# Cost Savings via Reuse

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## Abstract

This paper introduces an approach to determine cost savings in an IC design process through reuse of Intellectual Property (IP) (hardware, software cores and knowledge database). It describes the various components of reuse infrastructure that need to be deployed in a design environment to ensure cost savings and increased productivity in an organization planning to institute a reuse policy. It will cover type of models/data being reused, factors affecting reuse; current solutions in the market, cost savings calculations, industry data on cost savings through reuse and design collaboration.

### 1. Introduction

Today, in the semiconductor industry with the pressures of time-to-market, costs and increased integrated circuit design complexity, there is a trend to move to a virtual component-based System-On-Chip (SOC) methodology. As a result, complex Intellectual Property (IP), Virtual Components (hardware VCs) and Embedded Software (ESW) need to be designed and available in a reusable form that is most cost effective - both for the IP provider and the IP consumer.

Intellectual Property (IP) reuse has gained widespread acceptance throughout the semiconductor industry as an answer to problems created by new process technologies. The advent of deep sub micron process technologies has enabled the system-on-chip (SOC) generation, and each advance in process technology offers an opportunity to increase the level of integration. While that capability creates new opportunities, rising gate counts and shrinking device dimensions add to the complexity, cost and magnitude of the design problem. The most direct way to meet this challenge is to reuse intellectual-property (IP) blocks from existing designs and third-party vendors.

In order to develop a successful reuse policy, an organization needs to incorporate all aspects of a reuse infrastructure in their IP design methodology and design processes.

### 2. Key Components affecting Reuse Cost

There are various components an organization has to address to set up a successful reuse policy. Managing the costs incurred throughout the IP reuse process can facilitate the creation of successful system chip designs. The following topics describe the main components, which need to be addressed by such a policy.

### 2.1 Design Reuse Methodology

In order to increase the design productivity and lower costs it is becoming increasing important to define design methodology that will ensure reuse is built in the design cycle of a chip or core from conception to production.

This involves creating standard methodologies across the organization for creation of reusable IPs in IP Authoring, IP Qualification and verification and Chip Integration processes.

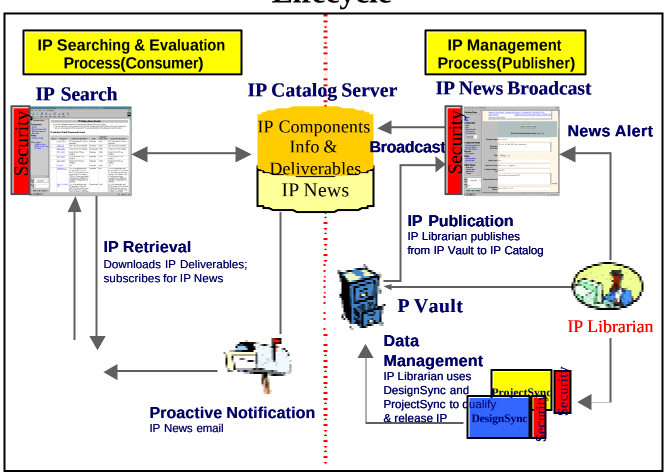
These methodologies and flows should also allow seamless access/integration to IP libraries, IP providers, cell libraries, different EDA tool databases, foundries, internal & external partners, verification and qualification processes and tools. This ensures that the chip designer is able to evaluate all existing, and 3rd party IP available to avoid costly purchase or duplicating of an existing IP core, hence reducing cycle time.

Figure 1 describes a typical chip design methodology supply chain where the design process needs to interact and exchange real time data and knowledge with external and internal systems throughout the design flow to ensure high productivity and lower cost.

## 2.2 IP Management Infrastructure

Along with a sound reuse methodology, it is very important for organizations to have a robust IP management system that not only manages the IP but also is able to distribute the qualified reusable core in an efficient cost effective manner. Figure 2 depicts a typical IP management lifecycle at use in various customer organizatio ns.

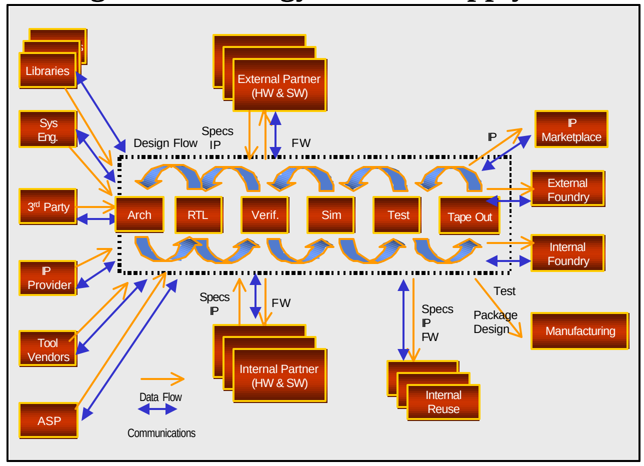
**Figure 2**
**IP Management Lifecycle**




This lifecycle shows the need for IP providers and IP consumers to be able to publish, qualify, browse, manage and securely distribute IP cores within and outside their organization. Such a system is mandatory to ensure enabling of reuse across organizations and design teams.

This system should be web based to allow easy access to distributed teams and customer over the

**Figure 1**
**Design Methodology Process Supply Chain**




Internet infrastructure. This system should provide the minimum basic functions of cataloging, browsing and search, publishing IP, managing and revision control of IP deliverables, providing secure access to catalog and deliverable data through secure logins.

Such a management and distribution infrastructure will ensure high productivity, faster designs and lower cost.

## 2.3 Design Data Management system

Building larger complex designs require larger teams that are often spread across multiple locations in different time zones. This requires a system that can manage all aspects of the design process and data resulting from these processes. In order to significantly boost the productivity of the design teams it is essential that such a system be web based and use well established standards of communication. Such a system needs some key basic features that allow substsantial productivity gain.

One of the key features of such a system is Version control & Release management which allow a project team to manage all versions of a file used and track and report all changes made to each and every file in a release stream across all sites in real time.

Workspace management is also very crucial to allow each engineer to create and manage a workspace with the right versions of files so that designers can work collaboratively as well as independently.

Design Process control, a key required function allows the entire design flow be controlled through set of triggers that are set according to the polocies set for the design process. This allows a standard methodology be managed through all the manadatory verification and design reuse steps ensuring reusable product .

It is also important that such a tool be used in conjunction with a robust project management tool that allow projects leads and managers to track and schedule the progress of the design process with real time updates of key tracking, resource and schedule data from a design data management system. Such a toll helps predict and manage release schedules and hence lower cost of the project.

### 2.4 IP Authoring and Verification Guidelines

One of the key components to having a successful reuse policy is to develop a standard guidebook that can be used across the organization. A well-defined reuse guideline book can ensure substantial cost savings in developing or integrating IP cores. It should not only contain rules for creating various design views for deliverables like hard, soft or firm VC but also verification models. Figure describes a typical flow where IP authoring and modification guidelines can be used for creating new IP or modifying legacy or 3rd party IP.

## 3 Factors affecting reuse costs

For the IP provider and the IP consumer it is important to be able to determine the cost savings resulting from reusing a design and the cost associated with using the IP in a new design.

There are three primary metrics that can determine the magnitude of the cost and savings; original development time, amount of design modification necessary, and re-verification time.

### 3.1 Original Design Metrics

The parameters of the original development give some insight into the complexity and size of the design undertaking. Looking at the major phases of that design gives some idea of the benefit of subsequent reuse. Looking at the original specification development, interface development, verification cost, and hardening of the design help shape the cost model for IP and reuse.

When reusing a design, the reuse benefit is maximized when the highest risk items in the original development are reused first. For example, complex designs are very difficult to properly specify. Many refinements and iterations of the original specification would have caused many iterations in the design flow. Reusing the resulting specification would have significant savings for the new design.

Also significant to the magnitude of the benefit would be the amount of time to development and refine the interface. A large amount of the time spent on Interface design and compliance analysis would be avoided in the new design. Refactoring of the interface boundaries can cause major iterations spins, which have a multiplier affect on the design cycle time.

The time spent originally developing the verification suite for the IP block can impact the cost savings most significantly. The verification for any new design is generally the most expensive part of the design process. If the verification suite is developed in a modular and reusable fashion, a significant impact to design cycle time is afforded. Verification resources can easily account for 50% of the design schedule and cost of a design.

### 3.2 Design Equivalency

An IP block that is being instantiated has a design component to it. Due to the nature of design, it is usually necessary to modify the design to implement new features, optimize the design, or interface to other blocks. Determining the magnitude and the cost of that modification can be done by evaluation the size/scope of the original design and derating it by the amount of change desired. The resulting design has a 'design equivalency' related to the original design. By looking at the magnitude of the changes required to the specification, interface descriptions, design functionality, and verification, the design investment begins take shape.

Relating software reuse models to soft-IP development models yields equations that relate the percentage of change and the amount of original investment.

To determine a design equivalency, the cost associated with using a previously designed block, the original design metrics and the magnitude of design changes must be considered. Software reuse metrics will offer that the resulting design equivalency is based of 40% of the specification and interface metrics, 30% from the development metrics, and 30% from the verification metrics. Since changes to the specification and interface dramatically affect both the development and verification it is weighted higher. As the original metrics themselves are imprecise, the weightings themselves are satisfactory in round terms.

Approximate Design Equivalency (ADE) can be determined by:

$$ADE = Effort_{SI} + Effort_{DD} + EffortVT$$

Where:

$Effort_{SI}$ : Original Specification and Interface design effort * %Changed * 40%

$Effort_{DD:}$ Original Design, Development effort * %Changed * 30%

$Effort_{VT}$: Original Verification and Testing effort * %Changed * 30%

## 4 Cost of Developing and Maintaining IP

To ensure cost benefits to both the internal IP provider and 3rd party IP provider, they must use appropriate business models to calculate the cost of reuse and the returns for implementing reused designs.

The cost of reuse to an external IP provider is dependent on number of factors. Keeping the cost low in three main areas ensures substantial savings. The major factors are IP authoring and modification cost, maintenance and support cost, and licensing administration cost. The authoring and modification cost is the amount of money the IP provider needs to invest to design an IP from scratch or that the IP Consumer needs to invest in modifying an existing IP to make it reusable. The first cost is a fixed cost while the IP consumers cost is variable based on the size of changes to the block. Adhering to best industry practices in terms of methodology and design guidelines ensure that this cost is low.

The cost of maintaining and supporting the IP is the amount the IP provider must budget to support the IP once it is sold. Proper usage documentation, test structures, and support-desk infrastructures help keep the cost down. The main cost is incurred supporting the first user license after which the cost levels out. Blocks that are the most frequently reused deserve the most investment in support infrastructures. Analyzing the reuse metrics for various blocks and investing in reducing the support burden of the most frequently used blocks can significantly reduce the cost of maintaining and supporting the IP. By reviewing issues that are raised by designers, insight into improved documentation and self-help guides can be gained. These changes also positively affect the end-user experience with the IP.

Licensing administration cost covers the cost of sales, distribution, marketing and handling licensing contracts etc. This cost is dependent on number of licenses sold and levels out after the sales of licenses increase.

For an internal IP provider inside an organization trying to develop an IP for reuse only the authoring, maintenance and support costs need to be factored in. The licensing costs are generally established by internal political boundaries.

## 5 Industry data on Reuse cost

The major downside of design reuse is the extra time and effort it requires to create a reusable IP. Industry data from communications, multimedia and networking applications report that a reusable core takes one and a half to three times as long as a new design for the same function. The increase results from the need for detailed documentation, well organized block based design, consistent standard coding style, creating design abstracts or models that adhere to industry guidelines like VSIA (virtual sockets Interface Alliance) and a thorough verification process. In dollar costs designing for reuse can be 30 to 50 percent more costly than single use designs.

Most companies use the yardstick of reusing the same core for at least three times to justify creating reusable IP. Also if a legacy core requires more than 10-15% change in its design to achieve the desired functionality, it is better to design the core from scratch.

## 6 Solutions available to enable reuse

Reuse solutions can come from two primary sources; internally developed ad-hoc solutions and commercially available solutions. Each have their benefits, but only the commercial solution offers the return and stability required of a major corporate infrastructure.

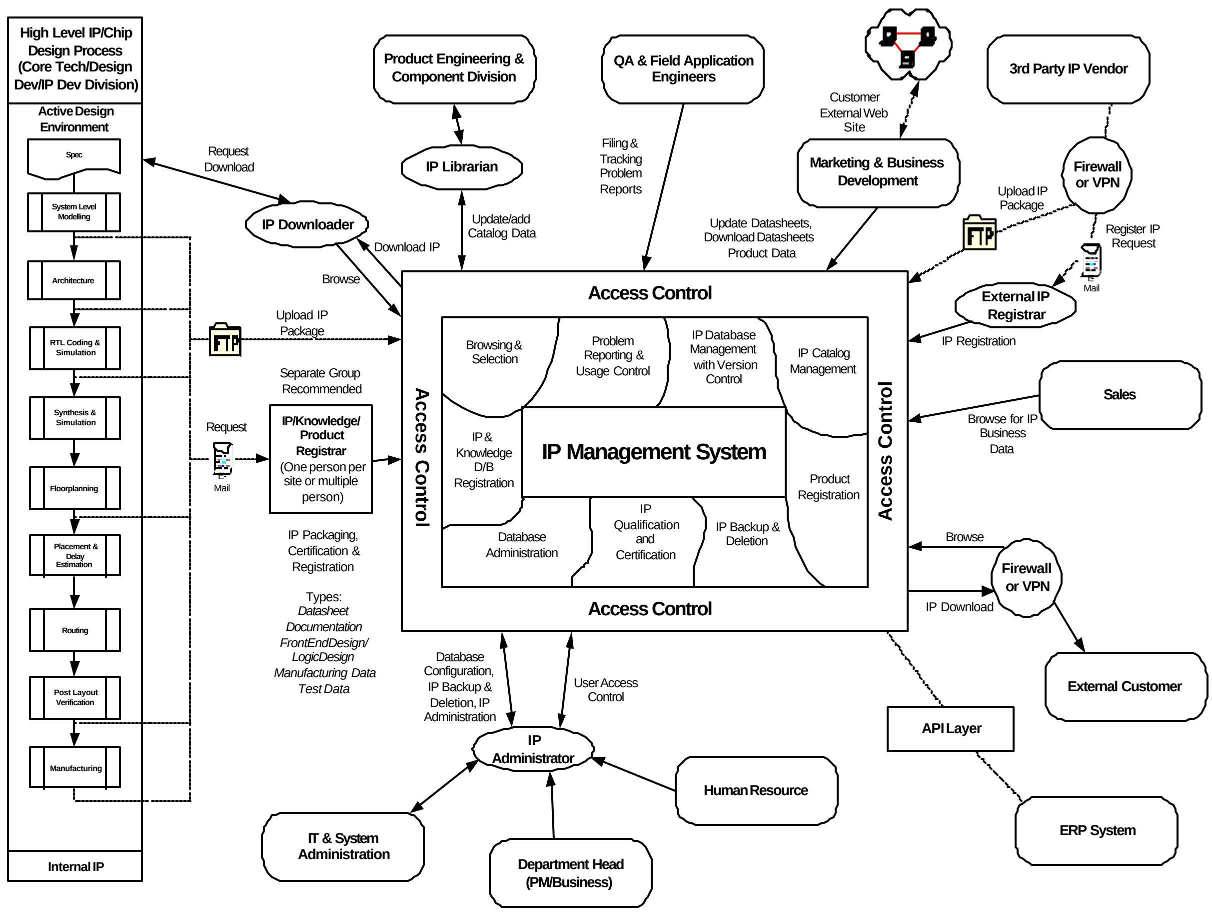
Internally developed ad-hoc solutions are generally crafted out of open-source, public-domain code and homegrown scripts. The benefit of these systems is that a focused feature set can be established in a relatively short period of time. The liability of these systems is anemic use-models and scability/supportability.

Ad-hoc solutions rarely account for the full use-model necessary to support a successful IP/reuse infrastructure. It is not enough just create catalog of IP and download system. Successful IP systems must take in to account the cataloging, modifications, searching, downloading, distribution, tracking, and support of IP. A failure to consider these creates a burden on the reuse infrastructure that undermines its effectiveness.

Also, ad-hoc solutions can be challenged by the scaling necessary of successful IP eco-systems. As the number of the IP blocks, IP consumers, and permutations of the designs increase, so does the loading on the IP systems. Large data sets and lots of interactions on the infrastructure must be maintained. Downtime associated with an ad-hoc system can be crippling to reuse productivity.

Commercial solutions offer organizations the ability to benefit from IP infrastructures and turns resources that would be developing these infrastructures towards developing functionality that isn't available commercially. Commercial IP solutions also have the advantage of learning different best practices across the IP industry and embodying them in the commercial solutions. The support networks of commercial solutions are also more stable than ad-hoc developed groups.

**IP Reuse System Usage Flow - Customer Model**




## 7 Complete IP Infrastructures

In order to maximize the savings associated with reuse, the IP infrastructure chosen need to be comprehensive and complete to suite to organizations design teams. In order to be complete the infrastructure should consider:

Comprehensive Design Catalogs including:
- Taxonomy and Schema Definition
- Browsing facilities
- Parametric searches and comparisons
- IP Lifecycle and Genealogy tracking
- IP Database management
- IP Status/Metrics collection and Analysis
- IP News Broadcasting to registered consumers

Transport and connectivity to the design teams.
Download and Distribution Servers
Recapturing IP developed by design teams
Certification of developed IP
IP knowledge bases and support
Licensing and Tracking of distributed IP
IP and reuse metric collection and analysis
Connectivity of internal IP system with third party IP providers
IT, network, and administration

## 8 Conclusion

Maximum Cost savings benefits are only realized when a organization actively develops & deploys an infrastructure as described above to enable reuse across all design teams, external IP suppliers, internal and external IP consumers, marketing, field support and sales organizations. This paper has captured some of the viable components of reuse infrastructure and cost factors being considered and used at various design organizations across the globe.

## 9 References

Harris Project Management Guidebook, Harris Corporation, Engineering Productivity Group