



Visibility-Adaptive AtoN Lights (VAAL)

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Note: The VAAL Demonstrator trials were part-financed by the Estonian Maritime Administration and the EfficienSea2 project



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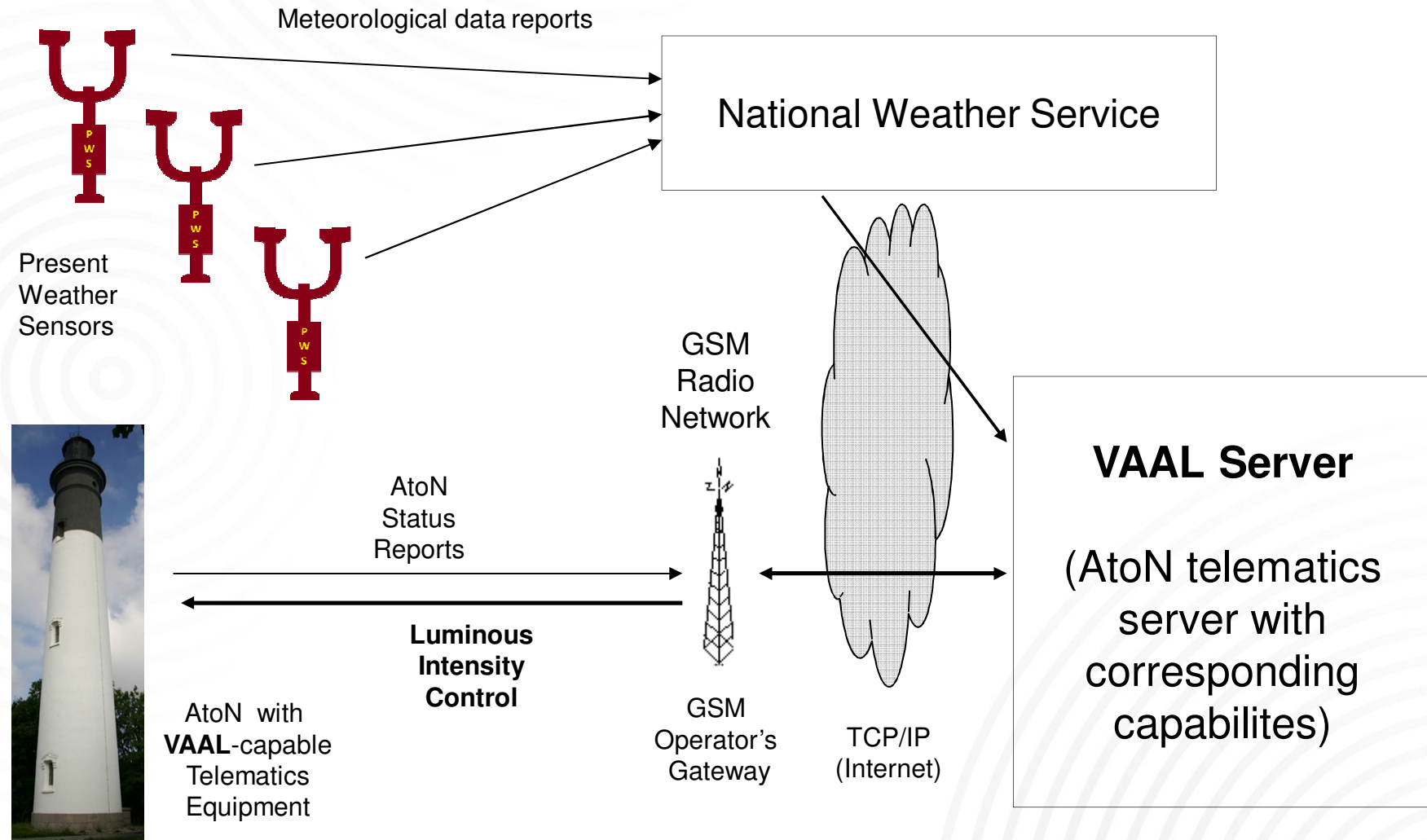
AtoN light signal range considerations

- ⊙ Nominal range of AtoN light signal is declared in the List of Lights for **10 M meteorological visibility** while luminous intensities are selected with sufficient static spare capacity considering service condition factor and prevailing location-specific atmospheric transmissivities
- ⊙ Operating an 11 M LED leading light designed for **7 M** visibility requires **~4x more power** compared to 10 M
- ⊙ Operating an LED AtoN light designed for „**2 to 5 M meteorological visibility**“ as recommended by IALA may require over **20..30x more power** compared to 10 M
- ⊙ Benefits of operating an AtoN light at high luminous intensity in excellent visibility are questionable: limited geographical range, impacts on power and lifetime, etc

Visibility-Adaptive AtoN Lights (VAAL)

- ⊙ Implementing a mechanism that allows to reduce or increase luminous intensity in accordance with actual meteorological conditions within service area to **maintain a nearly constant nominal range** would **increase marine navigation safety** and **reduce life cycle costs**
- ⊙ Visibility sensors co-located with most AtoN lights would not be sufficient while increasing system costs significantly
- ⊙ Key enabler: availability of network centric meteorological data provided by a dependable **national weather service**
- ⊙ Data link failure related risks can be mitigated by implementing proper control algorithms at the AtoN site

Visibility-Adaptive AtoN Light concept



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... another e-Navigation component

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VAAL Demonstrator implementation

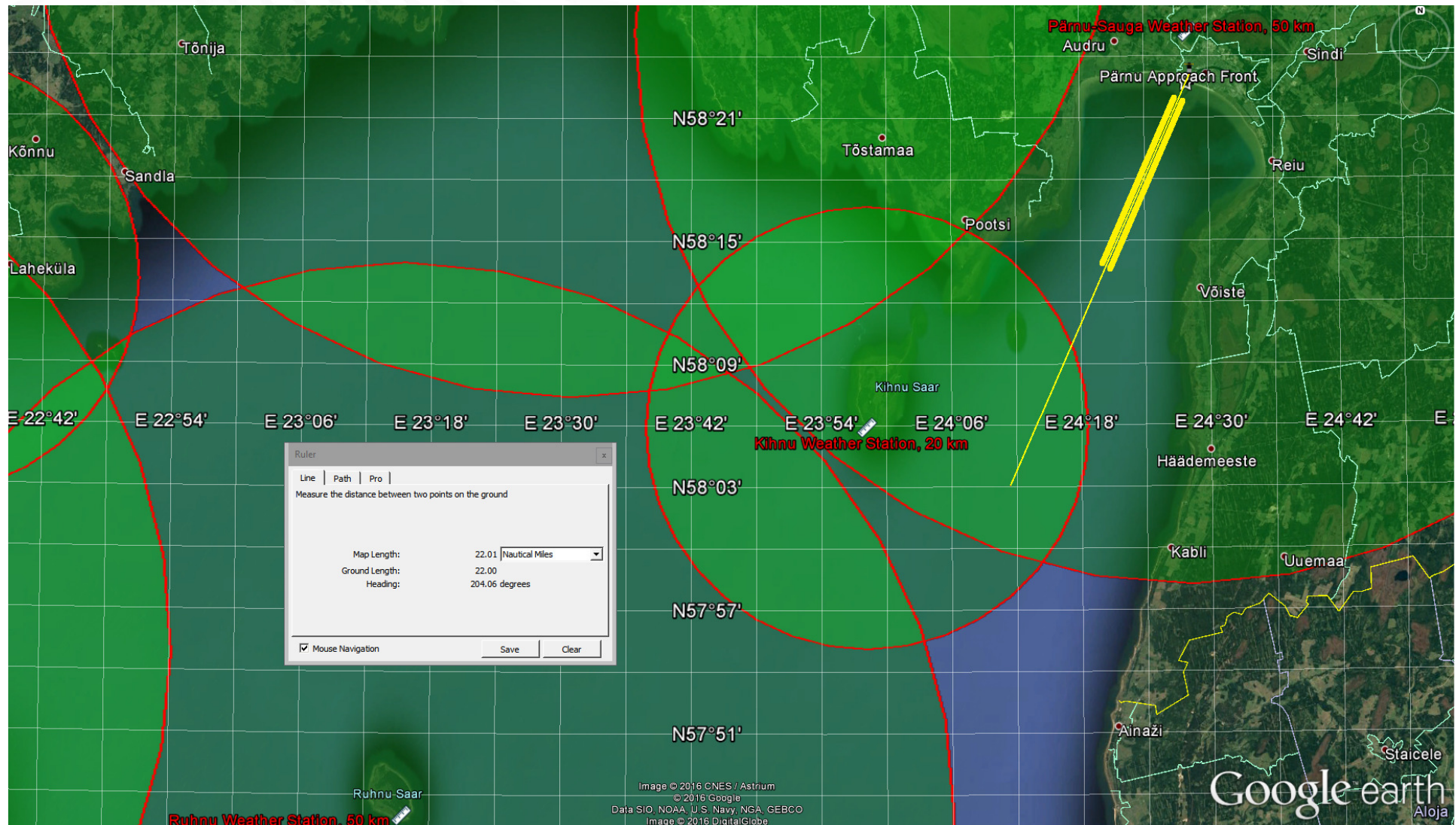
- ① The VAAL server requests relevant meteorological data from the Estonian Weather Service server and maintains meteorological visibility trend for AtoN service area
- ① When a VAAL AtoN reports in, the VAAL server adjusts the Pulse Width Modulation duty cycle (PWM%) of the Lantern Flasher to achieve optimum luminous intensity for current visibility conditions, considering negative trends
- ① When a VAAL AtoN reports a transfer to daytime standby mode, the VAAL server configures the PWM% of the Lantern Flasher to default value at which the next **night time** operation starts - in order to mitigate any communication failure related risks

VAAL target: Category 1 AtoN No. 872

- ⊙ Rear light station of Pärnu leading line
- ⊙ Far end of useful segment: **11 M**
- ⊙ Height 34 m, geographical range ~22 M
- ⊙ Fitted with dual LED Lantern E8554 producing **105 kcd** in flash @30W
- ⊙ 2 independent LED clusters operated at 50% PWM each (for spare capacity)
- ⊙ Rhythmic character: F.Iso 6s, red
- ⊙ Effective intensity (100%): 98.4 kcd



VAAL Demonstrator based on AtoN 872



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Far end of the useful segment at 11 M
Geographical range: beyond 22 M

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VAAL Demonstrator site

- ⊙ An actual AtoN hardware system operated at Cybernetica rooftop testbed
- ⊙ Mimics operation of AtoN No. 872 with flashing controlled by own light sensor
- ⊙ Reports to VAAL server and downloads PWM% updates for luminous intensity re-configuration based on atmospheric conditions at AtoN 872 service area obtained from **3 weather stations**
- ⊙ Fitted with LED for visual verification



VAAL luminous intensity regulation

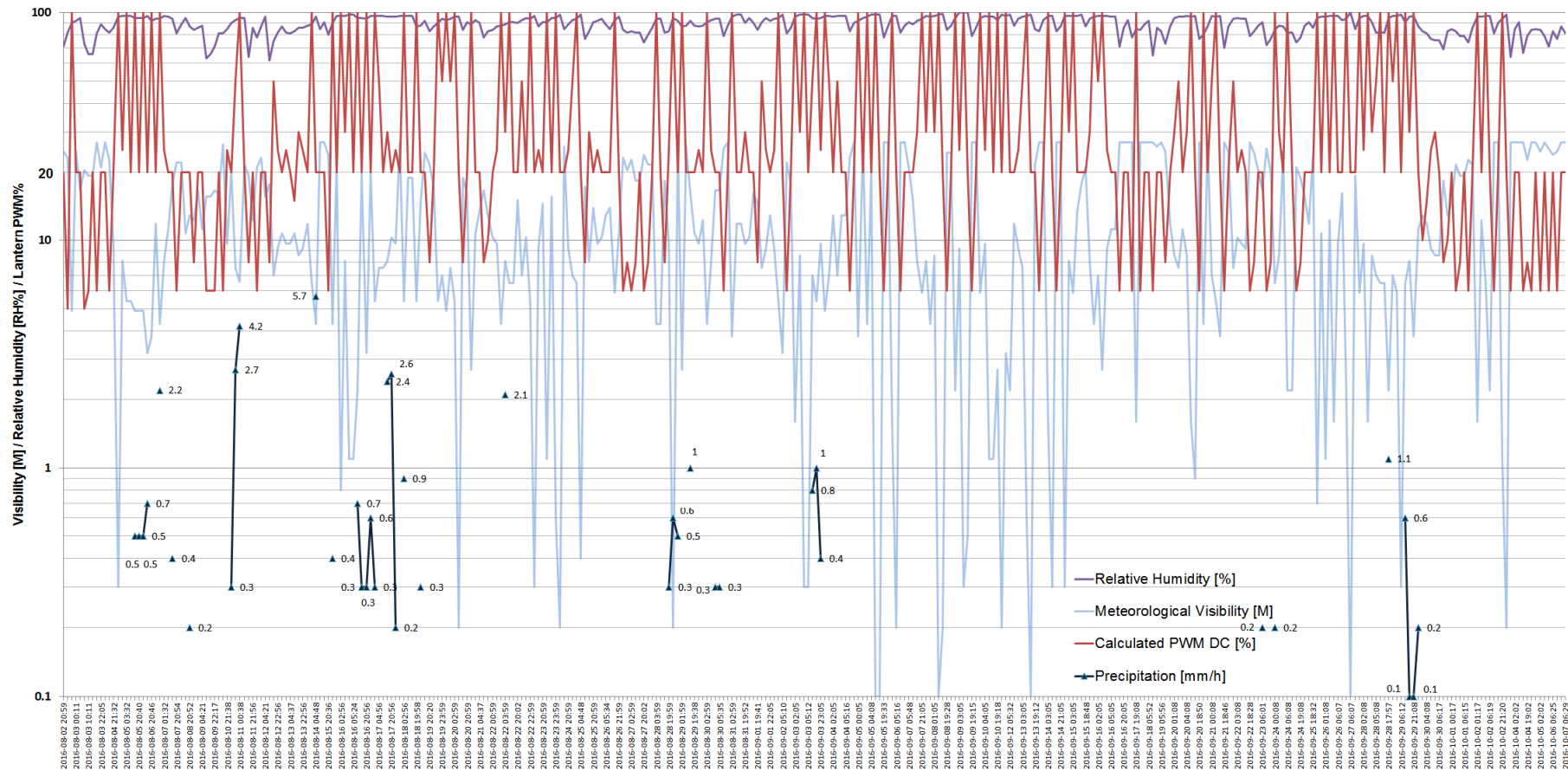
Luminous intensity steps of the VAAL Demonstrator were chosen in conservative manner, with default intensity of 20%

Visibility [M]	Atmospheric Transmissivity T_M	Required leff [cd]	Sufficient PWM %	Selected PWM%	Expected approximate intensity [cd]
6	0.607	102819	104	100	98438
7	0.652	46917	48	50	49219
8	0.688	26048	26	30	29531
9	0.717	16482	17	25	24609
10	0.741	11428	12	20	19688
11	0.762	8470	9	15	14766
12	0.779	6599	7	10	9844
13	0.794	5342	5	8	7875
14	0.807	4457	5	6	5906
15	0.819	3810	4	6	5906

VAAL Demonstrator operational statistics

VAAL Demonstrator operational time [h]	1573.9	
Total operational time of the AtoN light [h]	698.2	44.4%
Operation at default 20% luminous intensity [h]	314.0	45.0%
Operation at reduced luminous intensity [h]	125.2	17.9%
Operation at increased luminous intensity [h]	259.0	37.1%

VAAL operational history August-October



Worst readings from three relevant weather stations are used at making luminous intensity change decisions

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Comparison of VAAL / AtoN 872 signals

Operation at target AtoN 872 standard 50% luminous intensity [h]	20.8	3.0%
Operation at reduced luminous intensity compared to target AtoN [h]	482.4	69.1%
Operation at increased luminous intensity compared to target AtoN [h]	195.0	27.9%

VAAL / AtoN 872 signals in useful segment



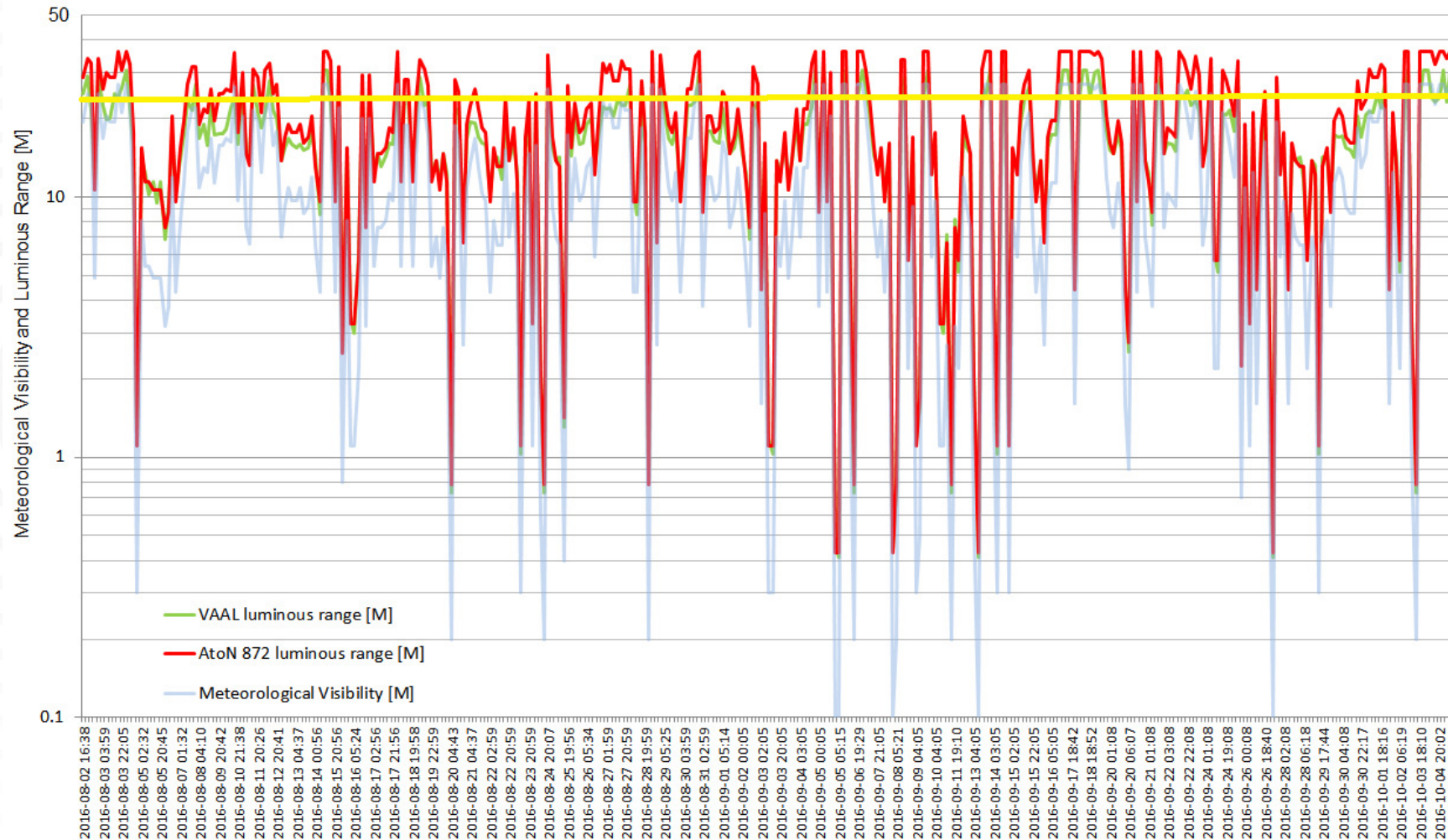
Visibility allowing, VAAL signals typically remained below 500% of required illuminance at the eye of the observer while AtoN 872 exceeded such requirement by over 3000%

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3 weeks in September 2016, visibility minimum 0.1 M

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Luminous range of VAAL / 872 signals

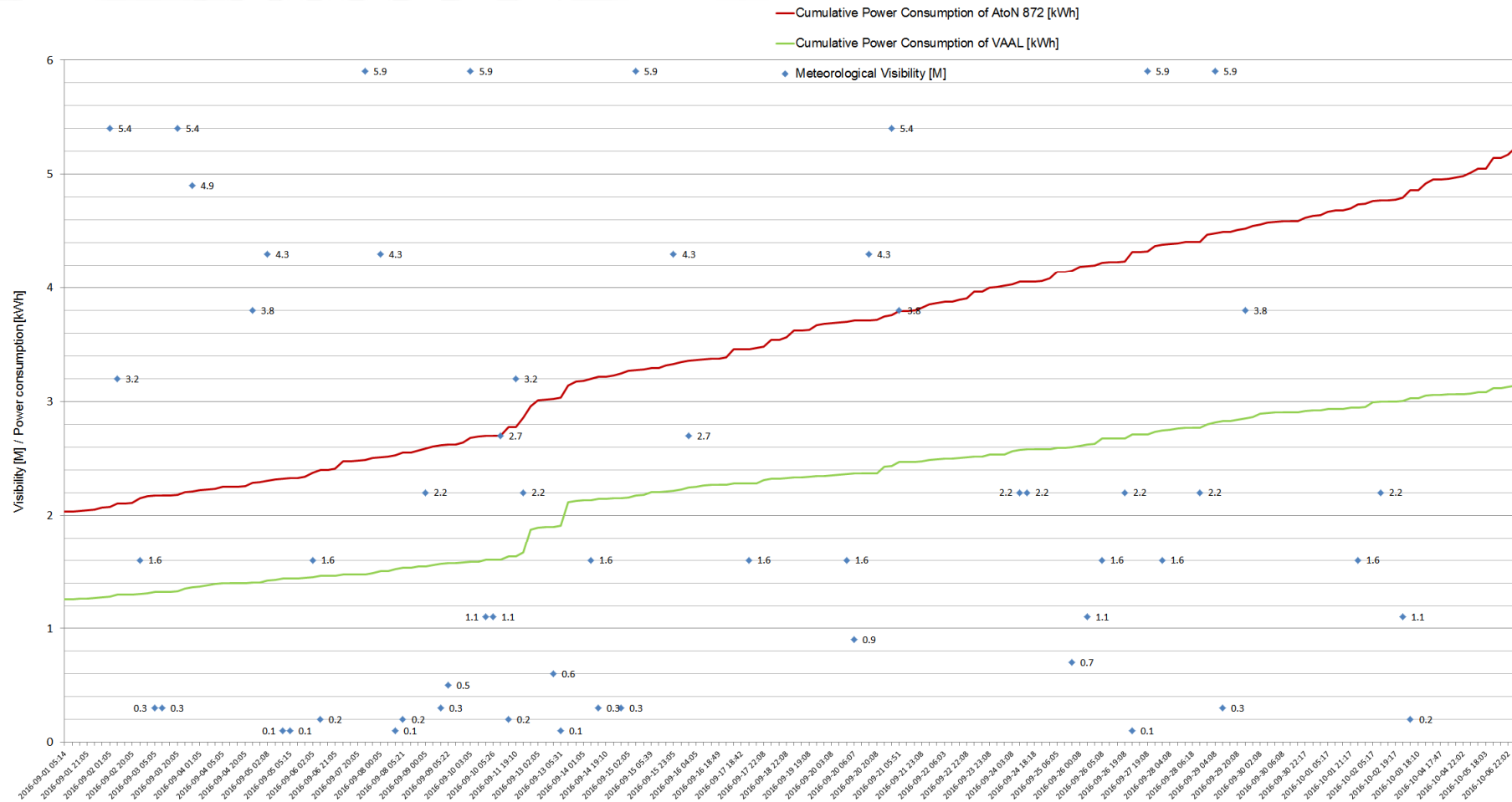


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Yellow line: geographical range 22M

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Cumulative power consumption



The green line shows the power consumption of AtoN 872 if the VAAL algorithm would have been implemented on it

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VAAL / AtoN 872 power consumption

Power consumption of target AtoN 872 at current luminous intensity settings [Wh]	5236.5	100.0%
Power consumption of VAAL during reduced to target luminous intensity periods [Wh]	2427.1	46.3%
Power consumption of VAAL during increased luminous intensity periods [Wh]	712.0	13.6%
Total power consumption comparison: VAAL vs target AtoN 872 [Wh]	-2097.5	-40.1%

Conclusions and Challenges

- ◎ The VAAL Demonstrator confirmed expected benefits:
 - Static spare capacity of AtoN 872 was seldom needed while peak capacity could have been used by VAAL
 - Nearly constant range was maintained (within capacity)
 - Power savings were achieved even regardless of occasional operation at higher power than AtoN 872
- ◎ Application of VAAL in countries with dependable weather service is considered feasible - perhaps even on buoys
- ◎ Questions remain:
 - How to convey the VAAL behaviour to mariners?
 - Would weather services upgrade sensor networks?

Thank you for your attention. Questions?

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