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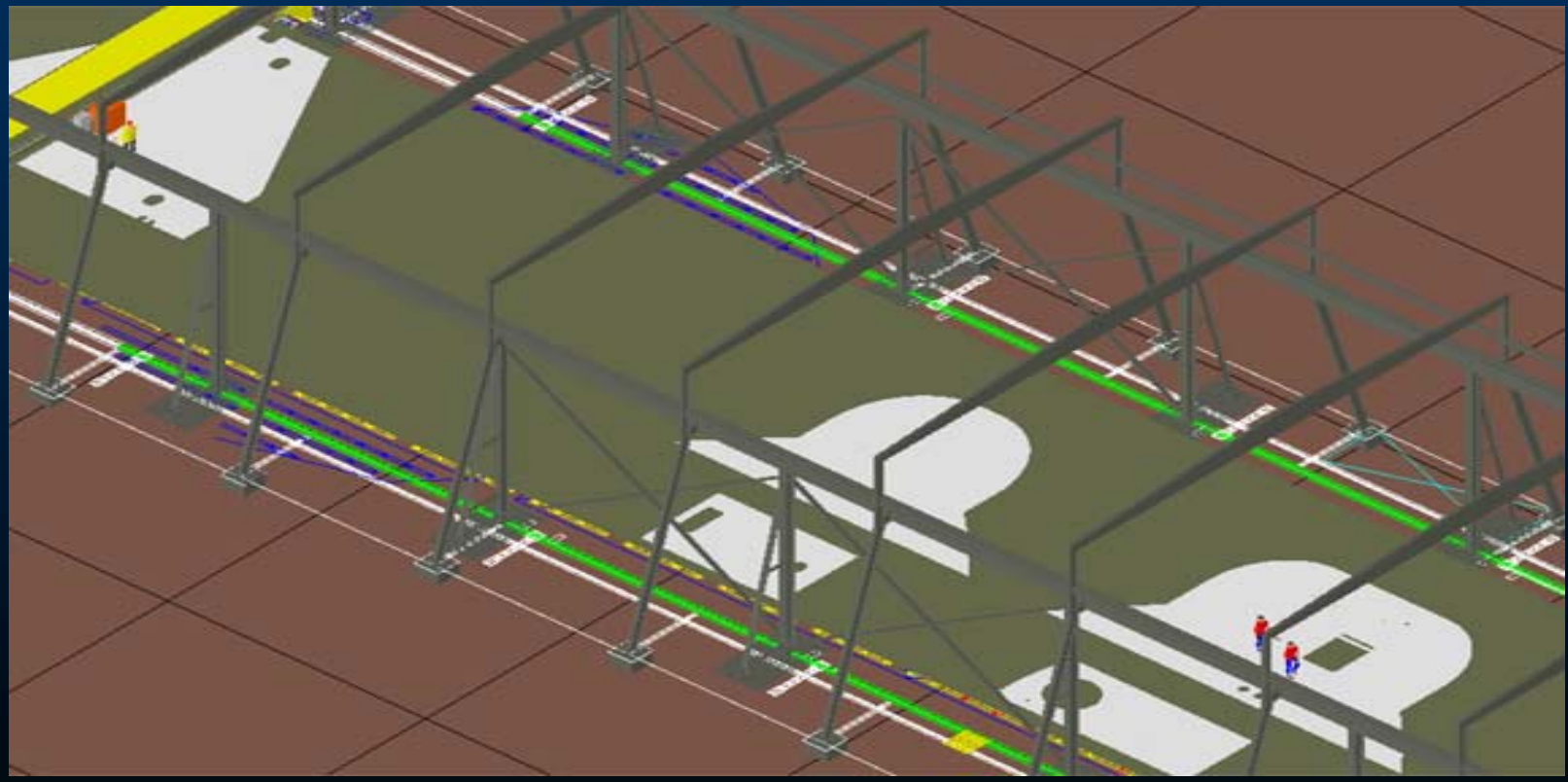
PLOPS

Panel Line Optimization through Predictive Scheduling

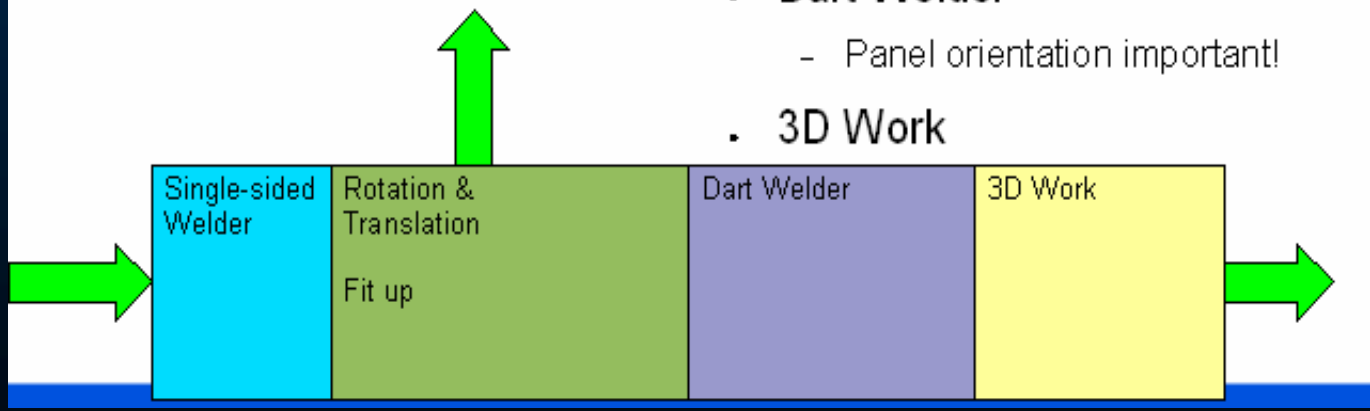


San Diego May. 16 2007

Basic Panel Line Work Flow

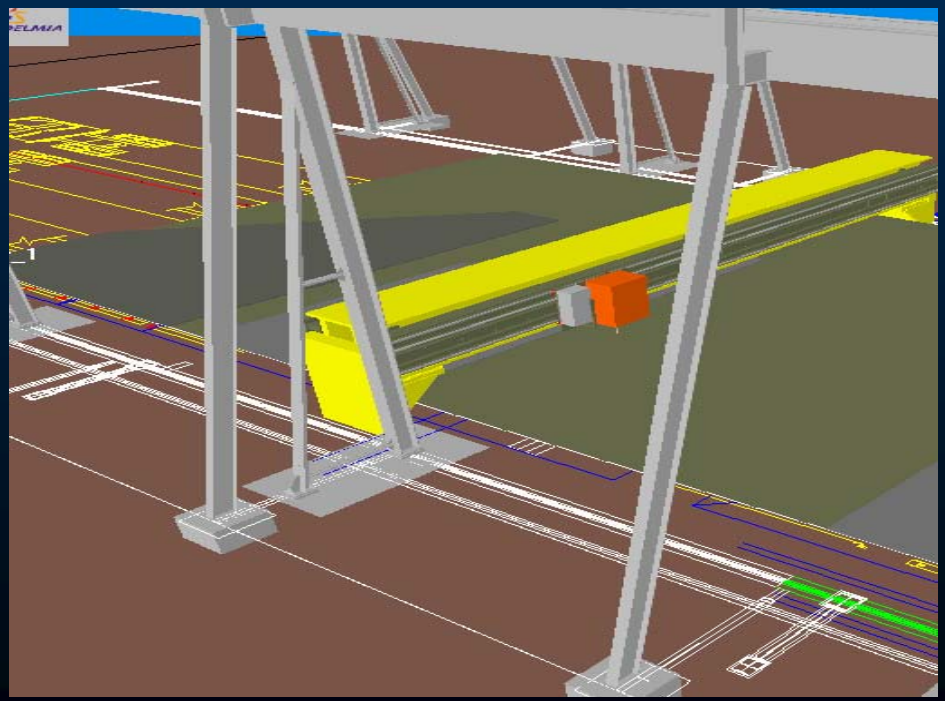
- Multiple Work Envelopes
  - Single Sided Welders
  - Plate rotation & translation
  - Dart welders
  - 3D work
  - Irregular Work flow (Removing panels in the middle of the line)

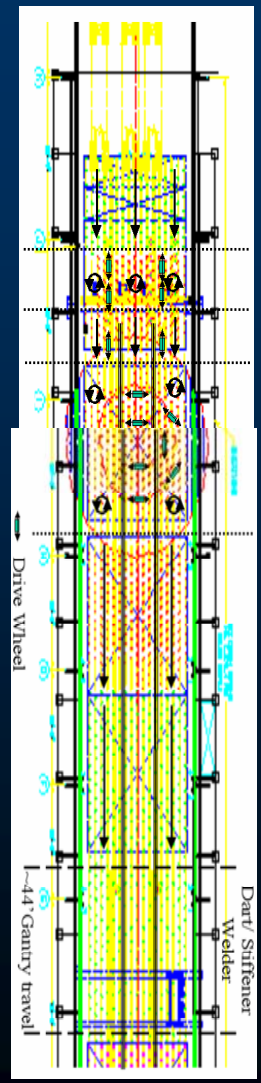
- Single Sided Welder
  - May require material to back-out and rotate for welding
- Rotation & Translation
  - Panels may require rotation for next step, or translation on the table
- Dart Welder
  - Panel orientation important!
- 3D Work



Panel Constraints

- Drive/ Roller combinations
- Physical restraints





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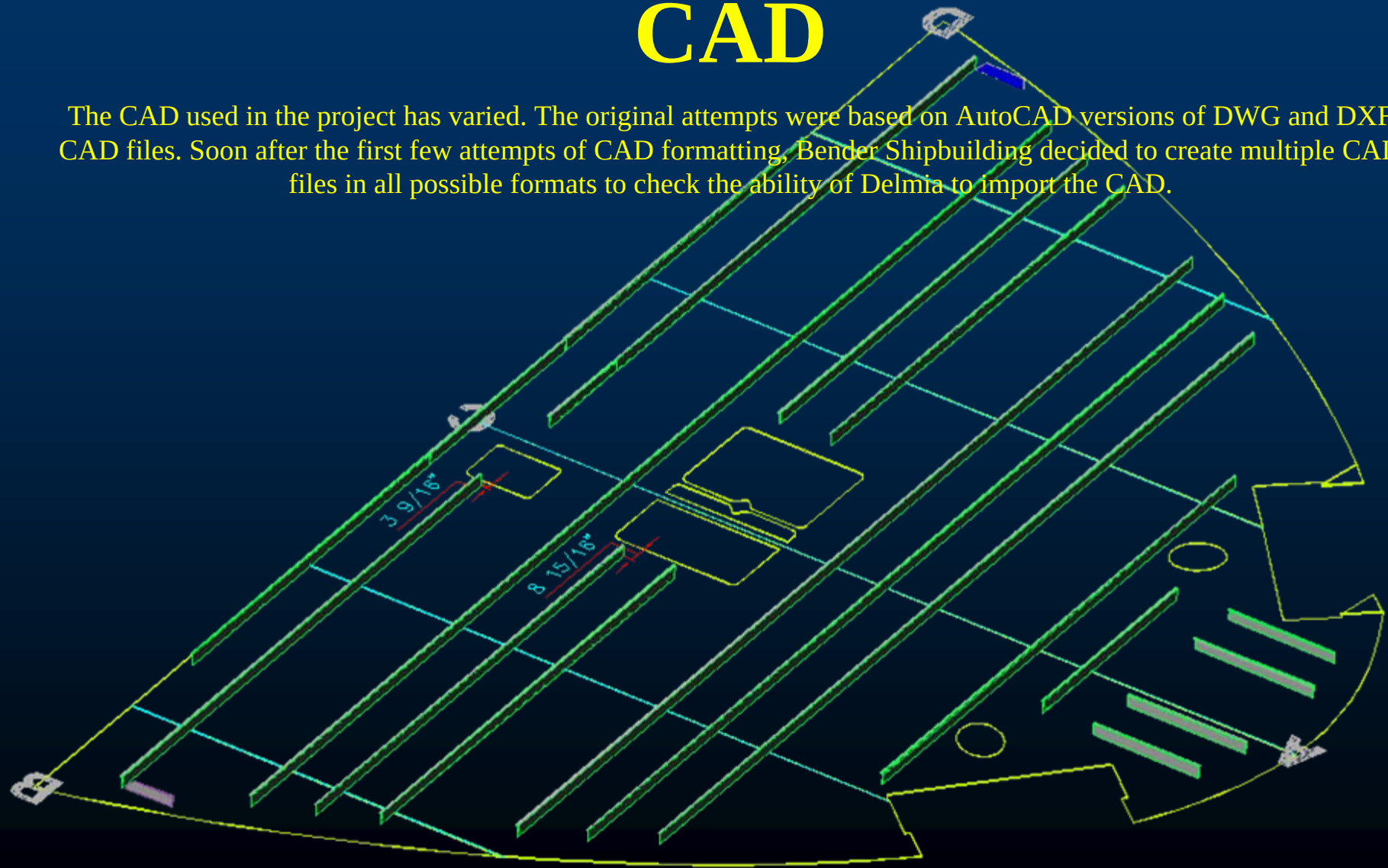
CAD

The CAD used in the project has varied. The original attempts were based on AutoCAD versions of DWG and DXF CAD files. Soon after the first few attempts of CAD formatting, Bender Shipbuilding decided to create multiple CAD files in all possible formats to check the ability of Delmia to import the CAD.



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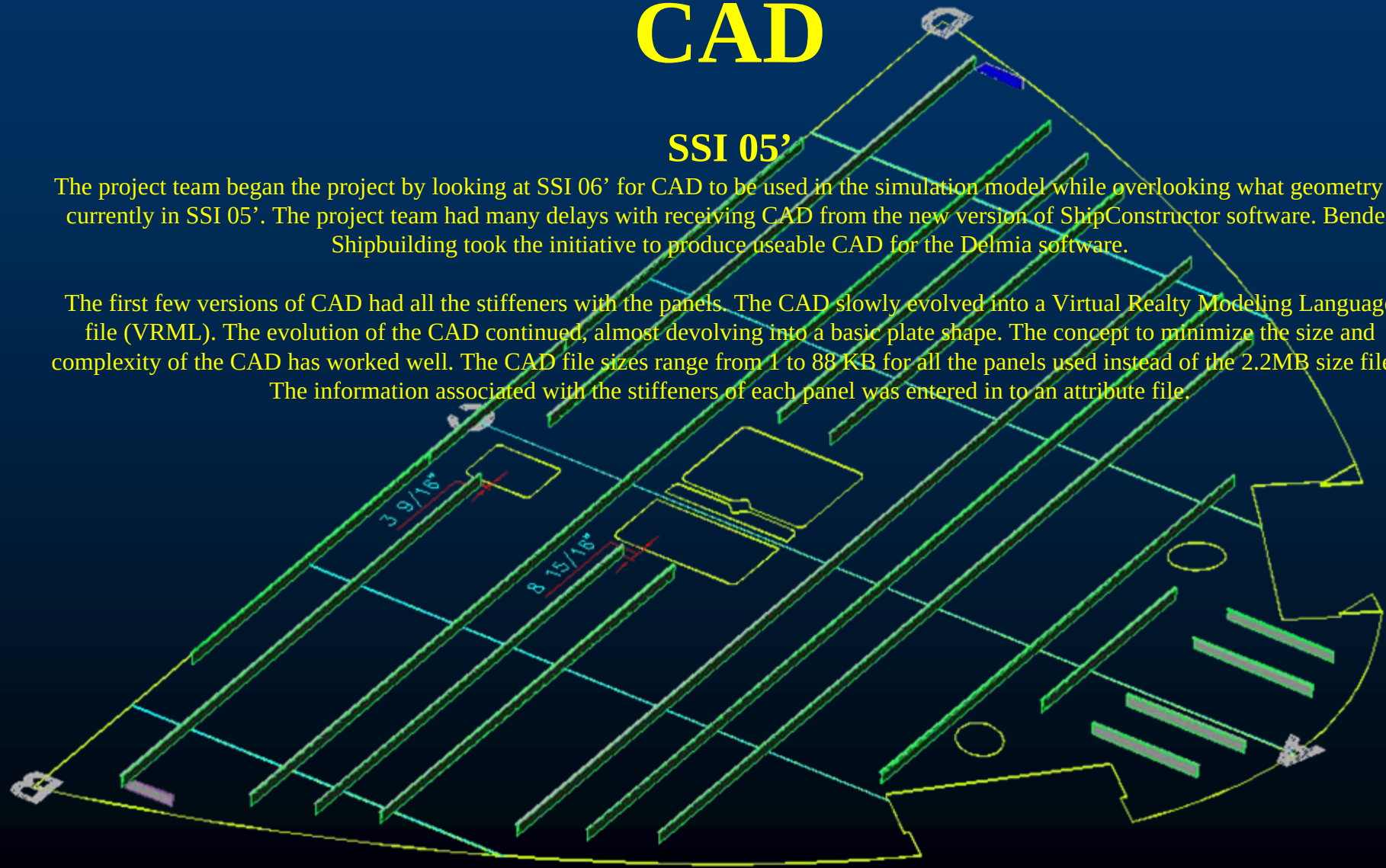
CAD

SSI 05’

The project team began the project by looking at SSI 06’ for CAD to be used in the simulation model while overlooking what geometry is currently in SSI 05’. The project team had many delays with receiving CAD from the new version of ShipConstructor software. Bender Shipbuilding took the initiative to produce useable CAD for the Delmia software.

The first few versions of CAD had all the stiffeners with the panels. The CAD slowly evolved into a Virtual Realty Modeling Language file (VRML). The evolution of the CAD continued, almost devolving into a basic plate shape. The concept to minimize the size and complexity of the CAD has worked well. The CAD file sizes range from 1 to 88 KB for all the panels used instead of the 2.2MB size files. The information associated with the stiffeners of each panel was entered in to an attribute file.



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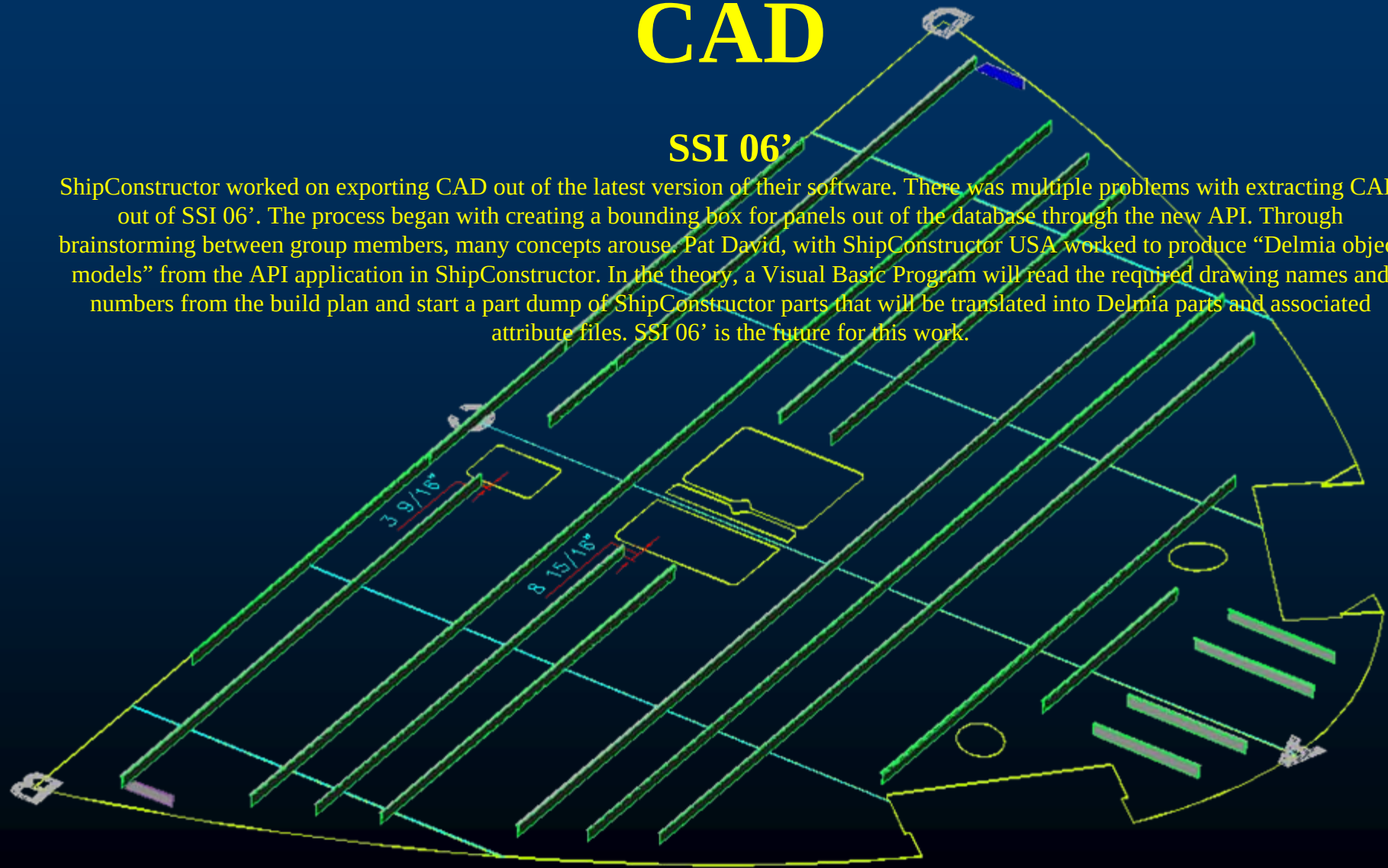
CAD

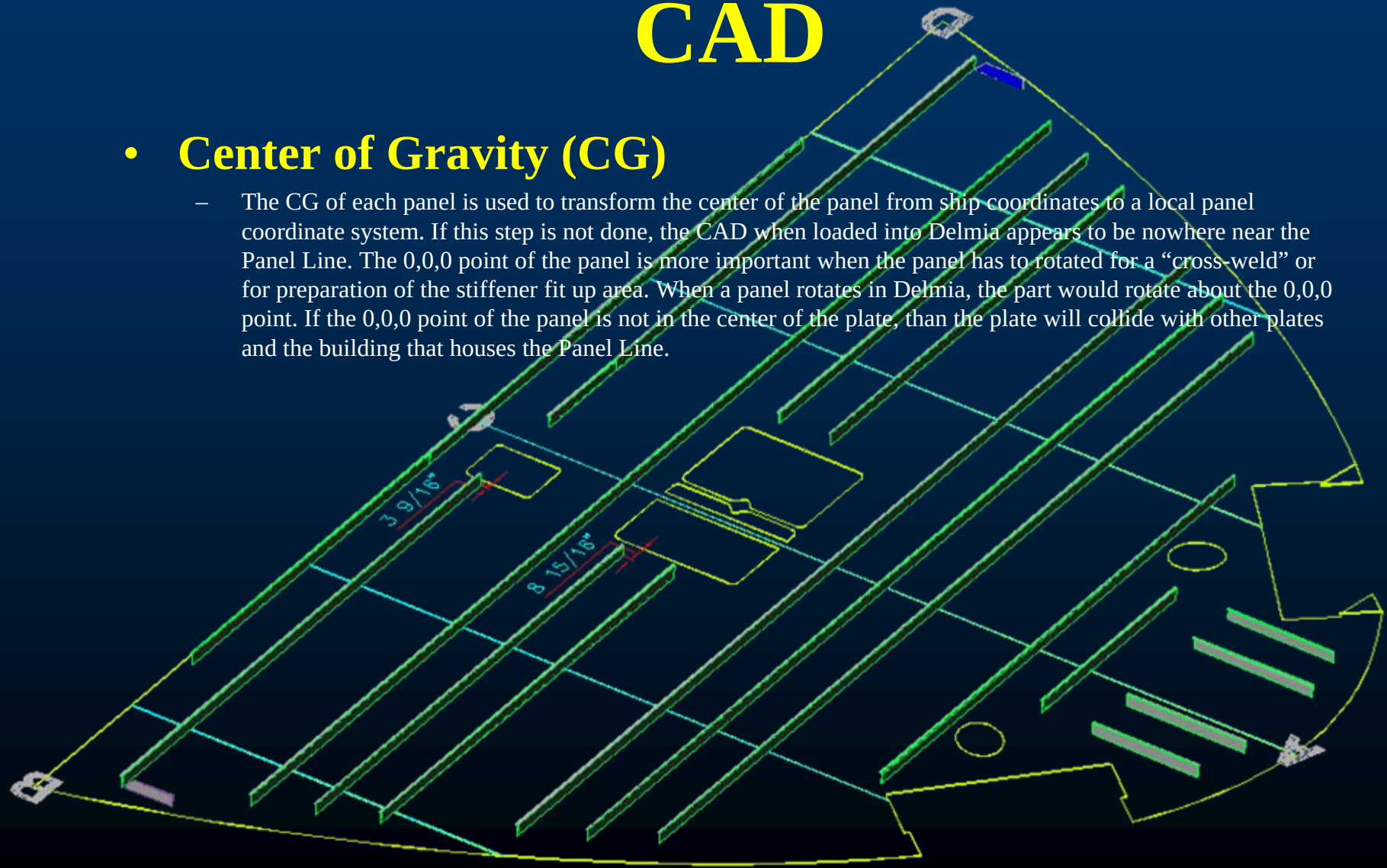
SSI 06’

ShipConstructor worked on exporting CAD out of the latest version of their software. There was multiple problems with extracting CAD out of SSI 06’. The process began with creating a bounding box for panels out of the database through the new API. Through brainstorming between group members, many concepts arouse. Pat David, with ShipConstructor USA worked to produce “Delmia object models” from the API application in ShipConstructor. In the theory, a Visual Basic Program will read the required drawing names and numbers from the build plan and start a part dump of ShipConstructor parts that will be translated into Delmia parts and associated attribute files. SSI 06’ is the future for this work.



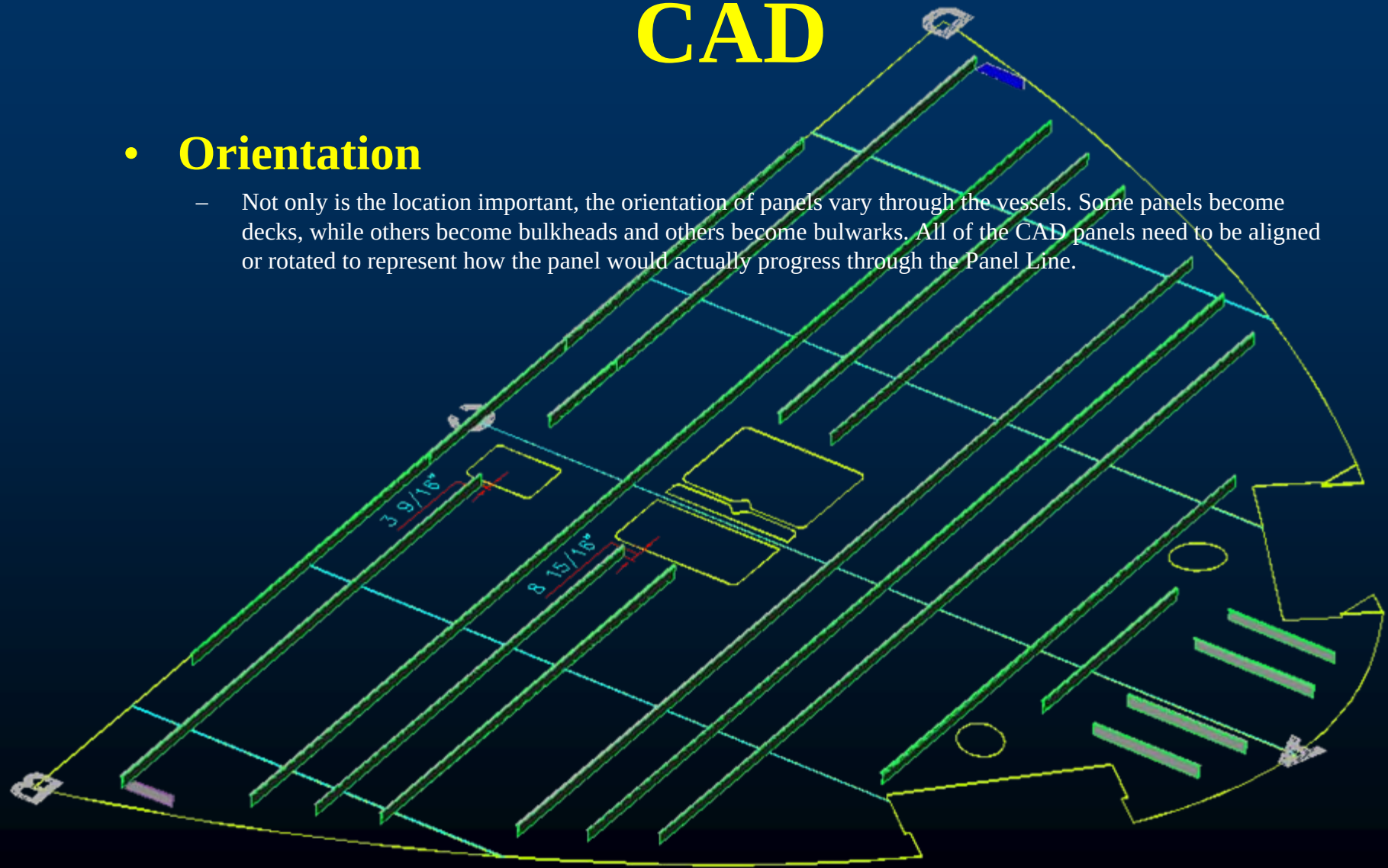
CAD

- **Center of Gravity (CG)**
  - The CG of each panel is used to transform the center of the panel from ship coordinates to a local panel coordinate system. If this step is not done, the CAD when loaded into Delmia appears to be nowhere near the Panel Line. The 0,0,0 point of the panel is more important when the panel has to rotated for a “cross-weld” or for preparation of the stiffener fit up area. When a panel rotates in Delmia, the part would rotate about the 0,0,0 point. If the 0,0,0 point of the panel is not in the center of the plate, than the plate will collide with other plates and the building that houses the Panel Line.



CAD

- **Orientation**
  - Not only is the location important, the orientation of panels vary through the vessels. Some panels become decks, while others become bulkheads and others become bulwarks. All of the CAD panels need to be aligned or rotated to represent how the panel would actually progress through the Panel Line.



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Typical CAD Files

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Panel Attributes

PART NAME	NO OF WELD	WELDS	LENGTH OF WELD	WELD LOCATION	NO OF CROSS WELDS	CROSS WELD	LENGTH	WELD LOCATION	Turn	BOUNDRY BO	THICKNESS	Flip	NO OF STIFFENER	STIFFENER	STIFFENER LENGT	Thickness
01-7770-0101-PDI	5	1	2281	0,5959.475,0	0	0	0	0	1	10255.25,13827	11.9	0	26	2	2760.6	8
0	0	2	7947	0,2979.738,0	0	0	0	0		0	11.9		0	1	2741.6	7
0	0	3	10255.25	0,0,0	0	0	0	0		0	11.9		0	1	1736.725	7
0	0	4	7947	0,-2979.738,0	0	0	0	0		0	11.9		0	2	2760.6	8
0	0	5	2281	0,-5959.475,0	0	0	0	0		0	11.9		0	1	2741.6	7
0	0	0	0	0	0	0	0	0		0	0		0	1	1736.725	7
0	0	0	0	0	0	0	0	0		0	0		0	1	6608.763	8
														2	5940.425	8
														1	4737.1	8
														1	3536.95	8
														1	2336.8	8
														1	1136.65	8
														1	2336.8	8
														1	1809.75	8
														2	5940.425	8
														1	4737.1	8
														1	3536.95	8
														1	2336.8	8
														1	1136.65	8
															2760.6	7
														4	2760.6	7

STIFFENER	STIFFENER LENGT	Thickness
2	2760.6	8
1	2741.6	7
1	1736.725	7
2	2760.6	8
1	2741.6	7
1	1736.725	7
1	6608.763	8
2	5940.425	8
1	4737.1	8
1	3536.95	8
1	2336.8	8
1	1136.65	8
1	2336.8	8
1	1809.75	8
2	5940.425	8
1	4737.1	8
1	3536.95	8
1	2336.8	8
1	1136.65	8
4	2760.6	7
4	2760.6	7

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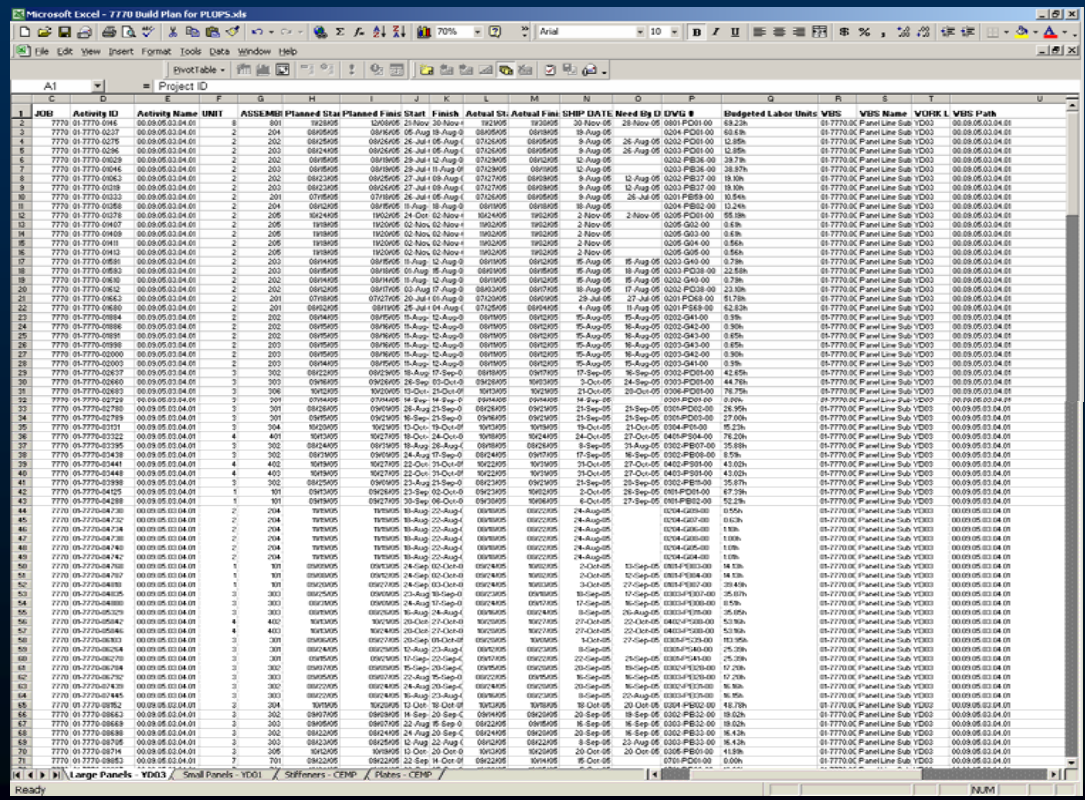
Build Plan

- **Input Data:**
  - The project used the Primaverre planning software used by Bender .



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Model Results

	A	B	C	D	E	F	G	H
1	CYCLE TIME DATA	7/14/05 0:00						
2	PANEL NUMBER:	START TIME	LOAD AREA	PANEL WELDER	ROTATION AREA	STIFFENER WAIT AREA	STIFFENER BUILD AREA	Total Time
3	P01_7770_0301_PD01	0.27	0.90	7.84	0.17	0.00	90.94	99.84
4	P01_7770_0201_PB59	9.45	0.15	0.00	0.00	90.69	19.26	110.10
5	P01_7770_0201_PD68	10.56	0.60	2.61	87.14	19.24	26.79	136.38
6	P01_7770_0201_PB70	14.35	0.15	86.79	19.31	26.77	18.38	151.40
7	P01_7770_0201_PS69	102.29	0.60	20.24	24.80	18.36	30.00	94.00
8	P01_7770_0204_PB02	123.97	0.60	25.51	16.77	29.98	90.94	163.80
9	P01_7770_0202_PB36	150.92	0.45	17.53	28.30	90.92	34.82	172.01
10	P01_7770_0203_PB36	169.93	0.45	29.15	89.12	34.80	34.35	187.86
11	P01_7770_0202_PB38	200.59	0.30	89.01	34.03	34.33	19.77	177.44
12	P01_7770_0204_PD01	291.03	0.60	34.66	32.74	19.75	57.46	145.21
13	P01_7770_0203_PB38	327.21	0.30	32.58	18.98	57.44	19.77	129.07
14	P01_7770_0303_PB11	361.27	0.45	18.96	56.45	19.75	24.75	120.36
15	P01_7770_0302_PB31	381.80	0.30	56.20	19.03	24.73	13.11	113.37
16	P01_7770_0302_PB33	439.53	0.30	18.75	24.01	13.09	13.11	69.26
17	P01_7770_0302_PD01	459.48	0.30	24.76	10.58	13.09	39.56	88.28
18	P01_7770_0303_PB31	486.54	0.30	10.64	12.37	39.54	13.11	75.96
19	P01_7770_0202_PB37	498.37	0.45	12.96	38.19	13.09	17.41	82.10
20	P01_7770_0203_PB37	512.62	0.45	38.78	11.74	17.39	17.41	85.77

NO OPT | No Opt 2-m | No Opt 3-m | No Opt 4-m | Chart4 | OPT 4 | OPT 3 | OPT 2 | OPT 1 | build sheet | manning | Chart1

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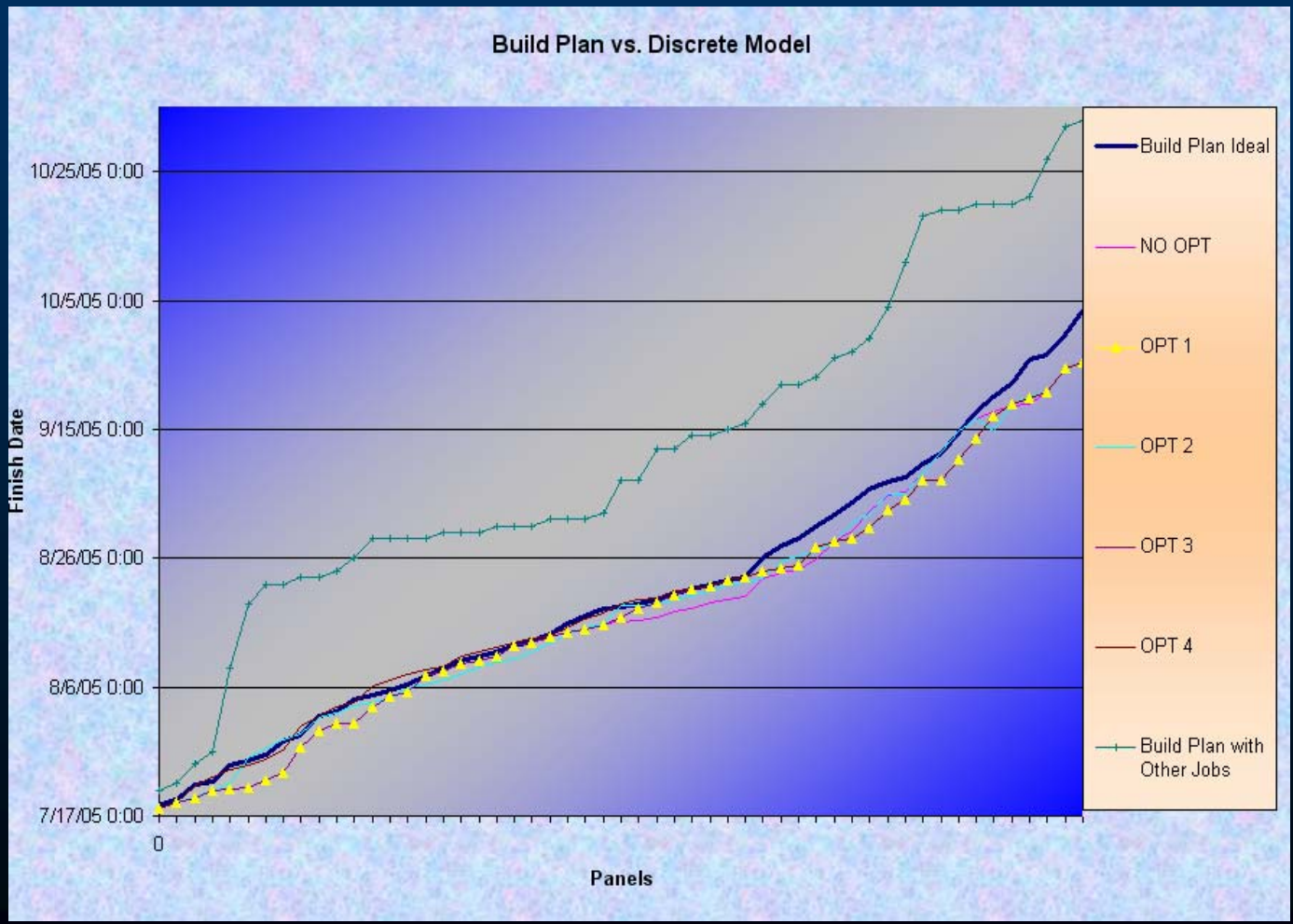
Results



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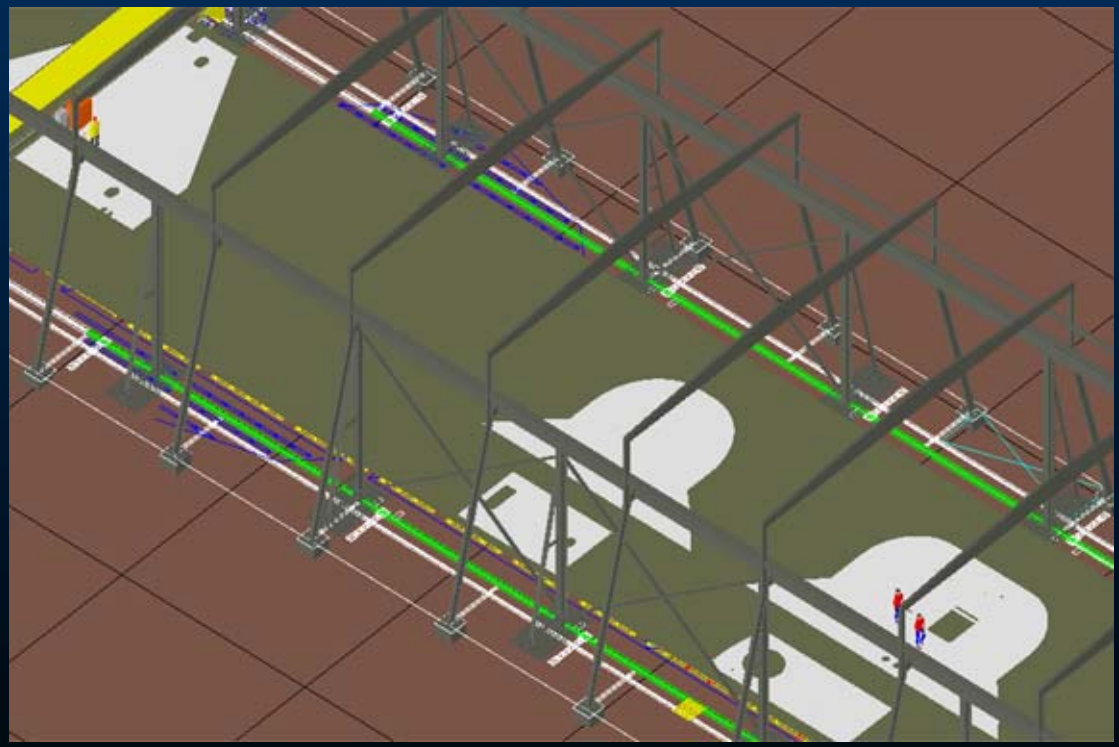
Optimization

The team produced logic for the software to load the panels on to the panel line five different ways.



Optimization

- **Option 1:**
  - No optimization. The model loads each panel based on the build sheet starting from line 1 to the end of the file. However the end user sorts the build sheet will determine the loading sequence.

Optimization

- **Option 2:**
- Before loading, the logic will search for 5 non-rotating panels based on the attribute data. The logic will search one by one through the build sheet (based on the end user sorting method,) each time adding a panel to the search loop. Once 5 non-rotating panels were found, it would fall from the search loop. The logic then scans each panel in the search loop and will skip over the rotating panels to get to the next non-rotating panel in the loop. The logic scans through all the panels in the loop and if none of them can fit on the Panel Line, it simply loads the next panel on the top of the loop regardless if it is a rotating panel or not. Thus, the rotating panels will load only if the 5 non-rotating panels do not have room and if that panel is at the top of the search loop.

Optimization

- **Option 3:**
- Similar to Option 2. However, if the next panel in the build sheet is a rotating panel, it simply loads the rotating panel and falls out of the optimizing loop.

Optimization

- **Option 4:**
- Based on Option 2. Thus, the rotating panels are skipped over to find the non-rotating panels to optimize. However, the logic counts how many times the FIRST rotating panel is skipped. If the panel is skipped over more the three times, the logic falls from the loop and simply loads that rotating panel.

Optimization

- **Option 5:**
  - This option is similar to Option 4. However, it takes the five non-rotating panels in the loop and reorders the load sequence based on budgeted hours. The panel with the highest budgeted hours is placed on the top of the list.

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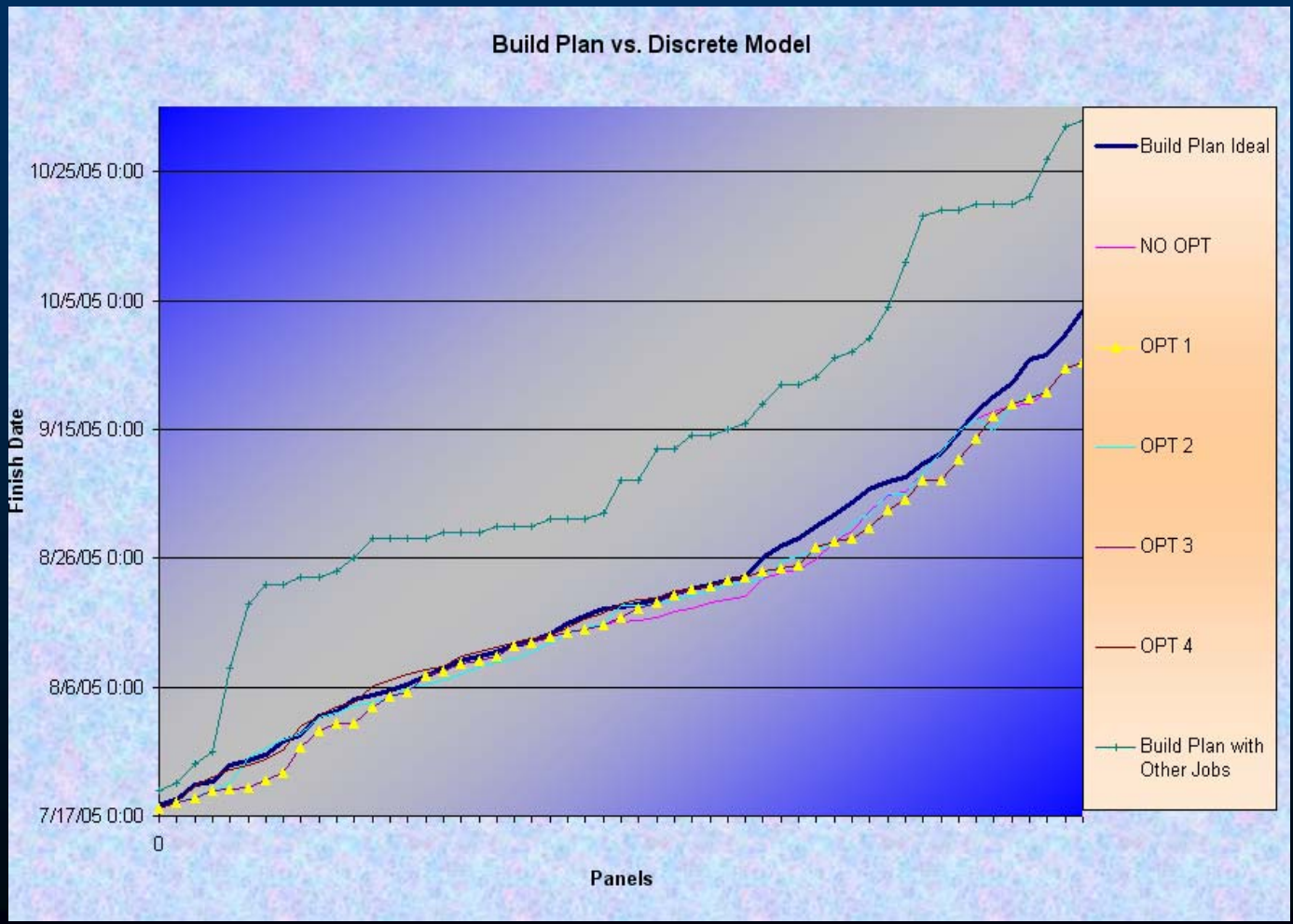
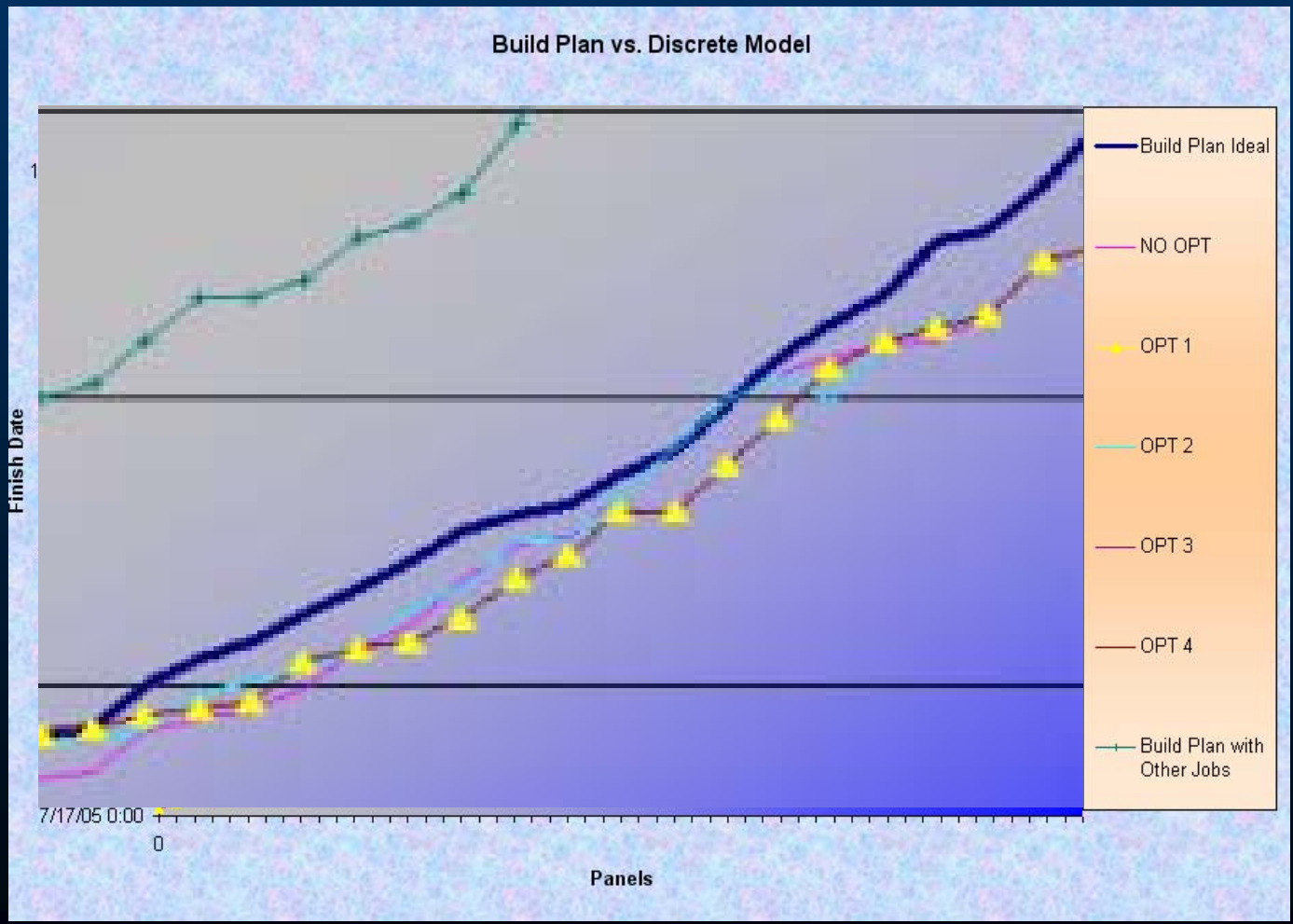
Results



Results


Build Plan vs. Discrete Model
Finish Date
1
7/17/05 0:00
0
Panels
Build Plan Ideal
NO OPT
OPT 1
OPT 2
OPT 3
OPT 4
Build Plan with Other Jobs

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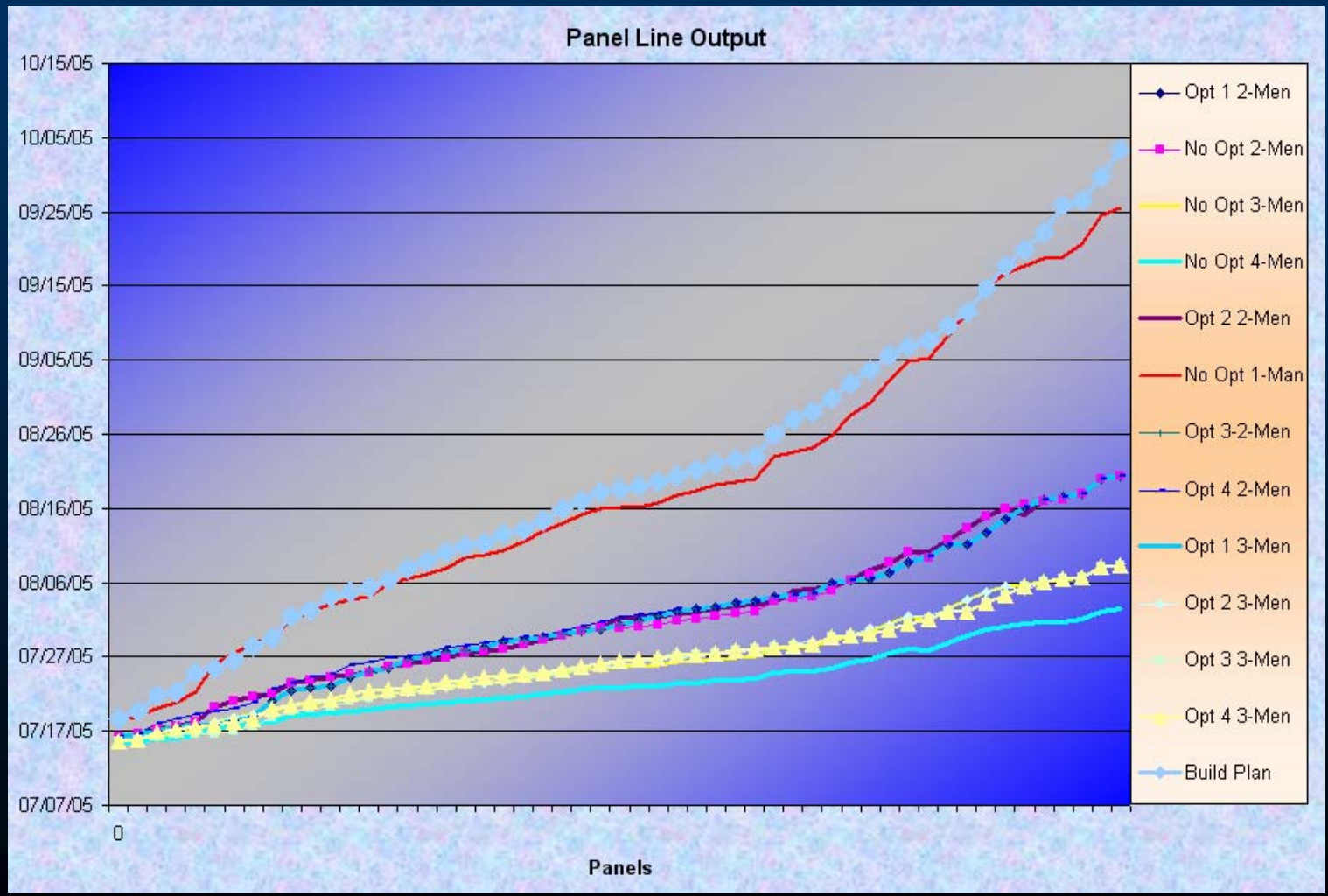
NO OPT | No Opt 2-m | No Opt 3-m | No Opt 4-m | Chart4 | OPT 4 | OPT 3 | OPT 2 | OPT 1 | build sheet | manning | Chart1

Results-*Additional Manning*



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Final Results

- *Proposed* - A 50% reduction in labor hours is anticipated in the shop floor planning and scheduling.

- **Actual** - The project team realized that the tool could load all relevant panel parts and the software could replace the scheduling currently done for the Panel Line by over 80%. The model has shown that it can manipulate the process flow and come up with the same if not better numbers that is currently being done by hand. The team also realized that it would be important to keep a person in the loop, allowing the addition of HOT work.

Final Results - cont

- *Proposed* - Panel throughput should increase 20% by improving the ability to predicatively schedule and optimize panel production by reducing WIP.

- **Actual**
  - Decreasing the process time in the stiffener fit-up area can reduce the WIP by 50%. The gains shown in process time reduction could be achieved through a multitude of different methods:
    - Increased manning
    - Improved processes
    - Improved jigs and fixtures
    - Improved fit-up rates
    - Improved tacking rates
    - Shifting labor on the Panel Line from positions waiting to work stations fully loaded.

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Final Results - cont

- *Proposed* - A 4% reduction in labor hours is anticipated on the manufacturing shop floor.

- **Actual** - Reduction in labor hours could be looked at different ways. The process of reducing the processing time of the stiffener fit-up area reduces the overall time it takes to produce the panel from three months to one. While reducing the overall production time by 2/3 the increased cost of manning by only 33%.

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Questions