Building a HIGH-PERFORMANCE FACILITIES ENGINEERING ORGANIZATION

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Introduction

This paper will present a methodology for constructing a Facilities Engineering organization for an Upstream-Midstream "operating" company. This approach could also be applied to other energy industry sectors, eg. Downstream/Refining and/or other company types, eg. Engineering contractors.

The assumed objective is to build an engineering organization that matches the company's facilities engineering capability with the engineering support requirements of the company's various assets. This is not necessarily an easy thing to do. Many companies experience difficulty with this process because of the division of responsibilities between different groups, which tends to make implementation of a coherent strategy difficult, eg.:

1. **The "end users" of engineers:**
   - ✓ Project teams
   - ✓ Engineering Line Managers
   - ✓ The assets themselves
2. **Human Resources**
3. **Learning and Development**
4. **Organizational Effectiveness**

Additionally, the company's asset base will change with time and cyclical business conditions, eg. oil and gas prices, will periodically impact sustainable staffing levels.

The main point is that the process should be driven by technical competency requirements.

There are a number of steps, key variables and decisions involved, which will be discussed in the 7 main elements of the process below.

1st Element: The Corporate Asset Portfolio

Clearly, the types of facilities engineers required to support a company's assets depends on the nature of the assets.

For the purposes of this paper, a given facilities asset can be characterized in two main ways:

1. The actual processes and equipment involved:

- ✓ Onshore sour gas plant
- ✓ Offshore sweet oil platform
- ✓ LNG plant
- ✓ Large oil pipeline
- ✓ etc.

Most of these asset types share common elements, eg. pumps, compressors, heat exchangers, pressure vessels, piping, instrumentation, etc, but they also also have broader distinguishing features, often "process" related, as well as differences in equipment.

2. The following are project/asset life-cycle stages using typical industry terminology:

- ✓ Appraise
- ✓ Select
- ✓ Define
- ✓ Execute
- ✓ Operate

Many companies start their facilities engineers out at an operating asset, preferably at the asset location. As these engineers gain breadth and depth of experience – including exposure to other assets, locations and "ways of doing things" – they become better qualified for higher-level "project/asset" support roles, eg. in the Appraise, Select, Define stages of a project, where broader, deeper experience is typically required, as well as optimization/troubleshooting roles with Operating-stage facilities.

Most companies will have a mix of asset types in various life-cycle stages and therefore will require a range of facilities engineering experience/competencies to support them.

Figure 1 provides an example of a hypothetical corporate asset portfolio.

	APPRAISE	SELECT	DEFINE	EXECUTE	OPERATE
Onshore gas	2	3	2	3	6
Offshore gas	3	3	2	2	5
Onshore conv oil	4	2	3	2	7
Offshore conv oil	3	2	1	2	4
Heavy oil/tar sands	2	1	2	1	2
LNG	1	0	1	0	1
Pipeline	1	2	0	1	3

# of projects

2nd Element: Facilities Assets Description

This is where more definition of the asset types is required. For example, "Onshore Sour Gas Plant", is a good high-level descriptor, but needs to be broken down further:

- Actual feed composition and conditions, eg. 30% H_2S is quite different than 200 ppmv H_2S, though both would be classified as sour gas.
- The gas sweetening process utilized
- The sulfur recovery (or disposal) process utilized
- The liquid product treating process(es) utilized
- Corrosion/materials selection issues
- Safety issues
- Environmental impact issues
- Community impact concerns
- etc.

Definition of the asset characteristics to this level is necessary to ensure that the various types of facilities engineers assigned to support these assets have the knowledge/competencies needed to do their jobs effectively. Many facilities engineering technical "skill areas" are broadly applicable across asset types, eg. Mechanical Rotating Equipment, Instrumentation & Controls, while others are very asset specific, eg. Subsea Systems, LNG liquefaction processes.

3rd Element: What Life-Cycle Stage?

In addition to the asset type, the engineering input/support required will vary with the life-cycle stage of the asset. Figure 2 shows typical project life-cycle stage definitions, terminology and general activities involved.

Figure 2 Main project stage-gate activities

APPRAISE	SELECT	DEFINE	EXECUTE	OPERATE
✓ Determine project feasibility & alignment with business strategy ✓ Understand project drivers ✓ Identify viable opportunities to pursue	✓ Perform technical definition & evaluation of prioritized project options ✓ Develop initial cost & schedule estimates for the options ✓ Compare options by focusing on uncertainties, risks, flexibility & associated economic criteria ✓ Recommend preferred option & further develop technical definition	✓ Develop the selected option to an appropriate level of detailed technical definition & planning required to freeze the scope of the project ✓ Confirm cost, schedule & production estimates	✓ Produce an operational asset consistent with scope, cost & schedule, including: • *Detailed engineering* • *Procurement* • *Follow-on engineering* • *Site support* • *Project management services*	✓ Evaluate asset to ensure performance is to specification, including: • *Facilities availability* • *Production performance*

Versions of Figure 2 can, and should, also be developed for the different facilities engineering disciplines/functions.

Generally speaking the required level of depth and breadth of experience is higher for the earlier life-cycle stages. In particular, knowledge re: what has worked well in the past, what hasn't and why, feasibility of using new technologies and their associated risks, limitations of local infrastructure and workforce capability, etc. These issues are especially important for "new frontier" project locations as opposed to well established oil and gas operating areas.

4th Element: Division of Responsibilities

What do you want your people to do?
What do you want someone else to do?

These are very important questions, and will have a large impact on the resulting engineering organization. Figure 3 provides a template for allocating different responsibilities between various departments inside the operating company and to external companies.

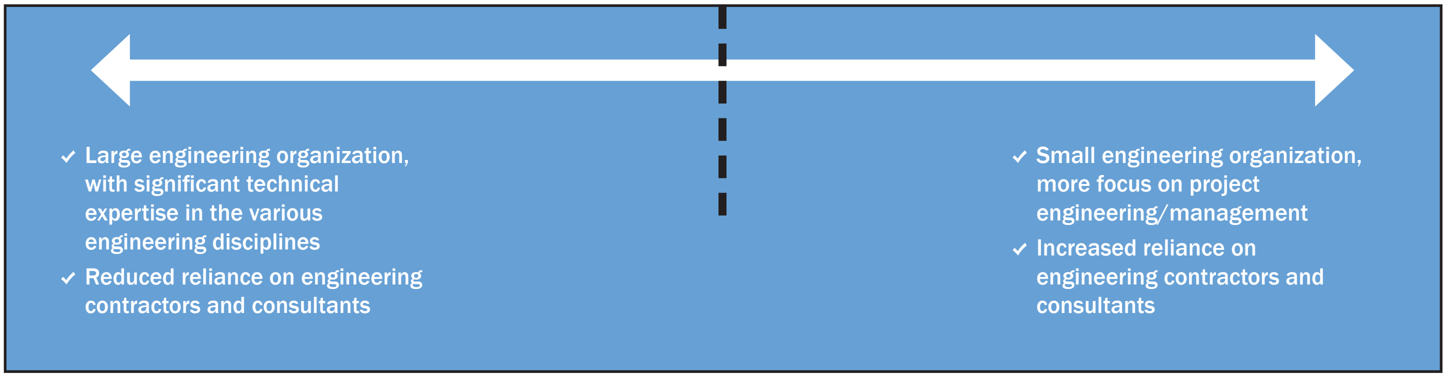
Figure 3 Division of Responsibilities

COMPANY TYPE	APPRAISE	SELECT	DEFINE	EXECUTE	OPERATE
Operating Company ✓ Engineering ✓ Project Management ✓ Operations ✓ Maintenance					
Contract Service Provider ✓ Engineering ✓ Project Management ✓ Operations ✓ Maintenance					
OEM's					
Consultants					
Other					

Generally different Facilities Engineering support requirements, eg. #'s of engineers, experience level & competencies, for each company "type" and asset life-cycle stage

There is a wide range of possibilities, with a conceptual representation of the spectrum involved indicated in Figure 4.

Figure 4 Facilities engineering organization spectrum



Years ago, many, if not most, operating companies had large engineering organizations that could handle most of the engineering work involved in the execution of a project as depicted in Figure 2, as well as the ongoing engineering support needed during the Operate stage. Some of these companies even had their own drafting departments. This is much less common now, with most of the engineering work – at least for projects – being outsourced to EPC contractors. Smaller operating companies often don't have technical Subject Matter Experts (SME's), and instead rely on consultants to provide this high level of technical expertise when it is occasionally required. Many companies are somewhere in between these extremes.

Which approach is best? There are a large number of factors involved. Although this is an important subject, and not the focus of this paper, a few comments are warranted: Facilities Engineering should not be looked upon as a commodity service, for which the only factor that matters is the $/hr cost. "Excellent" engineering has the potential to provide much better project life-cycle cost and value than "Poor", or even "Average", engineering. Operating companies need to be able to recognize the difference, and be willing to pay for it, whether through highly competent internal engineering capability or the selection of good, though often more expensive, external engineering providers. A periodic review of the suitability of the company's Facilities Engineering Organization makeup in relation to the asset portfolio - and current/ forecast business conditions - is also recommended.

5th Element: Types of Engineers

What kind(s) of engineers do you need?

For the purposes of this paper, “Facilities Engineers” includes:

1. “Discipline” Engineers (deeper but less broad)

- Process Engineers
- Mechanical Engineers
  - Rotating equipment
  - Non-rotating equipment
- Electrical engineers
- Instrumentation/Control Engineers
- Process Safety Engineers
- Pipeline Engineers
- Civil/Structural Engineers
- Maintenance/Reliability Engineers
- etc.

2. “All-Rounder” Multi-discipline Engineers (broader but less deep)

- “Jack-of-all-Trades”, multi-discipline engineers

The expression “Jack-of-all-Trades” sometimes has a negative connotation in that it is often followed with the words “master of none”. There is some truth to this in the early years of an all-rounders’ development, but in time, this person will be at a “skilled” level in multiple areas, approaching, or at, “Mastery” in one or two areas, and very valuable – and versatile – to his or her company.

The above titles are fairly indicative of the roles and responsibilities of each facilities engineer “type” but there is still room for flexibility in this regard, depending on the specific company’s requirements/ philosophy.

“What kinds of facilities engineers” a given company needs depends, to a large degree, on the answers to these three previously asked questions:

What asset types ?
What life-cycle stages ?
What will your engineers do, and what will others do ?

The dependence on “life-cycle stage” is perhaps not obvious. An example of this would be the on-site “plant engineer” position (which some companies have unfortunately eliminated over the years). This is a classic “all-rounder” facilities engineer job, responsible for providing engineering support for the facility, operations and maintenance groups, across all engineering disciplines, at least at a “basic” level. Obviously it is not practical to have a full discipline engineering team co-located at each facility and probably not even at each field/”district” office.

Two more significant factors include:

3. The size of the company and the number of facilities assets in its portfolio (Figure 1).

4. Local regulatory/professional certification requirements which tend to favor the "discipline" engineer approach.

With respect to company size, large companies with correspondingly large asset bases can normally justify having 25+ year experience SME's with very deep knowledge in specific technical areas, eg. welding, gas turbines, sulfur recovery, advanced process control, etc . These people may also be heavily involved in R&D efforts in their companies, be members of industry committees, etc. Small companies, with small asset bases, typically cannot justify having "experts" like this on staff – there isn't enough work that requires this level of expertise. Instead, they will rely on consultants when this expertise is occasionally needed.

Some companies lean strongly towards the "Discipline Engineer" model, some towards the "All-Rounder Engineer" model, and many utilize a mix of both. As a general statement, many of the smaller companies tend more towards the "All-Rounder" engineer approach, while larger companies typically utilize a mix of both. Very few operating companies seem to use an "all discipline engineers" approach.

Figure 5 is a simplified graphic illustrating the conceptual difference between the "Discipline" and "All-Rounder" facilities engineer types.

Figure 5 "Discipline" engineer or "All-Rounder" ? Conceptual

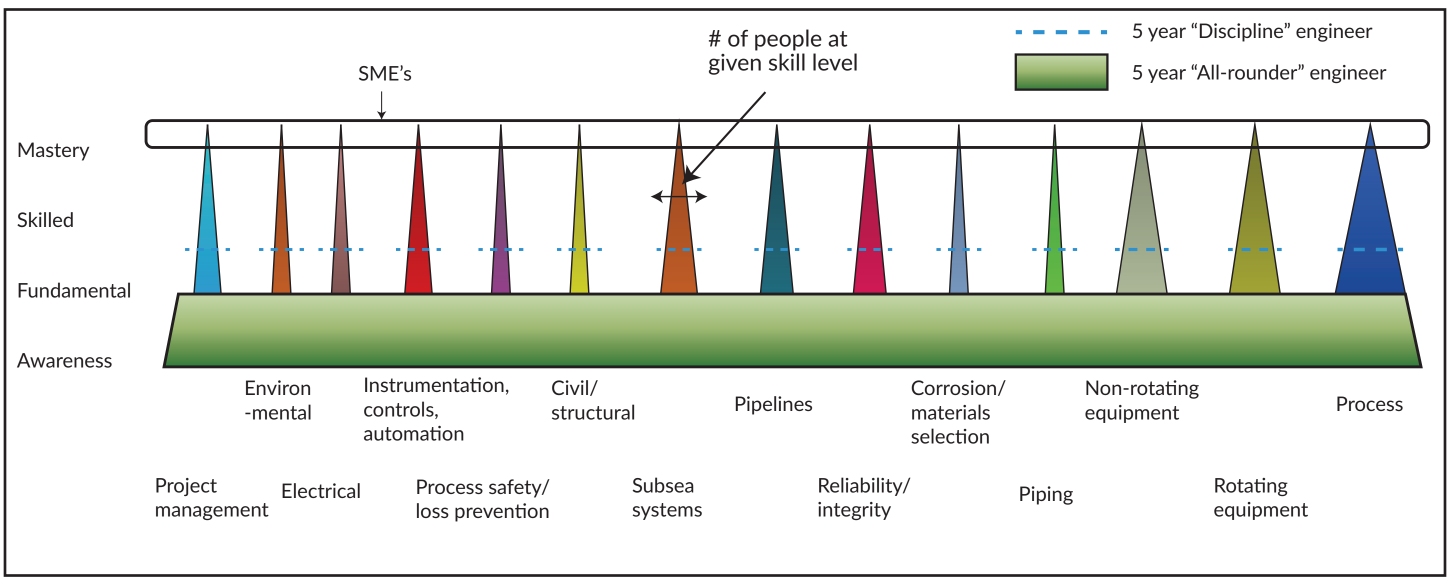


Figure 6 provides additional examples of the characteristics and perspectives that differentiate Discipline and All-Rounder engineers.

Figure 6 "Discipline Specialist" vs "All-rounder" differences

CHARACTERISTICS	
"ALL-ROUNDER"	**"DISCIPLINE SPECIALIST"**
Multidiscipline – Process, Mechanical, E, I&C, Process Safety, O&M, etc	Discipline-specific focus
Broader, less deep perspective	Narrower but deeper perspective
System view – how components work together/interact to achieve end result	More focus on specific components
Slightly biased towards "Process"	More detail oriented
Basic design, operations and key maintenance aspects, general troubleshooting	More focus on codes and standards
More "operations" oriented	More "design" oriented
EXAMPLE OF DIFFERENCE IN PERSPECTIVE	
PUMPS	**CENTRIFUGAL PUMPS**
Different types	API 610 (centrifugal pumps)
Basic construction/components	API 682 (seals)
Operating principles	Bearing types & applications
Performance characteristics	Auxiliary systems, eg. lube oil
Basic instrumentation & controls	Radial & axial forces on impleller
Advantages/disadvantages	Shaft deflection & bearing loads
Applications	Wear rings
Operational/maintenance issues	Casting thickness, flange thickness & bolting requirements
Basic troubleshooting & optimization	Nozzle loading limitations
	Rotor dynamics, vibration
	Alignment
	Materials selection
	Advanced troubleshooting

6th Element:
How to Develop the Kinds of Engineers You Need

The elements covered so far have helped determine what kinds of facilities engineers are required to support a company's asset base. This section will discuss options for how to develop these engineers.

There are two main routes to obtaining the engineering competence required:

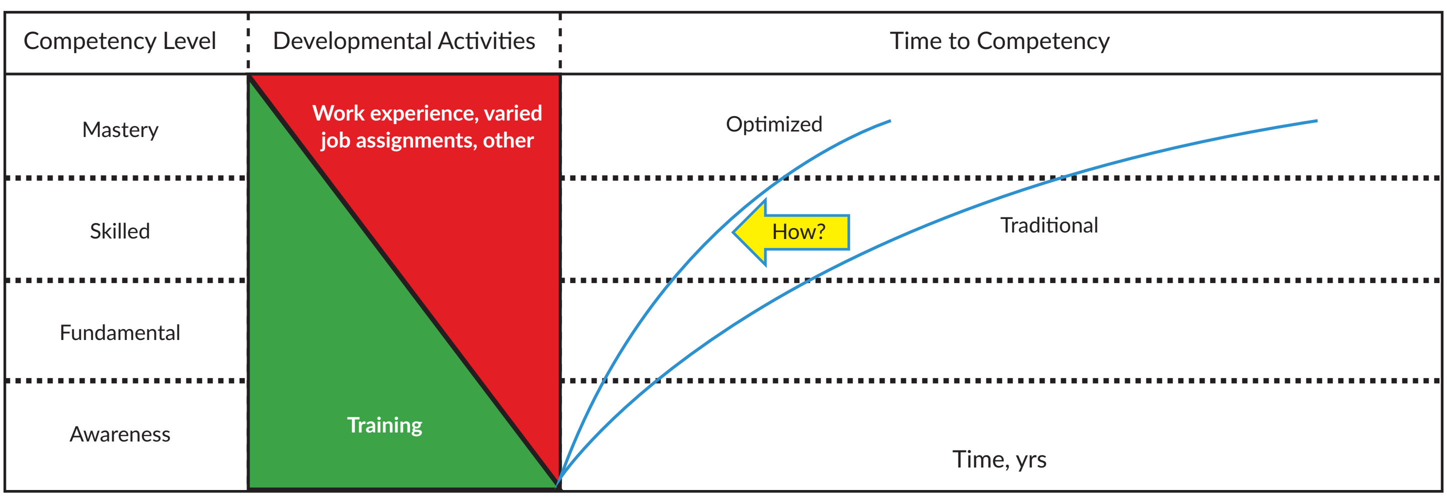
- **External hires of the engineers required**
- **Internal development of the engineers required**

In practice, both options will likely be necessary, depending on the company and its particular circumstances.

The "big crew change" in the oil and gas industry has been discussed at length and is well underway. In order to compensate for the loss of highly experienced technical personnel to retirement, it will be necessary to accelerate the development of the remaining younger staff.

Conceptually, the development goal can be represented as shown in Figure 7

Figure 7 Conceptual development program



The main components of “development” – the “how ?” part in Figure 7 – are listed below:

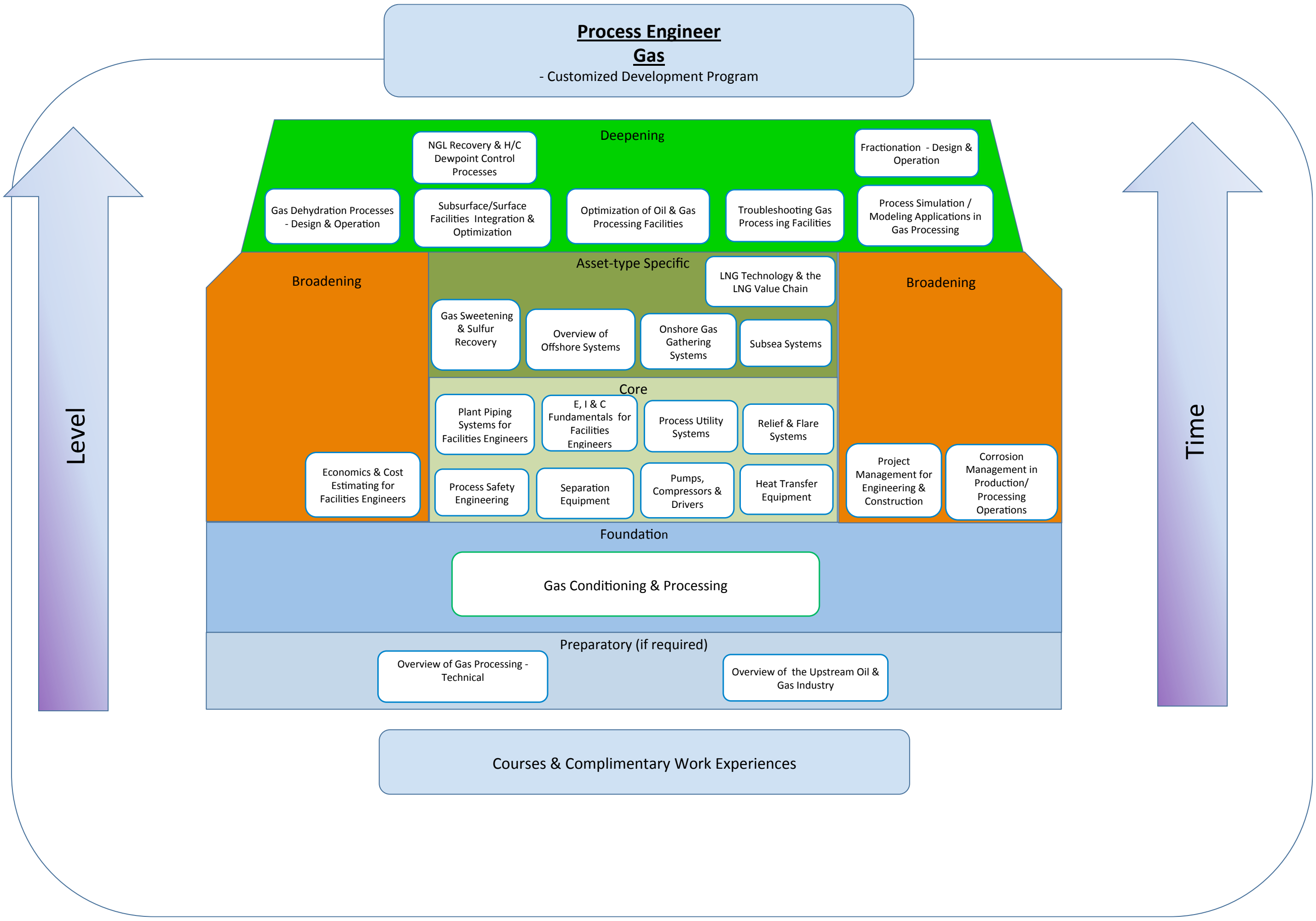
1. **Training**
2. **On the job experience/application of the knowledge gained in training**
3. **Different job assignments**
4. **A good coach/mentor**
5. **A lot of reading !**

These elements are not much different than they have ever been. The key difference required now is “effective acceleration” of competency development. This will require a more structured – and compressed – program, than has typically been employed by most companies in the past.

A logical question that sometimes arises is “after 4-5 years of university to obtain an engineering degree, why is so much additional training still required?” The primary reason is that university engineering programs are by necessity “generic” in that they are not intended to ready their enrollees for employment in a specific industry – they could go just about anywhere. Having said this, some of the “classical” engineering discipline programs offered at most universities align better with oil and gas industry facilities engineering job roles than others, eg. Mechanical, Electrical, Instrumentation & Controls align reasonably well. Petroleum Engineering is more oriented towards reservoir/drilling/production engineering than facilities. Graduate Chemical engineers naturally align best with Process Engineering positions, though the match-up is often not great because many university chemical engineering programs are typically quite downstream/chemical plant oriented. The “all-rounder” facilities engineering role is probably best suited to ChemE grads with MechE a close second. Having said this, it is not uncommon for a company to hire “engineers” in general – especially when there are shortages – and then to train them for the job roles that are required. This is a less than ideal situation but sometimes a necessity.

An example of a customized development program for a Gas Processing Engineer is presented below in Figure 8. The program shown reflects a fairly strong “all-rounder” philosophy with a significant “process” slant. The training component of this program is highlighted by the individual courses shown, but as discussed, the complementary activities, eg. Work experiences/activities, coaching/mentoring support, job assignment changes, reading, must be included to maximize the effectiveness of the training.

Figure 8 Example development progression



The training courses identified in Figure 8 could be delivered in an instructor led “face-to-face” format, an online format, or a combination of the two. This program would likely be delivered over a 3-5 year time frame, at the end of which, the engineer would be expected to be a competent, individual contributor. This is quite a lot of training, let alone the other supporting components, but accelerating the competency development curve per Figure 7 has a cost.

The training courses identified above are designed to deliver specific competencies relevant to the particular engineering discipline/job role, as defined in a series of Competency Maps (CMAP’s). These CMAPs were developed as part of a collaborative effort between PetroSkills and representatives from a cross-section of oil and gas industry partners.

Figure 9 shows a sample excerpt from a Process Engineering CMAP.

Figure 9 Example extract from a Competency Map

SKILL AREA	AWARENESS	FUNDAMENTAL APPLICATION	SKILLED	MASTERY
• Dehydration (Glycol, Solid bed (molecular sieve, silica gel), Calcium chloride, Refrigeration w/glycol injection, Membranes, Other)	• Able to describe the primary available gas dehydration processes and why dehydration is required. • Able to outline where the different dehydration processes are typically used. • Familiar with typical gas dryness requirements for different applications, e.g. cryogenic gas processing, sales gas specifications. • Able to prepare a PFD from a process simulation. • Capable of interpreting PFDs, H&MBs, P&IDs and process data sheets. • Aware of applicable industry and company codes, standards and design guidelines.	• Select the appropriate dehydration process for a given application. • Capable of design, equipment selection and specification development for one or more types of gas dehydration systems. • Uses common tools (simulation software, spreadsheets, etc) for design / sizing of the most common dehydration systems and their major equipment items. • Performs basic troubleshooting on one or more types of gas dehydration systems. • Participates in HAZOPs of most dehydration systems. • Reviews PFDs and P&IDs to ensure that the system objectives can be met. Identifies and optimizes utility demands for various process alternatives.	• Demonstrates in-depth knowledge of dehydration systems, including design, application, operability, CAPEX/OPEX, safety, environmental aspects, etc. • Performs process selection, optimization and debottlenecking studies. • Capable of design, equipment selection and specification development for most types of dehydration systems. • Uses the appropriate advanced software to model and design different dehydration systems. • Troubleshoots most types of dehydration systems. • Develops startup and operating guidelines and assists in startups of dehydration systems. • Provides process schemes for development planning with minimal input. • Oversees / leads a contractor process design group on a major project.	• Demonstrates broad based technical expertise in numerous areas of design and operation, including troubleshooting and optimization. • Knowledgeable of state-of-the art with respect to the area of expertise. • Evaluates new and unproven technologies, identifies risks and potential applications. • Recognized as a company expert in the area of expertise. • Advises senior management on the application of the technology for the most complex applications. • Generates substantial improvements to local practices and procedures for the area of expertise. • Prepares and presents technical papers on the area of expertise and is a member of industry committees. • Benchmarks worldwide operations (company and industry) and identifying best practices.

Development components 2 and 4 listed above, ie. On-the-job experience and coaching/mentoring support, respectively, are important and fairly self-explanatory. Of these, the coaching/mentoring support piece often seems to be the most problematic for many companies. It is a bit of a “chicken-and-egg” situation. There is a shortage of good coaches/mentors (not necessarily the same as “SME’s) in many companies, precisely because of why we are discussing this subject – many of these people are retiring. Components 3 and 5 – different job assignments and reading – are maybe less obvious.

The point of different job assignments is to see, and obtain exposure to, different asset types and different ways of doing things. Some large assets will have many different elements, others will be more one-dimensional. The company must be willing to move engineers, and the engineers must be willing to move, preferably every 2-3 years initially, quicker if the assets are less complex.

Reading might seem like an unusual development program element, but it really isn’t. There is a large amount of knowledge to be assimilated in order to become very good at a given facilities engineering job. The first four components identified previously can provide much of this, depending on the “quality” of each component, especially in the first 5 years of the engineer’s career. After that, if the individual remains on a technical development path, the training and coaching/mentoring support components will tend to diminish with time. Job assignment changes may only occur every 3-5 years, depending on the company and the engineer. In order to maintain a steady pace of competency development, reading becomes an increasingly important source of knowledge input. Conference technical papers, technical books and industry magazines are all good sources of information. A lot of good (and free) information is available from the internet. Reading technical information may not sound exciting, but it is a valuable and under-utilized development tool.

7th Element:
How Many Engineers of Each Kind Do You Need?

For the purpose of discussion, the assumption here is that the operating company's philosophy with respect to where they want their engineering organization to be on the spectrum shown in Figure 4 is somewhere just to the "right of center", which is probably quite typical today.

This is a big subject, but an example of how this evaluation could be performed is outlined below:

Step 1: Define the facilities asset portfolio (similar to Figure 1)

Figure 10 provides a hypothetical example of a large operating company's facilities asset portfolio.

Figure 10 Hypothetical facilities asset portfolio with more detailed breakdown of asset types

		FACILITIES ASSET PORTFOLIO					
		LIFE-CYCLE STAGE					
FACILITY ASSET TYPE	"MIX" FACTOR*	APPRAISE	SELECT	DEFINE	EXECUTE	OPERATE	TOTAL
		# OF PROJECTS					
Onshore sweet gas	1.0	2	3	2	2	8	17
Onshore sour gas	1.0	1	2	2	1	3	9
LNG - liquefaction	1.0	2	1	1	1	1	6
LNG - receiving/regas terminal	1.0	1	1	1	0	1	4
Offshore - sweet gas - no subsea component	1.0	2	2	2	1	5	12
Offshore - sweet gas - significant subsea component	1.0	2	3	2	2	3	12
Offshore - sour gas - no subsea component	1.0	1	1	2	1	2	7
Offshore - sour gas - significant subsea component	1.0	2	1	1	1	1	6
Onshore sweet oil (w/sol'n gas)	1.0	2	1	1	0	7	11
Onshore sour oil (w/sol'n gas)	1.0	2	2	2	1	2	9
Offshore - sweet oil - no subsea component	1.0	2	3	2	2	5	14
Offshore - sweet oil - significant subsea component	1.0	1	2	2	1	3	9
Offshore - sour oil - no subsea component	1.0	2	1	1	1	1	6
Offshore - sour oil - significant subsea component	1.0	0	1	1	0	1	3
Onshore - heavy oil/tar sands - thermal recovery - no upgrading	1.0	1	1	1	1	1	5
Onshore - heavy oil/tar sands - thermal recovery - incl upgrading	1.0	0	1	0	0	1	2
Onshore - tar sands - mining - no upgrading	1.0	1	0	0	0	1	2
Onshore - tar sands - mining - incl upgrading	1.0	0	0	0	0	1	1
Pipeline projects	1.0	1	1	1	0	1	4
Gas-to-liquids project	1.0	1	0	0	0	0	1
Total							140

* The "mix factor" is used to adjust manpower levels up or down from the assumed baseline asset case to account for asset size, complexity, regulatory regime, location, "assurance" level required, etc.

Step 2: Estimate the facilities engineering “horsepower” required to support the different asset types for each life-cycle stage.

This is probably the most difficult part of the process. In particular, Element 4: Division of Responsibilities, has to be well thought out.

An example is presented in Figure 11.

Figure 11 Engineering manpower estimate for a moderate-sized offshore sweet oil platform (no subsea component). The numbers reflect engineering staff counts. “0 – 5 years”, etc, reflects experience level.

	LIFE-CYCLE STAGE							
	APPRAISE				SELECT			
JOB FAMILIES	0-5 YEARS	6-10 YEARS	11-20 YEARS	20+ YEARS	0-5 YEARS	6-10 YEARS	11-20 YEARS	20+ YEARS
All-Rounder (Facilities engineer)		1				1	0.1	
Process			0.5				1	0.1
Mechanical - Rotating							0.1	
Mechanical - Non-rotating							0.1	
Electrical							0.1	
Instrumental & Control							0.1	
Maintenance & Reliability							0.1	
Corrosion & Materials							0.1	
Subsea - Hardware								
Subsea - Controls								
Pipeline							0.1	
Project Management								
Civil & Structural (onshore)								
Process Safety & Loss Prevention			0.1				0.1	
Offshore Structures/Naval Architecture			0.1	0.1			0.2	0.1
	0	**1**	**0.7**	**0.1**	**0**	**1**	**2.1**	**0.2**
	1.8				**3.3**			

	LIFE-CYCLE STAGE							
	DEFINE				EXECUTE			
JOB FAMILIES	0-5 YEARS	6-10 YEARS	11-20 YEARS	20+ YEARS	0-5 YEARS	6-10 YEARS	11-20 YEARS	20+ YEARS
All-Rounder (Facilities engineer)		1	0.1			1	0.2	
Process			1				1	0.1
Mechanical - Rotating			0.2				0.5	0.05
Mechanical - Non-rotating			0.2				0.5	0.05
Electrical			0.2				0.1	
Instrumental & Control			0.2				0.5	
Maintenance & Reliability			0.2				0.1	
Corrosion & Materials			0.2				0.05	
Subsea - Hardware								
Subsea - Controls								
Pipeline			0.2				0.3	
Project Management								
Civil & Structural (onshore)								
Process Safety & Loss Prevention			0.2				0.2	
Offshore Structures/Naval Architecture			0.5	0.1			0.2	
	0	**1**	**3.2**	**0.1**	**0**	**1**	**3.65**	**0.2**
	4.8				**4.9**			

	LIFE-CYCLE STAGE			
	OPERATE			
JOB FAMILIES	0-5 YEARS	6-10 YEARS	11-20 YEARS	20+ YEARS
All-Rounder (Facilities engineer)	1	1	0.1	0.01
Process	0.2	0.2	0.1	0.01
Mechanical - Rotating	0.1	0.2	0.1	0.01
Mechanical - Non-rotating	0.1	0.1	0.1	0.01
Electrical	0.1	0.1	0.1	0.01
Instrumental & Control	0.1	0.1	0.1	0.01
Maintenance & Reliability	0.1	0.1	0.1	0.01
Corrosion & Materials	0.1	0.1	0.1	0.01
Subsea - Hardware				
Subsea - Controls				
Pipeline	0.1	0.1	0.1	0.01
Project Management		0.2		0.01
Civil & Structural (onshore)				
Process Safety & Loss Prevention	0.1	0.1	0.1	0.01
Offshore Structures/Naval Architecture	0.1	0.1	0.1	0.1
	2.1	**2.4**	**1.1**	**0.12**
	5.7			

These engineering manpower estimates are based on the author's experience and have been developed for all of the asset types listed in Figure 10. There are numerous variables involved that can adjust these "base" figures higher or lower (the "mix factor" in Figure 10). The figures above also provide an allowance for development of new hires as well.

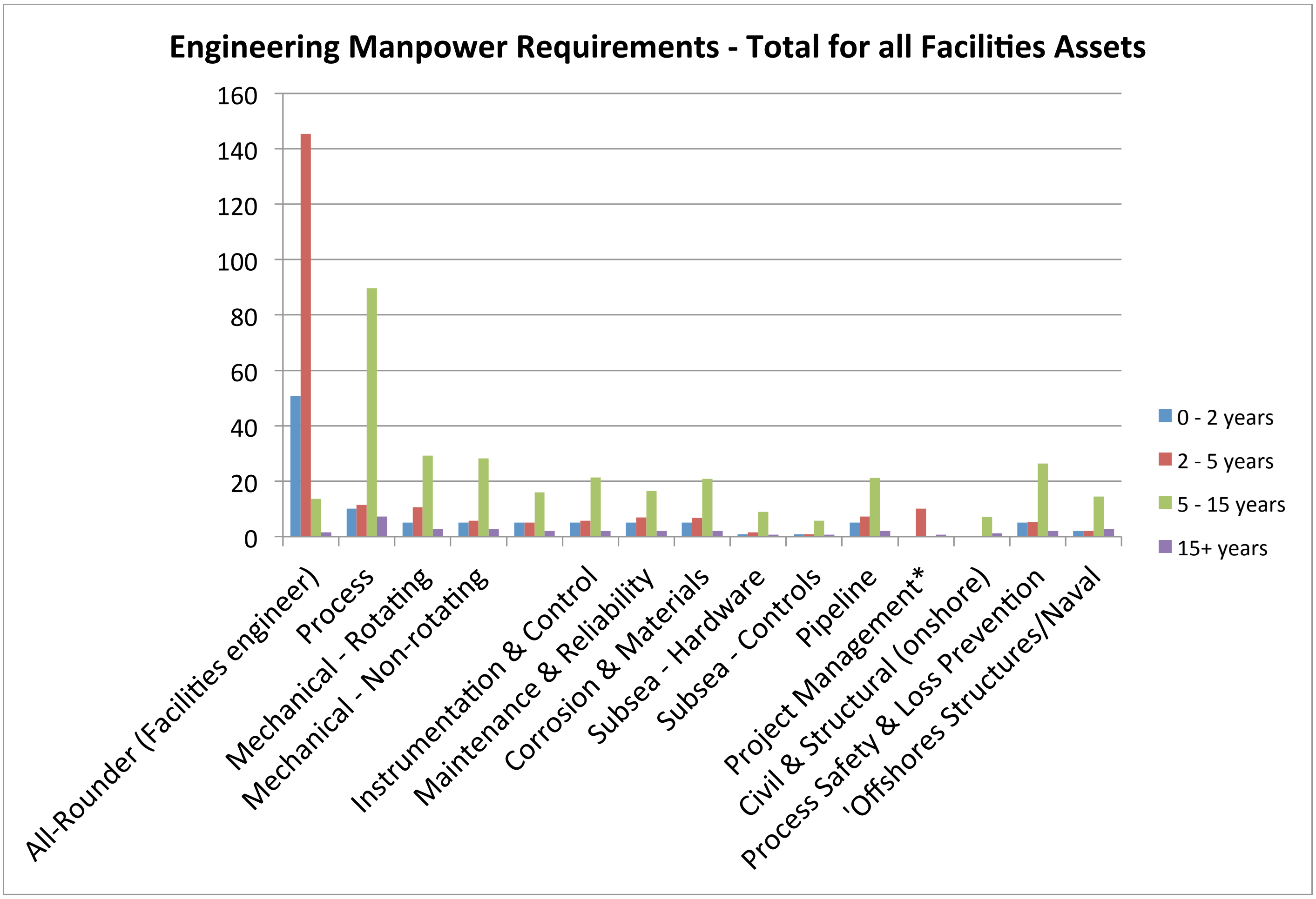
Step 3: Apply the individual asset-type manpower estimates to the asset portfolio and sum the figures.

This step basically involves multiplying the Figure 11 data (for each asset type) by the number of assets by life-cycle stage as given in Figure 10.

Figure 12 Roll-up of facilities engineering manpower requirements to support the corporate facilities asset portfolio as depicted in Figure 10

	FACILITIES ENGINEERING MANPOWER REQUIREMENTS				
JOB FAMILIES	0 - 2 YEARS	2 - 5 YEARS	5 - 15 YEARS	15+ YEARS	TOTAL
All-Rounder (Facilities engineer)	51	145	14	2	211
Process	10	12	90	7	119
Mechanical - Rotating	5	11	29	3	48
Mechanical - Non-rotating	5	6	28	3	42
Electrical	5	5	16	2	28
Instrumentation & Control	5	6	21	2	34
Maintenance & Reliability	5	7	16	2	31
Corrosion & Materials	5	7	21	2	35
Subsea - Hardware	1	2	9	0	12
Subsea - Controls	1	1	6	0	8
Pipeline	5	7	21	2	36
Project Management	0	10	0	1	11
Civil & Structural (onshore)	0	0	7	1	8
Process Safety & Loss Prevention	5	5	26	2	39
Offshores Structures/Naval Architecture	2	2	14	3	21
Total	105	225	319	32	681

Figure 13 Graphical representation of data in Figure 12



The results of this analysis can be used to compare the "theoretical" staffing requirements with "actual", identifying gaps and overlaps. This will assist with any reallocation of engineering resources that may be warranted and/or identification of new hires.

Conclusions

This paper has presented an approach to building a Facilities Engineering organization inside an Upstream-Midstream oil and gas operating company. The methodology used is believed to be logical and consistent and can assist in areas ranging from recruitment of new hires out of university through dealing with loss of expertise caused by retirement of senior employees. The process requires input from, and integration of the efforts, of multiple departments in order to achieve the objective – a high performance facilities engineering organization.

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