Automated Process Data Acquisition within Standardized Communication Systems and its Practical Applications

Prof. Dr. Hermann Auernhammer
Dipl.-Ing.agr. M. Rothmund

Centre of Life Sciences Weihenstephan
Department of Bio Resources and Land Use Technology
Crop Production Engineering

2004 CIGR International Conference • Beijing
Keynote Lecture
Beijing (China)
October 11-14, 2004
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
2. Standardized technologies
3. Process data acquisition systems
4. Data processing
5. Practical applications
6. Conclusions
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
   2. Standardized technologies
   3. Process data acquisition systems
   4. Data processing
   5. Practical applications
   6. Conclusions
<table>
<thead>
<tr>
<th>No.</th>
<th>Design</th>
<th>Innovation</th>
<th>Benefits</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Combustion engine + Rotary force</td>
<td>&quot;Biological&quot; independence</td>
<td>Self propelled working machine</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Pneumatic tyre</td>
<td>Mobility</td>
<td>Universal tractor</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Hydraulic system + Three-point-hitch</td>
<td>Automotive properties</td>
<td>Tractor implement unit</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Electronics + Communication</td>
<td>&quot;Technical&quot; intelligence</td>
<td>Process element within a communication system</td>
</tr>
</tbody>
</table>

Milestones in tractor usage

IT on the farm
Information technology in land use systems

- Precision Forestry
- Precision Agriculture
- Precision Horticulture

- Precision Pasturing
- Precision (Crop) Farming
- Precision Livestock Farming

- Documentation
- Site specific crop management
- Fleet management
- Field robotics

Crop Production Engineering

Auernhammer / Rothmund, Sep. 2004
Information technology (IT) applications in crop farming

- Automated data acquisition
  - Fieldbooks and bookkeeping
  - Basic data for Precision Farming
  - On-farm research
  - Administration
  - Quality management

- Site specific farming
  - Tillage
  - Drilling
  - Fertilizing
  - Spraying
  - Irrigation
  - Harvesting (with online decision)

- Fleet management
  - Route planning
  - Location monitoring
  - Location monitoring with map-matching
  - Fleet member control and navigation
  - Teleservice

- Field robotics
  - Implement control/
    Automatic guidance
  - Manned guiding vehicle
    and unmanned following vehicles
  - Unmanned vehicles
    of existing concepts
  - Unmanned vehicles
    of new specialised concepts

Traceability (documentation)

Crop Production Engineering
### Process data acquisition in crop production

#### Table: Task / Mechanisation

<table>
<thead>
<tr>
<th>Acquisition technology</th>
<th>Manual work</th>
<th>Stationary equipment</th>
<th>Mobile equipment</th>
<th>Mobile equipment</th>
<th>Mobile equipment</th>
<th>Mobile equipment</th>
<th>Assessment</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In-house Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field Irrigation</td>
<td>Implement without elektronics</td>
<td>Implement with elektronics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tractor-implement combination</td>
<td>Telehandler</td>
<td>Special machinery</td>
<td>Combines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual (form + PC)</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Low investment needs</td>
<td>Little in-depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low costs</td>
<td>Incomplete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low intellectual requirements</td>
<td>High temporal effort</td>
</tr>
<tr>
<td>Pocket PC</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Low investment needs</td>
<td>Little in-depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low costs</td>
<td>In complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paper superfluous</td>
<td>Insufficient software</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reduced temporal effort</td>
<td></td>
</tr>
<tr>
<td>Pocket PC + GPS</td>
<td>+/-</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Position is included</td>
<td>Little in-depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>More details possible</td>
<td>In complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low costs</td>
<td>Insufficient software</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paper superfluous</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reduced temporal effort</td>
<td></td>
</tr>
<tr>
<td>Use of installed sensor technology</td>
<td>--</td>
<td>--</td>
<td>+/-</td>
<td>+/-</td>
<td>++</td>
<td>+/-</td>
<td>Low additional costs</td>
<td>Only partitions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Automatic acquisition</td>
<td>ascertainable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Objective measurements</td>
<td>Additional costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>complete</td>
<td>No standardisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Detailing possible</td>
<td></td>
</tr>
<tr>
<td>Special acquisition technique</td>
<td>???</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>Automatic acquisition</td>
<td>Higher additional costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Objective measurements</td>
<td>Costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>complete</td>
<td>No standardisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Detailing fulfilled</td>
<td></td>
</tr>
<tr>
<td>Integrated automatic acquisition</td>
<td>???</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>Automatic acquisition</td>
<td>Standards necessary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Standardisation</td>
<td>Higher costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Objective measurements</td>
<td>Complet data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User specific</td>
<td>processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>configurable</td>
<td>Current software</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Detailing according to requirements</td>
<td>required</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Open systems**

**Closed systems**

**Crop Production Engineering**

Auernhammer / Rothmund, Sep. 2004
Two types of data acquisition sources

Closed systems!
(responsibility of the manufacturer)
May be proprietary!

Open systems!
(responsibility of the farmer)
Must be standardized!
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age

2. Standardized technologies

3. Process data acquisition systems
4. Data processing
5. Practical applications
6. Conclusions
GPS (Navstar / Galileo)

- Position
- Time

}\ Automated stop watch!

It’s a standard!
**Standardized electronic communication (ISOBUS)**

**Implements** (the tractor is an implement) are able to communicate
- with the **driver** (is well known)
- with the **tractor** (implement controls tractor)
- with other **implements**
- with the farm **management**

But only, if all have own intelligence and communication facilities!
Implement Indicator – the missing link!
- used with “stupid technology” -

These are examples of so called „stupid implements“, they don’t use any electronics

Primary soil preparation

Minimum tillage

Forage harvesting

Transportation
Implement Indicator – the missing link!
- used with “stupid technology” -

Just a small piece of electronics,
(may be in the connector)
and these implements are intelligent!

Crop Production Engineering

Auernhammer / Rothmund, Sep. 2004
A04-25 (13)
1. The information age
2. Standardized technologies

3. **Process data acquisition systems**

4. Data processing
5. Practical applications
6. Conclusions
Automated process data acquisition – data file
### Example of raw data: ASCII-format, relational data model

<table>
<thead>
<tr>
<th>Date, Time</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Tractor</th>
<th>Speed</th>
<th>Left</th>
<th>Right</th>
<th>Implement, Ww, AppVol, Sum, Sensor1, Napp</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.06.2004, 17:34:33, 10.25254822, 49.89058304</td>
<td></td>
<td></td>
<td>CaCs150, 3002, 043</td>
<td>-33.14, -28.80</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 141.23, 000, MiniVegN, 56</td>
</tr>
<tr>
<td>04.06.2004, 17:34:34, 10.25253296, 49.89060593</td>
<td></td>
<td></td>
<td>CaCs150, 3014, 044</td>
<td>-30.73, -29.01</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 142.81, 000, MiniVegN, 65</td>
</tr>
<tr>
<td>04.06.2004, 17:34:35, 10.25251865, 49.89062881</td>
<td></td>
<td></td>
<td>CaCs150, 3010, 041</td>
<td>-31.48, -32.75</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 143.45, 000, MiniVegN, 63</td>
</tr>
<tr>
<td>04.06.2004, 17:34:36, 10.25250340, 49.89065170</td>
<td></td>
<td></td>
<td>CaCs150, 3024, 040</td>
<td>-28.70, -20.93</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 141.64, 000, MiniVegN, 68</td>
</tr>
<tr>
<td>04.06.2004, 17:34:37, 10.25248814, 49.89067841</td>
<td></td>
<td></td>
<td>CaCs150, 2950, 046</td>
<td>-24.75, -23.14</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 140.68, 000, MiniVegN, 59</td>
</tr>
<tr>
<td>04.06.2004, 17:34:38, 10.25247288, 49.89070129</td>
<td></td>
<td></td>
<td>CaCs150, 2925, 046</td>
<td>-10.68, -07.17</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 138.83, 000, MiniVegN, 62</td>
</tr>
<tr>
<td>04.06.2004, 17:34:39, 10.25245857, 49.89074707</td>
<td></td>
<td></td>
<td>CaCs150, 3050, 046</td>
<td>-29.31, -29.85</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 139.34, 000, MiniVegN, 71</td>
</tr>
<tr>
<td>04.06.2004, 17:34:40, 10.25245857, 49.89076996</td>
<td></td>
<td></td>
<td>CaCs150, 2965, 074</td>
<td>44.53, 47.97</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 142.58, 000, MiniVegN, 82</td>
</tr>
<tr>
<td>04.06.2004, 17:34:41, 10.25244522, 49.89079285</td>
<td></td>
<td></td>
<td>CaCs150, 2200, 100</td>
<td>64.03, 70.37</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 149.82, 000, MiniVegN, 56</td>
</tr>
<tr>
<td>04.06.2004, 17:34:42, 10.25243187, 49.89081573</td>
<td></td>
<td></td>
<td>CaCs150, 2032, 100</td>
<td>64.83, 73.53</td>
<td></td>
<td></td>
<td>IMIgru1, 3000, 150.16, 000, MiniVegN, 71</td>
</tr>
</tbody>
</table>

- **GPS (position and time)**
  - Date, Time
  - Longitude, Latitude
- **tractor**
  - Tractor, Speed, Left, Right
- **implements**
  - Implement, Ww, AppVol, Sum
- **sensors**
  - Sensor1, Napp

**Logging frequency:** 1Hz
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
2. Standardized technologies
3. Process data acquisition systems

4. **Data processing**

5. Practical applications
6. Conclusions
Data processing in different organizations

Data processing

Local PC + local software
- First attempt in 2000 / 2001
- Based on Microsoft Access®
- Complete data processing, data management and analyzing tool
- Not capable for huge data amounts
  » Laborious to install and update on many farms

Web based information system
- Modelling and prototyping since 2002
- Use of OpenSource software only
- User interface via Web browser
- DB model for high performance
  » Central data management (Automated data processing)
### Data processing – spatial data classification

<table>
<thead>
<tr>
<th>Date, Time</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Tractor</th>
<th>Speed</th>
<th>Left</th>
<th>Right</th>
<th>Implement</th>
<th>WW</th>
<th>AppVol</th>
<th>Sum</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.06.2004,17:34:33</td>
<td>10.25254822</td>
<td>49.89058304</td>
<td>CaCs150</td>
<td>3002</td>
<td>043</td>
<td>-33.14</td>
<td>IMIgru1</td>
<td>3000</td>
<td>141.23</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:34</td>
<td>10.25253296</td>
<td>49.89060593</td>
<td>CaCs150</td>
<td>3014</td>
<td>044</td>
<td>-30.73</td>
<td>IMIgru1</td>
<td>3000</td>
<td>142.81</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:35</td>
<td>10.25251865</td>
<td>49.89062881</td>
<td>CaCs150</td>
<td>3010</td>
<td>041</td>
<td>-31.48</td>
<td>IMIgru1</td>
<td>3000</td>
<td>143.45</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:36</td>
<td>10.25250340</td>
<td>49.89065170</td>
<td>CaCs150</td>
<td>3024</td>
<td>046</td>
<td>-28.70</td>
<td>IMIgru1</td>
<td>3000</td>
<td>141.64</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:37</td>
<td>10.25248814</td>
<td>49.89067841</td>
<td>CaCs150</td>
<td>2950</td>
<td>046</td>
<td>-24.75</td>
<td>IMIgru1</td>
<td>3000</td>
<td>140.68</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:38</td>
<td>10.25247288</td>
<td>49.89070129</td>
<td>CaCs150</td>
<td>2925</td>
<td>046</td>
<td>-10.68</td>
<td>IMIgru1</td>
<td>3000</td>
<td>138.83</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:40</td>
<td>10.25245857</td>
<td>49.89074707</td>
<td>CaCs150</td>
<td>3050</td>
<td>046</td>
<td>-29.31</td>
<td>IMIgru1</td>
<td>3000</td>
<td>139.34</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:41</td>
<td>10.25244522</td>
<td>49.89076996</td>
<td>CaCs150</td>
<td>3102</td>
<td>047</td>
<td>-20.56</td>
<td>IMIgru1</td>
<td>3000</td>
<td>140.64</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:42</td>
<td>10.25243187</td>
<td>49.89079285</td>
<td>CaCs150</td>
<td>2965</td>
<td>047</td>
<td>44.53</td>
<td>IMIgru1</td>
<td>3000</td>
<td>144.89</td>
<td>000</td>
<td>d01</td>
</tr>
<tr>
<td>04.06.2004,17:34:43</td>
<td>10.25242138</td>
<td>49.89081573</td>
<td>CaCs150</td>
<td>2422</td>
<td>097</td>
<td>69.11</td>
<td>IMIgru1</td>
<td>3000</td>
<td>145.91</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:44</td>
<td>10.25241661</td>
<td>49.89083099</td>
<td>CaCs150</td>
<td>1987</td>
<td>102</td>
<td>64.67</td>
<td>IMIgru1</td>
<td>3000</td>
<td>147.39</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:45</td>
<td>10.25242329</td>
<td>49.89085007</td>
<td>CaCs150</td>
<td>1883</td>
<td>102</td>
<td>66.53</td>
<td>IMIgru1</td>
<td>3000</td>
<td>150.93</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:46</td>
<td>10.25243473</td>
<td>49.89086151</td>
<td>CaCs150</td>
<td>1789</td>
<td>102</td>
<td>61.54</td>
<td>IMIgru1</td>
<td>3000</td>
<td>151.56</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:47</td>
<td>10.25244808</td>
<td>49.89079964</td>
<td>CaCs150</td>
<td>1475</td>
<td>102</td>
<td>65.59</td>
<td>IMIgru1</td>
<td>3000</td>
<td>150.76</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:48</td>
<td>10.25245953</td>
<td>49.89087677</td>
<td>CaCs150</td>
<td>1335</td>
<td>102</td>
<td>65.13</td>
<td>IMIgru1</td>
<td>3000</td>
<td>149.73</td>
<td>000</td>
<td>none</td>
</tr>
<tr>
<td>04.06.2004,17:34:49</td>
<td>10.25245190</td>
<td>49.89087296</td>
<td>CaCs150</td>
<td>0885</td>
<td>102</td>
<td>66.03</td>
<td>IMIgru1</td>
<td>3000</td>
<td>149.82</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:50</td>
<td>10.25243187</td>
<td>49.89086151</td>
<td>CaCs150</td>
<td>2411</td>
<td>102</td>
<td>58.13</td>
<td>IMIgru1</td>
<td>3000</td>
<td>150.47</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:51</td>
<td>10.25241184</td>
<td>49.89084244</td>
<td>CaCs150</td>
<td>2423</td>
<td>102</td>
<td>65.75</td>
<td>IMIgru1</td>
<td>3000</td>
<td>150.95</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:52</td>
<td>10.25240803</td>
<td>49.89082336</td>
<td>CaCs150</td>
<td>2380</td>
<td>102</td>
<td>67.16</td>
<td>IMIgru1</td>
<td>3000</td>
<td>149.29</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:53</td>
<td>10.25242043</td>
<td>49.89080048</td>
<td>CaCs150</td>
<td>2341</td>
<td>103</td>
<td>62.48</td>
<td>IMIgru1</td>
<td>3000</td>
<td>151.74</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:54</td>
<td>10.25243187</td>
<td>49.89078140</td>
<td>CaCs150</td>
<td>2356</td>
<td>100</td>
<td>64.83</td>
<td>IMIgru1</td>
<td>3000</td>
<td>148.43</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:55</td>
<td>10.25244522</td>
<td>49.89076233</td>
<td>CaCs150</td>
<td>2315</td>
<td>100</td>
<td>64.04</td>
<td>IMIgru1</td>
<td>3000</td>
<td>147.74</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:56</td>
<td>10.25245667</td>
<td>49.89074707</td>
<td>CaCs150</td>
<td>2200</td>
<td>100</td>
<td>64.29</td>
<td>IMIgru1</td>
<td>3000</td>
<td>144.59</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:57</td>
<td>10.25246811</td>
<td>49.89073181</td>
<td>CaCs150</td>
<td>2032</td>
<td>100</td>
<td>63.30</td>
<td>IMIgru1</td>
<td>3000</td>
<td>142.16</td>
<td>000</td>
<td>d02</td>
</tr>
<tr>
<td>04.06.2004,17:34:58</td>
<td>10.25247478</td>
<td>49.89072037</td>
<td>CaCs150</td>
<td>1235</td>
<td>100</td>
<td>61.00</td>
<td>IMIgru1</td>
<td>3000</td>
<td>142.98</td>
<td>000</td>
<td>d02</td>
</tr>
</tbody>
</table>

**GPS (position and time)**

**tractor**

**implements**

**field**

**Crop Production Engineering**

*Auernhammer / Rothmund, Sep. 2004*
Data processing – spatial data classification

Row data

Crop Production Engineering

Auernhammer / Rothmund, Sep. 2004
Data processing – process analysis

**Operation 1** (field 1, tractor 2, grubber, date 1)
- *data point 1*: speed, hitch position, draught force,...
- *data point 2*: speed, hitch position, draught force,...
- ...
- *data point 2*: speed, hitch position, draught force,...

**Operation 2** (field 2, tractor 1, sprayer, date 2)
- *data point 1*: speed, PTO speed, application volume,...
- ...
- *data point 1*: speed, PTO speed, application volume,...

**Operation 3** (field 1, tractor 1, seeder, date 3)
- ...

- working time, turn-over time,...
- average working speed
- average draught force
- ...

- working time, turn-over time,...
- average working speed
- average application volume
- all-up application volume
- ...

Crop Production Engineering
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
2. Standardized technologies
3. Process data acquisition systems
4. Data processing

5. **Practical applications**

6. Conclusions
### Example of operation statistics: tillage (stubble mulching)

<table>
<thead>
<tr>
<th>date</th>
<th>start time</th>
<th>end time</th>
<th>field</th>
<th>tractor</th>
<th>implement</th>
<th>procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000.08.14</td>
<td>12:33 pm</td>
<td>06:48 pm</td>
<td>S04</td>
<td>Fendt714</td>
<td>grubber</td>
<td>tillage</td>
</tr>
</tbody>
</table>

#### Used time in field

<table>
<thead>
<tr>
<th>total</th>
<th>working</th>
<th>turning</th>
<th>standing</th>
<th>time / field</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.02 h</td>
<td>75 %</td>
<td>18 %</td>
<td>7 %</td>
<td>0.72 h/ha</td>
</tr>
</tbody>
</table>

### Used as a document of the task of a contractor (proof, invoice)

<table>
<thead>
<tr>
<th>cultivated area</th>
<th>draft force at work</th>
</tr>
</thead>
<tbody>
<tr>
<td>sum</td>
<td>sum</td>
</tr>
<tr>
<td>8.37 ha</td>
<td>25.96 kN</td>
</tr>
</tbody>
</table>

Crop Production Engineering

Auernhammer / Rothmund, Sep. 2004
Data processing (visualized data points)

Anzahl der ausgewählten Datensätze: 18400
### Analyse des Geräteeinsatzes

**Lemken Grubber**

**vom 01.08.2000 bis 31.12.2004**

- 77.5 ha Einsatzfläche
- 1.9 ha/h flächenleistung
- 4.9 % Schlupf bei der Arbeit, s = 5.7

<table>
<thead>
<tr>
<th>Einsatzzeit (h)</th>
<th>Gesamt</th>
<th>Hof</th>
<th>Weg</th>
<th>Feld</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67</td>
<td>3</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Arbeit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Einsatzstrecke (km)</th>
<th>Gesamt</th>
<th>Hof</th>
<th>Weg</th>
<th>Feld</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>484</td>
<td>8</td>
<td>169</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Arbeit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rad</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>260.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>85%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Einsatzgeschwindigkeit (km/h)</th>
<th>Weg</th>
<th>Feld</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rad</td>
<td>Arbeit</td>
</tr>
<tr>
<td>8.2</td>
<td>9.7</td>
<td>9.5</td>
</tr>
<tr>
<td>s = 7.9</td>
<td>3.1</td>
<td>s = 3.0</td>
</tr>
</tbody>
</table>

- benötigte Zeit (h/ha): 0.52
- benötigter Weg (km/ha): 3.95
Use of tractors on different farmsteads

- Experimentantal station I
- Experimental station II

Crop Production Engineering
Use of a Tractor (e.g. along a year per week)

wochentliche Einsatzzeit

der ausgewählten Traktoren

vom 01.08.2000 bis 31.12.2004

Versuchsstation Dürnast

Crop Production Engineering
Practical applications – soil resistance map

Schlag Schafhof
relativer Zugkraftbedarf
(μ=100)

blau = leicht
hell = mittel
violett = schwer

- < 60
- 60 - 80
- 80 - 100
- 100 - 120
- 120 - 140
- > 140
Part field management approaches of site-specific crop management

Site-specific crop management

Large-scale farming

Derivation and determination of homogeneous partfields

- Determination of heterogeneities
- Determination of management zones (same yields) under consideration
  - Technical differentiation
  - Economical efficiency
  - Ecological efficiency

Part field determination by minimum field sizes
(> 3 ha to > 10 ha)
Part field management approaches of site-specific crop management

**Site-specific crop management**

**Large-scale farming**

**Small-scale farming**

**Derivation and determination of homogeneous partfields**

- Determination of heterogeneities
- Determination of management zones (same yields) under consideration
  - Technical differentiation
  - Economical efficiency
  - Ecological efficiency

**Part field determination by minimum field sizes**

(> 3 ha to > 10 ha)

**Consideration of part fields from different landlords in a transborder field**

- Assembling of small fields with equal crop rotation
- Definition of part fields from ownership/field operators
- Field operations by common operation target
  - Ownership
  - Common yield target
  - Heterogeneity

**Size of transborder fields limited by existing infra structure (roads, ditches, ... ) and crop rotation**
Practical applications – transborder farming

Previous use of single plots

Joint use of the transborder farming field lengthwise

Farmer A

Farmer B

Farmer C
Practical applications – transborder farming

online-acquisition of operating-times, application- and yield-volumes

allocation of times and volumes within the outlines of parcels

property based validation for each participating farmer

Software

Software
Standards from “On-farm research”

Working time

\[ t_x = 0.35 \times l_w + 2.8 \]

Working sequences

\[ w_t = w_a + w_b + w_c + ... + w_n \]

Fuel consumption

\[ f_w = kW_{tractor} \times v \times g \times ... \]

...
Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
2. Standardized technologies
3. Process data acquisition systems
4. Data processing
5. Practical applications

6. Conclusions
Conclusions

• A well-founded documentation will be the base of many agricultural applications in the future.
• Automated data acquisition is the fit way to provide spatial and temporal high-resolutions and safe documentations.
• The huge amount of raw data needs to be processed by easy-to-use and safe data processing systems.
• A Web based data management and information system is able to provide safety and effective information management for the farmer - avoiding problems with local installed software, time and costs.
• In the project on hand a first approach has been realized using “open source” software components.