PSAM 9 International Probabilistic Safety Assessment and Management Conference
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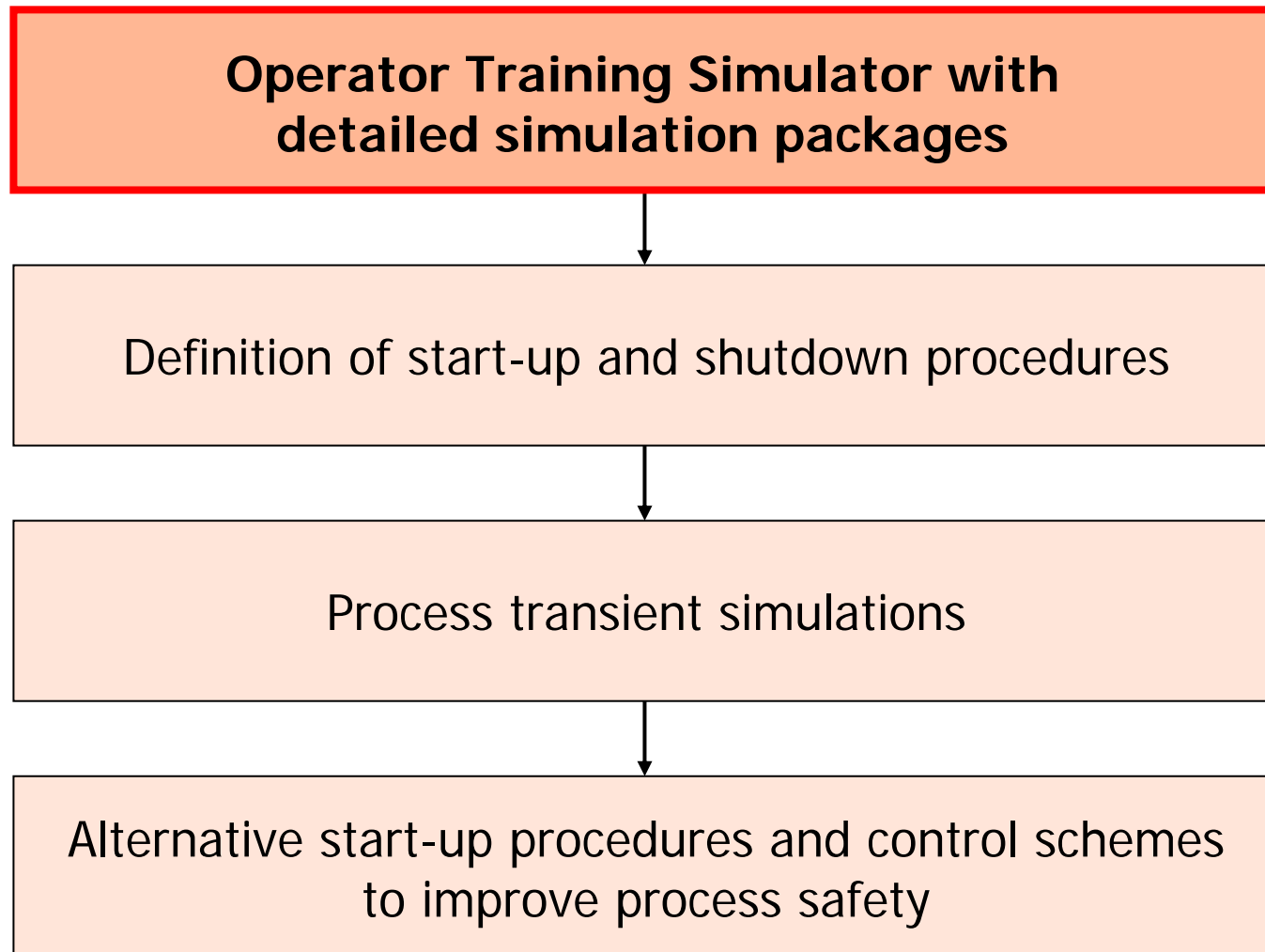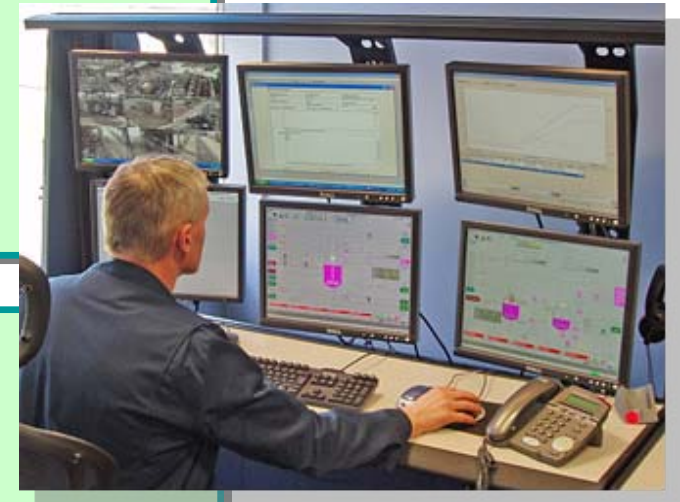
Safe Process Start-up Procedures Based on an Operator Training Simulator: a Case Study

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Presentation outline

Operator Training Simulator with detailed simulation packages

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Definition of start-up and shutdown procedures

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Process transient simulations

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Alternative start-up procedures and control schemes to improve process safety

Widespread Simulation Toolkits

- Dynamic simulation features
    - Batch dynamic simulations
    - Control strategies
    - Start-up and shutdown
    - *Distributed Control Systems*
    - Operator Training Simulators
- Control-room and field operator training

- SimSci-Esscor (**Dynsim**)
- Honeywell (**HYSYS**)
- Aspentech (**Aspen HYSYS**)
- PSE (**gPROMS**)
- CreateaSoft (**Simcad**)
- Simulation Solutions (**Virtual Refinery**)
- ...

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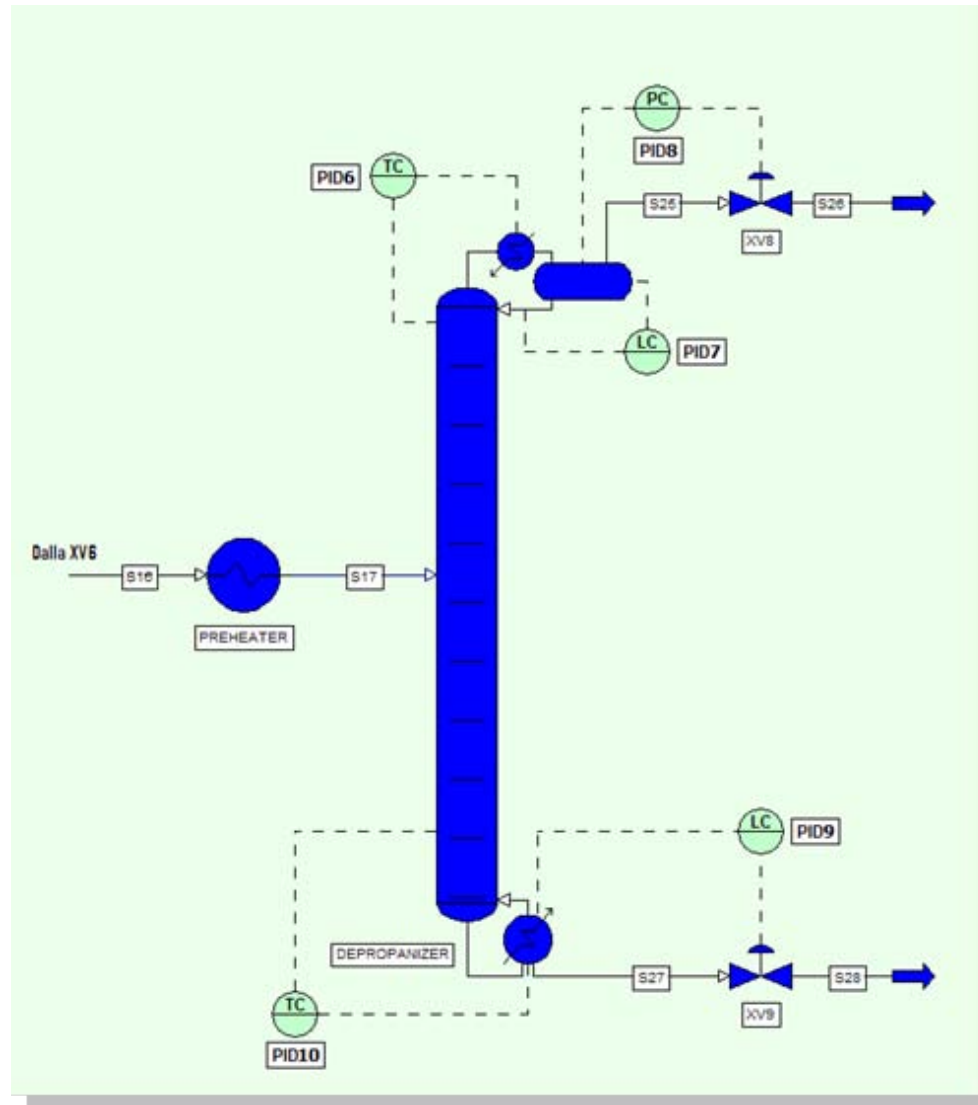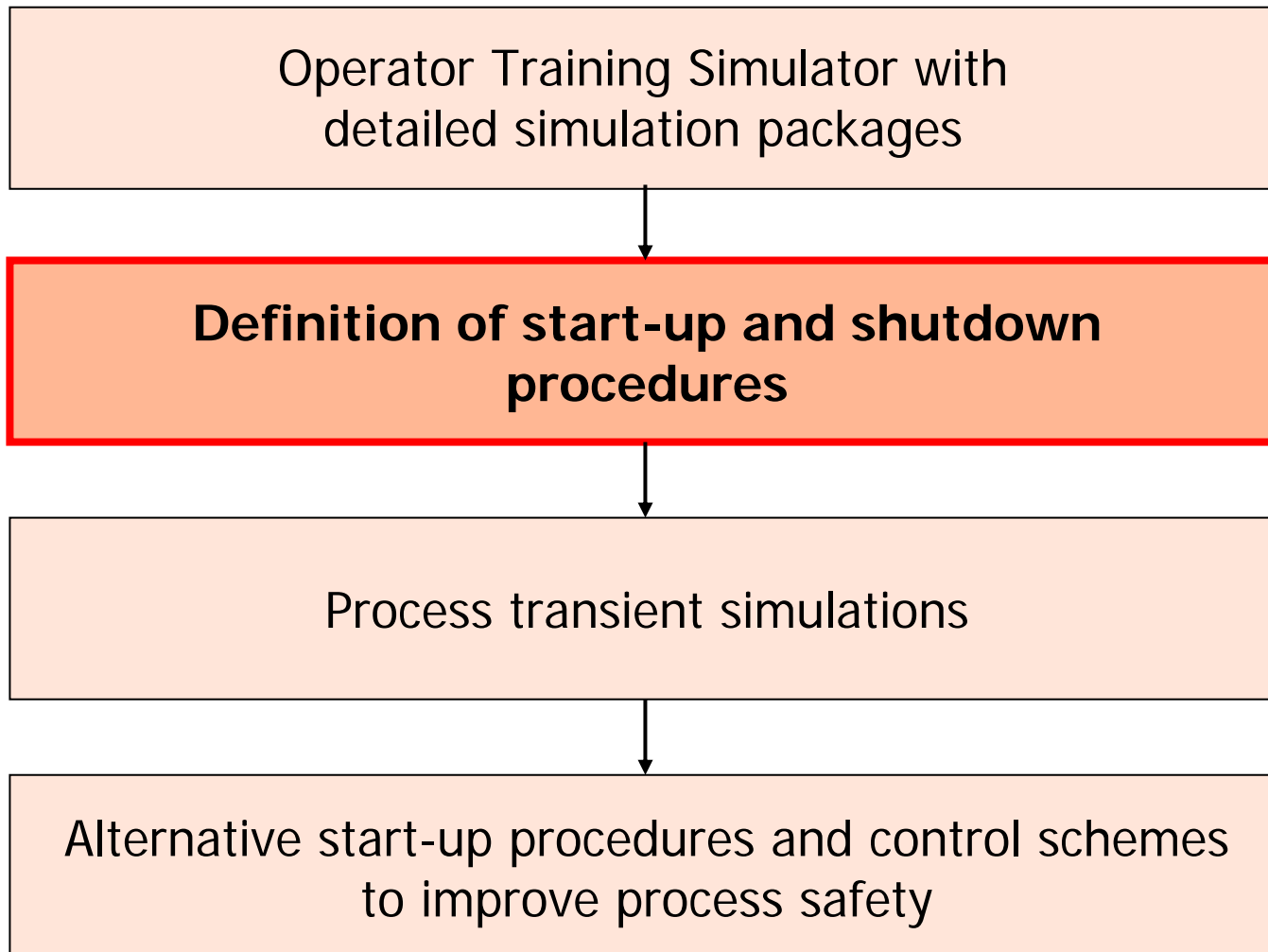## DYNAMIC MODEL BUILDING

Flow-Sheet definition

Thermodynamic method selection

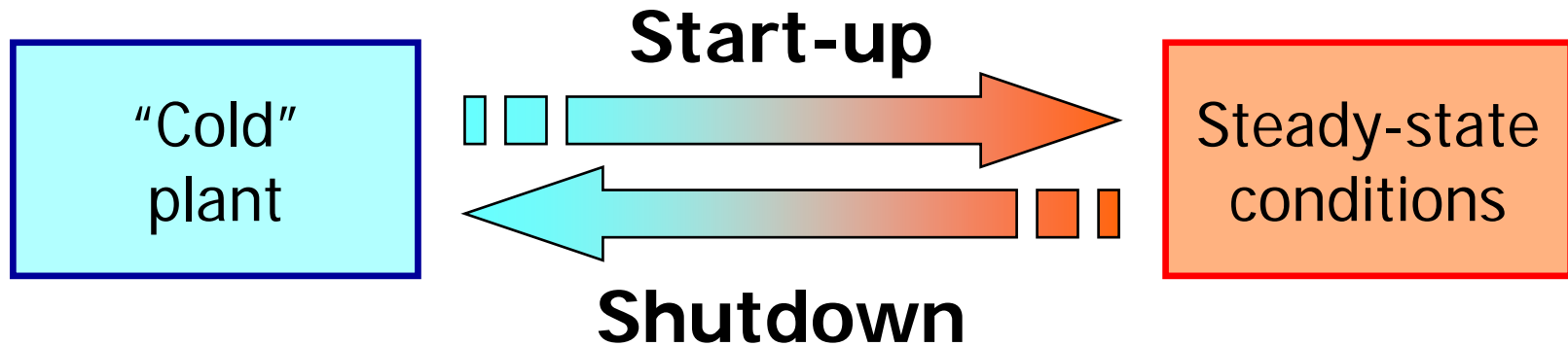**Definition of reaction and kinetic schemes**

Process unit geometries and boundary conditions

Flow-conductance factors and valve caracteristics

Dynamic Simulation and Control

Presentation outline

Start-up and Shutdown Procedures
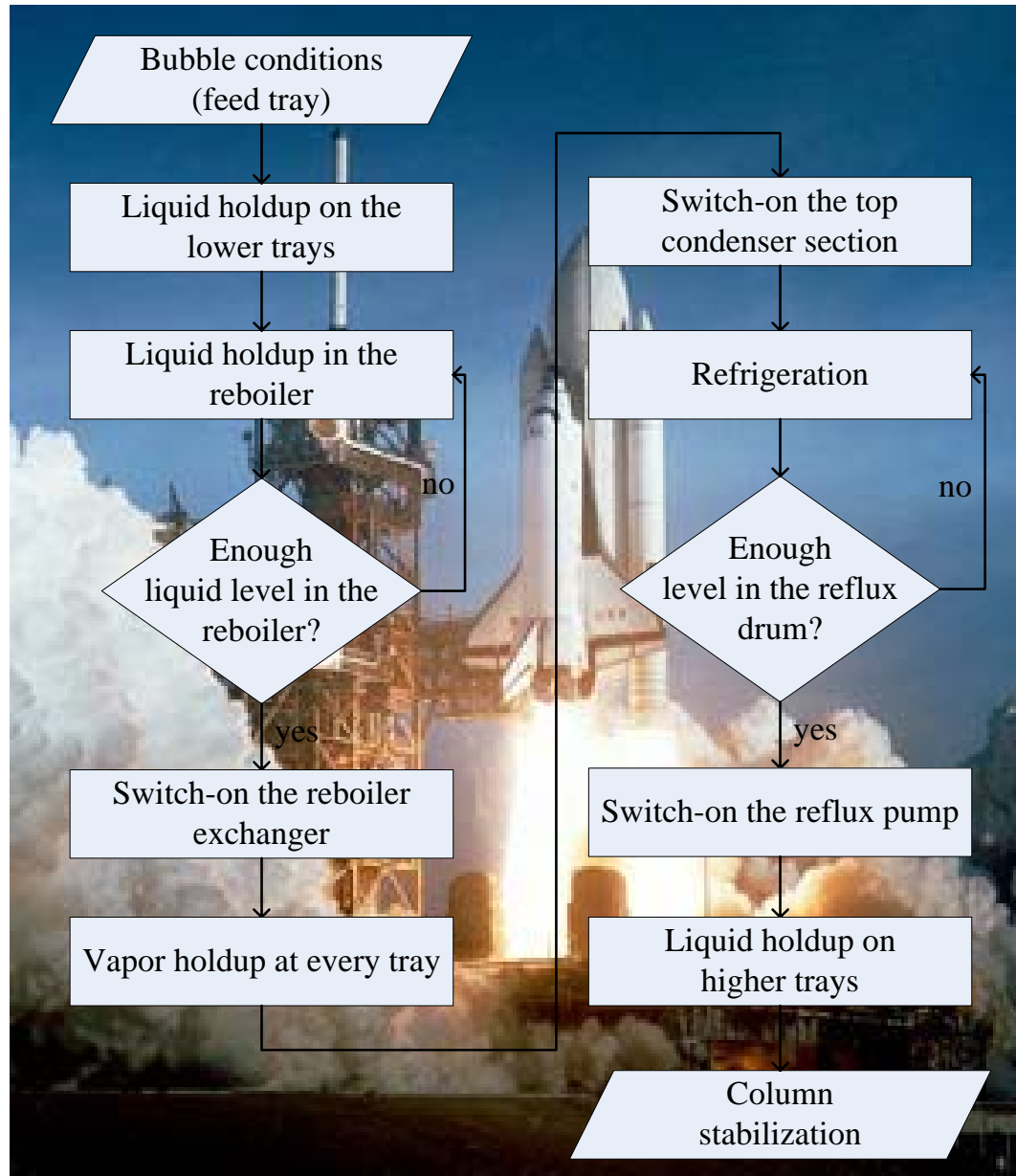
Start-up

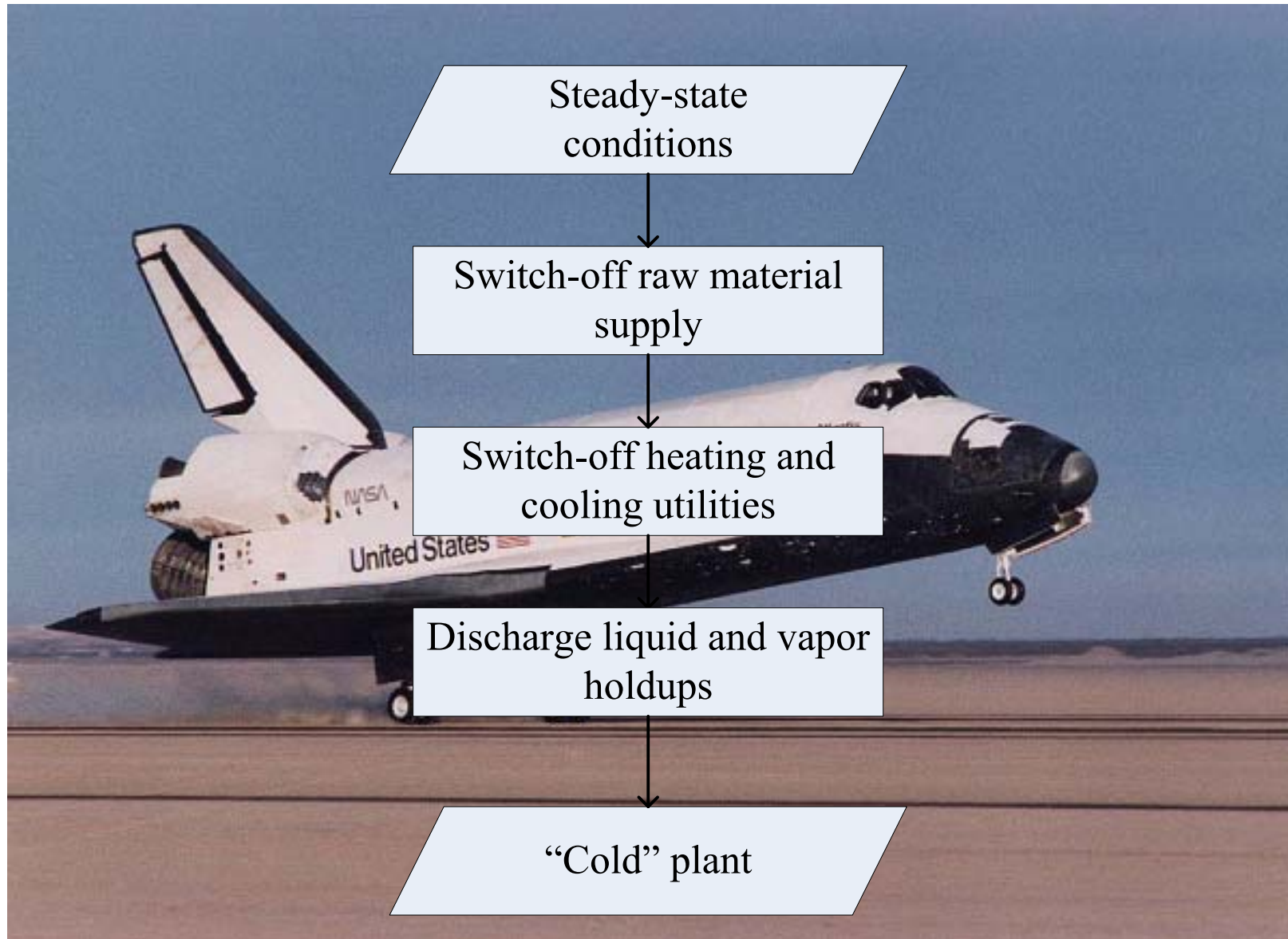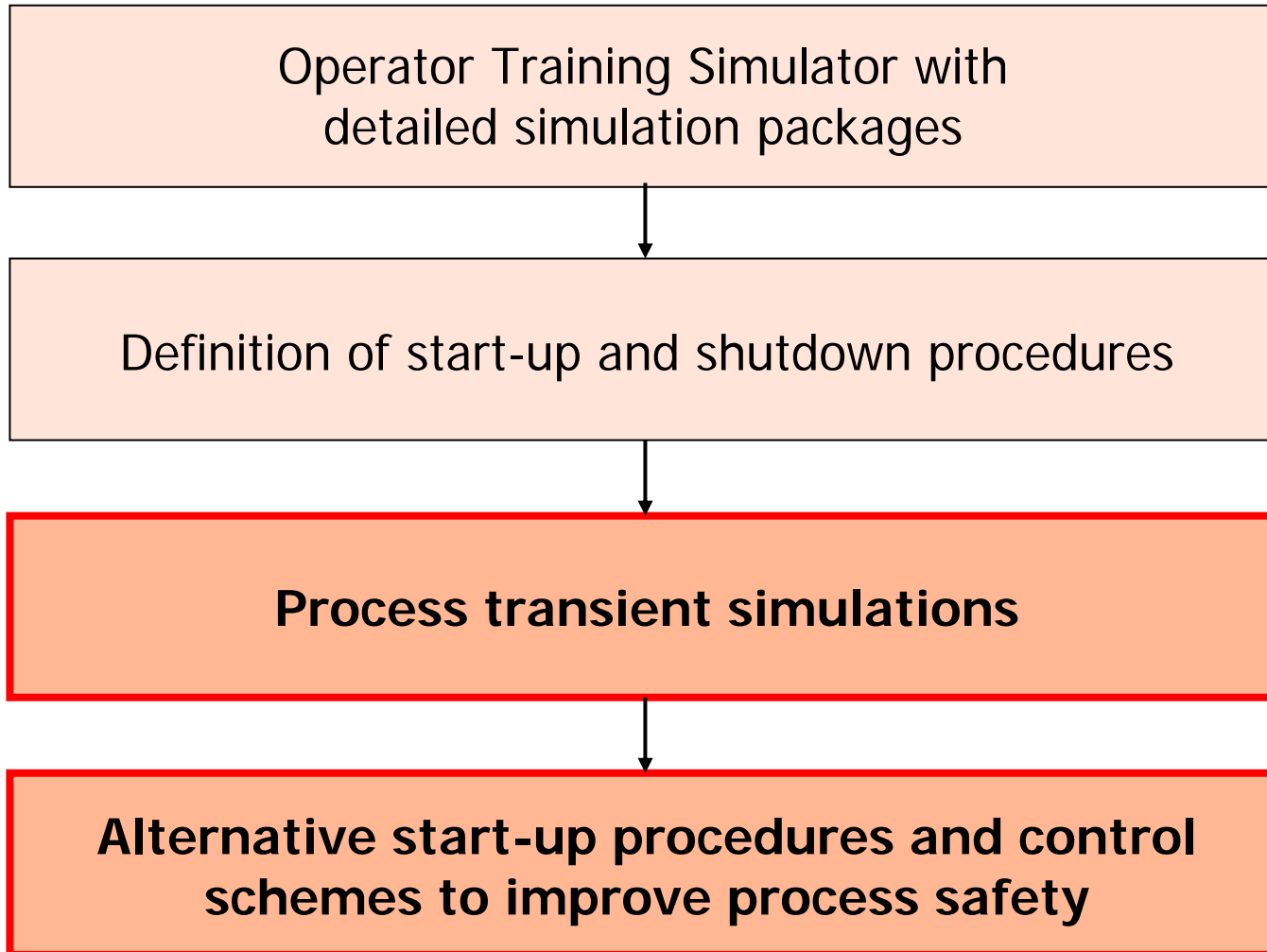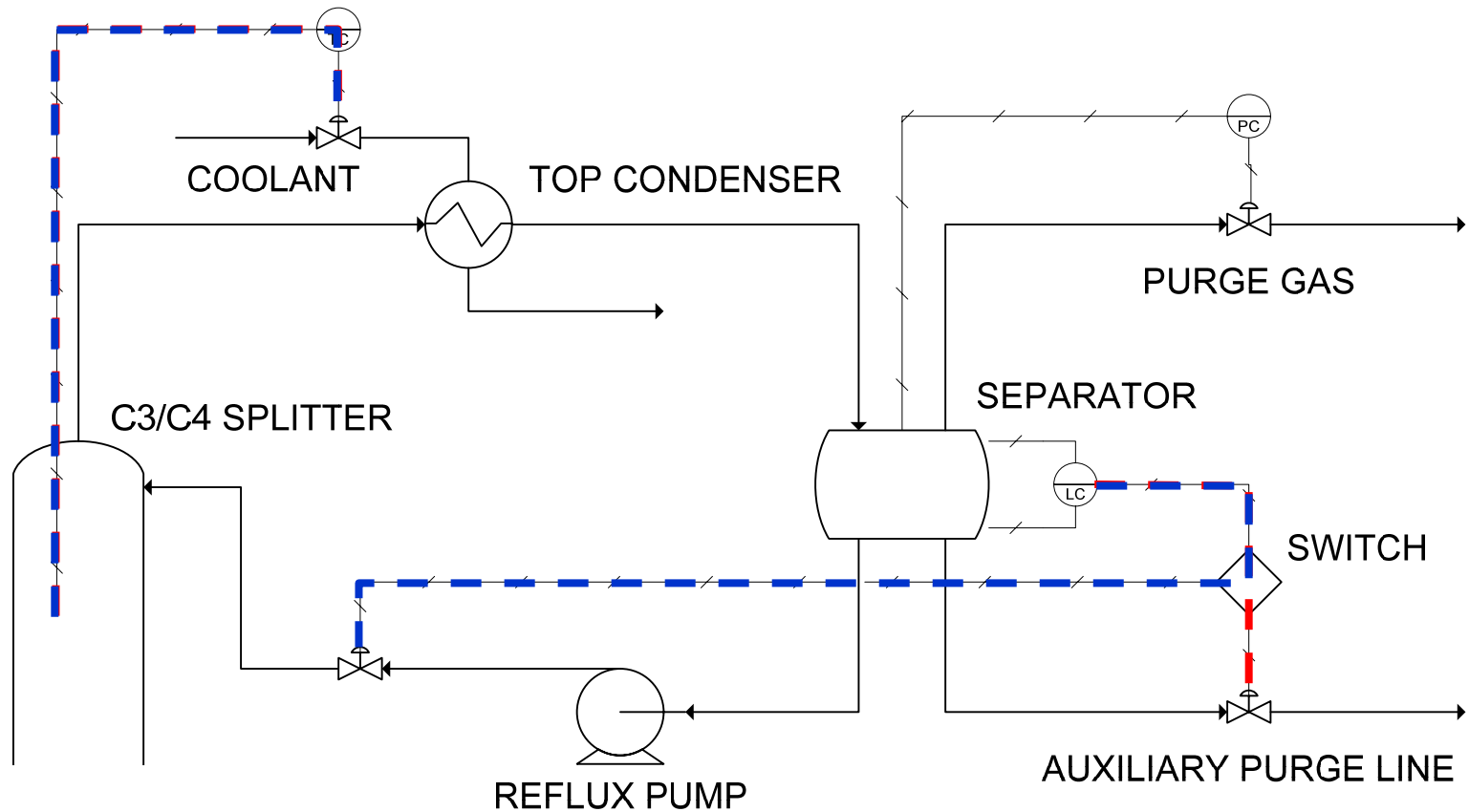| "Cold" plant | ⟶⟵ | Steady-state conditions |

Shutdown

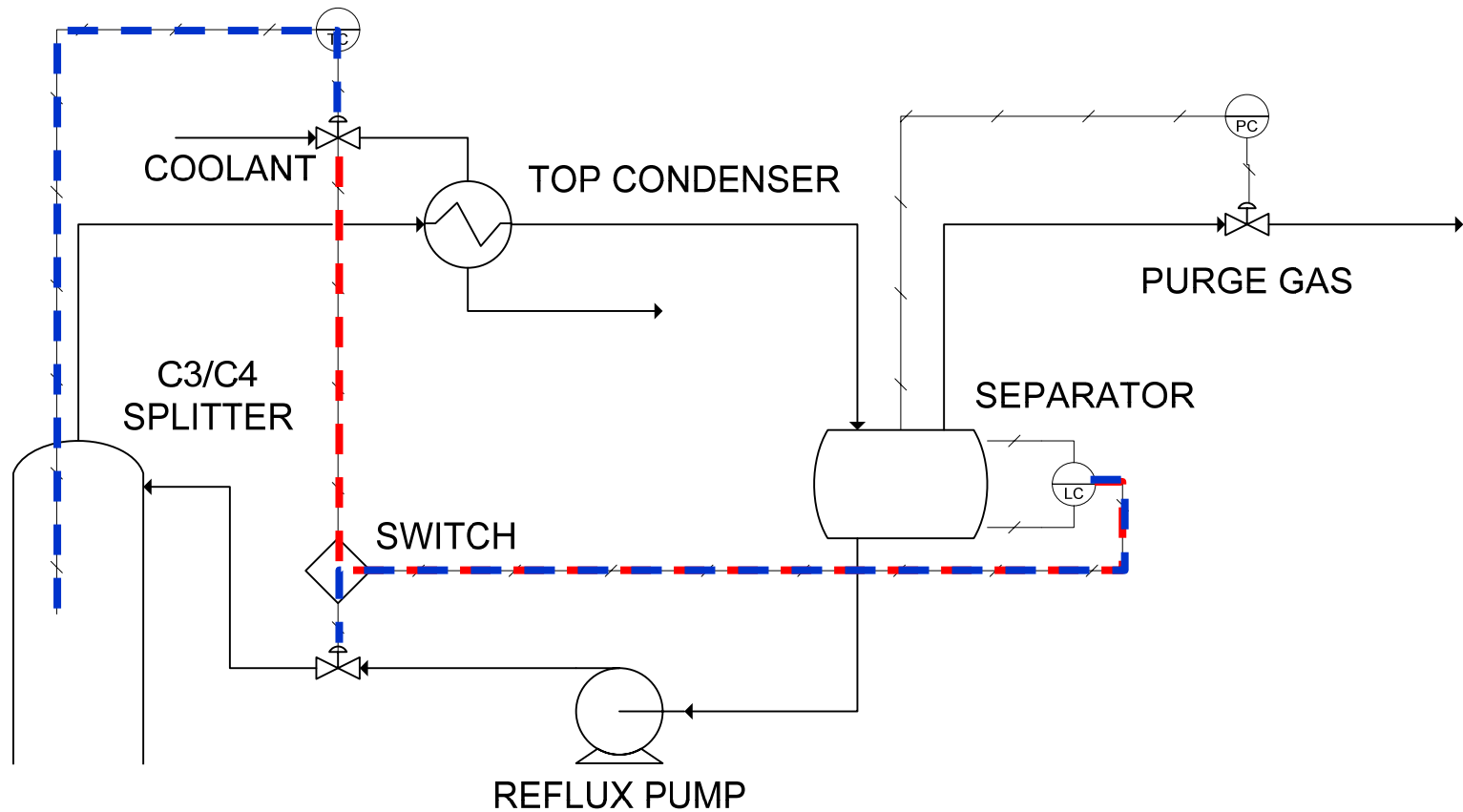## Importance of the analysis of unsteady conditions

- Decrease of off-spec periods
- Increase of plant productivity
- Start-up and shutdown operating conditions are significantly different from the steady-state conditions
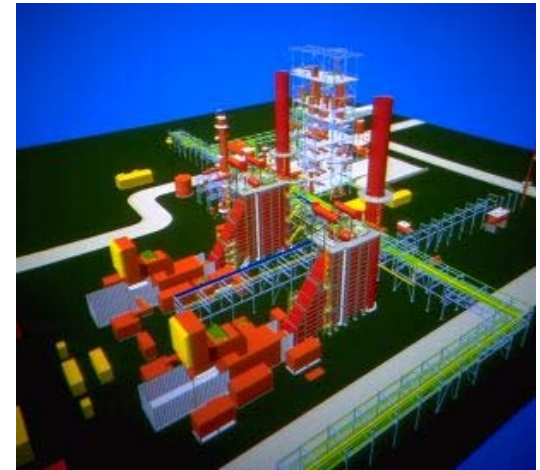- Relevant safety and operability problems

Flowchart:

Bubble conditions (feed tray) → Liquid holdup on the lower trays → Liquid holdup in the reboiler → Enough liquid level in the reboiler? — no (loop back to Liquid holdup in the reboiler) / yes → Switch-on the reboiler exchanger → Vapor holdup at every tray

Switch-on the top condenser section → Refrigeration → Enough level in the reflux drum? — no (loop back to Refrigeration) / yes → Switch-on the reflux pump → Liquid holdup on higher trays

→ Column stabilization

Flowchart:
- Steady-state conditions
- Switch-off raw material supply
- Switch-off heating and cooling utilities
- Discharge liquid and vapor holdups
- "Cold" plant

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**Alternative start-up procedures and control
schemes to improve process safety**

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Conventional control scheme

COOLANT

TOP CONDENSER

PC

PURGE GAS

C3/C4 SPLITTER

SEPARATOR

LC

SWITCH

REFLUX PUMP

AUXILIARY PURGE LINE

Modified Control Scheme

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Safety and Reliability Issues

- Loading

- Flooding

- Weeping

- Pressure shots

- Entrainment

- Wet Bundles

- Smooth dynamics

- ...

Condenser

Conventional control structure
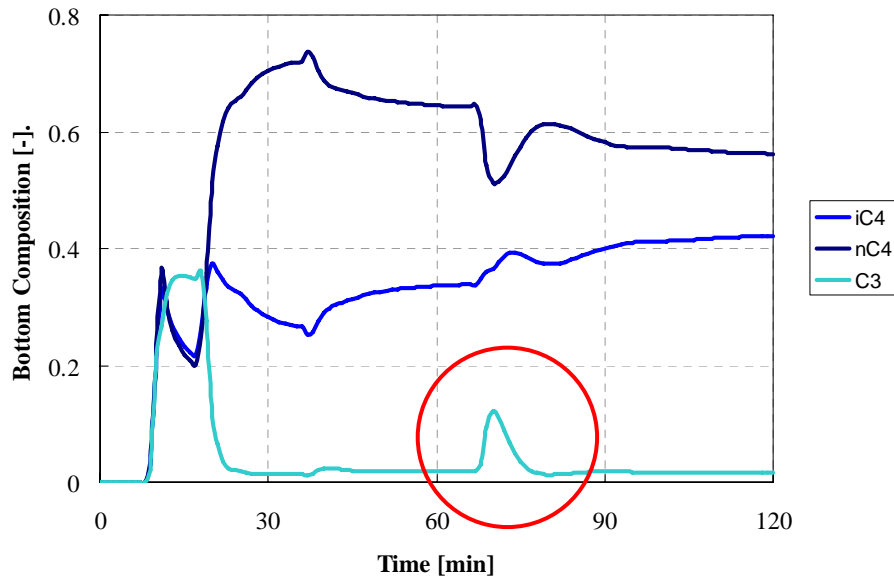

Modified control structure

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Reboiler

Conventional control structure

Modified control structure

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Bottom composition

Conventional control structure

Modified control structure

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Manipulated variables of the modified control structure

Modified control structure

Condenser

Reboiler

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Conclusions

- A detailed simulation of process transients allows:

  - **designing** new control structures;

  - **quantifying** the **performance** of start-up and shutdown procedures;

  - **assessing** the **safety issues** and **risky conditions** of start-up and shutdown procedures;

  - **training** both control-room and field operators;

  - **improving** process safety and performance.

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