Ghost Key Mission Lab

Plan a route, support your choices with physics, and use the recorded flight to improve your next attempt. You choose the route; these pages guide the decisions.

CADET / GROUP _____ CLASS _____ DATE _____

ATTEMPT ID _____ PARTNERS _____

Your assignment

Your Sol Heirs Partisan carries an infiltration team to an automated CN relay. Cross the minefield, disable both torpedo batteries, and deliver the team without disabling the station. The team plants a dormant covert access device for a later operation; boarding is resolved in the completion report.

Successful docking: both turrets disabled, ship and station operational, and the ship within 120 m of the docking point at a speed of 5 m/s or less for five consecutive seconds.

Take command of this flight

Finish the guided opening with the **Ghost Key Prelab Flight Manual**, then select **Take command**. Continue the same attempt: t = 35 s, p = (−1900, 400) m, v = (0, 0) m/s, 100 hull, five rounds. M04 is cleared; both turrets remain active.

Copy your actual handoff: t = _____ s; p = (_____, _____) m;

v = (_____, _____) m/s; hull _____; rounds _____; cleared targets _____.

If you left guidance early, use your actual readouts. Keep the same attempt ID.

Keep a flight record you can learn from

Read → choose → calculate → predict → commit → execute → compare → revise.
Keep first predictions visible, even when they are wrong. Label later versions separately. Planning, reading, and replay do not advance the live mission clock.

Use the first segment guide on page 4, then copy the reusable sheets as needed. Keep the same segment and weapon IDs on your map, worksheets, and digital record. You may also use the Student Calculation Record spreadsheet.

Packet route: Flight rules 2 · Original map 3 · First segment 4 · Reusable segment 5 · Main rounds 6 · Point defense 7 · Docking 8 · Observations 9 · Revision and debrief 10 · Revision map 11 · Contact coordinates 12

Your evidence should show the reasoning behind your decisions. Mission completion alone does not verify the calculations or explanations.
Worksheet shorthand: G/U = givens/unknowns; E = equations; S/S = substitute/solve.

Read the ship and mission limits

Use SI units and fixed world axes: +x right, +y up. A camera rotation changes the view, not the physics.

Readout or limit	Value	Use it to check
Handoff position	(−1900, 400) m	After the guided opening at 35 s
Handoff velocity	(0, 0) m/s	At rest after the braking burn
Total acceleration	$\sqrt{(a_x^2 + a_y^2)} \le 4$ m/s²	The combined command
Mission bounds	x: ±4000 m; y: ±3000 m	The ship center's location
Boundary allowance	15 s total outside	Cumulative time; it does not reset
Partisan hull	102.72 × 42.88 m	The whole hull; bow stays along +x

Two components share one limit. $a_x = 3$ and $a_y = 4$ m/s² would give 5 m/s², above the limit. Coasting preserves velocity. This mission has no drag, gravity, recoil, or automatic braking.

Threats and equipment

System	Planning rule
Mines	46 remain; M04 was cleared from the original 47. Radius 26 m; trigger radius 190 m. Any hull part entering a trigger circle activates a mine. Check between endpoints.
Main weapon	Five of six rounds remain. Relative launch speed greater than 0 and at most 600 m/s; shots at least 10 s apart. One direct hit disables a mine or turret.
Point-defense laser	Aim coordinates lock when charging starts. Fires 10 s later; range 2000 m; shots at least 10 s apart. Only torpedoes can be destroyed. Solids block the beam.
Turrets and torpedoes	Acquisition range 3300 m; first launch after 10 s; later launches at least 30 s apart while in range. Torpedoes start at 100 m/s, accelerate at 4 m/s² in a fixed direction, and last 45 s.

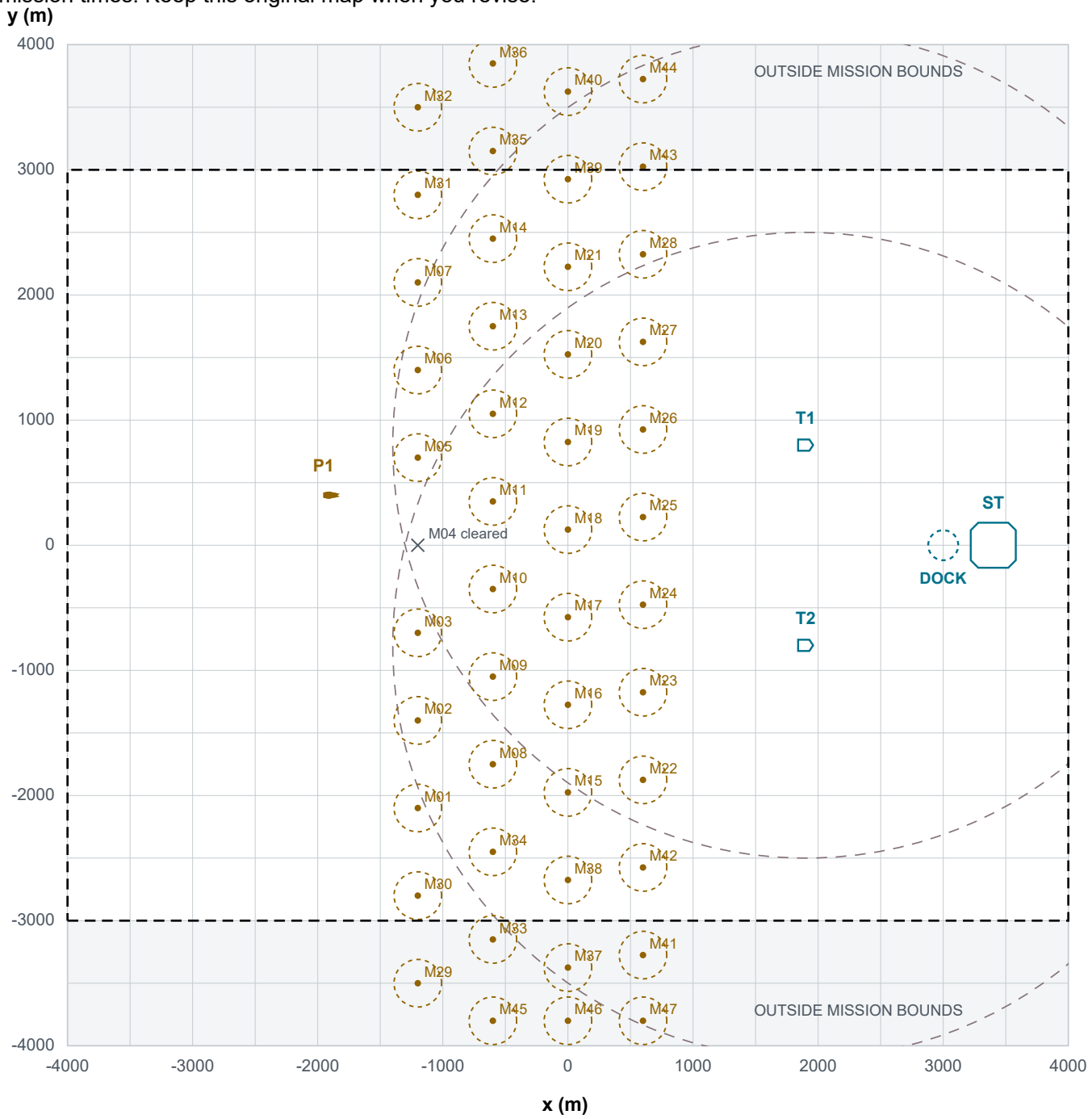
Torpedoes do not home. Their launch aim assumes your ship coasts. Main rounds can hit the station; each hit removes 50 of its 100 health points. Protect the station and check each shot's path.

Position x, y · m **Velocity v_x, v_y · m/s** **Acceleration a_x, a_y · m/s²**
Mission time t and interval Δt · s **Displacement Δx, Δy · m**

Pairs list x first, then y: p = (x, y) for position; v = (v_x, v_y) for velocity.

Choose a route through the field

Attempt _____ Sketch your intended route in pencil. Mark segment endpoints, intermediate positions, and mission times. Keep this original map when you revise.



Map key: P1 = handoff ship at 35 s; × M04 = cleared; M = mine; T = turret; ST = station. Small dashed circles: mine triggers. Large dashed circles: turret acquisition. Black dashed rectangle: mission bounds. Dock center: (3000, 0) m.

Each square is 500 m × 500 m, with equal x/y scale. Enlarged game icons do not show clearance. Mark your closest approach to a hazard and explain that check on page 4.

Plan your first independent segment

Choose a useful first waypoint or maneuver on your map. You decide the commands. This guide separates the burn from the coast so both axes use the same intervals.

G / U: After the opening, $p_i = (-1900, 400)$ m and $v_i = (0, 0)$ m/s at 35 s. Read current telemetry if different. Continue segment IDs from L4; find final x, y, v_x, v_y.

What should this first segment accomplish, and which hazard or clearance will you check?

Choose commands: total duration T = _____ s; burn t_b = _____ s;

coast $t_c = T - t_b$ = _____ s; a_x = _____ m/s²; a_y = _____ m/s².

E Calculate the burn, then carry its state into the coast

i = segment start; b = burn end; f = segment end. Acceleration is constant during the burn and zero during the coast. Δ means change; adjacent symbols multiply.

$v_{x,b} = v_{x,i} + a_x t_b$

$\Delta x_b = v_{x,i} t_b + \frac{1}{2} a_x t_b^2$

$x_b = x_i + \Delta x_b$

$x_f = x_b + v_{x,b} t_c$; $v_{x,f} = v_{x,b}$

$v_{y,b} = v_{y,i} + a_y t_b$

$\Delta y_b = v_{y,i} t_b + \frac{1}{2} a_y t_b^2$

$y_b = y_i + \Delta y_b$

$y_f = y_b + v_{y,b} t_c$; $v_{y,f} = v_{y,b}$

x direction
S / S Substitute; show burn, coast, and units.

y direction
S / S Substitute; show burn, coast, and units.

First prediction before execution

Mission time	Position / m	Velocity / m/s
t = _____ s	x = _____ y = _____	v_x = _____ v_y = _____

Check before committing: $0 \le t_b \le T$; $\sqrt{(a_x^2 + a_y^2)} \le 4$ m/s². Trace intermediate positions and the whole hull near hazards. A straight displacement arrow does not describe every accelerated path.

Flight segment calculation sheet

Segment ID _____ Attempt _____ Start mission time _____ s. Carry forward the previous segment's predicted state while planning; compare with observations after execution.

Givens and commands	x direction	y direction
Starting position / m	x_i = _____	y_i = _____
Starting velocity / m/s	$v_{x,i}$ = _____	$v_{y,i}$ = _____
Burn acceleration / m/s²	a_x = _____	a_y = _____

One shared clock: total T = _____ s; burn t_b = _____ s; coast t_c = _____ s.

Burn ends at mission time _____ s; segment ends at mission time _____ s.

E Write the equations before substitution. Use page 4 if you need the burn/coast model.

x direction
S / S Show burn, coast, and units.

y direction
S / S Show burn, coast, and units.

First prediction before execution

Mission time	Position / m	Velocity / m/s
t = _____ s	x = _____ y = _____	v_x = _____ v_y = _____

Name the closest hazard or boundary. How will you check clearance along this segment, including between endpoints?

Plan a main-round shot

Choose a target and a launch time. Predict your ship's position and velocity at launch before calculating the relative velocity you will enter.

Recall your opening shot at M04

At t = 10 s your ship was at (−2800, 100) m with velocity (60, 20) m/s. M04 was at (−1200, 0) m. The chosen 5 s flight interval gave displacement (1600, −100) m.

$v_{round,x}$ = 1600 / 5 = 320 m/s; **$v_{round,y}$ = −100 / 5 = −20 m/s**

u_x = 320 − 60 = 260 m/s; **u_y = −20 − 20 = −40 m/s**

Relative speed ≈263 m/s, within the 600 m/s limit. The round inherited ship velocity at release. It hit the mine surface near 14.92 s, before the 15 s center-arrival time.

Your shot

Weapon ID _____ Target _____ Why this target? _____

Fire at mission time _____ s. Chosen flight interval τ = _____ s; impact time _____ s.

Givens at firing	x component	y component
Ship position / m	_____	_____
Ship velocity / m/s	_____	_____
Target position / m	_____	_____

E: $v_{round,x} = (x_{target} - x_{ship}) / \tau$; $u_x = v_{round,x} - v_{ship,x}$. Repeat for y.
For a moving target, use its predicted position at impact. τ is time after launch, not the mission clock.

x direction
S / S Solve the relative component to enter.

y direction
S / S Solve the relative component to enter.

Enter: u_x = _____ m/s; u_y = _____ m/s. Relative speed = _____ m/s.

Check: speed limit; ammunition; 10 s between main shots; first object along the path; station clearance. Record the observed result on page 9.

Plan point defense from telemetry

Pause and read the incoming torpedo's position, velocity, and acceleration. Choose when charging begins, then predict both the torpedo and your ship at firing.

Timing model: telemetry at 40 s; charge starts at 42 s; firing is at 52 s. Predict forward **12 s** from that telemetry, even though the charge lasts 10 s.



Aim coordinates lock when charging starts. The beam fires from the ship's position **10 s later** toward those coordinates. It does not track the target. Check future range and a clear line of sight.

Weapon ID _____ Torpedo ID _____ Telemetry time t_0 = _____ s

Charge start = _____ s; fire time = _____ s; prediction interval Δt = _____ s.

Read or predict	x component	y component
Torpedo position at t_0 / m	_____	_____
Torpedo velocity at t_0 / m/s	_____	_____
Torpedo acceleration / m/s²	_____	_____
Your ship position at firing / m	_____	_____

E: $x_{torpedo,f} = x_0 + v_{x,0}\Delta t + \frac{1}{2}a_x(\Delta t)^2$; repeat for y. Use the torpedo's signed telemetry components. Calculate your ship's position through its own burn/coast intervals.

x direction
S / S Predict the torpedo's firing-time position.

y direction
S / S Predict the torpedo's firing-time position.

Aim x = _____ m; **Aim y** = _____ m.

Range at firing = $\sqrt{[(x_{aim} - x_{ship,f})^2 + (y_{aim} - y_{ship,f})^2]}$ = _____ m.

Check: range ≤2000 m; beam unblocked; target still present; 10 s between laser shots.

Plan a controlled arrival

Plan the slowdown before reaching the dock. An engine-off command preserves velocity; docking requires a low total speed and a continuous stay inside the marked zone.

Dock condition	Required value
Dock center, not station center	(3000, 0) m
Distance from dock center	$\sqrt{[(x - 3000)^2 + y^2]} \le 120$ m
Total speed	$\sqrt{(v_x^2 + v_y^2)} \le 5$ m/s
Continuous qualifying time	5 s; both turrets disabled; ship and station operational

Check the combined speed. Velocity (3, 4) m/s has speed 5 m/s. Velocity (4, 4) m/s has speed about 5.66 m/s and is too fast. Low x velocity alone is not enough.

G / U: arrival burn starts at t = _____ s; p = (_____, _____) m;

v = (_____, _____) m/s. Choose burn duration _____ s (>0) and final velocity (_____, _____) m/s.

E: $a_x = (v_{x,f} - v_{x,i}) / t_b$; $\Delta x = v_{x,i}t_b + \frac{1}{2}a_x t_b^2$; $x_f = x_i + \Delta x$. Repeat for y. Then check $\sqrt{(a_x^2 + a_y^2)} \le 4$ m/s².

x direction
S / S Calculate braking and the predicted endpoint.

y direction
S / S Calculate braking and the predicted endpoint.

Predicted entry: time _____ s; position (_____, _____) m; speed _____ m/s.

Proposed hold interval: _____ s to _____ s. Commands during the hold: _____

How will the ship remain within both the distance and speed limits for the whole 5 s? Check intermediate motion, not just the entry point.

Execute and compare the evidence

Attempt _____ Segment / weapon ID _____ Planned comparison time _____ s. Preserve the first prediction before executing.

Before you run

□ Enter predicted final x, y, v_x, and v_Y in **Flight**, then commit the route.

□ Enter weapon orders separately; check launch/charge times and units.

□ Check the map, whole-hull clearance, ammunition, and arrival plan.

Execute the opening plan. First defense acquisition pauses it automatically; later execution runs for at most 10 s at a time. Pause to inspect the telemetry. If a pause occurs early, compare at that same mission time or continue to the planned endpoint before judging the final prediction.

Quantity at t = _____ s	First prediction	Observed	Observed − predicted
x / m			
y / m			
v_x / m/s			
v_Y / m/s			

What matched or differed? Give a numerical comparison with units and a possible explanation.

Event evidence	Record the time, ID, and observation
Shot, intercept, or hazard	
Clearance or docking check	

Use **Review** to pause or scrub the recorded flight. Export before a revision or device change. The opening and lab share one attempt, with original predictions. Mark L1–L3 as prelab and later segments as independent work. Saves are local to this browser.

Revise the plan and explain why

Export the original attempt. Start revised attempt resets to t = 0; repeat the guided opening for the same 35 s baseline. Keep the original map and predictions, then test a specific change to your independent plan.

Original attempt _____ Revised attempt _____ Segment / weapon ID _____

Decision to change	Original value / choice	Revised value / choice
Burn, coast, route, or shot		

Before the revision runs: what measurable improvement do you predict, and why?

Route revision. Explain one route revision using coordinates and hull clearance. Compare the original prediction with recorded motion.

Ammunition tradeoff. Explain one ammunition decision. Which target or shot did you prioritize, and what was the consequence?

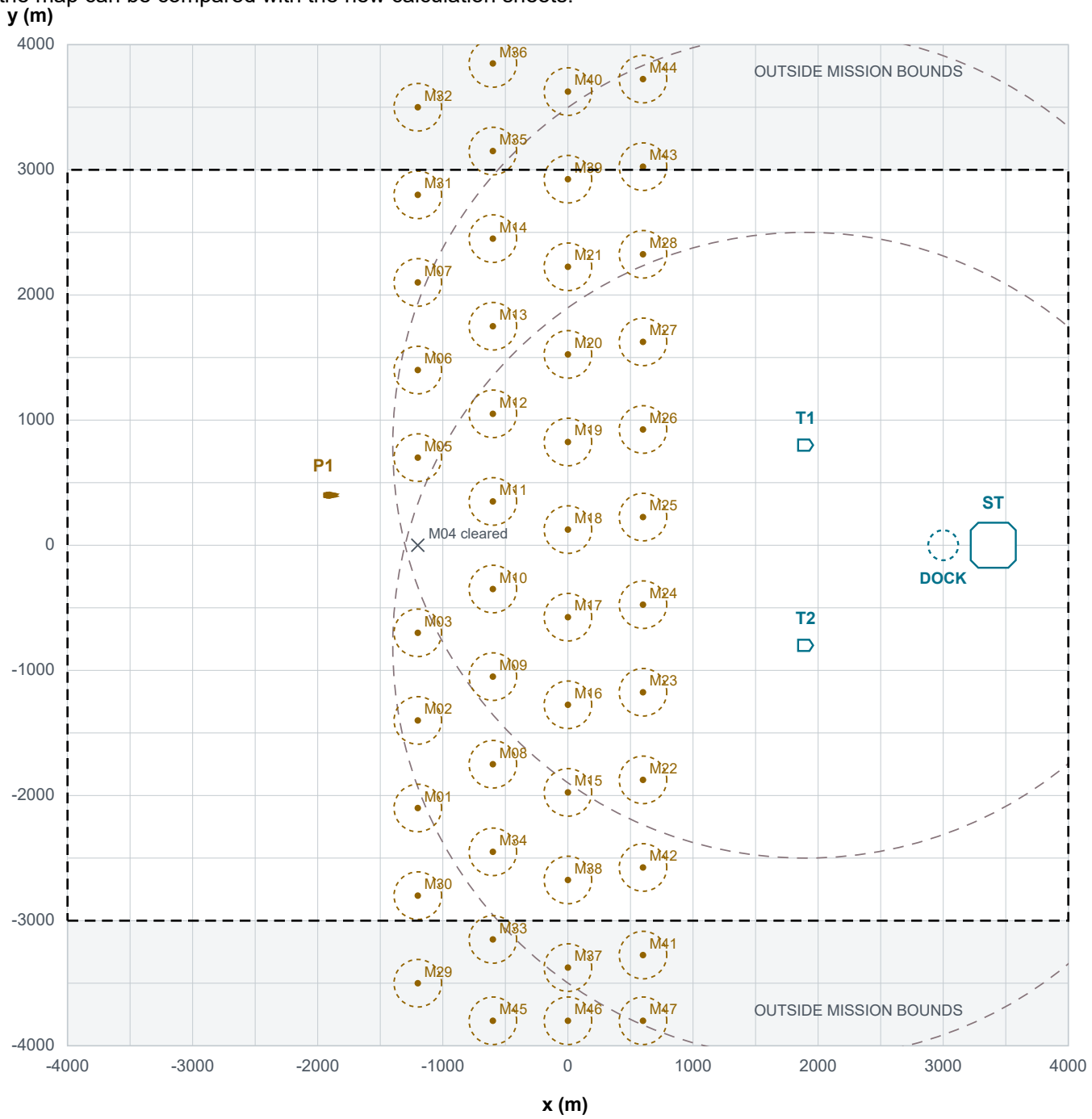
Timing decision. Explain one timing decision using velocities and mission times. Consider a burn, an inherited launch velocity, a 10 s laser charge or controlled docking.

Evidence to submit: original and revised maps; movement and weapon calculations; preserved predictions and observations; exported mission attempts; these explanations. Include a docking result or an explanation of what still prevented it.

Export filenames: _____

Plot the revised route

Revision _____ Based on attempt _____ Keep page 3 unchanged. Label revised segments and times so the map can be compared with the new calculation sheets.



Same 500 m grid and 35 s handoff as page 3; mark any differences in your actual ship or targets. Show displacement arrows and intermediate burn positions. Mark the closest approach you expect to improve.

Changed decision and expected effect: _____

_____

Contact coordinates and map key

Coordinates are contact centers in metres. Use the whole ship hull when checking mine triggers. The station center and the docking point are different locations.

Contact	x / m	y / m
M01	-1200	-2100
M02	-1200	-1400
M03	-1200	-700
M04	-1200	0
M05	-1200	700
M06	-1200	1400
M07	-1200	2100
M08	-600	-1750
M09	-600	-1050
M10	-600	-350
M11	-600	350
M12	-600	1050
M13	-600	1750
M14	-600	2450
M15	0	-1975
M16	0	-1275
M17	0	-575
M18	0	125
M19	0	825
M20	0	1525
M21	0	2225
M22	600	-1875
M23	600	-1175
M24	600	-475
M25	600	225

Contact	x / m	y / m
M26	600	925
M27	600	1625
M28	600	2325
M29	-1200	-3500
M30	-1200	-2800
M31	-1200	2800
M32	-1200	3500
M33	-600	-3150
M34	-600	-2450
M35	-600	3150
M36	-600	3850
M37	0	-3375
M38	0	-2675
M39	0	2925
M40	0	3625
M41	600	-3275
M42	600	-2575
M43	600	3025
M44	600	3725
M45	-600	-3800
M46	0	-3800
M47	600	-3800
T1	1900	800
T2	1900	-800
ST	3400	0

M01-M47: mines; M04 is cleared in the guided opening. **T1/T2:** batteries.
ST: station (3400, 0) m. **Dock:** (3000, 0) m, within a 120 m radius.

The map shows trigger and acquisition boundaries, not guaranteed safe passages. Camera icons may be enlarged. Turn on physical collision outlines when checking clearance. Asteroid mounts add no extra collision cover.