PASSION TO CREATE
SKA IGM

Idea generation management
For SKA Front End Mechanics

19 December 2013
Who is Pezy

Pezy people have a passion to create innovative products. Pushing technological boundaries in the fields of mechanics and applied plastics inspires us.
ASSIGNMENT & SCOPE
Background

» Astron is working on a new type of antenna called SKA.
» This antenna has the size of a square kilometer, consisting of 128,000,000 small antenna’s.
» The feasibility of this type antenna is proven on two sites with a limited amount of antenna’s.
» Due to the amount of antenna’s Astron is looking at a breakthrough on cost price for the antenna’s.

» Pezy is specialized in the development of products for mass production, from as small as 5000 a year until 100,000,000 parts per year.
Currently the cost for the antenna-unit is calculated at approx € 3000,= per m2.

The goal is to come as low as € 1000,= per m2

In order to achieve this goal an ideation process is used to find solution for several functions to be fulfilled going from antenna unit to complete site.

The process Pezy is using is called IGM, idea generation management.

The benefit is that several useful concepts are generated in a limited time.
Scope

» Front-end of mechanics
» Mass manufacturing perspective
» Cost reduction

» Array of 1 square kilometer (128 million antennas).
» Stations of Ø56 meter with electrically interconnected Vivaldi antennas.
» Embrace Westerbork as benchmark.
# Counting the numbers

<table>
<thead>
<tr>
<th></th>
<th>Oppervlak</th>
<th>sqkm</th>
<th>Station</th>
<th>Frame</th>
<th>Container</th>
<th>Tile</th>
<th>Board</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SKA</strong></td>
<td>1.000.000 m²</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Station (Ø56m)</strong></td>
<td>2.463 m²</td>
<td>406</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frame (Embrace)</strong></td>
<td>144 m²</td>
<td>6945</td>
<td>17</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Container (TEU)</strong></td>
<td>14.6 m²</td>
<td>68493</td>
<td>169</td>
<td>10</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tile</strong></td>
<td>1 m²</td>
<td>1.000.000</td>
<td>2463</td>
<td>144</td>
<td>14,6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Board</strong></td>
<td>0,17 m²</td>
<td>6.000.000</td>
<td>14778</td>
<td>864</td>
<td>87,6</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td><strong>Antenne</strong></td>
<td>128.000.000 m²</td>
<td>315264</td>
<td>18432</td>
<td>1868</td>
<td>128</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

Based on quick calculations

**Scope**
Mass production approach

» In mass production tooling cost are negligible.
  • €1M tools (e.g. moulds) / 1,000,000 = €1,- per m²

» Material cost is driving factor in cost.
  • Including efficient use of materials, reducing waste.
  • Available sizes of metal sheets defines product size.

» Automate as much as possible.
  • Try to eliminate assembly by humans.
  • Minimize cycles times
PROCESS
Idea Generation Management

1. Develop Criteria
   - Agreed list of calibrated criteria for screening and ranking

2. Prepare for Idea search
   - Idea search briefing document

3. Idea search
   - Documented ideas

4. Screening Ideas
   - Documented idea clusters

5. Workshop & Initial ranking
   - Outline concepts

6. Brief Investigation
   - Qualified concepts

7. Final ranking
   - Concepts ready for feasibility study
Workshop
CONCEPTS
Structure vs. cover

Separate structure from array

- Antenna
- Tile
- Frame
- Station

No interaction.
Array and housing can be developed independently.
Freedom to choose optimal solutions.

Cover over array

- Partial interaction.
  Array specification influenced by cover.

Integrate cover in tile

- Cover integration in tile.
  Cover and array are completely depended
  Reducing the number of options for the antenna array.
Concept | Wave

» **Material:**
  - *Antennas:* 0,75 mm aluminized steel.
  - *Base:* 1,5 mm aluminized steel.

» **Production:**
  - Antenna parts (2 types) made by blanking process.
  - Tool investment negligible on 1M tiles.

» **Assembly:**
  - Fully automated assembly.
  - Antenna push into clamp on tile.
  - Metal pins (72) connect waves and align with base.
  - Tile assembly uses same pins, but manual assembly.
Concept | Wave

» Benefits
  • Automated assembly possible.
  • Reduced material cost.
  • RF shielding from base plate: reduced cost of PCB?
  • Stiffness in base plate.

» Risks
  • Warpage of antenna wave if not handled correctly.
  • Electrical connection if waves aren’t manufactured with accurate tolerances.
  • Tiles can’t be replace individually.
  • Tile-to-tile connection (base plate)
Concept | Box

» **Material:**
  - Modules: 1mm aluminized steel plate.

» **Production:**
  - Antenna modules made by blanking process.
  - Tool investment negligible on 1M tiles.

» **Assembly:**
  - Fully automated assembly.
  - Metal pins (256) connect antenna modules.
  - Conductive tape or foil covers slits.
**Concept | Box**

» **Benefits**
  - Automated assembly possible.
  - RF shielding from base plate: Reduced cost of PCB?
  - No separate base plate.
  - Easy to adjust size of tile.

» **Risks**
  - Stiffness of assembly due to antenna geometry. Additional plastic carrier might be needed.
  - Tiles can't be replace individually.
**Material:**
- Antennas: Aluminum sheet & plastic carrier.
- Base: Aluminum sheet & plastic base.

**Production:**
- Antenna parts (2 types) made by blanking process.
- Injection molding of plastic parts.
- Tool investment negligible on 1M tiles.

**Assembly:**
- Fully automated assembly.
- Connections with snaps integrated in plastic parts.
- Embossed geometries on aluminum sheet overcome clearances between parts.
- PCBs snapped between parts.
Concept | Plastic carrier

» **Benefits**
  - Automated assembly possible.
  - RF shielding from foil on base plate: Reduced cost of PCB?
  - Feedboard squeezed between plastic carriers: reduced assembly step.
  - Snap connections between tiles.

» **Risks**
  - Tolerances (behavior of plastics over time & temperature)
  - Interference of plastics on signal.
  - Cost of plastics dependant on required properties.
  - Tiles can’t be replace individually.
Concept | PC module

» Plastic carrier concept with integrated cover.
» Molded plastic housing (4 parts) per tile.
» Integrated drain.
» Extrude & molded cap cover slits in top.
» Bottom cover can be removed to access electronics.
Concept | PC module

**Benefits:**
- Compact.
- Electronics protected during transport.

**Risks:**
- Integration of housing with tiles, make development more intertwined and complex.
- Water tightness at heavy rainfall.
- Sealing at bottom: moisture.
- Internal humidity.
Concept overview

Wave

Box

Plastic carrier

PC module
RESULTS
Taken the electronics for fixed (out of scope) the costs for mechanics are defined and related to the overall costs.

<table>
<thead>
<tr>
<th>components</th>
<th>wave</th>
<th>box</th>
<th>plastic carrier</th>
<th>PC module</th>
<th>Embrace</th>
<th>optimized Embrace</th>
</tr>
</thead>
<tbody>
<tr>
<td>assembly costs</td>
<td>€ 20,00</td>
<td>€ 20,00</td>
<td>€ 23,33</td>
<td>€ 23,33</td>
<td>€ 100,00</td>
<td>€ 28,33</td>
</tr>
<tr>
<td>mechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>investment</td>
<td>€ 3.310.000</td>
<td>€ 4.110.000</td>
<td>€ 5.100.000</td>
<td>€ 6.490.000</td>
<td>€ 8.800.000</td>
<td></td>
</tr>
<tr>
<td>redemption</td>
<td>€ 3,11</td>
<td>€ 4,11</td>
<td>€ 5,10</td>
<td>€ 6,49</td>
<td>€ 8,80</td>
<td></td>
</tr>
<tr>
<td>mech cost/ m2</td>
<td>€ 174,09</td>
<td>€ 185,59</td>
<td>€ 174,39</td>
<td>€ 222,13</td>
<td>€ 600,04</td>
<td>€ 278,23</td>
</tr>
<tr>
<td>feedboard</td>
<td>€ 512</td>
<td>€ 512</td>
<td>€ 512</td>
<td>€ 512</td>
<td>€ 512</td>
<td>€ 512</td>
</tr>
<tr>
<td>hex PCB</td>
<td>€ 1.800</td>
<td>€ 1.800</td>
<td>€ 1.800</td>
<td>€ 1.800</td>
<td>€ 1.800</td>
<td>€ 1.800</td>
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<tr>
<td>main PCB</td>
<td>€ 300</td>
<td>€ 300</td>
<td>€ 300</td>
<td>€ 300</td>
<td>€ 300</td>
<td>€ 300</td>
</tr>
<tr>
<td>total cost/m2</td>
<td>€ 2.786,09</td>
<td>€ 2.797,59</td>
<td>€ 2.786,39</td>
<td>€ 2.834,13</td>
<td>€ 3.212,04</td>
<td>€ 2.890,23</td>
</tr>
<tr>
<td>perc mech</td>
<td>6,2%</td>
<td>6,6%</td>
<td>6,3%</td>
<td>7,8%</td>
<td>18,7%</td>
<td>9,6%</td>
</tr>
</tbody>
</table>

In this calculations no cost for frame, structure or Radome/building are taken into account.
Learnings

Without ranking the 4 new concepts some learnings for the front end are already clear

- Reduce material as much as possible for the antenna
- Put maximum effort is making assembly automated (robot or dedicated assembly line)
- Put maximum effort in reducing costs of electronics because with all the effort done, investments taken into account, the share of the costs of mechanics is only 6% to 8% in total!
- To get a real price break through a break through on electronics level is key
## Attractiveness
Cost reduction potential & function

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cost reduction materials</td>
<td>10%</td>
</tr>
<tr>
<td>2 Optimized for automation</td>
<td>24%</td>
</tr>
<tr>
<td>3 Ease of installation in the field</td>
<td>24%</td>
</tr>
<tr>
<td>4 Cost of ownership: maintenance, replacement, servicability</td>
<td>14%</td>
</tr>
<tr>
<td>5 Lifetime &amp; protection against environmental influences (potential)</td>
<td>8%</td>
</tr>
<tr>
<td>6 Function: Accuracy, flatness</td>
<td>20%</td>
</tr>
</tbody>
</table>

## Fit
Technical & project risks

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Development Risk (feasibility, mechanics)</td>
<td>35%</td>
</tr>
<tr>
<td>2 Maturity (production, process)</td>
<td>20%</td>
</tr>
<tr>
<td>3 Development Time</td>
<td>10%</td>
</tr>
<tr>
<td>4 Adaptability of design (after production start) / Upgradability</td>
<td>25%</td>
</tr>
<tr>
<td>5 Investment / Capital Investment</td>
<td>10%</td>
</tr>
</tbody>
</table>
Ranking

<table>
<thead>
<tr>
<th>Embrace</th>
<th>Wave</th>
<th>Box</th>
</tr>
</thead>
</table>

Attractiveness vs. Fit

- Plastic carrier
- PC module
RECOMMENDATIONS
Recommendations

» Concepts
  - Keep it simple, sheet metal is state of the art and fits the application
  - Separate antenna from the structure (e.g. dome)
  - Focus on automation of assembly

» Next focus should be on cost reduction of electronics

» IGM can also be used to get an overview of feasible & attractive options for electronics
PASSION TO CREATE

THANK YOU, ANY QUESTIONS?