



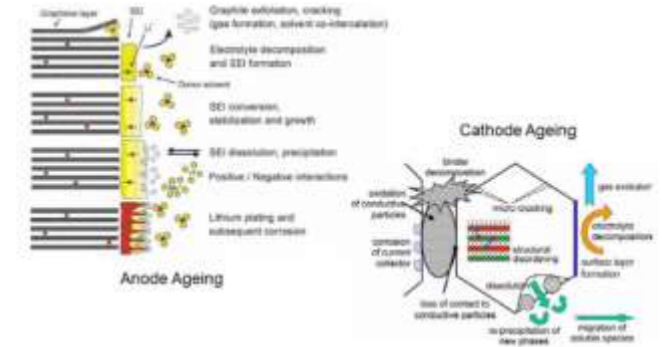
WattTower™

- Goals
 - Demand charge reduction
 - Small footprint and high seismic
 - Low to medium volume production
 - Certify to UL 1973 and UL 1974
- Use Cases
 - Price arbitrage
 - Demand charge reduction
 - PV smoothing/ load shifting
- Design Features
 - Parallel modules for reduced BMS cost
 - Nonservicable concept
 - SNT fully replaces tower with new
 - Side mountable inverter and switchgear



How do we know a battery is safe?

- Understand failure modes
 - Lithium plating
 - Dendrite formation
 - SEI overgrowth
 - Gas formation
 - Corrosion
 - BMS fault
 - Inverter fault
- Understand failure modes mechanisms
 - High voltage
 - Low voltage
 - High temperature
 - Low temperature
 - High charge/discharge current
 - Environmental controls
 - Hardware/software failure



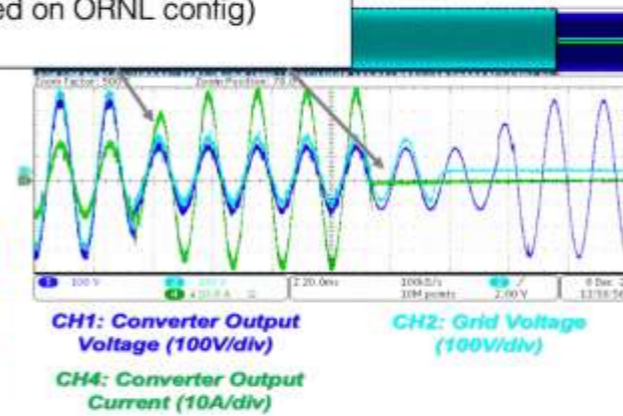
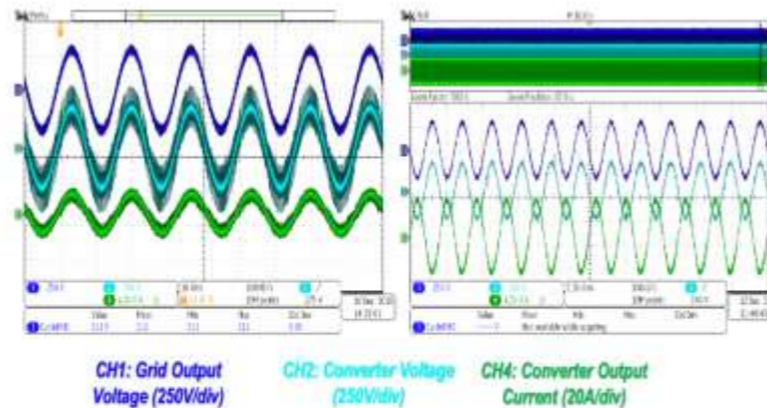
Source: NREL Energy, Vetter et al., "Ageing mechanisms in lithium-ion batteries," J. Power Sources, 147 (2005) 285-291



Levels of Safety

- Safety is critical
- Protect grid and ESS
 - Battery system self-protects
 - Inverter system self-protects
 - System Software layer protect
 - Managing Software layers notify

Grid Fault (Low Voltage) Emulated in Testbed – Inverter Safely shuts down in 3 cycles (based on ORNL config)



SPIERS NEW TECHNOLOGIES



Life Cycle Management of Advanced Batteries

Non-Technical Observations

Albuquerque, March 2019

Dirk.spiers@spiersnt.com

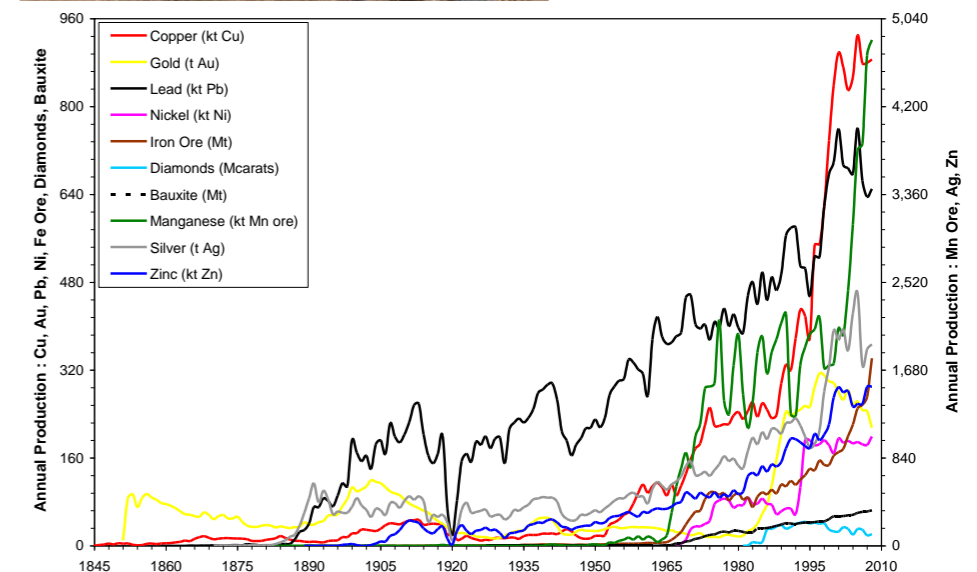


Half Full



Safety is Many Things

- Support
- Core Collection
- Disposal
- Secure Supply of Materials



Many Kinds of Batteries

- Chemistries
- Quality
- Price
- Objective



Batteries are not all the Same

Automotive: Not your typical battery



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Automotive: Not Your Typical Battery

TECH

**Samsung's Massive Galaxy Note 7 Recall Brings
Battery-Maker Into Focus**

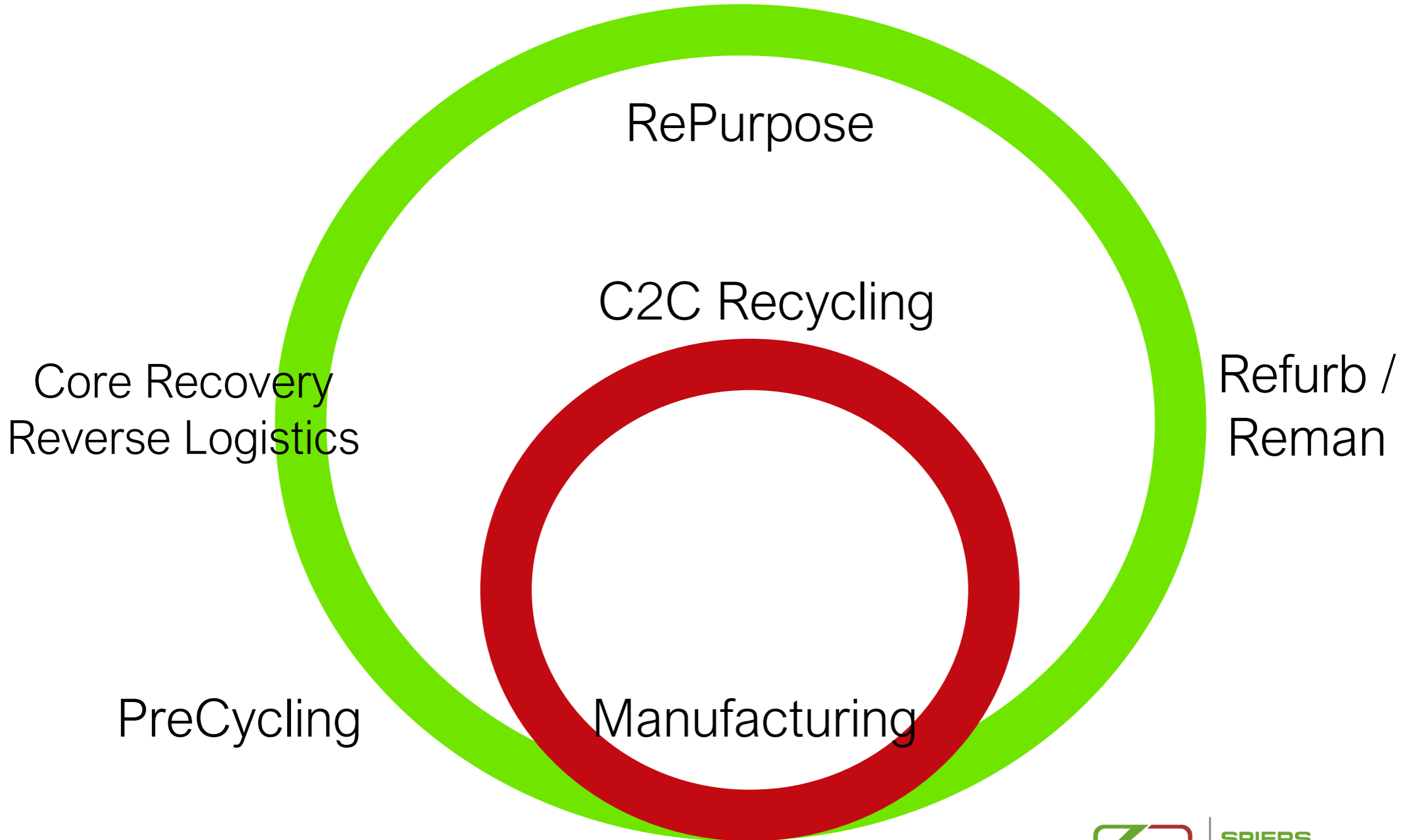
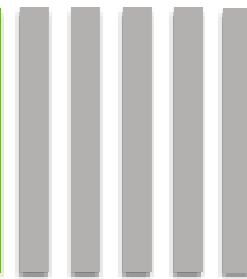


- Battery 5R (Life Cycle Management)
 - Remanufacture
 - Refurbish
 - (extending economic life)
- Logistics & Storage
- Repurposing (Second Life)
 - Energy Storage Systems (ESS):
Grade, Bin, Design, Manufacturing
- Recycle 2020
 - Cathode to Cathode



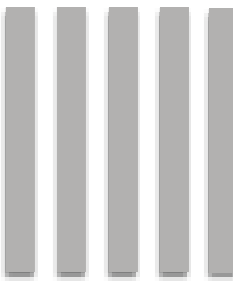


SNT: Cradle to Cradle, Closed Loop





A Funnel of returned Battery Packs



- USA & Europe
- Handling 2000+ packs a month
- (Test) Data of over 14,000 returned Battery Packs
- Every detail is tracked: location, vin, error code, SOH, SOC, Resistance, torque,.....
- 4TB of data, growing every day
- Provenance is Important





Stuff fails

- Sensors
- Bus Bars
- Electronics
- Seals
- Electrochemical (degradation)
- Accidents



Automotive ≠ Consumer

- Need for different regulations
- IFC
- Testing & Certifications
- Shipping



Ship From Germany Warehouse
3-5 days for the shipping



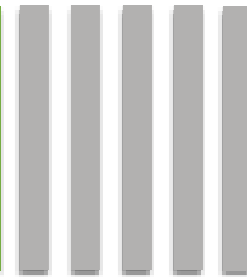
NO TAX TO EU



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Horses for Courses



Ship From Germany Warehouse
3-5 days for the shipping



NO TAX TO EU



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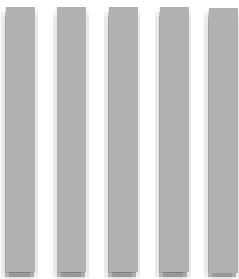
Logistics: Clock is ticking

- Shippers starting to drop Li-ion shipments
- Consumer batteries are threatening rest of the industry
- Regulations are useless if you have unscrupulous players





Regulations and Certifications

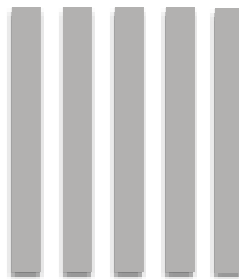


- Are we making it too difficult?
- Are they out of reach for smaller companies?
- Is it too expensive?
- Do we scare companies away?

Safety needs to be accessible



Unintended Consequences?



- What about Second Life?
- UL 1974: Will it help, will it kill?
- Can we afford to let go of all these Batteries?
- Extending Economic Life is important

Need to see the bigger picture



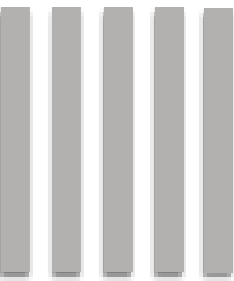
Second Life

- Only difference with First Life is retained capacity
- It is proven, it works
- Grading and Provenance are very important
- For the rest it is the same:
 - Engineering, Architecture, Understanding Usage profile, FMEA's, Control Plans, Communications, Markings, Thermal Loads





Regulations and Certifications II

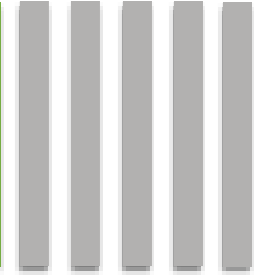


- Are we hiding behind them?
- Hypocrisy of the (Insurance) Industry.....

Practical Safety is as Important as Adherence to Regulations



Typical event time line



The screenshot shows an eBay search results page. At the top right is the eBay logo and a 'Shop by category' dropdown menu. Below the logo, there are two search results:

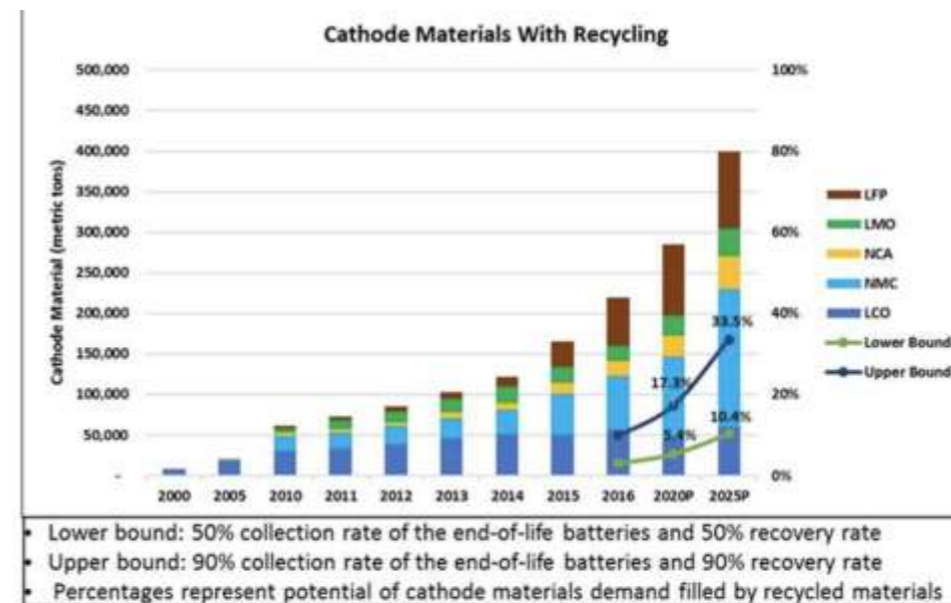
- Tesla Roadster Bricked Battery**
Pre-Owned
\$1,295.00
Buy It Now
Free Shipping
See more like this
- 10 Tesla battery modules from Rav4 EV for solar storage or DIY EV**
New (Other)
\$7,499.00
or Best Offer
Freight
57 Watching

At the bottom of the screenshot, there is a 'SPONSORED' label.





Environmental & Supply Security



- Total automotive Li-ion battery capacity is expected to exceed 90 GWh by 2020. It will have the largest share among LIB applications followed by consumer electronics
- This requires more than 400 thousand tons of battery materials (Li, Co, Mn, Ni, and Gr) by 2025
- Closed-loop recycling can supply significant amounts of the demand material (up to 30% of the cathode material demanded in 2025)

Source of data: BNEF 2017, Avicenne 2017, Navigant 2016, NREL analysis 2018

Core Recovery is Vital



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Our Goal (Dream)

A Closed Loop System through an integrated Business Model

Keep Batteries under control before accidents happen





In Closing

- Thanks to the Industry and National Labs
- Safety means many different things
- Different Packs need different approaches
- Need for a streamlined wholistic approach
- Safety needs to be accessible to everyone
- But is is good to be paranoid

