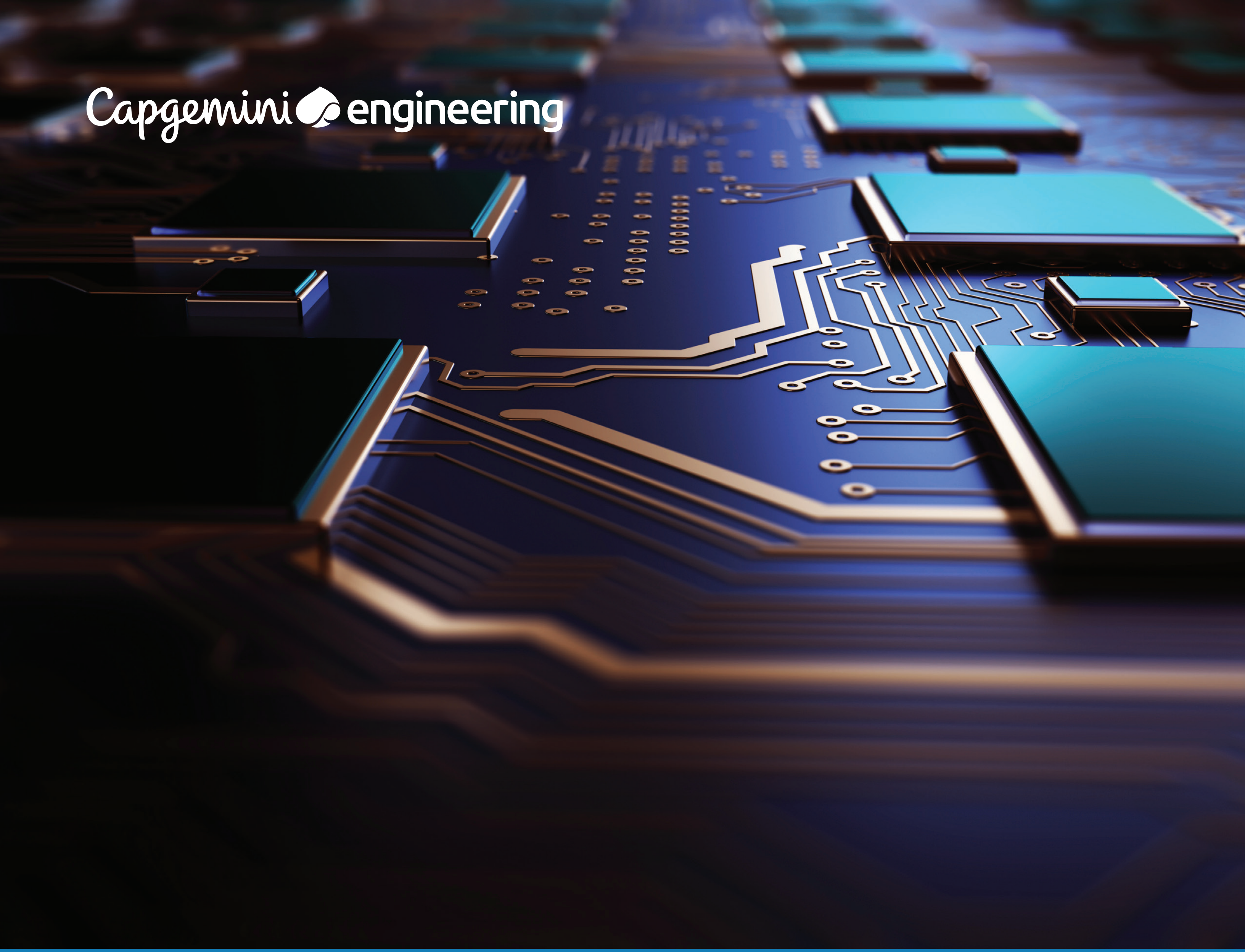
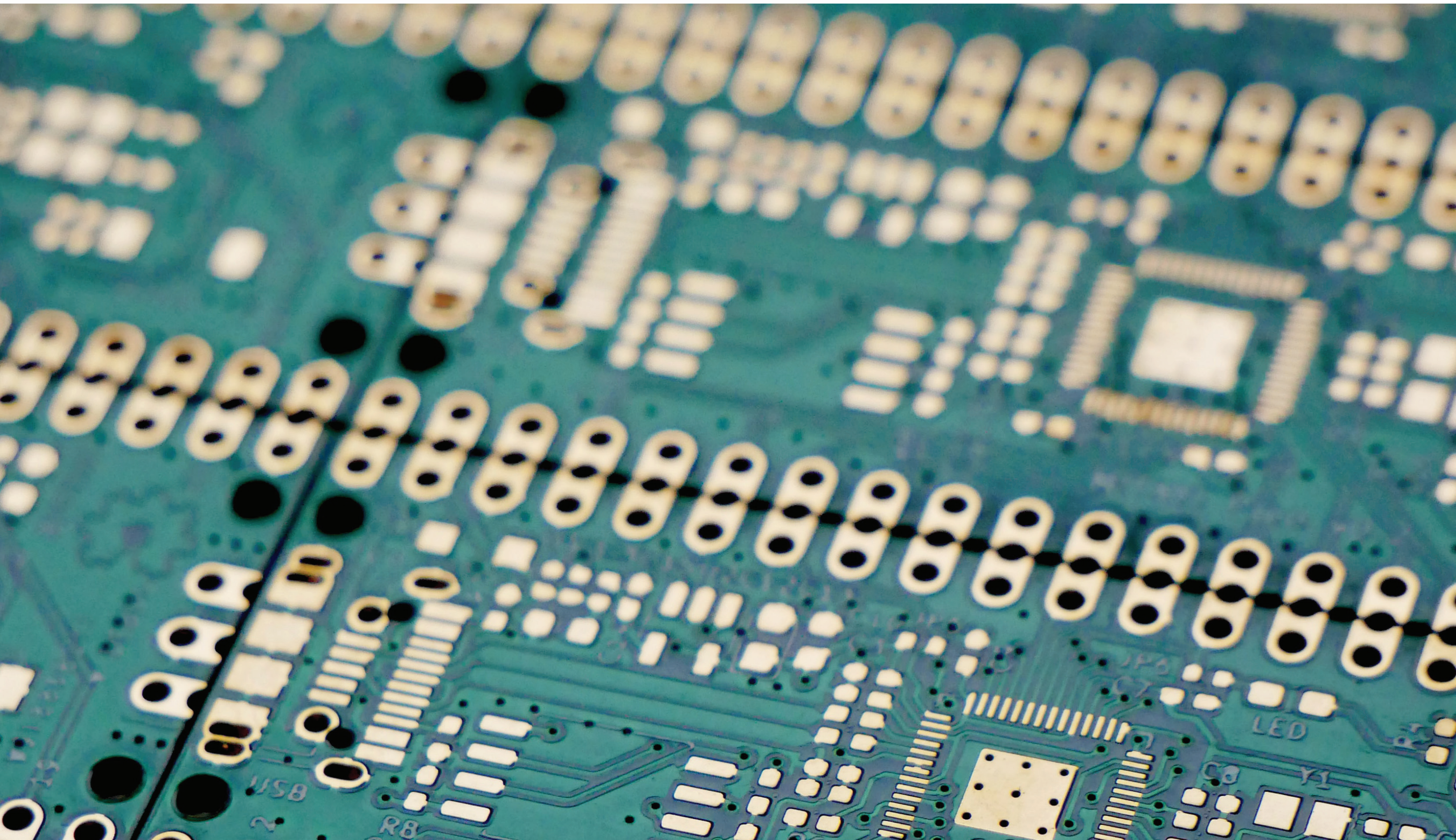


SOLUTIONS FOR CHIP AND IP PROCESS MIGRATION

Maximizing ROI and extending the lifespan of semiconductor assets

Over the last decade, a perfect storm of geopolitics, industry trends, industry best practices, pandemic stressors, and the natural dynamics of supply and demand economics kicked off a chip shortage in 2020 that, for some, may last years. The causes are complex and recovery will vary by industry, product, and process as the systemic causes are addressed and manufacturing capacity returns:

- Pre-pandemic, concerns over US-China trade tensions triggered chip over-ordering which was compounded by additional stockpiling in early 2020 as pandemic fears grew
- In 2020, many fabs slowed and even shuttered production of some processes, making it impossible to meet demand for all customers
- Remaining chip inventories, kept low during normal business conditions, were drained quickly when the production slowed. In 2020, some industries, such as many automakers, cut chip orders in response to a drop in sales. But supply was reallocated to other customers, making it hard for automakers to recover from excess inventory alone once demand returned
- The semiconductor manufacturing industry has been at the center of national sovereignty issues recently, as countries want more control over the supply chain within their borders. But bringing a new fab or process online is time-consuming and costly, limiting most manufacturers' abilities to add capacity as a short-term solution to the shortage crisis. Fab expansion is also delayed by a large backlog in semiconductor manufacturing equipment
- Creating even more competition for some chips, the transition of billions of workers and students to at-home work, school, and lockdown environments created an overwhelming and unexpected demand for laptops, communications equipment, TV sets, game consoles, and similar
- Second sourcing is an effective risk mitigation strategy against supply-chain instability, but it isn't common in the semiconductor industry. When manufacturing capacity for a chip's target process was not available, chip companies were not prepared to migrate quickly to another, available node

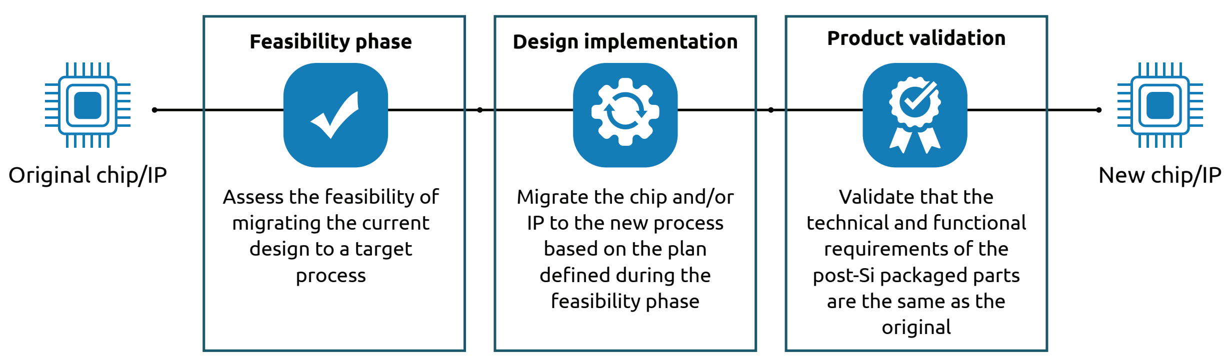


Process migration is an important part of extending the lifespan and optimizing the business value of existing chip designs and semiconductor intellectual property (IP). It can also hold the key to design resilience and reducing the risk and impact of supply chain disruptions such as the chip shortage being experienced across almost every vertical industry today.

Capgemini Engineering offers complete process migration services to help companies adapt and update existing chip designs and IP assets for manufacturing in a new process, at a second fab, or both. Our solution uses a three-phase approach – feasibility, migration, validation – to ensure that both the business and technology goals of the retargeting are met.

Extending lifespan and ROI of your semiconductor design investment

Process migration is part of the normal semiconductor life cycle and offers ways to lower risk and optimize revenue from existing designs. It is used to prepare derivatives for new price points or markets. It can extend chip or IP lifespan when processes are retired or become less available. When integrated into chip design best practices, second sourcing (migrating chips for production to an alternate process during the normal design cycle) can serve to mitigate the risk of supply chain disruption, such as today's chip shortage. Process migration also provides an opportunity to optimize power, performance, area (PPA), add new features, or leverage the benefits of a new or different semiconductor foundry. And for IP, process migration can also be key to extending IP longevity and profitability by making it available on multiple nodes, whether for new markets or device types that require specific nodes.



Complete migration services to adapt and update existing chip designs and IP assets for manufacturing in a new process, at a second fab, or both.

Solutions for chip and IP process migration

Capgemini Engineering's complete process migration services uses a three-phase approach to ensure that business goals are clear and achievable and that technology hurdles are known and surmountable before moving forward. Each phase includes:

- **Feasibility** – an assessment of business goals, technology challenges, and new opportunities for the proposed migration, identification of the target process, and an implementation plan
- **Design implementation** – the VLSI services to migrate the chip or IP to the target process
- **Product validation** – validation of the new chip or IP to confirm that the implementation of technical and functional requirements are the same as the original

Orchestrating a successful migration requires that the intended business outcomes are clear and achievable, and the technology challenges anticipated while moving the design to the chosen target process are understood and addressable. In addition, migration also provides the opportunity to examine whether new value can be achieved, such as improving performance, lowering cost, or eliminating redundant logic.

The feasibility phase helps companies fully understand their goals, challenges, and value opportunities for the proposed migration. This phase includes four key steps:

- **Readiness** – a readiness checklist is completed to capture key information relevant to migration complexity and resource availability (human, design, infrastructure, tools, etc.) and in-house expertise. It is used to guide discussion in the next step

- **Feasibility** – using the checklist as a guide, migration feasibility is reviewed and business goals and parameters such as budget, time, and cost are defined. A thorough discussion of the technology, resource, and design impacts on the IP/chip is completed including:
  – Design impacts (PPA, floorplan, IPs, memories, DFx, etc.)
  – Asset and tool availability (design database, EDA tools, etc.)
  – Product life cycle, process EOL, minimum volume, etc.
  – Review post-silicon ecosystem and infrastructure requirements such as packaging, OSATs, product testing, certification requirements, etc.
  – Assessment of whether the desired business goals can be met with targeted migration

- **New value** – opportunities to create new value are evaluated including (but not limited to):
  – Improving features and functionality through software
  – Improving PPA characteristics
  – Elimination of spare registers, ports, redundant logic of original design
  – Exploring whether a cheaper node is available (reducing cost per unit volume)
  – Implementing multi-site testing changes to improve testing throughput
  – Improving manufacturing efficiency through DfM
  – Other features relevant to business reason for migration, such as a new package, etc.

- **Plan of action** – when migration is feasible, a plan is created that can include:
  – Selection of process technology and fab with available capacity: older/newer node, same/new fab
  – Clear options, outcomes, and risks of each choice considered
  – A project implementation plan defining the scope of migration services to be performed

Design implementation

The second phase deploys the engineering services to migrate chip and/or IP to the chosen target process based on the implementation plan defined during the feasibility phase. This includes:

- Preparing to map the old design to new process
- RTL or Netlist to GDSII flow?
- Bringing up the current design database in the new design environment
- Mapping all changes required for RTL, constraints, floorplan
- Updating IPs from previous generation (e.g., USB 2 to USB 3.1)
- Evaluating the impact of design and constraint changes
- Assessing IO and register compatibility
- Evaluating and resolving IP compatibility issues
- Mapping memory structure and type changes
- Modifying to change any DfT, power, clocking, global signals
- Other factors impacting floorplan

Running the RTL-to-GDSII flow: in general, migration projects are treated as if they were a new RTL to GDSII project. This includes:

- Running RTL to GDSII flow
- Verifying every change – functional and physical
- Functional verification impact – new test cases?
- DFX impact and new test vectors?
- Physical verification impact – new DRCs?
- Signoff differences

Product validation

The final phase delivers a fully tested chip with any required certification. It includes services to validate that both technical and functional requirements of the new chip/IP are the same as the original, including:

- Develop test chip, if necessary
- Socket-level evaluation of functionality and other key metrics
- Perform IO characterization
- Test die and packaged part with OSAT vendors
- Port platform firmware and software
- Validate new parts using reference board for applications
- Complete compliance and certification testing of new chips/IPs

Accelerated delivery and quality from the world leader in ER&D semiconductor services

Capgemini Engineering is the world leader in semiconductor ER&D services and has been ranked #1 by industry analysts for the past **5 years**.* Trusted by industry leaders for over 16 years for our experience and expertise, we leverage industry standard tools, scripted automation, and other industrialized methodologies to accelerate the delivery and quality of chip and IP migration solutions. These include:

- End-to-end silicon engineering, system hardware, platform and embedded software, and embedded systems 'under one roof'
- Working with the world's leading foundries, technologies, and processes including leading edge 5nm TSMC and 7nm Intel and Samsung
- Expertise in all major certified design flows including TSMC, Intel, Samsung, Global Foundries, UMC, etc.
- Specialists in IP and SoC integration of CPUs, memory, interfaces, wired and wireless connectivity, RF, multimedia, etc.; cutting-edge technology domains such as 5G, AI, automotive, edge, IoT, etc.,
- Deep application experience across industry verticals
- All industry standard EDA tools such as Cadence, Synopsys, Mentor, Ansys, and others
- Custom scripts and flow automation for intelligent Netlist mapping, equivalency checks, automated DRC fixes, etc.
- Expertise in industry-specific testing, qualifications, and certifications for automotive, aerospace, safety, and more

Process migration is an integral part of optimizing the business value of your chips and IP. The ability to move chip and IP designs easily to a new process or fab should be part of design best practices, yet today it is not. Whether your goals include preparing or recovering from supply chain disruption such as today's chip shortage, extending the shelf life or market range of your chips or IP, or leveraging new domestic manufacturing facilities, Capgemini Engineering offers complete process migration services to help you achieve them.

*Capgemini Engineering, "Altran Tops Everest Group Ranking of the Leading Engineering Services Providers", 2020, available from: https://capgemini-engineering.com/us/en/news_press_release/altran-tops-everest-group-ranking-of-the-leading-engineering-services-providers/

About Capgemini Engineering

Capgemini Engineering combines, under one brand, a unique set of strengths from across the Capgemini Group: the world leading engineering and R&D services of Altran – acquired by Capgemini in 2020 - and Capgemini's digital manufacturing expertize. With broad industry knowledge and cutting-edge technologies in digital and software, Capgemini Engineering supports the convergence of the physical and digital worlds. We help clients unleash the potential of R&D, a key component of accelerating their journey towards Intelligent Industry. Capgemini Engineering has more than 52,000 engineer and scientist team members in over 30 countries across sectors including aeronautics, space and defense, automotive, railway, communications, energy, life sciences, semiconductors, software, and internet and consumer products.

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