End-to-end network
The nanoLab solution provides all of the elements necessary to create a mobile phone network, in effect providing a private network that has myriad uses in and out of the laboratory.

Application flexibility
The nanoLab solution can be applied to a wide range of use cases. Here is a sample of possible applications for nanoLab:
- UE testing
- Mobile app testing
- Equipment compatibility testing
- Hardware and/or software product functionality testing and verification
- Customer demonstrations
- Vulnerability testing
- Forensic analysis

Carrier grade Access Points
The ip.access carrier grade Access Points (APs) are deployed commercially by over 100 MNOs and in many private networks worldwide. Hence the nanoLab solution provides a highly accurate and realistic emulation of a mobile network.

Requiring only Ethernet and power connections, APs support 2G, 3G and 4G (LTE FDD and LTE TDD) air interfaces in a variety of worldwide frequency bands, including 3.5GHz Citizen's Broadband.

Modular and Scalable
The elements of the nanoLab solution are:
- Any combination of carrier grade 2G, 3G and 4G Access Points from ip.access, with 5G coming soon
- A fully featured mobile core switching system, with an HSS and MSS including MSC, SGSN, SGW and MME, depending on selected radio technologies
- A powerful management system, including the ip.access OMC-R, the ip.access Network Orchestration System and/or TR-069 ACS, depending on selected radio technologies
- SIM cards for handsets and terminals (UEs) connecting to the system

For portability, the mobile core and management VMs run on a laptop. This can be server based for static deployments and/or for serving large numbers of Access Points.

As a modular solution, there can be any number of Access Points. For example, one or two APs for small scale requirements or hundreds or thousands of APs for large scale network emulation.
nanoLab™ features

Band support
The nanoLab solution supports all standard 2G, 3G and 4G bands and frequencies from 425MHz to 3.8GHz. The standard ip.access small cells include support the following bands:
- GSM bands 2, 3, 5 and 8
- UMTS bands 1 and 2/5
- LTE FDD bands 2 and 3
- LTE TDD bands 40 and 48 (CBRS/OnGo)

For maximum flexibility, use the unbanded multi-RAT S60z AP integration module that can be configured to operate in any valid band/frequency combination from 425MHz to 3.8GHz. The S60z AP module is a low power device that, for high power applications, simply needs an RF front end module to support the required band of operation.

Mobility
All ip.access APs support intra-RAT and inter-RAT idle mode mobility between 2G, 3G and 4G.

Connected mode mobility (handover) support is as follows:

<table>
<thead>
<tr>
<th>From</th>
<th>2G</th>
<th>3G</th>
<th>4G</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G</td>
<td>CS only</td>
<td>CS only</td>
<td>no</td>
</tr>
<tr>
<td>3G</td>
<td>CS only</td>
<td>CS + PS</td>
<td>PS only</td>
</tr>
<tr>
<td>4G</td>
<td>VoLTE</td>
<td>VoLTE + PS</td>
<td>VoLTE + PS</td>
</tr>
</tbody>
</table>

Virtualised Core Network and AP Management
The core network functionality is provided by a software core running on a virtual machine. The software core includes all the functionality needed for any combination of 2G, 3G and/or 4G AP connectivity and switching, depending on the RAT licensing required.

The software core optionally provides 2G BTS management, hence a TR-069 ACS such as the ip.access NOS is required for 3G and/or 4G AP management.

If preferred, the ip.access OMC-R is available for 2G BTS management.