Products, Capabilities and Partnering in X-Band and Other Sources

Jim McVea
Scientific Products Sales Manager
Thales Components Corp.
Breakdown in Average Turnover

THALES Revenue

Rest of Thales

TED

TED by Applications

Digital Radiology

Conventional Radiology

Communication
Space
Telecoms
Broadcast

Security/NDT Industry

Science
roughly 20 M€

THALES – mainly systems company

THALES Electron Device (TED) – Components and Subsystems

Components & Subsystems
Components & Subsystems

Your Partner in Science
Recent Examples
Recent Key Orders

- Qty five 352 MHz pulsed; $1.6\text{MW}_{\text{pk}} / 144\text{kW}$ avg. UHF klystrons

- Thales is the prime contractor on 2 new complete RF Amplifier Systems
  - 500 MHz; 300 kW CW klystron and SS driver from TED

- Qty three 1.3GHz klystrons to be installed soon in a Wakefield accelerator
More Recent Key Orders

- CNRS for the procurement of a turn key test station for the conditioning of the X-FEL couplers.

- VHF Gun project
  200 kW 187 MHz amplifier
  For LBNL courtesy ETM

- Thales provided technical assistance for RF components installation at Trieste

Acc. Tunnel with Compression Cavities manufactured by Thales

Klystron gallery with qty 12 TH2132A
3 GHz, 45 MW pk; 4.5 usec pulse
More Recent Key Orders

- IFMIF – RF amplifiers
  - 20 RF chains with TH 561 SC & TH 781

- New RF positions for FELs and injectors
  - TH 2100 S-band klystrons at TPS and BESSY
  - TH2130 S-band klystrons at Nijmegen and Berlin

- New contract signed on the ITER gyrotron
Existing/active X-Band Products and General Capabilities
More than half of all images/data transmitted goes through a Thales space tube.
Uplink / Telecommunications

TH3855B
2.5 kW, 7.9 - 8.4 GHz

One X-band TWT but many more in Ku, DBS, Ka, EF

Components & Subsystems
## Defense – Airborn Radar

### Helix TWVs

<table>
<thead>
<tr>
<th>Band</th>
<th>Reference</th>
<th>Bandwidth</th>
<th>Peak output power</th>
<th>Duty</th>
<th>Gain min.</th>
<th>Cathode voltage</th>
<th>Cathode current</th>
<th>Dimensions L x W x T</th>
<th>Weight</th>
<th>Focusing (T)</th>
<th>Cooling</th>
<th>RF Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TH 4404</td>
<td>10</td>
<td>2</td>
<td>48</td>
<td>10.7</td>
<td>1.4</td>
<td>320 x 43 x 80</td>
<td>2.5</td>
<td>PPM</td>
<td>conduct</td>
<td>TNC</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 3926 A</td>
<td>5</td>
<td>3.5</td>
<td>35</td>
<td>12</td>
<td>1.4</td>
<td>295 x 96 x 79</td>
<td>3.0</td>
<td>PPM</td>
<td>forced-air</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 4021 A</td>
<td>20</td>
<td>4</td>
<td>39</td>
<td>12</td>
<td>1.7</td>
<td>393 x 70 x 64</td>
<td>2.5</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 3998</td>
<td>20</td>
<td>8</td>
<td>42</td>
<td>14.7</td>
<td>2.8</td>
<td>393 x 70 x 64</td>
<td>2.5</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 4472</td>
<td>6</td>
<td>9</td>
<td>42</td>
<td>14.8</td>
<td>2.8</td>
<td>392 x 128 x 80</td>
<td>-</td>
<td>PPM</td>
<td>forced-air</td>
<td>WR90</td>
<td>WR90</td>
</tr>
</tbody>
</table>

### Coupled cavity and metallic delay line TWVs

<table>
<thead>
<tr>
<th>Band</th>
<th>Reference</th>
<th>Bandwidth</th>
<th>Peak output power</th>
<th>Duty</th>
<th>Gain min.</th>
<th>Cathode voltage</th>
<th>Cathode current</th>
<th>Dimensions L x W x T</th>
<th>Weight</th>
<th>Focusing (T)</th>
<th>Cooling</th>
<th>RF Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TH 3772</td>
<td>3</td>
<td>4</td>
<td>25</td>
<td>19</td>
<td>0.95</td>
<td>394 x 153 x 108</td>
<td>8</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 4420s</td>
<td>5</td>
<td>15 to 20</td>
<td>43</td>
<td>25</td>
<td>3.2</td>
<td>445 x 130 x 130</td>
<td>7.5</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 4405s</td>
<td>3</td>
<td>35/5</td>
<td>55/31</td>
<td>32</td>
<td>5.4/1.4</td>
<td>505 x 160 x 143</td>
<td>12</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
<tr>
<td></td>
<td>TH 4406</td>
<td>3</td>
<td>120</td>
<td>0.5</td>
<td>45</td>
<td>45</td>
<td>430 x 150 x 140</td>
<td>9.5</td>
<td>PPM</td>
<td>conduct</td>
<td>WR90</td>
<td>WR90</td>
</tr>
</tbody>
</table>

Various **TWT** technology for defense applications
**Defense - Surface Radar & Other**

**Coaxial magnetron**

<table>
<thead>
<tr>
<th>Band</th>
<th>Reference</th>
<th>Tunable Bandwidth</th>
<th>Peak Output Power</th>
<th>Duty</th>
<th>Peak Voltage</th>
<th>Peak Current</th>
<th>Dimensions (L x W x H)</th>
<th>Weight</th>
<th>Radar bandwidth</th>
<th>Cooling</th>
<th>RF Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TH 3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>195 x 98 x 176</td>
<td>0.5</td>
<td>2.5</td>
<td>coolend</td>
<td>WR 112</td>
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</table>

**Magnetron**

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency</th>
<th>Reference</th>
<th>Peak Output Power</th>
<th>Duty</th>
<th>Peak Voltage</th>
<th>Peak Current</th>
<th>Tunable Bandwidth</th>
<th>Dimensions (L x W x H)</th>
<th>Weight</th>
<th>Radar bandwidth</th>
<th>Cooling</th>
<th>RF Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.5 - 8.9</td>
<td>TH 2170</td>
<td>70</td>
<td>1</td>
<td>100</td>
<td>12.6</td>
<td>2.2</td>
<td>15</td>
<td>20</td>
<td>0.15</td>
<td></td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>0.6 - 1.5</td>
<td>TH 3071-A</td>
<td>120</td>
<td>0.5</td>
<td>100</td>
<td>13.75</td>
<td>3.1</td>
<td>21.5</td>
<td>27.5</td>
<td>0.2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>8.025 - 9.225</td>
<td>TH 3121</td>
<td>90</td>
<td>3</td>
<td>400</td>
<td>12.6</td>
<td>2.2</td>
<td>15</td>
<td>18</td>
<td>0.05</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>0.5 - 6.9</td>
<td>MQU123</td>
<td>5.2</td>
<td>0.3</td>
<td>500</td>
<td>6.3</td>
<td>1</td>
<td>3.56</td>
<td>3</td>
<td>0.2</td>
<td></td>
<td>0.4</td>
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</tbody>
</table>

\( */\) The frequency range / \(77.5 \text{ to } 6 \text{ GHz}\) is measured for TH2477 in table

**TH2477 X- band**

**KLYSTRON**

- 3 cavities
- Insulated collector
- Waveguide input and output
- Integrated permanent magnet focus
- Liquid cooling: water
- Frequency range of operation: 9.5 to 10.0 GHz (not included)

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**Magnetrons, and klystrons** for defense applications

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Components & Subsystems
Defense - Surface Radar

High peak power, very wide band helix TWTs

<table>
<thead>
<tr>
<th>Band</th>
<th>Reference</th>
<th>Frequency</th>
<th>Peak output power</th>
<th>Average power</th>
<th>Standard gain</th>
<th>Duty cycle</th>
<th>Pulse length</th>
<th>Rectifier voltage</th>
<th>Helix Output</th>
<th>Beam voltage</th>
<th>Beam current</th>
<th>Cooling</th>
<th>Beam enlargement</th>
<th>(-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>TH 3826</td>
<td>2.4 - 2.5</td>
<td>22 550 42 3 23 12 8 24</td>
<td>4.6</td>
<td>forced-air</td>
<td>PPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 3926 A</td>
<td>8.4 - 9.3</td>
<td>6 120 55 6.23 65 6.3 3.5 12</td>
<td>1.4</td>
<td>forced-air</td>
<td>PPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 4021 A</td>
<td>8.5 - 10.5</td>
<td>4 400 39 10 150 6.3 2.5 12</td>
<td>1.7</td>
<td>conduction</td>
<td>PPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 3991</td>
<td>8.5 - 10.5</td>
<td>8 400 42 5 100 6.3 2.5</td>
<td>14.7</td>
<td>2.4</td>
<td>conduction</td>
<td>PPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 4472</td>
<td>8.4 - 10</td>
<td>9 600 42 6.5</td>
<td>120</td>
<td>6.3 3.5</td>
<td>14.8</td>
<td>2.8</td>
<td>forced-air</td>
<td>PPM</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

Pulsed traveling-wave tubes (continued)

<table>
<thead>
<tr>
<th>Band</th>
<th>Reference</th>
<th>Frequency</th>
<th>Peak output power</th>
<th>Standard gain</th>
<th>Duty cycle</th>
<th>Pulse length</th>
<th>Rectifier voltage</th>
<th>Helix Output</th>
<th>Beam voltage</th>
<th>Beam current</th>
<th>Cooling</th>
<th>Beam enlargement</th>
<th>(-)</th>
<th>Specific-usage or notes</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>TH 5501 A</td>
<td>(1) (1)</td>
<td>46 0.015 10 10 6.1 2.3</td>
<td>11</td>
<td>1.8</td>
<td>forced-air</td>
<td>PPM</td>
<td>helix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 3569</td>
<td>8.6 - 9.5</td>
<td>38 54 0.0004 20 11 3.1</td>
<td>20.5</td>
<td>7.1</td>
<td>forced-air</td>
<td>PPM</td>
<td>coupled-cavity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 3643</td>
<td>9.8 - 9.2</td>
<td>38 64 0.0004 20 11 3.1</td>
<td>20.5</td>
<td>7.1</td>
<td>forced-air</td>
<td>PPM</td>
<td>coupled-cavity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 4125</td>
<td>(1) (1)</td>
<td>46 (1) 30 10.5 5.1</td>
<td>48</td>
<td>16</td>
<td>liquid</td>
<td>conical (integral)</td>
<td>coupled-cavity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>X</td>
<td>TH 3867</td>
<td>8.5 - 9.5</td>
<td>100 51 0.001 100 7 7</td>
<td>45</td>
<td>13.5</td>
<td>liquid</td>
<td>conical</td>
<td>coupled-cavity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>TH 3984</td>
<td>8.8 - 9.5</td>
<td>8 61 0.02 45 6.3</td>
<td>21</td>
<td>13.5</td>
<td>2.5</td>
<td>conduction</td>
<td>PPM</td>
<td>dog-and-loop</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

World leader for **TWTs** for radars, electronic counter-measures, missiles and data links

Components & Subsystems
World leader for **transmitters** for radars, electronic counter-measures, missiles and data links
### Oscillator gyrotrons

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Reference</th>
<th>Output Power</th>
<th>Pulse Length</th>
<th>Efficiency</th>
<th>Output Mode</th>
<th>Peak Beam Voltage</th>
<th>Peak Beam Current</th>
<th>Focusing Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 GHz</td>
<td>TH1504</td>
<td>1 000</td>
<td>1</td>
<td>45</td>
<td>axial</td>
<td>85</td>
<td>27</td>
<td>TH20368</td>
</tr>
</tbody>
</table>

**TH1504 1 MW at 8 GHz Gyrotron**

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**High Power, High Frequency Products**

**Components & Subsystems**
Vélizy (France)

- Design and production of Traveling Wave Tubes, klystrons, gyrotrons, generators, space amplifiers, defense transmitters, energy storage...
- 32,000 m² of industrial surface, including 3,000 m² clean rooms
- ISO 9001 v 2000
  ISO 14 001
- 777 employees
- 34 industrial patents

Producing space tubes; scientific klystrons; telecom and defense tubes
Ulm (Germany)

- Design and production of traveling wave tubes, space amplifiers and ion thrusters
- 13,400 m² industrial surface, including 1,300 m² clean rooms
- ISO 9001 v 2000
- ISO 14 001
- 420 employees
- 32 industrial patents

# 1 for space tubes; Original sole source for the "Patriot" Missile system
Thonon (France)

- Production of grid tubes, x-ray sources and Traveling Wave Tubes
- 25 000 m² of industrial surface, including 200 m² clean rooms
- ISO 9001 v 2000
- ISO 14 001
- 379 employees
- 27 industrial patents

Producing industrial and broadcast tubes

Power triodes and tetrodes

X-ray sources

TWTs
General Vacuum Electron Device Capabilities

- **Experience**: high frequency capabilities demonstrated by precision TWTs; high power by our Gyrotron and S-band klystrons can assist with X-band designs.

- **Sustainable presence**: over 60 years of experience in the design and manufacturing

- **High technology**: 167 valid industrial patents - mastering key technologies

- **Know-How**: mastering processes and manufacturing methods of products sometimes unique in the world

- **Expertise**: in-depth knowledge of our customer’s applications

- **Industrial means**: heavy industrial means, manufacturing, control and test equipment tailor-designed
Thales is committed to the scientific market segment as demonstrated by our:

• Dedicated engineering, production service and marketing and sales teams

• Active R&D (cathodes, solid state, etc) and product design for the community

• Large investment (4M Euros) for a new high power klystron test stand
Thales has a number of existing x-band products of varying technologies and we have undertaken market studies for new potential products.

Admittedly, we do not have a klystron with high output power that has been discussed this week, but key technologies and know how can be adapted, especially with external information (and possible assistance).

We are always interested in products for the Scientific marketplace as long as there is an on going demand for these products (and funding...).
Thales wishes to thank Chris Adolphsen, SLAC and FLS for the opportunity to make this presentation.