



Optimizing an Engineered Slope Conveyor System

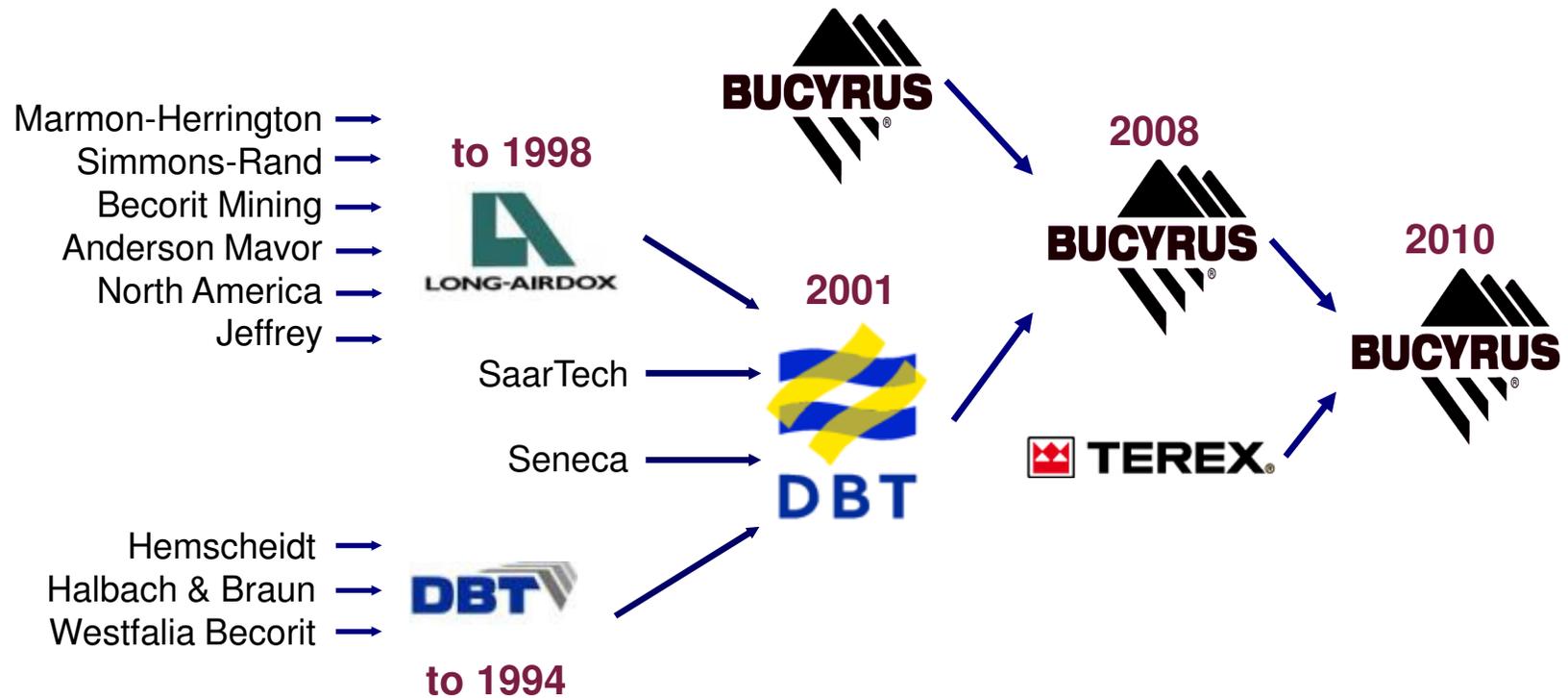
An OEM / Operator Collaboration

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Todd Burchett
February 21, 2012

WHEREVER THERE'S MINING



Who is Caterpillar Global Mining?



And in 2011...

Caterpillar Global Mining

Caterpillar Keeps Mining Emerging Markets With Bucyrus Buy

In a move that took the mining equipment sector—as well as investment analysts—by surprise, Caterpillar Inc. announced on November 15 it had entered into an agreement to acquire fellow mining supplier Bucyrus International for an outlay of \$7.6 billion. The acquisition, said Caterpillar, will position the company to capitalize on what it sees as a robust long-term outlook for commodities-driven rapid growth in emerging markets.

BCUY + CAT = mining equipment powerhouse

Caterpillar Gets 'Super-Sized' With Bucyrus Acquisition

As countries like China, India and Brazil continue to modernize at a fast clip, their demand for goods like precious metals and energy sources is rising just as quickly. Investors cheered the news as stocks in both companies rose. The planned merger would be the largest in the construction and mining industry in five years.

This week we're looking at Caterpillar Inc.'s (CAT) recently-announced acquisition of Bucyrus International (BCUY) for \$7.6 billion (\$8.6 billion including debt).

This deal is huge. It's big for Caterpillar, which hasn't made such an acquisition since 1980, according to Bloomberg. It's also one of the biggest in the mining and construction industry in the past five years. It's also a good time to do it: Financing costs are relatively low, and Caterpillar has some spare money in the bank.

CATERPILLAR (CAT) DIGGING BUCYRUS (BCUY)

In M&A activity, Caterpillar (CAT, \$83.13, up \$2.09), the world's largest construction and mining equipment maker, decided now is the time to buy Bucyrus International (BCUY, \$89.79, up \$20.17) and moved aggressively to capitalize on the demand for commodities in emerging markets. Both stocks are trading higher on the \$7.6 billion buyout offer.

CAT ADDING BUCYRUS TO ITS PRODUCT PAYLOAD FOR \$8.6B

Despite obstacles, Caterpillar roars on, analysts say

Despite crisis in Japan, a lethargic U.S. construction industry and increased corporate taxes in its home state of Illinois, analysts agree the outlook is good for Caterpillar Inc., the world's largest heavy-equipment maker. More than offsetting the difficulties, the analysts say, will be emerging-market demand for

construction equipment and miners' needs for equipment to increase production of metals. Although Caterpillar's agreement to acquire Bucyrus International Inc., an international mining equipment manufacturer, was approved by European Union anti-trust regulators last week, analysts aren't yet counting it in their forecasts.

CAT to Buy Bucyrus in Record Deal

Caterpillar Inc. (NYSE:CAT) is all set to buy Bucyrus International Inc. (NASDAQ:BCUY), a South Milwaukee-based manufacturer of surface and underground mining equipment, in a transaction worth \$8.6 billion. The deal, if it gets through, would be the

biggest in the company's history. The billion-dollar deal capitalizes on the rising demand for coal and minerals triggered by growth in the emerging nations. The acquisition, subject to regulatory and Bucyrus shareholder approvals, is slated to close in mid-2011.

CATERPILLAR TO BUY BUCYRUS TO EXPAND MINING RANGE

CATERPILLAR BUYING BUCYRUS IN BIG BET ON MINING

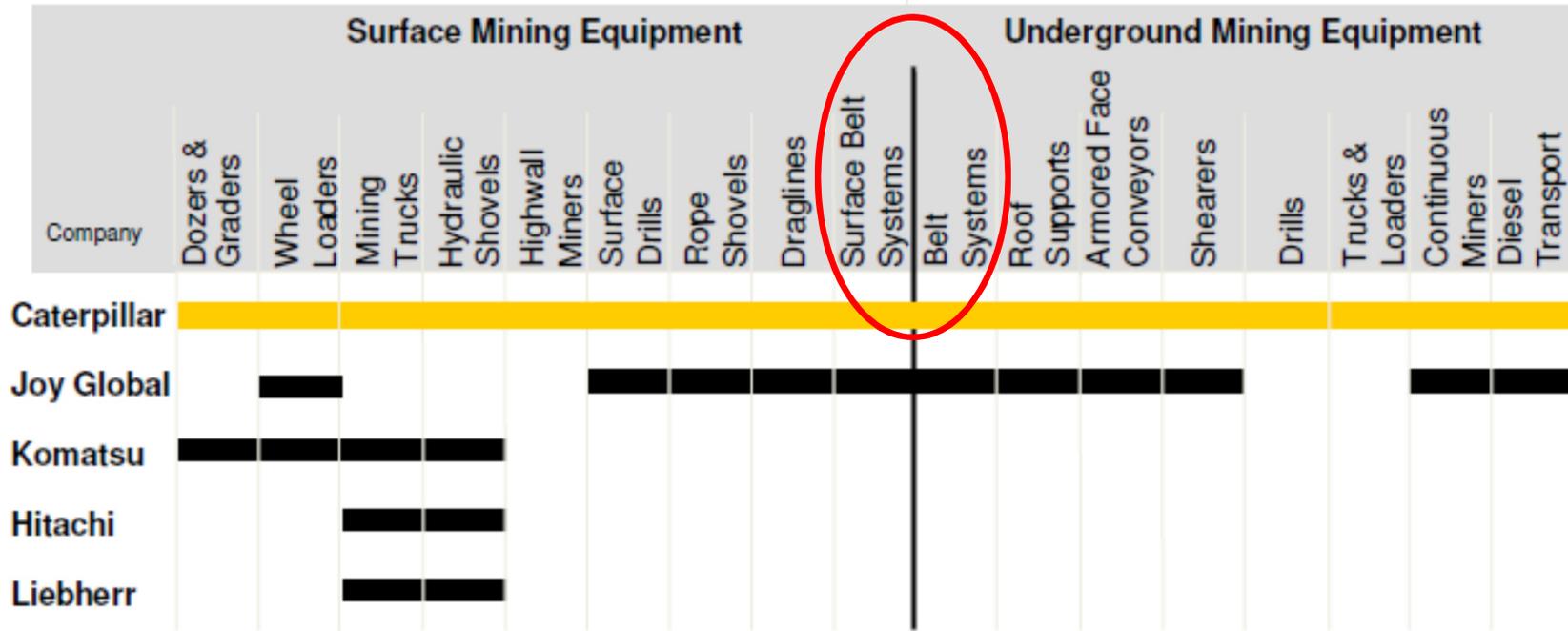
DETROIT/PROVIDENCE, Rhode Island — Caterpillar Inc. staked a larger claim in the booming global mining industry with a \$7.6 billion deal to buy Bucyrus International Inc., the biggest acquisition in its 85-year history. The deal would strengthen Caterpillar's position as the world's biggest maker of mining equipment, adding massive mining shovels and draglines to its lineup of trucks and excavators.

Shareholders of Bucyrus will receive \$92 cash per share, a 32 percent premium over the stock's closing price on Friday. Jim Dugan, a Caterpillar spokesman, said the deal, expected to close in mid-2011, was the biggest in the company's history by "a long shot." Including \$1 billion of Bucyrus debt being assumed by Caterpillar, the transaction is worth \$8.6 billion.

Caterpillar bets on continued commodities boom, acquires competitor

Shareholders have enough to ride the stock from the depths of the recession to the present have seen it nearly quadruple, from \$30.38 per share in July of 2009 to a 52-week high of \$116 on May 2.

Complete Mining Products Portfolio



Complete Mining Products Portfolio

The diagram illustrates a comprehensive mining operation across three main levels:

- Surface Mining - Coal:** Features large-scale equipment such as the **DRAGLINE**, **TRACK-TYPE TRACTOR**, **WHEEL LOADER**, and **WHEEL DOZER**. It also shows **WHEEL TRUCK** and **HYDRAULIC EXCAVATOR** units.
- OPEN PIT:** Utilizes **ARTICULATED TRUCK**, **HYDRAULIC EXCAVATOR**, **ELECTRIC CRAN**, and **MOTOR GRADER** for material handling and site preparation.
- UNDERGROUND:**
 - HARD ROCK:** Employs **UNDERGROUND TRUCK**, **UNDERGROUND LOADER**, and **UNDERGROUND DRILL**.
 - ROOM & PILLAR:** Uses **FEEPER BREAKER**, **ROOF BOLTER**, **UTILITY LOADER**, **FACE W/BLADE**, and **CONTINUOUS MINER**.
 - LONGWALL:** Includes **BREAKER**, **ROOF SUPPORT**, **APC SYSTEM**, **BOLT SYSTEM**, **ROOF SUPPORT CARRIER**, and **FLDR**.

Supporting infrastructure includes **ELECTRIC POWER GENERATION**, **BEKLER SUPPORT**, **MINESHAFT SYSTEM**, **TRAIN TUNNEL**, **LOCOMOTIVES & RAIL SERVICES**, and **WHEEL TRUCK**.

THE BROADEST PRODUCT LINE IN THE MINING INDUSTRY—
AND THE INFRASTRUCTURE AND SUPPORT NETWORK TO SERVE EVERY MINING REGION IN THE WORLD.

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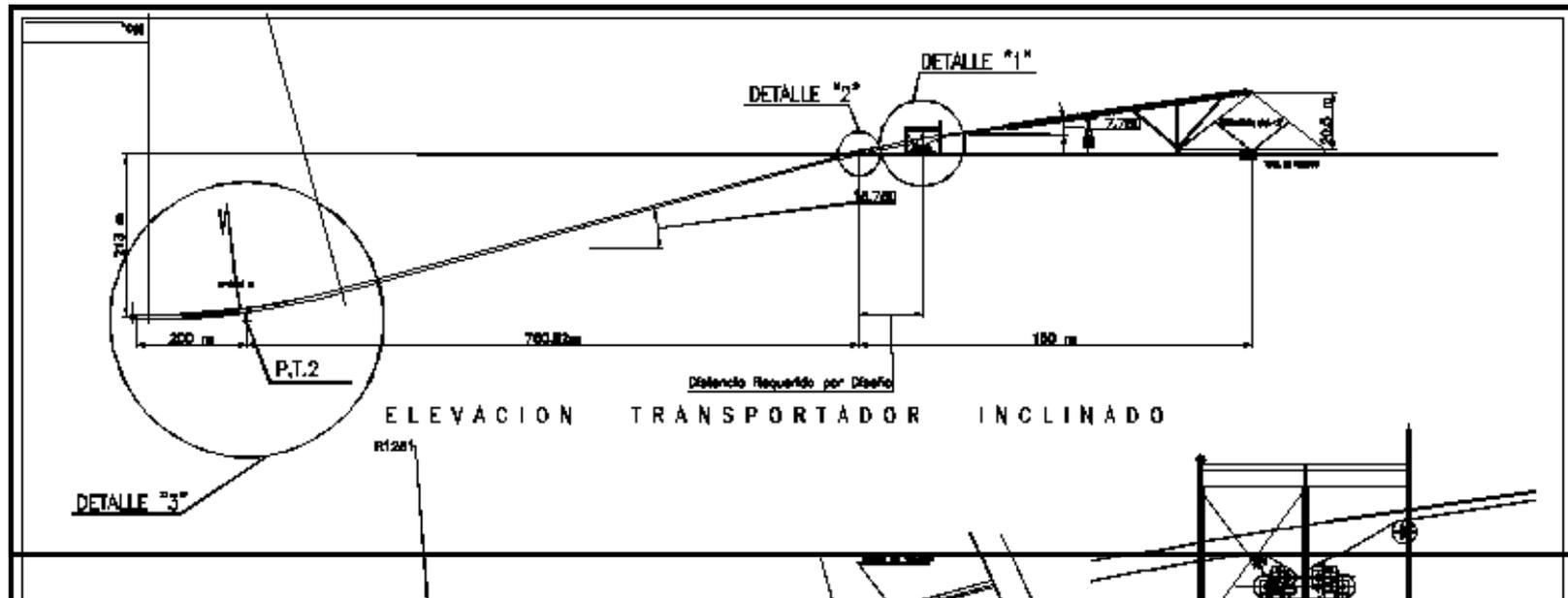
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Preliminary Slope Layout Drawing

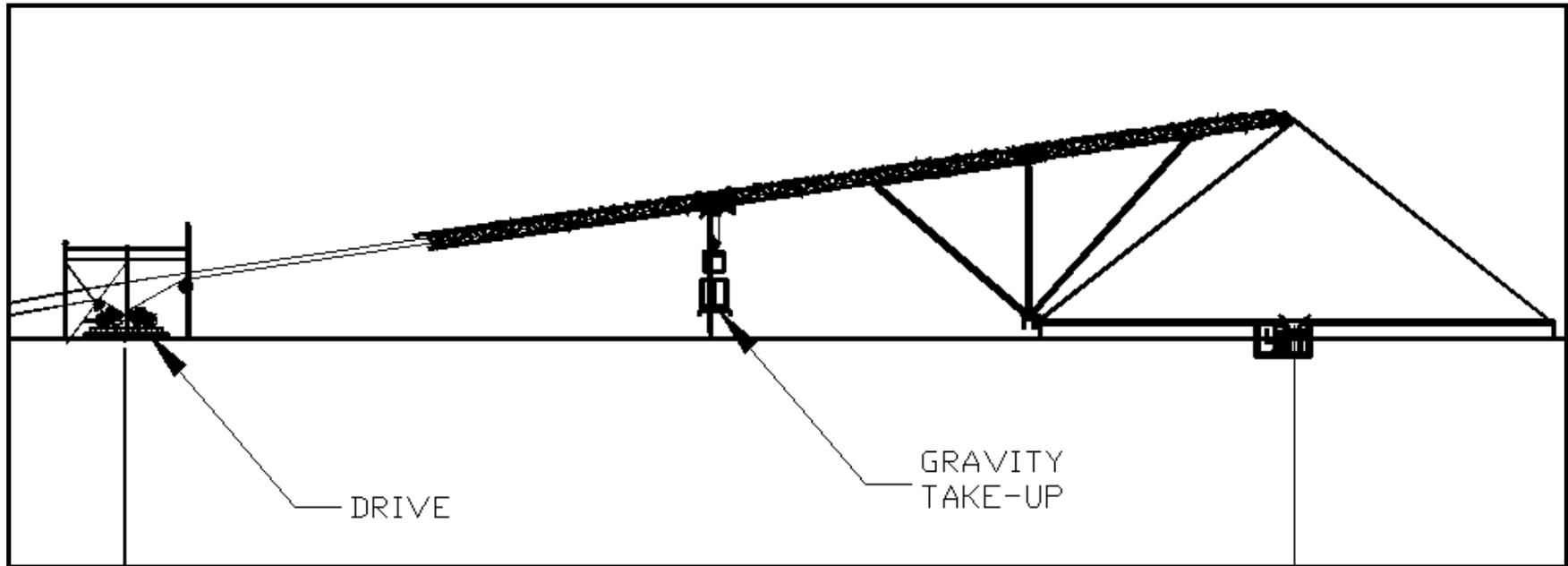
Design review

Preliminary Slope Design Layout Drawing



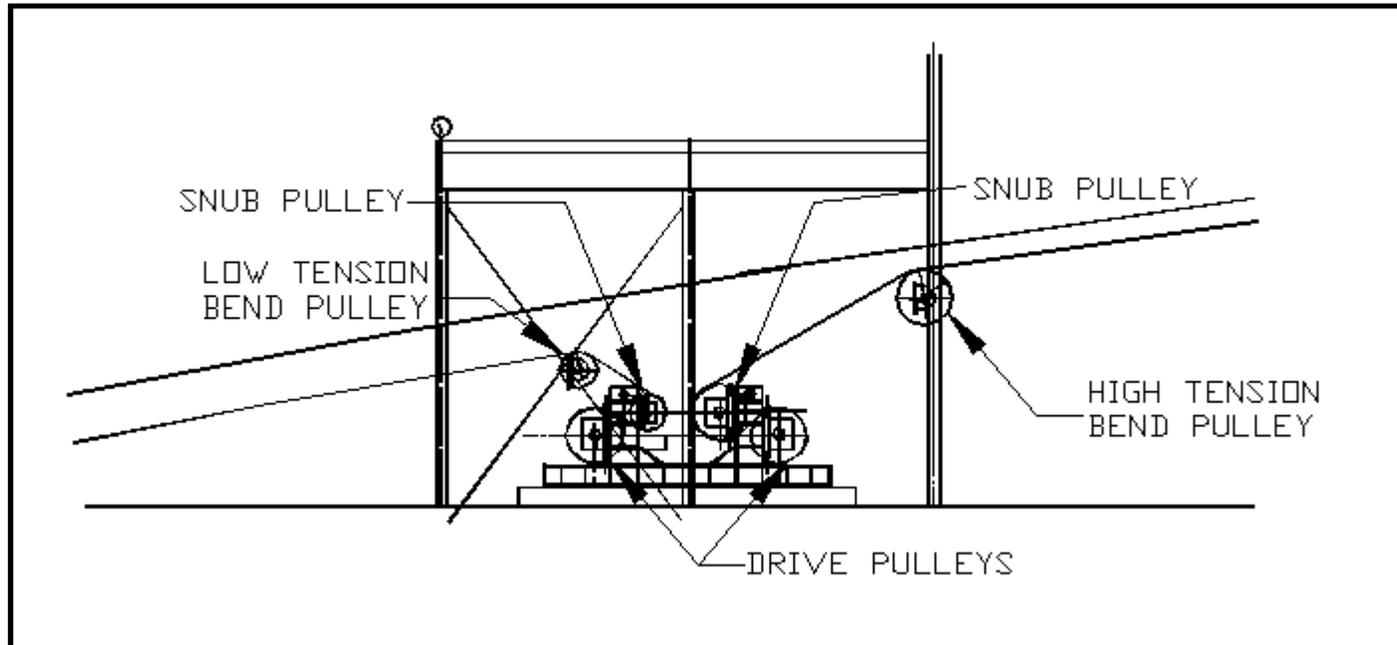
- Slope layout constraints provided by operator
 - Fixed points – opening of portal (PT 1) and bottom of slope (PT 2)
 - Distance between PT 1 and PT 2 is 760.82 m horizontal and 213.0 m vertical
 - From PT 1 to discharge pulley is 150 m horizontal and 20.5 m vertical
 - Distance from PT 2 to tail pulley depends on radius of curve; approximately 50 m + tangential point of radius at tail pulley (calculate the distance from tangential point of curve use $X = R * \tan(15.75/2)$)

Preliminary Design – Gravity Take Up Location



- Highest tension throughout the belt is seen at this location
- Would require a counterweight with 880,000 lbs of weight – over 440 tons!
- Obviously this is not practical

Preliminary Design – Drive Arrangement



- Four pulley drive arrangement
- Requires a low tension bend pulley inby the drive and a high tension bend pulley outby the drive
- Advantage – driving the clean side of the belt
- Disadvantage – higher cost solution

Preliminary Slope Conveyor Specifications

Design review

Preliminary Design Specification

	Option 1	Option 2	Option 3
Material Density	881 kg/m ³	881 kg/m ³	881 kg/m ³
Belt Width	60"	72"	72"
Length	1,086 m	1,111 m	1,357 m
Lift	233 m	233 m	233 m
Belt Speed	4.5 mps	4.5 mps	3.5 mps
Horizontal Curve Radius	2,956 m	1,251 m	2,865 m
Desired Tonnage	5,500 mtph	5,500 mtph	5,500 mtph

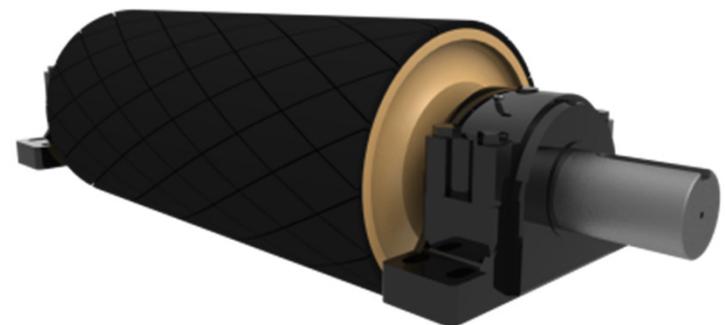
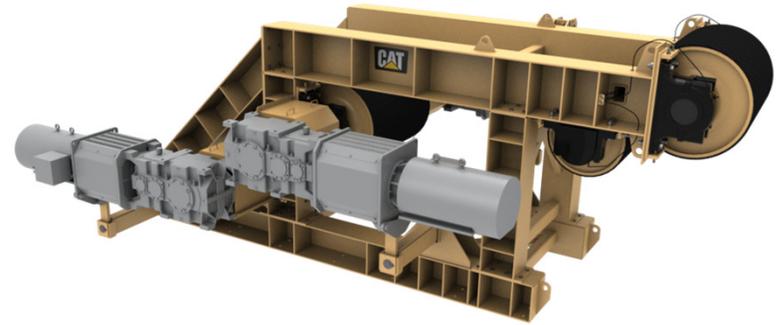
- Design constraints provided by operator
 - Voltage – 4160 v
 - Preferred drive technology – fluid coupling
 - Preferred take up type – gravity
 - Must be able to convey 5,500 mtph

Caterpillar Slope Design Review Data

		60" Belt Width			72" Belt Width					
		650 TPKL	866 TPKL	780 TPXL	650 TPKL	866 TPKL	780 TPXL	650 TPKL	866 TPKL	780 TPXL
Belt Width		60"			72"					
Length		1086 m			1357 m			1111 m		
Lift		233 m								
Belt Speed		4.5 mps			3.5 mps			4.5 mps		
Desired Tonnage		5,500 mtph								
Allowable Tonnage		3,750 mtph			4,250 mtph			5,500 mtph		
Drive	Main Drive Config	4 x 1100 HP		2 x 2200 HP	4 x 1300 HP		2 x 2600 HP	4 x 1600 HP		2 x 3200 HP
	HS Coupling	650 TPKL	866 TPKL	780 TPXL	650 TPKL	866 TPKL	780 TPXL	650 TPKL	866 TPKL	780 TPXL
	Backstop	BC-375MA			BC-540MA					
	Motor Speed	1800 RPM	1200 RPM		1800 RPM	1200 RPM		1800 RPM	1200 RPM	
	Total Horse Power	4400 HP			5200 HP			6400 HP		
	Voltage	4160 V								
	Drive Pulley Diameter	48"			54"					
Take-up	Cylinder	Take-up Type		Cylinder						
		Location		Tail						
		Take-up Tension Required		11,015#		20,716#		15,453#		
		Max Take-up Tension		21,536#		21,536#		21,536#		
		Max Line Pull		43,072#		43,072#		43,072#		
	Gravity	Take-up Type		Gravity						
		Location		Drive						
Take-up Tension Required		46,187#		65,268#		59,174#				
Take-up Weight		92,374#		130,536#		118,348#				
Take-up Pulley Diameter		36"		42"						
Belt	Cylinder	Cylinder TU Belt Suggested		ST3500		ST4500		ST4000		
		% Running Belt Rating		97%		93%		97%		
	Gravity	Gravity TU Belt Suggested		ST4000		ST4500		ST4500		
		% Running Belt Rating		91%		99%		93%		
	Belt Cover Thicknesses		.25 x .125							
Discharge Diameter		48"			54 "					
Tail Pulley Diameter		36"			42 "					

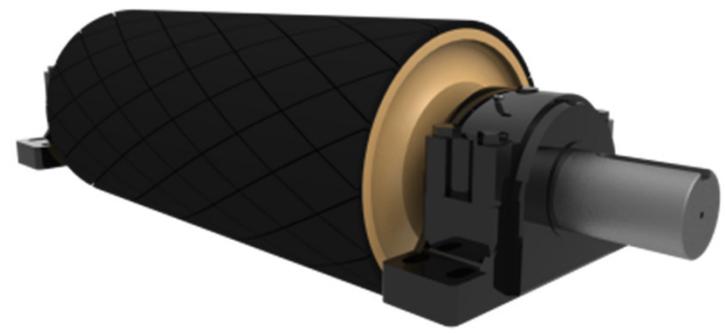
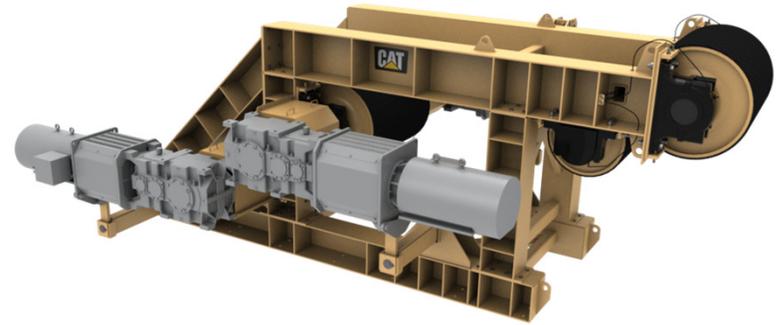
Option 1 – 60” Belt Width at 4.5 m/s

		60" Belt Width			
		650 TPKL	866 TPKL	780 TPXL	
Belt Width		60"			
Length		1086 m			
Lift		233 m			
Belt Speed		4.5 mps			
Desired Tonnage		3,500 mtph			
Allowable Tonnage		3,750 mtph			
Drive	Main Drive Config	4 x 1100 HP		2 x 2200 HP	
	HS Coupling	650 TPKL	866 TPKL	780 TPXL	
	Backstop	BC-375MA			
	Motor Speed	1800 RPM	1200 RPM		
	Total Horse Power	4400 HP			
	Voltage	4160 V			
	Drive Pulley Diameter	48"			
	Take-up	Cylinder	Take-up Type	Cylinder	
			Location	Tail	
			Take-up Tension Required	11,015#	
Gravity		Max Take-up Tension	21,536#		
		Max Line Pull	43,072#		
		Take-up Type	Gravity		
Belt	Cylinder	Location	Drive		
		Take-up Tension Required	46,187#		
	Gravity	Take-up Weight	92,374#		
		Take-up Pulley Diameter	36"		
		Cylinder TU Belt Suggested	ST3500		
	% Running Belt Rating	97%			
	Gravity TU Belt Suggested	ST4000			
	% Running Belt Rating	91%			
	Belt Cover Thicknesses	.25 x .125			
	Discharge Diameter	48"			
	Tail Pulley Diameter	36"			



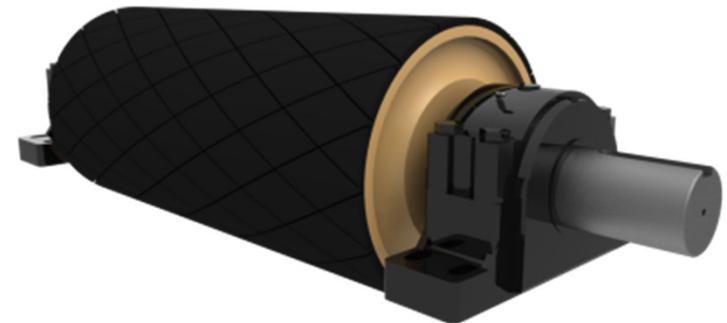
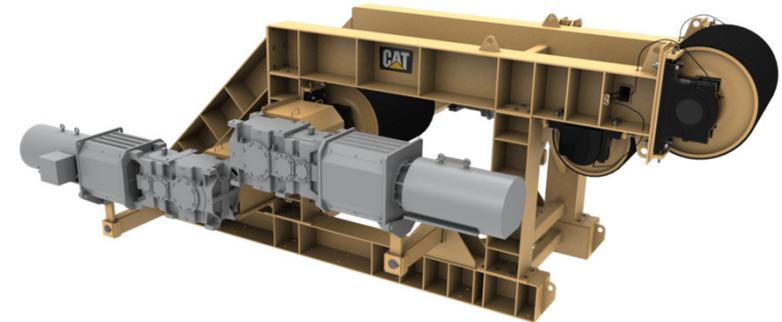
Option 2 – 72” Belt Width at 4.5 m/s

		72" Belt Width		
		650 TPKL	866 TPKL	780 TPXL
Drive		Belt Width 72" <small>Date: 09/29/2011</small> Length 1111 m Lift 233 m <small>Company: BUCYRUS</small> Belt Speed 4.5 mps Desired Tonnage 5,500 mtph Allowable Tonnage 5,500 mtph Main Drive Config 4 x 1600 HP <small>Cost, \$/m</small> 2 x 3200 HP HS Coupling 650 TPKL 866 TPKL 780 TPXL Backstop BQ-540MA Motor Speed 1800 RPM 1200 RPM Total Horse Power 6400 HP Voltage 4160 V Drive Pulley Diameter 54"		
Take-up	Cylinder	Take-up Type Cylinder		
		Location Tail		
		Take-up Tension Required 15,453#		
	Gravity	Max Take-up Tension 21,536# <small>Standard Rating</small>		
		Max Line Pull 43,072#		
		Take-up Type Gravity		
		Location Drive		
		Take-up Tension Required 59,174# <small>Ave Run Ten</small>		
		Take-up Weight 118,348# <small>Ave Accel Ten</small>		
		Take-up Pulley Diameter 42" <small>MFR Accel Ten</small>		
Belt	Cylinder	Cylinder TU Belt Suggested ST4000		
		% Running Belt Rating 97% <small>3411 PW</small>		
	Gravity	Gravity TU Belt Suggested ST4500		
		% Running Belt Rating 93% <small>Permanent</small>		
		Belt Cover Thicknesses .25 x .125		
		Discharge Diameter 54 "		
		Tail Pulley Diameter 42 "		



Option 3 – 72” Belt Width at 3.5 m/s

		72" Belt Width		
		650 TPKL	866 TPKL	780 TPXL
Drive		72"		
Belt Width		Date: 09/29/2011		
Length		1357 m		
Lift		Company: BUCYRUS 233 m		
Belt Speed		3.5 mps		
Desired Tonnage		5,500 mtph		
Allowable Tonnage		4,250 mtph		
Main Drive Config		4 x 1300 HP		2 x 2600 HP
HS Coupling		650 TPKL	866 TPKL	780 TPXL
Backstop		BC-540MA		
Motor Speed		1800 RPM	1200 RPM	
Total Horse Power		5200 HP		
Voltage		4160 V		
Drive Pulley Diameter		54"		
Take-up	Cylinder	Cylinder		
		Tail		
		20,716#		
	Gravity	Gravity		
		Drive		
		65,268#		
Take-up Weight		130,536#		
Take-up Pulley Diameter		42"		
Belt	Cylinder	Cylinder TU Belt Suggested		
		ST4500		
	Gravity	% Running Belt Rating		
		93%		
Gravity TU Belt Suggested		ST4500		
% Running Belt Rating		99%		
Belt Cover Thicknesses		.25 x .125		
Discharge Diameter		54 "		
Tail Pulley Diameter		42 "		



Summary of Preliminary Design Review

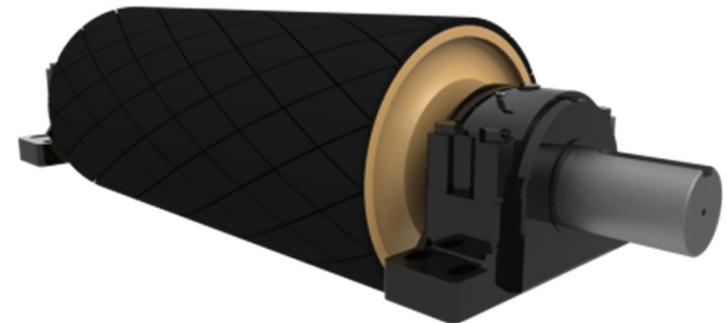
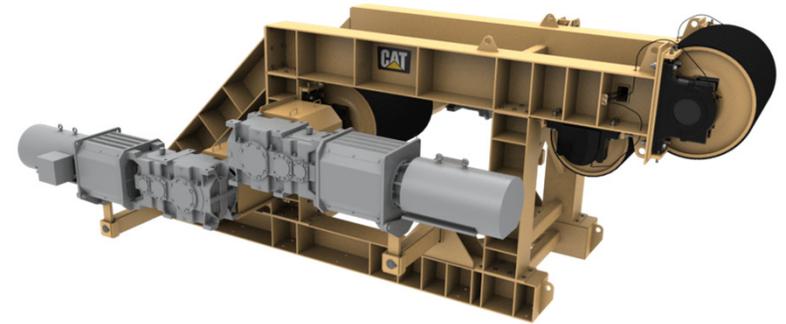
	Option 1	Option 2	Option 3
Belt Width	60"	72"	72"
Length	1086 m	1111 m	1357 m
Belt Speed	4.5 mps	4.5 mps	3.5 mps
Desired Tonnage	5,500 mtph	5,500 mtph	5,500 mtph
Allowable Tonnage	3,750 mtph	5,500 mtph	4,250 mtph
Main Drive Configuration Options	4 x 1100 HP 2 x 2200 HP	4 x 1600 HP 2 x 3200 HP	4 x 1300 HP 2 x 2600 HP
Total Horse Power	4400 HP	6400 HP	5200 HP
Backstop	BC-375MA	BC-540MA	BC-540MA

Technical Presentation at the Mine Site

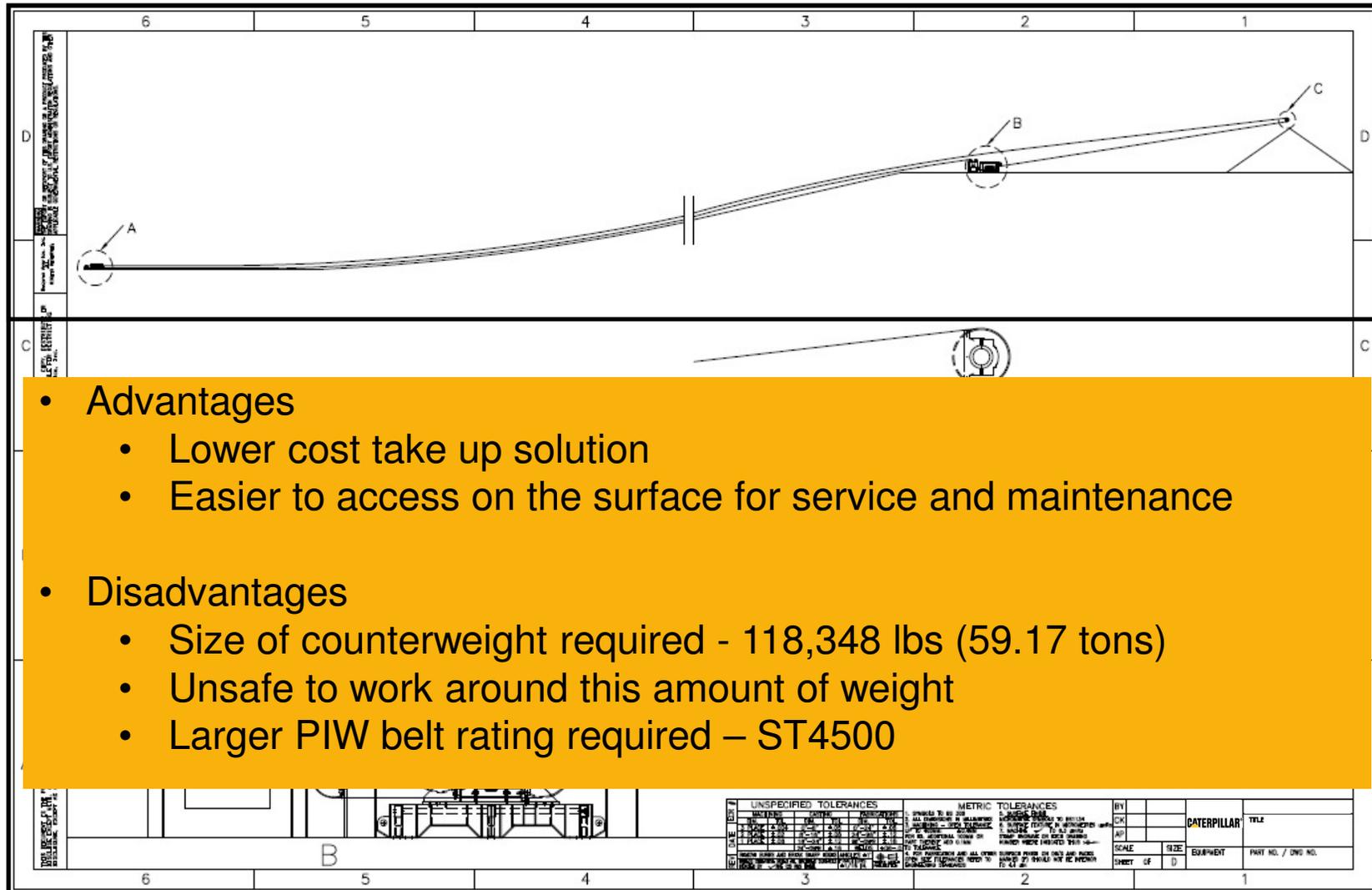
A collaborative process

Option 2 – 72” Belt Width at 4.5 m/s

		72" Belt Width			
		650 TPKL	866 TPKL	780 TPXL	
Belt Width		72"			
Length		1111 m			
Lift		233 m			
Belt Speed		4.5 mps			
Desired Tonnage		5,500 mtph			
Allowable Tonnage		5,500 mtph			
Drive	Main Drive Config	4 x 1600 HP		2 x 3200 HP	
	HS Coupling	650 TPKL	866 TPKL	780 TPXL	
	Backstop	BC-540MA			
	Motor Speed	1800 RPM	1200 RPM		
	Total Horse Power	6400 HP			
	Voltage	4160 V			
	Drive Pulley Diameter	54"			
	Take-up	Cylinder	Take-up Type	Cylinder	
			Location	Tail	
			Take-up Tension Required	15,453#	
Gravity		Max Take-up Tension	21,536#		
		Max Line Pull	43,072#		
		Take-up Type	Gravity		
Belt	Cylinder	Location	Drive		
		Take-up Tension Required	59,174#		
	Gravity	Take-up Weight	118,348#		
		Take-up Pulley Diameter	42"		
		Cylinder TU Belt Suggested	ST4000		
Cylinder	% Running Belt Rating	97%			
	Gravity	Gravity TU Belt Suggested	ST4500		
		% Running Belt Rating	93%		
Belt Cover Thicknesses		.25 x .125			
Discharge Diameter		54 "			
Tail Pulley Diameter		42 "			

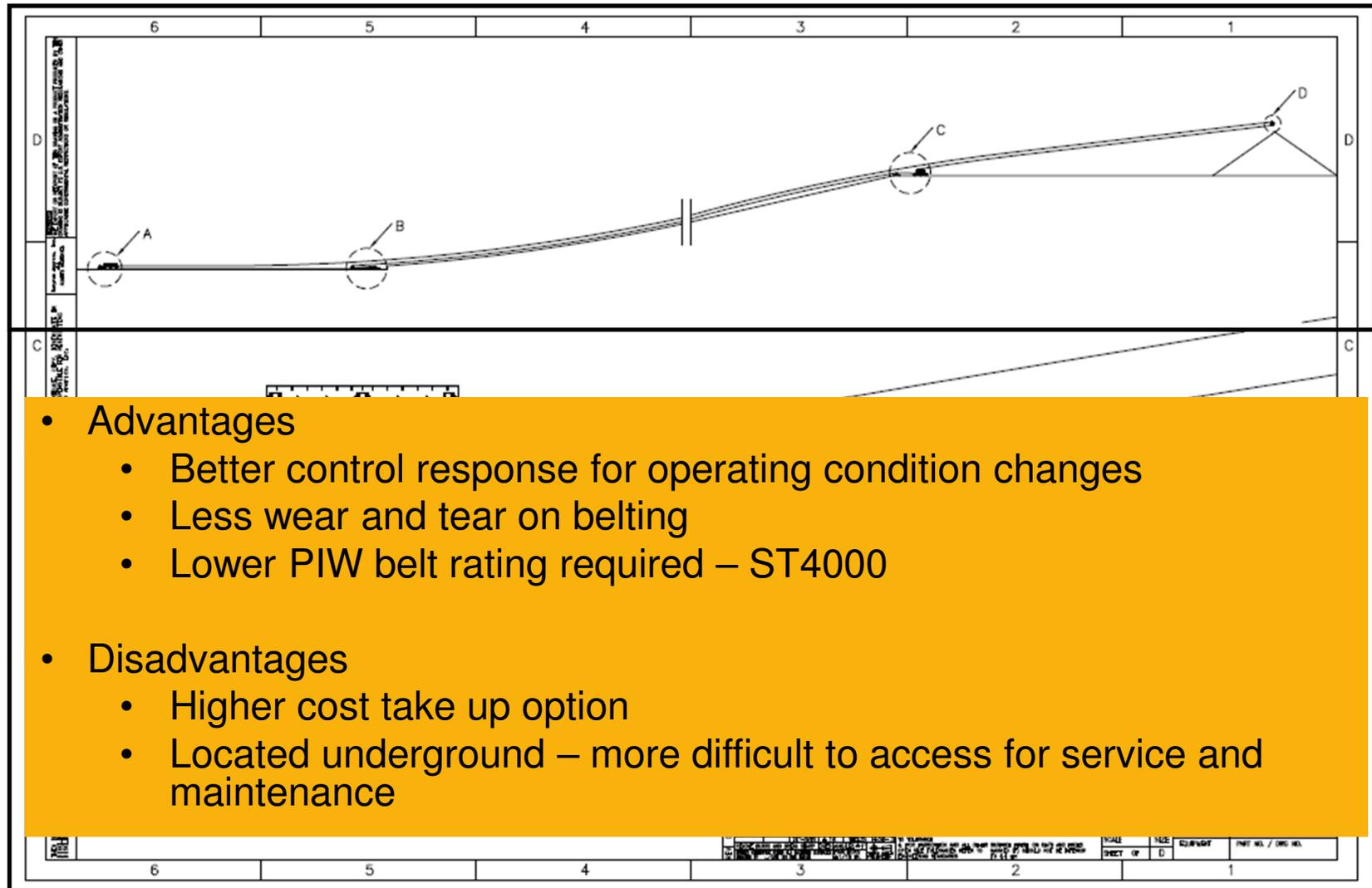


Slope Schematic – Gravity Take Up Option

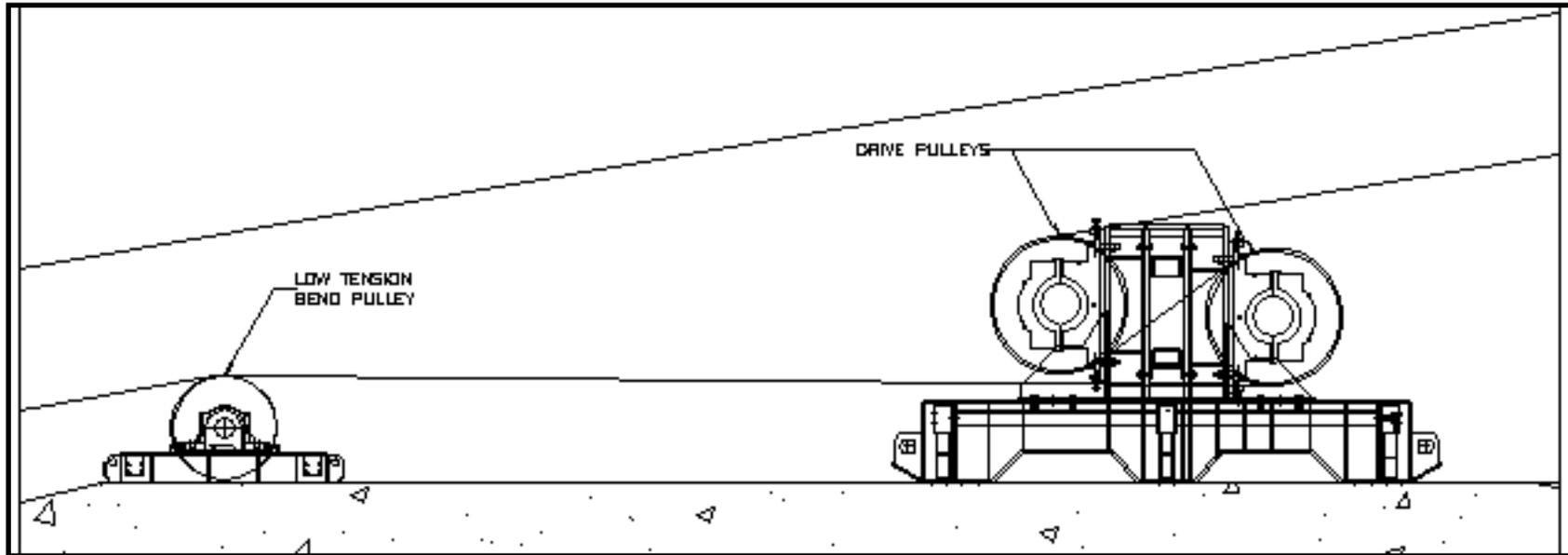


- Advantages
 - Lower cost take up solution
 - Easier to access on the surface for service and maintenance
- Disadvantages
 - Size of counterweight required - 118,348 lbs (59.17 tons)
 - Unsafe to work around this amount of weight
 - Larger PIW belt rating required – ST4500

Slope Schematic – Hydraulic Take Up Option

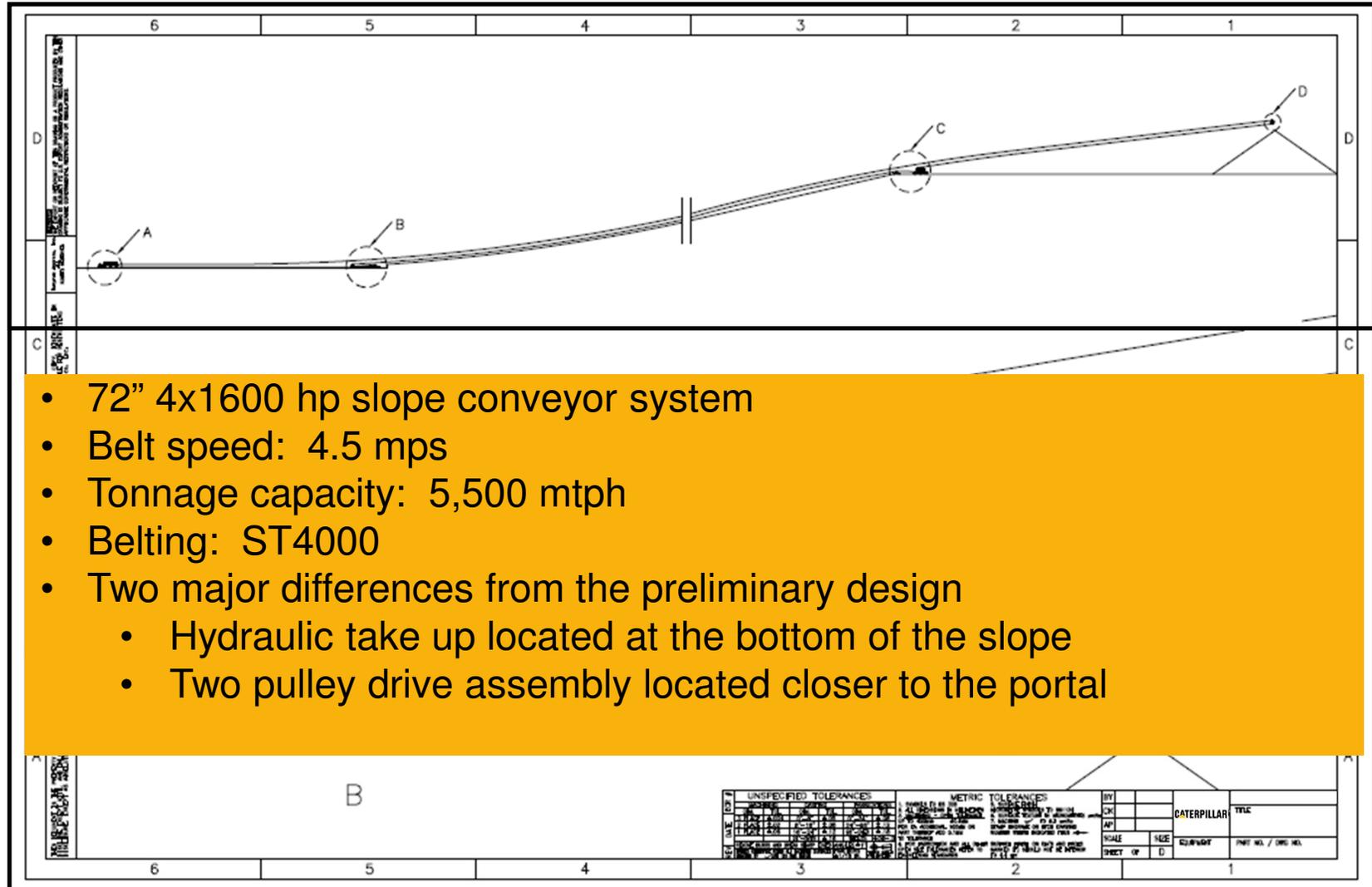


Caterpillar Proposed Drive Layout



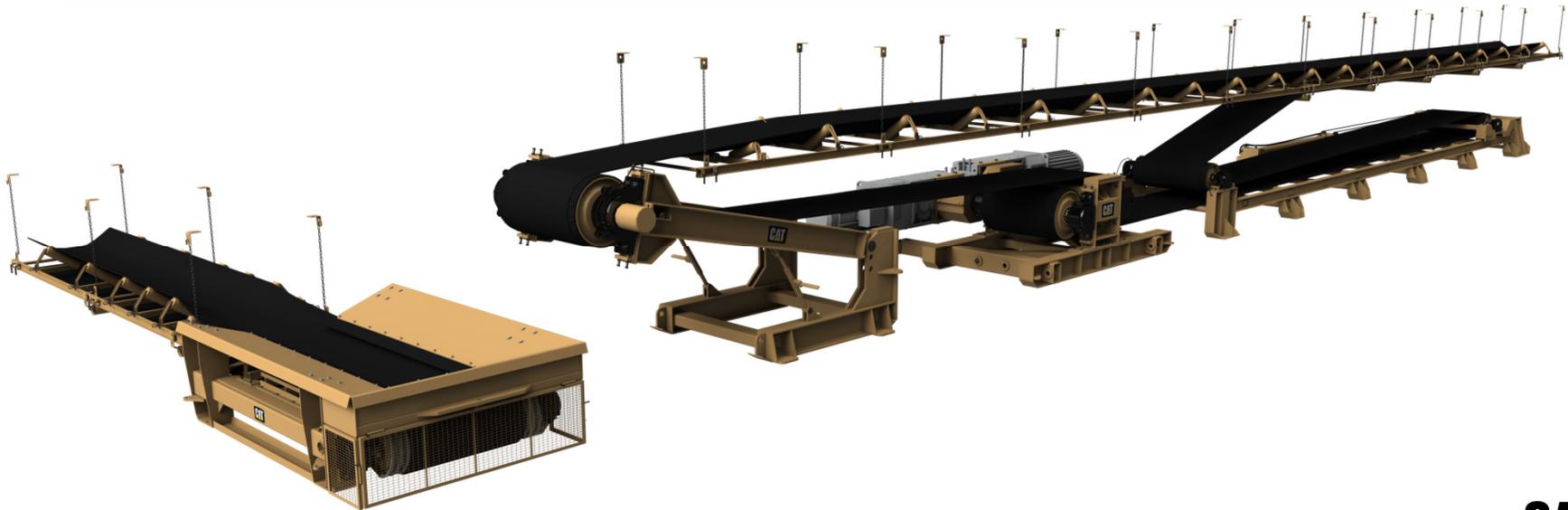
- Advantages
 - Lower cost drive solution
 - Eliminate the need for a high tension bend pulley
 - Eliminate the need for a drive truss frame
- Disadvantages
 - Primary drive pulley is driving the 'dirty' side of the belt
 - Requires good preventative maintenance procedures with belt cleaners

Caterpillar Proposed Slope Design



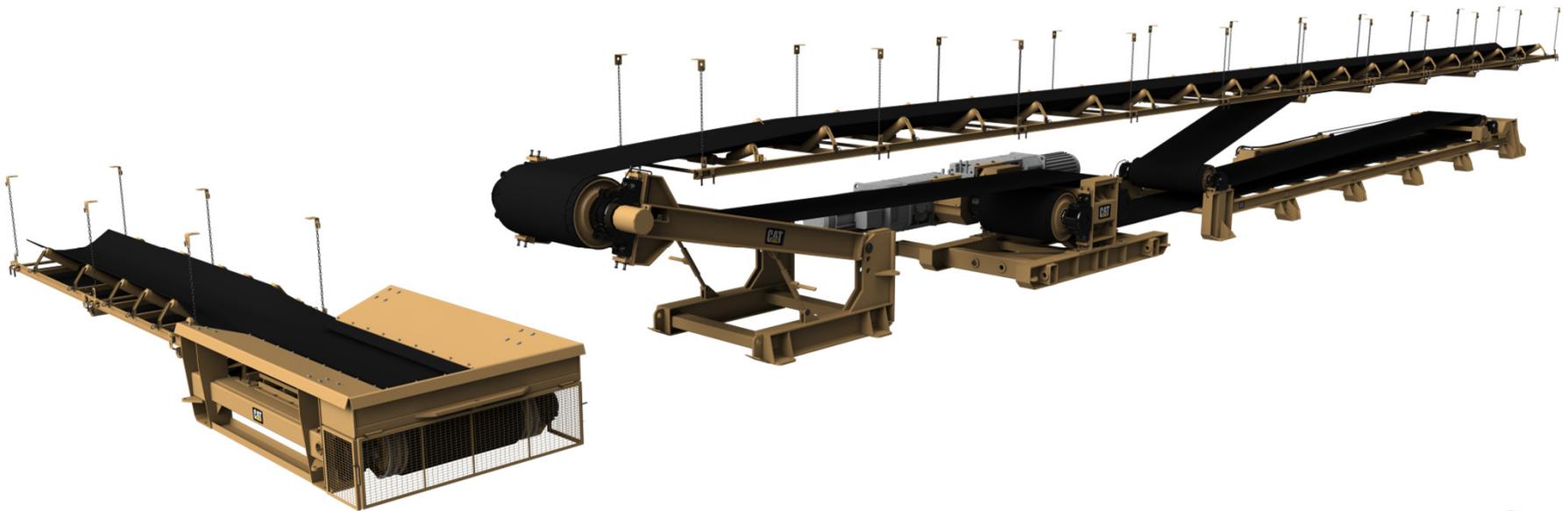
Collaborative Effort With Operator

- Jointly reviewed preliminary design options
- Discussed design concerns with preliminary slope layout drawing
- Discussed advantages and disadvantages of Caterpillar proposed slope design
- Discussed mine layout and mining plans
 - Two longwall panels mining two separate seams located on different levels in the mine (omitted from preliminary specifications)
 - Two separate main line conveyors transferring ROM coal onto the tail of the slope conveyor at different angles (omitted from preliminary specifications)



Summary

- Operator pleased with design review and proposed slope conveyor design
- Collaborative effort between Caterpillar and operator proved to be successful
- Agreed upon slope conveyor design that operator will use for the request for bid package
- Operator believes that because of this collaborative effort, the bid review process will be more efficient



Wherever there's mining, you'll find Caterpillar. Cat products are hard at work around the world — drilling and digging, loading and hauling, grading and dozing. And our people are there, too — supporting our products, training operators, helping customers mine safely and more profitably, and actively participating in the global mining industry.

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