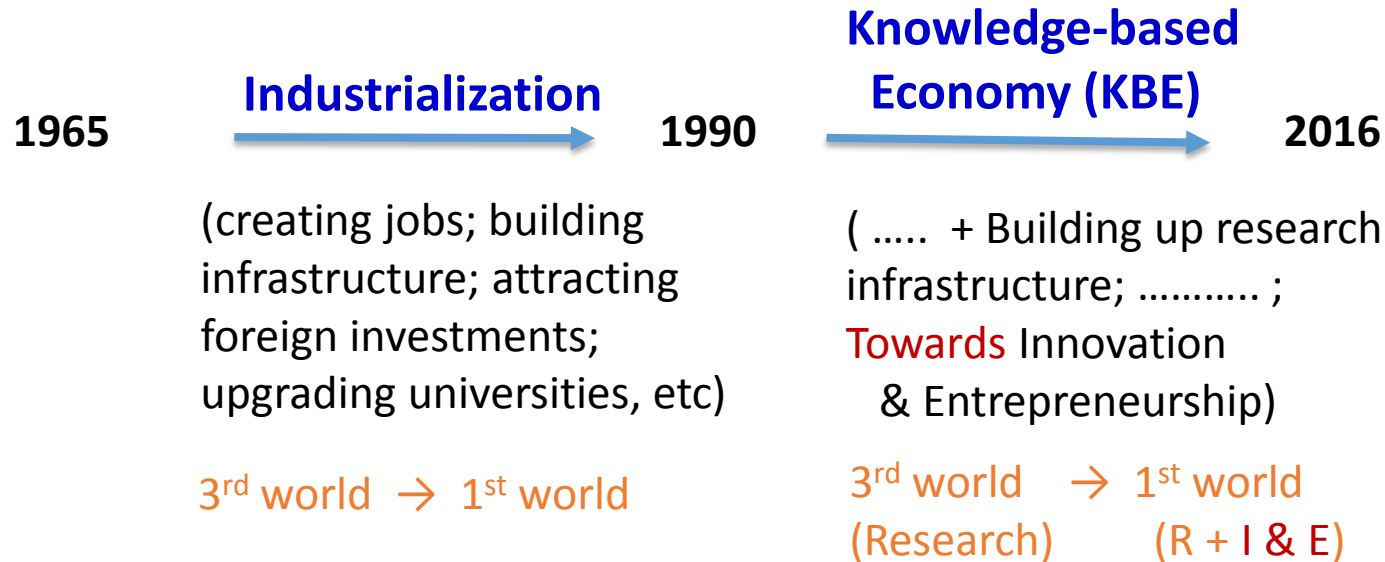


# Economic Development (Part 1)

- In Singapore, Economic Development Board typically hires xx% of Engineers!    xx= ?
- In China, during the peak of its economic development in the 2000's, yy of its 9 top political leaders were Engineers or Scientists!    yy = ?
  - ( Jiang Zemin, ....., Hu Jintao, Wen Jiabao and Xi Jinping
  - What do they have in common other than being top Chinese leaders? )
- In S'pore, many first generation public sector leaders were engineers (Philip Yeo, Tan Gee Paw, Lee Ek Tieng, Joe Pillay, .....);  
Mdm Ho Ching, CEO of Temasek Holdings  
– (surprise: she is also an Engineer by training!)

# Singapore



Jurong Island  
Port of Singapore  
The water story  
Land transport/  
Waste Management

One-North  
The water story  
SIMTech  
The R&D Story

**Jobs** : Labour; then beyond pure labour  
 → Technical & Engg Skills Intensive  
 (ITEs, Polys, Universities)

Research Institutes;  
 MNCs; SMEs, start-ups  
 → Research Talent  
 → I & E Talent ??

## Beyond “political wills”

- Financial Resources \*
- Infrastructure \*
- Expertise [ ....., **Engineers**, ..... ]

- \* Direct role of **Engineers** → Building up infrastructure
  - Driving Manufacturing
- \* Indirect role of **Engineers** → Wealth creation (\$\$)  
for all
  - Job creation for others

## Financial Resources

- Borrow money to pay for capital costs
- Generate revenue to recover investment costs (plus interests) within a reasonable period
- Lean and efficient → positive annual budget
- Supplemented by other revenue generating ideas  
[e.g. setting up state-owned companies (e.g. SIA, Neptune Orient Lines, ST) which were later privatized]

[ Situation of Singapore 51 years ago is similar to many developing countries today;

Needed state or corporate entrepreneurship to get started  
(S'pore: Many public officers/leaders **were** engineers!)]

## Building Infrastructure

a) During the first 25 years (of industrialization for nation building)

- Public utilities (power, water, environment)
- Communications (telephones, satellites, etc)
- Town planning (urban development, public housing, industry estate)
- Transportation (land, air, sea)
- Education (basic, tertiary)
- .....
- .....

[ Continued to be relevant and needed upgrading during the second 25 years and beyond

(somewhat neglected in recent years and the nation is now rebuilding the engineering core in public service!) ]

Experience & Lessons Learnt: Needed to plan ahead  
(visionary; feedforward & predictive thinking)

e.g. To build a new power station, we needed to  
plan at least 10 years ahead.

**Systems Thinking** – enabled national-level complex  
projects to be delivered on time, within budget,  
easy to operate, easy to expand, etc.

**Pragmatism** – Engineers ensure that things work,  
including the long-term impact!

# Systems Thinking

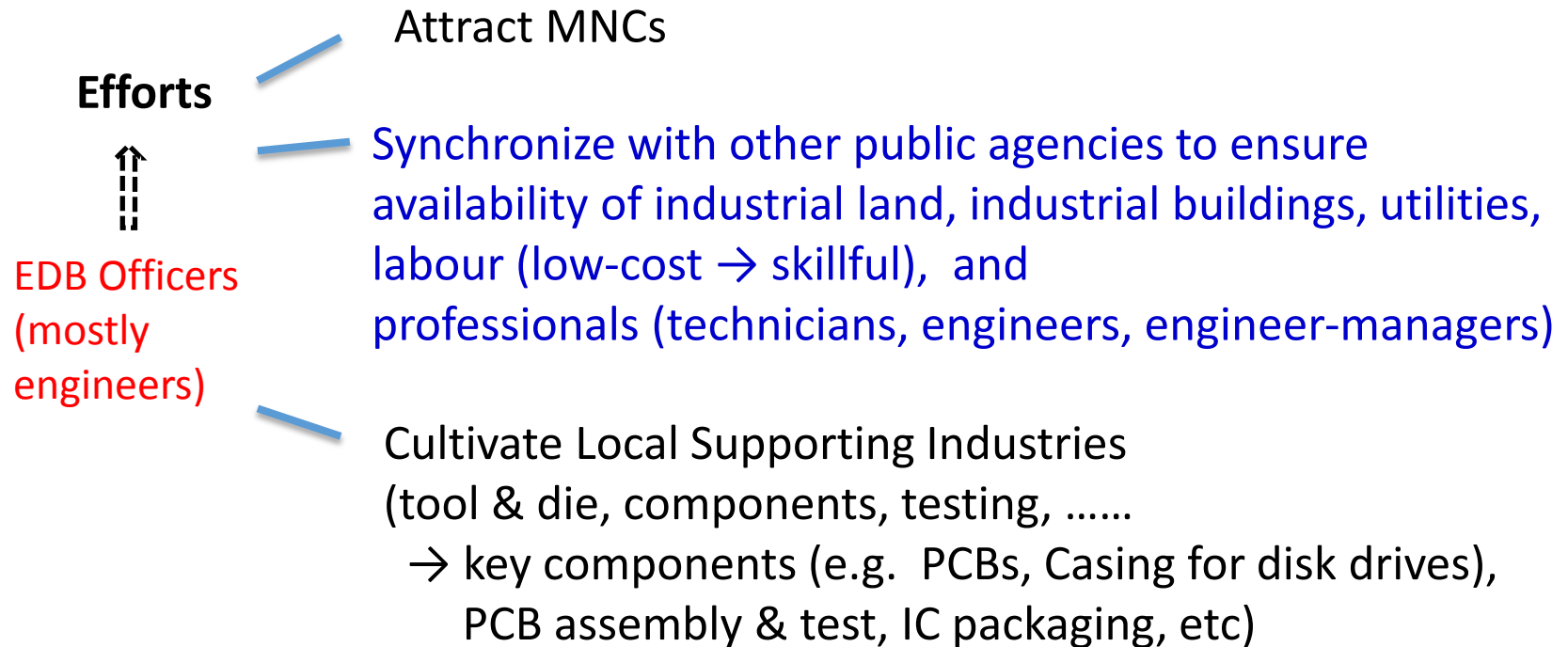
- Seeing the *big picture* (*helicopter view*) to understand why complex problems arise, what are the inter-relationships and patterns that drive events
- Understanding the *dynamics* (e.g. long time delay causes feedback action to be problematic – better to use feedforward action)
- Finding the *weakest links* in a complex system and *high-leverage points*
- Understanding potential interactions: Helping us appreciate short-term vs long-term; Reducing *Side Effects*

# A Key Agency: Economic Development Board (EDB)

## Manufacturing

60s - 70s - Low-cost labour

80s – 90s - Skills-intensive (high-wage policy)





EDB and the Ministry (Trade & Ind) often found the needs to establish public sector units and then spun them off:

- (SISIR + NPB) → PSB → SPRING
- JTC
- TDB → IE S'pore

*(employing mostly engineers, including their CEOs)*  
*(engineers were pragmatic and systematic)*

[ S'pore Institute of Standards & Industrial Research; National Productivity Bd; Productivity & Standards Bd; Jurong Town Corp; Trade Dev Bd; International Enterprise. ]

In the late 80s, one international expert advised that S'pore should follow Hong Kong to phase out manufacturing and focus on the Service Sector (finance, etc). But Singapore decided to continue its strategy of focusing on both Manufacturing and Service as

- Mfg created jobs for people who might not be suitable for Service (avoiding “structural unemployment”);
- Mfg also created related “services” .

(Another example of good systems thinking)

## Engineers were needed in large number

(including engineer-leaders – hence PSC channelled most scholarships to Engineering until Yr2000+!)

- Many engineers in public sector worked in: Statutory Boards like EDB, S'pore Telecom (IDA), PSA, URA, HDB, NCB (IDA), .....; Defence Agencies (DSO; DSTA), ....., and Government linked companies (GLCs)

( ..., National Computer Bd, ... , Defence Sc & Tech Agency, ... )

- Many engineers also contributed to help Singapore by serving MNCs first in supervising labour-intensive assembly types of manufacturing operations, and then in skills-intensive mass manufacturing (and materials processing).

e.g. Philips, Panasonic, ... in Consumer Electronics

Seagate, Maxtor, Hitachi, .... in Disk Drives

HP in Printers

Jurong Shipyards, Keppel, SembCorp ..... in Ship Repairs  
& Building

(Oil refineries; pharmaceutical plants; etc)

# Class Discussion:


- What can we learn from our experience in the first 25 years of building up national infrastructure??
- What are the consequences of not taking a pragmatic and holistic approach to nation building?"
- Your questions pls??

- After a severe economic recession in the mid 80s, the ground-breaking 1986 Economic Committee Report proposed a national R&D Strategy that had 4 major components:

- 1) Tax Incentives for R&D
- 2) R&D Manpower (including encouraging greater creativity in Schools)
- 3) R&D Infrastructure (including Research Institutes)
- 4) Funding of R&D (grants for R&D projects or Centres)

( plus another on Protection of Intellectual Property )

[ Story of our visit to Taiwan's Hsinchu Science Park in 1981]

 Major Strategic Shift to build KBE over the next 25 years  
(-- Decision still not so smooth; needed 2 MAD Engineers to jump in to become “pioneers”!)

## Building Up Infrastructure

b) During the second 25 years, Singapore built the necessary research infrastructure, . . . .

→ Towards Innovation & Entrepreneurship

- (Science Council) → NSTB → A\*STAR
- A long process of investment  
( 1<sup>st</sup> 5-year plan: \$2B; 2<sup>nd</sup>: \$4B; 3<sup>rd</sup>: \$6B; 4<sup>th</sup>: \$12B;  
5<sup>th</sup>: \$16B; 6<sup>th</sup>: \$19.2B )
- After 2006, NRF; RIEC chaired by the Prime Minister
- Jurong Island; Biopolis; Fusionopolis; **Smart Nation**

( Role of Research Scientists & Engineers;  
Engineer-Leaders at Research Institutes, A\*STAR and NRF to lead  
and execute strategies and policies)

(NSTB: National Science & Tech Bd)

January 1991  Established the National Science & Technology Board (NSTB)

Period	1990	→	1995	→	2000	→	2005	→	2010	→	2015
5-Year Public Research Budget	(S\$2 B)		(\$4 B)		(\$6 B)		(\$12 B)		(\$16 B)		

Total Research Spending (% GDP)

0.85

Researchers Per 10,000 Workers

28

└─→ NSTB established

└─→ NSTB renamed (A\*STAR)

[ A\*STAR: Agency for Science, Tech & Research  
RIEC: Research, Innovation & Enterprise Council  
NRF: National Research Foundation ]

└─→ New: RIEC & NRF



A\*STAR has established **14** public, **mission-oriented** Research Institutes, with over **3000** Researchers\*:

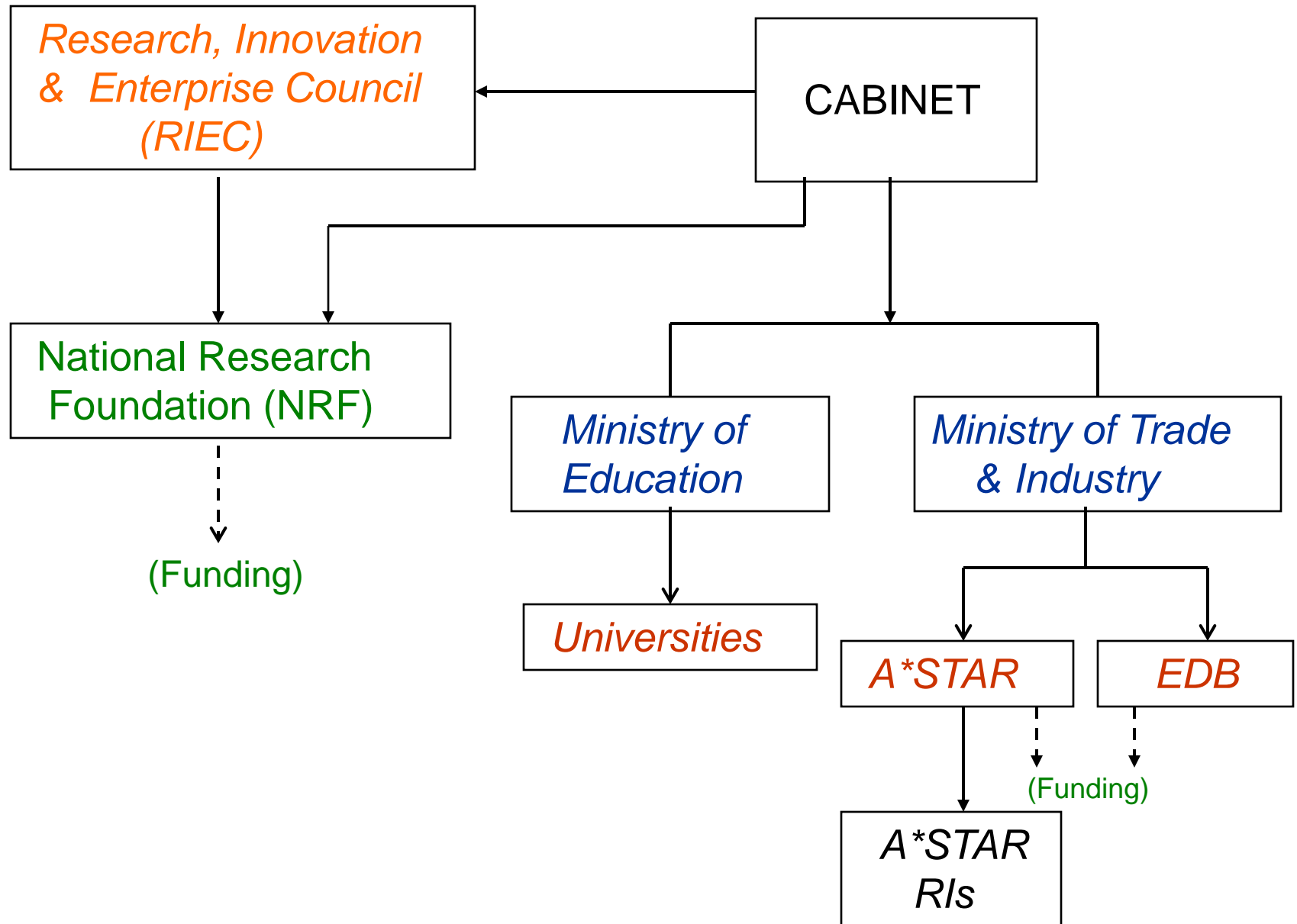
**Biomedical Sciences:** Institute of Molecular & Cell Biology  
Institute of Bioengineering & Nanotechnology  
Genome Institute of S'pore  
Bioprocessing Technology Institute  
Bioinformatics Institute  
Institute of Medical Biology  
S'pore Institute for Clinical Sciences

*[ Anchor tenants of **Biopolis** ]*

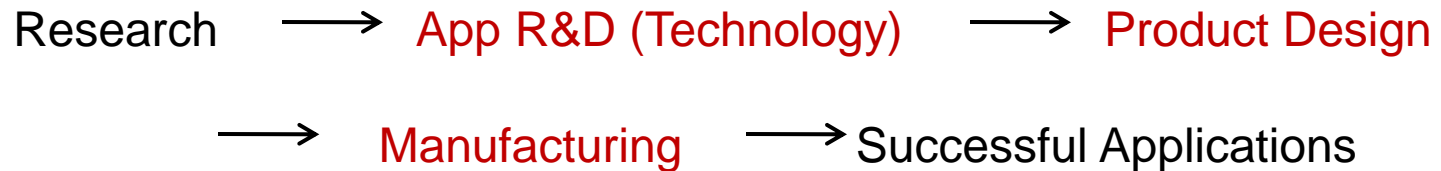
**Physical Science/Engg:** Institute of Microelectronics  
Institute for Infocomm Research  
Institute of Chemical & Engg Sciences  
Institute of High Performance Computing  
Institute of Materials Research & Engg  
S'pore Institute of Manufacturing Tech.  
Data Storage Institute

*[ Anchor tenants of **Fusionopolis** ]*

\*50% PhDs



# Innovation Value Chain



*[ Today, Singapore has done well and will continue to Excel as a Global Innovation Partner of MNCs. ]*

- Critique in the MIT Technology Review, September 2012:  
*Singapore Seeks a Breakthrough to Call Its Own!*
- ( Critique in 2010 by Andy Grove\*\* that US companies were not creating jobs in the US -- *whereas Asia did the reverse!* )

**\*\* Former Chairman of Intel**

## The Singapore Way:

### Pragmatic & “Visionary” Strategies

➡ Partnering MNCs in R&D

➡ Research Talent Development

(including attracting foreign talent – from  
experts all the way to students)

( Research Institutes to hold a pool of dynamic  
talent while developing national capabilities)

[ A ready and abundant supply of well-qualified Researchers  
will attract knowledge-intensive industries ]

Experience & Lessons Learnt: Needed to be bold and plan ahead (entrepreneurial to address extreme uncertainties; lots of feedforward and predictive thinking and adaptive actions)

Systems Thinking – Needed to plan and execute five 5-year National Science & Technology Plans; needed more and more creative and leadership skills at all levels.

MAD Engineers -- who wanted to “Make A Difference”.

**Numerous problems and obstacles were overcome, e.g.**

- How to find Heads of Research Institutes when we first started in the early 90s?
- How to find RSEs to rapidly build up the RIs in less than 10 years?
- How to get more locals (S'poreans; PRs) to do PhDs?
- How to supplement local talent by importing foreign talents?
- How to promote public-private collaborations?

.....

.....

[ Engineer-Leaders were challenged to create new solutions! ]

# Challenges in Talent Development

## Systems Thinking 1: How to attract local talent

- National Science Scholarship
- A\*STAR Graduate Academy

## Systems Thinking 2: How to attract foreign talent

- Tap the 2 billion talent within a 6-hour flight envelope
- A\*STAR Graduate Academy
- Local University Scholarship

## Systems Thinking 3: Retention

- Use Research Institutes to be the “holding post”

# Advanced Systems Thinking:

## *Promoting* Innovations in Engineering Systems

- During the last 50+ years, Singapore deployed its top engineering talent to develop complex engineering systems including public utilities, communications, transportation, housing, health-care, environment, manufacturing, defense, *technology-enabled services*, etc. Many indigenous innovations could be found beyond imported knowhow and solutions.
- Some corporatised public agencies or indigenous local companies have started to export systems solutions to other countries, e.g. Public Housing; Offshore & Marine Engineering; Water Treatment.



## Examples:

### -- **Surbana Jurong Pte Ltd**

(Surbana was formerly HDB Corp)

- In Infrastructure & Urban Development consultancy
- Aiming to grow its revenue to \$1 billion to \$1.5 billion in the next three to five years, while growing its staff strength from 4,000 currently to 6,000 people.

### -- **Keppel Corp Ltd**

- Leader in Offshore & Marine Engineering
- Revenue: >S\$10 B; Employees: 37,000 globally

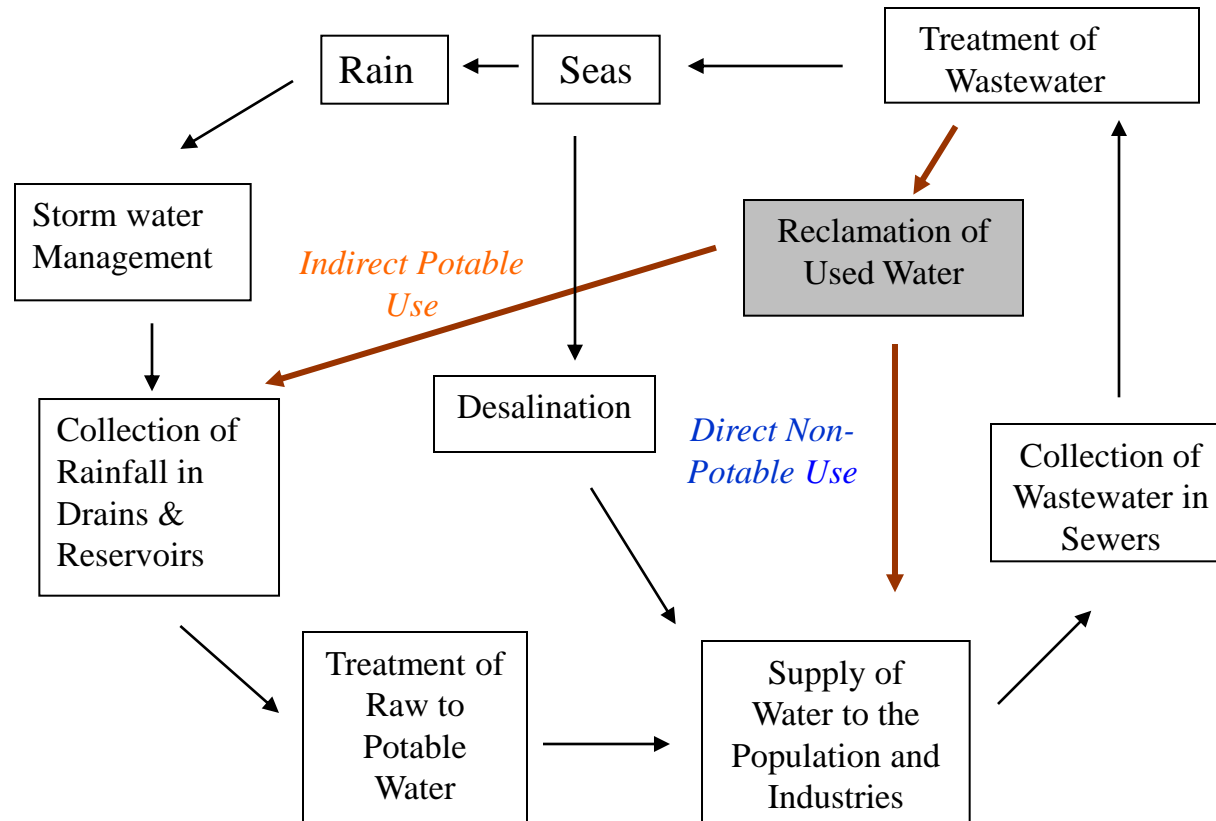
### -- **Hyflux Ltd**

- Specialist in Water Treatment
- Revenue: >S\$500 M; Employees: 2300 in Asia

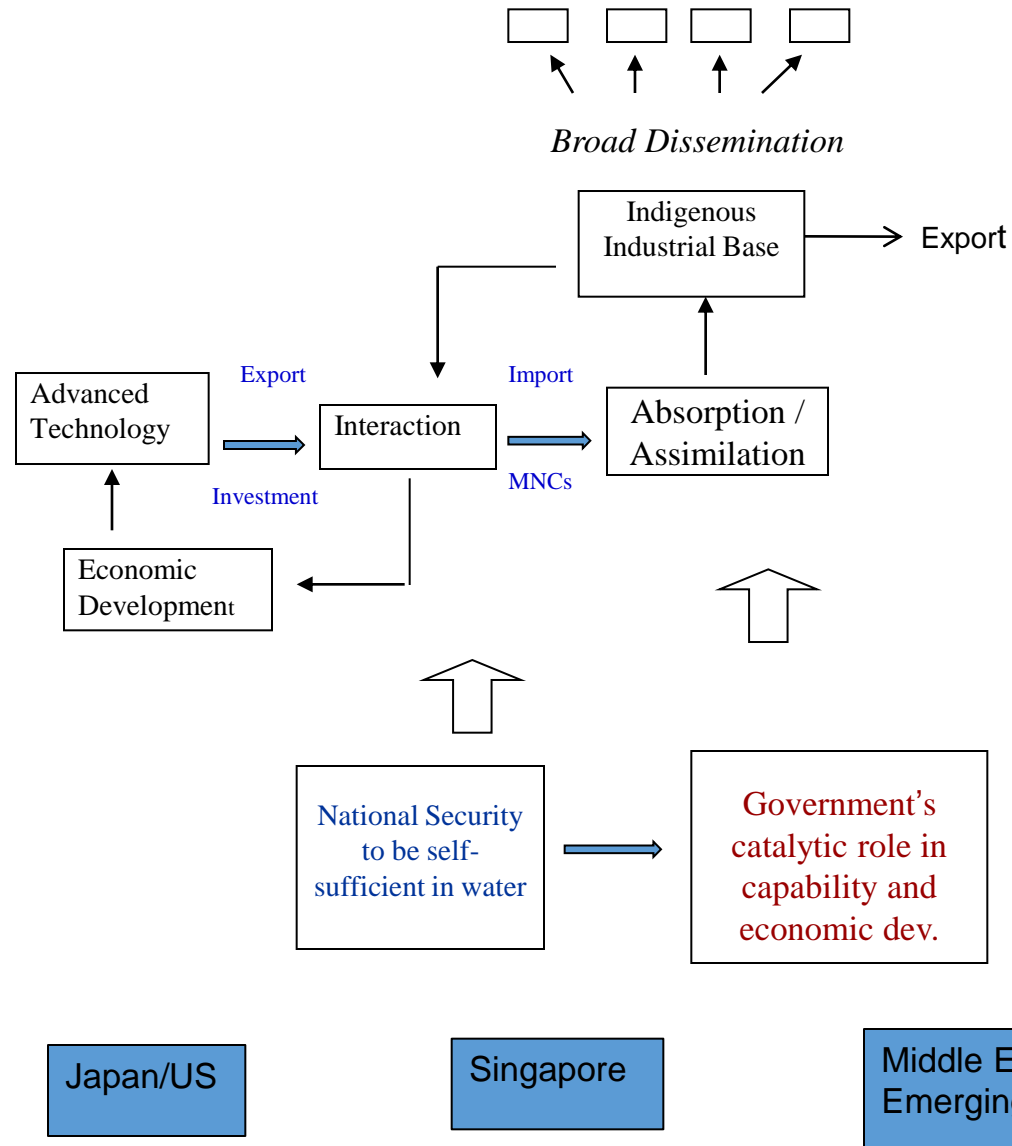


Jackup Rig Design & Construction (\$300M / Rig)

( Keppel Offshore & Marine & other S'pore firms have  
*over 70% of the world market share*)



An Engineering System Success:  
 NEWater for “*Direct Non-Potable*” Use”  
 and “*Indirect Potable*” Use”.



## Dual-Use Strategy for Industry Development

**Advanced Systems Thinking**: Singapore may evolve a national Strategy of “**Dual-Use**”: Using internal needs of Singapore to stimulate economic development -- encouraging and facilitating more public-private partnership to export Singapore’s innovative **Engineering Systems capability**.



*[ e.g. S’pore Economic Strategies Committee (2010) has recommended: “The public Sector to serve as a Lead User to position S’pore as a living lab or test-bed to explore & create “future-ready” green urban solutions.  
-- **more could be planned.**]*

( Opportunities may be found in **energy, environment, infrastructure, healthcare**, etc; will benefit both MNCs and local enterprises. )

## Future Systems Thinking: What should we do beyond “Research”?

- From National Science & Tech Plan to Research, Innovation & Enterprise Plan
- RIE 2015; 2020; 2025; etc

(More Engineers to become CTOs, CEOs and Techno-Entrepreneurs!)

(  Institute For Engineering Leadership  
 Engineering Doctorate Programme)

## Characteristics of Engineer-Leaders

- IQ + EQ
- Systems Thinking Skills
- (Outstanding in execution)

[ MT2001 Experiencing Engineering Leadership ]

[ MT3001 Systems Thinking & Engineering ]

[ InnoVenture ]

-----

[ Graduate Certificate in Engineering Leadership ]

EQ consists essentially of

- **Self-awareness**
- **Mood management**
- **Self-motivation**
- **Impulse control**
- **Interpersonal skills**

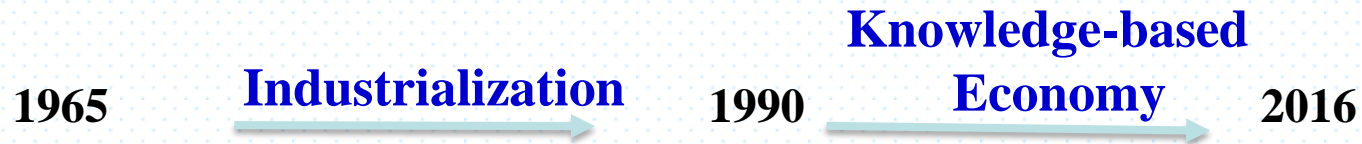
- 
- EQ can be improved as a deliberate life-long pursuit.
  - In universities, open-ended group assignments and project/design work, problem-based learning, etc, help students develop EQ skills.

[ Engineering education and *practice* ⇒ opportunities to improve one's EQ skills.]



# Summary of Part 1

- Engineers built up national infrastructure
  - will rebuild, adapt (simplify or even eliminate)
- Engineers applied Systems Thinking to solve problems
- Nurturing engineering talent (local + international)
- 1<sup>st</sup> 25 years of nation building; 2<sup>nd</sup> 25 years (Research + *Towards I&E*)
- Beyond learning from the best and leveraging/partnering MNCs, S'pore's engineer-leaders pioneered the development of Engineering Systems (+ Leading our I&E effort)
  - creating exportable service and indigenous capabilities for SG75 and SG100!



3<sup>rd</sup> world → 1<sup>st</sup> world

3<sup>rd</sup> world → 1<sup>st</sup> world  
(Research)      (RIE ?)

**KBE++**

**2020 & beyond**

RIE ??

-- + Innovations in Engineering Systems ?

-- + Learning from Switzerland  
[which has Nestle (US\$100B revenue),  
....., nation of Innovators ] ?