Politecnico di Torino

28 October 2004

Software Development as Generation of Business Options

John Favaro

Consulenza Informatica

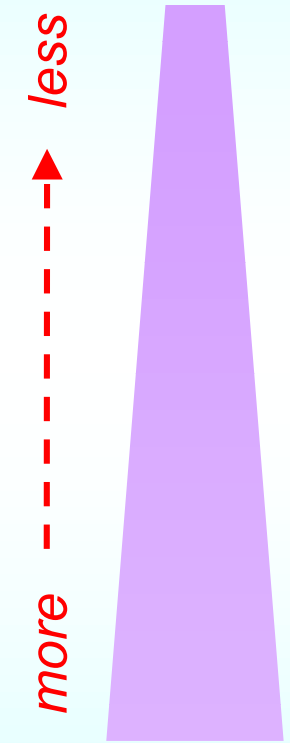
john@favaro.net

Abstract

This talk presents some of the most advanced topics in finance, notably Real Options and the theory of options developed by Black, Scholes and Merton (Nobel Prize in Economics in 1997). Then it discusses the application of real options to evaluate the economic value of IT systems. Next it gives a short introduction to one of the most recent and promising proposals in software engineering: Agile Methodologies and Agile Processes (Kent Beck, Ward Cunningham et al.). Finally, it proposes an interpretation of Agile Processes, and their high capability of generating strategic business options, in terms of Real Options.

© J. Favaro 2004

What do IT Professionals Know Today?



Work to date in IT community

Strategic Management

Economic Valuation

Costs & Benefits

Metrics

Finance and Strategy

Software Engineering

© J. Favaro 2004

Value Creation and Software Engineering

The EDSER Manifesto:

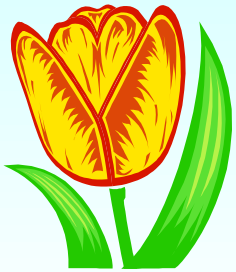
" … past work on software economics has improved cost and risk modeling and management enormously, but there has not been a symmetric development of benefit and opportunity modeling and management.

We also lack a theoretical understanding of the means by which core concepts of our field are linked to value creation: **modularity** in design (**architecture**), **iterative development methods**, testing, etc."

© J. Favaro 2004

Options and other Derivatives

- Financial options have been traded for centuries (since 17th Century Holland and the tulip mania)
  - In 1973 the Chicago Board Options Exchange (CBOE) was founded
- Options are a form of **derivative**: the value depends on the value of an underlying asset
- There are other kinds of derivatives:
  - A **forward** contract is an agreement (obligation) to buy or sell something at a fixed price and date
  - A **futures** contract is a forward contract with standardized terms for trading in the financial markets.



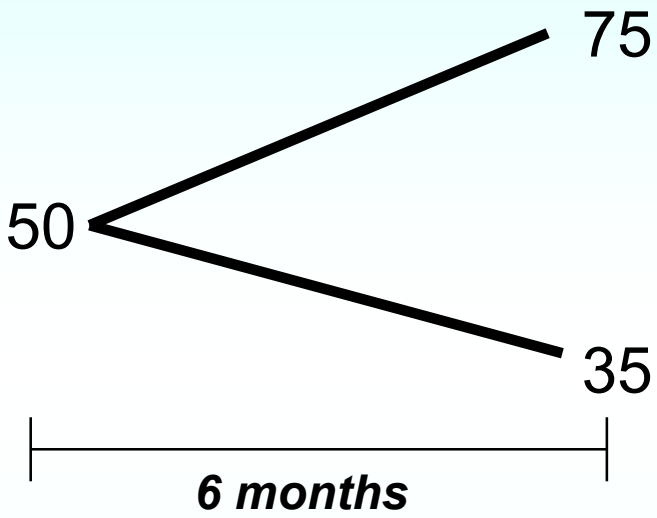
Options were born in 1630 in Holland during the tulip mania

CBOE
CHICAGO BOARD OPTIONS EXCHANGE

The CBOE was founded in 1973

© J. Favaro 2004

A Call Option Example



Consider two cases, where the stock has either gone up or down after 6 months

Current price = $50

Strike price = $45

Option payoffs at end of period	**If stock rises to $75**	**If stock falls to $35**
Stock price - strike price	$75 - $45 = $30	$35 - $45 = -$10
Call Option Value	**$30.00**	**$0.00**

© J. Favaro 2004

A Press Release

14 October 1997. “The Royal Swedish Academy of Sciences has decided to award the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 1997, to

Merton

Professor **Robert C. Merton**, Harvard University, and
Professor **Myron S. Scholes**, Stanford University,

for a new method to determine the value of derivatives.

Scholes

Robert C. Merton and Myron S. Scholes have, in collaboration with the late **Fisher Black**, developed a pioneering formula for the valuation of stock options. Their methodology has paved the way for economic valuations in many areas. It has also generated new types of financial instruments and facilitated more efficient risk management in society.”

Fisher Black
(1938-1995)

© J. Favaro 2004

Flexibility can be Viewed as an Option

Flexibility can be viewed as an option. To choose the best investment, it is therefore essential to value flexibility in a correct way. The Black-Merton-Scholes methodology has made this feasible in many cases.

- Nobel Prize Announcement, 1997

The work of Black-Scholes-Merton opened up a new way to gain insight into the economic value of flexibility

© J. Favaro 2004

The Birth of Real Options

- The application of option pricing theory to “real” investments is called **real options**
  - The term real options was coined in 1977 by Stewart C. Myers of M.I.T.
  - The real options approach is also known as **contingent claims analysis** (**CCA**)
- Many applications to real assets since early 1980s (natural resource development, pharmaceutical R&D)
- In IT: valuation of new ventures, contingent investments for flexibility, infrastructure investments, agile processes and best practices

Stewart Myers

“The New Economy, which is marked by rapid change and lots of uncertainty, cries out for a tool like real options.”

- Business Week, 7 June 1999

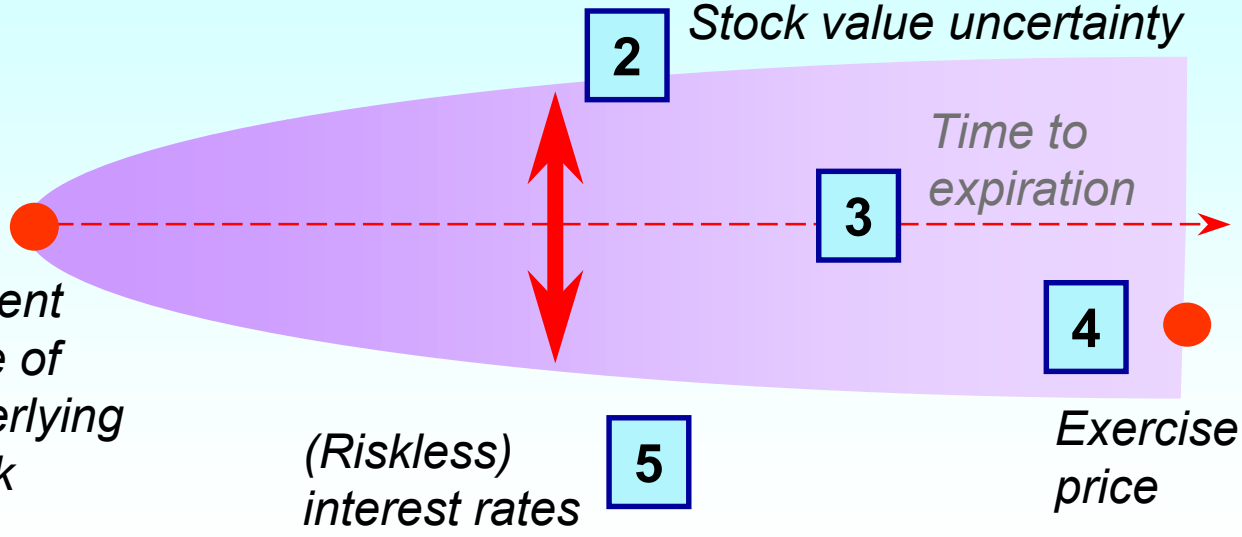
© J. Favaro 2004

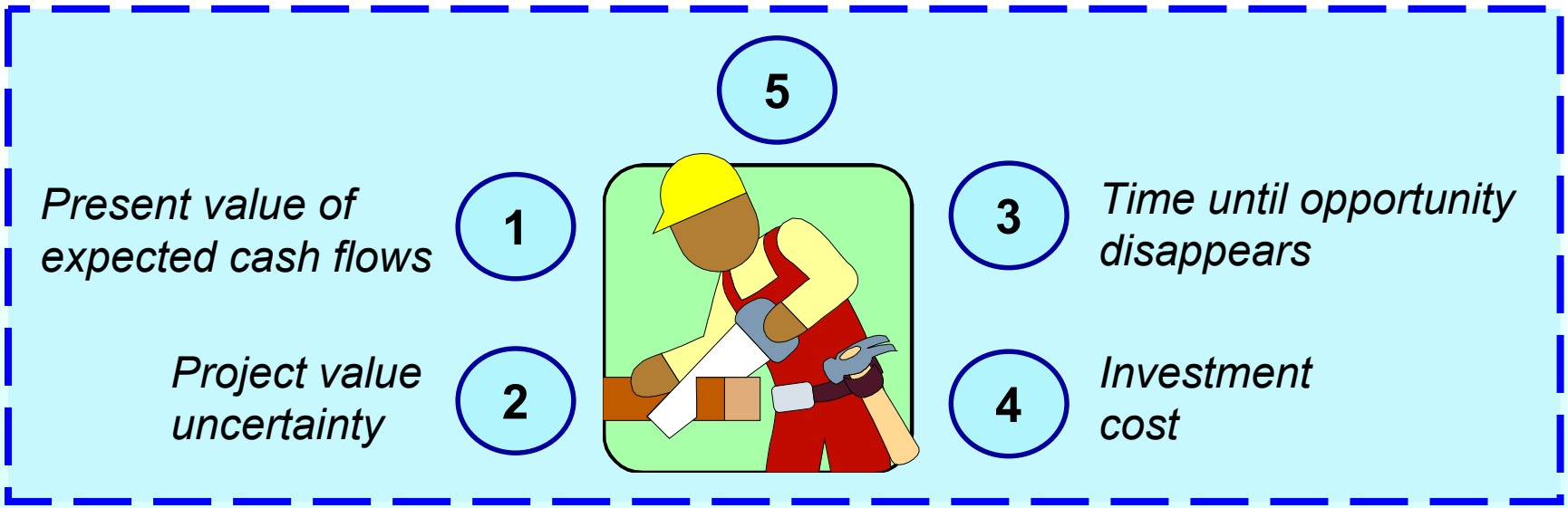
IT Investments as Real Options

Option	*Description*	*Example*
Growth option	Opening up future opportunities with infrastructure investment	Application framework infrastructure investment to enter E-banking market
Option to abandon	Possibility to stop investment if conditions worsen, without losing all the investment	Instead of custom solution, use COTS database that can be reused if project abandoned
Option to defer investment	Ability to defer an investment while waiting for better information	Wait a year to see if the market takes off before adopting wireless LAN technology
Learning option	Investing in stages, with each stage an option on the next	Iterative, incremental development to resolve uncertainty gradually
Option to switch use	Ability to change process (inputs) or products (outputs)	Component-based development infrastructure

© J. Favaro 2004

A Richer Financial Model

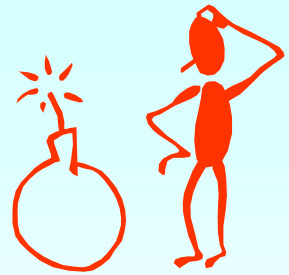




© J. Favaro 2004

A Growth Option

Will the market for value-added call services explode?



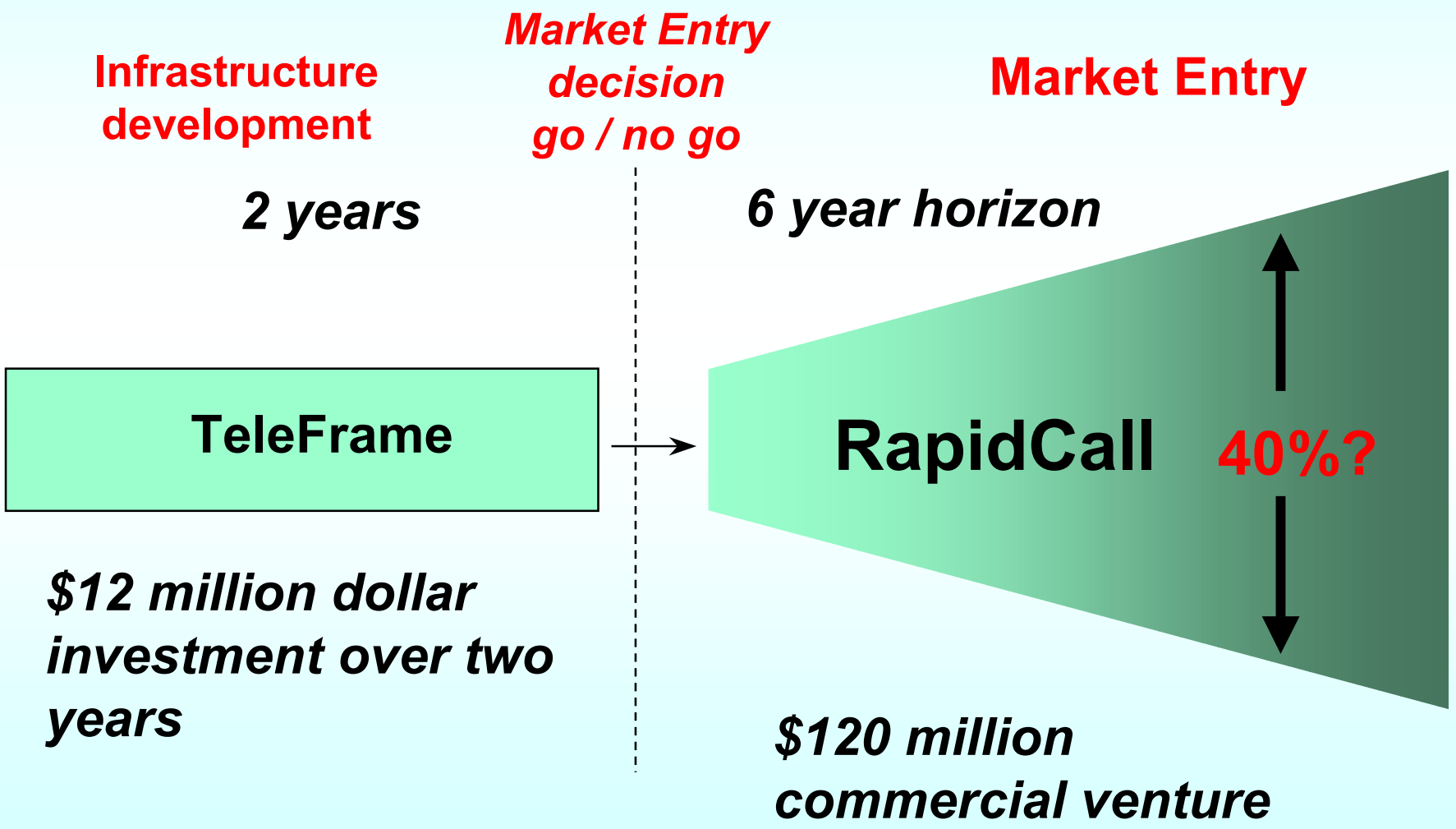
- Case Study: **RapidCall** — your answer to the huge (maybe?) future market for customized, rapid call service creation
- But first you must create **TeleFrame**, your **support infrastructure**
- *Does the opportunity justify the investment?*

RapidCall!

TeleFrame

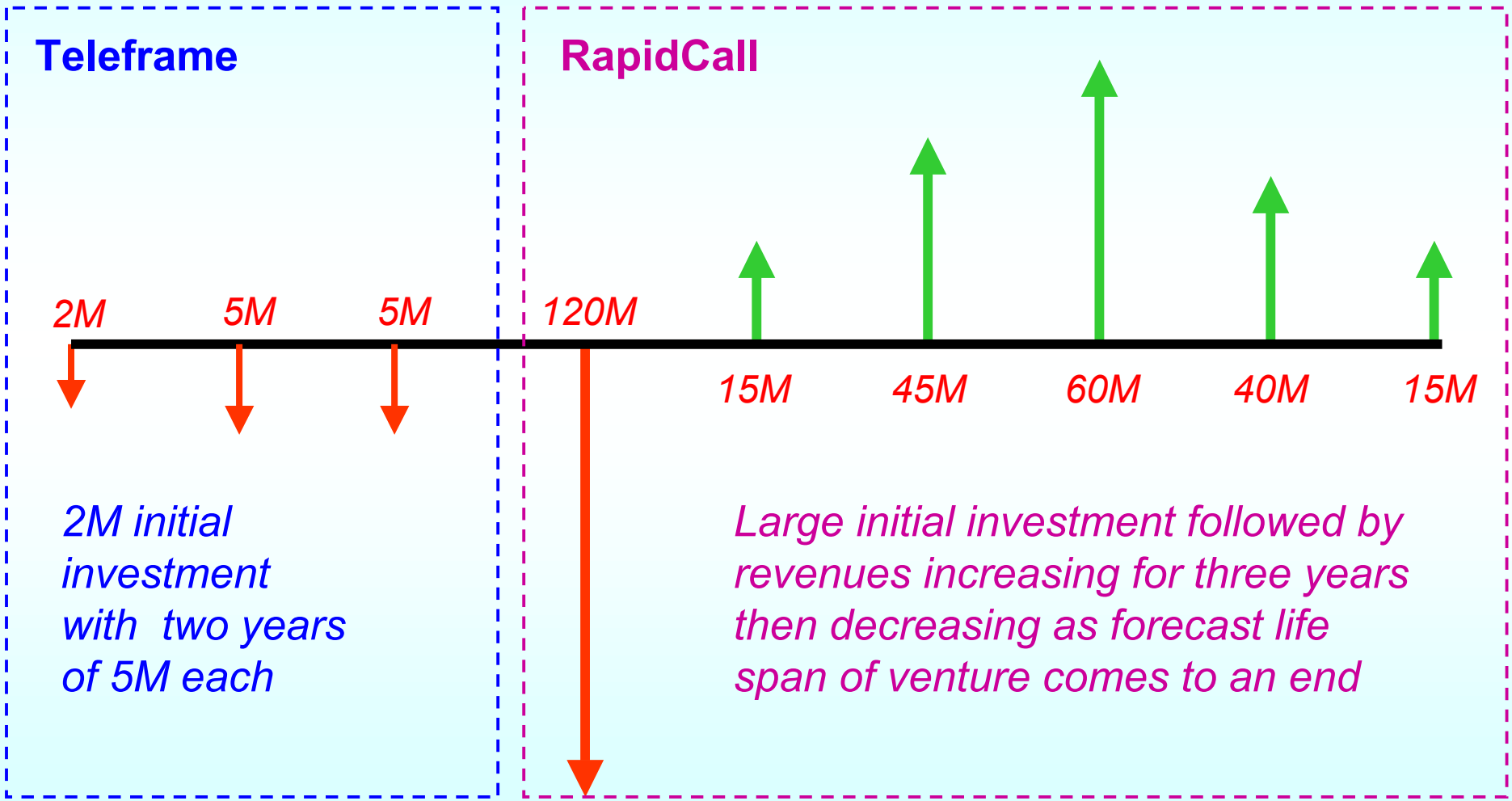
© J. Favaro 2004

Scenario for TeleFrame and RapidCall



© J. Favaro 2004

Forecast Cash Flows of TeleFrame & RapidCall



© J. Favaro 2004

NPV Analysis of TeleFrame & RapidCall

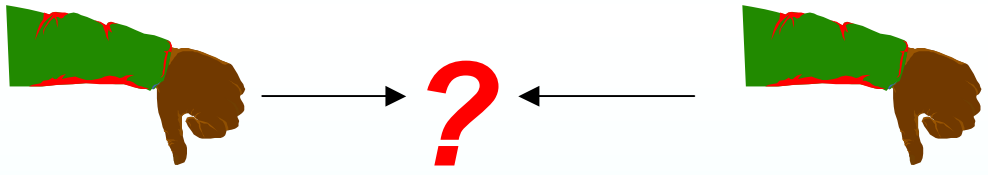
	TeleFrame	*PV*	RapidCall	*PV*
Year 0	-$2	*-2.0*		
Year 1	-$5	*-4.3*		
Year 2	-$5	*-3.8*		
Year 3			-$120	*-78.9*
Year 4			$15	*8.6*
Year 5			$45	*22.4*
Year 6			$60	*25.9*
Year 7			$40	*15.0*
Year 8			$15	*4.9*
Net Cash Flows	-$12		$55	
Total PV		-8.1		76.8
NPV		**-10.1**		**-2.1**

All cash flows in millions of dollars

© J. Favaro 2004

NPV Thumbs Down

- Teleframe is a black hole of investment
- But even RapidCall has a projected negative NPV
- In fact, the forecast NPV = (-10.1) + (-2.1) = **-12.2 Million** for both projects taken together



Value?

NPV = -$10.1 Million

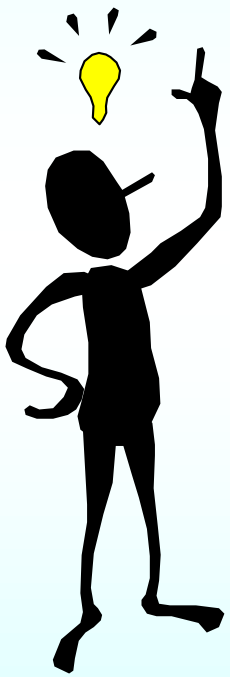
NPV = -$2.1 Million

Where is the value in this scenario?

© J. Favaro 2004

Strategic Thinking

- This is the time when it becomes important to understand the strategic relationship between the two projects
- The main purpose of TeleFrame is to create the *opportunity* to launch RapidCall. No TeleFrame: no RapidCall
- Management has no *obligation* to launch the RapidCall venture
- The prospects for RapidCall are highly uncertain: it could bust, or explode
- TeleFrame also provides a ***growth option***



© J. Favaro 2004

The TeleFrame Option Calculation

This is a European call option, whereby the Teleframe project is considered to be creating the option to acquire, at a price of $120M, the cash flows of the RapidCall venture ($76.8M). In spite of the lower expected value of the cash flows, the call has positive value because of the high uncertainty (40%).

	A	B
1	S	*$76.8 Million*
2	X	*$120 Million*
3	R	*5%*
4	T	*3 years*
5	sigma	*40%*
6	d1	-0.081
7	d2	-0.774
8	C	**$13.3 Million**

© J. Favaro 2004

A Valuable Growth Option

- The main purpose of TeleFrame is to create the *opportunity* to launch RapidCall. No TeleFrame: no RapidCall
- Management has no *obligation* to launch the RapidCall venture (contingent investment by active management)
- The prospects for RapidCall are highly uncertain (in both directions)
- Option pricing theory calculates the value of this (call) option is $13.3 million. It is a ***growth option***.So the full value of TeleFrame is (-10.1) + 13.3 = **$3.2 million**

Strategic NPV = DCF + growth option

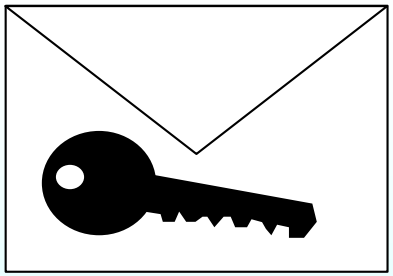
© J. Favaro 2004

The Option to Abandon

- Defensive IT processes and technology are modeled in real options by the **option to abandon**
- The abandonment option is the opposite of the growth option
  - the growth option pays off when things go well
  - the abandonment option pays off when things go badly - it is *insurance*

Growth Option = *Call* option

Abandonment Option = *Put* option



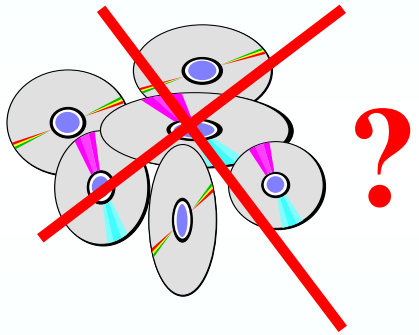
The option to abandon is insurance

© J. Favaro 2004

Conservation of Business Value

- Example: A Computer Based Training (CBT) company has a thriving business based upon CD-ROM technology.
  - But the rise of the Web threatens its business model.
- Now it is contemplating its next generation architecture. Should it invest "defensively" in its architecture to safeguard against radical changes?
  - move to explicit knowledge management processes
  - multimedia application framework infrastructure, training

Example: evolving CBT technology



Is it worth it to invest in technology and process improvement to defend against market upheavals?

© J. Favaro 2004

Abandonment Option Sensitivity Analysis

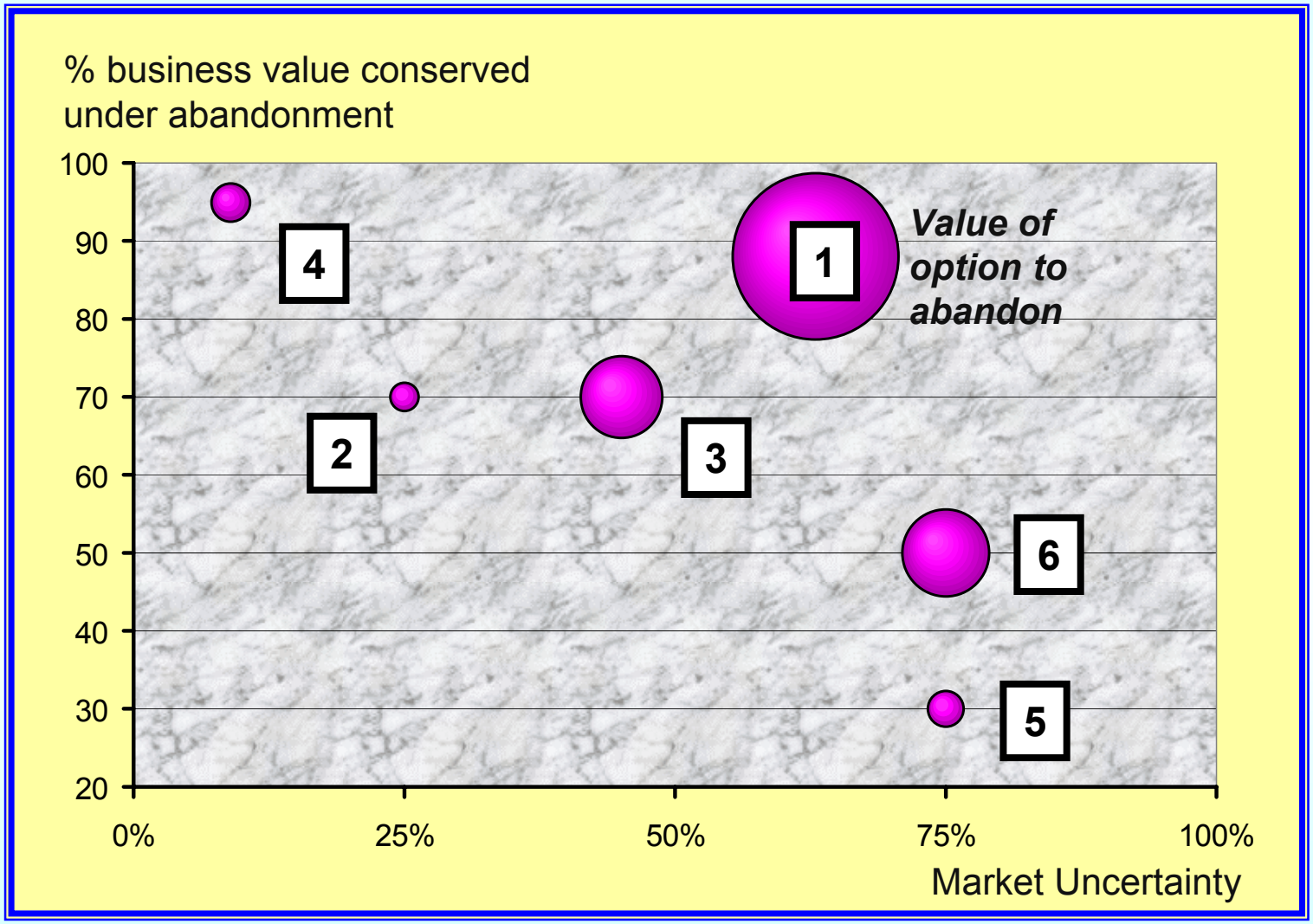
V = value of project
E = abandonment value
R_f = risk-free rate of return
t = time to abandonment decision (years)

sigma = volatility of project returns
delta = continuous dividend rate
d1, d2 = Black-Scholes variables
PUT = value of Black-Scholes put option

V	E	Rf	t *(yr.)*	sigma	delta	d1	d2	PUT
100	***95***	3%	1	***9%***	0	0.95	0.86	***0.9***
100	***70***	3%	1	***45%***	0	1.08	0.63	***4.0***
100	***70***	3%	1	***25%***	0	1.67	1.42	***0.5***
100	***30***	3%	1	***75%***	0	2.02	1.27	***0.8***
100	***88***	3%	1	***63%***	0	0.57	-0.06	***16.3***
100	***50***	3%	1	***75%***	0	1.34	0.59	***4.5***
steady	***varies***	**steady**	**steady**	***varies***	**steady**			

© J. Favaro 2004

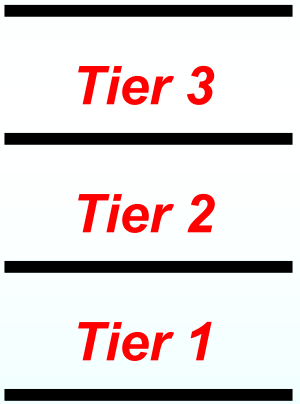
Sensitivity Analysis Results



© J. Favaro 2004

Abandonment and Architecture

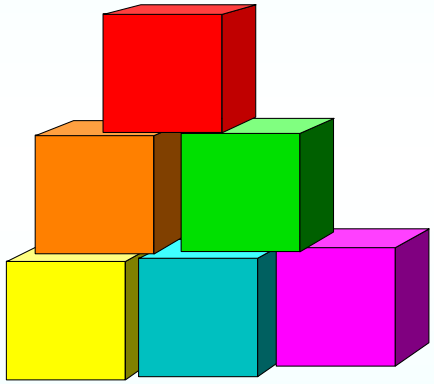
- The abandonment option is in many ways about **separating the things that change from the things that don't change**
  - **Multi-tiered architectures** are a good example of this approach in IT systems
- The abandonment option perspective can help guide the architecture by accompanying the architectural design with economic impact studies
  - what will be the impact of a requirement change on this tier?
  - what are the probabilities that the requirements for the GUI layer will change and what will be the cost implied?
  - What technology is salvageable if the project must be abandoned?



© J. Favaro 2004

Abandonment and Modularity

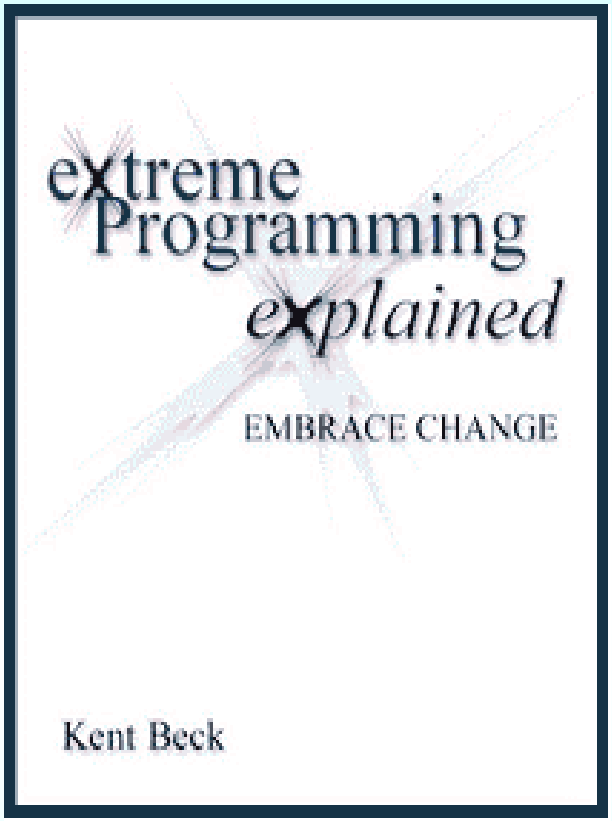
- Even more generally than multi-tiered architectures, the concept of the option to abandon and conservation of business value is related to the principle of **modularity**
- Modularity is the ultimate design principle for the insulation of things that don't change from things that do change
- See recent work of Baldwin and Clark on modularity in general, applied by Sullivan *et al.* to modularity in software



© J. Favaro 2004

Agile Processes

- There is currently a strong movement towards the so-called **agile methodologies**
  - Also known as “lightweight processes”
- These methodologies are based upon many short iterations
- The most famous of the agile processes is known as **Extreme Programming**
- Some important actors in XP:
  - Kent Beck
  - Ward Cunningham
  - Martin Fowler



“There is another way.”

*- **XPEX**, p. 166*

***XPEX** = Extreme Programming Explained*

© J. Favaro 2004

A Time-Based Option in XP

- One of the most widely publicized principles of XP is the "You Aren't Going to Need It" (**YAGNI**) principle
- Defer investment in features until uncertainty about their value is resolved
  - For example, in an uncertain business climate, the feature may turn out to be useless
- YAGNI is an example of the **option to defer** appearing in flexible IT processes

> "We are traditionally told to plan for the future … Instead, XP says to do a good job … of solving today's job today … and add complexity in the future where you need it.
>
> **The economics of software as options favor this approach.**"
>
> *- XPEX, p. 38*

© J. Favaro 2004

An Example of YAGNI

"Suppose you're programming merrily along and you see that you could add a feature that would cost you $10. You figure the return on this feature (its present value) is somewhere around $15. So the net present value of adding this feature [now] is $5.

Suppose you knew in your heart that it wasn't clear at all how much this new feature would be worth—it was just your guess, not something you really knew was worth $15 to the customer. In fact, you figure that its value to the customer could vary as much as 100% from your estimate. Suppose further that it would still cost you about $10 to add that feature one year from now.

What would be the value of the strategy of **just waiting**, of not implementing the feature now?"

- XPEX, pp. 13-14

Extreme Programming Explained *includes a complete YAGNI options scenario*

© J. Favaro 2004

The YAGNI Scenario

XP

You could implement the feature today, at a cost of $10.

You think it might be worth $15 in benefits. We'll know in a year.

Great uncertainty

Upside scenario. The customer is grateful

Downside scenario. The customer couldn't care less. You wasted time and money.

© J. Favaro 2004

The YAGNI Option Calculation

XP

> "Well, at the usual interest rates of about 5%, the options theory calculator cranks out a value of $7.87."
>
> *- XPEX, p. 14*

15	S (PV of feature)
10	X (Cost of implementation)
5%	r (interest rate)
1.0	t (years deferred)
100%	sigma (uncertainty of feature's returns)
0.955	d1, used in the Black-Scholes calculation
-0.045	d2, used in the Black-Scholes calculation
$7.87	**Value of Black-Scholes CALL option**

© J. Favaro 2004

Analysis of the YAGNI Scenario

Note that the value of the option to delay in XP depends on the ability to add the feature at a later date at the same cost – that is, a ***low cost of change***

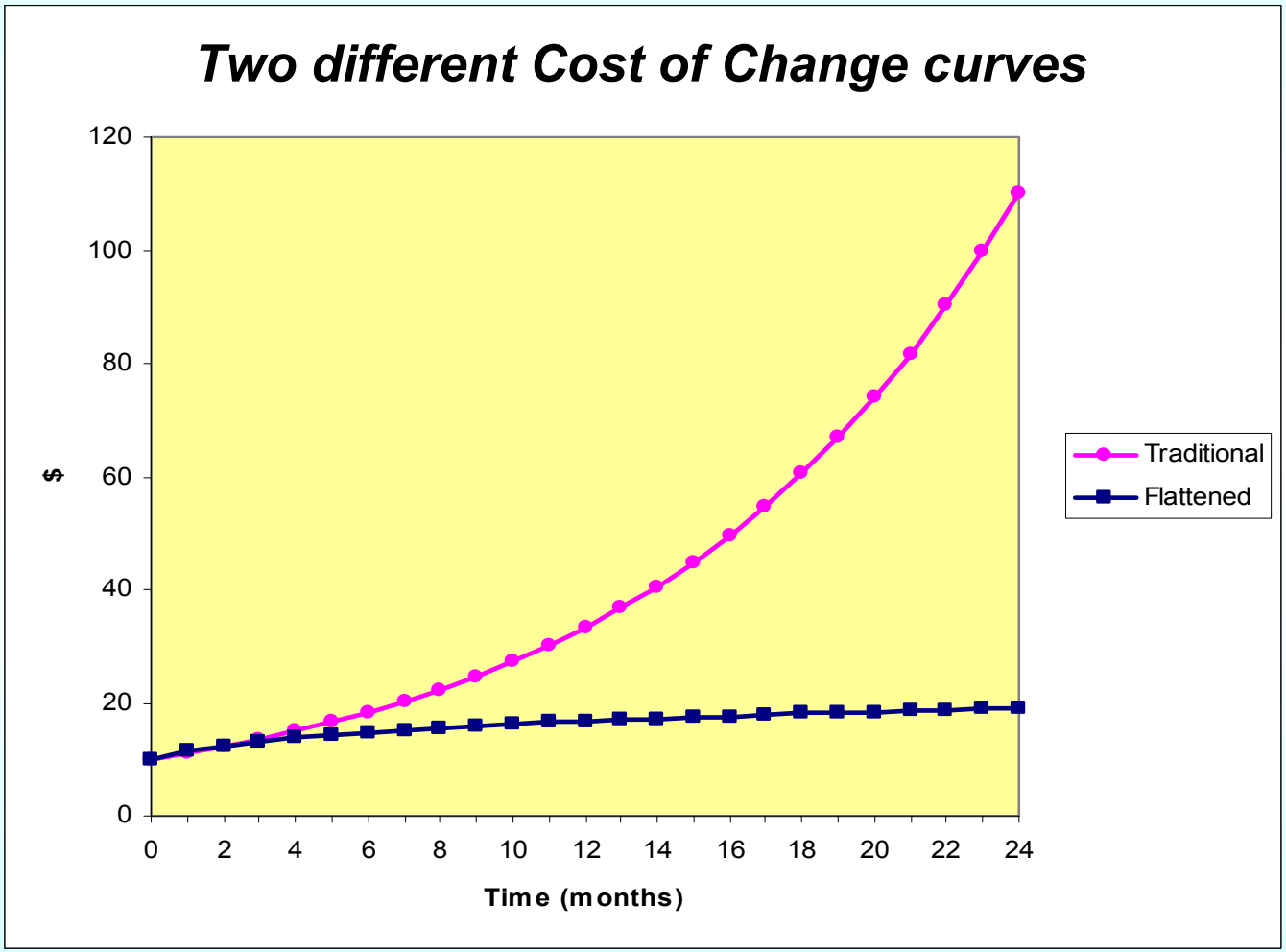
"The option of waiting is worth *more* than the value (NPV = $5) of investing *now* to add the feature. Why? With that much uncertainty, the feature certainly might be much more valuable to the customer, in which case you're no worse off waiting than you would have been by implementing it now. Or it could be worth zilch – in which case you've saved the trouble of a worthless exercise.

In the jargon of trading, options 'eliminate downside risk'."

- XPEX, p. 14

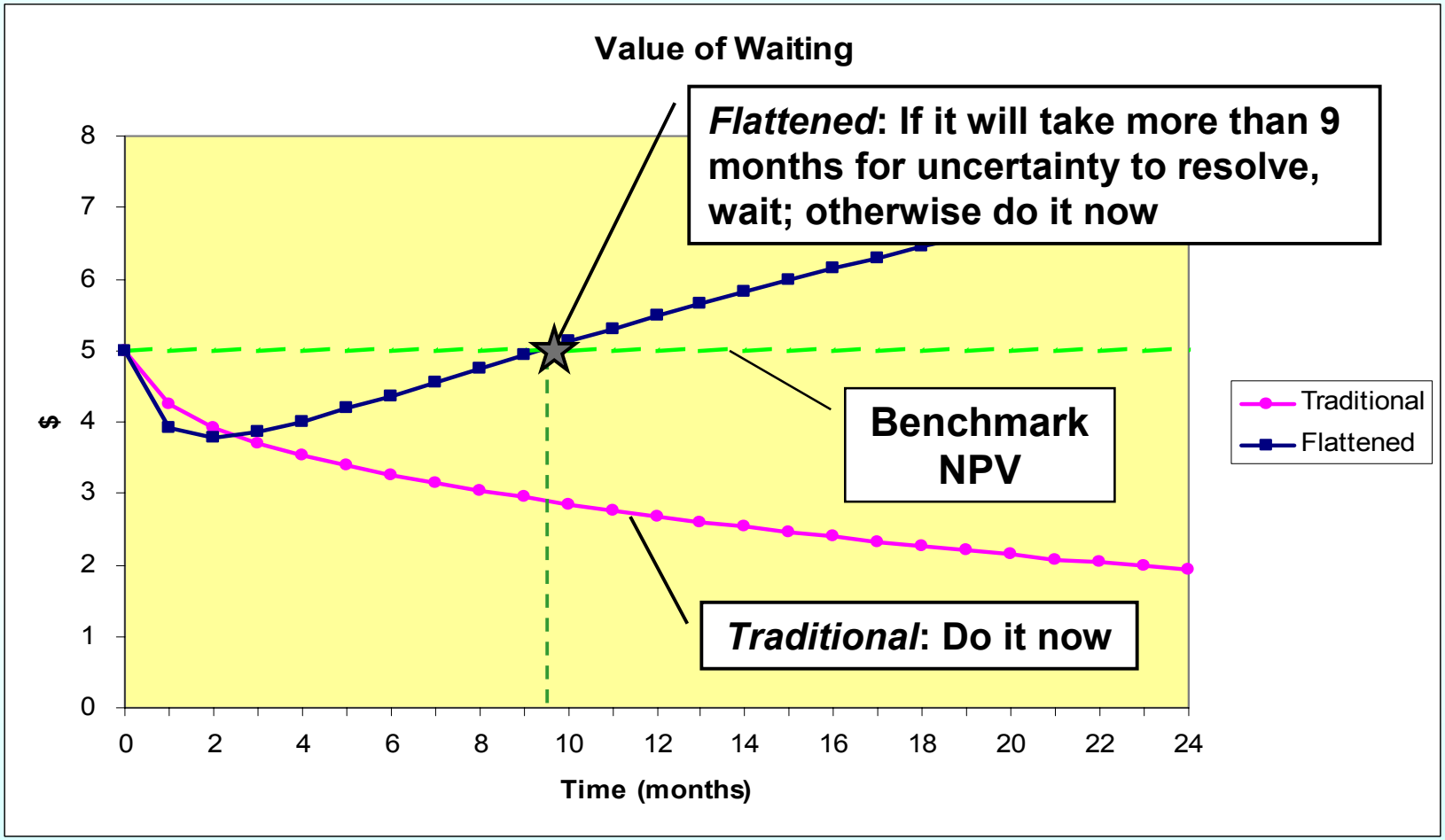
© J. Favaro 2004

YAGNI Depends on a Low Cost of Change



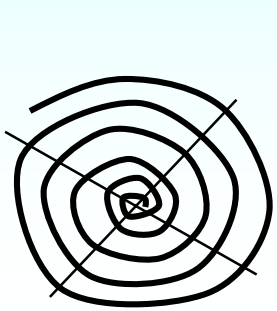
© J. Favaro 2004

To Wait or Not to Wait?



© J. Favaro 2004

Flexibility, Value & Iterative Processes



Spiral

Less focus on planning
Tighter iterations
More frequent releases

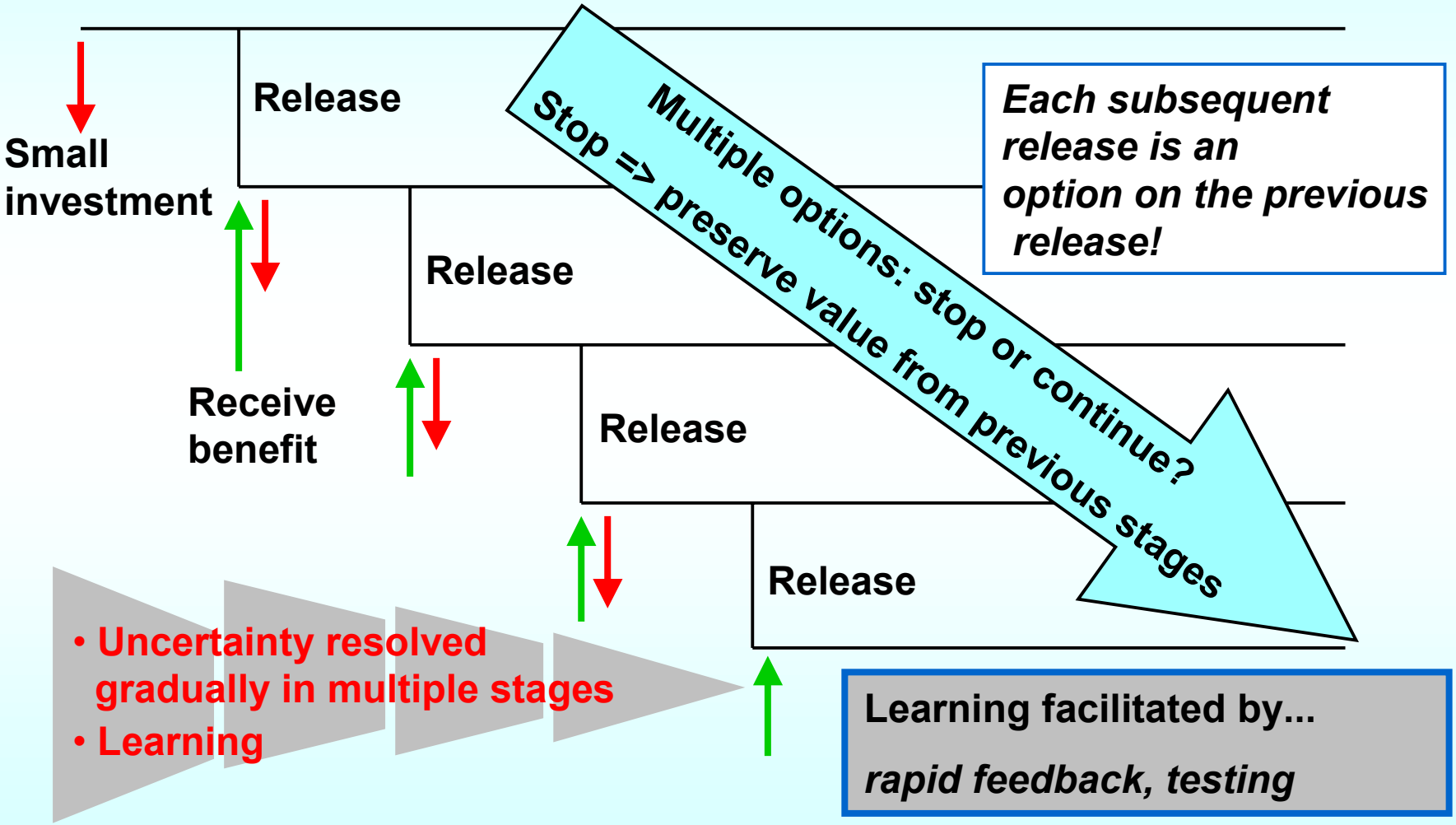
Agile Alliance

Scrum
DSDM
Crystal
Extreme Programming
Feature-Driven Development
Adaptive Software Development
Agile Modeling

Why tighter iterations and frequent releases?

© J. Favaro 2004

Small Investments, Small Releases



© J. Favaro 2004

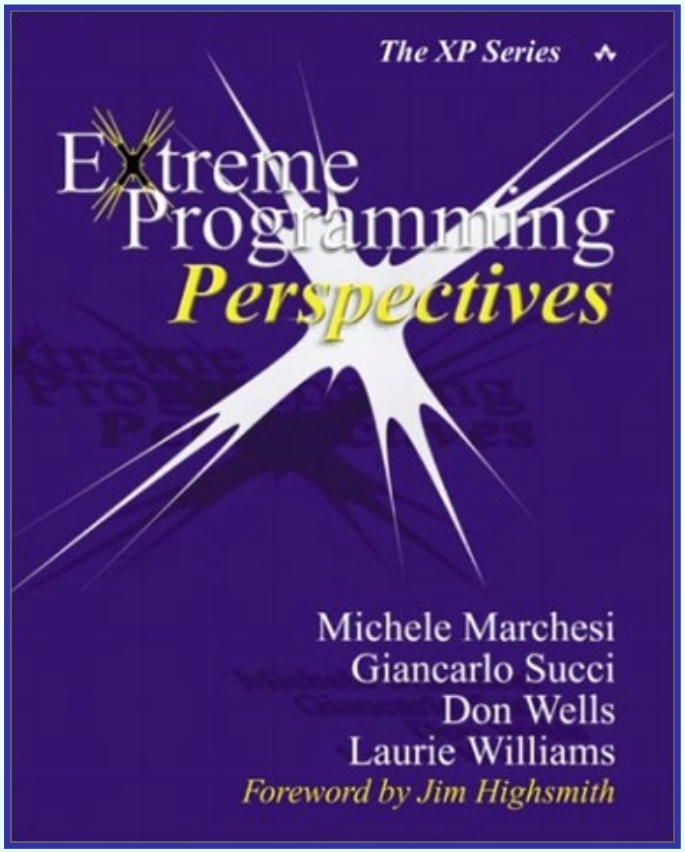
Conclusions and Future Work

- Interpreting software development as the generation of business options provides a way of approaching the problem of analyzing the economic value of flexibility
  - In the product
  - In the process
- There are plenty of problems remaining for future work:
  - Is the model accurate? – for example, non-proprietary options such as Java technology
  - Agency issues – are you willing to kill your baby?
  - Integration with management procedures – “kill projects, not careers”
  - Getting good data – especially data on volatility, etc.
- The integration of strategy and finance remains one of the great unresolved challenges in economics

© J. Favaro 2004

References

- Real Options in Flexible IT Processes
  - Erdogmus, H. and J. Favaro, “Keep Your Options Open: Extreme Programming and Economics of Flexibility,” in: *XP Perspectives*, ed. M. Marchesi & G. Succi, Addison-Wesley Professional Series, Fall 2002.



http://www.favaro.net/john/home/publications/xpecon.pdf

© J. Favaro 2004