Fig 2-12 Chemical Operations – Original Situation

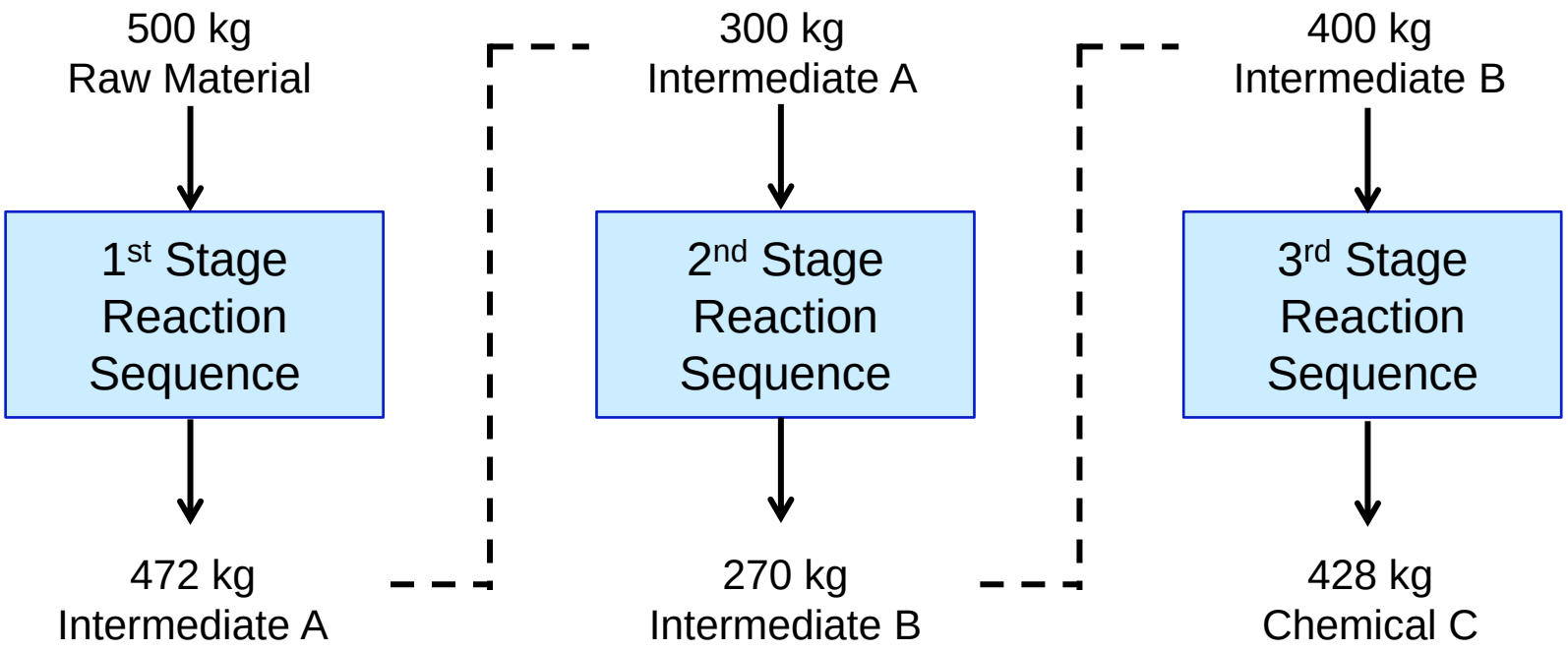

Fig 2-13 Chemical Operations – Original Summary & Objective

- Typical chemical process producing Chemical C at the rate of 55 tonnes per year
- Batch size 428 kg
- Producing at rate of 128 batches per year or 2.56 batches per week
- Lead Time 39 days (including 8 days QC clearance)
- Three stage manufacturing process –
  - 500 kg of raw material to 472 kg of Intermediate A
  - 300 kg of Intermediate A to 270 kg of Intermediate B
  - 400 kg of Intermediate B to 428 kg of Chemical C
- Complex batch tracking through intermediate stages
- Objective – to double output to approx 100 tonnes per year from same equipment

Fig 2-14 Chemical Operations – Blue Sky Vision

- Can we have “constant” batch size through total process? (Batch to batch oneness)
  - Would simplify batch tracking
  - Would like batch size of 425 kg of Chemical C to use multiple 25 kg drums
  - Thus would require 397 kg of Intermediate B, which would need -
    441 kg of Intermediate A, which would need -
    467 kg of raw material
  - Would therefore have problem with capacity on second stage
- Can we produce 1 batch per shift, ie 2 batches per day?
  - Would provide more than the output required
  - Would give regular ‘drumbeat’
  - Would simplify planning and scheduling
  - Would simplify plant management
  - Would require a maximum cycle time of 7 hours (one shift)

Fig 2-15 Blue Sky Vision – 1st Stage – RM to Intermediate A

Prepare and charge reaction vessel	3.5 hrs
Reaction time	7.75 hrs
Filter	8 hrs
Dry	4 hrs
Cool	overnight

- Reaction vessel required 3.5 + 7.75 = 11.25 hrs
  - Smaller batch size will reduce reaction time by 30 mins
  - Thus need another reaction vessel to get 1 batch per shift
  - This is available
- Filter line dependent on number of filters
  - Thus two extra filters will bring time down to 3 hrs – cost £6k
- Drying and cooling need to be done in 4 hrs to achieve drumbeat
  - Can be done by operating at higher vacuum – equipment available
- Thus can produce at the rate of 1 batch per shift

Fig 2-16 Blue Sky Vision – 2nd Stage – Inter A to Inter B

- Prepare and charge reaction vessel 5 hrs
- Reaction time 21 hrs
- Centrifuge 4.5 hrs
- Dry 20 hrs

- Reaction time is for 300 kg of Intermediate A
  - But we now have 441 kg from previous process – thus split into two half batches
  - Each half batch would take 18 hrs to process – thus vessel up time is 18 + 5 = 23 hrs
  - Thus to get two batches per day, need to run four half batches in 24 hrs
  - Thus need four 500 gal reaction vessels – only have three – extra vessel cost £500k
  - Also need to run three shifts in this area – requires an extra 6 people
  - Also need slurry tank for vessel discharging – cost £100k

- Centrifuge OK

- Drying needs to be done within 12 hr cycle
  - Can be done by combination of higher vacuum, temperature, etc – cost £100k

- Thus can produce at the rate of 2 batches per day

Fig 2-17 Blue Sky Vision – 3rd Stage – Inter B to Chemical C

- Filter, charge and reaction 7.5 hrs
- Chill and filter 10 hrs
- Dry 48 hrs
- Micronise 18 hrs

- Introduce “One Day” process techniques already developed
  - One shift for filter, charge and reaction
  - One shift for chill and filter

- Most of drying time (over 4 hrs) is actually deodorising
  - Using second Nauta dryer (available) would allow 2 batches per day
  - Would need pumps, transfer piping, software mods, etc – cost £50k

- Microniser processes 25 kg per hr at present
  - Thus need another microniser (50 kg / hr capacity) together with hopper and air compressor – cost £300k

- Thus can produce at the rate of 2 batches per day

Fig 2-18 Blue Sky Vision – Batch Scheduling

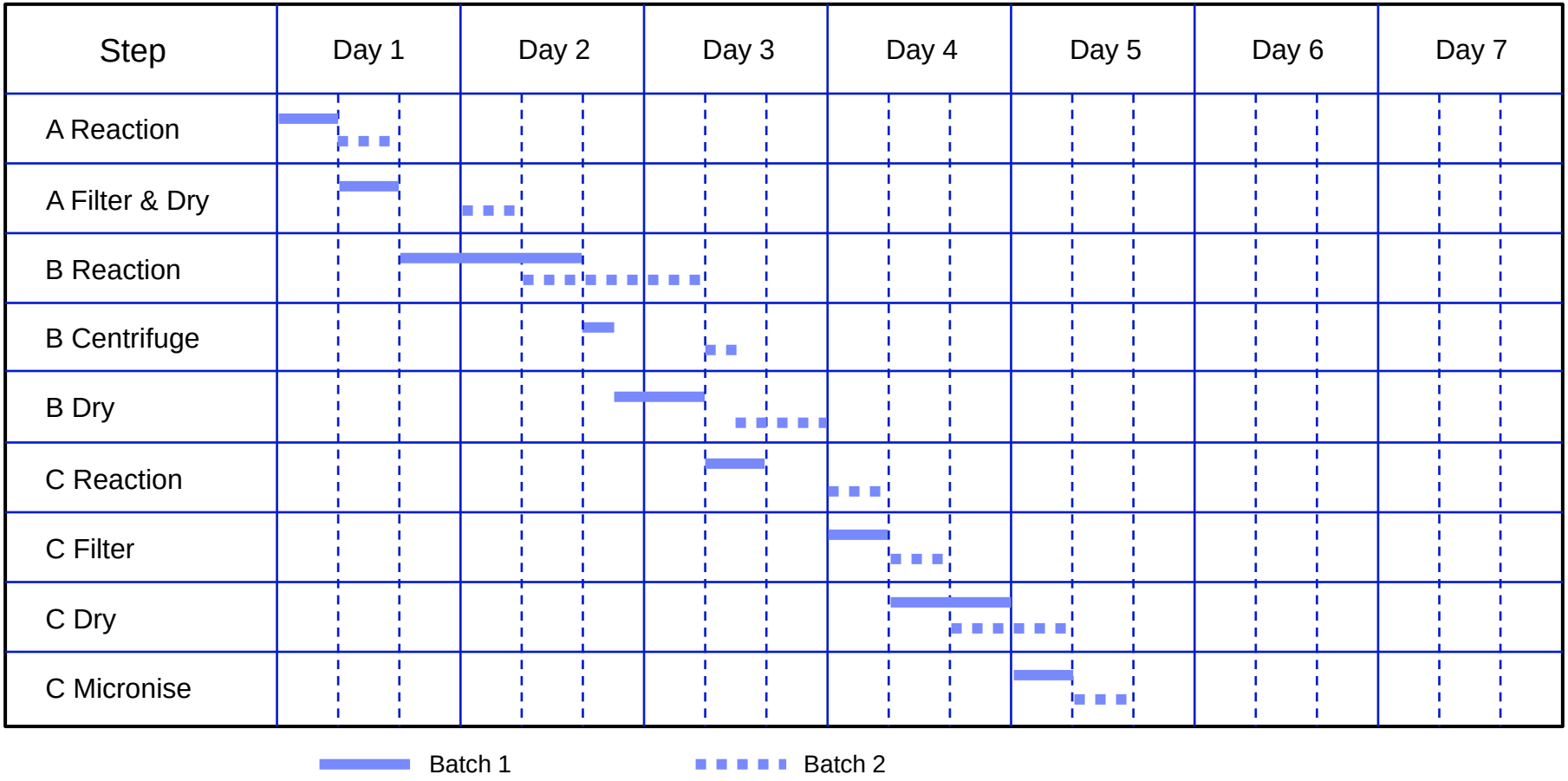

Fig 2-19 Blue Sky Vision – Final Analysis

- Can have “constant” batch size through total process
- Can produce 2 batches per day
  - Which is 850 kg per day or 212.5 tonnes per year
- Total extra spend
  - Capital £1056k
  - Revenue £270k (2 crews plus support)
- Lead time 5 days + 8 days QC clearance
  - Assuming all other QC tests done in parallel
- Thus lead time has reduced from 39 days to 13 days
- Work in progress is £1.5 million
  - Thus savings in work in progress would be £1 million
  - Since work in progress is proportional to lead time

Fig 2-20 Chemical Operations – Practical Vision

- First Stage – Raw Material to Intermediate A
  - Don't need second reaction vessel
  - No problem doing 1 batch per day
- Second Stage – Intermediate A to Intermediate B
  - Don't need fourth 500 gal reaction vessel – only use two
  - Still need slurry tank – cost £100k
  - Automate last part of reaction sequence to avoid third shift – cost £100k
  - Drying needs to be done in 16 hr cycle – still need higher vacuum etc – cost £100k
  - No problem doing 1 batch per day
- Third Stage – Intermediate B to Chemical C
  - Reaction and filter processes already established for 1 batch per day
  - Drying for 1 batch per day is OK
  - Upgrade microniser to achieve 14 hr cycle time
  - No problem doing 1 batch per day

Fig 2-21 Practical Vision – Batch Scheduling

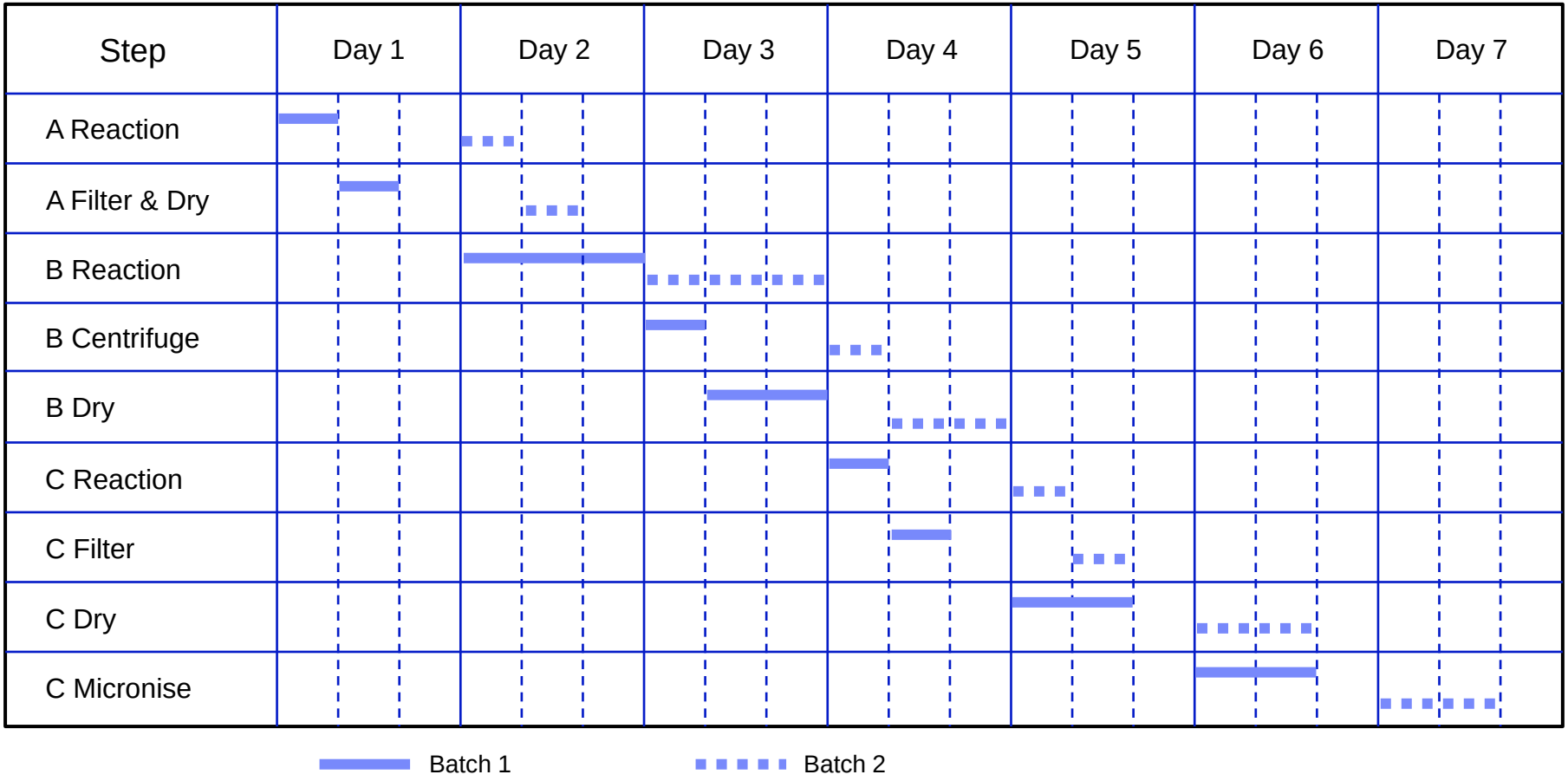

Fig 2-22 Practical Vision – Final Analysis

- Can have “constant” batch size through total process
- Can produce 1 batch per day
  - Which is 425 kg per day or 106 tonnes per year
- Total extra spend
  - Capital £300k
  - Revenue nil – no extra people required
- Lead time 6 days + 8 days QC clearance
  - Assuming all other QC tests done in parallel
- Thus lead time has reduced from 39 days to 14 days
- Work in progress is £1.5 million
  - Thus savings in work in progress would be almost £1 million
  - Since work in progress is proportional to lead time