2011 ARS, North America, San Diego

Track 1, Session 8

Begins at 1:00 PM, Wednesday, June 8th

Proving a New Refinery Design Using Reliability Throughput Modelling

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PRESENTATION SLIDES

The following presentation was delivered at the:

International Applied Reliability Symposium, North America
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http://www.ARSymposium.org/2011/

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1.0 Introduction

- Damien Willans
- Director, SSR Engineering Pty Ltd
- Incorporated in 2009
- Key Highlights :
  - Specialize in reliability modeling
  - 15 to 20 years minerals processing design backgrounds for both company partners
  - Previously in-house reliability modelling, now consulting
- Modelling software
  - SSR uses a flexible modeling platform - Goldsim
  - Goldsim is a numerical analysis platform with a wide range of applications including engineering systems reliability.

Agenda

- 1.0 Introduction 5 min
- 2.0 Modeling new projects 5 min
- 3.0 Case study - New project outline 5 min
- 4.0 Project setup – Client scope, data, documents 10 min
- 5.0 Producing the models 10 min
- 6.0 Model outputs and issues 5 min
- 7.0 Summary 10 min
- Questions 10 min

2.0 Modelling new projects

- Current Scenario
  - Resource demand and industry is booming.
  - Project scales have generated larger scale specialized engineering providers.
  - The larger they are, the harder it is to fully integrate all stages of project design and operations.
  - The path from resource ownership to fully functioning and integrated mine/processing facilities can be lengthy, expensive and rarely seamless.

2.0 Modelling new projects

- Engineering – Construction - Operation
  - Typically in Australia the major resource companies engage large engineering consultants to execute plant design.
  - The key criteria is project cost, combined with a performance guarantee.
  - Final design and construction is often handed off to large construction companies.
  - Plant is handed over to owner/operator for operations and maintenance.

Key point : The facility owner has limited opportunity to prove and optimise the design – particularly in the area of operations and maintenance effects.

3.0 Case study – New project outline

- Project outline
  - A relatively “new” player (in Alumina but not in resources).
  - Massive mine to raw product processing and port development.
  - Compelled to use publically available technology and engineering.
  - Utilizing a large engineering team with wide range of experience and design preferences.

3.0 Case study – New project outline

- Design process
  - Process flowsheet designed with final production number as starting point.
  - An assumed "operating" factor was then applied to get :
    - Final flowsheet data – this was then used to size pumps, filters, piping etc.
    - Entire success of the plant process is dependent on the plant equipment meeting the assumed operating factor, not just initially but over time…

4.0 Project setup – scope, data, documents

- Project definition stage is VERY important.
- 3 major requirements at model definition stage :
  - Client requirements
  - Data sourcing
  - Documentation and review

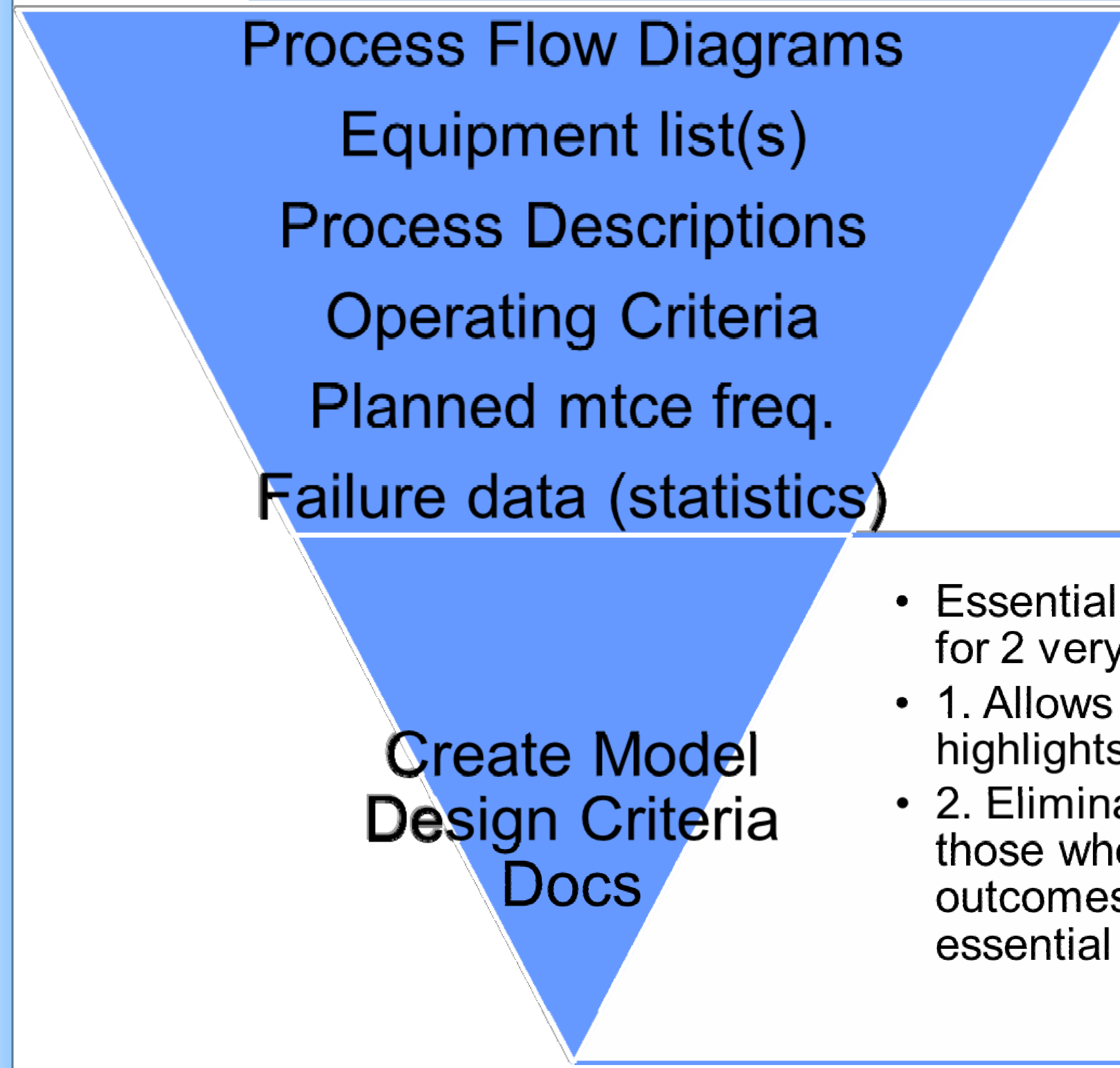
4.0 Project setup – scope, data, documents

- 4.1 Client requirements
  - Initial requirement was a reliability "model" which had different meanings to each person.
  - My job was to show the potential outcomes from the models and how they could use them.
  - Significant demonstrations of the program (Goldsim) and explaining numerical analysis.
  - All expectations from owners, design engineers and operating partners were documented and updated during the project duration.

4.0 Project setup – scope, data, documents

- 4.2 Data sourcing
  - Very critical to find/collate all available data and get agreement on its use.
  - Equally critical to assemble all of the data into a single source document for review by the client early in the modelling process.
  - For this project we required process flow diagrams (PFD's), equipment lists, area process descriptions, initial maintenance assumptions and failure data.
  - This (greenfield) project required some existing plant data from the operating partner.

4.0 Project setup – scope, data, documents



- Essential data comes together for 2 very important reasons :
- 1. Allows <u>alignment</u> of data and highlights <u>gaps</u>.
- 2. Eliminates uncertainty for those who only review the outcomes after modelling project essential completion.

4.0 Project setup – scope, data, documents

- 4.3 Project documentation
  - Design criteria documents were then compiled for each process area.
  - These contained ALL relevant data to be used in each model (i.e., <u>in one specific location</u>).
  - Criteria generated significant "discussions" regarding some assumptions – a great tool.
  - Invaluable for project final model review stages – when input data is often a point of contention (particularly for new players).

5.0 Producing the models

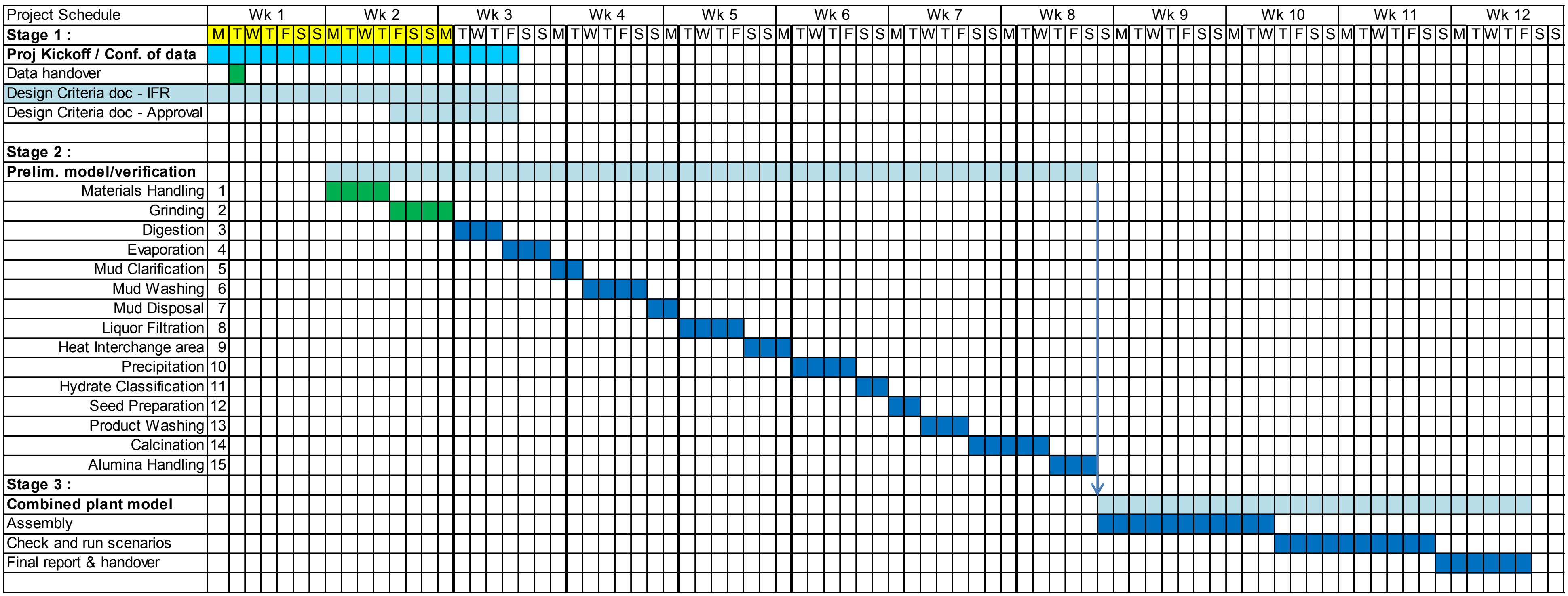
- Overview
  - 5.1 Starting with a plan
  - 5.2 Building the models
  - 5.3 Developing models the client can use
  - 5.4 Building the combined (full-plant) model

5.0 Producing the models

- 5.1 Start with a plan
  - Start by breaking down total plant by areas.
  - Build a schedule for the overall project.
  - Create the modelling schedule based on model development stages – preliminary, area verification, combined model stage.
  - Update progress each week.

5.0 Producing the models

- Build a schedule for the overall project.

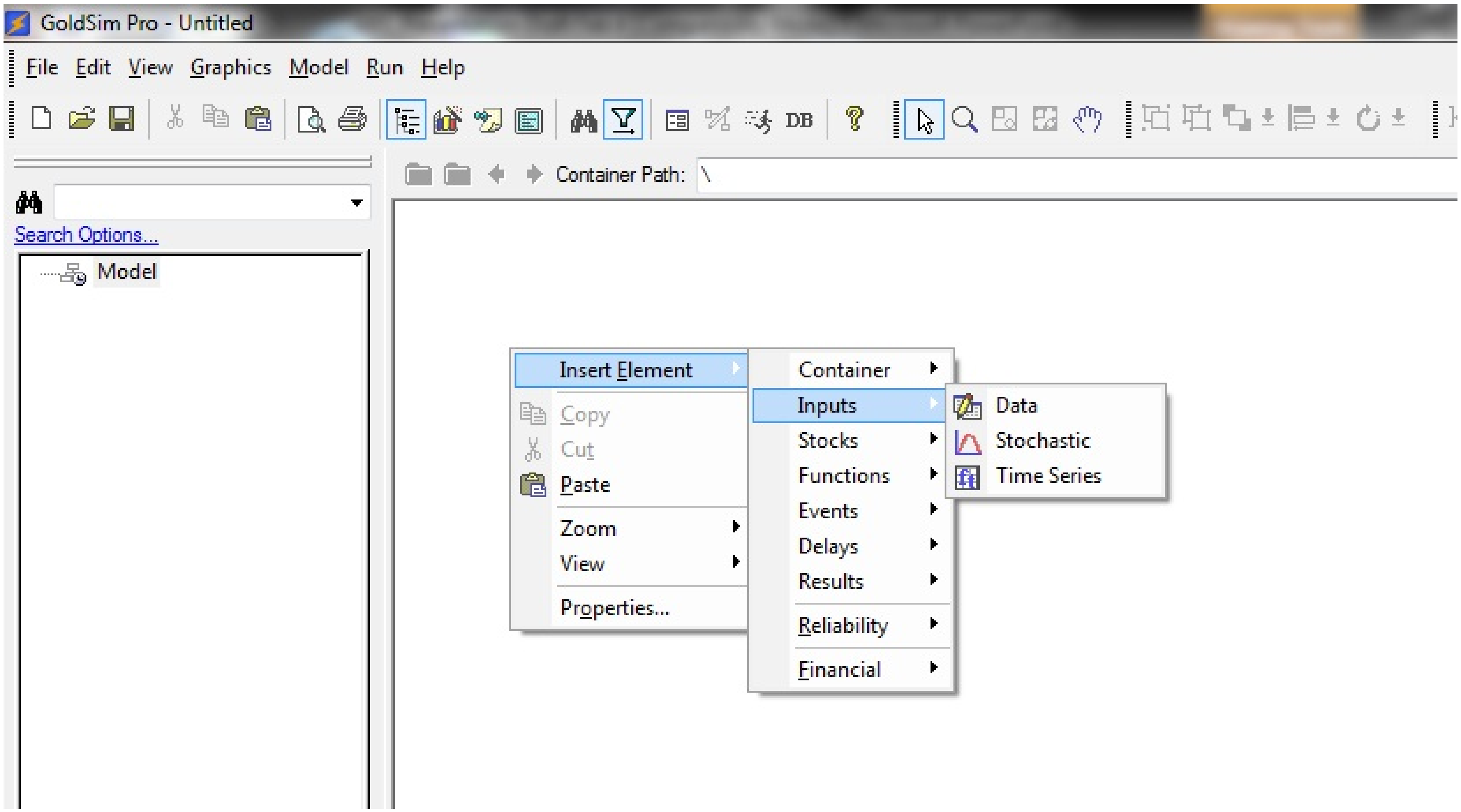


5.0 Producing the models

- 5.2 Building the models
  - Start with a structure in mind.
  - Inputs → Model → Outputs
  - Input data includes :
    - o Process criteria, flowrates
    - o Equipment capacities (Nor / Max / Design)
    - o Operating rules
    - o Planned maintenance freq and durations
    - o Unplanned stoppages (failure data)

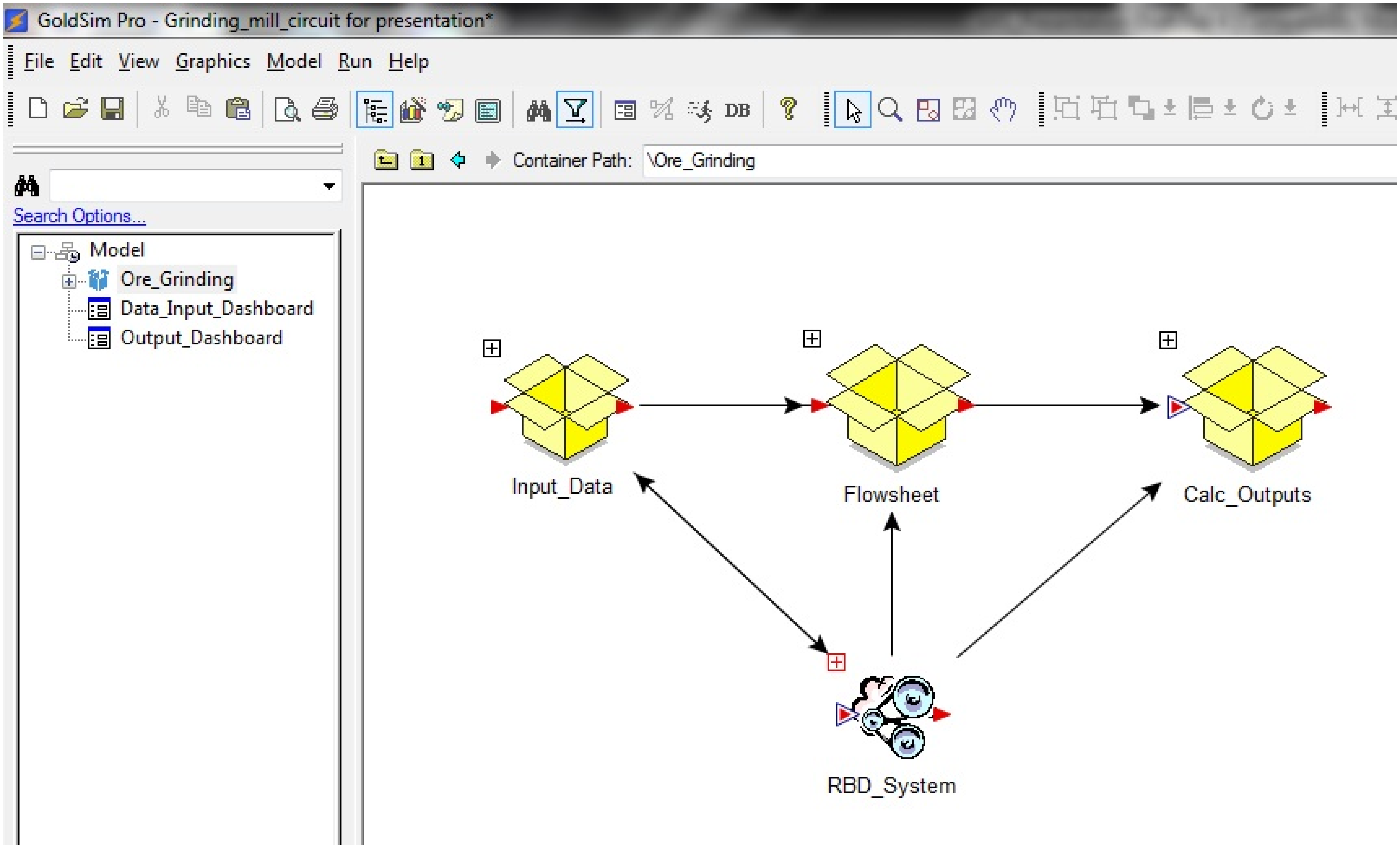
5.0 Producing the models

- Goldsim model architecture is flexible…



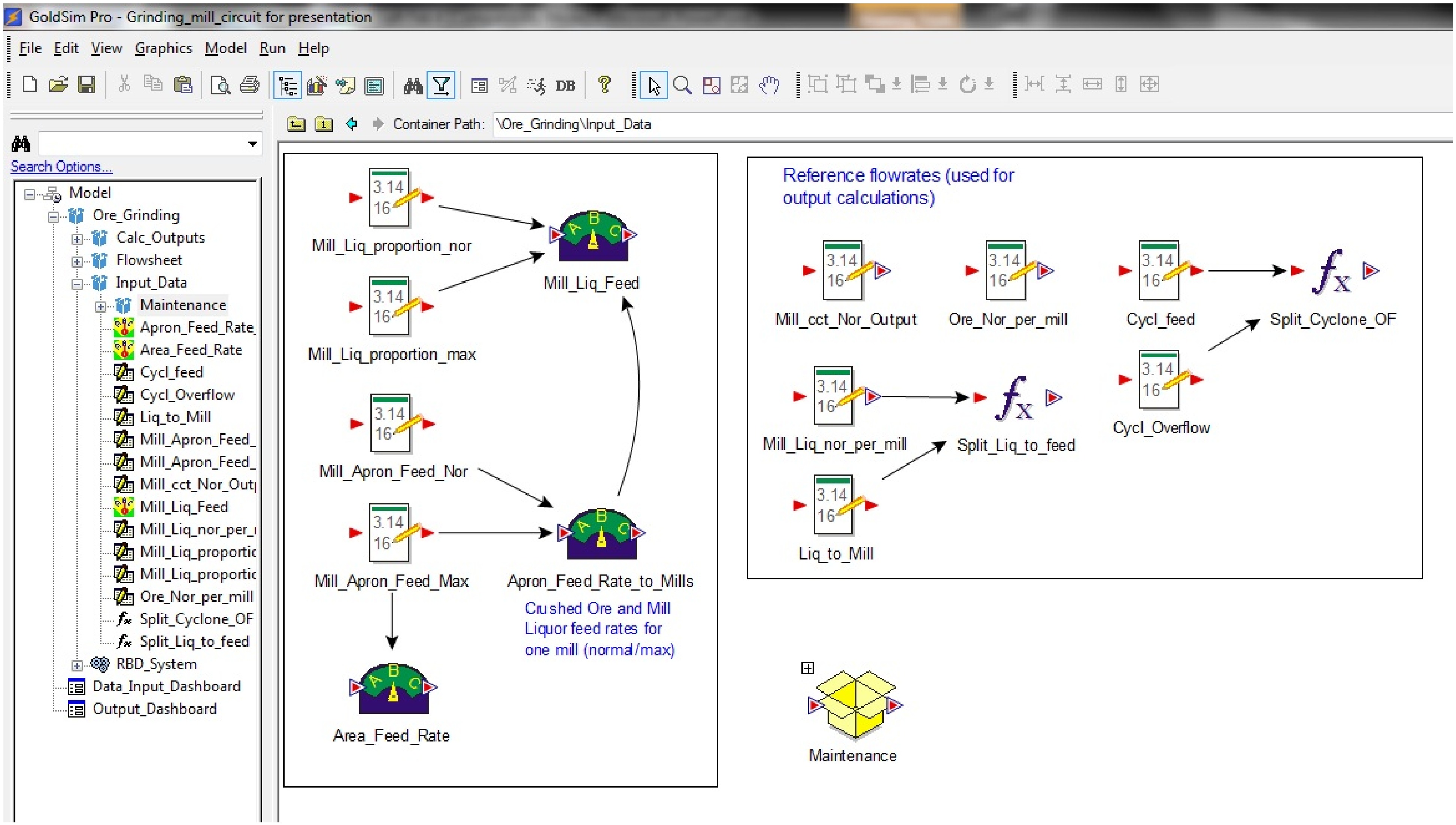
5.0 Producing the models

- So consistent model structures are essential.



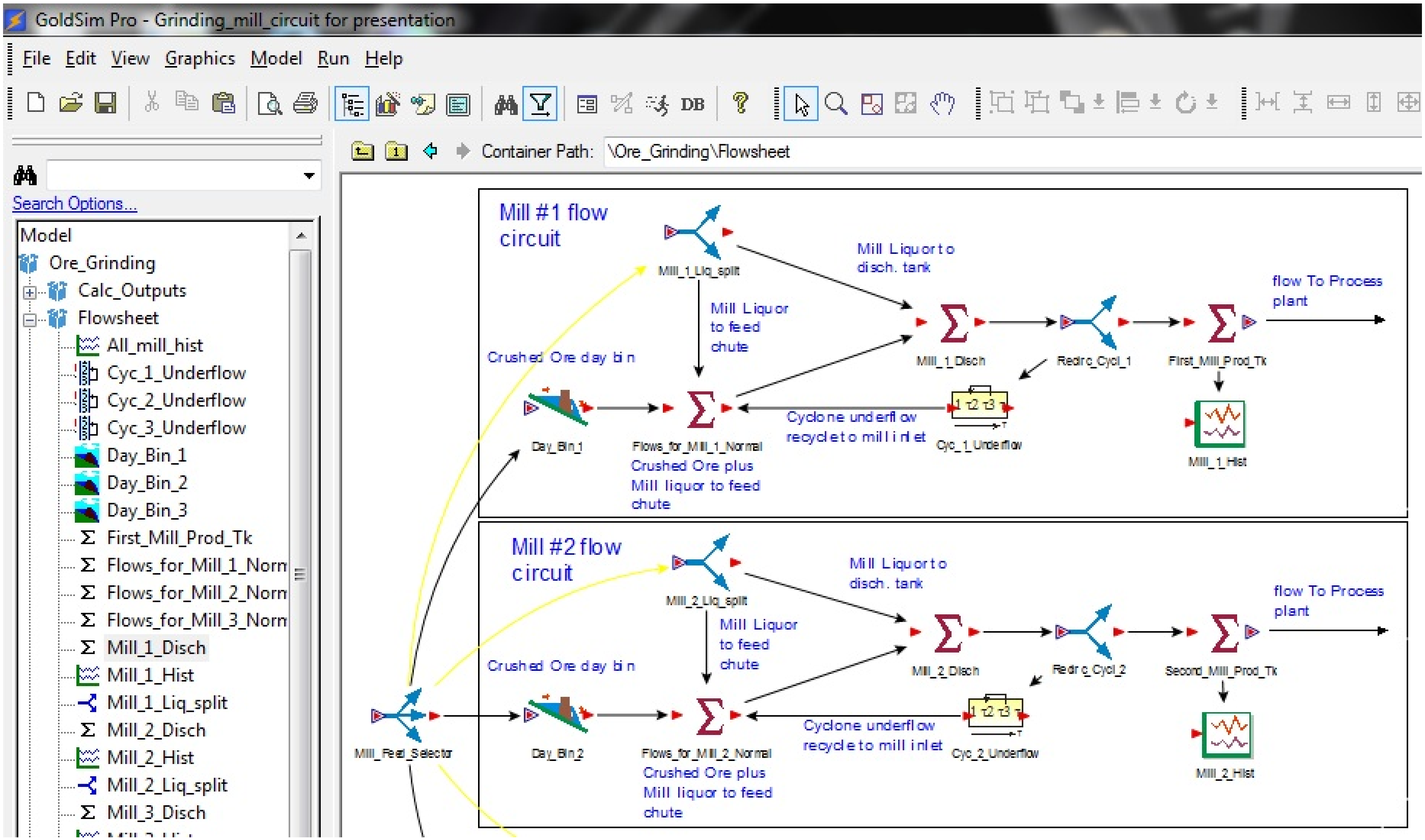
5.0 Producing the models

- Input data screen :



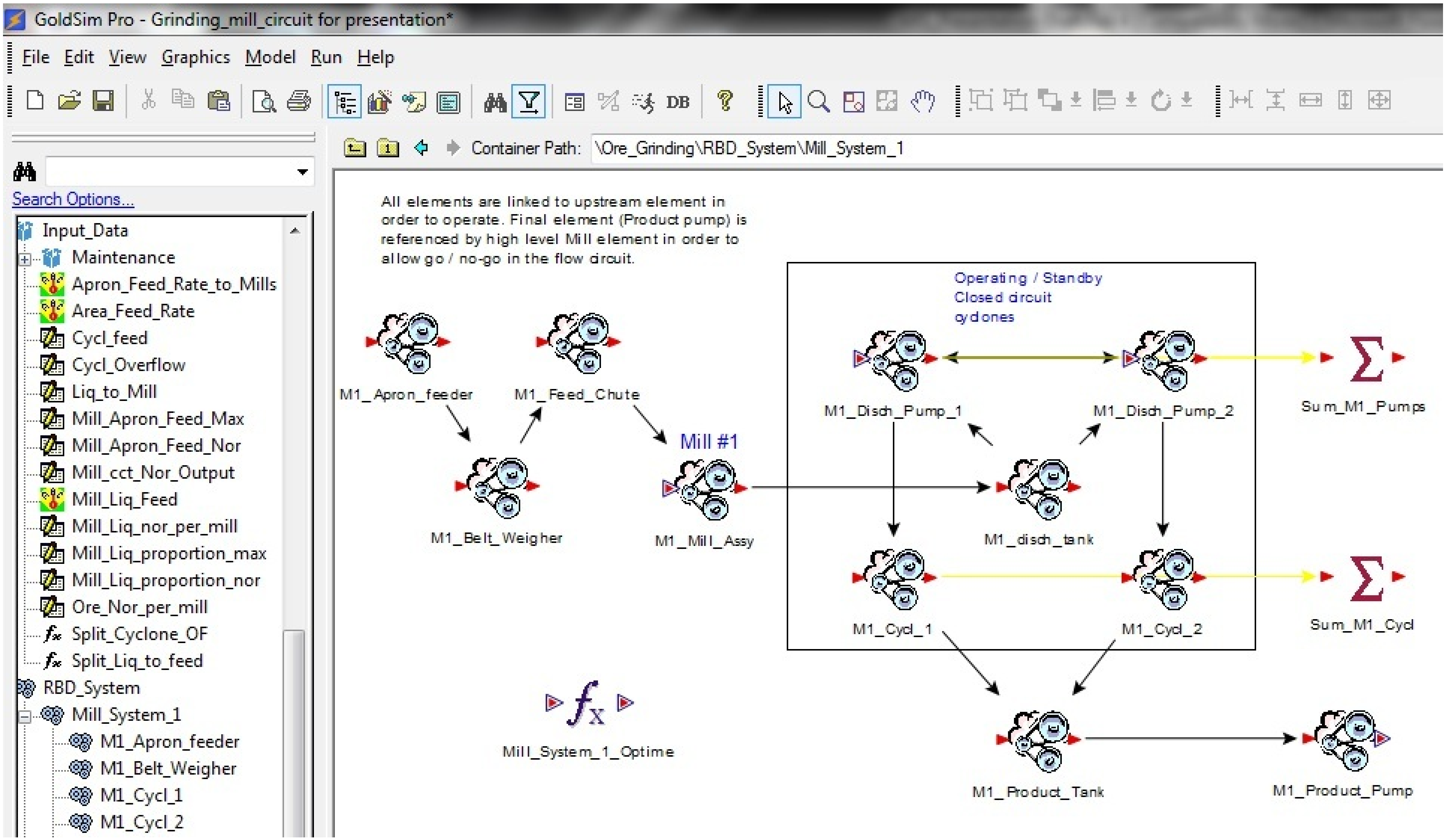
5.0 Producing the models

- Process flows :



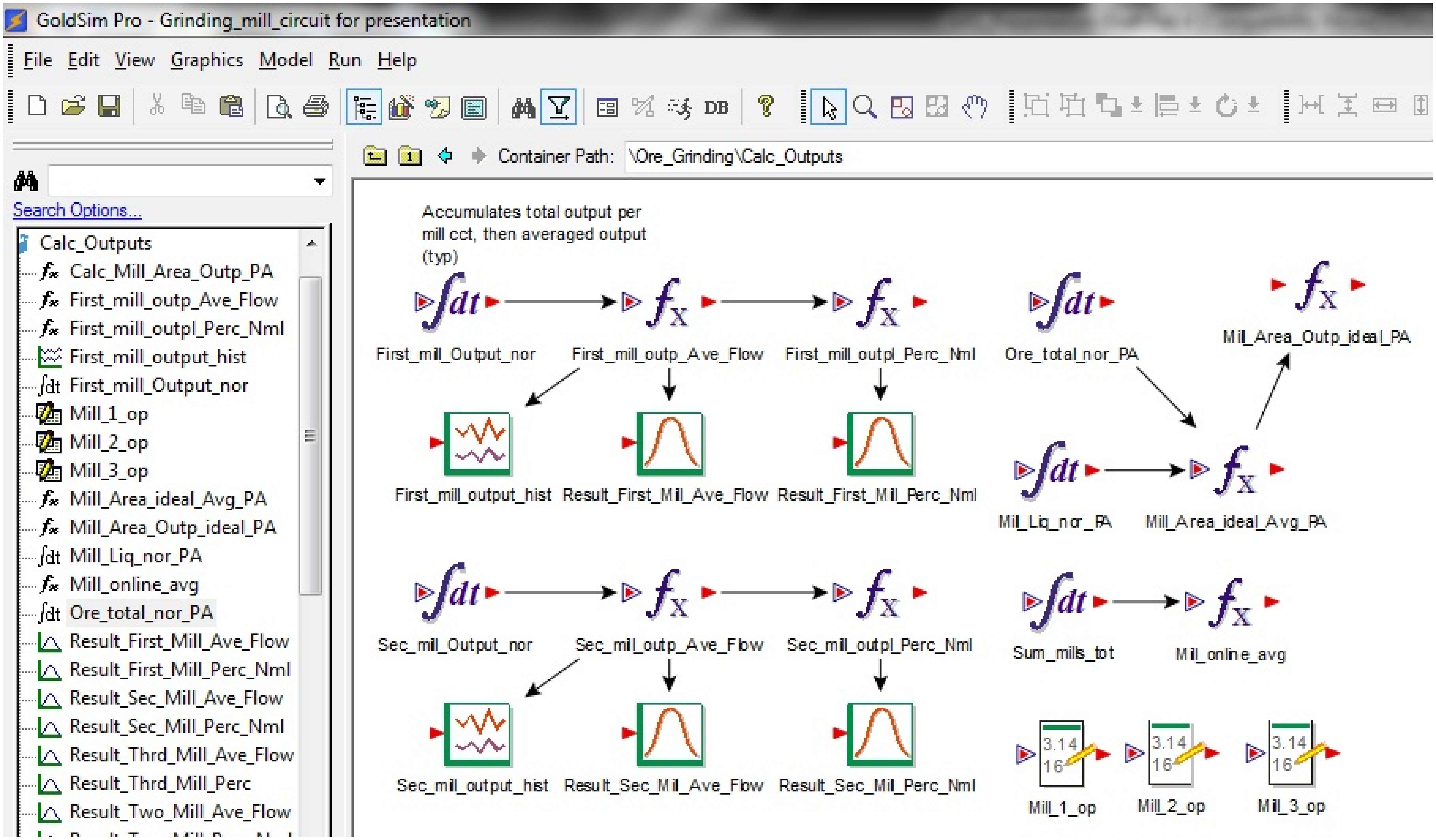
5.0 Producing the models

- Reliability/Equipment elements :



5.0 Producing the models

- Calculated output screen :

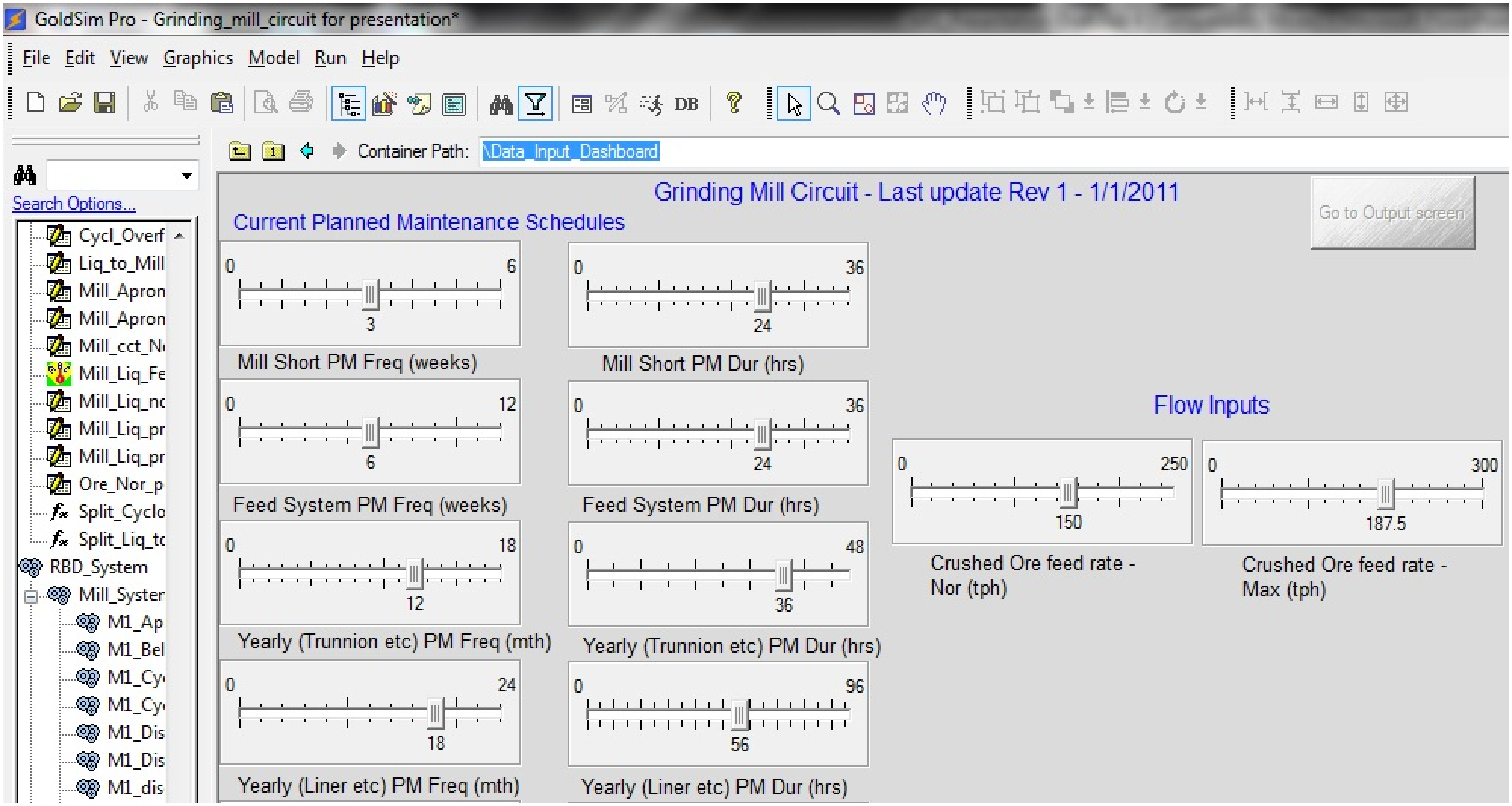


5.0 Producing the models

- 5.3 Developing models the client can use
  - Goldsim uses dashboards for client model interface.
  - Line up inputs in design criteria <u>*exactly*</u> with model dashboards.
  - Discuss resultant model outcomes face to face.
  - Input/Output dashboards for this project included the Grinding area.

5.0 Producing the models

- Client model interface – model inputs :



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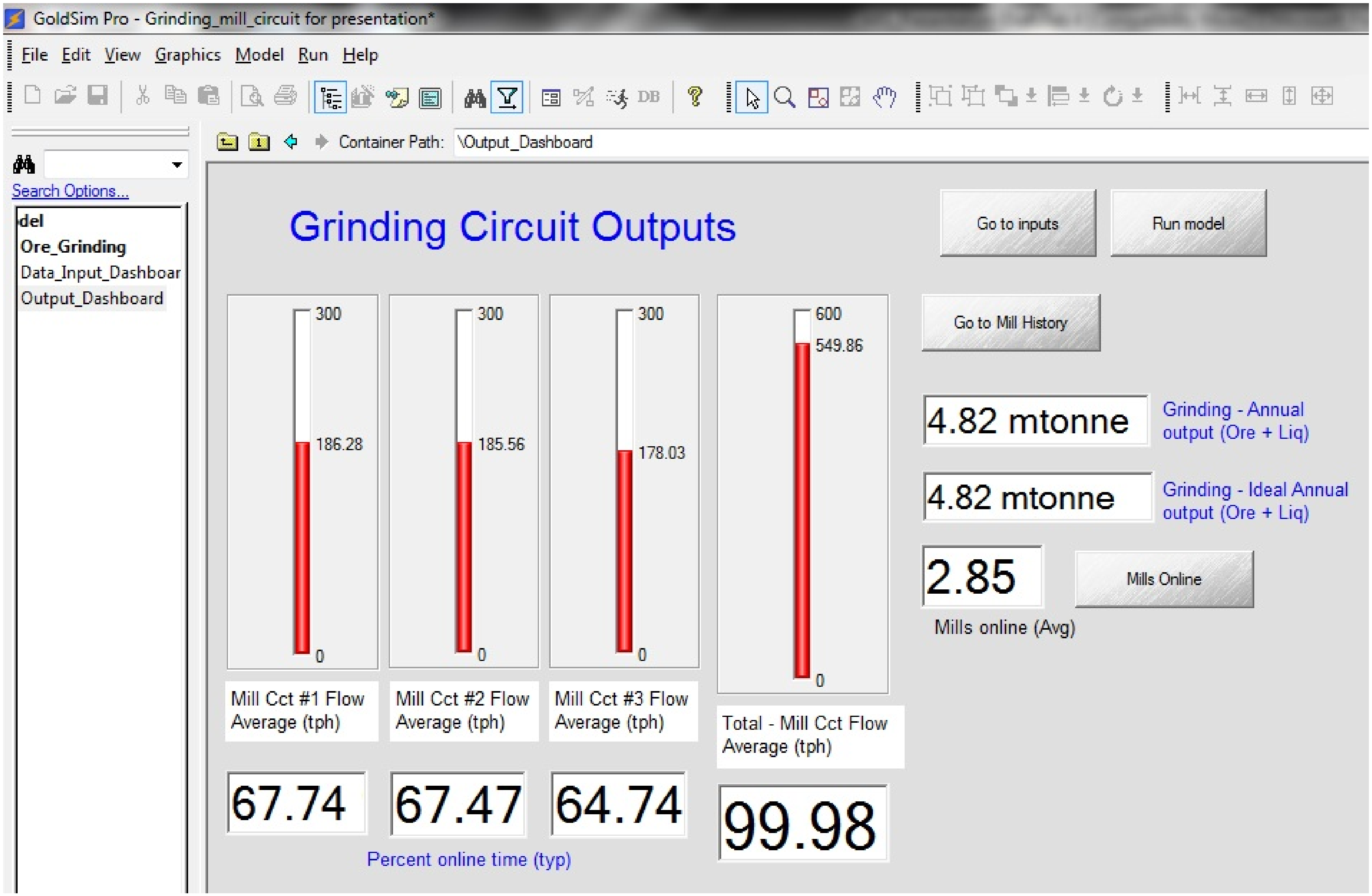
5.0 Producing the models

- Client model interface – model outputs :

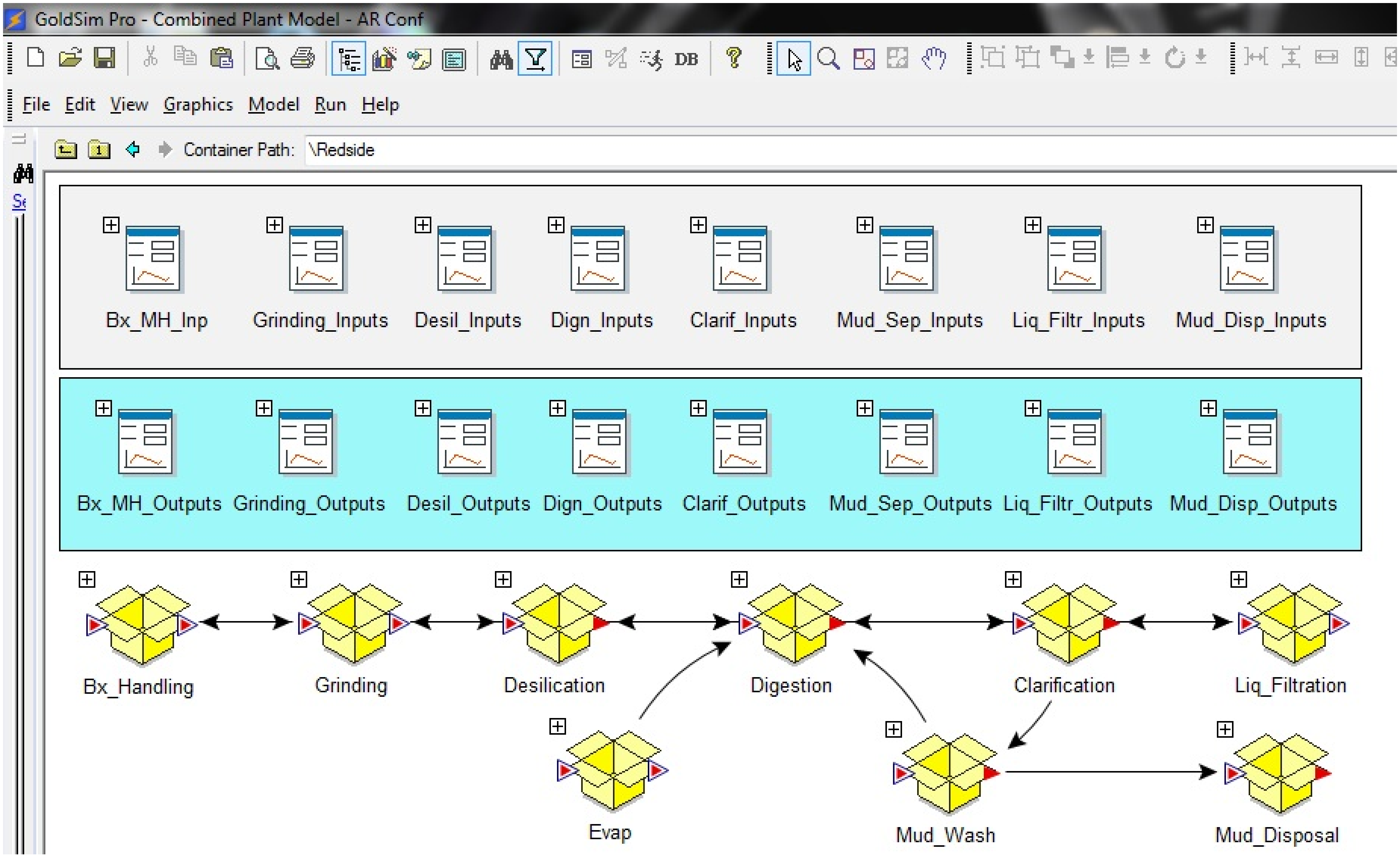


5.0 Producing the models

- 5.4 Building the combined plant model
  - Each area is built as a standalone model.
  - Utilise standard input/output formats.
  - Create a combined model by adding all process area models into one location.
  - Combined model simply connects inputs and outputs to provide a continuous circuit.
  - Important to re-evaluate operating and maintenance connections between areas (!!!)

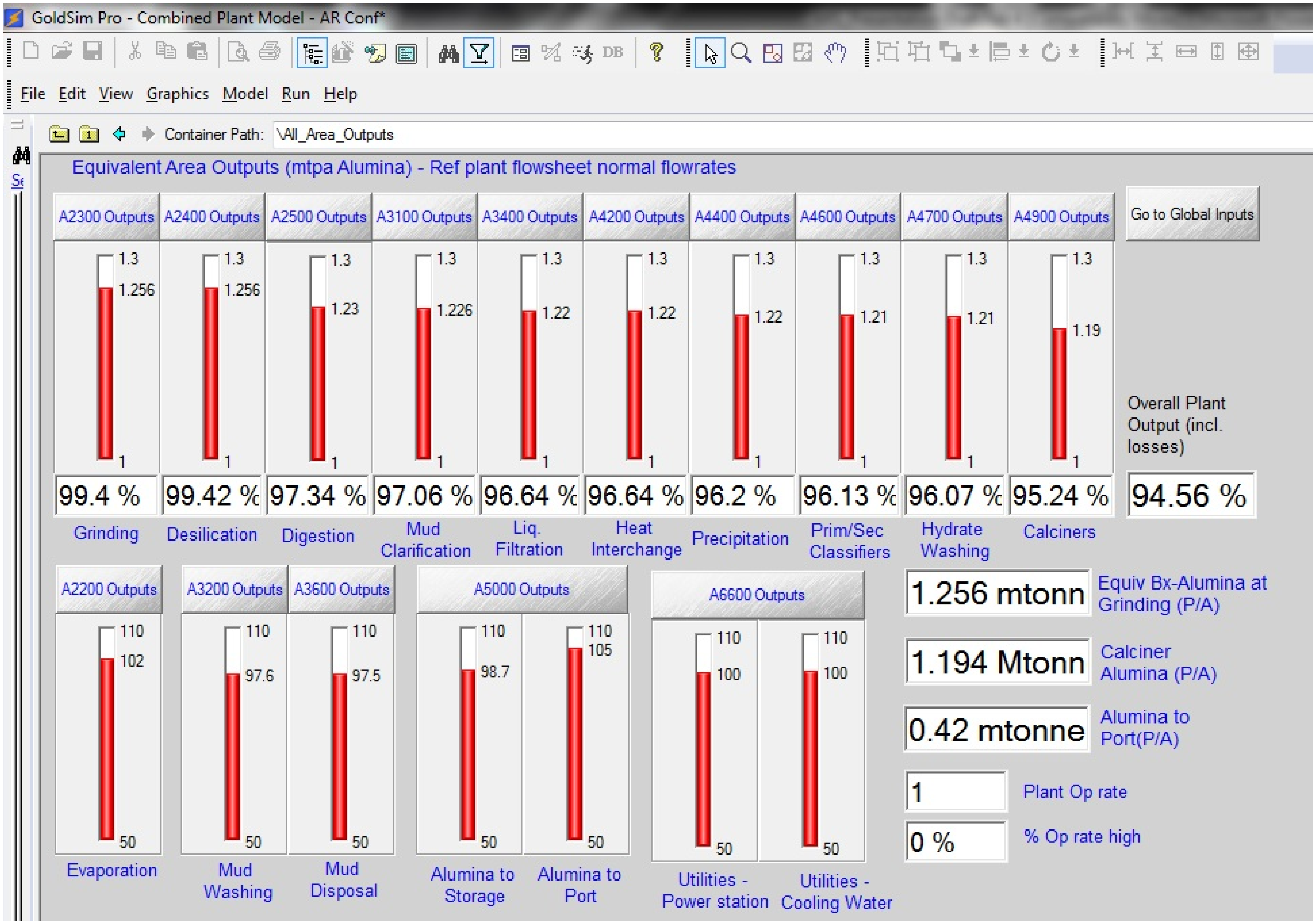
5.0 Producing the models

- Combined model assembly :



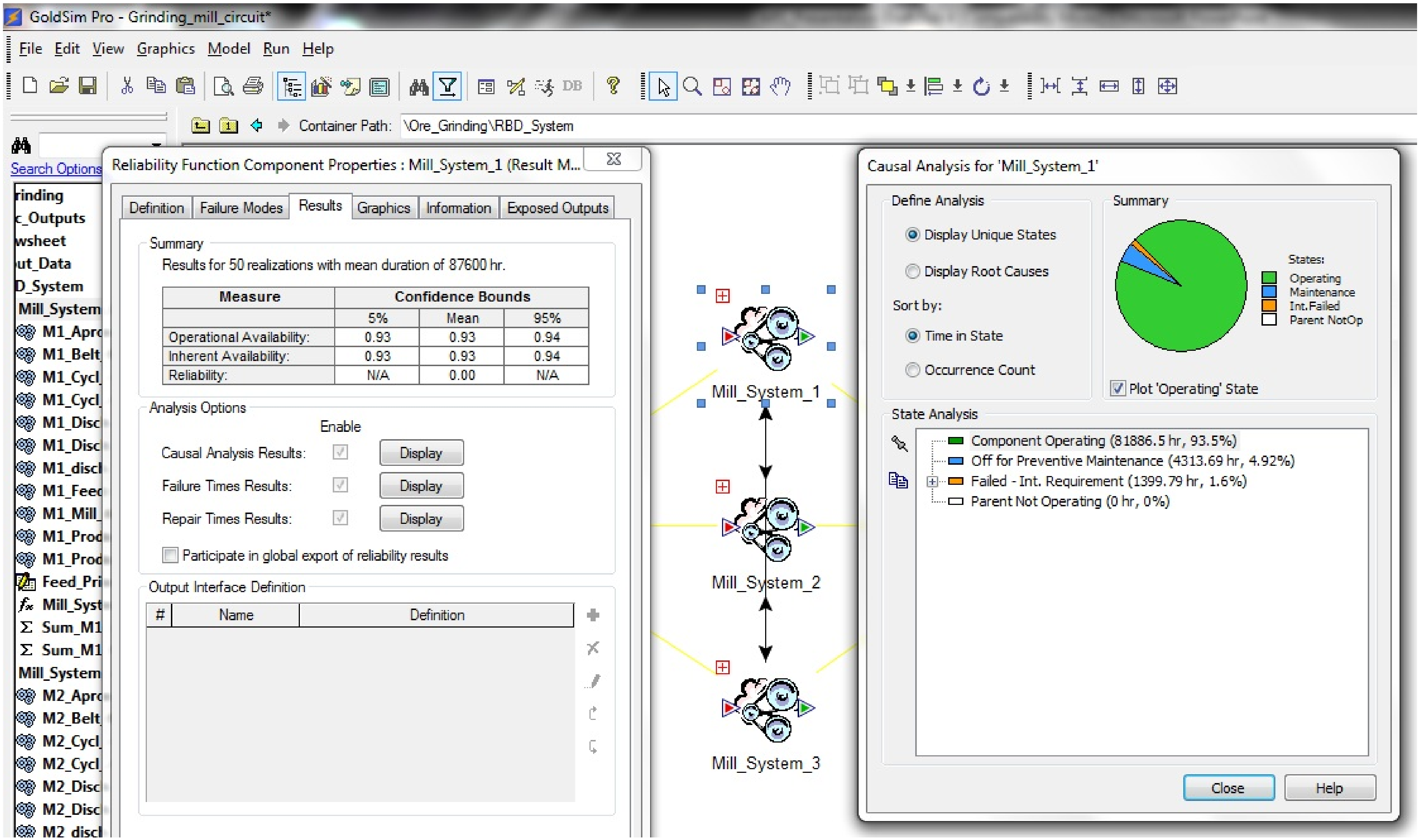
5.0 Producing the models

- Combined model – Overall Outputs :



5.0 Producing the models

- Combined model – System/Equipment analysis :



5.0 Producing the models

- Combined model – Bulk equipment analysis :

Model Description:
Exported on: 03/28/11 23:53:58
# of Realizations: 50

	Operational Availability			Inherent Availability			Reliability			Mean Time to Failure	Mean Time to Repair
Element ID	*5%*	*Mean*	*95%*	*5%*	*Mean*	*95%*	*5%*	*Mean*	*95%*	*hr*	*hr*
Mill_System_1	0.934248	0.934778	0.935307	0.934248	0.934778	0.935307	N/A	0	N/A	590	10.0878
M1_Apron_feeder	0.934247	0.934777	0.935307	0.99895	0.999021	0.999092	N/A	0	N/A	13412.9	13.4362
M1_Belt_Weigher	0.934248	0.934778	0.935307	0.999962	0.999971	0.999979	N/A	0	N/A	102245	3.90662
M1_Cycl_1	0.92041	0.920934	0.921458	0.991477	0.99155	0.991624	N/A	0	N/A	698.136	5.92896
M1_Cycl_2	0.920412	0.920914	0.921415	0.991385	0.991462	0.991539	N/A	0	N/A	697.283	5.96856
M1_Disch_Pump_1	0.928648	0.929171	0.929694	0.994148	0.994247	0.994347	N/A	0	N/A	991.115	5.69697
M1_Disch_Pump_2	0.928696	0.929207	0.929718	0.994178	0.99427	0.994361	N/A	0	N/A	998.717	5.70289
M1_disch_tank	0.934248	0.934778	0.935307	1	1	1	N/A	0	N/A	103063	0.0898838
M1_Feed_Chute	0.934248	0.934778	0.935307	0.999537	0.999556	0.999574	N/A	0	N/A	8629.59	4.0102
M1_Mill_Assy	0.934242	0.934772	0.935303	0.990476	0.99099	0.991504	N/A	0	N/A	3179.18	27.0512
M1_Product_Pump	0.934248	0.934778	0.935307	0.994206	0.99429	0.994375	N/A	0	N/A	991.191	5.64851
M1_Product_Tank	0.934248	0.934778	0.935307	1	1	1	N/A	0	N/A	102393	0.0985797
Mill_System_2	0.934228	0.93474	0.935251	0.934228	0.93474	0.935251	N/A	0	N/A	585.442	10.1122
M2_Apron_feeder	0.934228	0.934739	0.935251	0.999015	0.999095	0.999175	N/A	0	N/A	13764.1	12.7041
M2_Belt_Weigher	0.934228	0.93474	0.935251	0.999956	0.999967	0.999978	N/A	0	N/A	97608.4	4.0137
M2_Cycl_1	0.92048	0.92098	0.92148	0.991463	0.991536	0.99161	N/A	0	N/A	699.077	5.9465
M2_Cycl_2	0.92045	0.920957	0.921463	0.991508	0.991586	0.991665	N/A	0	N/A	704.517	5.96399
M2_Disch_Pump_1	0.928706	0.929205	0.929705	0.994201	0.994282	0.994363	N/A	0	N/A	996.975	5.67152
M2_Disch_Pump_2	0.928632	0.929138	0.929644	0.994156	0.994235	0.994315	N/A	0	N/A	988.513	5.67689
M2_disch_tank	0.934228	0.93474	0.935251	1	1	1	N/A	0	N/A	108461	0.102898
M2_Feed_Chute	0.934228	0.93474	0.935251	0.999539	0.999557	0.999574	N/A	0	N/A	8512.74	3.91783
M2_Mill_Assy	0.934223	0.934734	0.935246	0.99044	0.990887	0.991335	N/A	0	N/A	3128.15	27.2402
M2_Product_Pump	0.934228	0.93474	0.935251	0.994137	0.994224	0.994312	N/A	0	N/A	986.68	5.67177
M2_Product_Tank	0.934228	0.93474	0.935251	1	1	1	N/A	0	N/A	102965	0.103303
Mill_System_3	0.934098	0.934553	0.935008	0.934098	0.934553	0.935008	N/A	0	N/A	579.995	10.19

6.0 Model Outputs and Issues

- 6.1 Project requirements
  - Phased development – client is always confident of outcomes at each project milestone (no black box !!).
  - Use agreed inputs via reviewed design criteria.
  - Determine all model scenarios to be evaluated.
  - Present findings with a wider audience in mind (visual comparisons rather than just numbers).

6.0 Model Outputs and Issues

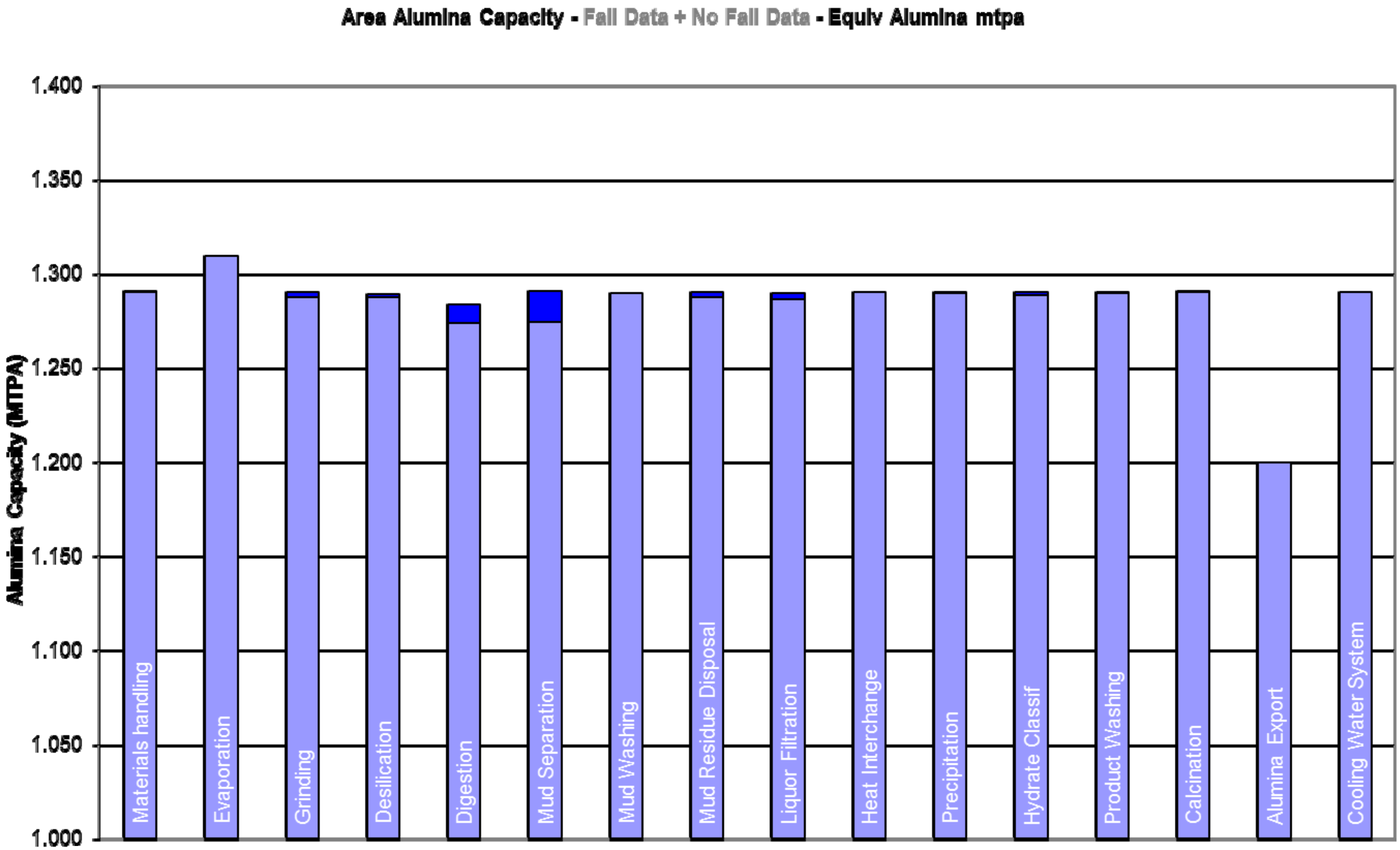
- Multiple model scenario investigations :
  - S1 - Evaluate baseline operating and maintenance criteria using initial design.
    - Look for areas with largest production shortfall and identify causes (Ops / Mtce / Design?).
  - S2 - Examine initial design assumptions – redundancy.

6.0 Model Outputs and Issues

- Multiple model scenario investigations :
  - S3 - Case studies included minimum level of equipment (i.e., no spares) to show where they are really needed.
  - S4 – Ran area and combined models both with and without failure modes to show both sensitivity (to failures) and plant potential in ideal conditions.

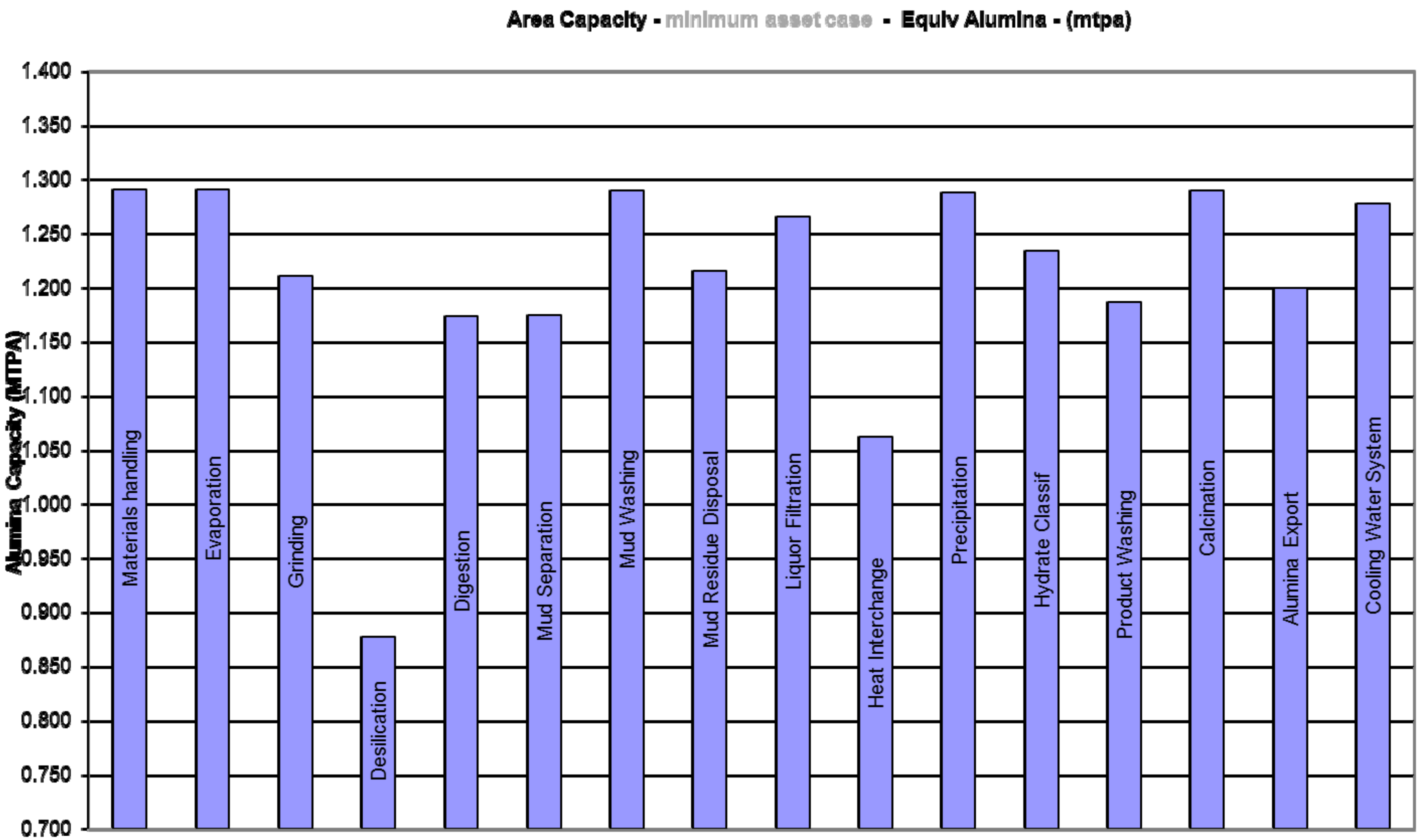
6.0 Model Outputs and Issues

- Model Results – by Area – as designed :



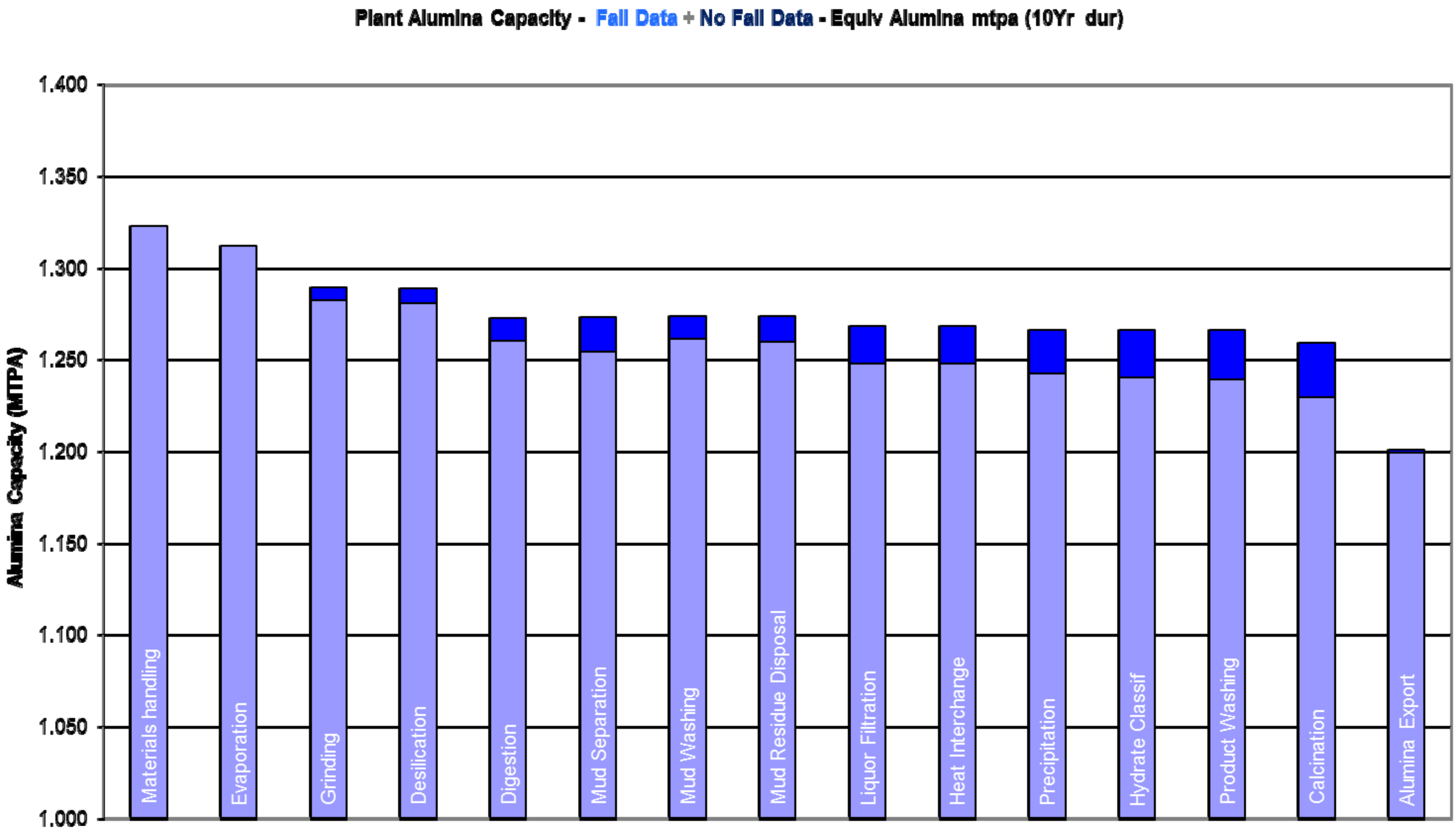
6.0 Model Outputs and Issues

- Model Results – by Area – minimum asset case :



6.0 Model Outputs and Issues

- Model Results – Combined Output :



7.0 Summary

- Case Study project outcomes
  - Clear definition and alignment of design data was achieved before detailed design process.
  - Proved the design engineer's operating factor assumption was exceeded (for given criteria!).
  - Provided a statistical basis for the plant design capacity for the client's project cost estimate.

7.0 Summary

- Case Study project outcomes
  - Also showed several process areas where value improvements could be investigated.
  - Client now has a tool to validate further maintenance strategy inputs vs. plant capacity.

7.0 Summary

- Capacity modelling vs. project stages
  - Early adoption (Feasibility/Study stage) – Capital savings through optimizing equipment capacities and redundancy.
  - During Design (Prelim/Basic engineering) – Value engineering processes, confirming effects of maintenance and operating strategies on adopted design.

7.0 Summary

- Capacity modelling vs. project stages
  - Detailed Engineering and construction – Use to refine and verify maintenance strategy development processes (e.g., RCM). Also provide initial resourcing estimates for labour, commodities (spares) etc.
  - After Startup – Verify model vs. plant outputs, then use for both capital and maintenance program validation.

7.0 Summary

- Value adding
  - Resourcing – Run the models to gauge resource requirements for varying strategies (labour, spares, commodities etc).
  - Energy – Energy use is time and condition related – so can be built into these models (e.g., pump efficiency vs. changeout freq).
  - Model company wide operational and mtce initiatives across multiple facility models before making the change (!).

Where to Get More Information

- Web links
- www.ssr-eng.com
- www.goldsim.com
- E-mail : damien@ssr-eng.com
- or : info@ssr-eng.com

Questions

Thank you for your attention ☺

Do you have any questions?