Vessel Entry Dose Accountancy

Hinkley Point B and Hunterston B 2008 - 2009

Ian Goldsmith

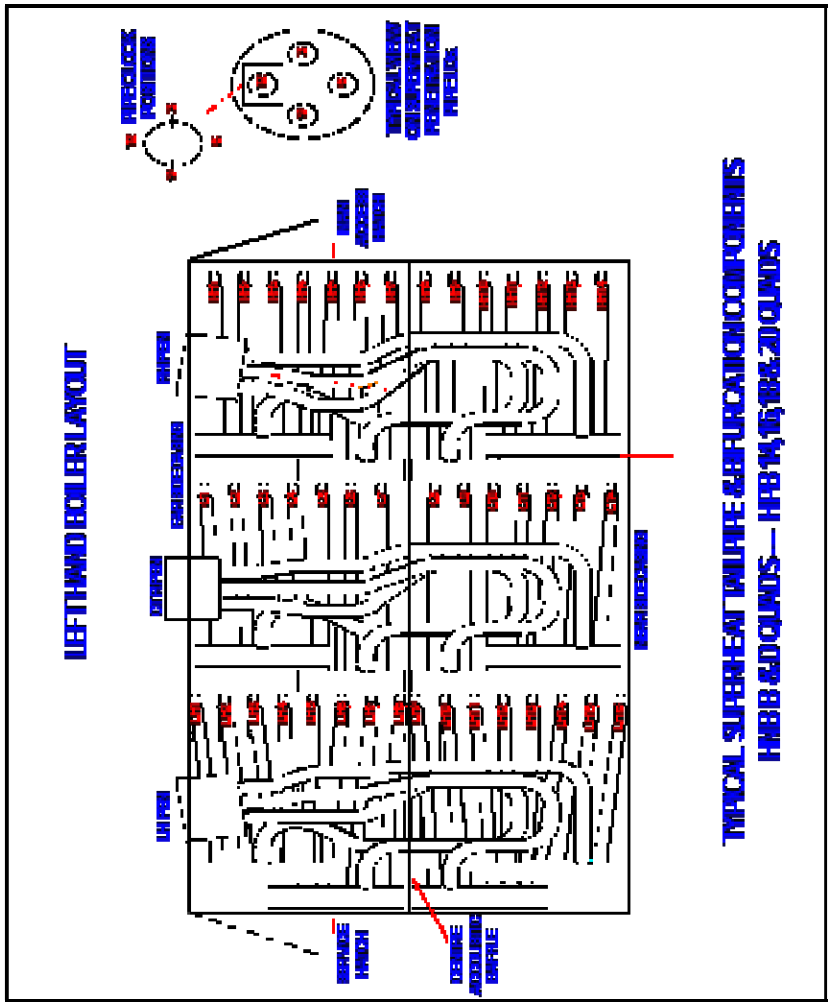
A SUBSIDIARY OF SOLETANCHE FREYSSINET

Introduction

- **ISOE 2008 Publication**
  - 14 operating AGRs in UK
  - Average collective dose of 167man.mSv
  - >90% of total AGR dose due to VE
- **2008**
  - Hunterston B R3; 1004man.mSv, 1370 man entries, 372 individual entrants
  - Hunterston B R4; 465man.mSv, 622 man entries, 204 individual entrants
  - Hinkley Point B R4; 592man.mSv, 698 man entries, 205 individual entrants
  - **Total Collective Dose; 2061man.mSv, 2691 full man entries**
- **2009**
  - Hinkley Point B R3; 636man.mSv, 697 man entries, 245 individual entrants
  - Hunterston B R3; 492man.mSv, 684 man entries, 226 individual entrants
  - **Total Collective Dose; 1128man.mSv, 1381 full man entries**
- **Typically only in vessel for ~21 days / reactor**

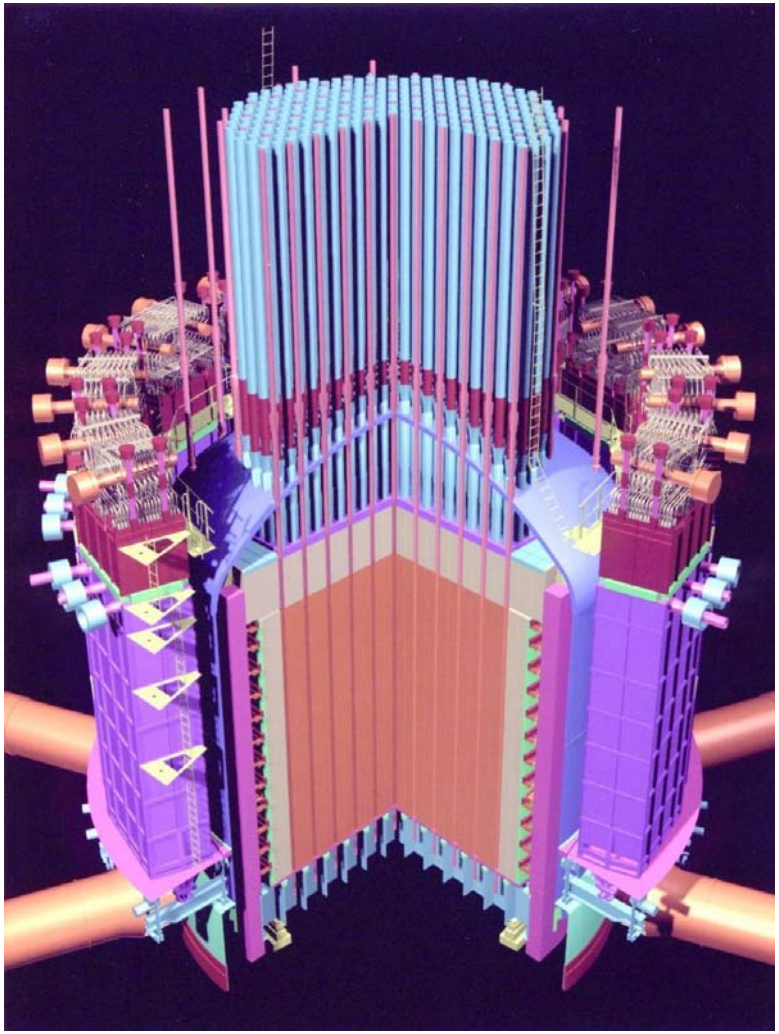
VERT

- **Hunterston B and Hinkley Point B**
  - Advanced Gas-Cooled Reactors
  - Generating since 1976
  - Vessel entry allows for extension of plant working life
  - Inspection and possible repair of all boilerwork components
    - 2 reactors at each site
    - 12 boilers in each reactor
    - Typically 44 inspection sites in each boiler
- **Vessel Entry Repair Team**
  - Doosan Babcock Energy Limited
  - British Energy
  - Various other contracted companies
  - Specialist trained entrants of various trades
- **Inspection and repair of boilerwork**



In-Vessel Conditions

- **In Vessel Rad Conditions:**
  - Multiple sources; core, carbon'dust', activated metal work and foreign materials
  - Typically min 0.4mSv/h gamma
  - Typically max 5mSv/h gamma
  - >10mSv/h gamma from discrete items
- **Conventional hazards**
  - Hazardous tasks; cutting, grinding, welding
  - Working at height
  - Confined spaces
  - Up to 60 degrees Celsius
  - Manual handling
  - Dangerous plant
- **Unavoidable dose burden**

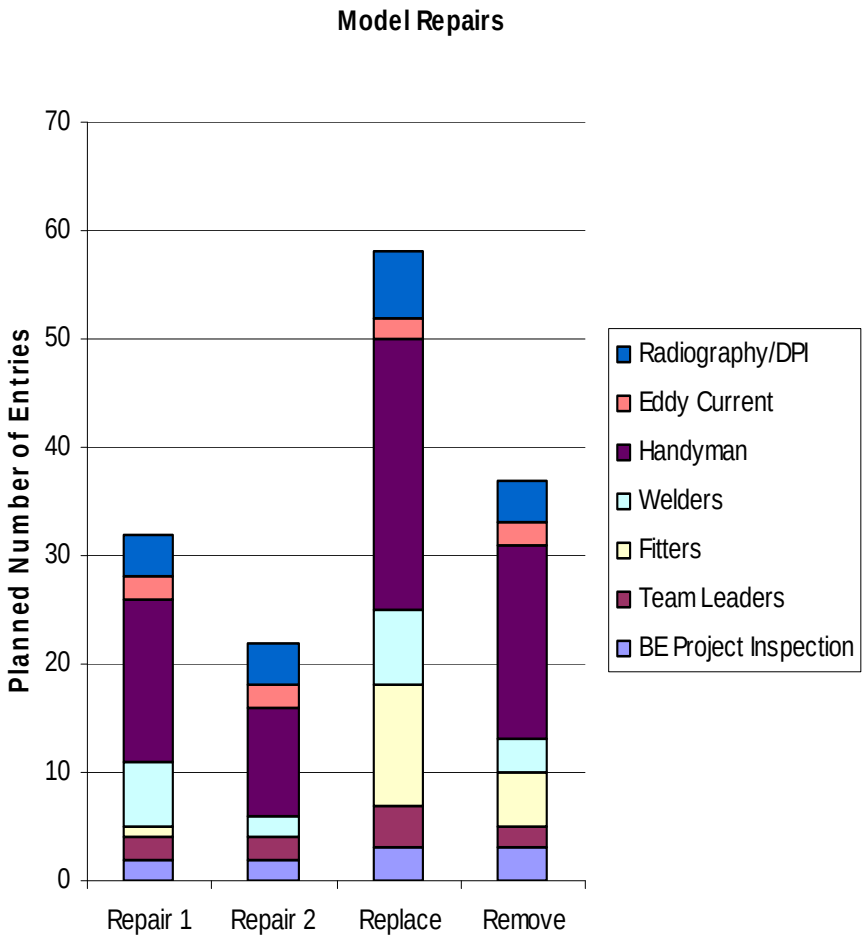


Dose Strategy

- **Business / corporate level**
  - Agreement of anticipated workscope and production of plan
  - Resourcing
    - Skilled trades – engineers, welders, fitters, radiographers
    - Fitness – demanding and unforgiving conditions
    - Frame of mind – anxiety and claustrophobia
  - Training
    - Radiation workers
    - Orientation
    - Task specific practice / mock ups
  - Employment paths / interim work
- **Dose constraints / planning levels**
  - 2008 and 2009:
    - Max 9mSv / individual
    - Max 1.5mSv / entry
    - Site specific dose constraints depending on employment path

Dose Management - Planning

- **The main repair types:**
  - Top Secret!
    - Details are of commercial sensitivity
  - Each repair type consists of a series of consecutive tasks
  - Repair
    - First choice
    - Lowest dose option
    - Fewest entries required
    - Potential remote repair
    - Risk of failure leading to…
  - Replace
    - Most significant action in terms of dose
    - Any dose spent on previous repair is now lost
    - Implications on campaign duration
  - Remove
    - Implications on generating capacity
    - Still requires dose



Dose Management – Planning & Manning

- **Each repair model is planned entry by entry**
- **Mutually beneficial workfaces**
  - Can two short tasks be completed during the same entry
  - Can entries be planned so as to avoid difficult hose management
  - Can one Handyman support work in two boilers
  - Is it appropriate to carry out radiography alongside other work
- **Can the shift supply adequate resource**
  - For example, welding activities tend to fall on same shift:
    - Enough entrants to avoid ‘dead’ entry
    - Are all entrants trained in the specific tasks scheduled
    - Towards the end of a campaign, do they have the dose resource
- **Reorganisation of shifts**
  - Changing a shift loses a shift, potential for delay

Night	**Entry 20**	Backout	Backout	Backout	Backout
	Entry 19	Inspect	Inspect	Inspect	Inspect
Day	**Entry 18**		Verify		
	Entry 17	Verify			
Night	**Entry 16**	Fit Task 3	Fit Task 3		Verify
	Entry 15			Verify	
Day	**Entry 14**	Weld 2	Weld 2	Fit Task 3	Fit Task 3
	Entry 13				
Night	**Entry 12**			Weld 1	Weld 1
	Entry 11	Weld 1	Weld 1		
Day	**Entry 10**			Fit Task 2	Fit Task 2
	Entry 9				
Night	**Entry 8**	Fit Task 2	Fit Task 2		
	Entry 7			Fit Task 1	Fit Task 1
Day	**Entry 6**	Fit Task 1	Fit Task 1		
	Entry 5				
Night	**Entry 4**			Set Up	Set Up
	Entry 3				
Day	**Entry 2**	Set Up	Set Up		
	Entry 1				
		Location 1	**Location 2**	**Location 3**	**Location 4**

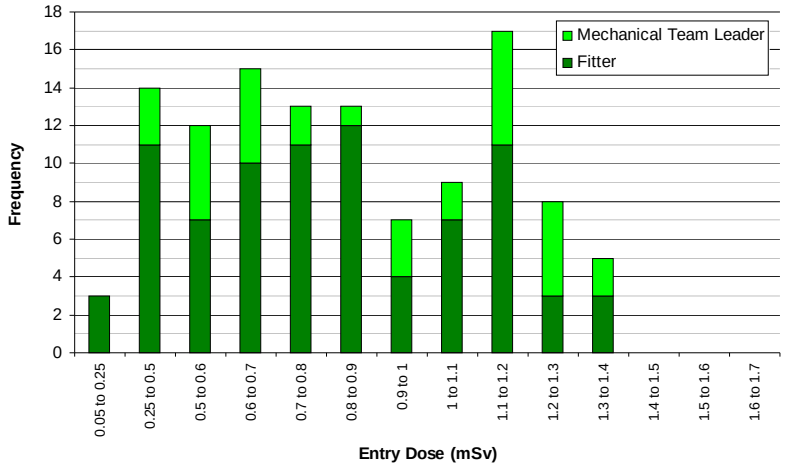
Dose Management – Control & Supervision

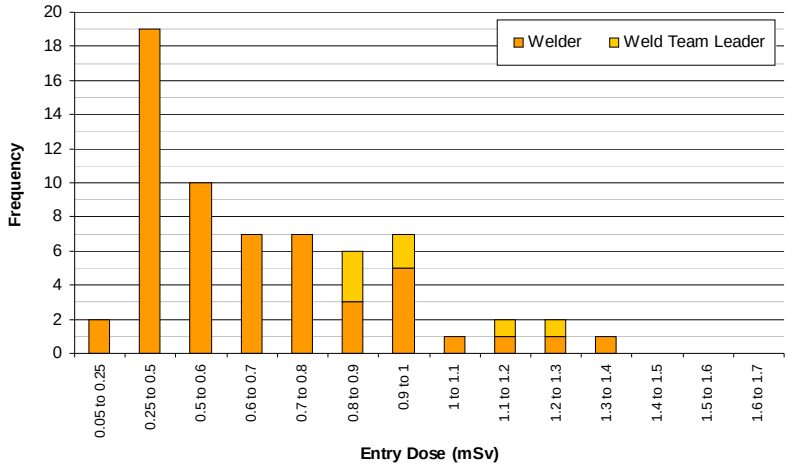
- **Vessel Entry Controller**
  - Experienced vessel entrant
  - Based in a control centre
  - Radio communications
  - Access to CCTV, telemetric dose data
  - Monitors in vessel conditions
  - Responsible for each entrant;
    - Which routes to take to avoid dose rate hotspots
    - Low dose rate refuge locations
    - Workface stay times
    - When to exit
  - Reports difficulties to Planning team

- **Technical Controller**
  - Experienced trades person
  - Knows the planned tasks for his trade team
  - Talks entrant through step-by-step
  - Manages difficulties as they arise to avoid abortion of the entry, and therefore wasted dose
  - Reports progress to Planning team

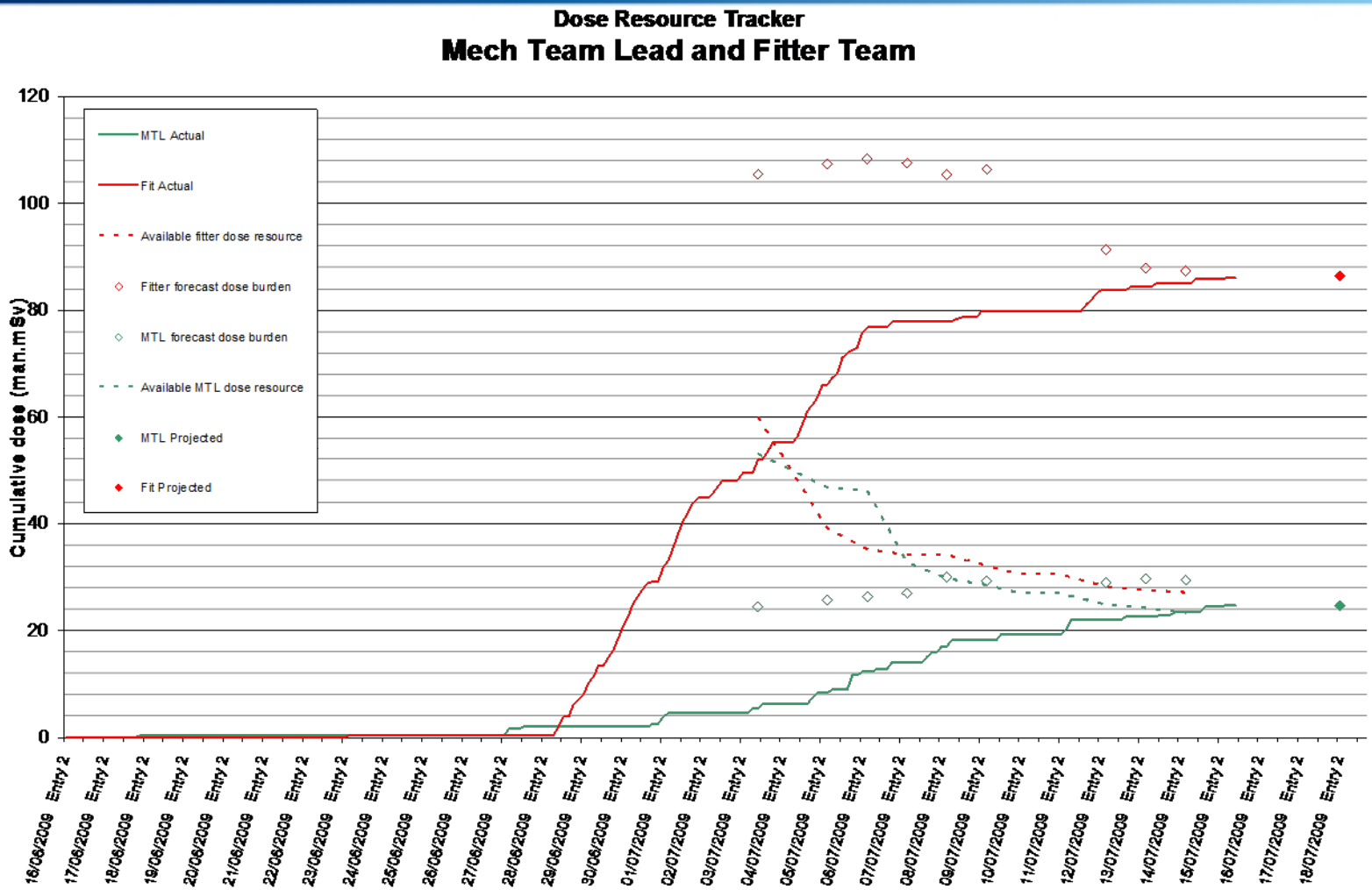
Dose Management – Measurement & Review

- **Most tasks are trade specific**
- **Entry dose is dependent on task**
  - Short discrete tasks
    - Fitting remote weld equipment
    - Movement/set-up of equipment
  - Continuous tasks
    - Manual weld
    - Cutting of multiple pipes
    - Multiple inspections / radiography
- **Average dose per entry informs the entrant selection process**
  - Is it appropriate to use high dose entrants before low dose entrants if we can show they will both finish equal
- **Is the RRA appropriate**
- **This can be fed back into the plan to re-evaluate projected dose**





Dose Management – Measurement & Review



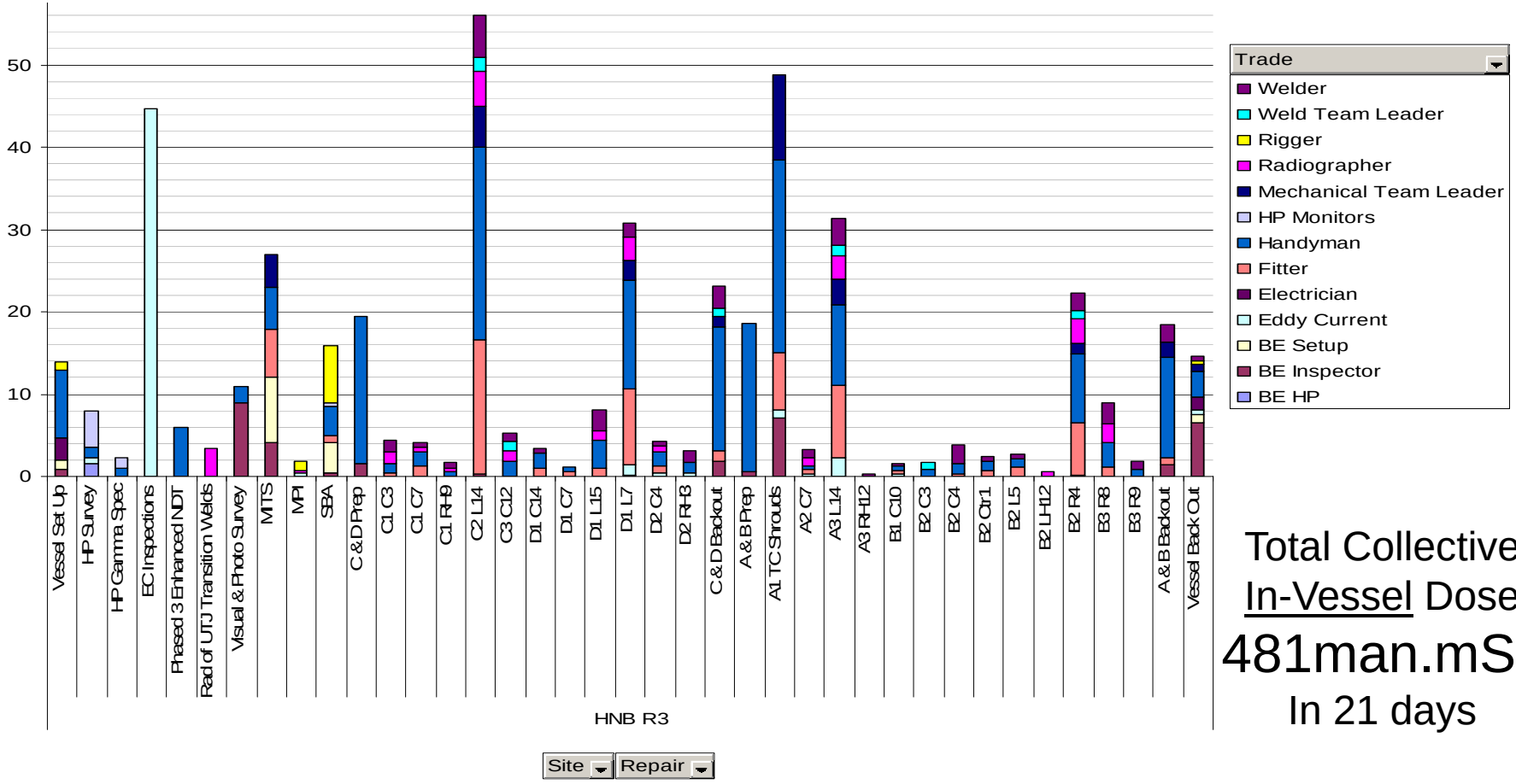
Dose Distribution by Phase – HNB R3 2009

Inspection:
119man.mSv
(25%)

C&D Quads:
165man.mSv
(34%)

A&B Quads:
167man.mSv
(35%)

Set up & backout:
29man.mSv
(6%)

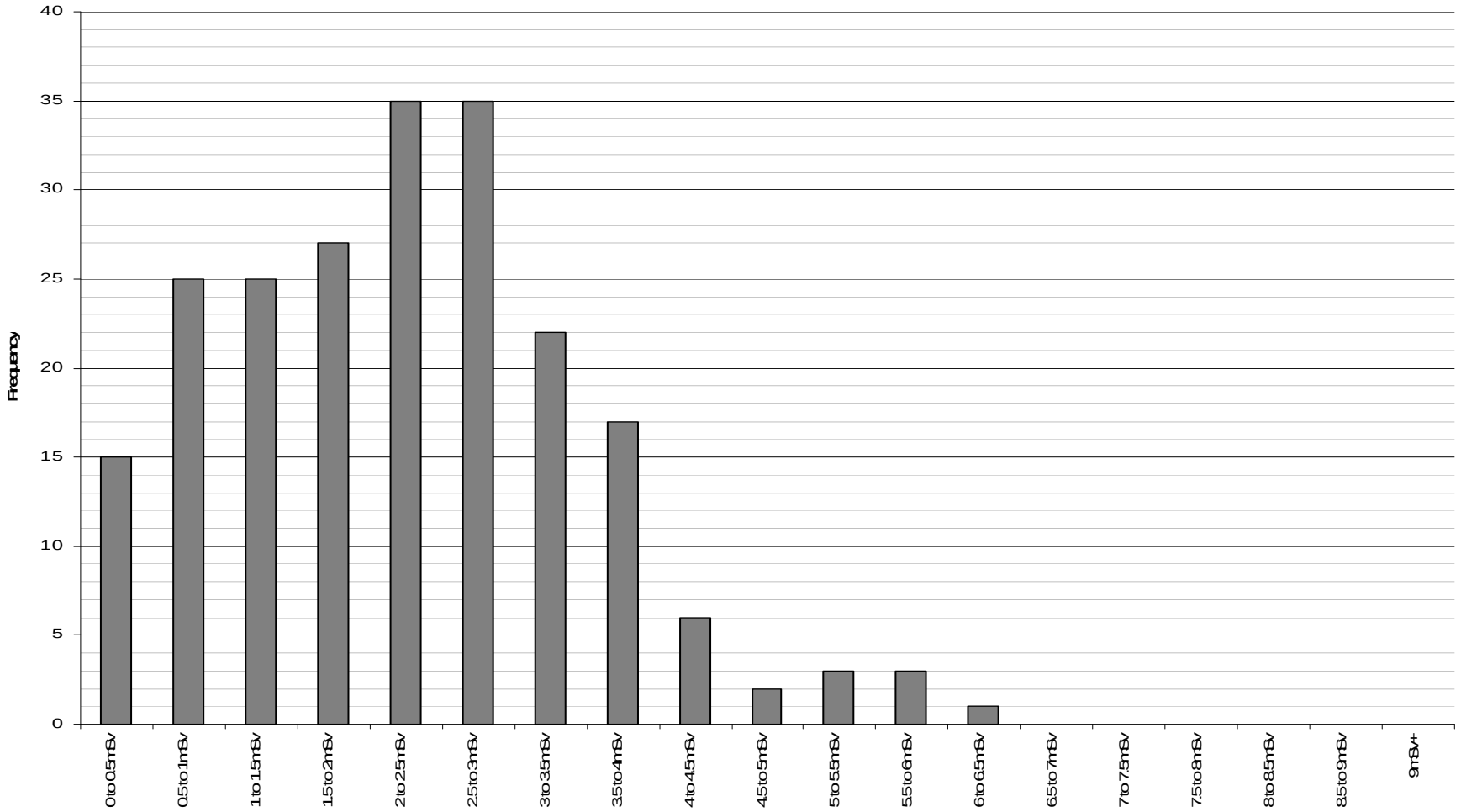


Total Collective
In-Vessel Dose
481man.mSv
In 21 days

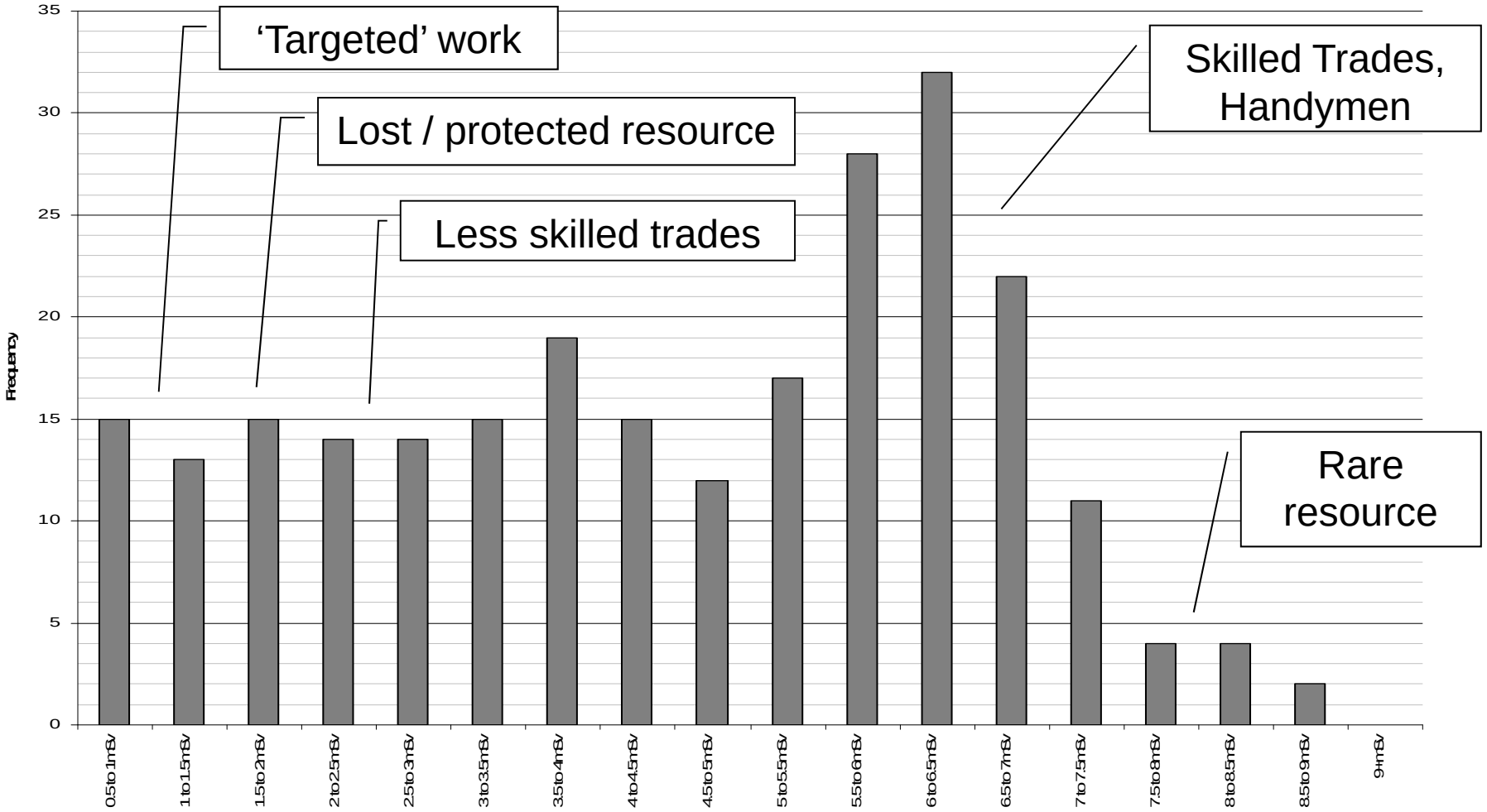
Dose Distribution by Key Trade – HNB R3 2009

Trade	Entrants	Entries Made	Collective Dose man.mSv	Average Dose / Entry mSv	Typical Repair man.mSv	Typical Replacement man.mSv
Inspection	12	88	**63** (6%)	0.72	0	4.6
Fitter	25	181	**152** (13%)	0.83	0.7	10
Welder	15	140	**88** (8%)	0.63	1	3.2
Handyman	82	771	**445** (40%)	0.58	1.5	13.4
Eddy Current	29	171	**139** (12%)	0.81	0.1	0.9
Radiographer	31	119	**77** (7%)	0.65	0.6	2.9
Total (including all trades)	**255**	**1381** (full entries)	**1128**	**0.81**	**35**	**4**

Dose Distribution by Site – HPB R3 2009, 636man.mSv

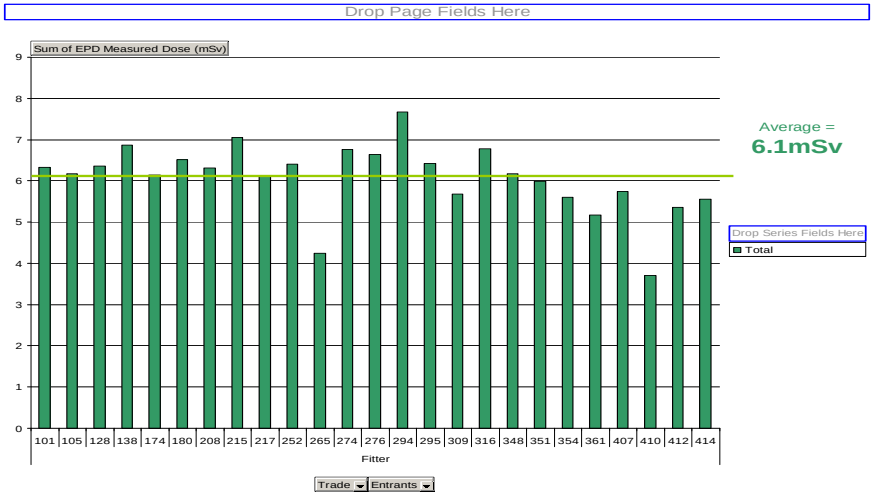


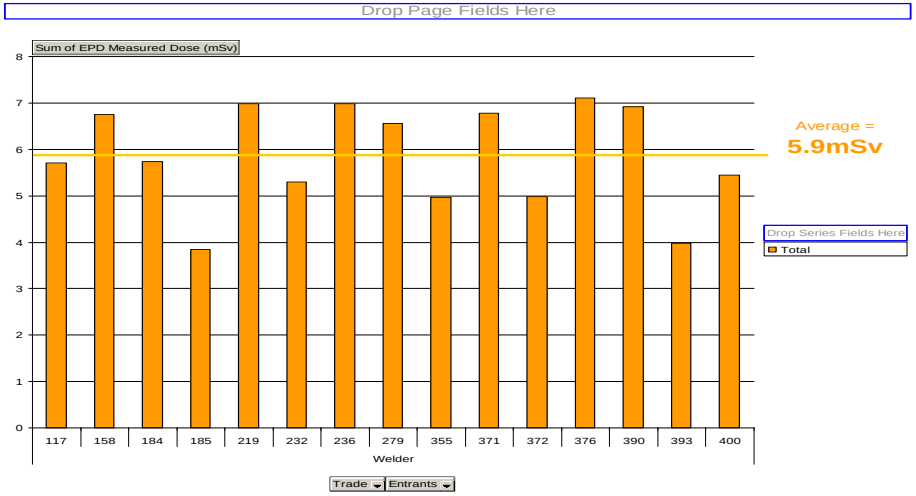
Dose Distribution by Site – HPB R3 & HNB R3 2009, 1128man.mSv



Dose Sharing & Other Challenges

- **Heavily dependent on Trade / skill set**
  - Generally higher SQEP means more entries
  - New recruits must be blooded
- **Steep profile means that even distribution is difficult**
  - 15 – 42man.mSv/24hr
  - Typically 25man.mSv/24hr
  - Individual may only get 6 entries in a year
  - Low dose entrants might not be available for appropriate entry slot
- **Human performance**
  - Hose tangles
  - Lost items
  - Missing, wrong or defective equipment

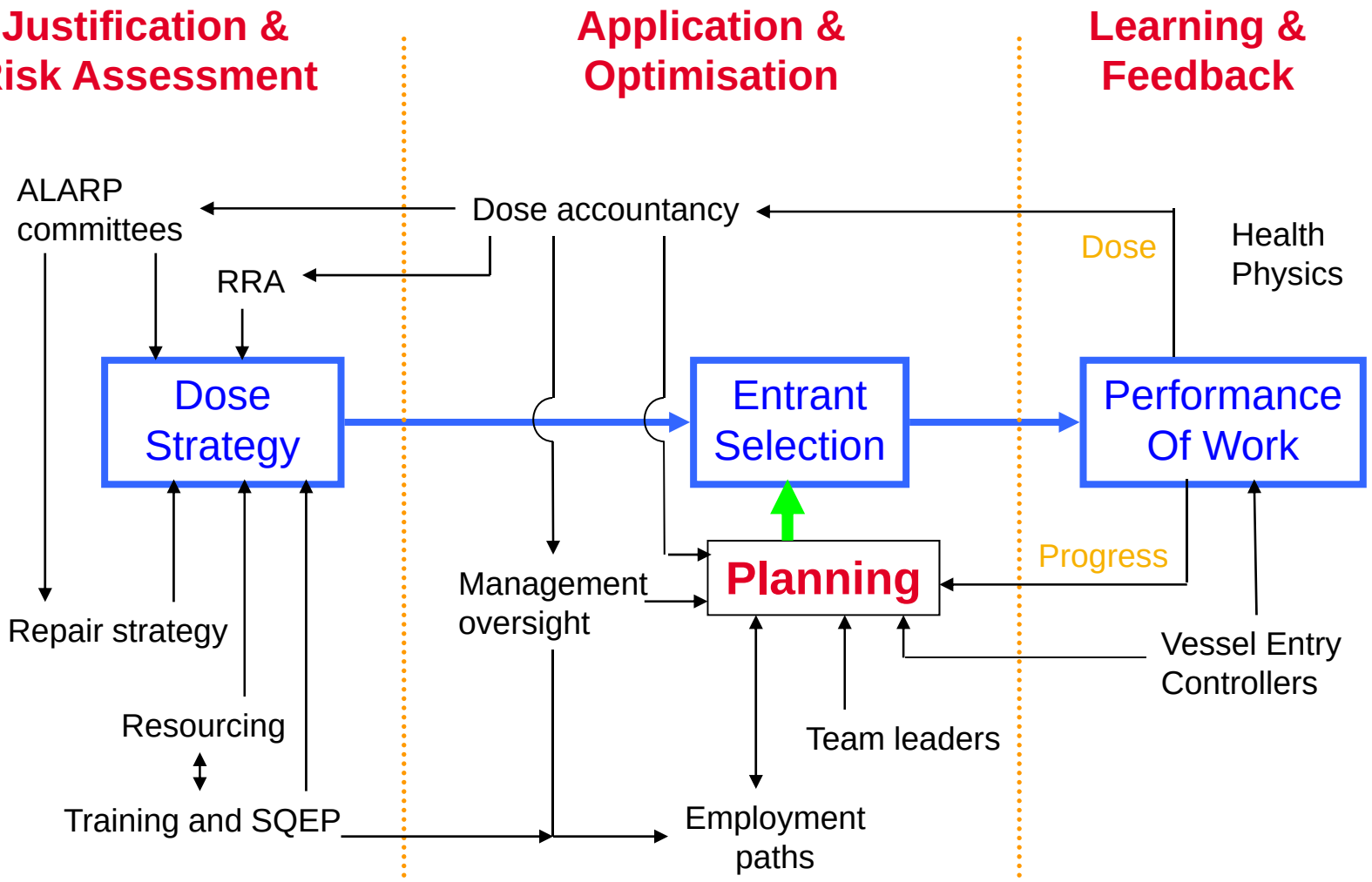




Achievements

- **Establishment of appropriate administrative controls and systems of work to allow safe exposure in demanding environment**
- **Systematic management of steep dose profile on every level**
  - Corporate
  - Project
  - Team
  - Individual
- **Ethical and proper dose expenditure**
- **No breach of challenging constraints**
  - In 2 years and >3 man.Sv only one individual breached 9mSv, 9.1mSv
- **No unplanned exposure**
  - >4000 man entries
- **No over exposure**
- **Completion of workscope!**
  - Respect for radiation as a hazard should not in itself prevent progress

Dose Management – Summary



Questions

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Dose Distribution by Repair

- **A tale of three New-Bifurcation replacements**
  - C2 L14 – Inaccessible location
  - Flagged projected dose to exceed model
- **Stats:**
  - C2 L14: 56man.mSv
  - D1 L7: 30man.mSv
- **Solution**
  - Simple lessons learned
    - Tube spreading, investment in time
    - Entrant selection
- **Result was saved dose**
  - A3 L14:
    - Also inaccessible
    - 30man.mSv