Joint Panel with Industry and Research: Third-Party Solutions for Ice Mitigation

UNIVERSITÉ LAVAL

NERGICA

eDF renewables

WICETEC
Ice Prevention Systems

Borealis Wind

Winterwind 2022, Skellefteå, Sweden
April 20, 2022

Raphael Jansen, Lead Fleet Engineer
Solenn Launay, Special Projects Manager
www.edf-re.com/ca

EDF-re icing challenge and actions taken

- EDF-re started operating a large wind fleet in Eastern Canada in 2013
- Icing losses were larger than expected
- Significant icing accumulation led to extended shutdown periods and production loss
- Project development for new projects was adjusted to include anti-icing capabilities
- However, projects already commissioned needed a solution

- After trying some optimisations with OEMs, EDF-re turned to retrofit IPS with the objective to recover more power production in winter time
- Retrofit projects were developed in collaboration with Wicetec and Borealis.
- Typical retrofit project cycle was: Assess icing losses over winter, select turbines for retrofit installation over the summer (short installation window), evaluate the performance over the following winter.
- Another challenge which required collaboration was the installation of power distribution system in the hub to supply the required power for anti-icing operation
- Challenging projects, but fortunately the retrofit IPS solutions allowed to implement very efficient anti-icing systems

Severe icing in Eastern Canada

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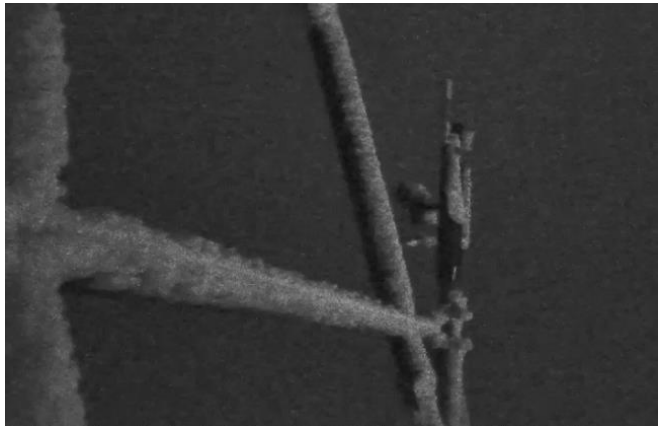

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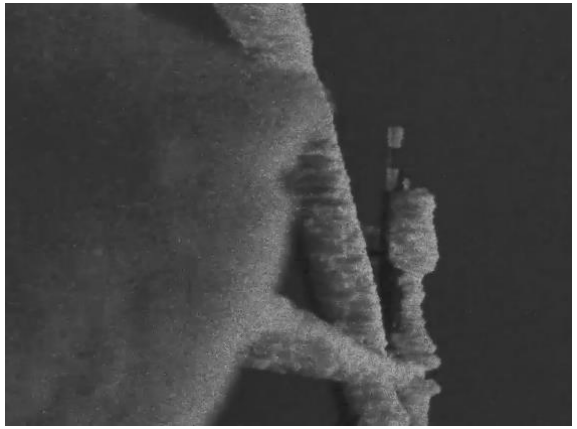

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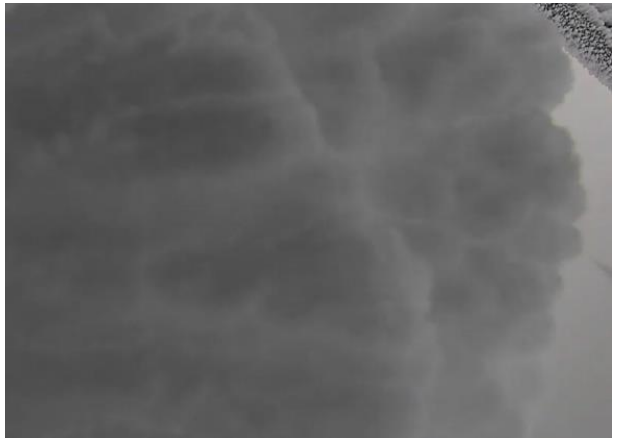


Active ice accretion during 39 hours!

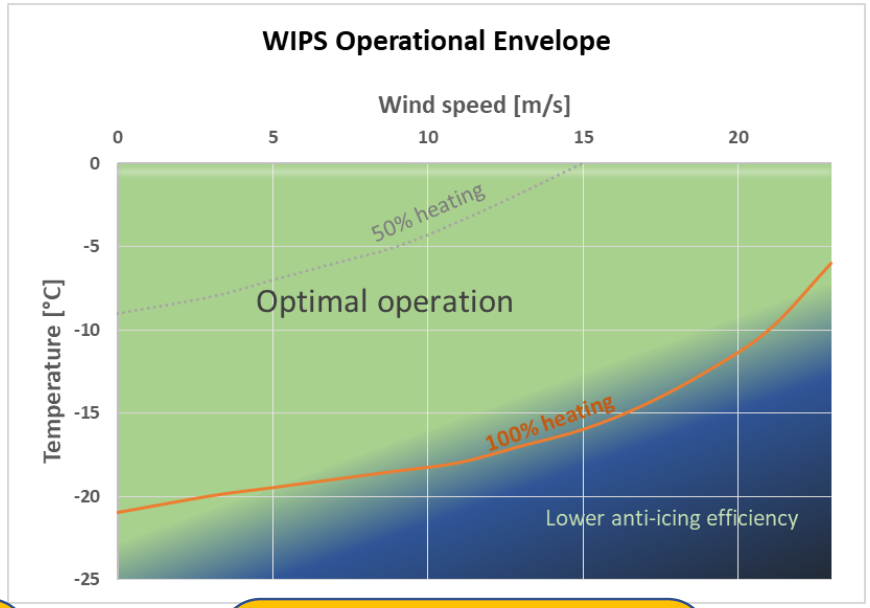
Petteri Antikainen, CEO
www.wicetec.com

WICETEC
Ice Prevention Systems

Solution

- Solution is surface heating
- New installations

and



Retrofit

Downtower

Uptower

One long element

Modular elements

Modular heaters

- Before installation
  - Manufacturing
  - Surface quality control
  - Electrical testing
- In case of a damage a single heater is easy to change

Retrofit uptower installation

- Rain is not an issue anymore
- Wind still is!

Modular heaters in operation

Heated blades

Not-heated blades

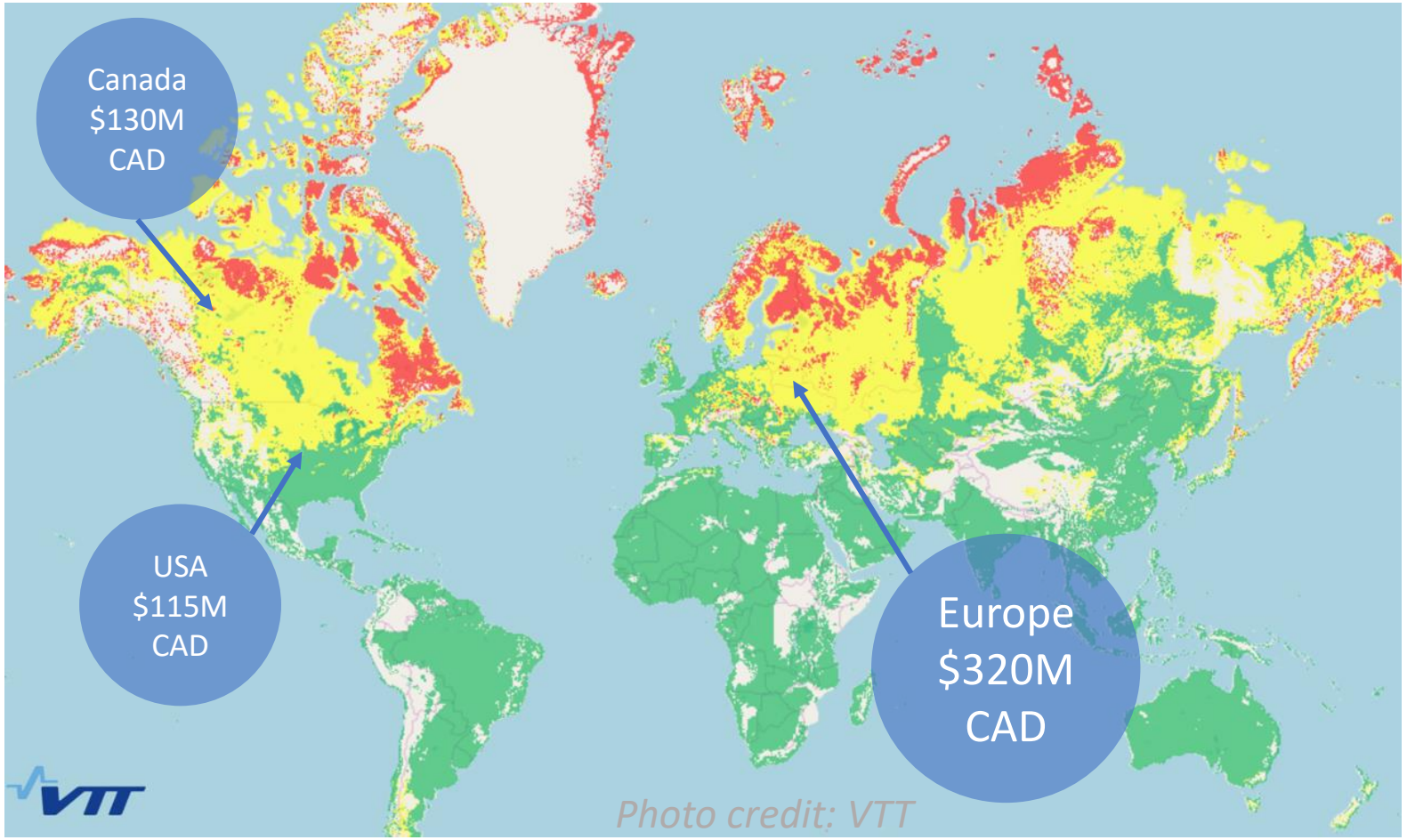
Borealis Wind

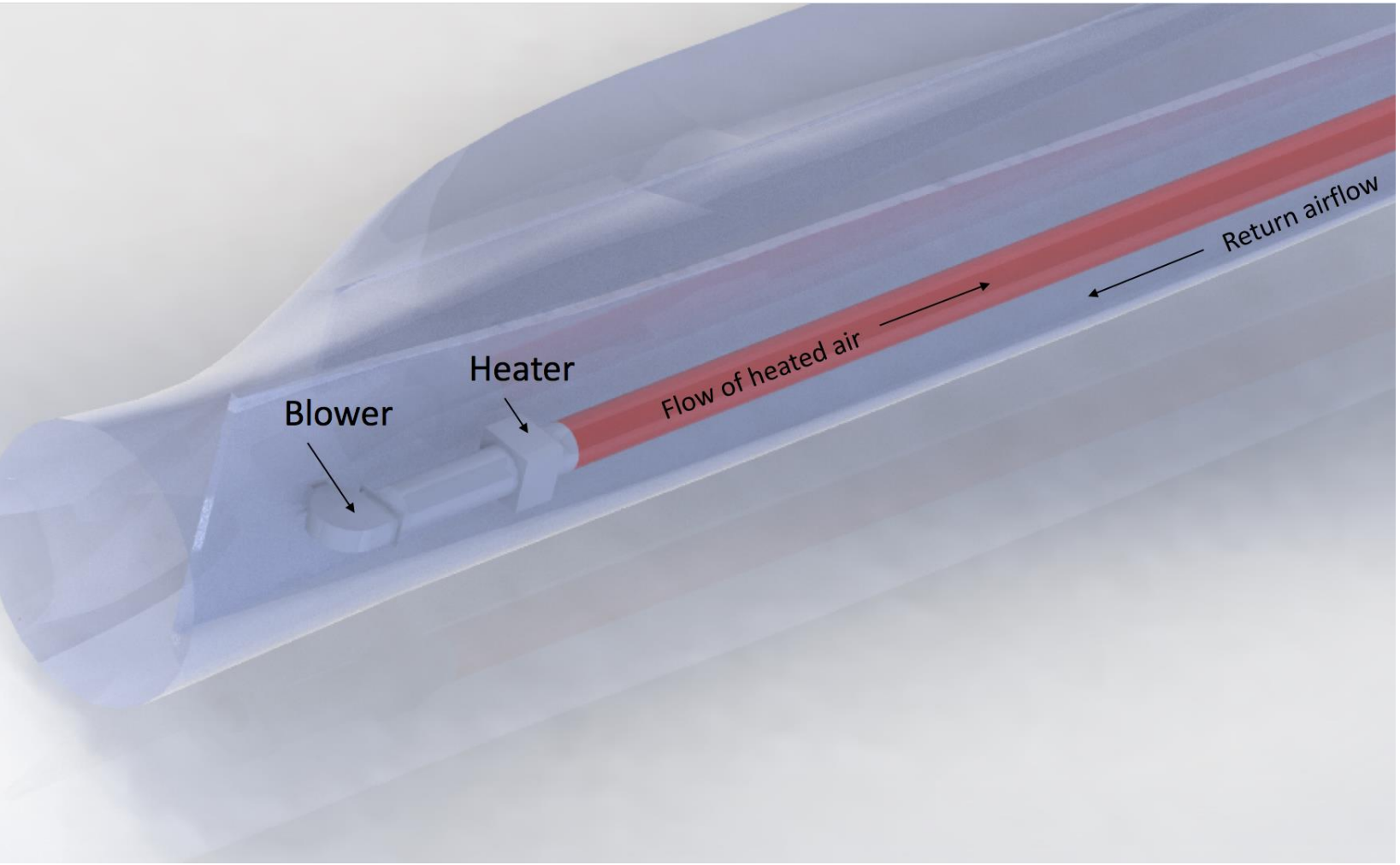
Daniela Roeper, CEO
www.borealiswind.com

Borealis Wind

Market & Annual Icing Losses ($CAD)

- Map shows icing severity
  - Green – Low (Ice class 1)
  - Yellow – Moderate (Ice class 2)
  - Red – Severe (Ice class 3-5)
- $600M annual icing loss
- $1.5B Market size for retrofits
- 15% increase in installed wind turbines in 2020
- Red & Yellow areas (Ice class 2-5) on the map are target areas of our product





Solution

Borealis Ice Protection System (“IPS”):

A patented blade heating system that uses heated air circulation to prevent and reduce ice buildup.

Can be offered for new turbines or as an after-market retrofit.

Borealis Wind

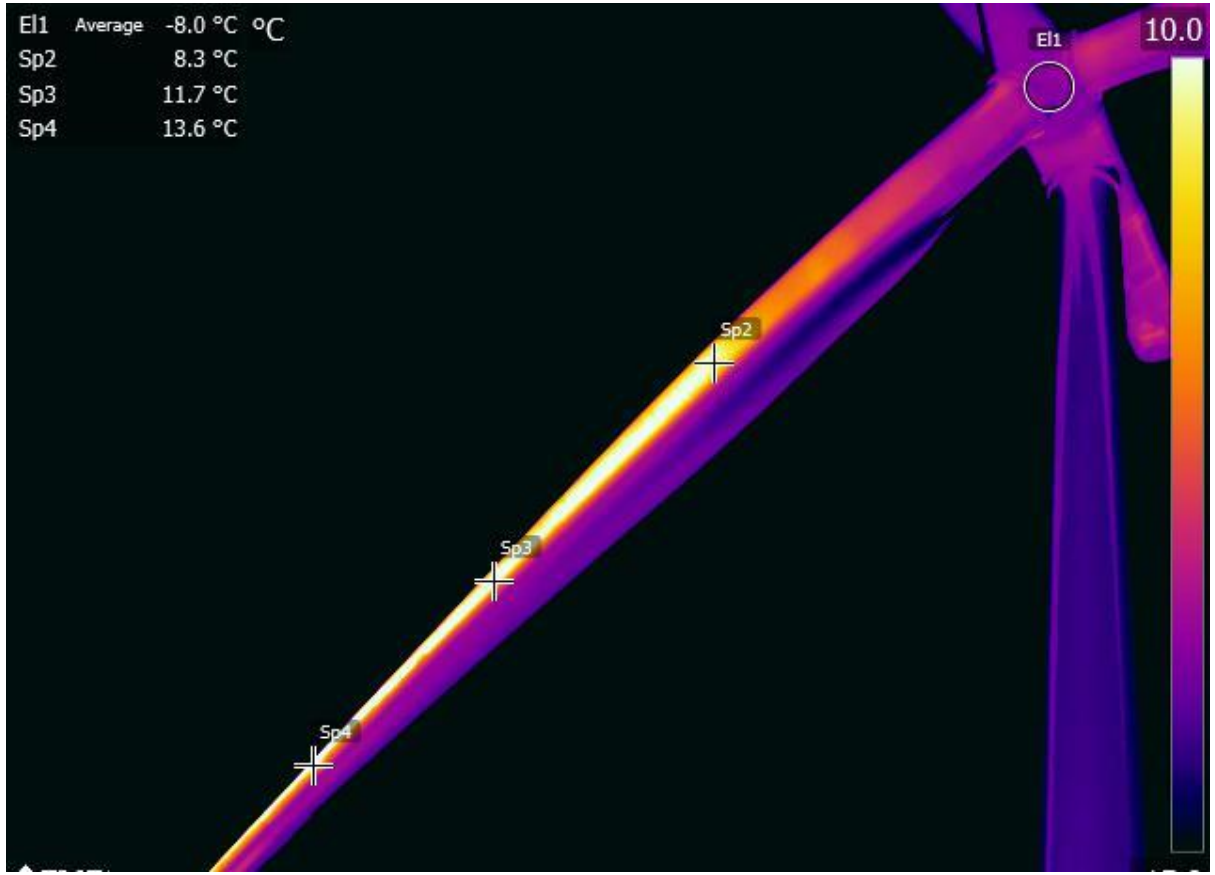
Installation

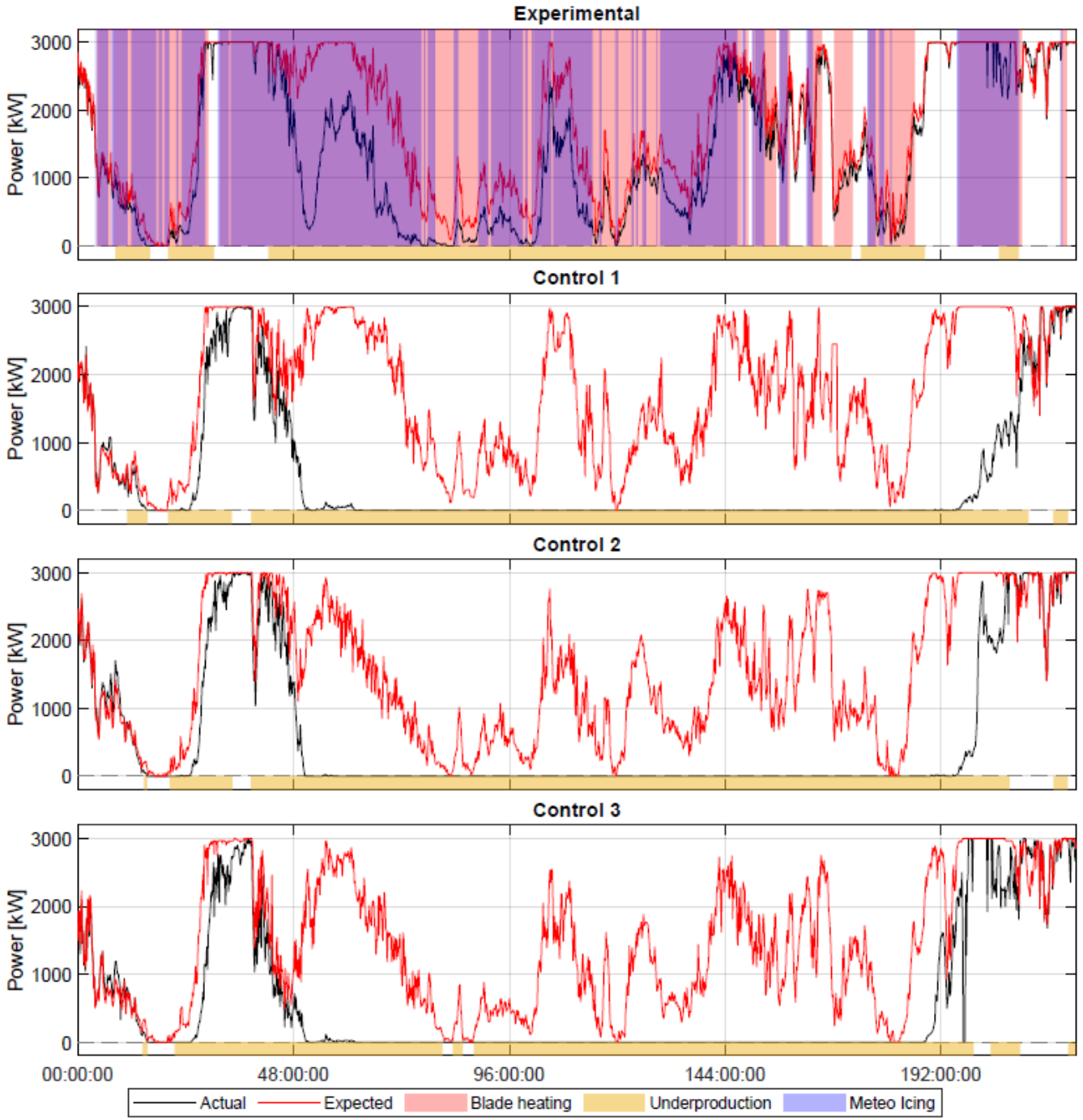
- 3 days to retrofit the Borealis System prior to turbine construction
- 9 days to retrofit the Borealis System into a constructed turbine
- Schedule is designed to have the turbine operational overnight
- All materials are sized so they can be easily passed into the blade
  - Less than 50 cm x 50 cm in cross section
  - Less than 70 lbs.

Borealis Wind

Proven Technology

- 4 years of operational validation, first systems installed in 2018
- Sold 23 IPS in Canada with 5 different customers
- Revenue recovery in winter 2020/21 and 2021/22 of up to $60k/turbine, representing a 6% revenue increase





Example Icing Event

Results vs Control	Gain (MWh)	Recovery (%)
1	197	67
2	178	69
3	166	66

Borealis Wind

Borealis Wind

Example De-Icing Operational Envelope

% of icing time	Wind [m/s]											
Temperature °C	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**inf**
-20	0.1%	0.1%	0.2%	0.2%	0.3%	0.2%	0.2%	0.0%	0.0%	0.0%		
-18	0.0%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%		
-16	0.1%	0.2%	0.3%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%			
-14	0.1%	0.5%	0.5%	0.4%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	
-12	0.3%	0.7%	0.8%	0.6%	0.4%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	
-10	0.6%	1.3%	1.3%	1.1%	0.6%	0.4%	0.3%	0.1%	0.1%	0.0%	0.0%	
-8	0.8%	2.0%	1.9%	1.4%	1.0%	0.6%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%
-6	1.2%	2.6%	2.5%	1.9%	1.2%	0.7%	0.5%	0.3%	0.1%	0.0%	0.0%	0.0%
-4	1.7%	3.4%	3.5%	2.7%	1.8%	0.9%	0.6%	0.4%	0.1%	0.0%	0.0%	0.0%
-2	2.7%	4.6%	4.5%	3.1%	2.3%	1.4%	0.9%	0.5%	0.2%	0.1%	0.0%	0.0%
0	5.0%	6.8%	6.5%	4.8%	3.4%	2.2%	1.1%	0.6%	0.3%	0.1%	0.1%	0.0%

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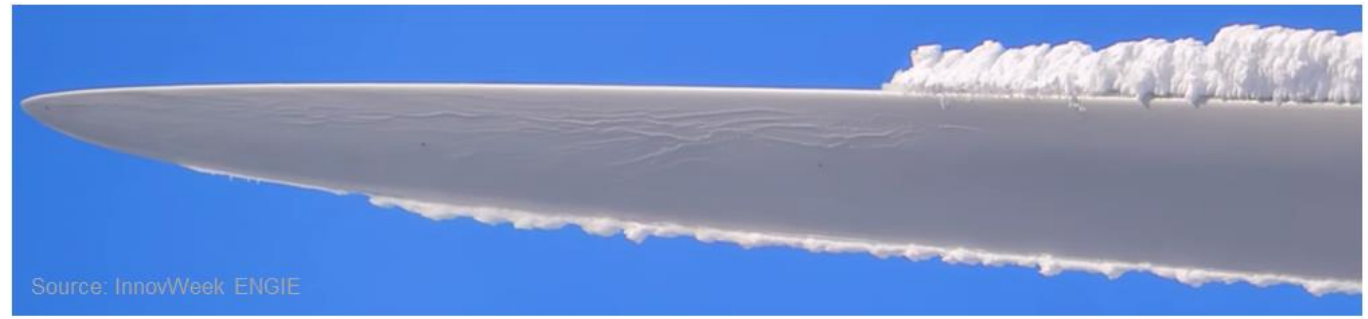
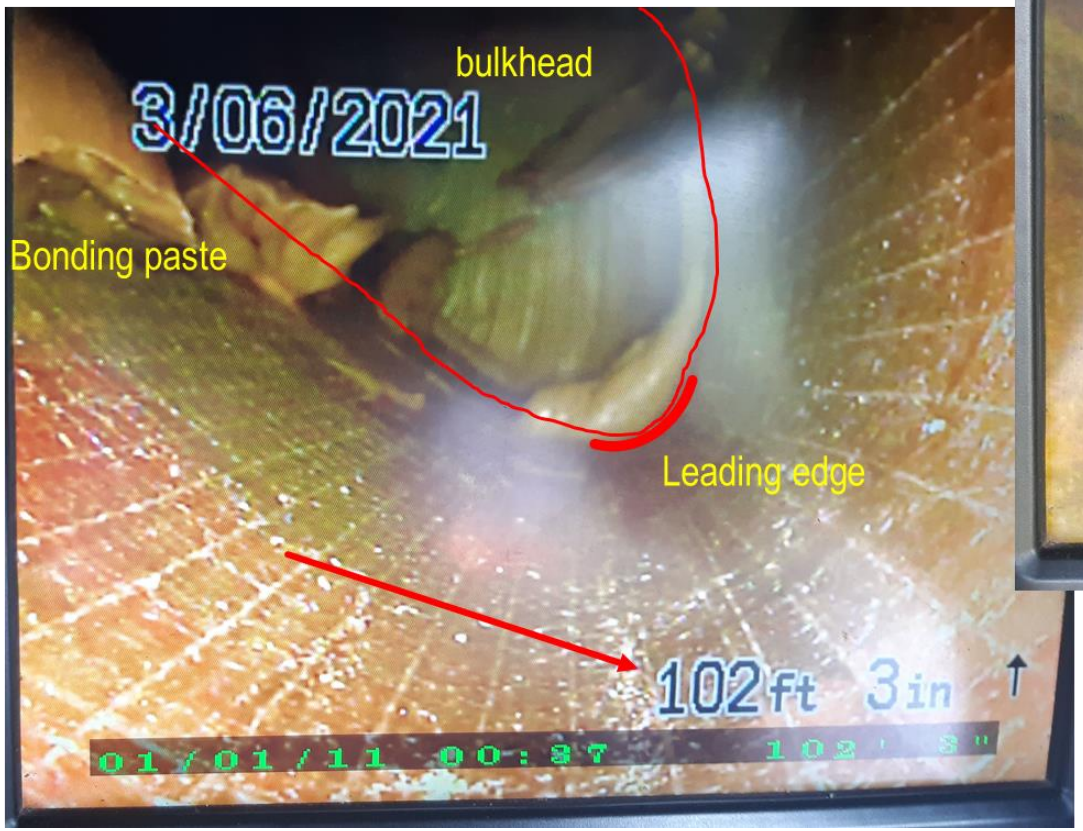
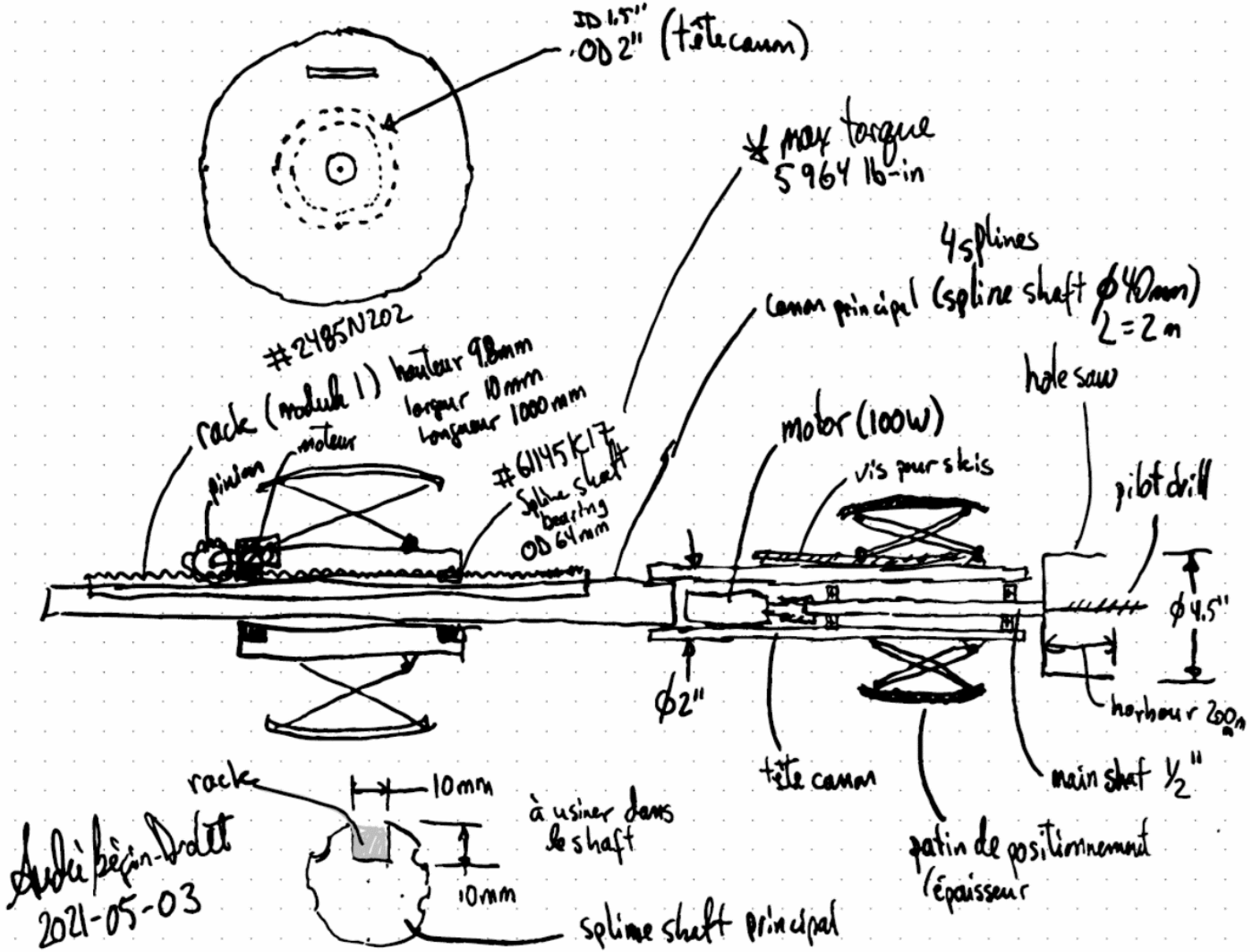
André Bégin-Drolet - Associate Professor
www.ulaval.ca

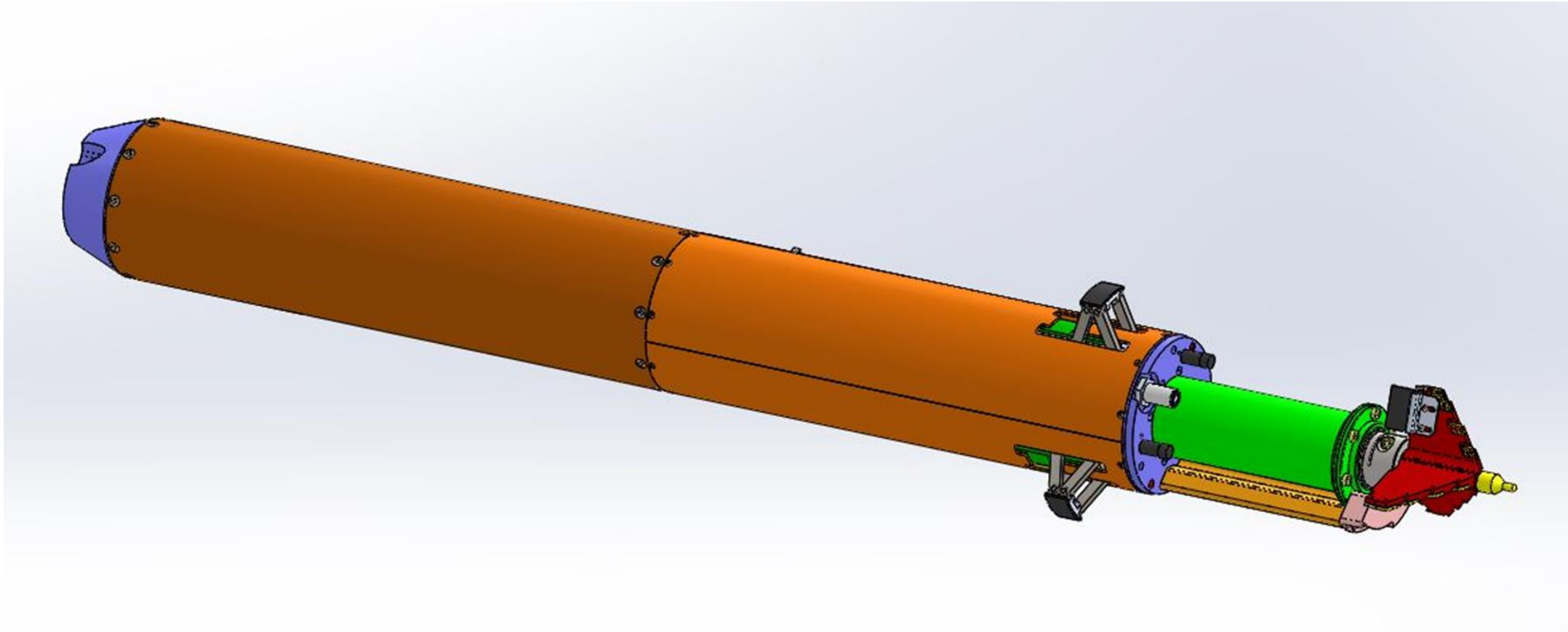


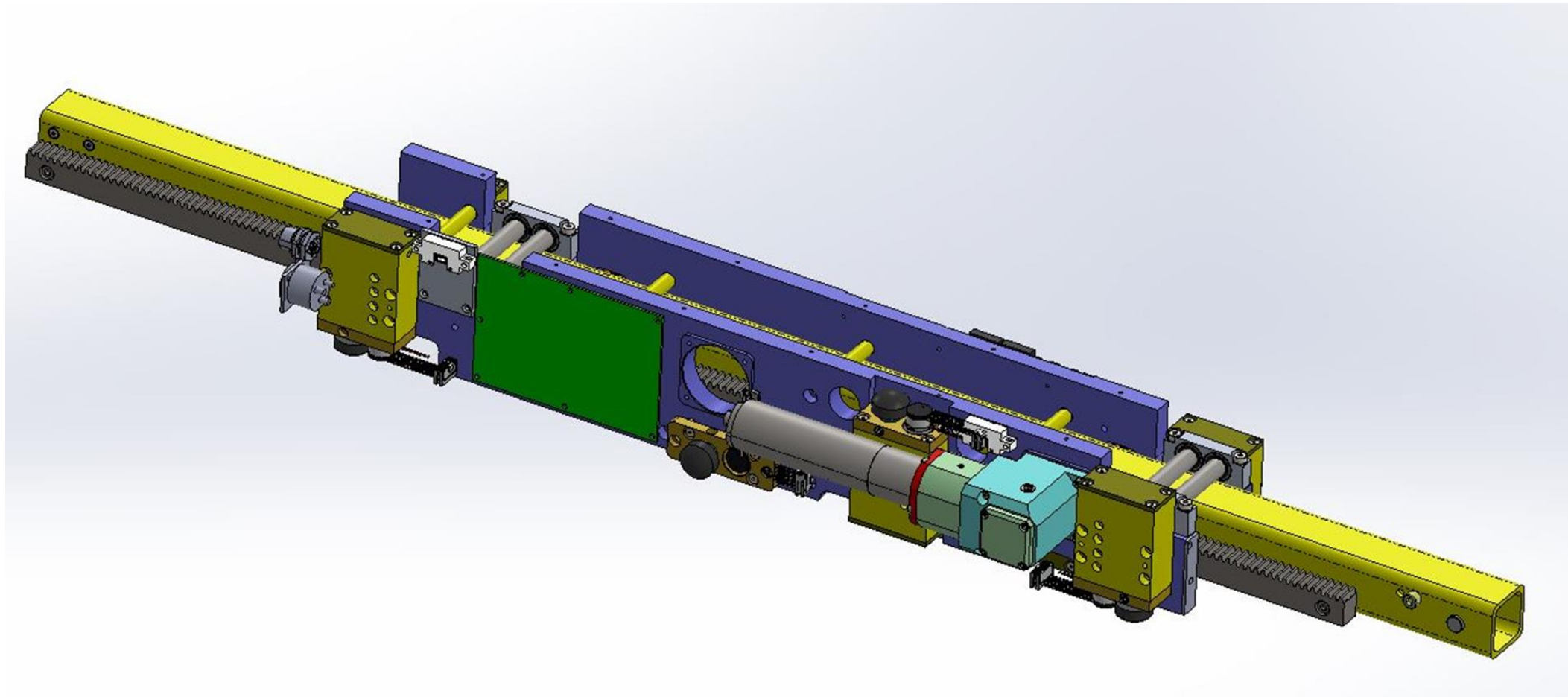
Source: InnovWeek ENGIE

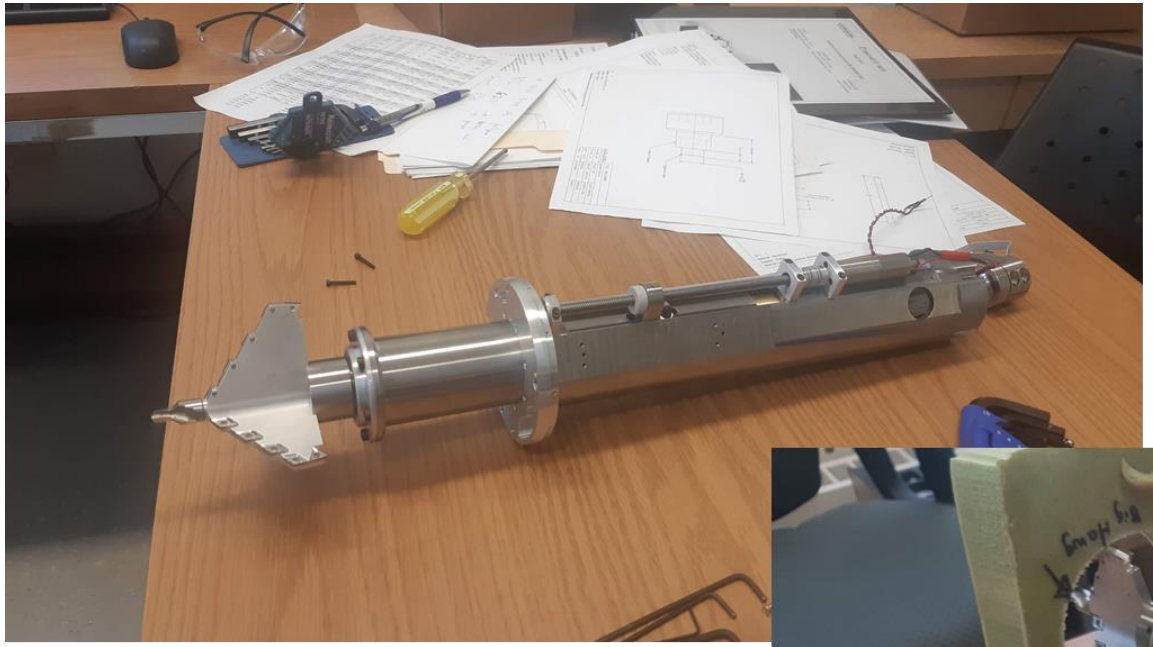

bulkhead
3/06/2021
Bonding paste
Leading edge
102ft 3in
01/01/11 00:37 102' 3"

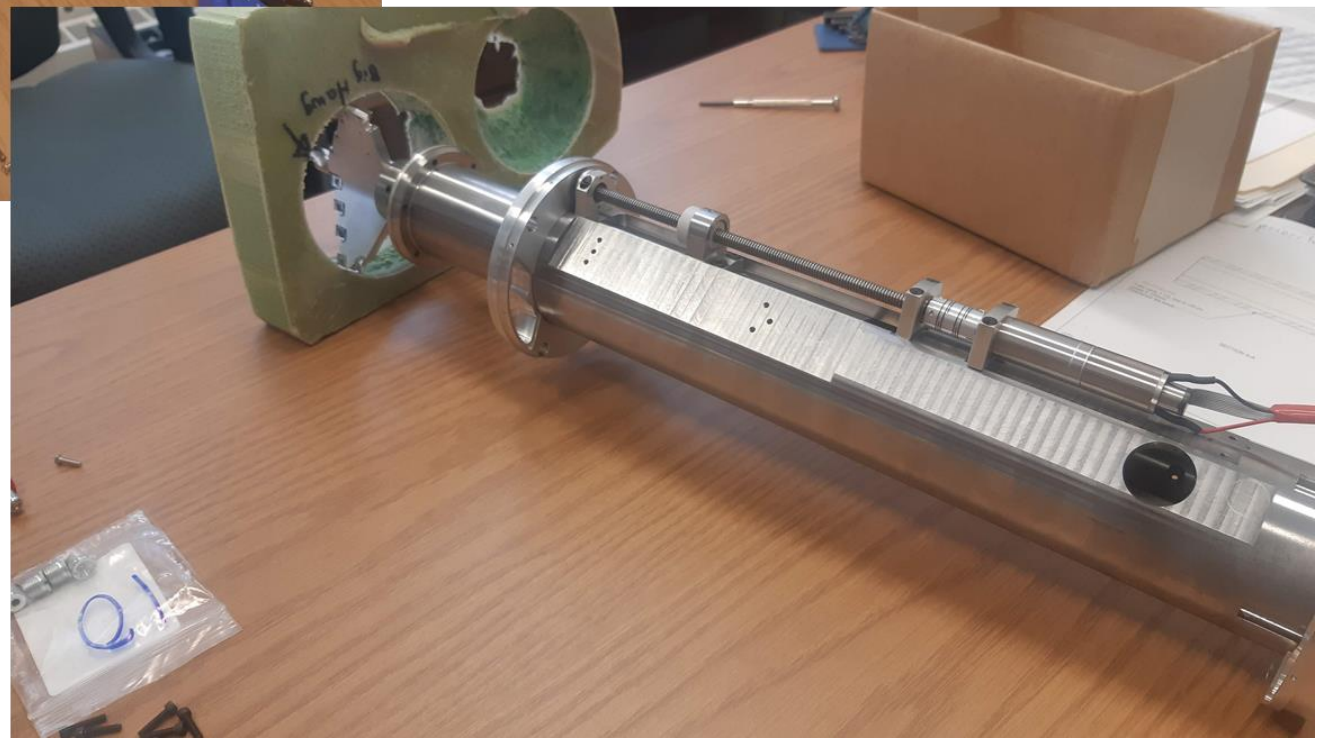

3/06/2021
bolt
Shear web
gusset
Leading edge
64ft 6in
01/01/11 00:04 64' 6"


ID 1.5"
OD 2" (tête canon)
#2485N202
* max torque
5964 lb-in
4 splines
canon principal (spline shaft ϕ40mm)
L = 2 m
rack (module 1) hauteur 9.8mm
largeur 10mm
longueur 1000mm
pignon moteur
#6114K17
Spline shaft bearing
OD 64mm
motor (100W)
vis pour skis
hole saw
pilot drill
ϕ4.5"
ϕ2"
tête canon
main shaft 1/2"
patin de positionnement
épaisseur
hauteur 200mm
rack
10mm
à usiner dans le shaft
10mm
spline shaft principal
André Béjin-Bolduc
2021-05-03







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Q&A Session by:

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