

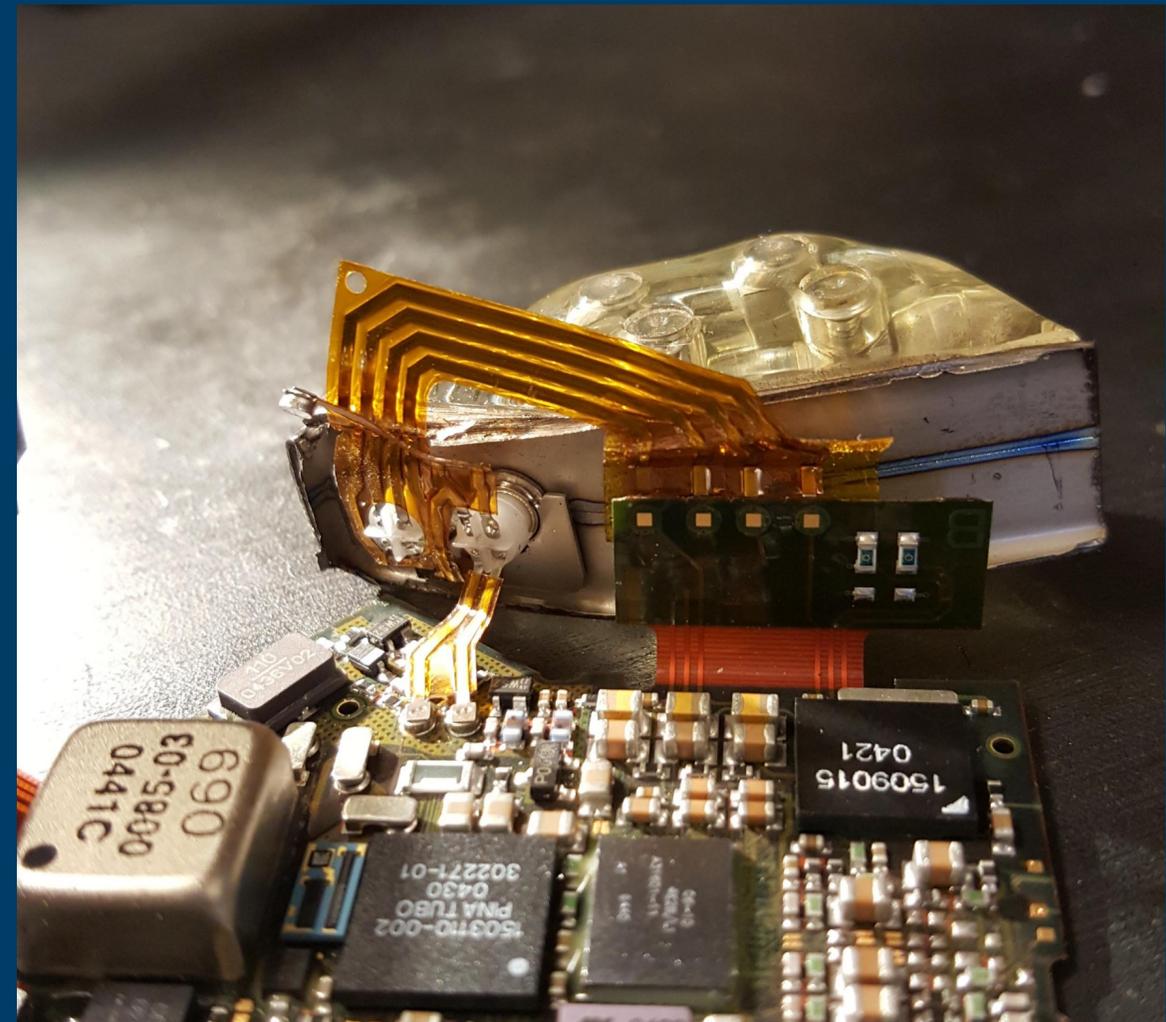
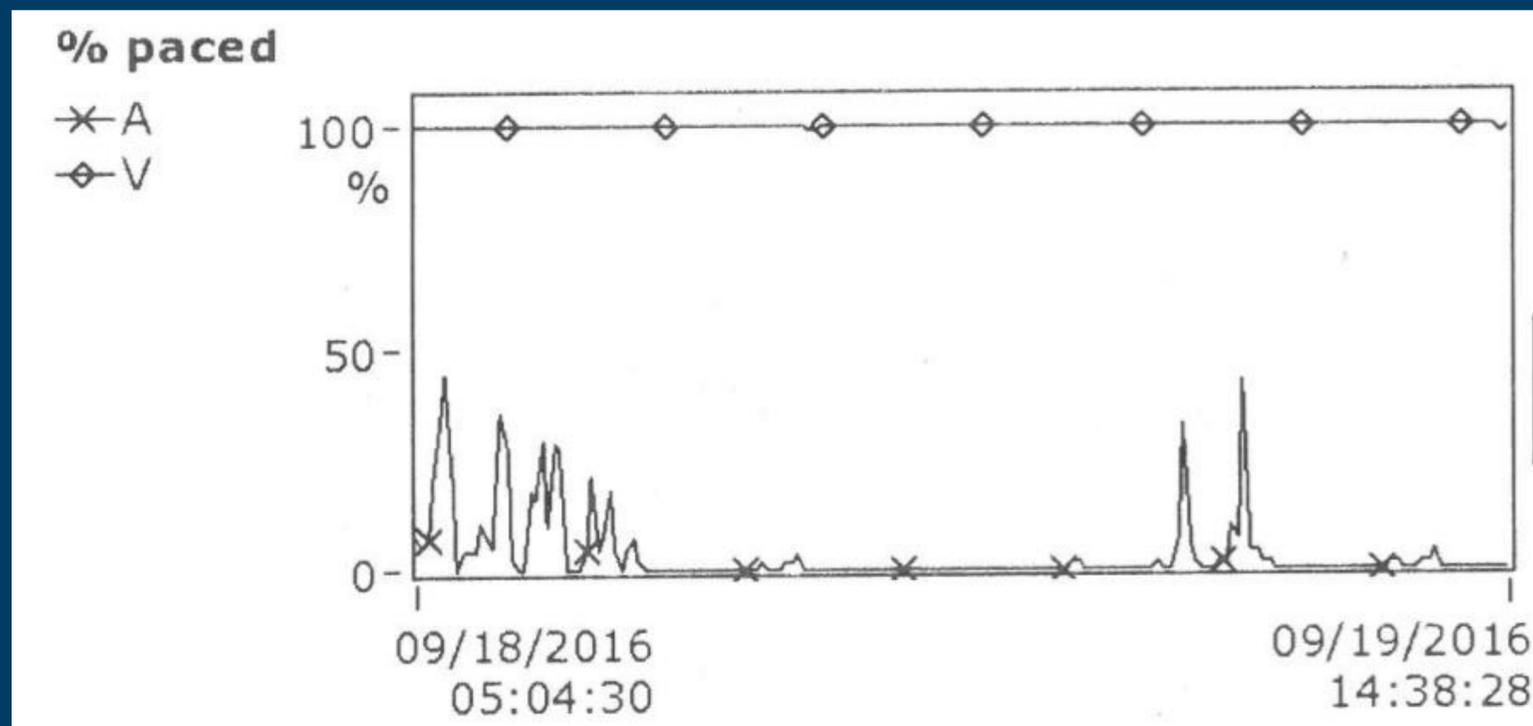
EMBODIED VULNERABILITIES — WHY I AM HACKING MY OWN HEART

Dr. Marie Moe, SINTEF

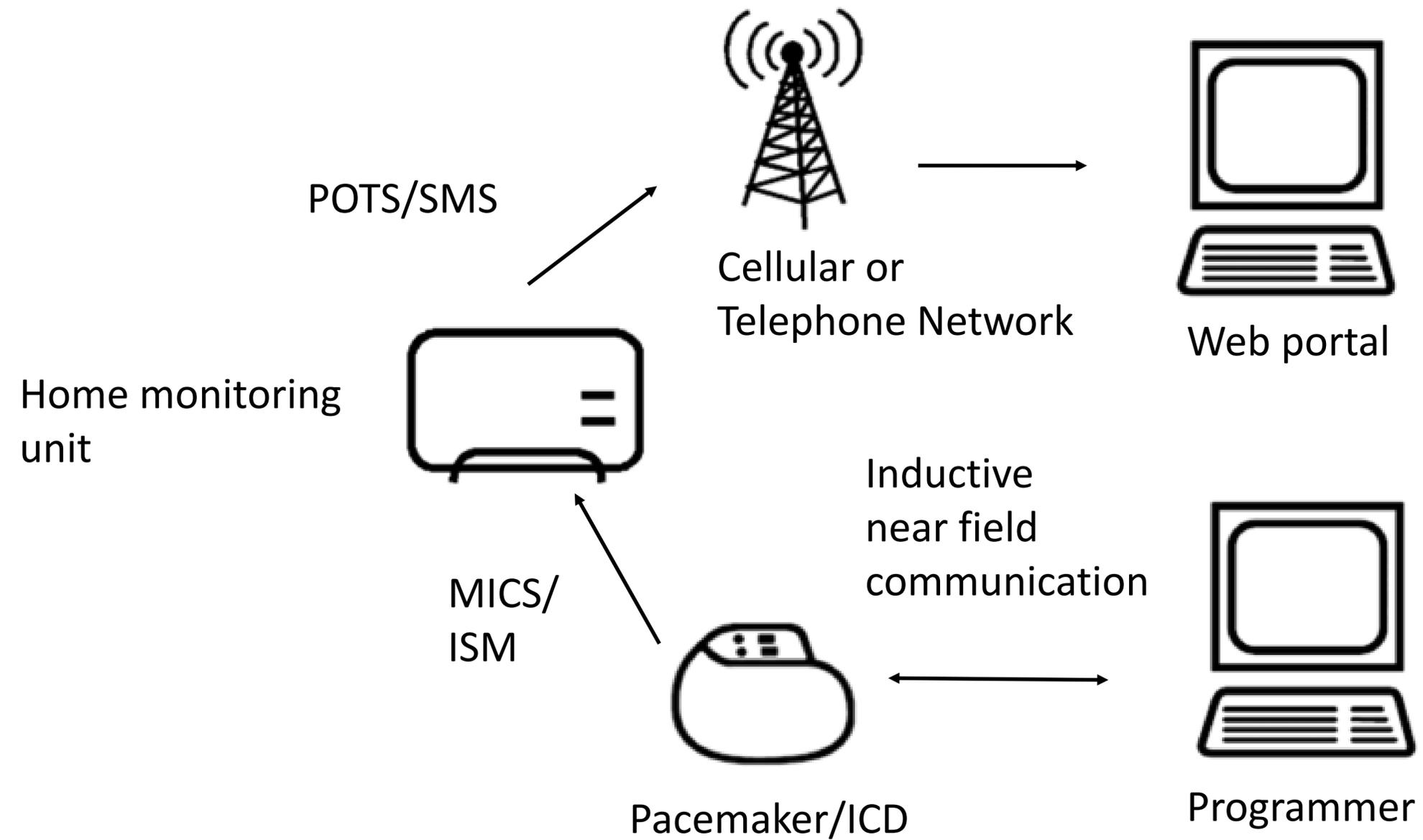
 @MarieGMoe

A BRIEF STORY OF MY HEART

MY LIFE DEPENDS ON THIS HARDWARE AND SOFTWARE



EMBODIED AND CONNECTED





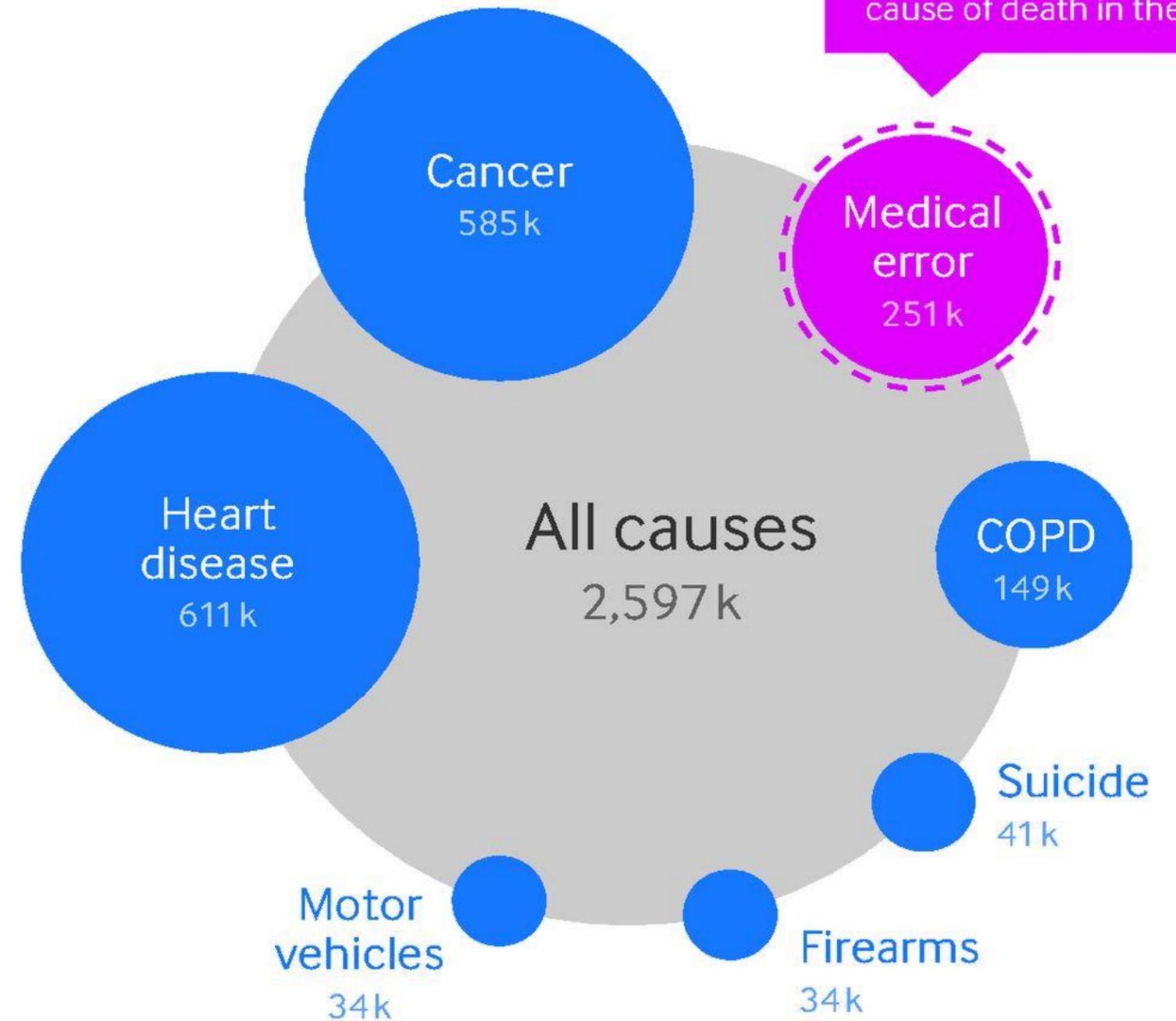
WHAT COULD POSSIBLY GO WRONG?

- Patient privacy issues
- Battery exhaustion
- Device malfunction
- Death threats and extortion
- Remote assassination scenario...

MEDICAL DEVICES SAVE LIVES AND TAKE LIVES

- Lack of testing user interfaces to prevent medical error
- Insufficient reporting of adverse events
- Missing logging and forensic capabilities

Causes of death, US, 2013



However, we're not even counting this - medical error is not recorded on US death certificates

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Data source:
http://www.cdc.gov/nchs/data/nvsr/nvsr64/nvsr64_02.pdf

Hippocratic Oath

F or C onnected Medical Dev ices

Cyber Safety Capabilities What is your ready posture toward failure?



- § **Cyber Safety by Design** – Anticipate and avoid failure
- § **Third-Party Collaboration** – Engage willing allies to avoid failure
- § **Evidence Capture** – Observe and learn from failure
- § **Resilience and Containment** – Prevent cascading failure
- § **Cyber Safety Updates** – Correct failure conditions once known

In Collaboration With



Security
Researchers



Patients



Device
Makers



Policy
Makers



Insurers
& Payers



Physicians &
Care Givers



Standards
Organizations



Healthcare
Providers



Government
Agencies



THE STAIRS THAT ALMOST KILLED ME

Upper rate response [bpm]	200/2:1	180/WKB
Wendelback response of [bpm]	136	180-182
Atrial upper rate [bpm]		240
Mode switching [bpm]		OFF
Intervention rate [bpm]		----
Switch to		----
Onset criterion [out of 8]		----
Resolution criterion [out of 8]		----
Change of basic rate [bpm]		----
Rate stabilization during mode switching		----
2:1 Lock-in protection		----
Vp suppression		OFF
Dynamic AV delay [ms]	240/70	130/70
after pace:		
AV delay at 60 bpm [ms]	240	130
AV delay at 80 bpm [ms]	195	130
AV delay at 100 bpm [ms]		115
AV delay at 120 bpm [ms]	85	90
AV delay at 140 bpm [ms]		70
Sense compensation [ms]		OFF
AV hysteresis		OFF

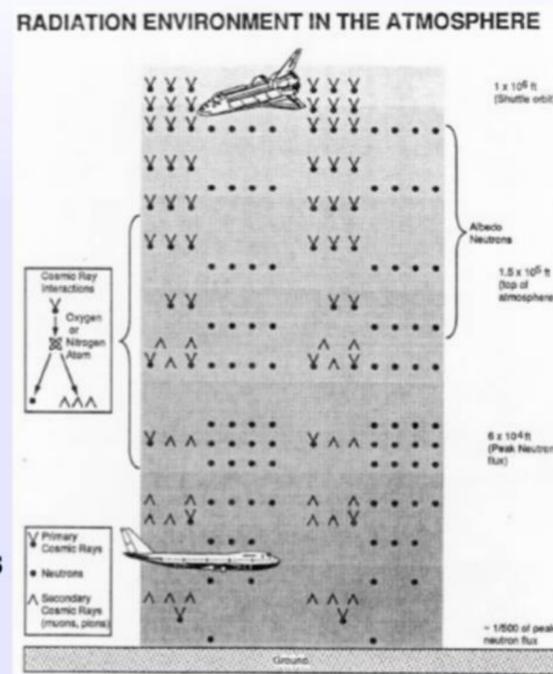
BITFLIP IN THE AIR AND DEBUGGING MY PACEMAKER



Neutron Environment in the Atmosphere

Boeing Radiation Effects Lab

Neutrons, created by cosmic ray interactions with the O_2 and N_2 in the air, peak at ~60,000 ft. At 30,000 ft the neutrons are about 1/3 the peak flux, and on the ground, ~1/400 of the peak flux. The peak flux is ~4 neutron/cm²sec. Other particles such as secondary protons and pions are also created, but for SEU the neutrons are the most important.

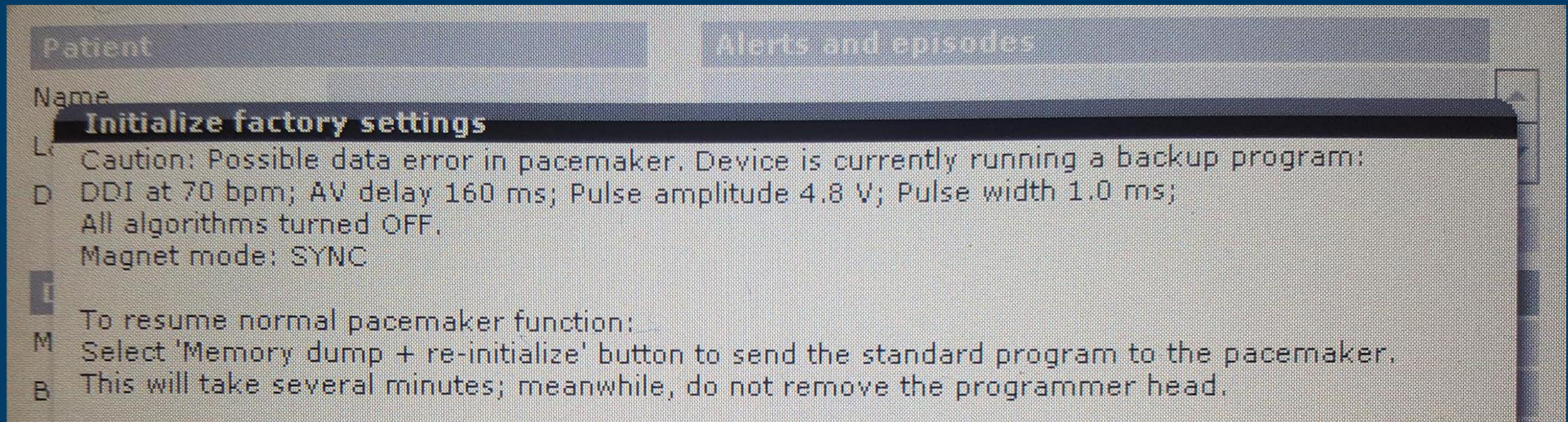




S3



DATA ERROR IN PACEMAKER



WHEN TRUST IS BROKEN...



St. Jude stock shorted on heart device hacking fears; shares drop

The stock of pacemaker manufacturer St. Jude Medical Inc (STJ.N) fell sharply on Thursday after short-selling firm Muddy Waters said it had pl...

Two deaths spark recall of St. Jude heart devices





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Cybersecurity Vulnerabilities Identified in St. Jude Medical's Implantable Cardiac Devices and Merlin@home Transmitter: FDA Safety Communication



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Firmware Update to Address Cybersecurity Vulnerabilities Identified in Abbott's (formerly St. Jude Medical's) Implantable Cardiac Pacemakers: FDA Safety Communication

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Date Issued

August 29, 2017

Audience

- Patients with a radio frequency (RF)-enabled St. Jude Medical implantable pacemaker
- Caregivers of patients with an RF-enabled St. Jude Medical implantable cardiac pacemaker

THE BENEFIT OUTWEIGHS THE RISK





Technology for a better society

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