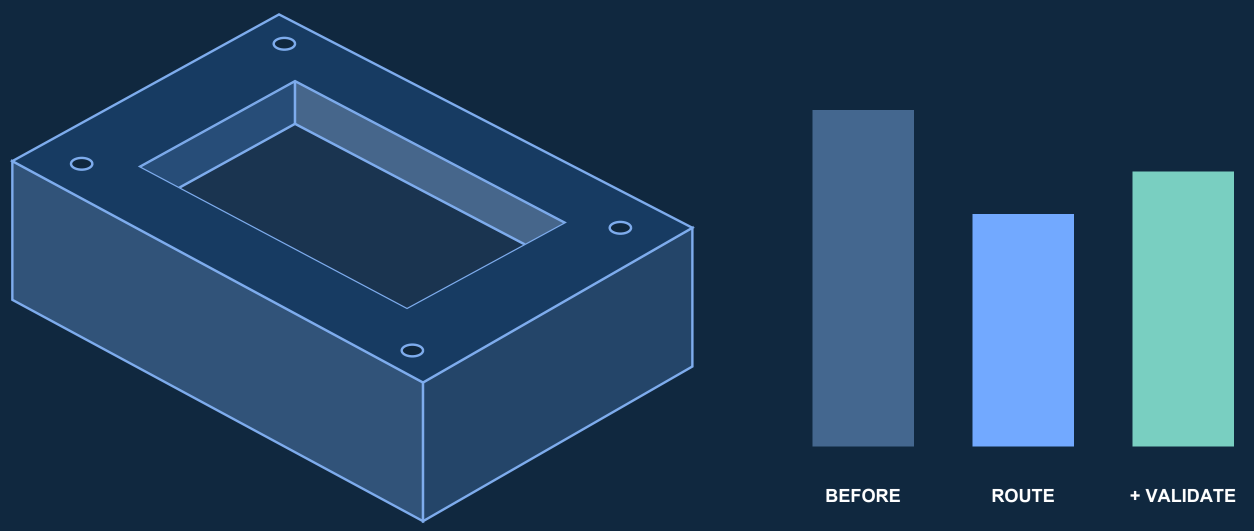
vetcnc
CNC MANUFACTURING

ENGINEERING RESOURCES / 05

CNC Part Cost Optimization

A Practical Guide

Change the work. Preserve the function.
Prove the saving with a complete cost model.



WORKED COST LEDGERS

DESIGN TRADE-OFFS

REUSABLE FORMS

V1.0 / SEPTEMBER 2026

vetcnc.com

READER MAP

Spend less on the part, not less on its purpose

A working guide for engineers, technical buyers and teams approving CNC cost-reduction proposals.

The central CT-120 example starts with a USD 7,400 modeled first lot of 100 accepted bodies. A coordinated proposal reduces modeled production cost to USD 5,600, before USD 900 of incremental design validation. You can follow every input, challenge each assumption and update the answer when trial evidence arrives.

Other examples are explicitly separate. Their savings cannot be added to CT-120. All prices, rates, cycle times, quantities, trial results and identities are original teaching data, not market quotations, customer results or vetcnc production guarantees. Dimensions are mm unless stated; all money is illustrative USD.

USE THE BLANK WORKSHEETS AFTER THE WORKED EXAMPLES

Page 35 records a comparable cost basis. Page 36 connects a design change to its risks, evidence and approval. The fields save locally in a form-capable PDF reader; they do not submit an inquiry.

01 / SCOPE AND DENOMINATOR

Name the cost before trying to reduce it

A lower machine-time estimate, a lower purchase price and a lower cash outlay are different outcomes.

PRODUCE → **PURCHASE** → **OWN / USE**

Resources and accepted output | Agreed commercial scope | Buyer costs beyond the invoice

View	Include	Do not confuse it with
Production cost	Defined resources used to produce conforming parts, plus the agreed allocation of fixed costs.	The selling price or immediate cash saved.
Purchase price	Supplier commercial offer for an explicit delivered scope and accepted quantity.	A transparent list of every internal factory expense.
Buyer total cost	Purchase plus non-included transport, receiving, inventory and verified consequential costs.	Every imaginable risk added again to an already inclusive quote.

Write the denominator first: 100 accepted bodies of one released revision, not 100 starts, 100 hours or 100 assemblies with different contents. State the delivery point, currency, schedule, required records and whether finish is included. Compare options only after the functional and commercial boundaries match.

For the main case, the factory model is $C(Q) = F + Qv + B(Q)$. F is the cost incurred once for the modeled first lot; v is the recurring per-piece cost before the outsourced finish; B is the finish batch charge. The baseline assumes every start becomes an accepted body. Page 23 removes that simplifying assumption.

A USABLE SAVING HAS AN OWNER

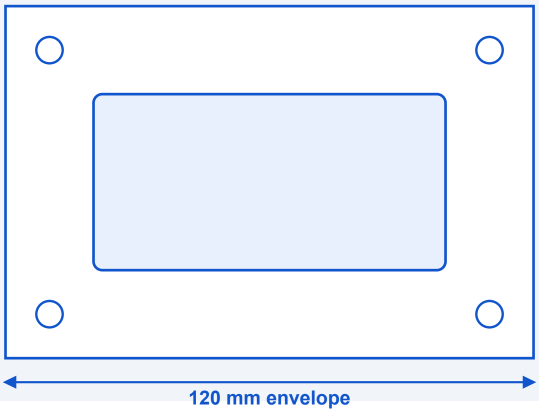
The designer may remove unnecessary work; the supplier may quote a revised price; purchasing may change order policy. Record which decision actually changes the buyer's bill. A calculation alone does not amend the purchase order.

Sources: [07] Protolabs Network | [13] ASQ | [18] NIST

02 / THE COMMON TEACHING PART

Meet CT-120: an equipment insert body

One functional brief supports the before-and-after route. This is a feature map, not a released manufacturing drawing.



CT-120 / INSERT BODY

Envelope: 120 x 80 x 25
Pocket: 80 x 40 x 16, R2
Candidate: 12 deep, R6

Material and functional interfaces remain controlled.

Keep fixed	May be investigated
120 x 80 x 25 envelope; mounting interfaces and approved datum scheme.	Pocket corner radius and excess cavity depth, after insert-envelope review.
Specified 6061-T651 plate, final protective finish and required masking.	Purchased blank dimensions and workholding method, with machining allowance verified.
Functional seats, thread requirements, edge safety and final acceptance plan.	Texture on identified non-contact faces; no blanket reduction of all requirements.
Delivered body mass limit of 0.60 kg; complete functional checks.	A shallower pocket adds mass. Update the model and check the finished body.

The starting pocket is 80 x 40 x 16 deep with R2 vertical internal corners. The proposal is the same plan envelope, 12 deep with R6 corners. The illustrative insert needs 10 mm of height plus 2 mm of vertical clearance, and its corner envelope is subject to design review. A larger radius is not acceptable merely because it machines faster.

WHAT THE CASE DOES NOT AUTHORIZE

Do not change mounting holes, thread engagement, material, corrosion protection or load paths to match this sketch. A real change needs the actual assembly model, loads, environment and released dimensions. Other examples in this guide concern different parts.

03 / BASELINE: 100 ACCEPTED BODIES

Build a ledger that can be challenged line by line

First-lot teaching model. All amounts are USD; no supplier margin, taxes or outbound freight are included.

Cost item	Basis	Lot cost
CAM / process planning	4 h at 60/h; off-machine engineering	240.00
Dedicated workholding	Fixture cost charged to this first lot	180.00
Machine setup	3 h at 75/h; not included in per-piece cycle	225.00
Inspection preparation / first article	Plan, program and first-article report preparation	155.00
Purchased cut blanks	100 at 12.00; includes agreed sawing	1,200.00
Occupied machine cycle	100 x 32 min / 60 x 75/h	4,000.00
Part-specific tool consumption	100 at 2.50	250.00
Off-machine deburr / clean	100 at 3.00	300.00
Routine external inspection	100 at 3.00; distinct from in-machine checks	300.00
Outsourced finish	max(180 minimum, 100 x 4.00)	400.00
Individual packing	100 at 1.50	150.00
TOTAL / per accepted body	800 + 100 x 62 + 400	7,400.00 / 74.00

The loaded machine rate includes ordinary operator attendance, machine ownership and normal operating overhead. It excludes the separately listed part-specific tools and off-machine work. Do not add another full operator-hour charge to the same cycle. Routine measurements, including the first piece, are in the per-piece inspection line; the 155 covers preparation and reporting, not those measurements again.

> **TAG WHAT ACTUALLY REPEATS**
>
> The 240, 180 and 155 items are first-lot costs here. Setup can recur each run. Their reuse is conditional on retained tooling, unchanged requirements and an accepted repeat route; none should be silently billed or removed on every future order.

04 / FROM A TOOLPATH TO A COSTED CYCLE

Count occupied time, not just the cutting animation

A CAM estimate is an input to the model. It is not necessarily the complete machine occupancy per accepted part.

CT-120 time component	Minutes / piece	Cost at 75/h
Feed motion in the cutting route	20	25.00
Non-cut motion and approach	3	3.75
Scheduled tool changes	2	2.50
Load, unload and part handling at machine	4	5.00
In-machine checks	3	3.75
Total occupied cycle	32	40.00

For a separate constant-feed segment, assume 6,000 rev/min, 3 effective teeth and 0.04 mm/tooth. Table feed is 6,000 x 3 x 0.04 = 720 mm/min. A 1,440 mm programmed feed path takes 2.00 min if that feed is maintained. With axial depth 4 mm and radial engagement 3 mm, the ideal removal rate is 4 x 3 x 720 / 1,000 = 8.64 cm3/min.

That segment does not establish the CT-120 cycle. Acceleration, corner control, linking moves, air travel, probing and machine limitations can change elapsed time. The inputs above illustrate units and formulas only; they are not a cutting recipe. A supplier must select safe data for its actual tool, holder, material and machine.

Record the source of each time: estimate, simulated complete NC program, timed pilot or repeat-run history. State whether measurement pauses and routine tool changes are inside the observation. Keep separately costed setup outside the per-piece cycle, and do not quietly exclude a slow second operation.

TEST THE BIGGEST ASSUMPTION FIRST

At 100 pieces and 75/h, every extra minute per piece adds 125 to the lot. A five-minute cycle error is 625, much larger than a 75 saving from removing one setup hour.

Sources: [01] Sandvik Coromant | [08] Renishaw

05 / FIXED COSTS AND BATCH MINIMUMS

A quantity discount is a curve, not a promise

Use the same route and specification when comparing quantities; a different process needs a new model.

Accepted quantity Q	First-lot total	Cost / body
1	1,042.00	1,042.00
10	1,600.00	160.00
25	2,530.00	101.20
50	4,100.00	82.00
100	7,400.00	74.00
500	33,800.00	67.60

Each row uses $C(Q) = 800 + 62Q + \max(180, 4Q)$. Below 45 pieces, the assumed finish minimum dominates its per-piece charge. Above that point the finish contribution is 4.00 per body. This is why a straight line through two observed unit prices can miss the real behavior.

A change from 100 to 500 reduces modeled unit cost by 6.40 but raises the immediate production outlay by 26,400. It is useful only if the additional accepted bodies have a justified use. A future design revision can make a low unit price an expensive inventory decision.

DO NOT EXTRAPOLATE BEYOND THE ROUTE

Tool-life limits, pallet capacity, inspection frequency, raw-stock minimums and finish lot sizes can introduce new steps. These six points are arithmetic under fixed assumptions, not a volume-price schedule or an offer from vetcnc.

Sources: [07] Protolabs Network

06 / WORKHOLDING ECONOMICS

Compare setups and machine classes as complete routes

A higher hourly rate can still produce a lower route cost. Fewer setups alone do not prove it will.

Route A	LOCATE / OP 10 →	RECLAMP →	OP 20
Route B	LOCATE →	INDEX →	FINISH

Separate route example	Three-axis route	Indexed/multi-axis route
Setup / route fixed cost	450.00	700.00
Occupied cycle / loaded rate	24 min at 75/h	14 min at 110/h
Machine variable cost	30.0000 / part	25.6667 / part
At 20 accepted parts	1,050.00	1,213.33
At 100 accepted parts	3,450.00	3,266.67

Here the second route costs 250 more to establish but saves 4.3333 per part. The modeled equality is $Q = 250 / 4.3333 = 57.69$; at integer quantities it first becomes cheaper at 58. Common material, finish, quality and packing costs are omitted only because this example stipulates that they are identical.

Before using the result, verify tool access, clamp clearance, locating repeatability, reachable inspection features and the final state of hidden surfaces. Include programming and prove-out differences in the fixed line. A fixture that accelerates loading but hides a required edge can simply transfer work elsewhere.

> **ASK FOR ROUTE EVIDENCE, NOT AN AXIS-COUNT SLOGAN**
>
> Request a setup sketch and a cycle breakdown. The CT-120 combined proposal on page 20 stays on its agreed route; the two routes above are a separate comparison and are not an additional saving to add to that case.

Sources: [08] Renishaw

07 / CORNER RADIUS AND TOOL ACCESS

Open up an internal corner only where the assembly allows

The cost opportunity is removal of difficult work, not the radius value by itself.

R2 / diameter 3 concept

R6 / diameter 8 concept

Plan-view geometry only; actual tool, holder and path require validation.

For CT-120, a proposed R6 corner creates more space for a larger cutter than the original R2 corner. A diameter-3 cutter fits geometrically inside R2; a diameter-8 cutter fits inside R6 and leaves room for a programmed center path. These are geometric illustrations, not a tool selection or proof of a stable cut at full depth.

Review before changing R2 to R6	What must be established
Mating insert and approach path	The insert clears the entire corner envelope during installation and use, including assembly tolerances.
Nearby holes, sealing or contact lands	Required material and functional boundaries remain intact. No unapproved relief crosses them.
Tool access and engagement	Actual cutter, neck, holder and remaining stock permit the intended roughing and finishing paths.
Released definition	The revised radius, tolerance and affected interfaces are controlled in the model and drawing.

Toolmaker guidance explains that engagement rises as a cutter enters an internal corner. Geometry and toolpath must be considered together. Simply matching the tool radius to the part radius can constrain the finish path; picking a smaller cutter can improve path freedom but also change rigidity and time.

> **ONE JOINT ESTIMATE, NOT TWO STACKED CLAIMS**
>
> The main case budgets seven minutes of cycle reduction for the combined corner-and-depth change. It does not claim seven minutes for the radius plus another seven for the depth. The combined route must be timed.

Sources: [02] Sandvik Coromant | [06] Protolabs

08 / VOLUME IS USEFUL, BUT IT IS NOT A CYCLE TIMER

Remove unnecessary pocket depth before chasing feed rate

The CT-120 cavity becomes shallower only after its functional height and corner envelope are approved.

16 deep / 9 base **12 deep / 13 base**

Concept section through the cavity; small radii and details omitted.

Idealized cavity geometry	Before	Proposed
Plan envelope / vertical radius	80 x 40 / R2	80 x 40 / R6
Depth / remaining nominal base	16 / 9	12 / 13
Plan area, rounded rectangle	3,196.57 mm2	3,169.10 mm2
Idealized removed cavity volume	51.145 cm3	38.029 cm3

For this ideal rounded rectangle, area = LW - (4 - pi)R^2, and cavity volume = area x depth. The combined geometry removes 13.116 cm3 less material, a 25.64% reduction in this cavity's volume. It does not reduce total stock removal or total cycle by that percentage. Floor fillets, holes, exterior cuts and toolpath details are omitted from this geometry calculation.

The body gets heavier: at the assumed density of 2.70 g/cm3, retaining that volume adds about 35.41 g. Its simplified body estimate remains below the 0.60 kg limit, but the finished-part mass and assembly clearance still need verification. A shallower cavity can also change thermal behavior or component accessibility.

> **DO NOT DIVIDE VOLUME BY AN IDEAL RATE AND CALL IT A QUOTE**
>
> Roughing, rest machining, finishing, chip clearance and probing have different time behavior. Use geometry to identify an opportunity; use a complete route to price and validate it.

Sources: [01] Sandvik Coromant | [03] Sandvik Coromant

09 / THIN WALLS AND DISTORTION

A slightly heavier feature can be cheaper to manufacture

Separate example: preserve the required function while reducing a difficult machining condition.

Extra material: 3.24 g

Hypothesized cycle saving: 5 min / part

Consider a 60 mm long, 20 mm high local wall increased from 1 to 2 mm thick. The added volume is 60 x 20 x 1 = 1,200 mm3, or 1.2 cm3. At an assumed 2.70 g/cm3 it adds 3.24 g. At a notional 6.00/kg that retained material has a mass-based value of about 0.0194. It is not an extra purchasing expense if the same blank is already being bought.

Suppose a tested route removes five minutes of finishing and handling at 75/h, saving 6.25 per part. With an unchanged blank purchase, no extra material charge is deducted. If a revised blank quote actually adds 0.02, the corresponding net becomes 6.23, before any other changes or validation cost. Mass-based value and cash paid for stock are different quantities; minimizing mass and minimizing purchase cost can point in different directions.

Potential benefit	Required challenge
More stable support during machining	Verify the actual clamp and cut sequence; do not assume every thicker wall needs fewer passes.
Less distortion after release	Measure in the specified final condition, not only while the part is held flat.
Simpler handling or deburring	Check access, assembly clearance, heat flow and the approved mass budget.
Possible lower scrap exposure	Use observed results; do not invent a yield improvement to make the proposal win.

NO UNIVERSAL MINIMUM WALL THICKNESS

Wall height, span, material, support and operation sequence all matter. Ask the manufacturing team which local change eliminates a difficult operation, then ask the design owner whether that change is acceptable.

Sources: [03] Sandvik Coromant | [04] Sandvik Coromant

10 / SPECIFY WHAT THE FASTENER NEEDS

Simplify holes and threads without weakening the joint

Cost optimization must not become an unreviewed reduction in load capacity or sealing performance.

Opportunity to investigate	Do not assume	Evidence to request
Consistent hole and thread families	Every size change creates a large saving.	Tool list, change count and measured cycle effect.
Adequate blind-hole bottom clearance	Drill depth equals full usable thread depth.	Section, drill point, tap lead/runout and minimum remaining wall.
Through access where permitted	A through hole is acceptable in a sealed or clean assembly.	Design approval for leakage, debris, protrusion and protection.
Only necessary thread depth	One engagement ratio works for every material and load.	Joint calculation, fastener grade, parent material and application requirements.
A suitable threading method	Tapping or thread milling is always cheaper.	Actual route, tool life, time and final gauge requirements.

A supplier can identify that an excessively deep thread is expensive, but it cannot infer the approved engagement from a picture. The design owner should distinguish required complete thread length, total hole depth and minimum remaining material. The manufacturing team then proposes a feasible tool and process that meets that definition.

For a separate feature-family study, assume consolidating two nonfunctional drill sizes eliminates one recurring 20-second tool change on each of 300 parts. The gross occupied-time reduction is 100 min, worth 125 at 75/h. If the program and verification change costs 180, that lot alone does not recover the investment. If the machine changes tools once per pallet, the calculation must use pallets rather than parts.

Tap selection depends on material and whether the hole is blind or through, among other factors. Keep chip handling and process reliability in the route review. Never treat a machining recommendation as proof of thread strength.

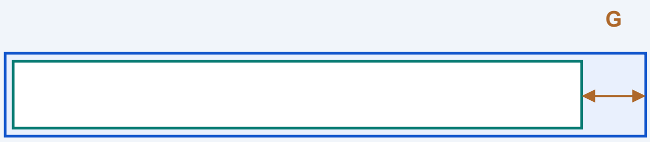
> **KEEP EDGE REQUIREMENTS EXPLICIT**
>
> Removing unnecessary cosmetic machining is different from shipping uncontrolled burrs or sharp edges. Agree an acceptable edge condition and a safe, repeatable way to achieve and check it.

Sources: [12] Sandvik Coromant

11 / A WORKED ONE-DIMENSIONAL CLEARANCE

Allocate the tolerance budget from the function backward

Relax a requirement only after proving the assembly still has the necessary margin.



S - I = nominal clearance

G = 20.40 - 20.00 = 0.40

Worst case: add the bounds.
Do not assume cancellation.

In a separate sliding-clearance example, an internal space S is nominally 20.40 and an insert I is 20.00. Clearance G = S - I is therefore 0.40. The permitted operating clearance is 0.15 to 0.65. Assume all other modeled service and assembly effects can shift clearance by at most +/-0.03; that bound must be justified for the actual product.

Worst-case budget	Current space +/-0.10	Candidate space +/-0.15
Insert tolerance contribution	+/-0.05	+/-0.05
Other bounded effects	+/-0.03	+/-0.03
Total clearance variation	+/-0.18	+/-0.23
Resulting clearance range	0.22 to 0.58	0.17 to 0.63
Margin to each functional limit	0.07	0.02

The functional half-width is 0.25. After reserving 0.05 for insert variation and 0.03 for other effects, at most 0.17 remains for the space dimension. Choosing 0.15 leaves a further 0.02 on each side. This is a worst-case interval calculation; it does not rely on tolerances being normally distributed or on favorable cancellation.

This scalar example does not account for form, angular error, position, contact deformation or a complex multi-part stack unless those effects are explicitly modeled. Measurement uncertainty is not a substitute for a physical variation allowance. Use the released tolerance system to define what each dimension actually controls.

REQUEST A PRICE DELTA AFTER TECHNICAL APPROVAL

If the relaxed space does not remove an operation, change a feed strategy, improve reliable yield or simplify verification, it may not produce a meaningful saving. Do not promise a percentage merely because the tolerance band is wider.

Sources: [09] ASME

12 / DATUMS, CAPABILITY AND VERIFICATION EFFORT

Do not buy precision that serves no identified interface

Specify the functional relationship clearly, then ask how the process and inspection will establish it.

Ambiguity that can add cost	Useful clarification
Every dimension carries the tightest tolerance.	Identify interfaces requiring close control and release separate justified limits for other features.
A pattern is dimensioned from several unrelated edges.	Confirm the functional datum scheme and how location will be established and inspected.
A convenient best fit is used to improve a report.	Retain the released reference frame; do not change evaluation to conceal a failing feature.
A report is required but its scope is undefined.	Define characteristics, pieces, records, final state and acceptance rule before quoting.
A short pilot is called process capability.	Request an appropriate stability and capability study if the application requires one.

An accurate definition can remove repeated interpretation and unnecessary measurement effort without changing the allowed product variation. Conversely, a datum change can alter function even when the numerical tolerance stays the same. Treat it as a design change, not a drawing-format cleanup.

For a separate inspection-workflow example, assume report preparation and measurement take 12 min per part at 50/h, or 10.00. A verified reusable program and automatic result transfer reduce that to 6 min, or 5.00, with the same approved scope. An incremental 600 development and validation effort breaks even at 120 parts. Check whether that development cost was already included elsewhere before adding it.

The program must still identify the part, use the correct revision and retain the required results. Automation does not justify deleting an awkward characteristic, averaging away a bad hole or reporting only a favorable first piece. The cost reduction comes from removing repeated work, not from redefining an unacceptable part as acceptable.

CAPABILITY IS EVIDENCE, NOT A DECORATION

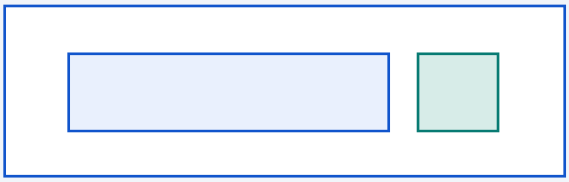
Capability indices have assumptions about process behavior, data and the statistical model. Ten passing parts do not establish long-term performance, and a supplier's machine specification does not establish capability on your feature.

Sources: [09] ASME | [14] NIST / SEMATECH

13 / SURFACE ZONES, EDGE WORK AND MARKING

Separate functional texture from cosmetic preference

A uniform premium requirement can impose work on surfaces that do not need it.



Defined zones, not one blanket premium

KEEP functional interfaces
DEFINE appearance zones
REVIEW hidden faces
VERIFY final requirements

Zone in the review	Question to answer	Release evidence
Mating, sliding or sealing surface	Which texture characteristics support the function?	Specified method, final state and required result.
Visible cosmetic surface	What appearance is acceptable under what viewing conditions?	Approved reference or defined acceptance description.
Hidden non-contact surface	Does it need the same finishing pass as the interface?	Approved local requirement; retained safe edge condition.
Marking area	Is CNC engraving required, or is an approved alternative suitable?	Legibility, durability, location and process compatibility.

Ra alone does not describe every aspect of texture or appearance. Use the agreed drawing convention and evaluation conditions. Do not replace a functional surface requirement with a photograph, and do not infer a surface-texture limit from a finish name such as black anodize.

Separate marking example: eight occupied minutes of CNC engraving at 75/h costs 10 per part. Suppose an approved marking alternative costs 150 per batch plus 0.50 per part. At 100 pieces, the comparison is 1,000 versus 200, a gross difference of 800 before qualification and transport. The nominal equality is 150 / 9.50 = 15.79 parts, so the alternative first wins at 16 under these assumptions.

PROTECT THE LOCAL EXCEPTIONS

The main CT-120 proposal removes only identified non-contact finishing passes. It retains functional texture, finish, thread and edge requirements. The separate marking calculation is not part of its savings ledger.

Sources: [06] Protolabs | [10] ISO

14 / MASKING, BATCH CHARGES AND FINAL DIMENSIONS

Model the finish route as a process with its own minimums

A cheap machining route can become expensive if its downstream finish requirements are incomplete.

Hypothetical finishing scope	At 20 pieces	At 100 pieces
Base route: max(180, 4Q)	180 total / 9.00 each	400 total / 4.00 each
Additional masking: 0.90Q	18 total / 0.90 each	90 total / 0.90 each
Optional second finish: max(120, 1.50Q)	120 total / 6.00 each	150 total / 1.50 each
All three combined	318 total / 15.90 each	640 total / 6.40 each

These are alternative commercial inputs, not a coating price list. CT-120 uses only the base route in its main ledger; that base price already includes its stipulated required masking. Do not add the optional masking line again to CT-120. Every real quote must state what is included in the base process.

Ask the processor to identify controlled coating areas, protected interfaces, rack or contact locations, color expectations and verification needs. If a tolerance applies after processing, the route must deliver it in that final state. Do not replace the processor's dimensional plan with a universal buildup ratio.

Eliminating a second finish might be valuable if its function is genuinely unnecessary. It is not a valid saving if it removes corrosion resistance, electrical behavior, wear protection or a required identification feature. Similarly, specifying every surface as cosmetically critical can add inspection and handling that the assembly does not require.

Request before accepting the revised price	Why it changes the decision
Written finish scope and acceptance reference	Prevents a lower price from buying a different product.
Charge basis for repeat and split batches	A minimum may recur on every release, color or process family.
Protection, packing and final inspection route	Avoids late damage or dimensional surprises after machining.

COUNT MINIMUMS ONCE, ON THE RIGHT BATCH

Do not apply a per-part rate plus a full minimum unless that is the actual charging rule. max(minimum, variable charge) and minimum + variable charge are different contracts.

Sources: [11] Aluminum Anodizers Council

15 / STOCK ENVELOPE AND MATERIAL UTILIZATION

Buy the blank that supports the route, not the largest default

The smaller blank is useful only if stock tolerances, cleanup and workholding still fit.

CT-120 stock scenario	Before	Proposed
Purchased nominal blank	130 x 90 x 30	125 x 85 x 28
Volume	351.000 cm3	297.500 cm3
Mass at assumed 2.70 g/cm3	0.94770 kg	0.80325 kg
Cut-blank cost input	12.00	10.00
Centered allowance per side: X/Y/Z	5 / 5 / 2.5	2.5 / 2.5 / 1.5

The purchased mass falls by 0.14445 kg, or 15.24%. The assumed price falls by 2.00, or 16.67%, because it is a cut-blank quotation input, not a mass-only formula. Sawing, stock availability, minimum purchase and documentation can all be priced differently. No chip-sale credit is included.

A body-volume estimate using only the outer block minus the idealized cavity is 0.50991 kg before and 0.54532 kg after the pocket change. Holes, local details and coating are omitted. This illustrates a useful distinction: the finished body can get heavier while the purchased blank gets lighter. Neither estimate replaces a released CAD mass calculation or finished-part check.

DO NOT SPEND THE MACHINING ALLOWANCE TWICE

The proposed centered allowances are geometric nominal values. Allow for stock variation, saw condition, distortion, clamping and cleanup. A stock-size reduction that forces another fixture or loses a functional face may not be a saving.

16 / A CONDITIONAL MACHINING-ECONOMICS COMPARISON

Compare material options only after both pass the use case

Low raw-stock price is only one input. A machining advantage does not establish material suitability.

Separate qualified-material scenario	Material M	Material N
Cut blank / part	8.00	12.00
Occupied cycle at 75/h	45 min / 56.25	30 min / 37.50
Part-specific tool consumption	3.00	2.00
Subtotal for these three items	67.25	51.50

If both candidates have already satisfied every functional and contractual requirement, N saves 15.75 per part despite costing 4.00 more as purchased stock. With a further 1,600 qualification and conversion effort, nominal break-even is 1,600 / 15.75 = 101.59 parts, so 102 is the first integer quantity recovering that investment. Other costs are stipulated equal in this isolated example.

M and N are deliberately not named alloys. An actual substitution can change strength, fatigue, corrosion, temperature response, magnetic behavior, thermal expansion, finish response and compliance evidence. A free-machining variant is not interchangeable solely because it has a similar family name. The approval must include grade, condition, form and purchase specification.

Material gate	Minimum decision input
Function and environment	Actual load, temperature, media, wear and service-life requirements.
Supply and processing	Qualified product form, traceable stock, available section, finish and heat-treatment route.
Evidence and change authority	Required tests, certification documents, responsible design approval and revision.
Economic completeness	Qualification, minimum stock, leftover material, lead time and disposal or reuse terms.

KEEP THE MAIN CASE CONTROLLED

CT-120 retains its specified 6061-T651 plate. Its 2.00 stock saving comes from a qualified blank-size change, not an unapproved alloy substitution. No material-comparison percentage is added to its ledger.

Sources: [05] Sandvik Coromant | [11] Aluminum Anodizers Council

17 / TOOL CONSUMPTION, CHANGE TIME AND SMALL-BATCH CASH

The cheaper cutter may cost more per usable part

Evaluate useful life to a defined quality endpoint, not merely the purchase price of the tool.

Separate repeated-production example	Tool A	Tool B
Purchase cost / qualified life	60 / 20 parts	90 / 45 parts
Consumption allocation per part	3.0000	2.0000
Cycle at 75/h, excluding this tool change	10 min / 12.5000	8 min / 10.0000
3-min change at 75/h, allocated over life	0.1875	0.0833
Subtotal per part	15.6875	12.0833

The repeated-production difference is about 3.6042 per part in favor of B. The assumed life ends when the defined wear or part-quality criterion is reached, not only when a tool breaks. Retain evidence for surface condition, dimensions and predictable replacement intervals. Unexpected failures and damaged parts belong in the model if they are material.

Now order only ten pieces, buy a fresh tool and assign no value to its remaining life. A costs 60 + 10 x 12.50 + 3.75 installation = 188.75. B costs 90 + 10 x 10.00 + 3.75 = 193.75. A is 5.00 lower in immediate modeled expenditure. The long-run consumption allocation and the short-run purchase decision answer different questions.

If the remaining tool is retained for a credible follow-on order, assign its value explicitly rather than changing conventions between alternatives. Likewise, exclude tool-change time from the per-part cycle above only if it is being added on the separate change line. Otherwise the same minute is counted twice.

> **USE CONTROLLED TRIALS, NOT AN ADVERTISED LIFE MULTIPLIER**
>
> Run suitable tools under approved conditions and compare complete occupied time, quality and useful life. A faster cut that creates unstable dimensions, burrs or unscheduled stoppages can erase the apparent gain.

Sources: [03] Sandvik Coromant | [05] Sandvik Coromant

18 / CT-120 PROPOSAL, RECONCILED

Rebuild one combined ledger instead of adding percentages

The following is one coordinated candidate route. Entries are estimates to be checked, not independent guaranteed savings.

100 accepted bodies	Baseline	Candidate	Difference
Fixed first-lot cost	800.00	725.00	75.00
Cut blanks	1,200.00	1,000.00	200.00
Machine: 32 to 21 min at 75/h	4,000.00	2,625.00	1,375.00
Part-specific tools	250.00	200.00	50.00
Off-machine deburr / clean	300.00	300.00	0.00
Routine external inspection	300.00	200.00	100.00
Required finish	400.00	400.00	0.00
Packing	150.00	150.00	0.00
TOTAL production cost	7,400.00	5,600.00	1,800.00

The candidate fixed cost is 240 planning + 180 workholding + 150 setup + 155 first-article preparation = 725. Setup falls from three to two occupied hours. Candidate recurring cost before finish is 10 stock + 26.25 machine + 2 tools + 3 deburr + 2 inspection + 1.50 packing = 44.75 per accepted body.

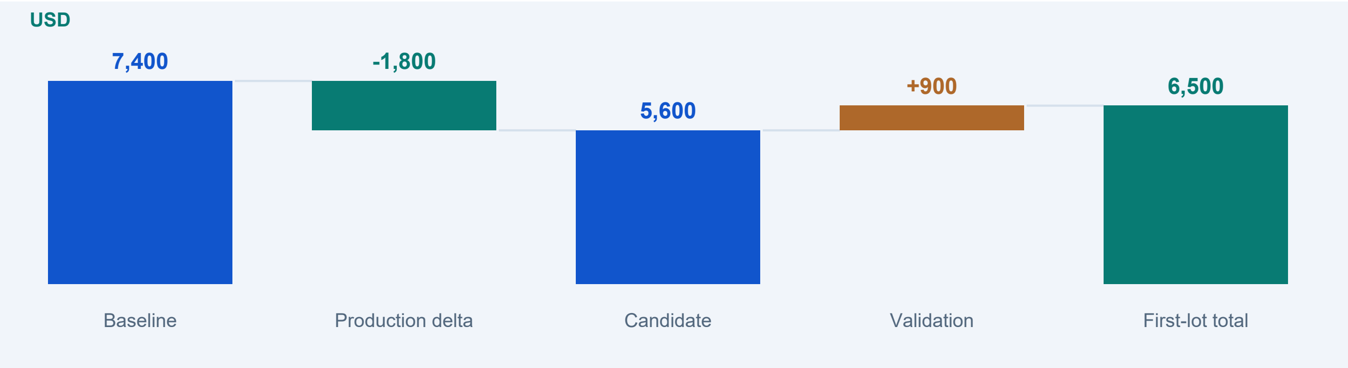
The time hypothesis is sequential: combined corner/depth changes reduce 32 to 25 min; the revised handling/locating route reduces 25 to 23; approved non-contact surface work reduces 23 to 21. Those intervals do not overlap in this ledger. A combined CAM review or pilot may reveal interactions, so the final route total takes priority over the individual estimates.

> **NO HIDDEN DELETION OF QUALITY SCOPE**
>
> Routine inspection is budgeted at 2.00 only after validated reuse of setup/program information removes repeated work. Required characteristics and final-state acceptance remain. Any extra cost to implement these changes belongs in the validation budget, not outside the comparison.

19 / PAYBACK AND THE FIRST APPROVED LOT

Recover the change investment before reporting net savings

The production difference is not the complete project benefit.



CT-120 at 100 bodies	Amount
Baseline first-lot production	7,400.00
Candidate first-lot production	5,600.00
Gross modeled production reduction	1,800.00 / 24.32%
Incremental design, trial and validation effort	900.00
Candidate total including that effort	6,500.00
Net first-lot improvement	900.00 / 12.16%

The 900 is additional to the planning and first-article costs already in both production ledgers. Its working allowance is 300 design review, 350 fixture/program validation and 250 functional/finish verification. If those activities overlap an already included charge, reconcile them rather than billing them twice.

Within the same piecewise finish model, the finish cancels because it is unchanged. Production saving is $75 + 17.25Q$. Recovering 900 requires $Q >= (900 - 75) / 17.25 = 47.83$, so 48 accepted bodies recover the incremental effort in this modeled first lot. At 48, gross saving is 903, leaving only 3 of modeled net benefit.

A SMALL POSITIVE ANSWER IS NOT A ROBUST APPROVAL

This is deterministic arithmetic, not a probability of success. Confirm actual demand, estimate uncertainty, timing, validation results and who captures the saving. Repeat lots require a new fixed-cost basis rather than reusing all first-lot charges.

20 / SENSITIVITY BEFORE CONFIDENCE

Show which uncertain inputs can overturn the decision

A range of explicit scenarios is more useful than a precise answer built from untested assumptions.

Candidate input at 100 bodies	Low-cost case	Base case	High-cost case
Occupied minutes / body	18	21	24
Cut blank / body	8.00	10.00	12.00
Fixed first-lot cost	575.00	725.00	875.00
Production total	4,875.00	5,600.00	6,325.00
Including 900 incremental validation	5,775.00	6,500.00	7,225.00
Net versus 7,400 baseline	1,625.00	900.00	175.00

Only the three listed inputs vary. The rate remains 75/h, other recurring items total 8.50 per body, and required finish remains 400. For example, the high case is 875 + 100 x (12 + 24/60 x 75 + 8.50) + 400 = 6,325. The corners of this table are stress scenarios, not statistical confidence limits or equally likely outcomes.

One extra minute per body changes the lot by 125. A 2.00 stock-price change shifts it by 200. A 150 fixed-cost change shifts it by 150. These sensitivities direct the next question: confirm the complete cycle before debating a tiny rounding difference in packing.

The baseline can be uncertain too. If the original 32-minute route is only a rough estimate, obtain comparable evidence for both routes. If the candidate requires a different machine rate, stock minimum or yield assumption, vary that input explicitly. Do not keep it fixed merely to preserve the preferred result.

PROTECT CORRELATED EFFECTS

Tool choice, cycle time and yield can move together. A faster cut may change tool use and quality. Evaluate a coherent route scenario rather than independently selecting the most favorable value from every alternative.

21 / SCRAP, REWORK AND THE RIGHT DENOMINATOR

Cost accepted output by the stage where losses occur

Separate observed-lot example: 105 starts ultimately deliver 100 accepted parts.

105 STARTS → **102** AFTER STAGE 1 → **100** ACCEPTED

3 early scrap + 2 late scrap; accepted = 98 first-pass + 2 reworked.

Actual modeled event	Quantity / rate	Cost
Fixed lot work	Once	600.00
Stage 1: blank and early machining	105 starts x 30.00	3,150.00
Three early rejects do not enter stage 2	102 survivors x 12.00	1,224.00
Two late rejects; two survivors require rework	2 reworks x 15.00, including recheck	30.00
Released output	100 accepted; 5 total scrap	5,004.00 / 50.04 each

Of the 105 starts, 98 pass without rework, two become accepted after rework, and five are scrapped. First-pass yield is 98/105 = 93.33%; final accepted yield is 100/105 = 95.24%. The exact count reconciliation is 98 + 2 + 5 = 105. No scrap recovery credit or unlisted replacement lot is assumed.

Charging all 105 starts both stages would produce 600 + 105 x 42 + 30 = 5,040, overstating cost by 36 because three early rejects never consume stage 2. Conversely, pricing 100 perfect parts gives 600 + 100 x 42 = 4,800 and misses 204 of actual resource cost. Stage-specific loss matters.

DO NOT DIVIDE AN ACCEPTED-PART QUOTE BY YIELD AGAIN

A supplier may already quote a fixed price for 100 conforming delivered parts and absorb its own process losses. This production-cost reconstruction is not permission to increase that buyer price by 1/yield. Confirm who bears which cost under the agreed terms.

Sources: [13] ASQ

22 / QUALITY ECONOMICS WITHOUT LOWERING THE ACCEPTANCE BAR

Price prevention against a defined avoidable loss

Use a cost-of-quality view to locate waste, not to justify knowingly shipping unacceptable parts.

Category	Examples in a CNC workflow	Accounting caution
Prevention	Requirement review, validated setup and process improvement.	Do not charge the same engineering task in two budgets.
Appraisal	Required inspection, testing and evidence review.	A smaller inspection bill is not automatically a better process.
Internal failure	Detected scrap, rework, sorting and repeated operations.	Allocate loss at the stage where it occurs.
External failure	Verified returns, replacement logistics and customer disruption.	Use supported exposure, not an invented catastrophic figure.

Consider a separate 1,000-part process study. Assume a supported planning defect probability of 0.03 and an avoidable incremental loss of 40 per defect. Expected loss is 1,000 x 0.03 x 40 = 1,200. A proposed control costs 500 and is hypothesized to reduce the probability to 0.01. Its modeled total becomes 500 + 1,000 x 0.01 x 40 = 900, an expected improvement of 300.

The minimum reduction needed to recover 500 is 500/(1,000 x 40) = 0.0125, or 1.25 percentage points. That is a target to test, not evidence the process will achieve it. Use a suitable experiment and enough production history to evaluate the probability change. If the loss per event depends on defect type or stage, replace the single 40 with separate categories.

The baseline production cost is common and excluded here; the 40 covers only genuinely incremental avoidable loss. If the same scrap or replacement expense is already included in a yield-adjusted ledger, do not add it a second time. Report both expected cost and the consequences that cannot responsibly be reduced to this arithmetic.

> **FUNCTION, SAFETY AND COMPLIANCE REMAIN GATES**
>
> An attractive expected-value calculation cannot authorize a nonconforming product, an unsafe process or a required inspection omission. The approved acceptance criteria do not change because a defect is cheap to replace.

Sources: [13] ASQ

23 / THREE HYPOTHETICAL SUPPLIER BIDS

Normalize the offer before ranking its unit price

Separate commercial comparison for 100 accepted parts of the same revision; these are not vetcnc quotations.

USD / complete lot scope	Bid A	Bid B	Bid C
Headline part price x 100	6,800	7,200	6,400
Nonrecurring charge	600	Included	450
Required finish	Included	Included	500 estimate
Required inspection evidence	Included	Included	200 estimate
Required packing	100	Included	100
Transport to same comparison point	400	250	350
Comparable subtotal	7,900	7,450	8,000 estimate
Subtotal / accepted part	79.00	74.50	80.00 estimate

B has the highest headline unit price but the lowest subtotal after the stated scope is aligned. C is not award-ready: missing finish and inspection entries have only buyer planning estimates. Obtain an inclusive revised quotation or a binding scope clarification before treating 8,000 as an actual offer.

All bids use the same currency, assumed accepted quantity and delivery point. Taxes and duties are excluded from every subtotal and must be evaluated for the actual transaction. Verify the selected trade term, named place and version, who arranges transport, and where responsibility changes. Do not compare an origin-only price with a delivered price as if their scope were identical.

Also align payment timing, quality obligations, revision, schedule, packaging, tooling ownership and validity. If one route has a real difference in failure exposure or delay risk, show that as a separate evidence-based scenario rather than hiding it inside the unit price.

INCLUDED IS NOT THE SAME AS FREE

An included setup or inspection cost may be recovered in the unit price. Its accounting presentation does not establish superior efficiency. Rank complete, technically acceptable offers first; then discuss the drivers that could change them.

Sources: [15] ICC

24 / WHY A PRODUCTION SAVING IS NOT A PROMISED PRICE CUT

Cost, markup and margin must use the right denominator

Separate the supplier's resource model from its commercial decision and the buyer's approved budget.

56.00	70.00	20%
MODELED COST	25% MARKUP PRICE	MARGIN AT 70

Illustrative conversion of 56.00 cost	Arithmetic	Selling price
25% markup on cost	56 x 1.25	70.00
Gross margin at a price of 70	(70 - 56) / 70 = 20%	Not a 25% margin
Price for a 25% gross margin	56 / (1 - 0.25)	74.6667

The 56.00 is the CT-120 candidate modeled production cost at 100 pieces, excluding the separate 900 change effort. The rates above are purely illustrative. They are not vetcnc pricing policy, an industry margin benchmark or a recommendation for a commercial agreement.

A supplier may need to recover engineering support, credit terms, warranty obligations, schedule commitments and other costs not in your factory model. Conversely, a loaded rate may already include some of those items. Ask what the cost basis includes before attempting to derive a selling price from it.

If the buyer has a valid fixed-price order, an internal cycle improvement does not automatically change that contract. Ask for a revised offer for the approved design and quantity. If a supplier proposes sharing verified savings, define the baseline, eligible changes, validation cost and measurement period in writing.

KEEP THE UNITS OF THE CLAIM HONEST

Say "the modeled factory cost decreases by 1,800 for this lot" until there is a commercial offer. Say "the purchase price decreases by X" only after the comparable quote or order confirms it. Do not present theoretical capacity value as cash saved.

25 / BUYING ONCE VERSUS STAGED RELEASES

Order quantity should follow demand and revision stability

Separate annual-policy example with a known need for 500 usable parts.

Simplified policy comparison	One run of 500	Five runs of 100
Variable production, 40 / part	20,000	20,000
Setup, 500 per run	500	2,500
Procurement cash for the original 500	20,500	22,500
Average cycle inventory, units	250	50
Illustrative annual holding cost	2,000	400
Comparable cost metric	22,500	22,900

The holding calculation is average cycle stock x 40 inventory-value basis x 20% per year. Demand is uniform, supply arrives in complete lots at the required replenishment time, and safety stock, shortages and changing lead times are excluded. The 20% is a teaching assumption, not a financing rate. Replace the valuation and policy model with your organization's actual conventions.

The single run is only 400 better in this defined metric. Now suppose a revision makes 20 more units from that policy unusable, while the staged policy avoids those units through a timely release change. A quoted 900 replacement order is required to meet the same 500 usable-part demand. Ignoring other unchanged costs, the single-run metric becomes 23,400, which is 500 worse than the staged option.

Do not also add the old units' book write-off as another procurement expense: their purchase cash is already in 20,500. Keep accounting write-offs, replacement cash and holding charges distinct. Similarly, future scheduled releases on a blanket order may still carry repeated setup and finishing minimums.

THE BUYING QUESTION IS NOT SIMPLY "WHAT IS THE LOWEST UNIT PRICE?"

Ask how much demand is committed, when the revision will freeze, who owns stored stock, and which releases remain cancellable. A forecast is not automatically a purchase commitment.

26 / FINISHED STOCK, WORK IN PROGRESS AND UNCOMMITTED DEMAND

Control revision exposure before authorizing more work

A controlled change can save money even before it changes the machining cycle.

200-piece order status	Quantity	Cumulative cost / piece	Exposure
Finished bodies	60	55.00	3,300
Machined, not yet finished	50	42.00	2,100
Cut blanks only	40	12.00	480
Uncommitted future starts	50	0.00	0
Total potentially affected resource value	200	Not a loss estimate	5,880

The 5,880 is work already invested, not an automatic write-off. Review compatibility by stage and identity. Finished parts may be usable, reworkable or obsolete; machined parts may still accept a controlled change; uncut stock may be reusable. Avoid ordering a blanket scrap action based only on the existence of a new revision.

Suppose the approved disposition reworks all 60 finished bodies at 8 each, redirects work in progress with 250 of incremental programming, and requires ten replacement cut blanks at 12 because ten old blanks cannot support the new geometry. Future incremental cash is 480 + 250 + 120 = 850. The obsolete blanks' existing book value is tracked separately, not added again to this future-cash subtotal.

Document an effective serial or lot boundary, the status of each affected quantity and the files that govern it. Confirm which operations must stop while review is pending. A verbal request to "use the new drawing" does not resolve already finished material, open subcontract work or parts already in transit.

Change-release question	Record before restart
Which identities change?	Old revision, new revision, affected quantities and physical location.
What is authorized for each state?	Use as approved, rework, replacement or hold; responsible approval.
How is the outcome verified?	Reinspection scope, updated evidence and reconciled final quantity.

SEPARATE SUNK COST FROM THE DECISION AHEAD

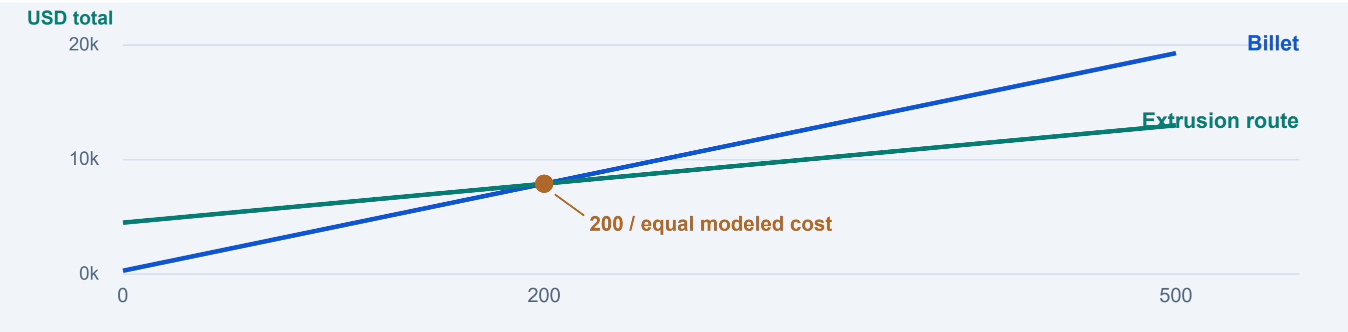
An old programming invoice does not disappear. Compare the future costs and consequences of the remaining feasible options, while retaining the financial record of what has already been spent.

Sources: [17] ASME

27 / BILLET MACHINING VERSUS AN EXTRUSION-BASED ROUTE

Change the starting process when the geometry and volume fit

Separate constant-section rail example. A closed CT-120 pocket does not become an extrusion by relabeling it.



Accepted rail quantity	Billet: 300 + 38Q	Extrusion route: 4,500 + 17Q
100	4,100	6,200
200	7,900	7,900
500	19,300	13,000

The extra fixed cost is 4,200 and the recurring difference is 21, so equality occurs at 200 accepted rails. Above 200, the modeled extrusion route is cheaper; at 201 it first wins by 21. The fixed terms include the stipulated tooling, setup and qualification, and the variable terms include all stipulated finishing and secondary machining. No extra cost is hidden outside those two route definitions.

Check minimum extrusion purchase, leftover lengths, cut yield, alloy/temper, straightness, twist, section tolerances and machining stock. Functional seats and hole patterns may still need machining. A nominally similar profile does not prove equivalent properties or assembly performance.

If a minimum raw-stock commitment exceeds usable demand, add that commitment and its recoverable remainder value explicitly. If die revisions or a second qualification are likely, show those as separate scenarios. A short delivery deadline can also rule out a route that is attractive at steady volume.

> **OTHER NEAR-NET ROUTES NEED THEIR OWN EVIDENCE**
>
> Casting, forging, additive manufacture and fabricated assemblies have different tooling, geometry, material and validation consequences. Do not reuse this crossover as a generic switch-to-another-process threshold.

Sources: [16] Aluminum Extruders Council

28 / ONE MACHINED BODY VERSUS AN ASSEMBLED ALTERNATIVE

A split design must save more than machining time

Separate concept study. Assembly creates new interfaces and verification obligations.

Cost per accepted assembly	One-piece body	Two-piece candidate
Machined components	95.00	28.00 + 31.00
Fasteners / joining consumables	Included in body scope	4.00
Additional assembly work	0.00	12.00
Additional interface verification	0.00	6.00
Total recurring scope	95.00	81.00

Assume both concepts can pass the actual requirements and that 1,800 of additional design and qualification effort is necessary for the split concept. The recurring difference is 14.00, giving equality at 1,800/14 = 128.57 assemblies. At 100, the one-piece total is 9,500 while the alternative is 8,100 + 1,800 = 9,900. At 500, the comparison is 47,500 versus 42,300, a 5,200 advantage for the candidate.

New interface risk	What to establish before approval
Stiffness, fatigue and load transfer	Qualified joint design and behavior under the actual loading and environment.
Leakage, cleanliness and service access	Applicable sealing, cleaning, retention and maintenance requirements.
Assembly stack and repeatability	Tolerance analysis and a repeatable assembly/verification route.
Corrosion, loosening or wear	Compatible materials, protection and application-appropriate validation.

The comparison includes only the stipulated scope. Add recurring seal replacement, maintenance or service labor if the product requires it. If the two-piece option fails a functional gate, it is not an economic alternative at any volume, regardless of the arithmetic.

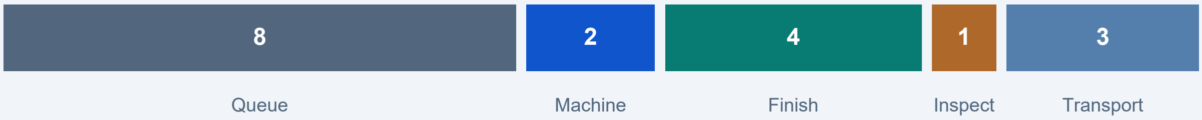
DO NOT HIDE ASSEMBLY COSTS IN ANOTHER DEPARTMENT

Component purchasing, line assembly and final test may have different owners. Reconcile them on the same accepted-assembly denominator before claiming a saving.

29 / ALLOCATED COST, AVAILABLE CAPACITY AND CASH

Turn shorter cycles into a benefit that can actually be realized

A time improvement can matter without producing an immediate reduction in paid labor or machine ownership cost.



18 serial days: reducing machining by 1 day yields 17 days, not 9.

For CT-120, the recurring cycle change from 32 to 21 min across 100 parts releases 1,100 min, or 18.33 machine-hours. At the model rate of 75/h, that is 1,375 of allocated machine-cost reduction already included on page 20. The separate one-hour setup reduction is not included in these 18.33 hours.

If the machine remains idle and payroll, lease and other fixed commitments stay unchanged, the same 1,375 is not automatically cash saved. If that machine is a real bottleneck with qualified demand waiting, the time can have opportunity value. For example, 18.33 hours at three additional saleable parts per hour yields 55 parts; at a justified contribution of 12 per additional part, the capacity opportunity is 660. Do not add this as another guaranteed cash saving to the original ledger.

Lead-time example: serial stages	Before	After faster machining
Queue / machining / finish / inspection / transport	8 + 2 + 4 + 1 + 3 days	8 + 1 + 4 + 1 + 3 days
Elapsed order lead time	18 days	17 days

Halving the two-day machining stage removes only one day from this explicitly serial schedule. To improve delivery further, investigate queues, handoffs, subcontract availability and transport. If stages overlap, model the actual critical path rather than adding all durations. A percentage cycle reduction is not the same percentage reduction in customer lead time.

CHOOSE ONE CONSISTENT BUSINESS CASE

For a buyer, confirm the revised price and delivery. For a manufacturer, distinguish avoidable expense, allocated cost and productive capacity. Do not count the same released hour as both a cost saving and an independent revenue benefit without reconciling the model.

30 / A COMPLETE TECHNICAL-COMMERCIAL REQUEST

Ask for specific alternatives instead of an unexplained discount

Give the supplier enough freedom to propose a route while retaining clear design authority.

WORKED WORDING

Subject: CT-120 Rev B candidate - comparable cost review

Please quote the released baseline and the attached candidate separately for 100 accepted bodies, using the same required material, finish, packing, acceptance records and delivery point. Do not substitute material or remove functional requirements.

For the candidate, review the R6 / 12-deep pocket, proposed cut blank, revised locating route and identified non-contact texture zones. Flag any clash with tool access, final mass, insert clearance, workholding or finish.

Please separate one-time engineering/fixture/validation charges, recurring part price, batch minimums and transport. State which charges recur on a repeat run and who owns retained tooling. Provide a practical cycle/setup breakdown where available, or identify which items are estimates.

No drawing change is approved by this pricing request. We will release the revised files only after design review and agreed validation. Reply to ruofan@ruojufanxing.com.

Supplier response	Buyer action
Lower price with unchanged explicit scope	Check validity, evidence, repeat-order assumptions and delivery conditions.
Lower price only if a requirement changes	Route the proposed change to the design owner before ordering.
No material price improvement	Ask which remaining operation or commercial constraint dominates; keep a useful technical improvement separate from a price claim.
Incomplete scope or unexplained exclusion	Request a revised offer. Do not fill gaps with optimistic assumptions.

If a detailed internal cost breakdown is commercially sensitive, ask for comparable alternative quotations and the decisions that cause the differences. A supplier need not disclose every margin input for you to evaluate whether an approved change is useful.

DOCUMENT THE DECISION THAT WAS ACTUALLY MADE

Record selected revision, quantity, scope, exclusions, validation owner and effective lot. Retain rejected alternatives and their reasons so the same unapproved substitution does not return on a later reorder.

Sources: [17] ASME

31 / COMPLETED TRIAL-RECORD EXAMPLE

Replace estimates with a controlled pilot and update the model

The following is a fictional demonstration of the review method, not a vetcnc production trial.

Trial record	Example entry
Identity and controls	CT-120 candidate; one controlled file set; qualified operator, machine, fixture and method recorded.
Occupied times for ten parts, min	20.8, 21.5, 21.2, 22.0, 21.1, 21.4, 21.7, 20.9, 21.8, 21.6
Observed mean / range	21.4 min / 20.8 to 22.0 min; setup timed separately.
Illustrative quality summary	10/10 meet their linked feature checks; body masses 0.540-0.548 kg; insert, finish and edge checks accepted. Individual records retained.
Cost update using 21.4 min	Machine 26.75/body; recurring pre-finish cost 45.25/body.
Updated modeled 100-part production	725 + 100 x 45.25 + 400 = 5,650.
Including 900 incremental validation	6,550 total; 850 net improvement versus 7,400.

The mean time is 0.4 min above the original 21-min budget, adding 50 to the 100-part model. Report the updated result instead of continuing to advertise 1,800 of gross production savings. The new gross difference is 1,750; the first-lot net difference after the stipulated change effort is 850.

A ten-part pilot can expose route problems and improve the time estimate, but does not establish long-term yield, tool life or capability. Include representative material and finish conditions, planned tool wear states, and the required measurement method. A pilot run with extraordinary manual support is not a fair production-rate estimate.

The 900 validation budget is assumed to include this incremental pilot/validation work; do not add it again. If actual trial expense, fixed cost or inspection time changes, update those entries too. Decide whether the remaining advantage justifies a controlled first production lot and what monitoring will accompany it.

> **CLOSURE REQUIRES MORE THAN A FASTER CYCLE**
>
> Release only after design and quality approvals, cost reconciliation, updated files and an effective revision boundary. If the candidate fails a functional check, return to design review rather than trading the failure for a lower price.

Sources: [14] NIST / SEMATECH | [17] ASME

CALCULATION DESK REFERENCE

Keep the arithmetic attached to its assumptions

Use the worked page before applying a formula to another part, route or purchasing policy.

Expression	Use and limits	Page
C(Q) = F + Qv + B(Q)	One defined lot and route; do not silently equate starts with accepted output.	3, 5
Machine cost = minutes x rate / 60	Consistent occupied-time scope and rate inclusions.	6
B(Q) = max(minimum, bQ)	Only where the actual batch charging rule has this form.	7, 16
vf = n x zc x fz	Feed, mm/min; actual motion can be below programmed feed.	6
Removal rate = ap x ae x vf / 1,000	cm3/min when lengths are mm; ideal engaged cut, not complete cycle.	6
Route equality Q = (F2-F1)/(v1-v2)	Requires v1 > v2; same scope and no omitted step charges.	8, 29
Net saving = baseline - candidate - E	E is only incremental effort not already in either ledger.	21
Cost / accepted part = total cost / G	G is actually accepted output; retain stage-specific losses.	23
Markup = (P-C)/C; margin = (P-C)/P	Different denominators. Price is not necessarily cost plus a fixed rate.	26
Worst-case gap variation = sum of bounds	For the explicit one-dimensional model; include other relevant physical effects.	13

Symbols: Q = the quantity defined for the comparison; F = fixed cost for that scope; v = recurring cost before separately modeled batches; B = batch charge; E = incremental change effort; G = accepted output; P = selling price; C = cost. For feed: n = rev/min, zc = effective teeth, fz = mm/tooth, ap = axial depth and ae = radial engagement.

FINAL RELEASE TEST

Same function? Same accepted-output scope? Complete route? Non-overlapping costs? Validated changes? Credible demand? Approved revision? If any answer is unresolved, report a conditional estimate rather than an achieved saving.

Sources: [01] Sandvik Coromant

APPENDIX A / REUSABLE WORKSHEET

Your comparable cost worksheet

Use one accepted-output scope. Record units and exclusions; attach the detailed quote or route ledger.

Part / revision / accepted quantity

Currency / delivery point / schedule

Fixed costs / what repeats

Recurring items / rates / units

Finish minimums / batch rules

Yield / rework / denominator basis

Baseline total / source / date

Candidate total / source / date

Incremental validation, exclusions and net comparable result

- [ ] Both alternatives cover the same required function and accepted quantity.
- [ ] Costs and savings are counted once, on a consistent basis.

Save and reopen in a form-capable PDF reader. These fields do not calculate, authorize a change or transmit data. Attach detailed records separately.

APPENDIX B / REUSABLE WORKSHEET

Your design-change business case

Connect the proposal to function, evidence and authority before claiming an achieved saving.

Part / baseline revision / proposal

Function and requirements to preserve

Specific geometry / route changes

New risks / affected interfaces

Cost delta / assumptions / sensitivities

Trial scope / acceptance evidence

Committed demand / revision horizon

Design / quality / commercial owners

Observed results, updated savings, approval reference and effective lot

- [ ] The complete changed route and all affected requirements are verified.
- [ ] Approved files, quantities and commercial scope agree before release.

Save and reopen in a form-capable PDF reader. These fields do not calculate, authorize a change or transmit data. Attach detailed records separately.

REFERENCE REGISTER / 1

Primary sources and their scope

Public sources checked 20 September 2026. Linked titles open the source; all cases, calculations and graphics are original.

[01] Sandvik Coromant

Formulas and definitions for milling - metric

Primary toolmaker reference for feed and removal-rate relationships. The numerical inputs in this guide are teaching assumptions, not recommended cutting data.

[02] Sandvik Coromant

Milling inside corners

Cutter engagement and corner strategy. No drawing change is authorized by a tooling recommendation; the design owner must approve revised geometry.

[03] Sandvik Coromant

How to reduce vibration in milling

Tool, holder, workpiece and fixture contributions to stability. No universal overhang or wall-thickness limit is adopted here.

[04] Sandvik Coromant

Shoulder milling

Includes strategies for thin deflecting walls and bases. Application-specific cutting recommendations are not general drawing requirements.

[05] Sandvik Coromant

Milling different materials

Material-specific machining considerations. This is not permission to substitute an alloy, temper, product form or purchase specification.

[06] Protolabs

How to Reduce CNC Machining Costs

Supplier discussion of corners, features and manufacturing choices. Its equipment limits, service defaults and savings claims are not vetcnc commitments.

Toolmaker guidance supports process reasoning. It does not establish the conditions, capability, rate, tool life or commercial terms of an unrelated supplier. The guide intentionally avoids universal cost-per-hour and percent-savings benchmarks.

REFERENCE REGISTER / 2

Primary sources and their scope

Public sources checked 20 September 2026. Linked titles open the source; all cases, calculations and graphics are original.

[07] Protolabs Network

14 proven design tips to reduce the cost of CNC machining

Commercial DFM guidance used for cost-driver context only. No quoted price, universal size rule or quantity discount is imported into this guide.

[08] Renishaw

Improve my process

Primary probing supplier context for setup and process control. Its advertised improvement percentages are not used as forecast savings.

[09] ASME

Y14.5-2018 (R2024) - Dimensioning and Tolerancing

Public edition record and scope for communicating dimensional and geometric requirements. Consult the full contractually agreed standard for interpretation.

[10] ISO

ISO 21920-1:2021 - Indication of surface texture

Public scope and edition record; catalogue shows revision work in progress. This guide does not reproduce the standard or prescribe a universal surface-texture default.

[11] Aluminum Anodizers Council

Anodizing Reference Guide

Industry guidance on coating and alloy considerations. Agree actual dimensional effects, masking, appearance and acceptance with the processor; no fixed buildup ratio is assumed.

[12] Sandvik Coromant

How to select the right tap

Toolmaker explanation of material, blind/through holes and tap selection. No thread engagement length or fastener strength rule is inferred.

Catalogue records establish public scope and edition context, not access to every licensed requirement. Apply the full agreed standards and project documents. Supplier guidance is not a replacement for design authority or functional validation.

REFERENCE REGISTER / 3

Primary sources and their scope

Public sources checked 20 September 2026. Linked titles open the source; all cases, calculations and graphics are original.

[13] ASQ
Cost of Quality
Prevention, appraisal and internal/external failure categories. Monetary examples and probabilities in this guide are original, hypothetical scenarios.

[14] NIST / SEMATECH
What is Process Capability?
Capability relates process variation to specifications under model and data assumptions. A short successful pilot is not evidence of long-term capability.

[15] ICC
Incoterms 2020
Official overview of allocation of transport-related costs, risk and obligations. No customs classification, duty rate, tax treatment or contract advice is supplied here.

[16] Aluminum Extruders Council
Aluminum Extrusion Tolerances
Public design context for extrusion dimensional and geometric tolerances. No proprietary tolerance table or supplier-specific capability is reproduced.

[17] ASME
Y14.100-2017 - Engineering Drawing Practices
Public scope covers drawing preparation and revision. Change-control examples are original working aids, not copies of standard forms.

[18] NIST
MCG for Supply Chain Statistics
NIST describes an industry-level input-output tool. It is cited to clarify scope: sector statistics are not a custom-part quote or a validated shop-hour rate.

The examples are decision aids, not quotations, engineering approvals or audited business results. Replace assumptions with project-specific evidence. No named institution endorses vetcnc or the original numerical cases in this guide.

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CNC MANUFACTURING

FROM A LOWER NUMBER TO A BETTER DECISION

Ask which change removes unnecessary work.

Share the released drawing, material, finish and quantity. Explain which interfaces must stay fixed and which areas are open for review.

01 **DEFINE**

The function, accepted quantity and complete commercial scope.

02 **COMPARE**

A clear baseline and a specific, costed alternative.

03 **VERIFY**

The changed route, required evidence and approved revision.

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