COGEMA COGEMA LOGISTICS	**Conceptual Designs for Transportation of Used Fuel to a Centralised Facility**	

Report of a Study carried out for Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited

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1. CHAPTER N° 1: INTRODUCTION

1.1. BACKGROUND AND PURPOSE

The purpose of the Used Fuel Transportation System (UFTS) is to transport all the used fuel arising from current Canadian program, consisting of approximately 3.6 million bundles, from their current storage facilities to a centralised long-term management facility (see Appendix A, Figure N°1). This facility may be a Deep Geologic Repository (DGR) or a Centralised Extended Storage (CES) facility, depending on the option chosen by federal government after the review of options required by the Nuclear Fuel Waste Act (Canada 2001). If continued storage at the current sites is chosen, then no transportation system will be required.
The UFTS will be required on a timescale dependent on the earliest in-service date projected for a centralised facility (~2023 for the CES facility; ~2035 for the DGR). Where needed in the design and logistics, the details of the shipping program applicable to the 2035 in-service date were used. For the purposes of the study, it was assumed that the centralised facility would be located somewhere in Ontario.

The UFTS study is divided in 3 phases:

- Phase 1: Conceptual design studies, including preliminary studies of the feasibility of certain transportation options,
- Phase 2: Logistics studies, including a study of the feasibility of the reference shipment schedules,
- Phase 3: Cost estimates.

The present report, is a Technical and Final Report entitled « Conceptual Designs for Transportation of Used Fuel to a Centralised Facility ». This report defines the conceptual designs and the descriptions for all components of the UFTS.

The report includes three alternative transportation systems:

- "All road",
- "Mostly rail",
- "Mostly water".

The systems will be based on one existing cask and one new cask:

Existing cask:

- OPG's Dry Storage Container Transportation Package (DSCTP)

New cask:

- Irradiated Fuel Transportation Cask for Baskets or Modules (IFTC/BM).

The UFTS will meet all regulatory requirements, and is designed for safe, efficient and cost-effective transport. The system is designed to operate under an environmental management system based on the ISO 14001 standard.

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1.3. DEFINITIONS

Basket means a sealed stainless steel container for holding used fuel, in use in the dry storage facilities at Point Lepreau, Gentilly 1 and 2, Douglas Point, Whiteshell and Chalk River **<2>**, **<7>**.

Cask means a robust, re-usable container used for transportation of highly active radioactive material such as used fuel, designed according to the requirements of CNSC's Packaging and Transportation of Nuclear Substances regulations. The cask provides containment, heat dissipation, radiation shielding, and protection of the contents in normal operation and in the case of a transportation accident. An internal structure, baskets, or module is used to constrain the fuel bundles within the cask.

Centralised Facility means a facility used for the extended storage or geologic emplacement of used nuclear fuel. The facility would be located at a single, central location and would accept used nuclear fuel from all reactor sites in Canada.

Current Storage Site means one of the seven sites shown in Appendix A, Figure N° 2 of the present document.

Loading means placement of used fuel in a transportation cask, and carrying out all draining, flushing, backfilling, sealing, bolting etc. activities needed to ensure continuation of containment, shielding and protection of used fuel.

Module means the OPG storage/transportation module used for handling and storage of used fuel at the Pickering (AIFB and dry storage facility), Bruce (dry storage facility), and Darlington sites **<1>**.

Preparation for shipment means cask decontamination, monitoring, attaching impact limiters if used, labelling and documenting,. Placing the cask on or in the transport vehicle, securing tiedowns, inspection and placarding and all other activities needed prior to release of the vehicle from the nuclear site.

Transportation package means a package designed for transportation of radioactive materials and meeting the requirements of the Canadian nuclear Safety Commission's Packaging and Transport of Nuclear Substances Regulations. The transportation package for used fuel is usually referred to a cask.

Transportation system in this document means a system for retrieving used fuel from the current storage facilities, and transporting it to a centralised site. It includes all facilities, handling equipment, test equipment, casks, vehicles, tie-down systems, maintenance provision, management provisions, emergency response provisions, communications, security, safe guards, contingency provisions, ancillary facilities, and all other items required for safe and effective functioning.

2. CHAPTER N° 2: PRELIMINARY STUDIES

2.1. EVALUATION OF OPTIONS FOR TRANSPORTATION OF USED FUEL CURRENTLY STORED IN SPENT FUEL BASKETS.

Options for transportation of used fuel currently stored in Spent Fuel Baskets as part of the Used Fuel Transportation System (UFTS) were evaluated. Fuel baskets are currently transported on site in a vertical orientation. Studies by AECL on the transportability of the baskets in the case of off-site transport are not yet complete. For the purposes of the present study, the used fuel currently stored in baskets is assumed to be transported to the centralised facility in the baskets, in a vertical orientation, within a transportation cask. The Dry Storage Cask Transportation Package, the Irradiated Fuel Transportation Cask and potential existing and new conceptual cask designs are evaluated for transportation of the baskets.

2.1.1 CONCLUSIONS

Various options for transport of used CANDU fuel currently stored in baskets have been evaluated. Based on the discussions above, the following table summarises the various options for transporting the used fuel bundles. Advantages and disadvantages for each transport scenario are also shown in the table hereafter. Transport by an used existing Transport Cask design is not listed in this table because there is no suitable existing cask.

Because the DSCTP is seal welded closed, intended for single use only, and because the DSCTP will incur excessive road transport restrictions due to its weight, the DSCTP is considered impractical for transport of the Spent Fuel Baskets.

The existing Irradiated Fuel Transportation Cask (IFTC), which is relatively light, incurring considerably less transport restrictions, and which is intended for repeated use, does not easily accommodate the Spent Fuel Bask geometry and configuration requirements.

No existing COGEMA LOGISTICS Transport cask can be readily used to transport Spent Fuel Baskets primarily because of their geometry and transport orientation.

2.1.2 RECOMMENDATIONS

Because of the arguments tabulated above, it is recommended that a modified IFTC with a slighter larger cavity size that could accommodate two (or possible three) of the larger baskets in the vertical orientation be designed and licensed. Increasing the cavity size of the IFTC represents only a small modification to the cask design, and therefore, should be easier to license than a completely new cask. Also, since the IFTC is currently licensed to transport Standard Fuel Storage Modules, the modified IFTC could be used to transport both baskets and modules, which would reduce operations and expenses. Inexpensive and lightweight aluminium inserts could be used to account for the differences in geometry between the large and small baskets and the modules.

FUEL BUNDLE PACKAGING	**TRANSPORT CASK**	**ADVANTAGES for transportation of baskets**	**DISADVANTAGES for transportation of baskets**
Fuel in Spent Fuel Baskets with fuel vertical	DSCTP	• Is currently licensed for rail or sea transport in Canada.	• Transport Cask must be rotated 90° on axis. • Only licensed for rail or sea transport. • Package weight incurs transport restrictions [**<10> - <20>**] • Difficult to load with baskets. • Can only hold two baskets. • Has seal-welded closure, intended for single use.
	IFTC	• Is currently licensed for transport in Canada. • The package is relatively lightweight and therefore incurs less highway restrictions. • With minor redesign, two large baskets could be accommodated.	• Transport Cask must be shipped horizontally, which has not been analysed or licensed. • Difficult to load with baskets. • Can only hold one basket.
	A new Cask design	• Perfectly suited to ship baskets. • Could be designed to ship both baskets and modules.	• Design, Analysis and licensing required.

2.2. FEASIBILITY STUDY FOR THE TRANSPORTATION OF THE DRY STORAGE CONTAINERS

The feasibility of transportation of Ontario Power Generation's (OPG) Dry Storage Containers (DSC) as part of the Used Fuel Transportation System (UFTS) was examined. Since work has already been done to design and license the DSCs for transport under the Dry Storage Container Transport Package (DSCTP) license, the DSCTP, instead of a new package design for protection of the DSC during transportation, was evaluated in this study. Requirements for transport, effects of DSC ageing, as well as requirements for preparing the DSCs for transport were evaluated. Advantages and disadvantages of using the DSCs as part of the UFTS are tabulated and **it is concluded that the DSCTP should be used to transport all fuel bundles stored in DSCs at the time of transport, and the remaining fuel bundles in wet storage should be transported in a lighter package such as the IFTC.**

2.2.1 CONCLUSIONS

Even though the DSCTP is currently only licensed for transport by rail or by water, only a small amount of additional analysis and licensing work would be required in order to transport the DSCTP by road.

The main disadvantage of using the DSCTP as part of the all-road UFTS is that the DSCTP is exceedingly heavy (100.31 Mg). Typical road-weight casks usually weigh less than 40 Mg (like OPG's IFTC), while the DSCTP exceeds 100 Mg. Heavy Transport Casks like the DSCTP are typically transported by rail or by water whenever possible. Based on the requirements contained in **<10>** to **<20>**, utilisation of the DSCTP for transportation would incur many transport restrictions. Vehicle type, mode, route, and season of transport are all restricted for a package of this weight.

At the time of transport, a total of 2,212,178 used fuel bundles will be stored in DSCs, and 1,062,253 bundles will still be in wet storage **<9>**. Therefore, roughly 5,761 DSCs will be loaded and in place in the Dry Storage Facilities at the various sites **<9>**.

The following table compiles advantages and disadvantages for each aspect of transportation of the DSC to a centralised facility.

	ADVANTAGES	DISADVANTAGES
Fabrication	• Does not require construction of additional Casks.	• Equipment to attach impact limiters and rotate package will be required. • A Number of sets of the Outer Packaging must be constructed.
Operations	• Does not require unloading of the fuel bundles from the seal-welded DSCs. • Roughly 2/3 of bundles will already be stored in DSCs at time of transport.	• Package must be rotated and placed into Outer Packaging.
Logistics	• Is already licensed for transport by rail or by water under the DSCTP SAR. • DSCTP can be licensed for road transport "easily".	Package weight incurs excessive road transport restrictions [**<10> - <20>**]

2.2.2 RECOMMENDATIONS

Because roughly 2/3 of all used fuel bundles produced at sites where DSCs are used for dry storage will already be stored in DSCs at the time of transport **<9>**, it would be most efficient to use these DSCs for transport of these bundles. The DSCs are currently licensed for rail and water transport under the DSCTP SAR and can be easily re-licensed for road transport. The additional work required to unload 5,761 seal welded DSCs and repackage the four modules inside each in another Transport Cask makes transport of these bundles in another package highly inefficient.

However, the 1,062,253 bundles that will still be in wet storage at the time of transport, can be loaded into any Transport Cask desired. The IFTC is currently licensed, and could readily be used to transport the fuel bundles in wet storage. Most used fuel bundles that will be in wet storage, will be stored in Standard Fuel Storage Modules, two of which can readily be loaded into a single IFTC for transport. The IFTC is a considerably lighter cask which does not incur the excessive road transport restrictions that are imposed on the DSCTP, and the IFTC is designed for repeat usage with a bolted closure which makes it operationally more efficient than the DSCTP.

If a new cask is to be designed to transport the Spent Fuel baskets then the new transport cask design may also accommodate the remaining modules left in wet storage at the time of transport. A new cask could be designed to accommodate both Spent Fuel Baskets and Standard Fuel Storage Modules, which would reduce operation time and effort, by enabling the use of common ancillary equipment and procedures.

If the Used Fuel Transportation System utilises the DSCTP, then there are also advantages to transporting the remaining fuel in wet storage in a heavy Transportation Cask like the DSCTP. Handling equipment, procedures, and necessary highway transport permits would already be in place for the DSCTP that could also be used for another heavy Transportation Cask. A larger cask has the obvious advantage of having the capacity to accommodate more used fuel. However, if rail or water transport is used, multiple smaller packages like the IFTC (which is already licensed) can be used in a single shipment essentially cancelling out the capacity advantage of a larger cask.

2.3. TRANSPORT MODE ASSESSMENT

The feasibility of transportation of used fuel from each current storage site to a centralised facility by:

- the road mode of transportation,
- the rail mode of transportation, and
- the water mode of transportation.

was investigated.

The transport of Canadian used fuel to a centralised repository – either the Deep Geologic Repository or a Centralised Extended Storage facility – is clearly feasible. The focus of forward-going analyses should therefore be on maximising the effectiveness of the used fuel transport system.

Given the geography, existing infrastructure and location of current storage sites, each of the studied modes - road, rail and water – has benefits and disadvantages when compared against specific locales.

In the present report, three alternative transportation systems are developed. The systems take account of site-specific aspects of transportation infrastructure.

2.4. DESIGN BASIS AND ASSUMPTIONS FOR THE USED FUEL TRANSPORTATION SYSTEM

2.4.1 CURRENT STORAGE SITES

The reactor sites where used fuel is currently stored in Canada are (see Appendix A, Figure N° 2 of the present document):

- Whiteshell Laboratories
- Bruce
- Pickering
- Darlington
- Chalk River Laboratories
- Gentilly
- Point Lepreau

2.4.2 REACTORS

For the Current Storage Site of (see Appendix B, Tables N° 1 to 3 of the present document):

- Whiteshell Laboratories the fuel is from the Douglas Point reactor (experimental fuel stored at Whiteshell is not included in the scope of the present study),
- Bruce the reactors are Bruce A, Bruce B and Douglas Point,
- Pickering the reactors are Pickering A and Pickering B,
- Darlington the reactor is Darlington,
- Chalk River Laboratories the fuel is from the Nuclear Power Demonstration reactor (experimental fuel stored at Chalk River is not included in the scope of the present study),
- Gentilly the reactors are Gentilly 1 and Gentilly 2,
- Point Lepreau the reactor is Point Lepreau.

All these reactors are CANDU type (Appendix A, Figure N° 3), designed by Atomic Energy Canada Limited (AECL). The Used Fuel belongs to different waste owners.

2.4.3 WASTE OWNERS

The waste of the reactors of Pickering A and B, Bruce A and B, Darlington belongs to **Ontario Power Generation (OPG)**.
The waste of the reactors of Gentilly 2 belongs to **Hydro Québec**.
The waste of the reactors of Douglas Point, Nuclear Power Demonstration, Gentilly 1, Chalk River and Whiteshell belongs to **Atomic Energy of Canada Limited (AECL)**.
The waste of the reactor of Point Lepreau belongs to **New Brunswick Power (NBP)**

This is illustrated in Appendix B, Tables N° 1 to 3 of the present document issued of **<1>**.

2.4.4 FORMS OF STORAGE

Five forms of storage are existing:

- Baskets in Silos,
- Baskets in CANSTORS,
- Trays in wet bays,
- Modules in wet bays,
- Modules in DSCs.

Modules in wet bays and trays in wet bays are wet storage.
Modules in DSCs, baskets in silo, canisters and baskets in CANSTOR vaults are dry storage.

The forms of storage per site/reactor/facility are given in Appendix B, Tables N° 1 to 3 of the present document.

2.4.5 FACILITIES OF REACTORS AT THE TIME OF TRANSPORTATION

Facilities are given on Appendix B, Tables N° 1 to 3 of the present document:

The waste of **Pickering A and B** will be stored at:
Pickering A and B Facility for Modules in wet bays,
Pickering Used Fuel Dry Storage Facility for Modules in DSCs.

The waste of **Bruce and Douglas Point** will be stored at:
Bruce B Facility for Trays in wet bays,
Western Used Fuel Dry Storage Facility for Modules in DSCs,
Douglas Point Facility for Baskets in Silo canisters.

The waste of **Darlington** will be stored at:
Darlington Facility for Modules in wet bays,
Darlington Used Fuel Dry Storage Facility for Modules in DSCs.

The waste of **Gentilly 1 and 2** will be stored at:
Gentilly 1 Facility for Baskets in Silo canisters,
Gentilly 2 Facility for Baskets in CANSTOR vaults.

The waste of **Point Lepreau** will be stored at:
Point Lepreau Facility for Baskets in Silo canisters.

The waste of **Chalk River** will be stored at:
Nuclear Power Demonstration (NPD) fuel Facility for Basket in Silo canisters.

The waste of **Whiteshell** will be stored at:
Douglas Point Fuel Facility for Baskets in Silo canisters.

2.4.6 TRANSPORTATION CASKS

The systems will be based on one existing cask and one new cask:

Existing cask:

- OPG's Dry Storage Container Transportation Package (DSCTP – see Chapter 2, section 2.4.7.2.3)

New cask:

- Irradiated Fuel Transportation Cask for Baskets or Modules (IFTC/BM - See Chapter 2, section 2.4.7.1.3)

2.4.7 MODES

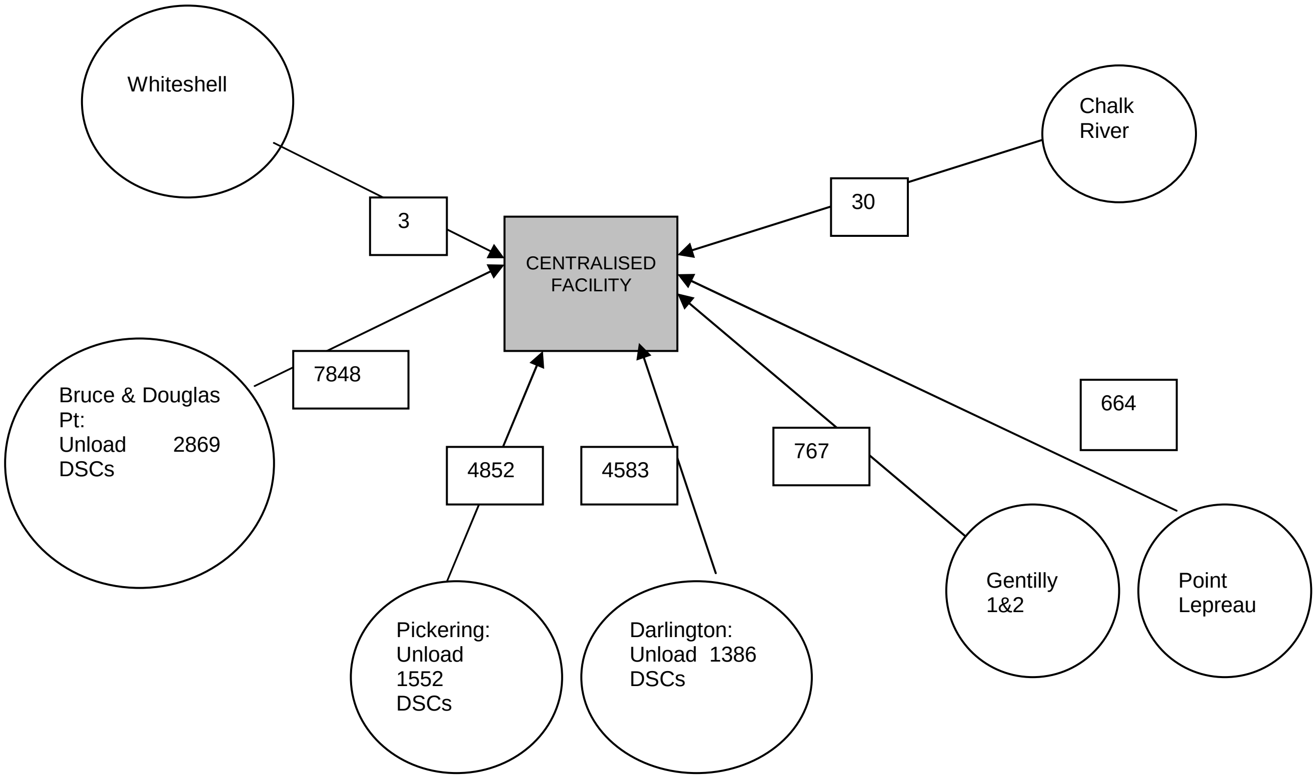
Three alternative transportation systems will be studied:

- "All road",
- "Mostly rail",
- "Mostly water".

2.4.7.1 All road

2.4.7.1.1 Features:

- Most flexible with respect to location of centralised site
- The only « one –mode » system
- All fuel loaded in IFTC/BMs
- 12 trucks arrive at centralised site each week (on average)
- Total 18 747 shipments over program
- Unload DSCs at current storage sites
- Upgrade on-site roadways



Key:

—— Road number, e.g. 7848 show total number of shipments:

Road – 1 x 192 bundle IFTC/BMs (modules) for Bruce, Pickering and Darlington
1 x 120 bundle IFTC/BMs (baskets) for Whiteshell
1 x 162 bundle IFTC/BMs (baskets) for Chalk River and Bruce (Douglas Point)
1 x 114 bundle IFTC/BMs (baskets) for Gentilly 1
1 x 180 bundle IFTC/BMs (baskets) for Gentilly 2 and Point Lepreau
The number of shipments is calculated in Table N°1 Appendix B, of the present document.

2.4.7.1.2 Interfaces for each site

Whiteshell (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactor: the fuel is from the Douglas Point reactor (experimental fuel stored at Whiteshell is not included in the scope of the present study),
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos, ready to be loaded into the transportation cask.

Bruce

a) Form of storage: Trays in wet bays (Appendix B, Table N° 6)
Reactors: Bruce B
Facility: Bruce B Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bay.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Bruce A and Bruce B
Facility: WUFDSF
Transportation cask: IFTC/BM
Interface between storage and transportation: The used fuel will be in transportation modules in a hot cell at the facility ready for loading into the transportation cask.

c) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Douglas Point
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Pickering

a) Form of storage: Modules in wet bays (Appendix B, Table N° 7)
Reactors: Pickering A and Pickering B
Facility: Pickering A and Pickering B Facilities
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the Primary bay (for Pickering B Facility) or in the Auxiliary bay (for Pickering A Facility).

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Pickering A and Pickering B
Facility: PUFDSF
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in a hot cell at the facility ready for loading into the transportation cask.

Darlington

a) Form of storage: Modules in wet bays (Appendix B, Table N° 7)
Reactors: Darlington
Facility: Darlington Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bays. There are two bays at Darlington, one at each end of the station.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Darlington
Facility: DUFDSF
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in a hot cell at the facility ready for loading into the transportation cask.

Chalk River (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactors: Nuclear Power Demonstration (NPD)
Facility: NPD Fuel
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Gentilly

a) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Gentilly 1
Facility: Gentilly 1 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

b) Form of storage: Baskets in CANSTOR (Appendix B, Table N° 5)
Reactors: Gentilly 2
Facility: Gentilly 2 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load Canstors ready to be loaded into the transportation cask.

Point Lepreau (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactor: Point Lepreau
Facility: Point Lepreau Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

2.4.7.1.3 Transportation casks

The transportation cask used is the Irradiated Fuel Transportation Cask for Baskets and Modules (IFTC/BM).

Description of IFTC/BM

The IFTC/BM design is based on the existing, licensed, OPG IFTC, shown in Figure N° 4 of Appendix A. Since only one IFTC has been constructed, an economical option would be to obtain a licence for a modified IFTC design having a slightly wider cavity that could accommodate both the Spent Fuel Baskets in the vertical orientation and the fuel modules. **This cask could have the following name: Irradiated Fuel Transportation Cask for Baskets and Modules (IFTC/BM**). This could be accomplished by designing a cask with a cavity large enough for both the baskets and modules and using inserts to account for their geometrical differences, as shown in Figures N° 5 and N° 6 of Appendix A. The inserts could be constructed from aluminium, which is light and inexpensive. The larger cavity could be achieved by reducing the thickness of two of the IFTC walls by roughly 10%. The effects of the change on shielding, heat dissipation, mass and structural performance would all need to be assessed during detailed design and licensing. Since both baskets and modules carry the same CANDU fuel, and are constructed from the same material, analysis and licensing for transportation of both would require only a little additional work relative to the work required to license a cask for transport of the baskets alone. A transport cask capable of handling both baskets and modules would also be more operationally efficient during transport and unloading at the centralised facility, since only a single type of transport frame, vehicle, and handling equipment is needed.

The IFTC/BM could transport 3 baskets or 2 standard Modules (see Appendix A, Figures N° 5 and 6). The number of bundles would be similar in either case, and so the existing analyses for the IFTC indicate that a similar design could be shown to meet regulatory requirements.

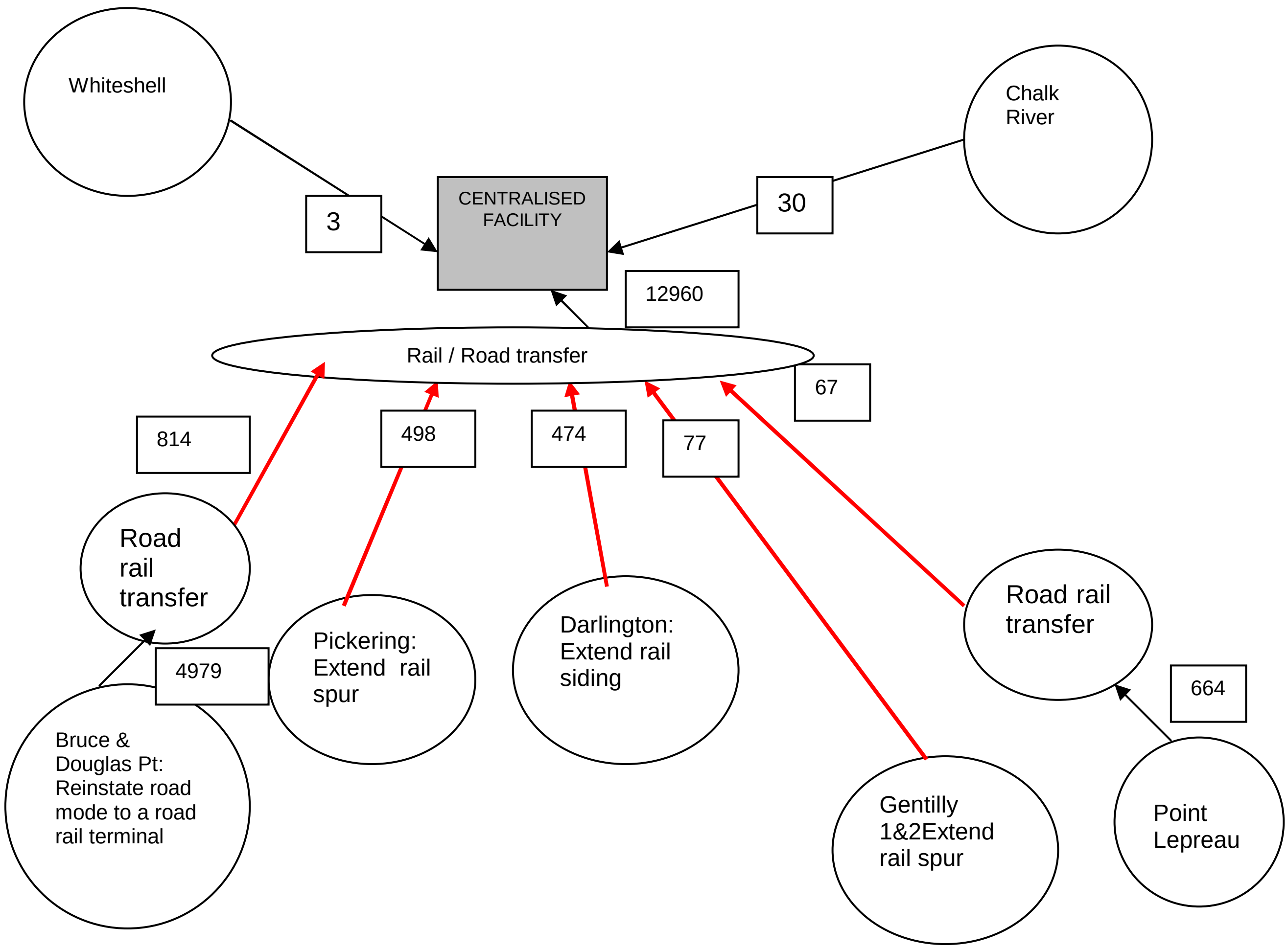
The weight of this transportation cask will be about 42.5 tons (Appendix C).

The Irradiated Fuel Transportation Cask for Baskets and Modules (IFTC/BM) can be used for all the Current Storage Sites and for all the forms of storage (Silo, CANSTOR, trays in wet bays, Modules in wet bays or DSCs).

2.4.7.2 “Mostly rail”

2.4.7.2.1 Features :

- Road links to railheads where needed. A possible alternative for the Bruce site would be to reinstate the rail line,
- Fuel loaded in IFTC/BMs (except DSCs),
- All DSCs transported,
- 8.3 trucks arrive at centralised site each week,
- Total 1930 rail shipments over program with 12960 connecting and additional road shipments,
- Assume road link to centralised site,
- Extend rail spurs into Pickering and Darlington UFDSFs and into Gentilly site,
- Up-grade on-site roadways at 2 possibly 3 sites,
- Potential cost savings from larger shipments.



Key:

Road
Rail

number, e.g. 814 show total number of shipments:

Road –
1 x 120 bundle IFTC/BMs (baskets) for Whiteshell
1 x 162 bundle IFTC/BMs (baskets) for Chalk River and Bruce (Douglas Point)
1 x 114 bundle IFTC/BMs (baskets) for Gentilly 1
1 x 180 bundle IFTC/BMs (baskets) for Gentilly 2 and Point Lepreau
1 x 384 DSCTP for Bruce, Pickering and Darlington
1 x 192 IFTC/BMs (modules) for Bruce, Pickering and Darlington

Rail – 5 x 384 bundle DSCTPs for Bruce, Pickering and Darlington or 5 x 2 x IFTC/BMs (baskets) for Point Lepreau and Gentilly 2 or 5 x 2 x 192 bundle IFTC/BMs (modules) for Bruce, Pickering and Darlington

The number of shipments is calculated in Table N° 2 Appendix B of the present document

2.4.7.2.2 Interfaces for each site

Whiteshell (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactor: the fuel is from the Douglas Point reactor (experimental fuel stored at Whiteshell is not included in the scope of the present study),
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Bruce

a) Form of storage: Trays in wet bays (Appendix B, Table N° 6)
Reactors: Bruce B
Facility: Bruce B Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bay.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Bruce A and Bruce B
Facility: WUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the WUFDSF.

c) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Douglas Point
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Pickering

a) Form of storage: Modules in wet bays (Appendix B, Table N° 7)
Reactors: Pickering A and Pickering B
Facility: Pickering A and Pickering B Facilities
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the Primary bay (Pickering B Facility) or in the Auxiliary bay (Pickering A Facility).

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Pickering A and Pickering B
Facility: PUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the PUFDSF.

Darlington

a) Form of storage Modules in wet bays (Appendix B, Table N° 7)
Reactors: Darlington
Facility: Darlington Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bays.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Darlington
Facility: DUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the DUFDSF.

Chalk River (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactors: Nuclear Power Demonstration (NPD)
Facility: NPD Fuel
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Gentilly

a) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Gentilly 1
Facility: Gentilly 1 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

b) Form of storage: Baskets in CANSTOR (Appendix B, Table N° 5)
Reactors: Gentilly 2
Facility: Gentilly 2 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load Canstors ready to be loaded into the transportation cask.

Point Lepreau

Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Point Lepreau
Facility: Point Lepreau Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

2.4.7.2.3 Transportation casks

The two transportation casks used are:

- Irradiated Fuel Transportation Cask for Baskets and Modules (IFTC/BM).
- DSCTP **<4>**, and **<5>** .

IFTC/BM (*see section 2.4.7.1.3)*

DSCTP

The DSCTP is a transport package, which is currently licensed for transport of OPG standard fuel storage modules in Canada. The package is currently only licensed for transport by rail or by water.

The DSCTP consists of the inner packaging (DSC), the outer packaging and the payload. The DSC together with the outer packaging constitutes the packaging. The DSCTP is shown in Figure N° 8 in Appendix A of this document.

The DSC, shown in Figure N° 7 of Appendix A, is currently used for dry storage of used fuel at OPG's reactor sites. It is placed in the outer packaging prior to shipment so that the complete package meets the requirements for transportation. In the transport configuration, the DSC is oriented horizontally with impact limiters attached to the front (top of the DSC) and rear (bottom of the DSC) of the package. The outer packaging is not present during the long-term storage of the DSC in the Dry Storage Facility.

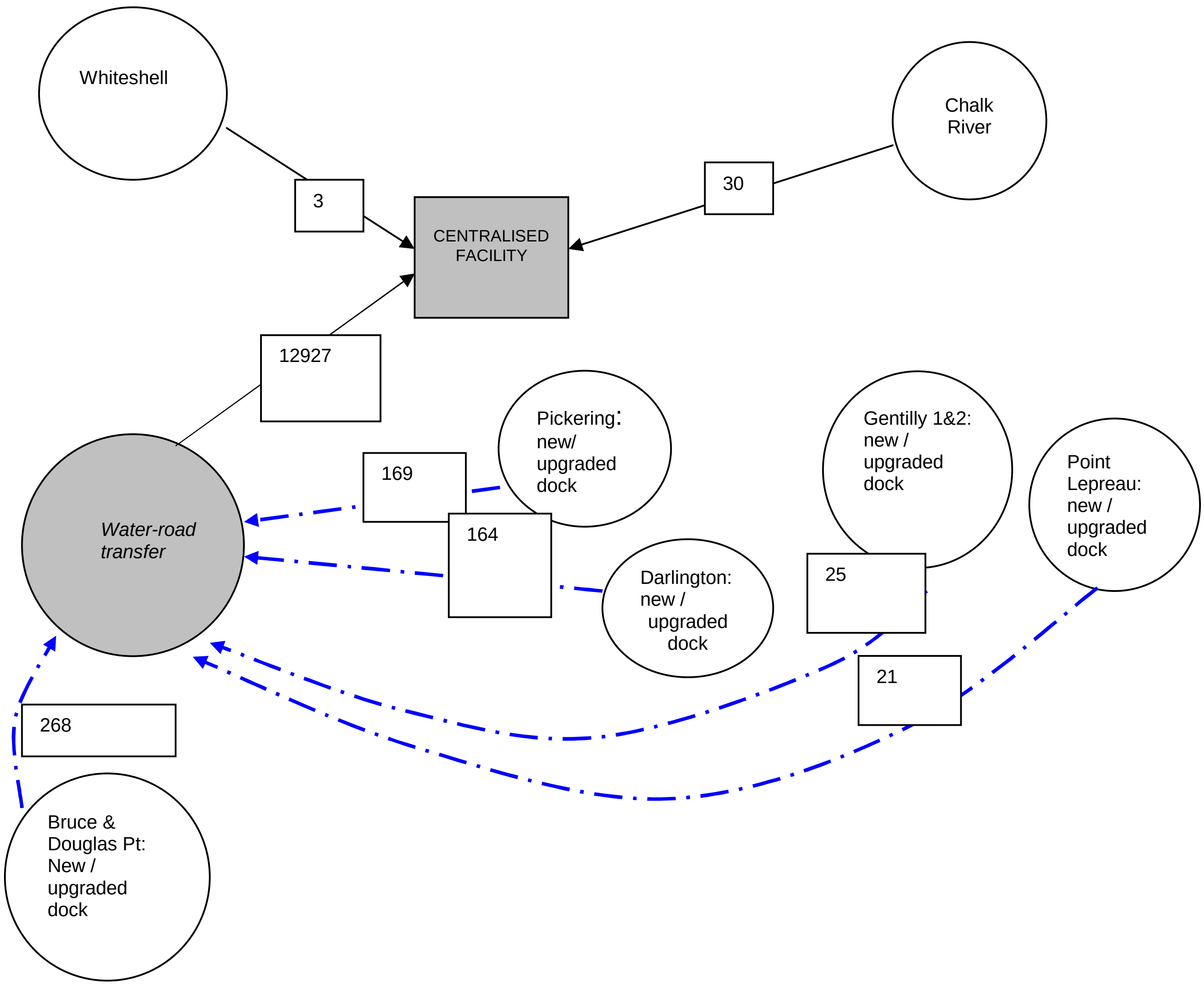
The outer packaging consists of top and bottom impact limiters, impact armoring, and attachments. The top and bottom impact limiters consist of stainless steel outer shells, 6 mm thick, filled with rigid polyurethane foam, with inner shells consisting of two plates 19 mm and 25 mm thick. The inner shells of the impact limiters are integrated with double-walled 304L stainless steel impact armoring, which extends downwards from the top impact limiter and up from the bottom impact limiter, overlapping around the circumference of the DSC. The top and bottom impact limiters are fastened to each other with wire rope assemblies.

Even though the DSCTP is currently only licensed for transport by rail or by water, it is technically feasible to transport the DSCTP by road, since all applied loads for transportation by rail are equivalent or higher than all applied loads for transportation by road. All pressure, temperature and free drop loads are the same for all modes of transport. Only transport shock and vibration loads differ between modes of transport. From **<1>**, Section 4, accelerations generated by road transport are less than accelerations for all other modes of transport. Only a small amount of additional analysis and licensing work would be required in order to license the DSCTP for transport by road.

2.4.7.3 “Mostly water”

2.4.7.3.1 Features :

- Road link to centralised site,
- New /upgraded dock at 5 or 6 sites,
- Potential cost savings from larger shipments,
- All DSCs transported ; fuel from wet bays loaded in IFTC/BM (baskets or modules),
- 8.3 trucks arrive at centralised site each week,
- Total 647 water shipments over program with 12960 connecting and additional road shipment,
- Purpose-built vessel (self-geared).



Key:

—— Road number, e.g. 88 show total number of shipments :

– · Water

Road – 1 x 120 bundle IFTC/BMs (baskets) for Whiteshell
1 x 162 bundle IFTC/BMs (baskets) for Chalk River and Bruce (Douglas Point)
– 1 x 384 bundle DSCTPs for Bruce, Pickering, Darlington,
or 1 x 192 bundle IFTC/BMs (modules) for Bruce, Pickering, Darlington or IFTC/BM (baskets) for Point Lepreau, Gentilly,

Water - 15 x 384 bundle DSCs for Bruce, Pickering, Darlington or 32 x IFTC/BMs (modules) for Bruce, Pickering, Darlington or 32 x IFTC/BMs (baskets) for Point Lepreau, Gentilly, Douglas Point.

The number of shipments is calculated in Table N°3 Appendix B of the present document

2.4.7.3.2 Interfaces for each site

Whiteshell (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactor: the fuel is from the Douglas Point reactor (experimental fuel stored at Whiteshell is not included in the scope of the present study),
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Bruce

a) Form of storage: Trays in wet bays (Appendix B, Table N° 6)
Reactors: Bruce B
Facility: Bruce B Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bay.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Bruce A and Bruce B
Facility: WUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the WUFDSF.

c) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Douglas Point
Facility: Douglas Point Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Pickering

a) Form of storage: Modules in wet bays (Appendix B, Table N° 7)
Reactors: Pickering A and Pickering B
Facility Pickering A and Pickering B Facilities
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the Primary bay (Pickering B Facility) or in the Auxiliary bay (Pickering A Facility).

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Pickering A and Pickering B
Facility: PUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the WUFDSF.

Darlington

a) Form of storage: Modules in wet bays (Appendix B, Table N° 7)
Reactors: Darlington
Facility: Darlington Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: the used fuel will be in transportation modules in the existing bays.

b) Form of storage: Modules in DSCs (Appendix B, Table N° 8)
Reactors: Darlington
Facility: DUFDSF
Transportation cask: DSCTP
Interface between storage and transportation: the used fuel will be in DSCs in the storage locations in the DUFDSF.

Chalk River (Appendix B, Table N° 4)

Form of storage: Baskets in Silo
Reactors: Nuclear Power Demonstration (NPD)
Facility: NPD Fuel
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

Gentilly

a) Form of storage: Baskets in Silo (Appendix B, Table N° 4)
Reactor: Gentilly 1
Facility: Gentilly 1 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

b) Form of storage: Baskets in CANSTOR (Appendix B, Table N° 5)
Reactors: Gentilly 2
Facility: Gentilly 2 Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load Canstors ready to be loaded into the transportation cask.

Point Lepreau (Appendix B, Table N°4)

Form of storage: Baskets in Silo
Reactor: Point Lepreau
Facility: Point Lepreau Facility
Transportation cask: IFTC/BM
Interface between storage and transportation: transfer flask similar to the one used to load silos ready to be loaded into the transportation cask.

2.4.7.3.3 Transportation casks

The two transportation casks used are:

- Irradiated Fuel Transportation Cask for Baskets and Modules (IFTC/BM).
- DSCTP **<4>**, and **<5>**.

IFTC/BM (*see section 2.4.7.1.3 of Chapter N° 2)*

DSCTP (*see section 2.4.7.2.3 of Chapter N° 2)*

3. CHAPTER N° 3: CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS

3.1. INTRODUCTION

In this section, we divide the study in 3 parts:

- “All road”
- “Mostly rail”
- “Mostly water”

For each Current Storage Site, we will describe the different phases needed to transport the bundles from their form of storage to the Centralised Facility, in the case of the three modes.
For each phase, we will give the concept and the description of the UFTS interfaces and components in the following order:

- Mode and route development
- Nuclear facility loading
- Transporter (vehicle)
- Transportation system maintenance facility
- Casks
- UFTS Auxiliary equipment
- UFTS Transportation system operation
- Decommissioning

Some items can have common descriptions for the Current Storage Sites and for the different modes of transportation, as for example: Maintenance facilities for casks, Maintenance facilities for Tractors and Trailers, Maintenance facilities for rail cars. These are discussed in sections 3.2 – 3.4 of this Chapter. It may be noted that it is assumed that vessels included in the UFTS description for mostly-water are assumed to be chartered, and would be maintained by the owner at a suitable facility. In the cost estimate an allowance is included in the cost of chartering to cover maintenance. In addition, the maintenance work described below could be contracted out, or could be carried out by the UFTS operator.

3.2. MAINTENANCE FACILITIES FOR CASKS (APPENDIX A, FIGURE N° 11)

3.2.1 GENERAL

Maintenance of any contaminated and/or irradiated equipment is expensive, and a large part of the cost goes to maintenance facilities: careful planning and sizing is essential.

The main factors are the radiological levels and the mass and size of the cask. High levels of radiation will make a decontamination workshop necessary. Large casks will require much handling space. The lifetime of the cask design shall also be considered, with workshop flexibility in mind for future cask designs.

It is expected that maintenance facilities will be used also for repairs and modifications, as the casks cannot go to a non-nuclear plant. The capabilities and limits, both technical and radiological, of the facilities should be given full consideration.

3.2.2 ADMINISTRATIVE AUTHORISATIONS AND SITING

Maintenance facilities will:

- usually be submitted to approval by competent authorities, which takes time,
- generate waste in solid, liquid and gaseous forms.

They should:

- be located next to installations where they are used, in order to minimise transports and lost time,
- offer suitable access to, or include, decontamination workshops and adequate waste treatment and storage,
- when possible, be an extension of an existing plant, which makes things easier for approvals, access to already available fluids...
- be subject to an environmental impact analysis.

3.2.3 LAYOUT

Access to workshop

Access may be on rail or road trailers. The latter is generally unsuitable because of exhaust gases, oil leaks... Electrically powered lorries should be preferred. Cask storage space, preferably covered or indoors should be provided just outside.

3.2.4 HANDLING

Lifting capacity shall be calculated to accommodate the largest casks. A safety margin is recommended as designers will always come with heavier designs.

Several independent lifting, handling, rolling, hovering devices allow for handling parts of different weight and size. This will preclude waiting for availability of equipment as it is already used for work or maintenance.

Storage should exist for lifting beams and equipment, as they will be possibly contaminated and will stay inside.

3.2.5 WORKSTATIONS

The number of workstations will be calculated according to the existing and planned fleet, to the maintenance frequency, to the time necessary. The number of operators working simultaneously on the same cask is usually limited by elbow room and occupational safety considerations, such as work-at-height.

It is emphasised that workstations will be occupied by casks that are stopped pending disposition of non-conformances or inspection. As it is generally difficult, impossible or not worthwhile to close and evacuate the cask, it is advisable to have more workstations or stands than strictly necessary.

The best position (vertical, horizontal, rotating...) for the cask will be determined. Stands, stools will raise the cask for good accessibility and working condition. Access platforms, stairs will be preferred to ladders. Platforms will be flexible in order to limit openings between cask and floors.

Hot cells shall be created whenever necessary to separate maintenance outside of the cask and maintenance inside or with the cask open. All components will have to be maintained or repaired, and there must be storage and workstations for all, including internals, baskets, that may require specific shielding.

Ventilation shall be adapted to pollutant concentration, with adequate depression between rooms so that airborne contamination is sucked in. Permanent radiation monitoring equipment shall be installed.

Ample storage will be created for tools and for dismantled parts. Workstations for parts such as shock absorbers, lids and covers, trunnions... shall be installed, with proper clampdown tools to provide safe working conditions.

It may be beneficial to have machining and welding equipment within the shop, as parts will not generally be acceptable in non-nuclear facilities. It will be often preferable to replace components rather than repair, as this will minimise worker exposure, and waste in unwanted form such as airborne or small chips.

Fluids should be distributed in wall mounted / embedded networks as close to the workstation as possible, as flexible pipes and wires must be strictly limited. Inert (such as nitrogen, argon...), detrimental, flammable gases, any chemicals shall be closely controlled and their use and available quantity shall be limited. Specifically, cask must be ventilated and air quality monitored during any work inside.

3.2.6 PERSONNEL

Personnel shall be properly educated in all technical, radiological, safety areas. A worker will normally need six months before being able to work without close supervision.

The capital cost of the maintenance facility is such that it will often be necessary to work in shifts. This will require special attention as any unexpected defect found in a cask may require expert advice that will be available only in office hours.

3.2.7 SPARE PARTS

It is necessary to plan:

- which spare parts are necessary, in what quantity,
- who will procure, own, and store the parts.

3.3. MAINTENANCE FACILITIES FOR TRACTORS AND TRAILERS

3.3.1 GENERAL

Maintenance of Tractors and Trailers is expensive, and a large part of the cost goes to downtime and servicing of the vehicles.

It is expected that maintenance facilities will be used also for repairs and modifications.

3.3.2 SITING

They should:

- be located next to installations where casks are loaded on the trailer or next to the route of the transportation, in order to minimise transports and lost time
- offer suitable access
- be subject to an environmental impact analysis especially for waste liquid form (when we wash the trailers)

3.3.3 HANDLING

No specific lifting except for frame of transportation cask, weather covers.

Storage should exist for lifting beams and equipment: frame of transportation cask, weather covers.

3.3.4 WORKSTATIONS

- Maintenance equipment for Trailer: one maintenance area with some mechanical and hydraulic conventional equipment especially for suspension.
- Maintenance equipment for Tractor: one maintenance area with some mechanical and hydraulic conventional equipment especially for suspension.

3.3.5 SPARE PARTS

It is necessary to plan with the trailer and tractor owner:

- which spare parts are necessary, in what quantity
- who will procure, own, and store the parts.

3.4. MAINTENANCE FACILITIES FOR RAIL CARS

3.4.1 GENERAL

Maintenance of rail car equipment is expensive, and a large part of the cost goes to maintenance facilities: careful planning and sizing is essential.
It is expected that maintenance facilities will be used also for repairs and modifications.

3.4.2 ADMINISTRATIVE AUTHORISATIONS AND SITING

Maintenance facilities will:

- usually be submitted to approval by competent authorities (railway authorities), which takes time,
- generate waste in liquid form.

They should:

- be located next to the route of the rail transportation, or next to a railroad terminal in order to minimise transports and lost time,
- offer suitable access to adequate waste treatment and storage,
- when possible, be an extension of an existing plant, which makes things easier for approvals, access to already available fluids...
- be subject to an environmental impact analysis.

3.4.3 LAYOUT

Access to workshop: access may be on rail and road trailers.

3.4.4 HANDLING

Lifting capacity shall be calculated to accommodate the largest rail cars. A safety margin is recommended as designers will always come with heavier designs.

Example (ABRF company in France):

- 2 cranes 15 tons,
- 3 hoists in order to load the main frame of the rail car,
- 3 fork-lift tracks.

Storage should exist for lifting beams and equipment.

3.4.5 WORKSTATIONS

The number of workstations will be calculated according to the existing and planned fleet, to the maintenance frequency, to the time necessary.

Example (ABRF company in France):

Total area: 115000 m2
Covered area: 13000 m2
Length of rail: 7000 m

The number of railcars they deal with is about 45. Ten persons are in charge of the maintenance of the railcars.

Equipment:

- Washing station for the rail car when they arrive at the plant with a special system to collect and to treat the liquid :
  - Exterior washing: 2000 psi / 70 °C
  - Interior washing: 3500 psi / 70°C
  - Vapour interior washing: 180°C

- Painting area: tunnel with oven (60°C, area : 360 m2)

- Granulating area: tunnel

- Sand blasting equipment

- Special equipment to check the breaks,

- Boilermaking: press, shearing..

- Machining : 1 milling machine, 3 drilling machines, 2 lathes.

3.5. CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "ALL ROAD" MODE FOR EACH SITE

3.5.1 ROAD TRANSPORT – OVERVIEW

Each of the current storage facilities has road access. Even if alternative or additional modes of transport are selected for the shipping campaign, it is anticipated that at least some portions of the transport would likely involve road (at least on-site or possibly into the centralised repository or extended storage facility). Road transport is a well-proven means of transporting used fuel, as demonstrated through the number of successful road shipments made by reactor operators and governments in a broad number of countries.

A critical factor associated with road transports involves weight of the load; for the purposes of this investigation, the load is assumed to include the following components: the transport cask, any associated cask systems (such as impact limiters), securement/tie-down equipment, the trailer and the power unit.

The upper limit for the payload assumes a fully loaded **IFTC/BM at a weight of 42.5 t [see Appendix C], and, for road links in the alternative mostly-rail and mostly-water systems, a fully loaded** Dry Storage Container Transportation Package (DSCTP) with outer package at a weight of 100.31 Mg.

Weight is a significant consideration as relates to environmental conditions and regulatory processes:

- Weather conditions and temperature – especially as linked to thaw periods **[<23>**, **<24>**, **<25>**, **<26>**, **<27>**, **<29>**, **<37>**, **<42>**] – affect authorised cargo weights and the time frames in which roads are available for the shipping campaign. It is assumed that roads are available for transport, without road restriction, between 270 and 300 days per year taking into account anticipated weather conditions. (It should be noted that this time frame does not take into account anticipated truck/trailer maintenance, scheduling issues, etc.)

- Given the additional effort associated with application and review for overweight permits on the part of both the regulators and the waste owners are proposed for the "all-road" transportation system.

It is also desirable that the length, width and height of the load are within the maximums allowed for the transport vehicle; this review therefore assumes that oversize permits are not required for road transport of used fuel. Similarly, it is assumed that authorised maximum loads for axle class of the transport vehicle are not exceeded.

Accordingly, size, weight and axle load limitations for the proposed road transport of used fuel – as well as overall road system characteristics – are assumed to be in compliance with the following regimes (this listing is provided for guidance and is not intended to represent a comprehensive assessment of regulatory requirements):

- Regulations for the Safe Transport of Radioactive Material, No. TS-R-1 (International Atomic Energy Agency) [**<32>**];
- Transportation of Dangerous Goods Regulations (Transport Canada) [**<49>**];
- Packaging and Transport of Nuclear Substances Regulations (Canadian Nuclear Safety Commission) [**<21>**];
- Provincial regulations applicable to the transport of radioactive material;
- Manitoba Transportation and Government Services Weights and Dimensions Compliance Guide (October 2000) [**<38>**];
- Manitoba Transportation and Government Services, Manitoba's Spring Road Restriction Program (March 18, 2002) [**<37>**];
- Manitoba Transportation and Government Services, Manitoba Highway Classification [**<36>**];

- Ontario Highway Traffic Act [<**41**>];

- Québec Ministère des Transports, Vehicle Load and Size Limits, The 2000 Edition (2000) [<**43**>];
- Québec Ministère des Transports, Thaw Zones and Periods [<**42**>];
- New Brunswick Department of Transportation, Notice to Transporters : Guidelines for Applying for and Obtaining Required Special Permits (July 2001) [<**40**>];
- New Brunswick Department of Transportation, Motor Vehicle Act [<**39**>];
- Guide to the Agreement on Uniform Vehicle Weights and Dimensions Limits in Atlantic Canada (October 2001) [<**22**>].

Consideration of road transport is predicated on use of dedicated trucks operating under exclusive use conditions. While this review does not include development of a detailed road transportation scheme, it is nonetheless assumed that drivers would comply with applicable national and provincial requirements for motor vehicle operation, including regulations associated with hours of work standards. Notwithstanding potential security arrangements and/or other provisions of the transportation program, it is assumed that team drivers would be utilised for road travel exceeding 575 kilometers in distance (based on a ten-hour day).

The sample road transport system envisioned for the program is predicated on the following characteristics:

- Modified 48-foot flatbed trailer with integrated tie-down;
- Trailer equipped with air ride suspension to cushion the load;
- Trailer equipped with four axles (IFTC/BM) or nine axles (DSCTP) (See Appendix C) of this document.
- One loaded cask per trailer;
- Standard commercial tractor sufficient for loaded weight: The weight for the fueled reference tractor is roughly 9,075 kg for IFTC/BM and 11 t for DSCTP.

For the purposes of this review, it is assumed that the UFTS operators purchase trailers. Availability of good quality, well-maintained trailers is desirable to ensure safe transport. Additionally, it is anticipated that tie-down and securement devices would be integrated into trailers; control over such modifications and maintenance of the transport equipment would be best assured through direct ownership.

Tractors for road transport could either be purchased or contracted for, depending upon preference of the UFTS operators. It is recommended that the UFTS operators examine current practices regarding truck ownership to determine if there is an existing basis for evaluating costs, liability and business structure.

The overweight road transport configuration (needed for DSCTP transportation on road links) was compared with that used in France for transport from the Valognes rail-road terminal. There, an 8-axle vehicle is used for 120 t cask. The Transport consists of the tractor and trailer, an escort front and rear, plus police, and travels at 40 km/h. The escorts are needed because of the weight, not for security.

3.5.2 CONCEPTUAL DESIGN AND DESCRIPTION

See Appendix D of this document.

3.6. CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "MOSTLY RAIL" MODE FOR EACH SITE

3.6.1 RAIL TRANSPORT – OVERVIEW

Rail lends itself well to the transport of heavy loads and could potentially provide for a fewer number of shipments of used fuel than would road, as more casks could be shipped in a single consignment. This ability to consolidate cargo is among the primary benefits associated with rail.

Rail transport is a well-proven means of transporting used fuel, as demonstrated through the number of successful rail shipments made by reactor operators and governments in a broad number of countries, especially Europe.

It is also noted that the Ontario region is well served with principal main lines that could be utilized for movement of used fuel. Use of main lines only is assumed for long-haul transport, noting, however, that feeder lines may be required between specific points.

For the purposes of the present study, the rail transportation system is predicated on the following elements:

- The train is dedicated to movement of used fuel under exclusive use conditions;
- Use of 100-ton rail flat car;
- Each flat car is loaded with one DSCTP or two IFTC/BMs;
- Each train equipped with locomotive and caboose;
- The locomotive is assumed to have sufficient power to safely and efficiently haul the load;
- Use of buffer cars is assumed, the total number of which is dependent upon total cask loadings per train, with buffer cars at a minimum to be placed between loaded rail cars and the caboose and between loaded rail cars and the locomotive;
- Flat cars are equipped with shock absorbing couplers;
- Potential use of extra car and/or caboose for security escorts and related personnel.
- Five loaded railcars per train (consistent with current European train movements.

Rail transport is deemed relatively unaffected by weather conditions; it is therefore assumed that rail transport is potentially available 365 days of the year. (It should be noted that this time frame does not take into account anticipated rail car/locomotive maintenance, scheduling issues, labor conditions, etc.) Should the rail mode be selected for further evaluation, it is recommended that contact be made with rail operators to verify assumptions and time frames.

Rail transport is also assumed to be in compliance with relevant national and provincial regulations, including at a minimum the following statues:

- Regulations for the Safe Transport of Radioactive Material, No. TS-R-1 (International Atomic Energy Agency) [**<32>**];
- Transportation of Dangerous Goods Regulations (Transport Canada) [**<49>**];
- Packaging and Transport of Nuclear Substances Regulations (Canadian Nuclear Safety Commission) [**<21>**];
- Provincial regulations applicable to the transport of radioactive material;
- Railway Safety Act (Transport Canada) [**<48>**].

For the purposes of this review, it is assumed that the Canadian UFTS operators would contract for use of rail engines as part of the rail service, but would purchase rail cars for use in the program. Availability of good quality, well-maintained rail cars is desirable to ensure safe transport. Additionally, it is anticipated that tie-down and securement devices would be integrated into rail cars; control over such modifications and maintenance of the cars would be best assured through direct ownership.

Final road link

A final road link must be created as it cannot be assumed that the centralised facility will have rail access. Because the location of the repository is not known, and because of the more extensive road network, it is assumed that the repository will be serviced as a minimum by road, but may not have rail access. The final leg of the journey is therefore assumed to take place by road. This means that a rail/road transfer has to be done at the railhead near the centralised facility.

3.6.2 CONCEPTUAL DESIGN AND DESCRIPTION

See Appendix E of this document.

3.7. CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "MOSTLY WATER" MODE FOR EACH SITE

3.7.1 WATER TRANSPORT OVERVIEW

Given the proximity of multiple reactor sites to usable waterways, a close review of water transport was conducted. Water transport is a well-proven means of transporting used fuel, as demonstrated through the number of successful waterborne shipments made by reactor operators and governments in a broad number of countries.

This investigation centered on the following types of conveyances:

- Barge;
- Integrated tug-barge system;
- Vessel.

Roll-on/Roll-off (or "RORO") vessels were not considered herein, as such vessels are primarily designed to carry cargo secured aboard another conveyance, such as a truck. This approach would obviate some of the benefits associated with a water-based system. Additionally, RORO vessels are typically larger and more expensive than the size vessel envisioned for the Canadian fuel removal program.

All three types of waterborne transport are feasible, however the most practical and cost-effective option involves use of a modern, geared commercial cargo vessel. This determination is based on a review of the following criteria:

- Draft: The type of vessel (see further comments below) anticipated for a waterborne shipping program would have a relatively shallow draft, making it suitable for shipments on the St. Lawrence Seaway and the Great Lakes [**<44>**].

- Cargo capacity: The type of vessel anticipated for a waterborne shipping program would be able to ship a large number of casks at one time, allowing for optimisation per cask shipment costs. While specific vessel loadings are not analysed within the scope this review, the type of vessel proposed for such a program could reasonably accommodate roughly road-weight casks (using the Ontario Power Generation Irradiated Fuel Transportation Road Cask as a sample cask) [**<6>**].

- The cargo capacity of the vessel is 15 DSCTP (see Figure N° 21 in Appendix A) and 32 IFTC/BM (see Figure N° 22 in Appendix A).

- Speed: Use of vessels would allow for a shorter waterborne shipping programs than would use of barges. The proposed sample vessel would be capable of sustained service speeds of 15 knots, although actual travel time would be dictated by waterway restrictions and other vessel traffic [**<44>**].

- Maneuverability: The sample vessel anticipated for use in the program would be equipped with maneuvering thrusters, allowing for unassisted entry and exit from dock facilities at the reactor sites and destination.

- Gearing: Use of a geared vessel would eliminate the need for loading cranes at dock facilities at the individual reactor sites and destination.

- Accessibility: Use of vessels would allow easy access to cargo during the voyage for monitoring purposes (radiation monitoring, condition monitoring, security and safeguards).

- Commercial availability of conveyance: The type of vessel proposed for a waterborne program is currently available on the maritime market; no changes in availability would be predicted between now and 2035.

- Cost factors: Based on the availability of suitable vessel types, as well as a desire to avoid complicated transport solutions, use of an ocean-going vessel would likely be more cost-effective than use of other vessel types.

The sample vessel used for the viability assessment is assumed to have the following characteristics:

- The vessel is equipped for carriage of Class 7 (radioactive) material.

- The vessel meets the requirements, as applicable, of the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (otherwise known as the “INF Code”) [**<34>**]. This Code delineates all required physical characteristics for the vessel; accordingly, the vessel would meet the INF Code provisions related to damage stability, fire safety, temperature control of cargo spaces, structural requirements, cargo securing requirements and electrical power supply. Additionally, it is assumed that the vessel is operated in compliance with INF Code provisions applicable to radiological protection, management and training, and emergency response guidelines.

- The vessel is Great Lakes fitted [**<44>**, **<46>**].

- The vessel is ice strengthened.

- At a minimum, the vessel is operated in compliance with the following:

  - *International Maritime Dangerous Goods Code* (International Maritime Organisation) [**<34>**];
  - *Regulations for the Safe Transport of Radioactive Material, No. TS-R-1* (International Atomic Energy Agency) [**<32>**];
  - *Transportation of Dangerous Goods Regulations* (Transport Canada) [**<49**>];
  - *Packaging and Transport of Nuclear Substances Regulations* (Canadian Nuclear Safety Commission) [**<21>**];
  - Provincial regulations applicable to the transport of radioactive material;
  - *Canada Shipping Act*, including the *Canada Shipping Act Dangerous Goods Shipping Regulations* (Transport Canada) [**<46>**, **<47>**];
  - *Navigable Waters Protection Act* (Department of Justice Canada) [**<22>**];
  - *The Seaway Handbook* (The St. Lawrence Seaway Management Corporation) [**<44>**];
  - *International Safety Management Code* (International Maritime Organisation) [**<35>**];
  - *International Convention on the Safety of Life at Sea* [**<33>**].

- The vessel is classed by a well-known, reputable classification society.

- The vessel type is a multi-purpose container vessel with tweendecks. This configuration is desirable to allow for flexibility in cargo loading configurations and securement activities.

- Vessel decks are strengthened for heavy cargo.

- The sample vessel meets the following size requirements:

Length o.a:	100,60 m
Length b.p:	93,80 m
Ship Width:	8,10 m
Draft:	6,40 m
Dwt:	4,800 to 5,000 dwt

- The vessel is geared with high-speed cranes capable of lifting the loaded casks and related securement materials. It is assumed that the combined crane lift capability is roughly 120 metric tons. This would avoid the need to install heavy lift cranes at marine loading docks at current storage sites.
- The vessel is equipped with bow thrusters for extra maneuverability, emergency generators, and modern nautical and communications equipment.
- The vessel is new at the time that the shipping campaign begins.
- A vessel suitability survey conducted by an independent, qualified marine inspector is performed prior to initiation of the shipping campaign.
- The vessel retains appropriate insurances, including P & I and Hull & Machinery coverage.

For the purposes of this review, it is assumed that the Canadian UFTS operators either purchase the vessel or obtain guaranteed access to the vessel under a long-term time charter. The intent is to assure that a vessel meeting the requirements detailed above is available for the full length of the waterborne program.

A long-term charter is recommended because of the specialist nature of marine transportation and crewing. The long-term arrangement (i.e., three or more years in duration) would not only guarantee access to a suitable vessel but would likely result in a cost savings of roughly 25 to 30 percent per year, as compared with contracting for a vessel on an annual basis. Such cost savings could be significant.

Should a time-charter be pursued, it is recommended that the charter arrangements allow the UFTS operators to direct the following activities:

- Loading and unloading;
- Stowage and segregation;
- Securement;
- Routing;
- Shipment monitoring (such as satellite tracking);
- Shipment schedule;
- Radiation monitoring;
- Emergency response.

As a general concept, casks would be loaded aboard the vessel at one or more reactor sites (or designated marine facilities near reactor sites). A waterborne program assumes open waterways from mid-April to mid-December of each year [**<28>**, **<29>**, **<30>**]. Accordingly, a waterborne program is predicated on a 245-day shipping window per year.

The suitability of water transportation was reviewed on a site-by-site basis. As with the rail mode of transport, the water mode offers the opportunity to consolidate casks into a fewer number of shipments. The site-by-site assessment indicates the potential to consolidate waterborne shipments between several sites, providing the potential to derive overall program efficiencies.

As the specific repository location is not well defined, it is impossible to more precisely determine the detailed routings. Within this constraint, waterborne transport to and within Ontario is deemed feasible when utilised in conjunction with an inland road or rail transport component. Use of water transport would therefore include development of a water transfer station.

It is noted that this postulated waterborne system would include transit through the United States. While political assessments are outside the scope of this review, it should be noted that international transport is viable from a regulatory standpoint [**<50>**]. International transport of irradiated nuclear materials is currently managed on an international basis with success. Canada and the United States already operate under a well-defined and tested regulatory regime in which cross border transports of radioactive material are routinely managed. In connection with the United States' Reduced Enrichment for Research and Test Reactor (RERTR) program, cross border shipments of Canadian origin used research reactor fuel have been successfully made on several occasions.

U.S. validation of the Canadian transport casks would be required [**<50>**], however such validations are clearly feasible; existing Canadian cask designs have previously been approved in the United States without difficulty. The work associated with obtaining such validations would be limited, as it is anticipated that U.S. review and approval would likely only be required for two Canadian cask designs in conjunction with the entire program.

Under this scenario, loaded casks would need to be transferred from the vessel to another mode of transport. From a technical standpoint, transfer is clearly feasible to either road or rail. From a logistical viewpoint, however, transfer to rail would provide considerably more benefits, as the higher volume vessel shipments could be maintained through similar rail car loadings. However, because the location of the repository is not known, and because of the more extensive road network, it is assumed that the repository will be serviced as a minimum by road, but may not have rail access. The final leg of the journey is therefore assumed to take place by road.

3.7.2 CONCEPTUAL DESIGN AND DESCRIPTION

See Appendix F of this document.

4. CHAPTER N° 4: EMERGENCY RESPONSE PLAN FOR TRANSPORTATION

Conceptual emergency response provisions for the UFTS are based on those put in place by COGEMA LOGISTICS. Within the year 2000, COGEMA LOGISTICS has performed almost 2800 transports of radioactive materials. The impressive international activity of transports provided by road, railway, sea and airway has oriented COGEMA LOGISTICS towards preparing for efficient reaction in the event of any incident or accident, thus providing for limited consequences.

Moreover, according to IAEA recommendations, and in order to comply with the French regulations, our company has implemented a specific organisation since 1997 which relies on an Emergency Response Plan for Transportation (ERPT).

We are thinking that this specific organisation can be duplicated for UFTS:

The organisation is composed of technical, logistic and communication experts as well as specific equipment.
When describing the organisation, the human resources and the equipment are the ones necessary for three steps of action:
1. To give the alarm
2. To analyse the situation
3. To operate the emergency means

Emergency Teams

Command and decision Section:
Its tasks are:
- Risks Assessment
- Logistic and technical assistance to Authorities
- Decision on OPG proper technical means to be implemented
- Management of the Technical Analysis Section (see next paragraph)
- Management of the Communication Section

Technical Analysis Section
Its tasks are:
- Provision of technical expertise
- Estimation of the technical state of the packaging and of associated impacts
- Proposition of technical emergency and assistance solutions.

Mobile command team
This team is « the eyes and ears » of the command and decision section; Its tasks are:
- Implementation of command, information and expertise near the accident
- Equipped with a first intervention case (satellite communication system, radio or chemical protection equipment, camera, computers,…) this team implements processes to minimise consequences or to bring solution to the situation

Communication Section
Its tasks are:
- Preparation and elaboration of a crisis communication specially dedicated to the media
- Provision of a specific communication plan
- Information for the press and for other communication entities
- Information from the press

Emergency Means

The crisis cell is located in a specially built crisis room fully equipped with communication means (Vehicles tracking system, telephones, telefax, teleconference system,…) and all the necessary documentation (regulations, maps, safety files, ERPT and specific plans,…). The main crisis room must be at the Centralised Facility but each Current Storage site has to have a little crisis area to communicate with the crisis room of the Centralised Facility.

The crisis room is operated permanently during our transports using the real Time tracking system (see Chapter N° 5):

- Location of the vehicle (trucks, wagons, ship) with the GPS system
- Transmission of information with the Inmarsat system

In addition, we are thinking that the UFTS, as COGEMA LOGISTICS, should be equipped with a **recovery system for heavy casks**. It may be needed if the casks are placed accidentally in a location where no classical means of recovery can be efficiently used.

This fully modular system can be shipped in ISO containers to any route in CANADA, and then implemented without any other infrastructure.

EMERGENCY RECOVERY SYSTEM : MODULAR CRANE AND RECOVERY SLIDE

5. CHAPTER N° 5: REAL TIME TRACKING

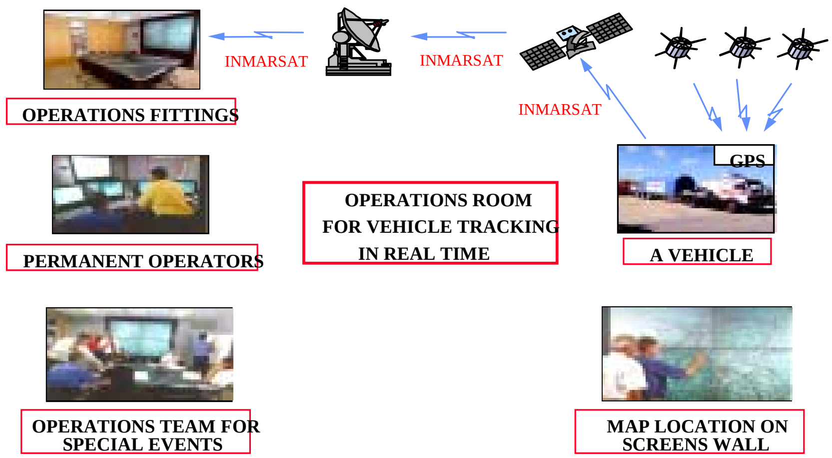
Dedicated water and ground transports for UFTS can be real time tracked from a UFTS headquarters located at the Centralised Facility. Road vehicles, railway wagons as well as dedicated vessels involved in the logistic network for the UFTS can be equipped with specific tracking systems.

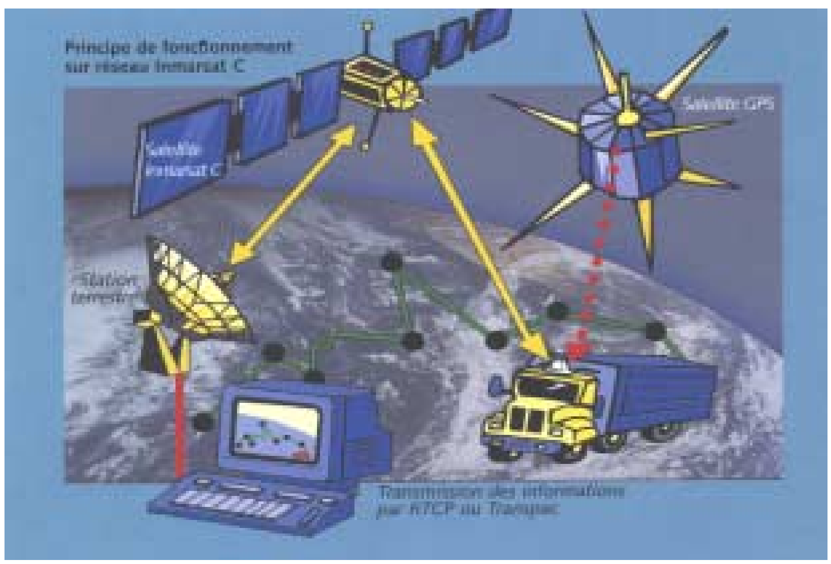
The real time tracking system based on the experience of COGEMA LOGISTICS can be an integral element of UFTS (See Appendix H):

It will be enabled to perform:

- Fast and regular information on cask location,
- Remote interrogation,
- Assurance of the good progress of the transport operation for the customer,
- Full confidentiality with regards to information transmittal.

REAL TIME TRACKING





6. CHAPTER N° 6: APPENDICES

APPENDIX A : FIGURES

General:

Figure N° 1: **Purpose of Used Fuel Transportation System**
Figure N° 2: **Reactor Sites where Used Fuel is Currently Stored in Canada**
Figure N° 3: **Typical CANDU Fuel Bundle**

Packaging and Transportation casks:

Figure N° 4: **IFTC**
Figure N° 5: **IFTC/BM Loaded with 2 Modules**
Figure N° 6: **IFTC/BM Loaded with 3 Baskets**
Figure N° 7: **Dry Storage Container**
Figure N° 8: **Dry Storage Container Transportation Package**

Equipment / Facilities:

Figure N° 9: **Fuel basket transfer flask on a IFTC/BM (similar to fuel basket transfer on a canister)**
Figure N° 10: **Transfer flask for baskets in Gentilly**
Figure N° 11: **Example of Maintenance Facilities for casks**

Vehicles:

Figure N° 12: **Example of a 9 axles Trailer**
Figure N° 13: **Example of a 4 axles Trailer**
Figure N° 14: **Example of a Tractor and a 4 axles Trailer**
Figure N° 15: **IFTC Tie Down**
Figure N° 16: **Example of a depressed centre, flat bed car Rail car**
Figure N° 17: **Tie-Down system of DSCTP on depressed centre, flat bed car**
Figure N° 18: **Example of a railcar**
Figure N° 19: **Example of a vessel**
Figure N° 20: **Example of a water-road transfer**
Figure N° 21: **DSCTP in a vessel**
Figure N° 22: **IFTC/BM in a vessel**

APPENDIX B: BASIS AND INTERFACES

Table N° 1: **Basis for “All road”**
Table N° 2: **Basis for “Mostly rail”**
Table N° 3: **Basis for “Mostly water”**
Table N° 4: **Interfaces between storage and transportation for each site where the form of storage is baskets in Silo**
Table N° 5: **Interfaces between storage and transportation for each site where the form of storage is baskets in Canstor**
Table N° 6: **Interfaces between storage and transportation for each site where the form of storage is trays in wet bays**
Table N° 7: **Interfaces between storage and transportation for each site where the form of storage is modules in wet bays**
Table N° 8: **Interfaces between storage and transportation for each site where the form of storage is modules in DSC**

APPENDIX C: ROAD TRANSPORT FEASIBILITY OF IFTC/BM AND DSCTP

APPENDIX D: CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "ALL ROAD" MODE FOR EACH SITE

APPENDIX E: CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "MOSTLY RAIL" MODE FOR EACH SITE

APPENDIX F: CONCEPTUAL DESIGN AND DESCRIPTION FOR ALL THE UFTS COMPONENTS IN THE CASE OF "MOSTLY WATER" MODE FOR EACH SITE

APPENDIX G: EXAMPLE OF THE COGEMA LOGISTICS RAIL-TO-ROAD TERMINAL AT VALOGNES

APPENDIX H: THE REAL TIME TRACKING SYSTEM OF COGEMA LOGISTICS