VISUALIZED FUELLING PROCESS AND 3 DIMENSIONAL REACTIVITY DEVICE AND CORE MONITOR

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Abstract

A new reactor fueling animated graphical display and a 3 dimensional view of the reactor core display are presented that are useful for the physics fuelling engineer, the Control Room Operators, the fuel handling operators and the fuel handling support engineers. Data is downloaded from the online fuelling computer to a data server that is network accessible. The fuelling display and 3Dview display can run on any network connected Computer. The animated graphical fuelling display offers a huge reduction in cognitive workload for all users. The authors recommend that animated graphical displays be developed and utilized wherever personnel have to visualize complex equipment operation.

Introduction

The Point Lepreau G. S. fuelling regiment calls for 14 channels per week, fuelling Monday, Tuesday, Thursday and Friday usually between 8am and 8pm. Weekends are avoided where possible. Monday, the Control Room Operator (CRO) collects Control Room Routine CR-03 physics data then fuels 5 channels. Tuesday the CRO fuels 4 channels. Wednesdays are reserved for fuelling machine maintenance days. Thursday, the CRO again collects CR-03 physics data and fuels 5 channels. Four different work groups are involved in four different departments. The Fuelling Specialist’s goal is to determine which fuel channels have exhausted fuel bundles and which of those fuel channels needs to be fuelled next with 8 new bundles to support core reactivity and flux shape.

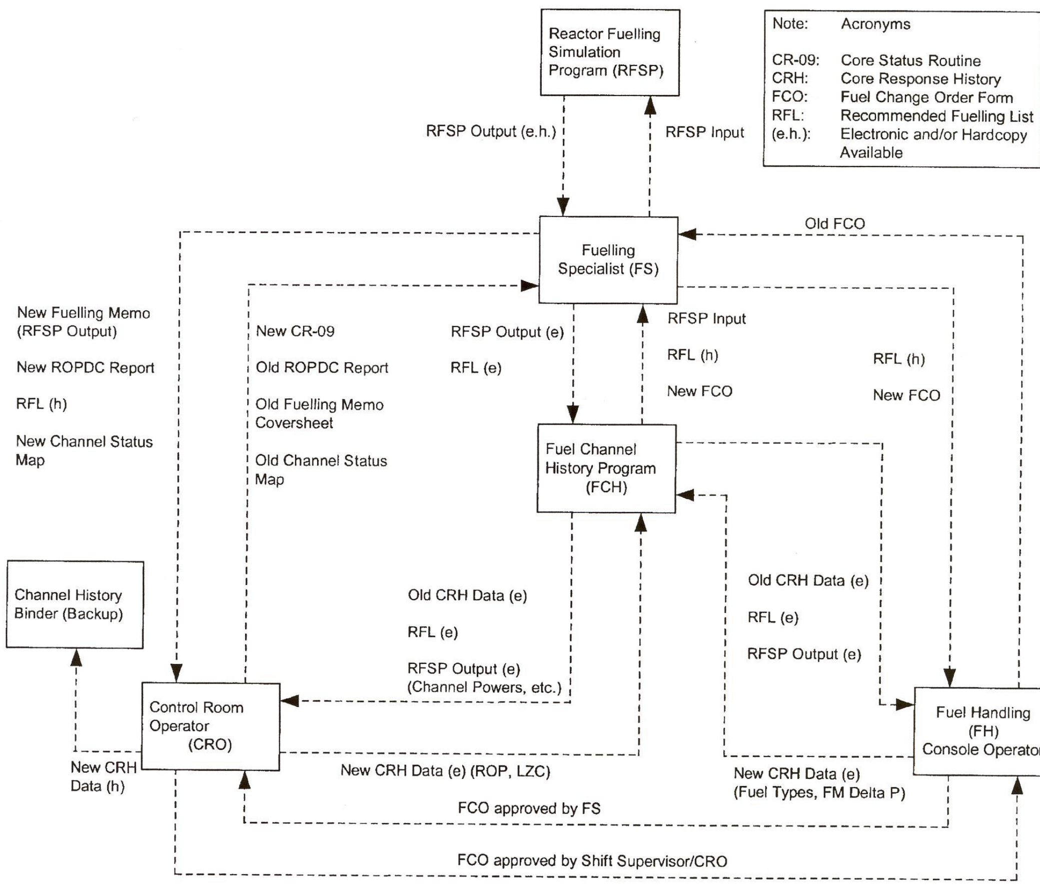
Fuelling Process

The fuelling process revolves around 4 work groups and 4 computer programs. The 4 work group positions responsible for fuelling are: Fuelling Specialist (FS), Control Room Operator (CRO), Shift Supervisor (SS) and the Fuel Handling Operator (FH). The 4 computer programs are Reactor Fuelling Simulation Program (RFSP), Fuel Channel History (FCH), Channel Temperature Monitoring (CTM) and Zone Level Predictor (ZLP). The following briefly describes the activities of each position and the uses of the computer programs.

Fuelling Process Diagram

Figure 1: Reactor Fuelling Process

Figure B.17 - Process and Document Control for Reactor Fuelling



Fuelling Specialist (FS)

The FS schedules fuelling such that the Reactivity Target is met and Steady State core conditions are established for RFSP production runs and subsequent issue of the Regional Over Power Detector Calibration (ROPDC) report. To accomplish these goals, the FS selects channels to be fuelled such that Safety Analysis limits on bundle and channel power (power density) are not exceeded, Spatial control is not compromised, ROP margins-to-trip are acceptable, the time-averaged burn-up distribution is achieved and target defect probability is not exceeded and failed fuel bundles are removed in a timely fashion. The FS produces and signs the Recommended Fuelling List (RFL), the Fuel Change Order (FCO), the Fuelling Memo that includes the reactivity balance and target reactivity, tolerances on spatial control, and current physics data. Finally, the Physics Group produces the Regional Over Power Detector Calibration (ROPDC) report.

Control Room Operator (CRO)

The CRO is at the hub of the fuelling process once it begins in the Main Control Room. The CRO confirms that the ROPDC report is valid and ensures fuelling will not affect the scheduled collection of RFSP Core Monitoring Data collected by Control Room routine CR-03. The CRO checks that the information attached to the Fuelling Memo is current and that the paperwork required for an update to the Recommended Fuelling List is complete before fuelling. Throughout the week, the CRO tries to achieve the Acceptable Water Level Deviations listed on the Fuelling Memo and explains why any tolerances were not met. Because there is no fuelling on Wednesdays, the CRO checks CR-34 on Thursday morning to ensure that the current fuelling schedule is adequate to meet the reactivity target. The CRO always checks the Channel Status Map before fuelling to identify channels not available for fuelling due to instrumentation or other restrictions and identify those with specific restrictions or notes to be observed during fuelling. When a channel fuelling is complete, the CRO checks that the fuelling date and time entered in the Fuel Channel History program by both the CRO and FH and that on the FCO all agree. To wrap up, the CRO confirms that the required paperwork is attached to the FCO.

Shift Supervisor (SS)

The SS has an oversight and approval responsibility. S/he ensures that the fuel is adequately cooled at all times, ensures that the power density limits are met by enforcing set rules, approves the Fuel Change Order (FCO), accepts and issues the ROPDC report, if a technical specialist review is unavailable, and authorizes changes to the fuelling schedule and/or revisions to the Recommended Fuelling List (RFL).

Fuel Handling Operator (FH)

The FH operates the computerized fuelling machines by loading them with the correct specified new fuel and then inserting that fuel into the correct reactor channel. The FH also uses the Recommended Fuelling List (RFL) and a new Fuel Change Order (FCO). The Control Room Operator and the Shift Supervisor must approve the FCO before fuelling takes place. The FH uses the Fuel Channel History Program to check old Core Response History data, the Recommended Fuelling List on screen and RFSP output data.

Fuelling Support Engineers

The Fuelling Support Engineers are not part of the immediate fuelling loop. Their use of the Fuelling Monitor is being developed. They are expected to benefit greatly from the use of the Fuelling Monitor display.

Reactor Fuelling Simulation Program (RFSP)

The RFSP computer program is used for criticality control and reactivity assessment. The FS routinely uses RFSP to calculate the channel power distribution and to update the reactivity balance. Three simulations are used to assess the current core conditions. The production run uses a diffusion theory based computation of an updated rippled fundamental flux shape followed by a Powermap calculation. To include the fuelling, since the last production run and achieve steady state core conditions, there must be a non-fuelling period of typically 16 hours. The FS also computes excess reactivity with this program.

The Powermap Run is used to compute channel power distribution; but not excessive reactivity. Powermap can be used when a non-fuelling period of 16 hours is not operationally feasible and it can be done within 30 minutes if the rippled fundamental from the previous Production Run is judged to be acceptable.

Predictive Simulations is a diffusion theory based option that uses anticipated core conditions and can be executed anytime. Predictive Simulations can be run when unexpected revisions to the fuelling list emerge and the impact on peak channel power of the next channel(s) to be fuelled is required.

Fuel Channel History (FCH)

The FCH program is a 3 user program that provides a series of operations screens for use by the CRO, fuel handling screens for use by the FH during fuelling and physics screens for the FS. The CRO and FH use FCH as a database of historical fuelling information to permit a quick assessment of the impact a current fuelling evolution may have on present core conditions. The CRO and FH both enter after channel fuelling data into the FCH program. A measure of quality control on the fuelling process and the FCH database is gained by only allowing fuelling information to be entered into the database only if the FS has included the channel on the Recommended Fuelling List (RFL). The FS uses FCH to provide input to RFSP including date, time channels are fuelled and type of fuel, by pallet number. The FS takes the output from RFSP and inputs it into FCH, including channel burnup and power. The FS makes up the RFL through the FCH physics screens. This completes the 3-way link through the computer network.

Fuel Channel History Program Display

Figure 2: Fuel Channel History Data Input Screen

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 NB Power - CHANNEL DATA INPUT                          ADDITIONS        CT2FC24
Data Entry

01: CHANNEL : P06            14: DP 1 : 622                  23:SDS1 9F    0.0
02: DATE    : 2003/04/14     15: DP 2 : 627                  24:   -- 2D   0.0
03: TIME    : 13:50          16: DDP  : 5                    25:   -- 9E   0.0
04: FCO     : 11295          17: MAX CHANNEL     : O17       26:   -- 5E   0.0
05: CRO     :                18: MAX CHAN PWR(1) : 6.70      27:   --      0.0
06: T(0) :                   19: MAX CHAN PWR(2) : 6.80      28:   --      0.0
07: T(5) :                   20: DPWR   :  0.01 (%)          29:SDS2 7H    0.0
08: CHANNEL BURNUP     : 155 21: DERATE :   0                30:   --      0.0
09: CHANNEL PWR/RFSP   : 6.06 22: PLIN   :   0.0             31:   --      0.0
10: CHANNEL PWR/FLX(1) : 0.00                                32:   --      0.0
11: CHANNEL PWR/FLX(2) : 0.00                                33:   --      0.0
12: AZL(1): 51                                               34:   --      0.0
13: AZL(2): 53                                               35: DC :   0.0

36:    COMMENTS :
37:
38:

 FIELD NUMBER TO CHANGE  :
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Channel Temperature Monitoring (CTM)

CTM is a Control Computer program that measures and displays the 380 channel temperatures. Each channel has a characteristic temperature response signature during the fuelling process.

Channel Temperature Monitoring Program Display

Figure 3: Channel Temperature Monitoring Analog Input Map

ADD 3000 TO EACH ENTRY SHOWN IN MAP

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
A									777	476	776	475	775	474									A
B						754	452	753	451	751	450	750	447	747	446	746	473						B
C					755	416	716	415	715	414	714	413	713	412	712	411	745	472					C
D				756	417	665	363	664	362	663	361	662	360	661	357	660	410	744	471				D
E			757	420	666	333	634	332	633	331	632	330	631	327	630	326	657	407	743	470			E
F			421	667	334	606	304	605	303	604	302	603	301	602	300	601	325	656	406	742			F
G		422	670	335	607	261	561	260	560	257	557	256	556	255	555	254	600	324	655	405	741		G
H		717	364	635	305	562	237	536	236	535	235	534	234	533	233	554	277	627	356	711	445		H
J	760	423	671	336	610	262	537	220	520	217	517	216	516	215	532	253	577	323	654	404	740	467	J
K	453	720	365	636	306	563	240	521	206	506	205	505	204	515	232	553	276	626	355	710	444	774	K
L	761	424	672	337	611	263	540	221	507	200	500	177	504	214	531	252	576	322	653	403	737	466	L
M	454	721	366	637	307	564	241	522	207	501	176	477	203	514	231	551	275	624	354	707	443	773	M
N	762	426	673	340	612	264	541	222	510	201	502	202	503	213	530	251	575	321	652	402	736	465	N
O	455	722	367	640	310	565	242	523	210	511	211	512	212	513	230	550	274	623	353	706	442	772	O
P		427	674	341	613	265	542	223	524	224	525	226	526	227	527	250	574	320	651	401	735		P
Q		723	370	641	311	566	243	543	244	544	245	545	246	546	247	547	273	622	351	705	441		Q
R			724	371	642	312	567	266	570	267	571	270	572	271	573	272	621	350	704	440			R
S			456	725	372	643	313	614	314	615	315	616	316	617	317	620	347	703	437	771			S
T				457	726	373	644	342	645	343	646	344	647	345	650	346	702	436	770				T
U					460	727	374	675	375	676	376	677	377	700	400	701	435	767					U
V						461	730	430	731	431	732	432	733	433	734	434	766						V
W									462	763	463	764	464	765									W
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	

Zone Level Predictor (ZLP)

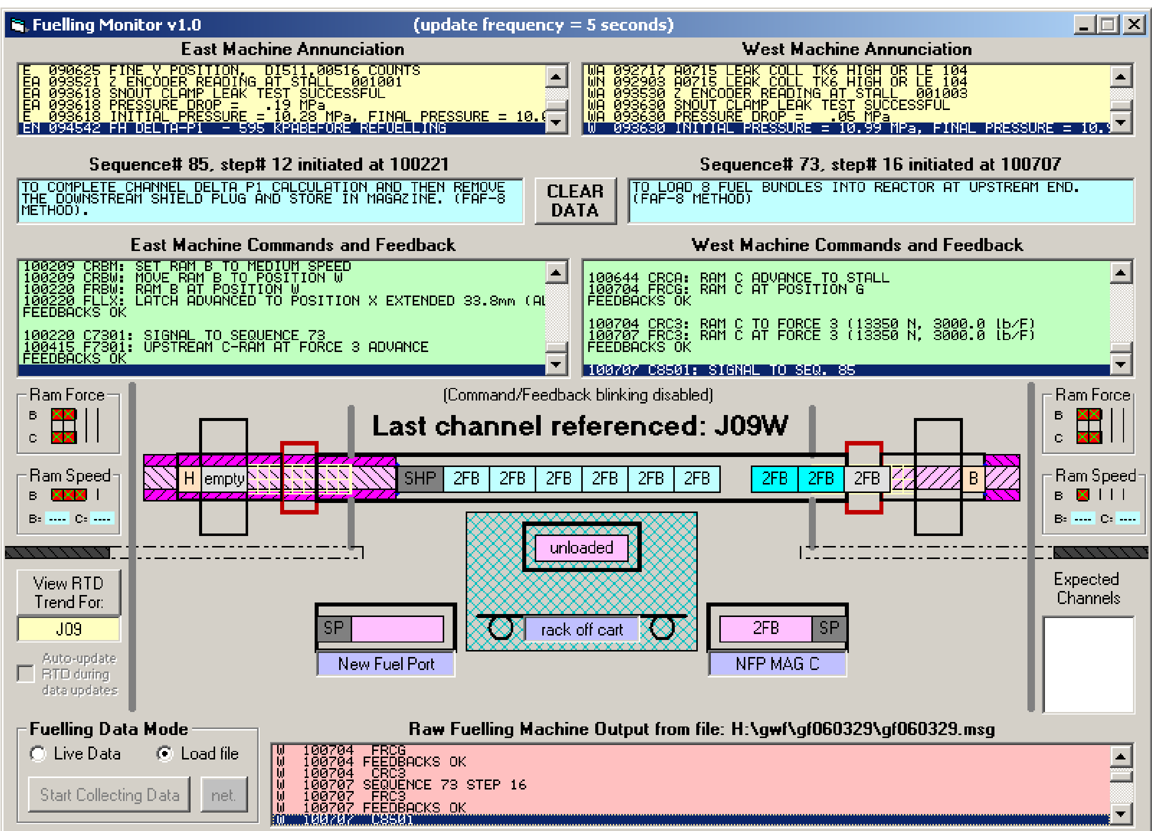
An acceptable zone level configuration is to be achieved at the completion of both daily and weekly fuelling. The ZLP is a PC program running on the CRO's PC. It is used to predict the zone level configuration after fuelling one or more channels. The program uses data from previous fuelling visits input into the Fuel Channel History program by the CRO. The data is extracted form the FCH database and averaged. Using a procedure, ZLP enables the CRO to plan the daily fuelling so that zone level predictions should be within +- 5% after one day's fuelling.

The four work group positions and the four computer programs have been used at Point Lepreau GS almost from startup commissioning. Now, two new displays are being used by the Fuelling Specialists to enable them to do their job. These two displays are sure to be even further developed and improved and used by others. The Fuelling Monitor and the 3-D View are presented in the following sections.

Fuelling Monitor Display

The Fuelling Monitor Display has 8 major panels of information. There are 2 annunciation panels, 2 Sequence display panels, 2 Machine Commands and Feedback panels, the Last Channel Referenced graphical display and a Live Fuelling Machine Output panel. Several patches of fuelling machine information are presented on both sides of the main graphical area.

Figure 4: Fuelling Monitor Display



The Fuelling Specialist is the major user of the Fuelling Monitor at the present time.

The Fuelling Process clearly demonstrates complex, interactive, multi-user processes that to-date have had little support for visualization aspects of the process. This is a week long process of reactivity control with multi layers of response delay at every user interface. There is no lack of forms and hard copy output of RFSP reactor face maps and data

tabulations to make this process work. Without some form of visual representation of so many aspects of this fuelling process, the formation of a mental model to facilitate understanding is difficult and taxing on the users. Truly the mental model, until now, has been supported by paper based instruments, indicators and dials and text messaging.
The Fuelling Monitor and 3Dview Displays now support the mental model by live update, colourful, 2 dimensional and 3 dimensional graphic, animations.

The Fuelling Specialist is now in the loop. The FS can now visually follow a process that s/he started on a Monday morning and keep up with process events at every instant through the process week. Monitoring the execution of the Recommended Fuelling List and the Fuelling Memo is the main task. Feedback in now available for the FS to collect the process conditions physics data and simulate on Thursday morning, permitting a check of the CRO's CR-03 data on Thursday morning before fuelling begins.

The Fuelling Specialist can assess reactor configuration, evolving situations and the CRO work load and judge how applicable the previous RFSP Production Run is and the need to perform RFSP updates and more simulations. For routine days, the FS monitors the daily progress to ensure acceptable zone levels for the end of each day and possible ripple concerns for the next day. Access to this information means that the FS does not trouble the Control Room Operator for update information to determine his/her next possible action. Operator's choice of channels to fuel can easily be monitored and any misinterpretation of the Recommended Fuelling List can be immediately addressed.

Knowing the status of fuelling is important because dropped channels affect predicted ripples and potentially detector calibration (DC) and they can affect zone water levels at the end of the day. Knowing status is also important if additional channels need to be scheduled and fuelled, to make up for dropped channels, before the end of the week. The FS needs to evaluate this situation and begin communicating this need to the appropriate work groups as soon as possible.

This type of monitoring avoids FS stress from receiving late day calls from operations to run a new simulation.

The Fuelling Support Engineers also have access to the Fuelling Monitor and can keep detailed track of the performance of the Fuelling Machines in the fuelling process. This aspect of monitoring will probably be further developed in the future.

3Dview Display

The 3Dview Display is a 3 dimensional view of the reactor core, reactivity devices and reactor instrumentation mechanisms.

Figure 5: 3Dview Display

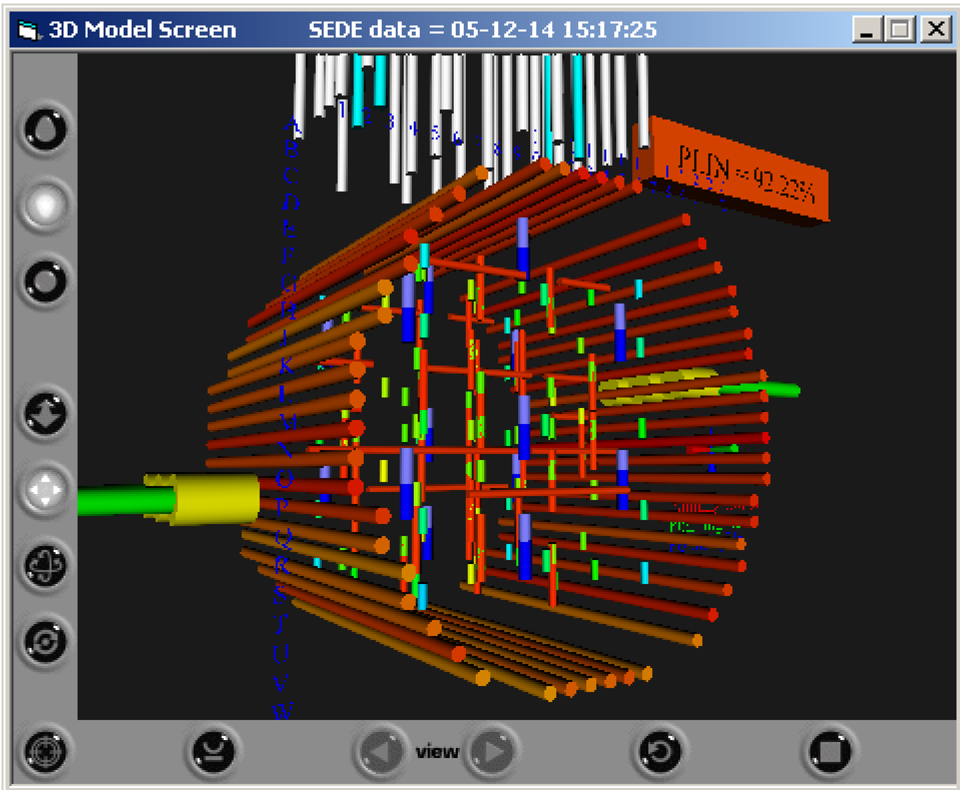


Figure 5: 3Dview Display shows a skeleton of the core with only a few fuel channels visible and SDS2 Ion Chambers are on the left. The Shutoff Rods, Mechanical Control Absorbers and Adjusters are shown above the core. In the core, the Liquid Zone Level controllers and some Platinum Flux Detectors are shown as well as a few horizontal mechanisms such as the SDS2 platinum detector assemblies. The letters A to W and numbers 1 to 22 form an overlaid coordinate system on the display showing 22 channels wide, 22 channels high. A flag shows power PLIN at 92.22% FP.

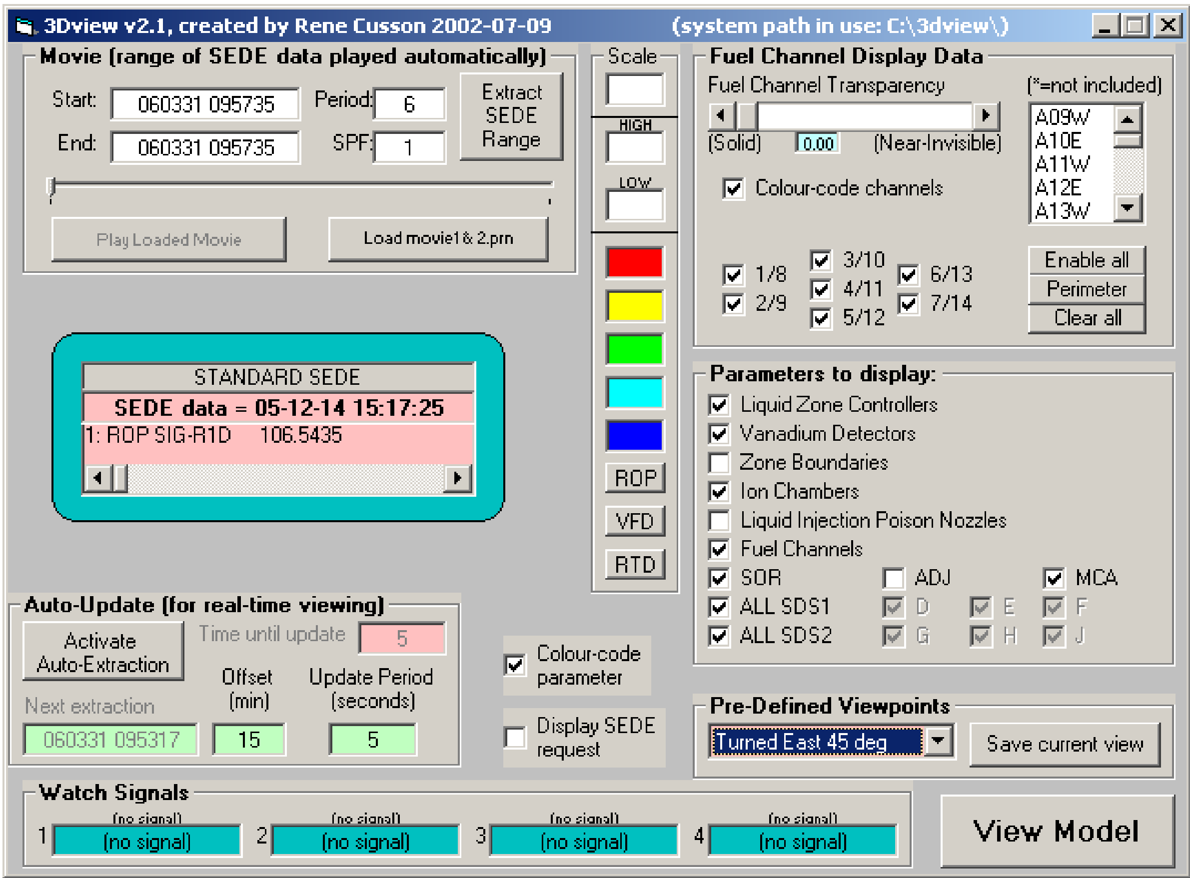
There are 13 navigational buttons located around the outside of the 3D view display screen. Anticlockwise around the control bars of the display there is: walk, fly, study, plan, pan, turn, roll, goto, align, view, restore and fit. The 3Dview model can be manipulated on its 3 axis in a continuous smooth fashion using a mouse.

The 3D view Control Setup Screen is discussed next and it permits user selection of a large number of displayed components and values.

3D View Setup Display

The 3Dview Control Setup Screen provides the user a lot of flexibility in setting up the 3Dview Model.

Figure 6: 3Dview Control Setup Screen



There are 9 major control areas on the 3Dview Control Setup Screen. The nine basic groupings going anticlockwise around the display screen are: a Scale and Colour selection bar for the ROP, VFD and RTD detectors, the Movie (range of SEDE data from a file played automatically or frame by frame), SEDE data view window, Auto-Update for real time viewing, Watch Signals (drag and drop a parameter from the SEDE window), the View Model button, Pre-Defined Viewpoints, Parameters to display, and Fuel Channel Display Data (with the display of Liquid Zone Controllers).

If the ROP button is set, a HIGH LOW range can be set. The colours are then proportioned to fit the range and their high value is entered into the colour block. Similiarly, the VFD and RTD detectors monitoring range can be set. These high low bands can be very narrow or full range; depending upon the user's monitoring needs at the time. With the reactor at steady state, a narrow range may be desirable on all detectors to indicate drifts to off normal conditions immediately.

The SEDE data can be extracted live and displayed or a previously extracted file can be used to trouble shoot past reactor conditions or simply use for training sessions. The first three control areas are really concerned with what data is used.

Four (4) instrumented signals can be numerically displayed in the 4 Watch Signals windows. Once the Control settings are all chosen, the user clicks the View Model button. Your favorite 3Dview aspect can be saved as a Pre-Defined Viewpoint. A variety of viewing scenarios can quickly be recalled with the click of the picklist button.

There are eleven (11) sets of parameters to display in the 3Dview model. The groupings of these selections can facilitate focused examination of a suspect problem or a particular performance observation.

The Fuel Channel Display Data area permits the fuel channels to assume a transparency. Since they are the largest and most numerous coloured objects in the model, this feature is valuable when studying instrumentation with respect to certain fuel channels. The zone check boxes permit displaying or hiding the block of channels associated with zones 1 to 14. Quick selects of fuel channels are available with the Enable all, Perimeter and Clear all buttons. Individual channels can be flagged for display from the pick list of the 380 channels. Clicking once displays the channel. Any number of channels can be displayed using this feature.

3Dview Model Display

Figure 7: 3Dview All Devices

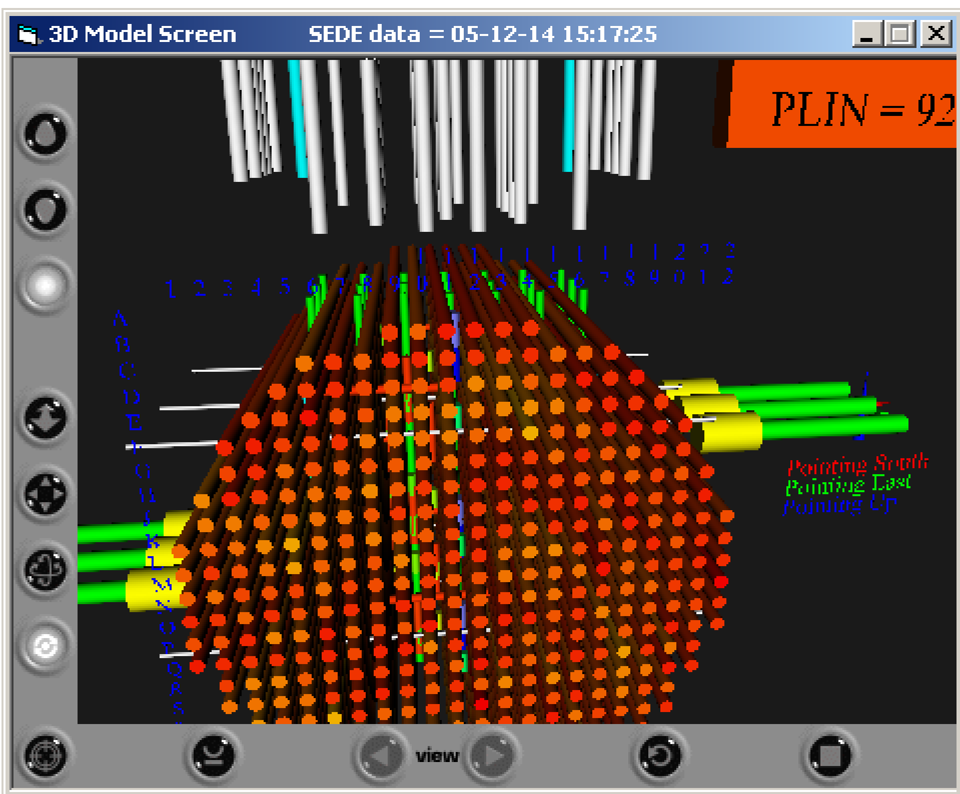


Figure 7: 3Dview All Devices displays all fuel channels, all reactivity mechanisms and all instrumentation. The silver coloured liquid injection nozzles can be seen on the left side of the image. Overall channel effects such as channel temperatures can be observed using the colour coded ranges. One can fly through the reactor to view zones and zonal instrumentation.

One of the most used periods of reactor operation for the 3Dview display is during Startup. Various prestart tests such as Shut Off Rod drop tests can be witnessed. A user can view withdrawal of the adjusters, the draining and filling of the liquid zone controllers, the increase in powers throughout the reactor and the channel temperatures. Unresponsive or failed flux detectors can be noted by their colour.

Programming Languages

There are 3 programming languages used in the creation of 3D_View.

The main program is written in Visual Basic, a powerful yet flexible language that provides all the controlling logic for the code, as well as a graphical user interface for the user to control the code from. Through this language all computations are performed, the arrays are controlled, and code input/output is controlled.

The data gathered from the plant is done through a SEDE system (System's Engineer's Data Extraction). This system is DOS based and uses ASCII request files properly formatted to request ASCII data from hundreds of plant parameters, including device position, power levels, detector flux readings, etc. The Visual Basic code writes these request files based on what data the user wishes to display, and as the DOS program is run asynchronously, monitor's the data retrieval status and processes the results.

The main display of this code is the interactive 3D core itself. This is written in VRML (Virtual Reality Modeling Language). To do so, the running systems first must install a Cortona VRML display reader package (freeware) which installs libraries and registry entries to teach the PC how to handle the modeling commands. One of these libraries is an ActiveX control display window, which is embedded into the Visual Basic form for alteration by the code. This is the users main display; the Visual basic code will generate the commands to the activex control to set the display to what is required by both the input data from SEDE and the users requirements, set by the main GUI. All 3 languages operate in tandem to produce one single program for the user to use.

Future Considerations

The 3D visualizations have not yet been fully applied to fuelling procedures. These displays have been developed on the side of other day to day work as a tool for the physicists and thus time is a factor in any growing development. Recognizing data that can be visualized, and in what manner, is new to most of us; mainly because the technology and programming cunning has not been available to make these displays possible. An examination of the fuelling procedures does yield lots of opportunities for data visualization.

The following is a list of possible 3Dview display features that could be implemented:

- The channel status map can easily be displayed as an ON/OFF feature or mostly ON feature. Channel specific data to show on the map are: RTD failure, Shield Plug Stuck, Closure Plug Stuck, High Leak Rate, Latch Problems, Low Flow, Suspect Defect, and Confirmed Defects.
- The Instrumented channels can be shown ON/OFF.
- The FAF/FARE boundary can be displayed ON/OFF.
- The CPPF boundary can be displayed ON/OFF.
- The Channels with Highest ROP Responses can be designated ON/OFF.
- Channels with Deshading and Zone Level Requirements can be displayed ON/OFF noting their particulars like high zone level response, zone boundary and Ion Chamber deshading.
- The Safety Analysis Channel Power Limits and the Administrative Channel Power Limits can be displayed ON/OFF.
- The Recommended Fuelling List (RFL) can be mapped onto the display when the Operator so desires to choose the next channel to fuel.
- Around each of the RFL channels, CRO Check List items such as:
    - Do not fuel next to 6.9MW or 1.09 ripple channels
    - Do not fuel more than 8 channels in 24 hours
    - Do not violate the lattice pitch rule – if a channel is chosen, the rule is checked
    - Keep zone levels between 15% and 75%
    - Avoid greater than 6 consecutive FAFs in the same direction
    - Avoid 7MW channel and 900kW bundle FLX powers
- The FCH program has 8 different messages that can be visually displayed on the 3D Core view.
- Visualizations of the following abnormal reactor configurations could be considered for development: stuck fuelling machine, fuelling out of Shim, Iodine Spiking, Bundles caught in cross-flow, spent fuel stuck in air, flow blockages, fuelling defects and shutdown fuelling.
- Visualizations of fluxes distributions from RFSP mapped onto 3Dview are possible such as those shown in Figure 8 Visualization of Mode 1 Fundamental.
- Visualizations such as Channel Power Distribution mapped onto 3Dview in 12 bundle planes are possible such as that shown in Figure 9 Channel Power Distribution.

If this all sounds complicated for one display system, users can easily run 1, 2 or 3 instances of the same 3Dview and have each instance dedicated for certain display features.

Figure 8: 3D Visualization of Mode 1 Fundamental

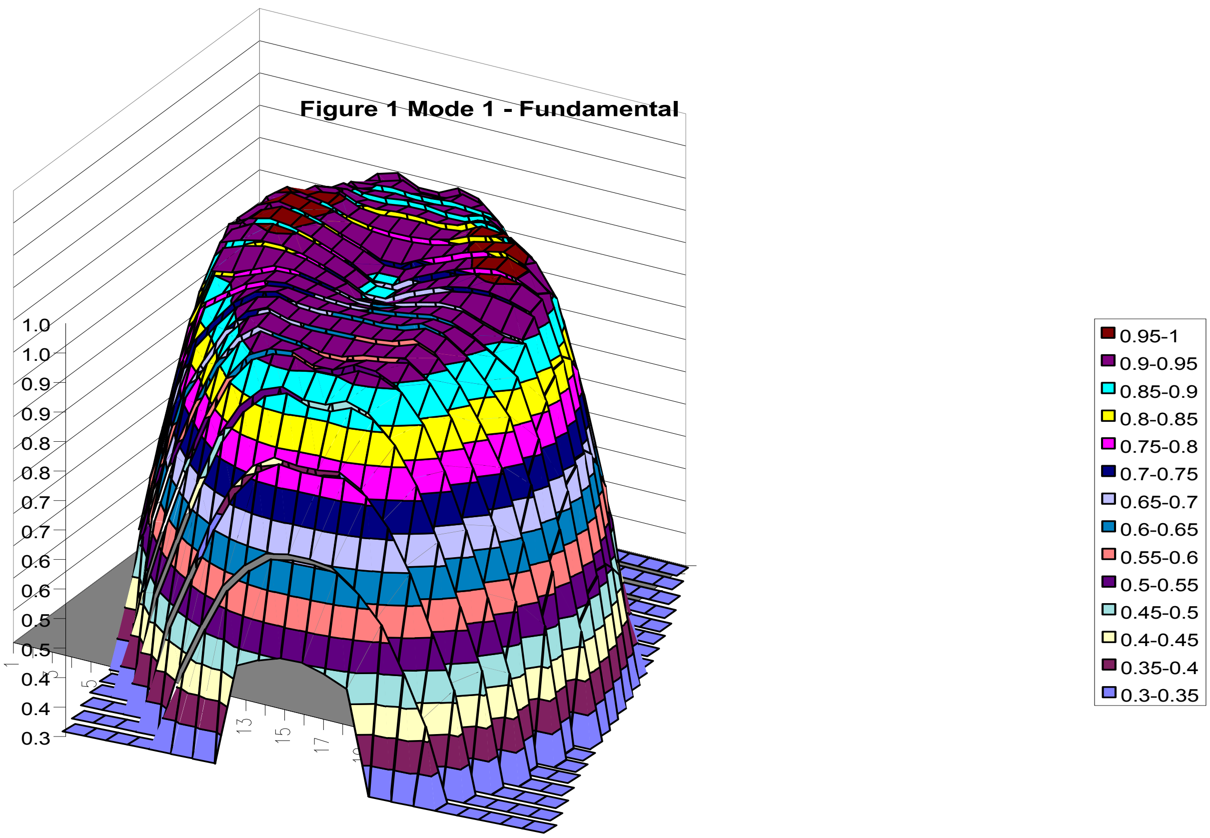


Figure 9: Channel Power Distribution

CHANNEL POWER DISTRIBUTION(kW) from run p060410z.apo

ALL 380 Chans

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	
A									3521	3626	3430	3520	3293	3407									A
B						3011	3457	4194	4439	4659	4400	4664	4692	4435	4234	3734	3050						B
C					3052	3538	4387	4926	5396	5451	5299	5121	5443	5315	4946	4678	3665	3184					C
D				3514	3768	4452	5297	5383	5905	6131	6078	5886	6186	6105	5919	5563	4626	3789	3461				D
E			3356	4166	4896	5433	5558	5970	5687	5870	6295	6364	5991	6491	6512	6230	5318	4724	3806	3178			E
F			3673	4705	5340	5506	5800	6095	6264	6331	6250	6124	6134	6607	6604	6547	6018	5440	4911	4141			F
G		3755	4404	5268	5883	6252	6494	6300	6056	6061	6432	5957	6433	6427	6377	6618	6435	5928	5072	4649	3794		G
H		3840	5175	5519	5934	6559	6657	6188	5981	6340	6530	6368	6253	6624	6736	6408	6341	5788	5410	5221	4203		H
J	3335	4663	5615	6273	6271	6578	6729	6498	6536	6483	6192	5976	6126	6510	6192	6199	6375	5958	5922	5587	4650	3537	J
K	3651	4947	5594	6432	6422	6652	6775	6367	6476	6045	5625	5757	6344	6418	6647	6628	6516	6276	5775	5793	4971	3811	K
L	3953	5090	5799	5896	6179	6194	6414	6611	6562	6215	6232	5884	6175	5861	6412	6560	6199	6121	5585	5820	4738	3678	L
M	3664	4721	6053	6622	6483	6569	6773	6018	6161	5875	6258	6394	6034	6206	6545	6704	6169	6431	6489	5754	4816	3613	M
N	3744	5006	5648	6514	6692	6375	6726	6681	6442	6057	6294	6543	6676	6413	6708	6384	6550	6336	6457	5792	4896	3670	N
O	3448	4656	5767	6134	6771	6579	6747	6390	6610	6505	6387	6677	6425	6605	6303	6769	6900	6722	5814	5626	4471	3491	O
P		4254	5357	5921	6346	6580	6759	6542	6110	5917	6474	6361	6735	6794	6921	6644	6713	6333	5567	5028	3869		P
Q		3948	4856	5475	5543	5962	6116	6561	6353	6593	6636	6731	6544	6352	6559	6597	5989	5733	4980	4629	3788		Q
R			4148	4409	5004	5509	5609	6423	6395	6117	6305	6521	6142	6524	6496	6168	5422	5122	4391	4041			R
S			3306	3608	4362	5143	5154	6234	6500	6517	6298	5992	6116	6112	5681	5658	4785	4624	4032	3046			S
T				3054	3840	4547	4957	5663	5848	6128	5755	5955	6008	5867	5315	5161	4408	3870	3313				T
U					3038	3469	4234	4821	5220	5045	5189	5218	4902	4894	4282	4301	3693	3033					U
V						2467	3257	3741	4101	4033	4316	4201	4189	3803	3680	3225	2487						V
W									2883	3026	2874	3026	2879	2798									W
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	

~ to 4000 | 4000 to 4500 | 4500 to 5000 | 5000 to 5500 | 5500 to 6000 | 6000 to 6500 | 6500 to 7000 | 7000 to ~

Conclusions

The time has come to take the huge amount of data available from reactor operations and make this data meaningfully visible to all the users. Technology is available to make data visibility a reality. Visible data displays provide real time visibility to operations both inside and outside the Main Control Room. Visible data displays facilitate inter group connectivity and responsiveness of group members. Intuitive data visualizations are the goal in producing data displays. Visualizations can be personalized by the user and enable him/her to see the data most important to them. The 3D visualizations can be zoomed, dragged, rotated and tilted. Hovering over a device produces additional data and information on that device. Once tabular data can now become intuitively actionable. Real time business intelligence has been and will be further enhanced as the user community develops more working displays.