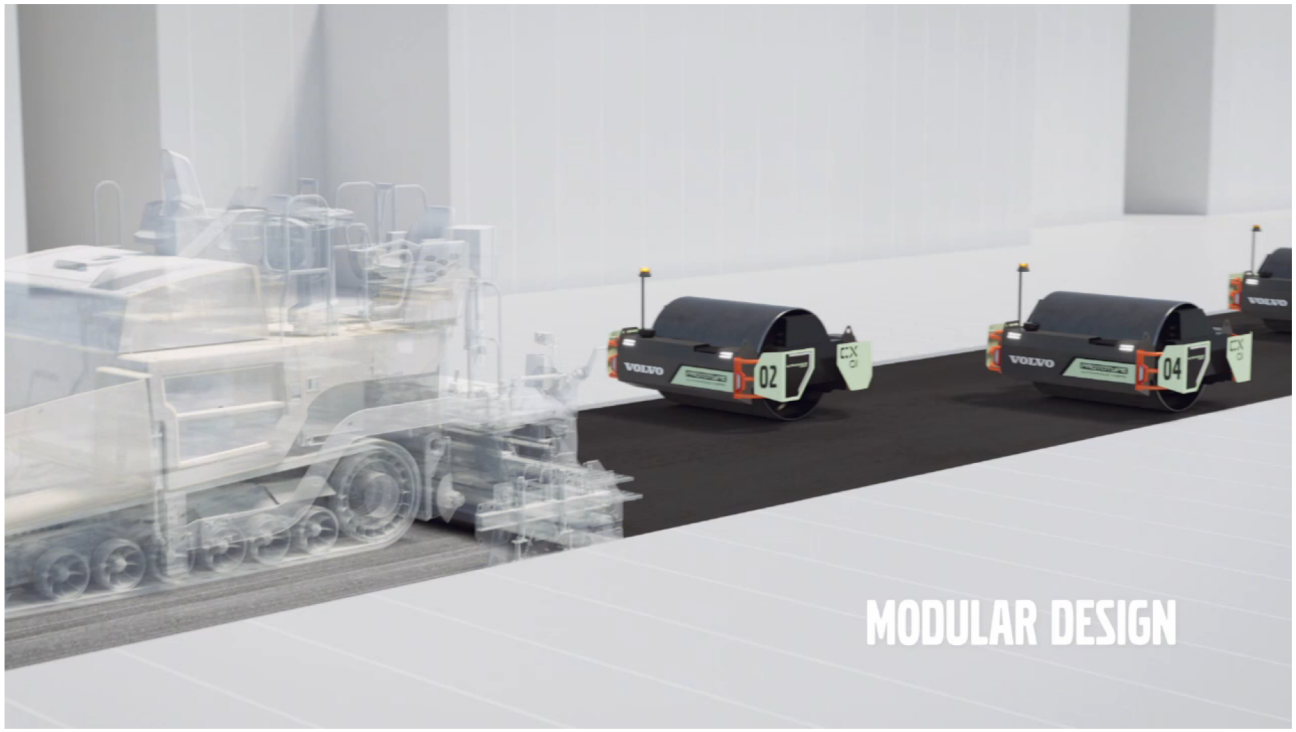

Animation:
Volvo CE

Shaping the Future of Built Environment through BIM, Berlin 8.5.2023

Autonomous Work Machines are changing the Infrastructure Construction Site

Tanja Kolli, Annika Kemppainen, Rauno Heikkilä,

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Infra Construction Sites

- Long work sites, typically 10-100 km, or over 1000 km (E39, Norway, 2015-2035)
- The number of working machines and vehicles are varied from tens to hundreds of
- Several construction tasks, such as soil bed cutting, rock cutting and blasting, construction of structural layers, asphalt spreading, compaction,…

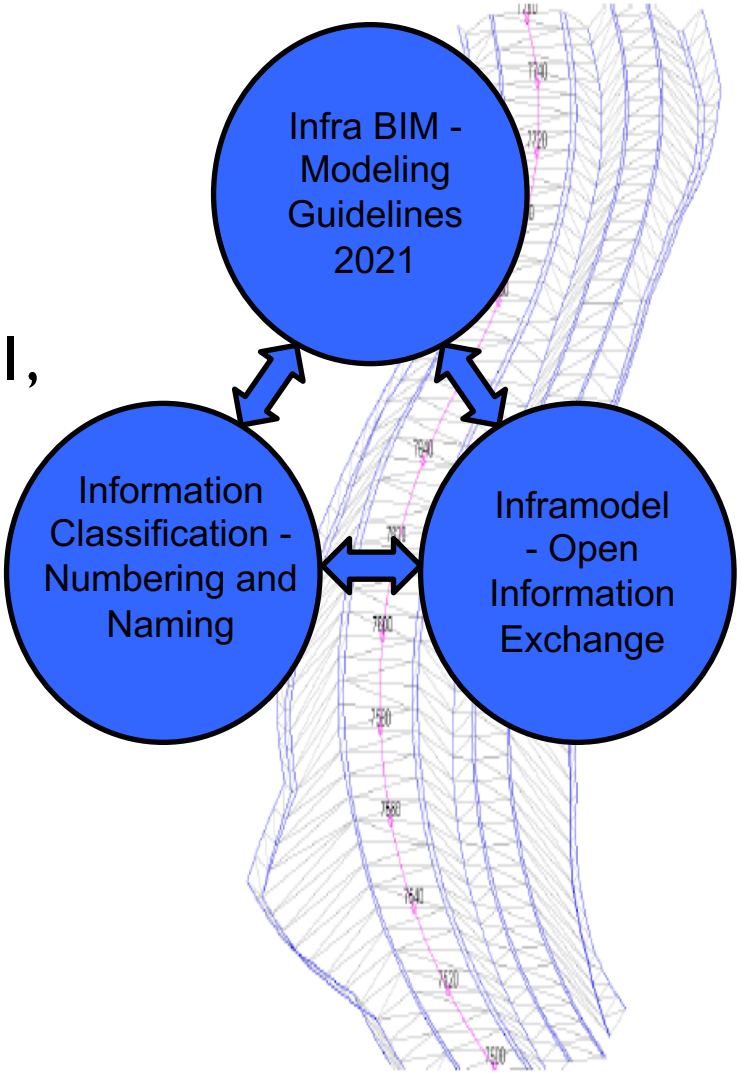
→ Lots of material movements

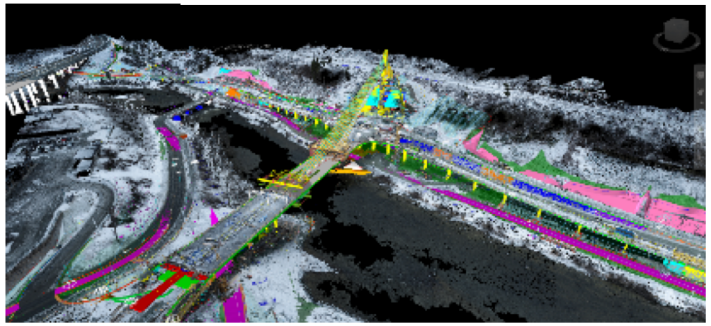
→ Continuous interaction with traffic

- Very costly, e.g. motor way 3-5 MEUR/km
- Duration of project 2-3 years
- <u>Relatively high construction accuracy is required!</u>

Open Infra BIM, Machine Control Model

- Common InfraBIM Requirements YIV2021, Infra BIM Classification, Inframodel
- Preparation Instructions for as-planned models of earth works (machine control models)
  - Content of machine control model
  - Modelled terrain break lines
  - Naming and coding of terrain break lines and surfaces
  - Continuity of terrain break lines and surfaces
  - Geometric accuracy of terrain break material
  - Regularity of triangulation network
  - Checking of models, model report, naming of as-planned model files, data exchange format





Levels of Automation for Infra Construction Machinery (Heikkilä *et al.*, ISARC 2019)

Level	Name	Description of the activity
0	No automation	Human operates machine
1	Remote control	Human operates remotely machine
2	Guidance	Operator supported, the operator drives manually machine and blade using computer user-interface to BIM model
3	Coordinated	Tip control, the operator moves the machine and manages the tool blade manually with the help of inverse kinematics
4	Partial automation	Controlling, the operator moves the work machine and manages the part of the tool blade manually while the system drives automatically some of the movements
5	Autonomous	Machine can operate without human driver
6	Autonomous machine swarm	Autonomous operation of work machines, interactivity and collaboration of working machines

Smart Excavator, Control Methods Available

1) Human Manual
2) Guidance
3) Remote
4) Teach-in
5) Autonomous

Remote – Our Record 400 km

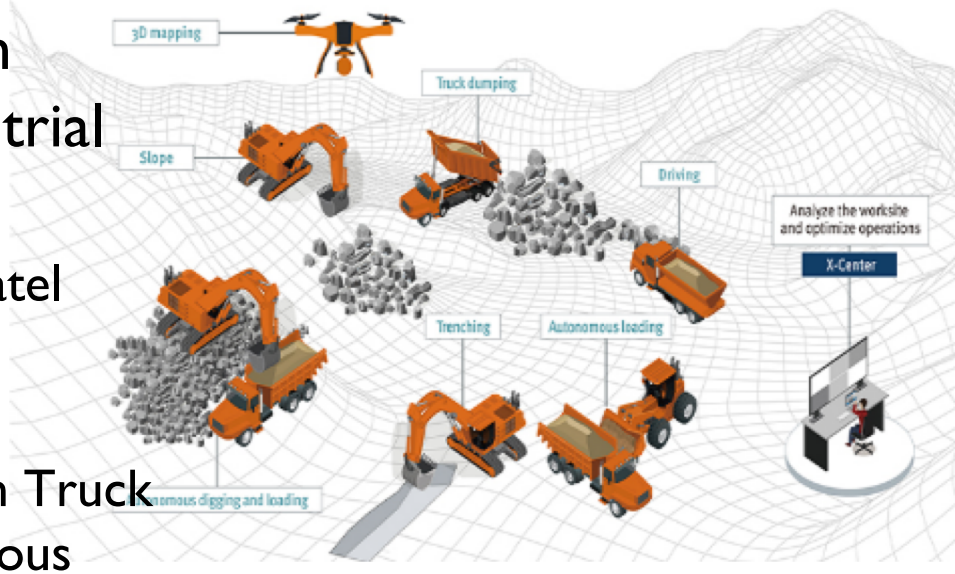
Model based Autonomous Control

Autonomous Swarm Demo at PWRI 21.4.2023

Autonomous Low-Emission Swarm of Infra Construction Machinery

Founding by Business Finland 5 Meur, 2022-2024

- University of Oulu, joint research project with a group of key industrial players:
  - Novatron (3D Machine Control), Satel (Wireless Communication), Destia (Contractor)
  - Noptel (LIDAR), Sisu Truck (Finnish Truck manufacturer), Sensible4 (Autonomous vehicles and trucks?), GIM Robotics (Adaptive sensing and navigation), Nokia (5G), Sandvik (Mining Automation, MIM)
- The work machine swarm: Excavator, bulldozer, compaction machine, dump truck



Picture: Concept-X Vision, Doosan

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Conclusion

- The more automation, the fewer humans on sites
- Semi-autonomous systems are more and more coming to infra construction sites
- New type of remote control centers will arrive, especially for large construction projects
- Wireless communication important
- Trained people to use automation on site will be needed
- Hopefully automation gives a possibility to improve the productivity in infra construction works and sector

Thank you!

BIM-seminar questionary:

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