PRODUCTION PLANNING

• Production Planning Issues/Goals
  - capacity planning/estimation
  - check feasibility of aggregate schedules
  - estimate delivery dates
  - translate long term goals into lower level task assignments

  e.g. how much capacity to devote to different product lines?

• Information Required
  - capacities @ all facilities
  - recipes for all products
  - yields
  - downgrading/binning data
  - inventories
  - sales projections (min & max)
  - price and cost data
Hierarchical Approach to handle disturbances/changes at each time-horizon
ASSUMPTIONS - LP & Front End Planning

1. Activities are activity levels on each route, measured as:
   - # wafers released
   - Quantity output (good die)
   ...can be alternative routes for each product type

2. Planning Horizon - multiple periods where demands, capacities, prod. rates \(\Rightarrow\) assumed constant.

3. Production Variable - quantity of product type to be released to a particular route
   Inventory Variable - inventory of product type at end of planning period
   Backorder Variable - die demand that cannot be satisfied on time at end of plan period

4. Demand - time-based die output requirements
   - May be in prioritized classes

5. Assume production is rate-based ... i.e., release quantity is distributed uniformly over period.

6. Capacity Constraints limit total workload on a machine type.

7. Steady State \(\Rightarrow\) constant rate production releases
• **GOAL:** Understand capacity limitations for various products in facilities with hundreds of machines.

• **CONVENTIONAL ASSUMPTION**
  - multiple identical machines
  - process steps assigned to unique machine type

  **VS.**

• **ALTERNATIVE CONSIDERATION**
  - may have different machine types that are all suitable for performing some operation

**Examples:**

• "**Mix & Match**" Lithography
  - expensive steppers may be able to handle the finest feature steps AND any others
  - less expensive steppers can only handle related feature steps

• Mixture of equipment technology generations
  - older tools for non-critical steps
  - newer tools for either
- **Benefits of alternative machines** - higher throughput and capacity utilization by balancing workload among alternative machine types.

- **So what's the big deal?**

  (A) Conventional LP formulation
  - define multiple possible routes/products
  - allocate capacity across these alternatives

  (B) Now add in alternative equipment types
  - 1 step product
    4 alt. eq. types
    \[ \text{4 routes; } \Rightarrow \text{4 alloc. views} \]
  - 2 step product
    using step twice
    \[ \text{16 routes; } \Rightarrow \text{16 alloc. views.} \]

  - With Re-entrant flows
    \[ \Rightarrow \text{Combinatorial explosion} \]
    E.g. litho - 20 reactions

- **Return to goal:**

  Set company-wide demands to achieve capacity feasibility
  \[ \Rightarrow \text{don't actually care about detailed routes!} \]
  ... use this to simplify the LP problem form.
• BASIC IDEAS / FORMULATIONS

1. "STEP-SEPARATED FORMULATION"
   - replace variables for ROUTES with variables for ACTIVITY at operations
   - ∀ product, oper → allocation vars ≤ alternative machines

2. "WORKLOAD ALLOCATION FORMULATION"
   - Assume process times identical across all alternative types, or proportional across all operations
     - e.g. type 2 machines are 3x slower than type 1 machines for any & all ops that both can perform
   - THEN
     - ∀ product → total workload
     - ... ignore workload for individual steps

3. "DIRECT PRODUCT MIX FORMULATION"
   - No allocation vars: just vars for the production of each product
   - => same size as LP conventional planning formulation w/o alternative resources