Robotic Backhoe with Haptic Display
Design Overview

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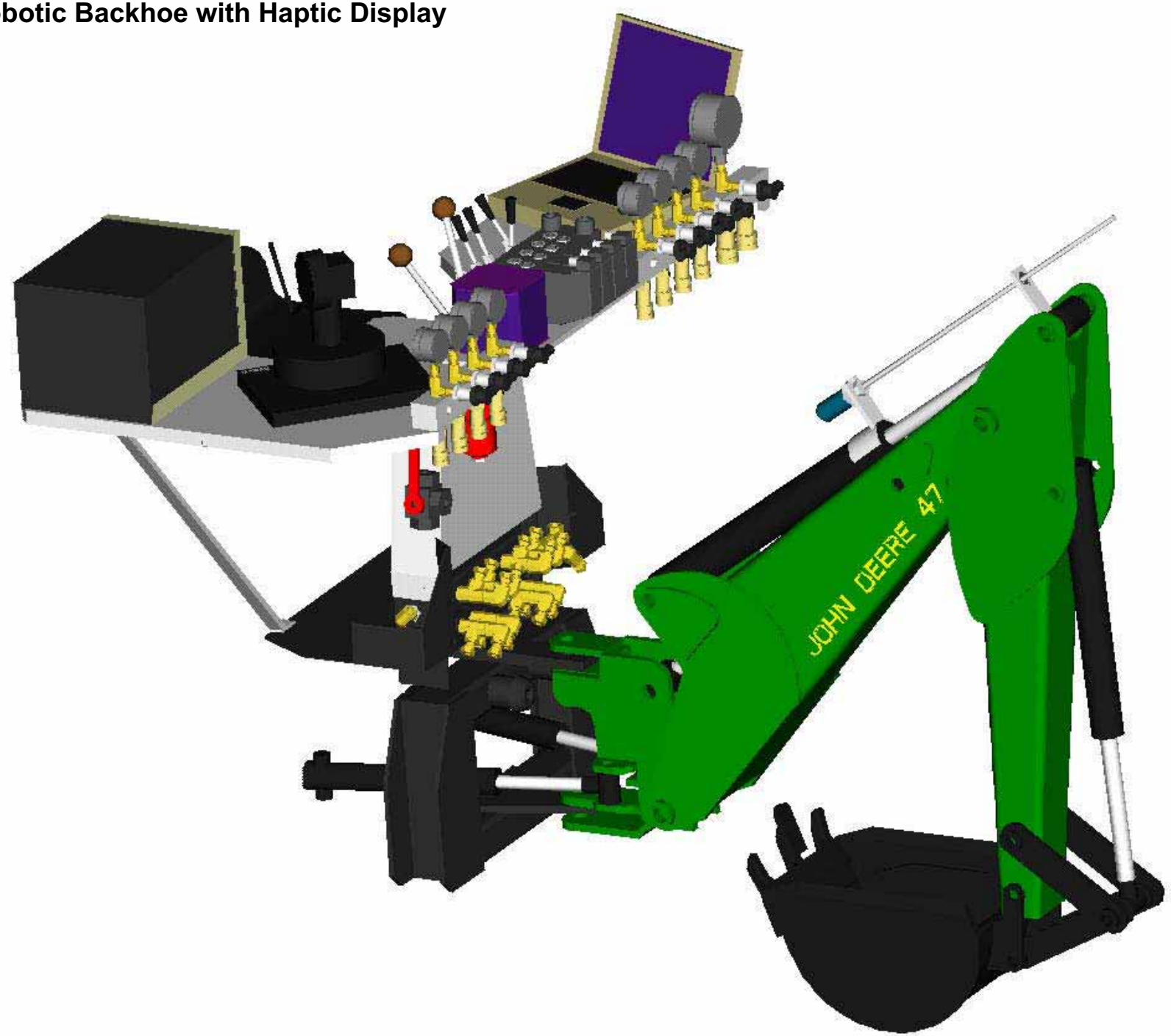
July 21, 2003

Robotic Backhoe with Haptic Display



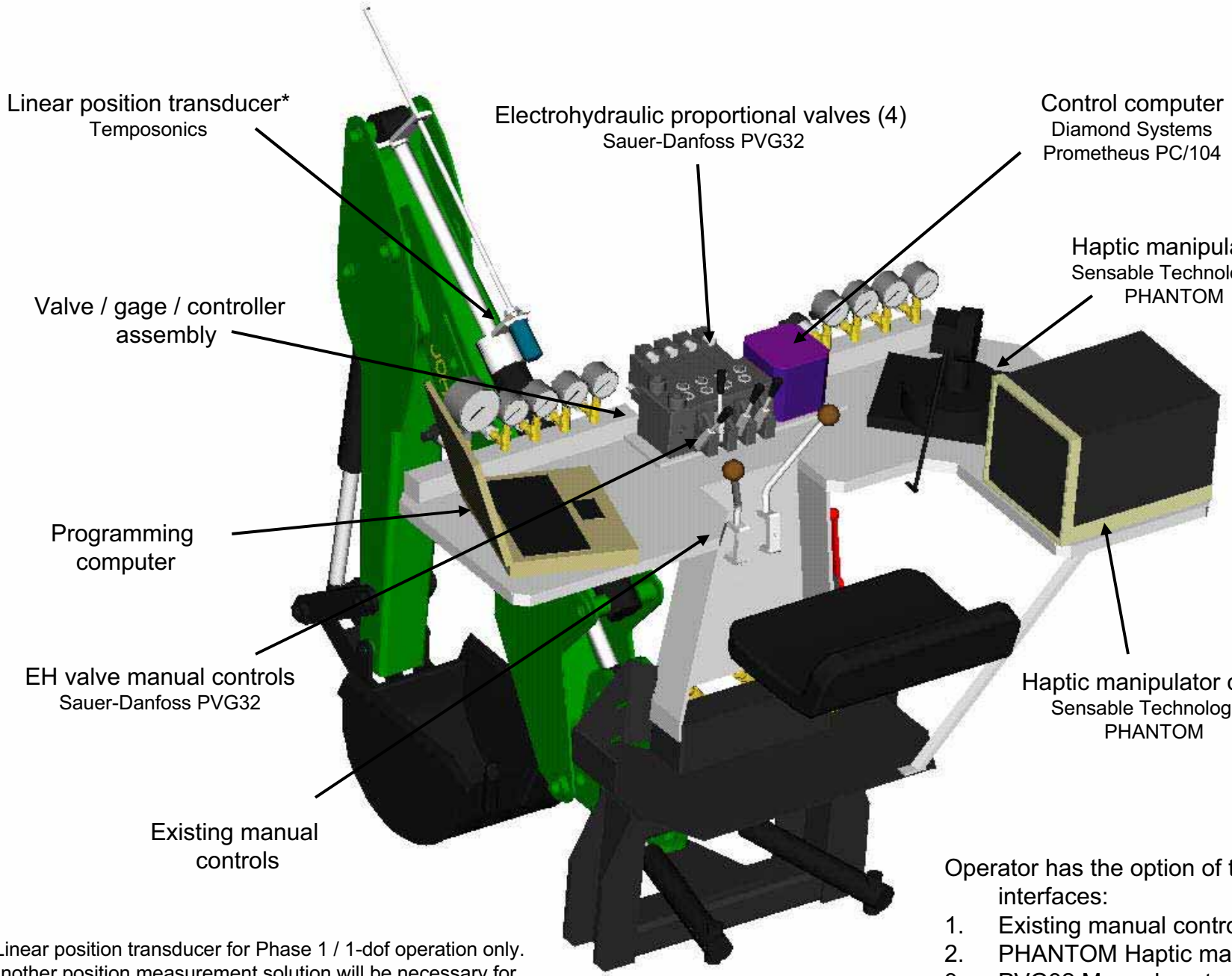
Model by Joe Frankel
July 21, 2003

Summary

The John Deere Company has expressed interest in developing haptic controls for their earthmoving equipment. The overall purpose of this project will be to develop a testbed for evaluating various haptic feedback control schemes as applied to a hydraulic backhoe, to be used as a tool in the development of haptic user interfaces for John Deere.

The project will involve several phases. In the first phase, haptic control will be applied to a single cylinder/degree of freedom on the backhoe, utilizing position feedback from a sensor mounted to the backhoe and controlled by the PHANTOM manipulator. Once the concept has been proven on one cylinder, the project will progress to the second phase, to include feedback and control of all four of the backhoe's links. Subsequent phases may explore the use of alternative haptic user interfaces, as well as the incorporation of GPS navigation into the system.

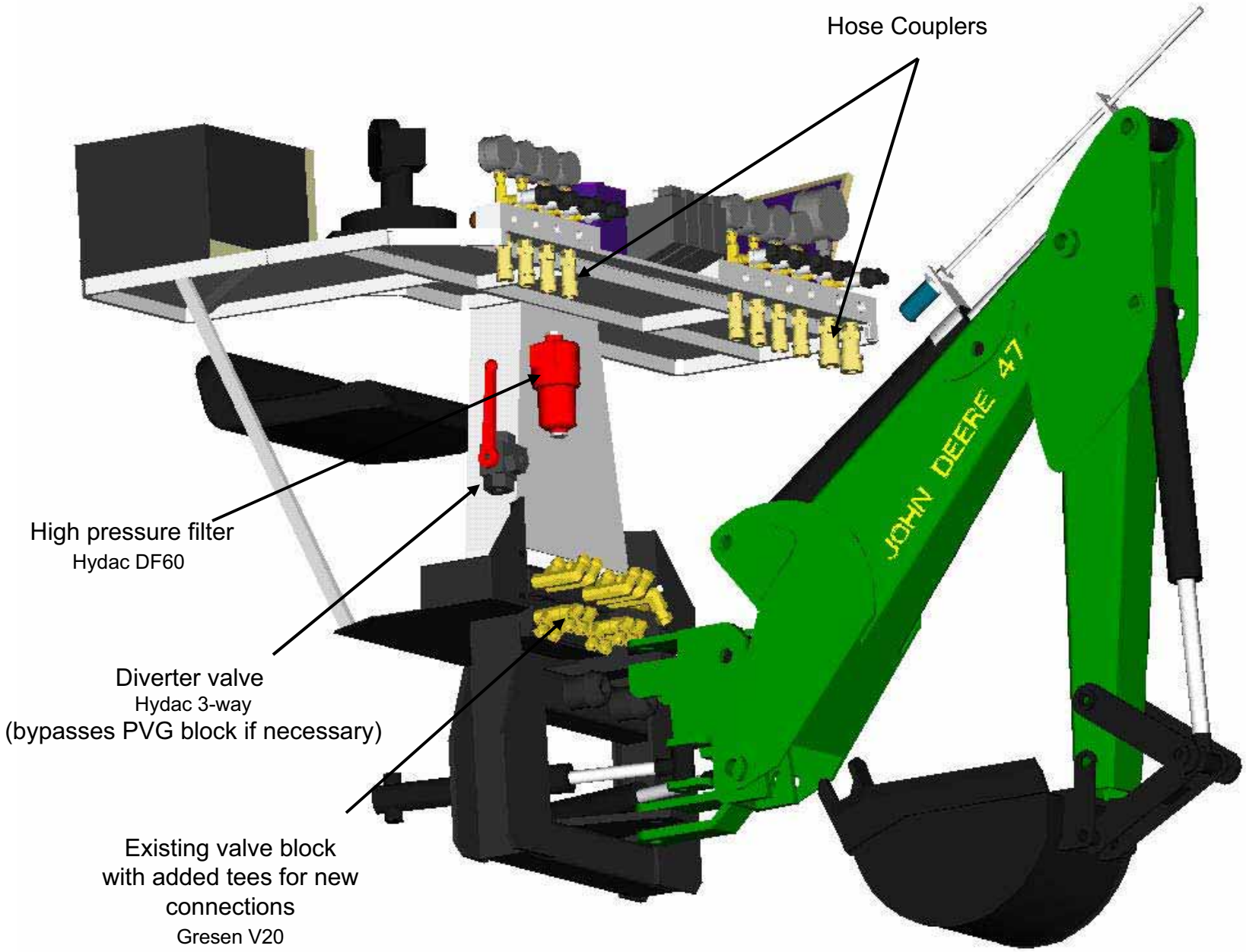
This design overview outlines the plans for the Robotic Backhoe with Haptic Display at the Georgia Institute of Technology, Fluid Power and Motion Control Center. This design is based upon goals set at the meeting at the John Deere Research Center in Dubuque, Iowa on May 29, 2003.

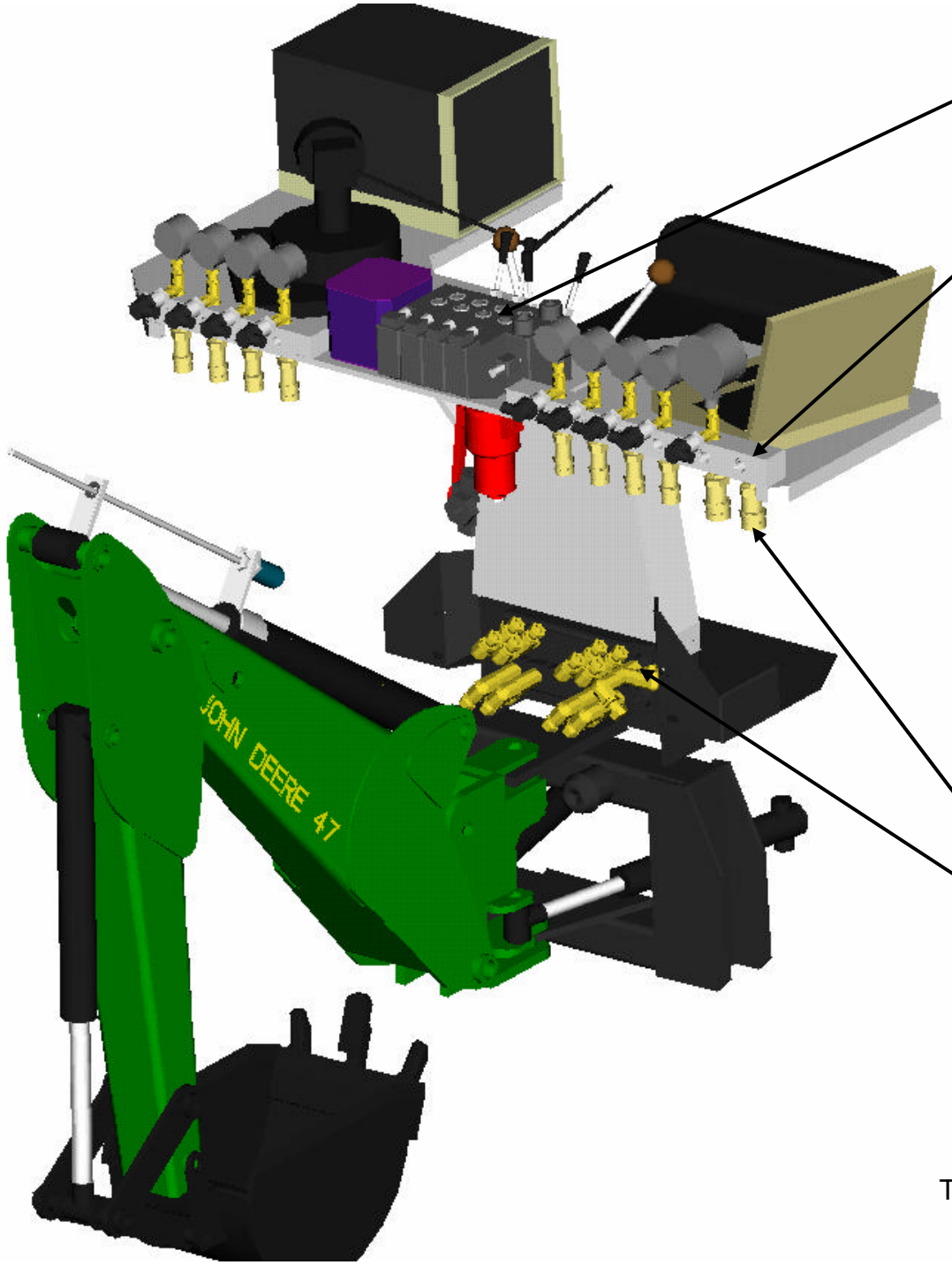


*Linear position transducer for Phase 1 / 1-dof operation only. Another position measurement solution will be necessary for Phase 2 / 4-dof control.

Operator has the option of three control interfaces:

1. Existing manual controls
2. PHANTOM Haptic manipulator
3. PVG32 Manual controls

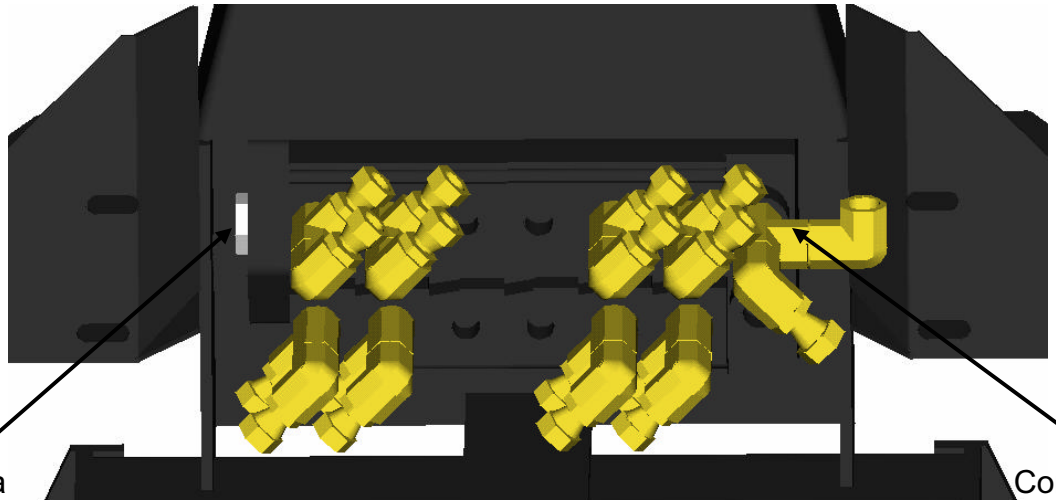

Hose Couplers
High pressure filter
Hydac DF60
Diverter valve
Hydac 3-way
(bypasses PVG block if necessary)
Existing valve block
with added tees for new
connections
Gresen V20
JOHN DEERE 47



Connect Sauer-Danfoss PVG valves to gage manifolds with hard tubing & Swagelock fittings (not shown)

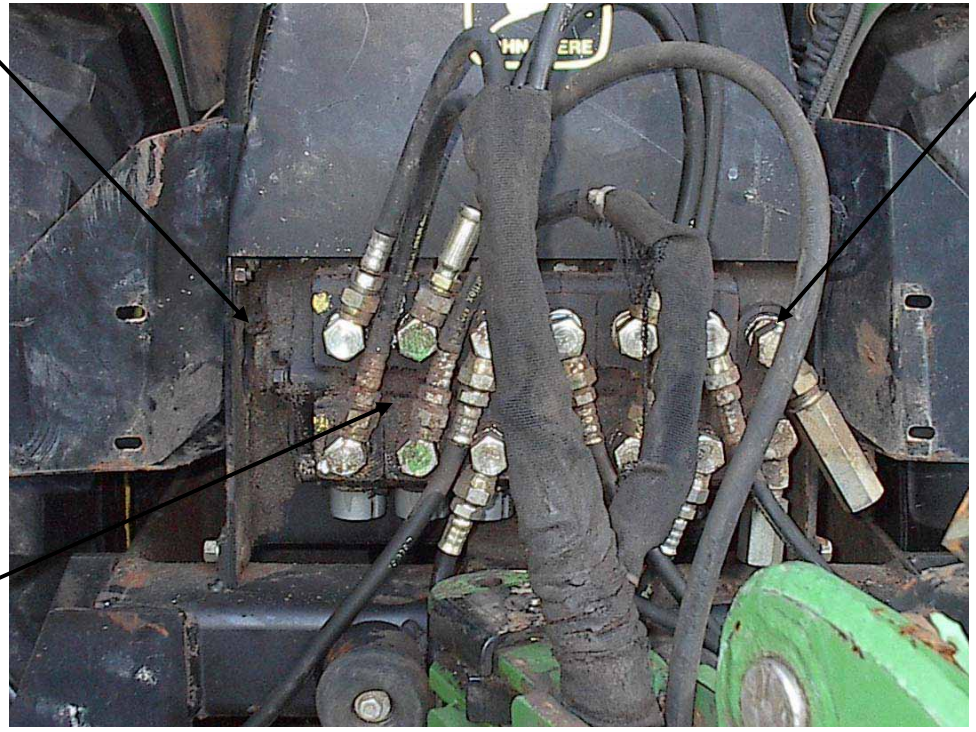
Connect quick-disconnect couplers to Gresen valve tees with flexible hose & SAE O-ring seal fittings (not shown)

Tubing sizes: 1” supply & return
½” cylinder lines



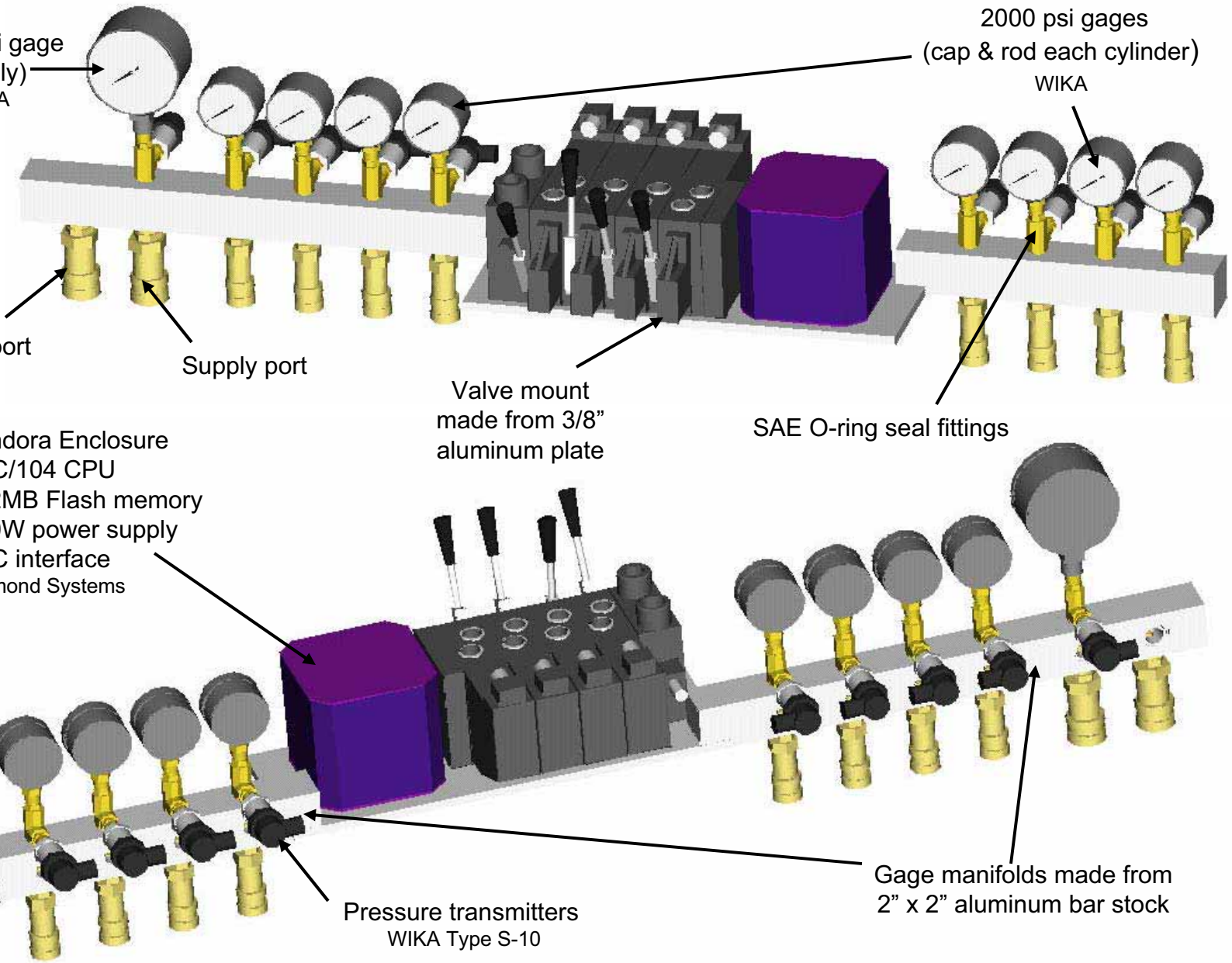
Connect to pump / supply via Power Beyond Sleeve here

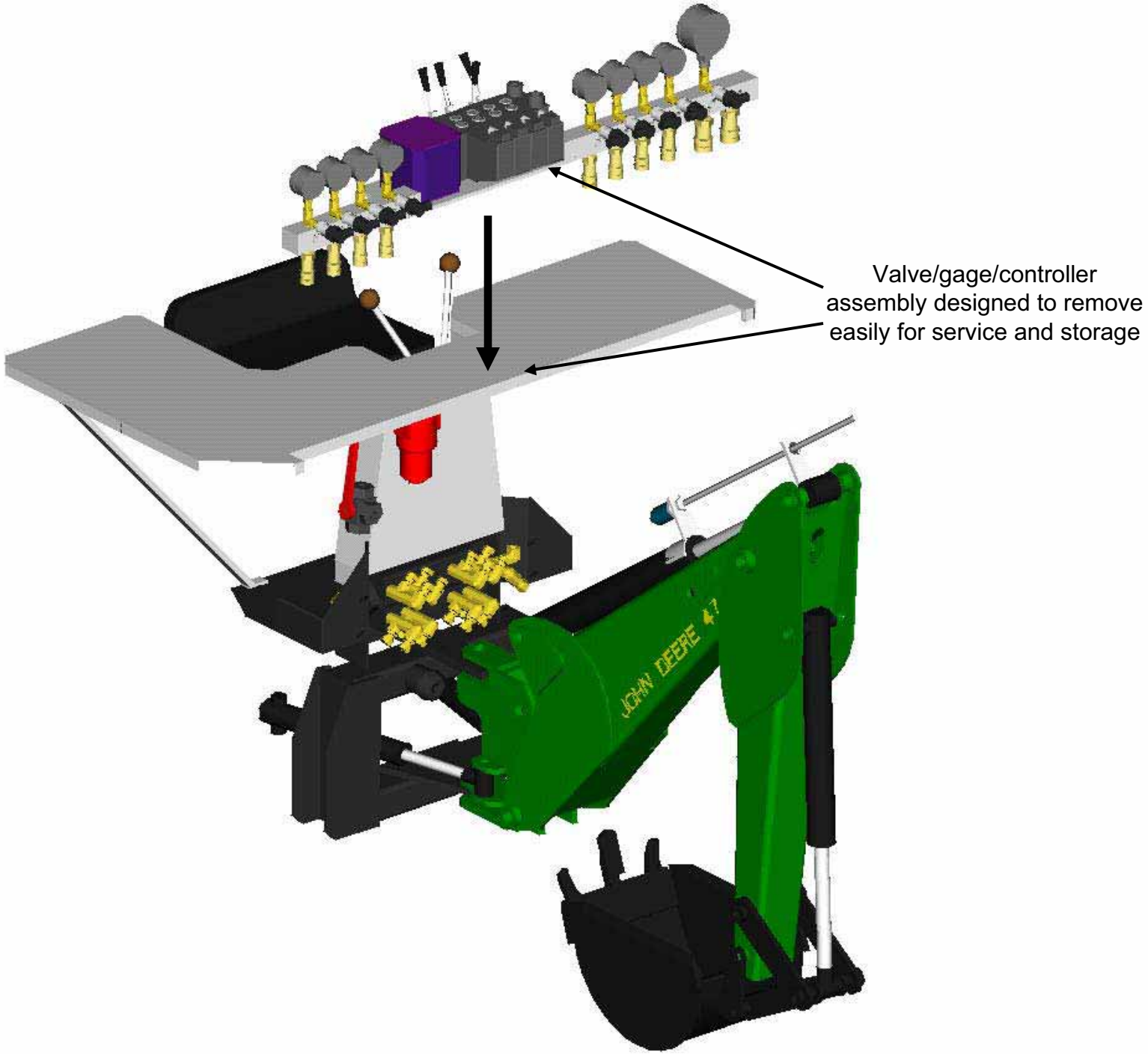
Connect to tank via Gresen outlet port here



Existing Gresen V20 valve block connected in series with Sauer-Danfoss PVG valve block: remains fully functional

Valve / Gage / Controller Assembly




Valve/gage/controller
assembly designed to remove
easily for service and storage
JOHN DEERE 47

Haptic manipulator and control computer can
be interchanged for left-handed operators

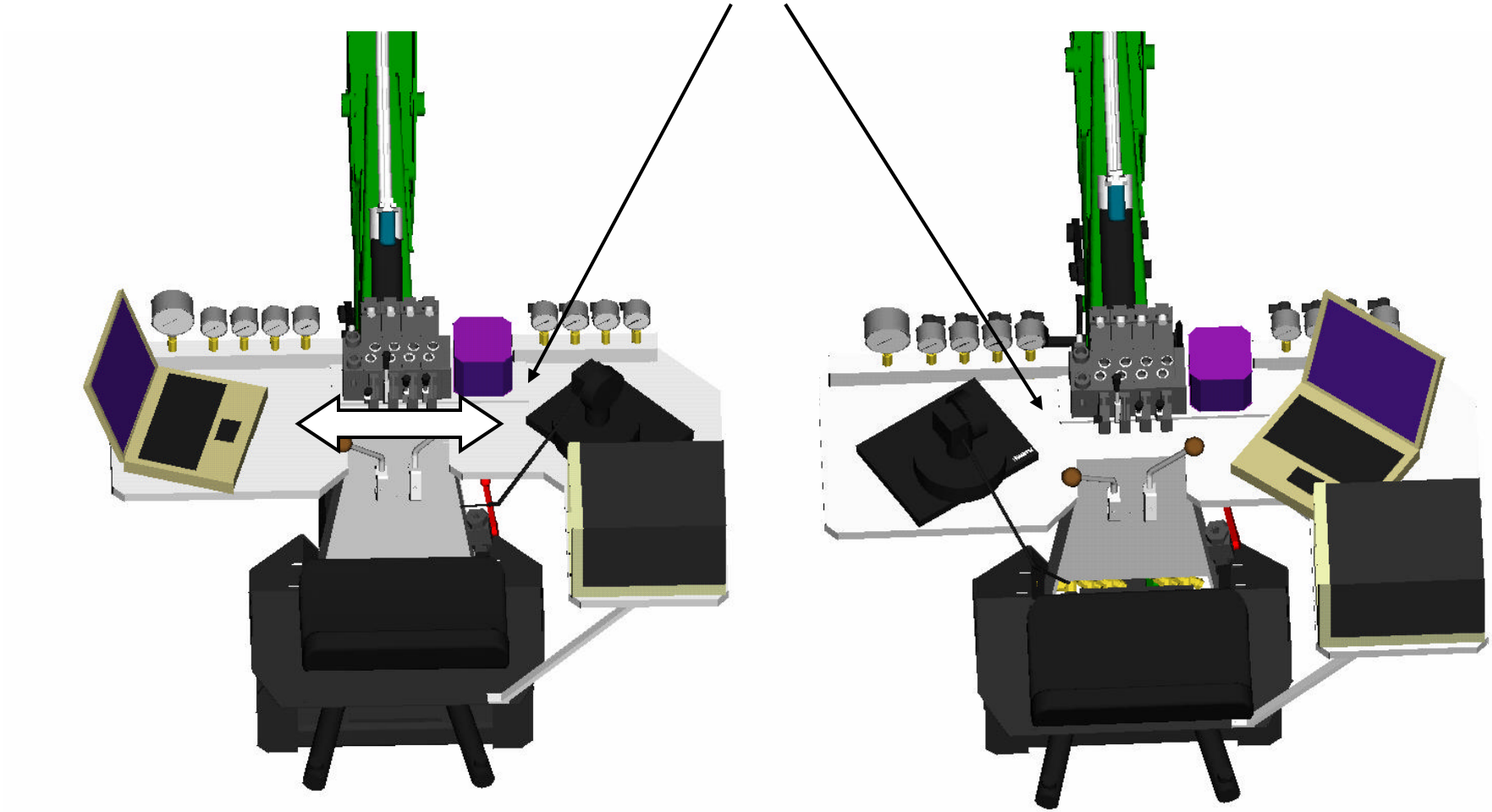
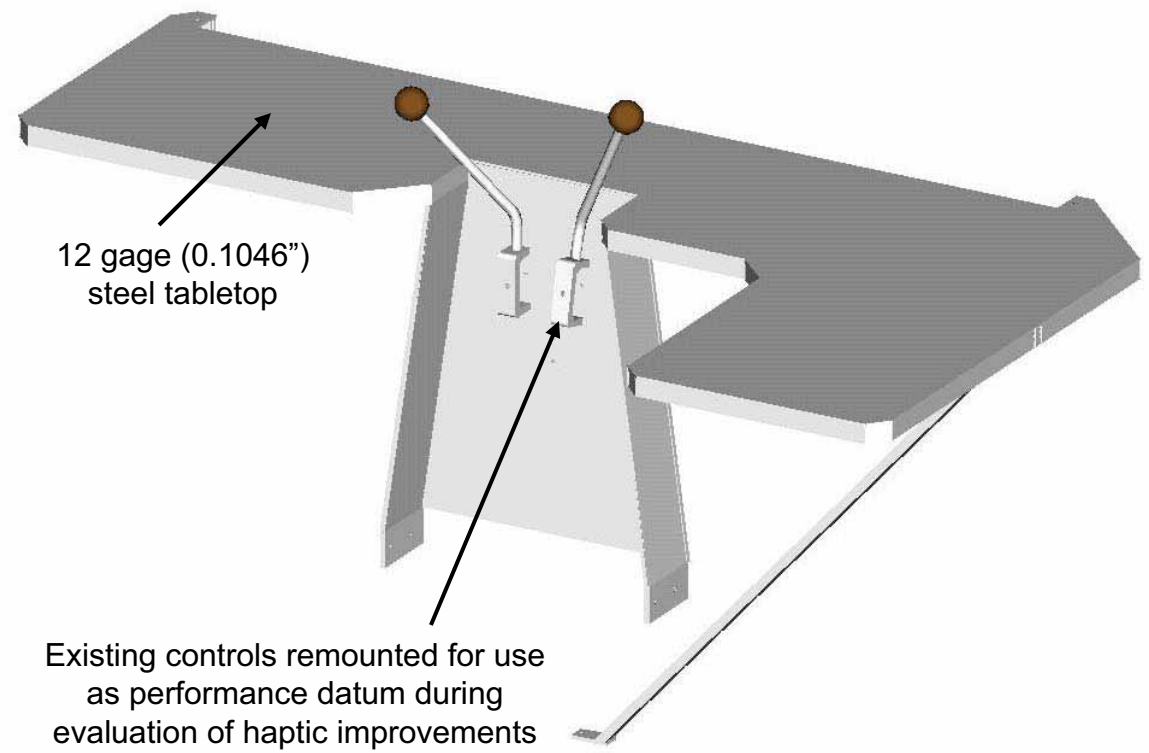
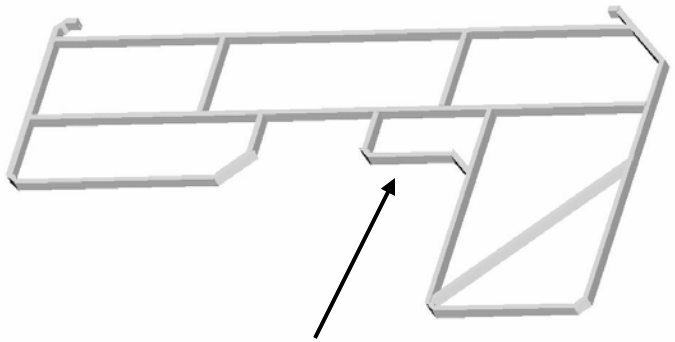
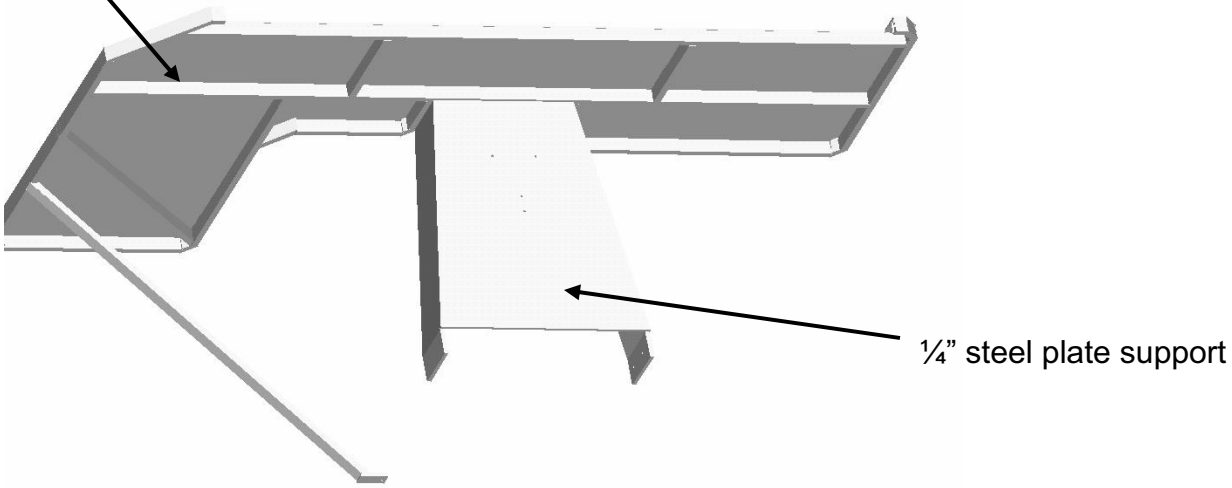


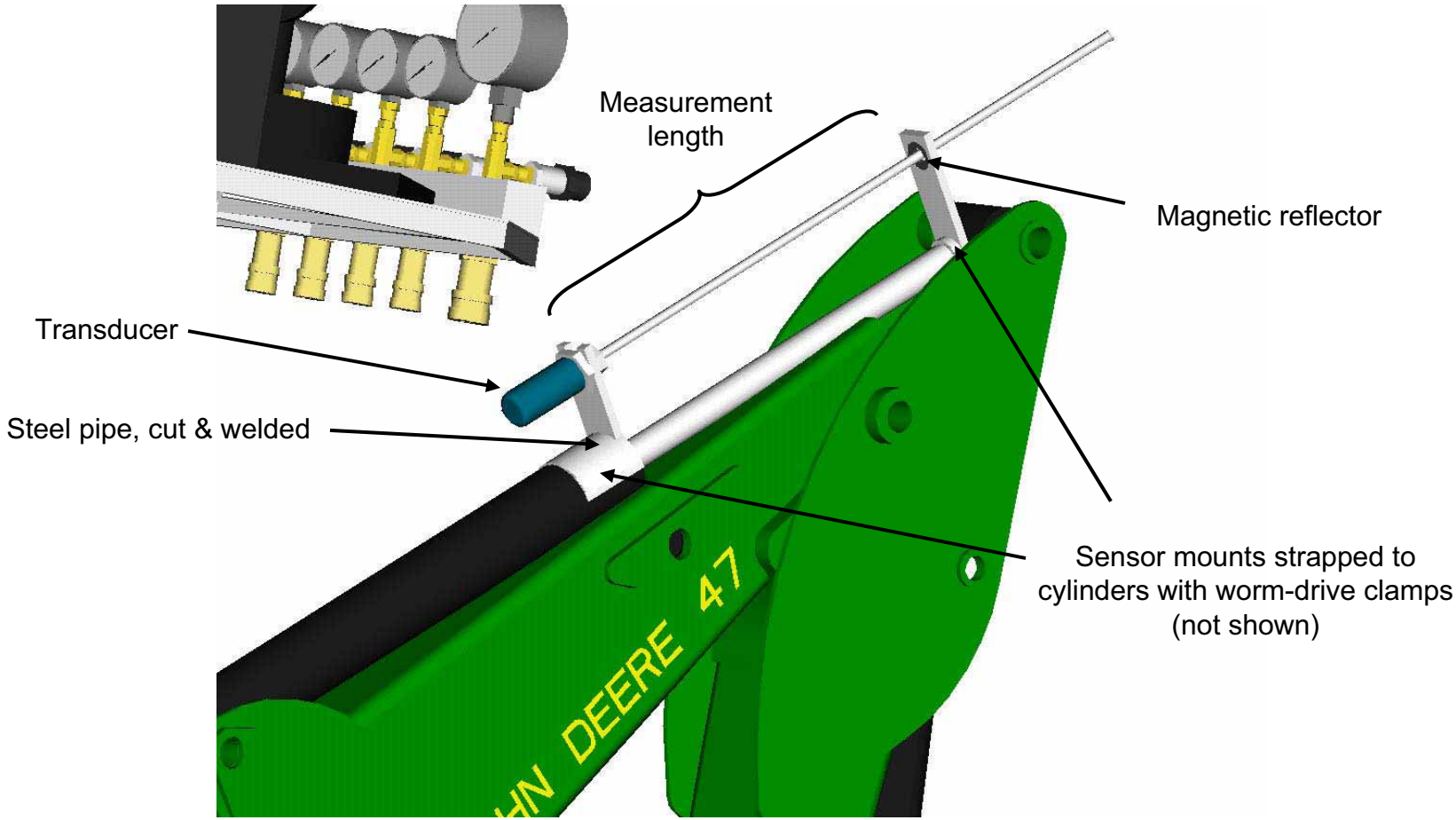
Table Assembly





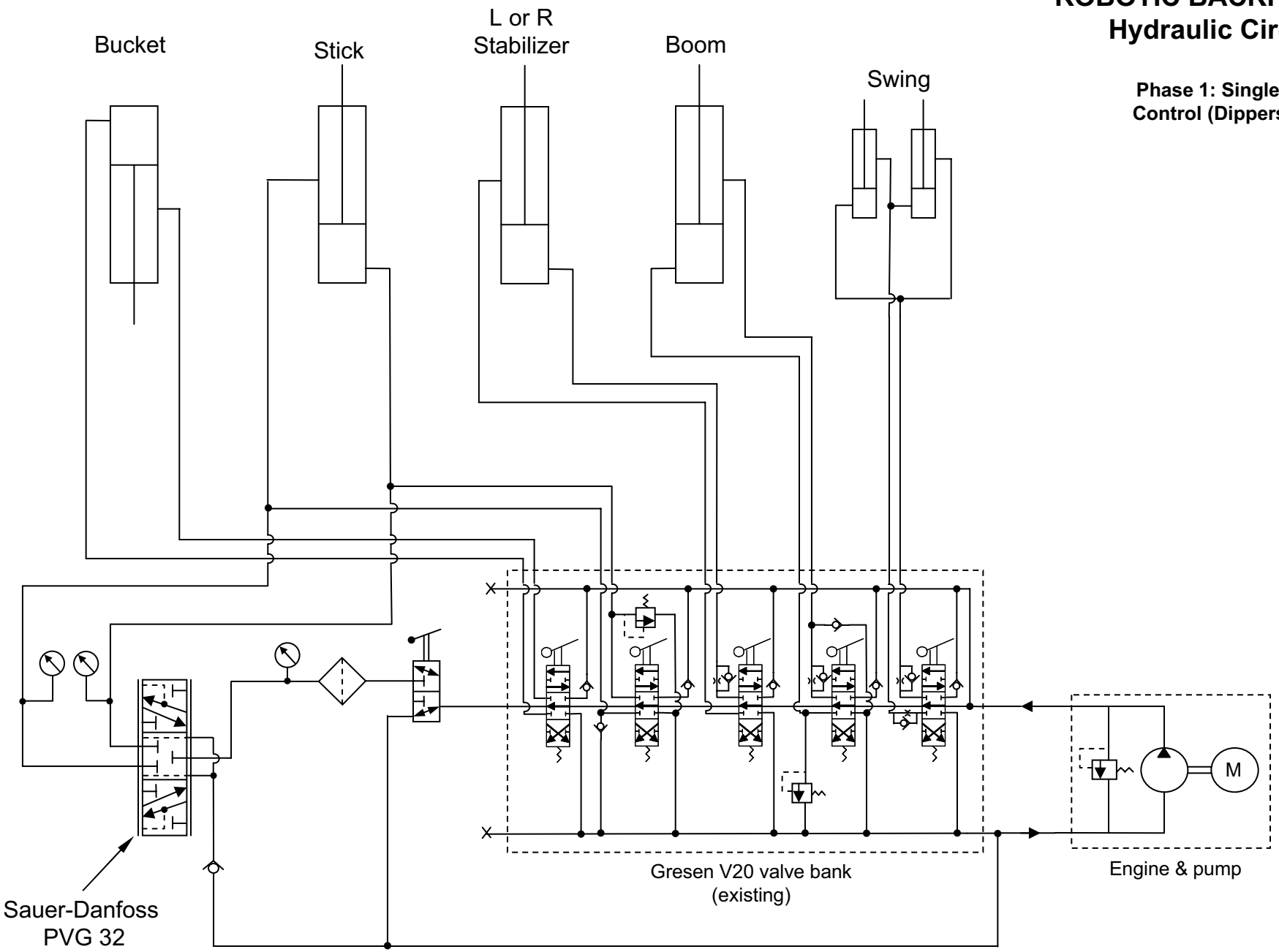


Position Sensor Mounting (temporary)



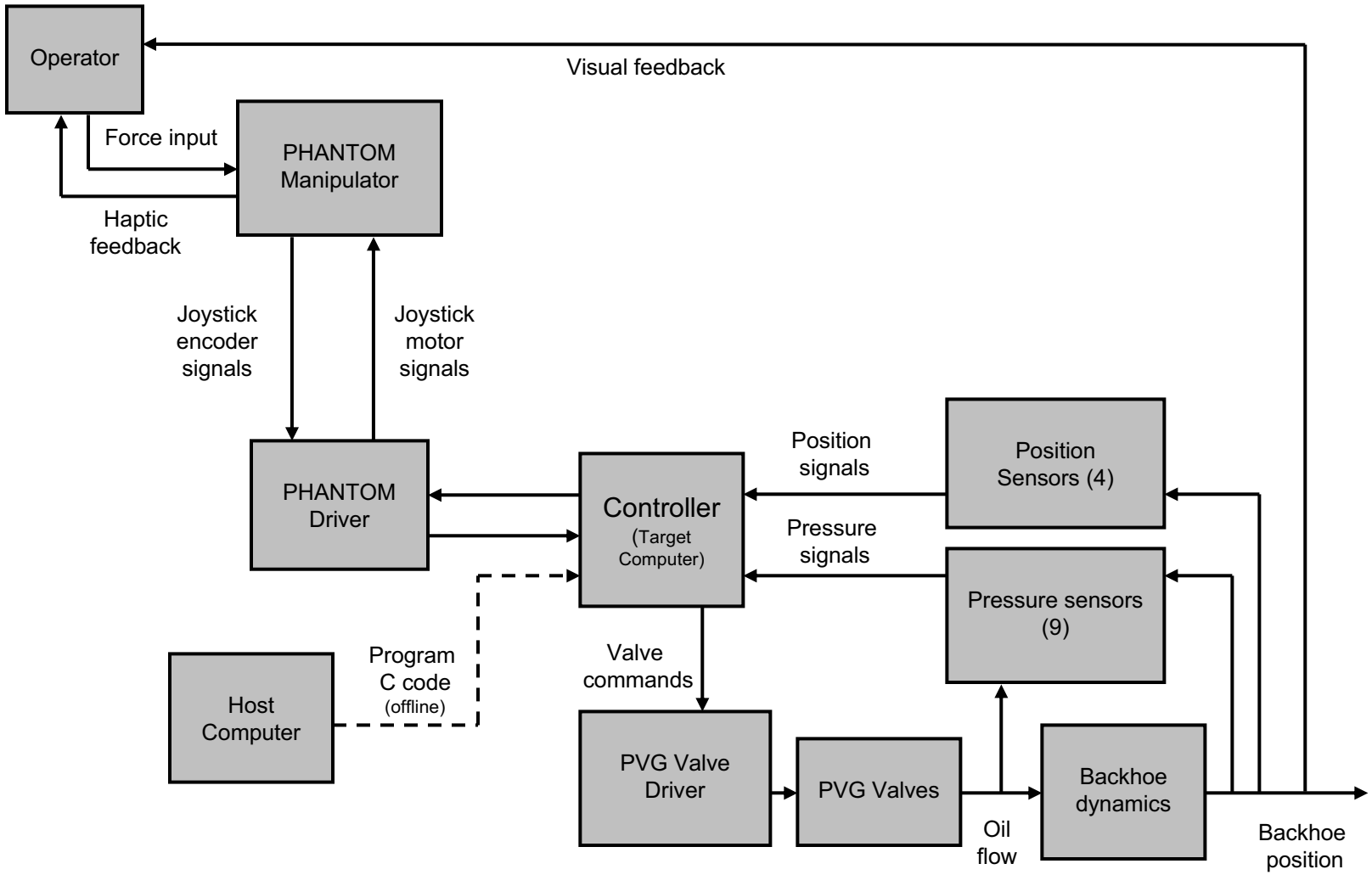
ROBOTIC BACKHOE
Hydraulic Circuit

Phase 1: Single DOF Control (Dipperstick)

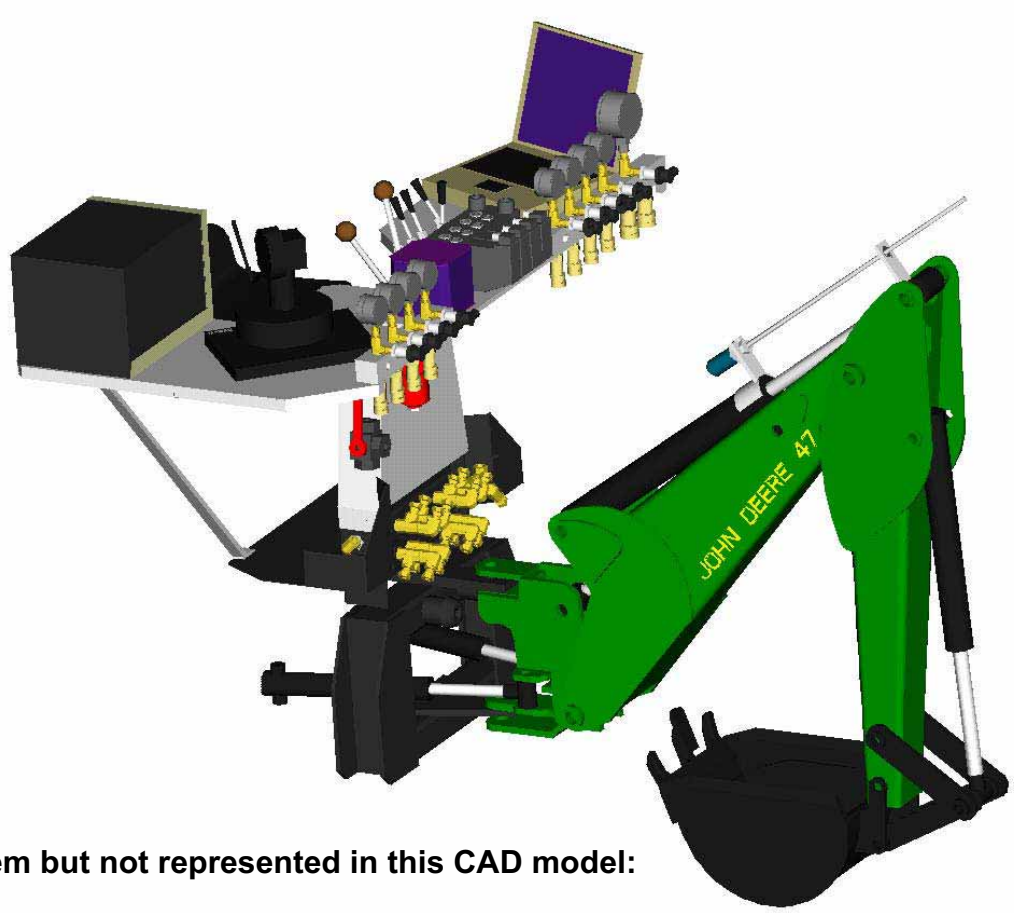


Rev. 4: 7/18/03

Signal Processing



Other Components



Components required for the functioning system but not represented in this CAD model:

- Hard tubing & fittings between PVG valves and pressure gage manifolds
- Flexible hose between couplers and Gresen block tees
- Positions sensors on swing, boom, and bucket cylinders
- Temposonics signal amplifier
- Connection to existing electrical system / auxiliary 12V car battery
- 110VAC Inverter for computer & PHANTOM
- Sensor & valve wiring
- Cables for computer and PHANTOM

See Bill of Materials for more detail

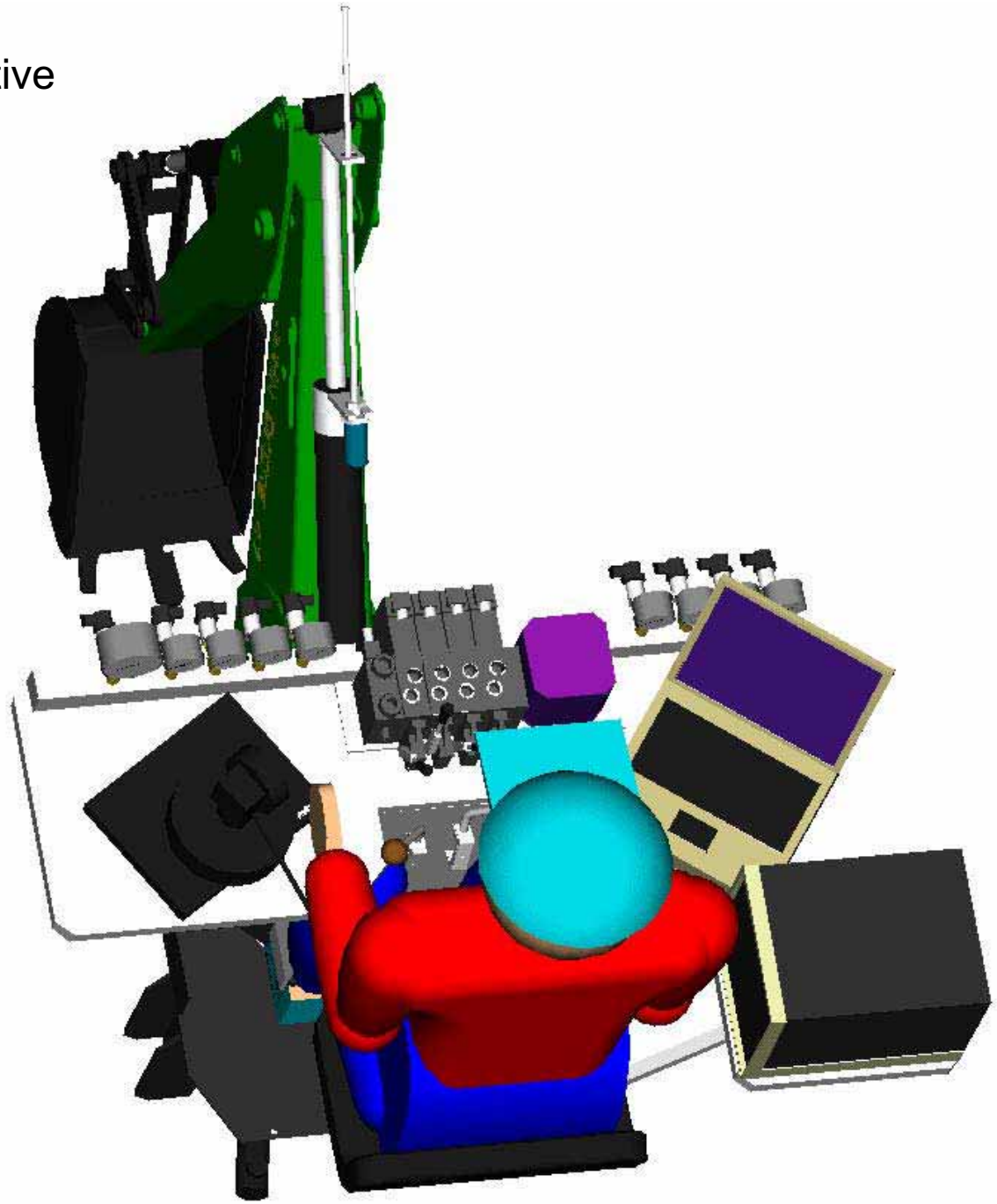
Robotic Backhoe with Haptic Display

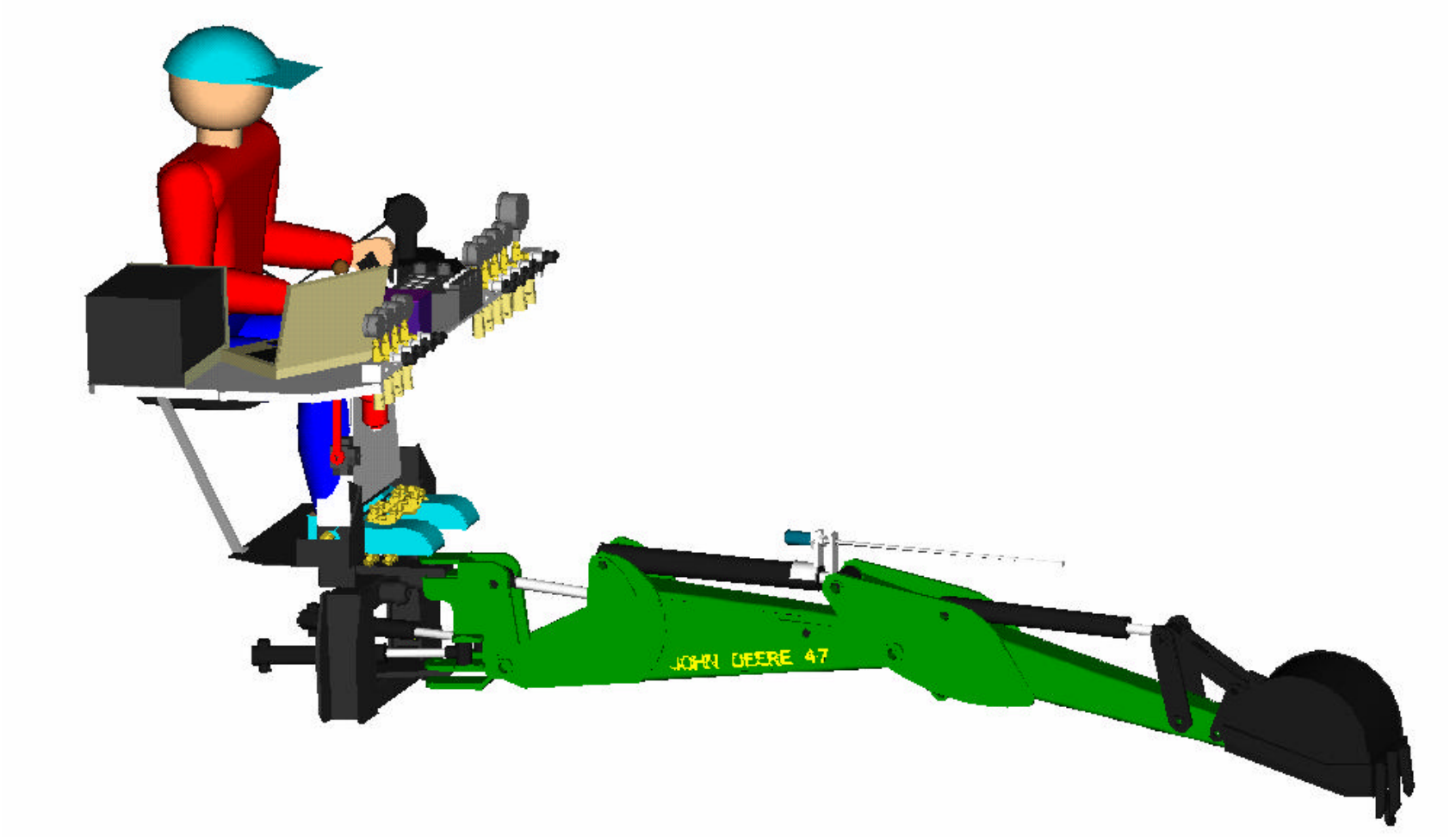
Bill of Materials

	Item	Supplier	Part#	Unit	Qty (1 dof)	Qty (4 dof)	Unit $	Total $
Valves	Proportional valve, PVES (PVG 32)	Sauer-Danfoss	4816 PVES	ea	1	4	$513	$2,052
	High pressure ball valve, 3-way diverter, 1-1/16-12 SAE	Hydac	KHB3K-20SAE	ea	0	1	grant	
	Check valve, 1-1/16-12 SAE	Hydac	RV-16-01.X/12-25	ea	0	1	grant	
Tubing & Hoses	1" Hose w/ 1/2-14 NPT ends, 24"(?)	Anchor Products		ea	2	2		
	1/2" Hose w/ 3/8-18 NPT ends, 24"(?)	Anchor Products		ea	2	8		
	1" hyd. Tubing	***on hand***		ft	10	10		
	1/2" hyd. Tubing	***on hand***		ft	5	20		
	3/4" Beugu hose clamps, HRBGS 0B GT 19.0	Hydac	264713	ea	0	4		
	Beugu head bolts, HRBGS 0A/1 ASKT M6x25	Hydac	2700852	ea	0	4		
	Beugu stirrups, HRBGS 0B BUE ST ZN	Hydac	263307	ea	0	4		
	Beugu sleeve, HRBGS 0B/2 HUE 15.5 ZN	Hydac	263419	ea	0	4		
	Beugu weld plate, HRBGS 0B AP ST BL	Hydac	263583	ea	0	4		
SAE Fittings	Branch Tee, 7/8-14 SAE	Anchor Products	10-G5G5JAO (Parker)	ea	1	1		
	Run Tee, 7/8-14 SAE	Anchor Products	10-AOG5JG5 (Parker)	ea	1	2		
	Run Tee, 3/4-16 SAE	Anchor Products	8-AOG5JG5 (Parker)	ea	3	9		
	Run Tee, 7/16-20 SAE	Anchor Products	4-AOG5JG5 (Parker)	ea	2	8		
	Straight Thread Elbow, 3/4-16 SAE	Anchor Products	8-AOEG5 (Parker)	ea	2	8		
	Straight Thread adapter, swivel, 1-1/16-12 SAE x 1/2 NPT	Anchor Products	0507-12-8 (Parker)	ea	4	16		
	Straight Thread adapter, swivel, 7/8-14 SAE x 1/2 NPT	Anchor Products	0507-10-8 (Parker)	ea	5	5		
	Straight Thread adapter, swivel, 3/4-16 SAE x 1/2 NPT	Anchor Products	0507-8-8 (Parker)	ea	1	1		
	Straight Thread adapter, swivel, 3/4-16 SAE x 3/8 NPT	Anchor Products	0507-8-6 (Parker)	ea	4	16		
	Straight Thread adapter, swivel, 3/4-16 SAE x 1/4 NPT	Anchor Products	0507-8-4 (Parker)	ea	1	1		
	Straight Thread adapter, swivel, 7/16-20 SAE x 1/4 NPT	Anchor Products	0507-4-4 (Parker)	ea	5	17		
	Straight Thread Union, 7/8-14 SAE	Anchor Products	10-F5OHAO (Parker)	ea	0	1		
	Straight Thread Red/Exp, 7/8 SAE F x 1-1/16 SAE M	Anchor Products	12-10-F5OG5 (Parker)	ea	1	1		
	Straight Thread Red/Exp, 1-1/16 SAE F x 7/8 SAE M	Anchor Products	10-12-F5OG5 (Parker)	ea	1	2		
	Hydraulic Non-Spill Coupler, 1/2 NPSF	Anchor Products	FF-501-*FP (Parker)	ea	2	2		
	Hydraulic Non-Spill Coupler, 3/8 NPSF	Anchor Products	FF-371-6FP (Parker)	ea	2	8		
	Hydraulic Non-Spill Nipple, 1/2-14 NPSF	Anchor Products	FC-502-8FP (Parker)	ea	2	2		
	Hydraulic Non-Spill Nipple, 3/8 NPSF	Anchor Products	FC-372-6FP (Parker)	ea	2	8		
Swagelock Fittings	Male Connector, 1" tube x 1-1/16-12 SAE straight thread	Georgia Valve & Fitting	S-1610-1-12ST (Swagelock)	ea	6	10		
	Male Connector, 1/2" tube x 7/8-14 SAE straight thread	Georgia Valve & Fitting	S-810-1-10ST (Swagelock)	ea	4	16		
Aluminum	2" x 2" aluminum bar, 36" long			ea	1	1		
	3/8" aluminum plate, 12.5" x 7"			ea	1	1		
Steel	1/4" plate, 24" x 24"			ea	0	1		
	12 gage (0.1046") sheet, 57" x 33"			ea	0	1		
	1" x 1/2" x 0.065" rectangular tubing			ft	0	30		

Filters	High pressure in-line filter body	Hydac	DF-BH3HC-60-G-3-B-1.1/12	ea	0	1	grant	
Pressure Measurement	Pressure gages	WIKA	23X.30 2.5" LBM 2000 psi	ea	2	8	grant	
	Pressure gages	WIKA	23X.30 4" LBM 3000 psi	ea	1	1	grant	
	Pressure transmitter, Type S-10, SAE #4, Std cable gland	WIKA	1006711 SAE #4	ea	3	9	grant	
Tools & Misc.	1" open end wrench			ea	1	1		
	1-1/16 O-ring seal counterbore			ea	1	1		
	7/8 O-ring seal counterbore			ea	1	1		
	3/4 Oring seal counterbore			ea	1	1		
	7/16 Oring seal counterbore			ea	1	1		
	10-24 x 1.5" SHCS			ea				
	3/16 x 1" Dowel Pin			ea				
	Welding rod			ea				
Signal Processing	Programming computer	***on hand (?)***		ea	1	1		
	Prometheus PC/104 Control computer	Diamond Systems	PR-Z32-EA-ST	ea	1	1		
	Jupiter-MM 50W power supply	Diamond Systems	JMM-512-V512	ea	1	1		
	Panel board	Diamond Systems	PNL-Z32-EA	ea	1	1		
	FlashDisk module 32MB	Diamond Systems	FD-32-XT	ea	1	1		
	FlashDisk / IDE extender board	Diamond Systems	ACC-IDEEXT	ea	1	1		
	Pandora Enclosure, 5.0"	Diamond Systems	PB-Z32-500-EA	ea	1	1		
	Pandora Endcap, PNL-Z32-EA cutout	Diamond Systems	PB-EC05	ea	1	1		
	Isolation Mounting Plate	Diamond Systems	PB-EC03	ea	1	1		
	Items below this line have not yet been fully specified							
Position Measurement	Position sensor	***1 on hand*** (Temposonics)	DCTM-1115	ea	1	4	$0	$0
Electrical Power	12V car battery	Napa		ea	0	1		
	Battery charger	Napa		ea	0	1		
Wiring	Position sensor cable			ea				
	Pressure sensor cable			ea				

Operator’s Perspective





Please disregard the position of the operator's feet!

To view a trenching animation of this CAD model, download the following files in .mpg format:

[trench_des1.mpg | trench_des2.mpg | trench_des3.mpg]