



Present and Future Technology Challenges for Fabless IC Implementation

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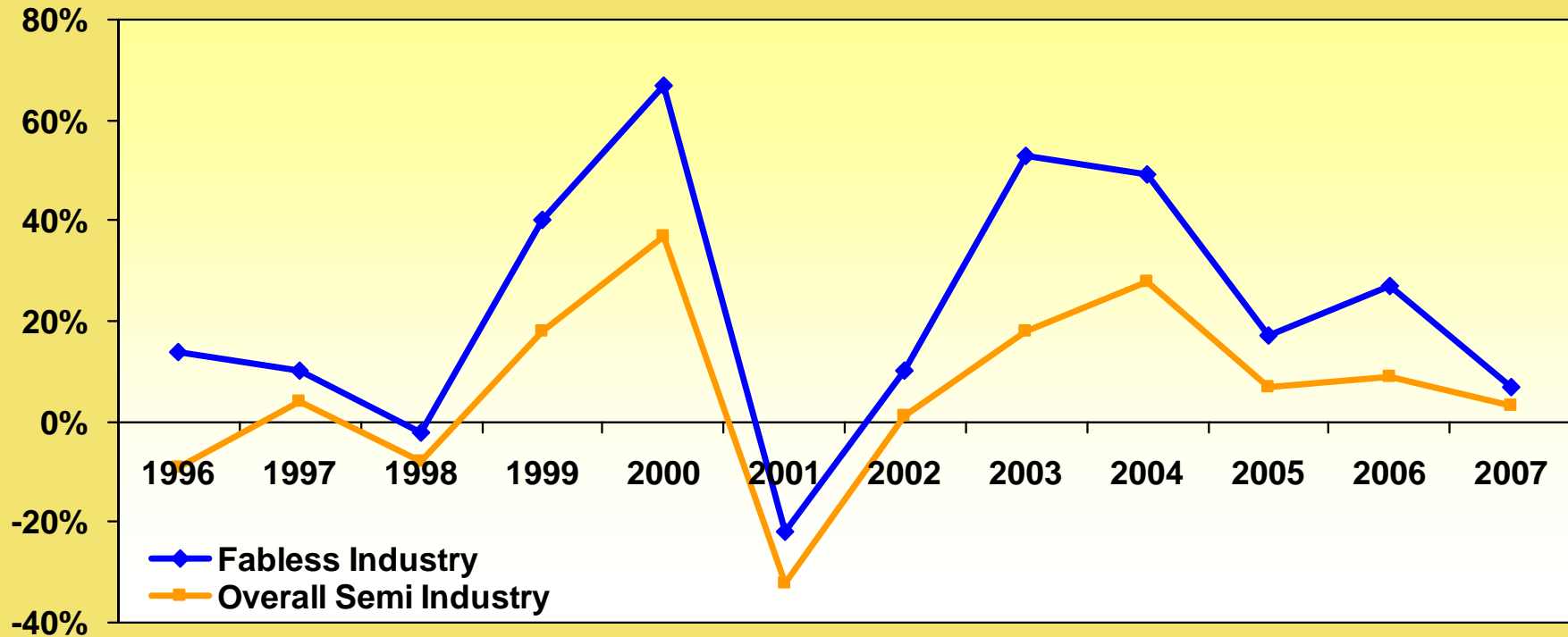
Table of Contents

- Fabless environment today
- How and Why the fabless model works – traditional view
- Technology Drivers in the Mobile marketplace
- Managing Cost, Power & Form Factor in the new fabless model
 - Future technology challenges
 - Silicon, design, packaging, modeling, test, yield prediction,...
- Fabless company business challenges
- Summary

The Fabless Model Generates Results

Revenue CAGR of 21% 1996-2007, vs. 6% for Overall Semiconductors

Fabless vs. Overall Semiconductor Revenue Growth 1996-2007

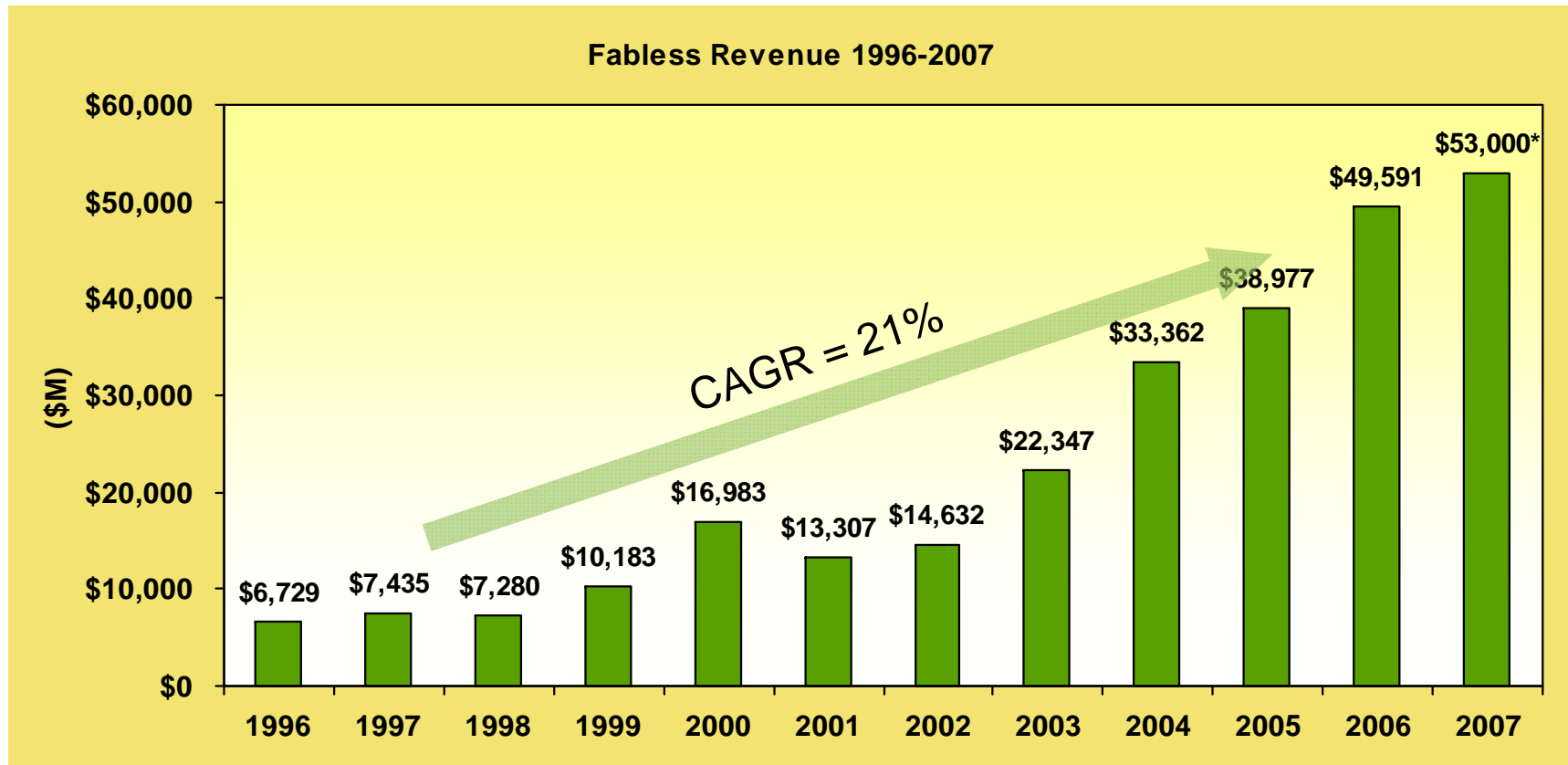


Source: Global Semiconductor Alliance (formerly FSA)

Note: Some smaller companies have not reported 2007 revenue, which may affect results.

Strong Fabless Revenue Growth

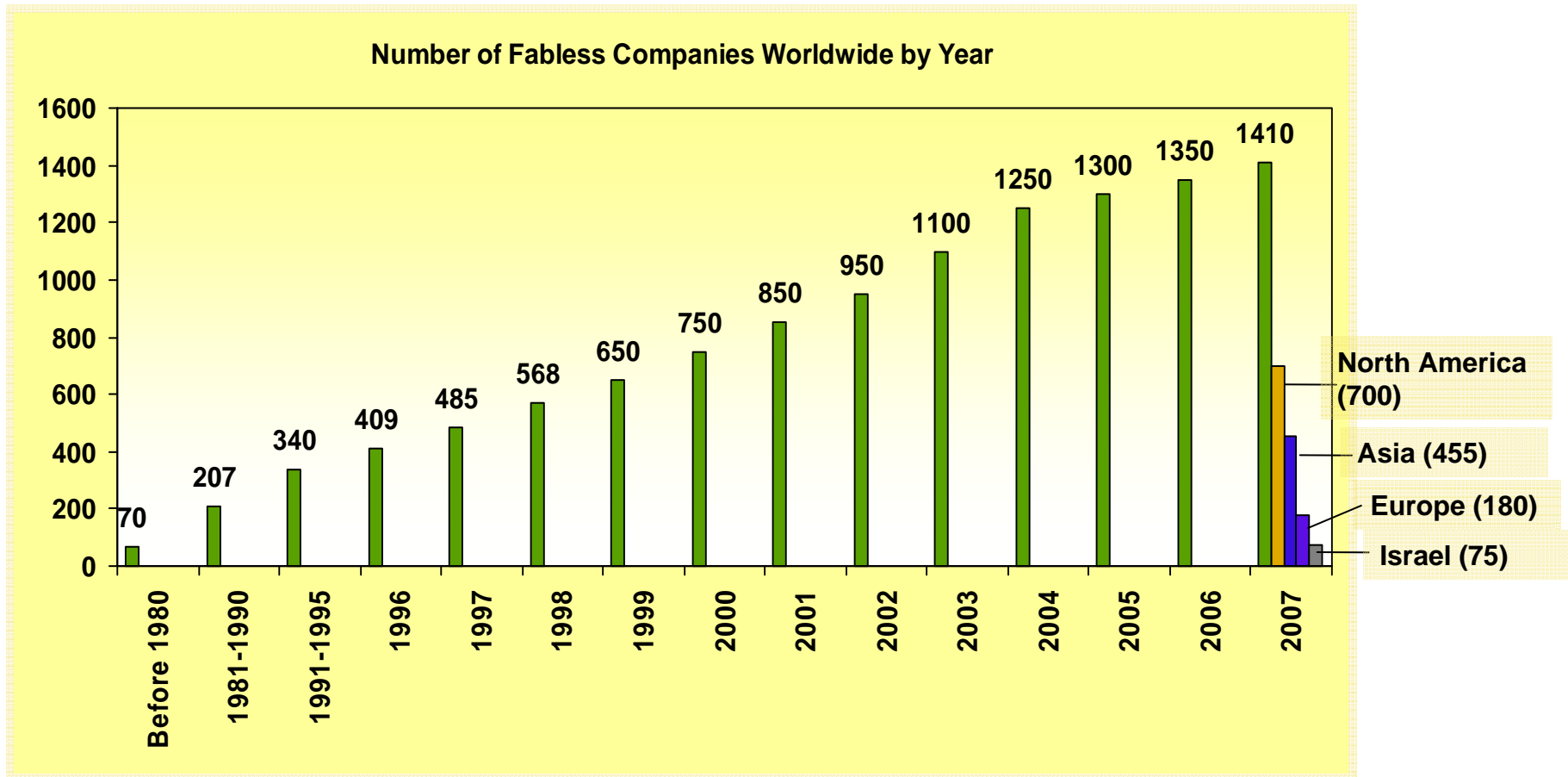
Fabless revenue is now 20% of overall semiconductor revenue



Source: Global Semiconductor Alliance (formerly FSA)

*Some smaller companies have not reported 2007 revenue, which may affect results.

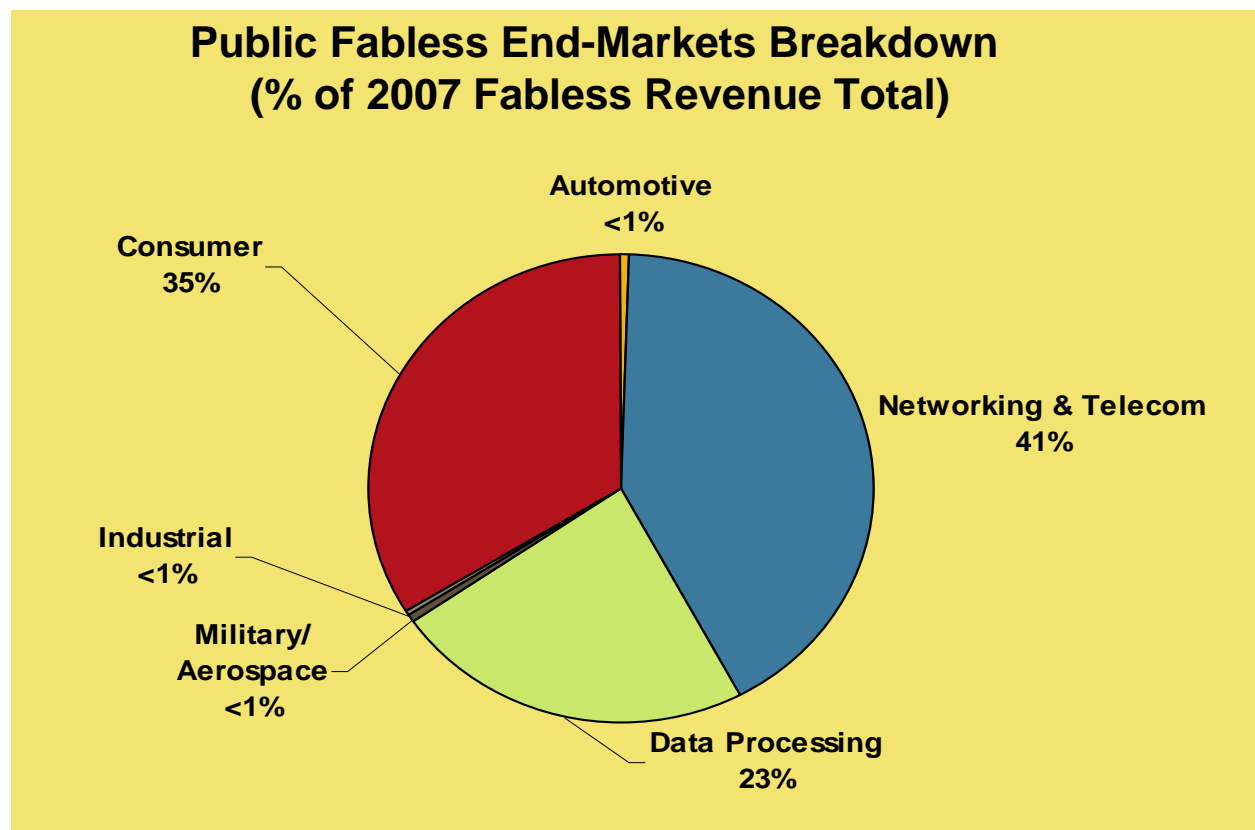
Worldwide Growth of Fabless Companies



Source: Global Semiconductor Alliance (formerly FSA)

Worldwide Fabless End Markets

Fabless companies participate in fastest growing market segments



Source: Global Semiconductor Alliance (*formerly FSA*)

Fabless Company Ranking

Top 10 companies account for 58% of Fabless revenue

2007 Rank	2006 Rank	Company <i>(Asia companies highlighted)</i>	Country	Ticker	CY2007 Revenue (\$000)	CY2006 Revenue (\$000)	% of Total Fabless Revenue
1	1	QUALCOMM (QCT Division)	USA	QCOM	\$5,619,000	\$4,528,000	10.8%
2	4	NVIDIA	USA	NVDA	\$4,097,860	\$3,068,771	7.9%
3	3	SanDisk	USA	SNDK	\$3,896,366	\$3,257,525	7.5%
4	2	Broadcom	USA	BRCM	\$3,776,395	\$3,667,818	7.3%
5	5	Marvell	USA	MRVL	\$2,894,693	\$2,237,596	5.6%
6	6	LSI Logic	USA	LSI	\$2,603,643	\$1,973,700	5.0%
7	8	MediaTek	Taiwan	2454	\$2,601,140	\$1,624,980	4.8%
8	7	Xilinx	USA	XLNX	\$1,809,084	\$1,871,000	3.5%
9	9	Avago Technologies <i>(Private)</i>	USA	N/A	\$1,554,000	\$1,603,000	3.0%
10	10	Altera	USA	ALTR	\$1,263,548	1,289,000	2.4%
						TOP 10	58%
TOTAL FABLESS REVENUE – CY2007					\$52B*		

Source: Global Semiconductor Alliance (formerly FSA)

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The Fabless model works because...

- **It enables all parties to focus on and invest in their core strengths**
 - **Allows Design houses to:**
 - focus on product/technology leadership in end user markets
 - have maximum flexibility
 - make effective use of capital for design R&D
 - **Allows foundries and SATS to:**
 - address multiple industries
 - have level loading across fabs
- **An “ecosystem” of supply-chain partners exists**
 - EDA, IP suppliers, design services, back end SATS, and foundries, debug service suppliers,...
- **Improved financials**

The financial model works because

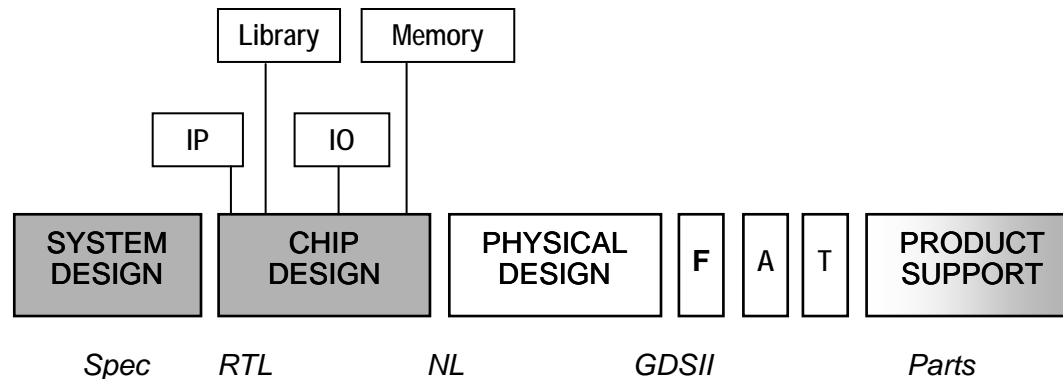
- **Improved financials at the fabless company (lower capex, better ROE/ROA,..)**
 - **Manufacturing partners invest in facilities, equipment and process development**
 - Investment cost amortized per unit, and passed on to the fabless customer
- **At the manufacturing partner**
 - High efficiency
 - Economy of scale
 - Product focused capex and r&D investments
 - Short ROI periods [for SATS, 0-1 year for time to initial money]
 - Low operating cost – labor, utilities,...

<i>CY 2005</i>	IDM	Fabless
ROE	10.5%	14.8%
ROA	6.4%	12.0%

Source: FSA

Application and Product Focus
Short term development
Short term investments

Traditional fabless model – the supply chain



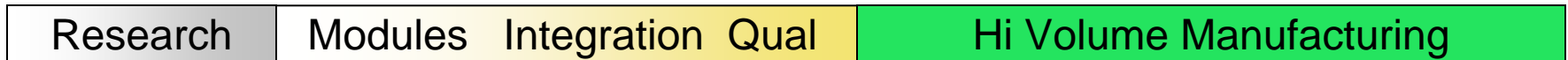
Ref: "Fabless Semiconductor Implementation" by R.Kumar, McGraw Hill, 2008

- Suppliers offer a portfolio of technologies and capabilities
 - A'la cart choices for best technology and business fit
- High volume and leading edge fabless houses are able to 'push' suppliers to meet their specific product needs

Traditional fabless model

- Designs start when process technology is stable at the foundry
- Schedule delayed relative to IDM's

At the Foundry:



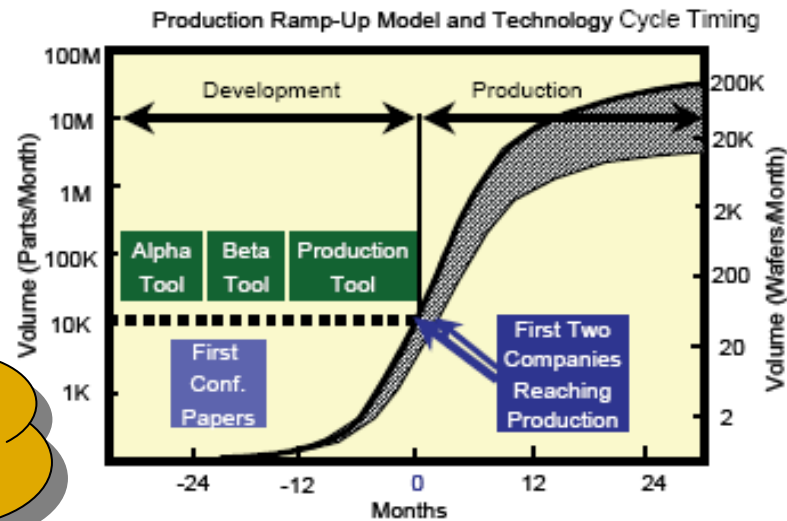
At the Fabless Co. or the ecosystem partner:



At the Fabless Co.



Does NOT work for Leading Edge users!!



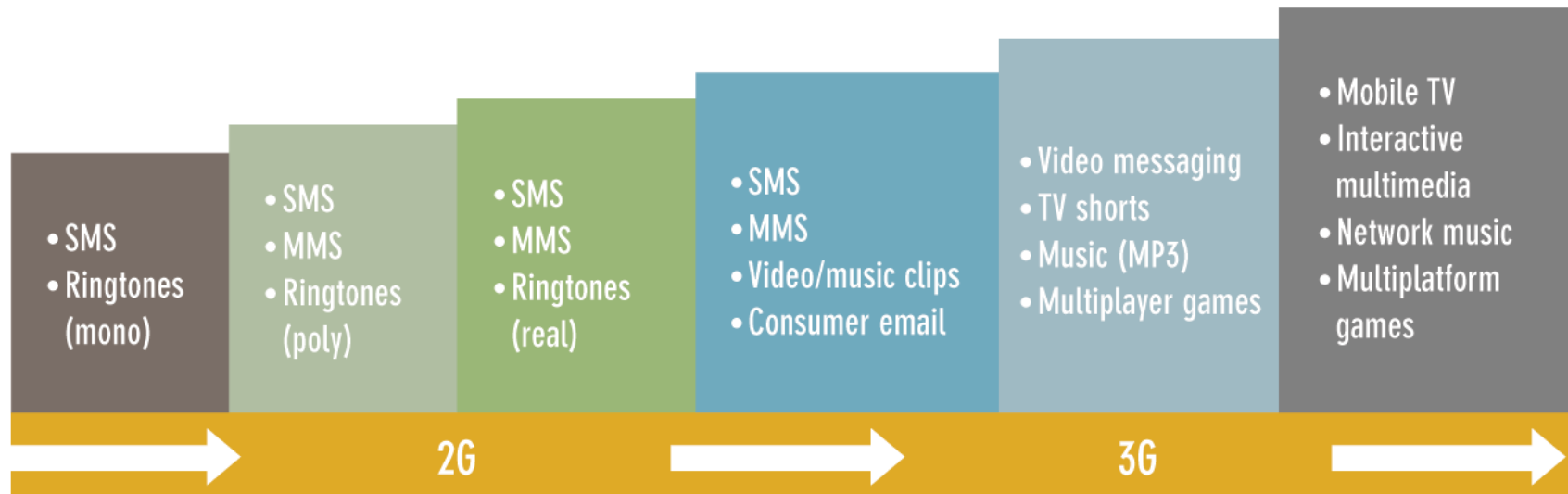
Source: ITRS 2007 Exec Summary

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Mobile Devices have become increasingly More Complex

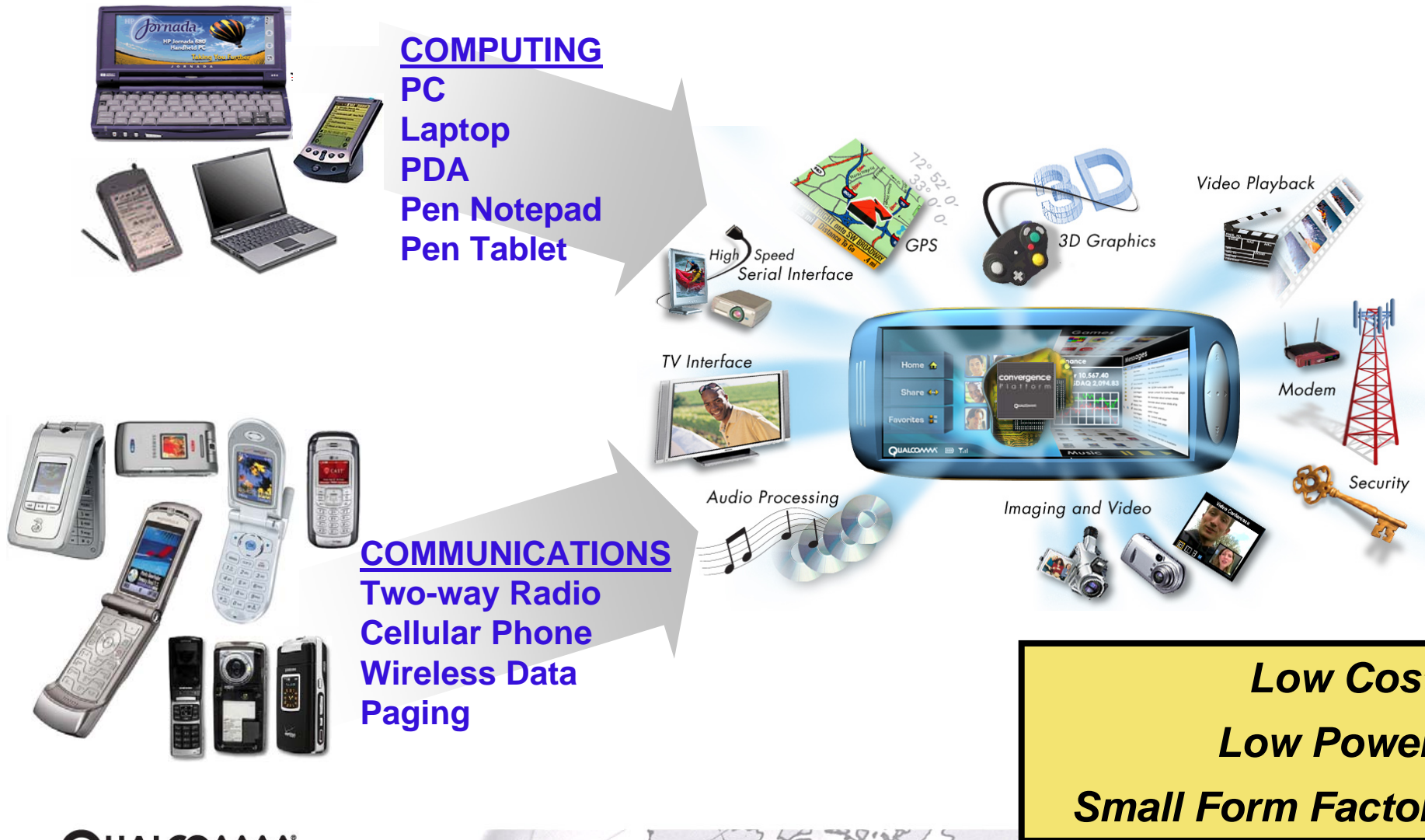
Mobile Content Evolution



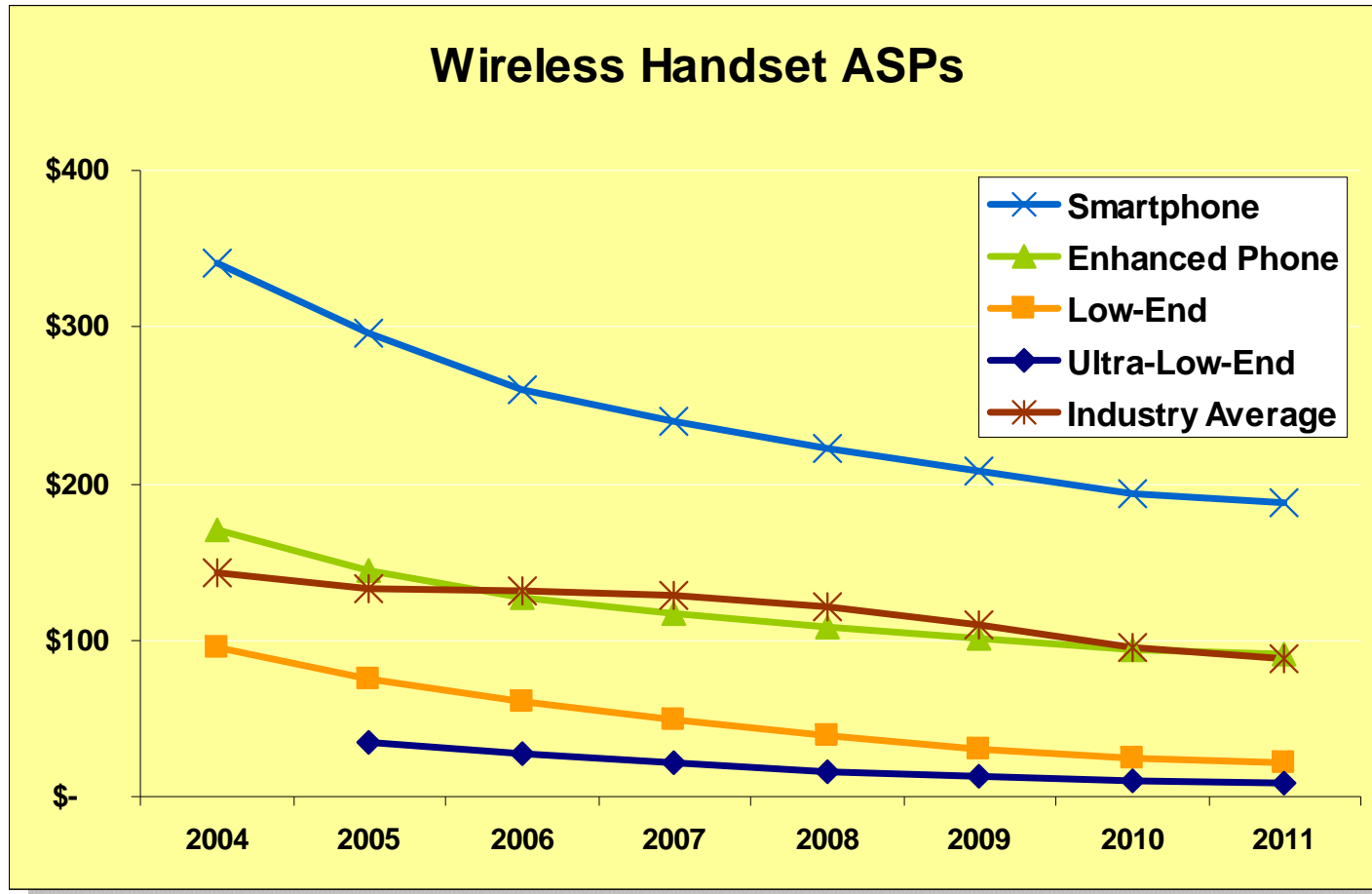
Source: Informa Telecoms & Media

Convergence of Computing, Communications & Consumer

...enhancing the Mobile experience thru content processing, storage and transfer



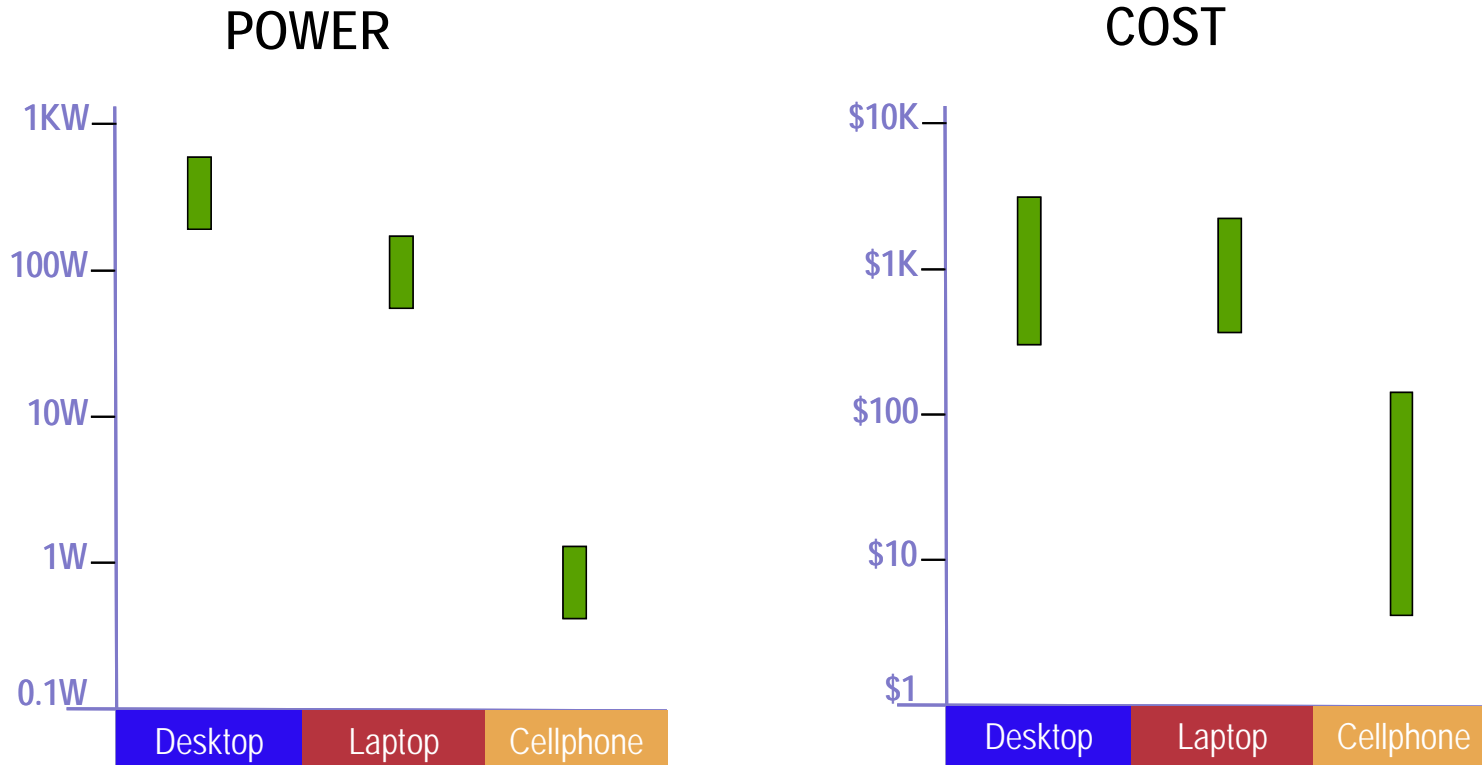
Our Handset Challenge – Increasing Features, Complexity and Power ...but *Prices Continue to Decline*



Source: ABI Research, August 2006

Handset Power and Cost

Much More Aggressive than Personal Computers



Some Notebook/Laptop vs. Handset statistics

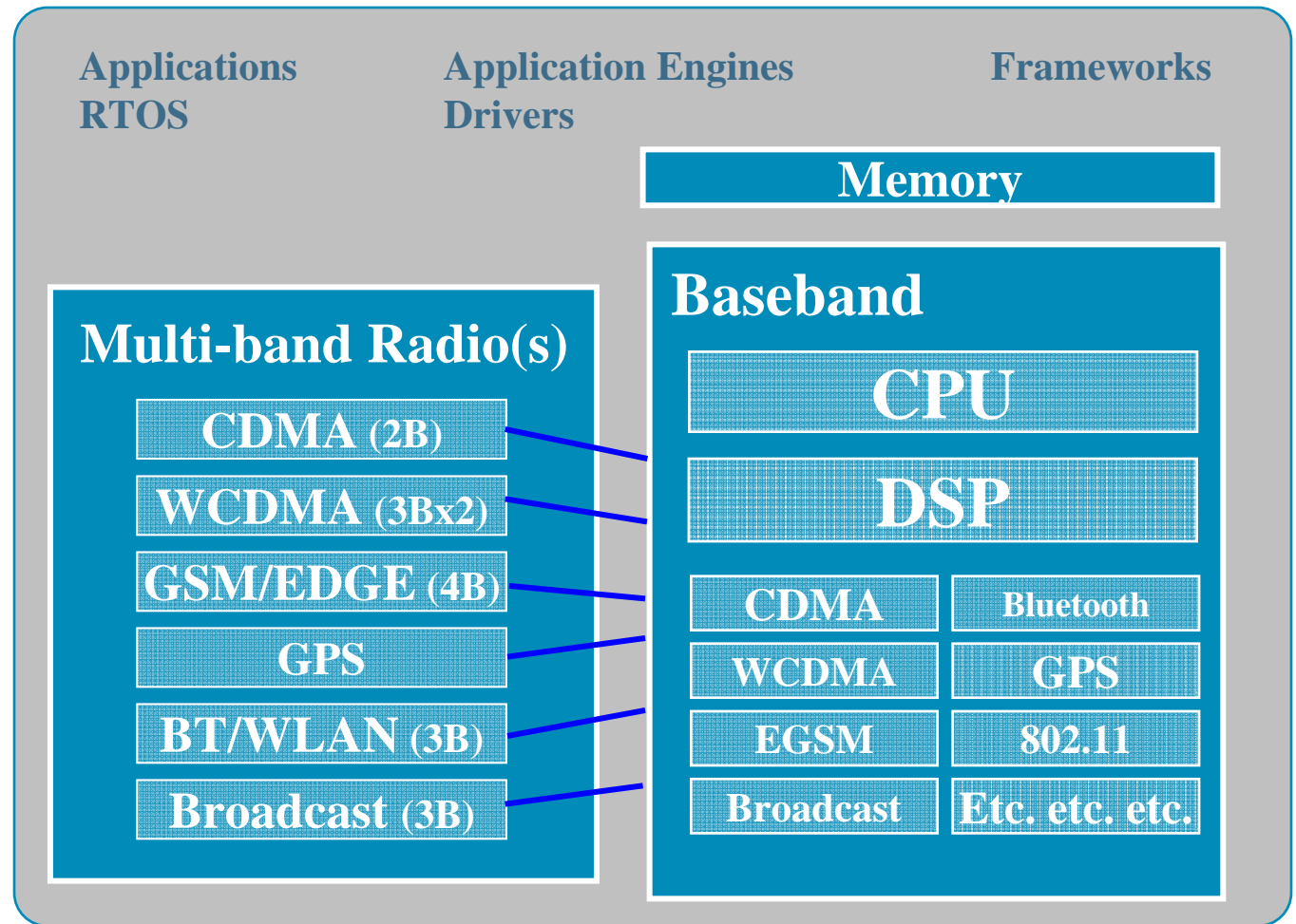


	<u>Notebook</u>	<u>Handset</u>	
Size, cc	2850	110	26:1
Weight, gm	2500	135	19:1
Battery, mAh	5,000	850	6:1
Volume, B units/yr	0.11	1.1	1:10
d2d Interconnect	PCB	Package	

➤ **Some example Technical challenge differences:**
Thermal
Mechanical

Wireless System Components

- ~ 20 Radios
- > 200MHz CPU
- > 200MHz DSP
- > 64MB Flash
- > 32MB RAM
- ~ 600 components
- ~ 20cm² PCB area



Mobile Handset Technology Drivers

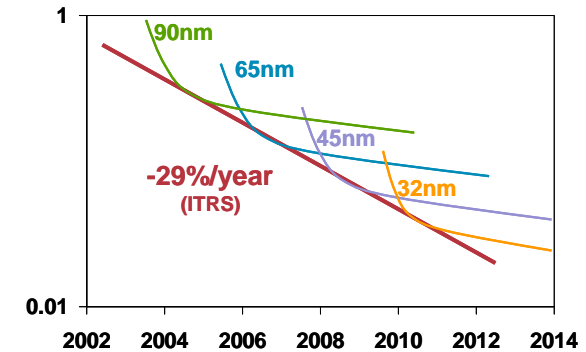
- Low Cost
- Low Power
- Small Form Factor

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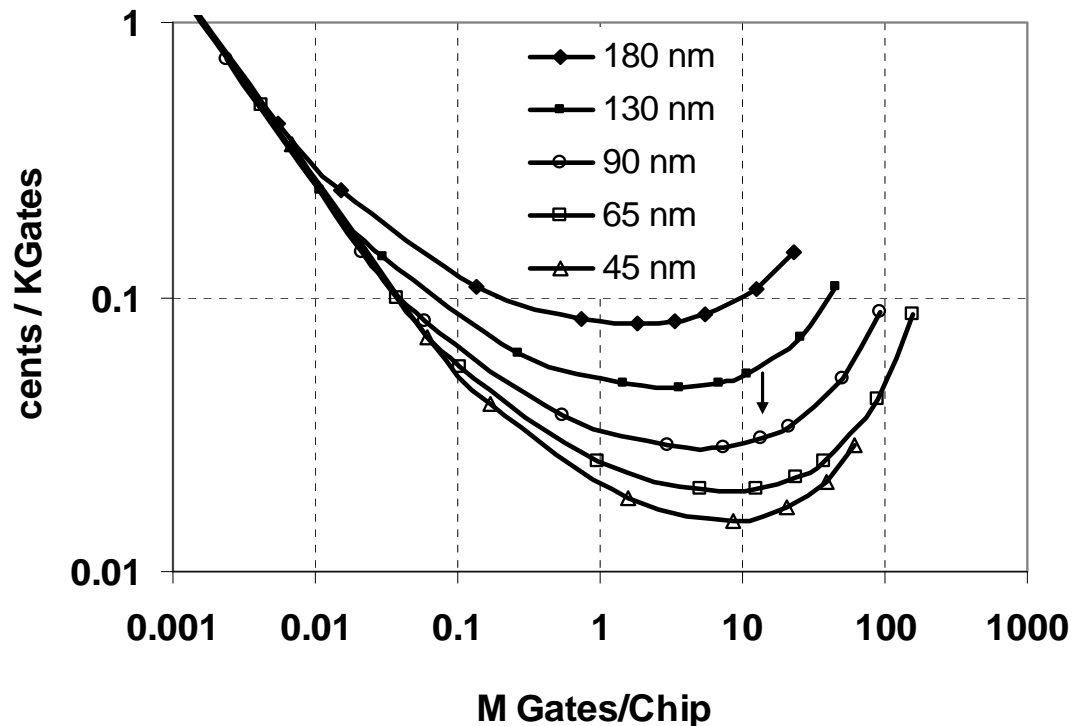
Using Technology to Manage Cost

- Technology Scaling
 - Aggressive transitions to advanced nodes
 - Invest in Advanced Technology Initiatives
- Low Cost Processes
 - Minimize mask counts vs. process features
- Reduce embedded Memory Costs (new technologies)
- Optimize yield & unit cost thru DFM methodologies
- Drive Accelerated Yield Ramps thru collaborative debug and analyses
- Low Cost Packaging



Collaboration with key Partners is essential

To optimize IC product cost in new technology nodes, need to understand Yield, defectivity trends

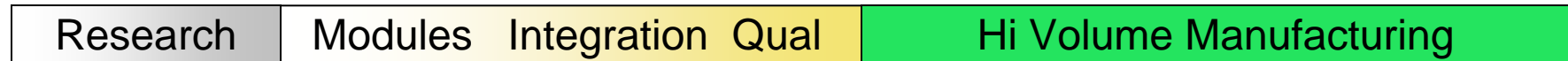


- Foundry must have competitive process technology
- Foundry technology must have features optimized for our applications
- Fabless company must have yield and cost models to predict technology cross-over points

New fabless model

...allows early process technology use

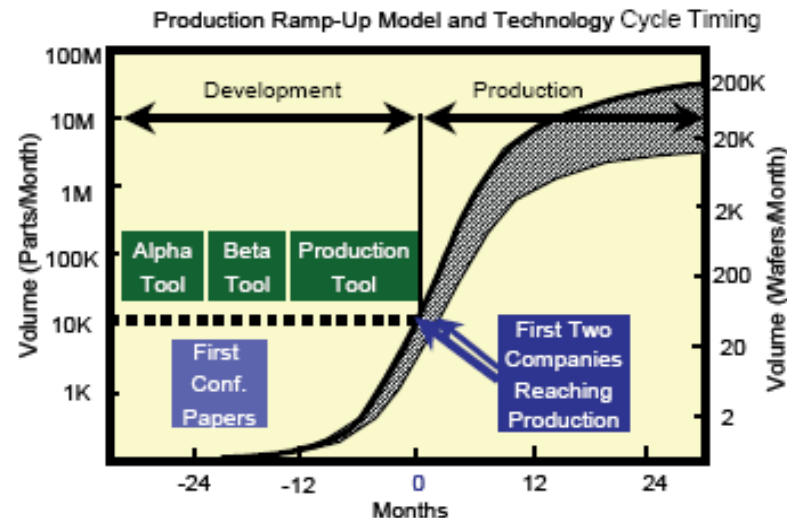
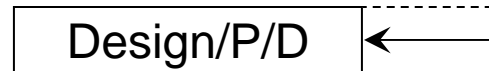
At the Foundry:



At the Fabless Co. or partner:



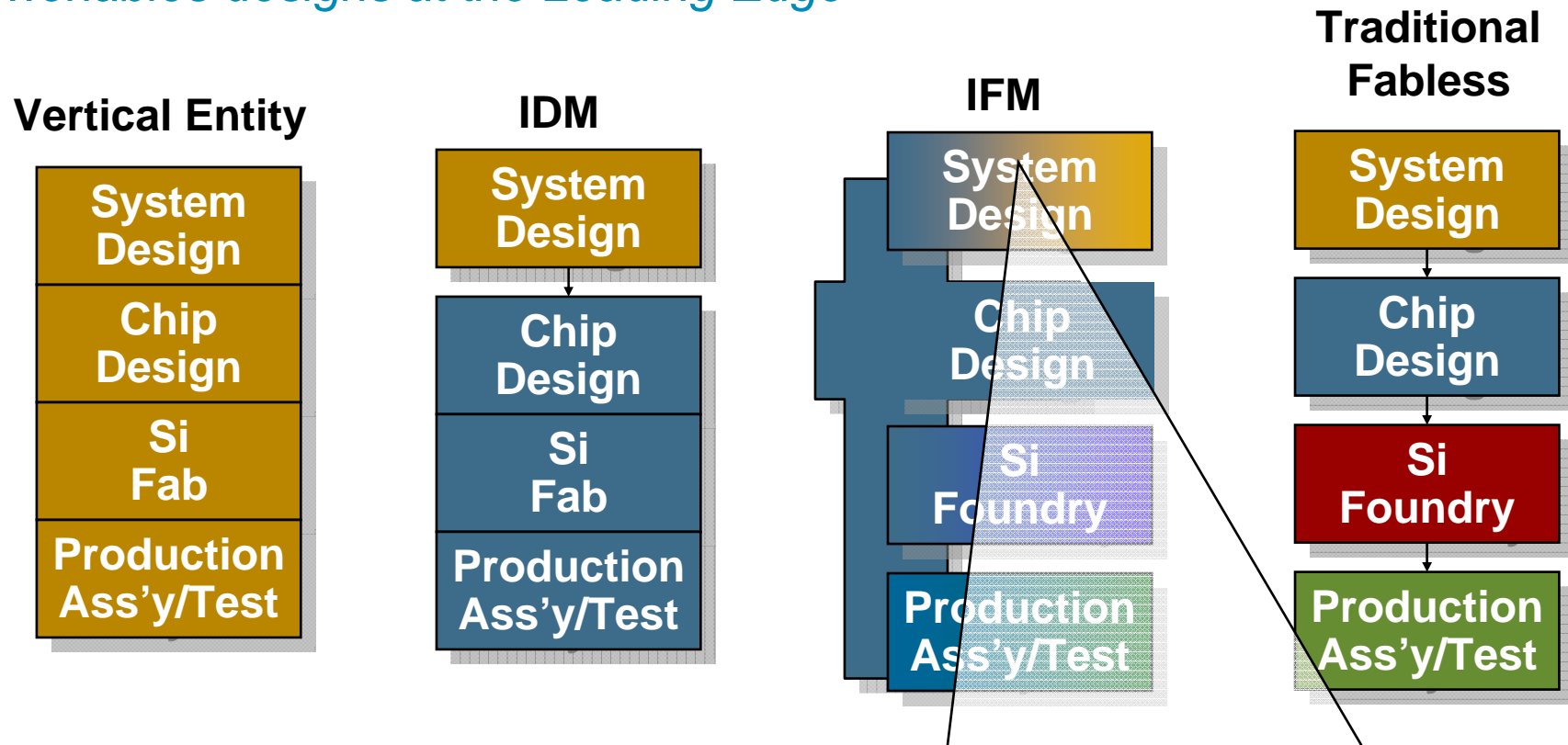
At the Fabless Co.:



- Early engagement allows earlier access to leading edge technology
- Reduces the IDM schedule advantage
- Fabless company influences process definition, features and rules at the foundry
- Foundry offers process technology as predicted by ITRS Roadmap

New fabless model (IFM)

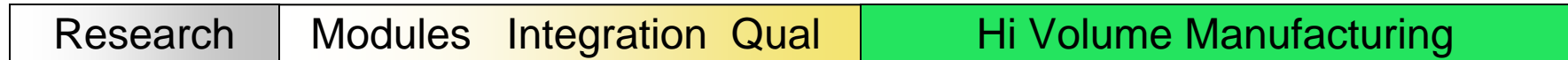
...focused on managing Collaborative Relationships
...enables designs at the Leading Edge



- **Aligned Technology Chain: through collaboration, NOT ownership**
 - **Best of All Worlds :** Business advantages and flexibility of the fabless world with technical alignment and integration of the IDM world

Moving Forward

...improved design/process integration



Library

Early Investigations

Design/P/D ←

- Leading fabless companies have an opportunity to:
 - Participate in technology selection [Bulk CMOS, 3D FETs, SOI,...]
 - Influence technology definition and tradeoffs
 - Perform circuit and architecture level tradeoffs
- **What's needed:**
 - Early models
 - EDA tools for advanced assessment of Variability, Power etc.

Managing the POWER

- Customers require Mobile devices with Time Between Recharge that is ~ Week(s)
 - Exacerbated by increasing functionality
 - Exacerbated by process scaling



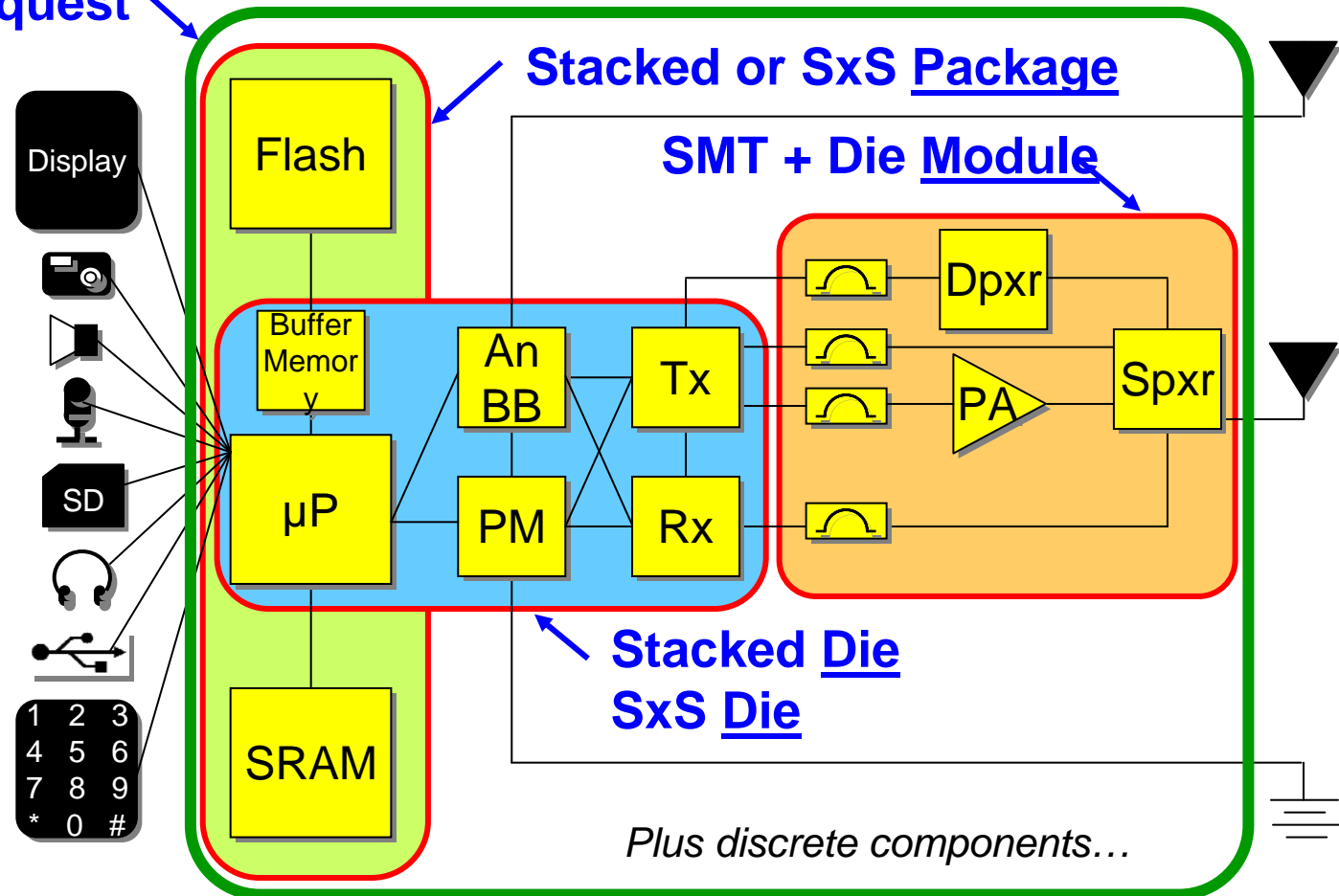
- Must have Design Solutions
 - Current Design Methodologies are focused on meeting performance targets
 - Unlike performance - which (mostly) came from process solutions
 - Need Design-for-Power Solutions
 - Architecture and Software
 - Logic Design
 - Circuit Design
 - Physical Design
 - Process

Managing the Form Factor

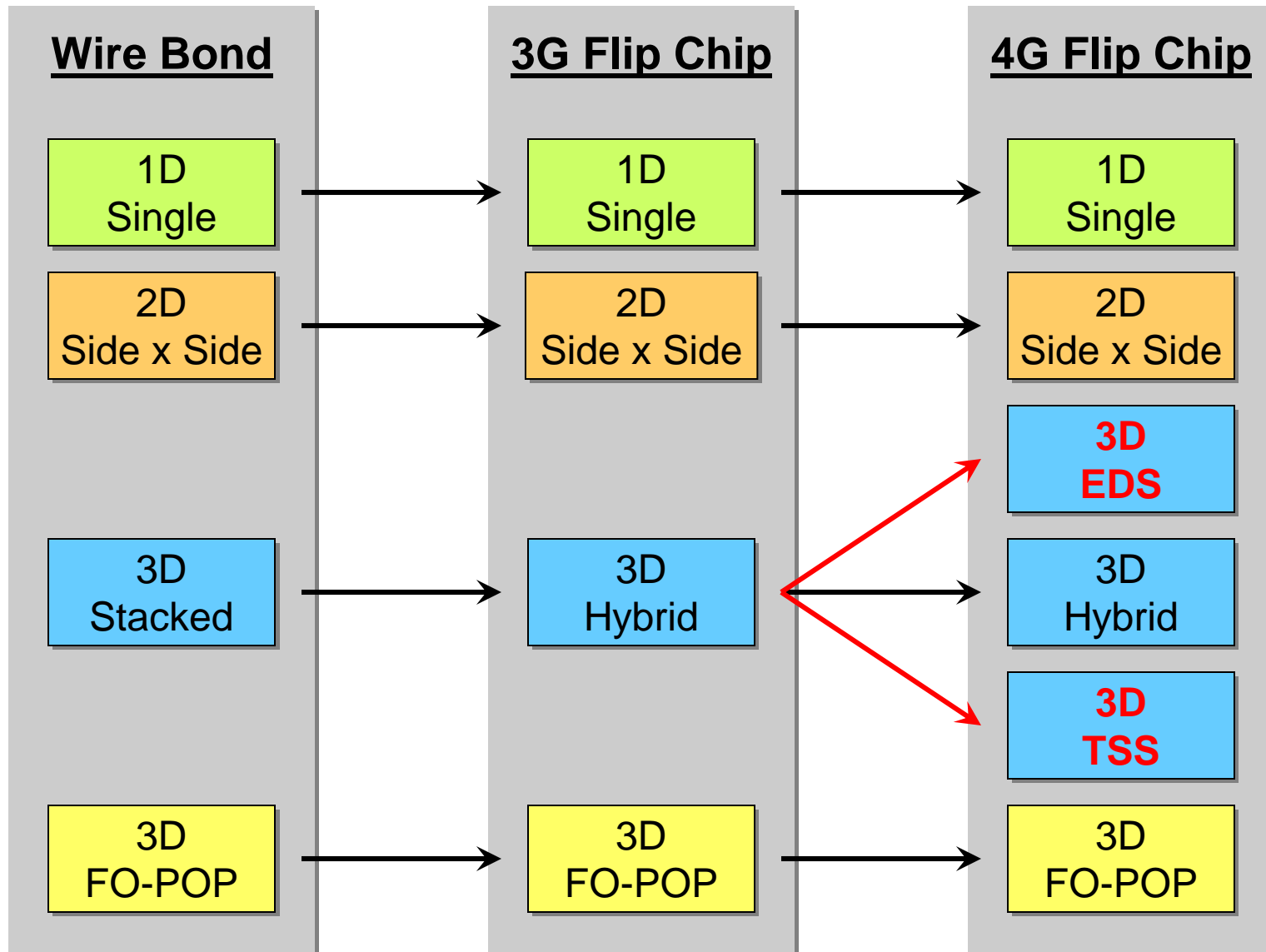
...driving "More than Moore's law" thru Innovative Packaging

...Typical Handset Block Diagram

Customer Request



Packaging Technology Evolution – Next Gen (4G)



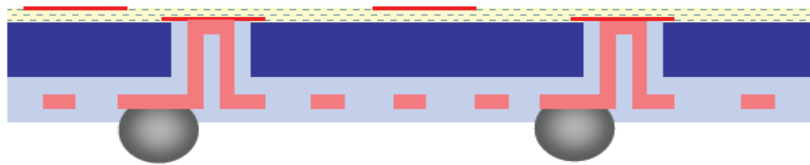
Innovative Packaging Reducing Form Factor – 3D TSS

TSS – Thru Silicon Stacking

VL (Via Last)

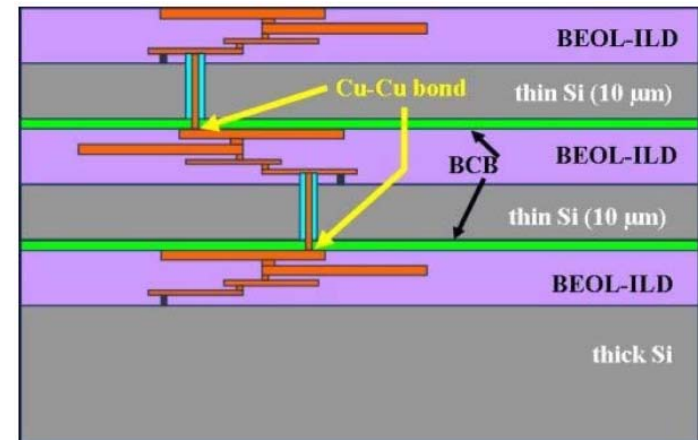
VF (Via First)

VL-TSS 3D IC Stacking



Source: IMEC

VF-TSS 3D Stacked IC's



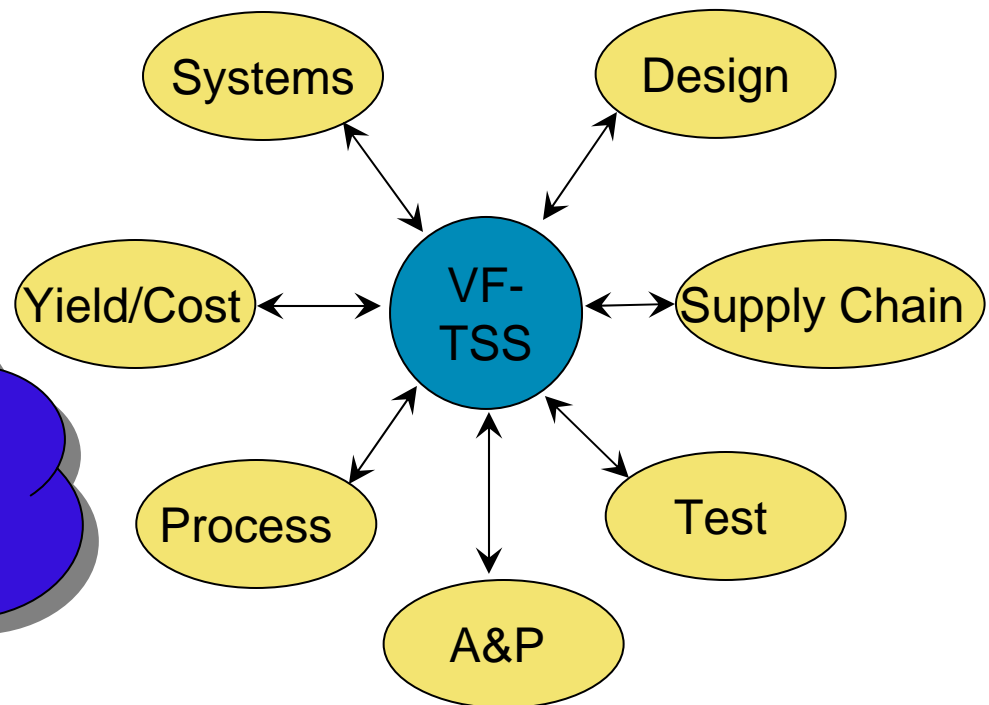
Source: IMEC

Looking ahead...VF-TSS will push “More than Moore” ...needs much Technology Innovation

What's needed:

- Tools for
 - Architectural tradeoffs
 - Partitioning analyses – chip, block, cell level
 - Power assessment
 - Thermal analyses
 - Cost analyses
- Test methodologies
- Supply Chain Integration

Many Technical & Business Challenges that need coordinated solutions ...maybe a ROADMAP!



Summary of Future Technology Requirements

Mostly common with those of fab'd companies & ITRS Roadmap

- Process Technology
 - Early access to predictive models
 - Architectural tradeoff analyses
 - Influence technology selection
- Design / EDA
 - Variability aware modeling
- Packaging
 - 3D stacking to push “More than Moore” concepts
- Test
- Yield and Cost assessment tools
- IP protection

Fabless and Fab-Lite Trends

- Leading edge fabless companies make selective technology investments to maintain competitiveness
 - Very high volume market segments is a must
 - Investments in:
 - collaborative IFM model
 - Research organizations
 - Innovative packaging and other MtM approaches
 -
 -
- Mainstream fabless companies will continue to use advance technologies, but at a slower pace
- Smaller IDM companies will continue to migrate to a “Fab-lite” model

Fabless and Fab-Lite Convergence??

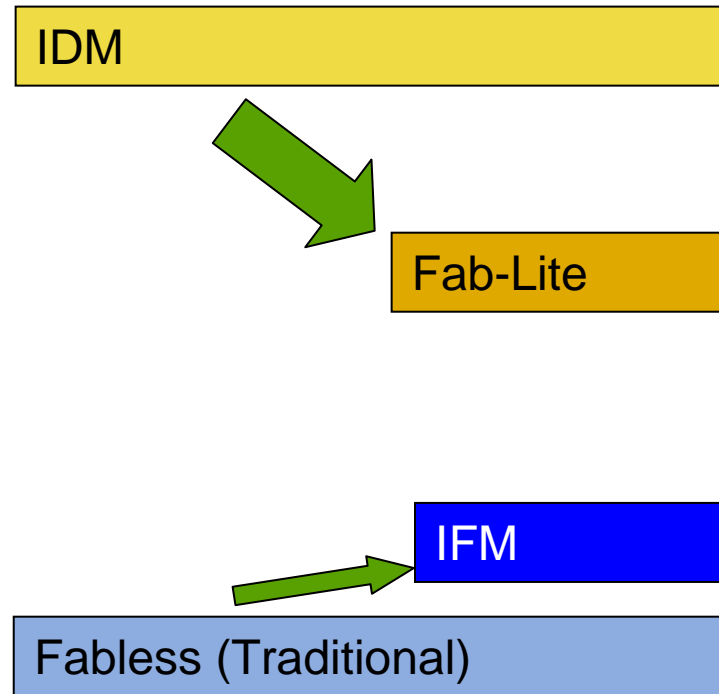


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Business Challenges

- High cost of Design will force judicious decisions for implementing new technologies
- Business model for investments in technologies 3+ years out
 - SATS and EDA focus is to invest in product driven cap-ex and development (0-1 year ROI)
 - Analytical and exploration tools not interesting to EDA companies (not enough 'seats' to sell)
 - Increased cooperation between foundries and fabless companies to invest in fabs and process development for advanced technologies
- Supply chain integration for 3D TSS / "More than Moore"
- Business Trust - IP protection across foundry, IP providers,...
- Design/Process integration between fabless design house and supply chain (vs. IDM's "seamless" integration)
 - Need to reduce time to market for technology/library development and qualification
 - Need to optimize for cost and efficiency as two equal partners

Summary

- Fabless model is here to stay
 - Horizontal model, both for end user products and semiconductors, has proven to be superior over time
 - Cellular phone and consumer electronics markets is a key driver in this dynamic
 - Further horizontalization is likely to continue...more efficient and cost reduced processes
- Technology requirements have been ‘stretching the envelope’, incorporating somewhat evolutionary enhancement to meet cost, power and form factor needs.
- Expect more aggressive technology push from leading edge fabless and fab-lite companies in the MtM arena, e.g., TSS