Application of lean methodology to improve sustainability in the construction and demolition waste industry

The Ambisider case study

Mariana Ribeiro

MSc Civil Engineering
CERIS, CESUR, Instituto Superior Técnico, Universidade de Lisboa

Marta Gomes
Amílcar Arantes

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TÉCNICO LISBOA

ADAPTING TO CLIMATE CHANGE

Application of lean methodology to improve sustainability in the construction and demolition waste industry

The Ambisider case study

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- Framework: Research goals
- Literature review: Lean and six sigma, lean and green
- Case Study: Application of lean tools
- Conclusion

M1

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CDW is any debris generated during the construction, renovation and demolition of buildings and civil infrastructures, and their maintenance.

CDW Production

EU: 500 Mton/year
Portugal: 7,5 Mton/year

(Coelho & Brito, 2010) → 25-30%
(Mália, 2010) → 20%

Waste Generated

CDW Recycling rate

EU: 47%
Portugal: 5-10%
Denmark, Holland and Belgium: > 70%

Slide 3

M1 Marta; 18/06/2016

Problems:

- High production of waste (CDW)
- Reduced recycling rate

Needs:

Optimization and efficient use of resources

- Prevention and reduction of waste production
- Efficient use of natural resources

General waste management regime DL n 73/2011

Achieve sustainability in the Construction Industry

Incorporation of recycled aggregates in construction is highly relevant to achieve sustainability and reduce the negative impact of climate changes

Problems:

- High production of waste (CDW)
- Reduced recycling rate

Needs:

Optimization and efficient use of resources

- Prevention and reduction of waste production
- Efficient use of natural resources

Achieve sustainability in the Construction Industry

70% CDW recovery in 2020

Portugal 2020 Program

Improve CDW recycling processes by adopting the lean management philosophy

Lean

Origin
1950 Toyota production system: Lean Production – Lean thinking

Purpose: Eliminate waste - Generate flow - Create value - Reduce costs - Improve quality – Increase competitiveness

Lean Six Sigma (LSS)

Lean principles		Six Sigma (DMAIC)
1.Identify value	→	Define
2.Map the value stream	→	Measure
3. Create flow	↘	Analyze
4. Establish pull	↘ →	Improve
5. Seek perfect	→	Control

Salah *et al*. 2010

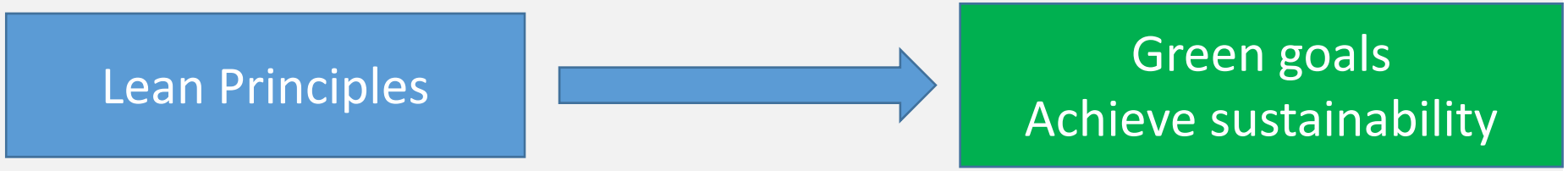
Lean and Green

- Lean studies are based mainly in the Automotive industry;

- Lean applications are expanding: Lean Construction and Lean Service;

- No studies were found related to Lean practices applied to the CDW treatment process;

- Some authors emphasize there is a positive relationship between Lean practices and environmental performance (Green).



Objective: Present a proposal for improving the production process of recycled concrete aggregates of Ambisider by applying the DMAIC method based on LSS management philosophy.

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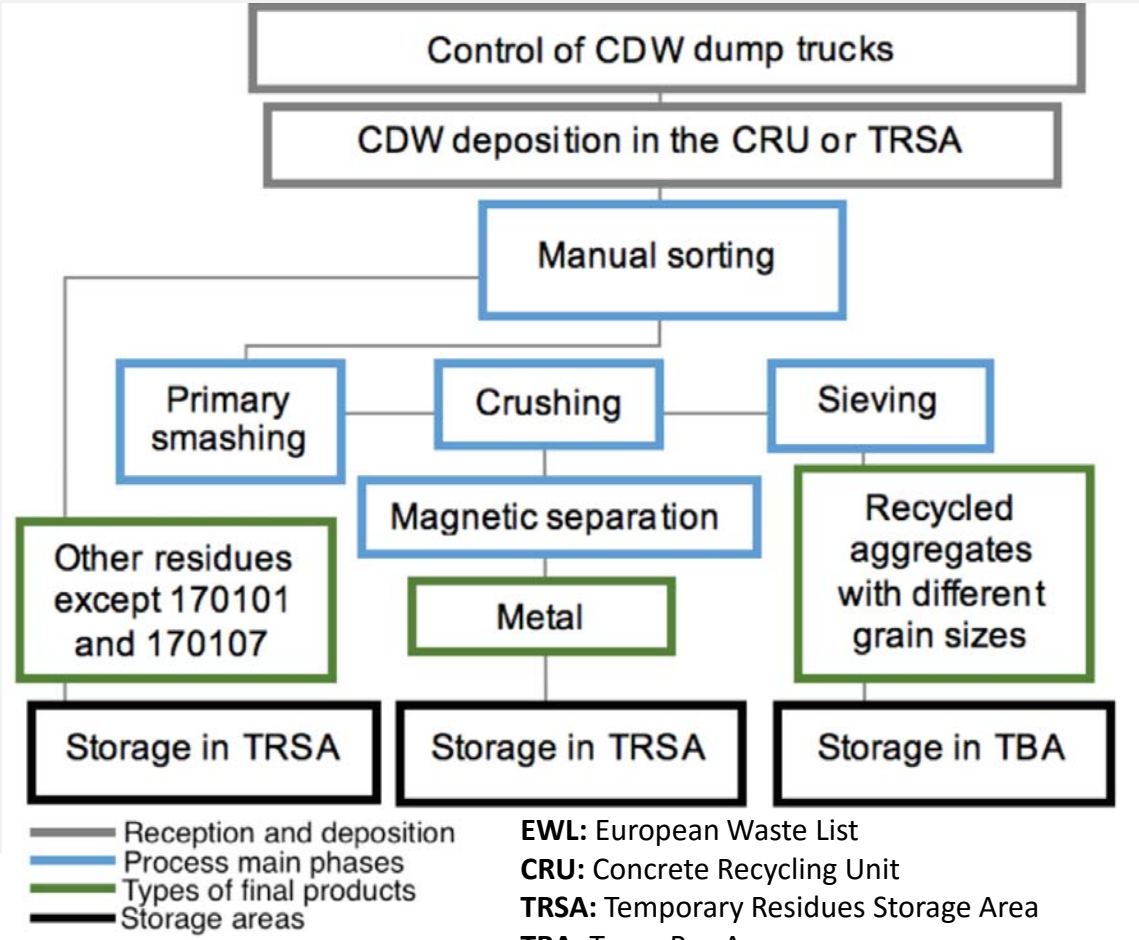
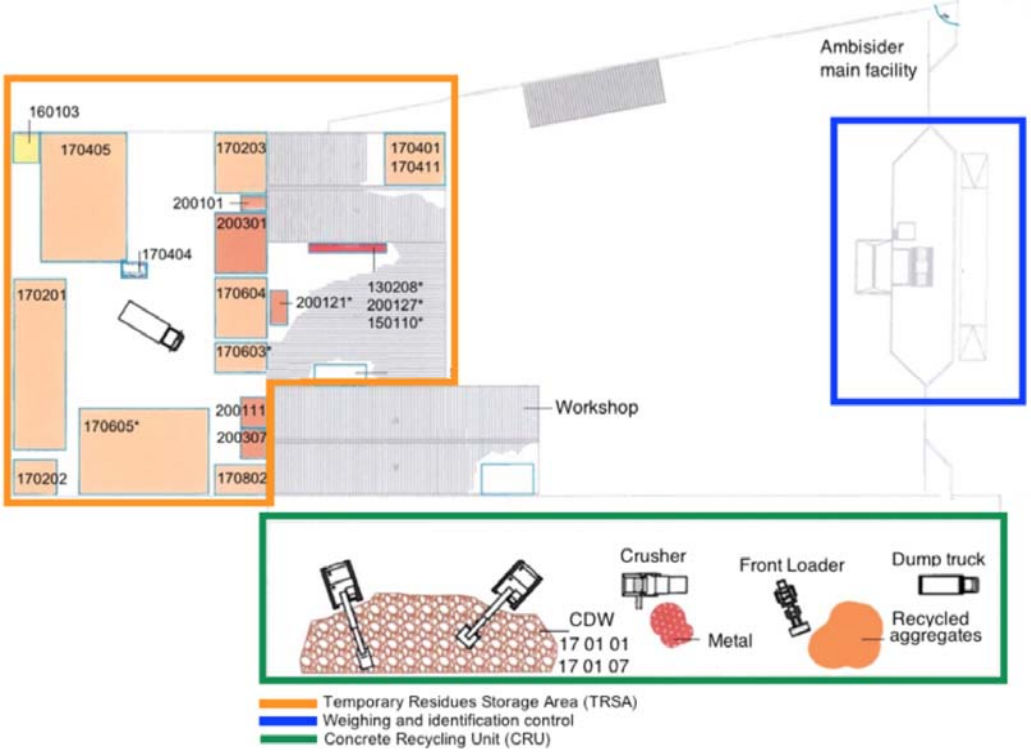
CDW treatment process of Ambisider
Concrete (EWL 17 01 01) and mixtures (EWL 17 01 07)



EWL: European Waste List
CRU: Concrete Recycling Unit
TRSA: Temporary Residues Storage Area
TBA: Tagus Bay Area

Ambisider main facility layout



Ambisider data (2013)

Waste valorization rate - 97%
Recycling rate - 91%

81% inert material
20% of the business volume

Extra activity: commercialization of recycled aggregates of concrete and mixtures

Not competitive

Shortcomings in the recycled aggregates productive process

Methodology

1. Preliminary stage (action “go and see”)
2. DMAIC method

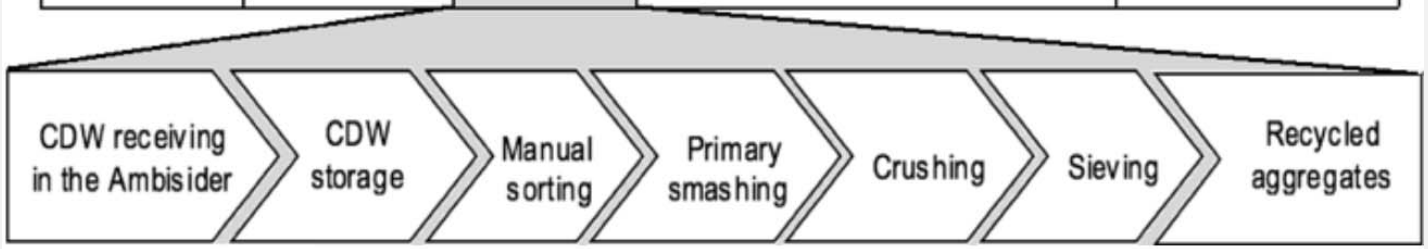
		Process Steps					
		Deposition TRSA or CRU	Manual sorting	Primary reduction	Crushing	Sieving	Storing in TBA
Preliminary Stage		Flowcharts; Detailed description; Improvement opportunities					
DMAIC Method	*Define*	SIPOC; VOC; VOE; CTQ Tree; Project Charter					
	Measure	Spaghetti Diagram; Current VSM; KPI					
	Analyze	Future VSM					
		Brainstorming	Cause-Effect Diagram	-	Cause-Effect Diagram	5 Whys	-
	Improve	5S; Procedures standardization; Future VSM; Other Solutions					
	Control	Visual control; Training; Standardization; Intern audits; Periodic review of KPI					

1) *Define*: Define the problem and project goals

Tools: SIPOC; VOC; VOE; CTQ Tree and Project Charter

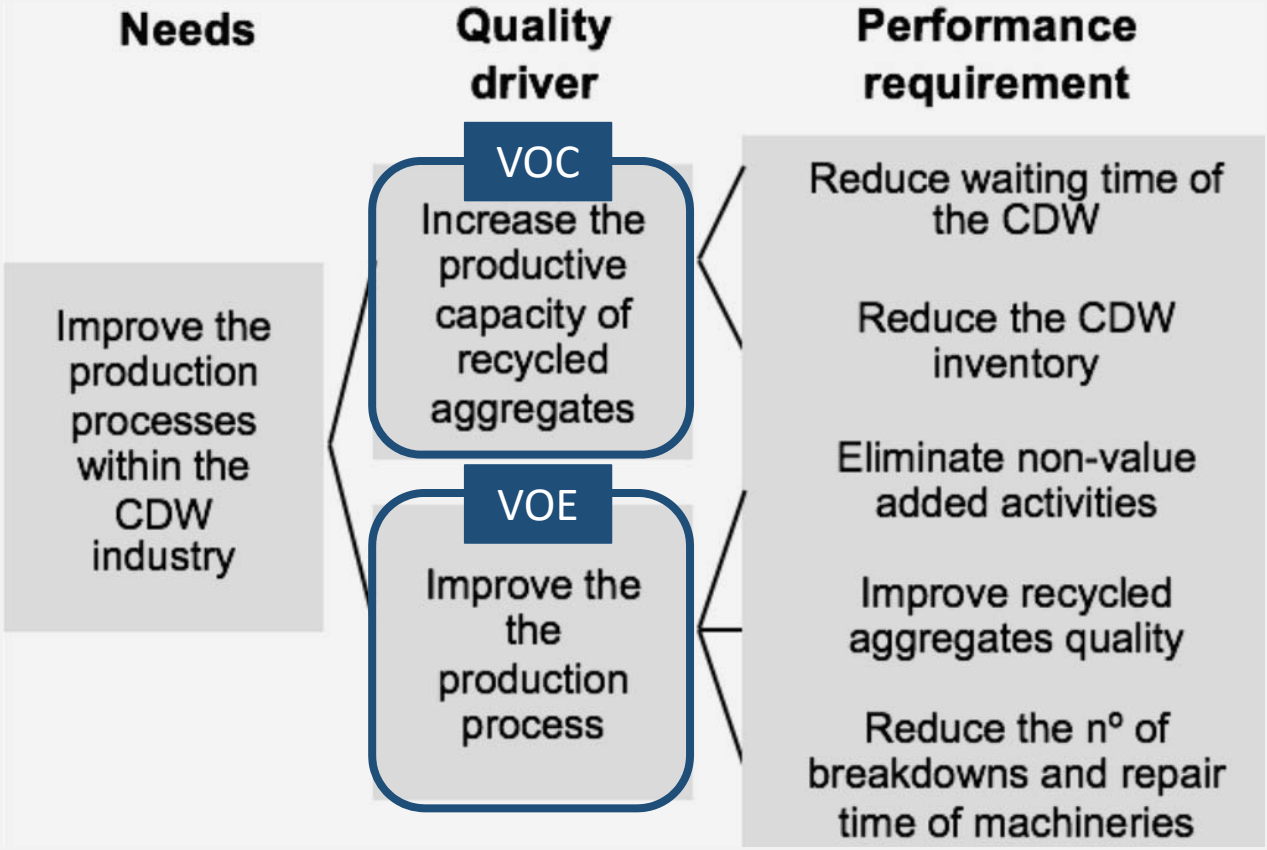
SIPOC

Supplier	*Inputs*	*Process*	*Outputs*	*Customer*
Owner	CDW		Piles of concrete-based crushed aggregates (17 01 01)	Owner (Main)
Diesel	Diesel		Piles of concrete mixtures, bricks, tiles and ceramics crushed aggregates (17 01 07)	Recycled aggregates costumers (Potential)
Lubricants and oils	Lubricants and oils		Other residues for TRSA	



1) *Define*: Define the problem and project goals

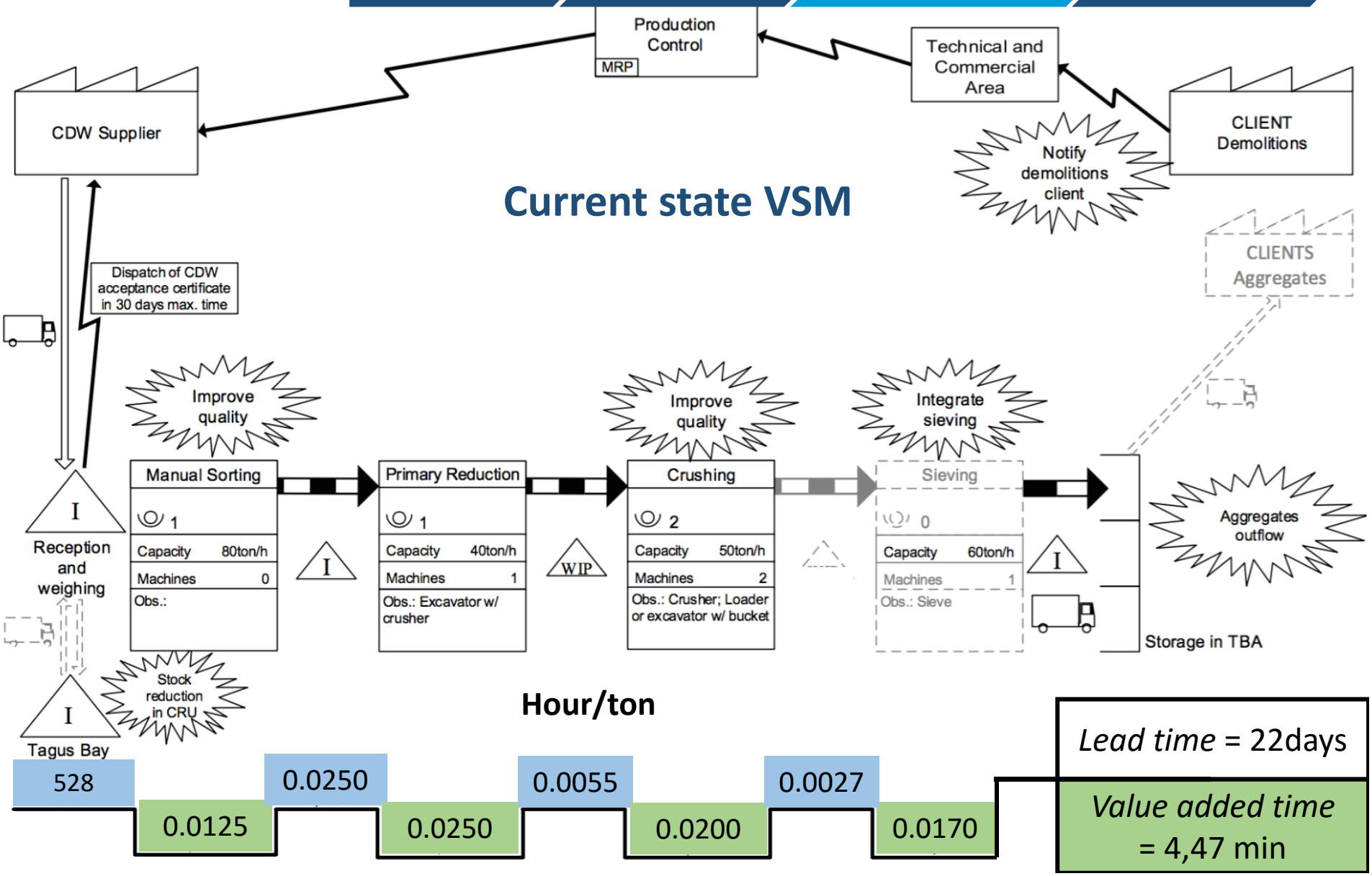
VOC (Voice of Costumer) and VOE (Voice of Employee) → ***Critical to Quality Tree***



2) *Measure*: measure process performance and establish metrics

Tools:

1. Spaghetti diagram – Understand materials flow
2. Value Stream Mapping (VSM) – Understand materials and information flow
3. Define Key performance indicators (KPI)


Production Control
MRP
Technical and Commercial Area
CDW Supplier
CLIENT Demolitions
Notify demolitions client
Current state VSM
CLIENTS Aggregates
Dispatch of CDW acceptance certificate in 30 days max. time
Improve quality
Improve quality
Integrate sieving
Aggregates outflow
Manual Sorting
1
Capacity 80ton/h
Machines 0
Obs.:
Primary Reduction
1
Capacity 40ton/h
Machines 1
Obs.: Excavator w/ crusher
Crushing
2
Capacity 50ton/h
Machines 2
Obs.: Crusher; Loader or excavator w/ bucket
Sieving
0
Capacity 60ton/h
Machines 1
Obs.: Sieve
I
WIP
Reception and weighing
Tagus Bay
Stock reduction in CRU
Storage in TBA
Hour/ton
528
0.0125
0.0250
0.0250
0.0055
0.0200
0.0027
0.0170
Lead time = 22days
Value added time = 4,47 min

2) *Measure*: measure process performance and establish metrics

Problems

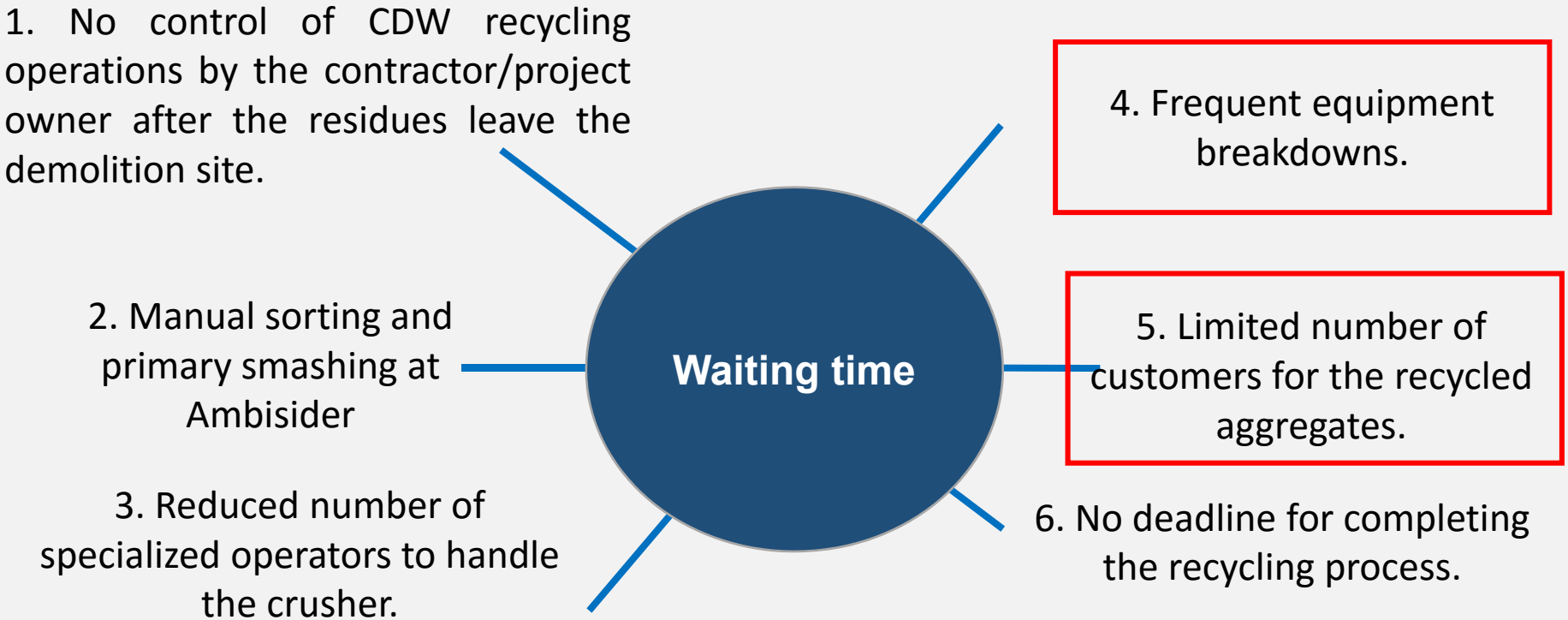
1. Waiting time of CDW to be recycled
2. Reduced quality of aggregates;
3. Crusher breakdowns
4. Occasional realization of sieving

Key Performance Indicators (KPI)

- Lead time (days/ton)
- Value added time (%)
- CDW Stock (ton)
- Production capacity (ton/hour)
- CDW quality (according to LNEC parameters)

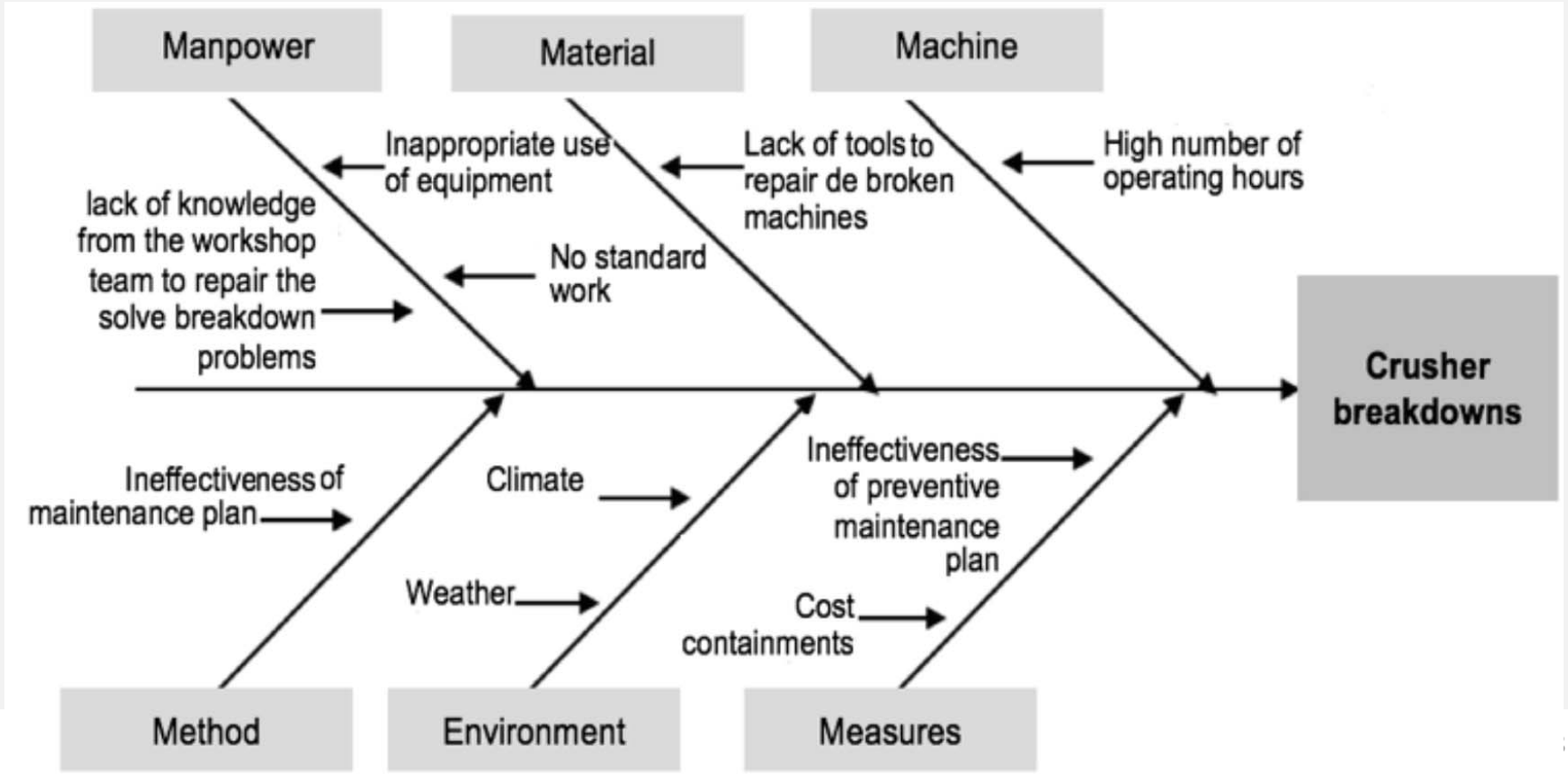
3) *Analyze*: identify potential root causes for the problems

1. Brainstorming - High CDW waiting time for recycling operations



3) *Analyze*: identify potential root causes for the problems

2. Cause and effect diagram to analyze crusher breakdowns



3) *Analyze*: identify potential root causes for the problems

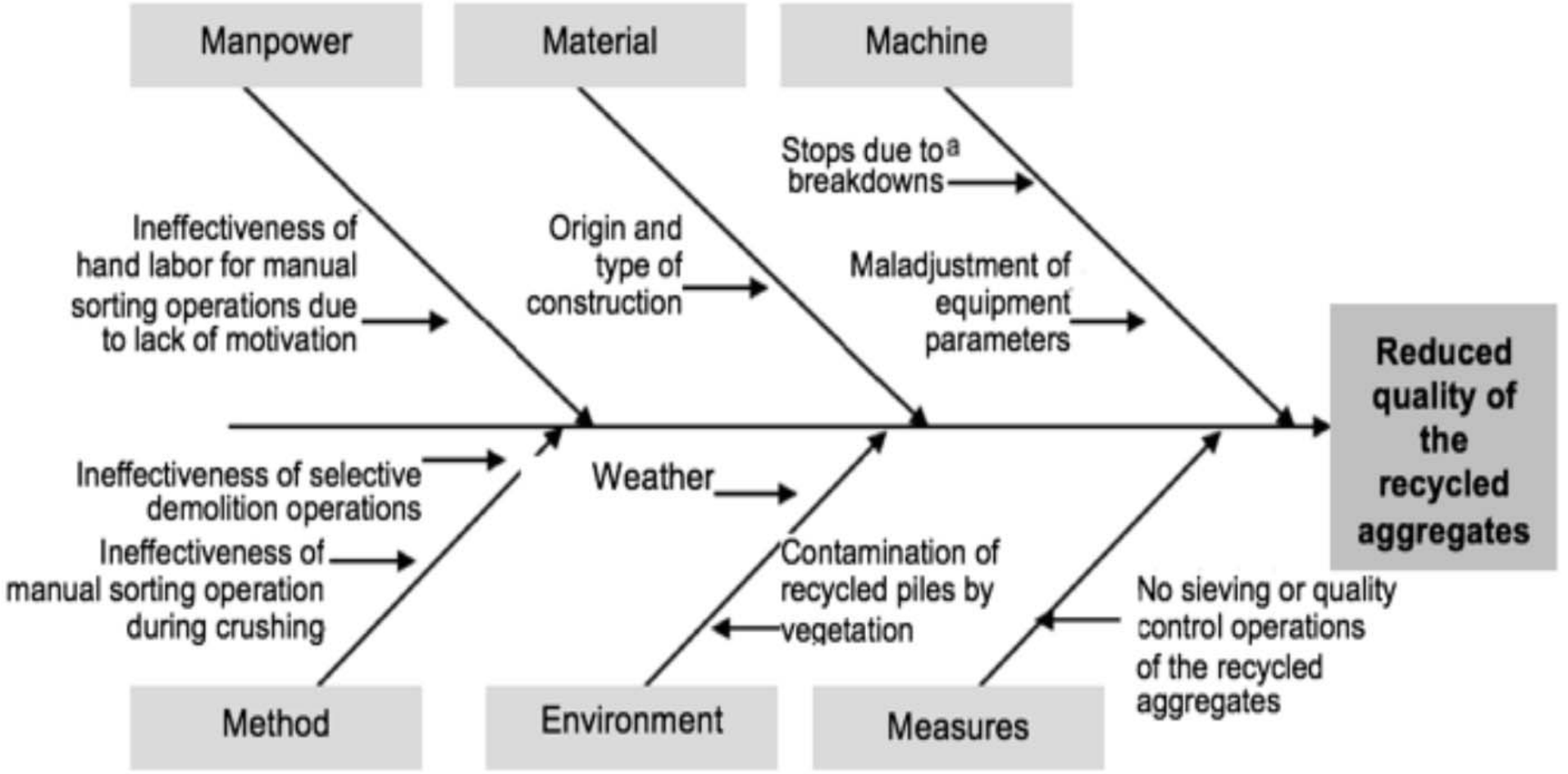
3. Five whys (5W) technique for the occasional realization of sieving operations

Problem: Occasional realization of sieving	
1W	From the standpoint of Ambisider sieving operations mean more human resources available, unnecessary time and cost, adding no value to the company or the main costumer.

From the main costumers point of view (demolition/deconstruction costumers)		From the potential costumers point of view (recycled aggregates costumers)
	2W (...)	2W (...)
3W	According to the Portuguese law it is only required the reduction of the waste dimensions. Thus, only sorting, primary reduction and crushing procedures are mandatory while the grain size differentiation is not.	3W (...)
		4W (...)
		5W There are defects in the selective demolition and in the recycling process.

3) Analyze: identify potential root causes for the problems

4. Cause and effect diagram to analyze reduced quality of recycled aggregates



4) Improve: Eliminate wastes and seek for Lean principles

Cultural changes: integrated vision of the production process

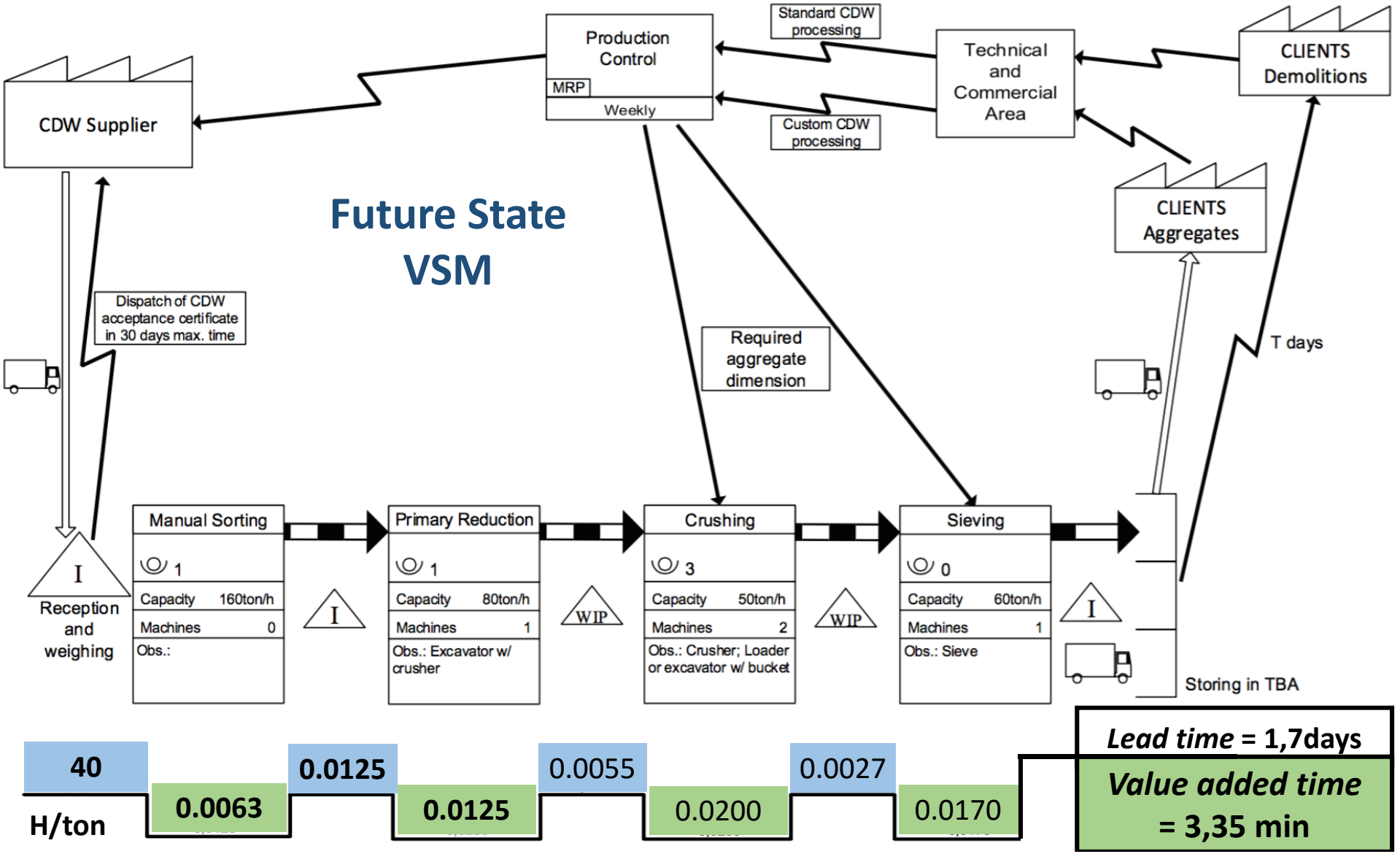
+ Quality

- Waiting time | **- Breakdowns** | **Inclusion of sieving**

Improvements

- ✓ More effectiveness during all CDW treatment steps;
- ✓ Laboratory tests – partnerships with Universities
- ✓ Follow LNEC specifications;
- ✓ Identify value (recycled aggregates costumers perspective);
- ✓ Standardize work;
- ✓ Continuous training events;
- ✓ Regular intern 5S audit (sort, straighten, shine, standardize and sustain)

Future State VSM



5) Control: Sustain the gains

5S Audit

Sort
Straighten
Shine
Standardize
Sustain

5S category

Area Audited

0-4 Scores

Rating Criteria

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AUDITORIA 5S

Número de Registo:____
Área Auditada:
Ambisider: URB, AATR, Oficina
Baía do Tejo: Armazenamento

Auditores: 1.
2.

Data da presente auditoria: ___/___/____
Data da próxima auditoria: ___/___/____

Objetivo*: %

5S	Nº	Critério de avaliação	N/A	1	2	3	4	Observações:
Separação (*Seiri*)	1	(ex.:ferramentas, equipamentos, máquinas, materiais,etc.)						
	2	Existe informação desnecessária/irrelevante na área de trabalho?						
	3	OS espaços destinados à circulação de camiões-banheira e dos móveis de britagem estão obstruídos?						
		Total						
		Média *Seiri*						
Organização (*Seiton*)	1	As placas e os avisos de segurança estão devidamente identificados nas áreas de risco?						
	2	Existem locais definidos e identificados para cada tipo de stock de resíduos segundo os códigos LER**?						
	3	Existem locais definidos para cada ferramenta e máquina?						
		Total						
		Média *Seiton*						
Limpeza (*Seiso*)	1	Existem equipamentos, máquinas e ferramentas em mau estado de conservação?						
	2	Todos os colaboradores usam devidamente equipamentos de proteção individual? (quando necessário)						
	3	Sempre que possível é feita a rega dos RCD antes e após a britagem para evitar a contaminação da zona envolvente?						
	4	Existem lubrificantes ou outros contaminantes derramados na área?						
		Total						
		Média *Seiso*						
Normalização (*Seiketsu*)	1	As normas de procedimentos estão disponíveis para consulta junto da área de trabalho?						
	2	Os colaboradores entendem e seguem as normas definidas para a execução dos procedimentos? (triagem manual, redução primária, britagem e armazenamento)						
	3	As áreas de trabalho estão devidamente identificadas de acordo com o *standard*?						
		Total						
		Média *Seiketsu*						
Disciplina (*Shitsuke*)	1	Todos os colaboradores estão envolvidos no cumprimento da implementação do sistema 5S?						
	2	A normalização/padronização dos procedimentos é seguida?						
	3	As auditorias 5S são documentadas e realizadas frequentemente?						
		Total						
		Média *Shitsuke*						
		Média total atingida pela área auditada						

Pontuação

Observações para melhoria do programa 5S:

*Objetivo a definir pela Ambisider
**LER: Lista Europeia de Resíduos

5) Control: Sustain the gains

Checklists for crusher maintenance

Daily maintenance

Standard*

Checklist

Weekly maintenance

Standard*

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CHECKLIST MANUTENÇÃO DIÁRIA/SEMANAL BRITADOR

Número de Registo: _____
Área/Departamento: _____

Manutenção Diária**	1ª Manutenção Data: __/__/____		2ª Manutenção Data: __/__/____		3ª Manutenção Data: __/__/____		4ª Manutenção Data: __/__/____		5ª Manutenção Data: __/__/____	
	✓	Observações*	✓	Observações*	✓	Observações*	✓	Observações*	✓	Observações*
1. Verificar nível de óleo (repor ser necessário)										
2. Verificar nível de combustível										
3. Purgar condensados no depósito de combustível										
4. Remover e limpar o filtro de ar										
5. Verificar alinhamento das placas e volante										
Assinatura do responsável	_____		_____		_____		_____		_____	

MANUTENÇÃO SEMANAL***	Data: / /____	✓	Observações*
1. Verificar o nível de óleo no depósito (através dos bujões de ambos os lados)			
2. Verificar e regular o estado das telas dos transportadores, rolamentos e outras partes móveis			
3. Eliminar qualquer obstrução da câmara de esmagamento e dos mordentes			
4. Verificar todas as fixações e se todos as placas estão bem colocadas e fixas			
5. Remover todas as poeiras dos filtros de óleo e do radiador			
6. Verificar desgaste das maxilas			
7. Verificar desgaste das placas			
8. Verificar indicadores de serviço dos filtros dos sistemas hidráulico (substituir se indicador vermelho)			
9. Verificar indicadores de serviço dos filtros do sistema de ar (substituir se indicador vermelho)			
10. Verificar indicadores de serviço dos filtros do sistema de água (substituir se indicador vermelho)			
11. Verificar a tensão nas correias de transmissão (Máx.deformação 6,5mm. Tensionar se necessário)			
12. Lubrificar todos os rolamentos			
Assinatura do responsável	_____		

NOTAS:
*Indicar reposições (ex.:óleo, combustível, etc.); substituições (ex.:filtros); ou outras inconformidades.
**A manutenção diária deverá ser efetuada a cada utilização do britador.
***A manutenção semanal deverá ser efetuada após realizadas as cinco manutenções diárias.

* Manual Crusher

5) Control: Sustain the gains

Visual Control – Informative Board

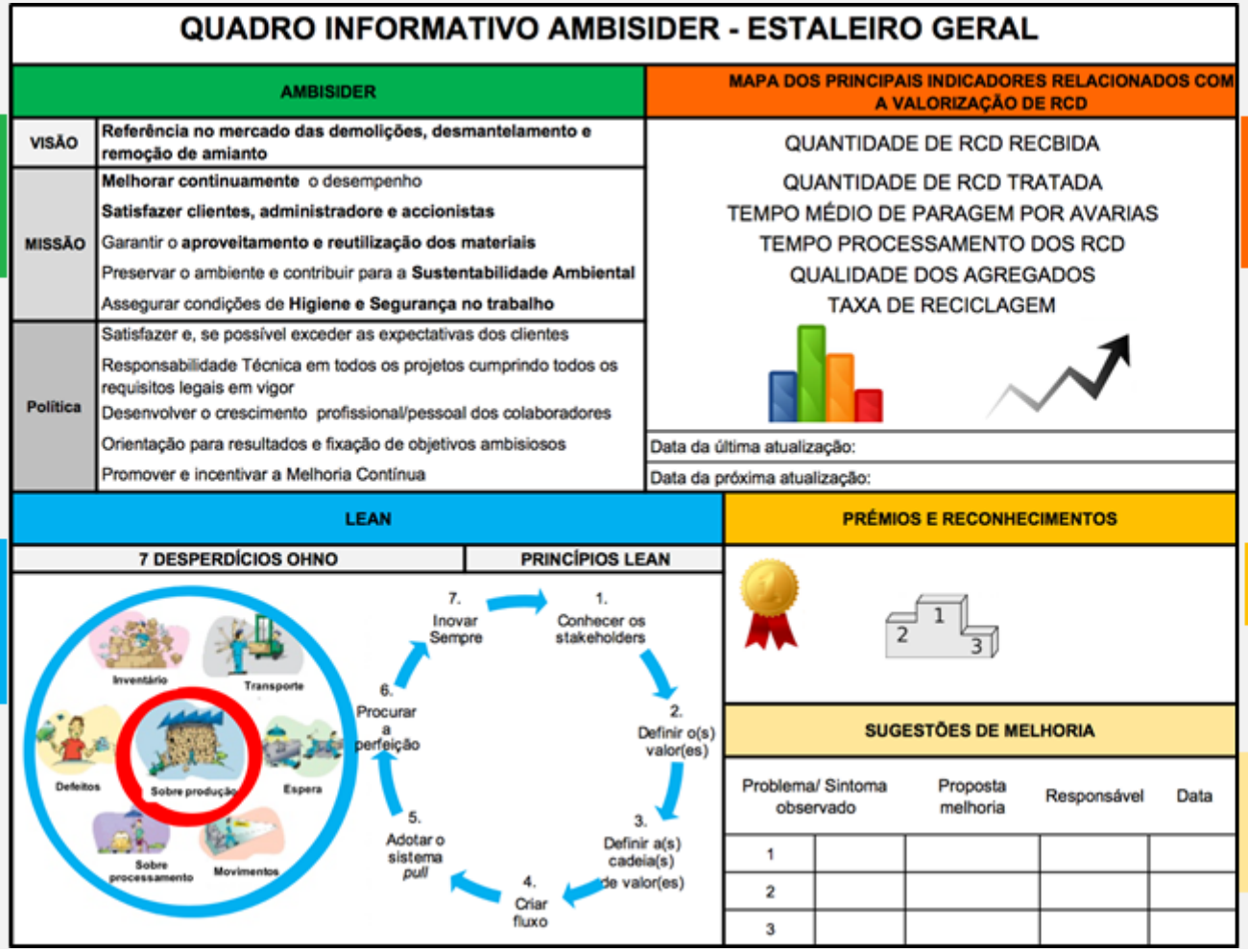
Ambisider
- Mission
- Vision
- Goals

Lean Principles and wastes

KPI Graphics Statistics

Best in class

Suggestions for improvements



Conclusion

Main suggestions for improvement

- Company cultural changes;
- Standardize work;
- 5S;
- Training events;
- Universities partnerships.

Main expected results

- ✓ Pull System
- ✓ Create production flow
- ✓ Increase production capacity
- ✓ Lead time reduction (92%)
- ✓ Better recycled aggregates quality
- ✓ Increase of company's competitiveness
- ✓ Positive impact in green goals

Shortcomings

Difficulties analyzing the production process
Lack of data regarding the CDW treatment process

Contributions

DMAIC method enabled to understand the problems, find their root causes and design suitable improvements
Expansion of Lean applications (construction and demolition industry)

Future developments

Deeper understanding of the process
Implementation of proposed improvements

Thank you

Mariana Ribeiro
mariana.mri.ribeiro@gmail.com

> Where there is no Standard
> there can be no Kaizen
> - Taiichi Ohno