoretical fields of astronomy and cosmology. The excitement and interest provoked by these new observations, and the insight they yielded on star and planet formation as well as galaxies at high redshifts, has done much to spur the development and planning of future facilities, such as the internationally envisaged Atacama Large Millimeter Array, ALMA.

3.1.1 The submillimetre galaxy population

Without doubt the most influential discovery made by the JCMT was the identification of a population of galaxies, which are strong emitters in the submillimetre-waveband. This discovery was made with the first integrations of a few hours using the newly-commissioned SCUBA camera in mid-1997. So influential has SCUBA become that these galaxies are frequently referred to as "SCUBA" galaxies. Even more astonishingly, within two years of detecting the first submillimetre galaxy, SCUBA had traced the number counts of galaxies over the entire flux range responsible for producing the extragalactic background light (EBL) in the submillimetre waveband. This result should be contrasted with the decades it has taken to achieve the same goal in the optical and X-ray wavebands.

These results from SCUBA have had a revolutionary influence on the study of the formation and evolution of galaxies. Before the discovery of the first submillimetre galaxies, we had little indication of the strong influence of dust on our view of young galaxies in the early Universe, at redshifts of $z = 2$ -3 around 10 -12 Gyr ago. SCUBA uncovered a population of sources which, while not particularly numerous, are individually so luminous that their integrated star-formation activity is likely to at least equal that seen in the optical waveband. This is graphically illustrated by the two images reproduced in Figure 1. They show two views of the Hubble Deep Field – one of the deepest optical images of the sky ever taken. The image on the left was obtained by the Hubble Space Telescope and detects around 3,000 faint galaxies. The other, far-less-striking, image on the right is the SCUBA 850 micron map of the same region. This detects just 5 galaxies, but the bolometric luminosities of these galaxies suggest that they account for as much star formation as the 3,000 optically-detected galaxies.

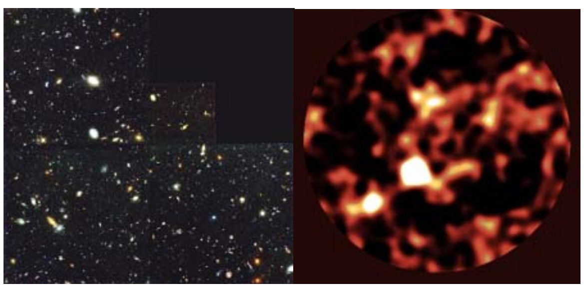


Figure 1. The Hubble Deep Field as seen with the Hubble Space Telescope and SCUBA. (R. E. Williams et al., AJ 112, 1335, 1994; D. H. Hughes et al. Nature 394, 241, 1998 .)

While SCUBA has made a profound impact on our understanding of galaxy formation and evolution, it should be stressed that, to date, it has detected fewer than 500 galaxies. The largest extragalactic surveys cover only a few tenths of a square degree at relatively shallow depths. To obtain demonstrably unbiased and representative views of this important population we will need to undertake much larger and more sensitive future surveys at both 850 and 450 microns. This will become possible with SCUBA's successor, SCUBA-2.

3.1.2 The Origin of the Initial Mass Function for Stars

Some of the most fundamental questions in astrophysics concern the origin of the masses of stars. Of particular interest is the distribution of stellar masses, the stellar initial mass function, widely thought to be universal. Observations with SCUBA on the JCMT have played a

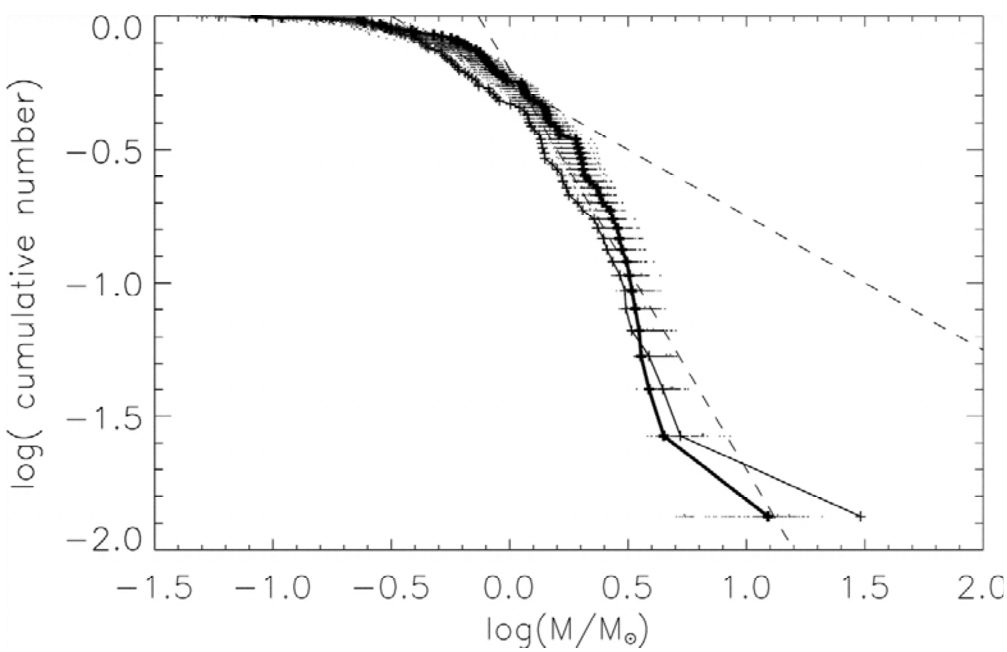


Figure 2. The cumulative number function for clumps with mass greater than M in Orion B. The different lines represent various model fits. The thin and thick solid lines roughly bracket the authors' best estimates for the distribution of clump masses. (D. Johnstone et al., ApJ 559, 307, 2001.)

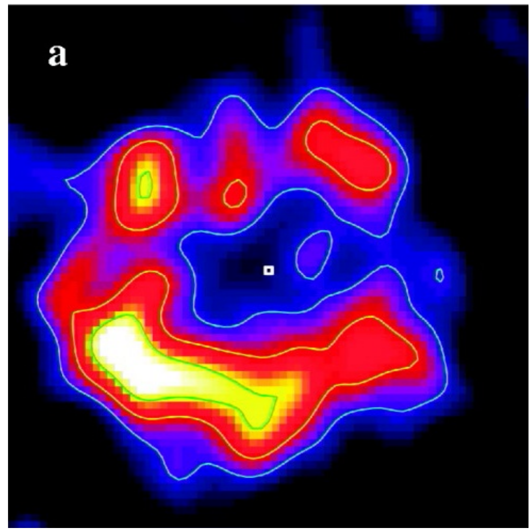
fundamental role in measuring the mass function of the dense cores of molecular clouds, clumps of gas and dust which may be the precursors to individual stars. Measuring core mass functions in a variety of environments and comparing the core and stellar mass functions are critical to understanding the physical processes which give rise to such a universal stellar mass function. As Figure 2 indicates, SCUBA and the JCMT have been used to measure the core mass function in half a dozen molecular clouds which have median core masses ranging from 0.2 to 200 solar masses. The good agreement between the shape of the core mass function and the stellar initial mass function implies that the mass of an individual star is largely set by its parent core. The observed shape of the core mass function is also in good agreement with the predictions of numerical simulations of turbulent molecular clouds.

3.1.3 Disks around Stars both Young and Old

Disks play a fundamental role in the formation of stars, being involved both in channeling infalling material and in the generation of dramatic large-scale outflows which remove excess angular momentum from the system. The JCMT-CSO single-baseline interferometer made the first resolved observations of a circumstellar accretion disk around the young protostar HL Tau. Combining data from the JCMT-CSO interferometer at 850 and 650 microns with similar longer-wavelength data from other telescopes resulted in strong constraints on the extent of the disk as well as the radial profile of both temperature and surface density.
On larger scales, SCUBA continuum images of older nearby stars have revealed the presence of extensive debris disks. Surprising in the SCUBA images is the extent of the disks as well as

the presence of substantial sub-structure within the disks. This substructure is thought to be produced by gravitational perturbations of the disk by unseen planets. Since dust grains cannot survive for the lifetime of such old stars, these disks must be constantly replenished with dust produced in the collisions of asteroids or released from comets orbiting the central star. Figure 3 shows the dust debris disk surrounding epsilon Eridani.

Figure 3. The 850 micron Continuum Emission from the Debris Disk around Epsilon Eridani (J. S. Greaves et al., ApJ 619, L187, 2005)



3.2 Scientific Output

The number of publications stemming from JCMT work remains high. The most recent Joint Astronomy Center Annual report lists 72 refereed papers based on observations with JCMT instruments produced in 2004 alone. In addition, a survey conducted in the UK, detailed in Appendix B and covering the most recent three years, counted 189 refereed papers in this period – published or in press – although no attempt was made to see whether duplication among respondents might have inflated these numbers somewhat. A corresponding survey conducted in Canada indicated publication of 122 refereed papers in the most recent five year span, again with no attempts to sort out duplication among respondents. The Dutch astronomical community also registered 96 papers in three years, although, again, there may have been some overlap.

The average annual numbers emerging from these surveys are somewhat higher than the individually listed papers for 2004. But the numbers are all in rough agreement and point to a healthy rate of publication in a new field of high interest to the astronomical community.

3.3 Training of Students

The survey undertaken in the UK showed that approximately 70 students had participated in observations at the JCMT in the past three years. 31 PhD theses, during these three years had included results of JCMT observations. The Dutch respondents counted 13 theses in a three year interval. Roughly 15 Canadian students had used JCMT data in their theses in the past 3 years. Appendix B to this report includes summaries of responses to the questionnaires circulated to the three communities.

3.4 The New Suite of Instrumental Capabilities at the JCMT:

The JCMT will initiate three new observing modes in the next year.

SCUBA-2: This next generation continuum camera will be equipped with two simultaneously active focal planes arrays separated by dichroics to operate, respectively, at

450 and 850 microns. Each array is equipped with 5120 Transition Edge Superconducting (TES) detector elements to cover a field of view of 50 $arcmin^2$. The JCMT 15-m aperture provides an angular resolution of ~ 8 arcsec at 450 microns and roughly 15 arcsec at 850 microns. The arrays are read out by SQUID multiplexers and will be 2 to 3 times more sensitive than the detectors on the original SCUBA arrays, which comprised only 37 and 91 detector elements, respectively at 850 and 450 microns. The mapping speed with the new arrays is, therefore, expected to be two to three orders of magnitude higher than that of their predecessors. SCUBA-2 is also equipped with an auxiliary Fourier Transform Spectrometer (FTS-2) and a polarimeter (POL-2), giving observers wide-ranging options.

The level of maintenance required by the aging SCUBA instrument during the past year forced its retirement in July 2005 after 8 years of service on the telescope. Current plans call for delivery of SCUBA-2 in August 2006. This makes for a regrettable but unavoidable hiatus of more than one year during which wide-field mapping will not be conducted at the JCMT.

HARP-B / ACSIS: HARP-B is a 4 x 4 pixel superconductor-insulator-superconductor (SIS) heterodyne receiver array operating in the 850 micron atmospheric transmission window. The pixels are separated by 30 arcsec, roughly twice the diffraction limit, but fully covered maps are produced through superposition of appropriately spaced lines of sight. HARP-B will, therefore, offer observers a mapping speed in spectroscopy that is more than an order of magnitude higher than available to date when used in conjunction with a new Autocorrelation Spectrometer and Imaging System (ACSIS).

ACSIS is a hybrid correlator that provides an intermediate frequency (IF), a correlator, a data reduction system that includes a real time display, and all the internal interfaces between these components. A variety of bandwidths can be selected that affect the number of channels and the channel separation. At 850 microns, ACSIS yields a spectral resolution of 750,000, a Doppler velocity measurement for spectral lines of 0.4 km s^{-1}. The data are fed into a system for reduction and display in near-real-time to help observers pursue their observations. ACSIS is being commissioned as this report is being written and HARP-B is expected at the JCMT in November 2005.

eSMA: The advent of the Smithsonian Institution’s Submillimeter Array (SMA) on Mauna Kea has prompted interest in joining the JCMT to the array, both to increase baseline length and thus image resolution and to provide added collecting area for greater sensitivity. Activities for linking the JCMT to the SMA are currently ongoing. Science demonstration observations at 1.3 mm are planned for later this calendar year, but the real payoff will lie in implementation of a link at 850 microns, for which commissioning of HARP-B is a prerequisite. The recent strategy of doing initial commissioning of the eSMA at 1.3 mm has worked very well and can be expected to smooth the final 850 micron commissioning of the eSMA in 2006. It is clear that the injection of additional funds to this work by Dutch astronomers has been absolutely critical to moving the project forward.

The JCMT Science Archive: To fully utilize the high data rates anticipated from SCUBA-2 and HARP-B / ACSIS and the prospects of large, homogeneously acquired legacy surveys, a fully dedicated JCMT Science Archive (JSA) is being designed. Each of the new JCMT instruments will be equipped with data reduction pipelines to process each night's data for storage. These data will be stored at the Canadian Astronomical Data Center (CADC). Advanced data products that have been further reduced at the JAC, by the legacy teams, or by other interested astronomers will also be stored at the CADC. Recently approved by the JCMT Board, the archive is expected to go into service in mid-2007.

3.5 **Unique Capabilities of the JCMT and Competition from other Observatories**

The JCMT is located on Mauna Kea, a site with some of the best atmospheric transmission in the world. While several sites at higher altitudes in Chile have better atmospheric transmission, Mauna Kea remains the best site in the northern hemisphere for submillimetre observations. The JCMT's large aperture and SCUBA-2's large scale detector arrays covering an area of 50 $arcmin^2$, will enable the facility to conduct the largest scale, deep surveys of the sky ever undertaken at 450 and 850 microns.

In cosmology, the mapping capabilities of SCUBA-2 are expected to open new avenues for studying the first stages of star, galaxy and quasar formation in the early Universe. In galactic studies, the SCUBA-2 surveys will identify regions in which the various phases of star and planet formation are currently at work. In combination with its polarimeter, SCUBA-2 will produce large-scale polarization maps that will constrain the role of magnetic fields in the dynamical support of molecular clouds and their evolution to permit the cloud collapse which ultimately forms stars (see Figure 4). Spectroscopic means for studying regions of particular interest will be provided by HARP-B / ACSIS. High spatial resolution mapping of small portions of the SCUBA-2 fields will also become possible at 850 microns through implementation of the extended Submillimeter Array, eSMa.

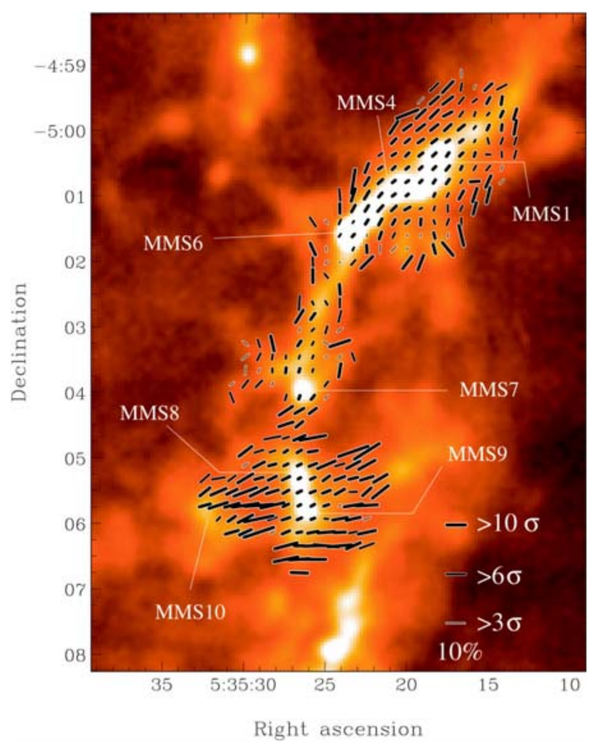


Figure 4. 850 micron polarization map obtained with SCUBA, tracing the magnetic field structure observed in the OMC-3 filament of Orion B. Vectors show the polarization orientation with lengths proportional to the percentage polarization, while the underlying image shows the 850 micron continuum emission. The thickness of the polarization vector is keyed to the detected signal-to-noise ratio. (B.C. Matthews, et al., ApJ 562, 400, 2001.)

While the rapid, large-scale mapping capabilities of the JCMT are expected to remain unique for many years to come, some of the observatory's other capabilities may soon be duplicated elsewhere or surpassed.

The current competition for the JCMT consists of the IRAM 30-m telescope at the Pico Veleta in Spain, the 10-m Caltech Submillimeter Observatory (CSO) on Mauna Kea, and the 12-m Atacama Pathfinder Experiment (APEX) in Chile. In addition, the 50-m Large Millimeter Telescope (LMT) being erected at 4600 m altitude on Cerro La Negra in Mexico is expected to be commissioned in 2008/2009. None of these telescopes currently plan to become equipped with bolometer arrays on the scale of SCUBA-2. The LMT will have a bolometer array with approximately 100-elements operating at a wavelength of 1.1 mm, with a beam somewhat better than that of SCUBA-2 at both 850 and 450 microns. SCUBA-2's 850 and 450 micron arrays will, respectively, have beam sizes of 15 and 8" vs. the LMT's 1.1 mm beam of 6 to 7". But the LMT's surface accuracy of 70 μm rms and atmospheric conditions at its site may make it competitive with SCUBA-2 only at 850 μm and under the best atmospheric conditions, and its array will have significantly fewer detectors and a correspondingly smaller field of view.

In contrast to SCUBA-2, HARP-B has potential competitors among other single-dish telescopes. All of the above-cited telescopes are or will be equipped with heterodyne arrays on scales comparable to HARP-B, although APEX is the only one that will operate in the 850 micron range. Because of its excellent site, APEX will be able to carry out ground-based observations at the shortest submillimetre wavelengths and will be a direct competitor to the JCMT for spectral line observations. Because of the geographic location of their sites, both of which have high atmospheric transparency, APEX and the JCMT may be viewed as complementary single-dish telescopes providing access to the northern and southern hemispheres. Portions of the sky not available from the southern hemisphere will be best studied at short submillimetre wavelengths by the JCMT. The northern sky is rich in astronomical sources that have been studied in many wavelength bands over past decades. Most of these have never been observed in the submillimetre range.

Future observations with the Herschel and Planck space observatories, and with SOFIA, the airborne observatory, will complement work at the JCMT, rather than compete with it. Herschel and SOFIA will have smaller apertures, 3.5 and 2.5 metres respectively, and hence poorer angular resolution, but will be able to cover submillimetre wavelengths inaccessible from the ground. Planck will provide all-sky submillimetre surveys to great depths, but with a 1-metre telescope that is diffraction limited at all its many operating wavelengths, ranging from 1 cm to 350 microns.

At 1.3 mm wavelength, where science demonstration is currently being pursued at the eSMA, competing facilities are the Plateau de Bure Interferometer (PdBI) and the Combined Array for Research in Millimeter Astronomy (CARMA) at Cedar Flats. While both facilities are sited at altitudes lower than Mauna Kea, their larger collecting areas mean that they will offer strong competition to the eSMA at millimetre but not at submillimetre wavelengths. Particularly for the PdBI, the large collecting area of each telescope in the array makes calibration much easier, and can mean the difference between a project being feasible or not. None of these facilities, however, will be able to operate at 850 microns, for which the eSMA is being designed.

After the current refurbishment of the JCMT, the next major development in submillimetre astronomy will be the Atacama Large Millimeter Array, ALMA, expected to be fully operational by 2012. As currently envisioned, ALMA will comprise 64 12-m antennas with a total collecting area of 7000 square metres and a web of 2016 simultaneous baselines spanning up to 10 kilometres. With dual polarization 8 GHz bandwidth receivers in wavelength bands at 3,000, 1,300, 850 and 450 microns, the facility will have an unparalleled capacity for high spatial and high spectral resolution imaging of faint sources. Nominal figures suggest sensitivities at the 1.5 and 8 mJy level (1 sigma) in one second of observing time, respectively at 850 and 450 microns. The excellent atmospheric transmission at Atacama is expected to also lead to further work over a significantly wider portion of the spectral range from 1 cm to 320 microns.

SCUBA-2 on the JCMT will be decisively faster than ALMA for wide-area continuum surveys until ALMA is close to completion. Even when ALMA is fully constructed, SCUBA-2 will be 2 to 8 times faster than ALMA at 850 microns to 1 mJy sensitivity, and 5 to 18 times faster at 450 microns for wide-area mapping to 10 mJy sensitivity, depending on the adopted ALMA sampling mode. While the maps obtained by SCUBA-2 will provide far lower spatial resolution than those produced by ALMA, it is possible that the SCUBA-2 maps will fill in low-resolution Fourier components that might be missing in ALMA's coverage. This comparison suggests that there will be a significant and high-impact scientific role for the JCMT using SCUBA-2 even after ALMA construction is completed in 2012. SCUBA-2 will be well matched to ALMA in that its main strengths lie in the detection of submillimetre sources not previously located, and in providing preliminary data indicating whether they are of potential scientific interest for further study. SCUBA-2 can therefore be expected to become one of the prime facilities for finding, selecting, and feeding interesting sources to ALMA for further study at high spatial and spectral resolution.

ALMA is also a potential competitor to HARP-B on the JCMT. When fully completed, ALMA will be 3 - 4 times faster than HARP-B to map a given region of sky, and will provide substantially better angular resolution. However, an open question is what fraction of ALMA time will be dedicated to such a wide-field spectral line observing mode. Depending on the level of competition for time on ALMA, it seems likely that APEX will be a more important competitor to the JCMT in this kind of science.

ALMA will also be a direct competitor to the eSMA; a reasonable guess at the ALMA construction schedule currently has first science (with at least 8 antennas) starting sometime in 2009, giving ALMA a larger collecting area than the eSMA. Even allowing for some delay in the ALMA schedule, it seems likely that the eSMA can be operated competitively only until about 2010, after which any source ALMA can reach (i.e. roughly any source south of declination +40 degrees) would be better observed with ALMA. However, the eSMA may remain useful for studying unique northern sources even in the era of ALMA operations.

The only real competition to the JCMT would come from a large-aperture, roughly 25-metre high-surface-accuracy submillimetre telescope operating on a superb site with a camera similar to SCUBA-2. Such a facility is currently under discussion, and its eventual construction and commissioning, at best likely to be in 2015, would pose a threat to the JCMT's unique scientific capabilities.

4. The Scientific Promise of the JCMT for the Immediate Future: 2006 – 2009

The suite of new instruments on the JCMT will replace wholesale most of the instruments that have served the observatory's users over the past decade. These powerful new resources will provide a breathtaking jump in the quality and quantity of data to become available. Correspondingly a new data archive is simultaneously being developed. Taken together these efforts promise impressive advances and a bold new future.

4.1 The Legacy Surveys

Potentially the most important contribution to astronomy that the JCMT will provide in the years ahead will come from the recently selected Legacy Surveys. The level of community interest in these surveys was so strong, reflected in an initial >500% oversubscription in proposed observing time, and the importance of the proposed surveys was judged to be so compelling by a panel of international expert referees, that the time allocation committee took the step of not only assigning observing time for the 2007 – 2009 period, but to issue a set of non-binding recommendations for the years 2009 – 2012. The importance and appeal of the surveys can only be understood in terms of the panoramic scientific scope they offer. As a whole they reflect the strengths of the world-class observing program that the JCMT will carry out in the years ahead. To this end, we briefly summarise the potential long-term significance of each of the surveys (the full science cases are available from the JCMT Board secretary):

The SCUBA-2 Cosmology Survey: This survey will obtain the first statistically reliable samples of thousands of distant submillimetre galaxies, selected at 850 and 450 microns over fields of 35 and 1.5 square degrees respectively. These data will definitively answer questions about the nature of these young, active galaxies – including the star formation activity in the most massive galaxies as a function of epoch, their clustering and their relationship to the growth of cosmic structure. No other facility can compete with SCUBA-2 to carry out this project.

The Galactic Plane Survey: We have only an incomplete census of the sites of massive star formation within our own Galaxy and hence our understanding of the formation of massive stars is still quite rudimentary. The molecular clouds which host this activity have temperatures around 10 – 20 K and so emit most strongly in the submillimetre domain, making surveys with SCUBA-2 by far the most propitious way to find them and study their properties. This survey will provide the first complete survey of massive star formation regions in the Galaxy to gain greater insight into the processes of magnetic field diffusion, angular momentum shedding and fragmentation, which are integral to the formation of massive stars.

The Gould Belt Survey: The Gould belt is a prominent feature in the night sky that encompasses virtually all the regions of (typically low-mass) star formation within 1500 light years from the Sun. The survey of this region will identify all the star-forming regions, pre-stellar cores and protostars within this structure and determine the pre- and protostellar clump mass functions—the distribution function of these masses—down to substellar masses an order of magnitude lower than previously possible. It will determine how the mass function of these objects is related to the stellar initial mass function, i.e. the distribution of masses of stars that have already reached the main sequence of the Hertzsprung-Russell diagram.

The SCUBA-2 "All Sky" Survey: The Atacama Large Millimeter Array (ALMA) is going to be the most powerful sub/millimetre interferometer ever constructed. However, ALMA is ill-suited to searching for rare luminous or short-lived phases of galaxy or star formation – which can be best identified by shallow panoramic surveys. These objects can then be mapped and studied at the highest spatial resolution with ALMA. The SCUBA-2 "all-sky" survey will locate and identify sources that will be accessible to ALMA and will also act as a pathfinder for the Space missions Herschel and Planck, neither of which will have the high sensitivity or spatial resolving power of SCUBA-2. An attractive feature of this shallow survey is that it can be carried out under poorer weather conditions than some of the other surveys.

Debris Disks: The recent discovery that planets are nearly ubiquitous around stars in the Sun's neighborhood has shown how much remains to be learned about the formation of planets and the evolution of planetary disks. Submillimetre observations with the JCMT have shown that debris disks are relatively short-lived. They are, therefore, considered likely to play a significant role in planet formation which subsides once a planetary system reaches a phase of permanence. Because these disks extend to great distances from the parent stars the debris is cold in the outer disk regions and observable only at long wavelengths. SCUBA-2 is likely to be the most powerful instrument to identify these cold disks and yield masses and temperature determinations necessary to model their evolution.

Physical Processes in Galaxies in the Local Universe: This legacy project focuses on understanding the physical properties of the interstellar medium in galaxies and probing the interplay between local physical properties and the wider-scale galactic environment, such as metallicity, star formation rate, mass and cluster environment. Combining an unbiased HI flux-limited sample with the well-studied galaxies from the Spitzer Infrared Nearby Galaxies Survey (SINGS) sample within a distance of 25 Mpc, the project will be able to search for evidence of very cold dust in galaxies, measure the amount of warm, dense molecular gas associated with star formation, and measure the local submillimetre luminosity function to luminosities 100 times fainter than previous studies.

Spectral Line Survey: Protostellar regions which are contracting to form stars need to emit radiation to rid themselves of energy. Simultaneously, however, they may be heated by ambient radiation fields. The balance between these competing processes depends on the available atomic and molecular species through which radiation can be absorbed or emitted in the submillimetre domain. A comprehensive survey of prestellar cloud cores and regions of high- and low-mass star formation will provide insight on chemical processes playing a significant role in star formation. Since the extent to which star formation is triggered by outflows from nearby massive stars or by expanding photodissociation regions is poorly understood, the kinematics of these clouds and their chemical constituents also need to be better understood. These are the problems this Legacy Survey is designed to attack spectroscopically using HARP-B.

In the context of these Legacy Surveys the Review Panel wishes to emphasize the importance of the planned science archive for maximizing the scientific impact of SCUBA-2 and HARP-B on the JCMT, both in the immediate future and post-2009. A uniform archive that contains all the Legacy Survey and PI data from the JCMT and is compatible with the Virtual Observatory will have far greater impact than any individual collections of advanced data products that could be generated by the individual Legacy Survey teams.

4.2 **Potential Issues for the Near-Future**

The Review Panel notes that the delivery schedule for SCUBA-2, the most critical element for the future scientific impact of the JCMT, remains success oriented. New instruments tend to require a great deal of attention before the best performance can be teased out of them. This takes skill, manpower and time. Commissioning of several of these instruments in rapid sequence is likely to place high demands on observatory staff, exacerbated by an anticipated reduction in staffing levels after 2005/2007. All this, makes quite uncertain any predictions on the scientific productivity of the JCMT over the years leading up to 2009 and the end of the current memorandum of understanding between the UK, Canada and the Netherlands.

At their invitation, one member of the Review Panel (MH) met with PPARC personnel and UK astronomers, and two members (MH and KM) met with NWO personnel and Dutch astronomers. All of the scientists attending these meetings, as well others who spoke with Review Panel members on different occasions, expressed concern about the competition the JCMT must expect from ALMA once that observatory becomes operational. All agreed that SCUBA-2 will be a unique facility without clear competition. Especially vulnerable to competition will be eSMA and HARP-B / ACSIS science. Most of the scientists felt that whatever innovative science can be conducted with eSMA and HARP-B / ACSIS should be attempted at the earliest opportunity, because after 2010 – 2012 the only unique contributions these two instruments are likely to make will involve northern hemisphere objects inaccessible to ALMA. This may not be as restrictive as it may sound, because many of the sources best studied to date lie in the northern hemisphere, and will undoubtedly require careful study with the capabilities that eSMA and HARP-B / ACSIS can offer; but the widely held opinion is that the years between 2006 and 2009 offer unique opportunities for these observing modes that should be exploited as early as possible to recover their promised scientific return on investments.

The brevity of the period before ALMA comes online may most strongly affect the eSMA. Given the competition at 1.3 mm from CARMA and PdBI, the eSMA must have full bandwidth and sensitivity to maximize the scientific return at 850 microns. A strong commitment from all three organizations – SMA, CSO and JCMT – will be required to reach the goal of 850 micron operations at a time when both the SMA and HARP-B / ACSIS are still in the process of being fully commissioned. In our view, significant observing time for the eSMA should only be considered once a full 850 micron system is available. A careful plan for joint preparations should be established by the three observatories involved to assure a fully committed effort. In addition, maintaining Receiver W in operation in the short term would keep open the option of eSMA operation at 450 microns, which could be accomplished in a 1 GHz bandwidth without costly changes to the receiver.

We understand that there is an agreement between the JCMT Board and the leadership of SMA that six weeks of joint operations are to be undertaken in a first year effort to assess the promise of the eSMA. As part of the process to extend the collaboration with the SMA beyond the initial 6 week pilot project, it will be important to consult the community (as was done for the Legacy Surveys) to assess the level of demand for eSMA observations and the quality of the potential science projects.

Assuming that the pilot project and the community consultation lead to additional observations in this mode, the eSMA will be a unique resource with a finite useful lifetime. As such, it is important to ensure that projects are selected which really require the unique capabilities of the eSMA and also are technically feasible. Having a single expert time allocation committee (TAC) to which proposals from all partners were sent would allow for a uniform assessment of all proposals, would prevent outright duplication of efforts, and would avoid placing barriers to collaboration among scientists from the three communities (JCMT, SMA, CSO). With an agreement on the number of nights available on the eSMA in a given year as a boundary condition for the TAC, this process could be both efficient and beneficial for all the partners.

SCUBA-2 is considerably less vulnerable to competition than HARP-B / ACSIS or eSMA. Until or unless a significantly larger submillimetre telescope than the JCMT is erected at a better site, most likely in Chile – and no such observatory is currently certain to be built – SCUBA-2 will have a broad and exciting scientific field more or less to itself.

With the increasing sophistication and complexity of the generation of instruments about to be commissioned at the JCMT, the level and quality of user support is going to be critical to maintaining the productivity and low fault rate the observatory has achieved. The Board should make every effort to assure continuity of the high performance levels attained by providing the small but excellent observatory staff with incentives that will motivate them to stay and continue their work at the JCMT.

5. The Longer-Term View: The JCMT after 2009—Instrumentation and Competitiveness

Given that the JCMT is starting the year 2006 essentially as a brand new observatory embarking on three entirely separate observational tracks, it seems almost premature to talk about what might be done when these three approaches have run their course. Thus, there is no rush to think about such future developments. The scope of the proposed Legacy Surveys is so broad that it is virtually bound to spill over into the years well beyond 2009. The Legacy Surveys would not have been proposed were they not full of promise of new discoveries that will undoubtedly lead to a rich return of further proposals from individual observers wishing to follow up some of the new findings. If they are even partially successful these new ventures will lead to new insights and new needs for novel instrumentation that are difficult to predict. Nevertheless, a number of possibilities suggest themselves.

We noted, above, that SCUBA-2 currently has no competition in wide-field submillimetre mapping. However, the construction of a 25-metre high-surface-accuracy submillimetre telescope operating on a superb site with a camera similar to SCUBA-2 is presently under discussion. Given the long lead times involved, the JCMT Board and its supporting communities should soon consider whether or not to actively participate in the construction of such a facility as a next logical step to maintaining leadership in submillimetre astronomy.

One option for additional new instrumentation for the JCMT for the post 2009 period would be a heterodyne array operating in the 450 micron atmospheric window. Such an instrument would give an improved scientific return during exceptional weather by multiplexing observations of extended objects. Due to weather and instrument constraints, there are relatively few observations at these wavelengths in the published literature. With the advent of ALMA and its short-wavelength capabilities, there will be an urgent need for pathfinder single dish observations to guide valuable ALMA time.

Among the larger submillimetre telescopes, only APEX is in the process of developing an array receiver for wavelengths shorter than 790 microns. Thus there is a clear niche of observing northern hemisphere sources that the JCMT could fill with a 450 micron receiver array. This short-wavelength array should be able to make good use of the ACSIS correlator and the data processing software developed for ACSIS and HARP-B, which should reduce its cost. The caveats are that such an instrument would compete directly with SCUBA-2 450 μm observations for the best weather conditions and that the instrument would need to be designed, built and commissioned in a timely fashion to allow maximum use by the JCMT user community.

Other potential directions in spectroscopy could involve increasing the heterodyne bandwidth of HARP-B to 12 GHz to capitalize on the capabilities of ACSIS and conduct spectroscopy on a wider variety of molecular species, with high area coverage.

Further suggestions that the Review Panel heard from potential users and instrumentalists included the possibility of improving the telescope surface error from a current ~22 microns rms to a reduced error of 17 microns rms. This would provide for an efficiency of 80% at wavelengths of 450 microns in place of a current efficiency of 68%, while also reducing unwanted side lobes. Pointing stability is currently limited by atmospheric conditions, but techniques being worked on for ALMA, using measurements of water vapor gradients and compensating for these, could provide the desired corrections.

While the performance of SCUBA-2 is not expected to be limited by detector sensitivity, improvement of the heterodyne receivers by a factor of 2 is likely to produce scientific gains. Currently the heterodyne receivers are operating at 400–500 K noise temperatures. The sky alone contributes a noise corresponding to 100 K and the telescope another 60 K. If the receiver noise were reduced to about 200 K, no significant further gains could be made through improved sensitivity. Gains in mapping speeds, however, could be substantial if larger heterodyne arrays were implemented. From a 4 x 4 array, one might be able to advance to a 10 x 10 array of receivers, and reduce cost by proceeding in a modular fashion. However, suitable backends would also be needed, which might require considerable development. Conceivably by 2010 such an upgrade might be in sight and lead to a 20-fold gain in heterodyne spectroscopic mapping. A factor of 4 in speed would be gained by reducing the receiver noise by a factor of 2, and a further factor of order 5 from going from the 4 x 4 to a 10 x 10 receiver array. Among many other exciting projects, this would permit the rapid spectroscopic mapping of regions of star formation to determine the chemodynamics of protostellar collapse --- the interplay of cooling by different chemical species, leading to contraction to form a star.

6. **Opportunities and Choices Facing the JCMT Board**

The Review Panel members are in no doubt that the JCMT is going to continue to be a world-class facility for many years to come. The quality of the site, the size of the telescope, and the excellent staff and infrastructure, all by themselves, will assure the JCMT of a bright future. As long as the level and quality of user support is maintained through incentives that continue to motivate its small but highly professional staff, the JCMT is bound to prosper. It will, however, be essential for the JCMT Board to lay down clear priorities, and to plan an orderly development of the facility.

While there is no doubt among the Review Panel's members that HARP-B / ACSIS and eSMA can yield significant scientific results in the next few years, we are also convinced that the JCMT's highest priority must remain SCUBA-2. The lack of any instrument, world-wide, that comes close to matching its anticipated capabilities, will make SCUBA-2 the work horse to maintain the JCMT's status as a world-class observatory for the foreseeable future. The converse, however, is equally true. The scientific capabilities of both HARP-B / ACSIS and the eSMA are expected to be surpassed once ALMA begins operations. This means that SCUBA-2 must be made to operate successfully if the JCMT is to maintain its status as a world-class observatory, along currently planned lines.

In our opinion, the Board should articulate this priority in unambiguous terms. There are compelling reasons for clarity:

First, the research aims of the three communities supporting the JCMT are diverging, with the Dutch community far more interested in spectroscopy and interferometry than in high-speed mapping, the direction that the UK community is emphasizing. If a vibrant research program is to continue, these differences have to be clearly spelled out, understood by all the partners, and taken into account in planning the future. A rational decision might be for the present partnership to be discontinued or modified, or for a new partnership to be initiated that will emphasize a clear future to which all partners can agree.

Second, the Board currently has to balance two competing responsibilities. One is to have the JCMT produce the best science. The other is to make sure that each of the partner countries receives an equitable scientific return on its investments. Since there are considerable differences in the scientific priorities of the three communities, these two aims are not readily resolved and inevitably lead to demands for different classes of instrumentation all of which remain less utilized than if a more coherent research program could be established, with a single focus supported by a smaller number of instruments at lower cost. A clear statement of scientific priorities arrived at by the Board could lead to a less costly, potentially more powerful observatory following the expiration of the current memorandum of understanding in 2009.

Third, the current situation, in which three new observational capabilities are being installed within a time span of about 18 months, faces risks that might be avoided if clear priorities were agreed on by all the partners. The panel recognizes that priorities have been laid down by the Board in broad terms, but constant re-examination and re-emphasis may be important. Without clearly emphasized priorities, individual specialists on the JCMT staff are likely to be overburdened if their expertise becomes key to the competing needs of two or three of the facilities selected for commissioning, while other members of the staff may be underutilized during this massive installation of new capabilities.

The panel recognizes that the present rapid turnover of instruments was not planned, but developed as a result of unanticipated delays in the realization of all three instrumental projects. Nevertheless, the situation may constitute a warning that the JCMT Board and Director may need to seek added control over the construction and delivery of novel capabilities for the JCMT, even though the bulk of the work is carried out by organizations not under the immediate supervision of the JCMT. While our panel has no recommendations on how this is to be achieved, it proposes that the issue be re-examined to see whether a workable solution might be found.

In the long run, the choices the JCMT Board faces are whether to concentrate its limited resources primarily on SCUBA-2, with the enormous promise that this instrument heralds, or whether to simultaneously push forward the efforts on eSMA and HARP-B / ACSIS to extract at least a few years' worth of returns on those instrumental approaches before they are overshadowed by ALMA. If this latter option is pursued, the Board may wish to press hard for added resources to make certain that a viable scientific program can be pursued on such a broad front during the limited time available. A factor affecting this decision will have to be any perceived or confirmed delays that ALMA may suffer and the potential breathing space and prolonged operational lives that eSMA and HARP-B / ACSIS might then enjoy.

These are immediate concerns, which should be resolved as soon as possible in order to make the transition envisaged at the JCMT as painless as possible. The commissioning of the three anticipated capabilities could well stretch beyond 2006-7, and the instruments involved may not hit their full stride for a year or two beyond this, perhaps not until the year 2009 approaches and the present memorandum of understanding between the three partner countries expires.

By then it will be essential for the Board to have reached clarity on what the astronomical communities in their member states expect, whether the JCMT can meet all their potentially conflicting expectations, where the observatory's future priorities should lie, and whether the present consortium still remains the best partnership to guide the observatory's future.

7. **Recommendations by Priority**

Long term:

1. SCUBA-2 will be unmatched for wide-field submillimetre mapping for the foreseeable future. Every effort should be made to continue operations of this instrument on the JCMT for at least three years beyond expiration of the current memorandum of understanding in 2009. The competitive lifetime of SCUBA-2 is largely determined by the as yet uncertain planning for a larger submillimetre telescope with a large panoramic camera at a high quality site. Given the long lead-times involved, the JCMT Board and its supporting communities should soon consider whether or not to actively participate in the construction of such a facility as the next logical step to maintaining leadership in submillimetre astronomy.

2. The scope of the planned legacy programs is so large that completing them seems very likely to extend into the years beyond 2009. These legacy programs will have sufficiently large scientific impact to also justify the extension of JCMT operations for three years beyond 2009.

3. The rapidly approaching expiration of the present agreement is a cause of major uncertainty for the affected astronomical communities, the observatory, and its staff. It is important for the Board and its funding agencies to decide as soon as possible whether to extend the existing agreement, and if so, which of the current partners will wish to participate and whether any new partners should or could be found.

4. The JCMT Board and the Director should seek added control over the construction and delivery of any future capabilities for the JCMT with the goal of mitigating the effects of delays in deliveries and to avoid the potential overloading of staff caused by simultaneous commissioning of major new capabilities.

5. If the JCMT continues to operate after the expiration of the current agreement, the Board should consider whether additional new instrumentation should be planned for the JCMT in the post-2009 period. Options we have identified include: improving or replacing the telescope surface; a larger and more sensitive heterodyne array in the 850 micron window; a heterodyne array for the 450 micron window; and eSMA operations at 450 microns.

Short Term:

6. We recommend that the Board provide a clear and public statement of scientific priorities for the JCMT. These priorities will aid in the decision of where to focus

limited resources during the crush of commissioning three new instruments over the next 18 months.

7. The unique capabilities of SCUBA-2 mean that commissioning this instrument must have the highest priority once it is delivered to the JCMT.

8. The importance of the planned science archive for maximizing the scientific impact of the new instruments for the JCMT cannot be overemphasized. It is essential that this development be funded adequately so that the archive can be completed by the planned date of mid-2007. This should be the JCMT's second highest priority.

9. Maintaining the observatory's highly qualified staff is vital to ensure the smooth installation, commissioning, and support for fault-free performance of the observatory's sophisticated new instruments once routine operations begin.

10. We recommend that the Board consult with the community to determine both the level of demand for eSMA observations and the quality of the potential science projects. This consultation should be carried out in the early part of the 1 year pilot program of 850 micron observations with the eSMA, once the technical capabilities of the eSMA have been established.

11. The JCMT, the SMA, and the CSO should jointly consider establishing a single expert time allocating committee to judge all proposals for observing with the eSMA. This is likely to prove itself the most efficient and mutually beneficial way to allocate time on this unique resource.

12. We recommend that the Board consider delaying the decommissioning of Receiver W until the capabilities of the eSMA become clearer. Maintaining Receiver W in operation leaves open the possibility of a future upgrade of the eSMA to operate in the 450 micron window, which could be particularly interesting should ALMA's schedule be further delayed.

Appendix A

Terms of Reference for the Review Panel

The JCMT Board wishes to set up a Review Panel to review the JCMT on Hawaii in order to provide an international and independent perspective on its likely scientific programme and strategic direction beyond 2009, when the current TriPartite agreement expires. The Review Panel will make recommendations to the JCMT Board and through it to the Director JCMT and the funding agencies PPARC, NRC and NWO.

The JCMT is operated by the Joint Astronomy Centre (JAC), which also operates the United Kingdom Infrared Telescope (UKIRT) for the exclusive use of PPARC. It is intended that a parallel review of UKIRT will be convened on a similar time scale. The interdependence of present operations need not be a constraint on recommendations for future operations.

The Review Panel is asked to:

1 Consider the astronomical role of the JCMT in the era beyond 2009, with particular attention to its competitive international position in the context of other submillimetre facilities.

2 With respect to the above:
- 2.1 consider the current and potential future scientific productivity and international competitiveness of the JCMT;
- 2.2 consider options for development of the facility, including, e.g., its suite of instrumentation, its mode of operation, time allocation and level of user support.

3 Having undertaken 1 and 2 produce a written report to the JCMT Board, to include recommendations for the future, to guide the JCMT partners in their strategic planning.

The Review Panel shall comprise a chairman and up to four members of international astronomical distinction and experience, membership to be agreed by the JCMT Board, in consultation with the Panel chairman. PPARC will provide administrative support as required, but it will be expected that the Panel will be responsible for drafting its own report. The Panel's work should be planned so as to be able to report to the 13 October 2005 meeting of the JCMT Board.

Appendix B

Summary of Survey Responses from the Astronomical Community

(The full text of the surveys is available on request from Deborah Telfer, PPARC)

Survey of UK Astronomers

Summary of the Responses

This document provides a summary of the responses from the UK astronomy community to a questionnaire asking them for information on their past usage of the JCMT and their views of its future competitiveness and scientific productivity. Responses were received from 22 individuals or groups representing roughly 70 UK astronomers.

The 22 respondents and groups had undertaken a total of 142 observing runs on the telescope in the past 3 years, with a further 70 visits by their students. The results from these observations were reported in 189 refereed papers (published or in press).[1] Data obtained with the JCMT were used in 31 theses. Note: these numbers refer to the past 3 years, not the past 5 years as in the case of the Canadian questionnaire which follows below.

To summarise the comments provided by the respondents:

- The many observing trips undertaken by the respondents indicate a high-level of activity in observational submillimetre astronomy within the UK. Moreover, the high number of students using the JCMT and the frequent inclusion of data in their theses demonstrate that the telescope plays a central role in the training of postgraduate students at UK universities.
- The average publication rate of 2.9 papers per respondent per year is a striking indicator of the productivity of the JCMT. This reflects both the position of the JCMT as the pre-eminent world-wide facility for deep submillimetre continuum mapping and the scientific excitement around the observational results which are flowing from the telescope in a wide range of research areas.
- The vast majority of the respondents (> 95%) expect that the JCMT will remain a critical element in their research output for the foreseeable future. This is due entirely to the combination of the unique capabilities of the new instruments for the JCMT, SCUBA-2 and HARP-B, and the quality of the telescope and site.
- Much of the interest in the future use of the JCMT revolved around the science which would be obtained from the Legacy surveys. It is clear that with at most 2 years of operations of SCUBA-2 before 2009, most of the unique science which will flow from the Legacy surveys relies entirely upon continued operation of SCUBA-2 and HARP-B on the JCMT beyond 2009.
- There is also an overwhelming belief that the JCMT will remain scientifically competitive beyond the end of tri-partite agreement in 2009. In part this is driven by the considerable skepticism of the community about the probable commissioning dates for new, competing and complimentary facilities (e.g. ALMA and LMT), based

on their experience of delays common to many projects and the time taken for a facility to become truly productive. Concerns were also raised over the likely level of community access to the new facilities.

- Nonetheless, there is also a clear consensus that wide-field continuum and heterodyne mapping in the submillimetre on the scale and quality which the JCMT can provide will remain a scientifically productive area of research for a considerable time to come. This is especially true of areas related to planet, star and galaxy formation – all key scientific goals for the UK, Ca and NL communities.
- The community were particularly excited by the opportunities available for testing new receiver technologies on the JCMT and the science which could be obtained from deploying very large-format heterodyne arrays across all of the atmospheric windows available from Mauna Kea.

[1] This figure includes just the papers published using JCMT data by the 22 respondents. However, no attempt has been made to account for double-counting in these estimates.

Survey of Canadian Astronomers

The responses to this survey emphasize several elements: Even among non-users, 80% of respondents believed that the JCMT would continue to be competitive and 60% thought that, although they hadn't used the JCMT much in the past, it would become an integral part of their future research. Invariably, this latter result was due to their interest in the JCMT Legacy Surveys. If we include the JCMT users, these numbers swell to 95% and 90% respectively, indicating a tremendous level of support for continued use of the facility. Second, over the last five years, students have been sent to the JCMT a total of 55 times (an average of 2.6 student trips per supervisor). This suggests that the JCMT has been an extremely useful facility at which to train high quality personnel. The 122 published papers (or an average of 5.8 papers per respondent) also point to the JCMT's productivity. Note, however, that no attempt was made to adjust for the possibility that the same paper is being counted multiple times (some of the respondents have been co-authors on the same papers). Finally, while SCUBA has been, by far, the most popular instrument (71% of all respondents have used SCUBA), RxA and RxB combined have also been used by 71% of the respondents. The relatively low use of RxW likely reflects the fact that it has only recently been returned to productive service. A variety of other instrumentation (FTS, polarimeter, etc.) have also been used.

The community feels that with its quantum leap forward in technology, SCUBA-2 will be the premier sub-millimetre camera for some time. Given its speed & sensitivity, combined with a large aperture telescope at a good site, there will be nothing comparable for mapping large areas. In addition, HARP-B will make feasible the mapping of large regions in the 850 micron band. Experience with the HERA array at the IRAM 30m telescope has shown that even smaller regions/objects can profit from the increased efficiency of a multi-beam array.

Access to facilities by the Canadian community is also an issue of concern, as is the ability to perform large, community-driven surveys. Until the arrival of ALMA, the JCMT will be the only mm/submillimetre facility to which Canadians will have guaranteed access. It is felt that ALMA, once it is operational, will have to cater to the requirements of a very large, international user community, with the consequence that most of its time will be devoted to small, PI-driven projects. Large, JCMT-style surveys will not be possible. The SMA and CARMA, as interferometers, will similarly be limited to small areas and bright sources because of their small collecting areas.

Survey of the Dutch Astronomical Community

A survey was circulated to 24 Dutch astronomers. There were 13 responses, mostly from scientists who have extensively used the JCMT for their research. These have published 63 refereed papers using JCMT data in the last three years. In addition JCMT data was used in 13 theses. The data for these papers was obtained from 17 staff trips to JCMT and a further 35 student trips in these 3 years.

For the next few years the JCMT will continue to play a vital role for all Dutch users. Key instruments are the eSMA, HARP-B, and SCUBA-2 for dedicated studies, large surveys, and as complement to and preparation for Herschel/HIFI, ALMA, and LOFAR observations. A few years ago it was expected that with the arrival of ALMA and APEX, much of Dutch submillimetre research would shift from the JCMT to those two facilities. This is still true, but with the delay in ALMA early science operations, the opportunity for e-SMA, and the need for complementary northern data for Herschel and LOFAR, as well as key-involvement in a few JCMT legacy programmes, there are many good scientific and programmatic reasons to continue Dutch participation in the JCMT until 2011/2012 rather than 2009. However, a firm decision on Dutch participation requires a clear strategic plan for post-2009 operations from the JCMT Board which the Dutch community can assess against their goals and requirements.