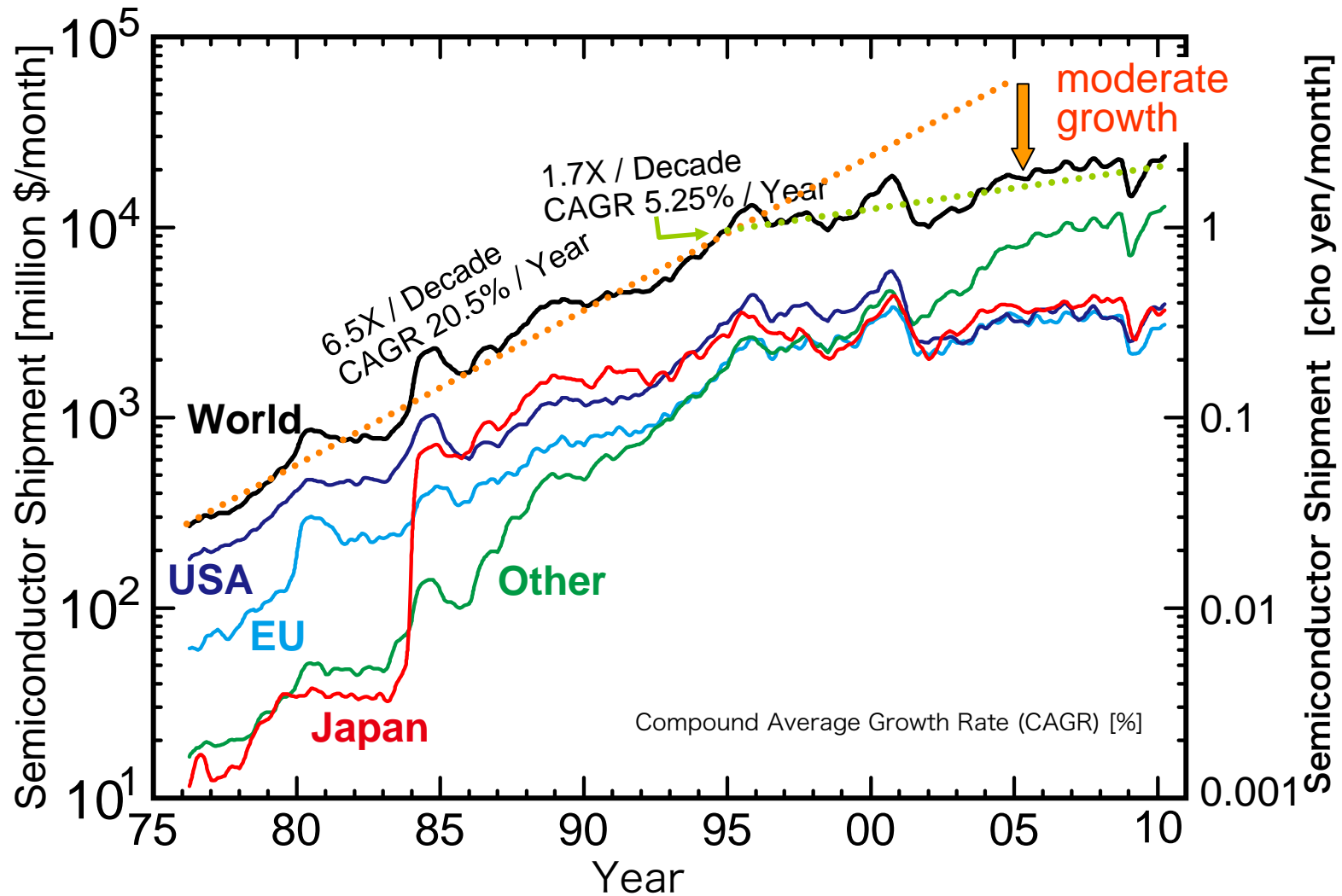




# minimal FAB

**Shiro Hara, Ph.D**  
**Representative of**  
**Fab System Research Consortium, AIST, Japan.**

# Moore's law



## Logistic Function

$$N(t) = \frac{K}{1 + \left( \frac{K}{N(0)} - 1 \right) e^{-rt}}$$

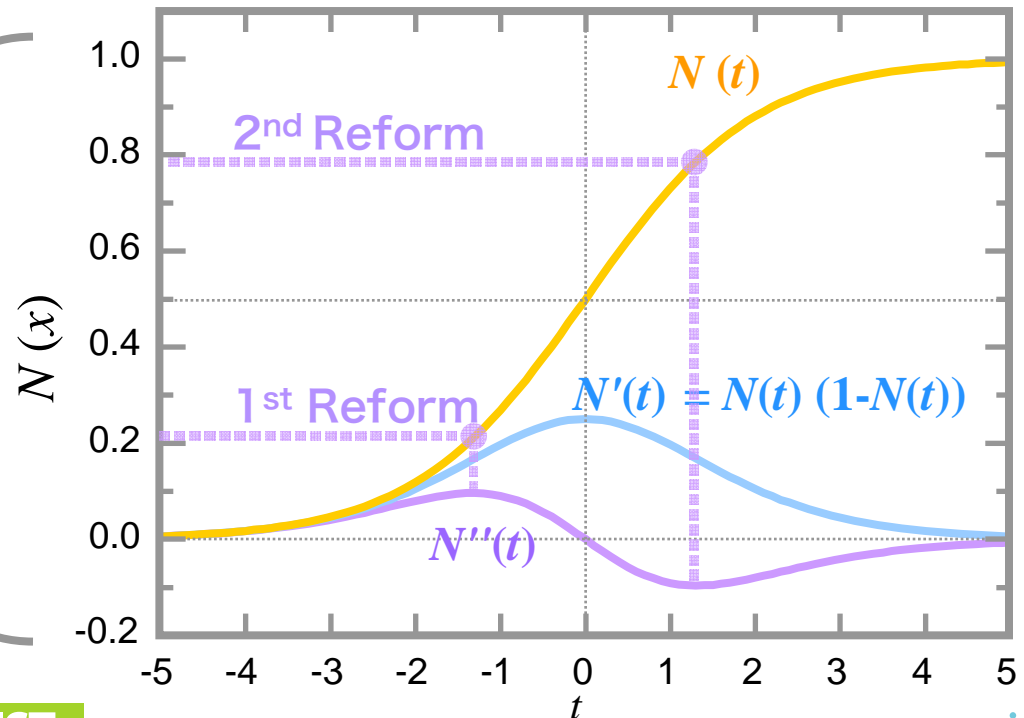
for  $K = 1, r = 1, N(0) = 0.5$

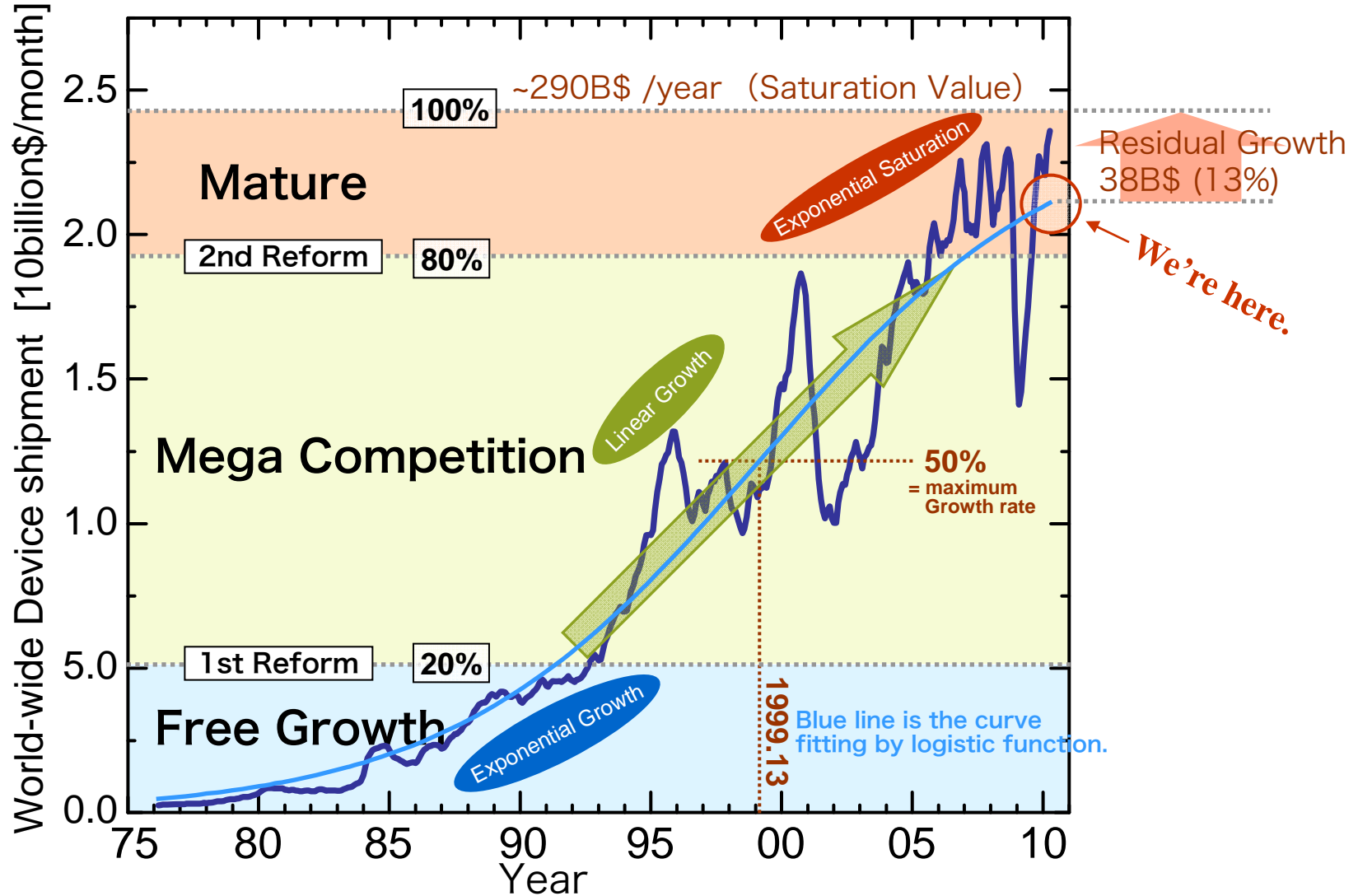
## Sigmoid Function

$$N(t) = \frac{1}{1 + e^{-t}}$$



Pierre François Verhulst  
1804-1849 Belgium

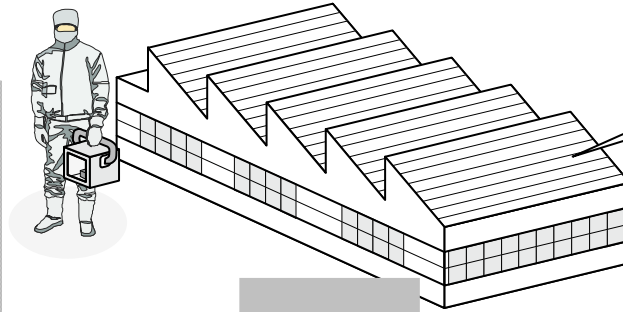




## Present Fab (Type1)

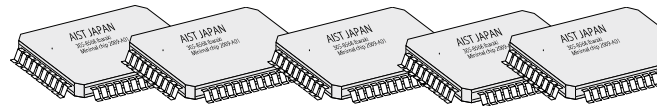
Users hope not only a low cost, but also a function that fits each user.

An Actual chip cost for a car is very high because of huge factory investment and low production volumes for cars.



It produces 500 million chips/year.

Suppliers can not deliver optimized functions and costs that users hope.



Luxury cars  
30,000/year



Poor Functions

Hybrid cars  
500,000/year



Insufficient  
Inspection

Suitable for  
1 minimal fab.

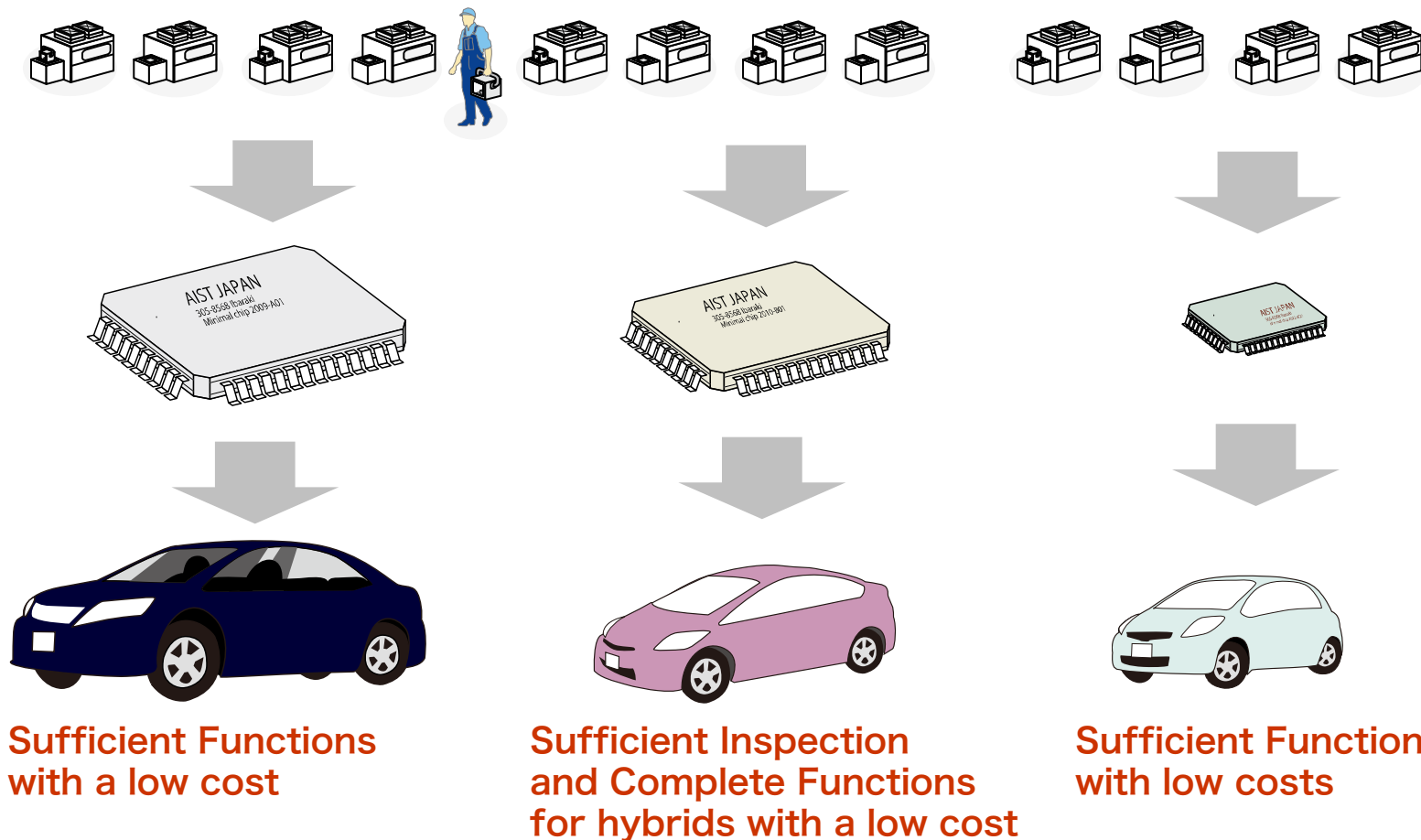
Economy cars  
120,000/year



Restricted Functions

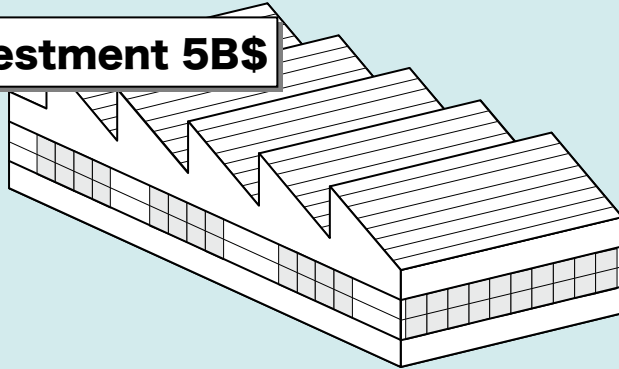
## Minimal Fab (Type 2)

- Minimal waste
- Sufficient functions
- low cost

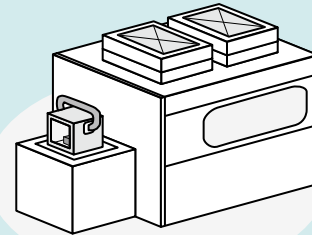


## Traditional MAGA FAB

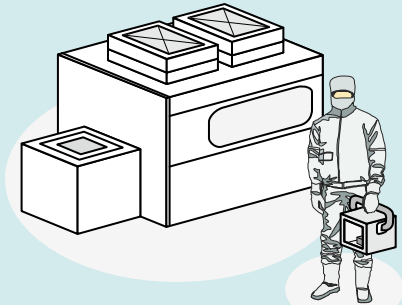
Fab investment 5B\$



200m

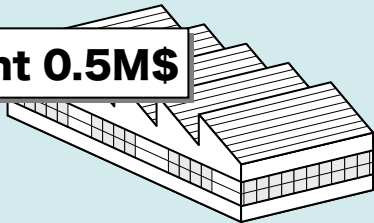


2m



## Room-sized Minimal FAB

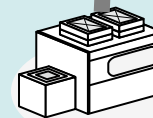
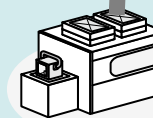
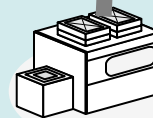
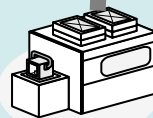
Fab investment 0.5M\$



10m

Minimal Manufacturing Technologies

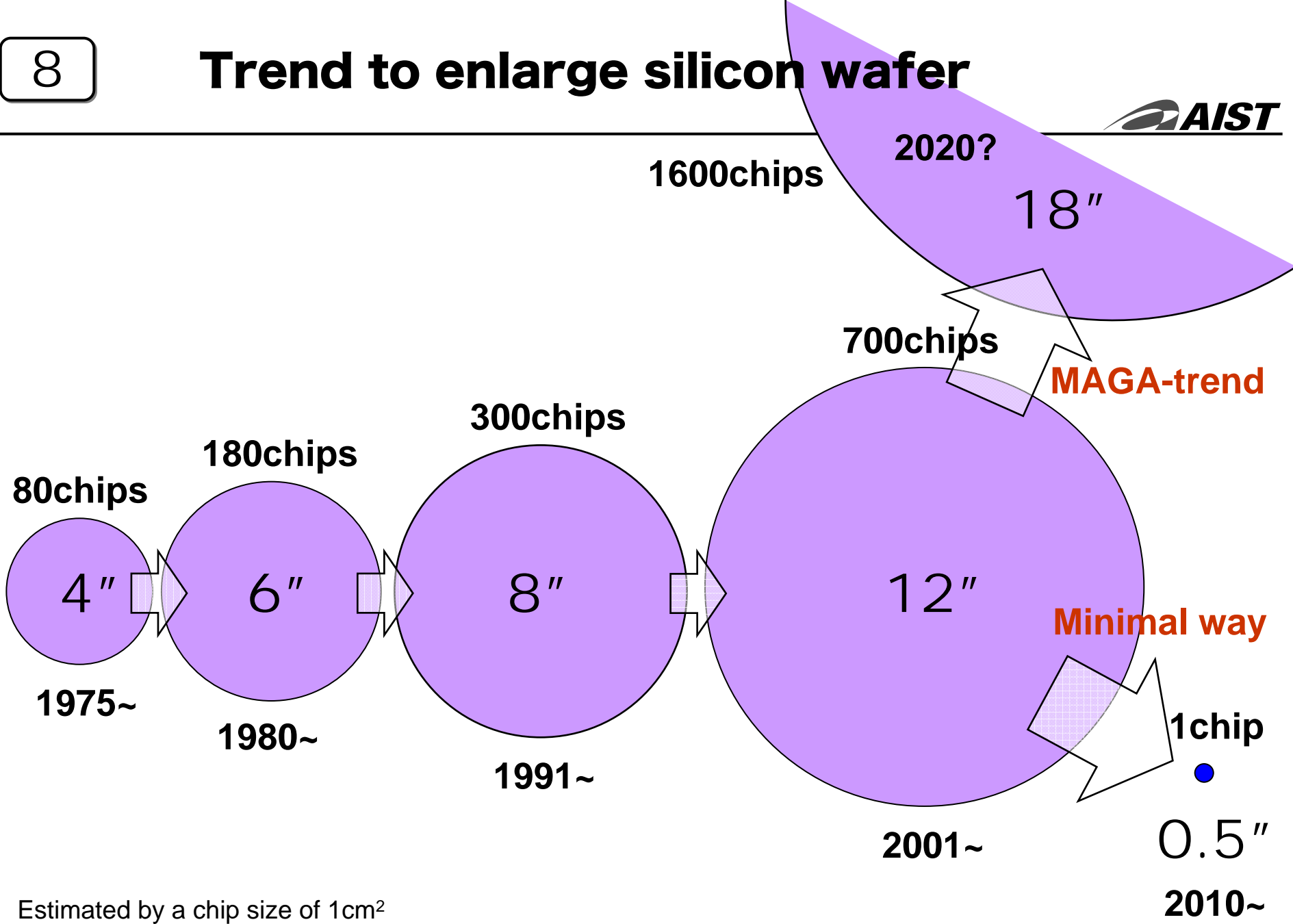
Saving energy&resources, cost, but high performance



0.3m

No clean room  
wafer size: 0.5"

# Trend to enlarge silicon wafer



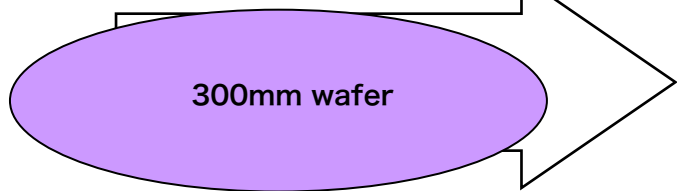
Estimated by a chip size of 1cm<sup>2</sup>



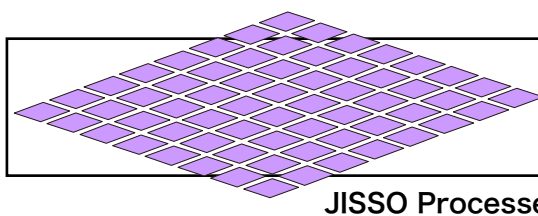
# 1 product/min is our principle

## TYPE 1

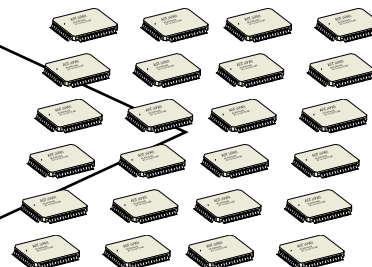
1 wafer/min



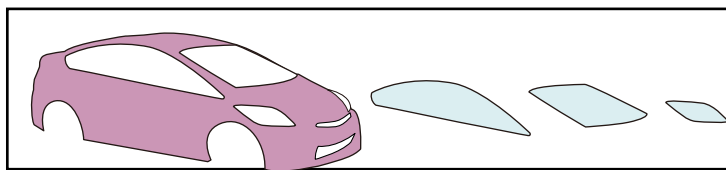
1,000 chips/min



1,000 products/min



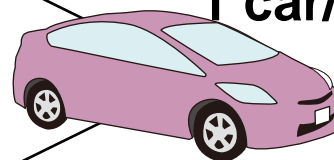
1 body/min



1~10 parts/min

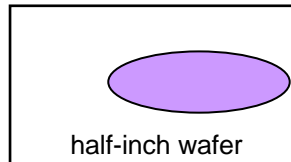


1 car/min

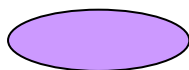


## TYPE 2

1 wafer/min



1 chip/min

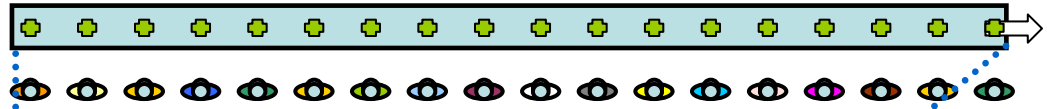


Assembly

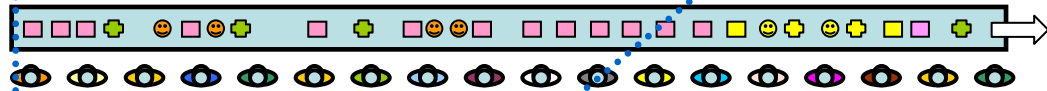


1 chip/min

**Type 1 Original Conveyor**  
 (Ford Production System)  
 • 1 product

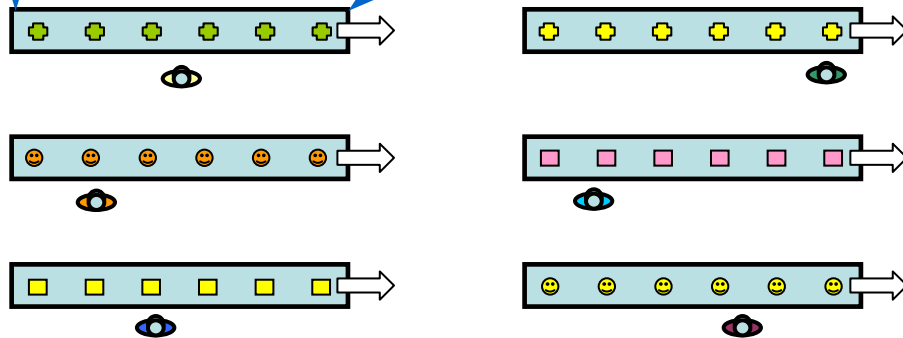


**Type 1' Present Conveyor**  
 • mixed flow  
 for large production capacity



※TOYOTA PRODUCTION SYSTEM (TPS) is to improve the low efficiency of mixed flow.

**Type 2 Minimal Manufacturing**  
 • minimal units  
 • Parallel lines  
 • Mono functional processes  
 • Cell production



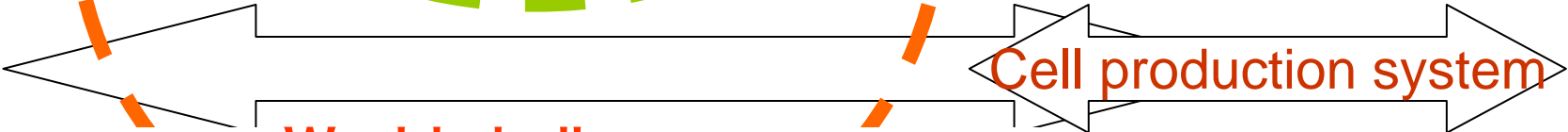
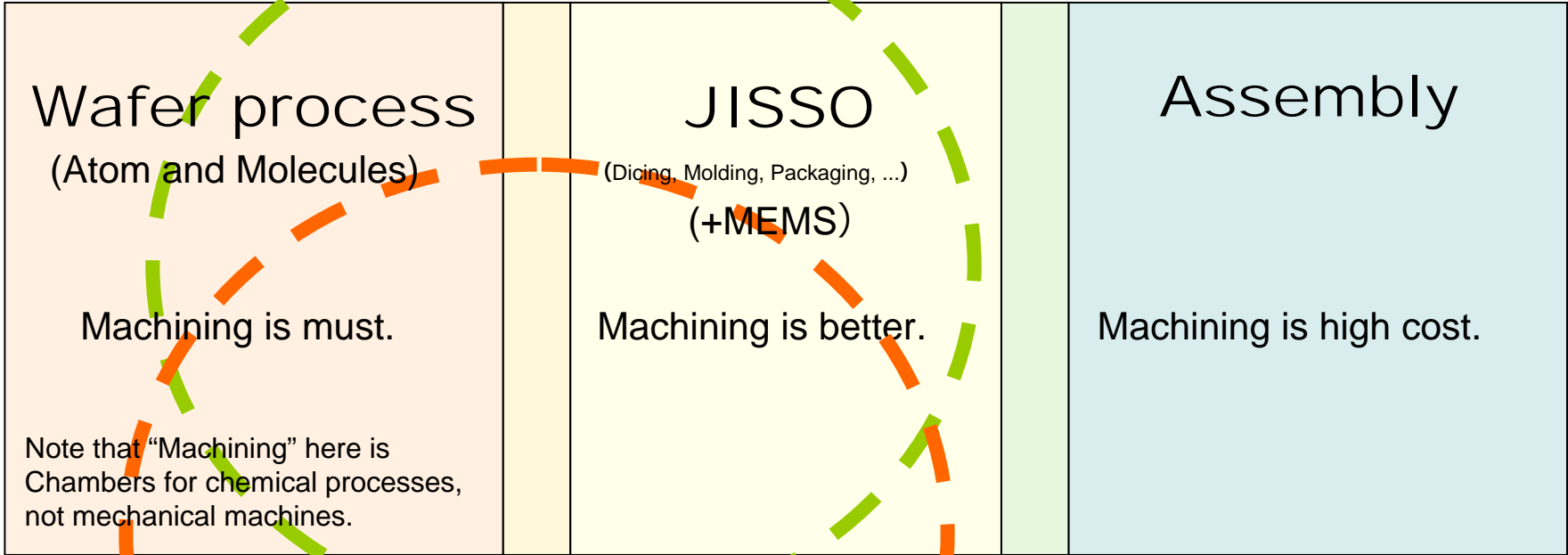
※Note that this type2 is totally different from Multi-functional Flexible Manufacturing System (FMS) that was remarkable before.

**Production Speed: Type1 = Type2 >> Type1'**

# Production Innovation from assembly to nanotechnology



## Nanotechnology



**World challenge:  
Next production innovation  
for high-mix low volume but high-efficiency**

Basic Condition

1 process = 1 min.

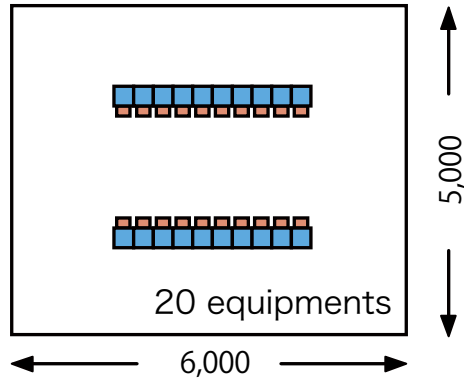
Production volume per month

= 1 min x 60min x 24hours x 30days

= 43,200 products

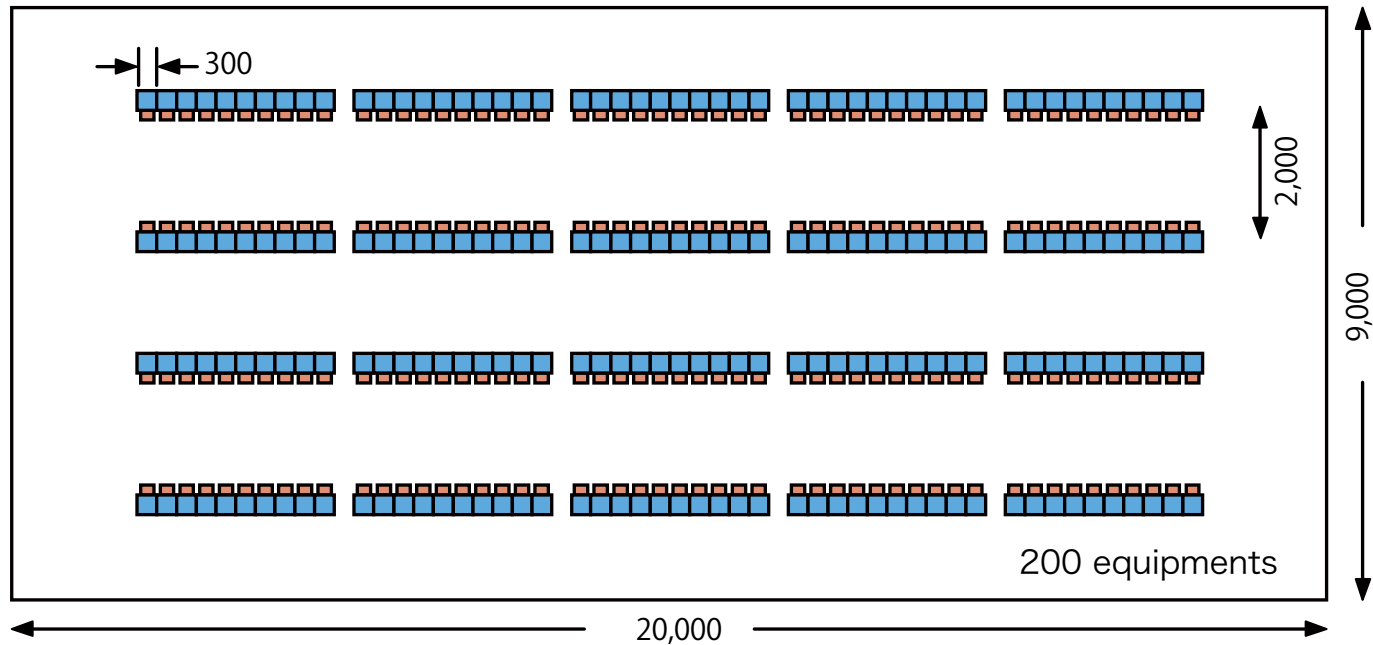
- ~40,000 products/month
- ~500,000 products/year

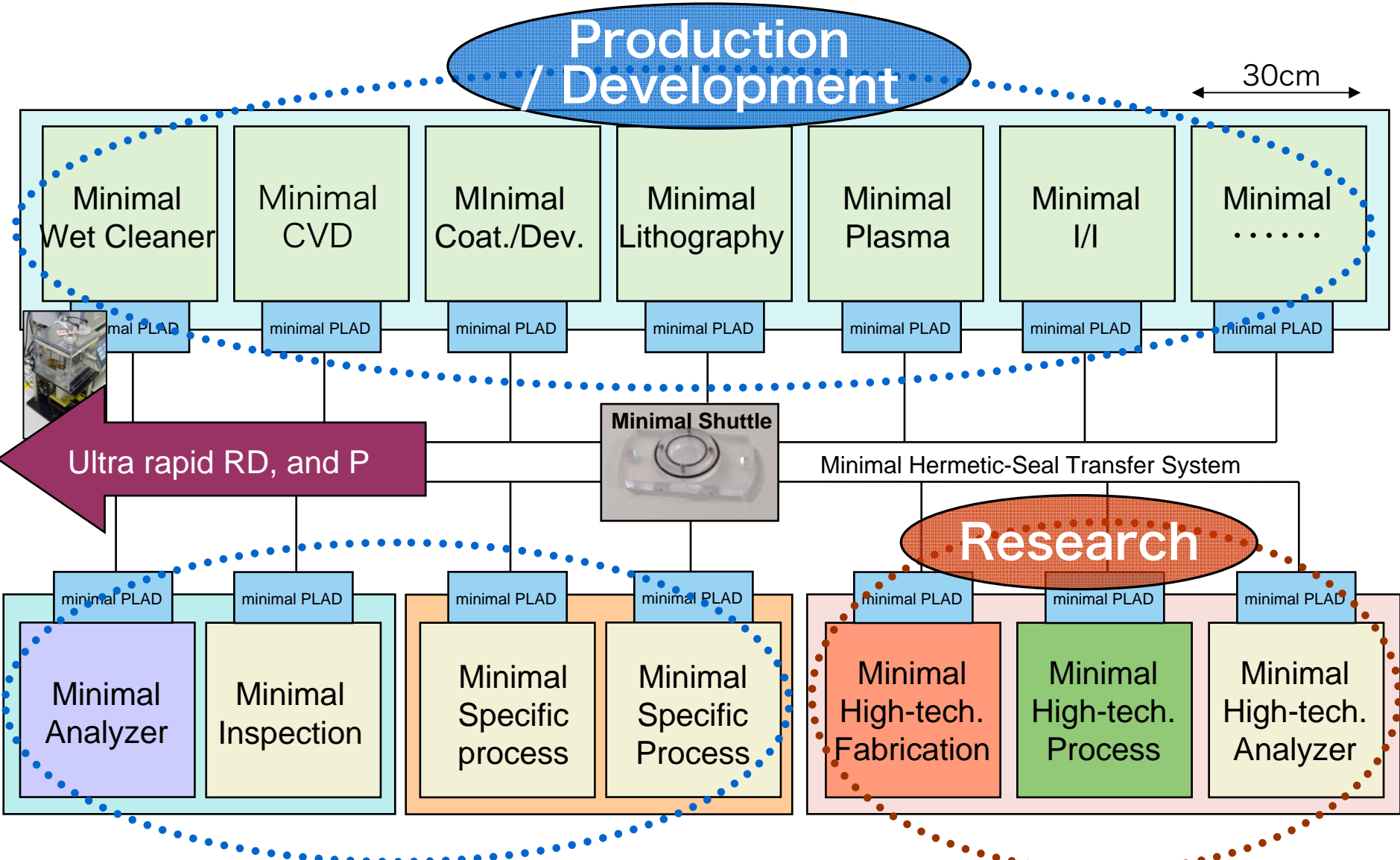
## Test Fab



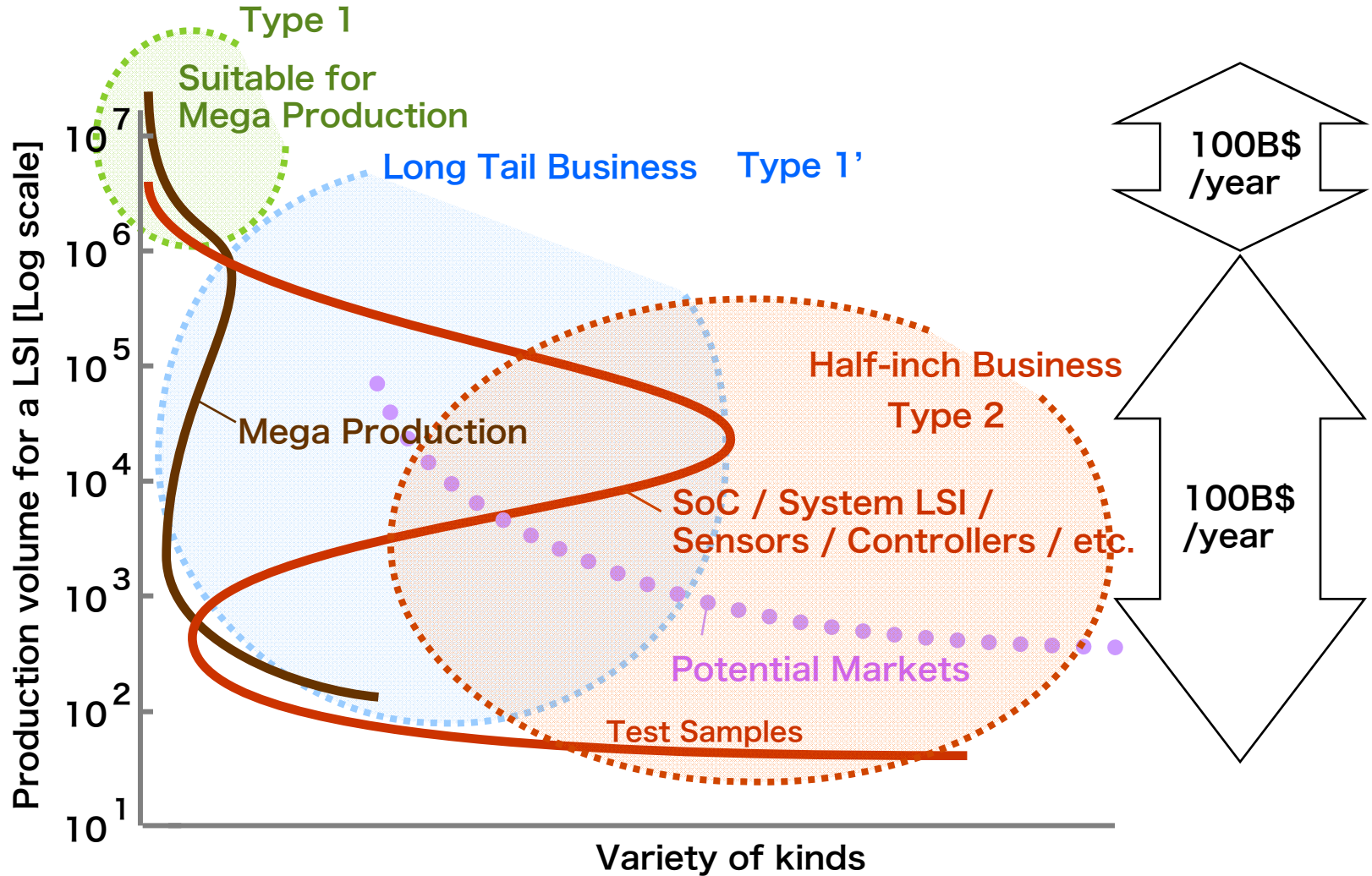
## Mass production Fab

(For simple LSI process)





# Business target



# Sizing effects of IC FAB



Assumption • cycle time=1min/wafer • processes=500(metal 8 layers) • design rule=90nm	Present Mega FAB	Mini-fab (HALCA) project	Room-sized FAB				Desk-top FAB
			Production FAB One process per equipment		Pilot FAB Multiple process per equipment		
Type of manufacturing processes	Present	Improved	Present	Minimal	Present	Minimal	nanotech
Fab area	150m <sup>2</sup>	30m <sup>2</sup>	10m <sup>2</sup>	5m <sup>2</sup>			1m <sup>2</sup>
Wafer diameter	12"	8"	0.5"				0.5"
Chips/wafer (1chip=1cm <sup>2</sup> )	600	300	1				1
Width of an equipment	3m	1m	30cm				-
number of Masks	34	34	Mask-less	Litho-less	Mask-less	Litho-less	Litho-less
number of Processes	600	500	350	32	350	32	~30
Wafers of work in progress (wafers)	17,000	7,500	350	32	1	1	1
Number of equipment	300	100	350	32	20	20	1 system
Factory investment	5B\$	0.1B\$	0.5M\$	450,000\$	300,000\$	250,000\$	10\$
Equipment layout	Job	Job	Flow	Flow	Flow	Flow	Flow
Wafer operation rate (process time/total time)	~1%	~1%	40%	50%	90%	90%	90%
Days for production	30 days	10 days	17 hours	32 hours	8 hours	18 hours	120 days
production capacity (300mm)	17,000	1,000	24	1	0.17	0.057	4x10 <sup>-4</sup>
Year capacity (1cm <sup>2</sup> chip)	140million	7million	0.5million	8,400	1,400	500	3
Capacity for PC Mass product	70%	3.5%	0.1%	4x10 <sup>-5</sup>	7x10 <sup>-6</sup>	2x10 <sup>-6</sup>	1.5x10 <sup>-8</sup>
Sales	10B\$	0.2B\$	0.5M\$	300,000\$	300,000\$	250,000\$	300,000\$
Chip price (Sales / produced chip no.)	12\$	29\$	1.7\$	36\$	36\$	500\$	100,000\$
Efficiency of resources	0.1%	0.2%	0.2%	100%	0.2%	100%	100%



# Fab System Research Consortium

to create ideal fab-system in the 21th century

