Industrial Involvement in the Construction of Synchrotron Light Sources

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Introduction

• Large demand for synchrotron light sources
  – Completed in past few years:
    • BESSY II, SLS, CLS, SPEAR III
  – Under construction:
    • DIAMOND, SOLEIL, SESAME, Australia, Spain, China

• Many newer sources are “green field”
  – No major national laboratory for support
  – Little pre-existing infrastructure
  – Small design teams
  – Little experience amongst team members
  – Greater reliance on industrial involvement and support
CLS Example

• CLS Project approved on 1999 March 31
  – 140.9 M $C to construct:
    • 2.9 GeV booster and third-generation storage ring
    • at least six beamlines
  – Only 22 staff at the start of the project, including:
    • 2 accelerator physicists
    • 1 mechanical engineer
    • 1 electrical engineer
    • 4-person group for IT, controls, diagnostics
    • 2 scientists

• Challenge:
  – Complete facility in ~ five years
  – Increase technical staff to ~60
  – Build organization for operations and future R & D

• Review industrial involvement through major CLS contracts
  – Examine issues and challenges
  – Determine “lessons learned”
Status – 1999 June 15
Major Contracts – Project Services

- **Canadian Light Source Inc.**
  - Not-for-profit corporation controlled by U. of Saskatchewan
    - Permits independent policies and management
  - Responsible for:
    - Overall management and operation
    - Liaison with users, 14 capital funding and 4 operating funding partners
    - Technical design of accelerators, storage ring and beam lines
    - License from Canadian Nuclear Safety Commission

- **UMA Management Services**
  - Day-to-day project and construction management
  - Design and Engineering of conventional facilities (building and services)
  - Additional technical design and engineering support as needed

- Formed an effective joint project team
Major Contracts - Strategy

• For accelerator systems:
  – Reduce detailed design as much as possible
    • Proceed with design only far enough to ensure feasibility
    • Functional and performance specifications only
  – Retain responsibility for:
    • Supervisory control
    • Machine protection
    • Personnel protection systems
  – Suppliers to perform as much testing as possible

• For beamlines and insertion devices:
  – Develop some beamline design capability
  – Develop room-temperature ID design and construction capability
Major Contracts - Booster

• First major technical contract awarded to Danfysik
  – CLS supplied nominal lattice design
  – Used to validate cost estimates for storage ring
  – Forced development of facility standards and guidelines
  – Allowed CLS staff to focus on storage ring system design
  – “Turn-key” System included:
    • All magnets supplied, pre-aligned on girders
    • All power supplies
    • RF system
    • Vacuum chambers
    • Diagnostics
    – Included installation supervision and commissioning assistance
    – Supply excluded control system, vacuum pumps

• Awarded in 2000 January
• Installation complete in 2002 July
• Commissioning tests complete in 2002 September
Booster Extraction Area
Major Contracts - IT

- **EDS Canada supplied:**
  - redundant network and server backbone for **all** data and communications including:
    - Office, control and beamline networks (VLANs)
    - Voice-over-IP telephones
  - **IT architecture:**
    - Guidelines and recommendations for future IT expansion
    - Analysis of CLS IT requirements

- **External Review Committee to monitor contract**
  - Valuable comments from expert reviewers

- **Difficult contract scope**
  - Few CLS management processes had clear IT needs
  - User requirements very difficult to determine so early in project
Major Contracts – Magnets and Power Supplies

• Magnets
  – Developed a magnet measurement laboratory
    • Primarily to support ID development
    • But supplies must measure all accelerator magnets
    • Can be rechecked at CLS, if necessary
  – Dipole magnets (TESLA)
    • Measurements done in Barcelona
  – Quadrupole and Sextupole magnets (Sigma-Phi)
  – All magnets within specifications

• Power Supplies
  – Programmable DC for storage ring magnets (IE Power)
  – Pulsed supplies and magnets (Danfysik)
Storage Ring Sector
Major Contracts – RF System

• Early decision to change to Superconducting RF
  – Determined frequency (change to 500 MHz)
  – Availability of cavity suppliers

• Cavity (ACCEL)
  – Single cavity (+spare) based on 500 MHz Cornell design
  – Includes cold valve box and instrumentation

• 300 kW RF Amplifier (Thales)
  – Turn-key system: power supply, klystron, circulator and loads

• Cryoplant (Linde)
  – >250 W cooling at 4.4 K

• CLS is first light source to use SRF storage ring acceleration!
  – Operations support part of responsibility of two technicians
  – CLS only provided waveguide and low-level RF control
Superconducting RF Cavity
Major Contracts - Vacuum

• Vacuum pumps and controllers (Varian)
  – Single supply contract for the entire facility
  – Negotiate standard prices for all procurement
  – CLS supplies pumps and controllers to all contractors

• Storage ring vacuum chambers (FMB)
  – Based on BESSY II and SLS design
  – Installation by local construction contractors under CLS supervision
Major Contracts - Beamlines

- Insertion devices
  - 4 designed and assembled in-house
    - Two PPM, one hybrid in-vacuum SGU, one EPU
    - Support structures by ADC (PPM+EPU) and RMP (SGU)
  - Superconducting multi-pole wiggler (BINP)
- Front-ends based on APS design (Johnsen Ultravac)
- Seven beamlines
  - 2 IR beamlines
    - spectrometers (Bruker) and optical chicane (ADC)
  - Five x-ray beamlines
    - Two turn-key (IDT+Koizu, ACCEL)
    - Two functional specification of components (Jobin-Yvon, Oxford Danfysik, and McPherson)
    - One build-to-print (Johnsen Ultravac) based on ALS design
Issues and Challenges - 1

• Project management view: scope, cost and schedule
• Scope:
  – Need “standard” scope for technical specifications
    • Availability of good sample technical specification important
    • no “bonus points” for originality in specifications
  – Need design standards and guidelines very early in project
    • Difficult with new or inexperienced staff
  – Desirable to have at least 3 bids
    • Can determine scope of major tenders
• Cost:
  – Importance of competitive bids
    • Typically factor of two or more in price if 3 or more bids for design-build tenders
    • Restrictive tendering practices will increase cost
  – Frequently used fixed price + incremental rates for most labour contracts
  – Competent installation labour will challenge design team to keep ahead
Issues and Challenges - 2

• Schedule:
  – Most design-build contracts arrived late
    • 10 major CLS accelerator contracts
      – 8 deliveries were late by between 5 and 8 months
    • Overall project schedule needs to allow for this possibility
      – CLS targeted all contracted deliveries by end of 2002
    • Approximately ¼ to 1/3 of delay was due to CLS
    • **Delays CANNOT be used to justify other schedule slippage**
      – Control of scope and design changes essential
        • Need engineering change control
        • New staff often unfamiliar with process
      – Used bonus-penalty contract for two smaller contracts - effective

• Communications (internal and external):
  – Need good tracking of issues raised and their resolution
  – Plan on 3 – 5 face-to-face meetings over contract duration
  – Use weekly teleconference with email of issue-tracking form
  – Difficult to reduce internal delays when contractor questions arise
2003 December

- SUCCESS: 10 mA Stored beam in “C L S” fill pattern
Conclusion

• Storage ring commissioning finished in 2004 May
  – Approximately six months behind original schedule
  – Cost over-run is approximately 0.05%
• Start Routine Operation in 2004 August
• I wish to acknowledge the huge contribution to our success by:
  – All CLS suppliers and vendors for their commitment to high quality work
  – University of Saskatchewan management and staff
  – UMA Engineering
  – All CLS staff