Developing an Asphalt Mix Plant Production Process Control System

NCAUPG Meeting February 15-16, 2012

25 YEARS 1986 - 2011
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Recognition

- FHWA
- Dr Alice Smith, Dr Jeff Smith, Azgur Kabadurmus, Min Zhang Min, AU Industrial & System Engineering
- Robert Troxler, Troxler Electronic Laboratories
- Greg Brouse, QC manager, Eastern Industries, Inc., Winfield, PA

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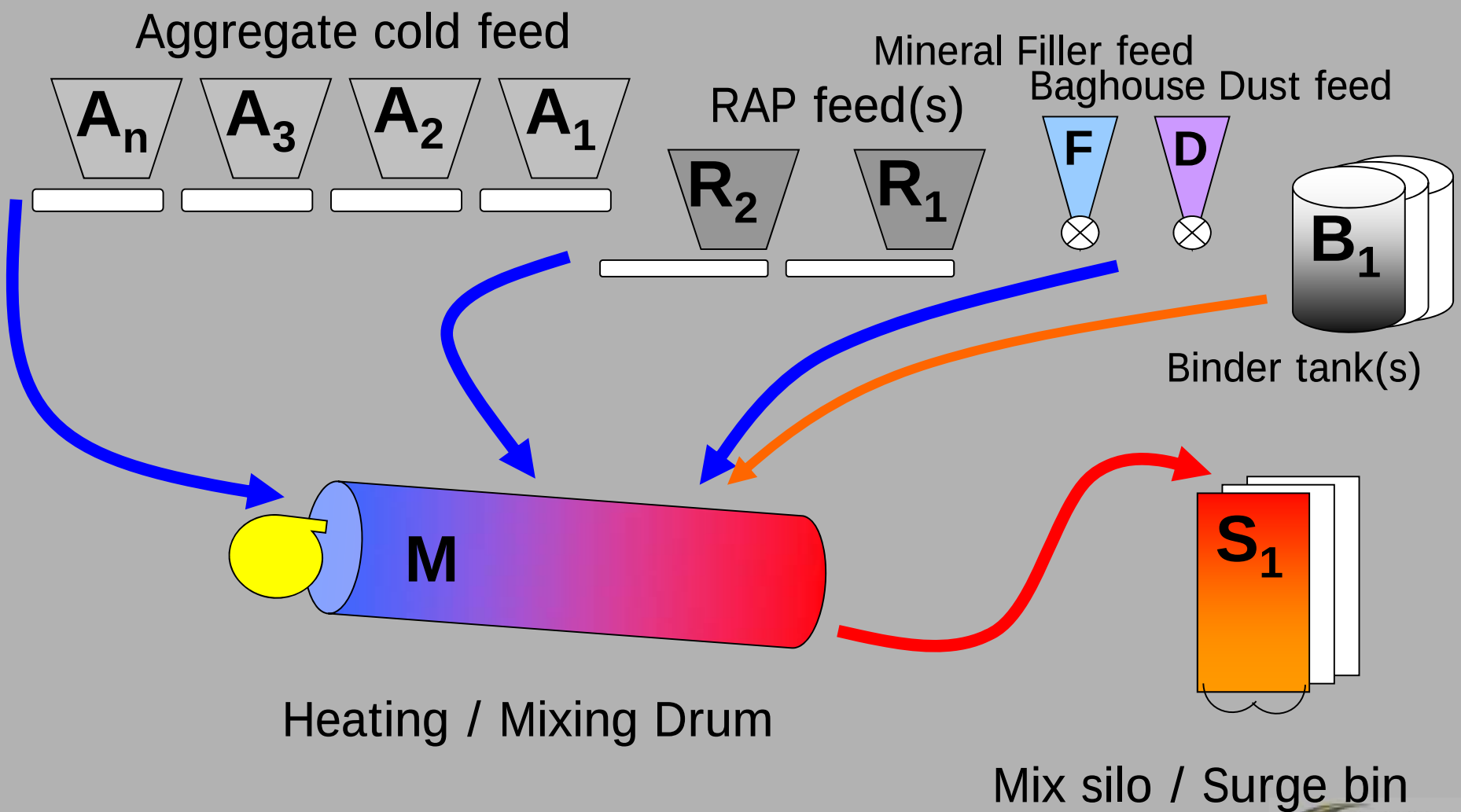

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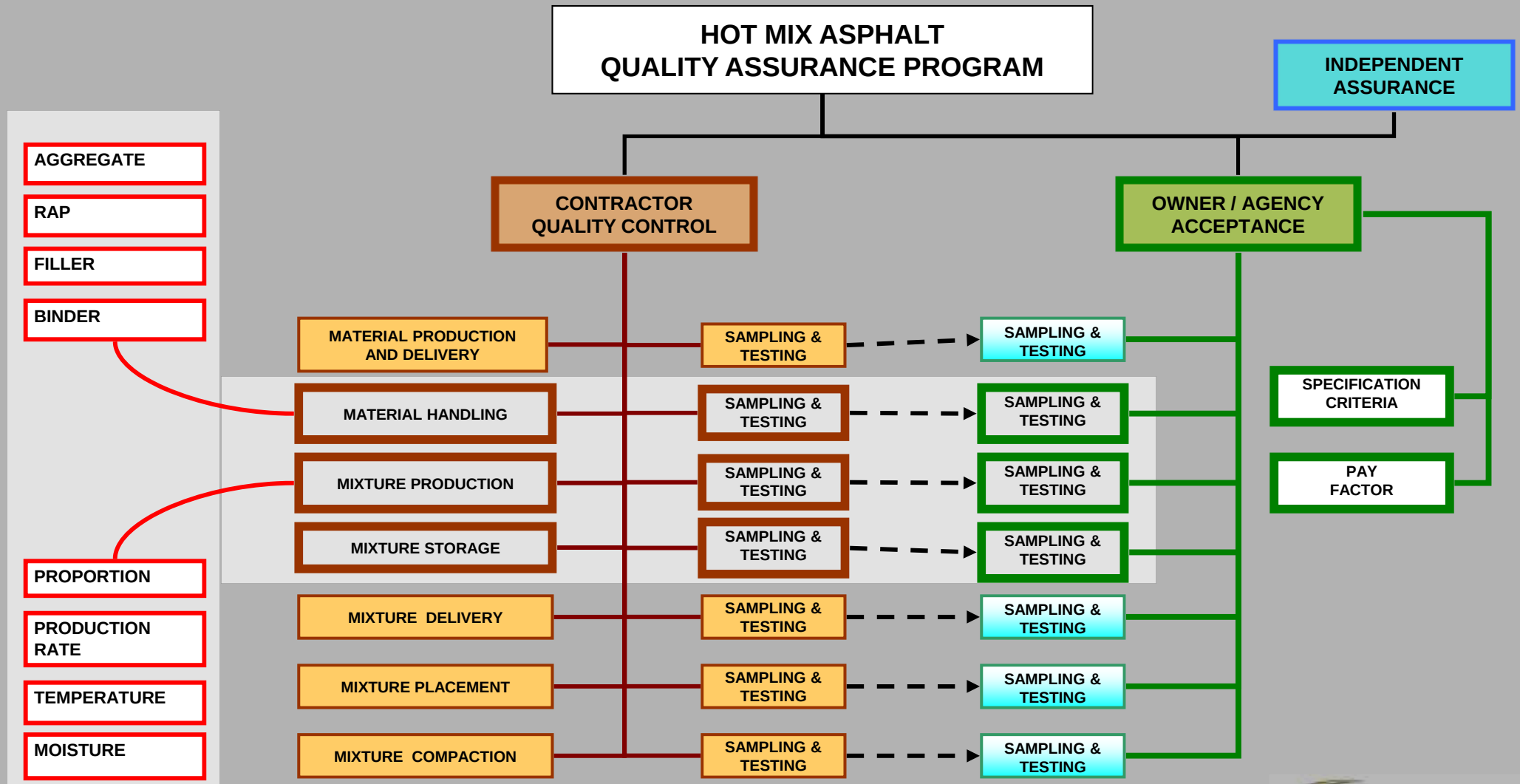
HOT MIX ASPHALT
QUALITY ASSURANCE PROGRAM
INDEPENDENT ASSURANCE
CONTRACTOR QUALITY CONTROL
OWNER / AGENCY ACCEPTANCE
AGGREGATE
RAP
FILLER
BINDER
PROPORTION
PRODUCTION RATE
TEMPERATURE
MOISTURE
MATERIAL PRODUCTION AND DELIVERY
MATERIAL HANDLING
MIXTURE PRODUCTION
MIXTURE STORAGE
MIXTURE DELIVERY
MIXTURE PLACEMENT
MIXTURE COMPACTION
SAMPLING & TESTING
SPECIFICATION CRITERIA
PAY FACTOR
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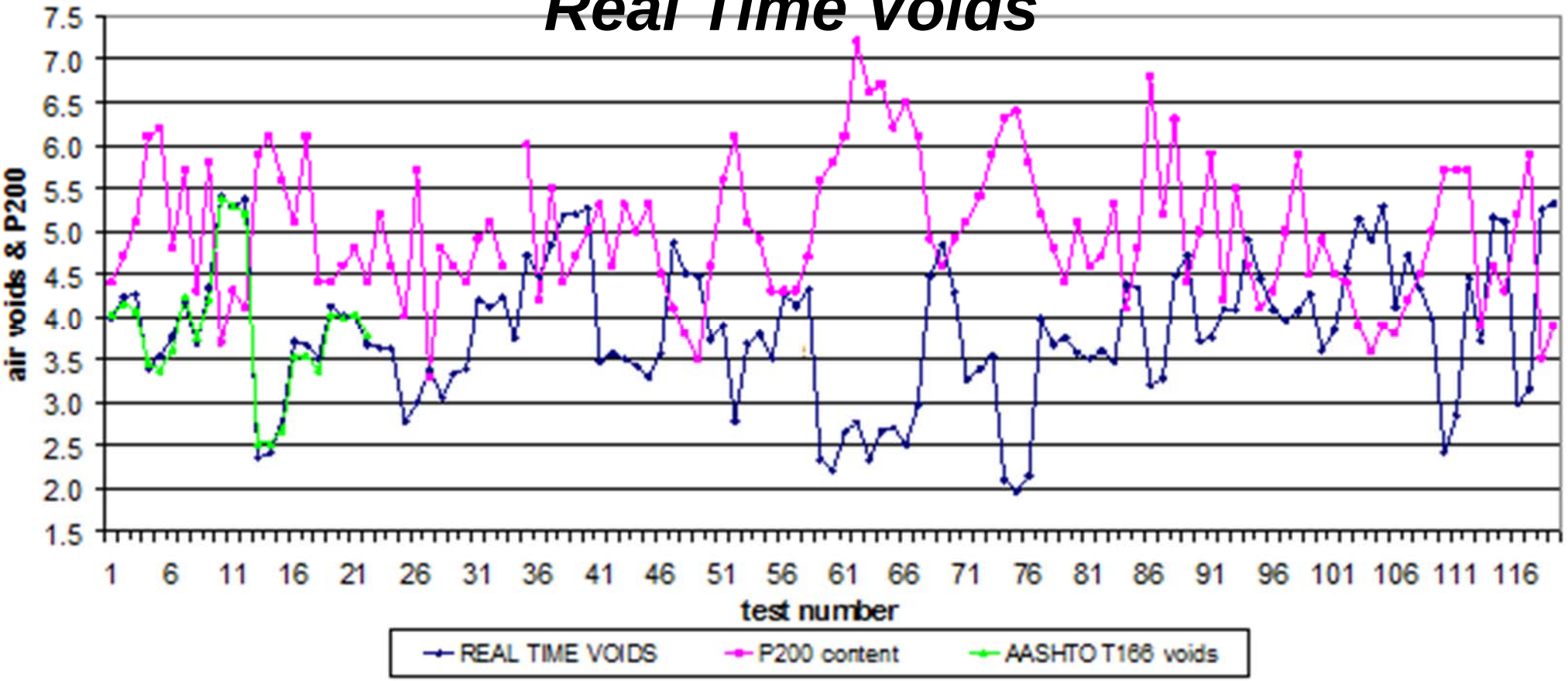
Real Time Voids



1 RTV / 35 tons

$$RTV = \frac{Gmm' - Gmb(adj)}{Gmm'} \times 100$$

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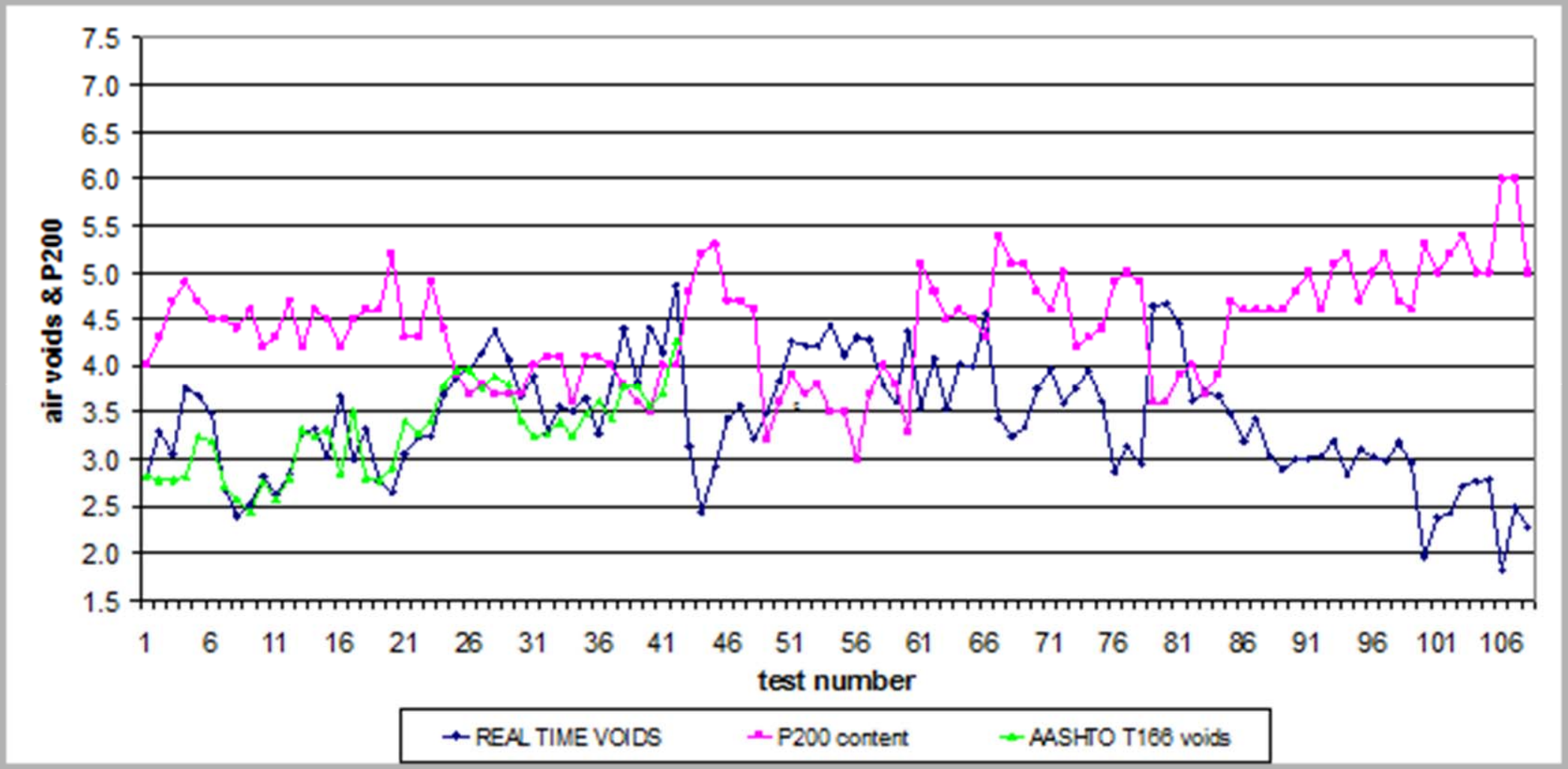

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Development of a Hot Mix Plant Production Process Control System

$$V_{aggr} = V_{geology} + V_{aggrprod} + V_{transport} + V_{stockpile} + V_{loader} + V_{coldfeed} + V_{s/t} + e$$

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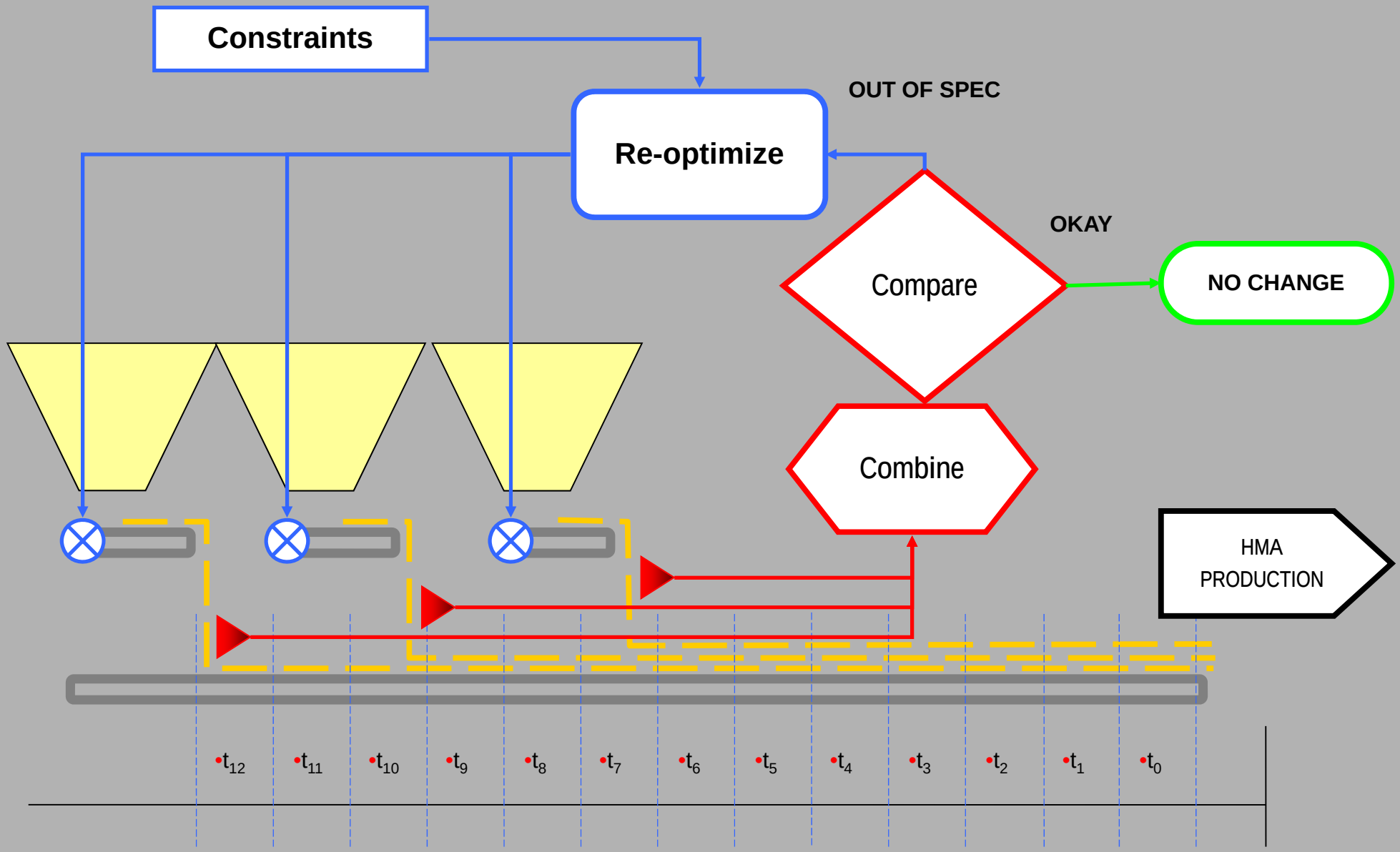
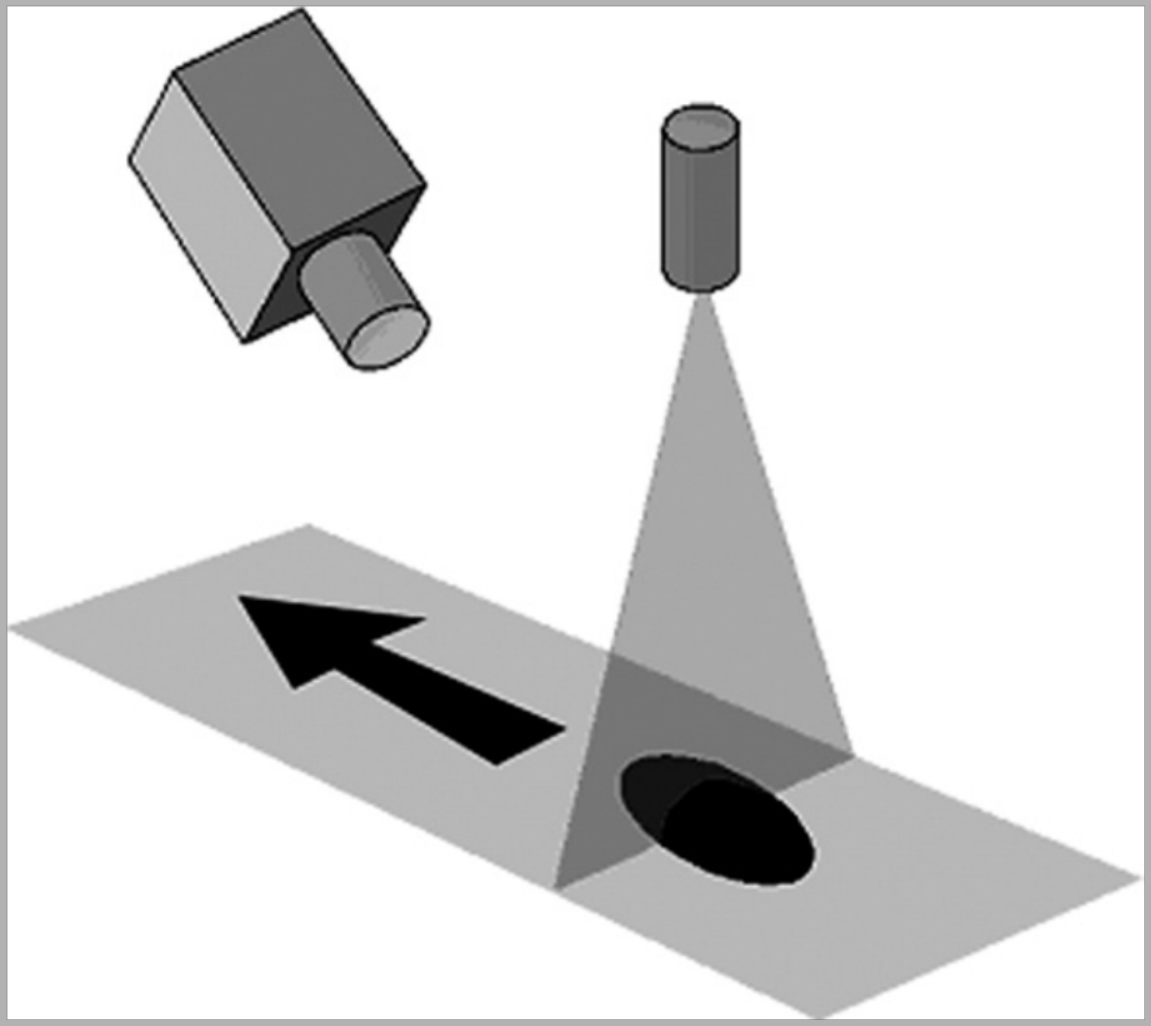
Aggregate Blending Model

- **Decision Variable**: Bin proportions for overall blend compliance
- **Objective Function**: Minimize total deviation (normalized) from target gradations over 4 control sieves
- **Measured Parameter**: Bin gradation measurements
- **Contraints:**
  - JMF target gradation
  - Upper and lower specification limits
  - Upper and lower production limits
  - Upper and lower feed limits for each bin
  - Minimum and maximum limits on % Crushed, friction and natural sand
  - Aggregate properties for each bin: % Crushed, friction and natural sand


Constraints
OUT OF SPEC
Re-optimize
OKAY
Compare
NO CHANGE
Combine
HMA
PRODUCTION
t12
t11
t10
t9
t8
t7
t6
t5
t4
t3
t2
t1
t0



J.R.J. Lee, M.L. Smith, L.N. Smith

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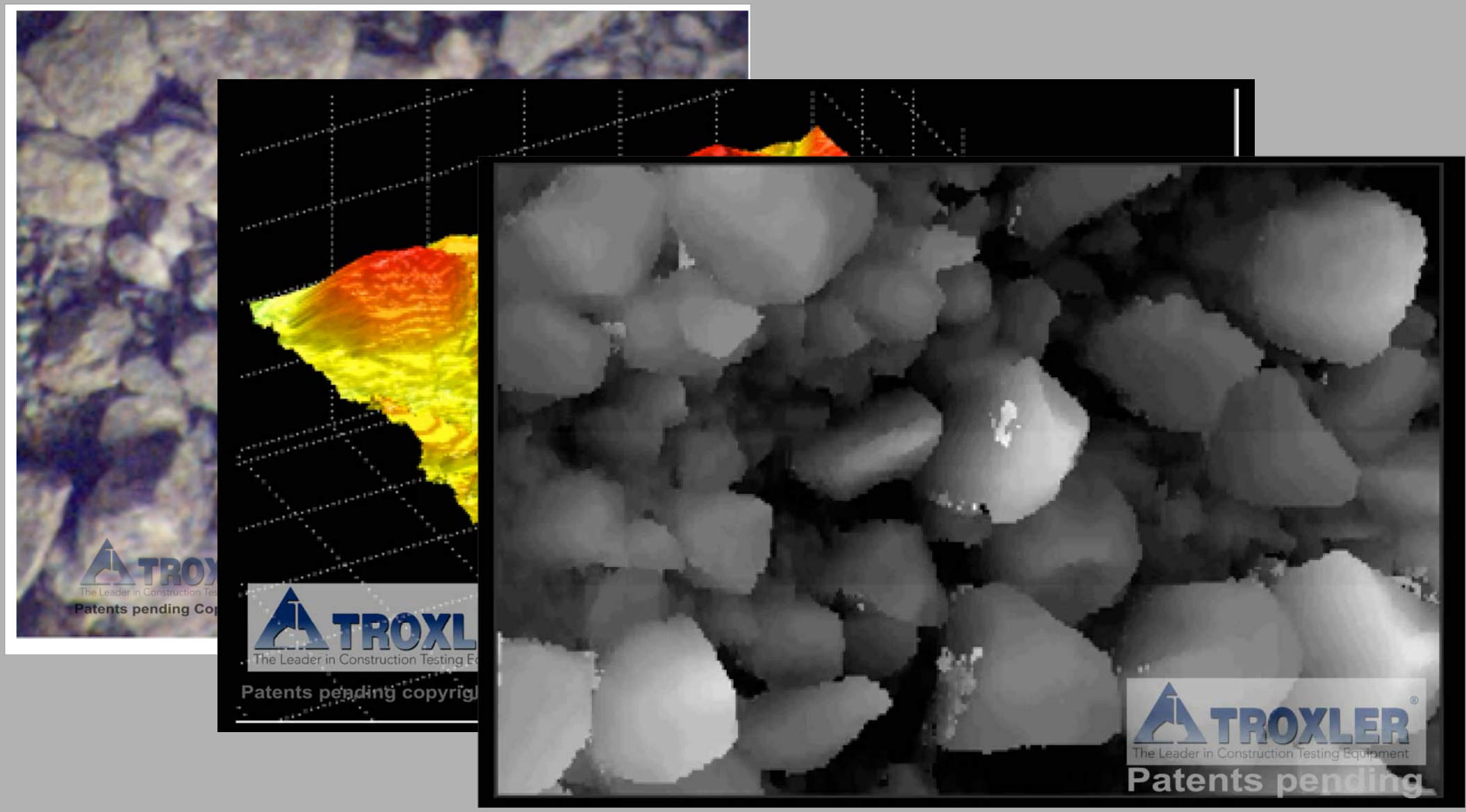

Sebastien Merit 2001

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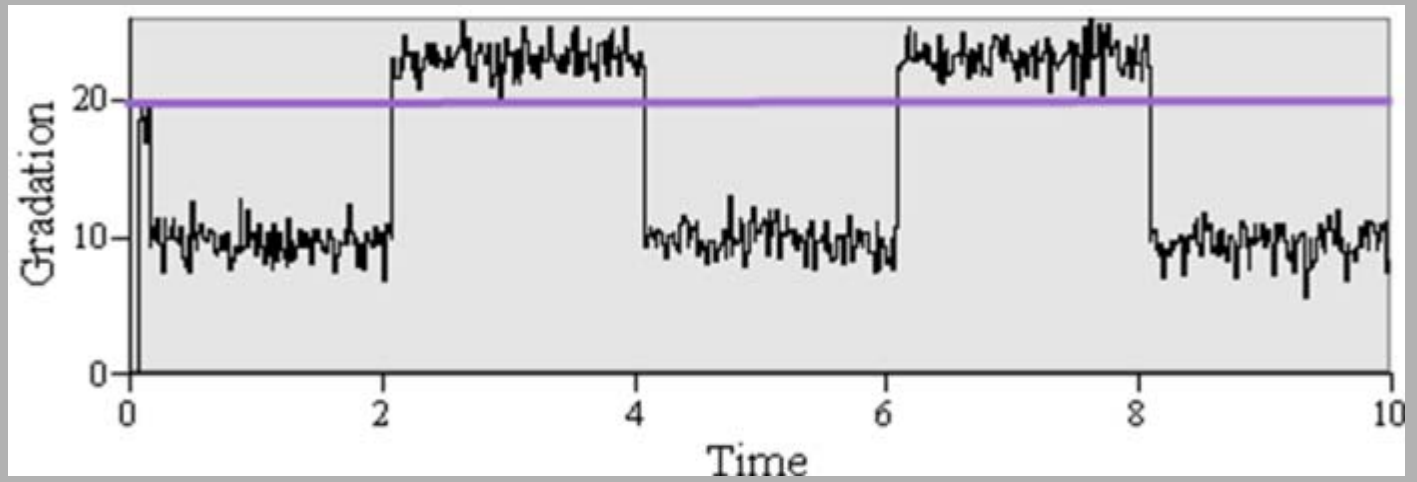
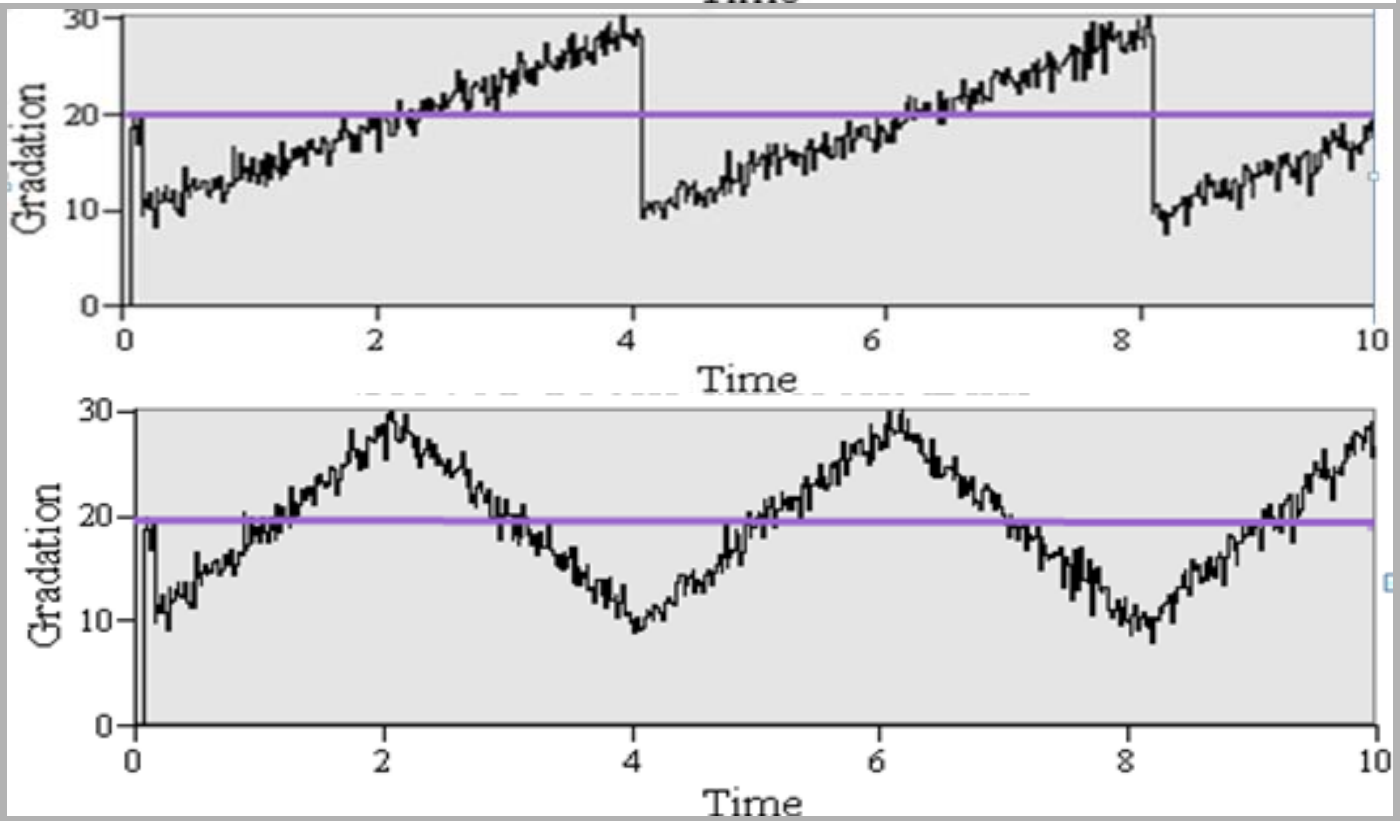
Simulation Model

Why use simulation?

- To compare the relative performance of different control policies
- To mimic the system and adjust/fine tune the parameters of the optimization model
- To estimate the benefits of the online control
- To convince industry that the proposed model can improve the production quality





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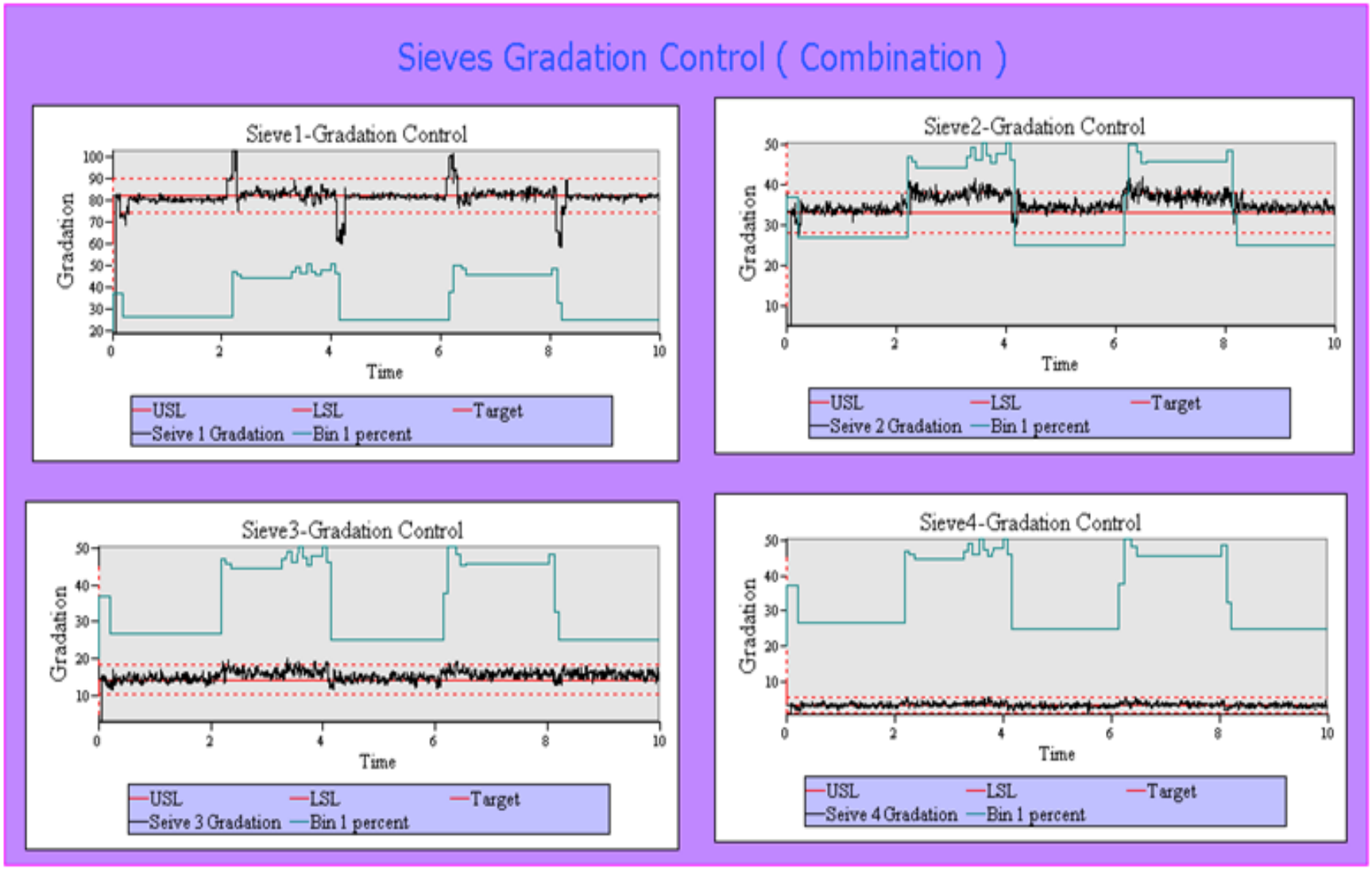
Production Control Policies

- **No Control Policy:** baseline to measure against

- **Control Policy 1**: Re-optimize the blend if gradation of one sieve is out of control
- **Control Policy 2**: Re-optimize the blend if gradations of two sieves are out of control
- **Control Policy 3**: Re-optimize the blend if total deviation from target is out of control
- **Control Policy 4**: Combine policy 1 & 3

Typical Simulation Output



out of spec
5 4

blend changes
2 3

#no solution
0

Sieve1Deviation
1 7 7 . 5 5

Sieve2Deviation
3 0 6 . 2 3

Sieve3Deviation
2 0 3 . 9 2

Sieve4Deviation
1 3 4 . 0 9

AllSievesDev
8 2 1 . 7 9

Summary of the Results

Scenario / Control Policy	Trend 1	Trend 2	Trend 3
Control 1 One Screen	20%	18%	36%
Control 2 Two Screens	0%	19%	29%
Control 3 Total Deviation	30%	20%	29%
Control 4 (1 and 3)	20%	18%	39%

Percent reduction of total deviation
Using contractor production limits
4-Pt moving average

Conclusions

- Aggregate gradation continuous process control is feasible
- The Aggregate Blending optimization is effective and sufficiently fast
- Using computer simulation, the process parameters can be optimized and different scenarios can be tested and robust settings can be obtained without negatively impacting production
- Image processing of aggregate gradation and accurate aggregate feed rate control are key to the system's successful implementation

Continuing Work

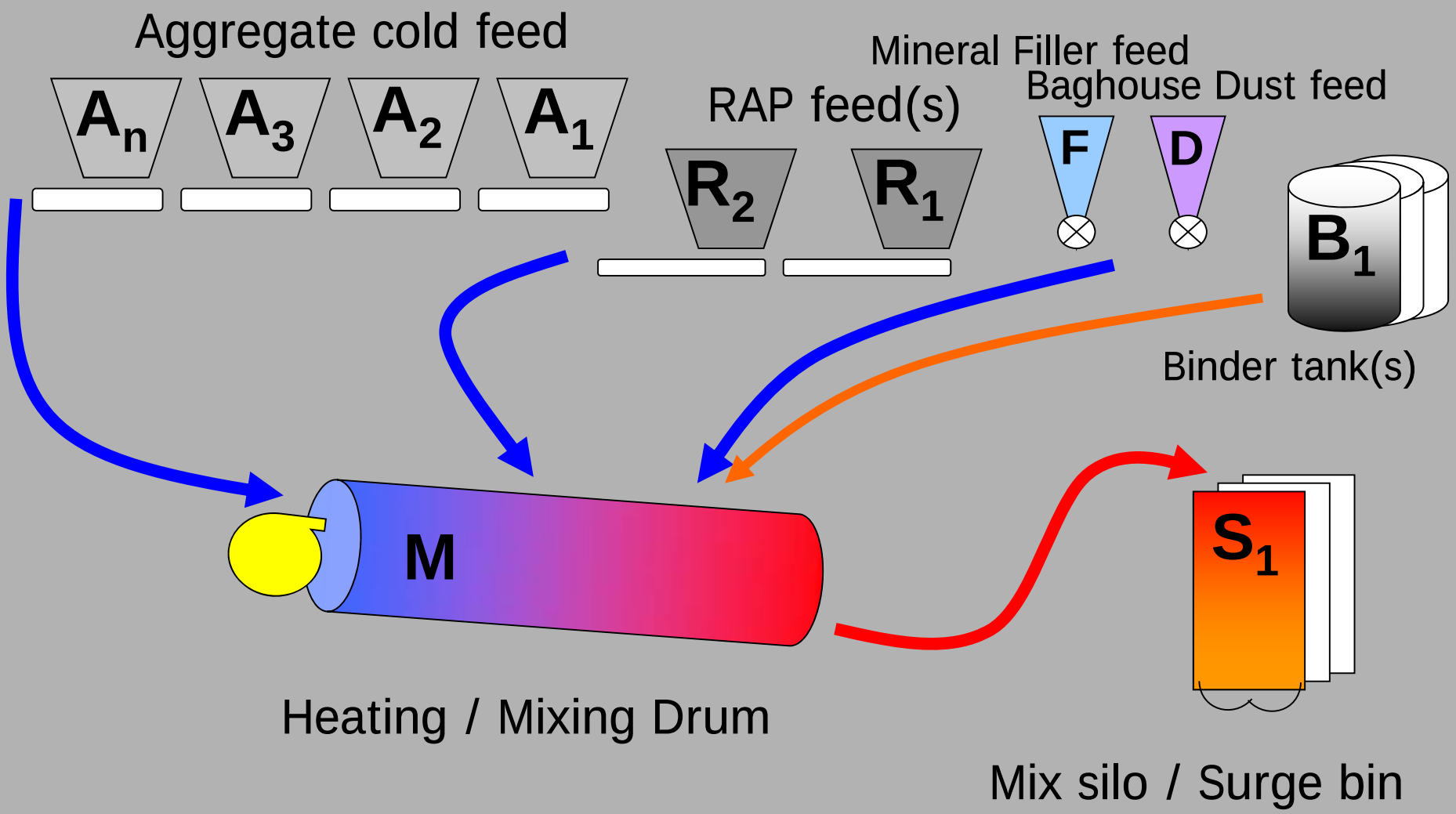
- Develop the gradation imaging system
- Determine the impact of moisture in the imaging
- Improve the Control optimization algorithm to reduce “overshoot” and improve mix consistency
- Test the optimization model at an asphalt production plant

National Forum

Dallas, TX, 22-23 September 2008

Forum identified following HURDLES towards implementation of this program

- **Cost/benefits** of the system. The cost of the process control system vs tangible benefits for both contractors and agencies.
- Need for a **fundamental change** in the industry and agency cultures
- Existence of **real advances** in production process control technology
- Need for a **change in sampling/testing** to support a real-time (quasi-continuous) measurement system


Aggregate cold feed
A_n
A_3
A_2
A_1
RAP feed(s)
R_2
R_1
Mineral Filler feed
Baghouse Dust feed
F
D
B_1
Binder tank(s)
M
Heating / Mixing Drum
S_1
Mix silo / Surge bin

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