SC6: Choking Currents on Guy Wires

CBC/Radio-Canada's Experimental Testings

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CBC/Radio-Canada

CCBE - September 28th, 2019

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Presentation plan

Why did we do this?

Bazooka Balun Theory & Simulations

Experimental Test Results (9 transmission sites)

What have we learned? What will we monitor?

Acknowledgements / Questions?

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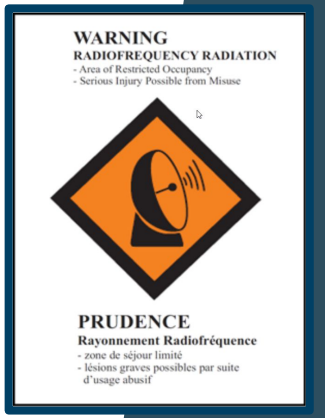
Why did we do this?



Safety Code 6: Health Canada's Radiofrequency Exposure Guidelines (SC6)

Compliance with SC6 is **mandatory** for all RF operators

High NIR levels are often found in **proximity of guy anchors** at transmission sites. Typically, the area is fenced.

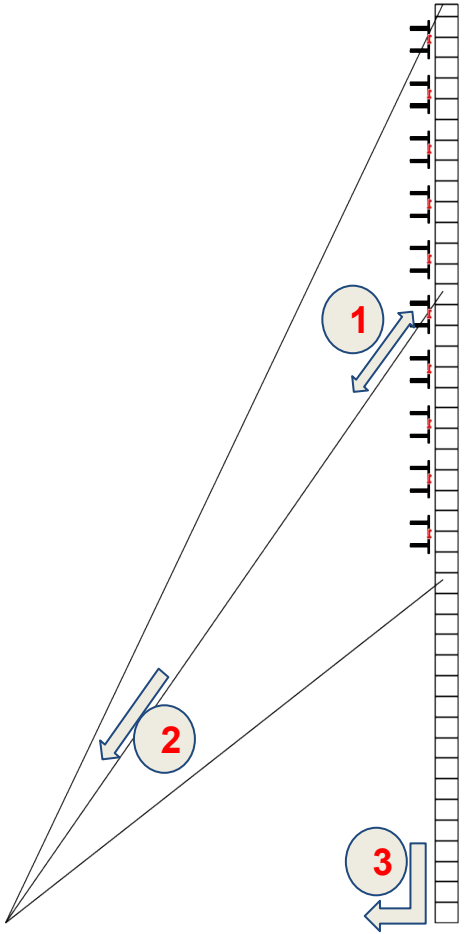
The Radio Advisory Board of Canada (**RABC**) SC6 sub-committee decided to try to gain better knowledge of the phenomenon and to find alternatives to fences (sometimes difficult / $$)

Max Larivière Birch: Suggestion to apply the Bazooka Balun principle on guy wires

Bazooka Balun Theory

Possible sources of guy-wire currents

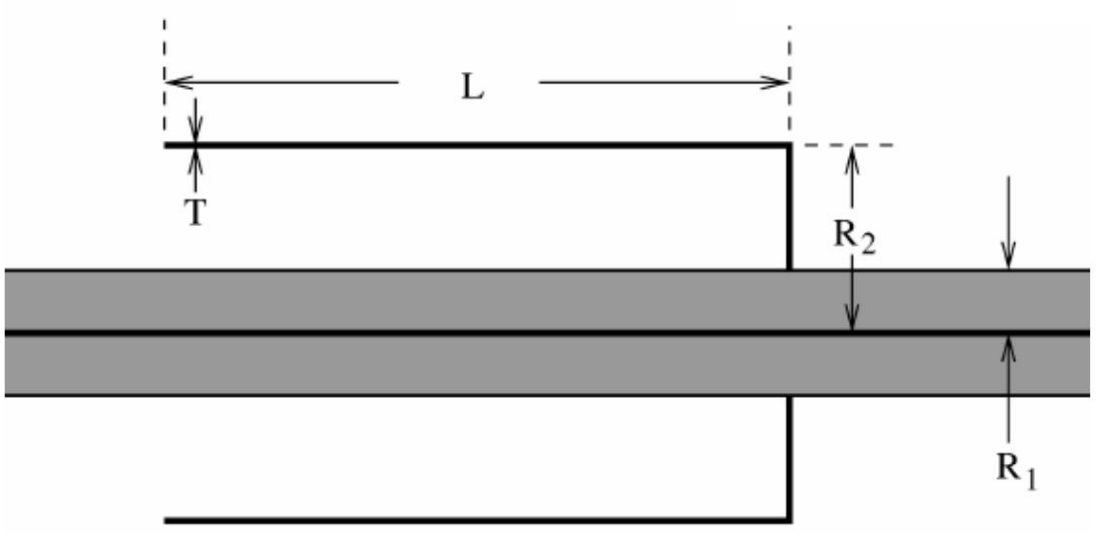
1. Induction by proximity of radiating element
2. Induction by side lobes on guy-wire
3. Induction through grounding system



Bazooka Balun Theory

Bazooka Sleeve Balun

- Baluns are seen as an open circuit for currents traveling on the conductor's surface
- A technical paper[1] describes the performance of balun on coax cables at 900 MHz
- We transposed those characteristics for the FM band

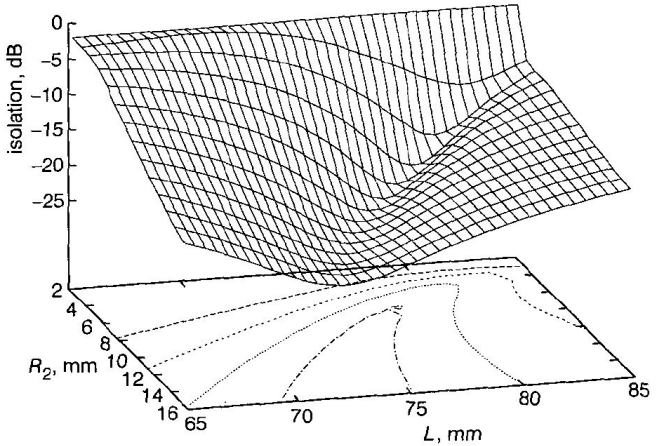


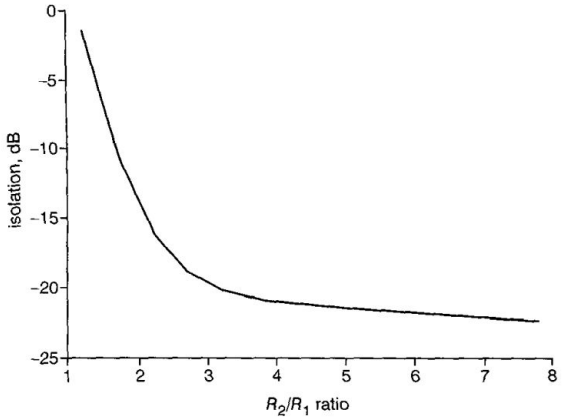
[1] Full-wave analysis of choking characteristics of sleeve balun on coaxial cables
S.A. Saario, J.W. Lu and D.V. Thiel

Bazooka Balun Theory

Bazooka Sleeve Balun

- Takeaways:
  a. Balun length ≈ λ / 4 or shorter
  b. Bigger baluns have better isolation
  c. Marginal improvements above $R_2/R_1 > 4$
  d. Bigger baluns require shorter length





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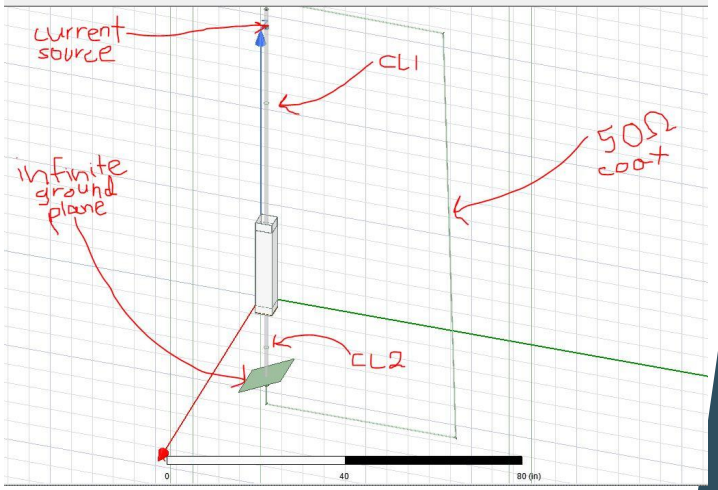
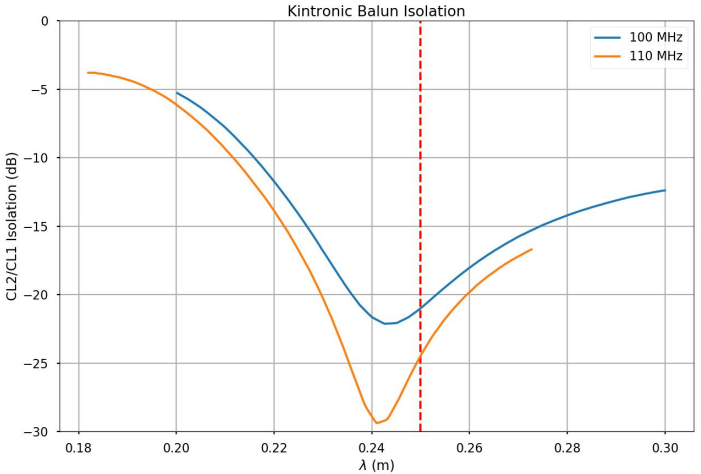
Simulations

Kintronic's HFSS Simulation

- Balun Face with 4:1 Radius Ratio
- Balun Length set to 0.25 λ
- Optimal Isolation at less than 0.25 λ
- Square Balun performs as wells as Cylindrical Baluns

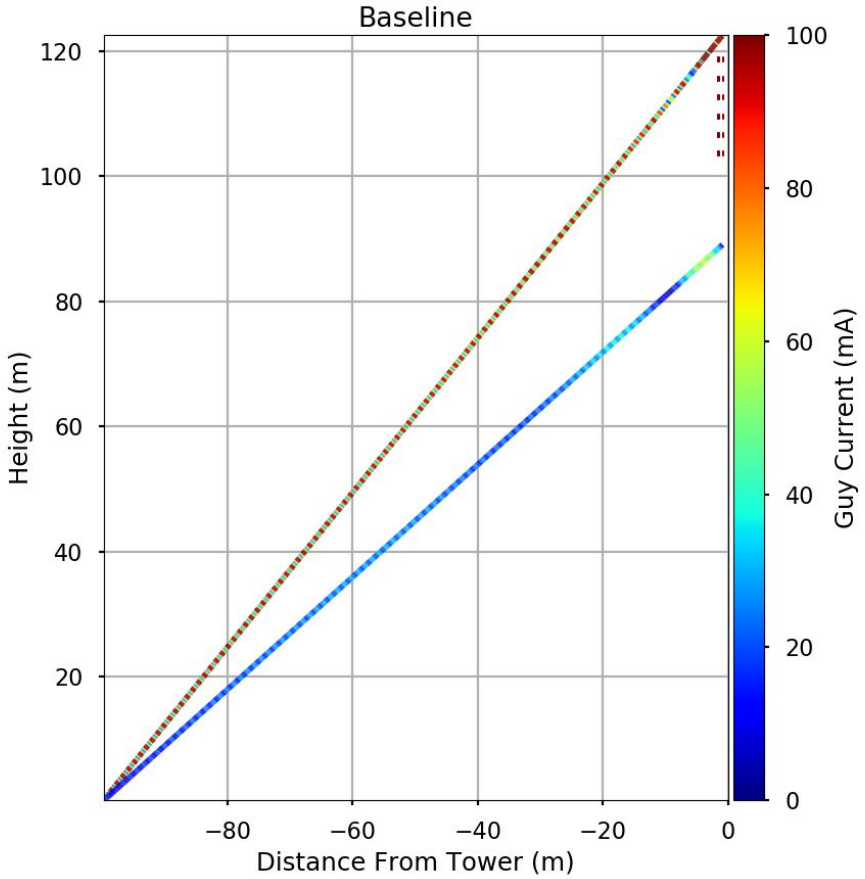


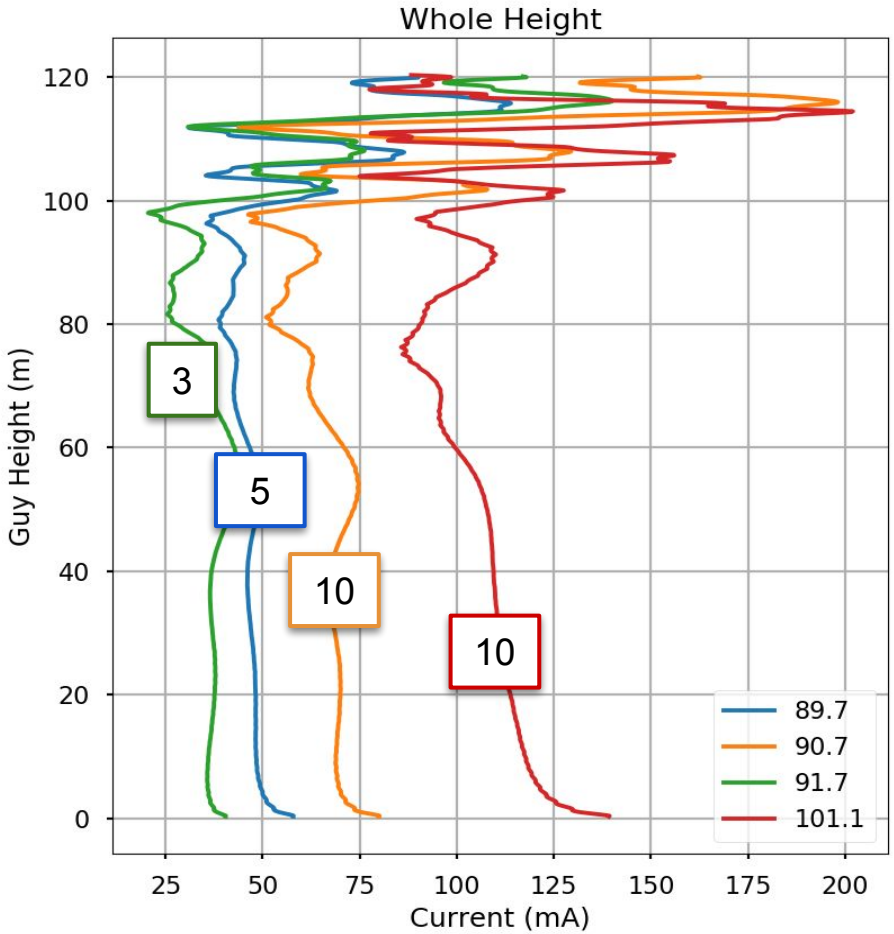


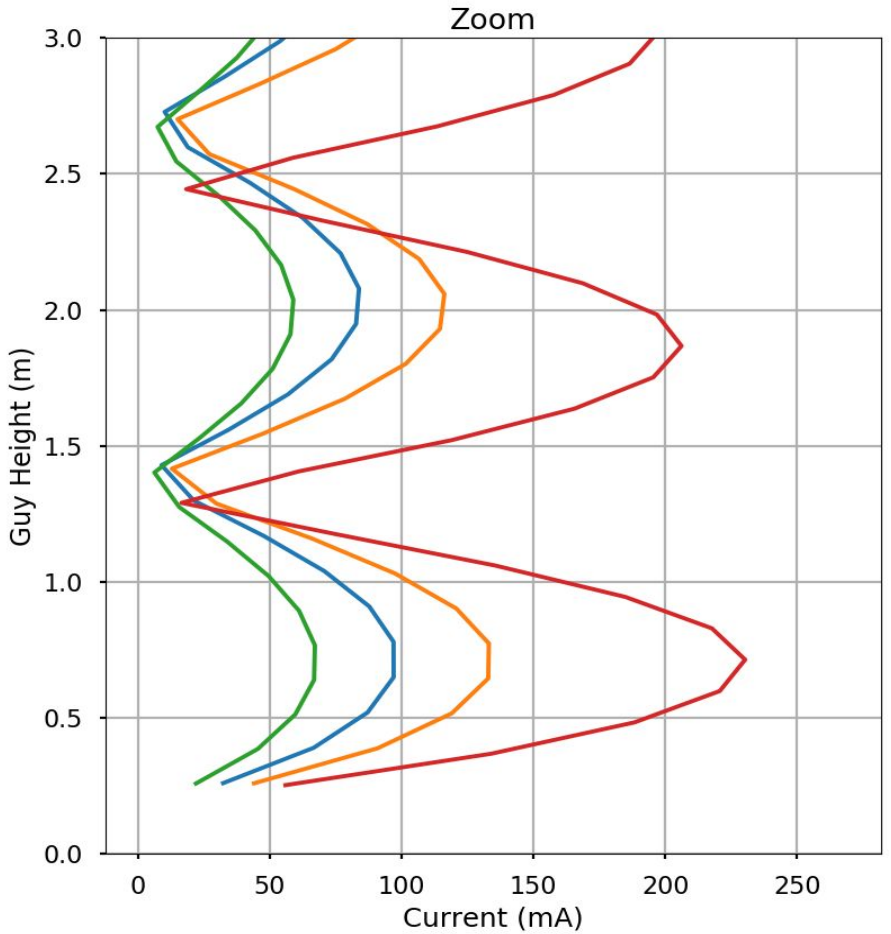
Simulations

CBC NEC Simulations

- Approximate Model Sherbrooke Tx Site Outer Anchors and Guy Heights
- Guy Wires 1” Ø
- Intensity of Induced Current varies with Frequency
  - Shown here for 101.1 MHz



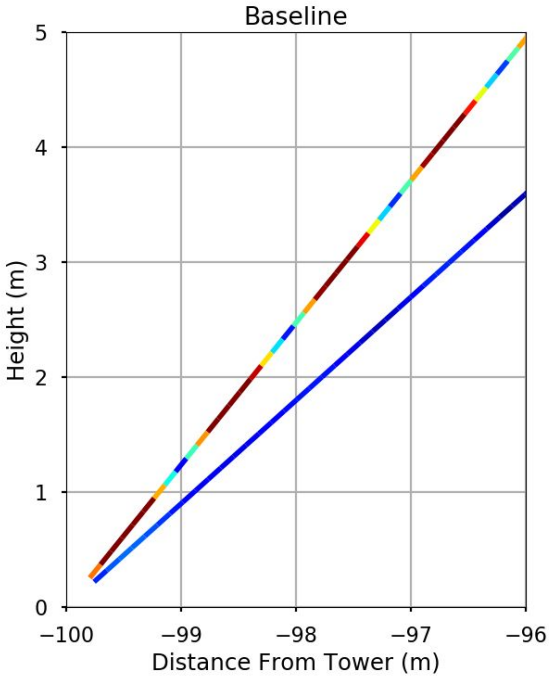

Whole Height
Guy Height (m)
Current (mA)
3
5
10
10
89.7
90.7
91.7
101.1

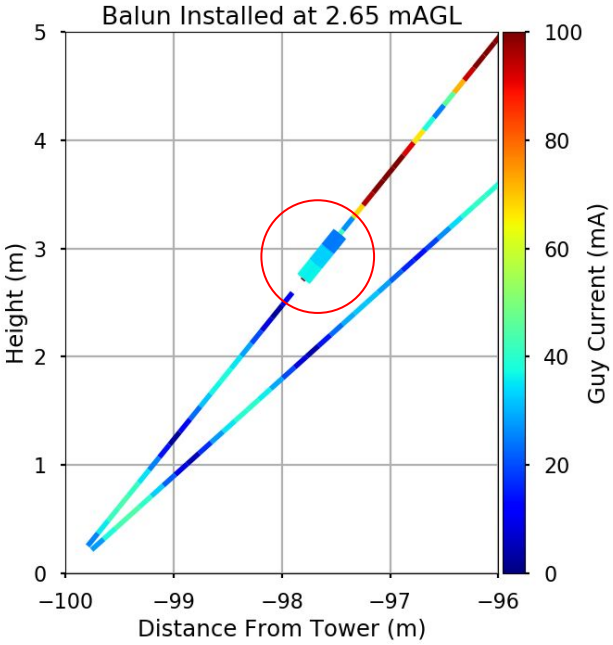

Zoom
Guy Height (m)
Current (mA)

Simulations

CBC NEC Simulations

- Standing wave -like current distribution on guy wire
- λ/2 periodicity
- Location of balun influences isolation performance

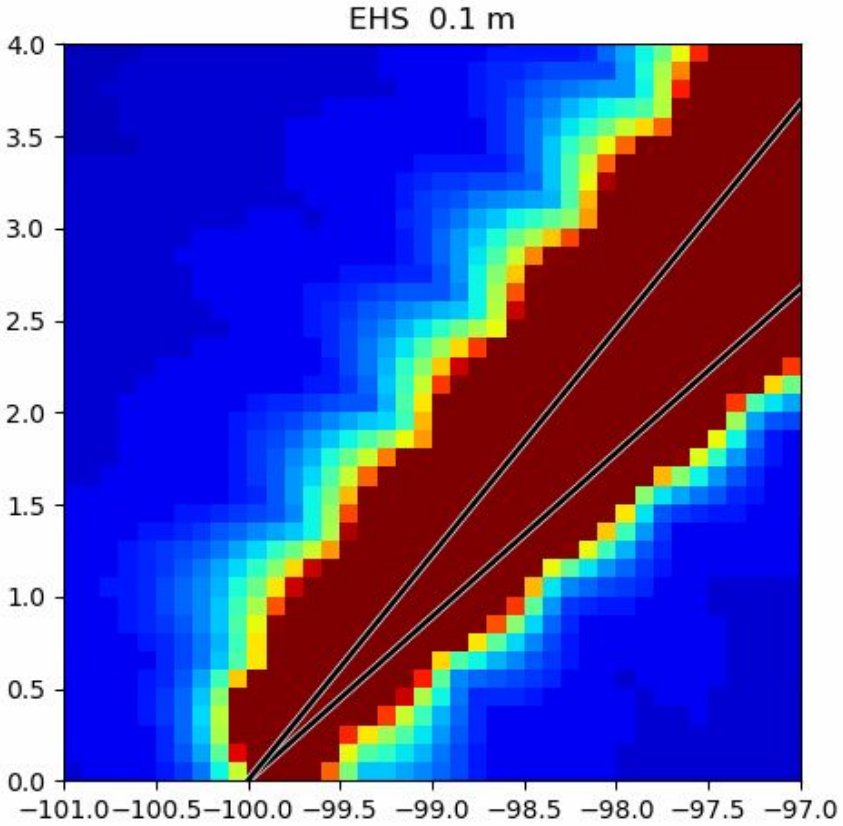




Simulations

CBC NEC Simulations

- RF Exposure without Bazooka
- SC6 Levels which include maximum of:
  - E-Field levels (E)
  - H-Field levels (H)
  - Power Density levels (S)



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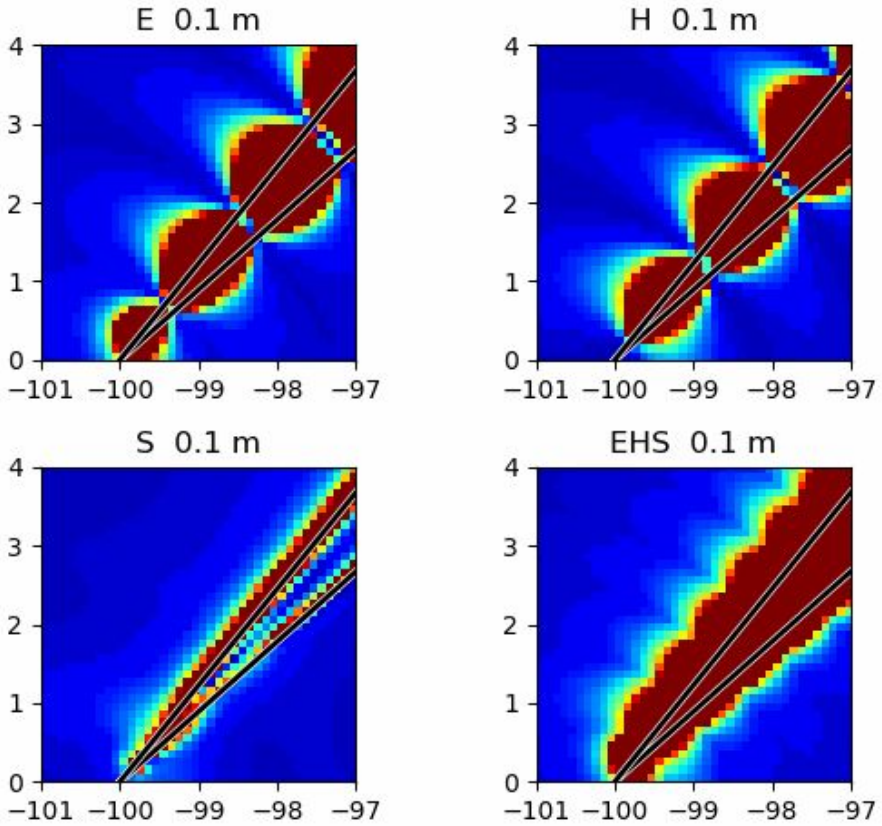

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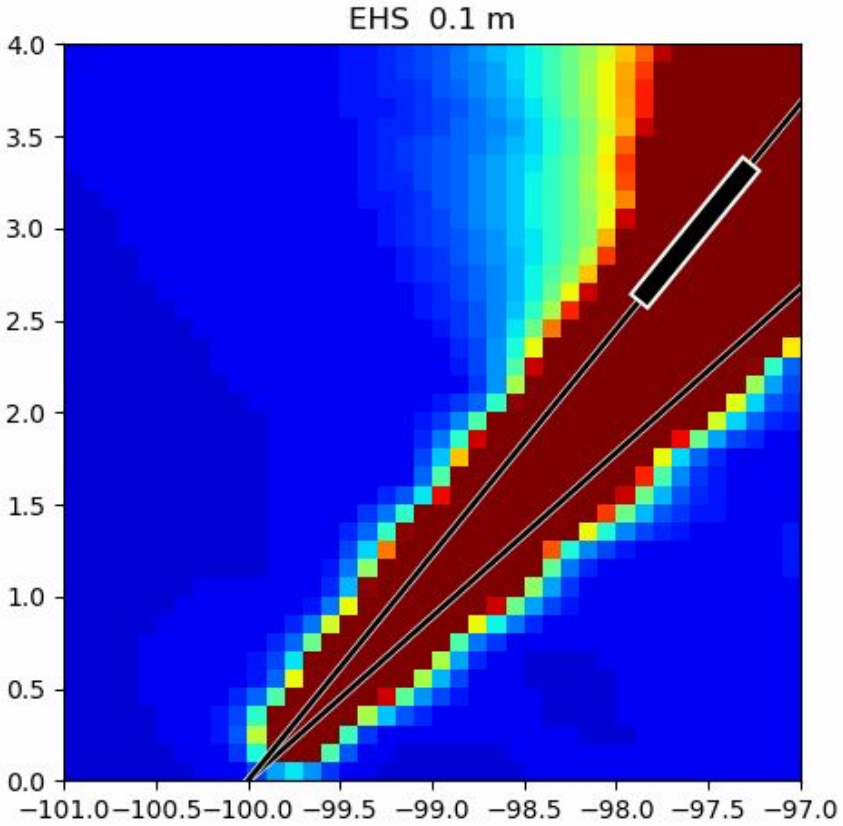

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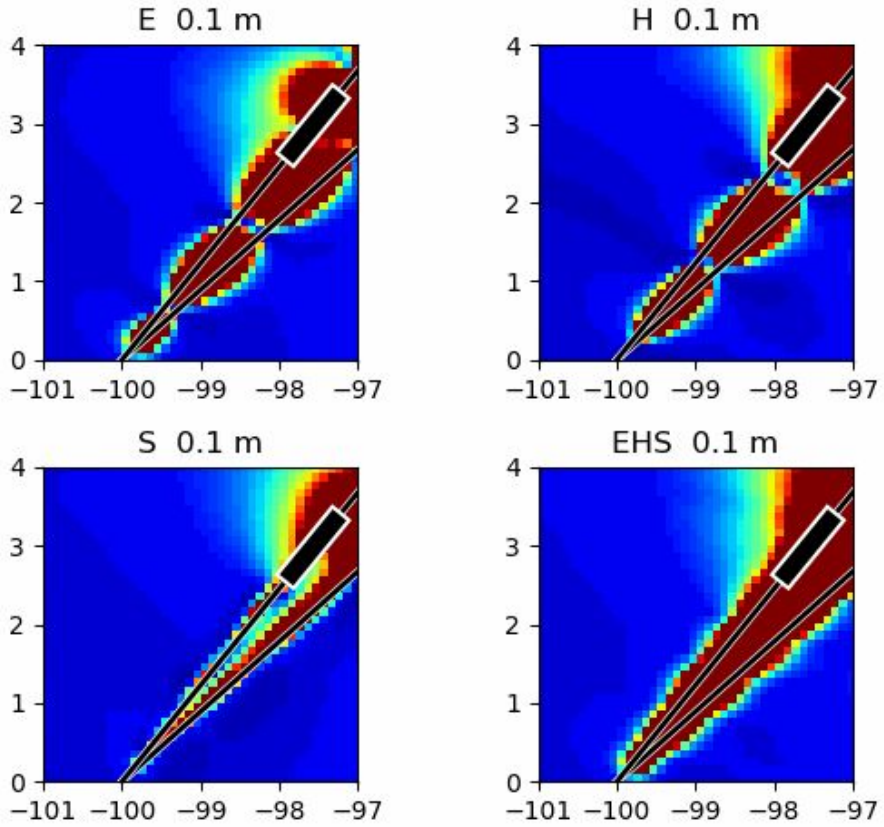

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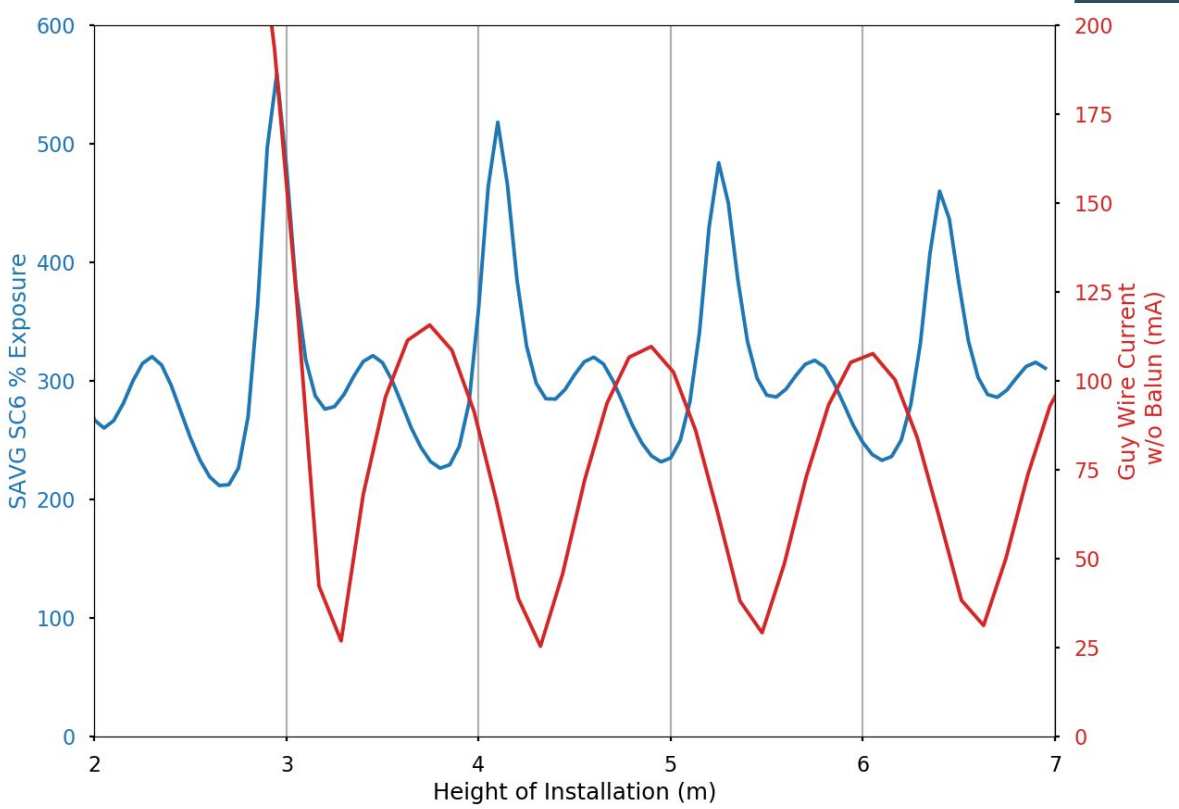

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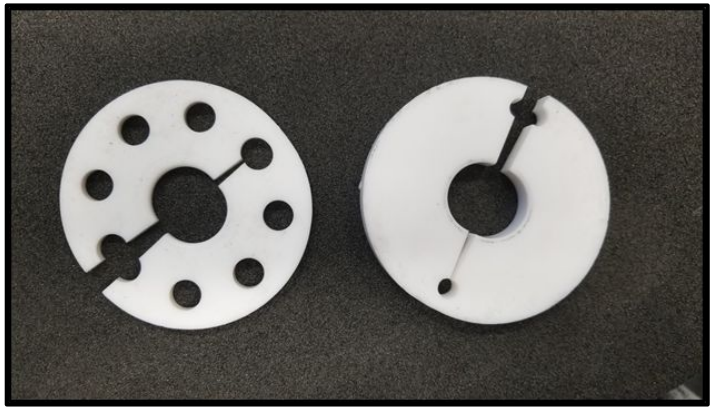
1st Prototypes

What happened in the field?

Homemade prototype (Recycle!)

3” 1/8 copper transmission line pieces
Teflon rings
Hose clamps
Copper grounding braids



We visited 9 transmission sites during summer 2019

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Test Setup

Optimise sleeve's position and length

- **Fixed E-field probe on tripod**
- **Current Clamp placed on guy wire**
- **Selective RF Meter**
  determine main contributors
  perform spatial averaging

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Winnipeg, MB

Starbuck transmission site (before)

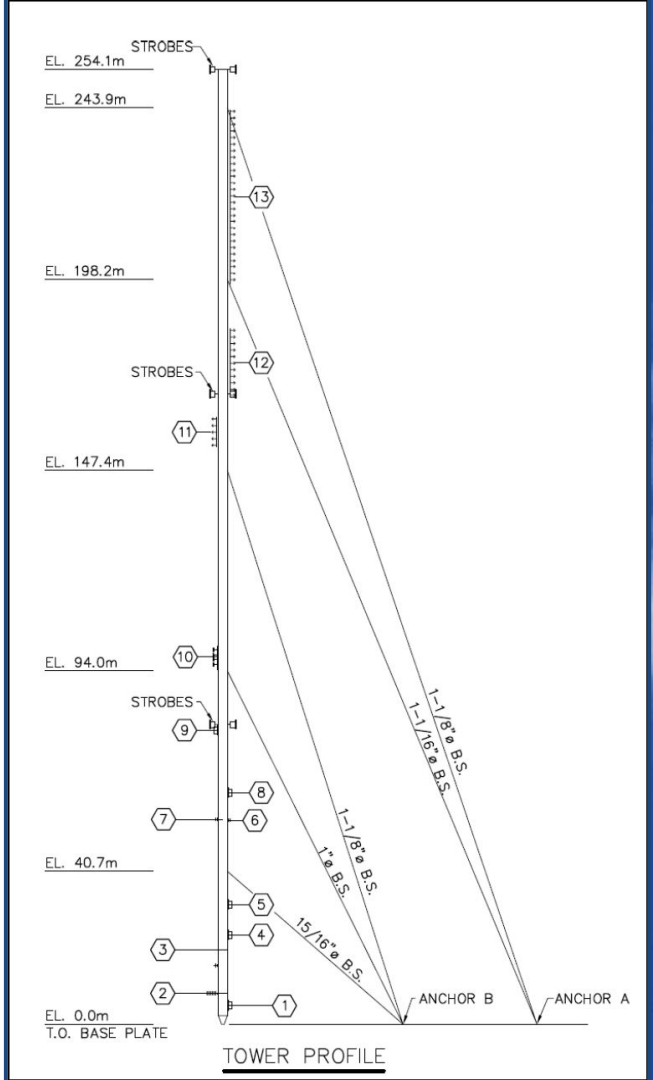
High power broadcast site (582 KW ERP)

Hotspot ≈ 2000% SC6

Multiple FM contributors

Very large cumbersome temporary fence installed to prevent access

→ Permanent solution needed to ensure compliance with SC6



57 **Before - Without Bazooka Balun**

Total : 1968.1 % (2015)

CKSB-10-FM	88.1 MHz	79.0 %
CKSB-FM	89.9 MHz	13.0 %
CKXL-FM	91.1 MHz	20.5 %
CHVN-FM	95.1 MHz	270.5 %
CBW-FM	98.3 MHz	1479.0 %
CKCL-FM	107.1 MHz	103.2 %
Others	inf MHz	3.0 %

73 **After - With Bazooka Balun**

Total : 49.8 % (2015)

CKSB-10-FM	88.1 MHz	9.5 %
CKSB-FM	89.9 MHz	1.9 %
CKXL-FM	91.1 MHz	0.3 %
CHVN-FM	95.1 MHz	11.0 %
CBW-FM	98.3 MHz	17.2 %
CKCL-FM	107.1 MHz	9.8 %
Others	inf MHz	0.1 %

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Bazooka balun installations

	Highest Spatial Average Measurement % SC6-2015 Uncontrolled Environment (with Uncertainties)	
Transmission site	**Before - No Bazooka Balun**	**After - With Bazooka Balun**
Belleville, ON	200%	22%
Kingston, ON	113%	58%
Campbell River, BC	> 2500%	92%
Little Current, ON	163%	93%
Fleurimont, QC	146%	68%
Winnipeg, MB	1968%	92%
Grande Vallée, QC	395%	82%

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2nd Prototypes

Stainless Outfitters

Belleville, ON - September 25, 2019

Kintronic Labs

More simulations and prototypes to come

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What have we learned in the field?

Conductive material used for sleeve: Aluminium /copper / steel

Optimal sleeve length: 0.20λ - 0.24 λ (with some surprises..)

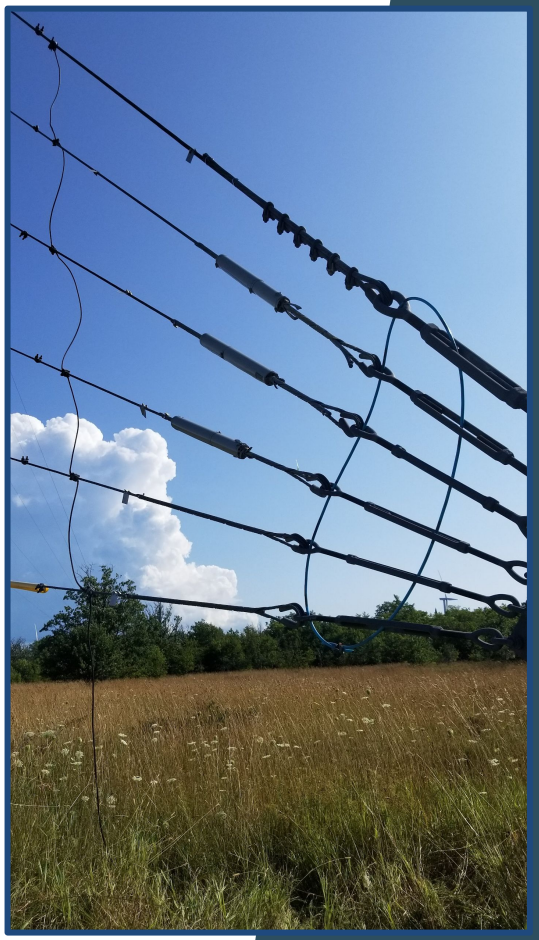
Sites with multiple frequencies and/or high power may require multiple baluns

Cylinder and rectangular shapes work

Positioning and length of the sleeve is crucial

Very high NIR levels measured near the sleeve

Significant impact of the ground wires on the guy wire



What to monitor?

Potential problems

Galvanic corrosion → next prototypes in stainless or galvanized steel
Displacement of ground wire connexion
If the sleeve breaks / makes contact with the guy wire, it no longer works
How snow or ice will impact performances?
Tower/guy wire loading, tension measurements

Monitor existing installations for long term effectiveness

Kingston & Belleville, ON
Installation: May 22
Validation: September 25 (4 months later) = ok!

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Next steps & Conclusion

Gain better knowledge (simulations and field tests)

Improve prototypes (effective, easy to manufacture, easy to install)

→ **The industry now has a new mean of solving SC6 issues near guy anchors!**
(fencing is not the only solution!)

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Acknowledgments

Max LaRiviere Birch, Alphawave Mobile Network Products (FieldSENSE) - For suggesting to use the bazooka balun principle on guy wires to solve SC6 issues

CBC/Radio-Canada Transmission Staff - For all the help, support and ideas to make it work in the field

RABC Radio Advisory Board of Canada - For the members contribution to the initiative

field SENSE
Personal RF Monitor

transmission

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CONSEIL CONSULTATIF CANADIEN DE LA RADIO

Acknowledgments

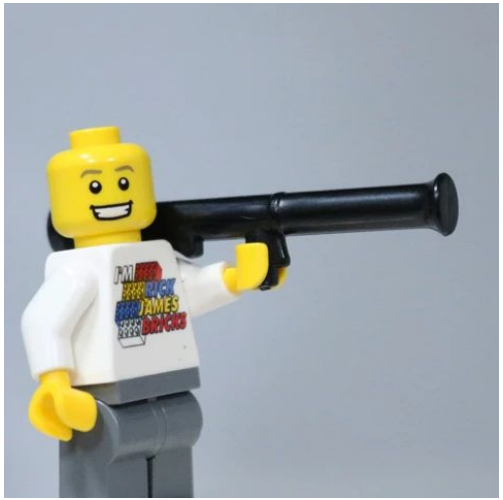
Yves R. Hamel & Associes Inc. (YRH) - For graciously providing a current clamp for the experimental testings

Stainless Outfitters Inc. - For manufacturing the firsts professionnel prototypes

Kintronic Labs - For the simulations and upcoming prototypes

Questions ?

Thanks !



A 5¢ bazooka is better than a 3000$ fence!
SC6 is no joke!