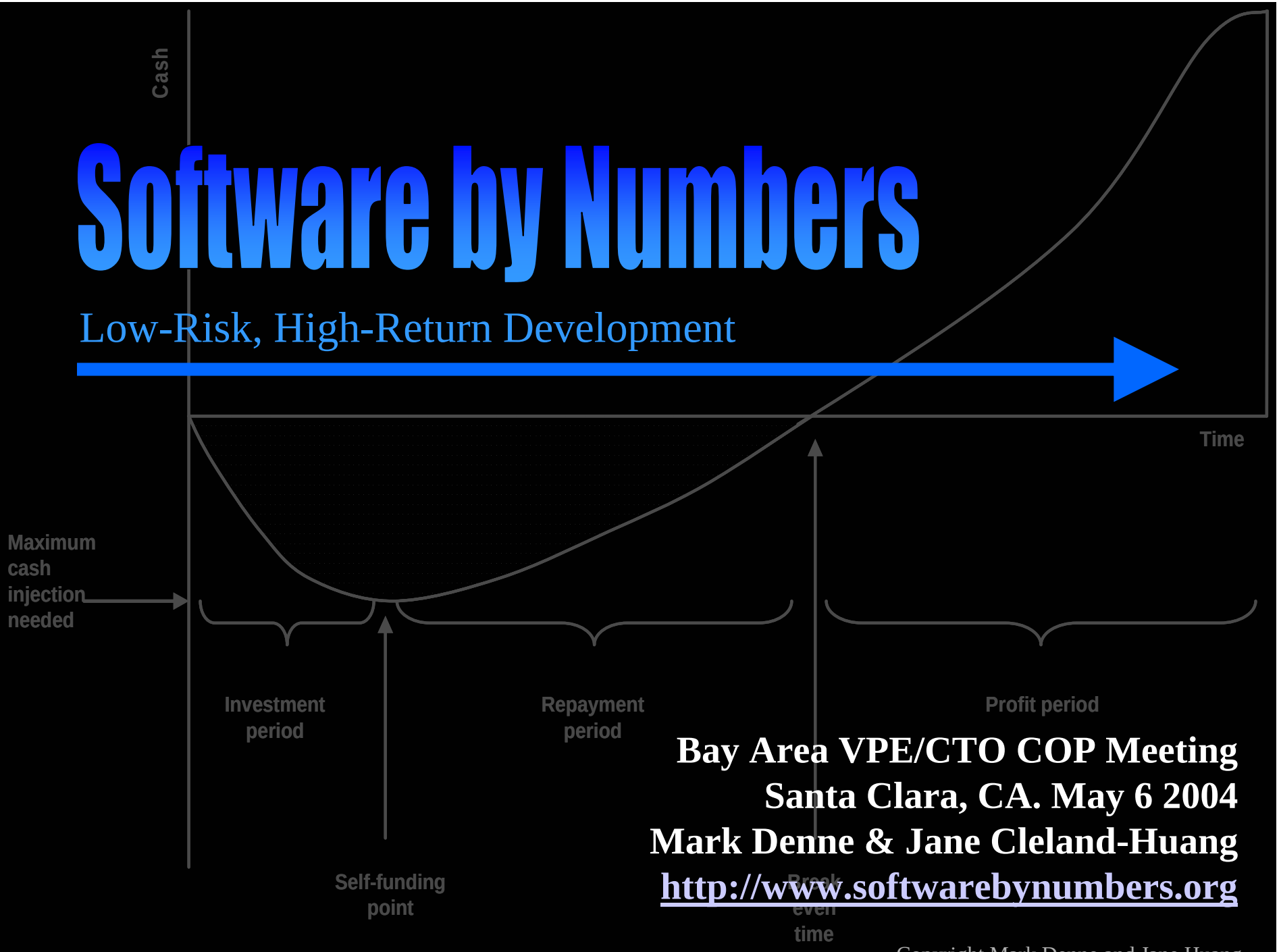
Software by Numbers

Low-Risk, High-Return Development



Bay Area VPE/CTO COP Meeting
Santa Clara, CA. May 6 2004
Mark Denne & Jane Cleland-Huang
http://www.softwarebynumbers.org

Rationale

- During dot.com era ROIs of 3-4 years were acceptable.
- Now business stakeholders demand ROIs of less than a year.
- Software delivered incrementally:
  - Higher project success rate
  - Opportunity to earn revenue sooner.

A customer oriented approach

Developers are responsible for MMF cost and effort estimations.

The entire team contributes to the success of the software development effort.

Business stakeholders determine the value of each MMF.

The Business Case

- ROI compares financial impact of different options over time.
- *Should we spend $1,000,000 to develop part of the system over 2 years or $1,500,000 to develop all of the system over 3 years?*
- The answer emerges from the construction of a business case:
  - A financial story based on facts, structured assumptions and logic.
  - Provides a vehicle by which the financial impact of the options can be examined and conclusions drawn.

The case for Incremental Delivery

Year	1	2	3	4	5	Total
Revenue				1,000	3,000	4,000
Hardware	-500	-100	-100	-200	-100	-1,000
Software	-300	-50	-50	-50	-50	-500
Headcount	-200	-300	-400	-300	-300	-1,500
Data Center	-30	-30	-30	-30	-30	-150
Sales/Mktg	0	0	-100	-200	-300	-600
Expense	-1,030	-480	-680	-780	-780	-3,750
Net Cash	-1,030	-480	-680	220	2,220	250
Investment	-1,030	-480	-680			-2,190
ROI						11%
DCF @ 10%	-936	-397	-511	150	1,378	-315

Year	1	2	3	4	5	Total
Revenue		500	1,000	1,500	2,000	5,000
Hardware	-500	-100	-100	-200	-100	-1,000
Software	-300	-50	-50	-50	-50	-500
Headcount	-200	-300	-400	-400	-400	-1,700
Data Center	-30	-30	-30	-30	-30	-150
Sales/Mktg	0	-100	-200	-300	-400	-1,000
Expense	-1,030	-580	-780	-980	-980	-4,350
Net Cash	-1,030	-80	220	520	1,020	650
Investment	-1,030	-80				-1,110
ROI						59%
DCF @ 10%	-936	-66	165	355	633	151

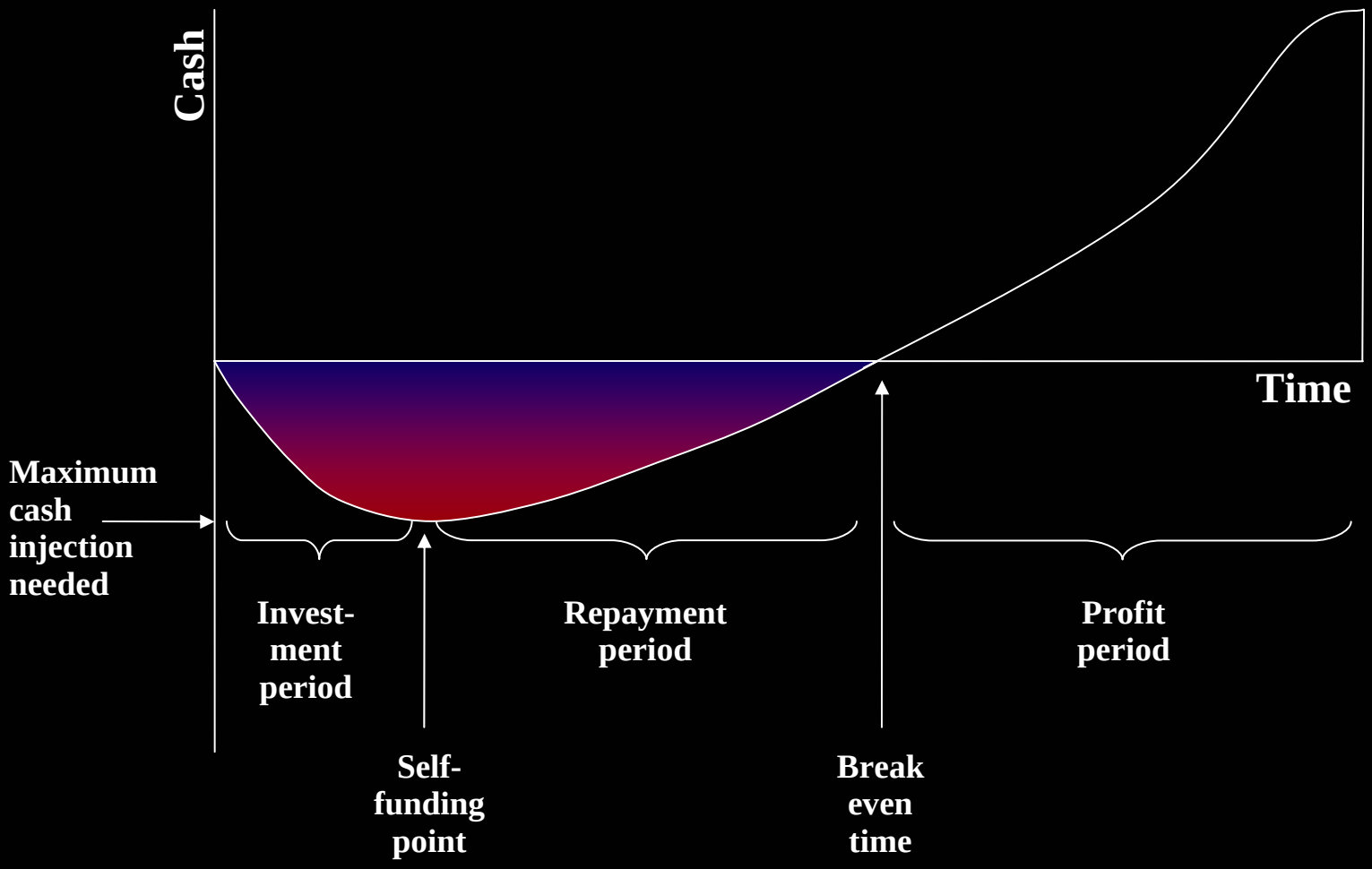
- The incremental project generates $5M vs. $4M over five years
- The business invests $1.11M vs. $2.19M to fund the project
- The resulting ROI over five years is 59% vs. 11%.

Incremental Delivery

Practice of delivering software incrementally is not new:

- In his 1988 book on Software Engineering Management, Tom Gilb refers to an IBM Federal Systems Division experience of “LAMPS’, which was a 200 person-year project, delivered successfully over four years in 45 incremental deliveries.
- Current emphasis on early delivery of executable functioning parts of the system
- The Standish Chaos report identified small project size as one of the most significant factors in project success

Project Metrics

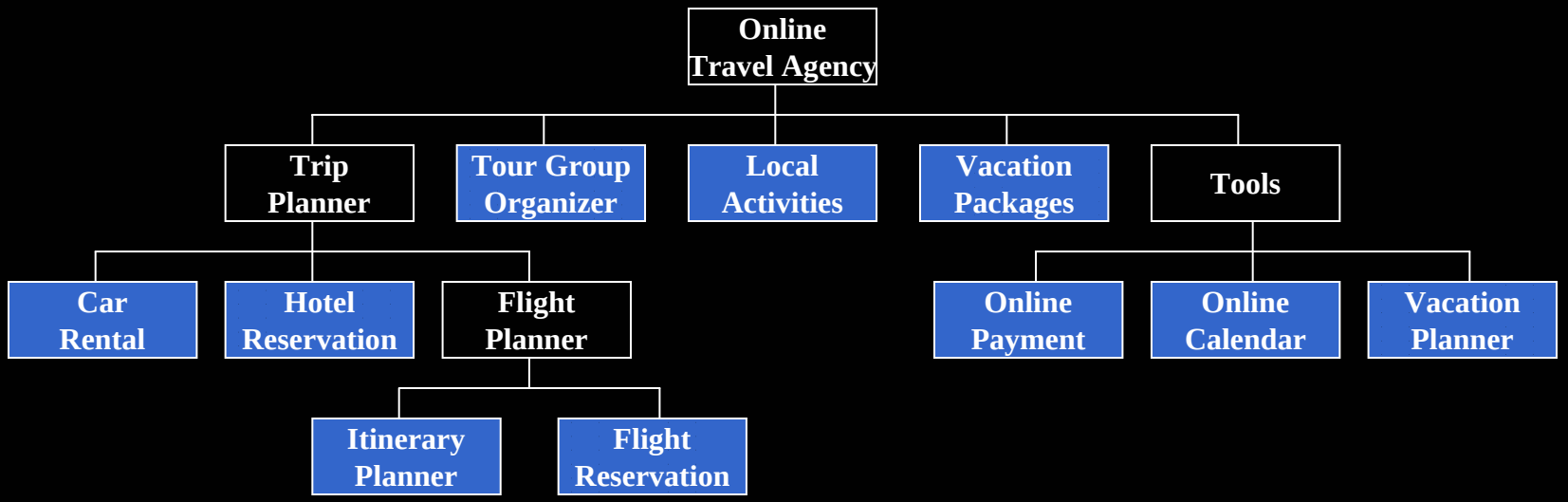


Minimum Marketable Feature

- MMFs are units of software value creation
- A component of intrinsic marketable value.
  - Competitive Differentiation
  - Revenue Generation
  - Cost Saving
  - Brand Projection
  - Enhanced Loyalty

MMFs

- In a planned methodology such as RUP, MMFs are identified in a top-down approach.



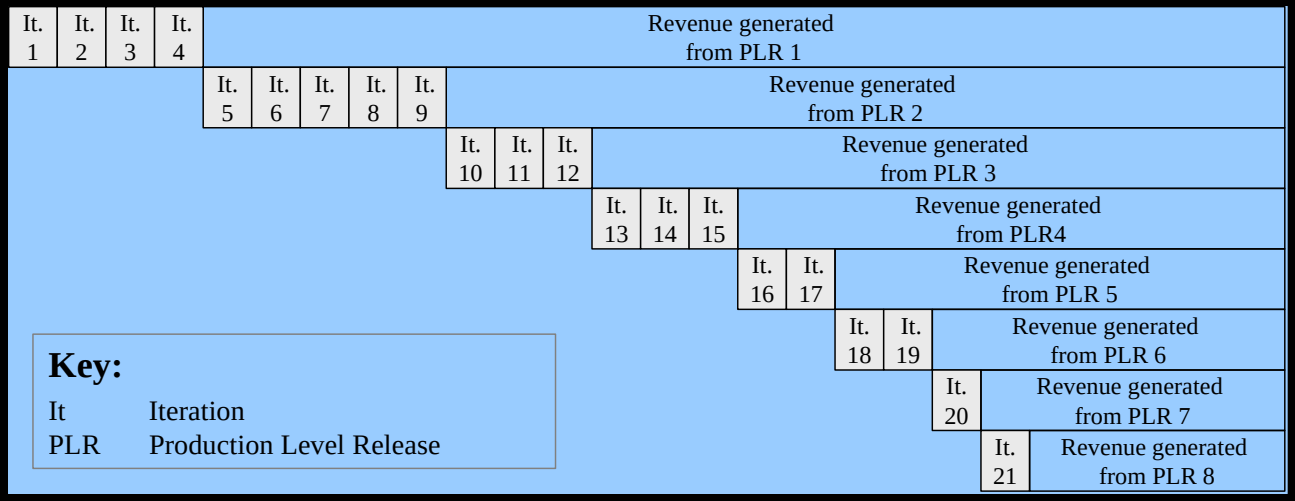
MMFs in eXtreme Programming

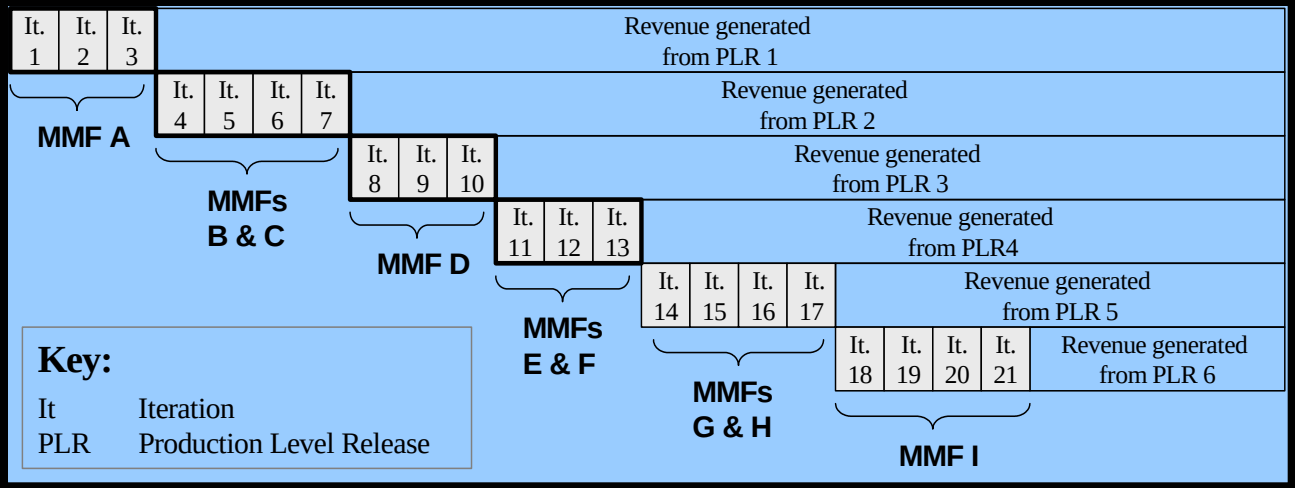
User Story:	**Time Estimate:**
View available Flights *Retrieve and display a list of flights that match users preferences.*	*2 weeks* **Benefits Analysis:** *As a stand-alone user story, the benefits are intangible. Should be bundled into a larger flight reservation MMF.*
See: MMF Flight Reservation	

MMF	**Time Estimate:**
Flight Reservation *User enters flight preferences* 1 week *View available flights* 2 weeks *Reserve roundtrip flight* 2 weeks *Review reservation* 1 week *Print flight details* 1 week	*7 weeks* **Benefits Analysis:** *20K per month* *(Derived from increased customer base plus savings in office and personnel costs)*

- User stories are bundled into MMFs.

XP's Planning Game





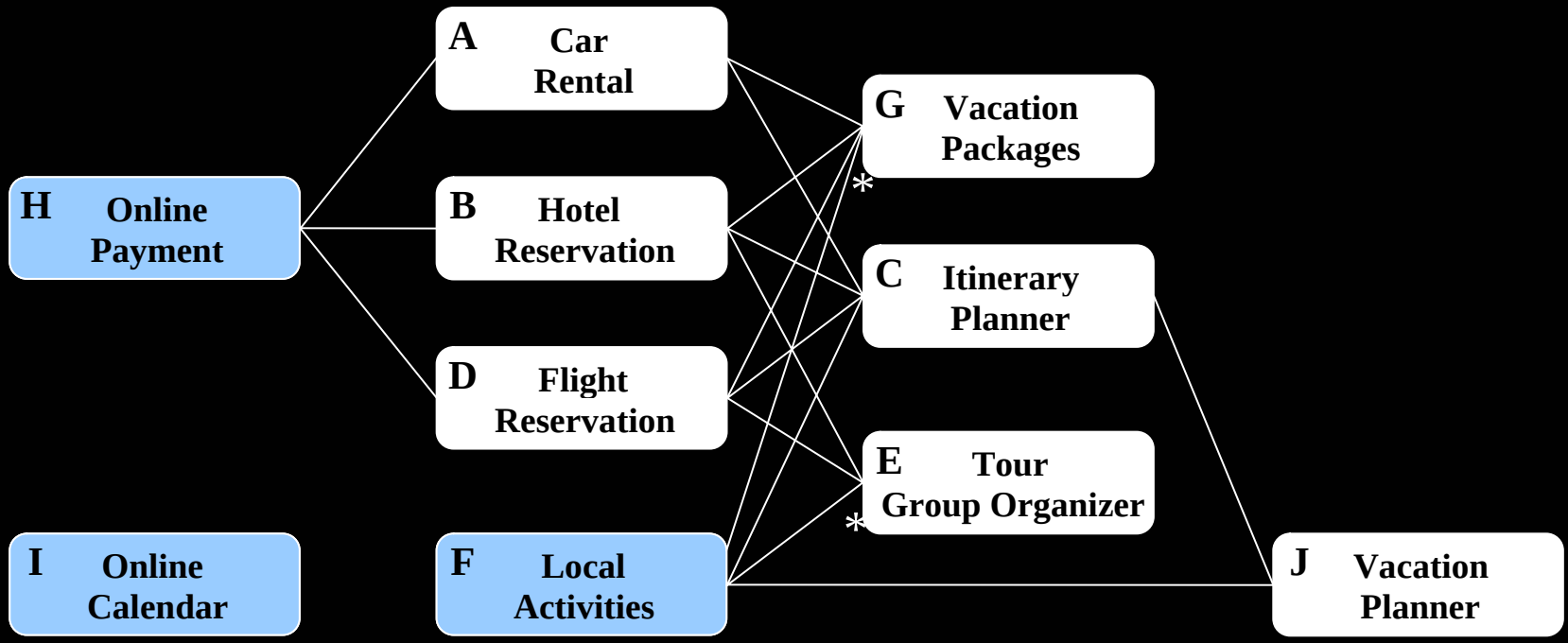
- MMFs must whenever possible be delivered within a single product level release.

MMF Precursors

MMF #	MMF Name	Precursors * = parallel delivery allowed
A	Car Rental	H
B	Hotel Reservation	H
C	Itinerary Planner	A,B,D,F
D	Flight Reservation	H
E	Tour Group Organizer	B,D,F*
F	Local Activities	
G	Vacation Packages	A,B,D,F*
H	Online Payment	
I	Online Calendar	
J	Vacation Planner	C,F

- Development precursors
- Delivery precursors

Precedence Graph



* Denotes that parallel development is allowed.

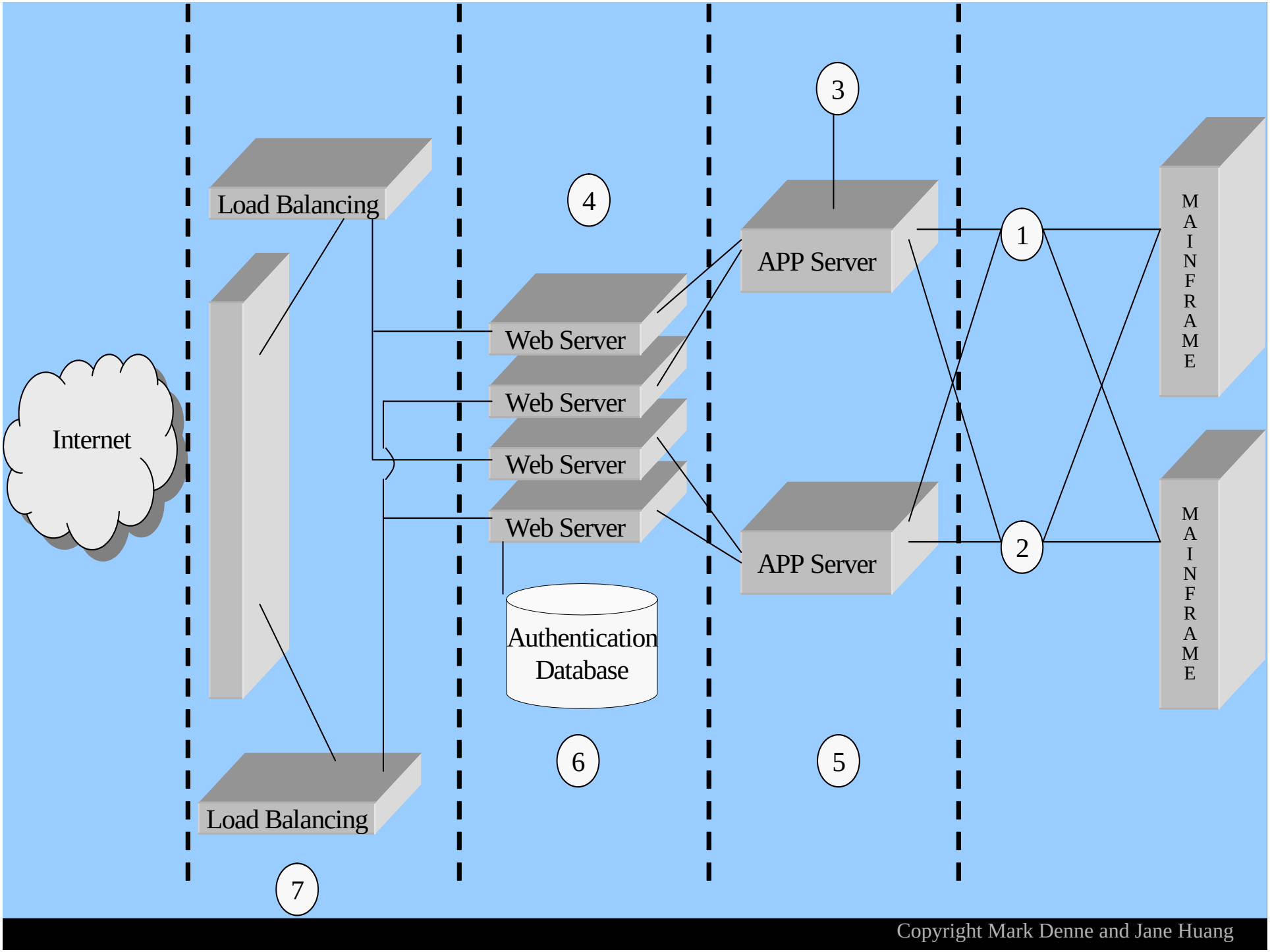
Architectural Elements

- Incremental approach to architecture
- Shape the architecture upfront
- Deliver architecture incrementally in terms of architectural elements (AE) or components.
- Each AE is developed ONLY as it is NEEDED by an MMF.
- AEs have cost, duration, but no revenues.

Architectural Elements

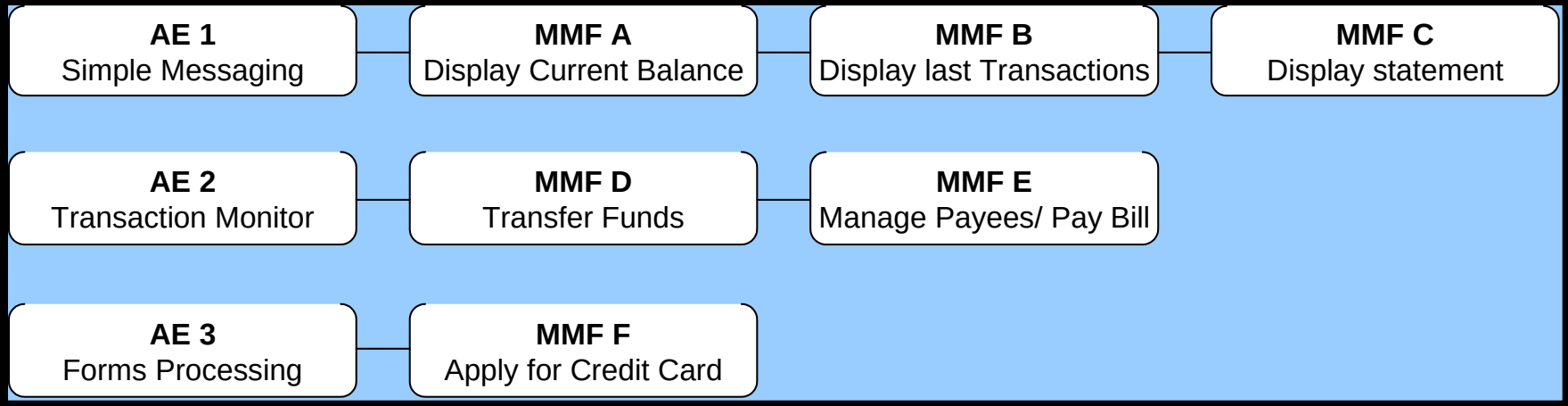
- A candidate architecture is decomposed into Architectural elements.
- Example: Banking portal

Ref	Architectural Element	Description
1	Simple messaging	Informational interface to bank's systems of record
2	Transaction Monitor	Transactional interface to bank's systems of record
3	Forms processing	Processing and routing of application forms
4	Web server infrastructure	Facilitate web facing applications
5	Application server	Container for business objects
6	Authentication System	Controls access
7	Load balancer	Control/routes sessions



Dependencies of MMFs upon AEs

- The AEs are integrated into the precursor table.



Evaluating MMFs

- Type of value
- Quantifying the value in terms of cost and revenue projections
- Tangible vs. intangible value
- Risk factors
- Cost and effort estimations
- Duration analysis

The time value of money

- Clearly money has a ‘time value’
- Software that delivers $1M in savings in one year is more interesting than software that delivers $1M in savings over 20 years.
- The value of future cash is discounted against an assumed interest rate to calculate its present value. $PV = \$x / 1 + i/100)^n$
- Interest rate of 5% per year. Then $1M in 20 years is the same as:

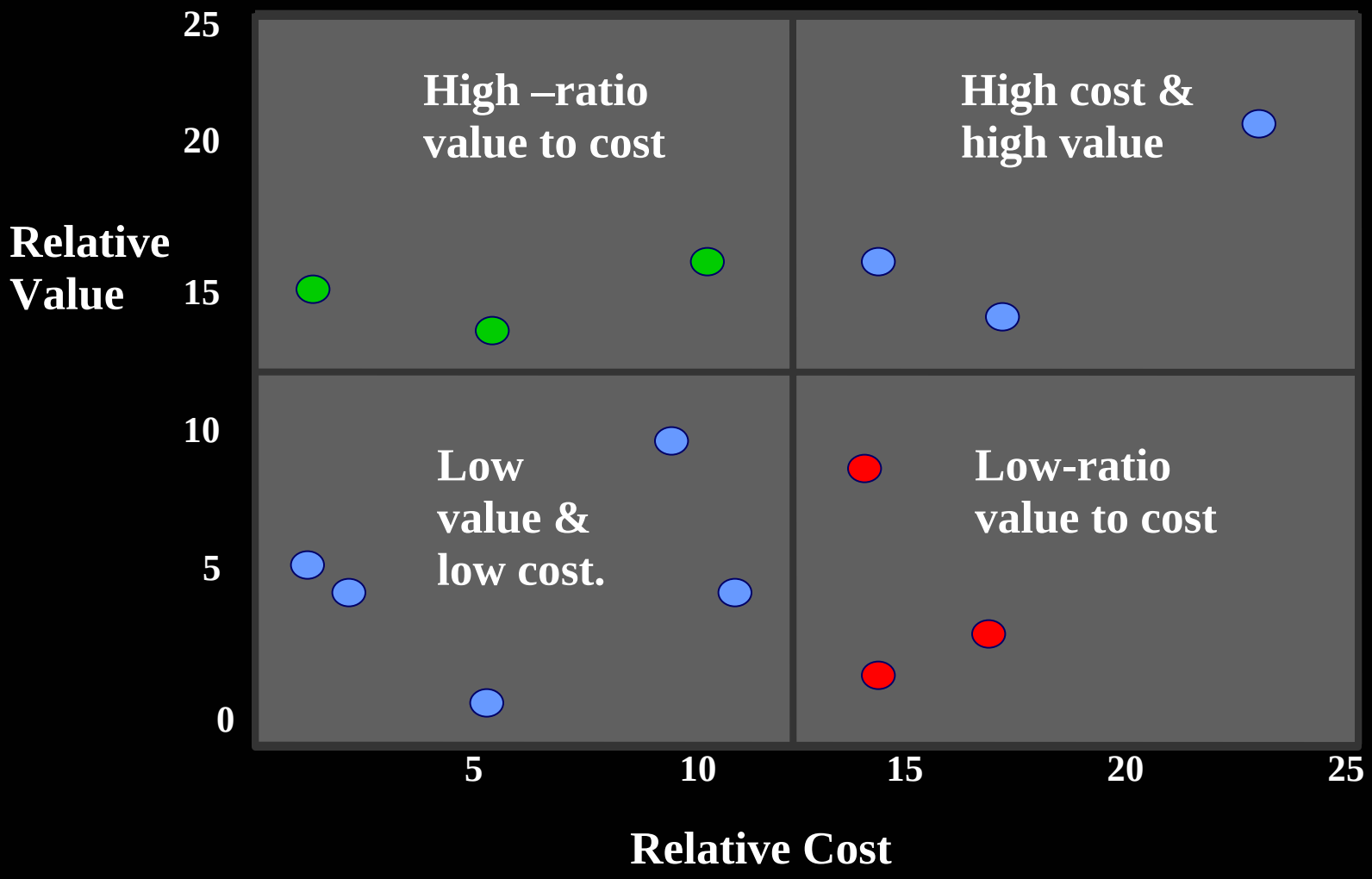
  $1{,}000{,}000 / (1+0.05)^{20} \cong \$377{,}000$ today.

MMF	Cost and Revenue per period $K											
	1	2	3	4	5	6	7	8	9	10	11	12
A	-200	-200	100	120	140	160	200	220	240	300	320	340
B	-250	50	50	80	100	120	140	160	180	200	200	200

Costs and Revenue per period with various delivery options ($K)												NPV@10%
1	2	3	4	5	6	7	8	9	10	11	12	
-200	-200	100	120	140	160	200	220	240	300	320	340	1,604
0	-200	-200	100	120	140	160	200	220	240	300	320	1,285
0	0	-200	-200	100	120	140	160	200	220	240	300	986
0	0	0	-200	-200	100	120	140	160	200	220	240	708
0	0	0	0	-200	-200	100	120	140	160	200	220	486
0	0	0	0	0	-200	-200	100	120	140	160	200	283
0	0	0	0	0	0	-200	-200	100	120	140	160	101
0	0	0	0	0	0	0	-200	-200	100	120	140	-44
0	0	0	0	0	0	0	0	-200	-200	100	120	-170
0	0	0	0	0	0	0	0	0	-200	-200	100	-277

MMF	SANPV per Period											
	1	2	3	4	5	6	7	8	9	10	11	12
A	1604	1285	986	708	486	283	101	-44	-170	-277	-365	-182
B	1138	949	761	574	407	260	132	22	-68	-140	-184	-227

Value vs. Cost



Why heuristics are needed

# MMFs	# Sequences
1	1
2	2
3	6
4	24
5	120
6	720
7	5,040
8	40,320
9	362,880
10	3,628,800

# MMFs	# Sequences
11	39,916,800
12	479,001,600
13	6,227,020,800
14	87,178,291,200
15	1,307,674,368,000
16	20,922,789,888,000
17	355,687,428,096,000
18	6,402,373,705,728,000
19	121,645,100,408,832,000
20	2,432,902,008,176,640,000

- For a project of 14+ MMFs the brute force approach is infeasible.
- Feasible sequences = n!

Sequencing Strategies

- Objective to maximize project wide NPV.
- Explore three approaches
  - Greedy
  - Strand-based look-ahead
  - Weighted strand-based look-ahead
- Other possible objectives will be explored later.

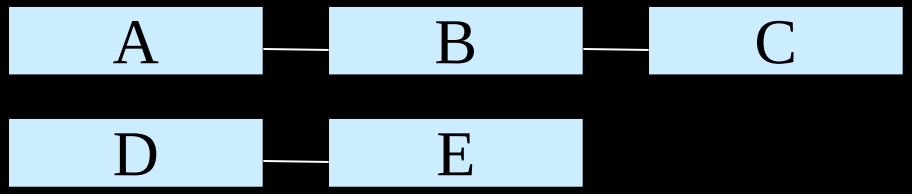
Greedy

- Select the MMF with the highest NPV that has no unfulfilled precursors (A-B-C, D-E)

MMF	Costs	Revenue	SANPV if development starts in period: (Disc 2.41% per period)						
			1	2	3	4	5	6	7
A	-50	45.00	231	189	149	109	70	32	-5
B	-40	60.00	334	278	223	169	117	66	16
C	-20	35.00	198	165	133	102	71	41	12
D	-50	50.00	262	216	170	126	83	40	-1
E	-60	30.00	128	101	74	48	23	-2	-26

- Identified sequence DABCE / $799K
- Optimal sequence ABDCE / $804K

Look-ahead



- Identify MMF strands from the precursors
- Strands A, AB, ABC, B, BC, C, D, DE, E
- Select the MMF belonging to the strand with the greatest NPV value for the current period.

Strand	SANPV if strand development starts in period:						
	1	2	3	4	5	6	7
A	231	189	149	109	70	32	-5
AB	509	412	318	226	136	48	-38
ABC	642	514	389	267	148	31	-38
B		278	223	169	117	66	16
BC		411	325	240	158	78	-1
C			133	102	71	41	12
D	262	216	170	126	83	40	-1
DE	363	290	219	149	81	14	-51
E		101	74	48	23	-2	-26

SANPV ABDCE

$= SANPV_{A:\ Period\ 1} + SANPV_{B:\ Period\ 2} + SANPV_{D:\ Period\ 3}$
$+ SANPV_{C:\ Period\ 4} + SANPV_{E:\ Period\ 5}$

= $231,000 + $278,000 + $170,000 + $102,000 + $23,000

= $804,000

Faulting the Look-ahead

- Fails to take into account # of delivery periods as a consumable resource.

MMF	1	2	3	4	5	6	7	8
A	-100	150	150	150	150	150	150	150
B	-200	50	50	50	50	50	50	50
C	-100	100	130	160	144	171	198	225
D	-100	30	30	30	30	0	0	0

- Apply look-ahead algorithm to identify the delivery sequence. (Precursors A-B, C-D) (Discount 8% per period)
- Problems?

NPVRank	Sequence	NPV	%Optimal	Loss
1	CABD	1804	100%	0
2	CAB	1787	99%	17
3	CAD	1761	98%	43
4	CADB	1758	97%	47
5	CA	1744	97%	60
6	ACBD	1734	96%	70
7	ACB	1717	95%	87
8	ACD	1691	94%	113
9	AC	1674	93%	131
10	CDA	1616	90%	189
11	CDAB	1612	89%	192
12	ABCD	1591	88%	214
13	ABC	1574	87%	231
14	AB	1000	55%	804
15	CD	998	55%	806
16	C	981	54%	823
17	A	910	50%	894

Applying a weighting factor

- Adding a weighting factor enables strands to be weighted according to their length.
- Weighting factor = 1 – (*weighting multiplier* X (number of periods in the strand –1))
- Apply a 10% weighting factor to the previous example:

Strand/Period	1	2	3	4	5	6	7	8
A	910	763	617	473	330	187	46	-94
B	138	90	43	-4	-50	-96	-142	-188
AB	900	726	552	380	210	41	-127	-84
C	981	764	573	410	272	121	-1	-94
D	18	17	17	17	-11	-39	-66	-94
CD	899	703	531	359	210	49	-85	-84

Sequence selection

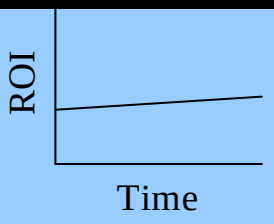
- Selection is made according to weighted strand.
- Sequence ACBD is selected and actually IS the optimal sequence.
- NPV is calculated on NON-WEIGHTED strands.

Strand/Period	1	2	3	4	5	6	7	8
A	910	763	617	473	330	187	46	-94
B	138	90	43	-4	-50	-96	-142	-188
AB	900	726	552	380	210	41	-127	-84
C	981	764	573	410	272	121	-1	-94
D	18	17	17	17	-11	-39	-66	-94
CD	899	703	531	359	210	49	-85	-84

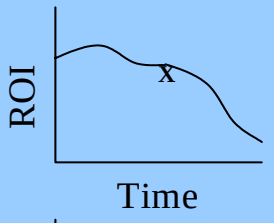
Impact of MMF behavior

- MMFs don't ALL behave in a standard way.
- Certain behaviors make it hard to predict an optimal sequence.

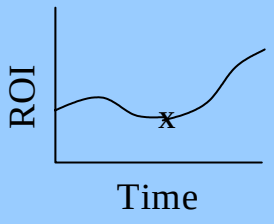
a. *An MMF that is not significantly influenced by time.*



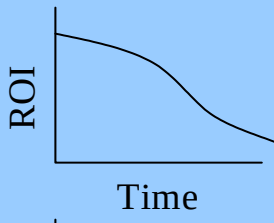
b. *An MMF that must be completed prior to a certain date in order to achieve close to maximum ROI.*



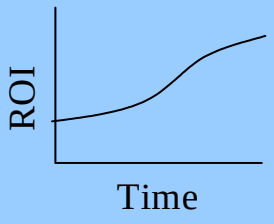
c. *An MMF that should not be developed until a certain date, at which time risks are expected to be more clearly defined.*



d. *There is a general trend for relative value of the MMF to decrease over time.*



e. *There is a general trend for relative value of the MMF to increase over time.*



Time Sensitive Delivery

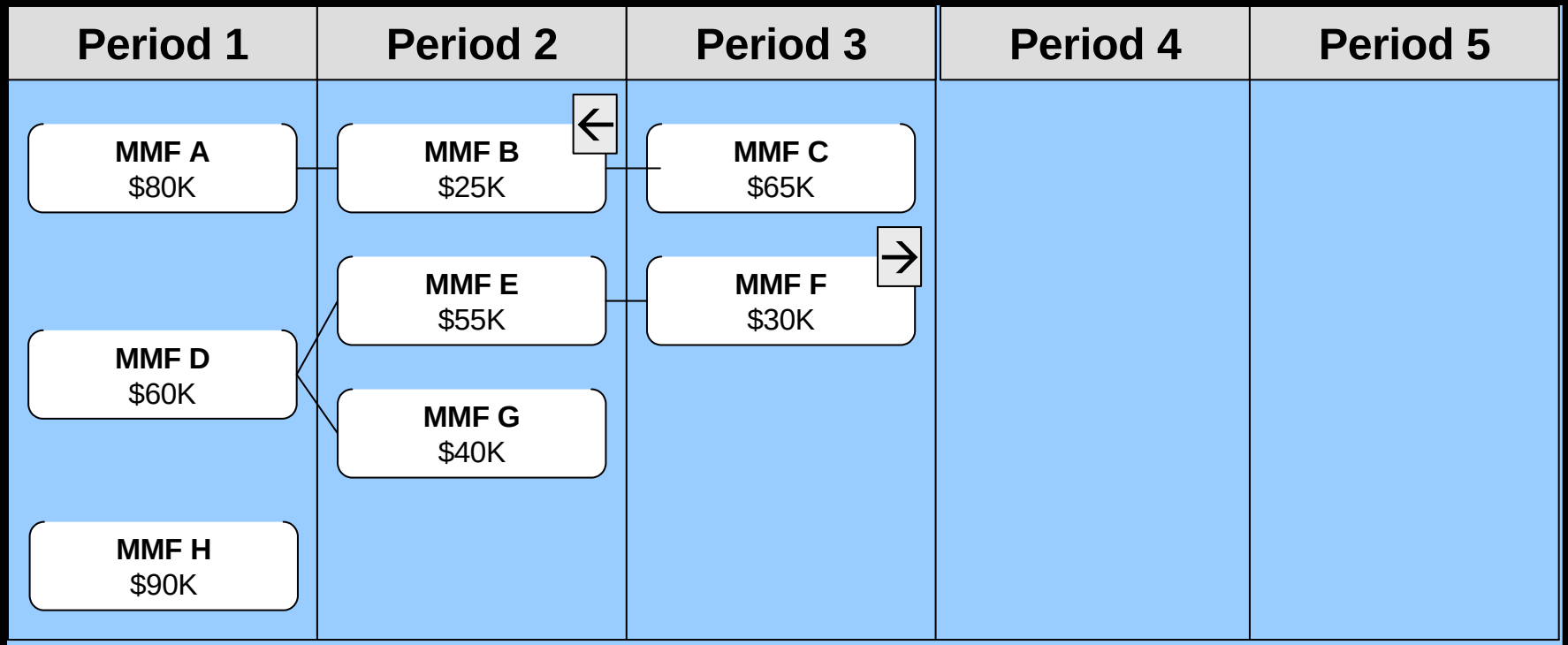
MMF A	Per-Period Revenue less Cost							
	1	2	3	4	5	6	7	8
(Delivered Early)	-60.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
(Delivered Late)	n/a	n/a	-60.00	30.00	30.00	30.00	30.00	30.00

- MMF with delivery sensitivity.

MMF	SANPV				
	1	2	3	4	5
A	216.80	177.13	88.28	58.71	29.21

- The SANPV incorporates the period-appropriate revenue into the SANPV calculation.

Annotate the Graph



Time sensitive: Must be delivered ‘early’ in the schedule.

Time sensitive: Must be delivered ‘late’ in the schedule.

Concurrent Development

Strand	Periods															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	-50	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
B	-20	10	10	9	8	7	6	5	4	3	2	1	0	0	0	0
C	-20	-20	10	13	16	19	22	25	25	25	25	25	25	25	25	25
D	-20	-20	10	14	18	22	26	30	34	38	40	40	40	40	40	40
E	-50	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

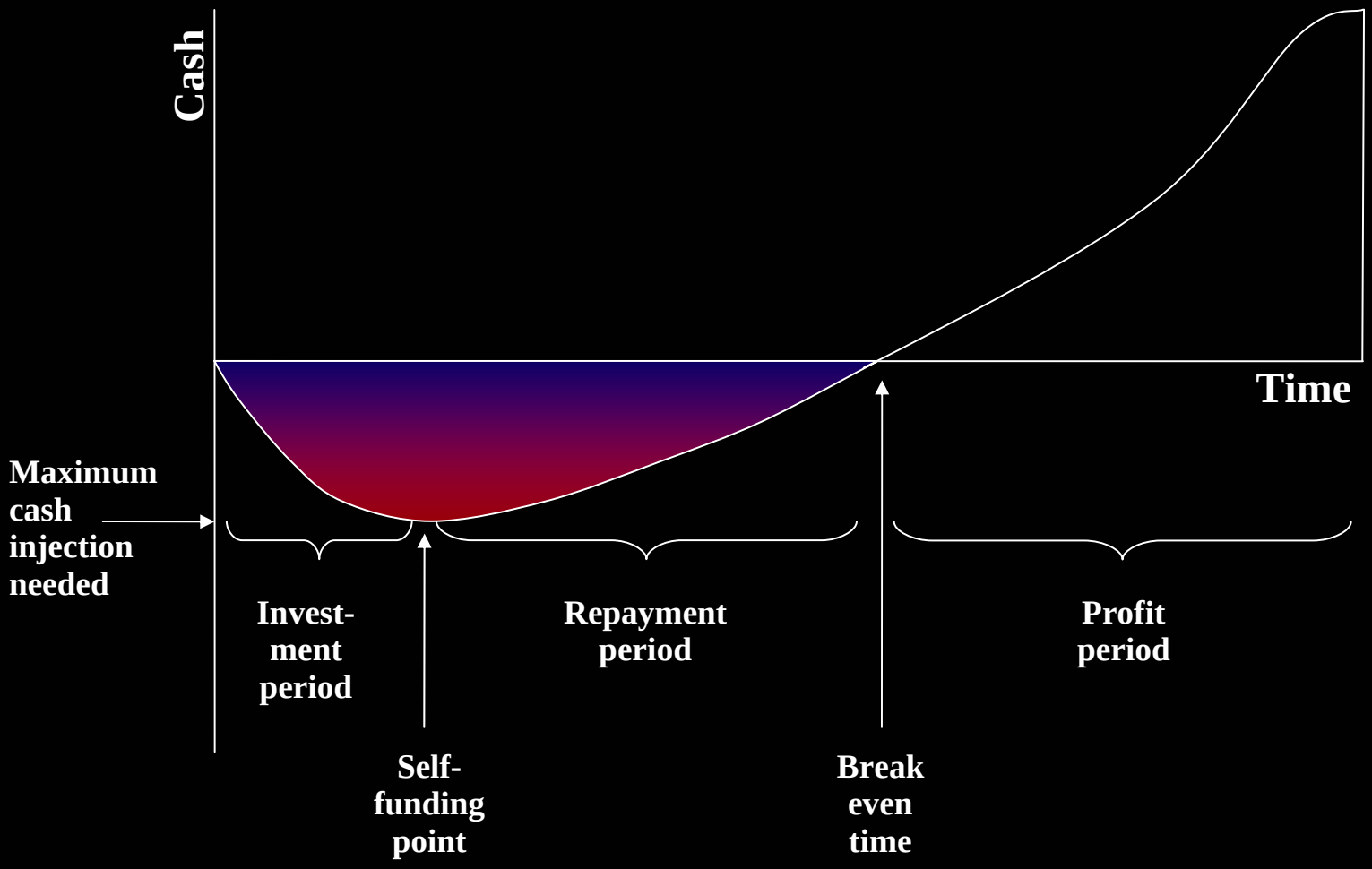
MMF	Precursor
A	
B	A
C	
D	
E	D

- Concurrent development enables MORE MMFs to be developed per period.
- How does it impact project level financial metrics?

Strand	SANPVs per Period															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E	439	405	372	338	305	272	239	207	174	142	111	79	48	17	-14	-44
D.	304	271	240	208	177	146	115	86	60	37	17	1	-13	-23	-30	-15
D.E	510	460	411	362	313	264	217	170	127	86	48	13	-20	-50	-25	-12
C.	205	185	165	145	126	106	87	67	48	29	13	-1	-13	-23	-30	-15
A	90	81	71	62	53	44	35	26	17	8	-1	-10	-18	-27	-36	-44
B	42	42	42	41	41	40	38	35	31	27	21	15	8	0	-9	-18
AB	112	104	96	88	79	69	59	48	37	24	12	-2	-16	-31	-45	-37

- Calculate 1 MMF per period vs. 2 MMFs per period NPV.
- Also consider other project level metrics.

Project Metrics



- Linear sequence: **D.EC.AB**.
- Funding required $80K
- NPV $981K
- Self-funding in period 4.
- Break-even time = 7.04
- ROI 1349%

Sequence	MMF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Net
D.EC.AB	D	-20	-20	10	14	18	22	26	30	34	38	40	40	40	40	40	40	**392**
	.																	
	E			-50	35	35	35	35	35	35	35	35	35	35	35	35	35	**405**
	C				-20	-20	10	13	16	19	22	25	25	25	25	25	25	**190**
	.																	
	A						-50	10	10	10	10	10	10	10	10	10	10	**50**
	B							-20	10	10	9	8	7	6	5	4	3	**42**
Cash		-20	-20	-40	29	33	17	64	101	108	114	118	117	116	115	114	113	**1,079**
Investment		-20	-20	-40														**-80**
ROI																		**1349%**
Self fund status					X													
PV		-20	-20	-39	28	32	16	61	95	101	105	108	106	105	103	101	100	**981**
Rolling NPV		-20	-40	-79	-50	-19	-3	58	153	253	359	467	573	678	781	882	981	
Breakeven status								X										**7.04**

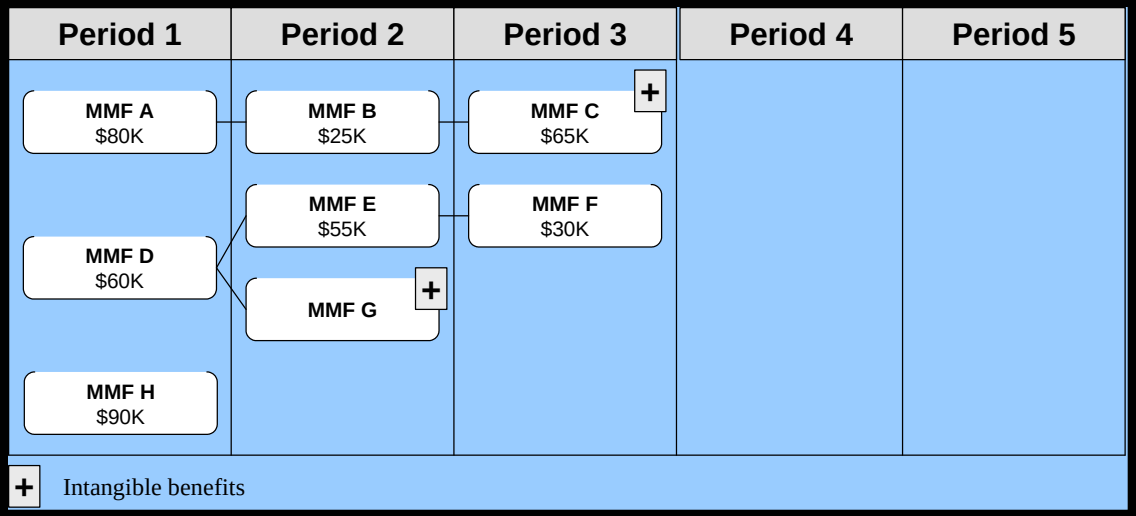
- Parallel Sequence (2 MMFs per period): **(D.C.)()(EA)(B)**
- Funding required $160K
- NPV $1083K
- Self-funding in period 4.
- Break-even time = 6.23
- ROI 742%

Sequence	MMF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Net
D.EB	D	-20	-20	10	14	18	22	26	30	34	38	40	40	40	40	40	40	**392**
	.																	
	E			-50	35	35	35	35	35	35	35	35	35	35	35	35	35	**405**
	B				-20	10	10	9	8	7	6	5	4	3	2	1	0	**45**
C.A	C	-20	-20	10	13	16	19	22	25	25	25	25	25	25	25	25	25	265
	.																	0
	A			-50	10	10	10	10	10	10	10	10	10	10	10	10	10	80
Cash		-40	-40	-80	52	89	96	102	108	111	114	115	114	113	112	111	110	**1,187**
Investment		-40	-40	-80														**-160**
ROI																		**742%**
Self fund status					X													
PV		-40	-39	-78	50	86	92	96	101	103	105	105	104	102	100	99	97	**1,083**
Rolling NPV		-40	-79	-157	-107	-21	70	167	268	371	477	582	686	788	888	986	1,083	
Breakeven status							X											**6.23**

Intangibles

- IFM recognizes the importance of intangibles.
- 200 IT and business professionals were asked how they weighted the benefits of intangibles vs. standard ROI measurements.
  - 47% weighed them equally
  - 33% weighed ROI measurements more heavily
  - 20% weighed intangibles more heavily.
- Clearly businesses value the role of intangibles within the decision making process.

Two approaches



- Handle them as totally unquantifiable.
  - All development projects are little more than ‘guesswork’
  - No realistic financial case for funding a project.
- Attempt to quantify them whilst
  - Clearly differentiating between measurable ROI and intangible projections.
  - Reporting related metrics.

Intangibles Example

MMF	Periods							
	1	2	3	4	5	6	7	8
A	-32	?	?	?	?	?	?	?
B	-50	10	14	22	36	52	72	96
C	-85	32	32	32	32	32	32	32
D	-60	20	23	26	30	28	25	22
E	-60	?	?	?	?	?	?	?
F	-120	42	44	46	48	50	52	54
G	-60	40	40	30	20	20	10	10
H	-60	21	22	23	24	25	26	27
I	-50	15	15	15	15	15	15	15
J	-20	15 ?	15 ?	15 ?	15 ?	15 ?	15 ?	15 ?

- Fill in all known costs and revenues.
- For intangibles fill in costs only.

A Pairwise Approach

1. Apply a comparative process to normalize intangible benefits in terms of NPV equivalencies.
2. Identify a set of ‘gauges’
   - Gauges must not exhibit delivery sensitivities or unusual patterns of income generation
   - Should follow a standard curve of projected revenues
   - Choose the ‘right amount’ of gauges.
3. Construct a pairwise comparison table.

Gauges: MMFs with Quantitatively Valued ROI Selected for Comparison Purposes

	MMFs	C	F	H
Intangibly Valued MMFs	A			
	E			
	Total Revenue Over Analysis Period	$224	$336	$168

Make pairwise comparisons

1. Each intangible MMF is compared to each gauge in turn.
2. Revenue comparisons are made in terms of perceived value.

Gauges: MMFs with Quantitatively Valued ROI Selected for Comparison Purposes

	MMFs	C	F	H
Intangibly Valued MMFs	**A**	0.5	0.4	0.67
	E	1.25	0.8	1.67
	Total Revenue Over Analysis Period	**$224**	**$336**	**$168**

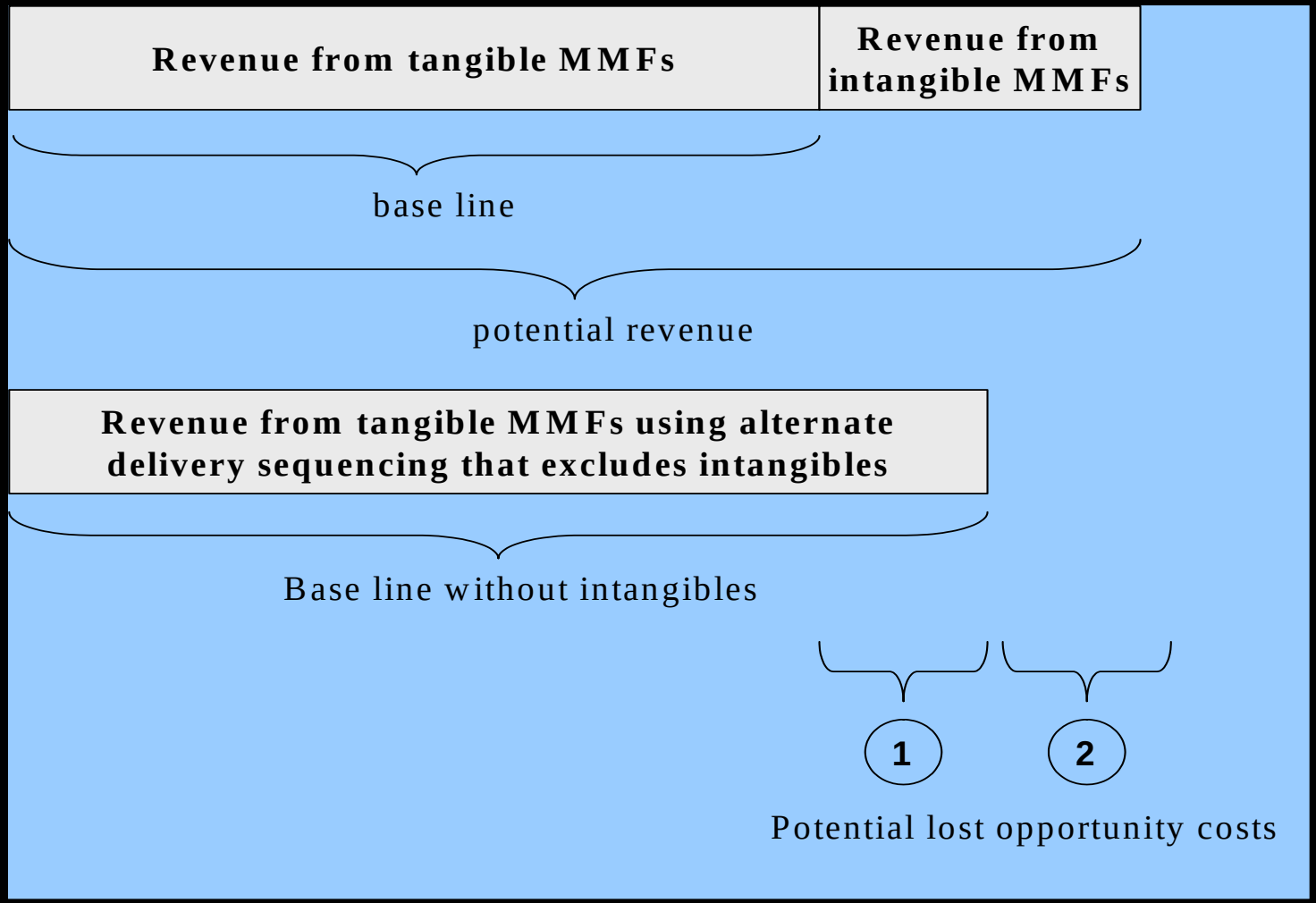
TangibleMMFs		1	2	3	4	5	6	7	8
MMF C		-85	32	32	32	32	32	32	32
MMF F		-120	42	44	46	48	50	52	54
MMF H		-60	21	22	23	24	25	26	27
a. Costs and Revenues for MMF Gauges									
Comparisons for intangible MMF A		1	2	3	4	5	6	7	8
A vs. C	0.5	-32	16.0	16.0	16.0	16.0	16.0	16.0	16.0
A vs. F	0.4		16.8	17.6	18.4	19.2	20.0	20.8	21.6
A vs. H	0.67		14.0	15.0	15.0	16.0	17.0	17.0	18.0
Synthesized returns for MMF A			15.6	16.1	16.6	17.1	17.6	18.1	18.6
b. Calculating Revenue Equivalencies for Intangible MMF A									
Comparisons for intangible MMF E		1	2	3	4	5	6	7	8
E vs. C	1.25	-60	40.0	40.0	40.0	40.0	40.0	40.0	40.0
E vs. F	0.8		33.6	35.2	36.8	38.4	40.0	41.6	43.2
E vs. H	1.67		35.1	36.7	38.4	40.1	41.8	43.4	45.1
Synthesized returns for MMF E			36.2	37.3	38.4	39.5	40.6	41.7	42.8
c. Calculating Revenue Equivalencies for Intangible MMF E									

Calculate Equivalent NPV

MMF	Period							
	1	2	3	4	5	6	7	8
A	75	58	42	27	12	-1	-14	-26
B	211	129	67	24	-6	-23	-34	-41
C	116	88	60	32	6	-20	-45	-70
D	96	76	54	30	5	-16	-34	-50
E	186	148	110	75	41	9	-21	-50
F	180	132	87	45	5	-32	-67	-99
G	96	86	75	58	40	15	-18	-50
H	90	66	44	22	3	-16	-33	-50
I	44	31	18	6	-6	-18	-30	-41
J	97	80	63	46	30	14	-1	-17

- Calculate equivalent NPV values.
- This example uses a discount rate of 2.4% per period.

Critical Project Metrics



NPV baseline = SANPV(B,1) + SANPV(F,2) + SANPV(C,2) + SANPV(G,3) + (SANPV(J,3)/1.25) + SANPV(1,4) + SANPV(D,4) + SANPV(H,5)
= $211,000 + $132,000 + $88,000 + $75,000 + ($63,000)/1.25 + $33,000 + $30,000 + $3,000
= $622,000

NPV potential = SANPV(B,1) + SANPV(E,1) + SANPV(F,2) + SANPV(C,2) + SANPV(G,3) + SANPV(J,3) + SANPV(1,4) + SANPV(D,4) + SANPV(A,5) + SANPV(H,5)
= $211,000 + $186,000 + $132,000 + $88,000 + $75,000 + $63,000 + $33,000 + $30,000 + $12,000 + $3,000
= $833,000

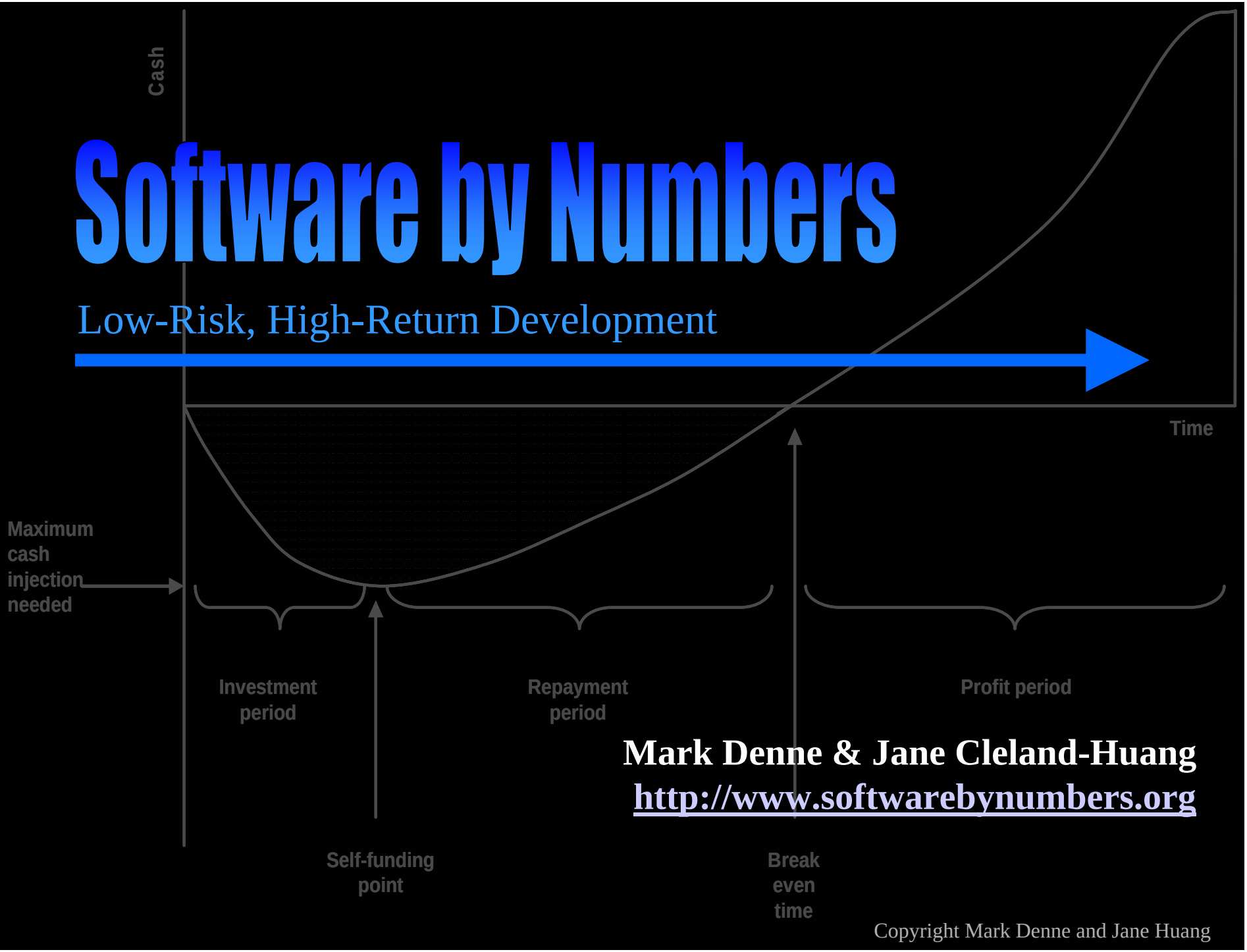
NPV optimized for tangibles = SANPV(B,1) + SANPV(F,1) + SANPV(C,2) + SANPV(G2) + SANPV(J,3) + SANPV(D,3) + SANPV(I,4) + SANPV(H,4)
= $211,000 + $180,000 + $88,000 + $86,000 + $63,000 + $54,000 + $33,000 + $22,000
= $737,000

LOC 1 = NPV optimized for tangibles – NPV baseline
= $737,000 - $622,000
= $115,000

LOC 2 = NPV potential – NPV optimized for tangibles
= $833,000 – $737,000
= $96,000

Software by Numbers

Low-Risk, High-Return Development



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