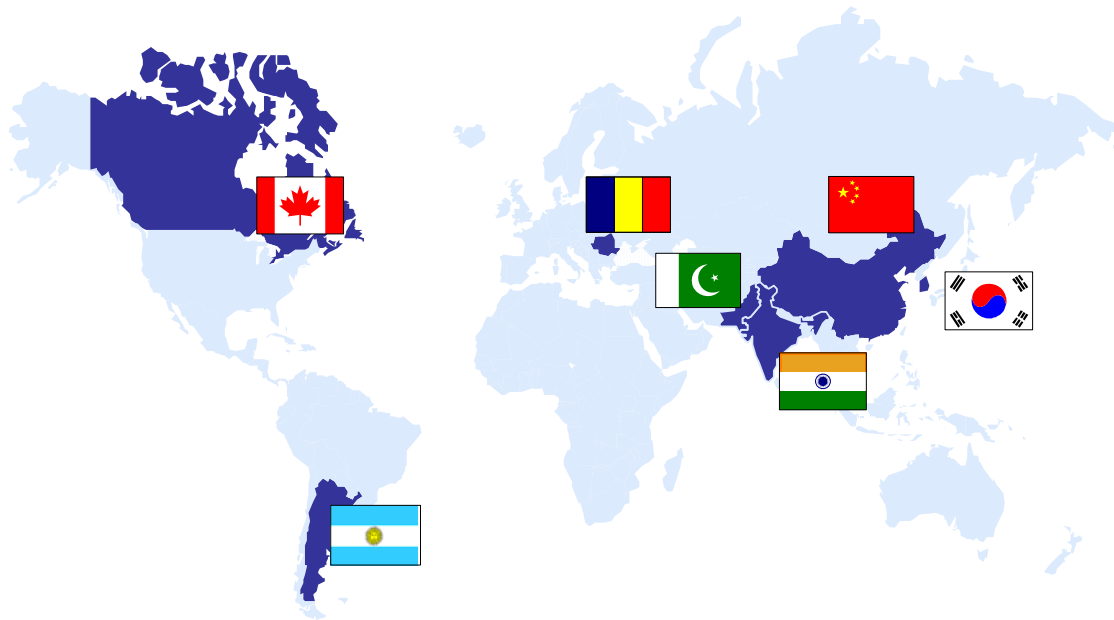




Research & Development

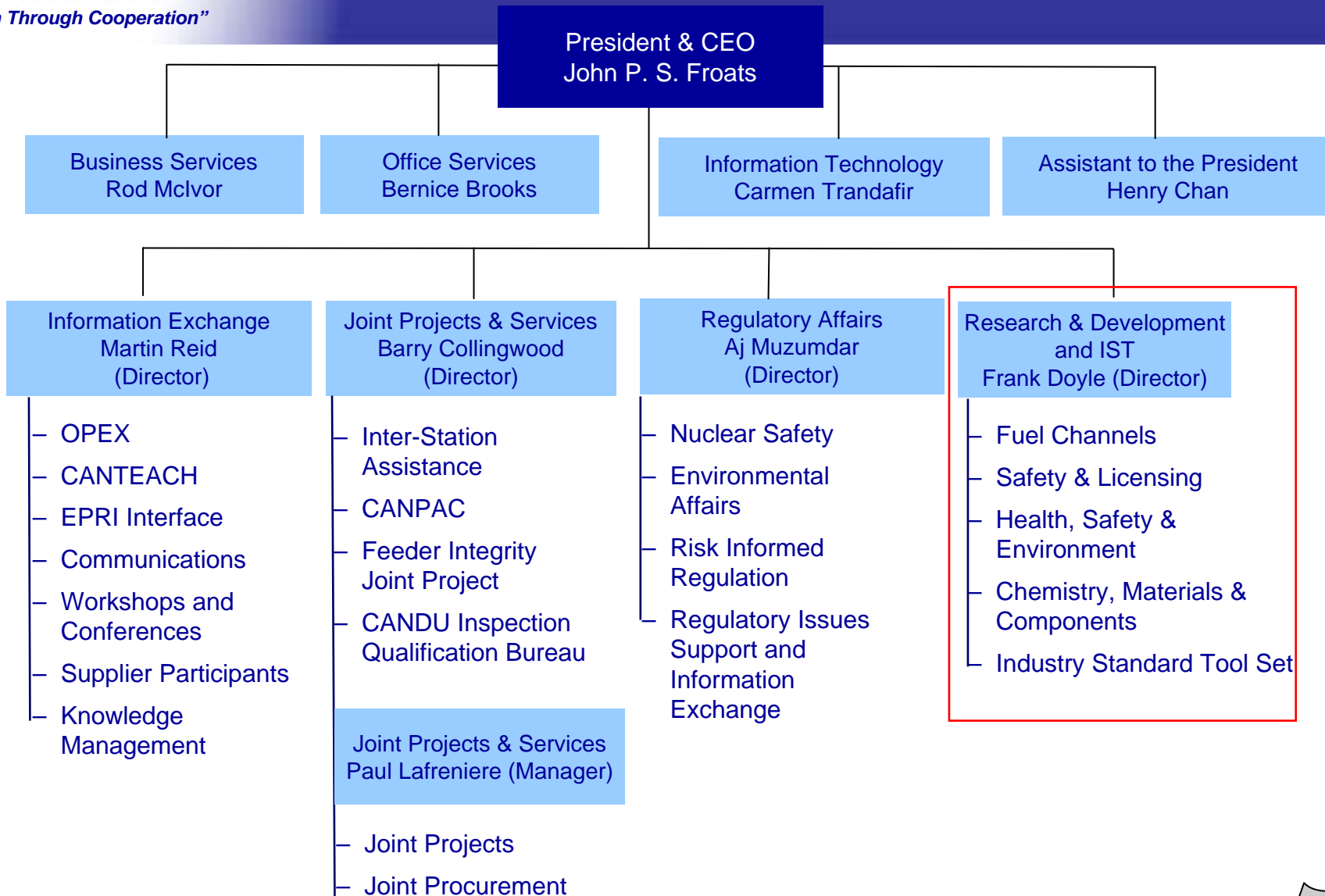


**Frank Doyle
Director,
Research &
Development**



"Strength Through Cooperation"

Program Areas





The Company

- Private *not for profit* Corporation

- President is accountable to Board of Directors
 - ◆ Paul Spekkens (OPG)
 - ◆ Gary Newman (Bruce Power)
 - ◆ Claude Drouin (Hydro Quebec)
 - ◆ Keith Stratton (New Brunswick Power)
 - ◆ Joan Miller (AECL)
 - ◆ Sorin Ghelbereu (SNN Romania)



"Strength Through Cooperation"

The Company (cont'd)

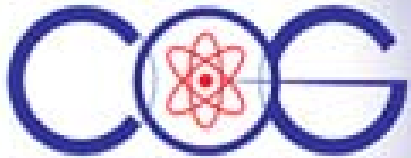
- The Board is really accountable to the Members ('shareholders')

- There are Voting Members (*) and Non Voting Members

Ontario Power Generation *	Bruce Power *
AECL *	NB Power*
Hydro Quebec *	SNN Romania *
KHNP Korea	NASA Argentina
TQNPC China	PAEC Pakistan
NPCIL India	












- There are 'Supplier Participants'

AMEC NSS Kinectrics B&W CAMECO CPUS



“Strength Through Cooperation”

CANDU Reactors in the World

COG Members	Operational Units	Laid-up Units	Units under Construction/Refurbishment
	6		2
	1		
	1		
	10	2	
	1		
	1		1
	4		
	2		
	13		5
	1		
	NRU research reactor		2 MAPLE isotope production reactors
TOTAL	41	2	10



Interfaces / Linkages

■ WANO

- ◆ Weekly OPEX review
- ◆ Potential to be CANDU contact for performance measures
- ◆ Some joint initiatives

■ NEI

- ◆ Some common interests / issues

■ EPRI

- ◆ Hold a Canadian CANDU licence
- ◆ Work closely to avoid duplication and influence programming

■ CNSC

- ◆ Facilitate Member / CNSC discussion & alignment
- ◆ Present when capable and asked – with a Member

■ IAEA

- ◆ Limited at the moment – looking at OPEX / contribution to International Standards alignment

■ CSA

- ◆ Produce 'seed documents' for standards and assist CSA in work programming (to align with Member needs)



COG R&D GOAL

- COG's R&D Goal is to assist participating Members to achieve excellence in the safety, reliability and economic performance of their CANDU stations worldwide by initiating and managing jointly funded R&D

- COG R&D
 - ◆ addresses current and emerging operating issues to support the safe, reliable and economic operation of CANDU reactors

 - ◆ is sponsored by Ontario Power Generation, Bruce Power LP, New Brunswick Power Nuclear, Hydro Québec, SNN-SA (Romania), and by Atomic Energy of Canada Limited



R&D Program Overview

■ Chemistry, Materials & Components

- ◆ addresses a diverse range of CANDU reactor operating and maintenance issues that impact the economics and reliability of a station and may shorten its operating life

■ Fuel Channels

- ◆ addresses the need to improve confidence in the fitness-for-service of CANDU pressure tubes
- ◆ develops industry standards for pressure tube integrity

■ Safety and Licensing

- ◆ addresses issues relating to the safety design basis and safe operating envelope of existing facilities
- ◆ focuses on the resolution of outstanding generic safety and licensing issues



R&D Program Overview

■ Health, Safety and Environment

- ◆ Addresses issues related to radiation monitoring and dosimetry, including the establishment of the risks of radiation exposure
- ◆ Addresses regulatory aspects of ecological impact, emission reduction and techniques for monitoring emissions and the environment

■ Industry Standard Toolset

- ◆ Is a consolidation of the validation, development and maintenance activities on different computer codes used for the design, safety analysis and operational support of CANDU reactors



Top 4 Issues for COG R&D

- **Plant Aging and Life Cycle management:**
 - ◆ SGs, FCs, Feeders, Other carbon steel components
 - ◆ Operating margins

- **Complete R&D to close regulatory actions (GAIs) and to address emerging safety issues**

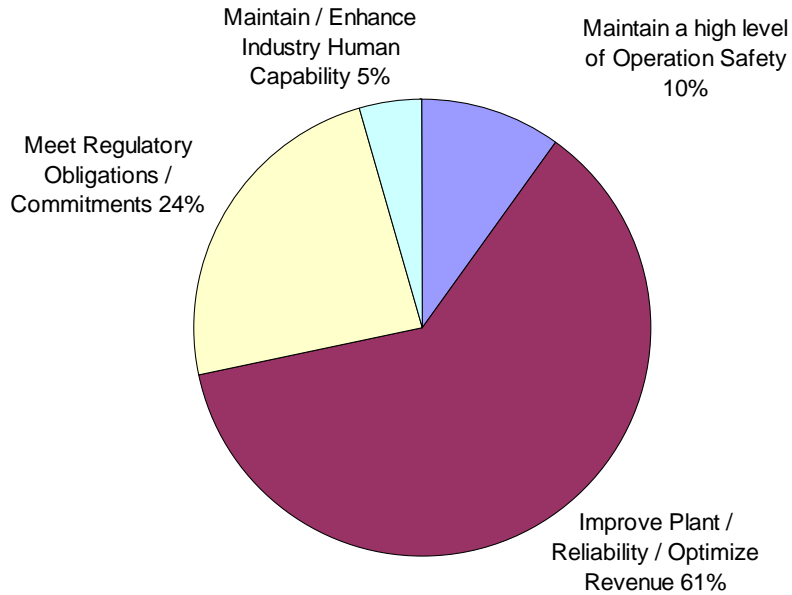
- **Maximize value for COG's Members by doing the right R&D, on time and on budget (includes utilizing national and international R&D programs to leverage COG R&D)**

- **Contribute to the maintenance of CANDU-specific R&D technical response capability**

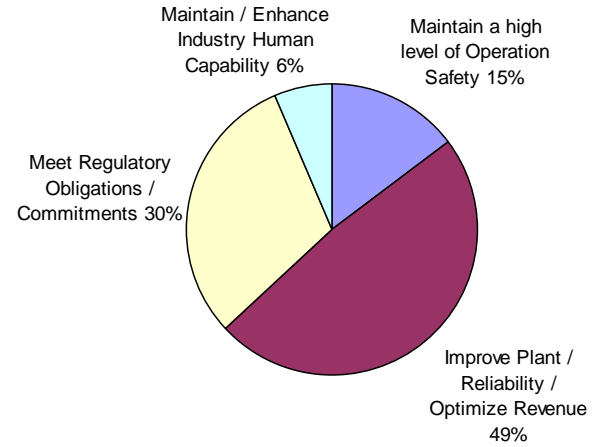


Business Drivers

COG Strategic Drivers Alignment to Business Drivers



COG R&D Strategic Drivers Alignment to Business Drivers



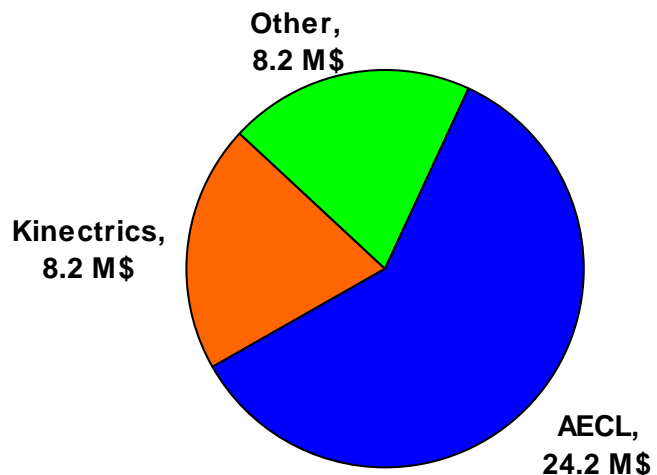


Canadian Nuclear R&D Program Overview 2008/09

R&D Funding

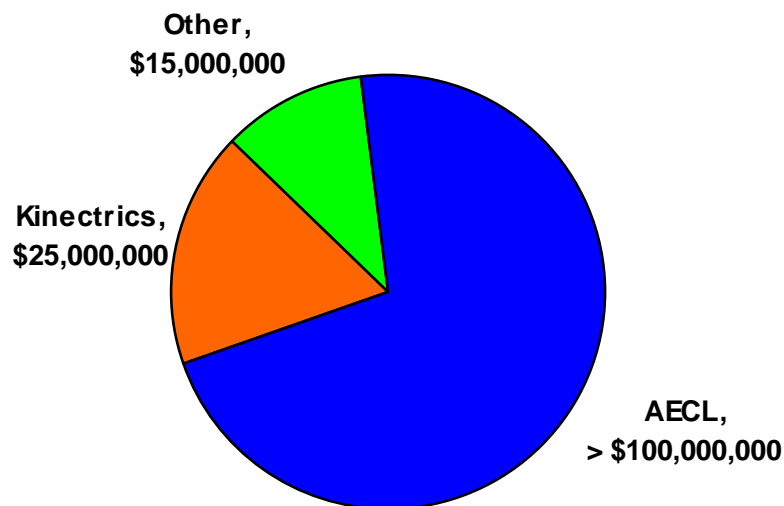
COG Funded

40.6 M\$



Total Funding

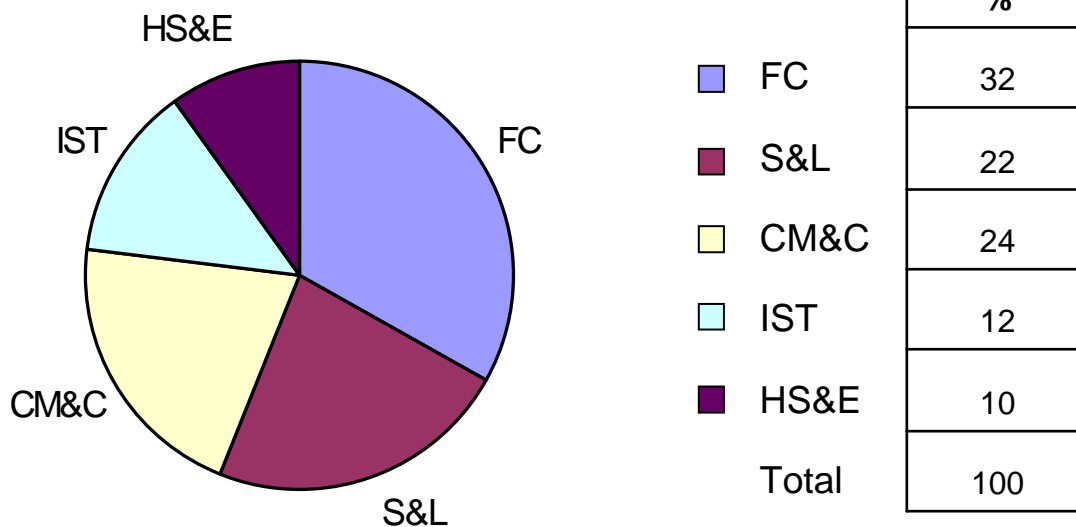
>140 M\$





COG R&D Program Overview

COG R&D FUNDING DISTRIBUTION

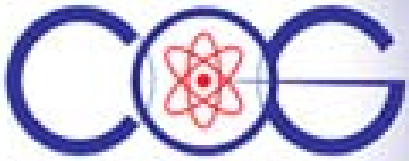




R&D Funding

R&D Funding (In Thousands of Dollars Canadian)

Program/ Year	FC	CM&C	S&L	IST	HS&E	COG	Total
2003/04	9,058	5,680	8,839	0	2,475	1,478	27,530
2004/05	10,146	6,218	9,091	0	2,607	1,727	29,789
2005/06	9,964	6,320	7,271	3,138	2,839	1,783	31,315
2006/07	10,326	6,565	7,216	4,248	2,982	1,866	33,203
2007/08	12,385	10,816	8,215	4,855	3,307	2,027	41,605
2008/09	12,321	9,329	8,340	4,833	3,692	2,103	40,619
2009/10	11,929	9,471	8,637	4,880	4,285	2,334	41,536



R&D Strategic Plans & Capability Maintenance

■ Strategic Plans

- ◆ COG-07-9006 (R&D)
- ◆ COG-06-9206 (S&L)
- ◆ COG-06-9406 (CM&C)
- ◆ COG-08-9102 (FC)
- ◆ COG-08-9306 (HS&E)

■ Capability Maintenance

- ◆ COG-09-9000



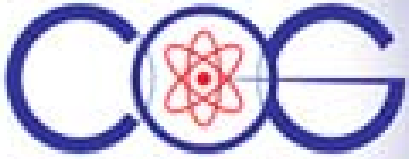
Annual Report & Operational Plans

■ R&D Annual Report 2008/09:

- ◆ COG-08-9007

■ Operational Plans 2009/10:

- ◆ COG-09-9105 (FC)
- ◆ COG-09-9205 (S&L)
- ◆ COG-09-9305 (HS&E)
- ◆ COG-09-9405 (CM&C)
- ◆ COG-09-9505 (IST)



Value of Investment in COG R&D

- **Leveraged Investment: e.g. Single unit C6**
 - ◆ 2.7 M\$ yearly investment gains access to 40M\$ R&D Program
 - 15:1 ratio
 - 86% utilization of R&D outcomes (7 year average)

- **Anticipated Business Impacts:**
 - ◆ Access to knowledge to manage plant aging, extend plant life, e.g.:
 - Fuel Channels
 - Steam Generators
 - Carbon Steel piping (including feeders)
 - Other components and structures
 - ◆ Access to Licensing related R&D and updated IST Codes
 - ◆ Knowledge Management:
 - More than 7000 COG R&D Reports on the COG Website



- R&D Program Examples
- Program Highlights



R&D Examples Featured in COGNIZANT

- Hydrazine Removal from Boiler Water
- Mapping Corrosion for SG Tube Alloys
- Long term Durability of Concrete Repair Material
- TRUSTIE for UT Inspection of SG Tubes
- UT Tubesheet Cleaning
- Activity Transport in the HT System
- Valves-Hardfacing
- Ultrasonic Cleaning System for Crud Removal
- Management of Component Fatigue
- The Impact of Magnetite Deposits on SG Inspections
- Flow Accelerated Corrosion in the Primary Heat Transport System Large Bore Piping
- Molten Fuel Moderator Interaction Program
- New Intermediate Level Tritium Suit



R&D Summary Highlights

- Enhanced experimental data in Safety and Licensing (S&L) Program
- Validation, Verification and Maintenance of Industry Standard Toolset (IST) Program
- Enhanced experimental data in Fuel Channel (FC) Program
- Testing and development in Chemistry, Materials & Components (CM&C) Program
- Development and Assessments in Health, Safety & Environment (HS&E) Program



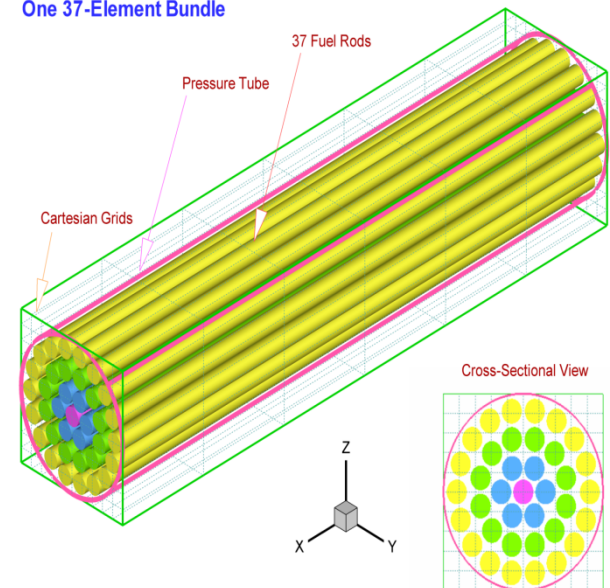
Program Highlights – S&L

Enhanced experimental data in Safety and Licensing Program

■ Supports licensing basis, analysis tools and methodology

- ◆ Testing modified 37-element fuel bundle with smaller diameter fuel centre element to demonstrate enhanced dryout power
- ◆ Fuel Fitness-for-Service tests (Crossflow; Fuel Return to Service after Intermittent Flow)
- ◆ State-of-the-Art Reports (Current State of Knowledge on Void Reactivity Error; State-Of-The-Art Report on Fuel Channel Integrity)
- ◆ 28-Element Critical Heat Flux Work used in Licensing Submission to Support Returning Pickering A to 100%FP
- ◆ Improved methodology and supporting software for identifying the location of defective fuel in-core
- ◆ Supporting Strategy of Rod Based GSS

Three-Dimensional View of GOTHIC Grids and Blockages for One 37-Element Bundle





Program Highlights - S&L

- **MFMI: completion of the Third Corium Test in the Molten Fuel In Moderator Interaction Facility**
 - ◆ no steam interaction occurred
 - ◆ analysis of results in progress
 - ◆ appears successful – needed for GAI closure

- **37 Element CHF Testing at Stern Laboratories**
 - ◆ breakthrough results have the potential to reduce or resolve the HTS ageing effects on operating power / trip margins

- **GAI 88G02 Closure**
 - ◆ CNSC closed the oldest GAI - hydrogen behaviour in containment
 - ◆ COG R&D program a major factor in resolution:
 - ◆ PARs laboratory and in-situ testing
 - ◆ development & validation of GOTHIC – IST



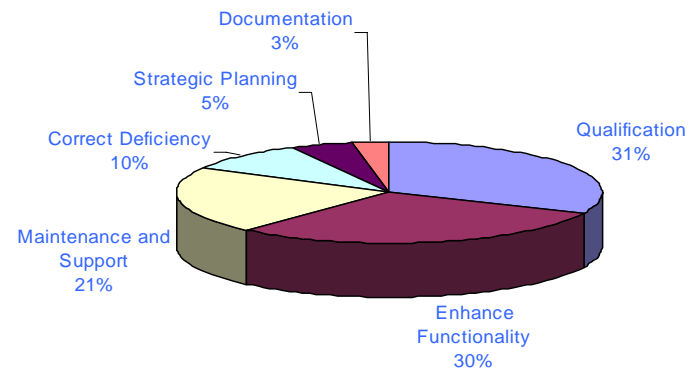
"Strength Through Cooperation"

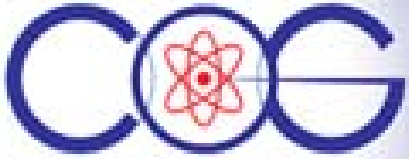
Program Highlights - IST

Validation, Verification and Maintenance of Industry Standard Toolset Program

- Promotes consistent licensees' positions with the use of a single set of codes
- Eliminates duplication of effort and makes better use of scarce resources
- Strategic planning reports produced for both the physics and thermalhydraulic safety analysis code sets

◆ These reports integrate industry needs, the state of the art and other key considerations to articulate a vision for code development and provide a basis for recommending the strategic direction for development/acquisition of the next generation codes to be used by the CANDU industry

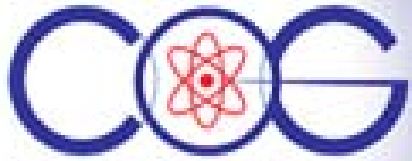




"Strength Through Cooperation"

Program Highlights - IST

- A revised version of the IST Agreement has been implemented
- The CSA has produced a draft Guideline for the application of N286.7-99, "Quality assurance of analytical, scientific and design computer programs for nuclear power plants". This guideline is based on a COG Report produced by a team sponsored by the IST Steering Committee
- Strategic plans have been completed for the reactor physics, thermalhydraulics, and containment areas of the IST program. These plans call for establishment of enhanced next generation toolsets

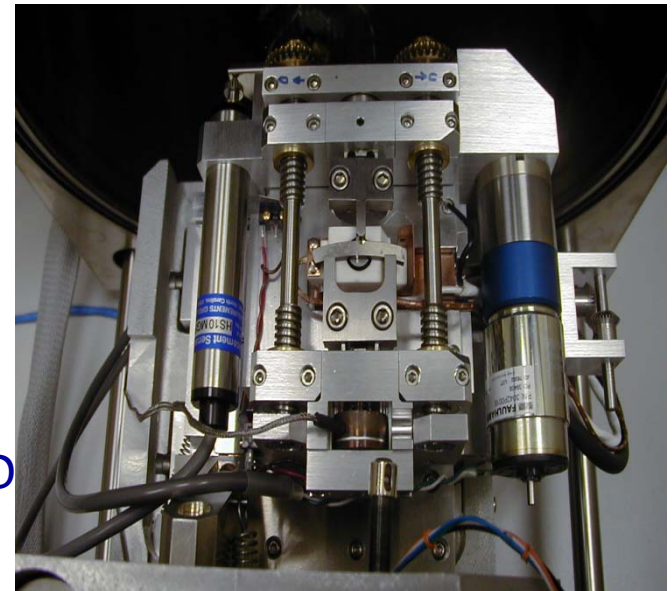


Program Highlights - FC

Enhanced experimental data in Fuel Channel Program

- Supports understanding of aging and damage mechanisms
 - ◆ Initiated a number of projects to determine the fracture toughness of pressure tube material at EOL high hydrogen concentrations

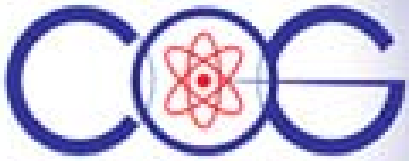
- Supports Fitness for Service and CSA Standard
 - ◆ CANMET Review Team (acting as technical reviewers for CNSC) have, in their preliminary conclusions, accepted a number of less restrictive methodologies for in-service flaw evaluation
 - Expected result is relaxed restrictions on number of reactor Heatup/Cooldown cycles
 - Achieved through work under the COG R&D Fuel Channels Program





Program Highlights - FC

- High rate of utilization of the FC Program deliverables
 - ◆ Each one incrementally adds to the development of the new FFSG
- The main focus of the program is to address crack initiation
 - ◆ Progress in removing the CNSC restrictions on the use of the Process Zone Model for flaw disposition
- Projects to address Fracture Toughness at End of Life hydrogen concentrations have been initiated
 - ◆ Techniques to increase hydrogen concentration without removing radiation damage are under development
- Improvements to the Rolled Joint Deuterium Ingress Model are in progress
- Deformation addresses aspects to avoid blister formation and the correlation between hydrogen ingress and deformation rates



Program Highlights – CM&C

Testing and development in Chemistry, Materials & Components Program

■ Supports optimized chemistry and improvements in material specifications and testing enhancements to support long term plant operation

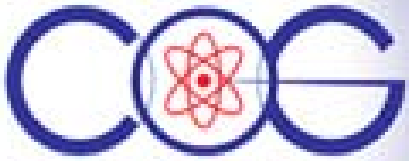
- ◆ Pipe Freezing Technology Handbook for Feeders
- ◆ Hardfacing Application Guidelines for CANDU Valves
- ◆ Rationale and Technical Basis for Optimizing Hydrazine Use in the Steam Cycle of Nuclear Power Plants
- ◆ Organic Material Containment Boundary Issues – Condition Monitoring, Repair and Procedures Interim Report
- ◆ Further Assessment of Pb-Based Catalyst for De-oxygenation of Stator Cooling Water
- ◆ CHECWORKS Primary Side Flow Accelerated Corrosion Models for Nuclear Generating Stations





Program Highlights - CM&C

- Successful completion of SG Sludge Removal tests at DEI with ASCA (SG Sludge conditioner) combined with UEC (Ultrasonic Energy Cleaning) in a Bruce SG Mock-up
- Completion of testing on a macroporous resin for improved colloidal cobalt removal from the HTS
- Qualification of MOV Long Life grease for valve stems has been completed
- The AECL enhanced electric cable indenter is undergoing final laboratory testing, and is ready for preliminary field tests at Pt. Lepreau
- Feeder Bend Testing Project Phase 3 – three successful destructive tests have been completed this year



Program Highlights – HS&E

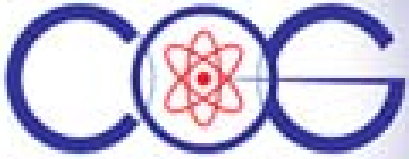
Development and Assessments in Health, Safety & Environment Program

- Improved source term understanding, dosimetry interpretation, emission and rad waste reduction
 - ◆ Dose Reduction Methods at the Reactor Face
 - ◆ Waste Reduction Options for Contaminated Equipment
 - ◆ Personal Protective Equipment Improvements

- Improved environmental assessment models and methodologies, including support for CSA standards
 - ◆ Guidance for Ecological Risk Assessment
 - ◆ Methodology for Ecological Baseline Characterization



Belt packs for wireless communication test system



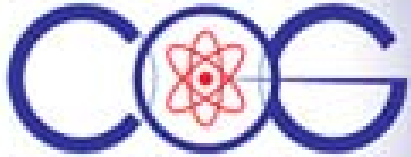
Program Highlights - HS&E

- CSA 288.1 re-issued based on COG seed documentation
 - ◆ This is the first standard developed under the new regime of using COG reports on industry "best practice" as seed documents to update CSA standards in collaboration with other stakeholders

- Methodology completed to determine Uncertainty Estimate for Airborne and Liquid Radioactive Effluents at CANDU Stations
 - ◆ Will now be applied in a detailed "how to" manner for an example utility

- A wireless communication system for use in protective clothing has been developed and successfully tested at Darlington

- Several State of the Art Reports have been produced this year



Role of COG R&D in Capability Maintenance



Introduction

- One of COG R&D's strategic drivers is to help enable current and future R&D capability of the Canadian nuclear industry to provide continuing support for safe and reliable CANDU reactor operation.
- Commitment to carry out periodic assessments and provide an update report to the CNSC every 3 years.
 - ◆ Reports provided in 2000,3,6,9



Background

Capability Maintenance Report:

- Assesses infrastructure (facilities and expert staff) of all five COG R&D Programs
- Level of detail significantly expanded to address issues raised by the CNSC



CM Report Scope

- Identify R&D capabilities and facilities to be maintained in the long term for:
 - ◆ Fuel Channels
 - ◆ Safety & Licensing
 - ◆ Health, Safety & Environment
 - ◆ Chemistry, Materials & Components
 - ◆ Industry Standard Toolset Programs
- Summarize contributions to CM from outside resources
 - ◆ Universities, international programs, etc.
- Describe COG and supplier initiatives aimed at workforce renewal and knowledge management.



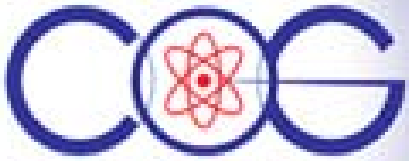
COG R&D Suppliers

- Major suppliers:
 - ◆ Atomic Energy of Canada Limited (AECL)
 - ◆ Kinectrics
 - ◆ AMEC NSS
 - ◆ Stern Laboratories (SL).
- Suppliers contribute to some or all aspects of the program, namely experimental and analytical R&D, and code development, qualification and maintenance.
- Other organizations with specialized capabilities used on an as-needed basis.



SOTARs, Guidelines and Workshops

- Preservation of expert knowledge required to train future expertise
- Limited number of experts with thorough knowledge in important areas
- SOTARs provide condensation of expert knowledge
- Guidelines & Workshops provide tools to improve design, operation, inspection & maintenance and refurbishment.
- SOTARs listed at end of presentation



Preservation of Experimental Data

- Data preservation important for model development and model/code validation
- 17 Industry Standard Toolset codes in four discipline areas
 - ◆ Containment & Severe Accidents
 - ◆ Thermalhydraulics
 - ◆ Physics
 - ◆ Fuel & Fuel Channels
- Codes are compliant with Software Quality Standard CSA N286.7-99
- Maintenance-and-support for each code



Contributions of Canadian Universities

- UNENE (University Network of Excellence in Nuclear Engineering) initiative has created 7 Industrial Research Chairs in Ontario
- Additional 7 nuclear-related chairs in Quebec, Ontario and New Brunswick.
- New nuclear science and engineering programs at University of Ontario Institute of Technology.
- UNENE-sponsored Collaborative Research and Development Program.
- Professors often retained to provide specialized contributions to individual COG work packages



University Industrial Research Chairs

■ Fuel Channels

- ◆ Advanced Nuclear Materials (Queen's)
- ◆ Risk-Based Life Cycle Management (Waterloo)

■ Safety & Licensing

- ◆ Nuclear Safety Analysis (McMaster)
- ◆ Radiation-Induced Processes in Nuclear Reactor Environments (U of Western)
- ◆ Nuclear Fuels (Royal Military College)

■ Health, Safety and Environment

- ◆ Health Physics & Environmental Safety (UOIT)
- ◆ Radiation Science (McMaster)



University Industrial Research Chairs (cont.)

- **Chemistry, Materials & Components**
 - ◆ Nano-engineering of Alloys (U of T)
 - ◆ Nuclear Engineering (U of NB)
 - ◆ Fluid-Structure Interaction (École Polytechnique)
- **Industry Standard Toolset**
 - ◆ Génie Nucléaire (École Polytechnique)
- **CANDU Design, Operation & Waste Management**
 - ◆ Control, Instrumentation & Electrical Systems (U of Western)
 - ◆ CAMECO Chair in Nuclear Fuel (UOIT)
 - ◆ Chemistry of Nuclear Fuel (U of Western)



International Collaboration

- Participate in International programs to enhance value of CANDU R&D and develop expertise
 - ◆ EPRI
 - ◆ International Atomic Energy Agency
 - ◆ Nuclear Energy Agency of the OECD
 - ◆ International Commission on Radiological Protection
 - ◆ US Department of Energy
 - ◆ United Nations Scientific Committee on the Effects of Atomic Radiation
 - ◆ International Standards Organization
 - ◆ Etc.



International Collaboration

■ EPRI Collaboration

- ◆ Radiation protection of workers
- ◆ Low-level waste treatment
- ◆ Steam generator chemistry and corrosion
- ◆ SG inspection tooling
- ◆ Valve performance

■ IAEA Collaboration

- ◆ Info. exchange on water reactor fuel performance
- ◆ Advanced nuclear fuel cycles



Summary & Conclusions

- COG R&D spending has increased
 - ◆ \$31M in 2006/07; more than \$40M in 2009/10
- Maintenance of technical response capability part of COG R&D Strategy.
 - ◆ CM the primary driver for \$2.1M in 2009/10 Program
- Many experimental facilities are getting old and some programs underway for refurbishment or replacement.
- The CM review in 2009 was more extensive in response to CNSC issues
- Industry is doing a good job of capability maintenance in the different technical areas.



Published SOTARs

■ Fuel Channels Program

- ◆ COG-05-1064: Corrosion and Deuterium Ingress in CANDU Pressure Tubes
- ◆ COG-07-1042: Corrosion and Deuterium Ingress at Rolled Joints in CANDU Pressure Tubes
- ◆ COG-07-1046: SOTAR on Contact Prediction
- ◆ COG-05-1049: SOTAR on Pressure Tube Fracture Toughness

■ Safety & Licensing Program

- ◆ COG-07-2091: Recent Contributions to the Current State of Knowledge on Coolant Void Reactivity Error
- ◆ COG-00-214: Experimental Program on Moderator Subcooling Requirements to Maintain Fuel-Channel Integrity Following Ballooning Contact.
- ◆ COG-07-2075: SOTAR on Fuel Sheath Oxidation And Embrittlement in LBLOCA
- ◆ COG-00-246: SOTAR on Flame Acceleration and Deflagration to Detonation Transition



Published SOTARs (continued)

■ Safety & Licensing Program (cont.)

- ◆ COG-02-2046: SOTAR on Iodine Behaviour in Containment
- ◆ COG-06-2007: SOTAR on Iodine Behaviour: Revision 1
- ◆ COG-01-194: Critical Heat Flux and Post-Dryout Heat Transfer in 37-Element and CANFLEX Bundles (SOTAR)
- ◆ COG-07-2019: SOTAR on Freon Modelling of Critical Heat Flux and Post-Dryout Heat Transfer in 37-Element Bundles
- ◆ COG-02-2053: Parameters Related to Pressure Drop Calculations in 37-Element Bundles (SOTAR)

■ Health, Safety and Environment Program

- ◆ COG-07-3099: Refreshing the Institutional Memory of Historical Fisheries Work (SOTAR)



Published SOTARs (continued)

■ Chemistry, Materials & Components Program

- ◆ COG-05-4008: Hydrazine Addition to the CANDU HTS During Outages and Startup (SOTAR)
- ◆ COG-08-4009: Reduction of Total Organic Carbon in Heavy Water for Improved Upgrading (SOTAR)
- ◆ COG-02-4022: Radiation Chemistry Manual, Revision 1
- ◆ COG-05-4019: Assessment of Decontamination Processes for Decommissioning of CANDU Reactors
- ◆ COG-05-4023R1: Summary Of Inspection Capabilities For 12.7 mm Diameter Monel 400 Tubing
- ◆ COG-05-4026: Summary of Inspection Capabilities for 12.9 mm Diameter Inconel 600 Tubing
- ◆ COG-05-4027R1: Summary of Inspection Capabilities For 15.9 MM Diameter Incoloy 800 Tubing



Published SOTARs (continued)

■ **Chemistry, Materials & Components Program (cont.)**

- ◆ COG-07-4046: Review of Physical Phenomena Important to ECC Recovery Operation
- ◆ COG-05-4051: Strategic Direction - Concrete and Containment
- ◆ COG-06-4042: Organic Material Containment Boundary Issues – Condition Monitoring, Repair and Procedures
- ◆ COG-07-4057R1: Hardfacing Application Guidelines for CANDU Valves
- ◆ COG-06-4056: Pipe Freezing Technology Handbook for Feeders



“Strength Through Cooperation”

Demand/Supply of S&L R&D Expertise

EXPERTISE	DEMAND			SUPPLY			COMMENTS
	AECL (FTE's)	AMEC NSS (FTE's)	Stern (FTE's)	AECL (FTE's)	AMEC NSS (FTE's)	Stern (FTE's)	
Fuel Channel Behaviour: Accident Conditions	4	0.5	2	2 (Yellow)	5 (Green)	4 (Green)	Includes high-temperature contact boiling experiments, small-scale flow blockage experts.
Containment Thermal hydraulics	3	3	N/A	3 (Green)	6 (Green)	N/A	Increasing involvement in international programs
Hydrogen Combustion Behaviour	1	2	N/A	1 (Green)	4 (Green)	N/A	
Iodine Behaviour	2	0.25	N/A	2 (Green)	2 (Green)	N/A	
Aerosol Behaviour	1	0	N/A	1 (Green)	2 (Green)	N/A	
Fission Product Behaviour	2	0	N/A	2 (Green)	2 (Green)	N/A	Singleton experimental expertise a concern



Demand/Supply of S&L R&D Expertise

EXPERTISE	DEMAND			SUPPLY			COMMENTS
	AECL (FTE's)	AMEC NSS (FTE's)	Stern (FTE's)	AECL (FTE's)	AMEC NSS (FTE's)	Stern (FTE's)	
Fuel Design, and Manufacturing Processes	20	6	10	10 (Red)	4 (Yellow)	14 (Green)	New hiring and mentoring AECL demand growth due to International Work
Fuel Testing/ Performance Assessment	30	N/A	2	20 (Red)	N/A	1 (Yellow)	Stern demand growing due to ACR and modified 37-Element fuel bundle.
Fuel Behaviour (Accident Conditions)	3	1	0	2 (Yellow)	4 (Green)	2 (Green)	Mentoring and knowledge transfer is ongoing
Fuel Modeling under Accident Conditions	4	0.5	N/A	2 (Yellow)	5 (Green)	N/A	
Reactor Physics experimental	10	N/A	N/A	8 (Yellow)	N/A	N/A	
Reactor Physics modeling and analysis	28	6	N/A	28 (Green)	10 (Green)	N/A	Does not include 40 at AECL-SP on Physics analysis.
TH Experiments	16	N/A	14	15 (Yellow)	N/A	18 (Green)	90% of demand outside COG
TH modeling and analysis	7	6	1	5 (Yellow)	20 (Green)	2 (Green)	



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Example of Facility Availability for S&L R&D

Facility Description	Facility Availability Rating			Comments
	Short Term (0-3 y)	Medium Term (4-10 y)	Long Term (10+ y)	
NRU Research Reactor	Green (G)	Yellow (Y)	Red (R)	Ongoing major effort to keep NRU going
Hot Cells	Yellow (G)	Red (Y)	Red (Y)	Current Fuel Materials Cells in serious disrepair. Transfer of some work to Universal Cells is planned. New hot cells to be operational within 10 years to restore capability.
U-1, U-2 Loops in NRU	Red (G)	Red (Y)	Red (R)	Have been unavailable for 2 years. Need upgrades and re-licensing
ZED-2 Research Reactor	Green (G)	Yellow (Y)	Yellow (W)	ZED-2 aging not an issue. ACR funding in place for 3 y. After that the demand is uncertain
Recycle Fuel-Fabrication Laboratory	Green (G)	Yellow (G)	Red (G)	Currently operational for ACR-MOX fuel fabrication. Old facility that is difficult to maintain. No work identified in medium and long term. To be replaced by new facility in new Active CA2 Laboratory within 5 years.



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