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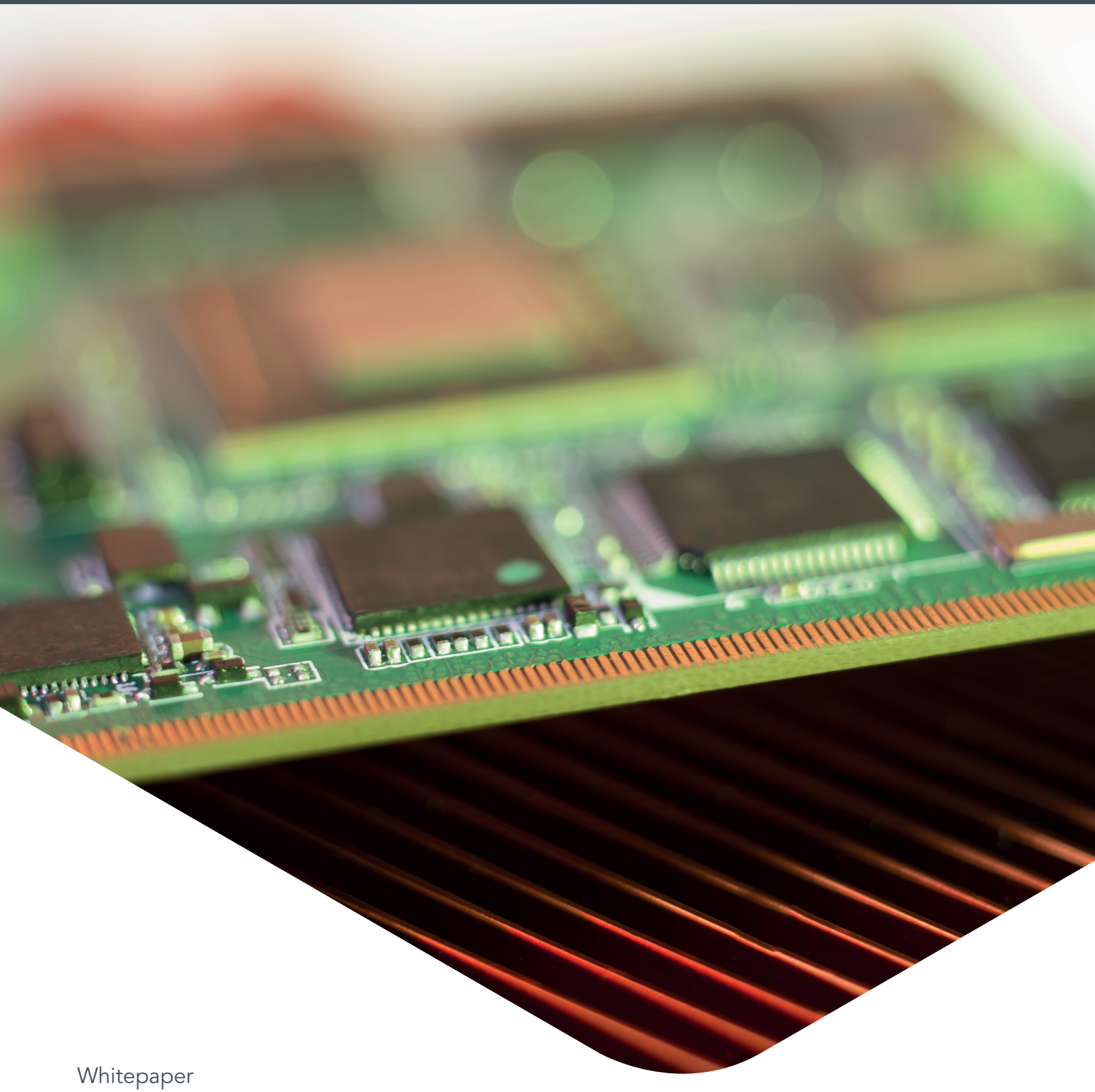


Whitepaper

# SMARC 2.0

## The perfect Standard between Qseven and COM Express

# SMARC 2.0 - A New Standard to Bridge the Gap between Qseven and COM Express

SMARC 2.0 modules from congatec stand out with their rich choice of graphics, camera, sound, network and optional wireless interfaces. They offer embedded system developers a complete, off-the-shelf, credit-card sized embedded computing core that is ideal for IoT connected multimedia platforms and many other graphics-intensive low-power applications.

## Quick overview

SMARC 2.0 is perfectly positioned between the two well-established module standards Qseven and COM Express. Compared with the Qseven standard, which allows low-cost entry into the world of computer modules and integrates various x86 and ARM low-power processors for the process and field levels, SMARC offers more interfaces – especially more multimedia ports. Compared with the high-performance COM Express modules that make up the upper class of COMs, SMARC 2.0 is targeted at the low-power processor segment and also supports less interfaces than COM Express. The interfaces offered by SMARC 2.0 are inline with this positioning. In particular, SMARC 2.0 provides modern serial I/Os as well as abundant video and network interfaces, making it a perfect fit for many multimedia and graphics-intensive IoT applications. To make the application developer's job as easy as possible, congatec has integrated optional WiFi and Bluetooth on their SMARC 2.0 modules in accordance with the M.2 1216 interface specification, thereby rounding off the SMARC 2.0 interface portfolio for the IoT. Applications include digital signage systems, commercial streaming clients, industrial thin clients and HMIs, all types of GUI devices, PoS systems, professional gaming machines, infotainment platforms, as well as IoT gateways.

## The technical highlights of SMARC 2.0

The 314 pins of the SMARC 2.0 connector, which is also used for the MXM 3.0 graphics card standard, provide space for up to four video outputs, underlining SMARC 2.0's particular suitability for multimedia applications. 2x 24 Bit LVDS / eDP / MIPI DSI plus HDMI/DP++ and DP++ are provided, along with 2x MIPI camera interfaces and two audio interfaces via HDA and I2S. New features include additional USB ports for up to 6x USB, including 2x USB 3.0, a second Ethernet port for vertical IoT connection or line and ring structures, a fourth PCI Express lane and 1x eSPI. Some obsolete interfaces, such as the parallel camera and display ports, external eMMC, SPDIF and one of the three I2S channels, are no longer supported. The Alternative Function Block has also been omitted; it was considered too random by many manufacturers and customers, because it allowed manufacturers to implement whatever they wanted and no efforts were made to standardize it before the SMARC 2.0 specification came into force. This resulted in little design security for SMARC 1.1 modules when the interfaces were executed via those pins.

## SMARC 1.1 and SMARC 2.0 in comparison

SMARC 2.0 introduces numerous enhancements compared to the old SMARC 1.1 specification,. The following features have been added to the specification:

- Second LVDS channel to support displays with higher resolutions
- Additional Gigabit Ethernet port for vertical IoT applications as well as line and redundant ring networks
- Individual IEEE1588 trigger signal for each Ethernet interface for precision timing applications
- PCI Express lane #4
- Additional USB ports (6x USB 2.0 + 2x USB 3.0)
- x86 power management signals to support low-power x86 processors in addition to ARM
- eSPI to drive Multi I/O Controllers and support fast EEPROMs
- Additional DP++

To make room for these innovations, older, rarely used interfaces were removed:

- Parallel Camera Interface
- Parallel Display Interface
- PCI Express Presence and Clock Request signals
- Alternate Function Block
- SPDIF Audio Interface
- eMMC signals for the carrier board
- One I2S interface (out of three)

| SMARC 2.0 | | SMARC 1.1 |
|---|---|---|
| 2x Gigabit Ethernet | | 1x Gigabit Ethernet |
| eSPI | | |
| SATA 0 | | SATA 0 / eMMC |
| MIPI CSI 0-1 | | Parallel Camera |
| HDA / I2S 0-1 | | I2S 0-2 / SPDIF |
| USB 2.0 0-5 / USB 3.0 0-1 | | USB 2.0 0-2 |
| HDMI & DP++ | | HDMI |
| PCIe 0-3 | | PCIe 0-2 |
| GPIO 0-11 / SDIO | | GPIO 0-11 / SDIO |
| LVDS 2x24 / eDP / MIPI DSI | | Parallel Display |
| SER 0-3 / CAN | | SER 0-3 / CAN |
| SPI / I2C | | SPI / I2C / AFB |
| Power | | Power |

## Extensive video interface options

SMARC 2.0 offers a rich choice of internal and external video interfaces. Two dual-mode DisplayPorts (also called DisplayPort++ or DP++) are provided for flexible external screen connections. The advantage: Systems that support DP++ for external displays can be controlled via DisplayPort, HDMI and even VGA signals. Which signals are exchanged depends entirely on the cables used, some of which include active electronics for this purpose. Another advantage is the fact that there are no license fees, which in the case of HDMI cost system manufacturers pay an annual fee of $10,000USD (see http://www.hdmi.org/manufacturer/terms.aspx). The latest version of DisplayPort is version 1.4, released on 1 March 2016. It supports screen resolutions up to 7680 x 4320 pixels.

The control of internal displays is also designed to be very flexible and forward-looking in SMARC 2.0. The most commonly used interface now is LVDS and with the two 24-bit data channels it is also possible to drive high resolution displays. Along with the display signals, there is also a complete set of support signals available. As a result, the configuration data of the graphic can be transmitted via I2C bus. It is further possible to control the power supply by two separate signals (VDD_EN). Backlight brightness can also be controlled separately for two panels by using the Enable signals that turn on the backlight (BKLT_EN) and the pulse width signal (BKLT_PWM).

As an alternative to LVDS, SMARC 2.0 modules also provide two independent embedded DisplayPort (eDP) signal sets to control two internal displays. An eDP implementation requires fewer signal lines than LVDS. The leaner cabling allows for easier system integration while supporting even higher screen resolutions. Up to 4 data channels are provided for each eDP interface.

The third, forward-looking option is panel control via the MIPI Display Serial Interface (DSI) as specified by the Mobile Industry Processor Interface Alliance (see http://mipi.org/specifications/display-interface). Today, displays supporting MIPI DSI are found mostly in smartphones. While generally smaller, they are nevertheless high-resolution displays, which are produced in very large quantities. Just like eDP, MIPI DSI is based on fast differential serial line pairs, but uses different data rates and protocols.

## Two Ethernet interfaces yield greater precision

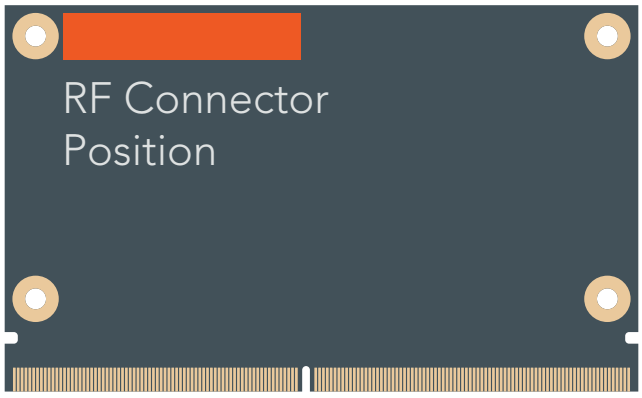
SMARC 2.0 implements two Gigabit Ethernet ports, which is a particular advantage for IoT or Industry 4.0 applications. Without any special hardware effort, it is now possible to realize two independent networks where the logic and security aspects are fully separate. And the two GbE ports also allow the implementation of cable-saving line and even redundant ring topologies.

Both Ethernet ports further provide SDPs (Software Defined Pins) on the SMARC 2.0 connector. These Ethernet controller I/Os are configurable and can be used for hardware-based IEEE 1588 Precision Time Protocol (PTP) implementation (see http://www.nist.gov/el/isd/ieee/ieee1588.cfm).

Such hardware implemented PTPs can achieve nanosecond accuracy, whereas software-based solutions require microseconds. This way, developers can achieve the highest synchronicity between multiple local devices and realize powerful IoT Gateways – also in combination with WLAN.

## Wireless technologies

Today, wireless is indispensable – even in demanding automation applications. To align the module concept with this trend, the SMARC 2.0 specification now provides a special area on the module that is dedicated to the placement of the miniature RF connectors (short u.FL connectors) required for high frequency signals. All SMARC 2.0 modules that need antenna connectors for wireless interfacing have these connectors in the same position to ensure consistent interchangeability. Modules from congatec also provide connectivity for logic devices, for example WLAN and Bluetooth, in line with the M.2 1216 interface specification. This allows a wide choice of radio protocols which in turn makes customizations for end user applications highly flexible.



## Camera interfaces

SMARC 2.0 provides all signals required to support digital cameras. For this purpose, two serial MIPI CSI (Camera Serial Interface) have been implemented. While the first port supports two data channels, the second port supports twice the camera data rate, since it can operate with up to 4 data channels. Both camera interfaces can be implemented in accordance with either MIPI CSI 2.0 or the newer MIPI CSI 3.0 specification. In addition to a higher data rate, version 3.0 uses differential pairs to configure the connected cameras instead of an I2C bus.

| MIPI CSI Signal | Description |
|---|---|
| CSI0_D[0:1]+<br>CSI0_D[0:1]- | Camera 0, 2x MIPI CSI differential data from camera to module |
| CSI1_D[0:3]+<br>CSI1_D[0:3]- | Camera 1, 4x MIPI CSI differential data from camera to module |
| CSI[0:1]_CK+<br>CSI[0:1]_CK- | Separate clocks for both cameras |
| CAM_MCK | Master clock output; can be used for both cameras |
| I2C_CAM[0:1]_CK<br>I2C_CAM[0:1]_DAT | I2C buses to configure the camera for MIPI CSI 2.0<br>Signals are implemented as differential data pairs CSI[0:1]_TX+ and CSI[0:1]_TX- for MIPI CSI 3.0 |

## Backward compatibility of SMARC 2.0

To master the necessary technology leap from SMARC 1.1 to revision 2.0, 105 out of 314 pins – roughly a third of all signals – were changed, the use of a new module in an older carrier board can cause signal conflicts. Whether it is possible to provide all required functionalities without any problems depends on the individual application and needs detailed examination. congatec provides free revision checks and advice on necessary re-designs of existing carrier boards as part of their individual integration support.

## SMARC 2.0 versus Qseven and COM Express

When comparing SMARC 2.0 with Qseven, the most obvious difference lies in the display and camera interfaces (see table). Even when compared with COM Express Type 10 modules - where the choice of interfaces is very similar to Qseven - SMARC allows a wider range of applications. But if one extends the comparison to include COM Express Type 6 and Type 7 pinouts (see table), it soon becomes clear that COM Express tends to address completely different performance classes.

| Qseven |
|---|
| Gigabit Ethernet |
| LPC |
| 4x PCIe |
| HDA / I2S |
| LVDS 2x24 / eDP |
| 2x MIPI CSI (Flatfoil) |
| DDI |
| 2x SATA |
| 8x USB 2.0 / 2x USB 3.0 |
| 8x GPIO / SDIO |
| 2x SER / CAN |
| SPI / I2C |
| Power |

| SMARC 2.0 |
|---|
| 2x Gigabit Ethernet |
| eSPI |
| 4x PCIe |
| HDA / 2x I2S |
| LVDS 2x24 / eDP / MIPI DSI |
| 2x MIPI CSI |
| HDMI & DP++ |
| 1x SATA |
| 6x USB 2.0 / 2x USB 3.0 |
| 12x GPIO / SDIO |
| 4x SER / CAN |
| SPI / I2C |
| Power |

| COM Express Type 10 |
|---|
| Gigabit Ethernet |
| LPC |
| 4x PCIe |
| HDA |
| LVDS 1x24 / eDP |
| DDI |
| 2x SATA |
| 8x USB 2.0 / 2x USB 3.0 |
| 8x GPIO / SDIO |
| 2x SER / CAN |
| SPI & I2C |
| Power |

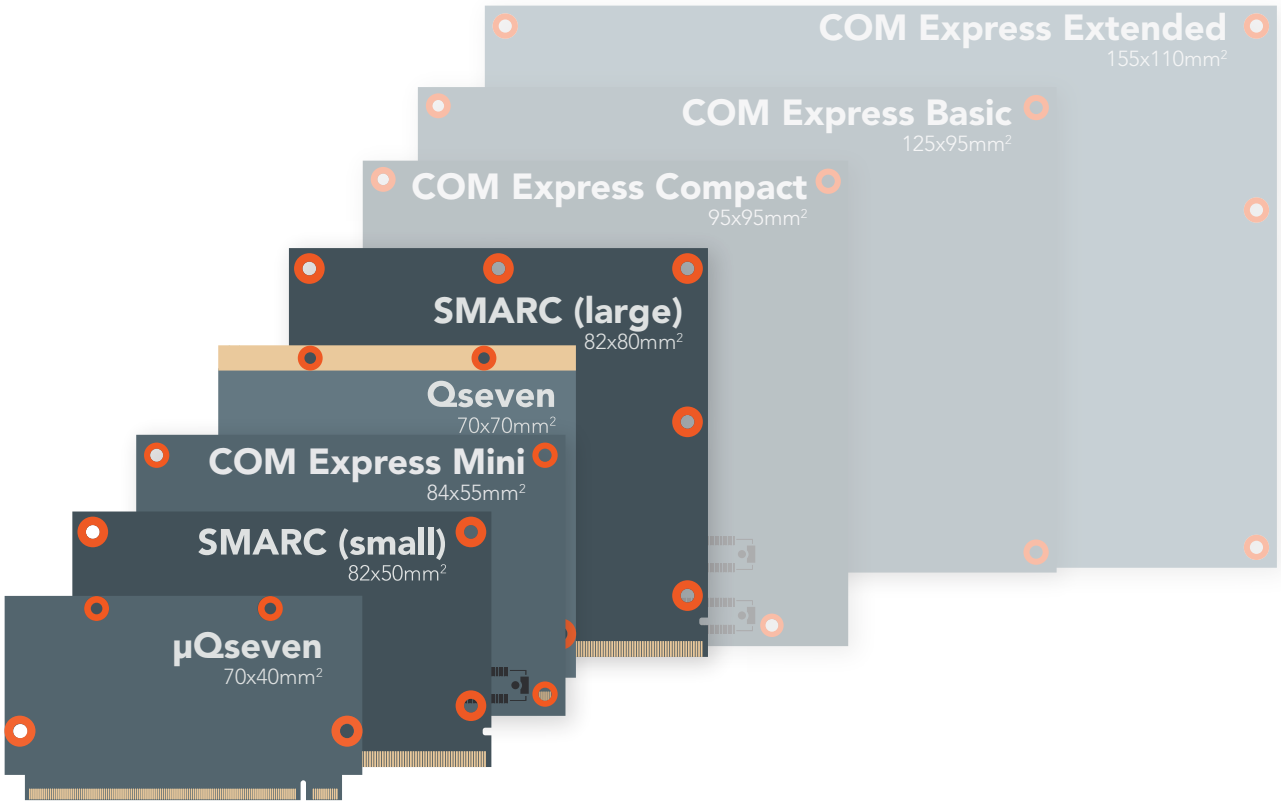
| SMARC 2.0 | COM Express Type 6 | | COM Express Type 7 | |
|---|---|---|---|---|
| 2x Gigabit Ethernet | Gigabit Ethernet | 4x USB 3.0 | Gigabit Ethernet | 4x USB 3.0 |
| eSPI | LPC | | LPC / eSPI | |
| 4x PCIe | 8x PCIe | | 32x PCIe | |
| HDA / 2x I2S | HDA | PEG x16 | | |
| LVDS 2x24 / eDP / MIPI DSI | LVDS / eDP | | | |
| 2x MIPI CSI | | | | |
| HDMI & DP++ | ExpressCard | | | |
| 1x SATA | 4x SATA | 3x DDI | 2x SATA | 4x 10GBaseKR |
| 6x USB 2.0 / 2x USB 3.0 | 8x USB 2.0 | | 4x USB 2.0 | |
| 12x GPIO / SDIO | 8x GPIO / SDIO | | 8x GPIO / SDIO | |
| 4x SER / CAN | 2x SER / CAN | | 2x SER / CAN | |
| SPI / I2C | SPI & I2C | | SPI & I2C | |
| Power | Power | Power | Power | Power |

## Processor technologies

Both SMARC 2.0 and Qseven allow the use of energy-saving SoC processors based on ARM as well as x86 processor technologies. This enables the development of products with very low power dissipation. The same applies to COM Express Mini. However, due to the higher I/O requirements of the Type 10 pinouts, here it mostly makes more sense to implement x86 technologies.

## Size comparison

Measuring 70x40mm with a footprint of 2800mm², µQseven is the smallest module standard. SMARC Small (82x50mm / 4160mm²), COM Express Mini (84x55mm / 4620mm² ) and Qseven (70x70mm / 4900mm² ) fall into the significantly larger 4000mm² class and are fairly similar in size (max. +/- 15%). The larger, full-size variant of the SMARC standard (82x80mm / 6560mm²) provides considerably more space than Qseven (135%) and COM Express Mini (142%) – and hence offers the potential for even more functionality and higher performance. µQseven therefore remains the best choice for particularly small low-power designs while SMARC is ideal for the upper performance classes of Small Form Factor (SFF) designs that are more likely to gain market share from COM Express Mini than Qseven because of the increasing performance per watt of SFF processors.



| | Width [mm] | Height [mm] | Area [mm²] |
|---|---|---|---|
| **µQseven** | 70 | 40 | 2800 |
| **SMARC** | 82 | 50 | 4100 |
| **COM Express Mini** | 84 | 55 | 4620 |
| **Qseven** | 70 | 70 | 4900 |
| **SMARC Extended** | 82 | 80 | 6560 |
| **COM Express Compact** | 95 | 95 | 9025 |
| **COM Express Basic** | 125 | 95 | 11875 |
| **COM Express Extended** | 155 | 110 | 17050 |

## Global market developments

According to a recent study by Technavio (http://www.technavio.com/report/global-embedded-systems-computer-module-market), the global COM market will grow at a CAGR of 17.9% (2016-2020). The leading standards in this study include the three form factors COM Express, SMARC and Qseven. It also references the legacy standard ETX and other, less significant COM specifications. It can therefore be assumed that SMARC 2.0 will provide developers with an equally high level of future security as COM Express and Qseven. congatec is a worldwide leading manufacturer of Computer-on-Modules and supports all major COM standards.

## Summary

SMARC 2.0 combines the very latest multimedia and IoT interfaces with a small footprint and low-power processor technology. Neither the extremely scalable COM Express nor the very compact and long-established Qseven offer this unique combination. SMARC 2.0 will therefore establish itself alongside COM Express and Qseven. The comprehensive choice of interfaces integrated in the modules considerably facilitates the design of customized systems based on these interfaces.

## Freely available specification

The specification was developed by a Standards Development Team (SDT) within the SGET. The team is currently (July 2016) updating the Carrier Board Design Guide to map all new functionalities. The specification is available for free download on the SGET website (www.sget.org).

SGeT STANDARDIZATION GROUP FOR EMBEDDED TECHNOLOGIES

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Christian Eder is a SGET board member and editor of the SMARC 2.0 specification. He also actively participates in numerous PICMG working groups and is editor of the following specifications: COM Express 2.0, COM Express 2.1, COM Express Design Guide, Embedded EEPROM, Embedded EAPI and COM Express 3.0.

### About congatec AG

Headquartered in Deggendorf, Germany, congatec AG is a leading supplier of industrial computer modules using the standard form factors COM Express, Qseven and SMARC as well as single board computers and EDM services. congatec's products can be used in a variety of industries and applications, such as industrial automation, medical, entertainment, transportation, telecommunication, test & measurement and point-of-sale. Core knowledge and technical know-how includes unique extended BIOS features as well as comprehensive driver and board support packages. Following the design-in phase, customers are given support via extensive product lifecycle management. The company's products are manufactured by specialist service providers in accordance with modern quality standards. Currently congatec has entities in Taiwan, Japan, China, USA, Australia and the Czech Republic. More information is available on our website at www.congatec.com or via Facebook, Twitter and YouTube.

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