A small SOPC-based aircraft autopilot system that contains an FPGA with a Nios processor core, a DSP processor, and memory is seen above. The bottom sensor board contains a GPS receiver, an A/D converter, MEMS gyros and accelerometers for all three axes, an airspeed sensor, and an altitude sensor. Photograph ©2004 courtesy of Henrik Christophersen, Georgia Institute of Technology Unmanned Aerial Research Facility.
Table 15.1 Features of Commercial Soft Processor Cores for FPGAs

<table>
<thead>
<tr>
<th>Feature</th>
<th>Nios II 5.0</th>
<th>MicroBlaze 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datapath</td>
<td>32 bits</td>
<td>32 bits</td>
</tr>
<tr>
<td>Pipeline Stages</td>
<td>1-6</td>
<td>3</td>
</tr>
<tr>
<td>Frequency</td>
<td>Up to 200 MHz(^\text{[1]})</td>
<td>Up to 200 MHz(^4)</td>
</tr>
<tr>
<td>Gate Count</td>
<td>26,000 – 72,000</td>
<td>30,000 – 60,000</td>
</tr>
<tr>
<td>Register File</td>
<td>32 general purpose &amp; 6 special purpose</td>
<td>32 general purpose &amp; 32 special purpose</td>
</tr>
<tr>
<td>Instruction Word</td>
<td>32 bits</td>
<td>32 bits</td>
</tr>
<tr>
<td>Instruction Cache</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Hardware Multiply &amp; Divide</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Hardware Floating Point</td>
<td>Third Party</td>
<td>Optional</td>
</tr>
</tbody>
</table>

\(^{[1]}\) This speed is not achievable on all devices for either processor core. Some FPGAs may limit the maximum frequency to as low as 50 MHz.
The CAD tool flow for SOPC design is comprised of the traditional design process for FPGA-based systems with the addition of the Processor Core Configuration Tool and software design tools. In this figure, the program and data memory is assumed to be on-chip for simplicity.
Figure 15.2 This arrangement of on-chip and external memories provides flexibility and performance to an SOPC system.
Table 15.2 Comparing SOPC, ASIC, and Fixed-Processor Design Modalities

<table>
<thead>
<tr>
<th>Feature</th>
<th>SOPC</th>
<th>ASIC</th>
<th>Fixed-Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>S/W Flexibility</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>H/W Flexibility</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Reconfigurability</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Development Time/Cost</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Peripheral Equipment</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Production Cost</td>
<td>○</td>
<td>●</td>
<td>[1]</td>
</tr>
<tr>
<td>Power Efficiency</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

**Legend:**  ● – Good; ○ – Moderate; ○ – Poor

[1] In very large quantities.