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SHOT PLANNING AND ANALYSIS TOOLS*

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ABSTRACT

Shot planning and analysis tools (SPLAT) integrate components necessary to help achieve a high over-all operational efficiency of the National Ignition Facility (NIF) by combining near and long-term shot planning, final optics demand and supply loops, target diagnostics planning, and target fabrication requirements. Currently, the SPLAT project is comprised of two primary tool suites for shot planning and optics demand. The shot planning component provides a web-based interface to selecting and building a sequence of proposed shots for the NIF. These shot sequences, or “lanes” as they are referred to by shot planners, provide for planning both near-term shots in the Facility and long-term “campaigns” in the months and years to come. The shot planning capabilities integrate with the Configuration Management Tool (CMT) for experiment details and the NIF calendar for availability. Future enhancements will additionally integrate with target diagnostics planning and target fabrication requirements tools. The optics demand component is built upon predictive modelling of maintenance requirements on the final optics as a result of the proposed shots assembled during shot planning. The predictive models integrate energetics from a Laser Performance Operations Model (LPOM), the status of the deployed optics as provided by the online Final Optics Inspection system, and physics-based mathematical “rules” that predict optic flaw growth and new flaw initiations. These models are then run on an analytical cluster comprised of forty-eight Linux-based compute nodes. Results from the predictive models are used to produce decision-support reports in the areas of optics inspection planning, optics maintenance exchanges, and optics beam blocker placement advisories. Over time, the SPLAT project will evolve to provide a variety of decision-support and operation optimization tools.

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PLANNING TOOLS

Optics are expensive consumables on the NIF Project. Through the use of the planning tools, operations can predict the optimum times to apply blockers to prevent further flaws from developing on an optic or to plan for optic exchanges. In doing so, the facility optics costs in terms of exchange time and money are minimized while maximizing the life time of the installed optics.

The foundation of the planning tools is the shot planning lane. A lane represents the best expectation of the set of experimental shots that will be taken at NIF, in the order they are expected to be taken. Multiple lanes are used to represent the ‘completeness’ of each experiment. Long term planning lanes may only be very loosely defined – typically specifying only the goals of the experiment – whereas the Approved Shot Plan contains experiments that are ready to be executed. The latter experiments have a complete setup specification, have been approved by expert working groups, and are validated against rules sets to ensure that they do not exceed the operational parameters of the facility.

The Shot Planning Subsystem is responsible for managing the NIF experiment lanes in an efficient manner with a view to minimizing facility downtime and ongoing maintenance costs. It enables this by providing a set of integrated planning tools for the experimenters, planning teams, operations teams, and coordinates with various expert groups.

The tool suite uses a calendar function that has been specifically tailored for scheduling experiments in the facility. The calendar is essentially a spreadsheet and provides similar functionality (Figure 1). For example, adding, copying and deleting rows where each row is a schedule experiment in the calendar. The columns represent attributes of the of experiment such as the diagnostics used and energy of the laser are either entered attributes by the users directly in the tool, loaded from a file, or extracted from the shot setup data contained in the Configuration Management Tool (CMT).

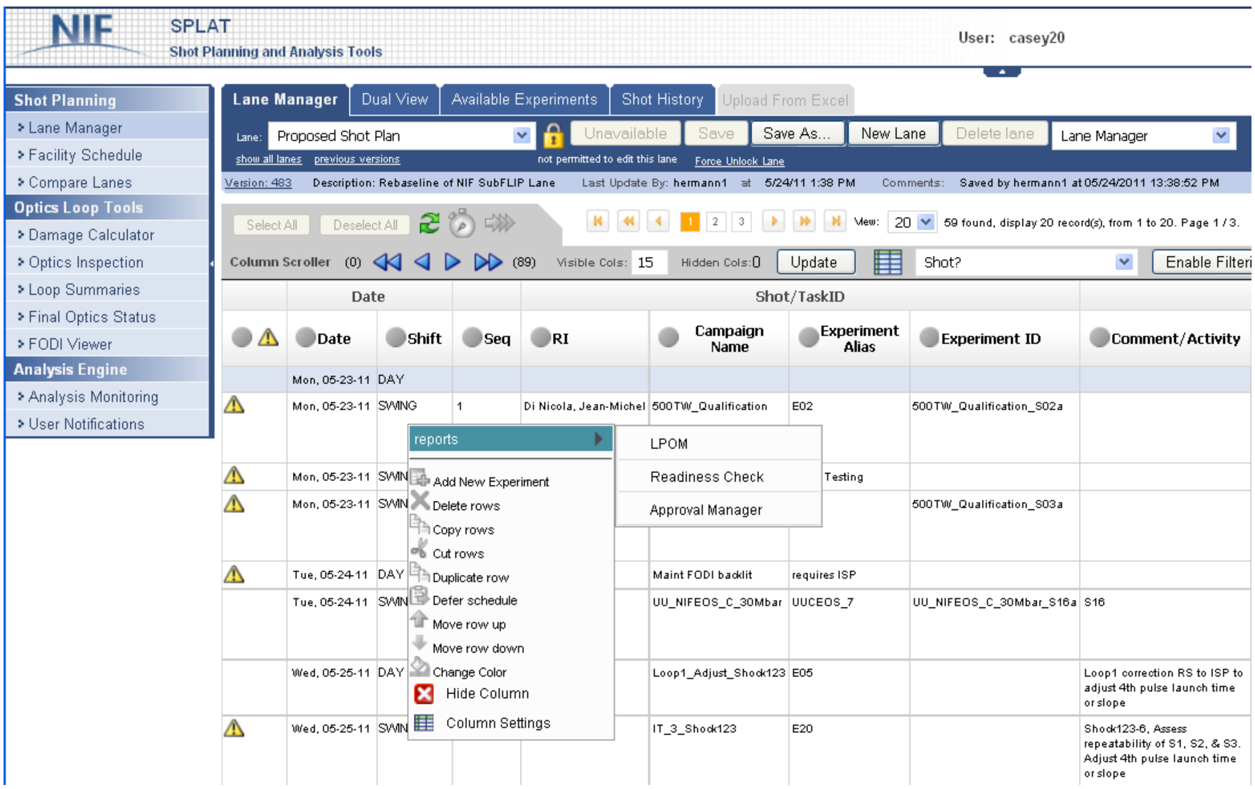

Figure 1 - The Shot Planning tool is a specialized spreadsheet for planning the order of experiments

In order to make the tool part of the operations planning process, integration with the other tools used in NIF is essential. Not only does the tool display setup data, it allows the planners to have access and visibility to the approval state (which expert groups have reviewed the experiment setup), the readiness state (is the facility configured to executed the experiment) and the results of LPOM analysis (will the experiment meet the experimental goals without violating the operational constraints). Providing a consistent, integrated view of experimental data is necessary to help make informed decisions about the order in which to conduct experiments.

It is from these planning lanes, that the SPLAT tools create predictive models that are used to produce decision-support reports in the areas of optics inspection planning, optics beam blocker placement, and optics maintenance exchanges. This sequence of events is known as the NIF Optics loop (Figure 2).

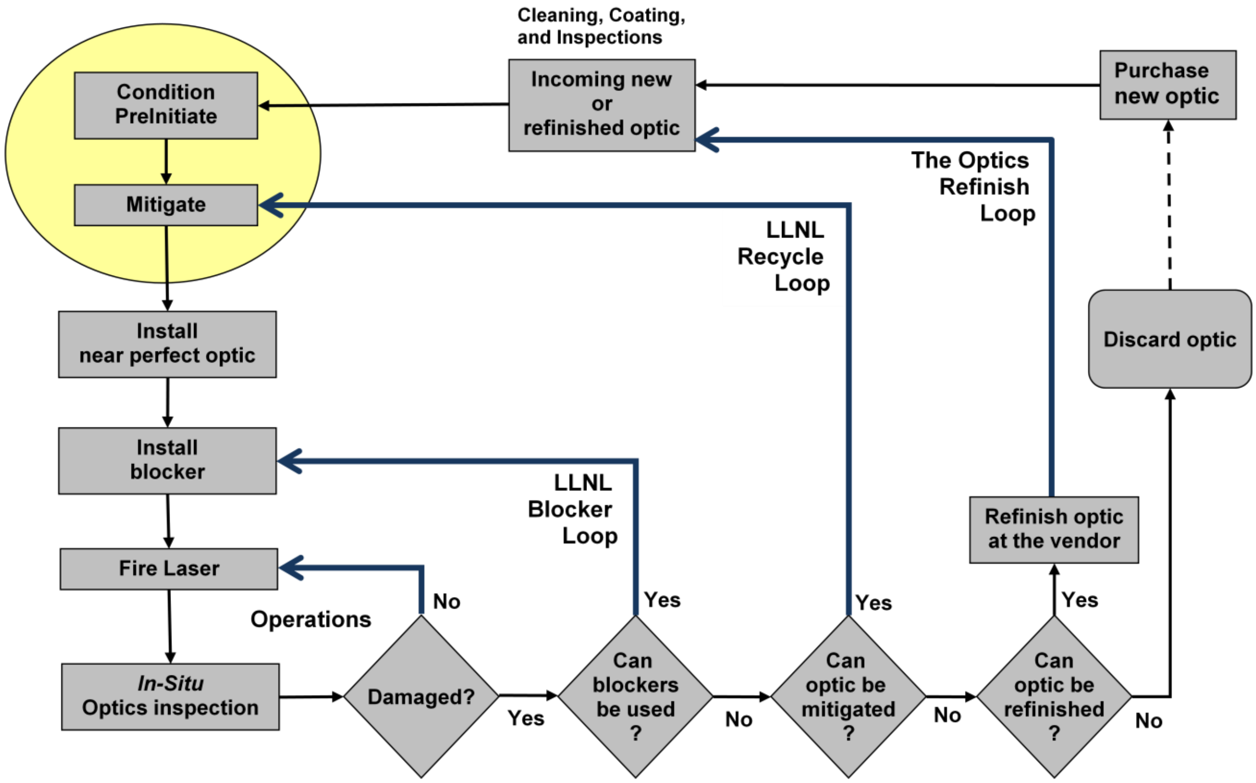

Figure 2 - The NIF Optics Loop is a series of questions regarding the suitability of an optic on an experiment

Another key function of the planning tools is to make sure that the right targets and the right diagnostics are available to meet the requirements of the experimenters. The planning tools give the factories advanced notice of what is needed and when, so they can plan their work based on the shot plan.

LOOP TOOLS

The SPLAT Analysis Subsystem uses a straight-forward design. There are the following major component types: a priority request queue where analysis requests are deposited by client applications, workflow preprocessing, workflow management processing that handles the detail steps of each request, analysis nodes that handle parallel tasks in the distributed compute cluster, a basic unit-of-work calculation task that takes one or more inputs and generates one or more outputs, and a notifications queue that is used to alert client applications awaiting the results of one or more calculation requests. In-flight tasks can utilize a combination of web services and/or data accessor API's to retrieve inputs from and write outputs to the data stores.

There are two basic types of calculator, the Damage and Loop. The Damage Calculator is responsible for predicting optics flaw growth and initiations of new sites. Inputs to the model include the current state of the optics, the list of planned experiments to be performed, and the Laser Performance Operations Model (LPOM) calculated values for the energetics (pulse shapes, laser waveforms, energies, etc.) This information is then coupled with the physics-based mathematical growth and initiation “rules” that perform the prediction to create models which are run on a forty-eight node analytical cluster and the results stores in a data warehouse. (Figure 3) The loop calculators are essentially post processors that take the damage calculator results and prepare reports for the different users of the tool suite. The reports provide the answers to the questions posed in the optics loop, for example; can blockers be used to extend the life of an optic, can the flaws in the optic be mitigated and when should the optics be exchanged.

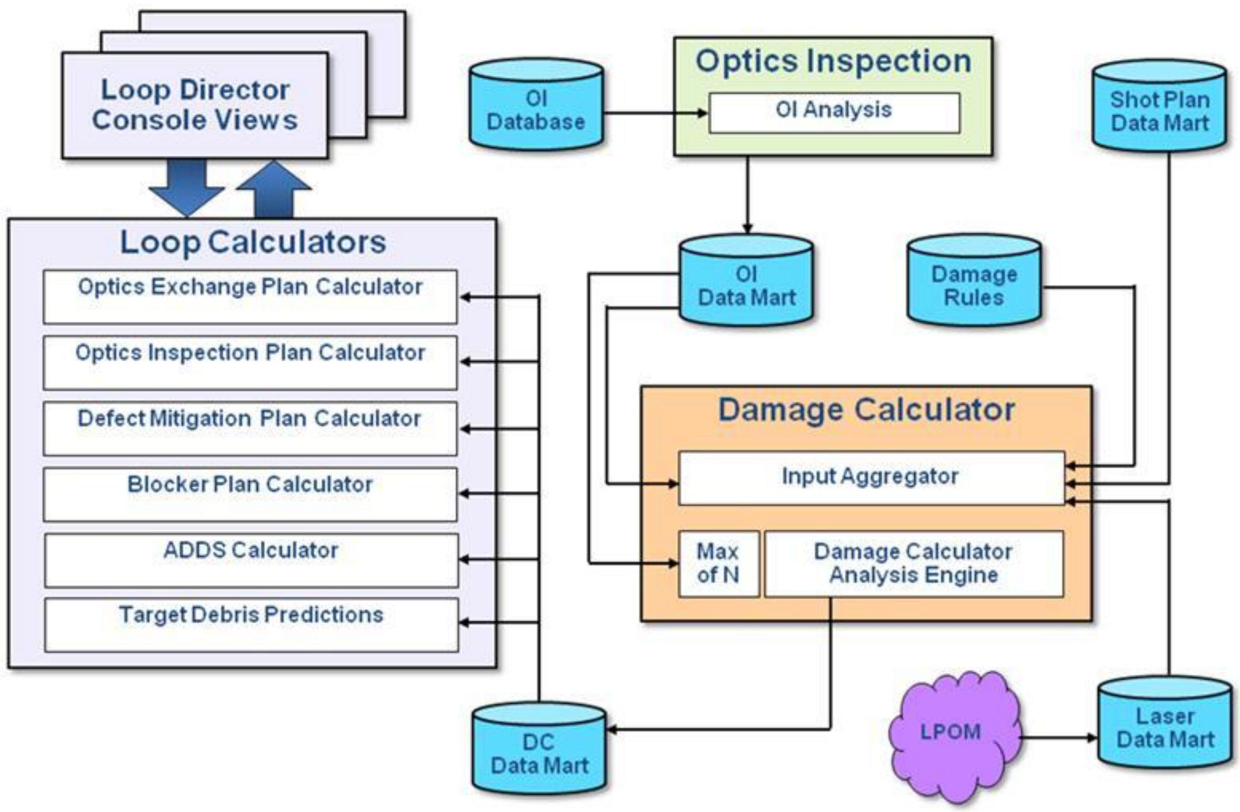

Figure 3 - The Damage calculator and the loop calculator provide reports that help answer the NIF Optics Loop questions.

FUTURE WORK

Current capabilities allow NIF to plan and reasonably predict flaw growth and initiation on the optics. This has been the focus of the development team to date. The loop tools have been very successful in providing the information and data needed to manage the optics.

On the other hand, the shot planning tools still require user knowledge of both of the facility state and the experiments in order to optimize the experimental order in the lanes. Providing decision support tools to planners will be the next functional area to enhance. Some of the capabilities being considered and designed include; “shot suggestion” which given the current state of the facility and the experiments in the lane suggests an experiment to take that minimizes reconfiguration of the facility and integrating the facility calendar with the planning lanes to show planners which experiments exceed the facility’s ability to support them.

CONCLUSION

The planning tools are proving very successful in assisting with the planning, coordination, and communication of the experimental plan with the various teams within the NIF community. They are well integrated in to the day to day operational procedures and as they continue to be refined, will become increasingly essential in effectively managing facility time.