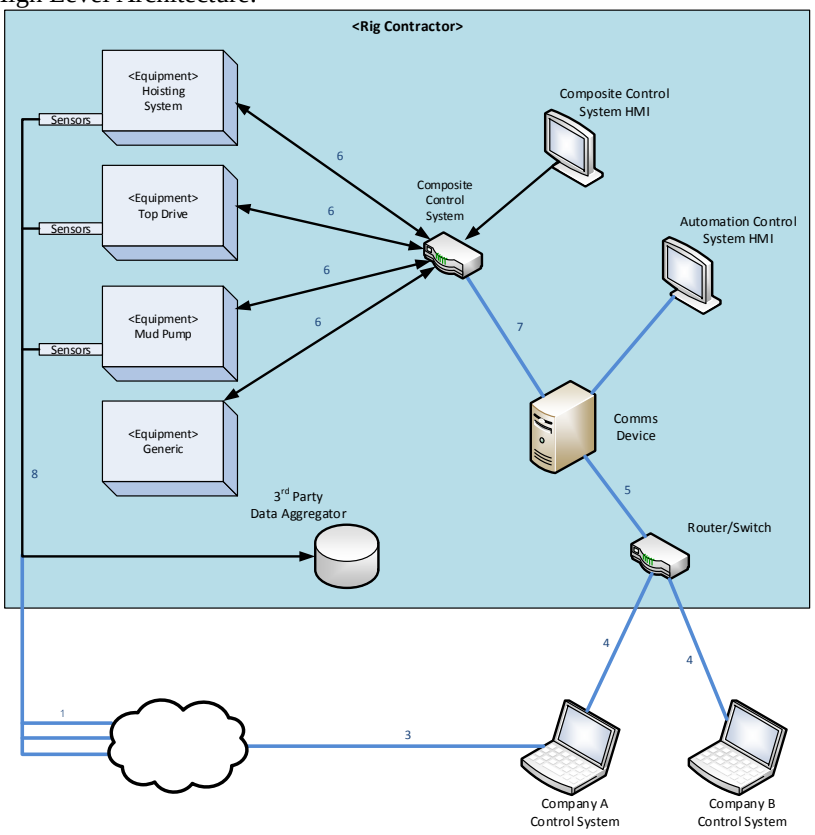
Drill-a-Stand: Use Case Descriptions

Drilling Automation Technical Section - Comms Team

High Level Architecture:



Composite Control System HMI
System synonymous with Driller's Console (pre-Automation). It is the primary control interface to the rig. There is no change in this system except any human interfaces changes which prevent safe switching between automated control and manual control.

Composite Control System (CCS)
The heart of today's manual rig, but now provides an interface that allows external or secondary control. The interface provides set points and read-only value for one or more devices which it controls. Additionally, the system provides a mechanism to notify the secondary control system (the Automation Control System) if the user has changed any of the primary control system control settings.

Comms Device
This system acts as a interface to automation for external control systems. It provides a phase based allocation of control of the equipment set points to individual automation agents (e.g. Company A Control System). Additionally it provides access to the read-only values exposed by the CCS.

Automation Control System HMI
This system provides an HMI to the driller to control access to the rig systems by external agents. It provides a status of all systems performing automation, such as connectivity and state (e.g. Ready, Offline, Active, etc.)

External Control System (Agent)
The external control systems desire to automate a particular phase of the operation by requesting control of specific equipment during that phase. The Driller must give permission to the external system to control during that phase.

Data Aggregator
This system reads and stores any value of interest. It is not required by the automation system, but can connect to the system, like any other agent and read data from the Comms Device.

Overall Assumptions:

1. System will be computerized and operate as a batch control system in a closed loop fashion.
2. The system will follow the Purdue model of control with instrumentation control at L2 and supervisory applications at L3.
3. The supervisory applications will control the rig equipment using exposed set points by the rig control system.
4. Health monitoring system (e.g. watchdog timers, heartbeats) in place to assure communication health.

Use Case	DSA01	
Name	Initialize	
Goal	Operations to initialize drilling operations	
Primary actors	Operator	
Secondary actors	None	
Independent Triggers		
Preconditions / Assumptions		
Subsequent Use Cases	DSA02	
Uses Use Cases	DSA01	
Success end Condition	System is initialized	
Failed end Condition	System and/or equipment not ready.	
Post Conditions	Initialization accomplished for DSA02	
Primary Scenario Description	**Step**	**Action**
	1	Verify required rig control system on-line and communicating
	2	Verify pumps off
	3	Verify rotation is off
	4	Verify bit is off-bottom
	5	Verify HD < (BD + stand length), i.e. that bit is close enough to bottom that is possible to drill with the current stand.
	6	Check that hook load is sensible
	7	Notify Driller that Drill-a-Stand is Ready to Commence
	8	Check for Driller OK
	9	If Driller OK, Advance to next Case
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Drawworks/DW Ready/Hook Load/Block Height Mud Pumps/Pump(s) Ready/Pump Count/Pump SPM Top Drive/TD Ready/TD RPM EDR System/Hole Depth/Avg. Stand Length	
Systems Impacted		
Issues		

Use Case	DSA02	
Name	Breaking Gels	
Goal	Breaking Gels to prevent pressure spiking the well on connections	
Primary actors	Operator	
Secondary actors	None	
Independent Triggers	User wishes to terminate Control	
Preconditions / Assumptions	1. Use case DSA01 completed successfully.	
Subsequent Use Cases	DSA03	
Uses Use Cases	DSA01	
Success end Condition	Ramping RPM and flow rate up to set point	
Failed end Condition	Pump or top drive does not achieve set point	
Post Conditions	Initialization accomplished for DSA02	
Primary Scenario Description	**Step**	**Action**
	1	Start rotation at 25% of set point
	2	Start mud pumps at 25% of set point
	3	Ramp rotation speed and mud pumps to set point over 30 seconds
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Top drive and flow rate	
Systems Impacted		
Issues		

Use Case	DSA03	
Name	Begin Pumping	
Goal		
Primary actors	Operator	
Secondary actors	None	
Independent Triggers	User wishes to terminate Control	
Preconditions / Assumptions	1. Use case DSA02 completed successfully. 2. Pumps are off. 3. Standpipe pressure is below pre-defined value	
Subsequent Use Cases	DSA04	
Uses Use Cases	DSA02	
Success end Condition	Pump(s) are running at required speed. Stand Pipe pressure is within predetermined range. Mud Flow Out has been detected.	
Failed end Condition	1 or more pumps failed to reach desired speed. Stand Pipe pressure too low or too high. Flow out has not been detected within predefined time period from pump start.	
Post Conditions	Initialization accomplished for DSA02	
Primary Scenario Description	**Step**	**Action**
	1	Determine which pumps to use
	2	Determine Pump rate(s)
	3	Determine Pump ramp style
	4	Ramp Pumps to desired Pump rate(s)
	5	Look for flow out in desired time frame while monitoring stand pipe pressure for over/under range
	6	Pump rates and flow out achieved
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Mud Pumps/Pump rate(s) EDR/Stand Pipe Pressure/Flow Out reading	
Systems Impacted		
Issues		

Use Case	DSA04	
Name	Stabilize Pumping	
Goal	Pump(s) are holding desired rate(s). Standpipe pressure is normal.	
Primary actors	Operator	
Secondary actors	None	
Independent Triggers	User wishes to terminate Control	
Preconditions / Assumptions	1. Use case DSA03 completed successfully. 2. Pumps are running 3. Mud Flow out is indicating flow	
Subsequent Use Cases	DSA05	
Uses Use Cases	DSA03	
Success end Condition	Pumps are running at desired rate within +/- 3 percent of desired set point(s). Mud Flow Out is within range expected for current pump speed. Stand Pipe Pressure is within its normal range.	
Failed end Condition	Pumps do not maintain proper speed. Mud Flow Out becomes excessive or Mud Flow Out decreases or stops. Pump pressure varies from stabilized point.	
Post Conditions	Initialization accomplished for DSA02	
Primary Scenario Description	**Step**	**Action**
	1	Start time out period
	2	Monitor Pump Rates, Flow Out rate, and Pump Pressure
	3	Check for time out if readings are good, else fail out
	4	If time out, end Case successfully. Else repeat steps 2-4
	5	Proceed to use case DSA05
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Mud Pumps/Pump rate(s) EDR/Stand Pipe Pressure/Flow Out reading	
Systems Impacted		
Issues		

Use Case	DSAS05	
Name	Top Drive On – Start Rotation	
Goal	Start rotation of top drive without damaging rig, BHA, or well.	
Primary actors	Drill-a-Stand Automation System	
Secondary actors	User	
Independent Triggers	Previous step finished	
Preconditions / Assumptions	1. Top Drive has power. 2. Rotation is Off 3. Drillstring is connected 4. Out of slips 5. Pumping 6. Using a Top Drive 7. Ability to control top drive granted 8. Max Torque set by user or computed from contextual data 9. Max Torque of top drive available to system 10. Threshold for erratic torque provided 11. Required Gear known	
Preceding Use Cases	Pumps on and perhaps MWD communication achieved	
Subsequent Use Cases	DSA06 or DSA-EmergencyStop	
Uses Use Cases	None	
Success end Condition	Steady state RPM and Torque	
Failed end Condition	Torque greater than MAX_TORQUE; RPM not achieved; Top Drive has no power; emergency stop	
Post Conditions	Top Drive rotating	
Primary Scenario Description	**Step**	**Action**
	1	System does precheck to verify rotation is off, brake is off and control is available.
	2	System sets target RPM, maximum rate of change, and Gear (if required) to achieve target RPM.
	3	Rig Control System verifies target RPM and RPM Rate of Change is within limits of system.
	4	System starts rotation
	5	System monitors RPM, Torque, and drive gear
	6	System waits for steady state RPM and Torque to be achieved
Secondary Scenario Extensions	**Step**	**Branching action**
	1a	System Precheck Fails [DASXXX]
	2a	Rig Control System rejects requested setting [DASXXX]
	5a	RPM, Torque, Gear or Brake not operating as expected [DASXXX]
	6a	Steady state not achieved within time limit [DASXXX]
Data Elements	Top Drive - Brake State - Gear - RPM - Torque - Max Torque - Direction	

	- Temperature?? Should we check temperature? - Power on/off Slips (In or Out) Drillstring Attached Bit Depth
Systems Impacted	Rig Control System Top Drive Controller BHA
Issues	**Need to have Emergency Stop Use Case** **Need generic use case for:** - **Precheck Failure** - **RCS Rejecting Requested SetPoint** - **Unexpected real-time feedback to control** - **Steady state not achieved, notify driller**

Use Case	DSA06	
Name	Tag Bottom	
Goal	Lower the rotating drill string until the bit is on bottom.	
Primary actors	Operator	
Secondary actors	None	
Independent Triggers		
Preconditions / Assumptions	1. Pumps running at a defined stroke rate (DSA04 Complete) 2. Top drive rotating at a defined RPM (DSA05 Complete) 3. Depth values are reasonably accurate (eg within 6" of error between hole depth and bit depth) 4. Off-bottom (bit depth is less than hole depth) 5. Drawworks is stationary 6. Control parameters set: a. Tag bottom speed (**TBS**) eg 50 ft/hr. Must be sufficiently slow to ensure proper clean out. b. Tag bottom weight (**TBW**) eg 2 klbs. Must be larger than typical weight seen due to drag when lowering. 7. Control of drawworks verified 8. Absolute torque limit established 9. A kick detection model exists and is always running to interrupt control procedures	
Subsequent Use Cases	DSA09	
Uses Use Cases	N/A	
Success end Condition	On bottom rotating with TBW	
Failed end Condition	Absolute torque limit exceeded before success condition Kick detection model event triggered	
Post Conditions	On bottom rotating with TBW Drawworks in downward motion *Immediate* automatic hand-off to DSA07 to continue to drill weight, and drill RPM	
Primary Scenario Description	**Step**	**Action**
	1	Begin lowering drawworks at defined TBS
	2	Continue to lower drawworks until either: a) Bit depth is near hole depth (eg 6"). Continue to step 3. b) Weight-on-bit begins to increase beyond normal lowering weight-on-bit. See branching action 1, this condition indicates either: a. Depth parameters are inaccurate beyond the threshold (eg 6") b. Caught-up on something c) Absolute torque limit exceeded. See branching action 2.
	3	Slow speed to X% of TBS and continue lowering as weight-on-bit begins to increase
	4	Continue until weight-on-bit is equal to TBW
Secondary Scenario Extensions	**Step**	**Branching action**
	1	From primary scenario 2b. Some options? a) Proceed as normal in primary scenario step 3 b) Stop the process and wait for manual intervention

	2	From primary scenario 2c. Stop the process and wait for manual intervention?
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Drawworks (Control) Pumps (Information) Top drive (Information)	
Systems Impacted		
Issues		

Use Case	DSA07	
Name	Make hole until all stand is used	
Goal	Drill complete stand as per defined drilling parameters	
Primary actors	Driller	
Secondary actors	Rig Control System	
Independent Triggers	1. Autodriller engaged by driller 2. Auto-engage autodriller when tag bottom is detected	
Preconditions / Assumptions	1. New stand in drillstring 2. Bit depth = Hole depth 3. Pumps on and running at required SPM 4. TopDrive turning at required RPM 5. Drillstring tagged bottom	
Subsequent Use Cases	DSA08	
Uses Use Cases	None	
Success end Condition	Complete stand drilled down and ready to pick up off bottom	
Failed end Condition	Stand incomplete	
Post Conditions	Initialization accomplished for DSA07	
Primary Scenario Description	**Step**	**Action**
	1	Check that bit depth = total depth and WOB is at threshold
	2	Check that Auto-Driller parameters are set, WOB, ROP, DP, Torque
	3	Check for Auto-Driller engaged
	4	Auto-Driller drills stand down to pre-defined block position
	5	Auto-Driller dis-engaged
	6	Drill-off until WOB threshold is hit
	7	DW Brakes are set
	8	Reduce TopDrive RPM to 60 to 80% of original and check for vibrations
	9	Reduce flow
	10	
Secondary Scenario Extensions	**Step**	**Branching action** Stand needs Back Reaming
	6a	Set reaming RPM, pump SPM, speed and distance
	6b	Set overpull and underpull limits
	6c	Ream back to predefined distance and back
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	AutoDriller – WOB Setpoint, ROP Setpoint, DP Setpoint TopDrive – Drill RPM, Ream RPM, Torque Drawworks – Bit Depth, Hole Depth, Block Position, Overpull/Underpull limits, WOB, ROP, Pumps – SPM, Standpipe pressure	

Systems Impacted	Rig Instrumentation, Rig Control System
Issues	

Use Case	DSA08	
Name	Drawworks Off Bottom	
Goal	Operations to accept control from the autodriller and position the bit off bottom	
Primary actors	Operator	
Secondary actors		
Independent Triggers	3. Autodriller stopped	
Preconditions / Assumptions	10. Bit will be on bottom when the autodriller completes 11. Drillstring will be rotating 12. Pumps will be on 13. Complete stand has been drilled	
Subsequent Use Cases	DSA09 – Rotation off	
Uses Use Cases	None	
Preceding Use Cases	DSA07 – Autodriller completed, stand drilled	
Success end Condition	1. WOB threshold achieved and drill off complete 2. Rotation has been reduced to 60 – 80% of original setpoint 3. Vibration is minimal 4. Torque, borehole pressures, and hookload values are sensible 5. Pump flow is reduced and pump pressures are sensible 6. Connection Procedure determines hole cleaning (back reaming and circulating sweep) 7. Bit has been raised off bottom to target established by the Connection Procedure	
Failed end Condition	Any of the successful end conditions not met.	
Post Conditions	Bit positioned for stop rotation	
Primary Scenario Description	**Step**	**Action**
	1. Drill Off	Allow bit to drill-off until the WOB threshold is hit
	2. Reduce RPM	Slow rotation to 60-80% of original setpoint value. Monitor vibration – keep below accepted limits (TBD)
	3. Monitor Torque/Drag	Check that the drillstring moves freely and that the hole is clean
	4. Reduce Flow	Slow the mud motor
	5. Follow Connection Procedure	Back ream and circulate if necessary to keep the hole clean Lift the bit off bottom to height prescribed in the Connection Procedure
Secondary Scenario Extensions	**Step**	**Branching action**
	1	Connection Procedure
Variations	**Step**	
Special		**Branching action**

Requirements		
Object/Data Elements Required		
	Rig	WOB Threshold for drill-off
	Top Drive	RPM Torque
	Pumps	Strokes or FlowIn Intake and Exhaust Pressures FlowOut Density
	Drawworks	Hookload Block Height
	Vibration	TBD
	Borehole	Standpipe and Annular pressures
Systems Impacted	Rig Control System Top Drive Drawworks Pumps Borehole	
Issues	Connection Procedure undefined Vibration data/diagnostics undefined	

Use Case	DSA09	
Name	Top Drive Off – Stop Rotation	
Goal	Stop rotation of top drive without damaging rig, BHA, or well.	
Primary actors	Drill-a-Stand Automation System	
Secondary actors	User	
Independent Triggers	Previous step finished	
Preconditions / Assumptions	1. Top Drive has power. 2. RPM > 0 3. Drillstring is connected 4. Out of slips 5. Pumping 6. Using a Top Drive 7. Ability to control top drive granted 8. Max Torque set by user or computed from contextual data 9. Max Torque of top drive available to system 10. Threshold for erratic torque provided	
Preceding Use Cases	DSA08	
Subsequent Use Cases		
Uses Use Cases	None	
Success end Condition	RPM = 0	
Failed end Condition	RPM > 0	
Post Conditions	Top Drive Not Rotating, Brake Set	
Primary Scenario Description	**Step**	**Action**
	1	System does precheck to verify RPM > 0, drill string attached, brake off, Torque > 0, Direction, Power On, Bit Depth > Threshold, Slips Out, and control is available.
	2	Request RPM = 0 and Rate of Change to User defined limit
	3	Monitor RPM, Torque
	4	Wait until RPM = 0
	5	Set Top Drive Brake
Secondary Scenario Extensions	**Step**	**Branching action**
	1a	System Precheck Fails [DASXXX]
	2a	Rig Control System rejects requested setting [DASXXX]
	5a	RPM, Torque, Gear or Brake not operating as expected [DASXXX]
	6a	RPM = 0 not achieved within time limit [DASXXX]
Data Elements	Top Drive - Brake State - Gear - RPM - Torque - Max Torque - Direction - Temperature?? Should we check temperature?	

	- Power on/off Slips (In or Out) Drillstring Attached Bit Depth
Systems Impacted	Rig Control System Top Drive Controller BHA
Issues	**Need to have Emergency Stop Use Case** **Need generic use case for:** - **Precheck Failure** - **RCS Rejecting Requested SetPoint** - **Unexpected real-time feedback to control** - **Steady state not achieved, notify driller** - **Alarm for Overpull** - **Alarm for Overtorque**

Use Case	DSA10	
Name	Slips In	
Goal	Operations to place the drill string back in Slips	
Primary actors	Operator	
Secondary actors	Driller	
Independent Triggers	1. Rotation stopped 2. Pumps stopped	
Preconditions / Assumptions	1. Pipe will be positioned properly to engaged slips	
	2. Table pressure sensor is in range	
	3. Driller accepts hand-over	
Subsequent Use Cases		
Uses Use Cases	None	
Preceding Use Cases	Pumps off	
Success end Condition	1. Hookload is sensible to operator and driller 2. Pressure sensor on table is sensible to operator and driller	
Failed end Condition	Drilling process stops until preconditions are met	
Post Conditions	Control of system is returned to the driller to engage slips	
Primary Scenario Description	**Step**	**Action**
	1	Check for Driller OK
	2	Check that hookload is sensible
	3	Check that table pressure sensor value is sensible
Secondary Scenario Extensions	**Step**	**Branching action**
	1	Pipe improperly positioned
	2	Table pressure sensor value is outside of expected range
	3	Driller not available
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Drawworks/hookload Rig/table/pressure Driller alive and functioning	
Systems Impacted	Rig Control System	
Issues		

Use Case	DSA11	
Name	Emergency Stop – Manual Control Request	
Goal	Stop automation of system or systems that driller has stopped or requested to manually control. [This is a simple way of handling returning to manual control. More complex cases could allow a single system to return to manual control or a single set point to return to manual control (and possible back again); or many other scenarios.] If driller attempts to manually control a set point which is under automation control, the automation system should release control and give driller the ability to resume manual control of all set points.	
Primary actors	Driller	
Secondary actors		
Independent Triggers	Human Interface Button pressed.	
Preconditions / Assumptions	Drill-a-Stand is executing	
Subsequent Use Cases		
Uses Use Cases	None	
Preceding Use Cases		
Success end Condition	Equipment is in manual control	
Failed end Condition		
Post Conditions	Control of system is returned to the driller, driller knows he is in control, Emergency Stop button is disabled.	
Primary Scenario Description	**Step**	**Action**
	1	Driller presses enabled Emergency Stop button
	2	Automation system is immediately prevented from sending set points to rig control system
	3	Automation system is notified that manual control has been requested.
	4	Automation system stops automated procedures.
	5	Automation system disables Emergency Stop button.
	6	Automation system notifies driller that it has released control.
	7	Automation system logs that automated control was released and why.
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**

Special Requirements		
Object/Data Elements Required	Rig Control System	
Systems Impacted	Rig Control System, Automation System	
Issues		

Use Case	DSA12	
Name	Fail-Safe in the event that an automation agent is disconnected	
Goal	Return to a fail-safe state that is appropriate for the current automation procedure to allow driller to assume control	
Primary actors	Driller	
Secondary actors		
Independent Triggers	Automation Agent (perhaps an agent which specializes in going-on-bottom) is disconnected while giving suggested set points.	
Preconditions / Assumptions	Drill-a-Stand is executing	
Subsequent Use Cases		
Uses Use Cases	All	
Preceding Use Cases	Any	
Success end Condition	Equipment is in manual control	
Failed end Condition		
Post Conditions	Control of system is returned to the driller, driller knows he is in control, Emergency Stop button is disabled.	
Primary Scenario Description	**Step**	**Action**
	1	Automation Agent, which is in control, is non-responsive (e.g. loss of heartbeat)
	2	Automation System (Comms Device) realize communication loss and implements failsafe set points that were previously set by Automation Agent, when it assumed control
Secondary Scenario Extensions	**Step**	**Branching action**
Variations	**Step**	**Branching action**
Special Requirements		
Object/Data Elements Required	Rig Control System	
Systems Impacted	Rig Control System, Automation System	
Issues		