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Contents



# Operational trial of the ForestWatch wildfire smoke detection system

**Abstract**

The ForestWatch wildfire smoke detection system was tested operationally in Alberta during 2004 by the Forest Engineering Research Institute of Canada (FERIC) and Alberta Sustainable Resource Development (SRD). The system was re-configured for use with satellite communications from its original microwave communications, and cameras were mounted on existing communications towers. This report presents the results of the system evaluation and costs.

**Keywords**

Fire management, Smoke detection, Wildfires, Towers, Video cameras.

**Author**

Dave Schroeder,
Wildland Fire Operations Research Group

## Introduction

Alberta SRD, Saskatchewan Environment, and FERIC evaluated three video-based smoke detection systems in 2003, and determined that semi-automated systems could detect smoke from a 0.1 ha fire up to 40 km distance (Schroeder 2004). However, more research was needed on how to transmit the large volumes of video data between the transmitter and receiver sites. The systems evaluated in Schroeder (2004) used high-frequency microwave technology for data transmission. These microwave systems are inexpensive to operate as they do not need to be licensed and require only the capital costs on start-up. However, these systems require that the transmitter and receiver locations have a direct line of sight, and their range typically does not exceed 50 km unless both the transmitter and receiver are located at high ground points. Signal repeaters can be used to extend range but additional equipment and tower sites add cost and complexity. Some potential sites in Alberta will require greater transmission range than might be possible using microwave links. Therefore, Alberta SRD and FERIC investigated the use of distance-independent satellite communications with existing communications towers as camera platforms. In this study, SRD and FERIC tested the ForestWatch[1] system that was evaluated in Schroeder (2004), and FERIC summarized the system costs.

## Objectives

The study had the following objectives:

- Test the ForestWatch system using satellite communications to transfer data from tower-mounted cameras to an operator station.
- Test the feasibility of using existing communications towers as camera platforms.
- Summarize system costs.

## Methods

For the trial, two communications towers were to be selected as camera platforms. Satellite communications would link the

[1] Envirovision Solutions, South Africa (http://www.evsolutions.biz/).

towers with the Lac La Biche fire centre, where there would be a full-time system operator in the dispatch office.

## Tower selection and camera mount

FERIC determined the areas of interest to SRD staff at the Lac La Biche fire centre, and then searched an Industry Canada database[2] for potential towers within those areas. FERIC then contacted tower owners to determine if their sites could be used as camera platforms for the study.

Two communications towers, 40 km west and 180 km northeast of Lac La Biche, were selected. Each tower site included a building with electrical power to run the tower computer, camera, and related hardware. The towers were 100 m and 110 m tall, but the tower tops were unavailable because of previously installed equipment. Therefore, the cameras were positioned at the highest possible locations (90 m) on the tower, on custom-built mounts (Figure 1). At this height, some views were partially blocked. To address this reduced vision, one of the towers was fitted with two cameras. The second camera would also allow the landscape to be scanned more frequently as the areas covered by each camera would partially overlap, and act as a backup in the event of a failure.

## Data communications

Large volumes of video data are required in the detection process. Figures 2a and 2b illustrate the data transfer flow with the ForestWatch system using microwave and satellite communications. Satellite communications can transmit live data, but at a high cost—approximately $10 000/month per camera.[3] An alternative is to reconfigure the software so that less data need to be transferred via satellite. Staff from ForestWatch's manufacturer, Envirovision Solutions, were able to reconfigure their system to reduce the

[2] Viewed at the following web site: http://sd.ic.gc.ca/pls/eng_alpha/web_search.geographical_input.

[3] Dale Gamber, Sales Manager, Infosat Communications Inc., personal communication January 2004.

Figure 1. Camera mount.

Forest Engineering Research Institute of Canada (FERIC)

Find us Online! www.feric.ca

**Eastern Division and Head Office**
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
(514) 694-1140
(514) 694-4351
admin@mtl.feric.ca

**Western Division**
2601 East Mall
Vancouver, BC, V6T 1Z4
(604) 228-1555
(604) 228-0999
admin@vcr.feric.ca



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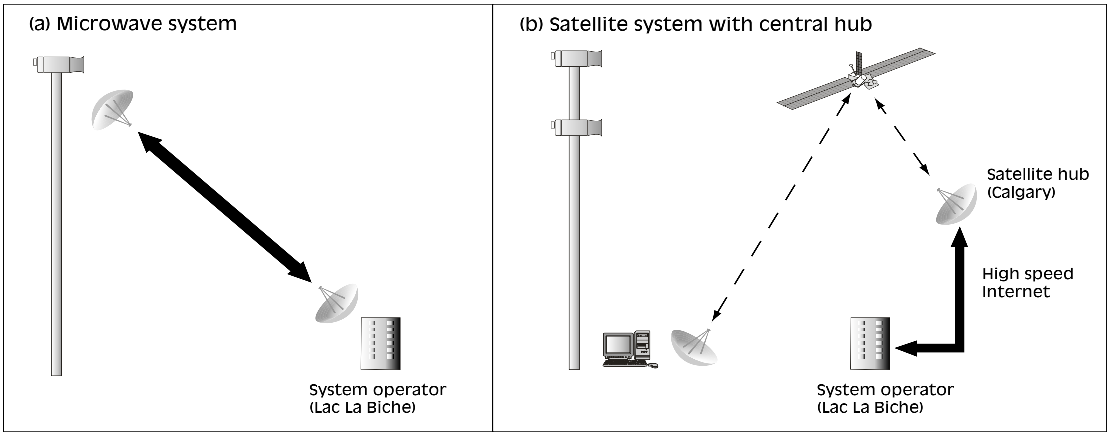


Figures 2 (a) and (b). Schematics showing data transfer methods used with the ForestWatch system. The arrows indicate data transfer direction and line thickness represents a relative amount of data transfer capacity. A solid line indicates continuous data transfer, and a dashed line indicates that data are transferred in individual packets.

bandwidth requirement.[4] The compromise was that a computer would be located at the remote site and manual camera control would be less responsive compared to a live video feed. FERIC determined that the Connect service from Infosat Communications Inc. of Coquitlam, B.C. could meet the data transfer requirements (100 kilobit per second [Kbps] connection), and estimated that the average monthly cost per tower for this service would be $3 500 ($1 500 base rate covering up to 1 Gb of data plus $2 000 for extra data).

Rigging crews installed the cameras, and an Infosat technician installed satellite hardware. A computer was located at each tower to process images prior to transmission so that data volume could be reduced to match the satellite system capacity. A receiving station could have been established in Lac La Biche, but this configuration was more costly than using a central hub. Instead, the central computer located in the Lac La Biche fire centre was connected to the Calgary hub via a high-speed Internet connection (Figure 2b). Envirovision Solutions also established remote access from South Africa to the tower and operator computers to be able to provide support to SRD's system operator.

### Software reconfiguration

Most of the ForestWatch software changes were to the image management database. Images were converted from analog to digital and transferred from the towers as single images instead of live video. The landscape was divided into thirty-six 10-degree subsections and a sequence of images was collected at each subsection. The image sequences were spooled through the detection algorithms at the central location in Lac La Biche.

## Results and discussion

### System performance with satellite communications

The Infosat Connect service was reliable throughout the season and no data transfer issues affected the detection capability. A noticeable system limitation was with the manual camera control feature. There was a time delay before the camera received the command to move from the operator, complete the move, and send a refreshed image back to the operator. The delay is a factor of light speed and the distance to and from the satellite. As a result, zooming or panning the camera on a questionable smoke alarm was too time consuming to be useful. Envirovision Solutions subsequently added a feature to the software allowing the operator to ask for an automatic refresh of an alarm and to request a zoomed image of the alarm location. The operator can also direct the camera to a point of concern by clicking the position on the map.

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4 Bandwith describes the amount of data that can be transferred by a particular technique. The higher the number, the more data per unit of time can be sent or received.

## Use of towers

### Visible area

Communications towers allow observations to be made from a much greater height than manned lookouts (90 m in this case compared to 30 m). The effect of this one difference was quantified using software called VisMap. This program, used by SRD for its smoke detection operations, calculates visible, indirectly visible, screened, and blind areas within 40 km of a tower, and produces maps for reference by detection staff. Smoke in indirectly visible and screened areas has to rise 30 m and 100 m, respectively, before it is visible from the observation point. The effect of observer height (Figure 3) was more pronounced for Tower 1, especially for the blind and indirectly visible areas. The comparison demonstrates a definite advantage for a 90 m observation point.

### Image quality

Image sequences must be perfectly aligned with each other prior to applying the detection algorithm, so camera shake can deteriorate detection capability. Subtle differences in how the cameras were mounted affected image stability. Cameras should be mounted near stabilizer torques or guy wire connections to minimize camera shake. As well, cameras should be mounted against the towers and not on the ends of extension brackets. Even a short extension (20 cm) could increase normal vibration that occurs on a tower, resulting in more blurry images compared to a mount that is right against the tower.

The system uses landscape features to align images. This proved to be a challenge in the relatively featureless landscape around the towers. Reference points selected during the initial set-up (snow on the ground,

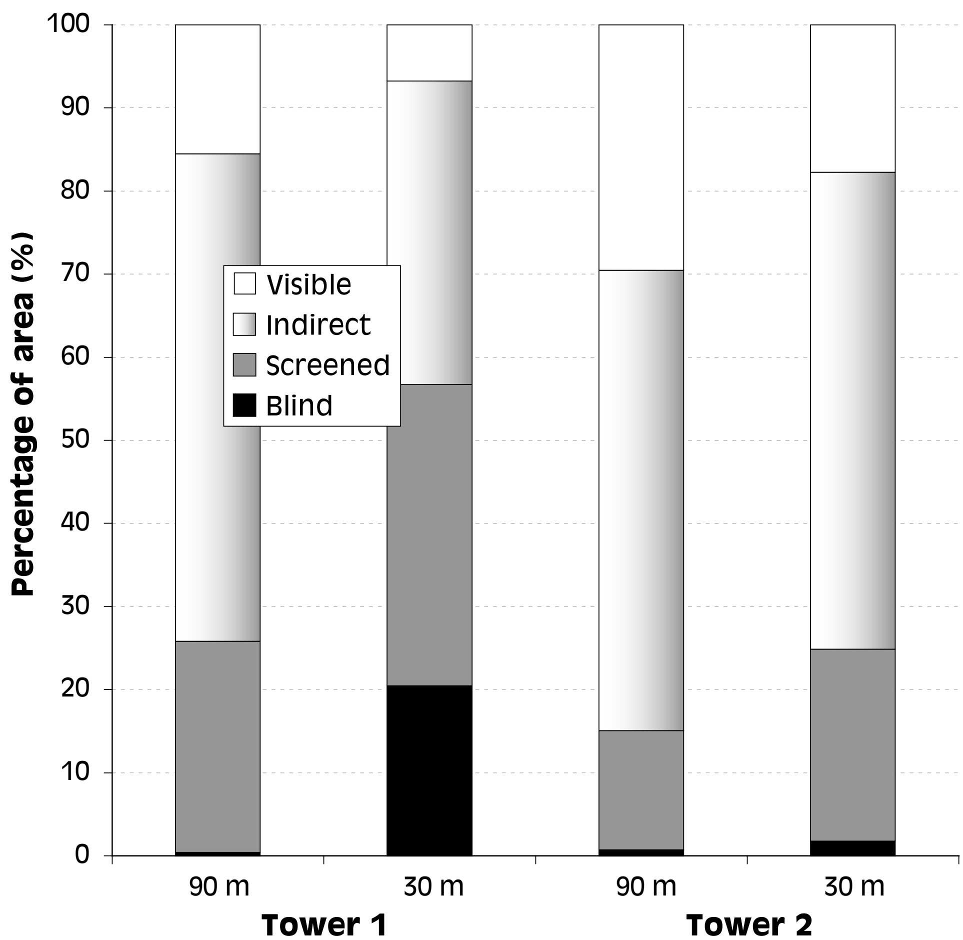


Figure 3. Visible area comparison between 30 m and 90 m height for two towers. (Total coverage area for each tower is 5 026 km$^2$.)

patches of leafless deciduous vegetation) eventually were ineffective and many false alarms were generated (>300 per day). Envirovision Solutions was able to reduce the false alarms to an acceptable level (10 to 30 per day depending on weather) by fine-tuning the settings.

### Dual versus single camera

The dual camera configuration provided increased scanning frequency due to partial overlapping of the area seen by each camera, and provided complete 360-degree coverage. Fortunately, both cameras worked throughout the season and a backup role was not needed. Although using two cameras may be advantageous in some respects, it also results in double the amount of data that need to be transmitted. However, the system can be set so that cameras scan only a portion of the landscape (i.e., no overlap on area scanned), thereby reducing the bandwidth requirement.

### Computer security and power supply

Computer security at other ForestWatch installations has not been an issue because the systems are stand-alone without outside access. However, the satellite system did open the computers to outside access and a virus disabled one of the tower computers. A software firewall was installed and no further attacks occurred. Power outages were also problematic, and power was lost periodically as only minimal battery backup was installed due to budget limitations. When power was lost, a visit had to be made to the tower to re-start the computer. Future installations should include a hardware firewall as well as a computer card to re-start the computer by a remote operator. A battery that can supply 8 to 10 hours backup is also recommended.

## System cost

Table 1 presents the costs of the system as used in 2004. Five towers is a reasonable number for one operator to manage, so Table 2 presents the estimated costs of using a 5-tower/1-operator system, based on the 2004 costs. Component life is expected to be 5 years before replacement, so the 5-tower cost is also shown as an average for the period.

Table 2 shows that the annual operating cost per tower is $35 000 when capital is

**Table 1. 2004 capital purchase and operating costs**

| | 1 camera/ tower ($) | 2 cameras/ tower ($) | Base system ($) | Total ($) |
|---|---|---|---|---|
| Capital costs | | | | |
| Hardware | 10 708 | 15 313 | - | 26 021 |
| Software | 20 259 | 20 259 | - | 40 518 |
| Installation/set up [a] | 1 311 | 3 125 | 17 740 | 22 176 |
| Miscellaneous | - | - | 2 145 | 2 145 |
| Total capital cost | 32 278 | 38 697 | 19 885 | 90 860 |
| Monthly cost [b] | | | | |
| Satellite | 1 495/mo | 1 495/mo | - | 14 950 |
| Software service | - | - | 2 000/mo | 10 000 |
| Tower rental [a] | 250/mo | 350/mo | - | 3 000 |
| System operator | - | - | 3 200/mo | 16 000 |
| Total operating cost | - | - | - | 43 950 |

[a] Tower rental and installation costs differed because of ownership, agreements with rigging companies, and tower location.
[b] Totals based on 5 months use.

**Table 2. Forecast system costs for a 5-tower network using two cameras per tower**

| | Year 1 – capital purchase | Years 2–5 | 5-year total | Average annual cost/ individual tower |
|---|---|---|---|---|
| Capital costs [a] | 213 370 | 0 | 213 370 | 8 535 [b] |
| Annual cost [c] | | | | |
| Satellite (base rate) | 37 375 | 149 500 | 186 875 | 7 475 |
| Satellite (extra data cost) [d] | 50 000 | 200 000 | 250 000 | 10 000 |
| Software service | 10 000 | 40 000 | 50 000 | 2 000 |
| Tower rental | 8 750 | 35 000 | 43 750 | 1 750 |
| Project manager | 10 000 | 40 000 | 50 000 | 2 000 |
| System operator | 16 000 | 64 000 | 80 000 | 3 200 |
| Subtotal – annual costs | | | | 26 425 |
| Total for fixed and annual cost/tower (5 towers averaged over 5 years) | | | | 34 960 |

[a] Year 1 fixed costs = $38 697 × 5 + 19 885 (Table 1).
[b] Average annual cost per tower over five years = $213 370 ÷ 5 towers ÷ 5-year total = $8 535 (no replacement costs included).
[c] Totals based on 5 months use with two cameras per tower.
[d] The Infosat Connect service has a 1 Gb upload maximum under the base rate. Additional data uploaded are charged at $200/Gb. This charge was not applied in 2004 because the Infosat invoice tracking system did not work. FERIC and Envirovision estimated that an additional 10 Gb/month would be transferred on average.

averaged over 5 years and annual costs are shared among 5 towers. This number is within the range of manned lookout costs that range from $30 000 to $40 000 annually. However, the detection system cost rises if the tower network is fewer than five because the software service, project manager, and system operator costs would not change. For example, a 3-tower network would cost $39 000/tower annually using the above 5-year average. Conversely, the system becomes more cost-effective if more than 5 towers are used. However, a single operator may not be able to cope with more than 5 towers if fire occurrence probability is high. The software is designed to distribute alarms across a network so that a second operator, perhaps in another management zone with low fire occurrence probability, could assist with incoming alarm signals.

The satellite transmission costs could be a limiting factor for implementation, as they account for half of the projected operating costs (Table 2). However, data transmission costs may be lower than estimated in Table 2 due to the following reasons:

- Use of non-satellite data communications wherever possible. For example, microwave transmission linked to a high-speed Internet node is a possibility in some areas, but can only be determined on a case-by-case basis. A microwave system, as used in Schroeder (2004), costs approximately $8 000/tower initially and nothing afterward, and would quickly pay for itself compared to satellite.
- Further re-design of ForestWatch. The system used in 2004 depended on all images to be sent to Lac La Biche where the detection analysis was done. Re-designing the system to do detection at remote sites would require images to be sent only in the case of alarms and follow-up confirmation.[5] The data

[5] G. Hough, President, Envirovision Solutions, personal communication September 2004.

transfer requirement would then be reduced enough so that only the base rate for Infosat Connect service would apply. This would reduce projected operating costs by $10 000 (Table 2).

- Availability of new technology will make a greater array of communications techniques available.
- Decreasing satellite costs have been a trend for several years and the pattern is predicted to continue.

## Conclusions

The ForestWatch smoke detection system was successfully converted from a live video feed to an intermittent video feed. This change allowed low-cost satellite communications to be used instead of the original high frequency microwave which is limited by range and therefore insufficient for some sites in Alberta.

The conversion required additional hardware to be installed at tower sites and some problems occurred with security from computer viruses and power failures. These problems were resolved with temporary fixes for the 2004 season. Robust changes to eliminate the problems can be implemented with commercially available hardware.

Existing commercial communications towers were effective platforms for mounted cameras. The cameras could not be mounted at the top of the tower but the height at which they were mounted (90 m) resulted in improved visibility relative to the height for most manned lookouts (30 m). On one of the towers, two cameras were mounted to provide full 360-degree coverage. The dual cameras provided back-up and increased scanning frequency. A downside of using dual cameras was the increased volume of data to be transmitted via satellite.

The system shows potential to be cost-effective relative to a manned lookout tower when operator wages and system support costs are spread across at least three multiple tower sites. An operator should be able to manage five tower sites (10 cameras) during all fire hazard conditions and more towers during low to moderate fire hazard. A long-term evaluation with an expanded camera network is needed to answer this question definitively.

## Future work

Alberta SRD has asked FERIC to continue evaluating ForestWatch in 2005. The objectives for the new study will be to quantify factors that affect smoke visibility and system performance, and to evaluate multiple data transmission techniques. The system will also be expanded to three towers with two cameras per tower. FERIC will also evaluate the ability of an operator to manage multiple cameras.

## Reference

Schroeder, D. 2004. Evaluation of three wildfire smoke detection systems. FERIC, Vancouver, B.C. Advantage Report Vol. 5 No. 24. 8 pp.

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