COMPARATIVE STUDY

U-BUILDER VS. CONSTRUCTION MACHINERY

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1. 1. INTRODUCTION

U-BUILDER VS. CONSTRUCTION MACHINERY

Below there is a comparative study exposed made on the basis of 24 concepts or technical characteristics related to the capacities, scope, mobility, operability, repeatability, IT integration, automation level, capability to manage BIM projects, data capture, etc...

Therefore, U-Builder is compared to the varied existing machines in their totality, which includes heavy machinery and robots and small machines, as well as different 3D-mapping electronic devices and other topographical elements.

Each column corresponds to one compared gesture. Each line corresponds to a heavy machine, robot o electronic device.

The positive outcomes are marked in green, those that came out negative are marked in red, those that are conditioned by some minor feature are marked in yellow and those that are not evaluated in some particular column are marked in grey.

In the first place there are introduced the comparative charts, followed by development of every concept or column and finally there are made a summary and a conclusion about all the data obtained.

As we will see U-Builder benefits from the largest number of positive evaluations (green), competing at 100% in power, versatility, scope and capacity with all the heavy machines, challenging middle-size and small robots as for precision, repeatability and speed and make a stand against individual electronic devices as in what to data capture, safety and detection gadgets, BIM-projects managing etc refers.

2.COMPARED MACHINERY

2.1 HEAVY MACHINERY

Tower- Cranes	Telescopic crane	Articulated crane

Pumping Arm	Lifting Platform	Trans-pallet system

Panel manipulator	Guniting system	Pneumatic Hammer

2.2 CONSTRUCTION ROBOTS

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Welding Robot arm **Painting Robot arm** **Co-bot arms**

Bricklaying Robot **...more Bricklaying robots** **Laying out robot**
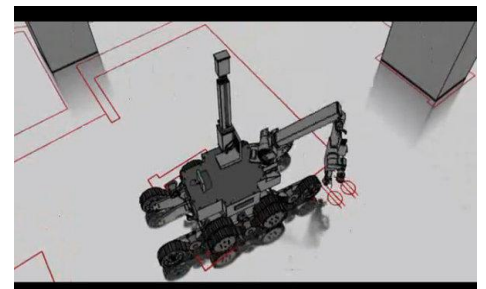
2.3 ELECTRONIC DEVICES

Topographical Station **3D Scanner** **360 HD video/photo**

3.   COMPARATIVE CHART

3.1 COMPARATIVE CHART (1-12)

		1 Nº Functions	2 Building sistems	3 Physics Op. heavy/light	4 heavy loading yes/no	5 concrete pump yes/no	6 heavy steel yes/no	7 personal lift yes/no	8 small operations yes/no	9 Floor 0 yes/no	10 high floors yes/no	11 in/out yes/no	12 guided transport yes/no
U BUILDER	multi-function	all	all	H/M/L	yes	yes	yes	yes	yes	yes	yes	I/E	yes
HUMAN	multi-function	all	all	L	no	no	no	yes	yes	yes	yes	I/E	yes
HEAVY MECHANICS	crane	1	all	H	yes	no	yes	no	no	yes	yes	E	yes
	telescopic crane	1	all	H	yes	no	yes	no	no	yes	yes	E	yes
	turning crane	1	all	H	yes	no	yes	no	no	yes	yes	E	yes
	concrete pump	1	concrete	H	yes	yes	no	no	no	yes	no	E	yes
	heavy grappel ha	1	off site pref.	H	yes	no	yes	no	no	yes	no	E	yes
	panel manipulato	1	off site pref.	H/M	yes	no	yes	no	no	yes	no	E	yes
	gunier	1	concrete	M		no	no	no	yes	yes	no	E	yes
	personal lift	1	all	H		no	no	yes	yes	yes	no	E	yes
	trans-pallet	1	all	H	yes	no	no	yes	yes	yes	yes	I/E	yes
LIGHT ROBOTS	welding robot	1	steel	L	no	no	no	no	yes	yes	yes	I/E	yes
	gunite robot	1	concrete	L	no	no	no	no	yes	yes	yes	I/E	yes
	painting robot	1	all	L	no	no	no	no	yes	yes	yes	I/E	yes
	brik robot	1	brik works	L	no	no	no	no	yes	yes	yes	I/E	yes
	3d printing	1	concrete/other	L	no	no	no	no	yes	yes	yes	I/E	yes
	Layer out	1	all	L	no	no	no	no	yes	yes	yes	I/E	yes
	other robots	1	off site pref.	H/M/L	no	no	no	no	yes	yes	yes	I/E	si/no
DATA	computer	multi-function	all	no					yes	yes	yes	I/E	yes
	3d scan	1	all	no					yes	yes	yes	I/E	yes
	360 cam	1	all	no					yes	yes	yes	I/E	yes
	Topographic st.	1	all	no					yes	yes	yes	I/E	yes
	wether st.	1	all	no					yes	yes	yes	I/E	yes
	sensitive pack	1	all	no					yes	yes	yes	I/E	yes

Legend:
- positive
- positive conditional
- negative
- not valued

3.2 COMPARATIVE CHART (13-24)

	control central (13)	BIM integration (14)	BIM Manage (15)	manual/automat (16)	data export (17)	data import (18)	cognition/A.V (19)	safety (20)	waiting times (21)	resting times (22)	programable task (23)	automatización (24)
value type	yes/no	yes/no	yes/no	M/A	yes/no	yes/no	yes/no	high/medium/low	yes/no	yes/no	yes/no	yes/no
U BUILDER	yes	yes	yes/no	M/A	yes	yes	yes	H	no	no	yes	yes
HUMAN	no	no	no	M	yes	yes	yes	H	yes	yes	yes	yes
HEAVY MECHANICS												
crane	no	no	no	M	no	no	no	L	yes	yes	yes	yes
telescopic crane	no	no	no	M	no	no	no	L	yes	yes	yes	yes
turning crane	no	no	no	M	no	no	no	L	yes	yes	yes	yes
concrete pump	no	no	no	M	no	no	no	L	yes	yes	yes	yes
heavy grapple head	no	no	no	M	no	no	no	L	yes	yes	yes	yes
panel manipulator	no	no	no	M	no	no	no	L	yes	yes	yes	yes
guniter	no	no	no	M	no	no	no	L	yes	yes	yes	yes
personal lift	no	no	no	M	no	no	no	L	yes	yes	yes	yes
trans-pallet	no	no	no	M	no	no	yes	L	yes	yes	yes	yes
LIGHT ROBOTS												
welding robot	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
gunite robot	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
painting robot	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
brik robot	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
3d printing	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
Layer out	yes	yes	no	A	yes	yes	yes	M	yes	no	yes	yes
other robots	yes	yes/no	no	A	si/no	yes	yes	M	yes	no	yes	yes
DATA												
computer	yes	yes	yes	A	yes	yes	no		no	no	yes	yes
3d scan	yes	yes	no	A	yes	yes	yes		no	no	yes	yes
360 cam	yes	yes	no	A	yes	yes	yes		no	no	yes	yes
Topographic st.	yes	yes	no	A	yes	yes	yes		no	no	yes	yes
wether st.	yes	yes	no	A	yes	yes	yes		no	no	yes	yes
sensitive pack	yes	yes	no	A	yes	yes	yes		no	no	yes	yes

Legend: positive · positive conditional · negative · not valued

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4. COMPARED CONCEPTS DEVELOPMENT

4.1 Number of real/virtual functions

The large part of the machines and tools engaged into the construction processes are mono-functional machines. The mono-functional concept is obliged historically to the necessities of the industry, assembly lines and working at permanently-located premises.

The construction in this aspect is considerably different. The cross-related work flows, the repeatability, the working environment in permanent change, the specifics of each building/structure and their geographical location are different in every project.

Special importance must be paid to this multi-functionality in the high-rise buildings where there are extremely reduced the possibilities of larger number of necessary machines in order to carry out the construction process.

U-Builder is announcing itself as a multi-functional and multi-task interface that enables it to perform major part of real and virtual operations. This means that it U-Builder dispose of whatever tool in whichever position at any moment during the duration of construction works.

4.2 Building systems

In general, the huge heavy machines, such as boom and cranes are adapted to the generic building systems in concrete, steel, or "off-site prefabrication". Other kind of heavy machines are more specific, such as concrete pump, guniters, panel handlers etc are adjusted to some determined concrete systems, steel structures or assembling of certain prefabricated elements.

The robots and light automatisms are also, mostly mono-functional and normally are adjusted specifically to one or to a limited number of building systems. Bricklaying, shotcrete, rendering, pavements, etc...

The U-Builder concept commits to the adaptability to the different building tools or systems from a general element which in this case is a telescopic rotating crane and our universal interface that provides quick and automatic assembly/disassembly of various sub-tools required for each building system, from loading and shifting of heavy and bulky elements, concrete pumping, panels and enclosures placing to specific applications in surfaces treatment, waterproofing, pavements, brick walls, etc...

4.3 Physical operations

The building processes are mainly composed of heavy operations of lifting and shifting, pouring or light operations of surface coating and assembly.

U-Builder shares common capacity of loading and displacement with heavy machinery such as cranes, given that it´s scalable as in what regards capacity and size and it adapts to the capabilities of main telescopic crane without limiting the ability of the set.

At the same time it outweighs specific small robots in performance, functionality, scope and mobility "on-site".

U-Builder is both smart and powerful carrying out heavy operations and quick and precise in operations that require accurate performing and high repeatability.

4.4 Heavy loading
4.5 Concrete pumping
4.6 Heavy steel structures
4.7 Personal lifting
4.8 Small operations

Heavy loading
Loading capacity, shifting, speed and power are similar to those of the existing cranes
while possesses a superior capacity compared to the small robots that perform tasks with lighter weight and smaller volumes.

Concrete pumping
U-Builder enables concrete pumping through the adequate application and, therefore, allows to count on a pumping crane in whichever working position and even more, it permits use the main crane for the rest of the tasks once the concreting is finished.

Heavy steel structures
Loading capacity, shifting, speed and power are similar to those of the existing cranes,
while possesses a superior capacity compared to the small robots that perform tasks with lighter weight and smaller volumes.

With the right application U-Builder is able to perform the assembling of the structures and its further welding, continuously or cross-tasked by quick changing of U-Apps applications.

Personal lifting
U-Builder can be provided with an operator basket in order for those to carry out small works or inspection tasks in the areas with difficult access etc Just by changing one application for another, without a necessity to have to have the basket, the crane and its complete vehicle "on-site".

<u>Small operations</u>

The cranes and other heavy elements are suitable for loading and shifting of heavy loads but at the same time, through U-Builder, they can assemble robotic elements of smaller weighs and volume, intended for carrying out of precise and accurate welding and painting works as well as joints sealing.

Thanks to the U-Builder design and given that the interface and the applications are shifting "at" but "above" the floor at which the works are actually performed, the displacement of the different robotic systems of smaller size with specific functionality, which is always complicated at the construction site, is avoided.

4.9 Floor 0 Construction
4.10 High-rise construction

The majority of large-size machines can only operate from the zero level of the building or structure except for the elements (climbing cranes and pumping arms) that could climb through the building, assembled to automatic climbing elements.

On the other hand, handlers and other smaller-size robots undergo tremendous difficulties, having reached a certain floor, making incredibly difficult and sometimes even impossible their displacement to higher levels.

In this aspect the design of U-Builder allows it to operate through assembling to the different climbing systems already existing, so the set is able to climb along the structures of the building until the necessary level, which permits to dispose of numerous tools on the higher floors of the building and in the areas with difficult access.

It´s worthy of mentioning that when higher the level, bigger is the difficulty for disposing and shifting of the machinery and therefore, larger is the relevance of the U-Builder multi-functional concept.

4.11 In/out

U-Builder is designed for to be able to operate both in the inside of the buildings and infrastructures thanks to climbing elements and on the outside of the buildings when it comes to finishing works and exterior facades either from the ground floor around the building or from inside positions by means of climbing element.

In this sense it outweighs heavy and middle-size machinery as well as small robots.

4.12 Guided transport

Similar to the majority of existing machinery U-Builder can operate from a fixed point (fixed structures or climbing element) or assembled to a guided vehicle by U-Builder unit itself.

As a matter of fact, U-Builder was envisaged as an accessory to crane vehicles or fixed cranes.

4.13 Centralized/computerized control

Most of the cranes, pumping jibs and other machines and robots operate independently, so they are not centrally managed. U-Builder integrates and centralizes all the information produced during the construction process by its various application and allows safe coordination and interaction between different U-Builder units assembled to different cranes either fixed or those on top of the guided vehicle.

4.14 BIM integration
4.15 BIM management

"The modeling of construction (BIM, *Building Information Modeling*), also called *building information modeling,* it´s the processes of creation and management of data in a building during its life cycle using dynamic software of building tridimensional modeling in real time, in order to reduce time and resources losses in the field of design and construction. This process gives place to the building information modeling (BIM) which tackles the geometry of the building, the spatial relations, the geographical information, as well as the quantities and the qualities of their components"

We´ve developed a mechanic/electronic element integrated into BIM platform in a way that the operations from U-Builder units are incorporated into BIM work-flow at the drafting stage.

At the same time, the privileged position and the electronic devices incorporated allow the project management, data feedback in real time, quality control and safe interaction with other machines or operators.

In this aspect U-Builder surpasses both the heavy machines and small-size robots, offering simultaneously and in a derived manner the performance of the tasks, the ability to manage the project, the cross-reference of real and virtual data in real time and permanent quality control.

4.16 Manual/Automatic

The U-Builder concept is aiming towards complete automation of the construction process.
The 100% automation is not possible currently and that´s why we propose a manually operated unit with open possibility to keep adding programmable tasks by means of e-learning and e-guiding learning protocols of the unit itself and the exchange, creation and updating of data and libraries of operations performed by other units "on-site" and "off-site".

In this way U-Builder exceeds the majority of heavy machines as in what refers to automation and functionality and, moreover, it competes with small robots in equality of conditions.

The integration of BIM and of the different devices of scanning and 3D mapping improve considerably the progressive development capacities of a nearby automation at the 100%.

4.17 Data export
4.18 Data import

The U-Builder unit captures, permanently produces and exports massively different level data, point maps, topographical maps, video-photo 360º, as well as other data related to the self-learning of operations, artificial vision, quality control, meteorology, safety and health protection etc...

The U-Builder unit is able to import and manage data of different levels, BIM-projects in 3D, work-flow, software updates, operation libraries and configurations of different U-apps, cross-reference of virtual and real data for the project management, quality control, safe interaction with other machines or operators.

In this sense U-Builder outperforms the heavy machinery and the small robots and challenges directly, from a privileged spatial position and as a derived value from the physical operations with the different electronic devices described in this document (Scanner 3D, topographical station, etc...)

4.19 Artificial vision, 3D real-time mapping (sensitive pack)

The position of U-Builder in the working area comes broadly favourable for the purpose of "sweeping" of its entire territory from a top point, which allows to avoid the occlusion and a global control of the working area, that´s why the Unit counts on different detection and sensitive elements among which should be highlighted such as artificial vision for parts recognition, laser measurement, 3D-mapping, motion, pressure and weather detectors, etc...

In this sense U-Builder outperforms the heavy machinery and the small robots and challenges directly, from a privileged spatial position and as a derived value from the physical operations with the different electronic devices described in this document (Scanner 3D, topographical station, etc...)

4.20 Safety

The centralized coordination, the mapping elements, artificial vision and detection makes out of U-Builder a highly safe element.

In addition to above mentioned gadgets there should be also added BIM-projects´ data layout and processing, logical work-flow, operator assistance, etc...

In this aspect U-Builder transcends the large machines and challenges special small robots as in what refers to safety and detection devices.

At the same time, we must point out that the central spot and superior operating position create a safe working area for the operator and for the other machines involved, as well as provide better flow of loads and operations.

4.21 Standby hours

The multi-functional nature of U-Builder allows to reduce considerably the costs caused by the hours of standby, the transportation and withdrawal from the construction site and all other duplicities produced during the development of building works.

So, the quick and automatic assembly-disassembly provide numerous tools and applications in a fast manner and with an important reduction of time lost between positioning and withdrawal of different machines

The different U-apps are interchangeable between different units within the same construction process, which allows a maximum optimization of working hours and the amortization of the U-apps, having in mind that the option of interchange vouches for 24 hours operability at 100% availability from each unit.

In this way, we would also avoid delays and standbys produced by miscalculation in a project or due to the difference between the project and the final outcome. The manual/mixed/automatic nature of U-Builder can support modifications "on-site", constructive system changes and computer record of those changes in real time.

4.22 Resting times

The steady automation of tasks cuts down gradually the presence of human factor, being possible to save time and costs caused by resting times of the operator and the rest of the crew involved in the construction works, both regarding manpower and technical staff.

4.23 Programmable task

E-learning devices and those of manual guidance, data export/import and other elements allow the exponential increasing of tasks library and other resources or processes as well as permanent update of all the U-Builder units and their applications or U-apps.

In this sense, as in what refers to programmability and computer and graphic resources U-Builder scores much higher than heavy machines and challenges the special small robots and electronic devices, which to a greater or lesser extent, do dispose of these elements.

4.24 Robotization

Nowadays, all the heavy and light-weight machines are subject to permanent improvement processes which step-by-step increase the automation and robotization of processes.
In this sense, U-Builder is not a confined element, but on contrary, it is designed to absorb, which he already does as a matter of fact, any kind of technical or technological additions both existing and future ones, rendering to the U-Builder system the ability to adjust to the future in the aspects of mechanics, electronics, robotics, software and hardware, assumable constructive functions and systems.

5. REDUCTION OF ESTEEMED CONSTRUCTION COSTS

The combination of different features analyzed in this comparative study cannot be emphasized enough as they lay beneficial grounds for all sorts of cost reductions in different aspects which are explained below and evaluated approximately in % of reduction compared to currently existing construction costs. We must point out that this evaluation is backed up by the personal experience in the construction business and other complementary studies.

Costs reduction

Machinery

Reduction of number of machines to be present "on-site" (60-80%)
Reduction of number of machines to be ready "off-site" (30-50%)
Maintenance reduction (50-60%)
Transport reduction, subsequent transportation and withdrawals (60-70%)
Reduction of Transport energy consumption of (50%)
Reduction for permanent amortization 24/7/365 (40-50%)
Reduction of costs of topographical data capture "on-site" (60-80%)

Terms and periods

Reduction/saving of time during periods of passive waiting (80-90%)
Reduction/saving of time during periods of rest (90-100%)
Reduction of time during periods of machinery or tools interchanges (70-80%)
Reduction of periods caused by interruptions due to the tasks overlapping (90-100%)
Reduction of the time necessary for errors or unexpected events amendment (50%)
Reduction of time for critical decision-making (50%)
Reduction of time destined to the quality control tasks (90%)
Reduction of time invested in the project management (20-30%)
Reduction of financial resources regarding the deadlines

Human factor

Reduction/steady elimination of manpower (50-99%)
    Illnesses
    Breaks/vacations
    Relocation
    Others
Reduction of staff engaged in the project management (50%)
Accidents reduction (80%)
Reduction of errors or unexpected events caused by the human factor (80%)

6. SUMMARY

As we will see U-Builder benefits from the largest number of positive evaluations (green), competing at 100% in power, versatility, scope and capacity with all the heavy machines, challenging middle-size and small robots as for precision, repeatability and speed and make a stand against individual electronic devices as in what to data capture, safety and detection gadgets, BIM-projects managing etc refers.

Large cranes/Heavy loads/concrete pumping/grappel hands

Improves the heavy machines through the insertion intelligent and hyper-connected (to the environment and to the network) hardware/software and reaches beyond the mono-functional nature of the majority of the machines of this kind, which are to a greater or lesser extent are based on the different telescopic hydraulic arms.

Mono-task robots

Provide with complementary robotic tools can compete with the small mono-task robot, enhancing their performance with a surplus of scope, power, accessibility and velocity of movement, virtual positioning etc

Topographical devices

Improves the topographical and sensorial devices such as 3D Scanner and considerably improves the data capture thanks to its privileged positioning, mobile, in permanent sweeping of the working areas, reducing occlusion and enabling the space updates in real time.

Lays grounds, above all, for the integration and interaction of real physical processes and virtual projects in one sole or several elements coordinated centrally and, more importantly, performs capture tasks in a complementary and parallel to the carrying out of the main physical tasks, manner.

The combination of different features analyzed in this comparative study cannot be emphasized enough as they provide favourable platform for all sorts of cost reductions in different aspects which have been explained in this document.

The characteristics of U-Builder make of it not only a multi-tasking machine, but also allow it to coordinate the whole construction process and massive data creation related to the project.

7. CONCLUSION

U-Builder is not just a machine, or a robot, it is in itself a system able to integrate, to manage, to collaborate and to compete with the majority of machines and devices that involved are nowadays into different construction processes all over the world.

U-Builder redefines the ability and usefulness of above mentioned set of existing machinery under a new conceptual paradigm specially developed for the construction field (different to the industrial field or to the field of robotics service provision) in order to develop a flexible multi-tasking machine, substantial and intelligent, well-adjusted to the current and upcoming needs

At the same time while working on the design of the unit and its applications, it has been taken into consideration its adaptation to modern industry. That is to say, we suggest an element that works in tandem with actual construction systems, avoiding forcing whatever modification in the auxiliary industry or at the building site itself. This factor is of utmost importance for the breakthrough of the system into construction field.

There are lots of different technological benefits, both operational and financial, comprised by U-Builder concept: reductions of costs in the transportation of machinery and its withdrawal, interaction between different machines slightly connected or not connected to the environment and BIM-project at all, velocity of tools´ interchange, simultaneous physical and virtual tasks, performing of different apps in different U-Builder units within the building itself, drastic decrease of waiting periods and breaks, reduction of necessary machinery stock "on site" and "off site", diminishing of human factor, virtual and physical assistance to the operator, management of BIM-construction processes, creation of virtual contents, possibility to receive and create software and tasks/process libraries updates, and all this in a centralized and hyper-connected manner,

As a concept, U-Builder is not a confined system but all the opposite, based on a manually operated unit it prepares the grounds for the exponential development of its applications, abilities and physical, electronic and computer capacities.

These unique and specific features applied to the construction field, makes of U-Builder a supreme specimen that outperforms heavy machinery, small-size special robots and current topographical elements.

These characteristics allow to U-Builder to lead, assume and carry out the entire construction process all by itself, now and in the future.