

# BIM-based Innovative Construction Workflow Simulations for Productivity Improvement



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**Productivity**

**Performance**

**Effectiveness**

**Production Rate**



**in general:**

input to output

output to one or more inputs

**an example in steel installation task:**

manhour per tonnage of erected steel

ton erected per spent manhour





*Being productive is vital to  
survive in today's market!*

that's what grandma always says! ☺

to improve the productivity  
we should be able to **measure it** precisely  
(as much as possible)  
and  
measure the **effect of various factors** on it

Construction is a complex system

Lots of interactions among the constituent parts

Unique conditions for each project

project-based

dynamic

reliable

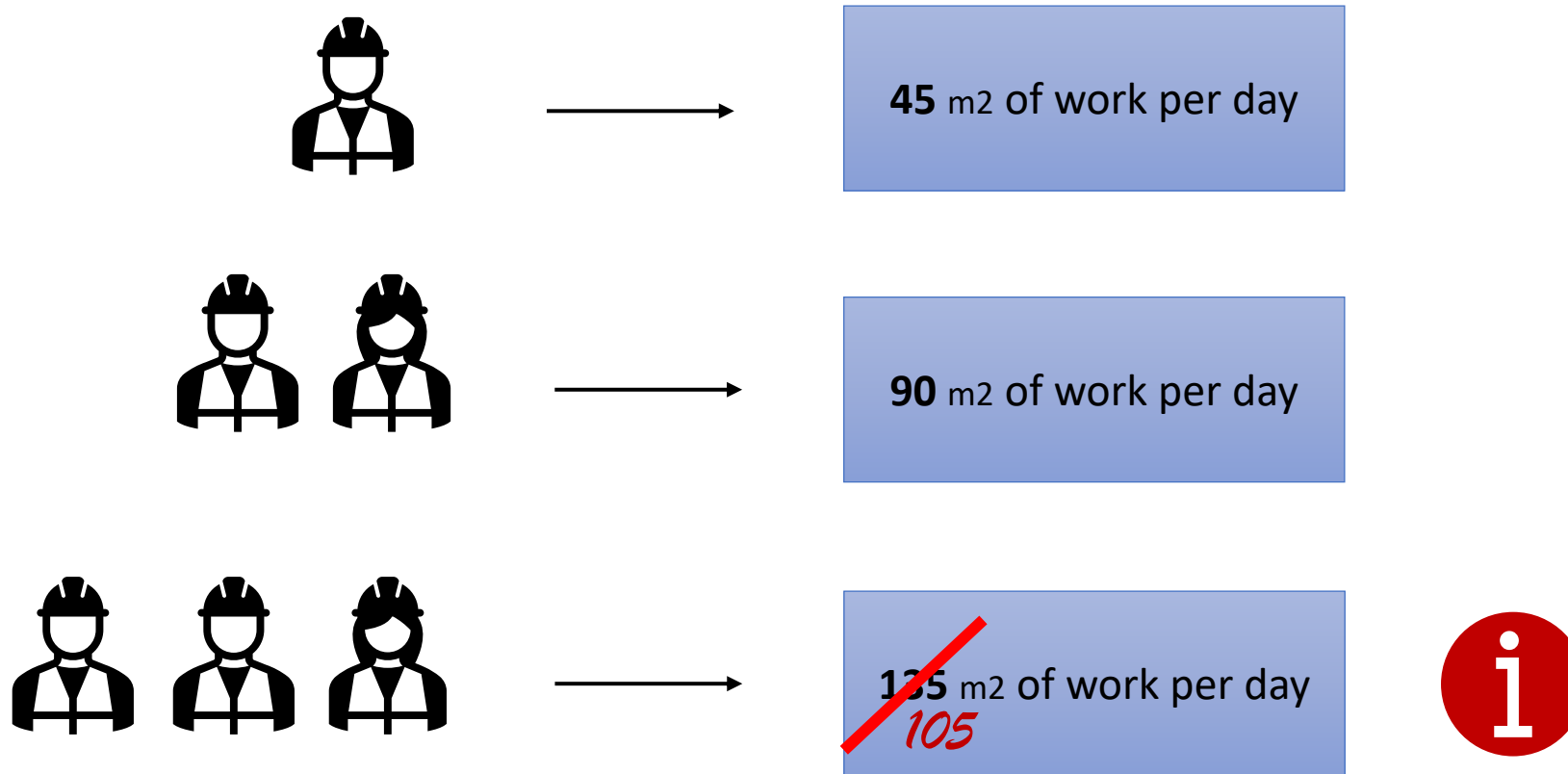




Traditional (subjective) approaches!

benefiting from new technologies!

## Traditional approach







# SPACE notion

## What we have?

### Building Information Modeling (BIM)

a model with elements enriched with data



```
1118 #1145=IFCARBITRARYOPENPROFILEDEF(.CURVE, $, #1144);
1119 #1146=IFCAXIS2PLACEMENT3D(#3, $, $);
1120 #1147=IFCSURFACEOFLINEAREXTRUSION(#1145, #1146, #9, 2.6);
1121 #1148=IFCCONNECTIONSURFACEGEOMETRY(#1147, $);
1122 #1149=IFCCARTESIANPOINT((4.6939999999999983, -11.042000000000001));
1123 #1150=IFCCARTESIANPOINT((6.356000000000001, -11.042000000000001));
1124 #1151=IFCPOLYLINE((#1149, #1150));
1125 #1152=IFCARBITRARYOPENPROFILEDEF(.CURVE, $, #1151);
1126 #1153=IFCAXIS2PLACEMENT3D(#3, $, $);
1127 #1154=IFCSURFACEOFLINEAREXTRUSION(#1152, #1153, #9, 2.6);
1128 #1155=IFCCONNECTIONSURFACEGEOMETRY(#1154, $);
1129 #1156=IFCPROPERTYSINGLEVALUE('Reference', $, IFCLABEL(''), $);
1130 #1157=IFCPROPERTYSINGLEVALUE('CeilingCovering', $, IFCLABEL('CeilingCovering'), $);
1131 #1158=IFCPROPERTYSINGLEVALUE('WallCovering', $, IFCLABEL('WallCovering'), $);
1132 #1159=IFCPROPERTYSINGLEVALUE('FloorCovering', $, IFCLABEL('FloorCovering'), $);
1133 #1160=IFCPROPERTYSET('0saSB1sx72BP1J5R6z2Gig', #33, 'Pset_SpaceCommon', $, (#1156, #1157, #1158, #1159));
1134 #1161=IFCRELDEFINESBYPROPERTIES('1Tzk3h4110_RfpPvrJ9tIt', #33, $, $, (#1059, #1160));
1135 #1162=IFCPROPERTYSINGLEVALUE('Number', $, IFCLABEL('A204'), $);
1136 #1163=IFCPROPERTYSINGLEVALUE('Name', $, IFCLABEL('Bathroom 2'), $);
1137 #1164=IFCPROPERTYSINGLEVALUE('Level', $, IFCLABEL('Level 2'), $);
1138 #1165=IFCPROPERTYSINGLEVALUE('Upper Limit', $, IFCLABEL('Level 2'), $);
1139 #1166=IFCPROPERTYSINGLEVALUE('Limit Offset', $, IFLENGTHMEASURE(2.6), $);
1140 #1167=IFCPROPERTYSINGLEVALUE('Area', $, IFCAREAMEASURE(5.415819401311199), $);
1141 #1168=IFCPROPERTYSINGLEVALUE('Perimeter', $, IFLENGTHMEASURE(9.841231529857001), $);
1142 #1169=IFCPROPERTYSINGLEVALUE('Unbounded Height', $, IFLENGTHMEASURE(2.600000000000001), $);
1143 #1170=IFCPROPERTYSINGLEVALUE('Volume', $, IFCVOLUMEMEASURE(12.24022085941887), $);
1144 #1171=IFCPROPERTYSINGLEVALUE('Phase', $, IFCLABEL('New Construction'), $);
1145 #1172=IFCPROPERTYSINGLEVALUE('OmniClass Table 13 Category', $, IFCLABEL('13-41 11 14 11: Bathroom'), $);
1146 #1173=IFCPROPERTYSINGLEVALUE('CeilingCovering', $, IFCLABEL('CeilingCovering'), $);
1147 #1174=IFCPROPERTYSINGLEVALUE('FloorCovering', $, IFCLABEL('FloorCovering'), $);
```

Geometry

Properties

Quantities

Classification

<https://blog.ereo.io/what-is-ifc/>

# TIME notion



What we have?

## Building Information Modeling (B I M)

a static 3D model

a dynamic (?) 4D model



<https://www.theengineeringcommunity.org/what-is-4d-bim/>

## What we have?

### 4D BIM & Simulation

a BIM model + time →

scheduling

Clash detection

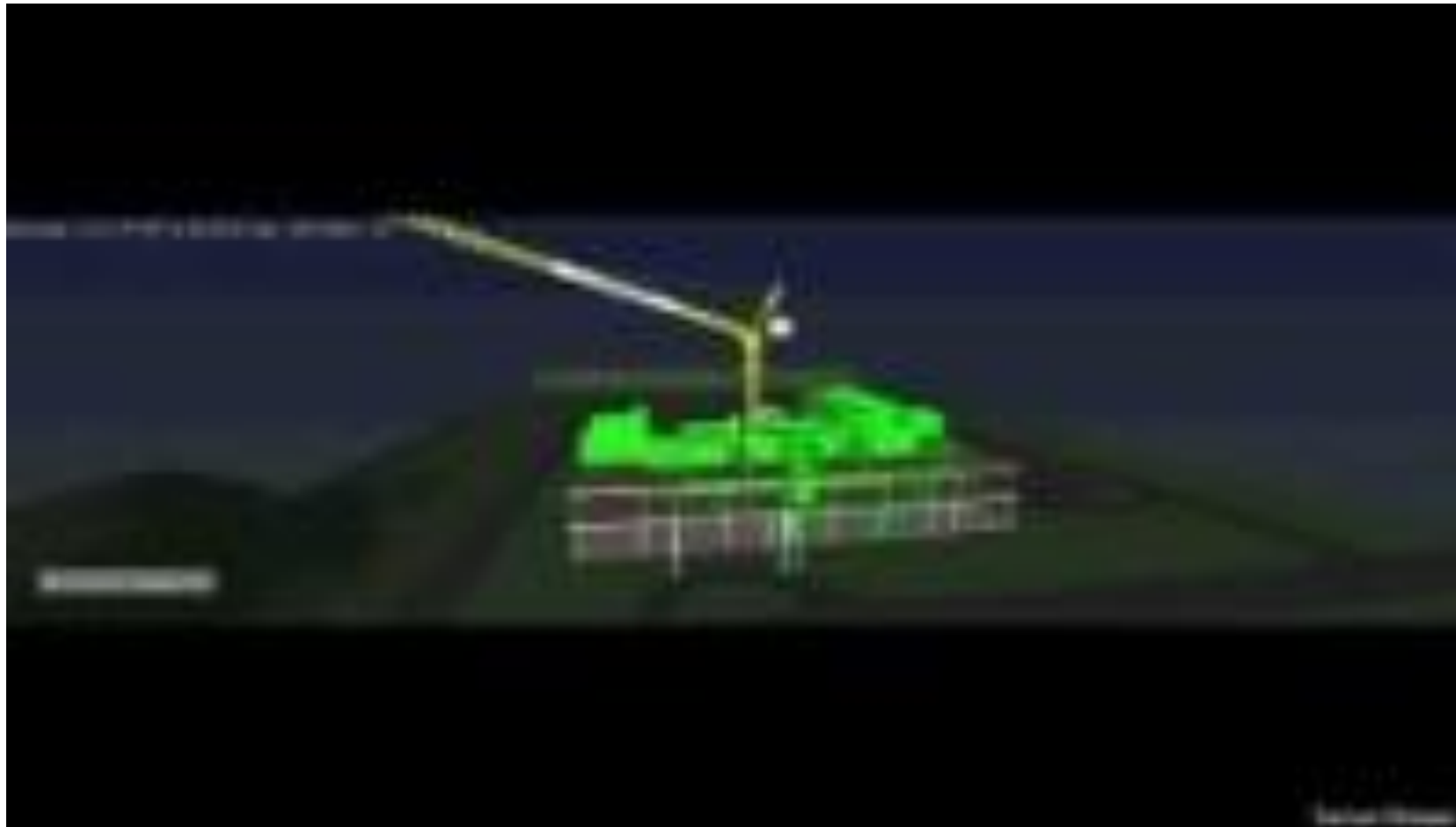
visualization

construction method analysis



Fistcher & Reed , 2007

## What we have?



# What we have?

## Modeling & Simulation

quantify the effects of several factors acting simultaneously

useful for complex systems like construction projects

to build a system virtually before building it in real

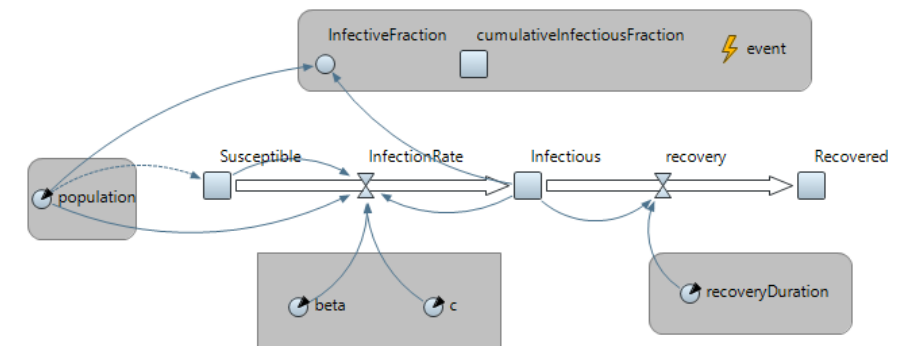
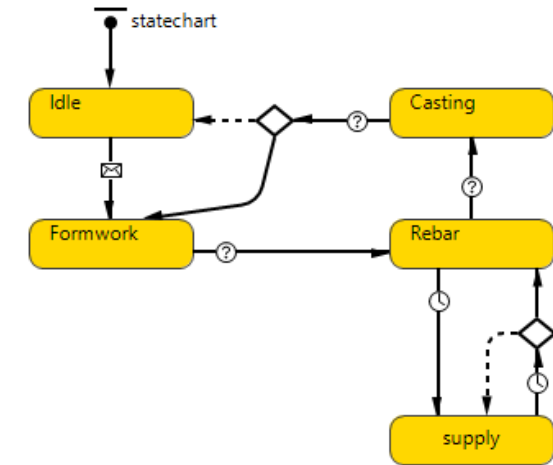
## What we have?

### Simulation Paradigms

Discrete Event Simulation (DES)

Agent Based Simulation (ABS)

System Dynamics (SD)



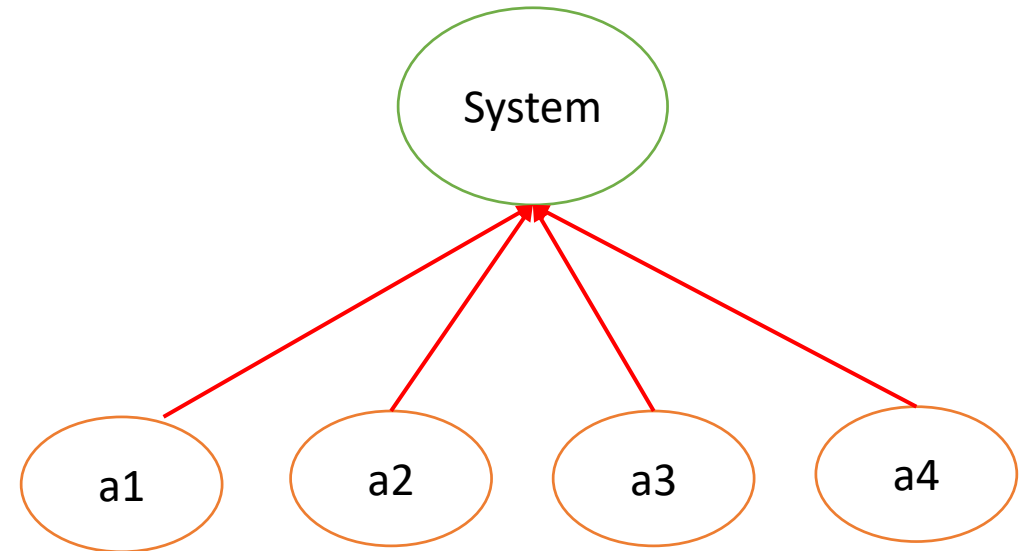
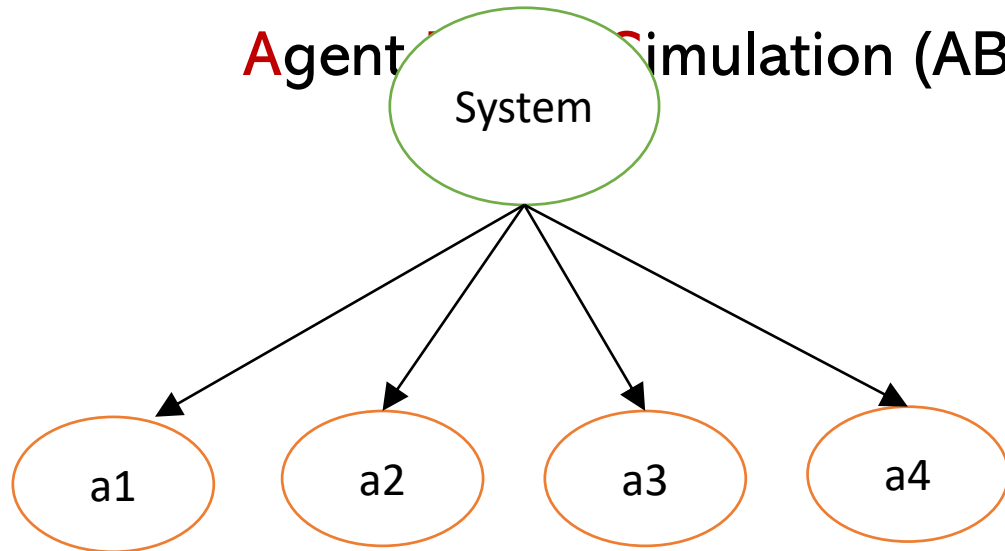


## What we have?

### Simulation Paradigms

Discrete Event Simulation (DES)

Agent Simulation (ABS)



Agent Based Simulation (ABS)



Building Information Modeling (B I M)



## why BIM-ABS instead of 4D BIM?

Interaction of the agents can be modeled

Behavioral patterns are defined

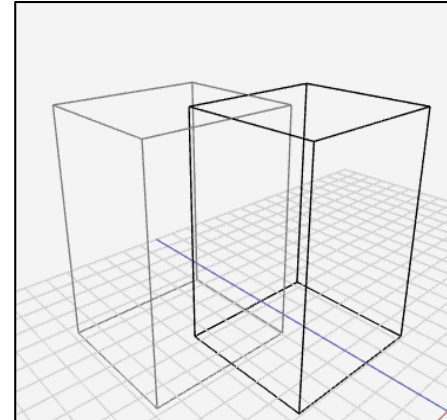
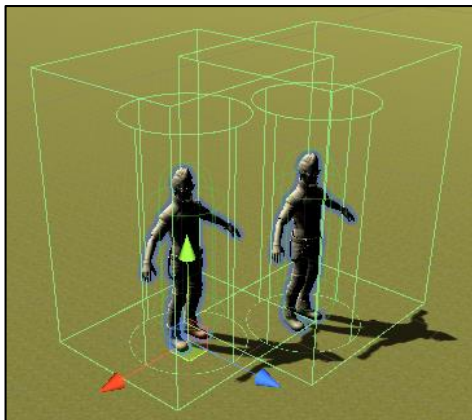
Artificial Intelligence (AI) algorithms can be integrated

Stochastic model can be used with ABS

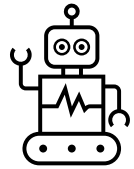
## why BIM-ABS instead of 4D BIM?

Helps us to measure the productivity of agents (crews)

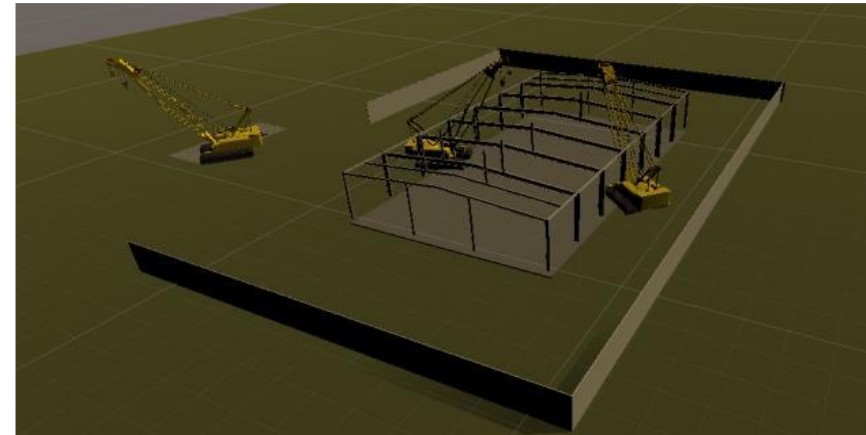
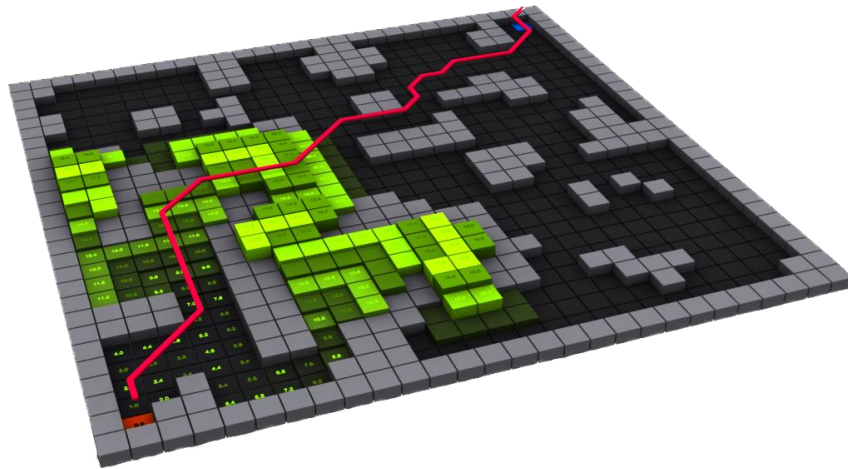
Considering the **unique** and **dynamic** nature of project



## why BIM-ABS instead of 4D BIM?



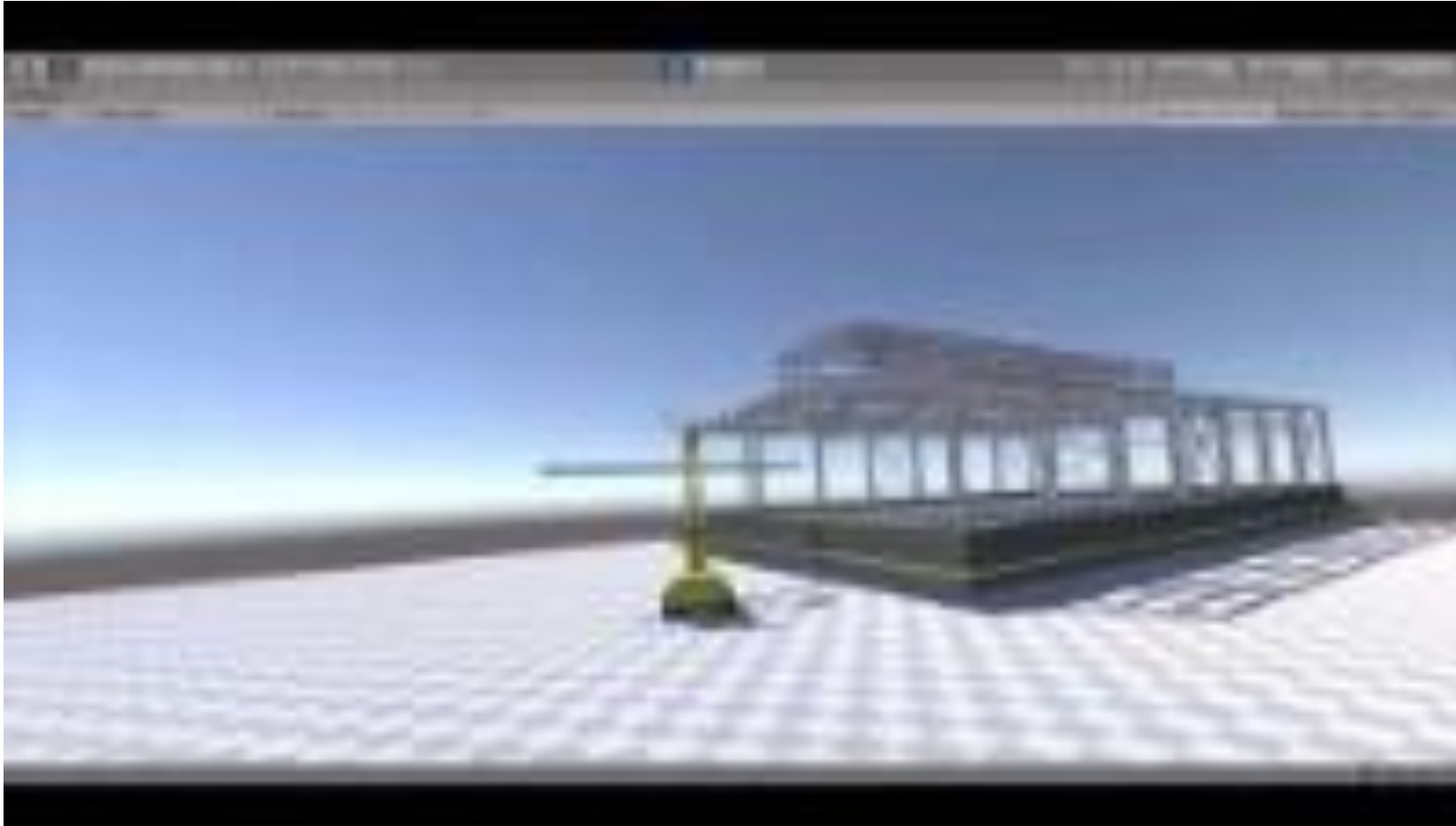
In ABS we integrate the AI pathfinding algorithms into the simulation to mimic the traffic among the crews



## BIM-ABS

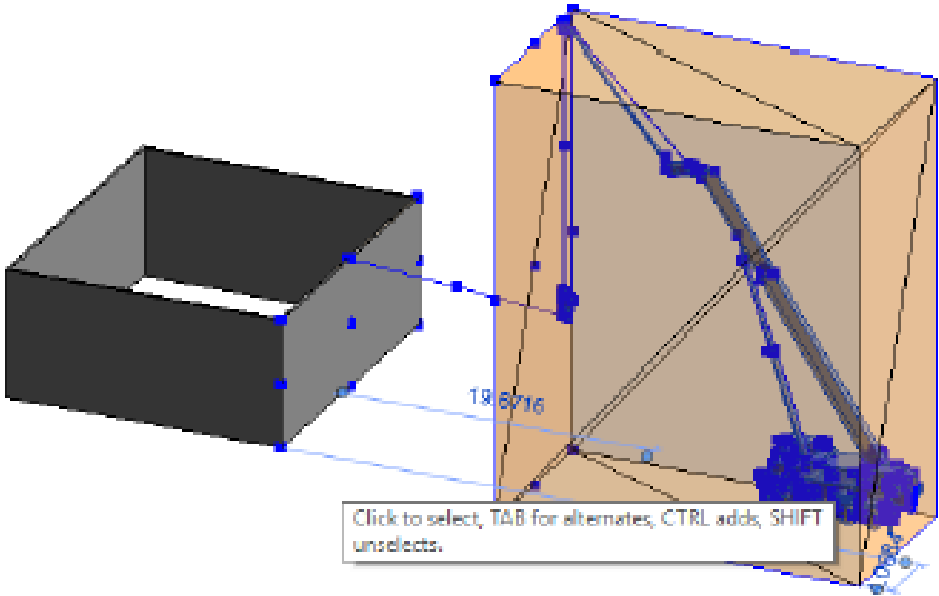
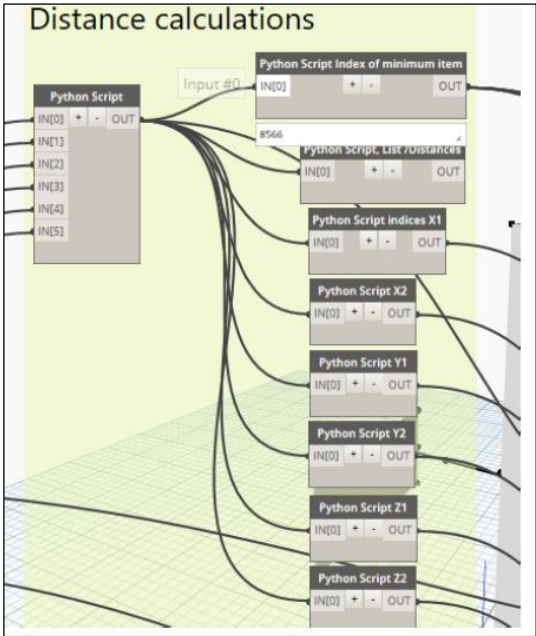
Once we measure the productivity, we can perform what-if scenarios  
and optimizations to **improve** it





```
ControlCenter.cs  X LiftingTime.cs
Assembly-CSharp  ControlCenter  StopPoints

42  //
43  //
44  //SQLite Initialization:
45  public int SQLID, Charindex;
46  public float SQLLENGTH, SQLWEIGHT, SQLELEVATION;
47  public string SQLCategory, SQLColumnL, SQLName, SQLLEVEL;
48  private string conn, sqlQuery , conn2, sqlQuery2;
49  IDbConnection dbconn , dbconn2;
50  IDbCommand dbcmd , dbcmd2;
51  1reference
52  private void insertvalue(int SET_ID, int CREW_SIZE, string TOTAL_DURATION ,string CRANE_SPEED, string CREW_P
53  {
54      using (dbconn2 = new SQLiteConnection(conn2))
55      {
56          dbconn2.Open(); //Open connection to the database.
57          dbcmd2 = dbconn2.CreateCommand();
58          sqlQuery2 = string.Format("insert into TotalDuration (SET_ID, CREW_SIZE, TOTAL_DURATION, CRANE_SPEED
59          dbcmd2.CommandText = sqlQuery2;
60          dbcmd2.ExecuteNonQuery();
61          dbconn2.Close();
62      }
63  }
64  0references
65  private void Deletvalue(int id)
```





Thanks! 😊



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