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A Radio Communications Protocol for Resource Roads in B.C.:

A Summary of Three Pilot Project Reports and Recommendations for Provincial Implementation

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March 2013

Prepared for the BC Radio Communications Working Group

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Executive Summary

This report summarizes outcomes of the Road Radio Communications Pilot projects and key findings from FPInnovations' evaluations of the three aspects of the resource road radio communications protocol in the pilot areas (i.e., signage, calling procedures and radio channels). On the basis of positive feedback from road users and stakeholders FPInnovations endorses the adoption of the signage convention and calling procedures as piloted, and the new, simpler, form of resource road radio channels.

In 2006, led by the Ministry of Forests and Range (MOFR), the BC Radio Communications Working Group (including participants from MOFR, FPInnovations (formerly FERIC), Industry Canada, Forestry TruckSafe and the Council of Forest Industries) was drawn together to create a comprehensive communications strategy for all of the radio-assisted resource roads in BC with the intent of improving user safety. The strategy had three key parts: refine resource road signage, create standardized radio calling procedures, and establish a bank of radio channels that are dedicated for resource road use in BC. A 2007 BC Coroner's inquest into the death of a logging truck driver travelling on a northern radio-assisted forest service road cited poor communication as one of the key factors which led to the fatal accident. The inquiry's jury recommended to the MOFR that forest service road signage be standardized; and, to the BC Forest Safety Council, that efforts be made to develop standardized radio use protocols.

The road radio communications strategy was piloted in two areas of BC: the Strait of Georgia Business Area of BC Timber Sales (including the Sunshine Coast), and the southern part of the Peace Forest District. FPInnovations was tasked with assessing whether the piloted radio communications protocol improved road user safety or not, and whether the protocol would be recommended for implementation Province-wide in its piloted form or with modifications. In the pilot areas, engagement and consultation occurred amongst resource road users at the local level including road safety committees consisting of a variety of industrial and commercial users (forest, oil and gas, mining, recreation, etc).

Positive road user and stakeholder feedback from the pilots in 2010 indicated that the first two communication protocols (refined resource road signage and standardized radio calling procedures) successfully improved road user safety and should be implemented province-wide. Acting on this, the Ministry of Forests Lands and Natural Resource Operations (FLNRO) (formerly MOFR) developed standardized radio communications signage and radio call protocols in 2009 and 2010, respectively.

Late in 2011, road user and stakeholder feedback from the South Peace pilot area identified significant concerns with the piloted bank of radio channels. Investigation determined an unforeseen complexity with the standardized channels (i.e., 84 channels consisting of 3 tones per frequency, and 5- or 30-Watt power) which contributed to mistakes in programming end-users' radios and resultant communication difficulties. Intermittent communication problems also resulted from unexpected interactions between some radios' settings and the bank of radio channels. The BC Radio Communications Working Group, in 2012, determined to adopt a simpler radio channel format, with fewer channels and no tone carriers, that is anticipated to avoid the problems encountered in the pilots. This technically simpler approach to a standardized bank of channels is scheduled for implementation in June 2013 in the southern

part of the Peace Forest District and in October 2013 in the Strait of Georgia Business Area of BC Timber Sales.

Report Description

The Engineering Branch of FLNRO engaged FPInnovations to participate in the BC Radio Communications Working Group, to monitor, document and evaluate the resource road radio pilots, and provide recommendations to government regarding the readiness of the resource road radio communications protocol for provincial implementation.

A key role of FPInnovations, in participation and support of the BC Radio Communications Working Group, has been to document progress and produce technical reports on various project initiatives. The objective of this report is to summarize FPInnovations' findings from the pilot project of a new resource road radio communications protocol developed by the BC Radio Communications Working Group.

This report summarizes the key findings associated with each of the three aspects of the resource road radio communications protocol, and makes recommendations in support of a provincial roll out of the new communications protocol. The key findings were derived from the following four FPInnovations project reports:

- *A Radio Communications Protocol for Resource Roads in B.C.: Pilot Project Results and Recommendations for Implementation.* September 2009.
- *A Radio Communications Protocol for Resource Roads in BC: A Review of Technical Issues in the Peace District Pilot Project*. April 2011.
- *2012 Survey of Road Users from the BC Resource Road Radio Protocol Pilot*. April 2012.
- *Summary of 2012 Investigation of Radio Communication Complaints from RR Radio Pilot Road Users at Chetwynd, BC*. June 2012.

Additional findings are presented from, soon to be published, interviews of BC radio shop technicians and owners regarding the number and compatibility of wideband-only radios with the standardized bank of narrowband resource road radio channels.

Introduction and Background

A need to focus on improving safety and reduce collisions on resource roads, including forest service roads, in British Columbia was identified starting in 2005. The Forestry TruckSafe Summits held in 2005 reported that stakeholders identified safety concerns with communications on resource roads including inconsistencies in radio protocols and road signage throughout the province (Fraser 2010). In addition, a 2007 BC Coroner's inquest into a fatality on a northern resource road found that improvements were needed province-wide (BC Coroners Service Ministry of Public Safety and Solicitor General 2007).

Recommendations from the summits and inquest called for improved signage for resource roads, creation of standard radio calling procedures, and the standardization of radio frequencies. Concurrent with the summits, Industry Canada took steps to lay out a framework to refine the spectrum management system by identifying a set of radio frequencies that could be dedicated for use only on BC radio-assisted resource roads. At the same time, BC Timber Sales engineering specialists proposed clearer signage[1] and began testing it on some FSR resource roads in the Campbell River District.

Radio-assisted resource roads are used by a wide variety and growing number of groups including resource industries, emergency personnel, utility companies, road repair & maintenance vehicles, service vehicles (e.g., fuel trucks, tire shop trucks), First Nation communities, and the general public. Having a consistent radio communications protocol will help improve safety for those who use these resource roads on a daily basis as well as give those who do not, some level of comfort that there are protocols in place.

In 2006, the BC Radio Communications Working Group (Appendix 1) was formed to address the development of a communications protocol and to ensure all aspects of a proposed protocol were taken into account. The Group was represented by a variety of experts and stakeholders: forestry and trucking safety (BC Forest Safety Council and TruckSafe), forest operations (Engineering Branch, FLNRO and Strait of Georgia Business Area, BC Timber Sales), operations-focused forestry research (FPInnovations), and radio communications (Industry Canada's Spectrum Management Branch[2] and Radio Operations Group, FLNRO). Substantial cooperation and support with road user surveys and complaint investigation was also received from the Chetwynd operation of West Fraser Mills Ltd. and the local road safety group. In order to facilitate an eventual provincial rollout of an improved radio communications protocol, a pilot project to test all three aspects of the protocol took place in two geographic areas of the province. These areas were the Strait of Georgia Business Area[3] of BC Timber

[1] Doug Erickson, Engineering Officer (retired) took a lead in improving resource road signage. Versions of his signage have been incorporated in the final resource road standard protocol.

[2] Industry Canada is the federal government responsible, among other things, for managing spectrum management in Canada and for protecting Canadian interests in International spectrum negotiations and treaties.

[3] The Georgia Strait Business Area is represented by the Campbell River, South Island and Sunshine Coast Forest Districts. In some cases, project reports referred to the Sunshine Coast Forest District as a third pilot area.

Sales[4] (including the Campbell River, South Island & Sunshine Coast Forest Districts) and the portion of the Peace Forest District lying south of the Peace River (referred to hereafter as the South Peace Forest District)(Figure 1).

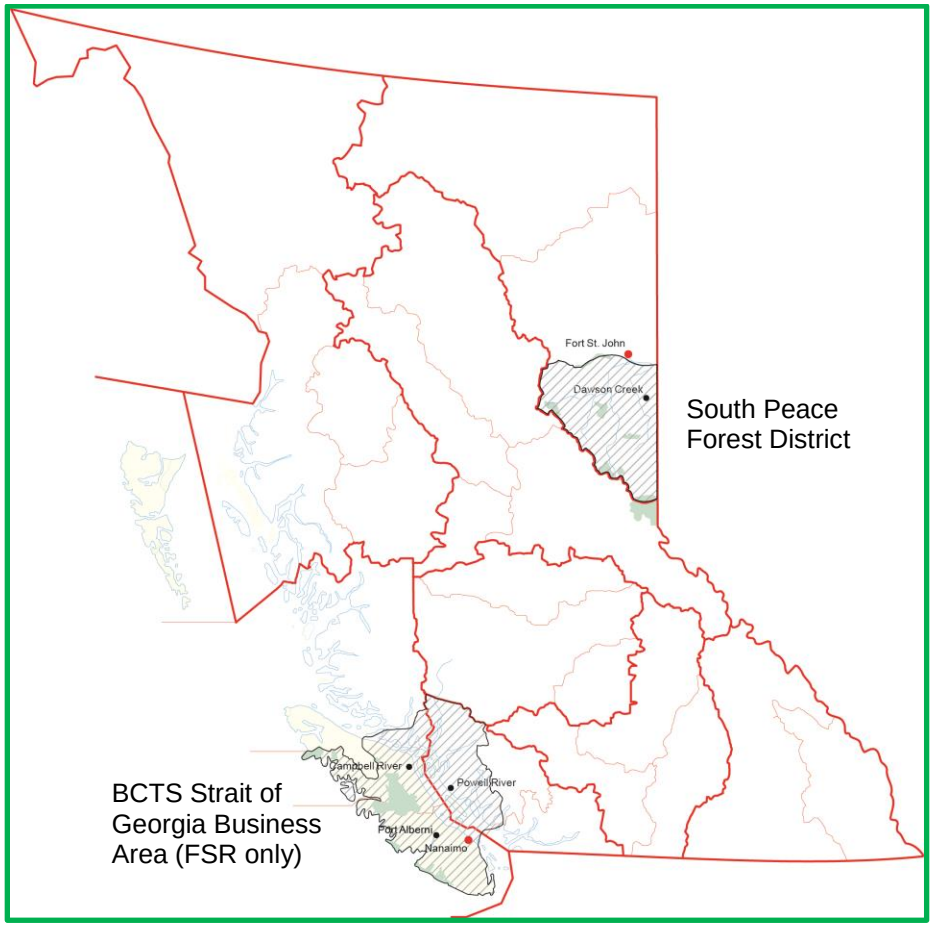

Figure 1. Pilot project locations.

The pilot project was conducted in two geographically distinct areas of the Province to test the radio communications protocol under a range of operating conditions and multi-sector road users. As BC Timber Sales in the Georgia Straight Business Area essentially initiated (led by Doug Erickson, Engineering Specialist) the concept of a standardized road radio communication system, this area was selected as the first area to conduct a pilot. The diversity of resource road traffic and industry stakeholder representation made the South Peace Forest District an ideal second test area. The combination of geographic conditions and industrial traffic associated in each pilot area was expected to provide a reasonable test for the pilot methodology and how a standardized radio communications protocol could work province-wide.

[4] Only FSR (resource roads) within BC Timber Sales' operating areas were included in the Strait of Georgia Business Area Pilot.

The roads in the pilot areas comprised mainly FSRs, which fall under the jurisdiction of the FLNRO, but also included roads under other tenure, such as PDRs (petroleum development roads) in the South Peace Forest District. Portions of Vancouver Island within the BCTS' Georgia Strait Business Area where the majority of roads are privately managed by forest licensees were not included in the pilot.

Extensive communication was conducted with local level stakeholders in promoting the pilot projects and engaging participants. Local community meetings were held to describe the objectives and obtain support for the pilot projects. This was followed by extensive planning to implement the pilot projects in each of the pilot locations. Road safety committees, industrial representatives, FLNRO, Industry Canada, and FPInnovations staff were all instrumental in implementation of the pilots. The pilots could not have been implemented without full support and cooperation of the users of the roads in the pilot areas.

Pilot Project Objective

The objective of the BC Radio Communications Working Group was to create and test a resource road radio communications protocol that would improve road user safety across the province. This protocol would:

- be simple and intuitive.
- be implemented consistently across the province.
- provide the greatest likelihood of reducing radio communication confusion.
- address overcrowding and radio walkover[5].
- provide road users with a clearer understanding of their location and the ability to identify hazards while driving on resource roads.

The new radio communications protocol developed by the Working Group would be focused on improving road safety by:

- refining and standardizing resource road radio communication signage.
- standardizing radio communication calling procedures.
- dedicating a uniform bank of standardized road radio channels for resource road use across the province.

Testing would be conducted to evaluate the effectiveness of the radio communications protocol and recommend improvements and measures that would support province-wide implementation.

[5] Radio walkover is a form of interference which occurs when more than one user tries to transmit a message at the same time on one frequency. The result is one of the messages being unheard by others listening on that frequency.

Project Tasks

The communications protocol had three key aspects: refined resource road signage, standardized radio calling procedures, and a dedicated bank of standardized road radio channels for resource road use.

The evaluation process included soliciting feedback from stakeholders and road users in the pilot areas, testing radio communications, and investigating communications-related issues. The following sections describe the research conducted by FPInnovations in order to complete these tasks.

Standardized Resource Road Radio Communications Signage

For the first part of the proposed resource road protocol, a variety of road signage was developed and installed for testing in the pilot areas (Figure 2). A standard sign format was desired because it would provide clarity and consistency for radio users travelling on any radio-assisted resource road. The new signage also needed to be economical and easily maintained. Guidelines covering the format, use, and placement were created for the following radio communications sign types:

a) **Resource Road Orientation** signs
b) **Km Marker** signs
c) Road Channel Identification signs
d) **Must Call** signs for road junctions and at Km markers

In response to road user feedback, an additional sign format was developed for **Must Call** and **Caution** signs that would be installed in high hazard areas such as, where radio reception or sight distance is reduced and where drivers must switch to a different road channel. Bennett et al. (2009) provides further detail about the development of the improved, standard signage.

FPInnovations evaluated the effectiveness of the piloted signage by conducting approximately 150 roadside interviews with road users in the pilot areas in 2008 and 2009. Details about the process and findings from these interviews can be found in Bennett et al. (2009).

Figure 2. Examples of pilot area road signage: Km marker call sign (left), FSR orientation and must call signs at the entrance to FSRs (centre and right).

Standardized Radio Calling Procedures

The second part of the proposed resource road protocol was to create rules to ensure that radio calling procedures are consistent, well understood and practised by all radio users on resource roads. To create consistency, a standardized call procedure was proposed which would apply to all radio-equipped vehicles travelling on resource roads that have implemented radio assist as a traffic control measure/device. The piloted provincial standard included call specifications that consisted of:

- the order in which descriptors for vehicle position are announced as well as a standardized direction descriptor.
- frequency of calling.
- rules for convoy calling.

Bennett et al. (2009) provides further detail about the development of the standardized calling procedures.

FPInnovations evaluated the effectiveness of these standardized calling procedures by conducting approximately 150 roadside interviews with road users in the pilot areas in 2008 and 2009. Details about these interviews can be found in Bennett et al. (2009).

Dedicated Channels for Resource Roads

The third aspect of the proposed Radio Communications Protocol was to standardize radio frequencies and channels used on resource roads in the pilot areas. Resource road channels (called RR channels) were designated for transmitting and receiving traffic control information between radio-equipped vehicles on resource roads in the pilot areas. When implemented province-wide, the standard bank of radio channels would allow a road user to travel on any resource road in BC and be assured that they have the required road channel available in their radio at all times. RR channels are location specific; Industry Canada will manage where

and when the RR channels are used and for what purposes. Loading (or LD) channels also were included in the standard bank of RR radio channels. LD channels are not location specific and are intended for general worksite communication.

Industry Canada is responsible for the licensing and management of all radio spectrum in Canada, including the assignment or reassignment of radio frequencies. Because of this, the BC Radio Communications Working Group recognized that the creation process of a standardized bank of resource road channels would need to satisfy some of Industry Canada's objectives for future radio spectrum management, as well as meet the requirements of the resource industry. If the RR channels were to be implemented in other parts of Canada in the future, care needed to be taken to assure their technical specification was progressive and conformed to spectrum management goals of adjacent provincial jurisdictions and the USA. With these technicalities in mind, the following objectives were proposed by Industry Canada in the development of the RR channel specification:

a) to eliminate the use of Appendix 6 radio channels[6] for communications on resource roads and replace them with a new standard bank of VHF frequencies licensed to the FLNRO as a logical assignment to allow for eventual use on resource roads province-wide.[7]
b) to specify the standard bank of channels so that they occupied a minimum of radio spectrum space and allowed for a reasonable number of replications of the same channel over the landscape.
c) to emulate an FCC mandate to transition existing land mobile radio frequency assignments to narrowband over a period of time, but make the new radio pilot frequency assignments narrowband immediately.[8]

These objectives laid the framework for developing the piloted RR channel specification. The new standard bank of channels was specified with only narrowband frequencies because this enabled interleaving the new RR assignments within the numerous existing licensed frequencies in the heavily congested VHF radio frequency band. Further, narrowband frequencies are now the standard in Canada.

A second measure to minimize spectrum space occupied by the channel bank, and maximize number of channels available, was to use the radio's continuous tone-coded squelch system (hereafter referred to as 'tones') to increase the number of channels available for a single carrier frequency. This was done by providing three tone variations per each carrier frequency. In order that radio channel names were easily recognizable when displayed on radios, the channels were named RR or LD, followed by the channel number and a suffix (A, B, C to denote tone)(e.g., RR 10B). The tone for all suffix A channels was 114.8 Hz, for suffix

[6] 'Appendix 6 channels' refers a bank of approximately 300 random non-dedicated wideband road channels in use throughout BC including those previously used in the resource road pilot areas.
[7] Mobile two-way radio channels used on FSR resource roads in BC must receive concurrence from FLNRO for this use.
[8] The Federal Communications Commission (FCC) is the regulator responsible for spectrum management in the United States. Narrow band frequencies became standard over most of the land mobile spectrum in the US on Jan 1, 2013, at which time wideband became non-standard.

B channels was 123.0 Hz, and for suffix C channels was 131.8 Hz. Tones were installed on both transmit and receive radio functions.

Walkover and excessive chatter problems were addressed by creating a large number of dedicated RR channels and carefully assigning them over the landscape to minimize the likelihood of interference. This mapping exercise required involvement of local FLNR and IC staff, as well as, input from road users. Landscape polygons for radio channel assignment were created by identifying geographic areas that had:

- high radio use or might experience high use in the future.
- no terrain features or long distances to interrupt radio reception.

Radio channels were then assigned to each area (landscape polygon) and to resource roads with relatively high traffic volumes and those that are considered a major access corridor. In order to avoid possible interference RR channels with the same base frequency were not assigned to polygons within 50 km of each other (Bennett et al. 2009). In addition, some RR channels and all of the LD channels were specified with reduced transmission strength in order to limit their transmission range. Figure 3 is an excerpt from a 2011 FLNRO radio frequency map that illustrates how the area around Tumbler Ridge was partitioned into landscape polygons, and RR channels assigned to those polygons and mainline resource roads.

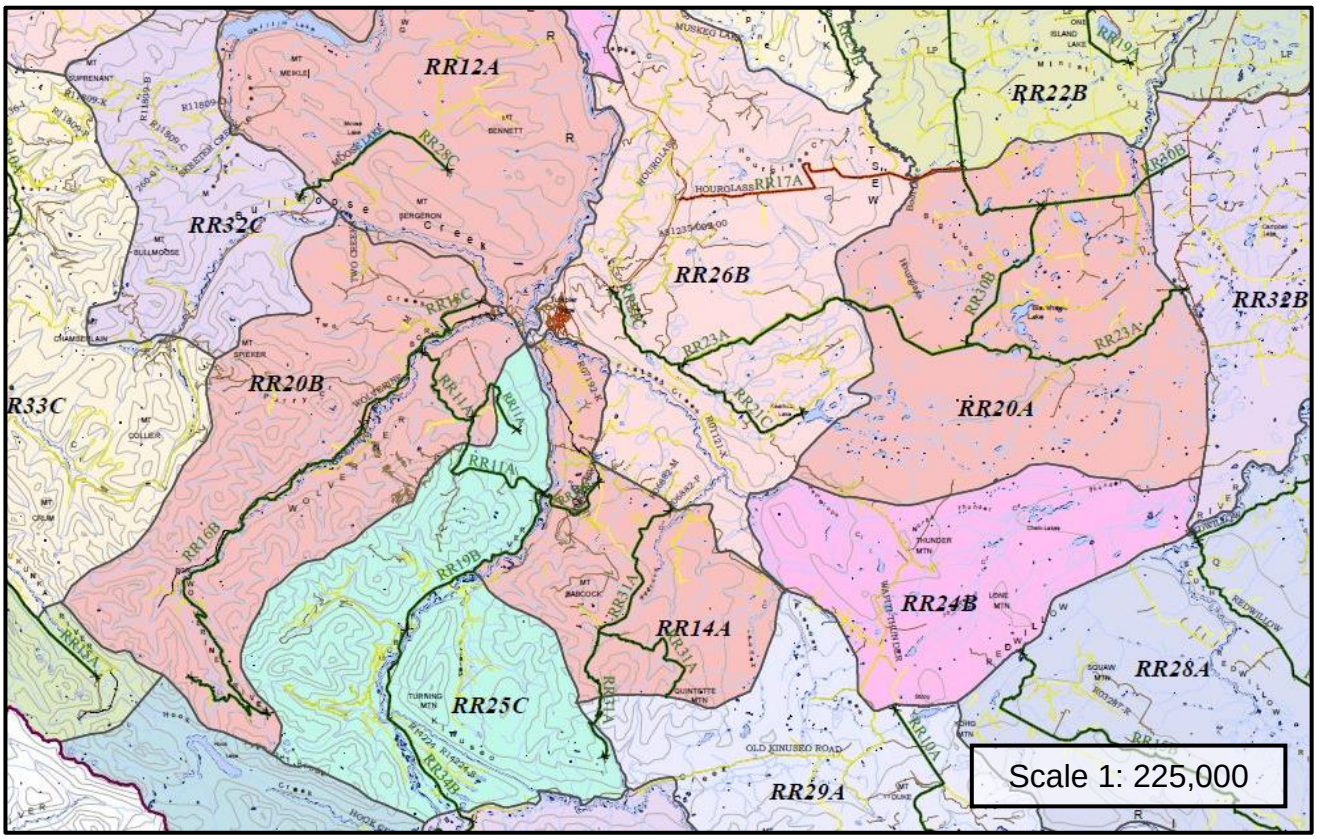

Figure 3. Distribution of RR channels in landscape polygons and on individual resource roads near Tumbler Ridge, BC during pilot project. August 2011.

The original 2008 channel assignments were 18 30-Watt RR channels and 24 5-Watt channels; 15 of the 5-Watt channels were designated as RR channels and nine as LD channels (Bennett et al. 2009). It was thought that 5-Watt channels would not be heard over extended distances and would provide options in high volume traffic areas. Table 1 illustrates the channel attributes and naming convention.

Table 1. Six radio channels and their attributes

Channel Name	Frequency (MHz)	Power (Watts)	Tone (Hz)
RR 10A	150.20	30	114.8
RR 10B	150.20	30	123.0
RR 10C	150.20	30	131.8
LD 1A	150.59	5	114.8
LD 1B	150.59	5	123.0
LD 1C	150.59	5	131.8

FPInnovations evaluated the effectiveness of these standardized radio channels in a variety of ways by:

- conducting roadside interviews with pilot area road users in 2008 and 2009 (Bennett et al. 2009).
- measuring transmission distances of 5- and 30-Watt channels on resource roads in the pilot areas (Evans 2011).
- developing a field procedure for designating must call sign locations based on insufficient radio reception distance (Bennett et al. 2009).
- conducting roadside interviews with road users in the Chetwynd area in 2011 (Evans 2011).
- conducting a web survey of pilot area road users in 2012 (Evans and Bradley 2012).
- investigating, with staff from Industry Canada, radio communication complaints from road users in the Chetwynd area in 2012 (Evans 2012).

Key Findings

Standardized Resource Road Radio Communications Signage

A limited number of sign formats were developed for trial on resource roads in the pilot areas. FLNRO signage guidelines were adopted in the creation of the final standards for sign size, font, colouring, reflectivity, material and surface coating (Bennett et al. 2009). Km marker signs were designed to match the calling protocol order of 'road name/ Km mark/ travel direction' read from top to bottom on the sign (Figure 4). Occasionally, road locations other than at Km markers warrant a site-specific radio call to alert other road users about a vehicle's position. These types of calls are initiated when a posted Must Call sign is read by the driver.

During 2008 and 2009, 150 road users from the pilot area roads were interviewed and their feedback was used to improve the piloted sign types. Signage layout was improved by modifying fonts, and removing the Km suffix to more create a clearer and simpler display. Must Call signs were added on secondary roads near junctions with mainline resource roads.

Figure 4. Content of Km marker sign matches content and order used for calling vehicle location.

The following findings from a web survey of 327 road users in the pilot areas in 2012 (Evans and Bradley 2012) confirmed that road users generally believed that the improved signage was clear and consistent, and that it improved resource road safety:

1. 92% of survey respondents agreed that standardized Km markers made it easier to locate and read them while driving on the road.
2. 86% agreed that standardized road orientation signs, located at the beginning of resource roads, have improved their knowledge of the radio calling procedures.
3. 77% agreed that standardized must call and warning signs have assisted in identifying hazards along the road.
4. 69% of survey respondents agreed that the new signage standards have improved road safety. Although 22% did not agree, there were a number of unresolved communication issues at the time which may have contributed to this number.

As a direct result of positive feedback from the pilots, the standardized signage protocol for radio-assisted resource roads in the pilot areas was adopted by the FLNRO as standard for FSRs in July 2010. The new standard signage is being implemented on FSRs whenever new signs are required or existing signs are replaced. Guidelines for the format, use and placement of each type are shown in Appendix 1.1 of the FLNRO Engineering manual.[9]

Standardized Radio Calling Procedures

Through consultation with road users and stakeholders, a default calling procedure was established for use on resource roads when no other procedure is indicated by road signage. One of the concepts for the default call protocol is that if you are on a road somewhere in the province where you are unfamiliar with the local call protocol, use of the default calling procedure will be safe. The default call protocol for vehicle location is, in the following order, **road name, Km, and the direction of travel (up or down)**. This calling order was adopted as a standard default because listeners were likely to hear the Km location—the most vital information—even if the start or end of the call was cut off. The default frequency for calling one's location was taken to be: **call when entering a new road and, thereafter, at every other kilometer**. When the pilots started various ways to call travel direction were in use around the province (and even multiple ways on the same road network). These included '*empty/loaded'*, '*north/south'*, '*in/out'*, and '*up/down'*. Calling travel direction with '*up*' and *'down'*, where '*up*' is in the direction of increasing kilometers, and '*down*' is in the direction of decreasing kilometers, was selected to be the standard calling procedure because of its simplicity and consistency.

The default calling procedures were modified by the local road safety committees when there were safety concerns such as, when the frequent calling of location by high numbers of road users resulted in 'walkover' or cut off calls. The following are examples of calling procedures defined by the road safety committees which did not follow the default pattern but were used on one or more roads in the pilot areas:

- *Down*-direction traffic called at all Km markers. *Up*-direction traffic called only at the '0 Km' marker (or road entry point), then listened for *down*-direction traffic and used pull outs to give them right-of-way. No must call signs were used on this road.
- *Down*-direction traffic called at all Km markers. *Up*-direction traffic did not call at all. They listened for and used pull outs to give right-of-way to all *down*-direction traffic. No must call signs were used on this road.
- *Down*-direction traffic called at all *odd* Km markers and must call signs. *Up*-direction traffic called at all *even* Km markers and must call signs.
- *Down*-direction traffic called at all Km markers. *Up*-direction traffic called only at must call signs and used pull outs to give right-of-way to all *down*-direction traffic.

[9] http://www.for.gov.bc.ca/hth/engineering/documents/publications_guidebooks/manuals_standards/Eng-Manual.pdf

A standard calling procedure is believed to promote road user safety by improving the accuracy and predictability of radio communications by travelers on the road as well as decreasing the amount of radio 'walkover' in areas with high traffic volume. A web survey of 327 road users in the pilot areas in 2012 (Evans and Bradley 2012) confirmed that road users believed that, in general, the new calling protocols had improved safety and reduced confusion. Some road users wished to retain regional flexibility in calling procedures and over half of the South Peace Forest District respondents said that 'walkover' and excessive chatter were still experienced:

1. 78% of respondents indicated support for adopting a standardized radio calling procedure across the province. Survey responses also indicated a preference for regional flexibility in setting finer details of what a calling protocol should be. For example, over 20% supported the use of varying the frequency of calling one's vehicle location or varying the call contents, as dictated by traffic levels and road conditions.
2. 56% of South Peace Forest District respondents believed that the problem of excessive radio chatter or 'walk over' had not been reduced with the use of the standard set of RR channels, use of low power 5-Watt channels, or with calling vehicle locations according to the piloted calling frequency. 39% thought it was reduced.

Bennett et al. (2009) recommended additional radio calling requirements that road safety committees could consider incorporating in local rules. These additional calling requirements would provide for convoy calling, for emergency situations, and for posted work sites on resource roads (Figure 5). Additionally, the local calling procedures should include calling at must call locations.

Figure 5. The radio protocol includes rules for convoy calling.

As a direct result of positive feedback from the pilots, the standardized radio calling procedure for radio-assisted resource roads in the pilot areas was adopted for application on FSR in December 2009 with the allowance for some local variation as determined by local road safety committees and corresponding local signage.

Dedicated Resource Road Channels

To achieve the objectives of the BC Radio Communications Working Group in pursuing the third aspect of the Resource Road Radio Communications Protocol, as well as accounting for the objectives of Industry Canada, the RR & LD channels were designed with radio spectrum efficiencies in mind. This meant specifying attributes for the channels that had not been used in the past for truck to truck communications on resource roads. Attributes such as tones, narrowband and, in some cases, low power was assigned to each frequency to make more efficient use of the radio spectrum (Evans 2011).

Initially, 33 dedicated RR channels and nine LD[10] channels were identified by Industry Canada for the two pilot areas. When the South Peace Forest District pilot expanded, in May 2010, from the Ojay road network to the remainder of the South Peace District, 42 additional 30-Watt RR channels were added for a total of 75 RR channels and nine LD channels. Interviews with road users and stakeholders indicated strong support for a standard bank of radio channels for resource road use province-wide.

To verify the effectiveness of the RR channels, FPInnovations, with the assistance of FLNRO staff, thoroughly tested the 5-Watt channels and compared them with 30-Watt channels on several resource roads before they were implemented in those areas (Evans 2011). At distances of less than 10 Km and where a clear line of sight existed, there was little difference in radio transmission and reception performance between the high and low power channels and no issues were found to prevent the use of the low power channels. Where terrain features (e.g., rock bluffs) compromised communications, both 5-Watt and 30-Watt signal propagation was affected. These results suggested that there were no advantages to be gained from inclusion of 5-Watt channels in the standard bank of channels.

Complaints from road users to project stakeholders in the winter of 2010 indicated there could be reduced performance of the RR channels compared with those used pre-pilot (although baseline pre-pilot performance was not gauged). With an unofficial reporting process in place for direct feedback from road users, complaints were not reported or they reached the Working Group through radio suppliers and stakeholders after some delay and with vague or incomplete detail. In response to some complaints, FPInnovations made a site visit and found that microphone keying errors were causing cut off calls. A radio supplier was also hired, by one stakeholder, to test radio equipment and found minor equipment maintenance issues but nothing technically wrong with radio programming. In early 2012, several near misses were reported to FLNRO staff in the Peace District pilot area and the BC Radio Communications Working Group agreed there was a need to investigate the complaints in more detail and determine if there was a technical problem with the radio channel specification (Evans 2012).

Monitor mode. An important finding of this investigation was that some pilot road users regularly operated their radios with the *monitor mode* activated—either intentionally (e.g., as a driver-enabled function) or unintentionally (e.g., as a pre-programmed feature or when the

[10] For the purposes of this document, technical discussion about the configuration of the RR channels also refers to the LD channels.

microphone was left hanging by its cord). When operated in this mode mobile radios ignore the tones of incoming transmissions and receive all calls from channels with the same base frequency. Normally this would not cause interference because RR channels with the same base frequency were assigned to polygons or resource roads at least 50 km apart. However, it was found to be a contributing factor to some near misses reported near Chetwynd.

The Chetwynd-area near misses occurred when road users, with *monitor mode* activated, selected an incorrect road channel with the same base frequency (e.g., RR 22A instead of RR 22B). The drivers had no indication that they were using the wrong channel because they could hear calls from other road users; however, the other road users could not hear calls from these trucks unless they, too, had *monitor mode* activated. Thus, a few road users calling on the wrong channel were unwittingly degrading radio communications, safety, and confidence in the piloted communications protocol for many using the road (Evans 2012).

Some drivers selected the wrong radio channel because their radios were mounted in a poor location for viewing or their radio's display window was dusty. This was a result of poor radio installation and maintenance practices. Drivers with TAD M10[11] radios sometimes inadvertently changed channels by pressing their microphones' up/down channel buttons when handling the microphone (Figure 6). Channel selection errors also occurred because the channels are arranged sequentially in the channel selection order and the A and B suffixes of RR channel names look similar on a radio display—making it easier to select the wrong channel and harder to notice the mistake.

Figure 6. TAD M10 radio showing microphone buttons and numerical display.

[11] The TAD M10 was a common VHF mobile radio used in the South Peace pilot area.

The problem of excessive radio chatter or 'walk over' can be exacerbated by use of *monitor mode. Monitor mode* overrides tone-squelching so that all channels with the same base frequency are heard. Transmissions from high elevations and where long line of sight exists may carry far enough to interfere with different RR channels used in neighbouring landscape polygons or mainline resource roads.

Monitor mode cannot be managed because radio users have the ability to manipulate it. Therefore, Industry Canada and the rest of the Working Group agreed to eliminate tones from the RR radio channel specification and, thus, address the monitor mode problem. Industry Canada determined to find, and is in the process of finding additional radio spectrum frequencies to establish a standardized resource road radio channel bank at the time of the writing of this report.

Use and hardware issues. 48% of respondents to FPInnovations' web survey of South Peace Forest District road users reported that as many or more cut off calls occurred during the pilot than before the pilot (42% thought the number of cut off calls was reduced in the pilot). Cut off calls are caused by human error. There is need for more education, training and enforcement of calling technique and calling order. Evans (2011) reported that road users who received training on proper radio use (e.g., microphone keying during calls) transmitted fewer cut-off calls.

Radio hardware (i.e., power cable, antenna and its connecting wire) requires periodic maintenance to ensure signals are not degraded by corrosion, loose connections and damaged wires. During FPInnovations' field reviews of user radio hardware a variety of problems were observed including: poor radio installations, poor antenna installation, etc. Some of the unexplained communication issues noted during the pilots may have been due to poor radio hardware maintenance or installation (Evans 2012). Based on reported issues, FLNRO requested FPInnovations to develop a best practices document for installation and maintenance of radio hardware.

Wideband-narrowband radio interaction. Wideband-narrowband radio interaction, although previously tested by Industry Canada, was not evaluated by FPInnovations in the pilot. However, FPInnovations found that it was the overall opinion of experts from provincial radio shops and Industry Canada that the design of newer narrowband radios allows them to effectively receive wideband transmissions without distortion. Depending on the wideband radio model, however, narrowband transmissions may sound quieter on a receiving wideband radio. Wideband radio owners should be made aware of this possibility and be encouraged to purchase narrowband radios.

Working Group experts believe that narrowband signal propagation is marginally less than wideband. As a result, users of the narrowband RR channels may notice garbled or distorted communications near rock bluffs, power lines, steep road dips and during bouts of inclement weather that wasn't present previously with wideband radio use. Stakeholders should be made aware of this and should review locations of Must Call signs to account for it. Note that zones of reduced radio reception are not anchored spatially over the landscape – their location and effect depend on the relative positions of the communicating vehicles (Bennett et al. 2009).

Low power radio channels. Reduced radio transmission and reception range did not necessarily reduce road user safety. On pilot roads where radio reception was limited to 10 Km or less (e.g., winding mountain roads) road users naturally travelled slower and this gave them plenty of time to react to calls from oncoming vehicles. Use of 5-Watt channels for this type of road appeared to work well in the pilot, however, radio shop experts cautioned that some radio models transmit inconsistently when on channels programmed for less than 10 Watts. The radio users may not be aware of the inconsistent transmissions that they are creating.

The programming complexity of the piloted RR channels may have contributed to programming errors that led to communication failures early in the pilot. It is believed that this issue may have been resolved by Industry Canada reminding radio shops to review the PRC 07-1 Issue 3 bulletin issued to them in May 2010. FLNRO has also posted the bulletin publically[12] and this may have helped address the issue of programming errors in radios that were self-programmed.

The LD channels were under-utilized in both pilot areas. 54% of respondents in an FPInnovations web survey agreed that the LD channels reduced the radio call volumes on the RR channels, however, 30% disagreed and 16% were neutral or had no opinion. The high number of responses that were neutral or had no opinion may have indicated a lack of awareness of these channels and highlighted an opportunity to utilize LD channels more effectively. Despite LAD channels[13] often being busy, many road users used them for loading and other worksite communications instead of using the LD channels. The LD channels, if administered well, should have less interference (radio traffic) than the LAD channels which also tend to be used for chatter. Stakeholders and road users should be informed that the LD channels are available for use and how they should be used.

Additional Findings from Regional Pilots

1. Partitioning geographic areas into landscape polygons was an effective approach to provide effective radio coverage with a limited number of radio channels over large areas. Many roads in the pilot areas did not have enough industrial activity to warrant their own road channel and nor were there enough RR channels to do this.
2. Road safety committees are an important part of the implementation process:
    a. Stakeholders that participate in these committees have up-to-date knowledge of current and planned industrial activity. This helps ensure that, during the channel implementation phase, radio channels are assigned where they are most needed (as per finding 1).

[12] http://www.for.gov.bc.ca/hth/engineering/documents/Road_Radio_Project/PRC-07-1issue3-June-2010.pdf
[13] LAD is short for Logging Administration, which are general usage radio communication channels used mainly for non-safety communications in BC and parts of Alberta. LAD channel usage is not restricted to logging or any other specific industry.

b. A road safety committee can also control variations in the calling procedures and tailor them to their needs.

c. Road safety committee could be a hub for an incident reporting process, and through this process, manage locations of must call signage and locations of road hazard signage. A formal reporting process involving pilot area road users might have identified concerns with the RR channels earlier leading to quicker and more effective resolution of safety issues.

3. Some road users were resistant to the piloted resource road radio communication protocol because of the costs involved. The cost to have radios professionally re-programmed with new channels is about $30 per unit, plus any costs associated with removing and installing radio equipment and getting to and from the radio shop. Users of the Ojay road network incurred the cost of having their radios reprogrammed a second time when the RR channel configuration was changed in 2010. While necessary for safety and consistency, this added cost was an unfortunate consequence of the testing process. Road users with wideband radios will have to incur a cost of $800 to $1000 per radio if required to purchase new narrowband equipment. In Canada, wideband radios officially became non-standard in 2004; however, radio shops reported to FPInnovations that many thousands are still in use. A low compliance rate among road users interviewed in the Georgia Straight Business Area pilot area was confirmed through interviews with radio suppliers in those areas. A few road users enquired about the possibility of a Provincial subsidy to assist with new radio purchases.

4. 75 RR channels provided adequate geographical coverage when assigned over the large and challenging area of the South Peace Forest District. FLNRO district engineering officers anticipate, however, that 99 channels may be required to meet future needs. Adding additional channels to the existing RR radio channel bank would result in additional costs and inconvenience to radio owners. As observed in the BCTS Strait of Georgia Business Area pilot, fewer than 75 channels were needed to cover smaller, less industrialized areas—even if they have mountainous terrain.

5. Once the standard bank of RR radio channels are finalized and implemented across the Province, radio owners should not need to reprogram their radios for resource road travel again—even if they move to different regions to work. Also, road managers will no longer need to apply to Industry Canada for new road channels. Amendments to the locations of the channel assignments can be discussed at the local level through meetings of the road safety committees.

6. Pre-pilot radio performance data was not collected and so comparisons cannot be made to effectively gauge the impact of the RR channel specification in the pilot areas. It is likely that some of the radio communication problems such as, poor radio and antenna installations, existed prior to the pilots and will continue.

7. Implementation of the revised RR radio channels has taken a long time because of set-up delays (Industry Canada needed to clear extra channels from existing licensees) and waiting for a convenient time for industry road users to get radios re-programmed (i.e., the 2013 break-up).

8. As recommended by Bennett et al. (2009), those considering a rollout of the radio communications protocol in a particular forest district should anticipate the following needs:
    a. Establishing a clear communications strategy with those stakeholders affected by the changes well in advance of the rollout date.
    b. Timing the implementation to coincide with the stakeholders' periods of downtime. This will facilitate implementation by
        i. timing installation of signage changes to low road use periods
        ii. allowing extra time for road users to have their radio equipment programmed at radio shops. Given the large influx of radios to re-program there will be delays in having service performed.
        iii. allow for additional training for road users to ensure their resource road travel is safe.
    c. Partitioning the landscape into polygons for RR channel assignment.
    d. Increased enforcement activity to ensure compliance with new procedures.

Conclusions

The resource road radio communications protocol currently under pilot in the BCTS Strait of Georgia Business Area and the Peace Forest District is part of a larger initiative to improve resource road safety in British Columbia.

As a direct result of positive feedback from the pilots, standardized protocols for radio-assisted calling and resource road signage were implemented across BC in December 2009 and July 2010, respectively.

A dedicated bank of resource road radio channels, consisting of frequencies and tones, was specified to meet both provincial and federal objectives, and was thoroughly piloted over the last 4 years. Technically the system was sound and should have met all the requirements for a safe radio assist option. However, safety incidents occurred because of the ability of radios to be user set to *monitor mode,* which overrides separation of toned radio channels. In order to address this safety issue, the Resource Road Radio Working Group is in the process of establishing a revised set of RR channels featuring a standardized bank of 40 narrowband channels that are not toned.

Conducting of the radio pilot in the South Peace provided testing of the system in an area of high traffic volumes and with a wide variety of industrial sectors. This resulted in findings which would not have been noted on other, lower volume, road networks. The testing required some radio channel reprogramming for which there were extra costs and inconvenience experienced by pilot area road users. Over the long term, however, standardization of one bank of RR radio channels is expected to reduce costs associated with reprogramming radios. The pilots would not have been possible or successful without the participation and

cooperation of those companies, road safety committees and individuals who have collaborated, contributed to the pilot adoption, implementation and evaluation.

The road radio communications pilot projects have been successful in improving road user safety in piloted areas through the implementation of standardized calling and signage protocols. Creating a standardized bank of radio channels is the third element of the resource road radio communication protocol. Industry Canada is leading the finalization of development of the revised standardized bank of resource road radio channels. Once developed and implemented (implementation is planned for June 2013 in the South Peace pilot area) the standard bank of channels will further improve resource road user safety. Safety benefits will expand in other areas of the province with gradual implementation and adoption of the resource road radio communications protocols.

Recommendations

The following recommendations are based on FPInnovations key findings' of the resource road pilots in the Peace District and the Strait of Georgia Business Area.

1. Continue with the adoption and province-wide implementation of the resource road radio communications protocol consisting of standardized:
    a. calling procedures,
    b. radio communications signage, and
    c. resource road radio channels.
2. Remove the tones from the RR Channel specification:
    a. The more complex and sensitive nature of programming, combined with an insufficient end-user understanding of their radio functioning, led FPInnovations (and the rest of the BC Resource Road Radio Communications Working Group) to conclude that a simpler system of RR channel specifications is needed.
    b. Removal of the tones will eliminate the chance of monitor mode negatively affecting radio communications and still allow road users to utilize monitor mode where required.
    c. Having three toned channels per each base frequency may not actually save as much spectrum space as originally thought if they need to be physically separated as far apart as non-toned channels in order to reduce the chance of interference. It was estimated that an additional 24 toned channels were going to be needed in the South Peace Forest District to avoid interference caused by line-of-sight radio transmissions from high elevation resource developments in neighbouring landscape polygons.
    d. Approximately 40 RR non-toned narrowband channels are anticipated to be needed to replace the current bank of 84 toned RR channels because of the interaction problems between toned channels and radios in *monitor mode*. While there will be fewer channels overall, there will actually be 30% more radio spectrum dedicated under the new configuration.
    e. Non-toned narrowband RR channels also satisfy the Industry Canada spectrum management objective to reduce spectrum from the Appendix 6 wideband channel system used in BC.
3. Keep the narrowband specification of the RR Channels but make sure stakeholders are aware that, in some cases, signal propagation of narrowband channels may be less than previously with wideband channels. Ensure that Must Call signs are installed in areas with reduced radio reception. Implementing narrowband will support the Industry Canada initiative to transition new frequency assignments to narrowband, and will also support the FCC move to narrowband in Jan 2013 for land mobile communications.
4. Study the difference in signal propagation of wideband and narrowband radio channels in actual field trials to verify the theory and alleviate road user concerns.

5. Re-configure the 5-Watt channels to be 30-Watt channels. This should eliminate incidents of spurious radio transmissions from radio models that were not designed to support 5-Watt power.

6. The final RR channel specification, with 40 non-toned channels, will be introduced in the spring of 2013 starting with the South Peace Forest District pilot area and followed by the BCTS Strait of Georgia Business Area pilot area. It is recommended that the final RR channel specification be implemented province-wide, as soon as possible.

7. Implementation should include training or other tools to assist road users in proper set-up of radio hardware in their vehicles, proper radio use, and general radio functions.

8. Develop a process to ensure that radio communications incidents are recorded and reported in a timely manner with the appropriate details. As noted previously, the local road safety committees may be an appropriate way to collect the information; however, the reports will be need to be organized and stored in a Provincial database where it can be used for evaluating road user safety, identifying issues, and directing future policy direction.

9. Ensure radio checks are performed by individual users, without fail, before entry to a resource road. The best reminders may be Must Call signs near all road intersections and increased education and enforcement.

10. Contractors should use the LD Channels when industrial activities other than road travel are happening on the main resource roads. Road users should be made more aware of their functionality and that they are a better alternative to using a LAD channel. Less radio traffic will be on them and all road users who have the entire bank will have them in their radios. Post the correct LD channel on the road in advance of the activities and notify road users when it is safe to transit the work site.

11. A provincial implementation of the RR channels will require cooperation and funding at both Provincial and Federal government levels. Funding will have to be secured to cover the substantial cost associated with clearing frequency assignments and implementing the RR radio communications protocol on a provincial scale. The cost for clearing the remaining frequency assignments across BC (work has already been completed to date in certain parts of the province) is estimated at $160,000[14] and may require over 5 years to complete.

12. Provincial implementation of the Protocol will be complex and its success will rely on comprehensive communication, planning and strong support from all sectors. Education, training, and enforcement efforts will be needed.

[14] Costs for displaced licensees were estimated by Industry Canada Spectrum Management through a working group lead by Dave Miller (ret.) of FLNRO Radio Operations.

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APPENDIX 1.

The BC Radio Communications Working Group (2006 – 2010)

Participants	Affiliation
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The BC Radio Communications Working Group (2011-2012)

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[15] Affiliated with the Central Interior Logging Association (CILA), as of July 15, 2009.
[16] Acting as a technical advisor.
[17] Replaced MaryAnne Arcand as chair and left the Working Group in mid-2012.