Replayable Cooperative Game Design: Left 4 Dead

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➢ Left 4 Dead is a replayable, cooperative, survival-horror game where four Survivors cooperate to escape environments swarming with murderously enraged "Infected" (ie: zombies)

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Left 4 Dead: The Survivor Team

Left 4 Dead: Enraged Infected Mob

Left 4 Dead: The Special Infected

Left 4 Dead: The Boss Infected

Left 4 Dead

Left 4 Dead

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Left 4 Dead

Left 4 Dead

Project Goals

➢ Observations

- Perceived Gap in the Market for Co-op gaming
  - The major risk of the project
- Experience creating single player games epic in scale, narrative
- Multiplayer builds community, generates long-term retail sales
  - Still selling Counter-Strike 1.6 today
- Experience with online multiplayer AI technology
  - Counter-Strike Bot

➢ Goal

- Using our AI tech, combine single player and multiplayer game mechanics into a new kind of replayable, cooperative, online experience

Strategy for Reaching our Goals

➢ **Require Cooperation**
- Primary product risk
- Crisp focus
  - Generate clear data on demand for feature
  - Explicitly fill perceived gap in market
- Game design must clearly encourage coop to mitigate risk

➢ **Replayability**
- Game design must encourage long-term replayability
- Build online community
- Entertainment as a Service

➢ **Requiring Cooperation**

➢ Replayability

- Designing for Dramatic Potential
  - Dramatic Anticipation
  - Structured Unpredictability
- Adaptive Dramatic Pacing
- Procedurally Populated Environment

➢ Encourage cooperation throughout game design
- Structure game so players *want* to do the right thing
- Ensure cooperation is the only winning strategy
- Treat entire Survivor team as "the player"

➢ Penalize non-cooperative behavior harshly
- Abandoning the team = death

➢ Avoid artificial/arbitrary enforcement
- Players rebel against overtly heavy-handed punishments
- No invisible leashes, teleporting stragglers closer, dealing "out of bounds" damage, etc

➢ Survival Horror genre is an excellent fit
- Well established mainstream genre
- Everyone knows "The Rules":
  - The Good Guys work together
  - The Jerks selfishly abandon the group (and die horribly)
  - The Enemies are ruthless and nearly unstoppable

Requiring Cooperation: Enemy Design

➢ You Are Clearly Outnumbered: The Horde
- Obviously too many enemies for one Survivor to handle alone
- "Grabby" Infected stop Survivors when they hit, making even a single Infected dangerous
- Enforces cooperation in an implicit manner without seeming heavy-handed because it fits the expected genre behavior

➢ Don't Go Out Alone: The Special Infected

- Tougher Infected with special abilities
- Adds a layer of variation to the homogeneity/predictability of battling the horde
- Each special ability exists to address specific gameplay issues
- Each has an overwhelming or incapacitating attack which create dramatic cooperative moments for the Survivor team

➢ The Hunter

- Purpose: Outrun and kill stragglers and "lone wolf" players
- Completely incapacitating Pounce attack

➢ The Smoker

- Purpose: Pull apart tightly coordinated teams to create unexpected moments of chaos
- Completely incapacitating long range Tongue attack

Requiring Cooperation: Enemy Design

➢ The Boomer
- Purpose: Break the rule of "shoot everything that moves", forcing players to think a bit before firing
- Boomer's Vomit/Explosion creates excellent moments of Dramatic Anticipation where you know the mob is coming to get *you*, soon…

Requiring Cooperation: Enemy Design

➢ The Special Infected Incapacitating attacks
- Make players fear becoming separated from the group, reinforcing team cohesion
- Give players near the incapacitated victim the opportunity to be the hero and save them
- Players really enjoy helping each other

➢ "OH $#*!!": The Boss Infected

- Boss Infected force the Survivors to immediately reevaluate their tactics

- Breaks Survivor team out of their familiar pattern of behavior

- Forces the Survivors to re-think whole-team situation and current strategy, encourages team talk

- Generates Dramatic Anticipation

Requiring Cooperation: Enemy Design

➤ The Tank
  - Halts forward momentum while Survivors focus on the imminent danger of the Tank
  - Requires full attention of entire team
  - Forces Survivors to defend instead of assault
  - Tank throw ability makes Survivors reevaluate their environment
  - Music change, Tank's yells and heavy footfalls create powerful moment of Dramatic Anticipation

➢ The Witch

- Breaks the rule of "shoot everything that moves" with higher contrast than the Boomer
- Forces Survivors to move stealthily and take extra care with flashlights and weapons
- Danger is communicated by broadcasting Witch presence via disturbing crying sound effects
- Creates powerful moments of Dramatic Anticipation

Requiring Cooperation: Vocalizations

➤ Survivor characters automatically emit various vocalizations

- Improves situational awareness
  - "Behind you!"
  - "Hunter's got Zoey!"
  - "Witch!"
  - "Here they come!"
  - "Grenade!"
  - Rebukes for friendly fire

- Communicates short term goals
  - "The subway is just up the street"
  - "Can you let me out? I'm stuck!"
  - "Get to the chopper!"
- Encourages cooperation via baseline of camaraderie
  - "Thanks for that"
  - "Don't worry I got ya..."
  - Friendly, supportive tone of voice (usually)

Requiring Cooperation: Limited Resources

➢ Limited resources that are required for success encourage cooperation

- Effective because the game clearly can't be won alone
- Obvious benefit to sharing (keep extra gun alive)
- Minimal sharing UI doesn't get in the way
- Sharing behavior breaks the ice, builds group solidarity
- Another opportunity for Players to directly help each other

Requiring Cooperation: Helplessness

➢ **A player in a clearly helpless and dependent state demands cooperation**

- Effective because the game can't be won alone
- Obvious benefit to sharing (keep extra gun alive)
- Obvious that you will likely be in a similar situation soon
- Easy to assist helpless player
- Benefit clearly outweighs cost (usually)
- Another opportunity for Players to directly help each other

➢ Requiring Cooperation

➢ Replayability

- Designing for Dramatic Potential
  - **Dramatic Anticipation**
  - Structured Unpredictability
- Adaptive Dramatic Pacing
- Procedurally Populated Environment

➢ Dramatic Anticipation

- Set up moments where event X implies interesting event Y *after a short delay*

- Anticipation of imminent reward/punishment is very powerful

- Example: Old Boomer vs New Boomer

Designing for Dramatic Potential

- ➢ **Many Dramatic Anticipation examples in Left 4 Dead**
  - **Infected Breaking Through Doors**
    - Classic horror movie moment of anticipation
  - **Boomer Vomit/Explosion**
    - A big attack coming in a few seconds. Anticipation enhanced via distinctive music and vision obscuring screen effect
  - **Tank Incoming!**
    - Distinctive music, Tank's distant yelling and pounding footsteps build anticipation as he approaches
  - **Witch Nearby**
    - Her sobbing in the distance creates anticipation, particularly when her position is unknown
  - **Music**
    - Many events are preceded by a distinctive piece of music that builds anticipation
  - **Finales/Crescendo Events**
    - These start with a angry crowd shrieking in the distance, implying chaos is on the way soon
  - **Finale Escape Vehicle**
    - Watching the escape vehicle arrive while fighting for your life

Designing for Dramatic Potential

➢ Dramatic Anticipation examples in Left 4 Dead (continued)
- Incoming Mobs
  - Seeing a huge mob of Infected running down the street or climbing over a fence
- "Third Strike"
  - Survivor has been revived twice will die next time – on "last legs"
- Moving slowly when injured
  - Limping into the safe room with a mob hot on your heels
- Ledge hanging
  - Classic example of anticipation – the "cliff hanger"
- Incapacitation
  - Lying helpless and bleeding on the ground generates anticipation for both the victim and his teammates
- Rescue Closets
  - Hearing trapped friends creates anticipation – especially if you are the only one left alive
- Car Alarms
  - Double anticipation: Of not setting it off, and of the mob that comes when you do

Designing for Dramatic Potential

➢ Dramatic Anticipation

➢ Requiring Cooperation

➢ Replayability
- Designing for Dramatic Potential
  - Dramatic Anticipation
  - **Structured Unpredictability**
- Adaptive Dramatic Pacing
- Procedurally Populated Environment

Designing for Dramatic Potential

➤ Structured Unpredictability – What is it?

- Collections of interesting possibilities selected at runtime using intentionally designed randomized constraints

➤ The value of Structured Unpredictability

- **Low probability + High drama = Memorable**
- Designers often want everything to be experienced, every time - resist the temptation
- Set up many *possible* moments, knowing few will happen at any run
- Unpredictability greatly enhances replayability and drama
- Combinations of randomized events generate memorable stories

➢ Requiring Cooperation

➢ Replayability

- Designing for Dramatic Potential
  - Dramatic Anticipation
  - Structured Unpredictability
- **Adaptive Dramatic Pacing**
- Procedurally Populated Environment

Adaptive Dramatic Pacing

➢ Adaptive Dramatic Pacing
  - Algorithmically adjusting game pacing on the fly to maximize "drama"

➢ Inspired by Observations from Counter-Strike
  - Natural pacing of CS is "spiky", with periods of quiet tension punctuated by unpredictable moments of intense combat
  - Constant, unchanging combat is fatiguing
  - Long periods of inactivity are boring
  - *Unpredictable* peaks and valleys of intensity create a powerfully compelling and replayable experience
  - Same scenario, often the same map, yet different and compelling experience each round

➢ The AI Director algorithmically drives overall pacing

- Creates peaks and valleys of intensity similar to the proven pacing success of Counter-Strike
- Pacing Algorithm
    - Estimate the "emotional intensity" of each Survivor
    - Track the max intensity of all 4 Survivors
    - If intensity is too high, remove major threats for awhile
    - Otherwise, create an interesting population of threats

Adaptive Dramatic Pacing

➢ Estimating the "emotional intensity" of each Survivor

- Represent Survivor Intensity as a single floating point value
- Increase Survivor Intensity
  - When injured by the Infected, proportional to damage taken
  - When the player becomes incapacitated
  - When player is pulled/pushed off of a ledge by the Infected
  - When nearby Infected dies, inversely proportional to distance
- Decay Survivor Intensity towards zero over time
- Do NOT decay Survivor Intensity if there are Infected actively engaging the Survivor
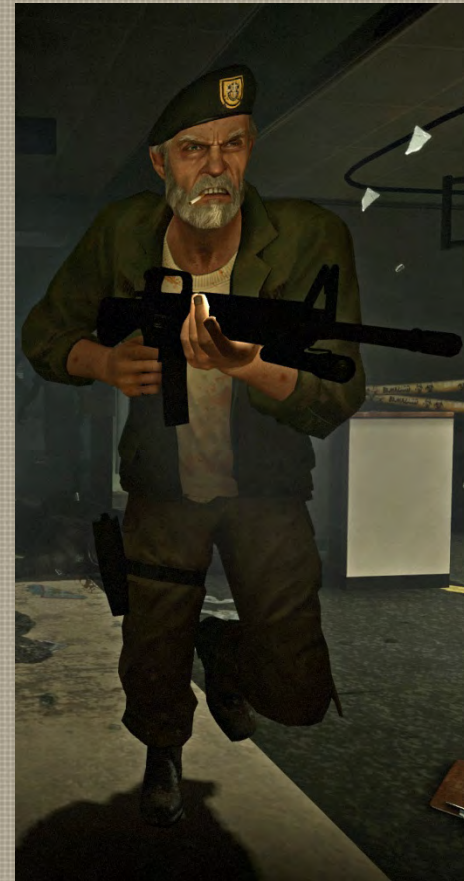
Adaptive Dramatic Pacing

➢ Use Survivor Intensity to modulate the Infected population

- Build Up
  - Create full threat population until Survivor Intensity crosses peak threshold
- Sustain Peak
  - Continue full threat population for 3-5 seconds after Survivor Intensity has peaked
- Peak Fade
  - Switch to minimal threat population ("Relax period") and monitor Survivor Intensity until it decays out of peak range
  - This state is needed so current combat engagement can play out without using up entire Relax period. Peak Fade won't allow the Relax period to start until a natural break in the action occurs.
- Relax
  - Maintain minimal threat population for 30-45 seconds, or until Survivors have traveled far enough toward the next safe room

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Adaptive Dramatic Pacing

➢ "Build Up" = Full Threat Population

- Wanderers
- Mobs
- Special Infected

➢ "Relax" = Minimal Threat Population

- No Wanderers until team is calm
- No Mobs
- No Special Infected (although existing Specials may attack)
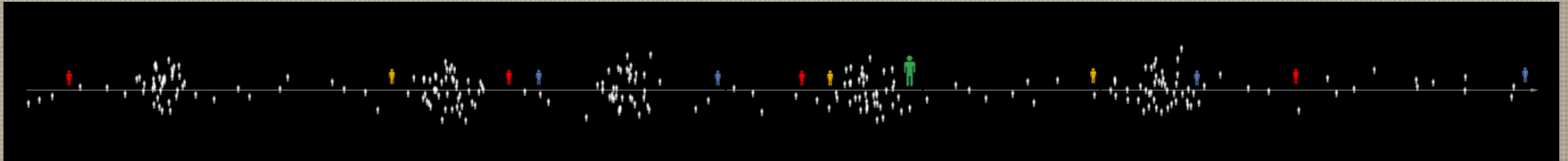
➢ Boss Encounters NOT affected by adaptive pacing

➢ Adaptive Dramatic Pacing reacts to Survivor team actions

- Generates reliable peaks of intensity without completely overwhelming the team
- Because of player variation, timing and location of peaks will differ each time game is played

➢ A procedurally generated population

➢ How the AI Director modulates the population based on the Survivor team's "emotional intensity"

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SURVIVOR INTENSITY

ACTUAL POPULATION

Adaptive Dramatic Pacing

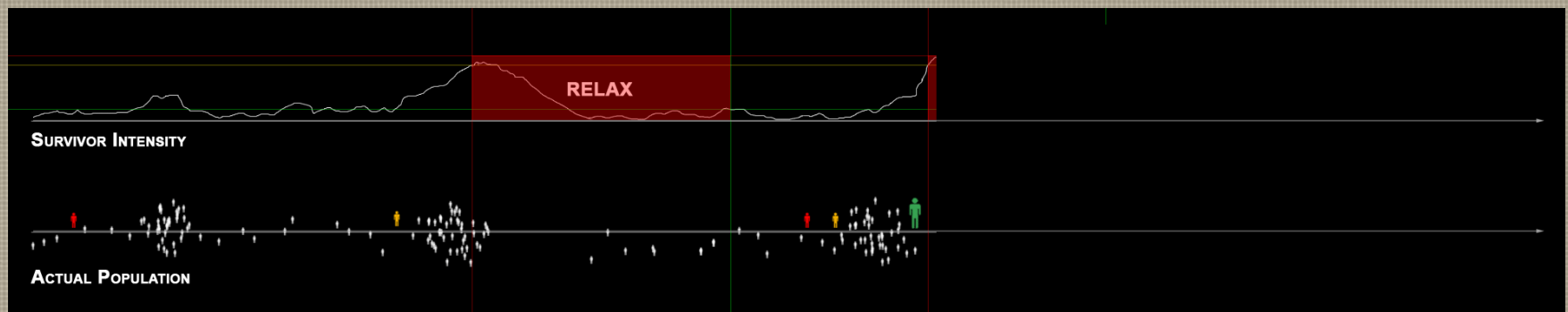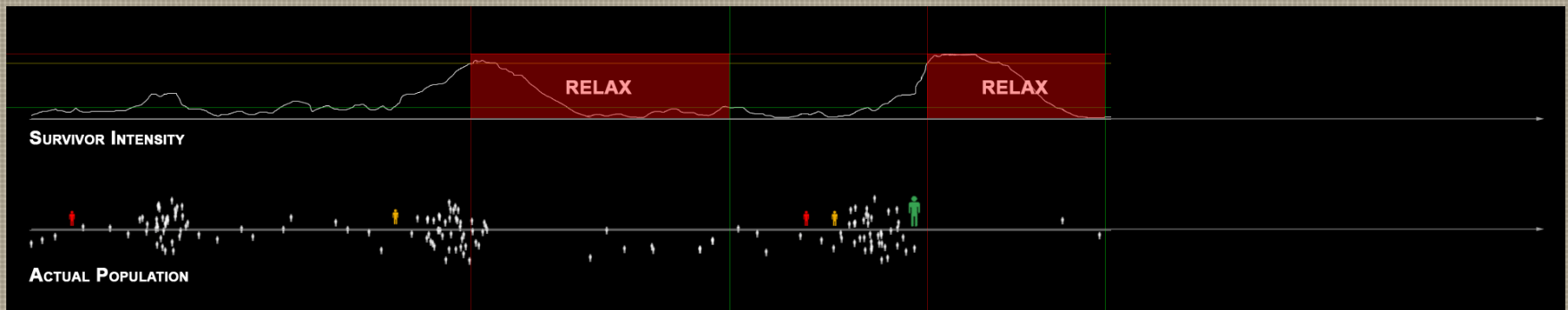➢ How the AI Director modulates the population based on the Survivor team's "emotional intensity"

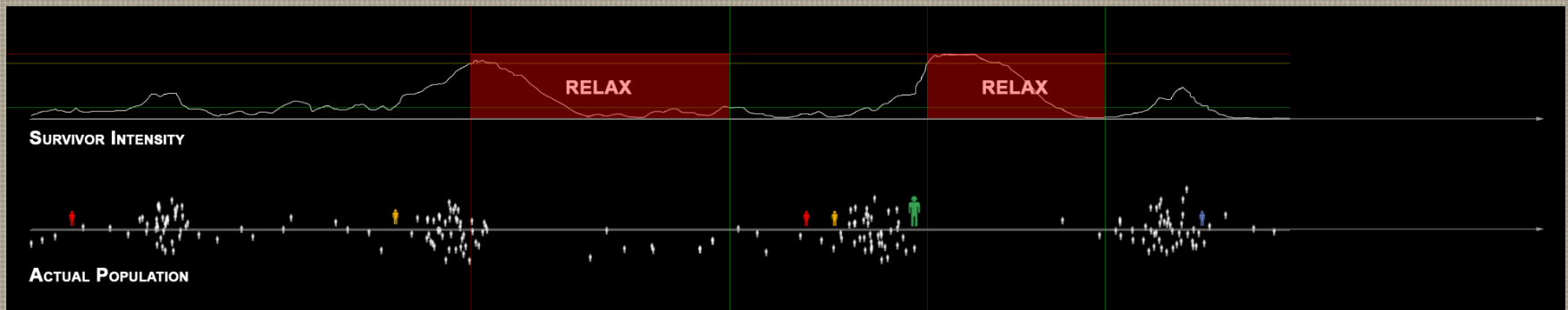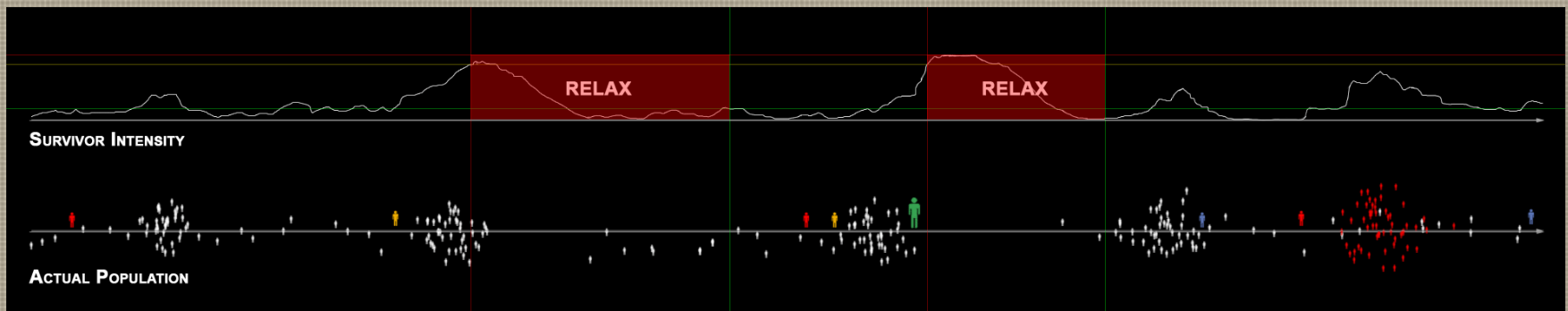➢ How the AI Director modulates the population based on the Survivor team's "emotional intensity"

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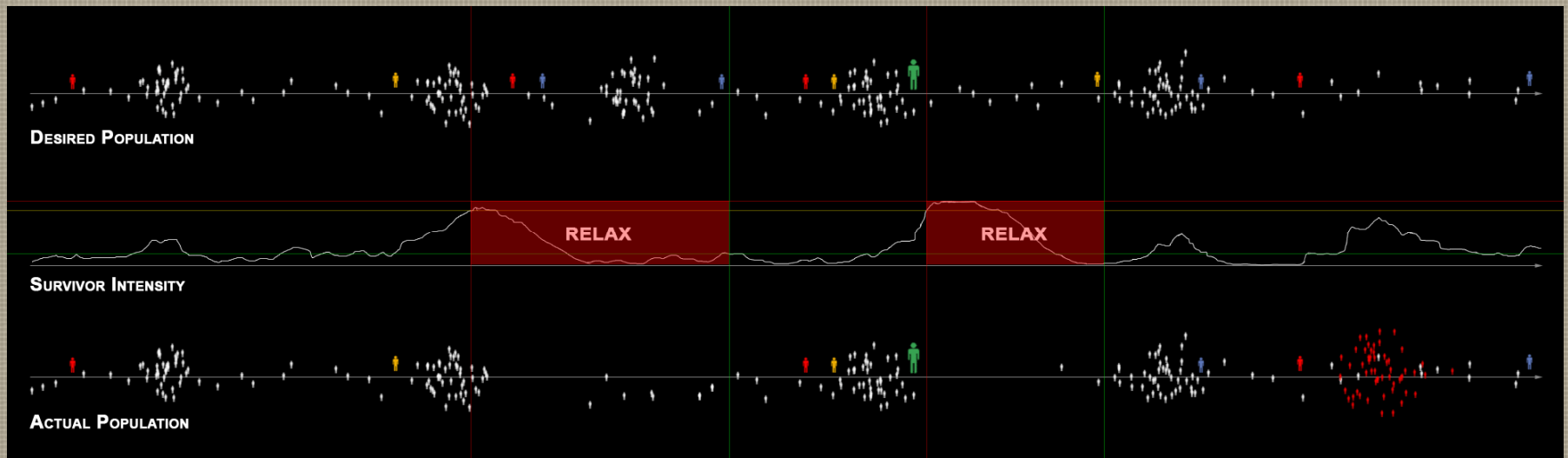➢ How the AI Director modulates the population based on the Survivor team's "emotional intensity"

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➢ Comparing population after modulation by the AI Director

➤ Requiring Cooperation

➤ Replayability

- Designing for Dramatic Potential
  - Dramatic Anticipation
  - Structured Unpredictability
- Adaptive Dramatic Pacing
- **Procedurally Populated Environment**

Procedurally Populated Environment

➤ How do we fill the environment with interesting distributions of threats?

- Layers of Structured Unpredictability

➤ How to populate world with hundreds of enemies efficiently?

- Reuse a limited number of entities
- Only populate the environment immediately surrounding the Survivor team via the Active Area Set

Procedurally Populated Environment

➤ Layers of **Structured Unpredictability** create interesting populations
- Wanderers
  - Common Infected that wander around in a daze, sit down, or lay down until alerted by a Survivor
- Mobs
  - A large group (20-30) of enraged Common Infected that rush the Survivors at unexpected times
- Special Infected
  - Infected with special abilities that skirmish with the Survivor team periodically
- Bosses
  - Powerful Infected encountered a few times per map that force the Survivors to change their strategy
- Weapon Caches
  - Collections of "2ⁿᵈ tier" weapons
- Scavenge Items
  - Pipe bombs, Molotovs, Pain Pills, Extra Pistols

Procedurally Populated Environment

➢ The Navigation Mesh
  • Originally created for Counter-Strike Bot pathfinding
  • Useful for general spatial reasoning and spatially localized information
    • Has an area been seen by an actor?
    • Is area X potentially visible by area Y?
    • "Flow" distance – distance to this area from the Survivor team start location in the map
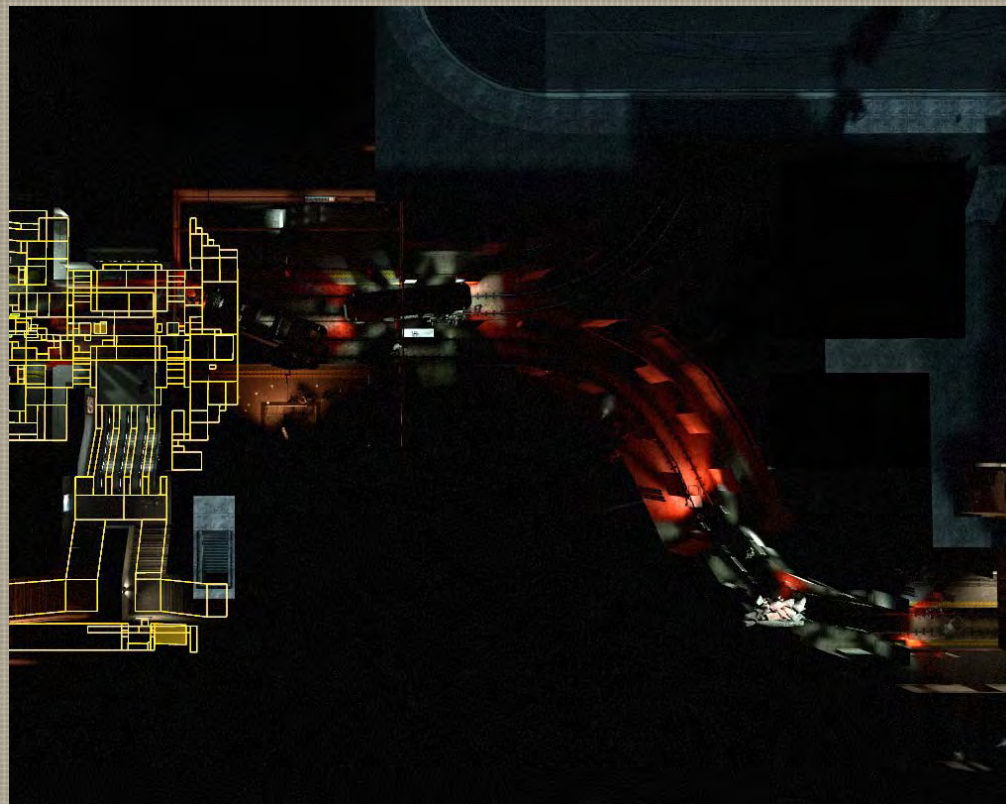   • Etc

➢ The Active Area Set (AAS)
- The set of Navigation Areas surrounding the Survivor team
- The AI Director creates/destroys Infected as the AAS moves through the environment

➢ The Active Area Set

Procedurally Populated Environment

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Procedurally Populated Environment

➢ Populating Wandering Infected
  - Stored as a simple count, C, in each area
  - Counts are randomly determined at map (re)start
  - When an area **enters** the AAS
    - Create C Infected (if possible)
  - When an area **leaves** the AAS, or a **pending Mob needs more members**
    - Wanderers in the area are deleted and C is increased accordingly
  - Wanderer count is zeroed:
    - When an area becomes visible to any Survivor
    - When the Director is in Relax mode

Procedurally Populated Environment

➢ Populating Mobs

- Created at randomized intervals (90-180 seconds on Normal difficulty)

- No mobs during Relax periods

- Boomer Vomit forces Mob spawn, resets random interval

- Mob size grows from minimum just after spawn to maximum after a duration to balance difficulty of successive, frequent Mobs

➢ Where to create Mobs

- Behind Survivors
  - Only select valid areas in the AAS that are at or behind the Survivor team's "flow" distance
  - 75% of Mobs come from behind, since wanderers and Special/Boss Infected are usually engaged ahead of the team
- Near Boomer Vomit Victim
  - Only select valid areas in the AAS that are near the Boomer Vomit Victim's "flow" distance
- Anywhere
  - Any valid area in the AAS
  - Default if there are no valid areas in the more specific sets

Procedurally Populated Environment

➢ **Populating the Special Infected**
- Created at individually randomized intervals
- No Specials during Relax periods
- Use any valid area not currently visible by the Survivor team
- Cleared status of areas ignored
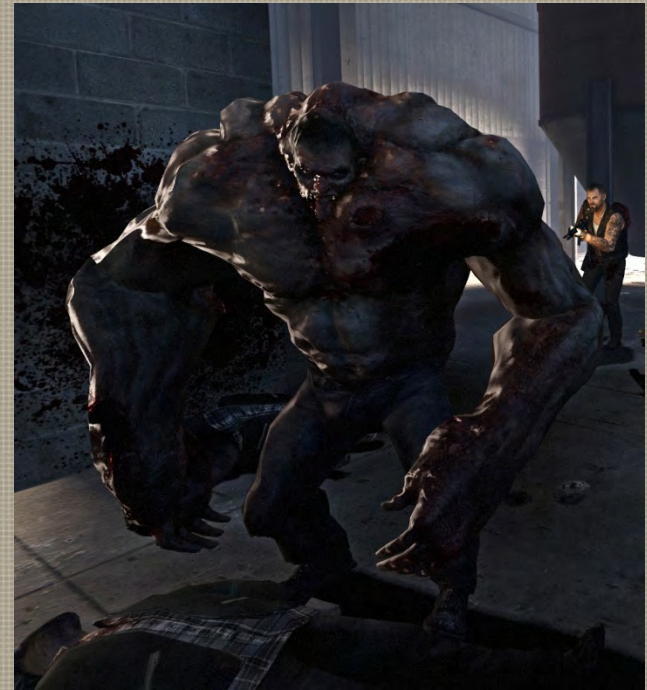- Smokers attempt to select areas above the Survivor team

Procedurally Populated Environment

➢ Boss Population

- Created every N units along "escape path" +/- random amount.

- Three Boss events are shuffled and dealt out: Tank, Witch, and Nothing.

- Successive repeats are not allowed (ie: Tank, then Tank again)

Tank	Witch		Witch		Tank		Witch	Tank

➢ Avoid manually placed scripts/triggers

- Specifically with respect to "when" and "where"
  - "what" can be ok
- Kills replayability
  - Players learn all script locations quickly
  - Removes suspense of not knowing what will happen next
- Kills cooperation
  - Players expect everyone to have memorized all encounters
  - Becomes a race

Procedurally Populated Environment

- ➢ Weapon Caches
  - Map designer creates several possible weapon caches in each map, the AI Director chooses which will actually exist
- ➢ Scavenge Items
  - Map designer creates many possible item groups throughout the map, the AI Direction chooses which groups actually exist
- ➢ Why designer-placed?
  - Prediction of possible locations beneficial in this case
  - Allows visual storytelling/intention
  - Solves item placement issues (leaning against wall, mounted in gun rack, etc)

Other Supporting Technologies

- ➢ Voice over IP
  - • "Open mic" allows spontaneous and rapid communication
  - • Hearing friend's reactions increases drama and camaraderie
- ➢ Game Instructor
  - • System of hints and visual directives allows new players to learn the game "on the fly"
- ➢ In-game Voting
  - • Allow community to police itself
- ➢ Split screen
  - • Supports casual "living room couch" cooperative play
  - • Introduces a friend to the game
- ➢ Achievements
  - • Reinforces desired co-op behaviors
  - • Poses challenges for future play sessions
- ➢ Steam/Matchmaking
  - • Friend lists
  - • Groups
  - • Free weekend passes
  - • Matchmaking
- ➢ Robust AI "Actors"
  - • CPU controlled Common, Special, and Boss Infected as well as Survivors

- ➢ A procedural, adaptive system like the AI Director needs a roster of robust AI agents to direct
    - Humans don't like to be explicitly directed (VS mode)
- ➢ Complex 3D Environment Navigation
    - Climb fences, rubble
    - Use ladders
    - Jump across rooftops
- ➢ Rich Behaviors
    - Custom HCSM system with integrated event processing
- ➢ Survivor Bots
    - Allowed us to assume baseline 4 player Survivor team for game tuning
    - Drop in/out ("Take a Break") incredibly valuable in the wild
    - Automated testing

➢ Random players in the wild will actually cooperate!
- If game is structured to facilitate it (ie: no way to win otherwise)
- Players enjoy helping each other

➢ Procedural Content
- Generates replayability
- Solution for replayable multiplayer experiences
- Greatly multiplies output of development team
- Improves community created content

➢ Dramatic Anticipation
- If an event is exciting, it will be more so if it broadcasts its impending arrival

➢ Structured Unpredictability
- Low probability + High drama = Memorable

➢ Simple algorithms can generate compelling pacing schedules
- Survivor Intensity estimation is crude, yet the resulting pacing works

Do These Techniques Work?

➢ In the six months since release, Left 4 Dead has
- … sold more than 2,500,000 retail units
- … received over 40 industry awards
- … become the #1 new IP on the PC and Xbox 360

➢ www.L4D.com
➢ www.valvesoftware.com
➢ mike.booth.gdc09 AT gmail.com

THANK YOU!