

Tracing Granular Products using RFID

Bjarne Bergquist

Quality Technology

Tracing Granular Products using RFID

Industrial partners and funding agents:

Electrotech AB

LKAB

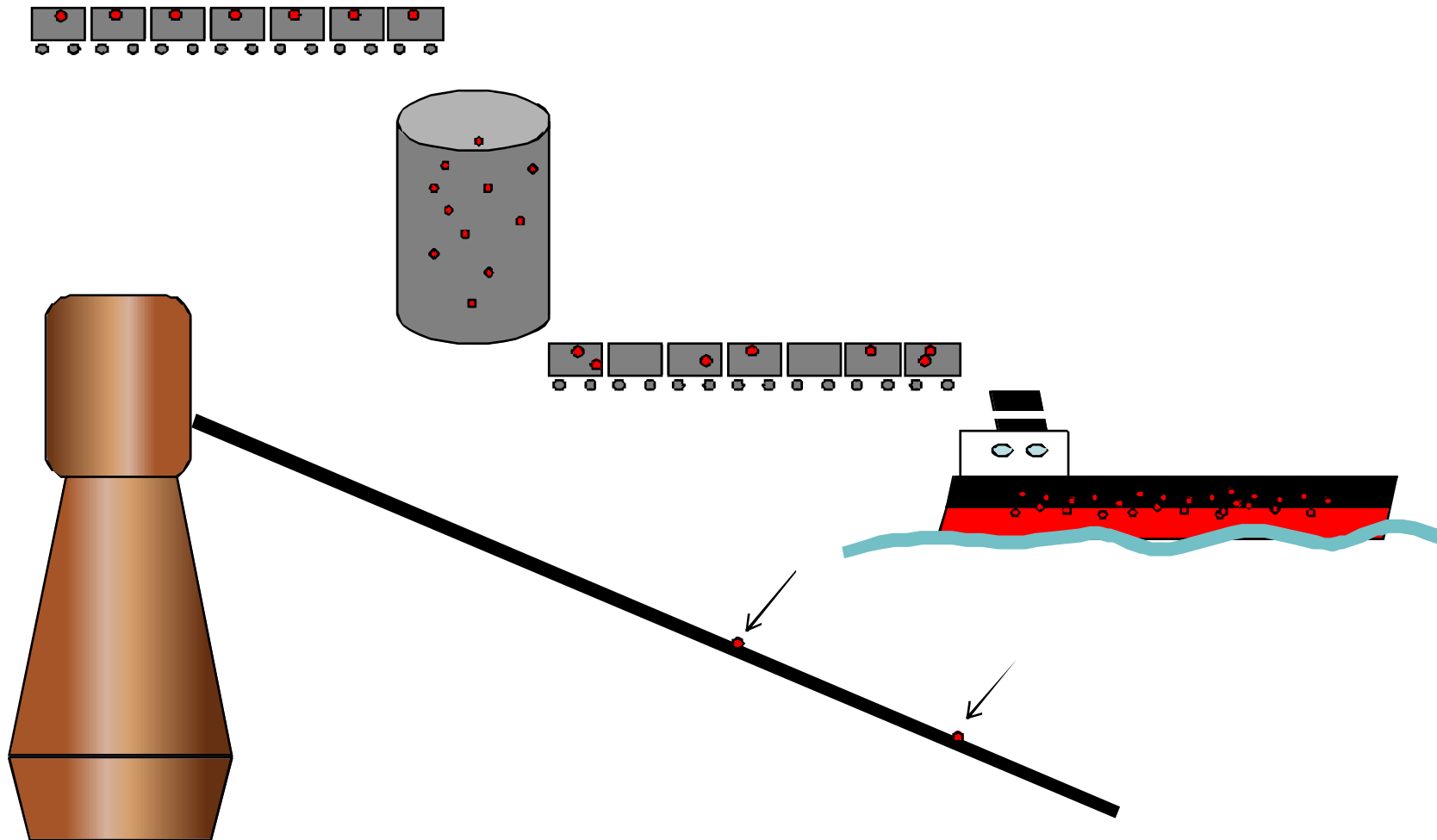
Vinnova

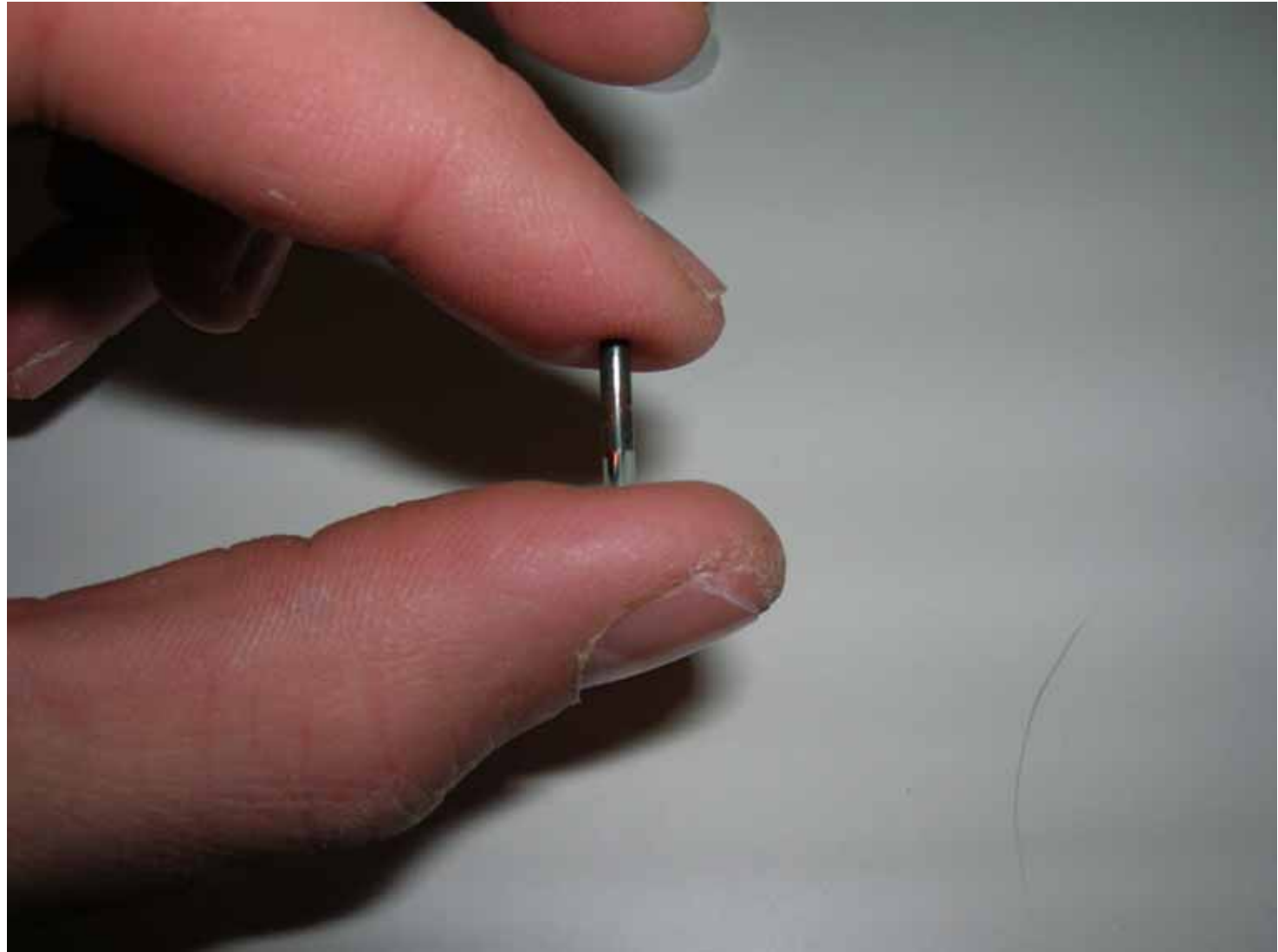
EU structural funds Mål 2

Traceability

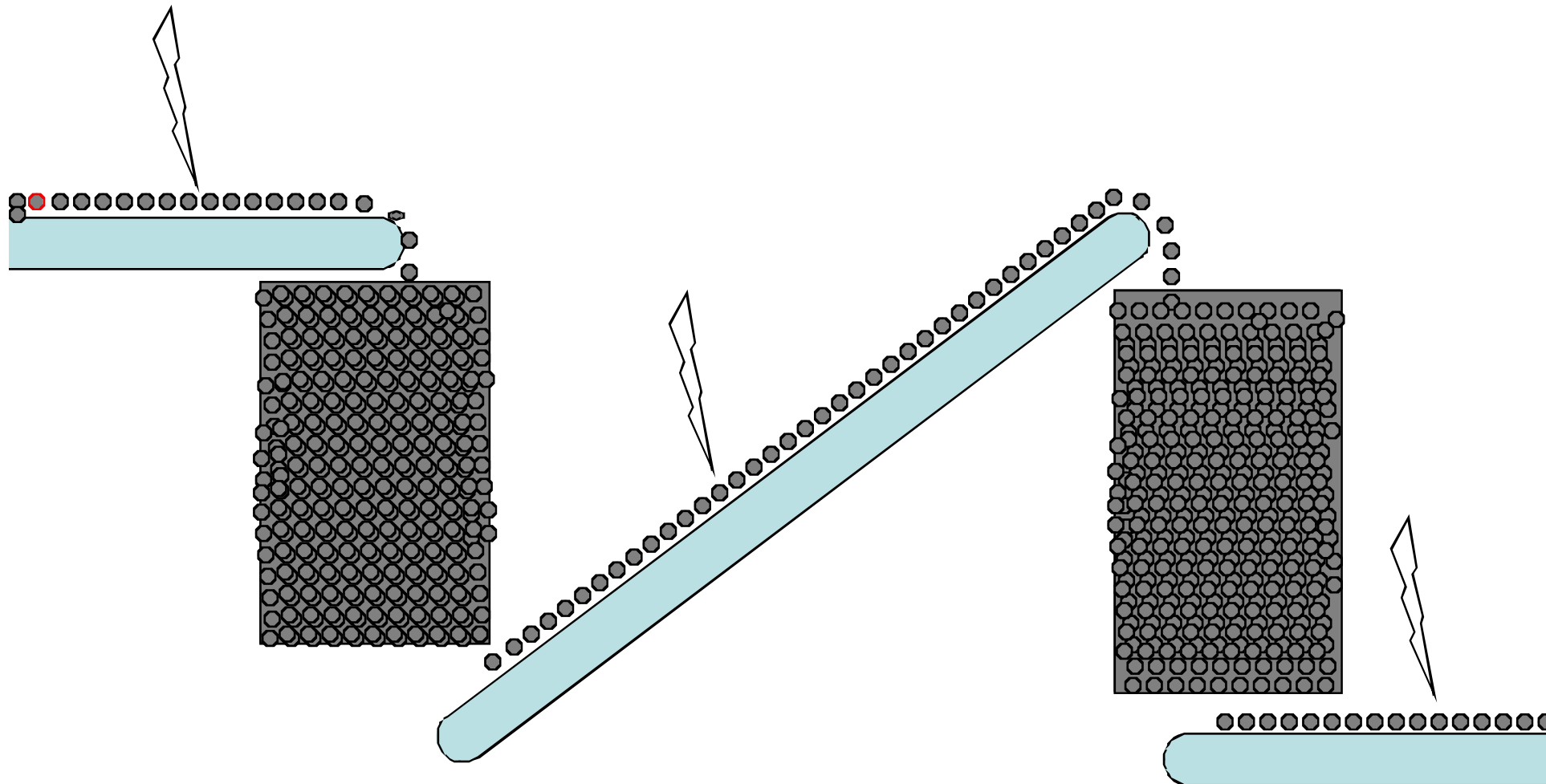


Project idea



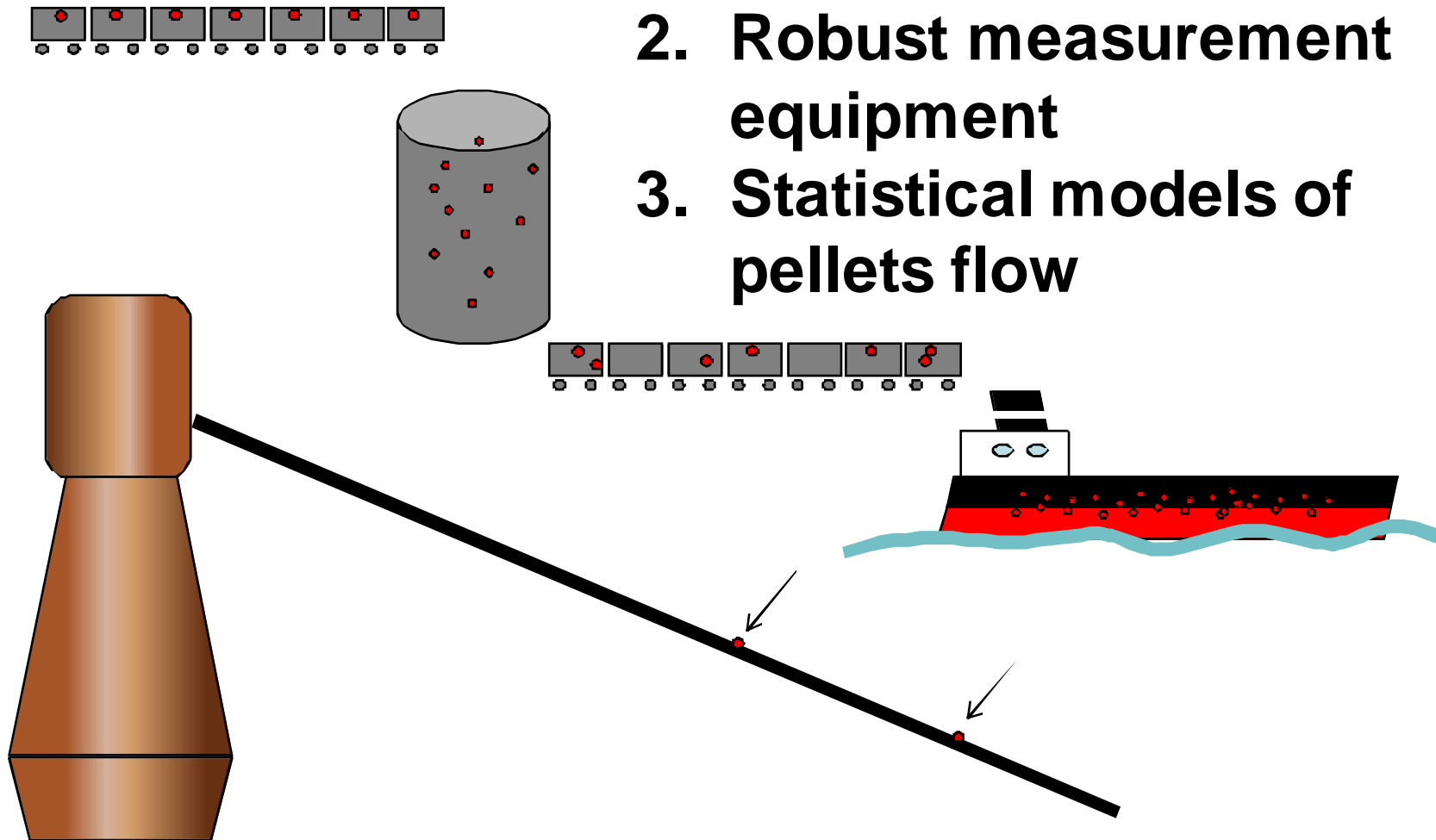






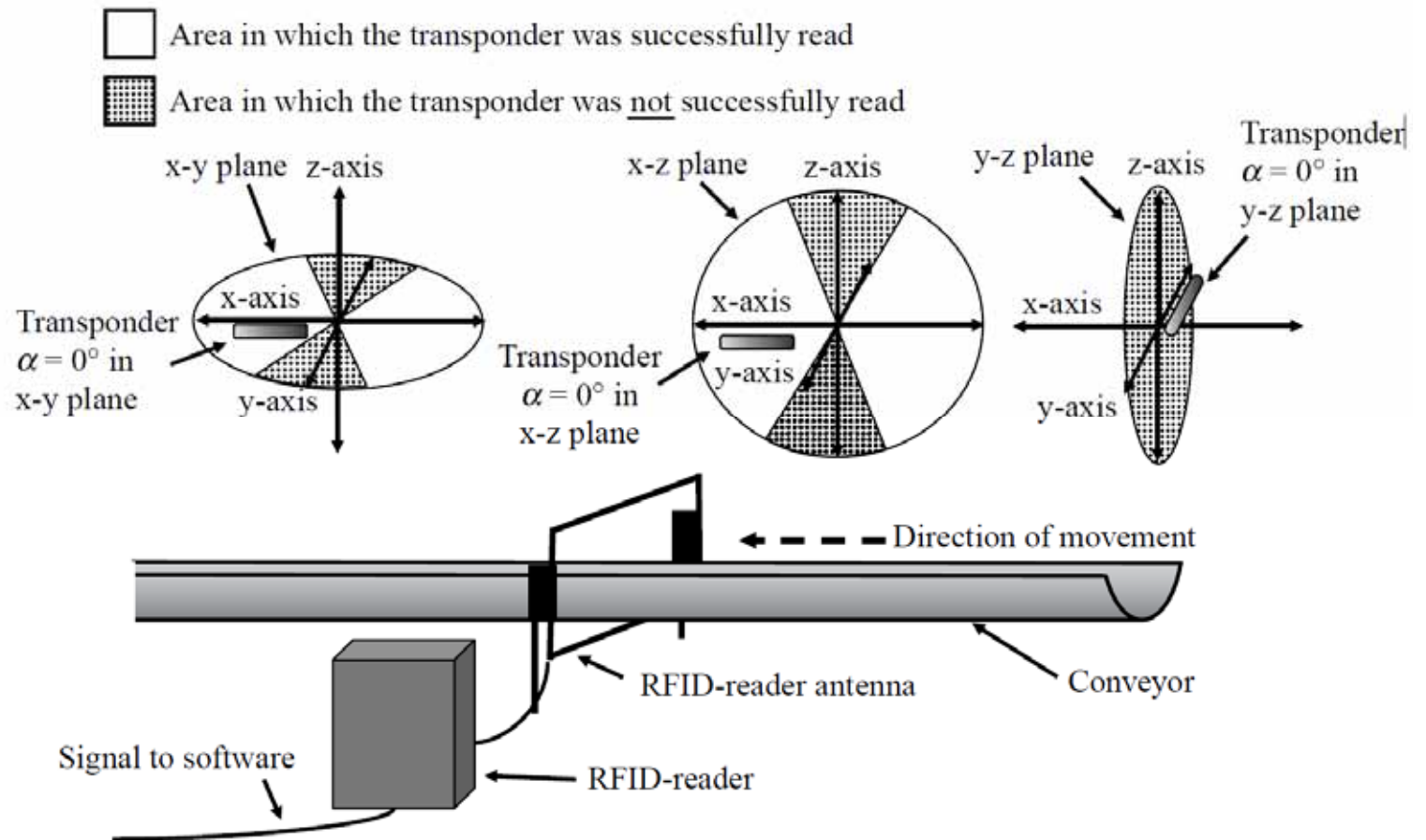


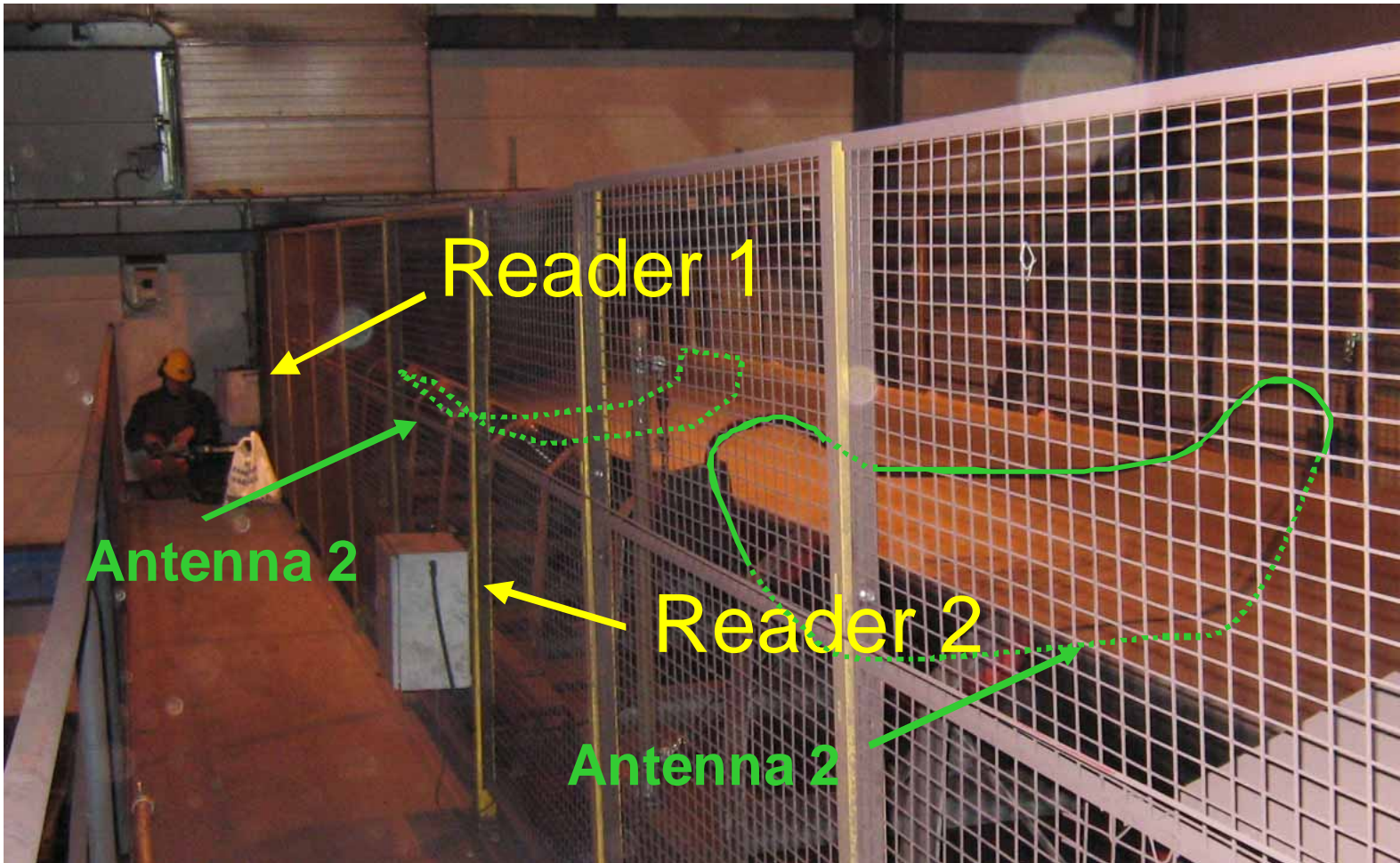
1. RFID pellets behaving as pellets
2. Robust measurement equipment
3. Statistical models of pellets flow





Kvarnström, B. & Vanhatalo, E. (2010). Using RFID to improve traceability in process industry: Experiments in a distribution chain for iron ore pellets, *Journal of Manufacturing Technology Management*, 21(1), 139-154.



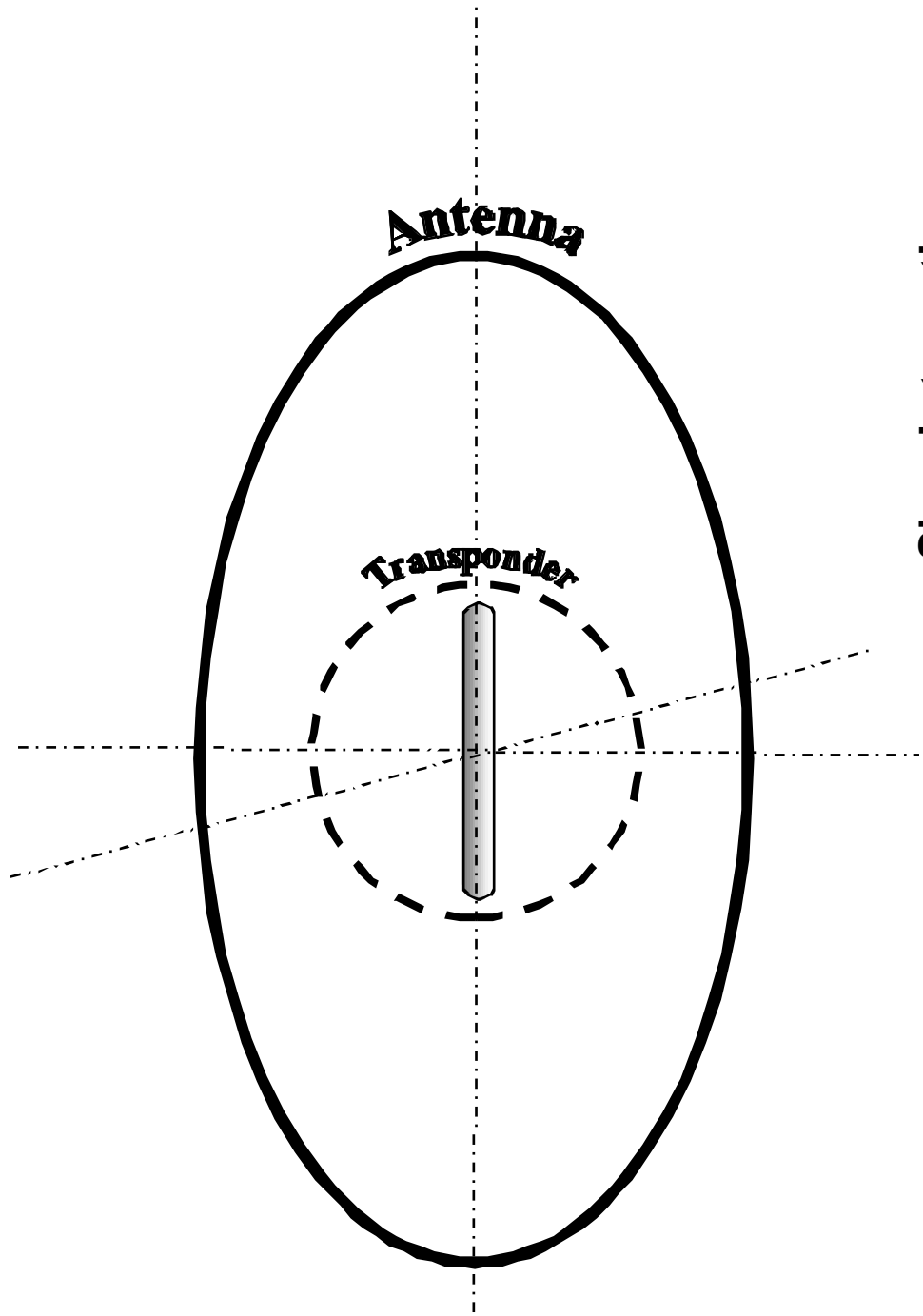


Reader 1

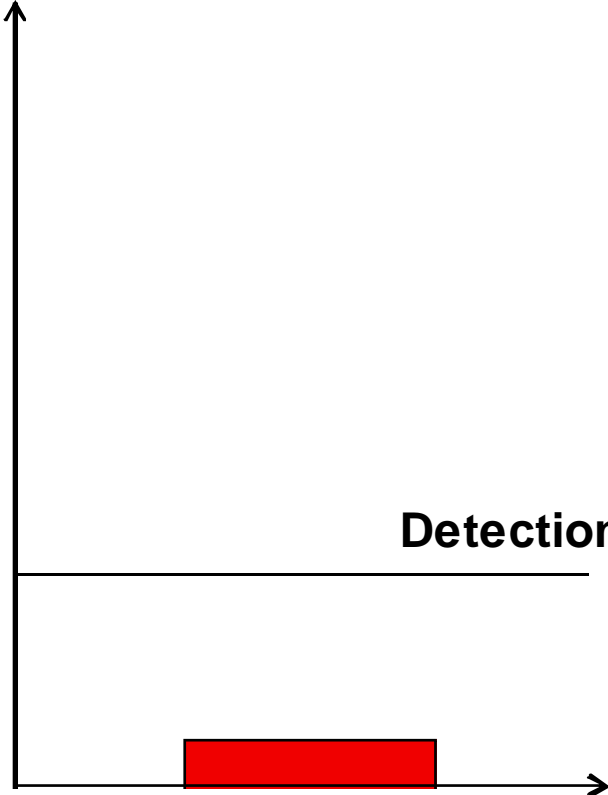
Antenna 2

Reader 2

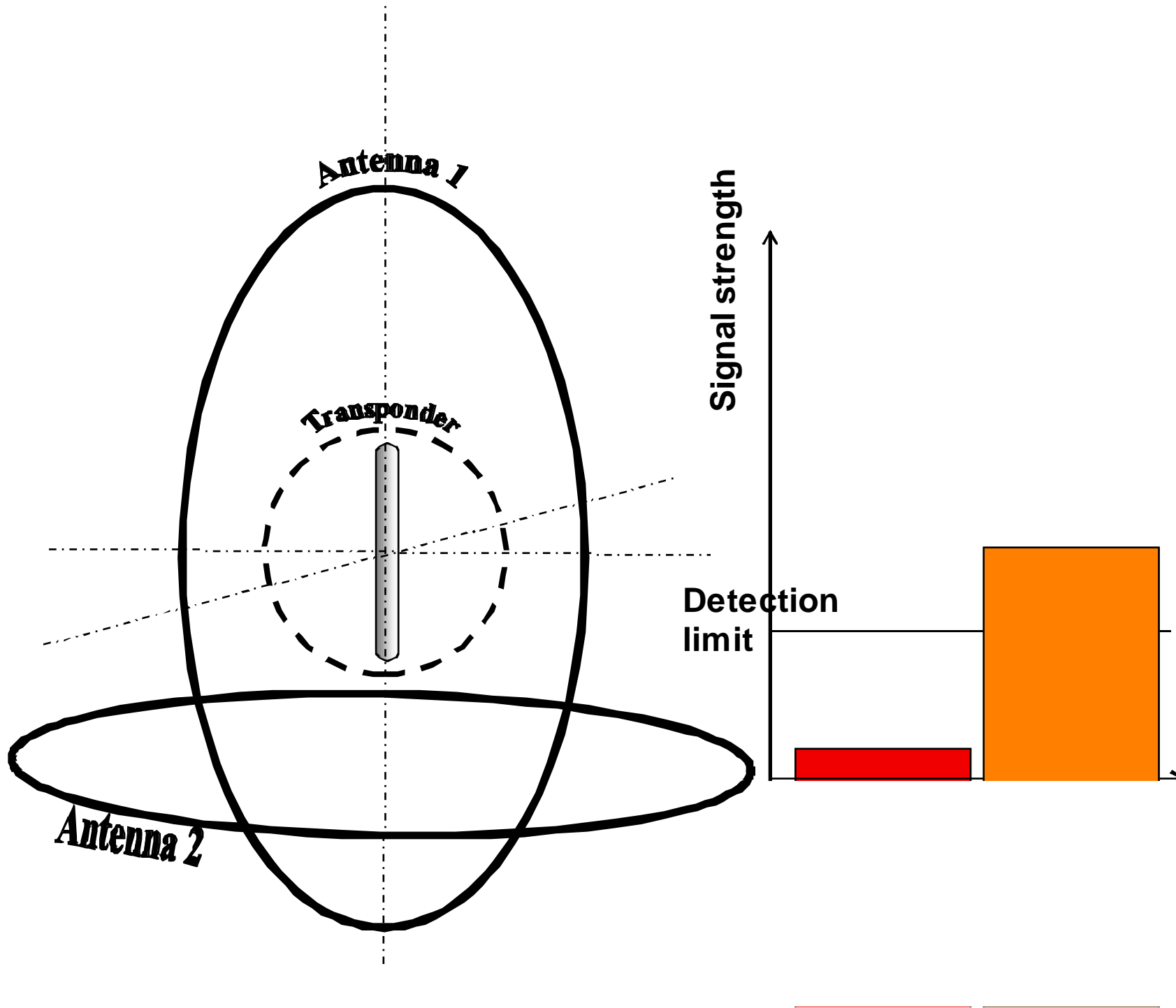
Antenna 2



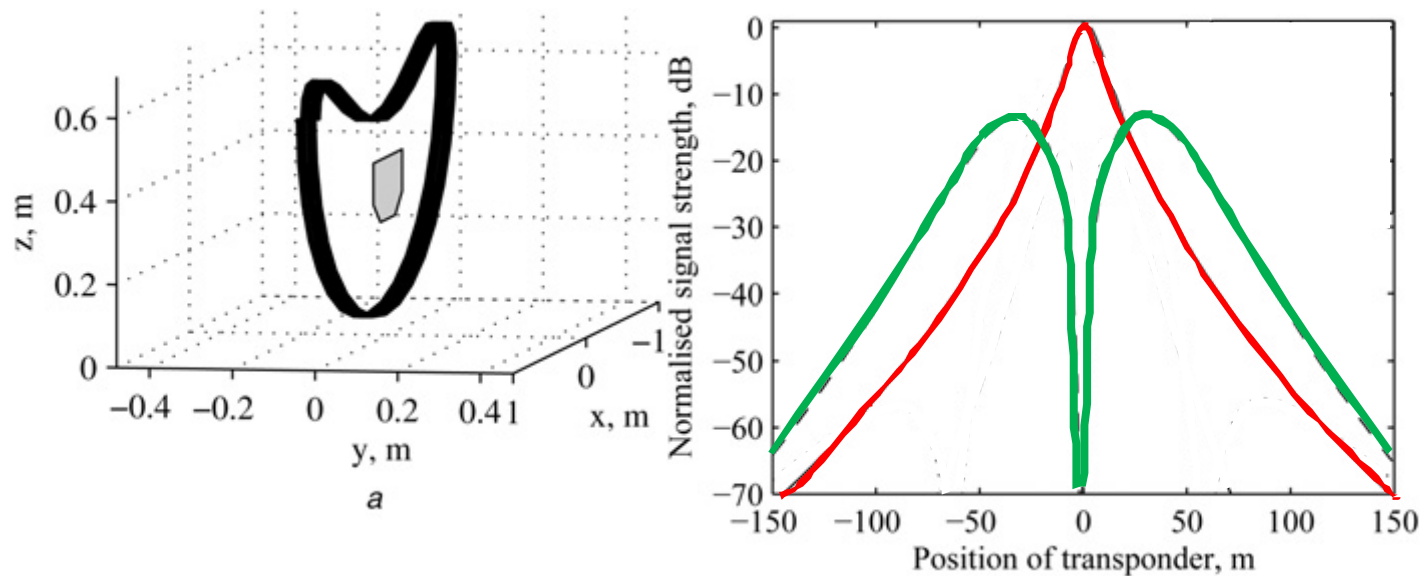
Signal strength



Detection limit

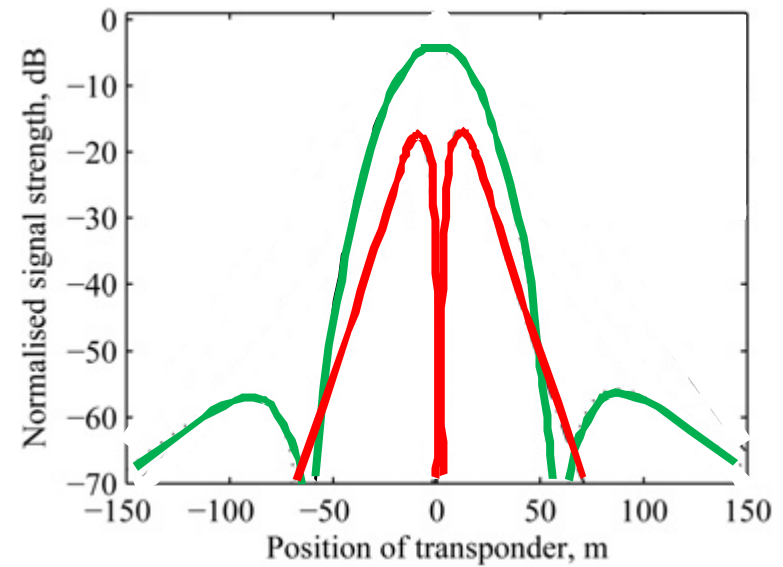
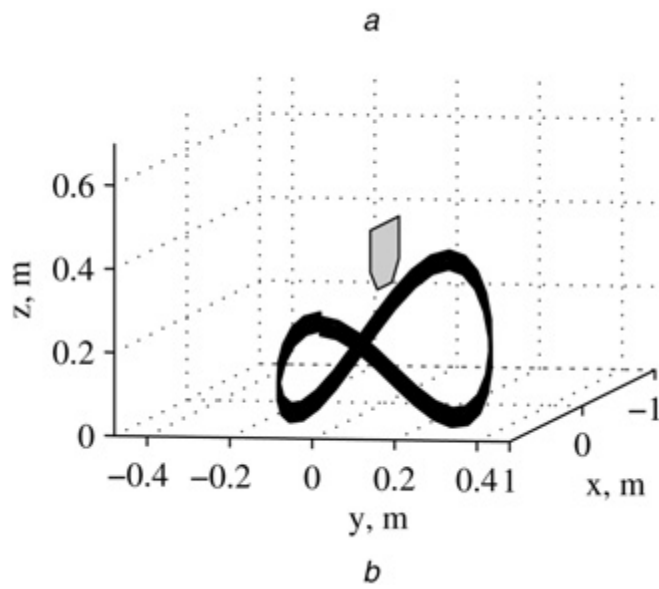


Antenna around belt

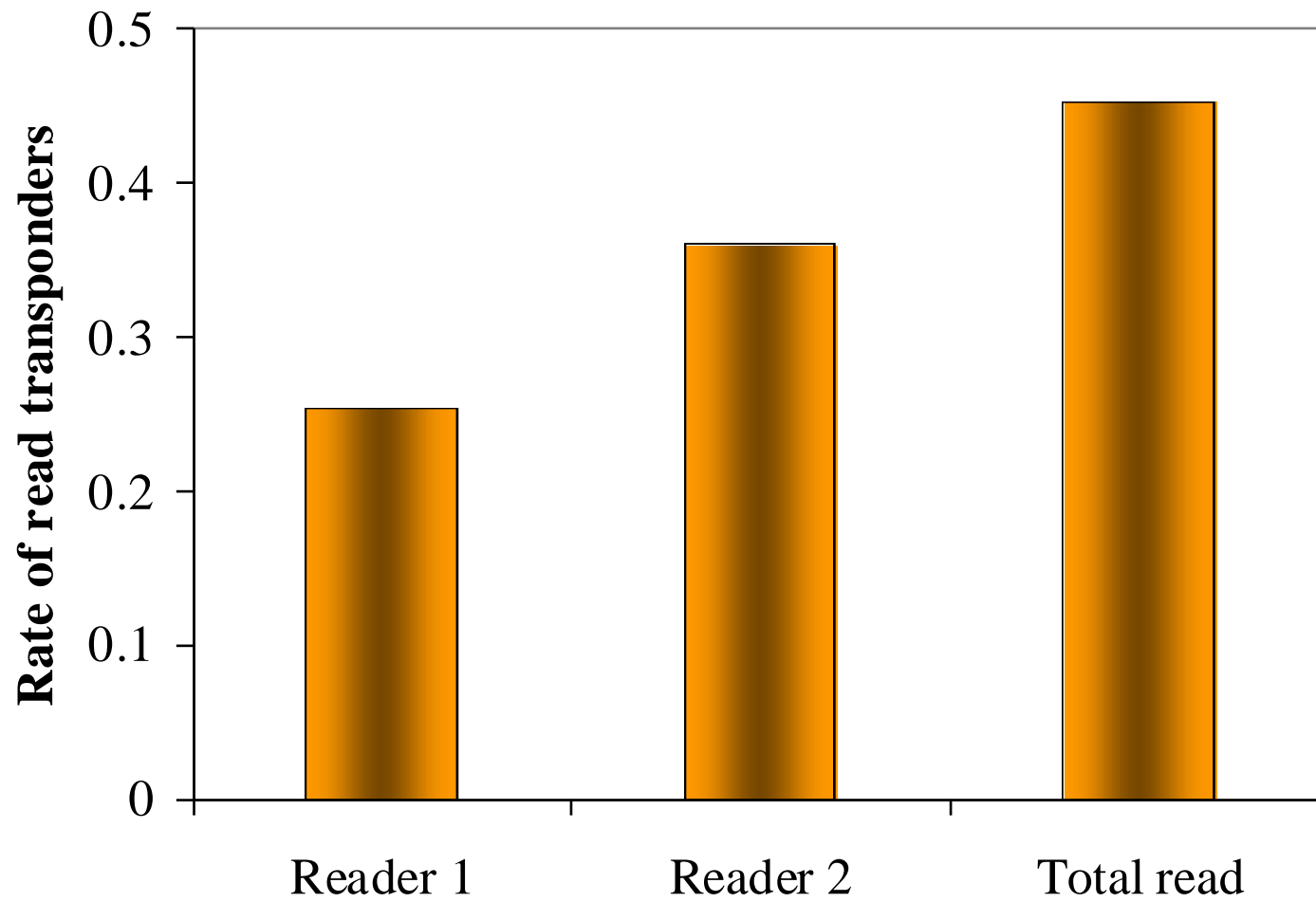


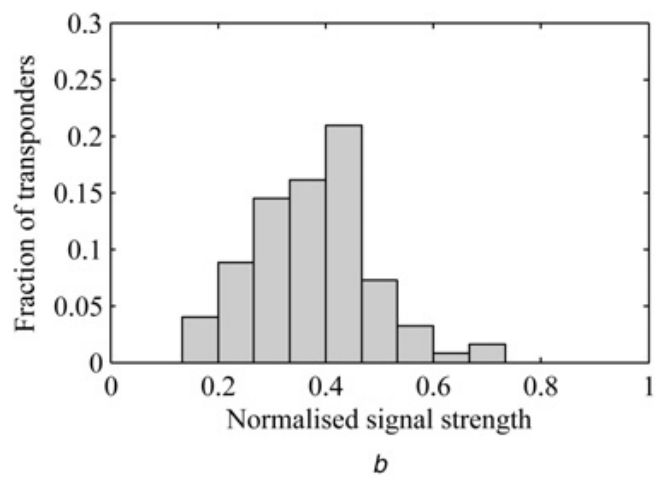
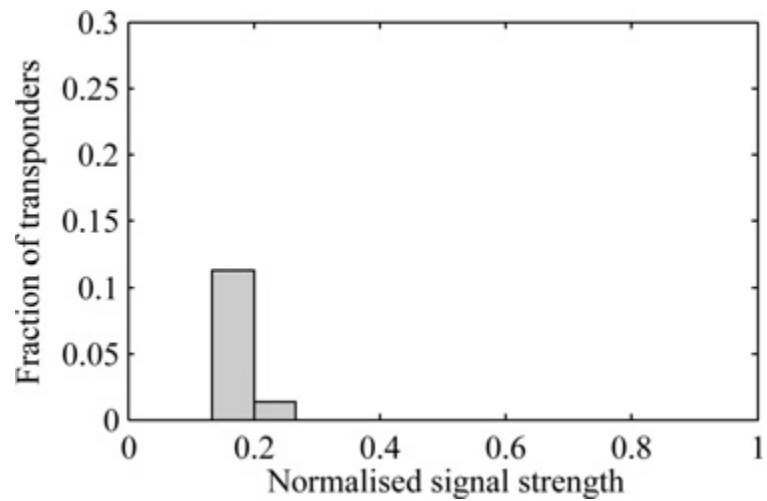
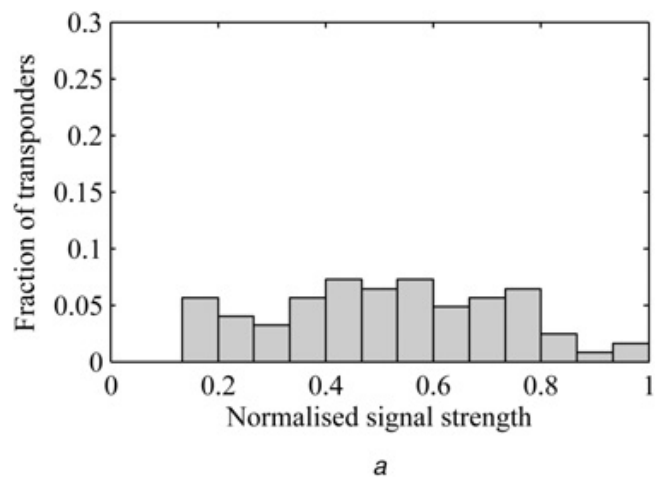
T. Lindgren B. Kvarnström J. Ekman (2010). Monte Carlo simulation of an radio frequency identification system with moving transponders using the partial element equivalent circuit method, *IET Microwaves, Antennas & Propagation*, 4 (12) 2069–2076

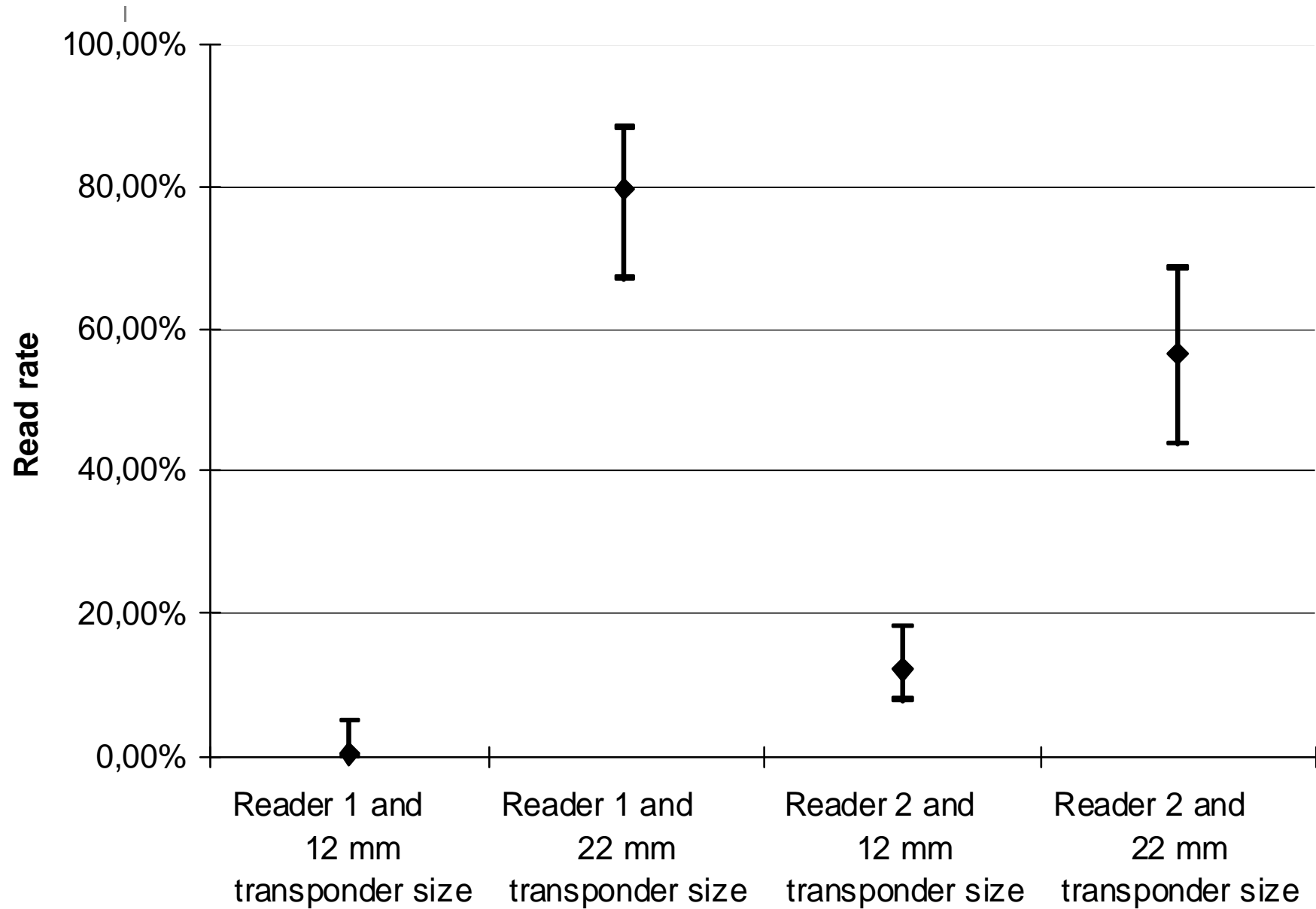
Antenna below belt



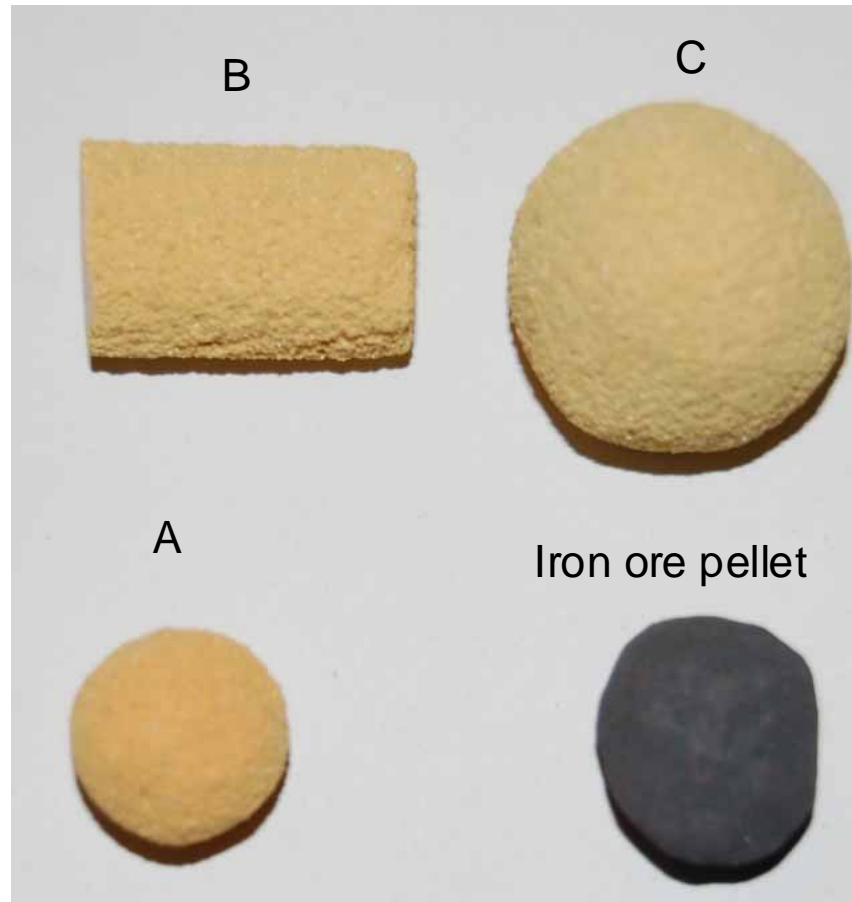
Read rate, all types of transponders







Brazil nut effect



Parameter Estimates

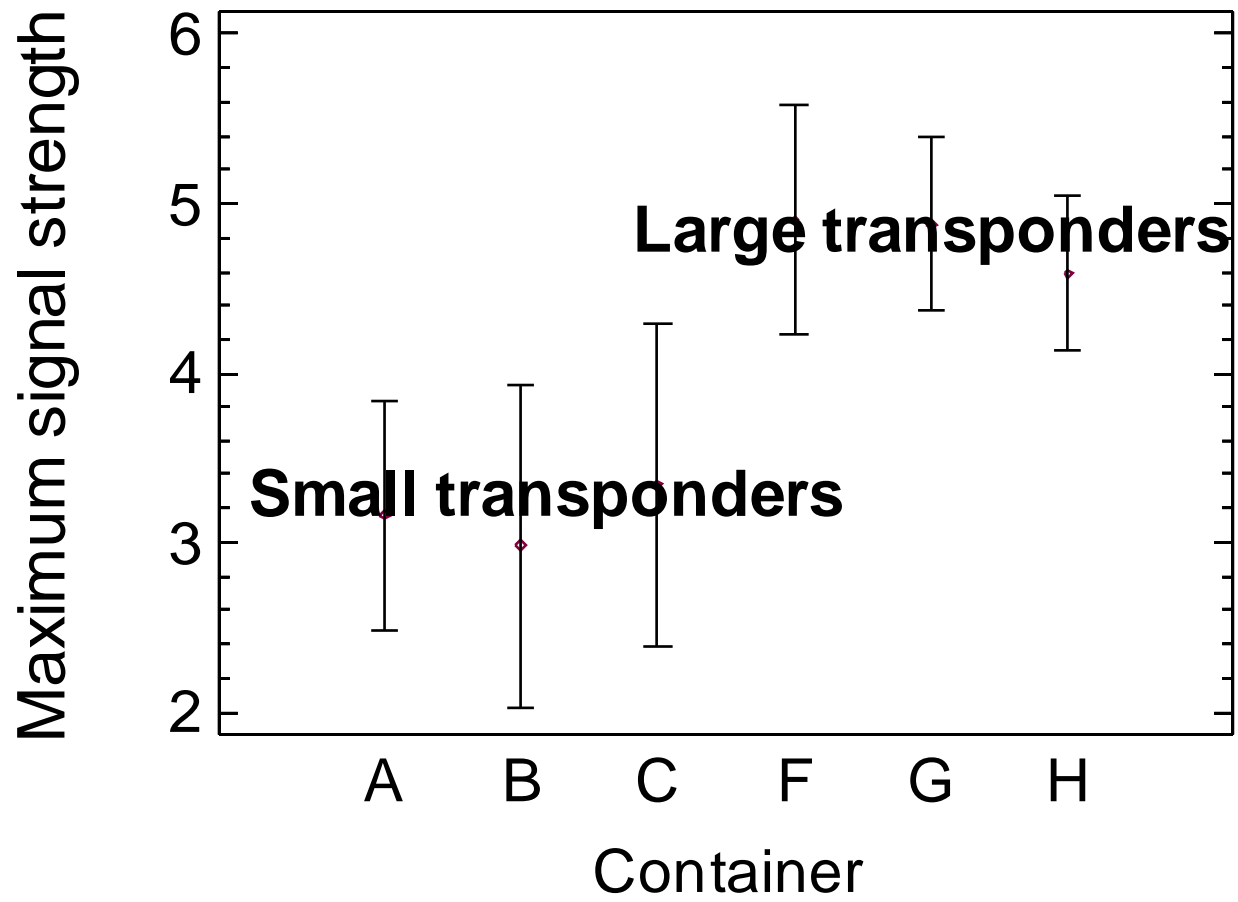
Predictor		Coefficient	S.E. Coef	Chi-Sq	Prob.>Chi-Sq.
Intercept	$\hat{\beta}_6$	-1,5141	0,3184	74,1640	<,0001*
Reader	$\hat{\beta}_7$	0,6616	0,3184	13,0226	0,0003*
Transponder size 22	β_8	2,3239	0,3184	267,3075	<,0001*
Reader *Transpondersize 22	$\hat{\beta}_9$	-1,2076	0,3184	46,8416	<,0001*

Goodness-of Fit Tests

Method	Chi-Sq.	DF	Prob.>Chi-Sq.
Pears on	18,7303	26	0,8476
Deviance	23,2271	26	0,6201

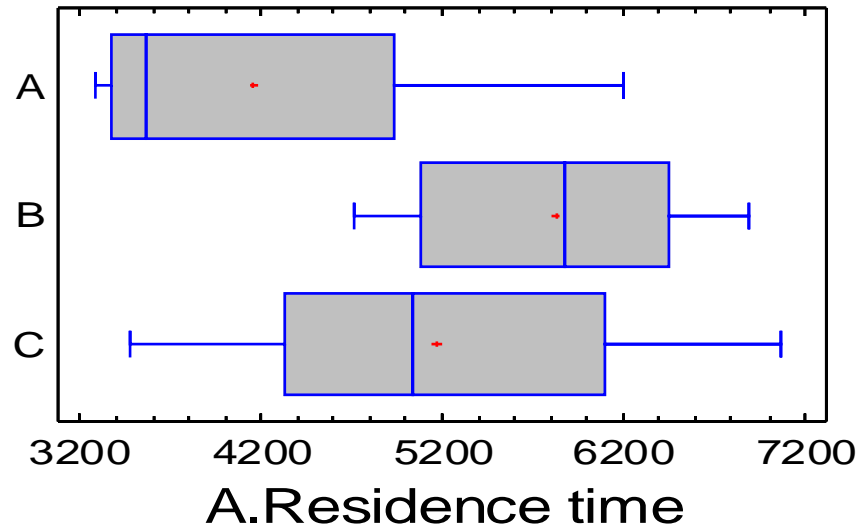
Likelihood Ratio Test

	-Log Likelihood	DF	Prob.>Chi-Sq.
Difference between reduce and full model	158,4281	3	<,0001*

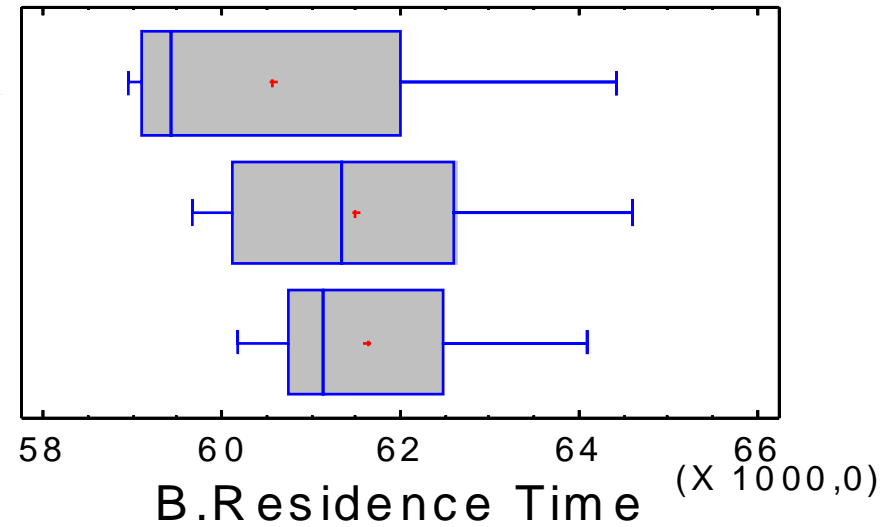


Residence times of two experiments

Box-and-Whisker Plot



Box-and-Whisker Plot



Follow up experiments



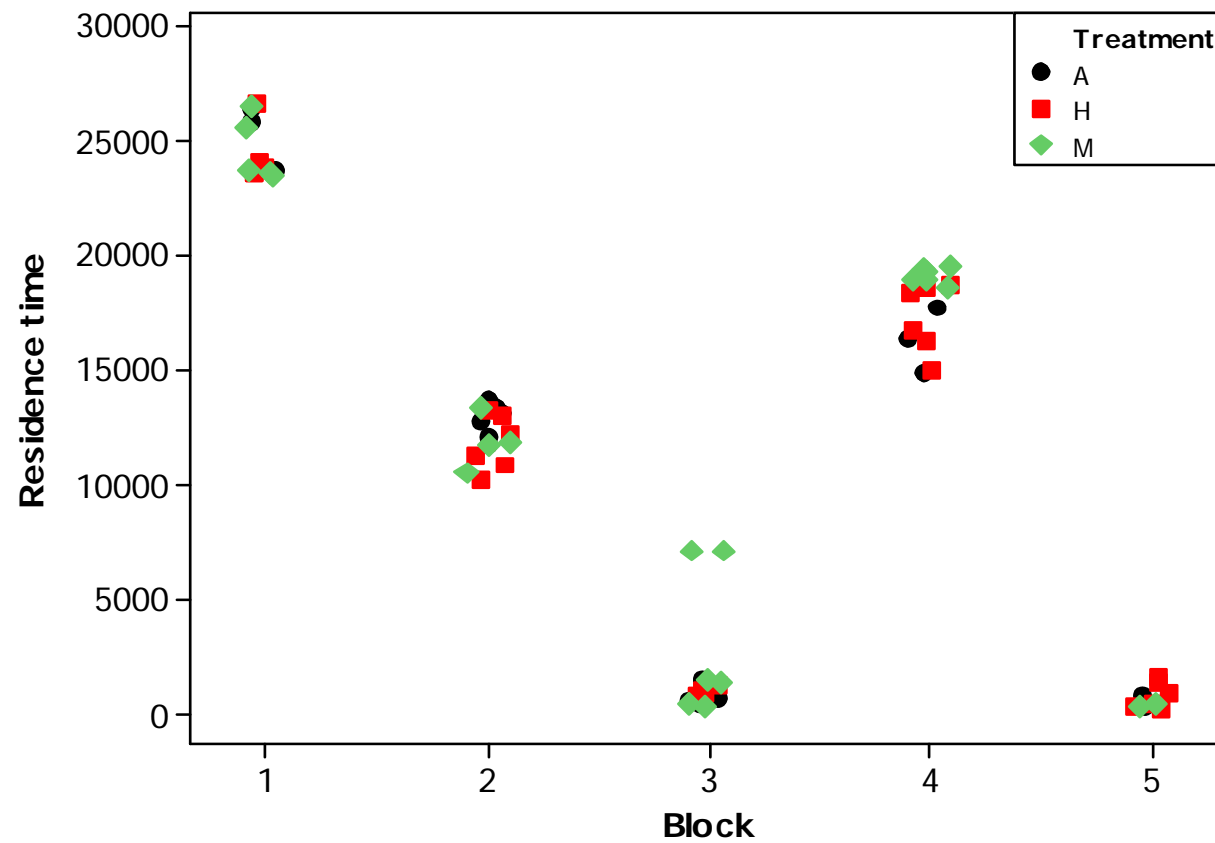
Iron ore pellet

A-type: spheres with 12mm tags, 4.3 g/cm³ density

M-type: spheres 4.3 g/cm³ density (same as pellets)

H-type: spheres 6.1 g/cm³ density

Kvarnström, B., Bergquist, B. & Vännman, K. (2011). RFID to improve traceability in continuous granular flows: an experimental case study. *Quality Engineering*. in press.



Ongoing work

Two readers relocated to Narvik SILA station

Difficulties obtaining signals

Practical difficulties

Products going to different warehouses

Loss of contact with readers

- Loss of power to readers

- Loss of GSM connectivity

Antenna failures

- Belt deflection likely to interfere with antennas encircling belts

Harsh, dusty environments

Experiments in these organizational and mechanically harsh environments need to be foolproof

Academic output

A man with short brown hair and glasses, wearing a dark suit, a purple tie, and a dark shirt, stands in front of a presentation screen. The screen displays text about his theses and book chapters. In the foreground, there are some colorful flowers and a blue chair.

Theses, Dissertations

Kvarnström, B. (2010). *Traceability in Continuous Processes – Applied to Ore Refinement Processes*, Quality Technology,

Book chapters

Kvarnström, B. & Oja, J. (2010): Applications of RFID to improve traceability in continuous processes, *in* Turcu, C. (red) *Sustainable Radio Frequency Identification Solutions*. Vienna, Austria : In-Tech s. 69-86.

Journal publications (published, in press or accepted for publication)

Kvarnström, B., and Vanhatalo, E. (2009): Using RFID to improve traceability in process industry: Experiments in a distribution chain of iron ore pellets, *Journal of Manufacturing Technology Management*, Vol. 21, No. 1, pp. 139-154.

Lindgren, T. Kvarnström, K., and Ekman, J. (2010): Monte Carlo simulation of radio frequency identification system with moving transponders using the partial element equivalent circuit method, *I E T Microwaves Antennas & Propagation*, Vol. 4, No. 12, pp. 2069-2076.

Vanhatalo, E., Kvarnström, B., Bergquist, B., Vännman, K. (2011) A Method to Determine Transition Time for Experiments in Dynamic Processes, *Quality Engineering*, 23(1), pp. 30-45.

Kvarnström, B. & Bergquist, B, Vännman, K. (2011): RFID to Improve Traceability in Continuous Granular Flows. To appear in *Quality Engineering*.

Kvarnström, B. & Bergquist, B. (2011). Improving Traceability in Continuous Processes Using Flow Simulations. To appear in *Production, Planning & Control*.





Invited conference presentations and papers

Bergquist, B. & Kvarnström, B. (2011) Tracking and Tracing Products in Continuous Processes, *2011 International Congress on Productivity, Quality, Reliability, Optimization and Modelling: ICPQROM 2011*. Indian Statistical Institute 10 s.

Other conference presentations

Kvarnström, B. (2008). Spårbarhet for granulära produkter, The Promote Workshop, Luleå, May 13.

Bergquist, B. & Kvarnström, B. (2009). Traceability in Continuous Processes, *Bergforsk*, Luleå, Luleå, May 5.

Bergquist, B. & Kvarnström, B. (2009). What is Traceability and How Can Traceability be Created in Continuous Processes?, The Promote Workshop, Luleå May 13.

Bergquist, B. & Kvarnström, B. (2010). Tracing Granular Pruducts using RFID, *Bergforsk*, Luleå, May 4-5.

Promote Workshop» Process industrial innovation and development work in the future«

Jernkontoret 18 May 9-17

Speakers include e.g.

Thomas Lundgren & Niclas Dahlström, Northland Resources

Rolf Hindström, Outotec

Magnus Wikström, Billerud AB

Mats Magnusson, KTH & IMIT

Mats Larsson, Höganäs AB

Johan Frishammar, Promote, LTU

Bjarne Bergquist & Erik Vanhatalo, Promote, LTU

- 10.00 – 10.40 **AFFÄRSUTVECKLING GENOM INTRAPRENÖRSKAP - LÄRDOMAR FRÅN BILLERUD**
Magnus Wikström, Billerud AB
- 10.40 – 11.05 **NYUTVECKLING AV PROCESSTEKNOLOGI - KUND OCH LEVERANTÖRSPERSPEKTIV**
David Rönnerberg Sjödin & Per Erik Eriksson, Promote
Bensträckare & mingel 15 min
- 11.20 – 11.50 **FRAMTIDENS PROCESSUTVECKLING**
Thomas Lundgren & Niclas Dahlström, Northland Resources
- 12.00 – 13.15 **GEMENSAM LUNCH PÅ HAMBURGER BÖRS**
- 13.15 – 13.40 **MYCKET DATA MEN LITE KUNSKAP - HUR KAN VI BÄTTRE FÖRSTÅ VÅRA PROCESSER OCH PRODUKTER?**
Bjarne Bergquist & Erik Vanhatalo, Promote
- 13.40 – 14.05 **KUND-LEVERANTÖRSSAMARBETEN PÅ DET PERSONLIGA PLANET**
Rolf Hindström, Outotec
- 14.05 – 14.30 **KUNSKAPSÖVERFÖRING OCH KUNSKAPSLÄCKAGE I GRÄNSÖVERSKRIDANDE FoU PROJEKT**
Kristian Ericsson, LTU
- 14.30 – 15.00 **EFTERMIDDAGSFIKA & MINGEL**
- 15.00 – 15.40 **KEYNOTE: ATT SKAPA OCH FÖRVERKLIGA INNOVATIONSPOTENTIAL I STORA FÖRETAG**
Mats Magnusson, KTH & IMIT
- 15.40 – 16.05 **FRÅN PULVERMETALLURGI TILL SMARTA RALLYBILAR - APPLIKATIONSUTVECKLING PÅ HÖGANÄS AB**
Mats Larsson, Höganäs AB
Bensträckare & mingel 10 min
- 16.15 – 16.40 **FRÅN IDEER TILL STABILA**

WORKSHOPEN ÄR KOSTNADSFRI för deltagare vars arbetsgivare är "Friends of promote" (Billerud AB; Boliden; Höganäs AB; LKAB; SSAB). Företag eller organisationer som inte är medlemmar i Promote betalar 1800 SEK exklusive moms per deltagare. För- och eftermiddagsfika, lunch, middag och dokumentation ingår för samtliga deltagare.

Avgiften betalas i samband med anmälan;
Bankgiro 5050-0495 Postgiro 760815-1
(Ange "Promote" på talongen.)

LOKAL: Jernkontorets lokaler på Kungsträdgårdsgatan 10, Stockholm.

EVENTUELL TRANSPORT FRÅN FLYG:
Ordnas av respektive deltagare.

DOKUMENTATION: Distribueras efter workshop som kopior på PPT-presentationer.

ANMÄLAN OCH KONTAKTER: Anmälan samt kontakter angående praktiska detaljer till Ihrene Niva-Strände ihere.niva-strande@ltu.se

Kontakter om workshopens innehåll, presentationer och genomförande; Johan Frishammar, johan.frishammar@ltu.se

