• RE is a new perspective on safety for complex socio-technical systems.
• Traditionally, improvements in safety have been based on *hindsight* – asking “what went wrong” in accident analysis and “what could go wrong” in risk assessment.
  o For instance, after a major accident involving loss of lives, an incremental change (a tweak to the regulations or building codes) or a barrier is implemented (fall protection if working over 6’) after statistics show a trend of injuries or fatalities.
  o Hindsight thinking colors how we think about failure and safety. In the traditional view failure is characterized as arising from a breakdown or malfunctioning of normal systems. Safety is defined as “freedom from unacceptable risk.” Both of these approaches require the analyst or investigator to think about how accidents can happen and what went/can “go wrong.” In general – it is a *reactive* approach
  o This approach has been successful in saving lives and preventing injury. However, we seem to have reached a plateau in the effectiveness of this approach in construction safety. Over the past 10 years we have averaged around 1,100 fatalities per year.
  o RE embraces the traditional approach but posits that it is only part of the picture – to get a better understanding of safety we need to ask “what can go right” for risk assessment and “what went right” for accident analysis.
• RE proposes that we observe work as it is *normally* performed on a day-to-day basis and look at how humans in the system “make ends meet” in the face of under-specification of conditions, constantly changing conditions, and unrelenting demands placed on the system.
  o We should observe what makes systems resilient, how to engineer resilience, and how to maintain and manage the resilience of a system.
  o Resilience is a quality of the system. It can’t be counted – it is something that the systems does (“acts in a resilient manner”) rather than something a system has (it would be wrong to say a system has “10 units of resilience”). Therefore, managing resilience is a kind of process control.
• In the RE view, failures arise from adjustments made by people to cope with under-specification of a system or a process, and safety is defined as “the ability to succeed under varying conditions.” Defining safety this way includes the reactive and proactive approaches. The term “performance variability” is used to describe the ways in which individual and collective performances are adjusted to match current demands and resources, in order to ensure that things go right.
  o Thus a key feature of a resilient system is its ability to adjust its performance. Adjustments can, in principle, be reactive, concurrent, and proactive.
    o Reactive adjustments are the most common and happen in the aftermath of an event (i.e. “lessons learned from a major change or disruption). This is an incomplete approach given that the adjustments made may not be suitable for the unique and uncertain events of the future.
    o Concurrent adjustments are basically fast reactive adjustments that take place while the situation is developing.
    o Proactive adjustments means that the system can change from a state of normal operation to a state of heightened readiness, and possibly also act, before something happens.
• A formal definition of RE is then “RE is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.”
• RE is based on the following 4 premises:
  1. Performance conditions are always underspecified. Individuals and organizations must therefore adjust what they do to match current demands and resources. Because resources and time are finite, such adjustments will inevitably be approximate.
  2. Some adverse events can be attributed to a breakdown or malfunctioning of components and normal system functions, but others cannot. The latter can best be understood as the result of unexpected combinations of performance variability. This is illustrated via the Functional Resonance Analysis Method (FRAM).
  3. Safety management cannot be based exclusively on hindsight, nor rely on error tabulation and the calculation of failure probabilities. Safety management must be proactive as well as reactive.
  4. Safety and field operations management are inseparable and do not operate independently. No conflict or tension should exist between these functions. Safety must therefore be achieved by improvements to the operations (i.e. by engineering a better operations process) rather than by simply constraining operations (i.e. by barriers, more regulations, etc.).
• In order to be resilient an organization must have four basic abilities. The mix depends on the context of the analysis.
  1. Respond to regular and irregular conditions in an effective and flexible manner.
  2. Anticipate long-term threats and opportunities.
  3. Learn from past events, understand what happened and why.
  4. Monitor short-term developments and threats
  o The analysis is at the organizational level given that an individual can’t be expected to possess all four abilities.
• At CIREC, we are working on exploring RE constructs to better understand disruptions to construction projects.