PRECISION RADIAL VELOCITY SPECTROMETER

Document Title	Executive Summary
Document Number	PRVS-PLA-00005-0001
Issue	1.0
Date	21st September 2006

Document Prepared By:	David Lunney	**Signature and Date**	David Lunney 20TH September 2006
Document Approved By:	John Rayner	**Signature and Date**	John Rayner 20TH September 2006
Document Released By:	Ian Bryson	**Signature and Date**	Ian Bryson 21st September 2006

1. EXECUTIVE SUMMARY

Finding and characterising the range of conditions in which we find extra-solar planets is a rapidly expanding field that is not only fundamentally interesting for researchers but also engages intense public interest. There are very few areas of science that capture the public imagination more effectively. Research results in this young and dynamic sub-field of Astronomy & Astrophysics is frequently in the news and is regularly listed among the top 10 or 100 science discoveries of the year, decade or even millennium. Indeed extra-solar planet research is the nucleus for the new science of astrobiology with its unique mixture of astronomy, atmospheric sciences, biology, chemistry and geology. In the United States National Research Council's most recent decadal survey for astronomy, *Astronomy and Astrophysics in the New Millennium,* one of the highest priorities for future astronomical research should be to "study the formation of stars and their planetary systems, and the birth and evolution of giant and terrestrial planets." Extra-solar planetary research is now and will remain one of the leading intellectual endeavours as it addresses fundamental questions concerning the origins of our cosmic environment and the origins of life. The Precision Radial Velocity Spectrometer (PRVS) is key to answering the International Gemini Observatory's "Aspen" program question "How common are extra-solar planets, including Earth-like planets?". Of the over 200 extra-solar planets discovered to date using a variety of techniques, the vast majority have been discovered using Doppler shift studies measuring Precision Radial Velocities (PRV). PRVS will take this technique into a realm that is not accessible using the visible PRV techniques available on 8 to 10 meter telescopes today.

Our approach to the PRVS design is a balance between detailed modelling and experiment. The team has explored in depth the fundamental principles that limit PRV in the near infrared. We have constructed realistic models simulating likely candidates and demonstrated the ability to recover exoplanetary RV signals. We have conducted limited experiments with a brass-board instrument to explore real-world issues. In summary, we find that our design of a fibre fed, white pupil echelle spectrograph working in the Y, J & H bands with simultaneous arc-line calibration will achieve an instrumental radial velocity error of 0.5 m/s. The precision and long term stability of PRVS will allow the detection of Earth-mass planets in the habitable zone around M-stars. The overall design is similar in many respects to the very successful optical PRV instrument HARPS, whose team provided valuable input to the Study.

We have modelled the radial velocity information in low-mass star spectra and checked our ability to recover this signal in the face of telluric contamination. Including instrumental error, telluric contamination and photon noise, PRVS will achieve a total RV error of <1.7m/s on a typical M6V star at 10pc. We use these results as an input to a simulated 5-year survey of nearby M stars. Based on a conservative scaling of optical results, such a survey will detect several terrestrial mass planets in the habitable zone around nearby stars. Furthermore PRVS will test theoretical planet formation models, which predict an over-abundance of Terrestrial-mass planets around low-mass stars.

Even without the exoplanetary science, the proposed resolution, throughput and wavelength coverage will make this a landmark instrument, enabling a wide range of cutting-edge astronomy. For example the fast acquisition, "always on" feature of PRVS will allow it to take high-resolution NIR spectra of GRBs over a range of redshifts, from $7 < z < 12$. From this we can map out the ionization history of the universe in full.

The comprehensive analysis and modelling of the Science Team, allied to experimental data, spectroscopy experience and engineering analyses have confirmed the basic instrument performance as expected below:-

Parameter	**Predicted**
Radial Velocity Error (instrumental)	0.5 m/s (primarily from opto-mechanical stability, centring and guiding and spectral response function error)
Sensitivity	Y=12.00, J=11.44, H=10.91, S/N =300 in 3600 s
Observational Efficiency	80% in 3600 s (based on integral acquisition system)
Spectral Resolving Power	70,000
Sampling	2.5 pixel
Simultaneous wavelength Coverage	90% of Y+J+H bands (not including telluric mask)
Instrument SRF stability	Drift: < 0.01pixel (±0.05K) Skewness: ± 0.001 (±0.05K)
Throughput	10%
Field of View	1.4″
Instrument Background	< 0.1 e/s (if no persistence)
Acquisition and guiding	< 0.1″
Guiding sensitivity	Z>14.8 for S/N=50 in 1 s
Image quality at fibre	50%EED = 1 pixel
Image quality at detector	50%EED=0.5 pixel
Array Cosmetic Quality	<1%

The Proposed Consortium of the UK Astronomy Technology Centre, University of Hertfordshire Centre for Astrophysics Research, the Department of Astronomy & Astrophysics at Pennsylvania State University and the Institute for Astronomy at the University of Hawaii, together with a dedicated group of Scientists, have all the experience, ingenuity and infrastructure needed for a successful Project. The UK ATC has a world leading reputation for the delivery of facility class instrumentation and especially in managing consortia through the application of appropriate Project Management, Systems Engineering and engineering quality. The teams in Pennsylvania, Hawaii and Hertfordshire bring equally impressive records in fibre systems, instrumentation and relevant science. The instrument can be completed in under three years at a Contract price of $9,541,205.