

T COSMO/CORMO

TRANSNET



freight rail

a resource allocation tool for
the coal line
in Transnet Freight Rail

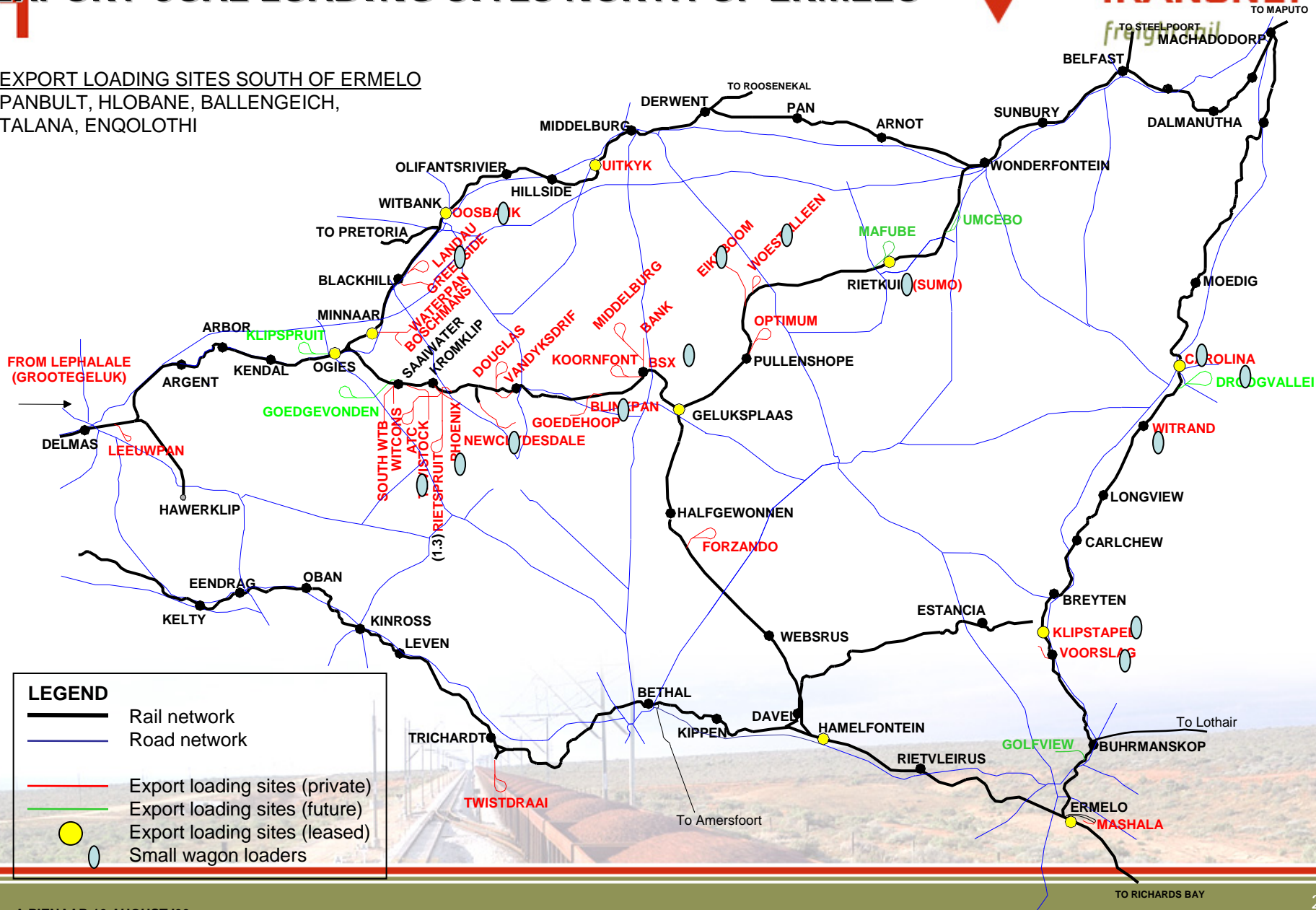
March 2009



EXPORT COAL LOADING SITES NORTH OF ERMELO

EXPORT LOADING SITES SOUTH OF ERMELO

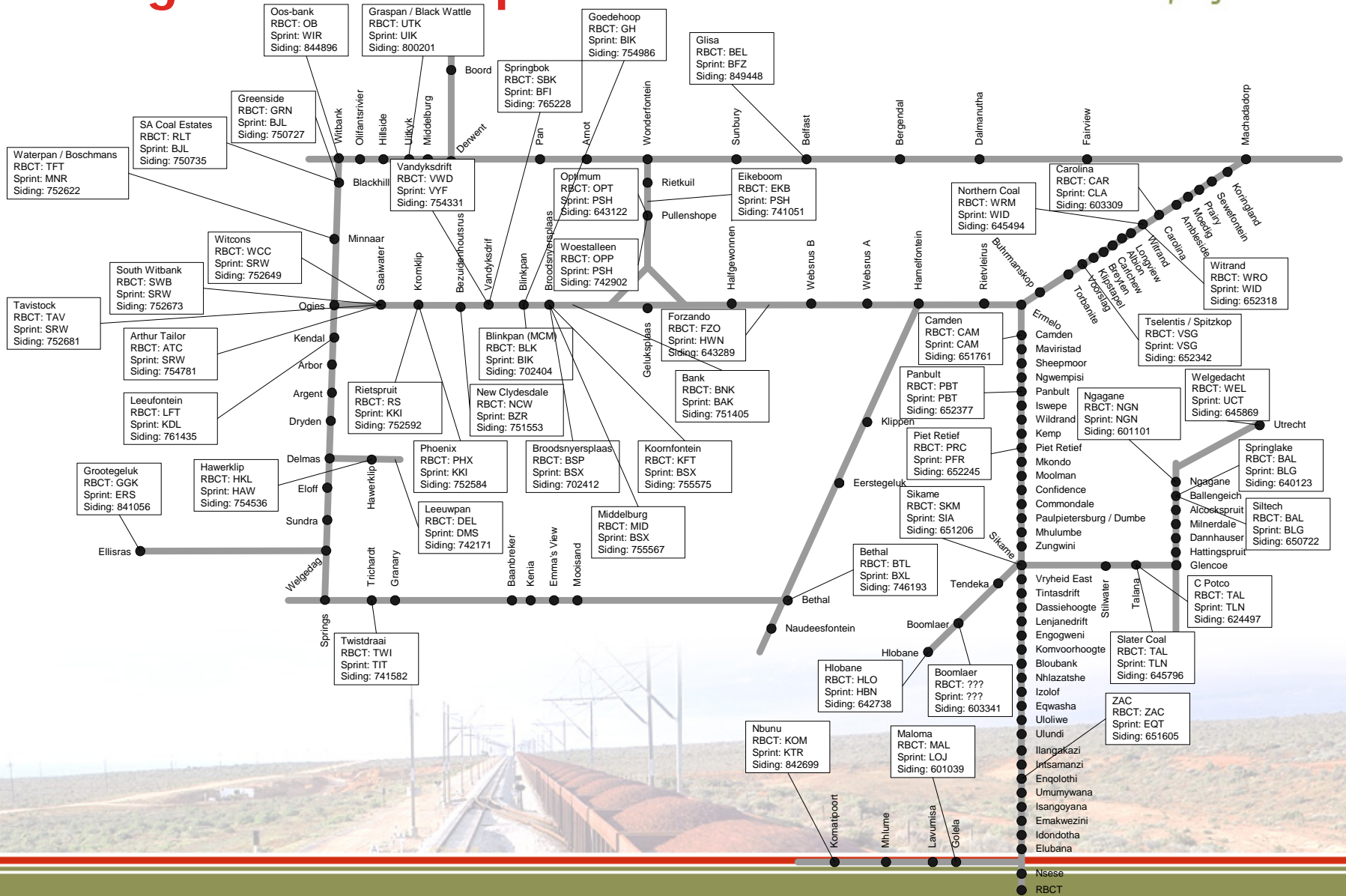
PANBULT, HLOBANE, BALLENGEICH,
TALANA, ENQOLOTHI



LEGEND

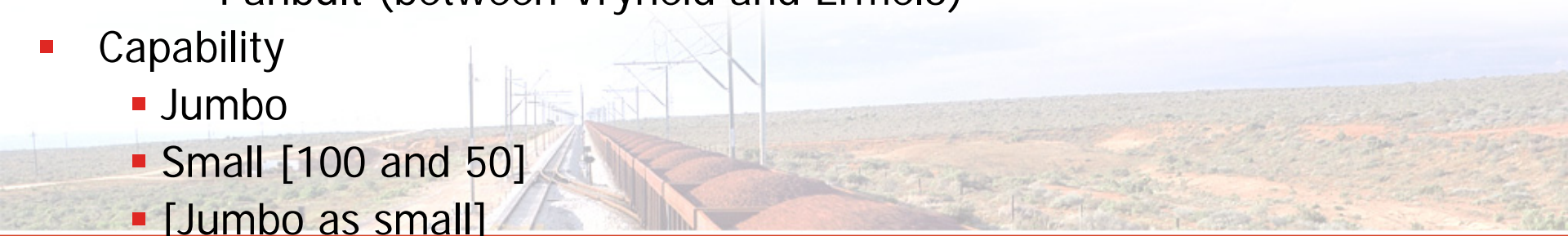
- Rail network
- Road network
- Export loading sites (private)
- Export loading sites (future)
- Export loading sites (leased)
- Small wagon loaders

Diagrammatic map



1 Mine Types

- Loading Types
 - Rapid loaders
 - Mechanical loaders
 - Drop loads
- Location
 - Coal field system
 - DC area and Diesel served 'branch' line
 - GFB system
 - Grootegeluk
 - Natal Midlands
 - 'En routes'
 - Panbult (between Vryheid and Ermelo)
- Capability
 - Jumbo
 - Small [100 and 50]
 - [Jumbo as small]



7 Required

- Schedule for week
 - Fixed schedule portion
 - Variable portion
 - Balanced and evenly spaced
 - Optimised
- Rescheduling capability for least impact recovery



1 Scheduling Requirement

- Train schedule must:
 - satisfy the **varying demand** by and special requirements of the mines;
 - conform to the **agreed operating philosophy** of rhythm and balance without bundling
 - consider the **availability and position** of rolling stock as well as unavailability of infrastructure
 - be **derived within a short period** without dependence on individuals



1 Rescheduling requirement

- Existing schedule
- There have been either
 - changes in execution – some planned trains did not run or ran in wrong slots
 - changed demands from mines or revised occupations
- Produce a revised schedule given the following input
 - The detail of trains actually ran (i.e. the incident recording or 'per train monitoring')
 - The changed demand
 - the currently planned schedule for the rest of the week plus additional demand
 - in addition a revised number of trains, feeder occupation and mainline occupation
- A revised schedule should be produced (if possible) to move the remaining demand with the least impact on existing schedule

1 CURRENT FUNCTIONALITY

Inputs

▪ Able

- Available capacity
- Next weeks demand
- Drop off information
- Mainline slots
- Feeder line information
- Mainline and Vryheid train information
- Crewing information
- Mine constraints
- Mine travel and dwell times
- Feeder Occupations
- Mainline maintenance
- Mainline travel and dwell times
- Transition information for rescheduling
- Business rules relating to wagon configuration
- Balancing logic

Generates

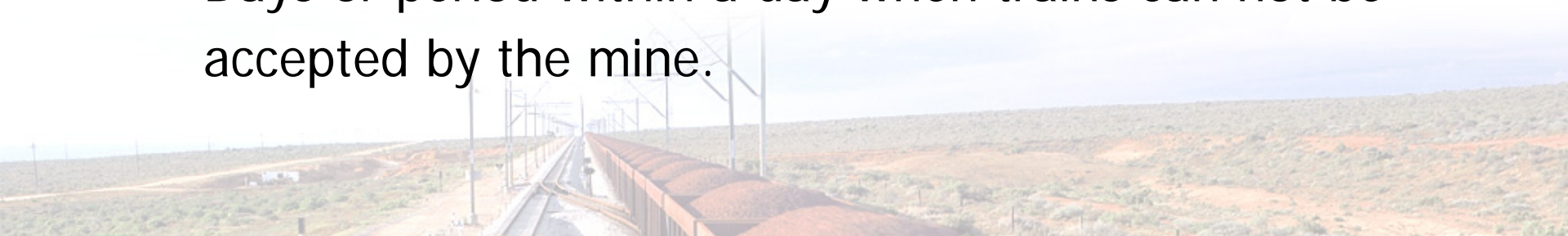
- Balanced Schedule for Mainline and to mines
- Balanced Schedule for the Natal trains
- Daily services
- Scheduled throughput
- Result wagons – detail log of planned set movements
- Indicate unallocated feeders
- Rescheduling of trains

▪ Unable

- Does not cater for the location of locomotives
- Does not have a parameter for the maximum number of trains at the yards (EML, VYD and RBCT)
- Does not allow the scheduling of sets that are larger than 100 wagons up to the mines
- Does not balance schedule through consideration of availability of locos (especially light loco scenario)
- Does not generate graphical representation of schedule

1 Detail Requirements in Scheduling (1)

- **Demand by the mine:**
 - Number of loads per week (eg. 190 trains to 40+ mines)
 - Type and size of load (Jumbo or Small (100 or 50 sets) or Jumbo loaded as small)
 - Days when required (or any day)
 - Maximum loads that can be accepted per day OR “At least” number of loads to be allocated per day
 - Days or period within a day when trains can not be accepted by the mine.





MineID	Code	Mine	Total trains	Short code mine	Train type & #wagons	Maximum number of trains Monday	Maximum number of trains Tuesday	Maximum number of trains Wednesday	Maximum number of trains Thursday	Maximum number of trains Friday	Maximum number of trains Saturday	Maximum number of trains Sunday
1	J VST	TSELENTIS	-	VST	J100	99	99	99	99	99	99	99
2	JS VST	TSELENTIS	-	VST	J100	99	99	99	99	99	99	99
3	S VST	TSELENTIS	4	VST	S100	0	0	1	0	1	1	1
4	S5 VST	TSELENTIS	-	VST	S50	99	99	99	99	99	99	99
5	J KOY	KOORNFONTEI	5	KOY	J100	0	0	0	1	2	1	1
6	JS KOY	KOORNFONTEI	-	KOY	J100	99	99	99	99	99	99	99
7	S KOY	KOORNFONTEI	-	KOY	S100	99	99	99	99	99	99	99
8	S5 KOY	KOORNFONTEI	-	KOY	S50	99	99	99	99	99	99	99
9	J MED	MIDDELBURG	16	MED	J100	3	3	3	3	3	3	3
10	JS MED	MIDDELBURG	-	MED	J100	99	99	99	99	99	99	99
11	S MED	MIDDELBURG	-	MED	S100	99	99	99	99	99	99	99
12	S5 MED	MIDDELBURG	-	MED	S50	99	99	99	99	99	99	99

Tonnage per train	"must be" feeders Monday	"must be" feeders Tuesday	"must be" feeders Wednesday	"must be" feeders Thursday	"must be" feeders Friday	"must be" feeders Saturday	"must be" feeders Sunday
8300	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
2900	0	0	0	0	0	0	0
8300	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
2900	0	0	0	0	0	0	0
8300	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
5800	0	0	0	0	0	0	0
2900	0	0	0	0	0	0	0

1 Mine constraint

MINE LOADING AVAILABILITY

██████████ = Mine not available from that time onwards Standby: Sampie van den EAH : 083 303 8931

reclaiming time (days)	0.1	0.1	0.1	0.5	0.3	1.0	0.5	0.1	0.1	0.1	0.1	0.1	1.0	0.5	0.2	0.5	0.5	0.1	0.2	0.5	0.2	0.1	2.0	0.5	0.5	0.2	0.2
requested # trains	10	24	15	1	4	5	1	5	5	16	18	10	2	2	6	3	2	2	7	5	5	9	1	1	2	13	4
RBCT code	BNK	RLT	GH	GRN	GGK	NCD	EKB	OPT	KFT	MID	VDD	RS	BSP	WAL	TFT	WCC	PHX	SWB	TAV	UTK	FZO	ATC	SBK	ANT	OB	TWI	VST
	BYY	LDY	GHM	GSE	GGK	BZR	EIY	PSH	KOY	MED	VYF	RSY	BSX	WAL	MNR	SRW	PHX	SWD	OUT	UIT	FOR	ATC	SBK	ANT	OBK	TIT	VST
Mon	00:00																										
	01:00																										
	02:00																										
	03:00																										
	04:00																										
	05:00																										
	06:00																										



1 Detail Requirements in Scheduling (2)

■ Mine details

- Running time to and from yard
- Loading period at the mine
- Reclaiming time: Minimum time between trains at mines to cater for replenishment at the mines. This is also considered between weeks, i.e. first train of week 2 should consider last departure in week 1.
 - Check for consistency between times and number of loads is done
- Hard and soft constraint
 - If the number of trains per day or the mine constraint can be considered as a request only, the scheduler could be set to attempt requested parameters first and then slackening constraints

Mine Details

Code	MineID	Mine	total # trains	Time before new train (loading time at mine + reclaiming time)	Driving time yard >mine	Driving time mine - >yard	loading time at mine	reclaiming time
VST	1	TSELENTIS	4	0 09:57	0 00:50	0 01:00	0 04:57	0 05:00
KOY	2	KOORNFONTEIN	5	0 05:45	0 01:48	0 01:55	0 02:45	0 03:00
MED	3	MIDDELBURG	16	0 04:36	0 02:02	0 01:55	0 02:36	0 02:00
FOR	4	DORSFONTEIN	5	0 09:00	0 01:30	0 01:17	0 04:00	0 05:00
PSH	5	OPTIMUM	5	0 06:16	0 01:59	0 01:58	0 03:16	0 03:00
TIT	6	TWISTDRAAI	13	0 09:01	0 02:00	0 02:20	0 04:01	0 05:00

# trains per day hard constraint (=0) or "request" (=1)	mine constraints hard constraint (=0) or "request" (=1)	"To" Mine No.	"From" Mine No.	Yard	Departure 00:00 = slot 96 (1=yes,0=no)
0	0	98	99	EML	0
0	1	40	41	EML	0
0	1	36	37	EML	0
0	1	0	1	EML	0
0	1	2	3	EML	0
0	1	98	99	EML	0



1 Detail Requirements in Scheduling (3)

■ Constraints

- Infrastructure occupations
 - Where and when occupations will be taken on the feeder lines when trains cannot be dispatched
 - Periods when main line occupations will be taken.
- Standard mine constraints: Regular weekly occupations and maintenance periods when trains cannot be accepted.
- Other mine constraints: When trains cannot be accepted at mines for other irregular reason.

Occupations

Occupations specified for the week of schedule AS WELL AS week following schedule for correct handling of overflow trains

MINE LOADING AVAILABILITY

██████████ = maintenance occupation on feeder line Standby: €

reclaiming time (days)	0.1	0.1	0.1	0.5	0.3	1.0	0.5	0.1	0.1	0.1	0.1	0.1	1.0	0.5
requested # trains	10	24	15	1	4	5	1	5	5	16	18	10	2	2

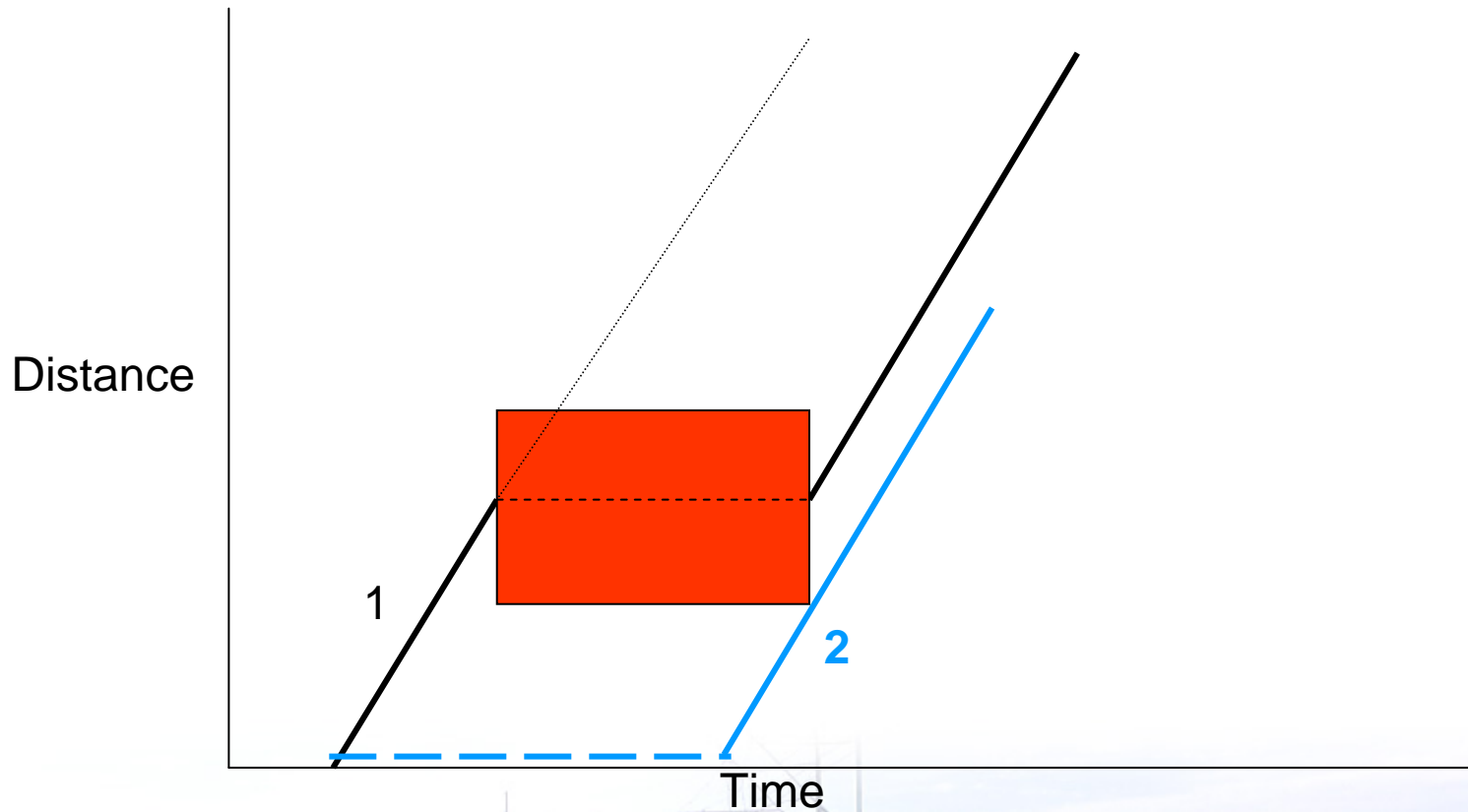
RBCT code	BNK	RLT	GH	GRN	GGK	NCD	EKB	OPT	KFT	MID	VDD	RS	BSP	WAL
	BYY	LDY	GHM	GSE	GGK	BZR	EIY	PSH	KOY	MED	VYF	RSY	BSX	WAL

Mon	00:00
	01:00
	02:00
	03:00
	04:00
	05:00
	06:00
	07:00
	08:00
	09:00
	10:00
	11:00
	12:00
	13:00



SectionID	Section	Start main line occupation	End main line occupation
1	EML-VHD	1 00:00	1 00:00
2	VHD-RBCT	1 00:00	1 00:00
3	RBCT-VHD	1 00:00	1 00:00
4	VHD-EML	1 00:00	1 00:00

Occupations options



Options [user selectable]:

1. Trains are scheduled “into” occupations or
2. not departed from yard if an occupation will be encountered

1 Mine Constraints (Temp and std)

MINE LOADING AVA

[Redacted] = Mine not available from that time onwards

reclaiming time (days)	0.1	0.1	0.1	0.5	0.3	1.0	0.5	0.1	0.1	0.1	0.1
requested # trains	10	24	15	1	4	5	1	5	5	16	18

RBCT code		BNK	RLT	GH	GRN	GGK	NCD	EKB	OPT	KFT	MID	VDD
		BYY	LDY	GHM	GSE	GGK	BZR	EIY	PSH	KOY	MED	VYF
Mon	00:00					[Redacted]						
	01:00					[Redacted]						
	02:00					[Redacted]						
	03:00					[Redacted]						
	04:00					[Redacted]						
	05:00					[Redacted]						
	06:00					[Redacted]						
	07:00					[Redacted]						
	08:00					[Redacted]						
	09:00					[Redacted]						
	10:00					[Redacted]						

Detail Requirements in Scheduling (4)

- Parameters
 - Throughput times – dwell time in yards and running time in between
 - Number of sets
 - Jumbo, Smalls and S50
 - Max wait for 2 sets
 - Max number of feeder trains per day
 - Total
 - *[@EML,VYD,Main line]
 - Soft constraints
 - Day end balancing

Parameter	Unit	Value
Throughput time		
EML-Loaded dwell	d hh:mm	0 03:45
EML-VHD	d hh:mm	0 04:59
VHD-Loaded dwell	d hh:mm	0 01:15
VHD-RBH	d hh:mm	0 04:31
RBCT dwell	d hh:mm	0 07:15
RBH-VHD	d hh:mm	0 04:21
VHD-Empty dwell	d hh:mm	0 01:41
VHD-EML	d hh:mm	0 04:21
EML-Empty dwell	d hh:mm	0 03:05

number of J100 train sets	161
number of S100 train sets	37
number of S50 train sets	4
maximum number of trains per day	30
run model with consistency errors (0=no, 1=yes)	0
"soft" constraints for all mines (=0) or selected mines(=1)	1
maximum number of feeder trains at EML	60
maximum number of feeder trains at VHD	30
maximum number of main line trains	30
day-end balancing on (=0) or off (=1)	0

*[not used]

1 Detail Requirements in Scheduling (5)

- Drop Off Group
 - “If you send a train to a mine in one of these groups (let's say to OBK in group 1) then the scheduler tries to allocate another feeder to one of the mines in the same group in the given time window. The reasoning behind this was to bring a feeder to the first mine, run back the locomotive and catch another feeder train and bring it to the second mine.”

Drop-Off group	MinelD	Start to select other mine in group (departure + d hh:mm)	End to select other mine in group (departure + d hh:mm)
1	OBK	0 01:00	0 15:00
1	GSE	0 01:00	0 15:00
1	MNR	0 01:00	0 15:00
1	UIT	0 01:00	0 15:00
2	SWD	0 01:00	0 15:00
2	BZR	0 01:00	0 15:00
2	BSX	0 01:00	0 15:00
3	OUT	0 01:00	0 15:00
3	SRW	0 01:00	0 15:00
3	PHX	0 01:00	0 15:00
4	WAL	0 01:00	0 15:00
4	EIY	0 01:00	0 15:00



1 Detail Requirements in Scheduling (6)

- Main Line Slots
 - Define which trains must be used on main line

Departure	Monday (1=on, 0=off)	Tuesday (1=on, 0=off)	Wednesday (1=on, 0=off)	Thursday (1=on, 0=off)	Friday (1=on, 0=off)	Saturday (1=on, 0=off)	Sunday (1=on, 0=off)
00:00	1	1	1	1	1	1	1
01:00	1	1	1	1	1	1	1
02:00	0	0	0	0	0	0	0
03:00	1	1	1	1	1	1	1
04:00	1	1	1	1	1	1	1
05:00	0	0	0	0	0	0	0
06:00	1	1	1	1	1	1	1
06:30	1	1	1	1	1	1	1
08:00	0	0	0	0	0	0	0
09:00	1	1	1	1	1	1	1
10:00	1	1	1	1	1	1	1
11:00	0	0	0	0	0	0	0
12:00	1	1	1	1	1	1	1
13:00	1	1	1	1	1	1	1
14:00	0	0	0	0	0	0	0
15:00	1	1	1	1	1	1	1
16:00	1	1	1	1	1	1	1
17:00	0	0	0	0	0	0	0
18:00	1	1	1	1	1	1	1
19:00	1	1	1	1	1	1	1
20:00	0	0	0	0	0	0	0
21:00	1	1	1	1	1	1	1
22:00	1	1	1	1	1	1	1
23:00	0	0	0	0	0	0	0

Detail Requirements in Scheduling (7)

- Feeder and main line trains
 - Train numbers and times of feeder trains

MineID	1. train ID		2.nd train ID			
	to mine	back to yard	to mine	back to yard	from (including)	to (including)
PBT	8800	8801	8800	8801	00:15	00:15
HBN	3102	3103	3102	3103	00:15	00:15
SIA	3104	3105	3104	3105	00:15	00:15
EQT	1816	1817	1862			
TAL	2853	2854	2843			
BLG	2853	2854	2843			
WED	2853	2854	2843			
NGN	2853	2854	2843			
GGK	8942	8943	8946			

Departure	EML Small	EML Jumbo
0 00:00	80000	90000
0 00:30	80200	90200
0 01:00	80400	90400
0 01:30	80600	90600
0 02:00	80800	90800
0 02:30	81000	91000
0 03:00	81200	91200
0 03:30	81400	91400
0 04:00	81600	91600
0 04:30	81800	91800

EML Departure	Train no to RBCT	RBCT departure	Train no from RBCT
0 00:00	8801	0 00:00	8800
0 01:00	8803	0 00:30	8802
0 02:00	8805	0 02:00	8804
0 03:00	8807	0 03:00	8806
0 04:00	8809	0 04:00	8808
0 05:00	8811	0 05:00	8810
0 06:00	8813	0 06:00	8812
0 06:30	8815	0 07:00	8814
0 08:00	8817	0 08:00	8816
0 09:00	8819	0 09:00	8818
0 10:00	8821	0 10:00	8820
0 11:00	8823	0 11:00	8822
0 12:00	8825	0 12:00	8824
0 13:00	8827	0 13:00	8826
0 14:00	8829	0 14:00	8828

EML				VHD				RBCT			
Scheduled departure	TrainID	Planned crews	Planned return	Scheduled departure	TrainID	Planned crews	Planned return	Scheduled departure	TrainID	Planned crews	Planned return
0 00:00	8801	EMR	8802	0 00:14	8837	VYD	8814	0 00:00	8800	RCB	8847
0 01:00	8803	EMR	8804	0 01:14	8839	VYD	KOMBI	0 00:30	8802	VYD	8825
0 02:00	8805	EMR	8806	0 02:14	8841	RCB	8842	0 02:00	8804	VYD	8827
0 03:00	8807	EMR	8808	0 03:14	8843	VYD	8814	0 03:00	8806	RCB	8805
				0 09:00	83600		93600	0 23:00	8847		8846

Output / Result

- Summary of schedule – To Mines, from Mines and arrive at RBCT

Week tonnages scheduled / planned dept from mines									Total tonnages planned daily	Daily Tempo for the week	Total Ermelo Trains per day	Total Trains per day
Day	Date	Ermelo mines			Natal	Panbult						
		Jumbos	Jumbos as Smalls	Smalls	Smalls	Jumbos	Jumbos as Smalls	Smalls				
Mon	11/02/08	21	2	4	0	0	0	0	209,100	72,348,600	27	27
Tue	12/02/08	21	4	4	1	1	0	0	231,900	80,237,400	29	31
Wed	13/02/08	17	4	8	2	2	0	0	233,100	80,652,600	29	33
Thu	14/02/08	18	2	6	1	0	0	0	198,700	68,750,200	26	27
Fri	15/02/08	19	3	5	0	2	0	0	220,700	76,362,200	27	29
Sat	16/02/08	20	3	3	0	0	0	0	200,800	69,476,800	26	26
Sun	17/02/08	19	5	7	0	0	0	0	227,300	78,645,800	31	31

Daily tonnages planned to mines	2008/02/11	174,300	11,600	23,200	0	0	0	0
	2008/02/12	174,300	23,200	23,200	2,900	8,300	0	0
	2008/02/13	141,100	23,200	46,400	5,800	16,600	0	0
	2008/02/14	149,400	11,600	34,800	2,900	0	0	0
	2008/02/15	157,700	17,400	29,000	0	16,600	0	0
	2008/02/16	166,000	17,400	17,400	0	0	0	0
	2008/02/17	157,700	29,000	40,600	0	0	0	0

Total trains for the week	204
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Total tonnages planned for the week from the mines	1,521,600
Total tempo planned for the week	79.12

Schedule to be shown on tempo

75.21 Mt/a

Output (2)

Detail train schedules

not alloc.

requested	10	24	15	1	4
LoadPt.	BNK	RLT	GH	GRN	GGK
	BYY	LDY	GHM	GSE	GGK
MON 2008/02/11	91434	90852	96410		8942
	97034	93452			
		95852			

DEPARTURE		00:00	00:30	01:00	01:30	02:00
MON 2008/02/11	TRAIN NO.	80012			80698	90852
	DESTINATION	BZR			KPL	LDY
	WAGON TYPE	S			S	J
	COMMENT					

NATAL SERVICE

2008/02/11 to 2008/02/17

DAY	Train no	Time	Mine	Supply Train	5/7 1/3
MON 2008/02/11	0		BLG	0	0
	0		EQT	0	0
	0		HBN	0	0
	0		PBT	0	0
	0		SIA	0	0
	2853	23:00	TAL	8826	50
TUE 2008/02/12	2853	20:30	BLG	8820	50
	1862	21:30	EQT	8820	100
	0		HBN	0	0
	8800	6:00	PBT	8824	100

0298			90842
TIT			VYF
JS			J



1 Challenges

- Bunching on return

- The system allocates trains to departure slots to the mines. Due to varying load and run times, trains may arrive back in same time slot, causing bunching which must be solved in the schedule



7 Considerations

- Running times between yards
- Dwell time in yards due to agreed processes.
- Running times between yards and mines
- Number of train sets (jumbo and small) available.
- Main line slots available for usage
- Where locomotives should drop loads for loading and continue to pick up loaded trains.
- Number of locomotives sets available
- Train personnel required

1 Required end state

- 'Rugged' system conforming to TFR CIO standards
- System Integrated with TFR systems
 - Resources
 - Demand
 - Personnel
 - etc
- New Functionality
 - Rescheduling - System ability AND replanning process
 - Locomotive scheduling integrated – with Drop-off logic
 - Consider crewing
 - Locomotive and Train diagram plot
 - Other wagon configurations – i.e. 200 wagons to mines