FPInnovations’ industry-driven R&D program in forest operations

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Abstract
FPInnovations (FPI) is Canada’s leading R&D organization covering all links of the forest value chain. FPI’s work is largely driven by industrial needs that are identified through a multi-level consultation process and incorporated into a focused and applied R&D program. In recent years, FPI has implemented the SRI Innovations process and uses the NABC (Needs, Approach, Benefits, Competition) approach to rate and prioritize R&D projects (Carlsson & Wilmot, 2006). Using a case study approach, the concept initiation and development processes for some of FPI’s products based on the SRI approach are described, as well as the business models used by industry to adopt and implement these solutions in their operations. The innovations described include FPSuite™ — a forest supply chain real-time monitoring system, a road safety inspection service and lightweight demonstration logging trucks (“Green Trucks”) featuring composite material pickets and bunks.

Keywords
Innovations, value chain, harvesting, roads, transportation, datalogger

Introduction
FPInnovations (FPI) is Canada’s leading R&D organization covering all links of the forest value chain. The organization helps the Canadian forest industry develop pathbreaking solutions based on the unique attributes of Canada’s forest resources, favoring a sustainable development approach and taking full advantage of the industry’s considerable scientific, technological and commercial capital.

To achieve this, FPInnovations has created a unique business model, based on a public-private partnership that allows responding efficiently to the needs of its members in the private sector, and of its partners in research, academic, and federal and provincial government circles. Based on the principle of collaborative research, this model allows high degrees of leveraged funding because for a relatively modest financial contribution, members gain access to a much larger R&D program through a principle of “shared funding, shared benefits, shared risks”. The FPInnovations model goes beyond traditional R&D, and has no direct equivalents in the US. There are many similarities however with some of the European and Australasian institutes such as SkogForsk in Sweden and Future Forest Research in New Zealand.

To foster a market-first focus for its innovation program, FPInnovations decided a few years ago to adopt the five disciplines of innovation proposed by SRI (Stanford Research Institute) and its NABC (Needs, Approach, Benefits, Competition) approach to project assessment (Carlsson & Wilmot, 2006). With this approach, potential R&D initiatives are evaluated based on:

Need – How well they respond to market needs. This limits the risk of working on curiosity-driven projects that will have limited uptake in the market at completion;

Approach – How sound is the approach, in terms of fit with existing resources, skill sets and technical risk (or probability of success)

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Benefits – How significant are the benefits, and clearly not to FPInnovations but to the members or clients. Also, how widely will the R&D results apply across the membership? For example, a very good project from a technical point of view that only benefits a very small proportion of the members will not be favored as strongly as one with broader applicability.

Competition – Are there any better alternatives possible? Will the results compete with existing solutions already available on the market?

To illustrate how FPInnovations uses the SRI approach in developing its projects, three case studies of recently innovative solutions will be described in the following chapters.

**FPSuite™**

FPSuite is an operational monitoring platform for forest operations. It comprises the FPDat™ onboard data logger, the FPCom™ data transmission system and the FPTrak™ data hosting & reporting web site.

**The Need**

In its consultation meetings with industry, FPInnovations researchers often heard complaints from members that there was no easy way to obtain accurate, up-to-date information on forest operations because these are typically remote, dispersed and relocate often. It was felt that mill operations had excellent control systems, whether through the use of scanners in sawmills or complex process control systems in paper machines, whereas logging operations provided sketchy, inaccurate and often obsolete information by the time it became available in the office.

It was also determined that there was a need to be able to send modified instructions or new work orders more quickly to the job sites, for example new bucking instructions, a different prescription for a given block or areas of concern to know about before harvesting. Because of their remoteness, typical Canadian forest operations are not covered by cellular mobile phone networks, making the use of most existing commercial systems inapplicable. Thus, no systems were commercially available that could adapt readily to the Canadian situation with the data communication challenges and the diversified fleets of cut-to-length or full tree machines of various makes and models.

**The Approach**

As a result, after reviewing existing technologies and systems on the market, FPInnovations embarked on a hardware/software development project in 2007. A first generation data logger called the MultiDAT had already been in existence since 2001. However, this basic unit could not easily provide all of the operational data sought by the industry. Therefore, a new development project was initiated using funding from the industrial membership base and from the federal government through the Transformative Technology Program. In 2011, the first prototypes of the FPDat data logger, the FPCom satellite/cell communication system and the FPTrak web site were produced (Figure 1).

![Figure 1. FPDat datalogger & touch screen (left); FPCom satellite modem (center); FPTrak web site screen shot (right).](image)

These first prototypes were distributed to a few member companies for field testing. The early feedback received enabled correcting some software issues and finalizing the hardware platform, which is still in use.
use and commercially available today. Between 2012 and 2013, FPInnovations managed the production, promotion, sales and support of the tools to its members in Canada. Nearly 400 units have been installed to this date. However, recognizing that FPI's business is mainly R&D and not equipment sales, private partners were sought to handle the commercial aspects such as promotion, sales and support, so that scarce R&D resources could focus on furthering the development of the technology. As of April 2014, distribution agreements covering 7 of the 10 Canadian provinces were in place and the whole country should be covered by this network by mid-2014.

**The Benefits**

Several testimonials were received from users about the benefits of having installed the technology in their machines. Since the FPDat contains an advanced, high-accuracy navigation system specially designed for forestry, many users claim to be able to work without flagging block boundaries, considerably reducing their lay-out costs. In addition, trespass fines when working on public land (90% of Canada’s forest are public, government-owned lands) have been virtually eliminated.

The FPDat is also designed to collect performance information such as working time, down time, down time causes, start/stop times, so that machine owners have a much better picture of their overall efficiency. Coupled with active displays of key performance indicators on the screen, efficiency gains of 5-10% have frequently been reported by operators and contractors.

Forest companies have also seen important benefits at many levels: for example, the GPS track logs provided by the system enable real-time monitoring of operational progress, facilitate planning of subsequent phases and updating of GIS maps. Also, the companies which hire the contractors benefit from the efficiency gains achieved through lower wood costs. Finally, in some cases, it is possible to track wood flow from stump to roadside, providing a good picture of available wood inventories for better truck schedules.

From an implementation perspective, it is interesting to note that a couple of business models have emerged. In most cases, the hardware has been purchased by the forest companies, and then passed on to their logging contractors. Sometimes, the company has absorbed the investment costs and in others secured a reimbursement via a discount in the rates paid for the wood. In other cases, the hardware and FPTrak service have been purchased outright by the contractors themselves.

**The Competition**

FPI is often challenged about the reasons it develops technology that in appearance seems to exist already. However upon closer look, while there are some data loggers, navigation systems, data hosting web sites, and other OEM systems that currently exist on the market, none were found that combine all the functionalities in the same platform and could adequately function in Canada’s operational context. The product has also been called “brand-agnostic”, in the sense that it can be installed in any make or type of machine and the data will be collected uniformly and centralized on a common platform. OEM systems typically require clients to access their asset tracking service, which works well if you have only their make of machine in your fleet. This is rarely the case in Canada with forest companies employing several independent contractors with different machine preferences.

For these reasons, and the strong pull from industrial members, it is believed that this development project was warranted under the NABC approach, and certainly the early commercial success so far would appear to confirm this.

**Resource Road Safety Inspections**

The resource roads safety inspection service (RSI) developed by FPI is based on a LiDAR-Video scan of resource roads to assess problem areas that present accident risks because of deficiencies such as line-of-sight limitations, poor signage and incorrect road geometry.
The Need
Many Canadian resource roads were built to a rudimentary standard several years ago and have gradually been upgraded in a piecemeal fashion to meet changing needs. Safety issues arise because traffic volumes have increased rapidly and the range of road users has broadened to include other industrial sectors and the public. Many roads have fallen behind in their ability to handle traffic safely.

Some of these networks can be considered amongst the most hazardous, high-risk workplaces in the province of B.C. and have resulted in an average of four industrial deaths and numerous serious injuries each year (WorkSafeBC, 2009). One of the predominant contributing factors has been identified as road design and maintenance, along with speed, personal impairment and lack of radio communication.

There was an urgent need to systematically assess road safety and to prioritize upgrades and traffic control measures to get the best result in terms of improved road safety. The goal of the research was to develop solutions for conducting road safety inspections (RSI) that are cost-effective, easily understood, and expedites the process of acquiring sound, engineering-based safety recommendations.

The Approach
FPI initially tested an array of mobile mapping systems (MMS) and technologies (hardware and software) for ease of data collection and procedures for information extraction. The MMS are equipped with digital video cameras and laser scanners (LiDAR) linked to a GPS/INS (Inertial Navigation System) for precise positioning and orientation. RSI service deploys a mobile mapping system for each project location. Trimble’s Trident-3D™ Capture software, which combines photogrammetric and LiDAR analysis is utilized to post-process the data after survey. Photogrammetric analysis allows for such tasks as semi-automated road width measurements, and LiDAR analysis can, for example, automatically identify signs using reflectivity information and record the associated locations and dimensions into a database. A software extension, developed by FPI, automates vertical and horizontal stopping sight distance (SSD) calculations using LiDAR data. The resulting tool requires parameters for eye height, obstacle height and SSD (based on road design speed) and subsequently identifies all vertical and horizontal sight issues, as for the example shown in Figures 2.

Figure 2. Perspective view of horizontal sight distance based on the location of an obstruction, showing the area of concern (shaded area).
**The Benefits**

Since 2008, FPI has performed over 1100 km of RSIs across Canada. These RSIs leveraged contributions from various industrial partners which helped reduce the cost to FPI of data collection and analysis. The RSIs were completed using road design speeds of 50 and 60 km/h. Data gathered from several RSIs were analyzed to illustrate the most common hazards documented throughout the various road networks. The most frequent issues observed were inadequate vertical SSD, followed by horizontal alignment (curve radius) and inadequate horizontal SSD caused by roadside vegetation. These are usually the top three hazards but vary in occurrences for each road (Légère & Kurowski, 2013). The RSIs also often revealed substandard signage, inadequate road width, and poor visibility of existing signage.

These results indicate that many road segments do not meet published design standards for the posted speed limit. FPI’s RSI service allows for independent, methodical, proactive, and standardized resource road inspections. By incorporating mobile LiDAR, the service provides a cost-effective solution that delivers economical, engineering-based safety recommendations. FPInnovations thus provides to its clients low-cost, high-precision data about inspected roads, as well as detailed assessment reports that contain upgrade recommendations and priorities.

Several RSI project locations have utilized the results by doing safety upgrades to road networks (figure 3). Follow-up visits to these sites indicate that the MMS RSI methodology provides two unique benefits to planning safety upgrades. Firstly, having a report that methodically summarized all safety issues helped in prioritizing road work, and secondly, the LiDAR data collected as part of the RSIs was useful as survey information for reconstruction. During post-upgrade assessments, several regular road users who were interviewed had very positive feedback.

![Figure 3. Before and after (left to right) example of improved sight distance and widening.](image)

**The Competition**

While MMS can provide accurate and high density point clouds for RSI and engineering design use, an alternative is to use aerial LiDAR because it can also provide adequate point cloud density at a much lower cost and wider land base cover. Several Canadian provinces and private forestry companies have commissioned aerial LiDAR data collection for forest inventory purposes but these same datasets may be used for RSI work even though the point cloud density is lower. FPInnovations has investigated and developed data analysis tools capable of detecting horizontal and vertical SSD issues using aerial LiDAR. Preliminary results indicate that the same SSD locations can be detected using aerial LiDAR.

High resolution video cameras including 360-degree cameras may also offer suitable data at a much lower cost than using LiDAR that requires IMU technology. FPI is evaluating close-range photogrammetry software (also known as structure-from-motion software) for its ability to produce a point cloud from collected video imagery.
The “Green Truck” Project
The “Green Truck” is the label given to a demonstration truck with an optimized configuration, featuring innovative technologies never used until now in forest operations. Built to meet the highest standards in terms of energy efficiency and minimum tare weight for given operating conditions and tasks, the green truck has an objective of maximizing useful payload and lowering the overall energy intensity by tonne-km, while promoting the culture of change in a normally resistant group of workers.

The Need
Perhaps more than any other country in the world, Canada experiences some of the highest delivered fiber costs because of the very long transportation distances between the forest operations and the mills. Trucking costs typically account for more than 50% of these costs, so the industry is constantly looking for opportunities to reduce the expenses related to the trucking phase.

Further compounding the problem has been the rapid rise in fuel prices in the last 5 years. Fuel costs typically represent 35 to 40% of the hourly operating cost of forestry trucks, and a 10% increase in fuel cost can add $0.60/t delivered in typical Canadian conditions. One of the best ways to do this is to lower the overall energy intensity of transportation, that is the amount of fuel burned by unit of product delivered (liters/tonne/100-km); this is not the same, and should not be confused with solely reducing hourly fuel consumption because in some cases, it may be preferable to burn more fuel per hour to deliver a larger net payload. One of the main challenges around this is changing the truckers’ traditional way of perceiving their truck to more of a work-tool perspective.

Another problem that has been plaguing the forest sector has been the growing shortage of available drivers and trucking contractors caused mainly by the increasing competition from other natural resource sectors such as mining and energy. This difficulty in attracting people is also a driver to find solutions for increasing truck payload, and thus reducing the number of units (and drivers) required to deliver a given amount of fiber.

The Approach
Based on the strong feedback from industry regarding the need to increase trucking efficiency, FPInnovations launched a demonstration project called the “Green Truck” project. The project involved a number of industrial partners in the Upper Laurentian region, about 200 km north of Montreal, Quebec, a forestry region strongly affected by the collapse of the economy in the last recession.

The project involved identifying and testing the best technologies available on the market designed to increase trucking efficiency, either by reducing the tare weight or reducing fuel consumption, yet be compatible with heavy-duty forest operations.

Prior to the beginning of the project, 10 trucks had been instrumented with on-board computers for a year to identify the areas where improvements were needed. In collaboration with local contractors, truck dealers and transport managers, the demonstration then involved purchasing, building and operating five trucks with these enhanced features (Figure 4), and adapted for the specific products being hauled, travel distances and topography.

The list of technologies incorporated in the “Green Trucks” included:

- Lightweight stakes and bunks made of composite material developed by FPInnovations in collaboration with Mat-Comp, a composite materials specialist; Pultrall, a composite product manufacturer; and Deloupe, a Quebec-based forest trailer manufacturer;
- Bi-energy LPG (liquid petroleum gas or propane) system from Prins, distributed by BL-Énergie. This system allows the trucks to run on both diesel fuel and propane at the same time, up to a blending level of 70% diesel and 30% propane.
- Optimized truck specification and configuration for the region (engine HP and torque, suspension, day cab, fuel tank capacity, frame inserts, etc.)
- Kleenoil’s Engine oil bypass filtration system that helps maintain oil quality and reduce molecular sheering.
- Automatic 6-speed Allison transmission or Eaton-Fuller automated transmission

Figure 4. A “Green Truck” featuring a 4-axle semi-trailer with composite stakes and bunks

The project was jointly financed by the Quebec government, local industrials partners and FPInnovations. One of the challenges of the project was to identify five truck owners that were ready and willing to purchase a new truck and trailer to be part of the project. Only the more expensive components not usually included in normal truck specifications were funded by the project.

Tests in actual operations started in December 2013 and performance monitoring will continue for a complete year. Once the year is completed, several tech transfer activities will take place to publicize the results and favor uptake and implementation. Truck drivers are notorious for not being early adopters but rather need to see technology proven in real operations before deciding to make similar investments.

The Benefits
Since the monitoring period has only just begun, with a couple of winter months of operation only to date, limited results are available from an overall efficiency or cost reduction perspective.

However, the Green Truck configurations were showing tare weights of around 17 500 to 18 000 kg, whereas the average tare weight for truck-trailers in the region is about 19 500 kg and many rigs exceed 20 000 kg when empty. This one to two-tonne gain in payload should lead to significant cost savings and accelerated payback on the more expensive components selected for these trucks. Also, fuel consumption per hour should not be more, and possibly less, than average trucks in the region, providing a significant reduction in overall energy intensity measured in L/tonne of wood delivered / 100-km.

Finally, this demonstration project will encourage the introduction of new technology and products to a market that is traditionally less open to innovation and new technologies. The early interest shown by local truckers in the project has been significant to date.

The Competition
The status quo of operating heavier configurations and proven technology provided guarantied reliability and predictable costs. Operating new technologies presented a higher risk and potentially higher cost...
should a given technology fail in adding value or improving efficiencies. Without a demonstration project, it can be very difficult to prove to an owner-operator that it can be worthwhile investing on new technologies and adapted specifications to reduce operational costs. Truck owners need to see (and believe) early financial benefits (quick payback) to justify the additional costs.

**Conclusion**
The research and implementation projects discussed around the FPSuite platform, the road safety inspections and the “Green truck” demonstrate the power of SRI’s NABC approach in ensuring that R&D projects are driven by actual needs and have the best chance at rapid implementation. While there will always be a need for curiosity-based research and serendipitous discovery to increase the collective knowledge base of the scientific community and generate unplanned innovation, FPInnovations’ needs-driven research has shown tangible uptake and value delivery within its members in the private sector.

**References**
