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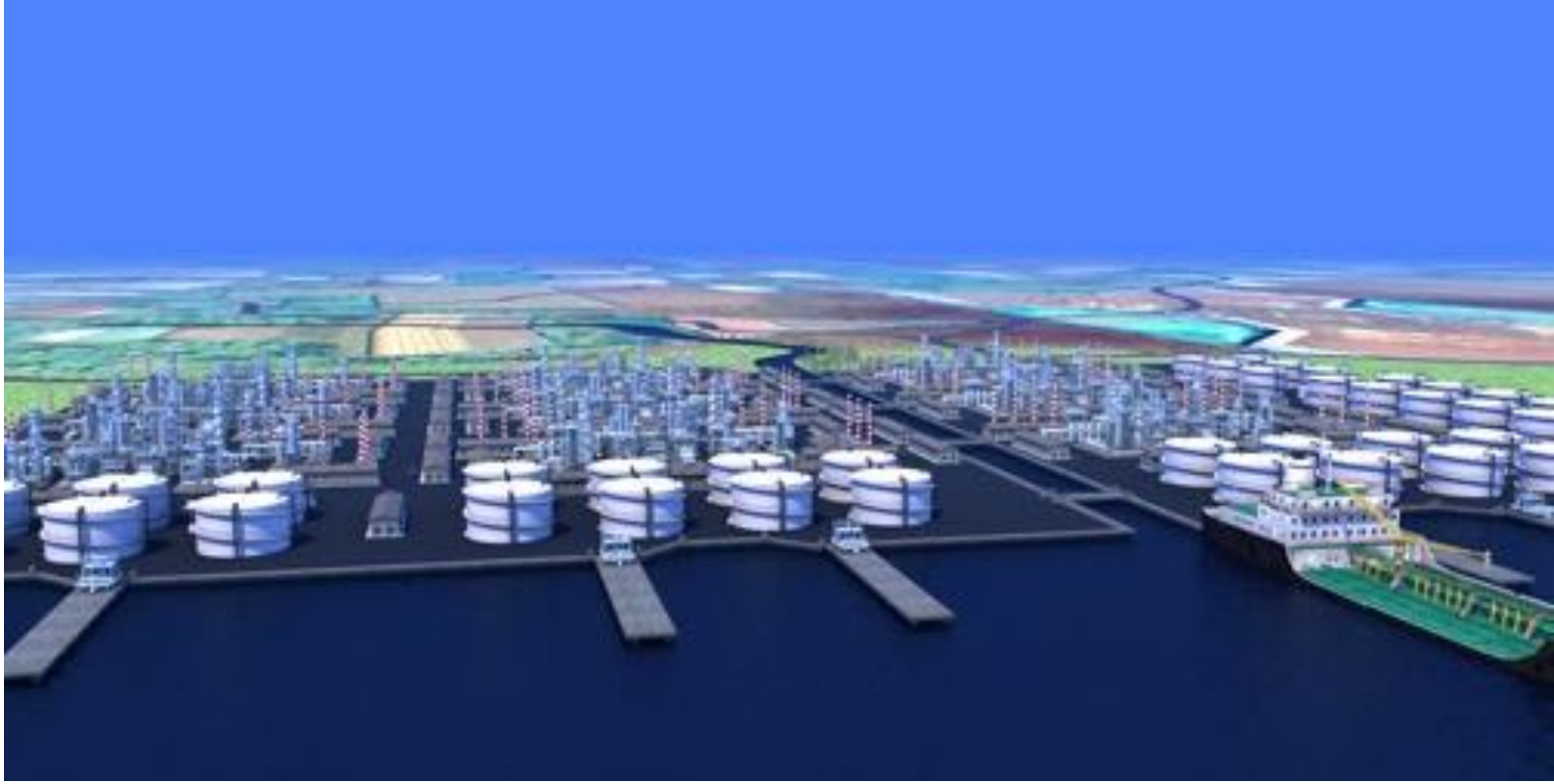


Refinery Product Blending Optimisation

Refining & Downstream Product and Solution Centre
Alan Munns – Product Manager alan.munns@gb.abb.com
14 June 2012 Refinery Product Blending_IRPC2012.pptx

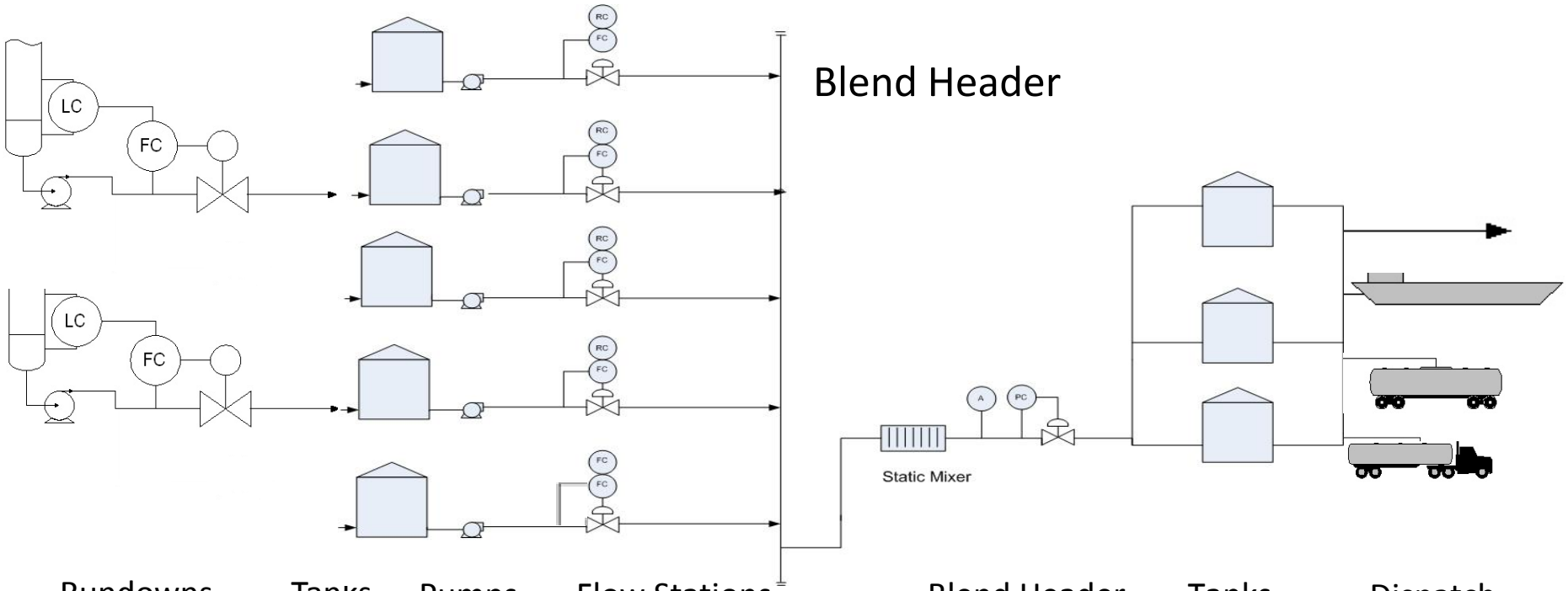
Oil Refinery Offsites Automation
Advanced Blend Control & Oil Movements Manager

- Oil Movements used for crude terminals, refineries, petrochemical complexes, bulk storage terminals etc
- Advanced Blend Control used for refineries and bulk storage terminals

- Advanced Blend Control integrated with Oil Movements Manager

- Comprehensive System for:
  - Blend and oil movement order management
  - Physical blend and movement line-up
  - Pre-blend optimization
  - Online control and blend recipe optimization
  - Monitoring & reporting
  - Configuration and maintenance

In-line Product Blending - Equipment



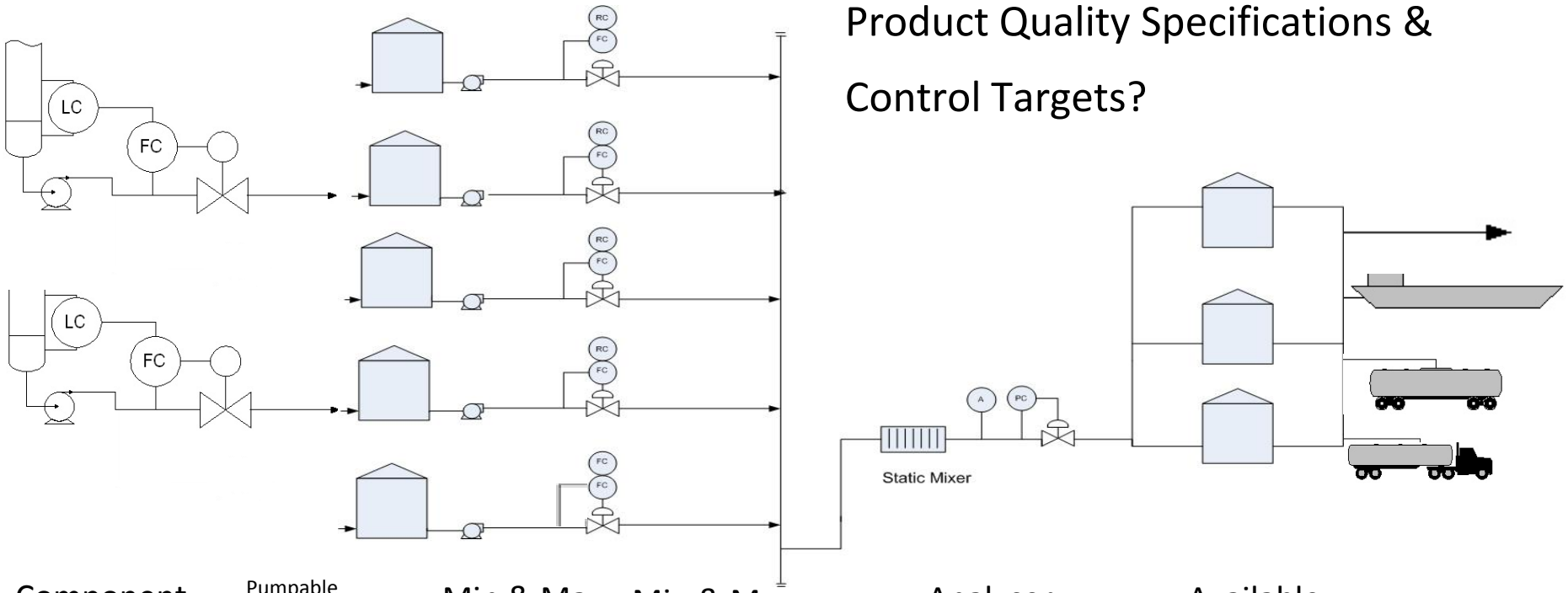
Rundowns Tanks Pumps Flow Stations Blend Header Tanks Dispatch

Analyzers

Components Products

Business Objective – Fulfil Orders for Product at Lowest Cost

In-line Product Blending - Constraints



Product Quality Specifications &

Control Targets?

Component Availablity?

Pumpable Volume?

Min & Max Flowrate?

Min & Max Flowrate?

Analyser Precision?

Available Room?

Tank Heel?

Component Properties

Tested 2 / Week

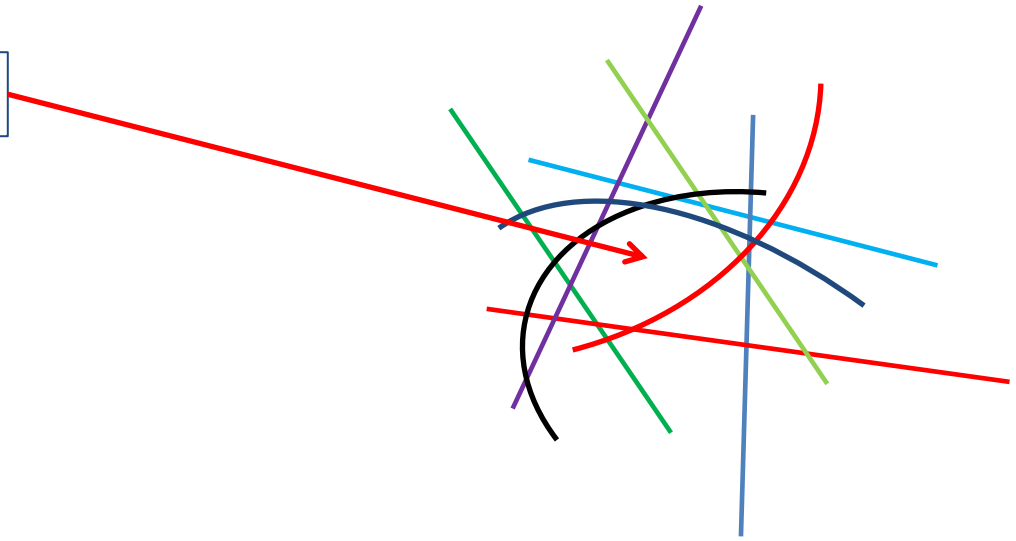
Lab Precision?

Find Optimum Recipe within Constraints

Refinery Product Quality Specifications & Constraints

- Feasible solution space – squeezed by changing specifications
- Solution space sometimes disappears completely – infeasible

Feasible solution space



- Gasoline
  - Reduced benzene, aromatics, olefins
  - Reduced RVP / DVPE
  - Reduced sulphur
  - Tighter D86 specifications E70 E100 E150 VLI
  - MTBE banned in some countries
  - Ethanol added at road truck rack
- Diesel (ULSD)
  - Reduced sulphur
  - Reduced PAH
  - Increased CN & CI
- Fuel Oil
  - Reduced sulphur (MARPOL)
  - CCAI for different ship diesel engines (ISO 8217)

Typical Differences in Optimised Blend Recipe

Recipe

Header | Blend | Intervals

	MATERIAL	TANK	MIN	PLAN	INIT	AVG	MAX	VOLUME
▶	HVY CAT	SR-56	50.40	56.00	55.23	52.71	61.60	27722.890
	LT CAT	SR-63	5.40	6.00	5.71	6.65	8.00	3496.477
	MIX	SR-60	11.98	14.98	17.71	17.90	17.97	9413.106
	BUTANE	SR-747576	10.96	15.66	15.43	16.37	20.36	8608.386
	SR-37 COMP	SR-37	6.00	7.36	6.00	6.37	8.10	3349.602

Planner / Scheduler

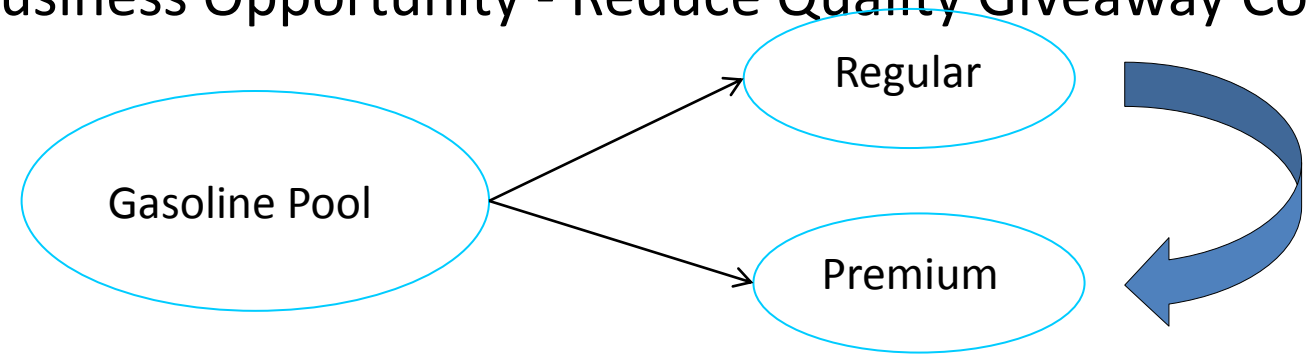
Initial recipe with offline optimisation

Actual closed loop optimised recipe

Blending Business Opportunity – Reduce Costs of…

- Inventory (blend right-first-time, just-in-time)
- Quality giveaway (Octane, RVP, Cetane, Sulfur, CFPP, Viscosity etc)
- Sub-optimal blend recipes
- Correction blends & reblends
- Distress & panic blends
- Downgrading to lower quality grades
- Contamination errors
- Demurrage for missed shipments & pipeline slots
- Tank maintenance & investment in new tanks

Business Opportunity - Reduce Quality Giveaway Cost AKI ON

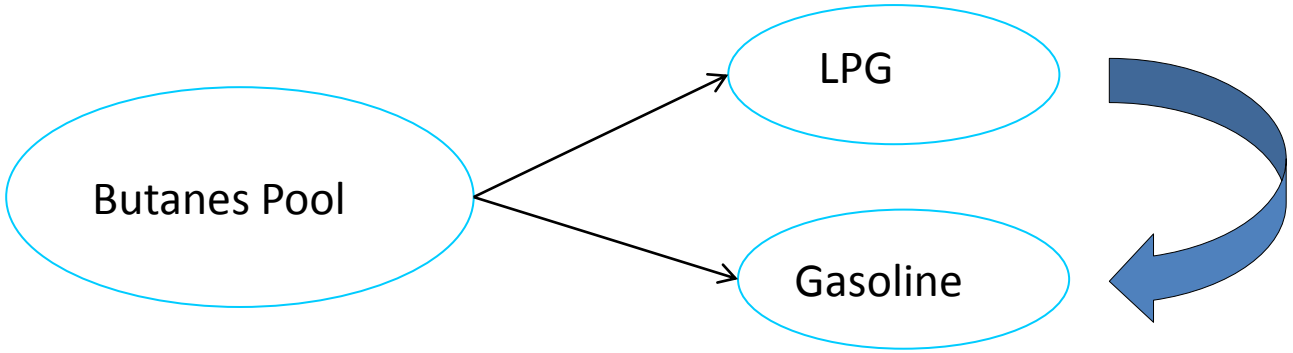


- Increase quantity of premium grades
- Sell petrochemical naphtha at gasoline price
- Sell higher / buy lower quality components

- Gasoline prices - Regular US$ 2.80, Premium US$ 3.19, / us gallon
- Premium – Regular = US$ 3.19 – US$ 2.80 = US$ 0.39 / usg = US$ 16.38 / bbl
  - Premium – Regular = 93 – 87 = 6 AKI ON
  - ON giveaway = US$ 16.38 / 6 = US$ 2.73 / ON / bbl
- Cost to refinery of 100,000 bpd gasoline with 0.25 ON giveaway =
  - 100,000 * 365 * 2.73 * 0.25 = US$ 24.9 million / year

Business Opportunity - Reduce Quality Giveaway Cost RVP

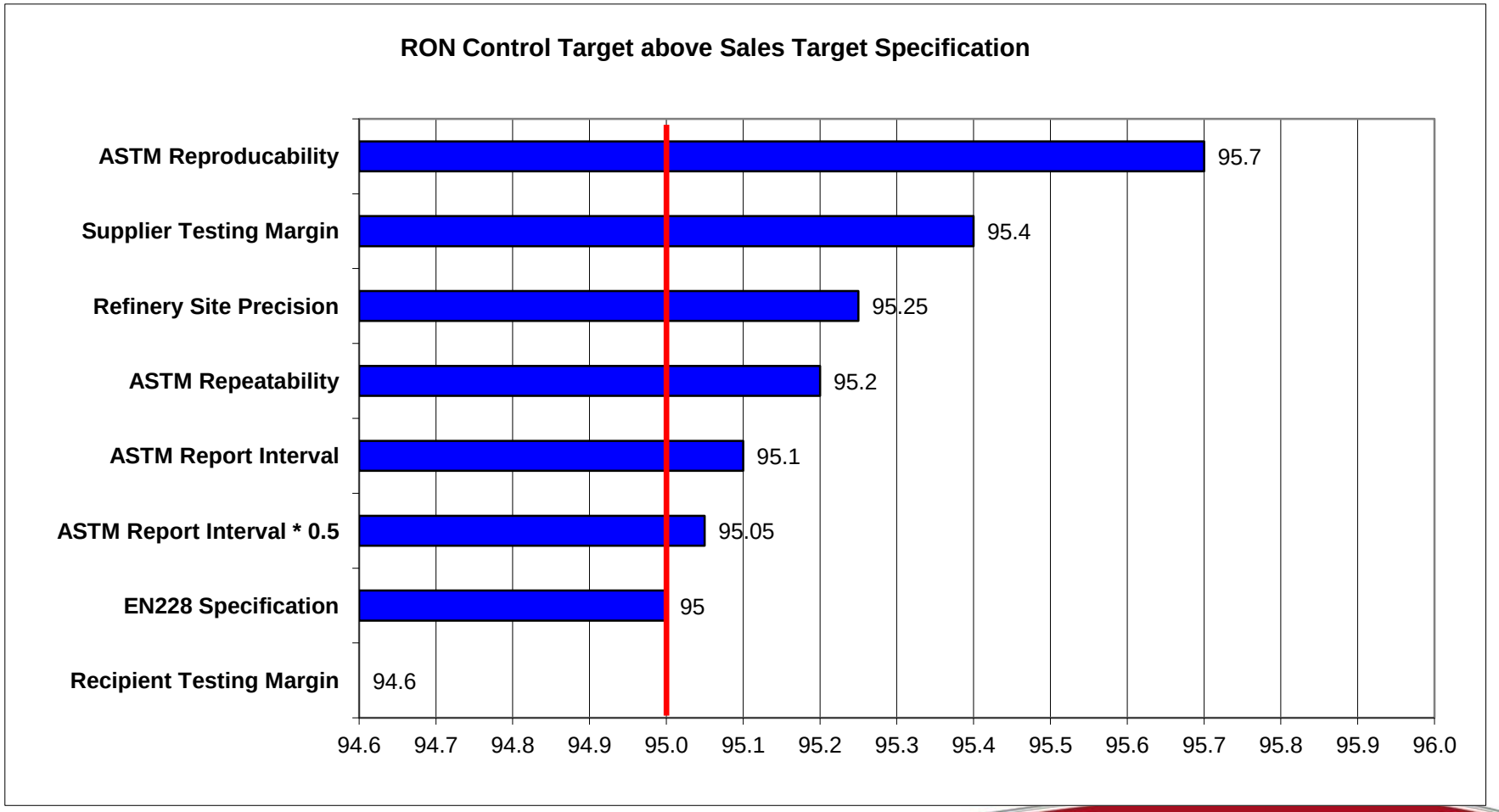
- Sell additional butane at gasoline price



- Gasoline forecourt prices - Regular US$ 2.80 / us gallon = US$ 117.6 / bbl
- LPG sales price US$ 0.84 / kg = US$ 82.5 / bbl
- Regular – LPG = US$ 35.1 /bbl
- Regular with 0.5 psi RVP giveaway would allow + 0.86 % n-butane to be added to increase RVP from 9.5 to 10 psi
- Gasoline 100,000 bpd production increased to 100,859 bpd
  - Sell 859 bpd of butane at Regular price
- Cost to refinery of 100,000 bpd gasoline with 0.5 psi RVP giveaway =
  - 859 * 365 * 35.1 = US$ 11.00 million / year

Use Planning LP to calculate cost of giveaway

Margin Between Sales Specification & Control Target – Depends on Confidence Level



How Much of the Business Opportunity Can Be Captured?

	Sales Specification	Control Target	Actual
RON	95.00	95.03	95.04
MON	85.00	85.03	85.03
RVP	93.00	92.60	92.60

How Is This Achieved?

Recipe

Header | Blend | Intervals

	MATERIAL	TANK	MIN	INIT	AVG	MAX	VOLUME
▶	REFORMAT_2	TK5303	0.00	34.08	31.74	100.00	2538.687
	ISOMERISAT	ISOMPOOL	20.00	23.00	23.78	24.00	1902.282
	BUTAN	TK4901	0.80	7.02	8.17	10.00	653.506
	HEXAT	TK4703	2.00	2.00	2.00	5.00	160.047
	LCN	TK4702	12.00	24.30	24.00	40.00	1919.781
	POLY	TK4704	3.60	3.60	3.58	5.00	286.088
	HCN	TK4404	3.80	6.00	6.72	7.00	537.611
	ANTISTAT	TK5309		3.00	1.21		24.259

Properties

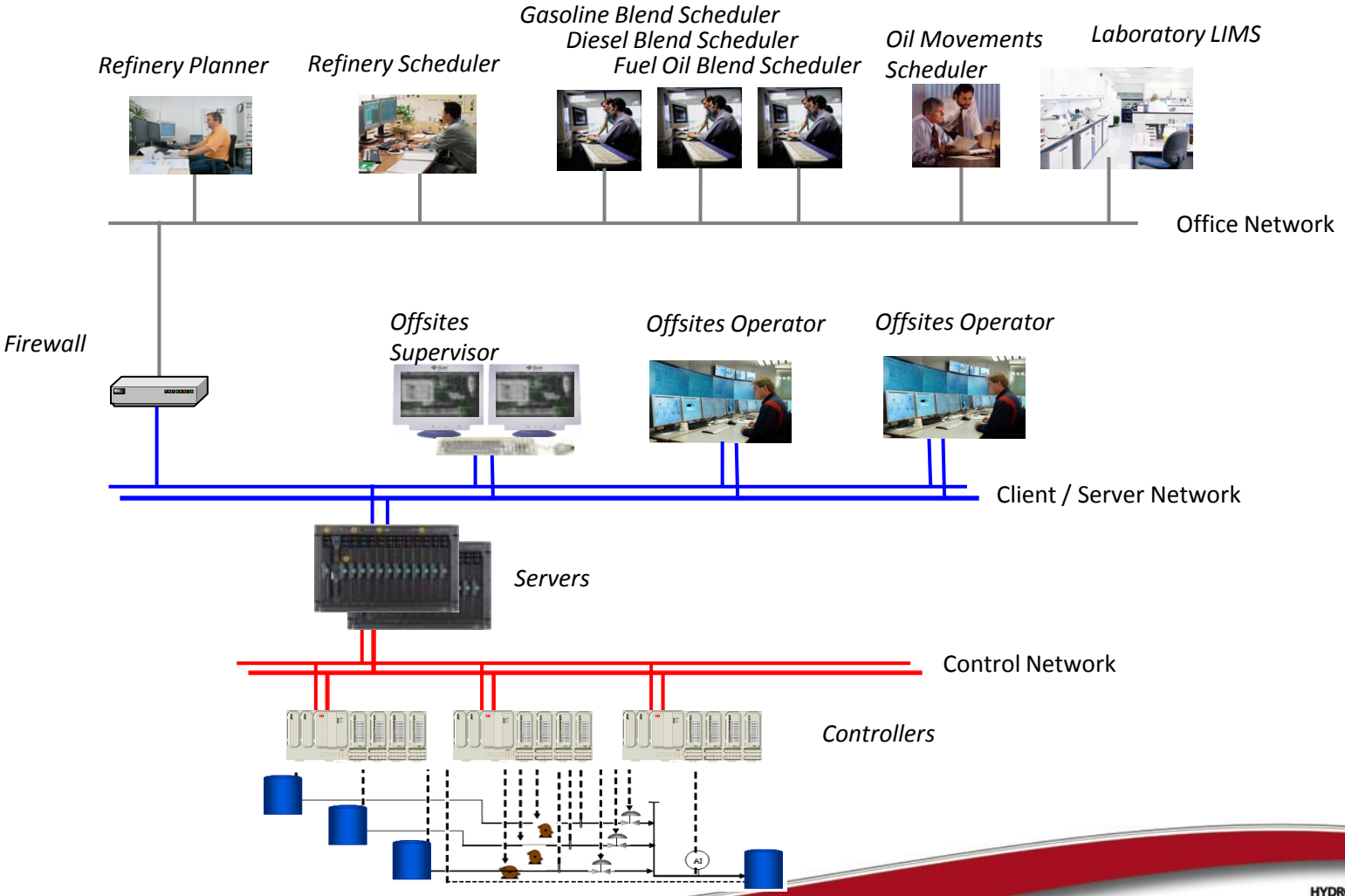
Header | Tank | Intervals

	PROPERTY	S_ MIN	C_MIN	CUR	FINALPRED	C_MAX	S_MAX	CNTRL	
▶	DENSITET	720.0	722.0	730.8	730.8	773.0	775.0	☑	K
	MON	85.00	85.03	85.03	85.03			☑	O
	VP	60.0	60.0	92.6	92.6	92.6	93.0	☑	K
	RON	95.00	95.03	95.04	95.04			☑	O
	E70	22.0	23.0	38.7	38.7	49.0	50.0	☑	V
	E100	46.0	47.0	56.5	56.5	70.0	71.0	☑	V
	E150	75.00	76.00	87.38	87.38			☑	V
	E180			94.4	94.4			☐	V
	FBP			191.2	191.2	208.0	210.0	☑	D
	VATTEN			27.3	27.3			☐	M
	BENSEN			0.71	0.71	0.86	1.00	☑	V
	AROMATER			32.2	32.2	41.7	42.0	☑	V
	OLEFINER			10.3	10.3	17.5	18.0	☑	V
	SVAVEL			3.2	3.2	7.0	10.0	☑	M
	VLI			1197.0	1196.9			☐	N
	SYREHALT			0.0	0.0			☐	W
	MTBE-HALT			0.0	0.0	0.3	0.3	☑	V
	10% PT			35.6	35.6			☐	D
	50% PT			78.0	78.0			☐	D
	90% PT			167.7	167.7			☐	D

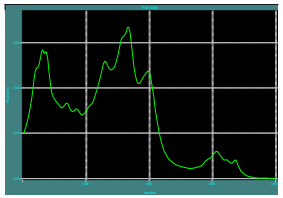
Key Issue #1 – Organisation & Culture

- Cross-Functional team
- Cooperative & collaborative working – can do attitude
- Using the same system and data
  - Planners / Schedulers / Blend Schedulers
  - Offsites Operators & Supervisors
  - Blend System Technical Services / Control Engineer
  - Laboratory QA Manager / Technicians
  - Analyser Engineers & Technicians
  - Instruments / Mechanical Equipment / IT Engineers & Technicians
- Close the loop – feedback results to optimise the refinery

Key Issue #1 – Organisation & Culture
Using the Same System and Data



Key Issue #2 - Blend Header Analysers - FTNIR



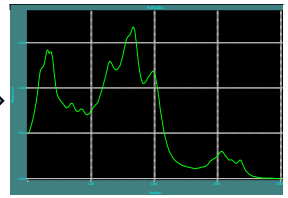
NIR Spectra

Lab Results

Model Build & Validation

Models used in online blend header analyser

Key Issue #2 - Blend Header Analysers - FTNIR



NIR Spectra

Lab Results

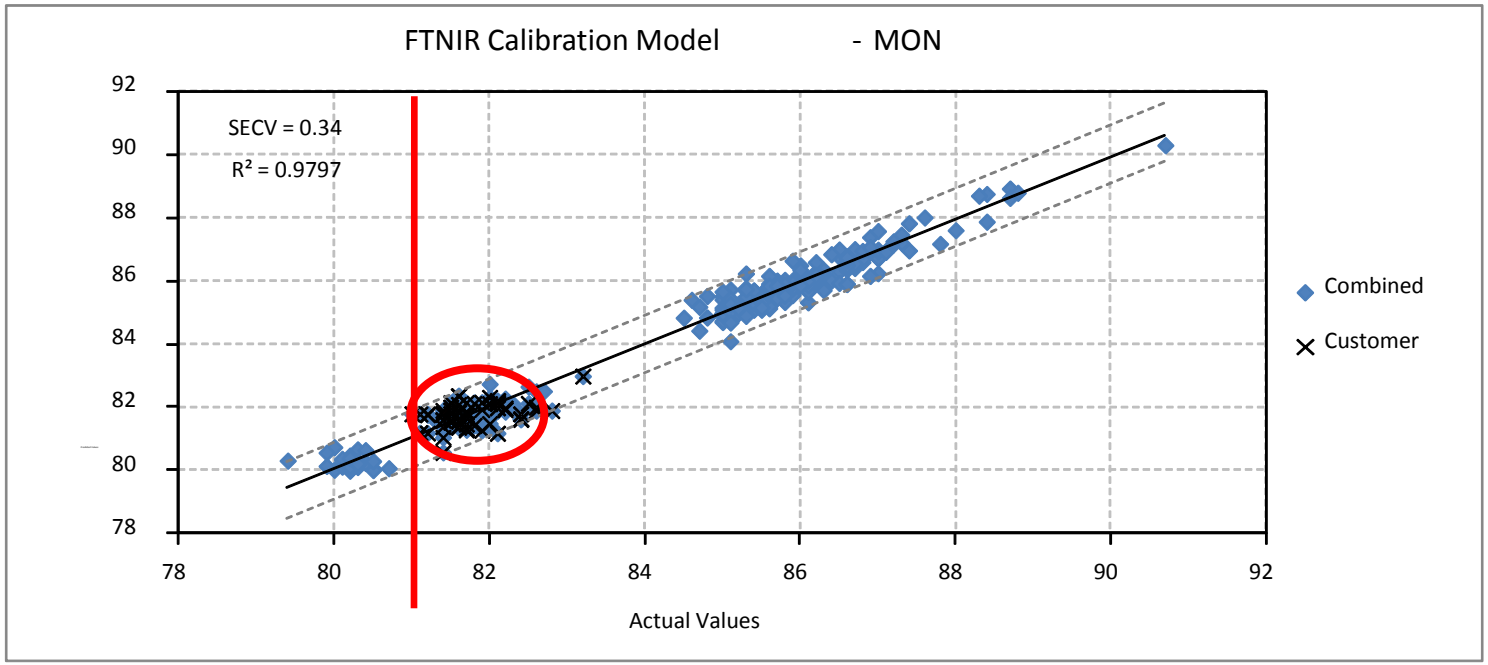
Model Build & Validation

- Lab Results include the site precision of your Refinery Laboratory
- FTNIR models will not have better precision than your Lab
- Lab should be responsible for blend header analysers & models
- Not all FTNIR analysers are the same, you get what you pay for – do not buy cheap & nasty analysers

Models used in online blend header analyser

Key Issue #2 - Blend Header Analysers - FTNIR

- Model calibration & validation sets must be representative
- And cover whole range of operation
- Use bottles of components and mix in the Lab



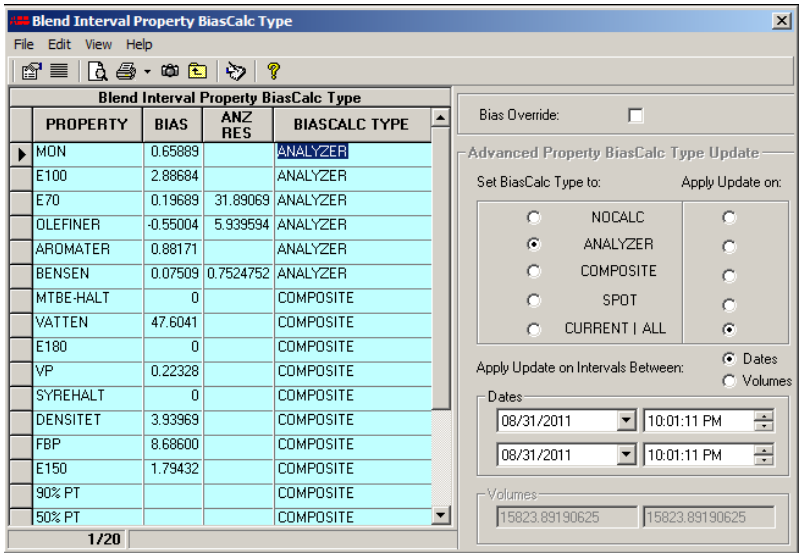
Customer data inadequate, ABB combined data from other refineries

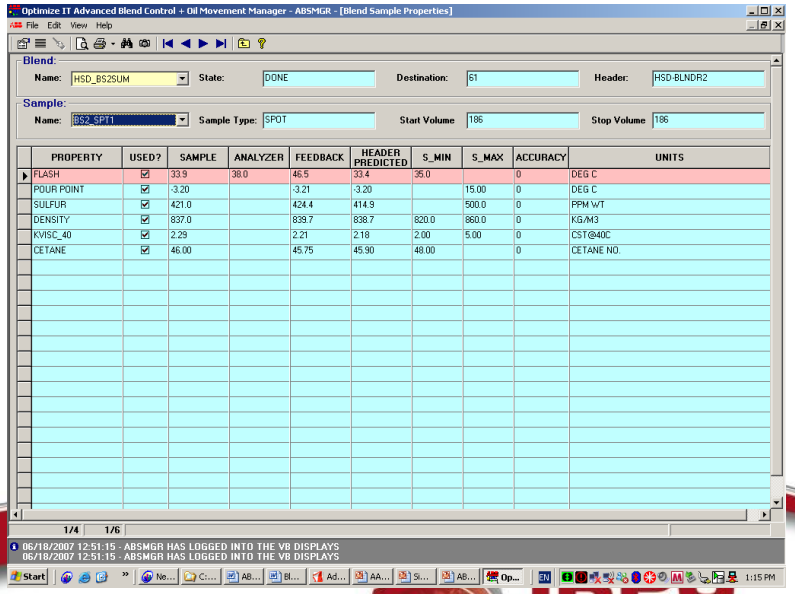
X No data at / below Sales Specification or Premium

X Model data sets highly clustered

Key Issue #3 – Optimiser Functionality

- Allows optimization and recipe correction even without analyzers
- Multiple bias source types for each property
- Spot and Composite sample handling
- Allows retroactive correction of the blend based on samples and lab result
- Tank quality integration over time TQI
- Data entry can be integrated with LIMS or manual entry in ABC
- Manages all Tank heels, user-tunable heel correction rate
- Manages rundown piping quantity and heel quality





Key Issue #3 – Optimisation Infeasibility Handling

- Optimiser diagnostics advise Operator why infeasible
- Limiting Min and max constraint shown in red
- User Min / Max – consider freeing up if constraining

Recipe Constraint Diagnostic

File Edit View Help

Interval		MIN				OPT	MAX				
	COMPONENT	USER	INV	LINEUP	DELTA	OPT	USER	INV	LINEUP	DELTA	PACING
▶	REFORMAT	0.00	0.00	11.54	29.41	36.27	100.00	100.00	100.00	43.41	71.16
	POLY	3.00	0.00	2.31	0.00	3.00	3.00	42.49	19.23	10.00	8.57
	LCN	12.00	0.00	3.08	13.88	20.83	23.00	100.00	51.54	27.88	33.14
	ISOMERISAT	15.00	0.00	2.69	16.10	23.00	23.00	100.00	25.38	30.10	34.79
	HEXAT	2.00	0.00	2.23	0.00	3.00	3.00	100.00	22.31	10.01	12.53
	HCN	5.00	0.00	1.54	0.00	6.00	6.00	100.00	22.31	12.90	14.58
	BUTAN	0.80	0.00	3.08	0.70	7.90	15.00	100.00	15.38	14.70	13.67

Average		MIN				OPT	MAX				
	COMPONENT	USER	INV	LINEUP	DELTA	OPT	USER	INV	LINEUP	DELTA	PACING
▶	REFORMAT	0.00	0.00	11.54	29.41	36.26	100.00	100.00	100.00	43.41	71.16
	POLY	3.00	0.00	2.31	0.00	3.00	3.00	42.49	19.23	10.00	8.57
	LCN	12.00	0.00	3.08	13.88	20.85	23.00	100.00	51.54	27.88	33.14
	ISOMERISAT	15.00	0.00	2.69	16.10	23.00	23.00	100.00	25.38	30.10	34.79
	HEXAT	2.00	0.00	2.23	0.00	3.00	3.00	100.00	22.31	10.01	12.53
	HCN	5.00	0.00	1.54	0.00	6.00	6.00	100.00	22.31	12.90	14.58
	BUTAN	0.80	0.00	3.08	0.70	7.90	15.00	100.00	15.38	14.70	13.67

1/7 1/7

Does your refinery need offsites automation?

If you answer YES to the following questions:-

- Capacity > 50,000 bpd crude ?
- Refinery > very low complexity ?
- Components > 2 per product (gasoline, diesel, fuel oil, bunkering) ?
- Products > 1 grade per product ?
- Unconstrained market ?
- Degrees of freedom > 2 ?
- Technical sophistication > minimum ?
- Product quality giveaway > ASTM repeatability ?
- Inventory (products + components) > 15 days ?
- Not enough tanks ?
- Reblends & corrections > 1 / month ?

- Typical project payback < 0.8 years

ABB Offsites Automation - Product and Solutions Centre

- Alan Munns PSC Manager & Product Owner
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- Work with local ABB company to deliver & support solution
- Consultancy for offsites automation, project justification, blending system design & operation
- Projects
- Business Development
- Customer Support & Training
- Software Product Development & Maintenance

- Located in StNeots 80km north of London UK

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