# Production Planning and Scheduling for a small Biopharmaceutical CMO using SchedulePro Cloud®

**INTELLIGEN, INC.**

*Simulation, Design, and Scheduling Tools*

*for the Process Manufacturing Industries*

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# 1 Introduction

This example deals with the planning of R&D and manufacturing activities at a small biopharmaceutical Contract Manufacturing Organization (CMO). This example is intended for individuals involved in management and planning of R&D and manufacturing activities in the biotech, pharmaceutical and relatedindustries.

A typical client project carried out by the CMO of this example includes small and large-scale process development (PD) batches to satisfy technology transfer and process optimization requirements. These batches are carried out in a non-GMP environment. The PD runs are followed by one or multiple engineering (ENG) runs in a GMP environment. If the engineering runs meet specifications, the main manufacturing batches are initiated in the GMP environment. The duration of a typical client project is several months.

This example covers three scenarios.

1) **Scenario 1** explains how to schedule and visualize three typical projects for three different clients. Each project includes PD, ENG, and GMP runs.
2) **Scenario 2** explains how to interject a 4th project between the activities of the 3rd. Scheduling options are explored and the impact of project 4 on the completion of project 3 is delineated.
3) **Scenario 3** presents the concept of current time and explains how to represent process delays and account for their impact. This scenario provides a glimpse of how to use SchedulePro Cloud for managing manufacturing facilities on an ongoing basis.

In order to load the complete examples into the application, go to the landing page, select the “Create Sample Workspace” option and navigate to the “Examples” tab. Select the desired example and click “Next”. On the final window, you may optionally edit the suggested name and then click “Create” to create the sample workspace.

The application creates the example workspace, which includes one scheduling board for each example case, and automatically switches to the first scheduling board. In order to navigate between the various example cases/scheduling boards, click the ⇄ icon in the information box at the middle-top of the page (see figure below) and select the desired scheduling board from the dropdown menu.

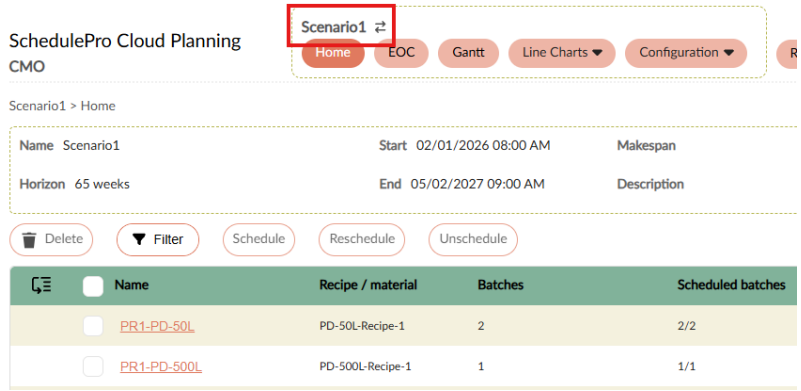



*Figure 1: Switching scheduling board in a workspace*

# 2 Building the model

A SchedulePro Cloud **recipe** describes how to make a batch of a certain product. A recipe includes one or more **procedures**, and each procedure may include one or more **operations**. A procedure typically represents a processing step that is carried out in a piece of equipment (e.g., fermentation, filtration, chromatography,etc.). Operations represent the tasks executed during a procedure. For instance, a fermentation procedure may include the following operations: Equipment setup, Charge of materials, Fermentation, Transfer of fermentation broth and Cleaning of equipment.

Recipes in SchedulePro Cloud can be created at any level of detail, but simplified recipes are recommended for solving production planning and capacity analysis problems. Detailed recipes are recommended for short-term scheduling and debottlenecking projects. This example utilizes simplified recipes since the focus is on long-term planning and project management.

The procedures and operations of a SchedulePro Cloud recipe may utilize equipment and other resources. These resources are associated with **facilities**. Hence, a logical approach for building the model is to begin by defining the facilities and their resources and then proceed to the creation of recipes and assignment of the resources.

**Note**: If you intend to create the scenarios of this example from scratch, you should also consult the SchedulePro Cloud User Guide.

## 2.1 Facilities

SchedulePro Cloud layout consists of two main parts; the top part of the page, shared by all application pages and the bottom part, which is page-specific. In the middle of the top part, the name of the currently selected scheduling board is shown. Below the name, five navigation items related to the selected scheduling board (**Home**, **EOC**, **Gantt**, **Line Charts** and **Configuration**) allow for displaying and editing board properties and campaigns, displaying the scheduling board resource occupancy, modifying the schedule, displaying the Gantt chart, as well as editing various scheduling board-related options. On the right side, four navigation items (**Recipes**, **Facilities**, **Materials** and **Others**) related to workspace data and actions allow for listing, adding, deleting and editing Recipes, Facilities and Materials, exporting/importing actions and displaying other options' pages.

The facilities window opens by clicking on the **Facilities** navigation item. A new Facility can be defined by entering its name in the **Enter facility name…** input field and pressing enter or clicking on the green **"+"** button on the right side of the Facilities window. The following three facilities were added for this example: PD-Facility, GMP-Facility and Labs. The PD facility is dedicated to process development activities at both the 50 L and the 500 L scales employed in the example. The GMP facility is dedicated to ENG and GMP activities whereas the Labs facility is dedicated to any analytical or QC work.

Once the facilities are defined, the next step is to add the resources of each facility. A facility can have the following types of resources: **Equipment**, **Staff**, **Labor** and **Storage units**. Equipment is the minimum resource required by SchedulePro Cloud's recipes. The inclusion and definition of all the other resources are optional. This example is limited to equipment definition only. Equipment can be added to a facility by selecting the **Equipment** navigation link of the facility and then entering its name in the **Enter equipment name…** input field (see Figure 1). For simplified recipes we advise users to lump related process steps into a single procedure and define fictitious equipment that

represents sequences of equipment items. For instance, each recipe of this example was represented with just four procedures: Preculture, Cell Culture, Downstream Processing (DSP) and Analytical work. Table 1 below lists all the equipment items added for this example and their types. Different types of equipment can be created by clicking on the **Others** navigation item at the top right of the workspace and then selecting **Equipment types**. A tabular page opens and new types can be specified in the **Add equipment type name…** input field. Going back to the list of equipment, a type can be selected for each piece of equipment by using the dropdown menu in the **Type** column. Equipment types can be particularly useful when assigning equipment to procedures in the following steps of this example (Recipes section).

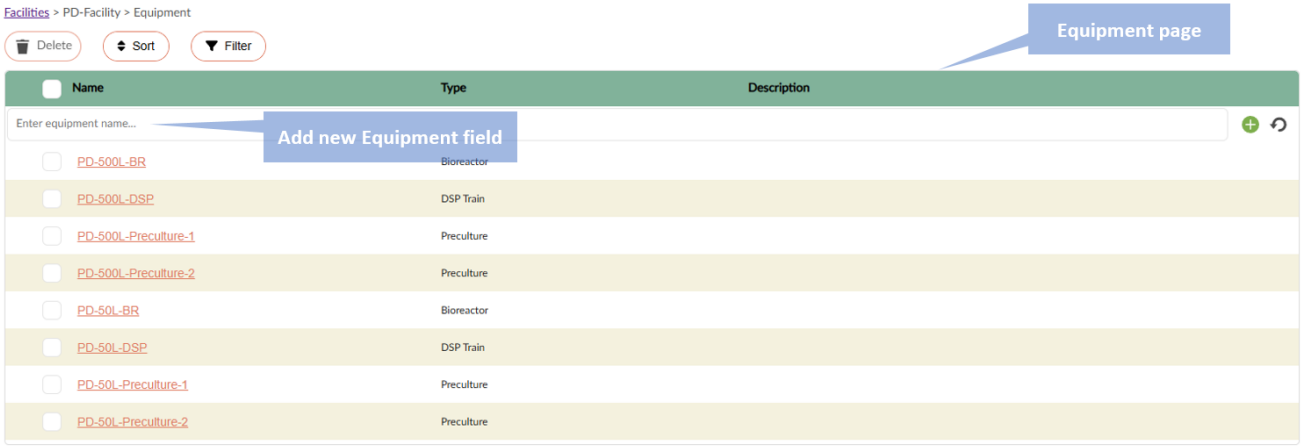



*Figure 2: Specifying new equipment*

*Table 1: Facilities and equipment lists*

| Facility | Equipment Name | Equipment Type |
|---|---|---|
| **PD-Facility** | PD-50L-Preculture-1 | Preculture |
| | PD-50L-Preculture-2 | Preculture |
| | PD-50L-BR | Bioreactor |
| | PD-50L-DSP | DSP Train |
| | PD-500L-Preculture-1 | Preculture |
| | PD-500-L-Preculture-2 | Preculture |
| | PD-500-L-BR | Bioreactor |
| | PD-500-L-DSP | DSP Train |
| **GMP-Facility** | GMP-500L-Preculture-1 | Preculture |
| | GMP-500L-Preculture-2 | Preculture |
| | GMP-500L-Preculture-3 | Preculture |
| | GMP-500L-Preculture-4 | Preculture |
| | GMP-500L-BR-1 | Bioreactor |
| | GMP-500L-BR-2 | Bioreactor |
| | GMP-500-L-DSP | DSP Train |
| **Labs** | PD-50L-Analytical | Analytical Work |
| | PD-500L-Analytical | Analytical Work |
| | GMP-500L-Analytical | Analytical Work |

As seen from the table, multiple preculture lines were defined for the PD and GMP facilities as well as two bioreactors for the GMP facility. The purpose of the addition of multiple equipment items will be discussed later in the document when the concept of equipment pools is explained.

To view and edit the properties of an equipment item, select it to open the equipment side panel (see Figure 2). Properties in the side panel are organized into multiple tabs, each of them containing different groups of information. In the context of this example, we specified the name, type, and changeover time of each equipment item. A **Changeover Time** of 1 week was added to all equipment items except those utilized for analytical work. The changeover time accounts for equipment cleaning and line adjustments at the end of a campaign. For a full explanation of all equipment properties, please refer to the manual.

The three equipment items associated with the Labs facility represent fictitious equipment allocated to procedures that represent analytical activities. In SchedulePro Cloud all procedures require main equipment. If some procedures of a recipe represent paperwork or other activities that are not constrained by main equipment, we recommend that

you create multi-tasking fictitious equipment items and allocate them to those procedures, as done in this example. An equipment item can multi-task if its **Can Execute Multiple Parallel Procedures/Operations** checkbox (in the Parallel Execution section of the General tab) is enabled. Scenario 1 provides more information on the subject.




*Figure 3: Equipment side panel*

## 2.2 Recipes

Four simple recipes were created to represent the activities carried out by the CMO of this example. Each recipe has four procedures: Preculture, Cell Culture, Purification, and Analytical. Some procedures have access to multiple equipment items (equipment pools). All procedures, except Analytical, have two operations. Table 2 below lists the attributes of the four different recipes.

The recipes window opens by clicking on the **Recipes** navigation item. A new Recipe can be defined by entering its name in the **Enter recipe name…** input field and pressing enter or clicking on the green **"+"** button on the right side of the Recipes window.

Recipes in SchedulePro Cloud may contain any number of procedures. Procedures can be added to a recipe by selecting the appropriate recipe and clicking on the **Contents** link on the right of the Recipes window. Then, a new procedure can be added to a recipe in the **Enter procedure name in recipe [recipe name]…** input field. Next, the appropriate equipment should be allocated to the procedures.

To allocate equipment to a procedure, click the pencil icon in the **Main Equipment Pool** column of the Procedures table. Then, click the downward arrow that opens a dropdown menu with available equipment and select the appropriate equipment. To save changes, press enter or the check icon (see Figure 3). Alternatively, open the procedure side panel by clicking on its name and going to the Main Equipment Pool tab. Here, the available equipment can be filtered by type, making it easier to select the appropriate units from the available options (**Select Equipment…** input field).

*Table 2: SchedulePro Cloud recipes created*

| Recipe | Procedures | Main Equipment | Operations | Duration |
|---|---|---|---|---|
| **PD-50L-Recipe-1** | Preculture | PD-50L-Preculture-1<br>PD-50L-Preculture-2 | Preculture | 14 days |
| | | | Turnover | 7 days |
| | Cell Culture | PD-50L-BR | Cell Culture | 14 days |
| | | | Turnover | 2 days |
| | Purification | PD-50L-DSP | Purification | 7 days |
| | | | Turnover | 1 day |
| | Analytical | PD-50L-Analytical | Analytical | 14 days |
| **PD-500L-Recipe-1** | Preculture | PD-500L-Preculture-1<br>PD-500L-Preculture-2 | Preculture | 22 days |
| | | | Turnover | 7 days |
| | Cell Culture | PD-500L-BR | Cell Culture | 14 days |
| | | | Turnover | 2 days |
| | Purification | PD-500L-DSP | Purification | 7 days |
| | | | Turnover | 1 day |
| | Analytical | PD-500L-Analytical | Analytical | 14 days |
| **ENG-500L-Recipe-1** | Preculture | GMP-500L-Preculture-1<br>GMP-500L-Preculture-2<br>GMP-500L-Preculture-3<br>GMP-500L-Preculture-4 | Preculture | 22 days |
| | | | Turnover | 2 days |
| | Cell Culture | GMP-500L-BR-1<br>GMP-500L-BR-2 | Cell Culture | 12 days |
| | | | Turnover | 2 days |
| | Purification | GMP-500L-DSP | Purification | 7 days |
| | | | Turnover | 1 day |
| | Analytical | GMP-500L-Analytical | Analytical | 14 days |
| **GMP-500L-Recipe-1** | Preculture | GMP-500L-Preculture-1<br>GMP-500L-Preculture-2<br>GMP-500L-Preculture-3<br>GMP-500L-Preculture-4 | Preculture | 22 days |
| | | | Turnover | 2 days |
| | Cell Culture | GMP-500L-BR-1<br>GMP-500L-BR-2 | Cell Culture | 14 days |
| | | | Turnover | 2 days |
| | Purification | GMP-500L-DSP | Purification | 7 days |
| | | | Turnover | 1 day |
| | Analytical | GMP-500L-Analytical | Analytical | 14 days |

Table 2 above displays the equipment that has been associated to the various procedures. In some cases, there are multiple equipment units assigned to the same procedure; this is known as an equipment pool. Equipment pools are commonly used for reducing the cycle time of a recipe. Consider, for instance, the **Cell Culture** procedure of the **GMP-500L-Recipe-1** which has a cycle time of 16 days (14 + 2). If the two allocated 500-L bioreactors (GMP-500L-BR-1 and GMP-500L-BR-2) alternate from batch to batch, the effective cycle time of that procedure is reduced to 8 days.

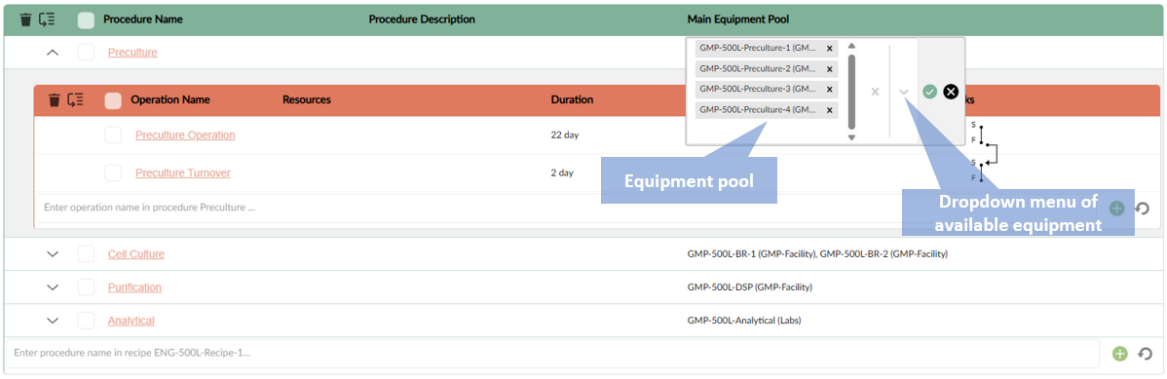



*Figure 4: Procedures window (equipment assignment)*

Clicking on the downward arrow to the left of a procedure name opens the operations table, displaying the operations within this procedure. A new operation can be added to a procedure in the **Enter operation name in procedure [procedure's name]…** input field. Multiple operations can be added. The properties of an operation can be viewed and modified by clicking on the operation name. That brings up the operation side panel (see Figure 4). For this example, we specified the duration of each operation (in the Duration section of the Duration tab) and its sequencing (in the Scheduling group of the Scheduling tab). Operations in SchedulePro Cloud may utilize a number of resources, such as Auxiliary Equipment, Staff Members, Labor (in the form of worker pools), Material Inputs and Outputs. For information on how to utilize operation resources, please consult the SchedulePro Cloud's manual.

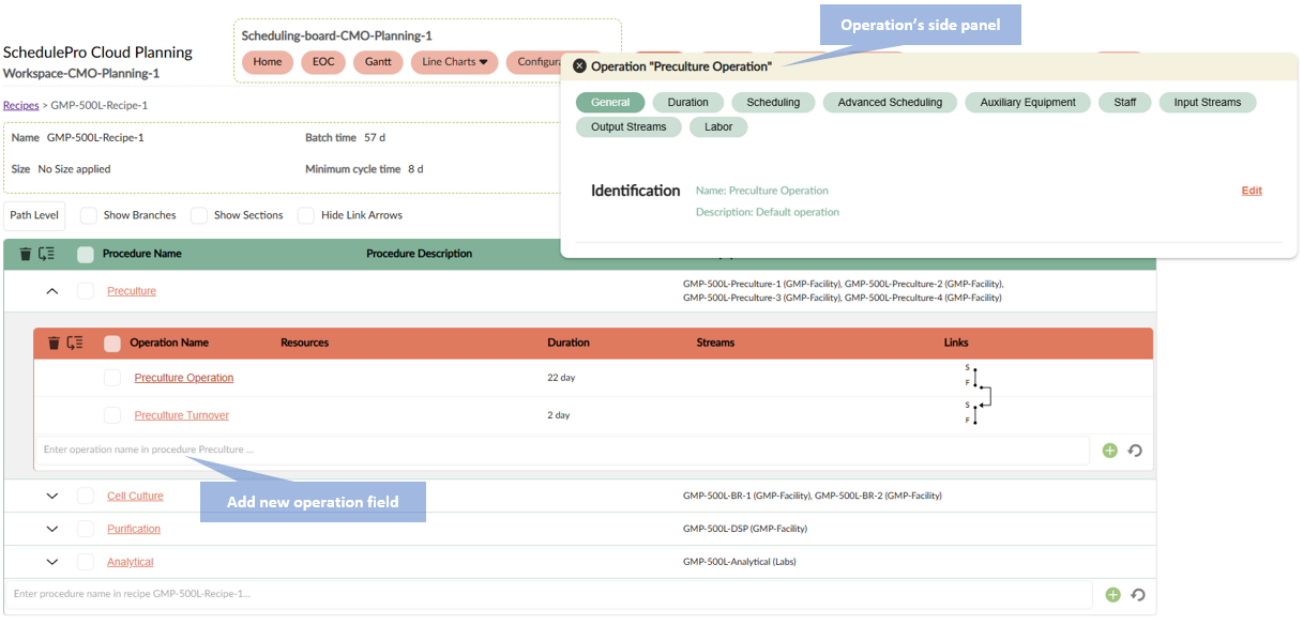



*Figure 5: Operation side panel*

## 2.3 Duplication of recipes

Table 2 displays the different recipes used in this example. The four recipes are quite similar. In such a case, duplicating existing recipes can expedite recipe creation. To make a duplicate of an existing recipe, click on the downward arrow next to the recipe name and select the **Duplicate** option (see Figure 5). Since the new recipe is a duplicate of the original (including procedures and operations), some of its properties must be edited to accurately represent the new recipe.

For this example, PD-50L-Recipe-1 was first created and then duplicated to create PD-500-L-Recipe-1. Large scale equipment was allocated to PD-500-L-Recipe-1 and the durations of some operations were adjusted. ENG-500L-Recipe-1 and GMP-500L-Recipe-1 were created in a similar manner. ENG-500L- Recipe-1 and GMP-500L-Recipe-1 are identical in terms of equipment resources and operation durations. Nevertheless, two separate recipes were created for visualization and communication purposes.

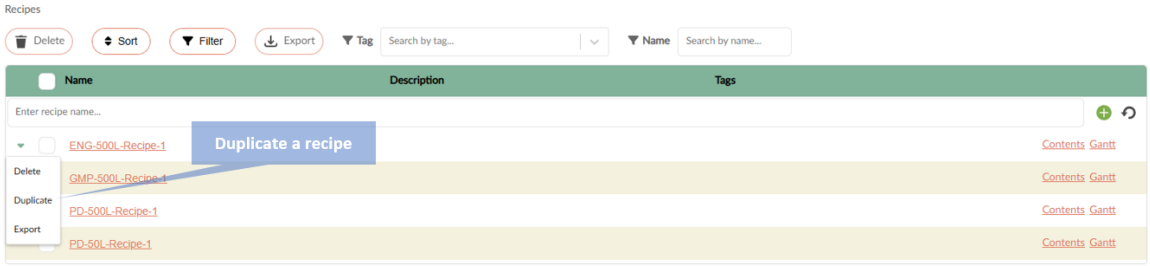



*Figure 6: Duplication of recipes*

# 3 Setting up the campaigns

A SchedulePro Cloud campaign represents a production or work order. It includes one or more batches of a specific recipe. In SchedulePro Cloud, a campaign may be planned or scheduled. A planned campaign does not have any scheduled batches but contains the information for scheduling them, e.g. number of batches, start time, due date, etc. A campaign is *scheduled* when all its batches are created.

To add a campaign, select the **Home** navigation item and add a campaign in the **Enter campaign name…** input field. Then, press enter or hit the green **"+"** button (see Figure 6). In the Recipe column, click the pencil icon and the downward arrow to select the recipe to be executed in the campaign. In the Number of Batches column, click the pencil icon to define the number of batches.

Clicking on the name of a Campaign brings up the campaign side panel, which displays the campaign properties organized into different tabs and sections (see Figure 7).

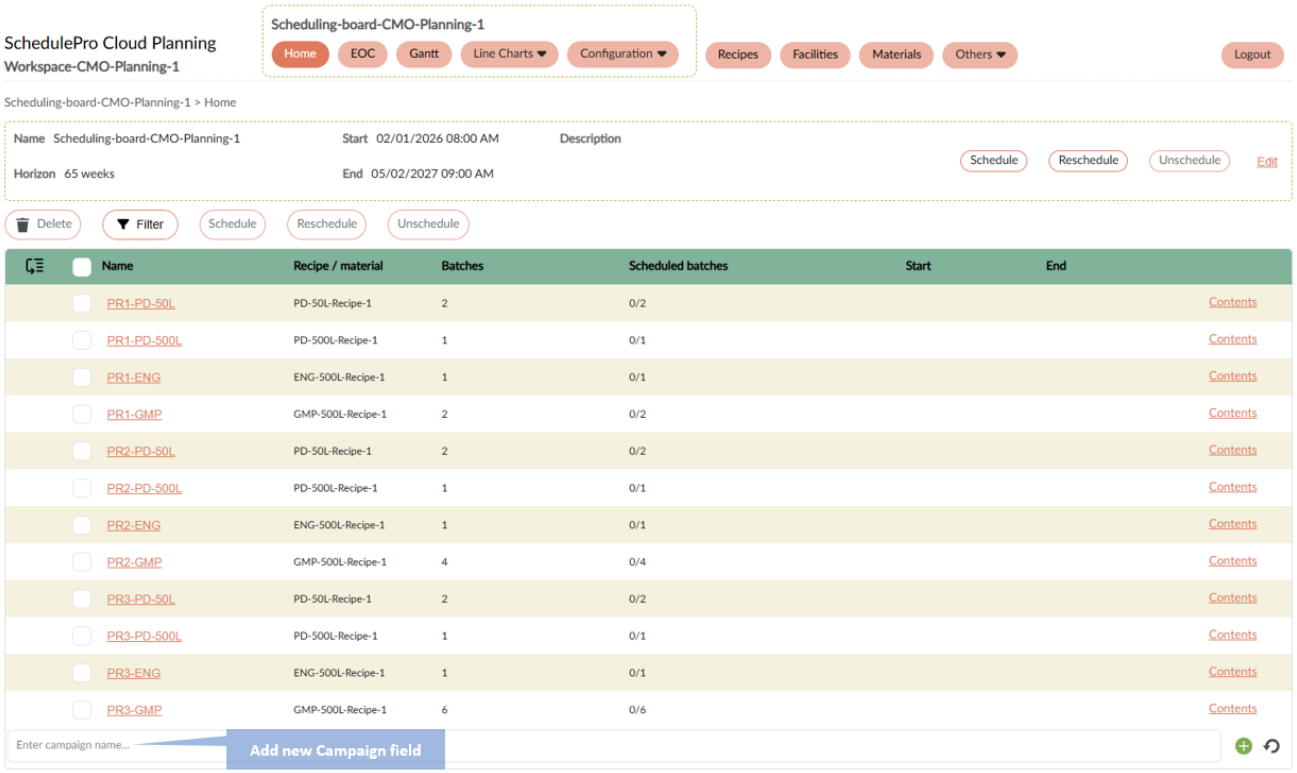



*Figure 7: Adding campaigns for scheduling*

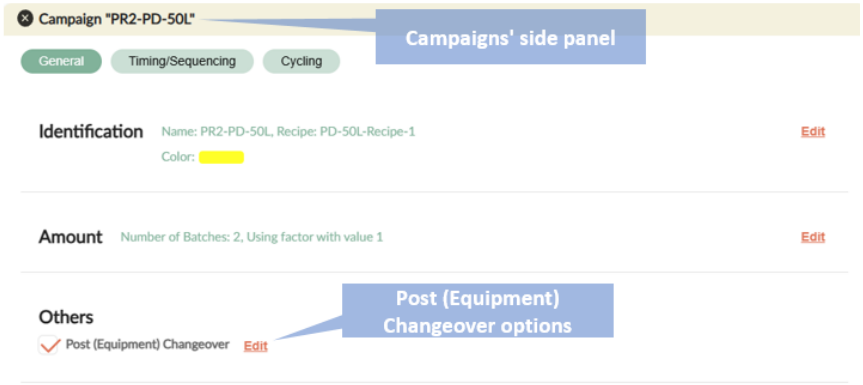



*Figure 8: Campaign side panel*

In the Time/Sequencing section of the Time/Sequencing tab you can set the campaign start or end date and time. The first campaign of the first project (the two PD-50L batches) was scheduled with the Release Date option (February 1, 2026). The second campaign of the first project (one PD-500L batch) was scheduled to start 30 days after the start of the previous campaign. This is accomplished by linking the start of the second campaign to the start of the previous campaign and specifying a 30-day **Time Shift** (see Figure 8).

The ENG campaigns (for all three projects) were scheduled to start at the end of the PD-500L campaigns and the GMP campaigns were scheduled to start at the end of the ENG campaigns. Thus, the campaigns of each project are fully linked.

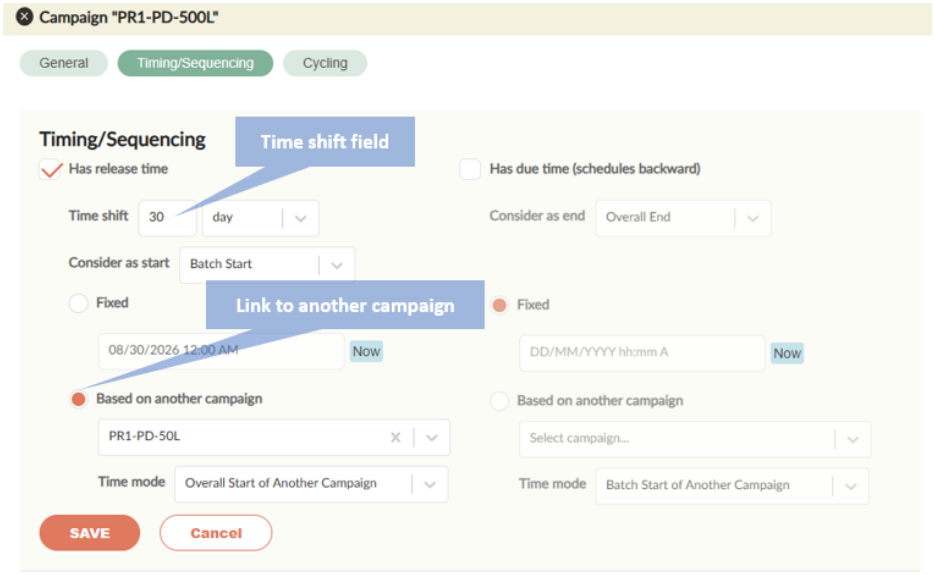



*Figure 9: Campaign Setup window (Time/Sequencing tab)*

In the Cycling tab of the Campaign side panel, you can specify the Batch Start Options. By default, the batches of a campaign are scheduled based on the minimum cycle time of the recipe (determined by the scheduling bottleneck equipment). You have the option to specify a larger cycle time or a slack time (i.e., idle time between consecutive batches) (see Figure 9). In this example, all multi-batch campaigns were scheduled based on their minimum cycle time (the default option).

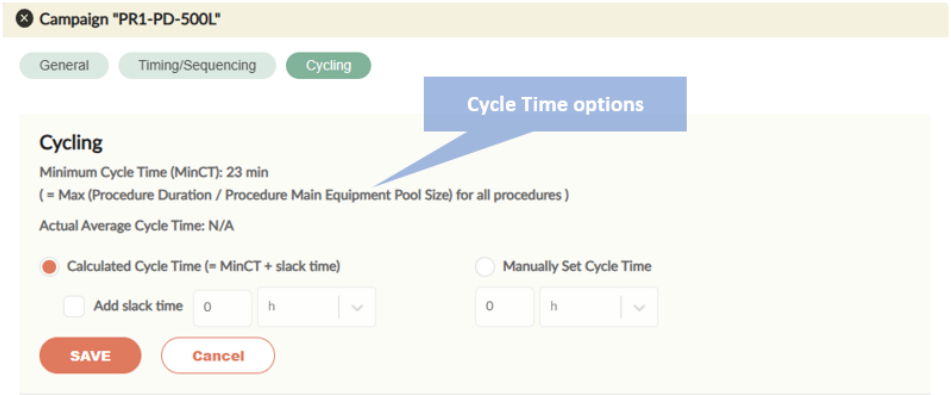



*Figure 10: Cycle Time options*

In the **Others** section of the General tab of the Campaign you can specify post (equipment) changeover options. It was assumed that one week of changeover time is required between different projects. This is equivalent to one week of client changeover since each project corresponds to a different client. To declare one week of changeover between projects, in the last campaign of each project we enable the **Post (Equipment) Changeover** checkbox. Then, by clicking on the **Edit** link, the PostChangeover Operation window opens, where settings for the operation's duration and scheduling can be selected. The duration can be either fixed for the operation or equal to the changeover duration of the equipment assigned to it. Moreover, changeover can be scheduled either at the end of the last batch of a campaign or after each equipment item's last use. In the first case, the changeover process occurs simultaneously for all the pieces of equipment, right after the end of the last batch, while in the latter case, the

changeover process occurs for each piece of equipment right after its last use in a campaign. In this example, changeover durations are based on equipment changeover times, and changeover operations take place after each equipment item's last use (See Figure 10 and 11).

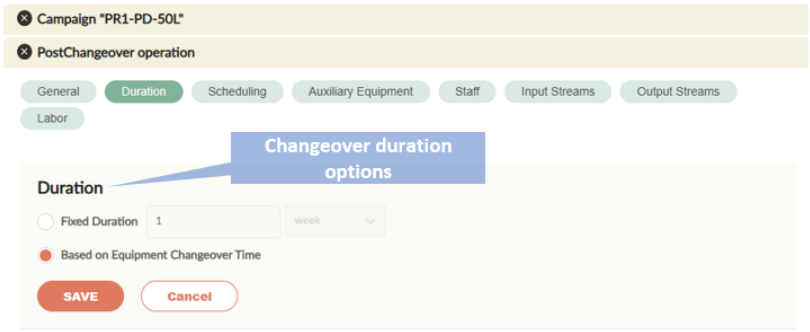



*Figure 11: Duration options of a Changeover operation*

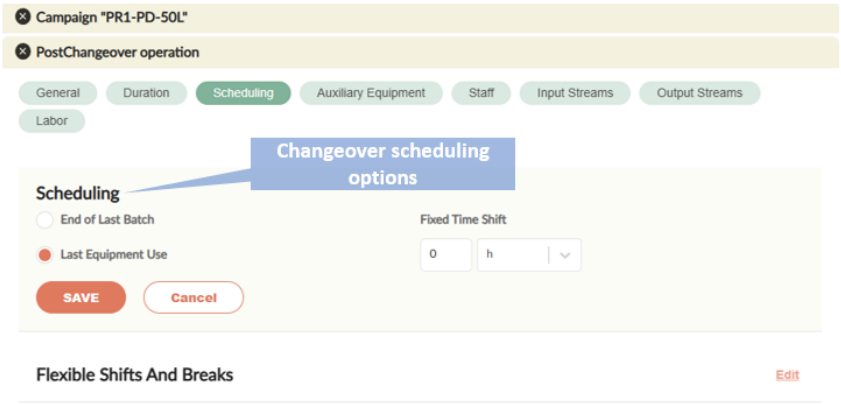



*Figure 12: Scheduling options of a Changeover operation*

# 4 Scenario analysis

## 4.1 Scenario 1

Scenario 1 corresponds to a situation where the CMO has secured three projects (for threedifferent clients) for execution in 2026. All three projects include PD campaigns at the 50-L and 500-L scales as well as ENG and GMP campaigns. More specifically, the following 12 campaigns are included in the three projects of scenario 1:

- Project 1:
  - 2 PD 50 L Batches
  - 1 PD 500 L Batch
  - 1 ENG Batch
  - 2 GMP Batch
- Project 2:
  - 2 PD 50 L Batches
  - 1 PD 500 L Batch
  - 1 ENG Batch
  - 4 GMP Batch
- Project 3:
  - 2 PD 50 L Batches
  - 1 PD 500 L Batch
  - 1 ENG Batch
  - 6 GMP Batch

After the campaign definition is completed, the production schedule can be generated by clicking on the **Schedule** item (see Figure 12). SchedulePro Cloud will use the information provided for the campaigns and recipes, and attempt to generate a schedule that satisfies all the constraints.

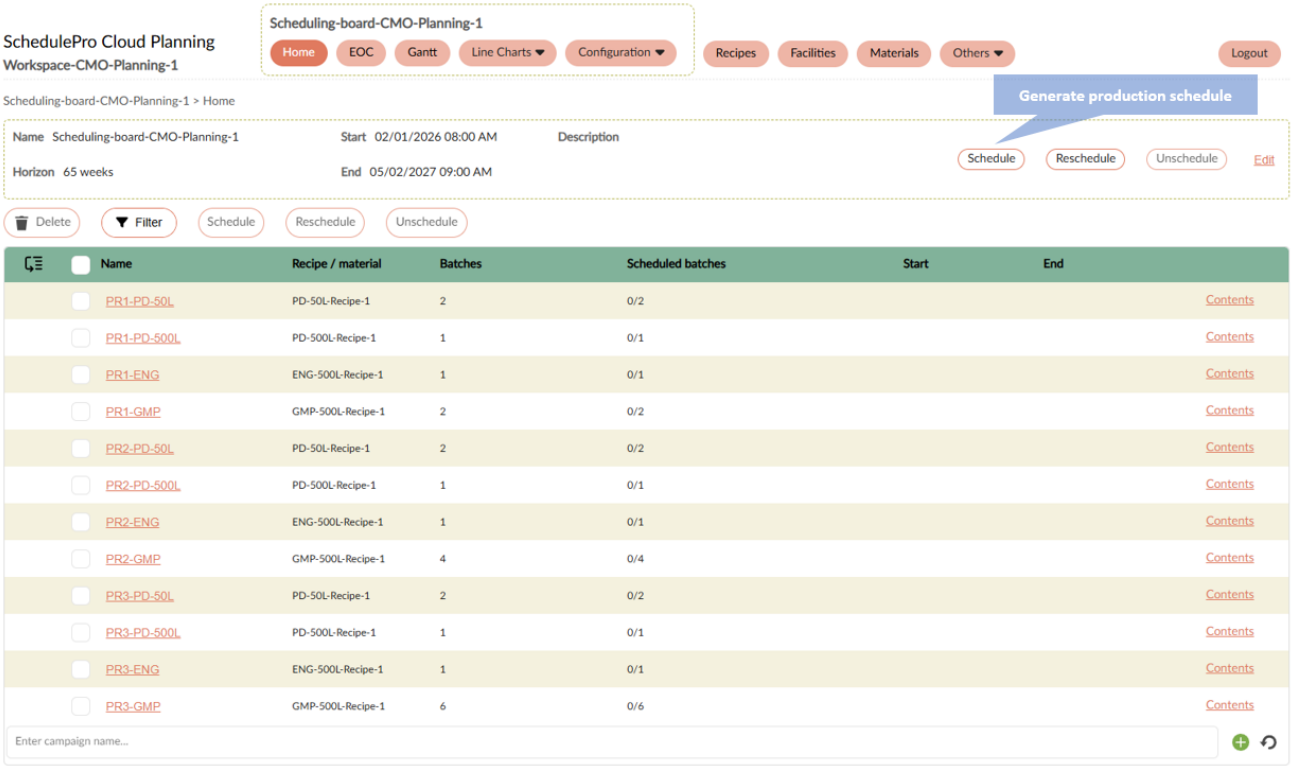



*Figure 13: Scheduling board (scenario 1)*

Scheduling results can be visualized by pressing the **EOC** item. That displays the Equipment Occupancy Chart (EOC) of Figure 13. Equipment is listed on the y-axis (PD equipment at the top and GMP at the bottom) and time on the x-axis.

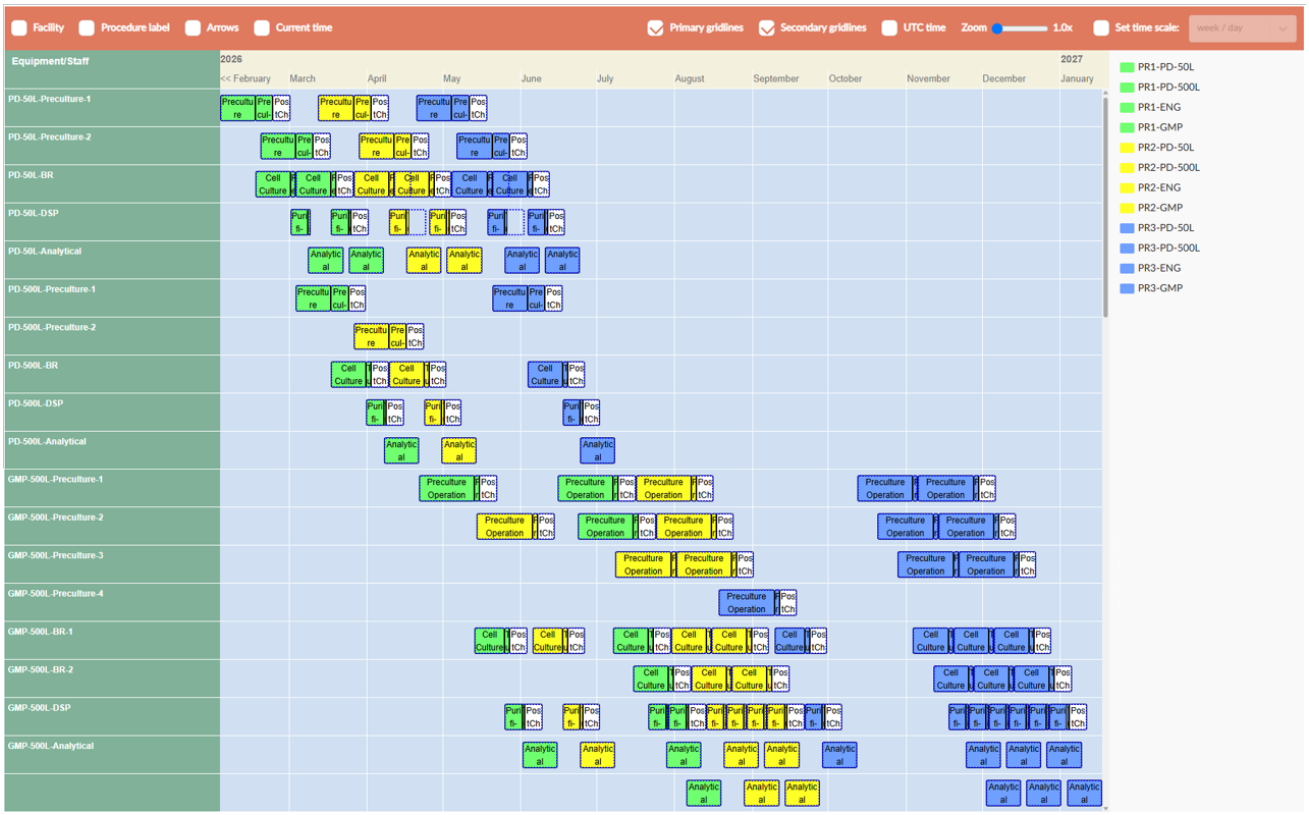



*Figure 14: Equipment Occupancy Chart (EOC) (scenario 1)*

The activities of each project are displayed in the same color (selected through the campaign side panel; Identification section of the General tab). This enables the user to visualize the start and end of each project. Activities in the EOC also can be colored by batch.

The chart above displays the schedule generated taking into account the constraints defined in the previous section. The first campaign of project 1, PR1-PD-50L (that includes the two PD-50L batches) is set to start on February 1, 2026 (start of the scheduling board horizon). The second campaign of project 1, PR1-PD-500L (that includes one PD-500L batch) is set to start 30 days after the start of the first campaign. The third campaign of project 1, PR1-ENG (that includes one ENG-500L batch) is set to start at the end of the previous campaign. Finally, the fourth campaign of project 1, PR1-GMP (that includes two GMP-500L batches) is set to start at the end of the previous campaign. The first campaign of project 2, PR2-PD-50L, starts as soon as possible (when equipment is available) after the start of the first campaign of project 1, with no additional settings specified for that campaign. The other campaigns of project 2 are linked to the first campaign of project 2 in a manner identical to that of project 1. The first campaign of project 3, PR3-PD-50L, starts as soon as possible after the start of the first campaign of project 2. The other campaigns of project 3 are linked to the first campaign of project 3 in a manner identical to that of project 1.

This high-level representation enables managers to visualize the utilization of their production lines andmanage projects effectively. Changes in project priorities and the impact of delays can be readily accounted for as explained in the other two scenarios.

Note that the cycle time of the PD-50L campaigns is determined by the single 50L bioreactor (PD-50L-BR) due to the availability of the two pre-culture lines (PD-50L-Preculture-1 and PD-50L-Preculture-2) which operate in staggered mode.

The white bars, following the last batch of the campaigns, represent the one-week changeover time required between different projects. Analytical equipment does not have a changeover time bar since changeover for the labs is not necessary.

The multiple horizontal lines that correspond to **GMP-500L-Analytical** in Figure 13 represent the parallel execution of analytical work tasks for overlapping batches. By default, equipment in SchedulePro Cloud can handle only one task at a time. **Parallel Task Execution** can be enabled for a piece of equipment by checking the corresponding checkbox in the Parallel Execution section of the General tab of the Equipment side panel (see Figure 14). This was done for all equipment used to represent analytical activities since analytical work is usually constrained by human resources and not equipment.

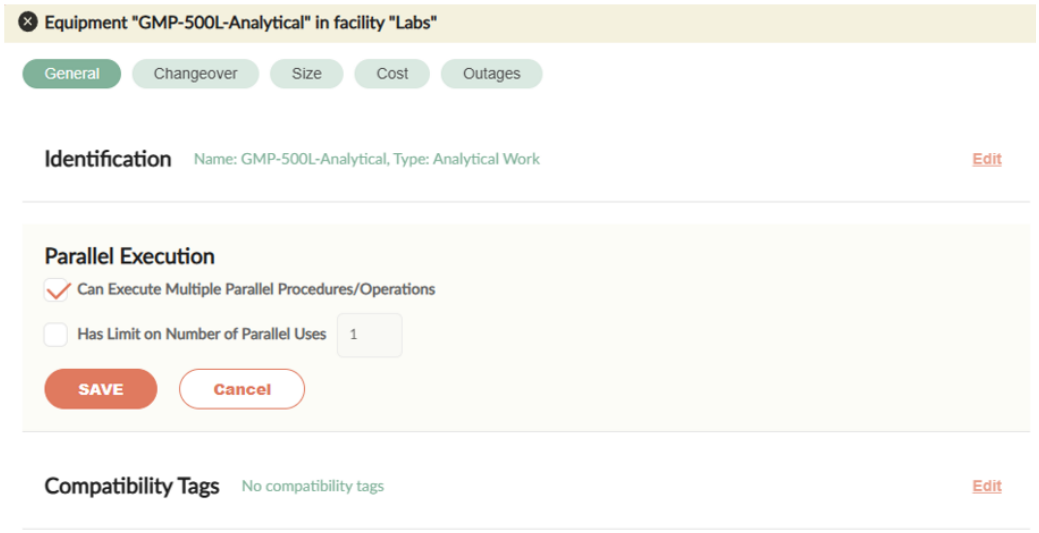



*Figure 15: Specifying Parallel Task Execution for Analytical Work equipment*

Planning activities in SchedulePro Cloud can also be visualized in the form of a Gantt chart (see Figure 15) which is brought up by clicking on the **Gantt** navigation item at the top-center of the app view. The Gantt chart of Figure 15 displays the campaign bars of the three projects in green color. The length of each bar represents the duration of the corresponding activity. The left (green) view of the chart displays the name, start date/time, end date/time and duration of the various activities. Activities can be displayed at the following levels of detail: campaign, batch, procedure, and operation. The level of detail for the entire chart can be selected from the **Detail Level** button at the top-left of the Gantt chart. The level of a specific activity can be expanded or collapsed by clicking on the (+) or (-) items, respectively.

The Campaign level of detail is recommended for planning managers. The Operation level of detailis recommended for short-term scheduling.

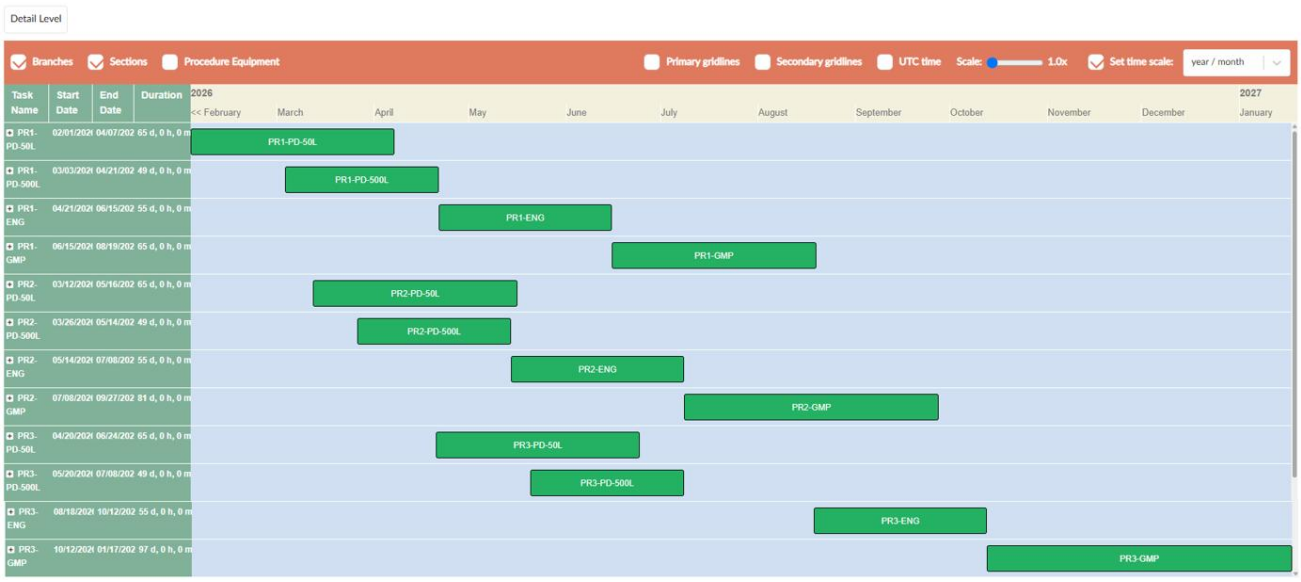



*Figure 16: Operations Gantt chart (scenario 1)*

If the execution of the three projects is performed as planned, their completion dates will be as follows.

*Table 3: Projects completion dates*

| Project # | Completion Date |
|---|---|
| 1 | August 19th, 2026 |
| 2 | September 27th, 2026 |
| 3 | January 17th, 2027 |

## 4.2 Scenario 2

Scenario 2 evaluates a situation where the services of the company are requested by a trusted client for aprocess already familiar to the CMO. The requirements of the new project (#4) can be met with 6 GMP batches. PD and ENG batches are not required for this project.

**Note**: It is assumed that the process of the trusted client can be represented by the existing GMP-500L- Recipe-1. If that is not the case, a new recipe can be created by copying and modifying one of the existing recipes as described earlier in the document.

Let's assume that the recurrent client gets in touch with the CMO in the beginning of August, 2026, and expresses interest in going ahead with his project as soon as possible. The CMO planning manager is considering squeezing the batches of project 4 between the ENG and GMP campaigns of project 3 by taking advantage of the available idle time during that period (from early September to November). The new campaign is added to the list with a release date of September 1st, 2026, and it is scheduled. Figure 16 displays the results of the initial solution (the activities of project 4 are displayed in dark orange. Four out of the six batches are inserted between the ENG and GMP campaigns of project 3. The remaining 2 batches of project 4 are executed after the completion of project 3. This solution takes advantage of the idle time between the ENG and GMP batches of project 3 without affecting the completion of the

first three projects.

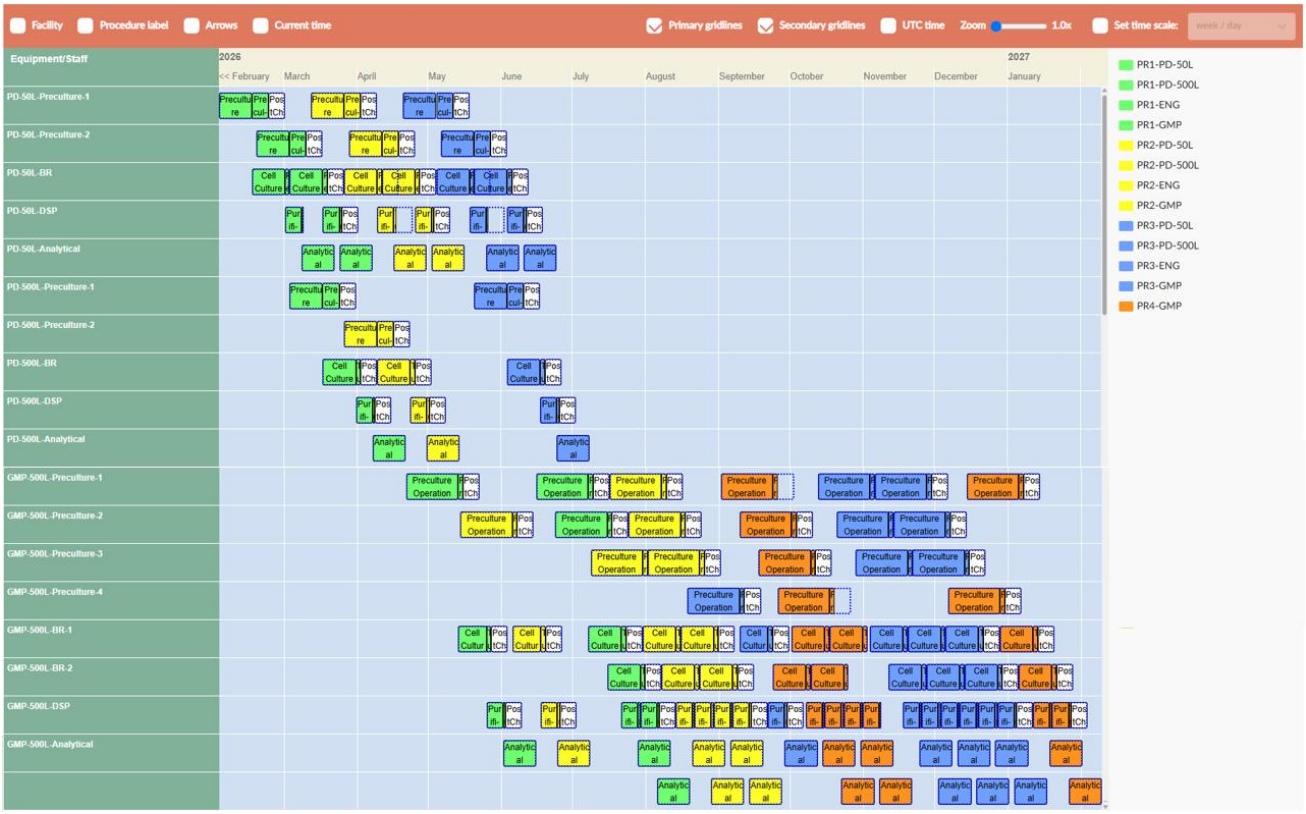



*Figure 17: Equipment Occupancy Chart (scenario 2 – first attempt)*

Since the recurrent client is willing to pay a premium price for quick delivery, the CMO planning manager decides to evaluate a situation where all six batches of project 4 are executed between the ENG and GMPcampaigns of project 3. Such a solution can be generated using the drag-and-drop capabilities of SchedulePro Cloud that are available on the Equipment Occupancy Chart. The user may drag and drop operations, procedures, batches or campaigns (selected from the Drag dropdown menu at the top-left of the EOC).

Since SchedulePro Cloud assigns resources to campaigns based on the order in which they appear on the campaign list, a better way to solve this problem is by raising the priority of the PR4-GMP campaign (the single campaign of project 4) above that of PR3-GMP (the last campaign of project 3). This is done in the Campaign Sequence view (Figure 6). By clicking on the icon, dragging the campaigns within the table is enabled.

Rescheduling of the PR4-GMP campaign inserts all of its batches before the PR3-GMP campaign, but it creates conflicts with some of the batches of the PR3-GMP campaign (see Figure 17). Conflicts in the EOC are displayed by creating multiple rows for the conflicting equipment (e.g., GMP-500L-Preculture-1, GMP-500L-Preculture-2, etc.) with exclamation marks (!) on the y-axis for the rows that represent conflicts, and by changing the outline of conflicting procedures to red. Rescheduling of the PR3-GMP campaign resolves its conflicts and results in the solution of Figure 18. In the **Home** page, a campaign can be rescheduled by enabling its checkbox and clicking **Reschedule / 1** on the top of the schedule board. The same solution can be generated by right-clicking on the PR3-GMP campaign in the **EOC** and selecting **Campaign \ Resolve Conflicts \ For Campaign.**

**Note:** The multiple rows associated with GMP-500L-Analytical do not represent conflicts, but rather overlapping activities of analytical work. As explained in scenario 1, the fictitious equipment used to represent analytical work can handle multiple parallel tasks.

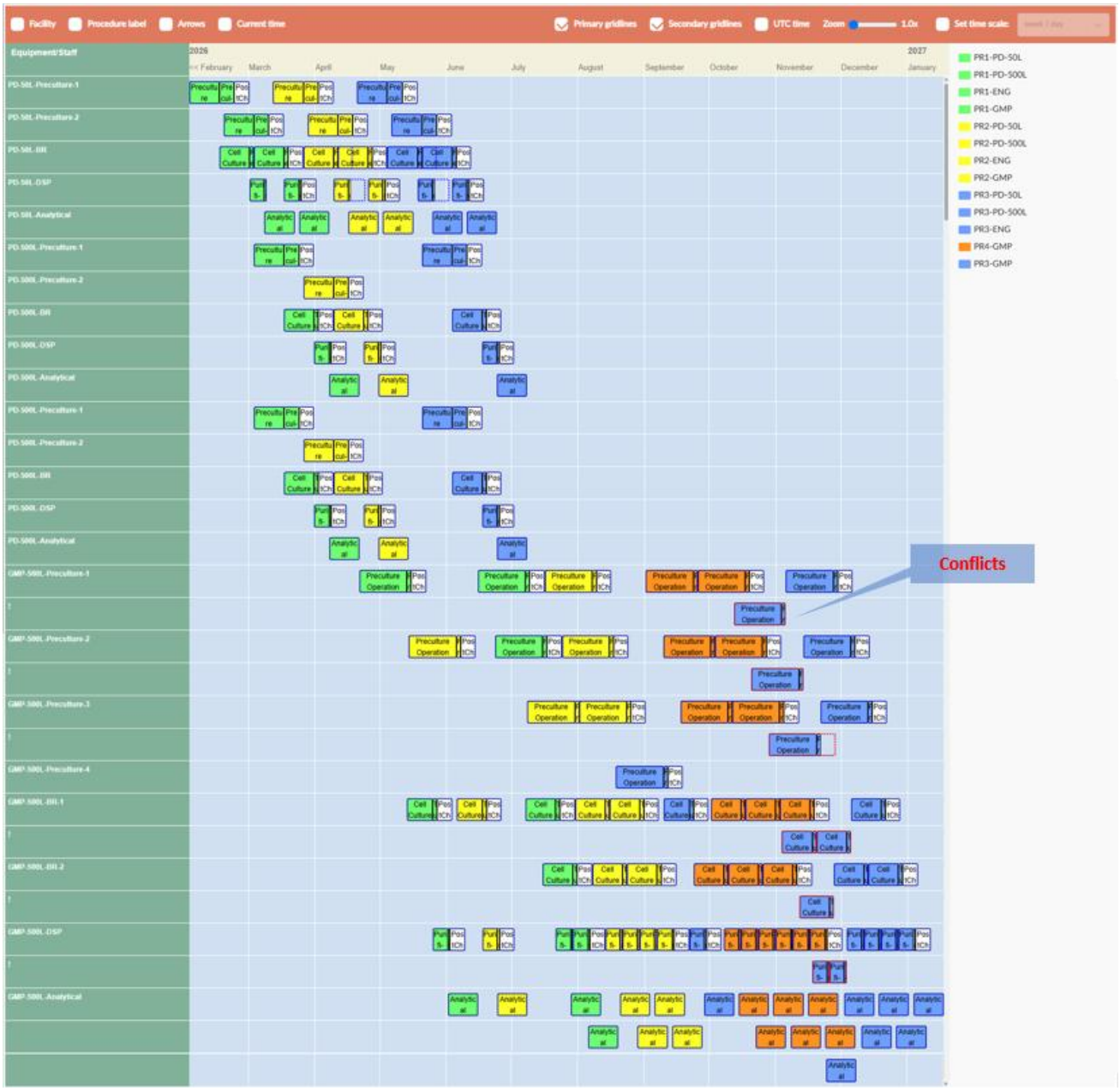



*Figure 18: Equipment Occupancy Chart (scenario 2 – intermediate state)*

The table below displays the original and adjusted completion dates of the projects. Projects 1 & 2 are not affected by the addition of project 4. Project 3 is delayed by 14 days. Considering the 286-day original make span of project 3, a 14-day delay can be easily justified to the owner of project 3. This demonstrates how SchedulePro Cloud can be used to manage projects, increase resource utilization and improve the profitability of a CMO.

*Table 4: Projects completion dates and delays*

| Project # | Completion Date (original) | Completion Date (adjusted) | Delay |
|---|---|---|---|
| 1 | August 19th, 2026 | August 19th, 2026 | 0 |
| 2 | September 27th, 2026 | September 27th, 2026 | 0 |
| 3 | January 17th, 2027 | January 31th, 2027 | 14 days |
| 4 | N/A | December 7th, 2026 | N/A |

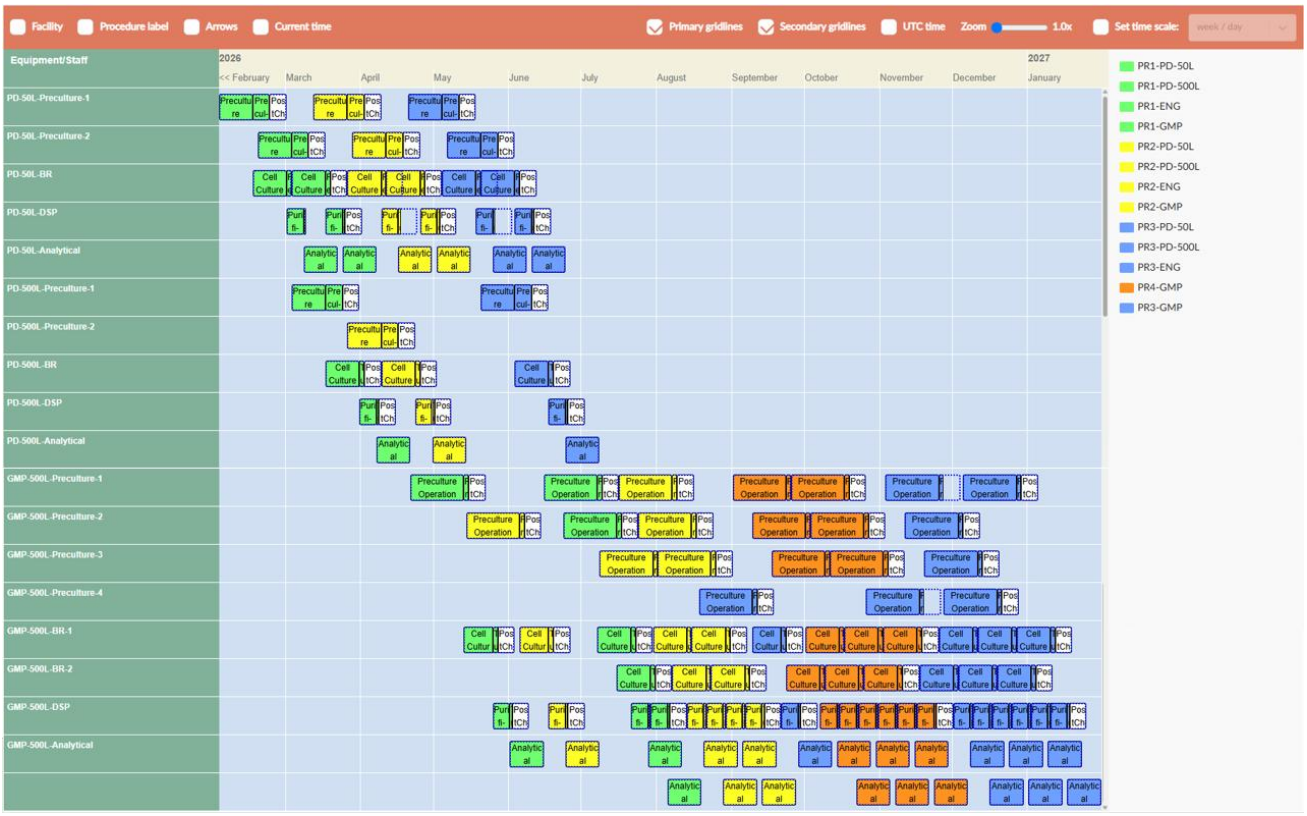


*Figure 19: Equipment Occupancy Chart (scenario 2 – final solution)*

## 4.3 Scenario 3

Tracking the status of scheduled activities is facilitated by the concept of **current time** which separates past from future activities. The current time represents the point in time at which the statuses of the activities are valid. This does not necessarily correspond to the actual clock-time. A red vertical line on the chart indicates the current time. The current time feature can be activated by enabling the **Current Time** checkbox above the EOC.

In manufacturing environments, the execution of certain operations may be delayed due to equipment failures and other unexpected events. Such delays may lead to scheduling conflicts with future activities.SchedulePro Cloud allows you to follow the schedule in real time and modify scheduled activities to represent process delays and

other deviations from the original production schedule. Scheduled activities can be modified through properties windows, as well as through the Gantt and Equipment Occupancy charts. In this example, the latter will be demonstrated.

Let's assume that a problem with inoculum preparation during the execution of the first GMP batch of project 2 (yellow color) is going to delay the completion of the preculture step by 8 days. To specify a delay, right-click on the bar of the corresponding operation and select **Operation \ Properties** in order tobring up the operation side panel of Figure 19. An 8-day delay can be specified either by increasing the duration of the operation from 22 to 30 days or adjusting its End date and time.

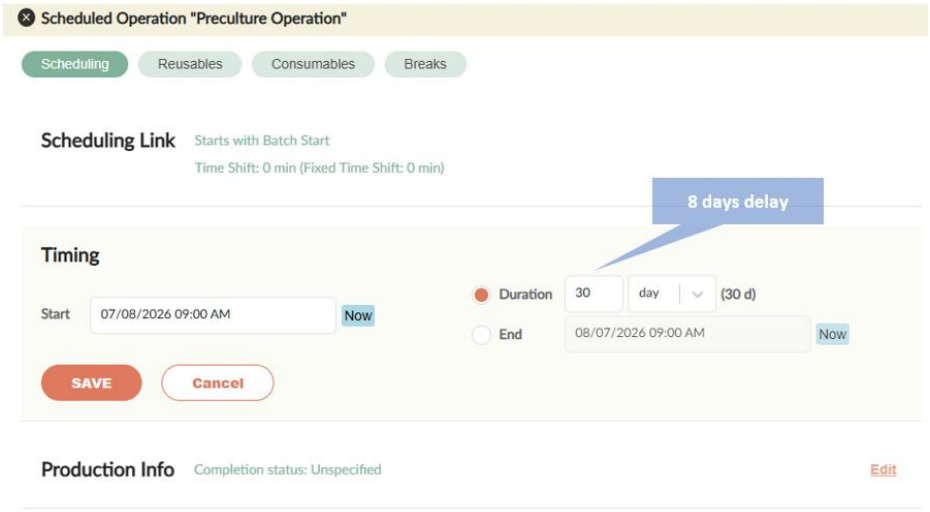



*Figure 20: Operation timing options*

When a delay is specified in SchedulePro Cloud, the application immediately updates the affected batch, delaying all the subsequent operations in that batch. However, subsequent batches in the campaign are not automatically delayed; instead, the application displays the conflicts created with other batches (see Figure 20). The conflicts can be resolved manually, using the drag and drop capabilities of the tool, or automatically, using its conflict resolution algorithms. To do the latter you must right-click on the conflicting entity and use the context menu options, or use the **Resolve Conflicts** button above the chart. Note that, when there is a conflict between two batches, it is assigned to the batch that is lower in hierarchy (and, in time). Also note that conflict resolution can be performed in a stepwise fashion, with the user controlling the extent to which SchedulePro Cloud will resolve the scheduling conflicts. So, if you right-click on a conflicting entity, the menu that pops up shows options to resolve conflicts for the corresponding operation, procedure, batch, campaign or the entire schedule. For better control of the schedule and to avoid excessive changes, the user should resolve conflicts at a local level (e.g. a single batch) and proceed gradually until all conflicts are resolved.

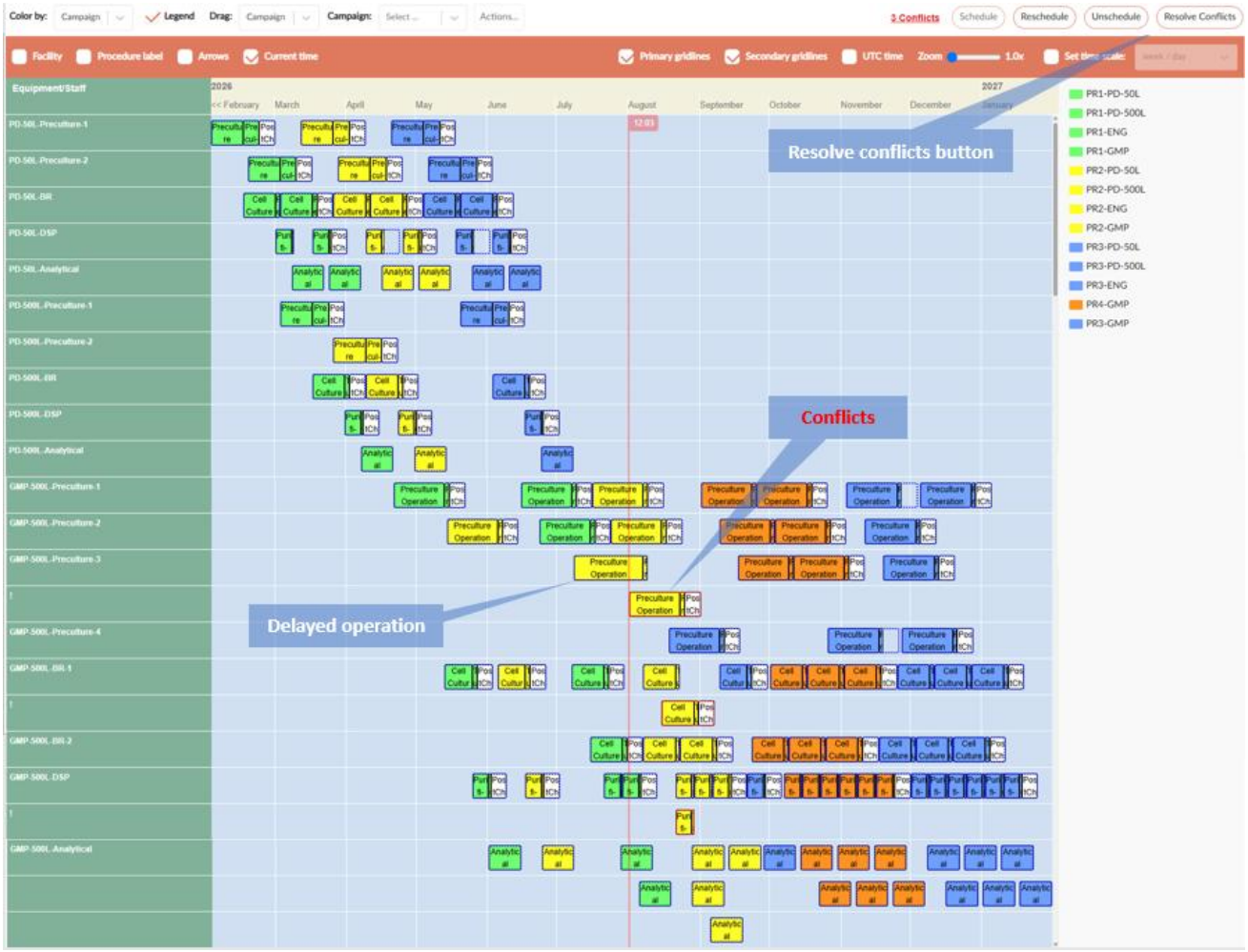



*Figure 21: Impact of delay (scenario 3)*

Figure 21 displays the updated schedule. The subsequent batches had to be delayed to resolve the conflicts introduced by the longer duration of the preculture operation. The table below displays the original and adjusted completion dates of the four projects. Project 1 is not affected by the delay in project 2 and is completed as planned. Project 2 is delayed by 8 days, while the expected completion of the other two projects is delayed by 7 days. That increases the total expected delay of project 3 to 21 days.

*Table 5: Projects completion dates and delays*

| Project # | Completion Date (scenario 1) | Completion Date (scenario 2) | Completion Date (scenario 3) | Total Delay |
|---|---|---|---|---|
| 1 | August 19th, 2026 | August 19th, 2026 | August 19th, 2026 | 0 |
| 2 | September 27th, 2026 | September 27th, 2026 | October 5, 2026 | 8 days |
| 3 | January 17th, 2027 | January 31th, 2027 | February 7, 2027 | 21 days |
| 4 | | December 7th, 2026 | December 14, 2026 | 7 days |

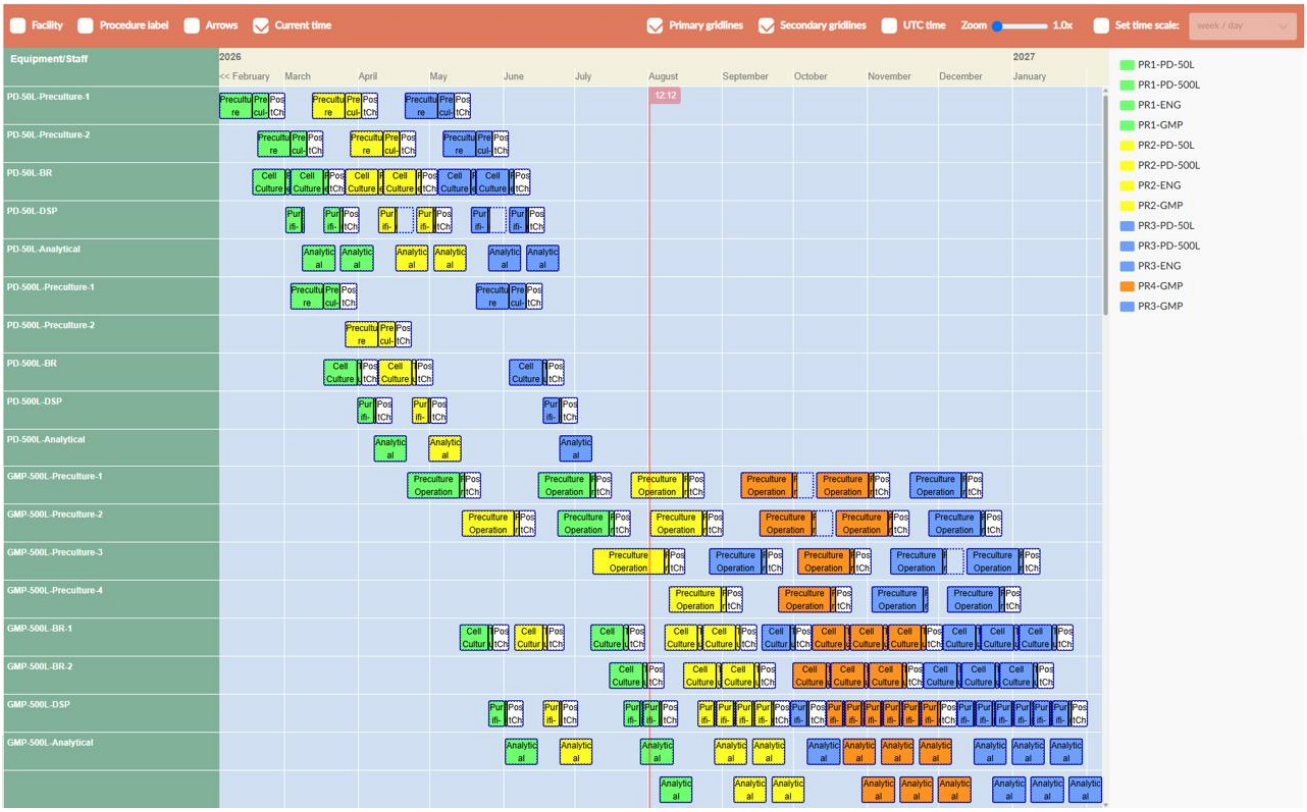



*Figure 22: Updated schedule (scenario 3)*

This simple example demonstrates how SchedulePro Cloud can be used to manage the planning requirements of a manufacturing facility on an on-going basis. SchedulePro Cloud enables planning managers to maintain a dynamic model of the entire facility that evolves with time and facilitates the generation of production schedules that are feasible and easily modifiable. The end result is increased productivity, improved customer service, and reduced manufacturing cost.

In this example, we only considered constraints imposed by main equipment. The throughput of manufacturing facilitates is often constrained by other resources, such as labor, utilities, auxiliary equipment, etc. Consideration of such resources typically requires the use of more detailed recipes. Please study the tutorial examples of SchedulePro Cloud for pertinent material.