Notes on the FRE S-curves
F.R.Estuar E.B.Tuason
January, 2015

Appendix E- The FRE S-curves

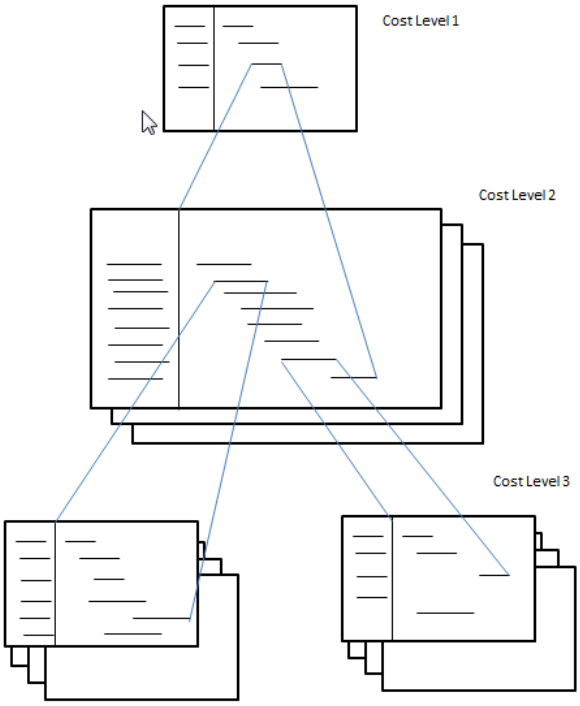
The FRE S-Curves are currently used by FB as the tool for monitoring and controlling cost, as a KPI, and an early warning system for catch-up activities in FB projects.

The lower level S-curves are quantity progress curves (like m3 of concrete, or tons of rebar). At rollup at highest level, they are tracked as percentage completion of the project major work breakdown structure. Percentage completion is weighted to the budgeted cost of the work item.

Overall Process

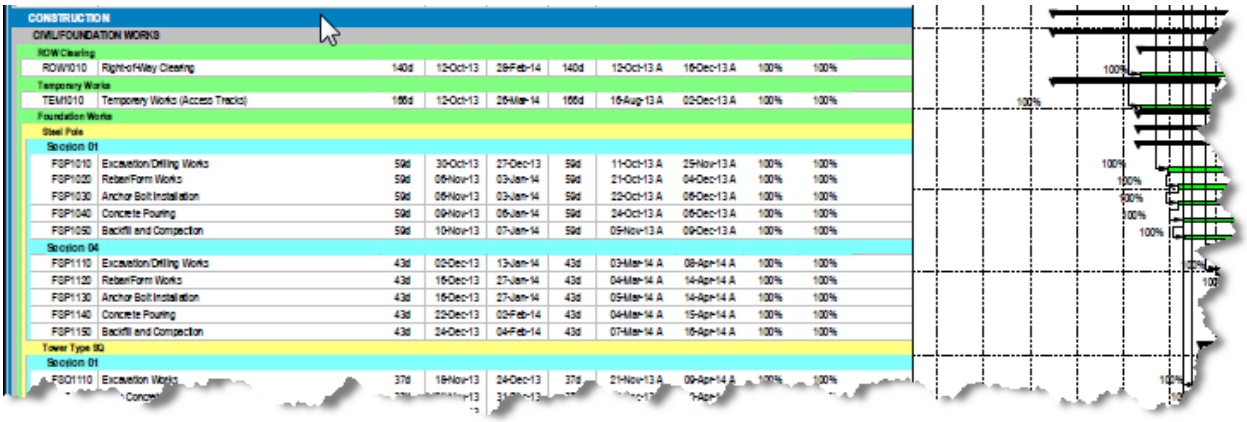
The overall process is as follows:

1. From Primavera or MS Project, extract certain fields from the schedule baseline
2. Identify the major work breakdown activities
3. From the Engineering construction drawings, and from highest level estimates, identify the major commodities or measurable work items (eg miles of right-of-way, number of tower bodies, number of steel poles, cubic meters of concrete, tons of steel).
4. Corelate these commodity or measurable work items under the major work breakdown structure
5. Spread the commodities or measurable work items on a schedule that synchronizes with the baseline schedule.
6. Track the work item progress (eg cubic meters poured during the week)
7. Track the major WBS as sum of work commodity items, weighted on cost.
8. Track overall progress of the project as a rollup of major WBS items, weighted on cost.
9. Create the FRE S-curves for plan and actual, for different levels, resulting in a hierarchical family of s-curves that can be shown on PMIS for review and drill-down



Step 1. From the baseline schedule, extract appropriate fields

PROCUREMENT									
PROH010	Finalize & Issue PO to Steel Towers Supplier	14d	05-Jul-13	19-Jul-13	14d	05-Jul-13 A	25-Jul-13 A	100%	100%
PROH020	Finalize & Issue PO to Steel Poles Supplier	14d	05-Jul-13	19-Jul-13	14d	05-Jul-13 A	07-Aug-13 A	100%	100%
PROH030	Procurement & Issue PO to Conductor & OHGW Supplier	14d	12-Aug-13	25-Aug-13	14d	12-Aug-13 A	13-Sep-13 A	100%	100%
PROH040	Procurement & Issue PO to OPGW Supplier	28d	29-Jul-13	25-Aug-13	28d	29-Jul-13 A	07-Oct-13 A	100%	100%
PROH050	Procurement & Issue PO to Insulators & Hardwares	30d	05-Oct-13	03-Nov-13	30d	25-Sep-13 A	04-Nov-13 A	100%	100%
PROH060	Procurement of Miscellaneous Indent Materials (Grounding, etc.)	35d	29-Jul-13	01-Sep-13	35d	29-Jul-13 A	10-Oct-13 A	100%	100%
PROH070	Procurement of Local Materials/Subcons for Main Works	35d	04-Sep-13	09-Oct-13	35d	05-Sep-13 A	11-Nov-13 A	100%	100%
STEEL POLE DESIGN, MANUFACTURING AND SHIPMENT									
SPDI010	Steel Poles Design & Structural (Shop & Erection) Drawings	28d	20-Jul-13	16-Aug-13	28d	20-Jul-13 A	16-Aug-13 A	100%	100%
SPDI020	Client, Review and Approval	15d	17-Aug-13	31-Aug-13	15d	17-Aug-13 A	02-May-14 A	100%	100%
SPDI030	Fabrication & Pre-assembly of Prototype Steel Pole	21d	01-Sep-13	21-Sep-13	21d	19-Sep-13 A	23-Sep-13 A	100%	100%
SPDI040	Factory Inspection & Approval of Prototype Steel Pole	3d	22-Sep-13	24-Sep-13	3d	23-Sep-13 A	01-Oct-13 A	100%	100%
SPDI050	Mass Manufacturing of Steel Poles	82d	25-Sep-13	15-Dec-13	82d	01-Oct-13 A	15-Dec-13 A	100%	100%
SPDI060	Shipment of Anchor Bolts	30d	16-Sep-13	15-Oct-13	30d	16-Sep-13 A	04-Oct-13 A	100%	100%
SPDI070	Customs Processing & Delivery to Site (Anchor Bolts)	14d	16-Oct-13	29-Oct-13	14d	04-Oct-13 A	12-Oct-13 A	100%	100%
SPDI080	Shipment of Steel Poles	28d	16-Dec-13	12-Jan-14	28d	16-Dec-13 A	23-Dec-13 A	100%	100%
SPDI090	Customs Processing & Delivery to Site (Steel Poles)	7d	13-Jan-14	19-Jan-14	7d	26-Dec-13 A	11-Jan-14 A	100%	100%
STEEL TOWER DESIGN, MANUFACTURING AND SHIPMENT									



Step 2 Identify major WBS activities

For this example,

1-000 Preliminary and General
2-000 Design Works
3-000 Main Works Pocurement and Construction
- 3-1000 Civil Works
- 3-2000 Foundation Works
- 3-3000 Tower/Pole Works
- 3-4000 Dressing and Stringing

Step 3
a--From the Engineering construction drawings, and highest level estimates, identify the major commodities or measurable work/cost items (eg miles of right-of-way, number of tower bodies, number of steel poles, cubic meters of concrete, tons of steel).
b--Corelate these commodity or measurable work items under the major work breakdown structure

For 3-2000 Foundation Works the following commodities/quantity tracking items were identified:

3-2000 Foundation Works
- 3-2100 Excavation 46,958 cubic meters total
- 3-2200 Lean Concrete 884 cubic meters total
- 3-2300 Rebars 592000 kg total
- 3-2400 Formwork 553 m2 total
- 3-26000 Backfilling 39 421 total

Step 4
Spread the commodities or measurable work items on a schedule that synchronizes with the baseline schedule.

SCOPE	ACTIVITIES	QTY.	UNITS	SCHEDULE START	SCHEDULE END	TRKG.	YEAR 2013						YEAR 2014										
							WK19	WK21	WK23	WK25	WK27	WK29	WK31	WK33	WK35	WK36	WK37	WK39	WK41	WK43	WK44	WK47	WK49
							16-Oct	30-Oct	13-Nov	27-Nov	11-Dec	25-Dec	8-Jan	22-Jan	5-Feb	12-Feb	19-Feb	5-Mar	19-Mar	2-Apr	9-Apr	30-Apr	14-May
							22-Oct	5-Nov	19-Nov	3-Dec	17-Dec	31-Dec	14-Jan	28-Jan	11-Feb	18-Feb	25-Feb	11-Mar	25-Mar	8-Apr	15-Apr	6-May	20-May
FOUNDATION WORKS	3-2100 Excavation	46,958.17	m3	9-Nov-13	8-May-14	Plan			8,506	15,090	18,672	28,255	37,114	41,052	42,036	42,036	42,036	42,931	43,826	44,721	45,168	46,511	

3-20000 Excavation Total Quantity = 46,958 m3

Step 6 Track the work item progress

SCOPE	ACTIVITIES	QTY.	UNITS	TRKG.	YEAR 2013						YEAR 2014										
					WK19	WK21	WK23	WK25	WK27	WK29	WK31	WK33	WK35	WK36	WK37	WK39	WK41	WK43	WK44	WK47	
					16-Oct	30-Oct	13-Nov	27-Nov	11-Dec	25-Dec	8-Jan	22-Jan	5-Feb	12-Feb	19-Feb	5-Mar	19-Mar	2-Apr	9-Apr	30-Apr	
					22-Oct	5-Nov	19-Nov	3-Dec	17-Dec	31-Dec	14-Jan	28-Jan	11-Feb	18-Feb	25-Feb	11-Mar	25-Mar	8-Apr	15-Apr	6-May	
FOUNDATION WORKS	3-2100 Excavation	46,958.17	m3	Plan			8,506	15,090	18,672	28,255	37,114	41,052	42,036	42,036	42,036	42,931	43,826	44,721	45,168	46,511	
				Actual				2,051	4,325	5,725	13,399	19,789	22,506	28,724	29,729	31,670	35,769	42,795	43,543	45,681	

3-20000 Excavation – units cum-to-date progress

Step- Track the major WBS as sum of work commodity items, weighted on cost.

Cost of each work commodity item is weighted as a percentage of the total project cost

SCOPE	ACTIVITIES	AMOUNT	PCT. WT.	TRKG.	YEAR 2013					
					WK19	WK21	WK23	WK25	WK27	WK29
					16-Oct	30-Oct	13-Nov	27-Nov	11-Dec	25-Dec
					22-Oct	5-Nov	19-Nov	3-Dec	17-Dec	31-Dec
FOUNDATION WORKS	3-2100 Excavation	31,920,315.35	15.65%	Plan			8,506	15,090	18,672	28,255
	3-2200 Lean Concrete	6,507,636.33	3.19%	Plan			153	283	369	545
	3-2300 Supply, Fabrication and Installation of Rebar	41,385,469.36	20.29%	Plan			112,803	196,947	251,089	365,232
	3-2400 Supply and Installation of Formworks	797,433.17	0.39%	Plan			71	161	221	341
	3-2500 Concreting Works	62,808,254.70	30.80%	Plan			1,543	2,543	3,244	4,544
	3-2600 Backfilling	11,523,818.98	5.65%	Plan			5,042	11,460	14,877	24,295
	3-2700 Pole Foundations (Including Towers 81 &	25,886,152.39	12.69%	Plan	75	207	278	338	367	456
	3-2700 Miscellaneous Civil Works (Hauling and Disposal of	23,123,562.72	11.34%	Plan				0.02	0.08	0.14
				PLAN	2.09%	5.76%	22.20%	34.77%	43.11%	60.90%
	TOTAL >>>	203,952,642.99	100.00%	ACTUAL	0.49%	2.67%	4.42%	9.87%	14.74%	28.32%

Contributions of all the commodities are summed up to get a point on the S-curve. For week 23, it will be ((8,506*679) + (153*7358) +…….) / 203952,642. This is work as a percentage of the total project cost. (planned completion of 22.20%.)

This is the point in the plan s-curve at week 23.

KEY PERFORMANCE INDICATOR (3-2000 - FOUNDATION WORKS)

STATUS AS OF : 12-Aug-2014

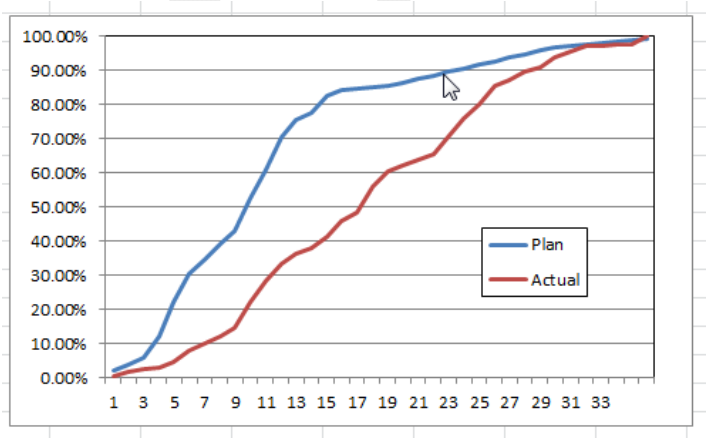
SCOPE	ACTIVITIES	QTY.	UNITS	UNIT COST	AMOUNT	PCT. WT.	TRKG.	YEAR 2013					
								WK19	WK21	WK23	WK25	WK27	WK29
								16-Oct	30-Oct	13-Nov	27-Nov	11-Dec	25-Dec
								22-Oct	5-Nov	19-Nov	3-Dec	17-Dec	31-Dec
3-2000 FOUNDATION WORKS	3-2100 Excavation	46,958.17	m3	679.76	31,920,315.35	15.65%	Plan			8,506	15,090	18,672	28,255
	3-2200 Lean Concrete	884.60	m3	7,356.59	6,507,636.33	3.19%	Plan			153	283	369	545
	3-2300 Supply, Fabrication and Installation of Rebar	592,640.27	kg	69.83236113874	41,385,469.36	20.29%	Plan			112,803	196,947	251,089	365,232
	3-2400 Supply and Installation of Formworks	553.37	m2	1,441.05	797,433.17	0.39%	Plan			71	161	221	341
	3-2500 Concreting Works	7,373.15	m3	8,518.51	62,808,254.70	30.80%	Plan			1,543	2,543	3,244	4,544
	3-2600 Backfilling	39,421.69	m3	292.32	11,523,818.98	5.65%	Plan			5,042	11,460	14,877	24,295
	3-2700 Pole Foundations (Including Towers 81 & 115)	456.00	m3	56,767.88	25,886,152.39	12.69%	Plan	75	207	278	338	367	456
	3-2700 Miscellaneous Civil Works (Hauling and Disposal of	1.00	lot	23,123,562.72	23,123,562.72	11.34%	Plan				0.02	0.08	0.14
							PLAN	2.09%	5.76%	22.20%	34.77%	43.11%	60.90%
	TOTAL >>>				203,952,642.99	100.00%	ACTUAL	0.49%	2.67%	4.42%	9.87%	14.74%	28.32%

The s-curve points are generated for each period.
Similar calculations are done for “Actual” curve points:

3-2000 FOUNDATION WORKS	3-2100 Excavation	46,958.17	m3	15.65%	Plan			8,506	15,090	18,672	28,255	37,114	41,052	42,036	42,036	42,036	42,931
					Actual				2,051	4,325	5,725	13,399	19,789	22,506	28,724	29,729	31,076
	3-2200 Lean Concrete	884.60	m3	3.19%	Plan			153	283	369	545	706	777	795	795	795	811
					Actual				19	43	71	212	274	312	442	499	527
	3-2300 Supply, Fabrication and Installation of Rebar	##########	kg	20.29%	Plan			112,803	196,947	251,089	365,232	472,952	520,827	532,796	532,796	532,796	543,677
					Actual				57,187	141,755	476,813	489,298	501,473	511,516	528,882	539,048	539,920
	3-2400 Supply and Installation of Formworks	553.37	m2	0.39%	Plan			71	161	221	341	442	486	497	497	497	508
					Actual					14	44	134	146	205	284	340	348
	3-2500 Concreting Works	7,373.15	m3	30.80%	Plan			1,543	2,543	3,244	4,544	5,884	6,480	6,629	6,629	6,629	6,764
					Actual					182	451	1,116	1,459	2,445	3,403	4,032	4,173
	3-2600 Backfilling	39,421.69	m3	5.65%	Plan			5,042	11,460	14,877	24,295	31,460	34,645	35,441	35,441	35,441	36,165
					Actual					128	1,278	2,968	3,872	11,034	12,012	14,476	16,750
	3-2700 Pole Foundations (Including Towers 81 & 115)	456.00	m3	12.69%	Plan	75	207	278	338	367	456						
					Actual	18	96	159	257	270	278	278	278	287	291	295	332
	3-2700 Miscellaneous Civil Works (Hauling and Disposal of Materials; Riprap Structures)	1.00	lot	11.34%	Plan				0.02	0.08	0.14	0.20	0.27	0.33	0.36	0.39	0.45
					Actual							0.14	0.18	0.21	0.23	0.27	0.32
					PLAN	2.09%	5.76%	22.20%	34.77%	43.11%	60.90%	75.52%	82.41%	84.66%	85.01%	85.37%	87.48%
	TOTAL >>>			100.00%	ACTUAL	0.49%	2.67%	4.42%	9.87%	14.74%	28.32%	36.50%	41.32%	48.46%	56.07%	60.57%	63.87%

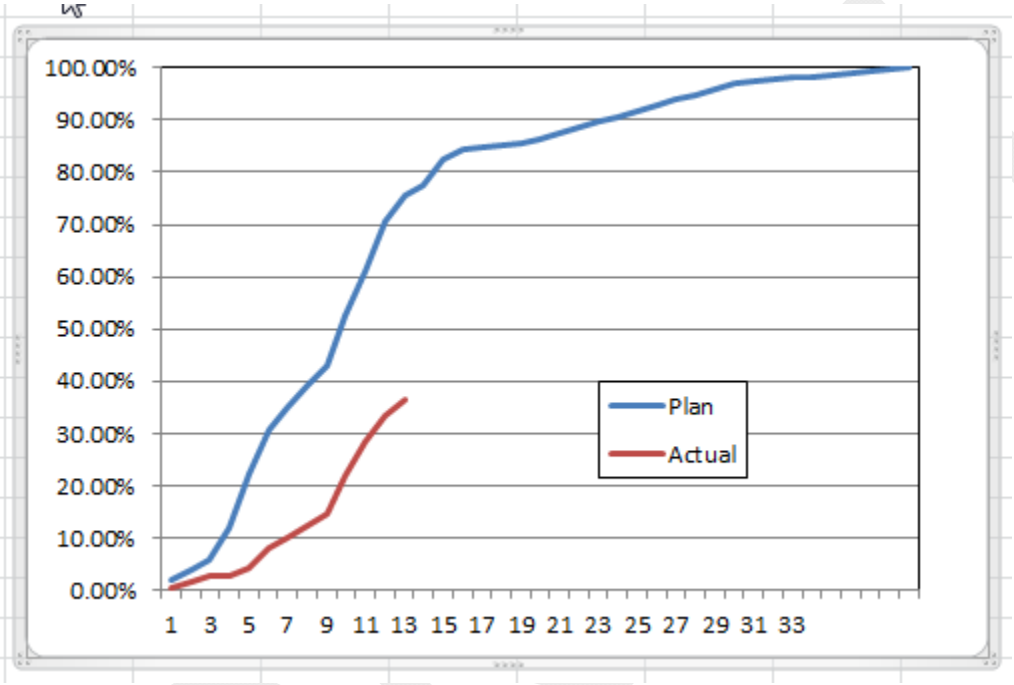
Step 9- Generate the FRE S-curves

From the Plan and Actual Totals, the S-Curve is generated, superimposed on the spreadsheet as a graphic showing plan vs actual:



Automating the S-Curve Reporting for the PMIS System

In a project review at PMIS for example, a presentation of an s-curve will immediately highlight items of a project that need attention. Here is an example:



This is where the the presentation capabilities of PMIS will help. S-curves can be shown at highest level, and drill-down to lower level curves will be possible.

Notation

Each cost item is identified with an intelligent cost code of the type

p-qrst

Examples 2-0000, 3-1000, 3-3200.

At the highest level they would be

1-0000
2-0000
3-0000
4-0000
…

A possible set of database tables would be

CostItemsTable	**TimePhasedValuesTable**
CostItemCode	CostItemCode
CostItemDescription	WeekNo
	PlannedValue
	ActualValue

In order to generate the S curve for a given CostItemCode, the program will gather all the cost items that belong to this code. That is, to get a rollup for 1-n000, it will be all the items with CostItemCode:

1-n100
1-n200
1-n300
……
1-nm00--- where for all values of m

In general, if the notation is
p-qrst

if p =3 and q=1 this will generate the s-curve for cost item 3.1
The s-curve for this will have all the contributions of all

p-qrst
3-1r00 for all r

That is
3-1100
3-1200
3-1300
3-1400

…

For each of the cost items (say for CostItemCode 3-1200), there will be time-phased records in the database, each record having the following:

CostItemCode
WeekNo
PlannedCumValue
ActualCumValue

To get one point on the s-curve---- say plan value for s-curve 3-1000

Gather all the items that contribute to 3-1000
result: 3-1100, 3-1200, 3-1300,…. Etc

For each of these items, get the planned value for the specific week.

Weight them according to cost, and sum as a percentage (see earlier discussion of the process)

This will give the planned value for the week for the the s-curve 3-1000

The same procedure can be made for “actuals”.

Rollups

Rollups, say to higher levels, are done in the same way

For example, the rollup for s-curve 1-1000 will be
1-1100
1-1200
1-1300
……
1-1m00--- where for all values of m

For higher-level roll=up, there are no more “measurable items” and the rollup is based on on cumulative percentage completed for the item. This cumulative percentage (translated into cost) is weighted against the total cost of the project.

Summary and General Comments

FRE S-curves are being used effectively for cost control and for key performance indicators. Slight re-orientation of the S curves can be used as an full EVMS System.

If the actual baseline schedule is used, and the time-phased data entries for a activity item are entered in period-costs, then the whole process is transformed to track BCWS, BCWP, and ACWP (budgeted cost of work scheduled, budgeted cost of work performed, actual cost of work performed) and from there, the calculations for variances, performance indices, and estimate-at-complete: CV, SV, CPI and SPI and EAC.

Appendix F. Misc Notes

Misc Notes From Visit Observations

Notes Re FGEN and FB

FB and FGEN have differences in the granularity of work breakdown structure. Creating the high-level integrated schedules, creating costs S-curves that will be effective for the control room PMIS --- is going to be a challenge.

FGEN as owner company of mega-project focuses on carrying out overall project planning and control of subcontractors. The subcontractors themselves (eg IEL) have their own PM staff and view their subcontract as a completely separate "project" with its own WBS. The primary subcontractor (eg IEL) could also subcontract part of the work to another company (eg FB). FB, in turn considers this as a completely separate project that is planned and controlled by its own PM staff. The FGEN project manager then integrates all the subcontractors' work as parts of the interlinked mega project. Interrelationships between individual subcontractor project plans making up the mega-projects will focus on key decision points or milestones.

First Balfour currently focuses on EPC work, with emphasis on Construction. It also has its own subcontractors --- but to some degree more under their closer supervision--- with their work done according to FB WBS.

More Observations re FGEN and FB

During the few meetings with FGEN and FB—there were some observations when compared with my prior experience:

While there is no shortage in talent, the companies do yet have formal company procedures on Project Controls, Project Management and Construction Management. The company is currently on a push on formalizing and institutionalizing these processes.

More Observations re FGEN and FB…..

There was no evidence that a full document management system is in-place. While there is archival of important papers--- widespread employee viewing/retrieval of documents is not in-place. Studies in the industry show that at least 30 to 40 percent of engineers time are spent on identifying and locating the right versions of documents. Without a document management system official project records are hard to find.

More Observations re FGEN and FB….

There is a recognition of EVMS as a very important PM tool. Formalizing this--- locating an EVMS software, training PM and control account managers, and interfacing the EVMS software to the cost system and the schedule system will be a challenge. There will be more challenges in proceduralizing the implementation on an FGEN mega-project (with a hierarchy of subcontractors with their own project control systems) .

One way of implementing an EVMS system would be to take the proven FRE S-curves and slightly re-orient its usage to track ACWP, BCWS, BCWP, SV, CV, and EAC. (see discussion on FRE S-curves Appendix E)