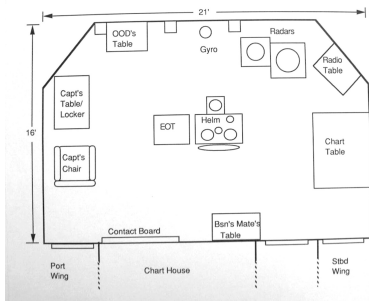


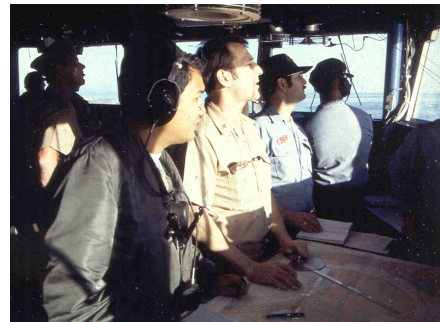
# Organizational learning



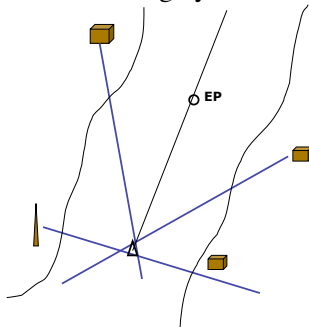
## Bridge Layout



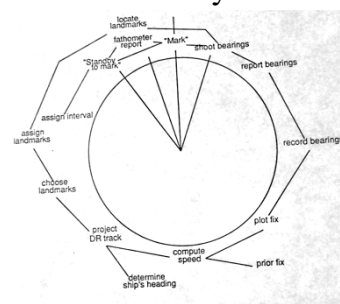
Navigation team on the bridge of the Palau

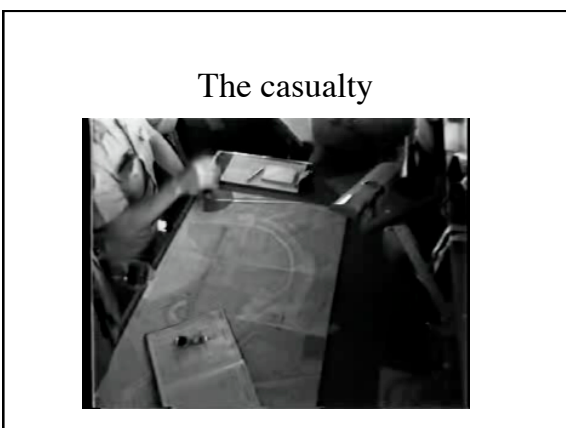
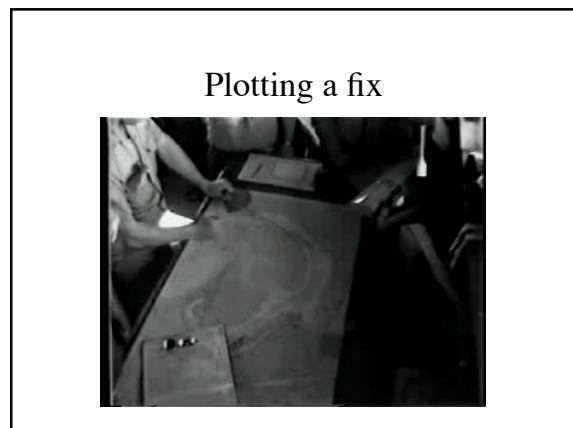
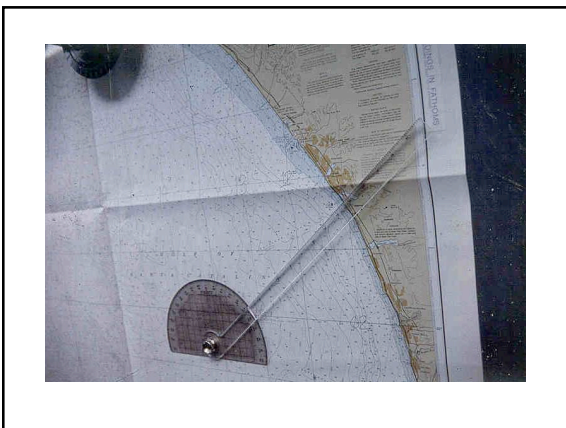
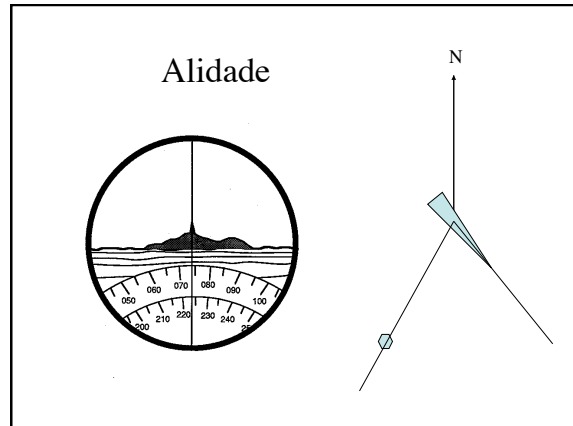
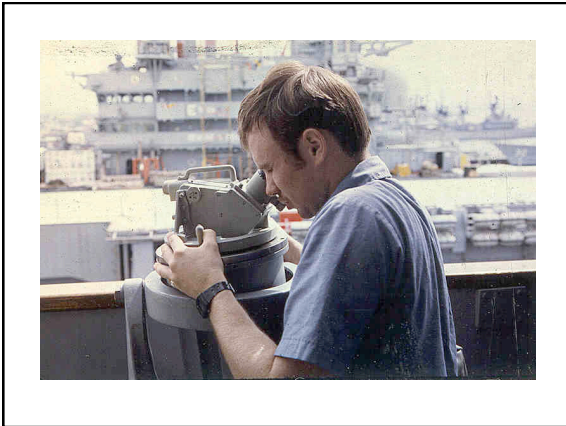


## Position Fixing by Visual Bearings



## The Fix Cycle





### Consequence of the loss of steam drum pressure

- Loss of all propulsion
- Loss of electrical power throughout the ship
- Severely diminished rudder response
  
- Loss of the gyrocompass
  - Backup gyro out of service for maintenance
  - Backup power supply fails

### Corrections to be applied

$V = 14^\circ$   
 C is read from magnetic compass  
 D depends on C

$TB = C + D + V + RB$

### The "normative sequence"

- Can Dead Men Vote Twice
- $C + D = M, M + V = T$
- $T + RB = TB$
- An opportunity for modularity

### Deviation Table

(not from the ship under study)

SHIP'S HEAD MAGNETIC	DEVIATIONS ON SWP	SHIP'S HEAD MAGNETIC	DEVIATIONS ON SWP
0	4.0 W 4.5 N	180	4.5 E 4.0 E
15	4.0 W 4.0 N	195	6.0 E 5.5 E
30	3.5 W 4.0 N	210	7.0 E 6.0 E
45	3.0 W 3.5 N	225	6.5 E 6.0 E
60	2.5 W 3.0 N	240	5.5 E 5.5 E
75	2.5 W 2.5 N	255	4.0 E 3.5 E
90	2.0 W 2.5 N	270	2.5 E 2.5 E
105	2.0 W 2.0 N	285	0.5 E 0.5 E
120	2.0 W 2.0 N	300	1.0 W 1.0 W
135	1.5 W 1.5 N	315	2.5 W 3.0 W
150	0.5 W 0.5 N	330	3.5 W 3.5 W
165	2.0 E 1.5 E	345	4.0 W 4.0 W

Figure 423. Deviation table.

### Worldwide Magnetic Variation

Figure 406. Simplified chart of magnetic variation of the world, from Chart 42. Shown are isogonic and agonic lines.

### Adaptation to the loss of the Gyrocompass

- Change in computational procedure
- Change in division of labor
- Evolutionary search of a complex design space

### Design criteria for a new procedure

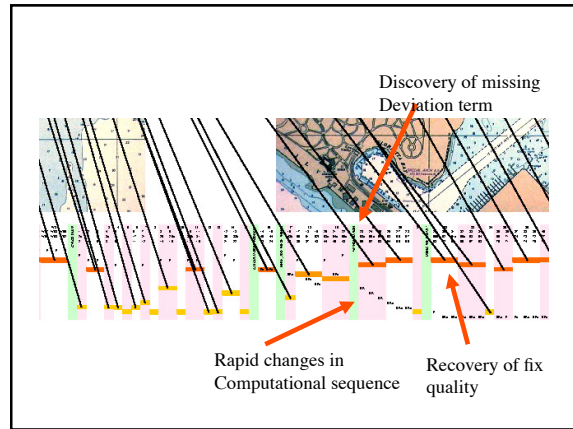
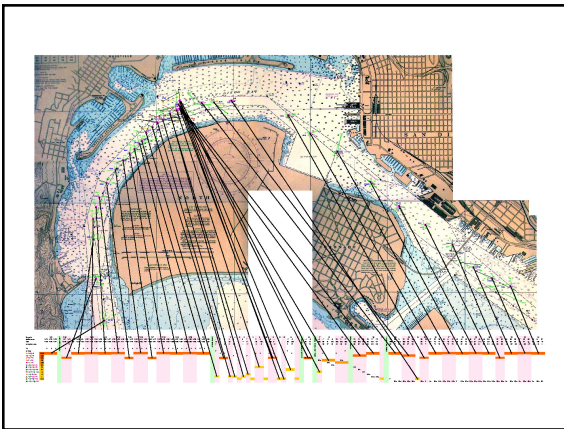
- Even distribution of workload
- Avoid dis-coordinations and conflicts
- Exploit parallel activity
- Avoid bottlenecks
- Exploit modularity

## Re-representing the computational sequence

- Is 3 3 5, 3 3 5. Oh wow. (Mumbles 3 seconds. The plotter watched the recorder write down the bearing to Silvergate. The plotter then jotted the bearing on the chart and did place value arithmetic in the margin of the chart.) 1 1 6, 60, 0, 6 from 1 is 5, 250, 2 5 0 ah, 2 5 0 would give me 2 6 4. 2 6 4, what the hell is it to? Ah, I know what it is to, it's got to be Silvergate. Yeah. 2 6 4.

## Reconstruction of a computational procedure

$$\begin{array}{r}
 C \ 3'3'5 \\
 RB+275 \\
 \hline
 610 \\
 - 360 \\
 \hline
 50 \ 250 \ 250 \quad C+RB \\
 \quad \quad \quad V \pm 14 \\
 \quad \quad \quad \quad \quad \quad 264 \quad (C+RB)+V
 \end{array}$$



## Exploring a space of configurations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. (C+RB)+V															
2. (RB+V)+C															
3. (C+RB)+V															
4. (C+RB)+V															
5. (C+RB)+V															
6. (C+RB)+V															
7. (C+RB)+V															
8. (C+RB)+V															
9. (C+RB)+V															
10. (C+RB)+V															
11. (C+RB)+V															
12. (C+RB)+V															
13. (C+RB)+V															
14. (C+RB)+V															
15. (C+RB)+V															

## Data Driven Sequences

Region 1:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LOP#				a	b										
1. (C+RB)+V		P	P						P	P	P				
2. (RB+V)+C				SP											
3. (RB+V)+C					SP	SP	P	P	P		SP				
4. (C+RB)+V												SP		P	SP

## Data Driven Sequences

Enter the whisper of normative sequence

Region 2:

LOP#	16	17	18					19	20	21			22	23	24
	a	b	c	d	e	f	a	b			a	b			
1. (C+RB)+V													P		
2. (RB+V)+C															
3. (RB+C)+V															
4. (C+RB)+V															
5. (C+V+RB)	PS			P	SP				P		P				S
6. (RB+C+V)		S	S	S	S	S				S	S			S	S
7. (C+V)+RB							P	P							

## The Discovery of Deviation and the Emergence of Modularity

Regions 3 & 4:

LOP#	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
	a	b															
8. [(V+D)+C]+RB		P	P														
9. (RB+C+D)+V			S														
10. RB+[(V+D)+C]				S	PS												
11. (C+D)+V+RB						S	S	S									
12. (C+D)+RB+V										P	PS		PS	S	S		
13. [(C+D)+V]+RB															P	S	S

## Data Driven Sequences

Region 1:

LOP#	1	2	3	4		5	6	7	8	9	10	11	12	13	14	15
				a	b											
1. (C+RB)+V	P	P								P	P	P				
2. (RB+V)+C			SP													
3. (RB+C)+V				SP	SP	P	P	P		SP						
4. (C+RB)+V														P	SP	SP

## The first fix with relative bearings



## Data Driven Sequences

Region 1:

LOP#	1	2	3	4		5	6	7	8	9	10	11	12	13	14	15
				a	b											
1. (C+RB)+V	P	P								P	P	P				
2. (RB+V)+C			SP													
3. (RB+C)+V				SP	SP	P	P	P		SP						
4. (C+RB)+V														P	SP	SP

## Data Driven Sequences

Enter the whisper of normative sequence

Region 2:

LOP#	16	17	18					19	20	21			22	23	24	
	a	b	c	d	e	f	a	b			a	b				
1. (C+RB)+V													P			
2. (RB+V)+C																
3. (RB+C)+V																
4. (C+RB)+V																
5. (C+V+RB)	PS			P	SP					P		P			S	
6. (RB+C+V)		S	S	S	S	S					S	S			S	S
7. (C+V)+RB							P	P								

“Here, add these things.”



LOP 16: (C + V +RB)  
*P returns from helm.*  
P: 2 3 1. What have we got? {231 + }  
*(Then slides the calculator to S.)*  
P: Here, add these things.  
P: You want...You want the head. You want the head which is 2 3 1.  
S: I and add variation.  
P: Plus variation.  
S: Oh, 231 is the head?  
P: 2 3 1. Here {clear 2 3 1}  
S: I got it. *(puts his hands on the keys.)*  
{clear, 2 3 1}  
P: Plus 14.  
S: {+ 14} Okay.  
P: Okay. *(intermediate sum not computed)*  
S: {+ 0 0 7 =} is 252 on Silvergate.  
P: 2 5 2 Silvergate.

LOP 18c (C + V +RB)  
S: 2 3 1, Chief, plus 14, plus 1  
P: {2 3 1 + 1 4 +} |Okay,  
what was ah,  
S: The bearing was 1 5 7. (3 sec)  
|Okay  
P {1 5 7 = } |4 0 2  
S: Minus 3 60 1 is  
P: { - 13 60 =} is 0 4 2. No  
it ain't. It isn't no 0 4 2. Its just not  
working. Look where 0 4 2 goes. *(P  
points to the chart.)* If it's 0 4 2, we're  
sitting over on Shelter Island!

LOP 21b: (C+RB+V) & ((C + V) + RB) =  
((C+V)+RB+V)  
S: {clear 2 2 1 | + 14 }  
P: |plus 14 is 2 3 5. (C+V  
*P does it in his head.)*  
S: 2 3 5?  
P: Yah, its 2 3 5 plus 1 1 8. ((C + V)  
+ RB)  
S: Oh. {clear} *(S doesn't realize that  
hitting = would have produced 235.)*  
P: 2 3 5 is 13 3 5, 3 4 5, how about 3  
5 3. Right?  
S: {235 |+ 1 1 8 + 14 =} How  
about 0 0 7.  
((C+V)+RB+V)  
P: 0 0 7.  
S: Chief, the computer just beat you.  
*(Chief glares at S) Just kidding. (all  
laugh 4 sec)* The modern  
technology.  
P: I'll modern technology you.

### The Discovery of Deviation and the Emergence of Modularity

↓

Regions 3 & 4:	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41.
LOP#																	
8. [(V+D)+C]+RB	P	P															
9. (RB+C+D+V)																	
10. RB+[(V+D)+C]			S	PS													
11. (C+D)+V+RB					S	S			P	S							
12. (C+D)+RB+V																	
13. (C+D+V)+RB									P	PS	PS	S	S	PS	S	P	S

### The Discovery of Deviation



1. P: I keep getting these monstrous goddamn, these monstrous frigging goddamn triangles. I'm trying to figure out which one is fucking off.
2. S: You need another round?
3. P: No, no no, uhuh. 1 2 0 I know what he's doing. Let me try, let me try, *(turns and moves to helm station)* let me try, with my new ones, say three. *(reads deviation card posted on compass stand.)* Say three, add three to everything.
4. S: Add three?
5. P: Yah.
6. S: 'Cause he's using magnetic? *(S does not get it yet.)*

**LOP 25 ((V+D)+C]+RB)**

7. P: On a southwest heading add three. So its (14 + 3 =)17 plus 2 2, 17 plus 2 2 6 is ah, 2 3 ah
  8. S: Plus 2 2 6 is 3 4 is 2 4 3 *(S working on paper with pencil)*
- ((V+D)+C)**
9. P: Okay, 2 4 3 and 0 1 3 is 2 5 6.  
21 5 6
- ([(V+D)+C]+RB)**
10. S: 12 5 9 *(this is an error)*
  11. P: 2 5 nuhuh?
  12. S: 2 5 9, plus 0 1 3? It's 2 5 9.
  13. P: 2 5 9 that's right. Okay. And plus 1 1 2 was what?

**LOP 26a**

14. S: 1 1 2 plus 2 2 6..*(Here is clear evidence that S doesn't understand the attempt to modularize. (RB+C))*

**LOP 26b ((V+D)+C]+RB) & (RB+[(V+D)+C])**

15. P: Plus 2 4 3, 2 4 3 plus 1 1 2.  
**([(V+D)+C]+RB)**
16. S: 1 1 2 plus 2 4 3 is 5 5 , 3 5 5.  
*(still working on paper)*  
**(RB+[(V+D)+C])**

**LOP 32: ((C+D)+V]+RB)**

1. S: You want the aero beacon?
2. P: Yah, I want the aero beacon now, yah. It's just.. 1 8 7, 8 8 , 8 7, 8 8.
3. S: 0 2 0 , what's the ship's head?
4. P: Huh? 0 8 7. 8 7, Ius! I west
5. S: 10 8 7 its 1  
west , 7
6. P: Its 8 6 (C+D)
7. S: (8 6.)
8. P: And 14 1 is 1 0 0  
**((C+D)+V)**
9. S: [(+14 )
10. S: (+ 1 0 0 ), hold it
11. P: No, it's 1 0 0 plus whatever.  
**([(C+D)+V]+RB)**
12. S: 1 0 , where are you getting?..
13. P: 1 0 0 is the heading, the whole thing, lplus relative.
14. S: lOh, the whole thing. plus relative, (+ 20 =), 1 20.
15. P: Okay
16. S: 1 20 lis for North Island Tower.

**LOP 33: ((C+D)+V]+RB)**

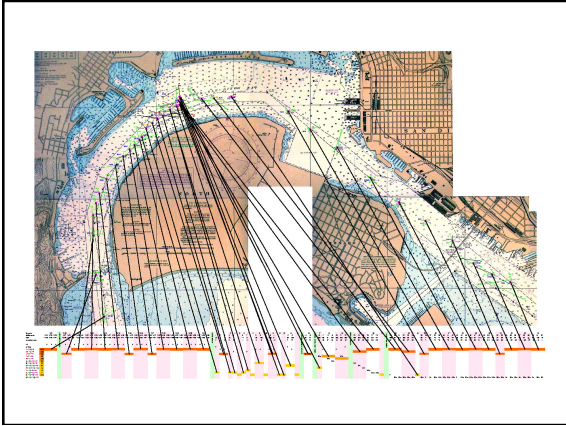
17. P: land Hamm's? (2 sec) 1 010 plus whatever for Hamm's.
18. S: lHamm's
19. Okay, {100 + 2 2 4 = }, 3 2 4  
onlHamm's
20. P: l3 2 4. That's all three of 'em. I got 'em all.
21. S: Okay.
22. P: Looks good. Right on. Perfect. Pinpoint fix.
23. S: Alright!

**LOP 35:**

- S: {9 6 + 2 1 2 =} 3 0 8 on Ham's light. **([(C+D)+V]+RB)**  
*(S has mis-remembered the true head. Should be 98, not 96)*
- P: Okay

**LOP 36:**

- S: {98 + 3 5 7}
- P: Damn near reciprocals.
- S: {- 3 6 0 = }
- P: 3 60 is 10 9 5
- S: ah 10 9 5 **([(C+D)+V]+RB)**



## Design criteria for a new procedure

- Even distribution of workload
- Avoid dis-coordinations and conflicts
- Exploit parallel activity
- Avoid bottlenecks
- Exploit modularity

