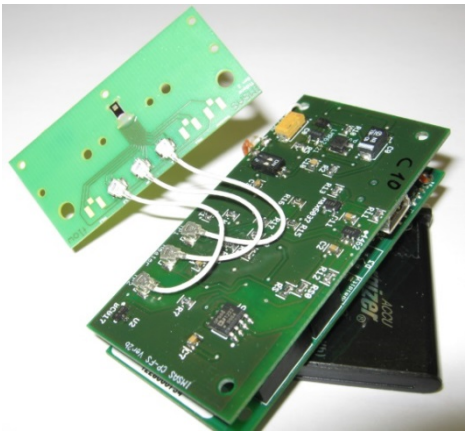
***Reiner Jedermann**, Ulrike Praeger, Walter Lang*

Lessons learned from the intelligent container



FRUTIC Symposium 2017: Quality and safety of fresh horticultural commodities
Berlin, Germany, 7th February 2017

Universität Bremen
IMSAS
Institut für Mikrosensoren, -aktoren und -systeme

Remote monitoring of shelf life

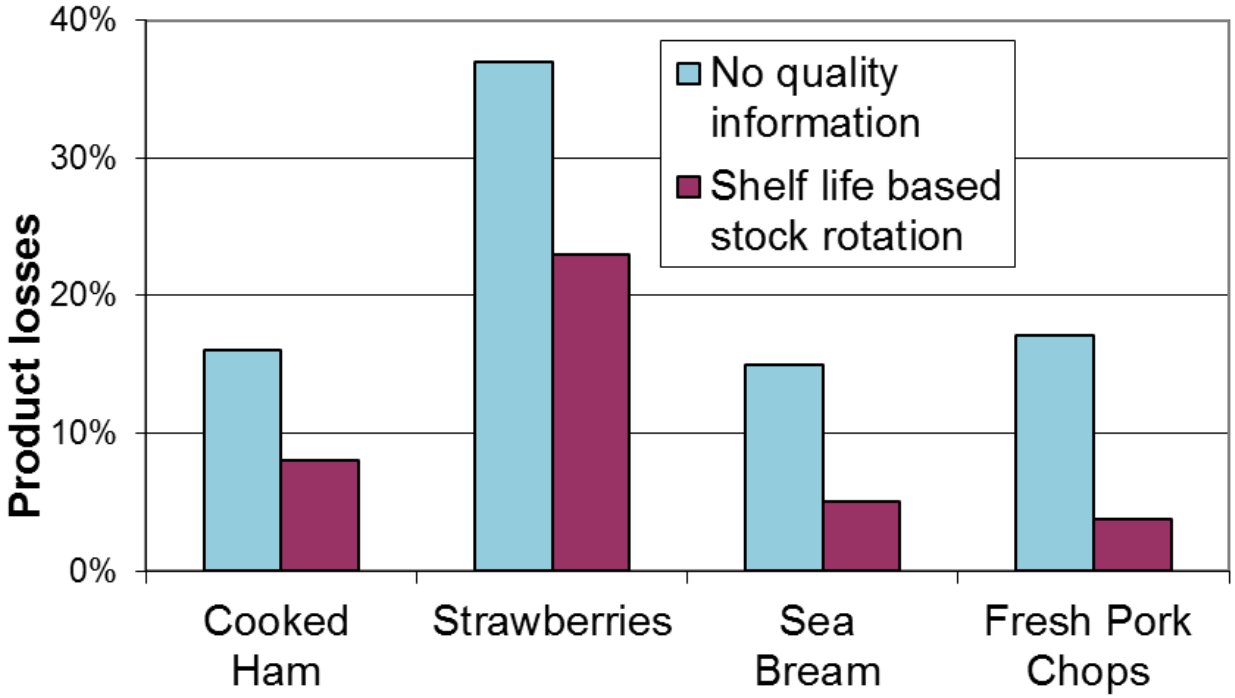
- Quality problems are only detected after arrival
- Early information → better planning of subsequent processing steps

- Project ‘Intelligent Container’
  - 22 partners
  - 2010 – 2013

- Current project
  - Air flow profiling in warehouses
  - Fungi and Ethylene sensors

First Expires → First Out (FEFO)

- Savings of up to 15% of total product volume



Post harvest chain for bananas

Harvest

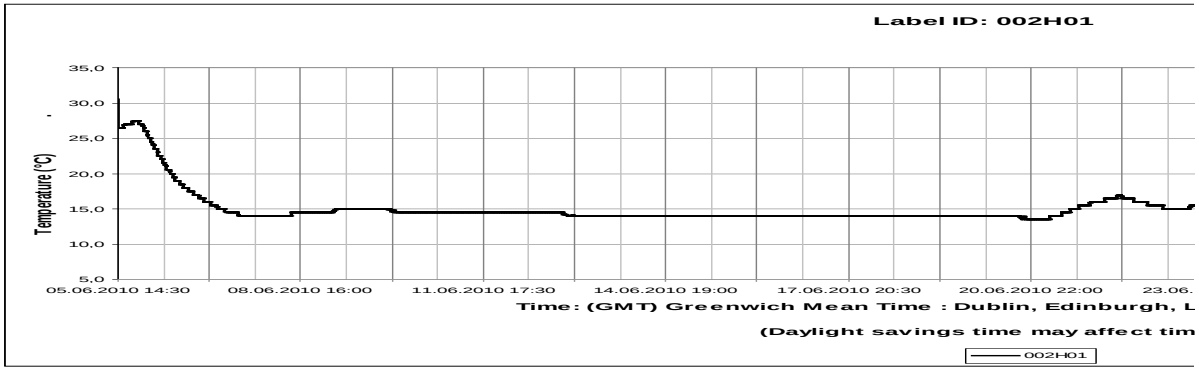
Packing
Foil / Boxes

Transport
Ship / Container
(14°C, high rH, MAP / CA)

Ripening
(Ethylene)







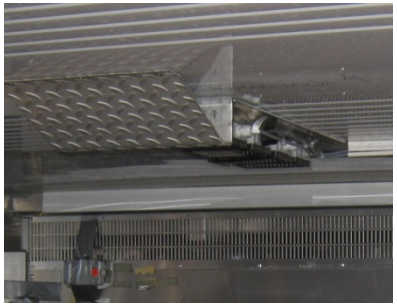
Costa Rica

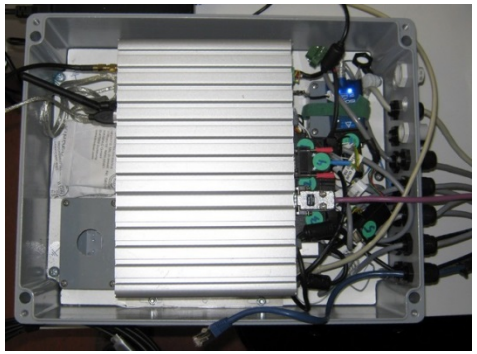
2 or 3 weeks

6 days

Hamburg

Technical system of the intelligent container





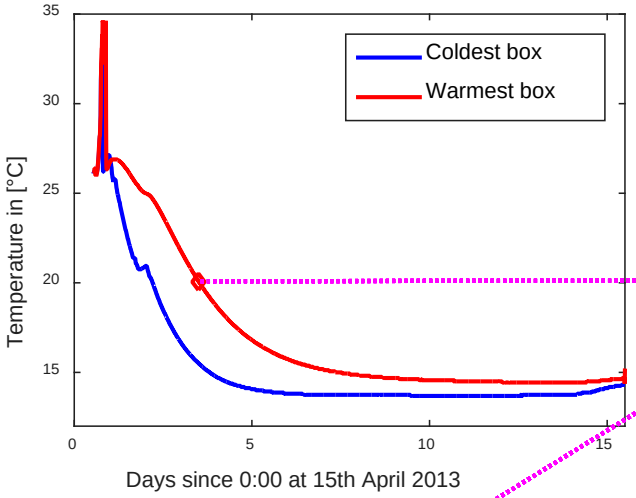
Wireless sensor base station

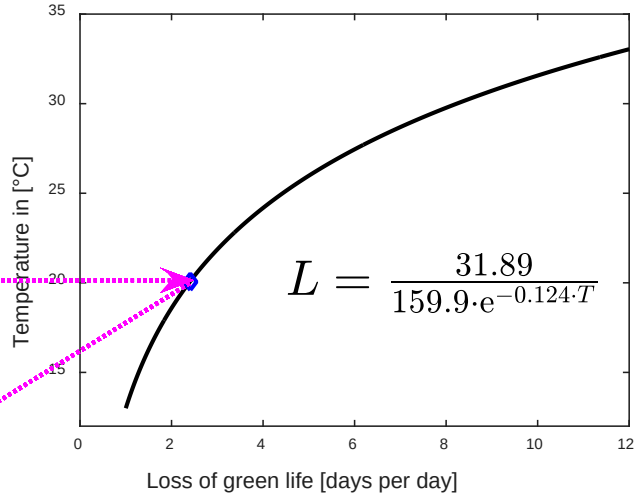
Freight supervision unit (FSU)

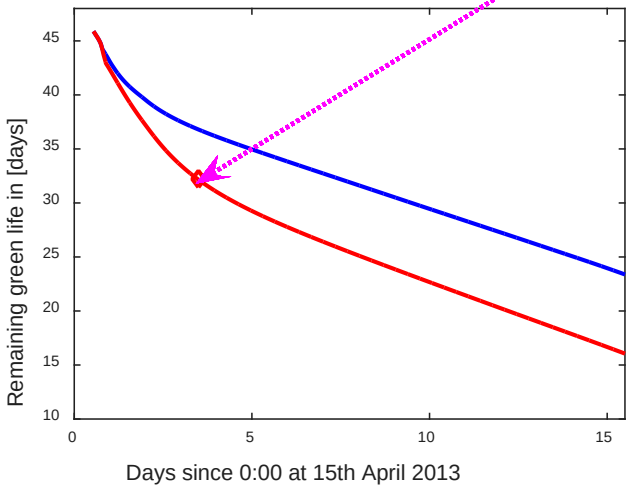
External antennas
Iridium
GSM
GPS Location

AFAM and remote control

Shelf life prediction







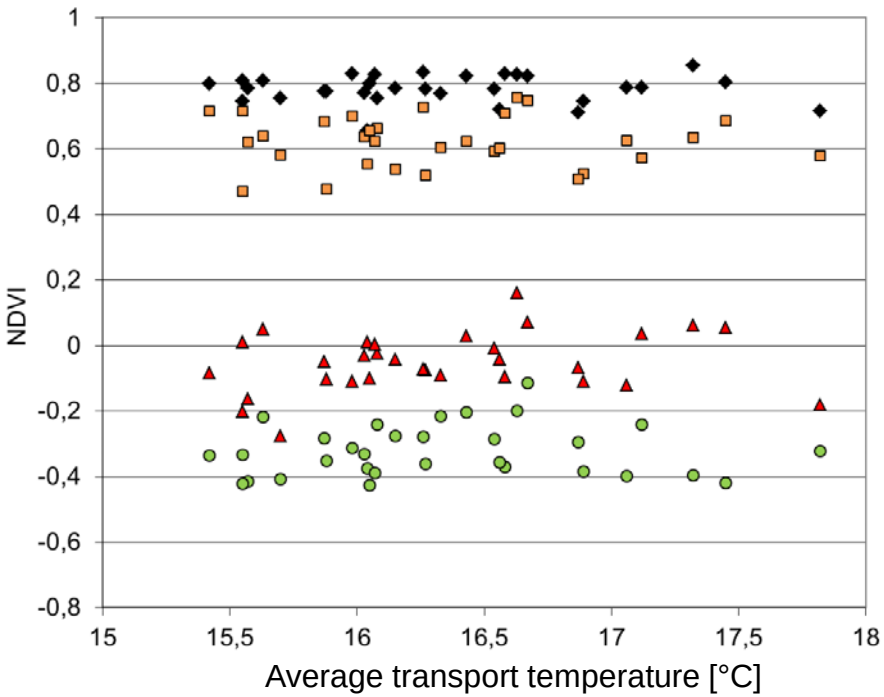
ATB

1. Biological variance

- No prediction per single box
- Temperature variation of >2°C
- High biological variance

Hard to improve

- CO_2 / gas sensor per box too expensive
- Destructive methods not suitable

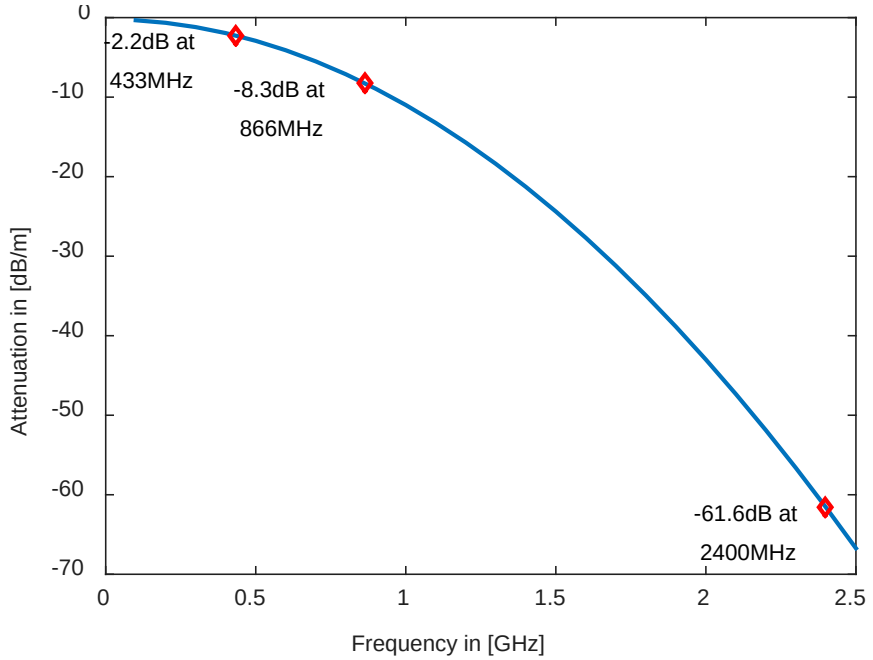


NVDI = Normalized Difference Vegetation Index (light reflection)

ATB

2. Wireless communication inside cargo hold

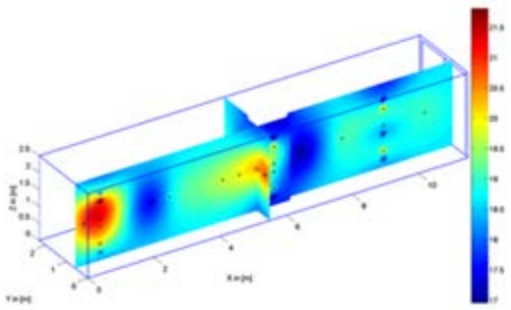
High signal attenuation by water containing products

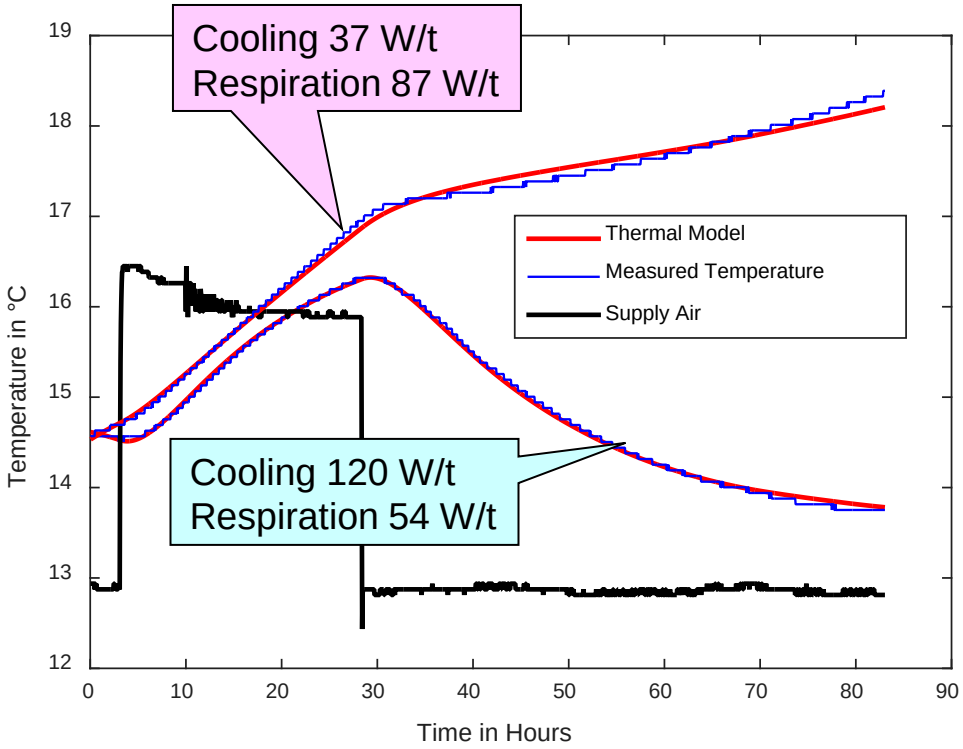


Lora / Proprietary protocols	433 / 866 MHz
Zigbee / 802.15.4	2.4 GHz
Wifi / Bluetooth	2.4 GHz

3. Risk of hot-spots

- Bananas can produce large amounts of heat by respiration and ‘unwanted’ ripening
- Modell to estimate ‘respiration heat’ and ‘cooling’ from temperature curves





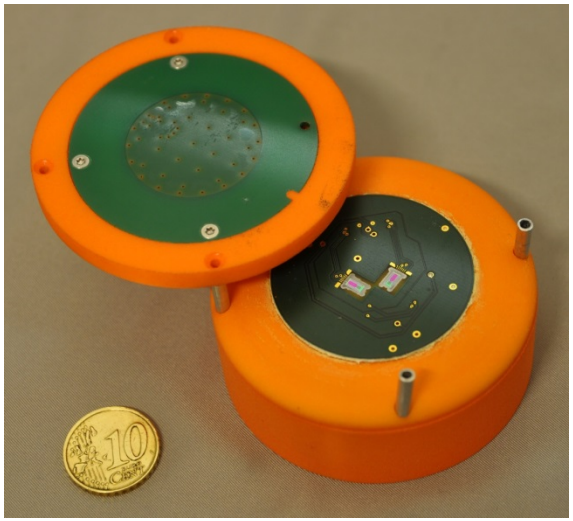
4. Improvement of packing

- By combination > 40% improvement of cooling
- Field tests / temperature model

- More detailed studies by wireless anemometers
- Current project on apple warehouses

Spacers

Chimney layout



Vent holes

Why not put into practice yet?

Remote Container Monitoring (RCM)

- Several systems on the market
  - Focus on cellular networks
  - Monitoring of reefer machinery

System	Key features	Satellite communication	Wireless sensors
ORB-COMM	Reefer status monitoring 270.000 Maersk Containers	Only by additional/optional device	Only at ceiling
Globe Tracker	Reefer status monitoring		Optional
Traxens			
Secure System	Theft protection electronic seal	YES	

Remote Container Monitoring (RCM)

- Several systems on the market
  - Focus on cellular networks
  - Monitoring of reefer machinery

System	Key features	Satellite communication	Wireless sensors
ORB-COMM	Reefer status monitoring 270.000 Maersk Containers	Dual-mode device available	Only under the ceiling
Globe Tracker	Remote monitoring / control of all reefer parameters in real-time	Focused on trucks, additional device available	Interface for up to 64 LoRa wireless sensors
Traxens	Detectors for movement, vibration, door status and temperature. Interface reefer controller	Using the ship's communication system	Optional
Secure System	Theft protection, door opening, electronic seal	YES	Optional

Temperature data loggers with wireless interface

System	Communication	Shelf life modelling
Sensitech/ TempTaleRF	• UHF • GSM / cellular	
Verigo	• Blue Tooth	
MOST	• GSM / cellular	
PakSense	• GSM / cellular	
ZestLabs/ ZestFresh	• UHF	Prediction of quality deviations
Xsense / BT9	No info. provided	FEFO mentioned
Blulog	• NFC (Near Field Communication) • UHF	
CAEN RFID	• UHF RFID	On-chip calculation of shelf life model
DeltaTrak / Flash Trak	Various 3rd party	

Applications

- Read-out after arrival
- Gateway in cold-storage warehouse
- Gateway in truck
- Hardly suitable for ocean containers

Missing link between RCM and wireless data loggers

- No common protocols
- Proprietary systems
- No interest in open standards
- Companies prefer selling ‘data-as-a-service / integration existing company software

Missing business case

- Transport chain split into several operators
- Who pays and who benefits?

Who	Costs	Benefits
Farmer / Producer	**Install sensors**	Better reputation of product
Logistic Service Provider	**RCM system, forwarding of data**	Remote machinery maintenance Guarantee compliance to given set-point
Exporter / Distributor	Neither owns RCM nor sensors	**Reduce losses by FEFO**
Retailer	Collect sensors	More consistent product quality Higher customer satisfaction

What has to be done?

- Common communication standards
- Transparent forwarding of temperature / shelf life messages
- New products need detailed case study / prototype tests

Thanks for your attention

Dr.-Ing. Reiner Jedermann
University Bremen, FB1
Institute for Microsensors, -actors and –systems (IMSAS)
Otto-Hahn-Allee, NW1
D-28359 Bremen, GERMANY
Phone +49 421 218 62603,
Fax +49 421 218 98 62603
Email rjedermann@imsas.uni-bremen.de

www.intelligentcontainer.com

The Intelligent Container

See new theme issue on '**Intelligent food logistics**'
Transactions of the Royal Society A, Volume 2017 (May/June 2014)
http://rsta.royalsocietypublishing.org/content/372/2017
for more articles on the project