Background material on 'More-Moore' & 'More-than-Moore'[1]

Intention:

This document is intended to provide the participants to the KETs Open Day with some background information to enable all to follow and participate. The Open Day seeks to address how to make Europe more competitive, to discuss demand and supply-side measures and how to create incentives for the deployment of KETs. The underlining question remains: ***where does Europe as a region want to be in this ever-exciting evolution of Micro/nanoelectronics?***

General overview:

Micro/nanoelectronics is one of the Key Enabling Technologies (KETS) for the modern economy and society. It will remain at the heart of most future innovations, notably those addressing key challenges such as energy efficiency, environment, healthcare, transportation, communication and computing. While micro/nanoelectronic '*chips*' are rarely visible, they determine the functionality the end-consumer purchases. And the trend for their use in ever larger volumes and wider domains continues to increase. More and more, our economies will depend on micro/nanoelectronic chips – without noticing them!

Today's Open Day brings together experts/stakeholders to discuss where Europe stands on the main challenges within this enabling industry. The challenges on the side of the industry circulate around the two basic technology trends of so-called '*More-Moore*' and '*More-than-Moore'* and the interdependencies between them. Parts of the trends are covered by an International Technology Roadmap for Semiconductors (ITRS).

In the late 1960s, Gordon Moore predicted the number of transistors on a chip would double every 18 months; an observation known as 'Moore's law'. Referred to as '**more Moore'** this trend continues, particularly for memories and microprocessors, which depend on size and power reduction for the introduction of ever increasing complexity. This evolution can be seen on the vertical axis of the chart 1 you see below. It centres on the constant miniaturisation efforts for increasing the performance in information processing. Without this process, e.g. the phone function of a mobile phone would still look, perform, feel and cost like the one in the below photo from 1973. This more-Moore technology accounts for a large share of the global semiconductor market.

At the same time, a greater variety of semiconductor devices can be combined on the same chip in so-called SoCs (*System-on-chip*) or in the same package using so-called SiPs (*System-in-Package*). This concept, adding not-digital functionalities known as '**more-than-Moore'**, involves a lot of other devices on top of the pure miniaturisation (CMOS) process, such as analog/radio frequency, passives, high voltage power, sensors, biochips and MEMS (*Micro-Electro-Mechanical systems*) components. This can be seen on the horizontal axis of the chart. These devices are processed and embedded in the chip/package instead of being added at systems level. This improves system integration and opens new applications fields. Interacting with people and the environment and powering the system are a main element of more-than-Moore.

Advances in both technology trends do not come cheaply, and cooperation and consolidations will be required to offset the exponentially increasing costs of the design, technology development and manufacturing. Further changes will also happen as businesses increasingly focus on their core capabilities and their product and services portfolio in response to international need. In view of this

[1] The below is not intended as exhaustive material. The references are ITRS July 2010, ESIA 2008 & ESIA 2010.

evolution, the electronics systems value chain has changed and diversified substantially. The traditional *Integrated Device Manufacturers* (IDM) keeps the whole Integrated Circuit (IC) value chain 'in-house'. This model is now complemented by the growing importance of *foundry* services (specialized manufacturing services mainly for standard CMOS) on one side, and of so-called *Fabless* companies on the other, with different degrees of so-called *Fablite* strategies in between; and by the availability of sophisticated Intellectual Property (IP) and know-how providers throughout the design cycle itself.

Short definitions:

More Moore: Continued shrinking of physical feature sizes of the ***digital*** **functionalities** (logic and memory storage) in order to improve ***density*** (cost per function reduction) and ***performance*** (speed, power).

More-than-Moore: Incorporation into devices of functionalities that do not necessarily scale according to 'Moore Law', but provide additional value in different ways. The 'more-than-Moore' approach allows for the non-digital functionalities (e.g. RF (radio frequency) communication, power control, passive components, sensors, actuators) to migrate from the system board level into the package (SiP) or onto the chip (SoC).

Picture: Man with mobile 1973. Source IMEC

(1973)

Chart 1: Source ITRS

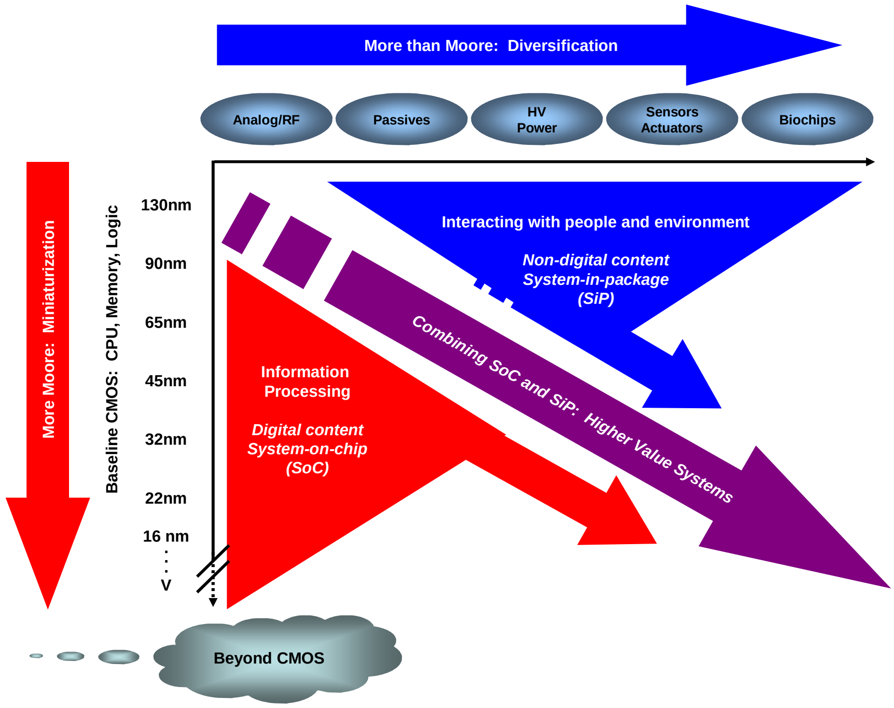

Chart 2: A different perspective. Source ITRS