



Loading and Hauling

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LOADING AND HAULING

Purpose

- Increase the understanding for how a machine fleet and site can be optimized (loading and transport) in regards to productivity and costs.

Goal

- To be able to choose the most effective load and transport solution, measured in cost/ton.



AGENDA

Agenda

- Optimal loading
 - Wheel loaders
 - Excavators
- Optimal hauling
 - Articulated trucks
 - Rigid trucks
- Case study:
 - Loading and Transport



DIGGING/LOADING SOLUTIONS

Alternatives

1. Wheel loader
2. Crawler excavator, backhoe
3. Crawler excavator, face shovel
4. Massive scale mining - continuous miner, cable shovel, dragline

1



2



3



DIGGING/LOADING SOLUTIONS

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- ~~4. Massive scale mining - continuous miner, cable shovel, dragline~~



DIGGING/LOADING SOLUTIONS



Criteria	Wheel Loader	Backhoe Excavator	Face Shovel
Productivity	YY	YYY	YY
Direct Digging	YY	YYY	YY
Mobility	YYY		
Flexibility	YYY L&C, QC	YY hammer, ripper, QC	
Bucket selection	YYY	YYY	Y
Selection/Boulder handling	YY	YYY	Y
Truck loading	side loading	side or rear	side loading
Loading level	pit floor	bench or floor	floor
Needing Support Machines	YYY	YYY	Y
Reach	YY	YYY	YY
Capital Expense	YY	YY	Y
Resale	YYY	YY	
Running Costs	YY	YY	YY
Reliability	YYY	YYY	YY



Key Rating

	poor
Y	fair
YY	good/excellent
YYY	exceptional

OPTIMIZE LOADING – WHEEL LOADERS



OPTIMIZE LOADING – WHEEL LOADERS

Quarry design

•Quarry Floor

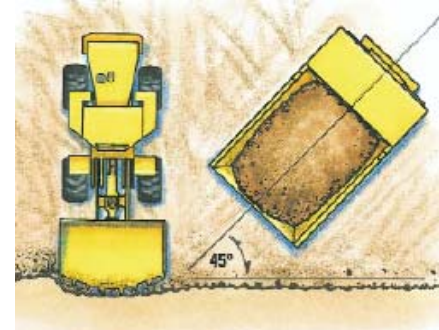
- Water removal
- Grades/Inclinations
- Even ground surface
- Keep the site clean from waste/equipment not in use
- If possible; Make sure that is enough space for at least two receivers of the load



OPTIMIZE LOADING – WHEEL LOADERS

Truck positioning

- Select a position as close to the material as possible
- Place the receiver of the load in the direction of travel
 - Sharp turns when truck leaves will destroy surface
 - If loading can be arranged with trucks passing without reversing capacity increases



OPTIMIZE LOADING – WHEEL LOADERS

Maintain the Roads

- Make sure the road is as smooth as possible and free from dropped gravel
- Smooth out rough routes with finer material and fill in holes
- Dropped material is wasted revenue and becomes a 2nd cost.

*Volvo L350F Load & Carry
100 m
Productivity rate = 570
ton/hr*

**Add one stop-and-go and
productivity **decreases 14%****

**Productivity rate = 490
ton/hr**



OPTIMIZE LOADING – WHEEL LOADERS

Take the Shortest Route

- Plan your transport routes so they are as short as possible.
 - Straighten out road curves.
 - Move obstacles (i.e. road signs)
 - Optimize roads in regards to inclination and length.
- Optimize placement of depots in regards to handled material.
- Consider a belt conveyor for long transports, especially if there is a large elevation change.



OPTIMIZE LOADING – WHEEL LOADERS

Uphill Grades

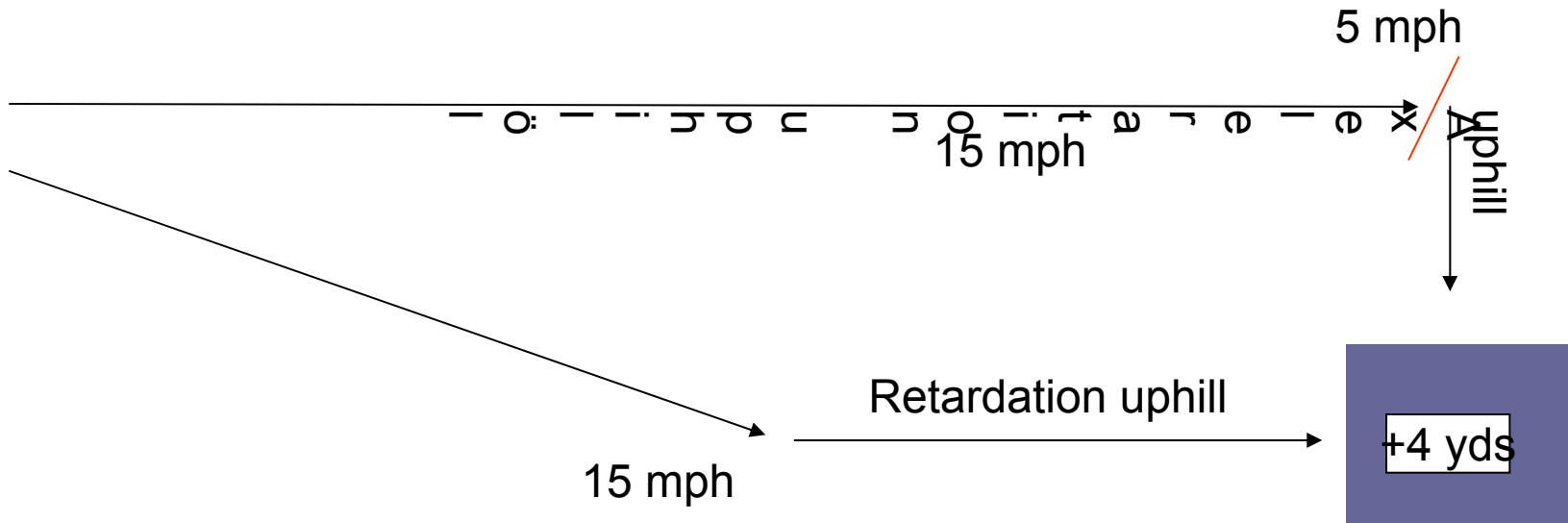
- Avoid sharp turns before uphill grades so that momentum is maintained and braking minimized.
- Uphill grades at the unloading area can assist deceleration without braking, and assist backup.

Use force of gravity to slow down at dump, and accelerate at re-start cycle.

Aids fuel efficiency and reduces wear on brake pads.



OPTIMIZE LOADING – WHEEL LOADERS



Volvo 350F load & carry 160 m

	<i>Productivity (ton/h)</i>	<i>Fuel eff. (ton/lgal)</i>
<i>90 deg. turn</i>	330	35
<i>Straight</i>	460	44
<i>Volvo L220F</i>	374	



OPTIMIZE LOADING – WHEEL LOADERS



OPTIMIZE LOADING – WHEEL LOADERS

Handling Finished Products

- Bucket selection
 - a Rehandling bucket [Test](#)
– makes a real difference.
- Tire selection
 - L2 or L3 is sufficient
Weight
Internal friction
Price
Test



OPTIMIZE LOADING – WHEEL LOADERS

Rehandling Bucket

- Optimized for fast filling - “knives” in to material instead of crowding.
- Large fill factor (full measure) for capacity.
- Minimizes spillage or waste, for example in a load and carry.
- Rounded corners and edges reduce stuck material in the bucket and increase the life of the bucket.
- Can increase fuel efficiency up to 10%.



Rehandling



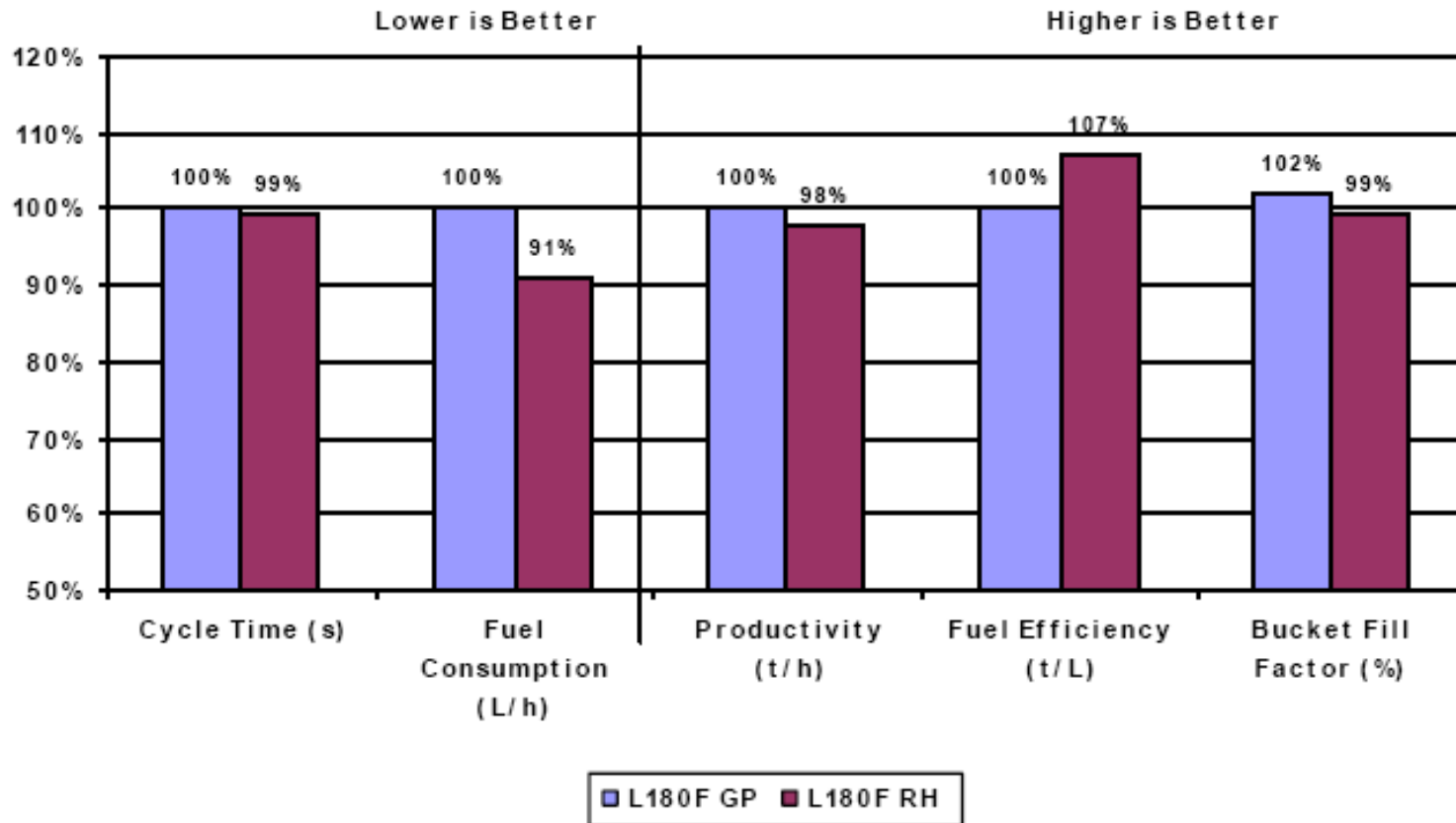
Standard GP

OPTIMIZE LOADING – WHEEL LOADERS

How much can fuel consumption be decreased per hour with a rehandling bucket compared to a General Purpose bucket?

OPTIMIZE LOADING – WHEEL LOADERS

Short Cycle Loading Normal Operation - Crushed



OPTIMIZE LOADING – WHEEL LOADERS

Tires

L2:

- When a good grip is important.
- When driving on sand with few/no sharp stones
- Load/carry, including material handling.



L3:

- All types of load /carry applications.
- When driving on sand.



L4:

- When handling aggressive material and protection against cutting is needed. For example when handling blasted rock.



L5:

When handling extremely aggressive material. For example in quarries and mining applications. Low travel/speed.



Increasing tread depth,
also increasing weight
and reducing TMPH!

OPTIMIZE LOADING – WHEEL LOADERS

Finished Material

- Right Bucket – Rehandling Bucket
- Right Tires – L2 or L3
 - Weight
 - Internal Friction
 - Price

Duplicate slide???



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OPTIMIZE LOADING – WHEEL LOADERS

Rock Handling

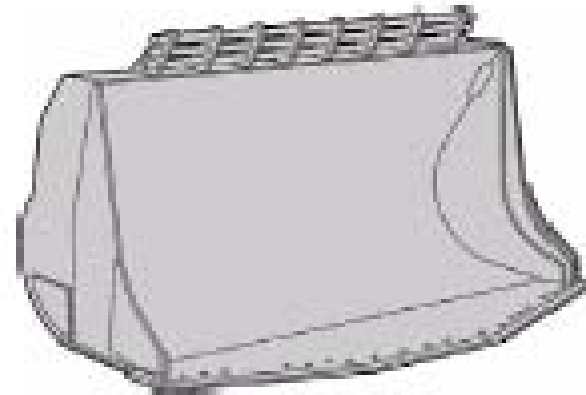
- Right Bucket – **spade nose bucket**
- With or without teeth
- Right tires – L5
- Chains are sometimes used



OPTIMIZE LOADING – WHEEL LOADERS

Spade Nose Bucket

- Adapted for loading of blasted rock
- Designed for superior penetration ability
- Can be equipped with both teeth/segments and bolt on edge



Pictures

OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry

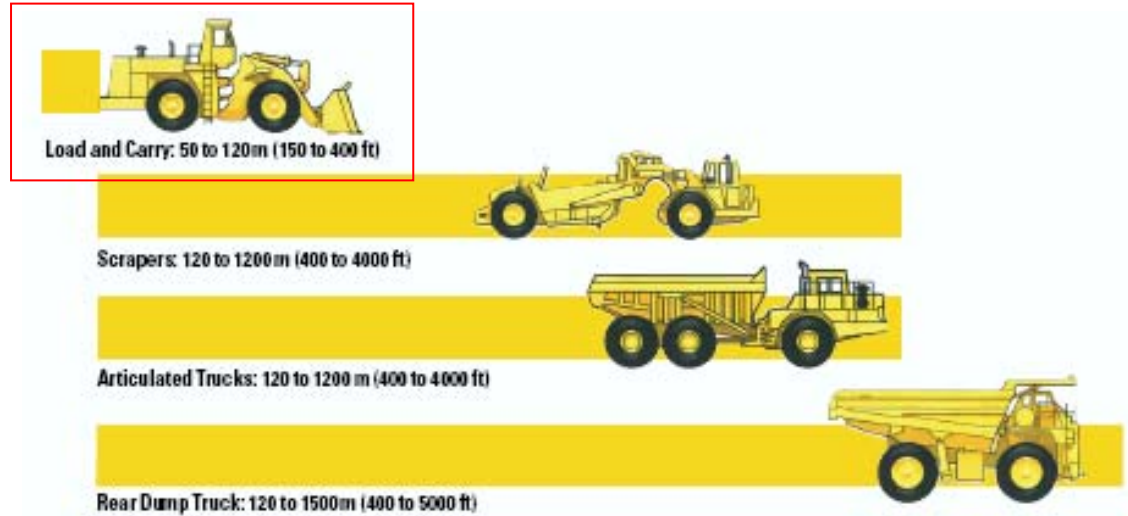
- Cost-effective transport from 0-650ft (200m), Why?
 - Reduce the fleet of mobile machines, less operators less traffic.
 - Lower investments
 - No/reduced need for loading ramp to hopper



OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry

- Cost-effective transport from 0-650ft (200m), Why?
 - Reduce the fleet of mobile machines, less operators less traffic.
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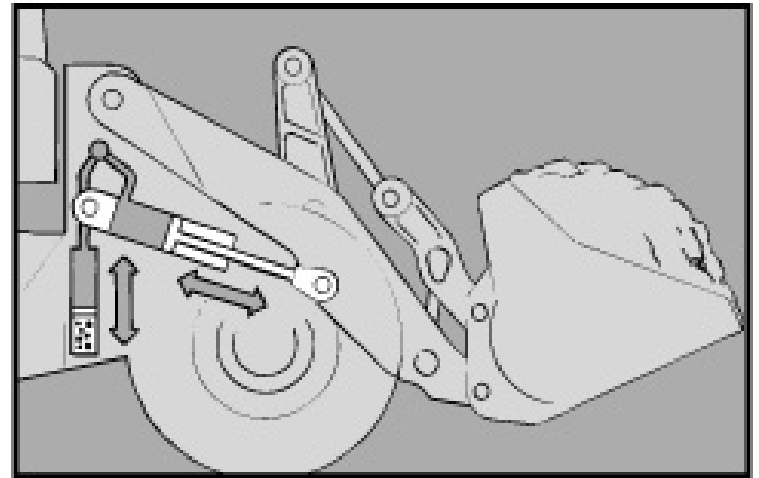
OPTIMIZE LOADING – WHEEL LOADERS

Configuratio n	Length of transport 160 yard		Length of transport 220 yard	
	Production	Cost	Production	Cost
Volvo L350F	338 tn/h	0,52 \$/tn	277 tn/h	0,62 \$/tn
Volvo L180F Volvo A35E	340 tn/h	0,68 \$/tn	325 tn/h	0, 72 \$/tn

OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry / Travel Enhancement

- A Boom Suspension system reduces bucket movement when driving on uneven surfaces.
 - Increased productivity (up to 20%)
 - Increased comfort and stability
 - Less spillage and waste
 - Less stress on axles, frames & lifting arms



Movie

OPTIMIZE LOADING – WHEEL LOADERS

Finished Material

- *The right bucket can reduce fuel consumption 5%*
- *The right tires can also reduce fuel consumption 5 %*
- Overall, in 1500 h / year
6.6 gal / h → 10,000 gal
10% saving → 1,000 gal
\$3,000/year



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SUMMARY OF LOADING – WHEEL LOADERS

Benefits of Wheel Loaders vs. Crawler Excavators

- Mobility
 - Possibility of load/carry on shorter distances (rule of thumb: up to 650ft)
 - Loading from different locations/depots for mixing material
- Utility
 - Maintain roads, clean up loading area
- With quick fit/coupler you can:
 - Do some odd or small jobs, for example clean under the conveyor belt
 - Use different buckets. The right bucket for the right purpose.
 - Easily switch to forks for block handling or material handling.

OPTIMIZATION OF LOADING – CRAWLER EXCAVATORS



SUMMARY OF LOADING – CRAWLER EXCAVATORS

Benefits of Excavators vs. Wheel Loaders

- Travel and Digging/Loading are separate modes
 - Faster load cycle times (swinging not traveling)
 - No/little undercarriage or tire wear during loading
- Handling variable material
 - Boulder handling, sorting
 - More reach
 - Better distributing of load in truck bed
- Ancillary Jobs
 - Hammer/breaker

Quick coupler allows ripper attachment, other buckets



OPTIMIZE LOADING – EXCAVATORS

Organized loading site

- Keep the loading site free from rocks and waste.
- Make it easy for the hauler/truck to approach/reverse for loading, thus giving a shorter and more effective loading cycle.
- 45-90 deg swing is optimal
- Use truck spotting time to pull material closer.

Give a shorter and more efficient loading cycle → Increased production



OPTIMIZE LOADING – EXCAVATORS



OPTIMIZE LOADING – EXCAVATORS

Positioning

- Load from the bench, if possible.
 - Better visibility
 - Better traffic flow
 - Better floor and pile management
 - Optimal digging forces
- Cooperation with the hauler gives a shorter, more effective loading cycle
- Make sure the excavator is placed on firm ground, don't swing over cab
- Aim for as short swing angle as possible, minimize boom/arm movements.

What's in it for me?

*Reduce cycle time from 22sec to 20sec
→ Loads one more 40ton truck/hour
→ **increase revenue \$150,000/year**
(at \$2 per ton)*



OPTIMIZE LOADING – EXCAVATORS

Use the right attachment

- A variety of boom/arm/bucket combinations – choose!
 - Mass Ex (ME) = short boom & arm → big bucket but limited reach. Resale value?
 - Long arm = reach can reduce travel but hurts digging capacity, may increase cycle time.
 - Standard boom + short arm → often best truck loading. Good digging & reach for a tight cycle.
 - Quickfit/coupler – switch to breaker, ripper, grading bucket, etc. → ripper sometimes used to unstick the crusher chamber.



OPTIMIZE HAULING



HAULING SOLUTIONS

Alternatives

1. Road trucks
2. Articulated dump trucks
3. Rigid framed dump trucks
4. Mobile crusher/conveyor



HAULING SOLUTIONS

2

3

Criteria	Articulated Truck	Rigid Truck
Power/Weight ratio	YY	YYY
Payload Capacity	YY	YYY
Top Speed	YY *	YYY
Gradeability	YYY	YYY
Traction	YYY	YY
Visibility	YY	
Flexibility	YYY	YY
<i>Seasonality</i>	YYY	YY
<i>Variable roads</i>	YYY	Y
Loading height	YYY	YY
Transportability	YYY	Y
Dump Speed	YY	YYY
Capital Expense	YY	Y
Resale	YYY	Y
Need Support Machines	YYY	Y
Running Costs	YYY	YY
Fuel Efficiency	YYY	YY
Reliability	YYY	YYY

Key Rating

	poor
Y	fair
YY	good/excellent
YYY	exceptional

OPTIMIZE HAULING

One load cycle 25 sec

XX
XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Load Matching

- 2 minute loading optimal
 - Wheel loader 3-5 passes
 - Excavator 4-7 passes.
- 3 minute loading acceptable.
- Avoid partial passes
 - extra payload rarely outweighs wasted time
 - reduced fuel efficiency
 - increased spillage issues.



OPTIMIZE LOADING – LOADER PASS MATCH

Trucks	Wheel Loaders						
	Volvo L220F		Volvo L350F		Cat 988H	Cat 990H	Cat 992H
	Std	Long	Std	Long	Either	Either	Either
	7.2 yd3 5.5 m3	6.5 yd3 5.0 m3	9.0 yd3 6.9 m3	8.4 yd3 6.4 m3	8.3 yd3 6.3 m3	11.0 yd3 8.4 m3	14.0 yd3 10.7 m3
A25E	2.45	2.72	1.96	2.11	2.13	1.61	1.26
26.5 Ton 24.0 t	2.5 Pass	2.7 Pass	2.0 Pass	2.0 Pass	2.0 Pass	1.6 Pass	1.3 Pass
A30E	2.87	3.18	2.29	2.47	2.49	1.88	1.48
31.0 Ton 28.1 t	3.0 Pass	3.0 Pass	2.3 Pass	2.5 Pass	2.5 Pass	1.9 Pass	1.5 Pass
A35E	3.43	3.79	2.73	2.95	2.97	2.24	1.76
37.0 Ton 33.6 t	3.4 Pass	3.8 Pass	2.7 Pass	3.0 Pass	3.0 Pass	2.2 Pass	1.8 Pass
A40E	3.98	4.41	3.18	3.42	3.45	2.61	2.05
43.0 Ton 39.0 t	4.0 Pass	4.0 Pass	3.0 Pass	3.4 Pass	3.5 Pass	2.6 Pass	2.0 Pass
40T RDT	3.70	4.10	2.96	3.19	3.21	2.42	1.90
40.0 Ton 36.3 t	3.7 Pass	4.0 Pass	3.0 Pass	3.0 Pass	3.0 Pass	2.4 Pass	2.0 Pass
50T RDT	4.63	5.13	3.70	3.98	4.02	3.03	2.38
50.0 Ton 45.4 t	4.6 Pass	5.0 Pass	3.7 Pass	4.0 Pass	4.0 Pass	3.0 Pass	2.4 Pass
70T RDT	6.48	7.18	5.17	5.58	5.62	4.24	3.33
70.0 Ton 63.5 t	6.0 Pass	7.0 Pass	5.0 Pass	5.6 Pass	5.6 Pass	4.0 Pass	3.3 Pass
100T RDT	9.26	10.26	7.39	7.97	8.03	6.06	4.76
100.0 Ton 90.7 t	9.0 Pass	10.0 Pass	7.0 Pass	8.0 Pass	8.0 Pass	6.0 Pass	5.0 Pass

Key

2 - 4	Optimal
5 - 6	Secondary
Passes	Lack load ht.

** Maximum counterweight and pin-on spade bucket size assumed.
Matching based on payload factor (body volume assumed to suit material density).

OPTIMIZE LOADING – EXCAVATOR PASS MATCH

Trucks	Excavators **							
	EC360CL		EC460CL Var		EC700CL		Hitachi EX1200	
	Std	ME	Std	ME	Std	ME	Std	ME
	3.0 yd3 2.3 m3	3.5 yd3 2.7 m3	3.8 yd3 2.9 m3	4.3 yd3 3.2 m3	5.0 yd3 3.8 m3	6.0 yd3 4.6 m3	5.8 yd3 4.4 m3	7.6 yd3 5.8 m3
A25E 26.5 Ton 24.0 t	5.89 6.0 Pass	5.05 5.0 Pass	4.71 4.7 Pass	4.16 4.0 Pass	3.53 3.5 Pass	2.94 3.0 Pass	3.05 3.0 Pass	2.32 2.3 Pass
A30E 31.0 Ton 28.1 t	6.89 7.0 Pass	5.90 6.0 Pass	5.51 5.0 Pass	4.86 5.0 Pass	4.13 4.0 Pass	3.44 3.4 Pass	3.56 3.6 Pass	2.72 2.7 Pass
A35E 37.0 Ton 33.6 t	8.22 8.0 Pass	7.05 7.0 Pass	6.58 6.0 Pass	5.80 6.0 Pass	4.98 5.0 Pass	4.11 4.0 Pass	4.25 4.0 Pass	3.25 3.0 Pass
A40E 43.0 Ton 39.0 t	9.56 10.0 Pass	8.19 8.0 Pass	7.64 8.0 Pass	6.75 7.0 Pass	5.73 6.0 Pass	4.78 5.0 Pass	4.94 5.0 Pass	3.77 3.8 Pass
40T RDT 40.0 Ton 36.3 t	8.89 9.0 Pass	7.62 8.0 Pass	7.11 7.0 Pass	6.27 6.0 Pass	5.38 5.0 Pass	4.44 4.4 Pass	4.60 4.6 Pass	3.51 3.5 Pass
50T RDT 50.0 Ton 45.4 t	11.11 11.0 Pass	9.52 10.0 Pass	8.89 9.0 Pass	7.84 8.0 Pass	6.67 7.0 Pass	5.56 5.6 Pass	5.75 6.0 Pass	4.39 4.0 Pass
60T RDT 60.0 Ton 54.4 t	13.33 14.0 Pass	11.43 12.0 Pass	10.67 11.0 Pass	9.41 9.0 Pass	8.00 8.0 Pass	6.67 7.0 Pass	6.90 7.0 Pass	5.26 5.0 Pass
70T RDT 70.0 Ton 63.5 t	15.56 16.0 Pass	13.33 14.0 Pass	12.44 13.0 Pass	10.98 11.0 Pass	9.33 9.0 Pass	7.78 8.0 Pass	8.05 8.0 Pass	6.44 6.0 Pass

Key
3 - 7 Optimal
8 - 9 Secondary

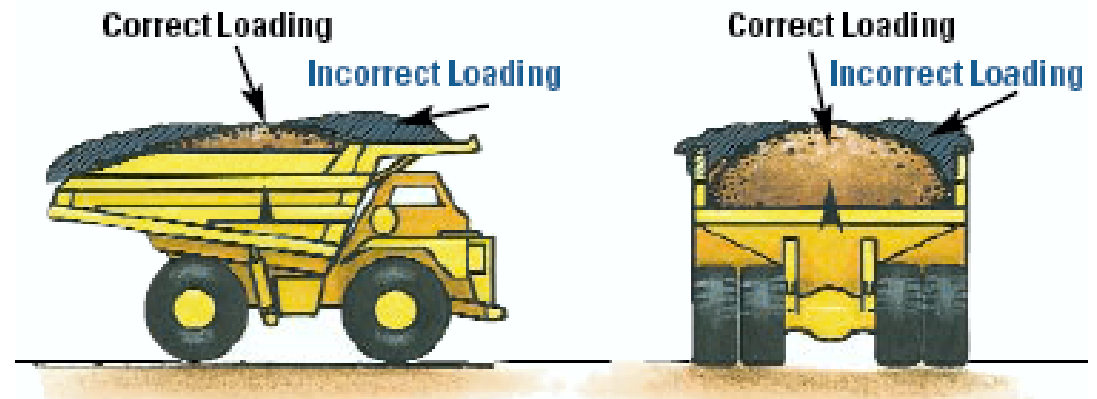
** Maximum counterweight and pin-on Rock bucket size assumed.
 Matching based on payload factor (body volume assumed to suit material density).



OPTIMIZE HAULING

Load Matching

- Load distribution is important, plan bucket placement
- Generally, an excavator can distribute the load better due to the additional reach and profile of the bucket.
- Off-balance loading is a safety threat, increases spillage, and increase tire/suspension wear.



OPTIMIZE HAULING

Plan the roads

- Unloaded machines always yield to a loaded machine.
- Consider a safe road width, ensure suitable passing points.
- Avoid repeated starts and stops as much as possible along the haul.
- Proper drainage and super-elevation in turns.
- Consistent grades, no variance:
 - 8-10% grade for rigids
 - 8-12% grade for artics

Rolling Resistance = \$\$\$\$

Tire penetration of 4" → +5% RR

→ reduce production 10%

→ increase running costs 10-25%



OPTIMIZE HAULING



ADT TIRE APPLICATIONS

Long cycle / High speed

Short cycle / Low speed



GP-2B

Earth moving Construction

TL-3A+ RL-2+ VLT STL2+

XADN STL3

L5 tires s
applicatio
abrasive

Operating in **SOFT SAND** requires different tire characteristics than in mud

- Very good
- Low ave
- Extra Lo
- Reduced
- Ex

- Good flotation
- Shallow tread depth
- Minimal ground disturbance

Sand

Sand rib (bias) XS

Quarry Mining

GP-4B VLT-S XADT

X-SUPER T AD GP-4D GP-3D

Under ground

VALS XKA

Soft ground Flotation

Soft ground Traction

Hard ground - Rock Cut resistance, Durability

Wheel Loader Match Excel file from David Nus

XXXXXXXXXXXXXXXXXX



OPTIMIZE HAULING

Tools to optimize site operation

- Site Sim (Volvo CE)
- Other tools...
- **RETARDING** not **BRAKING**



Case study

Newly opened quarry

Start: 1 jan 2010

Time span: 18 month (enddate 2011-06-30)

8h hour workday

5 days / week

44 weeks / year

(220 days)

Production

■ Crushed material to asphalt plant

- The asphalt plant needs 250 000 ton gravel per year.
- Asfalts production 6 month per year

■ Delivery to other markets

- 1100 ton / day
- 12 month per year

■ Hard Rock for harbour construction

- 1400 ton / day
- 12 month per year

Case study

- For loading and transport we are ONLY interested in the need for unloading of blasted stone.
- You should NOT consider the handling of intermediate or final material, loading on truck etc.

Case study

Alternative I:

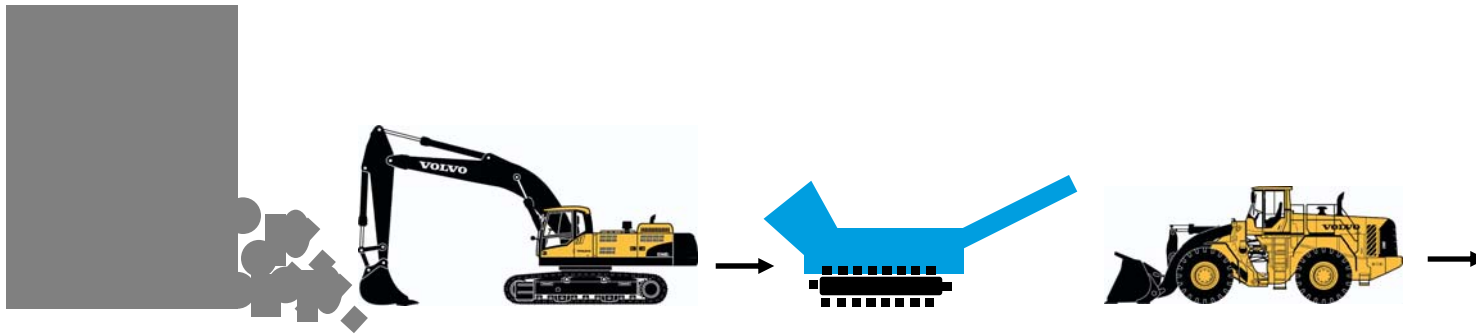
- Excavator loads mobile cross + mobile



FALLSTUDIE

Alternative II:

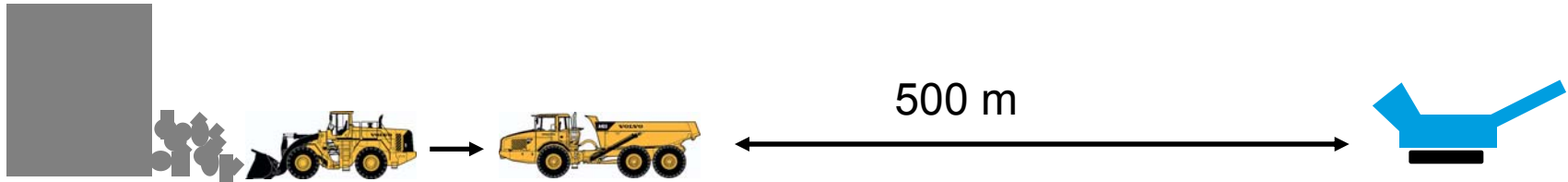
- Excavator loads mobile cross, wheelloader loads **material on trucks** for transportation to stationary secondary crusher and sorter



FALLSTUDIE

Alternative III:

- Wheel Loader loads Hualer. Hualer transports to fixed **primary crusher**
- Length of transports from **face** to stationary **primary crusher**, 500m



CASE STUDY

Tasks:

1. Create a production plan for the coming 18 month
2. Set the dimensions for loading
3. Use Simulation: Estimate **Dollar** / tonnes

Present:

1. Production plan
2. Choice of machines
3. Cost (**dollar/tonnes**)