The background of the slide is a photograph of several construction cranes silhouetted against a dramatic, cloudy sky at sunset or sunrise. The sun is a bright, glowing orb near the horizon, casting a warm, golden light across the scene. The cranes are of various heights and are positioned across the frame, with some in the foreground and others further back. The overall mood is industrial and powerful.

REAL WORLD PROJECT MODELING IN AURORA THAT SUPPORTS RELATIONSHIP DIAGRAMING METHOD (RDM) & RELATIONSHIP DIAGRAMMING CRITICAL PATH METHOD (RDCPM) FUNCTIONALITY

CPM Construction Conference 2026

Rob Richards, PhD
Stottler Henke Associates, Inc.
www.AuroraScheduling.com

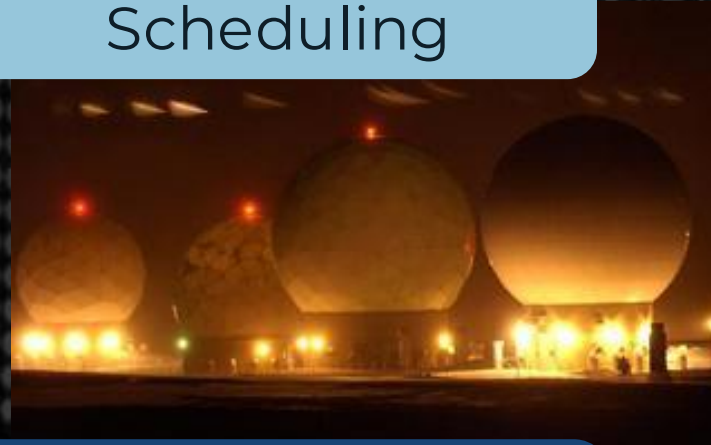
Stottler  **Henke**

Lessons Learned from Clients

The Boeing Company



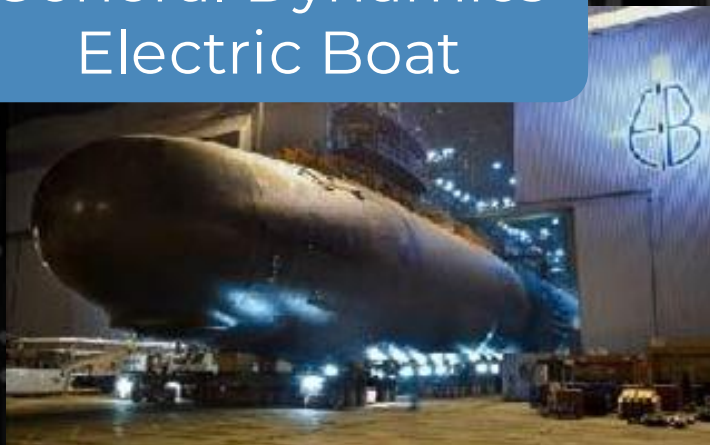
Air Force Satellite Scheduling



Mitsubishi Heavy Industries



General Dynamics Electric Boat



Siemens Integrated Program Planning & Execution



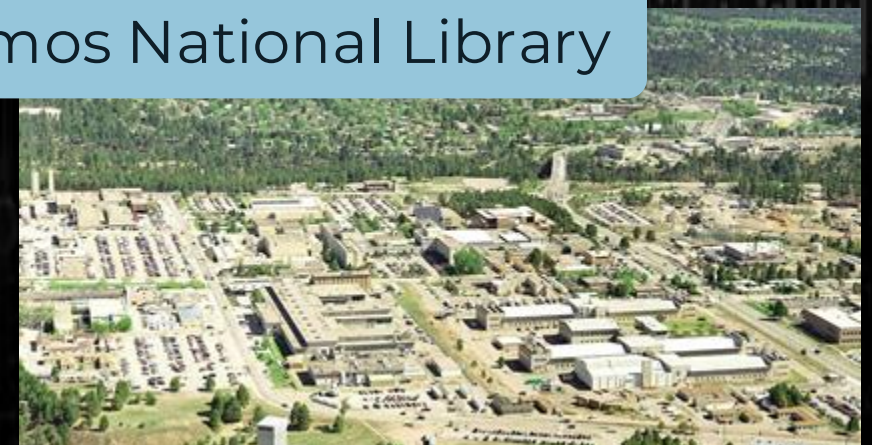
Camcar Textron



Spirit AeroSystems



Los Alamos National Library



LESSONS & RESULTS

- Project models require more real-world constraints
 - Significant productivity lost due to inferior model details
- Learn from the human schedulers
- Model to level of detail required
 - RDM & RDCPM
- Reveal & explain the schedule
- Easy & fast to perform scenarios / what-ifs
- Results: Reduced project duration & greater transparency



PROJECT MODEL NEEDS TO BE REALISTIC

- Inability to model many real-world situations causes model to update inaccurately during execution

EXECUTION EXCELLENCE

1. Model to the level of detail needed
2. Generated Global Priorities based on model & current situation
3. Humans make final decisions on what to work based on global priorities & other real-world factors, then update model with status

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LEARN FROM HUMAN SCHEDULERS

- Different scheduling applications generally require some different modeling capabilities, but many overlap
 - Human experts help drive the best decision per what non-standard modeling capabilities are most apropos
- When decisions / tradeoffs need to be made, use the expertise of expert schedulers
 - So that the scheduling system reacts as a human expert wants it to
 - E.g., when to work overtime, when to outsource

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MODEL TO LEVEL OF DETAIL REQUIRED

- Technical constraints (E.g., F-S, F-F, S-F, lags)
- Resources
 - Labor: Occupation, skills, certifications
 - Equipment, Tools (e.g., cranes)
- Usage constraints – e.g., tool can only be used for so many hours continuously &/or during a day.
- Spatial / physical space – e.g.,
 - job requires a certain location or type of space
 - two elements should (or should not) be next to each other
- Equipment substitutions – equipment down, know & use substitutes



HIERARCHY OF RESOURCES

Resources

LABOR

Occupation: e.g., Welding

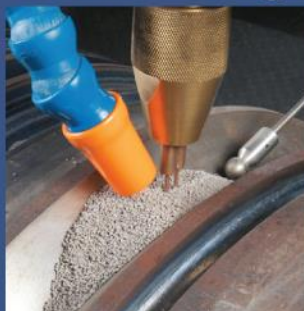
Skills/Certifications

Submerged
Arc Welding



(Canadian Fabricating & Welding, 2019)

Flux Cored
Arc Welding



(Venus Wires, 2018)

Gas Tungsten Arc
Welding



Gas Tungsten Arc
Welding 6" Pipe

Gas Metal Arc
Welding



(TEK, 2020)



EQUIPMENT RESOURCES

Resources

LABOR

EQUIPMENT/TOOLS

CNC milling
machine



Crane



Forklift



Cement mixer



EQUIPMENT SUBSTITUTIONS

- Equipment down, know & use substitutes



PREFERRED RESOURCES

Specify a preference order when defining a set of resources that are mostly interchangeable.

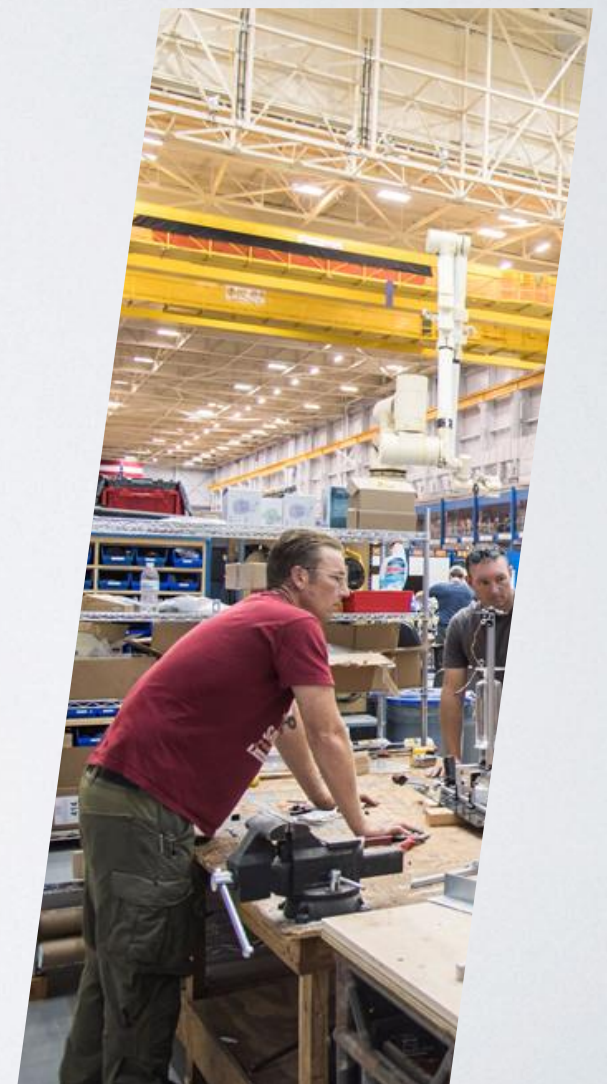
- Prefer work in default shop

- Prefer work by tech, but supervisor can substitute

- Prefer certain equipment

- Prefer certain lab space

- Use consistent auditors for a client

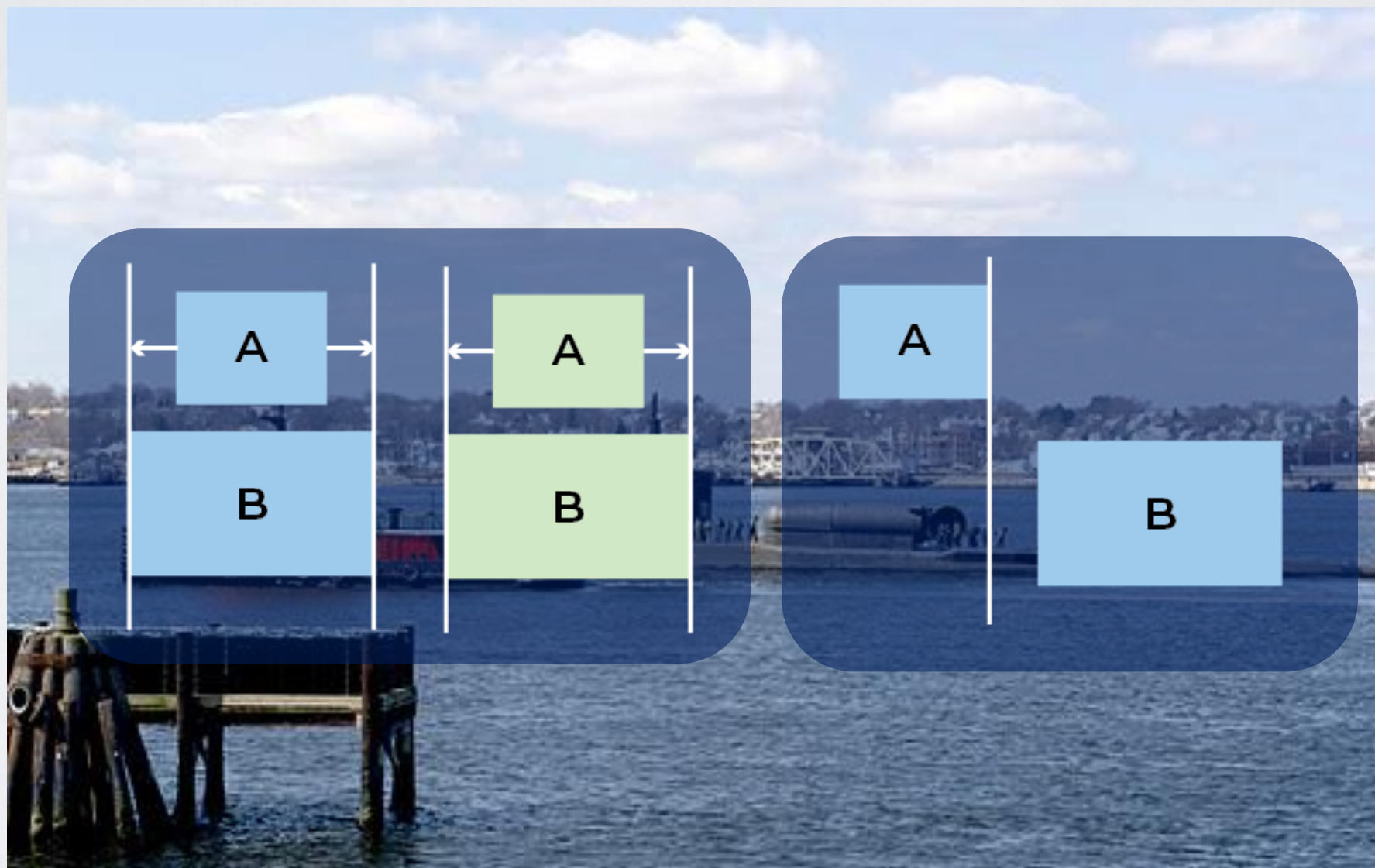


EQUIPMENT: USAGE CONSTRAINTS

- E.g., tool can only be used for so many hours continuously &/or during a day.



CONCURRENT & NON-CONCURRENT

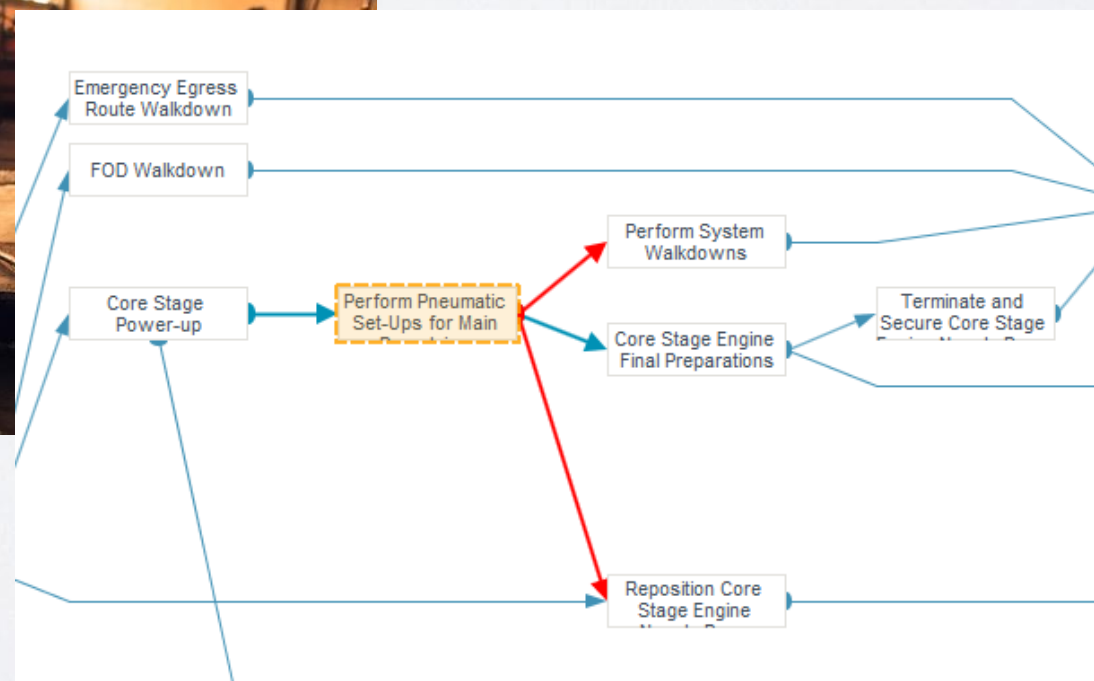


SPATIAL / PHYSICAL SPACE CONSTRAINTS

- For example:

Job requires a certain location or type of space

Two elements should (or should not) be next to each other
Concurrent or non-concurrent constraint



ERGONOMIC CONSTRAINTS – INDIVIDUAL LIMITATIONS ON WORK CONDITIONS

- E.g., only work so long:
continuously requiring kneeling, and/or
so much kneeling during a shift



SHIFT-BASED CONSTRAINTS

- This is a set of properties that allows the user to control how jobs interact with shift breaks
- Only start a job if it can finish during the same shift
- Job can only be performed during the day shift
- Job can take multiple shifts, but requires same resource constraints

ALTERNATIVE RESOURCE COMBINATIONS

- A task may require a Plumber and a Mechanic; however, there may also be Cross-trained person that can perform Plumber and Mechanic operations. So, the resource requirements for a task could be (Plumb & Mech) OR (Cross-trained).
- For cases where the same number of people are always needed, the resource requirement could be ((Plumb & Mech) OR (Cross-trained & Mech) OR (Plumb & Cross-trained) OR (2 Cross-trained)).
- Aurora's intelligent scheduling assigns the Cross-trained individuals to maximize throughput

SUCCESSOR START WITHIN LIMITED TIME FRAME

Normal

Finish <= Start

Offset: 0

Max Offset:

offset calendar Select

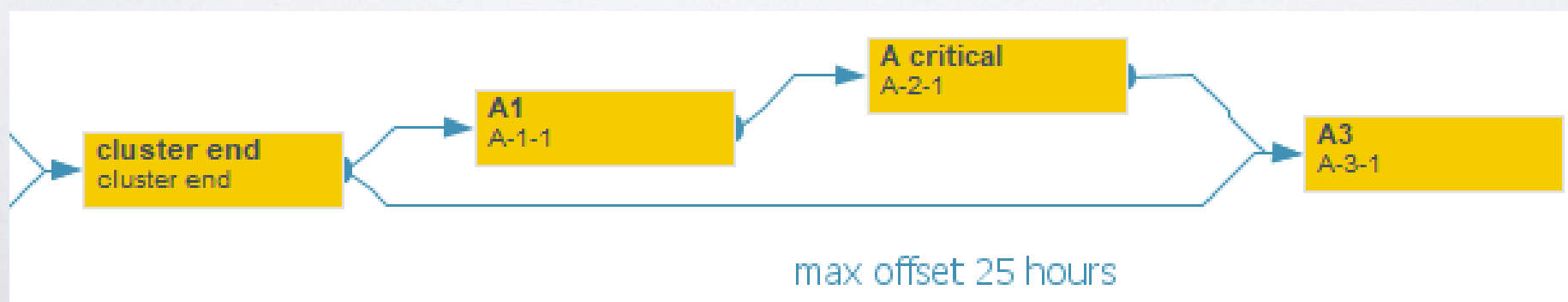
Core Properties

Note:

Bridging Constraint: ☐

Active: ☒

Close



ENHANCED CONSTRAINT DIALOG

Edit Constraint

31498041
↓
31499486

Normal

Not Compatible

Finish ≤ Start

Offset (Hours): 0

Max Offset (Hours):

offset calendar

Core Properties

Constraint Category:

Justification:

Note:

Bridging Constraint: ☐

Active: ☒

Constraint Type:

History

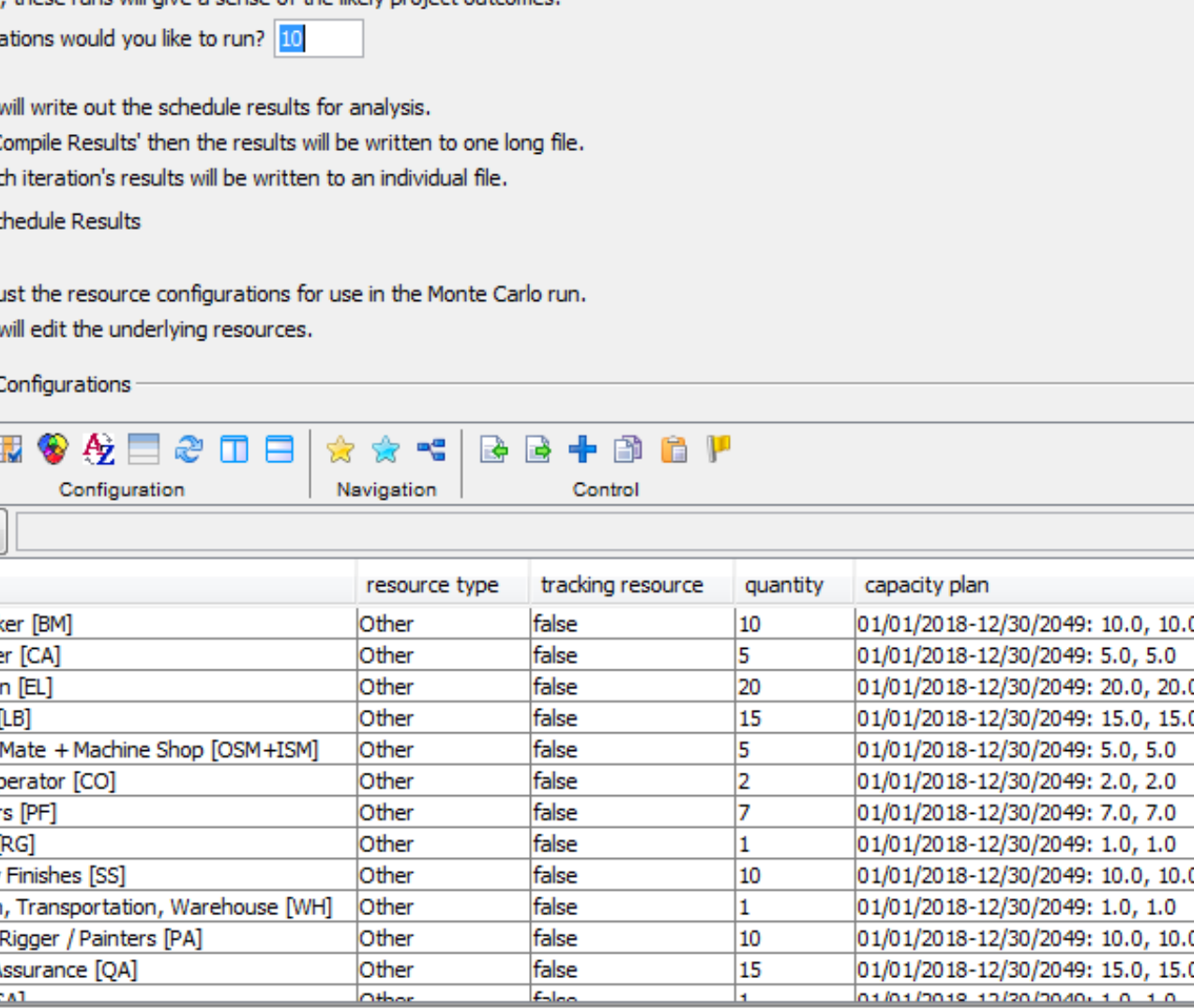
last updated by: none supplied
last updated on: 09/30/2024 13:42
last reviewed by: unknown
last reviewed on: before July 2021
attention counter: 0

INTEGRATION WITH DIGITAL TWIN

- Aurora is incorporated in the Siemens Integrated Project Planning & Execution (IPP&E) Xcelerator product.
- Links schedule tasks with digital



MONTE CARLO RISK SIMULATION



Each iteration will dynamically calculate a random duration for each job, based on its distribution, then schedule.
In combination, these runs will give a sense of the likely project outcomes.


How many iterations would you like to run?

Each iteration will write out the schedule results for analysis.
If you select 'Compile Results' then the results will be written to one long file.
Otherwise, each iteration's results will be written to an individual file.


☐ Compile Schedule Results

If desired, adjust the resource configurations for use in the Monte Carlo run.
Note that this will edit the underlying resources.


Resource Configurations



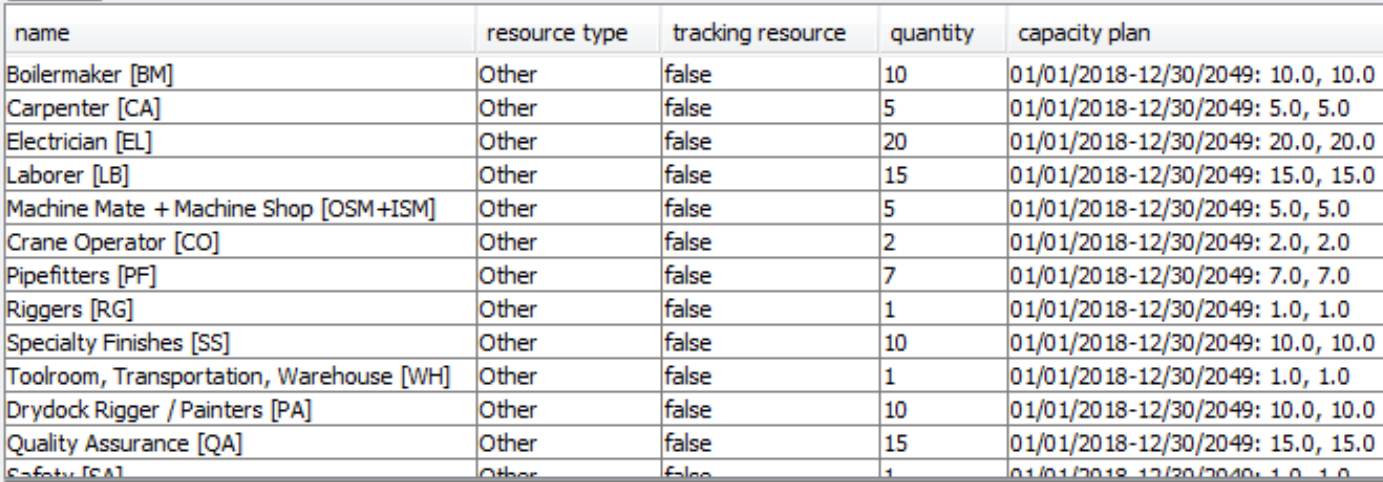
Configuration



Navigation



Control



name	resource type	tracking resource	quantity	capacity plan
Boilermaker [BM]	Other	false	10	01/01/2018-12/30/2049: 10.0, 10.0
Carpenter [CA]	Other	false	5	01/01/2018-12/30/2049: 5.0, 5.0
Electrician [EL]	Other	false	20	01/01/2018-12/30/2049: 20.0, 20.0
Laborer [LB]	Other	false	15	01/01/2018-12/30/2049: 15.0, 15.0
Machine Mate + Machine Shop [OSM+ISM]	Other	false	5	01/01/2018-12/30/2049: 5.0, 5.0
Crane Operator [CO]	Other	false	2	01/01/2018-12/30/2049: 2.0, 2.0
Pipefitters [PF]	Other	false	7	01/01/2018-12/30/2049: 7.0, 7.0
Riggers [RG]	Other	false	1	01/01/2018-12/30/2049: 1.0, 1.0
Specialty Finishes [SS]	Other	false	10	01/01/2018-12/30/2049: 10.0, 10.0
Toolroom, Transportation, Warehouse [WH]	Other	false	1	01/01/2018-12/30/2049: 1.0, 1.0
Drydock Rigger / Painters [PA]	Other	false	10	01/01/2018-12/30/2049: 10.0, 10.0
Quality Assurance [QA]	Other	false	15	01/01/2018-12/30/2049: 15.0, 15.0
Safety [SA]	Other	false	1	01/01/2018-12/30/2049: 1.0, 1.0

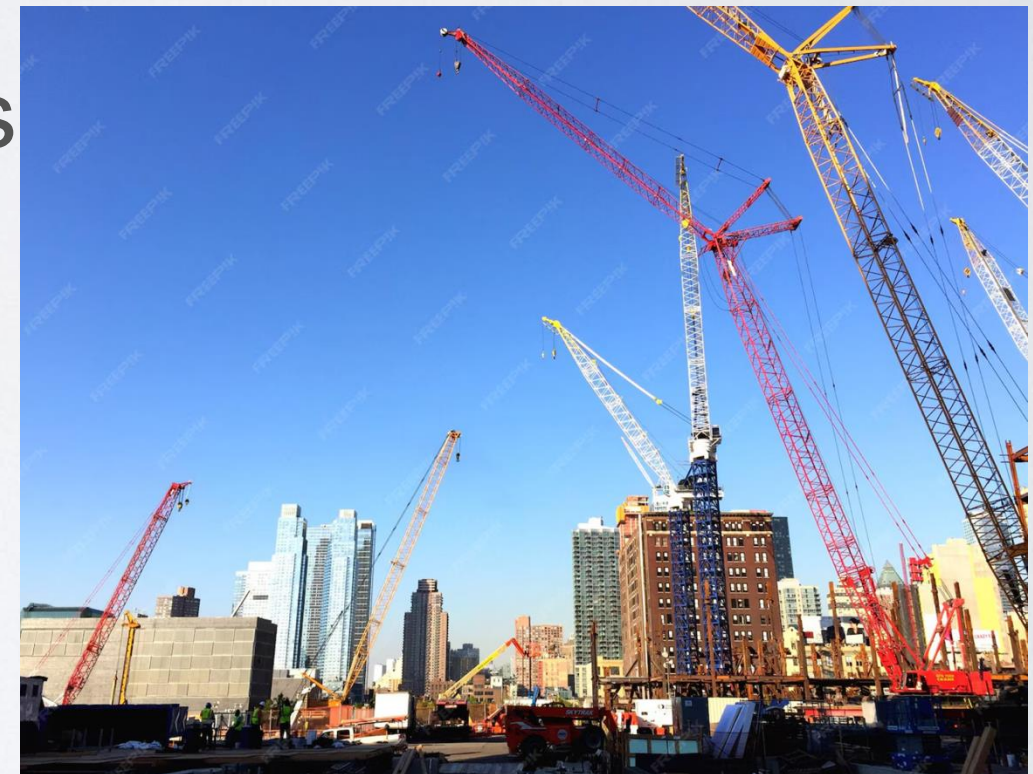
30 rows in table

OK

Cancel

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OVERLAP WITH RDM & RDCPM

- CT – Contiguous
- CC – Concurrent
- Continuous / Interruptible
- Risk / Monte Carlo
- Calendars of Durations of Activities and Restraints
- Event Codes
- Passage versus progress
- Reason/Why Codes: Reason/Why Restraint Code, Other Restraint Codes and Restraint Description Fields

CT – CONTIGUOUS

CC – CONCURRENT

- Aurora has the same functionality in the ABSOLUTE Finish-to-Start constraints, F=S.
- Aurora supports concurrent constraints.
In addition, Aurora supports non-concurrent constraints

CONTINUOUS / INTERRUPTIBLE

RISK / MONTE CARLO

- Aurora supports both continuous and interruptible activities.
- Aurora supports Monte Carlo analysis
 - Including fully resource loaded models with all the sophisticated modeling capabilities described herein and other capabilities unique to Aurora.

CALENDARS OF DURATIONS OF ACTIVITIES AND RESTRAINTS

EVENT CODES

- Aurora supports complex calendars.
Aurora supports shift-based constraints
- In Aurora Event Codes can be supported via Aurora's ability to support a large amount of user defined fields. So, a user defined field could be created called
 - Event Code Start
 - Event Code End
- If an Event Code is needed within an activity, then the activity can be split into multiple sub-activities connected with ABSOLUTE Finish-to-Start constraints, F=S.

PASSAGE VERSUS PROGRESS

- In Aurora the default offset lead/lag capability satisfies the passage version of “overlap of activities”.
- The usage of sub-activities connected with ABSOLUTE Finish-to-Start constraints, $F=S$, can be used so that a sub-activity is created to represent the amount of progress required, and then another constraint would be created between the sub-activity and the other activity that was waiting for the progress to complete.

REASON/WHY RESTRAINT CODE & RESTRAINT DESCRIPTION FIELDS

- For physical constraints, the Reason/why can be entered as part of the constraint definition, Justification field.

Constraint Wizard: Create a Constraint

Temporal Constraint

A
↓
B

Normal

Not Compatible

Finish <= Start

Offset (Hours): 0

Max Offset (Hours):

offset calendar Select

Core Properties

Constraint Category:

Justification:

Note:

Bridging Constraint: ☐

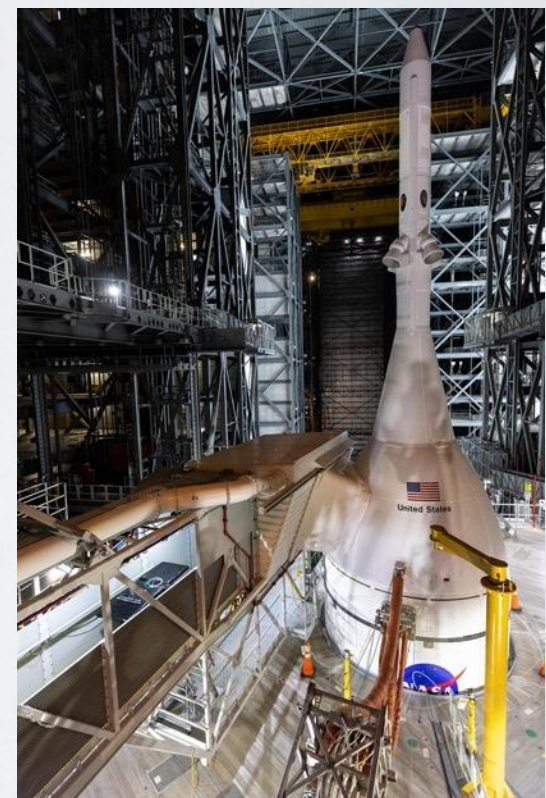
Active: ☒

Constraint Type: precedence

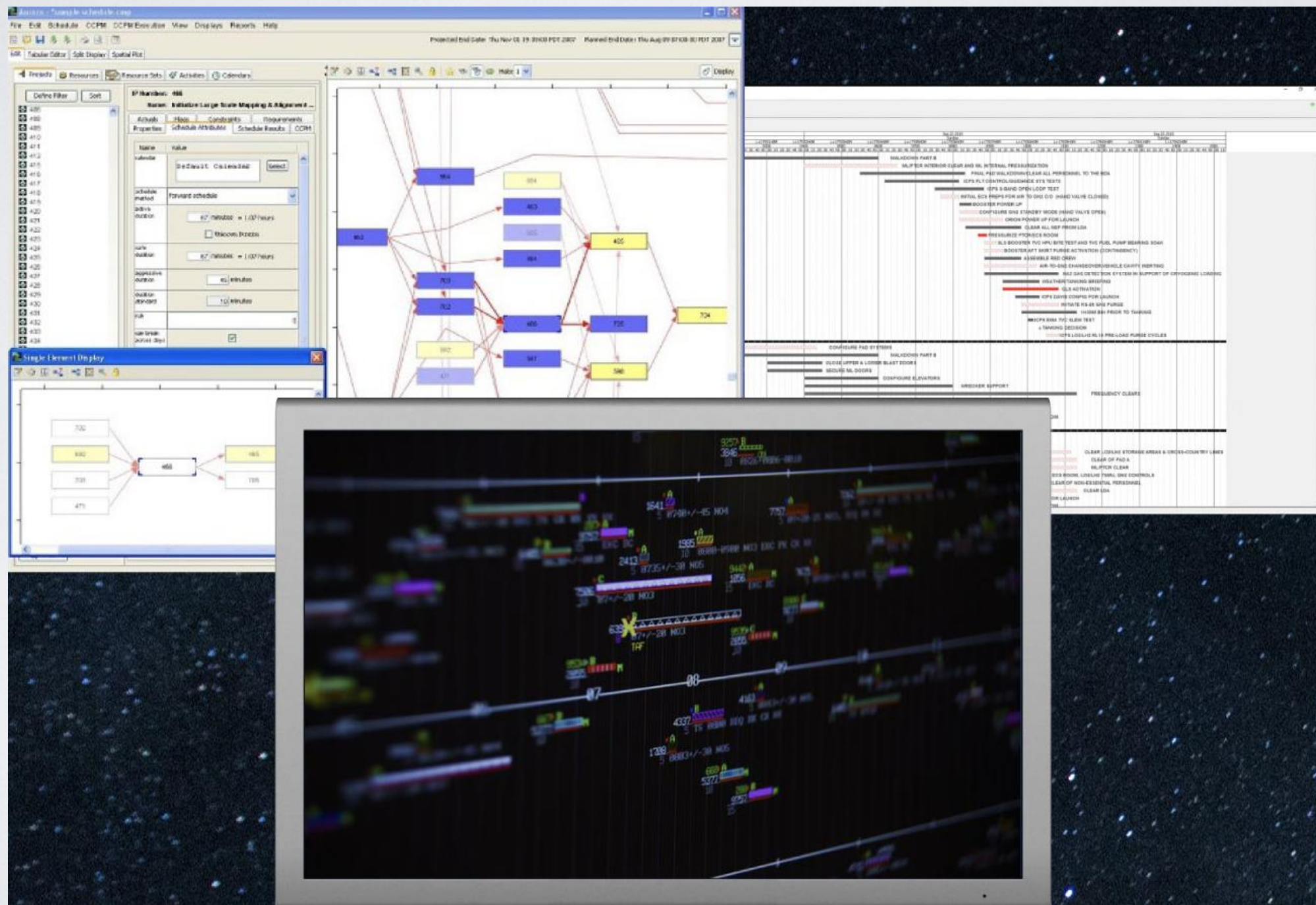
Previous Next Create Constraint Cancel

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REVEAL AND EXPLAIN THE SCHEDULE



PROJECT NETWORK

File Edit Schedule Utilities CCPM CCPM Execution View Displays PERT Chart Reports Help

New Open Save Print Preview Schedule

Projected End Date: 04/02/2016 17:00 Planned End Date: 04/15/2011 15:24

Edit Gantt Chart PERT Chart Gantt Chart Histogram Plot Tabular Editor

Projects Resources Resource Sets Activities Calendars

Instances Filter Sort Export

CCPM-EWS-005

- <no job>
- Site work Outfall Tunnels
- Site work Intake Pump Station
- Coloso substation expansion (C)
- Site work Coloso to West Tunnel
- Construction camp 1 Construction
- Piping - small bore - above ground
- Cable tray, conduit, raceway R
- Wire and cable Reverse Osmosis
- Instrumentation Reverse Osmosis
- Electrical equipment Reverse Osmosis
- Mechanical equipment Reverse Osmosis
- Structural steel Reverse Osmosis
- Architectural Reverse Osmosis
- Piping - large bore - above ground
- Piping - small bore - above ground
- Cable tray, conduit, raceway R
- Wire and cable Reverse Osmosis
- Instrumentation Reverse Osmosis
- Electrical equipment Reverse Osmosis
- Concesión Marítima NDP
- Modificación Concesión Marítima
- Obras Portuarias
- Interconexión sobre 23>kV
- Construcción de Obra Hidráulica
- Construcción de Obra Hidráulica
- Solicitud de Atravesado con Noroeste
- Solicitud de Atravesado con Blanco
- Solicitud de Atravesado con Gas
- Solicitud de Atravesado con LAT

Project: CCPM-EWS-005

Job:

CSMP Summary:

Task Name: Electrical equipment Reverse Os...

Property Search:

Properties Details

activity code

task name

job

CSMP Summary

project

external id

description

work assignment

job type

position

user attributes

name value

ProjectUID 180040

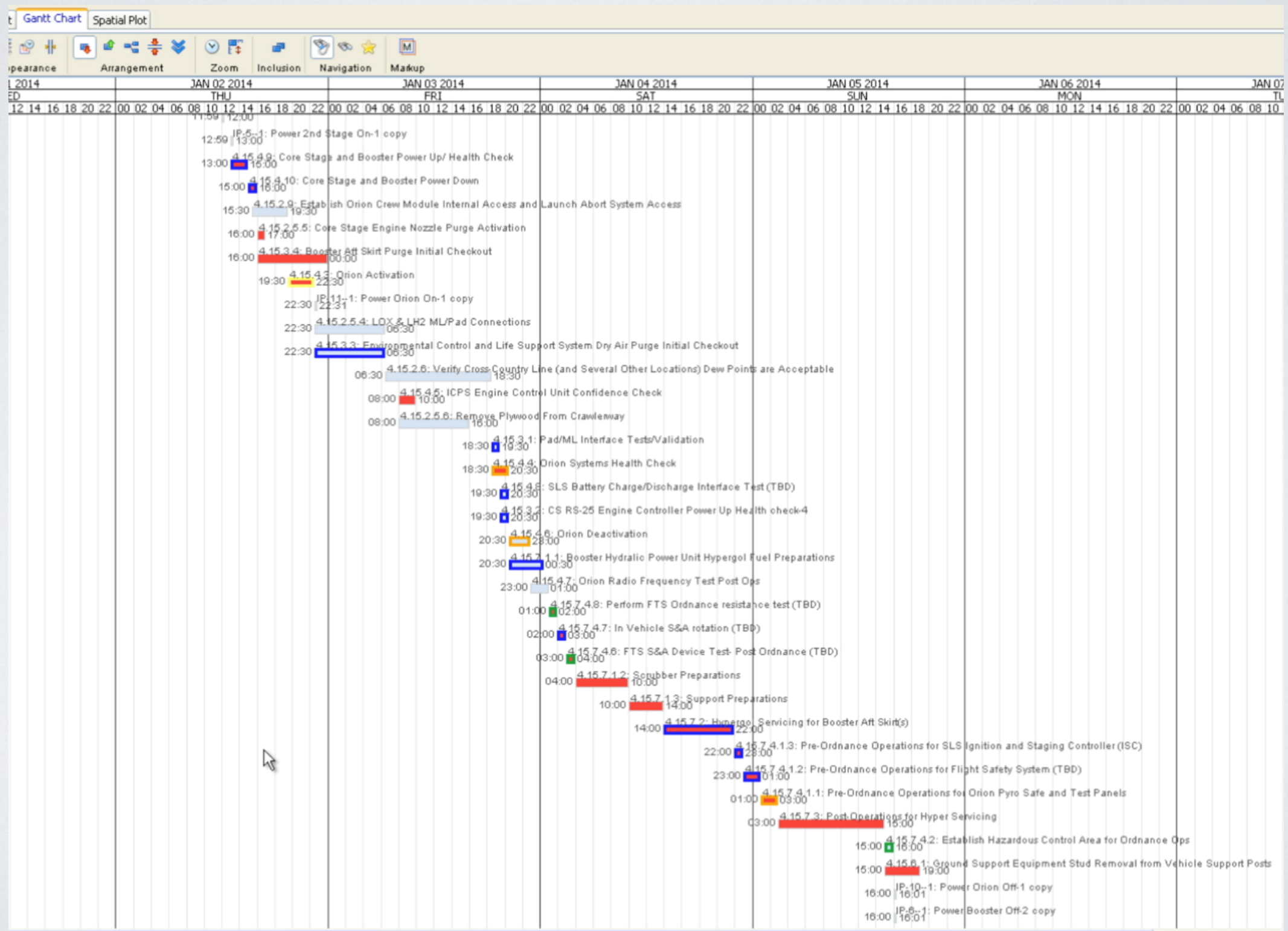
Add Remove

Configuration Appearance Arrangement Zoom Inclusion Navigation Markup

Flow Halo: 0

Display

GANTT CHART COLOR-CODED PER USER DESIRED CRITERIA



RESOURCE CONTENTION: VISUAL

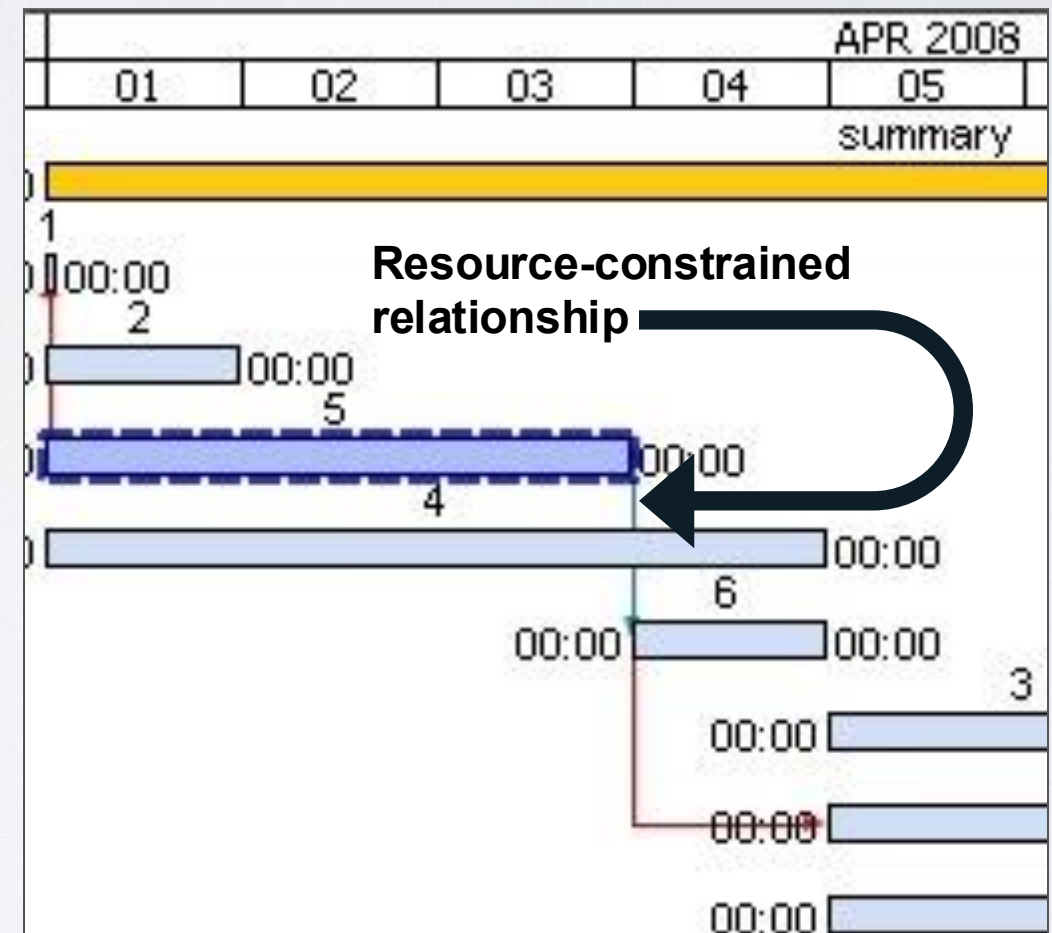
- Viewing resource contentions

In this sample schedule, each task has a resource requirement attached as follows

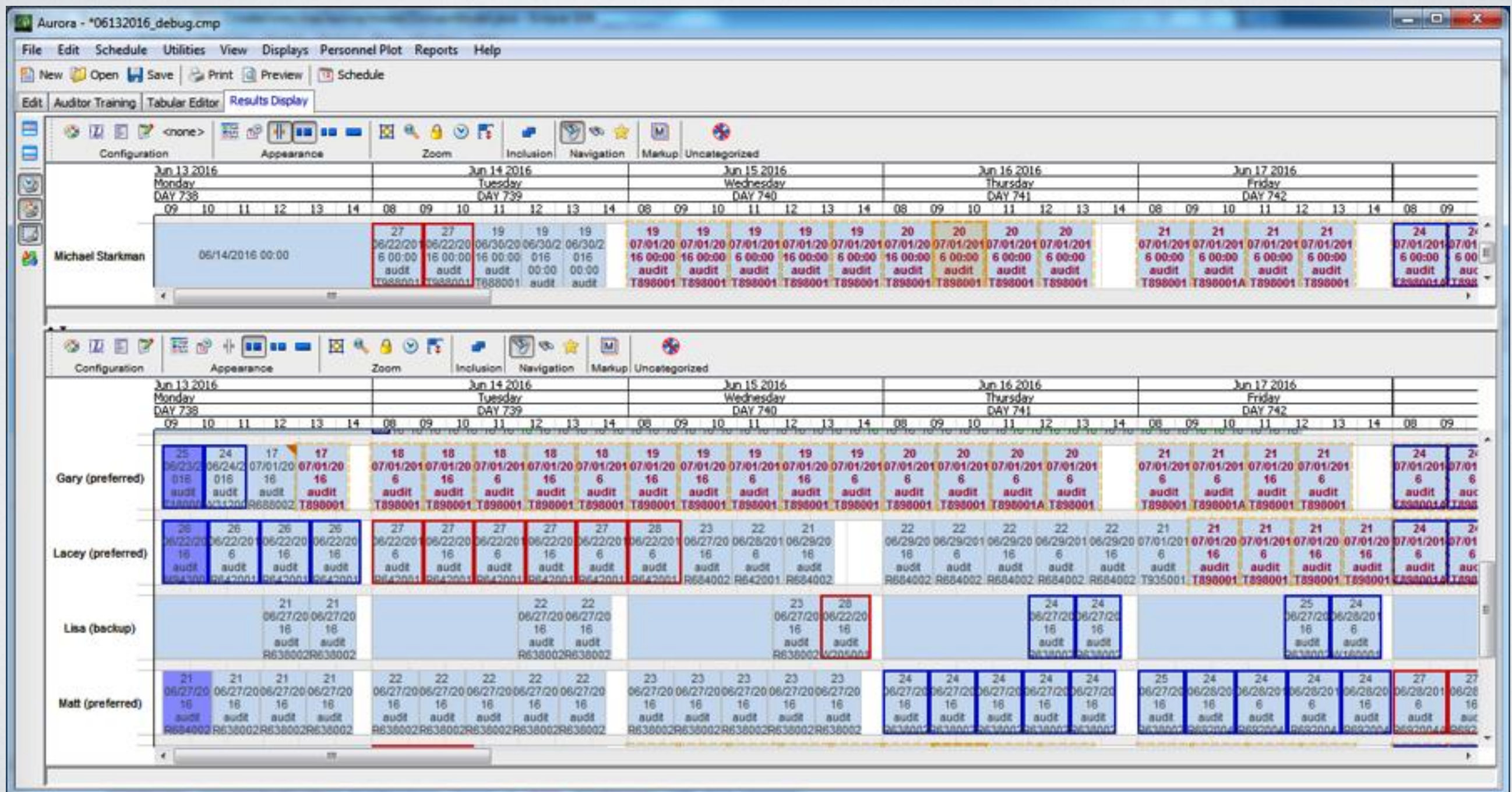
Task #	Resources Needed
2	1
3	2
4	2
5	2

Note that there is a total amount of only 5 resources. Tasks 2, 4, and 5 are started at the same time (5 resources used). Task 2 completes, but there are not enough resources left to start Task 6, so Task 6 must wait until Task 5 is complete.

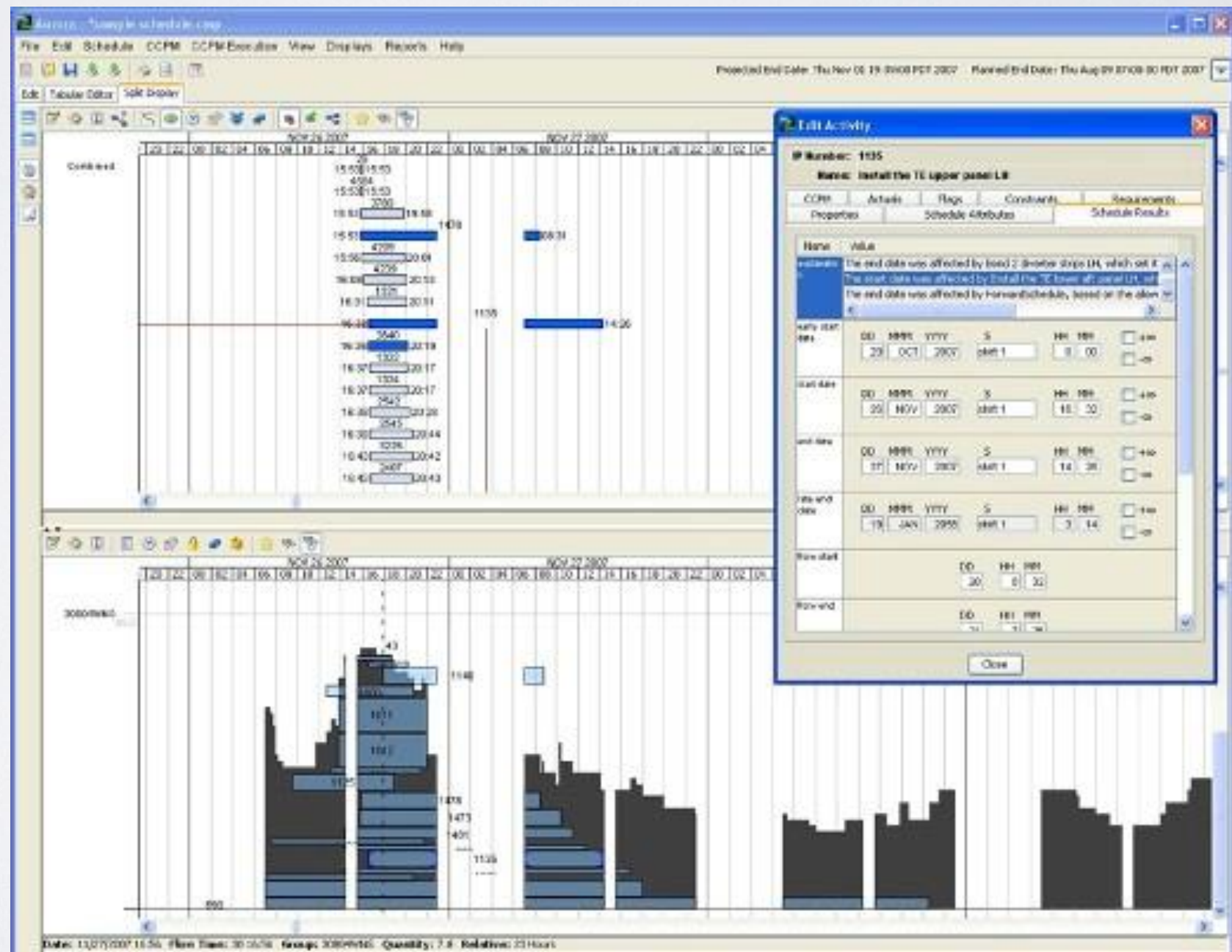
Aurora shows you this resource-constrained relationship with a blue-grey line between the two Tasks.



TEAM ASSIGNMENT DISPLAY



SPLIT VIEW SHOWING GANTT CHART SAME TIME SLICE AS HISTOGRAM, SHOWING ACTIVITIES CONSTITUTING RESOURCE NEED FOR ONE TIME INSTANCE



NETWORK DIAGRAM W/ MINI-MAP DISPLAY & SINGLE ELEMENT VIEW

Aurora - *GLP_Goldratt_Brazil_in Aurora 2013-11-18.cmp

File Edit Schedule Utilities CCPM CCPM Execution View Displays PERT Chart Reports Help

Planned End Date: Mon Feb 04 09:00:00 PST 2013

Projects Resources Resource Sets Activities Calendars

Instances Filter Sort E

- Comentários RM Petrobras - Sistemas
- Requisição de materiais - Detetores d
- Modelagem 3D
- Modelagem de Instrumentação
- Folha de Dados
- Comentários FD Petrobras - Termôme
- Folha de Dados - Válvulas PSV'S (top
- Folha de dados - Termômetro
- Folha de dados - Transmissor de Pre
- Comentários FD Petrobras - Chave de
- Comentários FD Petrobras - Válvulas I
- Folha de dados - Chave de Nível tipo
- Comentários FD Petrobras - Sistema c
- Comentários FD Petrobras - Sistema C
- Requisição de materiais - Transmisso
- Comentários FD Petrobras - Transmis
- Folha de dados - Válvulas Bloqueio El
- Comentários FD Petrobras - Válvulas I
- Folha de dados - Válvulas Esfera Atua
- Comentários FD Petrobras - Válvulas I
- Folha de dados - Detetores de Gás (H
- Comentários FD Petrobras - Detetores
- Folha de dados - Detetores de Gás (H
- Comentários FD Petrobras - Detetores
- Verificação do Desenho do Fornecedo
- Verificação de DF e Certificação - Det
- Verificação de DF e Certificação - Cha
- Verificação de DF e Certificação - Sisti
- Verificação de DF e Certificação - Ter

Project: GLP_Primavera_XER

Job:

CSMP Summary:

Task Name: Verificação de DF e Certificação - ...

Property Search:

Properties Details

IP Number e Certificação - Termômetro

task name e Certificação - Termômetro

job

CSMP Summary project

external id 2148

description

work ass

job

pos

use att

New Project New Instance

Add Task Delete

Copy

Single Element Display

Configuration Appearance Arrangement Zoom Markup

Recebimento DF (A) -

Verificação de DF e Certificação

Lista de Instrumentos

Término da Engenharia do

Configuration Appearance Arrangement Zoom Markup

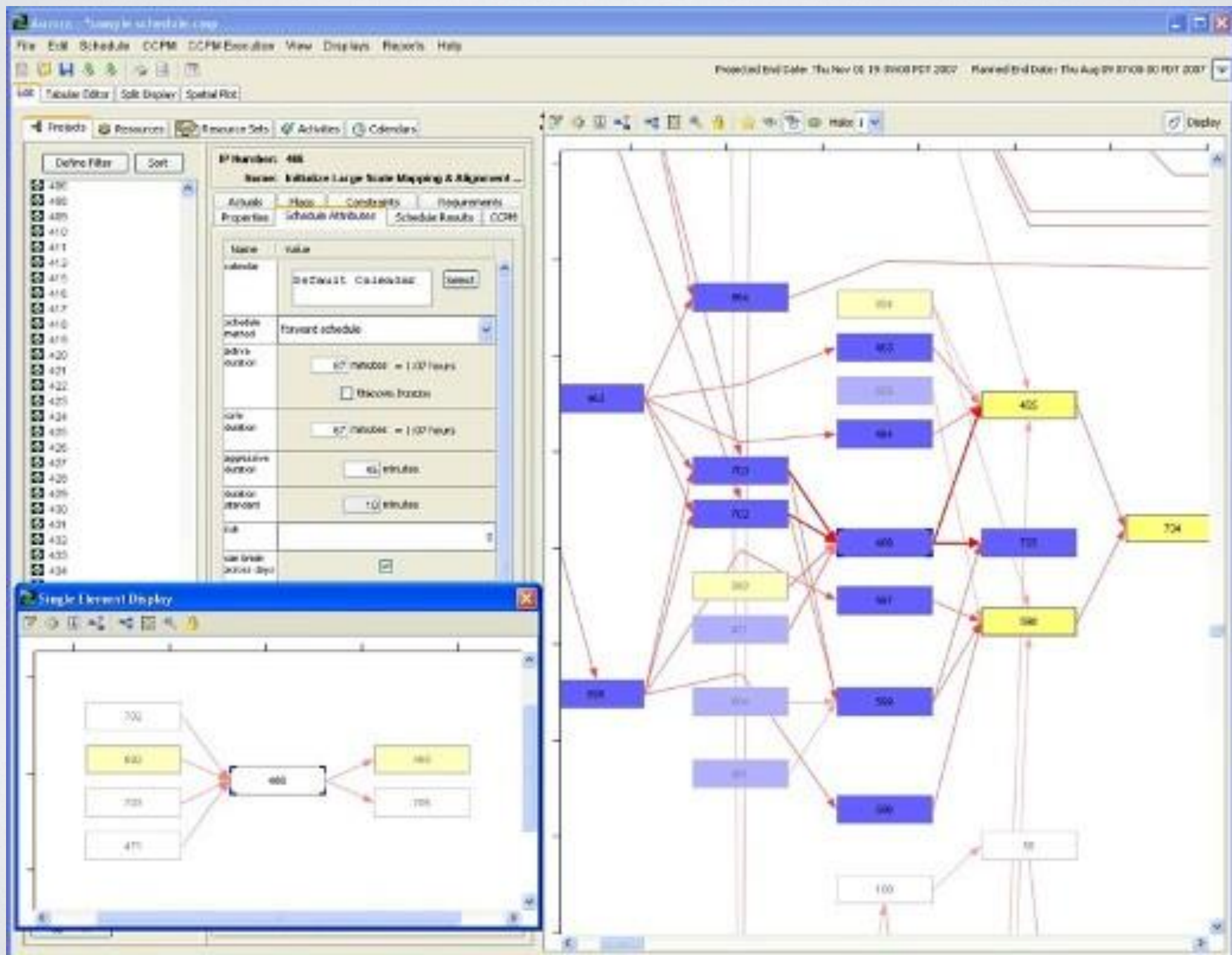
Flow Halo: 0

Navigation Markup

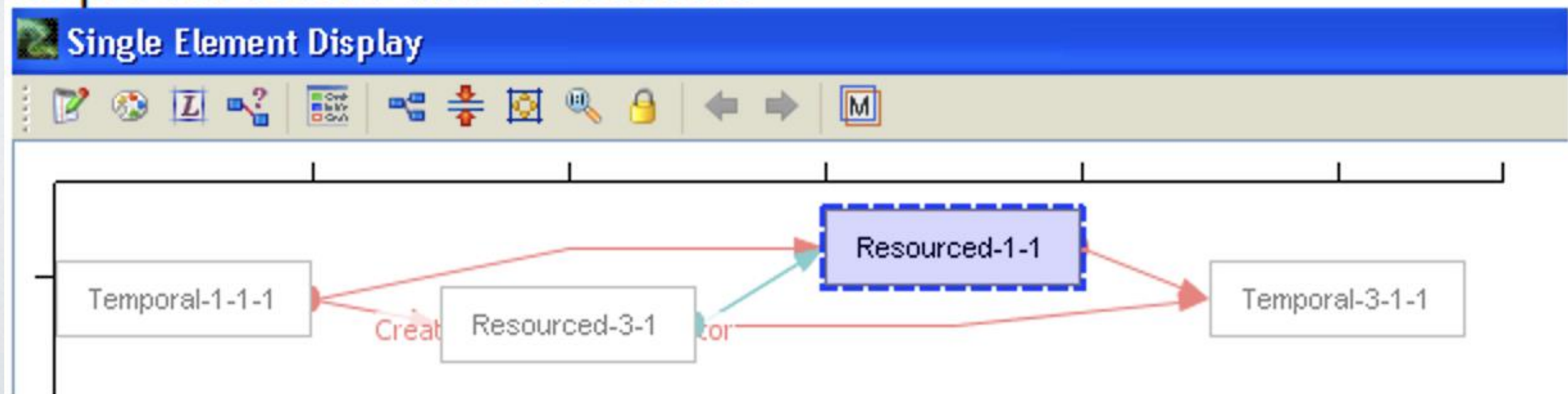
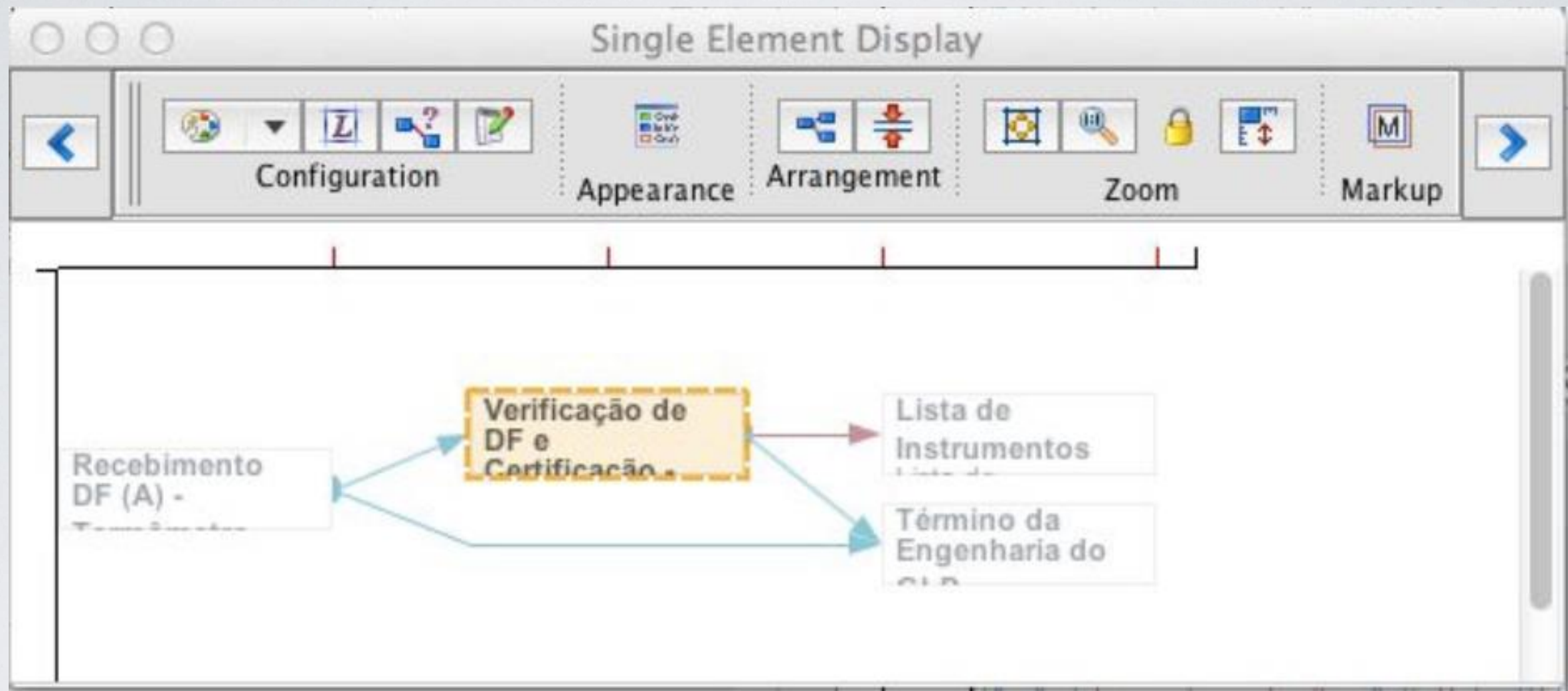
Display

The screenshot displays the Aurora software interface. The main window shows a network diagram with a grid background. A mini-map is visible in the bottom right corner. A 'Single Element Display' window is open, showing a detailed view of a task named 'Verificação de DF e Certificação'. The interface includes a menu bar at the top with options like File, Edit, Schedule, Utilities, CCPM, CCPM Execution, View, Displays, PERT Chart, Reports, and Help. A toolbar below the menu bar contains icons for various functions. On the left side, there is a 'Projects' pane with a list of project tasks. The central area is divided into a 'Properties' pane on the left and a 'Details' pane on the right. The 'Properties' pane shows fields for IP Number, task name, job, CSMP Summary, project, external id, and description. The 'Details' pane shows a 'Single Element Display' window with a diagram of the task's flow. The diagram shows a sequence of steps: 'Recebimento DF (A) -', 'Verificação de DF e Certificação', 'Lista de Instrumentos', and 'Término da Engenharia do'. The 'Single Element Display' window has its own toolbar with options like Configuration, Appearance, Arrangement, Zoom, and Markup. The main window also has a toolbar with options like Configuration, Appearance, Arrangement, Zoom, Inclusion, Navigation, and Markup. The status bar at the bottom shows the planned end date: Mon Feb 04 09:00:00 PST 2013.

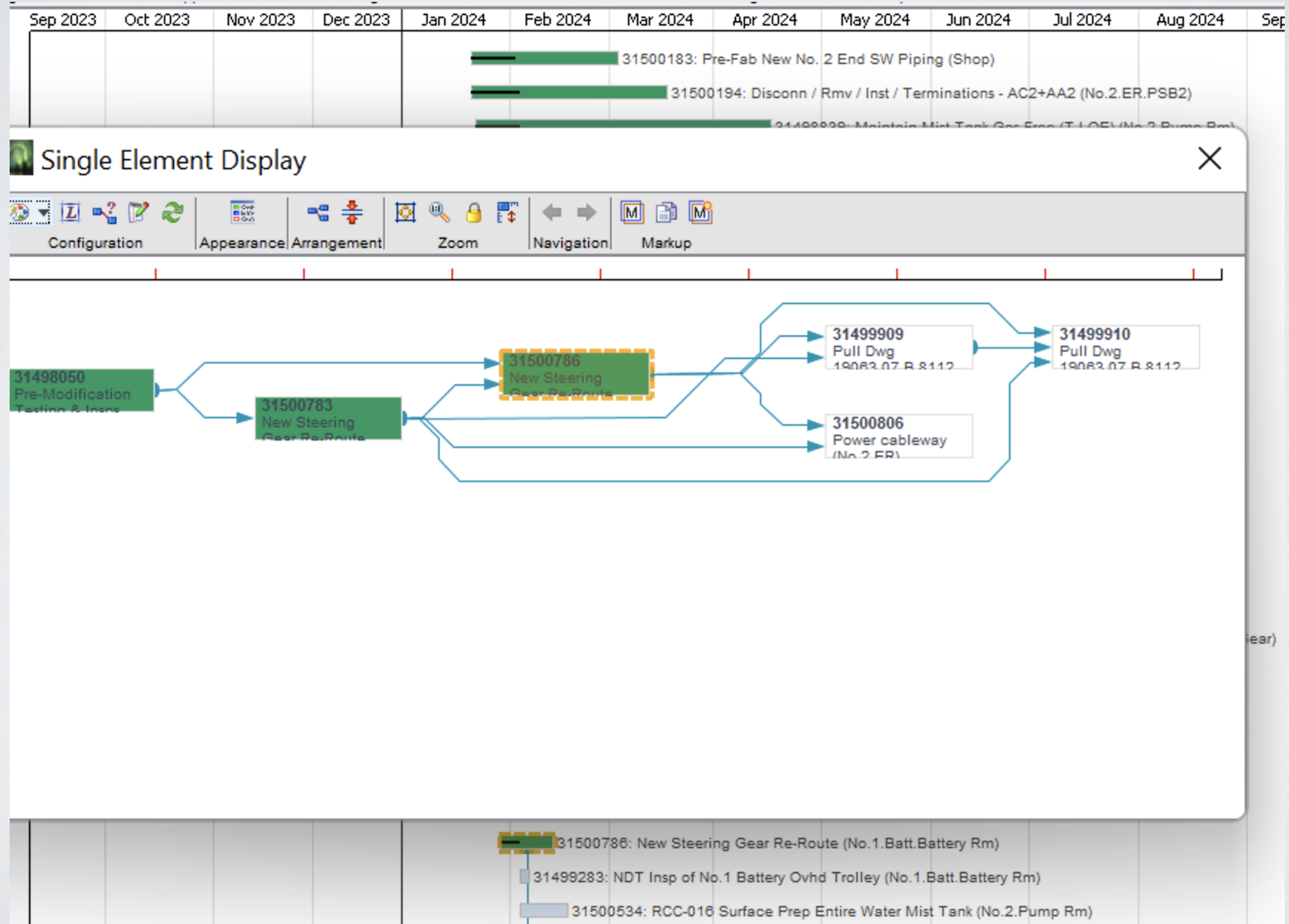
NETWORK DIAGRAM SHOWING SINGLE-ELEMENT VIEW OPTION



SINGLE ELEMENT DISPLAY

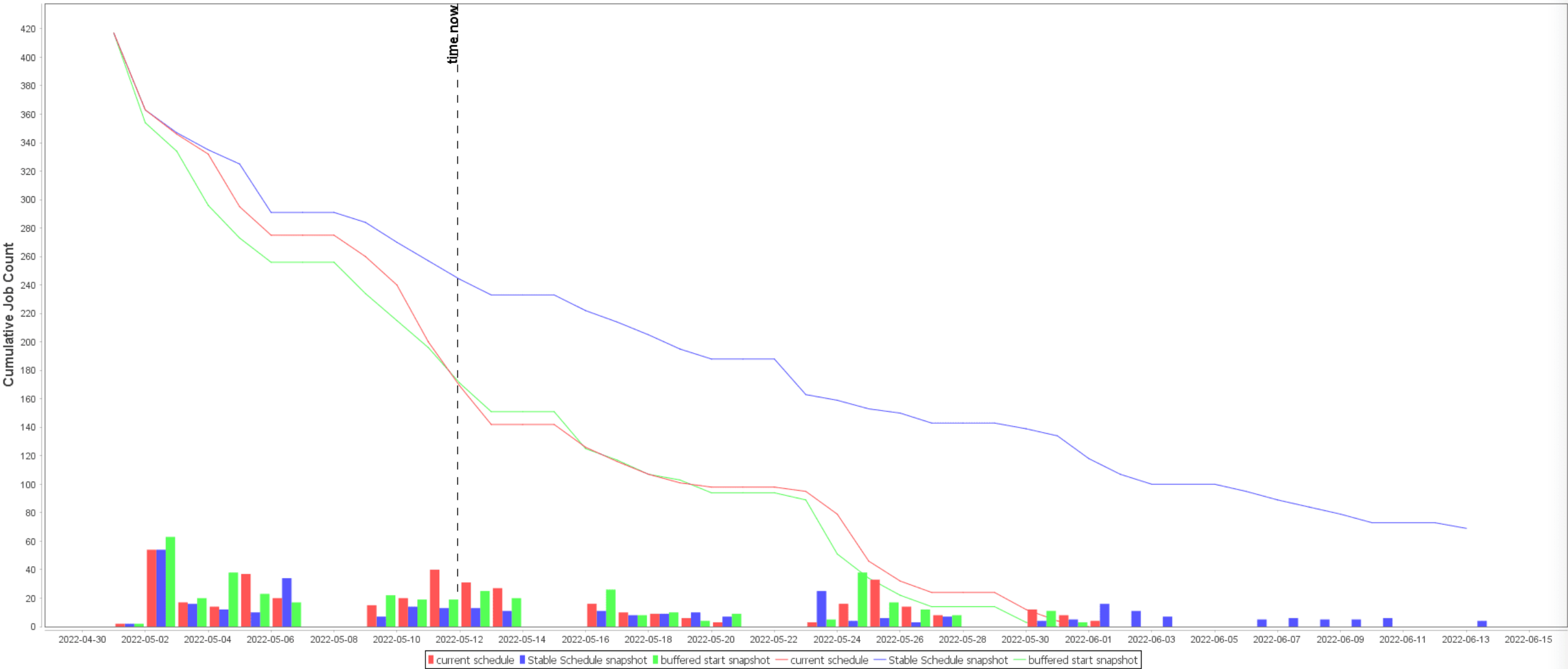


SINGLE ELEMENT DISPLAY FROM GANTT CHART



BURNDOWN CHART

Burndown by Day (start date)



EXPLAIN THE SCHEDULE

Name: Post-Operations for Hyper Servicing	
Property Search: <input type="text"/>	
Properties Details Geometry Duration Info Schedule Attributes Schedule Results CCPM Analysis Actuals Integrations Flags Constraints Requirements	
scheduled order	42
explanation	<p>The end date was affected by the maximum flow time of 7300.00 days, which set it to 12/27/2033 00:00</p> <p>The start date was affected by Hypergol Servicing for Booster Aft Skirt(s), which set it to 01/03/2014 00:00</p> <p>The end date was affected by Establish Hazardous Control Area for Ordnance Ops, which set it to 12/25/2033 10:49</p> <p>The start date was affected by Hypergol Servicing for Booster Aft Skirt(s), which set it to 01/04/2014 22:00</p> <p>The start date was affected by ForwardSchedule, restricted by availability of Hazardous Pad-1; waiting for Pre-Ordnance Operations for Orion Pyro Safe and Test Panels, which set it to 01/05/2014</p> <p>The end date was affected by ForwardSchedule, based on duration and start time, which set it to 01/05/2014 15:00</p>

The start date was affected by the flow start time, which set it to 12/01/2017 00:00

The end date was affected by the maximum flow time of 7300.00 days, which set it to 11/26/2037 00:00

The start date was affected by [null--66](#), which set it to 12/27/2017 11:00

The end date was affected by [null--108](#), which set it to 10/29/2037 12:00

The start date was affected by [null--66](#), which set it to 01/06/2018 11:00

The start date was affected by ForwardSchedule, restricted by availability of [LWUA](#); waiting for [null--72](#), which set it to 01/16/2018 11:00

The end date was affected by ForwardSchedule, based on duration and start time, which set it to 01/17/2018 17:00

LESSONS & RESULTS

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 - Significant productivity lost due to inferior model details
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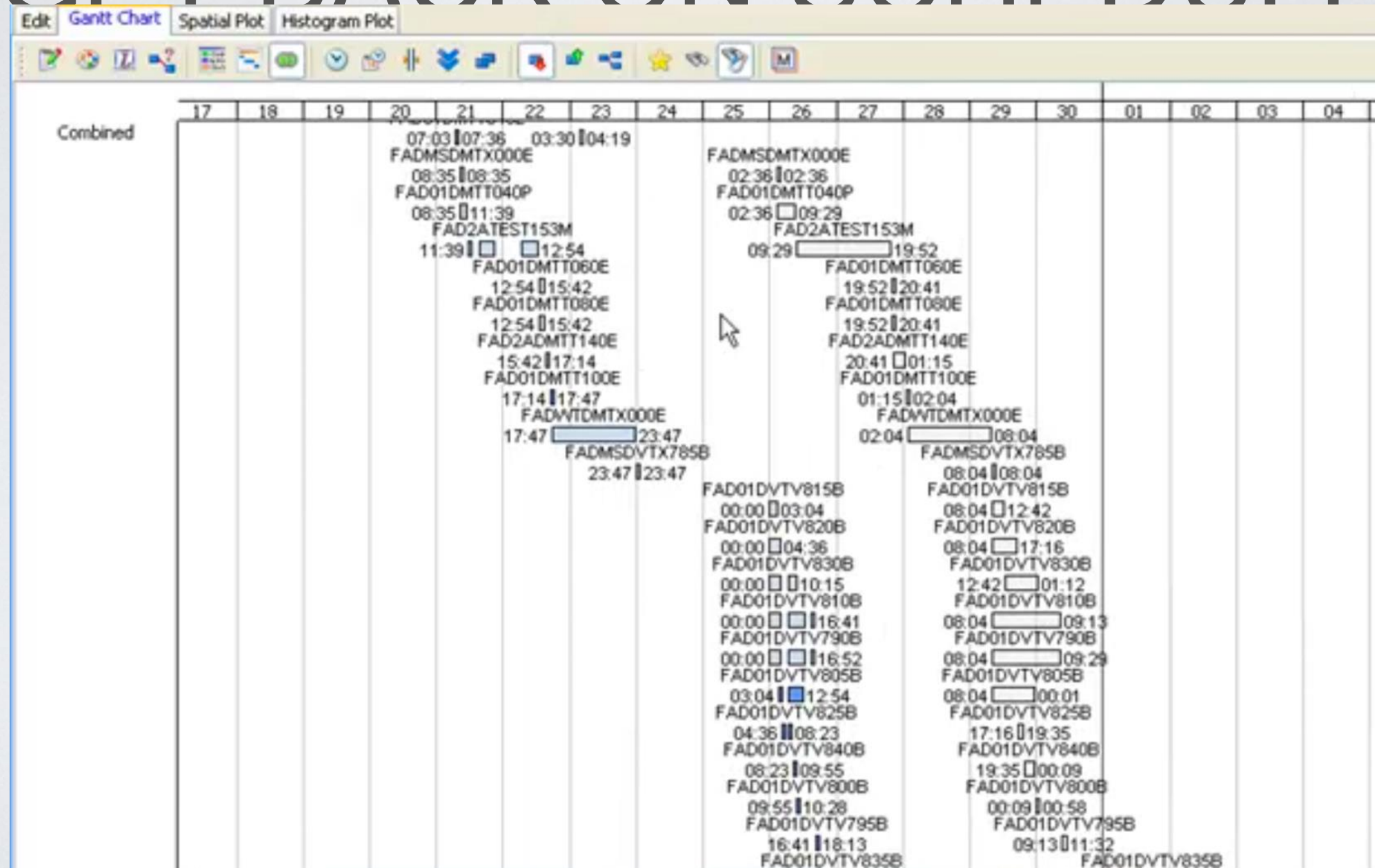


EASY & FAST TO PERFORM SCENARIOS / WHAT-IFS

- Wall clock minimization to run a scenario critical so human schedulers will actually run them
- Provide ways to graphically compare results



WHAT-IF: WORK WEEKEND TO GET BACK ON SCHEDULE



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BENEFITS OF SOPHISTICATED UNDERLYING SCHEDULER

- Results in a more realistic initial schedule
- Execution: Schedule is more flexible and better able to accommodate change.
- Schedule is “self-aware” of what tasks can most easily be moved. I.e., tasks store information about why it was placed (where it is placed).



SIGNIFICANT PRODUCTIVITY LOST DUE TO NON-REALISTIC PROJECT MODELING

- If current tool can not model the project model correctly, it can not execute efficiently.

QUESTIONS ?

CPM Construction Conference 2026

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