MEASUREMENT SYSTEMS

Cameron Measurement Systems

TransCanada Proposal

RAISING PERFORMANCE TOGETHER

TransCanada's Request for Information

Submission: Cameron Measurement Systems

March 16, 2011

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March 16, 2011

TransCanada PipeLines Limited
450 First Street S.W.
Calgary, Alberta.
T2P 5H1

Attention: Jay Lake

Dear Jay,

It is a pleasure to respond to TransCanada's Request for Information number 8798 for Flow Computer Architecture Selection.

Cameron and TransCanada have over many years and commodities engaged each other in a key customer and vendor relationship. It is a relationship that is symbolized by the three words that can be observed throughout Cameron marketing literature; "Raising Performance Together™". Regardless which of Cameron's three divisions that display these words; Compression & Process, Valves & Measurement, or Drilling & Production the meaning is the same; that by working closely with our customers and by meeting the challenges they entrust us to solve, we will raise the performance of both our companies.

Over twenty years ago Cameron modified an emerging electronic flow measurement technique to meet TransCanada's new business model. Today that solution remains durable and effective although the process of determining a successor has commenced via this RFI.

Raising Performance Together is the essence of this response. Today Cameron is providing a view of our future EFM product plans and as occurred 20 years previous Cameron is offering TransCanada the opportunity to direct Cameron to complete the product in a form that best meets their business needs and objectives. This customer focused product development strategy is effective because not all of our customers have the same business objectives and operating practices hence a universal industry solution is rarely an optimal solution.

In closing we look forward to discussing further the vision within this response.

Yours truly,
CAMERON

Pat Holley
President, Measurement Systems

FOREWORD

This proposal is in response to TransCanada RFI 8798.

THE INFORMATION CONTAINED IN THIS RESPONSE IS PRIVILEGED AND CONFIDENTIAL.

The sections have been organized in the following manner:

- Section 1 is the response to questions in the TransCanada RFI letter
- Section 2 is the response to TransCanada's Appendix 1
- Sections 3 through 6 consists of product information for the Scanner 1100, 2000, 2200 and 3000
- Sections 3.1, 3.2, 4.1, and 6.1 contain the EXCEL spreadsheet responses from Appendix 2 of the RFI
- Section 7 consists of details of the supporting products
- Section 8 consists of ISO documents

If there are any questions regarding this proposal, please contact:

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Phone 403-291-6272

SECTION 1. REQUEST FOR INFORMATION - VENDOR RESPONSE

1. 1 EXECUTIVE SUMMARY - SOLUTIONS

The following outlines how Cameron typically provides the solutions TransCanada has requested.

TransCanada has on three occasions experienced Cameron's Measurement Systems Division project deployment process.

In 2009/2010, Cameron supplied Ultrasonic flowmeters for the Keystone project. This successful project initially featured the delivery of 39, 20-inch Leading Edge Flow Measurement (LEFM) meters. The delivery of these meters has similarities to the flow computers detailed in this response. Those similarities show that the technological techniques were defined and established at the time of order award; however, the meters had not been previously manufactured in this size and style combination. This meant that a significant amount of both development and production work had to be achieved.

In the case of the LEFM meters, TransCanada had no existing meters installed that could be used should the meters not be delivered when required. Cameron met the expectations of TransCanada in the delivery of meters.

Cameron met the order objectives by directing both internal and contractor resources to the project. By application of Cameron's considerable financial resources and well-developed process-driven administrative tools, they ensure world-class solutions are delivered as promised.

Similarly in 1985, ITT Barton, who Cameron ultimately acquired, had developed a third generation EFM product. At the conclusion of an open market evaluation, Nova, who TransCanada ultimately acquired, selected Cameron as their preferred vendor to develop an EFM solution for their application. Within 18 months, Cameron redesigned virtually every aspect of the hardware which included:

- Selection of a new micro-processor
- Development of a low power scheme
- Development of a completely new electronics layout component selection
- A new chassis and enclosure system

In this instance, it is very relevant to consider ITT Barton's work as relevant to Cameron. Not only is Cameron's financial and administrative strength similar to ITT's at that time but Cameron continues to have on staff two of the staff members that were active in that development project: Chris Braid and Andy Seeger. Andy Seeger acted as Project Development Manager and will have a prominent customer interface role again in this next project. In addition to direct employees, Cameron has continuously and exclusively engaged Harding Instruments as the circuitry developer and manufacturer of the Scanner 1100 series. Known for their robust and durable designs and effective manufacturing, they will continue to provide development and manufacturing services for the Scanner 3000. Harding Instruments has also continuously retained the key staff members who were involved in the Scanner 1100: Al Williams, firmware and protocol developer; and Joe Wheeler, hardware developer. They are supported by 45 colleagues. These key contributors are in addition to other contractors who developed the Scanner 2000 and who are presently active in the development of the Scanner 3000 flow module.

The third instance occurred in 1998 with the Y2K upgrade of the Scanner user interface into a Windows PC application. Originally the user interface was imbedded in the hardware/firmware and was accessed with a DOS terminal emulator application. Recognizing the power of a Window-based application Cameron presented an evolutionary vision to TransCanada who identified that operational improvements could be found by extracting the user interface for the EFM/ RTU and transferring it to a Windows program. Doing so allowed "Wizards" to be developed to guide technicians through common processes. Over the span of 12 months Cameron developed, tested and, trained TransCanada technicians in the use and deployment upgrades.

Although it is no longer advantageous to have a PC-resident interface, this project was an example of one of several upgrades that were made to the original product form and function.

Cameron's global goal and quality objective is, "To be our customer's preferred vendor", therefore, when Cameron defines a desired business case and then prepares a commercial offer to a client it is done with the firm intent to deliver on that commitment, as defined and on-time. Complex projects such as the product defined in this Cameron information response have been based on detailed technical analysis, development plans and financial assessments. To be our customer's preferred supplier, we must share a clear understanding with our customer on the requirement for a successful project. That understanding has been continually reviewed and adjusted though Cameron's on-going EFM supply, together with the discussions preceding the RFI invitation. Definition fine tuning will advance through the communication that occurs as TransCanada evaluates Cameron's RFI response up to the point Cameron is invited to develop a commercial offer.

Given a suitable purchase commitment Cameron would direct all the resources required to meet the commitments that have been defined.

The corporation is a sum of human resource, processes and procedures, and it is people that are responsible for ensuring that the customer's expectations are met. Within other sections of this submission the details of those personalities are presented.

1.2 EXECUTIVE SUMMARY – INDUSTRY, MARKET AND TECHNOLOGICAL TRENDS

The following outlines industry, market and technological trends that will impact or influence this commodity over the next three to five years.

INDUSTRY AND MARKET

The types and characteristic of fluids being measured are becoming more diverse. These changes result in a greater range of computations together with additional quantities and types of sensors required for a measurement solution. With this diversity the ability to have a universal measurement site deployment becomes impractical in any but a narrowly focused business. An enterprise-wide solution requires that the EFM device be configurable but the device must have thoughtful and practical tools to make the multiple configurations easier to understand and maintain.

The growth of diversity is witnessed by the following observations:

A. Growth in liquid hydrocarbons transport

i. Continued growth of Crude Oil volumes

Synthetic crude oil volumes will continue to rise from Canada. All types of heavy oil volumes will increase globally. These oils are being derived from a greater range of formations and extraction techniques. Increasingly, they are engineered fluids that will require additional analytical devices for the determination of viscosity, Reid vapour pressure and similar attributes in order to equate their true commercial value. Related to this is, many of the fluids are more challenging to transport and measure in terms of pumping cost, equipment degradation and flow meter performance so these additional measurement determinations will assist to derive the true transport toll cost and fluid volumes. Flow computers will have to react to these changes to make additional computations.

ii. Growth of refined fuel products

Increasing value added processing will occur regionally thereby requiring the transport of refined or upgraded liquids over further distances. EFM devices for these devices are typically required to have features to adjust to the unique operational requirements of multi-product fluids and for the batching operation of the pipeline. Products like the Caldon Ultrasonic interface detector are intended for this purpose.

iii. Export of LNG

LNG production and export from North America is predicted to rise. This is anticipated to result in an increase in the deployment of Ultrasonic Liquid Flow Meters which are particularly effective at their ability to measure very low viscosity fluids. Cameron will tightly integrate the Scanner 3000 to their Caldon LEFM meters to enhance the determination of measurement integrity in applications such as these.

iv. Natural gas liquids production

In the upstream production sector, valuable natural gas hydrocarbon liquids production will continue to come from frontier production areas in Canada. Despite relatively low volumes, regulatory and royalty assessment requirements are specifying comprehensive pressure and temperature correction techniques. This is driving higher caliber measurement devices further upstream.

B Resurgence in the Canadian gas industry

The USA has enjoyed substantial growth in proven and deliverable natural gas volumes. This supply surge, that depressed North American prices, will subside which will increase the attractiveness of Canadian frontier natural gas sources.

Many new sources of natural gas are co-produced with water and other liquids and producers are increasingly motivated to avoid traditional separator devices for the purposes of determining the gas and liquid constituents. The solution to this challenge is to deploy multiphase measurement devices and techniques. These methods are in development by Cameron and require additional input sensors and computations.

C. Carbon dioxide transport and measure

Transport of carbon dioxide, usually in dense phase, is expected to be more frequent for carbon capture and sequestration purposes as well for enhanced oil recovery. These fluids require specialized measurement techniques and computations. As in LNG, ultrasonic based flow sensing is playing a lead measurement roll for the measurement on larger diameter pipelines.

TECHNOLOGICAL

A. Continued concern with the cost of deploying and operating instrumentation through its life cycle

Through on-going business with numerous users Cameron has observed that the cost of deploying and operating instrumentation through its life cycle is increasing relative to the purchase cost for a constant set of instrument capabilities. In fact, the cost for a baseline set of equipment capabilities has been steadily declining. The operational cost for equipment has become so significant that for many exploration and production companies, the option to rent their measurement system and simply pay a fixed price for their measurement data has become increasingly popular.

Companies that consider measurement a core expertise and wish to control it will also share a concern for the life cycle cost and their ability to effectively manage and optimize measurement integrity. Cameron observes that the density of RTU/EFM inputs and outputs remains relatively small. Regardless of that, some RTU/EFM manufacturers remain fixated on making a physical input or output resource as application-flexible as possible. They do this in order to appeal to applications outside of EFM and related station control. For these manufacturers, multi-industry and multi-application appeal is achieved by providing the I/O with an array of software settings alternatives. While this offers a low capital cost per point count, it is done with the addition of complexity or a bombardment of features and choices.

For the users deploying this more universal system, the risk of an error occurring during the life cycle is increased directly by the available choices. The risk for errors in understanding an application can be reduced by the user investing in site-specific documentation. While this is expensive to generate, there remains a probability that undocumented changes will subsequently occur. This is particularly true as measurement sites evolve in their configuration.

A designed for-purpose EFM, such as Cameron's Scanner 3000, can offer considerable value to the user by predefining a narrower scope of application uncertainty.

B. The deployment of smart sensing devices

Initially, smart technology was designed to improve sensing device capabilities. Then, the related smart interfaces improved the user's ability to effectively manipulate the equipment. Now, the smart information within a device is recognized as being able to provide information on the reliability of the measurement. Rephrased, this could be described as measurement of the health of the device. Unfortunately, these interfaces were developed by manufacturers without the guidelines of a standard, therefore, interconnectivity is nearly non-existent between interconnecting devices. In terms of measurement equipment, this lack of interconnectivity is preventing the SCADA host or even the field RTU from receiving this useful information. At present, and in general, a simple status output/input may be the only indication that a smart device is indicating an unusual condition.

The value of control room viewable diagnostics has been recognized by industry as a whole. In support of this an organization was formed to provide a universal Field Device Tool (FDT) Standard by which remote viewing could occur within a range of host platforms: http://www.fdtgroup.org/. Presently, the standard does not support the objective of a tight integration of a RTU to a field device; however the standard is evolving in scope and Cameron is monitoring the developments. Cameron's intent would be to allow the Scanner 3000 to continuously monitor the field devices and provide a field device and measurement health report with each hourly record. Ultimately a "cry-out" generated by the scanner 3000 would allow maintenance to be alerted to current or potential problems.

C. Implementation of diagnostics for orifice based measurement

Cameron is evaluating the implementation of a measurement and computation methodology that has the ability to detect errors within an orifice-based flow measurement element. The potential of this device would be to identify physical problems with the orifice plate such as wear and damage, incorrect orientation, and other installation abnormalities.

D. The addition of more analytical measurement devices such as:

i. More gas chromatographs which are being driven by new more compact, lower cost, less maintenance-intensive designs and, by more manufacturers
ii. More frequent deployment of oxygen analyzers and other devices for corrosion related inferences
iii. Continued growth and advancement in hydrogen sulfide measurement
iv. Increasing use of Coriolis and Ultrasonic flow meters which provide additional fluid property signals like density, viscosity, speed of sound, etc.

All these signal types must either be reported or integrated into computations.

E. An increasing cost and complexity in certification and qualifications

As with all technology, as time progresses, performance increases are made resulting in current technology becoming obsolete. This rate of technology advancement and obsolescence is occurring more quickly. Manufacturers of EFM devices would be better able to rapidly and cost effectively revise their equipment were it not for the third party testing and certifications which have become increasingly expensive. These costs have increased in terms of real and relative amounts.

Compared to just ten years ago there are simply more requirements and the requirements are more complex. These standards include; CE, ATEX, MID, API, ISO, Measurement Canada, IEC, CEC, NEC, to name just some of the major relevant standards. As troubling as that is, although the expenditure to achieve the qualifications has increased, so too has the time to acquire them. The manufacturer is now also faced with an increased time period from when the design and development expenses have been incurred to when revenue can commence.

To address this challenge, the design of the new Scanner 3000 pays close attention to compartmentalizing the device into separate flow and supervisor modules. Beyond this, division considerations have been made within the design of each module. Using the Central Processing Units as an example, Cameron has selected from a micro-processor family that is popular in a diverse range of applications. Doing so indicates that availability will continue and that there will be a high probability that development in the processor family will continue. For all product developers, it is far more feasible to apply the capabilities of a new component if that component is a direct descendant of a current component. This is because it shares many of the same attributes and deployment tools.

The Scanner 3000 firmware is being designed with an abstraction layer from the processor code to allow for processor changes with little or no code changes. Ultimately, both of these strategies allow upgrades to occur without a complete redevelopment. More important is that, once the upgrades have been implemented, the requalification testing and approvals can be focused on just a subset, thereby improving the manufacture's cash flow and profitability and, hence, making upgrading on a more frequent basis more feasible.

As Cameron's global industry focus is oil and gas they invest in the establishment of market intelligence. This information is used to guide business strategy including product development. As summarized in the preceding paragraphs change is on-going and the design of the Scanner 3000 has been influenced to embrace change while maintain the underpinning of measurement precision. For this reason Cameron's distributed measurement architecture was adopted as the best method to allow the product to grow and evolve.

1.3 SCOPE, RECOMMENDATIONS AND BEST PRACTICES

The following details how Cameron would address the TransCanada scope, including any recommendations and best practices.

Cameron's Measurement Systems Division was formed less than six years ago with the intent to continuously grow the measurement division to four times its original size. The measurement division will then be a dominant entity focused purely on measurement expertise. Having grown considerably and on-target to meet the objective, Cameron is already offering unique and innovative measurement solutions in each of our brands. However, multi-phase flow measurement, sampling and ultrasonic flow measurement are perhaps most notable. NuFlo and the subsequent acquisitions of the following companies have contributed to our expertise.

- Caldon - ultrasonic fluid flow measurement
- Prime Measurement products – supplier of key components to many Barton-brand instruments
- Jiskoot Quality Systems – sampling, liquid blending, multi-phase flow
- Linco- Ball provers and LPG transfer facilities
- Process Analytics – analytical device integration, sample extraction and conditioning

In all cases, Cameron has modernized and expanded the business processes of these companies with the application of encompassing administration policies, the SAP Enterprise Resource System, Six Sigma process tools, Enterprise Excellence focus program, ISO 9001 quality system and HSE programs.

Since Cameron assembled the Measurement System Division they have consistently invested amounts in R&D that are well above the industry norms. In 2011 Cameron will invest over $8.2 million which is in excess of 3.8% of revenue into measurement R&D.

The rejuvenation of the core businesses has been impressive. In certain cases the technology within the acquired company had stagnated or, in the case of Prime, the company had financially failed as a business. Successes within the division brands in the past six years are:

BARTON

- Establishment of a factory (old factory acquired by the bankruptcy court)
- Replacement of cryogenic level management RTU and multi-variable transducer
- Development of the DPE+ MVT that is now offered directly coupled to the Scanner 1100 series
- Re-development of qualifications to produce nuclear power industry-qualified instruments for mild and harsh nuclear service including rigorous 10 CFR 50 appendix B quality program and successful NUPIC and NIAC quality audits
- Redesign of 7000 series turbine body for PED compliance

- Scanner 1100 series EB01 & EB02 expansion boards. This daughterboard features a second microprocessor, supplemental memory, and an Ethernet connection with TCP/IP and FTP file transfer capabilities. These refit options offer enhanced connectivity to previous functionality and the addition of high resolution data logging. New connection methods include Bluetooth technology designed for wireless short-haul communications
- Introduction of safe master line break detection and data recorder

NUFLO

- MCIII turbine totalizer with Modbus
- Scanner 2000 flow computer
- PID control and Foundation Fieldbus imbedded in the Scanner 2000
- Scanner 2200; incorporation of various communications technologies to the Scanner 2000 capabilities including long haul wireless & Ethernet

CALDON

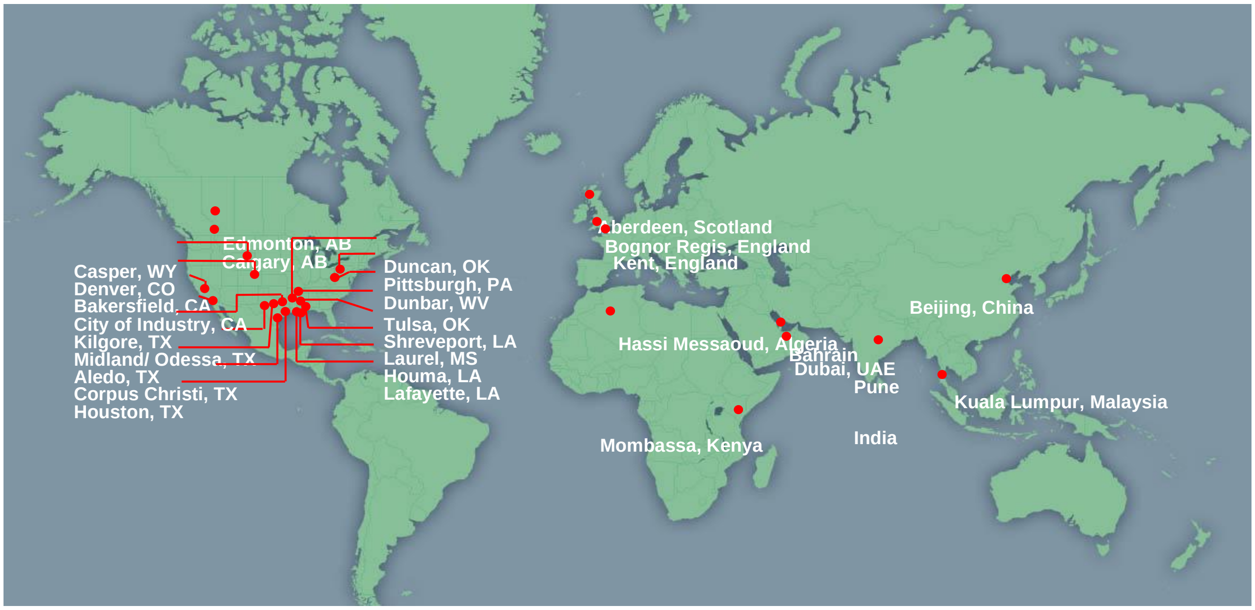
- Integral electronics to the LEFM Ultrasonic meters
- World class multi-viscosity proving facility
- Reduced bore LEFM ultrasonic meters
- New models for the hydro-electric generating industry
- E-check remote LEFM diagnostics and measurement heath monitoring

JISKOOT

- Development of a new ARM 9 microprocessor-based blender controller using Linux-based code
- Larger size range of cell samplers
- Synthetic/heavy crude probe samplers

The above list is in addition to smaller projects within each brand which are designated as sustaining engineering projects that occur to reduce cost, improve quality or manufacturability of existing products. Generally, sustaining projects may include changes to form and fit but do not change the intended purpose of the product.

Worldwide Measurement locations- Direct sales, Service and Manufacturing.



Cameron's EFM Evolution Vision

The Barton 1131/1140/1141 will remain our highest capacity flow computers through 2011. Cameron intends to continue to offer the full product line throughout the year 2013. In 2014, all marketing materials will be withdrawn and the product will be supported with parts and technical support services through 2016 or longer.

Next year, in 2012, the Scanner 3000 will become a commercial product when there is a favourable commitment from TransCanada. As a strong indication of our commitment to TransCanada, Cameron would offer a 50% discount on Scanner 1100 series flow computers from the time of the commitment to the time the Scanner 3000 is deliverable in quantities requested by TransCanada.

This pledge of commitment to TransCanada is intended to demonstrate two things to TransCanada: first, that although TransCanada has a strong desire to deploy leading-edge technology and related capabilities to their operations, the existing technology continues to support their current business needs and is known to be durable and reliable. By offering the existing 1100 series technology at a reduced price, Cameron acknowledges that TransCanada may not leave the last Scanner 1100 deployments in service for the same durations that the first deployments have been in service. Therefore, the life cycle value extracted will be reduced, and hence, the purchase price has been adjusted. Second, the discount is a tangible pledge by Cameron to meet the commitments of an agreement and begin supplying the more profitable Scanner 3000. The lapsed time will facilitate the completion of the Scanner 3000 development to TransCanada's satisfaction and specifications and facilitate comprehensive testing that TransCanada has indicated.

Should TransCanada not provide Cameron with a favorable response then Cameron will proceed with the development of the Scanner 3000 in a modified form. In the modified form the architecture will remain intact however in response to other customer wishes certain features and functions will be eliminated or deferred for a later release.

Beyond the initial introduction, Cameron envisions the following development plan for the Scanner 3000 product family. The attached plans are subject to revision without notice.

Activity	Target date
Introduction of the Scanner 3000 as presented in the draft-product technical datasheet	Mid 2012
Flow run module redeveloped to mount atop the multi-variable transducer. Purpose is to transfer all capabilities of the flow-run module to a head-mounted flow computer including but not limited to: - Modbus master for chromatograph, ultrasonic, Coriolis devices - ScanCom/Adept protocol - API pressure compensation for liquids The above project would establish the Scanner 3000 as a remote-distributed system communicating by high speed serial or Ethernet communications.This product would not replace the Scanner 2000 but would be an additional model.	Early 2013
Data Poller and Exporter for other industry customers to integrate existing Scanner 1100 series and Scanner 3000 into legacy-host systems using a current Microsoft operating system.	End 2012
Tight integration of the Scanner 3000 to the Caldon gas ultrasonic meter that had been introduced in late 2011. Tight integration would share retrievable diagnostic information with the Scanner 3000.	Mid 2013
Expansion of electrical and measurement certifications for Europe and Russia	End 2013
Expand firmware to add water-cut monitor inputs and related well test functions	End 2013
Design and implementation of second generation peripheral device interface, perhaps based on an evolved FDT standard	2014
Addition of Foundation Feildbus to the Scanner 3000	2014
The addition of wireless HART communication between a revised Scanner 2000 and the Scanner 3000	2015
Evaluate supervisor capabilities against results of user group survey for potential hardware upgrade	2015
Development of liquid prover module for addition0	2016

1.4 CAPACITY TO ALLOW TRANSCANADA TO ADEQUATELY TEST AND EVALUTE PROPOSED SOLUTIONS

Cameron has facilities and procedures to evaluate the accuracy of all Scanner EFM/RTUs produced. These procedures are documented in our manufacturing quality control documents (QMS-00-01) which are audited as part of the ISO 9001:2008 approval as a manufacturing facility (see section 8).

To provide TransCanada the opportunity to test and evaluate the proposed solutions Cameron will provide to TransCanada facilities and resources within our modern well equipped Calgary manufacturing center. Cameron proposes to include the following resources in order to test the Scanner 3000. As part of a commercial discussion Cameron would discuss the specific test and record keeping objectives and also if only or both the Scanner 2000 and 3000 are to be tested. From these understandings the resources could be scaled accordingly. If scaled upward certain testing could include assistance of various third party agencies.

The following is offered by Cameron for TransCanada directed Scanner 3000 testing;

- a 900 square foot dedicated test work area with work benches, pneumatic supply and electrical light and power
- four each 64 square foot business work centers with phone, furnishings and internet access
- eight Scanner test units of each model.
- one set of certified reference pressure, resistance, pulse, voltage and current generation and measurement instrumentation.
- exclusive use of a manually controlled 27 cubic foot temperature chamber.
- two full time ASET classified contract technical resources for test execution and documentation.
- access to Cameron's development and technical support team for guidance.

The above would be offered for a 60 day period without cost allocation to TransCanada .

The supply of the above is in addition to and independent of the testing that Cameron will perform as detailed in other portions of this proposal.

Overall the facilities in Calgary include:

- environmental chambers to allow verification of performance at room temperature and at the upper and lower extremes of the published operating temperatures
- certified pressure sources traceable to Canadian National Standards to apply known pressures to relevant transducers for verification of accuracy at all temperatures
- certified resistance, pulse, voltage and current test instrumentation to provide inputs to all other I/O to verify performance at all temperatures
- a computer-controlled ATE (Automated Test Environment) using National Instruments "Labview" to control and monitor the progress of the verification routines
- a computer-controlled test bench and software to verify the accuracy of all I/O and calculation algorithms under both static and simulated live conditions
- a dedicated FAT area within the Calgary manufacturing facility with test equipment where TransCanada personnel can observe and/or run simulations and tests to verify the accuracy of the devices under test
- equipment and assistance provided by Cameron personnel for metrological testing at certified third party test facilities such as CEESI or TCC

1.5 CUSTODY TRANSFER MEASUREMENT DESIGN EXPERIENCE

The following provides recent relevant custody transfer measurement design experience Cameron has had including (a) location, (b) Size, (c) cost, (d) scope of your involvement (e.g.: design/build, engineering, installation, etc.)

Cameron, being very aware of the increasing importance of hydrocarbon measurement created an entire division to focus only on Measurement. With the goal to provide customers with state of the art equipment and engineering competence in all areas of hydrocarbon measurement they have acquired companies and brands such as Barton, NuFlo, Clif Mock, Caldon, Jiskoot and Linco, all within the past few years. With the products and experience of these long term players in the measurement business Cameron is committed to maintaining and increasing its capabilities, and developing new and innovative products to meet the demands of our customers. The synergy of these companies provides an extensive knowledge base for the development of new technologies and the capability to integrate them into systems that meet the most stringent of our customers' demands. With the emphasis on the measurement of both the quality and quantity of hydrocarbons Cameron continues to demonstrate its commitment to the measurement industry by active participation in the working committees of the API – Committee on Petroleum Measurement. The company is committed to maintaining itself at the forefront of any new developments and implementation of new procedures and practices as they become accepted in the industry.

Prior to Cameron's acquisition of the Barton brand they provided only the equipment to be used in custody transfer measurement of natural gas and hydrocarbon liquids. At that time they did not provide detailed engineering to customers but assisted in the specification and configuration of our products to meet the required metrological standards.

In the past two years the addition of Jiskoot and Linco has introduced packaged skidded measurement solutions to the measurement division. Linco was acquired from the acquisition of NATCO and specialize in integration of various manufacturers' measurement equipment into systems. For liquid measurement many of these systems included Linco's own ball provers. Recent successful projects have included.

10/28/10	Chase Petroleum Limited	3) Quad 4" Product Loading Skids & Arms	Ghana, Africa
01/14/11	Gibson Energy Partnership	Triple 10" 150# ANSI PD Metering Skid	Calgary, AB Canada
12/30/10	TARGA RESOURCES LLC	Single Run 4" x 3" Coriolis Meter Skid 600#	Sterling City, TX.
12/15/10	Magellan LP	8"x 20"x 24" 150# Bi-Directional Prover	Tulsa, OK
04/24/11	Enterprise Products Company	4" x 3" 600# TM Skid	Deer Park, Texas
03/15/11	Plains Marketing, LP	3) 4"x 3" 300# Mass Meter Skids	Houston, Texas
03/30/11	Sunoco Logistics Partners, L.P.	1) 4" 150# & 1) 4" 300# PD Meter Skid	Houston, Texas
06/01/11	Optimized Process Design	Dual 3" x 2" 150# Coriolis Metering Skid	Centerville, Louisiana
05/20/11	Chesapeake Midstream	2000 BPD 2" LACT Units	OKC, OK
05/02/11	Sunoco Logistics Partners, L.P.	3" 150# Coriolis Crude Blending Skid	Colorado City, TX.

CAMERON'S CURRENT GAS MEASUREMENT COMPETENCES

In respect to custody transfer gas measurement Cameron has five product families that are Measurement Canada custody certified for gas measurement. They are:

- North Star (NuFlo) single and dual chamber orifice fittings and related meter runs.
- Barton 7400 series gas turbine meters
- Scanner 2000 MVT based EFM
- Scanner 1140/1141/1131 EFM/RTUs
- Barton transmitters

Recently these products have been deployed to customers as follows.

Specification for and provision of Scanner 1131 flow computers for use in Northern British Columbia for various customers who are tying into Encana's or Spectra's pipeline systems. This included the provisions for the use of new measurement technologies (e.g. ultrasonic meters and multivariable transmitters from different manufacturers) and traditional instrumentation (e.g. traditional analogue-based transmitters and process gas chromatographs etc.). These devices are connected to local and remote PLC/HMI systems for monitoring and control.

Provision of flow computers for TransCanada's North Baja pipeline addition, including training for personnel and assistance in configuration.

Cameron's Caldon Ultrasonic measurement team has developed a world class solution for measuring fluid flow and fluid properties by non-invastive ultrasonics. Part of this development was the Design and construction of a state of the art liquid measurement flow calibration facility at Cameron's Caldon factory in Coraopolis, PA. This facility has national and international accreditation (ISO/IEC 17025 & NVLAP) and is used by TransCanada for proving the liquid ultrasonic meters used on the Keystone pipeline project. In addition to the Keystone project, this facility and team successfully executed a measurement solution involving eleven 8 path ultrasonic meters for RazGas of Qatar used in the custody transfer loading of LNG. Project meter sizes ranged from 8" to 24".

FUTURE DEVELOPMENTS

Cameron's divisions continue to develop existing and new innovative products for hydrocarbon gas measurement. As a result of these activities, new designs in ultrasonic measurement are resulting in developments like the Caldon gas ultrasonic meter which will offer the ability to service the transducers without interrupting the flow.

With the advent of the new Scanner 3000 series EFM/RTUs, features and capabilities within the device will full fill its objective as being the best fiscal measurement device available in the market. Those details are described later in this response.

To provide gas quality information the Clif Mock brand, which is managed by Jiskoot, offers synergetic components and solutions for the sampling of gasses. The reconfigured Mock LGS 1500 is being completed with Canadian regulatory approvals.

Cameron's technical specialists continue to monitor the developments in flow calculation algorithms specified by the API and other international standards writing bodies, resulting in the latest algorithms and innovations being included in the firmware for the new measurement products.

1.6 PROJECT PLAN

The following provides a solution based project plan to integrate and accommodate TransCanada's needs, complete with schedule information and a list of key personnel for the execution of the scope of work as more particularly described in Appendix 1 of TransCanada's RFI.

SCHEDULE INFORMATION

Cameron has facilities, internal and external resources, procedures and background knowledge to develop state of the art flow computers that meet industry and customer expectations. Cameron development resources are currently focused on the Scanner 3000. Cameron's development team is utilizing test-driven development methodology to reduce the design and test cycle and to improve the reliability of the product. The Scanner 3000 can be described in 3 sections: a flow run module, a supervisor and a back plane. Below are the development milestones for these sections. Cameron is aggressively managing this project to completion. MS Project timelines are available upon request.

Task	Milestone (Completion)
Scanner 3000 Supervisor Hardware Design and Alpha Test	October 20, 2011
Scanner 3000 Backplane Design and Alpha Test	November 1, 2011
Scanner 3000 Flow Run Module Design and Alpha Test	November 4, 2011
Approvals (Measurement Canada, CSA)	February 24, 2011
Supervisor Firmware and Web Interface	February 28, 2011
Scanner 3000 Alpha Test	March 9, 2011
Pilot Production run (20 systems)	December 23, 2011
Scanner 3000 Approvals	February 24, 2012
Scanner 3000 Beta Units Ready	March 28, 2012
Scanner 3000 Beta Testing	June 29, 2012
Production Run (50 systems)	August 10, 2012
Training Program Development	August 10, 2012

Cameron has invested in the Scanner 2000, Scanner 2200 and easy-to-use ModWorX Pro Interface Software. There are desired and required items in this RFI that currently are not supported by these products. For example, Linear Mass measurement is currently not supported. If TransCanada is interested in the Scanner 2000 or Scanner 2200, resources will be assigned to add agreed upon features to the instrument's firmware and ModWorX Pro. Here are representative timeframes that Cameron will provide upon receipt of request:

- Add Linear Mass to the firmware and ModWorX Pro – 6 weeks
- Numerical Precision enhancement for ModWorX Pro – 7 weeks
- Perform required Shock and Vibration testing – 6 weeks
- Change terminal blocks to de-pluggable type – 6 weeks
- Update heating value and energy calculations – 8 weeks

LIST OF KEY PERSONNEL

Don Hammill –Technical Services & Sales Manager

- 29 years experience in Measurement Products
-

Andy Seeger – Project/Customer Liaison – Primary contact

- B.Sc. Engineering (Mechanical) P.Eng.
- 29 years experience in measurement product support and development
- TransCanada technical contact - 22 years

Warren Loch - EFM Software Product Leader

- B.Sc. Electrical Engineering, P.Eng.
- 14 years experience with gas measurement software and firmware including the ScanCom/ADEPT , modbus and Enron modbus protocols
- 8 years experience in oil and gas risk assessment and risk modelling

Dave Law -Software Developer/Project Lead

- B.Sc. Computer Information Systems
- 16 years oil and gas experience

Chris Braid – Measurement Applications Development Specialist

- 38 years of technical leadership in measurement and measurement systems development

Tony DePass – Measurement and Analytical Device Specialist

- B.Sc. (Chemistry & Applied Chemistry)
- 30 years experience in hydrocarbon measurement (gas and liquid)
- 20 years involvement in standards development with API Measurement Committees (GOGFM, COLM, COMQ)
- TransCanada technical contact – measurement support and training

Roy Williams - Implementation Manager

- B.Sc. Electrical Engineering, P.Eng
- 20 years local and international experience in SCADA and Measurement Applications Engineering
- TransCanada technical contact – product supply and technical support

Tom Madden – Manager R&D

- B.Sc. (Electrical Engineering)
- 20 years experience in measurement instrumentation hardware and firmware development

Rob Diederichs

- B.Sc. (Electrical engineering), P.Eng
- 17 years experience in development of electronic measurement equipment for liquid and gas applications

Jerry Yee

- B.Sc. (Computer science)
- 21 years experience in oil and gas systems

Al Williams - Firmware Development Manager - Harding Instruments

- B.Sc. Computer Science
- 24 years experience in development of firmware including operating systems and protocols for liquid and gas EFM applications

Joe Wheeler – President and Hardware Development Manager, Harding Instruments

- B.Sc. (Electrical Engineering)
- 32 years experience in flow computer hardware design; communication network and device designs involving leading technologies such as VOIP and video streaming in small communications networks

John Hereema

- B.Sc. (Computer Science and Pure Mathematics)
- M.Sc. (Digital Signal Processing)
- 20 years experience in oil and gas industry systems

Ken Mouratidis – Vice-President/COO MicroLynx Systems Ltd.

- P. Eng.
- More than 20 years experience in the areas of analog hardware, RF circuits and systems, and analog control systems

Pat Holley – President, Cameron Measurement Division

- B.Sc. (Electrical Engineering), MBA
- Management and project experience within multiple technology areas within Cameron
- Allocation of financial and organizational resources to the project

Other resources will be added in select roles including Supervisory Project Manager, a Permanent Sustaining Developer, multiple test specialists and multiple select contractors for specified development tasks.

Provided the opportunity to present our vision and demonstrate the development progress Cameron would co-ordinate a presentation involving most of the key players above.

1.7 REGULATORY DELIVERABLES

In delivering a custody transfer flow computer, Cameron's pre-requisite approvals include compliance and approval by Measurement Canada and a product compliance certificate to the standards of the Canadian Electrical Code and National Electric code. Although these are the minimum requirements, Cameron has experience with attaining metrology approvals for their current Scanner 1100 and 2000 series in Europe, Russia and Kazakhstan. With this international experience and the intent on offering the Scanner 3000 internationally, many design considerations have included the best practices of these international bodies. The scheduling and details of these features and activities are provided in subsequent sections of this document.

SECTION 2 APPENDIX 1 – FLOW COMPUTER ARCHITECTURE SELECTION

2.1 CURRENT MEASUREMENT FACILITY DESIGN

TransCanada currently has Scanner 1130, 1131 and 1140 EFM's installed in hazardous and unclassified areas. With each model number that TransCanada has standardized on a single main board configuration and by utilizing different power supply and charge controller modules, the products are intrinsically safe or division-2 certified, with and without integral battery power. This has enabled existing Scanner 1100 EFM hardware, installed in various locations, to be utilized as TransCanada, NOVA, ANG and PGT have been integrated into a single system by standardizing on a common firmware version.

2.2 DESIRED FUTURE STATE FOR ELECTRONIC MEASUREMENT

2.2.1 ENGINEERING DESIGN

2.2.1.1 SCALABLE

The Scanner 3000 has been designed from the beginning to be scalable to cover a very wide range of measurement and RTU applications. In terms of flow measurement, the Scanner 3000 was designed to support between one and twenty fiscal flowruns. The physical hardware has been designed to support one to four runs in the most basic configuration to cover smaller stations. To add more flowruns to the basic configuration, the user will add backplanes with each backplane supporting up to four additional flowruns. Once an additional backplane is installed, the user adds flowruns by adding flow modules. The following table lists the number of runs possible by hardware combination:

No. of backplanes	Min. number of flowruns	Max. number of flowruns
1	0	4
2	0	8
3	0	12
4	0	16
5	0	20

Both flow modules and backplanes are designed to be "hot-swappable" allowing addition and removal without shutting down the Scanner 3000. By creating a device with dedicated measurement modules, new measurement applications involving liquids or other energy forms can be added by creating new firmware for a module. If a measurement application needs specialized hardware such as liquid provers require, then a purpose-built module would be developed to ensure the measurement objectives are achieved without compromise.

Fiscal flow run measurement is not the only measurement required at a typical field location. The Scanner 3000 and its firmware have been designed to monitor, log and alarm, if required, common items such as tank level, UPS status, intrusion alarms, gas detectors, vibration detectors, etc. The Scanner 3000 measurement is scalable to fit the users' end applications.

For control applications, the Scanner 3000, again, has been designed to be scalable. If the user requires additional I/O for control or monitoring functions the flow module can be deployed as an I/O module. Internally the Scanner 3000 firmware is scalable as it natively supports multiple simple control schemas through user-defined alarms and multiple user-configured PID controllers. For advance features the Scanner 3000 can be equipped with an IEC61131 module to allow customer programs to be deployed.

In the future, if an application requires specialized hardware the Scanner 3000 design and architecture supports addition of new special purpose modules optimized for that application. The user will not have to install a new device or RTU but merely plug in the new module and configure it for the location. This is only possible due to the advanced backplane design and the concept of having each module completely self-contained resulting in a truly distributed computing platform – not just distributed I/O but actual distributed applications and processing.

Minimal Number of Parts to Stock

For large measurement systems, standardization of equipment, installation methods, wiring, and training can pay large dividends in reducing total installed cost as well as ongoing operational costs (life cycle costs). Much care and attention has gone into the Scanner 3000 design to provide standardization. The Scanner 3000 system was designed from the beginning to cover a wide range of applications with a minimal number of hardware devices, with one basic configuration. The flow module is designed to cover all standard measurement applications no matter what the meter type. There is only one backplane and only one supervisor. The same de-pluggable terminals have been used on all three pieces and there is only one I/O configuration for each piece keeping the terminals in the same place at all times to ensure drawing compatibility. The final result is that the end user only needs to stock three basic parts to cover all of their measurement and control applications: Scanner 3000 supervisors, backplanes and flow modules.

In some cases, "scalable" can also mean "complicated" and requires different hardware to get the upper portion of the scale. This is not the case with the Scanner 3000. The 1100 series firmware has always been configurable and scalable allowing the users to define how many flowruns or how many data logs or how many controllers, etc. that they wanted in the device. The 3000 expands on this by moving the commonly expanded items (flowruns and I/O) to the dedicated flow modules, allowing a much larger scalable range without penalizing the small applications.

Scalable into the Future

As with all technology, as time progresses, performance increases are made resulting in current technology becoming obsolete more quickly. As this is a known factor, the Scanner 3000 has been designed to accommodate technology advances without breaking backwards compatibility – future-proofing the measurement solution. This has been done by selecting widely accepted standards for key technologies such as the backplane. The Central Processing Units have been selected from one of the most common families to ensure long term compatibility and availability. The firmware in the flow modules and the supervisor have been designed with an abstraction layer from the processor code to allow processor changes with little or no code changes. The embedded WEB user interface is based on widely accepted WEB standards. With this design, the end user will get all of the benefits of technology advances without any of the incompatibility issues.

Scalable Measurement Model

The Scanner 3000 with MVT model offers better scalability and upgrade paths than stand-alone MVT-type flow computers. Stand-alone flow computers require a separate higher function RTU to perform common station functions such as totals, run switching and gas chromatographs. With the Scanner 3000 external host, communications are simpler because there is one address for the external hosts for all flowruns and a dedicated communications server (the supervisor) to optimize and resolve multiple host communications. This model completely isolates the measurement and communications functions to ensure that external hosts can not affect fiscal measurement. Simple MVT-style flow computers cannot offer this type of advanced features and need to be replaced, upgraded or paired with additional equipment when added functionality or capability is required.

Scalable MVT Solution

Though Cameron recommends starting with a Scanner 3000 for all applications, if the user starts with a Scanner 2000 as a simple MVT-style flow computer and then requires more functionality, the Scanner 3000 can be added and the Scanner 2000 becomes an MVT.

The Scanner 2000, when deployed as an MVT with the Scanner 3000, offers a similar feature set as industry MVTs such as the Rosemount 3095. Where the Scanner 2000 as an MVT differs is as follows:

- Since the Scanner 2000 is a full-flow computer the user can choose to configure the flowrun in the Scanner 2000 so that if the communications fail between the 2000 and 3000, or if the 3000 stops working, the 2000 will continue to gather the data to be used as an estimate later
- For temporary sites, the 2000 could be deployed using the internal battery, thus reducing installation effort and costs
- The 2000 has a local display standard which is typically an upgrade on industry MVTs
- Fully integrated with the Scanner 3000 flow module to accept a pulse input

Scalable without Programming

One way to achieve scalability is to provide a bare RTU and allow the user to program the functionality. If the user needs more functionality they just develop a new program to meet that functionality. Programmability is very useful for applications that are customized or specific to a particular application or if they change on a regular basis. Flow measurement is very well defined by the governing body and should not change or vary from implementation to implementation. It is best implemented as user-configurable programs by programmers intimate with the measurement standards and methods.

The disadvantages with programming capability are:

- Device stability can be affected by a poor program implementation
- Version control is necessary to ensure all devices in the field are using the same program
- User interface changes with every programmer and program
- The customer needs to maintain an internal or external group familiar with the programming
- Manufacturer provided “measurement programs” are limited by the programming model – they cannot be optimized to take full advantage of the hardware as they are just another program running on the device

- RTUs are by nature designed to be very generic in order to be programmable while flow measurement devices are very specific in purpose. Is it possible for an RTU to function both as a generic device and as a device programmed for specific applications like flow measurement?

2.2.1.2 ROBUST

The Scanner 1100 series EFM devices are installed in custody transfer applications all over North America and are found at most TransCanada natural gas measurement site. With weather proof enclosures the conformal coated circuit boards are designed for a long life. Many Scanner 1100’s are installed outside or in basic shelters, exposed to a wide range of ambient temperature, humidity and corrosive environments. Some Scanner 1130’s have been installed at TransCanada for over 20 years and because of their performance and reliability there is no whole sale plan to change them out.

The Scanner family of EFM’s are also some of the lowest power consumption EFM devices on the market, this low power and reliability make Scanner EFM’s ideal for applications with difficult access and limited power, such as remote solar or TEG powered applications.

2.2.1.3 EASY UPGRADE PATH

Change in Flow Requirements:

a) Adding Flowruns

If a site requires additional flowruns, flow modules must be added, one for each additional flowrun. The minimum configuration of a Scanner 3000, supervisor and backplane will support one to four flow modules. If more than four flow runs are needed then additional backplanes supporting four additional runs can be added. A Scanner 3000 is designed to support a total of five backplanes allowing a maximum of 20 flowruns.

To add a flowrun, the user will first ensure the area is safe then insert the flow module onto the backplane in the next available slot following procedures given in the user manual. Of note is that the user does not have to shut down or remove the power from the Scanner 3000 as it has been designed to support hot swapping of the flow modules. Once the module is inserted it will perform a self-check and start procedure to ensure proper base operations. When this self-test is complete, the flow module will provide a simple pass or fail result on the module display.

If the module is OK, the user will now connect to the supervisor and launch the embedded WEB interface. The supervisor will detect the presence of the new module automatically and the WEB interface will provide basic information for the module on the system pages. To add a flowrun, the user will go to the flowrun section of the WEB interface and use the Wizard to configure the flowrun present on the new module to the measurement requirements.

b) Flowrun Removal

To remove a flowrun from a Scanner 3000, the user will use the WEB interface to “Remove” the flowrun from the 3000. The first part of this procedure will ensure that operations related to, or dependent on, the flowrun are reconfigured to ensure proper operation. Once this is complete, the flow module can be physically removed from the Scanner 3000. A second part of the flowrun removal process will be an option to completely delete all data on the flow module to refresh the module for use in a different application or locations.

Change in Meter Type

The flow module has been designed to be universal to most meter types. Standard inputs include analog, RS-485 MVT, and pulse inputs to support most common meter types. If the meter type changes, the user will have to wire the new meter to the appropriate input terminals and then reconfigure the flowrun through the WEB interface present on the supervisor. No other changes would be required.

Add Sour Production

To add the functionality required for sour production, the user will have to add a flow module (if the amount of gas returned is to be recorded), and wire the inputs and outputs required for valve control to the Scanner 3000. To handle the actual monitoring portion of this application, the user would create an alarm point on either the live H2S value (as provided by the H2S analyzer) entering the Scanner 3000 as an analog input or the digital indication of exceeding an alarm point in the analyzer as a digital (status) input on the Scanner 3000. The alarm will monitor either input and if tripped, would actuate a digital (status) output to close the automated block valve. If the block valve has digital outputs to indicate limits they could be also monitored using alarms to indicate if the valve does not fully close.

All alarms will be recorded in the alarm queue for future review and analysis. If the user wants to log the live H2S value they can add it to a data log or flowrun *again* for future review and analysis.

The above method could be used for all types of external process analyzers.

Add a Gas Chromatograph

As gas chromatographs typically analyze multiple streams of gas, they will typically be connected to the supervisor to allow distribution of the different stream data to the different flowruns. In simple station configuration the gas chromatograph could be connected to the Scanner 3000 via RS-232 or RS-485 using one of the standard serial ports. In more advanced scenarios where the gas chromatograph is connected via Ethernet to a station communications backbone, the Scanner 3000 will retrieve values using Modbus TCP or Modbus over TCP.

Add Modbus Signals

As with the Scanner 1100, the Scanner 3000 will support multiple user defined Modbus maps both in standard and Enron format. These maps will be assigned to networks which will be assigned to physical serial ports that are connected to the external devices. If the external devices are connected within the station Ethernet they will be able to retrieve the Modbus information through the Scanner 3000 Ethernet port.

2.2.1.4 SYSTEM UPGRADE PATH

In the past, flow computers were custom-built, application-specific hardware devices with tightly integrated firmware and software. This approach was needed at the time to achieve the reliability and low power requirements of a flow computer but also made upgrading or improvements slow or even impossible. Embedded computer technology has come a long way in the past 20 years and a modern flow computer should use off-the-shelf technology and concepts to implement the hardware to allow rapid integration of new technology as it becomes available. Flow computers are basically ruggedized computers running custom software and the real heart or core of a flow computer is the custom software.

Cameron is no stranger to flow measurement or electronic flow measurement going back to our first EFM release in 1982 as the Model 381. The 1100 Scanner series, which the Scanner 3000 is designed to supersede, have been in service around the world for over 20 years. Good measurement techniques and standards do not change as often as technology advances so any new measurement platform needs to be a balance of technology and proven design methods.

The Scanner 3000 provides that balance by combining current off-the-shelf, embedded computer technology with fiscal measurement applications in firmware based on Cameron's vast experience in flow measurement. The Scanner 3000 architecture has been selected specifically to allow the platform to provide the rock solid fiscal measurement our customers expect, while allowing for technical advances to be incorporated. The Scanner 3000 hardware may change in the future but the firmware and applications will continue to provide the measurement and control data in a common format to ensure backwards compatibility.

Hardware Upgrade Paths

The initial release of the Scanner 3000 hardware has an expected lifecycle of 10 years. During this time span, if new parts or technology become available that would improve the Scanner 3000 further, the architecture and design allows Cameron to apply these improvements while maintaining total external compatibility. That being said, the hardware item's key to solid measurement such as input circuitry and clocks have been selected and designed to the best possible standards and are not expected to change often. Parts such as processors and memory which improve rapidly will be reviewed regularly and may change if warranted.

For functionality not provided by the initial release of the Scanner 3000 hardware, Cameron intends on using the power of the Scanner 3000 backplane to develop and add modules purpose-built for the required application. Potential products could be a liquid proving module or high speed controller.

For existing users of 1100 Scanners, the Scanner 3000 form factor has been chosen to allow compatibility with a majority of the existing field and rack enclosures.

Firmware Upgrade Paths

a) The initial release of the Scanner 3000 firmware is intended to be a replacement for the 1100 series and therefore will be the best fiscal measurement device for natural gas measurement
b) The next logical stage of development is to add support for liquid fiscal measurement to fully integrate with the Cameron Caldon liquid ultrasonic flow meters

Both the 1100 and 2000 Scanners have provided steam measurement so the next firmware development will be to provide the best steam measurement possible. For existing Scanner 1100 users, the Scanner 3000 firmware is based on ScanCom and ADEPT to allow backwards compatibility with existing hosts. New features offered in the Scanner 3000 may not be immediately available with existing hosts but all core functions ranging from ADEPT commands to data presentation methods have been maintained to allow seamless field upgrades from 1100 to 3000 Scanners. Further, if possible, new features have been added using methods that will not require host code changes but instead either polling configuration changes or functionality additions.

The continued support for ScanCom /ADEPT is based on two primary reasons. The first is the result of an extensive EFM protocol research project which investigated all available protocols including those outside of the EFM market. There are some more generic industry standard-based protocols available such as DNP3 and UCA(IEC-61850) but Cameron found that they were all optimized for RTU-based devices and fell short for the very specific requirements of EFM devices. ADEPT and ScanCom were designed specifically for EFM devices and still offer more native functionality required in EFM application.

The second reason for continued support of ADEPT and ScanCom is the number of EFM-compliant data hosts with support for this protocol combination.

If support for a different protocol is required in the future, the firmware design allows development and integration of new protocols on the Supervisor.

2.2.2 PHYSICAL LAYOUT AND CONSTRUCTION

The Scanner 3000 supervisor and flowrun modules will perform the measurement, site monitoring and control functions.

The low-powered and scalable Scanner 3000, supplied with the backplane module, can be mounted in the TransCanada envisioned small power and communication panel. In future measurement facility designs the Scanner 2000 can be used as an MVT located in the meter building. In legacy installations existing discrete transmitters can output to the Scanner 3000 directly.

The Scanner 2000 used as an MVT and connected to the flowrun module will perform the measurement function while the supervisor with additional flowrun modules will execute the site monitoring and control functions. In this way, the Scanner 3000 distributed functionality will permit a single interface for SCADA and EFM data retrieval while dividing the measurement and control functions into separate devices within a common architecture.

2.2.3 MEASUREMENT EQUIPMENT LAYOUT AND INTERCONNECTION

As the architectural system layouts show, the Scanner 3000 will support legacy analog transmitters and direct RTD connection thus allowing for a flexible upgrade for the legacy and retrofit facilities.

In the new meter station design, while our Scanner 2000 flow computer can replace the legacy transmitters, it is recommended the use of the Scanner 2000 as an MVT. The MVT, when combined with the Scanner 3000, offers better scalability and upgrade paths than the stand alone flow computer and also permits a single interface for SCADA and EFM data retrieval.

2.2.4 EQUIPMENT MONITORING

2.2.4.1 Scanner 2000

Both short term and long term equipment monitoring will be handled by using the analog and discrete inputs on the Scanner 2000 or 2200. If all of the native I/O is in use, additional I/O can be added by assigning one of the communication ports as a Modbus master, a feature embedded in the firmware, and adding an external modbus I/O device available from third party vendors.

The values from these inputs will be stored on either platform in Modbus registers which can then be accessed remotely by a SCADA Host.

2.2.4.2 Scanner 3000

Simple Monitoring

The Scanner 3000 alarms application is intended to provide flexible equipment monitoring. The alarms accessory will support monitoring both digital and analog inputs and allows the user to define alarm parameters such as set points, name and an output to be activated if the alarm is activated. To expand on basic alarm functionality the alarms accessory allows the user to assign the alarm to a group of alarms using AND or OR logic. The OR logic allows the user to create a group in which any alarm assigned will cause an output to activate. The AND logic allows the user to simply define a set of alarms that must all occur before the output is activated. As each alarm has an output, multiple outputs can be activated with either logic once the conditions are satisfied.

Another feature of the alarms accessory is the option to count the number of alarms and only activate outputs after a user-defined number of alarms has been exceeded. With the addition of a "time between alarms" parameter the alarm could be configured to reset the count automatically if no alarm has taken place for the time between alarms.

Finally, traditional alarms are based on exceeding a set point but the Scanner 3000 alarms accessory will offer an unchanged measurement mode, to trap frozen values. All of this capability is achieved without programming.

Advanced Monitoring

The Scanner 3000 will support industry common analyzers such as gas chromatographs and ultrasonic meters including digital communications with these devices to retrieve advanced information. As with the Scanner 1100 built-in peripheral devices will be defined for the most common devices. These peripheral devices are used to configure the end device and retrieve advanced features such as device health. As there are many different devices and each may support multiple configurations, it is envisioned that a universal peripheral device will be included on the Scanner 3000 that allows the user to create a map specific to devices that are not already supported. This custom map will be used to retrieve advanced information available in the end device.

Once the end device information is available on the Scanner 3000 for review, monitoring rules could be established using the alarm accessory. Most advanced devices provide internal diagnostic points or counts of failures, and alarms set in the 3000 could be used to monitor and inform SCADA host when an end device is experiencing problems. For advanced algorithms, the IEC61131 module could be used to create user specific monitoring rules and programs.

If desired, Cameron could work with the end user to integrate custom rules included only for that customer.

2.2.5 FACILITY CONTROL

2.2.5.1 Scanner 2000

The S2000 currently includes a variety of tools:

a. Flow Control: a simple single loop PID flow controller
b. Pressure Control: the previously listed flow controller can be selected to control any measured variable including pressure. If tandem single loop controllers are required, the Scanner 2000 has two independent PID blocks that could be interconnected to implement overrides, cascade control, feed-forward control, and many other configurations. Presently the user interface has incorporated tandem controllers; hence that functionality could be completed if required.
c. Flow control with pressure override: the fully implemented existing PID controller can be configured to perform this task

d. Control valve split range: not presently offered; could be competed in the functional-capability expansion along with tandem controllers
e. Run switching: not presently offered; could be competed in the functional capability expansion along with tandem controllers
f. Flow rate-based equipment control: a status output is configurable to send pulses at predescribed flow intervals. The pulse width is also selectable for maximum application flexibility.
g. Tariff enforcement: a status output is configurable to activate at a user defined set point. The output can be latching or auto-reset. An adjustable dead band is included.
h. Custom (user-configurable) Control: some additional specific-limited capabilities could be added as part of a control capability expansion project. An IEC 61131-style configurable controller tool set is not included.

2.2.5.2 Scanner 3000

The supervisor module is designed to offer both Cameron-developed control selections and the universal programmable tools of the IEC 61131 standard for control, logic and summation. The Cameron-developed selections include “combiners” that allows the addition or subtraction of values for display, logging or use as a process variable to a PID or on-off control strategy.

Facility control as requested will be achieved as follows:

a. Flow Control: by application of one of the included 20 single loop PID controllers. This is a Cameron-developed controller resident in the firmware selections. It will mimic the functionality of the Scanner 2000 controller capabilities.
b. Pressure Control: by application of one of the 20 simple single loop PID controllers
c. Flow control with pressure override: by application of one of the 20 single loop PID controllers. As in the Scanner 2000 each controller can be implemented in this way.
d. Control valve split range: by application of one of the 20 single loop PID controllers. This feature is standard in the Cameron controller.
e. Run switching: Simple run switching where additional runs are added as rate increases or removed as rate decreases, could be achieved using the new alarms module. Using a station total rate as alarm value in multiple alarms with staged increasing set points could open additional run valves as each new set point is exceeded or closed as the rate decreases. For run switching where the physical meter run is changed based on rate to the alarsm module could be used again by creating two alarms one to close the first meter run while the second opens the second meter run. For situations where it is run 1 or run 2 or run 1 and 2 the grouping feature of the alarms module would be used to to create a 3 stage approach. For other run switching applications it may make sense to create a new accessory that would facilitate easier configuration of the run switching.
f.
g. Flow rate based equipment control: a status output is configurable to send pulses at predescribed flow intervals. The pulse width is also selectable for maximum application flexibility.
h. Tariff enforcement The new alarms module in the Scanner 3000 will be used to implement tariff control by monitoring inputs (analog or digital) from external analysers, triggering alarms based on out of limit conditions and enabling digital outputs to actuate valves. The output can be latching or auto-reset. An adjustable dead band is included.
i. Custom (user configurable) Control: an IEC 61131-style configurable controller tool set is proposed to be included

Though the flow modules provide the inputs and outputs for these functions, control activities do not affect flow calculations, so fiscal integrity is maintained.

2.2.6 DATA COMMUNICATION AND SIGNALS

The Scanner 3000 design includes both the flow computer and the station RTU in terms of the flow modules and supervisor. To ensure measurement function is not affected, the supervisor acts a communication server for both functions. The ADEPT/ScanCom combination fully supports dedicated commands for hourly and daily measurement records as well as Alarm, Event and User Change records. It is envisioned that a files-based system for retrieving historical data will also be present and available for use with local connections as well as remote connections using FTP. SCADA communications can be in the native ADEPT protocol, or standard or Enron Modbus. Local network polling for control data and gas composition components will be supported on both the local serial ports and via the Ethernet connection. The ADEPT protocol supports the concept of sessions and forcing a user to log-in to the device to ensure both local and remote communications are secure. The supervisor comes standard with four serial ports and each backplane contains an additional serial port for use with remote and local hosts and processes.

The supervisor (the Station RTU) will be connected directly to the flow modules via the backplane and will have access to all flow parameters for control. The backplane is designed to provide very high speed communications to ensure excellent response times. MVTs will normally be connected to the flow modules directly and their values will be available over the backplane as well.

In the Scanner 3000 model, the supervisor would normally be used to communicate with local analyzers and provide that data both locally on the user interface and display and to remote SCADA hosts.

To optimize backplane traffic, the supervisor may act as a data concentrator for the flow module historical data. In this model, the flow module maintains a local log of historical data and the supervisor retrieves the data on a regular basis to build its own copy of that data. This way, when an external host requests historical data, it will be already present on the supervisor eliminating the need to move large amounts of historical data across the backplane and ensuring excellent Real Time/SCADA data response times.

2.3 HYDROCARBON LIQUID MEASUREMENT FACILITIES

Cameron, being very aware of the increasing importance of hydrocarbon production and distribution as demand increases in North America and globally, has been strengthening its capabilities to provide customers with state of the art equipment and engineering competence in all areas of hydrocarbon measurement. This has been done by the acquisition of companies such as NuFlo, Clif Mock, Caldon, Jiskoot and Linco, all within the past few years. With the products and experience of these long term players in the measurement business Cameron is committed to maintaining and increasing its capabilities, and developing new and innovative products to meet the demands of our customers. The synergy of these companies provides an extensive knowledge base for the development of new technologies and the capability to integrate them into systems that meet the most stringent of our customers' demands. With the emphasis on the measurement of both the quality and quantity of hydrocarbons Cameron continues to demonstrate its commitment to the measurement industry by active participation in the working committees of the API – Committee on Petroleum Measurement. The company is committed to maintaining itself at the forefront of any new developments and implementation of new procedures and practices as they become accepted in the industry.

CAMERON'S CURRENT HYDROCARBON LIQUID MEASUREMENT COMPETENCES

a) Volume measurement

i) Cameron's Caldon Ultrasonic Meters are the recognized leaders in liquid ultrasonic measurement for custody transfer. They are used worldwide for crude and refined hydrocarbon measurement, including being the choice of TransCanada for liquid leak detection on the Keystone pipeline system.

ii) Cameron's Barton 7000 series liquid turbine meters are well known and have been used by many international organizations worldwide for the custody transfer of hydrocarbon fluids.

iii) Cameron's Linco division designs and manufactures custody transfer solutions for liquid (and gas) measurement. These include system integration for the purposes of local and remote operation of custody transfer facilities such as LACTS, receipt and delivery terminals and pipeline pump stations.
Linco manufactures complete metering systems including meter runs and meter provers, as well as system integration of the necessary measurement and control instrumentation and HMI to full custody transfer standard.
Linco ball prover skids are in service in Canada on major crude oil pipeline operators.

iv) Cameron's Caldon Ultrasonic Measurement facility, in Coraopolis, PA., provides internationally recognized meter proving capabilities for liquid hydrocarbons. Utilizing a state of the art control and data acquisition system and multiple fluids of different viscosities, this facility is capable of proving liquid meters over a wide range of Reynolds numbers. The facility is accredited to nationally and internationally (NVLAP to ISO/IEC:17025:2005 by NIST) and is audited annually by NMI.

b) Sampling for Custody Transfer and Blending for Quality Assurance and Control

Cameron's Jiskoot division, leaders in the provision of sampling and blending solutions, design and manufacture sampling and blending systems for many of the major oil and gas producers worldwide. They provide and guarantee systems that meet the accuracies required by the API standards for sampling of hydrocarbons for custody transfer. This is done by a thorough analysis of the system requirements and the provision of the entire engineered solution, including the hardware for sampling, the instrumentation and integration of the system for monitoring the performance of the "whole package".

Liquid Sampling Overview

The automatic sampling of pipeline transfers is a key industrial requirement in the accurate assessment of fluid quality or value. Jiskoot is a pioneer in the design of sampling systems specifically for pipelined and stored crude oil, refined hydrocarbons and chemicals. As a leader in this highly specialized field Jiskoot has consistently enhanced and extended their product range to cover a wide variety of sampling applications. The reliability of their equipment is universally renowned, with over 600 installations. In fact, most of the world's major oil import/export terminals incorporate Jiskoot systems. The oil industry has established acceptable methods for accurate sampling of crude oils, a fluid often high in wax, sediment and other impurities. These are detailed in international standards ISO 3 171, API chapter 8.2 and the IP Part VI Section. 2. Jiskoot is actively involved in the progression of standards to address changing fluid characteristics and business needs. Currently Jiskoot is working with a number of stakeholders, including TransCanada PipeLines, to evaluate improvements that can be made in mixing a composite sample and withdrawing a representative portion from the composite.

Liquid Sampling System components

Cell Sampler

The Jiskoot cell sampler is a device extracting liquid samples from a fast-loop bypass line and small pipelines from 1” to 4” in diameter. Used for custody transfer, crude oil and NGL sampling, loading gantry, well test and LACT applications, the cell sampler accurately and reliably extracts samples from a loop by use of Jiskoot’s patented three-step sample action. A variant of the series 210 Cell, the ‘Hi- Temp’, has been developed to provide a safe and accurate method of sampling high-temperature products such as bitumen at temperatures as high as 260 Celsius and pressures of up to 30 bar.

By-scoop

The Jiskoot By-scoop is a specialized takeoff “quill” which ensures optimum sample representivity for Cell Samplers, Water Monitors, Densitometers and On-Line Analyzers. It is used in conjunction with a bypass loop. Its wide entry, internal beveled ‘Swans Neck’ off take reduces the size of the pipeline tapping required and ensures a streamlined sample is diverted from the main pipeline to the sampling system.

Probe Sampler

The series 210 in-line sample probe is designed to extract samples of crude oil, refined hydrocarbons or chemicals from the central third of pipelines from 8” to 52” in diameter. The tip of the probe is designed in a similar way to that of the by-scoop via the use of a forward extending pitot, internally-beveled both which result in enhanced sampling accuracy.

The probe is provided with a flanged-seal housing to permit insertion and withdrawal under pressure line conditions.

Jet Mixer System

The Jiskoot Jet Mixer is a highly efficient mixing device used to condition pipeline contents for accurate liquid sampling.

By withdrawing a small portion of liquid and re-introducing it through a high velocity traverse jet assembly, positioned at the bottom of the pipe, where the flow is likely to be stratified, the Jet Mix finely disperses and uniformly distributes water and sediment over the complete cross section of the pipeline using our patented “2Twincell” technique.

No other method can provide the advantages of a Jiskoot Jet Mix. It offers excellent mixing over an extreme range of flow rates and it can be installed without depressurizing the pipeline. Being non-obstructive to the flow, the power costs to operate a Jet Mix System can be a fraction of traditional in-line mixers.

Skidded Solutions

The details required to provide an effective fluid quality determination solution are numerous and often challenge industry practice that are common and preferred for other industrial packages. As a result the Jiskoot Quality Systems strategy is to take complete responsibility and provide a completely engineered and manufactured solution. Although Jiskoot can only provide this service by providing a skidded solution they can be supplied as a stand-alone module or sub-module to a larger project.

Operation of a sampling and pre-sample conditioning system can be a simple or sophisticated control problem. From basic dividers to powerful networked systems with centralized control, monitoring and reporting, Jiskoot can provide a full range of units suitable for all environments, safe and hazardous. Jiskoot's most recent controllers incorporate the latest proven technology and features in a format designed for ease of use using Modbus they can communicate with the latest flow control computers.

Clif Mock

To augment the Jiskoot family of products the Clif Mock brand, which is managed by Jiskoot, offers synergetic components and solutions for the sampling of gasses and liquids. In liquid sampling the Clif Mock products are designed to be delivered as components or as an integrated solution where the purpose for sampling does not demand compliance with standards designed to address the custody transfer and pipeline transport of fluids. Often this occurs in upstream production environments or refined product sampling.

v. BLENDING

Blend control of hydrocarbon streams to provide consistent product quality is also an important area of expertise. Blending systems are increasing in importance and complexity as product quality specifications tighten to meet economic and environmental standards. Jiskoot's experience with continuous sampling and analysis occurred as a requirement for their blending packages which was one of the original activities of the company. Jiskoot's blending experiences extend into Canada where they have provided skids to companies producing synthetic crude oil.

c) Flow Computation

Cameron's NuFlo series of Scanner flow computers have been used internationally for measurement and flow compensation of crude and refined products in non-batched pipeline systems and receipt/delivery terminals. Building on the reputation of accuracy and reliability of the Scanner series, the API - MPMS Chapter 11 algorithms for volume compensation are used to provide custody transfer quality measurement of these products.

FUTURE DEVELOPMENTS

Cameron's divisions continue to develop existing and new innovative products for all areas of hydrocarbon measurement. As a result of these activities, new designs in ultrasonic measurement have resulted in developments like the "reduced bore meters" which increase the ability to handle high viscosity fluids, the "SoundTrack" interface detector, and applications in the LNG measurement field where the extreme temperatures and fluid properties pose a significant hurdle to older technology.

With the advent of the new Scanner 3000 series EFM/RTUs, increased emphasis will be placed on liquid measurement activities. Such features as batch detection and batch-oriented logging will enhance the capabilities of the system. Additions of prover control and proving algorithms will reduce the need for external proving counters/computers and make both manual and automated proving more easily accomplished. The increased speed and communications capabilities of the Scanner 3000 platform will provide a pathway to remote monitoring and operating of non-manned stations with all the necessary capabilities for measurement and line balance monitoring and control.

Cameron's technical specialists continue to monitor the developments in flow calculation algorithms specified by the API and other international standards writing bodies, resulting in the latest algorithms and innovations being included in the firmware for the new measurement products. Our flow computers along with the Caldon Liquid Ultrasonic meters will provide leading edge technology in liquid measurement by innovative on-line corrections for variations in viscosity/density/Reynolds number, inherent health monitoring and reporting , remote diagnostics and other emerging technologies. Sampler control and pacing capability will be built in to the new Scanner 3000 and for cases where more advanced sampler control, can management and pacing are required Jiskoot sampler controllers will complete the system functionality.

Remote data access via Ethernet connection will be a standard feature and a web browser interface will replace the need for custom interface software in accessing the data and diagnostics in the system.

2.4 Architecture Drawings

2.4.1 Desired Future Facility Layout

Click to view proposed Scanner layout options

2.4.2 Upgrade

Click to view potential legacy site upgrade paths