

Rio Tinto

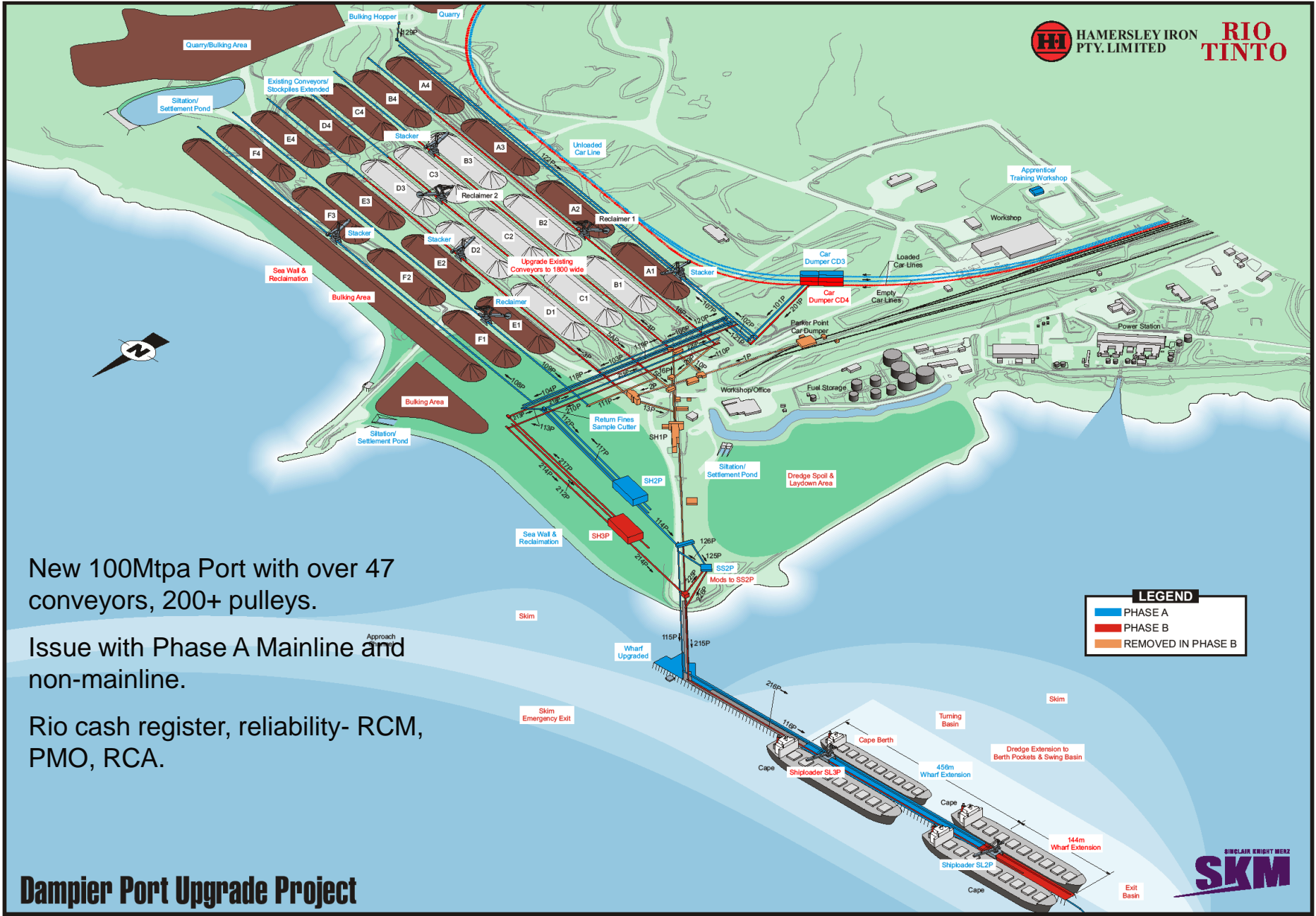
“Sir, we have 100 time-bombs in our new plant putting \$2b profit at risk...and we currently can't detect when they will go off”.

Paul Brades

Introduction

My aim is to take you through a fairly complex RCA (rare manufacturing defect) and reinforce the following:

- Rigorous analysis of causal factors and root causes is essential for all failures. Each are in-play until **proven** not to be.
- Involve OEM in RCA.
- Ensure RCA actions are practical, understood and agreed too.
- Check and document critical dimensions during assembly and rebuilds.



New 100Mtpa Port with over 47 conveyors, 200+ pulleys.

Issue with Phase A Mainline and non-mainline.

Rio cash register, reliability- RCM, PMO, RCA.

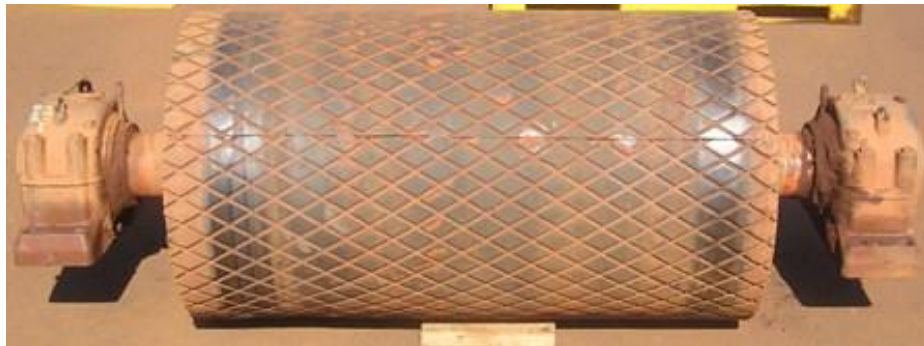
LEGEND	
█	PHASE A
█	PHASE B
█	REMOVED IN PHASE B

Dampier Port Upgrade Project

Pulley Assembly

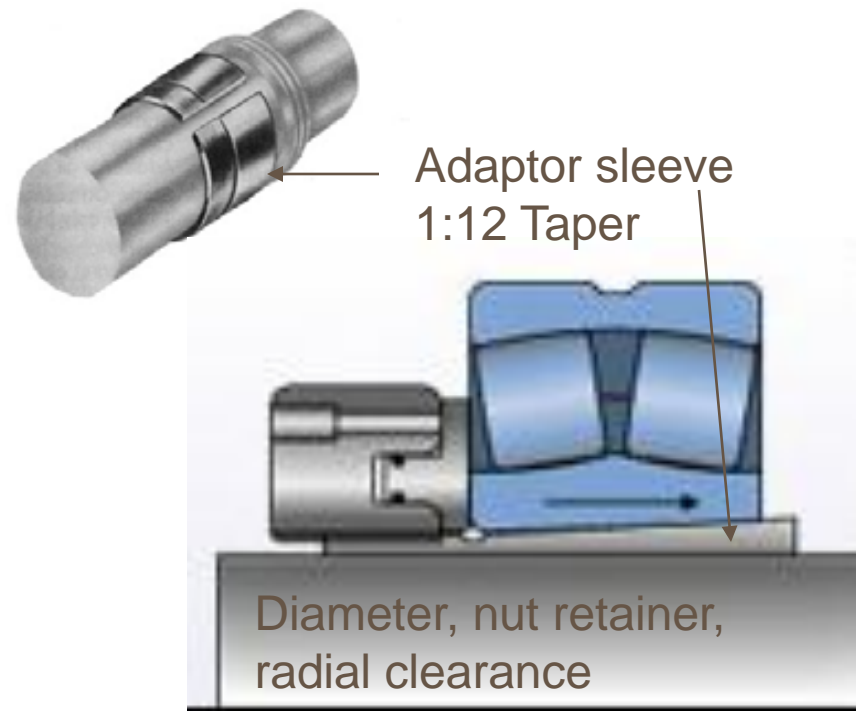


Leave room to remove!

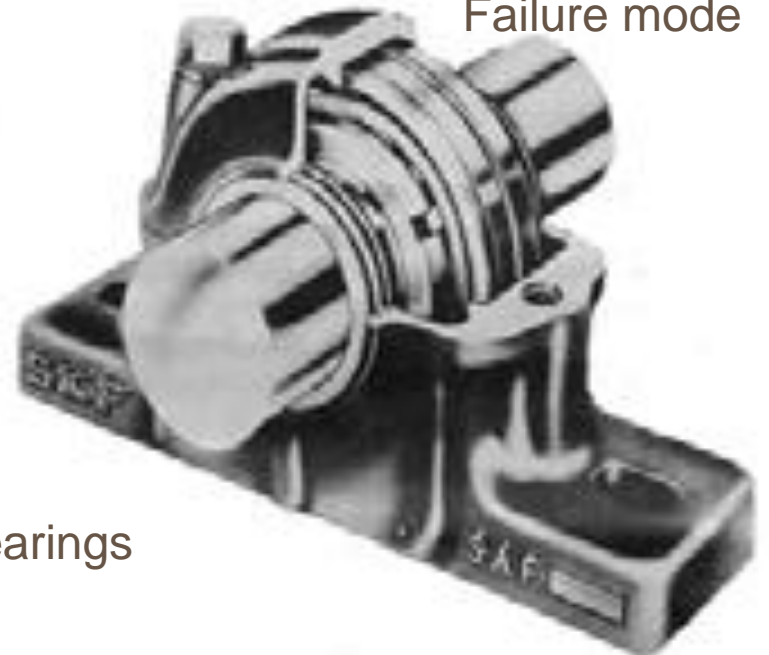


Pulley supplied by Sandvik, subcontracted bearings to NSK, subcontracted sleeves.

10 May 2011

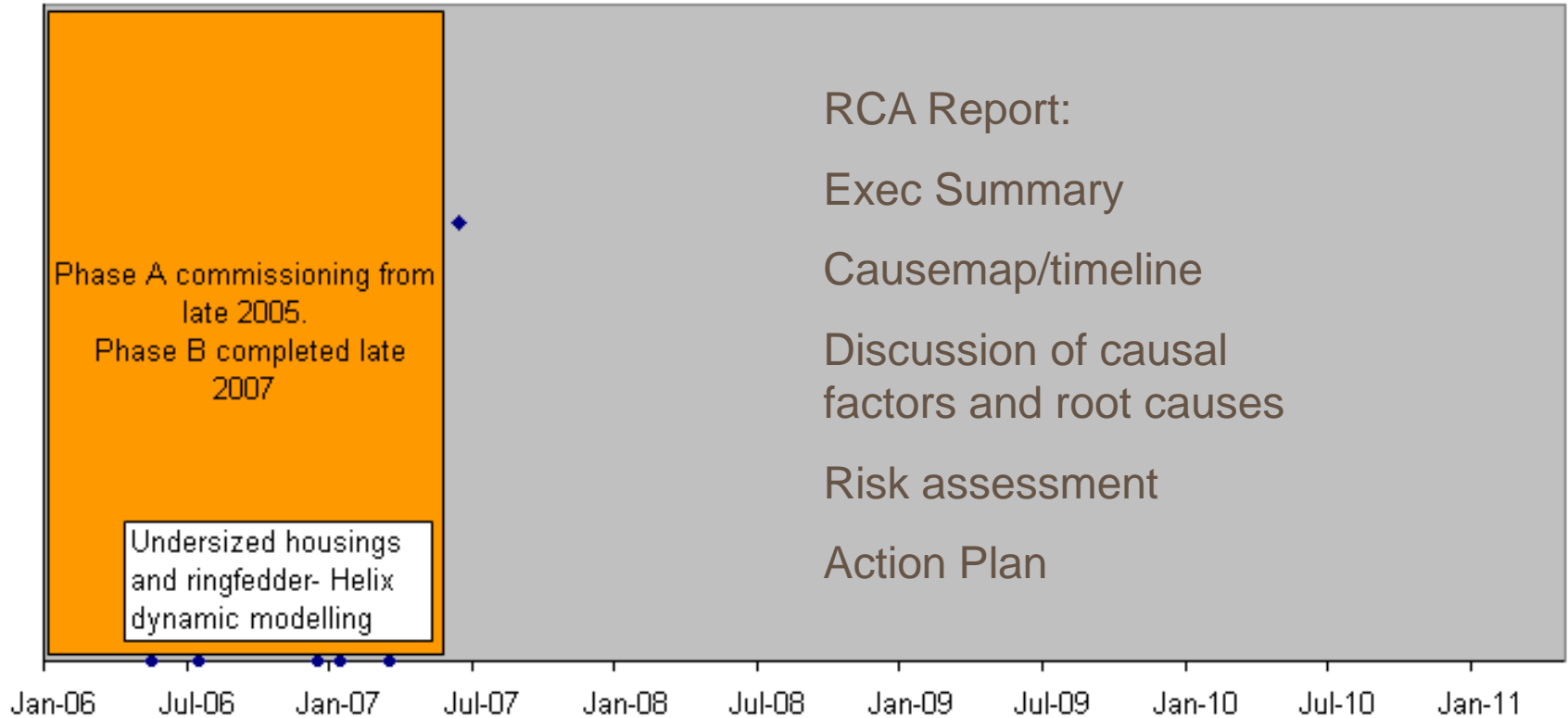


Failure mode



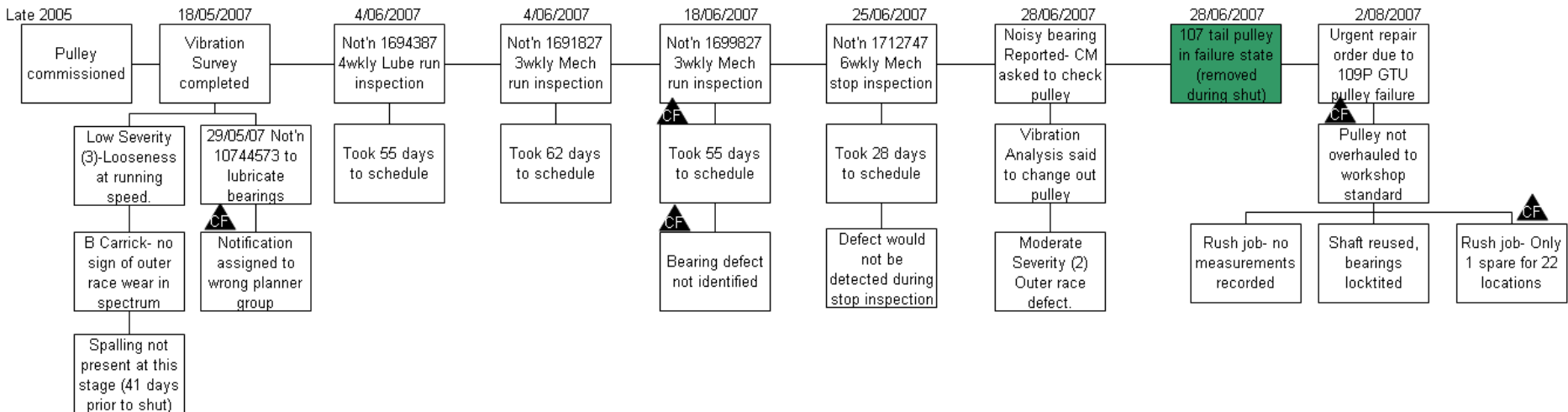
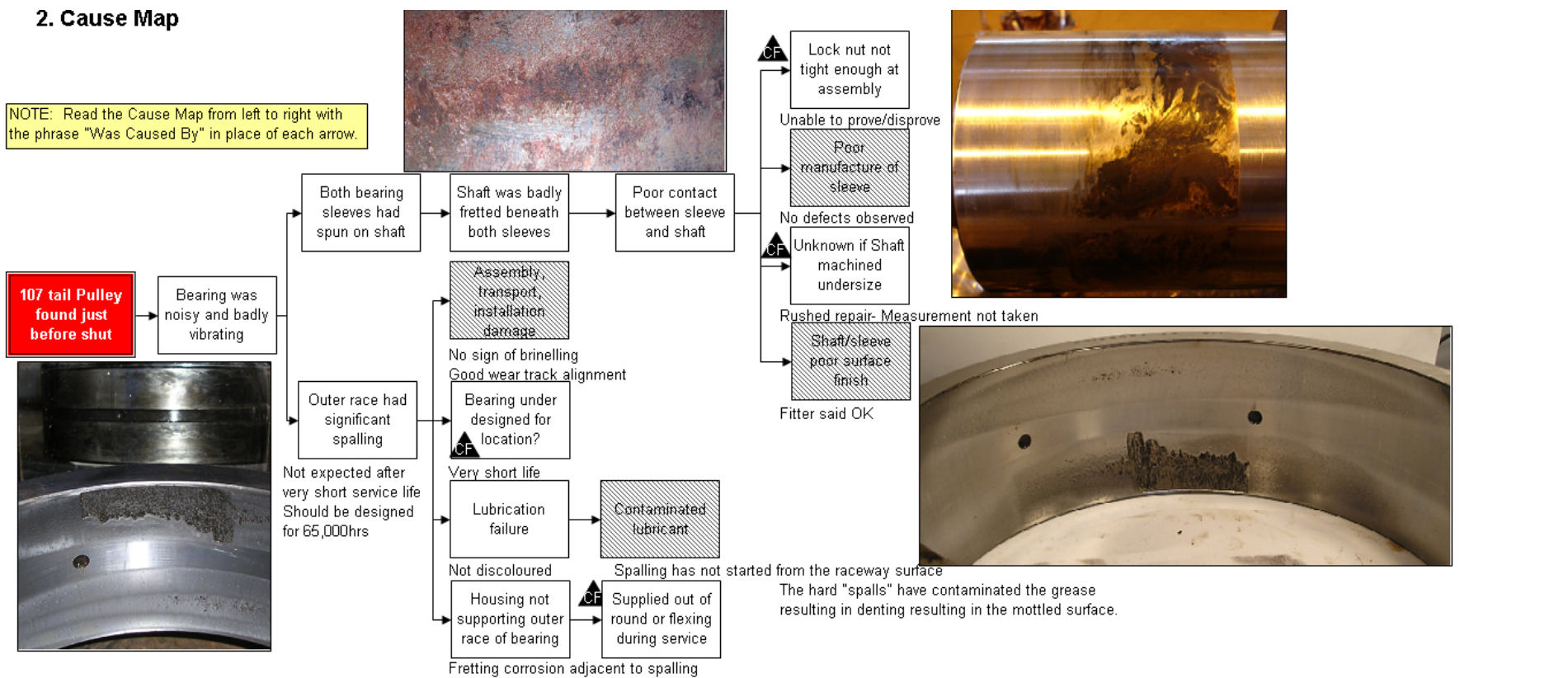
Timeline of pulley failures

Pulley Failures at Parker Point



2. Cause Map

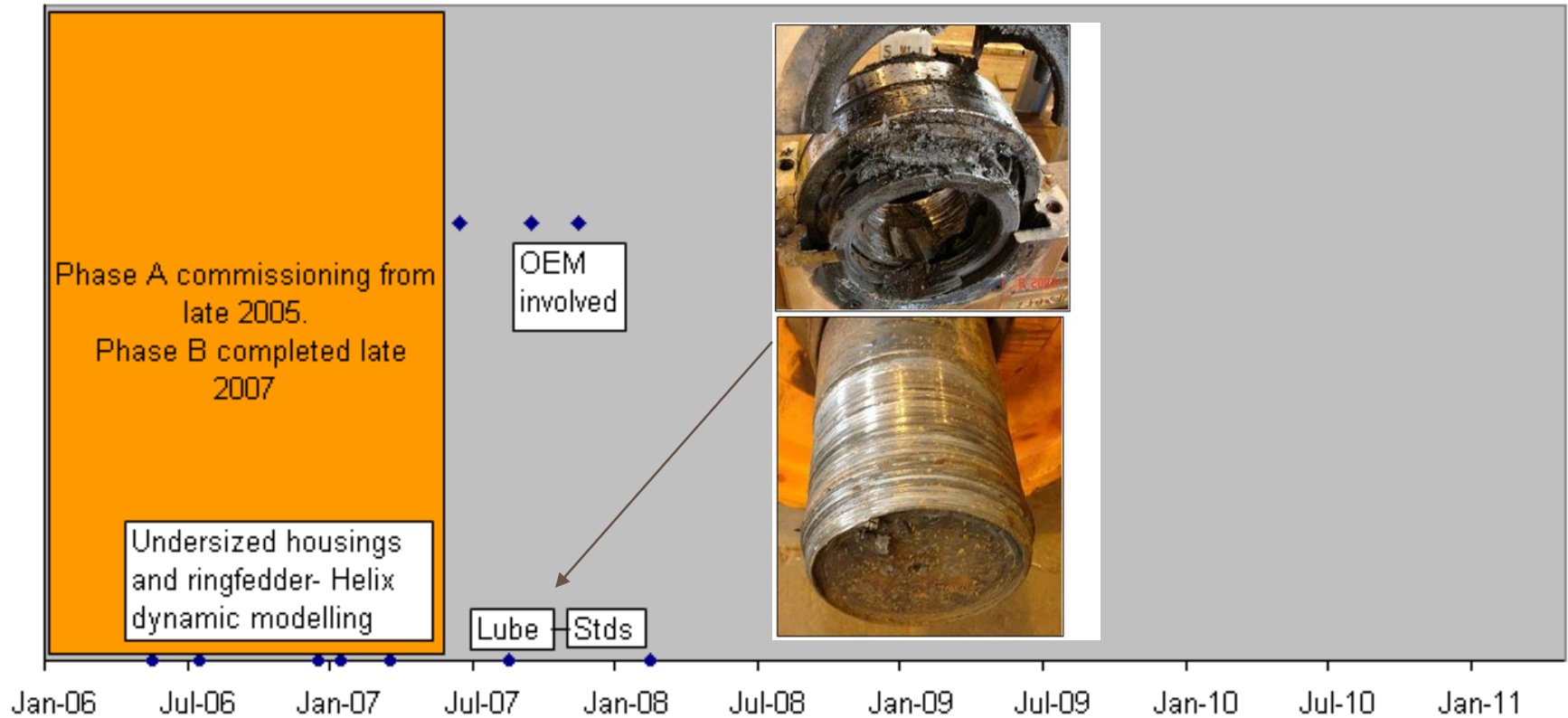
NOTE: Read the Cause Map from left to right with the phrase "Was Caused By" in place of each arrow.



Location	Failure date	Equipment	Outcomes & Actions	Owner	Importance 1- High 3- Low	Due Date
Dampier	28/06/07	107P Pulley No1 bearing	The bearing inner ring had spun on the adaptor sleeves and the outer race contained spalling (rolling contact fatigue) that had initiated below the surface. Plan a detailed inspection program to ensure quality of DPU spare pulleys (housing centres, housing OD and ovality, bearing OD, shaft OD and ovality beneath the adaptor sleeve, bearing radial clearance, "ringfeder" bolt tension check, replace "SBE" ringfeder bolts). All spare pulleys to be inspected by 1/3/08. If significant non-conformance to standards are found then it will be necessary to plan changeouts of the most highly loaded pulleys from the field (get list from Sandvik).			Check spares
Dampier	28/06/07	107P Pulley No1 bearing	This pulley was not overhauled to our workshop standards. 109P location number 6 needs to be removed and correctly overhauled as soon as possible.			Replace Pulley- Stds
Dampier	28/06/07	107P Pulley No1 bearing	There was only one spare for 22 locations. Steve Warwick has created a spreadsheet to determine the pulley spares requirement for Parker Point (1 spare for 6 locations). Recommendations have been made to Angus Pidgeon to purchase the spare pulleys for Parker Point. Tom to monitor progress and ensure adequate spares are delivered.		1- High 01 05 2008	Purchase spares
Dampier	28/06/07	107P Pulley No1 bearing	PRM inspections and a mechanical running inspection 10 days prior to the shut did not detect the spalling on the outer race. Discuss this failure with inspectors and ensure they report noisy bearings via the notification system.			Improve inspections
Dampier	28/06/07	107P Pulley No1 bearing	PM01's are taking too long to schedule. A KPI needs to be created and tracked.			Improve Scheduling
Dampier	28/06/07	107P Pulley No1 bearing	The outer race contained spalling (rolling contact fatigue) that had initiated below the surface. Get Helix to check the design of this pulley for this location.			Check design- was under
Dampier	28/06/07	107P Pulley No1 bearing	Notification to lubricate the bearings was assigned to the wrong planner group. Technician now uses the correct planner group.			

OEM Involvement

Pulley Failures at Parker Point

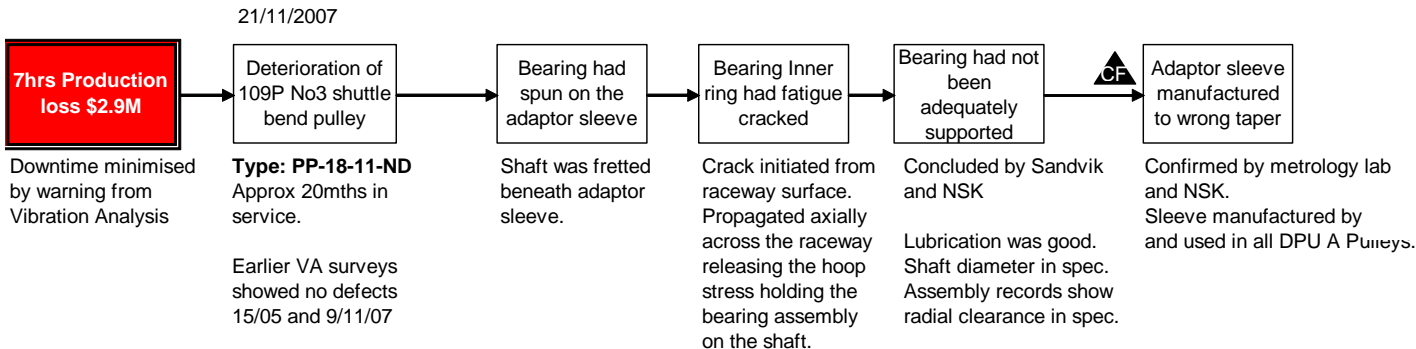
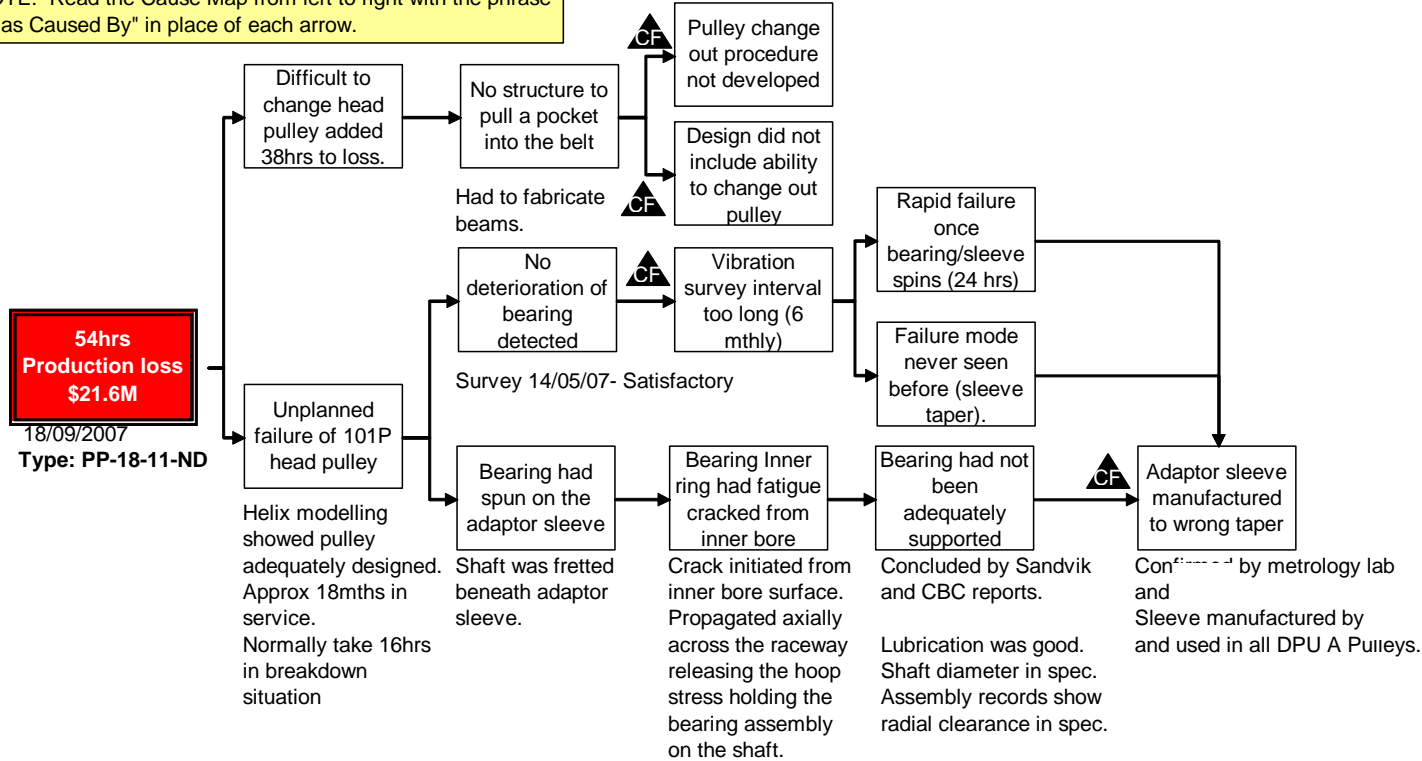


Sleeve moved on shaft



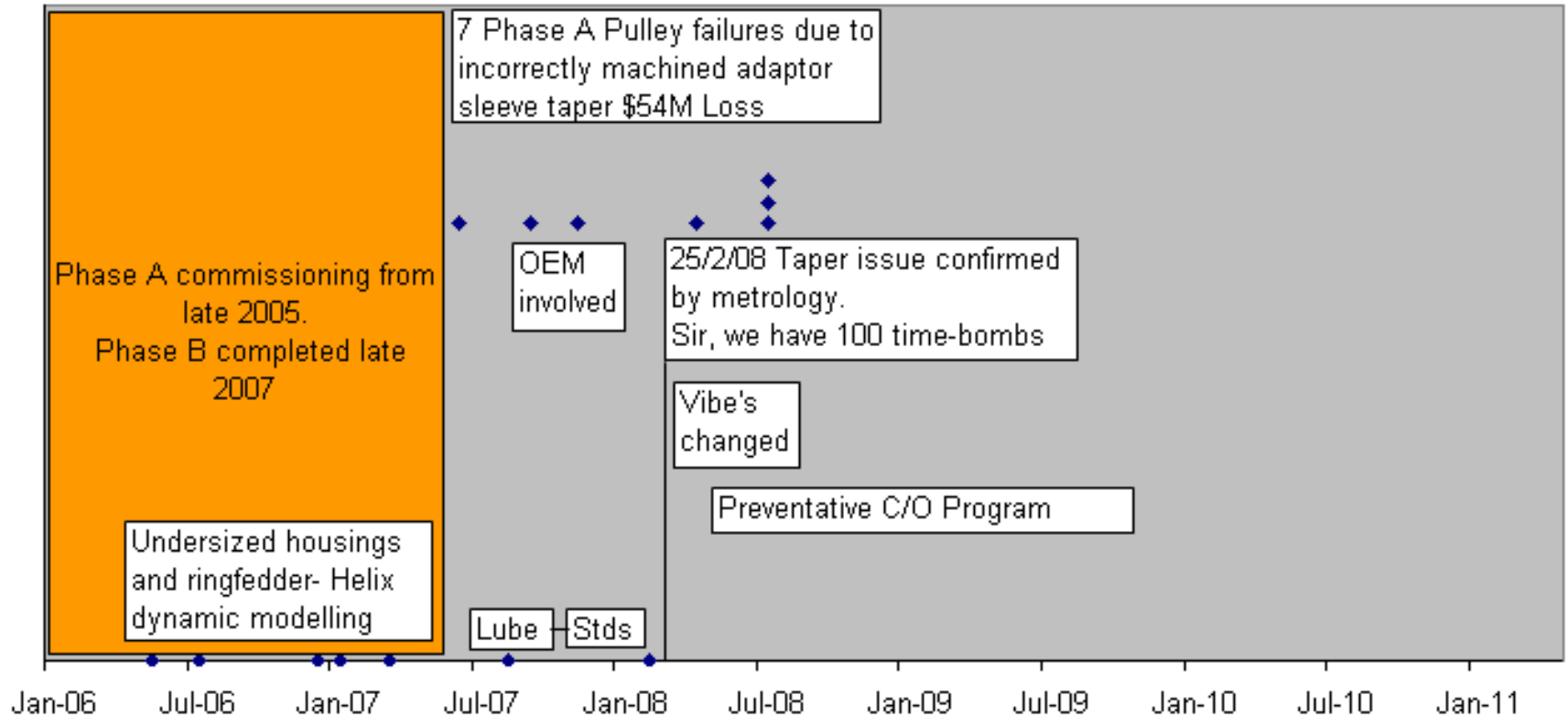
2. Cause Map

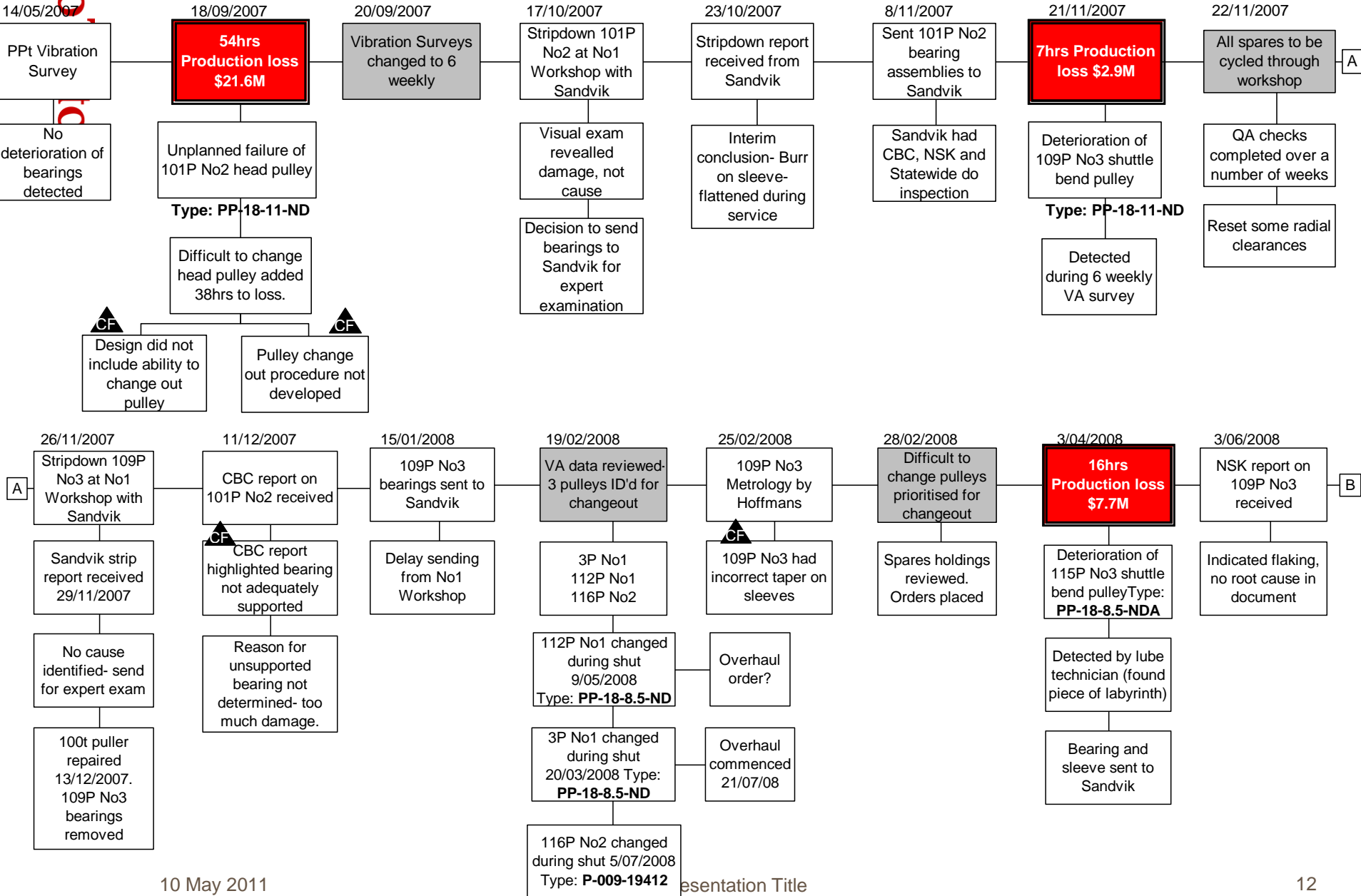
NOTE: Read the Cause Map from left to right with the phrase "Was Caused By" in place of each arrow.

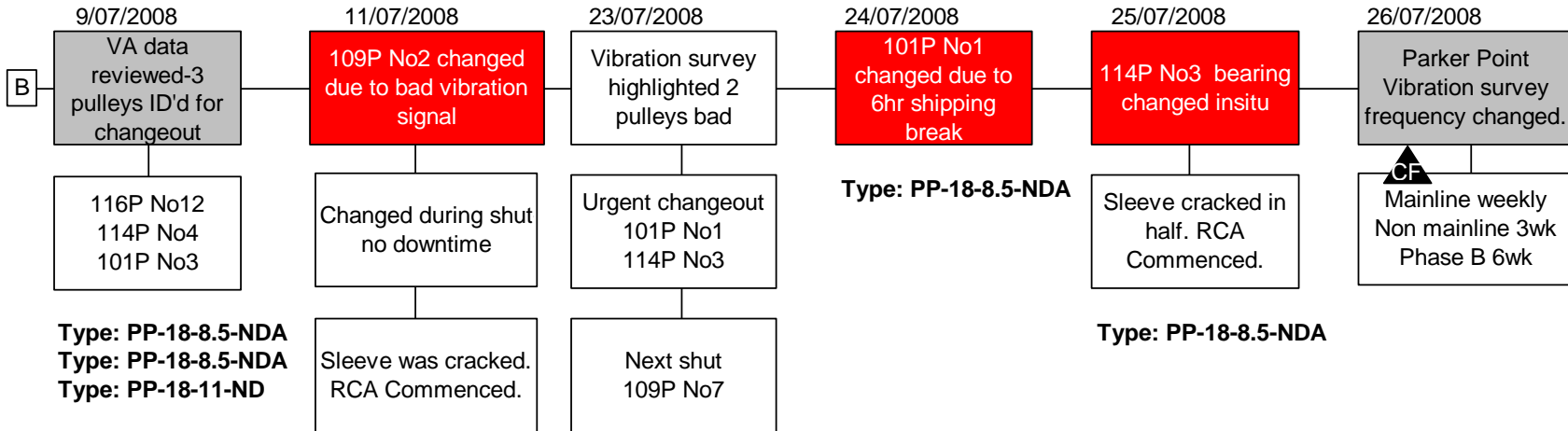


Develop and implement actions

Pulley Failures at Parker Point



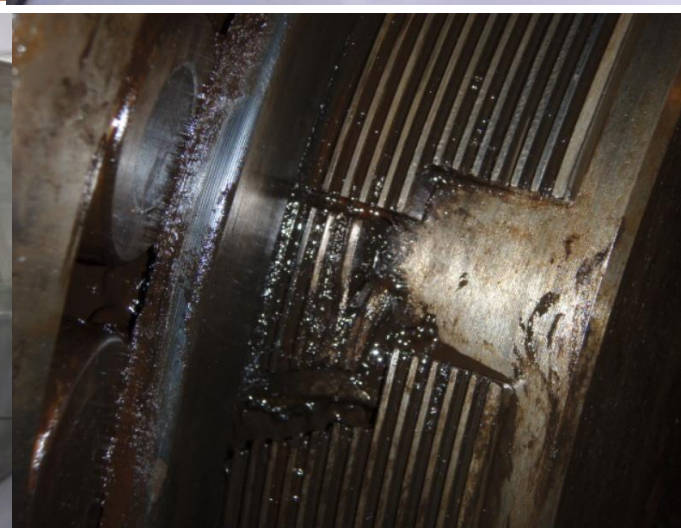
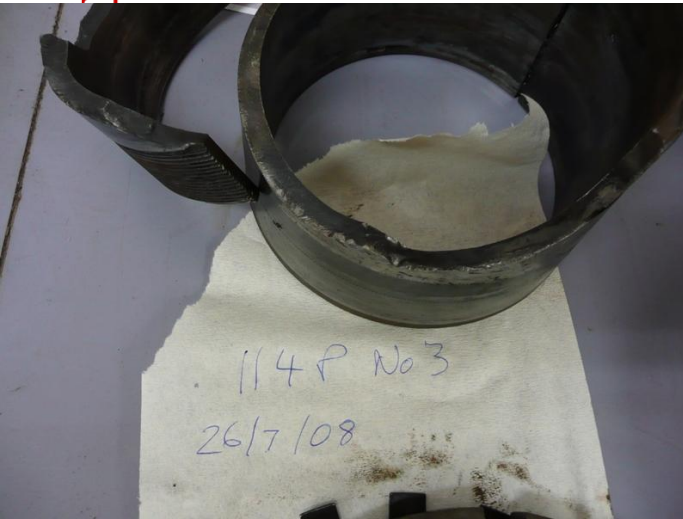




16hr to change a pulley at 10,000tph= 160,000 tonnes

At \$125/t = \$20M

113 pulleys at risk ie \$2.2 billion












Location	Failure date	Equipment	Action Item	Owner	Importance	Due Date
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Excessive time taken to changeout pulley (54hrs) because no procedure had been developed prior to the failure. A change out procedure should be developed for all PPt pulleys (new structures/beams may need to be installed into the plant).		Develop change out procedures.	
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Excessive time taken to changeout pulley (54hrs) because beams to pull a pocket in the belt had not been included in the design of DPU. Update standards so that all future conveyor designs address access issues and include a procedure to change out pulleys (maximum of 12 hours).		Design in ability to do 12hr changes	
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Bearings rapidly fail once they spin on the sleeve/shaft. Review other condition monitoring techniques that may give earlier warning of deterioration.		Improve CM to provide some warning.	
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Bearings rapidly fail once they spin on the sleeve/shaft. Increase the vibration survey interval to weekly for mainline and 3 weekly for non-mainline.		Increase survey frequency	
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Bearings rapidly fail once they spin on the sleeve/shaft. Develop a change out plan for all mainline (then non-mainline) pulleys that have the same size adaptor sleeve that has caused this failure.		Implement preventative changeout plan	

Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Bearings rapidly fail once they spin on the sleeve/shaft. Implement the change out plan for all mainline (then non-mainline) pulleys that have the same size adaptor sleeve that has caused this failure.	T Toledo	1- High	
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Shift fitters are not experienced in pulley bearing change outs. Conduct training so that fitters can change bearings to an adequate standard.	Train shift fitters		
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Pulley bearing failures can take significant time to recover from. A changeout kit to be developed to ensure parts and tools are available to quickly change a failed bearing (include belt clamps, cummalongs, bearings, hydraulic nuts etc).	Put kit together MTTR		
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	Spares may not be available to support the volume of breakdowns and changeouts. Determine and implement spares holdings and reorder points to ensure that we are not caught without a spare.	Review spares holdings		
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	sleeves were manufactured to the wrong taper. Pursue warranty with the supplier of the pulley	Warranty		
Dampier	18/09/2007	PPt DPU-A Pulley bearing failures (Tefco sleeve)	sleeves were manufactured to the wrong taper. Ensure that sleeves are not used by Pilbara Iron.	Ban supplier and improve ITP		

Mainline Changeout plan

			Tefco sleeve replacement program								
			Conveyor	Pulley 1	Pulley 2	Pulley 3	Pulley 4	Pulley 5	Pulley 6	Pulley 7	Pulley 8
Mainline	Phase A	101P									
			Done	Done	Done	Done	Done	Done	Done	Done	
			11/08/2008	13/08/2008	15/08/2008	01.12.2008	24.09.2008	24.09.2008	24.09.2008		
Mainline	Phase A	102P									
			Done	Mod	Hard	Done	Done	Mod			
			02/02/2009	15.09.2009	15.09.2009	24.09.2008	24.09.2008	15.09.2009			
Mainline	Phase A	110P									
			Done	Done	Done	Done	Done	Done	Done		
			08.10.2008	24.05.2009	25.05.2009	06.10.2008	29/10/2008	30.03.2009	22/08/2008		
Mainline	Phase A	121P									
			Done	Done	Done	Hard	Done	Done			
			05.11.2008	11/08/2008	11/08/2008	01.10.2009	11/08/2008	11/08/2008			
Mainline	Phase A	114P									
			Done	Done	Done	Done	Done				
			20.07.2009	23.07.2009	11/08/2008	11/08/2008	11/08/2008				
Mainline	Phase A	115P									
			Easy	Mod	Done	Hard	Hard	Done			
			15.02.2010	15.02.2010	15.07.2009	15.02.2010	15.02.2010	03.04.2008			
Mainline	Phase A	116P									
			Done	Done				Done	Done	Done	
			25.05.2009	5/07/2008				16.12.2008	16.12.2008	16.12.2008	
Mainline	Phase A	117P									
Mainline	Phase A	118P									
Mainline	Phase A	SL2P									

	Bearing	Number	Done	% Done			
	PP-18-8.5-NDA	P-099-1033	Prok 04035	22230K	21	19	90.5%
	PP-18-11-ND	P-099-1031	Prok 04033	23160K	13	9	69.2%
	PP-18-12-D	P-099-1028	Prok 4030	23160K	2	2	100.0%
	PP-18-10.6-D	P-099-1041	Prok 4070	23160K	2	1	50.0%
	PP-18-10-DA	P-099-1030	Prok 04032	23160K	5	2	40.0%
		P-003-19412	Prok 999915	23164K	3	3	100.0%
					46	36	78.3%
	Hard	Hard to change					
	Mod	Moderatly hard to change					
	Easy	Easy to change					

Non-Mainline Changeout plan

		Tefco sleeve replacement program									
Conveyor	Pulley 1	Pulley 2	Pulley 3	Pulley 4	Pulley 5	Pulley 6	Pulley 7	Pulley 8	Pulley 9	Pulley 10	
3P	Done	Done	TBA	TBA	TBA						
	13.11.2008	15.12.2008	2012	2012	30.10.2009						
4P	TBA	Done	TBA	TBA	TBA						
	2012	08.09.2008	2012	2012	2012						
5AP	Done	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled				
	22.08.2008	1.03.2010	10.05.2010	19.07.2010	27.09.2010	27.09.2010	6.12.2010				
18P	Scheduled	Scheduled	Scheduled	Scheduled	TBA	TBA	TBA	TBA	TBA		
	8.02.2010	19.04.2010	28.06.2010	6.09.2010	2011	2011	2011	2011	2011		
103P	TBA	Done	TBA	TBA	TBA						
	2011	13.04.2009	2011	2011	2011						
104P	TBA	TBA	TBA	TBA	TBA						
	2012	2012	2012	2012	2012						
106P	TBA	TBA	TBA	TBA	TBA						
	2011	2011	2011	2011	2011						
107P	Done	Done	TBA	TBA	Done						
	14/07/2008	14/01/2008	2012	2012	18.05.2008						
108P	Done	TBA	TBA	TBA	TBA						
	06.11.2008	2011	2011	2011	2011						
109P	Done	Done	Done	TBA	TBA	Done	Done				
	22.08.2008	11.07.2008	20.11.2007	2011	2011	22.02.2008	21.08.2008				
112P	Done	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled	Scheduled		
	9/05/2008	15.02.2010	12.04.2010	12.04.2010	7.06.2010	2.08.2010	2.08.2010	27.09.2010	22.11.2010		

	Bearing	Number	Done	% Done	Remaining
PP-18-8.5-NDA	P-009-1033	Prok 04035	22230K	16	0
PP-18-11-ND	P-009-1031	Prok 04033	23160K	8	2
PP-18-12-D	P-009-1028	Prok 4030	23160K	4	1
PP-18-10-D	P-009-1029	Prok 4031	23160K	4	0
PP-18-10-DA	P-009-1030	Prok 04032	23160K	3	1
PP-18-8.5-ND	P-003-19412	Prok 999915	23164K	12	3
	P-009-1032	Prok 04034	23140K	20	8
				67	15
				22	52

Hard	Hard to change
Mod	Moderately hard to change
Easy	Easy to change

Conclusions

Learnings from this RCA:

- Rigorous analysis of causal factors and root causes. Each are in-play until **proven** not to be.
- Involve OEM in RCA.
- Ensure RCA actions are practical, understood and agreed too.
- Need high Quality Standards, Quality inspections and Tracability/record keeping. Check and document critical dimensions during assembly and rebuilds.