





## **Romans to Mars**

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"The path made by a Leader is tread on sand;  
his track is seen for others to follow  
only as one footstep follows another.  
For if he stands still, the trail is erased;  
its footprints washed away by the changing tide. "

--- Domitius Lucullan, 195 AD

We are standing on a crumbling stone abutment that overlooks the port of Ostia on the mouth of the river Tiber, gateway to Imperial Rome. On late summer afternoons like this one, the breeze blows onshore and carries with it the pungent aromas of the Mediterranean and the shriek of gulls that wheel and dip in wide circles over the harbor. The harbor is crowded with vessels of every kind, from huge war galleys with multiple banks of oars that stroke the water in confident, well-coordinated, wingbeat-like sweeps, to lighters and tenders scurrying among the larger ships like beetles. And there are sailing vessels, too -- mostly merchantmen tied up at docks or riding at anchor near the harbor mouth, waiting for evening when the wind will shift from onshore to the offshore breeze that will carry them out to sea.

A few paces from us stands a very distinguished looking figure staring out to sea, his arms folded behind him at parade rest. His cape is scarlet, trimmed with ermine. He wears the silver breastplate of a proconsul. His retinue is huddled some distance behind him muttering to themselves and casting worried glances in his direction. Their master is scowling; his jaw is set with hard lines around his mouth. Lucius Marcellus Varsovian is not a happy man. He has driven his chariot hard all the way back from the capitol after being handed one of the few defeats in his career. To compound his frustration, insult has been added to injury -- the westbound courier already cleared the harbor earlier in the day, and so he is unable to obtain passage home on a military galley. The first leg of the long voyage back to Spain will have to be on a merchant vessel, a sailing ship. He is not accustomed to having to wait for the wind to change, and he is furious.



FIGURE 1.

The senate failed to back him again. Too bad -- his proposal was bold and imaginative. It could have resulted in a fresh infusion of riches for the Empire. Possibly, it could have restored Rome's declining fortunes and brought a new sense of purpose, ending the petty squabbling now going on. If China could be reached by going west across the ocean, then the wealth of the Orient could flow to Rome, not in a trickle on the backs of a few pack animals, but by the shipload. How could they be so shortsighted? All he had asked for was some men and a few ships. . . . .

At this point you might be tempted to characterize Lucius Marcellus as a visionary, a man ahead of his time. That would be a mistake. The ancients ( table I ) knew the world was round ever since Aristotle; from the calculations of Eratosthanes and Hipparchus, they had a pretty good idea of its size. By the second century A.D. they were making geometrically accurate maps by using astronomical observations to locate position.

And Lucius Marcellus Varsovian is not a dreamer, interested in discovery or commerce. He wants to take his legions to China and plunder their cities!

The riches of the Orient have tantalized the Romans for a long time. Their knowledge of China is more tangible than just fables because, in the third century, there is regular contact and trade. In Rome's heyday, the emperor Marcus Aurelius had maintained emissaries at the Han court in Peking. Their reports told of large cities, linked by a network of good roads, heavily populated, but not heavily fortified. The richest cities were furthest east, on a wide coastal plain that extended eastward to an ocean. The reports also indicated that the Chinese empire was more a loose confederation of fiefdoms than an empire. Although every warlord had an army, there was no national army nor the political cohesiveness to sustain one. It had not been necessary because they were so well isolated.

Distance and geography kept the two empires apart. The known route to China, traveled by the caravans, is a tortuous overland journey which permits a limited exchange of communication, trade goods, and culture, but so far has prevented the more direct form of cultural intercourse that Lucius Marcellus Varsovian is contemplating. Taking armies on a long march over the caravan route would be out of the question. Varsovian knew that all too well. As a young centurion in Atticus' disastrous Afghan campaign, he was one of the few who had made it back across the Khyber Pass alive.

## THE ANCIENTS

<b>Pythagoras</b>	(550 BC) First to offer scientific arguments that the world was round.
<b>Aristotle</b>	(350 BC) Proved convincingly, and to everyone's satisfaction, that the world was not only round but also the true center of the universe.
<b>Eratosthanes</b>	(240 BC) First accurate estimate of earth's size, based on solar observations.
<b>Hipparchus</b>	(120 BC) Discovered earth's precession; published first accurate astronomical tables predicting eclipses, positions of stars and planets throughout the year. First to systematically use trigonometric principles, he refined, based on astronomical observations, earlier estimates of the sizes, distances to sun, earth, and moon.
<b>Claudius Ptolemy</b>	(140 AD) Last and most authoritative of the classical Greek astronomers. Compiled and codified the body of Greek thought (including Hipparchus) on astronomy, earth sciences in thirteen volumes ('The Syntaxis'). Published first dimensionally accurate (conical projection) map of the known world; but underestimated size of earth by 30%.

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TABLE 1.

## PTOLEMY'S MAP OF THE WORLD

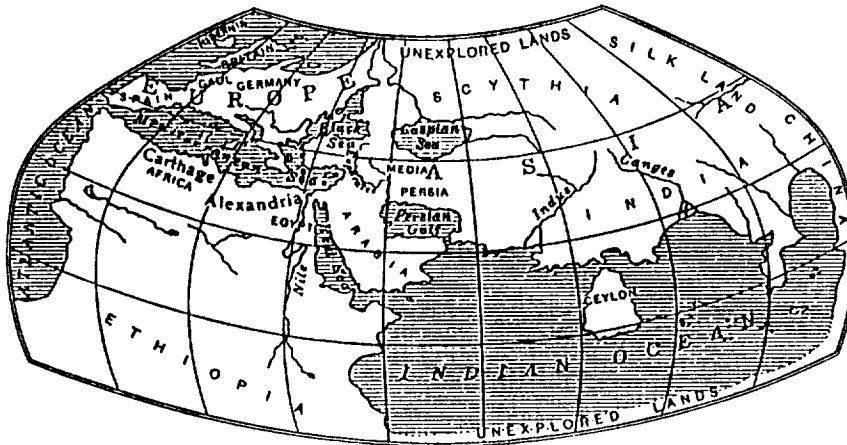


FIGURE 2.

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But a sea route would change everything. Lucius Marcellus was mainly a land soldier, but not entirely unappreciative of sea power. He understood the surprise value of an amphibious assault, having used this tactic successfully to crush the Berber rebellion in Mauretania. Ferrying his troops along the coast just out of sight of land until nightfall, he had come ashore at dawn and driven swiftly inland before they could rally their tribes, cutting off their main encampment and capturing their chief, who was subsequently drawn and quartered.

Wounded in that campaign, he was sent to Alexandria to recuperate. It was on one of his frequent visits to the Great Library there that he had encountered the astronomer Claudius Ptolemy's Map of the World ( fig. 2 ), the first conical projection based on astronomical observations and the most accurate map of its time. Intrigued by the map, he studied Ptolemy's Syntaxis, which explained how the map had been made, how astronomy could tell you the size of the world, and where you were located on it. The map showed the easternmost part of China, where the richest cities were, to be located furthest away from the west coast of Spain, where he had been born. But, if that map were wrapped around a globe according to the method explained in the book ( fig. 3 ), the east coast of China and the west coast of Spain were actually facing each other, separated only by an undetermined stretch of ocean.

According to the calculations and depending on the accuracy of the astronomical measurements, the distance across that stretch of ocean was somewhere between 1500 and 2000 leagues. Lucius Marcellus couldn't fully understand all the explanations which led to this result, but he was quick to grasp its military significance -- if the ocean could be crossed, the richest part of China might be directly accessible to his armies.

Would it be possible to cross the Great Ocean? The 1500 to 2000 leagues of open sea was certainly a formidable distance. But it was not an insurmountable distance. Roughly equal to the Empire's dimensions from western Spain to eastern Persia, it was in fact less than the sea distance routinely navigated from Asia Minor to Britain. What if he could muster his troops at the port of Gades ( now Cadiz ) on the west coast of Spain, load them into ships, and head directly west? The seas would be calm in summertime. They could follow the setting sun, or the lodestone. An accurate landfall wouldn't be needed; it would be hard to miss the China coast.

Compared to the perils of an overland march, a sea voyage would be short and uneventful. After a few weeks cooped up in their ships, his troops would be spoiling for a fight, eager to attack. A seaborne invasion would not be expected. From an eastern beachhead, his invasion force could easily sweep across the wide coastal plain unopposed; the cities would be easy prey for his seasoned legions and their siege engines. Even if the Chinese emperor were able to rally his minions and prepare a counterattack, it would take time -- time to allow him an orderly retreat back to his ships, laden with the spoils of war.

He could return to Rome in triumph, perhaps become Emperor. Lucius Marcellus had a rough understanding of the relationships between military strength and economic growth. By the third century, Rome had already absorbed the western world; there was nothing else nearby left to conquer. The army was not engaged in conquest any more but was, instead, relegated to maintaining order on the frontier, collecting taxes and putting down rebellions. That was no challenge. On the other hand, the fabled cities of the Orient would provide a worthy target for his legions. Why waste well-disciplined troops skirmishing with barbarians when their skills could be used so much more profitably against civilized societies? Why burn down some squalid frontier village when, to the east, there were magnificent cities waiting to be sacked? What satisfaction was there in ravishing unwashed savages in animal skins when, to the east, there were palaces to be looted -- with voluptuous princesses, succulent concubines draped in silk and jewels, their bodies bathed in perfumes and spices . . .

Before his armies could embark, however, he would have to know more about where they were going. Detailed information was needed. Exactly how far was it to the China coast? Where were the best places to land an army? Where could they land unopposed, or better yet, undetected? Before invading by sea, the coastline would have to be positively located and explored. His calculations indicated it should lie 1500 to 2000 leagues west of Spain, but that was only an estimate. Even though he believed an invasion was feasible, he couldn't commit hundreds of ships and thousands of men to a one-way voyage into the sunset without tangible proof that the Great Western Ocean could be crossed, and that China indeed lay on the other side.

The first mission of the campaign would therefore have to be a voyage of exploration -- or, in terms more familiar to Lucius Marcellus, a reconnaissance.



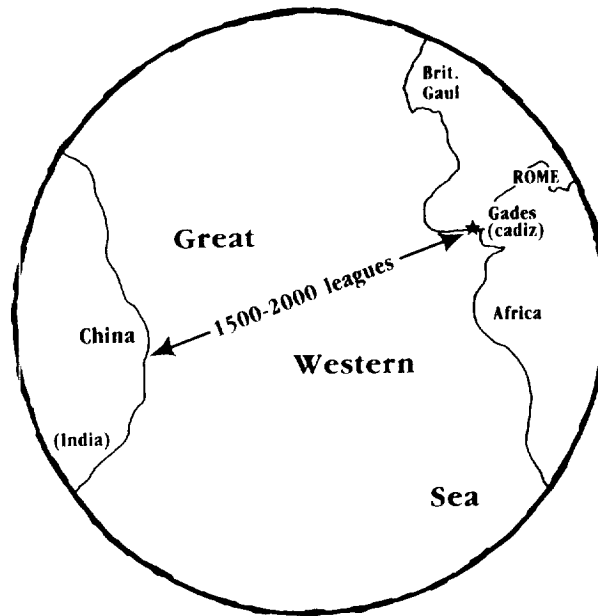


FIGURE 3.

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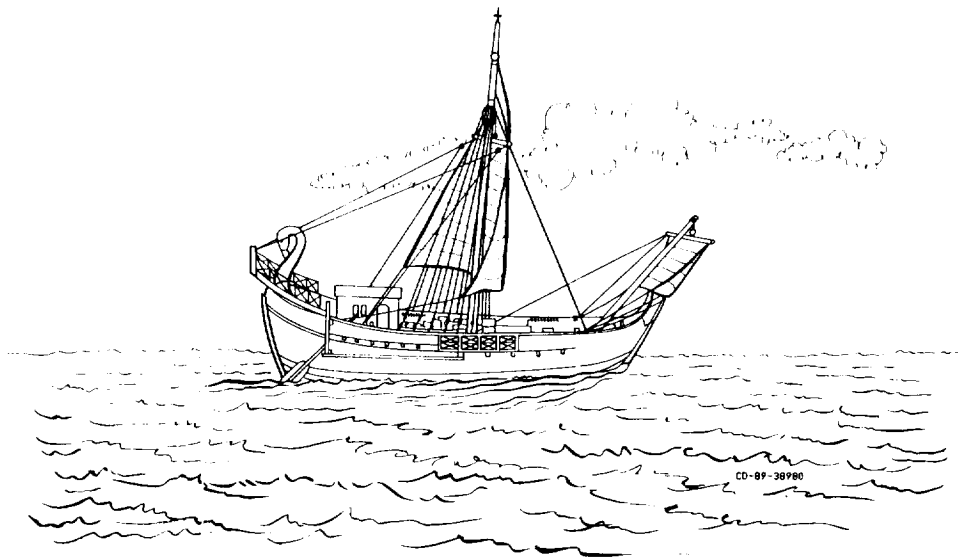


FIGURE 4.

To cross the Great Ocean, he would need a ship with extraordinary range. What kind of ship could go that distance? A sailing vessel would seem to be the logical choice, since it has the most economical form of propulsion. By Varsovian's time, the sturdy little merchantmen that carried Rome's trade to the four corners of the Empire were routinely sailed beyond the Mediterranean up and down the west coasts of Europe and Africa. Beamy and bluff-bowed, their trademark was a single, loose-footed, square mainsail, often augmented by a spiritsail carried well forward for added stability when the ship ran downwind in rough seas. Their Greek and Phoenician design heritage reflected sailing conditions on the Mediterranean -- which includes generally pleasant, but often unpredictable weather. They were unable to hold a course more than a few points away from the wind, but their shallow draft enabled them to be sailed right up to the shore. Most were light enough to be dragged onto the beach by their crew. Hugging the coastline and making forward progress as long as the wind was behind them, they could steer for shore whenever the wind turned against them, and wait there until better conditions prevailed.

That strategy, however effective along the well-settled Mediterranean, would not work offshore. The ungainly little Roman vessels were adequate for coastal navigation, but, unable to make headway against the wind, they would not be suited for travel on uncharted waters. If the prevailing winds were easterly, they would never make it to China. If westerly, they would never make it back.

A more reliable form of propulsion would be required. Oars, with the built-in reliability of hundreds of rowers straining their backs in unison, would be the propulsion system of choice. There was no larger, faster, or more reliable vessel ever propelled by oars than the Roman galley.

But the reliability of those straining backs comes at a price. The men who pull the oars must be fed and watered. This severely limits the amount of time a galley can stay at sea. For short voyages it is not a problem. For longer voyages, however, large amounts of food and water must be carried on board. Space is limited on any ship, but a galley is more restricted because such a large fraction of the available space is taken up by its crew. It is the amount of supplies that can be fitted into the remaining space, together with the rate at which they are consumed, which determines how many days at sea the ship can operate.

Compared with the nonstop distances commonly traveled by military vessels, Varsovian's requirement was unprecedented. A trireme, with its slender hull crammed with rowers for high performance, could achieve perhaps three days at 11 knots. The quinquireme, a much larger warship, could last about a week, but only at a sustained speed of about seven knots. That would be enough to cross the Mediterranean from Italy to North Africa, but not enough for a voyage beyond the Pillars of Hercules.

To row across the ocean, Varsovian would need a ship that maximized the range he could travel before his onboard supplies were exhausted. The solution was to find a galley with moderate crew size and extra cargo capacity, and a cruising speed that took a of minimum effort to sustain. Fortunately, his experience suggested a compromise -- the common troop galley ( fig. 5 ) which had served him so well in the Mauretanian campaign. A medium size vessel of about 70 tons displacement, there were hundreds of them in service throughout the empire, used to ferry the army to wherever there was trouble. Designed to carry a cohort of 100 fully armed troops and their officers, the ship was propelled by another 100 men pulling on the oars. It also carried a lugsail rig for periods of favorable wind. A good compromise -- the sails provided economy, the oars provided reliability. With moderate effort, a galley of this design could be rowed continuously at 4 to 5 knots, enough to cover 30 to 40 leagues per day.

This galley was not as fast as a warship, but it could stay at sea for a much longer period. With its wider hull and smaller crew, it normally carried enough food and fresh water for voyages of about 10 days. Varsovian could modify this vessel by removing the troop accommodations and putting in more supplies, essentially replacing the 100 fully armed troops with provisions for his rowers. Based on the weight and volume margins allowed by this modification, he could lay in enough extra provisions for an estimated 54 days of travel, a little less than two months at sea.

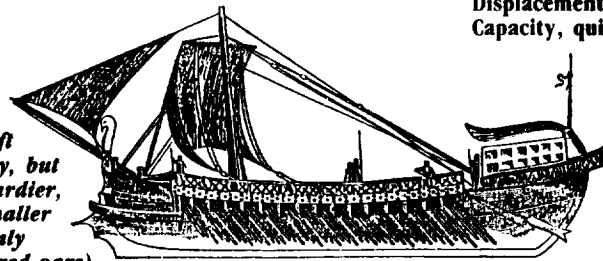
Varsovian calculated that if the ship could average 37 leagues per day ( assuming assistance from favorable winds no more than half the time ), 54 days of continuous travel would cover 2160 leagues. That would be enough to cross the Great Ocean, if Ptolomy was right.

However, crossing the Great Ocean nonstop would still not be enough range to accomplish the mission. If he got there -- if he really found the coast -- he wouldn't be able to count on a friendly port or fresh provisions. He

## ROMAN TROOP GALLEY

Length overall, feet: CXL  
 Beam, ft: XXI  
 Displacement, tons: CXX  
 Capacity, quintals: MCM

*Not a swift war galley, but wider, sturdier, with a smaller cohort (only one hundred oars). Not as fast, but able to stay at sea much longer.*



**SPEED**  
 nominal cruise 4-5 kt.  
 maximum sustained 7 kt.  
 dash 8 kt.

**PROPULSION:** sail or oars depending on wind direction (assume half time each mode).

**ENDURANCE**  
 continuous cruise 54 days

**COHORT,** officers: XII  
 oarsmen: XCVI

**RANGE**  
 nominal one way 2160 leagues (1 leagues = 3 mi.)  
 round trip 1080 " "

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FIGURE 5.

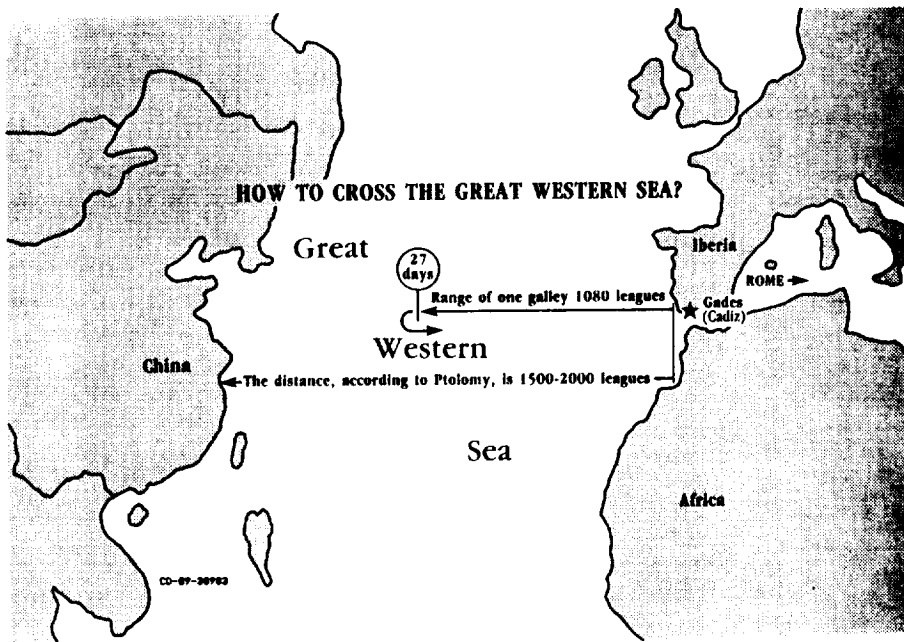


FIGURE 6.

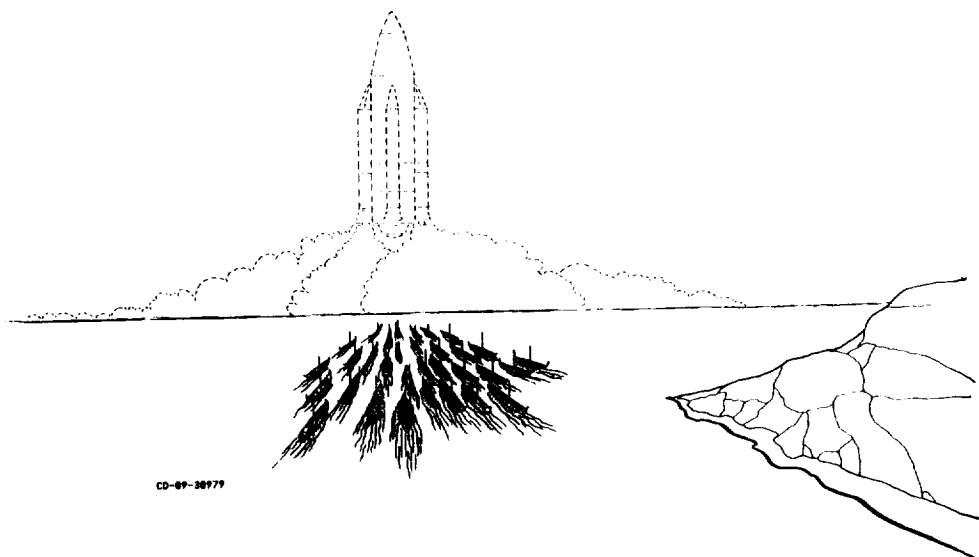
might just have to turn around in empty ocean and head home. The 2000 plus leagues of range that he had managed to squeeze out of his troop galleys so far was only a one-way range. What he actually needed was 2000 + leagues of round trip range, more commonly known as the "distance to point of no return" where half the supplies are exhausted. Rowing westwards from Gades, his ship would reach its point of no return ( fig. 6 ) only 27 days into the voyage, a little over 1000 leagues. If he was willing to gamble with the expedition and keep going, a one-way voyage might possibly land them on the China coast, and, with a little bit of luck, they might find a secluded harbor where they could foray ashore for food and water. But the risks jeopardized the success of his mission. What if they never sighted land? That would be disappointing but nonetheless valuable information. And how much worse would it be to make a successful landfall, only to be butchered on shore by the local cavalry while trying to hustle a few supplies. . . .

The only way his reconnaissance mission could be successful was to ensure that they returned home with the information. ( And knowing you can return generally enhances morale! )

It would have to be a two-way voyage: westward across that distance to China, or at least as far as China should be, then eastward across that distance back to Gades. Varsovian had to find a way to stretch his range to twice the 2000 or so leagues that he had so far obtained, from ships that were already at their limits. It was a problem which would have caused a lesser man to give up.

But Varsovian managed to solve this problem also. He did it by organizing the mission in stages, augmenting the expedition with additional vessels that would replenish the other ships at carefully timed intervals.

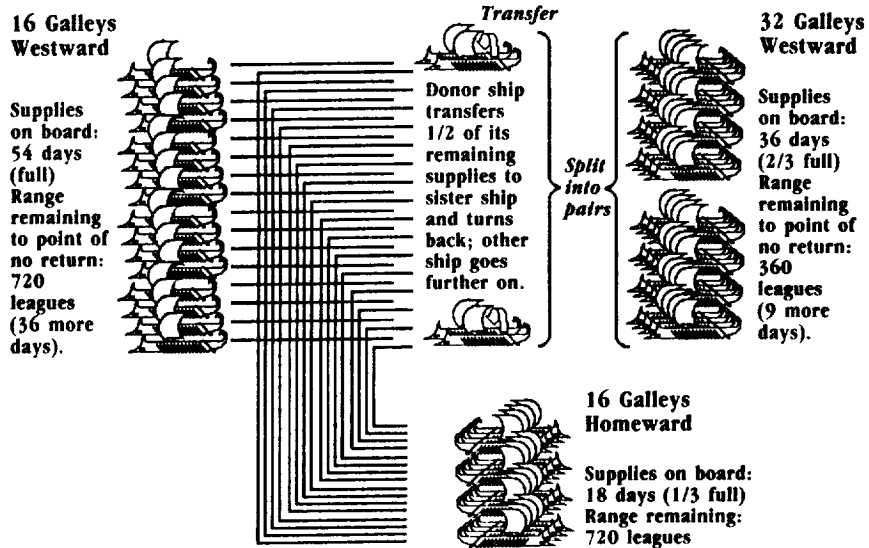
A fleet of 32 galleys would be required. They would all leave the port of Gades together on the Ides of June and row westward ( fig. 7 ). Eighteen days later, however, after one third of the food and water had been exhausted, the fleet would be split into two groups. The ships would pair off with one another in midocean, and, within each pair, supplies would be transferred from one ship to the other. The ship receiving supplies would be fully reloaded, and would continue westward ( fig. 8 ). The donor vessel, with just enough inventory left for a return trip, would turn east and head home. The westbound ships would gain an additional 54 days of operating



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FIGURE 7.

### 18 DAYS INTO VOYAGE 720 LEAGUES WEST



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FIGURE 8.

### 30 DAYS INTO VOYAGE 1200 LEAGUES WEST

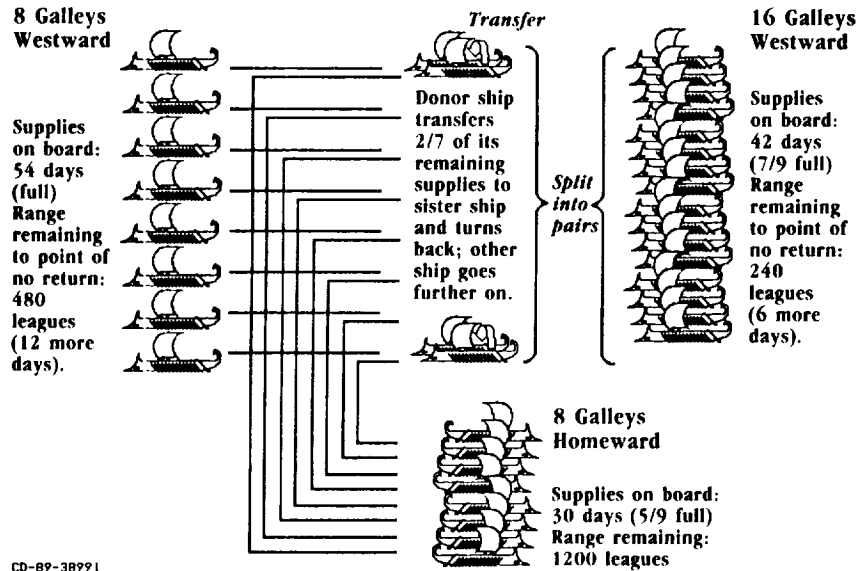


FIGURE 9.

### 36 DAYS INTO VOYAGE 1440 LEAGUES WEST

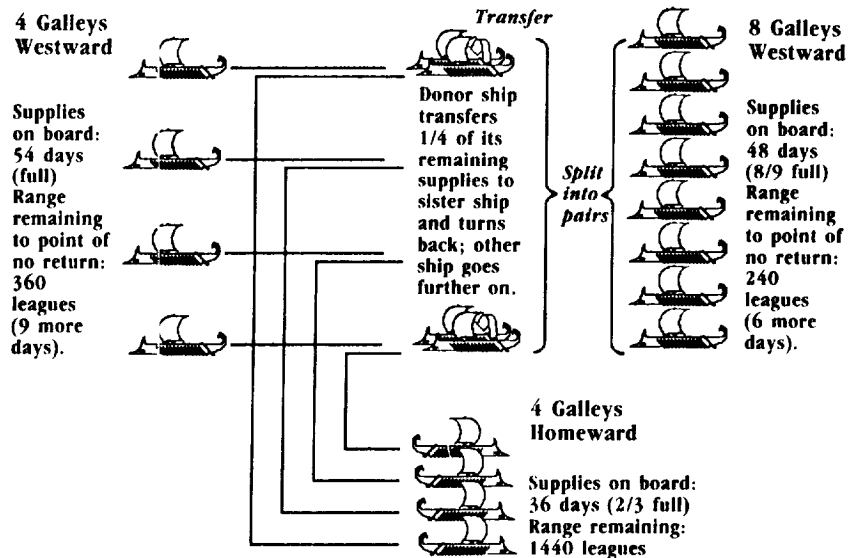


FIGURE 10.

# 42 DAYS INTO VOYAGE 1680 LEAGUES WEST

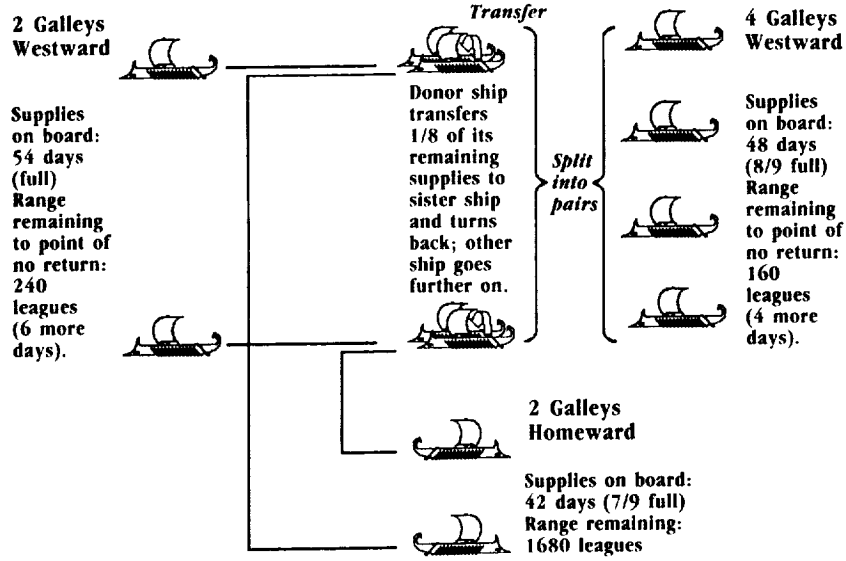


FIGURE 11.

# 46 DAYS INTO VOYAGE 1840 LEAGUES WEST

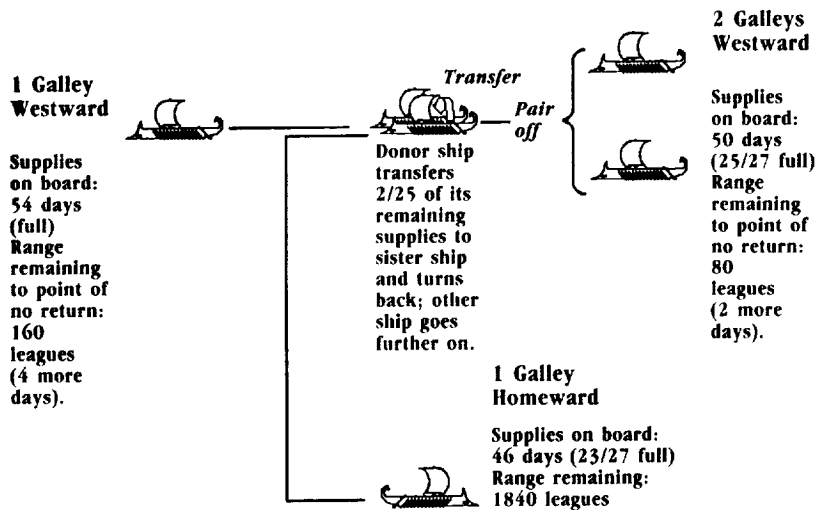


FIGURE 12.



time beyond the 18 already used, thus stretching their round trip range an extra 360 leagues beyond the original point of no return.

Twelve days later, or 30 days into the voyage, this maneuver would take place again. Of the sixteen ships that had continued to row westward, eight of them would relinquish a fraction of their supplies to their sisters and turn home, leaving eight ships to continue the voyage ( fig. 9 ). Again, the westbound ships would be fully replenished; the eastbound ships would head back with exactly enough food and water for the return trip, since it was, in fact, the same amount they had consumed on the outbound leg. The expedition would gain an additional 240 leagues of range.

Six days later, 1440 leagues west of Gades, the fleet would divide itself once more ( fig. 10 ). Four galleys rowing westward, four galleys rowing back. Another range gain -- 120 extra leagues.

After another six days, or 42 days elapsed, if land had not been sighted yet, the remaining ships could pair off again, leaving two galleys to venture onward ( fig. 11 ). The expedition would have covered 1680 leagues of ocean at this point, a round trip distance further than any individual galley could have gone, and close to the estimated distance from Spain to China. They would have another four days to push westward before dividing up the fleet again.

If land was not yet sighted after 46 days from home port, 1840 leagues beyond the Pillars of Hercules, there was still an additional four-day margin. The expedition could split itself up one more time ( fig. 12 ), stock up the last galley, and send it west for another 160 leagues. The final round trip range that resulted would be 2000 leagues. As always, every vessel would have just enough supplies left to make a safe passage home.

Varsovian's reconnaissance would be the first known use of staging to boost the range. Figure 13 summarizes the mission stages, their separation points, and the fractional gain in operating time and range.

This approach had major strengths. It allowed Varsovian to navigate a round trip distance which would have otherwise been impossible, obtaining the endurance he needed from ships whose individual capabilities were limited. Not only did his plan extend the range to almost double that of any individual ship, it guaranteed that every ship in the fleet could return. With portions of his fleet dropping out and returning home as the various

mission stages were expended, news of the expedition's progress could be reported home at regular intervals. At each staging point he could choose which ships should continue, thereby ensuring that only the soundest ships and strongest crews continue the voyage. Failed or weakened elements could be removed to the rear; these would not have to make the return voyage alone.

Best of all, the plan allowed for contingencies. There was plenty of margin for error. If his range estimate was wrong, if the China coastline proved inhospitable, or if he was unable to make landfall for any reason -- he could still complete the mission. The plan not only extended his range, it did so in a way which maximized the probability of success while minimizing the risks to his ships and crew.

Unfortunately, Varsovian's plan could not anticipate the most difficult phase of the mission where the risks were greatest: the presentation of his proposal to the Emperor and assembled senate ( fig. 14 ). The review began encouragingly enough; many senators supported his plan. In principle no one was opposed to a China campaign -- everyone agreed that, if a sea-borne invasion was to be considered, a reconnaissance mission would be the next logical step. As for feasibility of the voyage, no one doubted it; the analytical results Lucius Marcellus presented were far too convincing. The Emperor had listened to his plan carefully, had liked it, and had endorsed it. Varsovian's proposal would provide a practical demonstration of something that already appeared to be scientifically sound. His plan was reasonable, the risks were modest. Most important, the mission could be accomplished without any new technology development.

But the mission was expensive. In fact, the costs were enormous. Instead of a simple scouting foray, this expedition ( summarized by stages in table II ) had the dimensions of a full-scale military campaign -- 32 troop ships and 4000 men, just to see if China was on the other side of the ocean!

The cost of modifying 32 troop galleys alone was no small amount of money. Of course, shipyards from Venicia to Tarantum would be busy for months. Because of the amount of business the expedition represented, Varsovian obtained a great deal of political support from the shipbuilders who had once furnished the fleet that carried Julius Caesar to Britain. They festooned the outer halls of the senate chamber with banners that proclaimed --

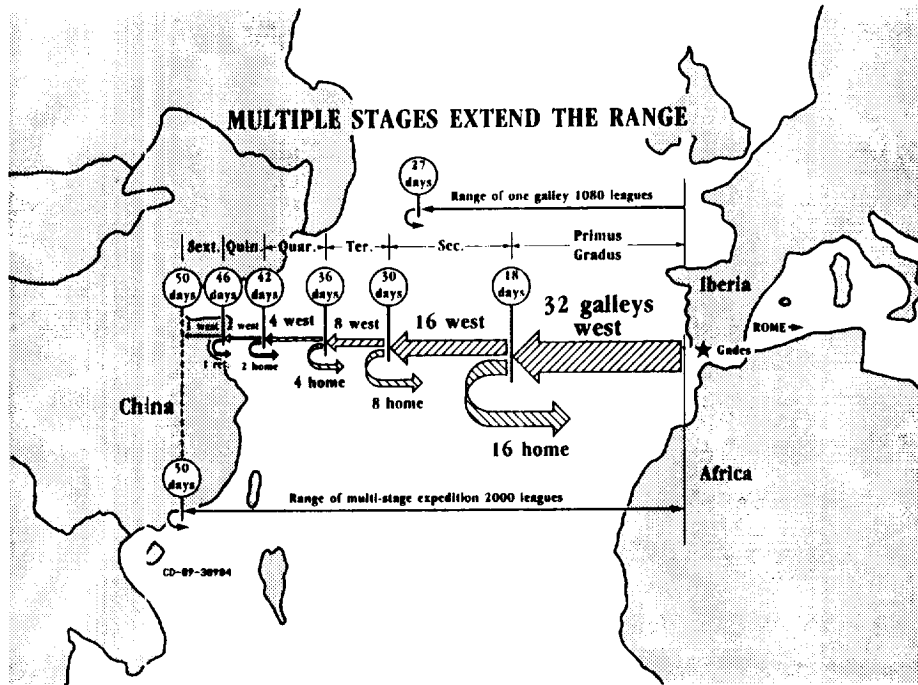


FIGURE 13.

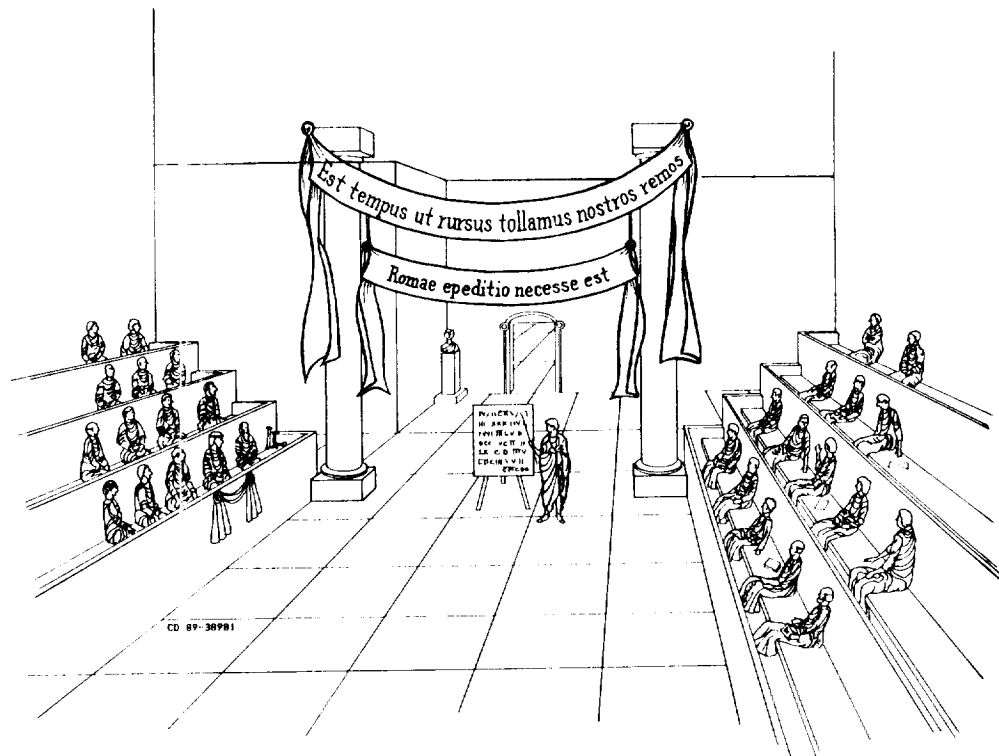


FIGURE 14.

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"Rome needs the Reconnaissance" and "It's time we raised our oars again."

But when the total costs of the mission were presented ( table III ), the opposition gave way to a clamor. The senators could not understand going to the expense of outfitting 32 ships for a voyage that would actually be completed by 1, or, at the most, 4 ships.

"Isn't your proposal just a little bit gold-plated?" asked Flattus Flavius, the ranking senator on the floor.

"Yes, it is gold-plated," replied Lucius Marcellus, "That is the only way we can do it when we really need to have gold, but can't afford it . . . "

With 32 galleys under stroke, the operating costs were outrageous. Consider the anticipated charges for provisioning the ships -- food, wine, fresh water and casking, not to mention wages for the crew ( they would all have to be volunteers ).

The opposition was vocal and the criticisms were hard to answer. How could these expenditures be justified? Varsovian's proposal violated the basic rule that governs every enterprise where public monies are involved: Where expenditure is great, great risk is not tolerated; where risk is great, great expenditure is not tolerated.

"It is nothing but a publicity stunt," some said. "Take the army on a boat ride to China?" With riots at home and rebellions abroad, there was no way to justify committing all those troops to such a speculative expedition. After all, Varsovian couldn't guarantee success. Could he show a tangible benefit? Maybe after the campaign was finished, but certainly not within the next fiscal year. . .

"What will they do when that last galley finally gets there? Conquer all of China with one cohort?" snorted Caius Crassus. "If you're going to take all those ships to begin with, why not just keep going and invade the place while you're at it? It wouldn't be any more expensive than the fiasco you have proposed!"

For several hours the debate raged on. No decision was reached. But they agreed to appoint a committee to study the plan further and subject it to a cost/benefit tradeoff analysis to see if the mission could be reoptimized

# EXPEDITION TO THE ORIENT ACROSS THE WESTERN SEA

GRADUS	Primus	Sec.	Tertius	Quartus	Quint.	Sextus	TOTAL
Number of Galleys Each Stage	XVI	VIII	IV	II	I	I	XXXII
Number of Days at Sea	XXXVI	LX	LXXII	LXXXIV	XCH	C	
OPERATING EXPENSES	(mille sestertium)						
WAGES							
oarsmen	IVDCCXC	IIICMXC	MMCD	MCD	DCC	DCCXXX	XIVCLXXX
officers	MDCCCLX	MDLX	CMXX	DXL	CCXC	CCCXX	VCCL
CONSUMABLES							
meat	MCXI	CMXII	DLVI	CCCXX	CLXXXI	CXCV	IIICCLXXV
bread	DLXVI	CDLXIX	CCCLXXXI	CLXIV	XC	CIX	MDCLXXX
goat butter	LXXIV	LXIV	XXXV	XXVI	X	XII	CCXXI
black olives	XLII	XXXIII	XXII	XIV	XII	XIV	CXXXVIII
grapes	CXL	CXXII	LXIII	XLIX	XIX	XIX	CDXII
zucchini	LXXXIV	LXXIX	XLVII	XXI	XII	XX	CCLXIII
pasta	CCXXII	CLXXXI	CXI	LXVIII	XLVI	XLV	DCLXXIII
water (incl. casking)	CCXL	CCXIV	CXXIII	LXIX	XXIX	XXXI	DCCVI
wine	CCCXII	CCLVI	CX	XCIX	LII	LVI	DCCCLXXXV

TABLE II.

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## IMPERIAL TREASURY EXPENDITURE EXPEDITION TO THE ORIENT ACROSS THE WESTERN SEA

### FIXED COSTS

Conversion of 32 troopships to extended range configuration LXXXVIII CXLIV

### OPERATING EXPENSE

WAGES  
oarsmen XIVCLXXX  
officers VCCL

### CONSUMEABLES

meat IIICCLXXV  
bread MDCLXXX  
goat butter CCXXI  
black olives CXXXVIII  
grapes CDXII  
zucchini CCLXIII  
pasta DCLXXIII  
water (incl. casking) DCCVI  
wine DCCCLXXXV

### TOTALS

(mille sestertium)

Fixed Cost LXXXVIII CXLIV  
Operating Expense XXVIII DCCCH  
material XLVIII CCXXV  
burden XIDCCXXXI  
labor LXXXVIII DCCXXXIV  
overhead XXXVCXCIV  
G + A LXXXIX CCXCIX  
cost of money VII DLXXIV  
fee LVII CMLIII

Grand Total CDXLIV CCXXVII

TABLE III.

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for a reduced range of performance parameters and budget constraints. It was at that point that Varsovian turned on his heel and marched out of the senate chamber in disgust.

In the end, they voted to table the issue until a more decisive mandate could be established.

Which brings us back to that brooding figure standing on the pier. Bitter, disillusioned and cynical, he stares out to the sea dancing on the horizon past the breakwall. His eyes pierce the afternoon sunlight, but they are blinded by disappointment. How can the Empire continue if it is not bold enough to mount even this modest expedition? When men and nations no longer dare to dream, what can the future hold?

But as he stands there staring out to sea, he fails to see a most marvelous thing taking place right in front of him. A graceful Arab dhow ( fig. 15 ), with her lateen rig and deep keel, her sharp prow and delicate forefoot biting cleanly into the waves, is threading its way out of the harbor close-hauled, beating upwind toward the breakwall opening and the open water beyond.

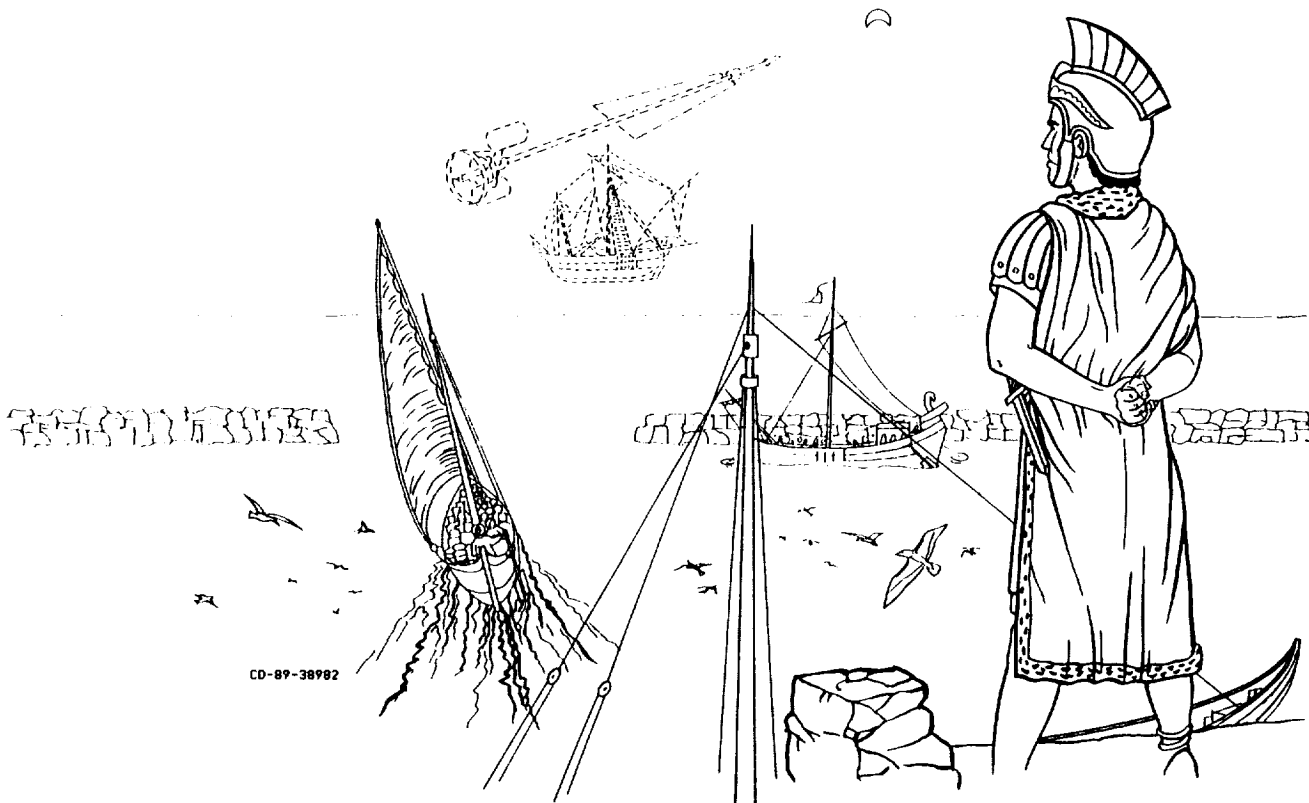


FIGURE 15.

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16. Abstract <p>This paper illustrates the key role played by technology advancement with respect to the anticipated era of discovery and exploration (in space): how bold new initiatives may or may not be enabled. A truly enabling technology not only renders the proposed missions technically feasible, but also makes them viable economically; that is, low enough in cost (relative to the economy supporting them) that urgent national need is not required for justification, low enough in cost that high risk can be programmatically tolerated. A fictional parallel is drawn to the Roman Empire of the second century A.D., shown to have possessed by that time the necessary knowledge, motivation, means, and technical capability of mounting, through the use of innovative mission planning, an initiative similar to Columbus' voyage. They failed to do so because they lacked the advanced technology necessary to make it an acceptable proposition economically. Speculation, based on the historical perspective, is made on the outcome of contemporary plans for future exploration showing how they will be subjected to the same historical forces, within limits imposed by the state of technology development, that shaped the timing of that previous era of discovery and exploration.</p>					
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