FREE Live Webinar

How to select the best battery for your cellular IoT devices

Speakers

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saft
a company of TOTAL

EMnify

EMnify IoT Webinars

Cellular Connectivity
Anywhere In The World

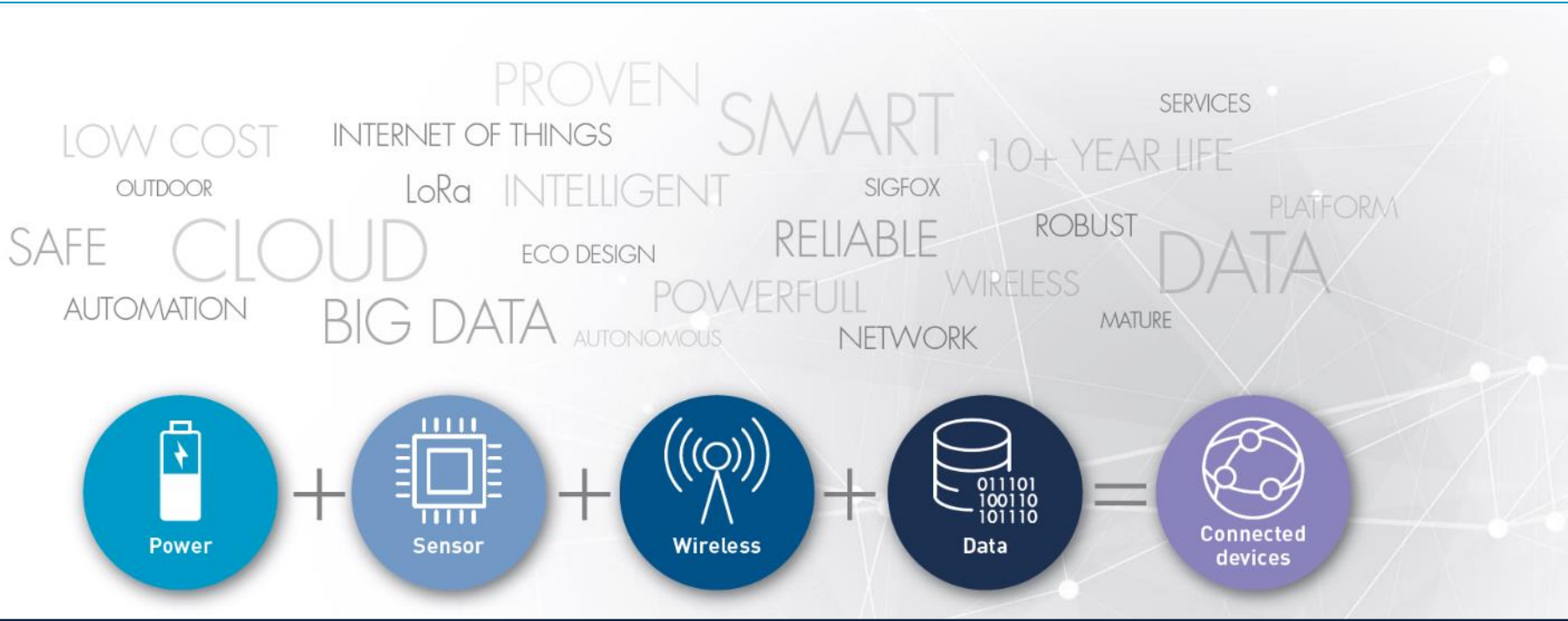
IoT Customer Cases
Their Challenges and Solutions

Seamless Integration
In the Cloud

aws Azure Google Cloud

Partners
Their view on State of Art IoT Technology

Why is the battery so crucial for a connected device ?



At the heart of every IoT system is POWER

Batteries are in Saft's DNA for more than 100 years

GROUP PROFILE

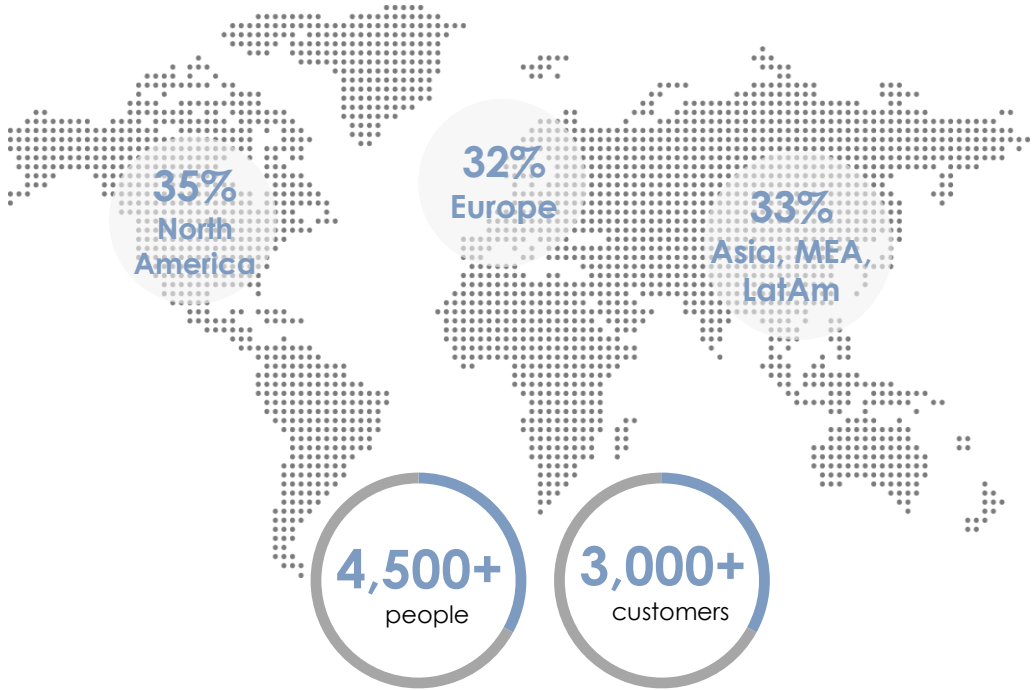
100+ years of history

Leadership position on 75-80% of revenue base

12.4% invested in **R&D** with **3** main technologies; primary lithium, lithium-ion & nickel-cadmium

€796m revenue FY 2019

GLOBAL PRESENCE - SALES



Saft Connected Energy Division

Focus on small primary and rechargeable lithium solutions

40 years of production experience

2 rechargeable chemistries:
- $LiNiMnCoO_2$ (NMC)
- Blend (NMC/NCA)

7 factories

3 brands:
- Saft
- Tadiran
- Eternacell

3 primary lithium chemistries:
- $Li\text{-}SOCl_2$
- $Li\text{-}MnO_2$
- $Li\text{-}SO_2$

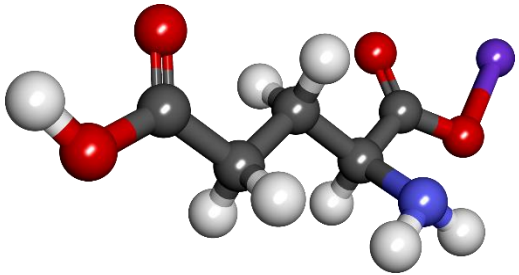
Our priority: reliably powering B2B IoT applications

Saft's Connected Energy for IoT: where to find our solutions ?

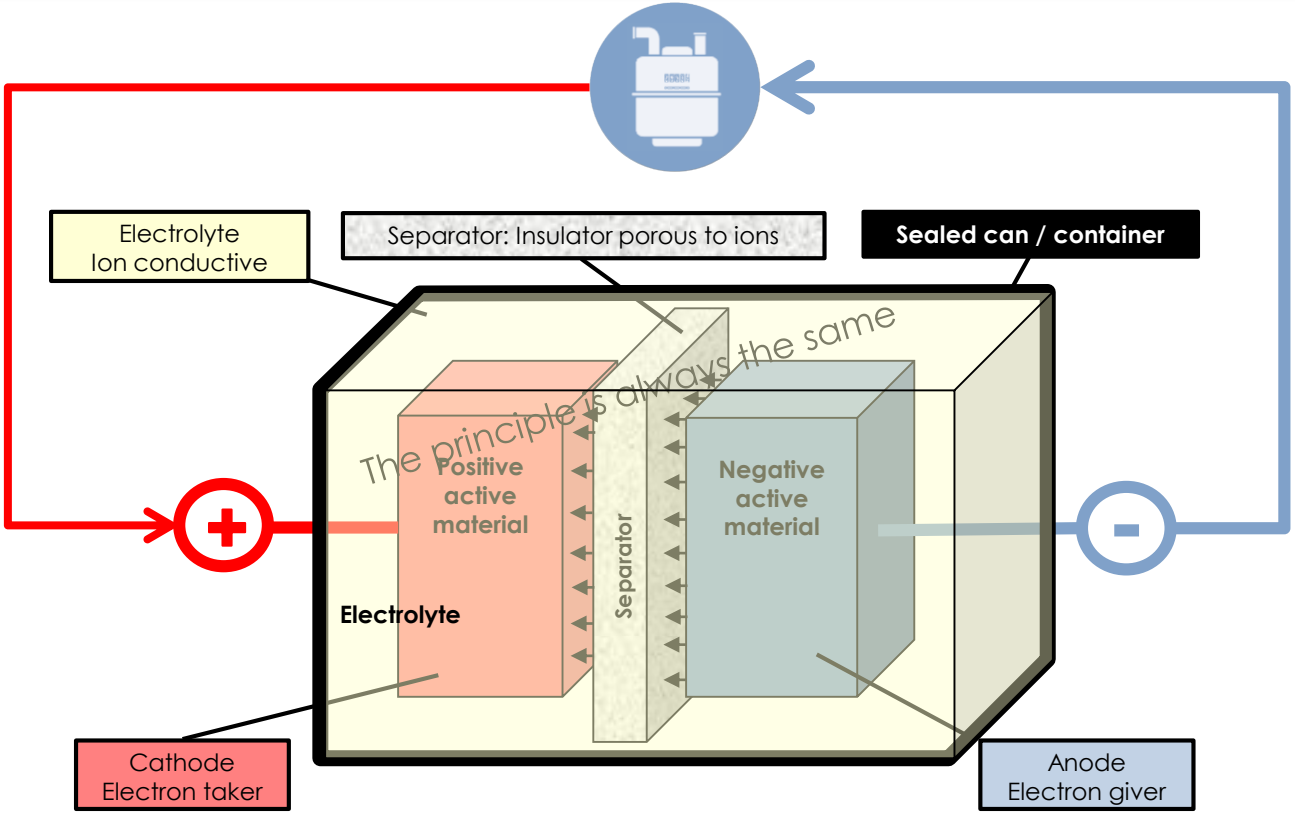
Saft CE is powering devices within a wide applications' domain

BATTERIES: A VAST WORLD

What is a battery ?



What is a battery ?



Many different shapes

– Single cells

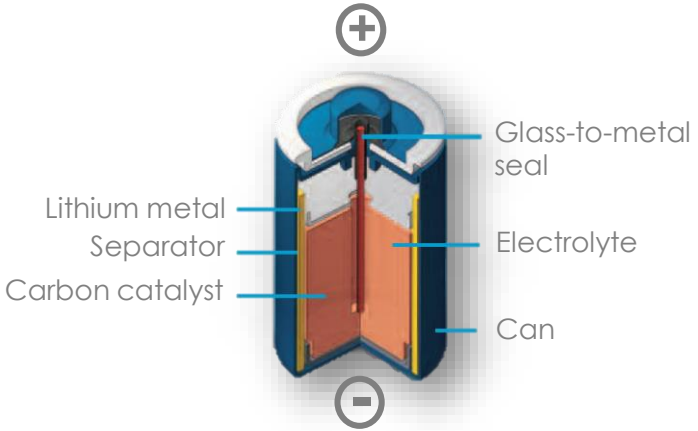
- Cylindrical
- Prismatic
- Button/Coin
- Pouch

– Battery packs (multiple cells)

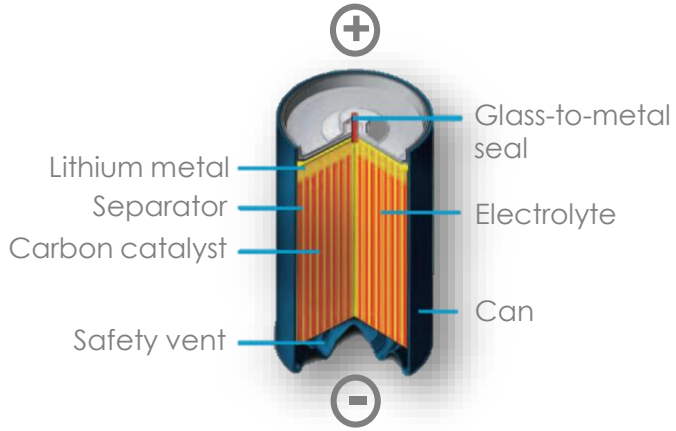
- Serial connection
- Parallel connection
- Serial – parallel connection

And different internal constructions too !

Ex of Lithium Thionyl Chloride cells

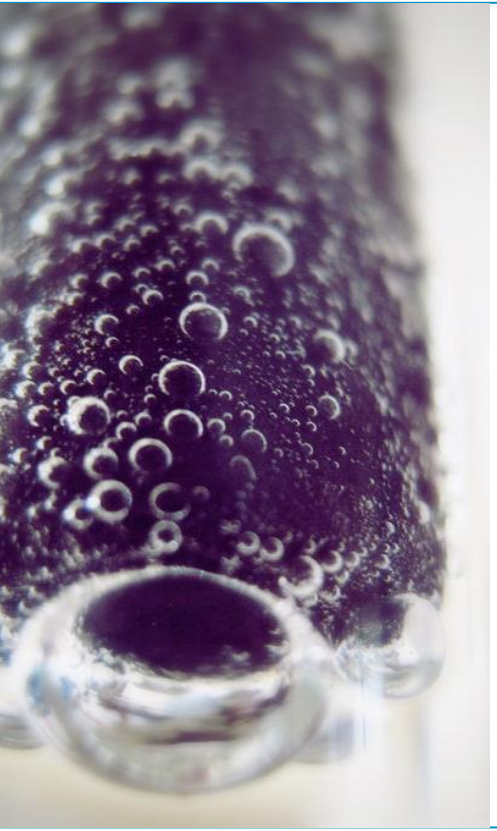


Bobbin construction (High energy cells)



Spiral construction (High power cells)

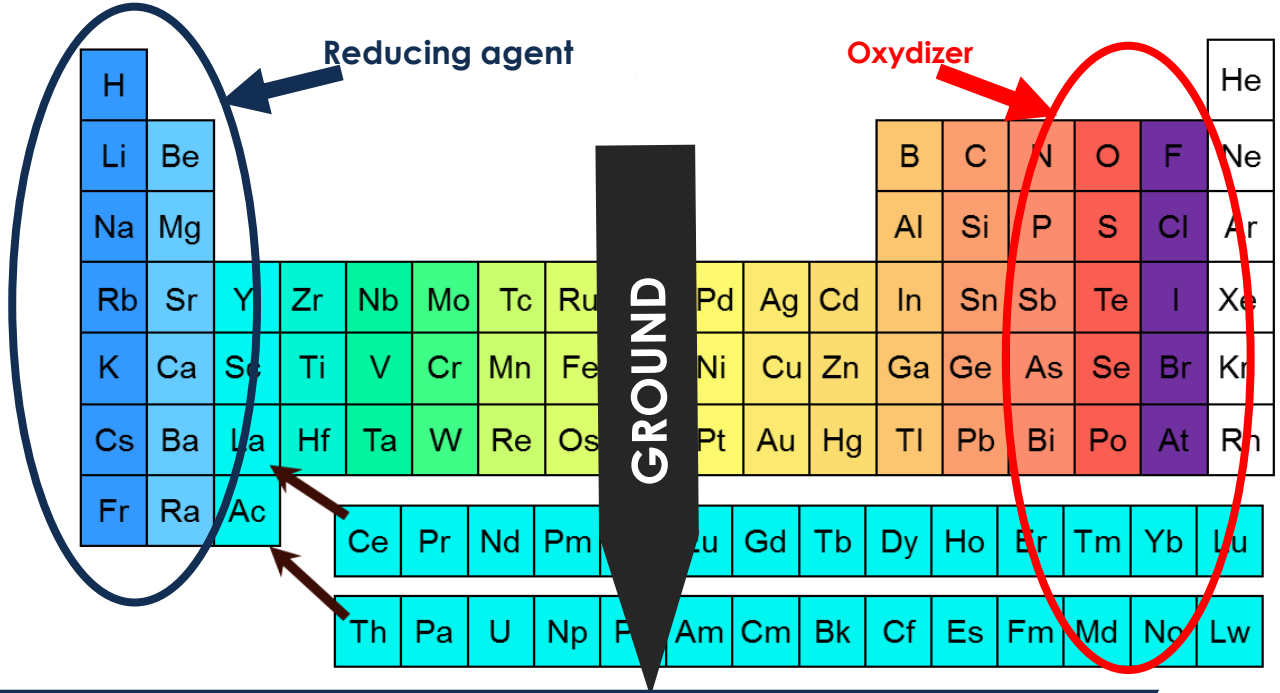
Basics in electrochemistry



- In an electrochemical generator
  - Voltage, current, load of the application drive chemical reaction
  - Energy produced is electricity
- The electrochemical reaction
  - Chemical reaction inside generator due to electrons exchange
    - Oxydizer: electron taker
    - Reducing agent: electron giver
  - Electrons are used through electrical current outside generator

Why are lithium-based technologies so popular ?

- Nominal voltage of the cell depends on electrochemical couple
  - **Li-ion : 3.7 V**
  - Ni-MH: 1.25 V
  - Ni-Cd: 1.25 V
  - **Li-$SOCl_2$: 3.6 V**
  - **Li-MnO_2: 3 V**
  - Alkaline 1.5 V



High nominal voltage is important to electronics applications

Most common battery chemistries

Rechargeable

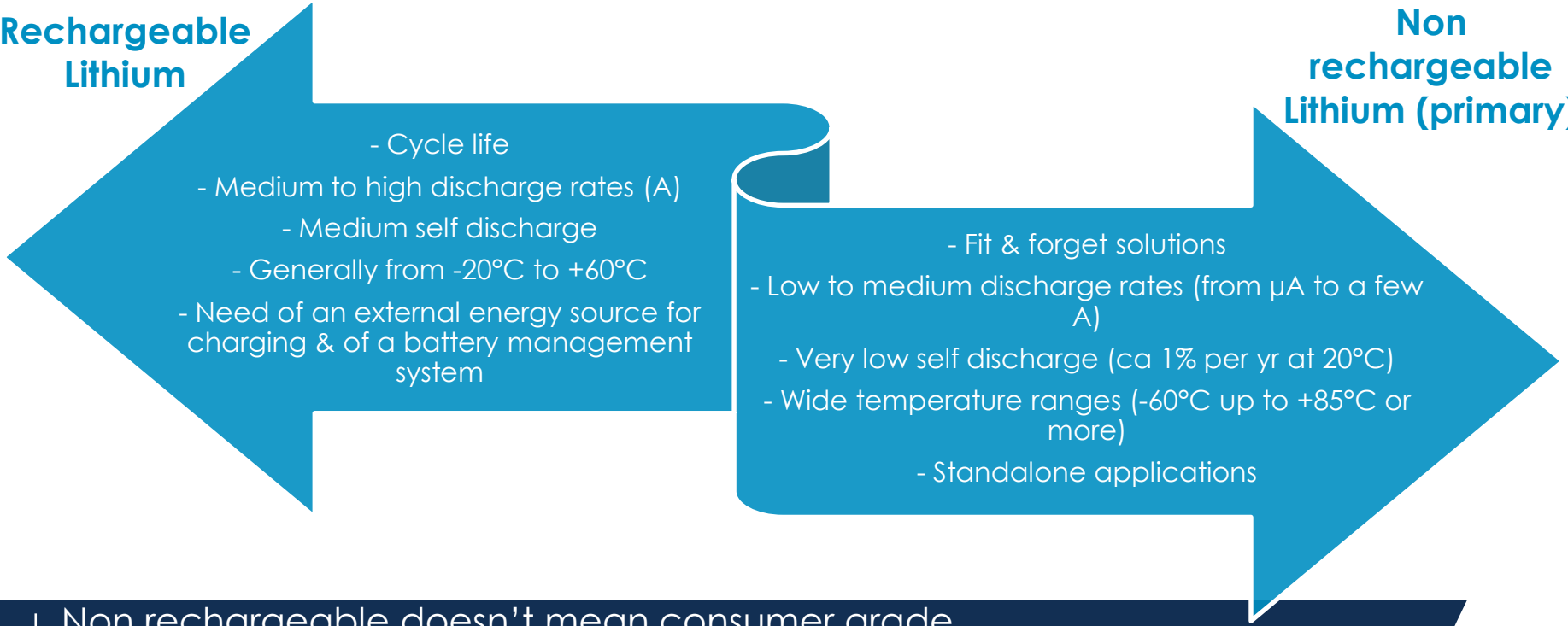
- **Lead acid** (2 V nominal voltage)
  - Low price, heavy, still highly used in industrial environments (forklift trucks, UPS, backup batteries…). Short life compared to other types
- **Nickel-Cadmium** (Ni-Cd, 1.25 V nominal voltage)
  - Medium price, used in lead acid replacement as Total Cost of Ownership is better
- **Nickel-Metal-Hydride** (Ni-MH, 1.25 V nominal voltage)
  - Higher energy density than Ni-Cd.
- **Lithium-ion** (3.7 V nominal voltage)
  - Designation of many different chemistries: NCA, NMC, $FePO_4$… with various characteristics. Needs a more sophisticated battery management than other types. Most popular form factor was 18650 cylindrical types, used in laptop
- **Li-ion Polymer** (3.7 V nominal voltage)
  - Same as lithium-ion but in soft casing (vs 18650) with a different electrolyte, used in mobile phones, tablets, thin laptops,

Non rechargeable (primary)

- **Alkaline** (1.5 V nominal voltage)
  - Consumer type, hi
- **Lithium Iron Disulfide** (Li-FeS_2 , 1.5 V nominal voltage)
  - Was used in replacement of alkaline cells
- **Lithium Manganese Dioxide** (Li-MnO_2, 3 V nominal voltage)
  - Exists in consumer grades (cameras..) and industrial. High power and good voltage response to pulse
- **Lithium Sulfur Dioxide** (Li-SO_2 , 2.8 V nominal voltage)
  - For military use and medical (defibrillators): high power cells, very good in cold environments
- **Lithium Carbon monofluoride** (Li-CF_x , 3 V nominal voltage)
  - High temp cells, for special applications
- **Lithium Thionyl Chloride** (Li-$SOCl_2$, 3.6 V nominal voltage)
  - Adopted by smart metering, IoT applications (and historically, by military equipment applications). Very wide range of temperatures (-60°C to +85°C and more for some cells)

With high energy densities, **low self-discharge**, **stable voltage**, lithium primary batteries are a good match with IoT needs for long life and standalone solutions

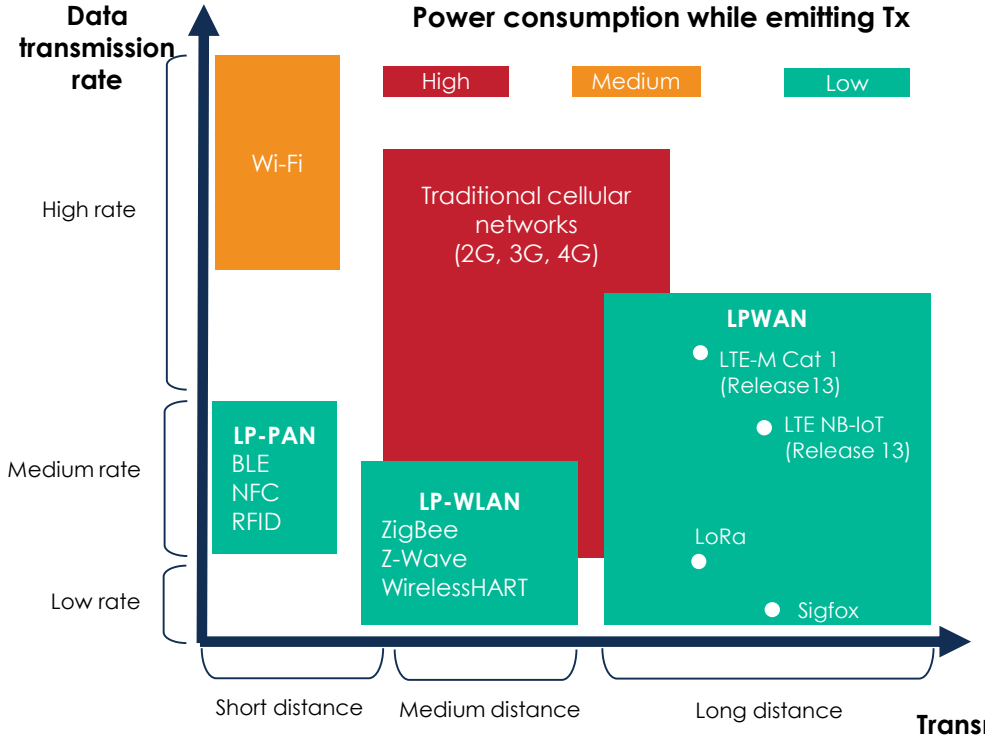
Do Lithium rechargeable batteries last longer than primary ones ?



Non rechargeable doesn't mean consumer grade
Single use doesn't mean "must be replaced"

CONNECTIVITY SOLUTIONS

Connectivity solutions : 3 impacting factors

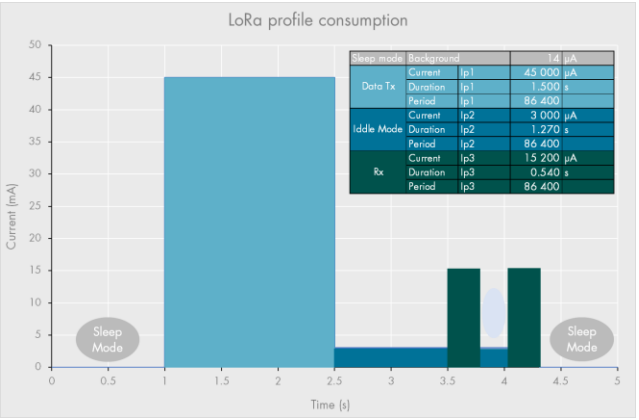


- **Data transmission rate**
- **Transmitting distance**
- **Power consumption**

are key features of a connectivity solution and are impacting each other

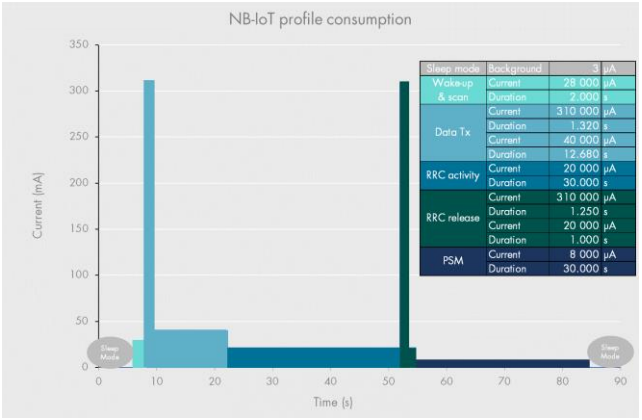
LPWAN protocols typical profiles

What is the yearly consumption for one transmission / day ?



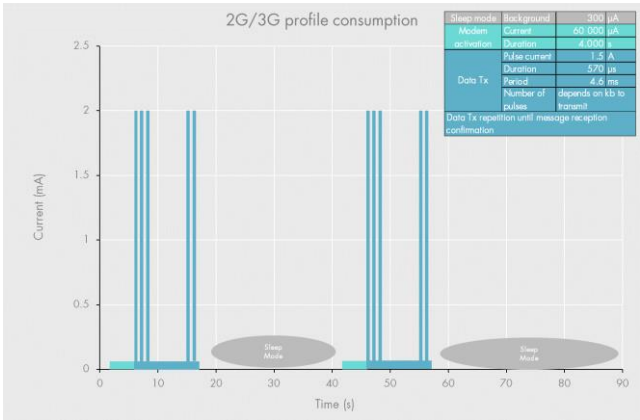
LoRaWAN: ca. 130 mAh

For 10 yrs: AA or A size cell



NB-IoT LTE-M: 250 to 300 mAh

A, C or D size cell



2G/3G > 4000 mAh

Complex solution: Multi D size

Traditional cellular connectivity is more compatible with Li-ion technologies

Battery Data sheet

What's in Batteries' data sheets ?

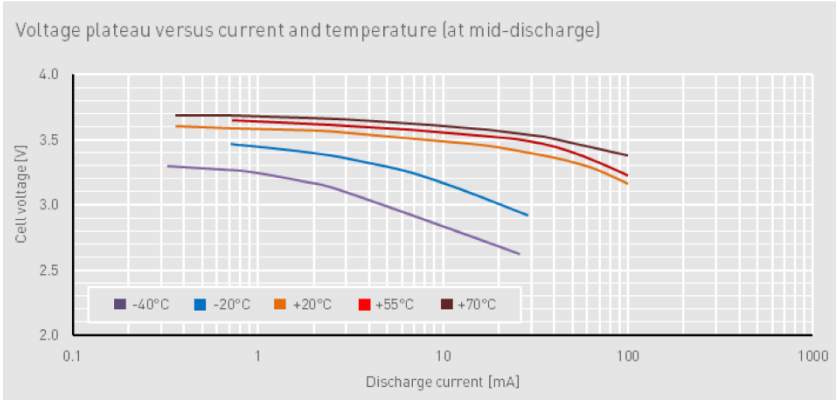
- Nominal Voltage
- Operating Temperature range
- Nominal Capacity
- Maximum Continuous Current
- Maximum Pulse Capability

How to properly use this information ?

VOLTAGE SELECTION

Cell voltage vs discharge current curve

Open circuit voltage (at + 20 °C)	3.67 V
Nominal voltage (under 0.2 mA, + 20 °C)	3.6 V

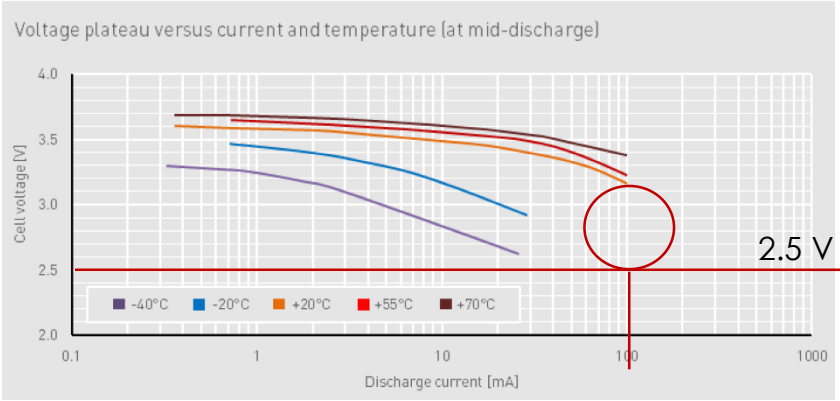


Datasheet's information

- Open Circuit Voltage
- Nominal Voltage
- Voltage Plateau

Batteries are NOT Constant Voltage Generators !!!!!

Check the battery voltage compatibility with your usage



100 mA

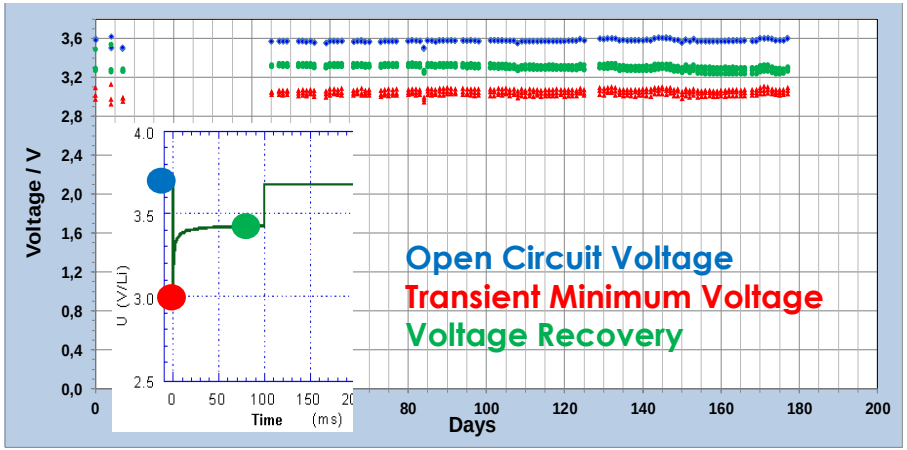
Ex of device's characteristics

- Minimum Operating Voltage = 2.5 V
- Minimum Operating Temperature = -20°C
- Data Tx Maximum Peak Current > 100 mA

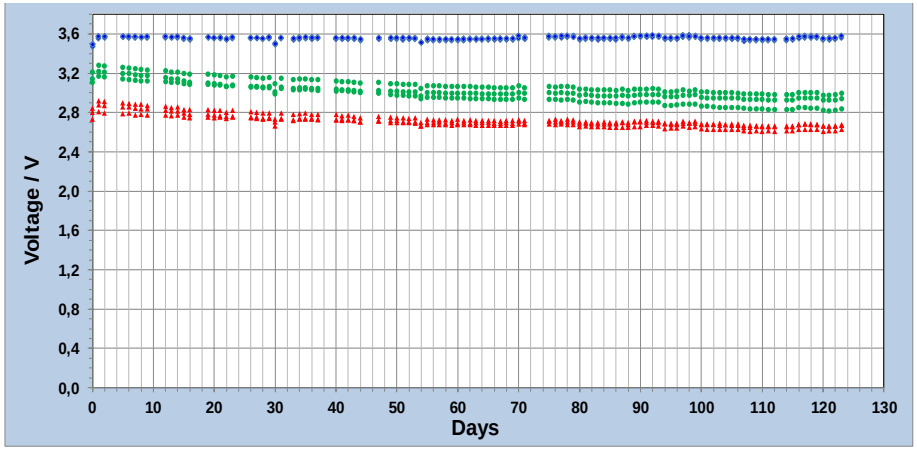
Data is not available for this voltage level -> testing is required

Example of Li-$SOCl_2$ AA size cell behavior under current pulse (100 mA)

Fresh cells



Cells artificially aged (1-month storage at 70°C)

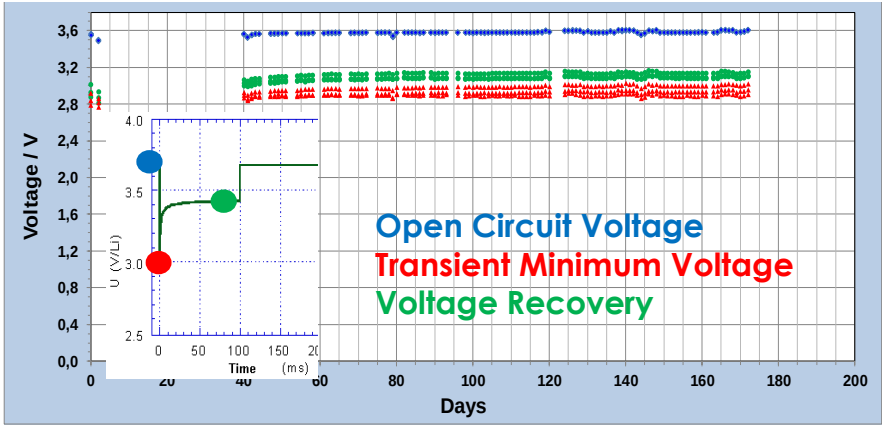


Even when "aged" cells, a long period of testing might be necessary

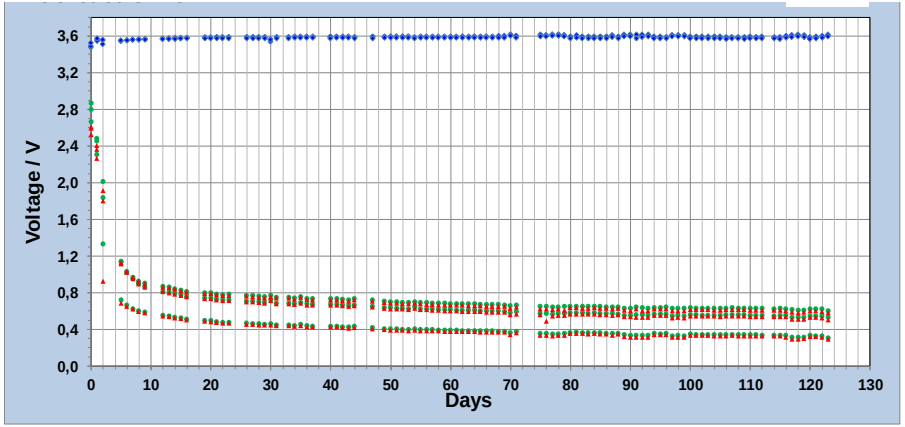
Example of Li-$SOCl_2$ AA size cell behavior under current pulse (100 mA)

WORST CASE

Fresh cells



Cells artificially aged (1-month storage at +70°C)



For some cells, you may observe depletive voltage response earlier

What are your options ?

Construction, chemistry, configuration

- Bobbin cells vs Spiral cells
  - To be checked: temperature and cut off voltage
- Addition of a booster (EDLC, Supercapacitor, Hybrid Capacitor, DC/DC Convertor) ?
  - To be checked: leakage current, internal resistance, temperature range
- Select another electrochemical system such as Li-MnO_2
  - To be checked: cut-off voltage and temperature
- Complex configuration with several cells in parallel and series

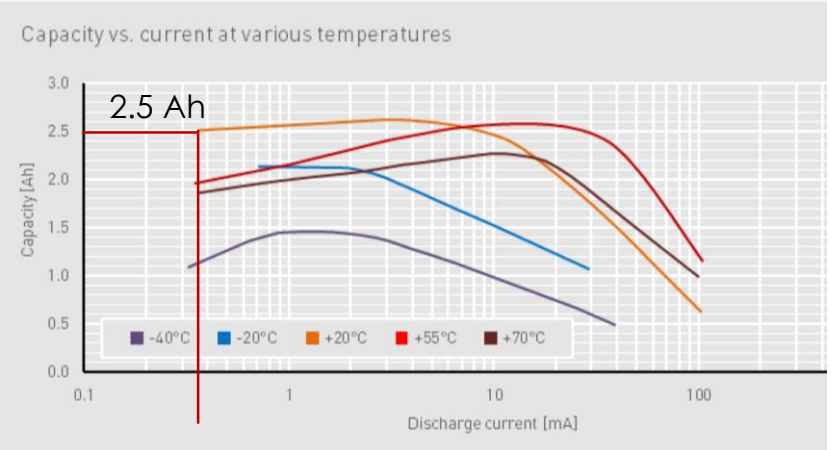
Battery manufacturers can support you !

What are Saft's solutions compatible with LPWAN needs ?

Pulse application solutions LSH, M/LM and LSP: up to 2 – 3 A pulse

CAPACITY SELECTION

Capacity vs discharge rate curve



ca. 350 µA

Ex of device's characteristics

- Total device consumption = 2000 mAh
- Data Tx Maximum Peak Current 100 mA
- Consumption mainly in Sleep Mode / PSM < 10 µA

NO DATA for search discharge rate !

A 2.5 Ah cell under 10 µA discharge rate with 1 % capacity self discharge / year

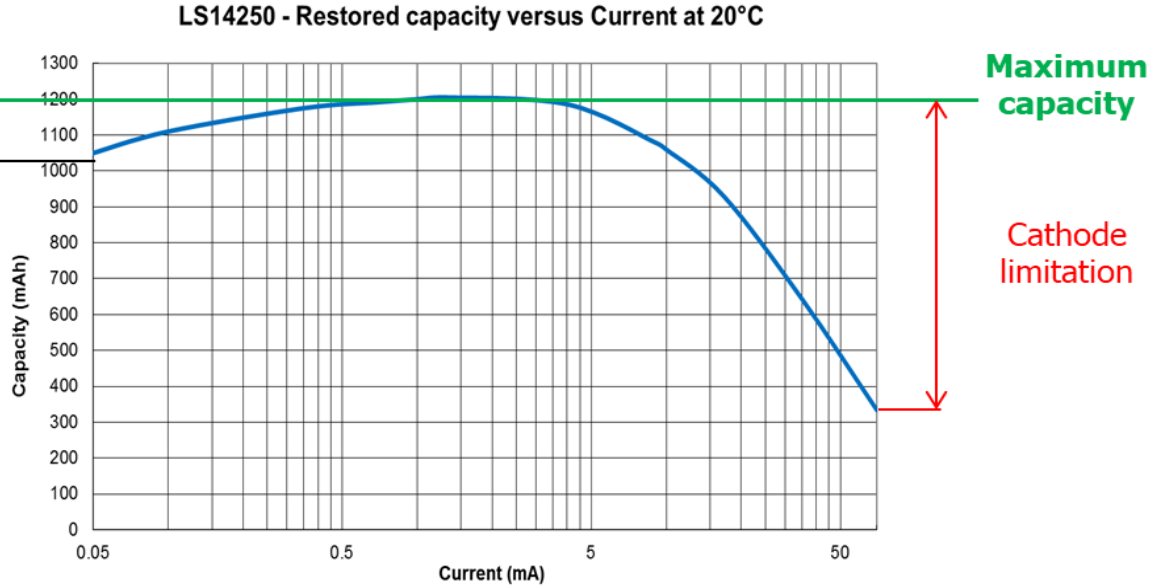
= discharge time > 15 years !

No data for very low discharge rate: testing time is not realistic

Influence of discharge rate on Useful Capacity

Anode vs Cathode limitation

Anode limitation (self-discharge)



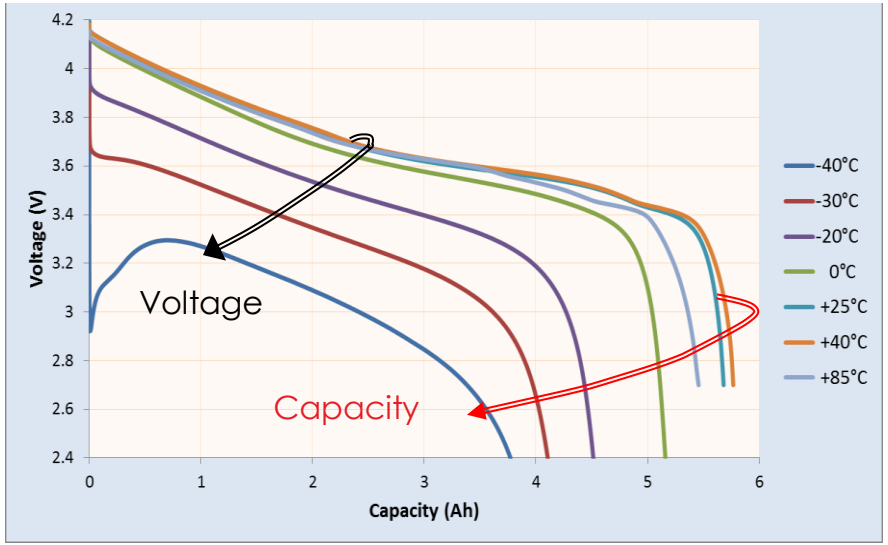
Maximum capacity

Cathode limitation

There is a range of discharge rates for which the efficiency is maximal

OPERATING TEMPERATURE SELECTION

Temperature effect on electrochemical system

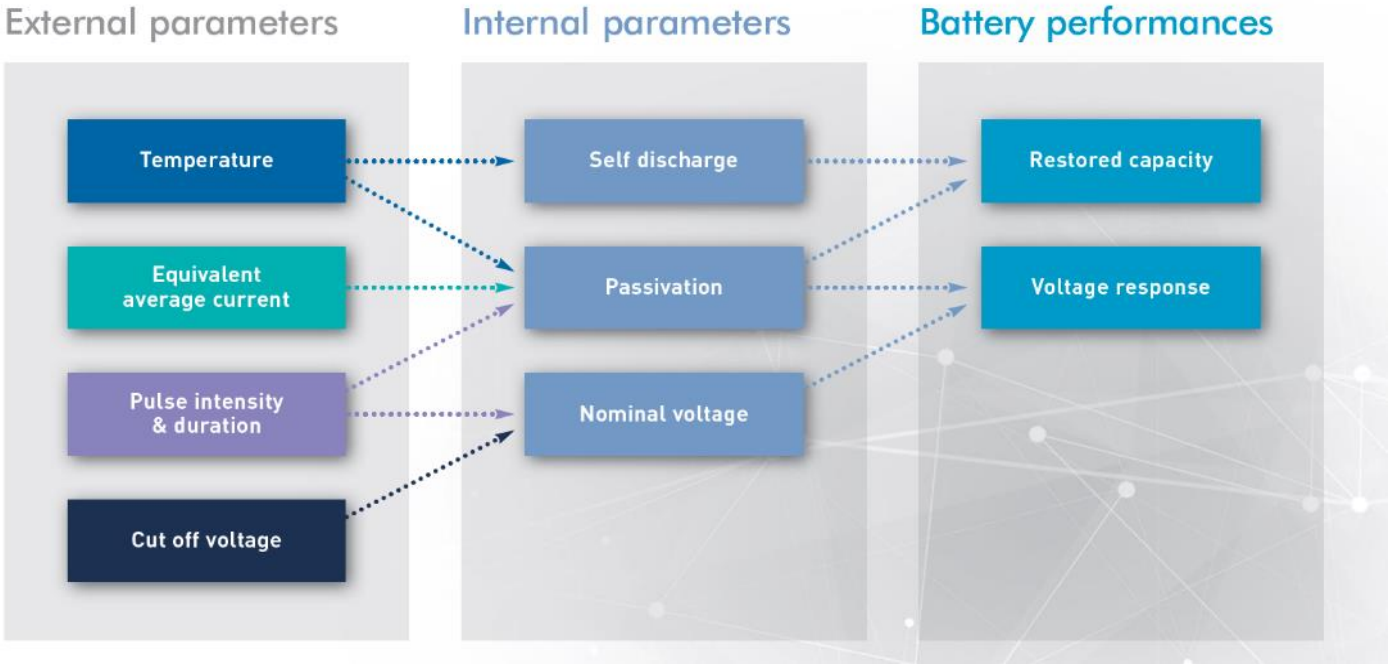


Temperature has the strongest impact of performances

- Low temperature
  - **slows down** the electrochemistry reactions
  - **increase the internal resistance**
- High temperature
  - **increases self-discharge**
  - **generates passivation** on liquid cathode system

Both restored capacity and voltage response are impacted

When using a non rechargeable battery…



Selecting the right chemistry, size and configuration is key to achieve your goal

BEYOND R&D…
POINTS OF ATTENTION

Battery Integration: to be considered at early stage

Technical possibilities

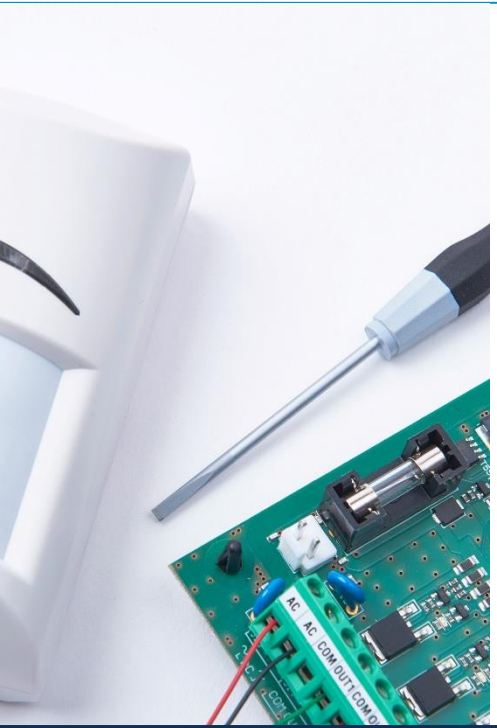
~~Battery Holder~~

- Welded on PCB
- Wires and Connector

Industrial and Reliable Application

- Welded on PCB
- Wires and Connector

What are the applicable Standards for your device ?



Device Standards Example

IEC 62368-1:2018: Audio/video, information and communication technology equipment - Part 1: Safety requirements

- Protections have to be added at device level
- Batteries have to be tested under device component failure modes

Applicable Standards can impact Battery Selection

Battery Safety Standards

Safety Standards	Primary Cell	Rechargeable Cell
UN 38.3 (Transport)	✓	✓
UL 1642 (Safety)	✓	✓
IEC 60086-4 (Safety)	✓	
IEC 62133 Ed2 (Safety)		✓
IEC 60079-11 (ATEX)	✓	✓

Battery Transportation

Lithium Batteries are Dangerous Goods !!!!!

- Under which conditions can I transport my device with battery inside ?
- How can I manage Battery Spare Parts for replacement ?
- How can I manage End of life Batteries (Disposal & Recycling) ?

Worldwide Rules & National Regulations to be checked (and respected)

5 takeways

- **Non rechargeable batteries may last longer than rechargeable**
  - With their high nominal voltage, lithium primary solutions match many IoT cases
- **Choice of connectivity has a huge impact on battery solution**
  - Traditional cellular connectivity may lead to complex battery solution
- **Knowing accurately the device's consumption is important**
  - Max peak current, average current, Cut off voltage impact battery's efficiency
- **Knowing accurately the device's environment is key**
  - Temperature impacts battery's capacity and voltage response
- **There is no one size fits all solution**
  - Ask for a customized support

Thanks for your attention !

Send us your questions

To learn more about batteries:
Read our energizing IoT blog

saft
a company of
TOTAL