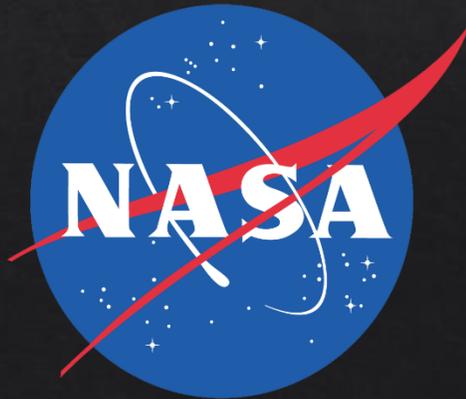


Gas House Autonomous System Monitoring

Fall Internship 2015



Luke Miller (SSC-EA34)
Ashley Edsall (SSC-EA34)

ABSTRACT

- ◆ Gas House Autonomous System Monitoring (GHASM) will employ Integrated System Health Management (ISHM) of cryogenic fluids in the High Pressure Gas Facility at Stennis Space Center. The preliminary focus of development incorporates the passive monitoring and eventual commanding of the Nitrogen System. ISHM offers generic system awareness, adept at using concepts rather than specific error cases. As an enabler for autonomy, ISHM provides capabilities inclusive of anomaly detection, diagnosis, and abnormality prediction. Advancing ISMH and Autonomous Operation functional capabilities enhances quality of data, optimizes safety, improves cost effectiveness, and has direct benefits to a wide spectrum of aerospace applications.

BACKGROUND

- ◆ Gas House provides gaseous Hydrogen, Nitrogen, Helium, and High Pressure Missile Grade Air to Stennis facilities
- ◆ Nitrogen and Hydrogen are stored as liquids and vaporized prior to delivery
- ◆ Cryogenic liquids are stored at very low temperatures and will boil when exposed to atmospheric heat
- ◆ Liquid Nitrogen boils at -321 degrees Fahrenheit
- ◆ Most gas house procedures are still operated manually



AUTONOMY

- ◇ Autonomous Operation (AO) requires no human intervention
- ◇ After unexpected events, AO continues towards the original or alternate objective
- ◇ AO incorporates adaptation, mitigation and re-planning
- ◇ Autonomy is not absolute
- ◇ Automatic vs. Autonomous



INTEGRATED SYSTEMS HEALTH MANAGEMET

- ◇ Generic system awareness capability
- ◇ Error prediction based on historical data
- ◇ Automation of complex procedures
- ◇ Tested and integrated at Kennedy Space Center - Cryogenic Testbed Laboratory



ISHM MONITORING CAPABILITIES*

- ◇ Sensor Anomalies
- ◇ Valve Anomalies
- ◇ Leak Detection
- ◇ Flow Propagation
- ◇ Diagnostics

*Concept and model based

NITROGEN SYSTEM

- ◆ Liquid Nitrogen is delivered by truck and stored in one 55,000 gallon backup reservoir
- ◆ Two 28,000 gallon tanks and a 27,000 gallon tank are used as primary storage
- ◆ Liquid is pulled from the tanks and pumped through three Skid Pumps to vaporizers for conversion to gas
- ◆ Gaseous commodity is then pushed to the site for use

LN2

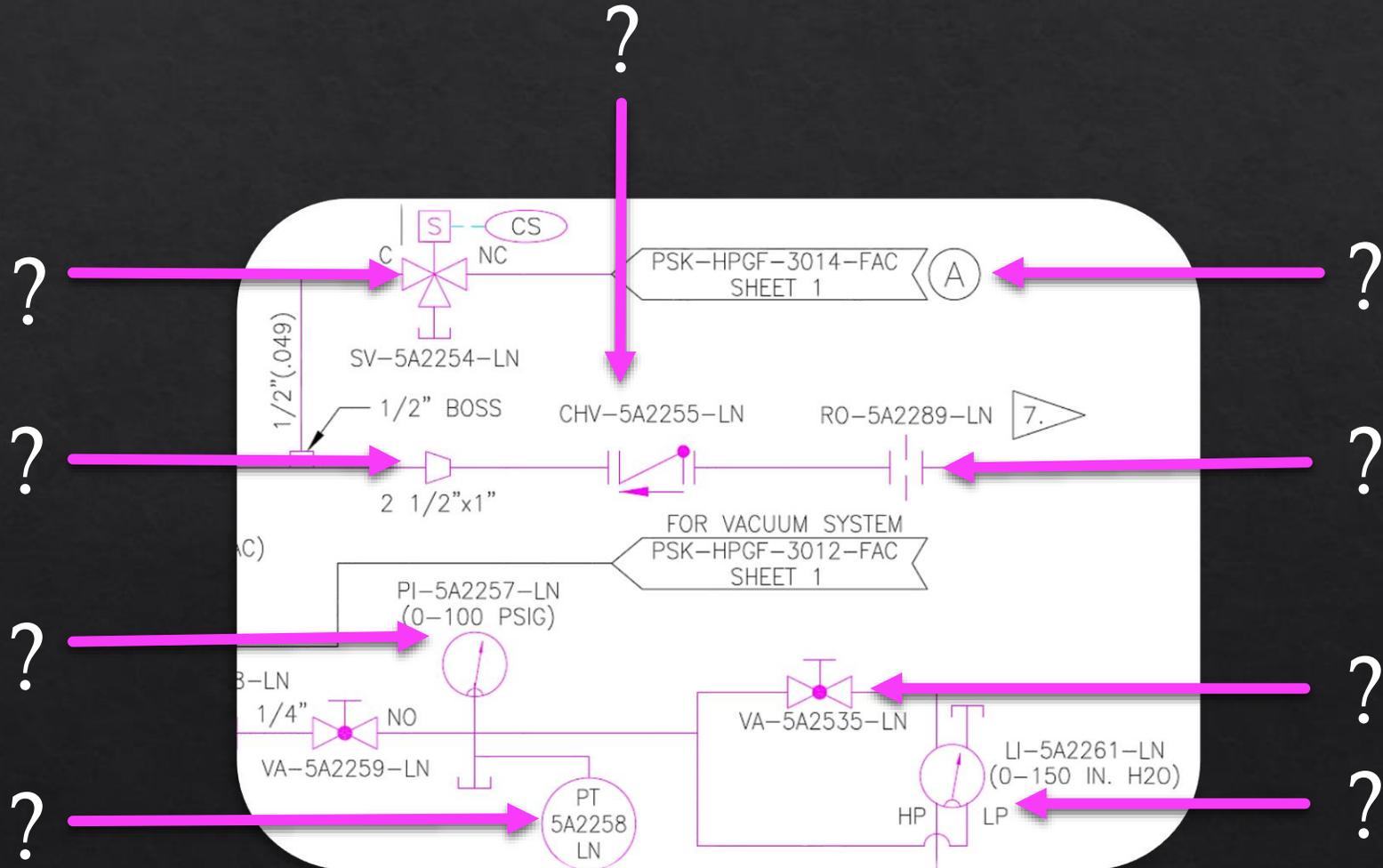
LN2

LN2

DESIGN APPROACH

- ◇ Toolkit is written using the G2 software platform (Gensym)
- ◇ The Nitrogen system is divided into 22 distinct schematic sheets
- ◇ Each sheet represents a functional unit
- ◇ All technical information on a sheet will be preserved
- ◇ Sheets must be visually separate but connected programmatically
- ◇ ISHM Toolkit objects will be used to ensure genericity
- ◇ Newly added objects and procedures will be pushed to the toolkit
- ◇ All components will be represented by their functional counterparts in the toolkit
- ◇ Every connection will have a piping section between the two objects

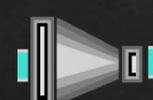
COMPONENT IDENTIFICATION



COMPONENT IDENTIFICATION

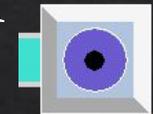
Check Valve 

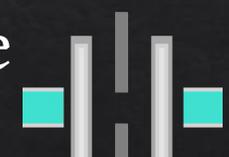
 3-Way Solenoid Valve

 Reducer

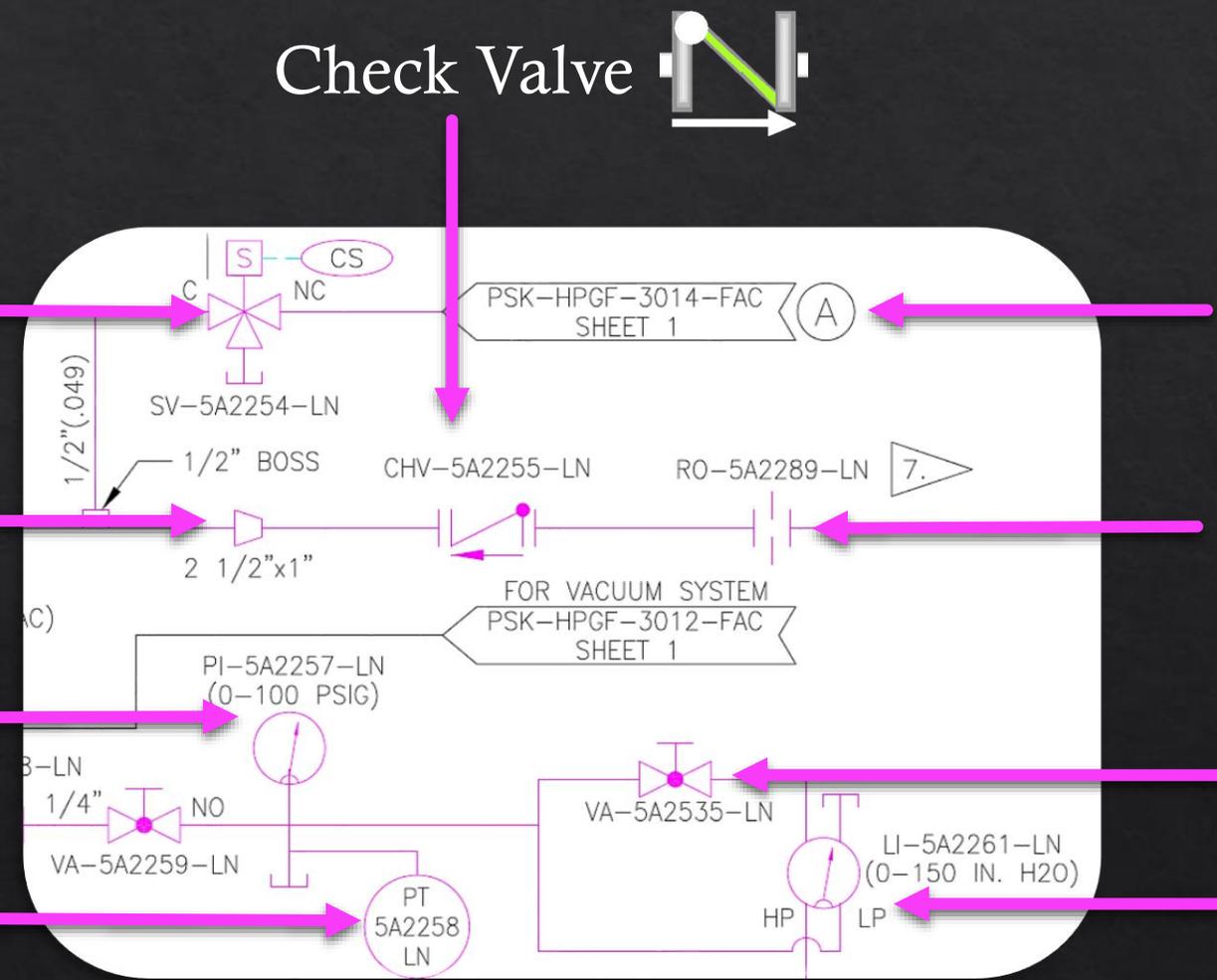
 Pressure Indicator

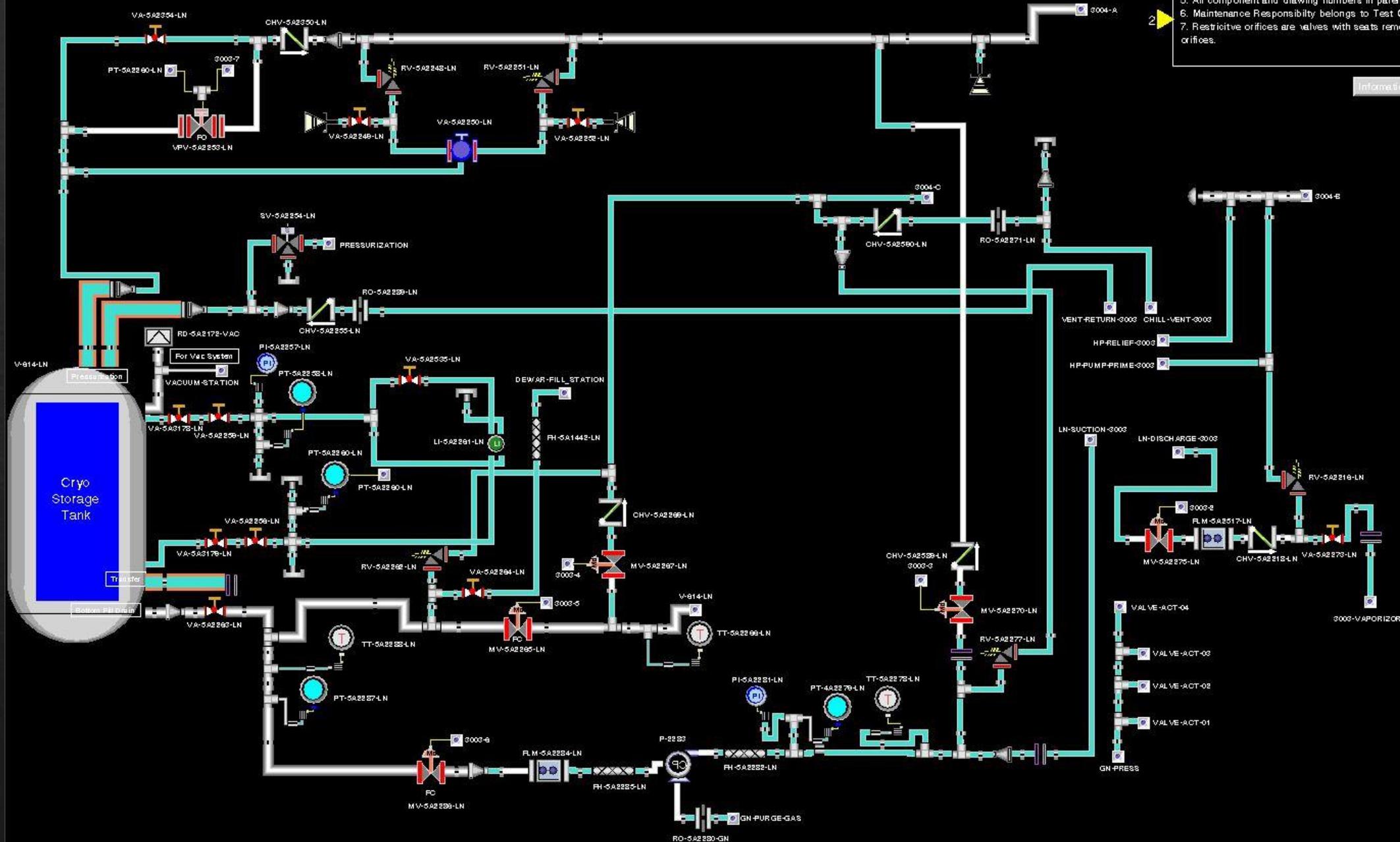
 Pressure Transducer

Connection Post 

Restrictive Orifice 

Globe Valve 
Level Indicator 





- NOTES:**
1. Pressure indicators do not require calibration unless otherwise indicated.
 2. Reference 54000-P001, legend and general notes.
 3. System cleanliness per PRTSTD-8070-001. Maintain clean level 1000A unless indicated otherwise.
 4. All tubing and fittings to conform to SSTD-8070-0126.
 5. All component and drawing numbers in parenthesis are for reference only.
 6. Maintenance Responsibility belongs to Test Operations Contractor (TOC).
 7. Restrictive orifices are valves with seats removed to work as variable restricting orifices.

Information

2

DESIGN TRADE-OFFS

- ◇ Icons can lack visual accuracy and require extensive time allotted for design
- ◇ Icons are restricted to rectangles, leaving gaps between connections on contoured objects
- ◇ G2 has no “undo” functionality
- ◇ Programming syntax in G2 can be convoluted
 - ◇ Ex. “for locsend = each item upon the workspace of Thing do”

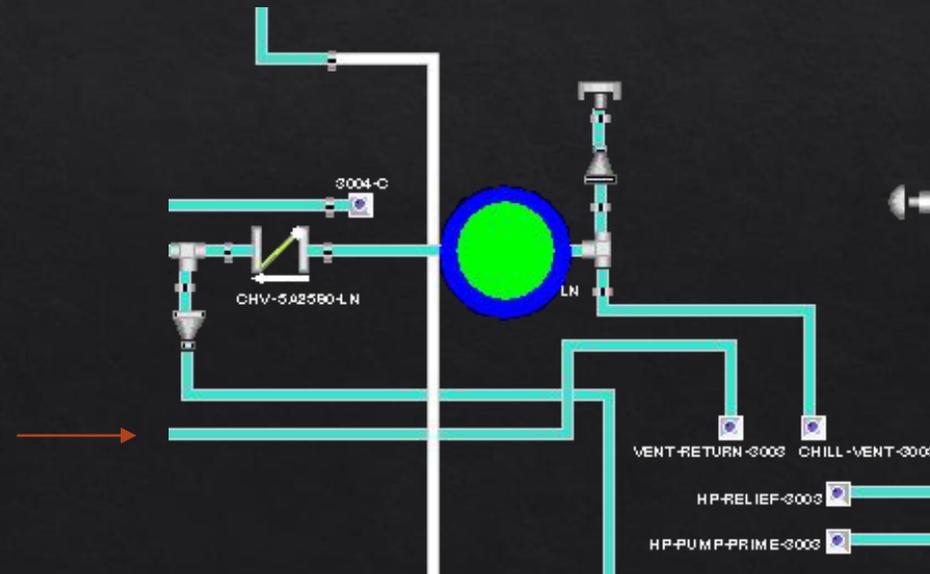
NEWLY IMPLEMENTED COMPONENTS

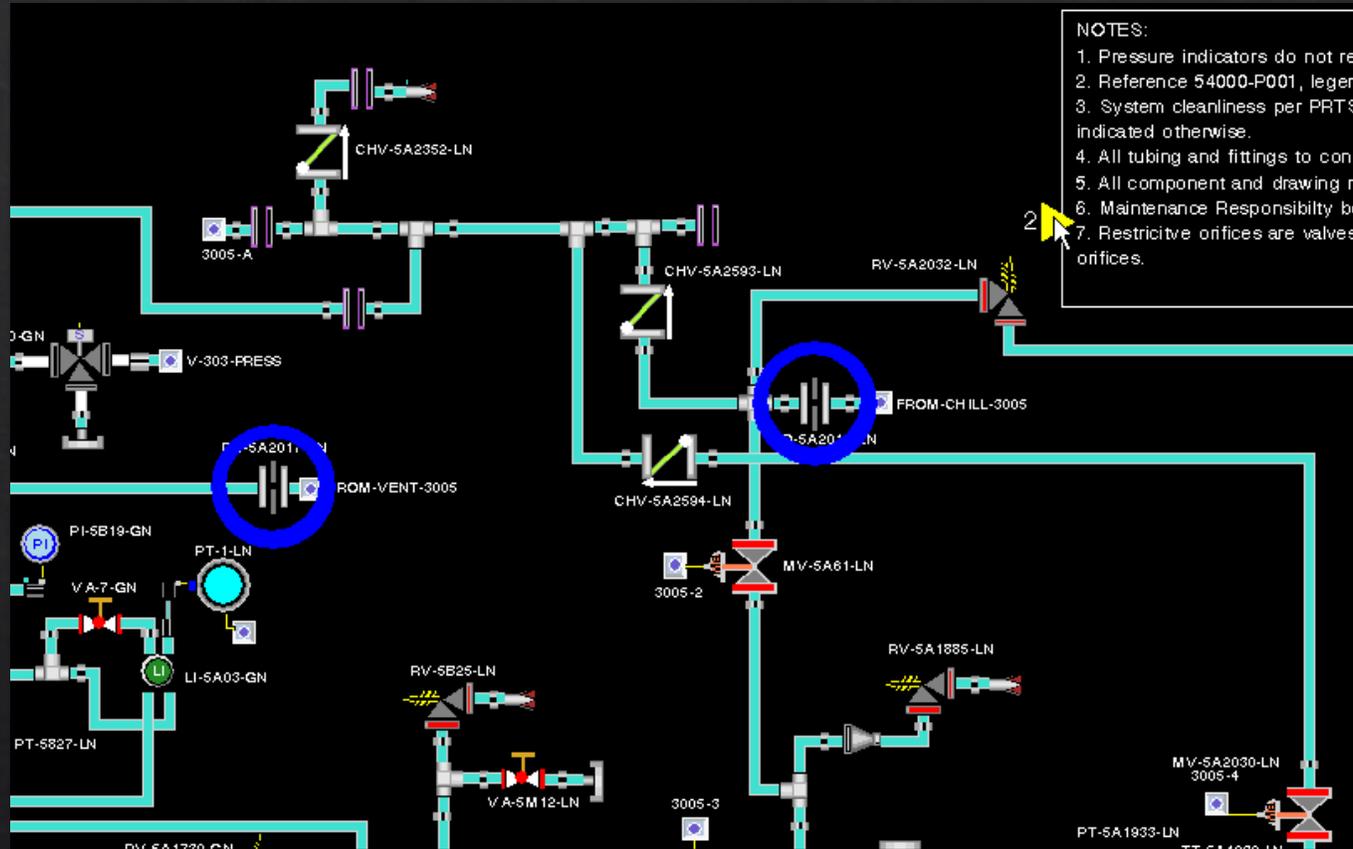
HM-NOTE-FLAG

- ◇ Visual representation linking schematic notes to the corresponding objects
- ◇ Clicking a note flag will temporarily highlight associated objects
- ◇ Number indicator represents amount of objects affected

Linka	RO-2289
Linkb	RO-2271

2 ▶ 6. Maintenance Responsibility belongs to Test Operations Contractor (TOC).
7. Restrictive orifices are valves with seats removed to work as variable restricting orifices.





- NOTES:
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ACS-LABEL-VIEW

- ◆ Preserves sheet notes within ISHM Domain
- ◆ Contains authoritative signatures
- ◆ Each field is populated by an attribute of the instance
- ◆ Clicking the “Label Sheets” button will refresh the display fields

SheetChecked	Luke Miller
SheetDrawn	Ashley Edsall



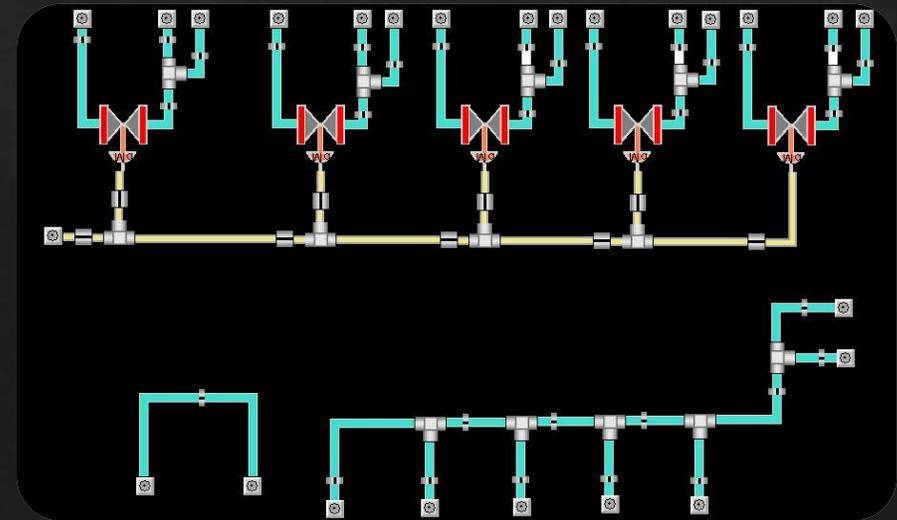
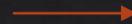
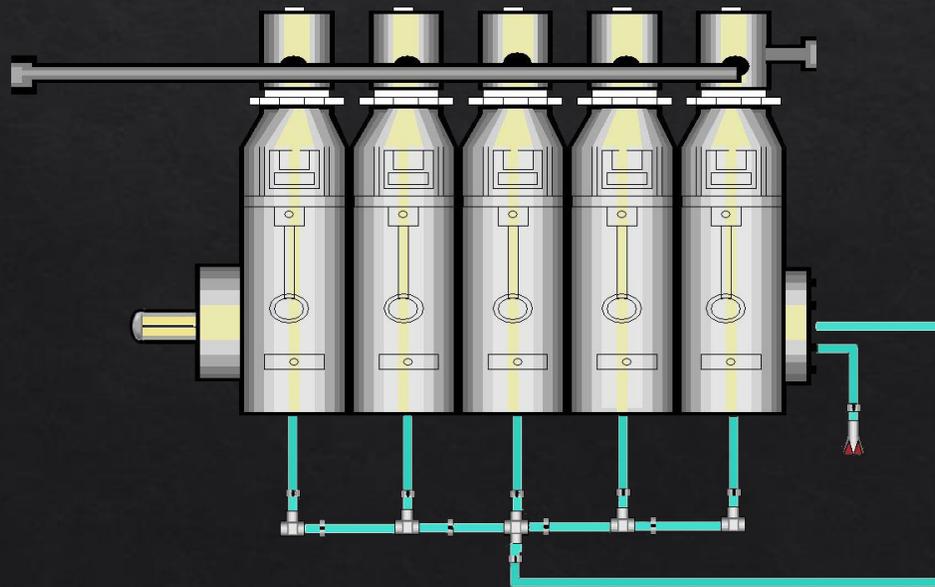
Label Sheets



23	FAKE	This isn't real	15/15/45	LM
Sym	Zone	Description	Date	Approved
Revisions				
Drawn	Luke Miller	05/12/54	National Aeronautics and Spaghetti Administration Spaghetti Sauce Center Ragu, NJ 80546	
Checked	Ashley Edsall	05/45/48		
Engineer	Luke Miller	45/15/23		
Engineer	Ashley Edsall	15/45/95		
Eng. Environmental	Luke Miller	45/78/32		
Site/Facility Manager	Ashley Edsall	15/02/89		
Concurrence	Luke Miller	05/15/76		
Submitted	Ashley Edsall	06/17/15		
Safety	Luke Miller	12/12/89	Size	Dwg No.
Approved	N/A	N/A	Issued Cef	Authority
			Authority	Sheet
				1 of 1

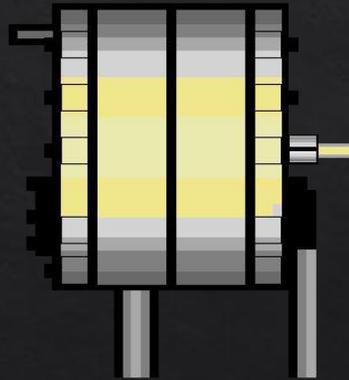
HM-SUBWORKSPACE-SKID

- ◇ Represents Nitrogen Skid Pumps
- ◇ Inputs of various connection types are handled with the subworkspace
- ◇ Valves are toggled by the status of the skid-motor



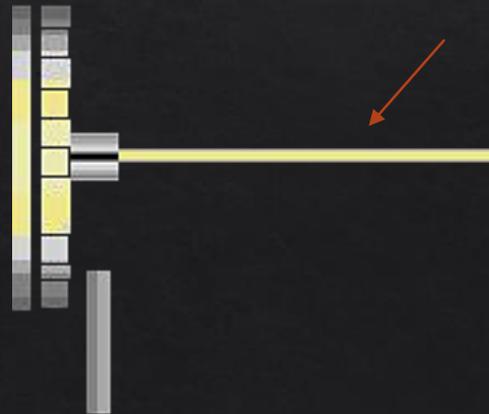
HM-SKID-MOTOR

- ◇ HM-Skid-Motor represents the motor driving each skid
- ◇ Controls the discrete valves within the skid over an “axle connection”



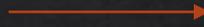
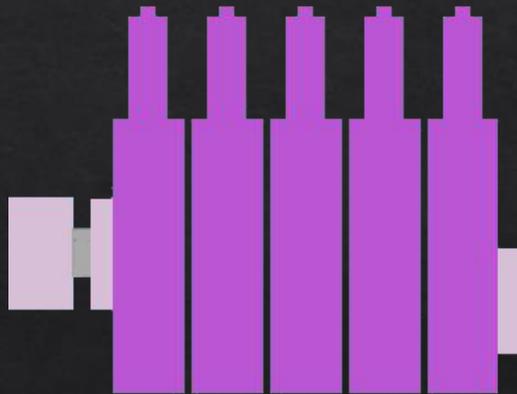
HM-AXLE-CONNECTION

- ◇ *Hm-axle-connection* represents a physical axle running between the Skid motor and the pistons within the skid
- ◇ Creates a link between the skid pump and enclosed discrete motor valves
- ◇ When the motor is on, the discrete motor valves will be simulated as open



ACD-NITROGEN-PUMP (Operational Screen)

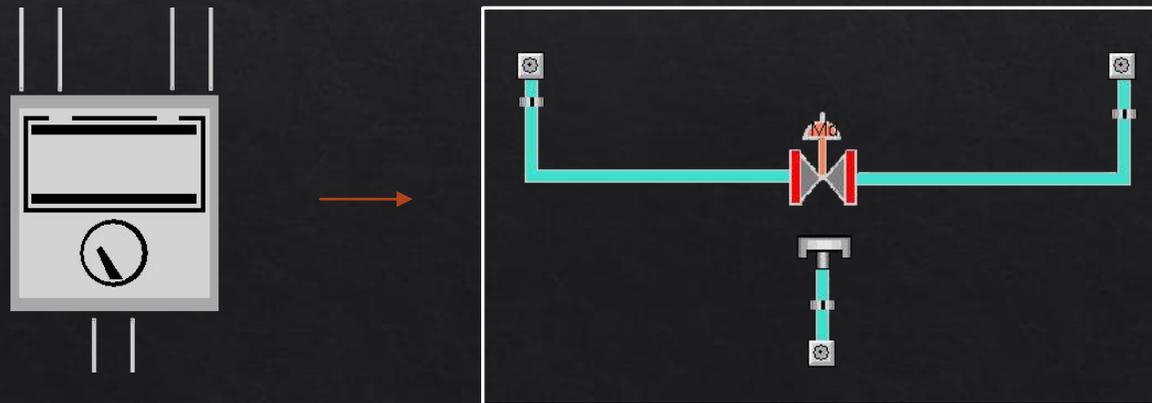
- ◇ Represents skids within the display domain
- ◇ Provides click access to informational and commanding screens



Run Mode	<input type="radio"/> Manual	Auto Start Pressure	2700 PSI	
	<input type="radio"/> Auto	Auto Stop Pressure	3970 PSI	
SKID 1	<input type="radio"/> Primary	<input type="radio"/> Secondary	<input type="radio"/> Backup	<input type="radio"/> Off-line
SKID 2	<input type="radio"/> Primary	<input type="radio"/> Secondary	<input type="radio"/> Backup	<input type="radio"/> Off-line
SKID 3	<input type="radio"/> Primary	<input type="radio"/> Secondary	<input type="radio"/> Backup	<input type="radio"/> Off-line

HM-CONTROLLER-PIC

- ◆ Utilizes pressure upon a pneumatic piston to actuate an opening, thus controlling the flow of commodity
- ◆ This controlled flow is then used as pneumatic actuation input to control another valve



DISP-CENTRIFUGAL-PUMP-NO-LOGO

- ◆ Represents a centrifugal boost pump within the ISHM display domain
- ◆ Modified from existing solution to function in any orientation



HM-DISCHARGE-MANIFOLD

- ◇ Fluid path element that distributes liquid Nitrogen between multiple channels
- ◇ Serves as a hub to connect multiple piping sections (13 in our application)



HM-DISPLAY-LUBE-OIL-UNIT

- ◆ Provides pressurized lubrication oil to each of the skids
- ◆ Exhibits crucial status information about the entire Lube Oil Systems

Lube Oil Unit 1

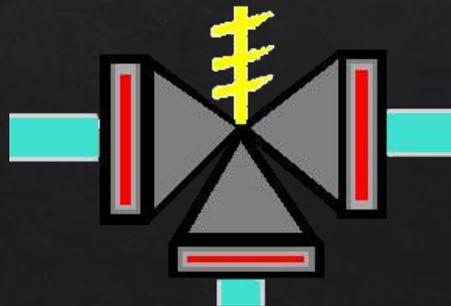
Overall Run Time (Hours) | 0

Lube Info



HM-3WAY-RELIEF-VALVE

- ◆ Used to relieve pressure in a segment of pipe when the pressure exceeds a specific threshold
- ◆ Pressure threshold is relieved by allowing commodity to flow through an auxiliary pathway to atmosphere



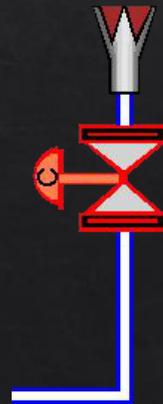
HM-PLUG

- ◆ A plug is a convenient solution for preventing the flow of commodity at the end of piping section.
- ◆ The plug helps to bind a piping subsystem within the ISHM Domain



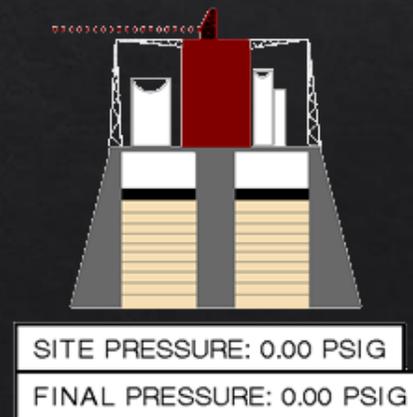
DISP-SMALL-FLOWPIPE

- ◆ Used to highlight alternate commodity flow path in the display domain
- ◆ Disp-flowpipe outlines the primary flow path



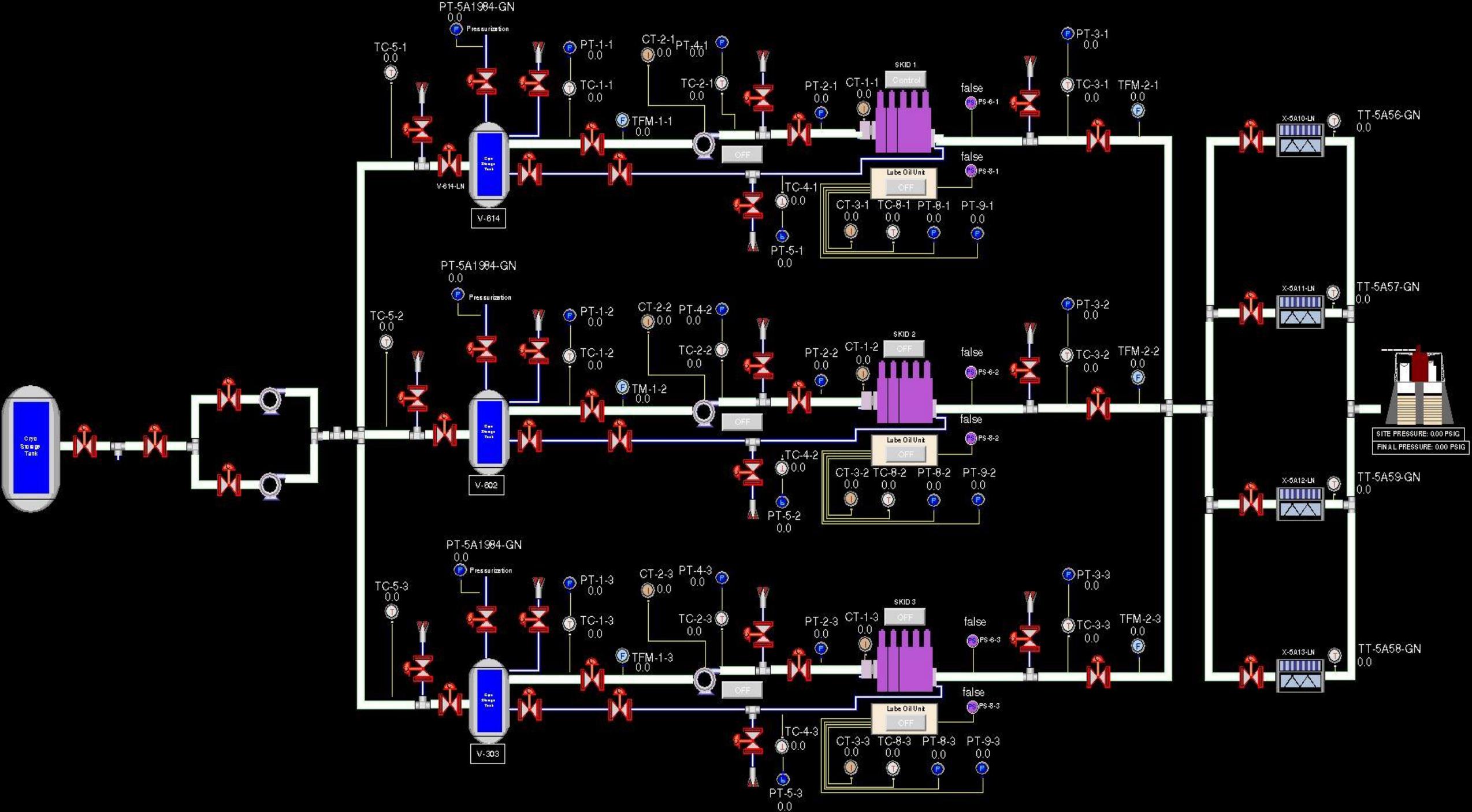
DISP-SITE-PRESSURE

- ◇ *Disp-Site-Pressure* visually represents the overall site pressure of Stennis Space Center
- ◇ Skids respond automatically to given pressure threshold
 - ◇ Above: deactivate
 - ◇ Below: activate



OPERATIONAL SCREENS

- ◆ It's crucial that users only see information pertinent to system operations and functionality
- ◆ On the Display Domain, each object is of the display class and is linked to an ISHM object with the identical key
- ◆ Highlight important sensors, valves, and controls essential for optimal processing at the High Pressure Gas Facility
- ◆ Commodity state is represented by blue (liquid) or yellow (gaseous) piping colors



PROFESSIONAL GROWTH

- ◇ Experience developing software in an expert/knowledge system environment for intelligent operations
- ◇ Involvement with intellectually charged, inspiring team in a challenging atmosphere
- ◇ Contributions to project expansions at Kennedy Space Center
- ◇ Interactions with operators currently using the system
- ◇ Exposure to cryogenics engineering

FUTURE GOALS

- ◆ Incorporation of programmable logic controller (PLC)
- ◆ Installation of passive monitoring system at facility
- ◆ Active commanding of the Nitrogen System
- ◆ Integration with the Hydrogen System