Loading and Hauling

Dr. Vilim Petr & Bill Hissem

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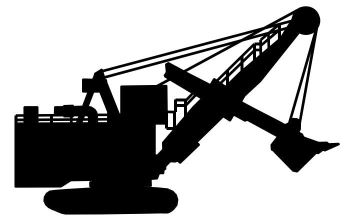
Loading and Hauling

Concepts

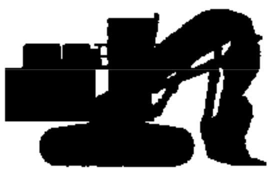
Basic Load & Haul Equipment

Wheel loaders (8 - 200 tons)

Rope shovels (330 - 1320 tons)



Front shovels (45 - 780 tons)



Articulated trucks (25 - 40 tons)

Hydraulic excavators (8 - 350 tons)

Trucks (35 - 370 tons)

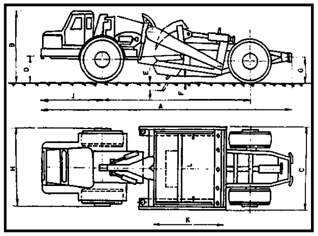
5 Factors for Productivity of Loading and Hauling

5 Factors which need to be considered for any earthmoving job:

- ✓ **Earthmoving Cycle components**
- ✓ **Job Efficiency Factors**
- ✓ **Material Weights & Swell Factor**
- ✓ **Vehicle Payloads**
- ✓ **Selection of Equipment**

Factor 1
Earthmoving Cycle Components

- The productivity cycle may be separated into six (6) Components:



1. Haul or Push
2. Dump
3. Return
4. Spot
5. Delay

Load Factor
- Size and type pf loading machine
- Type & condition of material to be loaded
- Capacity of unit
- Skill of the loading operator

Haul/Push Factor
- Performance ability of unit
- Hauling distance
- Haul road condition
- Grades
- Miscellaneous factors effecting haul speed

Dump Factors
- Destination of material: Hopper, Over Bank, Stockpile, etc.
- Condition of dump area
- Type &maneuverability of hauling unit
- Type & condition of material

Return Factors
- Performance ability of unit
- Return distance
- Haul road condition
- Grades
- Miscellaneous factors affecting return speed

Spot Factors
- Maneuverability of unit
- Maneuverability are available
- Type of loading machine
- Location of loading equipment

Delay Factors
- Time spent waiting on loading unit or pusher
- Time spent waiting to dump at crusher

Factor 2
Job Efficiency Factors (cont.)

An estimate must indicate sustained or average earthmoving production over a long period of time.

- **Night operating**
- **Shovel moving**
- **Blasting**
- **Weather**
- **Traffic**
- **Shutdowns, or for factors such as management and supervision efficiency, operator experience, proper balance of auxiliary equipment such as pusher or spreader bulldozers**

Maximum productivity of earthmovers:

Job Efficiency	Favorable	Average	Unfavorable
Working Min.Per Hour	55	50	40
Per Cent	92	83	67

Factor 2
Job Efficiency Factors (cont.)

- **Favorable Job Conditions**
  1. Material being excavated & Hauled: Topsoil, Clay (low moister content), ”Tight” earth (no rock)
  2. Loading Area : Unrestricted in length or width, Dry & smooth (maintained by dozer or grader), Unit load downhill (for scrapers)
  3. Total Rolling Resistance is under 4%
  4. Constant supervision at both loading & dumping areas

- **Average Job Conditions**
  1. Material being excavated & Hauled: wet, clay with some moister, mixture different earths
  2. Loading Area; Some restriction in length or width, Unit load on level (for scrapers)
  3. Total Rolling Resistance is 4% to 7%
  4. Intermittent supervision at both loading & dumping areas

- **Unfavorable Job Conditions**
  1. Material being excavated & Hauled: Heavy dense or wet clay, coarse gravel, Frequent boulder or rock outcropping
  2. Loading Area: Restricted in length or width, Unit load uphill or on a side slope (for scrapers)
  3. Total Rolling Resistance is over 7%
  4. No supervision at both loading & dumping areas

Factor 3
Material Weights and Swell Factors

- **The <u>weight of material</u> is in pounds per cubic yard [lb/cy]**
- **<u>Undisturbed</u> or " in place" <u>material</u> is called a bank cubic yard [BCY]**
- **Loose, broken or blasted material is called a loose cubic yard [LCY]**
- **The relationship between bank and loose cubic yards is *<u>swell factor</u>* or *<u>percent swell</u>***

- **Example :**
  - 1 cubic yard of 33% swell of shale is 1.33 cubic yards in the loose state
  - Shale weight 2800 lb per bank of cubic yard at the swell factor of 0.75(inverse of 1.33) the weight of one loose cubic yard of shale is 2100 lb (2800 lb x 0.75=2100lb)

Factor 4
Vehicle Payloads

Capacity: 40 Tons
Struck 25.3 cu yds.
Heap 2:1 Slope 31.9 cu.yds

Capacity: 104,000 lbs
Struck 32 cu. yds.
Heap 1:1 Slope 43 cu.yds

Capacity: 6,750 lbs
Heap 2:1
Slope 2 1/4 cu.yds

To assure adequate volumetric capacity:

<u>80,000lbs.rated payload</u>
2600lbs./LCY

31 loose (heaped) Cubic yards vs. 32 heaped yds Unit capacity

Factor 5
Selection of Hauling Equipment (cont.)

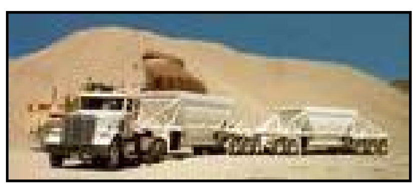
- **Examined the job requirements, operating conditions and which method offers the lowest cost per yard or ton.**
- **General Criteria:**
    - Will the operator be able to make maximum use of the equipment on whatever variety of applications he may encounter?
    - Are the units under consideration compatible with existing hauling and loading equipment?
    - Are there restrictions on maneuvering space?
    - Side or overhead clearance?
    - Will extreme grades or lengths of haul affect the selection?

Factor 5
Selection of Hauling Equipment (cont.)

- **Use Hauler or Rockers Where:**

  - The material hauled is large rock, ore shale, etc., or a combination of free-flowing and bulky material
  - Dumping into restricted hoppers or over edges of waste bank or fill.
  - The hauling unit is subject to sever loading impact while under a large shovel, dragline, or loading hopper
  - Maximum flexibility is required for hauling a variety of materials under variable job conditions

- **Use Bottom Dumps Where:**
  - The material hauled is free-flowing
  - The haul is relative level, allowing high speed travel
  - Dumping is unrestricted into a drive-over hopper, or the load is spread in windows



HAULER PRODUCTION
Loading Times (cont.)

- **Loading may be done by: Shovel, dragline, belt loader, rubber tired loader or gravity hopper. To determine the time to load a particular unit, the estimator must know the following:**

    1. Payload capacity of the hauling unit in pounds & loose cubic yards
    2. Rate of production of the loading unit
    3. Type and condition of the material
    4. Skill of the operator

HAULER PRODUCTION
Power Shovel (cont.)

- **Example: Find the load time of 55-ton hauler under an 8-yard shovel in blasted rock which weighs 2800 pounds/LCY. Dipper factor is 0.65.**

$$Load\ Time = \frac{55\,ton\ vehicle \times 2000\,pounds\,/\,ton}{922\,LCY\,/\,Hr. \times 0.65\mathrm{d.f} \times 2800\,lbs./\,LCY} \times \frac{60\,\mathrm{min}}{\mathrm{Hour}} = 3.93\,\mathrm{Min}$$

- **Analyze individual swings of the shovel using 90° pass.**
  - Digging Condition

Shovel Loading Cycle:	Easy	Medium	Hard & Rock
	0.40Min	**0.5 Min**	**0.65 to 1.00 Min**

$$\begin{array}{ccccc} Total\ Load\ Time & = & Number\ of\ \ Passes & \times & Shovel\ Loading\ Cycle \\ 4\,\mathrm{Min} & = & 4 & \times & 1 \end{array}$$

HAULER PRODUCTION
Power Shovel (cont.)

- **Number of Passes**
  - The number of passes is determined by dividing the payload capacity of the hauler by the payload in the dipper.

$$\text{Number of Passes} = \frac{\text{Payload of Hauler}}{\text{Pay load of Dipper}} = \frac{55 - ton}{10{,}800 - lbs/pass} = 4 \text{ Passes}$$

- **Payload of Dipper**
  - Is result of multiplying the yardage capacity of the bucket by a dipper factor and multiplying by the material weight per loose cubic yard of material

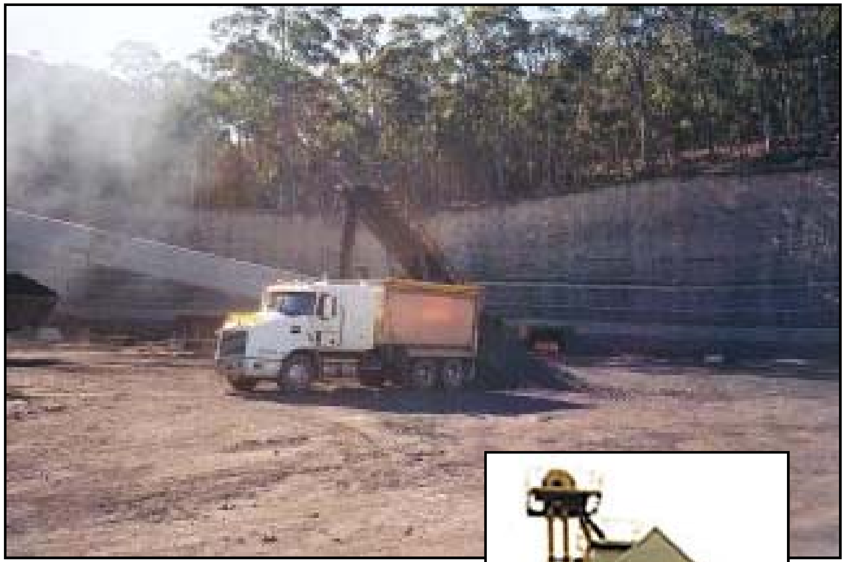
$$\text{Payload of Dipper} = \text{Yardage of Dipper x Dipper Factor x } \frac{\text{lbs}}{\text{LCY}}$$

Example: Assume: 4yd. shovel, 0.9 dipper factor, 3000 lbs/LCY

$$\text{Weight of material per Pass} = \frac{4 \text{ yd}}{\text{pass}} \times 0.90 \times \frac{3000 lbs}{yd} = 10{,}800 lbs/pass$$

HAULER PRODUCTION
Belt Loader and Hoppers (cont.)

- **Used when material is free-flowing and /or easily loaded with the belt loader**
- **Loading rates vary according to the size of the belt**
- **Hopper capacity or rate of loading hopper should be sufficient to supply the demands of the hopper discharge rate.**



Example: loading rate of a loader with 60” Belt employing two 82-50 tractors is one ton per second in average conditions.
Load time into a 55 ton hauler would be 55 seconds

Balance Between Size of Hauling and Loading Equipment

- **To lower the cost per unit of earth moved, high production must be obtained from the hauling fleet.**
- **When possible, loading from overhead hopper should be considered because of the faster loading time obtained when this arrangement is practical**
- **Generally, 3 to 6 passes of a shovel to fill a hauling unit represent a good balance.**
  - The size of the body is not too small in comparison to the shovel bucket, resulting in excessive spillage and shock to the unit
  - Loading time is not so short that another hauler would not be available without causing excessive shovel idle time

Turning, Dumping and Spotting Times

- Are dependent upon the unit being considered under the existing operating conditions.
- Operation Conditions = accounts for all factors which can effect the time for cycle component being estimated.
- The Favorable is a judgment made on base of personal experience and familiarizing with the job

	Turning &Dumping Times		Spotting Time at Loading Machine	
Operating Conditions	**Hauler**	**Bottom Dumper**	**Hauler**	**Bottom Dumper**
Favorable	1.0 min	0.3 min	0.15 min	0.15min
Average	1.3	0.6	0.3	0.50
Unfavorable	1.5 to 2.0	1.5	0.5	1.0

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Units Required to Complete a Hauling Job

- The number of units required for given job depends on the production requirements. The Number of required units can be found:

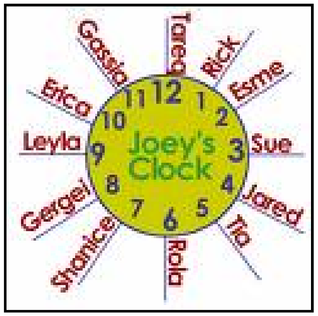
$$\text{Number Units Required} = \frac{\text{Hourly Production Requirement (Job Efficiency)}}{\text{Hourly Production Per Unit (Machine Availability)}}$$

- Generally, any fractional part of a unit more that 0.3 is to be considered a complete unit.

- Fractional part of a unit less than 0.3 should be carefully analyzed. Particularly on small operations, the user may prefer to work a longer shift rather than to buy an extra unit.

Units Required to Complete a Hauling Job

Job Efficiency



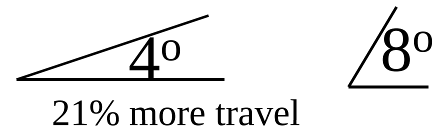
- **Job Efficiency is the estimated proportion of the working hour during which the machine is actually applied to the work cycle**
- **This factor is job-controlled and depends upon the skill and experience of job personnel is** *unavoidable delays on every job.*
- It is recommend that 50 minute hour is 83% is "*average*" Job Efficiency
- Unusual delays due to weather, traffic, blasting, shovel movement, crusher size, management and supervision efficiency, operator experience, etc., will reduced the "average" less than 50 minute hour

Units Required to Complete a Hauling Job
Machine Availability

- Machine Availability is the estimated proportion of the scheduled working hour during which a machine is mechanically able to work.
- This factor is controlled largely by daily prevention maintenance practices on the job, as well as operating conditions
- Factors such as sever operation conditions, multi-shift operations and unsatisfactory preventive maintenance practices can reduce machine availability.
- Working schedule must allow for maintenance and repair time outside of schedule machine working hours to assure maximum machine utilization during scheduled machine working hours.

Haul Road Construction and Maintenance

- **Investing in your haul roads gives a positive payback.**
  - Greater travel speeds
  - Less shock load **=> Higher Production & Lower Maintenance**
  - Grades, smoothness of surface
  - Calculations show that savings which result from a good haul road can contribute more than 2% of the total cost of the mining operation.



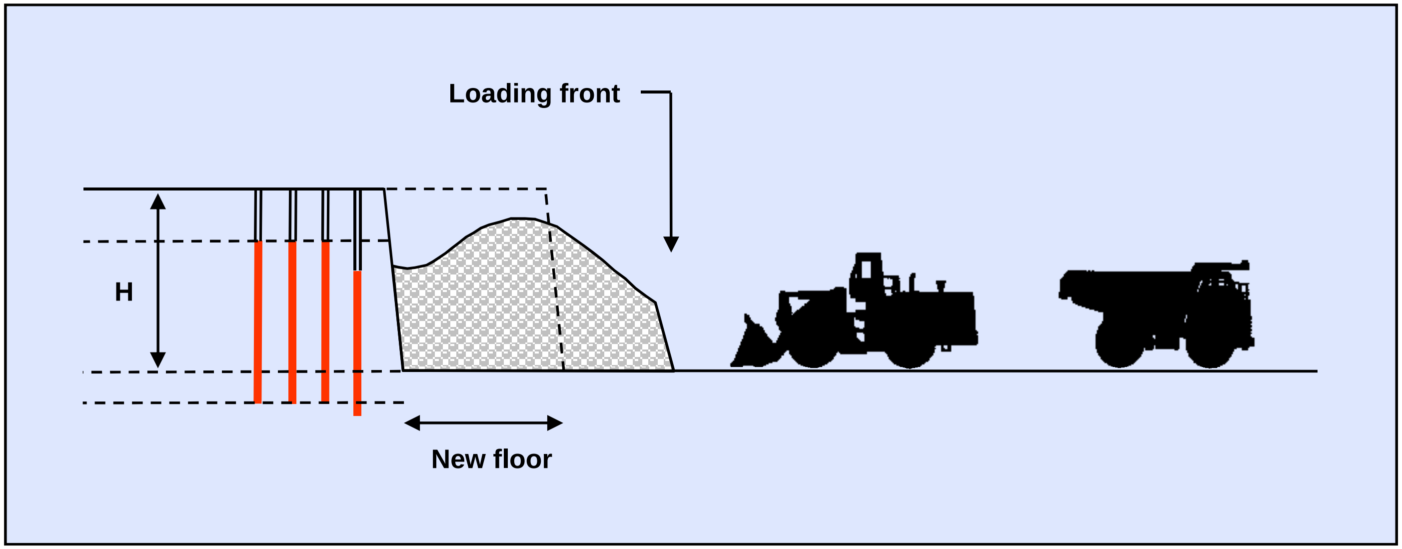
Loading and Hauling

Application

Load and Haul Management

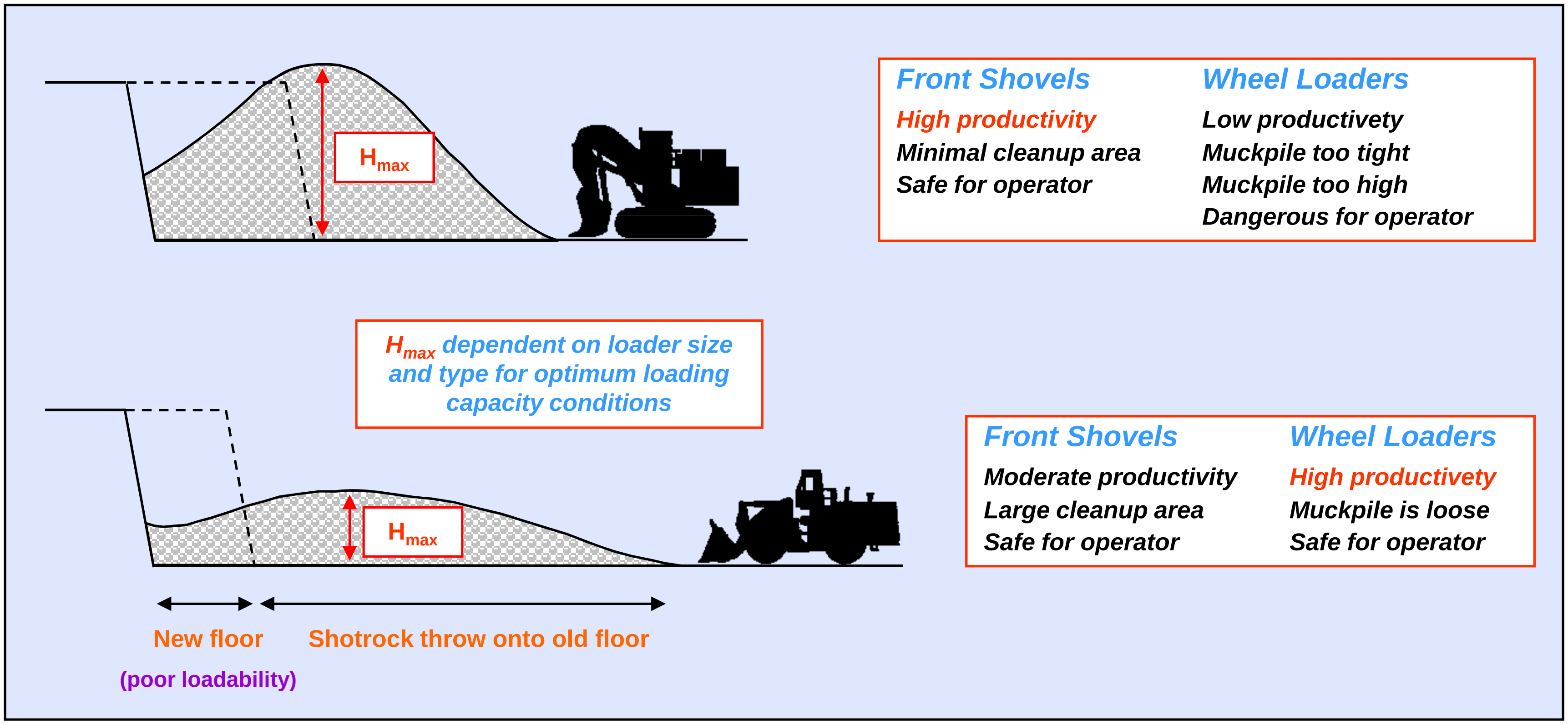
Terminology for earth moving operations

■ solid rock	1.3 cu-yds	=	1.0 bank m3
■ shotrock in muckpile	1.25 - 1.35 (% swell)		
■ shotrock on truck	2.1 cy-yds	=	1.6 loose m3
■ compacted rockfill day	1.76 cu-yds	=	1.35 dam m3



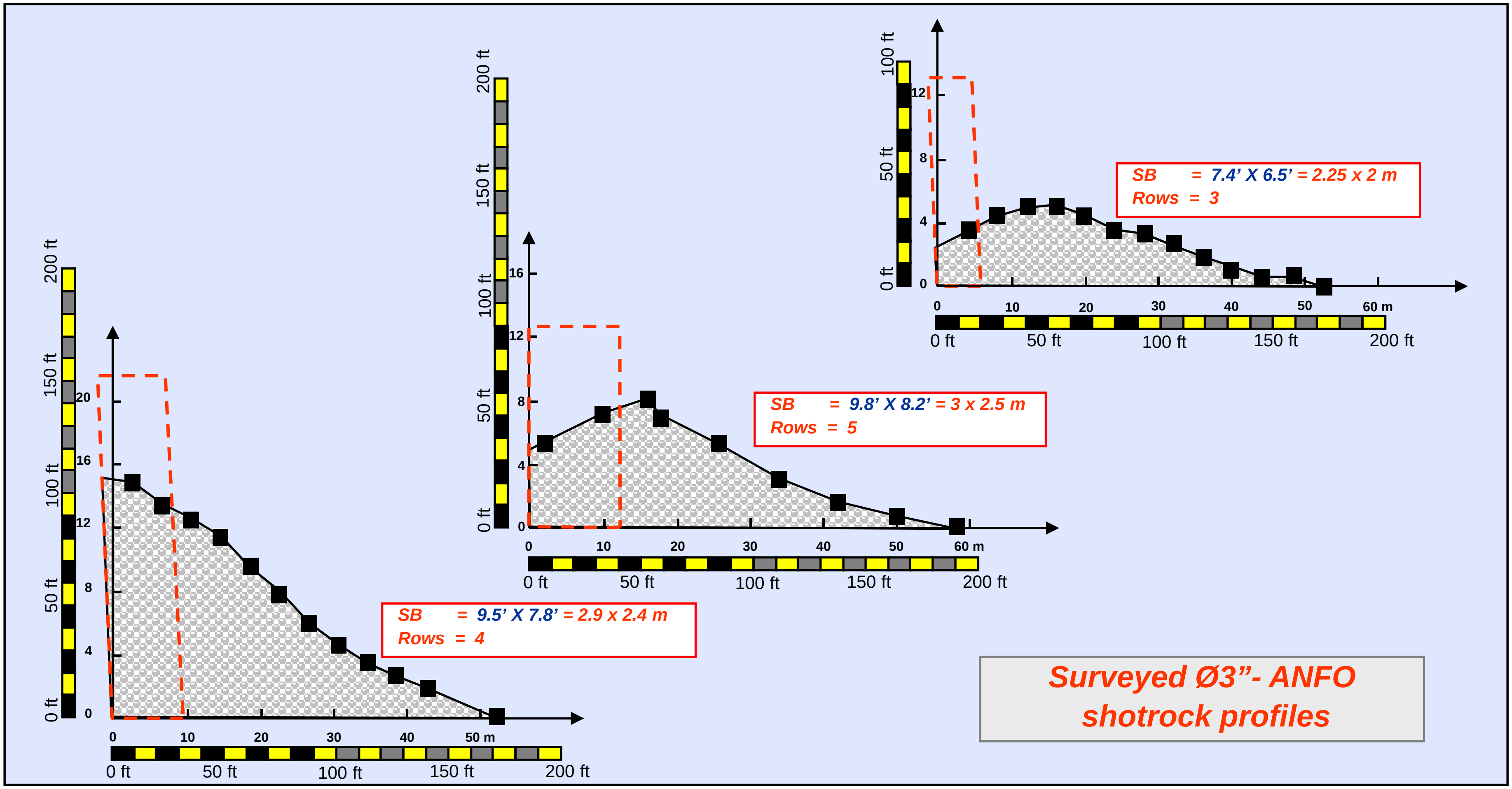
Load and Haul Management

Optimum shotrock profiles for bulk loading operations



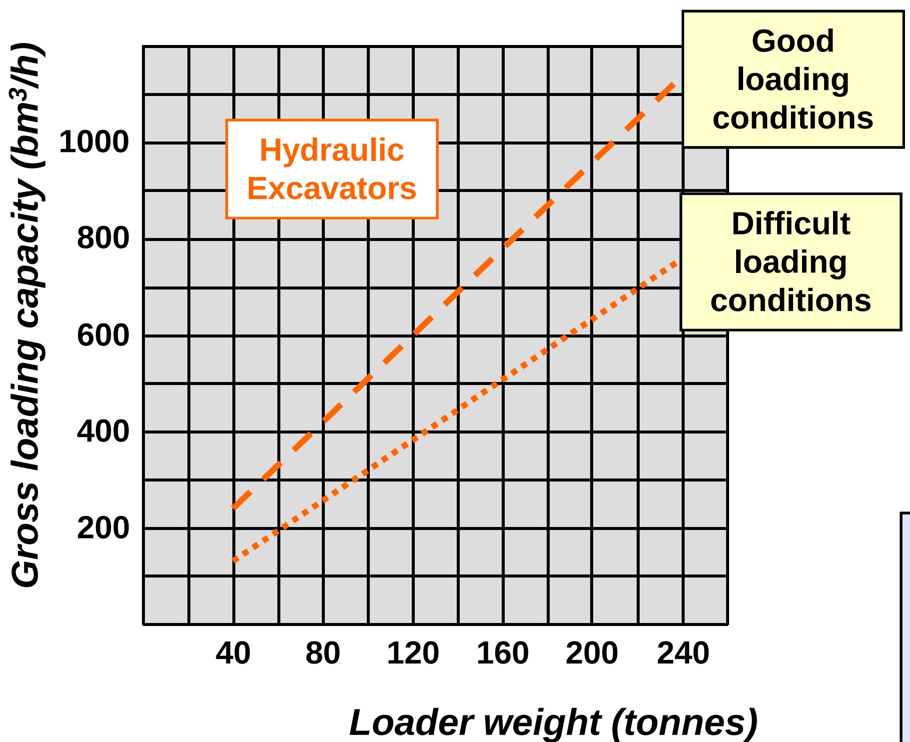
Load and Haul Management

Shaping muckpiles to maximise loading rates



Load and Haul Management

Loading capacities

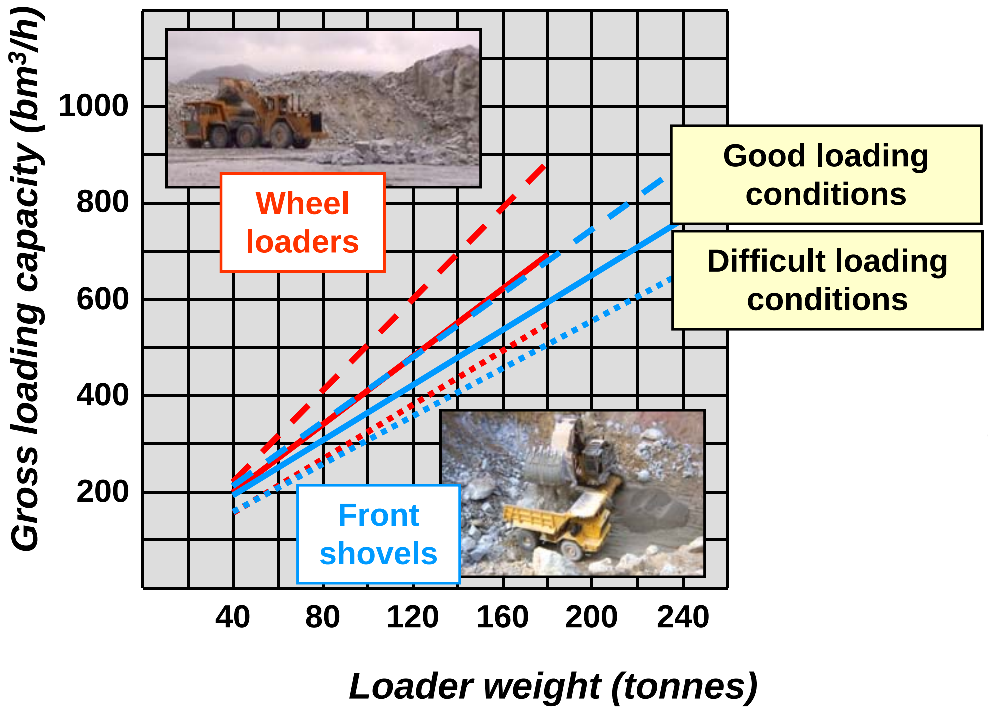


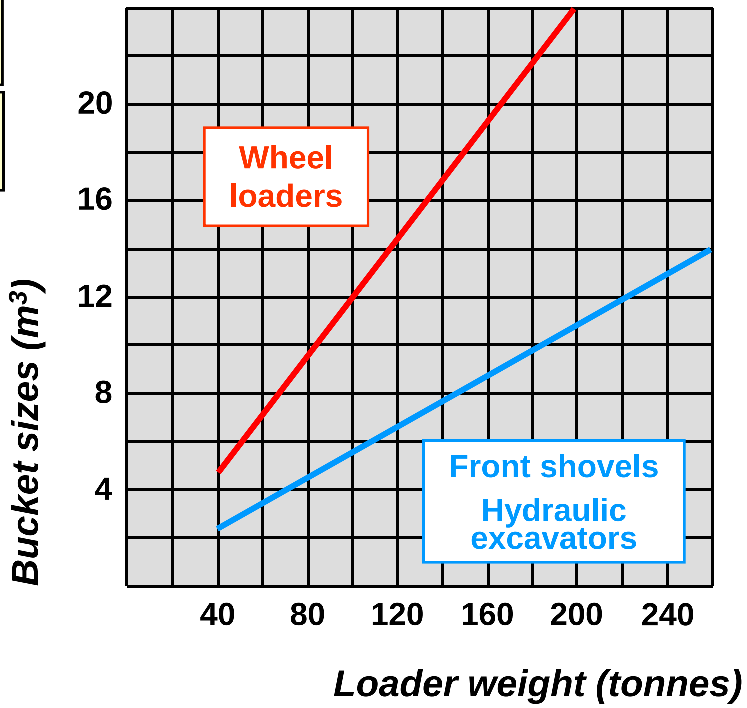
Difficult loading conditions requires additional time for:

- *trimming loading fronts*
- *sorting excessive amounts of boulders*
- *cleaning around floor humps and toes*
- *cleanup of poor side- and backwalls*
- *poor shotrock diggability*

Load and Haul Management

Loading capacities

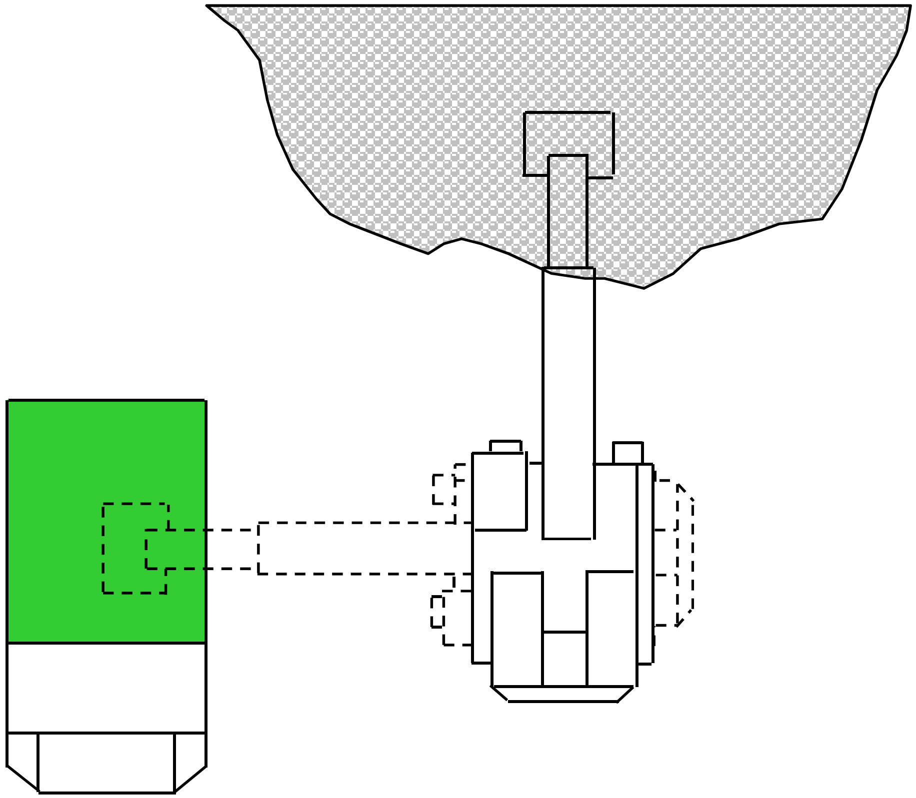




Front Shovels:

Pro:

- Less sensitive to poor fragmentation in the muck pile.
- Good kinematics for muck pile penetration and breakout force.
- Can serve a wider range of truck sizes for a given class size.
- Impervious to floor conditions for mucking.



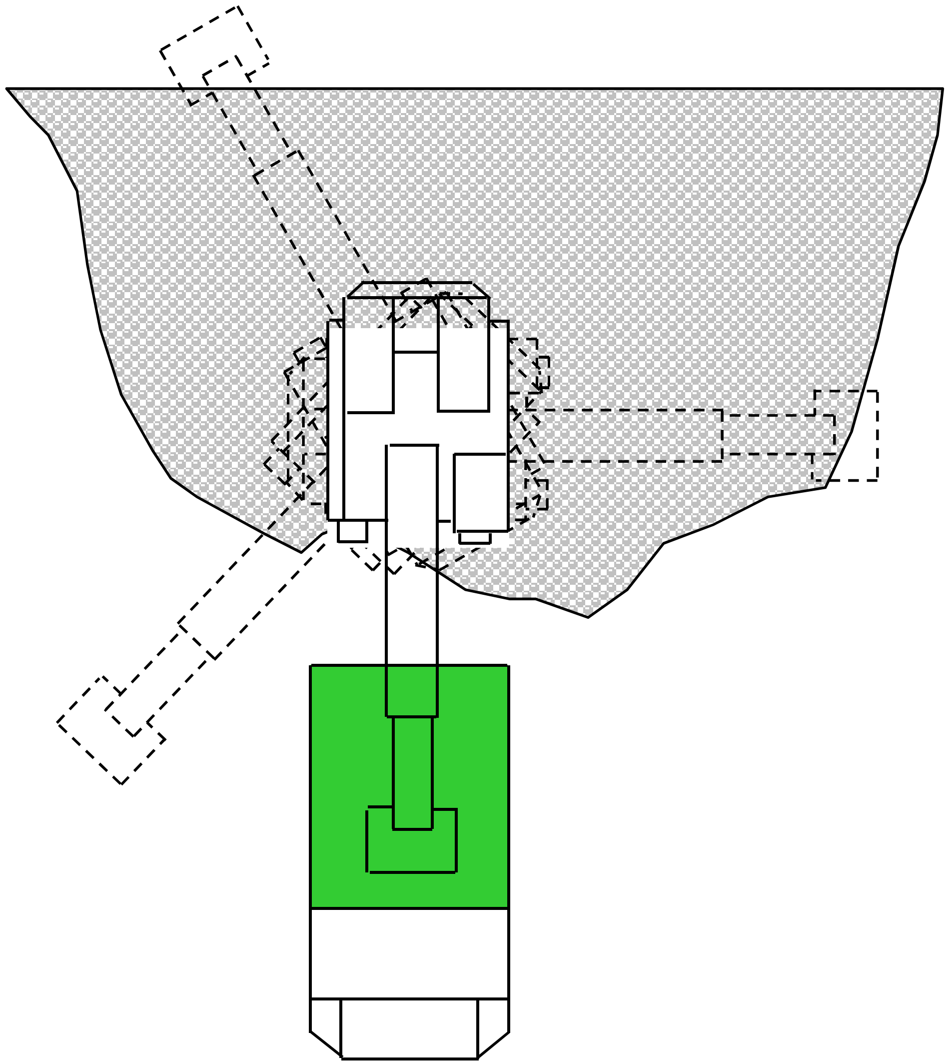
Con:

- Slow tramming speed between active faces with the pit.
- Poor flexibility, requires cleanup support.

Excavators:

Pro:

- Less sensitive to poor fragmentation in the muck pile.
- Good kinematics for muck pile penetration and breakout force.
- Can serve a wider range of truck sizes for a given class size.
- Impervious to floor conditions for mucking.
- Best stand-off from the working face.
- Can reach out to clean up the crest of a bench with greater safety.



Con:

- Slow tramming speed between active faces with the pit.
- Poor flexibility, requires cleanup support.
- Must reach further when working off the muck pile to load out.

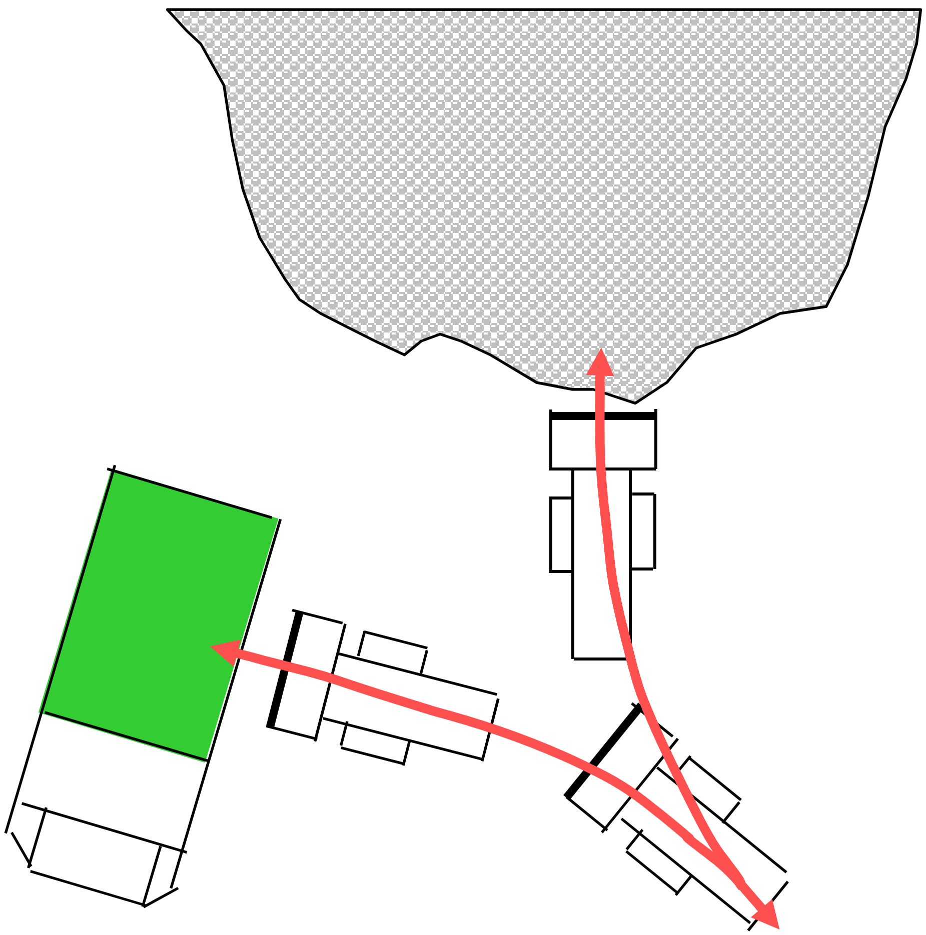
Wheel Loaders:

Pro:

- **Great speed and flexibility**
- **Can clean up and prform primary loading functions.**

Con:

- **Unit size/bucket size to truck size matching is very important.**
- **Energy consumption per ton of loaded rock is lower than with excavators and shovels.**
- **Tires are susceptable to wear and abrasion with poor floor conditions and inexperienced operators.**



L/H Unit Operations

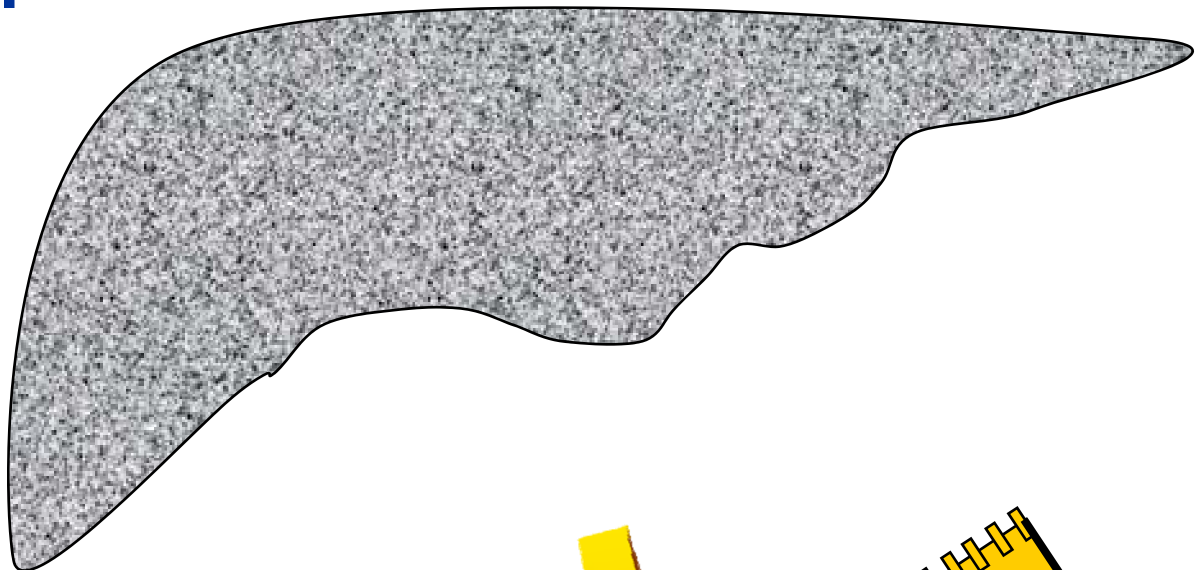
Fleet Sizing:

- **Annual tonnage required?**
- **Distance and grades for the haul circuit?**
- **Number of concurrent working face areas in the pit?**
- **Estimate load cycle times at the face?**

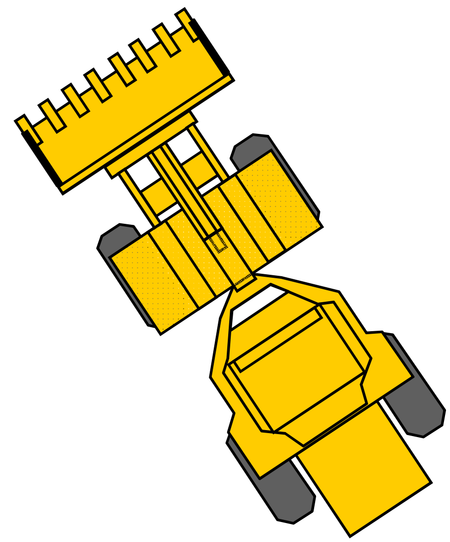
Calculate the number of trucks required.

- **Match Load out units to the truck size to obtain 3 to 4 passes to fill the truck.**

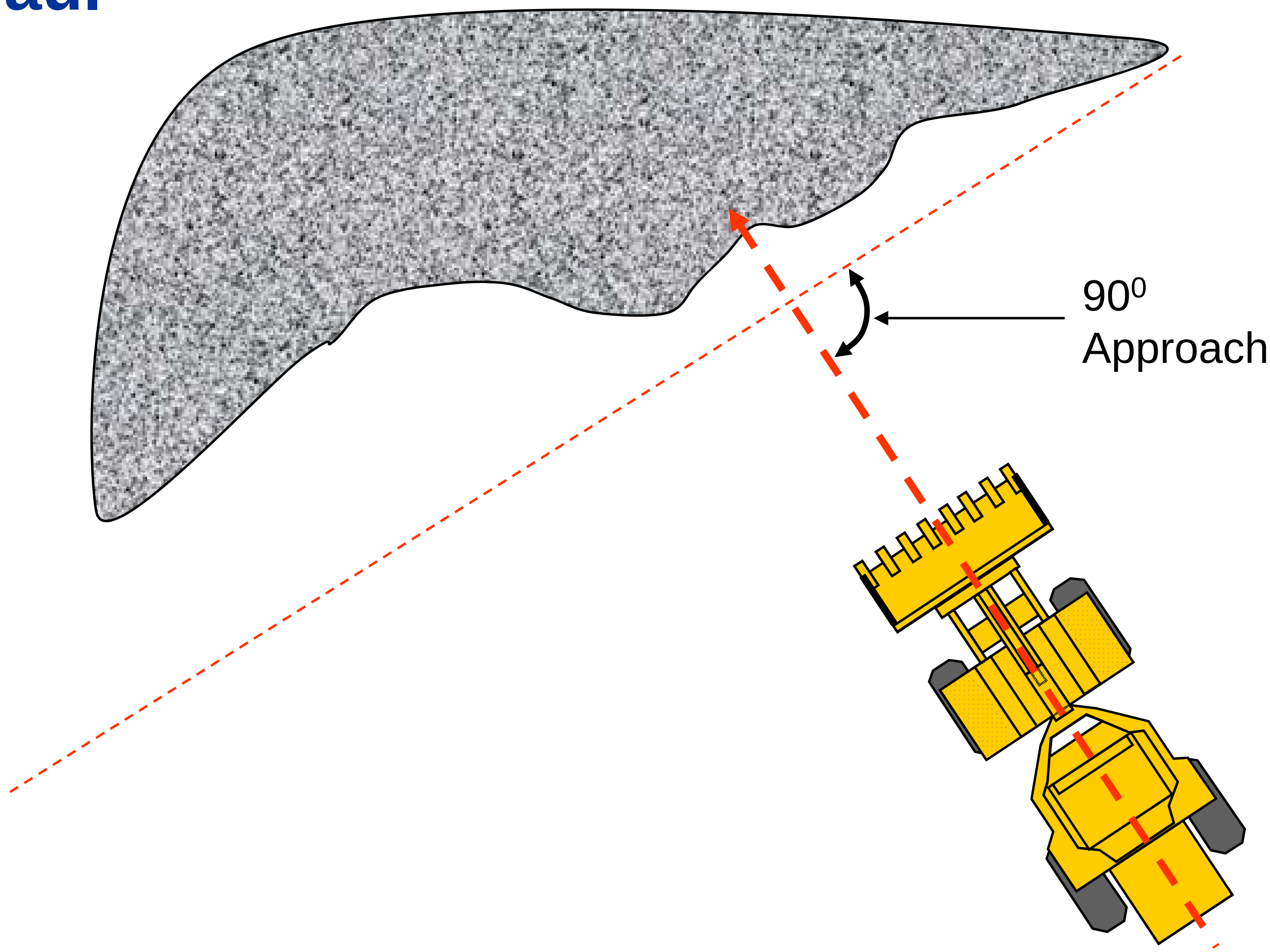
Load/Haul



The Ideal Scenario:



Load/Haul



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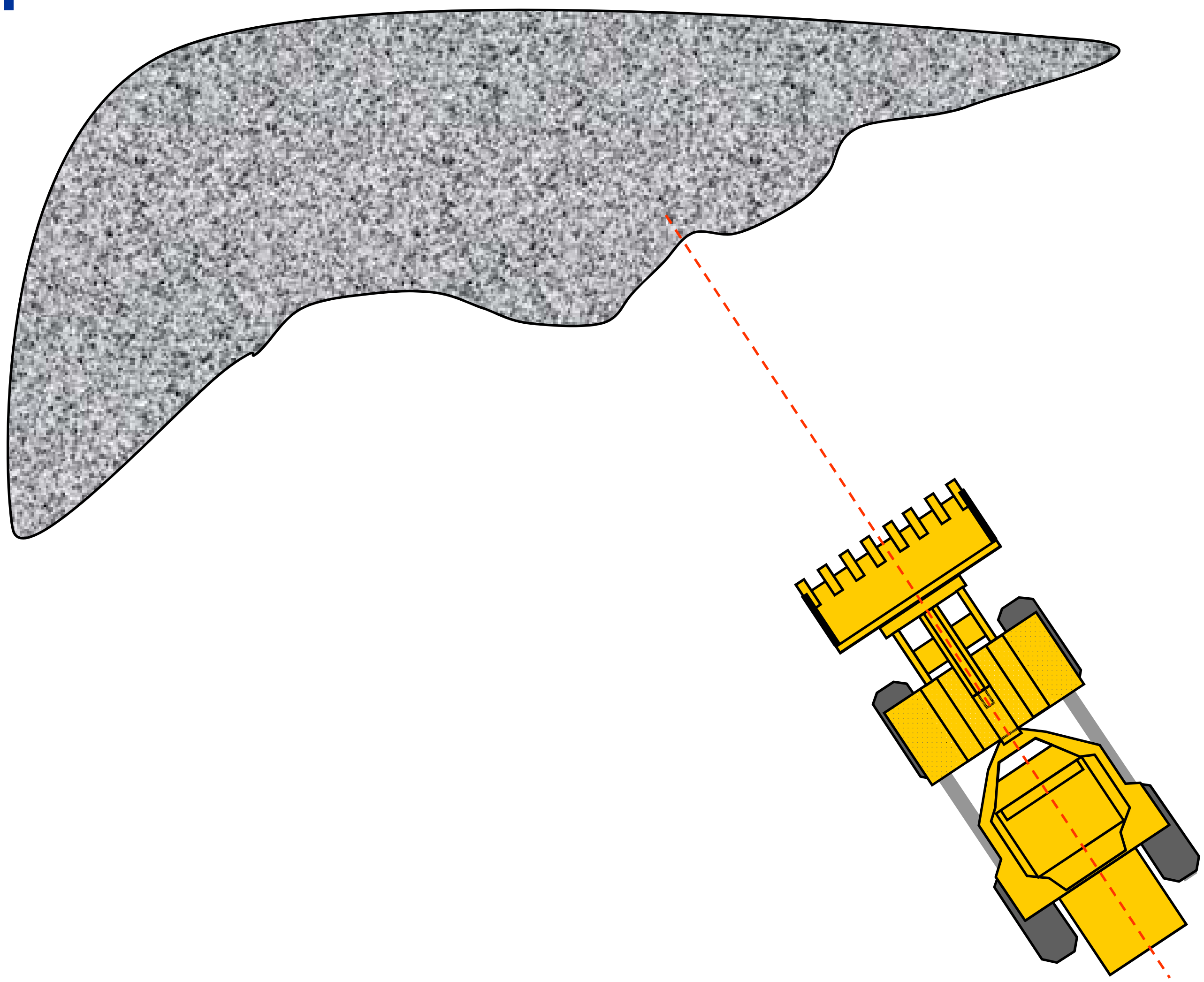

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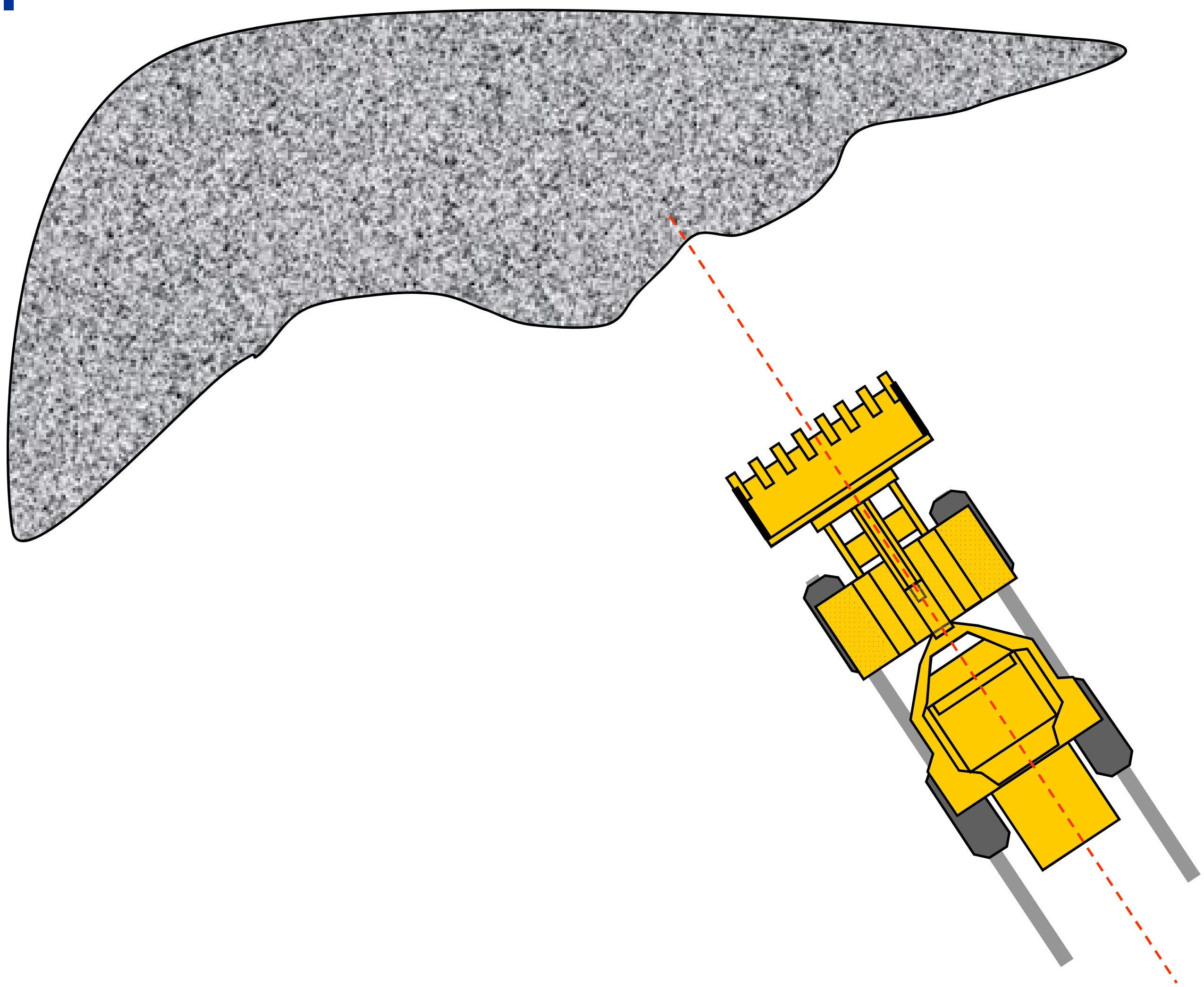

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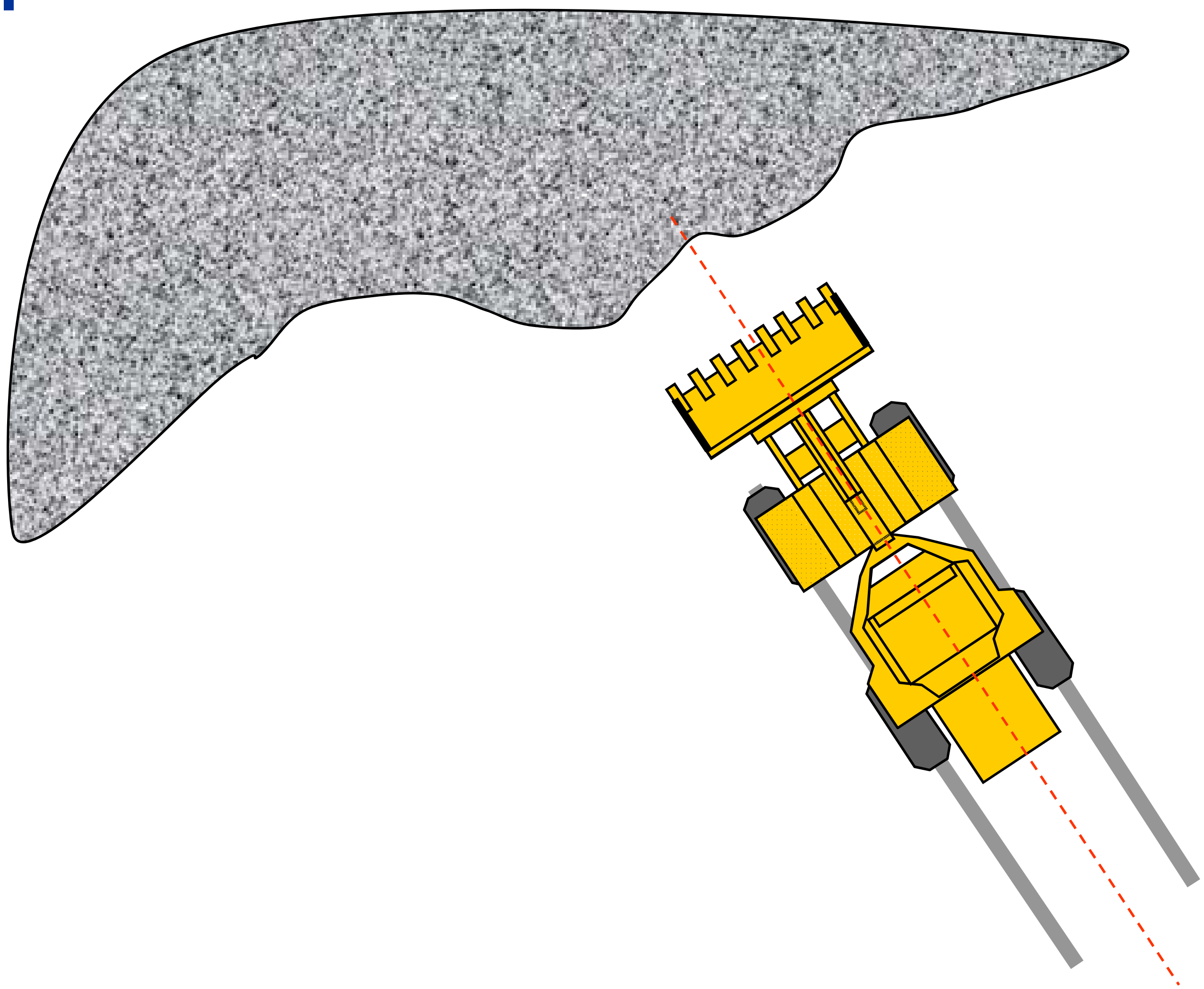

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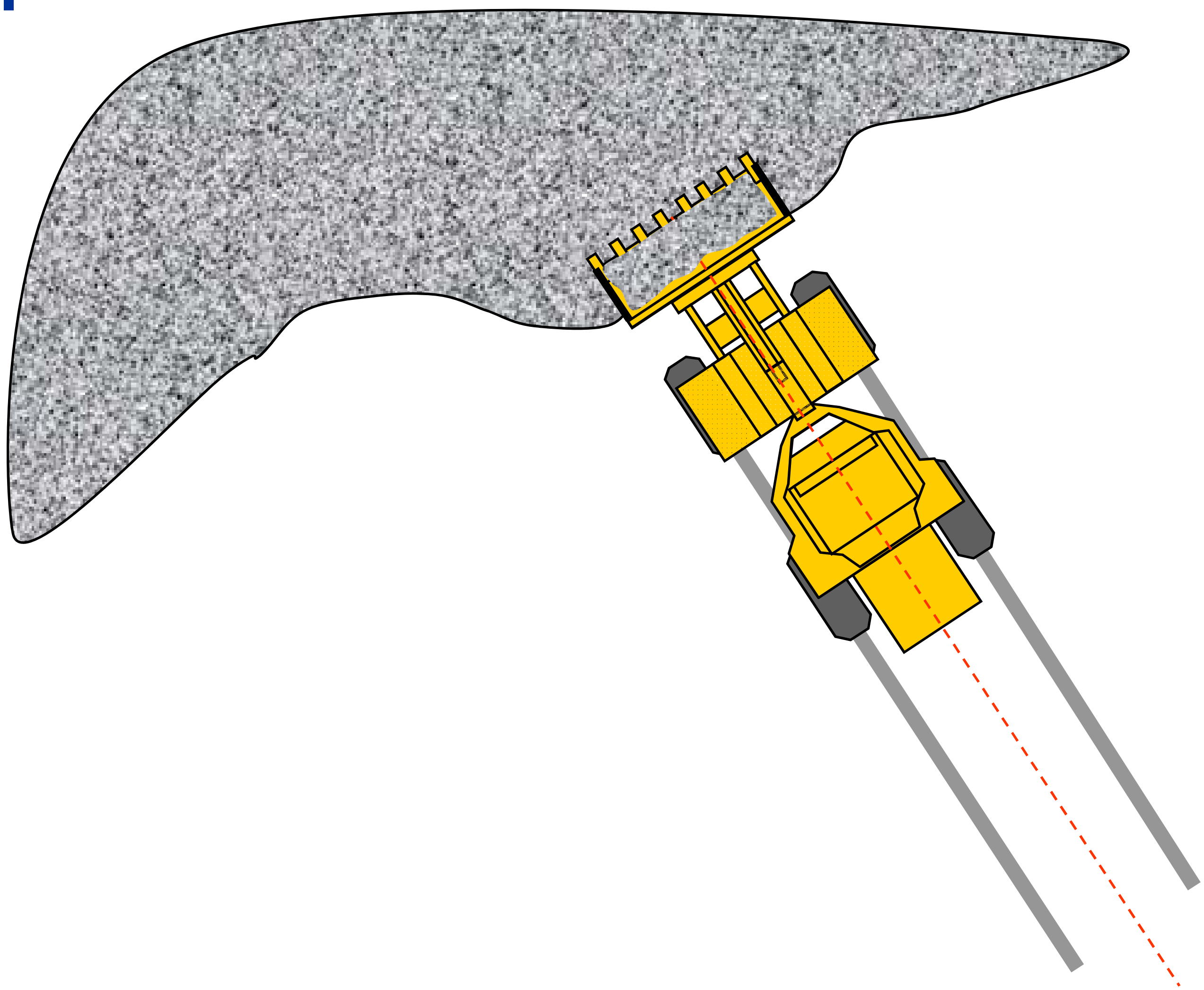

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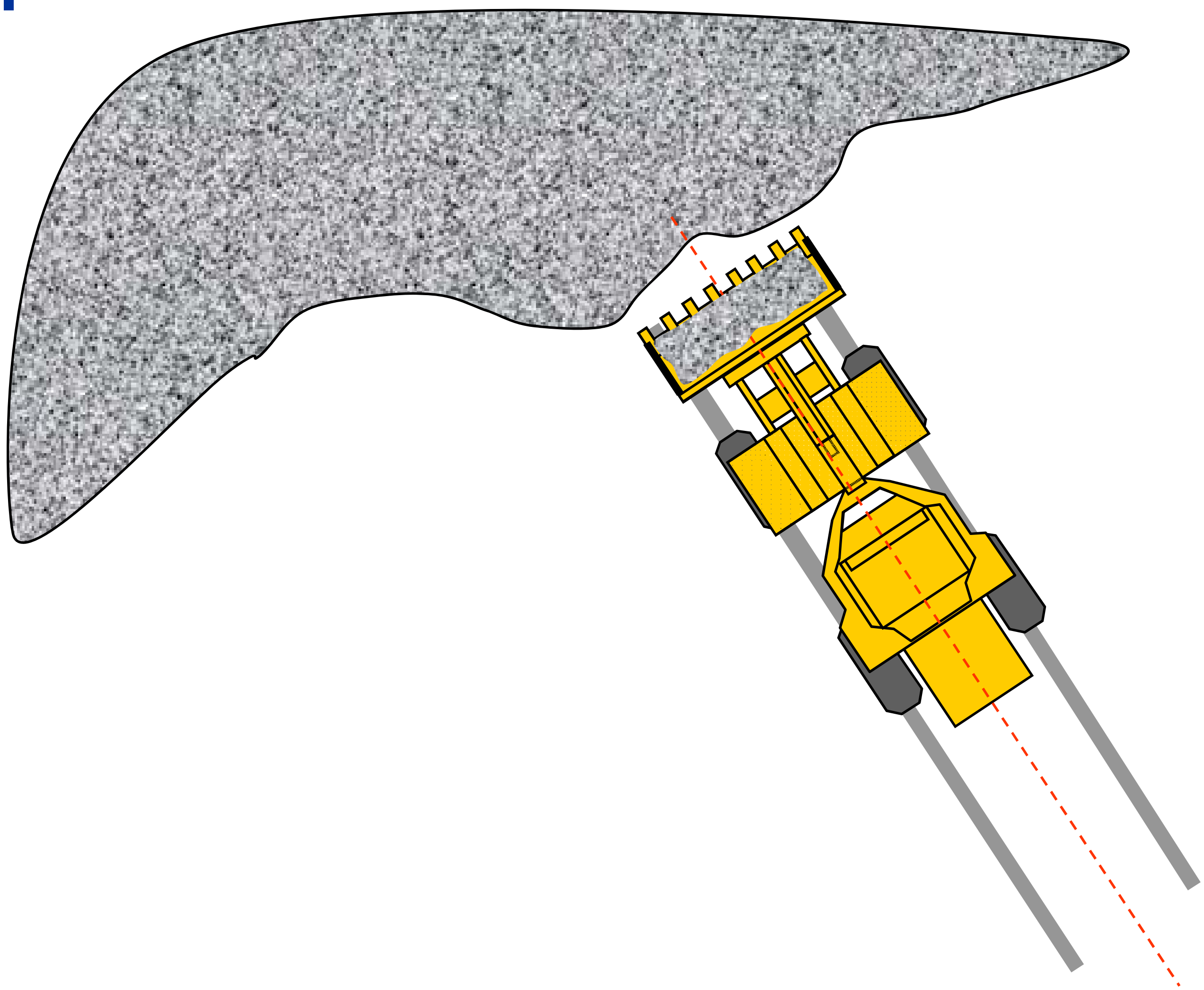

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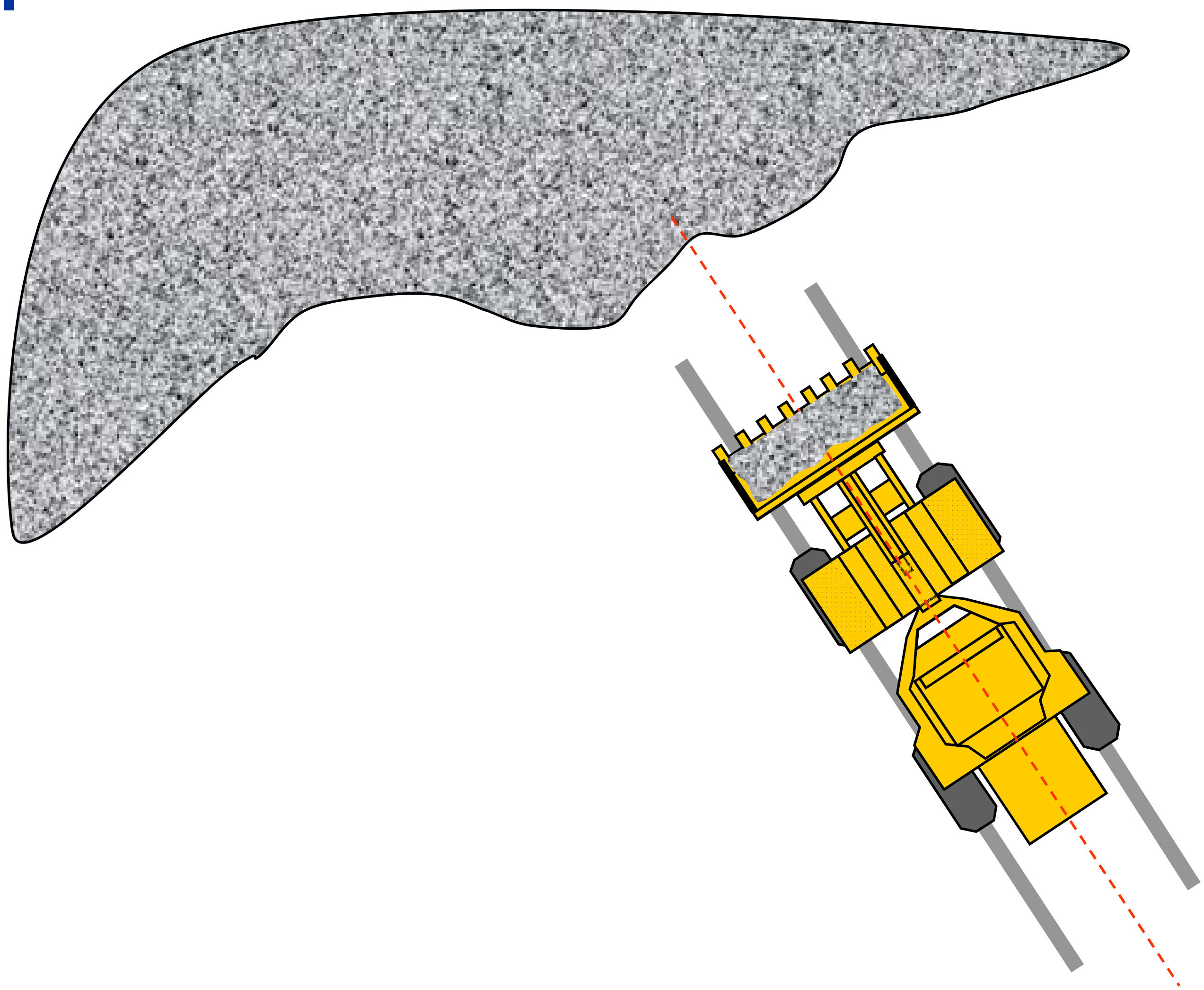

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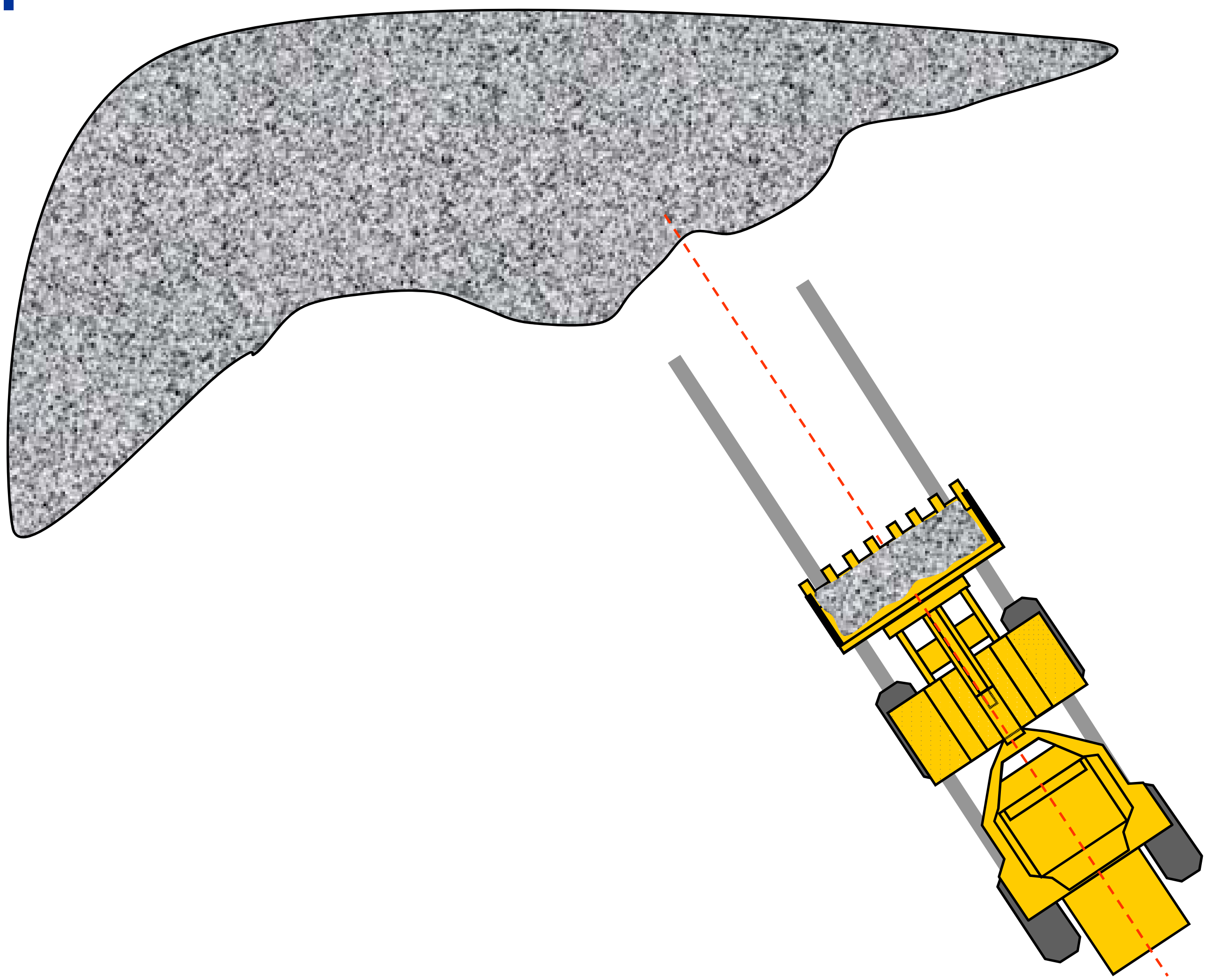

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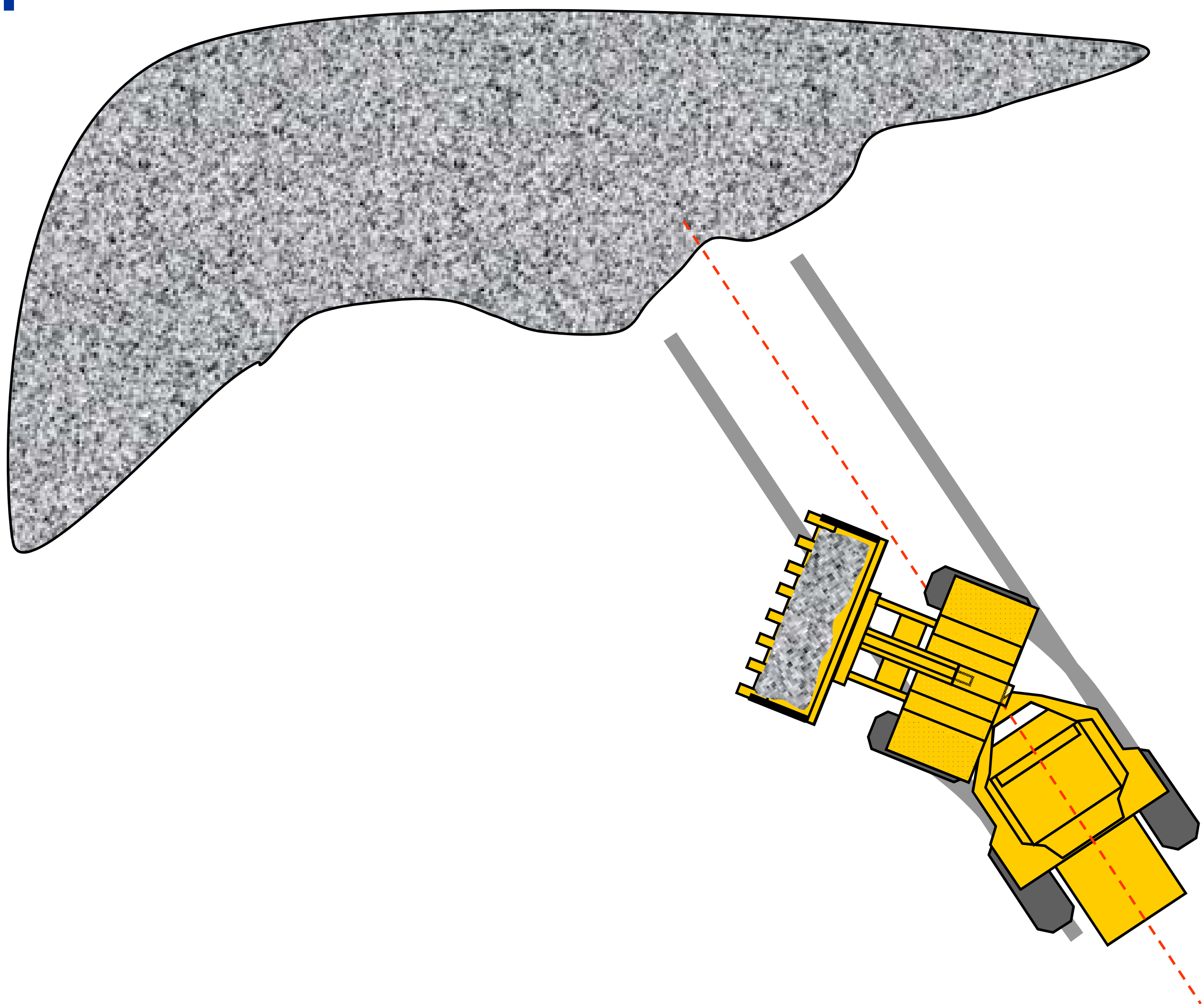
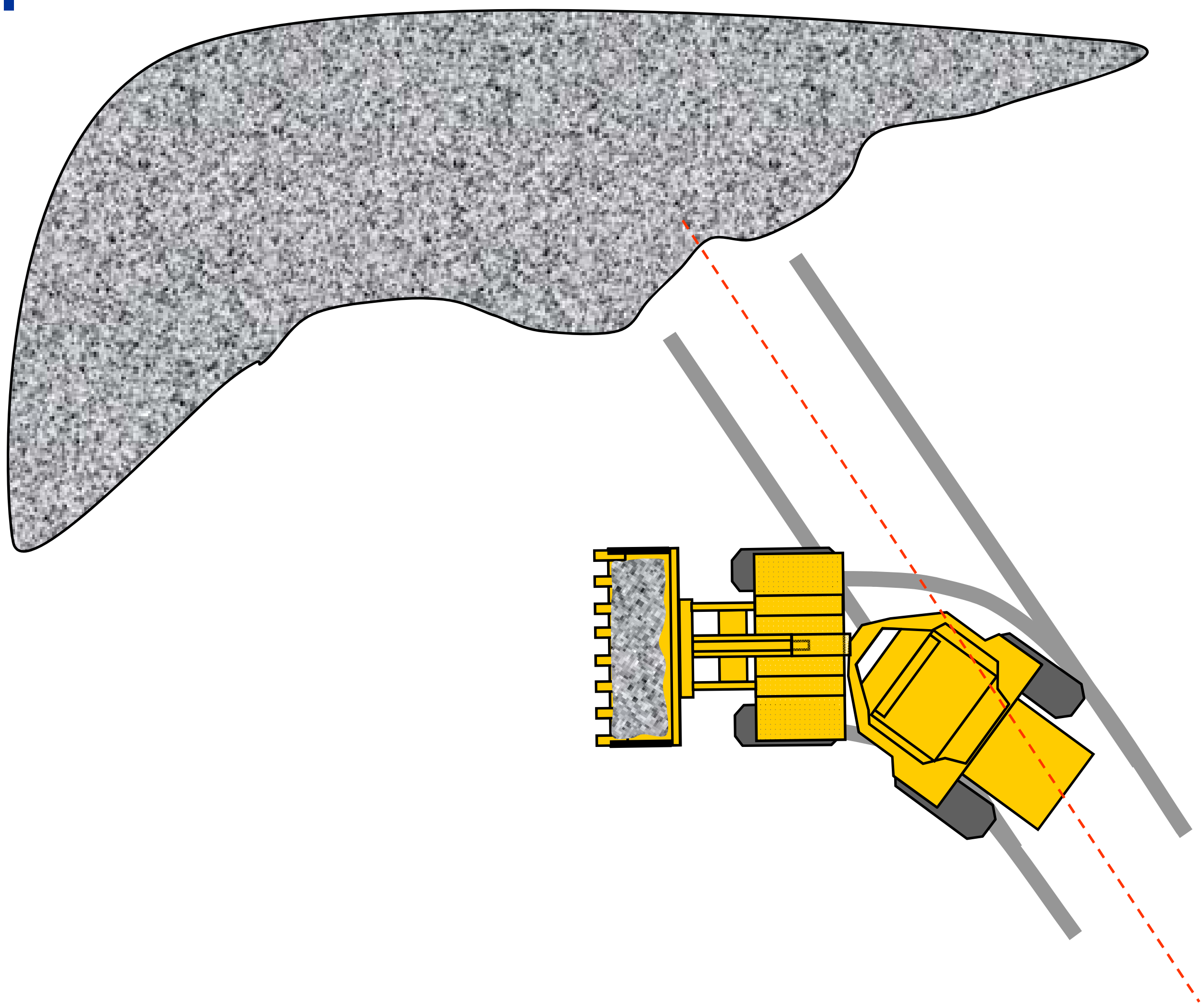
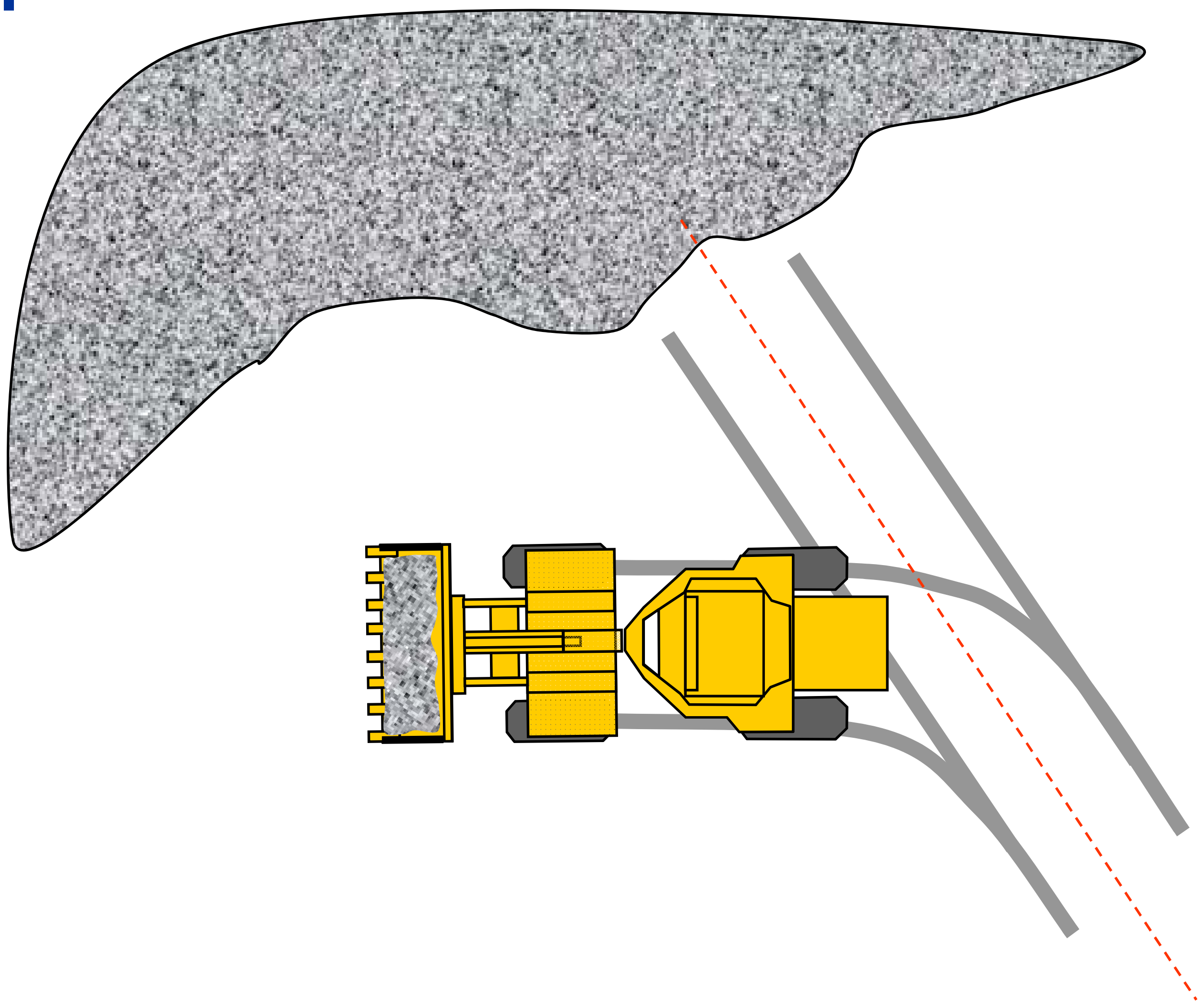


Load/Haul



Load/Haul



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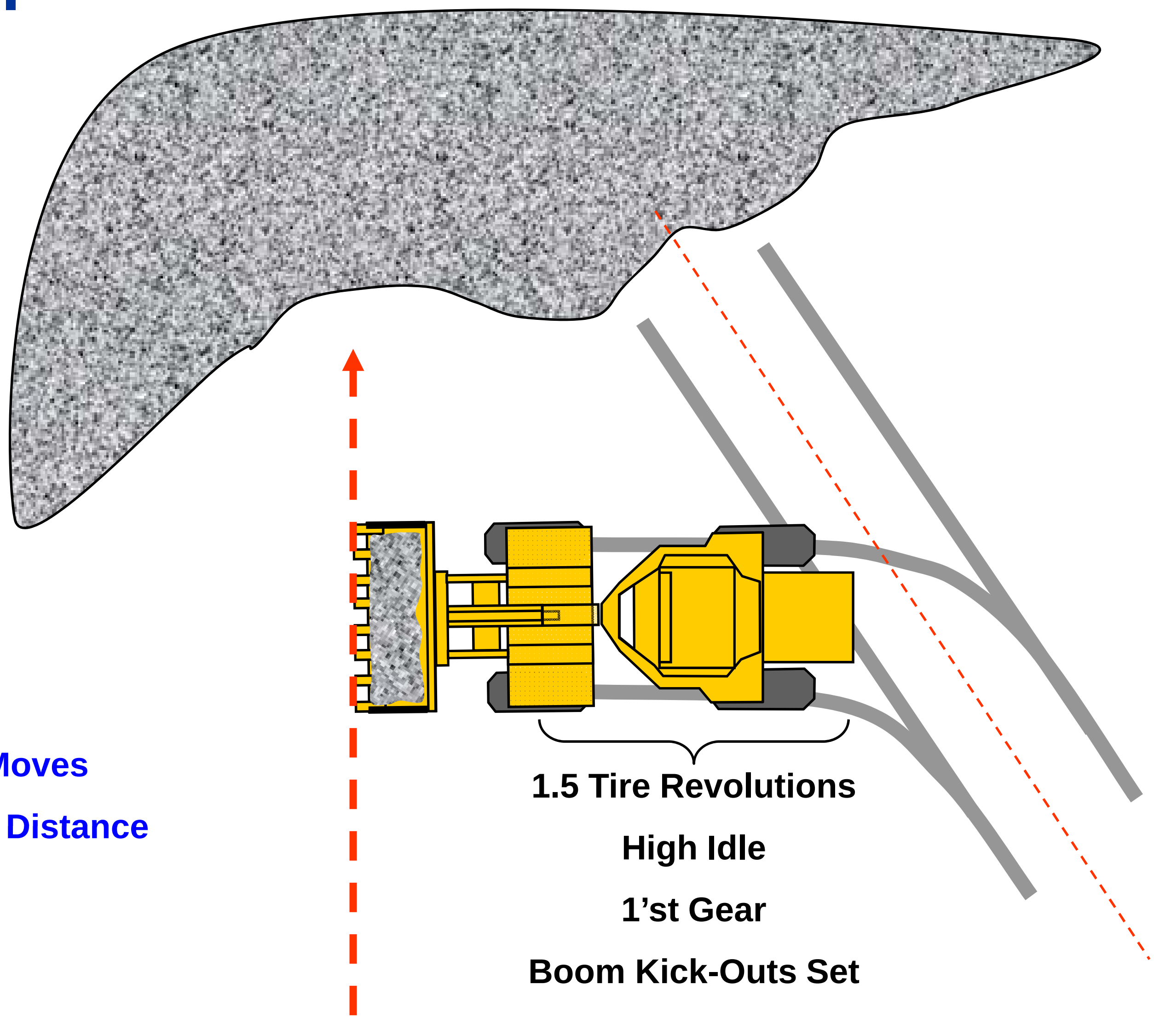
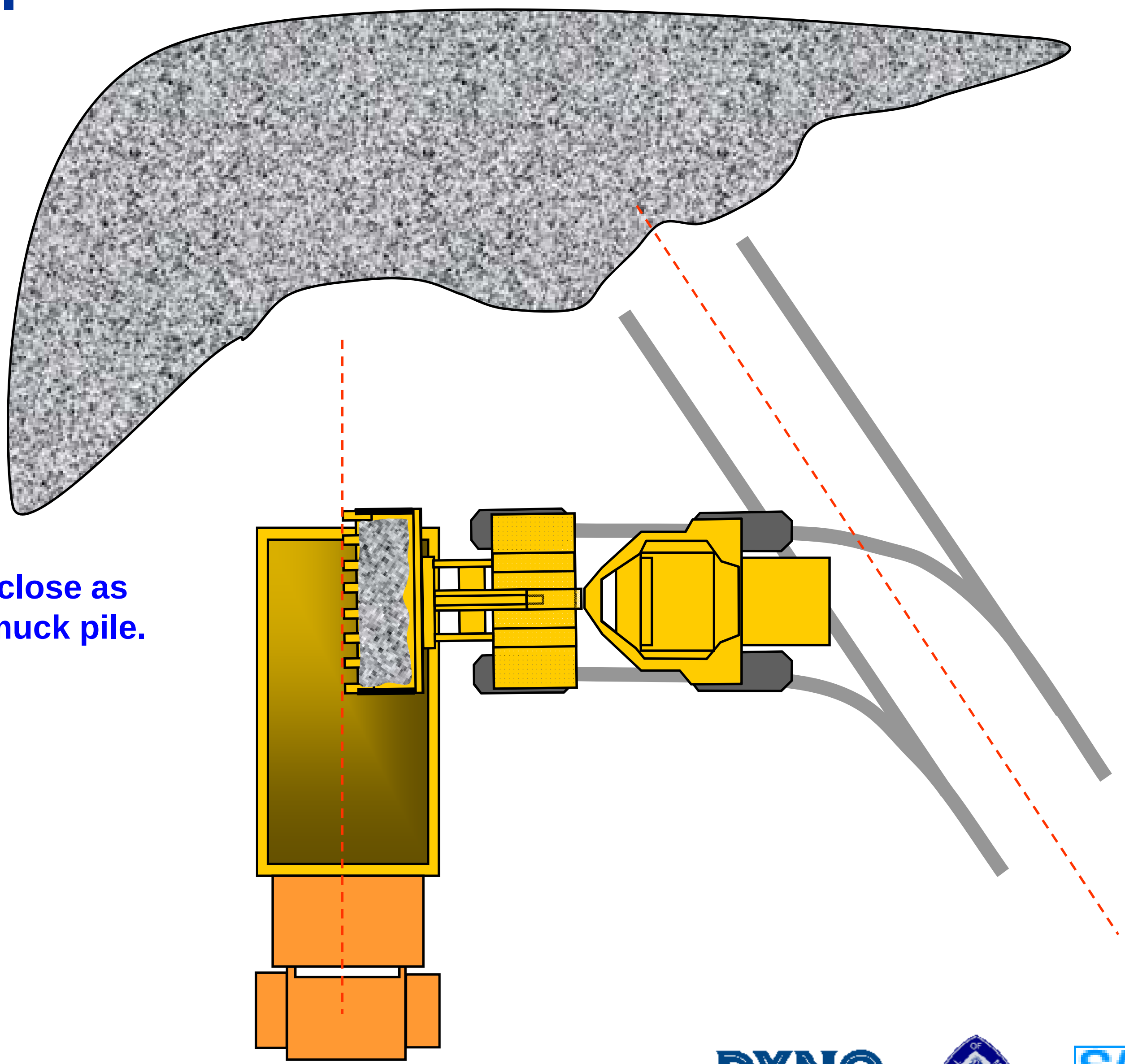
Load/Haul



No Wasted Moves

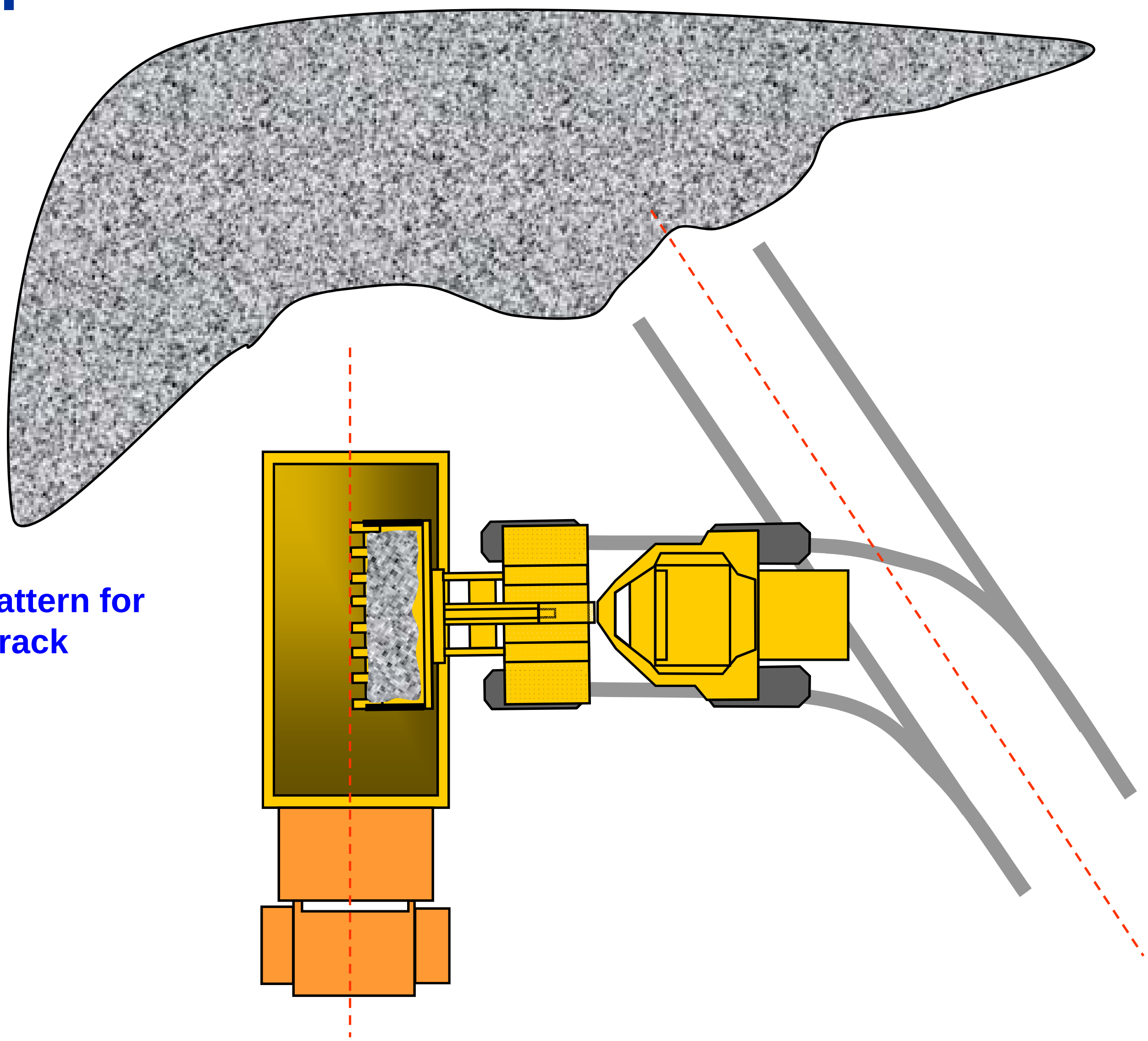
Minimum Travel Distance

Load/Haul



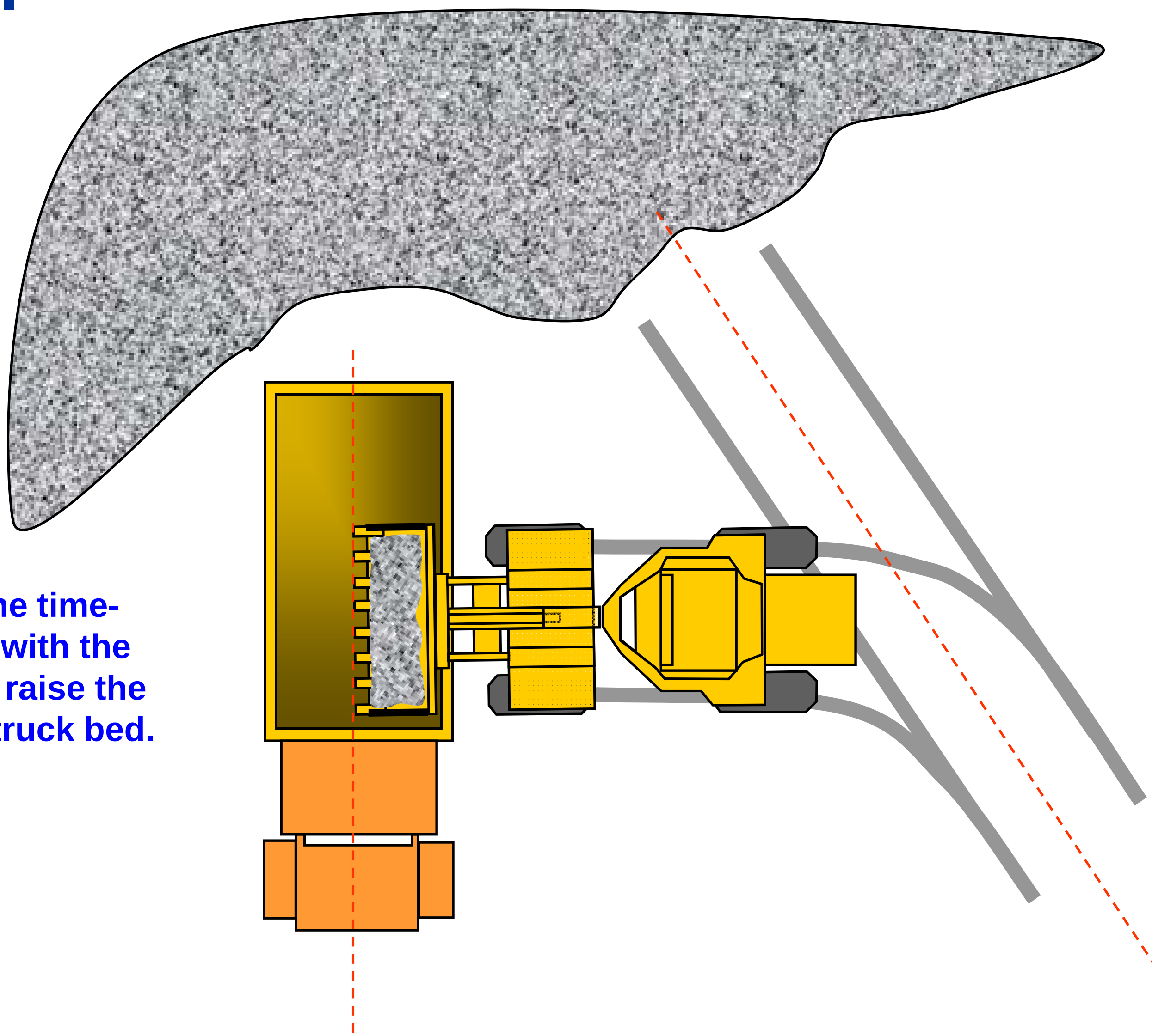
Spot trucks as close as possible to the muck pile.

Load/Haul



Keep a tight V-pattern for the loader track

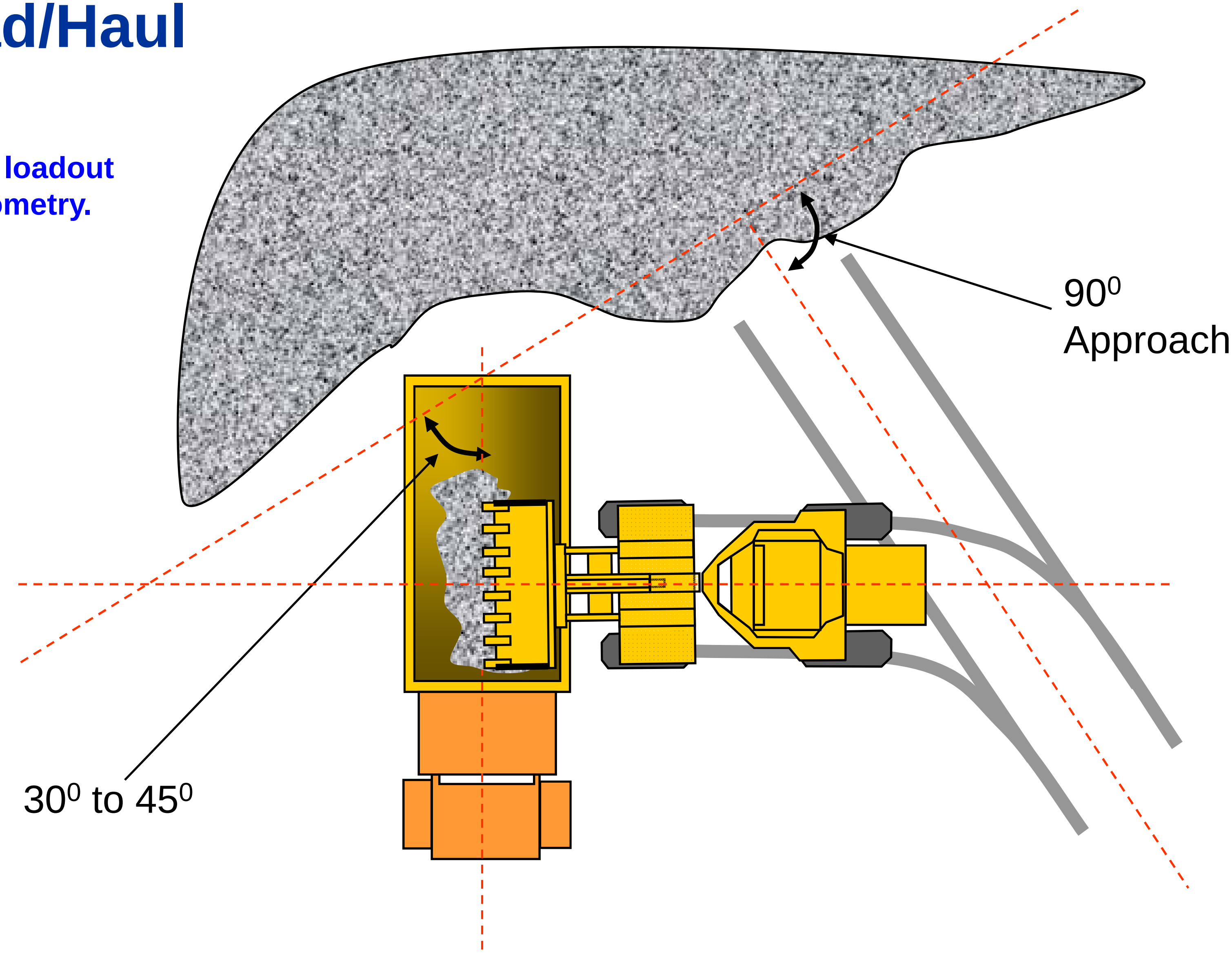
Load/Haul



Try to match the time-distance travel with the time required to raise the bucket over the truck bed.

Load/Haul

Ideal loadout geometry.



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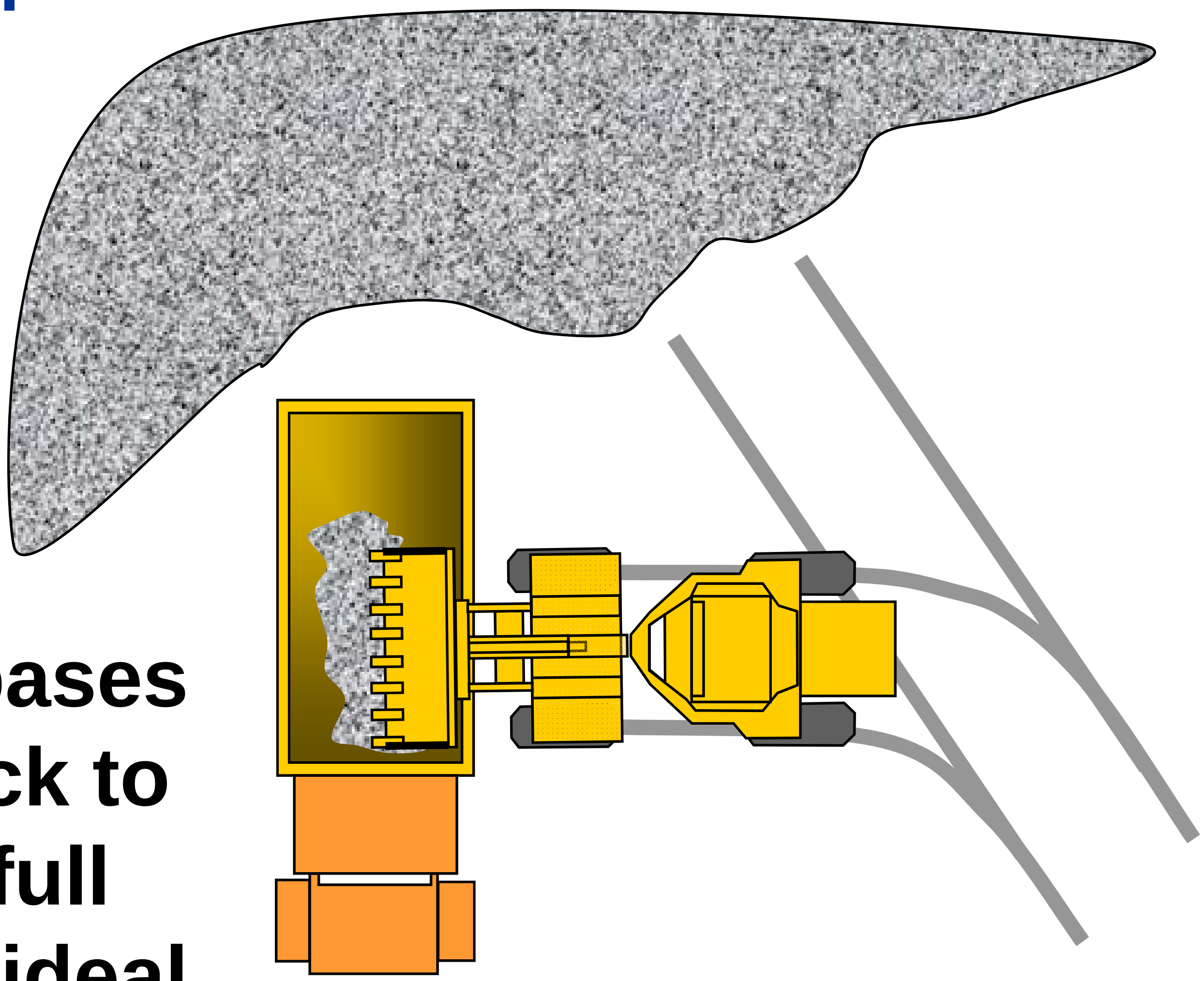
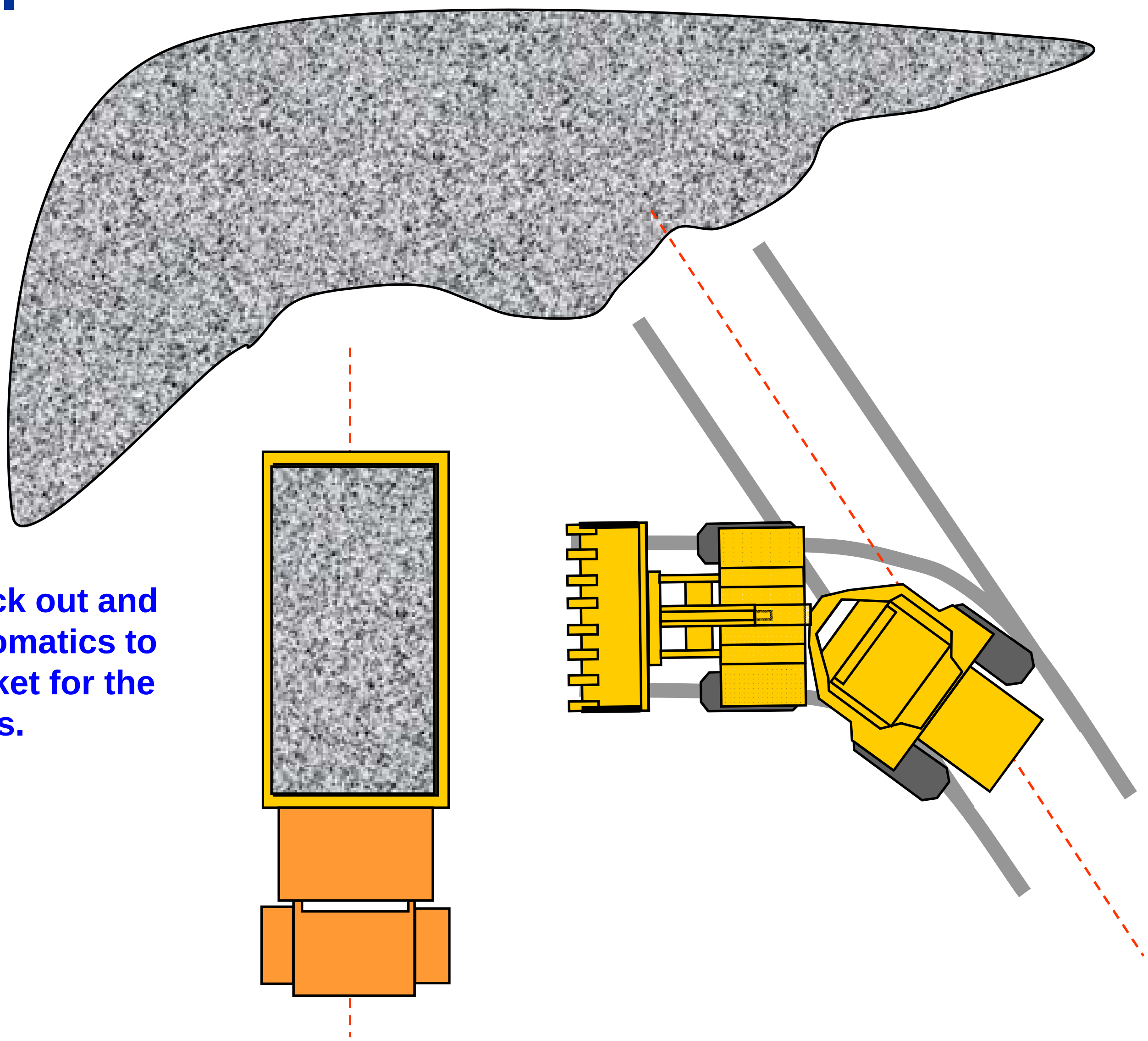


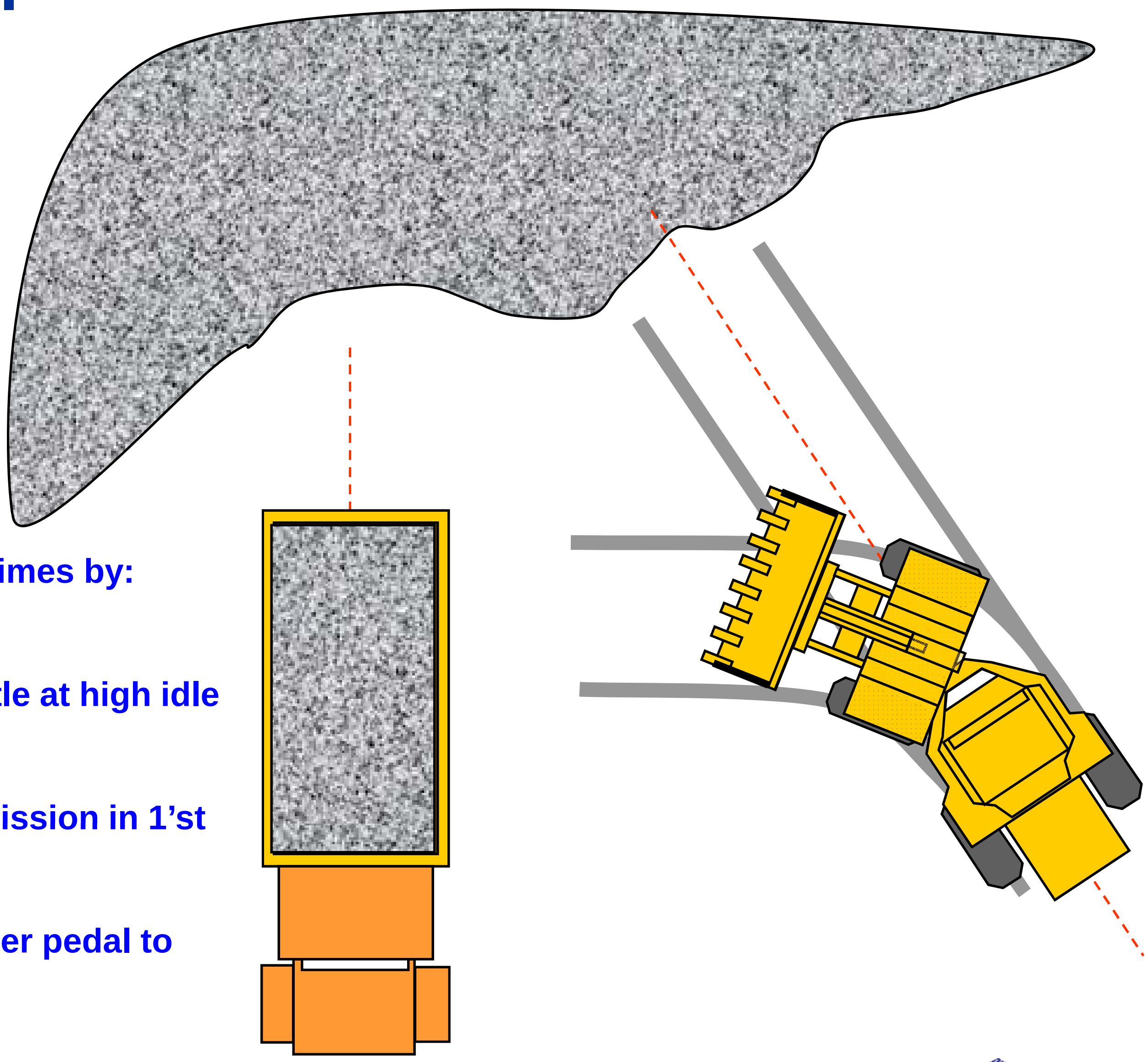
3 to 4 pases per truck to obtain full load is ideal.

Load/Haul



Use the boom kick out and return to dig automatics to position the bucket for the next pass.

Load/Haul



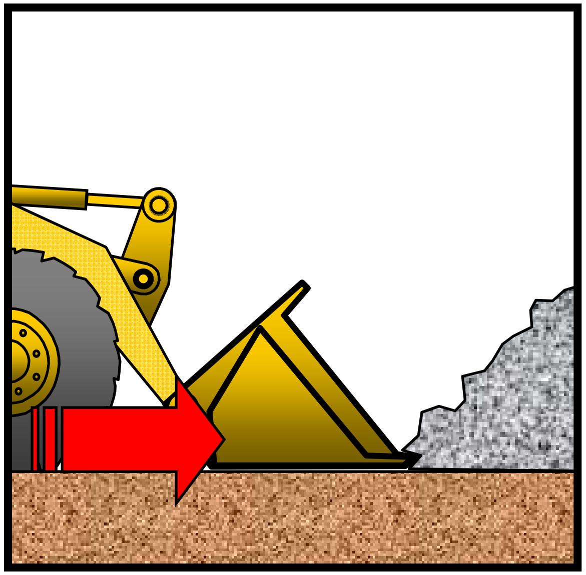
Improve the cycle times by:

1) Setting the throttle at high idle

2) Place the transmission in 1'st

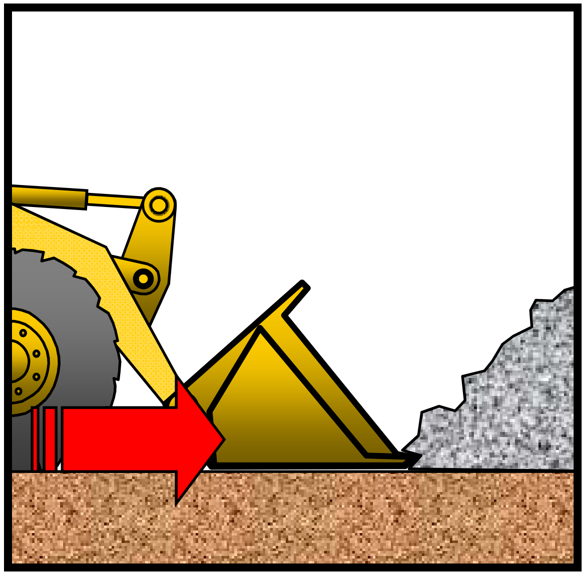
3) Use the neutralizer pedal to regulate speed

Load/Haul

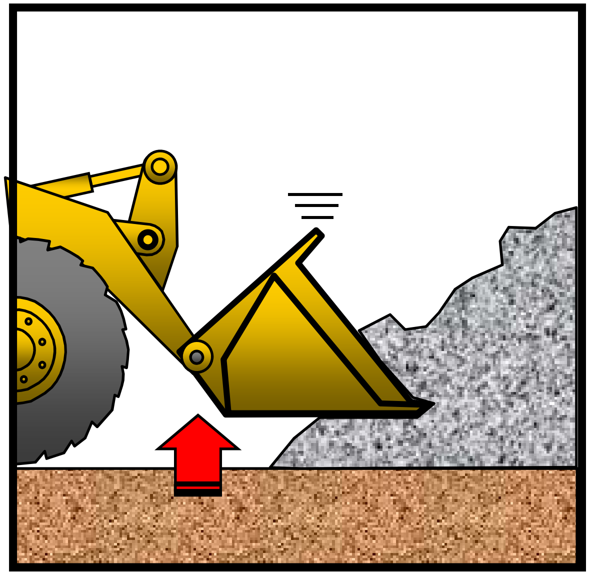


Bucket Flat,
1’st gear
high engine RPM

Load/Haul

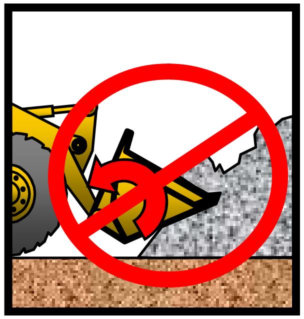


Bucket Flat,
1’st gear
high engine RPM



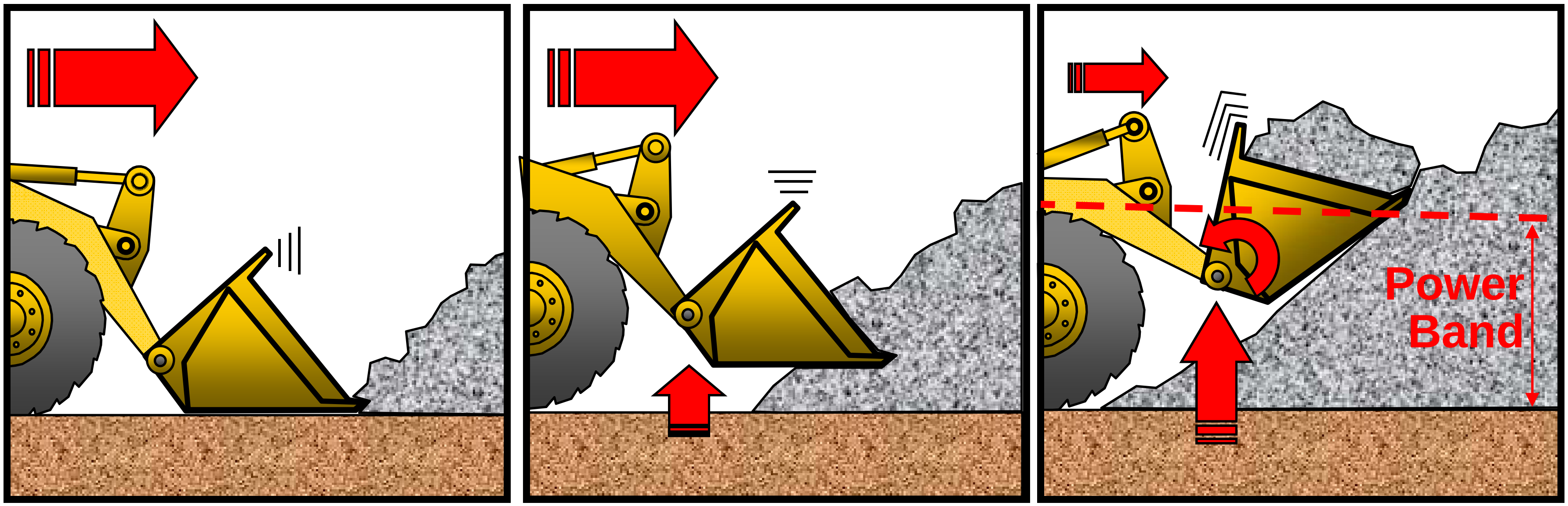
Hoist forks just
before wheels slip,
pushing hard into
the muck pile.

Do not curl
the bucket at
this point!



Load/Haul

Full loads in the power band zone



Bucket Flat,
1'st gear
high engine RPM

Hoist forks just before wheels slip, pushing hard into the muck pile.

Apply the neutralizer pedal, tilt the bucket full up while advancing into the muck pile.

Load/Haul

Load and Haul Management

Load & Carry case study

Summary

Boulder sorting occurrence	*~ 1 in 6 cycles*
Roadway cleanup occurrence	*~ 1 in 6 cycles*
Net cycles per hour	*31*
Boulder sorting sequences per hour	*5.2*

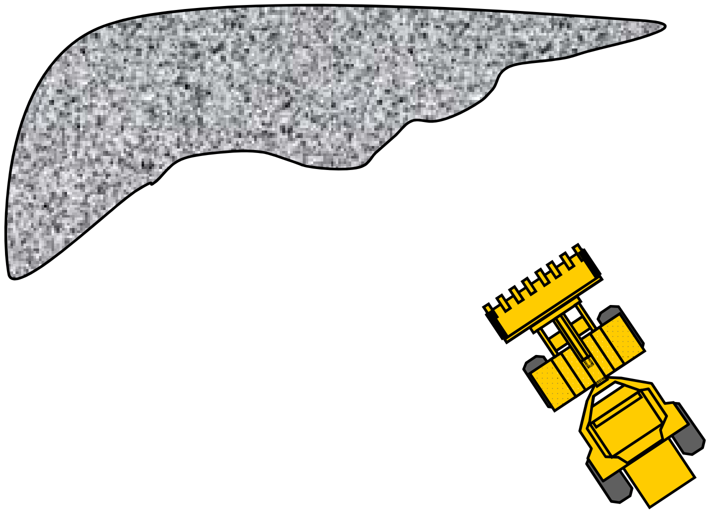
Net load & carry capacities

	(bm^3/h)	(tonnes/h)	(min/cycle)
• as measured	146	408	1.93 = 1.25 + 0.68
• normalized downtime	148	415	1.90 = 1.23 + 0.67
• no downtime	188	525	1.50 = 1.01 + 0.49
• boulder downtime only	164	458	1.72 = 1.23 + 0.49

Loader			CAT 988
Bucket volume			8 lm3
Bucket filling			~ 85%
			(bucket fill % versus roadway cleanu
Quarry floor conditon			uneven, new snow, slippery
Transport distance			~ 85m
Primary crusher opening			950mm

Cycle time (min)	Loading & to crusher (min)	Tip & to muckpile (min)	Comments
2,50	2,08	0,42	Trim face - sort boulders
1,21	0,75	0,46	
1,45	0,95	0,50	
1,50	1,00	0,50	
1,50	1,09	0,41	
3,55	0,92	2,63	Cleanup of roadway to crusher
1,12	0,62	0,50	
1,50	1,08	0,42	
3,08	2,50	0,58	Trim face - sort boulders
1,63	1,13	0,50	
1,95	1,42	0,53	
3,00	2,45	0,55	Trim face - sort boulders
1,88	1,38	0,50	
1,79	0,92	0,87	Cleanup of roadway to crusher
2,00	0,67	1,33	Cleanup of roadway to crusher
1,75	1,25	0,50	
1,42	1,00	0,42	
1,93	*1,25*	*0,68*	***Avg.***

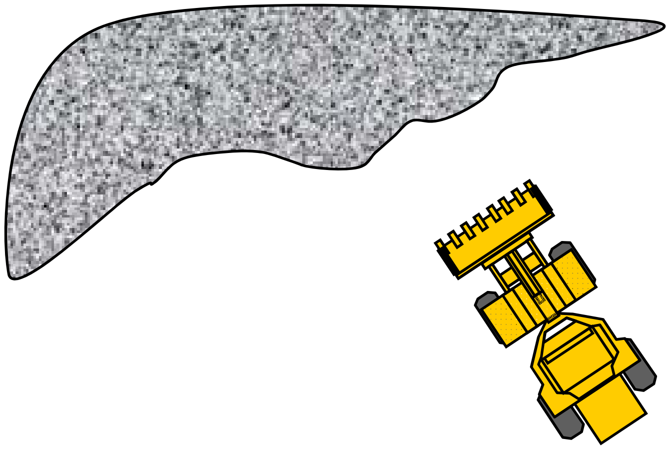
Load/Haul



Factors that effect equipment efficiency:

- **Poor fragmentation – minimal swell in the shot muck pile.**
- **Excessive oversize material, both scale and % content, in the muck pile.**
- **Oversize buckets get mounted on loaders/shovels.**
- **Un-even floor elevations – resulting from rough blasting controls.**
- **Tight working area – limited working space for equipment movement.**
- **Rough – narrow - poorly maintained roads.**
- **Haul road grades that exceed nominal ramp design standards.**

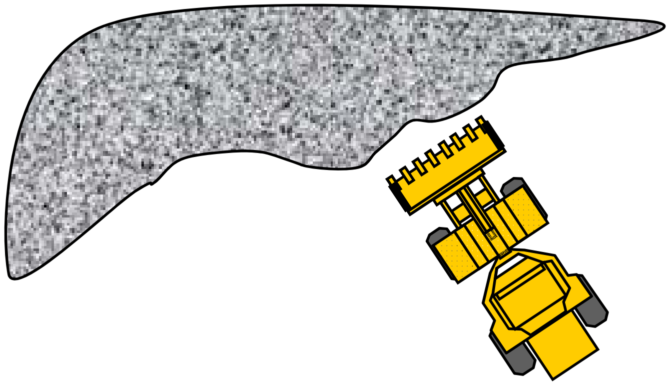
Load/Haul



Performance Degradation
And
Cost Escallation:

- **3 to 4 passes per load move out to 5 to 7.**
- **Truck spotting takes 2 to 3 times as long as it should.**
- **Sub-par technique increases stress on the loader frame and engine.**
- **Tires get chewed up faster.**
- **Overloaded loaders and trucks cost money and shorten service life.**
- **Non-standard cycle times compound loss of production.**
- **Discontunious feed to the plant can create sub-par crusher performance.**

Load/Haul



Correction and improvement:

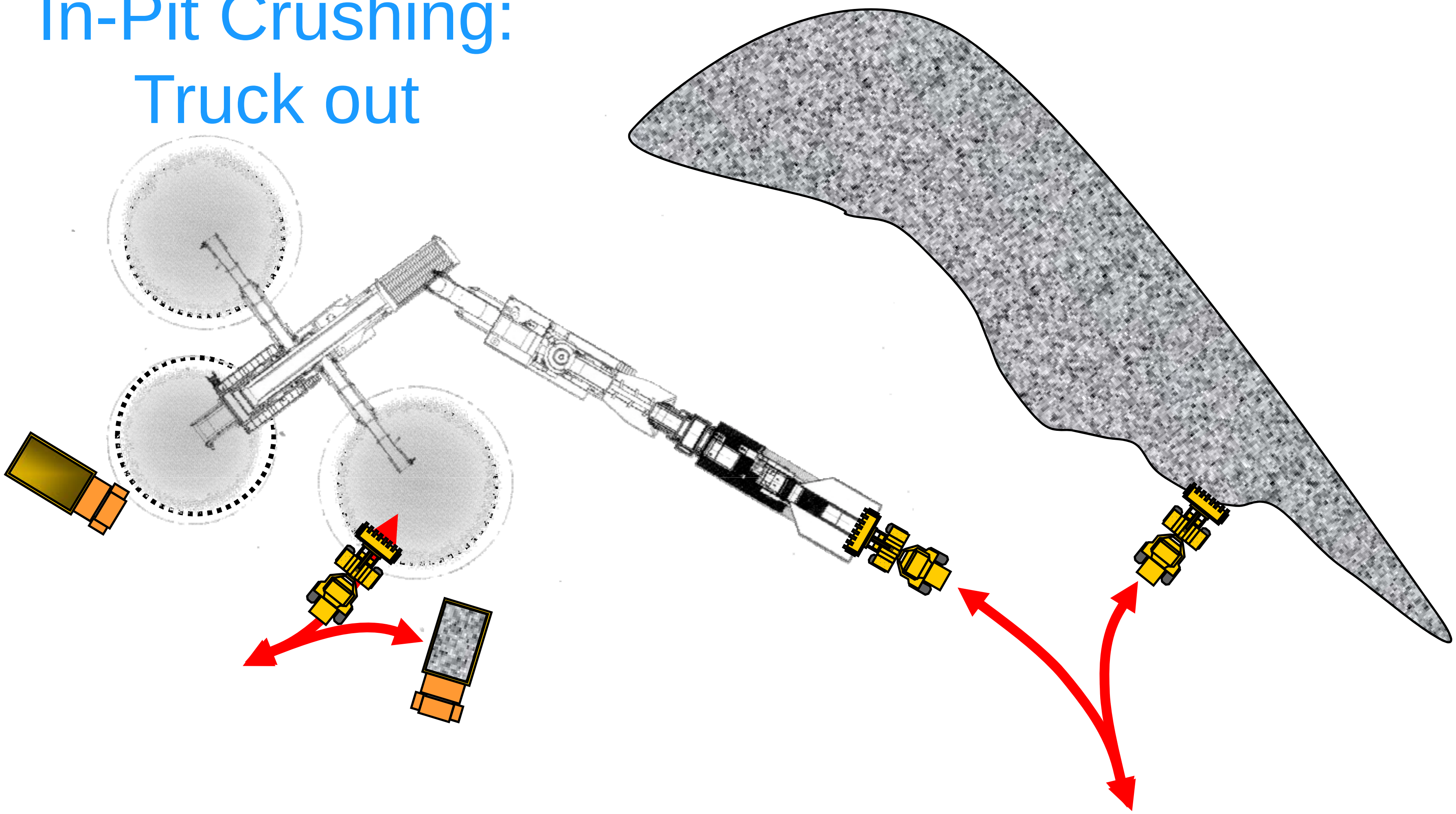
- Improve muck fragmentation control, muckpile shape, and consistent floor elevation with better blasting controls.
- Provide formal training for your operators.
- Set clear standards of performance for your operators.
- Time-study/video the load haul operations.
- Install load cell readout systems on the loader (trucks?) to provide “dashboard” feedback in real time.
- Keep the road system level, clean, and dry where possible.

Loading and Hauling

Alternatives

Variations On Tradition:

In-Pit Crushing:
Truck out



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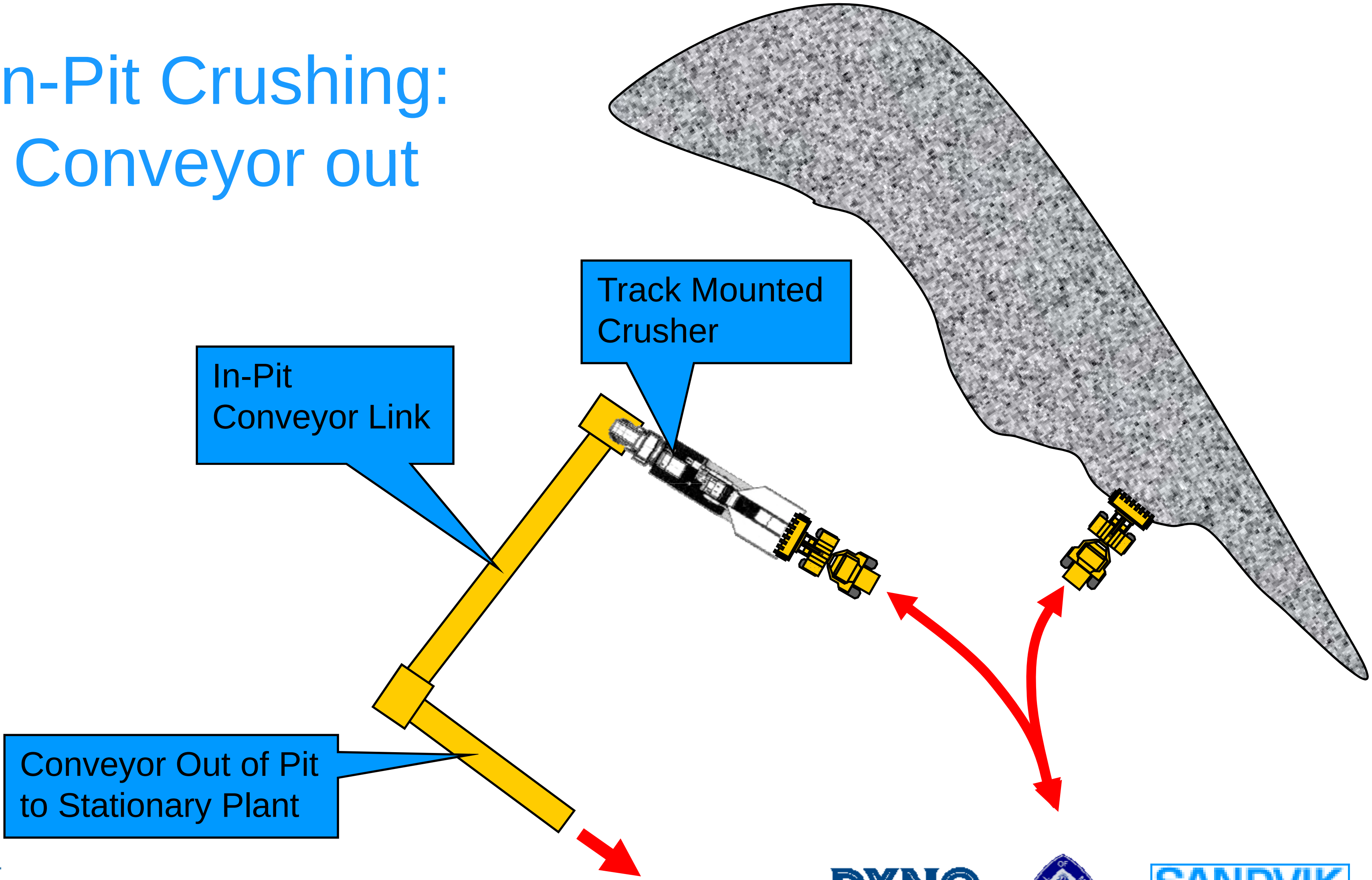
Variations On Tradition:

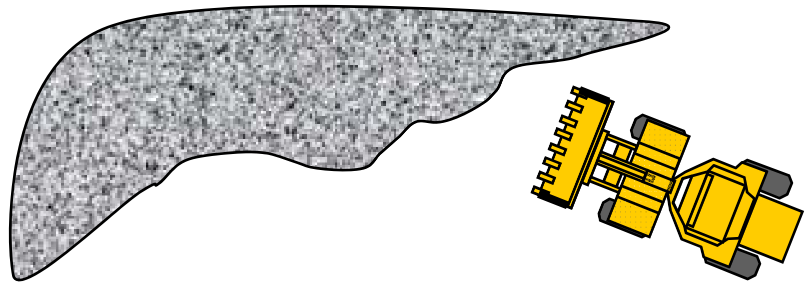
In-Pit Crushing: Conveyor out



Loading and Hauling

Conclusion

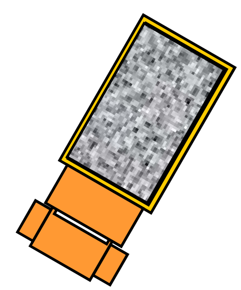
Load/Haul



- While load/haul is one of the most intuitive of unit operations in the pit, efficiency gains and cost savings can be had when everyone pays attention to daily details.

- Organizing and maintaining your pit so as to get a smooth rhythm and balance in the cycle activity is key to productivity and equipment longevity.

- Studying and managing the basics is the key to sustainable improvement.



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