NATIONAL OILWELL VARCO

The Role of the Human Operator

In future drilling operations

Outline

I Autonomous Drilling system
- Levels of Automation
- The Datasets
- Well Planning

I Human on the Loop
- Human Factors Engineering
- Levels of interaction
- Tailored humans interaction

Autonomous Drilling Systems

Levels of Automation

5 "suggests one alternative, **executes that suggestion if the human approves**"

6 "Allows the human a restricted time to veto before automatic execution"

1	Process awareness			Equipment awareness		7	8	9	10
The computer offers no assistance, human must make all decisions and actions	*The computer offers a complete set of decision/ action alternatives*	*narrows the selection down to a few*	*suggests one alternative*	*executes that suggestion if the human approves*	*Allows the human a restricted time to veto before automatic execution*	*Executes automatically, then necessarily informs the human*	*Informs the human only if asked*	*Informs the human only if it, the computer, decides to*	*Computer decides everything, acts autonomously, ignoring the human*

Parasuraman, R., T. B. Sheridan and C. D. Wickens (2000). "A Model for Types and Levels of Human Interaction with Automation." IEEE Transactions on Systems, Man, and Cybernetics 30(3): 286-297.

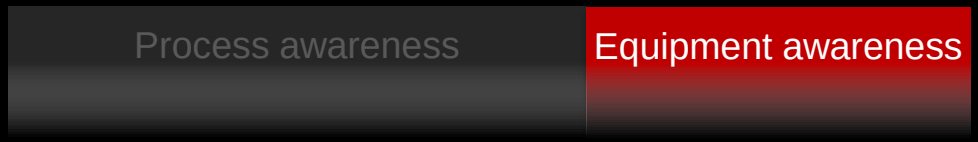
Autonomous Drilling Systems

Levels of Automation

- Process Context
- Well Plan
- Procedural Plan
- Observe and Re-plan

Autonomous Drilling Systems

Levels of Automation

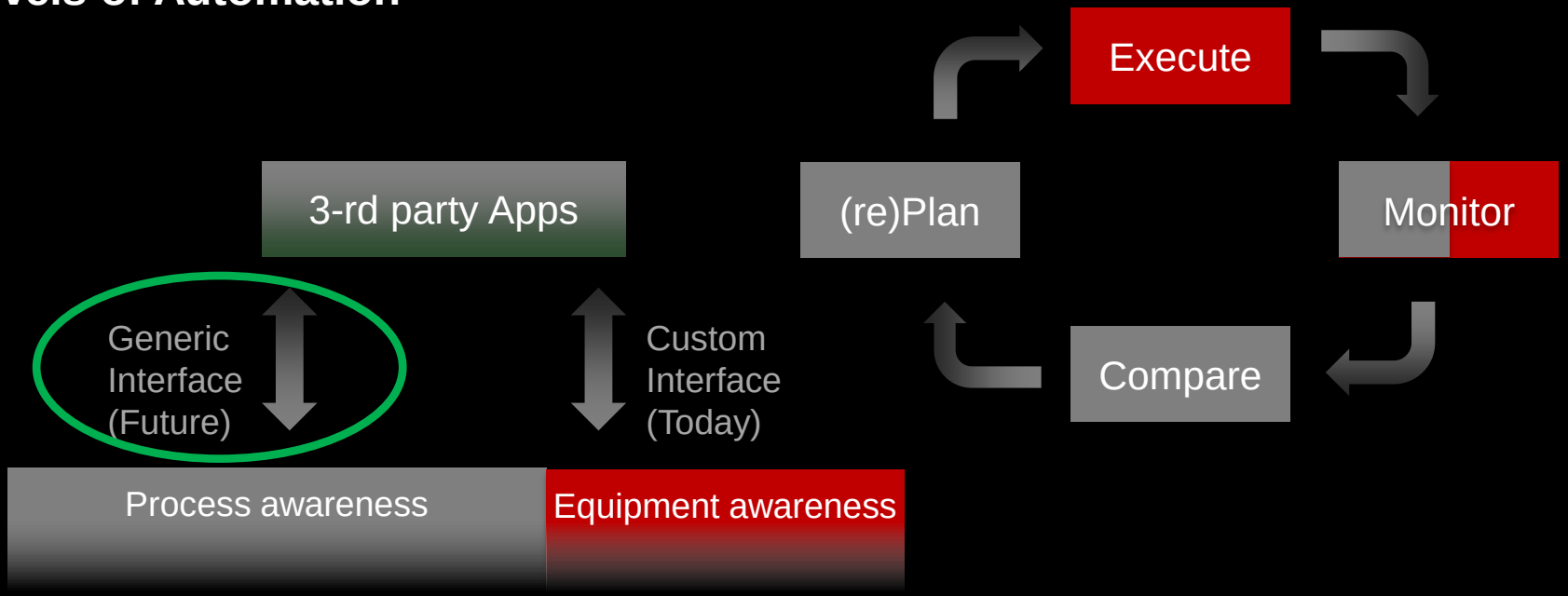


- Process Context
- Well Plan
- Procedural Plan
- Observe and Re-plan

- Equipment Context
- Map process domain to equipment domain

Autonomous Drilling Systems

Levels of Automation



- Process Context
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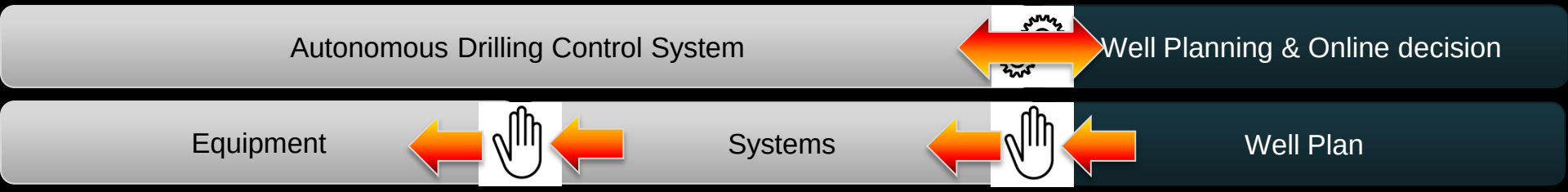
Autonomous Drilling Systems

The Datasets



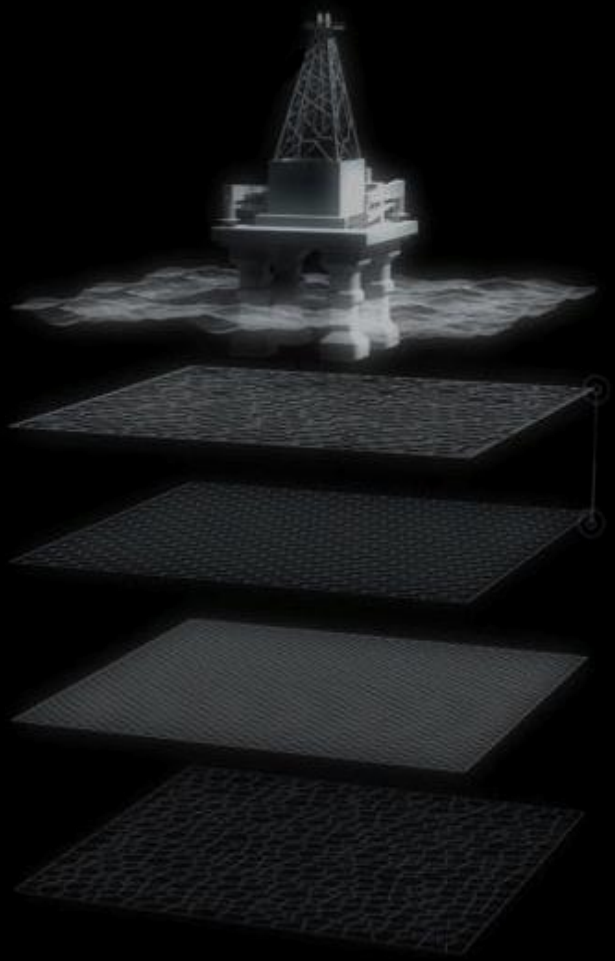
Control System data	Operation plan data	Rig/String Config. data	Well data

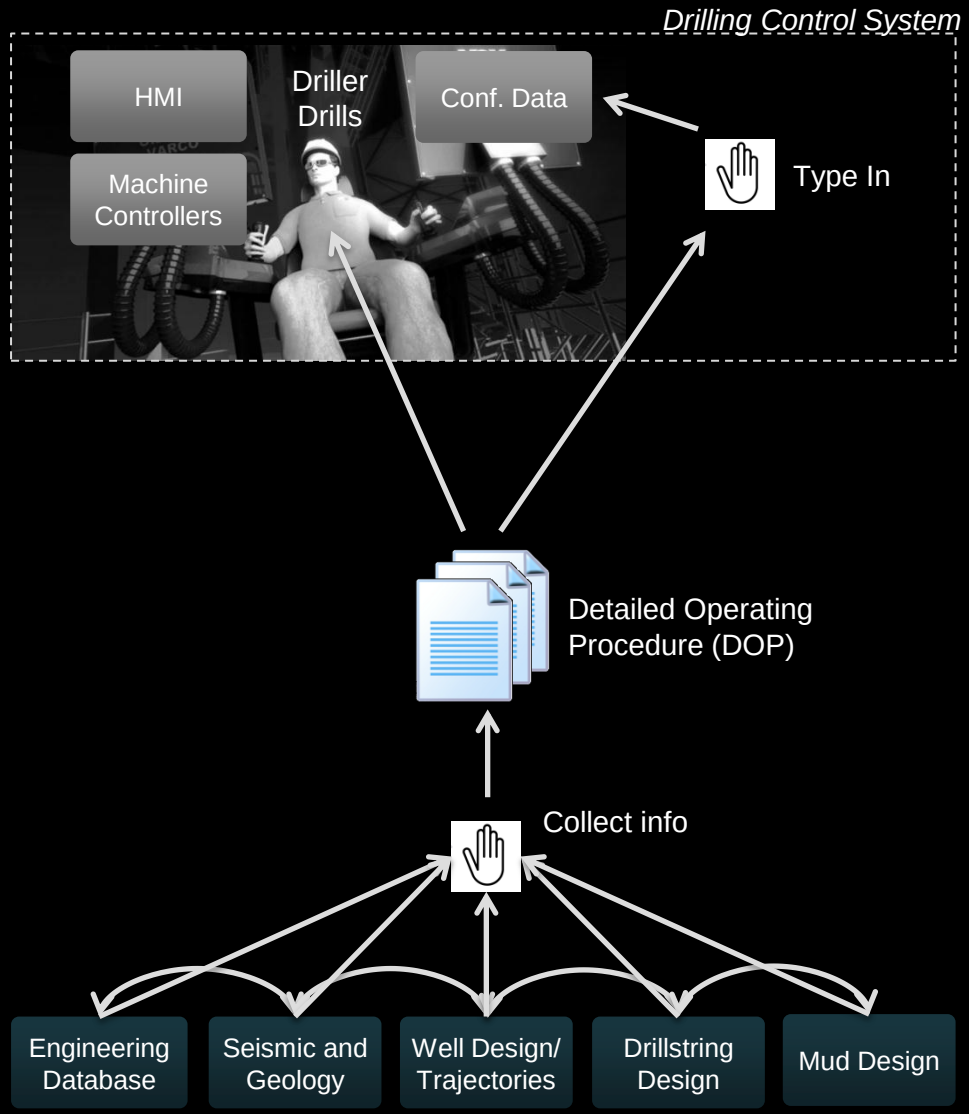
• Hoist / Lower
• Rotate
• Mud Pump strokes
 	
Contol System Domain
Real-time values.
 	
Equipment Details
	• Activity Breakdown
	• Operational Constraints
	  • Pressure Margins
	  • WOB Limits
	  • Torque Limits
	  • Flow Limits
	
	Set of values aligned with depth
		• Mud Pump data
		• Topdrive Data
		• Hoisting system data
		• Tanks and pits
		• Wellbay Architecture
		• Drillstring description
		• BHA description
			• Geographic location
			• Well design
			• Geology / Formation type
			• Trajectory and build requirements
			• Desired rate of penetration (ROP)
			• Drilling fluid requirements
			• Hole cleaning requirements

Update frequency f < 10 ms Reqired Latency t < 10 ms	Update frequency f > 5 sek Required latency t < 5 sek	Update frequency f > hours Required latency t < 5 sek	Update frequency f > minutes Required latency t < minutes

Autonomous Drilling Systems

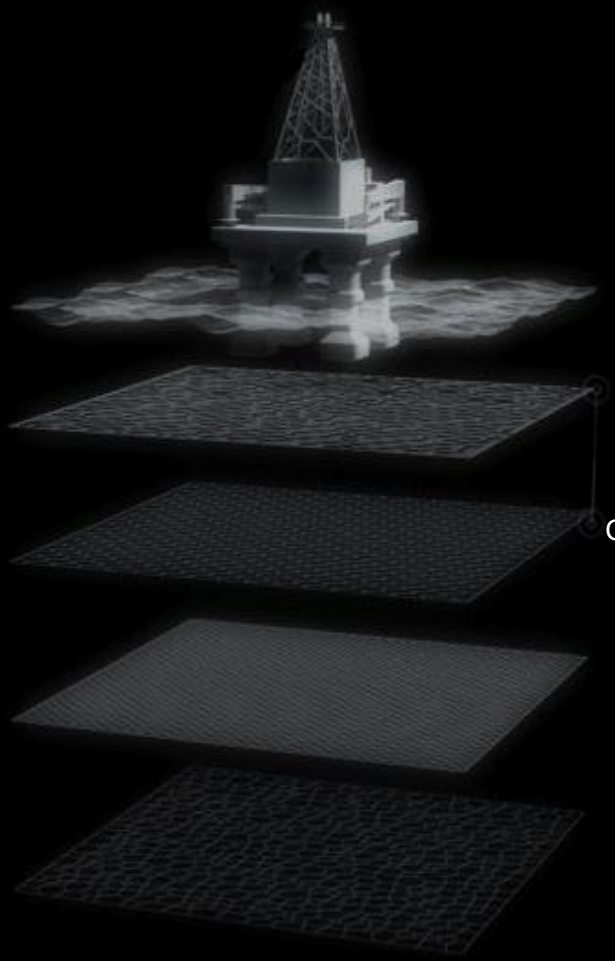
Well Planning

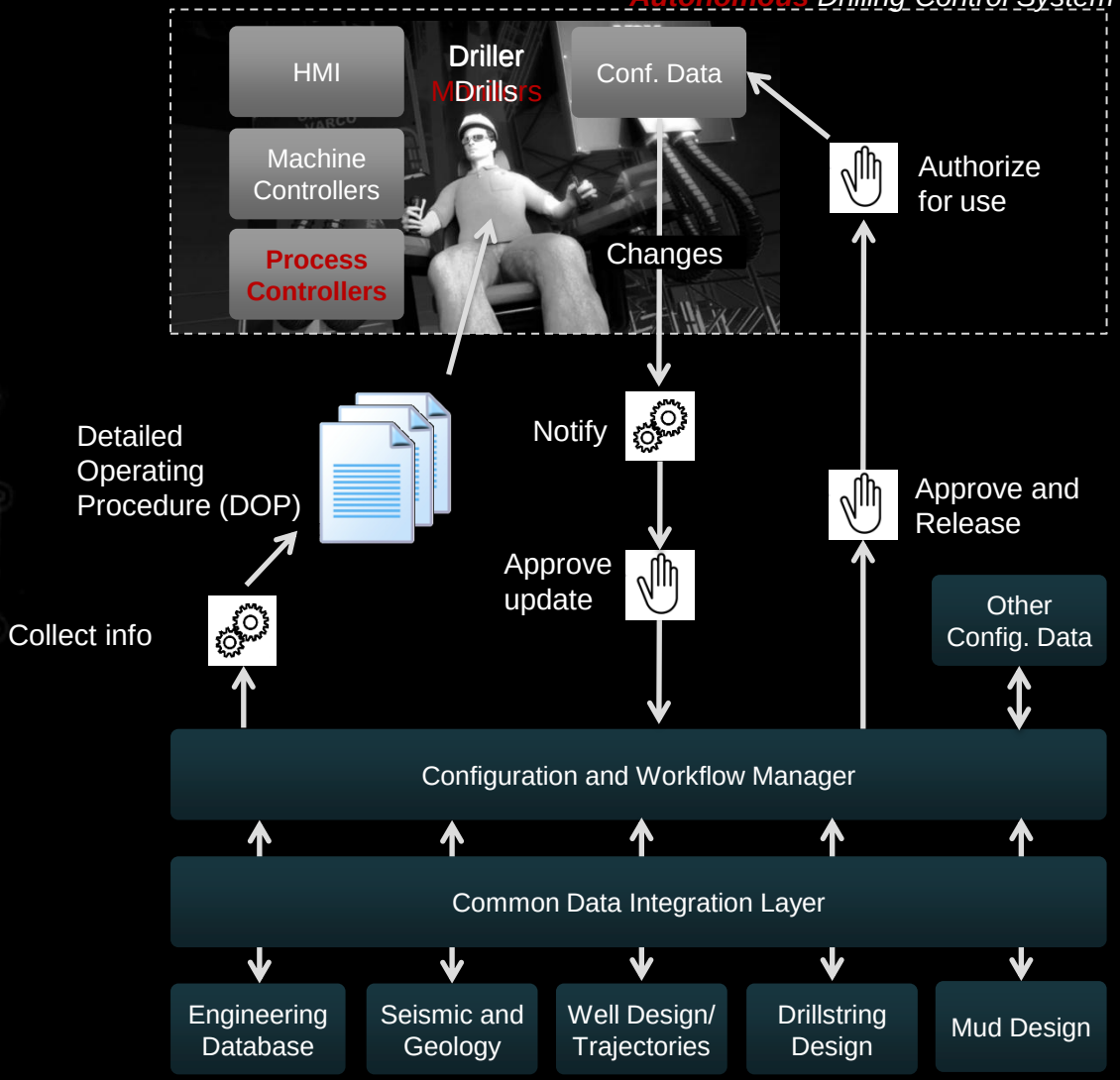




Autonomous Drilling Systems

Well Planning





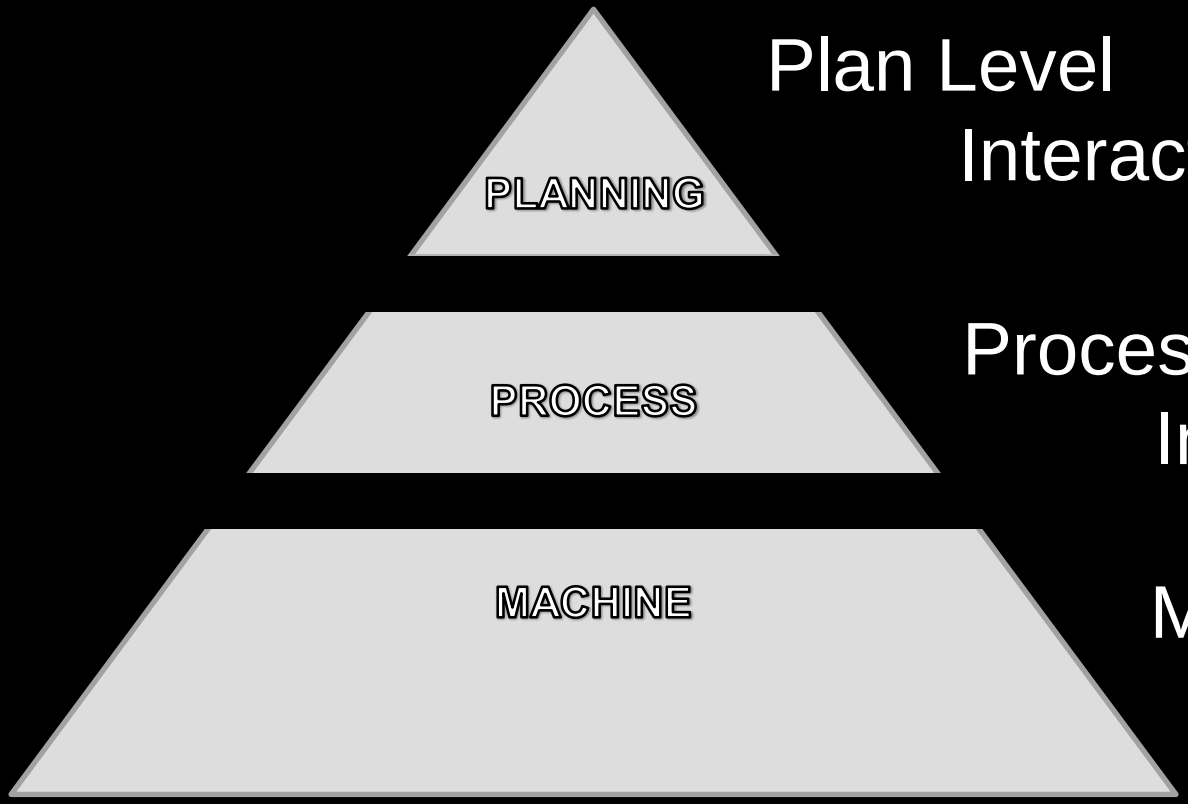
Human on the Loop

Human Factors Engineering

- Focus design decisions on the explicit allocation of cognitive functions and responsibilities between the human and computer to achieve specific capabilities.
- Recognizes that these allocations may vary by mission phase (operational context) as well as echelon (level of management)
- Makes the high-level system trades inherent in the design of autonomous capabilities visible.

Human on the Loop

- Human Interaction level



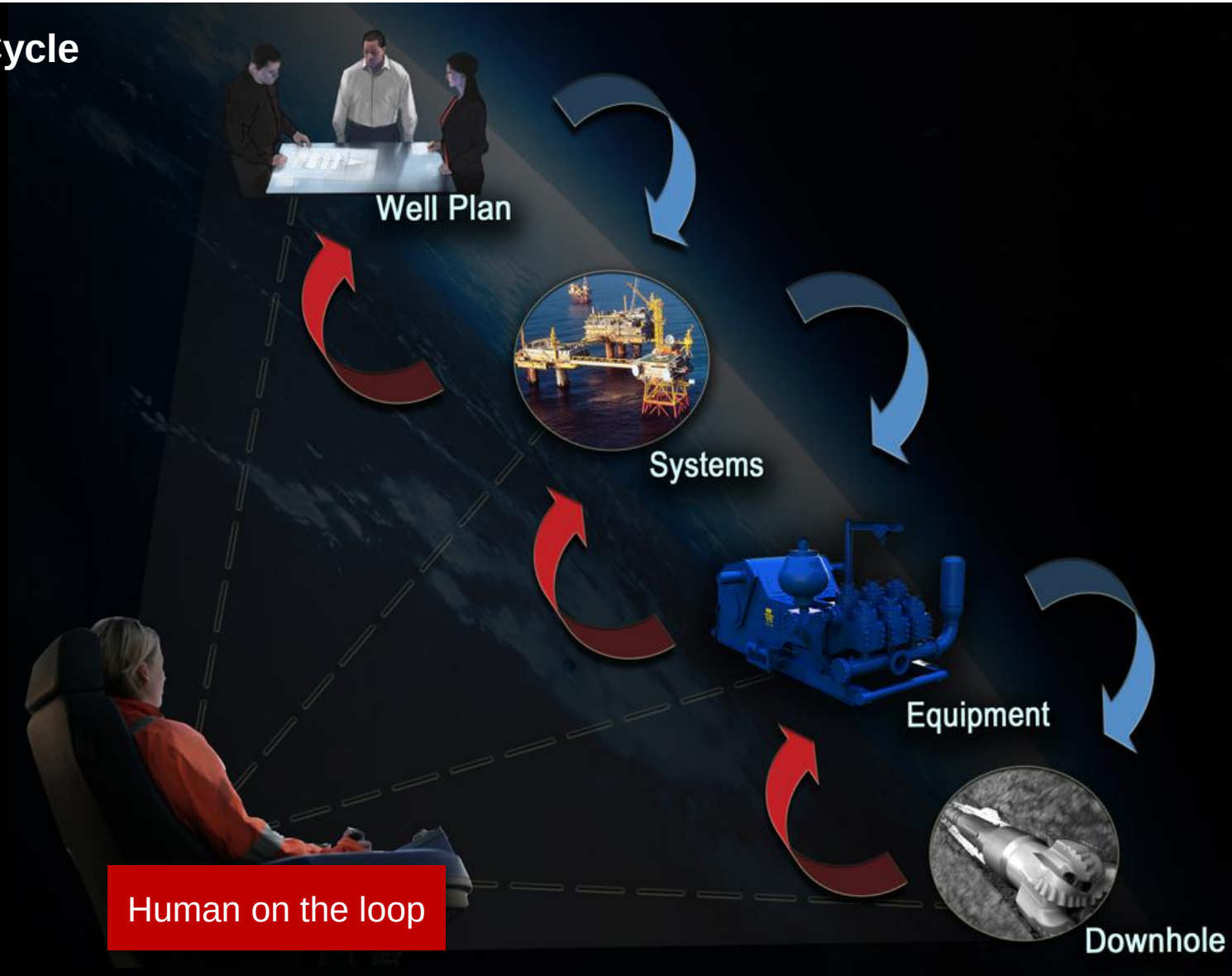
Plan Level Interaction

Process Level Interaction

Machine Level Interaction

Human on the loop

- Full Cycle



Human on the Loop

Tailored levels of automation

Definitions:

Manual: Tasks that can not be performed by a control system. Must be done manually by a human

Approve: Tasks can be done automatically by a control system – but human must approve first

Veto: Task will be done automatically by a control system – unless human rejects

Auto: Task will be done automatically by a control system – no human intervention.

Human on the Loop

Tailored levels of automation

Configuration:

Drilling | Tripping | Reaming | Cementing

Pipe Handling		Get pipe from FB	!
Pipe Handling		Move Pipe to Well Center	!
Connection		Spin inn	?
Connection		Make Up with Roughneck	M
Drilling		Land Bit (Pump, rotate, lower)	?
Drilling		Drill Stand	!
Drilling		WOB Safety Limits	?
Drilling		WOB actual Setpoint	A
Drilling		Drilling Torque Safety Limits	A