

## Intellectual Output 2 – Developing the curriculum

### From the application

Within the context of a road design project, students will be introduced to several new methodologies and concepts that have been enabled by new technology, better tools, and digitized workflows. These, to potentially be addressed in the new curriculum, include:

- Introducing concepts and guidelines for building information modelling (BIM) for infrastructure (open infraBIM)
- Introducing integrated project delivery (IPD)
- Introducing concurrent engineering methods
- Introducing methods for design control including clashes, quantities, costs etc.

We need to find a way that students work on different parts of the project in the same model and doing that simultaneously (or concurrently). The project must be delivered as a project model with necessary data attached.

- Introducing infraBIM based construction automation and the associated data flow using cloud service.

### Planning for the workshops

Workshop 1 was originally planned to be held in Jönköping in June 2021. Before the workshop early ideas for a project was written by JU 2021-03-20. Workshop 1 was later moved because of Corona but there was an International project meeting in Jönköping August 18-20 2021. During this project meeting a basic format for a workshop was designed. The outline of the intensive WS covered the following:

- The workshop would be 4 days.
- Work would be done in groups of 4 students, one from each university.
- Project work day 1-3 with time for advanced classes in Novapoint and project presentations from external parties before lunch. With this knowledge the students then work with specific project tasks in the afternoon.
- The afternoon sessions were at this point called ICE (Integrated Concurrent Engineering) sessions.
- Day 4 was to be spent on connecting the student project to “reality”. Exactly what this means is not decided but it could be about machine control or ICE.

The advanced classes in Novapoint are followed by the workshop participants without computers. The idea is to give examples and inspiration of how the software can be used to solve certain issues not a detailed “click-by-click” instruction on how to use the software. This knowledge will then be implemented in project work in groups where the participants will need to solve similar issues as a group.

### Workshops 1 and 2

Workshop 1 was held in Oulu during week 44 2021. Before the workshop JU refined the project part of the WS with instructions and data to be used. JU also made sure there were common storage areas for the project groups and Novapoint & Quadri licences through VDI (Virtual Desktop Interface).

During the workshop Torbjörn Schultz from Jönköping University acted as the instructor during day 1-3. Trimble Norway gave three advanced classes in Novapoint & Quadri connected to the project tasks. Only one presentation from an external party could be arranged day 1 about ICE, the remaining time before lunch day 2-3 was used for project work. Day 4 was about machine control connected to Ouluzone combined with

presentations of student project results. No actual ICE session was held during the workshop. Students worked using their own computers and all presentations in the morning were done through Teams or Zoom. Facilities varied through the week. The schedule for workshop 1 can be seen in figure 1.

Time	Monday	Tuesday	Wednesday	Thursday OULU zone	Friday
8.30 – 9.30	Coffee & Bread at university Introduction (Erik + Rauno) Introduction to the ICE concept <b>Location: seminar room YT116</b>  University map Navigator in your mobile phone	Coffee & Bread at university Model time Groups continue modelling  <b>Location: seminar room PR101</b>	Coffee & Bread at university Model time Groups continue modelling  <b>Location: seminar room PR115</b>	Leaving from hotel to <b>Haukipudas/OSAO</b> at <b>7:30</b>  8.00 Project presentations by students  Mr. Heikki Koret is presenting the simulators at 9:00-9:30	Going home
9.30 – 10.00	Break	Break	Break	Break	
10.00 – 11.30	Novapoint advanced (Daniel Sosna, Anders Hoie +Trimble) + assignment  <i>Crossroad/Tekla</i>	Novapoint advanced (Daniel Sosna, Anders Hoie +Trimble) + assignment  <i>Ditches with alignment (sewage, rain),</i>  <b>Location: seminar room AT 117</b>	Novapoint advanced (Daniel Sosna, Anders Hoie +Trimble) + assignment  <i>Ramps</i>	Model sharing in road design and construction by Rauno Heikkilä (Oulu)  Bus from Haukipudas to Ouluzone 10:45	
11.30 – 12.30	Lunch	Lunch	Lunch	Lunch in Ouluzone	
12.30 – 14.00	12.30 - 15.00: Model time Intro + presentation: Torbjörn Schultz (JU) Terrain, vegetation, roads, buildings, existing infrastructure	Ice session (InRoad)  5 groups: 2 alignment tasks, 2 crossroads, drainage  <b>Location: seminar room LO104</b>	Ice session (InRoad)  5 groups: 2 alignment tasks, 2 crossroads, drainage	Safety equipment's Autonomous excavator-show in Ouluzone; other activities	
14.00 – 14.30	Break	Break	Break	Break	
14.30 – 16.00	15.15 - 16.00: Ice session (InRoad) ICE method -presentation by Ragnhild Nøstvold (COWI) <i>virtually on zoom</i>	Ice session (InRoad)  5 groups: 2 alignment tasks, 2 crossroads, drainage	Ice session (InRoad)  5 groups: 2 alignment tasks, 2 crossroads, drainage Scenario alteration	Evaluation in OZ  Leaving from OZ to Oulu at 14:45. At city center around 16:00.  Wrap up of the day/ Assessment during the bus trip	
16.00 – 16.30	Wrap up of the day/ assessment	Wrap up of the day/ assessment	Wrap up of the day/ assessment		
Evening	Free time Students are free to organize their activities	Students' activity organized by Oulu students (Sauna)	Free time Students are free to organize their activities	Dinner at Sokeri-Jussi at 18:00	

Figure 1. Schedule for the first workshop in Oulu based on the Intellectual Outcome 1 and planning.

Before workshop 2 in Jönköping week 7 2022 JU and NTNU worked to arrange a real ICE session day 4. The workshop in Jönköping followed the basic format agreed upon during the meeting in August 2021. Differences from WS1 includes:

- Students worked on stationary computers.
- Participants from Norway joined online.

- Three presentations from external parties.
- Advanced classes from Trimble Sweden, two of them were also recorded.
- Day 4 spent on ICE based on project results. ICE case was mostly developed by NTNU

## **Lessons learned from workshop 1 and 2**

Based on the evaluations and observations several lessons were learned from the first two workshops. Participants need basic knowledge in the software used to be able to participate in an Inroad workshop. Working in an international environment the road standards used and the language of the software needed to be communicated in advance.

To get the best possible outcome a formal introduction to the workshop explaining the purpose and the expected outcome was introduced. Part of this introduction was to convey the message about expected learning outcomes better. The purpose is to learn by using the software to solve problems as a group, not to create perfect models using detailed “click-by-click” instructions.

For workshop 3 and 4 the project instructions and the instructions for the ICE session were improved. The start of day 2-4 of the workshop was formalised and not just used as extra modelling time. This was done by examining the progress of each group in a plenary session discussion encountered problems and how to solve them.

Besides these changes the basic format of the workshop was confirmed for workshop 3 and 4. The basic format thus is:

- Problem based learning with international project groups
- Time before lunch day 1-3 is used for individual learning in the form of evaluating work done earlier in the workshop, connection to reality with presentation from external parties and advanced classes in Novapoint
- Time after lunch day 1-3 is used for project work in groups. The project tasks are connected to the advanced class before lunch.
- Day 4 is spent in an ICE session.

## **Workshop 3 and 4**

Implementation of the lessons learned from workshop 1 and 2 was executed in workshop 3 in Aalborg week 43 2022. To improve on the project work in an international setting where the participants do not know each other a digital introduction was done one week before the workshop introducing the participants and the workshop.

The fourth and final workshop of the project was done in Trondheim week 7 2023. The purpose of this workshop was to test the final iteration of the curriculum and fine tune the execution, see schedule in Annex 1. The final version of the workshop is based on the observations and evaluations of the previous three workshops.

## **Conclusions**

The purpose of the Inroad project was to develop didactic methods to meet the challenges of teaching engineering subjects, in this case road design. In modern society students and new employees face ever more complex digital tools that they are expected to know besides traditional engineering skills. Apart from mastering the complex digital tools students are also expected to do this in new constellations, often in an international setting. The Inroad method proposes that to meet these challenges we need to step away from the traditional “click-by-click” instructions for teaching software.

The key concepts in the Inroad method are:

- Advanced software classes
- Problem based learning (the project)
- Concurrent engineering

In the project these concepts have been incorporated into a 4 day intensive course called an Inroad workshop. In this workshop during day 1-3 mornings are spent on instruction and afternoons are spent on project work. Day 4 is used to perform an ICE (Integrated Concurrent Engineering) session. The key concepts are incorporated with advanced classes in day 1-3 followed by project work where the participants must work concurrently in the same model.

### **Advanced software classes**

Instruction in the software is done by an “advanced class”. This means that rather than sitting in front of a computer following the instructor the participants sit in an auditorium following the presentation, taking notes. The presentation is not an exact instruction on how to perform a specific task in the software but rather an inspirational presentation on how the software can be used to resolve certain issues. As the presentation is fast paced the participant is not meant to memorize everything but rather take inspiration on how they can work with the software, an “advanced class”. To participate you will need a basic understanding of the software in question.

### **The project**

After the advanced class the participants are given a project task that is part of a larger project to be completed during day 1-3. The project group consists of 4 people from different countries, educational background etc. and they are expected to solve the project task (the problem) by working together in the same model (concurrent). The project tasks each day are related to the topic of the advanced class earlier that day.

### **Concurrent engineering**

During day 1-3 the participants work concurrently by solving their project tasks in the concurrent model. The final day of the workshop the participants take on different roles to resolve an interdisciplinary issue in an ICE session. In the Inroad workshop the issue is placements of bus stops and the roles are designing engineer, municipality, bus company and a NGO interested in riding bikes.

### **The rest of the workshop**

To complement the key concepts in the workshop day 2-3 starts with inspirational presentation from external parties to put the project tasks into context, i.e. showing real life application of what the data produced can be used for. After the presentations the project progress from the day before is reviewed in plenum to resolve specific issues before the next advanced class starts. At the end of day 4 the groups present the results of their project and how they resolved the issue in the ICE session. During the project work an instructor is available in the room. An example of a workshop schedule is included below.

### **Lessons learnt from the start**

To successfully execute a workshop according to the Inroad method a number of practical things have to be considered

### Software licenses

All the participants need access and licenses for the same version of the softwares that are to be used in the workshop.

### Project space

An appropriate physical space that facilitates work in project form must be used. Normal classroom seating does not work. This applies regardless if stationary computers are used or not.

### Charging opportunities for 20+ people

If laptops are used the participants must all be able to charge their computers at the same time which means that there needs to be at least 20+ power outlets in the room.

### Recording advanced classes

Giving the participants access to recordings of the advanced classes can facilitate their progress in the project. However, giving the participants unrestricted access to these recordings will have a negative effect since teamwork diminishes and the participants resorts to viewing videos to find solutions rather than solving problems in the group.

### Project group formation

When forming the groups prior knowledge in the subject and related softwares needs to be considered. In the Inroad project two versions were tested. The first version was to spread the most skillful participants through the groups so that all the groups would have an equal skill level. The second version was to make the individual groups balanced and instead have a span of skill level between the groups. Of these two versions the second one was by far the most successful.

### The use of big screens in the groups

Having access to a large screen in the group proved to be successful if the screen is used to resolve problems. If the screen is used for normal work tasks the participant using the screen tended to be the only one working while the other group members became observers.

### Introduction to the workshop

To achieve the best outcome for the participants and the best participant satisfaction the introduction to the workshop is important. One part of the introduction needs to explain the format of the workshop and the expected learning outcome. Another part of the introduction needs to facilitate the participants in getting acquainted with each other. The second part was resolved by having an online introduction the week before the workshop.

### Alternate tasks if the server fails

Since the software used in the workshop relies on connection to a server to function for concurrent engineering alternate work tasks needs to be prepared if the server fails. This happened one day in the Trondheim workshop. Having prepared alternate tasks meant that the project work could still progress in an alternate way.

### Feedback during the week

Following participant evaluation from the first two workshops an feedback and Q&A session was added to day 2 and 3. In this session the progress of each group was displayed and discussed in plenum to resolve any issues. The addition of this session reduced frustration among the participants and made progress faster.

### Contents of the presentation from external parties

The content of the external inspirational lectures needs to fit the content of the workshop and skill level of the participants otherwise it was considered wasted time.

### Size of the group

Initially workshop 1 and 2 was supposed to be tests with 5 participants from each university (20 total). Very

quickly in the first workshop it was discovered that doing a workshop in this format would be very complicated with more than 20 participants. The main issues with increasing the group size are:

- Familiarity between the participants. In a group of 20 everyone could socialize and help each other. If the group increases to 40 participants will start to become anonymous.
- One instructor can not handle more participants. Adding more instructors would also add discrepancies in how the workshop is actually carried out.
- It is hard to find appropriate physical spaces where 40 participants can work efficiently according to this methodology.

# Project: Integrated Project Development for Road Infrastructure Education

Final report on Intellectual Outputs



## Annex 1

### Schedule from workshop 4 in Trondheim

Time	Monday (13/02/2023)	Tuesday (14/02/2023)	Wednesday (15/02/2023)	Thursday (16/02/2023)
8.30 – 9.30	Introduction to the project and welcome (Thomas, Kelly) Location: 4. floor ZEB (Høgskoleringen 13, 7034 Trondheim)	8.30-9.00 Presentation FuelSave - Lisa Persson and Peter Pantzar, Rambøll (Swe/Nor)	8.30-9.00 Presentation SiteVision – Anders Høie, Trimble	Presentation: Virtual Design and Construction, with a focus on ICE (integrated concurrent engineering) Kamalan Rashasingham, ByggTrafikk
9.30 – 10.00	Break	(9.00-9.30) Break	(9.00-9.30) Break	Break
10.00 – 10:30	Project Introduction: Torbjörn Schultz (JU) 5 groups each working with one area	9.30 - 10.30 Model time Evaluation of the group progress and QA	Model time Evaluation of the group progress and QA	Plenary session on planning the ICE session
10.30 – 11.30	Novapoint advanced Existing objects, crossing roads and intersections, Carl Friberg, Trimble	Novapoint advanced Ditches, drainage and driving lanes Carl Friberg, Trimble	Novapoint advanced Ramps Carl Friberg, Trimble	
11.30 – 12.30	Lunch, TBD	Lunch, TBD	Lunch, TBD	Lunch, TBD
12.30-14.00	Project work (InRoad) Terrain, vegetation, roads, buildings, existing infrastructure	Project work (InRoad) Per area: 2 alignment tasks, 2 crossroads, drainage	Project work (InRoad) Per area: 2 alignment tasks, 2 crossroads, drainage	Evaluation of the case and ICE session. Presentation of group solutions. Plenum
14.00 – 14.30	Break	Break	Break	Break
14.30 – 16.00	Project work (InRoad) Terrain, vegetation, roads, buildings, existing infrastructure	Project work (InRoad) Per area: 2 alignment tasks, 2 crossroads, drainage	Project work (InRoad) Per area: 2 alignment tasks, 2 crossroads, drainage	ICE
16.00 – 16-30	Wrap up of the day/ assessment	Wrap up of the day/ assessment	Assessment in focus groups (16:15 – tour of ZEB (Zero Emissions Building))	Wrap up of the workshop/ assessment
Evening	Free time Students are free to organize their activities	Free time Students are free to organize their activities	Free time Students are free to organize their activities	18.30 Dinner Emilies ELD;