HFCC 2018 Bratislava

Product Launch:
Low Power Solid-State Shortwave
## Our Mission

| Science          | Ampegon designs and delivers high power systems for world-class research facilities.  
|                 | « We offer RF amplifier systems, high voltage and high current power supplies as well as short and long pulse modulators. » |
| MedTech         | Ampegon designs and delivers high power RF systems for medical institutions.  
|                 | « We offer pulsed power technologies, RF amplifiers and power supplies as well as our extensive system experience. » |
| Industry        | Ampegon cooperates with industrial partners to implement novel and more efficient processes.  
|                 | « We offer pulsed vacuum arc power supplies and a wide range of RF amplifiers and power supplies for specialized industries. » |
| Broadcast       | Ampegon is the leading designer, manufacturer and integrator of AM/DRM radio broadcast systems worldwide.  
|                 | « We offer the complete system including transmitters, antennas, towers and masts and a wide range of auxiliary equipment including adjacent power plants. » |
Heritage of Excellence

1937: Opening of the Broadcast division at BBC.
1988: BBC and Asea merge to new ABB Group.
1993: ABB Infocom sold to Thomson-CSF.
2000: Thomson-CSF is renamed to Thales, the Broadcast Division to Thales Broadcast & Multimedia.
2006: Thales Broadcast & Multimedia is sold to Thomson.
2010: Thomson is renamed to Technicolor and the Broadcast Division to Thomson Broadcast.
2012: Thomson Broadcast is sold to an Investor Group and part of it is established as Ampegon.
## Term: Solid State

<table>
<thead>
<tr>
<th>Tube</th>
<th>Solid State</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Tube Diagram" /></td>
<td><img src="image2.png" alt="Solid State Diagram" /></td>
</tr>
</tbody>
</table>

- Electrons are not flowing through the vacuum gap. Electron gun
  - Electron current flows only through solid semiconductor (transistor).
Shortwave Transmitter Range

**1,5 kW – 25 kW solid state:**

- Full Solid State class E amplifier, now heading to class A/B thanks to envelope tracking
- Up to 4 broadcast frequency bands with Class E and Wideband with class A/B
- Integrated DRM solution
- User-friendly control with touch screen UCS
- Full remote control facilities and interface
- Compact high quality and modular design
- Overall efficiency > 80%

**100 kW – 500 kW tube based:**

- Universal Control System UCS with touch
- New Tuning System and full remote control
- Simplified Measurement Acquisition System
- Data display, logging; analysis
- DRM integration
- Exceptional overall efficiency > 70%
Modular power scaling

- Transmitter system is in four different power classes available
  Optional redundant setup and configuration available

- 1.5 kW - 6 kW
- 12 kW to 25 kW
Universal/Unified Control System UCS

- Touch screen monitor
- Dedicated FPGA based control systems
  - SW, ASM, PSM
- Real time signal processing and information
- State machine controller
  - Coordination and supervision
- Provides safety for operating staff
- Equipment protection
- Ensures simplicity of transmitter operation
  - Dedicated login levels
  - Remote control interfaces
## Comparison: Solid state vs. tube based

<table>
<thead>
<tr>
<th>Item</th>
<th>Tube</th>
<th>SSA</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier Power</td>
<td>100 kW-500 kW</td>
<td>1.5 kW to 25 kW</td>
<td>SSA limited by RF power. Needs combiners but still limited.</td>
</tr>
<tr>
<td>Voltage</td>
<td>10 kV to 20kV</td>
<td>400 V</td>
<td>SSA plug &amp; play</td>
</tr>
<tr>
<td>Coverage</td>
<td>&gt; 1000 km</td>
<td>&lt; 1000 km</td>
<td>SSA good enough for most regional and national territories</td>
</tr>
<tr>
<td>Efficiency</td>
<td>&gt; 70%</td>
<td>&gt; 80%</td>
<td>Saves consumption: less power for the same coverage</td>
</tr>
<tr>
<td>Maintenance / after sales</td>
<td>Tube: consumable Not redundant</td>
<td>Semiconductor Redundant</td>
<td>SSA requires very low maintenance. Tubes are expensive. Transistors within days. Tubes : 4-6 months!!!</td>
</tr>
<tr>
<td>Installation &amp; infrastructure</td>
<td>4 to 5 weeks</td>
<td>1 week</td>
<td>Services are much less costly with SSA.</td>
</tr>
</tbody>
</table>
**Engineering/System Optimisation**

**Transmitter**

**Feeder Lines**

**Antenna**

**Radiation**

**Perfect Coverage**

**System Efficiency** = \( \eta_{\text{Transmitter}} \times \eta_{\text{Feeder}} \times \eta_{\text{Antenna}} \times \eta_{\text{Radiation}} \)

<table>
<thead>
<tr>
<th>( \eta_{\text{TX}} )</th>
<th>( \eta_{\text{Feeder}} )</th>
<th>( \eta_{\text{Antenna}} )</th>
<th>( \eta_{\text{Radiation}} )</th>
<th>( \eta_{\text{Total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern TX: 75 to 80 %</td>
<td>Best: 95 %</td>
<td>Best: 98 %</td>
<td>Perfect Design: 99 %</td>
<td>Best: ~ 70 %</td>
</tr>
<tr>
<td>Older TX: 50 to 55 %</td>
<td>Very Often: 70 %</td>
<td>Very Often: 95 %</td>
<td>With Shielding: 70 %</td>
<td>Very Often: ~ 25 %</td>
</tr>
</tbody>
</table>

- ground losses
- ohmic losses
- Radiation losses

Reality with slewing "rotating beams"
Solid state amplifiers
Full Solid-State Class-E, A/B Amplifier Module

- Class-E: $\eta > 80\%$ but limited to 10 MHz: 1st generation. Only 4 freq. bands
- Modern Class A/B $\eta > 70\%$, covers all SW range: 3 to 26 MHz. 2nd generation: Wideband
- Modern class A/B amplis efficient thanks to Enveloppe tracking
- Reliable and robust design
- Direct modulated RF and AF digitally controlled
- Fast measurement and supervision on board
- Embedded interface for control and monitoring
- Future aim is 50 kW
Linear RF Amplifier : e.g. Class A

Key Characteristics:
- Small RF input signal, large RF output signal
- Can **amplify** any kind of modulation  
  (Quality depends on linearity)
Output of an Amplifier

- Usable amplifier. Output filters-harmonics elimination-Distortions thanks to amplifier linearity.
Audio Quality measurement

- Excellent
  Audio level within 10 kHz bandwidth.
  Linear response

- Excellent
  THD+N
  Audio distortion and Noise figure
Future of SW Digital transmission

• Gradually traditional SW Radio broadcasting is being replaced with FM broadcast technologies. Thanks to DRM, new SW applications and opportunities are possible.

• This is freeing up bandwidth in the SW spectrum and providing opportunities for others (other applications).

• Digital DRM radio has the potential to further compress channels and over very large distances up to thousands of miles with minimal costs.

• To transmit the same amount of information, DRM saves about 60% of the electricity bill. It consumes much less energy than analog transmission to cover the target area and with much higher quality.

• Shortwave offers incredible potential as a communication medium, but what could we do with it?
**Strengths of Shortwave**

- Voice of Nigeria 500 kW/Abuja-Target Europe

- SW can propagate over intercontinental distances.

- Broadcaster can be remote from infinite numbers of receivers

- Minimal infrastructure required + Min. Costs

- Immediate data transmission: Extremely fast transmission
Strengths of Shortwave

- Hundreds of channels with 9/10 kHz bandwidth.
- Future possibility of double bands for increased data rate? Transmitters are capable of double band broadcast.

Zero fixed infrastructure required for receiver network.

Broadcasts are freely available to hundreds / thousands / millions of undefined, mobile locations.
Coverage area comparison FM vs DRM30

100kW SW or MW: DRM is compressed to get an ~ FM quality: 32 kbits /s

1 Transmitter

DRM Coverage
100kW transmitter
-> 40kW DRM

600km

40kW @ 80% efficiency
Digital error correction

Min. 15 FM Transmitters

FM Coverage
Min. 15 x 10kW FM

75km

150kW @ 60% efficiency
Digital SW coverage study: Myanmar: 10 kW Tx
Rapid Intercontinental Data Communication

• Transport
• Education
• Radio programs
• Military
Rapid Intercontinental Data Communication (1/4)

- 1965 - present
- Technology: Satellite communication
- Typical Message Transmission time: 250ms (+ signal processing)
- Application: High bandwidth TV and data
- Limitations: Expensive bandwidth, orbital distance limits speed

\[ \Delta t = \frac{2}{c} \sqrt{R^2 + r^2 - 2Rr \cos \phi} \approx 253 \text{ ms.} \]

(Assuming ground station latitude, $\phi = \pm 45^\circ$, where $R$ is Earth’s radius and $r$ is orbital radius)
Rapid Intercontinental Data Communication (2/4)

- 1988 – present
- Technology: Fibre-optic cable
- Typical Message Transmission time: 60ms - 100ms (+infrastructure delay)
- Application: Speech, TV and high bandwidth data
- Limitations: Repeaters, data security

« Can you send me the report for my client? »

« No problem! Please find it attached. »
Rapid Intercontinental Data Communication (4/4)

- 2016 - ?
- Technology: Digital SW transmission
- Typical Message Transmission time: <20ms (+ signal processing)
- Application: Encoded digital data
- Advantages: High speed, secure, digital error correction possible

111001010000 («Emergency! Go NOW!»)

«Immediately?!?»
«Good job! We made it just in time»!
Automotive communications

- Shortwave’s strengths: Existing technology allows broadcast to wide ranging, dispersed, mobile targets, without fixed infrastructure.

- A single large transmitter with an appropriate antenna could broadcast high quality digital audio and data to every car travelling in an entire country or continent! Software updates can cost billions!
- A simple SW message could do it within minutes for every single car within the broadcast footprint.
Built-In Car Receivers (examples)

- Car Manufacturers in India launch new models with line-fit DRM Receiver at no extra cost
Automotive Communication

- Even in large cities, a good antenna with the smallest SW transmitter would cover every vehicle within 20 miles and more.

- Using PACTOR IV mode data compression, 1MB software update can be transmitted in about 3min.

- Error correction means that after perhaps 3-6min, the update could be received and installed.

- Following the Diesel Emissions Scandal of 2015/16, VW set aside €6.8bn to recall cars. Of 8.5M vehicles in Europe needing to be recalled, the majority of these ONLY needed to update engine management software!
Automotive SW antennas

- Cars have had passive antennas inside rear windows for decades! The antenna is also the window heater!
Small SW Transmitter can be mobile for Sites?

Mobile Transmitter + Mobile Antenna + DRM = Redundancy or Emergency/Crisis Management System
New digital shortwave technology is fast approaching for digital data applications with:

- Requirements for rapid data transmission with min. investment costs
- Receivers without fixed infrastructure
- Expensive third-party data connections are avoided
- Enormous numbers of targets
- Regional, national or even continental coverage
- The potential for profitable business in this field is enormous!

What could YOU use it for?
Worldwide Broadcast Systems References
Selection of Consortium Members

- The non-profit DRM Consortium supports and promotes the DRM Standard and it takes up globally.
## DRM Transmission Schedules Online

<table>
<thead>
<tr>
<th>TIME IN UTC/GMT</th>
<th>BROADCASTER</th>
<th>FREQ in kHz</th>
<th>DAYS</th>
<th>LANGUAGE</th>
<th>TARGET</th>
<th>TRANSMITTING SITE</th>
<th>Power kW</th>
<th>Antenna beam degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>0100-0200</td>
<td>Radio France International</td>
<td>3965</td>
<td>Daily</td>
<td>French</td>
<td>France</td>
<td>France, Issoudun</td>
<td>1</td>
<td>Non Directional</td>
</tr>
<tr>
<td>0530-0700</td>
<td>BBC World Service</td>
<td>3955</td>
<td>Daily</td>
<td>English</td>
<td>NW Europe</td>
<td>UK, Woolerton</td>
<td>100</td>
<td>114</td>
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<tr>
<td>0700-0930</td>
<td>Radio Romania International</td>
<td>7330</td>
<td>Daily</td>
<td>French</td>
<td>W. Europe</td>
<td>Romania, Galbeni</td>
<td>90</td>
<td>285</td>
</tr>
<tr>
<td>0830-0800</td>
<td>Radio Romania International</td>
<td>7330</td>
<td>Daily</td>
<td>English</td>
<td>W. Europe</td>
<td>Romania, Tiganesti</td>
<td>90</td>
<td>307</td>
</tr>
<tr>
<td>0900-0930</td>
<td>Radio Romania International</td>
<td>7330</td>
<td>Daily</td>
<td>German</td>
<td>W. Europe</td>
<td>Romania, Tiganesti</td>
<td>90</td>
<td>307</td>
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<tr>
<td>0945-1325</td>
<td>Radio Kuwait</td>
<td>15110</td>
<td>Daily</td>
<td>Arabic</td>
<td>Europe</td>
<td>Kuwait, Sulaimiyah</td>
<td>200</td>
<td>110</td>
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<tr>
<td>1000-1700</td>
<td>WINE</td>
<td>11670</td>
<td>Mon-Fri</td>
<td>English and Spanish</td>
<td>Europe</td>
<td>USA, Red Lion, PA</td>
<td>15</td>
<td>62</td>
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<tr>
<td>1000-1800</td>
<td>Radio Romania International</td>
<td>9760</td>
<td>Daily</td>
<td>English</td>
<td>W. Europe</td>
<td>Romania, Tiganesti</td>
<td>90</td>
<td>307</td>
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<tr>
<td>1200-2100</td>
<td>Radio Kuwait</td>
<td>15540</td>
<td>Daily</td>
<td>English</td>
<td>W. Europe</td>
<td>Kuwait, Sulaimiyah</td>
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<td>1600-1830</td>
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<td>Daily</td>
<td>Italian</td>
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<tr>
<td>1800-1900</td>
<td>Radio Romania International</td>
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<td>2030-2100</td>
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<td>Romania, Galbeni</td>
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<td>300</td>
</tr>
</tbody>
</table>
Thank you!