Affordance Structure Matrix (ASM)

The analysis of USER and EQUIPMENT interaction on a Drilling Rig could help us to better describe and decide the type of equipment needed.

The AFFORDANCES of a Drilling Rig are what it provides, offers, or furnishes to the user. For example the Rig as a whole affords drilling a hole while the Iron Roughneck (IR) allows MU/BU of tubulars by eliminating the cathead.

These affordances between the Rig and the Crew can be called, Rig-User-Affordances (RUA), but since the IR requires a dedicated space on the rig floor and extra consumption of energy is needed then we have an affordance between the IR and the Rig itself that is called Rig-Equipment-Affordances (REA).

An important distinction between the affordances of a piece of equipment and its function is that the affordance depends on the physical form and features of the equipment, whereas the functions do not.

The fact that functions are form-independent is useful during the rig lay-out design process because it frees engineers to choose the equipment that best accomplishes each function. However, the fact that affordances are form-dependent can also be useful, because it allows engineers to analyze and compare the affordances of equipment concepts (especially at the system level) as well as of existing equipment for reverse engineering.

POSITIVE AND NEGATIVE AFFORDANCES

Another useful feature of the affordance approach is that it is able to describe intended as well as unintended aspects of the equipment. For example, a motor’s function is to transform electrical energy into rotational kinetic energy. Thus, it affords rotary motion, which is desired and is therefore what we classify as a positive affordance. However, because of the various resistances inside the motor, the motor also generates heat, which is undesired and is therefore what we classify as a negative affordance.

By consciously analyzing both the positive and negative affordances of equipment concepts during the design process, negative affordances can be designed against or mitigated. A similar process is not supported by function-based approaches in which the functions simply capture the “intended” or desired functionality.

A useful tool allowing engineers to use the additional information captured by the affordance approach is the Affordance Structure Matrix (ASM), wherein the system level affordances are mapped to the rig’s individual components. ASMs can be prepared for different device concepts or existing equipment, and then compared to each other or analyzed to attempt to improve various affordances.

There is also room to describe the quality of the affordances of a piece of equipment. For example, a rig hand can operate an IR just as easily as a Power Tong. They both possess the affordance of MU/BU fast and easily, but this affordance may require less space on the rig floor with the Power Tong than with the IR. By contrast, the basic function is the same—to MU/BU tubulars. In the case of old rig equipment compared to modern ones, we see that the basic functionality remains largely fixed over time, while the affordances have changed rather dramatically. Original positive affordances have been improved (such as speed and tubular manipulation), new positive affordances have been introduced (such as machine monitoring or embedded systems), and negative affordances (such as risks and accidents) have been significantly reduced.
The top captures which components are related to each other as in a traditional Design Structure Matrix (DSM).

| RF1 | RF2 | RF3 | RF4 | RF5 | RF6 | RF7 | RF8 | RF9 | Pd1 | Pd2 | Pd3 | WC1 | WC2 | DC1 | DC2 | DC3 | DC4 | MS1 | MS2 | MS3 | MS4 | PS1 | PS2 | PS3 | HS1 | HS2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

The left side captures which affordances are related to each other,

The interior of the matrix captures which components are related to each affordance.

The totals on the right show how many components are related to each affordance.

The totals on the bottom show how many affordances each component is related to.