State-of-the-art Construction sites realized with ICT Construction Machines. (ICT based - Excavator and Bull Dozer)

Tomohiro NAKAGAWA

* Department of ICT Development Group, Faculty of Engineering
KOMATSU
3-1-1 Ueno Hirakata-city, Osaka, 573-1011 Japan
(E-mail: tomohiro_nakagawa@komatsu.co.jp)

Abstract. The Japanese government had begun implementing the system "i-CONSTRUCTION" for construction sites from 2016.Significant productivity gains have been generated in construction sites though the use of ICT, IoT, AI and other new technologies. The Earthmoving industry is also changing rapidly with city planners, contractors and construction machine makers starting to adopt the technology.

Keywords: ICT construction Machines, Construction sites ICT based, IoT sensors, Machine Control, Design surface digital data

INTRODUCTION

Construction machine makers of course Komatsu and survey tool makers were developing many kind of machines or tools for matching to i-CONSTRUCTION.
Especially Komatsu developed not only Construction Machines but also system for offices,
Site managers are able to check a progress of site work and machines status.
These systems reduce manual surveys or machine operating by the seat of operator pants.

VISUALIZATIONS OF CONSTRUCTION SITE

In what follows, three facts are presented visualization difficulty of the construction sites.
(a) The detection of soil shape and make up can be in accurate, resulting in incorrect progress reports.
(b) Construction machines work in sites independently.
(c) Site managers do not fully comprehend the capabilities of the new technology.
It has often been discussed that design surface drawing should utilize digital data and construction machines should dig or finish according to design surface on machine's monitors.
FIGURE 1 illustrates a typical process of conventional construction.

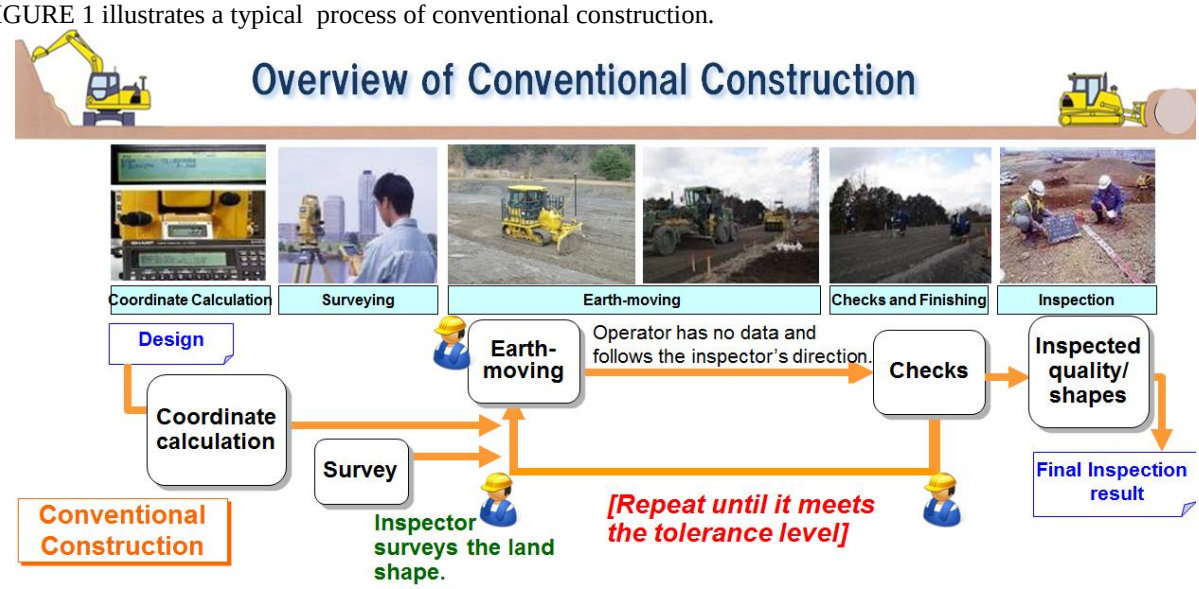


FIGURE 1 Many manual working in conventional construction

Komatsu introduced Construction Machines and Software for offices to comply with i-CONSTRUCTION.
FIGURE 2 illustrates the whole process of Komatsu system for i-CONSTRUCTION.
Komatsu system →servers
In what follows, five data flow.
(a) Measurement by Drone or 3D laser scanner.
FIGURE 2-1 illustrates that High -precision survey data from sites are stored on servers.
(b) Drawing design shape.
3D designs using 3D CAD are also stored on servers.
(c) Planning.
Accurate understanding of cut and fill volumes and changing shape on a day basis is calculated using office computer drawing data from servers.
FIGURE 2-2 illustrates that a construction area is computed precisely from the difference between (a) and (b).
(d) Preparation
Site managers in charge of Machines preparation can estimate number for preparing machines from computed volumes.
Then each design surfaces data is sent to each construction machine via 3G modem or via radio.
(e) Construction.
Design surfaces are consisted of three axes World coordinates x-y-z. Construction machine has high precision GNSS antennas and measures machine attitude by IMU. Beyond that, tip of work equipment in the World coordinates are computed from machine profile and each cylinder length are measured by cylinder stroke sensors. ICT Construction Machines works auto or semi automatically according design surface data and tip coordinates by itself. Machine trace by GNSS and tip of work equipment trace update sites landform changing and that are reflected in Smart Construction servers. Site manager check and modify plan in the office computer from servers. That means landform changing data circulated automatically.

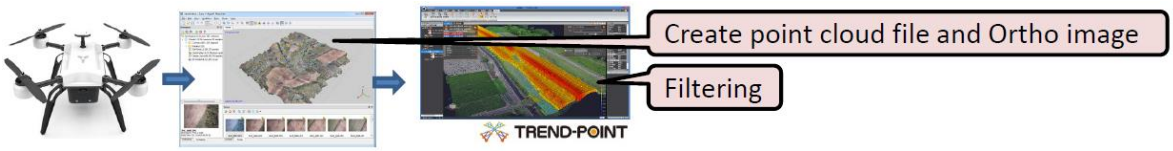


FIGURE 2-1.

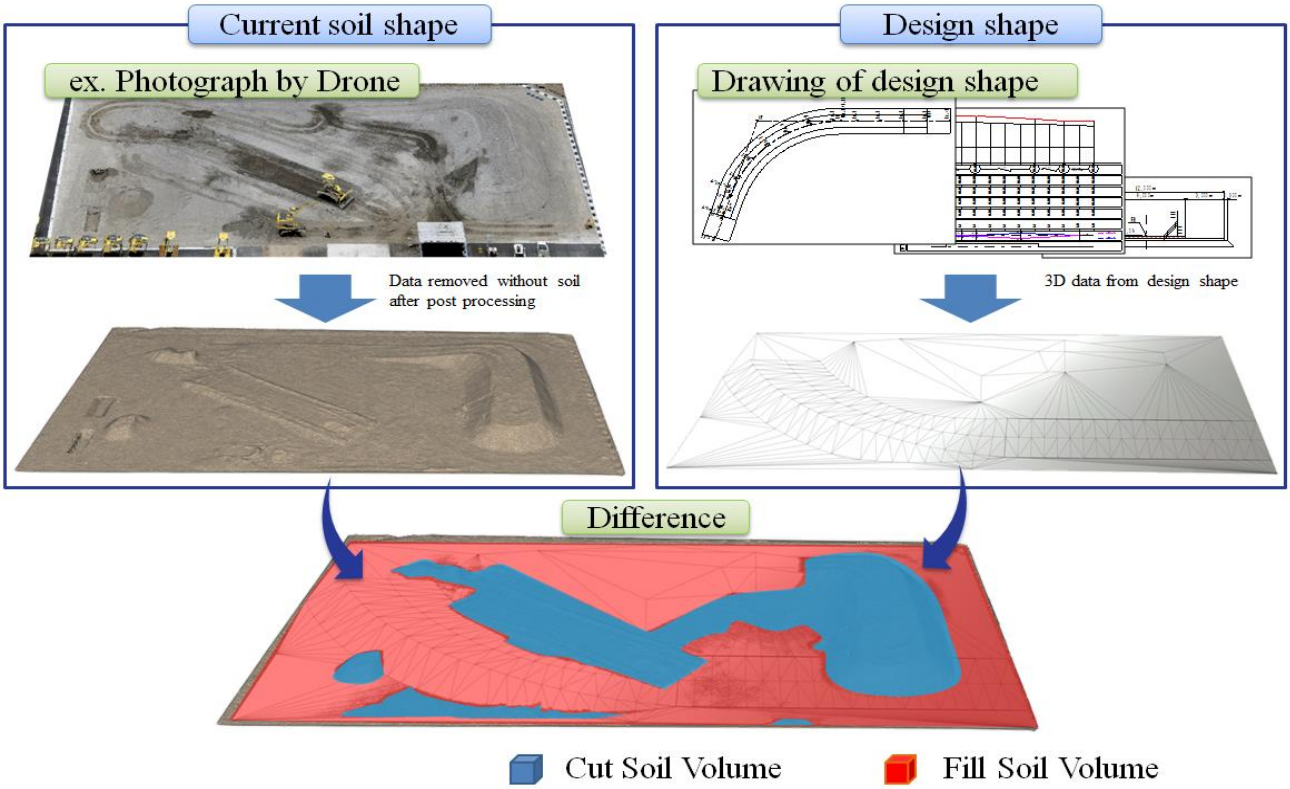


FIGURE 2-2.

FIGURE 2.

ICT-BASED EXCAVATOR AND BULL DOZER FUNCTIONS

ICT Construction Machines has GNSS antennas, receiver, IMU, cylinder stroke sensors and monitor panel for Design surface information. And for tracing to it, EPC for control Main Valve and controllers for machine control.
FIGURE 3-1 illustrates information of design surfaces and machine itself. ICT excavator has two functions of machine control.

FIGURE 3-1 Monitor in machine Cabin.

(a)Auto Stop Control
Machine computed tip of W/E and design surfaces coordinates then compare both value, stop W/E movement if tip of W/E will be under design surface. This function means prevent to rework if tip of W/E overcuts design surfaces. It works to stop
See FIGURE 3-2
(b)Auto Grade Assist.
Machine computed tracing design surfaces by W/E, so it shapes landform according to design surfaces.
See FIGURE 3-3

FIGURE 3-2

FIGURE 3-3

TECHNOLOGY USED TO ICT-BASED EXCAVATOR

It should be noted, ICT-based construction machines are required to measure the coordinates own work equipment tip in the World 3D coordinates.
In what follows, sensors are sensing for calculation coordinates of tip of work equipment in accuracy

(a)Sensors in Machine coordinate system.
Cylinder with stroke sensors. : Excavator's work equipment are moved by three axis cylinders.
These cylinders can measure length by itself and send data machine's controller.
Controller has machine's main measurement and cylinder length, so it can calculate coordinates their tip of work equipment by geometric math in the machine's coordinate system.

(b)Sensors in World coordinate system.
GNSS antennas receive signals of GNSS(GPS, GRONASS, BEIDU, etc..) and these are into machine controllers. Machine controllers also receive correction signal from base station or Virtual Reference Station.
Virtual Reference Station →VRS.
Then Machines has antenna's World coordinates in accuracy that is within 30mm.

(c)Angle sensor in World coordinate system.
In addition, Inertial Measurement Unit can detect machine's angle by comparison on the level.
Inertial Measurement Unit →IMU
Values of (a), (b) and (c) make computing a coordinate tip of machine's work equipment in the World coordinate system.

Of course drawing of design in the construction sites are defined, so machine can detect difference between machine's tip coordinate and design surfaces.

FIGURE 4 illustrates whole systems.

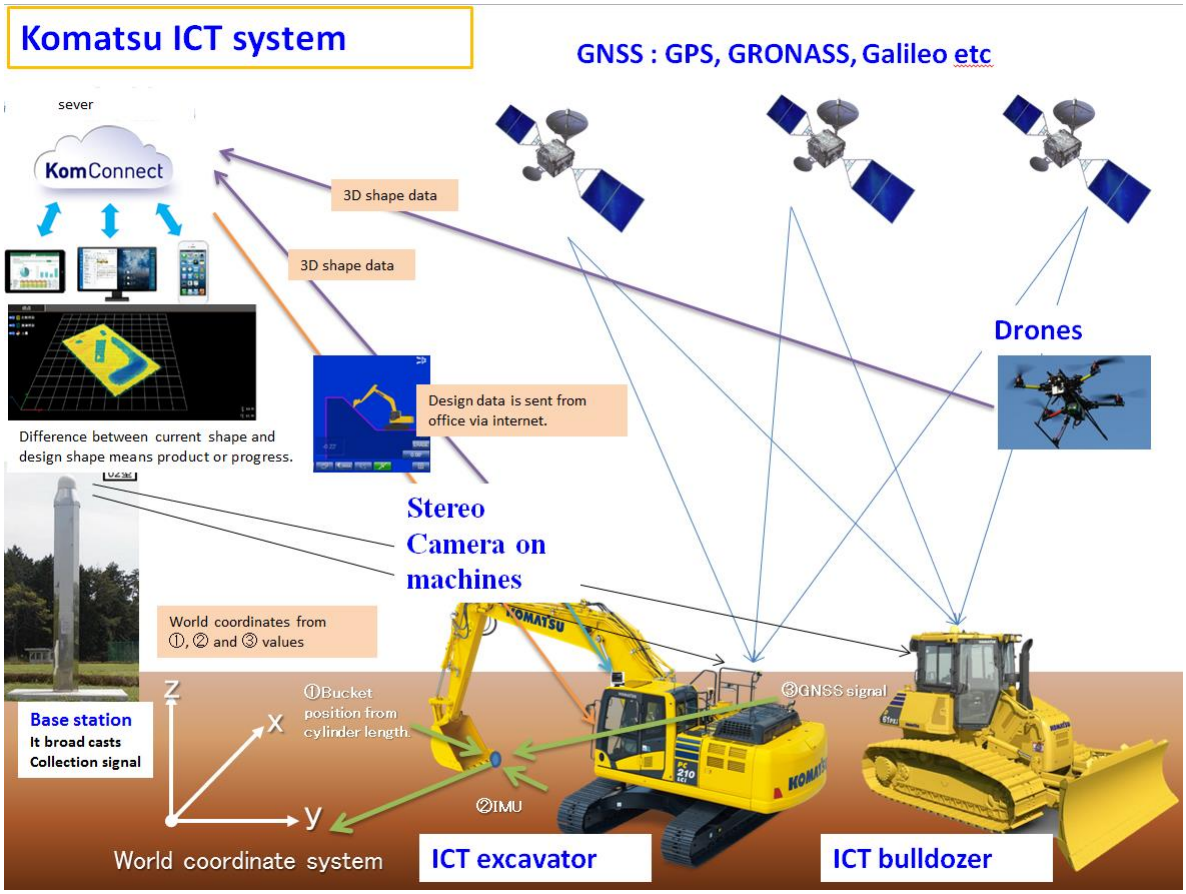


FIGURE 4

ICT-BASED EXCAVATOR AND BULL DOZER AUTOMATIC FUNCTIONS

Basically ICT based Machines can refer to work equipment : Blade or Bucket tip of edge in World Coordinate.
Therefor machines can detect edge violate design surface or not.
Komatsu ICT based machine has function : semi-auto work equipment system.

Bulldozer system :
Bull dozers controller check distance from its edge and design surface, controller control pilot hydraulic pressure for Main Valves.
Therefor edge is raised automatically before edge ender design surfaces, and if load exceed its pushing capacity, controller also release some soil by raise blade. See **FIGURE 5-1**

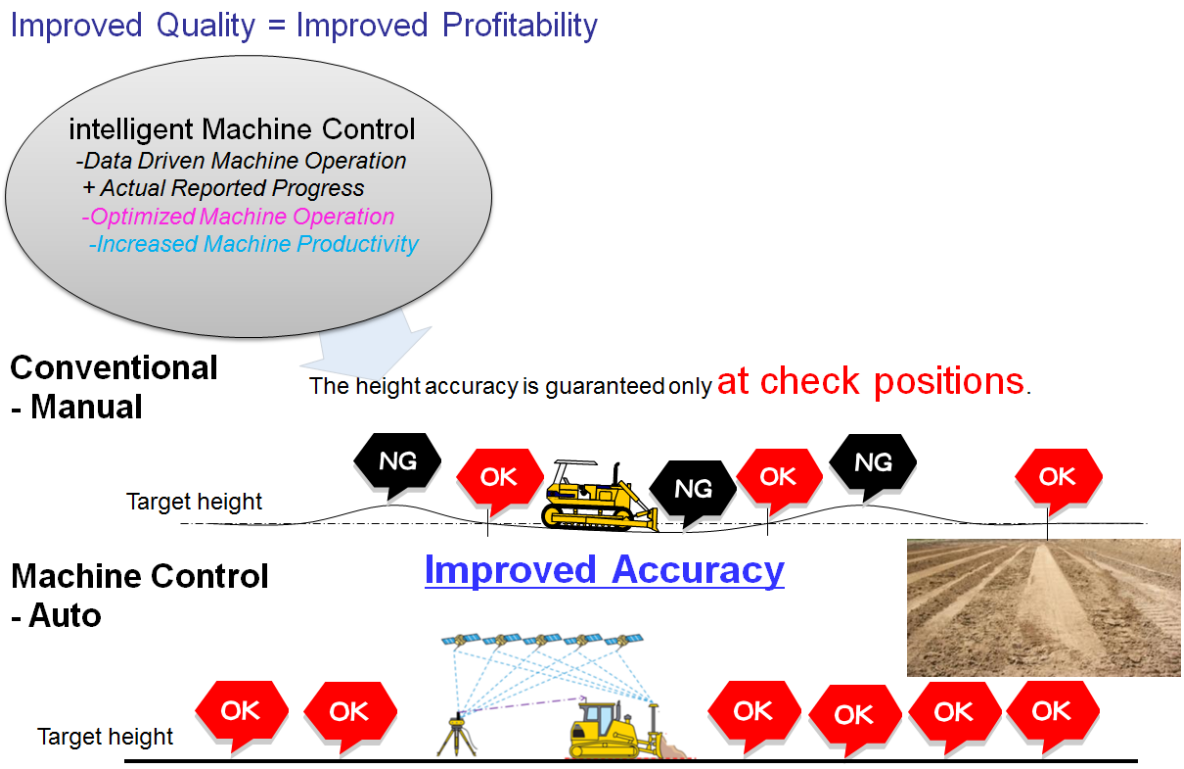


FIGURE 5-1 Dozer automatic control.

Excavator system :
Excavator controller also check between its edge and design surface.
Therefor controller operate work equipment automatically avoid its edge under design surfaces.
See **FIGURE 5-2**

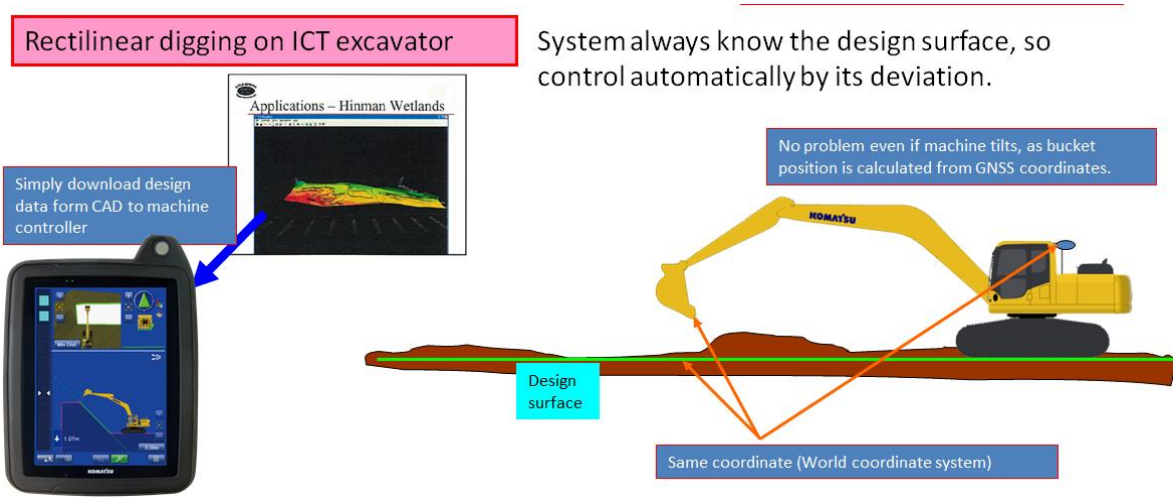
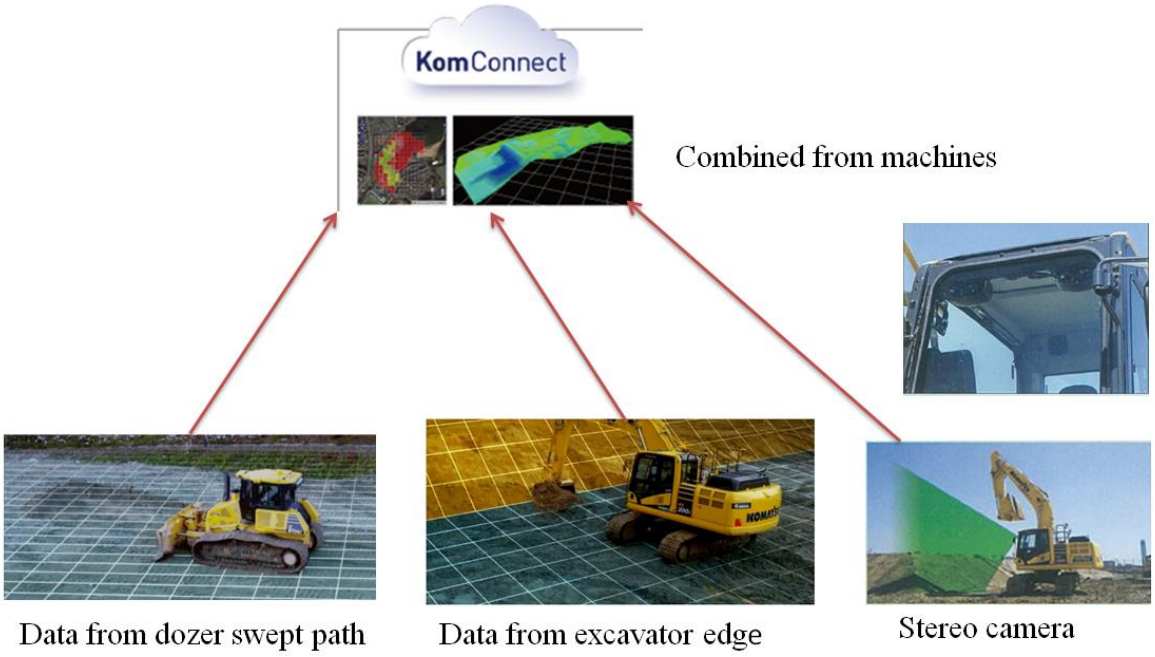


FIGURE 5-2

UP-DATING LAND SHAPE BY MACHINES

Construction machines make new land shape based on data of design surface as the same time stores new shape to the controllers in the machine.
Data are computed from machine's sensors include GNSS. Data circulation provide working progress to



CONCLUSION

Komatsu systems include of ICT based machine provide visualization to site manager, reduce cost for construction and save many times.
However I think the most important thing that the systems provide safety sites, because it reduce manual survey, manual sticking and visual contact. See FIGURE 6.

FIGURE 6.

ACKNOWLEDGMENTS

This system is founded by Komatsu development division. I am extremely all members in business.

REFERENCES

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