

Strategic Technology Portfolio Selection



- **Objectives:** To develop and implement an approach to selecting a NASA technology portfolio based on modern business decision techniques (Real-options analysis, portfolio optimization)
- **Why an Options Pricing Approach?**
 - In option pricing thinking, technology developments are treated as assets whose payoffs are uncertain, but that have the characteristic of enabling potentially spectacular returns with limited losses.
 - In simplest terms, the real-options framework captures the additional value inherent in some technologies that currently goes unrecognized in the NASA budgeting process.
 - Using the real-options framework, NASA can achieve greater strategic flexibility with its limited technology budget

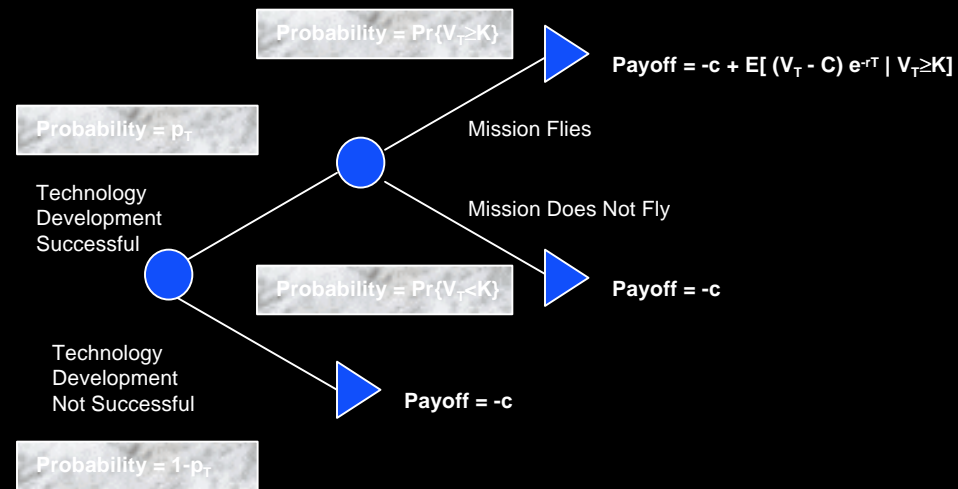
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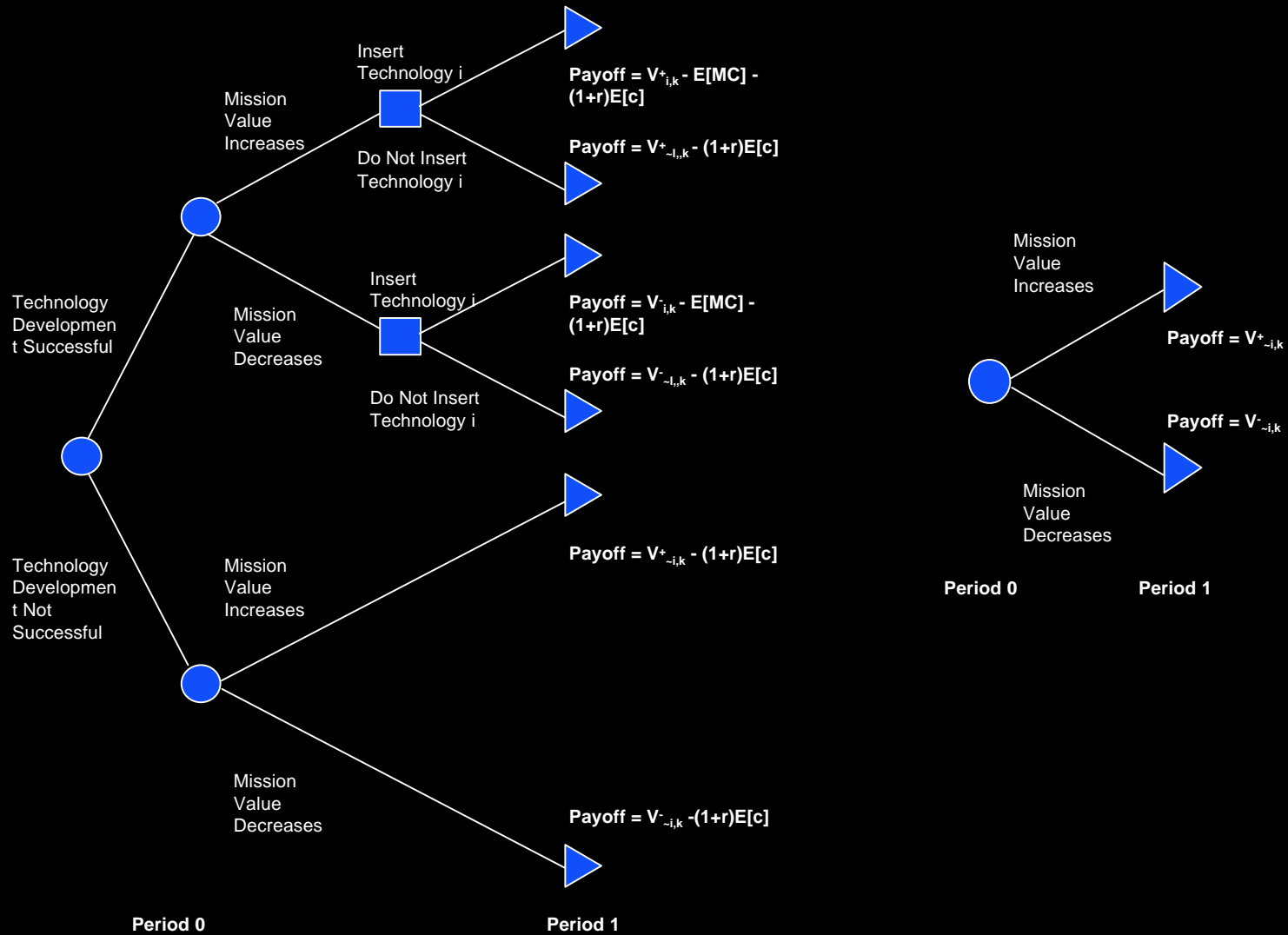
- NASA's three technology cases are treated in a common framework
 - Cost-Reducing
 - Mission-Enhancing
 - Mission-Enabling

- Two MSR technologies with TRL < 6 were selected to demonstrate the real-options approach
 - Low temperature and mass propulsion
 - Autonomous Mars-orbit rendezvous and docking

Black-Scholes Formulation



Simple Real-Options Formulation



Real-Options Approach Applied to R&D Investments

$$v_i(t, T) = \max \left(0, -E \left[\sum_{t=t}^T c_i(t) \exp(-r(t-t)) \right] + p_{i,T} E \left[\sum_k \max(0, \sum_{t=T}^{T^*} X_{i,k}(t) \exp(-r(t-t))) \right] \right)$$

$$X_{i,k}(t) = VMP_{i,k}(t) - MC_{i,k}(t)$$

$v()$ is the option value of technology i at time t for a technology readiness date of T

r is the riskless discount rate

p is the probability that the technology i development program will be successful by the technology readiness date, T

$X()$ is the net marginal value of technology i in all project/missions, given a successful technology i development program

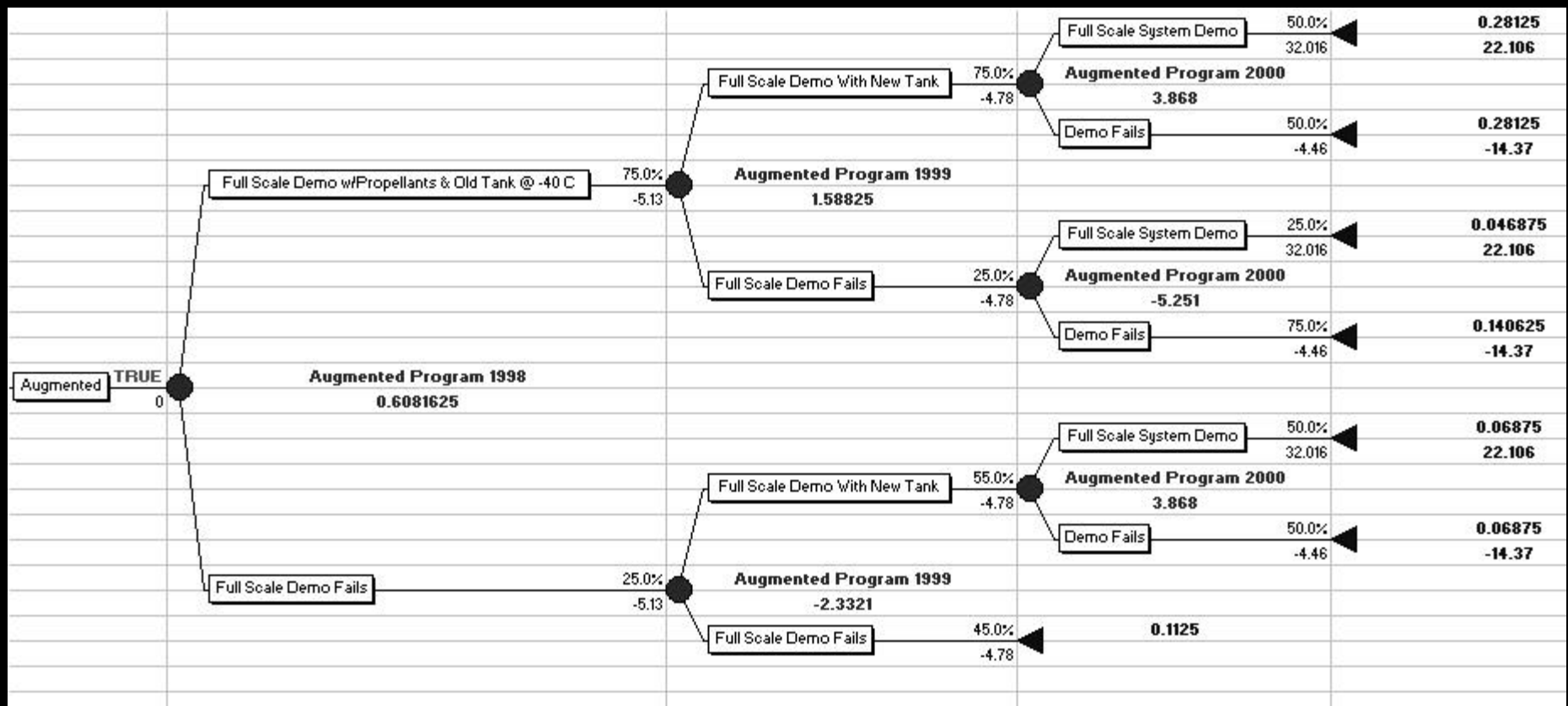
$VMP()$ is the value of the marginal product of technology i in project k

$MC()$ is the marginal cost of “productizing” technology i in project k

T^* is the time horizon

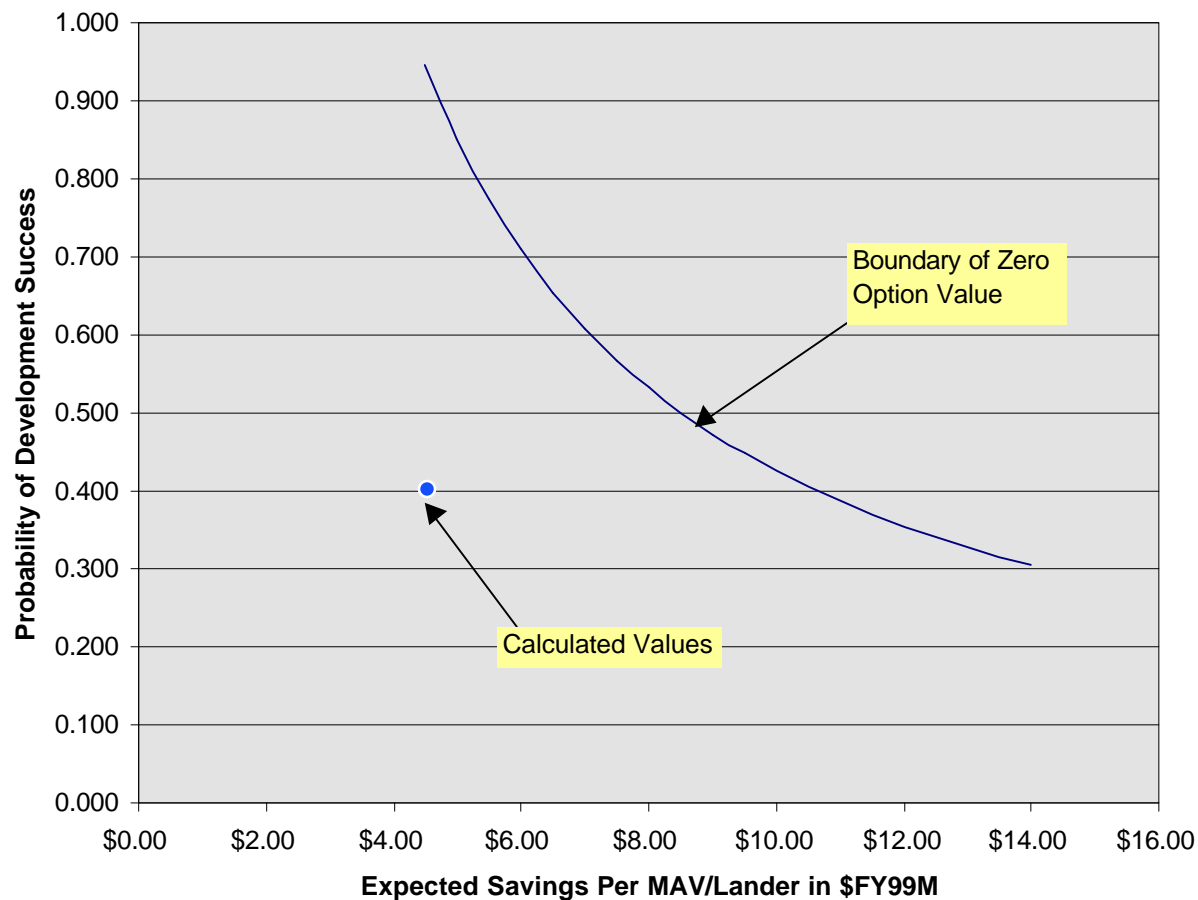
Cost-Saving Technology Example

Low Temperature and Mass Propulsion Technology



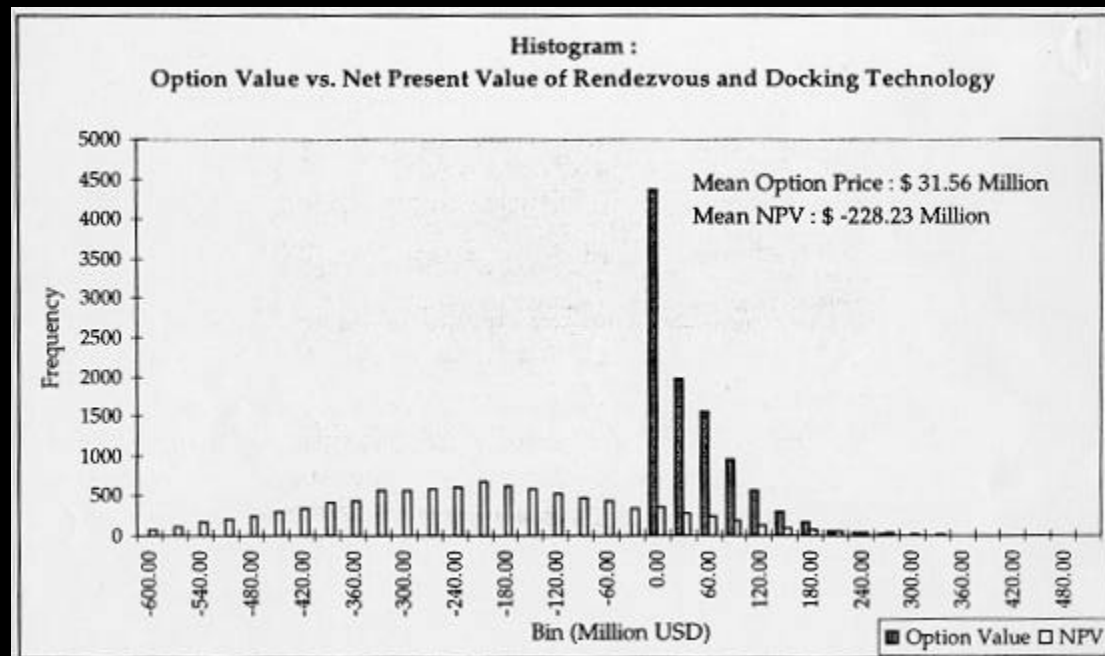
Cost-Saving Technology Example

Low Temperature and Mass Propulsion Technology



Mission-Enabling Technology Example

Autonomous Mars Orbit Rendezvous/Docking Technology



Real-Options Approach: Implications for NASA



- Real-options approach captures the value arising from a technology's potential uses in scenarios other than the budgeting one.
- Real-options approach considers the uncertainty about what future scientific discoveries might be made in space and what missions might have sufficient public support.
- The option value capture payoffs that could potentially occur over the long term without committing NASA to any particular mission
- Once option values are calculated, emphasis can be placed on maximizing the value of NASA's technology portfolio subject to a budget constraint and the level of portfolio risk NASA management desires.