PECASO: The Generic Space Strategies for Rehearsing Execution Patterns

'Space Competition'

The University of Teesside

Centre for Construction Innovation Research

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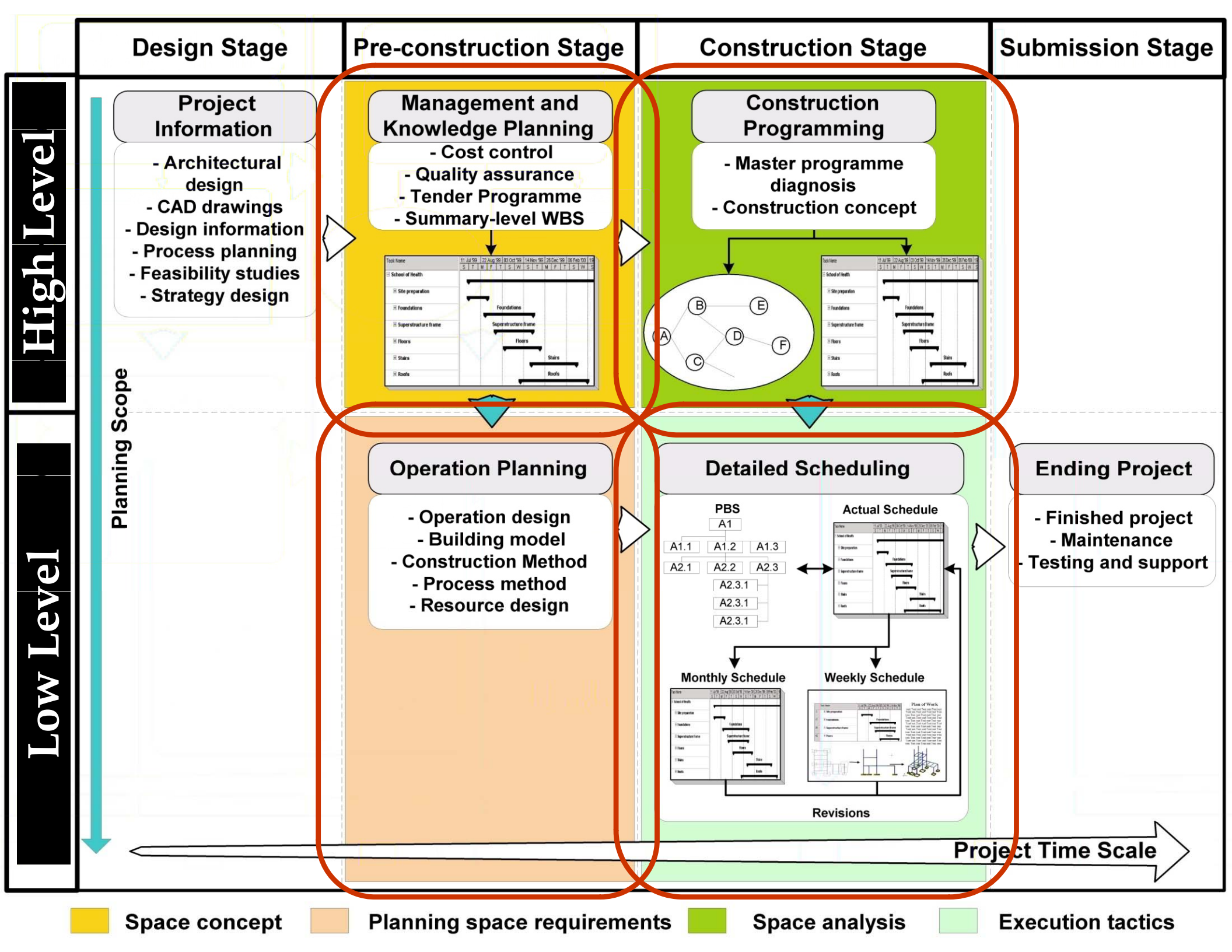
Outline

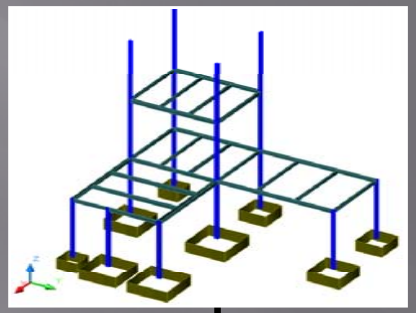
- Space planning questions
- PECASO model
- Space competition strategy (*towards a solution)*
- Principle space competition examples
- Critical Space-time Analysis (CSA)
- Experimental results
- Virtual Reality Visualisation
- Discussion

Space Planning Questions

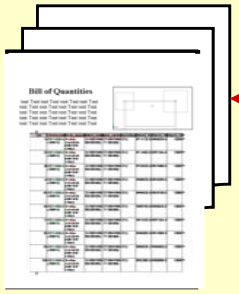
- **ONE: why site managers do not use *existing planning techniques* to coordinate construction activities?**
- **TWO: what are the differences between the schedule of work and the *execution of work* ?**
- **THREE: can *rehearsing* the execution of work improve the schedule of work, i.e. space planning?**
- **FOUR: is it possible to minimise *spatial congestions* and improve onsite productivity?**


Design Stage
Pre-construction Stage
Construction Stage
Submission Stage
High Level
Low Level
Planning Scope
Project Information
- Architectural design
- CAD drawings
- Design information
- Process planning
- Feasibility studies
- Strategy design
Management and Knowledge Planning
- Cost control
- Quality assurance
- Tender Programme
- Summary-level WBS
Construction Programming
- Master programme diagnosis
- Construction concept
Operation Planning
- Operation design
- Building model
- Construction Method
- Process method
- Resource design
Detailed Scheduling
PBS
A1
A1.1
A1.2
A1.3
A2.1
A2.2
A2.3
A2.3.1
A2.3.1
A2.3.1
Actual Schedule
Monthly Schedule
Weekly Schedule
Revisions
Ending Project
- Finished project
- Maintenance
- Testing and support
Project Time Scale
Space concept
Planning space requirements
Space analysis
Execution tactics

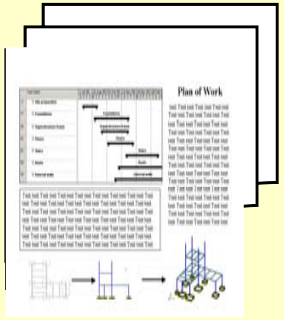
3D CAD building data



Bill of Quantities



Plan of Work



Spatial Data Library

a- Topological and geographical information space library

Input

Data

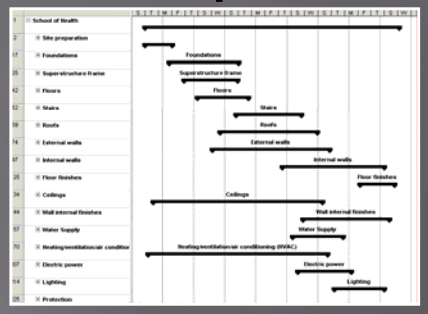
Support

DB

CSA

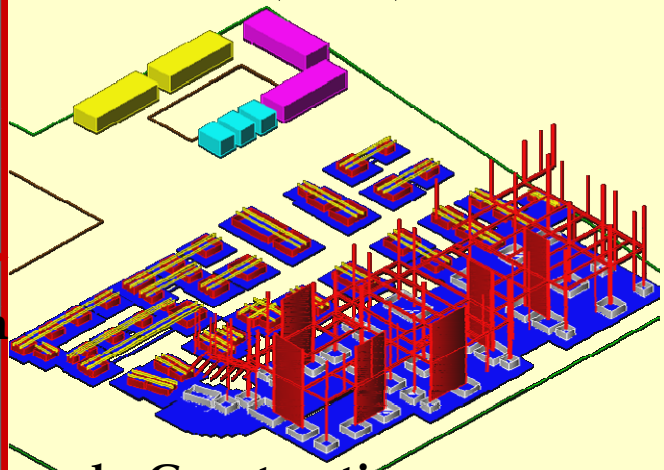
Visualization

Input



Project Schedule and space standards details

Critical Space Analysis (CSA)



b- Construction process simulation & space visualizations

Main Focus

Space Competition Strategy

- **Objective:** rehearse dynamically the execution of work and assess space criticalities *(multi-directional)*

- **Automated spatial reasoning:**

  a. Construction logic constraints

  b. Real-time work rate calculations

  c. Support-to-support assembly

- **What-if scenario :** utilising the site space *execution patters (EP) rules and work rate distribution*

Principle Space Competition Examples

Work Rate Simulation

Spatial Data Input:

-Spatial index: ORDER BY Centre_X DESC

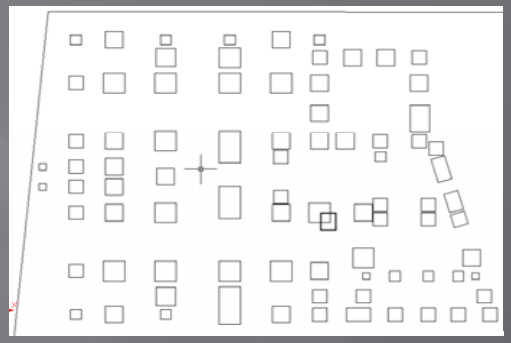
- Activity: Foundation Pads Concreting

- Execution pattern type: North-South-Access2

-Resource distribution type: Uniform

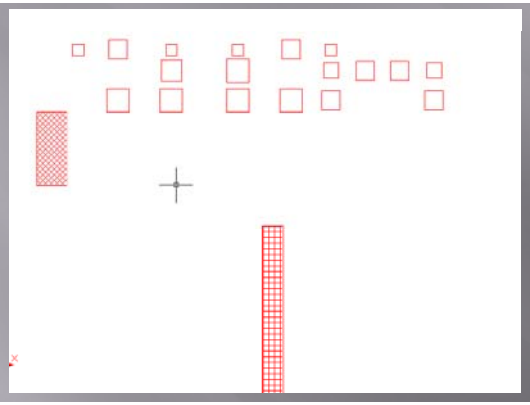
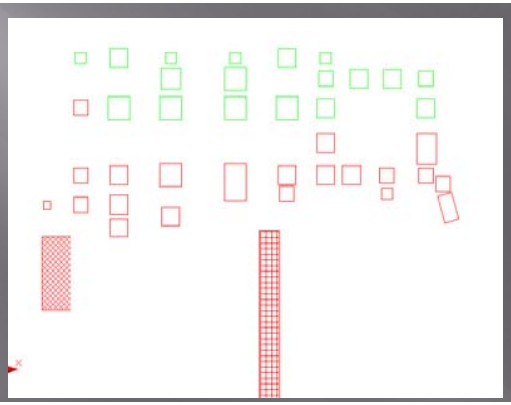
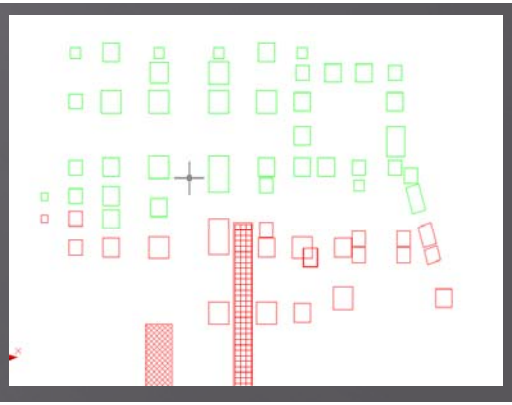
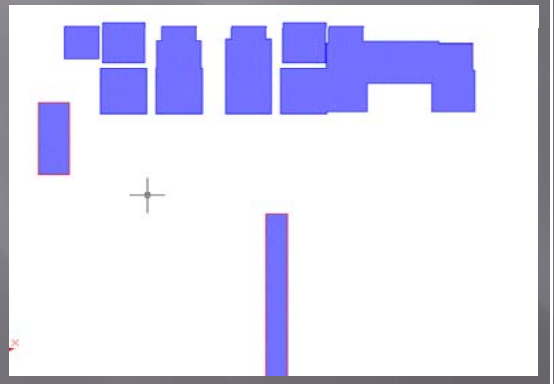
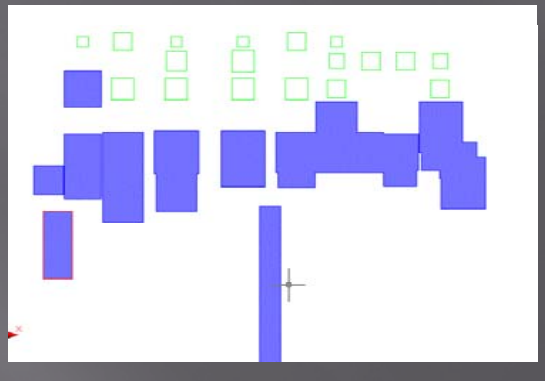
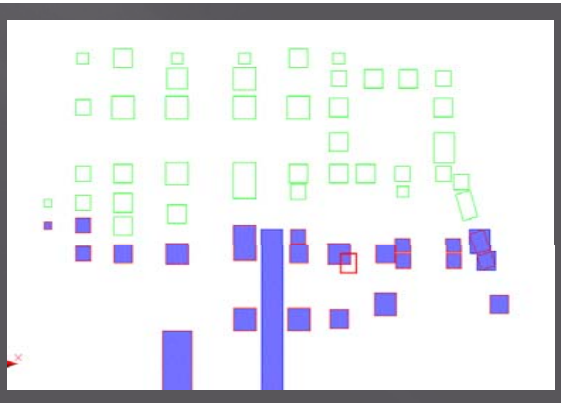
-$QW_{(tot)}$ = 471 m^3

-$QW_{(pw)}$ = 122 m^3



Three weeks simulation

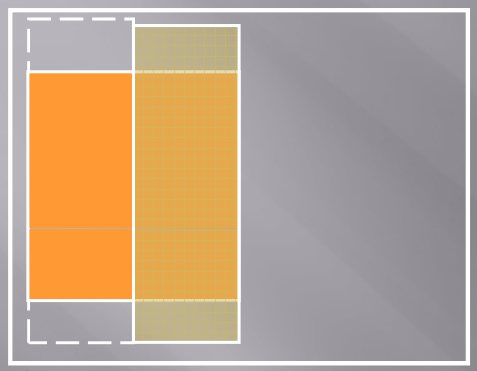
Pad Foundations (Actual Layout)

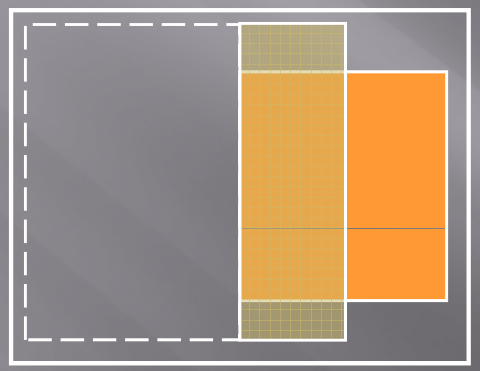
Activity Duration	Week 1			Week 2			Week 3		
Execution Pattern Vis.									
Quantity of Work	Finin.	Prog.	Unfin.	Finin.	Prog.	Unfin.	Finin.	Prog.	Unfin.
	0 m3	122 m3	349 m3	122 m3	122 m3	227 m3	244 m3	122 m3	105 m3
Site Space Usage Vis.									

Execution Patterns

	Week1	Week2	Week3	Week4
Activity A				
Activity B				

Week 2 Week 3

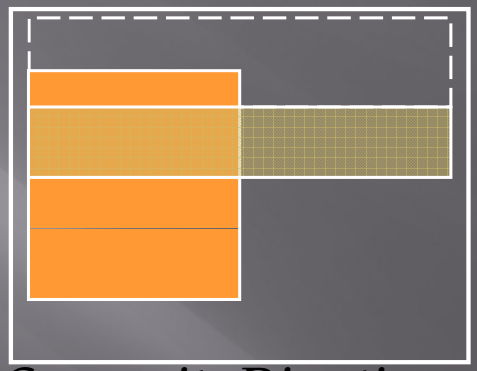


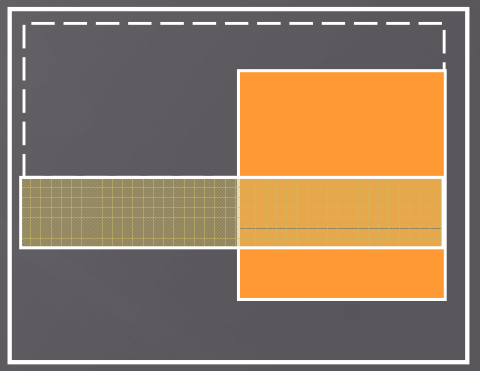


West-east

Clashing area = 30 units

Week 2 Week 3



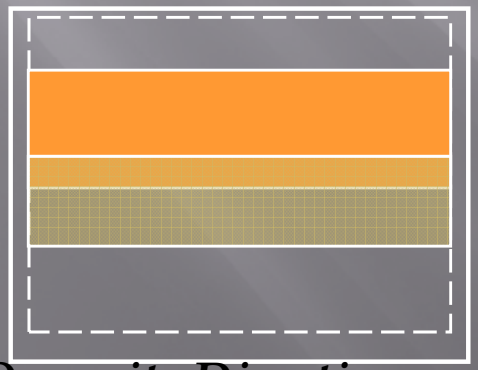


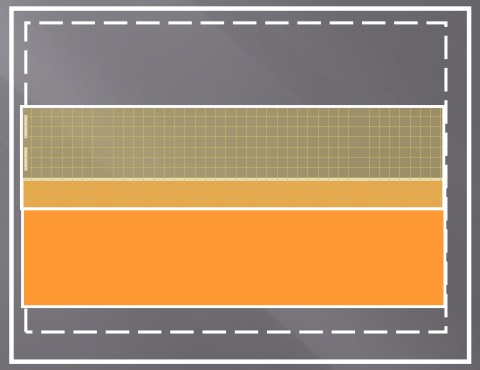
Composite Direction

Clashing area = 27 units

1	2
3	4

Week 2 Week 3

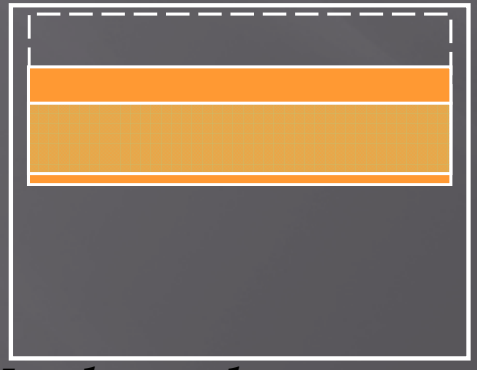


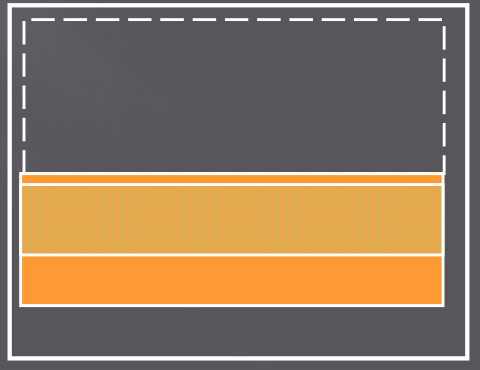


Opposite Direction

Clashing area = 18 units

Week 2 Week 3

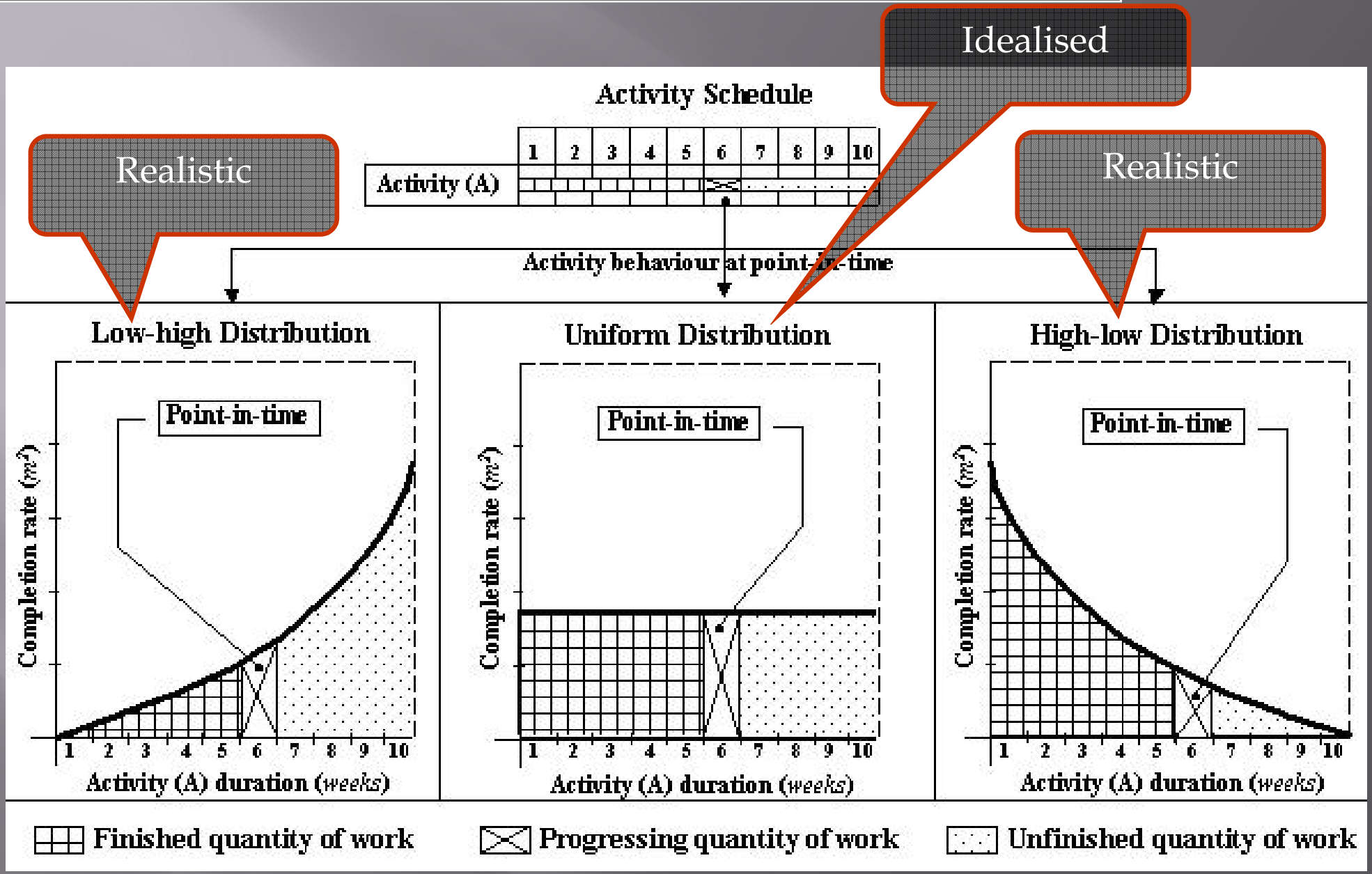


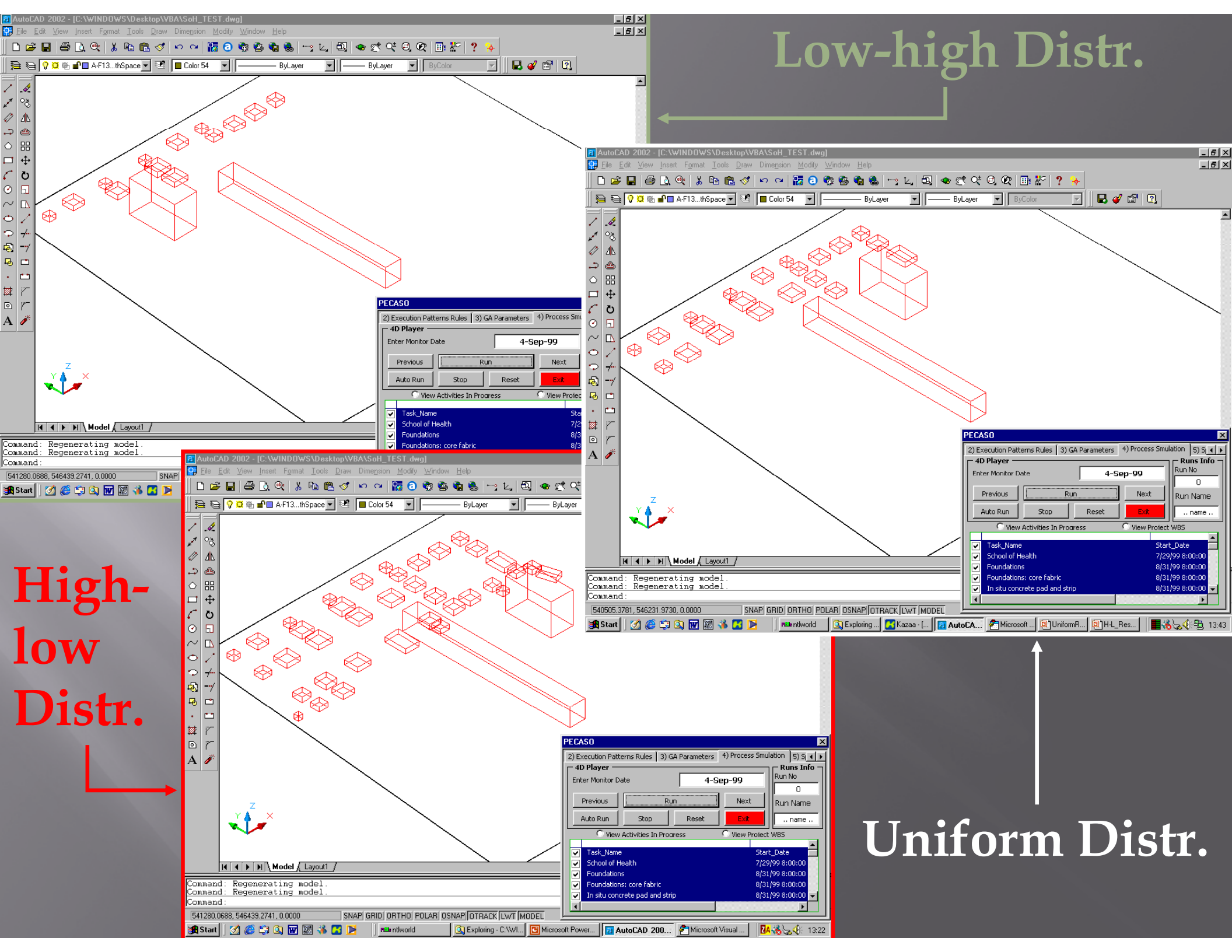


North-south

Clashing area = 36 units

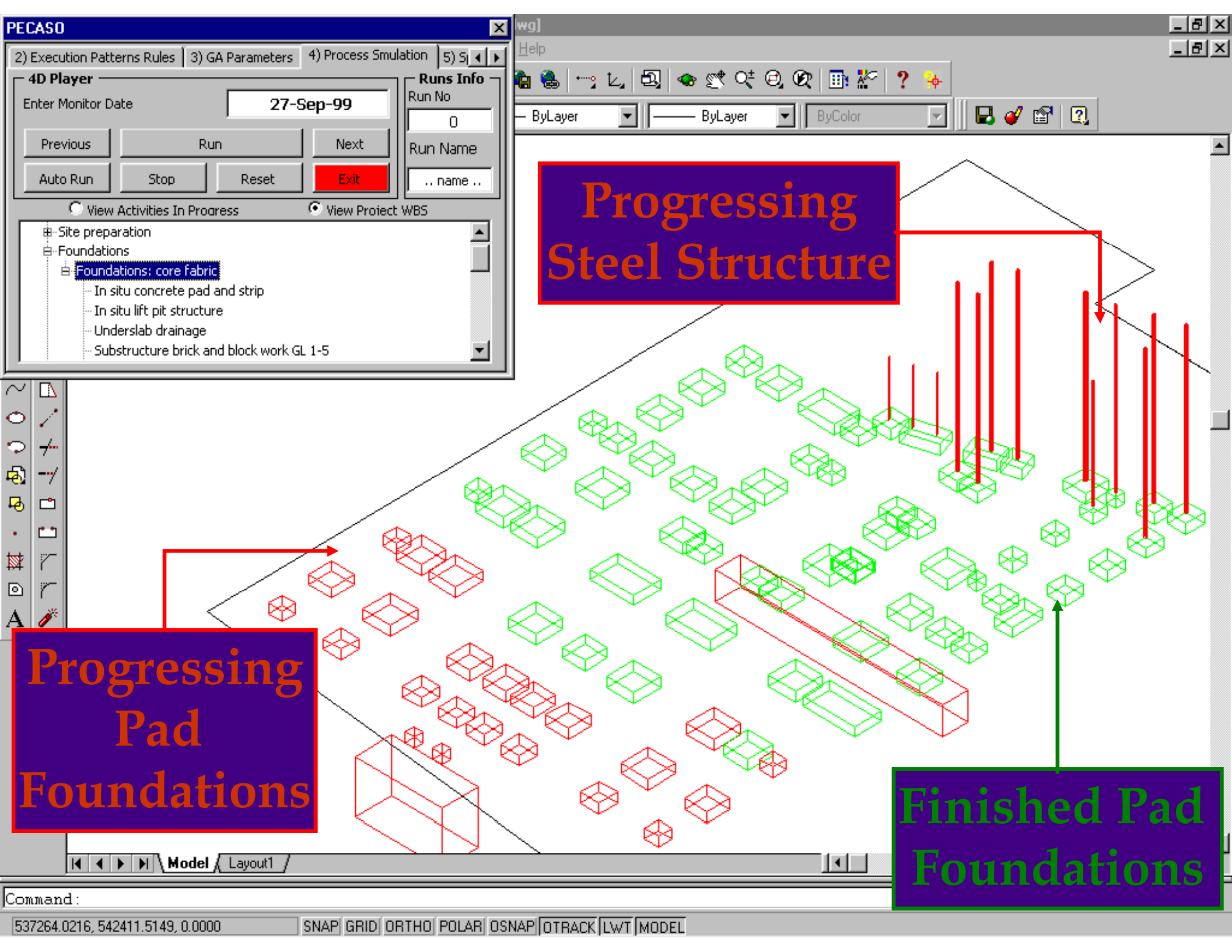
Work Rate Distribution

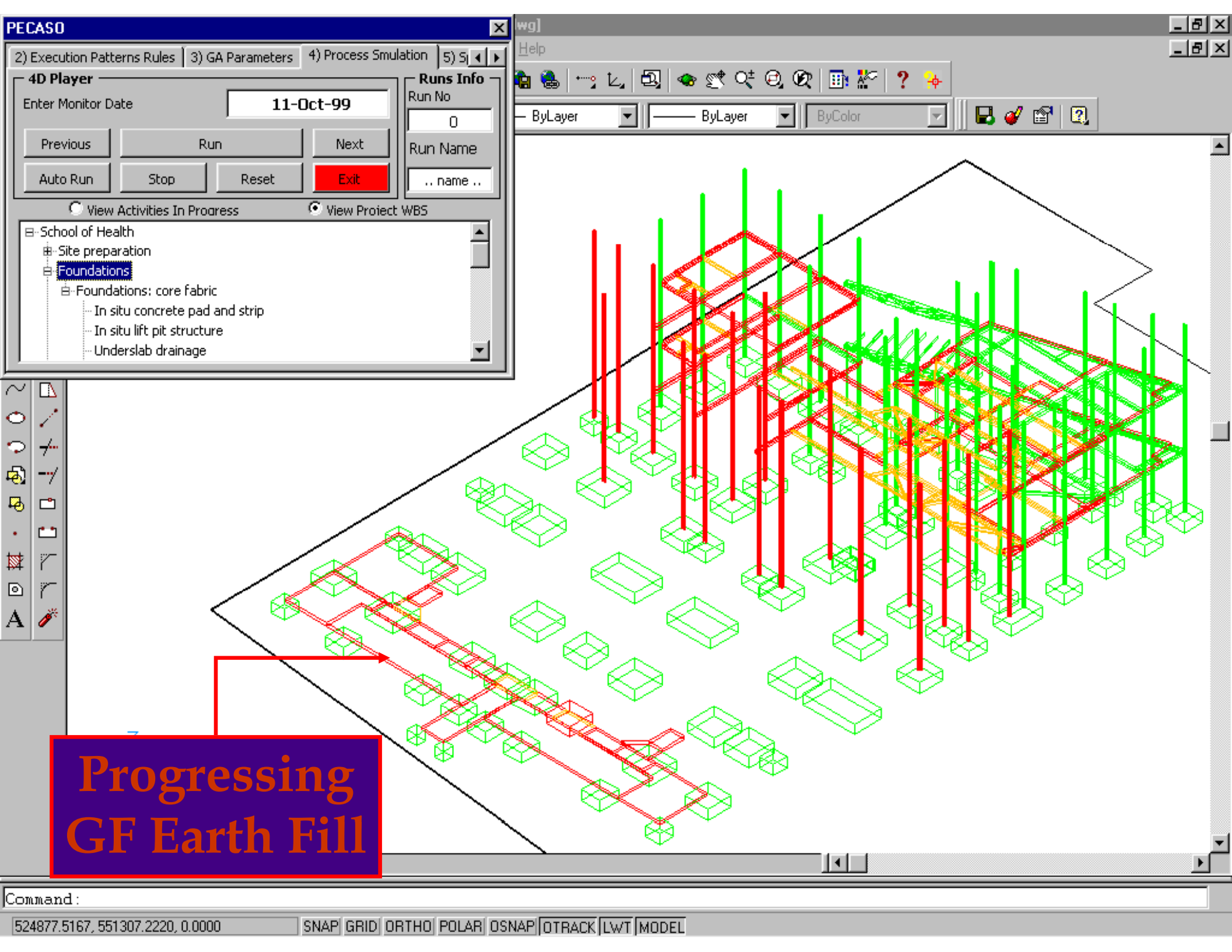



Low-high Distr.
High-low Distr.
Uniform Distr.
AutoCAD 2002 - [C:\WINDOWS\Desktop\VBA\SoH_TEST.dwg]
PECASO
2) Execution Patterns Rules
3) GA Parameters
4) Process Smulation
4D Player
Enter Monitor Date
4-Sep-99
Previous
Run
Next
Auto Run
Stop
Reset
Exit
Runs Info
Run No
Run Name
View Activities In Progress
View Project WBS
Task_Name
Start_Date
School of Health
7/29/99 8:00:00
Foundations
8/31/99 8:00:00
Foundations: core fabric
In situ concrete pad and strip
Model
Layout1
Command: Regenerating model.
Command: Regenerating model.
Command:
SNAP GRID ORTHO POLAR OSNAP OTRACK LWT MODEL

Critical Space-time Analysis (CSA)

- To obtain more reliable and interpretable programme of work
- Analyse the space competition between the construction operations
- Trace site-space usage change dynamically to accommodate space connectivity analysis
- Apply GA to optimise and search for suitable execution logic


PECASO
2) Execution Patterns Rules
3) GA Parameters
4) Process Smulation
5) S
4D Player
Enter Monitor Date
27-Sep-99
Previous
Run
Next
Auto Run
Stop
Reset
Exit
Runs Info
Run No
0
Run Name
.. name ..
View Activities In Progress
View Project WBS
Site preparation
Foundations
Foundations: core fabric
In situ concrete pad and strip
In situ lift pit structure
Underslab drainage
Substructure brick and block work GL 1-5
Help
ByLayer
ByLayer
ByColor
Progressing Steel Structure
Progressing Pad Foundations
Finished Pad Foundations
Model
Layout1
Command :
537264.0216, 542411.5149, 0.0000
SNAP
GRID
ORTHO
POLAR
OSNAP
OTRACK
LWT
MODEL


PECASO
2) Execution Patterns Rules
3) GA Parameters
4) Process Smulation
5) S
4D Player
Enter Monitor Date
11-Oct-99
Previous
Run
Next
Auto Run
Stop
Reset
Exit
Runs Info
Run No
0
Run Name
.. name ..
View Activities In Progress
View Project WBS
School of Health
Site preparation
Foundations
Foundations: core fabric
In situ concrete pad and strip
In situ lift pit structure
Underslab drainage
Help
ByLayer
ByLayer
ByColor
Progressing
GF Earth Fill
Command :
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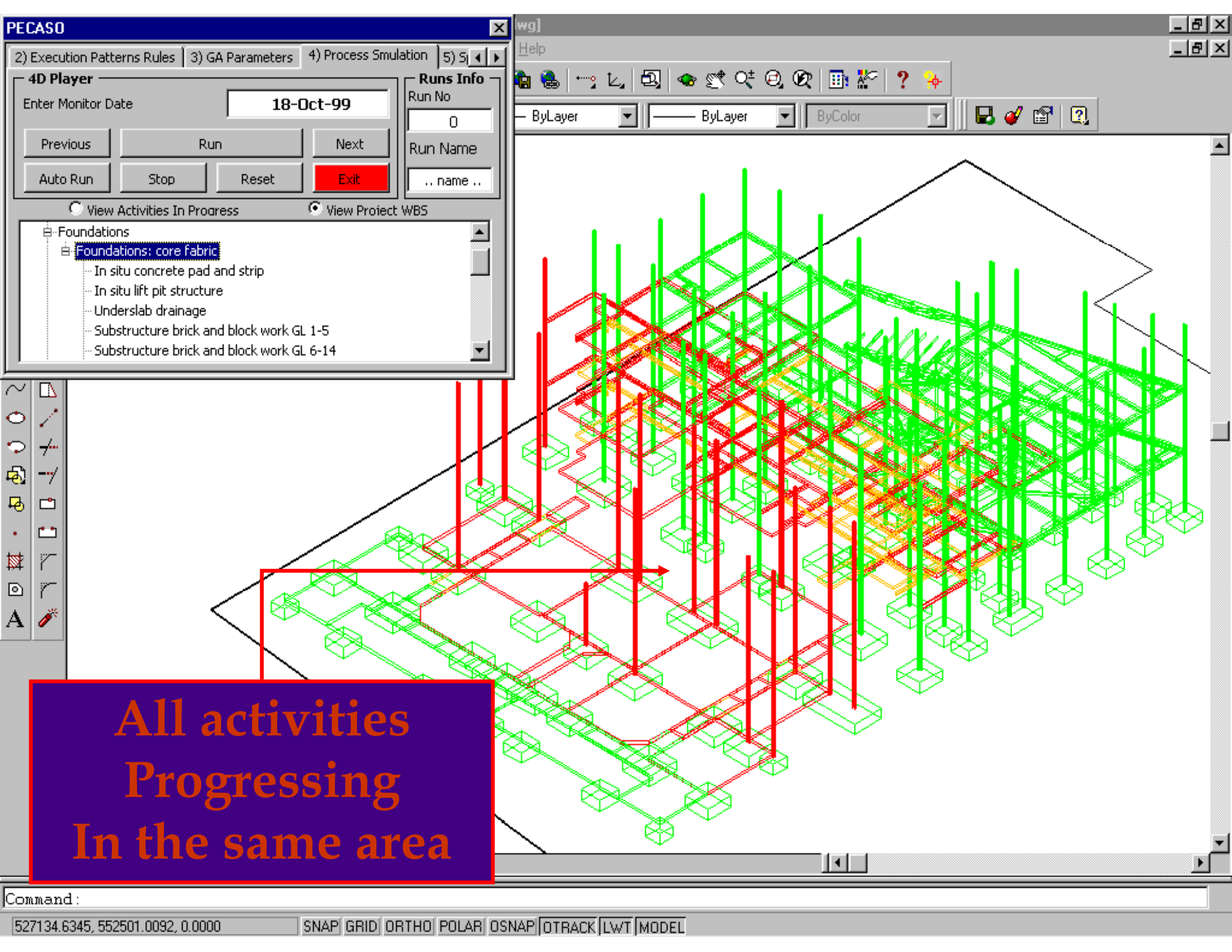
SNAP
GRID
ORTHO
POLAR
OSNAP
OTRACK
LWT
MODEL


PECASO
2) Execution Patterns Rules
3) GA Parameters
4) Process Smulation
5) S
4D Player
Enter Monitor Date
18-Oct-99
Previous
Run
Next
Auto Run
Stop
Reset
Exit
Runs Info
Run No
0
Run Name
.. name ..
View Activities In Progress
View Project WBS
Foundations
Foundations: core fabric
In situ concrete pad and strip
In situ lift pit structure
Underslab drainage
Substructure brick and block work GL 1-5
Substructure brick and block work GL 6-14
Help
ByLayer
ByLayer
ByColor
All activities
Progressing
In the same area
Command :
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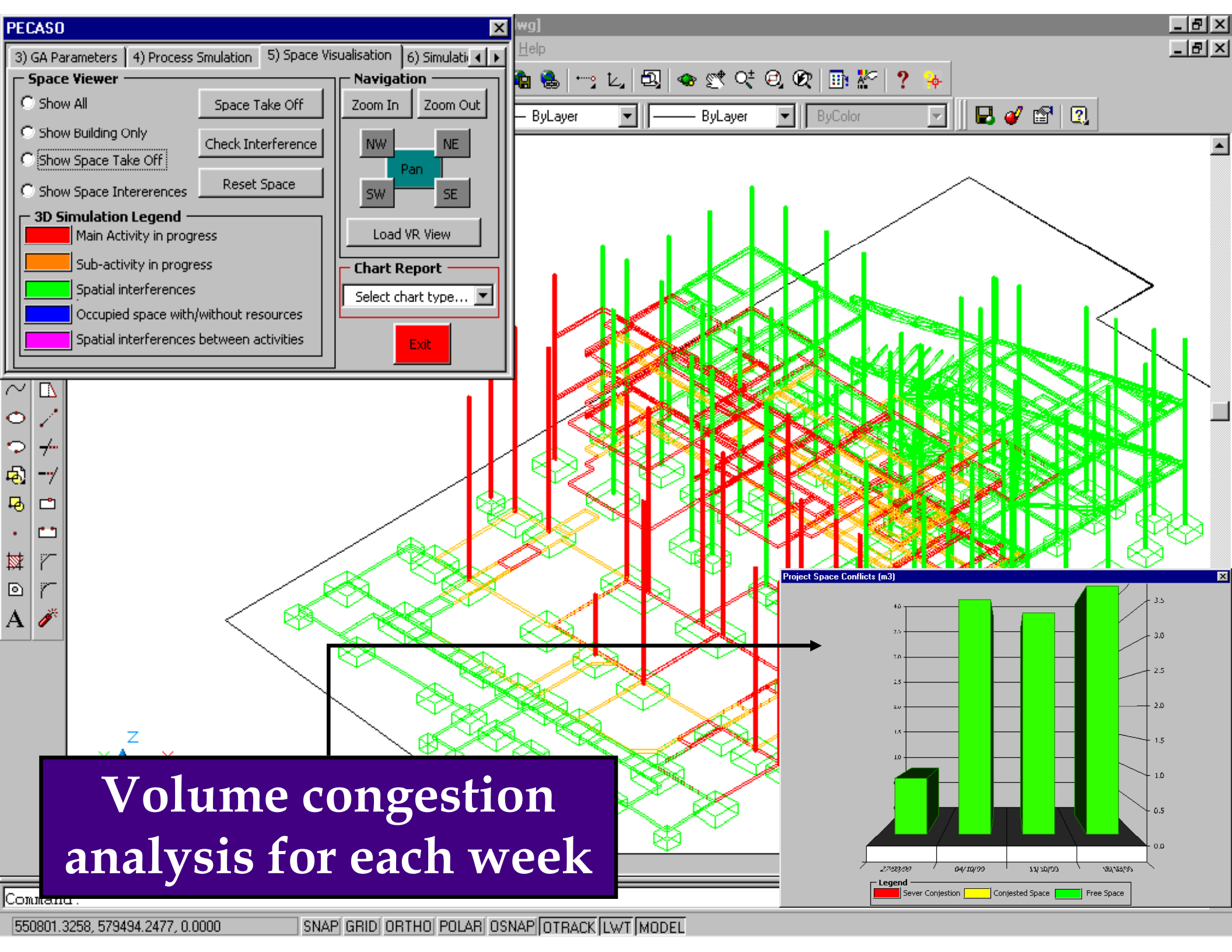
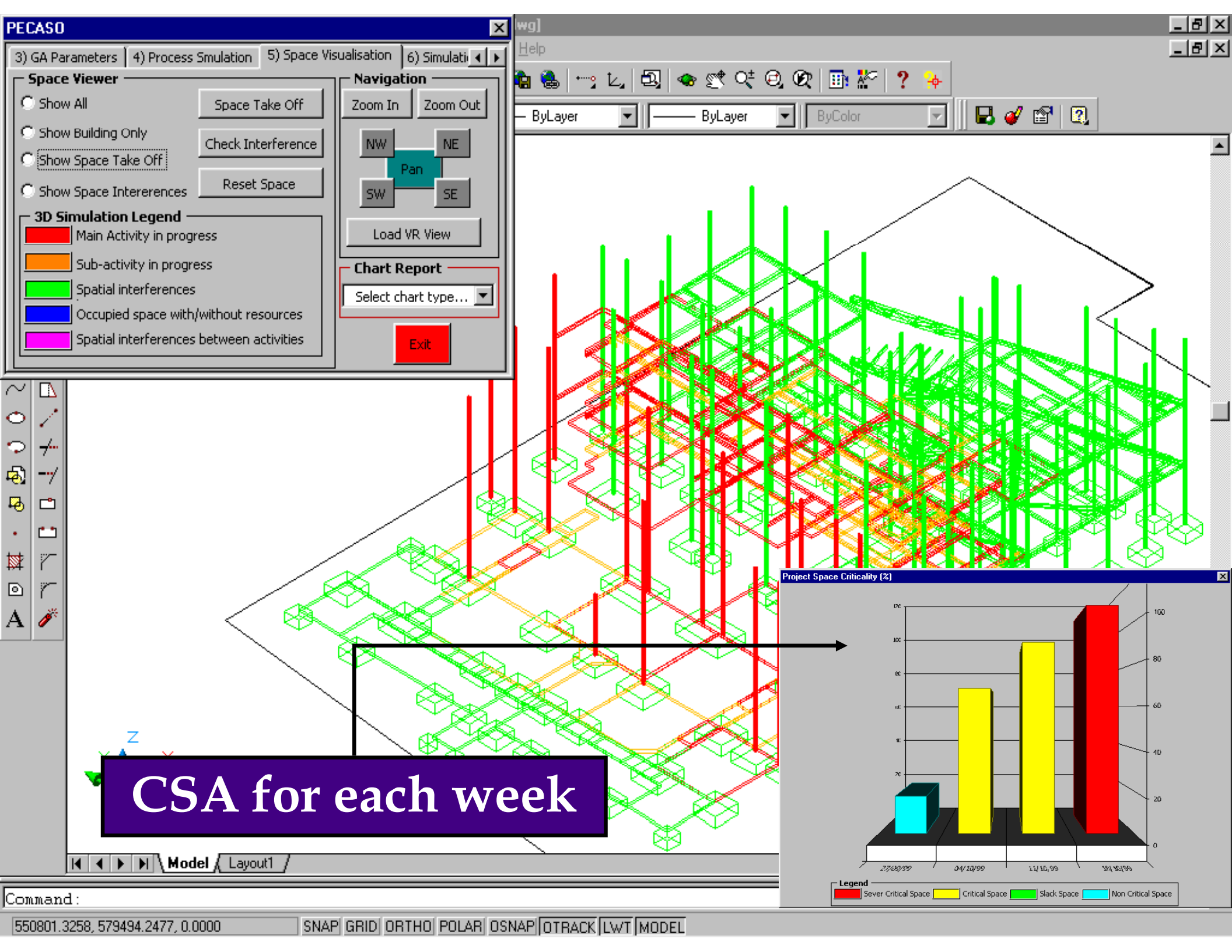
SNAP
GRID
ORTHO
POLAR
OSNAP
OTRACK
LWT
MODEL

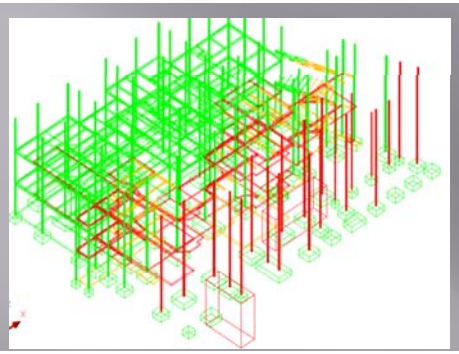
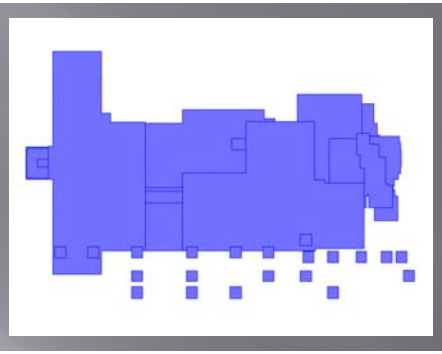
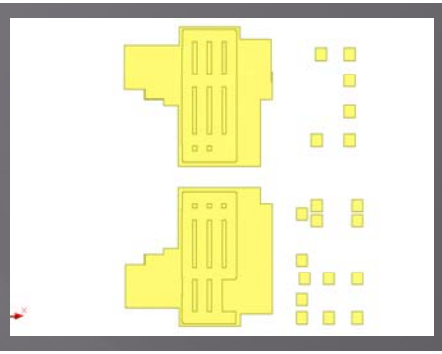
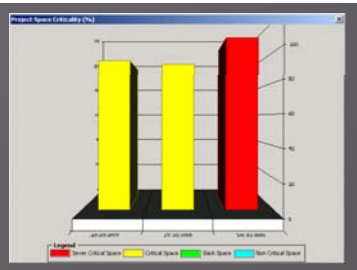
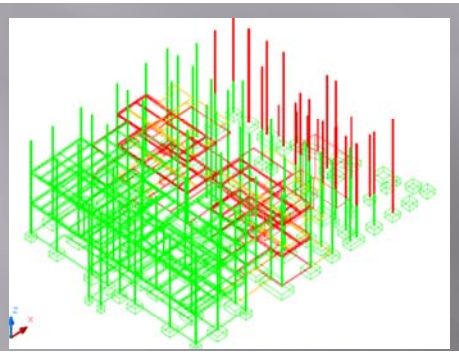
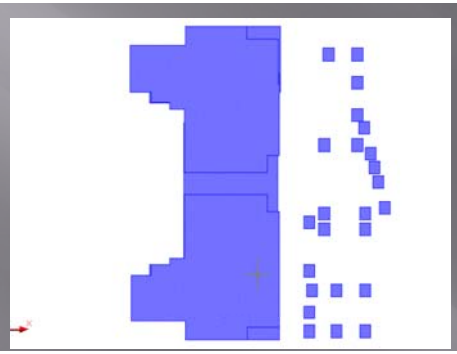
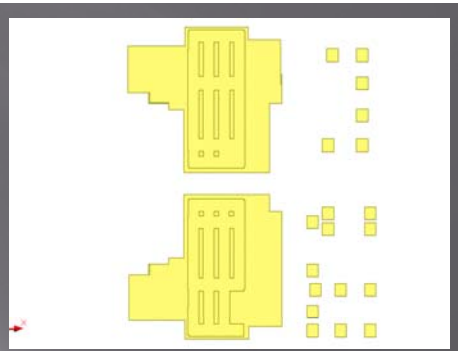
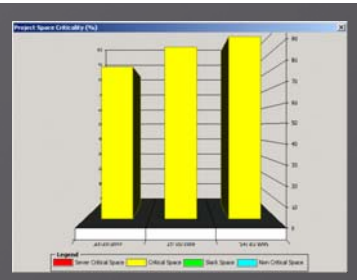
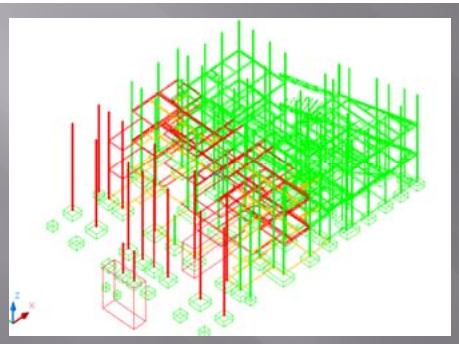
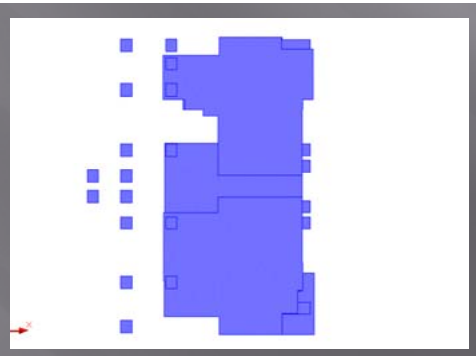
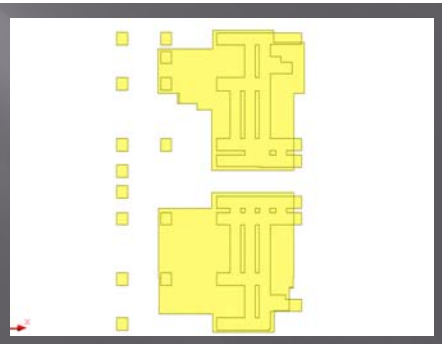
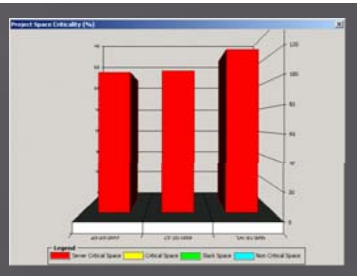
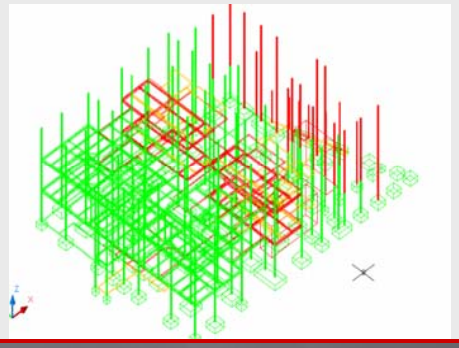
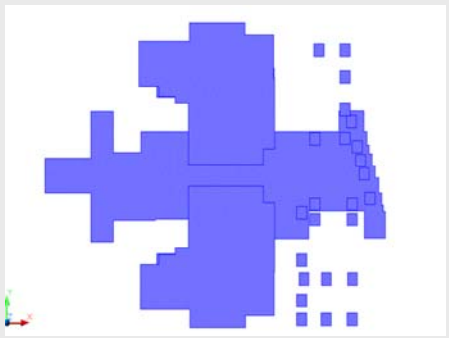
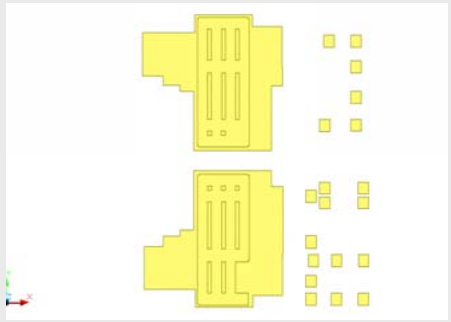
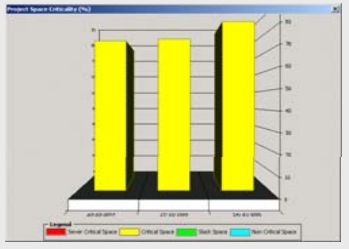


Volume congestion analysis for each week

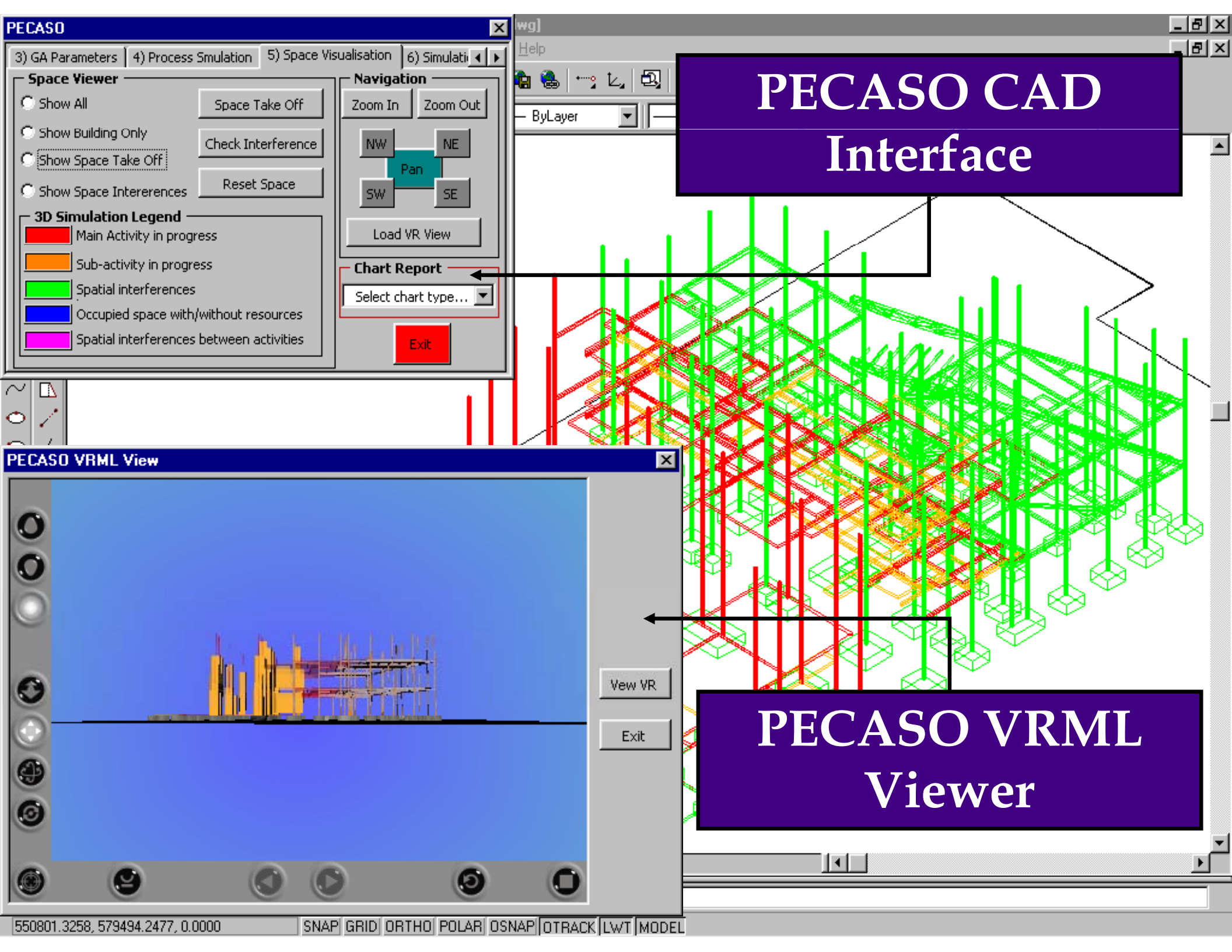


CSA for each week

Experimental GA Results

Run No.	4D Visualisations	2D Site Space Usage	2D Site Space Conflicts	Space Criticality Chart
1				 Max. Crit. = 108
2				 Max. Crit. = 95
3				 Max. Crit. = 121
4				 Max. Crit. = 83

Virtual Reality Visualisation


PECASO
3) GA Parameters
4) Process Smulation
5) Space Visualisation
6) Simulati
Space Viewer
Show All
Show Building Only
Show Space Take Off
Show Space Intererences
Space Take Off
Check Interference
Reset Space
3D Simulation Legend
Main Activity in progress
Sub-activity in progress
Spatial interferences
Occupied space with/without resources
Spatial interferences between activities
Navigation
Zoom In
Zoom Out
NW
NE
Pan
SW
SE
Load VR View
Chart Report
Select chart type...
Exit
PECASO CAD Interface
Help
ByLayer
PECASO VRML View
Vew VR
Exit
PECASO VRML Viewer
550801.3258, 579494.2477, 0.0000
SNAP
GRID
ORTHO
POLAR
OSNAP
OTRACK
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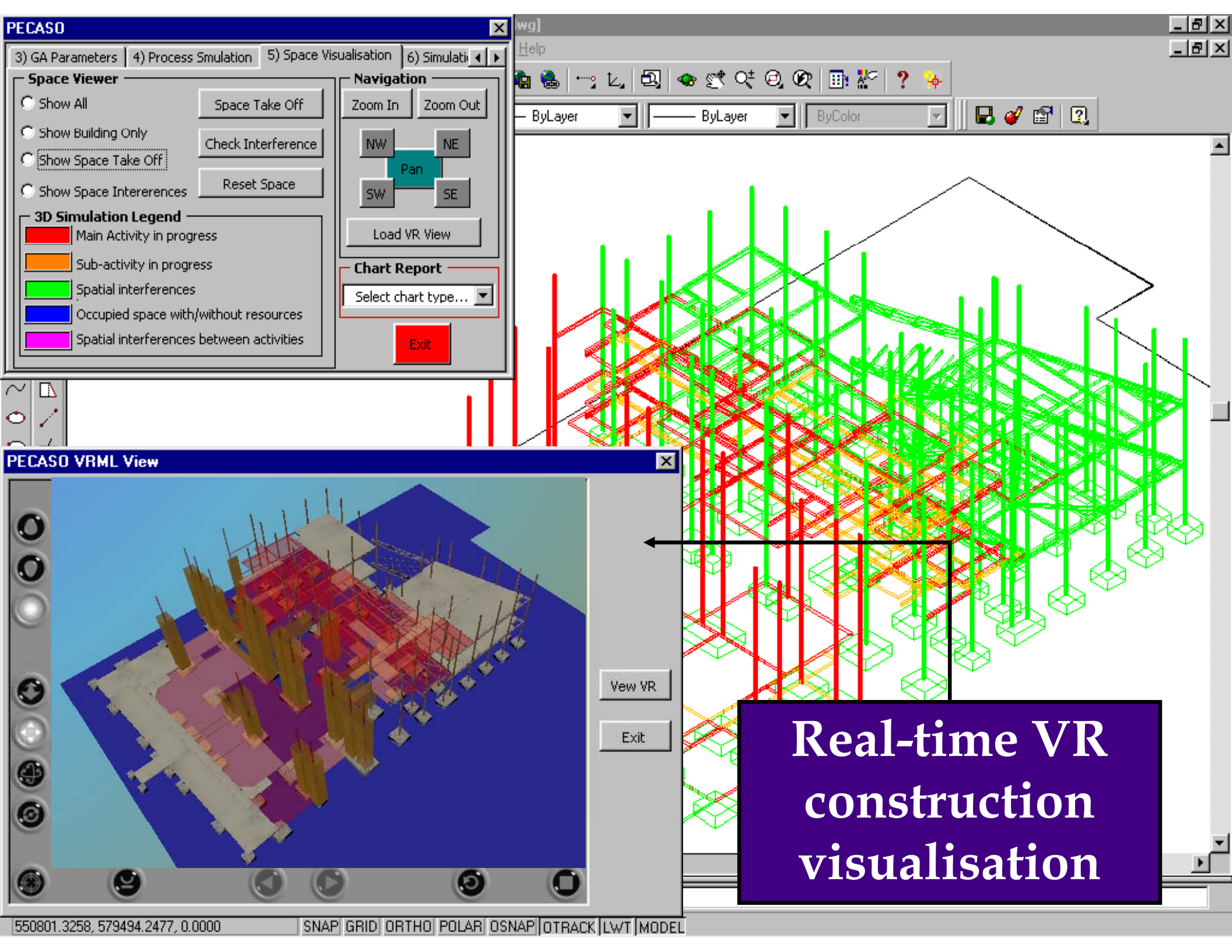
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4) Process Smulation
5) Space Visualisation
6) Simulati
Space Viewer
Show All
Show Building Only
Show Space Take Off
Show Space Intererences
Space Take Off
Check Interference
Reset Space
3D Simulation Legend
Main Activity in progress
Sub-activity in progress
Spatial interferences
Occupied space with/without resources
Spatial interferences between activities
Navigation
Zoom In
Zoom Out
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Pan
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Load VR View
Chart Report
Select chart type...
Exit
Help
ByLayer
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PECASO VRML View
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Real-time VR construction visualisation
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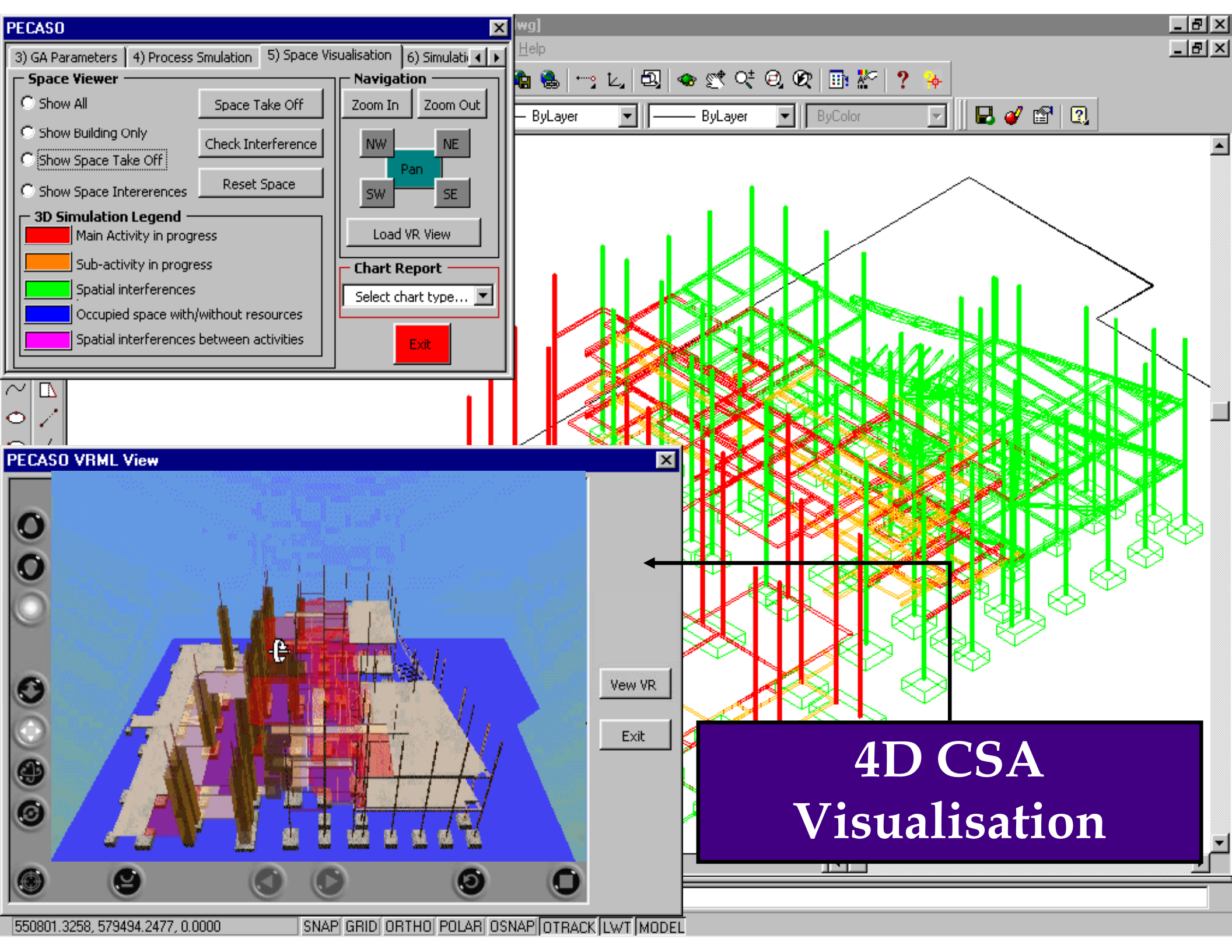
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4D CSA
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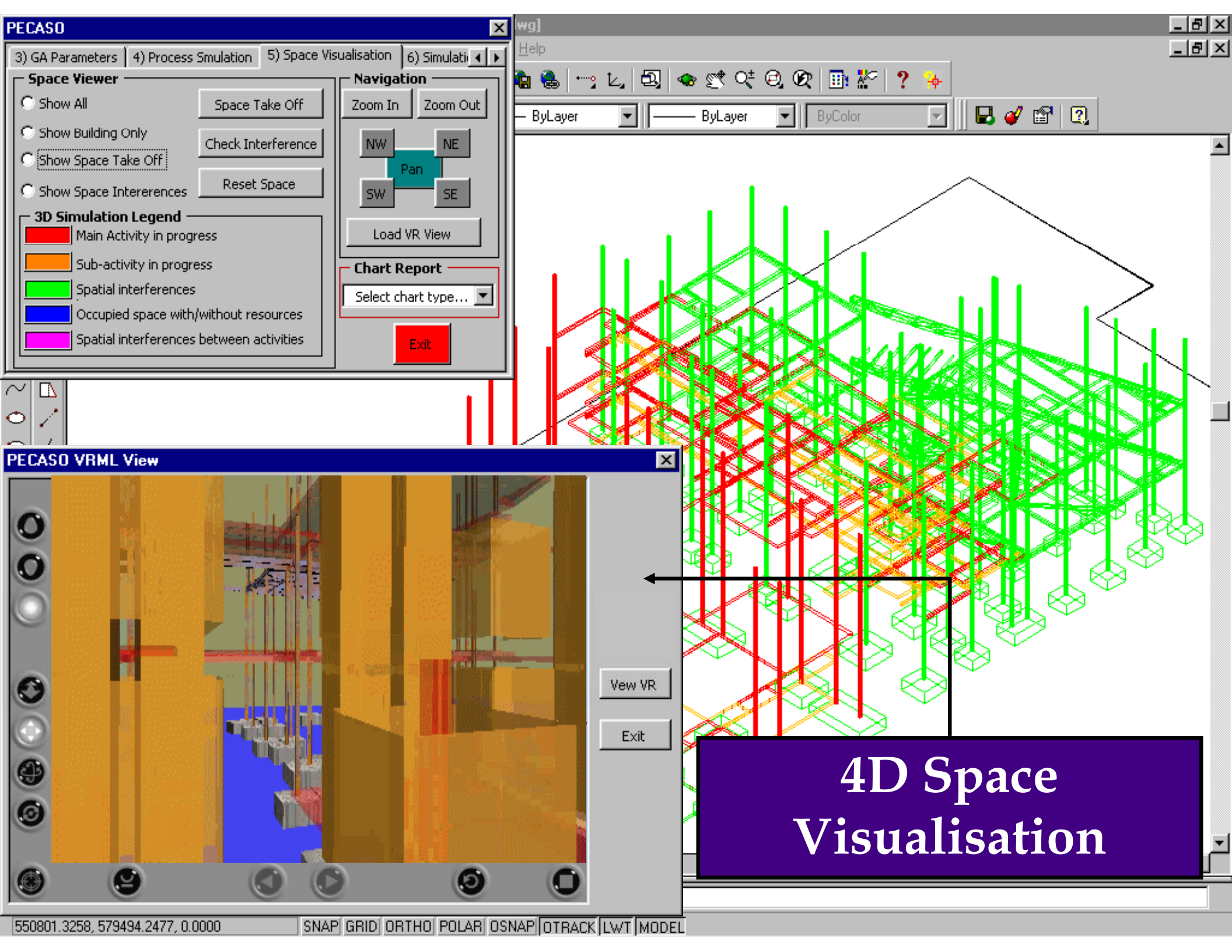
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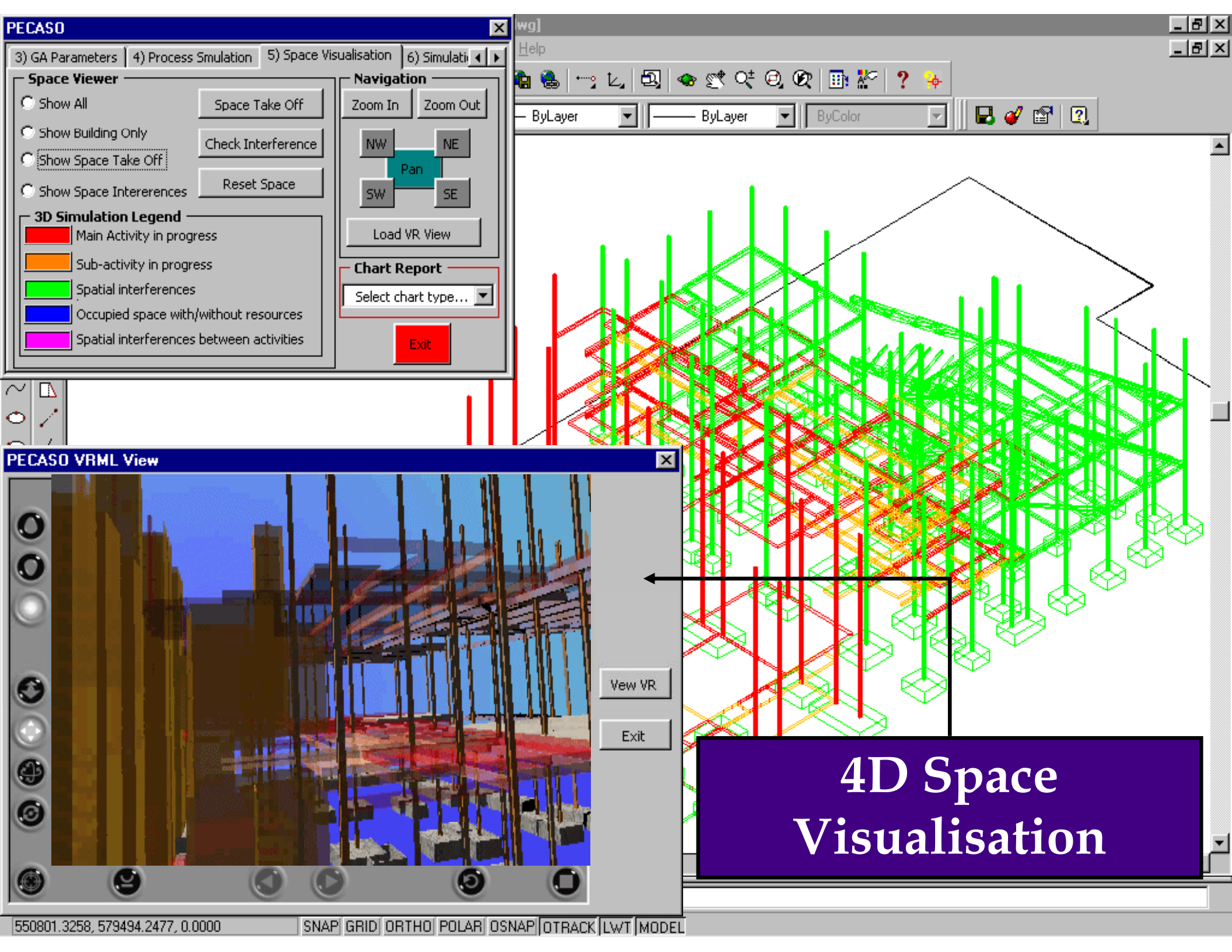
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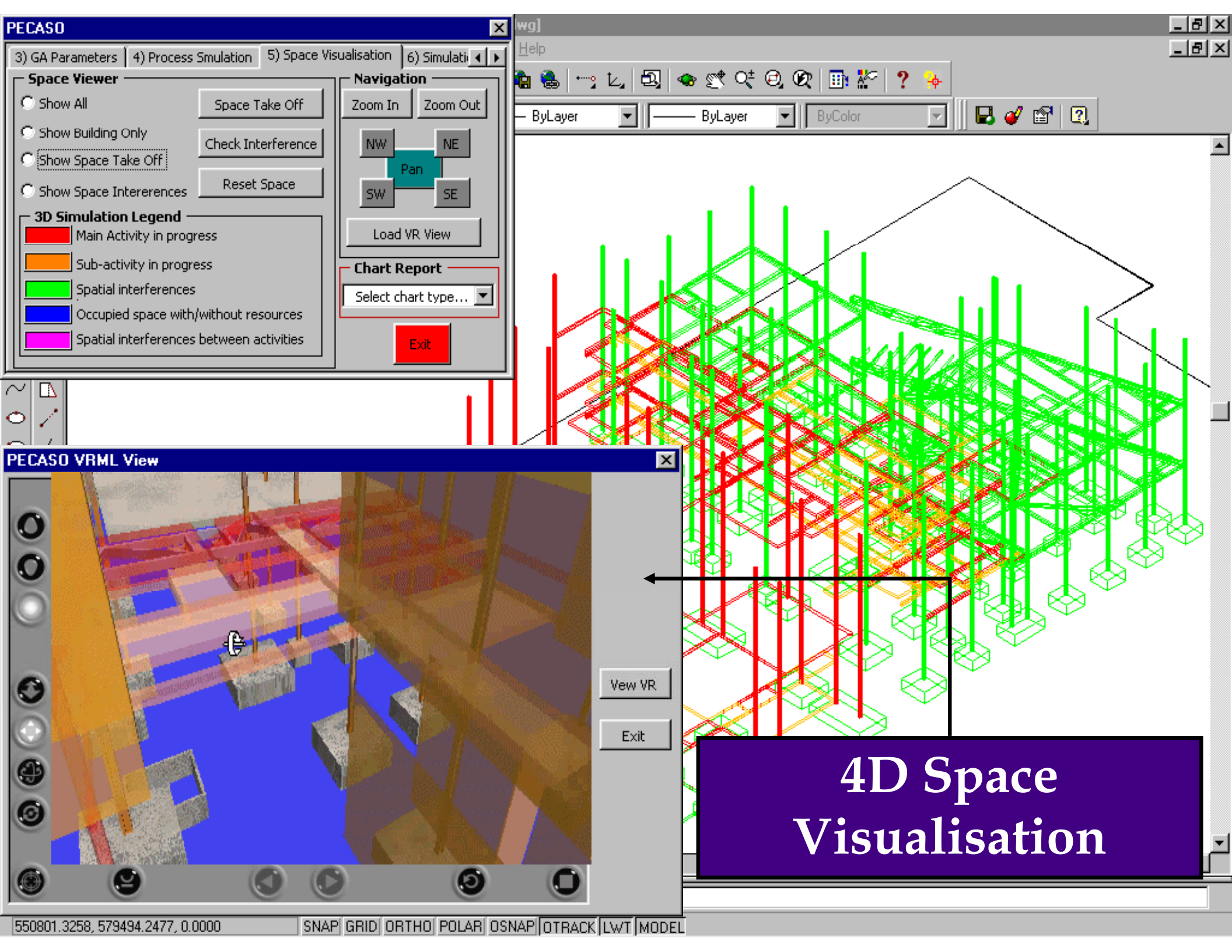
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Discussion

- **Theory:**

  - investigated and expanded space planning theory

  - innovative CSA technique for CSA
- **Research element: developed generic spatial strategies and space reasoning algorithm**
- **4D visualisation approach: captures the dynamic nature pf site space usage in real-time**
- **Evidence: minimised the space conflict by using GA search capabilities**
- **Universal method: for communicating the execution of work**