Cost Issues of ILC Construction

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Outline of My Talk

- In-kind contribution
- Cost estimation
- Cost reductions via industrial participation
- Conclusions

Importance of Cost Issues

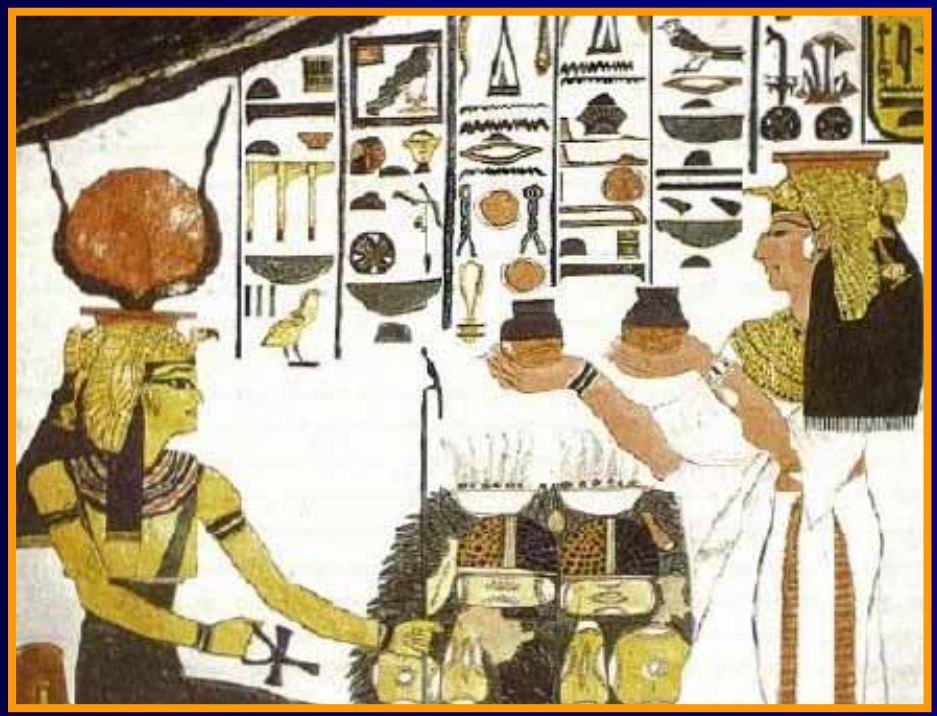
- Off course
  - Confirming global consensus for ILC construction.
  - Budgetary approval by financial agencies.

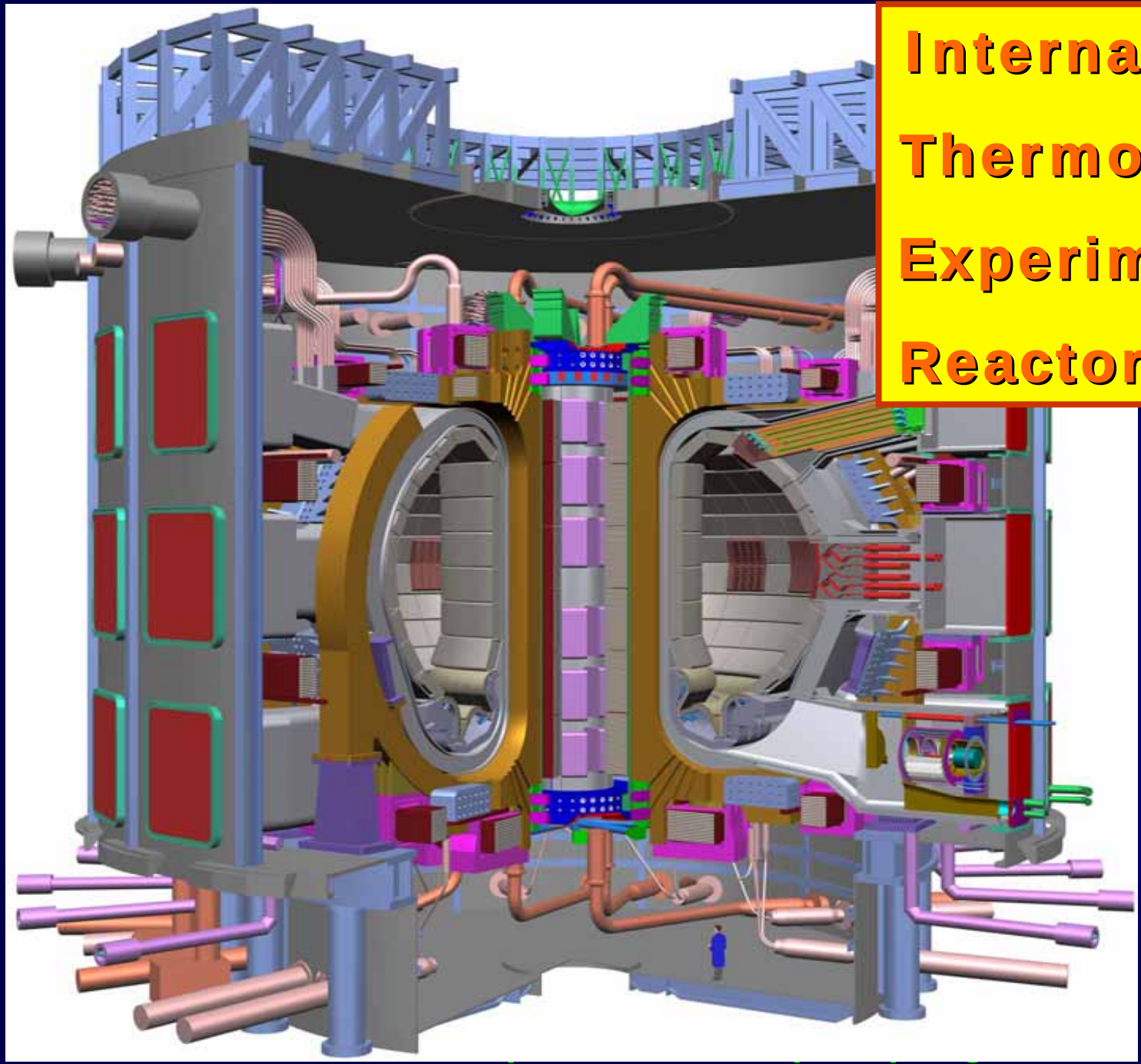
- Practical importance for ILC community
  - Cost data is a key for successful establishment of in-kind contribution scheme.

In-Kind Contribution, What?

- Constructing a huge and an expensive system by international collaboration.
- Participating countries contribute components and/or sub-systems to the project.
- Examples;
  - ITER
  - Space Station
  - International Radio Telescope (ALMA Project)

History of In-Kind Contribution





International Thermonuclear Experimental Reactor

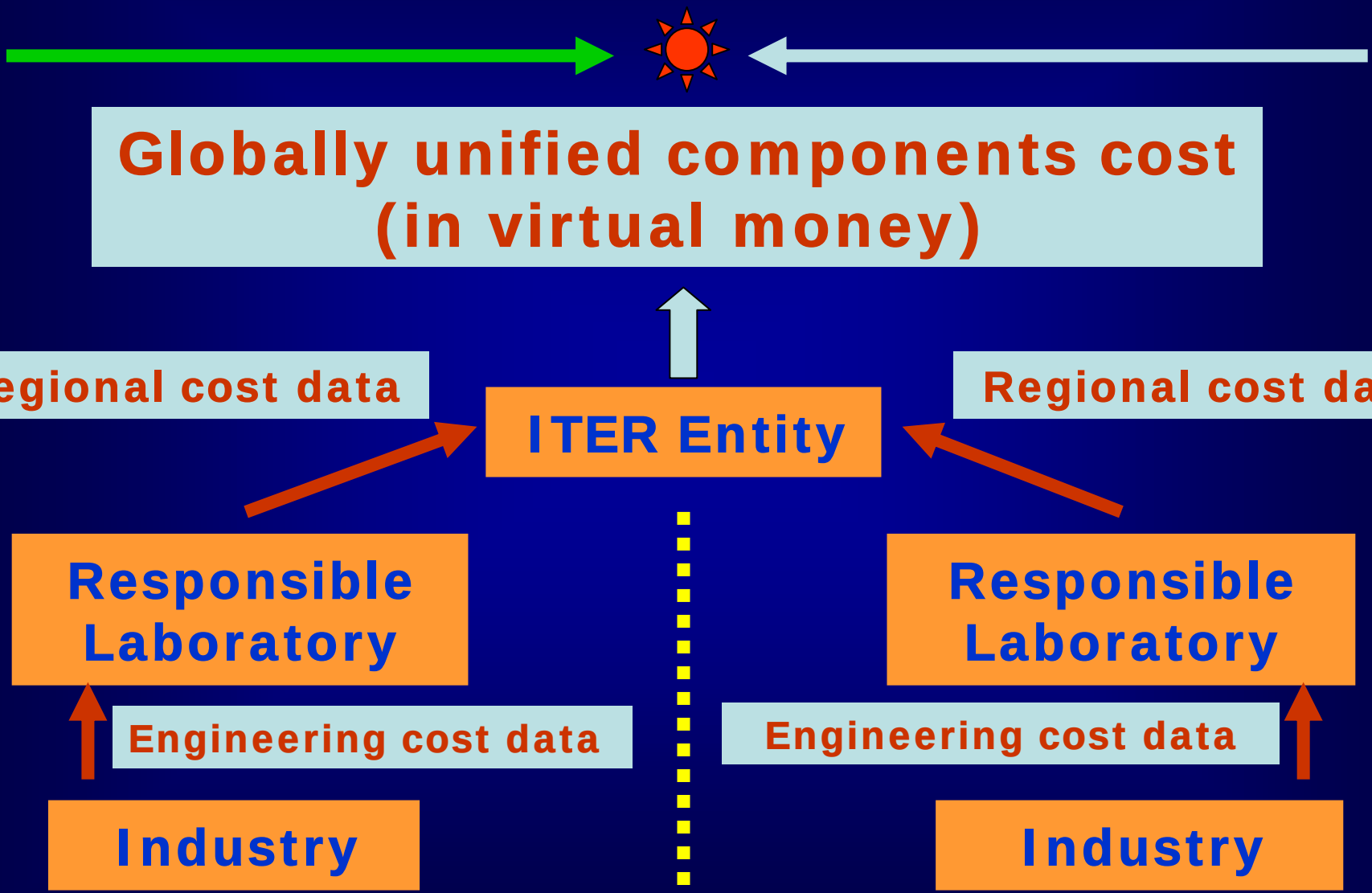
In-Kind Contribution in ITER (1)

- In-kind contribution scheme is properly designed in ITER Project and all participating parties agree with this scheme.
- This scheme is one of the best textbook for ILC project.

In-Kind Contribution in ITER (2)

- All components should be categorized according to the rule that these are fabricated by using key technologies or conventional technologies; the former the key component, the latter the conventional components.
- All components are evaluated in a globally unified virtual money, *i.e.* ITER Unit Account (IUA).
- These values are the basis of components allotment to participating parties.

Unified Cost in ITER



Components allotment in ITER

- Scheme of components allotment is as follows;
  - All components are allotted based on globally unified components cost,
  - There are different contribution patterns for key components and conventional components, and
  - Host country is burdened with infrastructure and civil engineering cost.

In-Kind Contribution in ILC

- We must
  - understand that in-kind contribution and cost estimation are two sides of the same coin,
  - determine principles for in-kind contribution scheme as soon as possible,
  - estimate all component costs at engineering, regional and global levels, and
  - allot all components to three regions based on global unified costs.

Process for Cost Estimation (1)

- Preparations by international entity
  - Provide globally unified structural specifications and manufacturing drawings for all components.
  - Define delivery date.
  - Define clear responsibility for manufacturer.

Process for Cost Estimation (2)

- Engineering cost;
  - Collect cost data from industry.
  - (at the same time) Collect idea for cost reduction.
- Regional cost;
  - Is determined by collaborative task of regional laboratories and industries.
  - Feedback and iterations may be required for converging engineering cost data from companies.
    - It looks like Delphi technique.
    - Then we get regional cost data.

Process for Cost Estimation (3)

- Regional cost data
  - Highest?
  - Medium?
  - Lowest?

Oracle of Delphi

Process for Cost Estimation (4)

- Global cost estimation by international entity
  - Three regional cost data are naturally different each other, but have to be unified by taking into account regional industrial level, labor cost, commodity price index, and so on.
  - Tough negotiation may be necessary.
  - Globally unified cost are assessed for all components.
- Construction cost
  - A regional cost is not a true ILC construction cost. It is a cost expression that ILC is constructed within that region by that region only.
  - True construction cost is a globally unified cost.

Allotments to Three Regions

- All components are allotted to three regions for in-kind contribution.
- Allotments are done in a pre-determined proportion (usually even contribution) based on globally unified cost.
- Key components should be equally allotted to three regions.
- Conventional components should be allotted by negotiation among three regions.

Infrastructure

- Host region is burdened with facilities associated with infrastructure, such as electric power supply, cooling water system, air conditioning system, experimental buildings, etc.
- Civil engineering cost is also a burden to host region.

Procurements

- Components allotted to a region should be procured within that region.
- Procurement cost
  - Procurement cost should not be directly linked with the unified cost that is determined only for in-kind contribution allotment
  - It should be linked with regional cost.
  - The actual cost, therefore, may vary by regions because the industrial level, labor cost and commodity price index are different in three regions.

Problems Remained

- Intellectual property rights (patents), especially those for key components.

Cost Reductions

- There are three routes for cost reductions via industrial participation
  - Production technology
  - Systems engineering
  - Joint fabrication factory

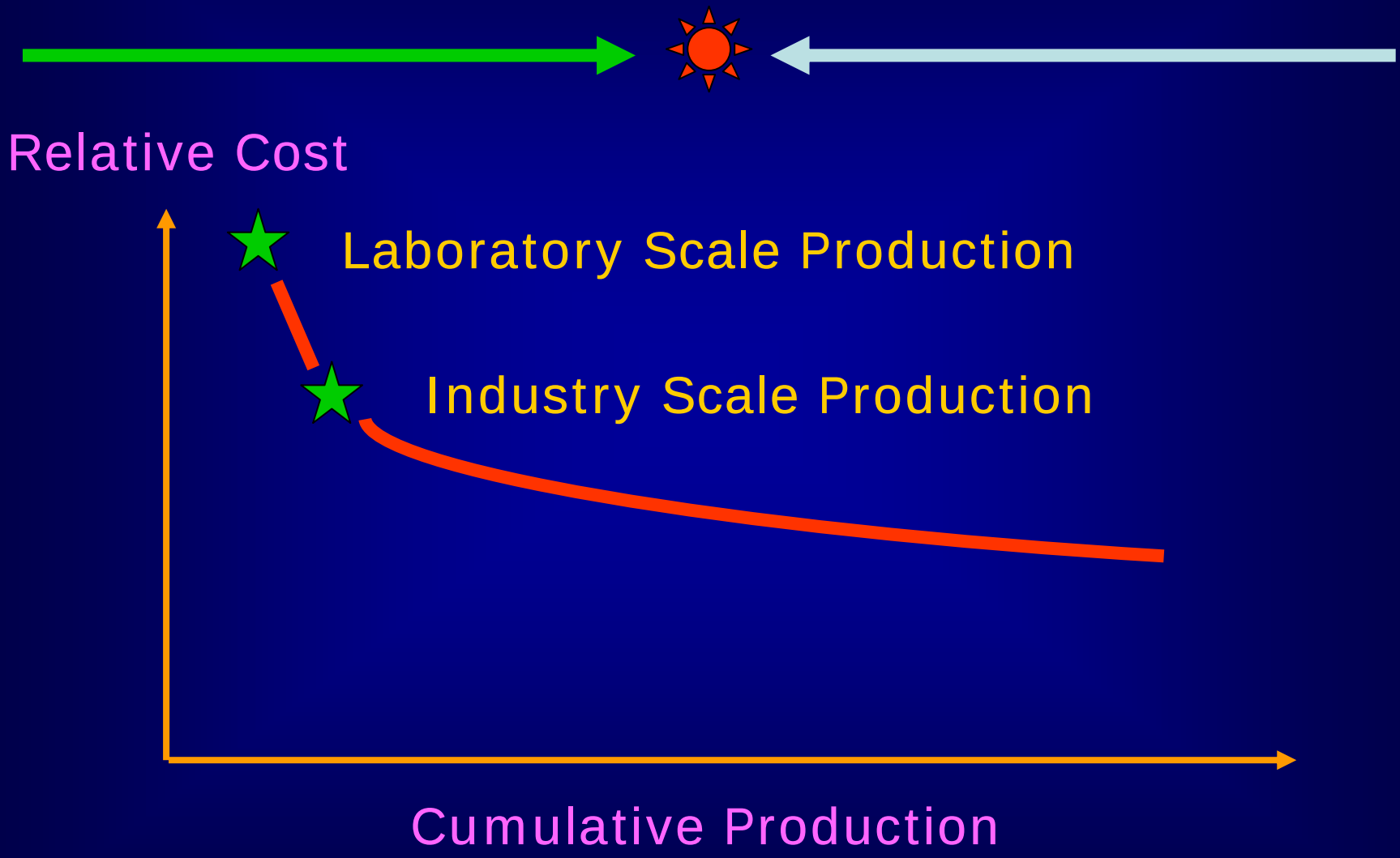
Cost Reductions via Production Technology (1)

- Each industrial company is characterized by its own production technologies including production facility, engineering skill, etc.
- In case when the design configuration and fabrication process of the ILC components fit to production technologies, cost might be remarkably reduced because no additional investment necessary.
- Reviews of product design and fabrication process are therefore very important.

Cost Reductions via Production Technology (2)

- Cost at industry scale fabrication is lower than that at laboratory scale fabrication.
- But don't expect too much for cost reduction through mass production, because ILC is not large enough for getting meaningful learning effects.
- Quantitative analysis is necessary.

Cost Reductions via Production Technology (3)



Cost Reduction via Systems Engineering (1)

- Systems engineering approaches to complicated fabrication process such as
  - Fabricating a component with multi-stage process (ex. Material preparation, electro-chemical polishing, machining, EB welding, …) by different industrial companies.

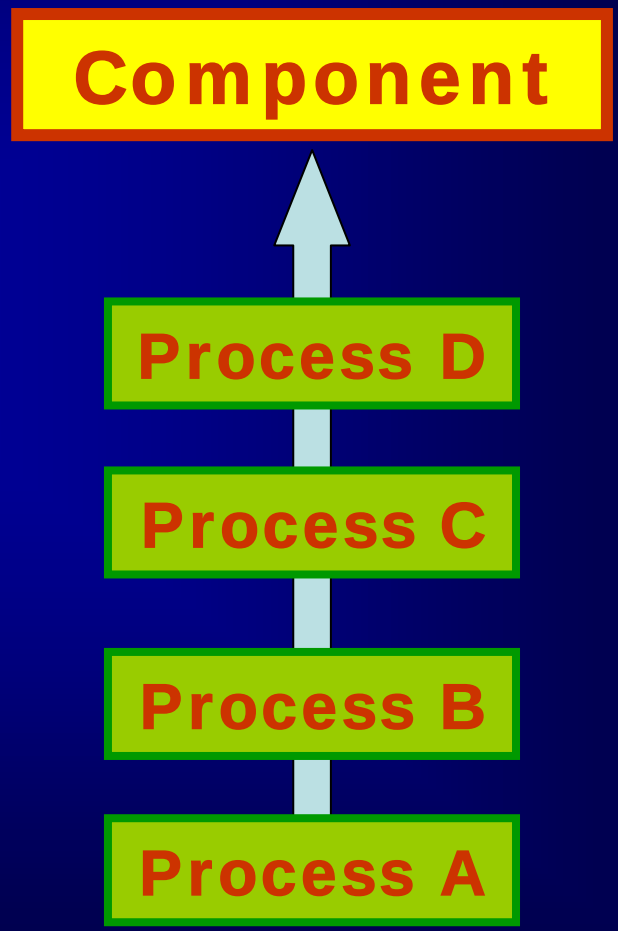
Cost Reduction via Systems Engineering (2)

Vertical Integration

- All in one company

or

- One company supervises several companies



Cost Reduction via Systems Engineering (3)

- The other fields where systems engineering approach are effective are;
  - Assembling a sub-system with a lot of components,
  - Sub-systems where consistency among them is important, such as cryostat and cavity.

Cost Reduction via Systems Engineering (4)

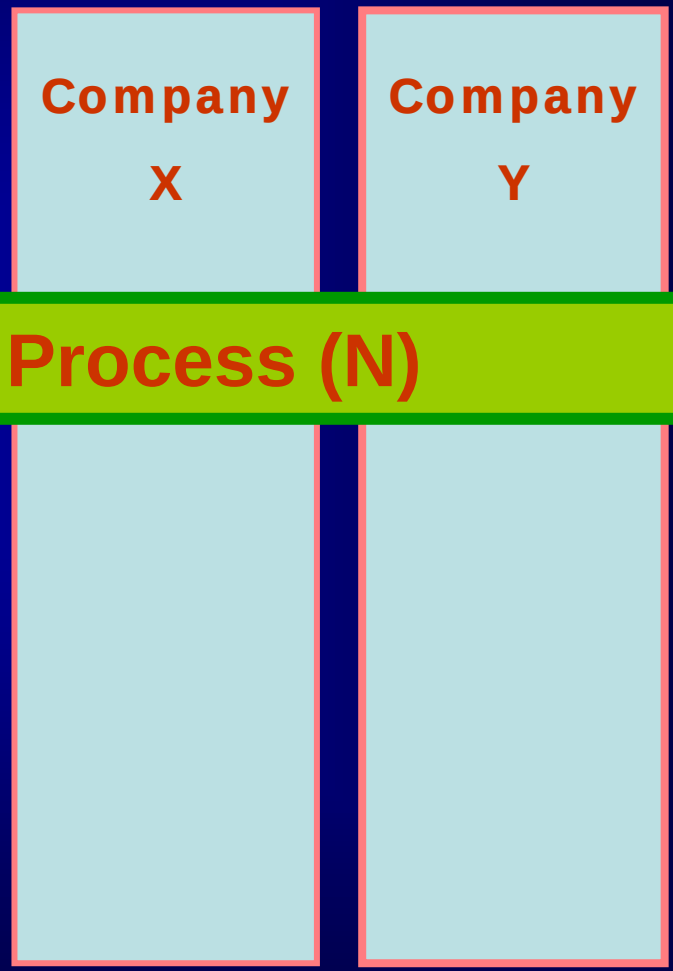
- Systems engineering for complicated fabrication process and integration of sub-systems will be effective in the scopes of
  - Process optimization
  - Delivery time control
  - Cost control
  - Quality control
  - Logistics control

Cost Reduction via Production Facility (1)

- Joint factories for avoiding duplicated investments
  - Electro-chemical polishing facility,
  - EBW facility,
  - Etc.
- Test facility using liquid helium is another example for joint facility.

Cost Reduction via Production Facility (2)

Horizontal Integration



- Rental Factory built by international entity

or

- Factory jointly established by industry

Cost Reduction via Production Facility (3)

- These facilities might be used by industry with reasonable charge (rental factory).
- It does not matter whether these facilities are located on-site or off-site.

Rental Factories

Hertz

AVIS We try harder.

National Car Rental

Budget Car Rental

DOLLAR RENT A CAR

Concluding Remarks (1)

- In-kind contribution and cost estimation
  - These are two sides of the same coin.
  - In-kind contribution scheme should be properly designed as soon as possible, and all participating regions should agree with this scheme for successful collaboration.
  - In this context, cost estimation is one of the highest priority issues for realizing ILC.

Concluding Remarks (2)

- Cost reductions are possible via industrial participation.
  - Reviews of design and fabrication process in order to match with industrial production technology,
  - Systems engineering approach (Vertical Integration), and
  - Joint production facility (Horizontal Integration).

How Much does ILC Cost ?