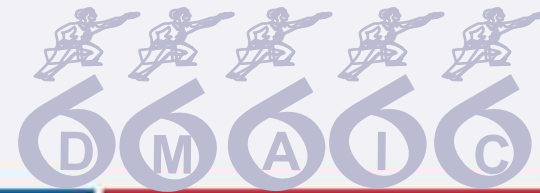




SIX SIGMA PROJECT

Reduction In Overhauling Cycle Time



TEAM MEMBERS

Sadanand M.Cholkar	:	Mechanical Maintenance
Srinivas Nittala	:	Electrical Maintenance
Mohan C. Kulkarni	:	C&I
Narayan N.Chavan	:	C&M
Hitesh R. Joshi	:	Mechanical Maintenance
Deepak J. Sankhe	:	Operation
P.Y.Alok Kumar	:	C&M (Samalkot Power Station)
PROCESS OWNER	:	Manish.Desai
CHAMPION	:	B.S.Dhere



Pain Description

- Time taken for Unit Overhauling is perceived to be high
- High Unit Overhauling cycle time leads to more generation loss and hence pain to all

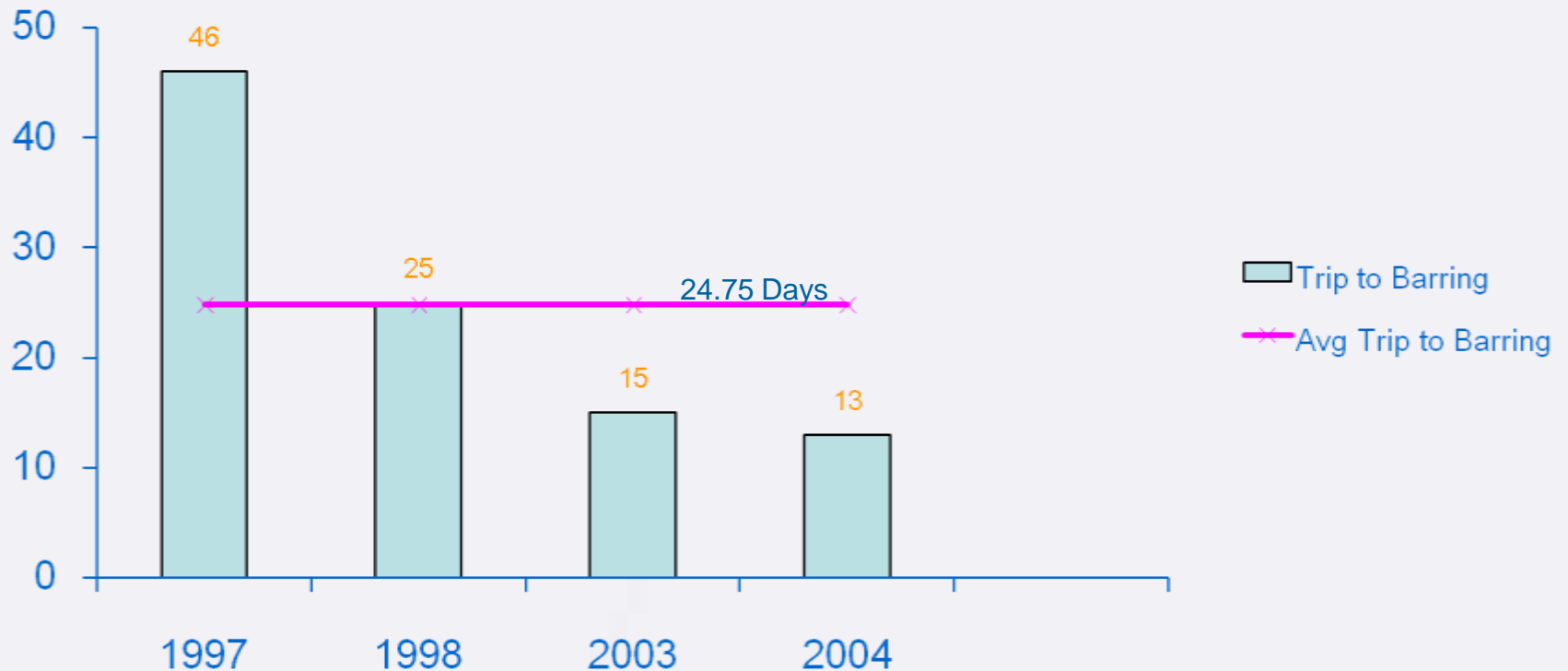


Data Collection

- **Unit Overhaul is classified in to three categories viz.,**
 - ❑ **OH of Generator + LP Turbine,**
 - ❑ **OH of Generator + HP + IP + LP Turbine,**
 - ❑ **OH of Generator + HP + LP Turbine.**
- **Data for 07 Unit Overhaul from 1997 collected.**
- **Data required for each category is collected**

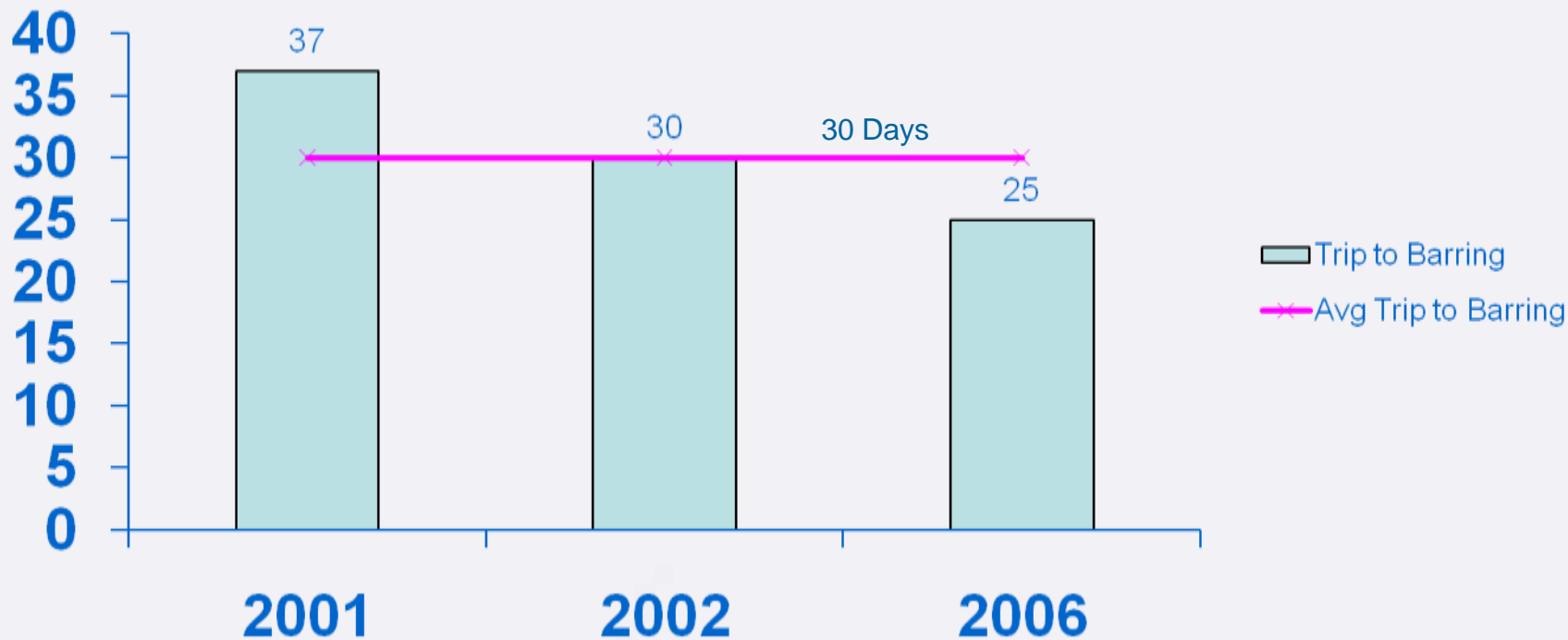


Overhaul Cycle Time – Gen. + LP





Overhaul Cycle Time – Gen. + LP + IP + HP





Project Constraints

- **The overhauling process of one unit comprises of overhauling of many areas such as Generator, Turbine, Boiler, Pumps, Electrical equipment & Switchgear, C&I, etc.**
- **It will be very difficult to study the whole process for all the above mentioned areas at one time in a single project as the no. of activities at micro level will run into thousands.**
- **Based on experience, it is observed that Overhauling cycle time for Turbine & Generator has always been critical and overhauling cycle time for all other areas are planned accordingly.**
- **Hence, it is decided to consider the critical case of Turbine and Generator overhauling cycle time in this project.**



Overhauling Process

SUPPLIER

- OPERATION
- OEM
- CONTRACTORS
- CONTRACTS & MATERIALS
- P&A
- WORK SHOP
- ALL MAINTENANCE DEPARTMENTS

INPUT

- TRAINED WORKFROCE
- DATA
- MATERIALS
- CONTRACTS
- ELECTRICITY
- WORK SHOP FACILITIES
- ADMINISTRATIVE FACILITIES
- STORE FACILITIES
- HOUSE KEEPING

PROCESS

- OVERHAULING OF EQUIPMENTS
- GIVING CLEARENCE TO OPERATION FOR PUTTING TURBINE ON BARRING.

OUTPUT

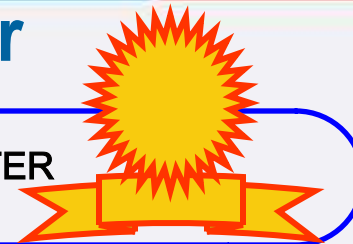
- EQUIPMENT FIT FOR START-UP

CUSTOMER

- OPERATION
- MANAGEMENT

Project Charter

SIX SIGMA PROJECT CHARTER



Date – 17-11-2006

Rev No. 0

Project Title – Reduction in Overhauling Cycle Time

Problem Statement –

Unit Overhauling cycle time varies from 37 days to 25 days with an average of 30 days.

This variation leads to unpredictability in availability of Unit and thereby generation loss.

Reduction of even a single day without compromising the QUALITY will ensure more generation gain and value for the customer.

Business Case –

As a part of our vision and quality policy we promise to supply uninterrupted and quality power to our customers, which always challenges us on our internal efficiency of completing O/H in less possible time, thus thriving to set up new standards and bench marks.

Reducing Overhauling cycle time by 6 days will gain us by 36 MUs and revenue of approximate Rs. 126 Million apart from getting value for the customer and obtaining customer satisfaction.

Goal Statement –

Reduce Overhauling cycle time by 20% from an average of 30 days to 24 days for overhauling of Generator and turbine.

Measure Phase Deliverable

- “AS IS PROCESS MAP”
- Measurement procedure
- Data collection plan for preparing As Is Process Map
- Operational definitions
- Identification of Non value added processes
- Calculation of present sigma level.
- Calculation of estimated savings.
- Review of other plants across India
- Project Definition

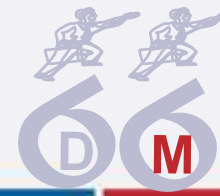
As Is Process Map

Overhauling for Generator & Turbines carried out in the years 2001, 2002 & 2006 varies from a period of 37 days to 25 days with an average of 30 days. “AS IS Process Map” for TG Overhauling process is prepared in accordance to the following points.

- Overhauling process is categorized according to equipment viz., Generator, Exciter, LP Turbine, IP turbine, HP Turbine, Bearings and MOP.
- Major events for each category were identified and marked as milestone events.
- Duration of overhauling process between each milestone event is calculated from the collected data.

Milestone Events

- 1) Generator trip
- 2) Barring gear Stop for LP-GEN Decoupling
- 3) Start of Generator, Exciter & their Bearing Activities
- 4) Generator rotor thread out.
- 5) Barring Gear stop for Turbine activities.
- 6) LP rotor Removal.
- 7) IP rotor Removal.
- 8) Shifting of HP module to service bay.
- 9) Dismantling of HP module.
- 10) Generator rotor Threading in.
- 11) LP rotor Placing.
- 12) IP rotor Placing.
- 13) HP module Placement.
- 14) Alignment
- 15) Final box up of Generator, Turbines & Bearing Pedestals.
- 16) Oil flushing
- 17) Clearance to operation dept. for putting machine back on Barring Gear



Identification Of Non Value Added Processes

- Only Milestone events are considered to identify the duration between them, where possibilities for reduction in cycle time can be studied and **Non value added processes will be identified during Analyze Phase.**

SIGMA LEVEL

Target of Overhauling Cycle Time	: 24 Days
YIELD	: 1
Average Cycle Time	: 30 Days
YIELD	: 0.80
CURRENT SIGMA LEVEL	: 2.34
Reduction in Cycle Time	: 06 Days
IMPROVEMENT IN YIELD	: 0.2
IMPROVED SIGMA LEVEL	: 6

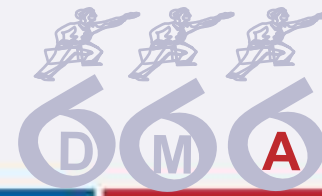
Project Savings

- Average Overhauling cycle Time : 30 Days
- Target of Reduction : 20% or 6 days
- Estimated savings for reducing Overhauling cycle time by **6 days**.

Total Generation units per day	: 6 MUs
Price per unit	: Rs. 3.50
Savings per day	: Rs 21 Millions.
Total Savings for 6 days	: Rs.126 Millions.

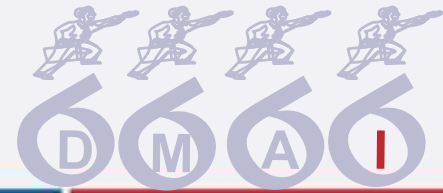
Capacity (MW)	Average Duration Days		
	Capital overhauling of Turbo-Generator		
	2003-2004	2004-2005	2005-2006
500	48	45	60
250	0	45	35
200-210	56	59	49
140-150	159	0	80
120-130	143	59	72
110	62	74	123
Less than 100	59	86	68
All Cap.	75	61	66

Source: Central Electricity Authority



Analyze Phase Deliverable

- Listing of Overhauling activities.
- Brainstorm sessions.
- Possible Causes for delay in O/H.
- Prioritization of Possible Causes
- Cause & Effect Matrix
- Validation of root causes
- Why – Why Analysis



Improve Phase Deliverable

- List of counteraction for Direct Improvement causes
- List of counter action for Controllable causes
- Counter Measure Matrix
- Should be process map
- Implementation Plan

List of Proposed Improvements for Direct Improvement Causes

- 1) Start Hydrogen purging at 0.1 Kg Pressure
- 2) Local pressure gauge to be installed for monitoring CO₂
- 3) Guidelines to be prepared for maintaining the required / suitable temperature at the time of Machine tripping.
- 4) Recirculation line to be provided to ensure effective cooling of the lube oil.
- 5) LPBS to be installed to enable frequent ON / OFF operation of JOP
- 6) Shim Cutting Machine to be procured as necessary shims in various sizes can be cut during alignment in lesser time.
- 7) Maintenance of EOT crane before O/H.
- 8) Consolidated list of Manpower, Tools & Tackles shall be prepared to facilitate C&M while finalizing the contract.

List of Counter Actions for Controllable Root Causes

Sr. No.	Actionable Root Cause	Counter Action
1	Spares not recommended in the standard spares list	Comprehensive list of required Spares with proper specification details to be prepared for each equipment
2	No past history of equipment failure to update the spare list	Structured format for reviewing and updating the List of spares to be prepared
3	Conventional method of turbine parting plane bolt loosening / tightening is Fire Hazard / Risk Prone activity.	Feasibility of using Induction heaters to be explored
4	Conventional method of turbine parting plane bolt loosening / tightening causes Uneven heating	
5	Conventional method of Coupling bolt stretching has Chances for Human error due to Improper Co-ordination	Feasibility of using torque wrenches to be explored
6	Conventional method of Coupling bolt stretching is Accident Prone	

List of Counter Actions for Controllable Root Causes

Sr. No.	Actionable Root Cause	Counter Action
7	Servicing of HP Module is High precision process	Spare HP Module to be procured
8	Servicing of HP Module involves High degree of inspection / checks	
9	Servicing of HP Module Spare replacement time is more	
10	Conventional method of alignment has Chances for Human error	Feasibility of using Laser Alignment Kit to be explored
11	Conventional method of alignment is a Trial & Error Method	
12	Spray Insulation has More steps involved in Process	Feasibility of using Dry Blanket Insulation to be explored
13	Spray Insulation is Hazardous process	
14	Spray Insulation - Parallel working with other activity is not possible	

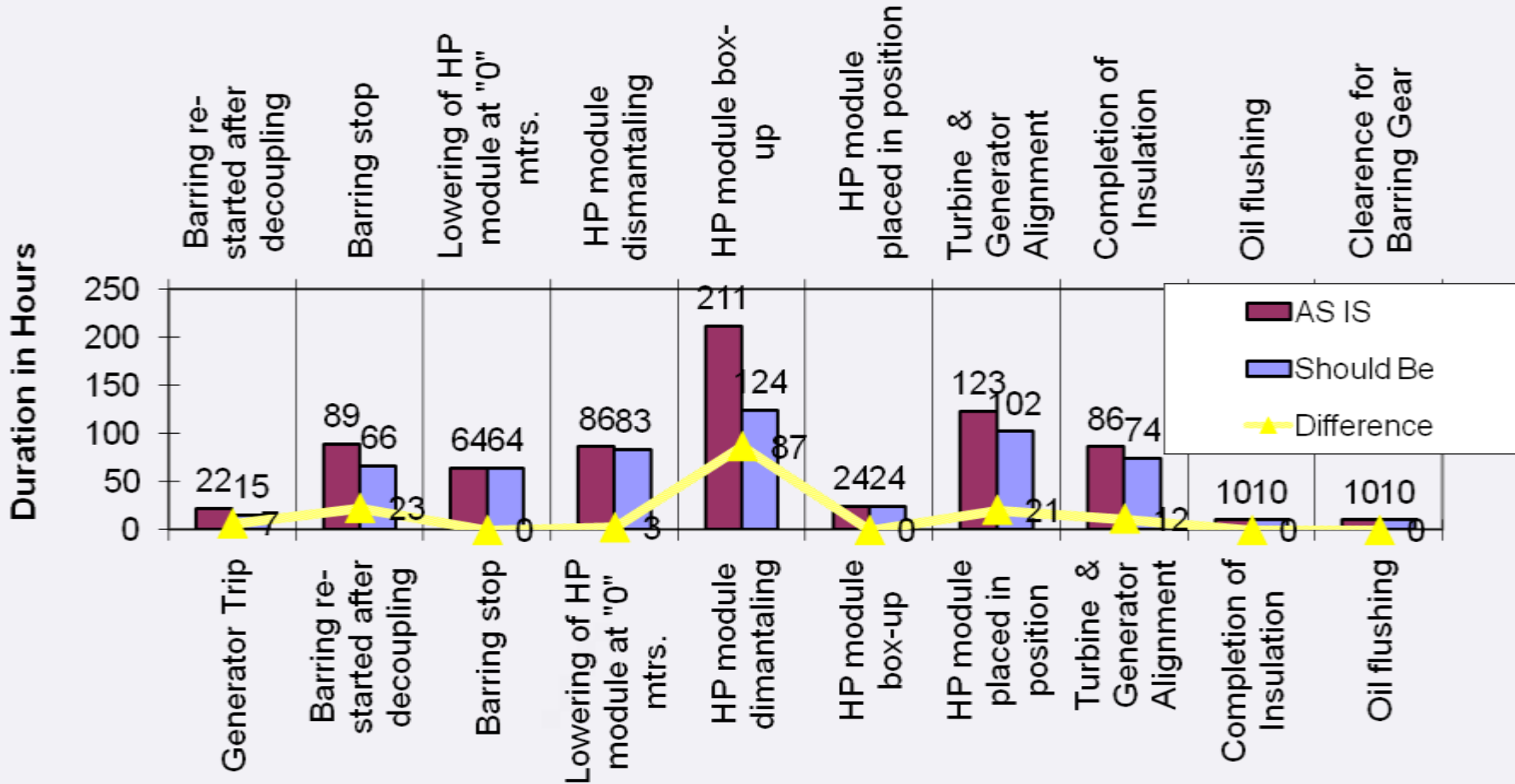
Implementation Plan

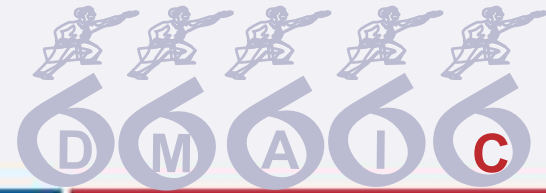
Sr. No.	Counter Action	Responsibility	Plan	Remarks
1	Start Hydrogen purging at 0.1 Kg Pressure	Section Head (Operation)	Modification in ISO Work Instructions (DTP1M/12M01/TG/05) after Pilot test	Needs approval for Pilot Testing
2	Local pressure gauge to be installed for monitoring CO2 pressure during purging	Section Head (C&I)	QIP raised	
3	Guidelines prepared for Turbine cooling (Part – C)	Section Head (Operation)	Prepared	Needs approval for Pilot Testing
4	Temporary Loop to be provided at Brg. No. 5 & 6	Section Head (Mech.)	QIP raised	
5	JOP ON/OFF Push button to be installed near turbine.	Section Head (Elect.)	QIP raised	
6	Shim Cutting Machine to be procured	Section Head (Mech.)	QIP raised	
7	Maintenance of EOT crane before O/H.	Section Head (Mech.)	Check list	
8	List of Manpower, Tools & Tackles shall be prepared	Section Head (Mech., Elect., C&I)	Check list	Manpower, Tools & tackles List format is prepared Needs approval.

Implementation Plan

Sr. No.	Counter Action	Responsibility	Plan	Remarks
9	Format for list of required Spares with proper specification details to be prepared for each equipment by individual department	Section Head (Mech.) Section Head (Elect.) Section Head (C&I.)	Check list	Spares List format is prepared. Needs approval
10	Format for Updating spare list	Section Head (Mech.) Section Head (Elect.) Section Head (C&I.)	Check list	Format is prepared. Needs approval
11	Report on induction heaters	Section Head (Mech.)	QIP raised	Report prepared and attached along with QIP
12	Report on Torque wrenches	Section Head (Mech.)	QIP raised	
13	Report on spare HP module	Section Head (Mech.)	QIP raised	
14	Report on laser alignment kit	Section Head (Mech.)	QIP raised	
15	Report on dry blanket insulation	Section Head (Mech.)	QIP raised	

Comparison of AS IS & Should Be Durations of O/H

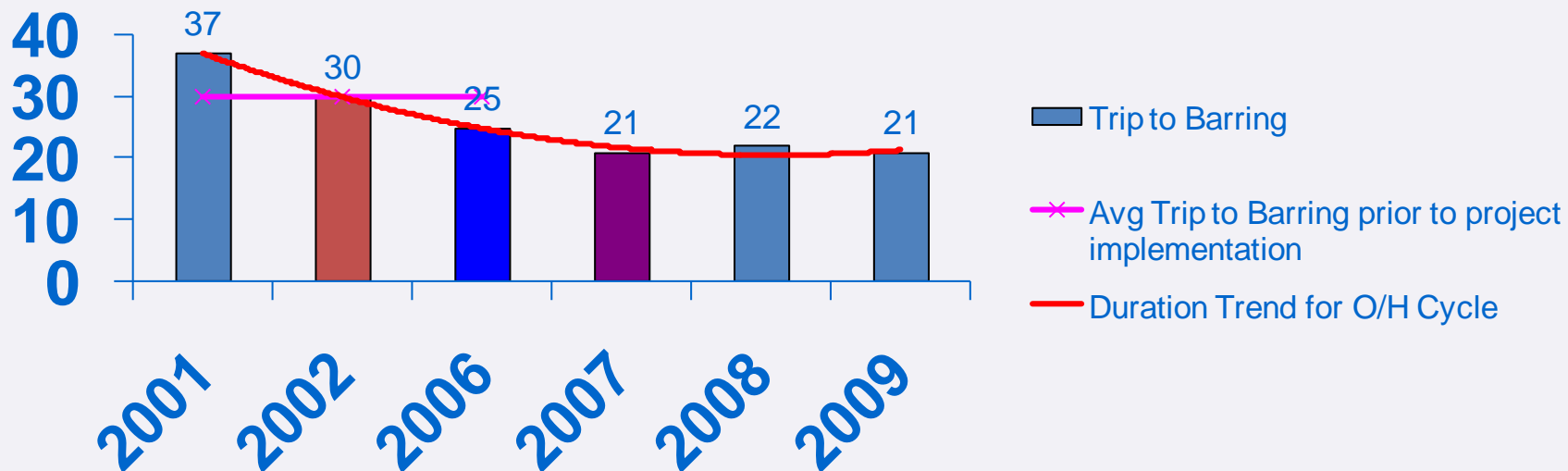


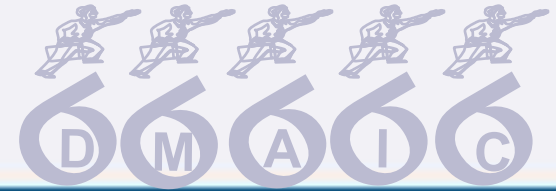


Control Phase Deliverable

- Control Plan
- Improvement Implementation Plan
- Data Collection Format
- Control Dashboards

Dash Board





Thank you