



NAWA TECHNOLOGIES

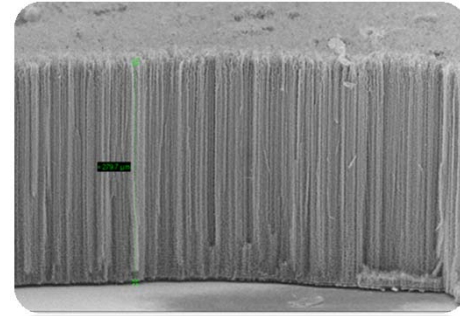
TURBO CHARGE INTERNET OF
THINGS WITH ULTRA CAPACITORS

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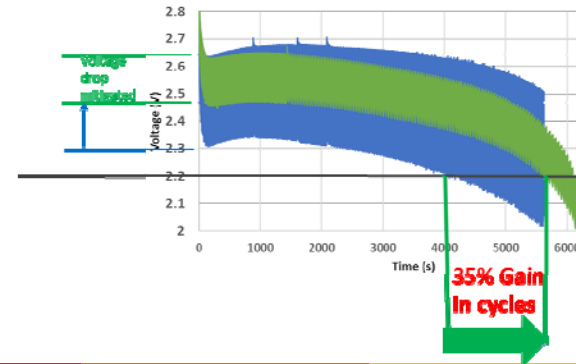
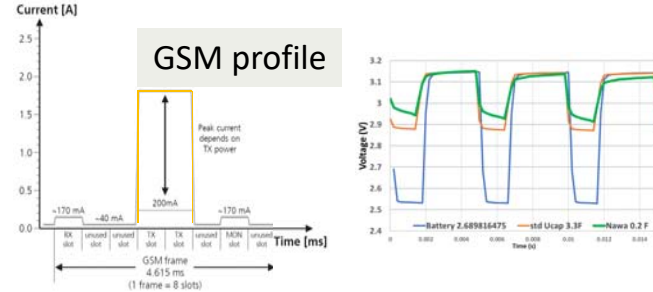
ULTRACAPACITORS ELECTRODE TECHNOLOGY BASED ON VERTICALLY ALIGNED CARBON NANOTUBES (VACNT)

- All VACNT based
- Vertically aligned conductive path
- High ion/electron conductive carbon
- Excellent peak power performance
- Eco-Friendly, no chemicals, non-toxic
- 100% re-cyclable
- Operational life-time equal or larger than device life-time
- No replacement required (fit-and-forget)
- No performance degradation over life-time, predictable performance
- Can be combined with battery and Energy Harvesting



GSM TRACKING DEVICE / ACCELERATED LIFE TIME TEST

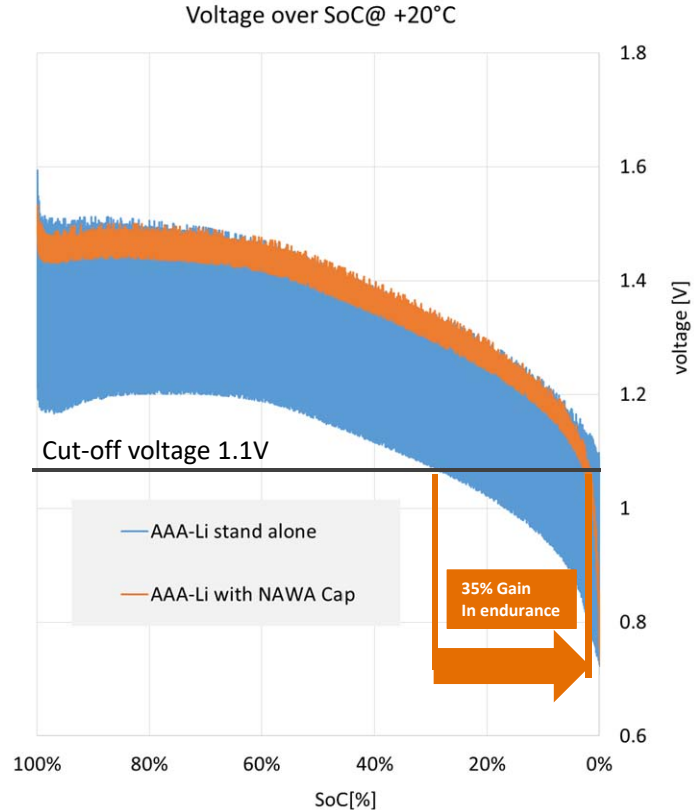
- 3V operated device
- Standby 40-170mA
- During transmission up to 2A peak
- Voltage drop during transmission
- Cut-off voltage shuts down system
- Use of Ultra-Capacitors mitigates voltage drop and pre-mature shutdown
- Result is 35% gain in operational life time



WHEN SIZE MATTERS

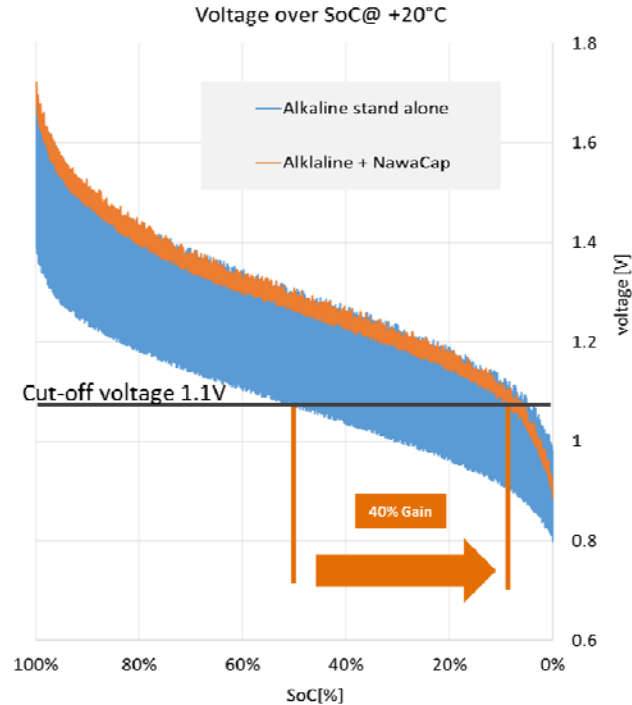
NAWACAP AS ENDURANCE EXTENDER FOR LITHIUM AAA AS REPLACEMENT FOR AA

- Nett usable energy of a AA battery would be 65%
- Nett usable energy AAA + Ucap would be >95%
- Therefore a 1000mAh AA battery would almost be equal 600mAh AAA battery
- Depending on configuration, space and weight savings could easily be 40% and 20% respectively



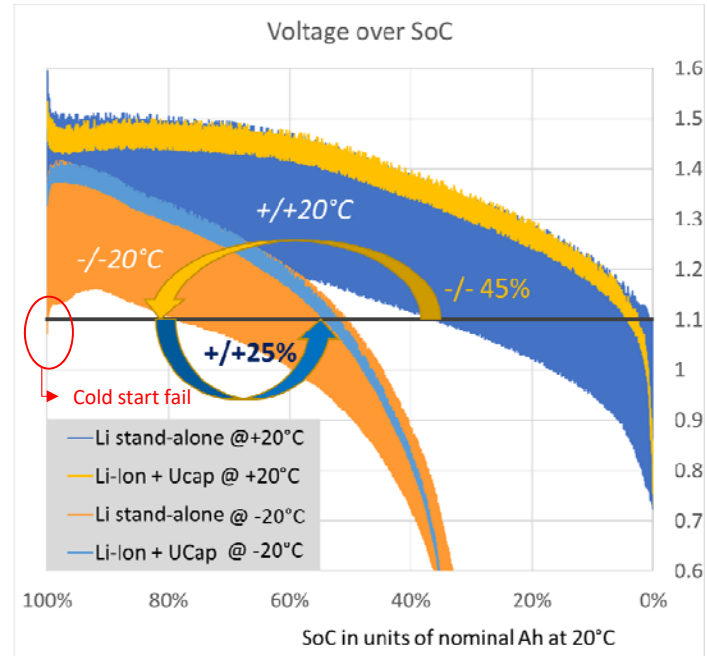
ENABLE ALKALINE AS ALTERNATIVE FOR LITHIUM

- AA Alkaline battery, 1.5V
- Alkaline in many cases not feasible due to linear degrading voltage platform over operational life time
- Ucap “flattens” voltage platform
- Enhances usable energy with 40%

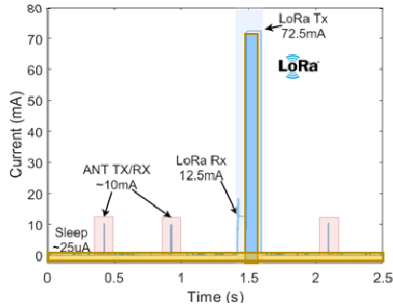


PERFORMANCE ENHANCEMENT AT EXTREME TEMPERATURES

- At low temperatures
 - Cold start troublesome
 - the cut-of Voltage is reached at a SOC of 80%
- Only 20% usable energy in the battery
- Ucap support more than doubles usable energy at cold conditions (SOC 55%)
- More reliable performance



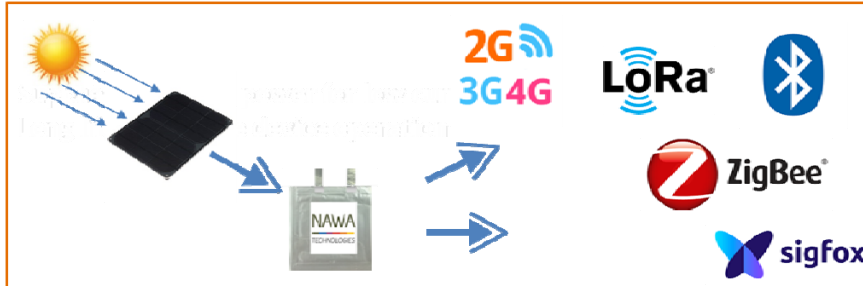
ENERGY HARVESTING WITH UCAP



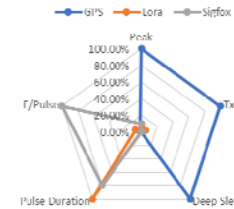
NAWACap – High Power – High Current

- Charged by Solar cell during standby
- Peak transmission by Ucap
- Ucap re-charged between intervals

Solar Cell – Deep Sleep – Low Current

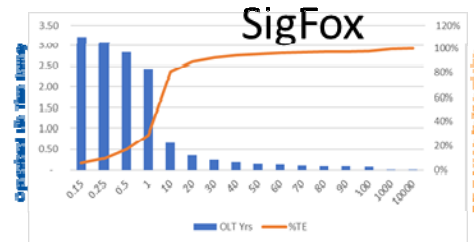
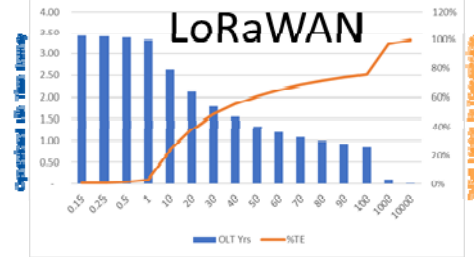
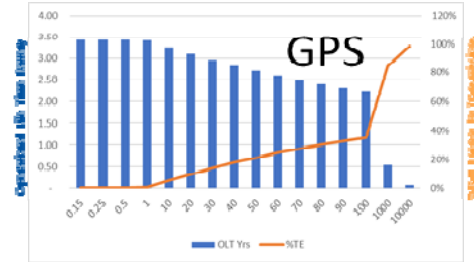


Protocol profiles evaluated on E parameters



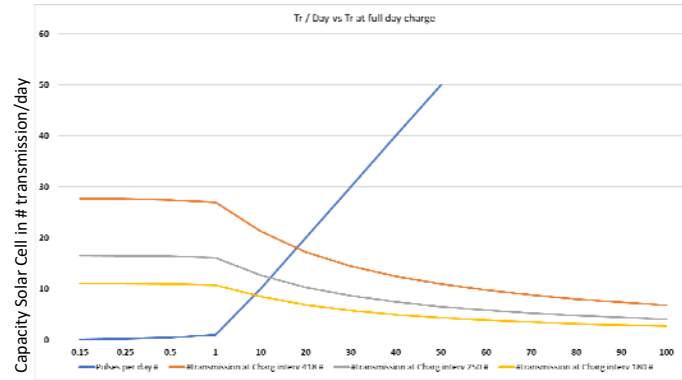
WHEN TO USE ENERGY HARVESTING

- Battery Operational Life Time strongly determined by #Transmissions / day
- At high level transmissions/day, >90% of battery energy is used for transmissions
- Batter better solution
- At low occurrence level (<10 Tr/day), BOLT determined by standby / deepsleep
- BOLT hardly affected by transmissions
- In this region EH (Solar) with Ucap better solution



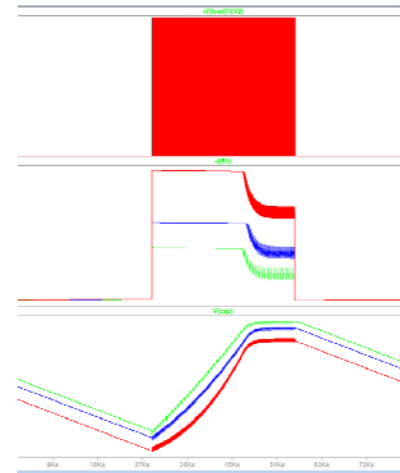
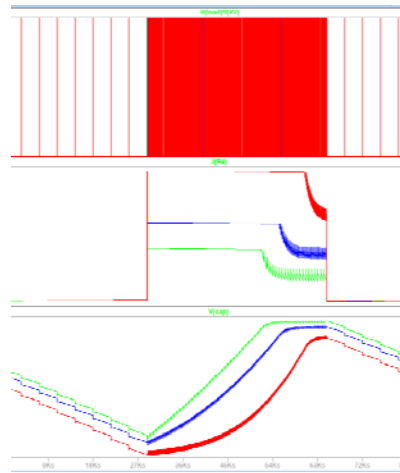
HOW TO OPTIMIZE CONFIGURATION

- Example LoRaWan
- Reviewing three different EH solar cells with output power (Indoor)
 - 480 μ W _____ #28 Tr/day
 - 250 μ W _____ #16 Tr/day
 - 180 μ W _____ #11 Tr/day
- In the range of 1-20 transmissions per day the solar panel / Ucap can optimized
- In case >20 transmissions/day, support of energy storage desired
- Output power matches transmission energy
- Ucap size mainly determined by E-Transmission



TRANSMISSION STRATEGY

- Day/night charging/transm.
- Day time charging/transm.



HYBRID USERCASES



Bulky



Flatter+ Lighter + Smaller



Lithium Free

Side View



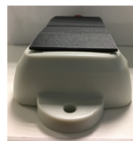
Reference AA Li-Ion Battery



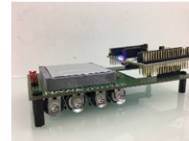
AAA + Ultracap



Coin Cell + Ultracap

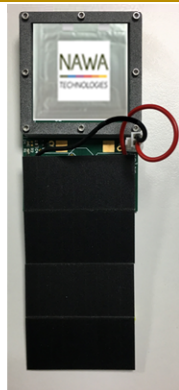


Solar Cell + Ultracap



Alkaline + Ultracap

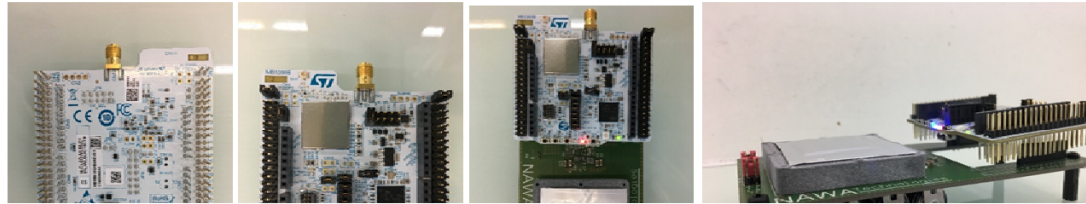
Top View



IOT USERCASE WITH STM32 + ALKALINE + IN-BUILDING SOLAR

STM LoRaWAN integrated solution Ucap powers by:

- Alkaline Battery + Ucap
- solar cell + Ucap



Venise (Marco Polo) FR 857

- Device was life demonstrated at the CES 2020 in Las Vegas
- Fully operational with Alkaline battery + Ucap and equal life time as Li-Ion
- Fully operational with Solar cel + Ucap harvesting ambient light

USERCASE E-PEAS WITH UCAP + SOLAR EH WITH BATTERY AS BACK-UP

- Ucap and EH holds-up performance under normal conditions
- Once operating conditions change drastically, battery is used as back-up



USERCASE: POST-CRASH EMERGENCY SIGNAL

- 2G/3G
- After main battery fail / detached battery
- One single charge NAWACap - 6 SMS transmissions demonstrated
- Suitable for any emergency alert transmission
- NAWACap can be charged by EH integrated solar cell or battery during operation
- Or Ucap can be charged by the event detected

Transmission	Voltage	Voltage drop
T1	6.39	Start
T2	5.94	0.45
T3	5.47	0.47
T4	4.97	0.5
T5	4.41	0.56
T6	3.79	0.62
	3.10	cut-off



GENERAL CONSIDERATIONS

- Factors to take into account when configuring a EH + Ucap combination:
 - Start-up of device
 - Firmware updates
 - Transmission interval
 - Transmission strategy
 - Protocol used
 - Consistency and efficiency Energy Harvesting solution
 - External operational conditions like °C
 - Signal strength and Tr/Tx repetition required for transmission
- EH needs to be configured towards the average energy consumption per day (St.By/Deepsleep/Leakage)
- Ucap configured towards the peak, peak duration and repetition

CONCLUSIONS

- Ultracapacitors are an excellent complementary solution for IoT devices with low transmission rates
- Li-Battery free solution perfectly feasible
- With EH + Ucap no need for battery replacement
- Low TCO solution

NAWARACER: A TECHNOLOGY PLATFORM DEMONSTRATOR FOR HYBRID CONCEPTS



NAWA RACER

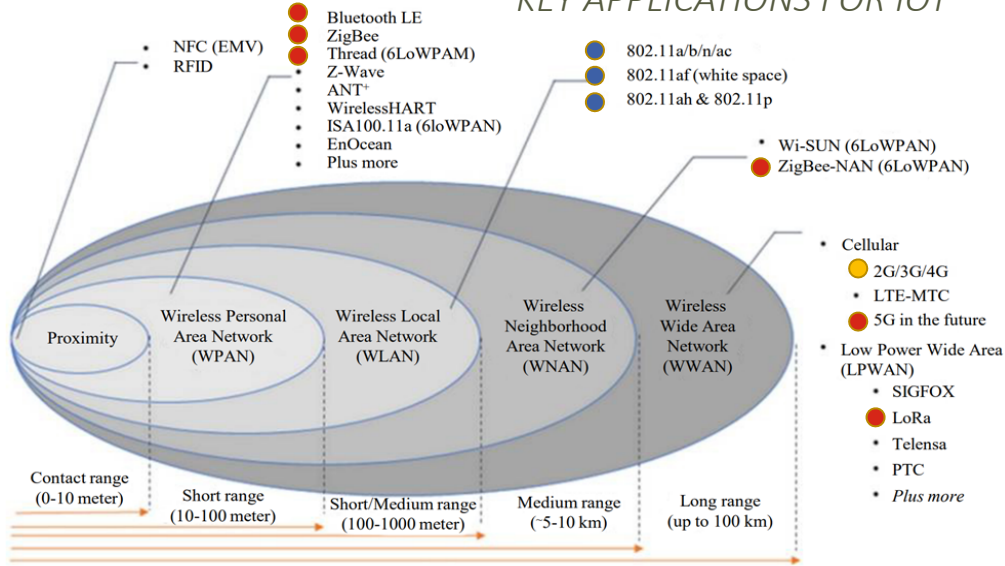
- First E-bike with integrated Hybrid Batteries
- Lithium battery for high density storage = autonomy
- NAWACap for energy, power and max recuperation
- NAWA seamless battery management system
- Lighter overall mass of energy solution: >150 kg less
- Higher range: 150 km standard - 300 km NAWA urban package
- Composites in frame and wheels

A blurred industrial machine, possibly a printing press or textile loom, with a central text overlay. The machine is composed of various metal parts, gears, and rollers, all rendered in a soft, out-of-focus state. The text 'WHAT CAN WE DO FOR YOU?' is centered in a white, semi-transparent rectangular box with a fine grid pattern.

WHAT CAN WE DO FOR YOU?

NAWAS UCAPS

KEY APPLICATIONS FOR IOT



High Energy Solution

NAWA CAP + Battery

- Power Performance
- Ultra Low ESR
- Flexible Form Factor
- Endurance Extender
- Li-Free

Low Energy Solution

UCAP + Energy Harvester

- Li-Free
- Device Life Time Eq.
- Extreme conditions
- Intermitting pulse supp

High Power Solution

UCAP as UPS

- Last Gasp Operation
- Controlled Shutdown

Short/Mid Range	Mid Range	Mid/Long Range
Building Retail SMART Industry Health	SMART City	Agri Logistics Car City SMART