



Container strategy and AMR investment

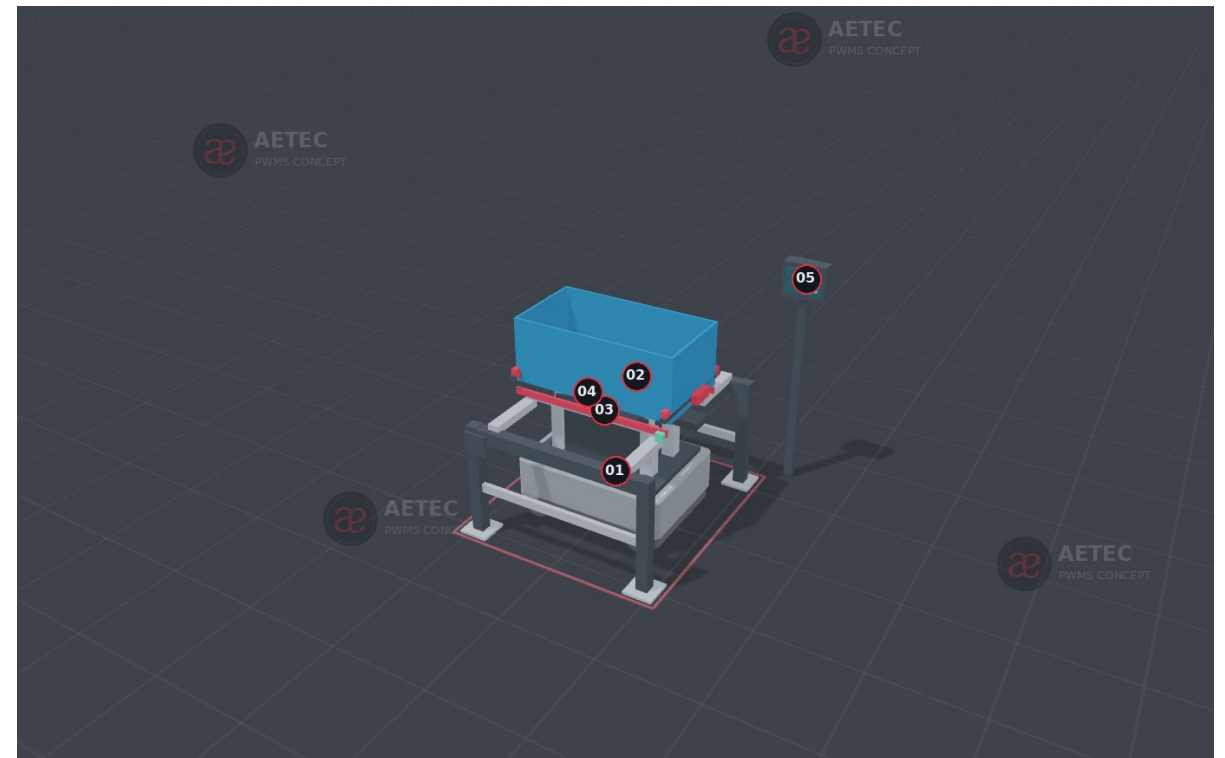
One common box. Five handling options.

35 kg raw part

17 process stations

Full system cost comparison

Prepared for Marshawn and the PWMS team
Lim Yee Wei, Aetec

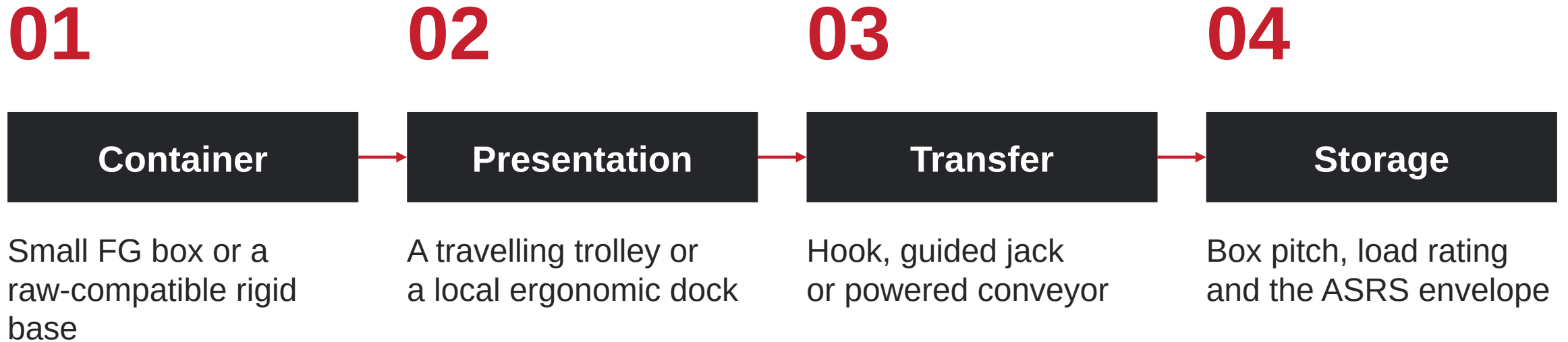


MiR250 box-jack concept. Geometry to be redesigned for the unified container.

Discussion study. Equipment selection, container dimensions and site layout remain open.



Four design decisions change the whole system



The same box can simplify tracking while increasing storage pitch.

PWMS must decide how much capital, floor area and process change each benefit justifies.



Confirmed facts and open assumptions

Item	Current basis	Status
Raw part mass	35 kg	Customer instruction; supersedes old mass
Process stations	17, including CMM Root at 12	Verified against customer mapping
Final inspection	Station 15; then 16 and 17	Box introduction after PASS is current basis
FG box fit	Raw part does not fit current FG box	Customer instruction
Unified box envelope	1,400 × 700 × 450 mm external	Illustrative only; internal fit unverified
Volume / operating time	40 parts/day; 24 hours/day	Prior 35–40/day basis; confirm current demand

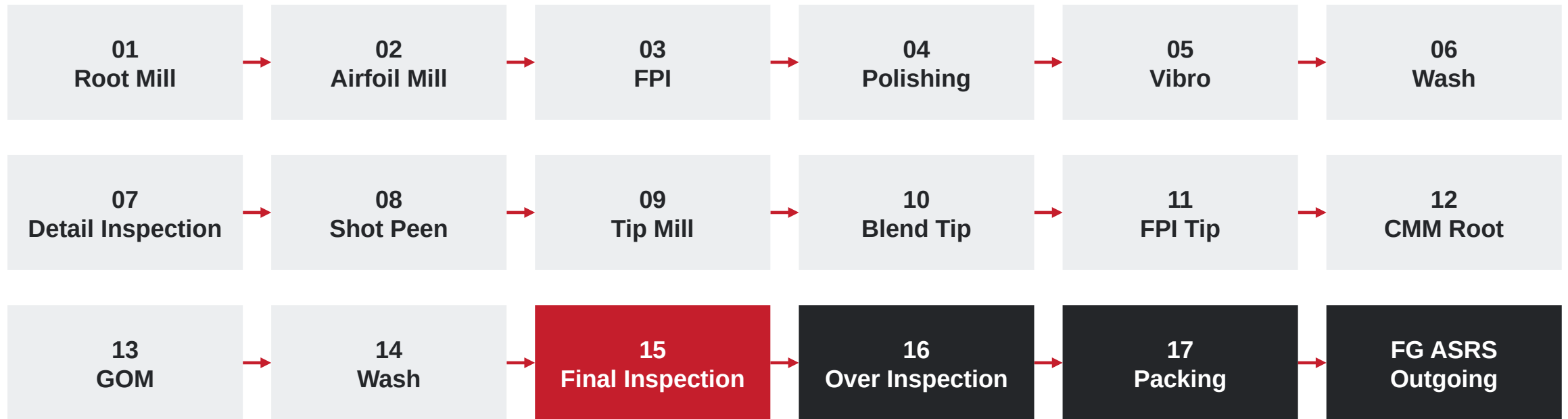
Incoming/outgoing are separate nodes. Nineteen nodes does not mean nineteen production processes.



The customer route contains 17 processes

Incoming store

01–06



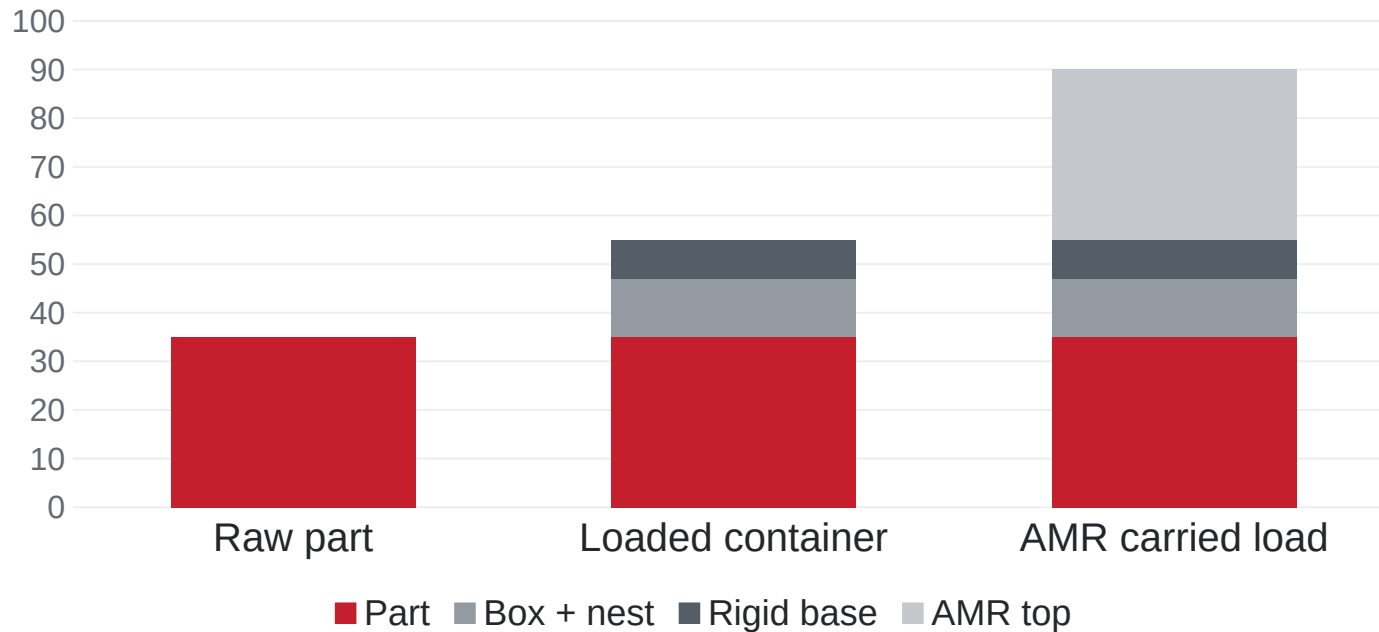
Continue 06 to 07, then 12 to 13

Current trolley route: incoming through process 15



35 kg defines the handling boundary

Load allowance, kg



55 kg

35 part + 12 box/nest + 8 base
Historical ASRS basis: 50 kg

90 kg

55 loaded container + 35 top
Base capacity alone does not
approve the application.

UR30 raw pick excluded: the 35 kg part leaves no payload for a gripper. Assisted loading remains.



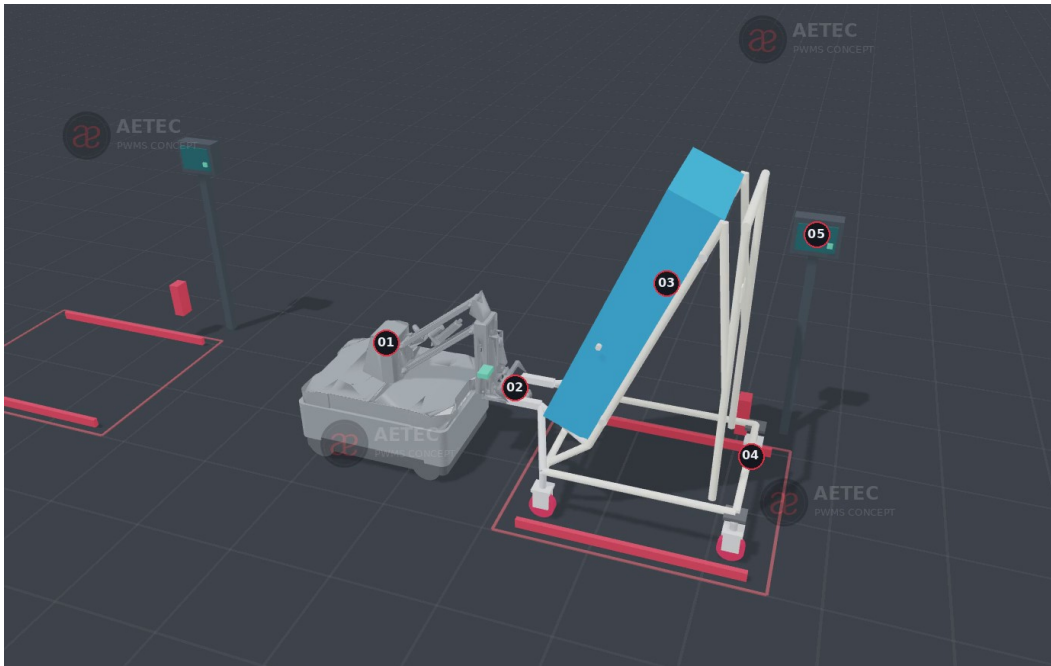
Five architectures, with the same comparison scope

Option	What moves	What stays at the station
A / Retain	Existing trolley by Hook; FG box later	Existing handling arrangement
B / Adapt all	Common box on a modified trolley	Dock supports and workstation interfaces
C / Jack	Common box with structural skid	Fixed docks + new ergonomic lifts
D / Conveyor	Common box across powered rollers	Powered docks + ergonomic lifts
E / Hybrid	Common box with structural skid	Selected modified ergonomic trolleys

All options retain assisted part loading. Transport automation does not automatically load the machines.



A / Existing trolley with Hook



MOST SUITABLE

Incoming through process 15

Retains the existing ergonomic trolley and requires the least carrier change.

Repacking and trolley queues remain.
Finished goods use a separate conveyor AMR route.



S\$4.32m

Full scope CAPEX
including ASRS

Engineering concept only. Geometry and cycle time require application validation.



B / Common box on every modified trolley



MOST SUITABLE

Manual routes where presentation matters

A common box ID follows the part. Existing trolley height remains available.

All 200 circulating trolleys need conversion. This gives little WIP floor saving.

Locate box

Lock skid

Tow trolley

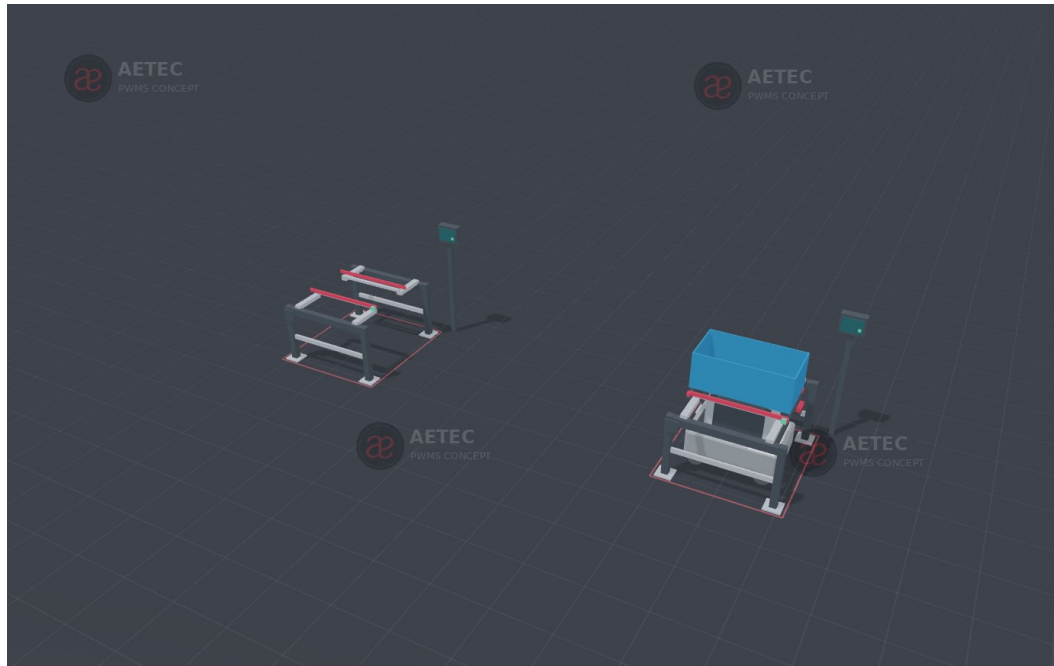
S\$5.81m

Full scope CAPEX
including ASRS

Concept illustration. Box, lock, reach and trolley structure require qualification.



C / MiR250 box jack between fixed docks



MOST SUITABLE

Point-to-point buffers and stable docks

Only the box and rigid base travel. Both docking frames stay at the stations.

Custom guided lift and retention need validation. New ergonomic lift stations add cost.



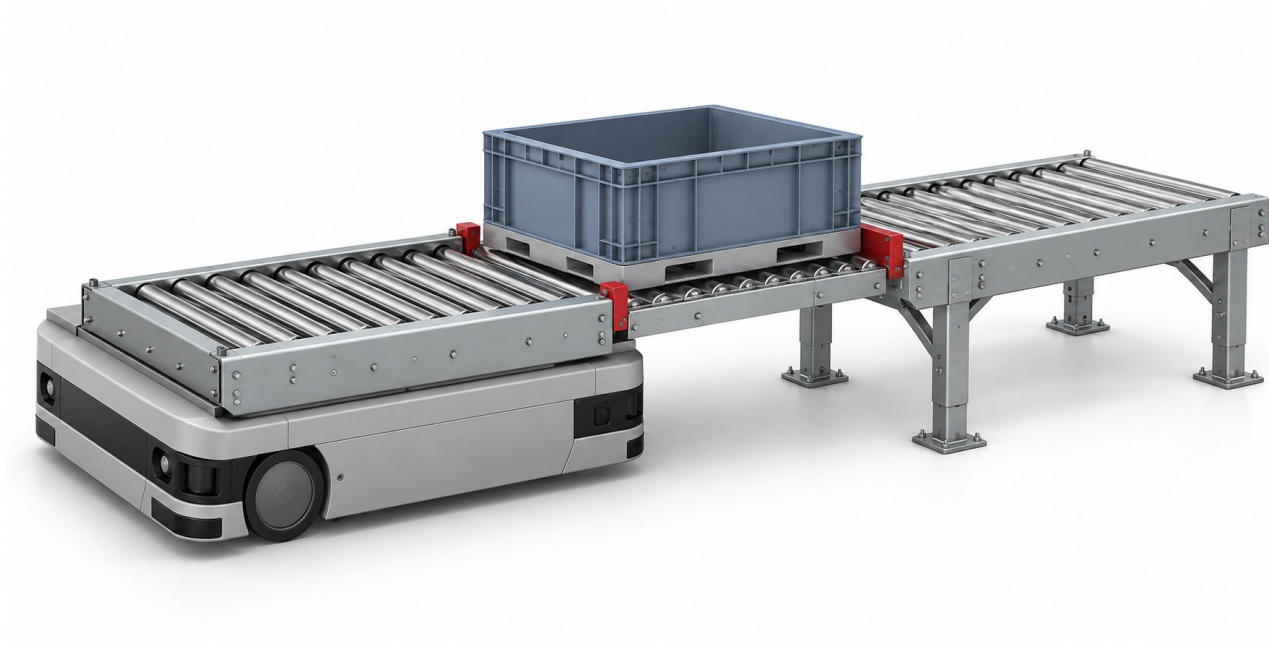
S\$6.07m

Full scope CAPEX
including ASRS

Rigid base required. Unsupported corrugated PP cannot be the jack lifting surface.



D / Conveyor AMR with powered docks



MOST SUITABLE

Repeat transfer lanes and ASRS ports

Automated handoffs suit repeatable transfer planes and conveyor interfaces.

Powered docks, sensors and guarding increase investment. Heights must match.



S\$6.59m

Full scope CAPEX including ASRS

Engineering concept only. Geometry and cycle time require application validation.



E / The box travels, ergonomic docks stay local

Concept illustration. Robot, load and docking geometry remain provisional.



STAYS AT STATION

34 local trolley docks
retain presentation height

MOVES WITH AMR

Common box + rigid base
5 jack AMRs in this scenario

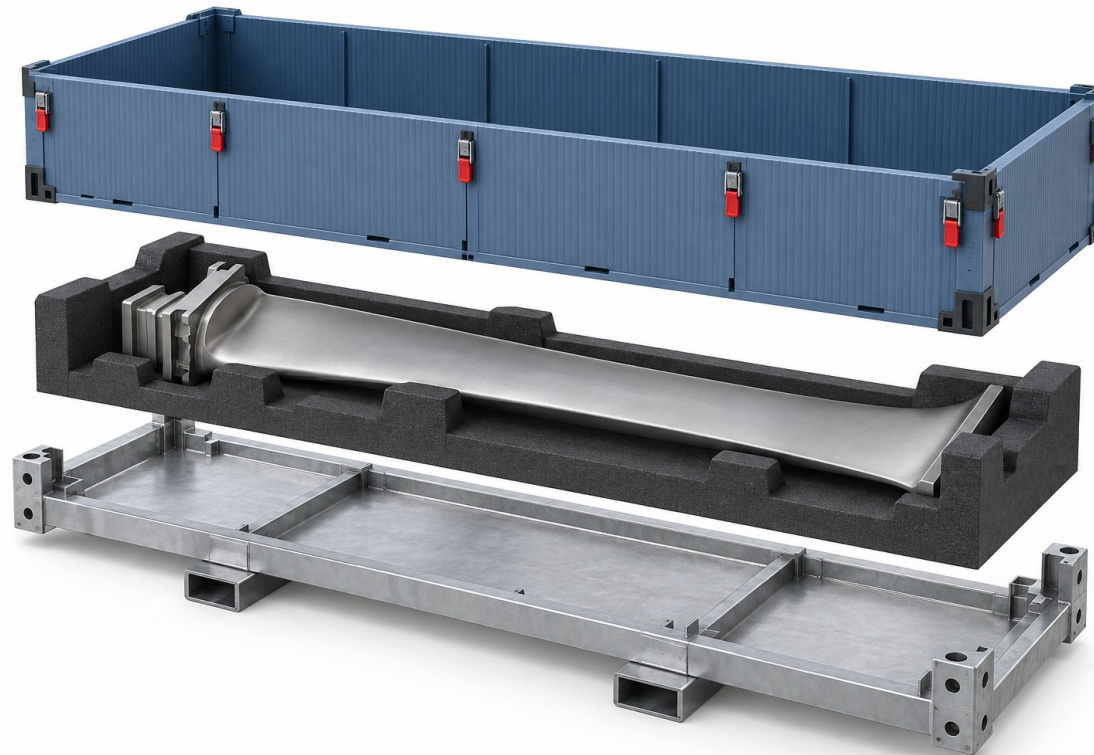
FULL SCOPE CAPEX

S\$5.27m

Best pilot candidate for manual stations. Existing trolley structures, locks and lift access must qualify.



A common box needs a structural load path



PP enclosure

S\$120

Replaceable sleeve. Confirm cleaning and chemical compatibility.

Nest + identity

S\$90

Protect surfaces and maintain part / container association.

Rigid base / skid

S\$250

Carries the load and provides qualified jack / roller contact.

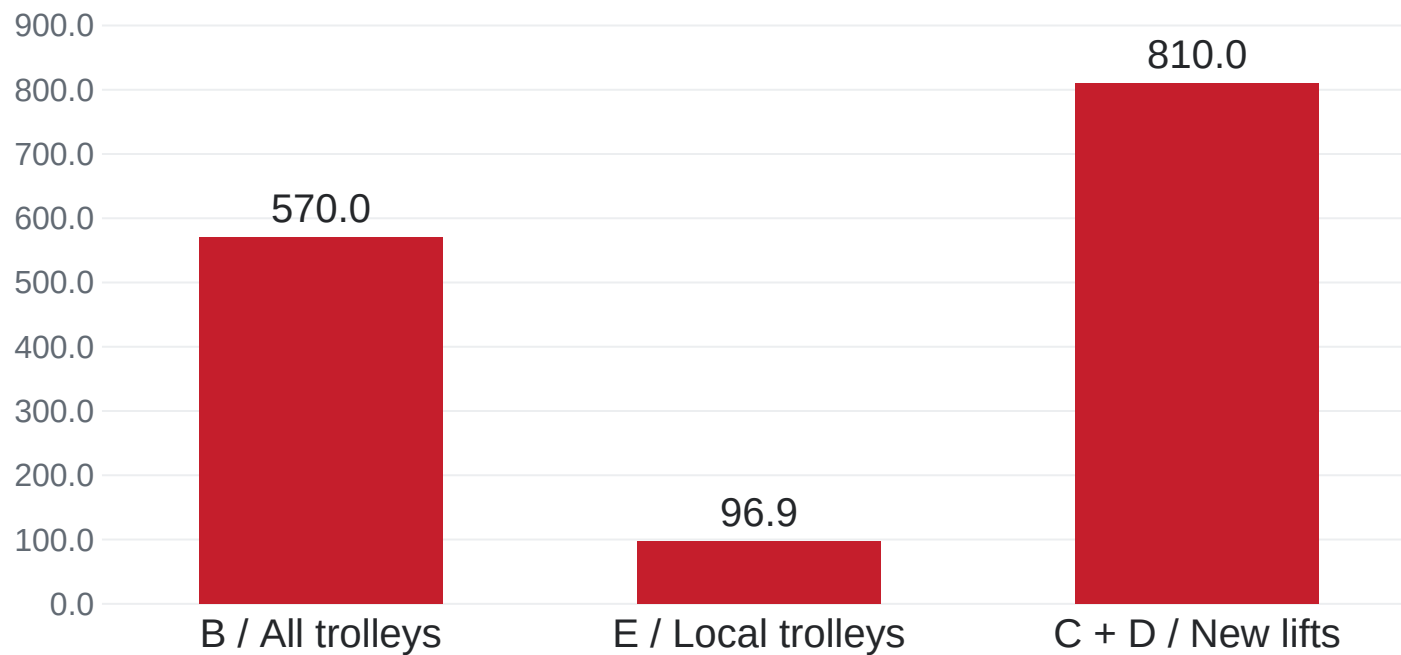
Concept illustration. Container size and protective nest require validation.

S\$460 per box set. 1,210 sets in the scenario, plus S\$55,000 for design and prototype trials.



Ergonomics changes the station investment

Presentation hardware only, S\$ thousand



200 vs 34

Modified trolleys
S\$2,500 conversion + S\$350
review each

18 × S\$28k

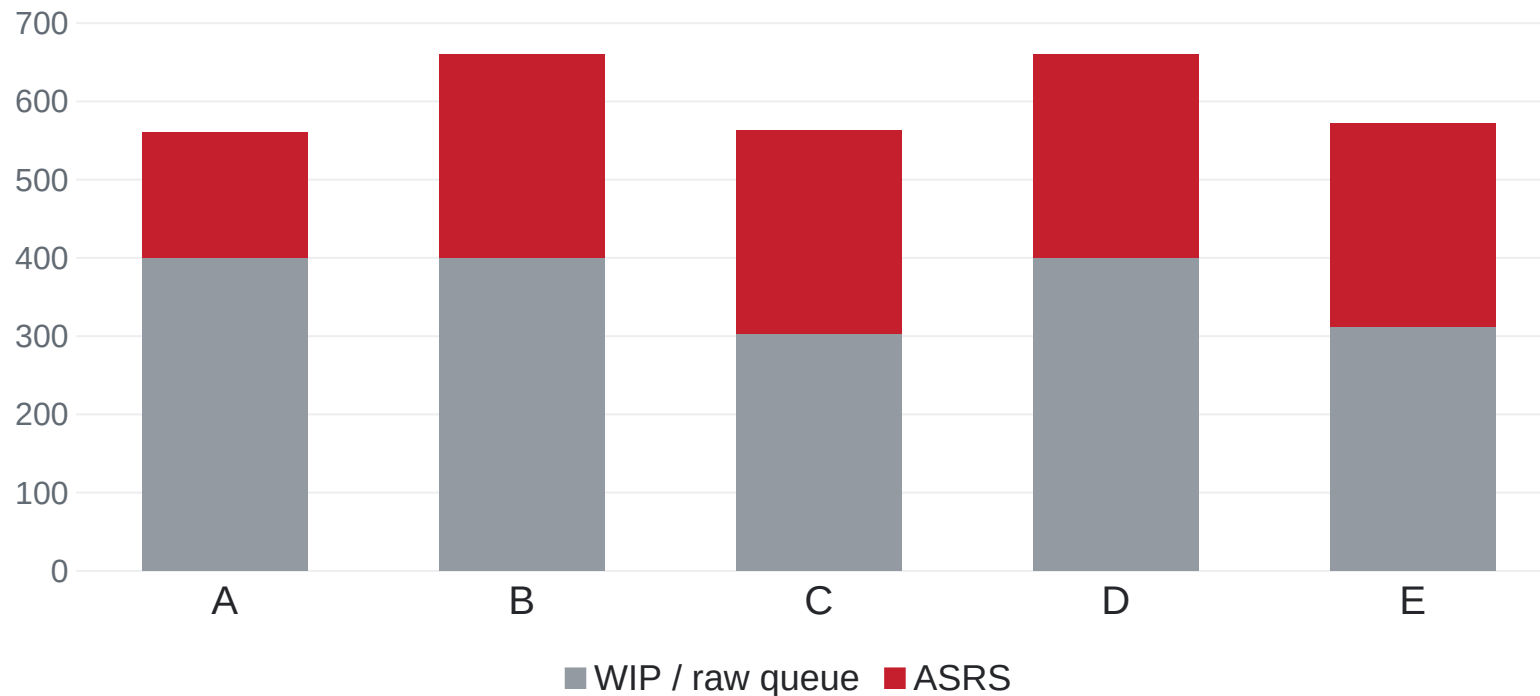
Part manipulators: S\$504k in
every option. Existing reusable
units can reduce this.

The model retains assisted part loading. Removing lift/tilt scope requires an accepted operator trial.



Queue savings can be offset by the larger ASRS

Planning envelope, m²



A 560 m²

E 572 m²

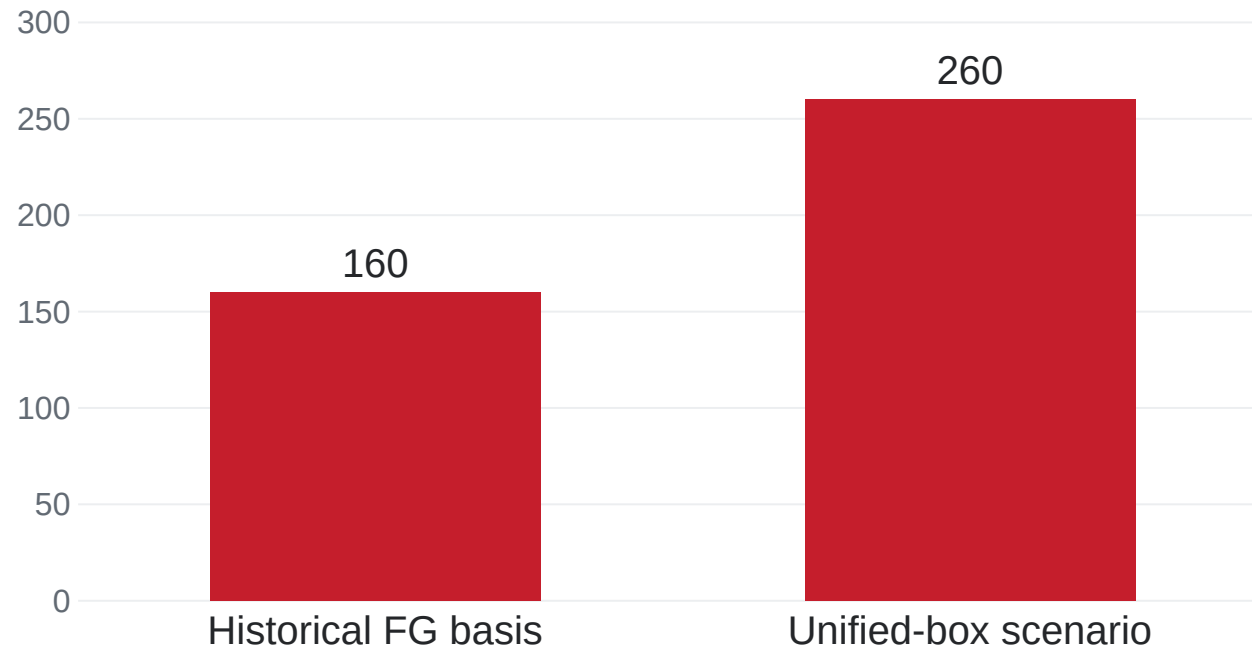
E queue: -88 m²
E ASRS: +100 m²
Net: +12 m² versus A

Modelled areas are comparison envelopes, not a verified site layout or a rental saving.



A larger box reduces levels and widens the store

Equipment envelope, m²



12 levels

21 bays
20.00 × 8.00 m
50 kg load basis

9 levels

28 bays
26.86 × 9.68 m
55 kg load scenario

Same target: 1,000 cells
4 storage faces, 5.04 m usable height
900 occupied cells at 90%

1,400 × 700 × 450 mm is provisional. Actual box dimensions and heavier-load design need reconciliation.



Fleet size follows demand and transfer time

876

missions / day

3.33

travel min / mission

842

usable min / robot / day

A / B

4 Hook + 2 conveyor AMRs

C / D / E

5 AMRs

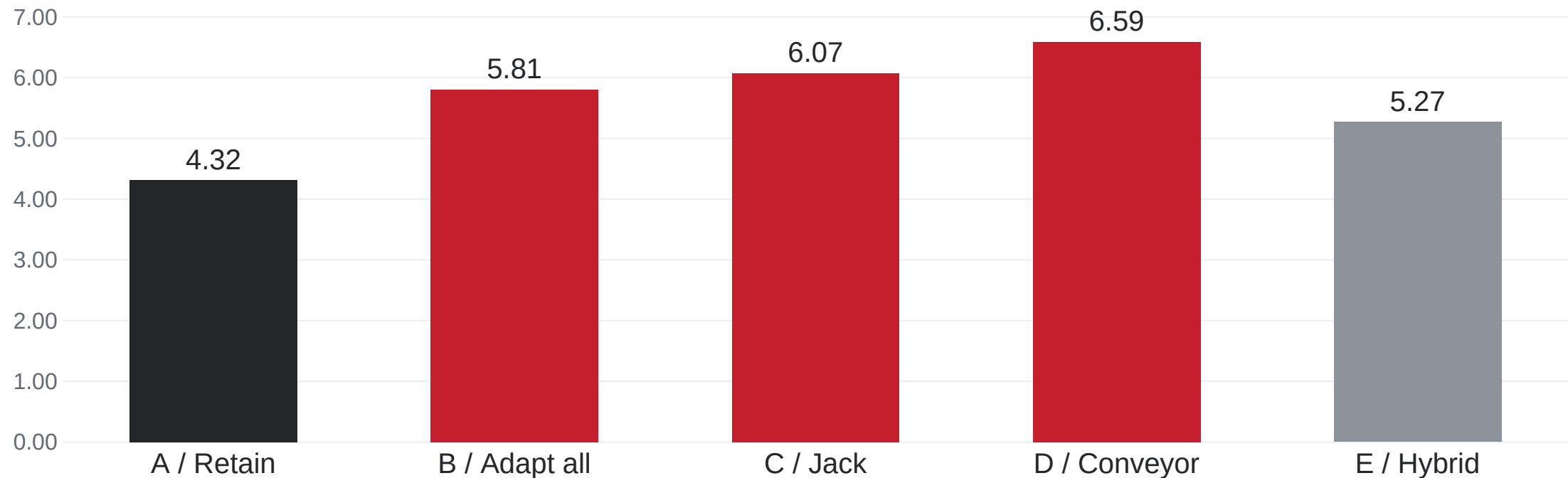
Handoff allowance: Hook 1.5 min, jack 0.9 min, conveyor 0.7 min

Capacity screen only. Charging, peak arrivals, congestion and failures need simulation. No N+1 spare included.



A has the lowest initial investment

Full-scope CAPEX, S\$ million



Includes ASRS, assisted handling and 15% contingency. Historical anchors + engineering allowances, not quotes.



Where the investment goes

Cost group	A	B	C	D	E
Handling	504.0	504.0	504.0	504.0	504.0
Containers	199.4	1181.6	641.6	641.6	733.4
AMR	724.7	724.7	722.7	792.7	722.7
Stations	370.0	370.0	1145.0	1525.0	355.0
Integration	375.0	375.0	375.0	375.0	375.0
ASRS	1580.0	1892.7	1892.7	1892.7	1892.7
Contingency	563.0	757.2	792.2	859.7	687.4
Total	4316.1	5805.2	6073.2	6590.7	5270.3

The next slides show quantities × rates, component subtotals and conditional savings.



How the discussion budget is calculated

Quantity × unit allowance

Direct subtotal + 15% development reserve = budget

Input type	Meaning	Confirmation needed
H / Historical	Prior budget price or unit rate	Updated supplier scope and validity
E / Engineering	New allowance or scaled historical rate	Design, quantities and supplier quotation
Customer budget	Same scope across all five options	Agreed scope, quantities and allowances

Unit allowances cover the proposed scope. Current supplier quotes and engineering hours remain to be confirmed.



The quantities behind the budget

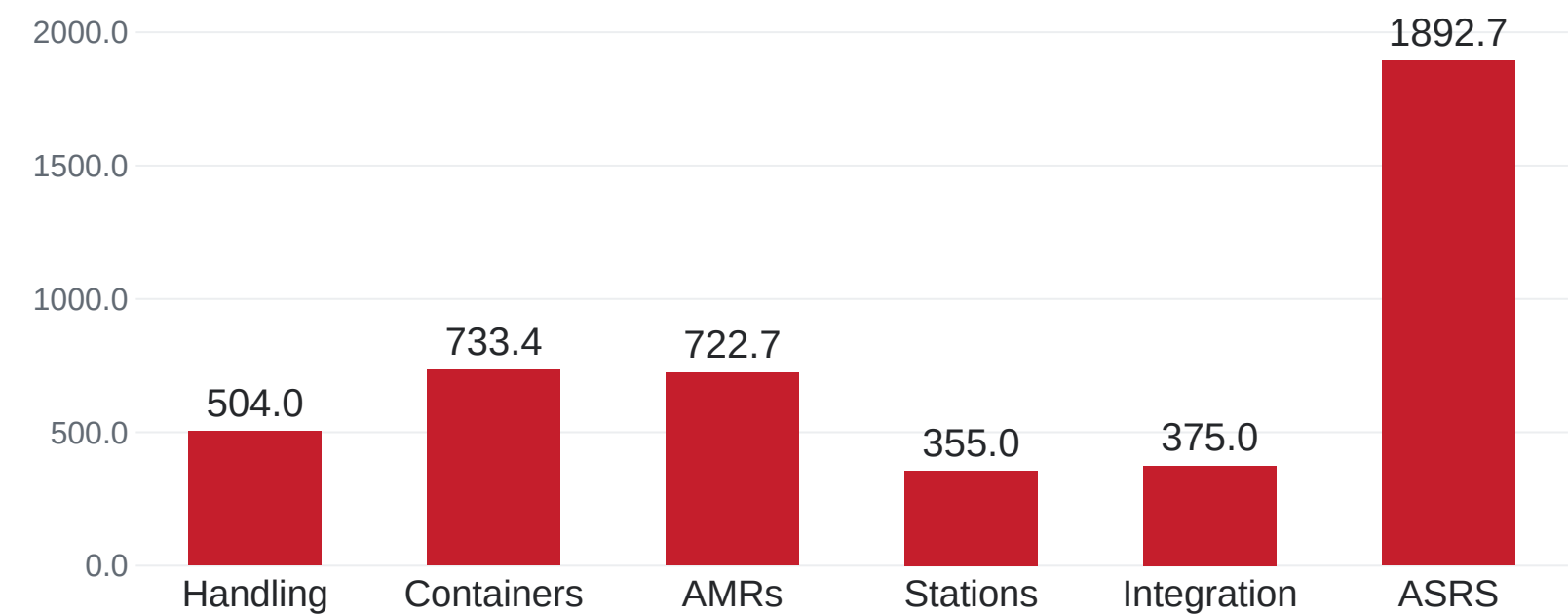
Quantity	Calculation in this scenario	Result
Circulating raw + WIP	$40/\text{day} \times (2 \text{ raw-buffer days} + 3 \text{ WIP days})$	200 loads
Occupied ASRS positions	$1,000 \text{ cells} \times 90\% \text{ working occupancy}$	900 loads
Common box sets	$(900 \text{ stored} + 200 \text{ circulating}) \times 1.10 \text{ reserve}$	1,210 sets
FG boxes in A	$900 \text{ stored} \times 1.10 \text{ reserve}$	990 boxes
Dock positions	$17 \text{ process groups} \times 2 + 4 \text{ other interfaces}$	38 docks
Existing / local trolleys	$200 \text{ inventory} / 17 \text{ groups} \times 2 \text{ local docks in E}$	200 / 34
Part-assistance positions	$17 \text{ process groups} + 1 \text{ incoming point}$	18 positions

Planning quantities only. One process group may contain several machines. PWMS must confirm coverage.



Option E budget, from components to total

Direct allowances, S\$ thousand



S\$4,582,830

Direct subtotal

+ S\$687,424

15% × direct subtotal

S\$5,270,254

Full-scope budget

Contingency is applied once. Example shows E; the same calculation applies to A–D.



Container costs, including the complete box pool

Item	Qty A / B–E	Unit SGD	A subtotal	B–E subtotal
Design, prototypes and trials	1 / 1	10,000 / 55,000	10,000	55,000
FG box / common PP sleeve	990 / 1,210	60 / 120	59,400	145,200
Rigid load-bearing base	0 / 1,210	250	0	302,500
Protective nest + identification	0 / 1,210	90	0	108,900
Box pool subtotal			69,400	611,600

S\$460 per common set

120 sleeve + 250 rigid base + 90 nest / identity



Trolley changes explain a major part of the difference

Trolley work	Unit SGD	A	B	C / D	E
Hook-only interface	300	200 × 300	0	0	0
Universal box-dock conversion	2,500	0	200 × 2,500	0	34 × 2,500
Inspection / repair allowance	350	200 × 350	200 × 350	0	34 × 350
Retire / relocate unused units	150	0	0	200 × 150	166 × 150
Trolley subtotal, SGD		130,000	570,000	30,000	121,800
Plus box pool, SGD		69,400	611,600	611,600	611,600
Containers group, SGD		199,400	1,181,600	641,600	733,400

E keeps 34 ergonomic trolley docks local. Removing the travelling trolley does not remove assisted part loading.



AMR budget, with quantities and unit allowances

Fleet item	Unit SGD	A / B qty	C / E qty	D qty
Hook hardware, historical rate	79,000	4	0	0
MiR250 + jack module	95,000 + 24,000	0	5	0
MiR250 + conveyor module	95,000 + 38,000	2	0	5
Chargers	8,400	3	3	3
Fleet licence allowance	27,500	1	1	1
Logistics / commissioning per robot	15,000	6	5	5
AMR group subtotal, SGD		724,700	722,700	792,700

Example C/E: $5 \times 119,000 + 3 \times 8,400 + 27,500 + 5 \times 15,000 = S\$722,700$.



Docking and ergonomic stations are separate costs

Station item	Unit SGD	A / B qty	C qty	D qty	E qty
Interface qualification	20k / 45k / 65k	1 × 20k	1 × 45k	1 × 45k	1 × 65k
Station gateway	7,000	17	17	17	17
Passive / restrained dock	4,500	32	38	0	38
Powered transfer dock	14,500	6	0	38	0
Ergonomic lift / tilt upgrade	45,000	0	18	18	0
Stations subtotal, SGD		370,000	1,145,000	1,525,000	355,000

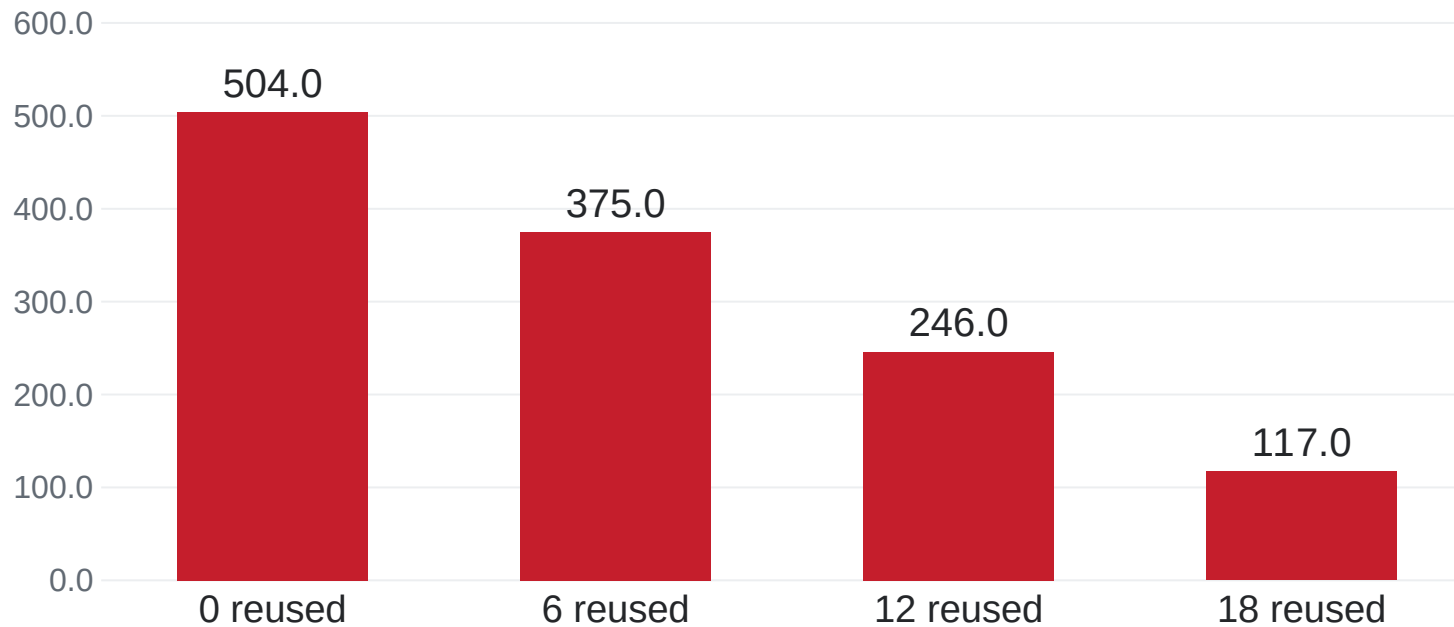
C / D: $18 \times S\$45,000 = S\$810,000$

E uses qualified local trolley docks instead. Powered docks alone do not guarantee ergonomic reach or height.



Qualified manipulator reuse can reduce the budget

Handling allowance before contingency, S\$ thousand



S\$21,500

Direct saving per approved reuse

28,000 new – 6,500 review

S\$24,725

Budget reduction per unit including 15% reserve

A review allowance excludes major repairs, new grippers and alterations. Reuse depends on load, reach and duty.



Integration budget and the work it covers

Work package	Qty × allowance	Deliverable / cost discussion
Wi-Fi survey and upgrades	1 × S\$55,000	Coverage survey, access-point work and acceptance
Part / box traceability	1 × S\$70,000	ID association, event history and recovery records
Route and dispatch model	1 × S\$60,000	Station routing, mission rules and dispatch logic
PWMS / machine / ASRS interfaces	1 × S\$60,000	Agreed data and handshake endpoints
Orchestration validation	1 × S\$30,000	Normal, blocked, failed and recovery scenarios
Rollout, FAT, SAT and training	1 × S\$100,000	Transport-system acceptance and handover
Integration group subtotal	S\$375,000	Applies once to each complete option

S\$70k + S\$60k explains the existing S\$130k software allowance. It is not an additional platform charge.



ASRS breakdown, mechanical equipment

Equipment	A / FG SGD	B–E calculation	B–E SGD
Design and load validation	125,000	$125,000 \times 1.20$	150,000
Racks	215,000	$215,000 \times 1.62503$	349,381
Two cranes	370,000	$2 \times 185,000 \times 1.10$	407,000
Two guarded I/O ports	100,000	$2 \times 50,000 \times 1.15$	115,000
ASRS carriers + 3% spare	175,000	$175,000 \times 1.30$	227,500
Mechanical subtotal	985,000		1,248,881

Scaling factors are budget assumptions. Crane capacity, rack structure and carrier dimensions need supplier design.



ASRS breakdown, controls and implementation

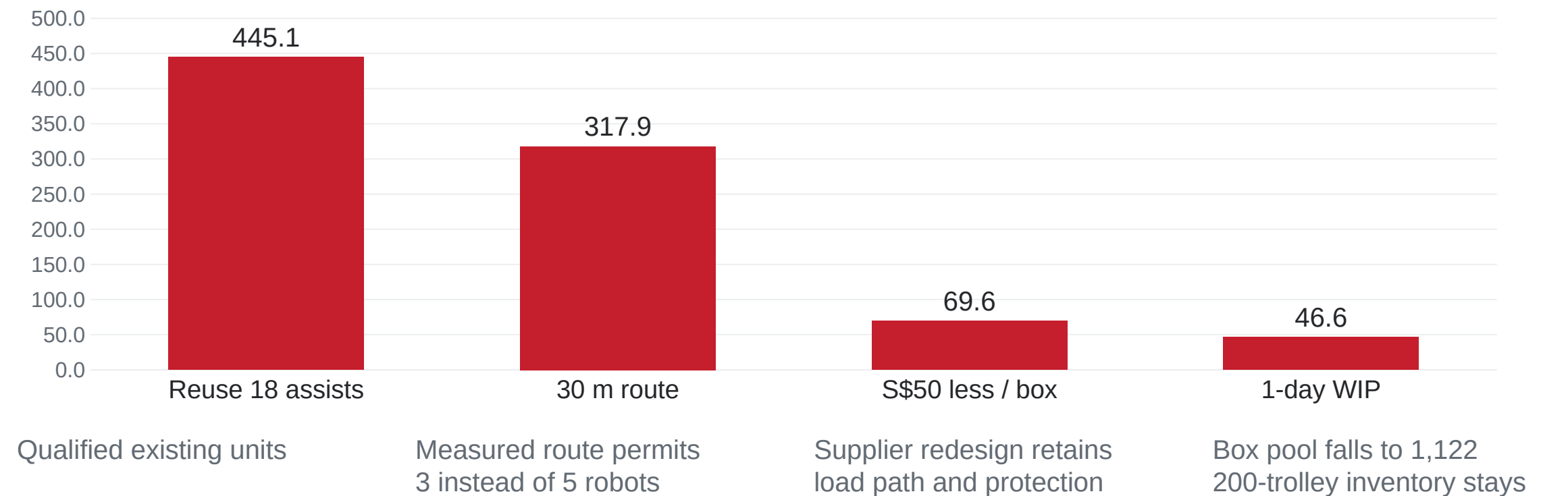
Work package	A / FG SGD	B–E calculation	B–E SGD
PLC and safety controls	160,000	$1 \times 160,000$	160,000
Warehouse control system (WCS)	80,000	$1 \times 80,000$	80,000
Transport API	45,000	$1 \times 45,000$	45,000
Freight, rigging and installation	115,000	$115,000 \times \sqrt{1.62503}$	146,598
FAT, SAT, validation and training	115,000	$115,000 \times 1.15$	132,250
Initial spares and warranty	80,000	$1 \times 80,000$	80,000
Controls / implementation subtotal	595,000		643,848
Total ASRS incl. mechanical	1,580,000		1,892,730

ASRS total is before the common 15% reserve. Store-side acceptance is separate from transport-system acceptance.



Cost reduction opportunities for Option E

Independent scenarios versus E baseline, including 15% reserve, S\$ thousand

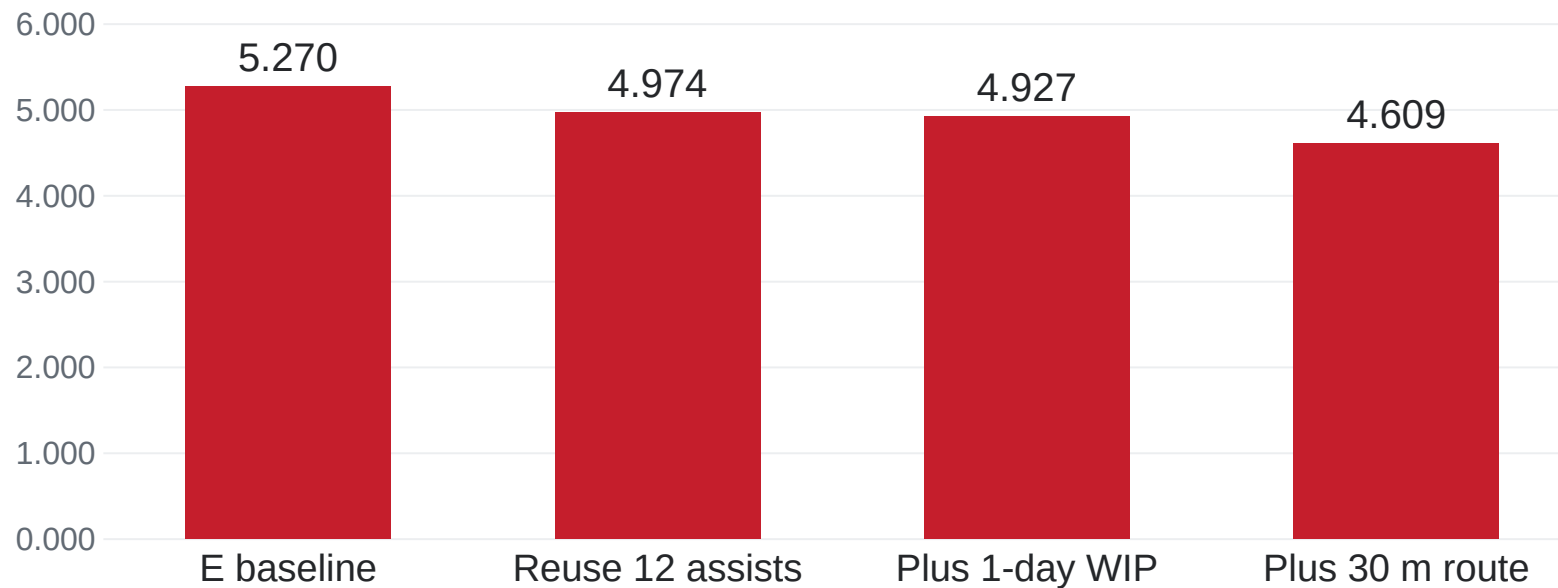


These scenarios are conditional. Combined changes must be recalculated together, especially fleet and charging.



A combined scenario gives a discussion target

Full-scope budget, S\$ million



S\$4.609m

Conditional target
S\$661,112 below baseline

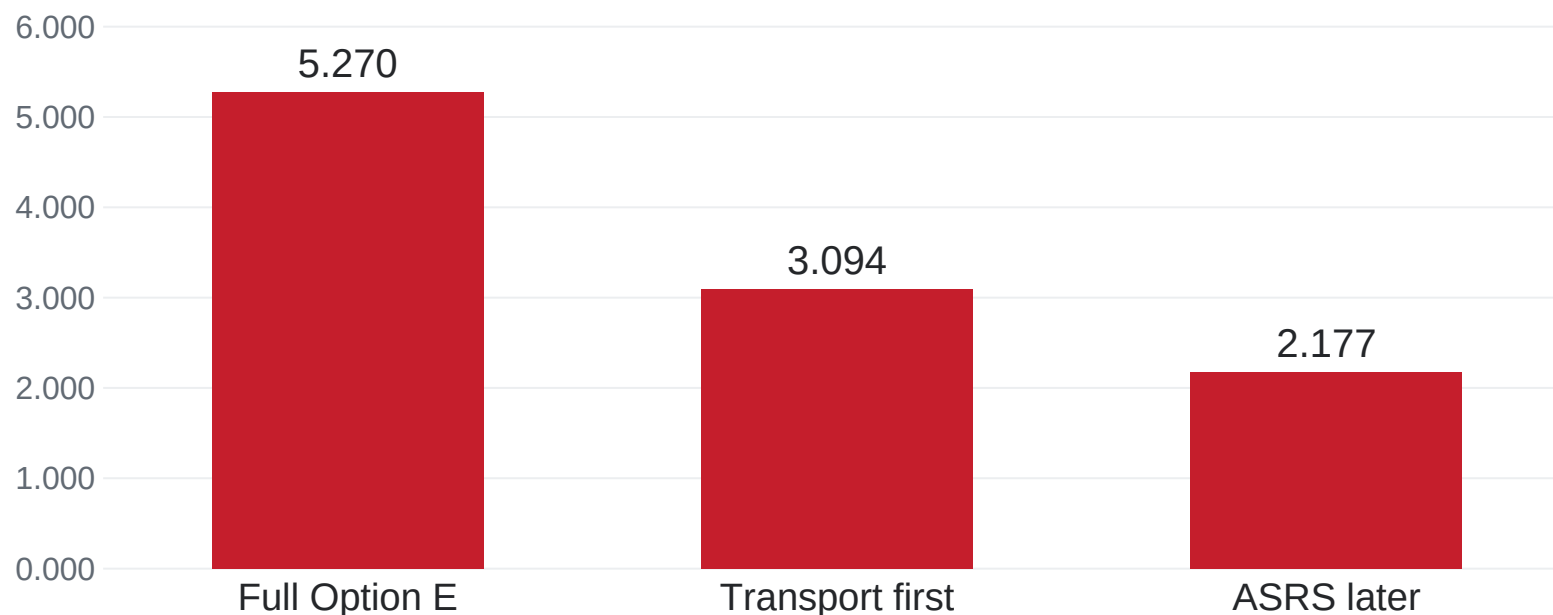
6 new + 12 reviewed assists
1,122 box sets
3 jack AMRs + 2 chargers
34 local trolley docks

ASRS capacity and all 38 docks remain. 166 existing trolleys still require relocation / retirement.



Phasing changes cash timing, not the full-system total

Illustrative budget allocation, S\$ million



S\$3.094m now

Transport, containers,
assistance and integration

S\$2.177m later

ASRS + allocated reserve
Retains S\$5.270m full total

A phased plan needs an accepted interim store and interfaces. Repeat mobilisation, rework and escalation are unpriced.



Different scope explains the increase from old ROMs

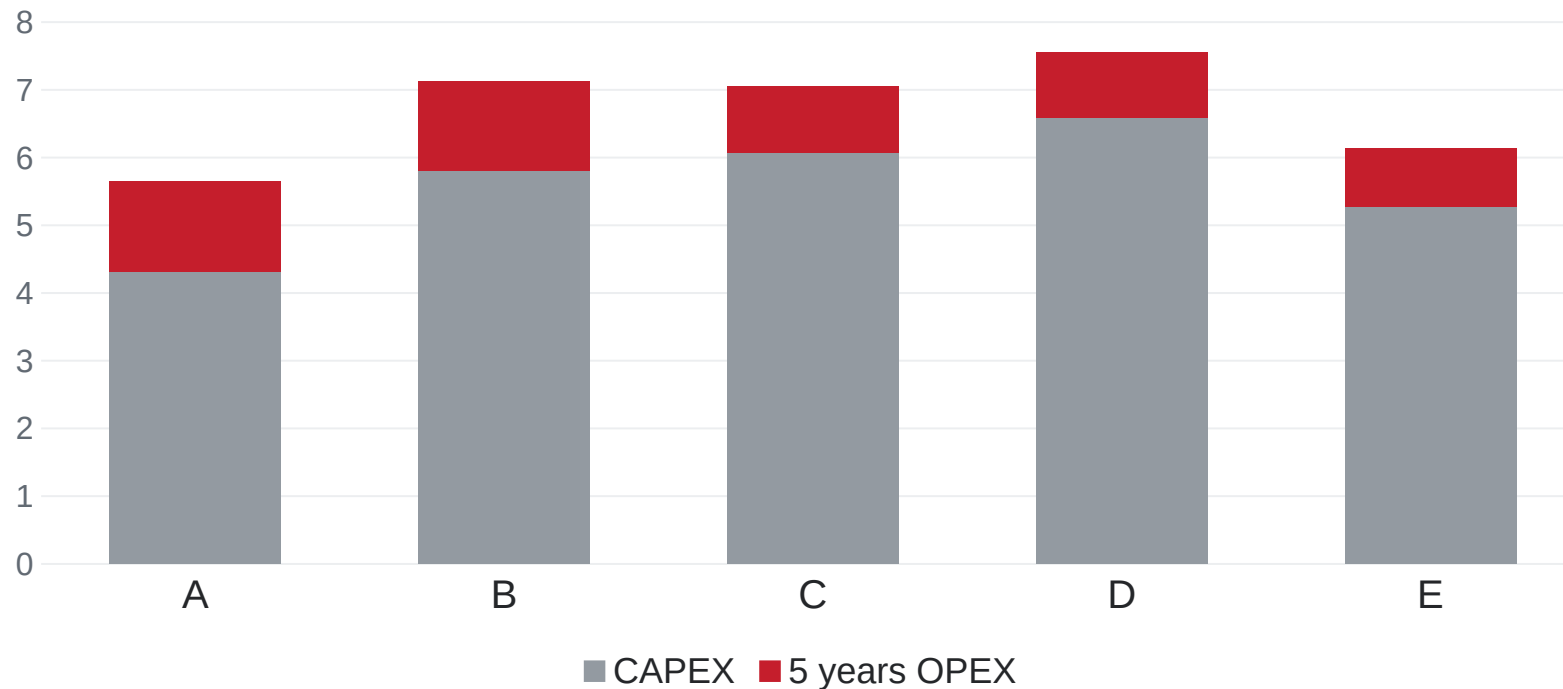
Historical anchor	Old scope	Current treatment
Hook option 1A / six-Hook	S\$603,900 / S\$1,168,200	Old route bundle and 20-trolley initial batch
FG-ASRS	S\$1,580,000	Retained as A base; larger / heavier box re-costed
Unified box + six lift AMRs	S\$3,000,000	Earlier unqualified container and handling assumptions
C05 two-dock pilot	S\$194,400	One route only; not a 17-station factory rollout
Complete scenarios	S\$4.32m–S\$6.59m	Adds full container pool, assists, station scope and reserve

Do not add the old bundles to this component model. September quotation validity has expired.



Five-year cost includes attendance and support

Five-year total cost, S\$ million



A S\$5.65m

E S\$6.13m

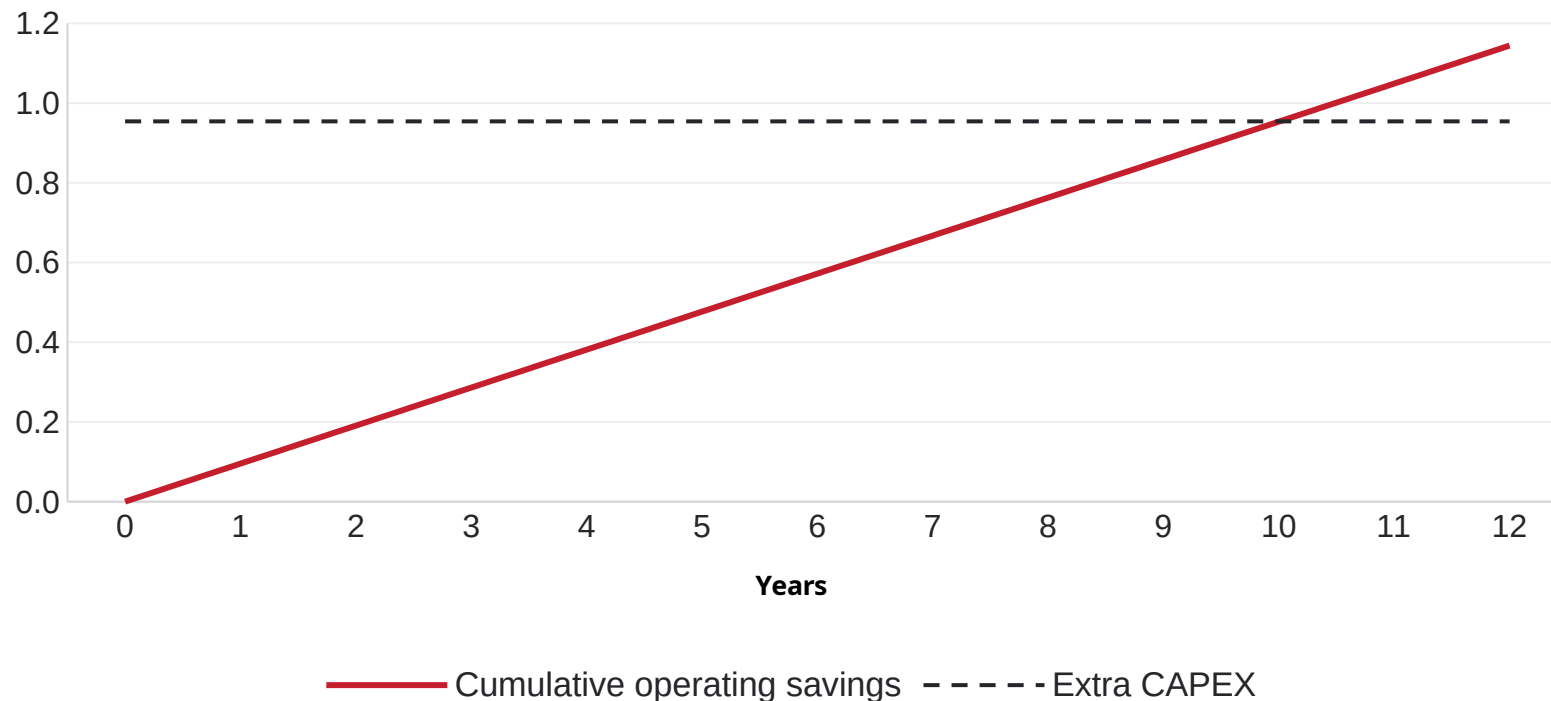
No production uplift or
quality saving credited.
Undiscounted model.

The comparison uses the same scope and operating assumptions. It does not promise headcount reduction.



E needs about 10 years to recover its extra CAPEX

S\$ million versus A



+S\$954k

Extra installed CAPEX

S\$95k/year

Modelled net saving
Payback: 10.0 years

E merits an ergonomic / flow pilot. It is not a demonstrated five-year financial winner over A.



Sensitivity: test the assumptions that move the result

Scenario	A / S\$m	B / S\$m	C / S\$m	D / S\$m	E / S\$m
18 existing assists reused	3.87	5.36	5.63	6.15	4.83
Route distance 30 m	4.03	5.52	5.76	6.24	4.95
Route distance 90 m	4.54	6.03	6.39	6.76	5.59
WIP reduced to 1 day	4.27	5.51	6.03	6.54	5.22
No new lift/tilt in C/D	4.32	5.81	5.14	5.66	5.27

Removing ergonomic hardware changes service scope; it is not an equivalent saving until the operator trial passes.



Batch transport is a route-specific sixth study

POTENTIAL APPLICATION

MiR600 Shelf Lift or a larger carrier for store-to-buffer milk runs. Reserve individual retrieval at each destination.

COST ANCHOR

Earlier five-MiR600 Shelf Lift fleet ROM: S\$740,200. Historical scope only; carriers and docks need new design.

MASS IS NOT CAPACITY

A larger robot can carry more mass, but a 1,400 mm box may limit slots first. Do not retain the old eight-box assumption.

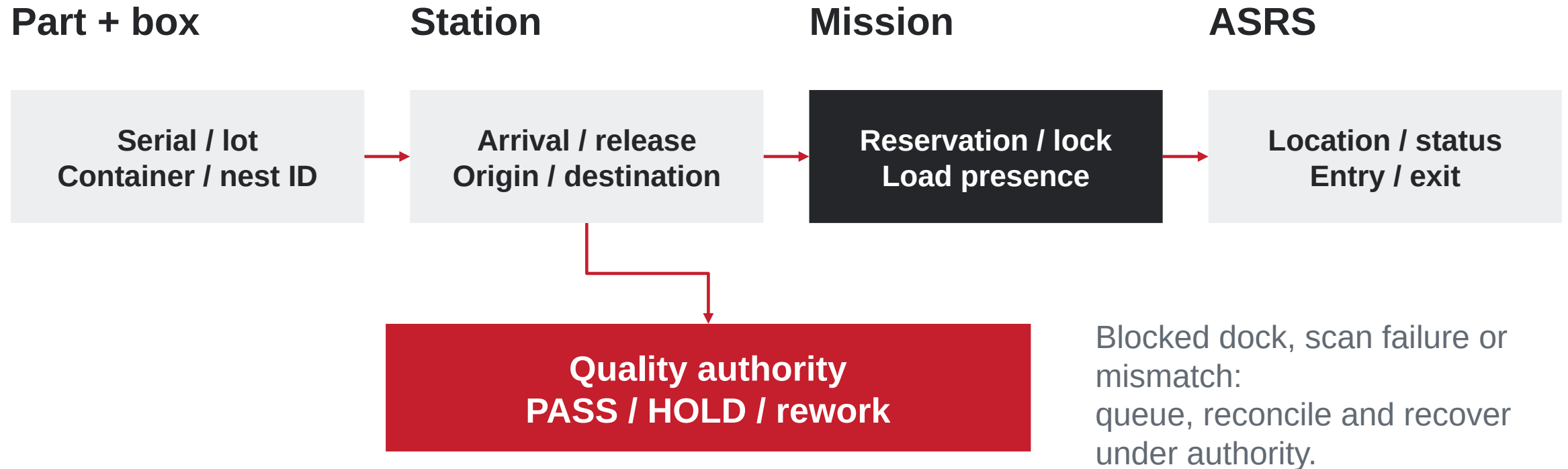
SERVICE PENALTY

At 40 parts/day over 24 h, a four-part batch takes about 0.9 h average fill delay with uniform arrivals and no timeout.

Batch delay = $(b - 1)/(2 \times \text{arrival rate})$. A practical timeout reduces delay but also reduces batch utilisation.



Traceability follows the part at every handoff



A common box helps identity continuity. PLCs, Fleet and WCS retain their motion and inventory authority.



Select the architecture by the binding constraint

Customer priority	Candidate	Condition to demonstrate
Lowest initial capital / minimal change	A / Retain	Trolleys serviceable; repacking acceptable
One common container, retain all ergonomics	B / Adapt all	Full trolley conversion justified despite floor use
Compact buffers and flexible point-to-point flow	C / Jack	Container access / lift stations and clearance approved
Repeatable automatic transfer lanes	D / Conveyor	Measured transfer frequency pays for powered docks
Preserve ergonomics with fewer circulating trolleys	E / Hybrid	Stationary trolley dock safely accepts the rigid base

Ask PWMS to weight capital, floor constraints, labour, process access and change risk before selecting.



Six gates before factory rollout

01

Measure

Loads, dimensions,
route and inventory

02

Prototype

Base, nest, locks
and product protection

03

Operator trial

Reach, height, tilt
and fixture access

04

AMR pilot

Handoff time, ID
and safe recovery

05

Store + fleet

ASRS capacity, peaks
and failure response

06

Commercial

Matched scope, quotes
and FAT / SAT criteria

Pilot E against an A control route. Keep C and D available until trials resolve the actual handoff.



A pilot is a bounded engineering experiment

Pilot cost element	Scenario allowance, SGD	Scope
Historical C05 pilot anchor	194,400	One AMR, two docks, commissioning; revise load basis
35 kg load redesign and validation	25,000	Custom lift, retention and rigid-base engineering delta
Ten prototype bases / boxes / nests	4,600	10 × S\$460 material allowance
Two trolley receiver conversions	5,000	2 × S\$2,500; verify structural suitability
Prototype quality / fit trials	15,000	Product protection, process and operator trials
Subtotal + 20% development allowance	292,800	244,000 subtotal +48,800 contingency

Excludes new manipulators, production ASRS and full software. Add S\$28,000 per new assistance point if needed.



Confirm these inputs with PWMS before pricing supply

PHYSICAL / PROCESS

Raw and finished dimensions; part mass by stage; PP material; trolley drawings; machine fixture access; FPI / wash / cleanliness rules.

DEMAND / SPACE

Actual daily / peak demand; travel distances; WIP and storage mix; aisle and fire constraints; 17 groups versus individual machines.

PEOPLE / EQUIPMENT

Existing manipulators and payloads; acceptable operator reach / height; automatic handoff expectations; maintenance and fallback ownership.

COMMERCIAL

New box quantities and shipping usage; cells versus occupied storage; support SLA; integration access; civil / enclosure scope and current quotations.

We may have misunderstood parts of the process. PWMS should review internally; Aetec can arrange a technical meeting.



Appendix / principal cost rates

Item	Unit rate, SGD	Basis / boundary
Hook robot / charger	79,000 / 8,400	H: hardware; current availability unconfirmed
MiR250 base + conveyor top	95,000 +38,000	H: component anchors; common commissioning separate
MiR250 base + jack module	95,000 +24,000	H/E: custom module needs load-case qualification
Fleet / per-robot commissioning	27,500 / 15,000	H/E: one licence provision and robot allowance
Passive / powered dock	4,500 / 14,500	E: reserved dock hardware scope, no double call kit
Gateway / universal trolley conversion	7,000 / 2,500	H/E: one gateway per group; conversion per trolley

Rates are historical anchors or engineering allowances. Quantities and scope appear in this comparison.



Appendix / common integration and exclusions

Included in all options	Scenario allowance	Separately resolved scope
Wi-Fi survey and upgrade	S\$55,000	Major building-network replacement
Route model + traceability	S\$130,000	ERP/MES licence purchases beyond interface work
PWMS / ASRS / machine interfaces	S\$60,000	Production-machine redesign and automatic tending
Orchestration validation	S\$30,000	Unspecified third-party integration scope
Transport FAT / SAT / rollout	S\$100,000	Production downtime / shutdown premiums
Design-development contingency	15% of listed direct cost	GST, financing, major civil / fire enclosure works

ASRS has its own controls, WCS and acceptance allowance. No unverified platform-reuse credit is deducted.



Appendix / ASRS estimate is explicitly rebuilt

ASRS subsystem	FG / S\$k	Unified / S\$k
Design	125.0	150.0
Racks + cranes	585.0	756.4
I/O + carriers	275.0	342.5
PLC + WCS + API	285.0	285.0
Install + acceptance + spares	310.0	358.8
Total	1580.0	1892.7

SGD1.89m unified store is a scaling scenario, not a quoted or capacity-validated ASRS.



Appendix / operating-cost and space formulas

CAPEX = listed quantities × unit rates + contingency.

TCO = CAPEX + years × annual operating cost.

Annual OPEX = transport attendance + support + energy + sleeve renewal.

Incremental payback = (CAPEX option – CAPEX A) ÷ positive annual saving.

Default economics: S\$25/hour, 250 days/year, 3% support on eligible cost,

S\$600 energy per robot/year, 5% PP sleeve renewal, zero space value.

Queue envelope: trolley count × 2 m², or container footprint × 1.5 circulation.

WIP pool = daily parts × WIP days; raw buffer = daily parts × buffer days.

These are exposed assumptions. No workforce reduction, production uplift or rental saving is promised.



Evidence, limitations and next discussion

Customer evidence

AETEC – ASRS and AMR Mapping R1.xlsx, Marshawn, 13 July 2026.

Current discussion: 35 kg raw part, box mismatch and ergonomic trolley trade-off.

Commercial evidence

PWMS End-to-End ASRS AMR Options Budgetary Quotation Rev6, 5 Sep 2026.

Five AMR Methods Budgetary Supplement Rev7, 14 Sep 2026. Historical only.

Manufacturer verification

MiR250 base / Shelf Carrier official documentation; UR30 official payload manual.

Application ratings, docking geometry and current prices require supplier sign-off.

Aetec can arrange a follow-up with the MiR / UR principal team after PWMS reviews the alternatives.