

Digital Construction Platform: Basic Operations Manual  
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**Purpose:** This document outlines basic manual operation of the Digital Construction Platform. This document is intended to allow the user to move the AT40GW and KUKA KR10 separately, and under manual control – it does not describe any sort of automated operation.

The original version of this document is maintained in the DCP team Dropbox, at MDCP2/Design/Hardware/DCPSystemSpecs.

## Getting Set Up to Run the DCP

### Software Installation & Setup

- MATLAB:
  - 1) Install MATLAB. We generally use MATLAB R2016b, although this version does require certain patches to run Simulink Desktop Real-Time models, and has known bugs. R2017a may address these failures, but this has not yet been tested.
  - 2) Install the Simulink Desktop Real-Time kernel by typing the following command at the prompt.  
`>> sldrtkernel -install`  
For more information, see the Simulink Desktop Real-Time Documentation at <https://www.mathworks.com/help/sldrt/index.html>.
  - 3) Install the MF-644 drivers following the appropriate instructions from Humusoft's website, available at: <http://www.humusoft.cz/datacq/mf644/>
    - i. **For OS X systems running R2016b:** There is a known bug in the Simulink Desktop Real-Time configuration that needs to be fixed in order for frequency output blocks to work correctly. This patch is included in the dcpctrl\_v2 library, at /util/sldrt\_MF644patch/. This needs to be done after the dcpctrl\_v2 Git repository has been pulled.
  - 4) Set up Simulink build directories (not imperative, but highly recommended).
    - i. From the MATLAB main window, select Home → Preferences
    - ii. Select Simulink from the left-hand window. The Simulink preferences window will open
    - iii. In the General tab, define a simulation cache folder and a code generation folder. These should not be in the dcpctrl\_v2 library – we generally place them in the MATLAB folder created in the user's home directory.
- Git Repository:
  - 1) You will need a GitHub account to access the dcpctrl\_v2 repository. Sign up for GitHub at <https://github.com/>, and then connect your account to the Media Lab GitHub Organization at <https://ml-github.media.mit.edu/>.
  - 2) Pull the dcpctrl\_v2 repository, available at [https://github.com/mitmedialab/dcpctrl\\_v2](https://github.com/mitmedialab/dcpctrl_v2). If you can't see this library, you need to be added to the dcpctrl\_v2 user group. Please contact NecSys (Media Lab tech support) for information on how to do this.
  - 3) Install dependencies:
    - i. Corke's Robotics, Vision and Control Toolbox: Download the latest version of RVC (tested with 9.10) from [petercorke.com](http://petercorke.com). Copy the rvctools folder to dcpctrl\_v2/lib/

- 4) (Optional) Set up MATLAB start path to automatically open to dcpctrl\_v2. From the MATLAB main interface, click Home → Preferences → General. In the “Initial working folder” dialog, navigate to the current installation location of dcpctrl\_v2. For example, under OS X, this might look like:  
/Users/dcp/Documents/Git/dcpctrl\_v2
- Other recommended software: Other packages that are frequently useful for interacting with the DCP include the following:
    - o Wireshark: Useful for monitoring IP communications, especially for troubleshooting connectivity issues between Simulink and the KUKA

## Network Configuration

The DCP uses a custom network configuration to communicate with the KUKA and any other system components that operate over an IP connection.

- 1) Connect the control computer to the DCP router via Ethernet. Controlling the system over WiFi may be possible, but it has not been tested and is not likely to work.
  - 2) Configure your wired connection with the following parameters:
    - i. IP Address: 10.100.48.100
    - ii. Subnet Mask: 255.255.255.0
- In OS X, this is done in System Preferences/Network. In Windows, this is done in Control Panel/Network and Internet/Network Connections/Ethernet → Properties → (TCP/IPV4).

## Turning On and Moving the DCP

### AT40GW: System Startup

The AT40GW aerial lift vehicle has two different hydraulic powertrains: a pump powered by a diesel engine, and a pump powered by an electric motor which is fed from the large battery pack on the front of the vehicle. These two powertrains are both connected to the rest of the AT40GW's hydraulic circuitry, but are designed to operate individually.

**WARNING:** Simultaneously running the diesel and electric hydraulic pumps will cause severe damage to the hydraulic system, and could potentially cause dangerous hydraulic leaks. NEVER turn on the diesel engine while the electric motor is running, or vis-versa. Always perform the following checks:

#### Diesel mode (before start):

- Yellow E-STOP on battery pack is depressed (Fig. XXX)
- Blue & white MOTOR ACTIVATE wire is disconnected (Fig. 2)

#### Electric mode (when operating):

- Ignition key is physically prevented from turning to IGNITION position (Fig. 1)

Electric mode: TBD – for now, please use diesel drive mode ONLY unless working under the supervision of a DCP team member.

#### Diesel mode:

- 1) Verify that the yellow E-STOP on the battery pack is depressed, and the blue & white MOTOR ACTIVATE wire (Fig. 2) is disconnected.
- 2) Verify that the ARM DRIVE MODE switch is set to off (neutral position) (Fig. 3)
- 3) Turn ignition key fully to IGNITION position (as you would when operating an automobile). The AT40GW diesel engine should turn on. Release the key when the engine has started to run.
- 4) If the engine fails to start:
  - a) Check all E-STOPS on vehicle. All E-STOPS, EXCEPT for yellow E-STOP on electric drive battery pack, should be released
  - b) Verify that the small 12V battery on the back of the DCP (between outriggers, in black plastic box) has not discharged. **Generally, if the DCP is not operating correctly, the 12V battery should be the first system to be checked.**

### AT40GW: Driving the AT40GW

The AT40GW may be moved around using its tracked platform. Generally, the tracked platform performs substantially better when operated in diesel mode, but it may be operated in electric mode if needed as long as the terrain is not too rough.

To operate the AT40GW tracked platform:

- 1) Start AT40GW.
- 2) Verify that AT40GW arm is in fully retracted position. The AT40GW boom should put enough load on the vertical support at the front of the AT40GW so that there is no discernable play in the support.
- 3) Turn MODE switch (Fig. 1) to TRACK position, and ensure that SAFETY OVERRIDE switch (Fig. 1) is in UP position.
- 4) Verify that outriggers have been retracted fully. If the outriggers are not retracted fully, use the outrigger control switches (Fig. 1) to retract them.
- 5) Verify that
  - a) Track control pendant E-STOP is released (Fig. 4)
  - b) 2-SPEED MODE switch is OFF for diesel drive, or ON for electric drive (Fig. 4). **NOTE:** It is important when operating the vehicle in diesel mode that you are aware of whether you are operating in 2-speed mode or not. In 2-speed mode, the vehicle moves much faster, and is harder to control. This is not the case in electric mode, and the vehicle will not move unless it is in 2-speed mode.
  - c) Cables – especially cable between pendant and vehicle – are clear of tracks. If the pendant cable gets pulled under the tracks and torn out, you won't be able to move the vehicle to get it out!
  - d) Other obstructions are clear of vehicle and tracks.
- 6) Depress enabling switch on side of pendant (Fig. 4). You should hear a distinct change in sound coming from the hydraulic drivetrain.
- 7) Use the paddles to control the velocity of the right and left tracks (Fig. 4). **NOTE:** Be extremely careful when starting to move the vehicle. The paddle control is nominally proportional, but it is not terribly smooth, and particularly when turning, the vehicle can move its endpoint extraordinarily fast.

### **AT40GW: Moving the AT40GW Boom**

The boom of the AT40GW may be operated through the handles mounted to the side of the vehicle pier.

To operate the AT40GW boom:

- 1) Start AT40GW.
- 2) Turn MODE switch (Fig. 1) to TRACK position, and ensure that SAFETY OVERRIDE switch (Fig. 1) is in UP position.
- 3) Verify that area below outriggers, and outrigger mechanisms, are clear of any obstructions.
- 4) Place plywood safety pads where outrigger feet will land, to protect ground and distribute vehicle load.
- 5) Extend outriggers using the outrigger control switches (Fig. 1). Extend outriggers until vehicle is lifted fully off the ground, and leveled (use indicators on side of vehicle).
  - a) **WARNING: When the override switch (Fig. 1) is enabled, the boom may be operated without the outriggers being extended. This is permissible for a limited range of motions, particularly those where the boom stays centered over the vehicle. However, the boom should NEVER be operated without outriggers extended if the J1 axis is**

**rotating more than 30 degrees; the boom will be extended more than 50%; the vehicle is operating outdoors; or if any substantial load will be applied through the boom.**

- 6) Turn MODE switch (Fig. 1) to ARM position.
- 7) Ensure that boom is clear of any obstructions. Be especially careful of cables wrapping around column when J1 is rotated.
- 8) Operate boom:
  - a) Press down and hold ARM DRIVE MODE switch (Fig. 3) in MANUAL position. If you release this switch, the vehicle will not move.
  - b) Carefully use handles to operate axes J1 through J4 (Fig. 3). Handle directions are labeled. Exercise caution when moving arm – arm can move extremely quickly, and direction of motion is not always intuitive.
    - i) **NOTE:** Please do not adjust J5 handle (pink) unless absolutely necessary. Make sure to notify a DCP team member if you do.

## KUKA: System Startup

The KUKA is a separate system from the AT40GW, and requires its own power. To turn on the KUKA:

- 1) Ensure that KUKA transformer is connected to power (15A acceptable for limited use, 20A dedicated circuit required for substantial use), and that controller cabinet is connected to transformer.
- 2) Flip green power switch on front of KUKA to ON position. The KUKA pendant (Fig. 6) should activate. It will say “Waiting for cyclic connection” for some time, and then eventually show the robot interface.
  - a) **WARNING: If the KUKA pendant ever displays an error message during boot, DO NOT TOUCH IT. Contact a member of the DCP team immediately with a description/photograph of the error.**
- 3) The KUKA will turn on in T1 mode. It is now ready to be jogged.

## KUKA: Moving the KUKA

- 1) Ensure that the KUKA is clear of any obstructions before beginning to move. Be particularly careful of cables that may obstruct the arm’s motion.
- 2) Depress one of the enabling switches on the back of the KUKA pendant (Fig. 6, rear view, Nos. 3 and 5) part-way. The KUKA controller should hum and the A1-A6 indicators on the pendant (Fig 7, No. 7) should go green.
- 3) Use the +|- buttons on the KUKA pendant to drive the robot (Fig. 6, front view, No. 5).
  - a) To increase the velocity at which the robot moves, click the Speed Control icon on the KUKA touchscreen (Fig. 7), and then drag the lower slider to the right.
  - b) To change the coordinate system in which the arm moves (joint, tool, base, etc.), press the Coordinate System icon on the KUKA touchscreen (Fig. 7, No. 6) and select your desired coordinate system. **NOTE:** Be cautious when moving in a new coordinate system, as the robot may move in unexpected directions!

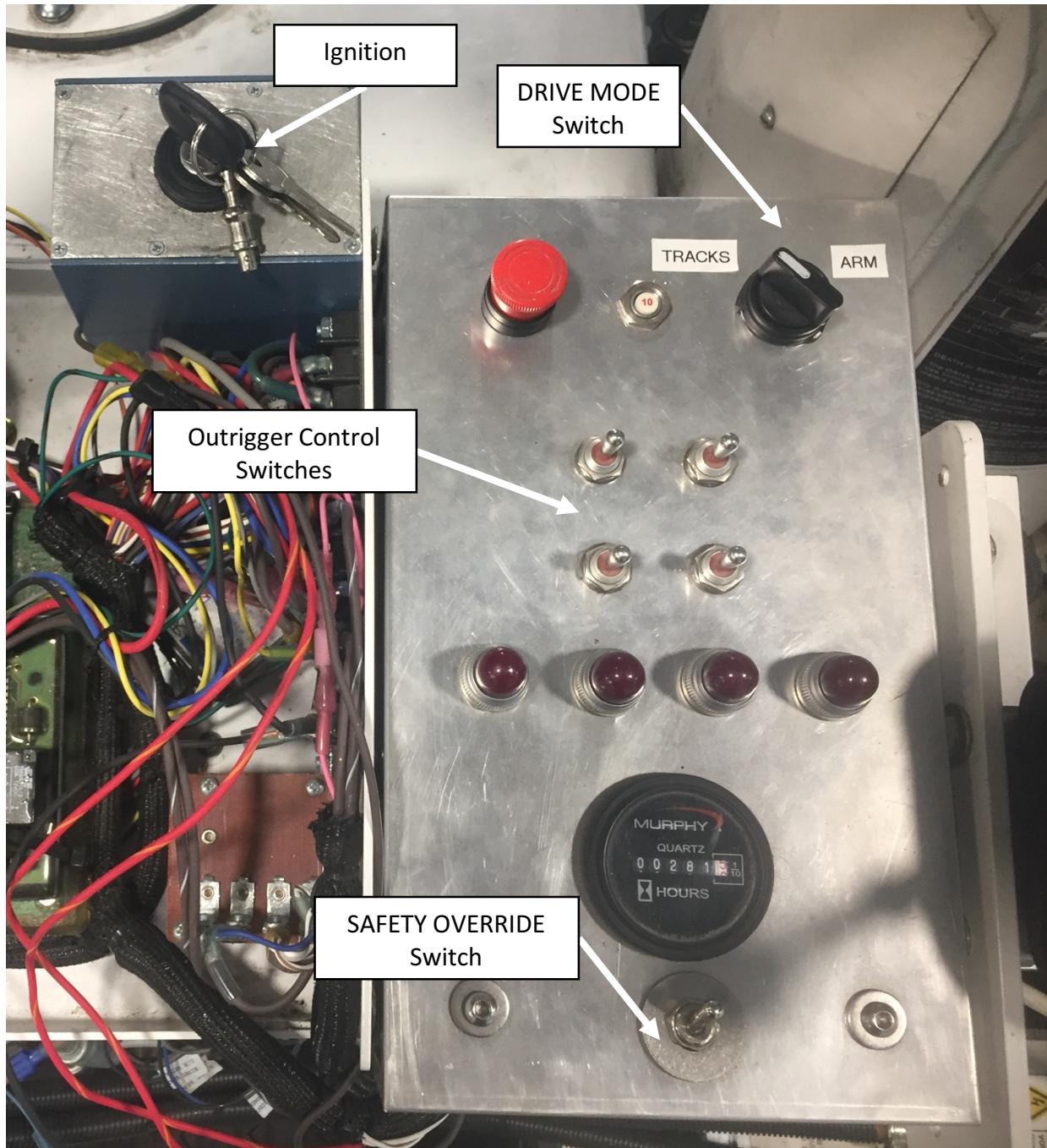


Figure 1: Ignition & Control Panel, AT40GW

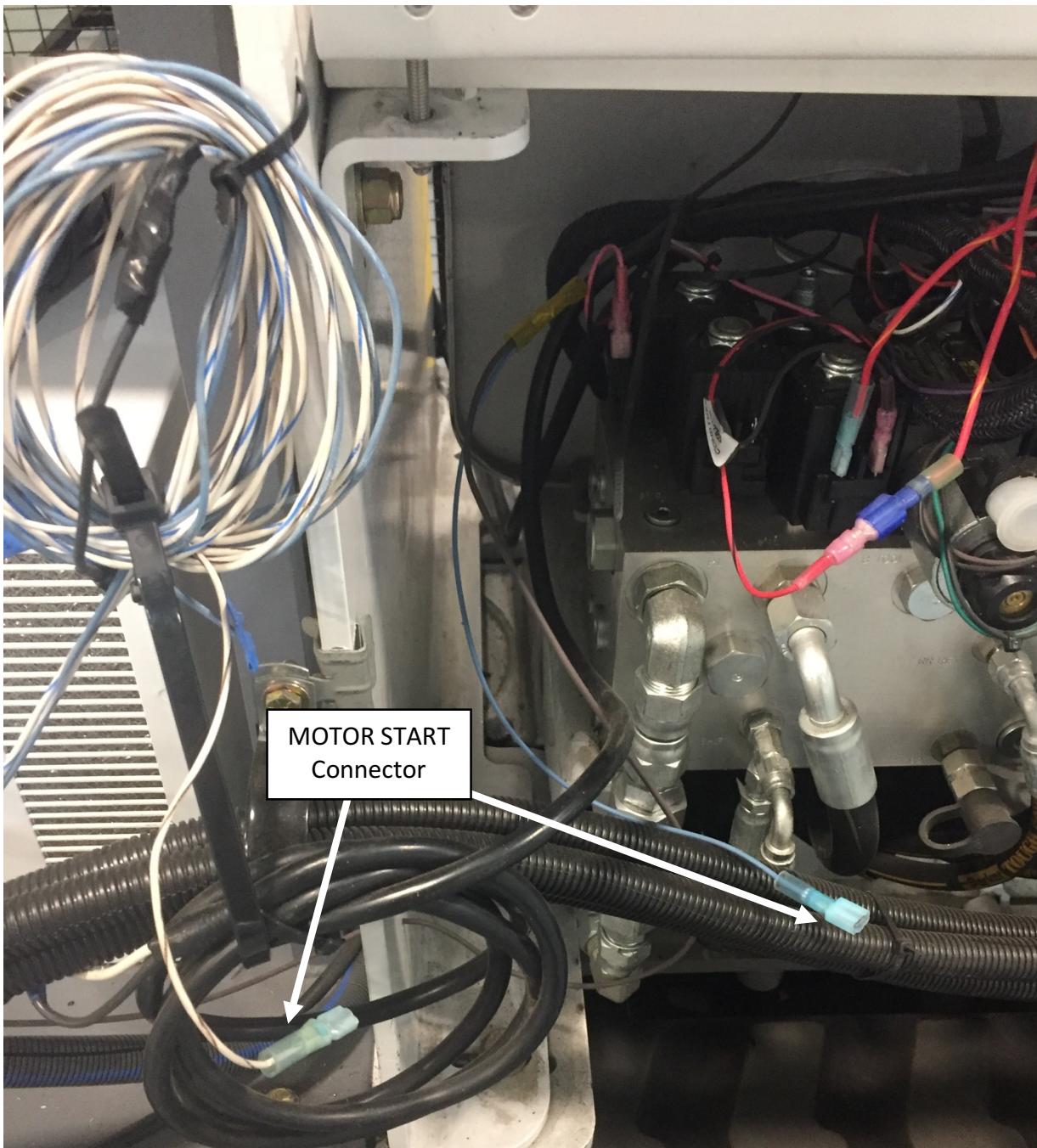


Figure 2: MOTOR ACTIVATE wire.

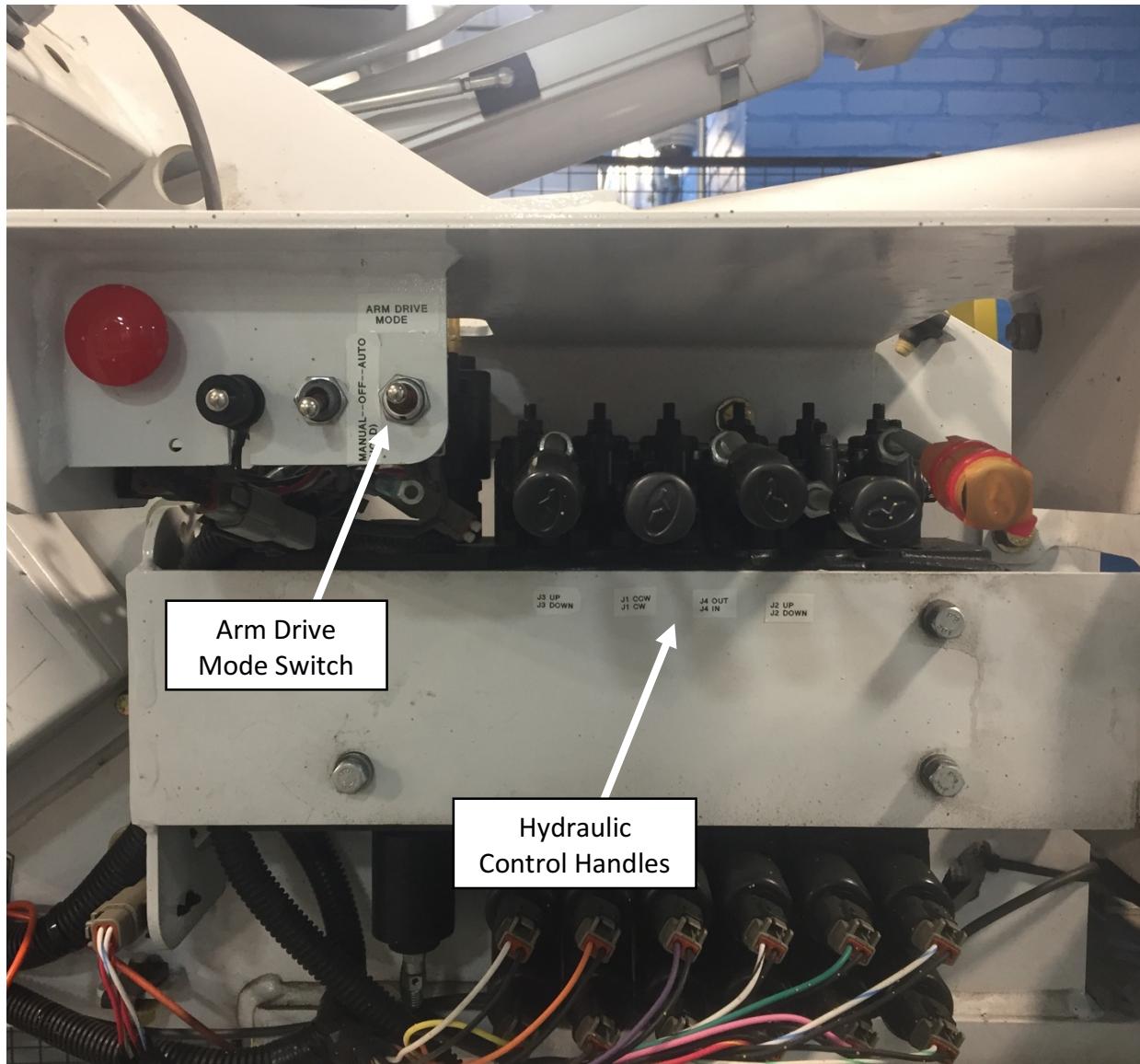


Figure 3: Boom Control Panel, AT40GW

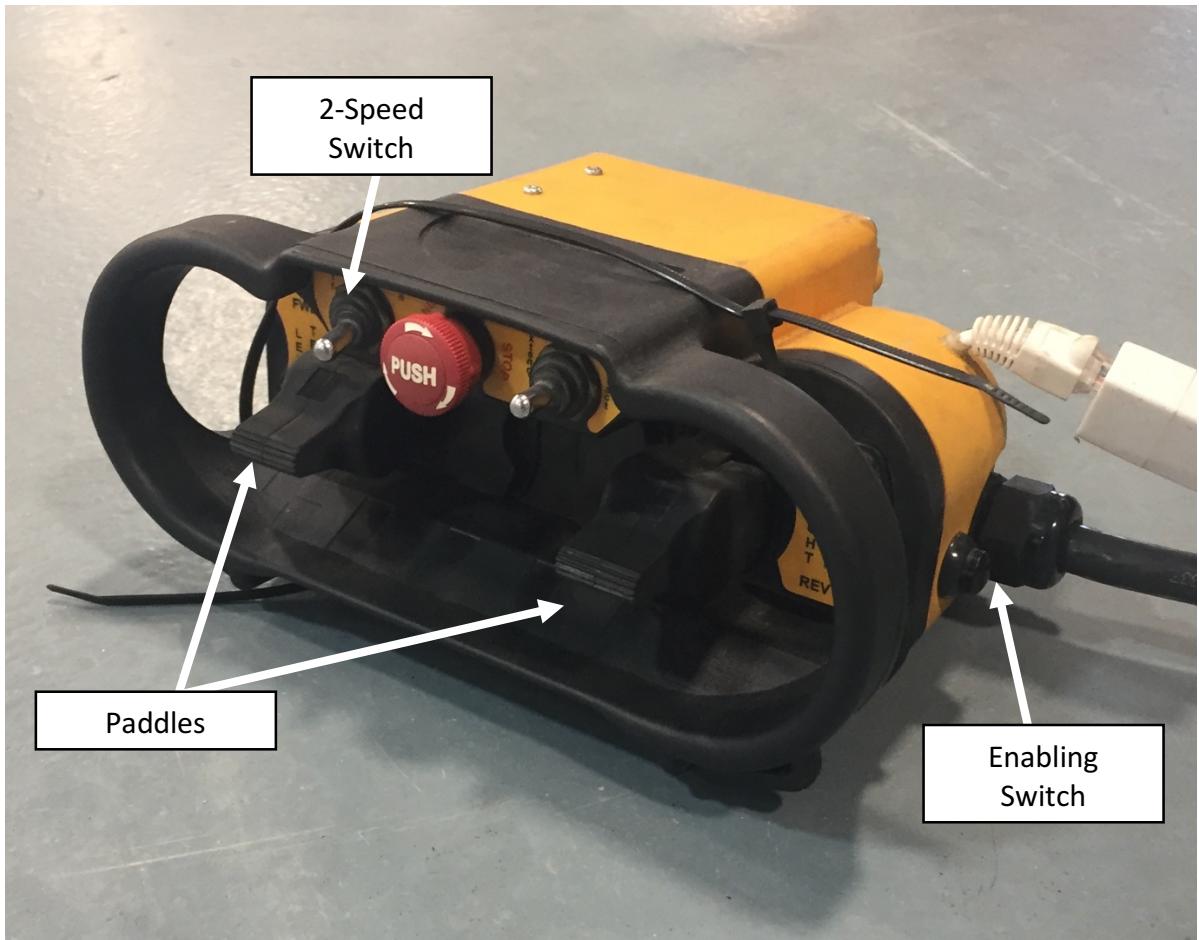


Figure 4: Track Control Pendant, AT40GW

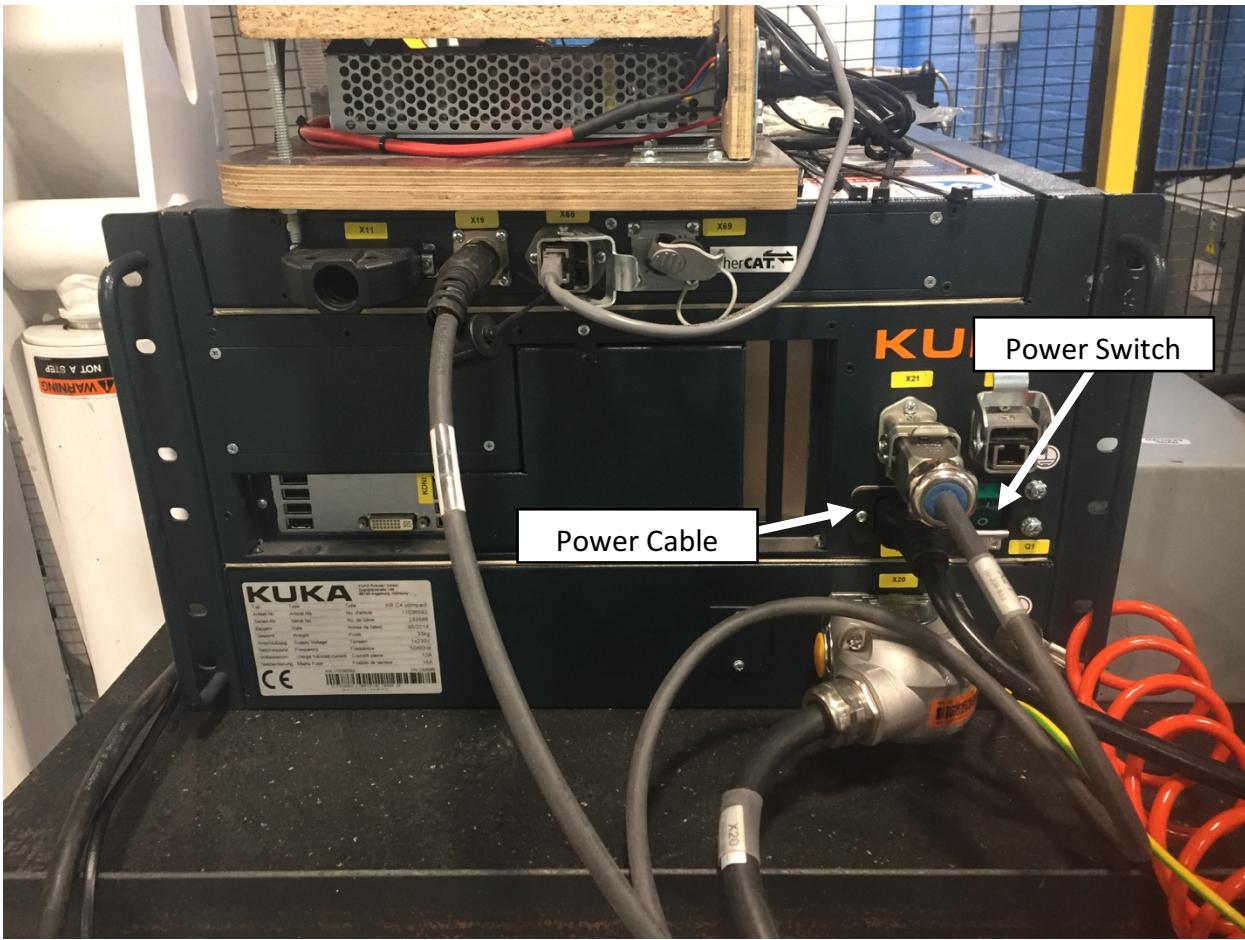


Figure 5: KUKA Control Cabinet



Figure 6: KUKA Pendant

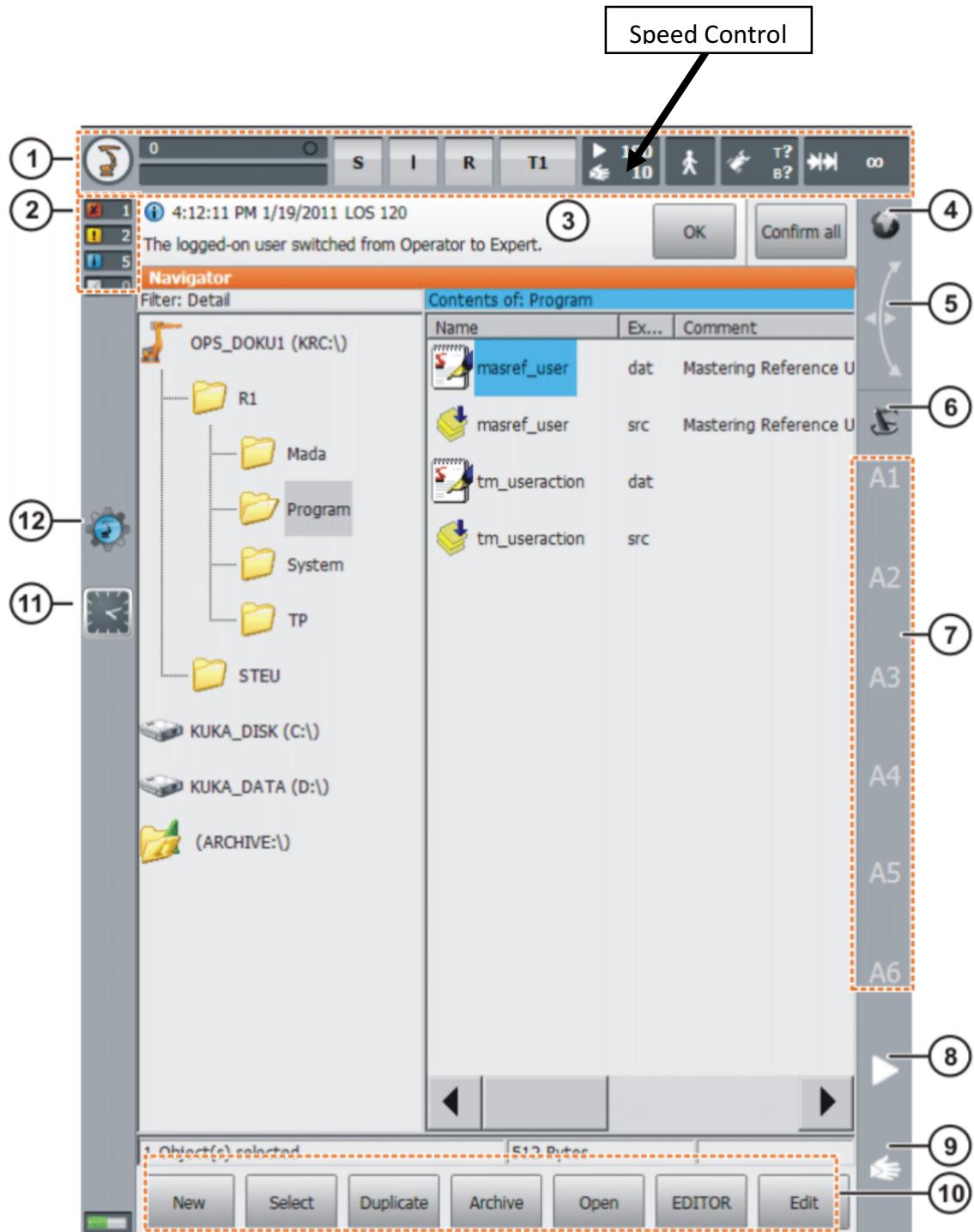


Figure 7: KUKA Pendant Interface

## Digital Control of the DCP

### System Startup Checklist:

- DCP Safety Interface Connections:
  - o DCP enabling switch pendant connected to ENABLING SWITCH IN port.
  - o DCP Control Interface AUX IN port connected to DCP AUX OUT port.
  - o AT40GW battery E-STOP terminal connected to AT40GW E-STOP port.
- DCP Safety Interface powered on
- DCP Control Interface powered on

## **Troubleshooting**

- When installing the dcpctrl\_v2 repository on a new control computer, it may be helpful to open the various Simulink Desktop Real-Time blocks (Analog & Digital In, Frequency Out, etc.) and test the MF-644 configuration with each block
- On Windows, Simulink build files can get corrupted when the system crashes. Deleting the build files will address this.
- To troubleshoot Simulink failures, start with simple programs and graduate up to more complex ones. A good order is kukaXYZctrl to test the KUKA; qraw\_readDemo to test AT40GW sensing and control; and then dcpController to verify control system functionality
- Under R2016b, the Simulink Dashboard Lamp blocks are known to cause failures when running in a SLDRT model. Do not use these blocks.