THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

ANNUAL REPORT COVER SHEET

for

UNITS, CENTRES & INSTITUTES

Name of Unit, Centre or Institute: The Light Metals Research Centre

Name of Director/s:

Mark Taylor, Director, Honorary Professor, Chemical and Materials Engineering
Margaret Hyland, Associate Director, Associate Professor, Chemical and Materials Engineering
Jim Metson, Associate Director, Professor, Head of Department, Chemistry

Attach: **Annual Report for 2009**
Financial Statement for 2009

Signed by: **Director……Date ……**

Dean…… Date ……

Send to: **The Manager - Research Office**

Management Committee

Professor Mark Taylor, UniServices (Chair)
Associate Professor Margaret Hyland, Chemical and Materials Engineering
Professor John Chen, Chemical and Materials Engineering
Professor Jim Metson, HOD, Department of Chemistry
Mr Gary Putt, Senior Business Manager, UniServices

Dates of the Board and Management Committee meeting
Quarterly

Light Metals Research Centre – Participating Members

Department of Chemistry
Professor Jim Metson

Chemical and Materials Engineering
Professor JJJ Chen
Professor Wei Gao
Associate Professor Brent Young
Professor Mohammed Farid
Associate Professor Margaret Hyland
Dr Mark Jones
Dr Mike Hodgson
Dr Bryony James
Dr. Chris Seal

Department of Mathematics
Professor James Sneyd
Dr Steve Taylor

Department of Information Science
Dr Mark Titchener
Dr Ullrich Speidel

Department of Operations Management
Associate Professor Tiru Arthanari

Department of Psychology
Dr Michael Hautus

Department of Mechanical Engineering
Associate Professor Xun Xu
Dr Mark Battley

Department of Electrical Engineering
Dr Dariusz Kacprzak
Dr Sing Kiong Nguang

Department of Engineering Science
Professor David Ryan
Professor Mike O'Sullivan

Tamaki Campus
Professor Ralph Cooney

University of New South Wales
Professor Maria Skyllas-Kazacos

Auckland University of Technology
Professor Thomas Neitzert, Engineering
Professor Darius Singh, CAMTEC
Associate Professor Zhan Chen, Engineering

University of Waikato
Professor Alfred Sneyd, Mathematics

University of Pretoria
Professor Phillip Crouse

Shanghai Jiao Tong University
Professor Qudong Wang

Beihang University
Professor Xinqing Zhao

Introduction

The Light Metals Research Centre is a centre managed by Auckland UniServices and hosted by the Faculty of Science. The Science and Engineering Faculties have both been contributing strongly to the Centre's activities, by participating in an increasing number of research projects.

Summary of Centre Activities

From the last quarter of 2008, through 2009, the Centre's core business suffered from the effects of the global financial meltdown. Many of our key clients were unable to commit resources to R&D, and put business expansion plans on hold. As a result, a significant number of potential contracts were suspended. In light of such drawbacks, the Centre experienced negative growth for the first time since 2004. Nevertheless, considerable effort was expended in making sure committed projects be delivered to a high standard. Focus was re-adjusted onto staff training and building scientific capability whilst maintaining close relationships with clients in preparation for a return to an improved business climate. As well, a major new R&D initiative, funded by the New Zealand government and presented as the Materials Accelerator, was successfully proposed, approved and undertaken. The Centre currently comprises 42 staff members, post graduate researchers, and 6 contracted project students. Through the efforts of staff, students and participating academic colleagues within the University Departments, the Centre has managed to deliver slightly over 4 million in revenue during a difficult year (a 6% drop relative to our best result in 2008). Consolidating past years of business effort, the Centre has accumulated a surplus of $1.25 million as of the end of 2009.

Highlights of the Centre's educational contributions in 2009 were:

- A number of the Centre's researchers presented keynote addresses at The Minerals, Metals and Materials Society Annual Meeting in San Francisco, USA in February, 2009. Several

conference papers and proceedings were published by the Centre's researchers and presented at the conference. This meeting is considered to be the most recognised worldwide international forum in the field of light metals and materials processing.

- In addition to the TMS conference proceedings, publications were also accepted by professional journals and international conferences. These include Applied Surface Science, Journal of Metals, Applied Physics Letters, Journal of the Ceramic Society of Japan, Key Engineering Materials, International Symposium on Sialons and Non-Oxides, The 8th World Congress of Chemical Engineering (WCCE8), The 7th IEEE International Conference on Control & Automation (ICCA'09, PMP Conf 2009, Auckland AIP Conference), The 17th International Conference on Secondary Ion Mass Spectroscopy in Toronto, Canada and the International Aluminium Conference in Teheran, Iran in April.

Key Research and Development activities conducted by the Centre are summarised below:

A number of technologies have undergone continuing refinements in 2009. These include sidewall heat exchangers, a new potroom/smelter supervisory control system, and new methods for lower cost production for magnesium and titanium materials. Further research and technical support contracts are promising.

Upstream Activities:

- Patents at the National Face Application stage for heat exchangers is pending in Aus, USA, EU, UAE, NZ, and the Process Control is pending for Aus, US.

- A full scale demonstration facility for heat exchangers continues to operate at the Centre's pilot plant in Birkenhead. Single pot trials have been conducted on different cell technologies and a multi-pot trial is currently underway. The principal goals are to increase production yields from existing cells, and ultimately to recover energy.

- The Centre has been developing modelling capabilities that will control and optimise the decision-making process in the aluminium supply chain, i.e. from the reduction line and casting in a smelter, to eventual end use on the factory floor. These capabilities are building towards a new method of smelting control which aims to be the world's best practice.

- Fundamental research on alumina structure with German and Australian clients continued in 2009. Further research work is to be extended in 2010 and likely beyond.

- The Centre has also conducted a series of customised smelting training and education programmes for managerial level and plant operators in the Middle-Eastern region. The feedback on these programmes was very positive and is to be pursued. Multi-level reduction training programmes and a Post Graduate Certificate course in Reduction Technology will be held in Bahrain later this year. This is one of our primary strategic focuses for 2010.

- Collaboration in a cluster of projects with CRSIO, Australia, commenced in 2009. The Centre was contracted for studies of new materials and methods for non consumable anodes and sidewall materials. As well, we are to study cell bubble formation and process control. The Centre aims to capitalise on research derived from these projects by seeking further funding and support from potential government bodies and industry partners.

- Two project teams consisting of 6 senior researchers and engineers have been assigned to undertake technology development projects in China, namely Shenyang Aluminium &

Magnesium Engineering & Research Institute (SAMI) in the North, and Zhongfu Smelter in Southern China. The project with Zhongfu presents a significant landmark to put the University on the global green energy map. This project is part of the Asia-Pacific Partnership (APP) initiative. Through this initiative, APP contracted the Centre to assist the Institute for Governance of Sustainable Development (IGSD); the collaborators-US Environmental Protection Agency (EPA), and the Chinese Nonferrous Industry Association (CNIA) to improve the smelting impact on the environment. The purpose is to assist Chinese smelters to eliminate perfluorocarbons (PFCs) emissions (which have an estimated global warming potential of 6,500 to 9,200 times that of carbon dioxide.), and to accelerate the development and deployment of clean energy technologies in line with the efforts of the UNFCCC and Kyoto Protocol.

Downstream Activities:

- In 2009, The Centre became a key part of "The Materials Accelerator" (TRST) initiative, joining together with six other institutes to assist and accelerate the growth of key New Zealand industries. The goal is to determine viable combinations of new materials; enable rapid virtual prototyping products and designs to be implemented locally; and to manufacture these enhanced high value products to the international market.

- In addition, light metals material processes and manufacturing transformation have been completed under the Foundation for Research Science & Technology (FRST) 2004-2008 grant. Thereafter, an extension of the 2-year transition funding was carried over to focus more on the defined areas, i.e. new Magnesium (Mg) and Titanium (Ti) based materials processing and product technologies. In combination with Technology New Zealand TIF expert and industry co-funding partnership, the Centre was able to emphasize Ti and Mg research work. At the Centre level, while focusing on Mg and Ti development, the end game is to tie in with the broader "Material Accelerator" initiative for more advance multi-material solutions which will lead to high value niche products for New Zealand industry. The progressive objective ensuing from the material/product development is to facilitate a coalescence of the industry associations (MINZ), companies and research providers to form a metal consortium; and to work towards a long term economy growth strategy in New Zealand.

The Centre's Staff

The Centre continues to place emphasis on New Zealand research and development endeavours. A post doctoral researcher and a masters engineer in titanium development, two magnesium specialists from China, and three senior project engineers from the Chemical and Material Engineering Department and from Australia were recruited to manage the "Material and Manufacturing" related projects. This is part of the Centre's commitment to assist and enhance the New Zealand downstream portfolio. Despite the scarcity of funding sources for NZ based manufacturing, the materials and manufacturing developments are still an important and integral part of the Centre's long term strategy.

Based on experience with the very heavy project load in the 3rd quarter of 2008 and the need for increased support for international client project work, the employment of a Chief Engineer (Deputy Director) from Canada with extensive industry experience and a strong network background was justified; prior to the credit crunch of Oct. 2008. The investment in human resources by bringing in international expertise and training/ developing local talent is imperative in building the capabilities of the Centre.

2009 Light Metals Research Centre staff list shown below:

Professor Mark Taylor, Director	Associate Professor Margaret Hyland, Associate Director
Professor Jim Metson, Associate Director	Michel Gilbert, Deputy Director
David Cotton, Manager - Technical and Laboratory	Pascal Lavoie, Manager – International Projects
Marcus Gustafsson, Manager - Computation and Control	Michael Hodgson, Manager, Manufacturing Materials
Jenny Lee Roper – Office Manager	Florence Pau Ching Taylor – Personal Assistant
Dr. Jimmy Bester, Project Manager - NZ Manufacturing	Dr. Mark Dorreen, Project Manager - Research
Dr. Eng Fui Siew, Project Manager - Research	Pretesh Patel, Project Manager - Research
Dr. Chris Seal – Research Scientist	Dr. Stuart Mitchell, Project Manager - Research
Dr. Sankar Namboothiri, Project Manager - Research	Dr. Zhang Wei, Project Manager - Research
Dr. Rainer Grupp, Project Manager - Researcher	Dr. Jianning Tang, Research Engineer
Dr. Ronny Etzion - SiC Sidewall Refractory	Dr. Balan Zhu – Research Engineer
Tatyana Groutso, Research Scientist	Nic Pennington, Project Manager – Australia
Francis Chung Wen Goh, Researcher Engineering	Nursiani Tjahyono, Research Engineer
Hasini Wijayaratne, Research Engineer	Susann Beier, Research Engineer
Jenny Hao-Hsin Hung, Research Engineer	Malcolm Hall, Technician
Tina Su, Research Engineer	
Doctoral Researchers:	
Chuong Luu Nguyen - Surface Properties & Finishing	Nazatul Aini Binti Abd Majid - Modeling
Haiam Abbas - Heat Transfer Simulation in Cells	Nicholas Depree - Annealing Furnace Modeling
Linus Perander - Characterisation of SGA	Yashuang Gao, Supervisory Control System
David Wong, Potroom Dust	Maryam Al Jallaf Mohamed – Potroom
Marco Stam – Process Control	QinSong Zhang – Modeling
Mark Cooksey – Inert Anode	
Project Students:	
Ashleigh Barber	Mattew Proctor
Mike Snow-Hansen	Samantha Rodriguez
Claire Chen	Tim Harton
Douglas Glen Mason	

The Centre's Publication List in 2009:

Journal Articles, Refereed

1. Nguyen C L, Armand A, Zhang W, Prince K E, Hyland M M, Metson, J B. "Phase-oriented surface segregation in an aluminium casting alloy". *Applied Surface Science* 255 [9] 4880-4885 (2009)
2. Perander, L.M., Z.D. Zujovic, T.F. Kemp, M.E. Smith, and J.B. Metson. "The Nature and Impacts of Fines in SGA". *Journal of Metals* 67 (11), P22-29, November 2009.

3. Zou, C., Yan, X.D., Han, J., Chen, R.Q., Gao, W., Metson, J.B. "Study of a Nitrogen-doped ZnO film with Synchrotron radiation", *Applied Physics Letters, 94, (17),* p171903/1-171903/3, 2009
4. Masuda, Y., Mashima, R., Yamada, M., Ikeuchi, K., Murai, K., Waterhouse, G.I.N., Metson, J.B., Moriga, T. "Relationship between anion and cation nonstoichiometries and valence state of titanium in perovskite type oxynitrides LaTiO2N", *Journal of the Ceramic Society of Japan, 117,* p76-81, 2009.
5. Mark I. Jones, Ron Etzion, Jim Metson, You Zhou, Hideki Hyuga, Yu-ichi Yoshizawa, and kiyoshi Hirao, "Reaction boded silicon nitride-silicon carbide and SiAlON-silicon carbide refractories for aluminium smelting", *Key Engineering Materials* Vol 403 (2009) pp 235-238.

Refereed Conference Proceedings

1. Nguyen C, Perander L, Hyland M, Metson, J. "TOF-SIMS Studies of Intercalated Gibbsite and Bayerite". *17th International Conference on Secondary Ion Mass Spectroscopy*, 14-18 September 2009, Toronto, Canada (2009)
2. Perander, L. and J. Metson. "Alumina Fines and their impacts on Smelter Operations". *Iran International Aluminium Conference*. 22-23 April 2009. Teheran, Iran.
3. D.Eisma and P. Patel, "Challenges in Power Modulation", *TMS 2009, Light Metals*: pp 327-332
4. Zou, C., Yan, X.D.N., Han, J., Chen, R., Gao, W., Metson, J.B., Cowie, B., Thomsen, L., Tadich, A. "Electronic states studies of ZnO/TiO2 core-shell nanowires by photoelectron spectroscopy and X-ray absorption near edge spectroscopy", *AIP Conference Proc*, Accepted, *2009*, p.-
5. Tania Groutso, Mark Taylor, A.K. Huston. "Aspects of Crust Formation from Today's Anode Cover Material". *TMS 2009*, San Francisco, CA, USA 15-19 February.
6. Namboothiri, S., Lavoie, P., Cotton, D. and Taylor, M.P. "Controlled cooling of aluminium smelting cell sidewalls using heat exchangers supplied with air", *TMS 2009*, San Francisco, CA, USA 15-19 February
7. Abd Majid, N. A., Young, B., Taylor, M. P., & Chen, J. J. J. (2009b) "Principal component analysis (PCA) application for early detection of faults in aluminium processing". *The 8th World Congress of Chemical Engineering (WCCE8)*, August 23 - August 27, Montreal, Canada.
8. Abd Majid, N. A., Young, B., Taylor, M. P., & Chen, J. J. J. (2009c) "Real-time system for monitoring aluminium reduction cells by using MPCA and dynamic Euclidean distances". *The 7th IEEE International Conference on Control & Automation (ICCA'09)*, December 9-December 11, Christchurch, New Zealand.
9. Abd Majid, N. A., Young, B., Taylor, M. P., & Chen, J. J. J. (2009a) "Detecting abnormalities in aluminium reduction cells based on process events using multi-way principal component analysis (MPCA)". *Light Metals 2009, TMS (The Minerals, Metals and Materials Society)*, 589-593.
10. Stam, Marco A., Taylor, Mark P.;, Chen, John J. J., Mulder, Albert; Rodrigo, Renuka. "Development of a multivariate process control strategy for aluminium reduction cells." *Light Metals (Warrendale, PA, United States) 2009,* 311-315.
11. Abbas,H., Taylor, M.P., Farid, M., Chen,J.J.J.,(2009) "The impact of cell ventilation on the top heat losses and fugitive emissions in an aluminium smelting cell". *Light Metals 2009, TMS.*
12. C.K. Seal, M.A. Hodgson & K. Vince "Biodegradable surgical implants based on magnesium alloys - A review of current research", *PMP Conf 2009, Auckland, IOP Conference Series: Materials Science and Engineering (MSE)*, 012011,Vol 4, 2009.
13. C W Chung, R G Ding, Y L Chiu, M.A. Hodgson, W Gao "Microstructure and mechanical properties of an as-cast AZ91 magnesium alloy processed by equal

channel angular pressing", *PMP Conf 2009, Auckland, IOP Conference Series: Materials Science and Engineering (MSE)* 012012, Vol 4, 2009

14. S. Mitchell, "An Introduction to pulp for Python Programmers" *The Python Papers Monograph* Vol 1 2009 (ISSN 1837-7092) *First Kiwi PyCon* (New Zealand) November 7 - 8, 2009, Christchurch, New Zealand.

Technical Reports

60 confidential technical and research reports for various clients have been submitted to companies including Outotec, Kappa, Asia-Pacific Partnership, AMIRA, SAMI, Alcoa, Noranda, Sika, ,NZAS, Dubal, SEC, Trimet and FRST etc.

Financial

Centre Costs

Light Metals is primarily a Uniservices activity centre. The Centre's research profile is tailored for practical on-site experimentation and technology development with global industry partners. These projects enhance the Centre's global reputation as well as the practical experience of its staff. During the past few years, the Centre has experienced rapid growth and constant resource constraints. Towards to the end of 2008, prior to the financial crisis, the Centre's scale of operations reached a peak, and staff was swamped with work. To uphold the operation, new recruits were deemed necessary to ensure project delivery on time and to high quality. However, the unforeseen recession severely hampered international project activity, and affected our financial position. As a result, compared to 2008, staff salary in relation to total costs has grown by 15%, while billings have decreased by 6% thereby causing a deficit for the first time since 2004. While staff salary grew exponentially, total other costs decreased 26%. In particular, travel expenses, equipment and tuition were much lower than in 2008 indicative of cautious management of variable costs. Given that human resources is the most important asset in an R&D organisation, the Centre continues with its present workforce as a long term investment while putting strong focus on developing research projects to sustain future growth.

Centre Revenue

Revenue was below forecast for the reasons given earlier. Considering the economic climate in 2009, billing contraction was apprehended. Billings consisted of several small and medium size projects in the range of NZ$100,000-300,000. Two potential half million proposals were suspended due to business uncertainty and clients' budgeting constraints. The Centre will continue explore these prospective projects, and develop new research contracts in 2010.

Conclusion

Business:

Downstream business doubled from $760,000 in 2008 to $1.6 million in 2009, which accounted for 40% of the Centre's total billings. The growth is mainly from several successful grant applications from FRST. Such grants are the backbone of the New Zealand R&D ecosystem, which enables service providers such as "The University" to assist those small and medium-sized companies. The Centre is working hand-in-hand with local industries (including the Plastics Centre of Excellence, Hybrid Plastics, and Advanced Composites) to further develop the multi-material product prototyping capability needed in NZ to compete globally. "The Materials Accelerator" (TRST)

initiative was initiated in 2009, and the Centre, as a key part of the group, is prominently engaging in the development work. In short, developing New Zealand materials and manufacturing sectors, establish network and collaborations within the sectors continues to be an important strategic endeavour of the Centre.

Despite international project billings dropping 16% in 2009 compared to 2008; efforts in securing international projects throughout the past 6 years have accumulated a consolidated surplus. This surplus serves as a buffer against the slump in 2009, and also provides UniServices with the ability to re-invest, over the long term, in fundamental research and development for the community.

Finance:

In 2009, despite the deficit, contributions made to the University were over $640,000 which does not include an additional $419,256 as consultant's fee paid out of Light Metals, on behalf of the University, to AUT. In addition, roughly $275,000 was contributed to UniServices costs.

The Centre's contracts and finances were both well managed by UniServices in 2009, with the information provided to the Director and management team being timely, and detailed enough to keep all contracts and overall Centre revenue and margins on track. This continues to be an essential requirement for successful operation. With the new Technology One financial system to be launched in April, 2010, expectations of being provided with more advanced and timely project management and financial information are anticipated.

2010 Plan

2010 will still be a challenging year given the slow pace of recovery facing New Zealand and the rest of the world. Research and development work does not normally become a company initiative until the signs of economy recovery are stronger than at present. However, we have identified the potential for Industry training and University-accredited educational short courses to smelter operations in Middle-Eastern Region. As well, the promotion, packaging and delivery of our expertise and knowledge in the smelter environmental field will be another strategic initiative for this year. We will also continue to focus on developing new technologies, and strengthening our research capabilities through training and education, in preparation for the challenges ahead; as well as capturing present and future commercial opportunities. The following areas will continue be the focus of our R&D activities:

1. Cell Sidewall Heat Exchangers, options and heat recovery technologies
2. Advanced Process Control and Improvement System
3. Alumina Dissolution Constraints & Control
4. Multi-material product prototyping capability development in NZ
5. Magnesium and titanium – based materials for advanced manufacturing in NZ

The first three technologies are targeted at major smelters around the world, and the 4^{th}-5^{th} are for assisting New Zealand downstream manufacturing. Depending on the pace of the global industry recovery, we will pursue the search for opportunities involving R&D initiatives and partnerships in the following fields:

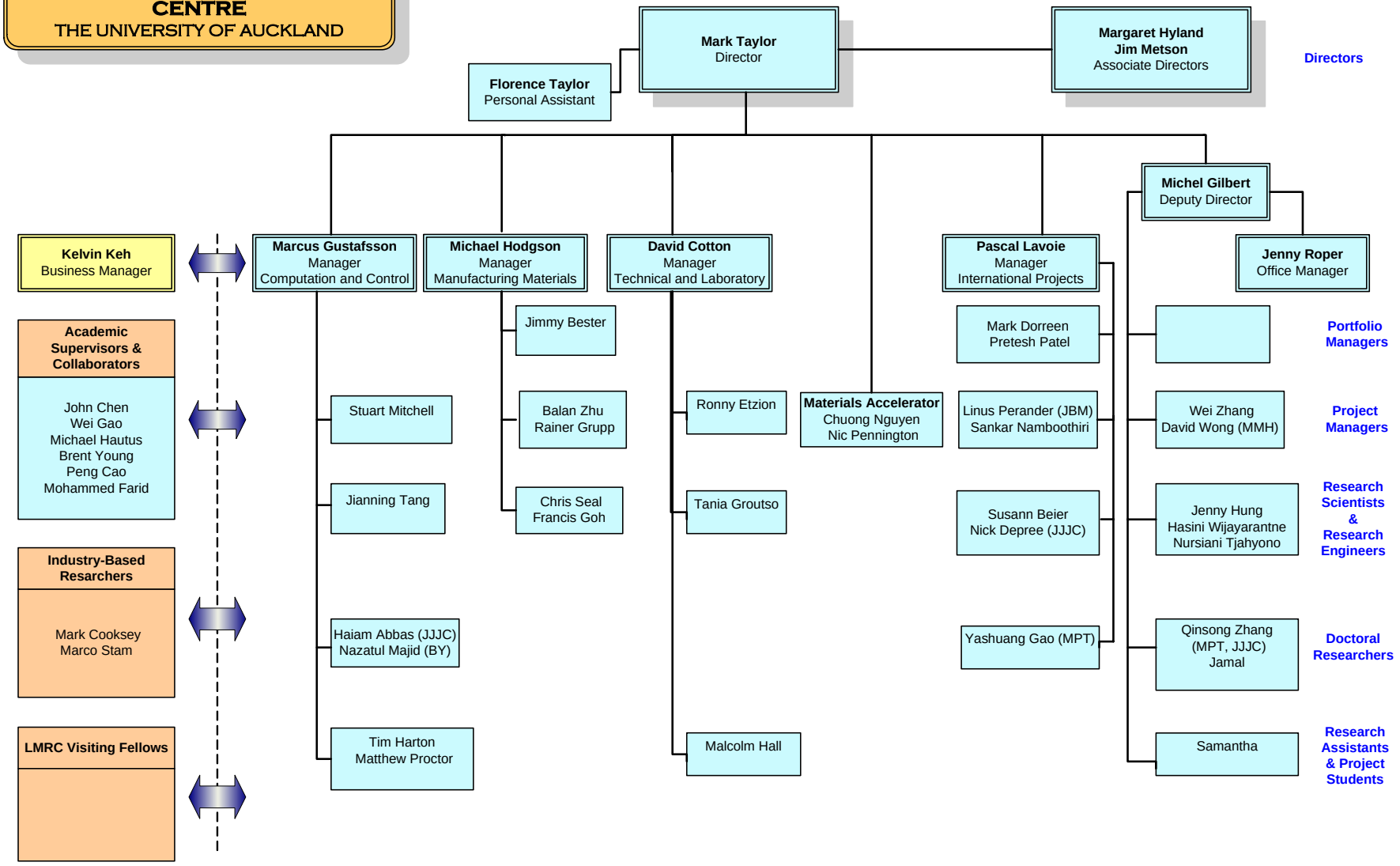
6. Designs for Heat Recovery Technology for Reduction Cells
7. Alumina Capability Building
8. Smelter Ventilation Modelling
9. Next Generation Scrubbing Technology

Whereas the recovery in both international and New Zealand project research in 2010 is expected to be slow, we will continue to carry on our efforts in the following areas:

1. Maintain a high level of delivery performance for existing research contracts
2. Pursue international collaboration with CSIRO, Hydro, Regal and some key industry associations; as well as off-shore co-funding bodies, such as US-EPA and the Chinese Government in environmental Green projects.
3. Collaborate with the New Zealand industry in developing high value added products for export.
4. Inter-departmental networking to assist in commercialising technology in areas such as multi-materials joint research, advanced process control in oil and gas industry in Malaysia.
5. Continue on-site training for staff to gain practical experience. Develop research skills and knowledge in commercial applications.
6. Launch off-shore industry training and education programmes such as ME, Post Graduate Certificate, and further capitalise on the relationship to penetrate larger R&D and technology support opportunities in various regions. (Such as Middle East, China, Malaysia etc.)
7. Market and promote developed technologies to multinational clients where opportunities exist.

Two postgraduate students have completed their PhD's in 2009 and are being offered senior roles as engineers and scientists in the Centre, with a further five expected to finish in 2010. In addition, one PhD and two Master students are expected to enrol in 2010 for project-related studies. The Centre's management structure is now set to provide more devolved leadership of people and management of the large number of projects. This structure is to ensure that adequate attention and supervision continue to be devoted to staff and to postgraduate researchers. The Centre's organisational structure for 2010 is shown below.

LIGHT METALS RESEARCH CENTRE
THE UNIVERSITY OF AUCKLAND



( ) Academic Supervisor or Principal Investigator – Needs consultation by Manager to assign tasks and for development of career path.

Last updated 08/1/10