Status of the MICE Diffuser

m. apollonio, j. cobb, m. dawson, t. handford,
p. lau, w. lau, j. tacon, m. tacon, s. yang-lau

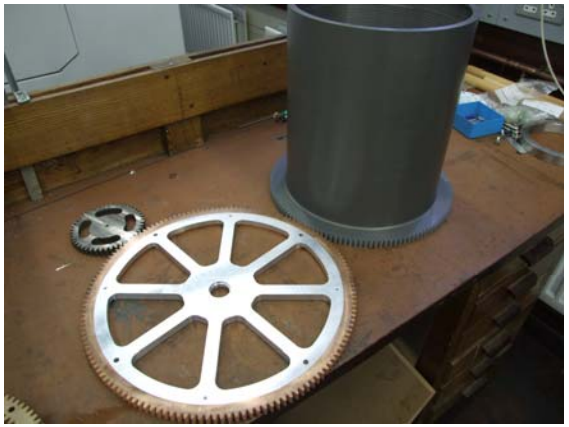
University of Oxford

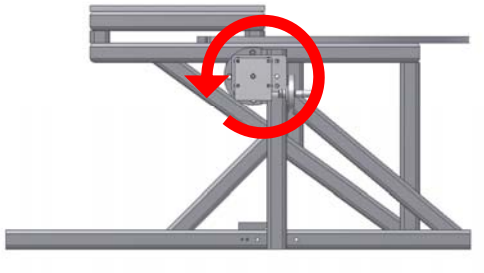
Tasks:

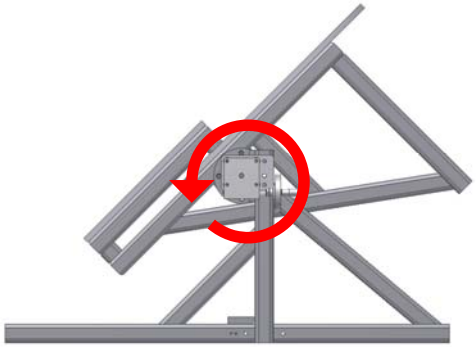
- mechanics: (j. & m. tacon)
  - cutting parts
  - build stand
  - assembly
  - test
- control system: (ma, m. dawson)
  - design logic
  - design air system
  - build air system (valves + front panel)
  - test motor + air system
  - air system: (p. lau, m. dawson, t. handford)
- electronics (m. dawson)
  - design
  - construction (circuit + control/front panel …)
  - test
- integration (all together …)

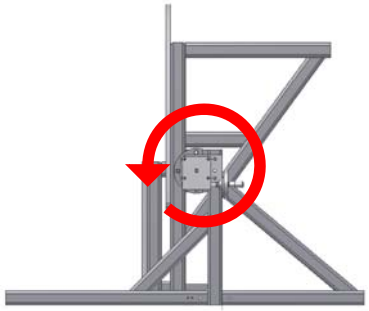
1) parts cutting goes on (~60% completed, m. tacon), feb 08
   1 FTE effort
2) stand is designed and will be built after (1)

J. Tacon









45 Degree Position

Carousel Base Plate

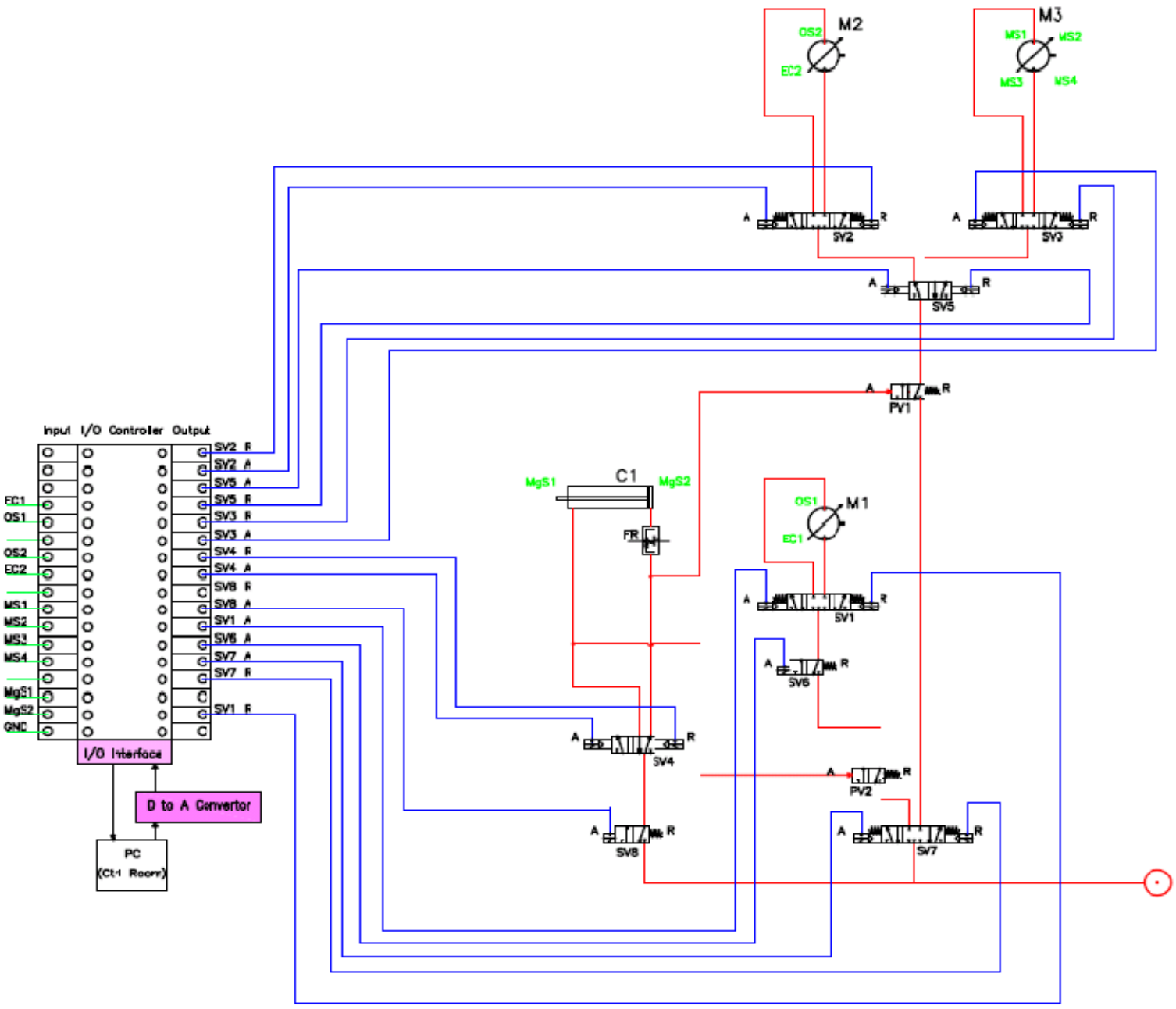
Diffuser Interface Plate

J. Tacon

air supply in MICE Hall

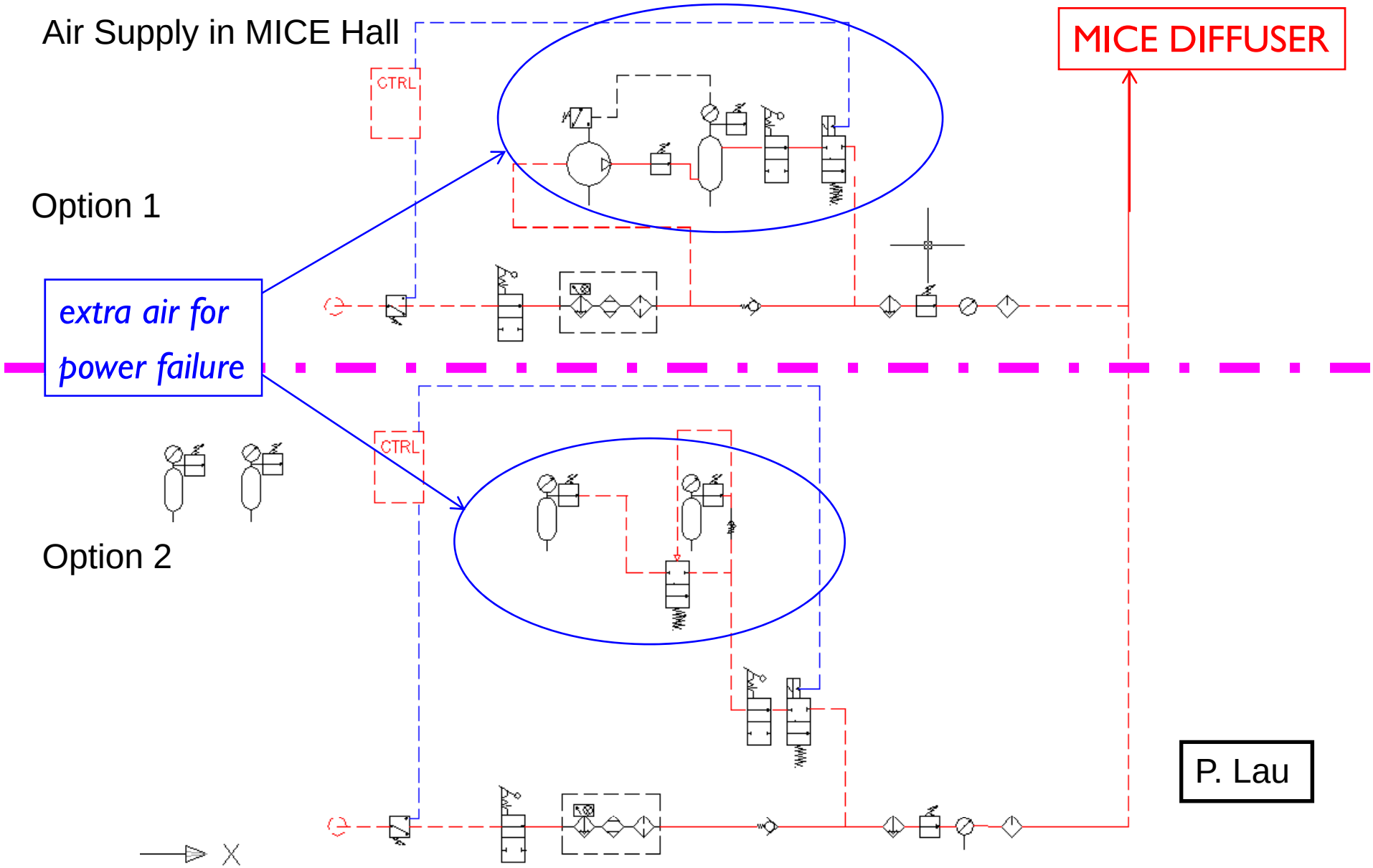
- Normal Air supply would be provided to MICE Hall (10 bar line)
- Additional air required in case of power failure
- Air volume required for safety parking of lead disc is 0.7 cubic meter @ ~10 bar

P. Lau



P. Lau
T. Handford
M. Dawson

Air Supply in MICE Hall



Option1	Option 2
Compressor plus an Air tank: size for 1m^3 @ 40 bar: 800 mm dia x 2700 mm height	Bottles of 200 bar compressed air (by BOC)
Advantage Completely independent	Advantage Less Space, Less Cost, Not Noisy
Disadvantage Space, Costly and Noisy Required regular maintenace (drainage)	Disadvantage Inventory, and require regular check on the bottle's pressure

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Compressed Air Cylinder Sizes

Size Reference	V	S	N
Approx. Dimensions (cm)	94x14	87x20	146x23
Approx. Gross Weight (kg)	19	34	82
Approx. Nominal Contents (m^3)	1.8	3.5	8.9
Fill Pressure (bar)	200	200	200

= 0.89 m^3 @ 10 bar

MCP Size

Size Reference	WN (15xN)	QN Quad* (12xN)
Approx Dimensions (cm)	129x181x84	109x110x200
Approx Gross Weight (kg)	1500	1200
Approx Nominal Contents m^3	133	107

*Offshore customers only

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Oxidant Gases

Compressed Air
Technical information, applications and packages available

Oxygen (O_2)
Technical informatio
packages available

▲Top

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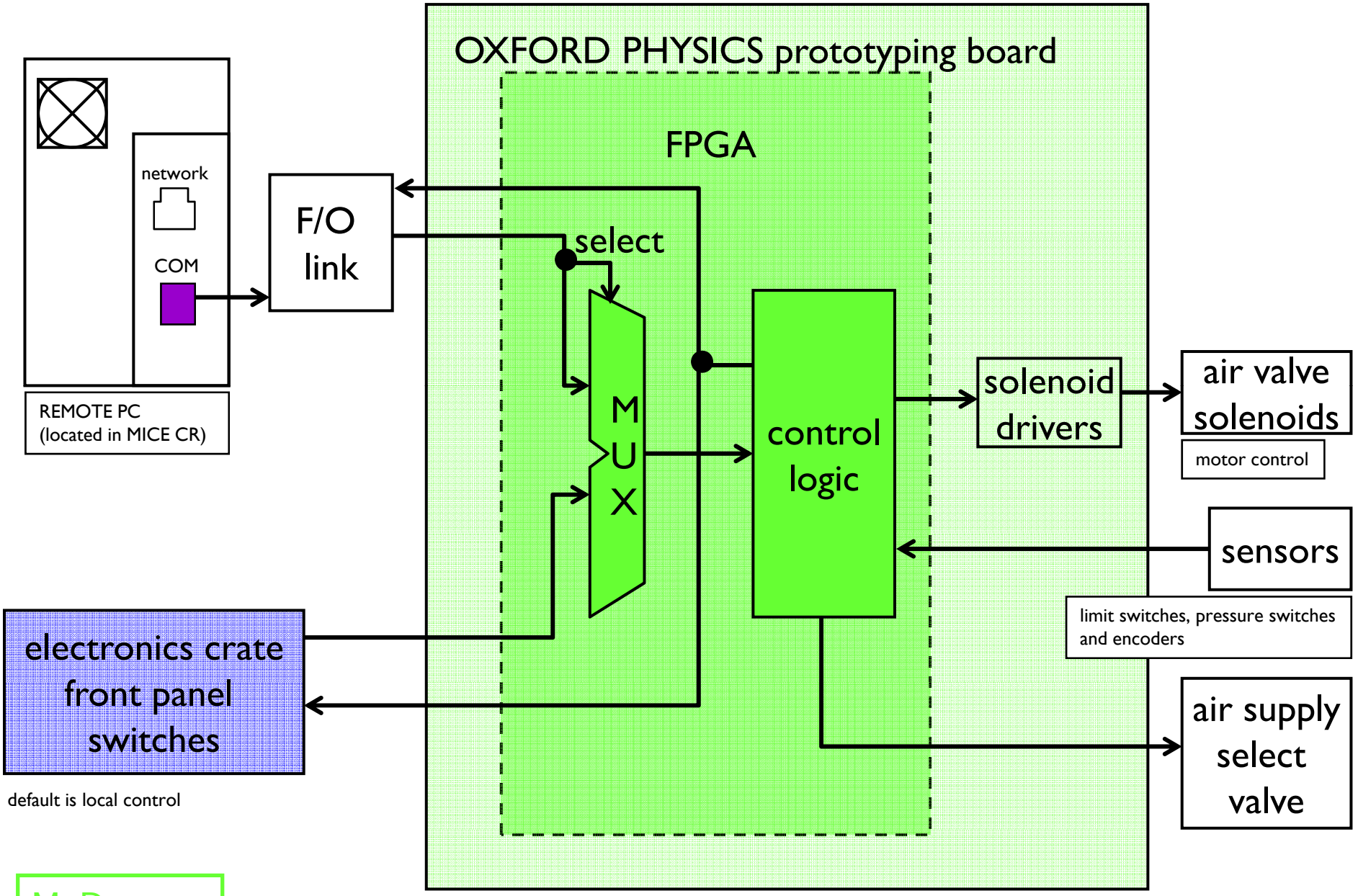
P. Lau

Control:

1) define the state diagrams for
   - normal operations
   - escape sequence (= power failure)
2) implement in verilog for FPGA

Electronics:

- circuit design
- realisation
- test functions


OXFORD PHYSICS prototyping board
FPGA
network
COM
REMOTE PC
(located in MICE CR)
F/O
link
select
M
U
X
control
logic
solenoid
drivers
air valve
solenoids
motor control
sensors
limit switches, pressure switches
and encoders
air supply
select
valve
electronics crate
front panel
switches
default is local control

M. Dawson

PROPOSED DIFFUSER CONTROL SYSTEM

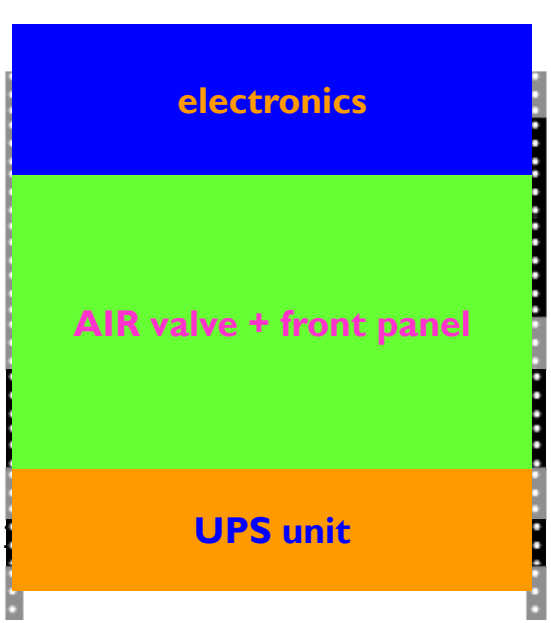
CONTROL SYSTEM COMPRISING OF:

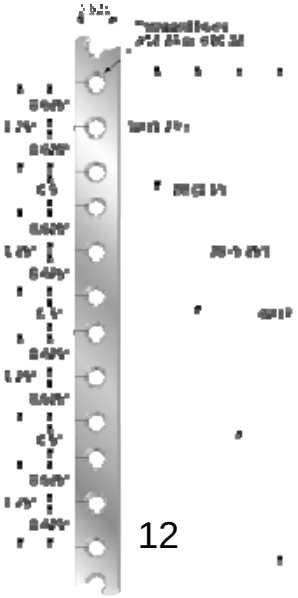
- PC situated in control room for remote control and monitoring running Labview.
- A half height 19"cabinet (approx 60cm x 66cm x 60cm) situated close to Diffuser containing 2 - 3 individual 19"crates.
  - Top crate - Electronics.
  - Middle crate - Air valve assemblies.
  - Bottom crate – UPS.
- UPS unit to maintain control of diffuser in the event of an electrical power loss.
- Emergency Air supply via storage bottles 2x(146 x 23 cm).
- Remote communications via Fibre Optic link between the Electronics crate and the remote PC.

For initial setup and testing of the control system and mechanical components, the operation of the diffuser will be in local mode from the electronics crate front panel push buttons.

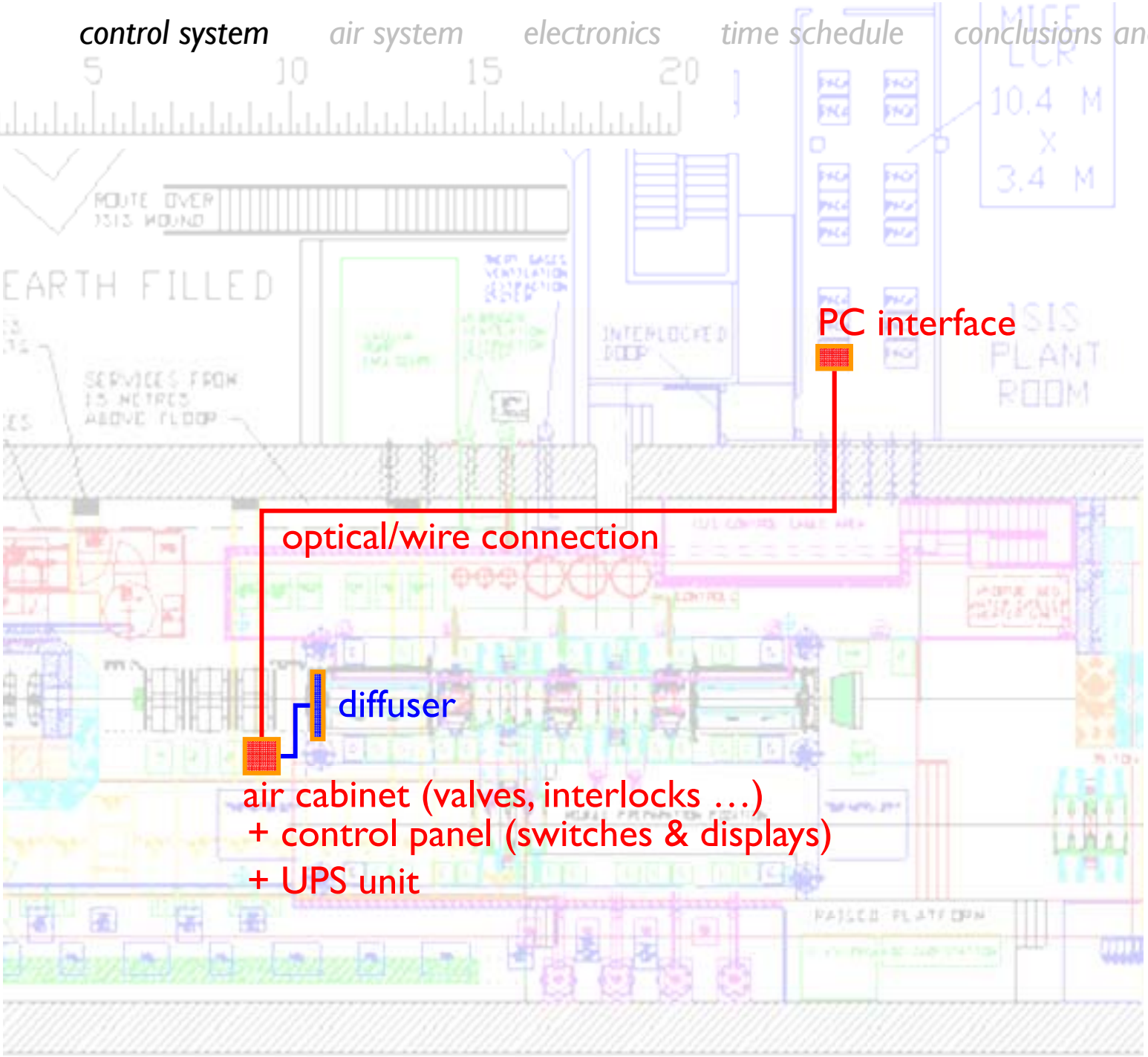
HALF HEIGHT CABINET (12U – 15U):

- Top crate (3U - 4U) containing:
  - Diffuser control software held on a Xilinx field programmable gate array (FPGA) mounted on a standard Oxford Physics prototyping interface card.
  - Interface electronics – signal conditioning.
  - Fibre Optical link for remote control and status monitoring.
  - Front panel for control via push buttons and status indication.
  - Single phase AC supply input power.
  - Air valve solenoid drivers.
- Middle crate (4U - 6U) containing:
  - Kuhnke solenoid operated Air valves for motor control.
  - Front panel legend for system status display.
  - Air supply control valve to select Air source between:
    - Building air supply.
    - Emergency Bottles supply.
- Bottom crate (2U – 3U) UPS.





M. Dawson 09/02/08


PC interface
optical/wire connection
diffuser
air cabinet (valves, interlocks …)
+ control panel (switches & displays)
+ UPS unit

PROVISIONAL MICE DIFFUSER CONTROL SEQUENCE

Initialisation (first power up):

- Unlock carousel (Retract piston – check mechanical switch pos).
- Rotate Carousel (ACW) to encoder 1 ref point (blank finger aligned with position 0).
- Lock Carousel (piston extended).
- Stop (air OFF to carousel drive motor).
- Zero Carousel counter (clocked by counter 1).
- Park position set (blank finger in position 0).
- Write counter 1 value to file.
- Return to start state.

Load disc:

- Select required disc position.
- Write disc selection (disc position number – counter 3) to file.
- Unlock Carousel (piston retracted).
- Air ON to carousel drive motor.
- Rotate selected disc position to disc check position (position 1).
- Lock Carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 value to file.
- Check disc sensor.
    - No Disc present unlock carousel & return to park position & flag error. Return to start state.
    - Disc present, unlock carousel & continue to carrier position (position 0).
- Selected disc position in carrier position (counter 1 reading).
- Lock Carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 value to file.
- Rotate disc holder to align disc loading pins on carrier (opto electronic sensor).
- Reset counter 2 (clocked by encoder 2).
- Write counter 2 to file.
- Drive carrier up to insert pins (micro switches 1 & 2).
- Rotate disc holder (ACW) 30 degrees (counter2) to release disc from holder and load into carrier.
- Drive carrier to bottom of top hat (micro switches 3 & 4).
- Unlock carousel.
- Air ON to carousel drive motor.
- Rotate carousel to park position.
- Lock carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 to file.
- Return to start state

Unload disc:

- Read current disc selection position from file (counter 3).
- Unlock Carousel.
- Air ON to carousel drive motor.
- Rotate carousel disc selection position to position 0.

- Lock Carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 value to file.
- Rotate disc holder to align disc loading pins on carrier (opto electronic sensor).
- Reset counter 2 (clocked by encoder 2).
- Rotate disc holder (ACW) 30 degrees (counter 2) ready to receive disc from carrier.
- Drive carrier up to insert pins (micro switches 1 & 2).
- Rotate disc holder (CW) 30 degrees (counter 2) to lock disc into holder.
- Drive carrier to bottom of top hat (micro switches 3 & 4).
- Unlock carousel.
- Air ON to carousel drive motor.
- Rotate carousel to park position.
- Lock carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 to file.
- Reset selected disc position counter (counter 3).
- Return to start state.

Disc change:

- Select required disc position.
- Write disc selection (disc position number – counter 3) to file.
- Read counter 1 from file.
- Unlock Carousel.
- Air ON to carousel drive motor.
- Rotate selected disc position to position 3.
- Lock carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 to file.
- Reset selected disc position counter (counter 3).
- Return to start state.
- Wait for return to park command.

Return to park position:

- Read counter 1 from file.
- Unlock carousel.
- Air ON to carousel drive motor.
- Rotate carousel to park position.
- Lock carousel.
- Stop (air OFF to carousel drive motor).
- Write counter 1 to file.
- Return to start state.

M.Dawson 08/02/08

STATE diagram + ESCAPE sequence

TIME to reach a safe position

DISC CHANGING SEQUENCE (disc a to disc b)

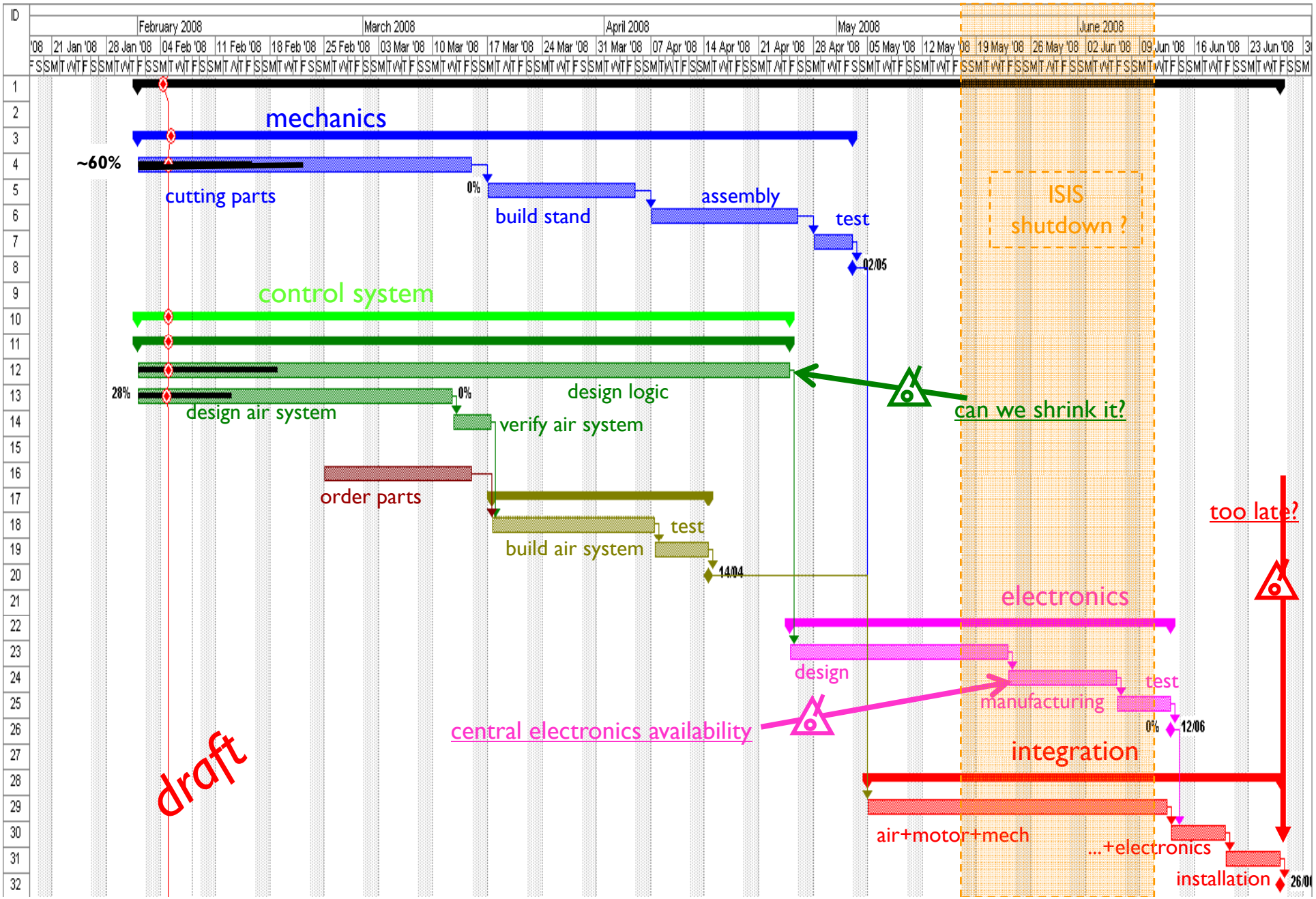
	STATE	description [NSC: Next Safe Configuration]	INPUTS: S(n+1)=F(S(n); I(n))	COMMENTS	TIS [Time In State] (s	
	1..			disc a in situ		
1	1.0.1	piston IN [E]	remove_piston&&piston_IN&&!rotate		0	5
2	1.0.2	piston OUT [E2]	rotate_CARO==(signal_rotate&&!piston_IN); rotate_CARO&&!search_zero		5	5
3	1.1.1	move CARO @ full speed to final POS [E1]	close_to_final_position		270	50
4	1.1.2	hinge CARO when close to final POS [E1]	final_position_reached		30	30
5	1.0.2	piston OUT: CARO in still mode @ final POS [E2]	insert_piston&&!signal_rotate&&!piston_IN		5	5
6	1.0.1	piston IN: CARO locked and still [E]	1-->3		5	5.25 5
7	3.0.1	CAR in still mode (bottom) [E]	signal_OUT	remove disc a	0	5
8	3.2.	pull CAR out [E3]	□S1 +□S2		166	166
9	3.0.2	CAR in still mode (top) [E]	3-->2 CAR		0	2.7667
10	2.2.	CAR engaged mode [E]	rotate -	CARrier engaged	0	0
11	2.1.2	rotate - mode [E4]	15_deg_reached		13	30
12	2.1.	free disc state [E4]	rotate -		0	30
13	2.0.2	rotate - mode [E4]	0_deg_reached		13	30
14	2.0.	HOL engaged [E4]	2-->3 HOL	HOLder engaged	0	0.4333 30
15	3.0.2	CAR in still mode (top) [E]	signal_IN	move CARrier to bottom	0	5
16	3.1.	push CAR in [E3]	□S3 + □S4		166	166
17	3.0.1	CAR in still mode (bottom) [E]	3-->1		0	2.7667 5
18	1.0.1	piston IN [E]	remove_piston&&piston_IN&&!rotate	move to next disc	0	5
19	1.0.2	piston OUT [E2]	rotate_CARO==signal_rotate&&!piston_IN; rotate_CARO&&!search_zero		5	5
20	1.1.1	move CARO @ full speed to final POS [E1]	close_to_final_position		270	50
21	1.1.2	hinge CARO when close to final POS [E1]	final_position_reached		30	30
22	1.0.2	CARO in still mode @ final POS [E2]	insert_piston&&!signal_rotate&&!piston_IN		5	5
23	1.0.1	piston IN: CARO locked and still [E]	1-->3	prepare to insert next disc	5	5.25 5
24	3.0.1	CAR in still mode (bottom) [E]	signal_OUT	move CARrier to new disc	0	5
25	3.2.	pull CAT out [E3]	□S1 + □S2		166	166
26	3.0.2	CAT in still mode (top) [E]	3-->2 HOL		0	2.7667 5
27	2.0.	HOL engaged [E]	rotate +		0	0
28	2.0.1	rotate + mode [E5]	15_deg_reached		13	30
29	2.1.	free disc state [E5]	rotate +		0	30
30	2.1.1.	rotate + mode [E5]	0_deg_reached		13	30
31	2.2.	CAR engaged mode [E5]	2-->3 CAR	disc b engaged on CAR	0	0.4333 30
32	3.0.2	CAR in still mode (top) [E]	signal_IN		0	5
33	3.1.	push CAR in [E3]	□S3 + □S4		166	166
34	3.0.1	CAR in still mode (bottom) [E]	3-->1	disc b in bottom position	0	2.7667 5
35	1.0.1	piston IN [E]	remove_piston&&piston_IN&&!rotate		0	5
36	1.0.2	piston OUT [E2]	rotate_CARO==signal_rotate&&!piston_IN; rotate_CARO&&!search_zero		5	5
37	1.1.1	move CARO @ full speed to final POS [E1]	close_to_final_position	move to EMPTY station	270	50
38	1.1.2	hinge CARO when close to final POS [E1]	final_position_reached		30	30
39	1.0.2	CARO in still mode @ final POS [E]	insert_piston&&!signal_rotate&&!piston_IN		5	5
40	1.0.1	piston IN: CARO locked and still [E]	1-->3	ready for NEW RUN	5	5
						27.683

ESCAPE configurations

E1	move CARO to next available position	E1-->E
E2	piston IN	E2-->E
E3	push CAR in	E3-->E
E4	complete [2.1.2 --> 2.0]	E4-->E
E5	complete [2.0.1 --> 2.2]	E4-->E
E6		
E	HALT	

0.7 m³ @ 10 bars

½ hr to change a disc


ID
February 2008
March 2008
April 2008
May 2008
June 2008
mechanics
~60%
cutting parts
0%
build stand
assembly
test
02/05
ISIS
shutdown ?
control system
28%
design air system
0%
verify air system
design logic
can we shrink it?
order parts
test
build air system
14/04
too late?
electronics
design
test
manufacturing
central electronics availability
0%
12/06
integration
air+motor+mech
...+electronics
installation
draft

CONCLUSIONS & PLANS

Progress
Mechanics:
- 60% of parts done
- test stand designed

Air System:
- basically designed (external review?)
- all valves + interlocks defined
- safety (emergency) systems proposed (OK with RAL?)

Control:
- state diagram in progress

To be done (see chart for times)
Mechanics:
- complete cuttings, first mech tests (by end of february)
- build stand
- mount mechanics and test

Air System:
- build valve box + front panel
- connect to diffuser (motors)
- test

Control:
- state diagram → circuit
- build circuit + front panel
- connect to air system and test

DOCUMENTATION ! ! !