Simulation to separate value add from non value add complexity: a semiconductor supply chain example

26. / 27. Januar 2015 im Casino der Universität der Bundeswehr München

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Table of Contents

Table of Contents

The Semiconductor Environment

An Industry Comparison (... easy to memorize)

What if …

…the **Automotive** and **Aircraft industries** developed at the same rates as **Semiconductors** did in the past 30 years ?

➔15 mio miles
(570 x across the globe)

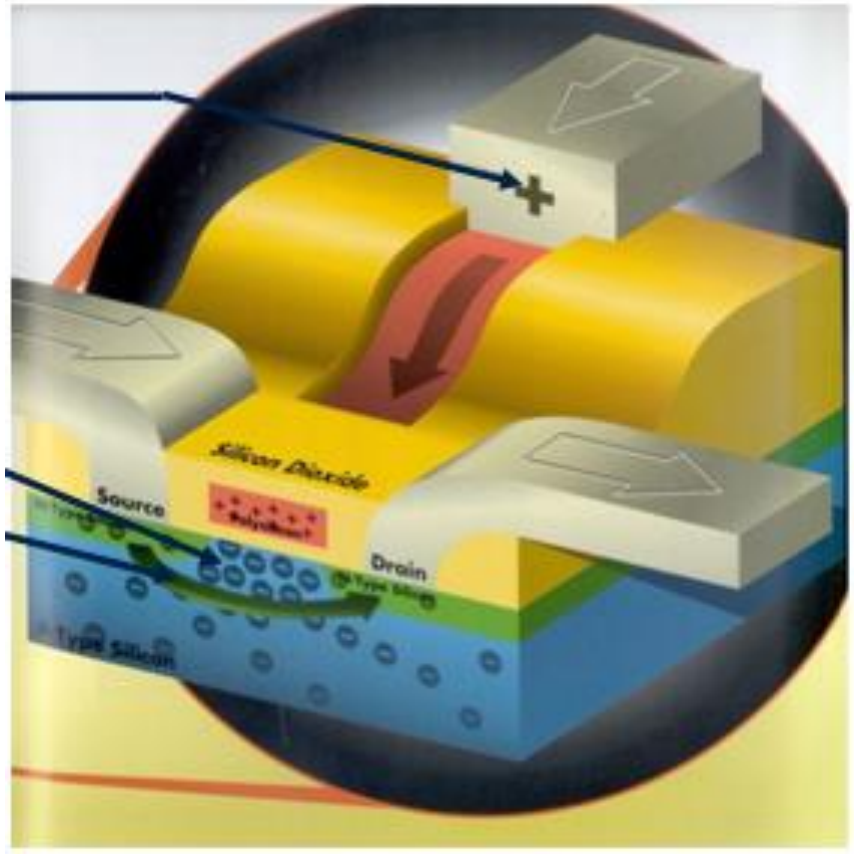
Why?

➔26.000 miles
(1 x across the globe in 20 minutes)

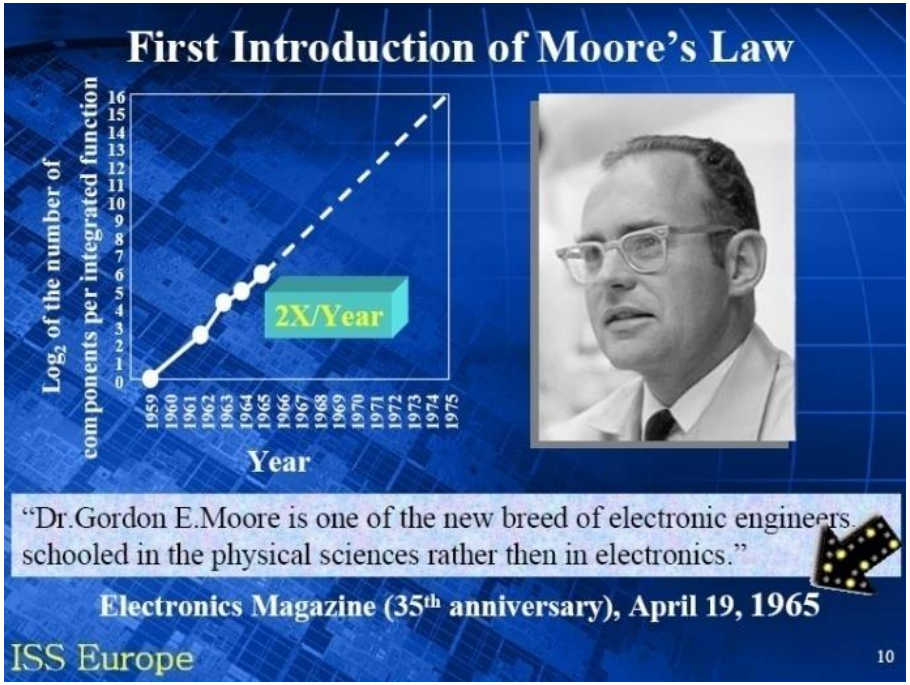
Jeffrey Rayport, professor at Harvard Business school

Dec 23rd 1947: The Starting Point of the Semiconductor Industry

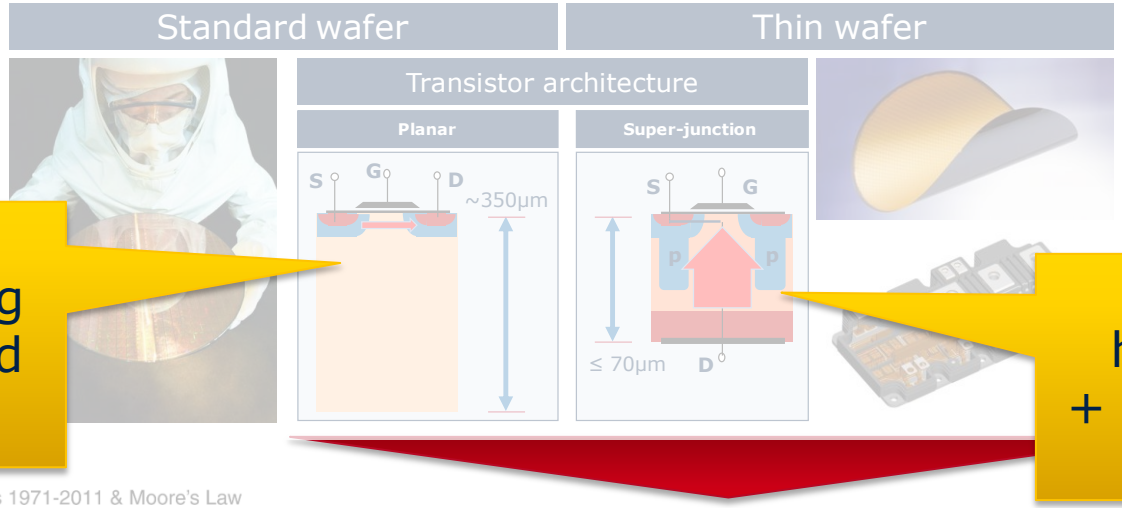
Because



and

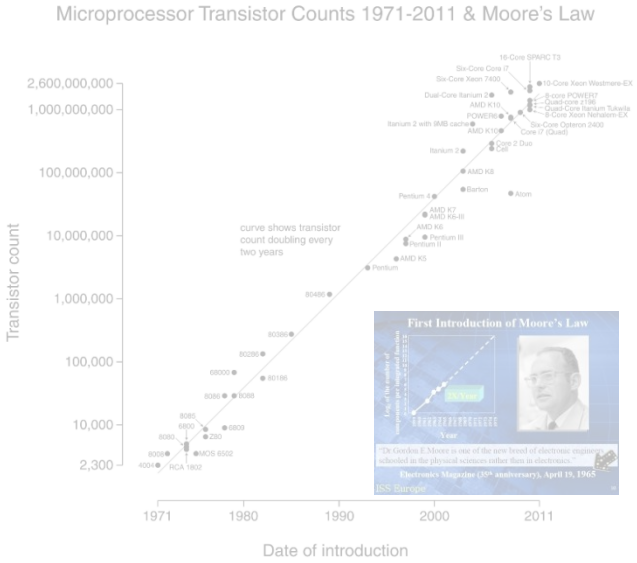


Moore's Law - in modern words: Much more functions for the same CO_2 consumption

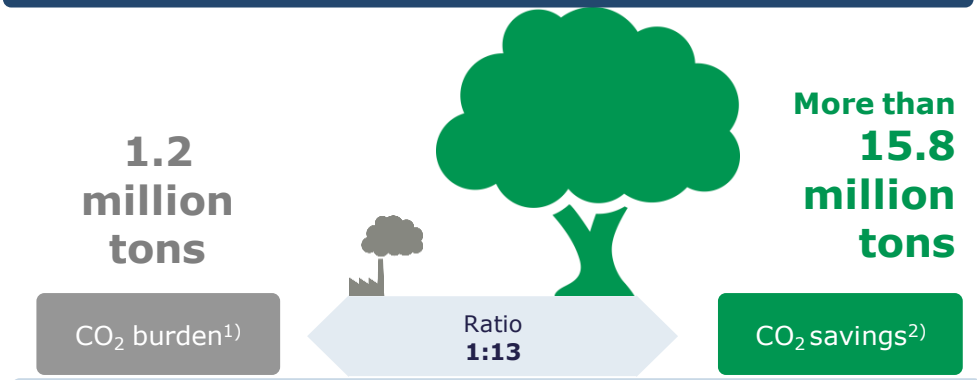


Focus 1
high switching frequency and high density

Focus 2
high current + low resistance



Infineon is a key enabler of sustainable society



Infineon enables a net ecological benefit of more than 14.6 million tons of CO_2 emission reduction per year

1) including manufacturing, transport, material, chemistry, emissions, water, waste and waste water, energy consumption; values are based on internal figures as well as official data for one year.
2) considering only automotive products, lighting, PC power supply, regenerative energy production (photovoltaic, wind) and drives, calculation based on average lifetime and Infineon market-share.

Infineon at a Glance

The Company

- Revenue FY2014: 4,320 bn EUR
- 34,000 employees
- > 22,800 patents and patent applications

Focus Areas

Energy Efficiency

Mobility

Security

Market-Oriented Business Structure

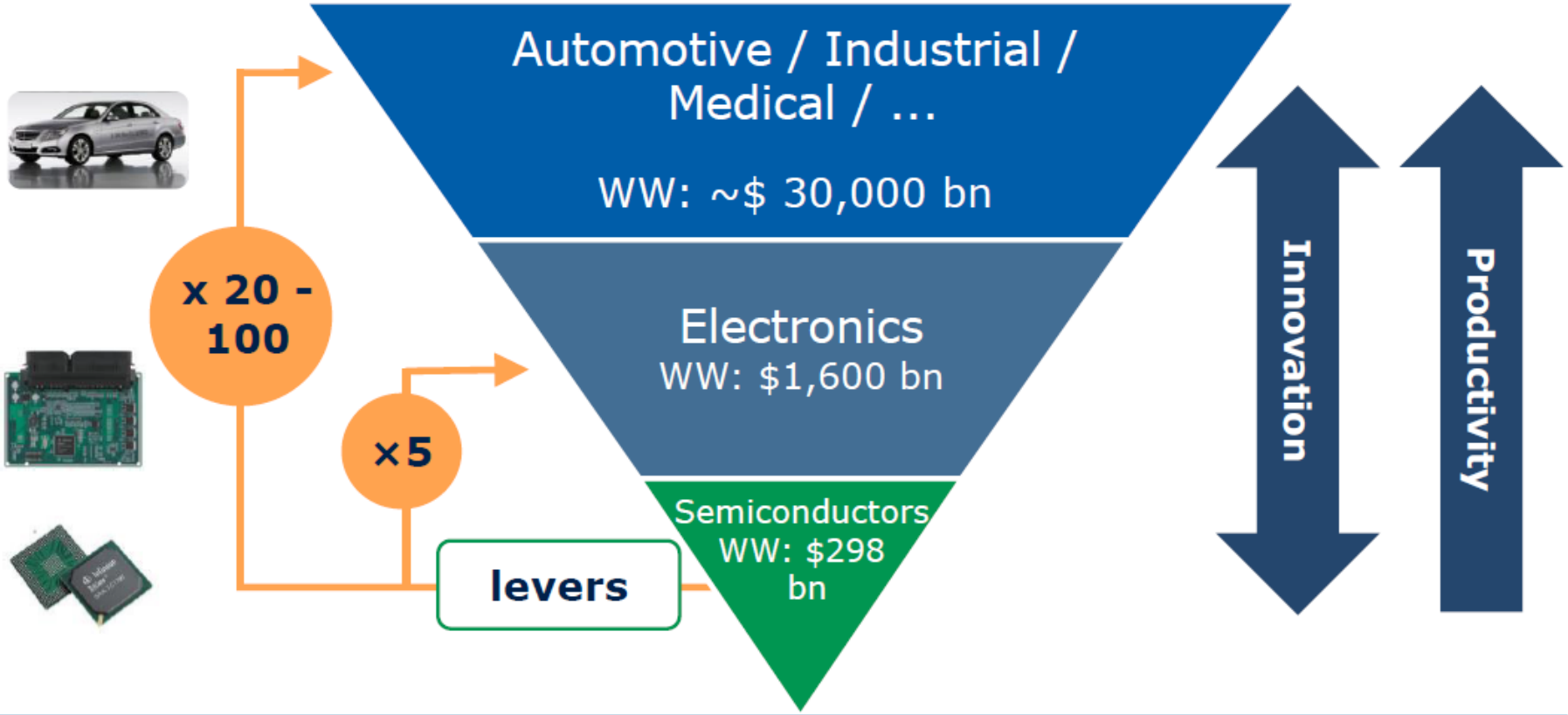
Automotive

Industrial Power Control

Power Management & Multimarket

Chip Card & Security

Semiconductors are Levers for Innovation, Productivity and Economic Growth

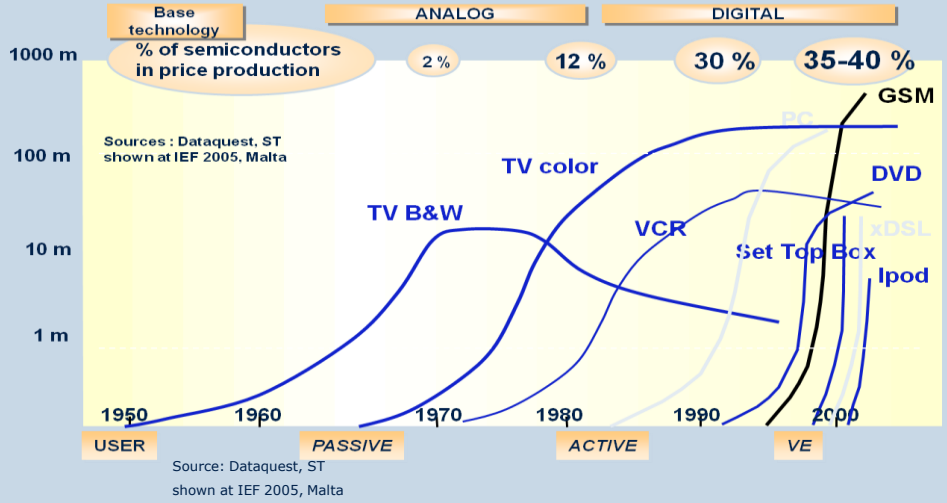


- About 45% of the OECD Economic growth since 1985 comes from increased productivity; electronics is a key driver for this growth.
- Up to **80% of innovation in automotive is enabled by semiconductors**, even more when it comes to Hybrid and EV.

Source: DECISION, ESIA, Future Horizons, IMF, WSTS 2010, AUDI, OECD Factbook 2013

Semiconductor Industry faces steep Ramps, short Life Cycles @ long Cycle Times

Fast changing demands vs. fixed boundaries



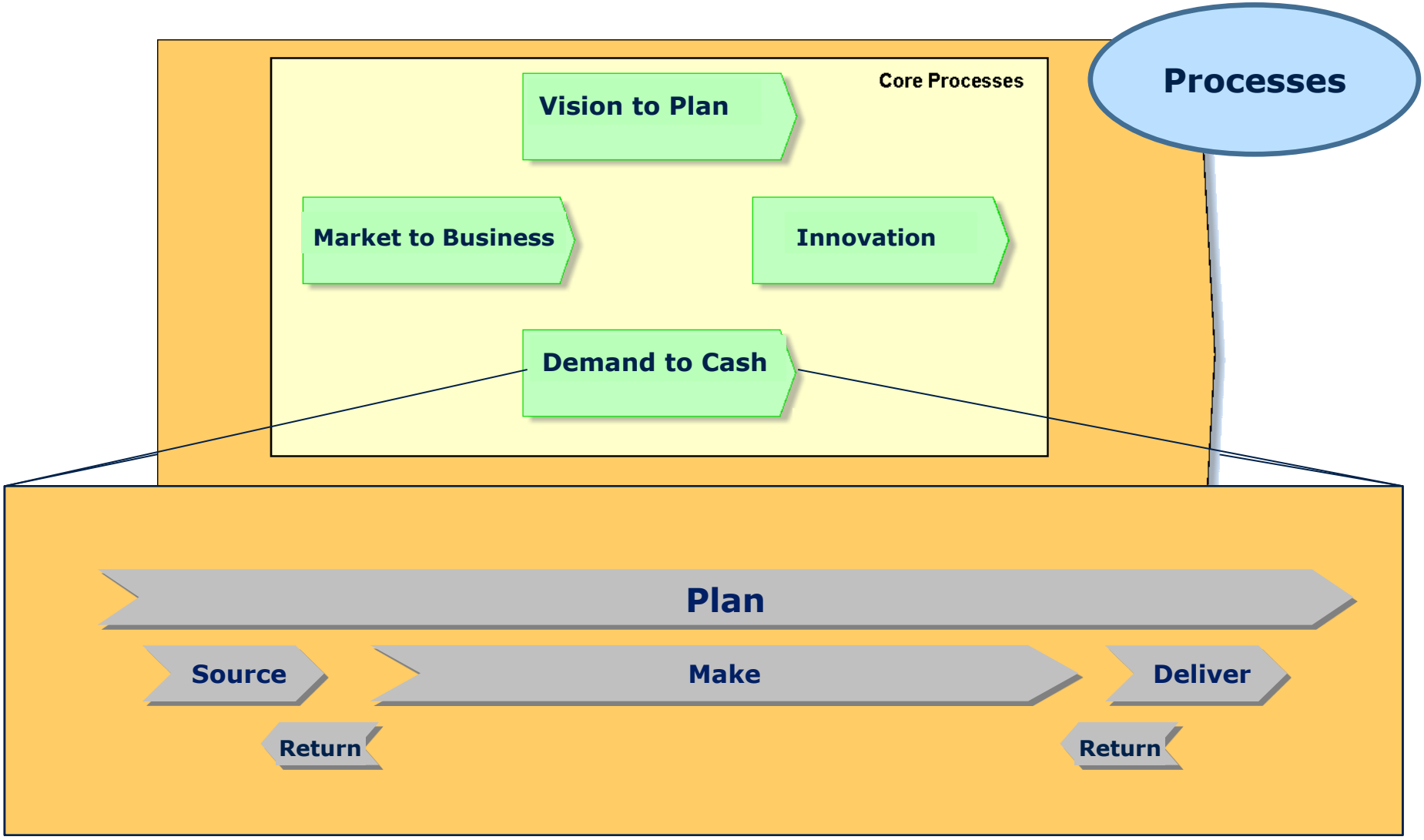
Source: Dataquest, ST
shown at IEF 2005, Malta

- **Steep Product Ramps**
- **Short Lifecycle**

- **Long Cycle Time**
- **Early in Value Chain**

Table of Contents

Our Supply Chain processes are designed and documented based on the SCOR model



IFX Supply Chain spans From Supplier's Supplier to Customer's Customer

Plan

Source | Make | Deliver

Return | Return

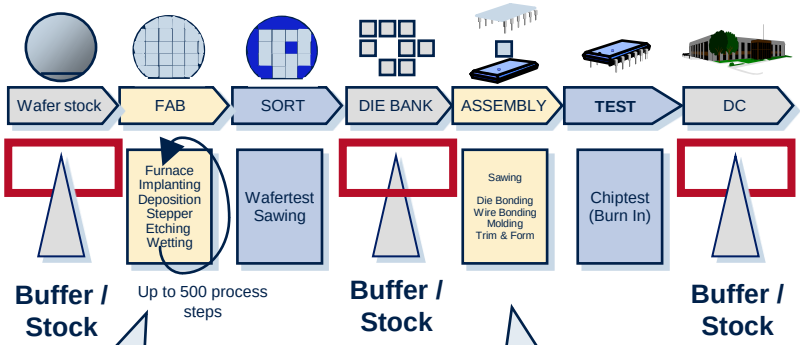
According to SCOR

Supply Chain Operations Reference; from Supply Chain Council.

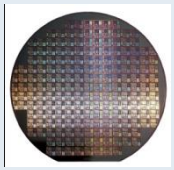
Suppliers

THE LINDE GROUP

siltronic perfect silicon solutions



Foundry Partner



UMC

tsmc

Subcontractors

Amkor Technology

unisem

KYEC The Testing Industry Benchmark

Customers

DELTA

ERICSSON TAKING YOU FORWARD

BOSCH

Continental

gemalto security to be free

LG Life's Good

SAMSUNG

SMA

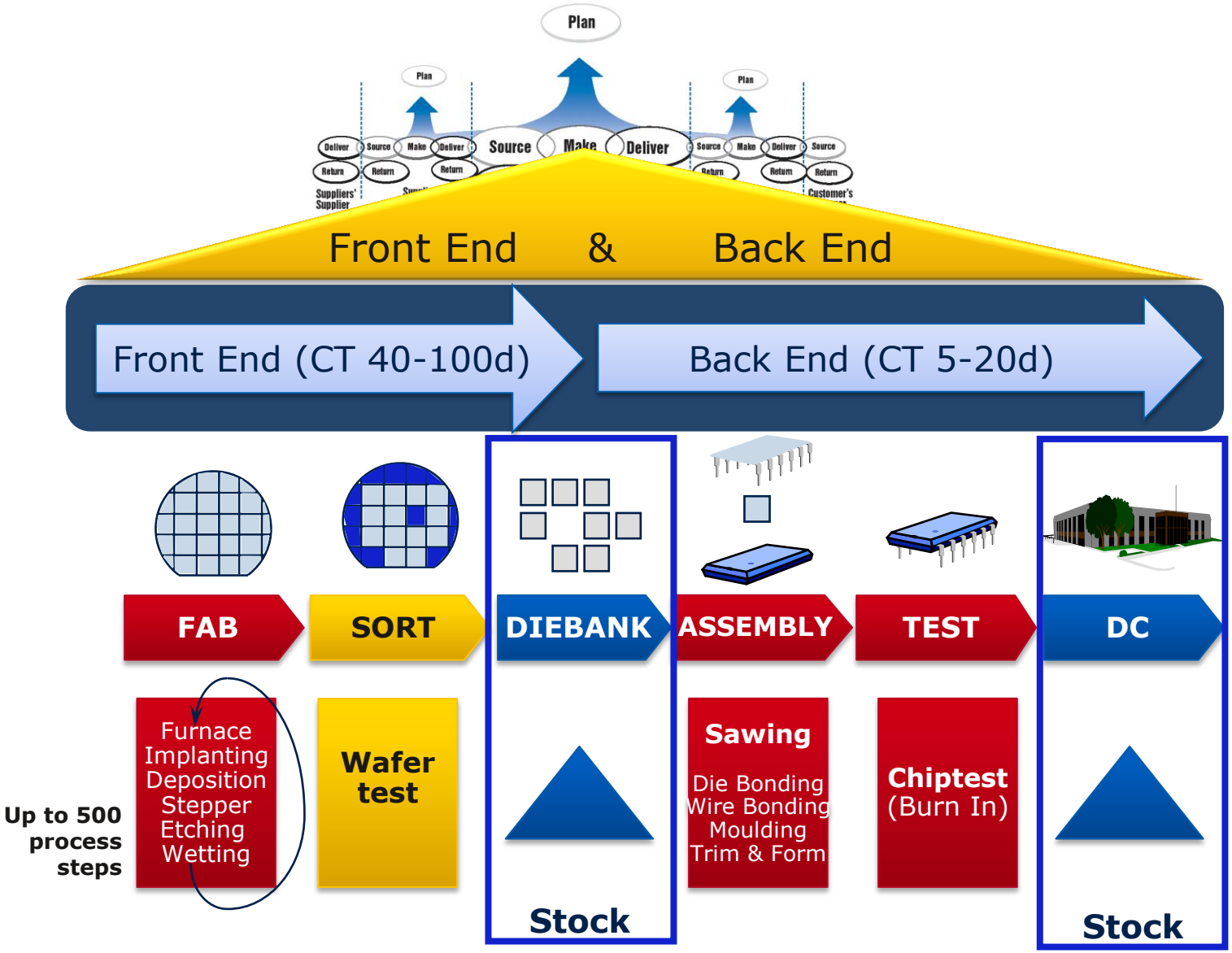
SIEMENS

FLEXTRONICS

ARROW ELECTRONICS

AVNET

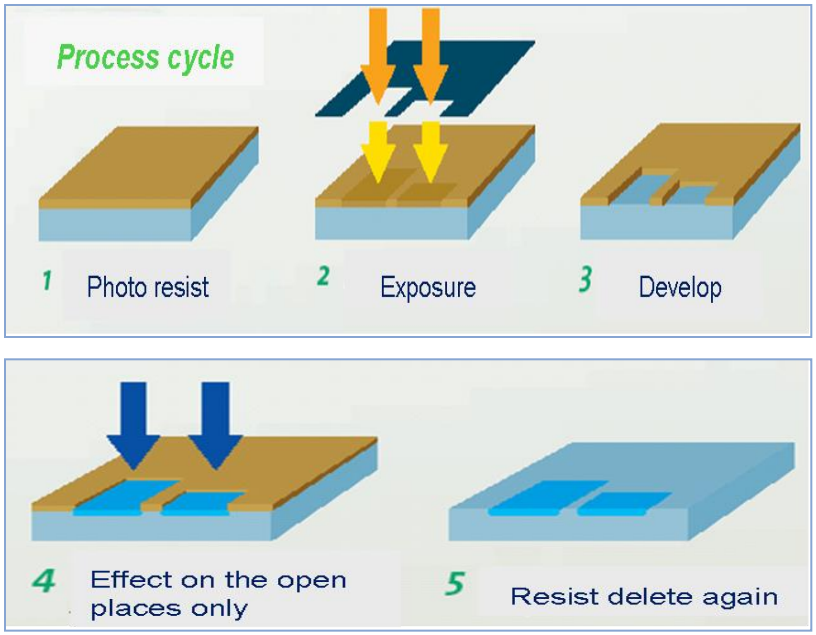
Front End and Back End Processes – Cycle Times of up to 120 days

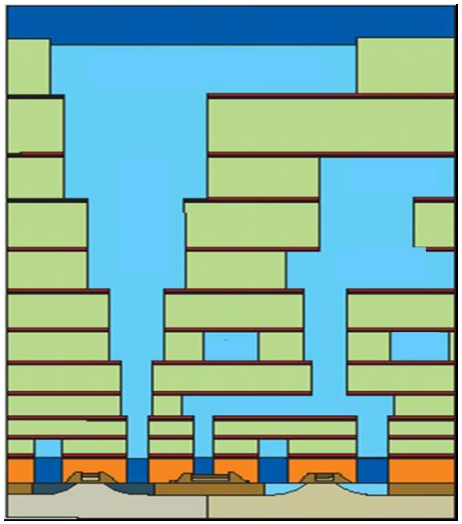


Up to 35 Revolving Lithography Steps per Wafer Transform the Design via Masks to the Wafer …

… generating a three dimensional" landscape on the wafer surface

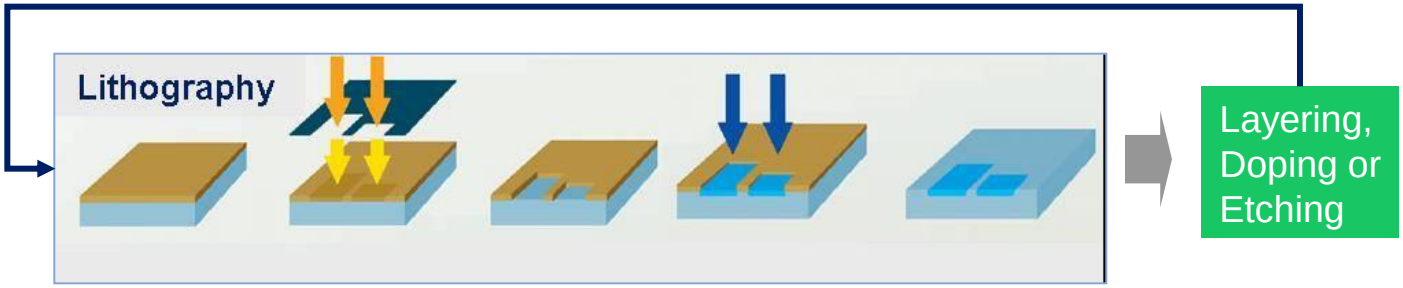
Lithography method: one chip after another is exposed



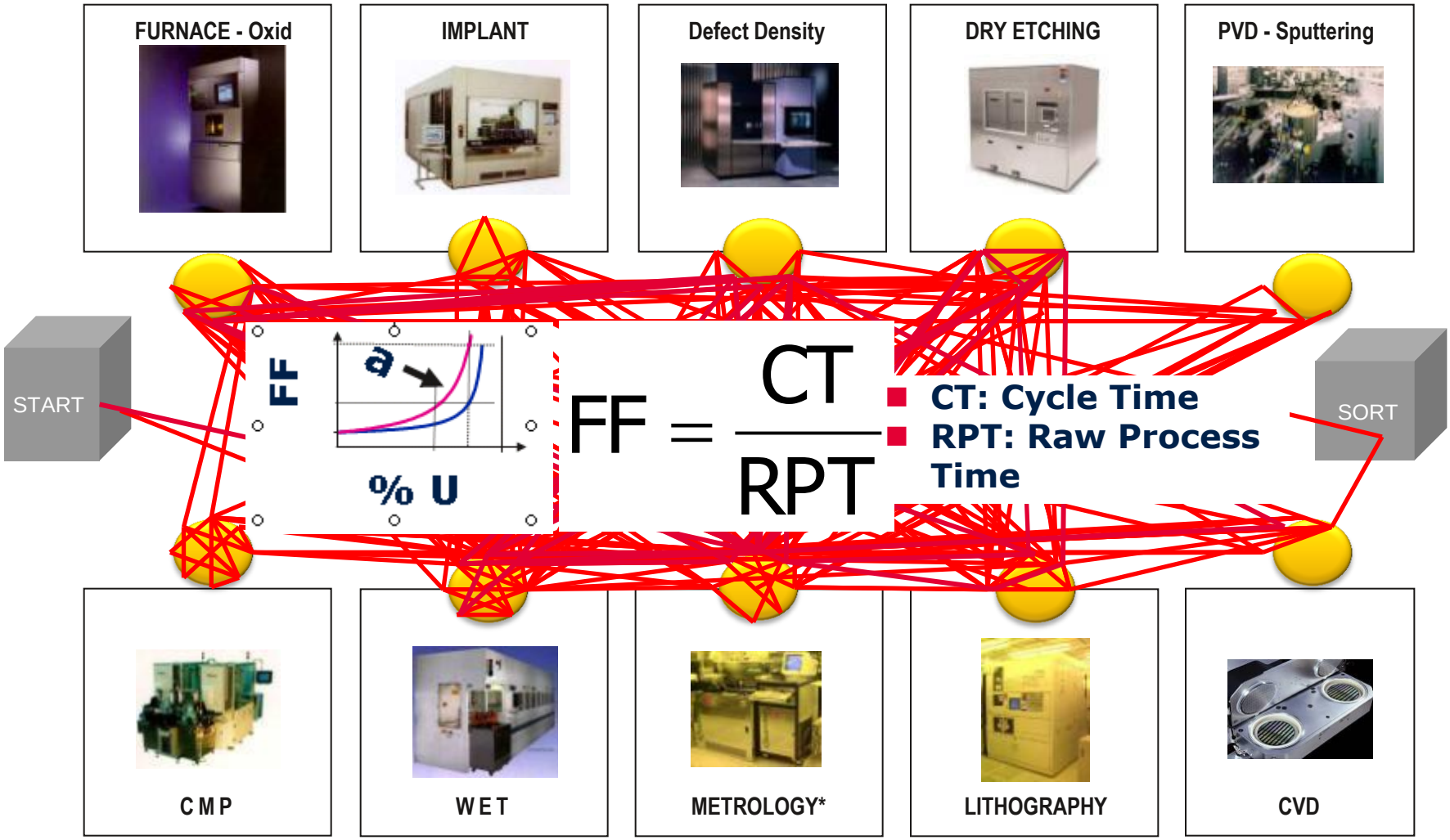


Other processes as etching, doping, layering can change the surface of the wafer permanently on the places that were exposed within lithography.

Next exposure step – up to 35 revolving steps

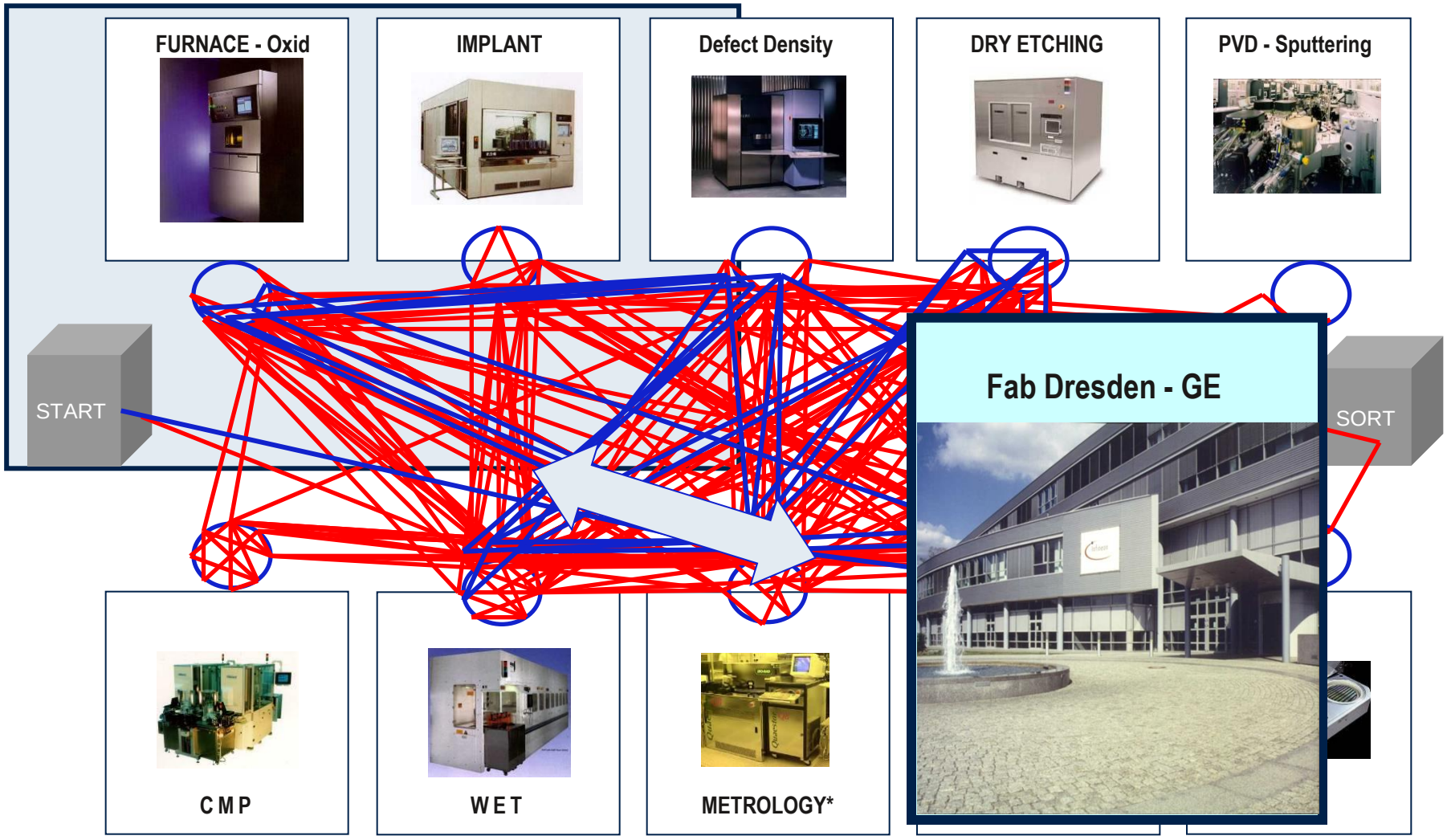


Frontend Production:
Up to 500 process steps are essential for Quality



* test step according to lithography

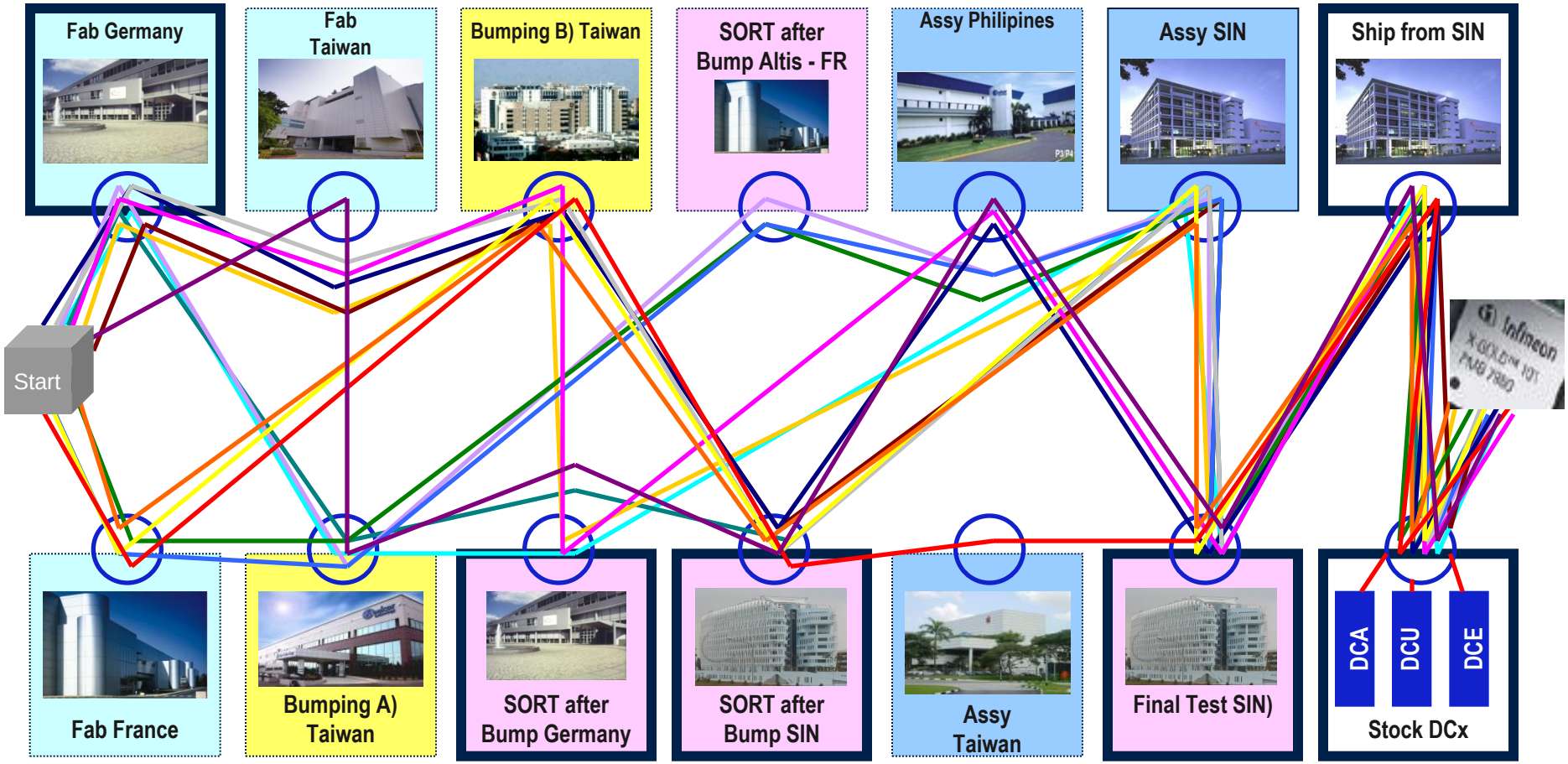
In the past it was required to manage Frontend SC fast, cost efficient, full visibility



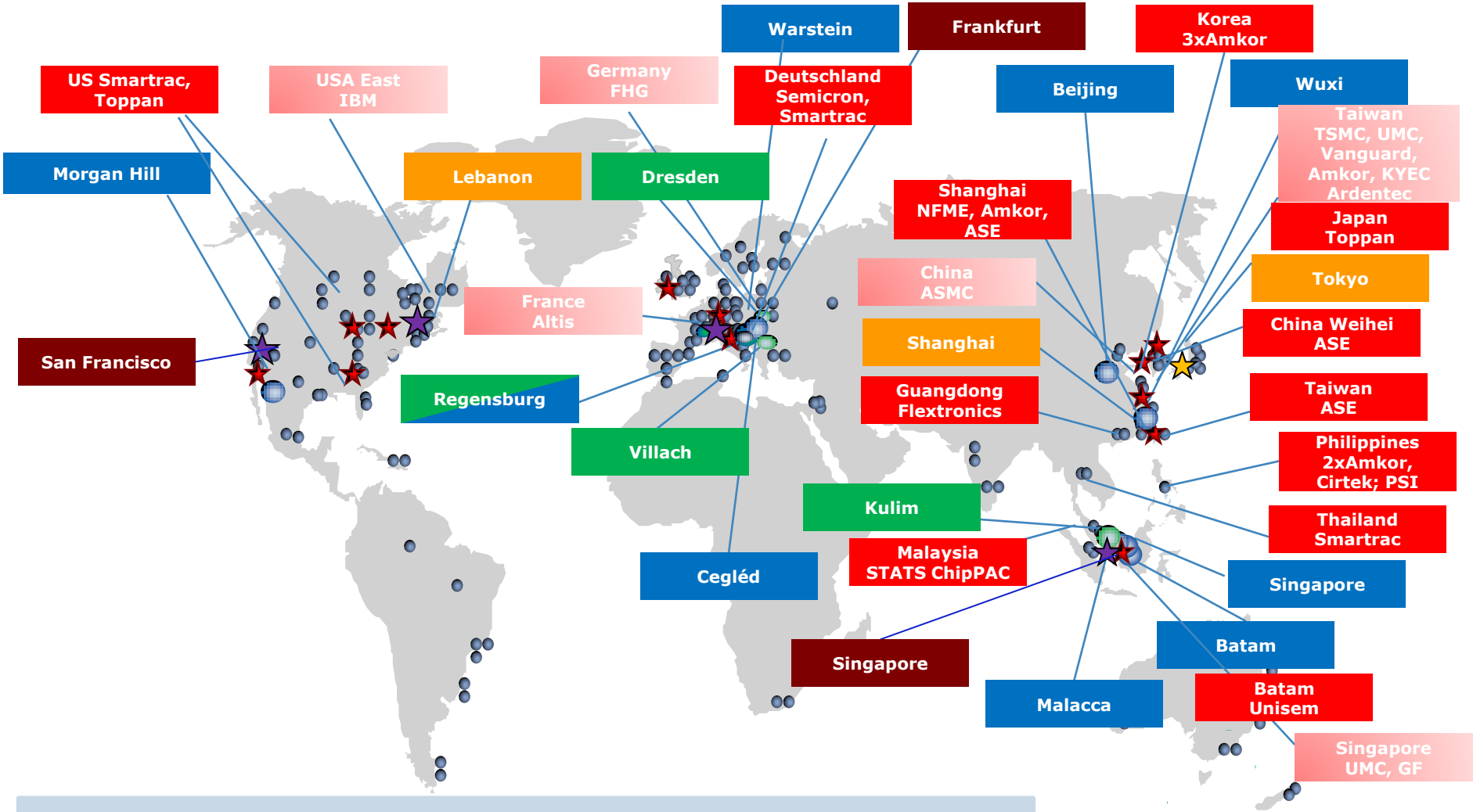
* test step according to lithography

Today we can benefit also from global production flexibility – "The global SC is our new Fab"

Each new supply chain was a step to win customers via capa increase – example from the qualification flexible mobile phone business

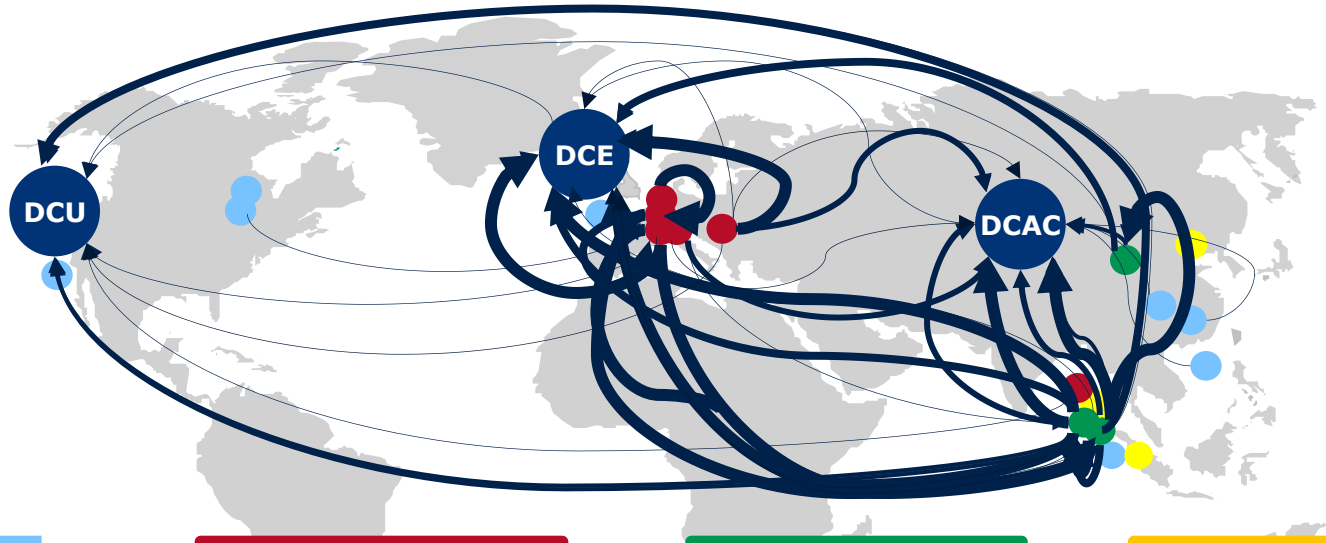


Infineon´s Supply Chain Network at a glance



Make - Flexibility: a global distributed production network comprising SIFOs, FEs, BEs and SUBCONs

Value flow (>7 Bn€/year)



SIFO
- ALTIS
- SMIC
- TSMC
- PSI
- Zarlink
- Triquint
- IBM
- CHRT
- UMC

FE
- Dresden (DE)
- Regensburg (DE)
- Kulim (MY)
- Warstein (Ge)
- Villach (AT)
- Cegléd (HU)

BE
- Malacca (MY)
- Batam (ID)
- Wuxi (CN)
- Singapore (SG)

SUBCON
- Nantong
- ASE
- AMKOR
- STATSChipPAC
- Unisem
- Carsem
- UTAC
- PSI

Plan Flexibility: Execution via integrated Business Planning

P1.2 Identify, Assess, Prioritize and Aggregate Supply Chain **Resources**

P1.1 Identify, Assess, Prioritize and Aggregate Supply Chain **Requirements**

Capacity Planning

Demand Planning

P1.3 **Balance** Supply Chain Resources and Requirements

Capa & Supply Provision

Supply Planning

Demand & Supply Consumption

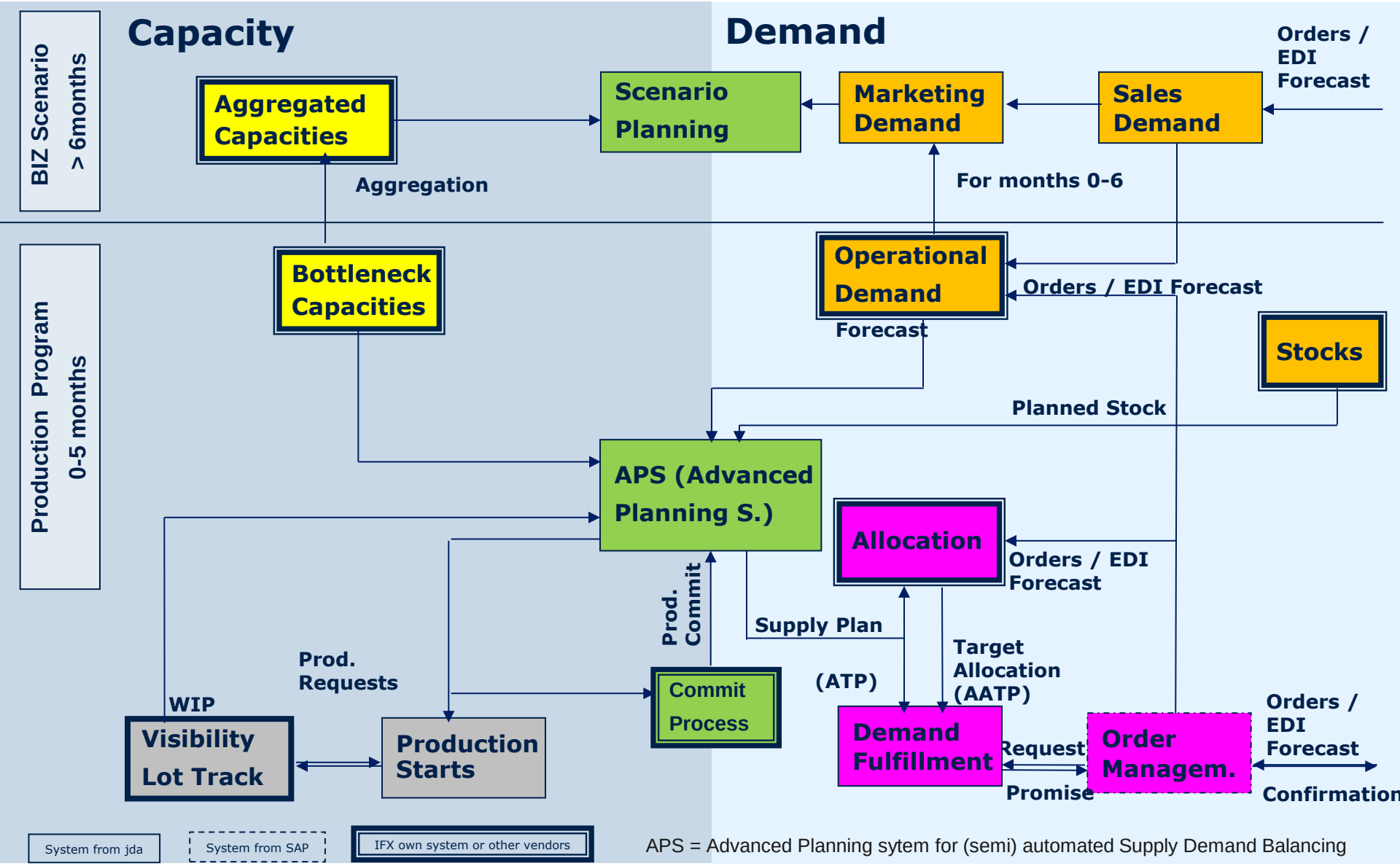
Production Management

Order Management

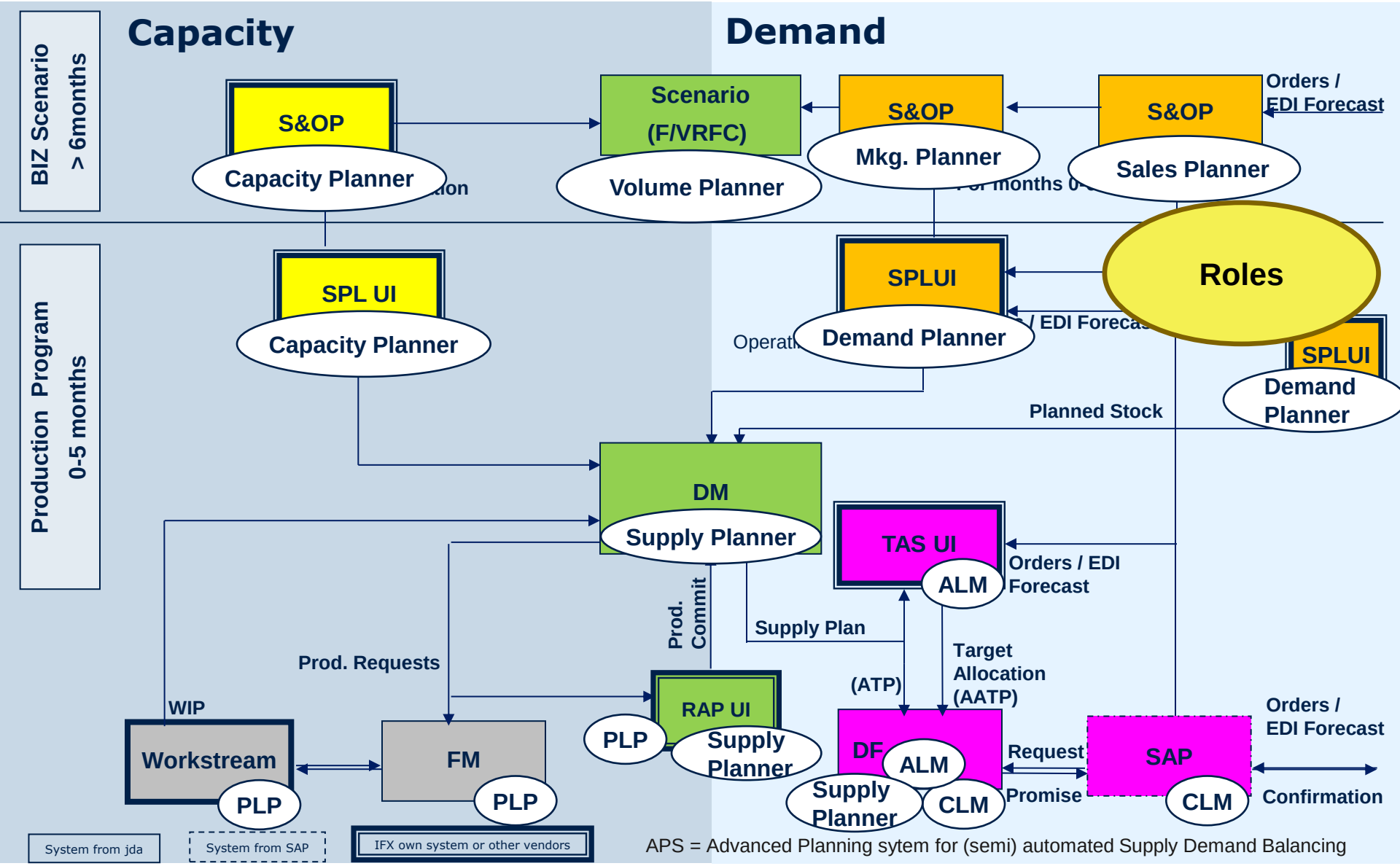
P1.4 Establish and Communicate Supply Chain **Plans**

P1.5 Establish and Communicate Supply Chain **Plans**

Main Processes in Integrated Business Planning at IFX



Best of breed IT tools and well educated specialists executing the processes



Does this really need to be so complicated?
We have found no better way & experts see us leading

SCC Supply Chain Excellence Awards

European Supply Chain Excellence Award 2014

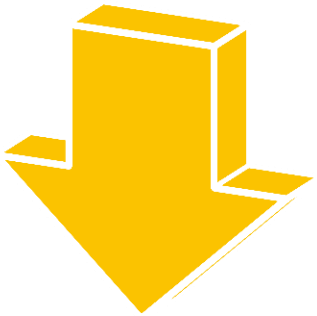
SupplyChainStandard european supply chain excellence awards 2014

WINNER

Automotive, Aerospace & Industrial

Table of Contents

Complexity management needs metrics for decision making

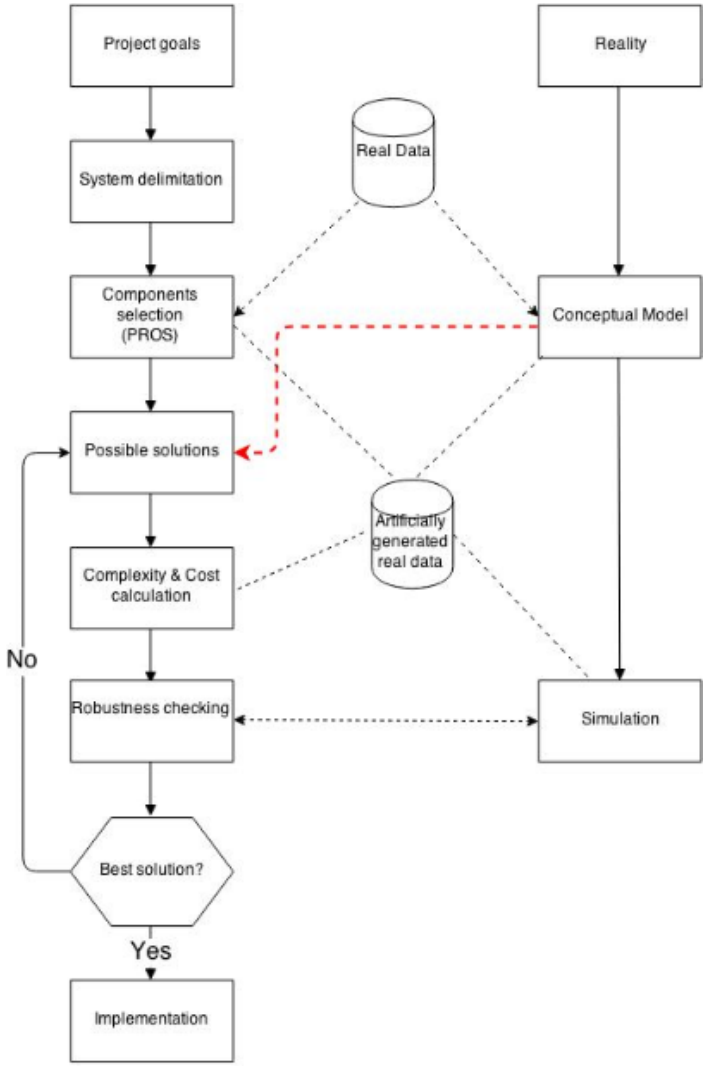


Increased complexity

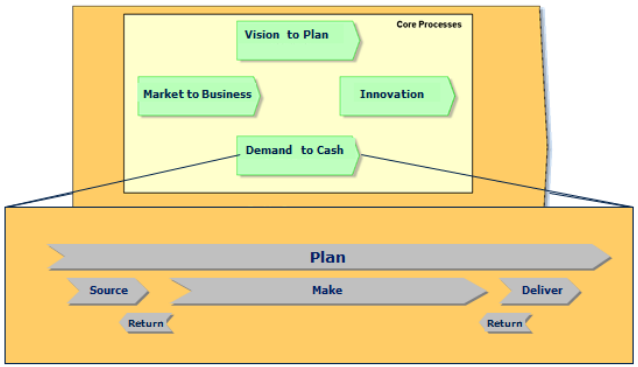
Added value

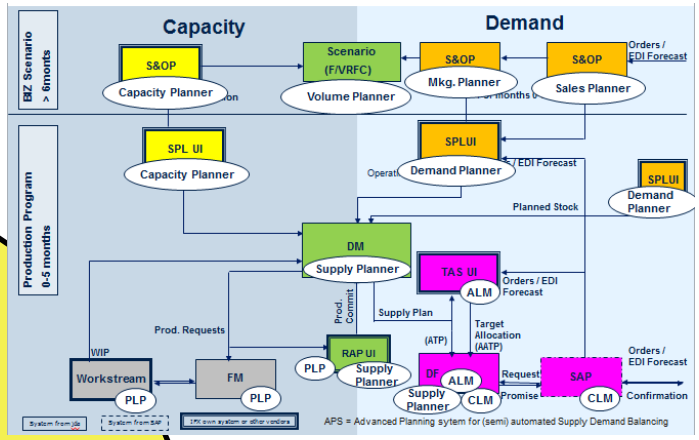
The approach to measure complexity and reduce the non value add complexity

- **Goal**: To measure complexity for decision making for reduction of non-value adding complexity (and foster value add complexity)
- **Challenge**: complex problem are usually twisted by many parts, and a holistic view is needed
- **Approach**:
  - use the holistic systematic called PROS (process, role, object, states) to measure complexity in a delimitated (but still complex) system to find best fitting solution (reduced non value add complexity)
  - Use a conceptual model & system dynamics / Agent based simulation combined with discrete event simulation proofs the robustness of the solution



Understanding the complex semiconductor supply chain via PROS



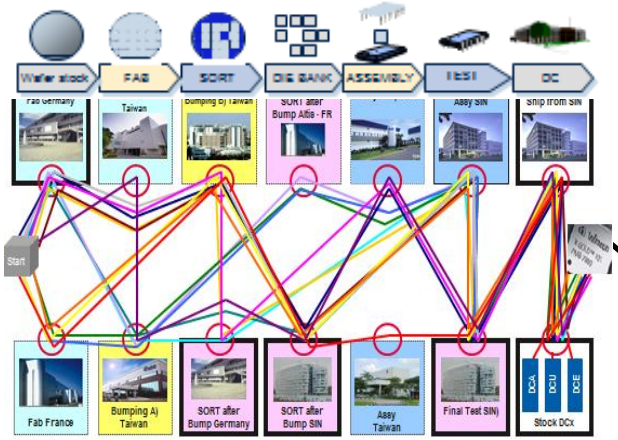


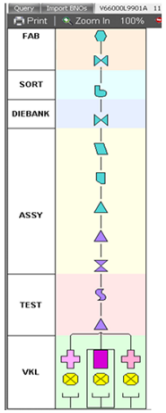
Processes

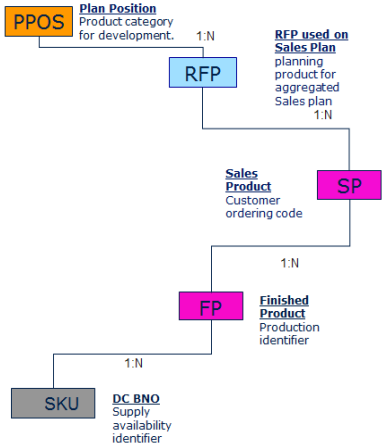
Roles

States

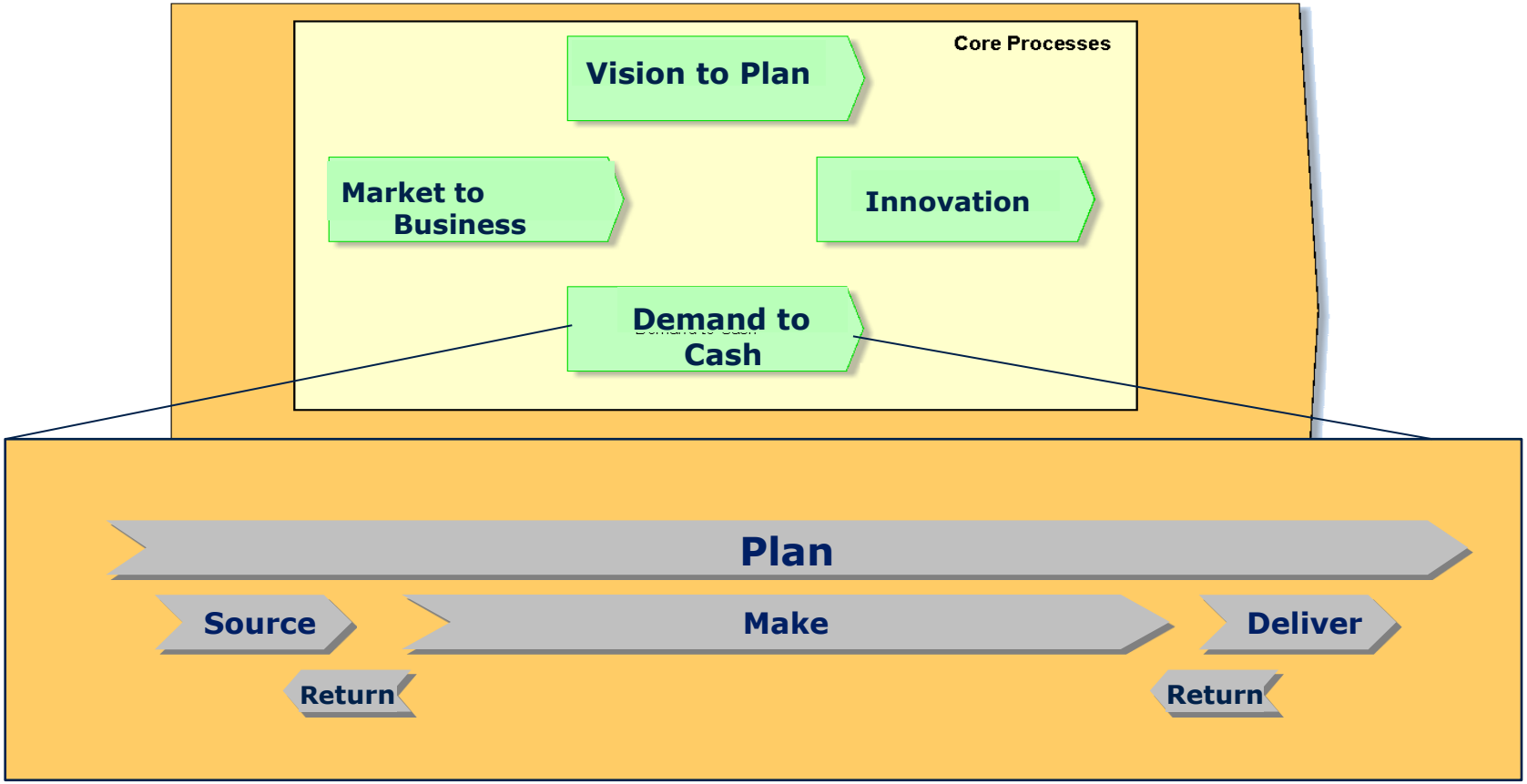
Objects







PROS – Example of a Process



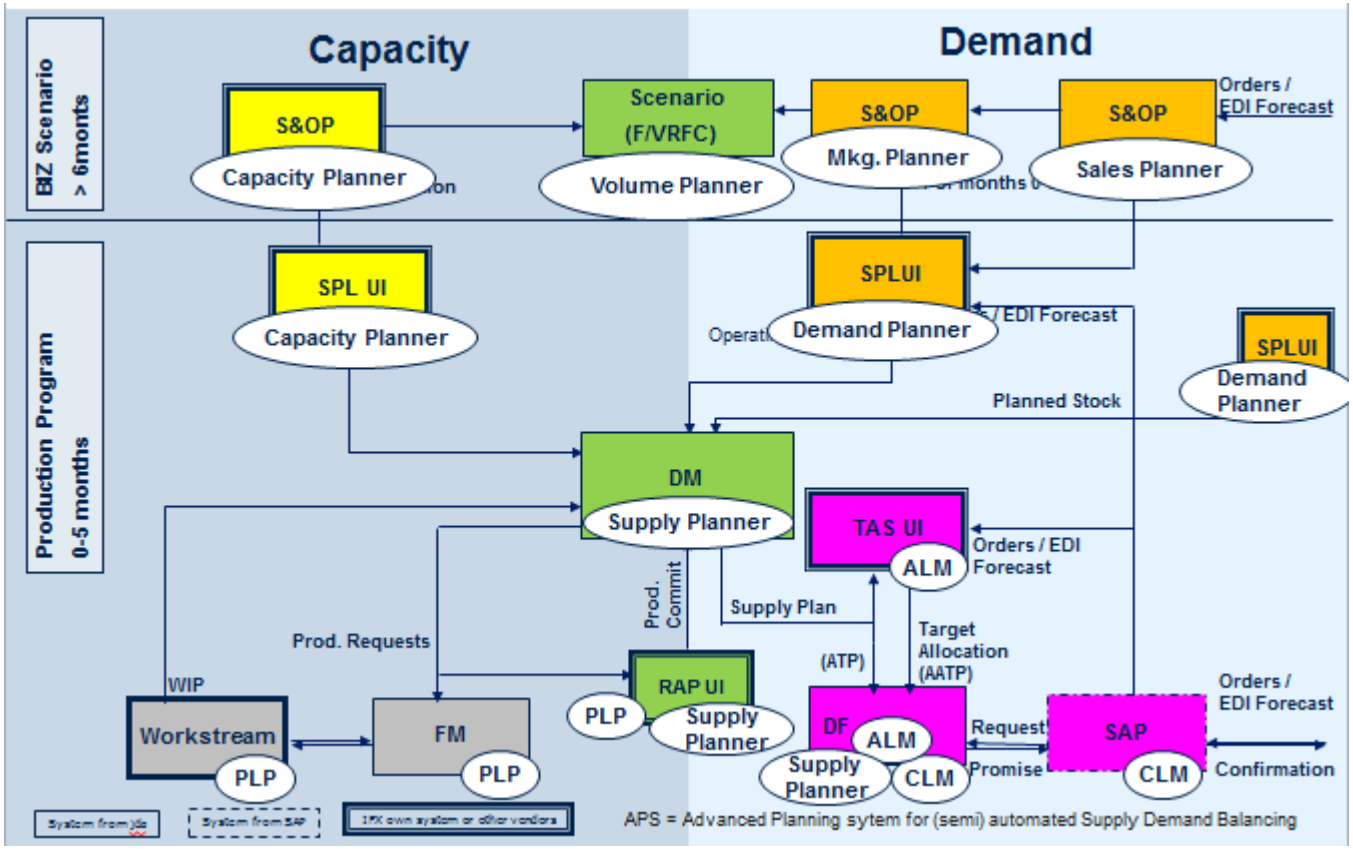
Processes

Visualized in swim lanes

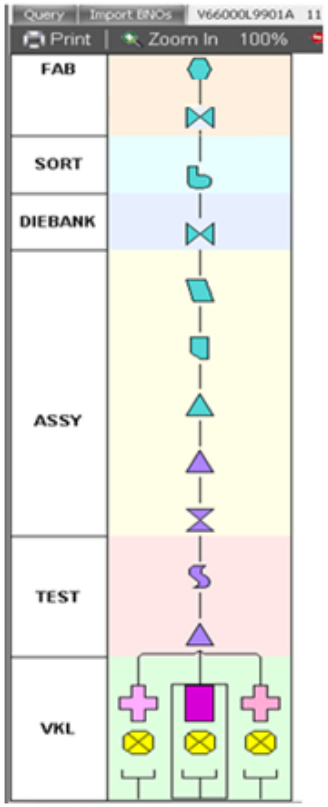
PROS - Example for Roles being a SCP = Supply Chain Planer

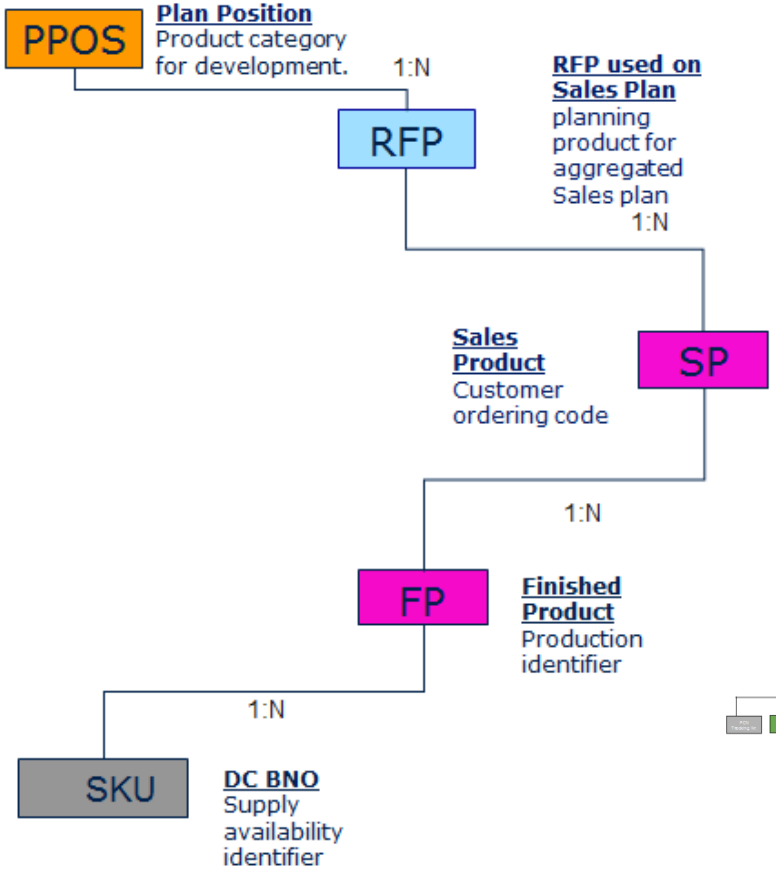
Roles

Visualized in swim lanes



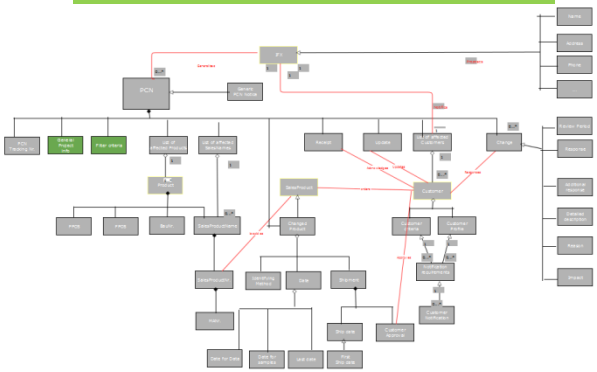
PROS Example for Objects – being a FP = Finished Product



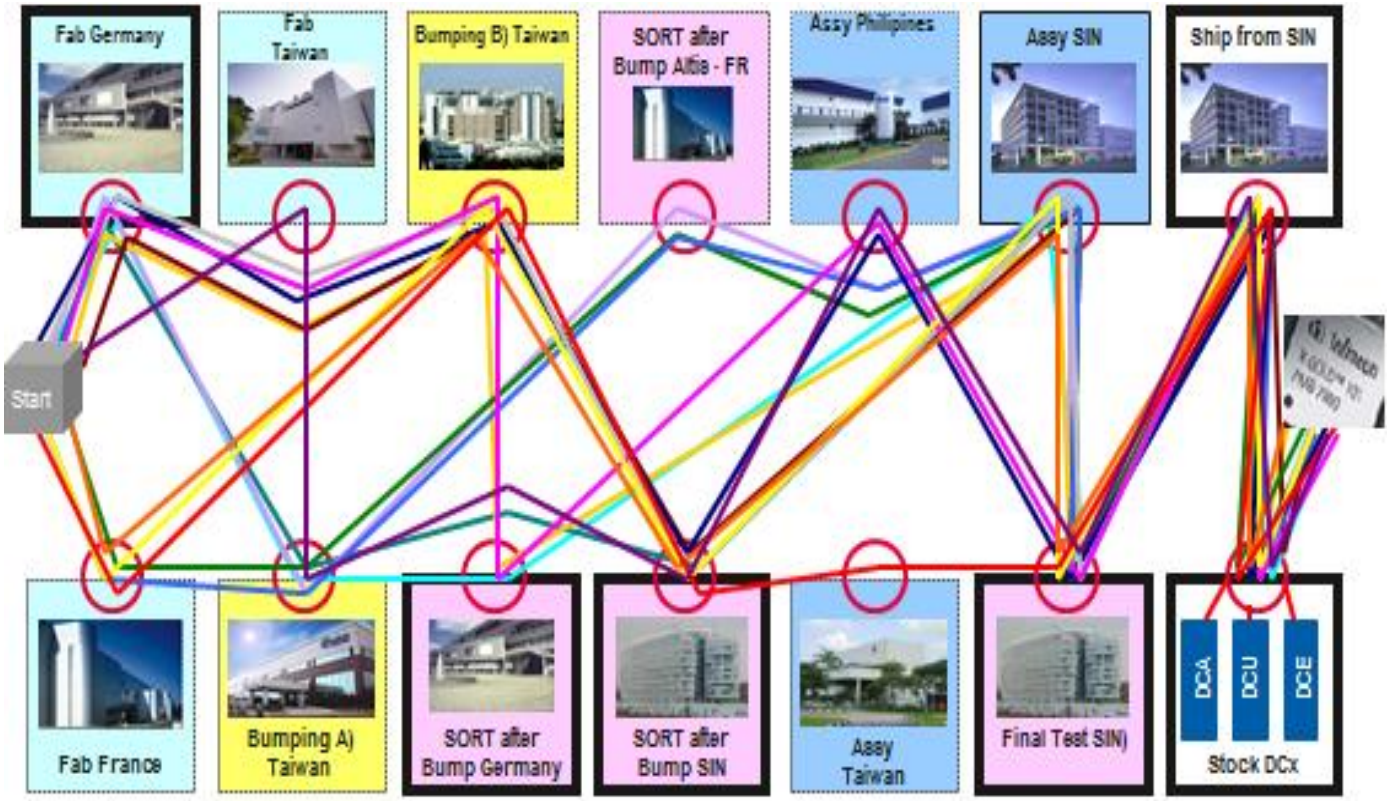


Object

Visualized in class diagrams

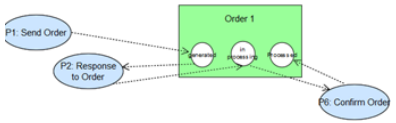


PROS Example of a State – being in process in Singapore at wire bond



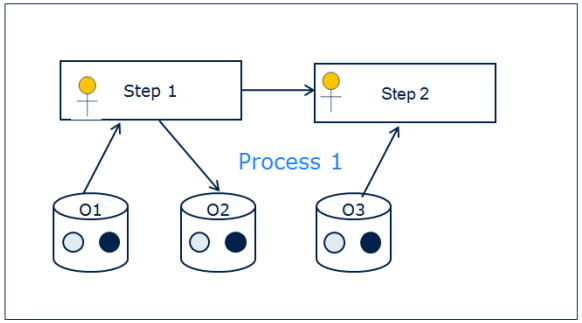
State

Visualized as object state diagram



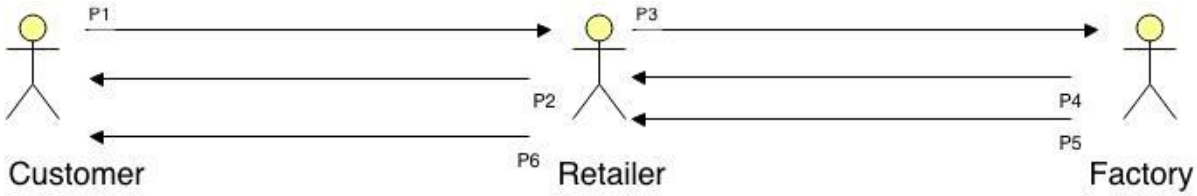
How to measure complexity using PROS: ideas and formula

- **Complexity of elements** (*Ce*)
  - # of processes (*N*)
  - # of states (*S*)
  - Tuning coefficient of role (R_n)
  - $Ce = \prod_{n=1}^{N} R_n \cdot N \cdot S$



- **Complexity of relationships** (*Cr*)
  - Connection between each process and state (X_i)
  - Tuning coefficient of role (R_n)
  - # of processes (*N*)
  - # of objects(*M*)
  - $Cr = \sum_{n=1}^{N} \sum_{m=1}^{M} R_n \cdot X_i$

A simple example: customer order system



- **Known**: 3 roles, 6 processes, 2 objects (3 states for each)
- **Results**:
  - **Complexity of elements** (*Ce*): 108
  - **Complexity of relationships** (*Cr*): 15

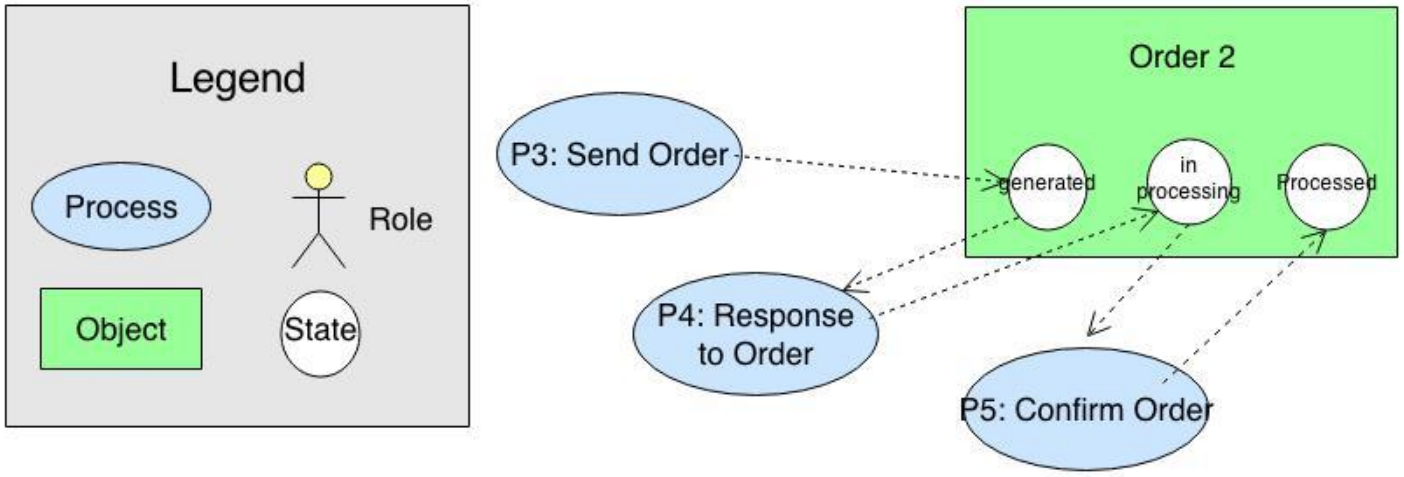
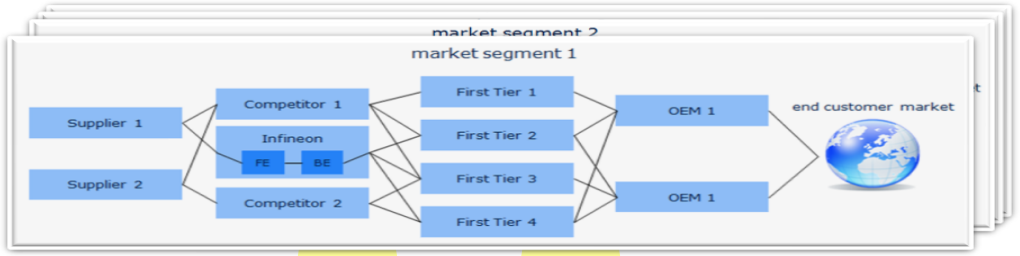


Table of Contents

… the real risk comes from the nonaligned supply chains - the bullwhip effect

- Level 4:

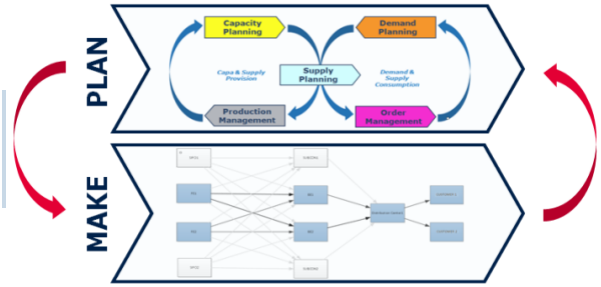
  End-To-End SC



Bullwhip

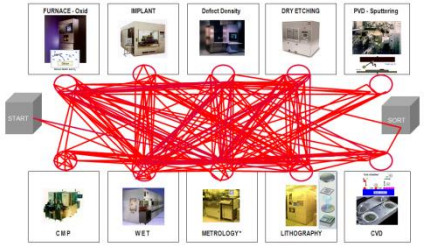
- Level 3:

  IFX SC

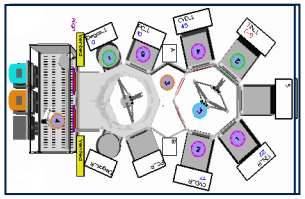


- Level 2:

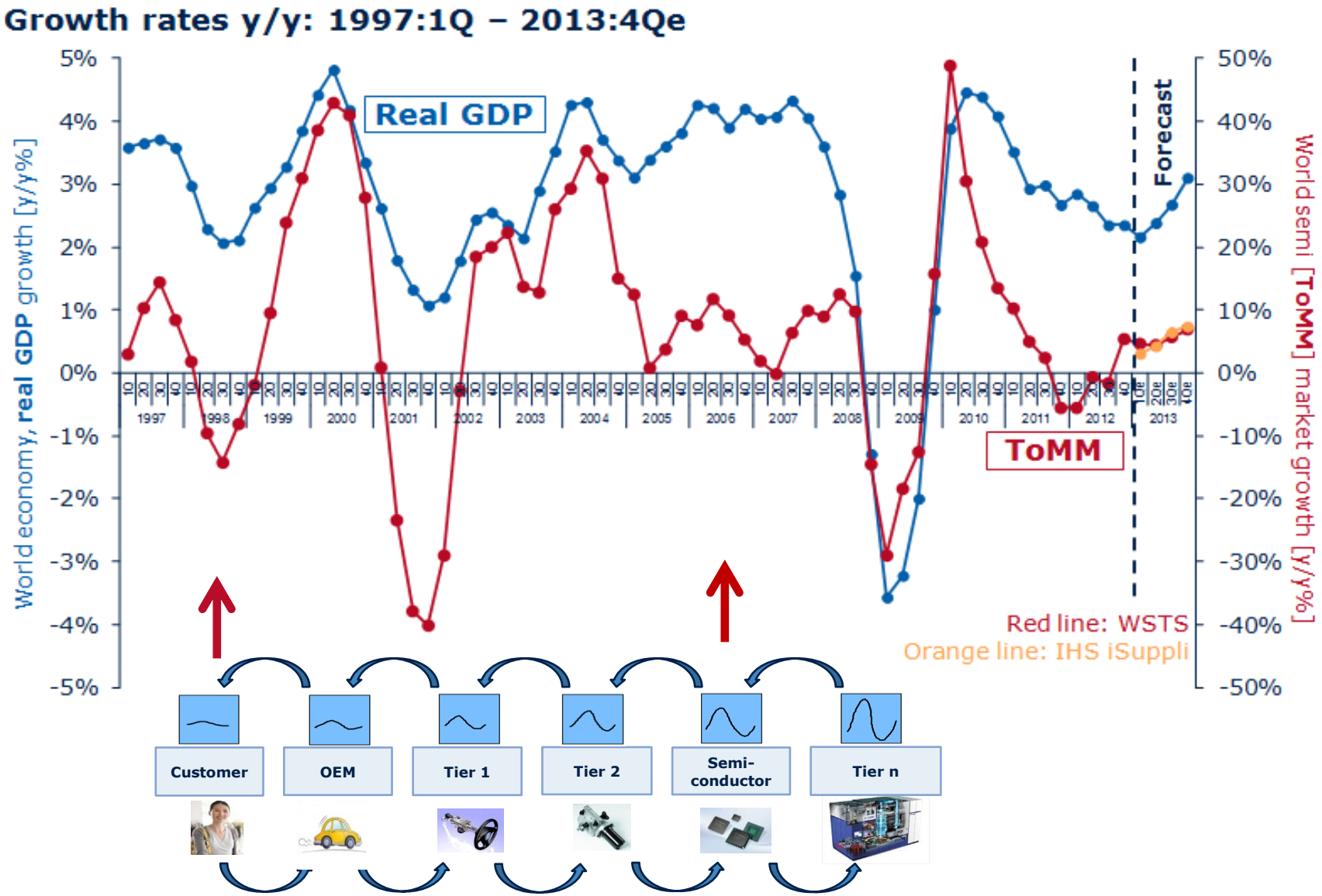
  Factory/Single Site



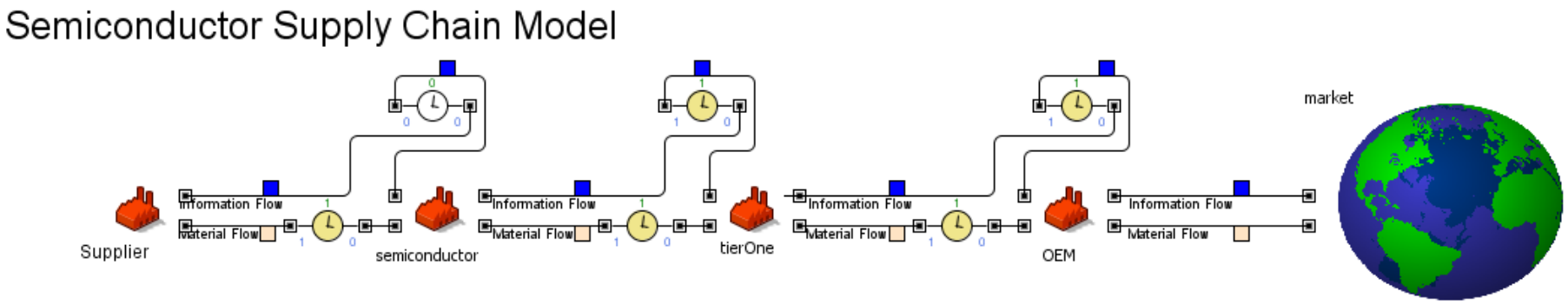
- Level 1:
  Equipment/Workcenter



The bullwhip effect – a non value add supply chain complexity with big impact



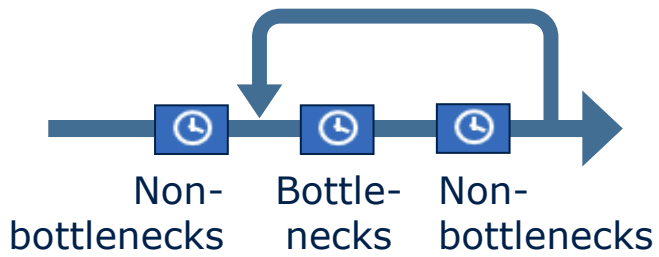
Bullwhip simulation

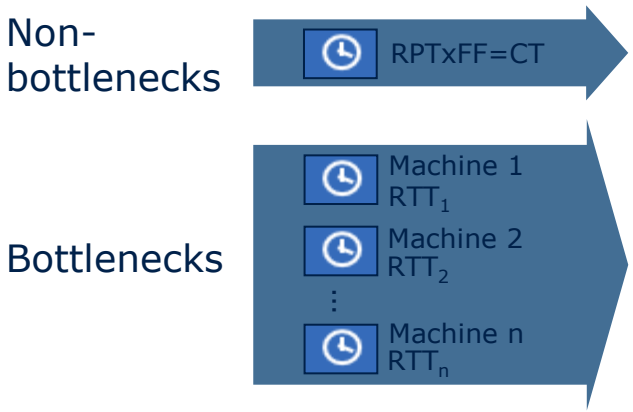


Simplified simulation models help to reduce complexity, time and cost effort

Reducing complexity **via** simulation vs. reducing complexity **in** simulation

Example: Bottleneck representation of front-end





Benefits:

- Time to implement ↓
- Time to run ↓
- Time to maintain ↓

…at comparable level of accuracy on supply chain level.

"Instead of *company to company* competition,

We are now in an era of *supply chain to supply chain* competition."

Dr. Hau Lee – Stanford University

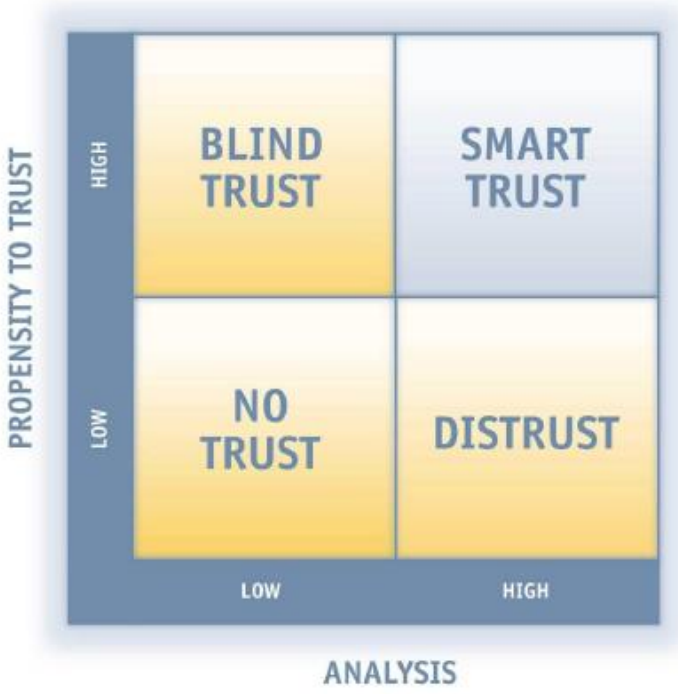
Building Supply Chain Collaboration at the Speed of Trust

- **"Nothing is as profitable as the economics of trust"**

Simon McGlone, FranklinCovey Europe

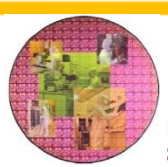
"Building workplace trust is the best investment an organisation can make, leading to better recruitment, lower turnover, greater innovation, higher productivity, more loyal customers and higher profits".

Great Places to Work Institute, April 2011



aSC³ (**a**ligned **S**upply **C**hains containing **S**emi**C**onductors via **S**cience **C**enters) to master external complexity

Prof. Martin Grunow
Prof. Rainer Kolisch
Prof. Jens Brunner
Technische Universität München



Prof. John Fowler
Prof. Oliver Rose
Modeling and Analysis of Semiconductor Manufacturing (MASM)

Prof. Lars Mönch
FernUniversität in Hagen

Research
Fundings
Associations
Education
Academics
aSC³

EDB SINGAPORE
IDA IRELAND
Federal Ministry of Education and Research
PEOPLE

Joe Francis & C. Hunsche
SCOR Supply-Chain Council
Dr.Rolf Winter
ZVEI: Die Elektroindustrie
AKJ Automotive
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Prof. Brüggemann-Klein
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Prof. Bauernhansl

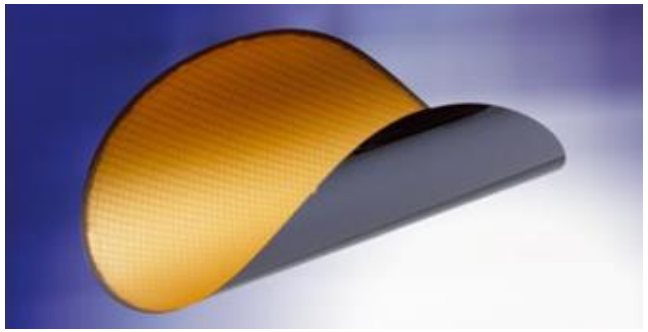
Prof. Koh
SMU Singapore Management University
Fraunhofer IAO
J. Lentes

DREAM—simulation based application **D**ecision support in **R**eal-time for **E**fficient **A**gile **M**anufacturing

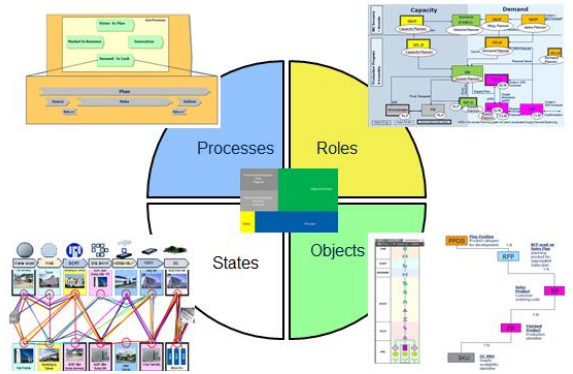
Table of contents

Executive Summary

- The semiconductor innovation race continues; Complexity is increasing



- Preliminary answers to master this complexity are based on PROS - aligned processes (SCOR), superior education (Roles), structured Masterdata (Objects) and visibility (States)



- There is a huge potential when company to company and industry to academia goes hand in hand to manage complexity – <u>allow value add but eliminate non value add complexity & educate to collaborate</u>

I will be glad to answer your questions

Thank you very much!

Contact: Hans.Ehm@Infineon.com

Join me in LinkedIn: www.linkedin.com

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